KING COUNTY

1200 King County Courthouse
516 Third Avenue
Seattle, WA 98104

King County

Signature Report

November 19, 2013

Ordinance 17697

Proposed No. 2013-0419.1 **Sponsors** Phillips

AN ORDINANCE relating to river and floodplain management, adopting the 2013 Flood Hazard Management Plan Update; and amending Ordinance 11112, Section 1 , as amended, and K.C.C. 20.12.480.

STATEMENT OF FACTS:

1. Six major river systems flow through King County - the South Fork Skykomish, Snoqualmie, Sammamish, Cedar, Green and White rivers - and their significant tributaries, the Tolt, Raging, Miller and Greenwater rivers. Other tributaries and smaller streams include Tokul Creek, Kimball Creek, Coal Creek (in Snoqualmie), Issaquah Creek, Fifteen Mile Creek and Holder Creek.

2. River and stream flooding impact private property, businesses, public and private infrastructure such as parks and utilities, transportation corridors, and can directly and indirectly result in loss of life.

3. The 2013 Flood Hazard Management Plan Update ("the 2013 flood plan update") consists of the adopted 2006 King County Flood Hazard Management Plan, as amended by technical updates and progress reports that reflect new information on flood-related hazards, vulnerabilities and accomplishments related to flood risk reduction that have occurred since

the adoption of the 2006 King County Flood Hazard Management Plan in January 2007 ("the 2006 plan"). The 2013 flood plan update does not change the policies that are contained in the 2006 plan, but does provide technical updates and progress reports to the 2006 plan, by adding additional material to Chapters 1 through 6 of the 2006 plan, and replacing Chapter 7 and Appendices A through F of the 2006 plan with a new Chapter 7 and Appendices A through L.

4. The 2006 plan provided an update to the 1993 Flood Hazard Reduction Plan in an effort to respond to aging flood protection infrastructure and unmet maintenance needs, new or updated federal regulatory requirements, environmental impacts of past flood hazard management practices and changes in watersheds since 1993.

5. In January 2007, King County adopted the 2006 plan, which contained operating principles to guide King County's river management program in meeting the intent of the water and natural resource policies of the 1994, 2000 and 2004 King County Comprehensive Plans.

6. Policy E-499r of the King County Comprehensive Plan 2012 directs that King County's floodplain land use and floodplain management activities shall be carried out in accordance with both the 2006 plan and the 2013 flood plan update.

7. The 2013 flood plan update, consisting of the 2006 plan as amended by the technical updates and progress reports, and a new Chapter 7 and Appendices A through L, continues to meet the requirements of the

National Flood Insurance Program's Community Rating System Class 2 rating, which provides up to a forty percent discount on federally backed flood insurance premiums for unincorporated King County property owners. Savings are approximately five hundred eighty-six dollars per year for the average flood insurance policy.

8. The 2013 flood plan update complies with the federal Disaster Mitigation Act and will assure that King County remains eligible and competitive for state and federal programs providing technical and financial assistance to local communities for flood hazard management.

9. As in previous plans, the 2013 flood plan update considers the impact of flood hazard management policies and actions on habitat for Puget Sound Chinook salmon and bull trout, which are listed as threatened under the federal Endangered Species Act.

10. The 2013 flood plan update continues to propose a comprehensive suite of actions to reduce flooding risks to people, property, critical public infrastructure, and the region's economy. This includes floodplain management programs such as the Flood Warning Center and maintenance of flood protection infrastructure, as well as construction projects to address a backlog of levee rehabilitation needs around King County.

11. The 2013 flood plan update describes identified flood risks and priority areas where flood risk reduction is necessary to protect life and

safety, valuable public and private property, the regional economy and general welfare of King County and its residents.

BE IT ORDAINED BY THE COUNCIL OF KING COUNTY:

SECTION 1. Ordinance 11112, Section 1, as amended, and K.C.C. 20.12.480 are each hereby amended to read as follows:

The 2006 King County Flood Hazard Management Plan, as shown in Attachment A to Ordinance 15673, is hereby amended by the 2013 Flood Hazard Management Plan Update, as shown in Attachment B to this ordinance and as amended is adopted as a functional plan to guide King County's river and floodplain management program and to meet the intent of the natural environment, and facilities and services policies of the King County Comprehensive Plan. The 2013 Flood Hazard Management Plan Update, Attachment A to this ordinance, amends the 2006 King County Flood Hazard Management Plan, Attachment A to Ordinance 15673, by adding new text to Chapters 1 through 6 of the 2006 Plan, by replacing Chapter 7 of the 2006 Plan with a new Chapter 7, and by replacing Appendices A through G of the 2006 Plan with new Appendices A through L. As an amplification and augmentation of the King County Comprehensive Plan, the flood hazard management plan as amended by the update constitutes official county policy with regard to river and floodplain management in King County. For each site-specific project, such as levee improvements or concentrated areas of home buyouts or elevations, a project summary is included to provide a better understanding of the flood or erosion conditions of concern and the action or actions proposed to address them. Project summaries, and references to easements, buffers or levee improvements, including levee laybacks, in connection with such project summaries are intended to function at the level of planning documents and do not assume that the nature and scope of each of the described projects are the final project or action that are described in ((~~this~~)) chapter 5 of Attachment A to Ordinance 15673, as amended by Chapter 5 of Attachment B to this ordinance, or in Appendices E, F and G of Attachment ((~~A~~)) B to this ((~~O~~))ordinance ((~~15673~~)). The proposed projects and actions are not intended to substitute for the site-specific analysis to determine what is required for each of the site specific capital projects that will be recommended and adopted as part of an annual capital improvement plan. The priority, scope, nature and cost of the proposed projects or actions may change as the hydraulic, engineering and geotechnical conditions at each site are analyzed in greater detail, and as engineering alternatives are developed, analyzed, reviewed and negotiated with federal, state, local and tribal agencies and affected property owner or owners. However, while the plan sets forth what the county currently believes are best practices, nothing in this plan creates or precludes the creation of new land use requirements, laws or regulations. For the reach of the Tukwila 205 levee and any extensions thereof between South 180th Street and South 204th Street, the setback, easement, and slope design recommendations of the 2006 King County Flood Hazard Management Plan, Attachment A to Ordinance 15763, as amended by the 2013 Flood Hazard Management Plan Update, Attachment B to this ordinance, are satisfied if the repair, extension or modification of an existing levee or the design of a new levee meet the design guidelines and factors of safety in United States Army Corps of Engineers Engineering Manual for the Design and Construction of Levees (EM 1110-2-1913) dated April 30, 2000, as most currently updated.

SECTION 2. **Severability.** If any provision of this ordinance or its application to any person or circumstance is held invalid, the remainder of the ordinance or the application of the provision to other persons or circumstances is not affected.

Ordinance 17697 was introduced on and passed by the Metropolitan King County Council on 11/18/2013, by the following vote:

Yes: 8 - Mr. Phillips, Mr. von Reichbauer, Mr. Gossett, Ms. Hague, Ms. Patterson, Ms. Lambert, Mr. McDermott and Mr. Dembowski
No: 0
Excused: 1 - Mr. Dunn

KING COUNTY COUNCIL
KING COUNTY, WASHINGTON

Larry Gossett, Chair

ATTEST:

Anne Noris, Clerk of the Council

APPROVED this 26 day of NOVEMBER, 2013.

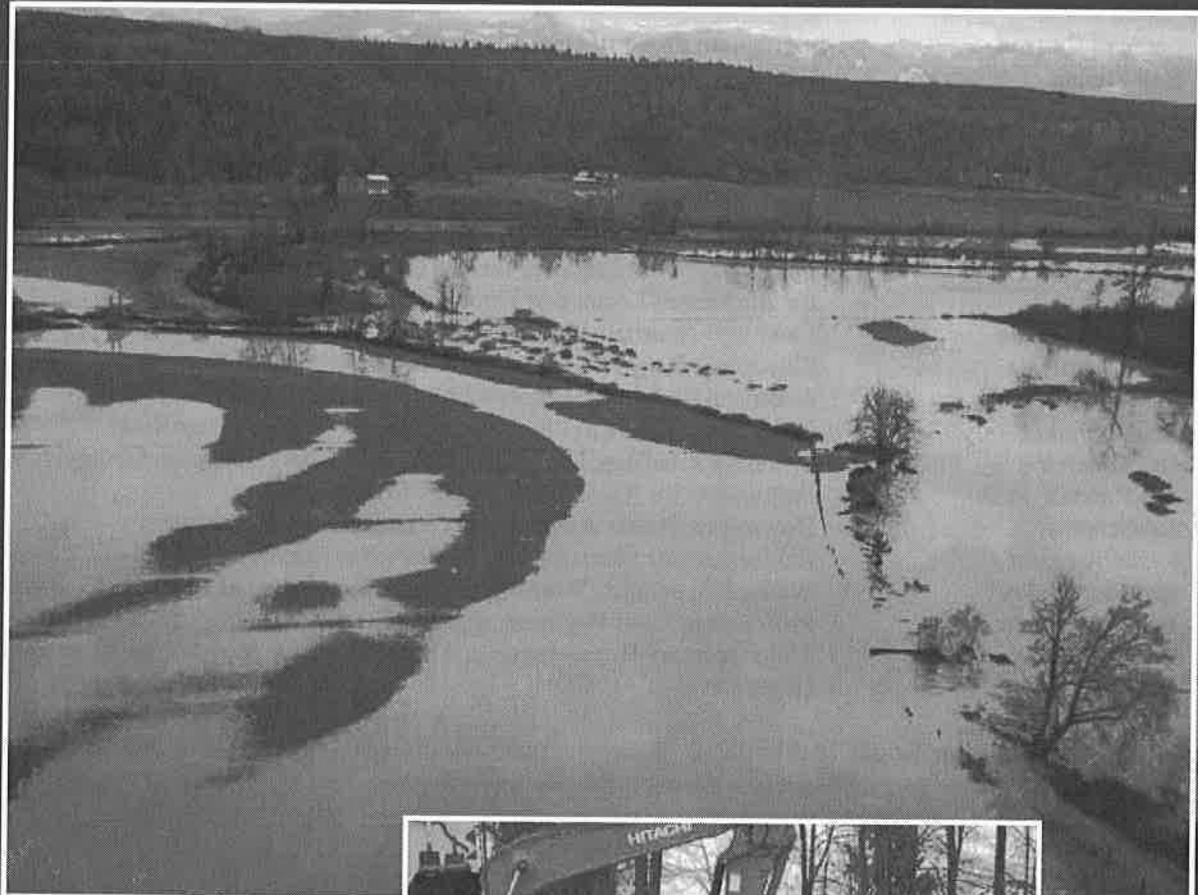
RECEIVED
2013 NOV 27 PM 3:49
CLERK
KING COUNTY COUNCIL

Dow Constantine, County Executive

Attachments: A. 2013 King County Flood Hazard Management Plan Update and Progress Report

2013 KING COUNTY FLOOD HAZARD MANAGEMENT PLAN UPDATE AND PROGRESS REPORT

An Amendment to the 2006 Flood Hazard Management Plan for the Community Rating System



King County
Department of Natural Resources and Parks
Water and Land Resources Division

17697

SPECIAL ACKNOWLEDGEMENTS

The King County Flood Control District and Water and Land Resources Division of the Department of Natural Resources and Parks thank members of the Citizen's Advisory Committee, who provided invaluable knowledge, personal experience, support, and advice in consideration of this plan update. We thank the following members appointed by the Flood Control District Board of Supervisors:

Leonard Carlson	Floodplain Property Owner, Lower Snoqualmie River
Bob Freitag	University of Washington Hazards & Mitigation Planning, Countywide
Dave Gashler	King County Housing Authority/Low Income, Green River
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Warren Halverson	Floodplain Property Owner, Upper Snoqualmie
Joseph Herr	Floodplain Property Owner, Cedar River
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Jeff Randall, PhD	Partnership for Rural King County, Countywide
Jon Scholes	Downtown Seattle Association/ Coastal Flooding, Seattle
Keith Swenson	Environmental Services, City of Bellevue, Countywide
Stephen Stanley	Wetland Specialist, Washington State Department of Ecology, Countywide
Joseph Wartman, PhD	Professor of Civil Engineering,University of Washington, Countywide
Brian Winslow	Major Industry Representative, The Boeing Company, Cedar River and Green River

Finally, the Division would like to thank the representatives of other agencies and jurisdictions who generously gave their time and expertise during preparation of this plan.

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PURPOSE OF THE 2013 FLOOD PLAN UPDATE

The National Flood Insurance Program's Community Rating System requires an update every five years to King County's Flood Hazard Management Plan. This update to the *2006 King County Flood Hazard Management Plan* (2006 Flood Plan) reflects new information on hazards, vulnerabilities, accomplishments, and proposed actions. The *2013 King County Flood Hazard Management Plan Update* (2013 Flood Plan Update) will maintain the County's Class 2 rating in the federal program, which provides a discount of up to forty percent on federally backed flood insurance premiums for unincorporated King County property owners. The 2013 Flood Plan Update is a technical update and progress report to the 2006 Flood Hazard Management Plan and does not include any new policies.

The 2013 Flood Plan Update is a companion document to the 2006 Flood Plan. Chapters, subsections and appendices of the 2013 Flood Plan Update are presented in the same order as the 2006 Flood Plan, and with the exception of the repetition of key elements of context, only new information is presented. To review current policies, basin descriptions and established floodplain knowledge, refer to the 2006 Flood Plan. The 2013 Flood Plan Update does not establish or propose new policy, though it does report on relevant regulatory changes and introduces policy issues which have emerged since the 2006 Flood Plan was adopted in January 2007.

PLAN UPDATE PROCESS

Citizen Input

King County and the King County Flood Control District initiated a public process to update the 2006 Flood Plan in July 2011 when the Board of Supervisors approved Flood Control District Motions FCD 11-03 and FCD 11-04.1, establishing a scope of work for the five-year update and appointing a Citizens Committee, which officially convened in December 2011. The scope of work included discussing policy issues that have emerged since the 2006 Flood Plan, reviewing goals and objectives, and updating the action plans for each river basin. The Citizens Committee met seven times between December 2011 and July 2012 to provide input, and staff generated a draft plan update based on this input. Three public meetings were held in December 2012 to discuss policy issues and the flood-risk-reduction strategies and action plans for each major river basin. In addition, a number of informal meetings were held with landowners and stakeholders within some basins to solicit input on potential strategies and actions.

In both the Citizens Committee process and the public meetings, considerable attention was focused on capital projects proposed in the action plans. While many of those who commented emphasized the need for "fewer studies and more action," many also emphasized that the region needs a better understanding of how actions relate to the "full picture" of land use changes, development decisions, and other actions that influence flooding in the basin. Many also asked questions along the lines of "How do we know when we will be done" and "What is the end result?" In short, while many thought the flood risk reduction actions were well thought-out and reasonable, they wanted a better understanding of the long-term goal or target for each river system so that they could better understand how specific actions and investments helped to reach that target. These comments echoed recommendations made by an independent expert panel.

Expert Review Panel Recommendations

During 2012, King County asked an Independent Expert Review Panel consisting of river and floodplain management professionals selected for their expertise in the various Water and Land Resources Division policy areas, to evaluate how well capital project scoping and implementation address four established policy objectives:

- Protecting public safety
- Preventing property damage
- Recovering salmon
- Providing recreation.

The recommendations from this expert panel were discussed with the Citizens Committee. The panel provided several constructive recommendations, including the recommendation that King County develop strategic river management plans for each major river that:

- Summarize the legal drivers and policy mandates that encourage use of ecological/dynamic floodplain management strategies when possible.
- Broadly describe the scientific and applied practice support for implementing ecological/dynamic floodplain strategies (while also identifying when more traditional approaches may be needed).
- Clearly document the river and floodplain management strategy, including project objectives and implementation approaches at the multi-basin, watershed, and river segment scale.
- Summarize programmatic processes by which individual projects are selected, funded, designed, sited, constructed, and monitored.
- Connect policy and programmatic elements to existing flood hazard and salmon recovery plans.
- More clearly identify strategic planning objectives, management actions, and criteria for project selection and implementation.
- Are concise and accessible to staff, agencies, stakeholders and the general public.

For individual capital projects, the panel further recommended that King County do the following:

- Clarify site-specific project goals and objectives and explain how they fit into larger basin-wide or multi-basin strategies.
- Identify potential tradeoffs between objectives for individual projects.
- Communicate key project features and illustrate potential outcomes to help the public and stakeholders understand how those will help meet river and floodplain management objectives.

FUTURE RIVER CORRIDOR PLANNING

As a result of the feedback from citizens, the expert panel, and other government agencies, additional work is necessary to develop river corridor plans that achieve the following:

- Establish desired floodplain management outcomes and levels of service appropriate to each river system. For a discussion on levels of service, refer to Chapter 4, page 30.
- Provide a clear description of measurable floodplain management outcomes provided by different levels of investment.
- Document the full life cycle costs and trade-offs between near-term construction and long-term maintenance costs for different capital project alternatives.

Alternative flood risk reduction projects proposed as a result of corridor studies will be analyzed for their costs and benefits, weighing such items as near-term acquisition and construction costs, long-term operation and maintenance, ecological impacts, and other ancillary costs and benefits to inform decisions about significant regional capital investments for public safety and the environment.

This 2013 Flood Plan Update addresses planning elements required to maintain King County's Community Rating System credits as a Class 2 community, while proposing the enhanced river corridor planning approach. A second phase of work will develop river corridor plans for each of King County's major river systems.

River corridor plans will inform flood-risk-reduction strategies based on current conditions, determine desired outcomes and levels of service, and offer alternative project approaches to achieve desired outcomes. Corridor plans are intended to be adopted by amendment as completed, and then combined into a new *2018 King County Flood Hazard Management Plan*.

CHAPTER 1. INTRODUCTION

Chapter 1 of the *2006 King County Flood Hazard Management Plan* (2006 Flood Plan) provides introductory information on the purpose of the plan, goals and objectives, guiding principles and the overall process for plan development. Since adoption of the 2006 Flood Plan, the King County Flood Control District was formed and a citizens committee was convened as a part of the planning process. Updated information to reflect these changes, as well as to document public involvement and the current planning process, is detailed below. Chapter 1 includes only updated information regarding the planning process, public meetings, and the formation of the King County Flood Control District, all required elements of a Community Rating System plan update. Refer to the 2006 Flood Plan for additional background information and status quo material such as plan goals, objectives, and guiding principles, which were not revised for the 2013 Flood Plan Update.

GOVERNANCE AND FORMATION OF THE KING COUNTY FLOOD CONTROL DISTRICT

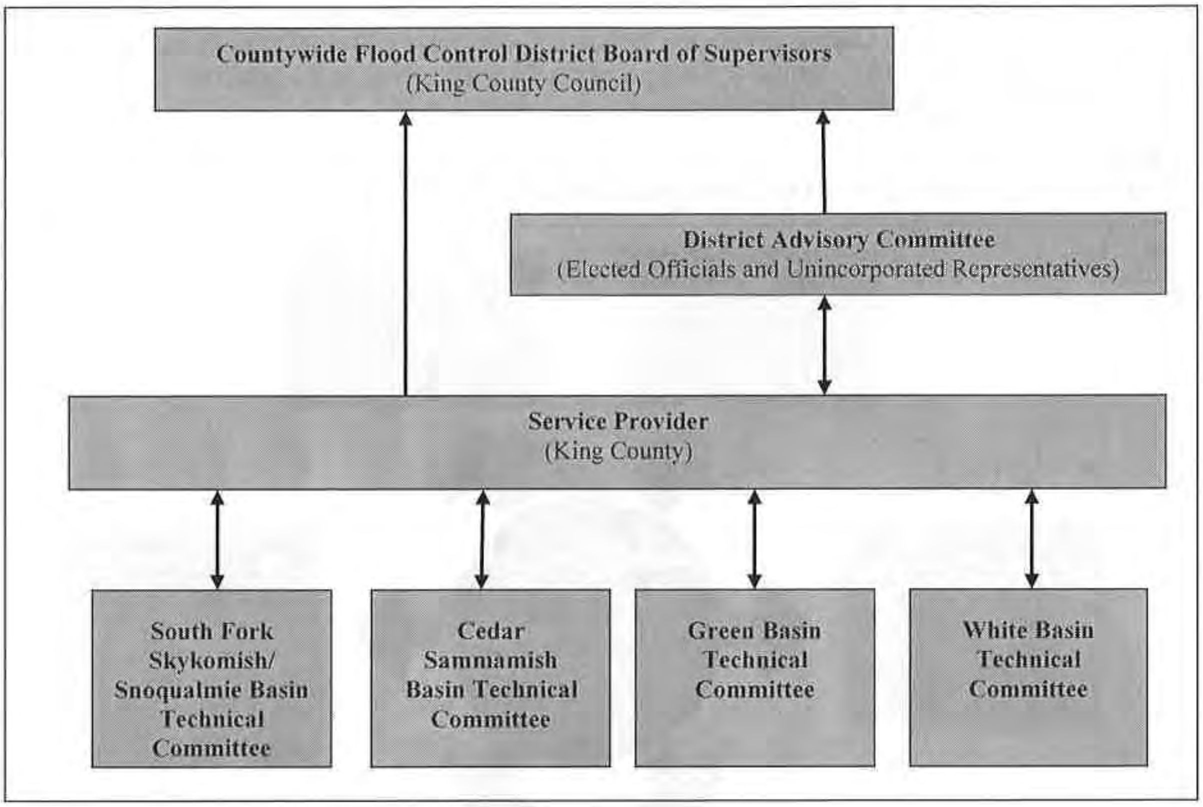
The *2013 King County Flood Hazard Management Plan Update* (2013 Flood Plan Update) builds on regional policies, programs and projects adopted in the 2006 Flood Plan to reduce the risk to people and property from river flooding and channel migration in King County. The 2006 Flood Plan created a long-term vision for flood hazard management of King County's floodplains and recommended specific near-term actions consistent with that vision. In order to fund and guide implementation of those recommendations, the 2006 Flood Plan proposed the formation of a countywide flood control zone district. This district would have property tax authority and would be led by local elected officials.

In April 2007, following the recommendation of the 2006 Flood Plan, the Metropolitan King County Council voted to create the King County Flood Control Zone District. The Flood Control Zone District was authorized to use the name "King County Flood Control District" and is referred to in this 2013 Flood Plan Update as" the District." The Revised Code of Washington authorizes the nine County Council members to be ex officio members of the District's governing body, which is known as the Board of Supervisors (Chapter 86.15 RCW).

The District's governance structure, shown in Figure 1-1, includes an executive committee, advisory committee and basin technical committees. The executive committee, made up of four members of the Board of Supervisors, meets monthly and develops policy recommendations for consideration by the full board. This committee oversees the day-to-day business of the District. The 15-member advisory committee consists of representatives of cities that have historically experienced significant flooding, representatives of the Suburban Cities Association, representatives of areas that are major revenue contributors, and a member from an unincorporated area council. The advisory committee provides the Board of Supervisors with policy recommendations on regional flood protection and annual budgeting issues, and on priorities and implementation strategies for the District's capital improvement program. Basin technical committees, made up of technical staff from local jurisdictions, represent each of King County's major river basins and ensure that basin-scale issues and basin-specific technical information are considered in District decision-making.

In forming the District, the King County Council authorized a property tax levy of $33.2 million in 2008. The property tax has been reauthorized annually and is levied throughout King County. The estimated 2013 levy collection is $41.3 million. This funding supports the comprehensive, countywide flood risk reduction program proposed in the 2006 Flood Plan and ensures funding to address maintenance, repair, and reconstruction of King County's aging flood protection infrastructure.

Figure 1-1.
KING COUNTY FLOOD CONTROL DISTRICT GOVERNANCE STRUCTURE



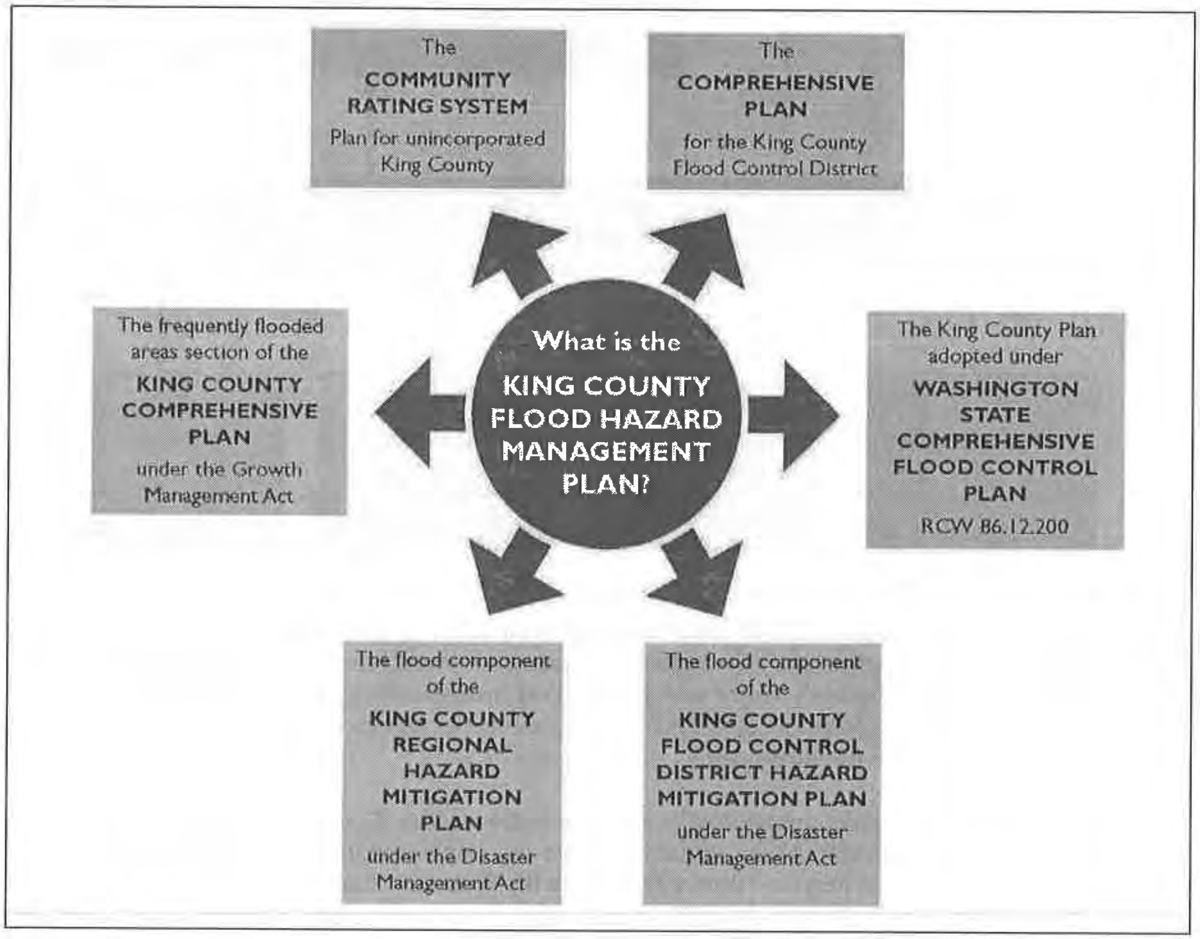
The District is a special purpose district under State law with authority over flood and stormwater control. King County provides complimentary floodplain management services, such as implementing floodplain management regulations to comply with the National Flood Insurance Program and the Growth Management Act, and providing services to maintain the ratings of unincorporated King County and cities under the Community Rating System.

The District executed and maintains an interlocal agreement with King County whereby the County functions as the service provider to the District for day-to-day implementation of District projects and programs. These services are provided primarily through the Water and Land Resources Division's River and Floodplain Management Section. Because of the cooperative arrangements between King County and the District, this document supports floodplain management services for both unincorporated King County and the King County Flood Control District.

As stated in the 2006 Flood Plan, floodplain management in King County is comprehensive and is implemented at a multiple-agency level. The level of management has evolved in response to state and federal mandates and in response to local flooding conditions. The 2013 Flood Plan Update complements and supports actions implemented under other King County programs relevant to the management of floodplains on smaller tributaries and water bodies. These programs include but are not limited to basin planning, lake management planning, and the management of stormwater runoff using the *King County Surface Water Design Manual*. The elements of the 2006 Flood Plan and the 2013 Flood Plan Update are relevant and applicable to all floodplains and channels within the county.

As shown in Figure 1-2, the 2006 Flood Plan and 2013 Flood Plan Update fulfill requirements of several local, state and federal regulatory programs. They were developed in accordance with the National Flood Insurance Program and the Community Rating System and contribute to the rating of King County and participating cities under the Community Rating System. They also serve as the comprehensive plan of the District, when adopted by the District.

Figure 1-2.
WHAT IS THE KING COUNTY FLOOD HAZARD MANAGEMENT PLAN?



The 2013 Flood Plan Update is a companion document to the 2006 Flood Plan. Both are adopted as a technical appendix to the King County Comprehensive Plan and achieve the following objectives:

- Meet planning requirements for unincorporated King County and participating King County cities under the federal Community Rating System, and maintain a superior rating that allows discounts for flood insurance to community members.
- Serve as the comprehensive plan for the District, when adopted by the District.
- Meet Washington Growth Management Act requirements for addressing frequently flooded areas (King County Comprehensive Plan Chapter 8, Section II. L. and RCW 36.70A.040).
- Fulfill state requirements for developing a comprehensive flood control plan and thus retain local eligibility for state grant funds under the Flood Control Assistance Account Program (RCW 86.12.200).

- Serve as the flood component of the *King County Flood Control District Hazard Mitigation Plan* and the *King County Regional Hazard Mitigation Plan*, thus maintaining consistency with the federal Disaster Mitigation Act and remaining eligible for federal flood mitigation grant programs.

Adoption of the 2013 Flood Plan Update builds on the long-term flood hazard management vision for King County that was established in the *1993 King County Flood Hazard Reduction Plan* and updated in the 2006 Flood Plan. This update reflects changing conditions and new directions in projects and programs since the 2006 Flood Plan was written. Like the earlier flood plans, the 2013 Flood Plan Update seeks to identify specific flood hazard management actions that can be taken to reduce flood and channel migration risks and to protect, restore, or enhance riparian and aquatic ecosystems.

2013 PLANNING AND UPDATE PROCESS

State law governs flood control by the County and authorizes flood control districts formed by the County Council to adopt comprehensive plans to guide capital expenditures.

The 2013 Flood Plan Update is the first update since adoption of the 2006 Flood Plan. The process for updating the 2006 Flood Plan began in July 2011 when the Board of Supervisors approved a motion establishing a scope of work for the five-year update and appointed a 20-member Citizens Committee, which officially convened in December 2011. The Citizens Committee included five members from the 2006 Flood Plan advisory committee. Two of the 20 members appointed to the Citizens Committee declined the offer to serve. The Citizens Committee, convened to serve as a sounding board at key milestones during development of the 2013 Flood Plan Update, reflected urban and rural floodplain interests and included floodplain property owners as well as professionals in the field of engineering and floodplain management. As with the 2006 Flood Plan development process, over half of the members live or work in floodplains.

Intended to inform the development of the 2013 Flood Plan Update, seven Citizens Committee meetings were held before August 2012. All Citizens Committee meetings were open to the public and featured a public comment period. A countywide outreach effort was conducted via direct mailing to all property owners adjacent to the county's major rivers and their tributaries. The mailing informed them of the 2013 Flood Plan Update timeline and next steps. Three public meetings were held in December 2012 to discuss flood-risk-reduction strategies for protecting people, businesses and the County's economic infrastructure. A four-week-long public review and comment period was conducted and a formal public comment period was established on June 14, 2013, once the draft Plan had been prepared. During the public review and comment period, one countywide public meeting was held (July 9, 2013) to receive comments and recommendations associated with the draft Plan. Comments were also received during the public review and comment period via e-mail, direct mail, and phone.

CHAPTER 2.
POLICIES

No changes to Chapter 2 are being proposed for the 2013 Flood Plan Update; there is no new policy language in this Chapter.

Chapter 2 of the 2006 Flood Plan focuses on policies that provide a framework for making decisions about floodplain management in King County. While the 2013 Flood Plan Update proposes no new policies, the District identified several policy issues which had emerged since the 2006 Flood Plan and asked for consideration and discussion by the Citizens Committee as part of the update process. Issue papers on these topics and a report of Citizens Committee discussions are located in Appendix L of this document.

- Levee Certification, and Accreditation and Flood Risk Reduction "Levels of Service"
- Levee Vegetation and Eligibility for U.S. Army Corps of Engineers Levee Repair Funding
- Capital Project Funding for Coastal Flood and Erosion Risks
- Urban Flooding and Small Streams
- Equity and Social Justice: Outreach to Vulnerable and Underserved Populations
- Property Acquisitions and Relocation Assistance Capital Project Prioritization and, Sequencing Approach, Criteria and Scoring and Eligibility Criteria
- Bioengineering and the Use of Wood in Flood Projects
- Gravel Removal and Sediment Management
- Gravel Removal and Sediment Removal

CHAPTER 3.
FLOODING IN KING COUNTY

Chapter 3 of the 2006 Flood Plan provides information and context on flooding issues in King County. Specifically, this chapter discusses the types of flood-related hazards experienced in King County, identifying areas at risk, the costs and impacts of flooding and flood related hazards, county participation in the Community Rating System, and general floodplain management practices in King County. For Community Rating System purposes, this five year plan update must include a review of new studies, reports, and technical information; and an assessment of the hazard and risk in the planning area; this required information is provided below. New and amended information for the 2013 Flood Plan Update includes the addition of lahar and coastal flood hazards, an updated evaluation of areas exposed to flood-related risks, updated statistics on impacts from flood disasters since adoption of the 2006 Flood Plan, and an updated summary of King County's Community Rating System program. Refer to Chapter 3 of the 2006 Flood Plan for additional information and for elements that remain unaffected.

TYPES OF FLOOD-RELATED HAZARDS

Lahar Hazards

Lahars are rapidly flowing mixtures of rock debris and water, sometimes referred to as mudflows, which originate on the slopes of a volcano and typically flow along a river valley. The White River Valley and the Green/Duwamish Valley downstream of Auburn have been inundated by lahar deposits multiple times in the last 10,000 years, such as the Osceola Mudflow. Although lahars are seldom compared to flooding, their potentially catastrophic consequences make a strong argument for including this hazard in regional disaster planning. Lahar hazards and mitigation strategies share elements in common with those related to flooding; it is appropriate to address these hazards concurrently where they overlap.

Coastal Flood Hazards

Coastal areas are subject to a variety of natural processes that present significant hazards to public safety and property, including storm surge flooding, waves, erosion, rainfall, and wind. Coastal flood hazards with potential to impact the sheltered waters of King County include coastal flooding and coastal erosion. Changes in sea level and climate change further increase the potential impact of these hazards. Coastal flooding results from high water and wave action produced by storm systems. Storm surges, also referred to as storm tides, can affect a number of beachfront areas in King County. Generally, storm surges are caused by an increase in the usual tide level by a combination of low atmospheric pressure and onshore winds. During a storm surge, water levels and waves may run significantly higher than the predicted tide level, and these higher waters may result in flooding and erosion.

IDENTIFYING AREAS AT RISK FROM FLOODING AND CHANNEL MIGRATION

King County identifies areas that are at risk from flooding and channel migration using a variety of mapping, analytic, and property-tracking approaches.

Channel Migration Hazard Mapping

Channel migration studies continue, but there have been no substantial changes since adoption of the 2006 Flood Plan.

Flood Inundation Hazard Mapping

Since 2006, King County has made significant progress in mapping the extent of the 100-year floodplain of many of the major rivers; however, not all river floodplain maps have been updated. Table 3-1 shows the total floodplain area along streams and rivers for which a 100-year floodplain has been mapped in both unincorporated and incorporated areas of King County. As river conditions change, the 100-year floodplain may extend beyond currently mapped areas. The mapped 100-year floodplains in King County cover more than 52,000 acres, or close to 82 square miles. As of 2012, there were 6,250 exposed structures in the mapped 100-year floodplains throughout King County, with a total assessed value of over $11.3 billion for combined structure and content value, as listed in Table 3-1. Coastal areas are represented in Table 3-1 under "other floodplain areas."

TABLE 3-1.
LAND AND STRUCTURES LOCATED IN MAPPED 100-YEAR FLOODPLAINS IN KING COUNTY

Total Area	Structures Within the Floodplain				Potential Damage from 100-Year Flood[a]			
in the 100-Year Floodplain (acres)	Number of Structures Exposed	Structure Value Exposed	Content Value Exposed	Total Value (Structure & Content exposed)	Structure Damage[b]	Content Damage[b]	Non-Residential Inventory Damage[c]	Total Damage (Structure, Content & Inventory)[b]
South Fork Skykomish River								
1,969	304	$51,583,037	$36,457,868	$88,040,904	$3,105,745	$5,837,718	$0	$8,943,463
Snoqualmie River								
21,434	2,415	$687,352,588	$509,739,747	$1,197,092,335	$56,370,711	$83,610,859	$32,071,554	$172,053,123
Sammamish River								
4,424	438	$764,857,780	$743,624,587	$1,508,482,366	$24,585,646	$80,554,813	$74,805,591	$179,946,050
Cedar River								
2,204	389	$186,050,029	$144,668,050	$330,718,078	$4,735,725	$2,981,102	$391,139	$8,107,966
Green River								
9,446	1,175	$3,663,127,662	$3,628,333,265	$7,291,460,927	$212,464,070	$673,790,375	$736,289,984	$1,622,544,429
White River								
3,580	196	$36,392,197	$18,470,644	$54,862,841	$3,616,557	$1,760,676	$201,156	$5,578,389
Other Floodplain Areas, Including Coastal Areas								
9,402	1,333	$521,623,330	$334,057,606	$855,680,936	$64,270,441	$58,455,992	$25,540,913	$148,267,347
Total For King County Major Rivers								
52,459	**6,250**	**$5,910,986,623**	**$5,415,351,766**	**$11,326,338,388**	**$369,148,895**	**$906,991,535**	**$869,300,337**	**$2,145,440,768**

a. Estimates do not account for potential losses outside of mapped floodplains, such as in levee-protected portions of the lower Cedar River and Green River valley.
b. Potential damage estimates from Hazards-United States, or HAZUS, model.
c. Potential inventory losses are estimated using U.S. Army Corps of Engineers depth-damage functions, in conjunction with HAZUS default inventory values determined as a percentage of annual sales per square foot for commercial, industrial and agricultural structures.

Repetitive Loss Areas

As stated in the 2006 Flood Plan, "properties included in FEMA's repetitive loss property inventory are another indication of floodplain areas that are at risk from flooding." FEMA's definition of repetitive loss remains consistent with that in the 2006 Flood Plan. An assessment of King County's repetitive loss inventory since adoption of the 2006 Flood Plan was conducted for the 2013 Flood Plan Update. Currently, the FEMA repetitive loss inventory includes 171 properties in unincorporated King County

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(Table 3-2). Repetitive loss inventory data for incorporated areas is included in Appendix C, Table 1. Since 1997, King County has reduced the flood risks associated with 54 of these privately owned properties through the completion of mitigation projects. Twenty-eight of these were home elevations, and 26 repetitive loss properties were acquired by King County and their structures demolished. All 54 properties have been identified as mitigated within FEMA's repetitive loss property inventory. The 2006 Flood Plan and 2013 Flood Plan Update recommend projects and programs to address the 117 remaining repetitive loss properties, as described in the Action Plan (Appendix F).

TABLE 3-2.
UNINCORPORATED KING COUNTY PROPERTIES ON FEMA'S REPETITIVE LOSS INVENTORY AS OF SEPTEMBER 2012

River Basin	Total Number of Repetitive Loss Properties	Repetitive Loss Properties with Completed Flood Mitigation Actions	Repetitive Loss Properties Not Mitigated
South Fork Skykomish	11	3	8
Snoqualmie River	128	36	92
Sammamish River	3	1	2
Issaquah Creek	3	1	2
Cedar River	19	11	8
Green River	3	1	2
White River	1	1	0
Central Puget Sound (Vashon Island)	3	0	3
Total	**171**	**54**	**117**

Source: King County River and Floodplain Management Program, 2011; FEMA National Flood Insurance Program's Community Rating System Repetitive Loss Properties, 2012.

As stated in the 2006 Flood Plan, FEMA's repetitive loss property inventory "consists of properties that are insured through the National Flood Insurance Program and have experienced the following since 1978, regardless of changes in ownership:

- Four or more paid flood insurance losses in excess of $1,000
- Two paid flood insurance losses in excess of $1,000 within any rolling 10-year period since 1978, or
- Three or more paid flood insurance losses that equal or exceed the current value of the insured property."

King County views its total number of repetitive loss properties to be a low estimate because not all property owners purchase flood insurance through the National Flood Insurance Program. As of April 17, 2012, flood insurance policies for repetitive loss properties made up nearly 4 percent of the total number of flood insurance policies in King County. Between 2006 and 2011, claims paid to owners of flood-insured repetitive loss properties accounted for 49 percent of the total damage claims filed by all flood insurance policy holders. These numbers underscore the need for mitigation measures for repetitive loss properties.

ACTUAL FLOOD DAMAGE AND IMPACTS

Loss of life and property damage remain the two most serious impacts of flooding along the major rivers in King County. To date, major river flooding in King County has infrequently contributed to injury or loss of life; more typically, major river flooding in King County results in property damage. There has been one documented flood-related fatality since 2006.Major flood events in King County have resulted in significant property damage. King County has been declared a flood disaster area 13 times since 1990, five of these since adoption of the 2006 Flood Plan. Reported flood-related damage to public property between 2006 and 2012 totals over $50 million, as shown in Tables 3-3 and 3-4. This estimate does not include flood damage to private properties or to publicly owned properties that were not eligible for federal disaster assistance. The information presented in Tables 3-3 and 3-4 represents damage sustained in King County, 33 cities and towns, and 32 other entities, including special purpose districts, state agencies, tribes, and miscellaneous agencies. The events listed include two federally declared disasters that did not technically include flooding.

TABLE 3-3.
FEDERALLY DECLARED FLOOD DISASTERS IN KING COUNTY, 1990-2012: DAMAGE TO PUBLICLY OWNED PROPERTY IN KING COUNTY

Flood Date	Federal Event Number	Estimated Damage: Unincorporated King County	Estimated Damage: King County Cities	Estimated Damage: Special Purpose Districts/Other	**Total Estimated Damage**
January 1990[a]	DR-852				**$5,246,411**
November 1990[a]	DR-883				**$3,694,824**
December 1990[a]	DR-896				**$477,737**
November 1995[a]	DR-1079				**$3,031,519**
February 1996[a]	DR-1100				**$4,226,719**
December 1996[a]	DR-1159				**$3,576,309**
March 1997[a]	DR-1172				**$1,266,446**
November 2006	DR-1671	$3,838,894	$1,225,765	$321,664	**$5,386,323**
December 2006	DR-1682[b]	$2,334,800	$12,570,656	$673,261	**$15,578,717**
December 2007	DR-1734	$661,999	$3,987,495	$474,347	**$5,123,841**
December 2008 - January 2009	DR-1825[b]	$1,730,190	$3,678,394	$2,197,966	**$7,606,550**
January 2009	DR-1817	$7,767,260	$6,231,751	$2,445,764	**$16,444,775**
January 2011	DR-1963	Estimated damage not yet available			
January 2012	DR-4056	Estimated damage not yet available			
Total		**$16,333,233**	**$50,192,931**	**$6,113,002**	**$71,660,171**

a. Only total estimated damage values are available.
b. King County sought federal flood mitigation grant funding under these federally declared disasters, although they did not technically include flooding.

Source: Washington Military Department, Emergency Management Division, 2012

TABLE 3-4.
FEDERALLY DECLARED FLOOD DISASTERS IN KING COUNTY, 1990-2012: LOCAL, STATE, AND FEDERAL COST SHARE TO REPAIR DAMAGED PUBLIC PROPERTY

Flood Date	Event Number	Federal Share	State Share	Local Share	**Total**
January 1990	DR-852	$3,696,349	$615,685	$615,685	**$4,927,719**
November 1990	DR-883	$2,627,506	$437,121	$437,121	**$3,501,748**
December 1990	DR-896	$346,792	$57,798	$57,798	**$462,388**
November 1995	DR-1079	$1,504,057	$250,672.50	$250,672.50	**$2,005,402**
February 1996	DR-1100	$3,476,523	$1,013,332.50	$145,505.50	**$4,635,361**
December 1996	DR-1159	$3,479,123	$579,851.50	$579,851.50	**$4,638,826**
March 1997	DR-1172	$949,834	158,306	$158,306	**$1,266,446**
November 2006	DR-1671	$4,039,743	$673,290	$673,290	**$5,386,323**
December 2006	DR-1682[a]	$11,684,039	$1,947,339	$1,947,339	**$15,578,717**
December 2007	DR-1734	$3,842,881	$640,480	$640,480	**$5,123,841**
December 2008-January 2009	DR-1825[a]	$5,704,914	$950,818	$950,818	**$7,606,550**
January 2009	DR-1817	$12,333,581	$2,055,597	$2,055,597	**$16,444,775**
January 2011	DR-1963	Estimated damage not yet available			
January 2012	DR-4056	Estimated damage not yet available			
Total		**$53,685,342**	**$9,380,291**	**$8,116,286**	**$71,578,096**

a. King County sought federal flood mitigation grant funding under these federally declared disasters, although they did not technically include flooding.

Source: Washington Military Department, Emergency Management Division, 2012.

KING COUNTY AND THE COMMUNITY RATING SYSTEM

As of May 1, 2012, 1,211 communities nationwide received flood insurance premium discounts under the Community Rating System. Communities receiving premium discounts through the Community Rating System range from small towns to large metropolitan communities and represent a broad mixture of flood risks, including both coastal and riverine flood risks. In Washington State, 33 communities participate in the Community Rating System program. Although insurance premium discounts are one benefit of participation in this program, more important benefits result from activities that save lives and reduce property damage. Participating communities represent a significant portion of the nation's flood risk, with a significant percentage of the National Flood Insurance Program's policy base located in these communities.

King County began its participation in the Community Rating System in 1990, the federal program's first year of operation. In October 2007, King County became a Class 2 community, which results in up to a 40 percent premium reduction within regulated floodplains and 10 percent premium reduction outside of special flood hazard areas; special flood hazard area is a term used by FEMA to describe the 100-year floodplain. Such areas are required to be regulated by communities participating in the National Flood Insurance Program, and structures in a special flood hazard area are required to purchase flood insurance. As of May 2012, there were 2,725 flood insurance policies in King County; 1,651 of the policies, 61 percent of the total, are for properties located either partially or completely within the floodplain. The remaining 1,074 policies, 39 percent of the total, are for properties located outside the floodplain.

Insurance policy premiums under the National Flood Insurance Program in King County average $665 per policy as a result of the Class 2 rating. As of April 2012, King County's rating amounted to an annual savings of $830,265 to policyholders in unincorporated King County, an average savings of $578 per policy. King County receives credit for 17 of the 18 creditable activities under the Community Rating System. King County's steadily improving Community Rating System classification since 1990 is a function of the County's commitment to comprehensive and cost-efficient floodplain management strategies. King County's ability to maintain or improve its Community Rating System classification will result from successful implementation of the policies, projects, and programs contained in the 2013 Flood Plan Update.

In addition to unincorporated King County, seven cities in the county participate in the Community Rating System: Auburn, Bellevue, Issaquah, Kent, North Bend, Renton and Snoqualmie, shown in Table 3-5.These communities obtain some Community Rating System points by activities funded by the District. The City of Kent is the most recent addition to the program, with an entry date of May 2010.

TABLE 3.5. KING COUNTY COMMUNITIES PARTICIPATING IN THE COMMUNITY RATING SYSTEM, AS OF JULY, 2013

Community Name	Current Class	Percent Discount in the Special Flood Hazard Area (100-year floodplain)	Percent Discount for non-Special Flood Hazard Area
City of Auburn	5	25	10
City of Bellevue	5	25	10
City of Issaquah	5	25	10
City of Kent	6	20	10
City of North Bend	6	20	10
City of Renton	6	20	10
City of Snoqualmie	5	25	10
King County	2	40	10

Source: FEMA Community Rating System (CRS) Communities and their classes. http://www.fema.gov/library/viewRecord.do?id=3629, Accessed July 17, 2013.

CHAPTER 4.
FLOOD-RISK-REDUCTION STRATEGIES AND TOOLS

Chapter 4 of the 2006 Flood Plan reviews flood-risk-reduction strategies and tools that will aid King County in meeting plan objectives. King County's flood risk reduction efforts are centered on five basic strategies:

- Updating, collecting and managing flood hazard information
- Managing land uses to prevent the creation of new flood risks and to promote flood-tolerant land uses
- Maintaining river channels
- Managing flood facilities
- Providing flood hazard education, promoting flood preparedness and improving flood warning and emergency response.

The 2013 Flood Plan Update provides new and updated information related to flood-risk-reduction strategies and tools in King County, a required element for a Community Rating System plan update. Higher standards such as a 3-foot rather than 1-foot elevation requirement for structures in the floodplain, new flood studies, the National Flood Insurance Program Biological Opinion, and updated education and outreach strategies are a few examples of the elements addressed below. For additional information, or to review elements that remain constant, refer to the 2006 Flood Plan.

FLOOD HAZARD INFORMATION

Primary sources of flood hazard mapping for most communities are Flood Insurance Rate Maps (FIRMs) and Flood Insurance Studies published by FEMA. King County and other National Flood Insurance Program communities implement land development regulations using FEMA's 100-year floodplain and floodway and other available flood data. However, FEMA maps are based on current or historical land use. Changing land use conditions and climate trends lead to changing rates and volumes of runoff, so maps can become outdated and not accurately represent the current flood hazard. When watershed conditions change, the 100-year floodplain can expand and flood depths can increase, inundating properties not currently mapped as being within the FEMA floodplain. With additional research allowing predictions of changes in precipitation due to climate change, temperature and snow levels, hydrologic and hydraulic analyses can be used to evaluate how such changes affect river flooding.

Since the 2006 Flood Plan, King County has completed new floodplain mapping on the Upper White River, Sammamish River, and the coastal shoreline of King County. Many of these studies (those including levees) are on hold due to FEMA re-evaluating the approach to mapping levees in floodplains. Under FEMA's program to produce Digital Flood Insurance Rate Maps on a countywide basis, the final release of all maps for a county requires completion of appeal periods for any individual river study.

In December 2011, FEMA released a national public review document describing a proposed policy on procedures for analyzing and mapping areas on the landward side of non-accredited levee systems. The proposed policy presents five options for analyzing and mapping a variety of physical levee settings. The procedures evolved from concerns raised by FEMA stakeholders that the existing methodology did not adequately reflect the level of flood hazard reduction that levee systems can provide. National Flood Insurance Program communities such as King County and floodplain management organizations such as the Association of State Floodplain Managers and the Northwest Regional Floodplain Management Association submitted comments on the proposed policy and procedures. FEMA has notified King

County that any study that includes a non-accredited levee is on hold due to the proposed new policy. Major ramifications might occur if FEMA determines that newly updated flood studies that include levee systems must be re-analyzed per any new technical procedures. Re-evaluating levee systems and producing new mapping would be a significant cost to FEMA and to communities such as King County that have spent significant funding on the current updated studies. The National Academy of Sciences released a report in April 2013 stating that "FEMA should move directly to a modern risk-based analysis for dealing with areas behind levees and not implement the Levee Analysis and Mapping Procedure." In July 2013, FEMA adopted the revised levee analysis procedures (referred to as the "LAMP" or Levee Analysis and Mapping Procedures") and will be conducting pilot projects to test the new procedures.

Previous Flood Studies and Mapping

The 1993 *Flood Hazard Reduction Plan* and the 2006 Flood Plan documented conditions based on modeling available at the time for the major river systems in King County. Improving flood hazard data and mapping has been a high priority since then, and King County has completed several major flood studies. To date, nearly all of King County's major rivers and its coastal shoreline have updated flood mapping. Although some of these studies were submitted to FEMA prior to 2006, final federal publication for some has been delayed. Table 4-1 lists flood studies completed by King County that have not yet reached final federal release. In addition to the studies referenced in this plan, other local jurisdictions, State and Federal agencies, Water Resource Inventory Areas (WRIAs), etc. have produced numerous analysis and studies on the rivers and levee systems in King County that are continuously improving our knowledge.

The Lower Snoqualmie River, Patterson Creek and Cedar River flood studies were technically reviewed and approved in 2006 or earlier and are included in preliminary federal mapping of November 2010. The most recent river studies completed by the County are for the following rivers:

- Lower and Middle Green River—For some portions of the Green River, survey data is over 30 years old and cross-sections are spaced over a mile apart. The contour interval of topographic maps is up to 5 feet rather than the more detailed interval of 2 feet in the updated study; a 2-foot interval greatly improves the mapping accuracy of flood hazard boundaries. In some reaches of the river, the channel has laterally migrated since data was collected for the previous flood study. Major commercial, industrial and residential developments, situated behind levee systems in the lower reach, have occurred throughout the basin since the floodplain maps were produced.
- Two reaches of the White River—The previous flood study for the King County portions of the White River used cross-section data collected in 1974. Because the White River is a sediment-rich system with deposition occurring in the lower reaches, the older study is not representative of current hazards.
- Sammamish River—Survey data for the Sammamish River dates from 1965. The contour interval used for previous FEMA flood mapping was 5 feet.

In 2011, King County completed a new flood study and coastal high hazard area maps for Vashon-Maury Island. A study of the incorporated shoreline of the county was initiated and significantly funded by FEMA and conducted as an expansion of King County's Vashon-Maury Island study. The coastline of unincorporated King County was previously last mapped for flood hazards nearly 35 years ago.

TABLE 4-1.
FLOOD STUDIES COMPLETED BY KING COUNTY AWAITING FEDERAL PUBLICATION

River	Study Reach (Length in river miles)	Hydrologic Period of Record	Date of Physical Base Data	Date Submitted to FEMA	Date of Effective FIRM
Cedar River	Elliot Bridge to Landsburg (17 miles)	Two gages: 1946 - 1999; 1920 - 1999	1999 aerials and 1999-2000 topographic maps and channel surveys	December 2002, technically approved in 2003	Preliminary Flood Insurance Rate Map November 2010
Lower Snoqualmie River	Snohomish County line to Snoqualmie Falls (34 miles)	1930 - 2004	2004 aerials, topographic maps and channel survey	May 2006	Preliminary Flood Insurance Rate Map November 2010
Patterson Creek	Mouth to upstream crossing of SR 202 (9 miles)	Three gages: 1991-2005; 1991-2005; 1991-2005	2004 aerials and topographic maps and 2005 channel survey	July 2006	Preliminary Flood Insurance Rate Map November 2010
Lower Green River	16th Avenue Bridge to SR 18	1962-2007	2006 aerials, topographic maps and channel survey	March 2008	Preliminary Flood Insurance Rate Map November 2010
Middle Green River	SR 18 to Flaming Geyser State Park	1962-2007	2006 aerials, topographic maps and channel survey	March 2008	Preliminary Flood Insurance Rate Map November 2010
White River (Zone 2)	King-Pierce county line to Muckleshoot Indian Tribe Reservation	1946-2007	2007 aerials and topographic maps and 2007 and 2008 channel survey	January 2010, technically approved in January 2012	On hold, awaiting Preliminary Flood Insurance Rate Map
White River (Zone 4)	SR 410 near Enumclaw to Mud Mountain Dam	1946-2007	2007 aerials and topographic maps and 2007 channel survey	September 2009, technically approved in January 2012	On hold, awaiting Preliminary Flood Insurance Rate Map
Sammamish River	Mouth at Lake Washington to Lake Sammamish	1948-2008	2009 aerials and topographic mapping and 2009 channel survey	July 2012, technically approved in January 2012	On hold, awaiting Preliminary Flood Insurance Rate Map
Vashon Maury Island	Entire marine shoreline	1948 to 2010 wind data and most recent tidal epoch	2009 aerials and topographic maps	August 2011, technically approved in January 2012	On hold, awaiting Preliminary Flood Insurance Rate Map
Incorporated Marine Shoreline	Marine shoreline Snohomish county line to Pierce county line, and Duwamish Waterway	1948 to 2010 wind data and most recent tidal epoch	2010 aerials and topographic maps	December 2011, technically approved in January 2012	On hold, awaiting Preliminary Flood Insurance Rate Map

Previous hazard mapping for nearly all of the county's marine shoreline was only approximate, with no specific information on flood elevations. The previous maps designated the coastline as Flood Zone A where no detailed wave generation and run-up analysis had been performed. The previous maps did not determine 100-year flood elevations or depths. King County flood hazard regulations for riverine floodplains were not appropriate for coastal floodplains.

The new coastal high hazard area flood maps take into account storm-induced velocity wave action and establish 100-year flood elevations from detailed wave generation and run-up analysis. The new coastal maps provide details for over 110 miles of marine shoreline in the county. New data sets—including aerial photography, topographic mapping, bathymetry data, river channel cross-sections, shoreline transects, hydrologic and hydraulic analyses, and wind and wave analyses—were used to provide the best available technical information following FEMA's technical guidelines (FEMA 2003).

Although final FEMA approval of these studies is still pending, King County regulates new development based on the best available flood hazard data, including the findings of these studies. Best available data also includes data King County has developed that exceeds FEMA standards, such as basin plans that use future-conditions hydrology.

Future Needs

Although a significant number of flood studies have been completed, further effort is needed to continue to update the remaining major river reaches and larger tributary streams in King County:

- Greenwater River—This is a major tributary to the White River. Detailed flood mapping is only available from Pierce County's Digital Flood Insurance Rate Map. But that study is based on regression equations that relate peak discharge-frequency data to drainage area and mean annual precipitation. An updated, detailed flood study is needed to reflect current conditions at a riverside residential community along the lowermost portion of the river.
- White River Above Mud Mountain Dam—This segment of the White River has only an approximate flood study, with no flood elevations and no delineated floodway. Significant flood inundation of State Route 410 has occurred, forcing closure of this state roadway. Fast, erosive floodwaters have exposed riverside residents to life-threatening conditions and loss of homes. New flood hazard information could be used to educate area residents about potential risks and as a basis for planning effective risk-reduction solutions.
- White River Muckleshoot Reach—This segment of the White River has no flood hazard mapping. While much of the river is within Muckleshoot Indian Tribe jurisdiction, developable areas would benefit from accurate delineation of hazard areas to avoid future at-risk land uses.

Although King County has completed numerous river flood studies, studies such as those conducted for the Raging River and Tolt River are based on data that is nearly 20 years old. King County should evaluate whether these studies adequately represent current flood hazards.

Geologic Studies and Maps

Geologic mapping and investigations by the U.S. Geological Survey and the Washington State Department of Natural Resources, conducted in cooperation with King County, directly inform King County flood hazard planning and management efforts.

Channel Migration Hazards and Channel Migration Zone Mapping

Since the 1990s, the science and technology involved in Channel Migration Zone (CMZ) mapping has progressed significantly, and other advances have occurred:

- In King County, preliminary work on CMZ mapping was conducted in 2003 through 2005 for the Cedar River, White River and South Fork Skykomish River.
- In 2004, provisions of the channel migration public rule were incorporated into the King County Critical Areas Ordinance and codified in King County Code Chapter 21A.24.
- At the state level, revisions to the state Shoreline Master Program administrative code required local shoreline updates to map CMZs along all channels within shoreline jurisdiction, and the Department of Ecology issued a publication providing guidance for delineating CMZs.
- The King County Shoreline Master Plan update process in 2011 included a preliminary CMZ mapping designation for channels within shoreline jurisdictions that do not yet have a CMZ map, using the regulatory 100-year floodplain boundary as a surrogate CMZ boundary. Future CMZ mapping will be conducted using standard CMZ mapping methods to delineate CMZ boundaries along these channels.
- King County commissioned a study, which was completed in 2012, to evaluate CMZ mapping methods in Washington State for use in completing CMZ studies on King County rivers.

Based on advances in CMZ mapping, new state CMZ mapping requirements and guidelines, and results of the 2012 CMZ mapping methods study, King County proposes to refine its CMZ mapping methods. This will require revisions to the King County Code and the channel migration public rule. Table 4-2 summarizes the status of CMZ mapping in King County.

Future Needs

There is a need for revision of the King County Code and the channel migration public rule in order to refine King County CMZ mapping methods. King County will coordinate with the Department of Ecology to ensure that refinements to King County CMZ mapping methods remain consistent with the Washington State Shoreline Management Act. Another need is to continue mapping CMZs along other large King County rivers, identified in the 2006 Flood Plan.

The 2006 Flood Plan recommendation for completing CMZ mapping along the Cedar, White and South Fork Skykomish rivers is the highest priority for the remaining large King County rivers. The 2006 Flood Plan also recommends CMZ mapping for the White River upstream of Mud Mountain Dam and the lower segment of the Greenwater River. This 2013 Flood Plan Update further recommends CMZ mapping for the main stem Snoqualmie River downstream of Snoqualmie Falls.

State Shoreline Master Program provisions require that CMZs be delineated and regulated along all channels within shoreline jurisdiction. That jurisdiction extends to all channels with a mean annual flow of 20 cubic feet per second or more, thereby requiring CMZ mapping on several relatively smaller channels, such as Issaquah Creek and Soos Creek. With the passage of time and advances in mapping technology, it would be appropriate to review and update completed CMZ maps based on the extent of channel changes, potential consequences to public safety, and the ability to restrict unsafe development in CMZs. CMZ mapping may be considered for other river segments on other King County rivers, as warranted.

TABLE 4-2.
CHANNEL MIGRATION ZONE MAPPING IN KING COUNTY

River	River Length Description	River Miles	River Length (miles)	CMZ Study & Map Completed?
South Fork Skykomish	County Line to Tye and Foss Rivers	6.4 to 19.9	13.5	In Progress
Lower Snoqualmie	County Line to Snoqualmie Falls	5.9 to 40	34.1	No
Tolt	Mouth to River Mile 6	0 to 6	6	Yes
Raging	Mouth to River Mile 9	0 to 9	9	Yes
Upper Snoqualmie	Snoqualmie Falls to Middle Fork confluence	40 to 44	4	Yes
North Fork Snoqualmie	Mouth to River Mile 1.9	0 to 1.9	1.9	Yes
Middle Fork Snoqualmie	Mouth to River Mile 5	0 to 5	5	Yes
South Fork Snoqualmie	Mouth to River Mile 6.5	0 to 6.5	6.5	Yes
Cedar	City boundary to Landsburg	4 to 22.1	18.1	In Progress
Green	Kent Levees to Flaming Geyser	25.3 to 45.2	19.9	Yes
Lower White	County Line to Mud Mountain Dam	5.5 to 29.6	24.1	In Progress
Greenwater	Mouth to River Mile 1	0 to 1.0	1	No
Upper White	Mud Mountain Dam reservoir to Greenwater	TBD	~ 10	No

Note: CMZ mapping for smaller channels that are within Washington State Shoreline jurisdiction may be beyond the geographic scope of this 2013 Flood Plan Update.

River Corridor

For this plan, the following definitions are used for terms related to areas in and around a river:

- A **river corridor** is defined as the area of a river and surrounding lands that is essential to the storage and conveyance of floodwaters and is integral to natural riverine processes.
- A **river segment** is an area of river and adjacent lands within which the presence, type and extent of flood hazards are similar.
- A **river reach** is defined as a length of river through which similar physical or geomorphic conditions persist.

In general, a river corridor is a larger geographic area that includes one or more river segments, and a river segment is made up of one or more river reaches.

Existing floodplain boundaries, CMZs, landslide hazards, geology, and other information relating to rivers and flood and erosion conditions can be combined to create composite river corridor working maps. These working maps can improve communication among agencies and entities active within flood hazards areas and riparian corridors. Additional information can be overlaid on the working maps to assist in meeting federal Endangered Species Act requirements and coordinating with other King County programs and objectives.

MANAGEMENT OF LAND USES

Flood Hazard Area Regulations

Regulations of land uses in flood hazard areas can be one of the most effective ways of reducing risk from flooding and channel migration. King County has established standards beyond minimum National Flood Insurance Program requirements and developed specific regulatory flood hazard zones. The Critical Areas Ordinance that went into effect in 2005 includes higher standards than are required by the National Flood Insurance Program or state law, such as a zero-rise floodway and the use of a 3-foot rather than 1-foot elevation requirement for structures in the floodplain. The following is a summary of changes that have been made to King County unincorporated area development standards since the 2006 Flood Plan was adopted.

Development Within the Zero-Rise Flood Fringe

Changes to the key standards for development within the zero-rise flood fringe in unincorporated King County include the following:

- Compensatory storage is required at flood elevations equivalent to where storage is displaced. Compensatory storage should normally occur on the site of displacement, but offsite storage may be allowed if approval is granted by King County.
- Development is not allowed if the flood depth is more than 3 feet and the velocity is more than 3 feet per second, except for agricultural accessory structures, roads, bridges, utilities, surface water and flood structures, and public park structures.
- Subdivisions must identify 100-year flood elevations, required flood risk reduction elevations, floodplain and floodway boundaries, CMZs, and building setbacks; ensure adequate drainage away from building sites; and include a notice for any site that is in a floodplain and for which emergency access may not be available during flood events.
- Utilities must be flood-proofed or elevated at least 3 feet above the 100-year flood elevation and are allowed only if no reasonable alternative is available.
- The lowest floor for residential and non-residential buildings must be elevated at least 3 feet above the 100-year flood elevation. Non-residential agricultural buildings with an assessed value of $65,000 or less may be built at grade if flood-resistant materials are used; those over $65,000 of assessed values can request an exception to the 3-foot elevation standard.
- Farm pads and manure storage facilities are allowed through a farm plan if there is no suitable holding area on site that is outside the floodplain.
- Recreational vehicles can be on site no more than 180 days unless they are licensed and ready for highway use.

Development Within the Zero-Rise Floodway

Minor changes to key standards for development within the zero-rise floodway in unincorporated King County include the following:

- Temporary structures and hazardous materials, except for those used in agriculture, must be removed from the floodplain during the flood season, which is from September 30 through May 1.
- New residential structures or improvements to residential structures that are equal to or greater than the market value of the structure are allowed only on lots that were in existence before November 27, 1990 and have at least 5,000 square feet outside the zero-rise floodway.

- Public and private utilities are allowed only if no feasible location is available outside the zero-rise floodway.

Development Within the FEMA Floodway

Minor changes to key standards for development within the FEMA floodway in unincorporated King County include the following:

- New residences and non-residential structures are prohibited in the FEMA floodway except for non-residential agricultural buildings and farm pads within an agricultural production district.
- Maintenance, repair and replacement of existing agricultural buildings, farmhouses, substantially damaged existing residential structures and historic structures in the FEMA floodway are allowed if they meet certain standards, provided in King County Code 21A.24.230 to 21A.24.270 .

Development Within Channel Migration Zones

Minor changes to key provisions in the severe channel migration hazard area (one of two portions of the channel migration zone, as defined in the 2006 Flood Plan) include the following:

- Development is limited to structures that do not house humans or animals or store hazardous materials and is allowed only when no feasible location on site is available outside the severe channel migration hazard area.
- Existing primary structures cannot expand their footprint or be improved where the improvement is equal to or greater than the market value of the structure.
- No structure can exceed 1,000 square feet or 10 percent of the severe channel migration hazard area on the site.
- Clearing of up to 1,000 square feet or 35 percent of the severe channel migration hazard area on the site is allowed, and grading of up to 50 cubic yards is allowed on lots less than 5 acres if at least 165 feet from the channel.
- Bank stabilization structures are allowed under limited circumstances.

Development Within Coastal High Hazard Areas

As a participant in the National Flood Insurance Program, King County was required to adopt coastal high hazard area flood regulations to implement the FEMA maps of coastal high hazard areas, also known as velocity flood zones or V-zones. Key standards for development within V-zones in unincorporated King County include the following:

- New buildings and substantial improvement to existing buildings are required to be elevated on pilings and columns.
- The lowest floor must be 3 feet above the 100-year flood elevation.
- The foundation must be anchored to prevent flotation, collapse and lateral movement.
- A registered professional engineer or architect must prepare the structural design.
- The applicant must provide a FEMA elevation certificate prepared by a licensed surveyor documenting the bottom of the lowest floor and whether the structure has a basement.
- King County must maintain copies of the FEMA elevation certificates.
- All new buildings must be landward of mean high tide.

- Non-supporting open wood lattice-work or insect screening that is intended to collapse under wind and wave loads without causing collapse, displacement or other structural damage to the elevated portion of the building or supporting foundation system is allowed.
- The space below the lowest floor must be free of obstruction and used only for parking, access or storage. No human habitation is allowed below the lowest floor.
- Fill is not allowed for structural support.
- Manufactured homes must meet the same standards as new buildings or substantial improvements to existing buildings.
- Recreational vehicles must be on site for fewer than 180 days or be ready for highway use.

National Flood Insurance Program Biological Opinion

On September 22, 2008, the National Marine Fisheries Service issued a biological opinion that implementing the National Flood Insurance Program causes jeopardy to several Endangered Species Act and Magnuson-Stevens Act listed Puget Sound salmonids and southern resident orca whales, as well as adverse modification to their habitat. The National Marine Fisheries Service drafted the biological opinion following consultation with FEMA, in accordance with the judicial order for National Wildlife Federation v. FEMA (U.S. District Court for the Western District of Washington 2004).

Analysis focused on three elements of the National Flood Insurance Program—floodplain mapping, minimum floodplain management criteria, and the Community Rating System. The intent was to assess whether causation exists between activities fundamental to the National Flood Insurance Program and habitat changes that adversely affect listed species and their critical habitat. The biological opinion establishes seven elements of a Reasonable and Prudent Alternative to modify implementation of the National Flood Insurance Program in a manner that would reduce the jeopardy to a level that may affect, but would not be likely to adversely affect, the listed species:

- **Reasonable and Prudent Alternative Element 1, Notification of Consultation Outcome**—FEMA is required to notify all communities that participate in the National Flood Insurance Program that development under the program could cause jeopardy to several Endangered Species Act and the Magnuson-Stevens Act listed Puget Sound salmonids and southern resident orca whales as well as adverse modification to their habitat.
- **Reasonable and Prudent Alternative Element 2, Mapping**—FEMA should only process Letters of Map Change addressing manmade alterations after determining that the alteration avoids habitat function changes or mitigates for those impacts. FEMA must also ensure that floodplain modeling incorporates on-the-ground data to increase the accuracy of maps depicting the floodplain and to consider future conditions and cumulative effects from future land-use changes, including the risk of flooding behind 100-year levees.
- **Reasonable and Prudent Alternative Element 3, Floodplain Management Criteria**—This element describes land use and development criteria for development within mapped floodplains.
- **Reasonable and Prudent Alternative Element 4, Community Rating System**—FEMA will change the credit given under the Community Rating System to incorporate habitat-based objectives. King County should benefit greatly under these changes because of the County's strong environmental protection policies, regulations, programs and projects.
- **Reasonable and Prudent Alternative Element 5, Addressing the Effects of Levee Vegetation Maintenance and Certain Types of Construction in the Floodplain**—FEMA shall not recognize levees that are certified by the U.S. Army Corps of Engineers utilizing PL

84-99 vegetation standards unless it is demonstrated that the standard will not adversely affect species or their habitat. King County and other jurisdictions in the Puget Sound Region, as well as other communities on the west coast, are working with the U.S. Army Corps of Engineers to modify the Corps' levee vegetation standards for participation in the Public Law 84-99 program or to allow regional variances to those standards.

- **Reasonable and Prudent Alternative Element 6, Floodplain Mitigation Activities**—Any development in floodplains that degrades channel or floodplain habitat and occurs prior to full implementation of Elements 2, 3 and 5 must provide mitigation.
- **Reasonable and Prudent Alternative Element 7, Monitoring and Adaptive Management**—FEMA is required to report to National Marine Fisheries Service on an annual basis regarding progress on implementing the Reasonable and Prudent Alternative elements. National Marine Fisheries Service will determine, in coordination with FEMA, if some alternative actions or additional changes in the Reasonable and Prudent Alternative elements are needed to avoid jeopardy and adverse modification of critical habitat.

The Reasonable and Prudent Alternative element that most significantly impacts local jurisdictions is Element 3: Floodplain Management Criteria, which is summarized as follows:

> FEMA shall modify its floodplain management criteria as soon as possible for Puget Sound National Flood Insurance Program communities to do the following:
>
> - Carry out at least one of the following measures:
>   - 1) Allow no development in the riparian buffer zone, identified as the greater of the CMZ plus a 50-foot buffer, the riparian buffer width specified by stream type, or the floodway, OR
>   - 2) Demonstrate to FEMA that proposed riparian buffer zone development does not adversely affect salmon habitat needs.
> - In addition to either 1 or 2 above, carry out at least one of the following measures:
>   - 1) Prohibit development in the 100-year flood floodplain, OR
>   - 2) Avoid, rectify or compensate for any loss of floodplain storage and fish habitat from development in the 100-year floodplain outside the riparian buffer zone. Any development allowed must use low impact development methods to minimize or avoid stormwater effects. Any indirect adverse effects must be mitigated, OR
>   - 3) Mitigate adverse effects on fish or their habitats from structural improvements or repairs resulting in greater than 10-percent increase in structure footprint.

More than 120 communities in the Puget Sound Region are affected by FEMA's response to the biological opinion. These communities were divided into three tiers:

- Tier One communities, which include King County, must restore fish populations to a low extinction risk status because their contribution to the abundance, diversity, spatial structure and productivity of the evolutionary significant unit or distinct population segment is critical.
- Tier Two communities may have traits that are important to evolutionary significant unit or distinct population segment viability, but their contribution is less critical.
- All other Puget Sound National Flood Insurance Program communities are in Tier Three.

FEMA has identified three options for National Flood Insurance Program communities to document compliance with the biological opinion:

- Option 1—Adopt the model ordinance developed by FEMA.
- Option 2—Complete a FEMA-developed checklist to document that local regulations and best available science will reduce jeopardy to a level that may affect, but is not likely to adversely affect the listed species.
- Option 3—Perform a case-by-case habitat assessment for development within the mapped 100-year floodplain.

King County selected Option 2 by preparing a programmatic habitat assessment to demonstrate its compliance with the Reasonable and Prudent Alternative elements. This document provides a broad description of salmonid habitat within main stem rivers, streams and lakes, along saltwater shorelines, and in the associated 100-year floodplains. The document identifies the Endangered Species Act- or Magnuson-Stevens Act-listed salmonid species that occupy these areas, and estimates the probable biological effects resulting from development after implementing all of King County's regulatory and non-regulatory programs that are aimed at protecting and restoring these habitats. The assessment was performed at the programmatic level following guidance from FEMA's *Floodplain Habitat Assessment and Mitigation: Draft Regional Guidance* (FEMA 2011).

Using the National Marine Fisheries Service's matrix of pathways and indicators to summarize the environmental parameters affecting Endangered Species Act-listed salmonids, King County assessed current conditions of all the indicators as either "not properly functioning" or "at risk" given the legacy of past land uses. King County does not anticipate additional degradation of any of these pathways and indicators; instead, they are likely on an improving trajectory due to a combined effort of regulations and non-regulatory protection and restoration actions. However, it will likely take years or decades for conditions to change to the point of being considered "restored" as per National Marine Fisheries Services criteria. As a result, King County anticipates that the conditions are conservatively expected to be maintained. Consequently, although the biological opinion establishes a take exemption of 44.16 acres per year for King County, the assessment is that take will not occur, although there may be some minor changes in land use based on development potential in the floodplain. Take, as defined by s. 3(19) of the Endangered Species Act, means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct".

Development in unincorporated King County is subject to a range of recently updated shoreline, critical area, clearing and grading, and stormwater regulations, all of which were developed through substantial use of best available science as required under the Washington State Shorelines and Growth Management Acts. Furthermore, as noted in the biological opinion, the County's floodplain regulations exceed the minimum requirements of the National Flood Insurance Program. Taken together with non-floodplain regulations and a wide range of King County programmatic actions—such as the transfer of development rights program, open space acquisitions, ecological restoration projects, and low density zoning—the floodplain regulations "minimize the effects of floodplain development on fish habitat and habitat forming processes" (National Marine Fisheries Service 2008). The programmatic habitat assessment and evaluation of potential future development impacts confirms the National Marine Fisheries Service's conclusion and further demonstrates that future development impacts may affect but are not likely to adversely affect protected species in King County's watersheds.

Technical Assistance and Consultation

King County offers assistance to public and private entities to make land use decisions that reduce flood-related risks. This includes sharing expertise in hazard identification techniques and reviewing and coordinating planning and design efforts. In addition to the information covered in the 2006 Flood Plan, the following reflects new and updated information.

Salmon Recovery and Riparian Habitat Conservation

King County's floodplains and river corridors directly support three distinct salmonid stocks and indirectly support one distinct stock of marine mammals that are listed as threatened under the Endangered Species Act:

- The Puget Sound Evolutionarily Significant Unit of Chinook salmon (*Oncorhynchus tshawytscha*) (Myers et al. 1998; Rosenberg 1999)
- The Puget Sound Evolutionarily Significant Unit of steelhead trout (*Oncorhynchus mykiss*) (Hard et al. 2007; Oliver 2008a)
- The West Coast/Puget Sound Distinct Population Segment of bull trout (*Salvelinus confluentus*) (Barry 1999).
- The Southern Resident population of killer whales (*Orcinus orca*), listed in 2005 by the National Oceanic and Atmospheric Administration as endangered under the Endangered Species Act (Hogarth 2005; Carretta et al. 2010; National Marine Fisheries Services 2011). These orcas spend several months of the summer and fall each year in Puget Sound, including in nearshore areas of Vashon Island in King County.

Puget Sound coho salmon (*Oncorhynchus kisutch*) and Puget Sound pink salmon (*Oncorhynchus gorbuscha*) are listed under the Magnuson-Stevens Act. This act requires identification of essential fish habitat (Oliver 2008b), defined as the waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity. The act requires federal agencies to consult with the National Oceanic and Atmospheric Administration on activities that may adversely affect essential fish habitat.

The Washington State Department of Ecology has divided the state into 62 Water Resource Inventory Areas, or WRIAs, to delineate the state's major watersheds. Within King County there are four WRIAs:

- WRIA 7, Snoqualmie (extends into Snohomish County)
- WRIA 8, Cedar/Sammamish (extends into Snohomish County)
- WRIA 9, Duwamish/Green and Vashon Island
- WRIA 10, Puyallup/White (extends into Pierce County).

With the listings of salmonid species as threatened under the Endangered Species Act, a number of partnerships were formed to develop conservation plans for individual WRIAs, with the specific goal of recovery of listed species and their essential fish habitat. In 2007, the Puget Sound Partnership was formed. This state agency works with citizens, governments, tribes, scientists and businesses to restore and protect Puget Sound. Through the work of the Partnership and local implementing groups, actions identified in the conservation plans are being implemented to restore salmonid populations and their essential habitat.

Most floodplain management projects are multi-objective, including improvement of listed species habitat degraded by past land use and floodplain management activities. When habitat elements are incorporated into the design of levees and revetments, funding from multiple sources often can be leveraged and habitat conditions can be improved. King County also looks for opportunities to set levees and revetments back from the river edge, or to remove them entirely to provide for more floodplain storage and conveyance, which also benefits salmon. Reconnecting floodplains that have been disconnected by past land use and floodplain management actions also increases the resilience of the river system to impacts from climate change.

RIVER CHANNEL MAINTENANCE

King County policies provide guidance regarding the application of channel maintenance actions. The following sections provide background information and recommendations for future actions.

Sediment Management

Sediment management, as referred to in this document, is a program to reduce the flood risks that result from sediment accumulation in channels. In this program, flood risks can be reduced either by removing sediment from the channel in order to increase channel flood conveyance—commonly referred to as gravel removal—or by removing existing structures from the area that is subject to flood hazards induced by sedimentation. Either of these approaches is a sediment management action in this program. Gravel removal is a type of sediment management action, but it is not synonymous with sediment management. Strategies that King County may use to manage the accumulation of sediment as it affects flooding in King County's rivers are described below.

Channel Monitoring

Channel monitoring provides information on sediment accumulation and its effect on channel capacity by characterizing existing conditions, quantitatively documenting changes in in-channel sediment levels through time, and evaluating corresponding changes in floodwater levels. While King County uses channel monitoring results to inform potential sediment management decisions, this same information would be required as part of the permit process for any gravel removal operation.

In-channel sediment levels can be monitored by collecting topographic data using a variety of methods, including traditional survey, bathymetric sonar readings combined with survey-grade GPS, aerial orthophotography, light detection and ranging (LiDAR), or combinations of these. Whatever the means of data collection, each data point is referenced to an established coordinate system so that the data collected at any given time can be compared accurately to similarly referenced data collected previously or subsequently. Channel monitoring data typically are configured as channel cross-sections—lines generally running perpendicular to the direction of flow—or they can be used to generate a digital topographic surface if the collected data are of sufficient density. Repeated collection of monitoring data over time intervals of one to several years in the same river segment allows quantitative comparison of riverbed and gravel bar surface elevations and calculation of changes in sediment deposition or erosion during the intervening time period.

Channel monitoring allows evaluation by hydraulic modeling of the effect of changes in sediment levels on floodwater levels. Typical hydraulic modeling is accomplished by using new survey data to update an existing 1-dimensional hydraulic model that was created for a flood study in the area. Hydraulic modeling results identify whether there have been significant changes in modeled floodwater levels or channel capacity that are attributable to changes in sediment levels.

King County monitors the following river segments for sediment:

- Lower Tolt River near the City of Carnation
- Lower Raging River
- South Fork Snoqualmie River along the City of North Bend
- Middle Fork Snoqualmie River near North Bend
- The main stem Snoqualmie River near Fall City and Carnation
- Lower Cedar River

- Lower White River along the Cities of Auburn and Pacific.

The City of Renton conducts channel monitoring for the lower 2 miles of the Cedar River. King County collaborates with the City of Auburn in collecting channel data in a 1.25-mile stretch of the Lower White River.

In-channel sediment levels have been monitored and associated hydraulic modeling has been conducted in these river segments at various intervals since the mid-1990s.

Sediment Management Actions, Including Gravel Removal

The 1999 listing of Puget Sound Chinook salmon and bull trout as threatened under the Endangered Species Act and the 2011 revisions to the *Washington State Shoreline Master Plan Guidelines* may further limit gravel removal.

Sediment Management Program

The sediment management program is being applied in all monitored river segments listed earlier in this section. The extent to which the program components have been implemented varies by river segment, as does the sediment management action that is likely to be taken:

- In the Lower Cedar River, annual channel monitoring by the City of Renton indicates that ongoing sediment accumulation is decreasing channel flood capacity below the identified flood protection objective. A maintenance dredging project is slated to be conducted as part of continued implementation of the 1998 Cedar River 205 Flood Control Project, and carried out as part of the King County Flood District 6-year CIP list, with the City of Renton as local sponsor. A 205 project is a project carried out by the U.S. Army Corps of Engineers under Section 205 of the 1948 federal Flood Control Act. Section 6.3.6 describes eligibility for such projects
- On the South Fork Snoqualmie, channel monitoring data indicated loss of channel capacity due to sedimentation, so an analysis of gravel removal scenarios was conducted (King County 2011). That study indicated some potential for localized flood hazard reduction effectiveness from gravel removal, and the study results are being incorporated into the overall South Fork Snoqualmie levee improvement project planning and design process, in which a full range of flood risk reduction alternatives is being considered.
- On the Lower White River, ongoing, widespread and rapid sediment accumulation has significantly decreased the channel capacity (Herrera 2010), with locally increased flooding and damage in January 2009 (Czuba et al. 2010). Setback of existing levees has been identified as the preferred approach for flood risk reduction in this river reach. Although gravel removal was evaluated generally in this river reach and found to be much less effective in reducing flood levels than levee setback (Czuba et al. 2010), a more specific evaluation of gravel removal will be prepared as part of the advanced design and review process for the levee setback project.
- On the lower segments of the Raging and Tolt rivers, the main stem Snoqualmie River along Fall City and Carnation, and the Middle Fork Snoqualmie River, channel monitoring under the sediment management program is ongoing. Consideration of sediment management action alternatives is yet to be completed for these river segments, although channel monitoring data have been used in basin-scale flood reduction strategies now underway, such as the Tolt River Corridor Plan, the Middle Fork Snoqualmie Corridor Plan, and the Snoqualmie River at Fall City levee setback project design. Gravel removal will be analyzed for flood reduction

effectiveness in these river reaches if the channel monitoring results demonstrate ongoing increases in flood hazards attributable to in-channel sedimentation.

Management of Naturally Occurring Wood in King County Rivers

King County's contemporary design approaches for river and floodplain projects allow the river to more closely mimic natural floodplain processes for flood storage and conveyance. Site changes resulting from these approaches can lead to the recruitment or accumulation of naturally fallen wood in the vicinity of project sites. Large-wood recruitment is sometimes an intended project feature, contributing to the achievement of flood risk reduction and watershed management project objectives.

While King County's approach to managing natural large-wood accumulations has changed dramatically, common understanding about the beneficial functions of wood in rivers is still evolving, and the County continues to routinely receive requests to remove fallen trees from river channels. In 2012, King County updated procedures originally drafted in 2008 regarding the management of natural wood on King County Rivers. King County is to dislodge, cut or remove naturally occurring large wood only where the material poses an imminent flood-related threat to public safety or infrastructure. Where action is deemed necessary by the established procedures, solutions are to reduce the imminent flood risk with the least disturbance to the wood and the surrounding river environment. This approach is intended to address situations of flood-related public safety threat while avoiding adverse impacts on the habitat of fish and wildlife.

Under current practice, all reports of public safety concerns, including those related to recreational use involving large wood, are directed to the King County Sheriff's Office. The King County Sheriff's Office investigates each report within its jurisdiction and makes a preliminary assessment of potential risk. If there is an imminent threat to public safety, the King County Sheriff's Office initiates emergency actions. Otherwise, the King County Sheriff's Office coordinates with River and Floodplain Management Section staff to evaluate the hazard, determine if there is elevated risk to flood protection infrastructure or public safety, and identify possible action responses. The River and Floodplain Management Section provides expertise in the geomorphology, ecology and engineering features of the site, assists in obtaining permits, and provides oversight for the use of heavy equipment, if used in the operation. As a management alternative, King County Sheriff's Office may use its legal authority to close a portion of the river to recreational use and passage until a risk is resolved. In incorporated areas outside the jurisdiction of the King County Sheriff's Office, River and Floodplain Management Section staff will evaluate the hazard for any flood-related risks, identify a technical solution and coordinate with local authorities.

The procedures updated through a public process in 2012 give special consideration to the management of natural wood when it is associated with a King County flood hazard management project. Beginning in 2012, King County has committed to an enhanced degree of communication regarding river projects, intended goals, possible outcomes and the range of adaptive management tools expected to be used on the site. When a project is expected to affect recruitment, mobility or accumulation of natural wood, King County proactively engages in a dialogue with nearby residents and interested citizens and considers public safety in all phases of the project, from design through monitoring, maintenance and adaptive management. Project-specific or area-specific plans for long-term and adaptive site management will describe anticipated wood movement and accumulation patterns, evaluate the nature and degree of public safety risk associated with the wood, and make recommendations consistent with adopted policies and project objectives.

To inform such analysis, information on locations of natural large-wood accumulations is beneficial. In 2009 King County conducted a pilot study to describe the location, character, functional value and potential flood-related and river recreational risks associated with large-wood accumulations in the lower reaches of the Cedar River. In 2010 an additional pilot study was conducted to characterize recreation use on this portion of the Cedar River. This pilot study information has proven to be a valuable resource for project managers planning capital improvement projects on the Cedar River.

Naturally Occurring Landslide Management

Landslides are common features in river and stream valleys across King County. While small landslides are often a result of human activity, the largest landslides are often naturally occurring phenomena with little or no human contribution. The sites of large landslides are typically areas of previous landslide movement that are periodically reactivated by significant precipitation or seismic events. Such naturally occurring landslides can disrupt roadways and other infrastructure lifelines, destroy private property, and cause flooding, bank erosion and rapid channel migration. Landslides can create immediate, critical threats to public safety. Engineering solutions to protect structures on or adjacent to large active landslides are often extremely or prohibitively expensive. In spite of their destructive potential, landslides are a part of the natural landscape of King County river valleys. They supply sediment and large wood to the channel network and can contribute to complexity and dynamic channel behavior critical for aquatic and riparian ecological diversity. Effective landslide management should include the following elements:

- Continuing investigation to identify natural landslides, understand their mechanics, assess their risk to public health and welfare, and understand their role in ecological systems
- Regulation of development in or near existing landslides or areas of natural instability through the King County Critical Areas Ordinance in King County Code Chapter 21A.24, the clearing and grading standards in King County Code Chapter 16.82, and the *King County Surface Water Design Manual*
- Preparation for emergency response to landslides to facilitate rapid, coordinated action among King County and local cities, state and federal agencies, and to provide emergency assistance to affected or at-risk citizens
- Evaluation of options including landslide stabilization or structure relocation where landslides are identified that threaten critical public structures or infrastructure, such as the Auburn-Black Diamond Road project and the Sinnema Quaale Upper Project.

FLOOD PROTECTION FACILITIES

King County monitors, inspects and maintains an extensive inventory of flood protection infrastructure, much of it initially constructed in the middle of the last century. Prior to 1993, flood hazard management efforts in King County relied heavily on constructed flood protection infrastructure to inhibit flooding, erosion and channel migration. Since 1993, portions of this infrastructure have been repaired or retrofit using newer techniques such as bioengineering. The County's flood protection infrastructure includes rock-faced levees and revetments, biostabilized revetments, overbank channels, instream structures, pump stations and associated appurtenances. The terms "flood protection infrastructure" and "flood protection facilities" are used interchangeably in this document.

Levees

As described in the 2006 Flood Plan, levees are raised embankments built adjacent to rivers and are designed to contain or direct flood flows when river water surface elevations would naturally inundate the surrounding floodplain. Levees in King County are not uniform. Total footprint dimensions of a levee depend on the length, height and side slopes of the levee; some levees extend for miles along river corridors such as the Green River and South Fork Snoqualmie River. Existing levees in King County provide a highly variable level of service or level of protection. Flood flows contained by levees may have a recurrence interval ranging from 10 years to 100 years.

Vegetation Guidelines

Since the 2006 Flood Plan, the U.S. Army Corps of Engineers has increased their requests for management of vegetation on levees in King County. In some locations, King County has elected to comply with U.S. Army Corps of Engineers guidelines to maintain eligibility for federal emergency repair funding. Yet, the County remains responsible for habitat recovery goals by federal law. This conflict of federal mandates is challenging. Vegetation removal has been costly and created additional liabilities for habitat mitigation.

The U.S. Army Corps of Engineers standards require minimum levee dimensions with respect to containment and freeboard and removal from levee slopes of all vegetation greater than 2 inches in diameter. The Seattle District of the U.S. Army Corps of Engineers has operated under a regional variance developed in response to the federal Water Resources Development Act Amendments of 1997, which allows vegetation up to 4 inches in diameter and the use of engineering discretion in determining when vegetation poses a risk to levee stability, emergency access or inspections.

In 2009, the U.S. Army Corps of Engineers proposed a policy change that would repeal existing regional variances and create a process for variances to be obtained for individual levee systems. A separate process has also been created to develop System-Wide Improvement Frameworks in which flooding problems are collaboratively prioritized by multiple stakeholders so that any risks posed by vegetation can be compared alongside other risks to levee stability and resilience. Since 2010, King County has been working with a team of state and federal partners, including the Seattle District of the Corps and the Puget Sound Partnership, to develop an alternative vegetation management framework that would achieve the following goals for levee vegetation management in Western Washington:

- Safe and Effective Levees—Resilient structures that can be accessed and inspected during floods
- Functional Habitat—Recognition that, in many densely developed locations, levees are the riverbanks
- Cost-Effective—Use of limited resources to address the worst problems first
- Science-Based—Responsiveness to new information and research.

It has not yet been determined whether these goals will be achieved through a vegetation variance, a System-Wide Improvement Framework, or a combination of the two, nor have any proposals been evaluated to determine if they are compliant with the federal Endangered Species Act or Clean Water Act.

Revetments

Revetments are not eligible for the Rehabilitation and Inspection Program available to qualified levees, and therefore lack a similar standard for design and maintenance. As such, revetments are not subject to U.S. Army Corps of Engineers standards for vegetation management. Increasingly, the County is using biostabilization techniques or incorporating native vegetation into designs as means to increase soil stabilization and provide improved conditions for fish and wildlife. While FEMA does not specify vegetation management requirements, the agency often views the presence of vegetation as evidence of deferred maintenance, despite FEMA reports that encourage the use of vegetation to stabilize revetments.

Management Considerations

Management of flood facilities, such as levees and revetments, includes consideration of risks associated with floodplain development, effects on recreational users, and level of service analysis. These considerations are incorporated into a broader risk-reduction strategy that includes risk avoidance, risk awareness, and other mitigation actions to ensure that the public is aware of remaining flood risks and is able to take appropriate action to manage this risk. As part of the broader basin strategy, level of service targets consider physical factors such as channel capacity, land use factors such as population density and development patterns, and environmental factors such as salmon habitat and water quality goals. Basin strategies and level of service targets will be reviewed under King County's Equity and Social Justice program, under King County Ordinance 16948, to ensure that King County citizens are provided equal access to flood risk reduction services.

Risks Associated with Encouraging Floodplain Development

Risk always exists that a levee may be overwhelmed during an extreme flood event, even if it is accredited by FEMA for floodplain mapping purposes. Very few of the levees in King County were designed to withstand the 100-year flood, and levees along the Lower Green and the South Fork Snoqualmie that were previously recognized by FEMA as accredited were never certified.

Effects on Recreational Users

Levee and revetment repair and reconstruction projects by their nature modify the river environment:

- Repair projects typically retain the existing alignment of a levee or revetment, but may modify the materials used in its construction and in some cases the local geometry of the river bank by incorporating flow deflectors, root wads or engineered log jams.
- Reconstruction projects more significantly alter the river. In some cases they may relocate a levee and encourage natural river processes to rework a portion of the floodplain so that the river becomes more dynamic and less predictable but is able to store floodwaters and sediment and create and maintain diverse habitats.

Because repairs and reconstruction result in new conditions along the river, they may change the experience of recreational users boating, floating, swimming, wading or walking along the river's banks. These changes may result in new or evolving hazards in the vicinity of a project, including placed and secured or naturally recruited large wood, rock structures that can impede flows, and overhanging vegetation. Potential risks associated with project elements such as these are considered during project design, in the context of the river environment's naturally occurring hazards such as cold, swift water, naturally occurring large wood, and undercut banks with steep drop-offs.

Level of Service Considerations

King County is challenged in the management, maintenance and replacement of existing flood protection structures because there are no level of service standards set within the County. The term "Level of Service" refers to a specified goal for flood protection that a levee or levee system is intended to provide. Existing flood protection infrastructure in King County provides a highly variable level of service or level of protection. Flood flows contained by King County levees may have a recurrence interval ranging from 10 years to 100 years. Flood protection infrastructure is only one of many tools and factors to consider when developing flood-risk-reduction strategies for each river basin, and must not be considered in isolation.

Policy guidance regarding level of service standards is limited. King County's Comprehensive Plan has the following policy associated with risk-reduction level of service:

> **F-290** King County should assess the most appropriate level of service for flood risk reduction along river segments based on existing and predicted development density, land use, and hydrologic conditions.

Establishing level of service standards will be complicated. The river systems in King County are highly variable from river to river and from reach to reach within a given river. Some of the variable factors for consideration in level of service discussions are listed below. Tradeoffs may occur between cost; long-, mid- and short-term priorities in implementation; land-use densities; assessed value; and economic disruptions.

- Existing land-use and development patterns and density in the adjacent floodplain—The type and density of land uses, the assessed value of land and improvements, and flood vulnerabilities varies significantly throughout King County.
- Presence of existing flood protection infrastructure—The two most common types of flood protection infrastructure in King County are levees and revetments. Presence of levees and revetments vary by river and river reach.
- Channel capacity, including channel gradient and width, sediment transport, aggradations, or erosion—Transport and deposition of sediment (sand, gravel, cobble, and boulder) and woody material are affected by sources, loading, flood protection infrastructure, and channel conditions such as gradient and width.
- Critical salmon habitat areas and salmon spawning and rearing habitat—All rivers in the geographic scope of Flood Plan are used by salmon, with the exception of the Snoqualmie River above the Snoqualmie Falls, which is a barrier for migration of anadromous forms of salmonids. Chinook, steelhead and bull trout species are listed as threatened under the Endangered Species Act.

Structural Flood Risk Reduction Alternatives

A wide range of alternatives are available for managing King County's flood protection infrastructure. King County seeks to construct, maintain and repair flood protection infrastructure in a manner that maximizes flood risk reduction, cost-effectiveness and environmental benefit, consistent with the goals of the Flood Plan. This requires careful consideration of alternatives and their cumulative impacts.

In 2012, King County published the *Water and Land Resources Division Project Management Manual* (King County 2012d) that guides a consistent and transparent approach to the development and consideration of projects. Alternatives are considered as part of basin, segment and reach-scale planning efforts and during the early phases of project design. Technical studies are conducted as appropriate to characterize existing conditions and to allow for a thorough comparison of alternatives, including a no-action alternative. This comparison evaluates the expected range of project outcomes immediately after construction and after the site evolves geomorphically. The comparison evaluates not only project benefits as the site evolves, but also any risks associated with site evolution, such as to adjacent or downstream properties, so that appropriate mitigation can be developed if needed.

Projects involve varying levels of stakeholder input, and an approach for engaging the community is developed as part of the initial project management plan. Projects involving the use of large wood undergo a design review for potential recreational safety risks and a public review at the preliminary design phase to seek community input on the safety of project features. This input, along with review by professional engineers, ecologists and geologists with experience in river and floodplain management is important to the final design.

The following sections describe updates to typical structural actions for addressing flood, erosion and channel migration hazards. They can be used independently or in combination to achieve the goals of the Flood Plan.

Bioengineering

Bioengineering, explained in greater detail in the 2006 Flood Plan, mimics natural bank stabilization techniques by incorporating live plans and large wood features into the fabric of the flood protection facility and as instream structures. Using the *King County Guidelines for Bank Stabilization Projects* adopted as a component of the *1993 Flood Hazard Reduction Plan* and more recently the *2002 Washington Integrated Streambank Protection Guidelines* and the *Stream Habitat Restoration Guidelines* prepared by Washington State Department of Fish and Wildlife (Washington Department of Fish and Wildlife 2012c), King County has moved away from the almost exclusive use of riprap toward the use of bioengineering as the basis for nearly all repairs and retrofits on existing levees and revetments.

Levee and Revetment Abandonment or Removal

Some levees and revetments may no longer be needed following land use changes or reduced flood risk achieved by completing one or more flood hazard management activities in the vicinity. In addition, some levees and revetments are remnants of past management strategies and do not provide effective flood hazard management consistent with the policies in the Flood Plan. Others may be in King County's inventory for monitoring, but never have had an easement or sufficient property rights for King County to take a capital action to repair or retrofit them when needed. In locations where a levee or revetment has become obsolete, the abandonment or complete removal of that structure may be useful to help alleviate flooding risks upstream and downstream and to assist in restoration of historical fish and wildlife habitat. Abandonment or removal can be done on all or just a portion of a levee or revetment.

Abandonment involves removing a levee or revetment from King County's inventory, without physically modifying the structure. In this way, King County makes the policy decision not to repair or retrofit the infrastructure if it is damaged in the future. This requires careful consideration of how the site and river segment are likely to evolve if the levee or revetment sustains damage that would not be addressed. It also requires analysis of whether King County has any maintenance responsibility due to a contractual agreement, recent history of maintenance, or other factors. Levee or revetment removal projects will commonly be designed in coordination with other flood hazard management activities as part of an overall strategy for a river segment.

Easements

King County has over 1,000 river protection easements, which have been acquired for flood protection infrastructure construction and maintenance. River protection easements typically coincide with flood protection infrastructure locations, but numerous easements exist where flood protection infrastructure was never constructed. On the other hand, there are some areas where the County does not have a recorded easement but on which the County has historically operated and maintained flood protection infrastructure, and for which the County may have obtained prescriptive rights through historical use over time. Such areas are commonly referred to as being subject to prescriptive easements, provided certain legal criteria are met. King County cannot undertake maintenance or rehabilitation without a recorded easement or other sufficient property interest to protect the public's investment, except in rare circumstances such as during an emergency or where the County may have obtained a prescriptive easement through historical use.

River protection easements grant King County access onto and across private property for flood protection infrastructure maintenance and management. Temporary rights-of-entry are also obtained to allow for field data collection.

Most existing flood protection infrastructure easements grant King County the right to enter the property to conduct flood protection infrastructure repairs, but do not obligate King County to do so in the event of damage. This language provides King County with the ability to prioritize repairs against other flood protection capital project needs and to direct funding toward the most important and urgent projects. Projects involving reconstruction and realignment of levees and revetments may require negotiation of easements with new property owners.

FLOOD HAZARD EDUCATION AND FLOOD PREPAREDNESS, FLOOD WARNING, EMERGENCY RESPONSE, AND POST-FLOOD RECOVERY

Given the amount of development that has already occurred within flood hazard areas, floods will continue to impact people and property indefinitely. In order to help minimize these impacts, King County has established four programs to help citizens and jurisdictions prepare for and respond to floods: the Flood Hazard Education and Flood Preparedness Program; the Flood Warning Program; the Emergency Response Program; and the Post-Flood Recovery Program.

In planning outreach strategies for these programs, King County considers how best to reach historically underserved or vulnerable populations that may face barriers based on age, income, disability, language, race or other factors as part of its equity and social justice agenda.

Flood Hazard Education and Flood Preparedness Program

Brochures

King County produces and distributes a flood warning information brochure each year in English and Spanish that features the following:

- Flood warning and emergency response services
- Flood phase explanations and impacts for each river
- Recommendations for flood insurance and personal preparedness
- Important phone numbers and Web addresses for information and assistance.

The brochure is mailed to about 5,000 property owners and addresses located in unincorporated King County floodplains, and is distributed through local libraries and the cities within these floodplains.

The pamphlet, *Before, During and After a Flood*, developed with Public Health—Seattle & King County, King County Office of Emergency Management, the Local Hazardous Waste Management Program in King County, and the King County Flood Control District, provides preparedness and response information in English and Spanish to help floodplain residents reduce flood-related risk, damage and provide contact numbers for more information.

Annual Outreach to Repetitive Loss Properties and Floodplain Residents

Each year, King County mails an informational letter and the flood warning information brochure to all owners of repetitive loss properties and owners of floodplain properties in unincorporated areas of King County, as identified by FEMA Flood Insurance Rate Maps. The letters are in English, with a sentence offering interpretation services in two dozen commonly spoken languages. These mailings make property owners and residents aware of the flood hazards likely to affect their property, highlight programs and projects available to help them reduce flood-related risks, describe steps they can take to protect themselves and reduce flood damage, and provide contact numbers for more information.

King County Flood Website

King County's Flooding Services Web page, www.kingcounty.gov/flood, consistently ranks as one of the most visited pages of the King County website. This site hosts extensive and detailed information about flood preparedness and local flooding conditions, including the following:

- River conditions and flood phase information
- Flood warning and emergency response information
- The King County Flood Alert subscription service, which sends automated messages via text, email or phone when rivers reach flood phases
- Flood safety and preparedness videos in 21 languages
- Floodplain and Channel Migration Zone mapping
- Flood Photo Viewer, a map-based application with aerial photos from previous significant flood events that illustrate the severity of flooding in inundation areas
- King County's flood protection infrastructure
- Home buyout and elevation program information
- A flood mapping application to assist in determining whether properties are within a 100-year floodplain, a CMZ or other hazard area
- Flooding documents, such as the *King County Flood Hazard Management Plan.*

In addition to the links identified in the adopted 2006 Flood Plan, the website links to iMap, at www.kingcounty.gov/iMap. iMap is a mapping application maintained by the King County Department of Permitting and Environmental Review that contains flood hazard information; flood hazard map information is also accessible though the iMap website page.

King County Television and Social Media

Public service announcements about flood preparedness information and services and special emergency conditions appear on King County Television (KCTV) and via King County's social media channels, such as Twitter, Facebook and Flickr.

Outreach to Vulnerable and Underserved Populations

King County has an on-call interpretation service during regular business hours to take calls from residents who speak limited or no English or to provide this service in the Flood Warning Center during a flood event. In addition, flood preparedness and safety videos are available on the King County Flood Services Web page, at www.kingcounty.gov/floodservices, in the top 21 languages spoken in King County and American Sign Language. The videos are also posted on YouTube.

All written materials are translated into Spanish routinely, or into the language that is the primary language of five percent or more of a neighborhood's or city's population per Executive Order INF 14-2 (AEO). Some materials are translated into the most commonly spoken languages in King County.

Improved communication coordination with Public Health—Seattle & King County, Office of Emergency Management, and the American Red Cross Serving Kitsap and King County is improving the ability to reach underserved populations. For example, flood preparedness information is routinely shared with Public Health's Community Communication Network, made up of more than 100 community-based organizations, many of which serve vulnerable populations

Flood Warning Program

Flood Warning Center

The Flood Warning Center is the center of operations for the Flood Warning Program during flood events. The flood emergency director activates the Flood Warning Center whenever one or more rivers reach Phase II of the four-phase flow-based flood warning alert system illustrated in Figure 4-1. At Phase III or greater, or at the flood emergency director's discretion, field inspection teams are sent out by the Flood Warning Center to monitor flood protection infrastructure and investigate potential flood risks.

The Flood Warning Center works with King County public information officers, who issue press releases frequently during flood events and work with local media outlets to provide accurate information to the public. Press releases are posted on the King County and Regional Public Information Network websites and transmitted through the Regional Public Information Network and Twitter via Web-based messaging, with on-call interpretation services if needed to accommodate limited or non-English speakers. The Flood Warning Center website provides real-time river gage data and other flood warning and preparation information. An automated, interactive voice-response phone message system with similar content is available year-round.

Figure 4-1
KING COUNTY FLOOD WARNING PHASE THRESHOLD AND FLOOD PEAK SUMMARY
2013 KING COUNTY FLOOD HAZARD MANAGEMENT PLAN UPDATE

Phase	Tolt River (near Carnation)	Snoqualmie (Sum of Forks)	Issaquah Creek (near Hobart)	Cedar River (Landsburg)	Green River (Auburn)	White River (near Buckley)
I	2,500 cfs	6,000 cfs	6.50 ft	1,800 cfs	5,000 cfs	5,000 cfs (Unless COE or NWS calls with specific info)
II	3,500 cfs	12,000 cfs	7.50 ft	2,800 cfs	7,000 cfs	8,000 cfs
III	5,000 cfs	20,000 cfs	8.50 ft	4,200 cfs	9,000 cfs	10,000 cfs
IV	8,500 cfs	38,000 cfs	9.00 ft	5,000 cfs	12,000 cfs	12,000 cfs

RECENT LARGE FLOOD PEAKS

Tolt River (near Carnation)	Snoqualmie (Sum of Forks)	Issaquah Creek (near Hobart)	Cedar River (Landsburg)	Green River (Auburn)	White River (near Buckley)
11,400 cfs 11/29/95	48,280 cfs 11/24/90	9.90 ft 11/24/90	10,800 cfs 11/24/90	11,500 cfs 11/24/90	14,100 cfs 1/9/90
11,800 cfs 12/15/99	53,500 cfs 11/6/06	9.73 ft 2/8/96	6,580 cfs 11/30/95	12,400 cfs 2/8/96	13,200 cfs 12/1/95
13,800 cfs 1/8/09	54,110 cfs 1/7/09	8.86 ft 1/8/09	7,870 cfs 1/8/09	12,200 cfs 11/7/06	11,700 cfs[1] 11/9/06 and 1/9/09

[1] Based on Corps data on flow releases from Mud Mountain Dam.

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Flood Alert System

Early flood warning notifications are critical in providing additional time for property owners, floodplain occupants and those responsible for their safety to respond to flood threats. The Flood Alert System was implemented to quickly and simultaneously send voice calls, text messages and emails to anyone who chooses to receive notifications. Messages are sent by King County staff using a software service when reliable river data is received that meets or exceeds Phase II, III and IV thresholds on individual rivers. Additionally, messages may be sent with flood-related emergency information. The following is an example of a flood alert message.

> "The Snoqualmie River has reached flood phase 2. Minor flooding is expected in low-lying areas. More information at www.kingcounty.gov/flood or 1-800-768-7932"

Subscribers can sign up for free flood alerts on a King County website or by phone:

- http://www.kingcounty.gov/environment/waterandland/flooding/warning-system.aspx
- 206-263-3400.

Subscribers have options to receive alerts regarding six different river systems using three separate phase thresholds on multiple phone, text and email contacts. Other agencies offer emergency notifications, including the U.S. Geological Survey. King County's flood alert website provides information on various notification systems to assist the public in selecting the services that are best suited to their needs.

Multiple public outreach efforts are ongoing to encourage the public to sign-up for flood alerts. Currently the system has over 5,000 subscribers.

Coordination With Other Agencies

The Flood Warning Center works closely with The King County Office of Emergency Management, the Road Services Division, local jurisdictions and other agencies to obtain and share up-to-date information about major flood risks, road closures, evacuations and other emergency services. Coordination also occurs with the U.S. Army Corps of Engineers and Seattle Public Utilities regarding dam operations.

The National Weather Service, Seattle Forecast Office in Seattle is another critical partner in the flood warning process, working with the King County Flood Warning Center and other partners in the overall mission of helping protect lives and property. The Seattle Forecast Office provides weather observations and forecasts for western Washington and issues warnings for many types of hazards, including floods, severe weather, windstorms, snowstorms and fire conditions. Although this critical partnership was not previously described in the 2006 Flood Plan, the King County Flood Warning Center has coordinated closely with the National Weather Service for many decades.

The National Weather Service issues a Flood Potential Outlook statement when heavy rain is expected to cause flooding or aggravate existing flood conditions. Flood Potential Outlook statements are generally issued two to three days before the potential event. Flood Watches for specific areas and rivers are issued one to two days before an event. Flood Warnings are issued up to one day in advance when flooding is imminent. This applies to a specific river forecast point that is expected to exceed a flood stage based on predictive computer river modeling output, including dam operation information, and to other streams and urban areas. For the large storms and major floods, the National Weather Service conducts direct Internet briefings and uses follow-up phone calls to King County. National Weather Service statements and information are communicated to other government agencies and the public via National Oceanic and Atmospheric Administration Weather Radio, radio and television, the Internet, telephone recordings and media outlets.

Public Sandbag Distribution

Sandbags, when used properly, can reduce damage from flooding. King County helps to provide sandbag materials to the public free of charge through a partnership with nine local cities—Auburn, Carnation, Duvall, Kent, North Bend, Pacific, Seattle, Snoqualmie and Tukwila—and one community group, the Fall City Community Association. Most of the cities purchase sand and sandbags before the flood season and distribute the materials at public works facilities. The King County Flood Control District has provided funding and materials to support the program since 2009. Occasionally the King County Flood Control District will support additional sandbag distribution events. The Flood Warning Center provides information to the public regarding sandbag availability as follows:

- Online at http://www.kingcounty.gov/environment/waterandland/flooding/sandbag-distribution.aspx
- Through an automated phone message system, at 206-296-8200 or 800-945-9263,
- Receiving phone calls to the Flood Warning Center.

Emergency Response Program

A presidential major disaster declaration authorizes a wide range of programs for recovery, including financial assistance to public agencies, loans for individuals, families and small businesses, loans for farmers and ranchers, financial assistance grants, and housing grants. A presidential emergency declaration provides more limited assistance. Major disaster assistance is provided through regional FEMA centers and the state. No presidential emergencies have been declared in King County; however, 12 presidential major disaster declarations related to flooding have been made since 1990.

Post-Flood Recovery Program

Post-flood recovery is generally the final step in responding to a flood event as property owners and jurisdictions take actions to return their lives to normal following a flood event. The recovery process includes immediate actions, such as recording high water marks and conducting inspections, and longer-term actions such as seeking financial assistance and making repairs. All of these actions are necessary to assess damage, restore services and make repairs quickly and permanently. Several King County departments play a role in post-flood recovery, with much of the overall coordination provided by the King County Office of Emergency Management. Coordination can be improved to streamline efficiencies in service delivery.

Recording High Water Marks

Immediately following a flood event, the height of the floodwaters is generally evident through high water marks on the side of buildings and through the deposition of mud and debris along the banks of streams and rivers. Property owners are generally quick to hose down their buildings and clean up the debris, but by doing so without recording these high water marks there is a loss of valuable information that can be used to prepare for future flood events. This information is important because when combined with other quantifiable data, such as river and stream discharge measurements, property owners can have a better prediction of how future flood events may impact their property. In addition, this information can often be used when calculating the benefit vs. the cost of a flood mitigation project by comparing the cost to elevate a home to the estimated damage that would be avoided based on depths of flooding calculated from these high water marks. High water marks can be recorded in many ways, including photographs, permanent marks on buildings or a measurement above known elevation. Ideally, high water marks are surveyed so that they can be used to calibrate flow models and be compared with floodplain maps.

Debris Removal and Disposal

During flood events, a wide range of debris is washed downstream; as floodwaters recede, this material is deposited along river banks and on the upland areas of the floodplain. Sometimes debris collects in areas where floodwater conveyance channels are constricted, such as bridge abutments or along river banks where trees that have fallen into the channel trap debris washing downstream. Debris removal policies and protocols vary based on whether the debris is natural material, such as large pieces of natural wood that can be beneficial to fish and wildlife, or material that would meet the definition of solid waste or special waste. King County will rely on the policy guidelines contained in Policy RCM-1 and Policy RCM-2 on when and how to reposition or relocate large wood in river corridors following a flood event.

In all cases, solid waste and special waste material must be removed from the channel and floodplain and disposed of in approved disposal sites. Property owners whose buildings and contents are damaged by floodwaters are often overwhelmed by the amount of flood-damaged material that needs proper disposal. Debris collection stations have traditionally been established in communities hardest hit by flooding. Following the January 2009 flood event, more than 790 tons of debris was collected in 10 days following the flood event.

Post-Flood Damage Inspections

King County and partner agencies conduct post-flood inspections of critical flood protection infrastructure to assess damage. It is essential to return this critical infrastructure to functional operation as soon as possible to avoid major disruptions to the delivery of health and safety services and restore the regional economy as soon as possible.

King County Road Department inspects flood damage to roads and bridges. King County Water and Land Resources Division inspects damage to critical levees, revetments, pump stations and other flood infrastructure. These inspections are used to generate cost estimates that can be used when seeking funding under the FEMA Public Assistance Program or planning the King County Flood Control District's work program and budget.

King County Department of Assessments conducts inspections to determine the extent of damage to real and personal property. Both state and King County Code provide property tax relief for property damaged by flooding or other natural disasters. The property must be located in an area that has been declared a disaster by the governor or the County.

King County Department of Permitting and Environmental Review inspects buildings in unincorporated King County to determine the level of damage and the required standard for repair. King County Code Chapter 16.06 defines level of repair for buildings and structures damaged by a disaster that was declared an emergency at the county level. This inspection assists property owners and the County in defining building code standards that will need to be met when repairs are made. Inspections are also conducted within incorporated cities to assess the level of damage and to assist property owners with post-flood repairs.

The Department of Permitting and Environmental Review should also conduct inspections following a flood event to determine if a property has been substantially damaged. While King County does not define substantial damage, both federal and state flood regulations have specific provision related to repair and replacement of structures that have been substantially damaged in mapped floodplains. Substantial damage is defined as damage that is equal to or greater than 50 percent of the market value of the structure. Federal law prohibits repair of a substantially damaged building in the FEMA floodway if that repair results in any increase in the flood elevations. State code prohibits repair or replacement of substantially damaged residential structures in the FEMA floodways except for residential structures in the agricultural production district and residential structures that can meet a specific depth and velocity standard to ensure that the structure is not located in a portion of the FEMA floodway with deep, fast flows. King County needs to determine the level of damage to a building in order to accurately implement the code. These inspections have not been routinely conducted due to inadequate staffing levels and the department's fee-supported financial structure.

By identifying properties that have been substantially damaged, King County can help property owners who carry flood insurance qualify for increased cost of compliance flood insurance claims. This money is used specifically to assist property owners with flood mitigation projects, such as home elevations or relocations. When combined with FEMA grant funding, property owners with substantially damaged homes can use their increased cost of compliance funding to pay a substantial amount, or in some cases all of their out-of-pocket expenses for their mitigation projects.

Public Health—Seattle & King County oversees recovery efforts to ensure that people are not subject to health hazards resulting from contaminated floodwaters, mold from flood-damaged buildings, or other health-related problems.

FEMA Public Assistance Program

Following a federal presidential emergency declaration or presidential major disaster declaration, FEMA implements the Public Assistance Program to help local governments, tribal nations and non-profit organizations recover from natural disasters and declared emergencies. The Public Assistance Program provides disaster funding for projects such as debris removal, emergency protective measures, and the repair, replacement or restoration of disaster-damaged public infrastructure such as roads, parks, utility lines and flood protection infrastructure that is not the responsibility of a federal agency, such as the U.S. Army Corps of Engineers or the Federal Highway Commission. Applicants for the Public Assistance Program must demonstrate that they are eligible for the program, that the emergency work performed was eligible, that the structure was damaged as a result of the declared disaster or declared emergency, that the project to repair or replace the damaged structure is eligible, and that the cost of the repairs is reasonable. The Public Assistance Program also includes environmental review of proposed repairs and can assist with funding required fish and wildlife habitat mitigation work.

The King County Office of Emergency Management coordinates collection of damage data to support the request for disaster relief funding under the Public Assistance Program. King County has experienced varying degrees of success in obtaining Public Assistance funding following a major disaster declaration. One of the major challenges has been to demonstrate that the damage is a result of the declared flood event and is not unrepaired damage from an earlier flood. King County is establishing an inspection, monitoring and adaptive management program that will provide the baseline information and data to demonstrate that King County is maintaining and inspecting its flood protection infrastructure and to document the pre-flood condition of flood protection infrastructure.

Another challenge faced by King County is the requirement to maintain consistency with the Endangered Species Act and Magnuson-Stevens Act, which require vegetation to provide habitat for listed species, and the Clean Water Act. King County often chooses to upgrade damaged infrastructure to meet contemporary design guidelines, such as incorporating habitat features into the project. Public Assistance funding may not provide funding for habitat elements that King County must provide to maintain consistency with the Endangered Species Act and the Clean Water Act.

Consequently King County needs to establish specific criteria to determine when to seek Public Assistance funding and when to pay for the repairs from local funds.

Repairing Damaged Flood Protection infrastructure

Following a flood event, King County uses the policies contained in Chapter 2 of the 2006 Flood Plan to determine whether damaged flood protection infrastructure should be repaired. If emergency repairs were made during a flood event, the conditions under which the emergency repair was authorized may require that the project be rebuilt to meet current design guidelines and mitigate for habitat impacts that may have resulted from the emergency actions.

Key policies that King County uses when completing flood protection infrastructure repairs include identifying whether the site is within the geographic scope of the 2006 Flood Plan as specified in Policy G-1. The infrastructure must provide some level of protection from the flood risks defined in Policy G-2 and must meet the multiple benefit objectives in Policy G-3. Finally, King County should prioritize and sequence flood repairs to address flood and channel migration risks using the scoring criteria for flood risk and project implementation, attached in Appendix K.

River Safety Risk Reduction

King County modifies rivers through capital projects to achieve flood risk reduction and other regional goals. Some capital projects encourage more dynamic river processes by reconnecting floodplains and increasing flow conveyance capacity. Such projects may result in substantial changes in river environments during large flood events, or incrementally over time. Physical changes whether resulting from natural processes or from river projects aimed at flood risk reduction may affect in-river recreational users who have previously used less complex and dynamic channels. Though these changes are viewed differently by different user groups, some river recreational users may face increases in hazards due to changed river conditions. River recreation is inherently dangerous because rivers are full of hazards and constantly changing..

The 2006 Flood Plan addressed public safety and risk reduction in rivers through discussion of the management of natural wood and the use of wood for erosion control and stability in bioengineering projects. Since that writing, King County has actively worked to clarify, improve and document public safety considerations, procedures and policies around the management of natural wood in rivers, and the use of wood in constructed projects.

In 2009, King County convened the Large-Wood Stakeholder Committee to address concerns regarding the safety of recreational river users as they relate to large wood. The committee's *Final Report and Recommendations*, published in October 2009, summarized the ecological, historical and regulatory context for large-wood management and made recommendations to King County in three key areas:

- Enhanced outreach and education to recreational river users is necessary to help users reduce their own personal risks by promoting thoughtful planning, preparation and decision-making.
- Stakeholders should be offered predictable, meaningful and transparent involvement related to large-wood placement projects.
- Policies, roles and procedures for responding to reports of hazardous naturally occurring wood should be clarified.

In 2010, the King County Department of Natural Resources and Parks adopted Public Rule LUD 12-1, *Procedures for Considering Public Safety When Placing Large Wood in King County Rivers*. This rule documented the County's procedure of identifying safety considerations at the preliminary design phase of County-sponsored riverine capital projects intended to use placed large wood. Procedures were outlined for involving stakeholders. Monitoring and adaptive management of projects is required, as is an independent review of placed-wood projects. King County Ordinance 16581, which required the public rule, also required that a committee of stakeholders be convened at least every three years to review and update the policy. King County is the only local government known to have such requirements, and these procedures are only applicable to projects sponsored or funded by the Department of Natural Resources and Parks, which includes projects implemented on behalf of the District.

In 2009, King County embarked on a pilot study in the Cedar River to describe the location, character, functional value and potential flood-related risks associated with large-wood accumulations. In 2010, a related pilot study was conducted to characterize recreation use on the lower reaches of the Cedar River, looking at the type and amount of in-water recreation, locations of uses, risk factors and awareness of users. In 2011, King County conducted telephone and Web-based surveys to better understand public values and attitudes about rivers and river management options. These studies provided a better understanding of river users and the related choices they make. This information is beneficial to project designers, resource managers and public safety officials.

King County is continuing to develop policy and program improvements that achieve flood risk reduction goals in a way that considers the safety of recreational users and responsibly manages the costs of safety-oriented measures. Capital programs are committed to implementing standardized project management practices for all phases of capital project development, as well as regular inspections, monitoring, maintenance and adaptive management. In addition, the County is committed to engaging with stakeholders at both the basin and project levels regarding goals, expected outcomes, the degree of inherent uncertainty and the possibility of unexpected outcomes.

The methods that King County uses to build and manage projects in the river environment cannot address every aspect of public safety: A large factor in safety risks of recreational users involves the knowledge, skill, experience and level of hazard awareness of the individual person involved in recreational activity. Personal decisions regarding how and when one chooses to recreate, how to prepare, and what equipment to use or leave behind, as well as training and physical abilities, all play an essential role in reducing or eliminating hazards and risk. While King County cannot be responsible for individual decisions related to recreational river use, there may be a role for public agencies in promoting informed choices. King County government has several departments that work to inform the public about the inherent hazards of rivers, with the goal of increasing public perception of associated risks and promoting a better informed public with regard to risk-reducing personal choices. These departments include Executive Services, Natural Resources and Parks, Public Health, and the Sheriff's Office.

CHAPTER 5.
COUNTYWIDE AND BASIN-SPECIFIC CHARACTERISTICS

Chapter 5 of the 2006 Flood Plan outlines countywide projects and programs and provides a basin by basin description of flood conditions along each of the major rivers in King County. It also presents proposed actions to reduce or eliminate risks associated with these hazardous conditions. Updates in the 2013 Flood Plan Update include new information on flood protection facilities, major flooding and flood damage; key accomplishments since adoption of the 2006 Flood Plan (Appendix D); and identified risks, required elements for Community Rating System purposes. For additional countywide and basin-specific information on geology and geomorphology, hydrology and hydraulics, ecological context, salmonid use, flood hazard management objectives and strategies and proposed actions, refer to the 2006 Flood Plan.

COUNTYWIDE PROJECT AND PROGRAM UPDATES

Countywide programs and projects to be implemented across all basins include flood preparedness, emergency response, flood protection infrastructure maintenance, flood hazard studies and mapping, flood hazard planning and public outreach, countywide opportunity funds for emergency repair of flood protection infrastructure, and residential flood hazard mitigation analysis and implementation.

Table 5-1 lists proposed countywide programs. These generally focus on the collection, use and dissemination of information on an annual or nearly annual basis, but also include routine maintenance of flood protection infrastructure and public outreach programs. These programs will be implemented by the River and Floodplain Management Section of King County's Water and Land Resources Division, as the service provider for the Flood Control District. Cost estimates for implementing these programs are presented as annual costs and as the estimated cost over the six-year period from 2013 through 2018.

TABLE 5-1.
PROPOSED COUNTYWIDE PROGRAMS AND COST ESTIMATES, 2013 - 2018

Proposed Action	Description	Annual Costs	6-Year Estimate
Flood Preparedness, Warning and Emergency Response, and Recovery	Implement a comprehensive approach to preparing and educating citizens about flood events, coordinating emergency response and regional Flood Warning Center operations during flood events, and ensuring consistency across basins for post-flood recovery actions.	$675,000	$4,049,000
Resource Management, Annual Maintenance, and Flood Protection Infrastructure Assessment Program	Perform maintenance for approximately 500 levees and revetments along 119 miles of riverbank, over 600 acres of floodplain-managed property, three pump stations, and related flood protection infrastructure. Carry out annual routine maintenance, including flood protection infrastructure mowing, noxious weed control, installation and repair of access controls, and minor repair and maintenance of flood protection infrastructure and related properties and appurtenances. Develop and implement a flood protection infrastructure inventory database and a routine program of inspection, condition assessment, and monitoring for all levees, revetments, raised banks, pump stations, stormwater discharge structures, cross-culverts, closure structures and appurtenances.	$1,912,000	$11,472,000

TABLE 5-1.
PROPOSED COUNTYWIDE PROGRAMS AND COST ESTIMATES, 2013 - 2018

Proposed Action	Description	Annual Costs	6-Year Estimate
Flood Hazard Studies, Mapping, and Technical Services Program	Implement a sediment management program that includes expanded channel monitoring, establishment of thresholds to trigger actions, and analysis of sediment management action alternatives. Conduct flood hazard studies and floodplain and channel migration zone mapping. Provide floodplain management technical support to all King County departments proposing activities or projects that affect floodplain functions.	$573,000	$3,437,000
Public Outreach, Flood Hazard Planning and Grants, and Repetitive Loss Mitigation	Carry out public outreach on floodplain management programs and projects, and respond to inquiries and complaints from citizens and from public and private agencies. Maximize federal, state and local funding opportunities through grant applications in support of completing capital improvement projects, technical studies and other flood hazard management activities. Provide supporting documentation, technical support and staff training required to maintain favorable status in FEMA's Community Rating System.	$660,000	$3,962,000
King County Flood Control District Implementation	Implement flood hazard management programs and capital improvement projects for the District. Coordinate with King County cities through Basin Technical Committees, which consist of jurisdictions' technical staff and 15-member advisory committees of elected officials. Provide technical support to King County's Department of Permitting and Environmental Review for floodplain permits and inquiries, floodplain mapping, elevation certificates, and Critical Areas Ordinance updates. Provide floodplain management technical support to Snohomish, Cedar, Green and White River watershed coordination and salmon habitat recovery activities. Administer Sub-Regional Opportunity Fund and WRIA Collaborative Watershed Management Grant programs	$3,609,000	$21,653,000
Program Management and Supervision; and Finance, Budget, and General Administration	Provide for program administration, staff supervision and training, flood hazard management plan updates, Comprehensive Plan Consistency, and the River and Floodplain Management Section Annual Report	$2,337,000	$14,024,000
Total Countywide Programs		**$9,766,000**	**$58,597,000**

SOUTH FORK SKYKOMISH RIVER UPDATES

King County Flood Protection Facilities, Major Flooding, Flood Damage

The primary King County flood protection facilities along the South Fork Skykomish River line most of the left riverbank and several hundred feet of the right bank through the Town of Skykomish. This includes training levees and revetments intended to hold the channel in place and resist bank erosion; most are not containment levees designed to prevent overbank flooding. There are also several levees and revetments along the South Fork Skykomish in the Baring area and along the lower Miller River.

The largest flood on record on the Skykomish River at Gold Bar occurred in November 2006; this flood inundated the Town of Skykomish along the South Fork Skykomish River. After the November 1990 event, many levees and revetments throughout the South Fork Skykomish basin were damaged and rebuilt with traditional rock riprap installations; these repairs have held up well. Subsequent to the November 2006 flood, a portion of the left bank levee in the Town of Skykomish downstream of the bridge was completely rebuilt.

In January 2011, a section of the lower Miller River avulsed, which is the rapid abandonment of a river channel and the formation of a new channel, and severed a 150-foot section of the Old Cascades Highway. The river channel is now west of its former alignment under the Miller River bridge. King County Road Services Division has determined that replacement of this road is not feasible.

Table 5-2 summarizes the highest flow records at the South Fork Skykomish River at Gold Bar.

TABLE 5-2.
HIGH FLOW RECORDS AT SOUTH FORK SKYKOMISH RIVER AT GOLD BAR

Date of Flood	Peak Flow (cubic feet/second (cfs))
November 2006[a]	129,000 cfs
December 1995	79,600 cfs
November 1990	102,000 cfs
November 1986	76,500 cfs

a. Largest flood on record

Key Accomplishments Since the 2006 Flood Plan

Since 2006, several properties in areas at high risk for erosion or inundation have been purchased. These include three houses in Timber Lane Village and four parcels constituting a monastery on the Miller River alluvial fan. A repair of the McKnight Revetment on the right bank of the South Fork Skykomish in Baring, which was damaged in the 2009 flood event, was completed in 2011.

King County River and Floodplain Management Section staff have assisted King County Roads in assessing options for addressing the damage to the Old Cascades Highway at the avulsion site on the Miller River alluvial fan.

Flood Hazard Management Identified Risks

King County has mapped historical channel locations of the South Fork Skykomish. The area where historical channels are located can be particularly hazardous for flooding and erosion. King County also recently evaluated areas of flood inundation and identified community areas along the South Fork Skykomish with buildings exposed to inundation.

Based on this preliminary review, about 75 houses appear to be located within the area of historical channel locations, which indicates high levels of present-day channel migration hazards. More than half of these are in the Baring community area, within the subdivisions of Montagna Park, Skylo Park, Riverwood Park, Skylandia and Chamonix Village. In addition, a few residences in the Town of Skykomish and in the Timber Lane Village subdivision appear to be located within the area of historical channel locations.

The preliminary evaluation also indicated that more than 40 homes in the Town of Skykomish are likely subject to inundation. Preliminarily, 13 or more homes appear to be exposed to 2 feet or more of flood depth on the first floor at the 100-year flood elevation. Another 10 or more homes upstream of the Town of Skykomish, near the mouth of the Beckler River, also appear to be subject to these flood depths.

Inundation hazard overlaps partially with erosion hazard, particularly in the Riverbend Park and Skylandia subdivisions in the Baring area, in Timber Lane Village upstream of the Town of Skykomish and within the Town of Skykomish. Because these three community areas have both erosion and inundation hazards, they are considered to be the areas within the river corridor with the most significant flood hazard conditions.

SOUTH FORK SNOQUALMIE RIVER UPDATES

King County Flood Protection Facilities, Major Flooding, Flood Damage

Flood protection facilities along the South Fork Snoqualmie River include a system of continuous levees through North Bend and several discontinuous levees and revetments up and downstream of the levees. There are 28 levees or revetments in the South Fork Snoqualmie River corridor, making up about 9 miles of armored riverbank. With the exception of the lower 2 river miles of the South Fork Snoqualmie, most outside river bends are armored up to river mile 9.1.

High flows overtop the banks and flood the neighborhoods of Circle River Ranch and Shamrock Park. The January 2009 event did not have record flows on the South Fork Snoqualmie, but flows were high enough to overtop the levee, inundating 19 homes. Damage occurred to numerous levees or revetments during this flood event: Circle River, Bendigo Lower Right, Bendigo Upper Left, Bendigo Upper Right, Si View Park, Reif Road, Si View, Holstein Extension, Riverbend, Stanley Carlin and Allen. Water over 415th Way Southeast caused road closures.

A major flood in 2006 and minor floods in 2010 and 2011 also caused damage to King County levees and revetments in this area. Table 5-3 summarizes the largest flows at the U.S. Geological Survey's South Fork Snoqualmie gage in North Bend, USGS gage 12144000. Table 5-4 summarizes the highest flows recorded at the South Fork Snoqualmie above Alice Creek near Garcia gage, USGS gage 12143400.

TABLE 5-3. HIGH FLOW RECORDS AT SOUTH FORK SNOQUALMIE GAGE IN NORTH BEND, USGS GAGE 12144000

Date of Flood	Peak Flow (cfs)
January 2009	12,300 cfs
November, 2006	13,600 cfs
November 1990	10,900 cfs
December 1977	12,400 cfs
December 1975	12,600 cfs

TABLE 5-4. HIGH FLOW RECORDS AT SOUTH FORK SNOQUALMIE ABOVE ALICE CREEK NEAR GARCIA GAGE, USGS GAGE 12143400

Date of Flood	Peak Flow (cfs)
November, 2006	8,450 cfs
November 1990	8,000 cfs
November 1986	8,450 cfs

Key Accomplishments Since the 2006 Flood Plan

Between 2006 and 2013, King County completed seven flood protection infrastructure repairs, including one as an emergency action during the 2010 flood season. Si View and Reif Road levees in the Leveed segment of the river and Allen and Riverbend revetments farther upstream have been repaired. The November 2006 and January 2009 events created sinkholes and cavities in the top of the levee prism that have since been repaired.

Ten homes in the Shamrock Park neighborhood have been elevated so that the first floor living space is above the 100-year flood elevation. One home has been purchased and demolished. Three additional home elevations are planned in Shamrock Park and four in the Clough Creek neighborhood.

A geomorphic hazard and risk assessment for the Circle River Ranch neighborhood has been completed to inform flood risk reduction actions in the river's Snoqualmie Valley Trail to Confluence segment. One home in the Circle River Ranch neighborhood has been purchased and demolition plans are underway.

The *South Fork Snoqualmie Gravel Removal Study* (King County 2011) considered the impacts of gravel accumulation on flood levels, as well as the potential effectiveness of gravel management actions. The results are being considered during preliminary design for the South Fork Snoqualmie Levee Improvement project.

Preliminary geotechnical and hydraulic analysis for the South Fork Levee Improvement project have been completed and design work including development of a suite of alternative actions to be developed and analyzed is underway. This updated technical information is being used to quantify the benefits of various potential floodplain management actions. Landowner and stakeholder input will help guide selection and sequencing of potential actions to reduce flooding impacts and improve habitat in the Leveed Section beyond the detail provided in this 2013 Flood Plan Update.

Flood Hazard Management Identified Risks

The following are the flood hazard management risks identified for this river:

- Risks to public safety from deep, fast flows
- Risks to public and private infrastructure, including drainage systems, streets and buildings
- Potential impacts on the regional economy if the City of North Bend is severely flooded
- Risks to private structures, both residential and commercial
- Potential for all of these risks to worsen suddenly in the event of a levee failure.

MIDDLE FORK AND NORTH FORK SNOQUALMIE RIVERS UPDATES

King County Flood Protection Facilities, Major Flooding, Flood Damage

The flood protection facilities on the Middle Fork Snoqualmie and North Fork Snoqualmie consist of a system of discontinuous levees and revetments. There are 13 levees and revetments on the Middle Fork Snoqualmie and 10 on the North Fork Snoqualmie; 3.4 miles of riverbank are armored in some fashion. The original construction methods and materials used to build most of these are unknown.

Flood flows in 2009 damaged several levees: Shake Mill Left, a private flood control structure, and Vallcuda on the North Fork Snoqualmie; and Mason Thorson Extension and Mason Thorson Ells on the Middle Fork Snoqualmie. Most of this damage was subsequently repaired. This flood event also caused overtopping of several roads, including Southeast Middle Fork Road and Southeast Lake Dorothy Road. The Shake Mill Left levee was damaged again by floods in 2010 and 2011.

Table 5-5 summarizes the highest flows recorded at the Middle Fork Snoqualmie gage. Discharge was estimated at nearly 50,000 cubic feet per second for the December 1959 flood, before the gage was installed, which would be the largest flood on the Middle Fork Snoqualmie since settlement times (Perkins 1996). The North Fork Snoqualmie gage has a long, nearly continuous data collection history dating to 1930. Table 5-6 summarizes the highest flows recorded at the North Fork Snoqualmie gage.

TABLE 5-5.
HIGH FLOW RECORDS AT MIDDLE FORK SNOQUALMIE GAGE

Date of Flood	Peak Flow (cfs)
January 2009	31,200 cfs
November 2006	31,700 cfs
November 1990	30,100 cfs
December 1977	30,200 cfs
December 1959	~50,000 cfs

TABLE 5-6.
HIGH FLOW RECORDS AT NORTH FORK SNOQUALMIE GAGE

Date of Flood	Peak Flow (cfs)
January 2009[a]	17,100 cfs
November 1995	14,500 cfs
November 1959	13,400 cfs
January 1945	13,400 cfs
October 1934	13,400 cfs

a. Largest flood on record

Key Accomplishments Since the 2006 Flood Plan

Between 2006 and 2013, King County completed five repairs on Mason Thorson Extension and Mason Thorson Ells levees and relocated three hazard trees. King County has completed early planning of a comprehensive strategy for flood hazard management along the Middle Fork Snoqualmie. This early work included analyzing and monitoring the Mason Thorson Extension levee. An emergency action plan was developed, to be used in response to potentially rapid changes at the site. Additional assessments were initiated to characterize geomorphology, hydraulics, hydrology, habitat conditions and land use that influence the Middle Fork Snoqualmie corridor. Since 2006, three properties have been acquired with King County Flood Control funds, totaling 8.8 acres.

Preliminary geomorphic, hydraulic and ecologic existing conditions analysis for the Middle Fork Corridor Management Project have been completed and design work including development of a suite of alternative actions to be developed and analyzed is underway. This updated technical information is being used to quantify the benefits of various potential floodplain management actions. Landowner and stakeholder input will help guide selection and sequencing of potential actions to reduce flooding impacts and improve habitat in the Leveed Section beyond the detail provided in this 2013 Flood Plan Update.

Flood Hazard Management Identified Risks

The following are the flood hazard management risks identified for this river:

- Risks to public safety from deep, fast flows
- Risks to public infrastructure, including drainage systems, streets, and buildings
- Potential impacts on the regional economy if the City of North Bend is severely flooded
- Risks to private structures, both residential and commercial
- Potential for all of these risks to worsen suddenly in the event of a levee failure, channel avulsion or relocation.

UPPER SNOQUALMIE RIVER MAIN STEM UPDATES

King County Flood Protection Facilities, Major Flooding, Flood Damage

There are 19 levees and revetments in the Upper Snoqualmie basin, representing 2.6 miles of armored riverbank. Six of those are on Kimball Creek and 13 are on the Upper Snoqualmie. The levees and revetments are discontinuous, but most outside river bends are armored. Historical aerial photos and file materials indicate that most of this flood protection infrastructure was constructed or significantly improved in the mid-1960s.

The major flood event in January 2009 and minor floods in 2010, 2011 and 2012 caused damage to several levees and revetments: Record Office, Meadowbrook, and the 202 to Mouth Left Revetment on Kimball Creek. The Record Office and Meadowbrook revetments have been repaired. The January 2009 flood event caused widespread damage to public and private property in the City of Snoqualmie and surrounding unincorporated area of Kimball Creek. King County Roads Division closed Southeast Mill Pond Road and Southeast Reinig Road in January 2009 and the City of Snoqualmie issued evacuation orders during this flood event.

Table 5-7 summarizes the highest flows recorded at the Upper Snoqualmie gage. According to U.S. Geological Survey staff, the November 1990 record discharge appears too high with respect to other gages in the Snoqualmie basin, although the U.S. Geological Survey does not have enough evidence to remove the computed discharge from published flow records.

TABLE 5-7.
HIGH FLOW RECORDS AT UPPER SNOQUALMIE GAGE

Date of Flood	Peak Flow (cfs)
January 2009	60,700 cfs
November 2006	55,000 cfs
February 1996	51,700 cfs
November 1990	78,800 cfs
November 1986	58,100 cfs
December 1977	53,800 cfs
December 1975	51,800 cfs
November 1959	61,000 cfs

Key Accomplishments Since the 2006 Flood Plan

Between 2006 and 2013, King County and the City of Snoqualmie collaborated to elevate 39 homes with FEMA grant funding—23 through the City of Snoqualmie's program and 17 by King County. The City of Snoqualmie has secured FEMA grant funding for an additional 39 home elevations for which King County is contributing 12.5 percent in matching funds. Additionally, King County, with FEMA grant funds, has completed six property acquisitions totaling 4.2 acres, removing 22 residences from areas of high flood and channel migration hazards, including the Riverside Mobile Home Park.

The completion of the mitigation needs assessment through the Upper Snoqualmie Valley Residential Flood Mitigation Project has led to a programmatic strategy for home elevations and acquisitions. More than 230 residential structures in this river segment have first floor elevations below the 100-year flood elevation and are candidates for non-structural flood mitigation projects.

Two revetment repairs have been completed since 2006. King County responded to 21 flood events.

Flood Hazard Management Identified Risks

The following are the flood hazard management risks identified for this river:

- Risks to public safety from inundation and deep and erosive flows
- Risks to public infrastructure, including drainage systems, streets and buildings
- Potential impacts on the regional economy if the City of Snoqualmie is severely flooded
- Risks to residential and commercial private structures
- Risks to three public schools
- Potential for all of these risks to worsen suddenly in the event of a levee failure.

LOWER SNOQUALMIE RIVER MAIN STEM UPDATES

King County Flood Protection Facilities, Major Flooding, Flood Damage

There are 126 levees and revetments in the King County River Flood Protection Facility Inventory along the Lower Snoqualmie River from the Tokul Creek confluence at River Mile 37.7 to the King and Snohomish county line at River Mile 5.5. This flood protection infrastructure is generally discontinuous and often located on the outside of meander bends, but sometimes the infrastructure lines both banks of the river to confine and limit lateral migration. Many of these levees and revetments originated as privately constructed bank protection along farm properties many decades ago. Two flood control bonds passed in the 1960s funded additional construction and dozens of flood protection infrastructure improvements. Most of the Lower Snoqualmie levees were not intended to provide significant containment of flood flows, and none of these levees provides containment for the 100-year flood. They function more as revetments, providing bank hardening and some resulting limitation to bank erosion and channel migration.

Other flood control infrastructure, constructed or maintained by other agencies or private entities, exists in a number of locations along the Lower Snoqualmie and is not part of the King County inventory. One such revetment, along the right bank of the river upstream of the State Route 202 bridge in Fall City, is maintained by the Washington State Department of Transportation to protect the state highway alignment and the approach to the bridge. A similar bridge approach protection was constructed in 2010 by the King County Department of Transportation on the right bank of the river just upstream of the N.E. Carnation Farm Road bridge. Additional, significant bank protection revetments of unknown history, constructed to protect agricultural areas, remain in a number of locations in the Lower Snoqualmie River corridor.

Flood protection infrastructure that was damaged during the November 2006 and January 2009 events includes the McElhoe Pearson and Aldair levees and the Sinnema Quaale and Winkelman revetments. State Route 202 was overtopped in January 2009 just upstream of the Raging River confluence, causing scour damage to the road and several residences, two beyond repair. The January 2009 event also caused extensive damage to farms, including scour of farm fields, damage to barns, fences and other structures, and deposition of debris and sediment on fields. The 2006, 2008 and 2009 flood events caused overtopping and closures of a number of State and County roads in the valley. Roads that were damaged by these or other flood events in the past include State Routes 202 and 203, N.E. Woodinville-Duvall Road, N.E. Carnation Farm Road, and Neal Road S.E.

Table 5-8 summarizes the highest flows on the Snoqualmie River in recent history, as recorded at the Snoqualmie River near Carnation gage. While these events produced widespread flooding and damage, several other moderate flow events between 2006 and 2012 caused additional damage.

**TABLE 5-8.
HIGH FLOW RECORDS AT LOWER SNOQUALMIE RIVER NEAR CARNATION GAGE, USGS GAGE 12149000**

Date of Flood	Peak Flow (cfs)
January 2009[a]	82,900 cfs
November 2008	63,100 cfs
November 2006	71,800 cfs
November 1990	65,200 cfs

a. Largest flood on record

Key Accomplishments Since the 2006 Flood Plan

Since January 2006, structural accomplishments in the Lower Snoqualmie River corridor include repairs to two levees. The McElhoe Pearson levee was damaged during the November 2006 flood event and was repaired through the U.S. Army Corps of Engineers' Public Law 84-99 program in the summer of 2008. The levee was damaged again during the November 2008 flood event and was repaired in the summer of 2009. The Aldair levee was repaired in 2008 due to damage caused during the high flows of November 2006. Large capital projects have been initiated to address damage at the Sinnema Quaale Upper and Winkelman revetments.

Non-structural accomplishments in the Lower Snoqualmie valley include home and barn elevations, property acquisitions, and technical and permitting assistance for the construction of farm pads for agricultural properties. Ten homes and two barns have been elevated since January 2006. King County shared elevation project costs on six of these structures as part of the Snoqualmie 205 flood reduction project. Additional non-structural accomplishments since 2006 include the acquisition of five properties with 15 residences on 36 acres; four of these properties are in the high-risk location where State Route 202 was damaged during the January 2009 flood. The County also provided technical and permitting assistance for construction of 24 farm pads. These non-structural actions supporting farmers, and other regulatory changes that have occurred, implement a number of recommendations included in the 2008 Snoqualmie Flood-Farm Task Force Report.

Programmatic accomplishments since January 2006 include ongoing channel monitoring in addition to updating flood hazard mapping. Portions of the Lower Snoqualmie segments below the Raging and Tolt rivers are study reaches in the Snoqualmie gravel study that is in progress under King County's ongoing channel monitoring effort. The study is evaluating the amount and rate of sediment deposition, the degree to which it is influencing flood elevations, and the degree of reduction in flood elevations that could be accomplished with gravel removal.

Hazard mapping in this basin includes detailed flood studies and Flood Insurance Rate Maps along the main stem Snoqualmie. Updated Flood Insurance Rate Maps were submitted to FEMA in May 2006 (Northwest Hydraulic Consultants 2006). These maps are not yet formally adopted but are used in practice as the best available science. More detailed floodplain modeling is being conducted in the Snoqualmie at Fall City segment as part of a capital project feasibility planning effort. While this modeling will not modify Flood Insurance Rate Maps or regulatory water surface elevations or boundaries, it will enhance the technical understanding of flooding conditions in the segment and inform analysis and comparison of potential actions to reduce flood hazards.

Channel migration zone mapping has not been done on the Lower Snoqualmie and will be prioritized among countywide flood and channel migration zone mapping needs.

Flood Hazard Management Identified Risks

Basinwide

The Lower Snoqualmie River main stem has a broad valley where flooding of agricultural, residential and commercial properties typically occurs valley wall to valley wall. While a network of levees and revetments provides varying levels of flood protection and resistance to bank erosion and lateral channel migration, flood hazards exist across nearly the entire floodplain. Farms, roads, homes and businesses scattered throughout the hazard area are at risk, as even moderate events, such as a 10-year flood, can cause extensive flooding and inundate nearly the same extent of the floodplain as larger floods. Approximately 87 percent of the floodplain consists of the Snoqualmie Agricultural Production District. The river is also home to Chinook salmon, steelhead trout and bull trout that are listed as threatened under the Endangered Species Act.

A significant project in the Upper Snoqualmie basin has influenced flood levels to at least a minor extent throughout the Lower Snoqualmie corridor. The Snoqualmie Flood Reduction Project, or Snoqualmie 205, was a cooperative project between the U.S. Army Corps of Engineers, the City of Snoqualmie and King County completed in 2004 and 2005 to reduce flooding in the City of Snoqualmie. This project included modifications to increase conveyance in the river channel just upstream of Snoqualmie Falls. This increased upstream conveyance and associated loss of flood storage likely increased flood flows downstream of the falls. A downstream impact analysis conducted as part of the project design determined that any rise in water surface elevations associated with the increased peak flows would be minor—on the order of 0.1 foot or less for flood events up to and including the 100-year flood. A downstream assistance program was initiated as part of the project to provide financial support for structure elevations in affected areas. Impacts of the completed project have not been documented.

Snoqualmie Falls to Fall City

This segment is relatively steep and narrow in its upstream end; flooding and erosion hazards occur primarily in the residential and commercial areas where the floodplain broadens upstream of the Raging River confluence east of Fall City. This segment has the highest recreational use in the Lower Snoqualmie.

Alluvial Fan Segments: Snoqualmie at Fall City and Snoqualmie at Carnation

The alluvial fans of the Raging and Tolt rivers and related sediment deposition make these segments more dynamic river process areas, where attempts to control the river have been more costly and had greater environmental impacts. Flood protection infrastructure in these segments has required more frequent repairs, resulting in more rock placed and more trees removed. Overbank flooding and high-velocity, erosive flows occur in these sections of the river valley due to the steeper gradient. Fall City and Carnation are located on the alluvial fans of the Raging and Tolt rivers, respectively. Agricultural uses dominate downstream of Fall City, and north and south of Carnation. These segments of the main stem, and the lower segments of the Raging and Tolt rivers, are the highest priority for Chinook salmon spawning and rearing.

Meander Segments: Patterson Creek to Tolt River and Chinook Bend to County Line

The Snoqualmie River in these segments meanders through a broad, low-gradient section of the valley where oxbows and wetlands are common. Flooding across the valley is frequent, even during smaller floods, though flows are typically lower-velocity. The dominant land use is agricultural. Nearly all of the floodplain within these segments is in the Agricultural Production District. Flooding becomes progressively deeper in the north end of the valley, in the vicinity of Duvall.

TOLT RIVER UPDATES

King County Flood Protection Facilities, Major Flooding, Flood Damage

Carnation Segment

The main King County flood protection facilities on the Tolt River are the nearly continuous levees and revetments along both sides of the lower 2 miles of the river. Built in about 1940, these facilities provide varying levels of flood containment through the Carnation segment. The greatest level of flood containment is provided along both banks upstream of the Snoqualmie Valley Trail bridge; there is less containment from the bridge to State Route 203, with areas of overtopping at flow levels below the 10-year flood. Overall, the Tolt River levees in the Carnation segment do not provide protection to the 100-year flood. However, the levee system has limited channel migration and avulsions in this segment.

Upstream of the Snoqualmie Valley Trail bridge, the left bank levee between River Mile 1.4 and River Mile 2.0, referred to as the Girl Scout levee, is the upstream part of the Tolt levee system on the river's left bank. This levee disconnects historical channel locations and floodplain and limits channel migration to the south toward the Girl Scout Camp River Ranch. There is potential for avulsion upstream of the levee, which could increase erosion and flood hazards to the levee and to the property behind it.

The Frew Upper and Holberg levees, on the right bank upstream of the Snoqualmie Valley Trail bridge, provide critical flood protection infrastructure for protecting the City of Carnation from flooding. The Holberg levee was reconstructed in 1995, greatly reducing the flood risk to the City of Carnation from this location. The flood containment function of the Holberg levee ends at River Mile 1.8, but bank protection continues upstream along a side channel known as the North Channel to River Mile 2.1. This revetment along the North Channel is the sole protection for 10 homes built within the mapped CMZ; however, it is not an effective barrier to channel migration.

The Snoqualmie Valley Trail bridge frequently collects large wood during floods, possibly contributing to increased flood depths upstream of the bridge and scour of the bridge piers. Elevated water surface elevations introduce increased flood risk into the City of Carnation over the right bank levee, the Frew Upper levee. This condition represents an ongoing need for emergency debris removal.

Downstream of the Snoqualmie Valley Trail bridge, the left bank neighborhood served by N.E. 32nd Street between State Route 203 and the Snoqualmie River Trail bridge is only marginally protected from flooding and erosion by a levee of questionable structural integrity, the Highway to Railroad Bridge levee. This levee was overtopped and breached during the January 2009 flood event. In addition to causing floodwater inundation and access restrictions, the levee breach damaged multiple residences on N.E. 32nd Street, some beyond repair. The right bank levee in this reach was also damaged at River Mile 1.0 during the January 2009 flood.

Downstream of the State Route 203 bridge, where Snoqualmie River backwater and overbank flow can have as much of an effect on flooding as the Tolt River itself, there is negligible flood containment. Widespread flooding occurs even during smaller flood events. The left bank levee downstream of the State Route 203 bridge is believed to exacerbate main stem Snoqualmie River flooding upstream of the confluence of the two rivers.

In January 2009, the Carnation segment levees were significantly damaged at six locations and experienced minor damage at a number of other locations. State Route 203 was overtopped north of the Tolt River bridge during this event. The overtopping reduced access to Carnation during the flood and resulted in damage to the highway. Minor damage to Tolt River levees also occurred as a result of moderate flood events in 2010 and 2011.

Ongoing sedimentation occurs within the full length of the Carnation segment due to its location on the Tolt River alluvial fan, a natural depositional area. Historical flood management practices included removing gravel from the channel within the Carnation segment, especially by dredging the Tolt River delta at the Snoqualmie River. This practice has been discontinued since the 1960s. Ongoing sedimentation is likely reducing the flood containment capacity of the levees. This is being evaluated as part of the Snoqualmie channel monitoring studies.

Upstream of Carnation Segment

Dynamic channel processes continue in the absence of significant structural barriers in the Upstream of Carnation segment. Just downstream of River Mile 3 on the right bank, a King County levee contiguous with a King County revetment protect the Tolt River Road and a few residential properties. Flood protection infrastructure in a number of other locations was constructed or is maintained by private entities. The San Souci neighborhood is currently afforded limited protection by a private informal structure constructed in the early 1990s, but is still at risk from flooding, erosion and channel migration.

In January 2009, a major avulsion occurred between River Mile 2.5 and River Mile 3.5, within the existing severe channel migration zone. The Tolt River main stem relocated from the east to the west side of the floodplain, reoccupying a former channel alignment.

Table 5-9 summarizes the highest flows in recent history on the Tolt River, as recorded at the Tolt River near Carnation gage.

TABLE 5-9.
HIGH FLOW RECORDS AT TOLT RIVER NEAR CARNATION GAGE

Date of Flood	Peak Flow (cfs)
January 2009	13,800 cfs
December 1999	11,800 cfs
November 1995	11,400 cfs

Key Accomplishments Since the 2006 Flood Plan

Since 2006, structural accomplishments in the Tolt River corridor include emergency repairs to the Highway to Railroad Bridge and Frew levees during the January 2009 flood and repairs to damage and an accompanying setback of the Tolt River Road Protection revetment later in 2009.

Additional structural work included repairs to the Snoqualmie Valley Trail bridge, including scour protection for the mid-channel bridge piers that were damaged in January 2009 and replacement of the timber trestle approach span on the left bank that had significant fire damage. The trestle was replaced with a new bridge approach span supported by deep foundation piles. This new approach span foundation allows for flow expansion and an increased extent of channel migration under future-project scenarios that include setting back the left bank levees upstream and downstream of the bridge.

The Lower Tolt River Floodplain Reconnection Project was a levee setback project on the right bank downstream of the State Route 203 bridge that was completed in 2009 in a cooperative effort between King County and the City of Seattle. The project facilitated significant floodplain reconnection, giving the Tolt and Snoqualmie rivers access to 45 acres of floodplain that had been previously disconnected by the Tolt River levee system.

Since 2006, the following properties have been acquired with King County Flood Control District and salmon recovery funds:

- 12 properties in the San Souci Neighborhood, including 12 residences and 40 acres
- 10 properties at the Tolt River Mile 1.1 Setback site, including 8 residences and 7 acres
- 1 residence on 1 acre at the Tolt Natural Area Floodplain Reconnection site.

Ongoing monitoring since 2006 includes a gravel study of the lower 1.72 river miles of the Tolt River. This section of the Tolt River is a study reach in the Snoqualmie gravel study that is in progress as a part of King County's ongoing channel monitoring effort. The study is evaluating the amount and rate of sediment deposition, the degree to which it is influencing flood elevations, and the degree of reduction in flood elevations that could be accomplished with gravel removal.

The Tolt River Corridor Action Plan was initiated in 2010. This effort includes updating available technical information about the existing physical conditions of the river and quantifying the benefits of various potential floodplain management actions. Potential effects of levee setback projects on the City of Carnation, such as changes in the 100-year flood elevation, will also be assessed as a part of this effort. Landowner and stakeholder input will help guide selection and sequencing of potential acquisitions, levee setback projects, and other actions to reduce flooding impacts and improve habitat in the Tolt River corridor beyond the detail provided in this 2013 Flood Plan Update.

Flood Hazard Management Identified Risks

Flood and erosion risks in the Upstream of Carnation segment include bank erosion, channel migration, avulsion, landslides, inundation, and cut-off access. Properties at risk include residences, small businesses, and small agricultural operations, as well as public and private roads and other infrastructure.

Flood and erosion risks in the Carnation segment are related to its location on the Tolt's alluvial fan and the levees that line most of this section of river. Levees can be overtopped or incur damage, leading to flooding and erosion of homes, businesses and farms in the City of Carnation and unincorporated King County.

RAGING RIVER UPDATES

King County Flood Protection Facilities, Major Flooding, Flood Damage

The main King County flood protection facilities on the Raging River are continuous levees constructed in the late 1930s that run along both sides of the river in the Fall City segment from the 328th Way S.E. bridge at River Mile 1.5 to the mouth. Areas adjacent to the Raging River at its confluence with the Snoqualmie River are subject to flooding from both the Raging and Snoqualmie rivers. This flooding is most prevalent on the Raging River right bank near the Snoqualmie confluence, where flooding frequently forces the evacuation of a campground used throughout the flood season. The Raging River levees downstream from the 328th Way S.E. bridge limit channel migration across the Raging River alluvial fan and provide variable levels of flood containment.

Although the existing levees downstream from the 328th Way S.E. bridge are higher than the 100-year flood elevation in some areas, they neither provide this level of protection in all areas nor have sufficient freeboard to be federally certified. Extreme high flows or a levee breach on the left bank in this reach would result in floodwaters flowing north from the Raging River through Fall City toward the Snoqualmie River. Ongoing sediment accumulation in the Raging River channel, particularly from the Preston-Fall City Road bridge at River Mile 0.5 to the mouth, may diminish future flood capacity and increase flood hazards on both sides of the Raging River. Sedimentation from the Raging River at its delta could have similar effects locally along the Snoqualmie River.

Upstream of the continuous levee system in the Fall City segment, there are 14 additional flood protection structures in the County's inventory, most of which are revetments. These protect roads and residences up to about River Mile 8 but are subject to damage from bank erosion and channel migration. Other flood protection infrastructure, constructed or maintained by other agencies or private entities, exists in a number of locations upstream of the Fall City segment.

Most of the development upstream of Fall City is sparse, but a mobile home park and several single-family residences just upstream of I-90 could suffer substantial damage if an avulsion were to occur through undeveloped property immediately upstream of the mobile home park. Despite several revetments in this reach—some in the County inventory and others not—evidence of erosion suggests that such an avulsion could occur. An avulsion during the November 2006 flood event, and subsequent lateral migration, undermined and destroyed a home at River Mile 5.7.

Major damage was caused to levees in all three river segments on the Raging River in November 2006: Arruda, Bryce, Bridge to Bridge Left, Bridge to Bridge Right, Bridge to Mouth Right, and Preston Fall City Lower. The flood of January 2009 resulted in moderate damage to levees in the I-90 to Fall City segment: Preston Fall City Lowest, Preston Fall City Lower, Preston Fall City Upper and 312th Avenue S.E. The Upper Preston Road just downstream of the Alpine Mobile Manor was damaged during the November 2006 flood event. Table 5-10 summarizes the highest flows in recent history on the Raging River, as recorded at the Raging River near Fall City gage.

TABLE 5-10.
HIGH FLOW RECORDS AT RAGING RIVER NEAR FALL CITY GAGE, USGS GAGE 12145500

Date of Flood	Peak Flow (cfs)
November 2006	4,310 cfs
January 1990	4,640 cfs
November 1990[a]	6,220 cfs
November 1986	5,330 cfs

a. Largest flood on record

Key Accomplishments Since the 2006 Flood Plan

Structural accomplishments along the Raging River since 2006 include seven repairs to six revetments and levees to address damage sustained in the 2006 and 2009 flood events: Arruda, Bryce, Bridge to Bridge Left, which received two repairs, Bridge to Bridge Right, Bridge to Mouth Right, and Preston Fall City Lower.

More than 1,000 feet of the Carlin levee in the I-90 to Fall City segment was removed in 2006. The levee removal allows the river to migrate laterally across the previously inaccessible floodplain. Nine groups of large boulders placed on the left floodplain edge protect the Preston Fall City Road from lateral scour while maintaining channel and floodplain roughness and complexity.

Non-structural accomplishments since 2006 include the acquisition of six properties in the Alpine Mobile Manor neighborhood in the Upstream of I-90 segment, comprising five residences and 8 acres.

Programmatic accomplishments since 2006 include ongoing channel monitoring of the lower 1.5 river miles of the Raging River. This section of the Raging River is a study reach in the Snoqualmie gravel study that is in progress and is a part of King County's ongoing channel monitoring effort. The study will evaluate the amount and rate of sediment deposition, the degree to which it is influencing flood elevations, and the degree of reduction in flood elevations that could be accomplished with gravel removal.

Flood Hazard Management Identified Risks

There are 6.5 miles of river above the Fall City segment at high risk for channel migration, bank erosion, and, in some locations, avulsion. Properties at risk include residences in the Channel Migration Zones (CMZ) and floodplain, as well as public roads, including the Preston-Fall City Road. These segments are important habitat for federally listed salmonids and other fish and wildlife.

In the Fall City segment, flooding risk is related to levee overtopping, damage or failure. Flood and erosion risks in the Fall City segment are related to its location on the Raging River's alluvial fan and the continuous levees that line both banks throughout the segment. Levees can be overtopped or incur damage, leading to flooding and erosion of homes and businesses in the unincorporated town of Fall City. This segment contains important spawning and rearing habitat for federally listed Chinook salmon and other fish and wildlife.

SAMMAMISH RIVER, ISSAQUAH CREEK, LAKE WASHINGTON TRIBUTARIES UPDATES

King County Flood Protection Facilities, Major Flooding, Flood Damage

Sammamish River

The entire Sammamish River acts as flood protection facility following channel straightening, deepening, and bank armoring in the mid-1960s. The flood control project was designed to reduce the frequency and severity of spring flooding, which, prior to channelization, often destroyed newly seeded row crops. Most of the flood protection consists of rock-lined banks that are flush with the adjacent grade at the top. The U.S. Army Corps of Engineers' flood control project for the Sammamish River also included improved conveyance of the lower ends of Bear Creek in Redmond, Little Bear Creek in Woodinville and North Creek in Bothell. Easements extending 22 feet from the top-of-bank line both sides of the river's 14-mile length. During the 1970s, public ownership was acquired for a trail system along much of the river's length. This easement extends landward 50 to 100 feet from the top of the riverbank.

A weir at the uppermost end of the river functions to retain water in Lake Sammamish at a higher level during summer, when the lake is used heavily for recreational activities. The weir includes a low-flow notch to support passage for migratory fish. Water that leaves the outlet of Lake Sammamish flows across the weir, then through the 1,432-foot-long transition zone into the trapezoidal river channel. Through this transition zone, the river drops 6.75 feet, a significant portion of the total 14-foot drop over the entire river.

There have been a series of structural modifications since 1964. In 1998, King County partnered with the U.S. Army Corps of Engineers to redesign and rebuild the deteriorating weir structure. This work was done in concert with fish passage improvements and extensive bank stabilization and revegetation. The project covered several thousand feet of bank in Marymoor Park. More recently, the City of Redmond designed and built several habitat enhancement projects in the river corridor.

The 1964 Sammamish River operation and maintenance manual outlines maintenance practices to ensure conveyance of the design flow through the river channel. Under these practices, the channel and its banks were expected to be kept free from any feature that would impede the conveyance of flood flows. As initially interpreted, this meant annual mowing of the banks to keep them clear of all vegetation, as well as occasional dredging or channel clearing to remove any accumulated sediment or wood.

Maintenance practices have since evolved to reflect subsequent environmental regulations and awareness. In 2002, King County and the U.S. Army Corps of Engineers jointly developed the Sammamish River Action Plan, which articulates a vision for multi-objective management along the length of the river. In recent years, maintenance practices have shifted away from annually mowing the banks to focus on selective vegetation thinning or removal where needed for flood conveyance. In many locations, keeping up with mowing the invasive plants that dominate the river's banks is neither practical nor necessary from a flood perspective. However, in 2011 the frequency and extent of mowing in the transition zone was increased in response to elevated lake levels. In addition, trimming of the willow buffer was increased to maintain a navigation channel and flow conveyance.

Major river flooding has become an infrequent occurrence since the river was deepened and straightened. Table 5-11 summarizes the largest flood events in the present-day channel, measured at USGS gage 12125200 near Woodinville.

TABLE 5-11.
HIGH FLOW RECORDS AT SAMMAMISH RIVER NEAR WOODINVILLE GAGE, USGS GAGE 12125200

Date of Flood	Peak Flow (cfs)
Dec 2005 – Jan 2006	1,770 cfs
January 1997	2,870 cfs
February 1996	2,470 cfs
January 1986	2,320 cfs
March 1972	2,390 cfs

Issaquah Creek

Flood protection infrastructure along Issaquah Creek is fairly minimal, consisting of short sections of riprapped banks for streambank protection. Management of that infrastructure typically involves post-flood repairs to restore damage. Much of Issaquah Creek within the Issaquah city limits has hardened banks—the result of past farming and urban development—and significant failures are rare.

Along Issaquah Creek, flooding historically was mostly confined to farmlands, and the farm properties were only minimally affected by high water. Early newspaper accounts generally wrote of flooded farmlands, washed out roads, and an occasional flooded basement. However, as development progressed to the edges of the streams and bridges were built for roads, flood impacts and damage increased. Flooding now affects urban areas of Issaquah that were farmland until only a few decades ago, impacting commercial and residential properties alike.

The recent history of significant flooding along Issaquah Creek and Tibbetts Creek began in December 1975 with a flood event that was then called the largest since 1933. Subsequent major floods occurred in November 1986, January and November 1990, February 1996, and January 2009. Flood insurance payments for the January 2009 flood event totaled $1.75 million. The 1996 flood had similar damage. Total FEMA payout for flood insurance claims within the city from 1978 through 2011 was $3.9 million. Commercial properties in the Gilman Square area of Issaquah accounted for about 40 percent of all historical flood insurance claims.

Lake Washington Tributaries

The slope of Lyon Creek flattens out as it reaches the commercial core of Lake Forest Park, where it is funneled into several culverts before passing under State Route 522. The culverts are undersized relative to current-day flows, causing the creek to backwater and spill over into adjacent McAleer Creek and flooding the entire area. Significant public infrastructure and critical facilities are affected, including the fire station, the community center, and the primary highway through this area. Also flooded are over 20 single-family homes in the Sheridan Beach neighborhood. Major flooding is persistent, with three 100-year events in the past 20 years. The most recent flood caused approximately $4 million in damage. The flood resulted in the closure of two lanes of the highway, and the fire station remained closed for many months.

Coal Creek is fed by stormwater runoff from multiple jurisdictions. The lower end of the creek was channelized and subsequently developed for residential use in the area formerly occupied by the alluvial delta. Lower Coal Creek currently flows from a regional detention facility at I-405, then passes through levee-lined banks and numerous culverts intended to safely convey flows through the densely populated residential neighborhood. The detention facility is a 20-acre-foot, in-channel detention pond, owned and operated by the City of Bellevue. The facility temporarily stores the stream behind a dam-like impoundment that doubles as the road prism for I-405. This facility helps reduce peak flows, but none of the flood protection structures—the detention pond, levees or culverts—have sufficient storage or flow capacity to protect the surrounding neighborhood during a 100-year flood event.

The problems are exacerbated by the fact that the creek transports a significant amount of sediment, much of it generated from the loose soils of a former coal mine near its headwaters. Ongoing streambed aggradation in the lower reach dramatically reduces conveyance capacity. Connection of the local storm drainage system contributes additional flooding in the neighborhood when backwater conditions occur. Once floodwater escapes the stream corridor, it can flow laterally down streets, often threatening homes, including homes not adjacent to the creek. Preliminary hydraulic modeling predicts that many homes are at risk of structural flooding, especially when the flow control facility is at full stage. Since 1995, there have been approximately 65 individual reports of flooding and flood damage.

Key Accomplishments Since the 2006 Flood Plan

In recent years, King County and the cities of Redmond, Woodinville, Bothell and Kenmore have engaged in a number of projects to enhance the Sammamish River corridor for aesthetic, recreation, and fish and wildlife habitat functions. These include reshaping the banks, replacing invasive plants with native species along the river's banks, installing instream large wood and bar features, and reshaping straightened sections of channel. The projects were designed such that flood conveyance was protected.

Recent concerns arose regarding the potential impact of greater vegetation retention in the transition zone, as it could affect water levels around the Lake Sammamish shoreline. Homeowners on the lake indicated that the lake's water surface elevations appeared to be rising over time. In response, King County conducted a study of Lake Sammamish outflow to the Sammamish River. The study demonstrated that there has been an increasing trend in lake water surface elevation over the past decade, which could not be clearly attributed to changes in Issaquah Creek inflows or precipitation effects. While vegetation in the Sammamish River transition zone was not definitively identified as the cause of the lake water surface elevation increase, it was demonstrated through modeling and empirical data collection that increasing maintenance actions to remove or thin vegetation in that area could increase lake outflow to the river during moderate winter flows.

In response to these findings, King County worked with homeowners to develop the April 2011 *Lake Sammamish Flood Reduction Plan*, which recommended several short and long-term strategies to improve understanding and management of the river as it relates to lake outflow, including increased maintenance and a feasibility study of sediment removal. Additional early monitoring results indicate that short-term steps successfully improved conveyance and navigability through this reach. Next steps include an aquatic weed removal trial. Working toward a more long-term solution for management of the transition zone, King County and the City of Redmond have engaged in a partnership to conduct a feasibility study for the Willowmoor Floodplain Restoration Project. The study will identify alternatives for reconfiguring the transition zone to improve fish and wildlife habitat conditions while maintaining flood control objectives.

On Issaquah Creek, the City of Issaquah has made significant progress with projects to mitigate flood problems. Severe bank erosion from the 2009 flood that threatened a city road and the Medical Center of Issaquah was addressed in a 2010 bank stabilization project funded and constructed cooperatively with the landowner. The Squak Valley Park South Restoration Project, constructed in 2010, involved property acquisition and partial removal of a streamside levee to reduce flood elevations in the Sycamore neighborhood. Other acquisitions have included an additional 12.2 acres in the Issaquah Creek basin since 2006, permanently removing these areas from flood risk. As a result of these and previous property acquisitions, the City of Issaquah has preserved about 100 acres of floodplain as permanent open space. This amounts to about 26 percent of the entire 100-year floodplain within the city limits.

In 2010 the City of Issaquah was awarded funding from the FEMA Flood Hazard Grant Program to elevate six flood-prone homes to current floodplain standards. As of 2012, five homes have been elevated; the sixth home identified in the grant was transferred to a FEMA Severe Repetitive Loss grant and will be elevated in 2013.

Flood Hazard Management Identified Risks

Sammamish River

Flood risks are minimal in the Sammamish River basin, largely because of past flood risk reduction efforts. As a result of the flood control project in the 1960s, Sammamish River flooding is infrequent, is generally limited to agricultural and recreational fields, and is usually not fast or deep. Riverbank failure is limited to small localized areas of slumping. There are only two FEMA repetitive loss properties. Many current land uses in the Sammamish River floodplain, such as recreation and agriculture, are largely compatible with infrequent, short-term, and low-velocity flooding. However, ongoing development continues, potentially reducing flood storage areas throughout the watershed, and increasing runoff volumes and peak flows.

While the channelization of the Sammamish River has greatly reduced flood risks in the Sammamish River and around Lake Sammamish, ecological considerations were not taken into account in development of the flood control project or its maintenance practices. The most significant outcome has been the loss of streamside vegetation and instream complexity that provide necessary food, shade and cover for fish and wildlife. Occasionally, parts of the river have been dredged or cleared of sediment and wood deposits. The river corridor has also experienced an onslaught of invasive species, including Himalayan blackberry, reed canary grass, and English hawthorn trees, which have come to dominate the banks of the river, thriving in the full sun environment created by historical riverbank clearing practices. The wholesale clearing of streamside trees and shrubs and instream wood and sediment has led to severely degraded habitat and water quality.

Dredging and vegetation clearing activities are now being closely monitored by the Muckleshoot Indian Tribe Fisheries Division and environmental groups who have expressed strong concern that changes in vegetation cover and flow management may negatively impact a river with an already impaired temperature condition.

Issaquah Creek

The middle and upper reaches of Issaquah Creek, which flows out of the foothills of the Cascade Mountains, are dominated by rural residential and forested lands; the lower reach runs through the City of Issaquah. Flood impacts are most notable in the city, which contains 20 of the 23 FEMA-identified repetitive loss properties in the basin.

Lake Washington Tributaries

The *Lower McAleer and Lyon Creek Flood Reduction Study* recently completed by the City of Lake Forest Park offers two alternatives for addressing flooding problems in the commercial hub. One solution involves constructing a high-flow bypass pipe on Lyon Creek to divert flood flows directly into Lake Washington from a point upstream from where the creek currently overtops. The second option involves constructing setback berms on both public and private property and upgrading existing culverts, to provide additional conveyance capacity for flood flows.

Reducing peak storm flows and enhancing stream channel conveyance capacity while maintaining or improving aquatic habitat are the key methods for addressing the flooding problems along Lower Coal Creek. Potential capital projects, which could be constructed alone or in combinations, include increasing the storage volume in the regional detention facility, increasing conveyance capacity of the culverts, increasing the height of the earthen berms, constructing a high-flow bypass pipeline, redirecting the local storm drainage system away from Coal Creek and connecting it directly to Lake Washington, and strategic acquisition of at-risk properties. As a first step to resolving the flooding problems on Lower Coal Creek, an engineering feasibility study will be conducted to identify alternatives and determine which approach is most cost-effective. The goal is to provide flood protection up to the 100-year flow event. The selected alternative will seek to achieve flood protection improvements in a way that maintains fish passage and enhances riparian and floodplain habitat conditions.

CEDAR RIVER UPDATES

King County Flood Protection Facilities, Major Flooding, Flood Damage

Since the 1960s, King County has constructed 65 structures for flood and erosion control in the Lower Cedar River valley. Despite decades of attention to maintenance of these levees and revetments and channel clearing practices, flooding and flood damage continue throughout the basin. This is due to past use of now-outdated design and construction standards which have led to deterioration of older flood protection infrastructure, extensive development located in areas with little or no flood protection measures, emergence of new flood hazard areas following major flood events, and an increase in the number of homes and infrastructure built in flood hazard areas. Over time, King County's levees and revetments and the homes and lands they protect will become more vulnerable to damage. Further, the techniques used to build and maintain these flood protection structures may make salmon habitat recovery efforts difficult.

In 1998 the City of Renton participated in a U.S. Army Corps of Engineers 205 Flood Control Project that resulted in removal of gravel and construction of floodwalls and levees along the reach of the Cedar River passing through the City of Renton. This was a substantial project that protects critical infrastructure that is important to the regional and state economy, including the Boeing Renton Plant and the Renton Airport. The 205 Flood Control Project structures are maintained by the City of Renton through an agreement with the U.S. Army Corps of Engineers.

Flooding in residential areas poses the greatest risk to public safety in the lower and middle Cedar River basins. Even moderate floods can cause high-velocity flows around homes and over sole access roadways. As of 2011, 19 homes in the Cedar River basin were identified by FEMA as repetitive loss properties based on flood insurance claims. Of these, 12 have been mitigated by purchase or home elevation. Many other homes that lack flood insurance are known to have experienced repeated flood damage as well.

Damage to levees and revetments from the 2009 event was estimated to be $3.1 million. An unknown amount of damage was sustained by other public infrastructure, such as roads, bridges and utilities, as well as private property. Many homes were surrounded by deep, fast flows, numerous roads became impassable, homes and furnishings were destroyed, wells were contaminated, and some residents were forced to access their homes by rowboat. Parts of the City of Renton, including the Renton Municipal Airport and industrial properties, were flooded during the 1990 flood but received little flood damage in 2009, largely as a result of the dredging and levee construction in this reach.

Table 5-12 summarizes the record floods on the present-day Cedar River. Major floods also occurred in 1975, 1995 and 1996, resulting in similar public and private damage and losses. Additional floods in 2006 and 2011 were of moderate magnitude, but also caused damage to levees and revetments as well as homes, infrastructure and other properties.

TABLE 5-12.
HIGH FLOW RECORDS AT CEDAR RIVER AT LANDSBURG GAGE AND RENTON GAGE

Date of Flood	Landsburg Gage Peak Flow (cfs)	Renton Gage Peak Flow (cfs)
January 2009	7,870 cfs	9,390
November 1990	10,800 cfs	10,600

Key Accomplishments Since the 2006 Flood Plan

King County has completed 25 major flood hazard management projects on the Cedar River since 2006, as well as several programmatic actions that reduced the risks of flood hazards. Projects have included three emergency repairs during major flood events, 17 major retrofits and repairs to flood protection infrastructure, five minor flood damage repairs, two levee setbacks, and buyouts of flood-prone homes. Programmatic actions included studies and public outreach efforts to improve citizens' understanding of local flood hazards and how to protect themselves and minimize personal damage.

Flood protection infrastructure repairs have used biotechnical bank stabilization techniques to retrofit and repair 2,850 linear feet of riverbank. These techniques integrate native vegetation and large wood into the structure in a way that strengthens the flood protection infrastructure and improves habitat value. The branching vegetation and large wood features slow localized velocities, reducing erosion, while the root system binds the soil increasingly over time. Overhanging vegetation and in-water structures provide food, cover and refuge for fish and wildlife. An additional 2,730 linear feet of levee have been reconstructed in a setback configuration, reconnecting 31 acres of floodplain for absorption of flood flows and habitat restoration.

In many neighborhoods along the Cedar River, the flood risk to residents cannot be eliminated through the construction of flood protection infrastructure, and buyout and relocation of homes may provide the best solution for eliminating repeated flood damage and safety risks. King County has acquired 90 flood-prone homes in the Cedar River basin through an ongoing voluntary home buyout effort, including a 51-unit mobile home park located in the river's floodway and 11 of the 19 FEMA-identified repetitive loss properties. Together, these acquisitions have opened up 116 acres of floodplain for natural functions. Many are key properties needed for larger-scale high-priority flood hazard reduction projects in the basin. These acquisitions not only reduce flood risks, but also create opportunities for partnerships for long-term restoration and stewardship of these lands. After acquisition, all structures on each property are demolished, the site is stabilized and revegetated using native plant species, and all lands are maintained as open space in perpetuity. The benefit of these flood hazard management projects has been increased through coordination with the WRIA 8 Salmon Recovery Council, multiple King County agencies, cities, and community-based groups. These coordination efforts led to the acquisition by the City of Seattle of six additional homes flooded during the January 2009 flood event. The city plans to restore these lands as part of its habitat conservation plan.

Major programmatic accomplishments in the Cedar River basin focused on reducing risk by improving the technical understanding of flood risks and sharing this information through outreach and education:

- A recently completed study of channel migration mapping methodologies will assist in the preparation of channel migration zone maps for the Cedar River. King County will use the new maps in selecting and prioritizing flood hazard mitigation projects and regulating future development that would be at risk due to channel migration.
- Another recently completed study documented the location, size and mobility of large wood over a three-year period. This information helps in understanding the background loading of wood in the system and provides valuable context for designing and building flood repair or mitigation projects.
- A recent study of recreational use on the Cedar River provides insight into the location of entry and egress by recreational users as well as seasonality, timing, skill level, type and locations of recreational use. This information is considered in the design and construction of projects in the river and on its banks.

Flood risks in the Cedar River basin have also been managed through programs to coordinate with other agencies and to provide public outreach and education. These activities have been instrumental in helping local communities prepare for and respond to flooding:

- At a planning meeting each fall in advance of flood season, the region's first-responders meet to review operations, communications and weather predictions, as well as any special conditions to watch.
- Coordination with the City of Seattle has resulted in considerable and ongoing success in reducing flood magnitude, frequency and severity by careful monitoring and modification of operations at the Masonry Dam.

- Through partnerships with the community, King County can learn from residents' knowledge of the river while residents benefit from becoming involved and informed about actions King County might take that will affect the river. To this end, King County hosted a public meeting in the fall of 2011 to share information about upcoming projects with the community. This exchange of information is expected to become an ongoing program element.

Flood Hazard Management Identified Risks

The following are the flood hazard management risks identified for this river:

- Risks to public safety associated with localized flooding
- Risks to public infrastructure, including drainage systems, transportation routes, a municipal airport and a variety of other public service facilities
- Impacts on the regional economy related to flooding
- Risks to private structures, including homes, businesses and industrial properties
- Major landslide hazards from debris movement or flood backwater to homes near the many locations where the river abuts the steep valley wall.

Risks to those living, working, and traveling through flood-prone areas include damage to the structural integrity of homes, health hazards from contamination of water supplies or damaged septic systems, inundation of living spaces, and dangers associated with attempts to travel on flooded or damaged roads. The Cedar River also poses serious risk from erosion and channel migration, which can cause loss of property and in worst-case scenarios loss of residential structures.

Flood-prone areas of the middle and lower reaches of the Cedar River are dominated by residential uses. Many homes, and even entire neighborhoods, are located in the FEMA floodway or are surrounded by historical river channels, which indicates significant channel migration hazard. Historical protection methods, focused on armoring the bank to limit channel migration and erosion, have stabilized the bank in many locations but have done little to prevent the risks associated with overbank flooding. In some cases, these revetments have contributed to a false sense of security for new home buyers and encouraged development in flood-prone areas.

Additional flood risks result from naturally occurring landslides, which are common in this basin. The potential for nearly instantaneous deposition of large sediment volumes directly into the river channel poses a flood risk that cannot be eliminated by levees or revetments. A landslide may completely block the river, causing it to change course; may block a portion of the channel, causing it to flow over its banks; or may lead to sediment being transported and deposited in a downstream reach, where it may build up and reduce conveyance capacity over time. A landslide resulting from the 2001 Nisqually earthquake backed up the river and caused several homes upstream to be inundated by floodwater during a relatively low-flow condition. Had this landslide occurred during a high water event, it would have caused even greater damage.

The condition of the Cedar River's levees and revetments is also a concern. The older levees and revetments that line the river are frequently less robust than structures built using more current standards and biotechnical bank stabilization techniques. This appears to be particularly true along the Cedar River Trail, where highly variable materials were used to create revetments for an old railroad and were likely installed by simple end-dumping. Bank armoring structures can result in increased scour conditions immediately downstream, which may lead to decisions to extend the structures downstream.

Secondary effects of flooding include redistribution of sediment and large wood that is conveyed downstream in flood flows. Armoring of much of the river has limited the capacity of the floodplain to function as a source and sink for sediment and large wood, conveying more of these materials through the armored reaches.

Many of the levees and revetments are also a subject of concern with respect to the recovery of Endangered Species Act-listed species native to the Cedar River. The simple blankets of rock used to armor most of the Cedar River flood protection infrastructure do not foster development of a healthy riparian buffer or interaction between the river and its floodplain.

GREEN RIVER UPDATES

King County Flood Protection Facilities, Major Flooding, Flood Damage

The Lower Green and Duwamish River levees and revetments form a nearly continuous bank protection and flood containment system from the City of Auburn to the mouth of the Duwamish River. Little of the continuous Green River levee system meets current construction standards.

Lower Green River levees and revetments typically have over-steepened banks, areas with inadequate or deteriorating rock buttressing at the embankment toe, and incrementally slumping or sloughing riverbank slopes supporting constructed earthen levee berms. Most of the historical levee reaches lack habitat features such as native riparian vegetation and instream wood accumulations. Howard Hanson Dam operations significantly reduce flood peaks but result in longer durations of elevated flows and relatively rapid rates of change in water levels. With flows confined to a narrow, leveed channel, the potential for flood scour of the riverbed is significant. Where this occurs, undermining and deterioration of the embankment toe have been observed. Such conditions can stress the levee and revetment system along the Lower Green River, with the potential to increase the occurrence and magnitude of slump failures. As a result, many of these flood management structures have needed frequent maintenance. Nearly all of them have been identified for needed rehabilitation and reconstruction to structural design standards better suited to the levels of flood risk present.

Levees and revetments along the Middle Green River are scattered, discontinuous and largely deteriorating. They are not intended to contain flood flows or prevent inundation, but rather to direct high flows and inhibit bank erosion and channel migration. Meanders upstream from the Hamakami Levee in 1990 destroyed both the upper end of the levee and its access roadway. In 2011, undercutting erosion and bank scour of the Lone's Levee resulted from ongoing channel migration in the reach just upstream.

Major historical floods on the main stem Green River produced flows at Auburn of 24,000 cubic feet per second in 1933, which had a pre-dam recurrence interval of 19 years; 18,400 cubic feet per second in 1951, a 7-year pre-dam recurrence interval; and 28,100 cubic feet per second in 1959, a 39-year pre-dam recurrence interval. Typical flood damage included undermining by scour along the toe of levees and revetments in the Lower Green River and erosion of flood protection infrastructure or avulsion around it in the Middle Green River. Table 5-13 summarizes the most recent high flows on the Green River, as recorded at the Green River at Auburn gage.

TABLE 5-13.
HIGH FLOW RECORDS AT GREEN RIVER AT AUBURN GAGE

Date of Flood	Peak Flow (cfs)
January 18, 2011	10,400 cfs
December 2010	9,720 cfs
January 2009	11,100 cfs
November 2006	12,200 cfs
February 1996	12,400 cfs
November 1995	11,200 cfs
November 1990	11,500 cfs

Key Accomplishments Since the 2006 Flood Plan

Major Projects

The King County Flood Control District has carried out an annual program of flood hazard management activities since it supplanted the Green River Flood Control Zone District after completion of the 2006 Flood Plan. Significant among these was major reconstruction of flood-damaged containment levee segments that had been over-steepened and structurally unstable and were set back to achieve stable slopes. Additional easement widths were obtained in order to achieve these stable slope geometries at portions of the federally authorized Tukwila 205 Levee in the City of Tukwila; and at the Briscoe Levee, Narita-Kent Shops Levee, Myer's Golf Levee, and Nursing Home and Breda portions of the federally authorized Horseshoe Bend Levee in Kent.

In some locations, repairs were conducted at major levee and revetment segments where sufficient easements were not secured to provide for optimal setback reconstruction at stable slope angles, primarily due to high costs of acquisition of commercial property along the river. In these cases, slopes were largely repaired in situ with biostabilization measures and extensive toe and slope buttress installations. Such repairs were constructed recognizing that maintenance and repair costs may be higher over time. Examples of this category of major levee repair include a portion of the 42nd Avenue Revetment in the City of Tukwila and a portion of the Stoneway Lower Revetment along Frager Road on the left bank in Kent. Some federally assisted repairs were also completed in this manner as part of the Horseshoe Bend 205 Project in Kent and at the Galli's Levee and portions of the Dykstra Levee, both in Auburn.

Setback reconstruction of the Fenster Training Levee was accomplished with funding from the Washington State Salmon Recovery Fund Board to improve salmon habitat. This project was intended both in response to incremental deterioration of the older structure and to implement a priority habitat restoration project identified in the U.S. Army Corps of Engineers' Ecosystem Restoration Project and in the *Green River Salmon Recovery Plan*.

Other Projects

Two smaller repairs were completed at the Foster Golf Course at River Mile 9.95 in Tukwila, where erosion damage to the rock revetment was repaired with FEMA cost sharing. An additional slumping bank just upstream at the Foster Golf course was stabilized with plantings, and a log-and-piling structure was placed in the water column as mitigation for trees cut at other Green River levee slopes, to retain eligibility for U.S. Army Corps of Engineers flood damage repair funding. Smaller repairs also include the installation of a flexible rubber check valve on the outlet culvert serving the private drainage system at the River Mobile Home Estates behind the Reddington Levee in Auburn.

Another significant project effort involves the local response to U.S. Army Corps of Engineers advice regarding levee vegetation. The U.S. Army Corps of Engineers uses levee vegetation as a major factor in the eligibility for federal assistance with post-flood levee repairs. In order to be eligible for such assistance, King County removed 461 trees from Green River levees in 2008 and 2009. State permits for this work require mitigation to replace the habitat functions of these trees, and land acquisition was necessary to provide this mitigation.

Land Purchases

In 2011, King County acquired the Teufel Nursery, a Lower Green River property that totals 36.7 acres and 0.92 miles of undeveloped shoreline along the Green River. This critical shoreline acquisition is in a portion of the Green-Duwamish River Watershed where open space, undeveloped shoreline, and functioning salmonid habitat features are scarce.

Emergency Preparation Due to Potential Dam Failure

A significant amount of unanticipated time, money and energy went toward preparing for the potential of a flood disaster due to seepage found at Howard Hanson Dam in 2009 after a significant flood event. Flood risk in the areas below the dam went from a 1-in-500 chance of exceeding design flows of flood control structures downstream to a 1-in-3 chance, creating the biggest challenge to flood control efforts in the Green River basin since the construction of the dam in 1962. Flooding scenarios were developed by the U.S. Army Corps of Engineers and local jurisdictions based on varying assumptions concerning containment at the dam. Following extensive review and discussion, with material support from the U.S. Army Corps of Engineers and funding assistance from the King County Flood Control District, the local jurisdictions of Tukwila, Kent, Auburn and King County embarked on an ambitious program to line 23 miles of the Lower Green River with sandbags and HESCO barriers. These temporary advanced measures were targeted to provide containment of flows up to a release of 15,300 cubic feet per second at Auburn without overtopping, representing roughly the estimated 500-year event as recalculated by the U.S. Army Corps of Engineers. Containment of higher levels of discharge was not considered feasible, though the threat of overtopping remained possible given the limited pool capacity at the dam.

Higher floods did not occur, and the U.S. Army Corps of Engineers confirmed a return to normal operations at the dam and reservoir in September 2011. The temporary advanced measures have been dismantled. The King County Flood Control District spent over $9.3 million installing, maintaining, and removing them. Combined disaster preparedness actions by local governments in response to damage to the dam was over $33 million.

FEMA Digital Flood Insurance Rate Map Updates

In 2006, King County initiated a major effort to re-calculate and map the floodplain of the Green River for submittal to FEMA. At the same time, FEMA began a program to convert all its existing Flood Insurance Rate Maps to a digital format, called Digital Flood Insurance Rate Maps. This nationwide effort started with an emphasis on heavily urbanized and populated floodplains, and the Green River was selected on this basis.

In compiling its existing Flood Insurance Rate Maps into a digital format, FEMA required that its standards for recognizing levee containment be confirmed for all levees formerly recognized as confining the 100-year flood. These standards require that a licensed professional engineer or federal agency such as the U.S. Army Corps of Engineers certify that the levee meets structural and performance criteria before it can be accredited as providing a containment boundary in FEMA's mapping efforts. Along the Green River, the federally authorized Tukwila 205 levee system meets these standards, but no other Green River levee has been certified in this manner. As a result, FEMA extended modeled flood elevations beyond the levees and across much of the historical floodplain, and published preliminary Digital Flood Insurance Rate Maps in September 2007 on this basis. Much as prior FEMA mapping overstated the levees' reliable protection, this FEMA mapping overstated the hazard in the levee-protected areas.

At nearly the same time, King County's flood mapping study was completed, with a much more refined model to support a far reduced overall footprint affecting much less of the valley floor. The resulting flood map was used as the basis for appeal of FEMA's preliminary Digital Flood Insurance Rate Map by King County and the cities of Renton, Tukwila, Kent, and Auburn. FEMA is now drafting new mapping procedures and standards in response to this appeal and to a nationwide reaction to the mapping approach used for the preliminary Digital Flood Insurance Rate Maps.

Local Initiatives and Partnerships

The heightened flood risk scenarios developed by the U.S. Army Corps of Engineers, seepage issues at Howard Hanson Dam, and FEMA's preliminary Digital Flood Insurance Rate Maps mapping of the Lower Green River have combined to significantly increase flood awareness in the Green River basin and has led to increased focus on project implementation in the Green River, including an effort by the City of Kent to certify and accredit all Green River levees in the city. This approach is supported by the King County Flood Control District as long as these efforts meet Flood District policies. Two exceptions have been made for the City of Kent's efforts to accredit the Boeing and Hawley Road levees, which are documented in a memorandum of understanding between the City and the District. These projects are funded through the Washington Department of Ecology, with the District as the project sponsor. In 2013 the Flood Control Distric approved resolution #FCD 2013-02.2, providing conditional support and funding to the Briscoe-Desimone levee improvement project, managed through an agreement for levee construction, operation and maintenance with the City of Kent.

King County works with multiple federal, state, and local partners on flood risk reduction policies, plans and projects in the Green River watershed. Significant partnerships include the following:

- Partnership with the U.S. Army Corps of Engineers on a variety of topics, including levee maintenance of federally authorized levees on the Lower Green River, levee rehabilitation projects, ecosystem restoration projects, and levee vegetation management policies
- Regular meetings of the Green River Technical Committee made up of staff from Green River cities to provide recommendations to the King County Flood Control District on technical matters pertaining to the Green River basin
- Partnerships with the State of Washington granting and permitting agencies on specific Green River projects.

Flood Hazard Management Identified Risks

For the Duwamish and Lower Green rivers, ongoing instability of levees and revetments is the primary concern, and potential levee breach and inundation of most of the valley floor would result in extreme consequences. In the Middle Green River, discontinuous levees and revetments will continue to experience bank erosion due to lateral channel migration and channel avulsion.

Lower Green and Duwamish Levee Conditions

Constructed mainly in the mid-1970s, the basic levee system in place today consists of minimal toe buttress structures, over-steepened, sloughing banks, eroding channel margins, minimal or invasive vegetation, and significantly degraded habitat.

Middle Green River Channel Migration

Significant channel migration continues to occur in the Middle Green River. In some locations, broad meanders and braiding channels are constantly shifting within a complex of active gravel bars, vegetated riparian floodplains, and remnant side channels.

Possibility of Flows Exceeding Flood Infrastructure Design Capacity

Flood protection infrastructure on the Green River has been built and designed for a maximum flow of 12,000 cubic feet per second at the Auburn Gage for up to a 500-year flood event. The U.S. Army Corps of Engineers recently estimated that the current risk of a Howard Hanson Dam release exceeding 12,000 cubic feet per second at Auburn is 1 in 140, compared to the previously assumed 500-year risk. As shown in Table 5-14, this means that there is a 19-percent chance of flooding in the Lower Green River valley in 30 years rather than a 6-percent chance.

TABLE 5-14.
PROBABILITY OF EXCEEDING A DESIGN FLOW OVER VARIOUS TIMEFRAMES

	Probability of Exceedance			
Flood Recurrence	In 30 years	In 50 years	In 75 years	In 100 years
1:100 (100-year flood	26%	39%	53%	63%
1:140 (140-year flood[a])	19%	30%	42%	51%
1:200 (200-year flood)	14%	22%	31%	39%
1:300 (300-year flood)	10%	15%	22%	28%
1:500 (500-year flood)	6%	10%	14%	18%

a. This is the current U.S. Army Corps of Engineers dam design event

Value of Property, Buildings and Number of People Needing Flood Protection

The lower Green River is lined by a near continuous system of levees and revetments. The area is highly urbanized and has significant commercial, industrial, and high-density residential areas with accompanying high assessed values.

An analysis conducted by FEMA in 2009 showed that failure of the current levee system in a 100-year storm event would result in damage of $1.34 billion to $3.77 billion, including damage to commercial and residential buildings, building contents, and business interruption. Also in 2009, the U.S. Army Corps of Engineers produced a worst-case analysis of flooding below Howard Hanson Dam, the *2012 Green River Valley Dams Sector Exercise Series Secondary Impacts Economic Analysis*. This analysis assumed flows of 25,100 cubic feet per second at Auburn and a breach at the Tukwila 205 levee. The analysis found that direct and secondary impacts of interruption in economic activity in the short term of one to three years could be as much as $32 billion in output loss, with losses of 132,554 jobs and almost $8 billion in lost wages. The analysis concluded that long-term impacts on the economy would be felt through 2030. Subsequent work by the U.S. Army Corps of Engineers (U.S. Army Corps of Engineers 2011) estimated that a large magnitude flood could result in over $3.7 billion in damages to structures, the loss of 72,000 jobs and $4.2 billion in wages, and over $16.7 billion in economic losses due to business disruptions in the first year alone.

Move Toward Multi-Objective Approach to River Management

The Green River basin is home to thousands of residences and businesses and contributes to a large portion of the economy of the Seattle metropolitan area. The Green River is also important to the Puget Sound ecosystem, is home to listed salmon and bull trout species, and performs key ecological functions. As such, local governments are responsible for implementing salmon recovery targets for the Green River watershed, complying with the National Clean Water Act, and mitigating for negative environmental impacts, including those that result from flood control practices.

In an effort to manage the Green River in a way that will protect more people at less cost and address environmental and recreational needs, the King County Flood Control District, with support from King County, is exploring an approach to manage for multiple goals and objectives through a multi-objective river corridor approach. This holistic approach to watershed management has support from regional partners including the Muckleshoot Tribe and the Puget Sound Partnership. The concept is being supported by the U.S. Army Corps of Engineers through a System Wide Improvement Framework (SWIF), a process intended to reduce conflicts between the federal Endangered Species Act and compliance with the U.S. Army Corps of Engineers levee vegetation policies.

The purpose of the Lower Green River SWIF is to develop a framework to address key issues on the Green River mainstem (with a focus on the Lower Green), including flood risk reduction facility and engineering deficiencies, levels of protection, capital project solutions, vegetation management, and habitat improvements. The SWIF will include an evaluation to determine if there are operating or structural improvements that could be considered to increase storage capacity of the dam to maintain target flows of 12,000 cfs at Auburn for larger flood events, above the current 140-year level. The resulting Technical Memorandum will summarize the key issues related to feasibility, discusses key aspects of future completion of either a General Re-evaluation Report or a General Investigation, costs and timeline, and makes a preliminary recommendation on a potential course of action associated with Howard Hanson Dam for the Flood Control District.

WHITE RIVER UPDATES

King County Flood Protection Facilities, Major Flooding, Flood Damage

Flood Protection Structures

The primary White River flood protection infrastructure maintained by King County is the set of levees and revetments lining the channelized portion of the river from River Mile 10 to the King and Pierce county line near River Mile 5. These flood protection structures were built through the 1914 Inter-County River Improvement Agreement. They lock the White River channel in place from the Auburn Wall to the confluence with the Puyallup River. This system provides some flood containment, although the level of containment varies due to openings or low points in the bank armoring and because channel conveyance capacity downstream of A Street has been decreased due to ongoing sedimentation (Prych 1988; Herrera 2010; Czuba et al. 2010). None of the White River levees are federally certified or enrolled in the U.S. Army Corps of Engineers Public Law 84-99 program.

There are no County flood structures from River Mile 10 through the Muckleshoot Indian Reservation and up to the State Route 410 bridge near Enumclaw. This portion of the White River functions naturally, without influence from floodplain modifications or land development. There are no County revetments or levees between State Route 410 and Mud Mountain Dam. The lower mile of the Greenwater River has two revetments on the right bank that provide bank erosion protection for a row of residential properties.

Privately owned structures such as the White River Hatchery and Cascade Water Alliance diversion dam are periodically affected by flood flows and sediments.

Flood History

In the 1990s and early 2000s, the combination of a channelized system along both riverbanks and the flood control operations at Mud Mountain Dam resulted in less frequent and less significant overbank flows than occurred historically along the lower reaches of the White River. Flood damage along lower reaches of the White River in this timeframe typically was in the form of bank erosion and undermining of existing bank armoring. However, present channel capacity in the river reach between A Street and 8th Street is such that flood flows overtop into uninhabited areas at about 3,600 cubic feet per second and into inhabited areas at flows of about 8,000 cubic feet per second. Two recent large flood events resulted in significant damage to developed areas, as described below.

November 2006 Flood Event

In November 2006, river flows overtopped low-level banks in the Pacific area, mainly entering riverside wetlands and Pacific City Park ball fields. Some roadways, such as 3rd Avenue in Pacific, also received shallow flooding and were temporarily closed. Damage from this flood event was not significant and consisted mainly of minor scour of near-bank areas, deposition of silts and sands in the park areas, and some localized flood debris that necessitated landscape-level clean-up.

Above Mud Mountain Dam, flooding and bank erosion in November 2006 resulted in the temporary closure of State Route 410 within Federation Forest State Park, south of Greenwater. The temporary closure cut off access to the community of Greenwater and other communities, as well as access to the Crystal Mountain Ski Resort located to the south in Pierce County.

January 2009 Flood Event

The flood of January 2009 had a controlled flow release from Mud Mountain Dam similar to that which occurred in November 2006; both events had a peak released flow of about 11,700 cubic feet per second. However, flood damage in 2009 along the Lower White River was significantly different.

In 2009, floodwaters overtopped the right bank by Pacific City Park in the late hours of January 8 and flowed southward through the White River Estates neighborhood, continuing into Pierce County along the floodplain areas of Butte Avenue. Over 100 homes in White River Estates neighborhood, several commercial businesses along Butte Avenue, and the Megan's Court Apartments near Pacific City Park experienced flooding of first floor living spaces, office areas, and building crawl spaces. Evacuations of residents occurred along Butte Avenue, south of White River Estates, and many efforts were made by citizens and City of Pacific staff to place sandbags in an attempt to protect residential structures.

On the morning of January 9, the U.S. Army Corps of Engineers ordered a reduced flow release from Mud Mountain Dam of 9,000 cubic feet per second. Given the large storm and the accumulated volume of stored floodwaters in the reservoir, the White River continued to experience high flows for several days as floodwaters were released from the dam. Attempts to pump crawl spaces were ineffective due to high groundwater and river conditions. Surface water was not draining in many locations because several stormwater outfalls did not have flap gates or back flow valves, exacerbating flooding.

As flows continued to recede, the U.S. Army Corps of Engineers responded to the City of Pacific's request to place a temporary dirt berm along the revetment edge of Pacific City Park to preclude overtopping in any subsequent flood event for the 2009 flood season. The berm was intended to prevent the overbank flow path that carried floodwaters toward the north side of the White River Estates neighborhood.

On the opposite riverbank, floodwaters overtopped into agricultural lands in the City of Sumner and overtopped 8th Street, also known as Stewart Avenue. This main arterial was closed during the night of January 9 and for most of the next day. As river flows decreased, private landowners also built dirt berms along the edge of the wetland where overtopping occurred on January 8-9.

Upriver areas and flood protection infrastructure within the City of Auburn were not damaged during the January 2009 event, although some concern was raised regarding scour and debris accumulation near the right bank abutment of the A Street bridge.

A small residential area along the White River almost a mile downstream from the confluence of the Greenwater River experienced severe overbank flows between homes and State Route 410, cutting off access. A significant amount of flood debris—wood and sediment—was carried across these properties, and the riverbank eroded closer to the homes. These flood-damaged private homes were repaired and remain close to the active channel, where they are exposed to flood and channel erosion hazards.

Streamflow Gages

Table 5-15 summarizes the most recent high flows on the White River, as recorded at the White River at Buckley gage.

TABLE 5-15.
HIGH FLOW RECORDS AT WHITE RIVER ABOVE BOISE CREEK AT BUCKLEY (USGS GAGE 12099200) AND WHITE RIVER ABOVE BOISE CREEK AT BUCKLEY (USGS GAGE 12099200)

Date of flood	Peak Flow (cfs)	Gage
January 2009	11,800 cfs	12099200
November , 2006	14,700 cfs	12099200
December 1995	13,900 cfs	12100000
January 1990	13,300 cfs	12100000
November 1986	14,900 cfs	12100000
December 1977	14,300 cfs	12100000

Ongoing channel aggradation has resulted in decreased channel conveyance capacity in some lower reaches of the White River, especially between A Street and 8th Street (Herrera 2010; Czuba et al. 2010). During the January 2009 flood event, it became apparent that aggradation was affecting the accuracy of the flow discharge readings at the gage at A Street, USGS gage 12100496, White River near Auburn. Consequently, the U.S. Geological Survey installed USGS gage 12100490, White River at R Street near Auburn, a location where the channel is not affected by ongoing sedimentation. USGS gage 12100496 still functions at A Street to provide stage-only readings.

With continued concerns about the effect of ongoing sedimentation on flow levels in this area, King County has requested that the U.S. Geological Survey install additional stage-only gages on the lower segment of the White River between the R Street and 8th Street bridges. Three new stage-only gages are being installed, and the existing A Street gage is being replaced, with stage sensors that use radar to read water levels. This will avoid the potential fouling of equipment by sediment or debris. Once calibrated to flow discharge readings at R Street, this coordinated set of stage gages will provide real-time information on fluctuations in stage levels as a more detailed method to monitor the potential effect of sediment levels on floodwater elevations.

Key Accomplishments Since the 2006 Flood Plan

Structural Projects and Acquisitions

In November 2006, the Stuck River Drive revetment was damaged over a length of 300 feet. In the summer of 2008, the revetment was repaired with large wood and rock placed along the toe of the bank. Biostabilization techniques were used to reconstruct the mid-bank. The repair is being monitored annually and was undamaged during the January 2009 flood event. The revetment protects Stuck River Drive, utilities and the City of Auburn paved trail.

In the fall of 2009, the U.S. Army Corps of Engineers provided materials to King County for installation to provide temporary flood protection in the City of Pacific, which experienced significant flooding in the January 2009 flood. King County crews installed over 4,000 lineal feet of temporary flood protection riverward of 3rd Avenue S.E., the Megan's Court Apartments, and the White River Estates neighborhood. A combination of HESCO barriers and large sand bags provide an increased level of flood protection for these flood-prone areas until a permanent flood risk reduction structure can be designed and constructed. To further reduce flood risks to White River Estates, the City of Pacific coordinated an effort to build a sandbag berm along the southern edge of the neighborhood to protect against low-velocity backwater flooding from the White River and Boeing Ditch. The U.S. Army Corps of Engineers and Pierce County Surface Water Division aided in the construction of the berm. Altogether, the temporary flood structures in the City of Pacific may also reduce flood risks to residences and industrial properties along Butte Avenue.

Also in 2009, King County was approached by and began discussions with property owners regarding acquisition of land for a setback levee in the City of Pacific. During 2010 and 2011, 11 homes in the White River Estates and nearly 7 acres of undeveloped agricultural land were acquired from willing sellers. Five homes, several out-buildings and landscape materials were relocated through an auction. The remaining six homes were demolished by a private contractor. The properties were converted to open space in the White River right bank floodplain. Grant funding from the Conservation Futures Trust and the King County Parks Levy contributed to the agricultural acquisition.

Since 2008, King County has been developing a project design for the County Line Levee Setback Project on the left bank of the White River from the 8th Street bridge to the A Street bridge. The project includes construction of over a mile of new setback levee and biorevetment, along with removal of existing channel-constricting flood structures. To date, accomplishments include design development, land acquisition and funding partnership agreements. Permit-ready designs, State Environmental Policy Act submittals and permit applications will be completed by the end of 2012. Three parcels have been acquired, and negotiations with five other landowners are continuing. Funding partners include significant support from the Natural Resource Damage Assessment partners, Pierce County Surface Water Management Division and the Salmon Recovery Funding Board. Final design and permit approvals are expected by the end of 2013, with a construction start date of May 2014.

Technical studies

Significant King County technical studies completed for the White River since 2006 include the following:

- The 2009 update of flood hazard mapping for the Pacific-Auburn area and the river segment from State Route 410 to Mud Mountain Dam (Northwest Hydraulic Consultants 2009)

- A sediment-trend analysis commissioned by King County to characterize existing sediment conditions and provide insight on future in-channel sediment conditions for the reach from the Muckleshoot Indian Tribe Reservation to the 8th Street bridge (Herrera 2010)
- Two White River sediment investigations in partnership with Pierce County and the U.S. Geological Survey:
  - A study that demonstrated decreased channel conveyance capacity and evaluated potential sediment management remedies such as gravel removal and levee setbacks (Czuba at al. 2010)
  - A study that assessed sediment inputs, transport and deposition in the river systems draining Mount Rainier (Czuba et al. 2012)
- A U.S. Geological Survey investigation now underway and supported by King County to examine the impact of flood management actions such as levee setbacks on the biological health of juvenile salmon (Black 2012 in progress).

These studies are valuable for understanding the White River system, particularly as design progresses to implement reach-length levee setback projects that seek to reduce flood risks while restoring the process, structure and function of the natural river system. The ability to complete these technical studies depends on the timely collection of topographic data, including the periodic resurvey of river cross sections and the collection of LiDAR data sets and aerial imagery. Topographic data in and adjacent to the White River channel are collected as part of King County's ongoing channel monitoring program, which resulted in compilation of channel data collected since the 1970s and ongoing collection of new data in the channel from River Mile 4.4 to River Mile 10.6. King County also coordinates with the City of Auburn in the city's resurvey of channel cross sections from A Street to R Street in most years since 1996; the Auburn data have been included in the County's ongoing channel monitoring program. King County has also conducted sampling and analysis of in-channel sediments.

The TransCanada Levee Setback Feasibility Study, completed in 2011, identified a preferred alternative for restoring process and function within a channelized lower section of the White River while preventing an increase in flood hazard from inundation or channel migration outside the study area. Channel constriction and adverse flow velocities currently limit salmonid habitat and natural riverine processes. The study was funded by the Washington State Salmon Recovery Funding Board and was coordinated with the Muckleshoot Indian Tribe, a project partner.

Flood Hazard Management Identified Risks

Flood hazards and flood risks vary from segment to segment in the White River flood hazard management corridor. Each segment has varying levels of risk conditions, reflective of its distinct physical hazards and the floodplain development and land uses that they impact. Resolving and lowering these risks requires different strategies, with incremental objectives implemented in the near-term and over several years.

8th Street to River Mile 10 Segment

Channel gradient decreases dramatically in this segment as the river flows down the White River alluvial fan, making it a natural depositional area. The channel is highly modified, constricted and disconnected from its floodplain, and ongoing sedimentation decreases the flood conveyance capacity. This is most apparent in the reach between the 8th Street and A Street bridges, where concrete revetments, a short length of levee, and bridges at both ends constrict the channel. Here, gravel bars have lengthened and increased in overall volume of material, and local scour resulting from the shifting channel has undermined some of the revetment.

Houses along 3rd Place South in a residential subdivision at the top of this reach are near the top of the revetment. Over time, the freeboard has decreased, placing these residences at high risk of flooding. Loss of channel conveyance presents a growing potential for overbank flooding to these right-bank riverside homes and for further damage to the aging and degraded concrete revetment along the right bank. The temporary flood structure installed by King County in 2009 reduces but does not eliminate the risk of overbank flooding reaching homes further south, including the White River Estates community.

Loss of channel conveyance also has resulted in river flows overtopping the left bank into a large wetland area. Private landowners have constructed dirt berms along the edge of the wetland to prohibit overbank flows from entering their agricultural and commercial properties, but modeling indicates an increased likelihood of major flooding in these areas and inundation of 8th Street, as occurred in January 2009.

Revetments and fill in the floodplain and channel between the A Street and R Street bridges also reduce flood conveyance capacity. With the valley wall protruding from the south side along Oravetz Drive just downstream of the R Street bridge, flood flows impinge into the north bank, where Mt. Baker Middle School is located. As flows turn from this meander bend, they are directed downstream into the unprotected left bank, eroding the bank and threatening trails in Roegner Park. These erosive flows could also affect the Auburn Riverside High School property, which is partly on fill that was placed in an historically highly mobile part of the active channel and floodplain. Opportunities to reconnect the river with its floodplain are more limited in this reach, and warrant further investigation.

Upstream from the Game Farm Wilderness Park on the Muckleshoot Indian Tribe Reservation, the channel is actively migrating and floodwaters have breached through the TransCanada levee, which extends from the Wilderness Park levee at River Mile 8 to the Williams natural gas pipeline crossing at River Mile 10.5. Flooding in the 1990s included overbank flows entering the floodplain from several breached locations and traveling across public and private land parcels before combining into a single, large floodplain channel that reentered the river by breaching through the back side of the Wilderness Park levee. A trail embankment with small culverts was installed by the City of Auburn after 1996 to receive these flood flows and prevent future damage to the trail crossing within the park. However, based upon the sediment trends analysis (Herrera 2010) and ongoing channel monitoring data, the main channel elevation of this river reach has degraded, generally since the 1970s and locally since the 1990s. The recent flood study (Northwest Hydraulic Consultants 2009) indicates that overbank flows would not occur during the 100-year event, which is consistent with channel degradation and increased conveyance capacity in this reach. Although overbank flooding is less likely, lateral channel migration is expected to continue where a meander bend is eroding into the left bank floodplain due to high velocities and direct impingement of flows on the already breached levee site at River Mile 9.5. The only structure that is at risk from channel migration for the foreseeable future is the breached TransCanada levee itself.

River Mile 10 to State Route 410

The segment from River Mile 10 to the State Route 410 bridge at about River Mile 22 is a natural and dynamic portion of the White River through the White River Canyon. Typified by little floodplain development or channel modification, there are no known significant flood risks. Channel migration recruits wood and sediment, which is delivered downstream to more constricted reaches.

State Route 410 to Mud Mountain Dam Segment

The segment from the State Route 410 bridge to Mud Mountain Dam at River Mile 29.7 has limited land development. However, a small residential community at River Mile 26.5 along Red Creek, just downstream of Mud Mountain Dam, is at high risk because of the potential for rapid channel changes, which could threaten residents as well as any rescuers who may respond in an emergency evacuation. No specific structural damage was reported in this community from the 2006 or 2009 flood events, although bank erosion was evident.

Mud Mountain Dam to Greenwater River Segment

The uppermost White River segment within King County's hazard management corridor, from Mud Mountain Dam to the confluence of the Greenwater River at River Mile 45.8, is unregulated and can experience significant, uncontrolled floods. The channel here is encroached upon by State Route 410.

Residential properties on the right bank between Federation Forest State Park at River Mile 45 and at the confluence with the Greenwater River experience periodic flooding and are at risk of channel migration hazards. A residential property on the right bank at the confluence of the White and Greenwater rivers experienced significant flooding in the 1995 and 1996 events due to rapid channel movement and overbank inundation. This area, along with State Route 410, could also be flooded by water forced out of the Greenwater River channel as a result of the accumulation of logs and debris on the center pier of the State Route 410 bridge.

Greenwater River Segment

A residential community within the first river mile of the Greenwater River includes numerous summer cabins and many year-round residences near the riverbank. Inundation of overbank areas has impacted the homes in this area.

CHAPTER 6.
PLAN IMPLEMENTATION

Chapter 6 of the 2006 Flood Plan describes Plan implementation considerations and provides recommendations associated with King County's implementation role, partnership and coordination opportunities, and adaptive management strategies. Only very minor updates were made to Chapter 6, as described below.

IMPLEMENTATION OF THE 2006 FLOOD PLAN

Under the guidance of King County Flood Control District leadership and in partnership with King County jurisdictions, King County's Water and Land Resources Division provided the staff resources and the technical expertise to implement the recommendations in the 2006 Flood Plan. In the time since the adoption of the 2006 Flood Plan, several of the high-priority project and program actions outlined in the 6-Year Action Plan have been implemented. In addition, many other projects and programs were implemented that were not identified in the 2006 Flood Plan but emerged from newly identified risks or emergencies. Plan implementation has thus far generated significant public benefit, including the reduction of flood and channel migration risks, the protection of roads and other critical infrastructure that support regional safety and economic viability, the enhancement of salmon habitat, and open space protection within floodplains.

CLIMATE CHANGE AND MAJOR RIVER FLOODING

Current climate change models predict a range of possible future timing, frequency, and volume of precipitation in Western Washington along with increased temperatures. There is currently a deep level of uncertainty about which outcomes are most probable, but there is some likelihood that precipitation will increase, that more precipitation will fall as rain instead of snow, and that the magnitude, duration, and frequency of extreme precipitation events will grow. As a result, fall and winter flood events along King County's major rivers may be more frequent and last longer. Climate change is also expected to affect atmospheric rivers—narrow corridors in the atmosphere responsible for most of the horizontal transport of water vapor outside the tropics that can produce extreme amounts of rainfall in the Pacific Northwest. More frequent flooding events and more erosive flows may test the protective capacity of King County's aging system of 500 levees and revetments. The potential for increased magnitude and frequency of fall and winter flood events in King County and the deep uncertainty about which effects the County will actually experience add urgency to the work already identified in the 2013 Flood Plan Update. The implications of climate change for flooding in King County require immediate near- and long-term strategies to increase the resilience of both natural systems and flood facilities to function under a range of outcomes.

King County is analyzing climate change models and trends to determine possible effects on King County's weather and flooding patterns. Recent work (King County 2010a) found a general trend toward higher discharges and precipitation in November and lower discharge and precipitation during summer, consistent with University of Washington modeling on how climate change may affect Pacific Northwest rivers. New coastal flood standards for King County adopted in 2011 took into account expected sea level rise from climate change to provide increased resilience to future flooding. These standards comport with an estimated sea level rise of 2 feet (based on a January 2008 report from the University of Washington Climate Impacts Group; Mote et al. 2008).

While the scientific understanding of and ability to model climate change outcomes specific to flooding is uncertain, it is still worthwhile; King County will continue to study the relationships between climate change and flooding and will monitor emerging climate change findings and models. The 2013 Flood

Plan Update proposes proactive public safety actions consistent with the University of Washington Climate Impact Group's recommendations to minimize the potential effects of a warming climate on major river flooding in King County (Snover et al. 2007). The 2013 Flood Plan Update also includes actions and planning strategies, such as setting back levees and using a regional river corridor approach, that increase the resilience of natural systems under a range of uncertain climate change outcomes.

CHAPTER 7.
FUNDING

This chapter is a substitute for and replaces Chapter 7 of the 2006 Flood Plan and describes funding sources and accomplishments, partnerships, tax levy suppression and levy increase limitations, projected expenditures and revenue, and options to address projected gaps between expenditures and revenues.

King County faces significant challenges to deal with a deteriorating flood protection infrastructure, most which was built over five decades ago. Many flood protection structures are currently damaged, are not regularly or adequately maintained because of funding limitations, and are subject to major damage or failure during a major flood event. Failure of these structures could have dramatic and adverse impacts on people's lives and property. The economic viability of the region could also be dramatically affected. Adverse impacts from floods also extend to roads, bridges and other public and private infrastructure and include significant impacts on important natural and environmental resources. Maintaining and reconstructing King County's flood risk reduction infrastructure to present-day standards is vitally important for public safety and for the economic well-being of King County. A strategic financial investment plan is essential to the future implementation of capital improvements, maintenance and repair of existing flood protection infrastructure, acquisition, relocation and elevation of at-risk structures, and flood hazard mapping studies. In addition, flood hazard warning and education are essential to protecting significant public and private investments throughout King County.

With the formation of the King County Flood Control District and establishment of a countywide levy to fund the District's activities, King County is better able to provide regional, comprehensive flood hazard management services that help protect public safety in the event of a flood disaster. District resources are enhanced with grant funds from local, state and federal agencies, as well as a small contribution from the Inter-County River Improvement Fund. Table 7-1 provides an accounting of revenues and expenditures for flood programs in King County for 2006 through 2011.

LOCAL FUNDING DEDICATED TO FLOOD RISK REDUCTION

King County Flood Control District

One of the most significant recommendations implemented from the 2006 Flood Plan was the creation of the King County Flood Control District in 2007 and the establishment of a levy to fund the District's activities in 2008. The King County Flood Control District is the main dedicated source of funding for the programs and projects in the 2013 Flood Plan Update. Since the first revenue collection under the Flood District levy, annual revenue collected has increased from to $33.2 million in 2008 to $36.5 million projected for 2012, an average annual increase of 0.8 percent. The Flood District levy rate was 10 cents per $1,000 assessed value when the District was established and has increased to 11.6 cents per $1,000 assessed value in 2012. As the total revenue has increased by 0.8 percent per year, the main reason the tax rate has increased is the decline in assessed values across King County during this timeframe.

River Improvement Fund

Prior to the establishment of the King County Flood Control District, the main source of local funding for flood risk reduction was the River Improvement Fund. Authorized under Chapter 86.12 RCW, the River Improvement Fund was a countywide property tax levy, including properties in incorporated cities, assessed at an equal levy rate and based on a property's total taxable assessed valuation. The River Improvement Fund of about $3 million per year was discontinued in 2008. Some revenue was collected from delinquent taxes after 2008, and the fund was closed in 2011.

**TABLE 7-1.
FLOOD PROGRAM HISTORICAL COSTS AND REVENUES**

	2006	2007	2008	2009	2010	2011
Revenue						
King County Flood District Levy	—	—	$33,239,735	$34,748,473	$35,555,142	$35,962,280
Green River Flood Control Zone District Levy[a]	$977,276	$2,171,229	$209,483	$18,598	$0	—
River Improvement Fund Levy[b]	$2,649,581	$2,733,974	$566,636	$44,900	$461	$1,000
Interest Earnings	$93,138	$81,798	$531,088	$469,154	$303,461	$258,965
Inter-County River Improvement	$51,257	$50,225	$67,000	$60,943	$46,108	$45,359
Grants	$967,381	$765,759	$1,862,116	$1,754,006	$3,515,863	$2,514,314
City Reimbursements[c]					$667,650	
Miscellaneous Revenue	$150,586	$301,203	$304,023	$235,304	$399,096	$193,257
Total Revenue	**$4,889,218**	**$6,104,189**	**$36,780,082**	**$37,331,379**	**$40,487,780**	**$38,975,176**
Expenditure						
King County Flood District Administration	—	—	($213,732)	($743,552)	($417,847)	($645,160)
Levy Suppression Payments[d]	—	—	—	—	—	($3,090,823)
Flood Operating	($3,907,053)	($5,637,392)	($4,517,110)	($5,399,826)	($5,914,061)	($5,969,528)
Flood Capital	($1,669,593)	($1,300,402)	($13,084,183)	($19,034,655)	($26,523,921)	($19,580,206)
Total Expenditure	**($5,576,646)**	**($6,937,795)**	**($17,815,025)**	**($25,178,034)**	**($32,855,828)**	**($29,285,716)**

a. The Green River Flood Control Zone District and levy were subsumed by the creation of the King County Flood Control District.
b. In 2008 the contribution from the River Improvement Fund was removed from the flood program, leaving only receipts of delinquent collections.
c. The 2010 city reimbursements were payments from the City of Auburn for King County's flood preparation work on the Porter Bridge and Valentine levees.
d. Payments made to senior taxing districts to voluntarily restrict their tax levy in order to avoid suppression of the entire Flood District levy.

Inter-County River Improvement Fund

Under Washington State law, whenever a river forms the boundary or part of the boundary between two counties or where the river waters alternate between counties with potential for flood damage in both counties, the counties may enter into an interlocal agreement to cooperatively develop and fund flood control improvements and maintenance (Chapter 86.13 RCW). King and Pierce counties created the Inter-County River Improvement Fund under this law in 1914 for the purpose of jointly funding maintenance and repair of flood protection infrastructure along the White and Puyallup Rivers. The Inter-County River Improvement Fund is a countywide property tax levy within King County assessed at an equal levy rate and based on a property's total taxable assessed valuation. From 1991 through 2011, the Inter-County River Improvement Fund tax levy has remained constant, collecting approximately $50,000 per year. The agreement establishing the Inter-County River Improvement Fund expires in 2020.

Like the River Improvement Fund, the Inter-County River Improvement levy is a component of King County's general levy and subject to statutory levy limits. Any levy increases beyond 1 percent in the Inter-County River Improvement levy must be offset by equivalent reductions in funding for other services funded by King County's general levy unless a majority vote of King County voters approves an increase that exceeds statutory levy limits.

GRANT AND PARTNERSHIP FUNDING

The significant increase in local funding provided by the King County Flood Control District property tax helps to leverage external fund sources. Prior to the formation of the District, external grant funds were approximately $1.5 million to $3.5 million per year. This money was largely provided by FEMA disaster mitigation grants and public assistance, with cost-share percentages ranging from 75 to 97.5 percent, depending on the grant program.

For 2006-2012 over $11.37 million in grant funding was awarded from FEMA, the Washington Department of Ecology Flood Control Assistance Account, and the Washington Salmon Recovery Funding Board. Another $25 million was provided in 2008-2009 by the U.S. Army Corps of Engineers for cost-shared flood damage repair projects. When costs such as rights-of-way, permits and mitigation are factored in, the cost share for this program ranges from 35 to 75 percent federal funding. An additional $23.5 million in external revenue for flood risk reduction projects is currently committed from state and federal agencies. Table 7-2 summarizes grant revenue received or secured from 2008 through 2011.

TABLE 7-2.
GRANT REVENUES RECEIVED IN PURSUIT OF THE KING COUNTY FLOOD DISTRICT WORK PROGRAM

Type	2008	2009	2010	2011	**2012**	**Total**
Conservation Futures Tax Levy			$150,000			**$150,000**
Washington State Department of Ecology					$1,030,000	**$1,030,000**
Federal Salmon Recovery Grants	$1,738,833	$171,719	$7,843	$373,393	($128,631)	**$2,163,158**
Federal Emergency Management Agency	$123,283	$736,576	$2,904,341	$1,811,824	$1,044,109	**$6,620,133**
King Conservation District	$0	$400,000				**$400,000**
Puget Sound Acquisition & Restoration	$0	$432,150	$341,678	($216,358)	$456,772	**$1,014,242**
Total	**$1,862,116**	**$1,740,445**	**$3,403,863**	**$1,968,860**	**$2,402,250**	**$11,377,533**

NOTE: This table includes revenue received by the King County on behalf of the King County Flood Control District. It does not include approximately $25 million in U.S. Army Corps of Engineers levee repair cost-share funding during 2008-9.

HISTORICAL PROJECT AND PROGRAM EXPENDITURES

King County has made significant progress on the implementation of flood risk reduction projects since release of the 2006 Flood Plan. Capital projects and technical studies totaling over $104 million have been completed. A total of $42 million was leveraged through grant partnerships between 2008 and 2011. $25 million of this amount was provided as a cost-share by the U.S. Army Corps of Engineers for levee repairs in 2008-9. Operating expenditures for the ongoing floodplain management activities described in Chapter 5 have ranged from $5 million to $7 million since the District was established in 2008. Capital expenditures to date in each basin are shown in Table 7-3. Basin-specific accomplishments are described in Chapter 5.

TABLE 7-3.
CAPITAL EXPENDITURES BY BASIN AND PROJECT PHASE 2006-2012

	Snoqualmie	Cedar	Green	White	Countywide Misc.	Seattle	Sub-Regional Opportunity Fund	**Total**
Acquisition	$18,662,000	$12,714,000	$12,315,000	$4,856,000	—	—	—	**$48,547,000**
Levee Construction/ Repair	$2,301,000	$3,572,000	$7,082,000	$484,000	—	—	—	**$13,439,000**
Design	$3,446,000	$3,121,000	$3,877,000	$2,758,000	—	—	—	**$13,202,000**
Elevation	$2,735,000	—	—	—	—	—	—	**$2,735,000**
Emergency Repair/Prep	$24,000	$120,000	$6,489,000	$358,000	—	—	—	**$6,991,000**
Feasibility	$416,000	—	$780,000	—	—	—	—	**$1,196,000**
Farm/Flood Task Force	$283,000	—	—	—	—	—	—	**$283,000**
Environmental Mitigation			$35,000		—	—	—	**$35,000**
Capital Monitoring/ Maintenance	—	—	—	—	$539,000	—	—	**$539,000**
Payments to Other Jurisdictions	—	—	—	—	$33,000	$7,264,000	$9,549,000	**$16,846,000**
Miscellaneous	—	—	—	—	$715,000	—	—	**$715,000**
Total	**$27,867,000**	**$19,527,000**	**$30,578,000**	**$8,456,000**	**$1,287,000**	**$7,264,000**	**$9,549,000**	**$104,528,000**

Projected Financial Plan

Existing dedicated sources for funding the Action Plan are the King County Flood Control District, the Inter-County River Improvement Fund, and external grants. Table 7-5, inserted at the end of this chapter, shows the projected financial plan, drawing upon these funding sources. This projected financial plan assumes continued annual adoption of the Flood District levy, including new construction and annual increases of 1 percent as allowed under Initiative 747. The exemption from property tax suppression expires in 2018; it is assumed that suppression will not occur. Grant revenues are based on known and contracted grant sources for 2013-2015 and an estimate of $1 million per year in subsequent years.

Designated Emergency Fund

When the District was initiated, the required available fund balance for emergency and insurance purposes was $2.5 million. That amount later increased to $3.5 million. In 2012 it increased again, to $7.5 million, based on guidance from King County's Office of Risk Management.

LOCAL, STATE AND FEDERAL PARTNERSHIPS

This section updates local, state and federal programs that provide funding opportunities for flood risk reduction activities. Examples of activities funded through these programs since 2006 are included in the accomplishments section of Chapter 5 for each basin.

King County Mitigation Reserves Program

The King County Mitigation Reserves Program is a King County-sponsored program through which those whose projects create unavoidable impacts on aquatic resources can pay a mitigation fee in lieu of completing their own mitigation. King County then uses fees to implement mitigation projects. The program complies with federal rules for compensatory mitigation issued in April 2008 by the U.S. Army Corps of Engineers and U.S. Environmental Protection Agency (Title 33 Code of Federal Regulations Part 332 and Title 40 Code of Federal Regulations Part 230) defining an in-lieu fee program as follows:

> "a program involving the restoration, establishment, enhancement, and/or preservation of aquatic resources through funds paid to a governmental or non-profit natural resources management entity to satisfy compensatory mitigation requirements... Similar to a mitigation bank, an in-lieu fee program sells compensatory mitigation credits to permittees whose obligation to provide compensatory mitigation is then transferred to the in-lieu program sponsor."

It is possible that fees paid through the Mitigation Reserves Program could fund implementation of the Action Plan. As of 2012, Mitigation Reserves Program funding is being considered for the Elliott Bridge project on the Cedar River as mitigation for the State Route 520 expansion. There are several considerations related to using mitigation fee payments to implement projects:

- Certain funding sources for acquisitions or project implementation do not allow use of supplemental mitigation funding.
- Any mitigation project must be clearly defined as such and must be discrete from project elements implemented with other funding sources.
- Mitigation projects may have special requirements for performance standards, monitoring and maintenance, and adaptive management plans.
- Land where mitigation projects occur must be permanently protected by conservation easements or similarly protective restrictive covenants.
- Mitigation payments result from impacts on aquatic resources; these impacts should be recognized when analyzing cumulative impacts and restoration in a watershed context.

A more detailed description of the King County Mitigation Reserves Program and program documents can be found at: http://www.kingcounty.gov/environment/waterandland/wetlands/mitigation-credit-program.aspx

CONCLUSION

With the creation of the King County Flood Control District and establishment of a countywide levy to fund District activities, King County and the King County Flood Control District are better able to provide regional, comprehensive flood hazard management services that help reduce public safety risks from flooding and channel migration. However, additional needs have emerged. New regional floodplain management costs have been added to the District's work program since its creation in 2007. These include flood damage repair costs, the creation of the Sub-Regional Opportunity Fund, cost-share funding for the Elliott Bay Seawall, installation and removal of 26 miles of sandbags along the Green River, and funding for watershed management grant programs, among others.

TABLE 7-4.
2013-2018 FLOOD DISTRICT FINANCIAL PLAN

King County Flood District Financial Plan: 2013 Proposed Revised Budget

26-Jun-13

	2012 Actual	2013 Adopted	2013 Revised	2014 Proposed	2015 Projected	2016 Projected	2017 Projected	2018 Projected
Beginning Balance	49,504,669	55,044,160	54,572,203	54,683,996	34,821,274	18,032,658	11,566,918	13,834,010
Revenue								
Flood District								
Flood District Levy [1]	38,772,548	41,346,031	40,932,571	41,605,202	42,326,656	43,088,894	43,869,375	44,668,924
Interest Earnings [2]	506,466	274,736	521,660	537,310	553,429	570,032	587,133	604,747
Miscellaneous Revenue [3]	394,193							
King County								
Delinquent River Improvement Fund Levy								
Inter-County River Improvement [4]	48,600	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Grants	2,424,866	1,736,261	13,053,211	2,000,000	2,775,000	1,000,000	1,000,000	1,000,000
Total Revenue	40,146,673	43,407,028	54,557,442	44,192,511	45,705,085	44,708,925	45,506,508	46,323,671
Expenditure								
District Administration [5]	(635,830)	(592,190)	(592,190)	(579,056)	(596,427)	(614,320)	(632,750)	(651,732)
Tax Refund	(95,374)							
Operating Expenditure	(7,082,968)	(9,913,606)	(9,913,606)	(9,527,523)	(9,130,606)	(9,404,524)	(9,686,660)	(9,977,260)
Capital								
New Capital Appropriation		*(38,248,015)*	*(38,248,015)*	*(66,181,635)*	*(39,596,089)*	*(29,544,976)*	*(18,698,735)*	*(16,721,403)*
Carryover		*(51,413,214)*	*(59,398,102)*	*(53,704,265)*	*(65,937,245)*	*(52,766,667)*	*(41,155,822)*	*(26,934,550)*
Target Expenditure Rate		*45%*	*45%*	*45%*	*50%*	*50%*	*55%*	*60%*
Capital Expenditure	(27,264,966)	(40,347,553)	(43,939,853)	(53,948,655)	(52,766,667)	(41,155,822)	(32,920,006)	(26,193,572)
Total Expenditure	(35,079,139)	(50,853,349)	(54,445,649)	(64,055,234)	(62,493,700)	(51,174,666)	(43,239,416)	(36,822,564)
Ending Balance	54,572,203	47,597,840	54,683,996	34,821,274	18,032,658	11,566,918	13,834,010	23,335,117
Target Fund Balance	*7,500,000*	*7,500,000*	*7,500,000*	*7,500,000*	*7,500,000*	*7,500,000*	*7,500,000*	*7,500,000*
Carryover Reserves	*(59,396,102)*	*(49,313,676)*	*(53,704,265)*	*(65,937,245)*	*(52,766,667)*	*(41,155,822)*	*(26,934,550)*	*(17,462,381)*
Ending Undesignated Fund Balance	*(4,823,899)*	*(1,715,836)*	*979,732*	*(31,115,971)*	*(34,734,009)*	*(29,588,904)*	*(13,100,540)*	*5,872,735*

Notes:

1 Property tax forecast provided by the Office of Economic and Financial Analysis on 3/13/13

2 Interest earnings based on average daily cash balances considering the timing of flood levy receipts and transfers to the operating and capital funds.

3 Miscellaneous revenue due to multiple sources such as state forest sales, private timber harvest tax, rent from tenants of acquired real estate, and immaterial corrections from prior years

4 The ICRIF amount is based on the 1914 Inter-County Agreement for improvements to the White River

5 Costs based on contract established under FCD 2008-07 for District executive services, and inflated at 3% in succeeding years

6 The "Levy Suppression Payment" is the amount paid to senior taxing districts in 2011 to allow the Flood District to continue collecting levy revenue

7 The capital expenditure is equal to the expenditure rate times the sum of the new capital appropriation and carryover

REFERENCES

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GLOSSARY OF TERMS

The 2013 Glossary of Terms is an addendum to the 2006 Flood Plan glossary consisting of either new concepts, or terms that have been updated since the 2006 Flood Plan was adopted (refer to the 2006 Flood Plan for a more complete glossary).

Advisory Committee. A committee consisting of representatives of cities that have historically experienced significant flooding, representatives of the Suburban Cities Association, representatives of areas that are major revenue contributors, and a member from an Unincorporated Area Council. The Advisory Committee makes recommendations to the King County Flood Control District Board of Supervisors (see Board of Supervisors) on flood control project planning and funding allocation.

Appurtenances. Machinery, appliances, or auxiliary structures attached to a main structure for the purpose of enabling the main structure to function, but not considered an integral part of the main structure.

Base Flood Elevation. The computed elevation to which floodwater is anticipated to rise during the base flood; the elevation that is the basis of the insurance and floodplain management requirements of the National Flood Insurance Program. Base flood elevations are shown on Flood Insurance Rate Maps and on flood profiles.

Basin Technical Committee. Committees consisting of city staff from jurisdictions in each of the following major river basins: Snoqualmie/South Fork Skykomish Rivers; Cedar/Sammamish Rivers; Green/Duwamish River; and White River. Basin technical committees provide information to King County Water and Land Resources Division to assist in the development of the annual capital program and provide annual recommendations to the Advisory Committee (see Advisory Committee). They ensure that basin-scale issues and technical information are factored into the King County Flood Control District's decision-making processes.

Board of Supervisors. A board consisting of all members of the Metropolitan King County Council and responsible for developing the King County Flood Control District's plan for funding maintenance and repairs of flood protection infrastructure.

Community Rating System. A program developed by the FEMA Mitigation Division to provide incentives for those communities in the National Flood Insurance Program that have gone beyond the minimum floodplain management requirements to develop extra measures to provide protection from flooding. Also known as CRS.

Corridor. The area of a river and surrounding lands that is essential to the storage and conveyance of floodwaters and is integral to natural riverine processes. A river corridor is a larger geographic area that includes one or more river segments (see River Segment), which are made up of one or more river reaches (see River Reach).

Cultural Resources. A range of sites, structures, buildings, landscapes, districts and objects that are significant in history, prehistory, architecture, archaeology, engineering or culture. Cultural resources include traditional cultural properties, which are places that are significant for historic and ongoing cultural purposes to Indian tribes and other groups, and both prehistoric and historic archaeological resources. Prehistoric archaeological resources date to the period prior to written historical records (pre-1850, before Euro-American contact). Historic archaeological resources in King County are generally considered to date from 1850, when Euro-Americans arrived, through 50 years before the present date. Also called historic resources and historic properties.

Executive Committee. Four members of the King County Flood Control District Board of Supervisors (see Board of Supervisors) elected by the Board to develop policy recommendations for consideration by the full Board and to oversee day-to-day business of the Flood Control District.

Flood Protection Elevation. An elevation 3 feet above the base flood elevation.

Freeboard. A factor of safety usually expressed in feet above a flood level for purposes of floodplain management.

Lahar. A rapidly flowing mixture of rock debris and water, sometimes referred to as a mudflow, which originates on the slopes of a volcano and typically flows along a river valley.

Large Wood. Large pieces of wood including logs, pieces of logs, root wads of trees, and other large chunks of wood that are in or partially in the channel or floodplain of rivers and streams. The term does not include rooted, standing vegetation. Large wood can stabilize streambeds and riverbanks, provide cover and refuge for fish, and create complex in-stream habitat by forming pools, regulating sediments, and dispersing stream energy.

Moderate Channel Migration Hazard Area. A portion of the channel migration zone, as shown on King County's Channel Migration Zone maps that lies between the severe channel migration hazard area and the outer boundary of the channel migration zone.

River Reach. A length of river through which similar physical or geomorphic conditions persist.

River Segment. An area of river and adjacent land within which the presence, type and extent of flood hazards are similar. A river segment is made up of one or more river reaches (see River Reach).

River and Floodplain Management Section. A section within King County's Water and Land Resources Division, Department of Natural Resources and Parks, and funded by the King County Flood Control District and Inter-County River Improvement Fund, to conduct the following activities:

- Structural capital improvement projects
- Relocation and elevation projects
- Maintenance and monitoring
- River planning
- Flood hazard education
- Flood warning and emergency response
- Complaint response and enforcement
- Interlocal coordination.

Severe Channel Migration Hazard Area. A portion of the channel migration zone, as shown on King County's Channel Migration Zone maps, that includes the present channel. The total width of the severe channel migration hazard area equals one hundred years times the average annual channel migration rate, plus the present width. The average annual channel migration as determined in the technical report, is the basis for each Channel Migration Zone map.

Sediment. Mineral and rock materials that are eroded, transported and deposited by rivers, in sizes that range from clay and silt through sand and gravel to cobble and boulders. Sediment may also include waterlogged organic debris.

Sedimentation. The deposition of sediment.

Setback Levee. A levee that is set away from a river in a manner to allow the river channel to migrate, increasing the connection between the river and floodplain to accommodate a floodplain that can store and convey flood flows.

Solid waste. All materials discarded, including garbage, recyclables and organics.

Special waste. Wastes that require special handling and waste clearance before disposal because of legal, environmental, public health or operational concerns, such as industrial wastes, asbestos-containing materials, contaminated soil, treated biomedical wastes, treatment plant grit and vacuum truck wastes, and other miscellaneous materials.

Special Flood Hazard Area. The 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 National Flood Insurance Program, and owners of structures in a Special Flood Hazard Area are required to purchase flood insurance for those structures.

Sub-Regional Opportunity Fund. A fund consisting of 10 percent of the King County Flood Control District's annual levy proceeds that is made available to jurisdictions throughout the District on a proportional basis, based on assessed valuation. Eligible activities include flood control and stormwater improvements, as well as watershed management activities such as habitat conservation.

APPENDIX A.
NATIONAL FLOOD INSURANCE PROGRAM COMMUNITY RATING SYSTEM ACTIVITY 510 CROSSWALK

This Appendix is a substitute for and replaces Appendix A of the 2006 Flood Plan.

OVERVIEW

King County has established progressive, proactive standards in floodplain management that have been used as models nationwide. These standards were developed using a planning foundation, beginning with the 1993 Flood Hazard Reduction Plan and further expanded upon in the King County Flood Hazard Management Plan and this current update. The *2013 King County Flood Hazard Management Plan Update*, in conjunction with the *2006 King County Flood Hazard Management Plan,* will aid King County in maintaining its Community Rating System (CRS) benefits by meeting program prerequisites and ensuring that credited programs remain in place at existing or enhanced levels.

This appendix provides a crosswalk to the CRS planning requirements and locations in the 2006 Flood Plan and 2013 Flood Plan Update that demonstrate compliance with them. King County's CRS classification is dependent upon the King County Flood Hazard Management Plan meeting prescriptive requirements as identified in the 2013 *Community Rating System Coordinator's Manual.* This crosswalk also will be beneficial in demonstrating compliance for other programs, such as Disaster Mitigation Act planning requirements and the Flood Mitigation Assistance Grant Program planning requirements. The CRS 10-step planning process was the foundation for both of these programs. Plans created using the CRS process tend to meet or exceed these programs' planning requirements.

The CRS includes requirements for elements to be included as content in a flood plan as well as requirements for the process to be used in developing the plan. Elements that are required to be included as content in the plan document are identified in the crosswalk table presented in this appendix. Process-related elements for developing the plan are described in a narrative following the crosswalk table.

CROSSWALK FOR FLOOD HAZARD MANAGEMENT PLAN

Table A-1 is a crosswalk demonstrating the King County Flood Hazard Management Plan's compliance with Community Rating System Activity 510 Floodplain Management Planning credit requirements, as identified in the 2013 *CRS Coordinator's Manual*. This crosswalk describes each of 10 CRS planning steps, indicates where in the 2013 Flood Plan Update and 2006 Flood Plan each element is addressed, and identifies the available and requested credit points for each step. Crosswalk users should have access to both the 2006 Flood Plan and the 2013 Flood Plan Update for reference.

This crosswalk was prepared to meet the CRS documentation requirements specified in the 2013 *CRS Coordinator's Manual*. Final verification of all credits will be based on the FEMA technical review process and CRS verification procedures.

A community must receive some verified credit under each of the 10 planning steps for the overall plan to be creditable. Elements indicated as "(Required)" in the crosswalk table are mandatory elements to receiving credit for the associated planning step. If any required element is not met, no credit can be verified for that planning step, and the plan would be considered non-compliant.

TABLE A-1.
COMMUNITY RATING SYSTEM CROSSWALK FOR KING COUNTY FLOOD HAZARD MANAGEMENT PLAN

Element	Description of Credit Criteria	Location in the Plan	Credit Points Available	Credit Points Requested
512.a.1 Step 1—Organize to Prepare the Plan (*Maximum credit: 15 points*). The credit for this step is the total of the following points, which are based on how the community organizes to prepare its floodplain management plan.				
512.a.1.(a)	If the office responsible for the community's land use and comprehensive planning is actively involved in the floodplain management planning process.	N/A	4	—
512.a.1.(b)	If the planning process is conducted through a committee composed of staff from those community departments that implement or have expertise on the activities that will be reviewed in Step 7.	Appendix A narrative	9	9
512.a.1.(c)	If the planning process and/or the committee are formally created or recognized by action of the community's governing body.	Chapter 1, page 4, 3rd paragraph. Appendix A narrative	2	2
	The plan document must discuss how it was prepared, who was involved in the planning process, and how the public was involved during the planning process. (***Required***)			
512.a.2 Step 2—Involve the public (*Maximum credit: 120 points*).				
512.a.2.(a)	If the planning process is conducted through a planning committee that includes members of the public and meets the following criteria:	Chapter 1, page 4, lines 196-217.	60	60
	(1) If the committee includes community staff (e.g., the planning committee credited under Step 1(b)), then at least one-half of the members must be representatives of the public or stakeholders for full credit. The credit is prorated for lower levels of public or stakeholder representation. Note that 50 percent of the maximum credit for this planning step is a prerequisite for Class 4 or better communities and item (a) is one half of the credit for Step 2.	Acknowledgements. Appendix A Narrative	—	
	(2) It must meet a sufficient number of times to involve the members in the key steps of the planning process, i.e., it must meet the same meeting criteria specified in Step 1(b).	Chapter 1, page 4, lines 208-209. Advisory committee meetings held between 12/2011 and 8/2012. Appendix A narrative	—	
	(3) All meetings must be open to the public and the meeting schedule must be publicly posted (e.g., on a website).	Chapter 1, page 4, line 209. Appendix A narrative	—	
	(4) If the community wants credit for participating in a multi-jurisdictional floodplain management or hazard mitigation planning committee, it must meet the criteria specified in Step 1(b).	N/A	—	

TABLE A-1.
COMMUNITY RATING SYSTEM CROSSWALK FOR KING COUNTY FLOOD HAZARD MANAGEMENT PLAN

Element	Description of Credit Criteria	Location in the Plan	Credit Points Available	Credit Points Requested
	(5) The formalities of organizing and naming the committee are not as important as the membership and the ability for all members to participate. For example, a community may augment an existing committee with an advisory body of stakeholders. Such an arrangement would be credited, provided the stakeholders were treated as full committee members during the meetings, i.e., they can speak up, vote, and receive all the materials that regular members do.	Appendix A narrative	—	
512.a.2.(b)	If one or more public information meetings are held in the affected areas within the first two months of the planning process to obtain public input on the natural hazards, problems, and possible solutions. The meetings must be held separate from the planning committee meetings credited in Item (1).	Page i, lines 16-20. Appendix A narrative.	15	15
512.a.2.(c)	For holding one or more public meetings to obtain input on the recommended plan. The meetings must be at the end of the planning process, at least two weeks before submittal of the recommended plan to the community's governing body.	Chapter 1, page 4, lines 214-216. Appendix A narrative	15	15
512.a.2.(d)	(***Maximum credit 30 points***) 5 points for each additional public information activity implemented to explain the planning process and encourage input to the planner or planning committee, up to a maximum of 30 points. Examples include, but are not limited to:			
	• A website that explains the planning process, posts the time and place for meetings on it, meeting agendas, status reports, and the draft plan, when it is ready for review.	Appendix A narrative	5	5
	• Conducting a public webcast that explains the planning process and solicits input.	N/A	5	—
	• Questionnaires asking the public for information on their natural hazards, problems, and possible solutions. A questionnaire or survey that is sent to everyone in the floodplain or everyone in the community will receive double credit (10 points).	Appendix A narrative	5	5
	• Outreach projects, such as those credited in Activity 330—Outreach Projects that explain the planning effort and seek comments. These could include brochures, mailers, booths at shopping malls, presentations at civic or neighborhood organizations, etc.	Appendix A narrative	5	5
	• Other (Please describe):	Appendix A narrative	10	10
	The planning process must include an opportunity for the public to comment on the plan during the drafting stage and prior to plan approval. (***Required***)			

TABLE A-1.
COMMUNITY RATING SYSTEM CROSSWALK FOR KING COUNTY FLOOD HAZARD MANAGEMENT PLAN

Element	Description of Credit Criteria	Location in the Plan	Credit Points Available	Credit Points Requested
512.a.3 **Step 3—Coordinate (*Maximum credit: 35 points*). Other agencies and organizations must be contacted to see if they are doing anything that may affect the community's program and to see if they could support the community's efforts.**				
512.a.3.(a)	If the planning includes a review of existing studies, reports, and technical information and of the community's needs, goals, and plans for the area. (***Required***) Where the information from the existing studies and reports is used in the plan, the sources should be referenced.	Expert review panel section, pages i-ii. Appendix A narrative and Appendix H	5	5
512.a.3.(b)	For coordinating with agencies and organizations outside the community's governmental structure. There is no credit for talking to other departments within the city or county government. For this credit, "coordinate" means to: • Contact the agency or organization and keep a record of the contact (a generic announcement or notice on a website is not sufficient), • Ask for data or information related to the hazard, • Ask if the agency or organization is doing anything that might affect flooding or properties in flood-prone areas, and • Offer the agency or organization an opportunity to be involved in the planning effort, such as attend a committee meeting or comment on the draft plan. One point is provided for each agency or organization that is contacted. Two points are provided for meeting with the agency or organization. Such a coordination meeting must be separate from attending a planning committee meeting.	Appendix A narrative	30	30
512.a.4 **Step 4—Assess the hazard (*Maximum credit: 35 points*). The credit for this step is the total of the following points based on what the community includes in its assessment of the hazard. To receive CRS credit for this step, the assessment must include item (a). If the community wants the plan to also qualify as a FEMA multi-hazard mitigation plan, item (b) must also be completed.**				
512.a.4.(a)	For including an assessment of the flood hazard in the plan. If the community is a Category B or C repetitive loss community, this step must cover all of its repetitive loss areas (***Required***). The assessment must include at least one of the following items:			

TABLE A-1.
COMMUNITY RATING SYSTEM CROSSWALK FOR KING COUNTY FLOOD HAZARD MANAGEMENT PLAN

Element	Description of Credit Criteria	Location in the Plan	Credit Points Available	Credit Points Requested
512.a.4.(a)	(***Maximum Credit: 15 points***) For including an assessment of the flood hazard in the plan. (***Required***) Flood hazard areas requiring assessment include: • The special flood hazard area shown on the Flood Insurance Rate Map • Repetitive loss areas • Areas not mapped on the Flood Insurance Rate Map that have flooded in the past • Other surface flooding identified in other studies	Chapter 3, pages 7-12		
512.a.4.(a)(1)	For a map of the flood hazard areas. Area maps are acceptable for multijurisdictional plans.	Appendix F	5	5
512.a.4.(a)(2)	A discussion of past floods for a description of the known flood hazards, including source of water, depth of flooding, velocities, and warning time.	Chapter 3, pages 9-12. Appendix C	5	5
512.a.4.(a)(3)	For a discussion of past floods.	Appendix C	5	5
512.a.4.(b)	For including an assessment of less frequent flood hazards in the plan. For this credit, the community must identify the hazard, including: a. Prepare an inventory of levees that would result in a flood of developed areas if they failed or were overtopped during a flood, and/or b. Prepare an inventory of dams that would result in a flood of developed areas if they failed, and/or c. Identify any of the flood-related special hazards listed in Section 401 of the CRS Coordinator's Manual that are found in the community, and/or d. Identify the coastal A Zone, i.e., the area where wave heights during the 100-year flood are between 1.5 and 3 feet.	Chapter 3, pages 7-12 Complete inventory of levees in King County in Appendix E Appendix A narrative.	10	10
512.a.4.(c)	If the assessment identifies areas likely to flood and flood problems that are likely to get worse in the future, including (1) changes in floodplain development and demographics, (2) development in the watershed, and (3) climate change or sea level rise. The credit is prorated if the assessment does not include all three types of changes.	Chapter 4 Appendix A narrative.	5	5
512.a.4.(d)	If the plan includes a description of the magnitude or severity, history, and probability of future events for other natural hazards, such as earthquakes, wildfires and tornados. The plan should include all natural hazards that affect the community. At a minimum, it should include those hazards identified by the state's hazard mitigation plan.	The King County Flood Hazard Management plan is the flood component of the King County Flood Control District All Hazard mitigation Plan adopted in July 2010. The two plans are linked by reference. Appendix A narrative	5	5

TABLE A-1.
COMMUNITY RATING SYSTEM CROSSWALK FOR KING COUNTY FLOOD HAZARD MANAGEMENT PLAN

Element	Description of Credit Criteria	Location in the Plan	Credit Points Available	Credit Points Requested
512.a.5 **Step 5—Assess the problem (*Maximum credit: 52 points*) The credit for this step is the total of the following points, based on what is included in the assessment of the vulnerability of the community to the hazards identified in the previous hazard assessment step. To receive credit for this step, the assessment must include item (a) and must evaluate the hazard data in light of their impact on the community. Simply listing data, such as the names of the critical facilities or the number of flood insurance claims, will not suffice for credit.**				
512.a.5.(a)	If the plan includes an overall summary of the jurisdiction's vulnerability to each hazard identified in the hazard assessment (Step 4) and the impact on the community. ***(Required)***	Chapter 3 in its entirety, Appendix C	2	2
512.a.5.(b)	***25 points***, if the plan includes a description of the impact that the hazards identified in the hazard assessment (Step 4) have on the following:			
512.a.5.(b)(1)	For life safety and the need for warning and evacuating residents and visitors.	Appendix C	5	5
512.a.5.(b)(2)	For public health, including health hazards to individuals from floodwaters and mold.	Appendix C	5	5
512.a.5.(b)(3)	For critical facilities and infrastructure.	Appendix C	5	5
512.a.5.(b)(4)	For the community's economy and major employers.	Appendices C and H	5	5
512.a.5.(b)(5)	For the number and types of affected buildings (e.g., residential, commercial, industrial, with or without basements, etc.). For this credit, the assessment must include an inventory of all buildings owned by the community located in flood-prone areas that identifies which buildings are insured for flood damage.	Chapter 3 in its entirety, Appendix C	5	5
512.a.5.(c)	If the assessment includes a review of historical damage to buildings, including all properties that have received flood insurance claims (in addition to the repetitive loss properties) and/or an estimate of the potential damage and dollar losses to vulnerable structures, including damage from mold and other flood-related hazards.	HAZUS loss estimation utilized to populate Appendix C	5	5
512.a.5.(d)	If the assessment describes areas within the floodplain that provide natural functions, such as wetlands, riparian areas, sensitive areas, and habitat for rare or endangered species.	Appendix I	5	5
512.a.5.(e)	If the assessment includes a description of development, redevelopment, and population trends and a discussion of what the future brings for development and redevelopment in the community, the watershed, and natural resource areas.	Appendix C	7	7
512.a.5.(f)	If the assessment includes a description of the impact of the future flooding conditions described in Step 4(c) on people, property, and natural floodplain functions.	Appendix C	8	8

TABLE A-1.
COMMUNITY RATING SYSTEM CROSSWALK FOR KING COUNTY FLOOD HAZARD MANAGEMENT PLAN

Element	Description of Credit Criteria	Location in the Plan	Credit Points Available	Credit Points Requested
512.a.6 Step 6—Set goals (*Maximum credit: 2 points*).				
	The two credit points for this step are provided if the plan includes a statement of the goals of the community's floodplain management or hazard mitigation program. (***Required***)	Introduction to Chapter 2. No changes to the goals or objectives identified in the 2006 Flood Plan were proposed for the 2013 Flood Plan Update.	2	2
512.a.7 Step 7—Review possible activities (*Maximum credit: 35 points*) The plan must describe those activities that were considered and note why they were or were not recommended (e.g., they were not cost-effective or they did not support the community's goals). (*Required*) The credit for this step is the total of the following points based on which floodplain management or hazard mitigation activities are reviewed in the plan.				
512.a.7.(a)	If the plan reviews preventive activities, such as zoning, stormwater management regulations, building codes, subdivision ordinances, and preservation of open space and the effectiveness of current regulatory and preventive standards and programs. (***Required***) For this credit, the review must include a discussion of the community's • Comprehensive or land use plan • Building code • Zoning ordinance • Floodplain management regulations • Subdivision ordinance • Stormwater management regulations.	Chapter 4 of the 2013 Flood Plan Update in its entirety. In the 2006 Flood Plan, see: Chapter 2, pages 11-24 Introduction, Policies: G-2, G-3, FP-1, FP-2, FP-3, FP-4, FP-5, FP-6, FP-7, FP-8, FP-9, FP-10, FP-11 All of Chapter 4, pages 35-92 Recommendations: MAP 1-7, CMZ 1-3, COR 1-6, REG 1-2 All of Chapter 5, pages 93-300	5	5
512.a.7.(b)	If the plan reviews whether the community's floodplain management regulatory standards are sufficient for current and future conditions, as discussed under Steps 4(c) and 5(f).	N/A	5	—
512.a.7.(c)	If the plan reviews property protection activities, such as acquisition, retrofitting, and flood insurance.	Chapter 4 of the 2013 Flood Plan Update in its entirety. In the 2006 Flood Plan, see: Chapter 2, pages 11-24 Introduction, Policies: G-2, FRR-3 All of Chapter 4, pages 35-92 Recommendations: ERA 1-7, All of Chapter 5, pages 93-300	5	5

TABLE A-1.
COMMUNITY RATING SYSTEM CROSSWALK FOR KING COUNTY FLOOD HAZARD MANAGEMENT PLAN

Element	Description of Credit Criteria	Location in the Plan	Credit Points Available	Credit Points Requested
512.a.7.(d)	If the plan reviews activities to protect the natural and beneficial functions of the floodplain, such as wetlands protection.	Chapter 4 of the 2013 Flood Plan Update in its entirety. In the 2006 Flood Plan, see: Chapter 2, pages 11-24, Introduction, Policies: G-2, G-8, FRR-2, FRR-5, RCM-1, RCM-2 All of Chapter 4, pages 35-92, Recommendations: COR 1-6, SED 1-5, WD 1-3. All of Chapter 5, pages 93-300	5	5
512.a.7.(e)	If the plan reviews emergency services activities, such as warning and sandbagging.	Chapter 4 of the 2013 Flood Plan Update in its entirety. In the 2006 Flood Plan, see: Chapter 2, pages 11-24, Introduction, Policies: G-1, G-2, ER-1, ER-2, ER-3, ER-4, and Recommendation RESP 1-2. All of Chapter 4, pages 35-92, Recommendations: WARN 1-4, RESP 1-2 All of Chapter 5, pages 93-300	5	5
512.a.7.(f)	If the plan reviews structural projects, such as levees, reservoirs and channel modifications.	Chapter 4 of the 2013 Flood Plan Update in its entirety. In the 2006 Flood Plan, see: Chapter 2, pages 11-24, Introduction, Policies: G-1, G-2, G-6, FRR-2, FRR-6, FRR-7, FRR-8, FRR-12 All of Chapter 4, pages 35-92, Recommendations: INFRA 1-3 All of Chapter 5, pages 93-300	5	5
512.a.7.(g)	If the plan reviews public information activities, such as outreach projects and environmental education programs.	Chapter 4 of the 2013 Flood Plan Update in its entirety. In the 2006 Flood Plan, see: Chapter 2, Pages 11-24, Introduction, Policies: G-2 All of Chapter 4, Pages 35-92, Recommendations: TECH 1-6, ERA 2-4, PREP 1-5, Chapter 5, section 5.1, pages 95-98	5	5

TABLE A-1.
COMMUNITY RATING SYSTEM CROSSWALK FOR KING COUNTY FLOOD HAZARD MANAGEMENT PLAN

Element	Description of Credit Criteria	Location in the Plan	Credit Points Available	Credit Points Requested
512.a.8	**Step 8—Draft an action plan (*Maximum credit: 60 points*). The action plan specifies those activities appropriate to the community's resources, hazards, and vulnerable properties. For each recommendation, the action plan must identify who does what, when it will be done, and how it will be financed. The actions must be prioritized and include a review of the benefits of the proposed projects and their associated costs. (*Required*)**			
512.a.8.(a)	***45 points***, depending on how many categories are covered by the action items:			
512.a.8.(a)(1)	If the action plan includes flood-related recommendations for activities from two of the six categories credited in Step 7, OR		10	
512.a.8.(a)(2)	If the action plan includes flood-related recommendations for activities from three of the six categories credited in Step 7, OR		20	
512.a.8.(a)(3)	If the action plan includes flood-related recommendations for activities from four of the six categories credited in Step 7, OR		30	
512.a.8.(a)(4)	If the action plan includes flood-related recommendations for activities from five of the six categories credited in Step 7.	All of Chapters 2, 4, 5, and 6 of the 2006 Flood Plan, Action Plan Matrix, Appendix F of the 2013 Flood Plan Update	45	45
512.a.8.(b)	Additional points are provided if the action plan establishes or revises post-disaster redevelopment and mitigation policies and procedures. These policies and procedures should account for the expected damage from a base flood or other disaster. For example, the action plan should identify the areas likely to be worst hit and the policies should determine whether they will be rebuilt if substantially damaged. Post-disaster mitigation procedures should assign responsibilities for public information, code enforcement, planning, and other efforts that encourage, mandate, and/or fund loss reduction activities.	N/A	10	—
512.a.8.(c)	Additional points are provided if the plan includes action items (other than public information activities) to mitigate the effects of the other natural hazards identified in the hazard assessment (Step 4, item (b)).	2006 Flood Plan: Chapter 1, section 1.5, page 6; Chapter 6, section 6.1, page 301-302; Chapter 7, section 7.4.3, page 329-337 Note: Compliance with this element is based on the creation of "linkage" between the Flood Hazard Management Plan and the King County Regional Hazard Mitigation Plan that was prepared by King County in response to the Disaster Mitigation Act. Appendix A narrative.	5	5

TABLE A-1.
COMMUNITY RATING SYSTEM CROSSWALK FOR KING COUNTY FLOOD HAZARD MANAGEMENT PLAN

Element	Description of Credit Criteria	Location in the Plan	Credit Points Available	Credit Points Requested
512.a.9 Step 9—Adopt the plan (*Maximum credit: 2 points*)				
	The 2 credit points for this step are provided if the plan and later amendments are officially adopted by the community's governing body. (***Required***)	Plan to be adopted by King County Flood Control District Board of Supervisors	2	2
512.a.10 Step 10—Implement, evaluate, and revise (Maximum credit: 26 points) The credit for this step is the total of the following points based on how the community monitors and evaluates its plan.				
512.a.10.(a)	If the community has procedures for monitoring implementation, reviewing progress, and recommending revisions to the plan in an annual evaluation report. The report must be submitted to the governing body, released to the media and made available to the public. (***Required***)	Plan maintenance procedures to be carried over from the 2006 Flood Plan, see: Chapter 1, Section 1.7, page 7; Chapter 6, Section 6.3, page 305	2	2
512.a.10.(b)	***24 points***, if the annual evaluation report is prepared by the same planning committee that prepared the plan that is credited in Step 2(a) or by a successor committee with a similar membership that was created to replace the planning committee and charged with monitoring and evaluating implementation of the plan. The points are based on how frequently the committee meets, as more frequent meetings result in more progress toward implementing the plan. The committee must continue to meet the representation, quorum, and other criteria that determined the credit points under Step 2(a).			
512.a.10.(b)(1)	If the committee meets only once a year.	N/A	6	—
512.a.10.(b)(2)	If the committee meets twice a year.	N/A	12	—
512.a.10.(b)(3)	If the committee meets at least quarterly.	N/A	24	—
	To maintain this credit, the community must submit a copy of its annual evaluation report with its recertification each year and update the plan at least every five years.			
512.a Impact Adjustment—Floodplain management plan ratio (rFMP) is a factor applied to the total credit score that reflects how much of the community's flood hazard areas are covered by the floodplain management plan.				
	If the plan covers all of the community's known flood hazard areas, rFMP = 1.0.		1.0	1.0
Total			**382**	**333**

NARRATIVE

The following sections provide additional discussion of information provided in the crosswalk. Since portions of this narrative refer to the 2006 Flood Plan, crosswalk users should have access to both the 2006 Flood Plan and the 2013 Flood Plan Update.

CRS Activity 510 Element 512.a.1.(b)

Like the 2006 Flood Plan, this update was prepared by staff from the King County Department of Natural Resources and Parks. This department is responsible for floodplain management in King County and plays an active role in floodplain development permit review and public information. The department's River and Floodplain Management Section is also the designated service provider for the King County Flood Control District. The following staff made up a multi-disciplinary project team of planners, project managers, biologists, earth scientists, engineers and consultants:

- Kate Akyuz, Environmental Scientist
- Sylvia Aro, Administrative Specialist
- Saffa Bardaro, Communications Specialist
- Chase Barton, P.E., Engineer
- Tom Bean, P.E., Green River Supervisor
- Shawn Bergrud, Engineer
- John Bethel, Environmental Scientist
- Steve Bleifuhs, CFM, Manager, Flood Warning Director
- Lisa Brandt, Environmental Scientist
- Chris Brummer, P.E., Engineer
- Terry Butler, Environmental Scientist
- Kyle Comanor, P.E., Engineer
- John Engel, P.E. Cedar River Supervisor
- Nancy Faegenburg, Project/Program Manager
- Craig Garric, P.E., Engineer
- Debbie Hart, Contract Specialist
- Katrina Johnston, Business and Financial Officer
- Priscilla Kaufmann, CFM, Project/Program Manager
- Sally King, Project/Program Manager
- Steve Klusman, Budget and Financial Officer
- John Koon, Engineer
- Mary Lear, P.E., Engineer
- Andy Levesque, Engineer
- Clint Loper, P.E., South Fork Skykomish, Snoqualmie Rivers Supervisor
- Fred Lott, P.E., Engineer
- Sarah McCarthy, Environmental Scientist
- Phyllis Meyers, Environmental Scientist
- Brian Murray, Countywide Policy and Programs Supervisor
- Erik Peters, P.E., Engineer
- Lorin Reinelt, Managing Engineer
- Jennifer Rice, Project/Program Manager
- Richelle Rose, Project/Program Manager
- Tammy Rowlan, Contracts Specialist
- Mark Ruebel, P.E., Engineer
- Ruth Schaeffer, Environmental Scientist
- Jeanne Stypula, P.E., White River/Technical & Maintenance Supervisor
- Katy Vanderpool, Project/Program Manager
- Monica Walker, Project/Program Manager
- Jay Young, P.E., Engineer

Of this team, four members also staffed the Citizens Committee: Steve Bleifuhs, Brian Murray, Priscilla Kaufmann and Monica Walker.

CRS Activity 510 Element 512.a.1.(c)

The King County Flood Control District adopted Motion FCD11-03 establishing a scope of work for the update to the King County Flood Hazard Management Plan. The Board of Supervisors, under Motion FCD11-04, appointed 20 stakeholders to serve on the Citizens Committee to help formulate and review the update to the King County Flood Hazard Management Plan.

CRS Activity 510 Element 512.a.2.(a)(1)

Four King County staff members credited in Step 1(b) also staffed the Citizens Committee: Steve Bleifuhs, Brian Murray, Priscilla Kaufmann and Monica Walker. The 20 Citizens Committee members were all members of the public or stakeholders representing floodplain property owners, public agencies, non-profit organizations, business, or environmental organizations. Table A-2 lists the Citizens Committee members.

TABLE A-2.
ADVISORY COMMITTEE PUBLIC MEMBERS

Name and Location	Expertise/Experience	Geographic Representation
Leonard Carlson, Carnation	Floodplain Property Owner	Lower Snoqualmie River
James McBride, Carnation	Floodplain Property Owner	Lower Snoqualmie River
Warren Halverson, Bellevue	Floodplain Property Owner	Upper Snoqualmie River
Dave Gashler, Auburn	King County Housing Authority/Low Income	Green River
Brian Winslow, Auburn	The Boeing Company	Green River
Joseph Herr, Seattle (Maple Valley)	Floodplain Property Owner	Cedar River
Martha Parker, Renton	Cedar River Council, Floodplain Property Owner	Cedar River
Nicole Hagestad, Pacific	Former City Council Member, Floodplain Property Owner	White River
Jon Scholes, Seattle	Downtown Seattle Association/ Coastal Flooding	Seattle
Keith Swenson, Bellevue	City of Bellevue Environmental Services	Countywide
Susan Pelaez, South Seattle	American Red Cross, Vulnerable Populations	Countywide
John King, Auburn	Flood Protection Engineer for FM Global, commercial insurance	Countywide
Dr. Gilbert Pauley, PhD, Bellevue	University of Washington Professor Emeritus, Aquatic & Fishery Sciences	Countywide
Stephen Stanley, Bellevue	Wetland Specialist, Washington Department of Ecology	Countywide
Bob Freitag, Seattle	University of Washington Hazard & Mitigation Planning	Countywide
Joseph Wartman, PhD, Seattle	University of Washington Professor of Civil Engineering	Countywide
Molly Lawrence, Seattle	Land Use Attorney, Gordon Derr, LLP	Countywide
Jeff Randall, PhD, Preston	Partnership for Rural King County	Countywide

CRS Activity 510 Element 512.a.2.(a)(2)

As stated in the 2013 Flood Plan Update, the Citizens Committee met seven times between December 2011 and August 2012. Table A-3 summarizes the Citizens Committee meetings.

TABLE A-3.
ADVISORY COMMITTEE MEETING CHRONOLOGY

Meeting Date, Time, Location	Topics Discussed	Attendance
December 13, 2011, 5:00-8:00 PM, Mercer Island Community Center	• Welcome and Staff Introductions • Advisory Committee Roundtable Introductions • Advisory Committee Charter • Scope of Work and Schedule • Overview of Floodplain Management in King County – 2006 King County Flood Hazard Management Plan – Accomplishments since 2006 – King County Flood Control District – Overview of each river basin and risk reduction strategies • General Public Comments	16
January 10, 2012, 5:00-8:00 PM, Mercer Island Community Center	• Goal Objectives and Guiding Principles • Flood Hazard Mitigation Tool Box – Flood Hazard Information – Management of Land Uses – Sediment Management – Flood Risk Reduction Structures – Flood Hazard Education and Flood Preparedness • General Public Comments	13
February 15, 2012, 5:00-8:00 PM, Mercer Island Community Center	• Role of Flood Control District in Coastal Flooding • Role of Flood Control District in Urban and Small Streams Flooding • General Public Comments	14
March 13, 2012, 5:00-8:00 PM, Mercer Island Community Center	• Report and Discussion on Committee Roles and Responsibilities • Independent Expert Panel Review of Water & Land Resources Division • Levee Vegetation and PL 84-99 Program • General Public Comments	13
June 12, 2012, 5:00-8:00 PM, Mercer Island Community Center	• Capital Project Prioritization, Sequencing Approach, and Eligibility Criteria • Gravel and Sediment Management • General Public Comments	9
July 10, 2012, 5:00-8:00 PM, Mercer Island Community Center	• Equity and Social Justice: Outreach to Vulnerable & Underserved Populations • White River Strategy and Action Plan • Relocation of Residential and Commercial Tenants • South Fork Skykomish River & Snoqualmie River Strategies and Action Plans • General Public Comments	6
July 25, 2012, 5:00-8:00 PM, Mercer Island Community Center	• Bioengineering • Sammamish River, Issaquah Creek, and Cedar River Strategy and Action Plan • Levee Certification and Accreditation • Green River Strategy and Action Plan • General Public Comments	8

* http://www.kingcounty.gov/environment/waterandland/flooding/documents/flood-hazard-management-plan-update/plan-update-citizen-committee.aspx

CRS Activity 510 Element 512.a.2.(a)(3)

All advisory committee meetings were open to the public and every meeting included time on the agenda for public input. A postcard was mailed to all floodplain property owners at the beginning of the planning process with the website address for the 2013 Flood Plan Update and instructions to consult this website for meeting dates, times, locations and materials:

- http://www.kingcounty.gov/environment/waterandland/flooding/documents/flood-hazard-management-plan-update/plan-update-citizen-committee.aspx

All advisory committee meetings were posted on this website. Email notices were sent to all who asked to be included on the email distribution list.

CRS Activity 510 Element 512.a.2.(a)(5)

As with the 2006 Flood Plan, the Citizens Committee was formed solely to provide oversight for this plan update process. Some 2013 update committee members previously participated on the Citizens Advisory Committee for the 2006 Flood Plan. A charter established for the 2006 effort and carried over to the 2013 update outlined ground rules for committee operation. This charter is available for review upon request.

CRS Activity 510 Element 512.a.2.(b)

Four public workshops were held at the beginning of the planning process when the King County Flood Hazard Management Plan was developed in 2006. Although public information meetings are not required at the beginning of the update process, the following public meetings were held to gather information on the vision and strategy for each river basin for the 2013 Flood Plan Update:

- December 4, 2012 at Sno-Valley Senior Center, 4610 Stephens Ave, Carnation, WA
- December 5, 2012 at Highlands Neighborhood Center, 800 Edmonds Ave NE, Renton, WA
- December 6, 2012 at William C. Warren Building, 405 E Street NE, Auburn, WA.

Meeting agendas, minutes and sign-in sheets are on file. The public meetings were advertised through the mailing of postcards to floodplain property owners, news releases, email, website, and Facebook. These meetings were in advance of the public meeting on the draft 2013 Flood Plan Update. Additional information on the public outreach can be found at the following websites:

- http://www.kingcounty.gov/environment/waterandland/flooding/documents/flood-hazard-management-plan-update/public-involvement.aspx
- http://www.bothell-reporter.com/news/181382221.html
- http://www.auburn-reporter.com/news/180888681.html
- http://renton.patch.com/groups/politics-and-elections/p/don-t-be-a-flood-victim-county-to-host-a-public-infor5163410ee6
- http://www.voiceofthevalley.com/community_news/news/article_ce48c7c0-3380-11e2-950a-001a4bcf6878.html

King County held a public review and comment period from June 14 to July 12, 2013. The draft 2013 Flood Plan Update was posted on the plan website and the comment period was advertised via a media press release. A public meeting was held on July 9, 2013. This public comment period was conducted in compliance with the State Environmental Protection Act. Postcards were mailed to floodplain residents announcing the public comment period (see Figure A-1).

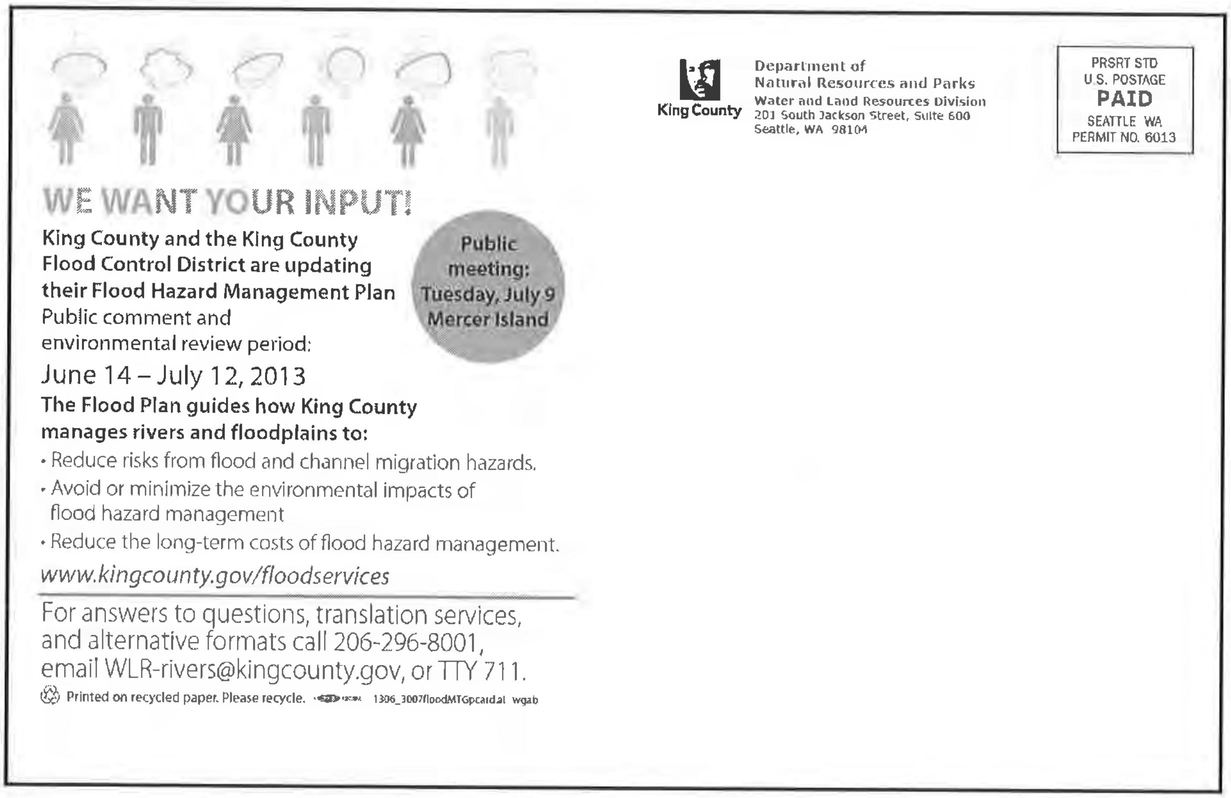

Figure A-1. Postcard mailed to floodplain residents announcing public comment period

Additional information on this public comment period can be found on the following websites:

- http://www.kingcounty.gov/environment/waterandland/flooding/documents/flood-hazard-management-plan-update.aspx
- http://www.kingcounty.gov/environment/dnrp/newsroom/newsreleases/2013/June/06-14-flood-plan-update.aspx

CRS Activity 510 Element 512.a.2.(d)(1)

King County established a website early in the plan update process to advertise public meetings, post issue papers and the draft plan for public review and comment, and list advisory committee meeting times, locations, agendas, meeting materials and meeting minutes:

- http://www.kingcounty.gov/environment/waterandland/flooding/documents/flood-hazard-management-plan-update.aspx

CRS Activity 510 Element 512.a.2.(d)(3)

King County distributed a questionnaire during the plan development in 2006. A 2010 telephone survey on flood awareness, in English and Spanish, was conducted by contacting a sample of floodplain property owners in the Green, Cedar and Snoqualmie River basins. Given the extensive size of King County, a countywide survey was not economically feasible.

In 2012, King County conducted a telephone and on-line customer satisfaction survey of floodplain residents to determine why customers do or do not use available services. The survey was also a way to assess satisfaction levels related to environmental and social justice. One of the objectives of the survey was to find out who is not receiving services and whether that is related to race, language spoken, age, disability or other factor. A final open-ended question asked, "What one thing could we do to improve our service?" The survey was promoted through the annual King County Flood Awareness and Flood Warning brochure mailing. Findings from the survey are available upon request.

CRS Activity 510 Element 512.a.2.(d)(4)

A postcard mailed to all floodplain residents at the beginning of the planning process for the 2013 Flood Plan Update described key issues that would be addressed in the update, where to find out more information, a tentative schedule for public input, and the update website. A second postcard mailing announced the meeting in Step 2(b) for public input on the risk assessment, proposed projects, basin vision and strategy and the goals and objectives.

CRS Activity 510 Element 512.a.2.(d)(5)

Other outreach efforts conducted during this update included the following:

- Mailings:
  - March 2012—Mailed 12,500 postcards about 2013 Flood Plan Update to floodplain property owners
  - November 2012—Mailed 19,000 postcards about December public meetings to floodplain property owners and residents
- County Staff Briefings:
  - May 23, 2012—Brown-bag briefing for King County Departments on the 2013 Flood Plan Update
- King County Flood Control District Advisory Committee and Board of Supervisors:
  - July 11, 2011—A motion adopting the scope of work for the 2013 Flood Plan Update
  - July 28, 2011—Briefing on the 2013 Flood Plan Update
  - September 12, 2011—A motion appointing an advisory committee for the 2013 Flood Plan Update
  - January 23, 2012—Briefing on the 2013 Flood Plan Update
  - February 24, 2012—Briefing on the 2013 Flood Plan Update and issue papers
  - April 27, 2012—Briefing on the 2013 Flood Plan Update and issue papers
  - November 26, 2012—Briefing on the 2013 Flood Plan Update status and schedule
- Newspapers, newsletters, other public publications:
  - April 9, 2012—King County Natural Resources and Parks website
  - November 28, 2012—King County News Release about 2013 Flood Plan Update and public meetings
  - November 28, 2012—Auburn Reporter events calendar advertised December 6, 2012 public meeting
  - November 28, 2012—Auburn Reporter news story on 2013 Flood Plan Update and public meetings
  - November 29, 2012—Renton Reporter advertised the December 4, 5, 6, 2012 public meetings

- November 29, 2012—Bothell Reporter news story on 2013 Flood Plan Update and public meetings
- November 30, 2012—Issaquah Press news story about 2013 Flood Plan Update and public meetings
- November 2012—Snoqualmie Watershed Forum News story about 2013 Flood Plan Update and meetings
- November 2012—Unincorporated Area Community News story about 2013 Flood Plan Update and meetings
- December 2012—King County Weeds news story about 2013 Flood Plan Update and public meetings
- December 3, 2012—Valley Record news story about 2013 Flood Plan Update and public meetings

State Environmental Policy Act Review

The 2013 Flood Plan Update required a State Environmental Policy Act (SEPA) Threshold Determination. The King County Flood Hazard Management Plan is a "non-project action" under SEPA (WAC 197-11-704(2)(b)). A determination of non-significance (DNS) was issued for the 2013 Flood Plan Update. Notice requirements for SEPA were provided in accordance with King County Code Chapter 20.20, which requires newspaper notices. In addition, the SEPA threshold determination and the environmental checklist were mailed to all 39 incorporated cities, state and public agencies, and Indian Tribes. The SEPA threshold determination was also posted on the 2013 Flood Plan Update website.

CRS Activity 510 Element 512.a.3.(a)

The 2006 Flood Plan was developed based on an extensive review of existing plans, studies and reports. This planning step was performed again for the 2013 Flood Plan Update. A different perspective of this process was provided by an independent expert review of Water and Land Resources Division's project scoping and implementation practices. The independent expert panel review provided an external analysis of the division's river and floodplain project practices, describing findings and offering suggestions for improvement. The independent review addressed aspects of river projects such as project scoping, delivery processes, technical assumptions, construction methods, maintenance procedures and post-project monitoring and mitigation. The report is a synthesis of assessments by river and floodplain management professionals who were selected for the independent expert panel based on their expertise related to four objectives: protecting public safety, preventing property damage from flooding, recovering salmon, and providing recreation. The report was independently produced by the consulting firm Montgomery Watson Harza of Bellevue, Washington. A copy of this report can be viewed at:

- http://www.kingcounty.gov/environment/dnrp/publications/wlrd-expert-review-report.aspx

In addition, King County conducted a comprehensive review of new studies, reports and technical information published since January 2007. When this information was used in the 2013 Flood Plan Update, the citation was added to the list of references.

CRS Activity 510 Element 512.a.3.(b)

The 2013 Flood Plan Update was developed in close working relationship with King County Flood Control District basin technical committees. The basin technical committees ensure that basin-scale issues and technical information are factored into countywide district decision-making processes. Basin technical committees consist of city staff from jurisdictions within each basin, as well as King County staff, to accomplish the following objectives:

- Provide input to Flood Control District staff regarding annual and longer-term capital improvement project priorities.
- Share relevant information across areas of the Flood Control District that would influence implementation of the district's work program.
- Review and help guide project implementation, as appropriate.
- Develop policies and issues papers as required.
- Coordinate jointly with state and federal partners on relevant issues.

Basin technical committees have been formed for the following major river basins:

- Snoqualmie/South Fork Skykomish Rivers
- Cedar and Sammamish Rivers
- Green/Duwamish River
- White River.

Public agency coordination for the 2013 Flood Plan Update consisted of the following:

- Water Resource Inventory Areas (WRIAs):
  - May 8, 2012 meeting with WRIA 8 Implementation Committee (25 Cities, King and Snohomish Counties, multiple environmental organizations and public agencies)
  - May 10, 2012 meeting with WRIA 9 Watershed Ecosystem Forum (12 cities, Department of Ecology, Washington Department of Natural Resources, King Conservation District, U.S. Army Corps of Engineers, Tacoma Public Utilities, MidSound Fisheries, Master Builders, Port of Seattle, EarthCorps, Puget Sound Partnership)
  - May 16, 2012 meeting with Snoqualmie Watershed Forum (4 cities, King County, King Conservation District, Snoqualmie Tribe)
- Flood Control District Basin Technical Committees:
  - June 1, 2012 meeting with Green River Basin Technical Committee (10 cities, King County, Muckleshoot Tribe)
  - June 5, 2012 meeting with White River Basin Technical Committee (8 cities and King and Pierce Counties)
  - June 8, 2012 meeting with Cedar River Basin Technical Committee (12 cities and King County)
  - June 11, 2012 meeting with Snoqualmie Coordination Team (Snoqualmie WRIA and King County)
  - June 21, 2012 meeting with Snoqualmie Basin Technical Committee (6 cities and King County)
- Agricultural Commission:
  - June 11, 2012 meeting with Agricultural Commission members and farmers
  - June 14, 2012 meeting with Agricultural Commission

- Cities and Counties:
  - June 20, 2012 meeting with City of Pacific
  - July 2, 2012 meeting with City of Sumner
  - August 13, 2012 meeting with Pierce County
- Unincorporated Areas Councils
  - February 4, 2013 meeting and presentation to the Greater Maple Valley Unincorporated Area Council
- Native American Tribes:
  - February 17, 2012 email to Muckleshoot, Puyallup, Snoqualmie and Tulalip Tribes about the 2013 Flood Plan Update, with a request for coordination
  - February 23, 2012 meeting with tribal relations coordinator
  - April 19, 2012 meeting with Muckleshoot Tribe
  - December 12, 2012 meeting with tribal relations coordinator
  - December 18, 2012 mailing to Muckleshoot, Puyallup, Snoqualmie and Tulalip Tribes about 2013 Flood Plan Update

CRS Activity 510 Element 512.a.4.(b)

Discussion on dams and levees can be found in the following locations in the 2006 Flood Plan, which is a companion document to 2013 Flood Plan Update:

- Levees
  - Chapter 5, Section 5.2.6 for the South Fork Skykomish River
  - Chapter 5, Section 5.3.1 and Section 5.3.6 for the South Fork Snoqualmie River
  - Chapter 5, Section 5.4.1 and Section 5.4.6 for Middle and North Fork Snoqualmie River
  - Chapter 5, Section 5.5.1 and Section 5.5.6 for the Upper Snoqualmie River
  - Chapter 5, Section 5.6.1 and Section 5.6.6 for the Lower Snoqualmie River
  - Chapter 5, Section 5.7.1 and Section 5.7.6 for the Tolt River
  - Chapter 5, Section 5.8.1 and Section 5.8.6 for the Raging River
  - Chapter 5, Section 5.9.1 and Section 5.9.6 for the Sammamish River and Issaquah Creek
  - Chapter 5, Section 5.10.1 and Section 5.10.6 for the Cedar River
  - Chapter 5, Section 5.11.1, Section 5.11.3 and Section 5.11.6 for the Green River
  - Chapter 5, Section 5.12.1 and Section 5.12.6 for the White River
- Dams
  - See Chapter 5, Section 5.7.3 for discussion of the South Fork Tolt River Dam.
  - See Chapter 5, Section 5.10.3 for a discussion of the Masonry Dam, the reconstructed Crib Dam or Overflow Dike, and the Landsburg dam on the Cedar River all operated by Seattle Public Utilities.

- See Chapter 5, Section 5.11.3 for an extensive discussion of the Howard Hanson dam operated by the U.S. Army Corps of Engineers on the Green River.
- See Chapter 5, Section 5.12.3 for a discussion of the Mud Mountain Dam operated by the U.S. Army Corps of Engineers on the White River.

CRS Activity 510 Element 512.a.4.(c)

In 2012, King County completed a comprehensive programmatic habitat assessment for listed Puget Sound salmonids and southern resident orca whales, in conformance with the National Flood Insurance Program Biological Opinion prepared under the federal Endangered Species Act and the Magnuson-Stevens Act. This programmatic habitat assessment was a parcel-by-parcel assessment of the predicted or potential buildout of the floodplains in King County and included a land use and zoning analysis to look at current and future floodplain development and impacts from upland development in the watershed, specifically related to vegetation coverage. The purpose of this study was to predict the level of development that is likely to occur in the future and the impact this will have on the floodplain. A discussion of this programmatic habitat assessment is included in Chapter 4. Chapter 6 provides a discussion on climate change related to sea level rise and riverine flooding.

CRS Activity 510 Element 512.a.4.(d)

The King County Flood Control District is defined as a "local government" under provisions of the Disaster Mitigation Act of 2000 (Section 201.5 44 CFR) and adopted an all-hazard mitigation plan pursuant to this act in August 2010. The King County Flood Hazard Management Plan serves as the flood component of the all-hazard mitigation plan. The two plans are linked by reference and will remain so with any subsequent revisions to the flood plan. The King County Flood Control District is committed to maintaining the plan, as specified in Chapter 6 of the hazard mitigation plan. See the introduction to Chapter 9 of all-hazard mitigation plan for linkage reference. The Mitigation Plan can be viewed at:

- http://your.kingcounty.gov/dnrp/library/water-and-land/flooding/local-hazard-mitigation-plan-update/2010-august-KCFCD-approved-hazard-plan.pdf

APPENDIX B.
FLOODPLAIN MANAGEMENT REGULATIONS

This Appendix is a substitute for and replaces Appendix B of the 2006 Flood Plan.

Federal, state and local regulations direct how floodplain management is conducted in King County. The wide range of regulatory programs and enabling legislation require floodplain managers to balance multiple objectives, including protecting public health and safety, preserving and restoring the natural environment, maintaining economic viability of the region and respecting private property rights.

NATIONAL FLOOD INSURANCE PROGRAM (44 CFR PART 59)

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 provides the financial backing for flood insurance policies within participating communities, making them more affordable to private property owners. Significant reforms occurred in 2012 which if fully implemented will affect flood insurance policy holders. 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. While participation in the NFIP is technically not required under federal law, it is highly impractical for King County to not participate since most federally-backed mortgage loans require the purchase of flood insurance.

According to FEMA, approximately 20,000 communities across the United States participate in the NFIP. (http://www.fema.gov/about/programs/nfip/index.shtm) King County began participation in the NFIP on September 29, 1978 and is currently a class 2 community under the Community Rating System (CRS), which is the method for rating communities that participate in the NFIP. In addition to King County, almost all incorporated cities (35 of 39) within King County participate in the NFIP.

DISASTER MITIGATION ACT (44 CFR PARTS 201 AND 206)

The Disaster Mitigation Act (DMA) was adopted in 2000 and is designed to encourage communities to develop a comprehensive disaster mitigation plan that incorporates all hazards, including both natural and human-created disasters, such as terrorism. The incentive to encourage communities to take on this planning effort is that only those communities that have an adopted Hazard Mitigation Plan are eligible for participation in the Hazard Mitigation Grant Program (HMPG). State Emergency Management Agencies are responsible for reviewing and approving local jurisdictions Hazard Mitigation Plans. Final approval must be granted by the Federal Emergency Management Agency (FEMA). The King County Office of Emergency Management developed the King County Regional Hazard Mitigation Plan in 2004 and completed the five-year update in 2009. The King County Flood Hazard Management Plan is considered to be the flood hazard component of the King County Regional Hazard Mitigation Plan, and must be consistent with DMA to assure that King County is eligible for participation in the Hazard Mitigation Grant Program. In 2010 the King County Flood Control District prepared a multi-hazard mitigation plan consistent with the DMA for the Flood District. The King County Flood Control District Hazard Mitigation Plan included an update to the risk assessment and vulnerability analysis for flooding countywide. The other hazards, dam failure, earthquake, landslide, severe weather, volcano, and wildland fire were assessed only to the extent of their impact on flood protection infrastructure under the authority of the King County Flood Control District.

NATIONAL ENVIRONMENTAL POLICY ACT (42 CFR 4321 ET SEQ.)

The National Environmental Policy Act (NEPA) requires that all federally sponsored actions, and all privately sponsored actions using federal funds, must evaluate the action to determine if it will have a significant adverse environmental impact on the environment. In addition, federal agencies that issue permits or give approval for actions, must also evaluate the action for significant adverse environmental impacts. A full disclosure of all impacts is required and regulatory agencies, both federal and local, with decision authority over the action must consider the impacts prior to an agency decision. Many of King County's flood hazard management projects and programs utilize federal funding or require permits from federal agencies and must, therefore, conform with the NEPA regulations.

ENDANGERED SPECIES ACT (50 CFR PART 17)

The Endangered Species Act (50 CFR Part 17) prohibits any actions that may result in a "take" of any species listed as threatened or endangered under the Act, including the prohibition against impacts to these species' habitats. "Take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. With the listing of Puget Sound Chinook salmon, Puget Sound steelhead trout and Puget Sound bull trout as threatened, and the potential for listing of other riverine and marine species, the policies, programs and projects established in this Plan take into consideration what these actions may have on listed species and their habitats to assure that King County is not subject to legal challenges under the Endangered Species Act.

MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT (PUBLIC LAW 94-265)

The Magnuson-Stevens Fishery Conservation Act is the primary federal law governing fisheries management in the United States. The law was passed to regulate fishing within 200 nautical miles of United States waters to prevent over fishing. The law was also adopted in order to allow over-fished stocks to recover and to conserve and manage fishery resources. National Marine Fisheries Service is responsible for implementing the Act. There are eight regional fishery management councils that oversee the fishery resources in their respective regions. The Act includes national standards for management and outlines the contents of fishery management plans. In addition, it gives the Secretary of Commerce power to review, approve, and implement fishery management plans and other recommendations developed by the councils. Within Washington state, there are three federal fishery management plans that protect associated essential fish habitat for:

- Pacific coast ground fish fishery—83 species
- Coastal pelagic species fishery—market squid and four fin fishes (Pacific sardine, Pacific [chub] mackerel, northern anchovy, and jack mackerel
- Pacific coast salmon fishery—chinook, coho, and Puget Sound pink salmon.

NATIONAL HISTORIC PRESERVATION ACT (36 CFR 800)

Section 106 of the National Historic Preservation Act requires that all federal undertakings including permits, licenses and privately sponsored actions using federal funds must be analyzed to determine if they will have an adverse effect on historic properties, including ,but not limited to historic buildings, structures, sites, districts and objects, including traditional cultural properties and archaeological resources that are listed or eligible for listing in the National Register of Historic Places. The analysis requires surveys to identify any historic properties that may be affected; consultation with state cultural resource officers, federally-recognized tribes, local government cultural resource agencies, and other interested parties regarding the properties and effects, and consideration of measures to avoid or mitigate effects to an acceptable level. Many of King County's flood hazard management projects utilize federal funding or require permits from federal agencies and must, therefore, comply with the National Historic Preservation Act regulations. Cultural resource requirements under National Environmental Protection Agency are typically satisfied through the National Historic Presentation Act Section 106 process.

WASHINGTON STATE FLOODPLAIN MANAGEMENT (CHAPTER 86.16 RCW)

The Washington state flood control regulations are contained primarily within chapter 86.16 of the Revised Code of Washington (RCW). The state has adopted higher standards than the minimum requirements for participation under the National Flood Insurance Program. All local floodplain management regulations must be reviewed and approved by the Washington State Department of Ecology before a community is eligible for participation in the National Flood Insurance Program. The state law establishes the duties of the Department of Ecology for floodplain management and assistance to local jurisdictions.

WASHINGTON STATE GROWTH MANAGEMENT - PLANNING BY SELECTED COUNTIES AND CITIES (CHAPTER 36.70A RCW)

The Washington State Growth Management Act (GMA) was passed by the Washington State Legislature in 1990 and seeks to further protect the quality of life in the Pacific Northwest. The GMA requires that the state's most populous and fastest growing counties and their cities prepare comprehensive land use plans that anticipate growth for a 20-year horizon. Smaller communities and those communities that are experiencing a slow rate of growth may choose to plan under the GMA, but are not required to do so. Comprehensive plans adopted in accordance with GMA must manage growth so that development is directed to designated urban areas and away from rural areas. The GMA also requires jurisdictions to designate and protect critical areas, including frequently flooded areas. Comprehensive Plans must identify and protect natural resource lands, which include commercially significant forestry, agriculture, and mining areas.

WASHINGTON STATE ENVIRONMENTAL POLICY ACT (CHAPTER 43.21C RCW)

The Washington State Environmental Policy Act (SEPA) was established in 1969 for the purpose of considering the impacts of actions on the environment. "Actions" are either project actions or nonproject actions and include a wide variety of activities that may impact the environment, such as new construction, developing comprehensive plans or establishing zoning. The Act also identifies a number of actions that are categorically exempt from SEPA review. The development of this Plan required review under SEPA. Construction projects conducted under the policies and programs established in this plan will require SEPA review on a case by case basis. The Washington State Environmental Policy Act is implemented in King County through K.C.C. chapter 20.44, which establishes categorical exemptions, guidelines for lead agency, use of actions in King County.

WASHINGTON STATE SHORELINE MANAGEMENT ACT (CHAPTER 90.58 RCW AND CHAPTER 173-26 WAC)

The Washington State Shoreline Management Act (Chapter 90.58 RCW) was first adopted in 1971 to address development along designated shorelines in the state. Under the Act, local governments have the responsibility to initiate the development of a Shoreline Management Master Program and to regulate development within those areas identified as "shorelines of the state." The Shoreline Management Act Guidelines are codified in Chapter 173-26 (WAC) and were updated in 2003. King County updated the

Shoreline Management Program in 2010, along with implementing regulations. All construction projects that are located within a shoreline of the state are subject to the requirements of the King County Shoreline Management Program and regulations.

WASHINGTON STATE CODE: INDIAN GRAVES AND RECORDS (27.44 RCW)

Chapter 27.44 RCW describes the procedures that must be followed upon discovery of human skeletal remains and states that "Any person who knowingly removes, mutilates, defaces, injures, or destroys any cairn or grave of any native Indian, or any glyphic or painted record of any tribe or peoples is guilty of a class C felony."

WASHINGTON STATE CODE: ARCHAEOLOGICAL SITES AND RESOURCES (27.53 RCW)

Chapter 43.21C RCW defines archaeological sites, states that it is a class C felony to knowingly disturb an archaeological site, and discusses procedures for obtaining a permit for excavation of an archaeological site. Archaeological Excavation and Removal Permit (WAC 25-48) specifies the requirements for obtaining an excavation permit.

GROWTH MANAGEMENT PLANNING COUNCIL AND COUNTY-WIDE PLANNING POLICIES

King County, along with the City of Seattle and Suburban cities established the Growth Management Planning Council (GMPC), as required by RCW 36.70A.210 to prepare a coordinated policy framework for future development in King County. In July 1992, the GMPC adopted Phase 1 of the County-Wide Planning Policies. Phase 2 was adopted in 1994 and updated in September 2011. The King County Countywide Planning Policies have been ratified by a majority of the jurisdictions in King County. One of the elements addressed by the County-Wide Planning Policies is the protection of critical areas, as required under the Growth Management Act (GMA). "Frequently flooded areas" are critical areas under the GMA. The updated Countywide Planning Policies include three policies to guide floodplain management in King County:

- **EN-10** Coordinate and fund flood hazard management efforts through the King County Flood Control District.
- **EN-11** Work cooperatively to meet regulatory standards for floodplain development as these standards are updated for consistency with relevant federal requirements including those related to the Endangered Species Act.
- **EN-12** Work cooperatively with the federal, state, and regional agencies and forums to develop regional levee maintenance standards that ensure public safety and protect habitat.

KING COUNTY COMPREHENSIVE PLAN

King County's first comprehensive plan dates to 1964 and has been revised many times in subsequent years. Following the 1990 passage of the Washington State Growth Management Act (GMA), King County revised its comprehensive plan for consistency with GMA in 1994. The GMA requires specific elements for inclusion in comprehensive plans and established a menu of optional elements that a local jurisdiction can choose to address. One key element of the GMA is to identify and protect critical areas. Frequently flooded areas are critical areas under GMA, and the comprehensive plan must establish policies on how they will be protected. King County also chose to address significant cultural resources, an optional element of comprehensive plans. The Flood Hazard Management Plan augments the

Comprehensive Plan polices for the protection of frequently flooded areas and floodplain management. The *2012 King County Comprehensive Plan* includes the following policies to guide floodplain management in King County:

- **E-499r** King County's floodplain land use and floodplain management activities shall be carried out in accordance with the King County Flood Hazard Management Plan.

- **E-499s** The existing flood storage and conveyance functions and ecological values of floodplains, wetlands, and riparian corridors shall be protected, and should, where possible, be enhanced or restored.

- **F-286** King County shall participate with cities to prepare, update and implement comprehensive flood hazard management plans that meet or exceed standards established by the National Flood Insurance Program and Washington State Flood Control statues.

- **F-287** King County shall consider equity and social justice in implementing the King County Flood Hazard Management Plan to assure floodplain property owners and residents are given equal access to flood risk reduction services. Outreach should consider vulnerable populations that may face barriers based on age, income, language, race or other factors.

- **F-288** King County shall maintain a regional flood warning program in King County.

- **F-289** King County should continue to assess and revise current flood warning phases based on the most current data on hydrology and climate change predictions and modify the King County Flood Warning Program, as needed, to reflect these revised flood phases.

- **F-290** King County should assess the most appropriate level of service for flood risk reduction along river segments based on existing and predicted development density, land use, and hydrologic conditions.

- **F-291** King County will review available information on the potential impacts of climate change on winter floods, and consider those potential impacts when updating the flood risk reduction policies and capital improvement projects for the King County Flood Hazard Management Plan.

- **F-293** King County shall continue to work with the U.S. Army Corps of Engineers, the Puget Sound Partnership, and other regional partners to develop a science-based vegetation management framework that provides for safe and effective levees, functional riparian habitat, and cost-effective use of limited resources.

- **F-294** King County will assess participation in the U.S. Army Corps of Engineers P.L. 84-99 Program to ensure compliance with the National Marine Fisheries Services Biological Opinion on the Federal Emergency Management Agency (FEMA) National Flood Insurance Program standards for levee vegetation, as well as cost-effective maintenance and repair of levees.

- **F-295** King County will maintain compliance with the National Flood Insurance Program by:

    a. Assessing the projects and programmatic actions recommended in the King County Flood Hazard Management Plan for compliance with the Biological Opinion prepared for the Program; and

    b. Making necessary amendments to the Plan and its implementing development regulations.

- **F-296** King County will work cooperatively with the King County Flood Control District, cities and other stakeholders to implement the Flood Hazard Management Plan to protect public safety, prevent property damage, and help protect the greater King County economy.

- **F-297** Consistent with guidance from FEMA and the USACOE, King County's risk reduction strategies should focus first on risk avoidance, followed by actions intended to reduce vulnerability in at risk areas. New levees and other flood facilities should be the last rather than the first line-of-defense.

- **F-298** King County shall continue to promote the purchase of flood insurance to businesses located within the floodplain, including those businesses located behind accredited levees, to protect the economic value of the business and reduce the vulnerability to the region's economic activity from a larger but less frequent flood event.

- **F-299** King County should continue to discourage new, at-risk development in mapped flood hazard areas.

- **F-299a** King County should seek to site new critical public facilities outside of the 500-year floodplain.

- **F-299b** The county should work with cities, businesses, and landowners to evaluate the alternatives for levee setbacks that would provide a higher level of risk reduction, reduce long-term maintenance costs, and enhance habitat while promoting long-term economic resilience and vitality.

- **S-406** The King County Shoreline Master Program will rely on the policies and programs established in the King County Flood Hazard Management Plan and flood hazard regulations to meet the requirements of the Shoreline Management Act and the Department of Ecology's guidelines for flood hazard reduction.

KING COUNTY CODE (K.C.C.)

Title 9 (Surface Water Management)

K.C.C. Title 9 is the County's Surface Water Management code and supplements the *King County Surface Water Design Manual* and basin plans, which are adopted in K.C.C. Title 20. Title 9 is divided into five primary sections: Surface Water Runoff Policy; the Surface Water Management Program; Water Quality; Groundwater Protection; and Fertilizers. Title 9 has been adopted to be consistent with and implement Comprehensive Plan policies, which have been adopted in accordance with Chapter 36.70A RCW, Growth Management.

Title 16 (Building and Construction Standards)

K.C.C. Title 16 is the County's building and construction standards code. King County has adopted the International Building Code, the International Residential Code, the International Property Maintenance Code, the International Mechanical Code and the International Security Code. These International codes have all been amended by the State of Washington for application in the state, including amendments to assure compliance with the Washington State floodplain management regulations. King County has made additional amendments to these codes for application within the County to assure that the County's higher regulatory floodplain standards are maintained. Those sections of the International Codes that are inconsistent with state or local regulations have either not been adopted or have been amended.

Title 20 (Planning)

K.C.C. Title 20 is the County's planning code and is the title that adopts the county's Comprehensive Plan for compliance with the Growth Management Act. K.C.C. 20.12.480 adopts the King County Flood Hazard Management Plan as a functional plan to guide flood hazard management in King County. Other relevant sections of Title 20 include Chapter 20.62, Protection and Preservation of Landmarks, Landmark Sites and Districts, established a system for designation of significant cultural resources as County landmarks to be protected through a special design review and approval process. K.C.C. 20.62.150 requires review of private and public projects that may affect cultural resources. K.C.C. chapter 20.44 is the county's environmental procedures and establises regulations for implementing the Washington State Environmental Policy Act (Chapter 43.21C RCW) in King County.

Title 21A (Zoning and Shoreline Management)

K.C.C. Title 21A is the County's zoning code and contains the majority of the development regulations for construction within floodplains. K.C.C. chapter 21A.06 contains definitions of terms used in the zoning code. The floodplain development regulations are located within K.C.C. chapter 21A.24, Critical Areas. King County's Shoreline Management Master Program, adopted in 1975 and updated in 2011, inventoried and designated shoreline environments based on natural characteristics, developed policies for activities and uses within each designation. Regulations implementing the shoreline policies are codified in K.C.C. chapter 21A.25. All activities implementing the River and Floodplain Management Program must be in compliance with the Shoreline Master Program and shoreline regulations in K.C.C. chapter 21A.25. The zoning code is enacted to be consistent with and implement the Comprehensive Plan in accordance with chapter 36.70A RCW, Growth Management.

Title 23 (Code Compliance)

The purpose of this Title 23 is to identify processes and methods to encourage compliance with county laws and regulations that King County has adopted pursuant to the Washington Constitution and other state laws to promote and protect the general public health, safety and environment of county residents. This title declares certain acts to be civil violations and establishes non-penal enforcement procedures and civil penalties. This title also declares certain acts to be misdemeanors. The regulations adopted by the County for development within floodplain are enforced by this Title.

APPENDIX C.
KING COUNTY FLOOD RISK ASSESSMENT

This Appendix is a substitute for and replaces Appendix C of the 2006 Flood Plan.

INTRODUCTION

The King County Flood Risk Assessment is used to determine potential losses from a flood event in terms of life, property, economy and environment. The assessment required the systematic use of all available information to determine how each flood hazard may affect King County, how often flood events can occur and the potential severity of their consequence. The information in this risk assessment was used in development of the *2013 Flood Hazard Management Plan* to support the decision-making process. Three steps were used in generating this analysis:

- Identify the flood hazard
- Determine impacts of the flood hazard
- Analyze vulnerability.

The Disaster Mitigation Act of 2000 is federal legislation that emphasizes planning for disaster events before they occur. It addresses local and state mitigation planning and requires that plans be completed before Hazard Mitigation Grant Program funds are available to communities. This is intended to reduce the risk of repetitive disaster damage on communities and establish long-term solutions to impacts from disasters. The Disaster Mitigation Act requires a local government to assess its risk from natural hazards that may impact it. Creation of this risk assessment completes this task for the flood hazard.

Planning Context

The risk assessment is a key element of the overall planning process prescribed by programs such as the Disaster Mitigation Act, the Community Rating System, the Flood Mitigation Assistance Grant Program, and the Washington State Flood Control Account Assistance Program. This process provides a loss estimation that identifies the effects of the flood events in monetary terms. The loss estimation informs the public, policy-makers and decision-makers about the tangible effects of disaster events on communities. The risk assessment can identify specific issues that will help determine areas that should be focused on and provide information to aid policy makers in comparing benefits and costs of possible mitigation strategies and establishing priorities for those strategies. The information used in the preparation of this risk assessment was the best available at the time of this assessment.

Methodology

The risk assessment was developed with guidance provided in the Federal Emergency Management Agency's (FEMA's) local mitigation planning guide, *Understanding Your Risks, Identifying Hazards and Estimating Losses* and Section 510 of the 2007 Community Rating System Coordinator's Manual. The assessment augments information provided in the main body of the Plan to ensure that programmatic requirements prescribed under federal and state planning programs are met. Specifically, it addresses the following planning requirements:

- **Identify the flood hazard**—A detailed description of the extent and location of flooding by basin is presented in Chapter 5 of the Plan.
- **Profile the flood hazard**— The risk assessment performed for each basin is reach-based, segregating each basin into segments with similar flood-related characteristics, such as land

use, geomorphology or hydrology. Profiling the flood hazard was determined with the following information:

- **Past Events**—This provides detailed information, where available, on past flood events, including dollar estimates of losses.
- **Flood Characteristics**—Flood characteristics are analyzed in two categories. Basin flow characteristics describe drainage, the 100-year flood flow at various gage stations and the flow for the flood of record. Basin flood characteristics describe land use, estimated depth of flooding, presence of channel migration zones as defined by King County and estimated warning time by reach. Land use by reach is evaluated in terms defined by the King County Comprehensive plan.

- **Vulnerability Analysis**—Vulnerability was determined using Geographic Information System (GIS) overlays of the King County floodplain and anecdotal information from County, state and other public sources. Vulnerability from flooding was analyzed based on impacts on life, safety and health, structures, natural and environmental areas, future development and economic areas.
  - **Public Health and Safety**—This is a discussion of how flooding affects public health and welfare. This is defined in terms of regulated floodplain area and length of unmapped floodplain.
  - **Critical Facilities**—This identifies the critical facilities and infrastructure that are vulnerable to flooding, using GIS overlays and anecdotal information.
  - **Land Use and Structures and estimated losses from a 100-year flood**—FEMA's HAZUS-MH GIS model together with King County data was used to determine the estimated number of exposed buildings, value of exposed buildings and the value of buildings contents. . The model also produced the value of the structure damage and content damage from a 100-year flood event.
  - **Environment**—An ecological review of each basin is presented in Chapter 5 of the Plan.
  - **Development Trends**—This is a description of likely development that will occur in the future.
  - **Economy—**This consists of a very brief discussion of what drives the economy in the basin and what is vulnerable to flooding. A more thorough analysis was completed in 2007 by ECONorthwest under contract by King County titled Economic Connections Between the King County Floodplains and the Greater King County Economy. For this risk assessment, an anecdotal approach was used to evaluate the economic impact of flooding in each basin. This evaluation was based primarily on historical flooding in the basin. The following classifications of potential impacts were assigned for planning purposes:
    - *Significant Impact*—Flooding in the basin would have a major countywide economic impact.
    - *Moderate Impact*—Flooding in the basin would have an economic impact on citizens in the basin, but not severely impact the countywide economy.
    - *Minimal Impact*—Flooding in the basin would not cause significant economic impact in the basin or countywide.
  - **Repetitive Loss**—This summarizes all properties in the basin that have repeatedly been flooded, as identified by FEMA.

Data Sources

The risk assessment was developed based on existing information from various sources, including several planning documents King County has developed. A large part of the analysis required the use of data from King County's GIS system. Other technical information, including river flow data, was taken from data developed by the U.S. Geological Survey (USGS). The outputs generated for this risk assessment represent those generated from FEMA's HAZUS-MH loss estimation tools and planning guidance.

Insurance Analysis

A Countywide flood insurance policy analysis was performed to identify the geographic distribution of policies and to assist in locating areas with the most severe flood impacts. Geographic clusters of policies are a good indicator of the actual and perceived threat of flooding in a given area. Policy holders are scattered throughout King County in both floodplain and non-floodplain areas. Not surprisingly, clusters of policies are located in areas where severe flooding has been observed in the past. Areas of unincorporated King County show a higher density of policy holders than adjacent incorporated areas with similar flooding characteristics. Unincorporated King County policy holders are eligible for a 40% discount due to the County's participation in the CRS program. This discount is thought to provide a significant incentive to property owners to purchase a flood insurance policy.

Repetitive Loss Properties

Repetitive loss properties require special attention in terms of flood mitigation planning. A repetitive loss property as defined by FEMA is a property insured under the National Flood Insurance Program that, since 1978 and regardless of changes in ownership during that period, has experienced any of the following:

- Four or more paid losses in excess of $1,000
- Two paid losses in excess of $1,000 within any rolling 10-year period since 1978
- Three or more paid losses that equal or exceed the current value of the insured property.

The main identifiers for repetitive loss properties are the existence of flood insurance policies and claims paid by those policies. The Community Rating System program, which King County is a part of, requires that repetitive loss properties be identified. A repetitive loss area is the portion of a floodplain where buildings that meet FEMA's definition of repetitive loss properties are clustered together.

Repetitive loss data is compiled by Insurance Services Office, a private company under contract with FEMA that collects statistical data, promulgates rating information, develops standard policy forms, and files information with state regulators on behalf of insurance companies that purchase its services. Insurance Services Office provides data annually to communities on the number of repetitive loss properties located within their jurisdictions. Repetitive loss data is an indication of the severity of flooding within communities, but can also be misleading because it is based on properties that are covered by a flood insurance policy. For communities where levees are not recognized as sufficient to contain the 100-year flood, the areas behind the levees are mapped as floodplain and mandatory flood insurance purchase requirements apply. FEMA has been updating flood insurance rate maps that in some areas will not recognize many levees previously recognized as containing the 100-year flood, thus expanding the mapped floodplain and increasing the mandatory flood insurance purchase requirements. Consequently some of the communities with new mapping could see an increase in the number of repetitive loss properties over time. In addition, the threshold for classifying a property as a repetitive loss property is very low and even small flood insurance claims can quickly exceed the repetitive loss threshold. Table 1 shows the number of mitigated and unmitigated repetitive loss properties in King County.

TABLE 1.
REPETITIVE LOSS PROPERTIES IN KING COUNTY

Jurisdiction	Number of Repetitive Loss Properties
Bellevue	2
Burien	7
Issaquah	17
Kenmore	3
Kent	1
Unincorporated King County	171
Kirkland	1
Lake Forest Park	1
Mercer Island	1
Normandy Park	1
North Bend	4
Sammamish	1
Seattle	7
Shoreline	3
Skykomish	1
Snoqualmie	172
Total	**393**

Data provided by Insurance Services Office

How to Use This Risk Assessment

This risk assessment is organized by drainage basin within King County. This follows the approach the County uses in the management of its floodplains, and thus better enables this assessment to provide the degree of information necessary to augment the County's floodplain management activities. The risk assessment methodology was followed for each of the following basins:

- South Fork Skykomish River Basin
- Snoqualmie River Basin
- Sammamish River Basin
- Cedar River Basin
- Green River Basin
- White River Basin

Basin specific information is analyzed for each of these basins in the following sections.

SOUTH FORK SKYKOMISH RIVER BASIN PROFILE

The South Fork Skykomish River basin lies predominantly in the northeast portion of King County and is a part of Water Resource Inventory Area 7. The King County portion of the basin drains 234 square miles of mountainous terrain within the forest production zone and Alpine Lakes Wilderness Area. Major tributaries within King County include the Foss, Tye, Miller, and Beckler Rivers.

Hazard Profile

Past Events

Table 2 summarizes the history of flood events for the South Fork Skykomish River Basin since 1990. Peak flows are listed in cubic feet per second (cfs). The most severe recent flood event was the January 2011 flood. The flow data used is collected in the Snohomish County portion of the Skykomish River. Most of the data in Table 2 is from gage data collected in Snohomish County.

TABLE 2.
SOUTH FORK SKYKOMISH BASIN FLOOD EVENT HISTORY

Date of Flood	Declaration (yes/no) #	Peak Flow (cfs)[a]	Type of Damage	Estimated Cost
11/26/1990	Yes/#883	102,000	Overbank flooding causing damage to both public and private property. Stream bank erosion.	$1.4 million for entire County
02/19/1995	No	44,100	Overbank flooding. No significant property damage reported	No information available
12/03/1995	Yes/#1079	79,600	Overbank flooding causing damage to both public and private property. Levee damage.	$ 1,141,498 in public property damage
02/10/1996	Yes/#1100	74,400	Overbank flooding causing damage to both public and private property. Stream bank erosion. Levee damage.	$215,142 in public property damage
10/20/2003	Yes/#1499	86,500	Private property damage only.	No information available
11/06/2006	Yes/#1671	129,000	Stream bank erosion. Levee/revetment damage.	$5,386,323 in public property damages county-wide
12/1/2007	Yes/#1734	N/A	No reported damages to river flood protection infrastructure	$5,123,841 in public property damages countywide
01/08/2009	Yes/#1817	74,000	No reported damages to river flood protection infrastructure	$16,444,775 in public property damages countywide
01/17/11	Yes/#1963	63,900	Miller River channel shift caused portion of Old Cascade Highway to washout, roadway remains impassable. Damage to river flood protection infrastructure.	No information available
1/14/2012	Yes/#4056	N/A	Information not yet available	No information available

a. Flow estimates based on USGS #12134500

Flood Characteristics

Tables 3 and 4 summarize observed flooding characteristics typical for this basin. Understanding the potential flood conditions for a specific area enables the County to identify mitigation alternatives appropriate for the level of risk for that stream or reach. Observed flooding depths for this basin vary from less than 1 foot to 6 feet. King County considers the South Fork Skykomish River to have channel migration potential, and regulates this region under the channel migration zone provisions of the King County Critical Areas Ordinance.

King County does not have a four phase flood warning system on the South Fork Skykomish River System. Snohomish County operates a stage only gage located on the bridge in the Town of Skykomish that provides flood warning information for Snohomish County and a limited area within King County. The USGS's only available flow data is collected near the City of Goldbar in Snohomish County, which is significantly downstream from hazard areas in King County. The available data is not useful for providing flood warning to residents in these areas.

TABLE 3.
SOUTH FORK SKYKOMISH RIVER BASIN FLOW CHARACTERISTICS

Gage Location	USGS Station Number	USGS River Mile	Drainage Area (square miles)	100-Year Flood Flow (cfs)	Flood of Record, Date & Peak Flow (cfs)
Goldbar	12134500	43.0	535	119,300	11/06/2006; 129,000 cfs

TABLE 4.
SOUTH FORK SKYKOMISH RIVER BASIN FLOOD CHARACTERISTICS

Reach	Land Uses Surrounding the Reach	Depth of Flooding	Mapped Channel Migration Zone (yes/no)	Approximate Warning Time
South Fork Skykomish	Clustered residential, National Forest.	0 - 6 Feet	No	No Warning Time

Vulnerability Analysis

Public Safety and Health

Flooding in the South Fork Skykomish River basin has a variety of potential impacts on life, safety and health. Very few lives have been lost, but damage and disruption caused by flooding have been significant. The South Fork Skykomish River is generally clean and free-flowing, with a very steep gradient and numerous rock cascades of white water in the King County portion. The steep gradient produces deep and high velocity flows that can be extremely dangerous for public health and safety. Several small communities have development within the floodplain, and deep flooding over State Route 2 has the potential to isolate these communities from the rest of the county.

There are many miles of small streams with unmapped floodplain within the South Fork Skykomish River basin. Since there is no mapped floodplain in these areas, the risk of flooding to the public may be more significant during severe events and may need to be monitored closely. This is especially true for communities having ingress and egress on only one road.

Critical Facilities

Critical facilities in the South Fork Skykomish River basin were identified using GIS and anecdotal information. For purposes of this document, critical facilities are identified in two categories: 1) facilities and infrastructure that are critical to public health and welfare that are especially important following a flood event; and 2) facilities and infrastructure that are critical to King County for floodplain management (roads, dams, etc.).

Table 5 lists the critical facilities in the South Fork Skykomish River basin. All of these facilities are considered to be vulnerable to the impacts of flooding. The degree of vulnerability for the public health and safety facilities identified in Table 5 varies. King County has established policies in both its Regional Hazard Mitigation Plan and the *Flood Hazard Mitigation Plan* to proactively mitigate impacts on identified critical facilities when opportunities arise. Several of the facilities listed in Table 5 are not under County ownership. The County will work with all agencies involved to achieve this objective.

TABLE 5.
CRITICAL FACILITIES IN THE SOUTH FORK SKYKOMISH BASIN

Facility or Infrastructure	Owner	Location (River Mile)	Public Health & Safety	Flood Protection Infrastructure
Skykomish Police Substation	Town of Skykomish	16	X	
City Hall	City of Skykomish	16	X	
Skykomish K to 12 School	Skykomish School District	15.8	X	
Levee (Town of Skykomish left bank)[a]	King County	15.9		X
Fire Station 1	City of Skykomish	15.9	X	X
Railroad Line and Bridges	Burlington Northern	Length	X	
State Route 2 and bridges	Washington State	Full length		X

a. This is a training levee that protects the school

Land Use, Structures and Estimated Losses from a 100-Year Flood Event

The predominant land use in the South Fork Skykomish basin is forest use. Fifty percent of the basin is protected wilderness; 43 percent is zoned for forest production; 6 percent is in rural residential use; and approximately 1 percent is in urban use (King County 2002c). Development in the basin has been limited, but much of it has occurred in the floodplain. There are several developments in the Town of Skykomish, the unincorporated communities of Grotto and Baring and scattered residential subdivisions. During the November 1990 flood event, several riverfront homes were affected by severe bank erosion (King County 1993b).

A floodplain study of the South Fork Skykomish was completed in 1998. The total area of regulatory floodplain for the South Fork Skykomish River basin includes all portions of the FEMA flood zones and King County's regulatory floodplain and floodway map, which includes most current floodplain studies. A channel migration study is in progress for portions of the South Fork Skykomish River. Approximately 94 percent of the South Fork Skykomish River basin regulatory floodplain is in unincorporated King County. Table 6 shows the area of regulatory floodplain.

Within the South Fork Skykomish River basin floodplain there are a total of 735 parcels. This is approximately 12 percent of the total number of parcels in King County floodplains (6,250). There are 407 structures at risk from flooding on these parcels.. The depth of flooding varies with location.

TABLE 6.
SOUTH FORK SKYKOMISH RIVER BASIN AREA OF REGULATORY FLOODPLAIN WITHIN KING COUNTY

	Area of Regulatory Floodplain (acres)
Unincorporated King County	1,856
Incorporated Areas	113
Total	**1,969**

Development Trends

The South Fork Skykomish River basin has maintained a rural land use environment. Significant development has not and likely will not occur in this area because a large portion of it is protected wilderness area and forest production area. Future land use is projected to be similar to current land use conditions. Only a small increase in households is projected for the 2001 through 2022 planning period (King County 2004). Table 7 summarizes estimated flood loss potential in the South Fork Skykomish River Basin's 100-year floodplain.

TABLE 7.
ESTIMATED LOSSES FROM A 100-YEAR FLOOD EVENT IN THE SOUTH FORK SKYKOMISH RIVER BASIN

Area of Floodplain (acres)	962
Buildings Exposed	304
Structure Value Exposed	$51,583037
Content Value Exposed	$36,457,868
Total Value Exposed (Structure & Contents)	**$88,040,904**
Structure Damage	$3,105,745
Content Damage	$5,837,718
Non-Residential Inventory Damage	$0
Total Damage (Structure, Contents & Inventory)	**$8,943,463**

Source: Hazards U.S. - Multi-Hazard (HAZUS-MH) Model for King County, WA (2012)

Economic Impact

Based on existing land use and past experience, flooding along the South Fork of the Skykomish River would have nominal economic impact within the basin, due primarily to the lack of significant population density within the basin. There are no major employment centers in this basin, but the loss of use of transportation corridors to major employment centers elsewhere in the County could have some economic impact within the basin. Due to the low population density, this potential impact is not considered significant. No detailed analysis of this potential impact was performed under this risk assessment. For planning purposes, King County considers the possible economic impact of typical flooding in this basin to be minimal.

Repetitive Loss Areas

There are eleven repetitive loss properties in the South Fork Skykomish River basin, three of which has been mitigated, as summarized in Table 8. Four of the unmitigated properties are located near Baring, Washington, and the remaining four are scattered along the length river. All of these parcels are single-family residences located in the floodway, and it is concluded that the cause of repetitive flooding for all of them is overbank riverine flooding, as reflected by the mapping for the basin.

TABLE 8.
UNMITIGATED REPETITIVE LOSS PROPERTIES IN THE SOUTH FORK SKYKOMISH BASIN[a]

Number of Parcels	Total Area (acres)	Total Land Value	Total Improvement Value
8	1.98	$199,000	$566,000

a. Table includes unincorporated King County data only.

SNOQUALMIE RIVER BASIN PROFILE

The Snoqualmie River basin covers northeast King County and drains to the Snohomish River and ultimately to Puget Sound. It is a part of Water Resource Inventory Area 7. The watershed includes the Tolt River, Raging River, Miller River, Tokul Creek, Griffin Creek, Harris Creek, Patterson Creek, and other tributaries.

Hazard Profile

To provide additional detail of the characteristics of flooding in Snoqualmie Basin, the analysis is separated into twelve reaches:

- North Fork headwaters to confluence
- Middle Fork headwaters to confluence
- South Fork headwaters to confluence
- Snoqualmie Forks confluence to Snoqualmie Falls
- Snoqualmie Falls to Fall City
- Snoqualmie at Fall City
- Patterson Creek to Tolt River
- Snoqualmie at Carnation
- Chinook Bend to County Line
- Tolt
- Raging
- Patterson Creek

Past Events

Table 9 summarizes the history of flood events for this basin since 1990. The most severe recent flooding event was the January 2009 flood. There has been millions of dollars worth of damage in the Snoqualmie River basin as result of flood events.

TABLE 9.
SNOQUALMIE RIVER BASIN FLOOD EVENT HISTORY

Date of Flood	Declaration (yes/no) #	Flood Phase/ Peak Flow (cfs)	Type of Damage	Estimated Cost
01/10/1990	Yes/#852	4/48,522	Overbank flooding causing damage to both public and private property. Channel avulsion.	$4.9 million for entire county
11/1990	Yes/#883	4/50,100	Overbank flooding causing damage to both public and private property. Channel avulsion.	$5.6 million for entire county
11/7/1995	Yes/#1079	4/49,350	Overbank flooding causing damage to both public and private property. Channel avulsion.	$ 683,612 in public property damage
01/1996	Yes/#1100	4/44,430	Overbank flooding causing damage to both public and private property. Channel avulsion.	$1,598,304 in public property damage
01/1997	Yes/#1159	3/>20,000	Overbank flooding causing damage to both public and private property. Channel avulsion.	No information available
03/1997	Yes/#1172	3/>20,000	Overbank flooding causing damage to both public and private property. Channel avulsion.	$647,005
10/1997	No	3/>20,000	No significant damage reported to public or private property.	No information available
11/1999	No	4/>38,000	Overbank flooding. No major damage to public or private property reported	No information available
12/2000	No	3/>20,000	No significant damage reported to public or private property.	No information available
01/2003	No	3/>20,000	No significant damage reported to public or private property.	No information available
03/2003	No	3/>20,000	No significant damage reported to public or private property.	No information available
10/21/2003	Yes/#1499	3/32,700	Overbank flooding causing damage to both public and private property. Channel avulsion.	Individual assistance only; approximately $68,748 countywide
11/06/2006	Yes/#1671	4/53,500	Overbank flooding causing damage to both public and private property. Channel avulsion.	$5,386,323 in public property damages county-wide
12/1/2007	Yes/#1734	N/A	No reported damages to river flood protection infrastructure	$5,123,841 in public property damages county-wide
1/07/2009	Yes/#1817	4/54,110	Overbank flooding causing damage to both public and private property. Channel avulsion.	$16,444,775 in public property damages county-wide
1/16/2011	Yes/#1963	3/34,740	Overbank flooding causing damage to both public and private property. Channel avulsion.	No information available
1/14/2012	Yes/#4056	N/A	Information not yet available	No information available

Flood severity is identified in terms of phases. Table 9 shows events that reached Phase 3 or above. Below are the phases of flooding for the Snoqualmie River.

- Phase 1—The flow is greater than 6,000 cfs and is considered an internal alert to the King County Flood Warning Center.
- Phase 2—The flow is greater than 12,000 cfs and lowland flooding will occur. Several roads will be overtopped or closed (Neal Road, SE Reinig Road, West Snoqualmie River Road NE, Snoqualmie Meadowbrook Road, and Mill Pond Road).
- Phase 3—This is considered moderate flooding and exhibits flows greater than 20,000 cfs. Flooding of varied depth will occur in the entire Snoqualmie area. Fall City-Carnation Road, Tolt Hill Road and Novelty Flats Road will be overtopped or closed.
- Phase 4—This is extreme flooding. Flow is greater than 38,000 cfs and some residential areas may experience dangerous high velocities and flooding of homes. Roads that may be overtopped or closed are Woodinville-Duvall Road, State Route 203 between Duvall and Carnation, Moon Valley Road, and South Fork Road.

Flood Characteristics

Tables 10 and 11 summarize observed flooding characteristics typical for this basin. These tables reflect the range of flood conditions by identifiable reach or stream for planning purposes only. Understanding the potential flood conditions for a specific area enables the County to identify mitigation alternatives appropriate for the level of risk for that stream or reach. Flood depths in this basin can vary from less than 1 foot to 6 feet, with significant velocities depending on extent and location within the basin.

TABLE 10.
SNOQUALMIE RIVER BASIN FLOW CHARACTERISTICS

Gage Location	USGS Station Number	USGS River Mile	Drainage Area (square miles)	100-Year Flood Flow (cfs)	Flood of Record, Date & Peak Flow (cfs)
North Fork	12142000	9.2	64.0	18,000 *a*	01/07/2009; 17,000 cfs
Middle Fork	12141300	55.6	154.0	37,100 *a*	11/06/2006; 31,700 cfs
South Fork	12143400	17.3	41.6	11,000 *a*	11/06/2006; 8,910 cfs
Snoqualmie @ Snoqualmie	12144500	40.0	375	79,100 *b*	11/24/1990; 78,800 cfs
Snoqualmie @ Carnation	12149000	23	603.0	91,800 *b*	01/08/2009; 82,900 cfs
Raging @ Fall City	12145500	2.75	30.6	6,970	11/24/1990; 6,220 cfs
North Fork Tolt	12147500	11.7	39.9	11,200 *a*	12/15/1959; 9,560 cfs
South Fork Tolt	12148000	6.8	19.7	8,720 *a*	12/15/1959; 6,500 cfs
Tolt @ Carnation	12148500	8.7	81.4	18,800	12/15/1959; 17,400 cfs

a. Based on USGS data through 2007. See Chapter 4, Section 4.1 for further discussion on derivation of flood frequencies.
B. Flow estimates based on hydrologic analysis for the Lower Snoqualmie and Skykomish River Revised Flood Insurance Study (2007).

TABLE 11.
SNOQUALMIE RIVER BASIN FLOOD CHARACTERISTICS

Reach	Land Uses Surrounding the Reach	Depth of Flooding	Mapped Channel Migration Zone (yes/no)	Approximate Warning Time
North Fork headwaters to confluence Middle Fork headwaters to confluence South Fork headwaters to confluence Snoqualmie Forks confluence to Snoqualmie Falls	Mixed land use. Commercial, Industrial, Residential. Urban area land uses from the Cities of North Bend and Snoqualmie. Upper areas of this reach predominately national forest.	6 feet or greater with measurable velocity	Yes	2-4 hours
Snoqualmie Falls to Fall City & Snoqualmie at Fall City	Urban residential, light commercial, agricultural	6 feet or greater with measurable velocity	No	4 hours
Raging River	Rural Residential, National Forrest	Shallow Flooding 0-6 feet, with measurable velocity	Yes	No Warning
Patterson Creek to Tolt River & Snoqualmie at Carnation	Mixed land use. High density residential, commercial, industrial and agricultural	Shallow Flooding 3-6 feet	No	12+ hours
Tolt River	Rural residential, agricultural, National Forrest	Shallow Flooding 0-6 feet, with measurable velocity	Yes	2 hours
Chinook Bend to County Line	Agricultural and open space uses	6 feet or greater with measurable velocity	No	24 hours

Vulnerability Analysis

Public Safety and Health

Flooding in the Snoqualmie River basin has a variety of potential impacts on life, safety and health. Very few lives have been lost, but damage and disruption caused by flooding have been a recurrent problem.

The Cities of Snoqualmie and North Bend have been urbanizing since 1980. Significant growth is expected throughout the basin. Between 1980 and 1999, the population in the basin went from approximately 20,000 to approximately 38,000 (King County 2002c). The Puget Sound Regional Council predicts that the population in the Snoqualmie basin will grow from its current estimated level of approximately 40,000 to over 70,000 residents by 2020 (King County 2001).

There are many miles of unmapped floodplain along small streams in the Snoqualmie River basin. The risk of flooding to the public may be more significant in these areas during severe event, requiring close monitoring.

Critical Facilities

Critical facilities in the Snoqualmie River basin were identified using GIS. For purposes of this document, critical facilities are identified in two categories: 1) facilities and infrastructure that are critical to public health and welfare that are especially important following a flood event; and 2) facilities and infrastructure that are critical to King County for floodplain management (roads, dams, etc.).

Table 12 lists the critical facilities in the Snoqualmie River basin. All of these facilities are considered to be vulnerable to the impacts of flooding. The degree of vulnerability for the public health and safety facilities identified in Table 12 varies. King County has established policies in both its Regional Hazard Mitigation Plan and the *Flood Hazard Management Plan* to proactively mitigate risks to identified critical facilities when opportunities arise. Several of the facilities listed in Table 12 are not under County ownership. The County will work with all agencies involved to achieve this objective.

Critical facilities can also include critical infrastructure, such as roads whose closure could cause isolation and evacuation problems during flood events. Isolation is a key issue for flood preparedness and response in this basin. King County has determined that the following major roadways and stream crossings (bridges or culverts) would be impassable during a 100-year flood event:

- Neal Road
- SE Reinig Road
- West Snoqualmie River Road NE (Walker Road)
- Snoqualmie Meadowbrook Road
- Mill Pond Road.
- Fall City-Carnation Road
- Tolt Hill Road.
- Novelty Flats Road.
- Woodinville-Duvall Road
- SR 203 between Duvall and Carnation
- Moon Valley Road, South Fork Road

Land Use, Structures and Estimated Losses from a 100-Year Flood Event

The major portion of the Snoqualmie River basin floodplain is in unincorporated King County, with small but significant portions in the cities of North Bend, Snoqualmie, Duvall and Carnation. Development throughout the incorporated portions of the Snoqualmie River floodplain is mainly commercial and residential. Agricultural and residential development predominates in unincorporated King County along the lower and upper portions of the river.

King County regulatory floodplain mapping shows 21,489 acres of mapped floodplain in the Snoqualmie River basin. This includes the Raging and Tolt River, the three Forks of the Snoqualmie River and the mainstem of the Snoqualmie River. A floodplain study of the mainstem of the Snoqualmie River was completed in 2006 and included in the FEMA Preliminary Digital Flood Insurance Rate Maps. Studies and new floodplain boundaries for the Forks and the Raging and Tolt Rivers were completed during the past 20 years.

Approximately 86 percent of the Snoqualmie River basin regulatory floodplain is in unincorporated King County. Table 13 shows the area of regulatory floodplain.

TABLE 12.
CRITICAL FACILITIES IN THE SNOQUALMIE RIVER BASIN

Facility or Infrastructure	Owner	Location (River Mile)	Public Health & Safety	Flood Protection Infrastructure
Snoqualmie City Hall	City of Snoqualmie	39.8	X	
North Bend City Hall	City of North Bend	South Fork—2.5	X	
North Bend Elementary	North Bend	South Fork—2.5	X	
Two Rivers High School	Snoqualmie Valley	South Fork—2.5	X	
Administration/Transportation (Snoqualmie Valley)	Snoqualmie Valley	39.7	X	
Mt. Si High School	Snoqualmie Valley	40.1	X	
Snoqualmie Elementary	Snoqualmie Valley	40.3	X	
Snoqualmie Middle School	Snoqualmie Valley	40.2	X	
Wastewater Treatment Plant	North Bend Treatment Plant	North Fork—2.4	X	
Wastewater Treatment Plant	Snoqualmie Treatment Plant	38.8	X	
Police Department	City of North Bend	South Fork—1.4	X	
State Patrol District 2 North Bend Detachment	City of North Bend	South Fork—2.5	X	
Fire Station 87	Fire District 38—North Bend	South Fork—2.5	X	
Snoqualmie Fire Department	Snoqualmie	39	X	
Tolt River Dam	City of Seattle	South Fork Tolt – 8.5	X	X
S. Fork Levee at N. Bend	King County	South Fork - 2.0-3.0		X
Tolt River levee @ Carnation	King County	Tolt– 0.0-1.0		X
Raging River Levee @ Fall City	King County	Raging -- 0.0-1.0		X
Wastewater Treatment Plant	City of Carnation	23.2	X	

TABLE 13.
SNOQUALMIE RIVER BASIN AREA OF REGULATORY FLOODPLAIN

	Area of Regulatory Floodplain (acres)
Unincorporated King County	18,499
Incorporated Areas	2,990
Total	**21,489**

Approximately 75 percent of the Snoqualmie basin is in the forest production district. Most of the Snoqualmie River floodplain below Snoqualmie Falls is within the agricultural production district. As timber harvesting in the basin has decreased, the timber companies have been slowly selling off their land. Much of that land could be developed, but there have been some efforts to conserve it. The potential for high density development in incorporated areas is increased by the presence of vested lots and plats.

Within the Snoqualmie River basin floodplain there are a total of 2,415 parcels with structures. This is approximately 40 percent of the total number of parcels with structures in King County floodplains (6,250). The depth of flooding varies depending on location. Table 14 summarizes estimated flood loss potential. Of the 2,415 parcels with structures in the Snoqualmie River basin floodplain, 2,143 are residential structures and 272 are commercial or other designations.

Development Trends

Much of the urbanization of the watershed has been contained in high density incorporated areas. While urban areas constitute only about 3 percent of the total watershed area, they make up a significant portion of some subwatersheds including Coal Creek (50 percent), mainstem Snoqualmie (15 percent), Patterson Creek (10 percent), and Cherry Creek (6 percent). The potential for high density development is increased by the presence of vested lots and plats, particularly in the Patterson and Ames Creeks areas (King County 2002c).

Economic Impact

With the largest floodplain in King County, the Snoqualmie basin has experienced significant economic impact from flooding. Although this basin is not a major employment center although is a significant commercial agricultural community, flooding can have an economic impact on employment for the County because many of the basin's residents are not able to get to work due to road closures and isolation caused by flooding. Functional down time of roads is a major economic factor in this basin. No detailed analysis of this potential impact was performed under this risk assessment. For planning purposes, King County considers the possible economic impact of typical flooding in this basin to be significant.

It is the working assumption of this Plan that cities such as Snoqualmie and North Bend are carefully addressing significant flood-related hazards through coordinated planning efforts. This coordination at a minimum should involve consultations with King County, the Washington Department of Ecology, FEMA, the U.S. Army Corps of Engineers, and other agencies with expertise and responsibility for addressing flooding concerns. It should be carried out in a manner that fully meets state standards for city consistency with County flood hazard planning, as set forth in Chapter 86.12 RCW as administered by the Washington State Department of Ecology.

Repetitive Loss Areas

The Snoqualmie River basin has 128 unmitigated repetitive loss properties. Table 15 summarizes the unmitigated repetitive loss properties in the basin. Of the 92 properties, all but 7 are single-family residential. All but 2 properties lies within a mapped 100-year floodplain, so it is concluded that the main cause of repetitive flooding for this basin is overbank riverine flooding reflected by the mapping for the basin.

TABLE 14.
ESTIMATED LOSSES FROM A 100-YEAR FLOOD EVENT IN THE SNOQUALMIE RIVER BASIN

	North Fork headwaters to confluence	Middle Fork headwaters to confluence	South Fork headwaters to confluence	Snoqualmie Forks confluence to Snoqualmie Falls	Snoqualmie Falls to Fall City	Snoqualmie at Fall City	Patterson Creek to Tolt River	Snoqualmie at Carnation	Chinook Bend to County Line	Tolt	Raging	Patterson Creek	Other areas outside identified subbasins	**Total**
Area of Floodplain (acres)	478	1102	2117	2228	238	2117	2101	2232	7493	638	244	446	55	**21,489**
Buildings Exposed	69	242	906	784	11	70	20	150	55	44	60	4	0	**2,415**
Structure Value Exposed	$13,680,260	$44,783,521	$292,935,946	$245,249,789	$3,581,207	$13,069,496	$4,167,399	$41,798,092	$10,954,349	$6,679,452	$9,981,635	$471,441	0	**$687,352,588**
Content Value Exposed	$6,840,130	$22,850,163	$224,707,347	$199,732,041	$1,790,604	$7,441,333	$2,457,891	$28,913,215	$6,343,098	$3,339,726	$5,088,478	$235,721	$0	**$509,739,747**
Total Value Exposed (Structure & Contents)	**$20,520,389**	**$67,633,684**	**$517,643,294**	**$444,981,831**	**$5,371,811**	**$20,510,829**	**$6,625,291**	**$70,711,307**	**$17,297,447**	**$10,019,178**	**$15,070,113**	$707,162	**$0**	**$1,197,092,335**
Structure Damage	$503,127	$1,713,708	$20,867,127	$26,143,086	$491,247	$1,284,811	$570,181	$2,032,041	$1,903,097	$467,703	$370,202	$24,381	$0	**$56,370,711**
Content Damage	$226,247	$723,904	$27,310,007	$49,348,499	$260,060	$1,533,022	$851,216	$1,568,202	$1,408,337	$211,818	$160,496	$9,051	$0	**$83,610,859**
Non-Residential Inventory Damage	$0	$5,368	$10,865,481	$19,886,476	$0	$326,596	$0	$602,774	$378,300	$0	$6,559	$0	$0	**$32,071,554**
Total Damage (Structure, Contents & Inventory)	**$729,374**	**$2,442,980**	**$59,042,616**	**$95,378,060**	**$751,307**	**$3,144,429**	**$1,421,397**	**$4,203,017**	**$3,689,734**	**$679,521**	**$537,256**	**$33,432**	**$0**	**$172,053,123**

Source: Hazards U.S. - Multi-Hazard (HAZUS-MH) Model for King County, WA (2012)

TABLE 15.
UNMITIGATED REPETITIVE LOSS PROPERTIES IN THE SNOQUALMIE RIVER BASIN[a]

Number of Parcels	Total Area (acres)	Total Land Value	Total Improvement Value
92	225.4	$9,816,900	$13,753,100

a. Table includes unincorporated King County data only.

SAMMAMISH RIVER BASIN PROFILE

The Sammamish River originates at Lake Sammamish and drains a 240-square-mile watershed that includes 97 square miles of the Lake Sammamish basin, 50 square miles in the Bear Creek basin and 67 square miles of the combined Little Bear, North, and Swamp Creek basins.

Hazard Profile

To provide additional detail of the characteristics of flooding in the Sammamish River basin, the analysis of this basin is separated into the following reaches:

- Issaquah Creek Reach—Issaquah Creek headwaters to Lake Sammamish
- Upper Sammamish Reach—Lake Sammamish at Issaquah to River Mile 15.3
- Lower Sammamish Reach—River Mile 15.3 to Lake Washington
- Evans Creek Reach—Evans Creek headwaters to confluence with the Bear Creek in Redmond
- Bear Creek Reach—Bear Creek headwaters to confluence with Sammamish River in Redmond

Past Events

Table 16 summarizes the history of flood events for the Sammamish River basin. The data collected is mainly from Issaquah Creek.

Severity of historical floods is listed in terms of phases in Table 16. Below are the phases of flooding for Issaquah Creek based on the stage (height) of the Issaquah near Hobart gage.

- Phase 1—This is considered an internal alert, stage of 6.5 feet.
- Phase 2—Stage of 7.5 feet.
- Phase 3—This indicates a moderate flooding event, stage of 8.5 feet.
- Phase 4—This is considered extreme flooding, stage of 9.0 feet.

So far, no flood events have surpassing the 100-year flood flow at the Hobart gage.

Flood Characteristics

Tables 17 and 18 summarize observed flooding characteristics typical for this basin. These tables reflect the range of flood conditions by identifiable reach or stream for planning purposes only. Understanding the potential flood conditions for a specific area enables the County to identify mitigation alternatives appropriate for the level of risk for that stream or reach. Table 17 shows events that reached above Phase 3 at the Hobart gage for Issaquah Creek unless otherwise indicated. Warning time estimates were not available for the Sammamish River basin. King County collects real-time gage information on Issaquah Creek. Observed depths of flooding in this basin range from less than 1 foot to 8.5 feet.

TABLE 16.
SAMMAMISH RIVER BASIN FLOOD EVENT HISTORY

Date of Flood	Declaration (yes/no) #	Flood Phase/ Peak Flow (cfs)	Type of Damage	Estimated Cost
12/1/1995	Yes/#1079	4/1,240	Overbank flooding causing both public and private property damage within the Issaquah Creek Basin.	$5.2 million for entire county
02/09/1996	Yes/#1100	4/1,240	Damage include downtown commercial areas and a large number of residential properties along Issaquah Creek. Total flood-related costs were in excess of $3 million ($1.2 million as reported flood insurance claims).	$3 million in the City of Issaquah
01/1997	No	4/1,240	Flooded farmland. No reports of significant public or private property damage.	No information available
11/06/2006	Yes/#1671	4/1,360	No reports of significant public or private property damage.	$5,386,323 in public property damages county-wide
12/1/2007	Yes/#1734	2/744	No reported damages to river flood protection infrastructure	$5,123,841 in public property damages county-wide
1/07/2009	Yes/#1817	3/1,290	No reports of significant public or private property damage.	$16,444,775 in public property damages county-wide
1/16/2011	Yes/#1963	N/A	No reported damages to river flood protection infrastructure	No information available
1/14/2012	Yes/#4056	N/A	Information not yet available	No information available

TABLE 17.
SAMMAMISH RIVER BASIN FLOW CHARACTERISTICS

Gage Location	USGS Station Number	USGS River Mile	Drainage Area (square miles)	100-year Flood Flow (cfs) a, b	Flood of Record, Date & Peak Flow (cfs)
Issaquah Creek @ Mouth	12121600	1.2	55.6	3,960	01/09/1990; 3,200 cfs

a. FEMA 2005.
b. Period of record of USGS gage data used to derive values in table may differ from period of record currently available. See Chapter 4, Section 4.1 for further discussion on derivation of flood frequencies.

TABLE 18.
SAMMAMISH RIVER BASIN FLOOD CHARACTERISTICS

Reach	Land Uses Surrounding the Reach	Depth of Flooding	Mapped Channel Migration Zone (yes/no)	Approximate Warning Time
Issaquah Creek	Urban residential, rural residential, Commercial, agricultural	6-8.5 feet with measurable velocity	No	3-4 Hours[a]
Upper Sammamish	Urban Residential, light commercial	Shallow flooding 0-3 feet	No	No Warning
Lower Sammamish	Agricultural, Recreational/Open Space, Urban residential	Shallow flooding 0-3 feet	No	No Warning
Evans Creek	Rural Residential/Urban Residential	Shallow flooding 0-3 feet	No	No Warning
Bear Creek	Rural Residential/Urban Residential	Shallow flooding 0-3 feet	No	No Warning

a. Flood warning system on Issaquah Creek is operated by the City of Issaquah.

Vulnerability Analysis

Public Safety and Health

Flooding in the Sammamish River basin has a variety of potential impacts on life, safety and health. There are many miles of small streams with unmapped floodplain within the Sammamish River basin. . Since there is no mapped floodplain in these areas, risk of flooding to the public may be more significant during severe events and may need to be monitored closely.

Critical Facilities

Critical facilities in the Sammamish River basin were identified using GIS and anecdotal information. For purposes of this document, critical facilities are identified in two categories: 1) facilities and infrastructure that are critical to public health and welfare that are especially important following a flood event; and 2) facilities and infrastructure that are critical to King County for floodplain management (roads, dams, etc.).

Table 19 shows the critical facilities in the Sammamish River basin. King County has established policies in both its Regional Hazard Mitigation Plan and the *Flood Hazard Management Plan* to proactively mitigate risks to identified critical facilities when opportunities arise. Several of the facilities listed in Table 19 are not under County ownership. The County will work with all agencies involved to achieve this objective.

Land Use, Structures and Estimated Losses from a 100-Year Flood Event

In recent decades, substantial development has occurred in the Sammamish River basin. Extensive commercial and residential developments have been constructed throughout the floodplain. There are also several parks and other recreational facilities. Land uses in the upper 10 miles are mainly recreational and agricultural as well as urban commercial, specifically in the Cities of Redmond and Woodinville. The lower 5 miles include significant residential and commercial developments as well as some open space areas.

TABLE 19.
CRITICAL FACILITIES IN THE SAMMAMISH RIVER BASIN

Facility or Infrastructure	Owner	Location (River Mile)	Public Health & Safety	Flood Protection Infrastructure
Flood Control Weir	Army Corps of Engineers	14.0		X
Redmond City Hall	City of Redmond	11.5	X	
Redmond Police Department	City of Redmond	11.5	X	
Support Service Center	Lake Washington School District	10.8	X	X
Metro Sewer Line[a]	Seattle Metro		X	
Hollywood Pump Station	King County	9.0		X

a. Considered a critical site due to its public health impacts

FEMA and King County floodplain mapping shows 9,524 acres of mapped floodplain in the Sammamish River basin, including Lake Sammamish. The total area of regulatory floodplain for the Sammamish River basin includes all portions of the FEMA flood zones and King County's regulatory floodplain and floodway map, which includes most current floodplain studies. No channel migration area has been mapped in the Sammamish River basin. Approximately 40 percent of the Sammamish River basin regulatory floodplain is in unincorporated King County. Table 20 shows the area of regulatory floodplain.

TABLE 20.
SAMMAMISH RIVER BASIN AREA OF REGULATORY FLOODPLAIN

	Area of Regulatory Floodplain (acres)
Unincorporated King County	3,777
Incorporated Areas	5,747
Total	**9,524**

Within the Sammamish River basin floodplain there are a total of 733 parcels with structures. This is approximately 12 percent of the total number of parcels in King County floodplains (6,250). The depth of flooding varies with location. Table 21 summarizes estimated flood loss potential. Of the 733 parcels with structures in the Sammamish River basin floodplain, 551 are residential and 182 are commercial or other designations.

Development Trends

The Sammamish River basin has been urbanizing rapidly since the 1950s. Future development is expected to continue throughout the Sammamish basin. Bellevue, Issaquah, Kirkland and Redmond have designated potential annexation areas, some of which are within the floodplain.

TABLE 21.
ESTIMATED LOSSES FROM A 100-YEAR FLOOD EVENT IN THE SAMMAMISH RIVER BASIN

	Bear Creek	Evans Creek	Issaquah Creek	Sammamish River	Other areas including Lake Sammamish and Phantom Lake	**Total**
Area of Floodplain (acres)	525	480	1196	2223	5100	**9,524**
Buildings Exposed	34	13	225	166	295	**733**
Structure Value Exposed	$83,464,237	$2,614,373	$138,913,975	$539,865,196	N/A	**$764,857,780**
Content Value Exposed	$70,969,956	$1,307,186	$119,299,933	$552,047,511	N/A	**$743,624,587**
Total Value Exposed (Structure & Contents)	**$154,434,193**	**$3,921,559**	**$258,213,908**	**$1,091,912,707**	**N/A**	**$1,508,482,366**
Structure Damage	$81,347	$84,202	$4,087,671	$20,332,427	N/A	**$24,585,646**
Content Damage	$33,497	$38,966	$4,880,925	$75,601,426	N/A	**$80,554,813**
Non-Residential Inventory Damage	$0	$0	$3,633,380	$71,172,211	N/A	**$74,805,591**
Total Damage (Structure, Contents & Inventory)	**$114,844**	**$123,168**	**$12,601,975**	**$167,106,064**	**N/A**	**$179,946,050**

Source: Hazards U.S. - Multi-Hazard (HAZUS-MH) Model for King County, WA (2012)

Economic Impact

Historically, flooding has caused significant public and private property in the City of Issaquah but not in other cities or in the unincorporated portions of the basin. The February 1996 and January 2009 floods were the most damaging in Issaquah's recent history, and were very similar. These floods impacted both commercial and residential areas, with total flood losses in the millions of dollars. This basin is fairly urbanized, with population centers in the Cities of Issaquah, Redmond, and Bothell. Within these population centers are businesses that employ many of the citizens of King County. However, past history shows that flooding in this basin has not shut down commerce for any prolonged period of time or had any measurable impact on tax base. No detailed analysis of this potential impact was performed under this risk assessment. For planning purposes, King County considers the possible economic impact of typical flooding in this basin to be moderate.

It is the working assumption of this Plan that cities such as Issaquah, Redmond and Bothell are carefully addressing significant flood-related hazards through coordinated planning efforts. This coordination at a minimum should involve consultations with King County, the Washington Department of Ecology, FEMA, the U.S. Army Corps of Engineers, and other agencies with expertise and responsibility for addressing flooding concerns. It should be carried out in a manner that fully meets state standards for city consistency with County flood hazard planning, as set forth in Chapter 86.12 RCW as administered by the Washington State Department of Ecology.

Repetitive Loss Areas

Repetitive loss areas are not numerous in the Sammamish River basin. Table 22 summarizes the repetitive loss properties in the Sammamish River basin. All properties are residential. Two properties are located on Issaquah Creek, but they are not clustered together. One is located along Bear Creek and the other is outside the floodplain.

TABLE 22.
UNMITIGATED REPETITIVE LOSS PROPERTIES IN THE SAMMAMISH RIVER BASIN[a]

Number of Parcels	Total Area (acres)	Total Land Value	Total Improvement Value
4	25.9	$ 828,000	$ 1,185,000

a. Table includes unincorporated King County data only.

CEDAR RIVER BASIN PROFILE

The Cedar River flows west from the Cascade Mountains and then turns north to enter the south end of Lake Washington. The Cedar River is approximately 36 miles long from its mouth at Lake Washington in the City of Renton to Chester Morse Lake.

Hazard Profile

To provide additional detail of the characteristics of flooding in the Lower Cedar, the analysis of this basin is separated into five reaches:

- The Cedar River Reach—Headwaters to Landsburg diversion dam
- Lower Mainstem Reach— Landsburg diversion dam to Renton City Limits
- The Renton Reach—Renton City Limits to Interstate 405
- The Boeing Reach—Interstate 405 to Lake Washington
- Lake Washington Reach—The Lake Washington drainage basin, including May Creek

Past Events

Table 23 summarizes the history of flood events for the Cedar River basin since 1990. The most severe recent flooding events were the 1990, 1995 and 2009 federally declared disaster events. Severity is identified in terms of phases. Table 23 shows events that reached Phase 3 or above at the Landsburg gage. Below are the phases of flooding for the Cedar River:

- Phase 1—The flow is greater than 1,800 cfs and is considered an internal alert to the King County Flood Warning Center.
- Phase 2—The flow is greater than 2,800 cfs and Jones Rd near 156th Place SE may overtop and close.
- Phase 3—This is a moderate flooding event that exhibits flows greater than 4,200 cfs. Lower Dorre Don Way and Byers Rd SE may overtop and close. These roads provide access to several neighborhoods where residents may become trapped and require evacuation.
- Phase 4—This is considered extreme flooding and the flow is greater than 5,000 cfs. Additional roads may overtop and close including: Cedar Grove Rd SE, Maxwell Rd SE and SR-169 near the intersection with Cedar Grove Rd SE. Dead end streets may overtop and

close including: Jan Rd SE (SE 197th St), SE 203rd St, SE 206th St, and SE 207th St. Fast and deep flows can create dangerous conditions throughout the floodplain.

TABLE 23.
CEDAR RIVER BASIN FLOOD EVENT HISTORY

Date of Flood	Declaration (yes/no) #	Flood Phase/ Peak Flow (cfs)	Type of Damage	Estimated Cost
01/09/1990	No	4/5,308	Landslides and road damage due to flooding on small streams	Information not available
11/22/1990	Yes/#883	4/10,800	Overbank flooding causing damage to both public and private property. Levee failure	$1.4 million for entire County
11/30/1995	Yes/#1079	4/6,750	Overbank flooding causing damage to both public and private property.	$882,965 public property damage ($5.2 million for entire county
02/10/1996	Yes/#1100	4/5,510	Overbank flooding causing damage to both public and private property. Levee failure	$1,385,193 in public property damage ($7.4 million for entire county
11/06/2006	Yes/#1671	3/4,670	Channel shifting causing undercutting, oversteepened banks. Bank slumping, erosion, and scour adjacent to trail and private property	$5,386,323 in public property damages county-wide
12/1/2007	Yes/#1734		No reported damages to river flood protection infrastructure	$5,123,841 in public property damages county-wide
1/07/2009	Yes/#1817	4/7,870	Levee and revetment damage	$16,444,775 in public property damages county-wide
1/16/2011	Yes/#1963	3/4,710	Levee and revetment damage	No information available
1/14/2012	Yes/#4056	N/A	Information not yet available	No information available

Flood Characteristics

Tables 24 and 25 summarize observed flooding characteristics typical for this basin. Understanding the potential flood conditions for a specific area enables the County to identify mitigation alternatives appropriate for the level of risk for that stream or reach. Table 25 also shows warning time in terms approximate amount of lead time county officials have to initiate warning procedures within the reach. These warning times are estimates based on the length of travel time from gage to gage where available and practical experience based on observed conditions.

Vulnerability Analysis

Public Safety and Health

Flooding in the Cedar River basin has a variety of potential impacts on life, safety and health. The mainstem Cedar upstream of the City of Renton is relatively narrow and steep. Flow velocities are generally high, and at many locations, the river approaches the steep valley walls at sharp angles, eroding the bases of several tall cliffs and at times, inducing landslides. The river's slope flattens in the city, reducing both its flow velocity and its sediment carrying capacity.

TABLE 24.
CEDAR RIVER BASIN FLOW CHARACTERISTICS

Gage Location	USGS Station Number	USGS River Mile	Drainage Area (square miles)	100-year Flood Flow (cfs) *a*	Flood of Record, Date & Peak Flow (cfs)
Cedar Falls	12116500	33.2	84.2	8,930	11/24/1990; 12,300
Landsburg	12117500	23.4	121.0	10,300	11/18/1911; 14,200
Renton	12119000	1.6	184.0	12,000	11/24/1990; 10,600

a. Final Flood Frequency Analysis Curve For Year 2000 Floodplain Mapping on the Lower Cedar River march 2000 include with King county's submittal to FEMA for a revised Flood Insurance Study for the Cedar River. Period of record of USGS gage data used to derive values in table may differ from period of record currently available. See Chapter 4, Section 4.1 for further discussion on derivation of flood frequencies.

TABLE 25.
CEDAR RIVER BASIN FLOOD CHARACTERISTICS

Reach	Land Uses Surrounding the Reach	Depth of Flooding	Mapped Channel Migration Zone (yes/no)	Approximate Warning Time
Cedar River	Open Space, Agricultural, Forest	1-6 feet	No	No Warning
Lower Mainstem	Rural Residential	1-6 feet	No	1.5 to 6 hours
Renton	Residential, Commercial, Some Open Space	3-6 feet	No	6 hours
Boeing	High density, Industrial, Commercial	1-3 feet	No	6 hours
Lake Washington	Forest, Rural Residential	3-6 Feet	No	0.5 to 1.5 Hours

Due to the valley's steep gradient, flood flows are generally very fast along the Cedar River. Given the heavy residential use of the valley bottom, these high velocities represent significant threats to health and safety. Flows can be made even more hazardous by the significant amount of logs and debris, generally carried by floods (King County 1993b). In one neighborhood during the November 1990 flood, floodwaters carried several trees out of the channel and piled them in two large jams on the riverbank, nearby crushing a garage and a residential structure.

The Renton reach of the mainstem Cedar has a wider floodplain and gentler channel gradient. These characteristics contribute to sediment deposition and repeated flooding. Between River Miles 1 and 3, channel capacity had been restricted by the encroachment of fill that was placed through the years by adjacent commercial operations (King County 1993b).

There are many miles of small streams with unmapped floodplain within the Cedar River basin. Since mapping is not available in these floodplain areas, risk of flooding to the public may be more significant during severe events and may need to be monitored closely. The lower Cedar River is highly urbanized and parts of the upper Cedar are beginning to urbanize. As more areas begin to urbanize the need for accurate floodplain mapping in unmapped areas becomes essential to minimize effects on public safety and health. King County has adopted comprehensive regulations to deal with the impacts of new development in the floodplain (see Appendix B of this Flood Hazard Management Plan). The impact of this regulatory program should hold in check the possible increase in vulnerability due to new development in this basin.

Critical Facilities

Critical facilities in the Cedar River basin were identified by anecdotal information. For purposes of this document, critical facilities are identified in two categories: 1) facilities and infrastructure that are critical to public health and welfare that are especially important following a flood event; and 2) facilities and infrastructure that are critical to King County for floodplain management (roads, dams, etc.).

Table 26 lists the critical facilities in the Cedar River basin. In Renton there are several roads and bridges in the floodplain as well as public facilities such as City Hall, a public library and the Renton Airport. However, since the Cedar River dredging project was implemented in the City of Renton, the area near the Renton Airport is generally considered at less risk from flooding. As long as there is periodic dredging of the channel, this is expected to remain so. Severe flood damage was experienced during the November 1990 floods, in which damage to river facilities totaled $1.2 million. Other than the public facilities in the City of Renton, there are no other identified critical facilities within the currently mapped Cedar river floodplain.

Critical facilities can also include critical infrastructure such as roads that could cause isolation and evacuation problems during flood events. King County has determined that the following major roadways and stream crossings (bridges or culverts) would be impassable during a 100-year flood event:

- Dorre Don Road
- Arcadia Road

TABLE 26.
CRITICAL FACILITIES IN THE CEDAR RIVER BASIN

Facility or Infrastructure	Owner	Location (River Mile)	Public Health & Safety	Flood Protection Infrastructure
Levees and Revetments[a]	King County	NA		X
Landsburg Dam	City of Seattle	21.7		X
Cedar Falls Powerhouse	City of Seattle	33.7		X
Masonry Dam	Seattle Public Utilities	35.7		X
Leachate Line[b]	King County	At Rainbow	X	

a. There are several critical levees and revetments along the length of the Cedar River that overtop or could be subject to failure.
b. Considered a critical site due to its public health impacts.

Land Use, Structures and Estimated Losses from a 100-Year Flood Event

Land use in the Cedar River basin is dominated by forest uses (60.6 percent). The other main uses are residential; 21.3 percent can be classified as low-density development, 7.7 percent as medium and

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0.9 percent as high density development. High-density development is located primarily in the Cities of Renton and Maple Valley. Damage in the City of Renton during the November 1990 flood was estimated to be $5 million.

The total area of regulatory floodplain for the Cedar River basin includes all portions of the FEMA flood zones and King County's regulatory floodplain and floodway map, which includes most current floodplain studies. A channel migration study is currently being completed for the Cedar River but it is not included in the area of regulatory floodplain because it has yet to be finalized. Approximately 86 percent of the Cedar River basin regulatory floodplain is in unincorporated King County. The area of regulatory floodplain in the Cedar River basin is reflected in Table 27.

TABLE 27.
CEDAR RIVER BASIN AREA OF REGULATORY FLOODPLAIN

	Area of Regulatory Floodplain (acres)
Unincorporated King County	1,272
Incorporated Areas	207
Total	**1,479**

Within the Cedar River basin floodplain there are a total of 268 parcels with structures. This is approximately 4 percent of the total number of parcels in King County floodplains (6,250). The depth of flooding varies with location. Table 28 summarizes estimated flood loss potential. All of the 268 structures in the Cedar River basin floodplain are residential.

TABLE 28.
ESTIMATED LOSSES FROM A 100-YEAR FLOOD EVENT IN THE CEDAR RIVER BASIN

	Renton	Elliott	Upper	**Total**
Area of Floodplain (acres)	39	170	1,270	**1,479**
Buildings Exposed	0	52	216	**268**
Structure Value Exposed	$0	$8,021,055	$33,531,081	**$41,552,136**
Content Value Exposed	$0	$4,010,528	$16,765,541	**$20,776,068**
Total Value Exposed (Structure & Contents)	**$0**	**$12,031,583**	**$50,296,622**	**$62,328,204**
Structure Damage	$0	$112,072	$2,021,877	**$2,133,949**
Content Damage	$0	$43,121	$1,033,413	**$1,076,534**
Non-Residential Inventory Damage	$0	$0	$0	**$0**
Total Damage (Structure, Contents & Inventory)	**$0**	**$155,192**	**$3,055,290**	**$3,210,483**

Source: Hazards U.S. - Multi-Hazard (HAZUS-MH) Model for King County, WA (2012)

Development Trends

The greater part of the Cedar River floodplain is in unincorporated King County, with a smaller portion in the City of Renton. There is commercial, industrial and residential development throughout the incorporated areas of the Cedar River floodplain. Residential development has also occurred in unincorporated King County along the upper floodplain, which is likely due to its proximity to Renton.

Renton is expected to annex portions of the land along the Cedar River. There is expected to be a significant amount of growth in Renton during the 2001 to 2022 planning period (King County 2005).

King County and City of Renton regulations currently in effect strive to limit the impact of new development on the floodplain and the impact of flooding on new development.

Economic Impact

Based on existing land use and past experience, flooding along the Boeing and Renton reaches of the Cedar River would have the most severe economic impact within the basin. Both of these reaches contain the major population centers in the basin, and the Boeing reach contains areas of major employment for the entire County. The functional down time associated with the flooding typical for this basin could have a significant financial impact on the region. No detailed analysis of this potential impact was performed under this risk assessment. For planning purposes, King County considers the possible economic impact of typical flooding in this basin to be significant.

It is the working assumption of this Plan that cities such as Renton are carefully addressing significant flood-related hazards through coordinated planning efforts. This coordination at a minimum should involve consultations with King County, the Washington Department of Ecology, FEMA, the U.S. Army Corps of Engineers, and other agencies with expertise and responsibility for addressing flooding concerns. It should be carried out in a manner that fully meets state standards for city consistency with County flood hazard planning, as set forth in Chapter 86.12 RCW as administered by the Washington State Department of Ecology.

Repetitive Loss Areas

There are 8 unmitigated repetitive loss properties in the Cedar River basin. Table 29 summarizes the unmitigated repetitive loss properties in the Cedar River basin. The properties are located in no consistent location in the basin and all are single-family residential properties. They all lie within a mapped 100-year floodplain, so it is concluded that the cause of repetitive flooding for this basin is overbank riverine flooding reflected by the mapping for the basin.

TABLE 29.
UNMITIGATED REPETITIVE LOSS PROPERTIES IN THE CEDAR RIVER BASIN

Number of Parcels	Total Area (acres)	Total Land Value	Total Improvement Value
8	7.1	$641,000	$652,000

a. Table includes unincorporated King County data only.

GREEN RIVER BASIN PROFILE

The Green/Duwamish River is a 93-mile long river system that originates in the Cascade Mountains at an approximate elevation of 4,500 feet. The headwaters are in the vicinity of Blowout Mountain and Snowshoe Butte, about 30 miles northeast of Mount Rainier (King County 2002b). The river basin is part of Watershed Resource Inventory Area 9.

Hazard Profile

For the purposes of this risk assessment, the Green River basin can be divided into five reaches:

- The Upper Green River reach —Headwaters to the Howard Hanson Dam at River Mile 64.5

- The Gorge Reach—Howard Hanson Dam to Flaming Geyser park at River Mile 45.2
- The Middle Green River reach—Flaming Geyser Park at River Mile 45.2 to Auburn city limit at River Mile 31.8
- The Lower Green River reach—Auburn city limit at River Mile 31.8 to confluence with the Black River at River Mile 11.
- The Mill Creek reach—Mill Creek headwaters to confluence at Tukwila

Past Events

Historically, there have been several severe flooding events in the Green River basin, with records dating back to 1933. Table 30 summarizes the history of flood events for this basin since 1990. The most severe recent flooding event was the January 2011 flood.

Severity is identified in terms of phases. Table 30 shows events that reached Phase 3 or above at the Auburn gage. Below are the phases of flooding for the Green River based on the actual or expected flow at the Auburn gage

- Phase 1—The flow is greater than 5,000 cfs and is considered an internal alert to the King County Flood Warning Center.
- Phase 2—The flow is greater than 7,000 cfs and minor flooding is expected in rural lowland areas upstream of Auburn. This river level is not a major flood threat to the urban areas of the Green River valley.
- Phase 3—This is a moderate flooding, flow is greater than 9,000 cfs. At phase 3 moderate flooding is expected in rural lowland areas both upstream and downstream of Auburn, Urban areas of the Green River valley are generally protected from Phase 3 floods by the levee system. Flood conditions can change rapidly in levee-protected areas.
- Phase 4—The flow is greater than 12,000 cfs. At phase 4 major flooding may occur. Critical flood control levees may weaken from saturation. Sudden changes in flood conditions are possible, especially in levee-protected areas. These changes may include rapidly rising water, widespread inundation, road closures, and utility disruptions.

Flood Characteristics

Tables 31 and 32 summarize observed flooding characteristics typical for this basin. Understanding the potential flood conditions for a specific area enables the County to identify mitigation alternatives appropriate for the level of risk for that stream or reach. Table 31 also shows the calculated 1 percent chance annual flood flow for each gage. Table 32 also shows warning time in terms of length of time from gage to gage where available. This is shown as the time that it takes peak flows to travel downstream from one gage to the next.

TABLE 30.
GREEN RIVER BASIN FLOOD EVENT HISTORY

Date of Flood	Declaration (yes/no) #	Flood Phase/ Peak Flow (cfs)	Type of Damage	Estimated Cost
01/09/1990	No	3/10,800	No significant public or private property damage reported for this event	Information not available
11/09/1990	Yes/#883	3/10,200	Overbank flooding. Property damage to both public and private property. Levee damage.	$5.6 million for entire county
11/22/1990	Yes/#896	3/11,500	Overbank flooding. Property damage to both public and private property. Levee damage.	$1.4 million for entire county
02/19/1991	No	3/10,300	No significant public or private property damage reported for this event	Information not available
02/19/1995	No	3/9,450	No significant public or private property damage reported for this event	Information not available
12/01/1995	Yes/#1079	3/11,700	Overbank flooding. Property damage to both public and private property. Levee damage.	$2,402,374 in damage to public property
02/10/1996	Yes/#1100	4/12,400	Overbank flooding. Property damage to both public and private property. Levee damage.	$1,728,704 in damage to public property
03/20/1997	Yes/#1172	3/9,290	No significant public or private property damage reported for this event	Information not available
11/26/1999	No	3/9,200	No significant public or private property damage reported for this event	Information not available
12/16/1999	No	3/9,130	No significant public or private property damage reported for this event	Information not available
11/06/2006	Yes/#1671	4/12,200	Damage to levees and revetments	$5,386,323 in public property damages county-wide
12/1/2007	Yes/#1734	N/A	No reported damages to river flood protection infrastructure	$5,123,841 in public property damages county-wide
1/07/2009	Yes/#1817	3/11,100	Overtopping, damage to flood protection infrastructure and to residential property	$16,444,775 in public property damages county-wide
1/16/2011	Yes/#1963	3/10,400	Damage to levees and revetments	No information available
1/14/2012	Yes/#4056	N/A	Information not yet available	No information available

TABLE 31.
GREEN RIVER BASIN FLOW CHARACTERISTICS

Gage Location	USGS Station Number	USGS River Mile	Drainage Area (square miles)	100-year Flood Flow (cfs)[a, b]	Flood of Record, Date & Peak Flow (cfs)
Howard Hanson Dam	12105900	63.8	221.0	Maximum flow release to meet target of 12,000 cfs at Auburn	12/21/1960; 12,200 (pre-dam)
Auburn	12113000	32.0	399.0	12,000 (as regulated by Howard Hanson Dam)	11/23/1959; 28,100 (pre-dam)
Tukwila	12113350	NA	440.0	12,400	01/31/1965; 12,100

a. FEMA (2005)
b. Affected by regulation at the Howard Hanson Dam

TABLE 32.
GREEN RIVER BASIN FLOOD CHARACTERISTICS

Reach	Land Uses Surrounding the Reach	Depth of Flooding	Mapped Channel Migration Zone (yes/no)	Approximate Warning Time
Middle Green	Forestry, Open Space/Recreation, Agricultural, Rural Residential	Up to 20 feet with measurable velocity contained in gorge channel. Shallow Flooding; 1 – 3 feet in agricultural areas.	Yes	8 hours
Reddington/ Green River Road, Horseshoe Bend/Russell, Midway/Johnson, Briscoe, Duwamish West, Duwamish East	Urban Residential, Commercial, Light Industrial	1 – 6 feet	No	12 hours
Mill Creek/Mullen Slough	Some agricultural, mixed rural and urban residential	Up to 12 feet in Johnson Creek vicinity, 1 – 6 feet everywhere else	No	No warning

Vulnerability Analysis

Public Safety and Health

Flooding in the Green River basin has a variety of potential impacts on life, safety and health. Very few lives have been lost, but damage and disruption caused by flooding have been significant. The river's historical floodplain on the Lower and Middle Green River includes the Southcenter commercial area and much of the region's industrial and warehouse capacity. The Middle Green River is a broad valley. The Middle and Lower Green River areas are protected by the Howard Hanson Dam and extensive flood containment levees and pumps. The Upper Green River is steep with high velocity flows.

During the January 2009 flood, the abutment to Howard Hanson Dam exhibited higher than expected rates of seepage and turbidity. Until a solution was in place, the dam operated using a limited capacity which greatly increased the odds of severe flooding. During this time extensive flood preparedness measures were enacted by government agencies, businesses and the public. Construction occurred to install a grout curtain on a significant portion of the abutment along with additional drainage wells. By the Fall of 2011 the U.S. Army Corps of Engineers began to operate the dam as it had in the past. The incident has increased awareness of the vulnerability associated with areas protected by the dam.

There are many miles of small streams with unmapped floodplain within the Green River basin. Since there is no mapped floodplain in these areas, risk of flooding to the public may be more significant during severe events and may need to be monitored closely. There are significant amounts of development throughout the Green River valley. It is home to several commercial and industrial centers and has a growing residential population. With this growth, it is likely that public health and welfare will be at risk from flooding. The population in the Green River basin, estimated to be 564,000 in the 2000 census, is mostly concentrated in the lower end of the basin, but the fastest rate of population increase is in the suburban cities and nearby unincorporated areas east of Seattle (King County 2002b).

Critical Facilities

Critical Facilities in the Green River basin were identified using GIS and anecdotal information. For purposes of this document, critical facilities are identified in two categories: 1) facilities and infrastructure that are critical to public health and welfare that are especially important following a flood event; and 2) facilities and infrastructure that are critical to King County for floodplain management (roads, dams, etc.).

Table 33 lists the critical facilities in the Green River basin. King County has established policies in both its Regional Hazard Mitigation Plan and the Flood Hazard reduction Plan to proactively mitigate risks to identified critical facilities when opportunities arise. Several of the facilities listed in Table 33 are not under County ownership. The County will work with all agencies involved to achieve this objective.

TABLE 33.
CRITICAL FACILITIES IN THE GREEN RIVER BASIN

Facility or Infrastructure	Owner	Location (River Mile)	Public Health & Safety	Flood Protection Infrastructure
Kent Junior High	Kent School District	10.0	X	
Fire Station 14	City of Renton	1.0	X	
Neely O'Brien Elementary	Kent School District	20.0	X	
Tukwila Fire Station	City of Tukwila	13.0	X	
Pipeline #5 (Water Supply)	King County		X	
Levees[a]	King County and private property owners			X
Howard Hanson Dam	Army Corps of Engineers	64.5		X
Black River Pump Station	King County	11.0		X

a. Various levees along the Green River are in need of repair. Projects and recommended priorities are located in Chapter 5 and Appendix G.

Highways, arterial roadways and additional pipelines are critical facilities located throughout the floodplain.

Land Use, Structures and Estimated Losses from a 100-Year Flood Event

Land use in the Green River basin varies significantly among the lower, middle and upper portions. The land in the Upper Green River is primarily forestland. The Middle Green River is primarily farmland and a mix of urban and rural residential. The major land uses are residential (50 percent), forestry (27 percent) and agriculture (12 percent) (King County 2005). Several large state and county parks abut the river in this segment. The Lower Green River contains less farmland and is mainly urban. Except for occasional stretches of parkland, a mixture of residential, commercial and industrial land uses are the main land uses. Residential development (50 percent), industrial development (17 percent), and commercial development (10 percent) are the primary uses along the Lower Green River.

King County floodplain mapping shows 12,340 acres of mapped floodplain in the Green River basin. A floodplain study of the Lower and Middle Green River was submitted to FEMA in 2008 and will be used to update the floodplain and floodway data in future Flood Insurance Rate Maps.

The total area of regulatory floodplain for the Green River basin includes King County's regulatory floodplain and floodway map that include most current floodplain studies. A channel migration study is completed for portions of the Green River; the results are not included in the area of regulatory floodplain. The area of regulatory floodplain is shown in Table 34. Approximately 42 percent of the Green River regulatory floodplain is in unincorporated King County.

TABLE 34.
GREEN RIVER BASIN AREA OF REGULATORY FLOODPLAIN

	Area of Regulatory Floodplain (acres)
Unincorporated King County	5,225
Incorporated Areas	7,115
Total	**12,340**

Within the mainstem Green River and Mill Creek basin floodplain (not including other areas within the basin) there are a total of 1,175 parcels with structures. This is approximately 19 percent of the total number of parcels in King County floodplains (6,250). Of these, 312 are residential structures and 184 are commercial. The depth of flooding varies with location. Table 35 summarizes estimated flood loss potential.

Development Trends

Urbanization of the Green River floodplain began in 1962, with rapid annexation of the valley floor by the valley cities as soon as the dam became operational. In the 1990s, Black Diamond, Enumclaw and Covington experienced rapid growth. Land development estimates indicate that the largest areas of future development will be in the Lower and Middle Green River areas.

TABLE 35.
ESTIMATED LOSSES FROM A 100-YEAR FLOOD EVENT IN THE GREEN RIVER BASIN

	Middle Green	Reddington/ Green River Road	Mill Creek/Mullen Slough	Horseshoe Bend/Russell	Midway/ Johnson	Briscoe	Duwamish West	Duwamish East	Other areas	Total
Area of Floodplain (acres)	1,753	482	2,349	2,170	584	1,602	482	260	2,658	**12,340**
Buildings Exposed	29	41	157	508	25	249	162	4	N/A	**1175**
Structure Value Exposed	$7,592,471	$42,751,692	$420,723,973	$1,623,256,048	$67,363,286	$1,393,477,676	$107,021,158	$941,358	N/A	**$3,663,127,662**
Content Value Exposed	$5,416,051	$26,088,658	$429,260,766	$1,581,047,600	$33,681,643	$1,413,554,072	$138,746,934	$537,541	N/A	**$3,628,333,265**
Total Value Exposed (Structure & Contents)	**$13,008,522**	**$68,840,350**	**$849,984,739**	**$3,204,303,648**	**$101,044,929**	**$2,807,031,748**	**$245,768,092**	**$1,478,900**	**N/A**	**$7,291,460,927**
Structure Damage	$139,528	$5,740,780	$2,208,205	$98,134,353	$537,893	$104,716,553	$971,539	$15,218	N/A	**$212,464,070**
Content Damage	$334,386	$4,793,482	$7,368,271	$313,654,941	$315,024	$346,151,961	$1,145,728	$26,581	N/A	**$673,790,375**
Non-Residential Inventory Damage	$378,200	$669,041	$6,792,385	$347,167,103	$0	$379,849,429	$1,404,333	$29,492	N/A	**$736,289,984**
Total Damage (Structure, Contents & Inventory)	**$852,115**	**$11,203,304**	**$16,368,862**	**$758,956,398**	**$852,917**	**$830,717,944**	**$3,521,600**	**$71,291**	**N/A**	**$1,622,544,429**

Source: Hazards U.S. - Multi-Hazard (HAZUS-MH) Model for King County, WA (2012)

Economic Impact

Based on existing land use and past experience, flooding along the middle and lower reaches of the Green River would have the most severe economic impact in the basin. Theses reaches contain the major population/employment centers in the basin and in the county. The river flows in the lower reaches of the Green River are contained by levee systems, and costs associated with flood fighting and levee repair have been the highest of all basins in King County. Such costs can have an impact on the tax base in the long run. The functional down time associated with the flooding typical for this basin could have a significant financial impact on the region. No detailed analysis of this potential impact was performed for this risk assessment although a risk analysis on levees was performed in 2007. For planning purposes, King County considers the possible economic impact of typical flooding in this basin to be significant.

It is the working assumption of this Plan that cities such as Auburn, Kent, Renton and Tukwila are carefully addressing significant flood-related hazards through coordinated planning efforts. This coordination at a minimum should involve consultations with King County, the Washington Department of Ecology, FEMA, the U.S. Army Corps of Engineers, and other agencies with expertise and responsibility for addressing flooding concerns. It should be carried out in a manner that fully meets state standards for city consistency with County flood hazard planning, as set forth in Chapter 86.12 RCW as administered by the Washington State Department of Ecology.

Repetitive Loss Areas

Based on the County's review of repetitive loss data provided by FEMA, there are two unmitigated repetitive loss properties in the Green River basin. These properties are single-family residential. One property is currently not mapped in the 100-year floodplain which means that the flooding was likely due to storm water drainage problems.

WHITE RIVER BASIN PROFILE

The White River is a glacially-fed river system that originates on the northeast face of Mount Rainier and is a part of Water Resource Inventory Area 10. The White River flows in northwest from its headwaters and then turns south to join with the Puyallup River near the City of Sumner. The Puyallup River flows for 10 miles through the Cities of Puyallup and Tacoma to Commencement Bay in south Puget Sound. The White River drains an area of approximately 494 square miles (King County 2002d).

Hazard Profile

The analysis of this basin is separated into five reaches:

- Upper White/Greenwater Reach—Basin divide to Mud Mountain Dam
- Boise Creek Reach—Boise Creek headwaters to confluence with the White River
- Dams Reach—Mud Mountain Dam to SR 410
- Natural Reach—SR 410 to upper end of levee protected channel
- Lower White—Upper end of levee protected channel to King County/Pierce County line

Past Events

Historically, there have been several severe flooding events in the White River basin. Table 36 summarizes the history of flood events for this basin since 1990.

Severity is identified in terms of phases. Table 36 shows events that reached Phase 3 or above at the Buckley gage, unless otherwise indicated. Below are the phases of flooding for the White River:

- Phase 1—The flow is greater than 2,500 cfs and is considered an internal alert to the King County Flood Warning Center.
- Phase 2—The flow is greater than 6,000 cfs and Red Creek area residents may experience overtopped roads and high water.
- Phase 3—This is moderate flooding and exhibits flows greater than 8,000 cfs. Red Creek area residents may experience dangerous, high velocities, debris flow, and residential flooding.
- Phase 4—This is considered extreme flooding. The flow is greater than 12,000 cfs and there is likely to be significant overbank flooding, possibly inundating areas of State Route 410 and Sumner. Area residents may experience dangerous high velocities and debris flows.

TABLE 36.
WHITE RIVER BASIN FLOOD EVENT HISTORY

Date of Flood	Declaration (yes/no) #	Flood Phase/ Peak Flow (cfs)	Type of Damage	Estimated Cost
01/11/1990	No	4/13,000	No significant public or private property damage reported for this event	No information available
12/02/1995	Yes/#1079	4/15,000 @ Auburn	Overbank flooding. Property damage to both public and private property.	$304,054 in damage to public facilities
02/10/1996	Yes/#1100	3/10,600	Overbank flooding. Property damage to both public and private property.	$20,213 in damage to public facilities
12/30/1996	No	3/>8,000	No significant public or private property damage reported for this event	No information available
11/06/2006	Yes/#1671	4/14,700	No reports of significant public or private property damage.	$5,386,323 in public property damages county-wide
12/1/2007	Yes/#1734		No reported damages to river flood protection infrastructure	$5,123,841 in public property damages county-wide
1/07/2009	Yes/#1817	3/11,800	Erosion and scour, damage to concrete revetment	$16,444,775 in public property damages county-wide
1/16/2011	Yes/#1963	1/7,410	No reported damages to river flood protection infrastructure	No information available
1/14/2012	Yes/#4056		Information not yet available	No information available

Flood Characteristics

Tables 37 and 38 summarize observed flooding characteristics typical for this basin. Understanding the potential flood conditions for a specific area enables the County to identify mitigation alternatives appropriate for the level of risk for that stream or reach.

TABLE 37.
WHITE RIVER BASIN FLOW CHARACTERISTICS

Gage Location	USGS Station Number	River Mile	Drainage Area (square miles)	100-Year Flood Flow (cfs)	Flood of Record, Date & Peak Flow (cfs)
Buckley	12098500	27.9	401.0	12,350 a	12/01/1933; 28,000 (pre-dam)
Auburn	12100496	6.30	464.0	15,500 a	02/10/1996; 15,000
Greenwater	12097500	1.10	73.5	6,780 b	12/02/1977; 10,500

a. Based on 2008 flood study.
b. Based on USGS data through 2007

TABLE 38.
WHITE RIVER BASIN FLOOD CHARACTERISTICS

Reach	Land Uses Surrounding the Reach	Depth of Flooding	Channel Migration Zone (yes/no)	Approximate Warning Time
Above Mud Mountain Dam – Greenwater River & Greenwater River	Low density Residential, Forestry	Shallow Flooding, 0-3 feet	No	No warning
Boise Creek	Low density Residential, Agricultural	Shallow Flooding, 0-3 feet	No	No warning
SR 410 – Mud Mountain Dam	Low density Residential, Agricultural	6 feet or greater with measurable velocities	No	2-4 hours
River Mile 10 – SR 410	APD, recreational-open space, Agricultural	Shallow flooding 0-6 feet with some measurable velocity	No	2-4 hours
8th Street – RM 10	Mixed Use: Urban residential, commercial, industrial	Shallow flooding,0-6 feet with some measurable velocity	No	4-5 hours

Vulnerability Analysis

Public Safety and Health

Flooding in the White River basin has a variety of potential impacts on life, safety and health. The large amount of sediment carried by the White River affects its drainage pattern and can cause flooding in the valley lands near the cities of Auburn and Pacific. In this area, the gradient lessens, the velocity slows and the sediments and debris tend to settle out onto the floodplain (King County 1993b).

There are many miles of small streams with unmapped floodplain within the White River basin. Since there is no mapped floodplain in these areas, risk of flooding to the public may be more significant during severe events and may need to be monitored closely. This is more of a concern in areas that are becoming more urbanized, such as the lower White River near Auburn and Pacific.

Critical Facilities

Critical Facilities in the White River basin were identified by using GIS and anecdotal information. For purposes of this document, critical facilities are identified in two categories: 1) facilities and infrastructure that are critical to public health and welfare that are especially important following a flood event; and 2) facilities and infrastructure that are critical to King County for floodplain management (roads, dams, etc.). Table 39 lists the critical facilities in the White River basin.

TABLE 39.
CRITICAL FACILITIES IN THE WHITE RIVER BASIN

Facility or Infrastructure	Owner	Location (River Mile)	Public Health & Safety	Flood Protection Infrastructure
Pump Station	King County—Wastewater Treatment Division	6.5	X	
Natural Gas Pipeline[a]	Williams	10.8	X	
Water Supply Pipeline #1[b]	Tacoma Public Utilities	23.3	X	
Water supply well-field[c]	City of Auburn	Approximately 9.0	X	
Auburn Wall[d]	King County—Water and Land Resources Division	8.1		X
Riverside High School[e]	Riverside High School	6.5	X	
Mount Baker Middle School[f]	Mount Baker Middle School	7.0	X	
Abandoned Land Fill[g]	King County	6.0	X	

a. Pipeline exposed in 1995 flood. In 2003, Williams replaced crossing with new pipeline well-below expected scour depth.
b. In 2003, TPU replaced crossing with the new pipeline well-below expected scour depth.
c. Only a major avulsion would affect the well-field
d. This facility protects the City of Auburn from any potential avulsion into the historic White River channel.
e. This is on the left bank and is built on fill and will likely be in a moderate channel migration zone.
f. This is on the right bank and is built on fill and will likely be in a moderate channel migration zone.
g. Considered a critical site due to its potential public health impacts.

Land Use, Structures and Estimated Losses from a 100-Year Flood Event

Approximately 175 square miles in the White River basin is owned and managed by the Mount Baker-Snoqualmie National Forest. Another 90 square miles of the basin is part of Mount Rainier National Park. In this upper portion, the basin is mainly undeveloped but includes some scattered residential and commercial property around Greenwater (King County 1993b). In the lower areas of the basin, there are some agricultural lands and a mix of residential, commercial and industrial uses closer to and in the cities. Upstream of the Muckleshoot Indian Reservation, the river is unconstrained and the valley is mostly undeveloped (King County 1993b).

King County floodplain mapping shows 4,171 acres of mapped floodplain in the White River basin. One of the major risks in the White River basin is that there are significant channel migration hazards related to the river's significant sediment load and debris local, especially in the upper basin.

A channel migration study will be completed on the White River but is not currently included in the area of regulatory floodplain. About 85 percent of the regulatory floodplain in the basin is in unincorporated King County. Table 40 shows the area of regulatory floodplain.

TABLE 40.
WHITE RIVER BASIN AREA OF REGULATORY FLOODPLAIN

	Area of Regulatory Floodplain (acres)
Unincorporated King County	3,568
Incorporated Areas	603
Total	**4,171**

Within the White River basin floodplain there are a total of 211 parcels with structures. This is approximately 3 percent of the total number of parcels in King County floodplains (6,250). The depth of flooding varies depending on location. Table 41 summarizes estimated flood loss potential. Of the 211 identified structures in the White River basin floodplain, 205 are residential structures and 6 are commercial or other designations.

Development Trends

The majority of the White River basin is in unincorporated King County, with a smaller portion in the cities and the Muckleshoot Indian Tribe Reservation. There is commercial, industrial and residential development throughout the incorporated areas of the White River floodplain. The majority of development is along the White River in the Auburn and Pacific area. This area has significant potential for new residential, commercial and industrial development.

Economic Impact

The economic impact for this basin is based on a review of historical flooding, the inventory of structures at risk, and current land use in the basin. The current land use is predominantly open space, forestry and agricultural in the upper reaches, and the urbanized lower reaches are channelized and protected by flood control infrastructure. The safety provided by flood control infrastructure is dependent on the functionality and integrity of the flood protection infrastructure at the time of a flood event. Failure of a flood control Infrastructure in this basin could have a measurable economic impact within the basin due to functional downtime, flood fighting costs and flood protection infrastructure repair. Costs have been significant during past events; King County considers the possible economic impact of typical flooding in this basin to be moderate.

TABLE 41.
ESTIMATED LOSSES FROM A 100-YEAR FLOOD EVENT IN THE WHITE RIVER BASIN

	Above Mud Mountain Dam-Greenwater River	SR 410 – Mud Mountain Dam	Boise Creek Reach	River Mile 10 – SR 410	8th Street – RM 10	Other areas	Total
Area of Floodplain (acres)	782	846	529	1,311	285	418	**4,171**
Buildings Exposed	16	4	38	0	138	15	**211**
Structure Value Exposed	$1,595,083	$611,936	$7,983,129	$0	$26,202,049	N/A	**$36,392,197**
Content Value Exposed	$797,542	$305,968	$3,991,564	$0	$13,375,570	N/A	**$18,470,644**
Total Value Exposed (Structure & Contents)	**$2,392,625**	**$917,904**	**$11,974,693**	**$0**	**$39,577,619**	**N/A**	**$54,862,841**
Structure Damage	$161,862	$69,959	$1,353,501	$0	$2,031,236	N/A	**$3,616,557**
Content Damage	$99,431	$49,245	$643,907	$0	$968,093	N/A	**$1,760,676**
Non-Residential Inventory Damage	$0	$0	$0	$0	$201,156	N/A	**$201,156**
Total Damage (Structure, Contents & Inventory)	**$261,292**	**$119,203**	**$1,997,407**	**$0**	**$3,200,486**	**N/A**	**$5,578,389**

Source: Hazards U.S. - Multi-Hazard (HAZUS-MH) Model for King County, WA (2012)

Repetitive Loss areas

There currently are no unmitigated repetitive loss properties in this basin. However, at one time, this basin included a single property with the most flood insurance claims of any property in the County. This property was located along the Boise Creek reach of this basin, and was mitigated through a property acquisition by King County in 2000.

APPENDIX D.
ACTION PLAN IMPLEMENTATION STATUS AND ACCOMPLISHMENTS: 2006 -2012

This appendix provides a summary of accomplishments or progress between January 1, 2006 and December 31, 2011; the 2006 Flood Hazard Management Plan provided a summary of accomplishments between 1993 and the end of 2005. These accomplishments, which are listed by river basin in the following tables (D-1 through D-13), include projects related to the maintenance, repair and retrofit of King County's flood protection infrastructure; property acquisitions to remove homes at risk from flood hazards, provide for future flood hazard reduction projects, or secure open space for the purpose of flood conveyance; other non-structural accomplishments such as studies conducted that inform on-the-ground projects; and technical assistance. Information on the location, nature, and driver associated with each project is provided.

A brief narrative description and type of action are provided for each flood mitigation action proposed in the 2006 King County Flood Hazard Management Plan. Individual actions are further characterized using standard flood mitigation action categories; Table D-14 provides definitions for these action type categories. The final columns reflect implementation accomplishments of these actions and next steps.

TABLE D-1.
COUNTYWIDE PROGRAMMATIC ACTIVITIES (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Public Outreach, Flood Preparedness, Warning and Emergency Response	Provide regional flood preparedness, warning and flood emergency response services. Coordinate and implement public outreach on flood preparedness and floodplain management programs and projects, and respond to inquiries and complaints from citizen and other public and private agencies.	Preventive/ Public Information	Implemented an automated Flood Alert System; conduct annual direct mail campaign to all King County floodplain parcel addresses; and provide real-time flood data online and via mobile device web pages.	Implement social media flood platform and develop flood warning application for smart phones.
Flood Protection Infrastructure Inventory and Assessment	Develop and implement a flood protection infrastructure inventory database and a routine program of inspection, condition assessment, and monitoring for all flood protection infrastructure and appurtenances, including levees, revetments, raised banks, pump stations, stormwater discharge structures, cross-culverts and closure structures.	Preventive	Inventory in the process of being developed, once fully implemented, will likely want a recommendation to continue with these activities	Continue developing and implementing inventory database, assessment, and monitoring
Flood Protection Infrastructure Maintenance	Carry out annual routine maintenance, including flood protection infrastructure mowing, noxious weed control, installation and repair of access control, and minor repair and maintenance of flood protection infrastructure and related properties and appurtenances.	Preventive	This action is implemented on an as needed basis.	Carry forward this action

TABLE D-1.
COUNTYWIDE PROGRAMMATIC ACTIVITIES (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Sediment Management Program	Establish a sediment management program that includes expanded channel monitoring, establishment of thresholds to trigger actions, and analysis of sediment management action alternatives.	Structural	Action has been implemented, with an expanded channel monitoring component being conducted on eight river segments. Sediment management action alternatives have been analyzed on three of the eight segments (South Fork Snoqualmie, Lower Cedar, Lower White), where implementation of a selected sediment management action would occur as a capital project. On the five other river segments (Lower Raging, Lower Tolt, Snoqualmie at Fall City and Carnation, and Middle Fork Snoqualmie), consideration of sediment management alternatives is yet to be completed, although channel monitoring data collected to date have been used in basin-scale flood reduction strategies underway.	Carry forward this action to continue the implementation of the sediment management program, with ongoing channel monitoring of sediment levels, and analysis, evaluation and selection of appropriate sediment management actions, which may include levee setback, acquisition and removal of at-risk structures, elevation of at-risk structures or gravel removal.
Floodplain Information and Permit Review Technical Support	Provide technical support to King County's Department of Development and Environmental Services for floodplain permits and inquiries, floodplain mapping, elevation certificates, and Critical Areas Ordinance updates.	Technical Assistance	Technical support to King County Programs for floodplain permits and responding to inquiries on mapping, elevation certificates as requested.	Carry forward this action; continue to provide assistance to help public and private entities make wise land use decisions that reduce or eliminate flood-related risks.
Salmon Habitat Recovery Technical Support	Provide floodplain management technical support to Snohomish, Cedar, Green and White River watershed coordination and salmon habitat recovery activities.	Natural Resource Protection	Action has been implemented; coordination with WRIA teams is on-going. Participation in salmon habitat recovery and other fish and wildlife habitat enhancement projects to ensure that flood-related risks associated with these projects are avoided or minimized.	Carry forward this action; continue participation in salmon habitat recovery and provide technical support associated with flood-related risks associated with projects.

TABLE D-1.
COUNTYWIDE PROGRAMMATIC ACTIVITIES (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Technical Support to Other Agencies	Provide floodplain management technical support to all King County departments proposing activities or projects that affect floodplain functions.	Technical Assistance	Action has been implemented. Technical support to all King County Departments and Programs as needed. King county continues to work with those involved in the use and management of agricultural, recreational, and open space lands, etc. in flood hazard management areas to ensure that land uses remain compatible with the natural conveyance of flood waters.	Carry forward this action; continue to provide assistance to help public and private entities make wise land use decisions that reduce or eliminate flood-related risks.
Grant Applications	Maximize federal, state and local funding opportunities through grant application submittals in support of completing capital improvement projects, technical studies and other flood hazard management activities.	Plan Performance	Action has been implemented. Grant applications have been submitted and awarded for various projects throughout King County	Carry forward this action; submit grant applications as applicable.
Community Rating System Certification	Provide supporting documentation, technical support and staff training required to maintain favorable status in the FEMA's Community Rating System. This work supplements work, carried out in the Department of Natural Resources and Parks and compliment-related work carried out by the Department of Development and Environmental Services	Plan Performance	King County remains in favorable status in FEMA's CRS as a Class 2 community. This rating allows flood insurance premium rates at a 40% discount.	Carry forward this action; continue participation in CRS.
River and Floodplain Section Administration	Provide for program administration, staff supervision and training, Flood Hazard Management Plan updates, Comprehensive Plan Consistency, and the River and Floodplain Management Unit Annual Report.	Plan Performance	Action has been implemented. 2006 Flood Hazard Management Plan was adopted in 2007. Plan update process began in 2012. Annual Reports have been completed and published.	Carry forward this action.

TABLE D-2.
COUNTYWIDE PROJECTS (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Flood Hazard Corridor Mapping	Update flood hazard management corridor maps with flood hazard, land use and evaluate the feasibility of assessing the cumulative effects of flood risk reduction projects. Integrate flood hazard and ecological data in a readily accessible information management system.	Preventive	Partial Implementation. King County has updated flood rate insurance maps for its major river systems and continues to make mapping changes as land use dictates. King County's "iMap" application integrates ecological and flood hazard data in a format accessible to the general public.	Action is ongoing
Countywide Risk Assessment	Carry out flood damage risk assessments to evaluate the potential consequences of flood protection infrastructure failure along major river systems. Risk assessments will focus on areas of potential levee failure and known repetitive loss areas.	Preventive	Action has been Implemented - King County has conducted robust risk assessments in known problem areas to identify potential consequences of flood protection infrastructure failure.	Action is ongoing
Flood Protection Infrastructure Revegetation	Implement flood protection infrastructure revegetation projects to promote the growth of native vegetation to decrease long-term maintenance needs and enhance fish and wildlife habitat Funding adequate to support one or two small projects per year	Natural Resource Protection	Partial Implementation-- Many flood protection infrastructure repair projects involve planting native vegetation.	In order to maintain eligibility with the Corps' PL 84-99 rehabilitation and inspection program, King County has been required to remove vegetation from levees in certain areas.
Flood Emergency Response	Provide funding to repair flood protection infrastructure damaged by floods. To the maximum extent possible, funds would be used to match state and federal emergency and disaster mitigation funds.	Emergency Services	Damaged flood protection infrastructure have been aggressively repaired, where possible partnering with the Corps of Engineers and FEMA.	Action is ongoing
Adaptive Management Analyses and Implementation	Monitor projects using performance measures and adaptive management to track the effectiveness of completed projects and inform the design and implementation of future projects.	Plan Performance	Post-project monitoring does occur, and the lessons learned inform future project designs.	Carry forward this action

TABLE D-2.
COUNTYWIDE PROJECTS (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Large Wood and Landslide Hazard Assessment and Management Alternatives Analyses	Complete an assessment of flood hazards associated with increasing accumulations of large wood in river channels and the potential impacts future landslides may have on flooding and erosion. Develop alternative analysis and protocols for the management of flood hazards related to these natural river and floodplain elements.	Plan Performance	Partial Implementation-- large wood assessments have been conducted, and protocols for large wood placement have been developed. Natural wood protocols are in development.	Carry forward this action; specifically carry forward landslide assessment and protocols
Small Stream and Marine Shoreline Area Flood Studies	Complete flood studies and flood boundary delineations to update the corresponding FEMA Flood Insurance Studies and Flood Insurance Rate Maps for small streams and marine shoreline areas in unincorporated King County.	Plan Performance	Partial Implementation – King County has completed mapping of marine shoreline areas and the studies have been submitted to FEMA allowing for the development of coastal FIRMs. Some small streams have been studied, but others remain and will be completed as availability of staffing and financial resources allow	Carry forward
Flood Mitigation Opportunity Fund	Identify and provide funding for home elevations and floodplain property acquisitions recommended through the analyses of repetitive loss areas, basin-specific alternative analyses, and countywide risk assessment	Property Protection	Partial Implementation - King County has identified priority mitigation areas and actively pursued grant funding to support elevations and acquisitions. A fund of the type described here was established for the Cedar River basin. Funding for mitigation activities in other basins is drawn from basins' capital funds, and the mitigation typically must be associated with a specific project.	King County is currently implementing elevations and acquisitions at the maximum level that staffing will allow.

TABLE D-3.
ACCOMPLISHMENTS FOR THE SOUTH FORK SKYKOMISH RIVER IN KING COUNTY (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Miller River Alluvial Fan - Road Protection *formerly known as Miller River Road Protection*	Develop and implement strategy for maintenance or removal of flood protection infrastructure and other infrastructure on the Miller River Alluvial Fan.	Structural Solutions	Analysis of log structure completed. Provide technical input to KC Roads Services on flood and erosion risks related to appropriate responses to Old Cascades Highway breach.	Continue to provide expertise to KC Roads Services.
Timber Lane Village Home Acquisitions (Erosion & Flooding) *formerly known as Timber Lane Village Home Buyouts (Erosion) and Timber Lane Village Home Buyouts (Flooding)*	Purchase homes and property in this residential neighborhood, which is subject to extreme erosion and flooding.	Property Protection	Three houses and 5 parcels purchased.	Conduct technical analysis to determine highest priorities for flood and erosion buyouts.
South Fork Skykomish River Channel Migration Zone Study	Conduct channel migration hazard mapping of the South Fork Skykomish River	Preventive	None.	Begin mapping and analysis for the study area.
Priority Acquisitions Throughout South Fork Skykomish Basin *formerly known as South Fork Skykomish River Early Action Residential Flood Hazard Mitigation*	Purchase or otherwise mitigate flood risks to repetitive loss properties.	Property Protection	King County recently purchased a repetitive loss property near Baring.	Assess high risk areas and identify and acquire high priority properties.
Miller River Home Demolition *formerly known as Miller River Home Buyout*	Demolish purchased monastery compound which was threatened by flooding and erosion.	Property Protection	One property purchased.	Project Complete.
Town of Skykomish Residential Flood Mitigation *formerly known as Town of Skykomish Home Buyouts*	Purchase homes and property subject to flooding risk in the Town of Skykomish.	Property Protection	None.	None planned.
Other Actions Implemented but not Addressed in 2006 FHMP				
McKnight Revetment Repair	Repair damage from 2009 flood event.	Structural Solutions	Completed 70 lineal feet of revetment repair project. Planted site with variety of native plants.	Project complete.

TABLE D-4.
ACCOMPLISHMENTS FOR THE SOUTH FORK SNOQUALMIE RIVER (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
South Fork Levee System Improvements	Determine and implement an effective suite of actions to repair, relocate and/ or strengthen selected portions of the levee system. Implement early actions as appropriate and in response to flood events.	Structural Solutions	Initial analyses and evaluations are underway to implement this project.	Compare suite of alternatives and begin preliminary design of selected alternative(s).
Upper Snoqualmie Valley Residential Flood Mitigation *formerly known as North Bend Area Residential Flood Mitigation*	Prioritize and implement residential home elevations, relocation and acquisitions. In the South Fork Basin the focus is elevations in Shamrock Park and Clough Creek neighborhoods and acquisitions in the Circle River Ranch neighborhood.	Property Protection	Ten homes elevated and 3 underway.	Pursue home elevations and acquisitions to mitigate or eliminate flood risks to residential structures.
Other Actions Implemented but not Addressed in 2006 FHMP				
Geomorphic Hazards and Risks Assessment Alternatives Analysis – South Fork Snoqualmie River Circle River Ranch Neighborhood	Conduct investigation to identify geomorphic hazards and alternatives to reduce their risks on South Fork Snoqualmie River.	Preventive	Identified hazards and risks in Circle River Ranch neighborhood.	Project complete.
South Fork Snoqualmie River Gravel Removal Study	Characterize sediment accumulation and evaluate effects of gravel removal along portion of leveed South Fork Snoqualmie River.	Preventive	Finished analysis of gravel removal scenarios for flood reduction effectiveness.	Project complete.
Circle River Ranch Alternatives Analysis and Implementation	Determine and implement an effective suite of actions to address geomorphic risks to the Circle River Ranch neighborhood. An analysis of the potential alternatives will inform potential implementation of projects.	Preventive	Completed analysis of flood and erosion risks in the Circle River Ranch neighborhood.	In progress.
Allen Revetment Repair	Repair damage from 2006 flood event.	Structural Solutions	Completed 150 lineal feet of revetment repair project.	Project complete.
Riverbend Repair	Repair damage from 2006 flood event.	Structural Solutions	Completed 60 lineal feet of levee repair project.	Project complete.
Si View Park Levee Repair	Repair damage from 2006 flood event.	Structural Solutions	Completed levee repair project.	Project complete.
Reif Road River Mile 4.1 Levee Repair	Repair damage from 2009 flood event.	Structural Solutions	Completed levee repair project.	Project complete.

TABLE D-4.
ACCOMPLISHMENTS FOR THE SOUTH FORK SNOQUALMIE RIVER (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Allen Revetment Repair	Repair damage from 2009 flood event.	Structural Solutions	Completed revetment repair project.	Project complete.
Reif Road Levee Emergency Repair	Repair damage from 2011 flood event.	Structural Solutions	Completed 40 lineal feet of levee repair project.	Project complete.
Si View Levee Repair	Repair damage from 2012 flood event.	Structural Solutions	Repairing 40 lineal feet of levee erosion.	Project in Design Phase.

TABLE D-5.
ACCOMPLISHMENTS FOR THE MIDDLE AND NORTH FORKS SNOQUALMIE RIVER (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Middle Fork Corridor Management Project *formerly known as Middle Fork Levee System Capacity Improvements*	Develop management strategies that reduce flood, erosion, and channel migration risks in a sustainable way. Products will include technical information detailing pros and cons of alternatives, a decision-making process and record, and an implementation plan for a suite of actions (preferred alternative).	Structural Solutions	Bathymetric survey completed in 2010.Report completed: "Middle Fork Snoqualmie River Channel Migration Update, 1996-2010". Emergency Action Plan created at Mason Thorson Extension prior to 2011 levee repair. Hydraulics, geomorphology and ecological resources work initiated.	Complete hydraulic, geomorphologic, and ecological resources characterization reports. Complete alternatives analysis. Implement high ranking actions from alternatives analysis.
Other Actions Implemented but not Addressed in 2006 FHMP				
Mason Thorson Ells Levee Repair	Repair damage from 2006 flood event.	Structural Solutions	Completed 400 lineal feet of revetment repair project.	Project complete.
Mason Thorson Extension Levee Repair	Repair damage from 2006 flood event.	Structural Solutions	Completed 450 lineal feet of levee repair project.	Project complete.
Mason Thorson Extension Levee Repair	Repair damage from 2009 flood event.	Emergency Services	Completed emergency repair.	Project complete.
Mason Thorson Extension Levee Repair	Repair damage from 2010 flood event.	Structural Solutions	Completed 20 lineal feet of levee repair project.	Project complete.
Mason Thorson Extension Levee Repair	Repair damage from 2011 flood event.	Structural Solutions	Completed 70 lineal feet of levee repair project.	Project complete.
Middle Fork Snoqualmie Large Wood Mitigation	Relocate logs in high flow channel from January 2009 flood event.	Structural Solutions	14 logs relocated around Mason Thorson Extension Levee.	Project complete.

TABLE D-6.
ACCOMPLISHMENTS FOR THE UPPER MAINSTEM SNOQUALMIE RIVER (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Actions Implemented but Not Addressed in 2006 FHMP (No actions from 2006 Flood Plan)				
Upper Snoqualmie Valley Residential Flood Mitigation *formerly known as Upper Snoqualmie Valley River Flood Mitigation Program*	Prioritize and implement residential home elevations, relocation and acquisitions. 331 Homes have been identified as elevation targets an additional 12 homes are acquisition targets. This project implements non-structural flood mitigation for the entire Snoqualmie Valley floodplain above Snoqualmie Falls.	Property Protection	Fourteen homes elevated and 1 underway.	Pursue home elevations and acquisitions to mitigate or eliminate flood risks to residential structures.
Meadowbrook Revetment Repair	Repair damage from 2011 flood event.	Structural Solutions	Completed 80 lineal feet of revetment repair project.	Project complete.
Record Office Revetment Repair	Repair damage from 2012 flood event.	Structural Solutions	Repairing 125 lineal feet of revetment erosion.	Project in Design Phase.

TABLE D-7. ACCOMPLISHMENTS FOR THE LOWER SNOQUALMIE RIVER (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Aldair/ Fall City Acquisitions, *formerly known as Aldair Buyout*	Pursue voluntary acquisitions of at risk structures in Snoqualmie at Fall City segment; includes potential support to levee setback projects in Snoqualmie at Fall City segment.	Property Protection	Five properties purchased so far including 15 residences and 36 acres. Participated in SAFC reach feasibility study, including technical analysis and outreach.	In progress.
Lower Snoqualmie Residential and Agricultural Flood Mitigation *formerly known as Lower Snoqualmie Residential Flood Mitigation Program*	Pursue house and agricultural structure elevations and acquisitions consistent with mitigation strategy criteria; provide other support for flood risk reduction for agricultural, commercial, residential uses in valley.	Property Protection	Seven homes elevated and 2 barn elevations underway.	In progress.
Winkelman Revetment Repair *formerly known as Tolt Pipeline Protection*	Analyze, design, and implement a capital project to repair 800 lineal feet of Winkelman revetment to maintain protection of Seattle Public Utilities Tolt water supply pipeline that runs adjacent to Snoqualmie River at this location.	Structural Solutions	In progress.	Project is proposed for 2015 construction.
SE 19th Way Buyout	Purchase farm which is at risk of being isolated by bank erosion.	Property Protection	Not pursuing buyout. See Appendix G for potential project action.	None.
Neal Road Relocation	Realign road currently closed due to bank failure.	Emergency Services/ Structural	None.	Project not completed. Project removed from CIP list due to low priority.
Other Actions Implemented but not Addressed in the 2006 FHMP				
Flood – Farm Task Force Implementation	Continue to support farm pads, barn elevations, and ongoing dialog with farmers regarding flood concerns and possible solutions. Participate in agency Fish/ Farm/ Flood process.	Technical Assistance	Twenty four farm pads have been constructed. Participating in WLR Fish/ Farm/ Flood work program.	In progress.
McElhoe Pearson Levee Repair	Repair damage from 2006 flood event.	Structural Solutions	Completed 50 lineal feet of levee repair project.	Project complete.

TABLE D-7.
ACCOMPLISHMENTS FOR THE LOWER SNOQUALMIE RIVER (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Aldair Levee Repair	Repair damage from 2008 flood event.	Structural Solutions	Completed 300 lineal feet of levee repair project.	Project complete.
McElhoe Pearson Levee Emergency Repair	Repair damage from 2009 flood event.	Emergency Services	Completed emergency repair.	Project complete.
Sinnema Quaale Upper Revetment Repair	Analyze, design, and implement a capital project to repair 1000 lineal feet of Sinnema Quaale Upper revetment that provides protection to an embankment supporting the Snoqualmie Valley Trail, a regional fiber optic line, and SR 203.	Structural Solutions	In progress.	Construction proposed for 2014.

TABLE D-8.
ACCOMPLISHMENTS FOR THE TOLT RIVER (2006– 2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Tolt River Mouth to State Route 203 Floodplain Reconnection Technical Support	Continue providing technical support for flood and channel dynamics aspects of the Tolt River Levee Setback project.	Technical Assistance	Provided technical assistance for Setback project.	Project complete.
Tolt River Road Shoulder Protection	Protect road from channel migration.	Emergency Services	Buried setback revetment installed to protect road.	Project complete.
San Souci Neighborhood Acquisitions *formerly known as San Souci Neighborhood Buyout*	Purchase homes in high flood and erosion hazard area.	Property Protection	Twelve properties purchased including 12 residences and 40 acres.	Continuing to purchase at risk properties for 3-5 more years.
Tolt River Flood Early Action Residential Flood Hazard Mitigation	Elevate structures on two repetitive loss properties.	Property Protection	None.	No RL properties in Tolt; 2 RL properties in Snoqualmie mainstem near Tolt will be part of LS residential mitigation program.
Tolt River State Route 203 to Trail Bridge Floodplain Reconnection	Setback Frew levee (right bank) to improve conveyance and allow habitat enhancement.	Structural/ Natural Resource Protection	None.	Priority for funding and implementation to be determined by Tolt Corridor Action Plan.
Tolt River Mile 1.1 Levee Setback	Setback Highway to RR Bridge levee (left bank) to improve conveyance and allow habitat enhancement. Includes purchase and removal of homes.	Structural/ Property Protection/ Natural Resource Protection	Ten properties purchased including 8 residences and 7 acres.	Purchase remaining at-risk properties; begin design of levee setback project.
Other Actions Implemented but not Addressed in 2006 FHMP				
Frew Emergency Repair	Perform emergency repairs to flood protection infrastructure during and immediately following January 2009 flood event.	Emergency Services	Completed emergency repair.	Project complete.
Tolt River Levee Right Emergency Repair	Perform emergency repairs to flood protection infrastructure during and immediately following January 2009 flood event.	Emergency Services	Completed emergency repair.	Project complete.

TABLE D-8.
ACCOMPLISHMENTS FOR THE TOLT RIVER (2006– 2011)

Action	Project Description	Type of Action	Accomplishm ents	Next Steps
Highway to RR Bridge Emergency Repair	Perform emergency repairs to flood protection infrastructure during and immediately following January 2009 flood event.	Emergency Services	Completed emergency repair.	Project complete.
Tolt River Natural Area Floodplain Reconnection Acquisitions	Purchase homes in high flood and erosion hazard areas associated with Tolt Natural Area (some of which will allow for future setback of Edenholm levee).	Property Protection	One property purchased with one residence on one acre.	One more appraisal underway; additional acquisitions will be pursued pending landowner willingness.
Tolt River Corridor Action Plan *formerly known as Tolt River Supplemental Study*	Study and planning effort underway to update technical information on flood and erosion risks and habitat restoration; and to recommend priority actions.	Preventive	The Tolt River Corridor Action Plan is currently underway. This effort includes the scope of work as originally envisioned in this action.	Completion of technical data collection, alternatives analysis, and outreach.
Lower Tolt River Acquisition	Purchase Swiftwater property to allow for future setback of Upper Frew levee (right bank).	Property Protection	Appraisal underway to determine fair market value of property.	Close on purchase in 2013 if price can be agreed to.

TABLE D-9.
ACCOMPLISHMENTS FOR THE RAGING RIVER (2006–2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Fall City Levee Setback Feasibility Study	Determine best alternative for homes in areas subject to flood hazards areas.	Preventive	None.	Develop study scope, schedule and budget for implementing levee setback feasibility study.
Alpine Mobile Manor Neighborhood Buyout	Purchase and remove homes from high flood and erosion hazard area and allow habitat enhancement. In long term, remove county and private flood protection infrastructure.	Property Protection/ Natural Resource Protection	Six properties purchased, comprising 5 residences and 8 acres.	Purchase 4 more single family homes and the mobile home park if landowners are willing and funding is available.
Other Actions Implemented but not addressed in 2006 FHMP				
Arruda Revetment Repair	Repair damage from 2006 flood event.	Structural Solutions	Completed revetment repair project.	Project complete.
Bryce Levee Repair	Repair damage from 2006 flood event.	Structural Solutions	Completed levee repair project.	Project complete.
Bridge to Bridge Left Levee Repair	Repair damage from 2006 flood event.	Structural Solutions	Completed levee repair project.	Project complete.
Bridge to Mouth Right Levee Repair	Repair damage from 2006 flood event.	Structural Solutions	Completed levee repair project.	Project complete.
Preston Fall City Lower Revetment Repair	Repair damage from 2006 flood event.	Structural Solutions	Completed revetment repair project.	Project complete.
Bridge to Bridge Left Levee Repair	Repair damage from 2009 flood event.	Structural Solutions	Completed levee repair project.	Project complete.
Bridge to Bridge Right Levee Repair	Repair damage from 2009 flood event.	Structural Solutions	Completed levee repair project.	Project complete.

TABLE D-10.
ACCOMPLISHMENTS FOR THE SAMMAMISH RIVER AND ISSAQUAH CREEK (2006–2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Willowmoor Floodplain Restoration	Reconfigure outflow from Lake Sammamish to maintain or reduced current level of flood risk along the lake in a manner that reduces impacts on fish and wildlife in the transition zone between the lake and the Sammamish River. Project is required mitigation for current maintenance practices required by the U.S. Army Corps of Engineers.	Structural Solution/ Natural Resource Protection	King County and the City of Redmond are jointly conducting a feasibility study to inform project constraints, opportunities, and alternatives.	King County is evaluating how to move forward with this project given its relatively low flood risk reduction potential. The City of Redmond committed their 2011 Sub-Regional Opportunity Fund to this project to advance it.
Sammamish River Flood Study	Survey data for the Sammamish River dates from 1965. Extensive urban development in the basin has altered flows and sediment loads entering from tributaries. The contour interval used for these existing flood maps is five feet rather than the more detailed interval of two feet. A two-foot interval greatly improves the mapping accuracy of flood hazard boundaries, used in planning future development in the valley. The insurance analysis performed in the Risk Assessment for this Plan in Appendix C supports the need for mapping by identifying that 71 percent of the flood insurance policies in force within the Sammamish River basin are outside the mapped 100-year floodplain. Prepare flood study and corresponding FEMA Flood Insurance Studies and Flood Insurance Rate Maps for the Sammamish River. (Sammamish River, Unincorporated, Cities of Redmond, Woodinville, Bothell, and Kenmore)	Preventive	Completed flood study and Flood Insurance Rate Maps for the Sammamish River.	N/ A
Issaquah Creek Early Residential Flood Hazard Mitigation	Twenty three existing homes and commercial buildings have repeatedly experienced damage from flooding on Issaquah Creek. Repetitive damage to structures was determined by FEMA based on existence of flood insurance policies and claims paid by those policies. Based on the amount and number of claims that have been paid, these properties are identified as being at high risk for future flood damage. Mitigate two repetitive loss properties on Issaquah Creek. Investigate other potential at-risk homes in repetitive loss areas. (Issaquah Creek, City of Issaquah and Unincorporated King County)	Property Protection	Of the 23 repetitive loss properties along Issaquah Creek, 2 have been mitigated through acquisition, with 6 additional acquisitions underway; 5 structures have been mitigated through elevation, with one more planned for 2013.	Carry forward this action
Issaquah Creek Bank Stabilization	Severe bank erosion threatened a city road and the Medical Center of Issaquah.	Structural Solution	Completed a bank repair to protect the infrastructure at risk.	N/ A

TABLE D-11.
ACCOMPLISHMENTS FOR THE CEDAR RIVER (2006–2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Cedar River Channel Migration Zone Study and Mapping.	Prepare channel migration zone study and maps for the Cedar River.	Preventive	A study of channel migration mapping techniques was completed. The results of this study will help guide next steps.	Preliminary analyses have been conducted, but the formal study and mapping process has not been completed.
Cedar Rapids Levee Setback	Set back levee to improve flood conveyance and restore habitat. Complete project design, permits, and construction.	Structural Solution/ Natural Resource Protection	Project was largely funded by habitat restoration-focused partners through the Salmon Recovery Funding Board. Project was completed.	Natural restoration processes are being adaptively managed to foster beneficial habitat without sacrificing flood protection.
Jan Road-Rutledge Johnson Levee Setbacks	Remove portions of both levees that protect only open space. Segments of existing levees constrict conveyance and direct erosive flood flows into the Cedar River Trail and State Route 169.	Structural Solution/ Natural Resource Protection	Acquisition of a key property necessary for the project has been completed with grant funding secured by a habitat restoration partner.	Feasibility study will be initiated in 2012 to evaluate levee inter-related levee setback projects within the reach. Study will guide project design and timing. Coordinate with habitat partners in ongoing acquisition and future project design efforts.
Cedar River Early Action Residential Flood Hazard Mitigation	As of 2011, there were 17 existing homes identified by FEMA, based on flood insurance claims that have repeatedly experienced damage from flooding. Based on the amount and number of claims that have been paid, these properties are identified as being at high risk for future flood damage. These typically represent only a small percentage of the total number of properties experiencing similar flood damages, but which don't have the insurance claims records. Investigate other potential at-risk homes in repetitive loss areas. (Cedar River, Unincorporated King County	Property Protection	Eleven of the FEMA identified repetitive loss homes have been mitigated through acquisition and home elevation. Acquisition of 84 additional homes subject to repeated damage includes 65 parcels that will contribute to large flood risk reduction capital projects and 15 acquisitions by our habitat partners.	Flood Hazard Mitigation Study will better define the flood problem and possible solutions. Continue to work with flood-prone property owners to identify and implement flood solutions. .

TABLE D-11.
ACCOMPLISHMENTS FOR THE CEDAR RIVER (2006–2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Herzman Levee Setback & Floodplain Reconnection	Set back levee to reduce erosive forces on the Cedar River Trail and State Route 169.	Structural Solution/ Natural Resource Protection	Completed acquisition through donation on one of the parcels necessary for the levee setback.	Feasibility study will be initiated in 2012 to evaluate levee inter-related levee setback projects within the reach. Study will guide project design and timing. Coordinate with habitat partners in ongoing acquisition and future project design efforts.
Cedar Grove Mobile Home Park Acquisition Project	Purchase mobile home park and provide relocation assistance to the residents in this area of major flood hazards.	Property Protection/ Natural Resource Protection	Completed project.	N/ A
Rainbow Bend Levee Setback and Floodplain Reconnection	Set back or remove levee to improve flood conveyance and storage through this reach and to restore floodplain functions.	Property Protection/ Structural Solution/ Natural Resource Protection	Acquired last remaining parcel in project area, completing flood mitigation objectives for the residents. Developed partnership with City of Seattle and Lake Washington/ Cedar/ Sammamish Watershed Salmon Recovery Council to design and construct the levee setback and floodplain restoration project. Some of the site restoration and revegetation has been completed.	Design is currently underway and project is scheduled for construction in 2013.

TABLE D-11.
ACCOMPLISHMENTS FOR THE CEDAR RIVER (2006–2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Getchman Levee Setback and Floodplain Reconnection	Set back the levee to improve river's flood conveyance, flood storage, and its interaction with lower Taylor Creek, while maintaining protection for Maxwell Road. Acquisitions are completed or underway.	Property Protection/ Structural Solution/ Natural Resource Protection	Acquisition of two key properties necessary for the project have been completed with grant funding assistance secured by a habitat restoration partner. All necessary acquisitions are complete.	Feasibility study will be initiated in 2012 to evaluate levee inter-related levee setback projects within the reach. Study will guide project design and timing. Coordinate with habitat partners in ongoing acquisition and future project design efforts. .
Rhode Levee Setback and Home Buyouts	Purchase homes along path of fastest, deepest flood flow, and set back the levee to lower localized velocities and depths.	Structural Solution/ Property Protection/ Natural Resource Protection	Acquisitions have been completed on six homes spanning seven parcels, eliminating flood risk to those residents. Negotiations are underway on several additional parcels. Grant funding from habitat partners has contributed to these acquisitions.	Feasibility study will be initiated in 2012 to evaluate levee inter-related levee setback projects within the reach. Study will guide project design and timing. Coordinate with habitat partners in ongoing acquisition and future project design efforts. .
Other Actions Implemented Not in 2006 FHMP				
Elliot Bridge Reach Floodplain Reconnection	Residential neighborhood, partially protected by low elevation levees, experienced damages from fast and deep flood flows in 2006 and 2009.	Property Protection/ Structural Solution/ Natural Resource Protection	Acquisitions have been completed on 14 properties. Negotiations are currently underway on one additional property.	Continue to work with flood-prone property owners to complete acquisitions necessary for setback of two opposing bank levees. Work with WSDOT to implement an early action restoration project on a portion of the project area.

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TABLE D-11.
ACCOMPLISHMENTS FOR THE CEDAR RIVER (2006–2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Royal Arch Neighborhood Flood Mitigation	Fast and deep overbank flows during January 2009 flood damaged homes and cutoff access for 10 residential properties.	Property Protection/ Natural Resource Protection	Through coordination with the City of Seattle on implementation of their habitat conservation plan grant, acquisitions have been completed on 7 properties containing 5 homes.	Continue to coordinate with City of Seattle to complete purchase the one remaining home at greatest risk.
Belmondo Reach Acquisition	This reach contains one of the only unconfined areas within which the river regularly shifts channel location across a wide band of active floodplain. A home located on a terrace above the channel is at risk from channel migration and erosion that could undercut the terrace. (Cedar River, Unincorporated)	Property Protection/ Natural Resource Protection	Project to acquire flood-prone home completed through coordination with City of Seattle.	N/ A
WPA	The WPA levee provides a minimal level of flood protection to five homes which are located in the floodway and what appears to be an area of severe channel migration based on preliminary findings of the channel migration zone study currently underway. The levee also constricts flow conveyance through this segment, where a mobile home park on the opposite bank is regularly inundated by flood flows. (Cedar River, Unincorporated)	Property Protection/ Natural Resource Protection	Habitat partners secured grant funding and have completed acquisition on 2 homes.	Carry forward this action
Cedar River Trail Site #2B Revetment Repair	Repair damage to the flood protection infrastructure caused bank scour from November 2006 flood.	Structural Solution	Completed 100 lineal feet of bank stabilization revetment repair project.	N/ A
Lower Dorre Don Levee Repair	Concrete debris (likely from old bridge abutment) in river causing flows to be deflected towards neighborhood	Structural Solution	Completed 440 lineal feet of bank stabilization levee repair project.	N/ A
Banchero-Barnes Revetment Repair	Repair damage to the flood protection infrastructure caused bank scour from November 2006 flood.	Structural Solution	Completed 310 lineal feet of bank stabilization revetment repair project.	N/ A

TABLE D-11. ACCOMPLISHMENTS FOR THE CEDAR RIVER (2006–2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Cedar Rapids Emergency Repair 2009	Flooding in 2008 and 2009 mobilized chained logs from project. Decision to retrieve all chained logs and stockpile for re-designed installation.	Emergency Services/ Structural Solution	Completed emergency repairs.	Design and construct permanent repair was completed in 2010.
Cedar River Trail Site #1 Revetment Repair	Severe erosion and scour damage to revetment as a result of 2009 flood.	Structural Solution	Completed 150 lineal feet of bank stabilization revetment repair project.	N/ A
Cedar River Trail Site #3 Revetment Repair	Flood damage from 2009 event caused scour hole within one foot of trail, and damage to toe and bank rock.	Structural Solution	Completed 65 lineal feet of bank stabilization revetment repair project.	N/ A
Jan Road Levee Repair	Scour along top-of-bank and backslope as result of January 2009 flood.	Structural Solution	Completed 22 lineal feet of minor levee repair.	N/ A
Petorak-Wadhams Revetment Repair	Severe erosion and scour at upstream end of flood protection infrastructure as a result of January 2009 flood. Home immediately behind revetment at risk.	Structural Solution	Completed 130 lineal feet of bank stabilization revetment repair project.	N/ A
Rainbow Bend Levee Repair	Damage to top-of-bank and backslope of levee as result of January 2009 flood.	Structural Solution	Completed 15 lineal feet of minor levee repair.	N/ A
Rhode Levee Repair	Damage to top-of-bank and backslope of levee as result of January 2009 flood.	Structural Solution	Completed 100 lineal feet of levee repair.	N/ A
Belmondo Emergency Repair	Emergency repair done during January 2009 flood covers a portion of the bank damages from both the November 2006 and January 2009 floods.	Emergency Services/ Structural Solution	Complete 300 lineal feet of emergency repair.	Repair remainder of damaged bank. Bring into compliance with permit requirements.
Cedar Trail Bridge - 2266-10 South Abutment Repair	Access roadway under bridge was damaged by January 2009 flood.	Structural Solution	Completed 90 lineal feet of bank stabilization revetment repair project.	N/ A
Cedar Rapids Wood Replacement Repair	Install engineered logjams to replace the function of the faulty chained logs that were removed as an emergency measure following the January 2009 flood.	Structural Solution	Completed project.	N/ A

TABLE D-11.
ACCOMPLISHMENTS FOR THE CEDAR RIVER (2006–2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Byers Curve Revetment Repair	Damage from the January 2009 flood include overtopping scour on levee top and backslope, face scour in several places, missing toe rock, and natural wood debris deposited on levee top and backslope.	Structural Solution	Completed 66 lineal feet of minor revetment repair.	N/ A
Cedar River Trail Site #2B Revetment Repair	Severe erosion and scour damage to revetment as a result of 2009 flood.	Structural Solution	Completed 150 lineal feet of bank stabilization revetment repair project.	N/ A
Herzman Levee Repair	January 2009 flood damaged the levee toe and bank.	Structural Solution	Completed 300 lineal feet of bank stabilization revetment repair project.	N/ A
Belmondo Repair Phase 1	Permanent repair needs to complete bank repair on remainder of damaged bank and mitigate for emergency work in order to meet permit requirements.	Structural Solution	Completed 200 lineal feet of bank stabilization revetment repair project along Belmondo Revetment.	Complete bank stabilization along remainder of damaged revetment and meet permit requirements.
Orchard Grove Levee Repair	Repair damage to levee backslope	Structural Solution		N/ A
Cedar Rapids Emergency Repair 2011	Perform emergency bank stabilization along setback levee alignment during January 2011 flood event.	Emergency Services/ Structural Solution	Completed emergency repair along 85 lineal feet of bank and replaced 100 lineal feet of setback levee.	Complete fortification of the setback levee.
Young Revetment Repair	Reposition logs that jammed up against the revetment during the January 2011 flood event, threatening the integrity of the flood protection structure.	Structural Solution	Completed log repositioning and minor bank repair.	N/ A
Cedar Rapids setback levee repair	Rebuild portion of setback levee based on vulnerability revealed during the 2011 flood.	Structural Solution	Completed replacement of 163 lineal feet of setback levee.	Rebuild and realign downstream portion of levee.
Cedar Rapids Right Bank Levee Repair	Realign downstream end of setback levee	Structural Solution		Rebuild left bank levee, if feasibility study indicates need.

TABLE D-11.
ACCOMPLISHMENTS FOR THE CEDAR RIVER (2006–2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Cedar River Public Outreach	Share information about King County's flood hazard management projects and programs affecting residents and users of the Cedar River watershed.	Public Information/ Plan Performance	Hosted a public meeting in the basin to share information and receive feedback from the community. Residents expressed interest and favored more regular communication of this type.	Plans are underway to host another community meeting(s) and perhaps repeat annually.
Cedar River Recreation Study	Increase our understanding of types, locations, and seasonality of recreational uses in the Cedar River.	Preventive	This study tested methods for describing and estimating the number of river floaters, where they float in relationship to river projects, the risks they take while floating, and their perceptions of large wood in the river.	This was a pilot study, and the techniques may be used to gain similar information on other King County river basins.
Cedar River Large Wood Study	A multi-phase project to better understand the large wood budget on the Cedar River. The study will identify source or recruitment areas, transport reaches, deposition or accumulation areas; and associated potential ecological benefits and risks of wood accumulations.	Preventive	Between 2009 and 2011 field data were collected on in-stream wood to help develop the wood budget.	In 2012 a canopy analysis and bank erosion evaluation will be conducted to better understand wood loading rates to the river.

TABLE D-12.
ACCOMPLISHMENTS FOR THE GREEN RIVER (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Pump Station Operation	Maintain and operate Black River, P-17 and Segale/ Southcenter pump stations in the Green River Flood Control Zone District.	Structural	Maintenance needs were identified and repairs completed. Overflow from a diesel fuel tank at the Black River/ P-1 Pump Station in Renton was addressed with emergency containment, recovery and removal of oil and contaminated soils, construction of an impoundment and runoff detention measures, and identification of long-term upgrades needed. Sediment accumulations in the storage forebay have been mapped and removal plans are underway. Operation of the pump stations has been transferred to pump operations staff at Metro Wastewater Treatment Division. System upgrades and needed repairs have been identified and implemented under their supervision.	Sediment removal plans will be finalized and implemented at the P-1 flood protection infrastructure. Monitoring and maintenance of all pumps will continue, with needed repairs and equipment replacements identified and accomplished in a timely manner. Fuel storage facilities at the P-1 flood protection infrastructure will be brought up to modern standards and code requirements.
Green River Flood Study	Complete flood study and corresponding FEMA Flood Insurance Studies and Flood Insurance Rate Maps for the Green River between River Mile 5.0 and River Mile 45.0.	Preventive	The Green River Flood Study was completed and submitted to FEMA in support of an appeal to their Draft Preliminary Digital Flood Insurance Rate Maps (DFIRMs) for the Green River. The appeal was supported by all Green River jurisdictions, and has resulted in the issuance of Preliminary DFIRMs by FEMA which utilize the Green River Flood Study mapping results.	Pending decisions made by FEMA, new mapping standards may be applied to the Green River Levees to define DFIRM floodplain extents based on new risk determination categories. These will require modifications to the Green River Flood Study. Absent any new mapping standards, Kent will ask FEMA to modify the Preliminary DFIRMs to reflect its own levee certifications through approval of its various CLOMRs, now in preparation.

TABLE D-12.
ACCOMPLISHMENTS FOR THE GREEN RIVER (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Desimone Levee Project 1, 2, 3, &4	Rehabilitate levees to reduce the risk of flooding in the lower Green River.	Structural	The individual Desimone Levee Projects 1-4 have been included in a reach-long feasibility analysis of alternatives for levee rehabilitation along both banks of the Green River between the S. 200th Street Bridge in Kent and the So. 180th Street in Tukwila. The study alternatives will be published with recommendations in late 2012. In the interim, the City of Kent has pursued geotechnical studies in preparation of a Conditional Letter of Map Revision (CLOMR) request to FEMA. These studies have confirmed that levees in this reach fail to meet recommended standards for slope stability under rapid drawdown conditions, and will require some type of setback modification to this end. Kent itself proposes that discontinuous sheetpile floodwalls be built to secure a minimal factor of safety (FS), while the 2006 Flood Plan recommends a consistent, overall reconstruction of setback earthen levees with flatter slopes. Discussion of these varying recommendations is ongoing between Kent and the District.	Once discussions with Kent are resolved and a recommendation from the alternatives analysis is selected, necessary easement acquisitions will be initiated and projects built.
Segale Levee Project 1	Rehabilitate levees to reduce the risk of flooding in the lower Green River.	Structural	In 2009 portions of the Segale Levee project 1 were reconstructed in a modified setback configuration, including a landward concrete floodwall segment, by the Corps of Engineers. Remaining portions of this project remain to be completed. The individual Segale Levee Project 1 has been included in a reach-long feasibility analysis of alternatives for levee rehabilitation along both banks of the Green River between the S. 200th Street Bridge in Kent and the So. 180th Street in Tukwila. The study alternatives will be published with recommendations in late 2012.	Once the study is published and a recommendation from the alternatives analysis is selected, necessary easement acquisitions will be initiated and projects built.
Segale Levee Project 2	Rehabilitate levees to reduce the risk of flooding in the lower Green River.	Structural	The individual Segale Levee Project 2 has been included in a reach-long feasibility analysis of alternatives for levee rehabilitation along both banks of the Green River between the S. 200th Street Bridge in Kent and the So. 180th Street in Tukwila. The study alternatives will be published with recommendations in late 2012. Once the study is published and a recommendation from the alternatives analysis is selected, necessary easement acquisitions will be initiated and projects built.	Once the study is published and a recommendation from the alternatives analysis is selected, necessary easement acquisitions will be initiated and projects built.

TABLE D-12.
ACCOMPLISHMENTS FOR THE GREEN RIVER (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Briscoe Levee Project 4	Rehabilitate levees to reduce the risk of flooding in the lower Green River.	Structural	The Briscoe Levee Project 4, at the 2006 levee failure location, was evaluated for several slope repair configurations by the King County Soils Materials Laboratory, with design alternatives developed by King County Rivers Section engineers and constructed by the Corps of Engineers under their PL-99 Rehabilitation Inspection program. Design studies concluded that Factors of Safety for rapid drawdown conditions should meet or exceed FS= 1.2 to 1.4, with the lower thresholds addressing localized stability with respect to shallow sloughing failures above and below a midslope bench, and with the higher values addressing global stability with respect to deeper-seated rotational slope failure potentials. This resulted in the design of slopes at or near 3H:1V inclination, requiring the acquisition of additional easement areas from adjoining commercial landowners to site the reconstructed, setback levee repair over a 600-foot reach. The design also included a series of log deflectors anchored into a rock toe buttress, and bioengineering slope stabilization with native plantings, built by the Corps of Engineers and repaired by King County.	Monitor and maintain as needed.
Nursing Home Levee Project	Rehabilitate levees to reduce the risk of flooding in the lower Green River	Structural	The Nursing Home Levee is one portion of the overall Horseshoe Bend Levee, selected for initial implementation in the 2006 Flood Plan due to its substantially oversteepened condition and incremental structural deterioration. Acquisition of additional easement area needed for the reconstruction of a portion of this levee was initiated by the District in 2008, which then sponsored a setback reconstruction of this portion by the Corps of Engineers in 2009, together with emergency shoring of an adjoining, less stable embankment and completion of additional Horseshoe Bend setback reconstruction previously initiated by the District. Structural analyses of the levee by the City of Kent's geotechnical engineers confirmed the need for additional setback of this and adjoining portions of the Nursing Home and Nursing Home Extension segments of the overall Horseshoe Bend levee. Kent was awarded $10,000,000 to acquire added easement areas and set additional portions of the levee back with construction of discontinuous segments of earthen berms.	Project discussions with Kent and the Corps of Engineers will determine the scope and character of further repairs and reconstruction needs in this levee reach, and throughout the Horseshoe Bend. Once project alternatives are reviewed, programmatic needs resolved, and a recommended alternative selected, acquisitions, design and construction of remaining levee upgrades will commence as needed.

TABLE D-12.
ACCOMPLISHMENTS FOR THE GREEN RIVER (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Salmon Habitat Recovery Cost Share	Provide financial support to, and participate in, Salmon Recovery Funding Board and U. S. Army Corps of Engineers Ecosystem Recovery Project habitat projects.	Natural Resource Protection	The District cooperated with the City of Auburn to provide the local cost share match and complete the construction of the Salmon Recovery Fund financed Fenster Phase 2A Levee Setback and Floodplain Reconnection Project within Auburn's Fenster Park at River Mile 32.0 on the Left Bank of the Green River. This project was part of the overall Fenster/ Pautzke Ecosystem Restoration Project (ERP) identified at this location, but the Corps did not participate in this work. Removal and setback of the Pautzke Levee was subsequently accomplished by King County's Ecological Restoration Engineering Section using additional SRFB funds and supplemental grants from additional sources.	The Fenster site will be used for construction of mitigation measures required to offset levee tree clearing actions within the City of Auburn, completed by the District since 2006 in response to determinations by the Corps that they would be necessary to maintain eligibility for Corps PL-99 levee flood damage repairs in the future. Instream log placement will be incorporated as a modification of existing SRFB-funded log structures previously built. A second phase of the Fenster Project is also planned and funding is being sought to supplement available SRFB awards.
Green River Flood Control Zone District Program Management	Provide program management and administration to Green River Flood Control Zone District projects, program and activities.	Plan Performance	Additional staffing resources were added to the Green river Basin Team to accomplish the Flood plan's long-term project and planning goals. This included two engineers and one program analyst positions. A significant effort was devoted to concerns with Corps operations of Howard A. Hanson Dam, flood scenario mapping in response to this crisis, coordination and placement of supplemental flood containment structures along the Lower Green river levees, and coordination with the City of Kent's continuing efforts to analyze, design, construct, and certify the levees and their proposed modifications.	One additional engineer will be added to the Green River Basin Team to assist with implementing the District's work program.

TABLE D-12.
ACCOMPLISHMENTS FOR THE GREEN RIVER (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Briscoe Levee Projects 1-3, 5-8	Rehabilitate levees to reduce the risk of flooding in the lower Green River.	Structural	The individual Briscoe Levee Projects 1-3, 5-8 have been included in a reach-long feasibility analysis of alternatives for levee rehabilitation along both banks of the Green River between the S. 200th Street Bridge in Kent and the So. 180th Street in Tukwila. The study alternatives will be published with recommendations in late 2012. In the interim, the City of Kent has pursued geotechnical studies for a Conditional Letter of Map Revision (CLOMR) request to FEMA. These studies confirm that levees in this reach fail to meet standards for slope stability under rapid drawdown conditions, and will require some type of setback modification to this end. Kent itself proposes that discontinuous sheetpile floodwalls be built to secure a minimal factor of safety (FS), while the 2006 Flood Plan recommends a consistent, overall reconstruction of setback earthen levees at a higher FS value. Discussion of these varying recommendations is ongoing between Kent and the District.	Once discussions with Kent are resolved and a recommendation from the alternatives analysis is selected, necessary easement acquisitions will be initiated and projects built.
Russell Upper Levee Project	Rehabilitate levees to reduce the risk of flooding in the lower Green River.	Structural	Basic geotechnical evaluation of the Russell Upper Levee has been completed by the City of Kent in connection with its request to FEMA for a Conditional Letter of Map Revision (CLOMR). This structural evaluation has shown that three major segments of the levee would need to be reconstructed in a setback configuration to meet even the absolute minimum Factors of Safety (FS) for rapid drawdown failures. As if to confirm this finding, the slopes in question developed several localized slumping failures following the 2011 and 2012 flood seasons. Using higher slope stability standards set in accordance with the 2006 Flood Plan, and also recognizing constraints posed by existing residential land uses, the District has outlined a more comprehensive overall setback proposal for the entire levee reach, and remains in discussions with Kent over decisions on consistent design standards, project phasing, and funding allocations for this work, expected to start in late summer of 2012.	Once discussions with Kent are resolved the necessary easement acquisitions will be initiated and projects built. Full completion of the project will be implemented with a phased funding and construction approach over time.

TABLE D-12.
ACCOMPLISHMENTS FOR THE GREEN RIVER (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Kent Shops Levee Project	Rehabilitate levees to reduce the risk of flooding in the lower Green River.	Structural	The Kent Shops Levee Project was combined with the Narita Levee Project and the Myers' Golf Levee Project, all of which were jointly designed and constructed by the Corps of Engineers under their PL-99 Rehabilitation Inspection Program, with the Flood District providing the local sponsor's cost share. The City of Kent provided the additional setback levee easement areas needed to meet slope stability requirements, within their municipal golf course adjoining the levees. The Flood District reimbursed Kent under the terms of an Interlocal agreement negotiated to offset the costs of rebuilding the golf course to accommodate the modified layout created by the levee setbacks. While the bioengineered levee reconstruction template previously used by the Corps at the Briscoe Levee 4 location was initially endorsed, changes in the Corps' administration of its national and regional standards for allowance of vegetation on levees, and an engineering emphasis on bed scour led to construction of a launchable rock toe with a modified design in this location.	Monitor and maintain as needed.
Narita Levee Project	Rehabilitate levees to reduce the risk of flooding in the lower Green River.	Structural	The Narita Levee Project was combined with the Kent Shops Levee Project and the Myers' Golf Levee Project, all of which were jointly designed and constructed by the Corps of Engineers under their PL-99 Rehabilitation Inspection Program, with the Flood District providing the local sponsor's cost share. The City of Kent provided the additional setback levee easement areas needed to meet slope stability requirements, within their municipal golf course adjoining the levees. The Flood District reimbursed Kent under the terms of an Interlocal agreement negotiated to offset the costs of rebuilding the golf course to accommodate the modified layout created by the levee setbacks. While the bioengineered levee reconstruction template previously used by the Corps at the Briscoe Levee 4 location was initially endorsed, changes in the Corps' administration of its national and regional standards for allowance of vegetation on levees, and an engineering emphasis on bed scour led to construction of a launchable rock toe with a modified design in this location.	Monitor and maintain as needed.

TABLE D-12.
ACCOMPLISHMENTS FOR THE GREEN RIVER (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Myer's Golf Levee Project	Rehabilitate levees to reduce the risk of flooding in the lower Green River.	Structural	The Myers' Golf Levee Project was combined with the Narita Levee Project and the Kent Shops Levee Project, all of which were jointly designed and constructed by the Corps of Engineers under their PL-99 Rehabilitation Inspection Program, with the Flood District providing the local sponsor's cost share. The City of Kent provided the additional setback levee easement areas needed to meet slope stability requirements, within their municipal golf course adjoining the levees. The Flood District reimbursed Kent under the terms of an Interlocal agreement negotiated to offset the costs of rebuilding the golf course to accommodate the modified layout created by the levee setbacks. While the bioengineered levee reconstruction template previously used by the Corps at the Briscoe Levee 4 location was initially endorsed, changes in the Corps' administration of its national and regional standards for allowance of vegetation on levees, and an engineering emphasis on bed scour led to construction of a launchable rock toe with a modified design in this location.	Monitor and maintain as needed.
Middle Green Floodplain Acquisition	Purchase one home and associated property subject to severe flood related hazards.	Property Protection	The Wallace property was purchased by the King County Environmental Restoration and Engineering Section with funding from a number of grant agencies. The home and associated structures were removed from a high channel migration hazard zone in the floodplain, and the site restored with extensive native riparian plantings. This effort complements earlier purchase and removal of the adjoining home and ongoing restoration of that site as well. In addition, a third site, the Freemouw property, was also purchased and removed from a chronic at-risk location situated on the floodplain channel of Burns Creek in the same Middle Green River reach as the Wallace site, which also adjoins Burns Creek.	Monitor and maintain as needed. Integrate additional floodplain acquisitions as needed to accomplish a series of levee setback and floodplain reconnection project actions within the Middle Green River, potentially including the Flaming Geyser Levees, the Crisp Creek neighborhood, Lone's Levee, Turley Levee, Horath/ Kaech Levee, Neely Bridge Levee, and Porter levee.

TABLE D-12.
ACCOMPLISHMENTS FOR THE GREEN RIVER (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Dykstra Revetment Repair	Repair damage from 2006 flood event.	Structural	The Corps of Engineers repaired flood damages to portions of the Dykstra Levee in Auburn by constructing a rock toe buttress and rock facing with some inclusion of willow cuttings and log flow deflectors. The Flood District funded the local sponsor's cost share for this work.	Monitor and maintain as needed. Evaluate overall levee and perform site investigations as needed to determine appropriate structural modifications to achieve currently recognized levee engineering standards. Explore a long-term program of property acquisitions to achieve stable levee geometries as thus determined.
Foster Golf Revetment	Repair damage from 2006 flood event.	Structural	The Flood district funded minor repairs to the Foster Golf Revetment in Tukwila. The work was performed by King County.	Monitor and maintain as needed.
Galli's Section Repair	Repair damage from 2006 flood event.	Structural	The Corps of Engineers repaired flood damages to the full length of the Galli's Section Levee in Auburn by constructing a rock toe buttress and rock facing with some inclusion of willow cuttings and log flow deflectors. The Flood District funded the local sponsor's cost share for this work.	Monitor and maintain as needed. Evaluate overall levee and perform site investigations as needed to determine appropriate structural modifications to achieve currently recognized levee engineering standards. Explore a long-term program of property acquisitions to achieve stable levee geometries as thus determined.

TABLE D-12.
ACCOMPLISHMENTS FOR THE GREEN RIVER (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Horseshoe Bend 205 Repair	Repair damage from 2006 flood event.	Structural	The Flood District negotiated with an affected property owner and acquired additional easement areas needed to reconstruct a damaged portion of the Nursing Home segment of the Horseshoe Bend 205 Levee (see also Nursing Home Levee Project, above, and Horseshoe Bend 2009 repairs, below). The Corps of Engineers then reconstructed the levee here to a setback design based on placing a sizeable launching toe structure and rock facing along the lower riverward slopes, with inclusion of some native plantings. Downstream at the Breda segment of the Horseshoe Bend levee, the initial portion of a phased levee setback constructed by the Flood District in 2004 was completed by the Corps with this same launchable toe structure. Additional rip-rap scour protection was also placed by the Corps just downstream from the Central Avenue Bridge abutment at this time, and was tied-in to earlier bioengineered repairs originally constructed downstream in 1997.	Monitor and repair as needed. Project discussions with Kent and the Corps of Engineers will determine the scope and character of further repairs and reconstruction needs in this levee reach, and throughout the Horseshoe Bend. Once project alternatives are reviewed, programmatic needs resolved and a recommended alternative selected, acquisitions, design and construction of remaining levee upgrades will commence as needed.
Tukwila 205 Repair	Repair damage from 2006 flood event.	Structural	The Corps of Engineers reconstructed of a flood damaged portion of the Tukwila 205 Levee at the Lily Pointe and Wells Fargo properties along the left bank just upstream from the S. 180th Street Bridge in Tukwila, and also at the Segale property just upstream from the levee along S. 180th. All design and construction costs were borne by the Corps for this work on the federally authorized Tukwila 205 Levee here, except for the cost and construction of a concrete floodwall eliminating the landward portion of the levee embankment on the Segale property. This was paid for by the landowner to minimize setback dimensions affecting the site. The work included reconstruction of the levee in a setback location to achieve more stable river embankment slope geometry, along with anchored deflector logs and a launchable rock toe buttress incorporating some native plantings. Costs for acquiring the additional easement areas on the Lily Pointe and Wells Fargo sites were funded by the Flood District in support of Tukwila's role as the local sponsor for the work.	Monitor and maintain as needed. Complete S. 180th Street to S. 200th Street Levee alternatives feasibility study. Once a project alternative is identified and recommended as a result of this study, pursue additional acquisitions as needed and proceed with project implementation.

TABLE D-12.
ACCOMPLISHMENTS FOR THE GREEN RIVER (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Foster Golf Course Mitigation	Mitigation associated with 2006 flood repair projects.	Mitigation	Newly emphasized federal compliance requirements for removing levee vegetation in order to remain eligible for federal levee repair funding under the Corps of Engineers' PL-99 Rehabilitation Inspection Program led to the decision to cut a significant number of trees and larger woody shrubs from Lower Green River Levees in 2009 and 2010. This action was permitted by the Washington Department of Fish and Wildlife (WDFW), with a requirement that mitigation be provided with placement of an equivalent number of trees into the water column and replacement plantings at a nearby mitigation site location. The Foster Golf Course was provided as a site for this purpose by the City of Tukwila for mitigation of levee clearing within Tukwila. Logs were anchored within the water column to wooden pilings driven into the riverbed. All work was designed and constructed by King County with Flood District funding.	Monitor and maintain as needed. Additional instream log placement and native plantings will be completed nearby in 2013 to satisfy similar obligations incurred in response to subsequent levee tree clearing actions.
42nd Ave South Repair	Perform repair to flood protection infrastructure due to damage from January 2009 flood.	Structural	Chronic slumping of the 42nd Avenue S. roadway embankment in Tukwila occurred again during the 2009 flood season. Tukwila maintains a high-pressure 18-inch diameter water main within the roadway shoulder, which was partially exposed and at risk due to the slump. An emergency repair was initiated with piling-driven support of the road shoulder to allow excavation of a construction bench just above the tide line here. Additional pilings were driven into the embankment toe within the water column to reinforce and consolidate the loose sediments present, and a matrix of logs was anchored to the pilings to deflect erosive, undercutting flows away from the base of the slope. Rock toe support was not included, as federal permits required for these measures would have delayed critical project implementation scheduling needs, to address potential rupture of the regionally significant water main serving all of Southcenter and supplying fire mains throughout much of Tukwila. Live geogrids were then constructed to rebuild the failed slopes, incorporating densely planted layers of native vegetation to reinforce the embankment.	Monitor and maintain as needed.

TABLE D-12. ACCOMPLISHMENTS FOR THE GREEN RIVER (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Stoneway Lower Repair	Perform repair to flood protection infrastructure due to damage from January 2009 flood.	Structural	A slumping failure caused by the January 2009 flood caused nearly 200 feet of Frager Road adjoining the Stoneway Lower Revetment along the left bank of the Green River upstream from the S. 231st Street Bridge in Kent to fail. Failed slopes were excavated, log pilings driven to consolidate and reinforce the toe, and log deflectors placed to reduce toe erosion. The slope was rebuilt with geotextiles and live geogrid lifts, with dense native plantings.	Monitor and maintain as needed.
Horseshoe Bend Repair	Perform repair to flood protection infrastructure due to damage from January 2009 flood.	Structural	The Corps of Engineers repaired flood damages to a portion of the Nursing Home portion of the Horseshoe Bend Levee in Kent by constructing a rock toe buttress and rock facing with some inclusion of willow cuttings. This work was immediately upstream from and integrated with the Nursing Home Levee Project described above (see also 2006 Horseshoe Bend 205 Repair, above). The Corps also constructed similar embankment reconstruction at two other flood damage locations downstream, using the same design and construction approach. These downstream locations adjoin both the upstream and downstream margins of earlier repairs constructed in 1997. The Flood District was the local sponsor for this work, with all design and construction costs borne by the Corps on the federally authorized Horseshoe Bend 205 Levee system.	Monitor and maintain as needed. Project discussions with Kent and the Corps of Engineers will determine the scope and character of further repairs and reconstruction needs throughout the Horseshoe Bend. Once project alternatives are reviewed, programmatic needs resolved, and a recommended alternative selected, acquisitions, design and construction of remaining levee upgrades will commence as needed.
Dykstra Sinkhole Repair	Repair to a sinkhole developing within the landward foundation of the Dykstra levee.	Structural	A 4-foot diameter sinkhole in a residential yard just landward of the Dykstra Levee and intersecting with the levee foundation materials was investigated with soils borings and laboratory analysis indicating it will require repair to ensure the integrity of the levee foundations at this location. Seepage conditions and soils types present require excavation and replacement of foundation materials to a depth of approximately ten feet. This work is immediately adjacent to the existing residence, and a shoring plan to secure both the trench and the residential foundations is needed. To date, a King County work order contractor has been unable to resolve design requirements for securing the foundations with respect to lateral loading requirements determined by the King County Soils Materials Laboratory's site exploration and testing results.	Complete an engineered shoring plan and complete project construction. Monitor and maintain as needed. An engineering design contract will be scoped and executed to provide for this project element, after which construction will proceed during the summer of 2012.

TABLE D-12.
ACCOMPLISHMENTS FOR THE GREEN RIVER (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Renton and Tukwila Pump Station Modifications	Upgrade the Renton and Tukwila Pump Station.	Structural	The Flood District has secured the services of professional pump operations staff located at the Renton Metro Wastewater Treatment Facility immediately adjoining the Black River/ P-1 Pump Station to thoroughly evaluate that flood protection infrastructure and the nearby P-17 flood protection infrastructure in Tukwila for needed upgrades. Equipment in these facilities dated from the 1970's, and several pumps and control mechanisms at Black River were in need of major overhaul, functional upgrades, or replacement. Access and emergency back-up electrical upgrades were completed at P-17, and all pumps and related accessory mechanisms at Black River were serviced, replaced and repaired to fully operational conditions.	Intake fish screens at Black River are being incrementally replaced, sediments removed from the pump intake locations, site evaluations are being completed and a dredging plan is being drawn up to remove accumulated sediments and restore the storage forebay at the flood protection infrastructure to its design capacity. These upgrades and dredging actions are ongoing. A wholesale evaluation of the old equipment present and options for its timely replacement will be completed as well.
Kent Containment	Install containment barriers along the Green River.	Structural (Temporary)	High flood storage reservoir pool elevations at Howard A. Hanson Dam in January 2009 resulted in seepage-related concerns at the right abutment to the dam. This led the Corps of Engineers to temporarily modify its operations at the dam, with a result that curtailed levels of flood protection were anticipated until the suspected problems were better identified and solutions implemented. As a result, the Flood District cooperated with the Corps, Kent and the other Valley cities to place temporary levee raising structures consisting of large sand-filled bags or barricade structures along miles of Lower Green River levees, wherever developed land uses might be at risk. Many of the bags and structures were supplied by the Corps, with sand fill materials and bag placement provided by the City. Significant funding was provided to the City by the Flood District to help with this effort. No unusual flood events actually occurred, and the Corps constructed several major repairs to the dam abutment, announcing that fully operational status had been restored in the early spring of 2012.	Remove containment structures and restore levees to original conditions.

TABLE D-12.
ACCOMPLISHMENTS FOR THE GREEN RIVER (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Auburn Containment	Install containment barriers along the Green River.	Structural (Temporary)	High flood storage reservoir pool elevations at Howard A. Hanson Dam in January 2009 resulted in seepage-related concerns at the right abutment to the dam. This led the Corps of Engineers to temporarily modify its operations at the dam, with a result that curtailed levels of flood protection were anticipated until the suspected problems were better identified and solutions implemented. As a result, the Flood District cooperated with the Corps, Auburn, and the other Valley cities to place temporary levee raising structures consisting of large sand-filled bags or barricade structures along miles of Lower Green River levees, wherever developed land uses might be at risk. Many of the bags and structures were supplied by the Corps, with sand fill materials and bag placement provided by the City. Significant funding was provided to the City by the Flood District to help with this effort. No unusual flood events actually occurred, and the Corps constructed several major repairs to the dam abutment, announcing that fully operational status had been restored in the early spring of 2012.	Remove containment structures and restore levees to original conditions.
Tukwila Containment	Install containment barriers along the Green River.	Structural (Temporary)	High flood storage reservoir pool elevations at Howard A. Hanson Dam in January 2009 resulted in seepage-related concerns at the right abutment to the dam. This led the Corps of Engineers to temporarily modify its operations at the dam, with a result that curtailed levels of flood protection were anticipated until the suspected problems were better identified and solutions implemented. As a result, the Flood District cooperated with the Corps, Tukwila, and the other Valley cities to place temporary levee raising structures consisting of large sand-filled bags or barricade structures along miles of Lower Green River levees, wherever developed land uses might be at risk. Many of the bags and structures were supplied by the Corps, with sand fill materials and bag placement provided by the City. Significant funding was provided to the City by the Flood District to help fund this effort. No unusual flood events actually occurred, and the Corps constructed several major repairs to the dam abutment, announcing that fully operational status had been restored in the early spring of 2012	Remove containment structures and restore levees to original conditions.

TABLE D-12.
ACCOMPLISHMENTS FOR THE GREEN RIVER (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Renton Containment	Install containment barriers along the Black River outlet at its confluence with the Green River.	Structural (Temporary)	High flood storage reservoir pool elevations at Howard A. Hanson Dam in January 2009 resulted in seepage-related concerns at the right abutment to the dam. This led the Corps of Engineers to temporarily modify its operations at the dam. Curtailed levels of flood protection were anticipated until the suspected problems were better identified and solutions implemented. As a result, the Flood District placed temporary levee raising structures consisting of large sand-filled bags and eco-block barricade structures along the Black River outlet channel at its confluence with the Green River. This was done to ensure a separation of interior floodwaters from potential Green River surcharge at the pump station forebay. King County furnished eco-block concrete barriers and fill materials for large sandbag obtained from the Corps. Funding for this effort was provided to the by the Flood District. No unusual flood events actually occurred, and the Corps constructed several major repairs to the dam abutment, announcing that fully operational status had been restored in the early spring of 2012.	Remove containment structures and restore site to original conditions.
Porter Bridge Levee Flood Prep	Implement emergency flood prep measures.	Flood Contingency	2009 impairment of Howard A. Hanson Dam led to concerns by Auburn regarding debris impacts on the 8th Street (Porter) Bridge Questions were raised about potential behavior of logjam accumulations upstream at the Auburn Narrows. King County coordinated with the Corps of Engineers to evaluate this substantial logjam, with the Corps recommending it not be disturbed. Further evaluation of the jam's mobilization potential was also requested as part of an independent peer-review panel by King County to evaluate its overall Green River program. This panel also found a low potential for re-mobilization of the logjam, and a high potential for this feature to actually protect downstream structures like the Porter Bridge by continuing to capture and sequester logs entering the lower river from upstream. Following these investigations, contingency plans were set to stage large trackhoe excavators at the bridge to remove any log accumulations during very extreme floods. These floods have not occurred, and the dam has been restored to normal operating conditions.	Maintain contingency plans for responding to potential debris accumulations at the Porter Bridge.

TABLE D-12.
ACCOMPLISHMENTS FOR THE GREEN RIVER (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Green River Levee Tree Removal	Remove trees and other vegetation from Green River levees to meet U.S. Army Corps of Engineers flood repair funding eligibility requirements.	Policy	Hundreds of native riparian trees and woody shrubs were cut from Green River Levees to satisfy Corps of Engineers funding eligibility requirements. Based on permitting requirements for this work, substantial mitigation in the form of replanting and instream log placement at other sites has been required. Some initial mitigation has already been accomplished (see Foster Golf Mitigation, above), but much work remains to be completed in 2013. To this end, a large parcel (the Teufel site in Kent) has been acquired to provide a site not also constrained by levees for such mitigation to proceed. The Foster Golf site in Tukwila and the Fenster Park site in Auburn will also provide for reach-specific mitigation needs to this end. A significant volume of additional vegetation has subsequently been identified for removal by the Corps of Engineers in 2012, and will require even further mitigation if policy choices are made to proceed with additional levee clearing. Regional and national discussions with the Corps of Engineers are ongoing with respect to modifying this national policy directive.	Set all levees back from the existing OHWM of the Green River to a distance of from 1.0 to 2.5 Site Potential Tree Heights. Provide for a perpetual, undisturbed shaded riparian zone with a vegetated corridor in this setback area. Plant and maintain a varied, robust mix of native riparian tree species and maintain to maturity. Site, reconstruct and maintain all river levees landward from the margins of this vegetated corridor.
Tukwila 205 – Lily Point Reimbursement	Reimburse Tukwila for local sponsor land acquisition costs at the Lily Pointe and Wells Fargo locations of the Tukwila 205 Levee Repairs.	Structural (Acquisition)	Lands necessary for reconstructing a flood-damaged federal levee to modern structural standards were acquired by the City of Tukwila, which is the local sponsor of record for this flood protection infrastructure(see also Tukwila 205 Repair, above). The levee was reconstructed in a setback location, requiring the lands in question. The Flood District agreed to provide Tukwila with reimbursement for these acquisition costs, allowing the Corps to fund the full cost of design and construction for the levee repairs.	Continue to cooperate with local jurisdictions to acquire lands and easements as needed to reconstruct levees to currently accepted levels of engineering excellence.
Green River Flood Emergency – Advance Measures	Fund coordination of Emergency Advance Measures	Program Coordination	Federal, County, and City actions were coordinated through planning and implementation, to establish emergency containment structures in response to impaired operations at Howard A Hanson Dam (see also Auburn, Kent, Tukwila and Renton Containment, above). Dam operations were returned to normal with repairs concluded in early 2012, allowing completion of this coordinating function with arrangements for removal of the Emergency Advance Measures containment structures involved.	Continue to participate in emergency flood response planning and contingency actions as appropriate.

TABLE D-13.
ACCOMPLISHMENTS FOR THE WHITE AND GREENWATER RIVERS (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
White River Channel Migration Zone Study and Mapping	Prepare channel migration zone study and maps for the White River.	Preventive	Some technical information on historical channel conditions has been compiled (Collins Report)	Apply technical methodology to prepare study and mapping for a study areas including Segments 1, 2, 3 and 4
White River Flood Studies	Prepare flood studies and corresponding FEMA Flood Insurance Studies and Flood Insurance Rate Maps for the White River.	Preventive	Two flood studies were completed in 2009: Within Segment 1, from the countyline to RM 10; and within segment 3from from SR410 to Mud Mountain Dam.	Flood studies for White River segments 2 (RM 10- SR 410) and 4 (MMD-Greenwater) should be pursued.
Greenwater River Flood Study	Prepare flood study and corresponding FEMA Flood Insurance Studies and Flood Insurance Rate Maps for the Segment 5: the Greenwater River.	Preventive	No progress.	Verify if the available Pierce County flood study is representative of current conditions. If not, collect new channel data and update the flood study. (Segment 5)
Countyline Levee Setback Project *Formerly known as County Line to A-Street Flood Conveyance Improvement*	Improve flood conveyance throughout this reach of Segment 1 reach and reduce flood-related risk to residential and commercial properties by setting back the existing levee and reconnecting the river channel to a portion of its floodplain.	Property Protection/ Structural	Acquisition of 3 properties, preliminary design and supporting technical analysis. Monitoring Plan and Pre-project monitoring data collection.	Complete necessary acquisitions, finalize design, SEPA and other permit review. Two year construction scheduled for 2014 and 2015.
Pacific City Park Revetment Repair	Repair damaged concrete revetment.	Structural	Frequent site monitoring has occurred. No repair work was completed. Project is now included within the Pacific Right Bank Levee Setback Project.	See description for Pacific Right Bank Levee Setback Project in Chapter 5 and Appendix F.
3rd Place and Pacific City Park Revetment Retrofit	Rehabilitate failing concrete slab revetment by replacing with bioengineered flood protection infrastructure.	Structural	Two fee-simple acquisitions have been completed to support the future levee setback project. No progress on feasibility studies or design. Project has been in the Right Bank Levee Setback Project.	See description for Pacific Right Bank Levee Setback Project in Chapter 5 and Appendix F.

TABLE D-13.
ACCOMPLISHMENTS FOR THE WHITE AND GREENWATER RIVERS (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
41st Street Setback Feasibility Analysis	Conduct levee set back feasibility study to protect homes and school.	Preventive	No progress to date. Project has been replaced by the A Street – R Street Feasibility Study.	See description for A Street – R Street Feasibility Study in Chapter 5 and Appendix F.
Red Creek Residential Flood Mitigation *formerly known as Red Creek Acquisitions*	Remove homes subject to flooding and erosion hazards through fee simple acquisition.	Property Protection	No progress to date on acquisitions. Annual outreach to keep the community informed of flood risks occurred through public meetings from 2006-2009, and personal letters in 2010-2011.	Maintain contact with private property owners for opportunities from willing sellers.
TransCanada Flood Conveyance Improvement	Implement levee modification project.	Preventive	Completion of Feasibility Study and preliminary engineering (2010)	Initiate other technical analyses (i.e. geotechnical bluff analysis) to continue with design development
River Mile 44 to Greenwater Residential Flood Mitigation *formerly known asWhite-Greenwater Acquisition*	Purchase and remove residential structures subject to flood and erosion hazards.	Property Protection	Landowners were engaged in acquisition negotiations in 2010. No agreement was reached.	Maintain contact with private property owners for opportunities for willing sellers.
Other Actions Implemented Not addressed in 2006 FHMP				
White River Flood Damage Repair at Stuck River Drive	Replace eroded revetment with stable log and rock toe and 300 feet of biostabilized riverbank.	Structural	Repair of flood damage incurred from 2006 flood event	Continue with site monitoring requirements and vegetation maintenance
Temporary Flood Protection Barrier	Provide temporary enhanced flood protection landward of existing revetments to reduce flood risks to private residential and commercial areas of Pacific.	Preventive / Property Protection / Structural	Installed in October 2009 and maintained (to present) a temporary floodwall with HESCO barriers and Supersaks along a setback alignment extending from County property at Pacific City Park and along private property to the southern riverward extent of White River Estates.	Maintain barrier in place until final Pacific Right Bank Levee Setback project can be implemented.

TABLE D-13.
ACCOMPLISHMENTS FOR THE WHITE AND GREENWATER RIVERS (2006-2011)

Action	Project Description	Type of Action	Accomplishments	Next Steps
Pacific Right Bank Levee Setback	Improve flow conveyance by removing artificial fill, reconnecting the river to a broader portion of its floodplain and building a setback levee to limit the bounds of channel migration in this reach.	Preventive / Property Protection / Structural	Acquired 1 agricultural property and 11 residential properties. 5 of these homes were auctioned and relocated, 6 were demolished.	Feasibility work, continued acquisitions, design, permitting and implementation.

TABLE D-14.
FLOOD MITIGATION CATEGORIES AND DEFINITIONS

Category	Definition	Impact	Examples
Preventive	Activities that keep problems from getting worse and helps the County identify risk and vulnerability.	Increases capability and decreases vulnerability and exposure.	• Planning • Land Use • Regulations • Mapping
Property Protection	Actions that can singularly protect property on a building –by-building or parcel basis. Actions can be implemented at a private and/ or public level	Decreases vulnerability and exposure.	• Acquisition • Relocation • Retrofitting
Natural Resource Protection	Activities that preserve or restore natural areas or enhance the environments ability to attenuate the impacts of natural hazards.	Reduces exposure	• Wetlands protection • Erosion and sedimentation control/ management • BMP's • Normative Flow practices
Emergency Services	Measures taken during an emergency to minimize the impact of the event. Also included preparedness and recovery actions.	Increases capability	• Hazard Warning • Hazard Response • Critical Facilities protection • Health and Safety Maintenance
Structural Solutions	Actions taken to prevent the hazard for impacting a populace. Involves controlling the hazard.	Manipulates the hazard	• Levees • Floodwalls • Diversions • Channel Modifications
Public Information	Activities implemented to inform the public about the preparedness for and the mitigation of the impacts of natural hazards.	Increases capability	• Websites • Publications • Media release • Public Awareness Time frame • Public meetings
Technical Assistance	Actions that support objectives of the plan by providing assistance to other stakeholders that can implement actions that will enhance the objectives of the plan	Increases capability by leveraging resources	• Promotes consistency • Enhances Coordination
Plan Performance	Actions that enhance the implementation of the actions identified in the plan	Increased capability	• Funding alternatives • Coordination • Oversight • Performance

APPENDIX E.
KING COUNTY FLOOD PROTECTION INFRASTRUCTURE

This Appendix is a substitute for and replaces Appendix E of the 2006 Flood Plan and contains a list of the revetments and levees managed by King County.

CONVENTIONS USED IN KING COUNTY RIVER PROTECTION INFRASTRUCTURE TABLES

The following conventions are used in the tables in this appendix:

- **Name**: The common, historic name used by King County for the levee or revetment. In many cases these names were derived from the names of the landowners at the time the flood protection infrastructure was constructed. In some cases, they are descriptive of the flood protection infrastructure location or what it protects or historically protected.
- **Type:** The letter "R" indicates that the flood protection infrastructure is a revetment, the letter "L" indicates that it is a levee, and the letter "O" indicates other types of Flood Protection Infrastructure in the River and Floodplain Management inventory such as a boat ramp or log crib. In some cases, the flood protection infrastructure type is not known, in which case this type designation is left blank.
- **D/S RM**: Downstream River Mile. The number shown indicates the approximate location of the downstream end of the flood protection infrastructure as measured in miles, from the mouth of the river or creek.
- **U/S RM**: Upstream River Mile. The number shown indicates the approximate location of the upstream end of the flood protection infrastructure as measured in miles, from the mouth of the river or creek.
- **Bank:** Indicates which bank the flood protection infrastructure is on when viewed facing downstream. The letter "R" indicates and right bank, the letter "L" indicates left bank.
- **Length:** Length of the flood protection infrastructure in feet.

TABLE E-1.
SOUTH FORK SKYKOMISH RIVER AND MILLER RIVER FLOOD PROTECTION INFRASTRUCTURE

River/Flood Protection Infrastructure Name	Type	D/S RM	U/S RM	Bank	Length (feet)
South Fork Skykomish					
Winkler	R	8.1	8.1	R	170
McKnight	R	8.2	8.2	R	121
Dallas	R	8.3	8.3	R	138
Town of Skykomish RB	R	16.0	16.1	R	741
Town of Skykomish LB	L	15.9	16.4	L	2959
Miller River					
Miller River Bridge	R	0.3	0.3	L	261
Miller River Curve	L	0.4	0.4	L	917

TABLE E-2.
UPPER SNOQUALMIE RIVER FLOOD PROTECTION INFRASTRUCTURE

River/Flood Protection Infrastructure Name	Type	D/S RM	U/S RM	Bank	Length (feet)
North Fork Snoqualmie					
Proctor	R	0.0	0.1	L	78
Scott	R	0.1	0.1	L	355
Pearson	R	0.2	0.3	R	320
Shake Mill LB	R	0.3	0.5	L	1117
Shake Mill RB	L	0.3	0.4	R	657
Tarp	R	0.5	0.5	L	586
Burhans	L	0.7	0.9	L	1022
Valcauda	L	0.9	1.2	L	1626
North Park	L	1.1	1.3	R	1348
Schodde	R	1.6	1.8	R	1249
Middle Fork Snoqualmie					
Middle Fork Bridge DS LB	R	0.4	0.4	L	73
Middle Fork Bridge DS RB	R	0.4	0.4	R	75
Middle Fork Bridge US LB	R	0.4	0.4	L	127
Middle Fork Bridge US RB	R	0.4	0.5	R	560
Norman Lower	R	0.5	0.7	R	741
Moskvin	R	0.6	0.8	L	1048
Norman Upper	L	0.7	0.9	R	1533
Duprels	R	0.9	0.9	L	217
Mason Thorson Ext	L	1.4	1.5	L	744
Mason Thorson Ells	L	1.9	2.3	L	2134
Mt Si Brg	R	2.7	2.9	R	1221
Mt Si Road Protection		2.9	3.0	L	379
Tanner	R	3.7	3.9	L	1203
South Fork Snoqualmie					
Circle River Ranch	R	1.4	1.5	R	426
Prairie Acres LB	L	2.1	2.3	L	1076
Prairie Acres RB	L	2.1	2.3	R	1022
Bendigo Lower LB	L	2.3	2.6	L	1342
Bendigo Lower RB	L	2.3	2.5	R	1373
Bendigo Upper RB	L	2.5	2.9	R	1967
Bendigo Upper LB	L	2.6	2.9	L	1927
Si View Park	L	2.9	3.3	R	2123
Reif Rd	L	2.9	4.8	L	9603
Si View Levee	L	3.3	4.8	R	7301
McConky	L	4.9	5.2	L	1776
Holstine Ext	L	4.9	5.4	R	2528
Below Cedar Falls Channel	R	5.4	5.9	R	2804
Brissack Brg Sidestream	L	6.0	6.0	L	185
Cedar Falls Brg US	R	6.0	6.1	L	1053
Sabean	R	6.2	6.3	R	759

TABLE E-2.
UPPER SNOQUALMIE RIVER FLOOD PROTECTION INFRASTRUCTURE

River/Flood Protection Infrastructure Name	Type	D/S RM	U/S RM	Bank	Length (feet)
Riverbend	L	6.3	6.5	L	1369
Stanley Carlin	R	6.5	6.8	R	1732
O'Bert	L	7.2	7.2	L	159
Edgewick Rd RB	R	8.9	8.9	R	208
B.P.A.	R	8.9	9.0	R	880
Edgewick Rd LB	R	9.0	9.1	L	117
Allen	R	9.5	9.5	L	246
Garcia Lower	R	15.4	15.6	R	1342
Garcia Upper	R	15.7	15.8	R	421
Alice Creek	R	16.1	16.4	R	1244
Camp Mason	R	16.4	16.9	R	2251
State Hwy	R	17.1	17.2	R	515
Kimball Creek					
202 to Mouth LB	R	0.1	0.1	L	425
202 to Mouth RB	R	0.1	0.1	R	450
Country Rd Brg 996	R	0.6	0.7	R	355
Vivi Hughes	R	0.7	0.8	L	326
Chicalero by Brg	R	1.2	1.2	L	366
Chicalero	R	1.3	1.4	L	446
Upper Snoqualmie Mainstem					
Snoqualmie 205 RB	R	38.5	38.6	R	240
Snoqualmie 205 LB	R	38.6	38.7	L	554
Mill Pond	R	38.8	39.0	R	1191
Record Office	R	39.8	39.9	L	660
Meadowbrook	R	40.0	40.3	L	1418
Pump Station	R	40.3	40.3	L	188
Meadowbrook Brg	R	40.3	40.3	R	120
Railroad Brg	L	40.4	40.7	R	1374
Railroad	R	40.6	40.9	L	1215
Pratt	R	41.1	41.3	L	1166
Groin	L	41.3	41.4	R	341
Waechter	R	41.5	41.5	R	160
Con Fury	R	41.6	41.6	R	52
Reinig Rd	R	41.6	42.2	R	2795

TABLE E-3.
LOWER SNOQUALMIE RIVER FLOOD PROTECTION INFRASTRUCTURE

River/Flood Protection Infrastructure Name	Type	D/S RM	U/S RM	Bank	Length (feet)
Lower Snoqualmie					
Meadowbrook Way Rd Protection	R	0.0	0.0	L	412
Dutch Row	R	5.5	5.8	L	1366
County Line	R	5.5	5.6	R	202
Dutchman Rd Lower	R	5.8	6.2	L	2218
Zylstra	R	5.9	6.0	R	438
Cherry Creek	R	6.0	6.1	R	351
Cherry Creek Mouth DS	R	6.1	6.2	R	280
Dutchman Rd Upper	R	6.2	6.6	L	2065
Cherry Creek Mouth US	R	6.2	6.2	R	449
Backus	L	6.4	6.5	R	510
Hampson Rd Lower	L	6.6	6.8	R	1161
Captain Larson	R	6.9	6.9	L	121
Hampson Rd Upper	R	7.1	7.1	R	1389
No. 1	R	7.4	7.5	L	209
Chapman Lower	R	7.5	7.6	L	585
Chapman Upper	R	7.8	7.9	L	155
Dutchman Rd	R	8.0	8.2	L	1164
Lampaert	R	8.2	8.2	L	381
Rupard	R	8.4	8.5	L	673
Roney	R	8.7	8.9	L	958
Joy	R	8.9	9.0	L	800
Duvall Boat Ramp	R	9.0	9.1	R	96
Herman	R	9.1	9.2	L	660
Wallace	R	9.4	9.5	L	1053
Tuck Creek Outlet	R	9.7	9.7	L	92
Nestegard	R	10.7	10.9	L	1565
Colette	R	11.7	11.7	R	638
Tolt Pipeline	R	12.0	12.1	L	852
S. Wallace #1	R	12.3	12.4	L	326
S. Wallace #2	R	12.4	12.6	L	1095
S. Wallace #3	R	12.8	12.9	L	1009
Winkelman	R	12.9	13.1	R	1160
Pickering	R	13.3	13.4	R	646
S. Wallace #4	R	13.4	13.5	L	425
NE 124th St DS	R	13.7	13.7	L	356
S. Wallace #5	R	13.9	13.9	R	117
NE 124th St US	R	13.9	13.9	R	101
S. Wallace #6	R	14.0	14.2	L	1425
S. Wallace #7	R	14.2	14.2	L	139
S. Wallace #8	R	14.3	14.5	R	844
S. Wallace #9	R	14.5	14.7	L	754
Rathbone	R	14.7	14.8	L	650
Decker Dairy	R	14.9	15.1	R	796

TABLE E-3.
LOWER SNOQUALMIE RIVER FLOOD PROTECTION INFRASTRUCTURE

River/Flood Protection Infrastructure Name	Type	D/S RM	U/S RM	Bank	Length (feet)
Unknown Farm	R	15.2	15.3	R	855
Case	R	15.3	15.5	L	1017
Sinn	R	15.6	15.8	R	1199
Busch	R	16.1	16.2	L	629
Carns	R	16.1	16.5	R	2334
Quaale	R	16.3	16.5	L	717
Adair Rd	R	16.6	16.8	L	1002
Sato	R	16.8	17.0	L	1212
Alberg	R	16.9	17.2	R	1076
Carns Alberg	R	17.3	17.3	R	577
Alberg 18.2	R	17.3	17.5	R	1503
Sinnema Quaale Upper	R	17.4	17.9	R	2579
Sinnema Lower	R	18.0	18.1	L	507
Sinnema Upper	R	18.2	18.3	L	1032
Sinnema Quaale Lower	R	18.4	18.5	R	654
Barry	R	18.6	18.7	L	880
Little Friskie Revet	R	19.3	19.4	L	680
Carnation Farms C	R	20.0	20.1	L	973
Carnation Farms B	R	20.2	20.3	L	1006
Game Farm De Rycke	R	20.3	20.4	R	880
Carnation Farms A	R	20.5	20.7	L	1210
Game Farm	L	20.9	21.3	R	2128
Carnation Dike Upper	R	20.9	21.0	L	470
Carnation Dike Lower	R	20.7	20.8	L	566
Carnation Dike Ext	R	21.0	21.1	L	120
Meehan	R	21.3	21.6	R	1806
Stossel Brg RB	R	21.6	21.9	R	1385
Stossel Brg LB	R	21.8	21.9	L	668
Old Brg Revet	R	21.9	21.9	L	191
Camp Gilead	R	22.1	22.4	L	1558
McElhoe Pearson Upper	L	22.3	22.7	R	2038
McElhoe Pearson Lower	L	22.2	22.3	R	360
McElhoe Pearson Setback	R	22.3	22.4	R	588
Schiessl-Phiffer	R	22.8	23.2	R	1861
McDonald Park	R	23.2	23.5	R	1638
Tolt Park	R	23.5	23.7	R	977
Welcome	R	23.5	23.9	L	1708
Boat Ramp	R	23.9	23.9	R	106
Foster #2	R	24.2	24.4	R	1061
Carnation Golf #1	R	24.7	24.9	L	1088
Carnation Golf #2	R	25.1	25.3	L	713
Foster Upper	R	25.3	25.5	R	1519
Griffin Creek DS	R	25.8	25.8	R	77
Griffin Creek US	R	25.8	25.9	R	83

TABLE E-3.
LOWER SNOQUALMIE RIVER FLOOD PROTECTION INFRASTRUCTURE

River/Flood Protection Infrastructure Name	Type	D/S RM	U/S RM	Bank	Length (feet)
Lynn DS	R	26.2	26.2	R	233
Lynn US	R	26.2	26.4	R	801
Glen Petersen	R	26.4	26.4	L	1019
Pleasant Hill School	R	27.3	27.3	R	575
Gonneson	R	27.4	27.6	L	1358
Angerer Lower	R	27.7	27.8	L	514
Robertson Lower	R	27.9	28.0	R	666
Angerer Upper	R	28.0	28.1	L	719
Robertson Upper	R	28.1	28.2	R	889
Harry Peterson	R	28.3	28.4	L	650
Schiessl Lower	R	28.6	28.7	R	257
Carlson LB	R	28.7	28.9	L	756
Rhode Snoqualmie	R	28.8	29.0	L	864
Baer	R	29.0	29.3	L	1396
Schiessl Upper	R	29.1	29.3	R	864
Ranson	R	29.4	29.5	L	1024
Pleasant Hill Farm	L	29.5	29.9	R	1949
Sletten '70	R	29.7	30.1	L	1808
Below Pleasant Hill Rd	R	30.1	30.3	R	1429
Pleasant Hill Rd Protection	R	30.3	30.4	R	694
Sletten '69	R	30.4	30.7	L	1769
Janicke Rd Protection	R	30.8	31.0	R	654
Sletten DS	R	31.0	31.1	L	760
Sletten US	R	31.4	31.5	L	520
SE 19th Way Rd Protection	R	31.5	31.6	L	329
Richter	R	31.5	31.8	R	1200
Hanson	L	31.6	31.6	L	450
Old Gravel Pit	R	31.7	32.0	L	1550
Hanson US	R	31.7	31.7	L	174
Carlson RB	R	31.8	32.3	R	2359
Aldair	L	32.3	33.1	L	4594
Carlson Upper	R	32.4	32.7	R	1481
Hafner	R	33.3	33.6	R	2176
Barfuse	L	33.4	33.8	L	1905
Sorenson	R	33.8	33.9	L	785
Fall City	R	33.9	34.1	L	821
Bush	R	34.1	34.1	R	357
Fall City Boat Ramp	O	34.4	34.4	L	133
SR 202 Rd Protection	R	34.7	34.9	R	927
Tarr	R	35.3	35.9	L	3494
Williams	R	36.4	36.5	L	773
Plum Lower	R	36.7	36.7	R	298
Plum Upper	R	37.0	37.0	R	256
Plum Boat Ramp	R	37.3	37.4	R	112

TABLE E-3.
LOWER SNOQUALMIE RIVER FLOOD PROTECTION INFRASTRUCTURE

River/Flood Protection Infrastructure Name	Type	D/S RM	U/S RM	Bank	Length (feet)
Tokul Creek					
Tokul Creek	R	37.7	37.7	R	536

TABLE E-4.
TOLT RIVER FLOOD PROTECTION INFRASTRUCTURE

River/Flood Protection Infrastructure Name	Type	D/S RM	U/S RM	Bank	Length (feet)
Tolt River Levee LB	L	0.1	0.6	L	2529
Tolt Campground	L	0.2	0.0	R	1054
Lower Tolt River RB	L	0.2	0.6	R	1964
Tolt River Levee RB	L	0.5	0.6	R	488
Frew	L	0.6	1.1	R	2862
Hwy to RR Bridge	L	0.6	1.1	L	2758
Pond Berm	L	0.6	0.7	R	313
Frew Upper	L	1.1	1.7	R	2768
Remlinger	L	1.1	1.4	L	1577
Swiftwater Berm	L	1.2	1.3	R	814
Girl Scout Camp	L	1.4	2.0	L	2573
Holberg	L	1.7	2.2	R	2764
Edenholm	R	2.5	2.9	R	1698
Tolt River Road Protection	R	2.9	2.9	R	450

TABLE E-5.
RAGING RIVER FLOOD PROTECTION INFRASTRUCTURE

River/Flood Protection Infrastructure Name	Type	D/S RM	U/S RM	Bank	Length (feet)
Mouth to Bridge LB	R	0.0	0.5	L	2276
Mouth to Bridge RB	R	0.1	0.5	R	2473
Bridge to Bridge LB	L	0.5	1.5	L	5036
Bridge to Bridge RB	L	0.5	1.5	R	4971
Above 328th St Brg	R	1.5	1.5	L	368
Bryce's Bump	L	1.8	1.9	R	222
Preston Fall City Lowest	R	3.3	3.3	L	222
Preston Fall City Lower	R	3.6	3.6	L	369
Preston Fall City Upper	R	3.9	4.0	L	384
312th	R	4.4	4.4	R	182
I-90 LB	R	4.9	4.9	L	210
I-90 RB	R	4.9	4.9	R	278
Hursch	R	5.0	5.1	L	649
Waring	R	5.2	5.2	R	100
Jelstrup	R	5.3	5.4	R	285
Leroy Hess	R	5.4	5.4	R	182
Georgeff	R	5.7	5.7	R	177

TABLE E-5.
RAGING RIVER FLOOD PROTECTION INFRASTRUCTURE

River/Flood Protection Infrastructure Name	Type	D/S RM	U/S RM	Bank	Length (feet)
Arruda	R	7.8	7.8	L	116
Upstream Brg on RB	R	7.9	7.9	R	40

TABLE E-6.
SAMMAMISH AND ISSAQUAH CREEK FLOOD PROTECTION INFRASTRUCTURE

River/Flood Protection Infrastructure Name	Type	D/S RM	U/S RM	Bank	Length (feet)
Sammamish River					
Sammamish River		0.0	13.9		73108
Issaquah Creek					
Alpine	R	1.4	1.6	L	703
Pickering DS	R	1.6	1.6	R	173
Pickering US	R	1.9	1.9	L	190
North of East Fork	R	3.1	3.1	R	92
Tweedale DS R	R	3.2	3.2	R	47
Tweedale DS L	R	3.2	3.2	L	58
Tweedale US L	R	3.2	3.2	L	63
Tweedale US R	R	3.2	3.2	R	35
Old Brook Birch	R	3.5	3.5	R	102
Old Brook	R	3.6	3.6	L	121
By Stone Bridge	R	4.1	4.1	L	75
Dodge	R	4.1	4.2	R	511
Anderson	R	4.6	4.7	R	156
Sycamore R	R	5.1	5.1	R	229
Sycamore Bayless	R	5.1	5.2	L	274
Bayless	R	5.2	5.2	R	126
Sycamore Bridge	R	5.3	5.3	R	207
Shearer	R	5.5	5.5	L	99
Hawer	R	5.5	5.5	L	125
Roath	R	5.5	5.6	L	142
Floyd/Erickson	R	5.6	5.6	R	202
Jerome	R	5.6	5.7	L	344
Petty DS	R	6.4	6.4	R	320
Mortenson	R	6.5	6.5	L	268
Petty US	R	6.6	6.6	R	111
Irwin L	R	7.6	7.7	L	502
Irwin R	R	7.7	7.8	R	231
Abernathy	R	8.1	8.2	R	493
Momb	R	10.4	10.5	L	519
Dodge by Bridge	R	10.5	10.6	L	166
Issaquah Creek gage R DS	R	11.8	11.8	L	202
Issaquah Creek gage R US	R	11.8	11.9	R	138
Kenyon	R	12.0	12.0	R	333
Fifteen Mile Creek					
15 Mile Creek L DS	R	0.4	0.4	L	153

17697

TABLE E-6.
SAMMAMISH AND ISSAQUAH CREEK FLOOD PROTECTION INFRASTRUCTURE

River/Flood Protection Infrastructure Name	Type	D/S RM	U/S RM	Bank	Length (feet)
15 Mile Creek L US	R	0.5	0.5	L	130
15 Mile Creek R	R	0.5	0.5	R	141
Holder Creek					
SR 18 DS		1.0	1.0	R	196
SR 18 US		1.0	1.0	R	256
Urlich L DS	R	0.7	0.7	L	186
Urlich L US	R	0.6	0.7	L	179
Urlich R	R	0.6	0.7	R	379

TABLE E-7.
CEDAR RIVER FLOOD PROTECTION INFRASTRUCTURE

River/Flood Protection Infrastructure Name	Type	D/S RM	U/S RM	Bank	Length (feet)
Haddad	R	2.7	2.8	L	290
Tabor-Crowall	R	2.8	2.9	R	503
Brodell	R	3.3	3.5	R	936
Person	R	3.9	4.1	L	834
Erickson	R	4.1	4.2	R	492
Maplewood Golf Course	R	4.3	4.3	R	302
Lower Elliot Park	R	4.3	4.4	L	798
Upper Elliot Park	L	4.8	4.9	L	759
Punnett Briggs	R	5.0	5.3	R	1879
Elliot Brg	L	5.4	5.5	L	353
Orting Hill	R	5.5	5.6	R	393
Tobacco-Dotson	R	5.8	5.8	R	286
Lund	R	5.9	5.9	R	200
Cedar Trl 1	R	5.9	6.0	L	361
Buck's Curve	R	6.1	6.2	R	926
Camp Freeman	R	6.2	6.3	R	391
Cedar Trl 2	R	6.4	6.5	L	486
Herzman	L	6.6	6.7	R	785
Riverbend Lower Ext.	L	6.6	6.8	L	465
Riverbend Lower	R	6.6	7.0	L	1533
Riverbend Upper	R	7.0	7.3	L	1474
Brassfield Maxwell Guth	R	7.0	7.4	R	1846
Cedar Rapids L	L	7.3	7.5	L	983
Cedar Rapids R	L	7.4	7.4	R	428
Cedar Trl 3	R	7.7	7.8	L	569
Cook-Jeffries	R	7.8	8.2	R	1670
Cedar Trail 4	R	8.1	8.2	L	519
Scott-Indian Grove	L	8.2	8.8	R	2937

TABLE E-7.
CEDAR RIVER FLOOD PROTECTION INFRASTRUCTURE

River/Flood Protection Infrastructure Name	Type	D/S RM	U/S RM	Bank	Length (feet)
Progressive Investment	L	8.4	8.5	L	645
Cedar Trail 5	R	9.4	9.4	L	327
Littlefield	R	9.4	9.6	L	755
Cummins	R	9.7	9.8	L	177
Cedar Trl 5B	L	9.8	9.9	L	929
Belmondo	L	10.4	10.3	L	450
WPA	L	10.7	11.0	L	1282
Cedar Trail 6	R	11.0	11.3	L	1815
Rainbow Bend	L	11.3	11.5	R	900
Seppi/Safe US	R	11.3	11.3	L	109
Mcdonald	L	11.5	11.7	L	1117
Rainbow Bend US	R	11.5	11.5	R	39
Lions Club	R	12.0	12.1	L	546
Rawson	R	12.5	12.6	R	246
Byer’s Curve	L	12.7	12.8	L	614
Ramon	R	12.8	12.8	R	425
Cedar Trl 7	R	13.1	13.1	L	340
Jan Road	L	13.2	13.4	R	1115
Rutledge Johnson	L	13.4	13.6	L	1096
Getchman	L	13.7	14.0	R	1760
Rhode Cedar	L	13.7	14.0	L	1282
Royal Arch	L	14.0	14.3	L	1276
Lower Bain Road	L	14.9	15.0	L	681
Bain Road	R	15.0	15.0	L	107
Bain Road Bridge	R	15.1	15.1	R	315
Ahlquist	R	15.4	15.5	R	305
Coleman-Lotto	R	15.6	15.7	L	928
Banchero Barnes	R	15.7	15.8	R	642
Edwards	R	16.0	16.0	L	112
Dorre Don Rd	R	16.3	16.3	R	401
Dorre Don Lower	R	16.3	16.6	R	1230
Elkinton-Cedar Trl Brg	R	16.5	16.6	L	136
Dorre Don Upper	R	16.6	16.8	R	1388
Young	R	16.9	16.9	R	391
Orchard Grove	L	17.3	17.6	R	1683
Mitchell	R	18.8	18.9	R	515
Arcadia Nobel	R	18.9	19.0	L	828

TABLE E-7.
CEDAR RIVER FLOOD PROTECTION INFRASTRUCTURE

River/Flood Protection Infrastructure Name	Type	D/S RM	U/S RM	Bank	Length (feet)
Kazzka	R	18.9	19.0	R	406
Petorak Wadhams	R	19.7	19.7	R	113
Cedar Trl 8	R	20.5	20.6	L	705
Cedar Trl 9	R	21.0	21.2	R	1031

TABLE E-8.
GREEN RIVER FLOOD PROTECTION INFRASTRUCTURE

River/Flood Protection Infrastructure Name	Type	D/S RM	U/S RM	Bank	Length (feet)
Boeing Left	R	5.5	5.6	L	547
Top Bank Protection Right	R	5.6	5.7	R	585
City Light	R	6.1	6.2	L	586
Rubber Tire Revetment	R	6.3	6.3	L	126
Boeing/old Duwamish Drive In	R	6.3	6.6	R	1169
Gateway Lowest	R	6.6	6.8	L	1558
Interurban South	R	7.1	7.1	L	282
S 115th St	R	7.1	7.2	R	307
Banchero Left	R	7.8	7.9	L	362
42nd Av S	R	7.8	7.2	R	3482
Banchero Right	R	7.9	8.0	R	357
Codiga Left	R	7.9	8.0	L	516
Gateway Lower	L	8.0	8.3	L	1520
Tukwila Community Center	L	8.0	8.2	R	693
Gateway Upper	R	8.3	8.4	L	732
Seattle-LA Freight	R	8.4	8.8	L	1844
Steel Hill Bridge Right	R	8.6	8.8	R	876
9.6 Revetment Right	R	8.8	8.8	R	326
Vanni	R	8.8	8.9	R	254
Rendering Works Lower	R	9.6	9.7	R	741
Foster Lower	R	9.8	9.9	L	1075
Rendering Works Middle	R	10.1	10.1	R	508
Foster Middle	R	10.2	10.2	L	162
Foster Upper (Green)	R	10.3	10.5	L	961
Tukwila Trail	L	10.7	10.9	L	920
Ft. Dent	L	11.0	11.8	R	4189
Fiorito	R	11.6	11.8	L	1469
Tukwila Bend Revetment	R	11.8	12.2	L	1905
Family Fun Center	L	12.0	12.2	R	1030
White Swan Left	L	12.3	12.3	L	128
White Swan	R	12.4	12.4	R	113
I-405 Levee	R	12.4	12.6	R	622
Tukwila 205 – Van Warden	L	12.5	13.0	L	3165
Best Western/Nedel's	R	12.6	12.8	R	1108
Tukwila 205 – Christensen Rd	L	13.0	14.3	L	6626
Nelson	R	13.2	13.2	R	248
N.C. Machinery	R	13.6	13.8	R	1100

TABLE E-8.
GREEN RIVER FLOOD PROTECTION INFRASTRUCTURE

River/Flood Protection Infrastructure Name	Type	D/S RM	U/S RM	Bank	Length (feet)
Tukwila 205 – Lily Pointe	L	14.3	14.6	L	1191
Desimone	L	14.5	15.5	R	5125
Tukwila 205 - Segale	L	14.6	15.7	L	6199
Briscoe Meander	L	15.5	16.2	R	2485
Tukwila 205 – GACO Western	L	15.7	15.9	L	898
Tukwila 205 – Gunter	L	15.9	16.7	L	4315
Briscoe	L	16.2	16.2	R	392
Briscoe School	L	16.2	17.0	R	3895
Tukwila 205 – Cutoff	L	16.7	1638	L	920
Frager Lowest	R	16.7	16.8	L	692
Christian Brothers	L	17.0	17.2	R	1133
Boeing Setback	L	17.1	17.8	R	4111
O'Connell	R	17.1	17.5	L	1918
Omlid	R	17.5	17.5	L	405
Boeing	L	17.5	17.8	R	1847
Russell Rd Lowest	L	17.9	18.3	R	2130
216th St	R	18.0	18.2	L	964
Old RM 19.5-19.6 Right	R	18.3	18.3	R	541
Holiday Kennel	R	18.3	18.7	R	1475
216th St US	R	18.4	18.5	L	516
Frager Rd Lower	R	18.5	19.3	L	4267
Russell Rd Lower	L	18.7	19.2	R	2987
Somes Dolan 1,2&3	L	19.2	19.7	R	2420
Stoneway Lower	R	19.3	19.6	L	1851
Russell Rd Upper	L	19.7	20.4	R	3681
Stoneway Upper	R	19.8	19.9	L	909
Narita 1&2	L	20.4	21.3	R	4614
Corps GR 1-75	R	20.8	20.9	L	404
Maddox	R	21.1	21.3	L	793
Myers Golf	L	21.3	21.8	R	2729
Leber Brothers	R	21.3	21.5	L	1215
P,D & J #1	R	21.8	21.9	L	217
Pipeline	L	21.8	21.9	R	440
Okimoto	L	21.9	22.0	R	775
Signature Pointe	R	22.1	23.0	R	4796
P,D & J #2	R	22.1	22.2	L	438
Frager Road Upper	R	22.3	22.6	L	2145

TABLE E-8.
GREEN RIVER FLOOD PROTECTION INFRASTRUCTURE

River/Flood Protection Infrastructure Name	Type	D/S RM	U/S RM	Bank	Length (feet)
County Road #8	L	23.0	23.2	R	976
Hawley	R	23.2	23.4	R	1369
Koch	R	23.4	23.5	L	475
Corps Revet	L	23.5	23.6	L	495
Bradley	R	23.6	23.7	L	634
Milwaukee #1	R	23.8	24.1	R	1124
Kent Airport	R	23.8	24.0	L	1164
Milwaukee #2	R	24.1	24.3	R	1002
Mccoy	R	24.3	24.4	R	1093
Breda	L	24.4	25.1	R	3541
78 Av S	R	24.5	24.9	L	2533
Plemmons	L	25.1	25.3	R	951
Monk	R	25.2	25.3	L	500
Nursing Home	L	25.3	26.0	R	3664
Nursing Home Extension	L	26.0	26.1	R	687
Titus Boat Ramp	R	26.5	26.5	R	248
Titus Pit	R	26.6	26.6	R	131
Jeff Estates	R	26.6	26.9	L	1565
Green River Rd Lower	R	26.9	27.1	R	934
Neilson	R	27.2	27.3	R	809
Mallory	R	27.6	27.7	R	1072
Malnati	R	28.2	28.4	R	1304
Auburn Golf & Olson	R	28.5	29.1	R	3192
Engel Extension	L	28.6	28.7	L	378
Reddington Section	L	28.6	29.3	L	3150
Brannan Park	L	29.3	29.5	L	1222
Galli's Section	L	29.5	29.7	L	1048
Dykstra	L	29.7	30.8	L	5838
Valentine	R	29.9	30.0	R	830
104th Road Protection	R	30.2	30.2	R	1302
Pig Farm	L	30.4	30.6	R	1009
Lone's Addition	L	30.8	30.9	L	592
Porter Bridge	L	31.0	31.1	R	697
Matson	R	31.1	31.2	L	187
Barnett	L	31.2	31.2	L	132
Porter Gage	R	31.3	31.3	L	275
Fenster	L	31.8	32.0	L	1547

TABLE E-8.
GREEN RIVER FLOOD PROTECTION INFRASTRUCTURE

River/Flood Protection Infrastructure Name	Type	D/S RM	U/S RM	Bank	Length (feet)
Pautzke	L	32.0	32.4	L	1657
Old RM 33.8 Right	L	33.3	33.3	R	139
Soos Creek DS	R	33.3	33.4	L	229
Soos Creek US	R	33.4	33.4	L	105
Lake Holm Rd	R	33.4	33.5	R	281
Porter	L	33.9	34.1	L	1349
Neely	R	34.4	34.8	L	1905
Kaech	L	34.5	34.8	R	1549
Pre-1959	L	34.8	35.1	L	1213
Horath	L	34.9	35.2	R	1913
Hamakami	R	35.7	35.7	R	1903
Turley	R	36.6	36.9	R	1631
Lone's	R	37.4	37.6	R	1520
Marguerite Hansell	R	40.3	40.3	R	259
Meyer Dike	R	40.5	40.7	R	942
Imhof	R	40.7	40.9	R	917
Old RM 41.8 Left	L	41.1	41.2	L	287
Old RM 41.9 Left	L	41.2	41.3	L	399
Green Valley Road Protection	R	41.6	41.8	R	770
DS Flaming Geyser Bridge	L	42.4	42.5	L	486
US Flaming Geyser Bridge	R	42.6	42.7	L	555
Old Flaming Geyser Bridge	L	42.7	42.8	L	781
Flaming Geyser Road	R	43.2	43.9	L	4107
Park DS	L	44.0	44.0	L	92
Park US	L	44.0	44.0	L	122

TABLE E-9.
WHITE RIVER AND GREENWATER RIVER FLOOD PROTECTION INFRASTRUCTURE

River/Flood Protection Infrastructure Name	Type	D/S RM	U/S RM	Bank	Length (feet)
White River					
Kahne	L	0.0	0.0	R	1173
Pacific City Park Levee	L	5.6	5.9	R	1522
Countyline-A St	R	5.6	6.2	L	3247
Pacific City Park Revetment	R	5.9	6.4	R	2833
Union Pacific	L	6.2	6.4	L	724
Oravetz School	R	6.4	6.7	L	1654
A-Street Trailer Court	R	6.4	7.0	R	2875
Roegner Park	R	6.7	7.2	L	2420
Segale-White	R	7.0	7.7	R	3640
R-Street DS	R	7.3	7.6	L	1794
R-Street US	R	7.7	8.0	R	1710
Stuck River Dr	R	7.7	8.1	L	2741
Auburn Wall	R	8.0	8.3	R	1529
Valley Wall	R	8.0	8.7	R	3679
Game Farm Wilderness Park	L	8.2	8.7	L	2183
Trans-Canada	L	8.7	9.4	L	3569
Greenwater River					
Greenwater Lower	R	0.5	0.5	R	199
Greenwater Upper	R	0.6	0.7	R	618

APPENDIX F.
ACTION PLAN

This appendix provides the 2013-2018 King County Flood Control District 6-year Capital Improvement Project list and basin specific maps, replacing Appendix F in the 2006 Flood Plan.

King County Flood District: 2013 Revised CIP

July 17, 2013

River	Project Number	Project Name	2013 Revised	2014	2015	2016	2017	2018	2013 - 2018 Total
Skykomish-Miller	1112057	WLFL0 MALONEY CR CONF IMPVMNTS	$76,244	$0	$0	$0	$0	$0	$76,244
Skykomish-Miller	1112059	WLFL0 MILLER R RD PROTECTION	$52,575	$0	$0	$0	$0	$0	$52,575
Skykomish-Miller	1044459	WLFL0 MILLER RIVER HOME BUYOUT	$249,998	$0	$0	$0	$0	$0	$249,998
Skykomish-Miller	1044461	WLFL0 SF SKYKMSH REP LOSS MIT	$2,001	$0	$0	$0	$0	$40,000	$42,001
Skykomish-Miller	1112052	WLFL0 SKYKOMISH HOM BUYOUTS	$0	$0	$0	$0	$0	$100,000	$100,000
Skykomish-Miller	1044460	WLFL0 TIMBER LN EROSN BUYOUTS	$70,004	$0	$0	$600 000	$600,000	$500,000	$1,770,004
Upper Snoqualmie	1044468	WLFL1 CITY SNOQUALMIE NA ACQ	$40,500	$0	$0	$0	$0	$0	$40,500
Upper Snoqualmie	1112055	WLFL1 MEADOWBROOK 2011 REPAIR	$4,999	$0	$0	$0	$0	$0	$4,999
Upper Snoqualmie	1044469	WLFL1 MF LEVEE SYSTEM IMPRVMNT	$1,531,674	$2,200,000	$0	$0	$0	$0	$3,731,674
Upper Snoqualmie	1112047	WLFL1 MSN THRSN EX 2011 REPAIR	$6,549	$0	$0	$0	$0	$0	$6,549
Upper Snoqualmie	1044465	WLFL1 N BEND RESID FLD MITGTN	$195,847	$176,817	$0	$0	$0	$0	$372,664
Upper Snoqualmie	1044466	WLFL1 SF LEVEE SYSTEM IMPROVE	$2,315,865	$3,000,000	$3,000,000	$1 500 000	$0	$0	$9,815,865
Upper Snoqualmie	FL1022	WLFL1 SR202 SF BRIDGE LENGTHEN	$0	$0	$0	$0	$0	$100,000	$100,000
Upper Snoqualmie	1044517	WLFL1 UPR SNO RES FLD MITIGTN	$2,723,057	$1,886,634	$1,311,272	$1,350,610	$115,927	$1,300,000	$8,687,501
Upper Snoqualmie	1112032	WLFL1 RECORD OFFCE 2011 REPAIR	$26,393	$0	$0	$0	$0	$0	$26,393
Lower Snoqualmie	1044576	WLFL2 ALDAIR BUYOUT	$1,574,100	$600,000	$1,200,000	$1,500,000	$121,724	$500,000	$5,495,824
Lower Snoqualmie	1044581	WLFL2 FARM FLOOD TSK FORCE IMP	$114,261	$106,090	$109,273	$112,551	$115,927	$119,405	$677,527
Lower Snoqualmie	1044580	WLFL2 L SNO REP LOSS MITGTION	$274,569	$0	$0	$0	$0	$200,000	$474,569
Lower Snoqualmie	1044582	WLFL2 LWR SNO RESDL FLD MITGTN	$450,000	$318,270	$437,091	$450,203	$347,782	$0	$2,003,346
Lower Snoqualmie	1112020	WLFL2 MCELHOE/PERSON LEVEE	$3,048	$0	$0	$0	$0	$0	$3,048
Lower Snoqualmie	1112046	WLFL2 SINERRA QUALLE 2011 REPR	$1,013,373	$3,070,244	$0	$0	$0	$0	$4,083,617
Lower Snoqualmie	1044579	WLFL2 TOLT PIPELINE PROTECTION	$680,173	$345,853	$2,531,739	$0	$0	$0	$3,557,765
Tolt	1112034	WLFL3 LOWER TOLT R ACQUISITION	$932,408	$2,122	$0	$0	$0	$0	$934,530
Tolt	1044645	WLFL3 SAN SOUCI NBRHOOD BUYOUT	$1,205,498	$1,129,858	$0	$0	$0	$0	$2,335,356
Tolt	FL3007	WLFL3 SR203 TO TRAIL BR FLDPLN	$0	$0	$0	$0	$0	$400,000	$400,000
Tolt	1112058	WLFL3 TOLT R MILE 1 1 SETBACK	$1,296,251	$816,893	$444,303	$0	0	$500,000	$3,057,447
Tolt	1115032	WLFL3 TOLT R NATURAL AREA ACQ	$838,172	$0	$0	$0	$1,063,022	$1,500,000	$3,401,194
Tolt	1044644	WLFL3 TOLT SUPPLEMENTAL STUDY	$241,297	$0	$0	$0	$0	$0	$241,297
Raging	FL4016	WLFL4 ABONDONED BR WARING RVTMI	$0	$0	$0	$0	$0	$100,000	$100,000
Raging	1044647	WLFL4 ALPINE MANOR MOB PRK ACQ	$987,674	$434,912	$625,102	$0	$0	$0	$2,047,688
Raging	1044649	WLFL4 PRESTON FALL CTY UPR RPR	$9,030	$0	$0	$0	$0	$0	$9,030
Snoqualmie Subtotal			$16,915,580	$14,067,693	$9,658,779	$5,513,365	$2,364,383	$5,359,405	$53,899,205
Sammamish	1112037	WLFL5 WILLOWMOOR FLDPLAIN REST	$414,729	$357,410	$353,280		$0	$0	$1,125,419
Lk Wash Tribs	1116846	WLFL6 LOWER COAL CRK PH I	$200,000	$736,890	$3,138,414	$4,491,272	$0	$0	$8,566,576
Lk Wash Tribs	1115747	WLFL6 ISSAQUAH CR REP LOSS MIT	$125,000	$0	$0	$0	$0	$0	$125,000
Lk Wash Tribs	1116847	WLFL6 MCALEER/LYON CHAN IMPRVM	$0	$350,000	$350,000	$350,000	$0	$0	$1,050,000
Cedar	1112024	WLFL7 BELMONDO REPAIR	$704,002	$10,000	$0	$0	$0	$0	$714,002
Cedar	1044734	WLFL7 CDR PRE-CONST STRTGC ACQ	$2,108,026	$1,867,184	$500,000	$500,000	$500,000	$500,000	$5,975,210
Cedar	1116060	WLFL7 CEDAR LEVEE SETBACK FEAS	$376,980	$388,289	$0	$0	$0	$0	$765,269
Cedar	1044651	WLFL7 CEDAR R REP LOSS MITGATN	$361,567	$164,439	$163 909	$168,826	$173,891	$196,428	$1,229,061
Cedar	1112045	WLFL7 CEDAR RAPIDS 2011 REPAIR	$141,579	$0	$0	$0	0	$0	$141,579
Cedar	1044729	WLFL7 CEDAR RVR GRAVEL REMOVAL	$2,330,620	$3,311,069	$0	$0	$0	$0	$5,641,689
Cedar	1044728	WLFL7 DORRE DON MEANDERS PH 1	$252,465	$8,487	$0	$0	$0	$0	$260,952
Cedar	1112041	WLFL7 ELLIOTT BR LEVEE SETBACK	$508,118	$832,605	0	0	0	$0	$1,340,723
Cedar	1112042	WLFL7 HERZMAN LEVEE SETBACK 2	$20 000	$0	0	0	$0	$54 636	$74,636
Cedar	1112039	WLFL7 JAN RD-RTLDGE LVEE STBCK 2	$45,600	$21,218	$0	$198,432	$1,362,568	$59 703	$1,687,521

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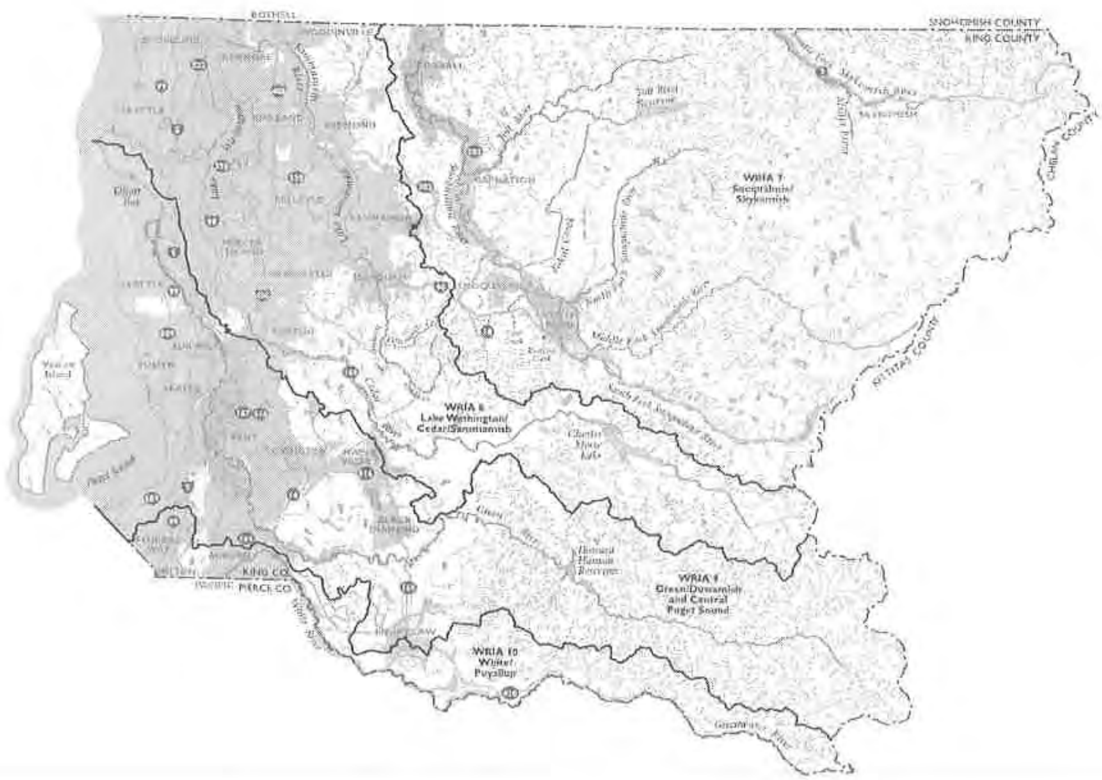
Cedar	1112031 WLFL7 MPLWD ACQ & SETBACK PH 1 2	$25,000	$0	$109,273	$0	$0	$0	$134,273
Cedar	1112029 WLFL7 RAINBOW BEND LEVEE STBCK	$1,104,704	$159,135	$109,273	$112,551	$115,927	$0	$1,601,590
Cedar	1112021 WLFL7 RHODE LVEE SETBACK 2	$40,600	$0	$0	$0	$0	$140,689	$181,289
Cedar	1115124 WLFL7 CEDAR RAPIDS REPAIR	$2,188	$0	$0	$0	$0	$0	$2,188
Cedar	1112043 WLFL7 YOUNGS REVETMENT REPAIR	$31,147	$0	$0	$0	$0	$0	$31,147
Cedar	1119888 WLFL7 RIVERBEND MPH ACQ	$3,000,000						$3,000,000
Cedar Subtotal		$11,792,325	$8,206,727	$4,724,148	$5,821,061	$2,152,386	$951,456	$33,648,123
Green	1116360 WLFL8 BLACK R PUMP STATION	$2,450,941	$1 263,956	$581 331	$598 771	$616,734	$635,236	$6,146,968
Green	1112025 WLFL8 BOEING LEVEE ADD-KENT	$2,086,034	$0	$0	$0	$0	$0	$2,086,034
Green	1116362 WLFL8 BOEING LEVEE USACE ERP	$0	$1 000,000	$0	$0	$0	$0	$1,000,000
Green	1116515 WLFL8 BRISCOE LEVEE SETBACK	$7,223,000	$5,804,500	$5,463 635	$5,627 543	$1,463,710	$835,836	$26,418,224
Green	1112051 WLFL8 BRISCOE REACH DESIGN	$120,000	$67 898	$0	$0	$0	$0	$187,898
Green	1044884 WLFL8 GREEN R FLD EMGNCY PREP	$181,075	$0	$0	$0	$0	$0	$181,075
Green	1044882 WLFL8 GREEN R PL84-99 MITIGATN	$854,816	$0	$0	$0	$0	$0	$854,816
Green	1112040 WLFL8 HAWLEY RD LEVEE-KENT	$897,039	$0	$0	$0	$0	$0	$897,039
Green	1112033 WLFL8 HORSESHOE BND ACQ-RCNCT	$2,518 564	$750 000	$500 000	$500 000	$500 000	$500 000	$5,268,564
Green	1120033 WLFL8 HOLIDAY KENNEL ACQ & BERM	$500 000	$0	$0	$0	$0	$0	$500,000
Green	1112035 WLFL8 REDDINGTON REACH SETBACK	$12,900,498	$1,336,305	$0	$174,454	$0	$185 078	$14,596,335
Green	1044881 WLFL8 RUSSELL RD UPPER	$2,331,484	$1,436,716	$0	$0	$0	$0	$3,768,200
Green	1117948 WLFL8 SANDBAG REMOVAL	$4,578,931	$0	$0	$0	$0	$0	$4,578,931
Green	1116363 WLFL8 USACE SWIF	$420,000	$70,019	$43,709	$45,020	$46,371	$47,762	$672,882
Green Subtotal		$37,062,362	$11,729,394	$6,588,674	$6,945,788	$2,626,814	$2,203,912	$67,156,965
White	1112049 WLFL9 COUNTYLINE TO A STREET	$2,592,389	$4,559,217	$4,176,949	$388,300	$40,575	$411,948	$12,169,378
White	FL9002 WLFL9 RED CREEK ACQUISITIONS	$0					$100,000	$100,000
White	1112038 WLFL9 RIGHT BANK LEVEE SETBACK	$1,792,250	$4,170,748	$1,446,226	$3,439,280	$4,000,000	$0	$14,848,504
White	FL9004 WLFL9 White-Greenwater Acquisition	$0					$100,000	$100,000
White Subtotal		$4,384,639	$8,729,965	$5,623,175	$3,827,580	$4,040,575	$611,948	$27,217,882
Mon/Maint	1112022 WLFLM FLOOD CIP MON/MAINT	$844,147	$250,000	$250,000	$250,000	$250,000	$250,000	$2,094,147
Opportunity Fund	1045042 WLFLO SUBREGNL OPPRTNTY FUND	$11,745,806	$3,766,501	$3,853,242	$3,921,428	$3,991,720	$4,064,489	$31,363,186
Seattle	1045041 WLFLS AK WY SEAWALL CONSTRUCTN	$5,022,729	$15,030,000	$5,780,000	$0	$0	$0	$25,832,729
Seattle	1112036 WLFLS SOUTH PARK DWMSH BACKWTF	$2,250,240	$1,250,000	$0	$0	$0	$0	$3,500,240
Countywide Miscellar	1044261 WLFLX CENTRAL CHARGES	$190,108	$223,814	$230,526	$237,444	$244,567	$251,904	$1,378,366
Countywide Miscellar	1044279 WLFLX FLOOD EMERGENCY CONTGNC'	$429,552	$0	$0	$0	$0	$0	$429,552
Countywide Miscellar	1117333 WLFLX WRIA GRANTS	$6,116,561	$3,150,000	$3,150,000	$3,150,000	$3,150,000	$3,150,000	$21,866,561
Countywide Subtotal		$26,599,143	$23,690,314	$13,263,770	$7,558,872	$7,636,288	$7,716,393	$86,464,781
Totals		$96,754,069	$66,444,093	$39,868,547	$29,666,687	$16,820,446	$16,843,114	$268,386,956



KING COUNTY - GEOGRAPHIC SCOPE OF FLOOD HAZARD MANAGEMENT PLAN

KING COUNTY FLOOD HAZARD MANAGEMENT PLAN

- Rivers and Streams with FEMA Mapped 100-Year Regulatory Floodplains
- Rivers and Streams with Unmapped Regulatory Floodplains
- Water Resource Inventory Area (WRIA) Boundary
- Major Road
- Incorporated Area

N

0 4 8 Miles

King County

Department of
Natural Resources and Parks
Water and Land Resources Division

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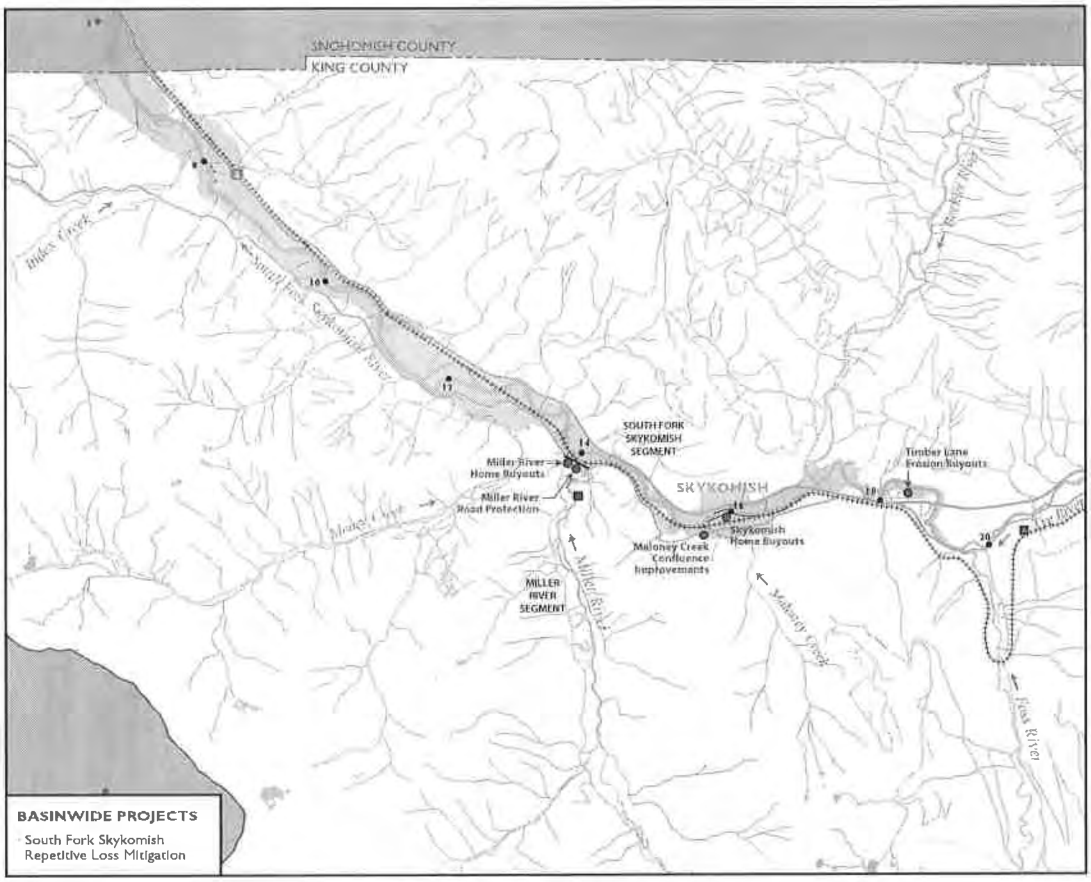
Data sources: King County datasets
File name: 1307_3412fhmpKC.ai vgab

17E07



SOUTH FORK SKYKOMISH RIVER

KING COUNTY FLOOD HAZARD MANAGEMENT PLAN

- 2013-2018 Capital Improvement Projects (Project locations are approximate)
- NAME River Segment Boundary and Segment Name
- Rivers and Streams with FEMA Mapped 100-Year Regulatory Floodplains
- Rivers and Streams with Unmapped Regulatory Floodplains
- Flood Protection Infrastructure (Levees & Revetments)
- WRIA Salmon Recovery 3-Year Work Plan Project Sites
- River Miles (Approximate)
- Watershed/Basin Boundary
- Road
- Railroad
- Incorporated Area

0 1 2 Miles

King County

Department of Natural Resources and Parks

Water and Land Resources Division

Data sources: King County datasets
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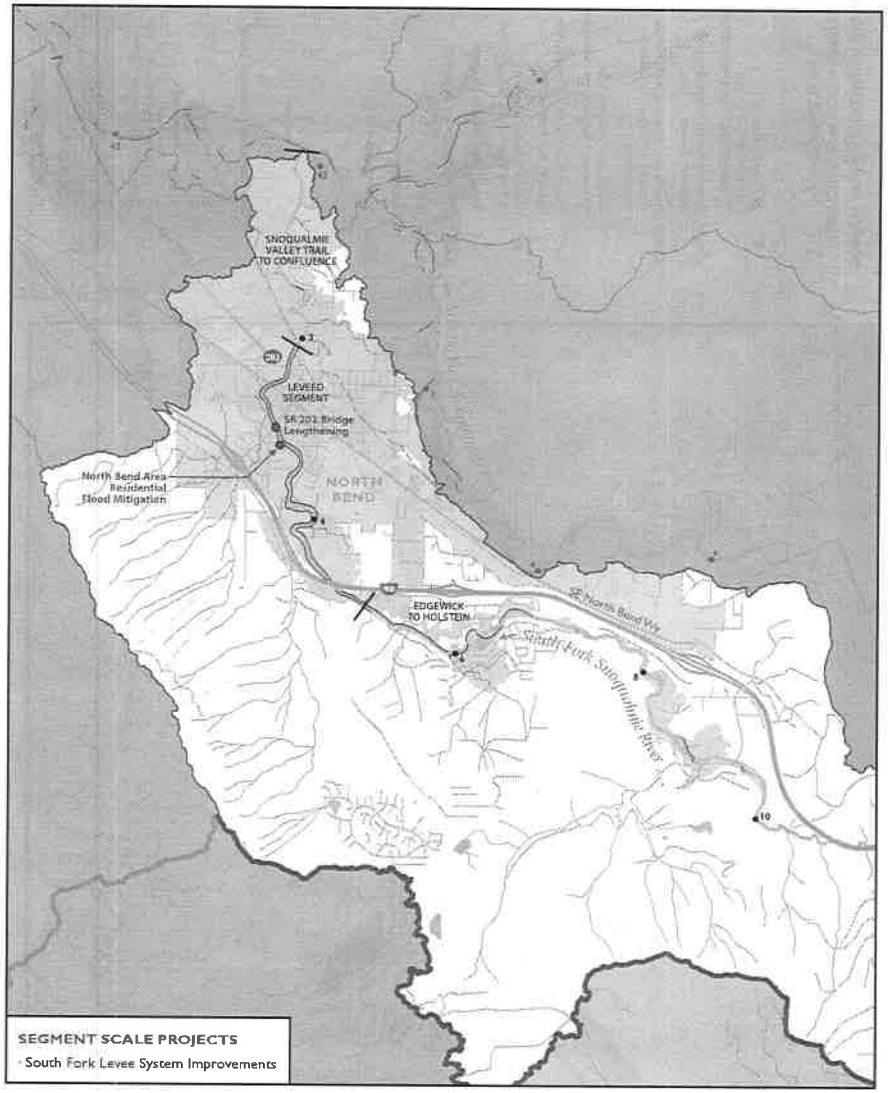

SOUTH FORK SNOQUALMIE RIVER

KING COUNTY FLOOD HAZARD MANAGEMENT PLAN

- 2013-2018 Capital Improvement Projects (Project locations are approximate)
- NAME River Segment Boundary and Segment Name
- Rivers and Streams with FEMA Mapped 100-Year Regulatory Floodplains
- Rivers and Streams with Unmapped Regulatory Floodplains
- Flood Protection Infrastructure (Levees & Revetments)
- Outer Boundary of Channel Migration Hazard Zones (Moderate & Severe)
- 2 River Miles (Approximate)
- Watershed/Basin Boundary
- Road
- Incorporated Area

King County

Department of Natural Resources and Parks

Water and Land Resources Division

Data sources: King County datasets

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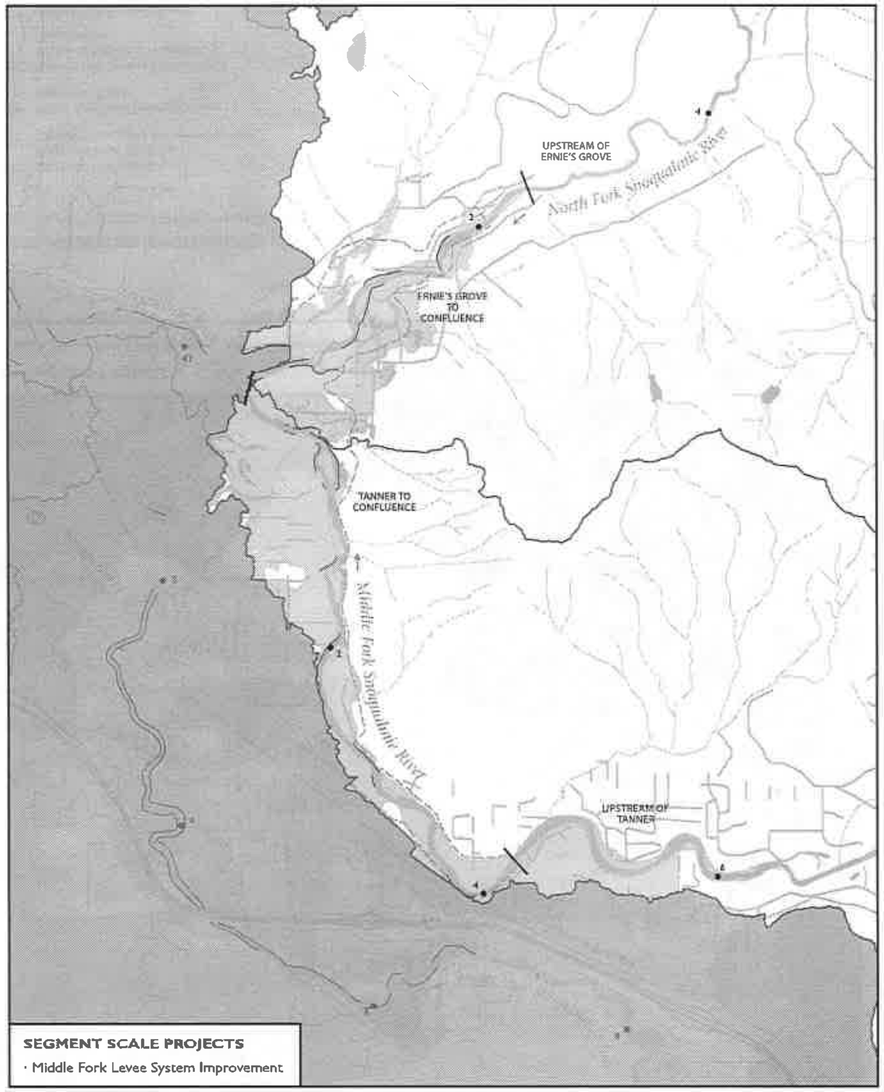

MIDDLE AND NORTH FORKS SNOQUALMIE RIVER

KING COUNTY FLOOD HAZARD MANAGEMENT PLAN

- ● 2013-2018 Capital Improvement Projects (Project locations are approximate)
- NAME River Segment Boundary and Segment Name
- Rivers and Streams with FEMA Mapped 100-Year Regulatory Floodplains
- Rivers and Streams with Unmapped Regulatory Floodplains
- Flood Protection Infrastructure (Levees & Revetments)
- Outer Boundary of Channel Migration Hazard Zones (Moderate & Severe)
- ●2 River Miles (Approximate)
- Watershed/Basin Boundary
- Road
- Incorporated Area

N

0 1/2 1 Mile

King County

Department of
Natural Resources and Parks
Water and Land Resources Division

Data sources: King County datasets
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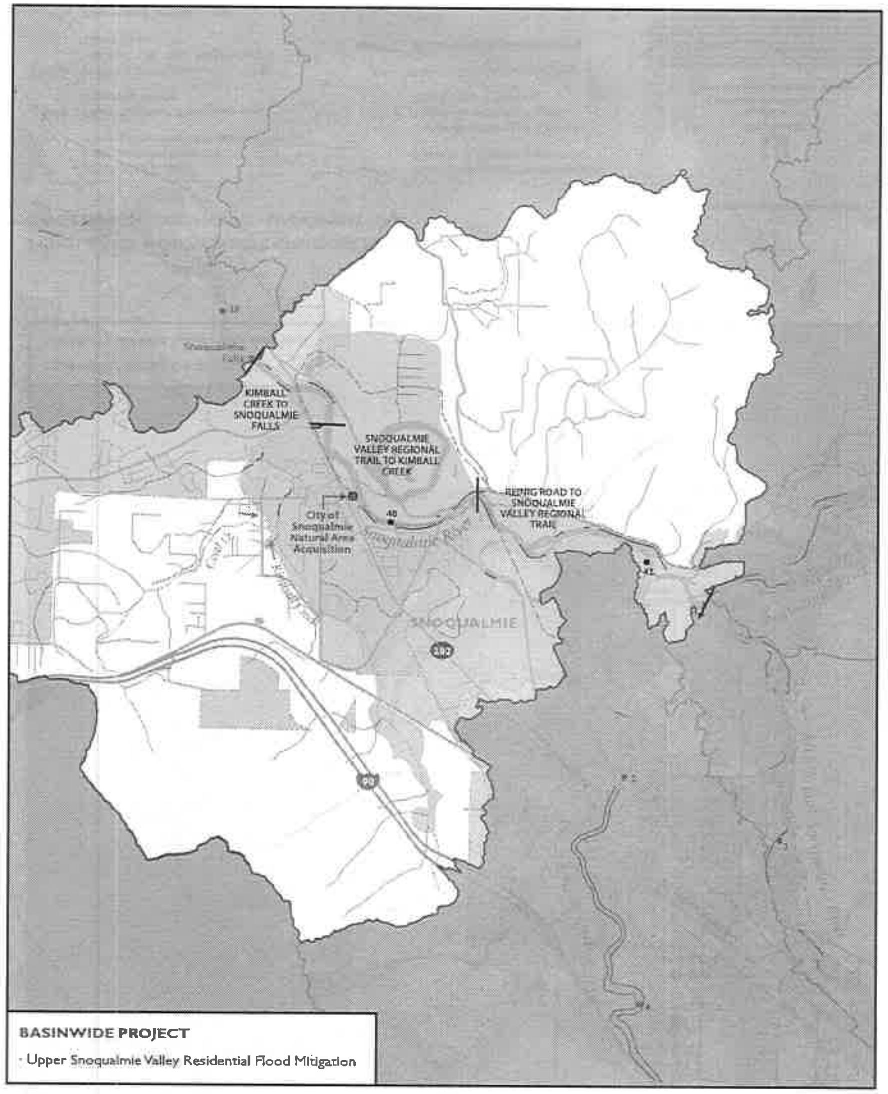


UPPER MAINSTEM SNOQUALMIE RIVER INCLUDING KIMBALL CREEK BASIN

KING COUNTY FLOOD HAZARD MANAGEMENT PLAN

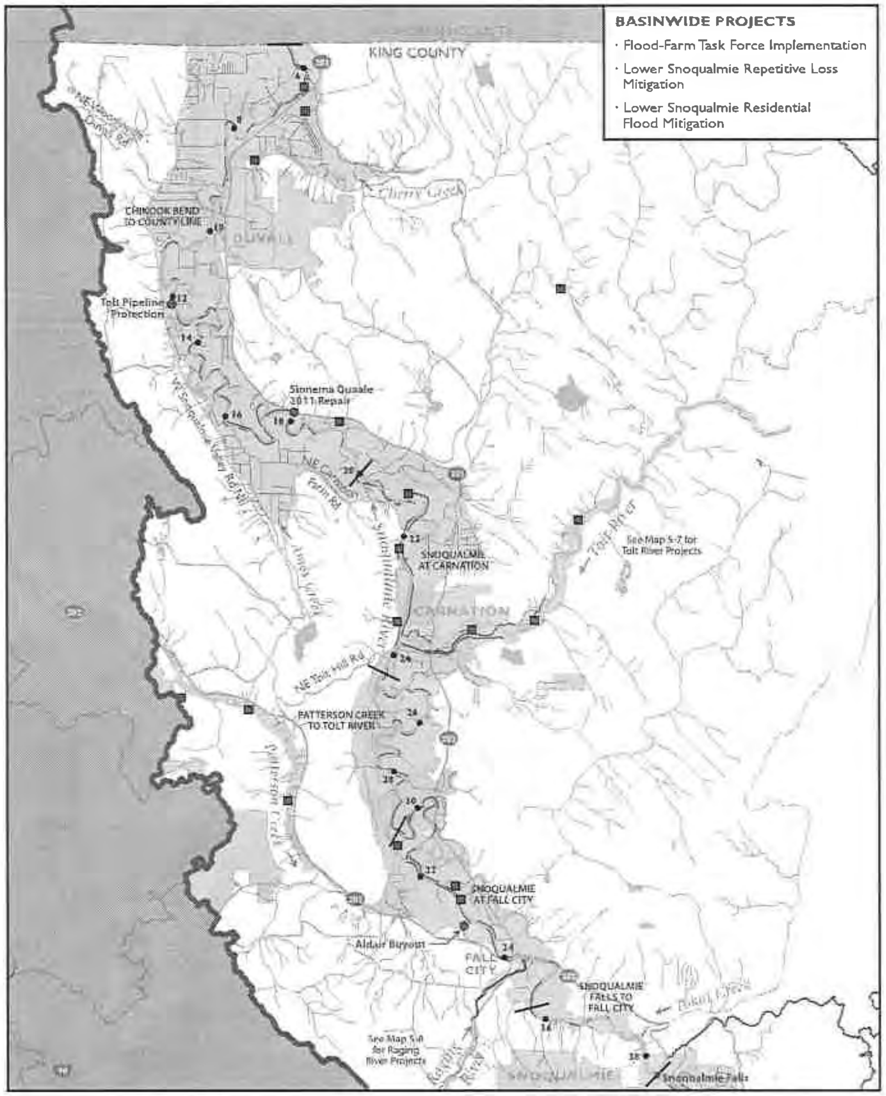
N

0 1/2 1 Mile

- ● 2013-2018 Capital Improvement Projects (Project locations are approximate)
- NAME River Segment Boundary and Segment Name
- Rivers and Streams with FEMA Mapped 100-Year Regulatory Floodplains
- Rivers and Streams with Unmapped Regulatory Floodplains
- Flood Protection Infrastructure (Levees & Revetments)
- Outer Boundary of Channel Migration Hazard Zones (Moderate & Severe)
- ●2 River Miles (Approximate)
- Watershed/Basin Boundary
- Road
- Incorporated Area

King County
Department of Natural Resources and Parks
Water and Land Resources Division

17897



LOWER SNOQUALMIE RIVER

KING COUNTY FLOOD HAZARD MANAGEMENT PLAN

0 — 2 Miles

- 2013-2018 Capital Improvement Projects (Project locations are approximate)
- NAME River Segment Boundary and Segment Name
- Rivers and Streams with FEMA Mapped 100-Year Regulatory Floodplains
- Rivers and Streams with Unmapped Regulatory Floodplains
- Flood Protection Infrastructure (Levees & Revetments)
- WRIA Salmon Recovery 3-Year Work Plan Project Sites
- River Miles (Approximate)
- Watershed/Basin Boundary
- Road
- Incorporated Area

King County
Department of Natural Resources and Parks
Water and Land Resources Division

Data sources: King County datasets
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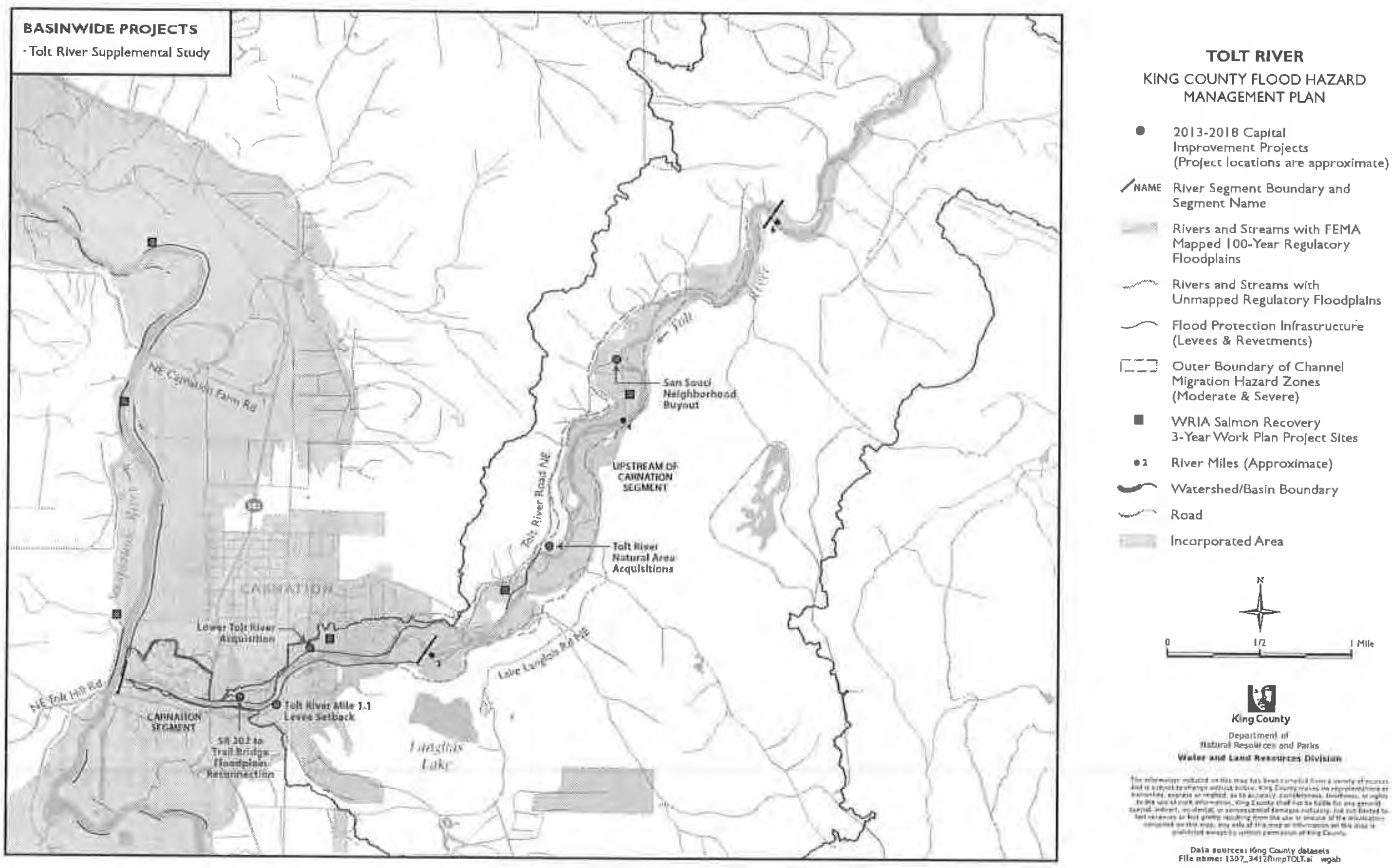
BASINWIDE PROJECTS
· Tolt River Supplemental Study
NE Carnation Farm Rd
CARNATION
Lower Tolt River Acquisition
NE Tolt Hill Rd
CARNATION SEGMENT
SR 202 to Trail Bridge Floodplain Reconnection
Tolt River Mile 1.1 Levee Setback
Lake Langlois Rd NE
Langlois Lake
Tolt River Road NE
Tolt River Natural Area Acquisitions
UPSTREAM OF CARNATION SEGMENT
San Souci Neighborhood Buyout
Tolt
TOLT RIVER
KING COUNTY FLOOD HAZARD MANAGEMENT PLAN
2013-2018 Capital Improvement Projects (Project locations are approximate)
NAME River Segment Boundary and Segment Name
Rivers and Streams with FEMA Mapped 100-Year Regulatory Floodplains
Rivers and Streams with Unmapped Regulatory Floodplains
Flood Protection Infrastructure (Levees & Revetments)
Outer Boundary of Channel Migration Hazard Zones (Moderate & Severe)
WRIA Salmon Recovery 3-Year Work Plan Project Sites
River Miles (Approximate)
Watershed/Basin Boundary
Road
Incorporated Area
N
0
1/2
1 Mile
King County
Department of Natural Resources and Parks
Water and Land Resources Division
Data sources: King County datasets
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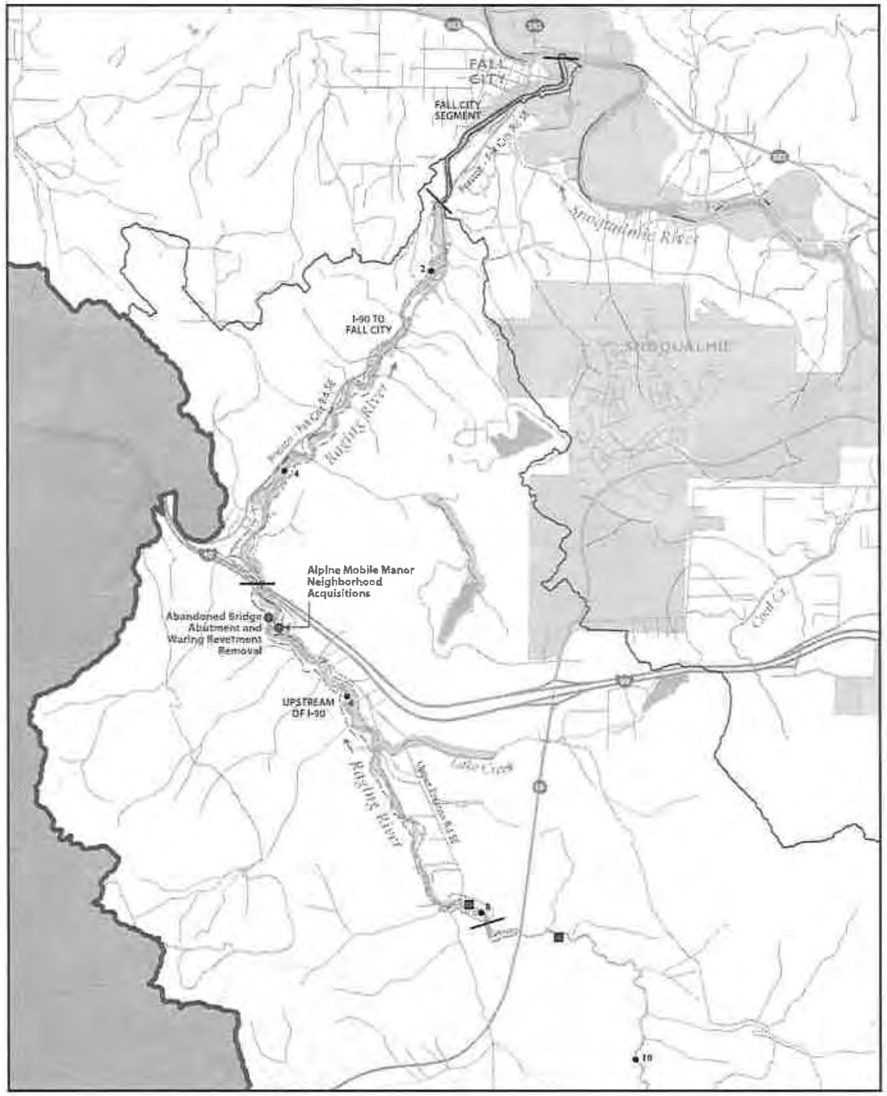

RAGING RIVER

KING COUNTY FLOOD HAZARD MANAGEMENT PLAN

- 2013-2018 Capital Improvement Projects (Project locations are approximate)
- NAME River Segment Boundary and Segment Name
- Rivers and Streams with FEMA Mapped 100-Year Regulatory Floodplains
- Rivers and Streams with Unmapped Regulatory Floodplains
- Flood Protection Infrastructure (Levees & Revetments)
- Outer Boundary of Channel Migration Hazard Zones (Moderate & Severe)
- 2 River Miles (Approximate)
- WRIA Salmon Recovery 3-Year Work Plan Project Sites
- Watershed/Basin Boundary
- Road
- Incorporated Area

N

0 1/2 1 Mile

King County

Department of
Natural Resources and Parks
Water and Land Resources Division

Data sources: King County datasets
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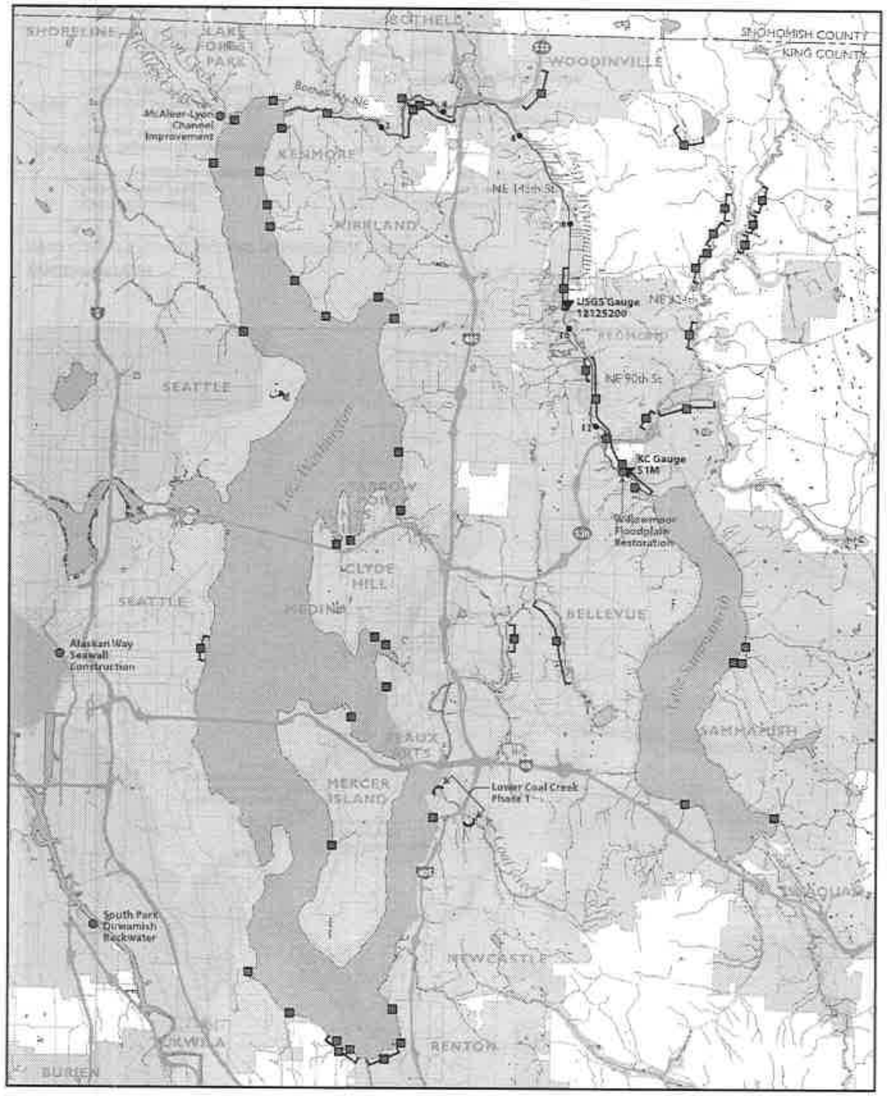

SAMMAMISH RIVER, LAKE WASHINGTON TRIBUTARIES AND CITY OF SEATTLE

KING COUNTY FLOOD HAZARD MANAGEMENT PLAN

0 1 2 Miles

- 2013-2018 Capital Improvement Projects (Project locations are approximate)
- Proposed Project Reach
- Rivers and Streams with FEMA Mapped 100-Year Regulatory Floodplains
- Rivers and Streams with Unmapped Regulatory Floodplains
- (WRIA Salmon Recovery 3-Year Work Plan Project Sites and Reaches
- Flood Protection Infrastructure (Levees & Revetments)
- 2 River Miles (Approximate)
- Road
- Incorporated Area

King County
Department of Natural Resources and Parks
Water and Land Resources Division

Data sources: King County datasets
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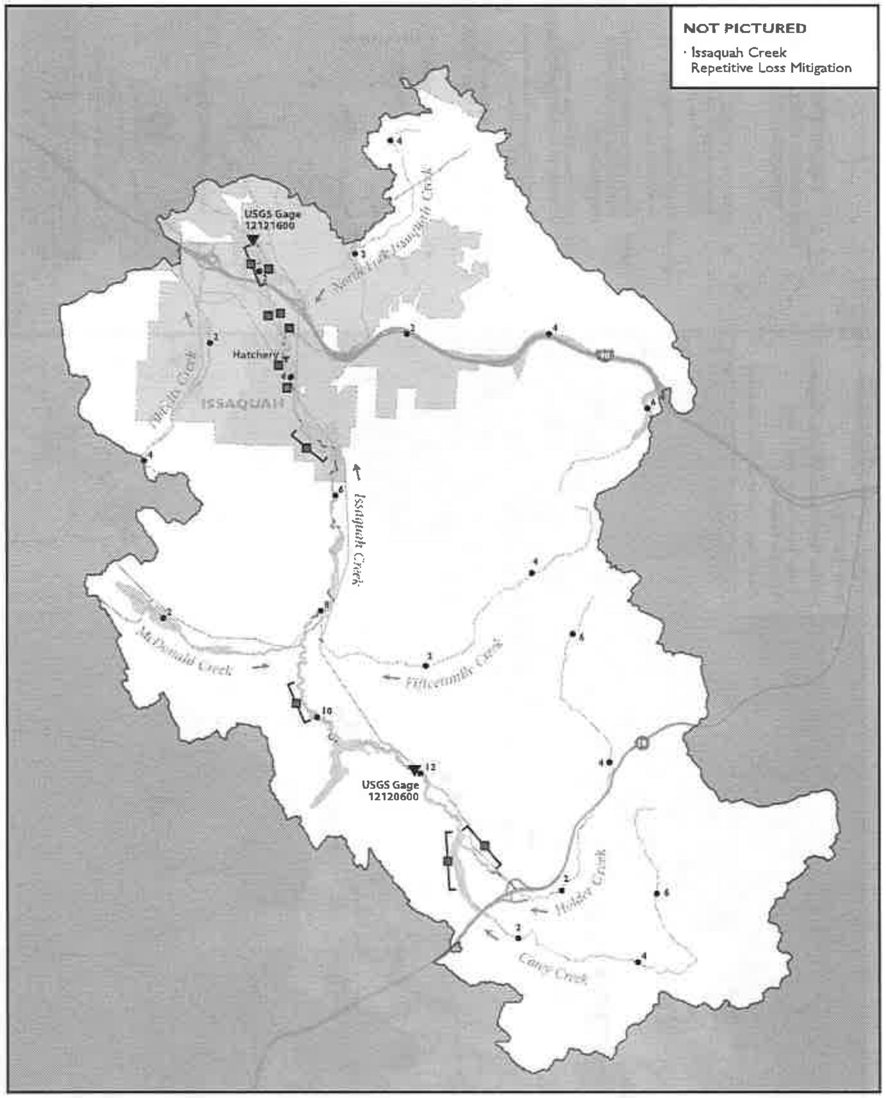
17697



ISSAQUAH CREEK

KING COUNTY FLOOD HAZARD MANAGEMENT PLAN

- 2013-2018 Capital Improvement Projects (Project locations are approximate)
- Rivers and Streams with FEMA Mapped 100-Year Regulatory Floodplains
- Rivers and Streams with Unmapped Regulatory Floodplains
- Flood Protection Infrastructure (Levees & Revetments)
- WRIA Salmon Recovery 3-Year Work Plan Project Sites and Reaches
- 2 River Miles (Approximate)
- Watershed/Basin Boundary
- Road
- Incorporated Area

N

0 1 2 Miles

King County

Department of
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Water and Land Resources Division

Data sources: King County datasets
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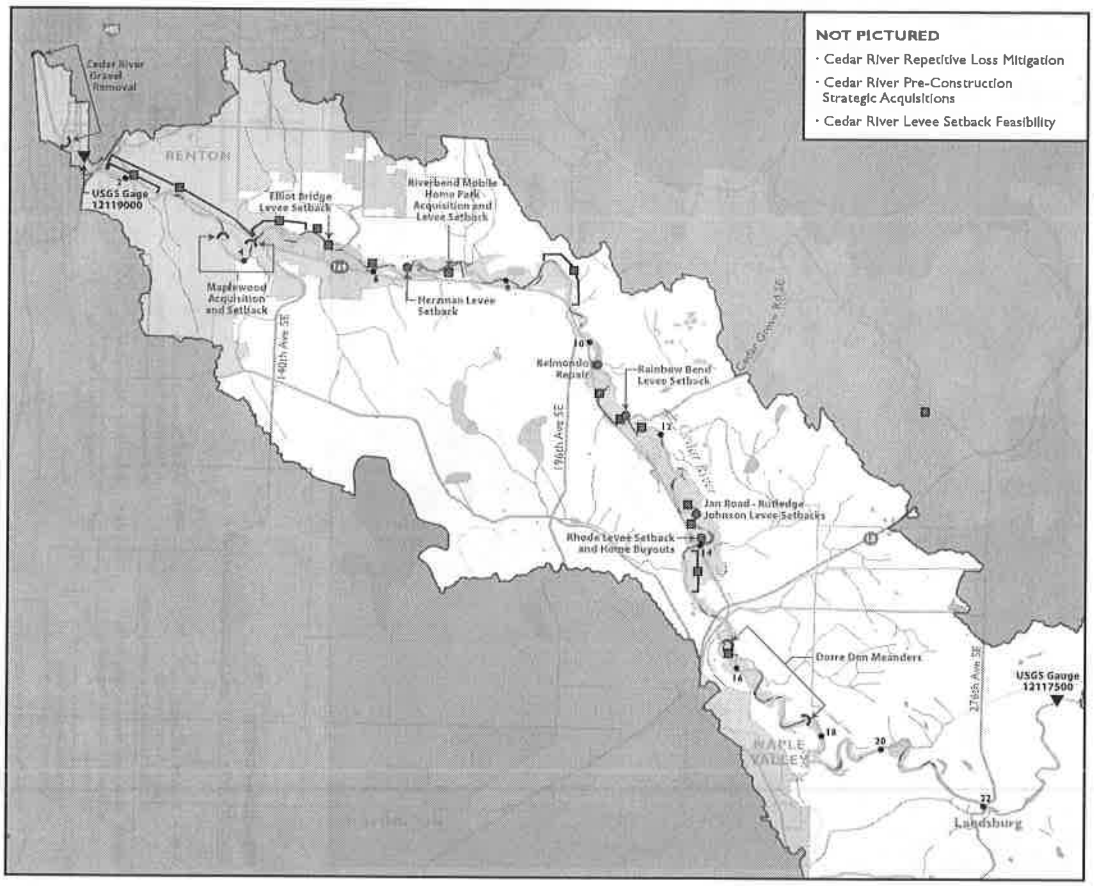
17607



CEDAR RIVER

KING COUNTY FLOOD HAZARD MANAGEMENT PLAN

- 2013-2018 Capital Improvement Projects (Project locations are approximate)
- Flood Hazard Mitigation Analysis Reach
- Rivers and Streams with FEMA Mapped 100-Year Regulatory Floodplains
- Rivers and Streams with Unmapped Regulatory Floodplains
- Flood Protection Infrastructure (Levees & Revetments)
- WRIA Salmon Recovery 3-Year Work Plan Project Sites and Reaches
- River Miles (Approximate)
- Watershed/Basin Boundary
- Road
- Incorporated Area

0 1 2 Miles

King County

Department of Natural Resources and Parks

Water and Land Resources Division

Data sources: King County datasets
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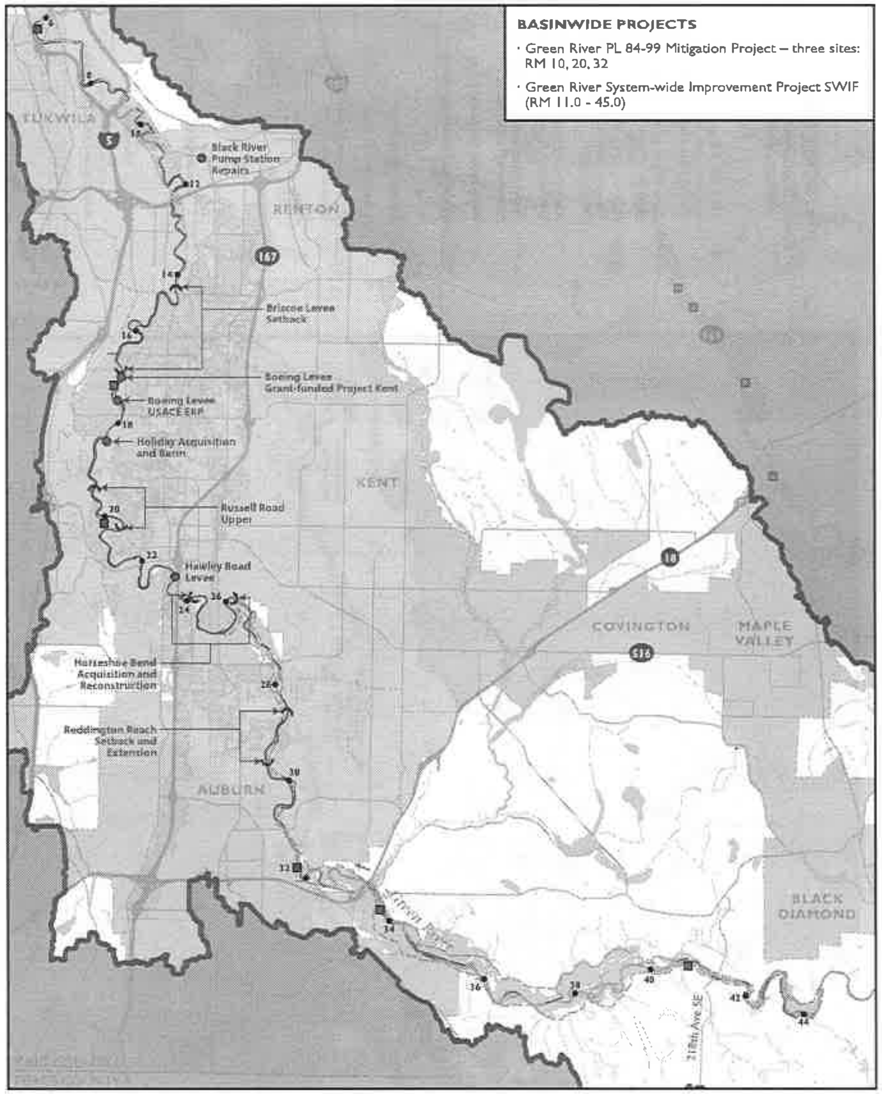

GREEN RIVER

KING COUNTY FLOOD HAZARD MANAGEMENT PLAN

0 1 2 Miles

- 2013-2018 Capital Improvement Projects (Project locations are approximate)
- Extent of Reach-based Project
- Rivers and Streams with FEMA Mapped 100-Year Regulatory Floodplains
- Rivers and Streams with Unmapped Regulatory Floodplains
- Flood Protection Infrastructure (Levees & Revetments)
- Outer Boundary of Channel Migration Hazard Zones (Moderate & Severe)
- WRIA Salmon Recovery 3-Year Work Plan Project Sites and Reaches
- River Miles (Approximate)
- Watershed/Basin Boundary
- Road
- Incorporated Area

King County

Department of Natural Resources and Parks

Water and Land Resources Division

Data sources: King County datasets

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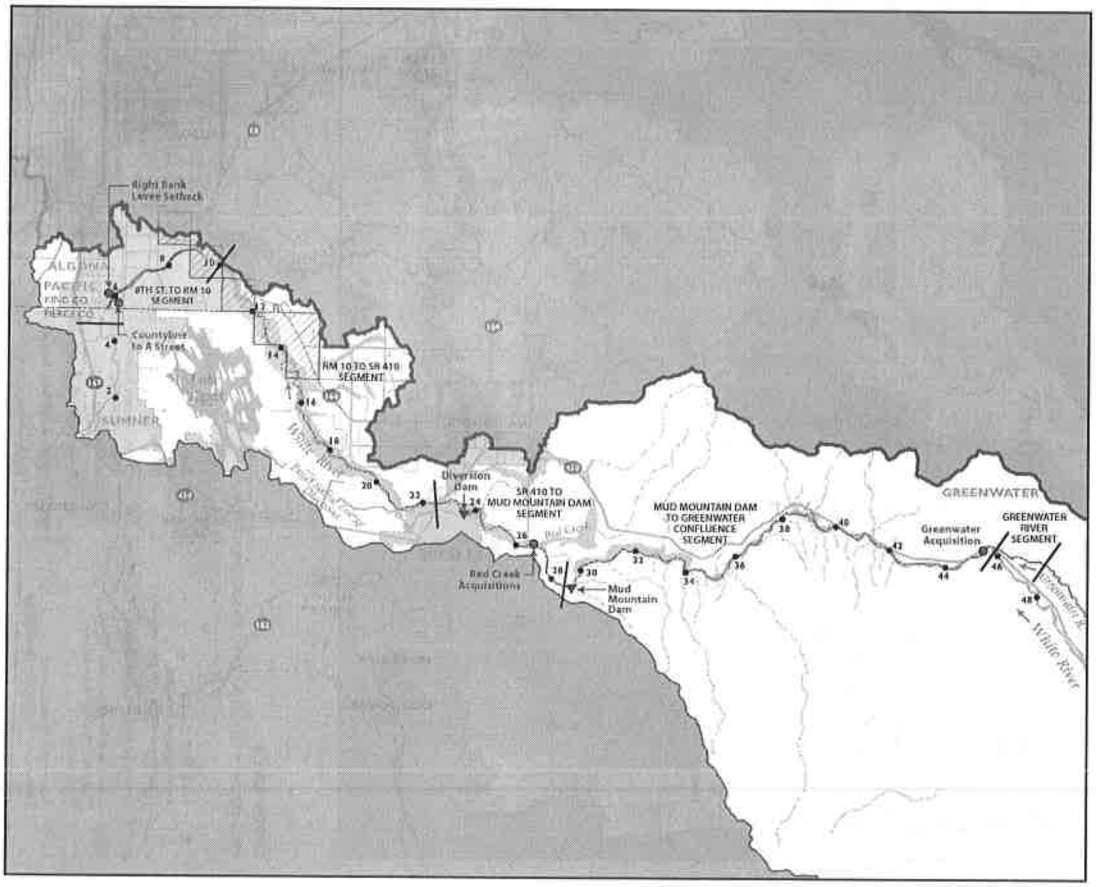
17697



WHITE RIVER

KING COUNTY FLOOD HAZARD MANAGEMENT PLAN

- 2013-2018 Capital Improvement Projects (Project locations are approximate)
- NAME — River Segment Boundary and Segment Name
- Rivers and Streams with FEMA Mapped 100-Year Regulatory Floodplains
- Rivers and Streams with Unmapped Regulatory Floodplains
- Flood Protection Infrastructure (Levees & Revetments)
- 2 — River Miles (Approximate)
- Watershed/Basin Boundary
- Road
- Incorporated Area
- County Boundary
- Muckleshoot Indian Tribe Reservation
- Dam

0 2 4 Miles

King County

Department of
Natural Resources and Parks

Water and Land Resources Division

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Data sources: King County datasets
File name: 1307_3412m_fhmpWHITEbase.ai wgab, mdev

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APPENDIX G.
FLOOD HAZARD MANAGEMENT RISK AREAS

This Appendix is a substitute for and replaces Appendix G of the 2006 Flood Plan.

This appendix contains a listing of the known flooding and erosion related risk areas identified by the River and Floodplain Management Program staff during the preparation of the *2013 King County Flood Hazard Management Plan Update* that will not be addressed by the Action Plan to be implemented from 2013-2018. The approach to identifying and characterizing these risk areas varied from river to river and was influenced by both the characteristics of each river, and by the professional judgment of the team compiling this information. In many cases the magnitude of these risks described is not well understood but will be further evaluated through future technical studies and risk assessments.

SOUTH FORK SKYKOMISH RIVER, MILLER RIVER, MALONEY CREEK, TYE RIVER AND ANTHRACITE CREEK (WRIA 7)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
7.1	7.4	R	Montagna Park: The upstream end of NE 196th Street has been undermined by severe bank erosion during moderate flooding. Emergency revetment construction did not achieve a slope that will be stable over the long term. Both the road and one residence are at risk from this erosion problem. Several homes and nonresidential structures exist in both the floodplain and floodway; many were built after 1993. (South Fork Skykomish River, Unincorporated)	Feasibility and technical analysis required.
7.4	7.6	R	Chamonix: Bank erosion threatens several homes built very near the edge of the river bank. A revetment of large rock riprap has slowed, but has not halted, this erosion. (South Fork Skykomish River, Unincorporated)	Feasibility and technical analysis required.
7.5	7.9	L	Skylandia: Existing homes have been inundated by fast-moving flood waters. Erosion and deposition damages are locally severe. Residential damages included structural problems as high-velocity waters shifted homes on their foundations. Flood study shows 100-year depths as great as 8 feet at these homes. (South Fork Skykomish River, Unincorporated)	Feasibility and technical analysis required.
7.8	8.0	R	Skyko Park: Several residential erosion problems have been patched with revetments and rockeries that are not showing recent damages but remain susceptible to extreme flood flow. Several homes and nonresidential structures exist in both the floodplain and floodway; it appears some were built after 1993. (South Fork Skykomish River, Unincorporated)	Feasibility and technical analysis required.
8.1	8.9	R	Riverwood Park: Several residential erosion problems have been patched with revetments and rockeries that are not showing recent damages but remain susceptible to extreme flood flow. Several homes and nonresidential structures exist in both the floodplain and floodway; it appears some were built after 1993. Flood study shows 100-year depths of 3 to 6 feet through most of this large subdivision. (South Fork Skykomish River, Unincorporated)	Feasibility and technical analysis required.

SOUTH FORK SKYKOMISH RIVER, MILLER RIVER, MALONEY CREEK, TYE RIVER AND ANTHRACITE CREEK (WRIA 7)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
7.9	8.4	L	Baring Left: Severe channel erosion problems have been evident in this area, especially near the south end of 639th Ave NE, where one home was nearly undermined and perched over a tall vertical erosion scar that has been patched with concrete revetments. Although such revetments and rockeries are not showing recent damages, they remain susceptible to extreme flood flow. (South Fork Skykomish River, Unincorporated)	Feasibility and technical analysis required.
10.8	12.2	R	Grotto: Extensive fill restricts natural floodplain conveyance and storage functions. (South Fork Skykomish River, Unincorporated)	Feasibility and technical analysis required.
12.6	13.2	L, R	Money Creek: Logs and debris are jammed against the piers of the Miller River Road bridge over the South Fork Skykomish River at the Money Creek Campground. Downstream of the bridge, severe bank erosion has claimed residential property but does not imminently threaten residences. Further upstream, overbank flows were concentrated along the riverward side of the BNSF Railway grade. Where these concentrated flows hit the Miller River Road, they exceeded culvert capacity and damaged the road where they overtopped it. Further damages occurred as these flows split and continued, generally westward, overbank. A northwest split scoured both the railroad grade and the adjacent portions of the Money Creek Campground. A southwest split scoured through commercial and industrial property on its way to the Money Creek channel. (South Fork Skykomish River, Unincorporated)	Feasibility and technical analysis required.
15.3	15.7	L	Milltown: Homes in old Milltown neighborhood west of Skykomish are subject to inundation by the river and by local drainage. (South Fork Skykomish River, Unincorporated)	Feasibility and technical analysis required.
17.2	17.9	L	Riverview: Eight homes along the left-bank of the Tye River (looking downstream) were damaged by erosion and inundation. Severe erosion continues to threaten several of these homes, and all but one are subject to inundation damages when overbank flows cross the Riverview point. Flood study shows depths of 5 to 8 feet near these homes, and all are within the one-foot floodway. (Tye River, Unincorporated)	Feasibility and technical analysis required.
18.3	18.4	L	Timber Lane Village Reach of Anthracite Creek: Sediment and debris flows in Anthracite Creek frequently plug its narrow channel. This sends flows over the Stevens Pass Highway (SR 2) and through Timber Lane Village. This damage area includes a private road, an extension of NE 122nd Street, and the community's potable water supply watershed and pump station. (Anthracite Creek, Unincorporated)	Feasibility and technical analysis required.
21.4	22.1	L	Profitts Pond: High-velocity inundation is likely for two residences situated on very large lots. Because there is a large log jam in main channel, channel migration is likely; an avulsion path is very near these homes. (Tye River, Unincorporated)	Feasibility and technical analysis required.

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SOUTH FORK SNOQUALMIE RIVER, (WRIA 7)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
5.6	6.2	L, R	Riverbend Flooding and Erosion: A manually-adjustable flood gate that separates the South Fork Snoqualmie River from a private lake can allow floodwater to enter the lake, increasing water surface elevations and causing flood damage to homes around the lake. Flood waters in this constricted reach also cause erosion problems on the right bank. (South Fork Snoqualmie River, Unincorporated)	Feasibility and technical analysis required.
8.5	9.2	L, R	Edgewick Area Flooding: Flooding along this steep reach affects homes on both banks of the river in this reach. The left bank abutment of the Edgewick Road Bridge encroaches sharply into the channel and is subject to erosion. (South Fork Snoqualmie River, Unincorporated)	Feasibility and technical analysis required.
2.2	2.3	L, R	Replacement / retrofit of SR202 Bridges	Feasibility and technical analysis required.

MIDDLE FORK SNOQUALMIE RIVER AND NORTH FORK SNOQUALMIE RIVER, KIMBALL (WRIA 7)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
0.4	1.0	L, R	Upper Norman Flooding, Erosion and Habitat Degradation: Channel aggradation and changes in the thalweg have contributed to damage to two river facilities in this constrained reach. The status of these two facilities with respect to the need to maintain is rather ambiguous. One home on the right bank is subject to both flood and, in the long term, channel migration. The Upper Norman flood protection facility effectively isolates a fish bearing wetland from the mainstem of the river except during extreme high flows. Both facilities inhibit natural riverine process and are largely devoid of native vegetation. (Middle Fork Snoqualmie River, Unincorporated)	Feasibility and technical analysis required.
3.7	4.0	L	Tanner Revetment Erosion: Extreme high flows could result in damage to the Tanner revetment which protects the intersection of SE Tanner Road and North Bend Way. (Middle Fork Snoqualmie River, Unincorporated)	Feasibility and technical analysis required.
4.1	4.4	L	Tanner Neighborhood Erosion: Bank erosion threatens several residential properties both upstream of the Tanner revetment. (Middle Fork Snoqualmie River, Unincorporated)	Feasibility and technical analysis required.
1.0	2.0	R	Schodde Revetment and Ernie's Grove Residential Property Erosion and Flooding: Reoccupation of the side channel running along the base of the Schodde revetment would likely result in damage to private property. (North Fork Snoqualmie River, Unincorporated)	Feasibility and technical analysis required.
0.5	2.2	L	Moon Valley Residential and Road (sole access) Flooding: Inundation of residential properties and public and private roads and fast-moving water on Moon Valley Road completely isolates this community during moderate and extreme flood events. (North Fork Snoqualmie River, Unincorporated)	Feasibility and technical analysis required.

UPPER SNOQUALMIE RIVER, (WRIA 7)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
39.1	41.1	L	Neighborhood Flooding in Snoqualmie Area: More than 600 homes and hundreds of other structures are subject to flood inundation in and around the City of Snoqualmie. Recent projects have reduced the frequency and severity of local flood conditions, but the area continues to be at risk. (Upper Snoqualmie River, City of Snoqualmie)	City of Snoqualmie Natural Area Acquisitions: This project is to acquire property along the Snoqualmie River for shoreline, floodplain and native habitat protection. The project would acquire flood-prone land and eliminate flood risk to one home. (Upper Snoqualmie River, City of Snoqualmie)
0.7	1.1	R	Confluence Channel Process Restoration and Floodplain Reconnection: Recent and on-going channel position changes on the North Fork Snoqualmie upstream of the North Fork Bridge, is causing dramatic lateral migration of the river channel within and adjacent to the Three forks Natural Area. These changes have severely damaged the privately owned and maintained Shake Mill Left levee on the left bank of the river immediately upstream of the North Fork Bridge. Understanding the recent changes and forecasting future geomorphic evolution is important to inform flood hazard management decisions in this area. (Upper Snoqualmie River, Unincorporated)	Three Forks Natural Area Restoration: The project would conduct a geomorphic, hydraulic, and natural resource study to evaluate the existing flood facilities and geomorphic conditions and propose actions that would reduce flood hazards. Development of actions would be consider the existing flood facilities, flood and geomorphic hazards, natural resources, infrastructure and property ownership, and management goals and strategies of the Three Forks Natural Area. Actions proposed could include modification, creation, or removal of flood protection facilities, roads, bridges or drainage infrastructure, property acquisition, vegetation management or restoration or other structural or non-structural actions.
40.3	41.9	R	Reinig Road Erosion and Neighborhood Flooding: A 1.8 mile segment of Reinig Road borders the channel migration zone and in one location has been damaged to the point that an emergency repair was required. Five homes along this road segment are also subject to flooding and erosion. (Upper Snoqualmie River, Unincorporated)	Feasibility and technical analysis required.
42.2	42.3	R	Reinig Road Slope Instability: Road bank failure at this location at which the river make a nearly 90 degree bend has been repaired by King County Roads. Continuing erosion at the revetment's shallow toe is likely to undermine this repair. Upstream and downstream banks are unprotected, leaving the road at risk from future erosion damage in these areas as well. (Upper Snoqualmie River, Unincorporated)	Feasibility and technical analysis required.
41.6	41.9	R	Reinig Road Erosion across from Confluence with South Fork: Right bank erosion at the confluence of the South Fork and the mainstem Snoqualmie may damage Reinig Road in this location. (Upper Snoqualmie River, Unincorporated)	Feasibility and technical analysis required.
38.8	40.8	L, R	Evaluation of flood risks and hazards main stem above the falls	Feasibility and technical analysis required.

LOWER SNOQUALMIE RIVER (WRIA 7)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
TBD	TBD	TBD	Repetitive Flood Damages to Residential and Agricultural Structures: There are a number of residences and agricultural structures in the Agricultural Production District along W. Snoqualmie River Road NE that have experienced repeated flood damages. (Lower Snoqualmie River, Unincorporated)	Lower Snoqualmie Elevations: Pursue elevations of residences or agricultural structures in this area, as appropriate and consistent with mitigation strategy criteria in Chapter 4.
TBD	TBD	TBD	Vegetation Maintenance: Existing levees and revetments have been built to reduce risk of damage from flooding and erosion. This represents a significant extent of riparian land that has problems with invasive, non-native vegetation. Eradication of these invasive plants and the establishment of native riparian plantings remain as a levee or revetment maintenance need. (Lower Snoqualmie River, Unincorporated)	Lower Snoqualmie Restoration and Maintenance: Revegetation of existing levees or revetments to reduce cost of flood risk reduction. Includes enhancement of 3 miles of riparian habitat, improve access to off-channel habitat, open 1.5 miles of rearing habitat by removing blockages and restore a three-acre wetland. (Lower Snoqualmie River, Unincorporated)
TBD	TBD	TBD	Vegetation Maintenance: Existing levees and revetments have been built to reduce risk of damage from flooding and erosion. This represents a significant extent of riparian land that has problems with invasive, non-native vegetation. Eradication of these invasive plants and the establishment of native riparian plantings remain as a levee or revetment maintenance need. (Lower Snoqualmie River, Unincorporated)	Snoqualmie River Restoration on Agriculture Lands: Revegetation of existing levees or revetments to reduce cost of flood risk reduction. The goal is to plant 50 acres of floodplain habitat throughout the Snoqualmie. (Lower Snoqualmie River, Unincorporated)
0.0	0.4	L, R	Levee and Revetment Maintenance: Existing levees and revetments have been built to reduce risk of damage from flooding and erosion. These facilities require maintenance and repair in order to preserve their function. (Lower Snoqualmie River, Unincorporated)	Cherry Creek Mouth Restoration: Revegetation of existing levees or revetments to reduce cost of flood risk reduction. This project would restore the old channel alignment, circa 1960, before it was straightened and channelized. This would create approximately 2000 feet of new channel. The project would also eliminate any need for maintenance of existing channelized outlet (to be abandoned). (Lower Snoqualmie River, Unincorporated)
5.5	9.2	L	Dutch Row Riverbank Erosion and Slumping: The shoulder of the West Snoqualmie River road, which is a primary access to 25 large agricultural properties, is exhibiting slumping caused by scour on the left bank of the Snoqualmie River. (Lower Snoqualmie River, Unincorporated)	Feasibility and technical analysis required.
8.9	9.2	L	Joy Revetment Erosion and Slumping: Erosion at the toe rock of the Joy revetment threatens this flood protection facility and adjacent private road. (Lower Snoqualmie River, Unincorporated)	Feasibility and technical analysis required.

LOWER SNOQUALMIE RIVER (WRIA 7)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
9.2	9.2	L	Woodinville-Duvall Road Backwater Flooding and Bridge Abutment Erosion: Fill placed in the floodplain for construction of the Woodinville-Duvall Road exacerbates flooding problems upstream of this heavily used cross-valley road. Despite the multiple bridges in this road fill, the road blocks most of the floodplain conveyance capacity, contributes to flood depths upstream, and can cause localized high-velocity flows that lead to scour damages on adjacent private lands. Road elevation leads to frequent inundation and access being cut off. (Lower Snoqualmie River, Unincorporated, City of Duvall)	Feasibility and technical analysis required.
16.6	16.8	L	Adair Road Revetment Erosion and Slumping: Erosion at the toe rock of the Adair Road revetment potentially threatens this flood protection facility and road. In addition, the bank opposite this flood protection facility is actively eroding. (Lower Snoqualmie River, Unincorporated)	Feasibility and technical analysis required.
21.9	22.7	R	NE 50th to Horseshoe Lake Flooding and Erosion: Flood flows over the right bank of the Snoqualmie River cause minor damage to 55th Ave NE and more significant damage to the more heavily used Carnation Farms Road. (Lower Snoqualmie River, Unincorporated)	Feasibility and technical analysis required.
22.1	22.7	R	Levee and Revetment Maintenance: Existing levees and revetments have been built to reduce risk of damage from flooding and erosion. These facilities require maintenance and repair in order to preserve their function. (Lower Snoqualmie River, Unincorporated)	McElhoe/Pearson Levee: The project will remove or set back about 1,300 feet of the levee, reconnecting floodplain habitat and increasing side channel formation. The setback project would reduce the need for maintenance and flood repair along existing McElhoe/Person levee. (Lower Snoqualmie River, Unincorporated)
22.4	22.7	R	NE 60th St. to NE 55th Flooding: There are a number of residences between NE 60th St. and NE 55th St. that could flood or have experienced flood damages. (Lower Snoqualmie River, City of Carnation Planned Annexation Area)	Lower Snoqualmie Elevations: Pursue elevations of residences or agricultural structures in this area, as appropriate and consistent with mitigation strategy criteria in Chapter 4.
23.8	27.6	R	There are a number of residences and agricultural structures in the Agricultural Production District between Tolt confluence and RM 27.6 (Changing Seasons Farm) that have experienced repeated flood damages. (Lower Snoqualmie River, Unincorporated)	Lower Snoqualmie Elevations: Pursue elevations of residences or agricultural structures in this area, as appropriate and consistent with mitigation strategy criteria in Chapter 4.

LOWER SNOQUALMIE RIVER (WRIA 7)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
26.0	26.6	L	Byers Farm Flood Damage: Unique hydraulic patterns on the Byers farm cause massive and repetitive deposition of flood-borne debris - mostly fallen trees - on arable land. (Lower Snoqualmie River, Unincorporated)	Snoqualmie River Byers Floodplain and Riparian Restoration: Install a 600 foot long "drift fence" to capture the large amount of woody debris that is accumulating in the back/tree line of the property to reduce erosion along agricultural property. Feasibility and technical analysis required to assess potential for removing flood facilities in conjunction with conversion of golf course to farming and restored wetland. (Lower Snoqualmie River, Unincorporated)
27.4	27.6	L	Levee and Revetment Maintenance: Existing levees and revetments have been built to reduce risk of damage from flooding and erosion. These facilities require maintenance and repair in order to preserve their function. (Lower Snoqualmie River, Unincorporated)	Gonneson Revetment Removal/Acquisition: The project will restore the Snoqualmie River to allow it to migrate laterally along this meander bend by removing existing bank armor. This proposal would require the acquisition of 12 acres of property in order to allow the project to occur. It would also eliminate any need for maintenance of existing Gonneson revetment (to be removed). (Lower Snoqualmie River, Unincorporated)
29.3	31.5	R	SE 19th Way Road and Revetment Damage: Erosion along the left bank of the Snoqualmie River channel threatens to undermine the road bed of SE 19th Way, a county road which serves one farm. A rock revetment was installed in response to this problem in the 1960s, but the problems involve deep failure surfaces that have not been stabilized by the rock riprap. (Lower Snoqualmie River, Unincorporated)	Feasibility and technical analysis required.
34.2	34.9	R	Washington State Department of Transportation Overbank Flooding: Floodwaters overtop SR 202 where it abuts the right bank of the Snoqualmie River, across from and upstream of the Raging River confluence. This causes deep, fast, erosive flows in this rural residential area. (Lower Snoqualmie River, Unincorporated)	Feasibility and technical analysis required.

TOLT RIVER (WRIA 7)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
2.3	2.9	R	Levee and Revetment Maintenance: Existing levees and revetments have been built to reduce the risk of damage from flooding and erosion. These facilities require maintenance and repair in order to preserve their function. (Tolt River, Unincorporated)	Tolt River Natural Area Floodplain Reconnection/Acquisition: This project would assess the feasibility of removing a levee that is currently disconnecting a side channel from being active. In order to remove the levee several residences must be bought out as they are directly in the old side channel. The project would reduce the need for maintenance of existing Edenholm levee (portion to be removed) resulting in an elimination of the risk to two homes. (Tolt River, Unincorporated)
4.2	4.9	R	San Souci Neighborhood Flooding: Deep, fast flood waters surround several residences in the San Souci area. These can isolate the neighborhood, preventing travel in or out, during relatively minor flood events. Many residents elect to stay in these homes, which are higher than moderate flood levels. However, all of the homes are at risk during extreme flood events. By the time the hazard becomes convincingly visible, high water may prevent evacuation. This compounds the life safety concerns in this area. (Tolt River, Unincorporated)	San Souci Neighborhood Buyout: Remove all homes from this hazardous area. Then, remove existing rubble levee at upstream end of community access road. Feasibility and technical analysis required to evaluate potential river response from levee removal .(Tolt River, Unincorporated)
2.0	6.0	L, R	Tolt River Residential Hazards: Problems described above for the San Souci area exist more generally. Due to the severity and concentration of these problems at San Souci, it is a priority for action, but similar needs will remain throughout the corridor upstream of the leveed segment after that project is complete. (Tolt River, Unincorporated)	Feasibility and technical analysis required; Tolt Corridor Study should provide much of required analysis.

RAGING RIVER (WRIA 7)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
0.0	1.5	L, R	Fall City Area Channel Aggradation and Flooding: Although the Fall City levees were raised in 1997, channel aggradation continues in a manner that may diminish flood containment capacity, particularly downstream of the Preston-Fall city Road Bridge at RM 0.5. Channel aggradation upstream of the Preston-Fall City Road bridge is not as severe as in the downstream reach, but continued aggradation, combined with the already constrained channel and the angle at which the river passes under the bridge, may create an increasing risk for flooding through Fall City. (Raging River, Unincorporated)	Fall City Levee Setback Feasibility Study: The proposed project would involve setting back portions of the existing levee system on both the right and left banks to increase channel capacity and optimize the angle at which the Raging River passes under the Preston-Fall City Road Bridge. The project would require acquisition of, or additional easement rights across, up to seven privately held parcels on the left bank of the river and up to 31 parcels on the right bank of the river. Because of the large number of property owners and stakeholders that would be involved in project, and the potential for alternative solutions, work on this project is currently proposed to be limited to the completion of a feasibility study. (Raging River, Unincorporated)
0.0	0.4	R	See Fall City Area Channel Aggradation and Flooding description (above).	Lower Raging River Restoration: This project seeks to setback existing Raging River levee system to increase its level of flood protection to the Fall City community. (Raging River, Unincorporated)
1.45	4.20	L,R	Preston-Fall City Road Flooding and Erosion: Preston Fall City Road and rural residential development in many locations are within or at risk from flood and channel migration hazards. Ongoing lateral migration and bank erosion creates numerous geotechnical instabilities for the road that require repairs. (Raging River, Unincorporated)	Feasibility and technical analysis required.
1.45	4.20	L,R	Preston - Fall City Road Realignment: A considerable length of the Preston – Fall City Road lies within, or immediately adjacent to the Raging River channel migration zone (see Preston - Fall City Road Erosion and Flooding A-F above). Ongoing lateral migration and bank erosion creates numerous geotechnical instabilities for the road. As an alternative to ongoing erosion and repair of the existing Preston - Fall City Road alignment, consider potential road realignment between the Town of Preston and the 328th Street Bridge. (Raging River, Unincorporated)	Feasibility and technical analysis required.
1.5	4.9	L,R	Levee and Revetment Maintenance: There are a number of flood facilities along the I-90 to Fall City segment which are subject to erosion and damage. (Raging River, Unincorporated)	Feasibility and technical analysis of potential facility removal or setback required; should include acquisition strategy.

RAGING RIVER (WRIA 7)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
4.30	4.47	L, R	Town of Preston Residential Erosion: Homes and a church camp downstream from the SE 86th St Bridge are at risk from erosion. (Raging River, Unincorporated)	Feasibility and technical analysis required.
4.70	4.90	L, R	Upper Preston Road Erosion: 0.3 miles of the Upper Preston Road and road bridge are within the moderate or severe channel migration hazard area. (Raging River, Unincorporated)	Feasibility and technical analysis required.
4.82	4.94	L, R	Hursh Neighborhood Access Erosion: Erosion around the freeway support on the left bank of the river may threaten the sole access to the upstream community of five or six homes. Most of access road is in severe channel migration hazard area. (Raging River, Unincorporated)	Feasibility and technical analysis required.
5.38	5.55	R	Upper Preston Road Slope Instability: A shift in flow patterns could result in increased flows in a side channel running along the slope upon which the Upper Preston Road has been built resulting in erosion and potential slope failure. (Raging River, Unincorporated)	Feasibility and technical analysis required.
7.64	8.14	L,R	Arruda Neighborhood Residential Flooding and Erosion: Several homes off the end of the Upper Preston Road are at varying degrees of risk from channel migration. (Raging River, Unincorporated)	Feasibility and technical analysis required.

SAMMAMISH RIVER AND ISSAQUAH CREEK (WRIA 8)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
0.0	0.0	N/A	Delta Sedimentation at Mouth: Sediment frequently tends to build up just downstream from the mouth of the river, forming a delta in Lake Washington. Periodically, dredging of these accumulated sediments is performed by the U.S. Army Corps of Engineers in order to maintain commercial navigation at the north end of the lake. During the interval between dredging, the expanding delta in the lake may reduce river velocities at the river's outlet, leading to sediment build-up in the channel. Homeowners along the lower end of the river frequently request that King County dredge the river in order to maintain recreational navigation for large-hulled boats between the river and the lake. (Sammamish River, City of Kenmore)	Feasibility and technical analysis required to determine where and how much sediment is accumulating, if there are an associated flood risks, and what actions are recommended for any identified flood risks.
All	All	L, R	Issaquah Creek Undeveloped Property (Issaquah Creek, City of Issaquah): Undeveloped properties in areas of known high flood hazard within the Issaquah Creek floodplain that can be developed into residential homes. Development of these properties could result in future flood losses and risks to public safety. Recent floods, including 1990 and 1996, demonstrates that this area experiences significant flooding causing repetitive losses at existing structures. While current development standards for construction in floodplains are in compliance with FEMA, residual safety risks remain because floodwaters cut off access to these properties, preventing emergency response actions during flooding events.	Purchase of flood-prone undeveloped residential parcels will help prevent future flood losses and risks to public safety. Existing homes in many neighborhoods along Issaquah Creek have experienced repetitive losses during the 1990 and 1996 floods. For current undeveloped parcels this can be avoided if acquired prior to development and dedicated as open space. Also, property acquired and dedicated as open space provides a significant benefit towards preserving valuable habitat for fish and wildlife. Issaquah has implemented several stream, floodplain and wetland restoration projects in the last five years, which can be expanded to newly acquired properties, and King County has also purchased many properties to prevent future floodplain development and preserve the stream corridor

SAMMAMISH RIVER AND ISSAQUAH CREEK (WRIA 8)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
All	All	L, R	Issaquah Creek Loss Area Structure Elevations and Floodproofing (Issaquah Creek, City of Issaquah): Single family repetitive loss structures, including two in rural King County and 13 in the City of Issaquah, located in high flood hazard areas of the Issaquah Creek floodway and floodplain. Many residential developments were constructed before flood development standards for construction in floodplains were enacted in 1980. Recent floods, including in 1990 and 1996, demonstrates that Issaquah Creek experiences significant flooding, resulting in repetitive losses at existing structures. Future floods will likely cause additional repetitive damages, along with risks to public safety because floodwaters cut off access to these properties, preventing emergency response actions during flooding events.	Provide assistance to repetitive loss single family structures within the Issaquah Creek floodplain to elevate and/or floodproof structures to current floodplain standards. This will help mitigate current repetitive losses to allow them to be taken off of repetitive loss lists. Elevations will raise first floors to 1-2 feet above the base flood elevation. Mitigation of future flood losses at existing repetitive loss properties.
2.5	2.8	L	Gilman Square Repetitive Loss Area Structure Elevations and Floodproofing (Issaquah Creek, City of Issaquah): Commercial structures, including five repetitive loss structures, next to Gilman Boulevard within a known high flood hazard area in the Issaquah Creek floodplain. The Gilman Repetitive Loss Area, located on Issaquah Creek next to Gilman Boulevard in the Gilman Square development, consists of several commercial buildings that were built many years ago in a high flood hazard area. Recent floods, including in 1990 and 1996, demonstrates that this area experiences significant flooding, resulting in repetitive losses totaling $786,000 at four structures. Future floods will likely cause additional repetitive damages, along with risks to public safety because floodwaters cut off access to these properties, preventing emergency response actions during flooding events.	Provide assistance to up to six commercial buildings within the Gilman Repetitive Loss Area to elevate and/or flood proof structures to current floodplain standards. This will help mitigate current repetitive losses at up to four structures, to allow them to be taken off of the City's repetitive loss list (the total number of repetitive loss properties in Issaquah is 19). Elevations will raise first floors 1-2 feet above the base flood elevation, or floodproofing methods will be used based on current criteria, based on floodplain mapping recently developed for the Issaquah Flood Insurance Study update. Mitigation of future flood losses at up to six properties, including four repetitive loss properties.

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SAMMAMISH RIVER AND ISSAQUAH CREEK (WRIA 8)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
All	All	L, R	Issaquah Creek Property Acquisition Opportunity Fund (Issaquah Creek, City of Issaquah): Existing developed single family, multi-family, and commercial structures in high flood hazard of Issaquah Creek, East Fork Issaquah Creek, and North Fork Issaquah Creek floodways and floodplains. Many existing developed properties in the Issaquah Creek watershed were developed before flood development standards for construction in floodplains were enacted in 1980. Past land use regulations allowed construction of buildings close to the creek, along with filling that impacted adjacent properties. Recent floods, including in 1990 and 1996, demonstrates that many areas of Issaquah experience significant flooding. Future floods will likely cause additional repetitive damages, along with risks to public safety because floodwaters cut off access to these properties, preventing emergency response actions during flooding events.	This project will provide long-term financing to acquire non-repetitive loss properties having flood prone structures along Issaquah Creek. Funds will be held in an opportunity fund that will be available for acquisitions when properties become available, either as identified through a City or County mitigation proposal or by property owners who contact the City or County for possible buyouts. This will help mitigate current flood losses and assists with stream and floodplain restoration projects in accordance with the policies and funding guidance of the WRIA8 Chinook Salmon Conservation Plan.
5.3	5.6	R	Squak Valley Park Levee Removal and Habitat Restoration (Issaquah Creek, City of Issaquah): Flooding of the Sycamore neighborhood, a single family residential development with approximately 1/2 dozen homes on left bank Issaquah Creek upstream of Sycamore Drive that is prone to flooding (including two repetitive loss properties). A levee that was constructed on the Erickson Property (now city-owned Squak Valley Park North) in the 1930's is contributing to flooding of the Sycamore neighborhood because the levee is on the right bank of Issaquah Creek and is much higher than the floodplain area where homes are built on the left bank. Floods of 1990 and 1996 caused widespread flooding in the Sycamore neighborhood area. Full or partial removal of the levee will help mitigate flood losses through lower flood elevations, and also provide an opportunity to improve stream and riparian habitat. The levee provides very little flood protection benefit; a small portion of Issaquah-Hobart Road that does obtain some benefit from the current levee can be protected with a small setback levee outside of the stream buffer area.	Construct the Squak Valley Park stream and riparian restoration project that includes partial or full levee removal. Project will include fish habitat enhancement, consistent with WRIA8 Salmon Conservation Plan proposal (on 3-year high priority list), and floodplain reconnection with remainder of city park property. Levee removal will help lower peak flood elevations in the area by creating additional conveyance area, and will reconnect Issaquah Creek to the floodplain which will restore natural floodplain processes such as sediment deposition, and also improve fish, riparian, and wetland habitats.

SAMMAMISH RIVER AND ISSAQUAH CREEK (WRIA 8)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
All	All	L, R	Issaquah Creek Bank Stabilization Opportunity Fund (Issaquah Creek, City of Issaquah): Many structures are located within a very short distance of Issaquah Creek, East Fork Issaquah Creek, and North Fork Issaquah Creek, and thus are at risk of flood damage caused by bank erosion. Construction of these structures was made possible by past land use regulations that allowed such development, and also by active public assistance programs from King County to stabilize stream banks. These assistance programs have ceased in recent decades due to lack of funding. After moderate to high floods there is typically a need to construct one or more bank stabilization projects to restore stream bank erosion to protect existing structures.	Provide assistance to private and public property owners by implementing bank stabilization projects and other needed maintenance, incorporating current techniques such as bioengineering, setback revetments, and relocation. Proposed work includes design, permitting and construction of minor projects costing less than about $150,000 each. Projects can be combined with habitat improvements, funded through other sources. Stabilization of stream banks and maintenance of existing bank stabilization structures that are located in areas of where existing structures are close to the active stream channel will help mitigate future flood losses and improve public safety.
0.1	1.7	L, R	Sunset Creek (Lake Washington, City of Bellevue): The regional METRO sewer line located in the Richards Creek valley in south Bellevue is at-risk due to stream erosion where a new channel is developing across a forested wetland adjacent to the sewer line. Through natural processes, the stream channel shifted course and today flows across an area where previously no stream corridor existed. The stream shift occurred where Richards Creek had been channelized along property lines in the 1970's (prior to Sensitive Area ordinances). At that time, the streams were forced into unnatural right-angle bends and aligned to flow between several commercial box structures. Three separate creek systems (Richards, East, and Sunset) merge in the project vicinity. Each creek is constrained by long, straight stream corridors between commercial warehouse buildings. The project site is a historic wetland/ floodplain area where the valley slope flattened and thus is a natural sediment deposition zone. Currently, the creeks in this area have no functioning floodplain and have extremely limited riparian habitat. Spawning salmon, including species protected under the Endangered Species Act, are known to use the corridors. Engineering solutions to increase conveyance capacity are limited due to narrow creek corridors, the need to excavate excess sediment and the presence of the buildings. Private property issues are also an obstacle.	Sunset Creek Acquisitions: Eliminate repetitive flooding by acquiring several commercial and vacant properties in the area where the three creeks merge. Next, design a stabile channel adjacent to the METRO sewer line. Demolish the commercial buildings and restore the area as natural open space to establish a functioning system by reconnecting the creeks with the floodplain, providing spawning and rearing aquatic habitat, and providing a natural deposition area for sediment.

SAMMAMISH RIVER AND ISSAQUAH CREEK (WRIA 8)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
0.0	0.7	L, R	Lower Coal Creek (Lake Washington, City of Bellevue): Homes downstream of the I-405 regional detention facility are constructed on an historic river delta where the creek empties into Lake Washington. Preliminary floodplain modeling predicts that many of the homes are at risk of structural flooding beginning with moderate storms. One house in this area is identified as FEMA repetitive flood loss property. It last flooded prior to construction of the regional detention pond, thus it is considered to be a mitigated property in the FEMA program. The creek is confined to a narrow corridor flowing through manicured lawns in an upscale residential neighborhood. Five box culverts interspersed throughout the neighborhood, each too small to convey the 100-year flow rate, exacerbate the flooding situation. Levees constructed along the left and right banks, do not meet federal standards, nor do they contain the 100-year flow, and do not connect to higher ground. Stream bed aggradation has dramatically reduced the stream conveyance capacity since the neighborhood was constructed in the late 1960's. Sediment delivery rates are higher than what might be expected in a watershed of this size due to mining practices in the upper watershed in the early 20th century. The I-405 regional detention facility is a 20 acre-foot, in-channel regional detention pond facility located at the upstream extent of the Newport Shores reach of Coal Creek. Peak storm flows are mitigated, but not sufficiently to prevent flooding for moderate to severe storm events (e.g. 100-year storm). Reducing the flood risk in this area is problematic because many of the threatened structures are not necessarily next to the creek. Those distant properties are threatened because the storm drain connections to the creek have very flat slopes thus allowing water to "backup" through the system.	Lower Coal Creek Phase 2: Increase the storage capacity of the regional pond while maintaining fish passage to effectively reduce flow rates to protect private property and maintain stream channel capacity. Increase conveyance capacity of five box culverts and construct Army Corp of Engineer's approved levees where feasible.

CEDAR RIVER – LAKE WASHINGTON (WRIA 8)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
			Several bridges over the Cedar River in downtown Renton (Logan Ave N, Williams Avenue N, Wells Avenue N, Bronson Avenue N, Houser Avenue N) were designed to accommodate the previous FEMA 100-yr flood discharge of 8,500 cfs. The 100-year flood discharge for the Cedar River has since been increased to 12,000 cfs. During flows equal or greater than ~8,000-cfs, flood waters impinge upon these bridges. Specifically, when water levels approach the height of the bridges' low chord, the bridges restrict flood water conveyance causing an increase in upstream water surface elevations. Additionally they may be impacted by large wood and create logjams. These conditions create a safety hazard to the public requiring bridge closure, thus impacting traffic and the economy. These flood conditions can also cause damage to the bridges and other infrastructure.	When the bridges are replaced or updated, design the low chord elevation to be higher in order to provide greater clearance for flood flows.
1.5	1.6	L	Old City Hall (Cedar River, City of Renton): During floods equal to or greater than 50-yr events (> 8000 cfs), the Old Renton City Hall building at 200 Mill Avenue South is flooded. The lowest floor of the building and parking lot is flooded. The City building had floodwater inside of it during the 1990 flood (10,600 cfs) and suffered flood damages. Flood fighting efforts during other floods has prevented the damage from reoccurring. A small wall was build in the 1990's to provide additional protection, but may not be sufficiently high enough to protect the building during the revised 100-yr flood flow of 12,000 cfs.	Old City Hall Flood Protection: Reconstruct or modify existing wall to increase height and include required freeboard so the wall can be FEMA certified as a floodwall. Modify onsite storm system to prevent surcharging during high flows and flooding behind the wall. Alternatively, a levee could be reconstructed by removing gabions, if sufficient space is available to meet levee design standards and FEMA levee certification requirements. The project would prevent damage to a public building and prevent damages from re-occurring. Habitat improvements could also be incorporated into the project if FEMA levee or floodwall certification requirements could be also achieved and maintained.
1.6	1.9	R	Carco Theater (Cedar River, City of Renton): During floods equal to or greater than 50-yr events (> 8000 cfs), the Carco Theater and Renton Community Center at 1717 and 1715 Maple Valley Hwy are flooded and damaged. The Carco Theater had water inside the building during the 1990 flood (10,600 cfs) and suffered flood damages. Flood fighting efforts during other floods has prevented the damage from reoccurring. Flooding of building due to high flows can cause drainage system back-up or over bank flows to flood the building.	Carco Theater Flood Hazard Reduction: Construct a setback levee to protect the building from damages and modify storm systems that surcharge during flood events to prevent surcharging back into the building. The project would prevent damage to a public facility and prevent damages from re-occurring.

CEDAR RIVER – LAKE WASHINGTON (WRIA 8)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
2.1	2.5	R	Riviera Apartments (Cedar River, City of Renton): During floods equal to or greater than 50-yr events (> 8000 cfs), the units in the existing apartment buildings closest to the river are flooded. The Riviera Apartments are located at 2205 Maple Valley Hwy. The lowest floor of the apartments and parking lot are flooded. The apartment units were flooded during the 1990 flood (10,600 cfs) and suffered flood damages. Residents had to be evacuated and placed into shelters. Flood fighting efforts during other floods has prevented the damage from reoccurring. High flows that overtop existing river bank results in flooding into the apartment buildings.	Riviera Apartments Setback Levee: Construct a setback levee that is FEMA certified to protect buildings. Alternatively the building can be elevated or bought out. If the site is redeveloped in the future, the possibility exists to get the redevelopment project to construct building at an elevation that prevents them from flooding (1-ft above 100-yr base flood elevation – Renton Standard).The project would prevent damage to private buildings and prevent damages from re-occurring, which impacts the residents of the apartment units. Habitat improvement could be also incorporated into the project if FEMA levee certification requirements could be also achieved and maintained.
6.50	7.3	R	Brassfield Revetment: Revetments currently constrain both sides of the river in much of this segment, creating high velocities and elevated flood levels. As a result, the flood protection facilities are highly susceptible to erosion and scour. On the right bank, the Brassfield Revetment armors the bank against undercutting to protect a row of homes located just along the top-of-bank, and Jones Road behind them. The banks throughout this area are over steepened, and the flood protection facilities are a major encroachment into the river channel, leading to increased velocities, reduced instream habitat, and inadequate riparian buffer. This flood protection facility has experienced significant damages in recent floods, and while repaired, remains vulnerable. (Cedar River, Unincorporated).	One possible flood solution could involve exploring possible flood buyouts and levee setback opportunities to reduce damages to the flood protection facility and adjacent homes, lower flood elevations and velocities through the reach, and improve riparian habitat conditions. Buyout of the flood-prone Riverbend Mobile Home Park, located behind a revetment on the opposite bank, is recommended in the Action Plan. Implementation of that project would reduce, but not eliminate, risk of damage to this facility. (Cedar River, Unincorporated)
			Riverbend Lower Revetment (Cavanaugh): Revetments currently constrain both sides of the river in much of this segment, creating high velocities and elevated flood levels. As a result, the flood protection facilities are highly susceptible to erosion and scour. The downstream extension of the Riverbend revetment protects the ecologically-significant Cavanaugh Pond from regular overtopping and channel migration, but this armoring may interfere with beneficial ecosystem processes. The banks throughout this area are over steepened, and the flood protection facilities are a major encroachment into the river channel, leading to increased velocities, reduced instream habitat, and inadequate riparian buffer. (Cedar River, Unincorporated)	Explore the possibility of lowering flood elevations and velocities and increasing overbank conveyance by removal or setback of the levee/revetment that currently separates Cavanaugh Pond from the mainstem river. (Cedar River, Unincorporated)

CEDAR RIVER – LAKE WASHINGTON (WRIA 8)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
7.75	8.50	R	Cook-Jefferies Revetment (Horse Farm): The Cook-Jefferies Revetment extends along the entire right bank through this reach and is a constriction to flood conveyance and channel forming processes. Portions of the revetment were modified by an adjacent landowner. Large rounded rocks were placed on the banks and toe. This rock overlay is intact along some portions of the flood protection facility, but in others it is placed over scour and erosion damage. This modified reach is likely to be unstable and vulnerable during future flood events, but does not pose a direct risk to homes, or public safety. At the downstream end, a former oxbow, lined by mature cottonwood trees, is still present but disconnected from the river by the revetment, limiting the availability and quality of habitat. The Cook-Jeffries Revetment also forces flood flows toward two Cedar River Trail revetments on the opposite bank that protect the trail, the Maple Valley Highway, and portions of the regional park system. Lacking room for setback, these two trail revetments are over-steepened and highly susceptible to erosion and scour. . (Cedar River, Unincorporated)	Feasibility and technical analysis required.
8.50	9.40	R	Scott - Indian Grove Revetment (Big Bend): A number of homes on the right bank are located in an area of severe channel migration based on preliminary findings of the channel migration zone study currently underway. Toward the middle of this segment, several additional homes are behind the Scott Indian Grove Revetment. Most of these homes are on relatively high ground, and are not known to experience regular flooding. However, they are susceptible to undermining by channel migration or erosion. At the downstream end, there are no homes at risk, but the Scott-Indian Grove revetment constricts conveyance, deflects flows toward the Cedar River Trail flood protection facility, and prevents natural river processes and establishment of an adequate riparian buffer. (Cedar River, Unincorporated)	The homes are not known to experience regular flooding, but are susceptible to undermining by channel migration or erosion. One possible alternative to address the over-steepened banks should explore options for setting back the banks to increase conveyance, independently or in combination with possible flood buyouts from willing sellers in this neighborhood. (Cedar River, Unincorporated)

CEDAR RIVER – LAKE WASHINGTON (WRIA 8)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
9.35	9.8	L	Littlefield-Cummins (Cedar Mountain): This reach contains two left bank flood protection facilities and a bridge, and is underlain by one of the river's few areas of bedrock. Toward the upstream end, the Cummens levee provides limited reduction in overbank flooding at low to moderate flood events affecting one or two homes. The river is confined by bedrock on the opposite bank, making the flood protection facility a constriction to flood conveyance and channel process. Downstream, a gravel bar has formed riverward of the Littlefield revetment, making it obsolete. New abutments were installed along both banks for support of the reconstructed Jones Road Bridge. These are expected to provide substantial stability in this segment of the river, but a portion of the Cedar River Trail protection downstream from the abutment on the left bank may remain vulnerable to scour, erosion, or slumping. (Cedar River, Unincorporated)	One alternative solution through this area could involve exploring options for setting back the banks to increase conveyance, independently or in combination with possible flood buyouts. Depending on site-specific conditions, where acquisitions eliminate the risks to homes, the levees could be setback or removed. (Cedar River, Unincorporated)
10.65	11.0	L	WPA Levee: The WPA Levee reduces the risk of channel migration and provides a minimal level of protection from overbank flooding to two homes on the left bank which are located in the floodplain, floodway and what appears to be an area of severe channel migration based on preliminary findings of the channel migration zone study currently underway. The levee also constricts flow conveyance through this segment, which is area that has been largely set aside for restored natural river and floodplain processes. . The levee's bank armor also inhibits establishment of adequate stream buffer in the vicinity of some of the highest quality instream habitat in the lower Cedar River. (Cedar River, Unincorporated)	Acquisitions have been initiated in this reach by several habitat restoration partners, with the long term goal of setting back the banks to lower flood velocities and elevations, reconnect side channels and floodplain areas, and restore habitat. A continuation of the buyout program is a viable solution to the flood hazards for the two remaining homes in this area. Depending on site-specific conditions, where acquisitions eliminate the risks to homes, the levees could be setback or removed. (Cedar River, Unincorporated)
11.50	11.7	L	Cedar Grove Road: High velocity flows overtop the MacDonald levee on the left bank, threatening several homes and their sole access road. At the downstream end of this segment, Cedar Grove Road cuts across the flow path of heavy overbank flooding through this neighborhood. Portions of the roadway are on a raised prism, making it susceptible to damage and causing backwater effects through the neighborhood. Flows over the lowest section of the roadway drop off a steep shoulder grade at the downstream edge before re-entering the river, leading to road washouts and closure of a major transportation connection. (Cedar River, Unincorporated)	A solution to this flood problem is likely to involve purchase of repetitive loss properties as well as adjacent flood-prone homes and parcels. Opportunities could then be pursued to reconfigure or remove the levee to reduce channel confinement and reconnect flows in the river with the flows across the floodplain. Modification of Cedar Grove Road and the overbank flow path through the upstream neighborhood should be explored to address the backwater behind the road and allow overbank conveyance to re-enter the river. This could be evaluated as a possible solution in the Byers Bend Flood Hazard Mitigation Analysis. (Cedar River, Unincorporated)

CEDAR RIVER – LAKE WASHINGTON (WRIA 8)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
			Taylor Creek Confluence: At high flow events, Taylor Creek backwaters from its confluence with the Cedar River, flowing across public and private properties and the privately maintained sole access road tot eh neighborhood, often damaging the road and cutting off ingress and egress to the neighborhood.	Feasibility and technical analysis required.
13.7	14.0	R	Getchman Levee: Maxwell Road and the homes behind the Getchman Levee are at susceptible to regular overtopping of flood flows and channel migration hazards. Several of the most severely flood-prone homes have already been acquired. Levees on both banks through this reach constrict flood flows, and cut-of the river from its historic floodplain. (Cedar River, Unincorporated)	Feasibility and technical analysis required.
14.05	15.1	L, R	Royal Arch: At high flows the river engages with multiple side-channels through occupying the wide floodway and floodplain covering the right bank through this segment Numerous homes in this area were severely flooded and access was cut-off during the 2009 flood. King County coordinated with the City of Seattle to buyout several of these homes, but others remain at risk. In the middle and downstream portion of this reach the left bank is dominated by an active landslide that contributes a substantial amount of hillside material to the river. A major landslide from this steep slope could block all or portions of the river, placing the homes upstream and across the river at even greater risk from overbank flooding. A revetment lines the downstream –most portion of the left bank to direct the river beneath a bridge span. (Cedar River, Unincorporated)	Feasibility and technical analysis required. One option for directly reducing flood hazards is continued acquisition of flood-prone homes.
15.10	15.25	R	Bain Road Upper: This stretch located between the SR-169 and SR-18 bridges has been identified as repetitive loss for two of the three developed properties in this area, all of which are outside the floodway but within the floodplain. Constriction of flows caused by the embankments under the SR-18 bridge at the downstream end of this segment may contribute to the recurrent flood damage. (Cedar River, Unincorporated)	Feasibility and technical analysis required to determine whether home acquisitions or elevations are appropriate to mitigate the risks to these repetitive loss properties.

CEDAR RIVER – LAKE WASHINGTON (WRIA 8)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
15.8	15.9	R	Banchero Revetment: The Banchero Revetment is a rip-rap armored bank designed to reduce erosion and scour along an outside bend of the river in the vicinity of several homes. The flood protection facility does not prevent overtopping, but rather reduces the likelihood of channel migration that could cut off the sole access to the neighborhood or undermine the homes closest to the river. The close proximity of several of the homes to the river prevents establishment of a healthy riparian buffer. The flood protection facility is in an area of historic channel migration, and is repeatedly damaged – most recently during the 1995-96 and 2006 floods. Repairs were completed in 2008, but the bank remains vulnerable to ongoing future damage. (Cedar River, Unincorporated)	One alternative solution through this area could involve exploring options for purchase of flood prone homes. Depending on site-specific conditions, where acquisitions eliminate the risks to homes, existing levees could be setback, modified, or removed in order to reconnect areas of the floodplain with the river, improving conveyance as well as restoring off-channel habitat. Feasibility and technical analysis required. This area should be included in the Dorre Don Flood Hazard Mitigation Analysis.
15.9	16.3	L, R	Dorre Don Side Channel: This area contains relatively dense residential use in areas of deep and fast flow. Flows overtop both leveed and unleveed sections at moderate flood events. The area is typified by wide meander bends and active side channels, and is subject to severe channel migration and avulsion hazards, which can flood homes or cut-off access. (Cedar River, Unincorporated)	One alternative solution through this area could involve exploring options for purchase of flood prone homes. Depending on site-specific conditions, where acquisitions eliminate the risks to homes, existing levees could be setback, modified, or removed in order to reconnect areas of the floodplain with the river, improving conveyance as well as restoring off-channel habitat. Feasibility and technical analysis required. This area should be included in the Dorre Don Flood Hazard Mitigation Analysis.
16.3	17.00	R	Lower Dorre Don: The right bank through this area contains relatively dense residential use, almost entirely within the floodway or the area that appears to be the severe channel migration hazard area, based on preliminary findings of the channel migration zone study currently underway. The entire right bank is hardened by levees and revetments which prevent channel mobility and create an inadequate stream buffer. Flows overtop the banks at moderate flood events, sometimes transporting and depositing substantial amounts of large woody debris. Several homes have been elevated, possibly above the base flood elevation, reducing but not eliminating overall flood risk. However, these elevations do not reduce the risks from levee failures, debris build-up against the structures, or access cut-off due to fast and deep flows through the neighborhood. (Cedar River, Unincorporated)	One alternative solution through this area could involve exploring options for purchase of flood prone homes. Depending on site-specific conditions, where acquisitions eliminate the risks to homes, existing levees could be setback, modified, or removed in order to reconnect areas of the floodplain with the river, improving conveyance as well as restoring off-channel habitat. Feasibility and technical analysis required. This area should be included in the Dorre Don Flood Hazard Mitigation Analysis.

CEDAR RIVER – LAKE WASHINGTON (WRIA 8)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
17.00	17.60	R	Orchard Grove: A continuous line of homes along the right bank are located in severe flood hazard areas. These homes are subject to flooding due to both inundation and erosion. Along the upstream portion of this segment, all but a few of the homes are in the floodway, but the extent and frequency of overbank flooding has been reduced for relatively minor floods by the Orchard Grove Levee. However, this levee does not provide protection for higher flows, nor does it tie into high ground at its downstream terminus, so even the homes behind the levee remain susceptible to overtopping and backwater flooding. While the benefits are limited, the largely intact levee provides some benefit, and due to growth of riparian vegetation along the banks, the downstream end of the flood protection facility has started to accumulate a sand and gravel bar along the channel margin. This slows localized velocities, reducing risk of future scour or erosion along the bank. In the downstream portion of this segment, the homes are largely located outside the floodway, but remain in the floodplain as well as the area that appears to be the severe channel migration hazard area, based on preliminary findings of the channel migration zone study currently underway. These homes are at risk from both overbank flooding and back erosion. Fortunately, the sole access road for the entire area is just outside the boundaries of these severe flood hazards. (Cedar River, Unincorporated)	One alternative solution through this area could involve exploring options for purchase of flood prone homes. Depending on site-specific conditions, where acquisitions eliminate the risks to homes, existing levees could be setback, modified, or removed in order to reconnect areas of the floodplain with the river, improving conveyance as well as restoring off-channel habitat. Feasibility and technical analysis required.
17.60	17.85	L,R	Cedar Trail Bridge at Orchard Grove: Steep unstable slopes along the right bank have contributed to a somewhat dynamic channel in this reach, with active mid-channel gravel bar formations in several locations. On the right bank, a private road skirting the unstable hillside has experienced repeated damage due to landslide activity. Homes located on this road are at risk for loss of their sole access. The approach to the trail bridge remains forested and supports varied and beneficial habitat, but is at risk from erosion and scour which could undermine the bridge abutments. Collapse of the bridge would cause a major blockage in the river that could have devastating effects up and downstream. On the left bank, the revetment that protects the base of the bridge abutment was repaired following damages in the 2009 flood. (Cedar River, Unincorporated)	Feasibility and technical analysis required.

CEDAR RIVER – LAKE WASHINGTON (WRIA 8)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
18.50	20.10	L, R	Arcadia-Noble: Homes on both banks of the river are located in the area that appears to be the severe channel migration hazard area, the floodway, or both. Mid-reach, the Arcadia Revetment runs along a number of homes, including one repetitive loss property, reducing flood risk due to channel migration and inundation during moderate flows. However, the flood protection facility does not provide containment or 100-year protection. This reach of the river also contains numerous landslide-prone hillsides. One slide site, at the apex of a tight meander bend, contributes an estimated 1600 cubic feet of material annually. Several other slide areas are evident through the reach, any of which could cause a blockage of the river. The riparian buffer is absent or disconnected from the river along the length of the levee alignment. (Cedar River, Unincorporated)	Feasibility and technical analysis required.
20.10	20.35	L, R	Below Landsburg: Two revetments are located along undeveloped portions of the river on publicly owned lands. These flood protection facilities were probably originally constructed to prevent channel migration or avulsion that might adversely affect the railroad, now the Cedar River Trail. The condition of these revetments is unknown largely because there are no structures other than the trail itself at risk in the vicinity, and because the adjacent lands are largely forested, providing limited access to them. The revetments, in combination with the trail, limit conveyance and storage as well as off channel habitat and natural river processes. (Cedar River, Unincorporated)	Feasibility and technical analysis required.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
5.2	5.98	L	Boeing Oxbow: The Boeing employee parking lot, recreational center, and trail sit at edge of a steep, eroding bank. Partial rip-rap repairs, older debris (car chassis), and slumps are present. Vegetation is sparse, non-native, and inadequate to stabilize slopes. Revetment toe is founded on deep, soft mud deposits, which are also subject to shifting, slumping, and erosion, with little large woody debris structure present. Buffer width is uniformly inadequate	Duwamish Revetment Setbacks and Shallow Water Habitat Creation: Revetment setbacks, bank restoration, and shallow water habitat creation. Rehabilitate steep, older, deteriorating revetments, establish stable slopes, restore native vegetation, and provide opportunity for shallow water habitat creation. Channel edge habitat creation will include reconstruction and stabilization of substandard toe buttress structures serving existing maintained facilities (Green River, Cities of Tukwila and Seattle)
5.98	6.11	L	Postal Service: Partially treed slopes border narrow ledge of salt-tolerant sedges and mud deposits along the aquatic edge. Debris (decaying catamaran) is present. Slopes are steep; buffer width is inadequate in places.	Duwamish Revetment Setbacks and Shallow Water Habitat Creation: Revetment setbacks, bank restoration, and shallow water habitat creation. Rehabilitate steep, older, deteriorating revetments, establish stable slopes, restore native vegetation, and provide opportunity for shallow water habitat creation. Channel edge habitat creation will include reconstruction and stabilization of substandard toe buttress structures serving existing maintained facilities (Green River, Cities of Tukwila and Seattle)
6.11	6.21	L	City Light/Postal Parking: Steep, older rip rap flood protection facility (City Light) borders edge of deep pool formed D/S of North Winds' Weir. Toe slope is unstable; slope is too steep, invasive vegetation is present, parking lot crowds inadequate buffer width.	Duwamish Revetment Setbacks and Shallow Water Habitat Creation: Revetment setbacks, bank restoration, and shallow water habitat creation. Rehabilitate steep, older, deteriorating revetments, establish stable slopes, restore native vegetation, and provide opportunity for shallow water habitat creation. Channel edge habitat creation will include reconstruction and stabilization of substandard toe buttress structures serving existing maintained facilities (Green River, Cities of Tukwila and Seattle)
6.21	6.28	L	Cecil Moses Park: Steep, older revetment with invasive vegetation and some tree cover borders rock outcropping at North Winds' Weir. Park include constructed off-channel connection to river, but only connects at high flows or high tides. Lower slopes are slumping and eroding, toe structure appears inadequate.	Duwamish Revetment Setbacks and Shallow Water Habitat Creation: Revetment setbacks, bank restoration, and shallow water habitat creation. Rehabilitate steep, older, deteriorating revetments, establish stable slopes, restore native vegetation, and provide opportunity for shallow water habitat creation. Channel edge habitat creation will include reconstruction and stabilization of substandard toe buttress structures serving existing maintained facilities (Green River, Cities of Tukwila and Seattle)

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
6.28	6.29	L	Rubber Tire Revetment: Steep, bizarre rubber tire pile covers the riverbank at a City of Seattle waterline crossing location.	Duwamish Revetment Setbacks and Shallow Water Habitat Creation: Revetment setbacks, bank restoration, and shallow water habitat creation. Rehabilitate steep, older, deteriorating revetments, establish stable slopes, restore native vegetation, and provide opportunity for shallow water habitat creation. Channel edge habitat creation will include reconstruction and stabilization of substandard toe buttress structures serving existing maintained facilities. Concrete restraining structure at pipeline location would require relocation to allow slopes to be reconstructed in a stable and environmentally responsible manner. (Green River, Cities of Tukwila and Seattle)
6.29	6.55	L	SR-599 embankment: Steep, unstable rip-rap slope covers riverbank along shoulder of SR-599. Minor amounts of invasive vegetation are present. Soft mud deposits along the toe slope are apparently restrained by the remnants of a series of old wooden pilings. Overall slope integrity is suspect. Road embankment may be at risk of failing.	Perform soil investigations and embankment survey to define physical and structural parameters. Evaluate road stability with geotechnical study. Define slope stability and structural needs. Acquire any lands needed. Reconstruct toe and slope to stable configuration with fully bioengineered solution, preferably including a vegetated midslope bench. Setback and reconstruct roadway as needed.
6.55	6.84	L	Gateway North (Lowest): Bank has been reconstructed with a midslope bench supporting a City of Tukwila Trail. Slumping of the lower embankment indicates that initial efforts to secure the integrity of this inter-tidal feature as toe support to the slope may not have been adequate. A slump has also developed at the upstream end of this reach, near a culvert outfall. Slopes supporting the trail at this location have been compromised.	Duwamish Revetment Setbacks and Shallow Water Habitat Creation: Revetment setbacks, bank restoration, and shallow water habitat creation. Rehabilitate steep, older, deteriorating revetments, establish stable slopes, restore native vegetation, and provide opportunity for shallow water habitat creation. Channel edge habitat creation will include reconstruction and stabilization of substandard toe buttress structures serving existing maintained facilities.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
6.84	7.5	L	Interurban South/Residential: Steep, generally poorly vegetated slopes adjoin houses and back yards, are slumping in places, and include a number of bank modifications such as boat haul-outs, rubber tire revetments, rip-rap placement by end-dumping over the slope, and other homeowner modifications. Toe slopes are founded in soft mud with natural imbedded large woody debris. Some native species are present. Generally these embankments support the back yards, some houses that are built very close to the edge of the embankment, and associated outbuildings, all of which remain at moderate risk of slope failures.	Acquire at-risk properties as market conditions and funding allow. Restore aquatic edge, inter-tidal, and riparian habitat over time.
7.88	8.8	L	Codiga Left /Gateway Lower & Upper /Seattle-LA Freight: The Tukwila Trail system sits immediately next to the top-of-bank, adjoining parking lots and commercial properties. The bank is steep, covered with some rip-rap in places, especially near the upstream end, and slumping in several places, especially near the downstream end, where rip-rap is largely absent. A pronounced slump is present at RM 7.95. Local bank failure has also affected the trail where it crosses a pumped storm outfall system at RM 8.5.	Perform soil investigations and embankment survey to define physical and structural parameters. Evaluate trail stability with geotechnical study. Determine design flood and freeboard elevations. Define slope stability and structural needs. Acquire any lands needed. Reconstruct toe and slope to stable configuration with fully bioengineered solution, preferably including a vegetated midslope bench. Evaluate the use of driven untreated wooden pilings to reinforce and stabilize the toe of slope within the soft sediments present. Setback and reconstruct trail as needed.
8.88	9.28	L	I-5 /Interurban Ave. S: The I-5 freeway, the adjoining Tukwila Trail, a warehouse and parking lot, and Interurban Avenue crowd a narrow buffer, which is completely absent in some locations. Next to the warehouse, the river bank is occupied by a vertical steel sheetpile wall, which replaced an earlier, failing log crib-wall. Steep rip-rap slopes abut Interurban Avenue So. Slopes are steep, prone to slumping, poorly vegetated, and founded on questionable toe structures along a truncated outer bend. (Green River, City of Tukwila)	Perform soil investigations and embankment surveys to define physical and structural parameters. Evaluate road, trail and bank stability with geotechnical study. Define slope stability and structural needs. Acquire any lands needed, including the warehouse and parking lot, as market conditions and funding permit. Reconstruct toe and slope to stable configuration with fully bioengineered solution, preferably including a vegetated midslope bench. Setback and reconstruct trail and roadway as needed.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
9.28	10.45	L	Foster Golf Course (Foster Lower, Middle, Upper and Right): Much of the golf course is mapped within the 100-year floodplain, which extends to Interurban Avenue to the west, and to and several commercial properties upstream as well. Portions of the site have been identified for placement of piling-anchored logs and plantings as mitigation for clearing of trees and other native vegetation from levee slopes elsewhere in Tukwila, as part of eligibility and compliance with the Corps of Engineers PL-99 Levee Rehabilitation and Inspection Program.(Green River, City of Tukwila)	Develop a plan for stabilizing the riverbanks along the margins of the golf course in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Reconstruct toe and slope to stable configuration with fully bioengineered solution preferably including a vegetated midslope bench, preferably including a vegetated midslope bench.. Reconfigure tees, fairways, and greens along channel margins as needed. Establish uniform riparian buffer with native vegetation.
10.45	10.54	L	Riverside Inn /Candy Factory /Casinos: Slopes are steep, toe structure is questionable, buffer widths are narrow to absent, vegetation is discontinuous and poorly established in places, and poorly maintained overall. Commercial buildings and parking areas in this reach are mapped within the 100-year floodplain, extending throughout this reach and westward to Interurban Avenue. .. (Green River, City of Tukwila)	The desirability and feasibility of siting flood containment structures in this reach should be investigated with a feasibility study. Define extents of raised flood containment structures needed, together with any interior drainage controls indicated. Survey and geotechnical evaluation of the river embankment should be performed as an initial step, and a plan for stabilizing the riverbanks defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Evaluate bank stability with geotechnical study. Determine design flood and freeboard elevations. Define slope stability and structural needs. Acquire needed properties and easements as needed, and as market conditions and funding may allow. Reconstruct toe and slope to stable configuration with fully bioengineered solution, preferably including a vegetated midslope bench. Establish uniform riparian buffer with native vegetation.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
10.54	10.99	L	Tukwila Trail: The lower end of the Tukwila Trail is setback from the river along a stormwater swale occupying a midslope bench with a row of mature cottonwoods along the riverbank. The trail more closely abuts the bank in upstream areas, and previous slumping is present right up to the trail edge in at least one location. Cottonwoods are also present near the upstream terminus by the bridge, as well. The bank is generally steep, but some naturally occurring large woody debris is present near the downstream end, and vegetation is surprisingly dense in several locations. Areas landward from the trail are mapped within the 100-year floodplain. (Green River, City of Tukwila)	Survey and geotechnical evaluation of the river embankment should be performed as an initial step, and a plan for stabilizing the riverbanks defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Evaluate bank stability with geotechnical study. Determine design flood and freeboard elevations. Define slope stability and structural needs. Acquire needed properties and easements as needed, and as market conditions and funding may allow. Reconstruct toe and slope to stable configuration with fully bioengineered solution, preferably including a vegetated midslope bench. Establish uniform riparian buffer with native vegetation. Reconstruct and raise the trail for flood containment as determined.
12.3	12.41	L	White Swan Left: Varied levels of native and invasive vegetation cover a very steep, locally eroding and slumping slope along the edge of a paved trail. A high pressure waterline is also present in or near the trail. A previous repair of a slope washout due to earthquake-induced waterline failure is present near the downstream end, with native willow layers and other plantings placed in live geogrid layers. Toe structure remains questionable. (Green River, City of Tukwila)	To the extent that embankment stability or structural support to the trail may be desired, here, survey and geotechnical evaluation of the river embankment should be performed as an initial step, and a plan for stabilizing the riverbank defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Evaluate bank stability with geotechnical study. Determine design flood and freeboard elevations. Define slope stability and structural needs. Acquire easements as needed. Reconstruct toe and slope to stable configuration with fully bioengineered solution, preferably including a vegetated midslope bench. Establish uniform riparian buffer with native vegetation. Reconstruct trail as determined.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
12.44	12.5	L	Tukwila 205 Levee Terminus: A paved asphalt trail ramping down to pass underneath I-405abuts a vertical concrete retaining wall along the riverward margins of the 66th Avenue S. abutment. Banks are steep, riverward margins of the trail show settlement and cracking. Toe support to the riverbank is questionable. A 90" iron flapgate at the confluence of Gilliam Creek, at the upstream end, has previously stuck open due to entrainment of large woody debris from upstream. The inlet to this outfall pipe is not screened to prevent debris accumulations, the flapgate impairs fish passage, and there is no backup closure device present. Local interior flooding occasionally needs to be pumped out of street manholes into the river during high water events.	Survey and geotechnical evaluation of the river embankment should be performed as an initial step, and a plan for stabilizing the riverbanks defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties and easements as needed, and as conditions and funding may allow. Reconstruct toe and slope to stable configuration with fully bioengineered solution, preferably including a vegetated midslope bench.. Establish uniform riparian buffer with native vegetation. Replace flood closure structure with fish passable device. Install backup flood closure device. Install trash rack at outfall culvert inlet end.
12.5	12.6	L	Tukwila 205 / Levee Christensen Park: A small mowed park with tables, non-native landscaping, and a parking area extends from Christensen Road to the top of the steeply vegetated riverbank. The overall structural integrity of the slope is undetermined. The presence of an adequate rock toe structure is also undetermined.	Survey and geotechnical evaluation of the river embankment should be performed as an initial step, and a plan for stabilizing the riverbanks defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties and easements as needed, and as conditions and funding may allow. Reconstruct toe and slope to stable configuration with fully bioengineered solution, preferably including a vegetated midslope bench. Reconstruct trail and raised levee crest as defined.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
12.6	12.65	L	Tukwila 205 /Christensen Road: Toe structure remains questionable. The margins of the road are supported on the riverbank with rock-filled gabion wire baskets. Local settling is present, as evidenced by separation along the adjoining sidewalk and curbing .	Survey and geotechnical evaluation of the river embankment should be performed as an initial step toward slope and roadway stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration Perform soil investigations and embankment surveys to define physical and structural parameters. Evaluate bank stability with geotechnical study. Determine design flood and freeboard elevations. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and roadway to stable configuration with fully bioengineered solution, preferably including a vegetated midslope bench. Establish uniform riparian buffer with native vegetation.
12.65	12.8	L	Tukwila 205 /Van Warden Park: The levee crest is narrow, and side slopes are steep in places. A paved trail is also present. Since this segment is located on an inside bend, erosion along the toe is not likely. That said, the nature of any toe buttress or other supporting structure has not been confirmed. Various restoration actions have been proposed at this site.	Continue to explore floodplain restoration opportunities riverward of the levee.
12.8	12.84	L	Tukwila 205 /Van Warden: A paved trail sits on the narrow levee crest at the edge of a relatively steep river bank slope. Toe structure is questionable. It is likely the riverward embankment slopes are marginally stable at best. Vegetation consists of invasive blackberries and reed canarygrass, while occasional native tree species naturally established over the past 18 years were cut to the ground in 2006. Existing commercial office buildings closely border the landward margins of the trail, substantially at grade with the levee crest elevation., to a few deciduous trees and mixed native and invasive shrubs, to a recently constructed stormwater outfall near Strander Bridge, which is stabilized with willow cuttings and other native plantings in live geogrid layers. Two pieces of installed large woody debris are imbedded into the bankline, right at the outfall. The levee and trail abut closely placed commercial and office buildings and parking areas, with no buffer present)	Riverward embankment slopes here should be carefully monitored. Survey and geotechnical evaluation of the river bank should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest and trail to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
12.84	12.85	L	Tukwila 205 /Van Warden/Pipeline Crossing Location: A gas pipeline crossing under the river and through the levee embankment was completed just prior to 1990 at this location. The open trench through the levee was stabilized against surface erosion with placement of light rip-rap and quarry spalls cover, joint planted with willow stakes. .A drainage swale is present at the landward margins of the levee. Recently the City of Tukwila has proposed a pedestrian bridge crossing structure here.	Riverward embankment slopes here should be carefully monitored. Survey and geotechnical evaluation of the river bank should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest and trail to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation. Ensure through adequate design, engineering, and permitting review that any proposed bridge structure preserves adequate flood patrol and maintenance equipment access, together with provisions to ensure implementation of any levee modifications indicated by the outcome of the structural and geotechnical evaluation described above.
12.85	12.99	L	Tukwila 205 /Van Warden: The levee is located at the crest of an extremely steep segment of river bank along an outside bend. Older rip-rap is visible along the toe and in lower portions of the slope, while minor sediment deposits and overgrowth of blackberries and reed canarygrass obscure direct observation of the rip-rap that is likely also present in mid-slope areas. Some minor sloughing of these deposits is visible in places. The character and extent of any toe buttress structure is in question. The levee crest is located essentially at grade with adjoining property elevations, and the landward margins of the levee and trail are closely encroached with existing commercial office buildings and associated landscaping.	Riverward embankment slopes here should be carefully monitored. Survey and geotechnical evaluation of the river bank should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest and trail to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
12.99	13.02	L	Tukwila 205 / Strander Park: The levee here passes through a small City of Tukwila municipal park. The levee crest supports a narrow portion of the paved trail, about 12 feet wide, and the levee itself is raised above adjoining grades about 3 to 4 feet with interlocking vertical masonry units, originally designed to avoid large trees, one of which has subsequently been removed. Riverward slopes are moderate with some midslope sediment deposits and associated minor slumping of these deposits in places. Toe structure is unconfirmed.	Riverward embankment slopes here should be carefully monitored. To the extent that slope settlement and deterioration of Survey and geotechnical evaluation of the river bank should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest and trail to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation.
13.02	13.04	L	Tukwila 205 / Strander Pump Outfall: The levee here is penetrated by an outfall pipe serving a pump station located within the small City of Tukwila municipal park at this location. The outfall invert is located just above the OHWM, and daylights over the original rock toe structure. The outfall pipe was placed in a trench excavated through the levee prism, then backfilled and compacted by City of Tukwila contractors. King County reconstructed the embankment slope at the outfall location with live geogrid structures consisting of native plantings and willow cuttings placed in layers between compacted lifts of coarse gravel fill materials wrapped with coir fabric. Since the toe rock was not reconstructed, and the bioengineered slope reconstruction may have been compromised by the repeated mowing, the overall slope needs to be carefully monitored for any signs of distress.	Riverward embankment slopes here should be carefully monitored. Survey and geotechnical evaluation of the river bank should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest and trail to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
13.05	13.11	L	Tukwila 205 / Christensen Road: The levee crest sits only a few feet above the landward grades here, and is bordered on the landward side by parking and access areas serving commercial offices, with a moderately vegetated area between the asphalt and the levee. Riverward slopes are moderate with some midslope sediment deposits and associated minor slumping of these deposits in places Toe structure is unconfirmed. A gasline crossing, a waterline crossing, and at least one storm outfall penetrate the levee.	Riverward embankment slopes here should be carefully monitored. Survey and geotechnical evaluation of the river bank should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest and trail to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation.
13.11	13.20	L	Tukwila 205 / Christensen Road: The riverward levee embankment supports a narrow midslope bench, which nonetheless supports several mature cottonwood trees in a small grove. The riverward edge of the bench falls away steeply to the river along the downstream portions of an inner bend, with shallow sediment deposits just below the OHWM along the bank and extending into the channel. Some naturally occurring wood structure is visible in this sediment bar feature here. Toe structure remains unconfirmed.	Riverward embankment slopes here should be carefully monitored. Survey and geotechnical evaluation of the river bank should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest and trail to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
13.20	13.30	L	Tukwila 205 /Christensen Road: The levee here is locally very steep, and overall toe structure is highly questionable. Lower slopes are dominated by reed canarygrass and blackberries, with some localized minor sediment deposits in midslope areas. Toe rock is visible in some areas, but appears to have locally eroded or settled into the channel to some extent.	Riverward embankment slopes here should be carefully monitored. Survey and geotechnical evaluation of the river bank should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest and trail to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation.
13.3	13.34	L	Tukwila 205 / Christensen Road: The levee crest elevation is several feet above the adjoining landward areas. This elevation difference is especially pronounced at the excavated ditch that extends perpendicularly to the levee along the Union Pacific Railroad from the bridge at the upstream end of this segment. Apparent seepage has previously been observed within this ditch by flood patrols during prolonged high flows in the Green River. The riverward slope includes a narrow, mowed "bench" area, with actual park benches and a few small non-native tree plantings. Lower levee slopes fall steeply from this bench to the channel, with some toe rock visible at low flows.	Riverward embankment slopes here should be carefully monitored. Survey and geotechnical evaluation of the river bank should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest and trail to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
13.35	13.41	L	Tukwila 205 / Christensen Road: The landward edge of the levee is constructed as a vertical rock wall, nearly ten feet in height, to accommodate a parking lot and access for a commercial warehouse. The levee does have some modest width here to offset the clear seepage potential this presents, and in fact seepage has not been observed during flood patrols. The riverward portions of the slope drops rather steeply from the bench to the OHWM. The nature of the toe and the extent of any rock toe buttress is unconfirmed.	Both landward and riverward embankment slopes here should be carefully monitored. Survey and geotechnical evaluation of the river bank should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the landward slopes or riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest and trail to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation.
13.41	13.6	L	Tukwila 205 / Christensen Road: Landward levee slopes adjoin asphalt access and parking for several commercial structures, and support non-native, sparsely spaced "landscaping" trees. Some of these have been cut in 2006 and 2009 to comply with Corps directives. Levee crest elevations rise some six to eight feet above landward grades. The riverward slope in this reach occupies the outside margins of a sweeping bend; slopes are significantly steep here. Rock armor is visible in places along the lower slopes and at the toe, and shows some evidence of minor erosion and settlement in places. Minor sediment deposits occur in places along the midslope, and show occasional slumping.	Riverward embankment slopes here should be carefully monitored. Survey and geotechnical evaluation of the river bank should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest and trail to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
13.6	13.68	L	Tukwila 205 / Tukwila Maintenance Shops: The levee crest is widened here to support access from the adjoining Tukwila Maintenance Shops. Landward slopes and elevation differences between the levee crest and adjoining ground are less pronounced than just downstream. A modest midslope "bench" is present on the riverward slopes. Lower embankment slopes fall steeply from the riverward margins of this bench and support a mixture of native and non-native vegetation. Sediment deposits are present in midslope areas, and are visible at low-water along the toe. Any rock toe buttress structure here is largely obscured by these sediments, and therefore remains generally unconfirmed.	Riverward embankment slopes here should be carefully monitored. Survey and geotechnical evaluation of the river bank should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest and trail to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation.
13.68	13.75	L	Tukwila 205 / P-17 Pump Station: The landward margins of this segment are occupied by the County-maintained P-17 Pump Station and slope down to the storage forebay pond serving the Southcenter area. The outfall from the pump station passes through the levee, and sits in a narrow opening maintained for this purpose in the middle of a bench formed from depositional sediments. Riverward slopes are dominated by these sediment deposits, which are overgrown with reed canarygrass and blackberries throughout. Visual confirmation of toe buttress structure cannot be confirmed.	Riverward embankment slopes here should be carefully monitored. Survey and geotechnical evaluation of the river bank should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest and trail to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
13.75	13.95	L	Tukwila 205 / P-17 Pond: Landward levee slopes descend at a moderate angle to the P-17 storage pond. The pond is essentially an urban wetland with a surrounding stand of native riparian forest cover, except on the levee slopes themselves. Riverward levee slopes are steep at the upper end, then transition to the depositional bench which continues downstream. Midslope sediment deposits exhibit minor slumping in places. Toe rock is present but shows some indications of erosion and settlement in places, and its overall extent and character is difficult to determine.	Riverward embankment slopes here should be carefully monitored. Survey and geotechnical evaluation of the river bank should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest and trail to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation.
13.95	14.1	L	Tukwila 205 / Costco Segment: The levee crest is from 8 to 10 feet above the adjoining grade, which supports a parking lot and access for the Costco warehouse store here. Landward levee slopes are relatively gentle, and are covered with ivy, pruned shrubs, and non-native shade trees. Riverward slopes occupy a curving outer bend and are extremely steep. Some minor midslope sediment deposits are present, and show signs of minor slumping in places. Toe rock is exposed at low flows, and shows signs of erosion and settlement in many places.	Riverward embankment slopes here should be carefully monitored. Survey and geotechnical evaluation of the river bank should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest and trail to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
14.1	14.16	L	Tukwila 205 / Christensen Road: . Riverward slopes support a narrow midslope "bench" of sediment deposits, which is mowed and managed in a "park-like" setting. Riverward levee slopes are steep at the upper end, then transition to the depositional bench which continues downstream. Midslope sediment deposits exhibit minor slumping in places. Toe rock is present but shows some indications of erosion and settlement in places, and its overall extent and character is difficult to determine.	Riverward embankment slopes here should be carefully monitored. To the extent that slope settlement and deterioration of the levee embankment may become more problematic with time, survey and geotechnical evaluation of the river bank should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest and trail to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation.
14.16	14.26	L	Tukwila 205 / Home Depot: The levee crest elevation here is from 8 to 10 feet above adjoining grades. Landward slopes are moderately steep and adjoin an access roadway next to the Home Depot warehouse store. Landward slopes support dense non-native landscaping shrubs and smaller trees. Riverward slopes have previously been reconstructed, both by King County and by the Corps, following episodes of pronounced slumping involving the entirety of the slope, extending to the levee crest. Repairs have been constrained by the steep slopes present, and have involved the construction of large rock toe buttress structures, incorporating only a few log elements, and bioengineered slope stabilization measures using layers of native willow cuttings. Previously these plantings have thrived; in 2006 and 2009 they have been extensively "thinned" into sparsely spaced clumps pursuant to Corps' directives.	Monitor and maintain as required. Retain lower slope structures and incorporate upper slopes into any reach-length levee setback reconstruction efforts that may be necessary for stable long-term flood protection in the reach, including consideration of revised 500-year flood elevations forthcoming from current Corps' investigations.

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GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
14.26	14.31	L	Tukwila 205 / S. 180th Street Bridge Trail Ramp North: The levee crest is set back here to tie into the Strander bridge abutments, adjoining a parking lot for trail users. The riverward slopes are moderate here and support a ramp for the trail to pass underneath the bridge. Riverward margins of the slope are subject to repeated episodes of sediment deposition and slumping. Due to the pervasive sediments present, toe structure cannot be confirmed.	Monitor and maintain as required. In particular, eradication of knotweed stands and replacement with native vegetation would be a good idea.
14.32	14.35	L	Tukwila 205 / S. 180th Street Bridge Trail Ramp South: The levee here consists of a vertical concrete wall adjoining the landward edge of the trail ramp descending beneath the bridge. A steeply inclined earthen berm is present along the landward side of the wall, next to a parking lot and access for the adjoining commercial structure.	The transitions here from an earthen levee to a concrete wall with a steep earthen backslope, both tied-in to the bridge abutments and approach fills, will require special attention during and following flood events. In the event that more reach-long levee reconstruction efforts may be undertaken here in the future, this feature should be considered for re-design and reconstruction as well, preferably with the same gentle slopes as immediately downstream.
14.35	14.55	L	Tukwila 205 / Lily Pointe:. Unstable levee slopes were reconstructed here by the Corps of Engineers in 2008, in a setback configuration facilitated by Tukwila and utilizing property acquisitions funded by the King County Flood Control District. This reconstruction involved the placement of a series of instream, rock-anchored logs along the toe, the construction of a large launchable rock toe at the margins of the summer low-flow channel, the construction of a rock-armored slope, and revegetation of all exposed rock armor and launchable toe structure areas. The future of this vegetation remains in some question with respect to current Corps clearing directives.	Monitor and maintain as needed. Some minor adjustment of several rock-anchored logs may be needed in the near future.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
14.55	14.76	L	Tukwila 205 / Ratolo: The levee crest elevation here is from 3 to 8 feet above the adjoining landward parking lots and access grades. Significant cracking and settlement of the levee crest trail and landward parking lot grades has previously been observed near River Mile 14.74. Riverward slopes are extremely steep. Rock armor is visible along the toe and lower slope areas during low-water conditions, and shows signs of erosion and settlement in places. Midslope areas support minor sediment deposits, which are subject to minor localized slumping.	Riverward embankment slopes here should be carefully monitored. To the extent that slope settlement and deterioration of the levee embankment may become more problematic with time, survey and geotechnical evaluation of the river bank should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest and trail to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation.
14.76	14.9	L	Tukwila 205 / Ratolo / So. 180th Street Wall: The levee crest trail here sits about 9 feet above the adjoining South 180th Street roadway. The landward edge of the levee consists of a vertical concrete wall adjoining the edge of the road. The landward margins of the levee crest trail are provided with a safety fence. Riverward slopes drop very steeply from the edge of the trail. Rock armor is visible along the toe and lower slope areas during low-water conditions, and shows signs of erosion and settlement in places. Midslope areas support minor sediment deposits, which are subject to minor localized slumping.	Riverward embankment slopes here should be carefully monitored. To the extent that slope settlement and deterioration of the levee embankment may become more problematic with time, survey and geotechnical evaluation of the river bank should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest and trail to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
14.9	15.09	L	Tukwila 205 / Segale Floodwall: The levee crest here is located at an elevation about 10 to 11 feet above the adjoining asphalt parking lot. The landward margins of the levee crest access roadway are provided with a safety fence. The landward levee edge consists of a vertical concrete floodwall, set on a spread footing. This levee segment was reconstructed in a setback configuration by the Corps of Engineers in 2008. Portion of the segment were provided with placement of instream logs anchored with rocks along the toe. A large emplacement of launchable toe rock was constructed at the margins of the summer low-flow channel, incorporating one to two layers of native willow cuttings. Levee slopes were also armored with rock. The launchable toe structure was subsequently planted with native vegetation. The treatment of this vegetation remains in some question as it matures, due to current Corps directives regarding clearing.	Monitor and maintain as needed. Special attention should be directed to the area along the toe of the concrete floodwall, as the reach upstream has experienced repeated seepage-related stability problems.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
15.09	15.36	L	Tukwila 205 / Segale Repair Segment Landward portions of the levee in this reach have all experienced extensive, seepage-related stability problems during flood events, with a series of repairs made to address these as follows; seepage and piping of the landward levee toe were experienced in1983 and 1984, and were repaired with a filter blanket installed along the base of the slope. Ground heaving, liquefaction, and sand boils were experienced in 1990 and addressed by construction of an emergency landward toe drain trench and a raised landward buttress structure. Additional sand boils and liquefaction of landward levee slopes were experienced at the upstream end of this reach in 1996, and were addressed by an extension of these measures. The central portion of this segment was rebuilt with drilling of a series of relief wells connected to a drainage manifold and discharging to a large concrete vault, to be pumped to the river through the crest of the levee freeboard by an automated system. And finally, the landowner raised the upstream portions of the landward grades adjacent to the levee with fills, effectively providing a counterweight to potential heaving of previously excavated areas. All landward areas are routinely treated with herbicides by the landowner, and are barren. Riverward slopes are steep, and not quite even 2H:1V in inclination. These have experienced repeated instability and have been repaired in 1991 by the Corps, and in 1995 and 2003 by King County. Corps repairs included extensive slope excavation and rock placement. County repairs provided a rock toe buttress and bioengineered slope reconstruction, with rock-anchored logs along the toe in two locations. All bioengineered slope areas established robust growth of native plant species, which were extensively "thinned" into sparsely scattered clumps by Tukwila pursuant to Corps directives in 2010, which cost was then reimbursed by the King County Flood Control District.	Riverward embankment slopes here should be carefully monitored. To the extent that slope settlement and deterioration of the levee embankment may become more problematic with time, survey and geotechnical evaluation of the river bank should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
15.36	15.51	L	Tukwila 205 / Segale Headquarters Bend: This segment of the levee occupies an inside bend. Grades landward of the levee have been raised with fill and range from 1 to 4 feet below the levee crest elevation. Landward areas include a planted "landscaping" strip with small non-native trees. Riverward levee slopes are moderately steep, and covered generally with sediment deposits, These form a poorly defined, irregular bench of sorts, which drops off steeply in its lower margins to the low-flow channel. The sediment deposits here are barren except for reed canarygrass and blackberries, which are mowed at intervals. Some rock is visible along the toe at low water, but is somewhat obscured by the sediments present.	Riverward embankment slopes here should be carefully monitored. To the extent that slope settlement and deterioration of the levee embankment may become more problematic with time, survey and geotechnical evaluation of the river bank should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation.
15.51	15.75	L	Tukwila 205 / Segale Headquarters: The levee crest here varies from one to three feet above adjoining grades, and abuts a truck loading access area behind a commercial building. Upstream portions of the levee support a chain-link fence placed along the landward margins of the levee crest, hindering access and use by maintenance vehicles and equipment. A sparse row of smaller non-native trees is present along the landward edge of the levee in its downstream portions. Riverward slopes are extremely steep, and have been surveyed at up to 1.4H:1V. Some rock is visible along the levee toe and the lower embankment slopes at low water, but shows signs of erosion and settlement. Minor sediment deposits are present in midslope areas, with slumps visible from time to time. Only an occasional native tree has ever established in this reach, but these few have been removed pursuant to Corps directives. The slope is largely barren, except for invasive reed canarygrass and blackberries, which are severely mowed.	Riverward embankment slopes here should be carefully monitored. To the extent that slope settlement and deterioration of the levee embankment may become more problematic with time, survey and geotechnical evaluation of the river bank should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
15.75	15.88	L	Tukwila 205 / Gaco Western / Gunter: The levee crest here is raised from 4 to 8 feet above landward grades. Landward levee slopes range from dense plantings of non-native landscaping shrubs and trees at the downstream end of this segment to blackberries and grasses near the upstream end. The corner of a commercial concrete warehouse protrudes into the landward margins of the levee near River Mile 15.82. Riverward slopes are very steep. Rock is visible along the toe and lower slopes during low water conditions, including some larger rock near River Mile 15.83. With the exception of several well-established native willows along the water line in the midpoint of this outside bend, slopes are largely barren except for invasive reed canarygrass and blackberries, which are severely mowed.	Riverward embankment slopes here should be carefully monitored. To the extent that slope settlement and deterioration of the levee embankment may become more problematic with time, survey and geotechnical evaluation of the river bank should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
15.88	16.5	L	Tukwila 205 / Gunter: The landward area is presently an undeveloped former agricultural site, but has been annexed into the City of Tukwila as part of a major proposed development. The levee crest elevation is from 4 to 7 feet above adjoining landward grades. Riverward slopes range from steep to very steep, especially in the upstream half of this segment. Toe rock is visible along the toe and in lower slope areas at low water, and shows some signs of erosion and dislocation. Intermittent sediment deposits are present in lower slope and midslope areas, especially in the downstream half of the reach, and show signs of slumping along their margins. These deposits and all riverward slope areas in general are covered with invasive reed canarygrass and blackberries, which are severely mowed. A single 4-inch diameter volunteer native alder established once, near River Mile 16.48, but was promptly cut pursuant to Corps directives, leaving the slopes barren.	King County has requested additional easement areas be provided in connection with future site development, sufficient in width to accommodate stable levee slopes and adequate buffers supporting native riparian vegetation. This entire reach has been identified as a habitat restoration project element in the Green River Salmon Recovery Plan. Riverward embankment slopes here should be carefully monitored. To the extent that slope settlement and deterioration of the levee embankment may become more problematic with time, survey and geotechnical evaluation of the river bank should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
16.5	16.61	L	Tukwila 205 / Gunter / Gopher Hole Reach: The landward area is presently an undeveloped former agricultural site, but has been annexed into the City of Tukwila as part of a major proposed development. The levee crest elevation is from 4 to 7 feet above adjoining landward grades. Riverward slopes are very steep. Toe rock is visible along the toe and in lower slope areas at low water, and shows some signs of erosion and dislocation. Intermittent sediment deposits are present in lower slope and midslope areas and show signs of slumping along their margins. These deposits and all riverward slope areas in general are covered with invasive reed canarygrass and blackberries, which are severely mowed. Two outfall culverts were partially reconstructed here near River Mile 16.52, and have previously shown signs of general rusting and leakage. Seepage from these outfalls could weaken or otherwise adversely affect levee subgrade and foundation conditions. Extensive "potholes" were observed here in areas landward from the levee, and were suspected as having been created by upwelling sandboils related to pipe seepage of this nature. Access to affected areas was not provided by the landowner to facilitate County foundation inspection and pinpoint failure mechanisms; instead, the landowner's private consultants concluded in writing that the extensive "pothole" development was the result of gopher holes. King County has been unable to confirm this finding and remains concerned that sand boils may be present. The landowner subsequently both repaired the affected outlet culverts and then placed a gravel buttress structure along the landward toe in this segment.	King County has requested additional easement areas be provided in connection with future site development, sufficient in width to accommodate stable levee slopes and adequate buffers supporting native riparian vegetation. This entire reach has been identified as a habitat restoration project element in the Green River Salmon Recovery Plan. Areas landward from the levee should be monitored during all high water events and evaluated for development of sand boils or generalized seepage and ground heaving conditions. Riverward embankment slopes here should be carefully monitored. To the extent that slope settlement and deterioration of the levee embankment may become more problematic with time, survey and geotechnical evaluation of the river bank and landward foundations should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
16.61	16.71	L	Tukwila 205 / Frager Road & Hillside Tie-In: The levee here consists of a raised portion of Frager Road, together with a raised earthen levee berm extending to high ground along the hillside to the west.. Frager Road itself is proposed to be replaced by a new access roadway serving this future development, leaving the disposition of the existing roadway and the existing levee geometry in some question.. Riverward slopes are occupied by significant sediment deposits, eroded and slumping in places along their lower margins. With these sediments in place, slopes are moderate. Slumping sediments obscure the lower slopes and toe, and rock is not visible during low water conditions. Therefore the presence of a rock toe buttress structure is unconfirmed.	King County has requested additional easement areas be provided in connection with future site development, sufficient in width to accommodate stable levee slopes and adequate buffers supporting native riparian vegetation. Riverward embankment slopes here should be carefully monitored. To the extent that slope settlement and deterioration of the levee embankment may become more problematic with time, survey and geotechnical evaluation of the river bank and landward foundations should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
16.71	16.83	L	Frager Road Lowest: The existing roadway shows signs of arcuate crack formation within the existing asphalt, indicating possible initiation of large-scale slumping failures. Riverward slopes are very steep. Toe rock is visible along the toe and in lower slope areas at low water, and shows some signs of erosion and dislocation. Intermittent sediment deposits are present in lower slope and midslope areas and show signs of slumping along their margins.	King County has requested additional easement areas be provided in connection with future site development, sufficient in width to accommodate stable levee slopes and adequate buffers supporting native riparian vegetation. This entire reach has been identified as a habitat restoration project element in the Green River Salmon Recovery Plan. Riverward embankment slopes here should be carefully monitored. To the extent that slope settlement and deterioration of the levee embankment may become more problematic with time, survey and geotechnical evaluation of the river bank and landward foundations should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
16.83	16.99	L	Frager Road Setback: Frager Road serves as the levee in this reach, with a crest elevation some 3 to 6 feet above adjoining grades. A detention pond serving South 200th Street abuts the landward margins of Frager Road just downstream from the bridge. Remaining landward areas were formerly undeveloped agricultural sites and wetlands, but have been annexed into the City of Tukwila as part of a major proposed development and are in the process of being raised with placement of fill materials. Frager Road itself is proposed to be replaced by a new access roadway serving this future development, along with a new levee structure. Riverward areas are occupied by a modest bench, also formerly used as an agricultural site, with the edge of this bench falling steeply down to the edge of the low flow channel. Upstream portions of this bench were formerly used as a mitigation planting site for bridge construction. The bench is currently occupied by roadway fill, serving as a construction access route underneath the South 200th Street Bridge just upstream. Renewed slumping in early 2012 extends to the margins of this temporary road near River Mile 16.87. The temporary access roadway will be removed following construction, and the entire area currently occupied by the bench and Frager Road will be excavated to form a hydraulic sanctuary in the lee of the bridge to serve as instream and riparian habitat. A new levee will be sited along the landward margins of the excavated area	A request by the landowner and the City of Tukwila to add this levee reach as a modification to the existing Tukwila 205 federally authorized levee downstream was denied by the Corps of Engineers. King County has requested additional easement areas be provided in connection with future site development. The nature and extent of County involvement in review, approval, construction, maintenance, or operation of the new levee structure to be constructed here remains to be determined.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
17.0	17.12	L	Frager Road: Frager Road serves as the levee here with its crest elevation raised some 2 to4 feet above landward areas. These areas were formerly undeveloped agricultural sites and wetlands, but have been annexed into the City of Tukwila as part of a major proposed development and are in the process of being raised with placement of fill materials. Frager Road itself is proposed to be replaced by a new access roadway serving this future development, leaving the disposition of the existing roadway and the existing levee geometry in some question. Sediment deposition is present throughout this midslope bench, and is pronounced in places. Some slumping and erosion is also evident along the riverward margins of the bench. Lower slopes and the instream toe are obscured by the sediments present, with the result that the presence of any rock toe buttress structure remains unconfirmed.	A request by the landowner and the City of Tukwila to add this levee reach as a modification to the existing Tukwila 205 federally authorized levee downstream was denied by the Corps of Engineers. King County has requested additional easement areas be provided in connection with future site development, sufficient in width to accommodate stable levee slopes and adequate buffers supporting native riparian vegetation. This entire reach has been identified as a habitat restoration project element in the Green River Salmon Recovery Plan. The nature and extent of County involvement in review, approval, construction, maintenance, or operation of the levee structure here remains to be determined.
17.12	17.2	L	Frager Road: Frager Road serves as the levee here with its crest elevation raised some 3 to 6 feet above landward areas. These areas were formerly undeveloped agricultural sites and wetlands, but have been annexed into the City of Tukwila as part of a major proposed development and are in the process of being raised with placement of fill materials. The current levee has previously been abandoned as a vehicular roadway and established as a trail. It appears that easements for this trail usage may have also expired. Frager Road itself is proposed to be replaced by a new access roadway serving this future development, leaving the disposition of the existing roadway and the existing levee geometry in some question. The current raised levee structure is located immediately at the margins of very steep slopes covered with blackberries, reed canarygrass, and sparsely scattered willows along the water line. Sediment deposition is present in midslope areas, and some slumping and erosion is also evident in lower slope areas. Instream toe rock is visible under low water conditions, but shows signs of erosion and dislocation here and there.	A request by the landowner and the City of Tukwila to add this levee reach as a modification to the existing Tukwila 205 federally authorized levee downstream was denied by the Corps of Engineers. King County has requested additional easement areas be provided in connection with future site development, sufficient in width to accommodate stable levee slopes and adequate buffers supporting native riparian vegetation. This entire reach has been identified as a habitat restoration project element in the Green River Salmon Recovery Plan. The nature and extent of County involvement in review, approval, construction; maintenance, or operation of the levee structure here remains to be determined.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
17.2	17.28	L	Tukwila South Pond / Johnson Creek Outlet: Frager Road formerly served as the levee in this reach, but has been replaced with the excavation of a new outlet for a relocated portion of Johnson Creek, together with a new outlet for a large detention pond. This pond serves areas which were formerly undeveloped agricultural sites and wetlands, but which have been annexed into the City of Tukwila as part of a major proposed development and are in the process of being raised with placement of fill materials. Both the pond and the newly relocated Johnson Creek channel have been excavated into native alluvial soils along the landward margins of the levee prism, effectively increasing the height of the overall flood containment prism. Green River flood elevations in this reach are up to 20 feet in elevation above portions of Johnson Creek and upstream wetland areas, including portions of South 204th Street. The levee also effectively serves as the riverward containment for the detention pond, as well as containment for river flooding, potentially increasing seepage gradients in either direction, depending on stage differentials between the two. The newly modified levee structure in this reach has been raised with placement of additional levee fill, and outlet structures provided with rock armor facing. No modifications to the overall riverward slope geometry have been made in this context, and the slopes remain very steep and covered with blackberries and reed canarygrass in areas not affected by the newer rock. Older toe rock is visible along the toe and in lower slope areas during low water conditions, and shows evidence of dislocation and erosion in some places. Midslope areas are affected by shallow sediment deposits subject to slumping in places. A request by the landowner and the City of Tukwila to add this levee reach as a modification to the existing Tukwila 205 federally authorized levee downstream was denied by the Corps of Engineers.	King County has requested additional easement areas be provided in connection with future site development, sufficient in width to accommodate stable levee slopes and adequate buffers supporting native riparian vegetation. Additional analyses of areas subject to excavation of the landward levee toe have also been requested. This entire reach has been identified as a habitat restoration project element in the Green River Salmon Recovery Plan. The nature and extent of County involvement in review, approval, construction, maintenance, or operation of the levee structure here remains to be determined.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
17.28	17.52	L	Frager Road Lower / Omlid / O'Connell: This reach borders four residential homes with barns and a number of agricultural outbuildings set in close proximity to the landward edge of the road. The elevation of the roadway serves as the levee crest, and is from 2 to 4 feet above adjacent landward grades; however, protected areas to the west along the Johnson Creek wetlands, within adjoining agricultural fields, and along South 204th Street itself are up to 20 feet below Green River flood elevations in this reach. Riverward slopes here are extremely steep, and the riverward margins of Frager Road show evidence of extensive cracking and settlement of slopes along the road shoulder. Toe rock is visible under low water conditions, but shows some evidence of scour and dislocation. Midslope areas experience intermittent deposits of flood-borne sediments to shallow depths over the slopes, which experience recurrent slumping. Findings in the January 27, 2012 Green River Geotechnical Investigation of Frager Road Levee show that reliance on the existing river bank for the structural stability of the road and associated flood containment functions is highly questionable at present	.. Riverward embankment slopes here should be carefully monitored. To the extent that slope settlement and deterioration of the levee embankment may become more problematic with time, further survey and geotechnical evaluation of the river bank should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation.
17.52	17.72	L	Frager Road: Frager Road serves as the levee crest here, and is from 2 to 4 feet above adjacent landward grades. However, protected areas to the west along the Johnson Creek wetlands, within adjoining agricultural fields, along South 204th Street, and extending to South 212th Street itself are up to 20 feet below Green River flood elevations in this reach. Riverward of the road fill a midslope floodplain "bench" is present, up to 200 feet wide in places. The bench and these lower slopes experience sediment deposition, especially on downstream portions of the bench, and periodic slumping occurs along the margins of the bench. Sediments obscure the lower slope and toe areas, and therefore the presence of any toe rock remains unconfirmed. Findings in the January 27, 2012 Green River Geotechnical Investigation of Frager Road Levee show that reliance on the existing river bank for the structural stability of the road and associated flood containment functions is highly questionable at present.	Depending on decisions taken with regard to the location and need for future defined flood containment structures in this general reach, or for stabilization of the road and its additional function as a recreational trail, further survey and geotechnical evaluation of the existing road should be performed as an initial step toward levee stabilization. A plan for utilizing the existing riverward bench should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
17.72	17.84	L	Frager Road: Frager Road serves as the levee crest here, and is from 2 to 4 feet above adjacent landward grades. Riverward slopes are moderate to steep, and are characterized by dynamic episodes of sediments depositing and slumping. Lower embankment slopes are especially prone to slumping, despite the presence of rather well-developed thickets of native dogwood and some willows in places. The low flow channel here is uncharacteristically deep for the lower Green River, up to 20 feet in places, and a long pool extends downstream from the bridge crossing as a result of flow modulation by old bridge piers and entrained debris forming a "sill" of sorts in the riverbed just upstream. Findings in the January 27, 2012 Green River Geotechnical Investigation of Frager Road Levee show that reliance on the existing river bank for the structural stability of the road and any associated flood containment functions is highly questionable at present.	Depending on decisions taken with regard to the location and need for future defined flood containment structures in this general reach, or for stabilization of the road and its additional function as a recreational trail, further survey and geotechnical evaluation of the existing road should be performed as an initial step toward levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. Establish a uniform riparian buffer with native vegetation. The deep channel bottom here must be considered as part of any levee planning and design decisions made in the future.
17.86	18.0	L	Frager Road Nursery: Frager Road abuts several homes and a former nursery site here, where it ties in to South 212th Street and serves as a levee raised from 3 to 6 feet above the landward areas. The upstream portions of this short segment abut a setback area established as part of a newer development by the Polygon Corporation. Despite the setback, the roadway sits immediately at the top of a moderately steep riverbank, with significant sediment deposits present in the midslope and along the lower slope areas Slumps are visible along the lower slopes, involving the riverward margins of the sediment deposits. Toe rock is visible in a few places, but is largely obscured by the sediments. It is likely that any toe rock is affected by bed scour and settlement here. The northerly portion of the riverbank supports a trail ramp passing under south 212th Street. Findings in the January 27, 2012 Green River Geotechnical Investigation of Frager Road Levee show that reliance on the existing river bank for the structural stability of the road and any associated flood containment functions is highly questionable at present.	Depending on decisions taken with regard to the location and need for future defined flood containment structures in this general reach, or for stabilization of the road and its additional function as a recreational trail, further survey and geotechnical evaluation of the existing road should be performed as an initial step toward levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed, including use of the setback area provided by the Polygon development. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
18.0	18.22	L	Frager Road / "216th Street": Frager Road serves as the levee here, and is located immediately at the top of an extremely steep, actively sloughing riverbank. Distress cracks are visible within the asphalt pavement along the riverward edge of the roadway throughout the reach. River bank slopes are characterized by minor sediment deposits overgrown with reed canarygrass. These form and then slough in a continuously dynamic pattern, and have been monitored over a span of some 20 years. Localized shallow failure scarps from 20 to 150 feet long have repeatedly been observed here. Wholesale failure of the slope has not occurred to date, but may be expected at any time. Findings in the January 27, 2012 Green River Geotechnical Investigation of Frager Road Levee show that reliance on the existing river bank for the structural stability of the road and any associated flood containment functions is highly questionable at present.	Depending on decisions taken with regard to the location and need for future defined flood containment structures in this general reach, or for stabilization of the road and its additional function as a recreational trail, further survey and geotechnical evaluation of the existing road should be performed as an initial step toward levee stabilization.. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed, including use of the setback area provided by the Polygon development. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench.
18.22	18.31	L	Frager Road / Eagle Scout Park: Frager Road serves as the levee here, near its intersection with South 216th Street. The road crest elevation is raised from 2 to 3 feet above adjoining grades. . Sediments deposit along the margins of the bench, and slump into the channel from time to time. Due to the presence of these sediments toe structure remains unconfirmed. Overall, the integrity of the slope is only slightly higher than elsewhere in the overall Frager Road reaches, due to the flatter slope angles established by the modest setback of the roadway, and perhaps also by the rooting structure of the cottonwood stand along the bench. Findings in the January 27, 2012 Green River Geotechnical Investigation of Frager Road Levee show that reliance on the existing river bank for the structural stability of the road and any associated flood containment functions is highly questionable at present.	Depending on decisions taken with regard to the location and need for future defined flood containment structures in this general reach, or for stabilization of the road and its additional function as a recreational trail, further survey and geotechnical evaluation of the existing road should be performed as an initial step toward levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed, including use of the setback area provided by the Polygon development. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution preferably including a vegetated midslope bench.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
18.31	18.55	L	Frager Road Lower / 216th Street Upstream: The downstream portions of this segment abut several older residential homes set relatively closely behind the curve in the road Flood patrol access through this reach is hindered by the presence of locked bollards which are not provided with County locks. The roadway upstream from these bollards is used strictly as a bicycle and hiking trail and as access for maintenance vehicles. The river bank is extremely steep throughout, with a thin cover of rip rap supporting reed canarygrass and blackberries, and with intermittent sediment deposits mobilizing as localized slumps in places. The riverward margins of Frager Road at the top of bank show pronounced settlement and cracking along nearly the entire edge of the asphalt paving, and a pronounced slump extends right to the top of bank and for nearly 200 feet along the slope near River Mile 18.54.Sediments routinely deposit within this scarp area, partially vegetate with reed canarygrass, and then slump again. A relatively deep pool abuts the base of this slump, and is sustained by the presence of a pronounced back eddy feature at the upstream end of the outer bend here. Findings in the January 27, 2012 Green River Geotechnical Investigation of Frager Road Levee show that reliance on the existing river bank for the structural stability of the road and any associated flood containment functions is highly questionable at present.	Depending on decisions taken with regard to the location and need for future defined flood containment structures in this general reach, or for stabilization of the road and its additional function as a recreational trail, further survey and geotechnical evaluation of the existing road should be performed as an initial step toward levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed, including use of the setback area provided by the Polygon development. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
18.55	18.71	L	Frager Road Lower: This segment of Frager Road also abuts the 200-foot-wide open space area adjoining the Polygon Corporation development. It differs from segments upstream and downstream due to the presence of a relatively broad midslope "bench," covered for the most part with reed canarygrass along its upper surface and native dogwood shrubs along the riverbank itself. This feature flattens the overall slope, which is much less steepened relative to the position of the roadway itself. Sediment deposits along the channel margins below the bench seem to be aggrading over the years, but no rock structure is visible under low water conditions.. Findings in the January 27, 2012 Green River Geotechnical Investigation of Frager Road Levee show that reliance on the existing river bank for the structural stability of the road and any associated flood containment functions is highly questionable at present.	Depending on decisions taken with regard to the location and need for future defined flood containment structures in this general reach, or for stabilization of the road and its additional function as a recreational trail, further survey and geotechnical evaluation of the existing road should be performed as an initial step toward levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed, including use of the setback area provided by the Polygon development. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench.
18.71	19.0	L	Frager Road Lower: This reach of Frager Road consists of a relatively straight reach with consistently steep embankment slopes characterized by midslope sediment deposits, intermittent slumps in these sediments,. The downstream end of this reach abuts the Polygon open space setback area and an associated sewage lift station. The rest of the reach borders largely undeveloped open space formerly used as a sand quarry, and which now supports both former sediment ponds now reverting to wetlands, together with natural floodplain wetlands at the base of the west valley hillside. All these wetland areas are cut off from river flooding by the presence of the raised roadway fill. The roadway here is used strictly as a bicycle and hiking trail and as access for maintenance vehicles. A pedestrian footbridge supporting utility crossings of the river is present at River Mile 18.81. Findings in the January 27, 2012 Green River Geotechnical Investigation of Frager Road Levee show that reliance on the existing river bank for the structural stability of the road and any associated flood containment functions is highly questionable at present.	Depending on decisions taken with regard to the location and need for future defined flood containment structures in this general reach, or for stabilization of the road and its additional function as a recreational trail, further survey and geotechnical evaluation of the existing road should be performed as an initial step toward levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed, including use of the setback area provided by the Polygon development. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench, while considering appropriate re-connection of higher flows to the floodplain wetlands present.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
19.0	19.16	L	Frager Road Lower: This segment of Frager Road sits immediately at the top of bank along a pronounced outer bend. The roadway here is used strictly as a bicycle and hiking trail and as access for maintenance vehicles. Shallow sediment deposits cover a rock layer still visible along the toe at low water, and intermittently slump in blocks or clumps held together with reed canarygrass. The landward margins of the road abut a narrow fringing of forested wetlands at the base of the equally well-forested hillside defining the west valley wall nearby. Overall stability of the steep embankment here is highly questionable. Other than perhaps confining a possible flow route affecting the upstream margins of the Polygon housing development downstream, the roadway serves no essential flood containment function by keeping higher flows out of the floodplain wetlands here.	Depending on decisions taken with regard to the location and need for the road, a trail, or future defined flood containment structures in this general reach, further survey and geotechnical evaluation of the existing road should be performed as an initial step toward bank stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed, while considering appropriate re-connection of higher flows to the floodplain wetlands present. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench.
19.16	19.27	L	Frager Road Lower / South 231st Street Bridge Mitigation: The roadway here abuts a narrow fringing of forested wetlands at the base of the equally well-forested hillside defining the west valley wall, together with the bridge abutment fill nearby. The riverward embankment occupies an inner bend with sediment deposits present. The bulk of this riverward area is occupied with a mitigation project area constructed by King County for the City of Kent as partial mitigation for impacts associated with bridge construction. The embankment was re-sloped at a relatively flat angle, between 2.5 H:1V and 3H:1V for the most part, and was replanted with native riparian trees and shrubs. Areas closer to the bridge were not re-sloped, but have been cleared of blackberries and planted as well. A number of logs with rootwads were chained to buried rock anchors just above the water line, and interact with flows at intermediate river levels. Sediments continue to recruit along the slopes near the downstream end of this reach, which was not included in the restoration work.	While the road embankment in this reach is largely stable and supports no obvious flood containment function, consideration should be given to appropriate re-connection of floodplain wetlands to higher river flows as part of any longer-term project actions involving downstream segments of Frager Road.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
19.3	19.44	L	Stoneway Lower: Frager Road follows closely along the base of the adjoining west valley hillside here, and is located immediately at the top of the very steep river embankment. The riverward margins of the roadway show numerous arcuate cracks generally indicative of instabilities and settlement in the slope below. Rock is visible along the lower slopes and at the toe during low water conditions. Several discontinuous rows of old wooden pilings are also visible in the water along the toe in places. Due to the proximity of the adjoining hillside and the bridge abutment at the downstream end here, no flood containment function is associated with this segment. Stability of the road embankment appears highly questionable.	Depending on decisions taken with regard to the location and need for the road, a trail, or stabilization of the leachate line in this general reach, further survey and geotechnical evaluation of the existing road should be performed as an initial step toward bank stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench.
19.44	19.48	L	Stoneway Lower Slope Repair: The entire roadway embankment in this reach failed in a slump extending up to the centerline of the pavement following flood discharge in 2009. Funding assistance was provided by FEMA through the City of Kent, acting as the local sponsor. Roadway reconstruction was completed by King County using piling anchored log deflectors along the toe, geotextile reinforcement of crushed stone fill layers integrated with bio-engineered slope reconstruction of the face slope, and a full reconstruction of the failed roadway. The adjoining hillside immediately abuts the roadway here, together with the City of Seattle's Midway landfill leachate line, also buried along the landward edge of the pavement. To help flatten to very steep slope angle here to the maximum allowed by these landward constraints, the pavement width was reduced from two lanes down to a single lane, and the road shoulder was replaced with a guardrail.	Due to the use of piling anchored logs along the toe to expedite construction permitting, as compared with instream rock buttress construction, and also due to the remaining overall steepness of the slope involved, careful monitoring of this construction will be needed over time. Monitor, repair, or reconstruct as needed.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
19.48	19.73	L	Stoneway Lower / Midway Creek: The roadway here is set back from the low flow channel margins by the presence of a relatively wide midslope bench deposited along an inner bend. Midway Creek discharges to the Green River here beneath a bridge at River Mile 19.53. Landward areas flood during high river flow events, and are largely characterized by forested floodplain wetlands. The City of Settle maintains a seepage impoundment barrier at the mouth of a filled ravine now serving as the Midway landfill near the valley wall west of these wetlands, with an enclosed aeration pond and pump system treating and conveying leachate in an enclosed forcemain also present. Because the mouth of Midway Creek is open to the river here, no essential flood containment function is provided by the roadway.	The broad bench located riverward from the roadway here should be included in any systematic restoration efforts within this general reach, including replacement of invasive vegetation with native riparian plantings. A more general re-connection of the river to its floodplain might also be achieved through setback of the roadway/trail system to the base of the valley wall, west of the floodplain wetlands.
19.73	19.9	L	Stoneway Upper: Frager Road Lower: This segment of Frager Road sits immediately at the top of bank along a pronounced outer bend. Shallow sediment deposits cover a rock layer still visible along the toe at low water, and intermittently slump in blocks or clumps held together with reed canarygrass. The landward margins of the road abut wetlands at the base of the hillside defining the west valley wall nearby. Overall stability of the steep embankment here is highly questionable. Other than perhaps confining a possible flow route affecting the upstream margins of the Polygon housing development downstream, or in curtailing backwater effects possibly affecting driveway access to scattered residential uses just upstream, the roadway serves no obvious or essential flood containment function by keeping higher flows out of the floodplain wetlands here.	Further survey and geotechnical evaluation of the existing road should be performed as an initial step toward bank stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed, while considering appropriate re-connection of higher flows to the floodplain wetlands present. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. .

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
19.9	20.55	L	Teufel Nursery: This reach is situated along an elongated inner bend, and together with the segment just upstream defines the former Teufel Nursery site purchased in 2010 by the Flood District to provide a mitigation site Preliminary site investigations reveal the presence of slightly elevated levels of herbicides and possibly other horticultural chemical residues in soil samples obtained from limited portions of the site. Significant sediment deposits are present along the bend, and sloughing is visible in places. Vegetation includes some mature native and non-native tree species, occasional stands of dense native willow and dogwood clumps, and broad distribution of invasive blackberries and reed canarygrass along the riverbank.	Perform a detailed site survey. Identify, characterize, treat and remove contaminated soils from the site as appropriate under applicable state and federal statutes. Define a site grading plan sufficient to re-connect a lowered floodplain surface to the range of elevations defined by currently managed flows as discharged by Howard A. Hanson Dam, and to provide for access along the riverbank for placement of required log mitigation structures. Consider the magnitude and extent of possible channel re-alignment likely as a consequence of removing bank armor along the segment immediately upstream. Consider alternatives for incorporating identified channel dynamics into the restoration plan outcomes. Select a preferred alternative. Develop a wood placement and anchoring plan. Develop a site revegetation plan sufficient to accomplish mitigation planting requirements. Obtain all necessary construction permits and approvals. Construct site mitigation measures.
20.55	20.81	L	Teufel Nursery: Slopes are very steep in places, with slopes flattening due to sediment accumulations as flows proceed downstream.	Perform a detailed site survey. Identify, characterize, treat and remove contaminated soils from the site as appropriate under applicable state and federal statutes. Define a site grading plan sufficient to re-connect a lowered floodplain surface to the range of elevations defined by currently managed flows as discharged by Howard A. Hanson Dam, and to provide for access along the riverbank for placement of required log mitigation structures. Consider the magnitude and extent of possible channel re-alignment likely as a consequence of removing bank armor and concrete rubble along this segment. Consider alternatives for incorporating identified channel dynamics into the restoration plan outcomes. Select a preferred alternative. Develop a wood placement and anchoring plan. Develop a site revegetation plan sufficient to accomplish mitigation planting requirements. Obtain all necessary construction permits and approvals. Construct site mitigation measures.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
20.81	20.92	L	Frager Road / Corps GR 1-75: This reach segment appears to be named after a long-ago Corps repair along this outer bend, with rock armor still visible along the toe and lower bank at low water. An accumulation of wood and sediment is also present near the downstream end, forming a deflector of sorts. Interior runoff from a neighboring wetland flows seasonally over the lower slope from an open culvert. A long residential driveway crosses the adjoining wetland near the upstream end of the reach, which borders the left bank portions of the City of Kent's Riverbend Golf Course. Slopes range from steep to very steep, and Frager Road sits right at the crest of the slope with no particular road shoulder present next to the guardrail. A back-eddy at the upstream end of this segment has deepened the channel and undermined the slope, with the formation of sharply defined arcuate settlement cracks in the asphalt paving extending to the centerline of the road showing evidence of previous slope settlement and potential continuing local instability.	The structural stability of the road and any associated flood containment functions is highly questionable at present. Depending on decisions taken with regard to the location and need for the road, a trail, or future defined flood containment structures in this general reach, further survey and geotechnical evaluation of the existing road should be performed as an initial step toward bank stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed, while considering appropriate re-connection of higher flows to the floodplain wetlands present. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench.
20.92	21.13	L	Frager Road / Kent Golf Left: This relatively straight reach provides a perfect example of long-term bank stability supported by a mixed overstory of mature native riparian trees on a broad midslope floodplain bench present here, combined with dense stands of shade-tolerant native dogwood species along the riverbank itself. Frager Road is set back from the riverbank along the margins of this bench, separating it from the balance of the floodplains serving as the left bank portions of the City of Kent's Riverbend Golf Course here. No toe structure appears to be present, other than natural wood accumulations and the velocity attenuation provided by the overhanging dogwood stands. The long-term stability of this feature is evidenced by the age of the vegetation present. Frager Road is quite secure in this setting. Other than for the golf links, the driveway downstream, and a residential structure, the roadway here does not appear to serve an obvious or essential flood containment function.	Monitor. Document as a naturally stable vegetated riverbank and floodplain bench. Consider additional research opportunities to evaluate the use and performance of native vegetation in stabilizing riverbanks..

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
21.13	21.28	L	Frager Road / Maddox /Kent Golf Left: This segment is incredibly steep along the river bank. Toe rock is visible at lower flows along the base of the slope. The left bank portions of the City of Kent's municipal golf course abut the landward margins of Frager Road, which sits right at the crest of the slope with no particular road shoulder present next to the guardrail. A pool extends downstream from the "chute" at the bridge, deepening the channel and undermining the slope. Sharply defined settlement cracks in the asphalt paving along the margins of the road show evidence of previous slope settlement and potential continuing local instability.	The structural stability of the road and any associated flood containment functions is highly questionable at present. Depending on decisions taken with regard to the location and need for the road, a trail, or future defined flood containment structures in this general reach, further survey and geotechnical evaluation of the existing road should be performed as an initial step toward bank stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed, while considering appropriate re-connection of higher flows to the floodplain wetlands present downstream. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
21.29	21.5	L	Frager Road /Leber Brothers: This reach of Frager Road along an outer bend extends from the Meeker Street Bridge upstream to the bridge over Mullen Slough at its confluence with the Green River. The landward side of the road is raised from 3 to 12 feet above adjoining grades, which include lands owned and managed by the City of Kent. These lands include a recreational fishing pond at the downstream end of this segment, a ditch-contained, seasonally flowing outlet of a wall-based tributary from the base of the western valley wall bordering the Mullen Slough floodway areas upstream from State Route 516 to the west and south, and undeveloped open space between Frager Road and SR 516. The tributary outlet discharges over a concrete splash pad embedded in rip-rap in the midslope of the steep riverbank, making it inaccessible to fish under nearly all flow conditions; despite this limitation, Sticklebacks have been observed in upstream areas. The mouth of Mullen Slough at the upstream end of this reach is open to the combined Mill Creek / Mullen Slough floodway of the Green River here, and backwater flooding of both Mullen Slough and the tributary culvert assure that the fishing pond and tributary outlet channel are both under several feet of floodwaters under higher river flow conditions. No practical flood containment is present. Toe rock of variable integrity is visible at low flows. Banks are very steep, with scattered immature native riparian trees present here and there. Shallow sediment deposits covered with blackberries and reed canarygrass are visible in midslope areas and are prone to localized minor slumping.	The structural stability of the road embankment is highly questionable at present. Depending on decisions taken with regard to the location and need for the road, a trail, or any future defined flood containment structures in this general reach, further survey and geotechnical evaluation of the existing road should be performed as an initial step toward bank stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed, while considering appropriate, fish-passable re-connection of the wall base tributary to either the Mainstem Green River, or to Mullen Slough. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench. .

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
21.5	22.05	L	Frager Road / Downey Property / PD & J Packing No.1: Frager Road borders a steep, slump-prone embankment here with no obvious prior flood management structures incorporated into the riverbank, with the exception of a short segment of bank armor historically placed at the site of the former PD & J Packing Company. Frager Road itself does not presently serve as a containment structure for floodwaters, as areas landward from the roadway are wholly within the combined Mill Creek / Mullen Slough floodway of the Green River, with the exception of the fill embankment for State Route 516. The extent to which Frager Road will be modified as a flood management structure or as a stable boundary to the site restoration area remains to be determined, as does its future maintenance.	Determine future flood management and channel boundary functions associated with Frager Road in connection with future modification of the site by the City of Kent as a salmon habitat restoration project. Determine flood management structure maintenance requirements and commitments as appropriate.
22.07	22.15	L	Frager Road Upper / PD & J Packing No. 2: Frager Road sits immediately at the top of a steep riverbank here. Adjacent lands are enrolled in the Farmland Preservation Program within King County's Lower Green River Agricultural Protection District. The road crest is raised 2 to 3 feet above adjoining grades. A narrow strip of land along the road is just above the 100-year flood elevation here, within the combined Mill Creek / Mullen Slough floodway of the Green River. Therefore, while the roadway itself confines the adjacent river, it serves no overall flood containment function. The steep riverbank supports scattered immature native trees and some shrubs, with blackberries and reed canarygrass rooted in shallow sediment deposits. These deposits are visible and locally slumping in midslope areas. Older rock armor is visible here and there along the toe and lower slope areas under low water conditions. Overall the structure is marginally suited to its purpose of securing the roadway alignment.	The structural stability of the road and any associated local flood containment functions is questionable at present. Depending on decisions taken with regard to the location and need for the road, a trail, or future defined flood containment structures in this general reach, further survey and geotechnical evaluation of the existing road should be performed as an initial step toward bank stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed, while providing appropriate offsets for any resulting impacts affecting properties enrolled in the Farmlands Preservation Program. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
22.15	22.27	L	Frager Road Upper: A relatively narrow depositional bench is present along the riverward slope of Frager Road, which is raised only a few feet above adjoining landward grades here. A narrow strip of dry land along the landward edge of the road supports several homes and farm outbuildings, all raised just above the mapped 100-year flood elevation, which otherwise occupies the combined Mill Creek/Mullen slough floodway of the Green River here. Adjacent lands are enrolled in the Farmland Preservation Program within King County's Lower Green River Agricultural Protection District. No visible toe structure is evident here, and sediment deposits alternatively form and slump along the bank in places.	Restoration of the midslope bench present along the riverward embankment should be considered for appropriate incorporation into any comprehensive modification of the roadway to achieve stabilization of the embankment within the overall reach extending both upstream and downstream from this segment. Appropriate offsets should be provided for any resulting impacts affecting properties enrolled in the Farmlands Preservation Program.
22.27	22.6	L	Frager Road Upper: Frager Road sits immediately at the top of an extremely steep riverbank here. The combined Mill Creek / Mullen Slough floodway of the Green River regularly inundates nearly the entirety of the valley bottom and farm fields landward from the homes. Therefore, while the roadway itself locally confines the adjacent river and provides access to the homes, it serves no overall flood containment function. Shallow sediment deposits are visible and locally slumping in midslope areas. Older rock armor is visible here and there along the toe and lower slope areas under low water conditions, and as exposed by the heavy use made of the riverbank in this location for fishing access. Here and there along the toe and lower slopes rock has dislocated and settled into the channel due to undercutting scour along this sharp outer bend. Overall the structure is marginally suited to its purpose of securing the roadway alignment.	The structural stability of the road and any associated local flood containment functions is questionable at present. Depending on decisions taken with regard to the location and need for the road, a trail, or future defined flood containment structures in this general reach, further survey and geotechnical evaluation of the existing road should be performed as an initial step toward bank stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed, while providing appropriate offsets for any resulting impacts affecting properties enrolled in the Farmlands Preservation Program. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
22.6	22.66	L	Frager Road Upper: The roadway here sits immediately at the top of a very steep embankment. The road crest elevation is only one or two feet above landward grades. The upstream end of this segment does not appear to have been modified from the natural riverbank with any previous structural modifications. Older toe rock is visible in the downstream portions at low water, but does not appear to be in good order due to settlement and dislocation caused by localized scour along the sharp outer bend that initiates at this location. The riverbank here has previously slumped into the channel along a distance of some 300 feet. It has not been reconstructed. The slump is obscured by subsequent deposition of sediments. Some settlement cracks are visible along the margins of the asphalt. Overall stability of the riverbank is highly questionable.	The structural stability of the road and any associated local flood containment functions is highly questionable at present. Depending on decisions taken with regard to the location and need for the road, a trail, or future defined flood containment structures in this general reach, further survey and geotechnical evaluation of the existing road should be performed as an initial step toward bank stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed, while providing appropriate offsets for any resulting impacts affecting properties enrolled in the Farmlands Preservation Program. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench.
22.66	22.74	L	Frager Road Upper: The road crest elevation is only one or two feet above landward grades. Landward areas are all farm properties enrolled in the Farmlands Preservation Program within the Lower Green River Agricultural Protection District, and are routinely inundated within the combined Mill Creek/Mullen Slough floodway of the Green River. Therefore, while the roadway itself locally confines the adjacent river and provides local access, it serves no overall flood containment function. This segment does not appear to have been modified from the natural riverbank with any previous structural modifications. The bank geometry remains very steep overall. Cracks extend along nearly the full length of the roadway asphalt in this segment, indicating possible slope settlement. Midslope and lower slope areas are dominated with episodic sediment deposits. Localized slumping is widely visible.	The structural stability of the road and any associated local flood containment functions is questionable at present. Depending on decisions taken with regard to the location and need for the road, a trail, or future defined flood containment structures in this general reach, further survey and geotechnical evaluation of the existing road should be performed as an initial step toward bank stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed, while providing appropriate offsets for any resulting impacts affecting properties enrolled in the Farmlands Preservation Program. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
22.74	22.84	L	Frager Road Upper: The road crest elevation is only one or two feet above landward grades. Landward areas are all farm properties enrolled in the Farmlands Preservation Program within the Lower Green River Agricultural Protection District, and are routinely inundated within the combined Mill Creek/Mullen Slough floodway of the Green River. Therefore, while the roadway itself locally confines the adjacent river and provides local access, it serves no overall flood containment function. This segment does not appear to have been modified from the natural riverbank with any previous structural modifications. Together with the Left Bank segment at River Mile 21, this segment provides a perfect example of long-term slope stabilization with natural riparian vegetation, involving no known prior construction of stabilization measures, and no history of maintenance costs or repair needs.	Monitor and maintain as needed. Include in future studies evaluating slope stability and vegetative interactions.
22.84	22.92	L	Frager Road Upper: The roadway here is set back from the channel margins at a relatively modest overall slope angle along an inside bend. The road crest elevation is only one or two feet above landward grades. While overall geometry from the channel to the roadway is likely quite stable, midslope areas fall off steeply along the channel margins with episodic sediment deposits and slumping present. This may be exacerbated at the very downstream end of this segment, where a back-eddy feature may locally undermine the margins of the sediment deposits and accentuate slumping.	Monitor and maintain as needed. Consider restoration or mitigation use of the midslope and lower slope margins as needs and opportunities may present themselves. It is unlikely this segment will require structural remediation.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
22.92	23.18	L	Frager Road Upper: The roadway here closely borders the crest of a moderately steep embankment. Residential homes and agricultural outbuildings closely border the landward margins along the downstream end of the road. The road crest elevation is only one or two feet above landward grades. Landward areas in the downstream half of this segment are all farm properties enrolled in the Farmlands Preservation Program within the Lower Green River Agricultural Protection District, while upstream agricultural and horticultural lands are located within the City of Kent. All these lands are routinely inundated within the combined Mill Creek/Mullen Slough floodway of the Green River. Therefore, while the roadway itself locally confines the adjacent river and provides local access, it serves no overall flood containment function. This segment does not appear to have been modified from the natural riverbank with any previous structural modifications. The riverbank, is subject to pervasive and repetitive slumping throughout. To date, these slumps do not appear to have affected the roadway itself, but recur here and there throughout the lower and midslope areas. Slumping is especially pronounced near the upstream end of this segment, just downstream from the Washington Avenue South Bridge.	The structural stability of the road and any associated local flood containment functions is questionable at present. Depending on decisions taken with regard to the location and need for the road, a trail, or future defined flood containment structures in this general reach, further survey and geotechnical evaluation of the existing road should be performed as an initial step toward bank stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed, while providing appropriate offsets for any resulting impacts affecting unincorporated King County properties enrolled in the Farmlands Preservation Program. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
23.41	23.71	L	Koch/Corps Revetment/Bradley: This short reach along an outer bend is defined by three individual bank stabilization locations apparently constructed separately at different times in the distantly fading past. The downstream third of this composite reach consists of the Koch Revetment, which borders the farmhouse occupying the Dahlia Farm segment just downstream. The middle third of this reach is defined as the Corps Revetment, and borders a short segment of the West Valley Highway located immediately at the top of the very steep embankment present. The road is barely raised above adjacent grades, and is bordered by small farms along the margins of the combined Mill Creek/Mullen Slough floodway of the Green River. Recent flood studies have shown both the roadway and the adjoining properties just at or below the 100-year water surface elevation here. The upstream third of this reach is named Bradley, and borders a residential home with scattered outbuildings and a small farmed plot of floodplain. All three riverbank features are markedly steep. The central portion along the highway includes variously sized concrete rubble along with the rip-rap rock armor also visible in the other two features.. Despite the apparent longevity of the features here, erosion and undercutting of the toe rock is also visible in places, especially in the upstream and downstream portions. Overall stability is certainly in question.	Depending on decisions taken with regard to the location and need for the road or future defined flood containment structures in this general reach, further survey and geotechnical evaluation of the existing road and riverbank should be performed as an initial step toward bank stabilization. Previous discussions with the City of Kent have included some consideration of including adjoining properties in a larger restoration effort now underway just upstream, at the mouth of Mill Creek. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench.

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GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
23.71	23.8	L	Mill Creek Restoration Site: This segment includes the mouth of Mill Creek and extends along a more or less densely vegetated riverbank extending upstream to the State Route 167 Bridge abutment. It is highly likely that the embankment was structurally modified at some point in the past, and the top of the slope supports what appears to be a modestly raised berm. No known flood management structure is documented here, however. The adjoining site has been acquired by the City of Kent, and is intended to be modified through floodplain excavation and revegetation to serve as an off-channel floodplain restoration project funded in part by the State of Washington's Salmon Recovery Funding Board. These areas are part of a much larger extent of flood-prone areas affected by Green River flood flows exiting the Mainstem Green River channel and flowing "upstream" at the mouth of Mill Creek into the combined Mill Creek/Mullen Slough floodway of the Green River. Several residential homes border Mill Creek and the proposed restoration site, and the mapped 100-year floodplain extends southerly along both State Route 167 and the West Valley Highway, south of South 262nd Street. This reach provides no flood containment function. The extent to which the proposed restoration efforts may eventually modify the riverbank has not yet been determined.	Monitor and maintain as required. Any future actions taken here need to be fully coordinated with the City of Kent's Salmon Recovery Funding Board project outcomes on adjacent properties.
23.82	24.4	L	Kent Airport: Toe structure is questionable throughout. A significant slump has previously been observed in the upstream third of the site. Slopes remain steep and unstable, and no functional buffer is present. (Green River, City of Kent)	Riverward embankment slopes here should be carefully monitored. To the extent that slope settlement and deterioration of the levee embankment may become more problematic with time, survey and geotechnical evaluation of the river bank should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration.

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GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
24.16	25.0	L	Wrecking Yards /78th Ave. S: Several existing and former wrecking yard sites adjoin either the steep riverbank or 78th Avenue So., along the steep, unstable riverbank, throughout the downstream 2/3 of this segment. The riverbank is steep and lacking any previous structural modifications downstream from the bridge. Littering and garbage dumping is a chronic issue here. Toe structure is questionable throughout. Localized erosion and slumps are visible. A modest depositional bench is present within the midslope areas near River Mile 24.73. Slumping near the upstream end of the roadway frontage has previously been observed, and was repaired with end-dumped rip-rap, in 1991. 78th Ave S may not provide adequate freeboard above newly estimated flow elevations for events exceeding the once-in-140-year event, including the 500-year flood elevation, or even above the 100-year base flood elevation. Based on the overall steepness of the road embankment, its long-term stability is highly questionable.	A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench.
25.1	25.22	L	Rent-A-Row Reach: No bank armor is visible. Some slumping is present. Green River floodwaters may not directly overtop the bank, but local flooding due to Northeast Auburn Tributary flows passing under East Valley Highway at the upstream end may affect these county-owned lands.	To the extent that existing structures at the southerly end of the site may be at risk due to revised estimates of 500-year flood elevations, now in preparation by the Corps of Engineers, they may require reconsideration or re-scheduling of potential actions within a more immediate time frame. Any flood management actions affecting lands enrolled within the Farmlands Preservation Program would need to fully provide for offsets to any impacts involved.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
25.32	25.7	L	Carpinito Farm Downstream / Northeast Auburn Creek: This reach is characterized by steep natural banks along an outside bend. In the middle portions of this reach, slopes are extremely unstable and prone to channel migration and related erosion and slumping failures. Entire clumps of trees have caved into the river near RM 25.7, and with them, a former access roadway along the previous top of bank	Relocate deteriorating access roadway to landward to protect future King County trail corridor from bank erosion and channel migration, and to conserve productive agricultural soils with respect to channel migration hazards As part of the trail relocation and bank stabilization effort, replace non-compliant flood closure flapgate with fish-passable structure at the mouth of Northeast Auburn Creek and restore stream habitat with large woody debris and native tree and shrub plantings. Stabilize channel migration, regrade steep, failing riverbanks to stable angles of repose, excavate midslope benches/buttresses, and restore and stabilize mid-slope benches, riverbanks, and reconnected floodplain, side channel and wetland habitat areas with native riparian tree and shrub plantings.
25.7	26.54	L	Horsehead Bend: This pronounced inside bend of the river is entirely undeveloped County-owned Open Space. The channel margins support mature cottonwoods and, especially in low-lying upstream areas, dense stands of mature native riparian trees and understory shrubs. Where the bend starts to curve away at the downstream end, bank erosion and undercutting of the slope has facilitated recurrent toppling of trees into the channel. These may temporarily span the flow, but generally end up along the lower bank. The central portions of the bend are former farmlands which support localized monocultures of either blackberries or reed canarygrass. The access roadway for the Jeff Estates flood management structure is located along the southern margins of the open space here, separating this site from agricultural lands to the south.	Regrade and reconnect additional floodplain areas and re-create side-channel habitat within areas now dominated by blackberries and reed canarygrass in the central portions of the site. Do not disturb intact riparian floodplain forests in areas along the channel margins, even to the extent that these may be targeted as side-channel excavation sites in the Corps of Engineers Ecosystem Restoration Program. Configure any restoration efforts here at adding to functional floodplain habitat area, not subtracting.
26.9	27.3	L	Carpinito Farm Intermediate: This area is within a mapped Severe Channel Migration hazard Zone. Ongoing erosion of the central outer bend margins is evident, but appears to be progressing at a slower pace than elsewhere in the same overall river channel migration setting nearby.	Integrate any structural response to channel migration here with plans for recreational trail placement. Consider use of engineered log structures for control of ongoing channel migration, and include overall river channel morphology and dynamics in the design and placement of any structures thus determined. Integrate any such planning with consideration of appropriate setback relocations of the Green River Road Lower and Neilson revetments of the Lower Green River Road along the opposite bank in this reach.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
27.3	27.62	L	Carpinito Farm Upstream/Rubble Fill: This rapidly eroding and migrating channel segment adjoins the Carpinito Farm buildings, where the channel has moved over 175 feet to the west in the past 20 years, in a rapidly advancing and active outer meander bend. This segment is entirely within a mapped Severe Channel Migration Hazard Zone.	Several proposals have been advanced for addressing the pronounced meander bend development here, with respect to its impacts on the County's trail corridor and adjoining agricultural uses. Consider the entire context established by the dynamic river processes present, including the new floodplain being excavated by the river in response to controlled release of flows from Howard A. Hanson Dam over the past 50 years, and the contributing effects of the Mallory Revetment at the south 277th Bridge abutment along the opposite bank upstream. A long-term solution to accommodate this dynamism and corresponding habitat recovery and maintenance within the reach will be central to achieving the more localized goals of securing the trail corridor and protecting preserved agricultural soils from future erosion.
27.63	28.22	L	Reddington Extension / Green River Trail Corridor / Port of Seattle: The reach is entirely within a mapped Severe Channel Migration Hazard Zone, and channel migration has advanced over 150 feet into the reach along a broad outer bend over the past twenty years. Active bank erosion and undercutting is ongoing, and is particularly evident at River Mile 27.85.	Implement the Second phase of the Reddington Levee Extension Project, to include negotiation of future easements affecting the Port of Seattle property. Construct a setback levee. Modify the margins of the river channel with placement of wood structures to interact with flows and stabilize the remaining riparian corridor against destructive loss of property potentially affecting the new levee structure. Restore and re-plant the entire riverward corridor area.
28.5	28.6	L	Labrador Spoils Pile: An existing 3 acre capped pile of pesticide-contaminated soil abuts the alignment of the proposed Reddington Levee Setback and Extension project, which is designed to protect the area, including the spoils pile, from flood flows and damages.	Remediation or removal of the contaminated soil would reduce the risk of pesticide migration to the river, and could facilitate further setback of the levee alignment.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
29.49	29.68	L	Galli's Section: This entire flood management structure was repaired in-situ by the Corps of Engineers in 2008 for $2.8 Million. Initial placement of broken boulders for use as large armor rock proved problematic, and led to dislocation of some face armor during flooding in 2009, which was subsequently re-built. Several anchored logs were included in places along the reconstructed rock toe. Two layers of willow cuttings were included along the waterline, within the rip-rap armor facing layers. While these efforts have no doubt improved toe stability and scour resistance along the bank, the proximity of the existing homes has precluded a reconstruction of the riverbank to a flatter slope angle more in keeping with long-term slope stability requirements based on underlying soil strength limitations.	The underlying limitations posed by soil strength limitations will require that access areas along the top of bank be closely monitored for indications of deeper seated slope instabilities. To the extent that future deterioration of these slopes may become problematic, further survey and geotechnical evaluation of the existing road and riverbank should be performed as an initial step toward bank stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench.
29.5	29.68	L	Galli's Section: Nearly the entire reach adjoins residential properties, with a mix of single and multifamily homes present. Where rip-rap armor is present, as between RM 29.54 and 29.75, and again between RM 30.1 and 30.85, it is frequently over steepened, with localized erosion, and toe structure is questionable throughout. The exceptions here are limited to several local areas where the levee was reconstructed with large toe buttress rock, large woody debris deflectors, and with willow and dogwood cuttings installed in live geogrids.	Feasibility and technical analysis required.

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GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
29.68	30.8	L	Dykstra: Portions of the Dykstra Levee from RM 30.0 to 30.2 were repaired in-situ by the Corps of Engineers in 2008 for $1.6 Million. Several anchored logs were included in places along the reconstructed rock toe. There are two active, vegetated mid-channel bars near RM 30.2, which recruit natural large woody debris deposits, and which may influence flow direction and velocities affecting the Dykstra Levee. In addition, a low spot in the levee near River Mile 29.87 was raised by King County in 2009 to provide a uniform freeboard elevation at least two feet above the 100-year flood elevation. Substantially more freeboard is present in upstream areas near River Mile 30.6, and several earlier repairs dating the 1990's are present in upstream levee areas as well.	The underlying limitations posed by soil strength limitations will require that access areas along the top of bank be closely monitored for indications of deeper seated slope instabilities. To the extent that future deterioration of these slopes may become problematic, further survey and geotechnical evaluation of the existing levee crest and riverbank should be performed as an initial step toward more robust levee embankment stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench.
30.8	30.9	L	Lone's 3rd Addition: Long term stability of the riverbank remains questionable, especially with these practices present. Since adjacent homes were constructed about one foot or so above the estimated 100-year flood elevations, no freeboard is provided for levee containment here. Homes may therefore be at risk for newly estimated 500-year flood events, based on current estimates by the Corps of Engineers that Howard A. Hanson Dam may not be able to contain flooding for events larger than the one-in-140-year flood.	To the extent that future deterioration of these slopes may become problematic, further survey and geotechnical evaluation of the existing levee crest and riverbank should be performed as an initial step toward more robust bank stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
30.9	31.08	L	Downstream From Porter Bridge Left: No flood management structures are present in this segment. Adjacent apartment buildings and residential homes are raised just above the 100-year flood elevation, but no freeboard allowance is provided. Homes may therefore be at risk for newly estimated 500-year flood events, based on current estimates by the Corps of Engineers that Howard A. Hanson Dam may not be able to contain flooding for events larger than the one-in-140-year flood.	To the extent that future flood containment needs are identified within this segment, as may be likely to secure downstream areas with consistent freeboard provisions, design flood and freeboard elevations should be defined. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Construct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench.
31.12	31.33	L	Matson /Barnett /Porter Gauge /Auburn Residential: A series of idiosyncratic, individual attempts at bank protection are present in this reach, especially just upstream from the Porter Bridge (8th St. NE Bridge, Lea Hill Bridge). These use varying elements such as rip rap, concrete blocks, and concrete rubble, usually placed at near-vertical slope angles. . Any toe structures present are highly questionable. The Green River's Auburn Gauge is also in this reach, and is secured by a County-maintained revetment (Porter Gauge Though floodwaters do not appear to overtop the yards in this segment, no raised freeboard structure is provided. Homes may therefore be at risk for newly estimated 500-year flood events, based on current estimates by the Corps of Engineers that Howard A. Hanson Dam may not be able to contain flooding for events larger than the one-in-140-year flood.	To the extent that future deterioration of these slopes may become problematic, or the need for enhanced levels of flood containment and freeboard become evident within this reach, further survey and geotechnical evaluation of the existing levee crest and riverbank should be performed as an initial step toward more robust bank stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
31.8	32.02	L	Fenster Levee Setback and Floodplain Reconnection: The upstream half of the Fenster site was reconstructed between River Miles 31.9 and 32.0 with a cooperative levee setback and floodplain restoration project jointly funded by King County, the City of Auburn, and the State of Washington's Salmon Recovery funding Board in 2008. This involved wholesale removal and of the deteriorating Fenster Levee, setback levee reconstruction, regrading of the floodplain to better interact with floodwaters over a range of dam-controlled flow releases, construction of a setback buried rock toe and floodplain swale feature, anchoring of 95 logs with roots along the margins of the river channel, and dense revegetation of the site with a variety of native riparian tree and shrub species. Pronounced flooding in November of 2008 and January of 2009 resulted in channel migration within the setback area larger than anticipated, with the result that the anchored logs are now positioned up to 60 feet away from the retreating cutbank. The setback toe and levee are not affected by this outcome. Relocation and reconfiguration of the anchored log features is now planned. This action will be coordinated with the introduction of an additional 31 anchored logs serving as required mitigation for the impacts of clearing trees from the Dykstra and Galli's Levees downstream. The clearing was completed in order to maintain funding eligibility of these structures in the Corps of Engineers' PL-99 Rehabilitation Inspection Program. It is anticipated that the repositioned and newly installed logs will be anchored with wooden pilings to also reinforce the retreating riverbank. Recreational safety concerns will be fully addressed in this proposed action. Plans are also underway to design, permit, fund, and construct a second increment of similar levee setback, floodplain reconnection, and riparian restoration for the downstream portions of the remaining, original Fenster Levee structure.	Design and construct the Fenster log relocation and mitigation project actions. Design, fund, and construct the Fenster Phase II Levee Setback and Floodplain Reconnection Project at the downstream half of the site.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
33.41	34.61	L	Porter /Neely: The entire Porter site is subject to flooding on a nearly annual basis, with higher flow events extending to the SE Green Valley Road and seeping up through the gravel shoulder to flow across the asphalt near the Green Valley Meats Company. The river in this reach shows active channel migration, with the Neely levee acting as a training levee here. Nearly the entire area" floods on a nearly annual basis. Toe buttress structure is questionable, overtopping of the Neely Levee is a repeated phenomenon, flood containment is not provided for intermediate flow events, and a functional vegetative buffer is not present.	Relocate deteriorating levees to the edge of the floodway within the adjoining agricultural areas at the Neely site, and to the Green Valley Road at the Porter site. Appropriate mitigation must be provided to offset any impacts to properties enrolled in the Farmlands Preservation Program. Address chronic roadway flooding and associated flooding of the Green Valley Meats site across the road from Porter. Restore old side-channel connections and re-activate the former channel migration areas. Restore and stabilize the aquatic edge of the channel with large woody debris installations, reconnect and restore isolated floodplain wetlands, and plant all disturbed areas with native riparian and wetlands vegetation, as appropriate.
34.62	35.06	L	Neely /Pre-1959: The levee embankment is very steep, and the levee crest is currently inaccessible to vehicles due to its overgrown condition. Flood mapping completed in 2006 to FEMA standards shows that flows are likely to proceed through areas landward of these substandard levees, including around the farm buildings and home, and then pass around the left bridge abutment at the downstream end.	Raising and reconstructing the existing access roadway in its current setback alignment would allow re-location of the existing levee landward, while retaining the existing toe structure location and the greater portion of the extremely healthy volunteer vegetation now present along the lower slopes of the existing levee intact. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
40.1	40.2	L	Landslide Potential Reach: The river along the left bank flows right along the base of a steep, nearly vertical hillside that has previously produced small-scale landslides directly into the river channel. A major slide here is certainly possible, and would block the existing mainstem channel, similar to what occurred in the Elliot Reach of the Cedar River during a large earthquake. At this Green River location, this slide event would re-route the flows directly through a large-lot residential area immediately across the river, along Crisp Creek and the distributary inlet to Burns Creek, potentially causing extensive property damage and posing a potential safety threat to residents.	Perform a thorough geological and geotechnical evaluation of potential landslide risks along the hillside in this reach. Consider the magnitude and likelihood of potential slide events, and potential impacts on river channel conveyance and flow patterns in the floodplain along the opposite bank. Consider both upstream (backwater) and downstream impacts likely from the range of potential events considered. Determine alternative actions and a recommended appropriate course of action based on findings delivered.
40.2	42.2	L	Newaukum Creek /Green River Waterway /Whitney Bridge / "Soapstone": The Newaukum Creek confluence is near the downstream end of this segment, forming a partial alluvial fan at the outlet of a small, densely wooded ravine. The downstream 2/3 of the fan has been restored as riparian habitat by King County, while cleared pastures extend upstream. There do not appear to be any flood containment facility or actively maintained revetments in this reach, though older farming activity may have constructed some, now covered with trees and brush. Floodwaters do not appear to overtop the banks, as this reach is relatively straight, steep, and somewhat incised. Gravel bars are present, as are two prominent vegetated mid-channel bars downstream from the bridge, which recruit large wood deposits from time to time.	No defined mainstem river project is present in this reach, with the exception of maintaining the bridge abutments. The restoration area at the Newaukum Creek alluvial fan needs to be monitored and maintained as needed, especially with respect to minimizing flooding and fan-building episodes on the agricultural pastures just immediately upstream.
42.2	42.3	L	Flaming Geyser Landslide: The river here forms a wide outer bend along the base of a steep, wooded hillside at the downstream end of Flaming Geyser State Park. The center of this segment is occupied by a landslide, covering perhaps three or four acres of hillside. Sediments from this slide are periodically released into the river, including a great deal of fine sediments which may impact spawning gravel quality and salmonid survival downstream. The slide mass is large enough, and active enough, that a complete blockage of the existing channel is quite possible. If this were to occur, the river would likely cut a new course through wooded, undeveloped parklands on the meander bend directly across the current channel from the slide location	Some previous interest has been expressed in managing the input of fine sediments from the slide here into downstream spawning areas. Though the scale of the slope stabilization measures needed would be quite substantial, simply isolating the base of the slide from undercutting along the channel margins may be somewhat helpful in this regard. This could be done by periodic replenishment of a wide berm constructed of sacrificial spawning gravels placed along the margins of the channel where the river intersects the toe of the slide deposits.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
43.1	45.0	L	Flaming Geyser Left: Much of the riverbank within the State Park is covered with old rip-rap armored revetments, including portions along the road shoulder and a densely vegetated older rip-rap levee structure entering the picnic area. These revetments are steep, toe structure is questionable where it borders on the active flow area of the channel, , and local evidence of erosion and rip-rap dislocation is visible.	Several proposals for setback road reconstruction, channel restoration, and floodplain reconnection have been advanced here over the years. Bridge and road stability would be carefully considered and secured in any such proposal.
5.2	5.52	R	Boeing Frontage: Old pilings and wooden current deflector structures attempt to reduce erosion and slumping of narrow embankment fronting private (Boeing) access and covered walkway immediately at top-of-bank. Building corner is built right to edge of embankment near downstream end. Channel is deep with a moderately vegetated depositional area in the lee of an old piling array near the upstream end. Extreme tides have been shown to flood adjacent parking in the past. Privately owned and maintained.	None feasible at this time due to land use conditions.
5.52	5.69	R	S. 104th Road Protection/Top Bank Protection Right: Log piling current deflector structure at downstream end attempts to minimize erosion of Boeing Oxbow Bridge. Facility fronts S. 104th Street at top of extremely steep slope with unknown toe depth or structural characteristics. Upper bank has previously been repaired by Tukwila with County cooperation, using a version of bioengineered slope repair. Overall integrity of the slope and the road is highly questionable. Overall habitat value is negligible at present.	Perform soil investigations and embankment survey to define physical and structural parameters. Evaluate road embankment and slope stability with geotechnical study. Define slope stability and structural needs. Acquire any lands needed. Reconstruct toe and slope to stable configuration with fully bioengineered solution preferably including a vegetated midslope bench.. Setback and reconstruct roadway, or abandon.
5.69	5.82	R	East Marginal Way Slope Protection: Outer bend with road at immediate top of bank. Toe structure undetermined. Erosion and slumping of embankment have occurred in the past with localized repairs by the City of Tukwila using a version of bioengineered slope stabilization. Overall the slope is steep, structurally at risk and of uncertain construction and structural integrity. The roadway is a major 6-lane arterial and sits immediately at the top of slope and would be impacted by any slope failures.	Perform soil investigations and embankment survey to define physical and structural parameters. Evaluate road stability with geotechnical study. Define slope stability and structural needs. Acquire any lands needed. Reconstruct toe and slope to stable configuration with fully bioengineered solution, preferably including a vegetated midslope bench.. Setback and reconstruct roadway as needed.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
5.82	6.14	R	Privately owned: Slopes are steep, erosion and slumping is visible, the toe structure is questionable and the vegetation is limited to the riverbank itself and is dominated by blackberries with scattered, immature deciduous trees present in a few locations. Industrial properties border over steepened slopes with substantial debris and rubble fills forming the embankment. Parking lots, roads and commercial structures are located at the top of bank. Space for a vegetated buffer area is absent.	Consider acquisitions over time based on market conditions to allow bank restoration, and shallow water habitat creation.
6.29	6.54	R	Boeing / Old Duwamish Drive-In: The river bank here was reconstructed at a 2H:1V slope angle in connection with construction of the office towers at this site Unconsolidated sediments deposits along the channel edge form a broad shallow shelf along the toe of the slope. Large woody debris placed during bank reconstruction is also present.	A careful survey and structural evaluation of the embankment and supporting toe is needed, due to inadequate construction of the original slope stabilization measures by the property owner. Slope reconstruction would provide an opportunity to restore riparian vegetation and shallow water habitat.
6.54	6.83	R	Gateway Lowest Right/Duwamish Gardens: This steep eroding and slumping bankline shows no evidence of previous stabilization measures. A narrow shelf of unconsolidated sediments forms the toe slope along the channel edge. The upstream portion of this reach is under acquisition by the City of Tukwila for eventual funding and construction of the Duwamish Gardens habitat restoration project.	Duwamish Revetment Setbacks and Shallow Water Habitat Creation: Revetment setbacks, bank restoration, and shallow water habitat creation. Rehabilitate steep, older, deteriorating revetments, establish stable slopes, restore native vegetation, and provide opportunity for shallow water habitat creation. Channel edge habitat creation will include reconstruction and stabilization of substandard toe buttress structures serving existing maintained facilities.
6.83	7.85	R	S 115th St / 42nd Ave S: Paved streets (some of which lack road shoulders) are located at the top of bank in many portions of this intertidal segment. A high pressure water main is located at the top of bank in the road shoulder along portions of 42nd Ave S. Several previous slumps have been stabilized with large rock or piling and log toe structures and biotechnical stabilization measures, including the 42nd Ave S bridge abutment at the upstream end of this reach. Large woody debris was installed at several previous repairs sites, and has locally induced sediment deposition, helping to stabilize the toe of the slope. The roadway remains at risk of continued settlement of the bank and cracking of the asphalt road pavement.	Perform soil investigations and embankment survey to define physical and structural parameters. Evaluate road stability with geotechnical study. Define slope stability and structural needs. Acquire any lands needed. Reconstruct toe and slope to stable configuration with fully bioengineered solution, preferably including a vegetated midslope bench. Setback and reconstruct roadway as needed.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
7.85	8.85	R	Banchero Right / Tukwila Community Center / S 125th St / Codiga Farm / Steel Hill Bridge / 9.6 Revetment Right: This segment includes an older riprap revetment and riprap fills that cross the river over a King County sewer line, an asphalt trail with a concrete retaining wall along the channel edge at the Tukwila Community Center, a steep, riprapped road shoulder embankment along S 125th St, several residential properties bordering the top of bank, an off-channel constructed wetland in Codiga Farm Park and an additional steep riprap embankment bordering 50th Pl S. The Community Center trail is occasionally submerged during exceptionally high tides and high flows, or both. Where riprap embankments are present, they are steep, the toe structure is questionable and local evidence of slope settlement and erosion is visible.	Perform soil investigations and embankment surveys to define physical and structural parameters. Evaluate road, trail and bank stability with geotechnical study. Define slope stability and structural needs. Acquire any lands needed. Reconstruct toe and slope to stable configuration with fully bioengineered solution, preferably including a vegetated midslope bench. Evaluate the use of driven untreated wooden pilings to reinforce and stabilize the toe of slope within the soft sediments present. Setback and reconstruct trail and roadway as needed.
8.85	9.6	R	Allentown: A number of residential properties border steep eroding banks. Many of the backyards and outbuildings are located within the mapped 100-year floodplain, and portions of several lots are within the mapped floodway of the Green River. Bank erosion and slumping are evident, including the occasional recruitment of cottonwoods into the channel. (Green River, City of Tukwila)	Flood risk management actions are currently up to individual owners. Any attempts at riparian restoration would need general agreement among these owners, along with the acquisition of easements, or would require the incremental acquisition of parcels as market conditions and funding may allow.
9.6	10.14	R	Rendering Works Lower and Middle The toe structure is questionable throughout. The banks remain locally steep and minor erosion and slumping is visible in places. Portions of the site are mapped within the 100-year floodplain, and the margins of the site are within the mapped floodway. (Green River, City of Tukwila)	Consider long term acquisition and restoration of the site as market conditions and funding may allow, including floodplain reconnection.
10.15	10.95	R	Railroad Embankment: It may be presumed that the toe structure here is adequate.	Preliminary evaluation.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
10.25	10.75	R	Foster Golf Course (Foster Lower, Middle, Upper and Right): Much of the golf course is mapped within the 100-year floodplain, which extends to Interurban Avenue to the west, and to and several commercial properties upstream as well. Portions of the site have been identified for placement of piling-anchored logs and plantings as mitigation for clearing of trees and other native vegetation from levee slopes elsewhere in Tukwila, as part of eligibility and compliance with the Corps of Engineers PL-99 Levee Rehabilitation and Inspection Program.(Green River, City of Tukwila)	Develop a plan for stabilizing the riverbanks along the margins of the golf course in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Reconstruct toe and slope to stable configuration with fully bioengineered solution preferably including a vegetated midslope bench, preferably including a vegetated midslope bench. Reconfigure tees, fairways, and greens along channel margins as needed. Establish uniform riparian buffer with native vegetation.
10.95	12.2	R	Fort Dent to Tukwila Bend A steep levee with older riprap armor present in places borders Fort Dent Park. Slopes remain steep overall, and toe structure has not been confirmed to be adequate. Localized erosion and slumping is present in places. Freeboard is variable and inadequate in places, and portions of the reach are within the mapped 100-year floodplain	Survey and geotechnical evaluation of the river embankment should be performed as an initial step, and a plan for stabilizing the riverbanks defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Evaluate bank stability with geotechnical study. Determine design flood and freeboard elevations. Define slope stability and structural needs. Acquire easements as needed. Reconstruct toe and slope to stable configuration with fully bioengineered solution. Establish uniform riparian buffer with native vegetation. Reconstruct and raise the trail for flood containment as determined. Restore the failing toe buttress structure and rehabilitate aquatic habitat along the channel edge with large woody debris placement. Replant the riverbank and midslope bench areas with native trees and shrubs to restore riparian habitat conditions. (Green River, City of Tukwila)

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
12.44	12.56	R	I-405: This segment includes levees built in connection with the relocation of the Green River during construction of I-405. A small relict portion of the original channel is present behind the levee together with a hotel property and an historic farmhouse. Mature native deciduous trees occupy a narrow strip confined to the riverbank at the downstream end, and along the margins of the I-405 off-ramp. Native woody shrubs also grow around the margins of the abandoned channel segment. Blackberries and other invasive species dominate the steep face of the levee at the upstream end of this segment Although there is no constructed outfall from the relict channel to the existing river, high flows in the river appear to seep through the intervening berm and fill the wetlands. Portions of the adjoining site are mapped within the 100-year floodplain.	Identify flood containment requirements around the margins of the abandoned channel. Construct these measures to secure adjoining properties from any flooding, and remove that portion of the existing riverbank levee which is separating the old channel from the current river. Re-connect the abandoned river channel to the existing mainstem as a side channel habitat area. Set back remaining portions of the steep, eroding levee, and increase flood storage and conveyance capacity. Stabilize and rehabilitate the channel edge with large woody debris installations, and restore riparian and wetlands habitat areas with a uniform buffer of native tree and shrub plantings.
12.56	12.78	R	Best Western (Nendel's): The levee here is steep, armored with riprap and includes rubble near its upstream end. A few cottonwoods are present where it joins SR-181, also known as the West Valley Highway, and adjacent to I-405. The toe structure is questionable throughout this segment, and the levee face is dominated by blackberries. Localized slope failures are present and progressing. Portions of the adjoining site are mapped within the 100-year floodplain.	To the extent that 500-year flood risk management policy decisions may require levee modifications to protect other uses in affected floodplain areas, survey and geotechnical evaluation of the river embankment should be performed as an initial step, and a plan for stabilizing the riverbanks defined in concert with riparian buffer restoration. Relocation of structure to setback levee possible in the future pending zoning code changes. Perform soil investigations and embankment surveys to define physical and structural parameters. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties and easements as needed, and as conditions and funding may allow. Reconstruct toe and slope to stable configuration with fully bioengineered solution, preferably including a vegetated midslope bench. Reconstruct raised levee crest to design flood and freeboard elevation as defined.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
12.78	14.49	R	SR-181: This segment includes a portion of the riverbank adjoining SR 181, with the roadway at its riverward margins effectively acting as the flood containment structure. The bank itself is very steep, intermittently affected by localized sediment deposits and their subsequent erosion or slumping, and the integrity of the toe structure is questionable.	Clear establishment of flood and highway management responsibilities here is essential to flood risk mitigation planning and actions. To the extent that embankment stability and 500-year flood risk management policy decisions may require levee modifications to protect other uses in affected floodplain areas, survey and geotechnical evaluation of the river embankment should be performed as an initial step, and a plan for stabilizing the riverbanks defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties and easements as needed, and as conditions and funding may allow. Purchase of the single family home may be required in this context. Reconstruct toe and slope to stable configuration with fully bioengineered solution, preferably including a vegetated midslope bench. Provide a uniform riparian buffer. Modify the roadway and reconstruct a raised levee crest to design flood and freeboard elevation as defined. A separate levee structure may be required.
12.85	13.11	R	Homewood Suites / Burnaby's: This reach consists of a small inside meander bend adjoining the Homewood Suites hotel units downstream from Strander Bridge and Burnaby's Restaurant just upstream from Strander Bridge. The banks are locally steep, and erosion and slumping have been observed. A jet fuel conveyance pipeline passes under the riverbed here just upstream from Strander Bridge, , and then along the area riverward of Burnaby's Restaurant.(Green River, City of Tukwila)	To the extent that embankment stability and 500-year flood risk management policy decisions may require levee modifications to protect other uses in affected floodplain areas, survey and geotechnical evaluation of the river embankment should be performed as an initial step, and a plan for stabilizing the riverbanks defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties and easements as needed, and as conditions and funding may allow. Reconstruct toe and slope to stable configuration with fully bioengineered solution, preferably including a vegetated midslope bench. Provide a uniform riparian buffer. Modify the trail and reconstruct a raised levee crest to design flood and freeboard elevations as defined.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
13.11	13.23	R	SR-181 / Nelson: This segment includes a portion of the riverbank adjoining SR 181, with the roadway and a raised floodwall at its riverward margins effectively acting as the flood containment structure. The downstream end of this reach includes a single family residence riverward of the roadway, perched directly at the top of the steep riverbank, which is overgrown with invasive bamboo. The riverbank serves as the immediate structural support for the road over the upstream half of this segment, with the "back yard" of the home bordering the river at the downstream end. The lower bank supports invasive blackberries and reed canarygrass. The bank itself is very steep, intermittently affected by localized sediment deposits and their subsequent erosion or slumping, and the integrity of the toe structure is questionable. County maintenance easements may be present for some portion of the reach. The riverward (southbound) driving lane adjoining the bank shows clear indications of settlement, with the formation of a continuous series of arcuate scarps and cracks visible in the asphalt.	Clear establishment of flood and highway management responsibilities here is essential to flood risk mitigation planning and actions. To the extent that embankment stability and 500-year flood risk management policy decisions may require levee modifications to protect other uses in affected floodplain areas, survey and geotechnical evaluation of the river embankment should be performed as an initial step, and a plan for stabilizing the riverbanks defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties and easements as needed, and as conditions and funding may allow. Purchase of the single family home may be required in this context. Reconstruct toe and slope to stable configuration with fully bioengineered solution, preferably including a vegetated midslope bench. Provide a uniform riparian buffer. Modify the roadway and reconstruct a raised levee crest to design flood and freeboard elevation as defined. A separate levee structure may be required.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
13.23	13.78	R	Nelson / N.C. Machinery / SR-181: Industrial and commercial buildings, parking lots, and equipment storage areas occupy a small inside meander bend. Riprap repairs have been made to the river bank at the upstream end of this segment. . A few narrow floodplain benches are present, but most of the segment is characterized by older riprap Slope stabilization is discontinuous, the toe structure is highly questionable, and highly visible, intermittent sediment deposition, bank erosion and slumping are present. Except for a few isolated trees, a narrow band of native riparian trees and shrubs downstream from the railroad bridge, some of which have recently been toppled into the channel, and a row of Lombardy poplars at the very downstream end of this segment, the bank vegetation consists almost entirely of a blackberry-reed canary grass biculture. A railroad bridge with concrete abutments bisects the reach at RM 13.35. Although it is not within the mapped 100-year floodplain, localized shallow flooding has previously been observed just upstream from the railroad bridge, and along SR 181 near the downstream end here. No uniform flood containment or freeboard elevation is present. These areas and sites to the east and north across from SR-181 may therefore be at risk for flooding during the 500-year event, based on recent estimated by the Corps of Engineers that the storage reservoir at Howard A. Hanson Dam may not be able to control flow releases for events larger than the one-in-140-year event. (Green River, City of Tukwila)	. To the extent that embankment stability and 500-year flood risk management policy decisions may require levee modifications to protect other uses in affected floodplain areas, survey and geotechnical evaluation of the river embankment should be performed as an initial step, and a plan for stabilizing the riverbanks defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties and easements as needed, and as conditions and funding may allow. Reconstruct toe and slope to stable configuration with fully bioengineered solution, preferably including a vegetated midslope bench. Provide a uniform riparian buffer. Reconstruct a raised levee crest to design flood and freeboard elevation as defined

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
13.78	14.48	R	SR-181/West Valley Highway: The state highway here performs the levee containment function, even though it is not a formal part of the levee system. No easements or agreements exist with the State of Washington Department of Transportation to operate the roadway as a part of the flood containment system, or for the County or the Flood District to manage this function here. That said, several portions of the reach include vertical steel walls along the upper margins of the riverbank to support the road grade, and roadway elevations are generally high enough to confine 100-year flows. Questions remain however about the ability of the roadway to serve as a containment system for floods up to the 500 year event, with appropriate freeboard. Therefore areas to the north and east may be at risk of flood inundation, based on recent estimates by the Corps of Engineers that the storage reservoir at Howard A. Hanson Dam may not be able to constrain flow releases from the dam for floods exceeding the one-in-140-year event. Based on current FEMA floodplain mapping standards, a Preliminary Digital Flood Insurance Rate Map prepared as part of the 2006 Green River Flood Study includes much of this area within a mapped floodway of the Green River. As FEMA is currently considering revisions to its levee evaluation procedures, revisions to this mapping result may be forthcoming in the near future.	Clear establishment of flood and highway management responsibilities here is essential to flood risk mitigation planning and actions. Depending on policy decisions to maintain historic containment of 500-year flooding in the lower Green River valley, additional levee containment and freeboard elevation increases may in fact be required as well, based on newer estimates of 500-year flows now being confirmed by the Corps of Engineers. To resolve these concerns and questions, interlocal agreements will need to be negotiated between the Washington DOT, the City of Tukwila, King County, and the Flood District to define roles, responsibilities, and mutually agreed-upon outcomes. To the extent that embankment stability and 500-year flood risk management policy decisions may require levee modifications to protect other uses in affected floodplain areas, survey and geotechnical evaluation of the river embankment should be performed as an initial step, and a plan for stabilizing the riverbanks defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties and easements as needed, and as conditions and funding may allow. Reconstruct toe and slope to stable configuration with fully bioengineered solution, preferably including a vegetated midslope bench. Provide a uniform riparian buffer. Modify the roadway and reconstruct a raised levee crest to design flood and freeboard elevation as defined. A separate levee structure may be required.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
13.78	14.49	R	SR-181: This extensive segment includes multiple portions of the riverbank adjoining SR 181, with the roadway and raised floodwall segments at its riverward margins effectively acting as the flood containment structure. The riverbank serves as the immediate structural support for the road over much of this length, with some intermittent floodplain bench deposits also present here and there between the roadway and the actual riverbank. The lower bank supports invasive blackberries and reed canarygrass. The bank itself is very steep, intermittently affected by localized sediment deposits and their subsequent erosion or slumping, and the integrity of the toe structure is questionable. The riverward (southbound) driving lane adjoining the bank shows some indications of settlement, with some cracks visible in the asphalt. A thriving stand of native willows covers the slope just upstream from the S 180th St bridge. These willows were installed as mitigation for widening of the bridge. Except for the riverbank itself, no riparian buffer area is present. The highway is at the top of bank through most of this reach.	Clear establishment of flood and highway management responsibilities here is essential to flood risk mitigation planning and actions. To the extent that embankment stability and 500-year flood risk management policy decisions may require levee modifications to protect other uses in affected floodplain areas, survey and geotechnical evaluation of the river embankment should be performed as an initial step, and a plan for stabilizing the riverbanks defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties and easements as needed, and as conditions and funding may allow. Reconstruct toe and slope to stable configuration with fully bioengineered solution, preferably including a vegetated midslope bench. Provide a uniform riparian buffer. Modify the roadway and reconstruct a raised levee crest to design flood and freeboard elevation as defined. A separate levee structure may be required.
17.86	19.27	R	Russell Road Lowest / Holiday Kennel / Russell Road Lower: This segment is severely confined almost throughout by the close proximity of Russell Road S to the top of bank. Steep banks and slumping an issue in this reach.	Setback the Levee, Road, and Trail to a minimum stable slope inclination of 3H:1V, and integrate them into an overall solution meeting the design standards and performance requirements for each. Acquire all lands needed to this end. Additional survey and geotechnical evaluation of the river embankment should be performed as an initial step, and a plan for stabilizing the riverbanks defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Evaluate bank stability with a geotechnical study. Define slope stability and structural needs. Acquire properties and easements as needed. Provide a uniform riparian buffer. Reconstruct a stable levee toe, and a fully stabilized, bioengineered slope, preferably including a fully vegetated midslope bench.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
21.92	22.13	R	Pipeline / Okimoto: Both levees in this segment have been previously repaired. The Pipeline Levee at the downstream end has been set back into the margins of a large retention/detention pond adjacent to an apartment complex. The slopes were regraded to form two midslope benches and the bankline was scalloped at the water's edge to create shallow marginal habitat. Logs were also anchored to large rocks along the channel edge. Native riparian vegetation planted during this project has slowly established. Extensive vandalism occurred following initial revegetation of this site with removal of almost 100 % of the plantings on the landward slope of the flood protection facility, which has subsequently been invaded by Scots broom. The lower river bank is steeper on the Okimoto Levee, which adjoins a portion of the Signature Pointe residential apartment complex, but the paved trail here was also set back and the upper slopes subsequently regraded to form a bench as well. While large wood was not installed with the Okimoto repair, live geogrid plantings have grown profusely to form dense cover overhanging the channel. The levee appears to provide two feet of freeboard above the base flood elevation. Landward areas are about two to 12 feet in elevation below the levee crest. The extent to which new estimates of 500-year flow elevations may require addition of freeboard in this reach still needs to be determined.(Green River, City of Kent)	The City of Kent has proposed to construct a setback levee berm at the upstream end of this segment, tying the levee off to the downstream margins of the State Route 516 Bridge abutment. The recreational trail and a private roadway connecting the upstream portions of the Signature Pointe Apartment complex will still need to pass beneath the State Route 516 Bridge abutment, and riverbank slopes supporting these structures remain extremely steep. These will have to be closely monitored and engineering solutions developed to address any future deterioration of the embankment or toe. The extent to which new estimates of 500-year flow elevations may require addition of freeboard in this reach still needs to be determined, and may require additions to the existing levee crest elevation, together with appropriate acquisitions to accommodate corresponding widening of the base of the levee prism along the landward toe.
22.06	23.18	R	Signature Pointe Lower / Signature Point Upper / County Road #8: This mostly armored revetment segment extends from the State Route 516 Bridge at the downstream end up to the Washington Avenue Bridge at its upstream end. A sharp inner meander bend is wholly occupied by the Signature Pointe Apartments. The toe structure is questionable throughout these steeper areas and historical slumping has occurred.	New estimates of 500-year flow elevations may require addition of freeboard in this reach. Recognizing that large-scale slope failures have been in evidence along both the upper and lower segments of this reach, any additions of freeboard should also address a reconstruction of the steeper slopes present, targeting stable slope geometries based on studies of soil strength properties and river scour depth potentials. Additional survey and geotechnical evaluation of the river embankment should be performed as an initial step, and a plan for stabilizing the riverbanks defined in concert with riparian buffer restoration.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
23.82	24.04	R	Milwaukee #1 / Foster Park: The original levee is steep and armored with older riprap, the toe structure is questionable, and localized bank erosion is visible in slumps dominated by reed canary grass and blackberries, with some scattered willows also present along the waterline. The trail along the crest of the old levee here shows cracking and settlement of the asphalt throughout, possibly indicating settlement or instability in the underlying levee embankment. The City of Kent has used funding provided by the Washington Department of Ecology to construct a "secondary" levee tied in to SR167 at its downstream end, along the southerly margins of South 259th Street, at the north end of the pond. This alignment leaves the detention pond on the riverward side of the levee containment structure. Neither the old levee along the riverbank or the new secondary levee provides freeboard above the currently estimated elevation of the 500-year flood, based on currently revised estimates from the Corps of Engineers.	Any investigations of the old levee here should include further survey and geotechnical evaluation of the existing trail and riverbank as an initial step toward bank stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and trail alignment to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
24.06	24.26	R	Milwaukee #2: Upstream from the RR bridge, the Milwaukee #2 Revetment borders the edge of S 259th St and a small commercial structure, extending upstream to the 3rd Avenue Bridge abutments. The bank here is very steep, armored with riprap, the toe structure is questionable, localized bank erosion is visible in slumping areas dominated by reed canary grass and blackberries, with some willows also present. A segment of the bank comprised of older fill slumped up to the crest of the slope in 2006 near River Mile 24.1, and miscellaneous rubble fill was dumped over the slope by the land owner here in an attempt to address erosion. It is likely these efforts were ineffectual or actually made the situation even less stable. A proposed extension of the Green River trail is planned here, but will require additional right-of-way and a set back of S 259th St. The entire buffer area is occupied by the roadway and adjacent commercial properties. Road grades along South 259th are only slightly elevated with respect to neighboring sites, except near the upstream end at the bridge abutment. Ground elevations are just at or above calculated 100-year flood elevations, but provide no freeboard. Lands extending northward from the roadway edge are likely subject to flood risks associated with 500-year events, based on currently revised estimates from the Corps of Engineers.	Riverward embankment slopes here should be carefully monitored. To the extent that slope settlement and deterioration of the levee embankment may become more problematic with time, survey and geotechnical evaluation of the river bank should be performed as an initial step toward slope and levee stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Elimination of the existing detention pond and substitution of a bioswale function along a setback levee bench may adequately provide any lands needed to this end, with direct discharge to the river via the existing pump station. Reconstruct toe, slope and levee crest to a stable configuration with a fully bioengineered solution, preferably including a midslope bench. Establish a uniform riparian buffer with native vegetation.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
26.5	28.43	R	Titus Boat Ramp / Titus Pit / Green River Road Lower/ Neilson / Mallory / Malnati The road embankment along the river is uniformly steep, unstable, eroding, slumping, covered with deteriorating and undercut riprap. The toe structure is highly questionable throughout these road locations. A poorly functioning flood closure structure is present at the outlet of the culvert discharging tributary flows from the Cooter Pond wetlands to the river under the roadway near River Mile 27.28. A common feature of all the road revetments is that they appear to be involved in deflecting flows downstream and across the channel, and are likely involved in the development and progression of active bank erosion and channel migration in affected locations. The depositional bends between the road revetments show clear evidence of meander advance, and can be characterized as new river floodplains formed in response to altered flows resulting over the past 50 years form active management of flood peaks by Howard A. Hanson Dam.	The flood closure system at the Cooter Pond outlet should be upgraded and reconstructed with a fish-passable closure device, and a backup closure in a flood accessible manhole structure. To the extent that road shoulder embankments may continue to deteriorate, riverward embankment slopes here should be carefully monitored. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and roadway to a stable configuration with a fully bioengineered solution, preferably including a midslope bench. Establish a uniform riparian buffer with native vegetation. A long-term solution to accommodate this dynamism and corresponding habitat recovery and maintenance within the reach will be central to achieving the more localized goals of both securing the roadway on the right bank, and the levee and trail corridor and agricultural soils across the river from future erosion.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
28.45	30.0	R	Auburn Golf & Olson / Isaac Evans Park / Valentine's Road Protection: Portions of the roadway near the downstream end of the golf course have previously been closed due to flooding, and extensive flooding is frequently present throughout much of the golf course. Flooding affects large areas of the Isaac Evans park where this older confinement system has been breached for recreational beach access to the river. The roadway and adjoining residential areas just upstream from the golf course and landward from the park may be at risk of flooding for river elevations exceeding the newly estimated once-in-140 year flood, including newly calculated 500-year flood levels.	To the extent that road and residential areas may be found to be at risk of flooding for larger future flood events, a uniform containment system defining the margins of the residential area could be proposed in this reach. This might entail raising of the Green Valley Road and an accompanying berm along the upstream margins of the golf course. To the extent that road shoulder embankments may continue to deteriorate, riverward embankment slopes here should be carefully monitored. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and roadway to a stable configuration with a fully bioengineered solution, preferably including a midslope bench. Establish a uniform riparian buffer with native vegetation. The densely vegetated older levee structure within Isaac Evans Park might also serve as an element in future analysis of the effects of vegetation of levee and slope stability, as it has likely been present since the early portions of the 20th Century.
30.09	33.26	R	North Green Valley Wall: Just upstream from 8th St NE, several single-family homes are located along the top of bank. These homes may be at risk of flooding for newly calculated flow events larger than the once-in-140 year event, including newly estimated 500-year flow elevations.	To the extent that long term risk reduction may be desired for homes potentially at risk for newly estimated flood elevations corresponding to the 500-year event, the feasibility of their raising, floodproofing, or acquisition and removal should be evaluated. Acquiring homes nearest the bridge might also allow for staging emergency equipment as needed to remove any future log accumulations potentially affecting the structure.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
30.18	30.4	R	104th Road Protection / 30.5 Road Protection: The 104th Avenue Southeast roadway here is placed right at the top of a steep rock armored riverbank. The road has no shoulder in the majority of this segment, but is bordered with a jersey barrier set right at the edge of the riverbank. A dense growth of vigorous immature alders and willows occupies most of the riverbank.	To the extent that road shoulder embankments may continue to deteriorate, riverward embankment slopes here should be carefully monitored. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and roadway to a stable configuration with a fully bioengineered solution, preferably including a midslope bench. Establish a uniform riparian buffer with native vegetation.
30.4	31.09	R	Porter Bridge / Pig Farm: The Porter Bridge Levee at the upstream end is discontinuous, with homes built right down to the base flood elevation in the middle portions of this segment. Slopes are steep, toe structure is questionable, and flood closure and freeboard is discontinuous or absent. Residential homes may be at risk of inundation during the 500-year flood event, based on current estimates by the Corps of Engineers that Howard A. Hanson Dam may not be able to contain flooding for events larger than the one-in-140-year flood.	Based on concerns with future deterioration of the levee structure here, or with decisions to provide residential areas in this reach with 500-year flood confinement plus freeboard, acquisition of one or two homes near the upstream end of the Porter Levee may allow for it to be set back to a more stable angle and integrated with a raising of 102nd Avenue Southeast. A continuous containment structure could then be sited along the same setback corridor used for placement of temporary flood containment "Supersack" levees in 2009, which would then continue to the east along the southerly margins of the Pig Farm open space and tie into the hillside or a raised portion of 104th Avenue Southeast at its downstream terminus.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
34.54	37.65	R	Horath / Kaech / Hamakami / Ross / Turley / Lone's: The Green River is bordered by several older levees and revetments which truncate a set of formerly active meanders along the margins of several agricultural properties that occupy the adjacent floodplain terrace. In other locations the bank is actively and rapidly eroding as at the Ross Farm near RM 36.15 at the Hamakami Farm near RM 35.7, and at the Lone's Levee near River Mile 37.5. Much of the old levee face and all of the armor has been eroded from the embankment at this latter location. Bank stabilization of the active meander at the Hamakami flood protection facility was accomplished with installation of large woody debris and native riparian plantings. This location has subsequently developed extremely complex and natural large woody debris accumulations with multiple, highly dynamic side channels, active vegetated gravel bars, and extremely complex instream habitat. Burns Creek enters the Green River around the upstream end of the Loans Levee at the very upstream end of this segment. Overbank flooding is frequent in lower lying areas throughout this reach. The pattern of flooding is complex, and involves a network of older channel alignments passing through the valley floor. Several residential structures are affected, most notably those just upstream from Hamakami.	Horath-Kaech Levee Setback and Floodplain Reconnection at RM 34.55 to 35.22: Relocate deteriorating levee to edge of agricultural area, restore side-channel connection, channel migration, aquatic edge, floodplain wetlands, and riparian habitat. Hamakami Levee Setback at RM35.28 to 35.7: Relocate deteriorating levee to edge of agricultural terrace, restore side-channel connection, channel migration, aquatic edge, floodplain wetlands, and riparian habitat. Turley Levee Setback at RM36.6 to 36.9: Relocate deteriorating levee to edge of agricultural terrace, restore side-channel connection, channel migration, aquatic edge, floodplain wetlands, and riparian habitat. Lone's Levee Setback at RM37.36 to 37.7: Relocate deteriorating levee to edge of agricultural terrace, restore side-channel connection, channel migration, aquatic edge, floodplain wetlands, and riparian habitat.
38.2	40.06	R	Burns' Creek / Naglich / Cooke (Kruger) / Metzler-O'Grady: Overbank flows in this reach form a complex pattern of distribution within the floodplain to the north, with a significant portion passing across the Metzler Park area and private lands to frequently inundate portions of the Green Valley road where this adjoins Burns' Creek. Burns Creek itself distributes flows from higher stage events, which exit the river into the creek channel near river Mile 39.7. This flooding is exacerbated by the presence of an active alluvial fan entering Burns' Creek from the valley wall and pinning the channel to the margins of the roadway with sediment deposits. Deposition and flooding in Burns' Creek also affect driveways crossing to residential homes and small farms at several locations. At least one additional home remains affected by fan building, in addition to the several driveways.	Middle Green Floodplain Acquisition: Monitor and maintain the home acquisition sites as restored natural riparian habitat. Consider purchase of at least one additional flood-prone property at the alluvial fan along Burns' Creek. Work with King County Roads division to set flooding and eroding portions of the Green Valley Road back from the stream margins, and raise the roadway over a series of box culverts to allow for safe passage of floodwaters under the roadway and across the Right-of –Way to the creek. Restore the stream margins as natural riparian habitat. Replace and raise affected driveways along the creek, downstream from the fan, to provide safe access to residential homes north of the creek and relieve pressure on dredging initiatives.

GREEN RIVER (WRIA 9)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
40.27	41.2	R	Crisp Creek / Margerite Hansel / Meyer Dike / Imhoff / Whitney Bridge: Any major landslide that might occur here could easily re-direct flows right through this neighborhood. It is likely that under this scenario a new channel would be cut in the present location of Crisp Creek. Even though this may be considered a very rare event with only a small probability of occurrence, the hazards associated with any such occurrence would be severe. Absent any major potential channel altering events like this, flood flows are consistently contained within the channel, which is both relatively steep in gradient and modestly incised within its banks.	Perform a thorough geological and geotechnical evaluation of potential landslide risks along the hillside across the channel at the downstream end of this reach. Consider the magnitude and likelihood of potential slide events, and potential impacts on river channel conveyance and flow patterns in the floodplain along the opposite bank. Consider both upstream (backwater) and downstream impacts likely from the range of potential events considered. Determine alternative actions and a recommended appropriate course of action based on findings delivered. Perform a detailed site assessment of the condition of the older and infrequently maintained revetments present, and determine a long-term management strategy with respect to their continued maintenance, or abandonment.
41.2	41.78	R	Whitney Bridge /Green Valley Road Protection: This short segment extends upstream from Whitney Bridge past another portion of the replanted County Park property to the gravel shoulder along Green Valley Road. The bank here is steep, armored with rip-rap, and unstable. Flows are relatively high velocity and strike the road embankment at a sharp angle, with erosion present.	To the extent that continuing erosion of the road shoulder embankment may become a concern here, further survey and geotechnical evaluation of the existing roadway and riverbank should be performed as an initial step toward more robust bank stabilization. A plan for stabilizing the riverbank should be defined in concert with riparian buffer restoration. Perform soil investigations and embankment surveys to define physical and structural parameters. Determine design flood and freeboard elevations. Evaluate bank stability with geotechnical study. Define slope stability and structural needs. Acquire properties as needed. Reconstruct toe, slope and roadway to a stable configuration with a fully bioengineered solution, preferably including a vegetated midslope bench.

VASHON ISLAND (WRIA 15)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
N/A	N/A	N/A	Parcel Number 0823039006: This existing home has repeatedly experienced damage from flood events in King County. Repetitive damage to this structure was determined by FEMA based on existence of a flood insurance policy and claims paid by that policy. Based on the amount and number of claims that have been paid, this property is identified as being at high risk for future flood damage. (Vashon Island, Unincorporated)	Vashon Island Early Action Residential Flood Hazard Mitigation: Purchase and remove structure, or otherwise mitigate flood risks to repetitive loss properties. (Vashon Island, Unincorporated)
N/A	N/A	N/A	Parcel Number 0823039033: This existing home has repeatedly experienced damage from flood events in King County. Repetitive damage to this structure was determined by FEMA based on existence of a flood insurance policy and claims paid by that policy. Based on the amount and number of claims that have been paid, this property is identified as being at high risk for future flood damage. (Vashon Island, Unincorporated)	Vashon Island Early Action Residential Flood Hazard Mitigation: Purchase and remove structure, or otherwise mitigate flood risks to repetitive loss properties. (Vashon Island, Unincorporated)

WHITE RIVER, GREEN WATER RIVER AND RED CREEK (WRIA 10)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
6.40	6.60	L	A-Street Bridge Channel Constriction: The channel is constricted by reveted banks that narrow the flow area into and through the bridge opening. Buffers are degraded, resulting in a lack of cohesive vegetation which may reduce erosion protection on the bank face and overbank areas. (White River, City of Auburn)	Bridge is within jurisdiction of and maintained by the City of Auburn. Adjacent bridge is owned by Burlington Northern Santa Fe Railroad. King County could potentially partner with other jurisdictions, agencies and organizations on a project to address potential flood risks in this location. Feasibility and technical analysis required.
22.40	22.45		SR 410 Bridge at Enumclaw Potential Scour: The SR 410 bridge lies within the historic active channels area indicating some potential for exposure to erosive flows and channel migration. Overtime, the flow constriction through this bridge may result in abutment scour. The channel is constricted by the bridge; however, no known significant scour problems are evident at this time. (White River, Unincorporated)	Bridge is within jurisdiction of the City of Buckley and unincorporated King County, but owned and maintained by the Washington State Department of Transportation. King County could potentially partner with other jurisdictions, agencies and organizations on a project to address potential flood risks in this location. Feasibility and technical analysis required.

WHITE RIVER, GREEN WATER RIVER AND RED CREEK (WRIA 10)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
23.90	24.10	R	Kahne Levee Potential Overtopping: The river flows directly into the north valley wall bluff and impinges perpendicularly into this rock levee built in 1974. The county maintenance file indicates repetitive maintenance at this site prior to the 1990's. The upstream end of the flood protection facility protects the toe of the bluff upon which lies Mud Mountain Road. The downstream end is now the Hatchery Levee, not a county flood protection facility, that levee protects the upper portion of the White River Fish hatchery property. During the 1995/96 flood event, an emergency sandbag effort was conducted to block off flows that threatened to overtop the levee. An existing wall base channel and historic floodplain channel lie in the right overbank, landward of the hatchery levee. (White River, Unincorporated)	Feasibility and technical analysis required. The best solution here may be to consider abandoning this facility and allowing the State to take over ownership of the facility.
45.60	45.65	R	Slippery Creek Bridge Flow Blockage: The abandoned concrete highway bridge the crosses Slippery Creek lies remains in place but the 1995 and 1996 flood events destroyed the commercial building on the right bank of Slippery Creek on the upstream side of the bridge. The old bridge is an obstacle, causing sediment and debris to block the bridge's small clearance area and potentially directing flood flows onto SR 410. Also, the mainstem of the White River is immediately adjacent to SR 410. (White River, Unincorporated)	Bridge is within jurisdiction of unincorporated King County but lies within State right-of-way. Bridge should be removed from the floodplain and restoration options considered. Feasibility and technical analysis required.
39.00	45.80	R	SR410 Channel Encroachment: The road alignment of SR410 encroaches into the channel and floodplain area of the White River in several locations along this reach above Mud Mountain Dam. Protection measures, (i.e. rock riprap) have been implemented by Washington State Department of Transportation following major flood events, most recently in 1995 and 1996. The rock placement impacts channel habitat and is not a permanently solution to the actively migrating channel. (White River, Unincorporated)	The Washington State Department of Transportation has SR 410 right-of-way ownership along the White River. Pierce County FHMP has identified the need to address flood risks at approximately River Mile 43. King County could potentially partner with other jurisdictions, agencies and organizations on a project to address potential flood risks in this location. Feasibility and technical analysis required.

WHITE RIVER, GREEN WATER RIVER AND RED CREEK (WRIA 10)

DS RM	US RM	Bank	Flood or Channel Migration Risk	Proposed Project
0.05	0.10	L, R	SR410 Bridge Debris Blockage: The SR 410 bridge has a center pier which has repeatedly accumulated log jams. In the flood of record in 1977, the debris blockage at the bridge caused a backwater condition that flooded and damaged buildings in the Greenwater community. Some maintenance work has been completed by Washington State Department of Transportation to place a concrete scour pad around the channel and the center pier, however, debris accumulation during flood events is still likely and could cause flooding of SR410 and the adjacent commercial and residential structures. Although the scour pad protects the pier from being undermined, pool habitat in the bridge area was eliminated. (Greenwater River, Unincorporated)	Bridge is owned and maintained by the Washington State Department of Transportation. King County could potentially partner with other jurisdictions, agencies and organizations on a project to address potential flood risks in this location. Feasibility and technical analysis required. A more comprehensive, multi-objective project may be possible should the county acquire the parcels at the confluence of the White and Greenwater Rivers.

APPENDIX H.
IMPACTS OF FLOODING ON THE KING COUNTY ECONOMY: A REVIEW OF PROMINENT LITERATURE
SUMMARY REPORT

EXECUTIVE SUMMARY

A literature review was conducted to identify prominent studies that provide an understanding of how flooding and flood risk reduction measures can affect the economy of King County, Washington. Key findings of the studies collected through this review are summarized and compiled by topic below.

Avoided Cost Estimates

Avoided cost is a measure of the benefit provided by a project, program or policy that reduces or eliminates costs that would otherwise be expected. In the case of flood risk reduction activities, avoided cost commonly is estimated based on the cost of damage that would result from flooding if the activities were not implemented. Numerous studies were identified that present flood damage costs. Some present actual damage from previous floods; others estimate future costs of flood damage to people, structures or the economy based on computer modeling or other analysis techniques.

Previous King County Flood Damage History

Two studies identified through the literature review presented estimates of damage from past floods, as summarized in Table ES-1.

TABLE ES-1.
ESTIMATES OF DAMAGE FROM PREVIOUS FLOOD EVENTS

Flood	Damage to Public Facilities Only, from 2006 King County Flood Hazard Management Plan	Damage to Public and Private Property, from 2009 Regional Hazard Mitigation Plan
January 1990	$5.2 million	$17.8 million
November 1990	$3.7 million	$57 million
December 1990	$0.5 million	$5.1 million
November 1995	$3.0 million	$45.9 million
February 1996	$4.3 million	$113 million
December 1996	$3.6 million	$83 million
March 1997	$1.3 million	$6.5 million
November 2003	—	$30 million

Another study (Booth et al., 2006) estimated the total amount of flood insurance claim payments made in the Puget Sound region by the National Flood Insurance Program since 1978; the estimated total of $56 million does not include all flood losses borne by property owners, due disparities in insurance coverage.

Estimates of Potential Flood Damage to Property in King County

Three studies identified through the literature review used modeling to estimate the value of properties exposed to flood hazards and the potential damage to those properties from a future flood. Table ES-2 summarizes the estimates from these studies.

TABLE ES-2.
FLOOD EXPOSURE AND VULNERABILITY ESTIMATES

	Value of Properties in 100-Year Floodplain (millions)	Estimated Damage from 100-Year Flood (millions)
From 2006 King County Flood Hazard Management Plan (Unincorporated County Areas Only)	$2,708	$513
From 2009 Regional Hazard Mitigation Plan (Unincorporated County Areas Only)	$867	$302
From 2010 King County Flood Control District Hazard Mitigation Plan	$10,085	$2,031

Estimated Impacts on the King County Economy

One study (ECONorthwest, 2007) evaluated the level of economic activity in King County floodplains, the degree to which economic activity in the floodplains is connected to the greater King County economy, and the importance of economic activity in the floodplains to the county's economic vitality. Its key findings include the following:

- A one-day shutdown of economic activity in King County floodplains would result in at least $43 million in foregone economic output in the floodplains and $46 million countywide.
- 20 percent of the County's total manufacturing employment and 30 percent of the County's aerospace employment is located in floodplains.
- 6 percent of employed persons in King County work in floodplains and 2 percent of the total population lives in floodplains.
- A long-term 10-percent change in aerospace employment in the King County floodplains would lead to a $160 million change in personal income in the county.

Green River Flood Impact Studies

Four studies were identified that address economic impacts of flooding on the Green River rather than all of King County. Conclusions of these studies are as follows:

- Shannon & Wilson (2002) estimated an average annual damage cost due to Green River flooding of $65.73 million ($3.73 million to residential structures and $62 million to non-residential structures).
- The Federal Emergency Management Agency (FEMA, 2009) estimated damage costs and business impact losses for three scenarios of Green River flooding:
  - Base 100-Year Flood (12,800 cubic feet per second (cfs)) with some levee failures—Damage costs of $1.956 billion, business losses of $11 million
  - Flood of 17,600 cfs without levee failures—Damage costs of $1.324 billion, business losses of $22 million

  - Flood of 17,600 cfs with some levee failures—Damage costs of $3.710 billion, business losses of $38 million
- Goodwin (2010) estimated the following economic factors that would be affected by a Green River flood of 25,000 cfs with no levee failures
  - There are 100,000 jobs in the inundation area with a payroll of $16 million per day.
  - The total value of output in the inundation area is over $63 million per day.
  - There are 4,771 retail business sites in the inundation area.
  - Over $1.2 million per day in sales tax revenue would be lost during a flood event.
  - The assessed value of property in the inundation area was over $6.7 billion in 2008.
- The Department of Homeland Security's Dams Sector Exercise Series estimated the following impacts from a Green River flood exceeding the 100-year base flood, with one levee failure:
  - Damage to structures, contents, and automobiles of about $3.70 billion
  - Total economic losses up to $40 billion in the first year after the flood, or $16.7 billion if accounting for the positive offsetting effect of restoration investment.

Ecosystem Service Valuations

The relatively new field of ecosystem service valuation attempts to define monetary equivalent values for benefits provided by ecosystems. A standard set of such benefits commonly evaluated in studies includes "disturbance prevention," which includes the ability of natural systems to dampen the effects of flooding; for example, wetlands can naturally store floodwaters, helping to keep the waters from inundating developed areas. Ecosystem service valuation attempts to define the monetary value of that flood prevention benefit, as well as numerous other benefits that natural systems provide. The literature review collected three studies that estimate the flood-prevention value of ecosystems in parts of King County:

- Earth Economics (2007) performed case studies to estimate the value of all ecosystem services that would be generated by completing six projects along the Cedar River recommended in King County's 2006 Flood Hazard Management Plan. The study found that the projects would yield ecosystem services valued at $65,000 to $3.1 million per year, including a flood-prevention value of $10,000 to $2.7 million per year.
- Asia Pacific (2005) estimated the value of services provided by all existing ecosystems in the Green/Duwamish and Central Puget Sound watershed, which is designated Water Resource Inventory Area (WRIA) 9. The study estimated that existing systems in WRIA 9 provide a disturbance prevention benefit of $105 million to $758 million per year.
- Economics (2010) estimated the value of services provided by all existing ecosystems in the Snoqualmie River watershed. The study estimated that existing systems in the watershed provide a disturbance prevention benefit of $7.56 to $235.73 per acre per year. The study does not apply these unit values to the entire watershed to show a total estimated value for disturbance prevention, but a calculation described in this literature review summary report suggests the watershed-wide value may be $272,000 to $8.48 million per year.

Another study collected through the literature review (Leschine et al., 1997) estimated the flood-prevention benefit of wetlands throughout Western Washington. It concluded that the value of this benefit is in the range of $36,000 to $51,000 per acre.

A final ecosystems service study collected for the literature review (Costanza et al., 1997) does not address the King County or Puget Sound area, but it was included because it is one of the earliest and most comprehensive studies to gather together the large but scattered amount of information on ecosystem service valuations worldwide. The study provides a table giving average ecosystem service value in US$ per hectare per year for 17 ecosystem services provide by 21 vegetation-cover types (referred to in the study as "biomes"). It estimates a disturbance regulation benefit ranging from $2 to $7,240 per hectare per year ($0.8 to $2,930 per acre per year), depending on the biome.

Costs of Flood Risk Reduction Activities

Capital Project and Flood Control Program Costs

King County's 2006 Flood Hazard Management Plan shows that, from 1991 to 2005, King County's River and Floodplain management program spent $34 million in capital projects and technical studies to address flood risk; of that amount, $11 million was local funding and $23 million was state and federal funding. For the action plan presented in the plan, the estimated cost over 10 years (2007 – 2016) is $206 million; approximately $20 million each year.

Booth et al. (2006) evaluated expenditures on stormwater management programs throughout the Puget Sound region. It found that by Puget Sound cities and counties covered under National Pollutant Discharge Elimination System Phase 1 permits spend a combined $134 million per year on stormwater management programs. For eight specific jurisdictions surveyed (not including King County), the portion of these expenditures used for flood prevention ranged from about 25 percent to 100 percent; most were in the range of 40 to 60 percent.

Cost-Benefit Analyses

The literature review identified two studies that provided comparisons of cost and benefit for specific flood-risk-reduction projects in King County:

- A loss avoidance study by Washington's Emergency Management Division (2010) compared the cost and benefit (estimated as the avoided cost of potential flood damage to structures) of elevating 11 homes in Snoqualmie above the base flood elevation. The study demonstrated a positive return on investment (as high as 132 percent) for all 11 homes. The report also provides a summary of a similar study by FEMA of 28 flood-proofed Snoqualmie homes. The FEMA study estimated a project benefit of $1.6 million from a single flood that occurred after the work was complete, compared to a project cost of $1.3 million.
- Tetra Tech (2011, DRAFT) estimated costs and benefits for several options of a levee replacement project along the Green River. Although the report does not give totals for costs and benefits (it presents ranges of values for components of both cost and benefit), it is noteworthy for its approach to estimating benefit. The valuation of benefit uses both an modeling study to estimated avoided cost of flood damage and a literature review and analysis to estimate ecosystem services that would be enhanced by the project.

Qualitative Findings

Two studies that do not provide cost-specific evaluations or results were identified by the literature review because they discuss important general concepts related to the economic impacts of flooding:

- Critical Infrastructure Group (2009) summarizes presentations by local experts at a 2009 workshop addressing the likely impacts of a severe flood on the Green River. Impacts identified in this document could provide a framework for future cost evaluations of the economic impacts of flooding. The workshop identified the following critical infrastructure as susceptible to damage from an extreme flood:

  - Electric and gas service
  - The Olympic Pipeline, which supplies most of the fuel needs of Western Washington and all of the fuel needs of Sea-Tac Airport and the Port of Seattle.
  - Sea-Tac International Airport
  - Local and state highways
  - Phone service
  - Sewer systems
  - Potable water systems
  - Public health

- Rossi et al. (1978) is an early and influential study on the long-term impacts of disasters in the United States. The study performed modeling of Census data for communities affected by major disasters in the 1960s to evaluate whether such events had long-term effects on the communities' growth, as indicated by population and housing. The study concluded that natural disasters have no discernible effects on county or census tract population or housing trends that last beyond a few years after the event. It proposes the following policy considerations based on this conclusion:
  - For an "average" (rather than extreme) disaster, long-term post-disaster assistance may be more appropriate for individuals, families and businesses than for larger communities.
  - The most reasonable policy may be to admit that catastrophic (extreme) events cannot be prepared for and to expect that special measures would have to be taken ad hoc if such events occur. Disaster policy should be tuned to the needs associated with an average disaster and applied to those events alone.

1. INTRODUCTION

This report presents the results of a literature review conducted to identify prominent studies that provide an understanding of how flooding and flood risk reduction measures can affect the economy of King County, Washington. The review was performed by Tetra Tech at the request of King County's Water and Land Resources Division, as a work order under Tetra Tech's floodplain planning and management contract with the County.

Scope of Work

The work order for this project requests a literature review on the importance of flood risk reduction efforts in protecting the King County economy. Studies to be identified should cover the following topics, if available:

- Traditional economics including the economic disruption of a flood event (transportation, freight disruptions, etc.)
- Ecological economics associated with flooding ("ecological services," or the benefits provided to humans or the environment by a functioning ecosystem)
- Long-term impacts of a flood event, including timeframe of effects after a disaster (reduction of revenues, connections to other regions, etc.)
- Other economic data such as data from Hazus modeling (Hazus, or Hazards, U.S., is modeling software developed by the Federal Emergency Management Agency).

Methodology

Studies were identified for this literature review by the following methods:

- Two studies were provided by King County as part of the work order.
- Previous Tetra Tech documents related to the review topics were examined for potential relevance.
- Internet searches (using Google web search and Google scholar) were performed on the following sets of key words:
  - Flood economic impact King County
  - Flood economic impact risk reduction King County
  - Flood ecological services King County
  - Long-term flood impacts Washington.
- The reference lists of all studies collected in the first three steps were reviewed to identify additional relevant materials.

These review methods identified many hundreds of articles, studies, books and reports with potential relevance to the research topic. Given the limited scope and budget for this literature review, the selection of articles for inclusion in the final review was based on the following criteria:

- Only documents that were easily accessed in complete electronic form were obtained and reviewed.
- Studies were chosen based on specific geographic areas that they address, in the following order of preference:

  - Studies that address all of King County and only King County
  - Studies that address any of three larger areas that include King County: Washington State; Western Washington; Puget Sound
  - Studies that address an area that is completely or mostly within King County: Green River; Water Resource Inventory Area (WRIA) 9; Snoqualmie watershed
- Two studies that are not specific to the geographic areas listed above were collected because the search process indicated, based on frequent citation in other sources, that they are influential studies on a topic relevant to the literature review. These are included in this report in the section that summarizes larger-area studies.

This search methodology yielded 20 documents for review, totaling over 2,000 pages. The documents are summarized in the following sections, which are based on geographic area addressed. Within each area-based section, documents are listed chronologically.

Given the volume of material collected, the summaries are based on review of introductory or summary material in each document, along with review of specific sections or chapters of interest. Electronic copies of the complete documents in .pdf format are provided on a CD submitted with this report to allow for more in-depth review as appropriate.

2. SUMMARY OF DOCUMENTS SPECIFIC TO KING COUNTY

King County 2006—King County Flood Hazard Management Plan

Citation

King County, 2006. Flood Hazard Management Plan: King County, Washington. King County Department of Natural Resources and Parks, Water and Land Resources Division. Seattle, Washington. 607 pp. Final, January 2007.

Scope

The King County Flood Hazard Management Plan provides a comprehensive review of flooding issues throughout King County, including a review of historical flooding and policies, an assessment of conditions in all major river basins, and an action plan for flood hazard mitigation measures. Chapter 3 of the plan provides an evaluation of the costs and impacts of flooding in King County. Section 7.2 provides cost estimates for the recommended action plan. The detailed action plan is presented in Appendix F.

Methodology

Key findings in the 2006 Flood Hazard Management Plan that are relative to this literature review were developed as follows:

- Section 3.2.3 summarizes historical flood damage costs for declared flood disaster events. The costs of damage to public facilities were taken from the County's 2003 Regional Hazard Mitigation Plan. Repair costs were obtained from the Washington Department of Emergency Management.
- Section 3.2.2 develops estimates of flood loss potential based on 100-year floodplain mapping at the time of the plan and Federal Emergency Management Agency (FEMA) methodologies for flood loss estimation.

Conclusions

Flood Damage Costs

The plan's review of previous federally declared flood disasters found public-facility damage estimates as follows for the seven events between January 1990 and March 1997.

- January 1990—$5.2 million
- November 1990—$3.7 million
- December 1990—$0.5 million
- November 1995—$3.0 million
- February 1996—$4.3 million
- December 1996—$3.6 million
- March 1997—$1.3 million

The estimated breakdown of repair costs for all of these events showed a federal share of $16 million, a state share of $3 million and a local share of $2 million.

Based on flood mapping at the time of the plan, King County assessor data for property values, and FEMA procedures for estimating flood loss, the plan estimated the property values in the 100-year floodplain and potential flood damage from 100-year floods unincorporated areas in the six major river basins in the county. This estimate does not account for damage potential outside the mapped floodplains. The risk assessment estimates are summarized in Table 1.

TABLE 1.
FLOOD EXPOSURE AND VULNERABILITY ESTIMATES FROM 2006 FLOOD PLAN

	Value of Properties in 100-Year Floodplain (millions)			Estimated Damage from 100-Year Flood (millions)
	Land	Structure	**Total**	
S. Fork Skykomish River	$1.8	$7.5	**$9.3**	$2.1
Snoqualmie River	$197.3	$258.9	**$456.2**	$101.7
Sammamish River	$276.3	$485.1	**$761.5**	$123.4
Cedar River	$102.5	$75.1	**$177.6**	$20.6
Green River	$388.7	$937.8	**$1,276.6**	$260.7
White River	$10.3	$15.0	**$25.3**	$4.1
Total	$927.0	$1,779.5	**$2,707.5**	$512.8

Flood Hazard Mitigation Expenditures

The plan shows that, from 1991 to 2005, King County's River and Floodplain management program spent $34 million in capital projects and technical studies to address flood risk; of that amount, $11 million was local funding and $23 million was state and federal funding. For the action plan presented in the plan, the estimated cost over 10 years (2007 – 2016) is $206 million; approximately $20 million each year.

Earth Economics 2007—Ecological Economic Assessment of Flood Hazard Plan

Citation

Earth Economics. 2007. An Ecological Economic Assessment of King County's Flood Hazard Management Plan. Prepared for King County Department of Natural Resources and Parks River and Floodplain Management Program by Paula Swedeen and James Pittman of Earth Economics. Seattle, Washington. 47 pp. August 10, 2007.

Scope

This report examines the value of ecological services that result when floodplain and river ecosystems are restored as a means of flood damage prevention. The first part of the report contains background information on an ecological economics approach to analyzing the benefits of flood protection programs, a general discussion of ecosystem services in King County floodplains, and the techniques used to determine their economic value. This sets up a case study, reported in Part 2 of this document, which analyzes the changes in value that would likely result from implementation of specific flood protection measures on six projects from the 2006 King County Flood Hazard Management Plant proposed for implementation in the Cedar River Watershed. The projects include home buyouts, levee setbacks, and bank stabilization. The results are intended to provide a general idea of what ecosystem service values can be gained with these strategies for flood hazard reduction in other watersheds in the county. The ecosystem services considered in this study listed in Table 2.

TABLE 2.
ECOSYSTEM SERVICES EVALUATED IN EARTH ECONOMICS 2007

Ecosystem Service	Description	Example of Benefit
Gas regulation	Role of ecosystems in biogeochemical cycles	Provides clean, breathable air, disease prevention, and a habitable planet
Climate regulation	Influence of land cover and biologically mediated processes on climate	Maintenance of a favorable climate promotes human health, crop productivity, recreation, and other services
Disturbance prevention	Influence of ecosystem structure on dampening environmental disturbances	Prevents and mitigates natural hazards and natural events, generally associated with storms and other severe weather
Water regulation	Role of land cover in regulating runoff and river discharge	Provides natural irrigation, drainage, channel flow regulation, and navigable transportation
Water supply	Filtering, retention and storage of fresh water (e.g. in aquifers and snow pack)	Provision of water for consumptive use, includes both quality and quantity
Soil retention	Role of vegetation root matrix and soil biota in soil retention	Maintains arable land and prevents damage from erosion, and promotes agricultural productivity
Soil formation	Weathering of rock, accumulation of organic matter	Promotes agricultural productivity, and the integrity of natural ecosystems
Nutrient regulation	Role of biota in storage and recycling of nutrients	Promotes healthy and productive soils and gas, climate, and water regulations
Waste treatment	Role of biota in removal or breakdown of nutrients and compounds	Pollution control/ detoxification and filtering of dust particles through canopy services

TABLE 2.
ECOSYSTEM SERVICES EVALUATED IN EARTH ECONOMICS 2007

Ecosystem Service	Description	Example of Benefit
Pollination	Role of biota in movement of floral gametes	Pollination of wild plant species and harvested crops
Biological control	Population control through trophic-dynamic relations	Provides pest and disease control and reduces crop damage
Refuge function	Suitable living space for wild plants and animals	Maintenance of biological and genetic abundance and diversity
Nursery function	Suitable reproduction habitat	Maintenance of commercially harvested species
Food	Conversion of solar energy into edible plants and animals	Hunting, gathering of fish, game, fruits, etc. and small-scale subsistence farming and aquaculture
Raw materials	Conversion of solar energy into biomass for human uses	Building and manufacturing, fuel and energy; and fodder and fertilizer
Genetic resources	Genetic material and evolution in wild plants and animals	Improve crop resistance to pathogens and pests
Medicinal resources	Variety of chemical substances in, and other medicinal uses of, natural biota	Drugs, pharmaceuticals, chemical models, tools, test and assay organisms
Ornamental resources	Variety of biota in natural ecosystems with potential ornamental use	Resources for fashion, handicraft, jewelry, pets, worship, decoration, and souvenirs
Aesthetic information	Attractive landscape features	Enjoyment of scenery
Recreation	Variety in landscapes with potential recreational uses	Travel to natural ecosystems for eco-tourism, outdoor sports, etc.
Cultural and artistic information	Variety in natural features with cultural and artistic value	Use of nature as motive in books, film, painting, folklore, national symbols, architecture, advertising, etc.
Spiritual and historic information	Variety in natural features with spiritual and historic value	Use of nature for religious or historic purposes (i.e., heritage value of natural ecosystems and features)
Science and education	Variety in natural features with scientific and educational value	Use of natural systems for school excursions, etc. Use of nature for scientific research

Methodology

The case study of six proposed projects in the Cedar River Watershed involves a "value-transfer" analysis of all ecosystem services except flood protection (flood protection is represented by the "disturbance prevention" ecosystem service). The value-transfer method uses existing economic estimates of the value of services and adapts the estimates to place value on those services as provided by functioning ecosystems. The critical assumption of this method is that the economic value of ecosystem services can be inferred with sufficient accuracy from analysis of existing valuation studies.

For flood protection, an original empirical estimate of value from the project was conducted based on avoided cost. In this approach, data is collected on as many of the following flood-related costs as possible: damage to homes, lost labor, insurance payouts, alternative housing, flood warnings, emergency response expenses, emergency repairs, and repair to public infrastructure. An estimate is then made as to how much less frequent and severe damage from flood events will be after proposed flood prevention measures are implemented. The costs avoided per flood event are then summed for the expected number of flood events that would cause damage over a 100-year period.

The flood protection values derived using the avoided-cost method are combined with the value-transfer data of other ecosystem services to get a full picture of all the ecosystem services gained by restoring floodplain habitats and functions.

Conclusions

The case study of six Cedar River projects from the 2006 Flood Plan estimates that the projects will yield a total ecosystem service benefit ranging from $65,000 to $3.1 million per year. This includes $55,000 to $400,000 per year for avoided flood damage costs and $10,000 to $2.7 million per year for all other ecosystem services.

An important result presented in the report is a table showing ranges of values per acre for each ecosystem service for which data was available from recent peer-reviewed studies. These values are given for six land-cover types typical of the project areas.

The report concludes the following major benefits of flood hazard reduction projects:

- Many costs are avoided from flood damage that would otherwise occur.
- By reconnecting the river to its natural floodplain, flood protection is accomplished naturally without recurring infrastructure costs to the county and the public.
- Other valuable ecosystem services are gained that will be delivered in perpetuity.

In order to apply the approach used in this study in a more formal cost-effectiveness framework, the report recommends the following:

- Comprehensive hydraulic modeling of the cumulative effects of flood hazard reduction in the subject watershed, to improve estimates of avoided costs and improved habitat-associated ecosystem services
- A centralized database of all components that go into avoided cost calculations (e.g., home damage, flood facilities damage, road and trail damage, emergency service costs, and lost work time)
- State funding of local and regional empirical studies of ecosystem services and their economic value.

ECONorthwest 2007—Floodplains and Greater King County Economy

Citation

ECONorthwest. 2007. Economic Connections Between the King County Floodplains and the Greater King County Economy. Prepared for King County Water and Land Resources Division by ECONorthwest. Eugene, Oregon. 35 pp. October 2007.

Scope

This study addresses the regional economic benefits related to implementing the 2006 King County Flood Hazard Management Plan. The analysis focuses on the level of economic activity in King County floodplains, the degree to which economic activity in the floodplains is connected to the greater King

County economy, and the importance of economic activity in the floodplains to the county's economic vitality. The analysis consisted of sub-analyses examining the following topics:

- Employment and payroll in the floodplain areas
- The potential short-run impact on the countywide economy of a one-day work stoppage in the floodplain areas (as a proxy for a flood event)
- The long-run impact on the countywide economy of a permanent change in aerospace employment in the floodplain areas (the study assumes that implementing the flood hazard management action plan, or failure to do so, could affect aerospace manufacturers' perception of safety in the floodplain and consequent decisions regarding investment in manufacturing capacity there).

The results of the three analyses are not cumulative. Rather, each provides a different view of the extent to which the economy of the floodplain areas is part of the larger King County economy and the extent to which a change in the level of economic activity in the floodplain would affect the countywide economy.

Methodology

The approach to the three sub-analyses was as follows:

- **Floodplain Employment and Payroll**—Using micro-level employment data for King County, the study examined employment and income by industry sector in the floodplain regions and compared them to the county as a whole. The study assessed the importance of business activity in the floodplains to the economic vitality of the rest of the county.
- **Impact of One-Day Work Stoppage**—Using an economic input-output model, the study estimated the direct and some of the indirect impacts associated with a major flood event.
- **Long-Term Effect of Change in Aerospace Employment**—Using a long-term economic and demographic forecasting model for the Puget Sound region, the study examined the impact that a small change in aerospace employment in the King County floodplains would have on the Puget Sound and King County economies.

Conclusions

The three sub-analyses indicate that there is substantial economic interaction between the floodplains and the rest of King County, and suggest that there are economic benefits to the County of protecting the floodplain. The following sections describe key findings.

Employment in the Floodplain

The floodplain region has many jobs but relatively few residents:

- Approximately 6 percent of the county's employment is located in the floodplain region (65,000 jobs).
- 20 percent of the County's total manufacturing employment and 30 percent of the County's aerospace employment is located in the floodplains.
- Manufacturing pays wages higher than the County average and aerospace pays the highest wages of any employment sector in King County.
- Nearly 7 percent of King County's total annual wage and salary income is generated within the floodplain ($3.7 billion).

- Approximately 2 percent of King County's population lives in the floodplain (32,000 persons). Most employees working in floodplain areas commute from other parts of King County or surrounding counties.

Because the floodplain region employs many people who live elsewhere in King County, the benefits of flood hazard management accrue beyond the floodplain to the entire County economy.

Effect of a One-Day Work Stoppage

A one-day shutdown of economic activity in the King County floodplain areas would result in at least $43 million in foregone economic output in the floodplains and $46 million countywide:

- Much of the effect of the stoppage would be felt in foregone wages to employees, most of whom live outside the floodplains in other King County communities.
- Business income and taxes paid to state and local governments throughout the County would be also be negatively impacted.
- The 10 King County industry sectors outside floodplains that would be most affected by a shutdown in the floodplain are oriented toward business services. They pay wages that are higher than the County average, and are predominately located in the County's major cities.

The estimated impact of the one-day work stoppage is conservative because it does not account for impacts on persons living in the floodplains who are unable to commute to jobs elsewhere, businesses outside that rely on goods and services produced by businesses inside floodplain areas, the value of damaged or destroyed property or equipment, or multi-day flood impacts.

Role of Aerospace Employment

A change in aerospace employment in the floodplain would have long-term impacts on employment and personal income growth in King County and the Puget Sound region:

- Public investment in flood hazard management would likely affect long-term business location decisions of aerospace manufacturers currently located in the floodplains.
- Thirty percent of King County's aerospace employment is located in the floodplains.
- Aerospace employment in the Puget Sound region has a positive causal relationship to employment in other sectors of the economy.
- A 10 percent change in aerospace employment in the King County floodplains would lead to a $160 million change in personal income in King County.

King County 2009—Regional Hazard Mitigation Plan

Citation

King County Office of Emergency Management. 2009. King County Regional Hazard Mitigation Plan, Phase 1. 288 pp. (without annexes) November 2009.

Scope

King County's Regional Hazard Mitigation Plan provides a risk assessment and hazard mitigation action plan for the major natural and human-caused hazards facing King County. It updates the County's previous plan, which was completed in 2004. The 2009 plan applies primarily to unincorporated county areas, though it provides for subsequent linking to the plan by incorporated jurisdictions and special purpose districts within the county.

The plan includes a hazard identification and vulnerability analysis for all hazards, including flooding, which it rates as a high-probability, high-impact hazard. The flooding section includes a review of damage from federally declared flood disasters in King County from January 1990 through November 2003. The plan also includes a risk assessment for the flooding hazard.

Methodology

Estimated damage to private and public property from past federally declared flood disasters was obtained for the hazard mitigation plan from the King County Flood Control District. The flooding risk assessment was completed using FEMA's Hazus risk assessment computer model to estimate the value of exposed and vulnerable properties in the 100-year floodplains of the six main river basins in King County.

Conclusions

The plan's review of previous federally declared flood disasters found private and public property damage estimates of $358.3 million from eight events between January 1990 and November 2003. Individual event damage estimates are as follows:

- January 1990—$17.8 million
- November 1990—$57 million
- December 1990—$5.1 million
- November 1995—$45.9 million
- February 1996—$113 million
- December 1996—$83 million
- March 1997—$6.5 million
- November 2003—$30 million.

The risk assessment estimated exposed and vulnerable property values in unincorporated areas of King County floodplains as summarized in Table 3.

TABLE 3.
FLOOD EXPOSURE AND VULNERABILITY ESTIMATES FROM 2009 HAZARD PLAN

	Value of Properties in 100-Year Floodplain (millions)			Estimated Damage from 100-Year Flood (millions)		
	Structure	Contents	**Total**	Structure	Contents	**Total**
S. Fork Skykomish River	$25.2	$13.6	**$38.9**	$5.3	$4.2	**$9.5**
Snoqualmie River	$282.7	$156.9	**$439.6**	$93.7	$68.2	**$161.9**
Sammamish River	$89.6	$58.0	**$147.6**	$8.3	$22.9	**$31.2**
Cedar River	$61.6	$30.4	**$92.0**	$11.7	$7.9	**$19.5**
Green River	$76.7	$39.6	**$116.3**	$32.4	$27.9	**$60.4**
White River	$21.8	$11.0	**$32.8**	$10.4	$9.4	**$19.8**
Total	**$ 558**	**$ 310**	**$ 867**	**$ 162**	**$ 141**	**$ 302**

King County Flood Control District 2010—Hazard Mitigation Plan

Citation

King County Flood Control District. 2010. Hazard Mitigation Plan. Prepared for the King County Flood Control District by Tetra Tech, Inc. Seattle, Washington. 176 pp. August 2010.

Scope

The King County Flood Control District's Hazard Mitigation Plan provides a risk assessment and hazard mitigation action plan for the major natural hazards facing all of King County. Flooding is one of seven natural hazards addressed

Methodology

Much of the flooding-related content in the Flood Control District's hazard mitigation plan was taken from the 2006 King County Flood Hazard Management Plan. New flood risk assessment analyses were performed using FEMA's Hazus model.

Conclusions

The flooding risk assessment in the District's hazard mitigation plant provides estimates of exposed and vulnerable properties throughout King County in the 100-year and 500-year floodplains, as well as estimates of potential damage to these properties from the 100-year and 500-year floods. Table 4 summarizes the results.

**TABLE 4.
COUNTYWIDE FLOOD EXPOSURE AND VULNERABILITY ESTIMATES FROM 2010 FLOOD DISTRICT HAZARD PLAN**

	Value of Properties in Floodplain (millions)			Estimated Damage from Flood Event (millions)		
	Structure	Contents	**Total**	Structure	Contents	**Total**
100-Year	$5,233.7	$4,851.9	**$10,085.6**	$716.7	$1,313.9	**$2,030.7**
500-Year	$5,883.6	$5,413.3	**$11,296.9**	$911.9	$1,610.9	**$2,522.8**

Tetra Tech 2012—King County Hazus Analysis

An updated analysis of King County flooding using FEMA's Hazus model is currently underway but was not completed in time for incorporation into this report.

3. SUMMARY OF DOCUMENTS ADDRESSING A BROADER REGION

Leschine et al. 1997—Wetlands and Western Washington Flooding

Citation

Leschine, Thomas M., Katharine F. Wellman and Thomas H. green. 1997. The Economic value of Wetlands: Wetlands' Role in Flood Protection in Western Washington. Ecology Publication No. 97-100. Prepared for Washington State Department of Ecology Northwest Regional Office. Bellevue, Washington. 68 pp. October 1997.

Scope

This report argues that economic valuation of wetlands' flood protection services can provide a strong rationale for Western Washington communities to protect remaining wetlands. After describing an economic rationale for pricing non-marketed natural resource services such as flood protection and outlining the approaches economists use to establish such values, the study assesses how the "alternative/substitute cost" method can be used to produce a proxy for the value of the flood protection services that many wetlands currently provide. Illustrations of the study's argument are provided by estimating the dollar-per-acre values of wetlands systems for flood protection in two Western Washington communities experiencing frequent flooding—Renton in King County and Lynnwood in Snohomish County.

Methodology

Cost estimates for engineered hydrologic enhancements to wetlands currently providing flood protection are used to establish proxies for the value of the flood protection these wetlands provide. A "ratio analysis" scheme is employed, making the method transferable to other communities seeking ways to enhance the flood protection that remaining wetlands provide.

The economic analysis of the value of flood protection provided by wetlands used data on projected flood benefit (reduced flow or increased storage) that would result from proposed engineered flood-mitigation projects. The analysis assumed that the willingness of a jurisdiction to pay the estimated costs of the proposed enhancements is an accurate reflection of the value to residents of the ability of wetlands to provide an equivalent flood benefit. Ratios were calculated of the costs of the proposed enhancements to the flood benefit they would achieve, and of existing wetlands acreage to the flood benefit it achieves. These ratios were then combined mathematically to produce a dollars-per-acre estimate of the value of flood protection provided by wetlands.

Conclusions

The results of the analysis, when annualized to dollars per acre per year, are comparable to values found in other economic studies that have been done of the value of wetlands for flood protection. The study's estimates of "whole system" wetlands value for flood protection range from about $36,000 per acre to about $51,000 per acre.

The broader lesson of the analysis is that the per-acre value estimates appear to increase rapidly as the cost inefficiency of enhancing wetlands also increases; this happens as wetland systems become increasingly fragmented and degraded. This suggests that policies allowing the removal of wetlands that are presently contributing little to flood protection but that have the potential to do so in the future, could lead to rapidly rising flood-protection values for remaining wetlands, as increasingly marginal wetlands are called into service. At some point the "next best" alternatives to enhanced flood protection will not involve wetlands at all, and the purely engineered systems that might have to be built could prove very expensive. These results suggest that price-sensitive market signals do exist that provide a strong economic rationale for communities in Western Washington to protect wetlands today in order to avoid what are likely to be much higher costs of flood protection in the future.

Booth et al. 2006—Puget Sound Stormwater Runoff Costs

Citation

Booth, Derek B., Bernadette Visitacion and Anne C. Steinemann. 2006. Damages and Costs of Stormwater Runoff in the Puget Sound Region. Prepared for Puget Sound Action Team, Office of the

17697

Governor by University of Washington Department of Civil and Environmental Engineering Water Center. Seattle, Washington. 22 pp. August 30, 2006.

Scope

This report describes the costs of stormwater damage within the Puget Sound region, documents the costs of stormwater mitigation, and presents some of economic benefits of stormwater management. The stormwater impacts assessed include flooding, landsliding and property damage; a decline in drinking-water and surface-water quality; habitat degradation; and contamination of shellfish growing areas. The study groups these impacts into categories of stormwater-related costs:

- Direct damage caused by stormwater
- Cost of government and/or private actions and programs to reduce the effects of stormwater
- Indirect damage caused by stormwater
- Unquantified costs caused by stormwater.

This report presents examples of economic costs associated with the first two categories. The last two categories are difficult to quantify in economic terms and therefore are addressed separately.

Methodology

Findings of this study were drawn from interviews with city and county officials and review of public records and previous studies.

Conclusions

Key findings of the study related to flood impacts are as follows:

- The total amount of flood insurance claim payments made in the Puget Sound region by the National Flood Insurance Program has totaled $56 million since 1978. This does not include all flood losses borne by property owners, due disparities in insurance coverage.
- The annual budget of stormwater and flood management programs can be on the order of hundreds of thousands to millions of dollars, depending on size and population of the jurisdiction. The largest Puget Sound jurisdictions (namely, cities and counties covered under National Pollutant Discharge Elimination System Phase 1 permits) reported expenditures of $134 million. When stormwater management costs are expressed per capita, typical management costs are on the order of $100/person/year, exclusive of episodic damage costs.
- Efforts to reduce flooding and drainage problems are the largest capital project costs among all jurisdictions, regardless of size, as shown in Figure 1.

Washington Emergency Management 2010—Loss Avoidance Study

Citation

Washington State Emergency Management Division. 2010. Loss Avoidance Study *in* Washington State Enhanced Hazard Mitigation Plan. Olympia, Washington. 33 pp. October 2010.

Scope

This study evaluates the cost-effectiveness of 20 flood mitigation projects and four earthquake mitigation projects completed in Washington and funded through various disaster declarations. Of the flood mitigation projects, 12 were in King County (11 in the City of Snoqualmie and one near Issaquah); the rest were in Pierce or Snohomish County. The Snoqualmie projects were all for elevations of existing flood-prone homes.

The study also summarizes the findings of FEMA loss avoidance studies for the City of Snoqualmie, a mobile-home park in Sumner, and the City of Centralia.

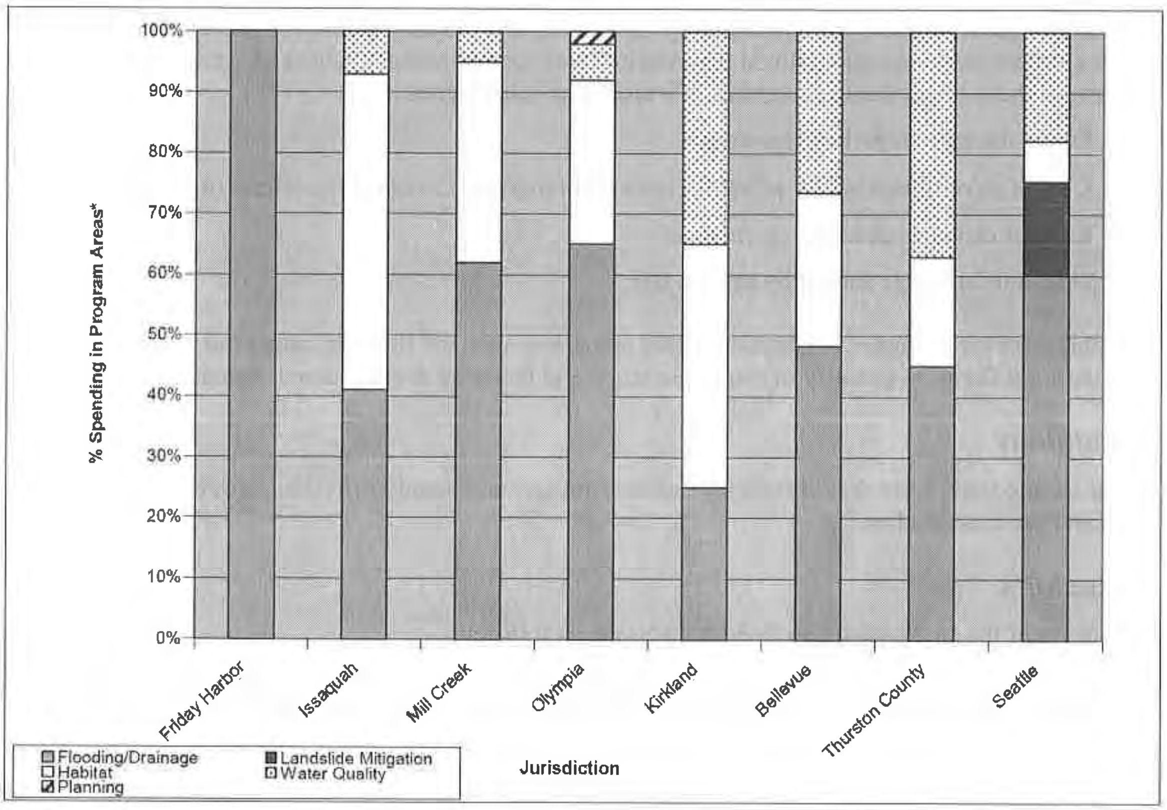

Figure 1. Division of Capital Improvement Project Costs for Various Puget Sound Stormwater Programs

Methodology

This study used a FEMA loss avoidance study methodology that evaluates cost-effectiveness based on an actual hazard event that has occurred at a mitigation project site prior to completion of the project. The methodology determines actual damage cost from the event and compares that value to estimates of damage that would be expected with the mitigation project completed. For the 11 Snoqualmie home elevation projects (the bulk of flood projects evaluated that are in King County), three calculations of avoided cost were made:

- The difference between Hazus modeling of damage from the 100-year flood with and without the project
- The difference between Hazus modeling of damage from the 100-year flood with the project and actual damage from a flood in 2006 (before the project)
- The difference between Hazus modeling of damage from the 100-year flood with the project and actual damage from a flood in 2009 (before the project).

For each of these values, return on investment was calculated as the avoided cost divided by the home elevation project cost.

This study does not calculate loss avoidance associated with social impacts, such as economic impact, loss of use, displacement, employment impact, or environmental impact. The software used to conduct this study (Hazus) does not allow for inclusion of these impacts. The study considers only structural losses and recovery. It also presents a qualitative review of regulatory authority in place to strengthen mitigation.

Conclusions

The study demonstrated a positive return on investment for each project, based on the comparison of awarded funding for the project to avoided losses in subsequent events. Table 5 summarizes the return on investment calculated for the 11 Snoqualmie properties. If various other elements of loss were to be included, such as the social impact, displacement of residents, potential impact on the environment, etc., the return on investment would be greater still.

This report also presents a review of a FEMA loss avoidance study of flood mitigation projects in the City of Snoqualmie. The city, King County, Washington State and FEMA committed millions of dollars to relocating or elevating more than 100 residential properties in the Snoqualmie River floodplain over a period of about 30 years. The FEMA loss avoidance study evaluated 28 of these structures for which all necessary data was available. The study calculated a total project cost for the 28 structures of $1.3 million and estimated total avoided losses of $1.6 million during the flood of November 2006. FEMA noted that the avoided losses would likely have been greater had the U.S. Army Corps of Engineers not removed a constriction in the Snoqualmie River downstream of the City that had caused backwater in the study region during previous flood events.

**TABLE 5.
RETURN ON INVESTMENT FOR 11 ELEVATED HOMES IN SNOQUALMIE FROM 2010 LOSS AVOIDANCE STUDY**

	Return on Investment (Avoided Cost as Percent of Project Cost)		
Property #	Hazus Model Avoided Cost	2006 Flood Avoided Cost	2009 Flood Avoided Cost
1	65.38%	29.74%	41.48%
2	79.31%	14.69%	10.95%
3	56.33%	12.33%	2.43%
4	56.32%	2.03%	11.46%
5	121.60%	44.41%	53.75%
6	85.71%	53.90%	65.57%
7	63.61%	35.08%	—
8	84.76%	102.35%	132.56%
9	59.71%	109.72%	52.40%
10	80.13%	94.84%	94.39%
11	69.87%	35.76%	57.82%

Rossi et al. 1978—Long Term Effects of Natural Disasters

This study is not specific to the King County or Washington State area. Its study area is the United States. However, it was included in this literature review because it was deemed to be influential, based on frequent references to it in other literature. Its conclusions regarding disaster policy and assistance programs are meaningful for King County as for anywhere else in the United States.

Citation

Rossi, Peter H., James D. Wright, Sonia R. Wright and Eleanor Weber-Burdin. 1978. Are There Long Term Effects of American Natural Disasters? Estimations of Effects of Floods, Hurricanes, and Tornados Occurring 1960 to 1970 on U.S. Counties and Census Tracts in 1970. Social and Demographic Research Institute, University of Massachusetts. Amherst, Massachusetts. 16 pp. *In* Mass Emergencies 3 (1978) 117 – 132.

Scope

This paper was among the first to systematically evaluate how natural disasters have long-term impacts beyond the timeframe immediately after their occurrence. Most previous studies on long-term disaster impacts were case studies looking at individual events that may or may not have been typical. This study evaluated all major floods, tornadoes and hurricanes in the U.S. between 1960 and 1970. To better identify the impacts of these disasters, the study includes estimates of how communities would have developed had the disasters not occurred.

The destruction of homes, stores, factories, public utilities and public facilities, as well as injuries and deaths inflicted upon inhabitants, constitute the direct impacts of a natural disaster. Consequently, it is reasonable to expect that a major indicator of long-term disaster effects would be alterations in the growth patterns of an area's housing and population. This study examines U.S. Census data for areas affected by disasters to identify any such alterations in growth patterns. It assesses whether Census tracts that were subject to tornado, flood or hurricane events showed growth trends in the period between 1960 and 1970 that were more, less or the same as tracts that did not suffer such incidents

Methodology

This study used U.S. Census demographic, housing and economic data to model changes in these characteristics over a decade's time. The model was applied to 1960 Census data in order to project conditions in 1970. Actual 1970 Census data for areas affected by disasters was then compared to the projections to estimate the disaster's impact. This approach was applied to all U.S. counties or metropolitan tracts that experienced a major disaster in the decade and to a control sample of areas that experienced no disaster.

The models were not able to separate the effects of disasters from the effects of public policies implemented in response to the disaster, so study results indicate the impacts of disasters and of recovery efforts, aid contributions, and housing market reactions to disasters.

Conclusions

This study found that natural disasters have no discernible effects on county or census tract population or housing trends that last for an appreciable period of time. Based on its findings, it presents the following key conclusions:

- Assessments of the likely effects of natural disasters must take into account the magnitude of the losses involved against the resources at the command of the unit in question (e.g., a household or a county). The larger the impact ratio (ratio of loss to available resources), the larger the need for outside help. Post-disaster long-term assistance may be more appropriate for individuals, families and businesses than for the larger community. More extreme disaster events are likely to have higher impact ratios than an "average" disaster.
- In an ideal case of unlimited resources, policies based on the worst imaginable disasters are reasonable and defensible. In such a world, every city could be prepared for a 1,000-year flood. However, given other demands on resources, it is reasonable to question how big a

disaster it is rational and efficient to prepare for. The most reasonable policy may be to admit that catastrophic events cannot be prepared for and to expect that special measures would have to be taken *ad hoc* if such events occur. Disaster policy should be tuned to the needs associated with an average disaster and applied to those events alone.

Costanza et al. 1997—Value of Ecosystem Services

This study is not specific to the King County or Washington State area. Its study area is the world. However, it was included in this literature review because it was deemed to be influential, based on frequent references to it in other literature. Its conclusions findings on average unit values for ecosystem services are meaningful for King County as for anywhere else in the world.

Citation

Costanza, Robert, Ralph d'Arge, Rudolf de Groot, Stephen Farberk, Monica Grasso, Bruce Hannon, Karin Limburg, Shahid Naeem, Robert V. O'Neill, Jose Paruelo, Robert G. Raskin, Paul Sutton and Marjan van den Belt. 1997. The Value of the World's Ecosystem Services and Natural Capital. 8 pp. *In* Nature, Vol. 387. May 15, 1997.

Scope

This study's goal was to estimate the incremental value of ecosystem services (the estimated rate of change of value compared with changes in ecosystem services from their current levels). Many previous studies had estimated the value of a wide variety of individual ecosystem services. This is one of the earliest and most comprehensive studies to gather together this large but scattered amount of information and present it in a form useful for ecologists, economists, policy makers and the general public. From this synthesis, the study estimated values for ecosystem services per unit area by biome (vegetation cover type), and then multiplied by the total area of each biome for a global estimate of the value of ecosystem services.

Methodology

The study methodology involved a literature review and a few original calculations. The literature review recorded valuation methods, location and stated value from over 100 studies. Many of the valuation techniques used in the studies are based, directly or indirectly, on attempts to estimate individuals' "willingness-to-pay" for ecosystem services. Each estimate was converted to US$ (1994) per hectare per year using the USA consumer price index and other conversion factors as needed. To adjust for income effects for some estimates, service estimates were converted into US$ using the ratio of purchasing power GNP per capita for the country of origin to that of the USA. Where possible, estimates were stated as a range, based on high and low values found in the literature, and an average value. Some estimates from the literature on 'total ecosystem value' were recorded for comparison with totals from the other techniques.

To estimate the total global extent of each ecosystems, the study used an aggregated classification scheme with 16 primary categories to represent global land use. The major division is between marine and terrestrial systems. Marine was further subdivided into open ocean and coastal, and coastal was subdivided into estuaries, seagrass/algae beds, coral reefs, and shelf systems. Terrestrial systems were broken into two types of forest (tropical and temperate/boreal), grasslands/rangelands, wetlands, lakes/rivers, desert, tundra, ice/rock, cropland, and urban.

Conclusions

The study provides a table giving average ecosystem service value in US$ per hectare per year for 17 ecosystem services and 21 biomes. These estimates represent worldwide unit values, and estimates are also provided for total worldwide value by ecosystem service and by biome. A world map of total ecosystem service value per hectare per year is also presented.

The study estimates that the average annual value of ecosystem services is US$33 trillion—1.8 times the global gross national product. One practical use of the estimates presented is to help modify systems of national accounting to better reflect the value of ecosystem services and natural capital. A second important use of the estimates is for project appraisal, where ecosystem services lost must be weighed against the benefits of a specific project. Because ecosystem services are largely outside the market and uncertain, they are often ignored or undervalued, leading to the error of constructing projects whose social costs outweigh their benefits.

4. SUMMARY OF DOCUMENTS ADDRESSING PART OF KING COUNTY

Shannon & Wilson 2002—Green River Flood Damage Analysis

Citation

Shannon & Wilson. 2002. Preliminary Risk-Based Flood Damage Analysis: Green River Flood Control Zone District, King County, Washington. Prepared for King County Water and Land Resources Division by Shannon & Wilson, Inc. Seattle, Washington. 41 pp. January 2002.

Scope

A risk-based analysis was performed to determine flooding-related damage that could occur as a result of levee and revetment instability in the Green River Flood Control Zone District (which has since been replaced by the King County Flood Control Zone District). The objective of the study was to develop a preliminary estimate of the expected annual damage to structures and contents within the District's floodplain. This risk-based analysis accounted for uncertainty in available data associated with the complexity of systems such as rivers, levees and floodplains and their uses. Risk-based analysis identifies and quantifies the effects of uncertainty. The results were intended to provide an initial basis for developing a long-term levee- and revetment-maintenance and repair funding plan and to identify elements of the risk-based analysis that may require a more thorough evaluation.

Methodology

The analysis used the U.S. Army Corps of Engineers' Hydrologic Engineering Center Flood Damage Analysis (HEC-FDA) software to estimate expected annual damage. The study used a simplified model of the river, levees and economic impacts of flooding:

- The river is represented by a **discharge-probability function** and a **stage-discharge function**, obtained from single locations.
- Modes of levee failure evaluated in the study included under-seepage, through-seepage, slope stability of the levee on the riverside under static conditions, slope stability of the levee on the landside under static conditions, slope stability of the levee on the riverside during rapid drawdown, and scour due to river flow. These failure modes were evaluated separately and then combined to determine a composite **river-stage/levee-failure-probability function**.

- Historical flood damage data was used to establish the **stage-damage function**, which expresses the relationship between water level and the cost of damage incurred.

Conclusions

The estimated damage per year in the Green River Flood Control Zone District determined by the study for existing conditions is $65,730,000, with a standard deviation equal to $330,000. The estimated annual damage to residential structures and contents is $3,730,000 (3.4 percent of the total assessed value of improvements and contents for these structures). The estimated annual damage to non-residential structures and contents is $62,000,000 (1.1 percent of the total assessed value of improvements and contents for these structures).

This estimate could be more accurately defined given a larger scope, including further investigation and exploration of the river, levees, floodplain characteristics, and adjacent land use. The study recommends a detailed survey of the levee, river and floodplain, including visual reconnaissance and inspection, photogrammetry, topographic surveys, subsurface exploration, and soil testing.

Asia Pacific 2005—WRIA 9 Ecosystem Services and Conservation

Citation

Asia-Pacific Environmental Exchange. 2005. Ecosystem Services Enhanced by Salmon Habitat Conservation in the Green/Duwamish and Central Puget Sound Watershed. Final Report. Prepared for WRIA 9 Steering Committee and King County and King County Water and Land Resources Division by David Batker, Elizabeth Barclay, Roelof Boumans and Terri Hathaway of Asia Pacific Environmental Exchange. 93 pp. February 2005.

Scope

This study estimated the value of ecosystem goods and services—including flood prevention—produced within the Green/Duwamish and Central Puget Sound Watershed, which is designated Water Resource Inventory Area (WRIA) 9. WRIA 9 lies completely within King County; it covers 664 square miles in the southern portion of the county—29 percent of the total county area of 2,307 square miles.

The study was conducted as part of the effort of preparing the WRIA 9 Salmon Habitat Plan (*Salmon Habitat Plan – Making Our Watershed Fit for a King,* Green/Duwamish and Central Puget Sound Watershed WRIA 9 Steering Committee, August 2005). It identifies ecosystem goods and services that would be enhanced by implementing the WRIA 9 Habitat Plan and examines two case studies for salmon restoration actions. The study's methodology, results and conclusions are summarized in Chapter 6 of the Habitat Plan.

Methodology

Taking the lowest and highest dollar value range per acre for each vegetation type established in academic literature (forest, wetland, etc.) and multiplying that range by the acreage of that vegetation type in the study area provides a rough range of estimates for the value of ecological services provided by the subject ecosystem. Using geographic information system (GIS) data for WRIA 9, the acreages of forest, grass and shrublands, agriculture and pasturelands, wetlands, urban areas, lakes, ponds, rivers and streams, and rock were multiplied by the estimated value per acre for each identified ecosystem service. Peer reviewed journal articles were reviewed for each GIS classification and the values associated with each of 23 ecological services. The high and low values for each ecosystem type and ecological service were selected to provide the high and low range estimates. A value-transfer methodology was then used to calculate a range of dollar values for ecosystem services provided annually in WRIA 9.

The study categorizes ecosystem services into the same groupings used in Earth Economics 2007, as listed in Table 2 of this summary report. In that framework, flood protection is included in the category referred to as "disturbance prevention."

Conclusions

The study estimates the value of the disturbance-prevention ecosystem service for all of WRIA 9 based on land cover type, as summarized in Table 6.

TABLE 6.
RANGE OF DISTURBANCE-PREVENTION ECOSYSTEM SERVICE VALUES FOR WRIA 9 FROM ASIA PACIFIC 2005

	Range of Annual Value of Disturbance Prevention Ecosystem Service	
Land Cover	Low	High
Forest	$78,999,560	$571,956,814
Grasslands and Shrubs	$22,311,072	$161,532,161
Agriculture and Pasture	$349,977	$2,533,615
Urban	$0	$0
Lakes, Rivers, Ponds, Reservoirs	$0	$0
Wetlands	$1,579,001	$11,431,965
Coastal	$1,484,084	$10,744,768
Rock	$0	$0
Total	**$104,723,694**	**$758,199,323**

FEMA 2009—Green River Hazus Analysis

Citation

FEMA. 2009. Hazus Analysis for the Green River Valley. Prepared by Federal Emergency Management Agency Region X. Seattle, Washington. 50 pp. October 6, 2009.

Scope

Green River flows are controlled by the Howard Hanson Dam, which is owned by the Army Corps of Engineers. Following a record high level of water behind the dam in January 2009, the Corps discovered two depressions on the right abutment, increased water levels in groundwater monitoring wells, and silty water entering the abutment drainage tunnel. The Corps then installed additional monitoring equipment and conducted tests to determine the elevation to which the pool behind the dam can be raised without significant adverse impact on the abutment. Potential impacts of dam operation restrictions included increased flood risk to the Green River valley below the dam.

In June 2009, King County Emergency Management requested support from FEMA Region X in assessing risk to communities potentially affected by the dam restrictions. FEMA evaluated the impacts and effects of three flooding scenarios on the Green River using Hazus-MH and incorporating depth grids developed by King County and the Corps, planning and infrastructure data from local communities, and default Hazus information where no more accurate data exists. Each scenario represents a situation whereby flooding occurs downstream of Auburn that is beyond the capability of the existing levee

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system. The results of this study provide estimates of loss and damage that are likely to occur given the data modeled.

Methodology

Hazus requires the following information about the built environment to calculate loss due to flooding:

- Structure location
- Occupancy type
- Square footage
- First floor height above grade
- Replacement and content values.

All but content value and first floor height above grade were available in King County's April 2009 GIS data package, which includes parcels, assessment information, and essential facilities. Improvement values from King County's Assessor were used for replacement values. Content value and first floor height above grade were calculated using Hazus default methodologies. Hazus also requires flood depth grids, which are created from hydrologic and hydraulic modeling to show flood depth in feet. For this study, three depth grids were used:

- Scenario 1, the Corps' depth grid for a flow of 17,600 cubic feet per second (cfs)—The key assumption in this scenario is that the levees remain intact (i.e. the channel and levees contain 12,800 cfs while 4,800 cfs overtops the levees and floods the overbank areas).
- Scenario 2, the King County 100-year base flood study—The key assumptions in Scenario 2 are a base (1-percent annual chance) flood event with a volume of 12,800 cfs and a combination of six "with and without" levee scenarios modeled to simulate levee failure.
- Scenario 3, a combination of the two studies, with 17,600 cfs and levee removals—The depth grids imported into Hazus for this scenario are the result of applying the levee modeling assumptions from Scenario 2 with the water volume (17,600 cfs) used in Scenario 1.

Using the combination of the depth grid and the local data, Hazus calculates economic losses, shelter requirements, and debris. A comparison was also completed between each flood scenario. Economic loss is calculated as building, content, and inventory (business) loss as well as business interruption costs.

Conclusions

Estimated losses for the three scenarios modeled are summarized in Table 7.

TABLE 7.
HAZUS-ESTIMATED FLOOD LOSSES DUE TO GREEN RIVER FLOODING FROM FEMA 2009

	Hazus-Estimated Flood Loss Value (millions)		
	Scenario 1—17,600-cfs Flood Flow	Scenario 2—100-Year Flood with Some Levees Removed	Scenario 3—17,600 cfs Flood Flow and Some Levees Removed
Building Losses			
Structure	$340.28	$508.00	$977.70
Content	$725.84	$1,048.05	$2,038.26
Inventory	$257.99	$400.52	$694.35
Building Subtotal	***$1,324.11***	***$1,956.57***	***$3,710.31***
Business Losses			
Income	$2.39	$2.88	$6.03
Relocation	$1.53	$1.73	$3.15
Rental Income	$1.23	$1.45	$2.76
Wages	$17.13	$4.79	$26.15
Business Subtotal	***$22.28***	***$10.86***	***$38.09***
Total	**$1,346.39**	**$1,967.43**	**$3,748.39**

Critical Infrastructure Group 2009—Green River Flood Impacts Workshop

Citation

Critical Infrastructure Protection Working Group 2009. Summary Report on the Critical Infrastructure Interdependencies Workshop; Focus: Potential Flood Impacts and Short and Longer Term Regional Risk Mitigation Associated with the Green River; Held November 12, 2009 in Seattle, Washington. Workshop conducted by the Washington Homeland Security Region 6 Critical Infrastructure Protection Working Group, the Pacific Northwest Economic Region Center for Regional Disaster Resilience, and the Puget Sound Partnership for Infrastructure Security and Resilience, in cooperation with the City of Tukwila and King County Office of Emergency Management. 31 pp. November 12, 2009.

Scope

Local government agencies, private stakeholders and other key organizations convened on November 12, 2009 in Seattle to discuss potential impacts from a major flood in the Green River Valley and identify ways to mitigate consequences for public health and safety and the region's economy. The workshop was designed to highlight key infrastructure dependencies and to facilitate discussion among critical infrastructure owners on preparedness, response, recovery and long-term restoration.

The first session presented background on the Howard Hanson Dam, a status report on repairs associated with the dam and downstream levees, and an overview on infrastructure dependencies and types of vulnerabilities and impacts. The second session presented "snapshots" of critical infrastructure sectors in the region and issues involved in developing a flood mitigation and restoration plan. The workshop concluded with discussion of additional short-term mitigation measures that could be undertaken and development of a longer-term regional mitigation strategy to deal with potential flood impacts.

Methodology

This report is a workshop summary. The workshop consisted of presentations by government and business officials. Workshop results are based on participant comments and feedback forms.

Conclusions

Economic impacts of flooding were not presented as cost estimates at this workshop, but the types of economic disruptions that could occur were outlined, as follows:

- Electric and gas service disruptions could be of significant duration. Utilities will not be able to restore power until all floodwaters have subsided and equipment is dried out. Customers may be required to have service inspections.
- The Olympic Pipeline running through the Green River Valley supplies most of the fuel needs of Western Washington and all of the fuel needs of Sea-Tac Airport and the Port of Seattle. Potential flood impacts on this operation are as follows:
  - The main hub for pipeline operations is in Renton and could be forced to shut down during a flood. An alternate command center in Tacoma can run the pipeline should this happen. Without the Renton hub, operations would be down to 70 percent.
  - Affected fuel companies typically maintain a three-day supply of product. After three days, there would be a need to transport fuel by means other than through the pipeline, using trucks and barges.
  - Sea-Tac Airport keeps enough fuel on hand for three days; distribution disruption for longer than that would have far-reaching effects. Should the pipeline segment to Sea-Tac be shut down when transporting product other than jet fuel, the line would have to be cleared once operations were running again, causing further delay in providing jet fuel. If there were significant flooding, it could take several weeks to months to get facilities repaired, rebuilt, and back on-line.
- A one-day shutdown of the airport (due to flood impacts on the pipeline supplying jet fuel) would take three days to get air flights back to normal. Also, the airport is the major hub for the State of Alaska, which is dependent on air cargo supply chains.
- Many transportation routes would be impassable. Debris traveling down the river could damage bridges. Thirty transit routes would be affected. State Route 18 would probably remain open, but State Route 167 would be impacted. There would be high volume on I-5. This, in conjunction with an evacuation, would cause major traffic disruptions and interrupt the trucking industry.
- Qwest (the local phone service provider at the time of the workshop) has five central offices in the region, including a cyber-center in Tukwila, a warehouse in Kent, and cables, equipment, garages, and controlled environmental vaults. Qwest serves the FAA, 911, local emergency services and law enforcement, schools, and hospitals. If the company's assets were inundated, telephone service would be disrupted to Qwest customers. Restoration of telecommunications services could take weeks in the event of major flooding and would follow power restoration.
- The King County sewer system in the Green River valley is only capable of handling routine wastewater flows and would not be able to handle additional flows that would come from the interior drains of inundated homes and businesses. The conveyance system in the area of concern is a gravity system that flows to the King County South Treatment Plant, and the system in essence would become a sump for the inundated areas and would quickly be

overwhelmed. Wastewater systems in the inundation area would not be fully operational for some time because of contamination, lack of power for pumps, and the need to drain, flush, and test the system.

- In the event of major flooding, each city in the flooded area would need to test its potable water to ensure that it was not being contaminated.
- Public health concerns associated with flooding include hazardous materials co-mingling with floodwaters, sewage overflows, drinking water system integrity, solid waste/debris management, rodents/vectors, dead animals, household chemicals, food safety and sanitation, food warehousing and distribution, and mass care sheltering.

Earth Economics 2010—Snoqualmie Watershed Valuation

Citation

Earth Economics. 2010. A New View of Our Economy: Nature's Value in the Snoqualmie Watershed. Prepared by Earth Economics. Tacoma, Washington. 89 pp. June 2010.

Scope

This study estimated the value of ecosystem goods and services—including flood prevention—produced within the Snoqualmie Watershed. The Snoqualmie watershed covers 692 square miles, largely in King County but with a small portion in Snohomish County. It represents over a quarter of the total county area of 2,307 square miles.

Methodology

The methodology used to conduct this economic valuation was the technique called benefit-transfer or value-transfer, wherein the estimated economic value of an ecological service is determined by examining previous valuation studies of similar services in comparable locations. Additive values provide different services and contribute to the total value of an ecosystem. An acre of forestland provides water regulation and filtration, aesthetics, flood protection and habitat. One study may establish the value per acre of watersheds for drinking water filtration. Another study may examine the value per acre of wildlife habitat. To determine the full per acre value provided by a vegetation type, ecosystem service values are summed up and multiplied by the acreage. The Snoqualmie Watershed was divided into 15 vegetative land cover types, and the ecosystem service valuation was performed for each type.

The study categorizes ecosystem services into the roughly same groupings used in Earth Economics 2007, as listed in Table 2 of this summary report, although a few services have been combined or omitted. In the framework for this study, flood protection is included in the category referred to as "disturbance regulation."

Conclusions

Of the 15 vegetative land cover types identified in the Snoqualmie Watershed, this study found ecosystem services and any kind provided in only 11 land cover types, and estimated the value of flood protection (disturbance regulation) provided only for the riparian buffer land cover type. The estimated range of disturbance regulation value for this cover type is $7.56 per acre per year to $235.73 per acre per year.

This study does not show an acreage of riparian buffer in the Snoqualmie Watershed to which these unit estimates of flood protection service values can be applied. However, comparison of total ecosystem service unit value estimates in two tables (Table 8 and an un-numbered table on page 58) suggest that the riparian buffer designation is the same as the "riparian forest mid to late," which is shown as have an area of 35,977 acres. Applying this area would give a range of annual flood protection benefit in the Snoqualmie Watershed of $272,000 to $8,481,000.

This study notes incidentally that "It was recently estimated that a 100-year flood along the Snoqualmie River would displace approximately 1600 residents in Snoqualmie alone and cost more than $29 million." This estimate is referenced to "100-year flood hazard exposure data by jurisdiction" developed in 2010 by "King County Flooding Services"; this source was not able to be located for this literature review.

Goodwin 2010—Green River Flooding Economic Impacts

Citation

Goodwin, Tom. 2010. Economic and Tax Revenue Impacts of Potential Flooding in the Green River Valley. Prepared by Tom Goodwin, Chief Economist, Office of Economic & Financial Analysis, Metropolitan King County. Seattle, Washington. 18 pp. January 13, 2010.

Scope

Because of water seeping through an earthen bank next to the Howard Hansen Dam after record high water in 2009, the U.S. Army Corps of Engineers must limit the amount of flood water it stores behind the dam until it can make permanent repairs. Given this dam storage limitation, Green River valley residents, businesses and farms below the have been preparing for a higher risk of flooding. This report addresses the potential economic and tax revenue impacts of such flooding.

Methodology

A computer simulation scenario constructed by the Corps of Engineers was the basis for this analysis. The Corps estimated the level of inundation for a Green River flow of 25,000 cfs measured by the gauge at Auburn, with no levee failures. This is a severe case but not the worst case. A GIS "shape file" with the exact coordinates of the 25,000 cfs scenario inundation area was created, and economic data sources were overlaid on this shape file. The mapped inundation area does not take into consideration recent defenses placed along the river such as levee fortification and sandbagging.

Conclusions

Key findings of this study are as follows:

- There are close to 100,000 jobs in the inundation area with a payroll of $16 million per day.
- The total value of all output in the inundation area is over $63 million per day.
- Over 100,000 people commute into or out of the inundation area.
- There are 4,771 retail business sites in the inundation area, which generated $4.7 billion in taxable retail sales in 2008.
- Based on 2008 data, over $1.2 million per day in sales tax revenue would be lost during a flood event. Of that, $156,000 per day would be lost to King County's general, criminal justice, mental illness and drug dependency, and Metro Transit funds; $111,000 per day would be lost to the cities of Auburn, Kent, Renton, and Tukwila.
- The assessed value of property in the inundation area was over $6.7 billion in 2008, generating $112 million in annual property tax. Property tax revenues would not be immediately affected but could depress new construction in the area and shift the tax burden to other parts of the county.

DSES-10 2011—Green River Valley Regional Consequence Assessment

Citation

DSES-10. 2011. Regional Consequence Assessment Report: 2010 Dams Sector Exercise Series, Green River Valley. Prepared by the Department of Homeland Security and the U.S. Army Corps of Engineers. 127 pp. May 2011.

Scope

A significant Green River flood event would create serious consequences for local communities and businesses. The 2010 Dams Sector Exercise Series (DSES-10) involved public and private stakeholders in the Green River valley to address regional disaster resilience in response to this potential threat. Los Alamos National Laboratory and the U.S. Army Corps of Engineers used a worst-reasonable-case flood scenario to assess potential Green River flood impacts on infrastructure, population, and the economy. The Regional Consequence Assessment presents the following findings of an evaluation of potential flooding consequences:

- Direct population and housing impacts
- Direct infrastructure impacts affected by floodwater and electric power outages
- Cascading infrastructure impacts
- Short- and long-term economic impacts.

The primary goal of the DSES-10 project is to achieve a greater understanding of potential impacts of significant flooding events along the Green River Valley and to identify critical infrastructure interdependencies that influence local and regional disruptions in such an event. A Regional Resilience Strategy will be developed as the overall outcome of the DSES-10 project.

Methodology

The Regional Consequence Assessment used a flood scenario based on a 1-percent-chance-annual-exceedance flood event and an emergency release from Howard Hanson Dam to maintain reservoir elevation at 1,167 feet. Levees were assumed to remain in place without added flood protection measures, except for a failure of the 180th Street levee (commonly referred to as the Tukwila 205 levee).

The hydrologic and hydraulic models used to evaluate flood impacts included a steady-state Hydrologic Engineering Center River Analysis System (HEC-RAS) model of the entire study reach and a two-dimensional hydraulic model (FLO-2D) for more urban areas.

The Hydraulic Engineering Center Flood Impact Analysis (HEC-FIA) model, Los Alamos National Laboratory infrastructure models, and the Regional Dynamics (REDYN) economic analysis model were used to identify and estimate the population, infrastructure and economic impacts, respectively.

Conclusions

Modeling of the extent and duration of floodwaters indicates that floodwater may take up to two weeks to recede from some areas. The following are key impacts were predicted by the evaluation:

- Estimated damage to structures, contents, and automobiles ranges from \$3.70 to \$3.76 billion, depending on the amount of time between the warning and the flood.

- Building restoration times are estimated to be as long as 36 months, depending on the type of construction and flood depth period. FEMA standards requiring non-residential buildings to elevate or flood-proof to 1 foot above base flood elevation after a flood could lengthen the restoration period beyond 36 months.
- Businesses exposed to the flood hazard include:
  - 5 farm/ranch businesses and 10 food processing and manufacturing facilities
  - 27 banking entities
  - Critical manufacturing facilities including steel plants, defense industrial base suppliers, and aerospace and aircraft industries
  - Many retail stores and warehouses
  - 24 long-term care facilities
- More than 15,000 customers may be affected by power outages.
- Road travel times and average trip distance may increase by 13 percent to 38 percent.
- When indirect and induced output losses are combined with direct output losses, King County economic output losses are as high as $40 billion the first year. These losses decrease but persist throughout the restoration period of up to three years. When the positive, offsetting effect of restoration investment is incorporated into the estimate, King County economic impacts are reduced but still negative; with first-year output losses of $16.7 billion and first-year employment losses of 71,900.
- Long-term negative impacts on the King County economy persist throughout most of the forecast period through 2030, largely due to King County losing market share to businesses outside King County as those businesses become more profitable and attract labor and other resources away from King County.

Tetra Tech 2011—180th to 200th Street Levee Setback Study (Draft)

Citation

Tetra Tech. 2011. 180th to 200th Street Levee Setback Study—DRAFT. Prepared for King County Water and Land Resources Division by Tetra Tech, Inc. Seattle, Washington. 382 pp. May 2011.

Scope

As an early component of a King County project to replace 2.7 miles of levees along the Green River between South 180th Street and South 200th Street was a series of technical analyses to assess the advantages and disadvantages of building the new levees in the same location as the existing levees or setting them back various distances from the river. The 180th to 200th Street Levee Setback Study describes those analyses and their key findings. Key elements of the levee setback study include a flood-damage risk assessment and an analysis of the value of ecosystem services that could be provided by various setback options. Although these analyses are for a specific project location on the Green River, their methodologies and general conclusions are meaningful for a broader assessment of flood economic impacts throughout King County.

The version of the study report reviewed for this summary report was a draft; the final report has yet to be completed and accepted by King County.

Methodology

Estimated Costs

Construction costs were estimated for three levee options:

- Replace the existing levee in the same alignment along the river bank.
- Remove the existing levee and build a levee set back 300 feet from the river bank.
- Remove the existing levee and build a levee set back 600 feet from the river bank.

Estimated Benefits

Avoided cost for each alignment option was calculated through a risk assessment that estimated flood damage with and without the proposed project for three flooding scenarios:

- Scenario 1—Howard Hanson Dam providing its full design level of flood control
- Scenario 2—Howard Hanson Dam providing a partial level of flood control below its design level
- Scenario 3—No flood control provided by Howard Hanson Dam

The risk assessment was based on the following:

- A hydrologic analysis that established probabilities for various river stages
- A geotechnical analysis that estimated probability of levee failure as a function of river stage
- A levee breach analysis that estimated extent and depth of floodwaters in the event of a levee breach
- Hazus modeling to estimate damage costs associated with modeled levee breaches
- Modeling using FEMA's Benefit Cost Analysis Re-engineering (BCAR) software to calculate annualized avoided damage and the net present value of avoided damage over the project's effective life.

Estimates were made of the value of ecosystem services that could be enhanced by making additional riparian area available with the levee setback alignment options. Methods for estimating each ecosystem service were as follows:

- Wetland Habitat—Determine the increase in area providing wetland habitat due to the proposed levee setback; determine wetland value per acre based on a literature review
- Salmon Habitat—Make an assumption about salmon population increase resulting from setback; determine household willingness to pay for salmon based on assumed increase, using data from a previous study; multiply household willingness to pay by number of households in Puget Sound region
- Outdoor Recreation—Calculate new riparian area within setback as a percentage of current park area in project vicinity; determine the increase in number of area recreational activities by applying the area percentage increases to the number of recreational activities in one year by residents within 2 miles of the project (from previous studies); multiply the number of additional recreational activities by an estimated "recreational surplus value" per activity (from a previous study).

- Precipitation Storage—Estimate the precipitation storage value of increased impervious surface in the setback area as equal to the cost of constructing an infiltration facility that would provide an equivalent volume of storage.
- Carbon Absorption—Estimate the number of trees that would grow in within the new setback areas; estimated tons of carbon dioxide sequestered by those trees based on previous studies; determine unit value of carbon dioxide sequestration from a literature review of previous studies.
- Air Quality—Estimate the number of trees that would grow in within the new setback areas; estimated tons of non-carbon pollutants sequestered by those trees based on previous studies; determine unit value of carbon dioxide sequestration from a literature review of previous studies.

Conclusions

The costs and benefits estimated for the three levee options are summarized in Table 8.

TABLE 8.
SUMMARY OF REPLACEMENT LEVEE COSTS AND BENEFITS FROM TETRA TECH 2011 (DRAFT)

Benefit or Cost	In-Place Replacement Levee	300-Foot Setback Levee	600-Foot Setback Levee
Costs			
Levee Construction	$81.9 million	$58.8 million	$55.2 million
Parcel Acquisition	$155.5 million	$224.6 million	$293.8 million
River Corridor Restoration	$0	$4.4 million - $14.4 million	$7.1 million - $23.0 million
River Corridor Excavation	$0	$0.43 million - $6.5 million	$5.0 million - $9.0 million
Benefits			
50-Year Present Value of Avoided Flood Damage			
Scenario 1 (Full Dam Flood Control)	$30.2 million	$31.2 million	$32.0 million
Scenario 2 (Partial Dam Flood Control)	$129.4 million	$138.0 million	$159.9 million
Scenario 3 (No Dam Flood Control)	$230.8 million	$153.6 million	$204.9 million
50-Year Present Value of Ecosystem Service Benefit			
Wetland Habitat	$0	$3.5 million - $5.2 million	$4.2 million - $8.6 million
Salmon Habitat	$0	$30.9 million - $38.3 million	$61.7 million - $76.7 million
Outdoor Recreation	$0	$84.5 million	$145.0 million
Precipitation Storage	$0	$9.8 million	$17.4 million
Carbon Absorption	$0	$3.7 million - $3.3 million	$8.4 million - $7.4 million
Air Quality	$0	$0.6 million - $0.7 million	$1.5 million - $1.6 million

APPENDIX I.
PUGET SOUND SALMON RECOVERY 2012 3-YEAR WORK PLANS
FOR WRIA 7, WRIA 8, WRIA 9, WRIA 10

This appendix contains a listing of the 2012 3-year work plans prepared for the Puget Sound Partnership for the following watersheds: Snohomish, Lake Washington/Cedar/Sammamish, Green/Duwamish, Puyallup-White/Chambers-Clover. On an annual basis, each of the watershed groups representing the fourteen watershed chapters of the Puget Sound Salmon Recovery Plan develop three-year work program updates to describe the watershed's accomplishments during the previous year, identify the current status of recovery actions, and to propose future actions in the next three years necessary to implement the Salmon Recovery Plan. These work programs are intended to provide a road map for policy and technical decision makers across the Puget Sound region on priorities for implementing the salmon recovery plan, inform and support funding requests, and establish a recovery trajectory within each watershed and the region.

Funding and New Project	Project Name	Project ID	Sub Basin Strategy Group	Project Performance	Likely End Date	Likely Sponsor	Total Cost of Project
Fully funded	**Renourish Existing Jetty Island Berm**	07-NR-005	Nearshore Restoration	reoccurring (every 2-3 years) renourshiment to maintain existing habitat functions on 2300 ft. of the berm to protect ~ 15 acre saltmarsh habitat.	12/31/2020	Port of Everett	$ 475,000
Fully Funded	**Nearshore Beach Nourishment Design and Permitting**	07-NR-025	Nearshore Restoration	Produce 100% Design Drawings for Sites 2, 5, and 9 ; Develop and obtain required permits for implementation.	8/31/2014	Snohomish County, Snohomish County Marine Resources Advisory Committee	$ 139,000
NEW	**Day lighting Japanese Gulch Creek**	07-NR-029	Nearshore Restoration	Daylight approximately 300 linear feet of Japanese Gulch Creek that has been culverted and paved over as part of the old Mukilteo Tank Farm site.	12/31/2017	City of Mukilteo	$2,200,000
NEW	**Mission Beach Nearshore Restoration Feasibility and Design**	07-NR-026	Nearshore Restoration	1100 feet of armoring and bulkheads removed;	12/31/2015	Tulalip Tribes	$ 2,000,000
NEW	**Snohomish County Nearshore Restoration-Construction**	07-NR-028	Nearshore Restoration	.73 Miles (1.1 acres) beach nourishment; remove .6 miles shoreline armoring	4/1/2015	Snohomish County Marine Resources Advisory Committee	$ 1,111,077

Funding and New Project	Project Name	Project ID	Sub Basin Strategy Group	Project Performance	Likely End Date	Likely Sponsor	Total Cost of Project
NEW - Funded	**Jetty Island South Extension Phase III**	NO HWS Entry but like '07-NR-003	Nearshore Restoration	~1000 feet of Island extension	12/31/2015	Port of Everett, US Army Corps of Engineers	$ 450,000
	North Mukilteo Nearshore Restoration and Creosote Removal	07-NR-011	Nearshore Restoration	Removal of the existing ferry terminal site includes removal of 248 pilings & 406 tons treated timber. Removal of the Tank Farm Fuel Dock includes removal of 3950 pilings and 7300 tons treated timber. The entire project (existing terminal site & TF Fuel Dock) will include removal of approximately 145,000 sq feet overwater structures.	12/31/2017	Washington State Ferries	$ 21,700,000
	Tulalip Nearshore Acquisition and Restoration	07-NR-012	Nearshore Restoration	Acquire parcels along the Tulalip Tribes nearshore; remove armoring.	1/1/2014	Tulalip Tribes	$ -
	Priest Point Pocket Estuary Restoration	07-NR-014	Nearshore Restoration	Acquire 3.1 acre parcel within the historic pocket estuary for future restoration.	12/31/2015	Tulalip Tribes	$ -

Funding and New Project	Project Name	Project ID	Sub Basin Strategy Group	Project Performance	Likely End Date	Likely Sponsor	Total Cost of Project
Estuary Restoration							
Fully Funded	**Blue Heron Slough Habitat Conservation Bank**	07-ER-013	Estuary Restoration	320 acres off channel habitat reconnected; 13,500 ft. edge habitat restored	2/28/2015	Port of Everett, Wildlands, Inc.	$ 2,700,000
Fully Funded	**Qwuloolt Estuary Restoration Project**	07-ER-036	Estuary Restoration	400 acres tidal influenced wetlands restored; improved 16 miles of salmon access	12/31/2017	Tulalip Tribes	$ 11,100,000
	Diking District 6 Inter-tidal Restoration Project	07-ER-035	Estuary Restoration	230 acres restored to tidal influence; non-tidal wetland enhancements	12/31/2015	City of Everett	$ 10,000,000
	Smith Island Estuary Restoration - Construction	07-ER-037	Estuary Restoration	400 acres tidal influenced wetlands restored;	12/31/2016	Snohomish County	$ 15,000,000
	Bigelow Creek Re-channelization and Enhancement and the South Wetland Complex	07-ER-038	Estuary Restoration	Enhance 10.4 acres of floodplain/tidal marsh (berm or dike removal); 1,000 feet of tidal channel with associated wetlands	12/31/2015	City of Everett	$ 3,000,000

Funding and New Project	Project Name	Project ID	Sub Basin Strategy Group	Project Performance	Likely End Date	Likely Sponsor	Total Cost of Project
	Steamboat Slough Tidal Marsh Enhancement	07-ER-040	Estuary Restoration	100 acres berm or dike removal/modification	12/31/2015	Snohomish County	$ 435,000
	Everett Riverfront North Wetland Complex and adjacent proposed Public Park	07-ER-053	Estuary Restoration	Re-establish, approximately 21.6 acre tidally influenced forested, scrub-shrub and emergent marsh over 50 years	12/31/2015	City of Everett	$ 2,004,048
Mainstem Restoration							
Fully Funded	**Lower Tolt Restoration Project - Camp River Ranch**	07-MPR-005	Mainstem Primary Restoration	9 acres weed control; 3 acres planting	4/30/2014	Sound Salmon Solutions	$ 50,000
Fully Funded	**Upper Tychman Slough Restoration**	07-MPR-214	Mainstem Primary Restoration	6 acres weed control; 6 acres riparian planting; 6 flood fences; 15 instream LWD; 1000 ft. livestock exclusion fence	12/31/2014	Sound Salmon Solutions	$ 380,000
Fully Funded	**Raging River Knotweed Control and Revegetation**	07-MPR-216	Mainstem Primary Restoration	30 acres treated and riparian planting	12/31/2014	Mountains to Sound Greenway Trust	$ 100,000
Fully Funded	**Investigation of Low Dissolved Oxygen in the Cherry Creek Floodplain**	07-MPR-328	Mainstem Primary Restoration	Data collected on water quality, hydraulic properties - ID degraded WQ drivers to be addressed. Evaluate. Impacts of ditch cleaning on WQ.	12/31/2014	Wild Fish Conservancy	$ -

Funding and New Project	Project Name	Project ID	Sub Basin Strategy Group	Project Performance	Likely End Date	Likely Sponsor	Total Cost of Project
Fully Funded	**Fall City Park Riparian Restoration Phase 2**	07-MPR-365	Mainstem Primary Restoration	9 acres of riparian restoration	12/31/2014	Snoqualmie Tribe	$ 280,000
Fully Funded	**Tolt River Conservation**	07-MPR-397	Mainstem Primary Restoration	25 acres acquired	12/30/2016	King County DNR & Parks	$ 250,000
Fully Funded	**Tolt River Floodplain Restoration**	07-MPR-224	Mainstem Primary Restoration	3.5 acres riparian	12/31/2014	Mountains to Sound Greenway Trust	$ 45,000
NEW	**Snoqualmie Private landowner restoration 2012 -2016**	07-MPR-329	Mainstem Primary Restoration	10 acres riparian planting	12/31/2016	Stewardship Partners	$ 400,000
NEW	**McCormick Park Restoration - Phase II**	07-MPR-194	Mainstem Primary Restoration	Weed Control and Planting on 5 acres		Sound Salmon Solutions	$ 45,000
NEW	**Pilchuck Dam Removal**	07-MPR-403	Mainstem Primary Restoration	re-establishment of fish passage to 37 miles of fish habitat for Chinook, Coho, Chum, Pink, Steelhead, Bulltrout and Cutthroat.	12/31/2015	City of Snohomish	$ 3,500,000

Funding and New Project	Project Name	Project ID	Sub Basin Strategy Group	Project Performance	Likely End Date	Likely Sponsor	Total Cost of Project
NEW	**Upper Carlson Floodplain Reconnection**	07-MPR-900	Mainstem Primary Restoration	remove 1,600 feet long Upper Carlson Facility (levee & revetment); reconnection and restoration of 50 acres of floodplain habitat; 4-6 large logjams installed; enhancement of 2,000 linear feet of mainstem edge habitat and 1.75 acres of existing off-channel habitat	12/31/2015	King County DNR & Parks	$ 2,877,499
NEW	**Tolt River Floodplain Reconnections**	07-MPR-225	Mainstem Primary Restoration	Restore 2500 feet of shoreline along the Tolt River.	12/31/2017	King County DNR & Parks	$ 1,000,000
NEW	**WRIA 07 CO2/02 Pilot Program**	07-MPR-233	Mainstem Primary Restoration	Invasive removal and riparian re-vegetation along at minimum 6.0 acres of river channel	6/30/2017	Wild Fish Conservancy	$ 117,500
NEW	**Indian/Langlois Cr. Restoration**	07-MPR-319	Mainstem Primary Restoration	Naturalize ditched channel	12/31/2015	Wild Fish Conservancy	$ 150,000
NEW	**Peoples Creek Channel Relocation and Riparian Restoration (Phase I)**	07-MPR-231	Mainstem Primary Restoration	Naturalize ditched channel	12/31/2016	Wild Fish Conservancy	$ 125,000
	Investigation of Low Dissolved Oxygen in the Snoqualmie Floodplain	07-MPR-328		Data collected on water quality, hydraulic properties	12/31/2014	Wild Fish Conserva	$ 63,710
	Lower Snoqualmie River Protection	07-MPR-025	Mainstem Primary Restoration	10 acres acquired	12/29/2017	King County DNR & Parks	$ 500,000

Funding and New Project	Project Name	Project ID	Sub Basin Strategy Group	Project Performance	Likely End Date	Likely Sponsor	Total Cost of Project
	Island Formation at Thomas' Eddy	07-MPR-030	Mainstem Primary Restoration	2000 ft. linear side channel; remove 50 ft. of armoring; restore 5 acres of riparian habitat; restore 1/5 acres of summer off-channel habitat; install 100 large wood complexes (2000 ft.)	12/16/2016	Snohomish County	$ 380,000
	Lower Snohomish Mainstem (and Snoqualmie) Assessment	07-MPR-031	Mainstem Primary Restoration	completed assessment identifying potential restoration sites	6/30/2015	Snohomish County	$ 80,000
	Conservation Reserve Enhancement Program - Mainstem-primary	07-MPR-057	Mainstem Primary Restoration	'2,000 feet riparian livestock exclusion fencing; 5 acres riparian planting	12/15/2016	Snohomish Conservation District	$ 20,000
	Raging River Upper Preston Reach Acquisitions	07-MPR-072	Mainstem Primary Restoration	24 acres acquired	12/31/2015	King County DNR & Parks	$ 500,000
	Tolt River Focus Area 5 Protection	07-MPR-108	Mainstem Primary Restoration	30 acres acquired	12/31/2015	King County DNR & Parks	$ 500,000

Funding and New Project	Project Name	Project ID	Sub Basin Strategy Group	Project Performance	Likely End Date	Likely Sponsor	Total Cost of Project
	Raging River Kerriston Reach Restoration	07-MPR-119	Mainstem Primary Restoration	15 acres riparian planting	12/31/2014	King County DNR & Parks	$ 200,000
	Shinglebolt Slough	07-MPR-137	Mainstem Primary Restoration	4000 ft. off channel habitat; 5 acres invasive plan control and plantings	12/31/2014	Snohomish County	$ 396,000
	Snoqualmie River at Cherry Creek Riparian and Edge Enhancement	07-MPR-193	Mainstem Primary Restoration	6 acres weed control; 6 acres planting	12/31/2015	Sound Salmon Solutions	$ 149,000
	Tolt Footbridge Restoration	07-MPR-196	Mainstem Primary Restoration	1000 ft. edge, 5 ac. Off-channel, 2 ac. Riparian	12/31/2015	King County	$ 650,000
	South Fork Skykomish Roads	07-MPR-215	Mainstem Primary Restoration	38 miles road treatments	12/31/2018	US Forest Service	$ 700,000
	Lower Skykomish Restoration Phase I: Groeneveld, Bahnmiller, Labish Projects. Phase II: Remlinger Project	07-MPR-370	Mainstem Primary Restoration	3.3 miles of Mainstem and off channel flood plain enhancement. 22 instream vertical wood arrays, 1.5 linear miles Riparian edge plantings, 12 acres riparian planting,3 (large) woody material placement areas, 7 (small) woody material placement structures	12/31/2016	Snohomish County	$1,300,000

Funding and New Project	Project Name	Project ID	Sub Basin Strategy Group	Project Performance	Likely End Date	Likely Sponsor	Total Cost of Project
	Middle Pilchuck River Final Design	07-MPR-186	Mainstem Primary Restoration	Complete final design and permitting for 1 project	12/31/2014	Snohomish County	$ 120,000
	Snoqualmie Fall City Reach Reconnection	07-MPR-305	Mainstem Primary Restoration	5280 feet of edge habitat restored; 5 acres of off-channel habitat restored, 12 acres of riparian restoration	12/1/2016	King County DNR & Parks	$ 4,000,000
	Riley Slough Culvert Replacement Project	07-MPR-318	Mainstem Primary Restoration	remove and replace 1 fish passage barrier; 1 acre riparian planting	12/31/2015	Snohomish Conservation District	$ 50,000
	McElhoe-Pearson Restoration Project	07-MPR-321	Mainstem Primary Restoration	Channel Connectivity/Rehabilitation/Creation - Floodplain Restoration 2,500 Linear Feet	9/30/2016	King County DNR & Parks	$ 918,000
	Snoqualmie Riparian Restoration	07-MPR-322	Mainstem Primary Restoration	10 acres riparian restoration	12/31/2014	King County DNR & Parks	$ 100,000
	CC Phase II. Cherry Creek Floodplain Restoration	07-MPR-326	Mainstem Primary Restoration	Riparian re-vegetation. Along ~4500 feet of newly constructed channel	12/31/2016	Wild Fish Conservancy, Sound Salmon Solutions	$ 200,000

Funding and New Project	Project Name	Project ID	Sub Basin Strategy Group	Project Performance	Likely End Date	Likely Sponsor	Total Cost of Project
	South Fork Skykomish Knotweed Control and Riparian Restoration	07-MPR-366	Mainstem Primary Restoration	3.5 river miles of initial treatment; up to 14 river miles of maintenance retreatment; riparian plantings along 3,000 linear feet per year.	12/31/2014	King County DNR & Parks	$ 278,500
	Pilchuck Culvert Replacement	07-MPR-398	Mainstem Primary Restoration	Culvert retrofit or removal. Non-native vegetation control and native re-vegetation. Outreach and education. Effectiveness monitoring.	12/31/2014	Wild Fish Conservancy	$ 550,000
	Raging River Side Channel Fish Passage Project (Phase II)	07-MPR-400	Mainstem Primary Restoration	Replace one 1.5 ft. partial barrier culvert with a 4.0 ft. box culvert.	6/30/2016	Wild Fish Conservancy	$ 83,000
	Pilchuck River Outreach & Restoration Campaign	07-MPR-402	Mainstem Primary Restoration	15 acres riparian planting; 1 acre off channel habitat restored	12/31/2016	Snohomish Conservation District	$ 200,000
Fully Funded	Conservation Reserve Enhancement Program - Mainstem-secondary	07-MSR-018	Mainstem Secondary Restoration	2000 ft. livestock exclusion fencing; 5 acres riparian planting;	12/15/2016	Snohomish Conservation District	$ 20,000
NEW	Wallace River Acquisition	07-MSR-404	Mainstem Secondary Restoration	135 acres protected/acquired, 5346 ft. shoreline protected/acquired	12/31/2015	Forterra	$ 1,600,000
Lowland Tributaries Restoration							

Funding and New Project	Project Name	Project ID	Sub Basin Strategy Group	Project Performance	Likely End Date	Likely Sponsor	Total Cost of Project
	Woods Creek Riparian Restoration Partnership	07-RPR-022	Rural Streams Primary Restoration	30 acres riparian planting	12/31/2017	Snohomish Conservation District	$ 300,000
NEW	**Woods Creek In-Stream Restoration Partnership**	07-RPR-034	Rural Streams Primary Restoration	30 large wood placement	12/31/2017	Adopt A Stream Foundation	$ 300,000
NEW	**Vanhulle Fish Passage Restoration (Phase I)**	07-RPR-035	Rural Streams Primary Restoration	Complete conceptual designs for two culvert replacements.	12/31/2015	Wild Fish Conservancy	$ 80,240
	Conservation Reserve Enhancement Program - Rural Streams-primary	07-RPR-017	Rural Streams Primary Restoration	2000 ft. livestock exclusion fencing; 9 acres riparian planting	12/15/2016	Snohomish Conservation District	$ 30,000
	Cherry Valley Dairy Stream Enhancement	07-RPR-018	Rural Streams Primary Restoration	.5 mile stream re-channelization and barrier removal, 1.5 acres riparian plantings, .5 Miles exclusion fencing;	12/31/2015	Snoqualmie Tribe	$ 200,000
	Sorgenfrei Fish Passage Project	07-RPR-030	Rural Streams Primary Restoration	1 partial fish passage blockage removed; upstream accessible to fish.	12/31/2014	Adopt A Stream Foundation	$ 55,000

Funding and New Project	Project Name	Project ID	Sub Basin Strategy Group	Project Performance	Likely End Date	Likely Sponsor	Total Cost of Project
	Upper Waterwheel Restoration (Phase II - Final Design and Construction)	07-RPR-033	Rural Streams Primary Restoration	Final Design and Construction	12/31/2016	Wild Fish Conservancy	$ 250,000
NEW	**French Creek Healthy Soils Initiative**	07-RSR-003	Rural Streams Secondary Restoration	20 hedgerows planted; 20 acres riparian buffers;	2/1/2018	Snohomish Conservation District	$ 200,000
	Patterson Creek Protection on Stevlingson Property	07-RSR-049	Rural Streams Secondary Restoration	10 acres acquired	12/31/2015	King County DNR & Parks	$ 425,000
	Patterson Creek State DNR Land Acquisition	07-RSR-050	Rural Streams Secondary Restoration	160 acres acquired	12/31/2014	King County DNR & Parks	$ 2,500,000
	Harris Creek Barrier Removal and Off-Channel Habitat Restoration	07-RSR-051	Rural Streams Secondary Restoration	Removal of a fish passage barrier (road prism) to reconnect approximately 0.6 miles and 7 acres of off channel habitat	12/31/2015	Tulalip Tribes	$ 45,620
	Patterson Creek Culvert Replacement(s)	07-RSR-061	Rural Streams Secondary Restoration	Culvert retrofit or removal. Non-native vegetation control and native re-vegetation. Outreach and education. Effectiveness monitoring.	12/31/2016	Wild Fish Conservancy	$ 560,000

Funding and New Project	Project Name	Project ID	Sub Basin Strategy Group	Project Performance	Likely End Date	Likely Sponsor	Total Cost of Project
NEW	**Northpointe Park Riparian Restoration**	07-USR-019	Urban Streams Restoration	3 acres invasive control and riparian planting	5/1/2015	Snohomish Conservation District	$ 30,000
	Allen Creek Streamkeeper	07-USR-044	Urban Streams Restoration	Approximately 3 acres riparian enhancement	6/1/2015	Adopt A Stream Foundation	$ 243,000
	Jones Creek Relocation and Wetland Enhancement	07-USR-034	Urban Streams Restoration	700 ft. channel relocation; .13 miles instream habitat treated; 5 acres riparian planting; LWD installed; Water Quality/Quantity improvements, instream habitat, flood control	12/31/2017	Adopt A Stream Foundation	$ 400,000
	Olaf Strad Relocation and Restoration	07-USR-059	Urban Streams Restoration	1000 ft. channel reconfigured/relocated, Water Quality/Quantity improvements, instream habitat, flood control	*not specified*	Adopt A Stream Foundation	$ 200,000
Headwaters Restoration							
	South Fork Snoqualmie Road Decommissioning	07-HRA-008	Headwaters Restoration Above Falls and Dam	48 miles road abandonment and obliteration	10/15/2014	Mountains to Sound Greenway Trust, US Forest Service	$ 1,025,000

Funding and New Project	Project Name	Project ID	Sub Basin Strategy Group	Project Performance	Likely End Date	Likely Sponsor	Total Cost of Project
	Upper Snoqualmie River Knotweed Control and Riparian Restoration	07-HRA-030	Headwaters Restoration above Falls and Dam	1 acre knotweed removal along 16 miles of river	12/31/2016	King County DNR & Parks	$ 460,000
	Griffin Creek Natural Area Addition	07-HSR-023	Headwaters Secondary Restoration	25 acres acquired	12/31/2014	King County DNR & Parks	$ 100,000
	South Fork Skykomish Headwaters Acquisitions	07-HSR-008	Headwaters Secondary Restoration	'Protect up to 2,000 acres in headwaters of the South Fork Skykomish Watershed	12/31/2016	Forterra	$ 9,050,000
	South Fork Skykomish Acquisitions	07-HSR-019	Headwaters Secondary Restoration	Miller, Beckler, Foss, Tye Reach acquisitions	12/31/2015	Forterra, King County DNR & Parks	$ 500,000
	Alpine Baldy Road Decommissioning - U.S. Forest Service Roads 6066 & 6067	07-HSR-029	Headwaters Secondary Restoration	9 miles road treatments'	10/28/2013	US Forest Service	$ 215,000
Fully Funded	**Tokul Creek Fish Passage - Phase 2**	07-HSR-014	Headwaters Secondary Restoration	fix the Chinook and steelhead barrier at the Tokul Creek hatchery	12/31/2014	WDFW	$ 250,000
	Lower Miller River Restoration	07-HSP-004	Headwaters Secondary Protection	.95 miles Revetment and levee removal along the Miller River and side channels; 7 acres riparian planting	12/31/2016	King County DNR & Parks, US Forest Service	$ 280,000

Funding and New Project	Project Name	Project ID	Sub Basin Strategy Group	Project Performance	Likely End Date	Likely Sponsor	Total Cost of Project
Basinwide and Non-capital							
	WRIA 07 Fish Passage Barrier Prioritization - King County (Phase I - III 2013-2015) and Snohomish County (Phase I-2013)	07-BW-008	Mainstem Primary Restoration	Evaluate fish passage of at least twenty high priority culvert/tide-gates. Stream channels which appear to have been incorrectly mapped (based on current WDNR and KC hydro layers) or are currently unmapped and associated with identified culverts or	6/30/2016	Wild Fish Conservancy	$ 600,000
	Implement the Targeted Stewardship Model - King County and PRKC	07-NC-002	Basinwide		Ongoing	KC, Partnership for Rural King County	$ 900,000
	Policy work conducted by basin partners?	07-NC-017	Basinwide			KC, SC, TT, SCL	$ -
	PBRS and landowner current use tax incentives	07-NC-009	Basinwide		Ongoing	King County	$ 300,000
	Land-use specific stewardship	07-NC-003			Ongoing	SC, KC, Tulalip Tribes, local jurisdictions, SCD, KCD, CLC, WSU	$ 630,000
	NPDES implementation	07-NC-004				all local jurisdictions	$ -

Funding and New Project	Project Name	Project ID	Sub Basin Strategy Group	Project Performance	Likely End Date	Likely Sponsor	Total Cost of Project
	Provide basin steward staff.	07-NC-005			Ongoing	SC, KC	$ 630,000
	Snoqualmie Watershed Water Quality Synthesis Report Implementation	07-NC-006			Ongoing	Snoqualmie Watershed Forum and King County	$ 150,000
	WSU Extension Beach Watchers Program	07-NC-007			Ongoing	WSU Extension	$ 350,000
	Outreach specialist - Tulalip Tribes	07-NC-008				Tulalip Tribes	$ -
	Public Beach Naturalist Program and Shore Stewards	07-NC-010			Ongoing	WSU extension	$ -
	Puget Sound Starts Here Campaign	07-NC-011					$ -

Funding and New Project	Project Name	Project ID	Sub Basin Strategy Group	Project Performance	Likely End Date	Likely Sponsor	Total Cost of Project
	School outreach: King County; Snohomish County; Nature Vision Blue Teams, SSTF REYs education program	07-NC-012			Ongoing	Stilly-Snohomish Fisheries Enhancement Task Force	$ 270,000
	Advocacy / watchdog?	07-NC-016				People for Puget Sound, Wild Fish Conservancy, Puget Soundkeepers Alliance	$ -
	Cascade Agenda	07-NC-020				Cascade Land Conservancy	$ -
	General Program Maintenance	07-NC-021				Econet Participants...	$ 900,000
	General Program Maintenance	07-NC-022					$ -
	Information Sharing	07-NC-023				EcoNet, STORM, PWG, TC, PDC	$ -
	Snohomish County Beach Watchers	07-NC-024			Ongoing	WSU extension	$ 270,000
	Snoqualmie Conservation Strategy	07-NC-013				Stewardship Partners	$ -
	Habitat Protection Strategy	07-NC-014			Ongoing.	SC, KC, Tulalip Tribes	$ -
	Skykomish Valley Conservation Projects	07-NC-015				Cascade Land Conservancy	$ -
	Shoreline Master Program Updates and Restoration Plans	07-NC-018			2011	Cities in WRIA 7	$ 100,000
	TDR and PDR Development	07-NC-019				Cascade Land Conservancy, King County, Snohomish County	$ -

Funding and New Project	Project Name	Project ID	Sub Basin Strategy Group	Project Performance	Likely End Date	Likely Sponsor	Total Cost of Project
Harvest, Hatchery, H-Integration							
	Assessment of ecological interactions between hatchery and wild fish				ongoing	Tulalip Tribes	$ 450,000
	Develop, communicate, and enforce fishing regulations				ongoing	WDFW, Tulalip	$ -
	Estimate exploitation rates, reconstruct run sizes				ongoing	WDFW, Tulalip	$ -
	Preseason fishery planning				ongoing	WDFW, Tulalip	$ -
	Hatchery escapement monitoring				ongoing	Tulalip and WDFW	$ 30,000
	Adipose fin removal				ongoing	Tulalip Tribes	$ 180,000
	Coded-wire tagging				ongoing	Tulalip Tribes	$ 120,000
	Fishery monitoring				ongoing	Tulalip Tribes	$ 180,000
	Recreational fishery monitoring					WDFW	$ -
	Selective fishery monitoring					WDFW	$ -
	Direct assessment of gene flow in Chinook				2015	Tulalip Tribes	$ 225,000
	Analysis of stock assessment samples				ongoing	Tulalip Tribes	$ 225,000
	Straying reduction study				2016 for funding, 2021 for data recovery	Tulalip Tribes	$ 300,000

Funding and New Project	Project Name	Project ID	Sub Basin Strategy Group	Project Performance	Likely End Date	Likely Sponsor	Total Cost of Project
	Mass marking improvements				2011 for funding, thereafter no funding but needed for annual thermal 100% marking, sample recovery, analysis, contribution rate analyses (hatcheries, fisheries, or natural escapements), gene flow, hat/wild excel/genet interactions	**Tulalip Tribes**	$ 169,254

Funding and New Project	Project Name	Project ID	Sub Basin Strategy Group	Project Performance	Likely End Date	Likely Sponsor	Total Cost of Project
	Analysis of stock assessment samples				2012 for funding, thereafter no funding but equipment will be used annually to analyze CWTs extracted from Chinook/Coho in terminal fisheries/hatcheries/natural escapement	Tulalip Tribes	$ 60,000

Funding and New Project	Project Name	Project ID	Sub Basin Strategy Group	Project Performance	Likely End Date	Likely Sponsor	Total Cost of Project
	Analysis of stock assessment samples				2011 for funding, thereafter no funding requested to annually analyze CWTs extracted from Chinook/Coho in terminal fisheries/hatcheries/natural escapement	Tulalip Tribes	$ 6,100
	Skykomish Chinook broodstock integration				ongoing	Tulalip and WDFW	$ 36,000
	Thermal marking of Tulalip hatchery production				ongoing	Tulalip Tribes	$ 22,500
	Annual Snoqualmie and Skykomish smolt trap operations				ongoing	Tulalip Tribes	$ 1,200,000
	Natural escapement monitoring				ongoing	Tulalip and WDFW, Sno. PUD	$ 180,000
	Whidbey Basin Juvenile Salmon Origins	07-MON-03					$ -

Funding and New Project	Project Name	Project ID	Sub Basin Strategy Group	Project Performance	Likely End Date	Likely Sponsor	Total Cost of Project
	Whidbey Basin Nearshore Marine Juvenile Salmonid Distribution	07-MON-04					$ -
	Tulalip Stock Assessment Laboratory				ongoing	Tulalip Tribes	$ -
	Develop Steelhead Recovery Plan with NOAA.	07-NC-025			2010	NOAA with Tulalip Tribes, WDFW, SC, KC	$ 50,000
	Baseline monitoring of Juvenile Fish Use of Nearshore and Coastal Streams	07-MON-01			41274	Tulalip Tribes	$ 180,000
	Monitoring Fish (Smolt Traps)	07-MON-02			ongoing	Tulalip Tribes	$ 750,000
	Estimate magnitude and spatial distribution of natural spawning escapement				ongoing	WDFW	$ -
	Juvenile sampling					Tulalip Tribes	$ -
	Passage of adult fish around Sunset Falls velocity barrier				Ongoing	WDFW	$ -

2013 WRIA 8 Three-Year Work Plan - Captial Project and Program Priorities

	A	B	C	D	E	F	G	H	I	J	K	L	M
2	Project Type	Plan Category	Year Added	Status: A=Active; C=Complete; I=Inactive	WRIA 8 Plan #	Project Name	Project Description	Population (C=Cedar, S=Sammamish, M=Migratory both populations); P=Programmatic; A=Assessment	Priority Tier	Primary Limiting Factors Addressed	Likely end date	Likely sponsor	Total Project Cost
3	Capital	Acquisition for Restoration	2012	A	C219	River Bend Floodplain Acquisition (formerly River Bend Mobile Home Buyout)	Purchase property underlying 19 mobile homes nearest river, recontour existing revetment to reduce erosion, flood damage and improve flood conveyance and habitat. Alternatively, purchase all property and remove all mobile homes and the revetment and the downstream levee to create a continously unarmored left bank from RM 8 5 (outlet of Cavanaugh Pond) to RM 9 5 (Cedar Mtn Bridge) (C219)	C	Tier 1	Floodplain Connectivity & Function		King County	
4	Capital	Restoration	2012	A	C255	Cedar River Floodplain Restoration at river mile 16	Restore floodplain habitat on left bank of the Cedar River at river mile 16 Native vegetation and large wood installation will create needed rearing habitat for juvenile salmon Minor riparian re-grading may occur if necessary to engage floodplain benches Property is surrounded by King County property (C255)	C	Tier 1	Floodplain Connectivity & Function		Mid-Sound Fisheries Enhancement Group	
5	Capital	Restoration	2012	A	C005A	Cedar River riparian restoration and invasive species control	Protect priority riparian habitat from knotweed and other priority invasive species in the Cedar River consistent with land use actions C5 and C7. Control invasive knotweed and other priority invasive species on a coordinated basis in priority riparian habitats and all areas upstream of them After initial control is achieved, regularly monitor, detect and rapidly respond to any new infestations Implement planting with native species in treated areas Includes, but is not limited to projects C203, C205, C206, C212, C217, C221, C248, C251, and C253 in the Cedar River consistent with the restoration technical hypotheses for the Cedar River in Plan Volume II (Other non-numbered projects also eligible).	C	Tier 1	Riparian areas, invasive species			
6	Capital	Acquisition and Restoration	2010	A	C206	Cedar Reach 3	Protect and improve riparian habitat in future redevelopment	C	Tier I	Floodplain Connectivity & Function	2014	SPU, CLC, Renton	
7	Capital	Acquisition	2006	A	C228B	Jones Reach Acquisition and Habitat Protection - C228b	Jones Reach: 20 8 acres, 13 parcels (of total 29 acres, 16 parcels) targeted for protection Left bank of river already protected Acquiring parcels on right bank of the river would allow both banks of the river to be protected (C228)	C	Tier 1	Channel Structure and Complexity, Riparian Areas & LWD Recruitment	2013	King County (City of Seattle partnership)	$ 3,800,000
8	Capital	Acquisition	2006	A	C245	Mouth of Taylor Creek Reach Acquisition	Mouth of Taylor Creek Reach Acquire approximately 40 acres of forested riparian floodplain associated with both the Cedar mainstem and the lower reach of Taylor Creek The target parcels include approximately 1,000 feet of mainstem channel, nearly 1,300 feet of the lowermost reach and mouth of Taylor Creek, and one of the largest remaining floodplain wetlands adjacent to the mainstem Some of the acquisitions will facilitate future levee removal and/or modification projects (Getchman and Rhode Levees) Completes acquisition by 2009 with restoration by 2012 (C245)	C	Tier 1	Floodplain Connectivity & Function	2010	King County	$ 3 500 000
9	Capital	Acquisition	2006	A	C232	Belmondo Reach Acquisition	Belmondo Reach: 71 acres, 10 parcels, rural residential, riverfront. No levees in reach, numerous side channels, braided reach Located between WPA and Cummings levees Reach includes Trib 0316 confluence area Area is just downstream of Cedar Grove Road / Rainbow Bend acquisition and meander bend restoration (C232)	C	Tier 1	Floodplain Connectivity & Function	2010	King County	$ 3 100 000
10	Capital	Acquisition	2009	A	C216 B	Elliot Bridge Habitat Acquisitions	Acquisition of high habitat value properties (7 parcels, 6 7 acres) in the Elliot Bridge reach These acquisitions will supplement flood buy-outs in the reach and will facilitate early removal and setback of the levee (C216-B)	C	Tier 1	Floodplain Connectivity & Function	2010	King County	$1,676,000
11	Capital	Acquisition	2009	A	C247	Royal Arch Reach Acquisitions	Acquisition of parcels in the Royal Arch Reach (RM 13 19 to 14 19) of the Cedar River mainstem Potential habitat restoration opportunities include restoration of a historic side channel for high flow refuge for juveniles, and spawning and rearing habitat.	C	Tier 1	Floodplain Connectivity & Function	2011		$2 000 000
12	Capital	Acquisition	2006	A	C253	Dorre Don Meanders Reach Acquisition	Dorre Don Meanders Reach: Protect 71 acres, 14 parcels, rural residential, riverfront with flooding issues. Includes an extensive floodplain riparian forest, numerous valley floor spring-fed features including side channel, stream, and oxbow habitats (C253)	C	Tier 1	Floodplain Connectivity & Function	2011	King County / City of Seattle	$ 4,000,000

	A	B	C	D	E	F	G	H	I	J	K	L	M
2	Project Type	Plan Category	Year Added	Status: A=Active; C=Complete; I=Inactive	WRIA 8 Plan #	Project Name	Project Description	Population (C=Cedar, S=Sammamish, M=Migratory-both populations); P=Programmatic; A=Assessment	Priority Tier	Primary Limiting Factors Addressed	Likely end date	Likely sponsor	Total Project Cost
13	Capital	Restoration	2006	A	C235B	Cedar River Rainbow Bend Restoration (C235-B)	(Name change from Cedar Grove Road - Rainbow Bend Levee Removal) Conduct further levee modification work to maximize channel-floodplain interactions. (C235)	C	Tier 1	Floodplain Connectivity & Function	2010	King County / Seattle Public Utilities	$ 50,000
14	Capital	Restoration	2006	A	C351	Enhance Flows at Lower Rock Creek	Lower Rock Creek Flows: Enhance Flows for Pre-Spawning Migrants: Work with the City of Kent in establishing instream flows that are protective of Chinook through their HCP process. (C351)	C	Tier 2	Stream flow, Water quality		Kent	$ -
15	Capital	Restoration	2006	A	C209 / C210	City of Renton Riparian Restoration	Riparian restoration in City of Renton-owned parkland upstream of I-405 bridge on left bank. Define area and then restore (C209/C210)	C	Tier 1	LWD recruitment, Floodplain connectivity	2010	Renton	$ 81,000
16	Capital	Acquisition	2006	A	C213	Acquisition and Habitat Protection Upstream of Ron Regis park: Reach 4	Protect Habitat in Reach 4: Protect existing riparian habitat, instream habitat conditions and extensive LWD in reach Most of reach already in public ownership or protected by regulations (e g steep slopes) Targeted parcel is adjacent to landslide reach immediately upstream of Ron Regis park on right bank (C213)	C	Tier 1	Channel Structure and Complexity, Riparian Areas & LWD Recruitment	2013	King County	$ 200,000
17	Capital	Acquisition	2006	A	C215	Bucks Curve Buyout and Levee Setback/Removal	Continue buying out structures to build on previous restoration efforts in vicinity of RM 6 2 to RM 6.4. Once sufficient land acquired, remove or setback existing levee, and revegetate floodplain In best alternative, a portion of SE Jones Road could be relocated northward. (C215)	C	Tier 1	Floodplain Connectivity & Function	2013	King County / City of Seattle / Corps of Engineers	$ 2,300,000
18	Capital	Acquisition	2007	A	C239	Lower Lions Stream Reach Acquisition	30 acres (12 parcels) includes a large area of riparian forested floodplain between the Cedar River and SE 188th Street. Enhances side channel that was constructed in the area, allows expansion, and completion of side channel. (C239)	C	Tier 1	Floodplain Connectivity & Function	2010	King County	$1,620,000
19	Capital	Acquisition	2006	A	C244	218th Place Side Channel Protection and Enhancement	218th Place Side Channel: Protect 5 acres, 1 parcel, rural residential, riverfront. Once acquired there are opportunities for habitat enhancement in floodplain and off-channel areas. (Related to C242 to enhance 218th side channel once protected C242 is not on start list.) (C244)	C	Tier 1	Floodplain Connectivity & Function	2012	King County	$500,000
20	Capital	Restoration	2006	I	C214	Study Options to Protect Habitat in Reach 4 and Reduce Flooding and Erosion in Ron Regis park	Study Options to Protect Habitat in Reach 4 and Reduce Flooding and Erosion in Ron Regis Park: It is unclear how much further river is going to erode bank and migrate into Ron Regis park in landslide area. Eventually there will be a conflict with park uses. Explore using LWD and levee setback to prevent excessive erosion and flood damage to public lands associated with Ron Regis Park while protecting natural habitat forming processes in reach Study should include lower Madsen Creek (C214)	C	Tier 1	Floodplain Connectivity & Function	2013	Renton / King County	$ 40,000
21	Capital	Restoration	2006	C	C260	LWD over Landsburg Dam	Explore feasibility of passing large woody debris over Landsburg Dam (C260)	C	Tier 1	Channel structure and complexity	ongoing	City of Seattle	
22	Capital	Restoration	2012	A	C282 & C303	Enhance small creek mouths in Lake Washington shoreline segments 3, 4, 5, 6, and 7	highest priority areas in the southern portion of the Lake (segments 1 and 2) For example, in 2012 Adopt A Stream Foundation is interested in implementing a project to restore the mouth of tributary #0056 in Kenmore, which supports implementation of land use priority N63 in lakeshore segment 4.	M	Tier 1	Shoreline complexity			
23	Capital	Restoration	2012	A	C287	Madrona Park Bulkhead Removal and Shoreline Restoration	Friends of the Cedar River Watershed, in partnership with Seattle Parks, Friends of Madrona Woods, and GAYNOR, Inc , would expand the current re-vegetated shoreline restorations at Madrona Park to the north The project would support a priority project for the City of Seattle and maximize resources previously invested in the Madrona Creek day-lighting and shoreline project This project would be a 400 lineal foot shoreline restoration extension continuing north from the current 400'+ Shoreline Restoration done as part of Madrona Park Creek day-lighting and new mouth estuary at Lake Washington (C287)	M	Tier 1	Shoreline complexity		Seattle Parks; Friends of the Cedar River Watershed	

	A	B	C	D	E	F	G	H	I	J	K	L	M
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24	Capital	Restoration	2012	A	M008A	Migratory Areas riparian restoration and invasive species control	Protect priority shoreline habitat from priority invasive species in the Migratory Corridors(Lake Washington, Lake Sammamish, Ship Canal, and marine nearshore) consistent with land use actions C27, N13, M8 and M9 Control priority invasive species on a coordinated basis in priority shoreline habitats After initial control is achieved, regularly monitor, detect and rapidly respond to any new infestations Implement planting with native species in treated areas Includes, but is not limited to projects C264, C266, C272, C273, C275, C277, C280, C281, C297, C298, C302, M208, M211, M213, M215, M218, M219, M224, M226, M228, M232, M237, M238, M247, and M248 in Migratory Areas consistent with the restoration technical hypotheses for Migratory Areas in Plan Volume II (Other non-numbered projects also eligible)	M	Tier 1	Riparian areas, invasive species			
25	Capital	Restoration	2011	A	C288a; c285	Lake Washington Shoreline Restoration	Lake Washington Shoreline Restoration: Remove bulkheads and place gravels. C288A (Chism Beach Park); C288B (Beaux Arts Shoreline); C288C (Luther Burbank Park – Phase II); C288D (Clyde Beach Park); C288E (Meydenbauer Bay Park); C285 (Newcastle Beach Park)	M	Tier 1	Shoreline complexity		City of Bellevue	
26	Capital	Restoration	2011	A	M233	Willow Creek Daylighting	Daylight Willow Creek along much of its length downstream of Edmonds Marsh to create an open channel Willow Creek would be moved out of the existing pipe from the marsh to the Sound into a daylighted channel The creek would pass under a new bridge culvert (trestle) that is being placed beneath existing and future BNSF rail lines near Pt. Edwards and enter the Sound near or through Marina Beach Park (M233)	M	Tier 1			People for Puget Sound	
27	Capital	Restoration	2006	A	C267, C269 - C271	Small Creek Mouth and Shoreline Restoration in Lake Washington shoreline segments 1 and 2	Restore small creek mouths or restore shorelines (remove bulkheads, reduce armoring, reduce number of docks, or restore vegetation) Work with private landowners (including homeowner demonstration project) or on public lands throughout section 1 and 2 (C267, C269 - South Lake Washington Habitat Design and Restoration, C270 - Lower Taylor Creek Restoration, and C271- Mapes Creek daylighting demonstration site)	M	Tier 1	Shoreline complexity	2015	Seattle	$ 3,500,000
28	Capital	Restoration	2009	A	C266	South Lake Washington DNR Shoreline Restoration	Shoreline restoration of WA Department of Natural Resources property Remove am portion of flume (along lakeside), create shallow water habitat, protect existing cove, and plant overhanging riparian vegetation	M	Tier 1	Reduced habitat complexity; Shoreline complexity	2015	Dept of Natural Resources	
29	Capital	Restoration	2008	A	M2/M3	Feeder Bluff Restoration Feasibility Study and pilot restoration projects	Nearshore feasibility assessment to develop multiple beach nourishment designs for restoration (M2 & M3)	M	Tier 1	Sediment supply	2010	King County	$300,000
30	Capital	Restoration	2006	I	M204	Operational Improvements to Locks	Operational Improvements to Improve Juvenile and Adult Chinook Survival (e g , Add/replace strobe lights to locks to deter smolts and prevent entrainment.) (M204)	M	Tier 1	Fish Passage	Ongoing	Corps	$ 150,000
31	Non-Capital	Habitat Restoration	2012			Invasive species control in all watershed sub-basins	Protect priority riparian habitat from knotweed and other priority invasive species. Control invasive knotweed and other priority invasive species on a coordinated basis in priority riparian habitats and all areas upstream of them After initial control is achieved, replant treated areas with native species and regularly monitor, detect and rapidly respond to any new infestations	P	Tier 1-3	Riparian Vegetation			
32	Non-Capital	Restoration; Outreach and education	2012			Riparian area protection and restoration	Work with public and private landowners to protect and restore riparian areas in both rural and urban areas of the watershed (basin wide), including targeted technical assistance and outreach and education activities	P	Tier 1-3	Riparian Vegetation			

3	Project Type	Plan Category	Year Added	Status: A=Active; C=Complete; I=Inactive	WRIA 8 Plan #	Project Name	Project Description	Population (C=Cedar; S=Sammamish; M=Migratory-both populations); P=Programmatic; A=Assessment	Priority Tier	Primary Limiting Factors Addressed	Likely end date	Likely sponsor	Total Project Cost
33	Non-Capital	Outreach and education	2012	A		Increase Awareness and Support for Salmon Recovery	Increase support for salmon recovery, including promotion of programs that enable the public to see returning adult salmon and learn about salmon and river ecology, annual tour of habitat protection and restoration projects for elected officials, identifying and promoting watershed salmon recovery legislative priorities, coordinated messaging, etc. Examples of Programs: Salmon SEEson Cedar River Salmon Journey Beach Naturalists Stewardship - Encourage community stewardship (e.g. C721 with C719/C731 but basinwide) Streamside Landowner Education workshops for education, stewardship and BMP implementation Promote tree cover value (C720/N719/N735/I715) Stormwater actions - basinwide Natural Yard Care – basinwide Protection of nearshore	P	Tier 1	Hydrology, Water and Sediment Quality, Floodplain Connectivity, Riparian Vegetation, Sediment Processes, Shoreline Complexity, Passage	*Ongoing*	*Multiple stakeholders and WRIA 8*	*$0*
34	Non-Capital	Outreach and education	2012			Telling Salmon Recovery Story	Partner with Friends of the Cedar River Watershed to engage untapped funding sources in the development of a Salmon Recovery video series as a new chapter of the Watershed Report and as primary source material for science and civics curricula in the 13 school districts in WRIA 8	P	Tier 1	Hydrology, Water and Sediment Quality, Floodplain Connectivity, Riparian Vegetation, Sediment Processes, Shoreline Complexity, Passage			
35	Non-Capital	Habitat Project Development	2008			5-6% PSAR Capacity Funds	Assistance to site-specific projects or addressing barriers to implementation of projects or programs. Identifying priorities for programmatic actions	P	All		Ongoing	Multiple stakeholders	$161,655
36	Non-Capital	Habitat Protection	2008			Integration of regulatory flexibility to benefit salmon	(No examples proposed)	P	Tier 1	Hydrology, Water and Sediment Quality, Floodplain Connectivity, Riparian Vegetation, Sediment Processes, Shoreline Complexity, Passage	*Ongoing*	*Multiple stakeholders and WRIA 8*	*$175,000*

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37	Non-Capital	Habitat Protection	2006			Incentive programs	Examples of Programs: Incentives to restore ecosystem function (C007) Riparian – Negotiate for enhancement of riparian buffers (C006)	P	Tier 1		*Ongoing*	*Multiple stakeholders and WRIA 8*	*$0*
38	Non-Capital	Habitat Protection	2006	A		Innovative approaches to stormwater and shoreline management	Examples of programs: Green Shorelines C729/C730, I730, C030/C033, I056/N051/N057: Outreach to encourage lakeshore restoration Activities could include workshops, media campaign, permitting or financial incentives, technical assistance, lakeshore design criteria, or demonstration projects Technical assistance for stormwater pollution abatement	P	Tier 1		*Ongoing*	*Multiple stakeholders and WRIA 8*	*$0*
39	Non-Capital	Habitat Protection	2008			Increase Best Management Practices (BMPs)	Examples of Programs: Septic tank maintenance Encourage commercial car wash and alternatives for charity car washes, and car maintenance	P	Tier 1		*Ongoing*	*Multiple stakeholders and WRIA 8*	*$0*
40	Non-Capital	Habitat Protection	2008			Support existing regulations that benefit salmon	No examples proposed	P	Tier 1		*Ongoing*	*Multiple stakeholders and WRIA 8*	*$0*
41	Non-Capital	Monitoring	2006			Evaluating Cumulative Effectiveness	Evaluating Cumulative Effectiveness of Actions (Habitat)	A	All		Ongoing	Multiple stakeholders	#VALUE!
42	Non-Capital	Monitoring	2006	A		Stock Monitoring Support	Stock monitoring support (Fish In/Out)	A	All		Ongoing	Multiple stakeholders	#VALUE!
43	Non-Capital	Monitoring	2006			Project Effectiveness	Evaluate projects to determine the benefit to Chinook of specific features of restoration projects	A	All		Ongoing	Multiple stakeholders	$1,800,000
44	Non-Capital	Outreach and education	2006			Outreach and education		P	Tier 1		*Ongoing*	*stakeholders and WRIA 8*	*$0*
45	Non-Capital	Plan Implementation &	2006	A		Salmon Recovery Coordination	Salmon Recovery Coordination/ Adaptive Management Framework and Plan Implementation tracking	P	All		Ongoing	Multiple stakeholders	$300,000
46	Non-Capital	Watershed Plan Implementation & Coordination	2006	I		Habitat, Hatchery, and Harvest Integration	Enhanced Integration of Habitat, Hatchery, and Harvest Management Actions	P	All		Ongoing	Co-Managers and Multiple Stakeholders	$150,000
47	Non-Capital	Watershed Plan Implementation & Coordination	2006	A		Lead Entity Coordination & Administrative Support of Watershed Committees	Lead entity coordination* & Administrative Support and coordination of the watershed committees / Completion and periodic revisions to the watershed salmon plan	P	All		Ongoing	Local gov't & Lead entity	$1,683,000
48	Capital	Restoration	2011	C	N432	Evans Creek Relocation Study	Study feasibility of relocating Evans Creek to the North, away from industrial area Potential project elements would include increasing buffer, connecting wetlands to the creek, adding stormwater facilities to improve water quality, adding LWD to increase channel complexity Some of the property where creek would be relocated is owned by City of Redmond	S	Tier 1	Channel Structure and Complexity		City of Redmond	
49	Capital	Restoration	2012	A	N432A	Evans Creek Relocation	The City of Redmond completed the Evans Creek Relocation study (N432) and is moving ahead with relocating Evans Creek in 2012 As a result, project N433 from the Comprehensive Plan project list (Restore Evans Creek in-place) will not be implemented	S	1	Channel Structure and Complexity		City of Redmond	
50	Capital	Restoration	2012	A	N485 & N487	Kelsey Creek Restoration Phase 2	Restore downstream reach of Kelsey Creek at 13th Place in Bellevue, building off of Phase 1 restoration in 2011 Project includes bank stabilization via bioengineering and LWD installation Spawning and rearing habitat will be created with the building of log jams, adding stream complexities and spawning gravels Participating parcels are not yet determined	S	Tier 2	Riparian Areas		Mid-Sound Fisheries Enhancement Group	

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51	Capital	Restoration	2012	A	N214	Riparian restoration in Friendly Village development along Cottage Lake Creek	Adopt-A-Stream Foundation completed some buffer restoration at the "Little Bit" equestrian center in 2011 The City of Redmond and/or Adopt-A-Stream Foundation will work to enhance riparian buffers at Friendly Village within a 3-year timeframe In coordination with the City of Redmond, Adopt A Stream is currently developing a restoration strategy with the owners of Friendly Village in Redmond	S	Tier 1	'Channel Structure and Complexity, Riparian Areas & LWD Recruitment		Adopt-A-Stream Foundation, City of Redmond	
52	Capital	Restoration	2012	A	N289; N290; N291	Restore riparian conditions along Cottage Lake Creek	Work with private landowners to create a riparian buffer around known Chinook redds on Cottage Lake Creek, just upstream of the Avondale Way road crossing Install fencing to limit livestock access to creek, determine feasibility of livestock stream crossing	S	Tier 1	Riparian areas		Mid-Sound Fisheries Enhancement Group	
53	Capital	Restoration	2012	A	N079A	Riparian restoration and invasive species control (North, Little Bear, Evans Cks)	Protect priority riparian habitat from knotweed and other priority invasive riparian weeds in the Sammamish River consistent with land use actions N40, N42, and N43 Control invasive knotweed and other priority invasive species on a coordinated basis in priority riparian habitats and all areas upstream of them After initial control is achieved, regularly monitor, detect and rapidly respond to any new infestations Implement planting with native species in treated areas Includes, but is not limited to, projects N334, N339, N341, N343, N344, N346, N348, N349, N350, N351, N356, N358, N361, and N362 in the Sammamish River consistent with the restoration technical hypotheses for the Sammamish River in Plan Volume II (Other non-numbered projects also eligible)	S	Tier 1 & 2	Riparian areas; invasive species			
54	Capital	Restoration	2012	A	N013A	Riparian restoration and invasive species control - Bear/Cottage Lake Creeks	Protect priority riparian habitat from knotweed and other priority invasive species in Bear and Cottage Lake Creeks consistent with land use action N13 Control invasive knotweed and other priority invasive species on a coordinated basis in priority riparian habitats and all areas upstream of them. After initial control is achieved, regularly monitor, detect and rapidly respond to any new infestations. Implement planting with native species in treated areas. Includes, but is not limited to projects N206, N211, N214, N221, N228, N236, N250, N251, N261, N262, N276, N281, N289, N298, N300, N307, N316, and N324 consistent with the restoration technical hypotheses for these tributary creeks in Plan Volume II (Other non-numbered projects also eligible)	S	Tier 1	Riparian areas; invasive species			
55	Capital	Restoration	2012	A	N130A	Riparian restoration and invasive species control - Kelsey Creek	Protect priority riparian habitat from knotweed and other priority invasive species in Kelsey Creek consistent with land use action N130 Control invasive knotweed and other priority invasive species on a coordinated basis in priority riparian habitats and all areas upstream of them After Initial control is achieved, regularly monitor, detect and rapidly respond to any new infestations Implement planting with native species in treated areas. Includes, but is not limited to projects N442, NN455, N457, N459, N464, N470, N476, N487, N494, N502, and N512 consistent with the restoration technical hypotheses for Kelsey Creek in Plan Volume II (Other non-numbered projects also eligible).	S	Tier 2	Riparian areas, invasive species			
56	Capital	Restoration	2012	A	N362	Riparian revegetation on Tosh Creek, tributary to the Sammamish River, between weir and Lake Sammamish	Enhance tributary 08-0141 (Tosh Creek Realignment and Culvert Replacement), including some revegetation near the Sammamish River in this area	S	Tier 1	Riparian Areas		City of Redmond	
57	Capital	Restoration	2012	A	N042A	Sammamish River riparian restoration and invasive species control	Protect priority riparian habitat from knotweed and other priority invasive riparian weeds in the Sammamish River consistent with land use actions N40, N42, and N43 Control invasive knotweed and other priority invasive species on a coordinated basis in priority riparian habitats and all areas upstream of them After initial control is achieved, regularly monitor, detect and rapidly respond to any new infestations Implement planting with native species in treated areas Includes, but is not limited to, projects N334, N339, N341, N343, N344, N346, N348, N349, N350, N351, N356, N358, N361, and N362 in the Sammamish River consistent with the restoration technical hypotheses for the Sammamish River in Plan Volume II (Other non-numbered projects also eligible)	S	Tier 1	Riparian areas; invasive species			

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58	Capital	Restoration	2012	A	I028A	Issaquah Creek riparian restoration and invasive species control	Protect priority riparian habitat from knotweed and other priority invasive species in Issaquah Creek consistent with land use actions I24, I28, and I30 Control invasive knotweed and other priority invasive species on a coordinated basis in priority riparian habitats and all areas upstream of them. After initial control is achieved, regularly monitor, detect and rapidly respond to any new infestations Implement planting with native species in treated areas Includes, but is not limited to projects I202, I209, I211, I212, I213, I219, I220, I223, I224, I226, I227, I228, I232, I236, I239, I243, I246, I248, I266, I272, I277, I278, and I280 in Issaquah Creek consistent with the restoration technical hypotheses for Issaquah Creek in Plan Volume II (Other non-numbered projects also eligible)	S	Tier 1	Riparian areas; Invasive species			
59	Capital	Acquisition	2011	A	N277	Protect headwaters of Cottage Creek and Bear Creek	Acquire forest property, development rights/conservation easements, and provide enhanced incentives to retain and plant forest area environments. (N277)	S	Tier 1			Snohomish County	
60	Capital	Acquisition/ Restoration	2011	A	I310A; I310B	Ebright Creek Enhancement and Acquisition (new for 2011: I310A and I310B)	Ebright Creek: Enhance mouth and protect lower reaches of Ebright Creek on East shore of Lake Sammamish If property on lower reaches of creek is acquired there could be educational outreach opportunities on the site (I-310) Description to include I310A Ebright Creek Wetland Enhancement and I310B Ebright Creek Fish Passage Restoration (NOTE: Projects considered by WRIA 8 Technical Committee to have benefits to juvenile Chinook at creek mouth	S	Tier 1	Loss of Habitat, Reduced Habitat Capacity	2010	City of Sammamish	$ 300,000
61	Capital	Restoration	2011	A	N379, N384	North Creek Reach 5- Riparian Restoration and Stream Enhancements	Riparian Restoration and Stream Enhancements: Work with Landowners in Reach 5 to restore riparian vegetation and to do stream enhancements Adopt-a-Stream Project in Snohomish County portion of North Creek Project overlaps with Snohomish County North Creek Drainage Needs Report Project proposal	S	Tier 2	Degraded Habitat-Channel Structure and Complexity, Degraded Habitat-Riparian Areas and LWD Recruitment	12/31/2015	Snohomish County of	
62	Capital	Restoration	2011	A	N356	Sammamish River Restoration	Re-grade banks, create flood benches at or below high-water mark, and plant banks and benches with native vegetation Particular focus should be given to the upper river (RM 11 to RM 13 6) and downstream of the major tributaries An emerging bench/ wetland would provide juvenile salmonid shallow rearing habitat (N356)	S	Tier 1	Floodplain connectivity and function		City of Redmond	
63	Capital	Restoration	2011	A	TBD A B C	Lake Sammamish tributary delta improvements (Project Number TBD)	Improve natural delta formation processes along stream tributaries to Lake Sammamish to improve habitat for juvenile Chinook as well as Kokanee salmon. Projects (A,B,C) were investigated for maximum Chinook and Kokanee benefits and feasibility and approved by Kokanee Work Group in 2010: • A) Lewis Creek Delta Restoration and Upstream Sediment Stabilization; • B) Zeccuse Creek Trail Culvert Removal; • C) Laughing Jacobs Creek: Sammamish State Park Channel Re-route	S	Tier 1	A) fish passage barrier; non-natal stream mouth and shoreline rearing areas (juvenile Chinook) B) fish passage barrier (kokanee) C) kokanee spawning habitat - substrate, instream habitat complexity and riparian cover; Chinook shoreline and non-natal stream		A) City of Sammamish; B) City of Sammamish; C) WA State Parks	
64	Capital	Restoration	2011	A	I211A; I211B	Restoration at confluence of Issaquah Creek and E Fork Issaquah Creek	Project concepts developed by Kokanee Work Group for multiple species benefit: • I211A) Cybill-Madeleine Park Habitat Enhancement – Regrade banks, add large wood and other pool-forming features, create side-channel habitat • I211B) E Fork Issaquah Creek Confluence restoration – Remove armoring and re-grade right bank to increase connection to floodplain Add large wood and plant native riparian species	S	Tier 1	instream habitat complexity (LWD, pools, spawning gravel)		City of Issaquah	
65	Capital	Acquisition	2010	A	N239	Reach 9- Bear Creek Waterways Program (N239)	Continue Bear Creek Waterways program to protect best remaining habitat This reach includes Reach D Change in feasibility with a willing seller of a large parcel	S	Tier 1	Riparian Areas & LWD Recruitment	2012	King County	$1,350,000

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	A	B	C	D	E	F	G	H	I	J	K	L	M
66	Capital	Restoration	2010	A	N473	Kelsey Creek Fish Passage and Channel Restoration - Reach 3 (N473)	N473 Fish Passage: Reduce jump height at concrete weirs using artificial riffle or other "safer" engineering With N454/N458 - Installation of LWD, design and install LWD to provide hydraulic refuge areas during peak flows in stream segments 76-03 through 76-08 of Kelsey Creek With N457/N459 – Restoration of Riparian Areas: Identify and implement opportunities to plant native coniferous trees in the riparian zones throughout the subarea First priority should be the mainstem of Kelsey Creek	S	Tier 2	Fish Passage, 'Riparian Areas & LWD Recruitment	2014	City of Bellevue	
67	Capital	Restoration	2010	A	N335	Swamp Creek Regional Park Wetland and Stream Restoration (N335)	Swamp Creek Regional Park Wetland and Stream Restoration: As identified in the Sammamish River Corridor Action Plan, restore large, publicly owned wetland complex at the confluence of Swamp Creek and the Sammamish River, creating a diversity of wetland elevations and habitats in the floodplain	S	Tier 1	Channel Structure and Complexity, Riparian Areas & LWD Recruitment, High Water			
68	Capital	Restoration	2010	A	N337 N336	Sammamish River Reach 2- Wetland Restoration on Right Bank in Bothell and Riparian Wetlands adjacent to 102nd Avenue bridge	Wetland Restoration on Right Bank in Bothell: Restore historic wetlands on right bank downstream of 102nd Avenue bridge to be seasonally inundated wetlands with small channels connecting them to the river (N337) Enhance and reconnect riparian wetlands and remnant side channels adjacent to 102nd Avenue bridge on left bank (N336)	S		Degraded Habitat-Floodplain Connectivity and Function	12/31/2015	Bothell City of	
69	Capital	Restoration Projects	2010	A	N401 N402 N403	Little Bear Creek Reach 2- Fish Passage 132 Ave NE (N401) and Fish passage 134th Ave NE (N402) with riparian restoration (N403)	Fish Passage Benefiting Chinook: 132nd Avenue NE (a low flow blockage), RM 0 45, and 134th Ave NE (3 cement pipes, broken), RM 0 5, City of Woodinville; Restore Riparian Vegetation up to H 522 and add large wood	S	Tier 2	Degraded Habitat-Fish Passage, Riparian Areas & LWD Recruitment	12/31/2055	Woodinville City of	300000
70	Capital	Acquisition	2006	A	N232, 303, N293, N286	Bear Creek Waterways Program	Continue Bear Creek Waterways program to protect best remaining habitat. Includes "Reach D" and Reach E In particular, forested riparian parcels contiguous to already protected properties. Also protect undeveloped properties that can be restored (N232, N303, N293, N286)	S	Tier 1	Riparian Areas & LWD Recruitment	0	King County	$ 500,000
71	Capital	Acquisition	2006	A	I250	Issaquah Waterways Acquisition and Restoration and Carey/ Holder/ Issaquah Creek Confluence	Issaquah Waterways Acquisition and Restoration (I249) and Carey/Holder/Issaquah Creek Confluence (I248 I250, I252): Middle Issaquah Reach 12 acquisition and restoration and the confluence of Issaquah, Carey and Holder Creeks Acquisition in fee or conservation easement to restore or expand riparian buffers Removal of invasives Plan includes increased fenced buffers (100 ft for named tributaries and 50 ft for unnamed tributaries), and restricted access to the riparian corridors. (I248 I249 I250 I252)	S	Tier 1	Riparian Areas & LWD Recruitment	2009	King County	$ 700,000
72	Capital	Hatchery	2007	A	I221	Issaquah Integrated Fish Passage	Issaquah Integrated Fish Passage Allow unhindered adult passage of Chinook and coho Open up over 10 miles of habitat (was "Issaquah Hatchery Dam Passage") (I221)	S	Tier 1	Spawning Habitat-Fish Passage/Anthropoge	2013	Corps of Engineers, and WDFW	$4,000,000
73	Capital	Restoration	2006	A	N201	Lower Bear Creek Restoration	Lower Bear Creek Restoration: Provide an enhanced channel alternative to the ditched and leveed lower 3,000 feet of Bear Creek, including a new refuge confluence with the Sammamish River Add LWD, restore riparian conditions (N201)	S	Tier 1	Channel Structure and Complexity, Riparian Areas & LWD Recruitment	2010	Redmond	$10,000,000
74	Capital	Restoration	2006	A	N208 / N211	Evans/Bear Creek Restoration	Evans/Bear Creek Restoration: In-channel restoration is needed in Bear Creek and Evans Creek through the former dairy farm at the confluence; RM 1 25 to RM 2 5 on Bear Creek and RM 1 2 to RM 4 6 on Evans Creek (Same as Keller Farm) Reconfigure channel where it has been widened due to past farm practices, enhance riparian area, add LWD, replant (N208/N211)	S	Tier 1	Channel Structure and Complexity	2010	Redmond / WSDOT	$ 3,000,000
75	Capital	Restoration	2008	C	N378	North Creek School (now called Clearwater School) Restoration	Continue North Creek School Project Work with school to do additional riparian restoration, large woody debris addition and side channel enhancements on their property. This project has been one of Snohomish county's top priorities in recent years (N378)	S	Tier 2	Channel Structure and Complexity, Riparian Areas & LWD Recruitment	2011	Snohomish County	$ 374,710

	A	B	C	D	E	F	G	H	I	J	K	L	M
2	Project Type	Plan Category	Year Added	Status: A=Active; C=Complete; I=Inactive	WRIA 8 Plan #	Project Name	Project Description	Population (C=Cedar, S=Sammamish, M=Migratory-both populations); P=Programmatic; A=Assessment	Priority Tier	Primary Limiting Factors Addressed	Likely end date	Likely sponsor	Total Project Cost
76	Capital	Restoration	2006	A	N206	NLW Tribs Riparian Restoration	Riparian restoration in reach. Most of the reach is publicly owned, but need to remove invasive plants and replant with native vegetation. (N206)	S	Tier 1	Riparian Areas & LWD Recruitment	2010	Redmond	$ 25,000
77	Capital	Restoration	2006	A	N228	Horse Farm Restoration (Bear Creek)	Restoration needed on Horse Farm property on NE 140th St. Reduce fine sediments, restore riparian areas. Pursue farm plan to address impacts to Bear Creek. (N228)	S	Tier 1	Riparian Areas & LWD Recruitment, Excessive Sediment	0	Conservation District, King County	$ 25,000
78	Capital	Restoration	2006	A	N276	Paradise Valley Conservation Area Restoration (Bear Creek)	Remove invasive plants and plant riparian buffer along Bear Creek throughout Paradise Valley Conservation Area, as well as infested areas on public property immediately south of Woodinville-Duvall Road. (N276)	S	Tier 1	Riparian Areas & LWD Recruitment	0	Snohomish County	$ 50,000
79	Capital	Restoration	2006	A	N358	Transition Zone Restoration	Restore Transition Zone: Restoration of the left meander (Marymoor meander) below the weir as either the main channel or a seasonal channel with wetlands is recommended. Reroute tributary 0141 into wetland. Enhance or create pools at small tributary outlets, at meander bends downstream of the transition zone, and just downstream of the weir. Restoration elements could include excavation of new channel, creation of pools, and an overflow bench with wetland vegetation; removal of non-native vegetation; placement of gravel substrate in new channel; connection to capture hyporehic flows; and revegetation of riparian and wetland areas with native plants. (N358)	S	Tier 1	and Complexity, Riparian Areas & LWD Recruitment, High Water Temperatures, Reduced Access to Spawning Habitat - Fish	2011	King County	$ 2,070,000
80	Capital	Restoration	2007	A		Lower Bear Creek Confluence Restoration	Lower Bear Creek Confluence Restoration. Regrade banks, create flood benches at or below high-water mark, and plant banks and benches with native vegetation. Particular focus should be given to the upper river (RM 11 to RM 13.6) and downstream of the major tributaries. An emerging bench/wetland would provide juvenile salmonid shallow rearing habitat. (N356)	S	Tier I	Regulatory Mechanisms		Redmond	
81	Capital	Restoration	2006	A	N201, N339, N346, N357	Sammamish River Tributary Mouth Restoration Feasibility and Restoration	Sammamish River Tributary Mouth Restoration Feasibility and Restoration: Feasibility and design study for each of the tributary mouths in the Sammamish River. Implement restoration projects. Includes Bear, Little Bear, North, and Swamp Creeks, as well as Willows (trib 0102), Peters (trib 0104), and tribs 0057A, 0068, 0069, 0095, 0095A, 0095B, and mouth of Horse Creek Western Branch. (N201, N339, N346, N357)	S	Tier 1	Floodplain connectivity and function	2015	King County	$ 150,000
82	Capital	Restoration	2006	C	I204	Sammamish State Park Restoration	Sammamish State Park Restoration: Revisions of the State's Plan for the park emphasis restoration of the wetlands, streams and lakeshore areas. EDT modeling results suggest park restoration in Reach 1 has highest restoration potential to affect VSP attributes, but based on an aggressive approach. Opportunity to work with State and consultants on restoration actions. (I204)	S	Tier 1	Regulatory Mechanisms	2010	Washington State Parks	$ 150,000
83	Capital	Restoration	2007	C	I226 B	Squak Valley Park Restoration	Squak Valley Park Restoration. Improve habitat complexity and riparian forest, create off-channel areas connected to the stream, large woody debris placement. Levee removal (all or parts - unknown). Right bank Issaquah - 8. (I226)	S	Tier 1	Floodplain Connectivity & Function, Channel Structure and	2010	Issaquah	$700,000
84	Capital	Acquisition	2006	A	N216	Bear Creek Forest Cover Protection	Bear Creek Forest Cover Protection: Acquire forest property, development rights/conservation easements, and provide enhanced incentives to retain and plant forest area environments. Particularly forested area south of Puget Power Trail and at corner of 116th and Avondale Road. (N216)	S	Tier 1	Riparian Areas & LWD Recruitment, Water Quality	2010	King County	$ 800,000
85	Capital	Acquisition	2006	A	N422	Little Bear and Great Dane Creeks Forested Wetland Protection	Forest Cover, Wetland Protection: Protect large, undeveloped forested wetland on both Little Bear and Great Dane Creeks. Approximately 100 acres including 10 parcels. Also listed under Great Dane Creek Reach 1. (N422)	S	Tier 2	Water Quality, Reduced Habitat Capacity	2009	Snohomish County	$ 1,000,000
86	Capital	Acquisition	2006	A	N424	Little Bear Reach Riparian Wetland Protection	Protect Riparian Wetland in Little Bear Reach 10: Protect undeveloped, forested wetlands (second growth forest) in reach covering approximately 55 acres and 12 parcels owned by two landowners. Enhance with large woody debris. (N424)	S	Tier 2	LWD Recruitment, Water Quality, Reduced Habitat	2010	Snohomish County	$ 1,000,000
87	Capital	Acquisition	2006	A	N429	Little Bear Creek Forested Headwater Wetlands Protection	Little Bear Forest Cover Protection: Protect forested, headwater wetlands from corner of 51st and 180th upstream approximately 2 miles along Little Bear Creek through conservation easements and acquisition. Includes three wetland complexes totaling over 200 acres. 4 parcels along 180th St. on mainstem; ~7 parcels along Trout Stream from 180th to Interurban Blvd.; and 5 parcels north of 164th Street to 156th Street. (N429)	S	Tier 2	Riparian Areas & LWD Recruitment, Water Quality	2011	Snohomish County	$ 1,500,000

	A	B	C	D	E	F	G	H	I	J	K	L	M
2	Project Type	Plan Category	Year Added	Status: A=Active; C=Complete; I=Inactive	WRIA 8 Plan #	Project Name	Project Description	Population (C=Cedar, S=Sammamish, M=Migratory-both populations); P=Programmatic; A=Assessment	Priority Tier	Primary Limiting Factors Addressed	Likely end date	Likely sponsor	Total Project Cost
88	Capital	Acquisition	2007	A	I209, I210	Issaquah Waterways Acquisition and Restoration	Acquire and restore undeveloped streamside property on Issaquah Creek downstream of Juniper St and downstream of Berntsen Park (I209 and I210)	S	Tier 1	Riparian Vegetation			
89	Capital	Acquisition	2007	I	I222	Wildwood Acquisition	Wildwood Acquisition: Acquisition of the left bank property opposite recent acquisition of one of the few remaining large undeveloped parcels (8 acres - Johnson property) on lower Issaquah Creek (I222)	S	Tier 1	Riparian Areas & LWD Recruitment	2009	Issaquah	$ 300 000
90	Capital	Acquisition and Restoration	2007	A	I206 I208 I274 I270	Bush Lane Acquisition and Restoration	Bush Lane Acquisition and restoration When combined with Pickering Place could create a large protected/restored section of Issaquah Creek on both banks and some of lower NF Issaquah Stream, riparian, and floodplain restoration on 1,200 feet of Issaquah Creek east bank Stream/buffer enhancements can be combined with other public use of upland area of site, such as active recreation (I206 & I208)	S	Tier I	Floodplain Connectivity & Function, Channel Structure and Complexity	2010	Issaquah	
91	Capital	Restoration	2006	A	N242	Evaluate Locations for LWD Additions	Evaluate locations for LWD addition Focus on Reach 6, which has the highest restoration potential but does not presently include any projects (N242)	S	Tier 1	Channel Structure and Complexity Riparian Areas & LWD Recruitment	2013	King County	$ 350 000
92	Capital	Restoration	2006	A	N282	Cottage Creek Restoration	Cottage Creek: Explore opportunities to improve floodplain connection in reach by removing riprap or artificial constrictions. (N282)	S	Tier 1	Channel Structure and Complexity	2010	King County	$ 90,000
93	Capital	Restoration	2007	A	I207	Pickering Place Channel and Riparian Restoration	Pickering Place Channel and Riparian Restoration, Stream restoration along 1,800 feet of west bank Issaquah Creek Restoration could include removal of hardened banks and floodplain, side channel, and riparian enhancements (I207)	S	Tier 1	Floodplain Connectivity & Function, Channel Structure and	2010	Issaquah	$500,000
94	Capital	Restoration	2007	C	I212	Juniper Acres Restoration	Juniper Acres Restoration A small 2-acre parcel recently acquired When combined with Issaquah Park and other City owned parcels, represents good restoration potential in urban reaches (I212)	S	Tier 1	Floodplain Connectivity & Function	2010	Issaquah	$150,000
95	Capital	Acquisition	2013	A	N272	Reach 15 - Bear Creek Waterways Program	Continue Bear Creek Waterways Program to protect best remaining habitat This reach includes Reach A In particular, protect Stevens and Doolittle properties.	S	Tier 1	Water Quality, High Water Temperatures		King County	$350,000
96	Capital	Restoration	2013	A	N342	Enhance Tributary Confluences of Derby, Gold, and Woodin Creeks	Enhance tributary confluence of Derby Creek with Sammamish River Project should include as appropriate correction of fish passage barriers, riparian restoration, placement of large woody debris and creation of cool-water refuge pool	S	Tier 1	Barriers, Water Quality, Riparian Areas Channel		King County	$1,100,000
97	Capital	Restoration	2013	A	N395	McCollum Park Restoration	Install grade control structures from Northwest Stream Center to 128th to reduce peak flows and erosion; restore riparian vegetation	S	Tier 2	Channel Structure and Complexity, Riparian Areas		Adopt-A-Stream Foundation	
98		Acquisition	2013	A	N319A	Hooven Bog Acquisition	targeted area for acquisition is approximately 25 acres, which will offer protection to a headwaters area of Cottage Lake Creek and thus provide protection to water quality and a source of cold water input.	S	Tier 1	Water Quality, High Water Temperatures		Sno-King Watershed Council	
99		Restoration	2013	A	I311	Lower Lewis Creek Restoration	Restore lower 1,800 feet of Lewis Creek, including the Lewis Creek delta at Lake Sammamish, to improve juvenile Chinook rearing and kokanee spawning habitat.	S	Tier 1	Channel structure and complexity, Riparian vegetation		City of Issaquah	$390 000

Three-Year Watershed Implementation Priorities - Puget Sound Salmon Recovery Plan

WRIA 9 Habitat Work Schedule for Green/Duwamish and Central Puget Sound Watershed

					2014		2015		2016		
Project Name	**Priority Tier**	**Project Description**	**Likely sponsor**	**Total cost of first three years/phases**	**Year 1 Scope**	**Year 1 Cost**	**Year 2 Scope**	**Year 2 Cost**	**Year 3 Scope**	**Year 3 Cost**	**Likely end date**
Capital Projects											
Duwamish Subwatershed: Enlarge Duwamish estuarine transition zone habitat by expanding											
North Wind's Weir (Project, DUW-10) COMPLETED!	1	Shallow Water Habitat Rehabilitation at RM 6.3: Create two acres of off-channel, shallow water habitat in the transition zone	King County	$3,200,000	Monitoring	$20,000	Monitoring	$20,000	Monitoring	$20,000	2014
Duwamish Gardens Shallow Water Habitat Creation at RM 7.0 Project DUW-7) Acquisition Completed!	1	Acquire land within transition zone in order to create shallow-water habitat.	Tukwila	$2,846,000							
Duwamish Gardens Shallow Water Habitat Creation at RM 7.0 Project DUW-7) Restoration in design phase; 30%design expected June 30, 2013	1	Restore estuarine transition zone habitat to provide critical habitat for juvenile salmon in the Duwamish Transition Zone.	Tukwila	$3,300,000	Construction	$2,000,000	Revegetation finalized/stewardship and maintenance	$20,000	Stewardship and maintenance	$0	2015
Duwamish Revegetation (Program WW-5)	1	Plant native trees in the riparian zone/floodplain of the Green River and Soos Creek	King County	$150,000	Construction (revegetation)	$200,000	Construction (revegetation)	$0	Construction (revegetation)	$15,000	2016
Subtotals				**$9,496,000**		**$2,220,000**		**$40,000**		**$20,000**	
Lower Green River Subwatershed: Protect/restore refuge, habitat complexity and connectivity											
Riverside Estates Levee Setback Project (LG-1) - (Reddington Levee)	3	Levee setback, revegetation, benching, LWD	King County Flood Control District (KCFCD)	$3,078,983	Construction	$2,746,715					2014
Riverview Park Restoration (Project LG-7) CONSTRUCTION COMPLETED 2012	1	Provide summer rearing habitat and high flow winter refuge through excavation of an off-channel area combined with placement of large woody debris and revegetation.	Kent	$7,613,571	Monitoring	Funded	Monitoring	$0	Monitoring & Adaptive Management	$20,000	2015
Downey Farmstead Restoration Project (formerly Lower Green River Acquisition) (Project LG-7) ACQUSITION COMPLETE	1	Acquire three properties immediately upstream of the Mullen Slough confluence and demolish buildings on one. A feasibility study will determine options for modifying Frager Road, reconnection of the upland to the river, and restoration of riparian habitat.	Kent	$1,205,085							

Project Name	Priority Tier	Project Description	Likely sponsor	Total cost of first three years/phases	2014		2015		2016		
					Year 1 Scope	Year 1 Cost	Year 2 Scope	Year 2 Cost	Year 3 Scope	Year 3 Cost	Likely end date
Capital Projects											
Lower Green Acquisition (Downey Farmstead) (Project LG-7)- DESIGN AND CONSTRUCTION - Project currently in final design	1	The current conceptual design for this project is to excavate a perennial side channel connected to the Green River (mainstem) at both ends. This concept would require Frager Road S to be relocated to a location adjacent to SR 516. The channel would contain contain anchored large wood installations in the wetted channel. Stream banks would be shaped to create a stable angle of repose and be planted with native vegetation	Kent	$6,100,000	Final design and permitting	Funded	Construction	$4,750,000	Construction/ Revegetation		2015
Mill Creek Floodplain Wetland and Off-Channel Habitat Rehabilitation (Project LG-7) - Leber Property - DESIGN AND CONSTRUCTION (design complete, seeking construction funding)	1	The project will construct a side-channel off of Mill Creek, providing 2 acres of floodplain habitat below the ordinary high water mark, increase floodplain refuge habitat for Chinook and other salmonids, enhance riparian habitat and increase floodplain storage.	Kent	2300000 (construction)	Complete Design & Permitting	$0	Construction	$3,500,000			2014
Teufel/Rosso Nursery Off-Channel Rehabilitation and Riparian Restoration Between RM 20.8 and 20 (LG-9) - ACQUISITION	1	Acquire property and rehabitate habitat by constructing an outlet at RM 20.1. Actions would include removing fill, excavating off-channel flood refugiaum for juvenile rearing habitat ,a nd planting native wetland and riparian vegetation	KCFCD,	$3,500,000							
Teufel/Rosso Nursery Off-Channel Rehabilitation and Riparian Restoration Between RM 20.8 and 20 (LG-9) - RESTORATION Currently seeking design funding for 2014	1	Acquire property and rehabitate habitat by constructing an outlet at RM 20.1. Actions would include removing fill, excavating off-channel flood refugiaum for juvenile rearing habitat ,a nd planting native wetland and riparian vegetation.	KCFCD,	$2,500,000	Design	$300,000	Design		Construction	$2,000,000	2013

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					2014		2015		2016		
Project Name	Priority Tier	Project Description	Likely sponsor	Total cost of first three years/phases	Year 1 Scope	Year 1 Cost	Year 2 Scope	Year 2 Cost	Year 3 Scope	Year 3 Cost	Likely end date
Capital Projects											
Mainstem Maintenance (Project LG-10) - Boeing Levee Setback- initial design by USACOE in partnership with Kent began in 2013	2	Boeing Levee Setback and Restoration between RM 18 and 17.1 to enable extensive habitat rehabilitation	Kent & USACOE	$12,000,000	Design and permitting	$300,000	Complete Construction/ Monitoring	$8,000,000	Monitoring	$50,000	2016
Desimone Levee (Project LG-13) -	3	Levee setback, revegetation, benching, LWD.	King County	$2,844,256	Design	$80,607	Engineering, design, permitting.	$898,673	Construction	$1,864,976	2015
Subtotals				**$38,801,895**		**$680,607**		**$17,148,673**		**$3,934,976**	

Project Name	Priority Tier	Project Description	Likely sponsor	Total cost of first three years/phases	2014 Year 1 Scope	2014 Year 1 Cost	2015 Year 2 Scope	2015 Year 2 Cost	2016 Year 3 Scope	2016 Year 3 Cost	Likely end date
Capital Projects											
Nearshore Subwatershed: Protect, restore, or rehabilitate: sediment transport processes by											
Pier 90 Shallow Water Habitat Rehabilitation (NS-1)	1	Protect and expand that area of shallow water habitat. The land comprising shoreline east of Pier 90 would need to be purchases. The riprap and fill would be moved in order to create additional shallow water habitat and the shoreline planted with riparian vegetation.	City of Seattle	$2,500,000	Feasibility, Technical Design	$500,000	Design and permitting	$750,000	Construction	1,250,000	2015
Myrtle Edwards Park Small Pocket Beaches/Shallow Water Habitat Rehabilitation (NS-2)	1	Create pocket beaches in Myrtle Edwards Park on Elliott Bay in Seattle. Riprap armoring would be removed and the slopes would be graded back to create natural slopes. Pocket beaches have a mix of sediments placed on thesm. Riparian area would be planted with native vegetation. A shallow water bench may also be constructed.	City of Seattle	$6,000,000	Feasibility, Technical Design	$500,000	Design and permitting	$750,000	Construction	$4,000,000	2015
Elliott Bay Shoreline Enhancements(Project NS-4) -	1	Create shallow water habitat benches and fish friendly structures along the waterfront, install a shoreline beach. This would open up a migration corridor and increase the amount of shallow water are for juvenile Chinook foraging.		$56,000,000	Construction	$5,600,000	Construction		Construction/ Monitoring		2016
Beaconsfield-On-The-Sound (project NS-11) - Acquisition	1	Purchase and restore one of the last major privately-held undeveloped feeder bluffs along the mainland marine shoreline.	Normandy Park	$1,000,000	Acquisition	$600,000	Acquisition	$300,000	Revegetation	$250,000	unknown
Piner Point Restoration Bulkhead Removal (Project NS-17) - Restoration	1	Remove creosote bulkhead.	King County	$243,894							
Dockton Heights-Restoration - CONSTRUCTION IN 2013	3	Remove creosote pilings, restore shoreline		$490,000	Construction		Monitoring		Monitoring		
Maury Island Gravel Pit Acquisition (NS-17) - completed!	1			$39,000,000							

					2014		2015		2016		
Project Name	**Priority Tier**	**Project Description**	**Likely sponsor**	**Total cost of first three years/phases**	**Year 1 Scope**	**Year 1 Cost**	**Year 2 Scope**	**Year 2 Cost**	**Year 3 Scope**	**Year 3 Cost**	**Likely end date**
Capital Projects											
Maury Island Fill Removal (NS-20) - (remnant dock footing)	2			$150,000			Design and permitting	$80,000	Construction	$200,000	2016
Burien Seahurst Park Shoreline Restoration, Phase II (Project NS-5) - CONSTRUCTION TO BEGIN Fall 2013	1	Continue shoreline restoration actions conducted in southern portion of Seahurst Park in Burien by removing a portion of shoreline armoring in the central area of the park, restoring natural beach slopes, and adding riparian vegetation	Burien	$5,675,000	Construction (construction to begin 2013, with remainder of work in 2014)	$6,500,000	Revegetation, stewardship and monitoring	$50,000	Monitoring	$50,000	Construction complete in 2014; monitoring complete in 2017
Point Robinson Estuary Restoration	1	Salt Marsh Reconnection and Improvements	King County	$500,000	Design and Pre-Construction Monitoring	$100,000			Construction	$400,000	2016
Cove Creek - Restoration (NS-7)	1	Fish blockage removal and pocket estuary restoration. Project would restore the mouth of Cove Creek and move the stream crossing upstream. The northern half of the bulkhead would be removed and stream mouth area replanted.	King County	$487,000.17	Design and Pre-Construction Monitoring	$100,000	Acquisition (see separate project below)	$387,000.17	Monitoring		
Cross Landing Estuary (NS-17) - Restoration	1	Restoration of the pocket estuary is dependent upon acqusition.	King County	$50,000			Design and permitting	$100,000.00	Construction (revegetation)	$400,000	
Raab's Lagoon Restoration - Pocket Estuary Restoration (plant shoreline) (NS-17)	2	Revegetation	King County	$100,000	Construction (revegetation 2011 and 2012)	$100,000	Monitoring and Maintenance		Monitoring and Maintenance		
McSorley Creek at Saltwater State Park - Design (NS-15) Design proposed to begin in 2013	1	Removal of nearshore armoring, enhance fish passage									
Maury Island Marine Park (NS-17)	2	Invasive Removal and Revegetation.		$1,200,000	revegetation underway						
Functioning Nearshore Habitat on Vashon/Maury Island - Portage (Project NS-17)	1	Reconnect salt marsh to Puget Sound	King County	$400,000	Feasbility		Acquisition		Design		
Restoration of shoreline between Piner Point and Northilla	1	Nearshore restoration	King County	$600,000					Design		

					2014		2015		2016		
Project Name	**Priority Tier**	**Project Description**	**Likely sponsor**	**Total cost of first three years/phases**	**Year 1 Scope**	**Year 1 Cost**	**Year 2 Scope**	**Year 2 Cost**	**Year 3 Scope**	**Year 3 Cost**	**Likely end date**
Capital Projects											
Maury Island Revegetation	2	Revegetation at Glacier Pit		$500,000	(revegetation 2011 and 2012)	$30,000	Construction (revegetation)	$40,000	Construction (revegetation)	$100,000	
Marine Nearshore Acquisition Projects									[illegible]	[illegible]	
Beaconsfield on the Sound (Project NS - 11) - ACQUISITION	1	Protect sites with high habitat resource values - Southwest Drift Cell - South Shoreline	Normandy Park	$1,100,000	Feasibility	$125,000	Acquisition	$2,000,000	Acquisition	$4,500,000	2014
Functioning Nearshore Habitat Protection on Vashon/Maury Island-Inspiration Pt. (Project NS-17) (inholdings)	2	Protect sites with high habitat resource values - Inspiration Pt	King County	$500,000	Acquisition						2008
Functioning Nearshore Habitat Protection on Vashon/Maury Island-Neill Pt (Project NS-17)	2	Protect sites with high habitat resource values - Neill Pt	King County	$500,000	Acquisition						
Functioning Nearshore Habitat on Vashon/Maury Island - Portage (Project NS-17)	3	Acquisition needed in order to reconnect salt marsh to Puget Sound	King County	$400,000							
Functioning Nearshore Habitat Protection on Vashon/Maury Island-Rabb's Lagoon (Project NS-17)	3	Protect sites with high habitat resource values - Rabb's Lagoon	King County	$100,000	Acquisition						
Functioning Nearshore Habitat Protection on Vashon/Maury Island-Piner Pt. (Project NS-17) Acquisition Completed!	2	Protect sites with high habitat resource values - Piner Pt.	King County		Acquisition						
Functioning Nearshore Habitat Protection on Vashon/Maury Island-Northilla (Project NS-17) - eeking Asarco funding	2	Protect sites with high habitat resource values - Northilla	King County	$1,100,000	Acquisition						

					2014		2015		2016		
Project Name	Priority Tier	Project Description	Likely sponsor	Total cost of first three years/phases	Year 1 Scope	Year 1 Cost	Year 2 Scope	Year 2 Cost	Year 3 Scope	Year 3 Cost	Likely end date
Capital Projects											
Functioning Nearshore Habitat Protection on Vashon/Maury Island- Pt. Heyer (Project NS-17) -	1	Protect sites with high habitat resource values - Pt. Hever Drift Cell	King County	$10,000,000	Acquisition	$1,500,000	Acquisition	$1,500,000	Acquisition	$1,500,000	
Cross Landing - Acquisition (NS-17) -	2	Protect sites with high habitat resource values	King County	$1,000,000					Acquisition	$1,000,000	
Subtotals				**$111,058,894**		**$15,655,000**		**$2,457,000**		**$6,650,000**	
Porter Levee Setback and Floodplain Reconnection (Project MG-17) - DESIGN AND PERMITTING. Project is funded to 30% design, additional funding will be sought in 2013/2014 for final design	1	Remove (modify) existing levee to facilitate river connection to floodplain. LWD placement and riparian revegetation would be included	King County	$650,000	Design & Permitting	$200,000	Design & Permitting	$450,000			2014
Porter Levee Setback and Floodplain Reconnection (Project MG-17) - CONSTRUCTION	1	Remove (modify) existing levee to facilitate river connection to floodplain. LWD placement and riparian revegetation would be included	King County	$2,400,000				$1,000,000	Construction	$2,400,000	2014
Newaukum Creek Mouth Restoration Between Creek Miles 0.0 and 4.3 (Project MG-6) - Completed!	1	Place large woody debris and plant native trees along the lower 4.3 miles of the creek, and reconfigure the lower 1,800 feet of the creek near the mouth.	King County	$1,175,000	Design & Permitting	$100,000	Construction	$1,075,000	Monitoring/Adaptive Management		
Newaukum Creek Restoration Between Creek Miles 0.0 and 14.3 - Both Banks (Project MG-6)		Restore process-based ecological funtions that include wetland and riparian restoration along Newaukum Creek (Enumclaw Plateau).	King County	$300,000	Construction	$100,000	Construction	$100,000	Construction	$100,000	Ongoing
Middle Green Riparian Revegetation(Program WW-5)		Plant native trees in the riparian zone/floodplain of the Green River and Soos Creek	King County	$200,000	Construction	$150,000	Construction	$150,000	Construction	$150,000	Ongoing

					2014		2015		2016		
Project Name	Priority Tier	Project Description	Likely sponsor	Total cost of first three years/phases	Year 1 Scope	Year 1 Cost	Year 2 Scope	Year 2 Cost	Year 3 Scope	Year 3 Cost	Likely end date
Capital Projects											
Setback and Removal Pautzke Levees to Reconnect the Floodplain and Allow Channel Migration near RM 32(Project MG-18) Completed!	1	Fenster Levee Phase IA - Remove levees, lower the elevation of terraces and construct engineered logjams to reinstate floodplain connectivity and channel migration.	Auburn, King County	$1,400,000	Construction	$1,220,000	Monitoring/Adaptive Management	$75,000	Monitoring/Adaptive Management	$75,000	2008
Setback and Removal of Fenster Levees _Phase 1 to Reconnect the Floodplain and Allow Channel Migration near RM 32 (Project MG-18) Construction completed!	1	Pautzke Levee - Remove levees, lower the elevation of terraces and construct engineered logjams to reinstate floodplain connectivity and channel migration. Phases A - E.	King County	$3,500,000			Design & Permitting	$100,000	Construction	$3,400,000	
Setback and Removal of Fenster Levees _Phase 2 to Reconnect the Floodplain and Allow Channel Migration near RM 32(Project MG-18) Currently in design Construction planned for 2013	1	Fenster Levee Phase IB - Remove levees, lower the elevation of terraces and construct engineered logjams to reinstate floodplain connectivity and channel migration.	Auburn, King County	$600,000 - $800,000			Design & Permitting	$150,000	Construction	$650,000	2010
Big Spring Creek Acquisition (Project MG-7) - Completed	1		King County	$2,115,000							
Big Spring Creek Restoration (Project MG-7)	1	Construct new stream channel to replace ditch. Connect coldwater springs to Newaukum Creek.	King County	$4,079,726	Construction	$1,973,000	Construction	$785,000	Construction	$285,000	2014
Subtotals				**$20,520,000**							
Totals				**$39,924,586**							
Non Capital Programs-Not Prioritized											
Lead entity coordination			Lead entity	$225,000	Staffing (1 FTE)	$75,000	Staffing (1 FTE)	$75,000	Staffing (1 FTE)	$75,000	Ongoing

Project Name	Priority Tier	Project Description	Likely sponsor	Total cost of first three years/phases	2014		2015		2016		
					Year 1 Scope	Year 1 Cost	Year 2 Scope	Year 2 Cost	Year 3 Scope	Year 3 Cost	Likely end date
Capital Projects											
Seahurst Environmental Learning Center (annual basis)			City of Burien and Environmental Science Center	$30,000							
Project Management and Public Outreach			WRIA Staff								
Stewardship & Educational Outreach			WRIA Staff								

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Project Type	Project Name	Project Summary	Likely End Date	Likely Sponsor	Total Cost of Project	Project ID
Restoration Projects	Calistoga Oxbow Levee & Access Road Culvert Replacement (RM 21.2)	The goal of this proposed project is to replace two culverts on an oxbow of the Puyallup River near the Calistoga Bridge: one on the levee and another on the access road. This project is locate near RM 21.2 and near the Calistoga Bridge Orting; its intent is to increase backwater rearing habitat and reconnect historic oxbows to the main river channel.	12/31/2011	South Puget Sound SEG	$503,000	05-1488
Restoration Projects	Greenwater River ELJ Phase I (RM 5.3-7.8)	Through this project the the South Puget Sound Salmon Enhancement Group led an effort to install 5 engineered log jams on US Forest Service property near River mile 7. The project also removed more than 0.5 mile section of an andandoned portion of Forest Road 70 from the floodplain. These five ELJs are large, incorporating 43 key pieces logs, 150 racking logs and 200 cubic yards of slash material. Each jam had immediatly provided complex pool habitat with overhead cover for salmonids in the watershed.	12/31/2010	South Puget Sound SEG	$570,600	06-2223
Restoration Projects	Greenwater River ELJ Phase II (RM 4.5-5.3)	The South Puget Sound Salmon Enhancement Group used this grant, as well as the Greenwater ELJ and Road Decommissioning Project (06-2223), to place five engineered logjams in the Greenwater River upstream of the U.S. Forest Service Road 7010 bridge in the Greenwater River, which forms the border between Pierce and King Counties. Additionally the project removed 4,500 linear feet of the decommissioned FR 70 from the floodplain.	3/27/2012	South Puget Sound SEG	$694,150	07-1867
Restoration Projects	Boise Creek Preliminary Design: Channel Relocation @ Golf Course	The Puyallup Tribe of Indians used this grant to complete a preliminary design for relocating Boise Creek to its historic channel within the Enumclaw Golf Course.	7/15/2010	Puyallup Tribe	$105,059	08-2006

Restoration Projects	TransCanada Levee Setback Feasibility and Design	The purpose of the TransCanada Levee Setback Feasibility Study was to analyze alternatives for modification of the TransCanada Levee and select a preferred alternative for restoring process and function within a channelized section of the Lower White River, while preventing an increase in flood hazard from inundation or channel migration outside the study area.	8/31/2011	King County DNR & Parks	$83,027	08-2009
Acquisition Projects	Middle Puyallup River Acquisition	Cascade Land Conservancy is seeking funding for acquisition of approximately 250 acres of high quality salmon habitat located south of Orting along the Puyallup River. The project site includes approximately a mile of river frontage, pristine riparian habitat, and floodplains.	12/31/2008	Forterra	$400,000	08-2017
Restoration Projects	South Prairie Creek Knotweed Removal	A partnership of the Pierce Conservation District, Pierce County Noxious Weed Control Board, and Pierce County Surface Water Management has formed to collaborate across jurisdictions to remove knotweed. A large outreach campaign to landowners and community members will educate landowners about the dangers knotweed presents to the South Prairie Creek Basin. This partnership is requesting $240,000 in funding for the next three years. Immediate priorities include completing survey work in the basin, and eradicating knotweed found there.	12/31/2013	Pierce Co Conservation Dist, Pierce County	$190,200	09-1538
Restoration Projects	Setback Levee 24th St (White River RM 2.3-3.7), Prelim Design	This project studied the feasibility of several options to provide flood control and/or habitat benefits on the White River in the area near 24th Street East, between RM 2.3 and 3.7 (left bank).	8/11/2011	Pierce County, City of Puyallup, City of Sumner	$171,803	09-1618

Restoration Projects	Salmon Creek Culvert Replacement	This fish passage project replaced two undersized culverts on Salmon Creek, tributary to White (Stuck) River and located in Sumner, Washington. Design for this project included replacing an existing 36-inch concrete culvert (Parker Road) and a 54-inch corrugated metal pipe culvert (Sumner Watershed) with two 8 x 16- foot concrete box culverts. This project created additional access to habitat for spawning salmon, opening up approximately 0.75 miles of upstream habitat from the mouth of Salmon Creek.	9/1/2012	City of Sumner	$247,020	10-1858
Restoration Projects	Calistoga Setback Levee–Construction (RM 20.0-21.2)	The Calistoga Setback Levee Project in Orting on the Puyallup River between RM 19.3 and 21.5 will set back 6,500 feet of right (east) bank levee and reconnect 53 acres of floodplain to the Puyallup River.	12/31/2014	City of Orting	$1,440,880	10-1863
Acquisition Projects	Alward Road Acquisition and Planning	Pierce County owns several parcels along Alward Road and would like to purchase more properties in order to setback the existing levee and improve fish habitat. We would like to design a groundwater channel that will make use of the property that we already own, and extend this channel to additional properties as we purchase them. This would be an interim habitat improvement measure until we own enough property to set the levee back.				10-Alward Rd-13
Acquisition/Restoration (Combination)	Middle Boise Creek Acquisition (RM 1-3)	Purchase land in fee or conservation easements to facilitate the restoration of aquatic and riparian habitat in and along Boise Creek between RM 1 – 3.	12/31/2015	King County	$1,575,000	10-Boise-02
Non-Capital Projects	Boise Creek fish passage (above golf course) - 35% Design	This project would design fish passage at the cascades above the golf course on Boise Creek (RM 4.5).	12/31/2011	King County, Puyallup Tribe	$550,000	10-Boise-03

Restoration Projects	Alward Road Levee Setback (RM 6.4-8.7)	Proposed actions at the Site include removing approximately 8,923 linear feet of existing levee located along the left (south) bank of the Carbon River. An armored levee of approximately 9,853 linear feet would be constructed and set back from the Carbon River to the south, encompassing an area of approximately 6,190,596 square feet (142 acres).	12/31/2012		$0	10-Carbon-01
Acquisition/Restoration (Combination)	Marine View Drive Acquisition and Nearshore restoration	In Commencement Bay in front of Marine View Drive. Create intertidal habitat adjacent to the Trustee's area. Foss Log storage - $50K per acre. This project proposes the acquisition of ~17 acres of nearshore and upland feeder streams along ~0.75 miles of the northeast shoreline of Commencement Bay.	12/31/2011	Forterra	$1,000,000	10-CommBay-01
Restoration Projects	Olympic View Triangle - Commencement Bay	Tip of Foss and Middle waterways - salt marsh habitat - currently upland on DNR property- Eelgrass on bay side.	12/31/2011	Washington Department of Natural Resources (DNR)	$900,000	10-CommBay-02
Non-Capital Projects	Bay Watcher (CHB)	Weekly on the water patrols cover entire Commencement Bay shoreline. Also, weekly foot patrol to specific hot spots or outfalls.	12/31/2011	Citizens for a Healthy Bay	$60,000	10-Education-01
Non-Capital Projects	Communications/ Public Outreach Support	This project includes technical help to coordinate public education and outreach between the numerous agencies and organizations working in the watersheds. A significant effort would be placed in web-based access to actions, opportunities and goals.	12/31/2011	Pierce County	$80,000	10-Education-02
Non-Capital Projects	Salmon Recovery Outreach	Create outreach function targeted at salmon recovery.	12/31/2011	South Puget Sound SEG	$120,000	10-Education-03

Non-Capital Projects	White River Watershed Stewardship Program	Enforcement, education, engineering (according to Forest Plan) dos and don'ts on recreation in habitat areas. Providing aquatic conservation education services to Forest recreators alongs sensitive stream sources.	12/31/2011	USDA - US Forest Service (USFS)	$90,000	10-Education-04
Restoration Projects	Voights Creek Hatchery Clarifier	Construct 2 bay clarifier, provide covers for pollution abatement ponds, venturi/eductor system.	12/31/2011	Washington Department of Fish and Wildlife (WDFW)	$896,800	10-Hatchery 01
Restoration Projects	Improvements at the Buckely Fish Trap	Explore opportunities to improve fish passage at Buckley.	12/31/2011	Washington Department of Fish and Wildlife (WDFW)	$105,000	10-Hatchery 03
Acquisition/Restoration (Combination)	West Hylebos Creek acquisition	This projecy completes the purchase, preservation, and restoration of the properties detailed in the recovery strategy. Project benefits coho and Chinook.	12/31/2011		$1,500,000	10-Hylebos-04
Restoration Projects	East Hylebos Ravine Habitat Restoration	Extends the habitat restoration actions just north of the West Milton Nature Preserve (located on the east fork). Stream bank stabilization and upland restoration in the most productive area on the East Fork of the Hylebos.	12/31/2011	Earth Corps	$750,000	10-Hylebos-05
Restoration Projects	Swan Creek Restoration channel geometry at Pioneer Way	Restore channel geometry in Swan Creek at Pioneer Way. There is high potential for restoration according to modelling by EDT - Sediment detention pond upstream.	12/31/2011		$400,000	10-LowPuy-01
Acquisition Projects	Puyallup River (Union Pacific) Setback Levee (RM 2.6-3.0) - Acquisition	Acquire up to 30 acres of floodplain and former intertidal habitat; acquisition would allow for construction of setback levee and restoration of intertidal habitat in the transition zone for juvenile rearing.	12/31/2012	Pierce County	$8,500,000	10-LowPuy-02

Restoration Projects	Puyallup SFork Restoration Phase I Construction	The modified plan includes construction of 1,900 Lin-Ft of the left overbank major side channel at the south end of the South Fork Restoration project site. The overbank channel inlet will begin at about river mile 18.4, left bank side (about 525 Ft upstream of the river channel bend) and confluence in at the river channel near river mile 17.9, left bank side (about 1,600 Ft downstream of the river channel bend). Five major ELJ structures and several large woody debris clusters will be placed along the right and left side of the overbank channel for fish habit and channel complexity. The overbank channel will be designed for active sediment and gravel transport through the channel for a 5-yr recurrence flow and greater.	12/31/2013	Pierce Co Water Programs Div	$1,076,000	10-LowPuy-08
Acquisition/Restoration (Combination)	Matlock Farms Development Rights Purchase and In Stream Restoration	The goal of this project is to conserve this 155 acre working farm in order to preclude its conversion to non-farm uses in order to preserve the ecological values on-site and nearby. The goal is to purchase development rights from the property so as to lower the real estate value and allow the current farmer who is leasing the property to afford to purchase the underlying fee of the property and continue farming it in perpetuity.	1/1/2015	Forterra	$1,194,000	10-LowPuy-11
Restoration Projects	Implement Levee Setback Projects from Levee Setback Feasibility Study	Implement projects from the Levee Setback Feasibility Analysis for the Puyallup River Watershed (this study identified 32 levee setback sites on the Puyallup, Carbon and White Rivers for potential future restoration to reconnect the river to the floodplain).	12/31/2013	King County, Pierce County, City of Orting		10-Puyallup-01

Restoration Projects	Puyallup River Setback Levee at Fennel Creek - Design	Pierce County is proposing to construct a setback levee or revetment along McCutcheon Rd on the middle Puyallup River at the mouth of Fennel Creek (RM 15.2 to 15.8), in order to reconnect 54 acres of floodplain to the river, and revegetate the floodplain. Pierce County currently owns 44 acres of the site. Under a separate grant, Pierce County is acquiring up to 19 additional acres.	1/5/2015	Pierce Co Water Programs Div	$500,000	10-PuyFennel-01
Restoration Projects	South Prairie Creek Restoration (RM 2-4.6)	South Prairie Creek instream and riparian restoration, including LWD placement, removal of rip rap streamside revegetation on over 300 acres and 2 miles of public land.	12/31/2011	Pierce County	$690,000	10-SPrairie-01
Acquisition Projects	South Prairie Creek Acquisition (RM 0-8)	Protect 60-120 acres of instream and riparian habitat along South Prairie Creek, primary tributary to the Carbon River and the most important salmonid spawning area in the Puyallup watershed	12/31/2010	Forterra, Pierce Co Water Programs Div	$800,000	10-SPrairie-02
Restoration Projects	Electron Dam Diversion Fish Screening	Install inclined floor screen structure on flume at Electron Dam diversion to reduce juvenile mortality during out migration.	12/31/2011	Puyallup Tribe, South Puget Sound SEG, Puget Sound Energy	$6,000,000	10-UpperPuy-01
Restoration Projects	Upper White Road Decommissioning	This project would plan and implement road decommissioning in floodplains throughout the upper White River (Greenwater River/ Huckleberry Creek/West Fork White River). This project would involve creating an access/travel management plan as well as on-the-ground work (include removing culverts, pulling back unstable fill, recontouring slopes, outsloping, water-barring, road-bed ripping, and revegetating). This project is estimated to cost $20K/mile and make modifications along as much as 100 miles.	10/15/2015	Puyallup Tribe, South Puget Sound SEG, USDA - US Forest Service (USFS)	$1,500,000	10-UpperWhite 01

Restoration Projects	Pacific Right Bank Levee Setback (RM 5.5 - 6.3)	This project is located on the right bank of the Lower White River in the City of Pacific, between River Mile 5.5 and 6.3. The project will reduce flood risk in a way which restores habitat and habitat forming processes. The project will remove over 4,100 linear feet of existing revetment and other artificial fill, reconnect the river to a broader portion of its floodplain, build a setback levee to limit the bounds of flood and erosion hazards in this reach, and improve the riparian buffer and wetlands.	12/31/2017	King County DNR & Parks	$20,263,683	10-White-02
Acquisition/Restoration (Combination)	Countyline (White River) Levee Setback Project (RM 5.0-6.3)	The project is a combination of property acquisition and levee modifications along the left bank of the lower White River from river mile 5.0-6.3. The project will reconnect the White River to 115 acres of its floodplain by modifying an existing levee and establishing a buffer that more closely matches the floodplain terrace, and includes a setback levee. The goal of this project is to restore riverine processes and functions while reducing flood risks along the right bank and behind the existing levee and revetment.	12/31/2016	King County DNR & Parks	$2,739,926	10-White-03
Restoration Projects	TransCanada Levee (RM9.0-9.3)-Final Design, Construction	The TransCanada Levee Modification Project will modify the TransCanada Levee according to the recommendations in the TransCanada Levee Setback Feasibility Study completed by King County in 2011.	12/31/2015	King County DNR & Parks	$3,100,000	10-White-04
Acquisition Projects	White River Land Acquisition	Acquire ecologically important land within the White River watershed.	12/31/2015	King County	$6,000,000	10-White-05

Restoration Projects	Clearwater River Road Removal (Phase 2)	The project seeks to improve floodplain function and connectively through removal of non-native road fill impinging upon the Clearwater River along a section of the 6000 forest road set for decomissioning. This phase 2 approach will support previously funded work (in process) to add large wood structure to the Clearwater River to parition flood flows into the floodplain, encourage deposition and sorting of sediment, and create instream complexity in the Clearwater River. In partnership with other road removal activities proposed by Hancock Forest Management on a section of road downstream of this reach, this project will encourage reconnection of up to 14 acres of floodplain to the Clearwater River, including a very productive wall-based wetland side channel.	4/15/2014	South Puget Sound SEG	$60,000	11-1463
Restoration Projects	White River Knotweed Control Project Phase 1	The Pierce Conservation District is forming a partnership to collaborate across jurisdictions to remove knotweed. A large outreach campaign to landowners and community members will educate landowners about the dangers knotweed presents to the White River Basin. This partnership is requesting $87,262 in funding for one-year project startup costs. Immediate priorities include completing survey work in the basin, and begin eradicating knotweed found there.	12/31/2014	Pierce Co Conservation Dist	$87,262	11-1500
Restoration Projects	Clarks Creek Riparian Habitat Restoration	The project replaced 8,000 square feet of pervious road/path with a pervious surface, amended soils and planted 17,000 square feet of riparian habitat along a salmon bearing portion of Clarks Creek.	11/30/2012	Pierce Co Conservation Dist	$120,000	11-Clarks-10
Restoration Projects	Deer Creek Channel Restoration	This proposed restoration for Deer Creek includes the restoration of a 1,500-foot section of the stream beginning just south of 12th Ave SE and west of Shaw Road in Puyallup, running northwest to the corner of 25th Street SE and 12th Ave SE.	12/31/2013	City of Puyallup		11-Deer-10

Restoration Projects	Greenwater River ELJ Phase III (RM 3.0-4.5)	This grant serve as a third phase to two projects completed in 2010 and 2011. This project proposes to install 5 additional jams downstream of the phase I and phase II project sites. The project will build upon previous efforts in this reach of the Greenwater River to: create large stable structures that will trap mobile debris and sediment, increase floodplain connectivity and off channel habitat, Increase number of pools with overhead cover, decrease median substrate size, and overall improve spawning and rearing conditions for salmonids in the Greenwater River.	12/31/2014	South Puget Sound SEG	$391,053	12-1288
Restoration Projects	Buckley Dam Fish Passage Improvements	Update fish passage facilities owned by Army COE. Project located at mile 24.3 of the White River. The project is to provide safe fish passage to all fish species, including three listed species. The dam in its current state is resulting in delay, injury and mortalitty of all species, particularly in odd years when pink salmon are abundant.	4/10/2018		$80,000,000	12-5000
Restoration Projects	Garrison Springs Restoration	Conduct feasibility study to see if Garrison Springs can be used to release juvenile Chinook from the WDFW hatchery to Puget Sound. The study would also estimate the cost of any alterations needed to permit the fish to successfully reach the Sound.	6/30/2011	Puyallup Tribe, South Puget Sound SEG, Al Schmauder	$5,000	12-Chambers-01
Restoration Projects	Chambers Beach Reconstruction and Riparian Enhancement	The Chambers Beach Reconstruction and Riparian Enhancement project will reconstruct natural beach profiles along Chambers Beach and provide active nourishment of degraded areas in key locations within the drift cell. Restoration efforts will also reconstruct a riparian corridor in select areas through removal of invasive species and planting of native vegetation.	12/31/2011	South Puget Sound SEG	$400,000	12-ChambersBeach-01

Restoration Projects	Chambers Creek Adult Trap and Juvenile Acclimation Facility Improvements	Rebuild ponds and intake, and install pollution abatement system (HSRG recommendations) to improve upstream passage for non-target wild stocks; improve acclimation for smolts and adult holding for returning Chinook; establish pollution abatement system for effluent; and improve screen to minimize impacts on wild stocks.	12/31/2011	Washington Department of Fish and Wildlife (WDFW)	$3,200,000	12-Hatchery 01
Restoration Projects	Chambers Bay Estuarine and Riparian Enhancement	This goal of this project is to restore and enhance the estuarine habitat structure within Chambers Bay; as well as, to restore marine riparian corridor in and around Chambers Bay and increase salt marsh and estuarine area inside the Bay.	12/31/2011	South Puget Sound SEG	$2,100,000	12-Marine-01
Restoration Projects	Commencement Bay - Puget Creek Estuary Restoration	Remove contaminated sediment, sediment replacement, softening of rip-rap shoreline with gravel/cobble mix, restore eelgrass beds, restore sand lance spawning.	12/31/2011	Washington Department of Natural Resources (DNR), Pierce County, Puget Creek Restoration Society	$1,450,000	12-Marine-02
Restoration Projects	Sequalitchew Creek Estuary Reconnection	Restore estuarine processes to Sequalitchew Creek Estuary through placement of a large rail trestle across the mouth of the estuary.	5/5/2015		$10,000,000	12-Marine-03
Restoration Projects	Sequalitchew Creek Estuary-Beach and Riparian Restoration	Remove derelict creosote pilings and bulkhead structures, restore natural beach profile, remove invasive plants and restore native, marine riparian corridor at the mouth of Sequalitchew Creek on the WRIA 12 shoreline, Northeast of the Nisqually reach.	12/31/2011	South Puget Sound SEG	$350,000	12-Marine-04

Restoration Projects	Sequalitchew Creek Estuary- Diversion and Streamflow Restoration	Re-route the Fort Lewis water treatment diversion and refit flood control structures to return flows to Sequalitchew Creek.	12/31/2012	South Puget Sound SEG	$400,000	12-Marine-05
Restoration Projects	Pocket Beach Enhancement/Nourishment Pilot: Sequalitchew to Solo Point	Initiate a pilot beach restoration and marine riparian planting projects on existing pocket beaches persisting waterward of the BNSF railine between Sequalitchew Creek and Solo Point to monitor and streamline beach nourishment and riparian enhancement techniques along the degraded shoreline.	12/31/2011	South Puget Sound SEG	$200,000	12-Marine-06
Restoration Projects	Puget Creek Rearing Pond	An off-channel pond will be developed to provide an acclimation area for out-migrating Coho smolts and Chum fry. This area has an influx of marine water at high tide, which would benefit the out-migrating smolts/fry so they can be better situated for survival. This pond could also work in the reverse for in-migrating adult salmonids. This pond would also provide over-wintering habitat for Coho and rearing area.	12/31/2011	Puget Creek Restoration Society	$80,000	12-Marine-07
Restoration Projects	Narrows and Sequalitchew-Steilacoom Feeder Bluff Reconnection	Reconnect priority (historic) feeder bluffs along Nisqually to Point Defiance shoreline in the Tacoma Narrows and between Sequalitchew Creek and Steliacoom to restore lost process of sediment input. Feeder bluff reconnection could be accomplished by installing trestles under the BNSF railroad at key locations.			$10,000,000	12-Marine-09
Restoration Projects	Titlow Pocket Estuary Feasibility Study	Complete a feasibility study for the replacement of the culvert/tidegate through BNSF railroad to improve connectivity and fish passage between Titlow lagoon and Puget Sound, beach cleanup/ enhancement.	12/31/2010	South Puget Sound SEG	$56,860	12-Marine-10

Restoration Projects	Titlow Estuary Restoration - Construction	This phase of the project will implement the overall project to restore Titlow Lagoon to a connected and productive estuary.	12/31/2011	People for Puget Sound, South Puget Sound SEG, Metro Parks Tacoma	$7,000,000	12-Marine-11
Restoration Projects	Titlow Estuary Restoration-Design Development	This project will develop design and permits documents for replacement of a culvert/tidegate through BNSF railroad with a 40 foot-span rail bridge to improve connectivity and fish passage between Titlow Lagoon and Puget Sound. Project efforts will also develop design and permit documents for removal of pool and parking lot infastructure on the footprint of the historic Lagoon/saltwater wetland for expansion of the exisiting lagoon and restoration of riparian and salt marsh habitat.	6/30/2013	People for Puget Sound, South Puget Sound SEG	$92,065	12-Marine-12
Restoration Projects	Sequalitchew Watershed Restoration Planning	Initiate stakeholder coordination for long-term watershed recovery of Sequalitchew Creek.	12/31/2011	South Puget Sound SEG	$90,000	12-Watershed-01
Restoration Projects	South Prairie Creek Riparian Knotweed Restoration 2013	This project will restore approximately 10 acres of riparian forest habitat along South Prairie Creek, in areas previously infested with Japanese knotweed. In addition the project will refine existing GIS data related to presence of knotweed throughout the basin, and work crews will work to bring an additional 30 acres of knotweed into a "controlled" status.	12/31/2014		$110,000	13-1417

Restoration Projects	Meeker Creek Riparian and Stream Restoration	The Meeker Creek Riparian and Stream Restoration Project will remove a 1,000-foot section Meeker Creek from its current manmade trapezoidal ditch and return it to a natural, meandering stream channel in the adjacent City-owned parcel. This project will improve water quality by reducing untreated stormwater loading to the creek, restore the riparian area, create shading and restore Salmon spawning habitat through designed in-channel stream features. As of spring 2013 the project is at 30% design and is beginning the permitting process while researching additional funding options.	6/30/2016	City of Puyallup	$998,635	13-1424
Restoration Projects	Sheras Falls Barrier Removal	A fish barrier consisting of a drop of approximately 3 feet occurs near a private bridge about 650 feet upstream from the mouth of Clover Creek (outlet to Steilacoom Lake). The creek is asphalt and lined in the immediate vicinity of the bridge. The drop appears to occur at the downstream end of the asphalt treatment. The elevation difference will be corrected by installation of a fish way design, step pool design or a roughened channel design. The project is still in the scoping phase and the final solution has not been chosen. The roughened channel approach is most likely to be implemented.	9/30/2012	Pierce Co Water Programs Div	$150,000	2012-3-20
Restoration Projects	Middle Boise Creek Restoration Planning	King County is in the process of developing a Habitat Restoration Plan for Middle Boise Creek (RM 1-3) to identify approximately five to six habitat restoration projects that could be constructed within the next ten years. A more comprehensive hydraulic model of the middle Boise Creek reach is important prior to constructing restoration projects.	9/30/2013		$95,017	BoiseRstPln
Non-Capital Projects	Chambers Estuary Restoration Planning Project	This project will conduct preliminary planning for the restoration of Chambers Estuary, primarily through acquisition of part or all of the "Abitibi" site.		Pierce Co Conservation Dist	$50,000	ChambersEstuary

Non-Capital Projects	Pollution Hotline (CHB)	Consolidated citizen/agency hotline for reporting potential toxic problems. Follow up and correction of issues/results from the calls.	12/31/2011	Citizens for a Healthy Bay	$30,000	Education-02
Non-Capital Projects	Smolt Trapping-Puyallup River	Operate smolt trap on the Puyallup River - $150,000 per year - includes manning site.	12/31/2011	Puyallup Tribe	$450,000	Monitoring-01
Non-Capital Projects	Smolt Trapping- White River	Operate smolt trap on the White River - $150,000 per year - includes manning on site (Initiate long-term screw trapping of White River)	12/31/2011	Muckleshoot Tribe, Puyallup Tribe	$450,000	Monitoring-02
Non-Capital Projects	Smolt Trapping- South Prairie Creek	Operate smolt trap on South Prairie Creek - $150,000 per year - includes man on site.	12/31/2011	Muckleshoot Tribe, Puyallup Tribe	$450,000	Monitoring-03
Non-Capital Projects	Smolt Trapping-Chambers Creek	Operate smolt trap on Chambers Creek - $150,000 per year - includes manning site; monitoring also includes counting and identifying returning adult salmon.	12/31/2011	Washington Department of Fish and Wildlife (WDFW)	$450,000	Monitoring-04
Non-Capital Projects	Mud Moutain Dam Mortality Study	Assess the survival of adult and juvenile fish through Mud Moutain dam.	12/31/2011	US Army Corps of Engineers (USACE)	$250,000	Monitoring-05
Non-Capital Projects	Fish Tagging for Chinook Tracking	Fish tagging to track Chinook - trapping and tagging salmonid smolts for monitoring distribution and habitat usage and timing (POST tag) adaptive management [Increase telemetry and hydro-acoustic tagging of Chinook and Steelhead in system]	12/31/2011		$90,000	Monitoring-06
Non-Capital Projects	Nearshore Restoration Project Effectiveness Monitoring	Develop and implement a nearshore effectiveness monitoring plan for future restoration projects.	12/31/2011	South Puget Sound SEG	$300,000	Monitoring-07

Restoration Projects	Greenwater LWD Study	Effectiveness monitoring of Greenwater LWD Project and assessment for placement of several LWD structures (mostly jams) throughout Greenwater mainstrem and some tributaries: LWD structure placement.	12/31/2011	South Puget Sound SEG	$200,000	Monitoring-08
Acquisition/Restoration (Combination)	Big Dog Floodplain Acquisition/Restoration	This project will acquire 36 acres of prime South Prairie Creek floodplain habitat for salmon conservation. Large Japanese Knotweed monocultures on the property will be eradicated and the property will be fully restored as forested riparian habitat. This property ranked #4 on the CLC South Prairie Creek Action Plan (2002).	12/31/2017			SPC2013b
Restoration Projects	South Prairie Creek Knotweed Eradication Phase 2	This project will continue the work that was begun with SRFB project #09-1538 in 2010, by funding eradication of Japanese knotweed in the South Prairie Creek basin. This is Phase 2 of that project.	12/31/2013	Pierce Co Conservation Dist	$65,880	SPCKnotweed2
Non-Capital Projects	SPC Riparian Restoration Planning Project	This project will complete engineering for removal of manmade structures at the former Inglin Dairy property, now part of the South Prairie Creek Reserve.	2/28/2014	Pierce Co Conservation Dist	$30,000	SPCRiparian2012
Non-Capital Projects	Create South Puget Sound Regional Organization	Create South Puget Sound Regional Organization to develop, coordinate, and implement South Sound Salmon Recovery Plan.	12/31/2011	South Puget Sound SEG	$160,000	Watershed-01
Restoration Projects	Develop Nearshore Projects	Use comparable benefits protocols for synchronized project selection - Using exisiting nearshore assessments develop protocols for nearshore project identification, development and priortization.	12/31/2011	South Puget Sound SEG	$10,000	Watershed-02
Restoration Projects	White River Restoration Assessment	Evaluate historic and current reaches of the White River important for salmon habitat and identify 10 priority habitat restoration actions that can be implemented within 10 years.	12/31/2015	King County	$75,000	Watershed-03
Restoration Projects	Update Regional Culvert Study	Re-evaluate the system to check on work done since the original study was completed - function of those removed and make sure there are not any new ones.	12/31/2011	Pierce Co Conservation Dist	$320,000	Watershed-04

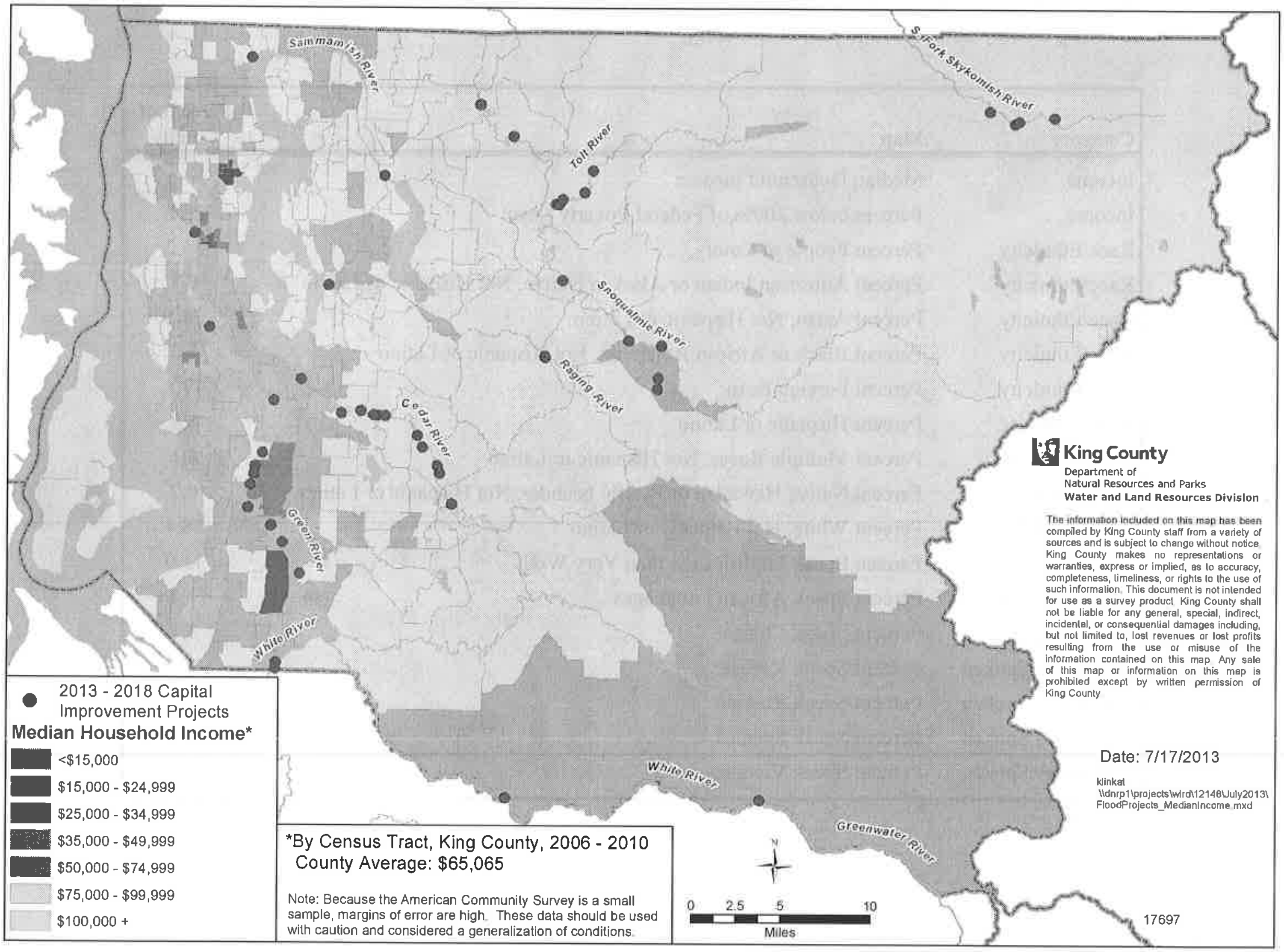
Non-Capital Projects	State/Locall/NOAA TRT Technical Support	Provide access to state and local agency resources for better coordination and integration of plan components. Also to ensure the support of NOAA's TRT remains constant to help with the salmon recovery efforts.	12/31/2011	Pierce County	$250,000	Watershed-05
Restoration Projects	White River Knotweed Eradication Project	The Pierce Conservation District is forming a partnership to collaborate across jurisdictions to remove knotweed. A large outreach campaign to landowners and community members will educate landowners about the dangers knotweed presents to the White River Basin.	12/31/2013		$87,262	WhiteRiver Knotweed1

APPENDIX J.
EQUITY AND SOCIAL JUSTICE

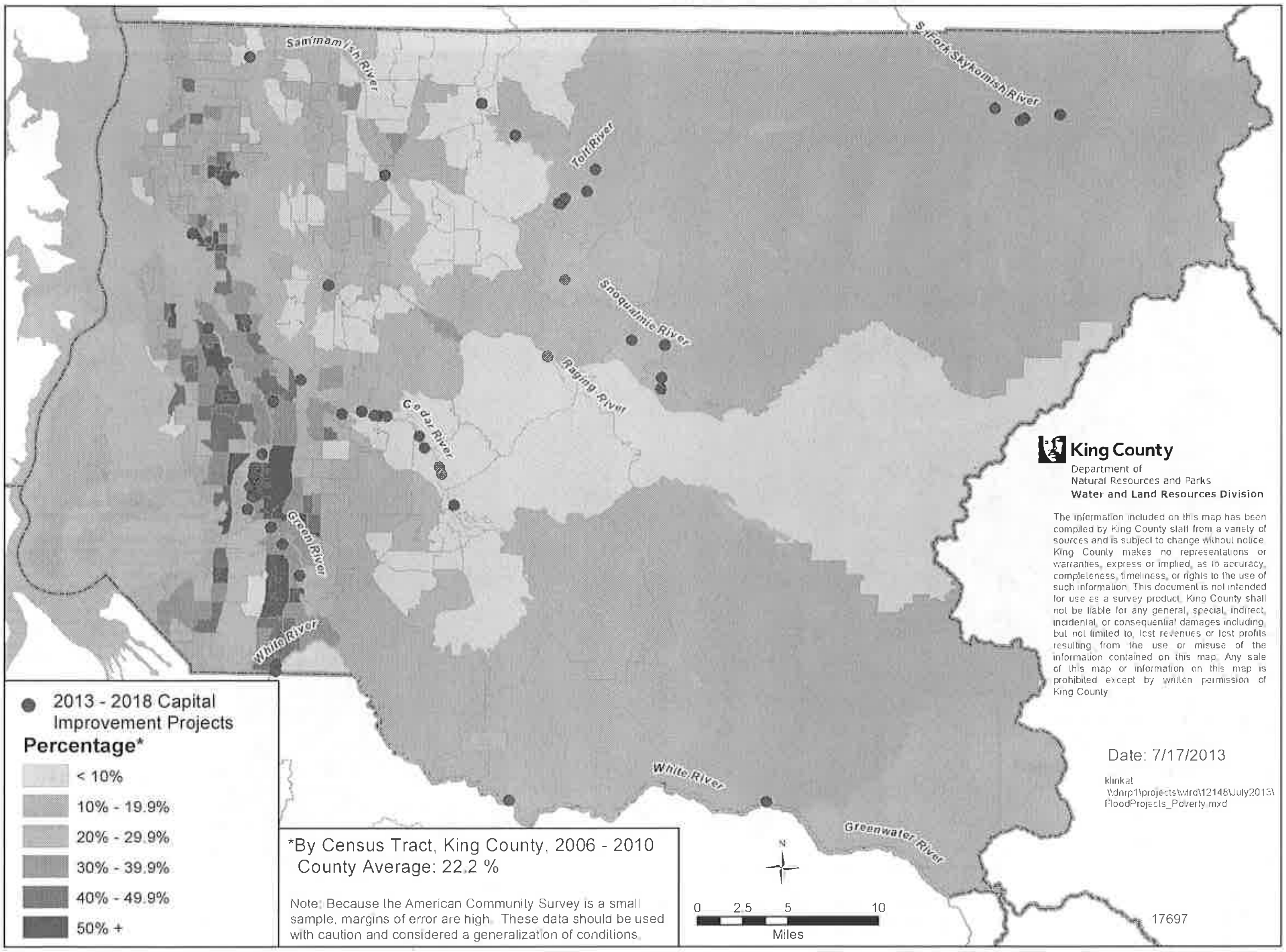
King County's Equity and Social Justice work focuses on creating more equal opportunity not only for people of color and people with limited- English proficiency, but also for low-income communities. Mapping demographic data in King County shows significant variation across geographic areas. This appendix contains a set of maps that overlays the proposed capital improvement projects recommended in Appendix F of this plan onto maps to show the distribution of King County population based on income, race and ethnicity, and languages spoken. The purpose of these maps is to identify any inequities in how the King County addresses the risk of flooding.

Category	Map	Percent of County
Income	Median Household Income	
Income	Percent below 200% of Federal Poverty Level	22.2
Race/Ethnicity	Percent People of Color	35.2
Race/Ethnicity	Percent American Indian or Alaskan Native, Not Hispanic or Latino	0.7
Race/Ethnicity	Percent Asian, Not Hispanic or Latino	14.5
Race/Ethnicity	Percent Black or African American, Not Hispanic or Latino	6.0
Race/Ethnicity	Percent Foreign Born	19.8
Race/Ethnicity	Percent Hispanic or Latino	8.9
Race/Ethnicity	Percent Multiple Races, Not Hispanic or Latino	4.1
Race/Ethnicity	Percent Native Hawaiian or Pacific Islander, Not Hispanic or Latino	0.7
Race/Ethnicity	Percent White, Not Hispanic or Latino	68.4
Languages Spoken	Percent Speak English Less than Very Well	11.0
Languages Spoken	Percent Speak African Languages	1.4
Languages Spoken	Percent Speak Chinese	3.1
Languages Spoken	Percent Speak Korean	1.3
Languages Spoken	Percent Speak Russian	1.0
Languages Spoken	Percent Speak Spanish	6.3
Languages Spoken	Percent Speak Vietnamese	1.8

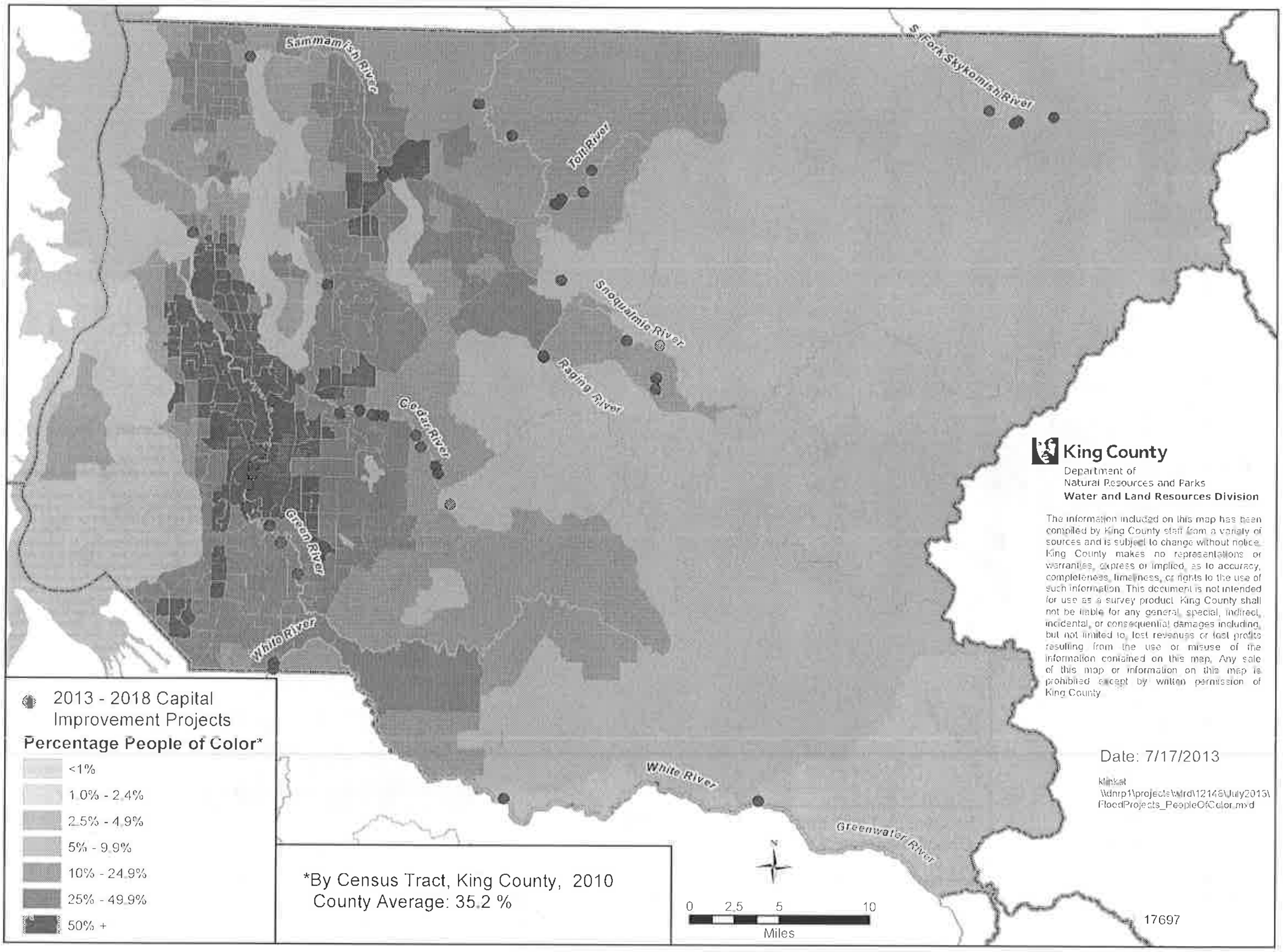
Flood Projects and Median Household Income



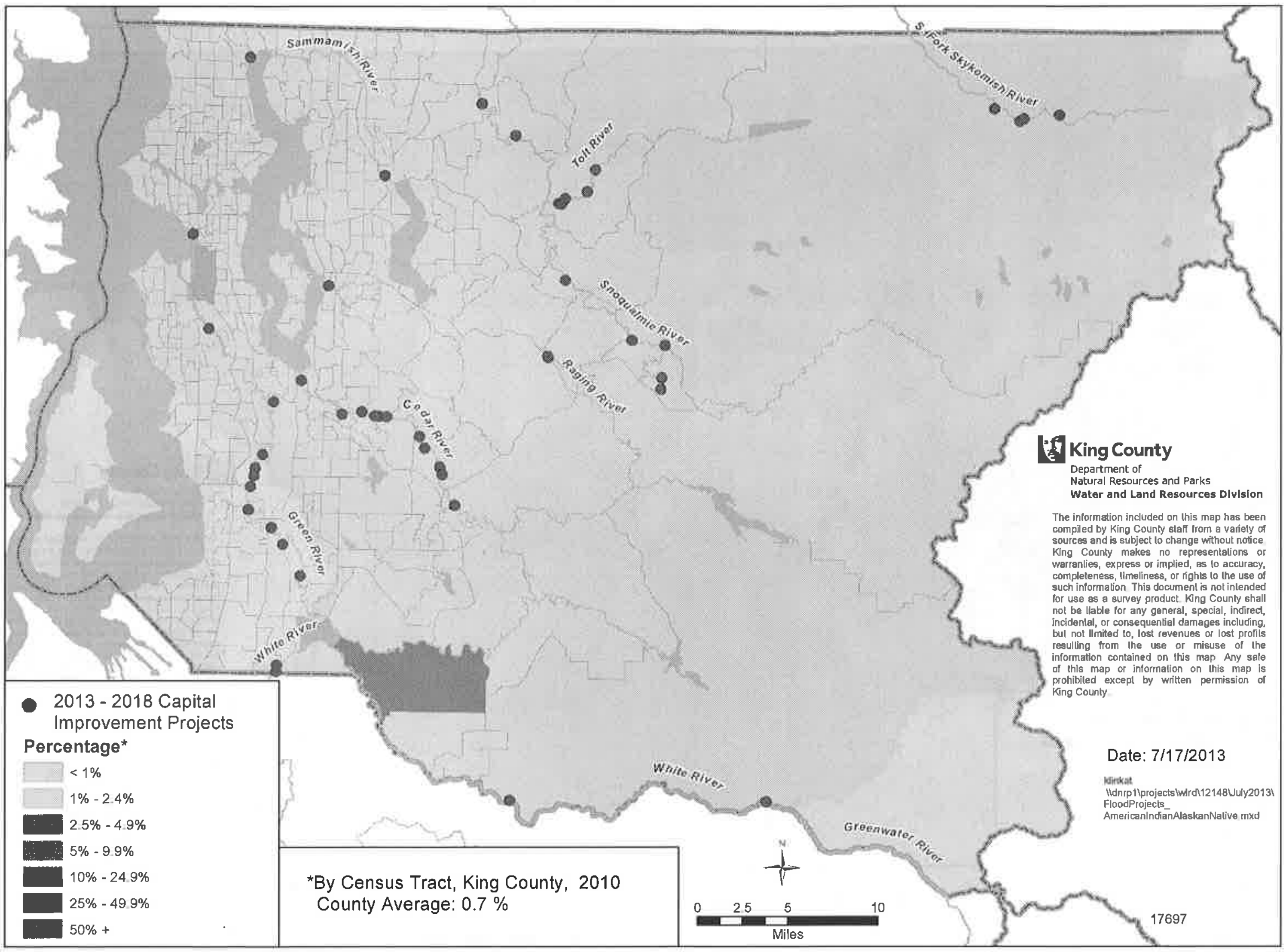
Flood Projects and Percent Below 200% of Federal Poverty Level



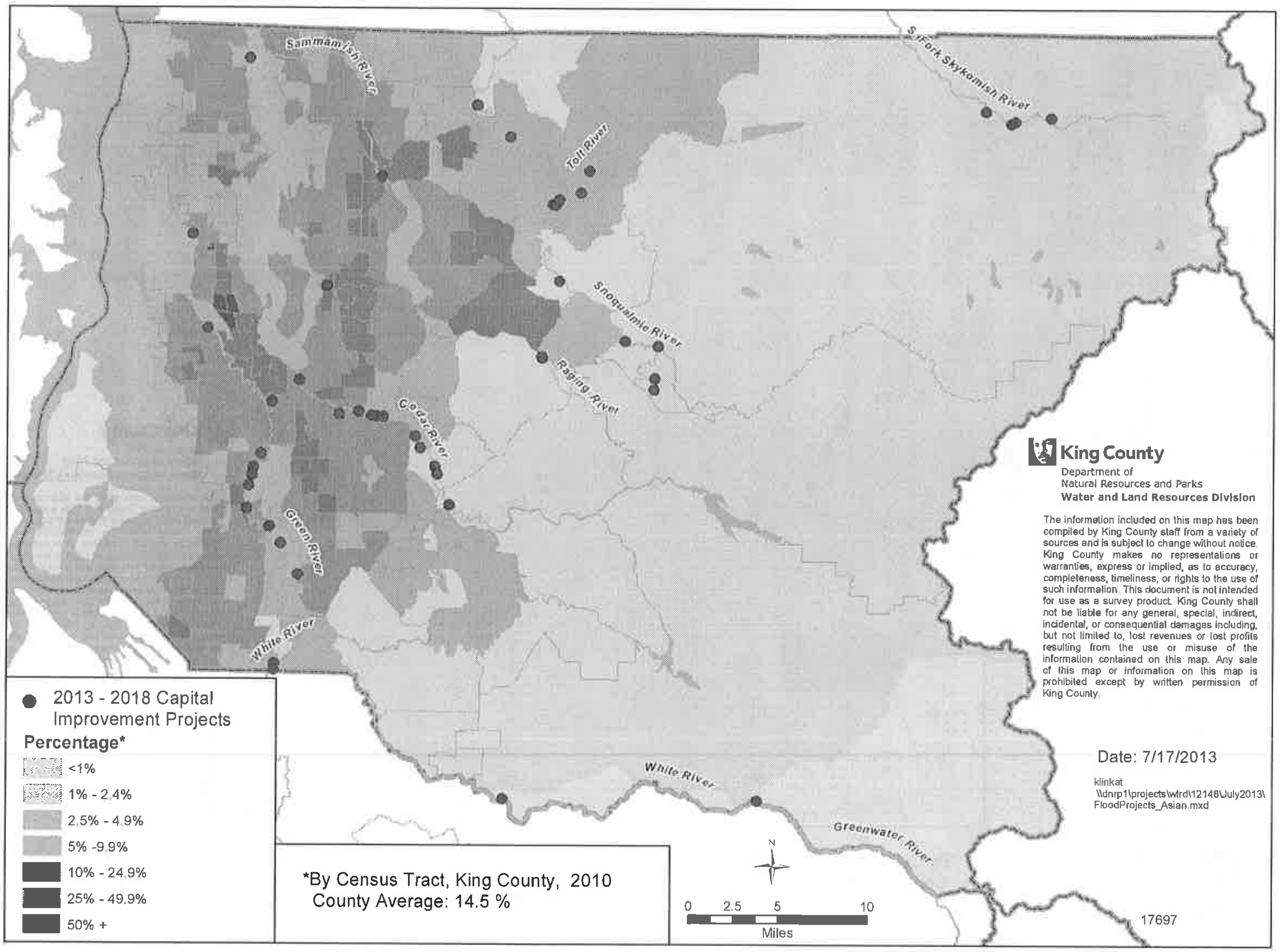
Flood Projects and Percent People of Color



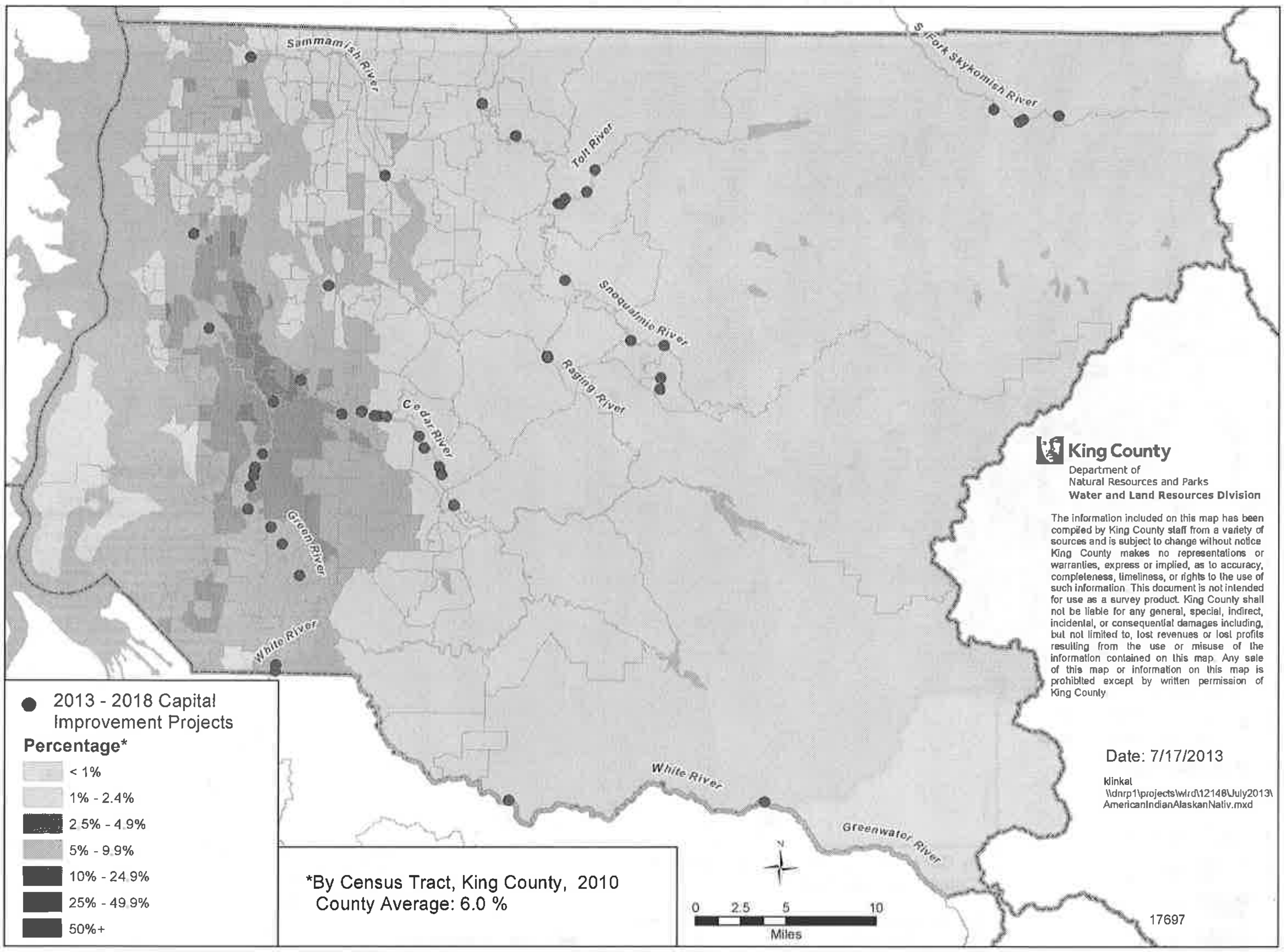
Flood Projects and Percent American Indian or Alaskan Native, Not Hispanic or Latino



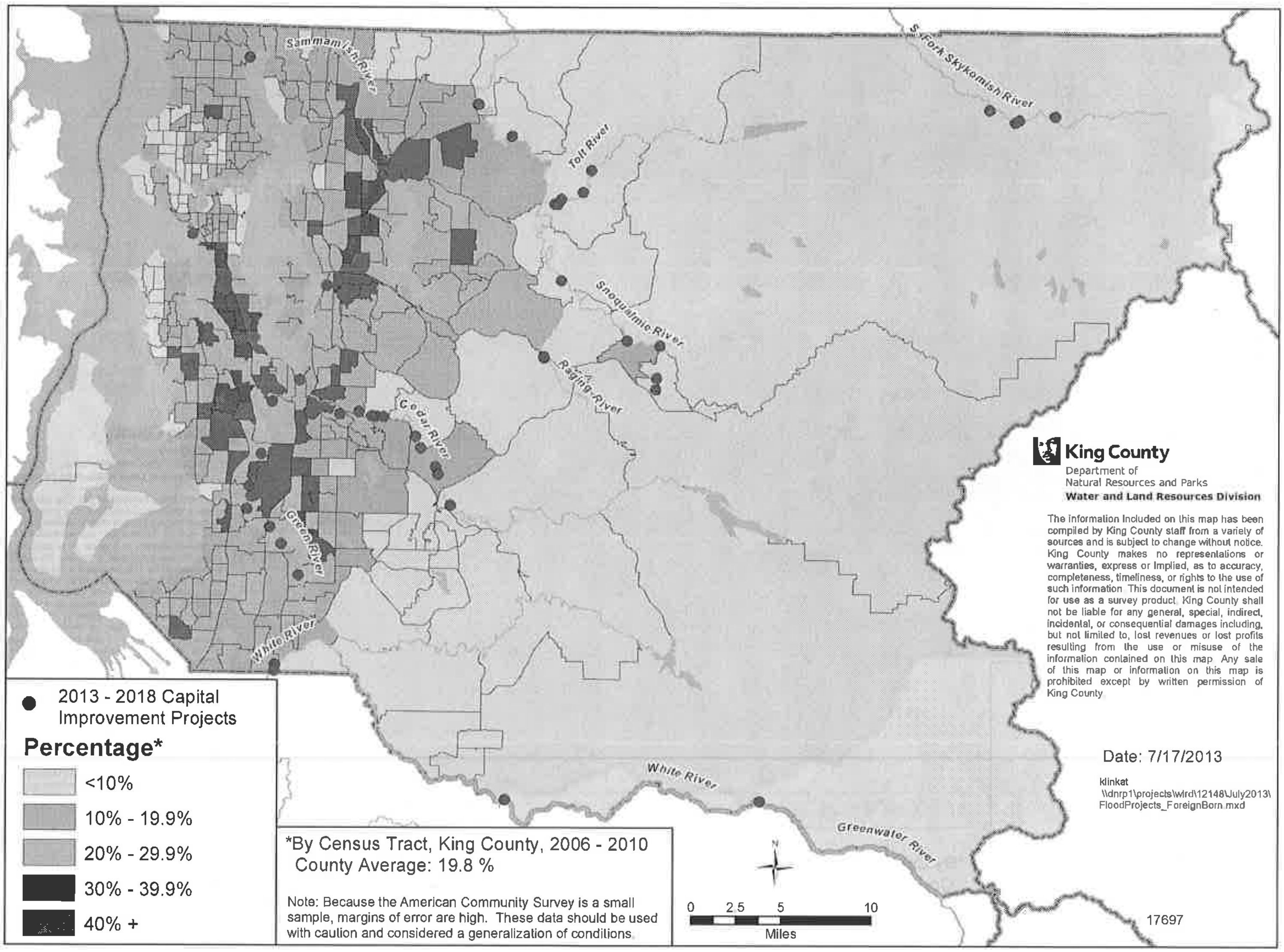
Flood Projects and Percent Asian, Not Hispanic or Latino



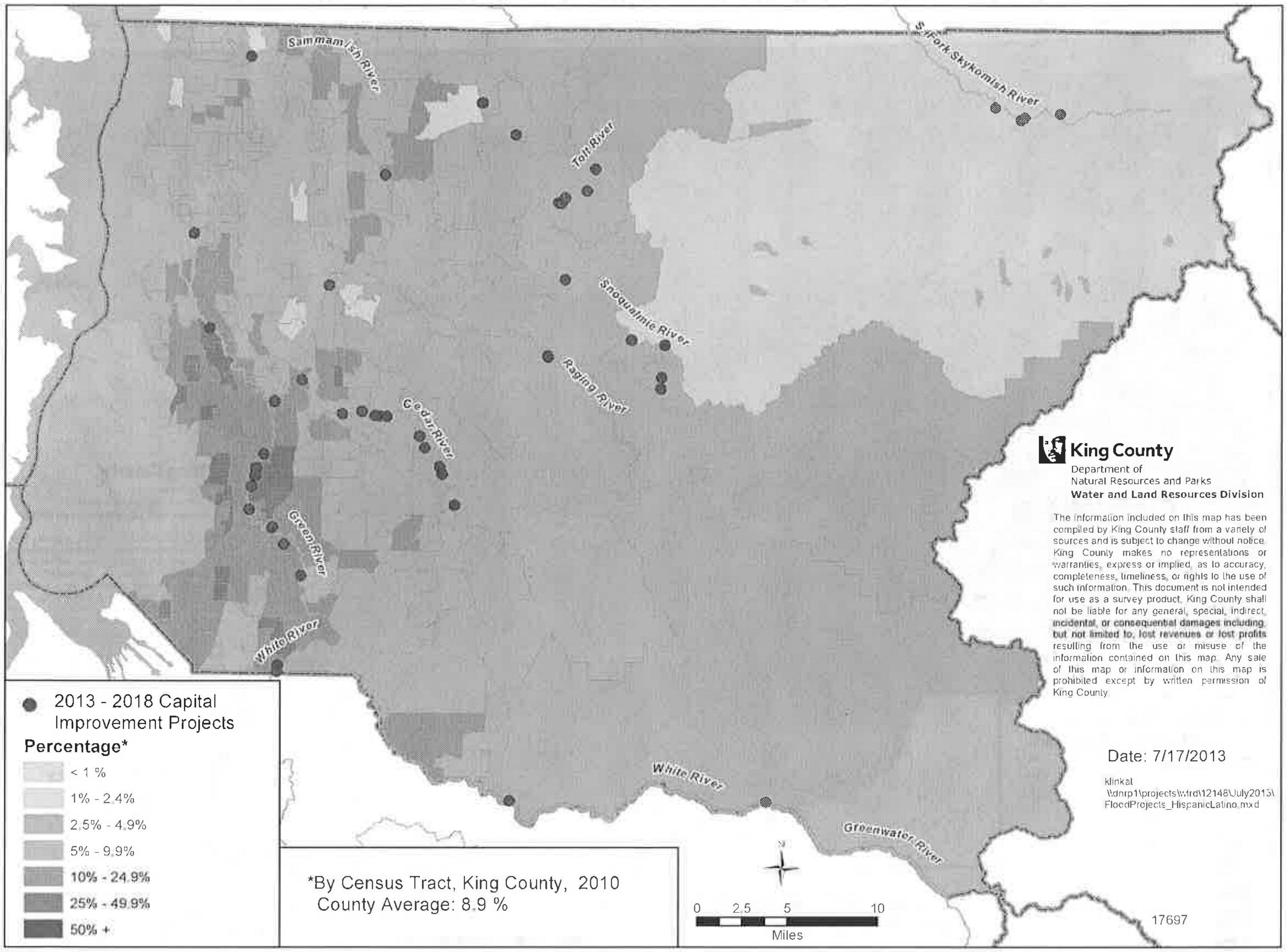
Flood Projects and Percent Black or African American, Not Hispanic or Latino



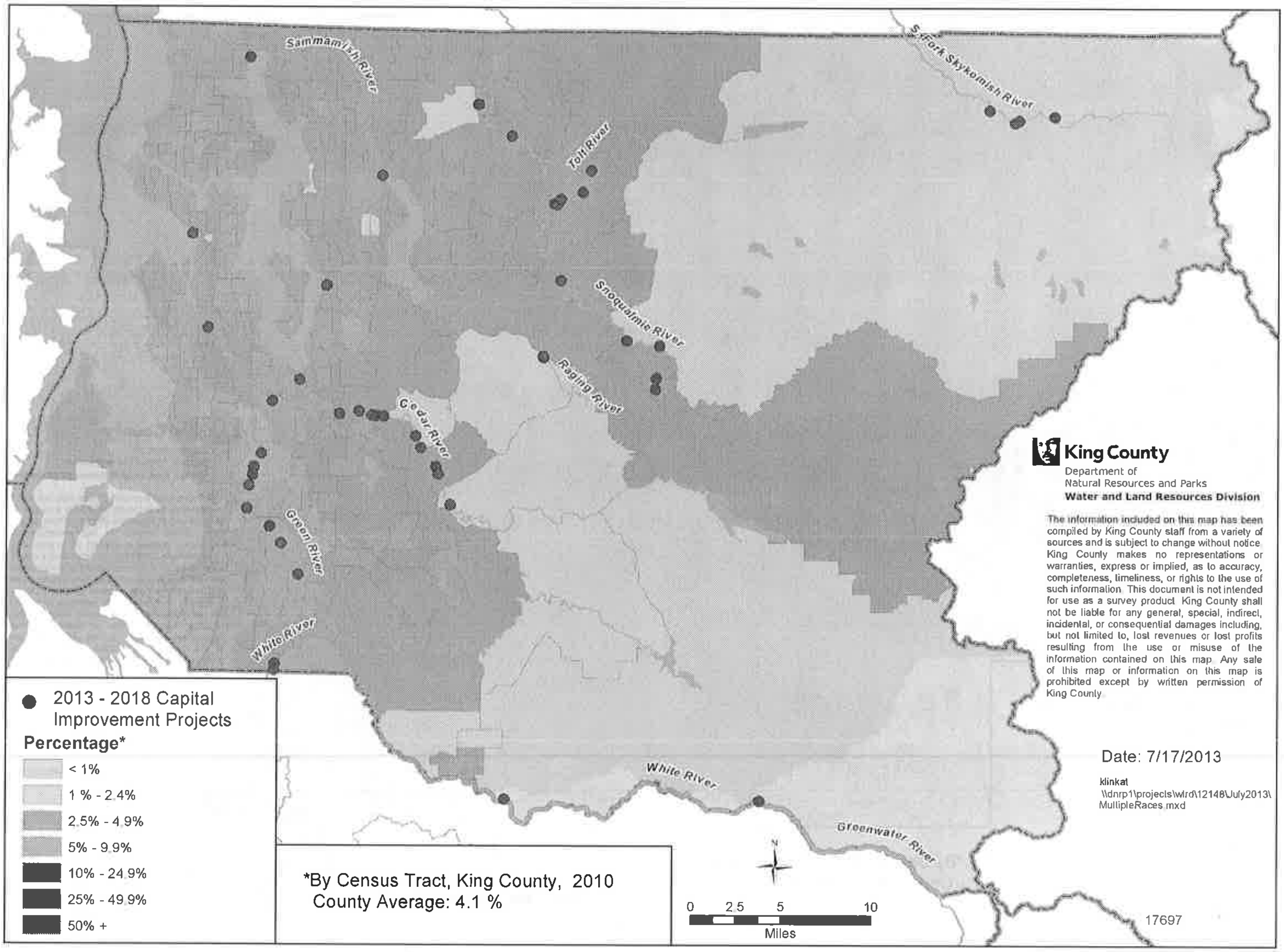
Flood Projects and Percent Foreign Born



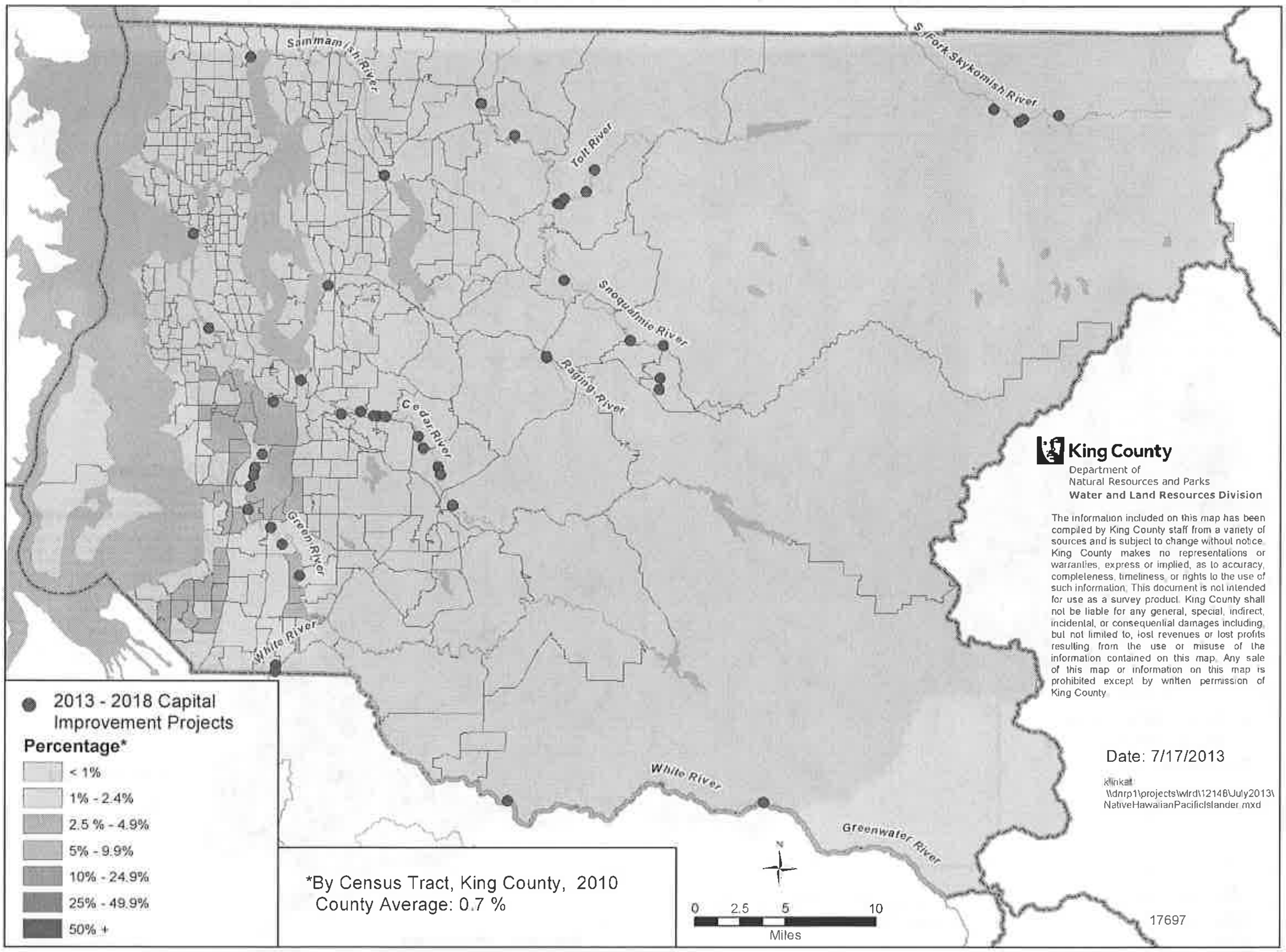
Flood Projects and Percent Hispanic or Latino



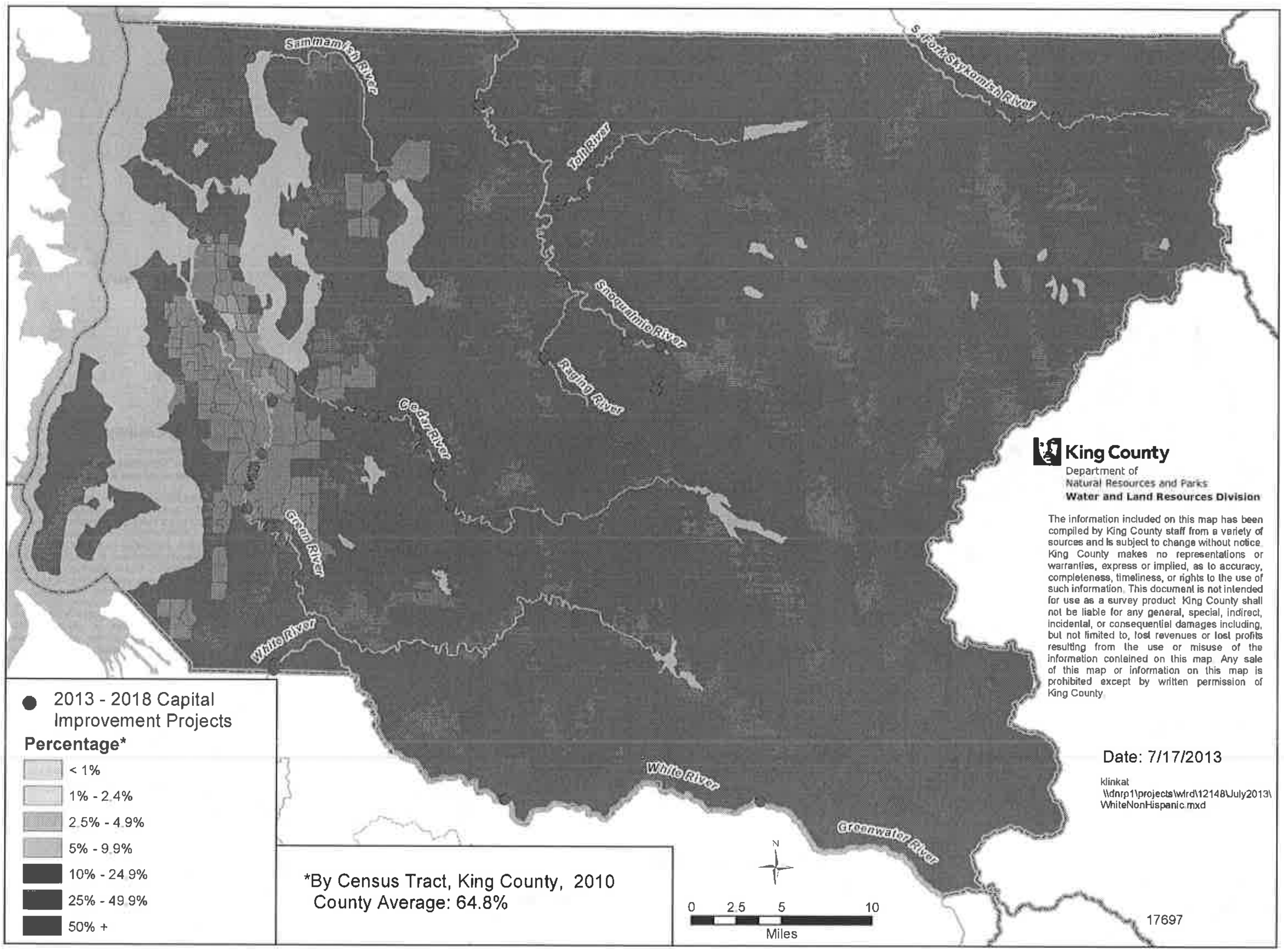
Flood Projects and Percent Multiple Races, Not Hispanic or Latino



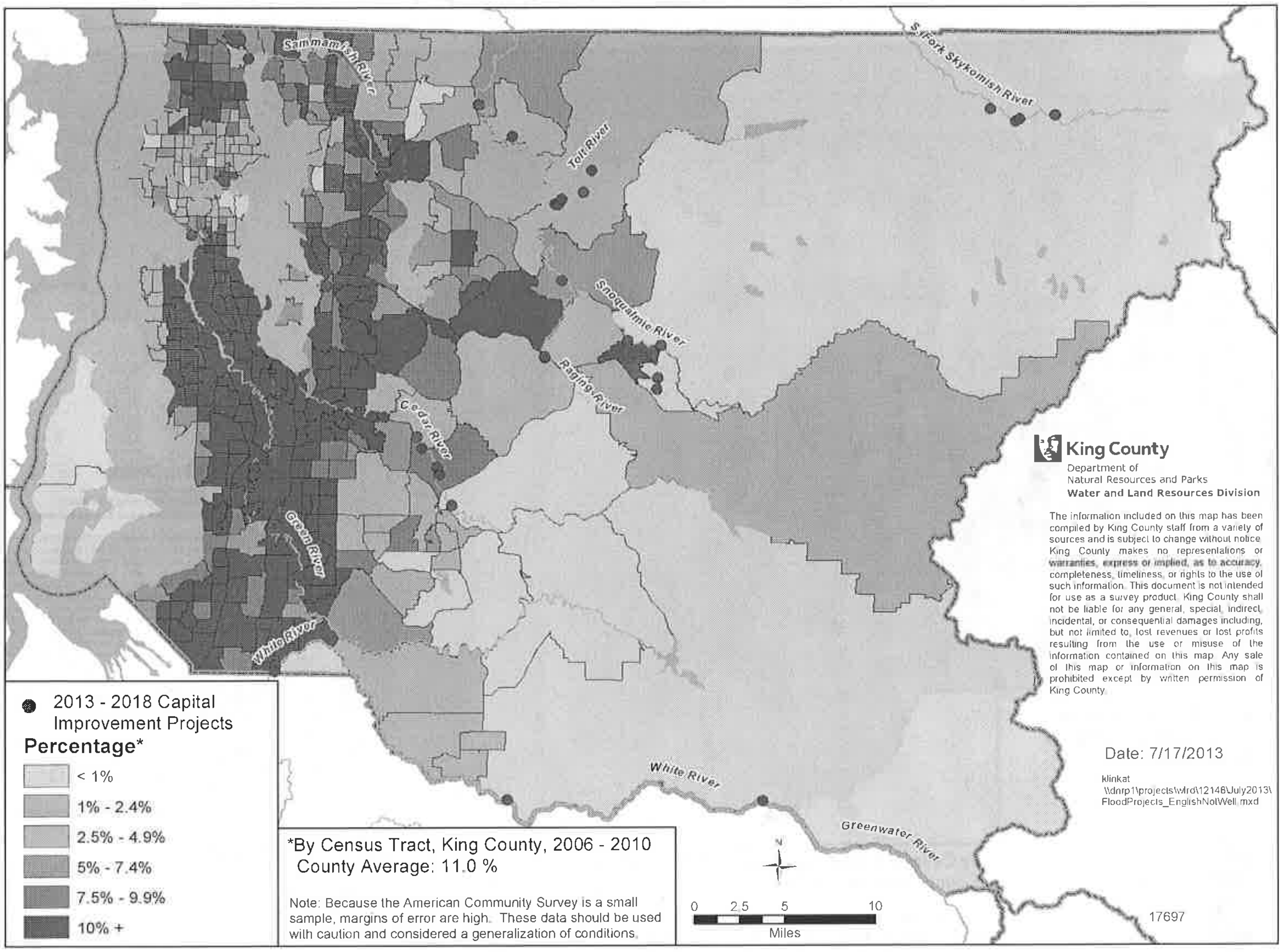
Flood Projects and Percent Native Hawaiian or Pacific Islander, Not Hispanic or Latino



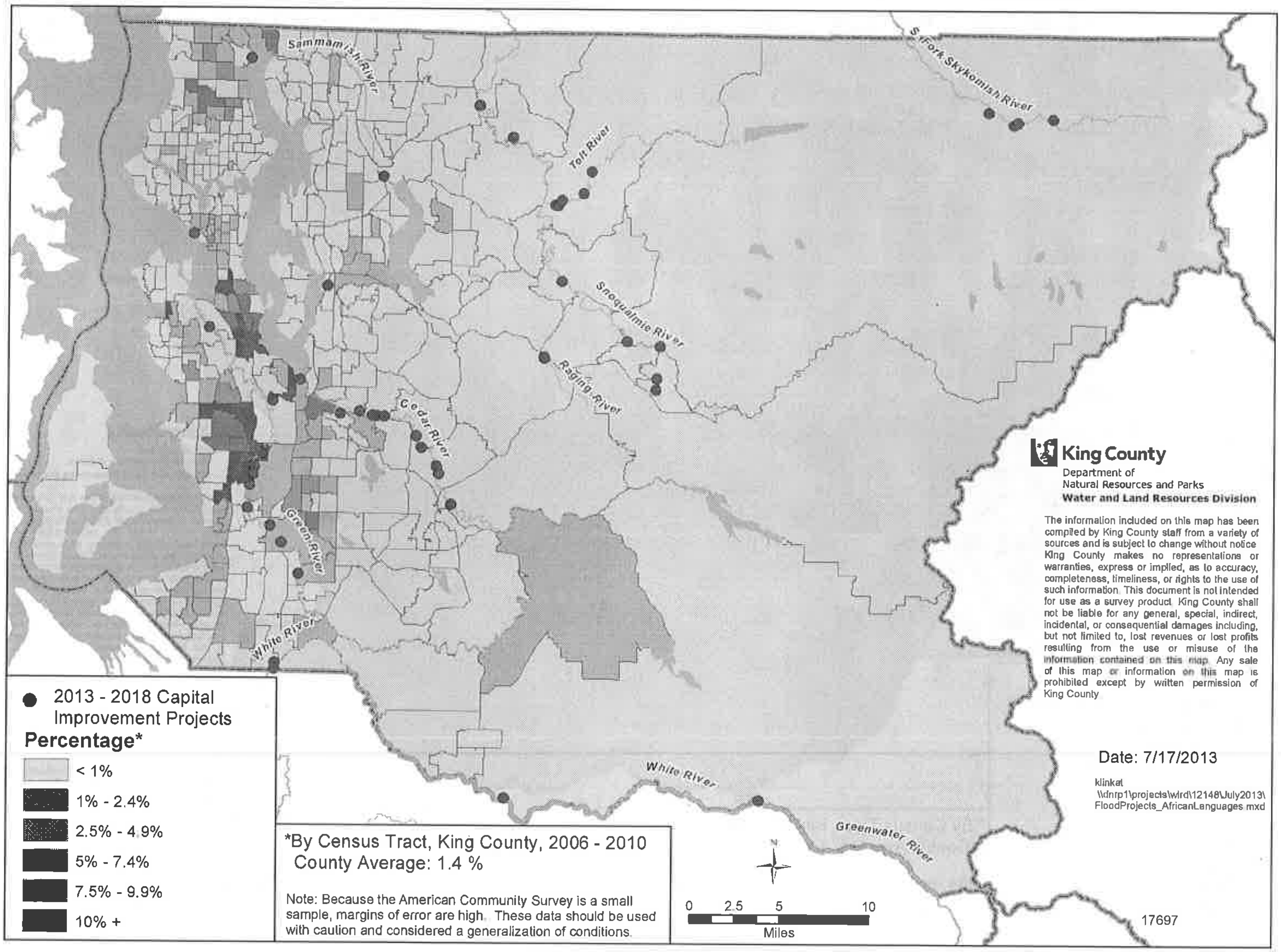
Flood Projects and Percent White, Not Hispanic or Latino



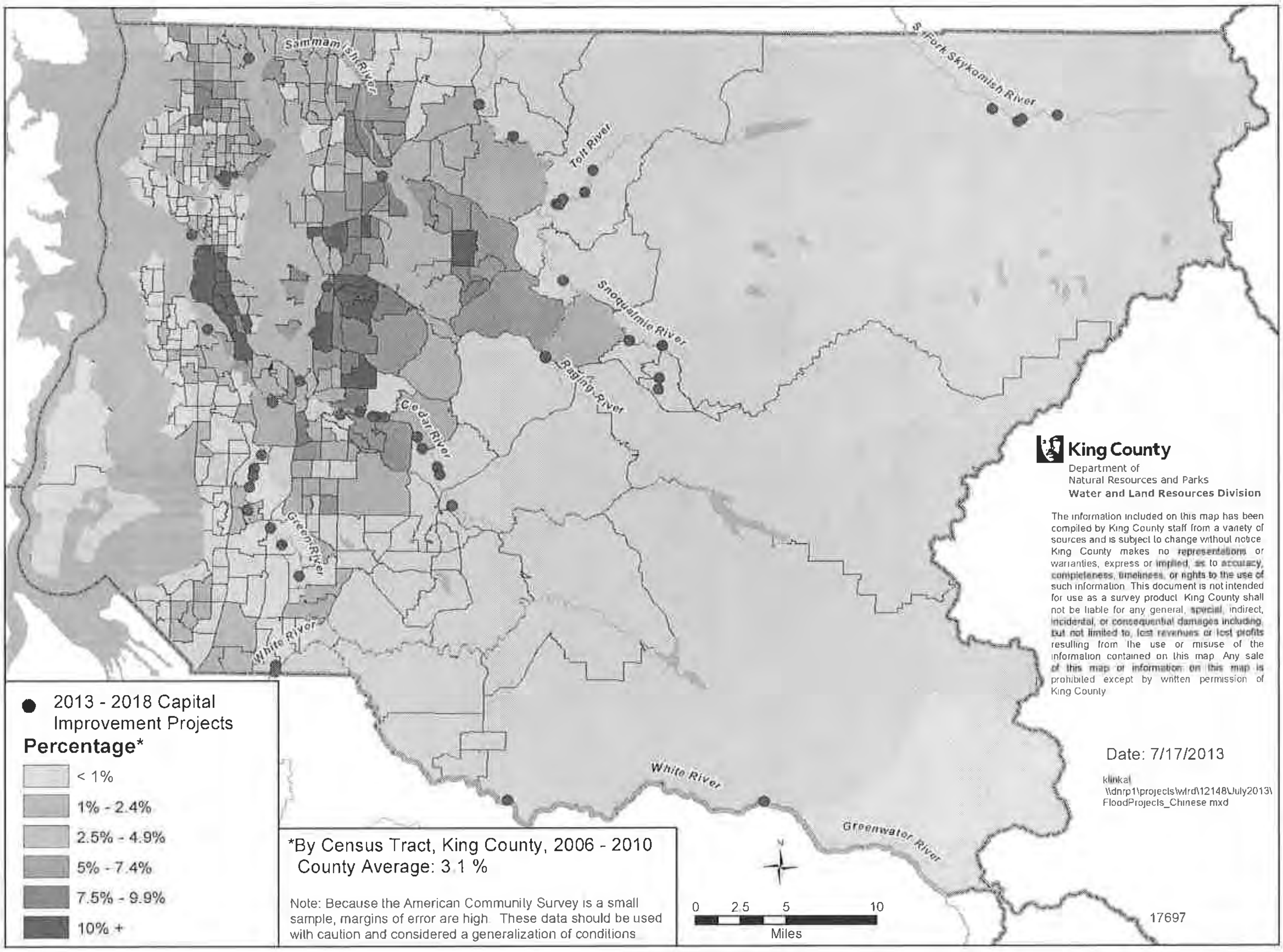
Flood Projects and Percent Who Speak English Less Than Very Well



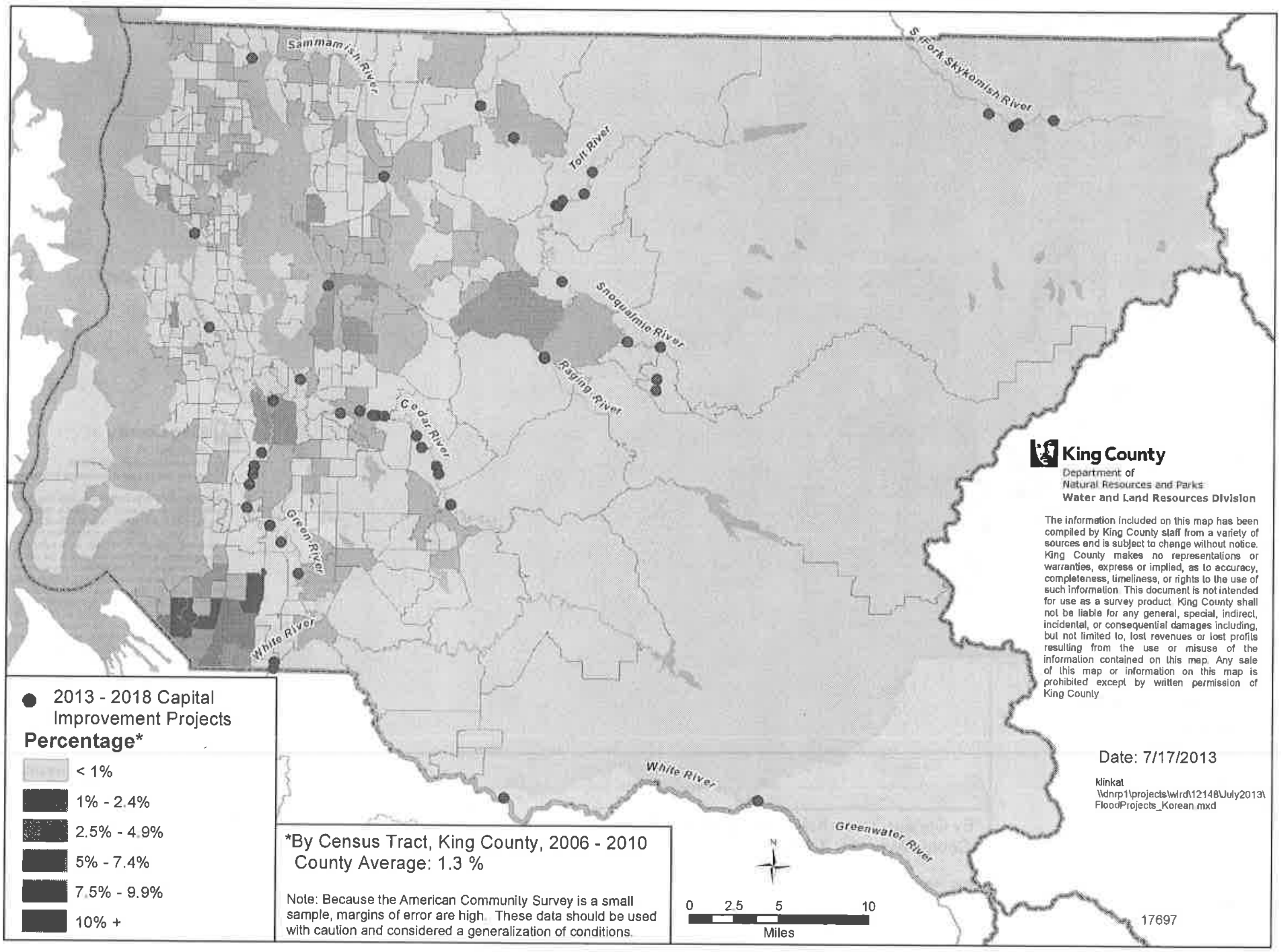
Flood Projects and Percent Who Speak African Languages



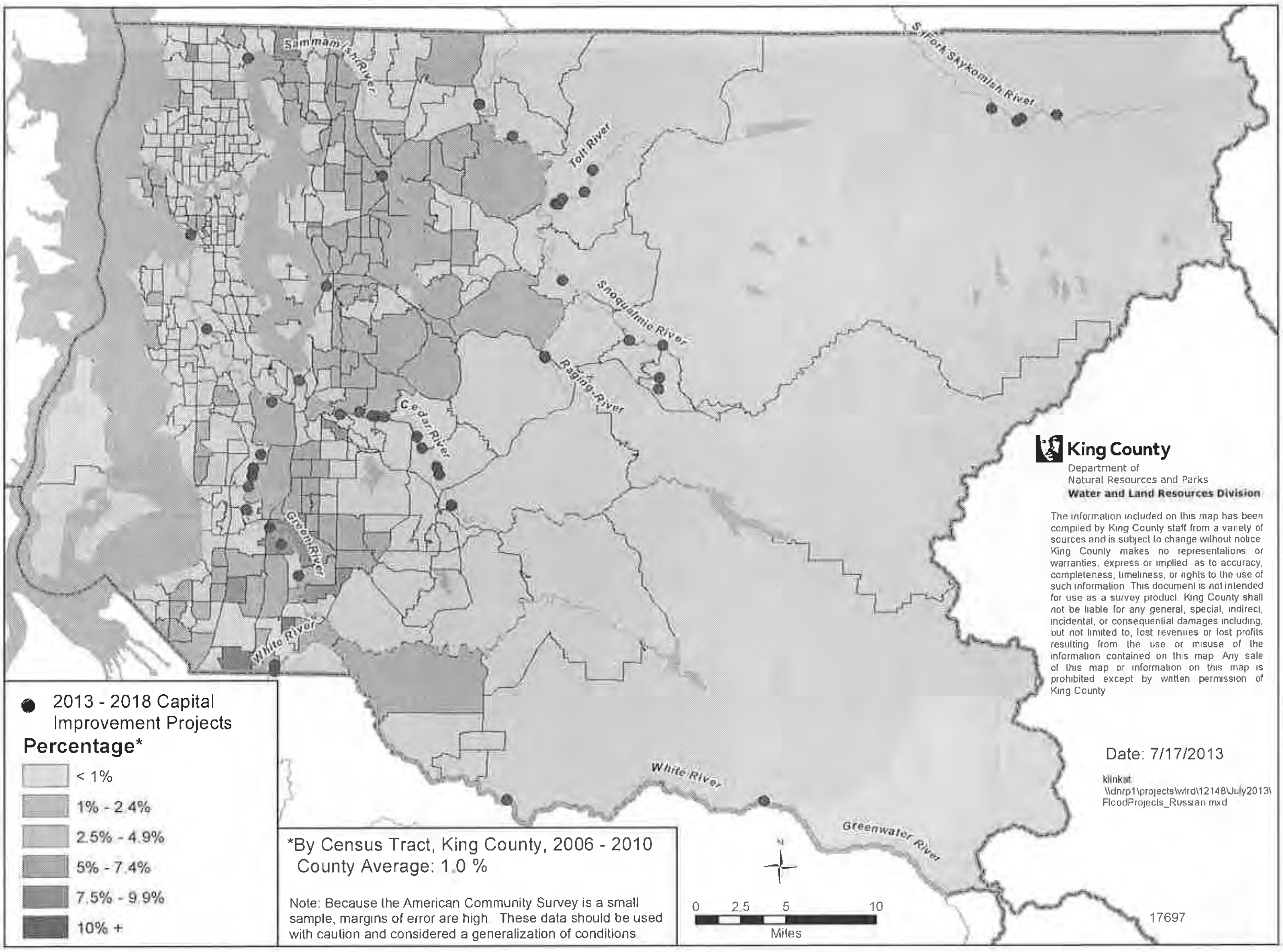
Flood Projects and Percent Who Speak Chinese



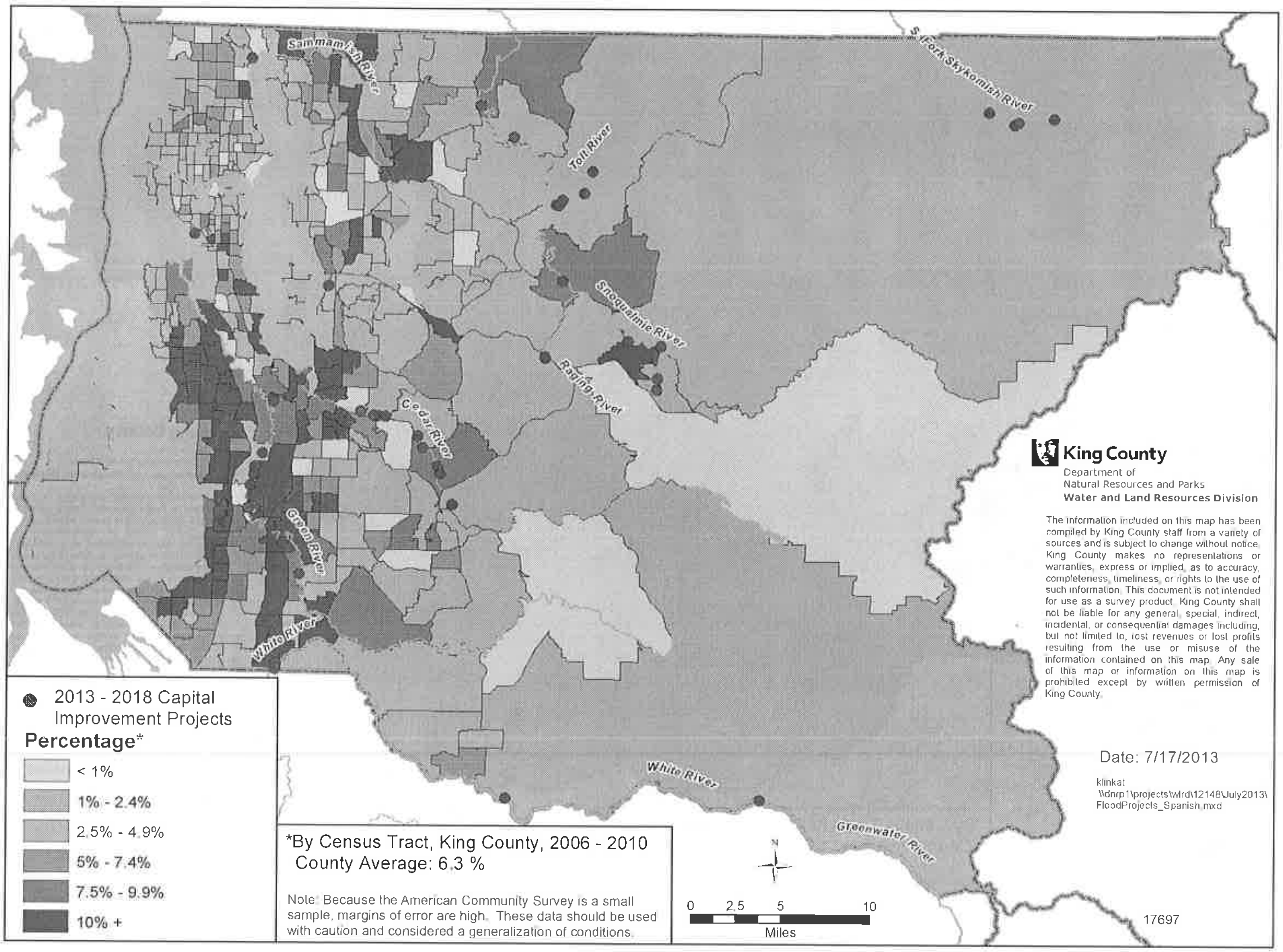
Flood Projects and Percent Who Speak Korean



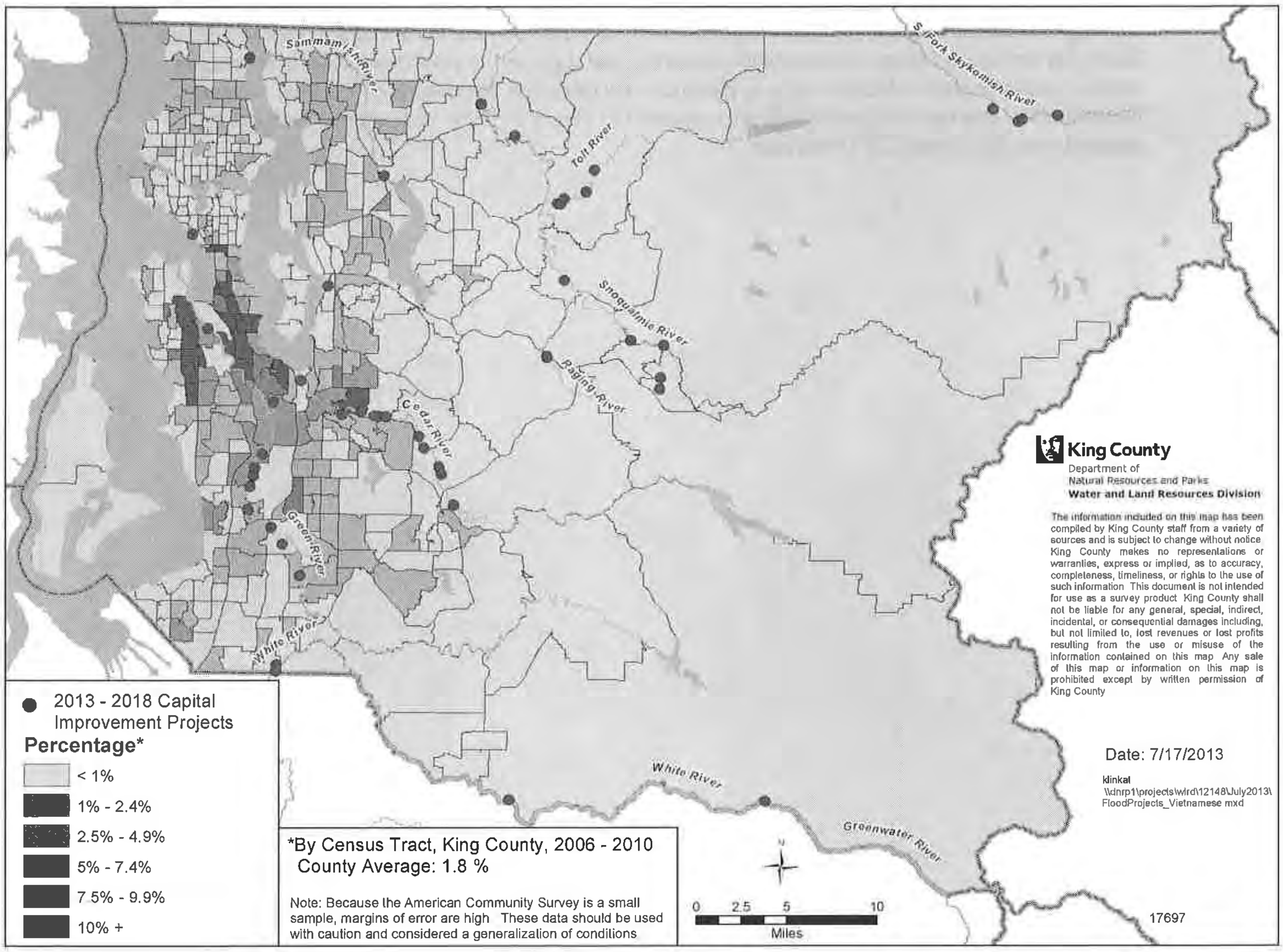
Flood Projects and Percent Who Speak Russian



Flood Projects and Percent Who Speak Spanish



Flood Projects and Percent Who Speak Vietnamese



APPENDIX K.
ELIGIBILITY AND EVALUATION CRITERIA FOR CAPITAL PROJECTS

This appendix contains the King County Flood Control District "Project Prioritization Criteria" and "Capital Project Evaluation: Implementation Factors" used to score capital improvement projects. Through the current capital project prioritization process projects are reviewed and scored against flood risk reduction factors (consequence, severity, and urgency) to prioritize projects across the county. Implementation factors, such as readiness, partnerships, leveraging of external funding opportunities, and legal responsibility are evaluated to determine how to sequence high-priority projects over the 6-year CIP timeframe.

King County Flood Control District Project Prioritization Criteria

The following prioritization scheme is intended to help prioritize KCFCD projects based on the imperative to complete each project from a flood risk/vulnerability perspective only. The basis for these criteria is the 2006 King County Flood Hazard Management Plan policies related to flood risk hierarchy (G-2) and project prioritization (PROJ-1). Sequencing of these priorities over time is guided by the application of implementation factors described and evaluated separately. (NOTE: Current land use and seriousness of impact were given relatively greater weight due to the fundamental objective of reducing risk to health, safety, and welfare.)

1) What is the current land use? (Consequences)

This criterion is intended to give different weights to different types of land uses. If more than one type of land use is at risk, select the applicable land use with the highest score. Use the score range provided to give more or less weight base on site specific conditions. For example a sole access road would be given a higher score than one for which a reasonable alternative route exists.

Description	***Score***
Critical Facilities (See list on page 2)	11-12
Residential	9-10
Commercial (Some commercial structures are critical facilities - see list)	7-8
Agricultural (FPP land should be given higher score than non FPP lands)	5-6
Developed Recreational (Those with regional importance should receive higher scores.)	3-4
Undeveloped land in floodplain or Moderate CMZ	1-2
Undeveloped land in floodway or Severe CMZ	0

Projects providing regional economic benefits receive a bonus of 5 points. A project is considered to provide regional economic benefits if it provides flood protection for a Statewide Strategic Freight Corridor category T1 or T2, high concentrations of employment as identified by the Puget Sound Regional Council (PSRC), or a Manufacturing and Industrial Center identified by the PSRC.

2) How serious is the potential impact? (Consequences and Severity)

This criterion is intended to evaluate the nature and severity of the impacts irrespective of the scale at which the impact will occur. The scoring range can be used to differentiate between similar types of impact that have different liklihoods of occuring.

Description	***Score***
Human injury or death could result from deep fast flows or sudden changes in flood conditions. (e.g. levee or road failure.)	9-12
Total loss of developed land use (e.g. developed land is converted to river channel.)	7-8
Severe flood or erosion damage that will heavily impact those affected.	5-6
Moderate flood or erosion damage which will not likely have a long term impact on those affected.	3-4
Flooding that interrupts human activity or will result in some clean up needs but which will results in little or no damage that will need to be repaired.	1-2

3) How extensive will the impact be? (Consequences and Severity)

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 largely localized. In instance were the physical impact is over a small area, but a larger number of people will be affected, apply score based on the impact rather that just the physical area. Scoring range can be used to differentiate between different degrees of extensivness within the listed catagories.

Description	*Score*
Regional (Impacts will be felt well outside the area in which the flooding or erosion occurred.)	7-8
Severe (City centers, larger neighborhood)	5-6
Moderate (Several structures, roads et impacted)	3-4
Localized (Affects a few homes or business)	1-2

4) How soon will the impact occur? (Urgency)

This criterion is used to describes how soon the flood risk needs to be addressed to avoid its occurrence or reoccurrence.

Description	*Score*
Some or all of the damages described will likely occur or recur during the next major high flow event.	5-6
Damages may occur during the next high water event, or the potential for them to occur is rapidly increasing.	3-4
Damages will eventually occur, but the risk of them occuring is not increasing rapidly	1-2

Critical Facilities Defined

The following list is intended to help understand what constitutes a "Critical Facility". This list has been compiled from the KC Critical Areas Ordinance and the International Building Code.

1. Facilities in which > 300 people congregate
2. Daycares, elementary schools and secondary schools with > 250 people
3. College and adult education facilities with > 50 people
4. Hospitals and Healthcare facilities with > 50 resident patients
5. Jails and detention facilities
6. Facilities with > 5000 occupants
7. Power, Wastewater and potable water treatment facilities
8. Fire, rescue and police facilities
9. Designated emergency shelters
10. Power generation and public utility faculties
11. Aviation facilities
12. Critical national defense facilities
13. Nursing and personal care facilities
14. Senior citizen assisted housing
15. Public roadways and bridges
16. Sites that produce, use or store hazardous substances or hazardous waste (not including sites that temporarily store household products intended of sale on the site)

Ordinance 15051 (CAO), lines 605 - 614

Critical facility: a facility necessary to protect the public health, safety and welfare including, but not limited to, a facility defined under the occupancy categories of "essential facilities," "hazardous facilities" and "special occupancy structures" in the structural forces chapter or succeeding chapter in the K.C.C. Title 16. Critical facilities also include nursing and personal care facilities, schools, senior citizen assisted housing, public roadway bridges and sites that produce, use or store hazardous substances or hazardous waste, not including the temporary storage of consumer products containing hazardous substances or hazardous waste intended for household use or for retail sale on the site.

Section 1602 International Building Code

Esseintial Facilities. Buildings and other structures that are intended to remain operational in the event of extreme environmental loading from flood, wind, snow or earthquakes.

King County Flood Control Zone District
Capital Project Evaluation: Implementation Opportunity Factors

Pts	Readiness
10	Project is ready for construction or acquisition. For construction projects, landowner negotiations are in progress for any acquisitions that may be necessary, and/or design is complete and permits are in hand. For floodplain buyouts, appraisals are complete and landowner negotiations in progress.
8	For construction projects, landowner negotiations are in progress for any acquisitions that may be necessary, and permit agencies support design concept. For floodplain buyouts, landowner is interested and appraisals are in progress.
5	Landowner interested; no appraisal. For construction projects, design constraints exist but can likely be addressed through coordination with other agencies.
0	Landowner not interested and/or significant design constraints (ie roads or other infrastructure) necessitate rescoping of the project
Pts	**Project leverages District funds with external resources or funding**
8	3:1 > X
6	2:1< X < 3:1
4	1:1 < X < 2:1
2	0 < X < 1:1
1	Grant proposal in development to leverage District funds
Pts	**Project supports multiple floodplain objectives**
2 pts each up to 8 pts	Identified in local flood hazard management plan
	Identified in federal ESA Recovery Plan for Puget Sound Chinook
	Identified on SRFB 3-year CIP list
	Identified in Basin Plan
	Identified in adopted stormwater or habitat CIP list
	Identified in open space and recreation plan
	Identified in non-point source action plan
	Protects productive agricultural soils within an Agricultural Production District
Pts	**Cost Effectiveness**
5	High – project provides a permanent solution, such as a buyout that removes flood hazard risks
3	Medium – project reduces rather than removes flood risks; facility is designed to minimize O&M (for example, design uses biostabilization approaches such as those described in King County's Guidelines for Bank Stabilization rather than rock)
1	Low – Project design will result in annual maintenance and land management
Pts	**Proponent has floodplain management regulations in place**
3	Exceeds NFIP
1	Meets NFIP minimum requirements
Pts	**Proponent participates in FEMA's Community Rating System**
3	FEMA Community Rating System rating less than 5

King County Flood Control Zone District
Capital Project Evaluation: Implementation Opportunity Factors

1	FEMA Community Rating System rating greater than 5
0	Proponent is not a participant in Community Rating System
Pts	**Active CIP**
1	Proponent maintains and funds an active CIP program for flooding and/or stormwater drainage
Pts	**Active O&M**
1	Proponent maintains and funds an active CIP program for flooding and/or stormwater drainage

APPENDIX L.
ISSUE PAPERS AND CITIZENS COMMITTEE REPORT

This appendix contains the nine issue papers discussed at the Citizens Committee meetings, held between December 2011 and July 2012, and the Citizens Committee Report which summarizes the feedback received from the Citizens Committee.

The issue papers include:

- Levee Certification, Accreditation and Flood Risk Reduction "Levels of Service"
- Levee Vegetation and Eligibility for U.S. Army Corps of Engineers Levee Repair Funding
- Capital Project Funding for Coastal Flood and Erosion Risks
- Urban Flooding and Small Streams
- Equity and Social Justice: Outreach to Underserved and Vulnerable Populations
- Relocation of Residential and Commercial Tenants
- Capital Project Prioritization, Sequencing Approach, and Eligibility Criteria
- Design Guidelines and Bioengineering Approaches to Levees and Revetments
- Gravel Removal and Sediment Management

2012 KING COUNTY FLOOD HAZARD MANAGEMENT PLAN UPDATE

July 2012

TOPIC:

Levee Certification, Accreditation and Flood Risk Reduction "Levels of Service"

STATEMENT OF ISSUE:

The Board has adopted a motion regarding District operations and maintenance responsibilities for levee certification and accreditation on the Green River. The motion identifies several criteria for determining when the District will take on these responsibilities. These include consistency with adopted Plan policies, contribution to long-term risk reduction solutions, and risk-based repair and maintenance. The motion asks that this policy review balance the certification and accreditation process and costs with long-term solutions that increase public safety and reduce flood risks throughout the county.

1. Do you suggest any other conditions or circumstances for determining when the District should consider taking on the long-term operations and maintenance responsibilities necessary to achieve levee certification and FEMA levee accreditation?

2. How should the District determine the appropriate level of service for levee systems in different parts of King County? What criteria should be used to determine the targeted level of service?

BACKGROUND:

The minimum standards used by FEMA for levee certification and levee accreditation on flood insurance maps are often misperceived as a safety standard for levees in general. This paper will review the differences between levee certification, levee accreditation, as well as the concept of a 'level of service' for levee systems that may in some contexts differ from FEMA's insurance program minimum standards.

Terminology

- Certification is the technical review process "certifying" that a levee meets certain engineering standards—conducted by a licensed Professional Engineer. Notably, the federal regulations governing certification and FEMA accreditation state that '*a certification by a registered professional engineer or other party does not constitute a warranty or guarantee of performance, expressed, or implied.*' FEMA goes on to further clarify that certification is not a safety standard: "It is important to note that the FEMA NFIP standards and flood hazard mapping do not reflect the performance, reliability or overall safety of a levee system." Actions taken to certify and accredit levees may result in improved stability for a given levee in some situations, but they should not necessarily be considered sufficient for long-term risk reduction.Accreditation refers to FEMA's recognition on flood maps that the certified levee system offers base flood protection.
- Engineering certification and FEMA accreditation administratively removes areas from the regulatory floodplain on flood insurance rate maps, but the process does not guarantee flood protection or eliminate all flood risk.
- Certification and accreditation of levees typically corresponds to the minimum of a 100-year (or, more accurately, the base flood which has a 1% chance of occurring each year) level of protection, but a higher standard is possible.
- To attain greater than 100-year protection, one can choose to construct taller levees alongside the river channel,allow for a wider corridor with setback facilities, or construct floodwalls.

Benefits of Certified and Accredited Levees under the National Flood Insurance Program

- National Flood Insurance Program (NFIP) floodplain development regulations and insurance requirements no longer apply. For property owners that elect to purchase flood insurance, premiums are lower.
- Simplifies requirements for new development and redevelopment in areas formerly regulated as floodplain.
- Certification and accreditation are perceived as providing greater certainty for economic development purposes, as land protected by FEMA accredited levees is considered low- or moderate-risk and not included as a mapped flood hazard area

Drawbacks of Certification and Accreditation

- Encourages development in inherently risky areas, and without requirements for flood-resistant construction methods and materials, property owners are more vulnerable to flood-related losses. Since flood insurance is not required, these owners may lack insurance coverage for their increased vulnerability.
- Does not recognize or convey residual risk, which leads the public to misinterpret the degree of flood risk present.
- Requires significant investments in time and money. Investments leading to improved infrastructure or flood mitigation actions may reduce flood risk, but investing in the creation of documentation at a rough cost of $1 million per levee segment sufficient to satisfy federal reviewers offers no real flood risk reduction benefit.
- Should the levee system fail or be overtopped, the certifying engineer or the engineer's employer faces liability concerns. Case law suggests that agencies with levee operation and maintenance responsibilities may be similarly liable.
- Implementation of near-channel certification and accreditation may preclude the pursuit of lower-maintenance, more ecologically-sensitive long-term flood risk reduction approaches.

National Debate regarding Levee Certification and Accreditation
The suitability of the 100-year standard for levee certification and accreditation has often been debated at the national level, thus drawing into question the logic of relying on certification to provide regulatory benefits. As far back as 1982, the National Research Council recommended to FEMA that FEMA *"should require purchase of flood insurance in all areas where the ground is lower than the unconfined 100-year flood level except where protected by a levee built to contain the 500-year flood."* The additional resources include additional findings from multiple Congressionally established committees, as well as engineering professional societies regarding levees. See the 'Additional Resources' for more congressional report highlights.

In recognition of this responsibility and acknowledgement of the reality that flooding has caused significant damage across the nation in communities protected by certified and accredited levees, the State of California has established a 200-year minimum design standard for urban areas (locations where levees protect more than 10,000 people), the City of Dallas is pursuing an 800-year level of service, and the Corps of Engineers now applies a probabilistic analysis of risk to determine the most appropriate level of service for levees.

For reference, Table 1 summarizes the cumulative risk associated with different flow events over time.

Table 1: Probability of Exeeding Flow Events Over Time:

	30 Years	50 Years	75 Years	100 Years
1:100	26%	39%	53%	63%
1:140	19%	30%	42%	51%
1:200	14%	22%	31%	39%
1:300	10%	15%	22%	28%
1:500	6%	10%	14%	18%

Regional and Local Considerations

The national debate over levee certification and accreditation has also played out locally. In response to a request from the Washington State Legislature to evaluate the certification status of levees in Washington, the Department of Ecology concluded:

> The 100-year standard may be woefully insufficient in some areas (such as highly urbanized environments) and perhaps overly protective in others (such as agricultural lands, undeveloped lands, etc), thus FEMA accreditation should include risk and economic analysis.

The 2006 King County Flood Hazard Management Plan does not include policy language regarding levee certification and accreditation. In King County, levee accreditation concerns have been most pressing in the Green River valley cities, which are home to over 100,000 jobs, the fourth largest warehouse and distribution complex in the nation, an annual payroll of $2.8 billion, one eighth of the gross domestic product of the state of Washington and annual taxable revenue of over $8 billion. In addition to the insurance and floodplain development benefits of FEMA accreditation, levee certification is seen by the cities as necessary to reassure the business community their investments are relatively safe. While the concern is most immediate on the lower Green River, other communities in King County may seek FEMA accreditation status. On the currently adopted FEMA flood hazard maps for the Green River the lower Green River levees are 'recognized as accreditated' despite the lack of any engineering certification other than a segment in Tukwila that is federally certified by the Corps of Engineers. This 'recognized as accredited' status will be removed from future FEMA flood insurance maps unless the levees are certified and accredited. At this time, the only certified and accredited levees in King County are the North Creek levee system in Bothell (privately certified) and the Tukwila 205 federally certified levee along the lower Green, which is also site of some of the District's highest priority levee rehabilitation needs.

In response to a request from the mayors of the four Green River valley cities in March 2011, the Board adopted a motion stating its intent to assume levee maintenance and operations responsibilities for FEMA accreditation efforts under the following conditions:

- Levee design and construction must be consistent with the policies in the 2006 King County Flood Hazard Management Plan,
- Short-term solutions to achieve certification should not conflict with long-term levee setback needs.
- Any future maintenance responsibilities for the District will be based on an assessment of risk.

Consistent with this Motion, King County staff have worked closely with the City of Kent to review the City's proposed levee and floodwall certification documentation submittals to FEMA. The City is seeking accreditation of these levees and floodwalls by FEMA, so that when new FEMA floodplain maps eventually take effect the land behind these levees will not be subject to FEMA floodplain development or insurance requirements. At this time operations and maintenance agreements are underway with the City of Kent but have not been formally adopted.

At this time FEMA is revising the technical approach used to map floodplains, meaning that current draft federal insurance maps are on hold, and the timeline for FEMA to revise their approach is uncertain.

ALTERNATIVES TO CONSIDER:

To establish appropriate levels of service for levees along King County's river systems, at least three general approaches could be applied:

1. Performance-Based Goals: Evaluation of 'tolerable risk' similar to US Army Corps of Engineers risk-based analysis. This results in a much more detailed risk analysis looking at the probability of different levels of damages, economic disruption, and threats to life safety, but also requires additional data and time to complete analyses.

2. Design-Based Goals: Use flow event as design standard, with different levels of service depending on contextual factors such as land uses behind the levees, population at risk, and hydrologic and physical factors. Examples include the Pierce County approach included in the 'Additional Resources' section and California's urban levee design standards.

3. Insurance-Based Goals: Use the National Flood Insurance Program (NFIP) minimum base 1% annual flood as a design standard.. Under this approach the design standard is the minimum necessary to remove insurance and floodplain development requirements, but may or may not be sufficient to protect health, safety, and welfare

4. Consider a District role for certification and accreditation when the appropriate 'level of service' is provided for a given community.

QUESTIONS:

1. Under what circumstances should the District consider taking on the long-term operations and maintenance responsibilities necessary to achieve levee certification and FEMA levee accreditation? What benefits and costs should be included in making this determination?

2. Under what circumstances, should the District consider taking on a larger role than operations and maintenance for certification efforts?

3. How should the District determine the appropriate level of service for levee systems in different parts of King County? Which of the three approaches described above are most appropriate? Are other approaches preferable? Should the approach vary by basin? What analyses should be included to inform decision-making regarding the most appropriate level of service (e.g. engineering design standards for safety, cost effectiveness, feasibility, opportunity costs, short-term versus long-term actions)?

ADDITIONAL RESOURCES:

1. FEMA Bulletin: The NFIP and Levee Systems.
   http://www.fema.gov/library/viewRecord.do?id=2159

2. American Society of Civil Engineers Policy Statement 529.
   http://www.asce.org/Content.aspx?id=8341

3. Washington State Department of Ecology Statewide Levee Inventory and Flood Protection Study: Levee Certification and Accreditation. November 2010. http://www.ecy.wa.gov/pubs/1006029.pdf

4. Army Corps of Engineers 'Tolerable Risk' Overview
   http://www.iwr.usace.army.mil/docs/iwrreports/10-R-8.pdf

5. Congressional Research Services – 2008 Missouri Flood Lessons Learned.
   http://www.policyarchive.org/handle/10207/bitstreams/18805.pdf

6. ASFPM – Levee Policy paper

7. General Gerald Galloway testimony to Congress, October 27 2005.

8. Briefing memo to the King County Flood Control District Executive Committee – March 28, 2011

9. King County Flood Control District Levee Accreditation Motion, July 2011

2012 KING COUNTY FLOOD HAZARD MANAGEMENT PLAN UPDATE
March 6, 2012

TOPIC:
Levee vegetation and eligibility for US Army Corps of Engineers (Corps) levee repair funding

STATEMENT OF ISSUE:
How should the Flood Control District engage with the Corps on levee vegetation management and disaster funding eligibility under the PL 84-99 program?

Local governments in the Puget Sound region continue to be caught between conflicting federal mandates: we are required to degrade riparian areas identified as critical habitat for federally listed species so that we can retain our eligibility for federal PL 84-99 funding for critical public safety projects. In other words, to comply with one federal mandate we must risk violating both the Endangered Species and Clean Water Acts. Since 2009 the State of California Department of Fish and Game and several environmental organizations have filed a notice of intent to sue the Corps over vegetation management policies.

BACKGROUND:

- Since the early 1990s King County has successful constructed levee projects that rely on native riparian vegetation as a primary means of erosion protection.
- Under Public Law 84-99 (PL 84-99), the Corps is authorized to provide emergency assistance to cost-share and construct levee repairs following a disaster event. Eligibility for this cost-sharing program requires that levee sponsors comply with the Corps Rehabilitation and Inspection Program (RIP), which requires the removal of vegetation greater than 2 inches in diameter from levees.
- Through an existing regional variance the Corps' Seattle District allows the presence of vegetation up to 4 inches in diameter.
- While the purpose of these Corps standards is solely eligibility for federal disaster funding, they are often incorrectly perceived as federal guidance for maintenance necessary for levee accreditation by FEMA. Land behind FEMA accredited levees is not subject to federal insurance requirements or floodplain development regulations. To the degree that the Corps is considered the authority on levee safety, their standards are often cited as the default maintenance standard even for levees outside the PL 84-99 program.
- Federal funding levels under PL 84-99 vary considerably. Since 1990 Corps funding of levee repairs in King County has totaled $27 million, including $25 million received in 2008-9 alone. The 2008-9 level of Corps funding was unique in the last 20 years.

The Corps has proposed the following changes to the policy for local vegetation variances:
- To apply for a variance, local levee operators will need to submit a variance request for individual levee systems, but may look at river systems in a larger planning context.

Variances for each individual levee would require approval at multiple levels, with a final decision by Corps Headquarters rather than the local District.

- Responsibility for providing the engineering justification and federal environmental compliance for the variance shifts from the local Corps District to the local sponsor (i.e., King County).
- Drafts of the PGL Corps Policy Guidance Letter (PGL) to date have not included clear standards for an acceptable variance – while the required submittals are clear the criteria against which these submittals will be evaluated is not.
- Along with the PGL revisions, the Corps is also proposing changes to the System-Wide Improvement Framework (SWIF). Under a SWIF, any risk to levee stability posed by vegetation can be prioritized alongside other levee safety risks, with the target of eventual compliance with a levee variance from the national standard developed under the PGL / SWIF process. The two may be used in combination to develop a prioritized SWIF that includes vegetation variances for specific levee segments. A SWIF would be developed collaboratively by multiple parties including the Corps, County, tribes, federal and state agencies, and other local governments, and be used to inform a capital budget that addresses the most pressing levee stability issues along a river system.

King County has been working with a team of state and federal partners (including the Corps Seattle District) to develop a two-pronged approach to achieving the following goals for levee vegetation management in Western Washington:

1. *Safe and Effective Levees*: resilient structures that can be accessed and inspected during floods.
2. *Functional Habitat*: in many densely developed locations our levees are our riverbanks.
3. *Cost-Effective*: use limited resources to address the worst problems first.
4. *Science-Based*: responsive to new information and research.

With these goals in mind, the team has been pursuing a science-based federal policy that reflects regional conditions and provides flexibility from uniform national standards, support for other stated federal habitat and clean water goals, appropriate prioritization of levee vegetation alongside other known levee safety risks, and a commitment to future research.

In pursuit of these objectives we have worked with state and federal colleagues on a two-pronged levee vegetation strategy to (1) apply political pressure to revise the PGL so that regional approaches would be allowed and (2) participated, at the invitation of the Corps Seattle District, in the levee vegetation framework effort to develop an alternative vegetation management proposal with the Corps, federal and state agencies, and the Muckleshoot Tribe.

In part due to the political pressure, the draft PGL policy was delayed several times before being released for public comment in February 2012. The Corps is also proposing changes to the System-Wide Improvement Framework (SWIF), an alternative that allows vegetation to be prioritized against other levee safety risks with the long-term intent of bringing all PL 84-99 levees into compliance with either the national standard or individual variances issued under the revised PGL. The work group convened by the Seattle District has developed a Levee Vegetation Management Framework as an alternative to the national standard. This Framework has not been reviewed and approved by Corps Headquarters, but has been described as a 'powerful tool' in helping to address multiple floodplain objectives It been evaluated for Endangered Species Act (ESA)/or Clean Water Act (CWA) compliance. The Flood Control District is currently working with the Puget Sound Partnership and the Corps to host a workshop on how the Framework might be implemented via a SWIF and vegetation variances to support the four goals listed above.

ALTERNATIVES TO CONSIDER:

1. Comply with national standard; no variances or SWIFs.
   PRO: Eligible for Corps levee repair funding if it is available.
   CON: Depending on Corps requirements, would divert up to $165M from high-priority risk reduction needs to remove vegetation and root systems, patch levees, and mitigate for the removal of vegetation; inconsistent with Endangered Species Act and Clean Water Act objectives; does not reflect regional conditions.

2. Apply for variances under the new PGL from the Corps; no SWIF.
   PRO: If approved by the Corps, funding eligibility is maintained.
   CON: Uncertain what constitutes an acceptable variance, and unclear whether such a variance
   would comply with ESA and CWA. Time and money spent on variance application and review process will be diverted from risk reduction projects.

3. SWIF plus individual levee variances
   PRO: Prioritizes funding based on risk over a larger geographic scale as above; variances would enable some additional vegetation to remain on levees while maintaining federal funding eligibility
   CON: Unclear what constitutes an acceptable SWIF or variance. Assumes that some vegetation will eventually be removed over a longer timeframe if not consistent with variance. Development and approval of a SWIF and variances will divert resources from existing work program, although significant work has already been completed for the Green River. ESA and CWA compliance are uncertain.

4. Withdrawal from PL 84-99 (would not include Horseshoe Bend and Tukwila federal levees)
   PRO: Reduced ESA/CWA liability. Increased ability to support ecological objectives as part of public safety flood risk reduction program.
   CON: Does not contribute to regional effort to resolve problem of conflicting federal mandates. Ineligibility for federal levee repair funding. May increase legal exposure related to levee performance should a levee breach occur.

ADDITIONAL RESOURCES:

Levee Vegetation Symposium Keynote Speech (2007)
https://www.kingcounty.gov/environment/waterandland/flooding/ron-sims-levee-vegetation-speech/video-transcript.aspx

Overview of Levee Vegetation Management and Army Corps Funding Eligibility (2010)
http://your.kingcounty.gov/dnrp/library/water-and-land/flooding/kcfzcd/Overview_Levee_Vegetation_Board_042610.pdf

Federal Executives Letter on Levee Vegetation (USACE Northwest Division, EPA, and National Marine Fisheries Service, 2010) (attached)

Army Corps of Engineers Levee Vegetation Research Fact Sheet (Sept 2011)
http://wri.usace.army.mil/documents/woody_vegetation_report/FactSheet-Woody_Vegetation_Report.pdf

Levee Vegetation Presentation - Floodplain Management Association (Sept 2011)
http://www.floodplain.org/cmsAdmin/uploads/Murray-Trees_on_Levees.pdf

2012 KING COUNTY FLOOD HAZARD MANAGEMENT PLAN UPDATE

February 1, 2012

TOPIC:

Capital project funding for coastal flood and erosion risks

STATEMENT OF ISSUE:

Should the Flood Control District's capital program include funding for coastal flood and erosion risk reduction projects?

BACKGROUND:

The geographic scope of the 2006 King County Flood Hazard Management Plan includes the unincorporated and incorporated areas of King County, with a 'focus' on the major river floodplains and their significant tributaries. The 2006 Plan also includes a recommendation to cost-share hazard mapping studies with FEMA for marine shorelines so that this technical information identifying hazard areas can be made available to jurisdictions, other public agencies, as well as the residents and businesses exposed to these hazards. While the adopted plan for King County calls for a 'focus' on major rivers, the state authorization for flood districts does allow for improvements that include "the extension, enlargement, construction, or acquisition of dikes and levees, drain and drainage systems, dams and reservoirs, or other flood control or storm water control improvements; widening, straightening, or relocating of stream or water courses; and the acquisition, extension, enlargement, or construction of any works necessary for the protection of stream and water courses, channels, harbors, life, and property" (RCW 86.15.100).

When the 10-year work plan was developed for the newly formed countywide Flood Control District in 2007, the capital project list included $2M for a feasibility study for a potential coastal project (replacement of the Elliott Bay Seawall). During subsequent discussions in 2010 of a proposal to provide additional engineering design support for the Seawall project, the technical staff participating in the Basin Technical Committees and the elected officials on the Advisory Committee did not question the need to replace the Seawall, but many requested additional clarity regarding whether the capital project prioritization policies and criteria in the 2006 Plan were intended to be applied to coastal projects such as the Seawall. The Board provided some clarification with respect to the Elliott Bay Seawall in 2011 by adopting a technical amendment to the Plan and appropriating $4.25M for pre-engineering design support, along with a commitment to provide an additional $25.75M in the six-year capital program. In the motion adopting the amendment, the Board cited RCW 86.15.100, noted the consequence and severity of a seawall failure on the region's economy, and cited a U.S. Army Corps of Engineers finding that there is a 'federal interest' in rehabilitating the Elliott Bay Seawall.

While the decision to cost-share the Elliott Bay Seawall is not in question, the Board has requested input from the Citizen Committee to more clearly articulate a policy for coastal risk reduction actions along the unincorporated Vashon/Maury Islands shoreline and the incorporated shorelines along Puget Sound.

The Board also asked for input on urban and small stream flooding, which is related but discussed in a separate issue paper.

ALTERNATIVES TO CONSIDER (stand-alone or in combinations):

1. Capital funding used for river and stream flooding only; limit coastal funding to existing commitments previously adopted by the Board.
   PRO: Maintains focus on reducing flood and channel migration risks in mapped floodplains of King County while continuing technical support for hazard identification and mapping. Would not impact projects identified on the existing CIP.
   CON: Coastal risk reduction projects that might otherwise be considered high priority would not be funded by the Flood Control District.

2. Capital funding for coastal areas only if the U.S. Army Corps of Engineers finds there is a federal interest in the project.
   PRO: Ensures that the public safety and economic benefits of the project are clearly defined and regional in scope.
   CON: Places a higher standard on coastal project funding than river floodplain projects. May displace existing high-priority floodplain projects.

3. Capital funding for coastal areas is considered only to reduce risk to public property or infrastructure.
   PRO: Ensures that public funding is not used to rebuild private seawalls and bulkheads.
   CON: Places a higher standard on coastal project funding than river floodplain projects, where public property and infrastructure are given greater weight but private property is considered. May displace existing high-priority projects.

4. Capital funding for coastal areas is evaluated based on consequence, severity, and urgency alongside other flood risk reduction actions.
   PRO: Consistent treatment of risk reduction needs, regardless of freshwater versus saltwater distinctions.
   CON: Unless additional revenue is obtained, consideration of additional needs could delay high priority projects that have already been identified along major river systems.

5. Possible addition to the options listed above:
   Capital funding for coastal areas should be provided only on the condition that additional resources are provided such that other projects are not deferred, and there is a significant cost-share from other funding sources.
   PRO: Matches expenditure increases with revenue increase so that other high-priority flood risk reduction needs are not delayed.
   CON: Options to obtain additional funding are limited.

ADDITIONAL RESOURCES:

1. Preliminary map of public and private shoreline armoring along King County marine shorelines

2. Flood Control District's Motion amending the 2006 Flood Plan (FCD 2011-05)

3. Advisory Committee Annual Recommendations (August 2010):
http://your.kingcounty.gov/dnrp/library/water-and-land/flooding/kcfzcd/KCFCD_advisory_committee_2011_draft_recommendations.pdf

4. Advisory Committee Q&A on the Elliott Bay Seawall (April 2010)
http://your.kingcounty.gov/dnrp/library/water-and-land/flooding/kcfzcd/03_Advisory%20Committee%20Q&A_DRAFT.pdf

2012 KING COUNTY FLOOD HAZARD MANAGEMENT PLAN UPDATE
February 15, 2012

TOPIC:
Urban Flooding and Small Streams

STATEMENT OF ISSUE:
How should flood district funds allocated for urban flooding and small streams that are not the 'focus' of the 2006 FHMP?

BACKGROUND:
The adopted 2006 King County Flood Hazard Management Plan (FHMP) includes policies and actions related to hazard identification and mapping, outreach and communications about these hazards, land use management (including regulations, acquisitions, and elevations), channel maintenance (including sediment and wood management), and rehabilitation of flood risk reduction structures (levees and revetments). The geographic scope of the 2006 King County Flood Hazard Management Plan includes the unincorporated and incorporated areas of King County, but the plans calls for a 'focus' on the major river floodplains and their significant tributaries. Under state law (RCW 86.12.210), countywide flood plans shall be adopted by each jurisdiction within 120 days. Because this statue has not been enforced, the 2006 plan includes a policy stating that minimum compliance with the National Flood Insurance Program (NFIP) constitutes 'consistency' with the 2006 Plan. Analysis is needed to more fully understand the extent to which city land use policies are integrated with FHMP policies, and the reason for deviation from these countywide policies.

Capital projects identified in the FHMP are prioritized and sequenced using a scoring system that evaluates the consequence, severity, and urgency of each problem as well as implementation factors such as readiness, multiple floodplain benefits, partnerships, and cost-sharing.

During the initial discussions of the Advisory Committee following the formation of the Flood District, King County staff clarified that while the state law authorizing flood districts allows funds to be used for both flooding and stormwater management, King County's original intent was to address regional flood management rather than local stormwater problems resulting from land development that are typically addressed through local stormwater utilities. However, jurisdictions outside the major river floodplains have countered that 'flooding is flooding', whether due to runoff caused by land development or by land development in locations where rivers naturally overtop their banks.

With the establishment of the countywide Flood Control District and a new property tax to provide revenue for high-priority projects and programs that provide regional benefits, several have sought additional funding for projects outside the major river floodplains that are the focus of the Plan. Since the formation of the District the Board has provided direction through the budget process based on three key Advisory Committee recommendations:

1. 'Flooding is flooding' – regardless of whether on major rivers or small streams, projects should be evaluated using the prioritization criteria. If, for example, a small stream floods a state highway posing a threat to life safety and interfering with regional economic activities, than it should be judged on these attributes rather than the size of the waterbody.
2. The capital project prioritization process has been refined to more clearly recognize 'regional economic benefits', and the implementation criteria have also been enhanced to recognize whether a jurisdiction has an active CIP program of their own and undertakes planning efforts to reduce flood risk, as evidenced by their rating under FEMA's Community Rating System.
3. Consistent with these two recommendations, additional projects outside of the major river floodplains have been included in the District's capital program, including two small stream projects and one coastal project.
4. In recognition of the fact that communities throughout King County have flooding and water quality problems, the Board established a 'Subregional Opportunity Fund' that allocates a portion of all tax revenue collected to all jurisdictions proportional to property taxes generated in each jurisdiction. The fund has been set at 10% of tax revenues since its establishment in 2009; in 2012 this amounted to $3.6 million. For example, if 35% of the property taxes collected come from one jurisdiction, than that jurisdiction receives 35% of the Opportunity Fund. Funds must be used consistent with the requirement in state law and the Board's adopted resolution.

As noted above the requirement that countywide flood plans be adopted by cities has not been rigorously enforced by the Department of Ecology, and many of the land use elements of the 2006 Plan are unlikely to be supported by all jurisdictions. In an external expert review of King County's floodplain program, it was noted that the resulting differential land use standards may result in flood risks being transferred from one jurisdiction to another, and may also result in the need for capital funding to mitigate the effects of developing in at-risk areas.

ALTERNATIVES TO CONSIDER:

1. As a first step toward achieving the intent of RCW 86.12.210, work with cities to inventory floodplain land use policies and regulations, and collaboratively identify ways to improve the integration of floodplain land use practices across jurisdictional boundaries.
   PROS: Builds understanding of different regulatory approaches and areas where integration could be improved so that land use practices do not unintentionally increase risks or result in the need for capital investments such as new levees.
   CON: Staff time and resources for multiple jurisdictions; does not enable the letter of RCW 86.12.210 to be met within 120 days of plan adoption.
2. Evaluate all projects based on prioritization criteria; no direct allocation for the Opportunity Fund
   PRO: Provides for a more transparent and accountable allocation of funds in the capital program

CON: Opportunity Funds have the potential to help leverage other funds for local stormwater drainage issues, and provide significant funding flexibility for local governments.

3. Same as #2, but urban flooding problems are eligible if they cross jurisdictional boundaries.
   PRO: Enables funding for drainage problems that cross jurisdictional boundaries and may therefore not be adequately addressed via the local stormwater utility.
   CON: High-priority flood problems may exist within basins that are entirely located in one jurisdiction

3. Opportunity Funds available only for those jurisdictions that do not have capital projects funded within their jurisdiction within a set timeframe (i.e. the prior year or two of appropriations)
   PRO: More clearly focuses Opportunity Fund on those jurisdictions that are not already directly benefiting from the larger capital program (mainly floodplain cities).
   CON: Floodplain jurisdictions would not be able to access Opportunity Funds for local drainage issues, to cost-share grants, etc.

4. Revise Opportunity Fund to a competitive process.
   PRO: Provides for a more transparent and accountable Opportunity Fund, and depending on the size of individual awards it could fully rather than partially fund projects.
   CON: Competitive process might put jurisdictions with fewer resources at a disadvantage.

5. Increase Opportunity Fund allocation to jurisdictions. This increase could potentially be combined with options 3 or 4, and it could also be backed by additional revenue.
   PRO: Provide additional direct funding support for local stormwater needs
   CON: May divert funds from existing high-priority projects unless matched with revenue

6. Connect eligibility for capital project funding with compliance with land use policies and regulations that help to limit residual risk and reduce the need for more capital projects over time.
   PRO: Encourages jurisdictions to pro-actively reduce flood risks via land use policies
   CON: Need better understanding of why cities are reluctant to adopt higher regulatory standards. Consider survey to understand the opportunities and constraints for integrated land use policies.

ADDITIONAL RESOURCES:

1. Flooding vs Stormwater Background paper
http://your.kingcounty.gov/dnrp/wlr/flood/flood-control-zone-district/advisory-committee-docs/pdf/070720-meeting/15-faq-swm-x-fczd.pdf

2. Opportunity Fund Resolution (KCFCD2008-10.2)

3. Advisory Committee report on the formation of the Opportunity Fund and revision to the capital project prioritization approach.
http://your.kingcounty.gov/dnrp/library/water-and-land/flooding/kcfzcd/2008_Annual-Report.pdf

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2006 KING COUNTY FLOOD HAZARD MANAGEMENT PLAN UPDATE
March 2012

TOPIC:

Equity and Social Justice: Outreach to Vulnerable and Underserved Populations

STATEMENT OF ISSUE:

The River and Floodplain Management Section's (RFMS) public service roles are primarily to:

1. **assess** flood and erosion risks in King County;
2. **communicate** flood risks to the public; and
3. **reduce** flood risks, including repairing and maintaining levees.

How should the King County Flood Hazard Management Plan be used to direct our efforts to ensure that the River and Floodplain Management program is providing these services equitably throughout King County?

BACKGROUND:

The King County Equity and Social Justice Initiative[1] (ESJI) directs all King County government services to be done in a fair and just manner – ensuring that those without traditional access to resources are being served – and to view the development of all policy, procedures and communication through this lens.

King County also has an Executive Order in place, establishing criteria for a Written Language Translation[2] process that requires a reasonable effort be made to provide all print materials in the languages spoken by the target audience.

Lastly, the King County Flood Control District has directed the River and Floodplain Management Program to ensure that we are reaching vulnerable populations[3] in our public outreach and education efforts.

RFMS, in response to these directives, has:

- Produced and promoted flood safety videos in the top 21 languages spoken in King County
- Provided language translation services available 24 hours a day to callers
- Developed maps based on King County 2010 census data to show the predominant language(s) spoken in the King County floodplain
- Produced all flood outreach materials in Spanish.
- Inserted directions for contacting King County, translated into 21 languages, into all critical flood information mailings sent countywide.
- Improved communication coordination with Public Health – Seattle & King County, Office of Emergency Management, and the American Red Cross Serving Kitsap and King County.
- Accounted for vulnerable population segments that may be positively or negatively affect by future outcomes of a levee setback planning study in the Lower Green River valley. Study results

[1] King County Equity and Social Justice Initiative - http://www.kingcounty.gov/exec/equity.aspx

[2] Written Language Translation - http://www.kingcounty.gov/operations/policies/executive/itaeo/inf142aeo.aspx

[3] Vulnerable Population Segments - http://www.kingcounty.gov/healthservices/health/preparedness/VPAT/segments.aspx

found that the study area included a larger percentage of vulnerable population than King County and the Puget Sound as a whole. Therefore, residents of the study area stand to benefit the most from ecosystem services provided by flood risk reduction services, contributing to the goals of King County's Equity and Social Justice Initiative.

Flood risk reduction projects are sited and designed to mitigate flood and erosion impacts regardless of the economic group or population. Flood risk reduction project priority, selection and implementation are based on risks associated with death, human injury, and potential land use damage.

King County considers equity and social justice impacts in their public information and education programs to provide fairness and opportunity for all people, particularly for people with limited English proficiency or when decisions that have a negative impact on fairness and opportunity are unavoidable, steps are implemented that, mitigate the negative impact.

ALTERNATIVES TO CONSIDER:

1. What networks can we build or enhance to improve our delivery of the Flood Education and Flood Preparedness Program[4] to vulnerable or historically underserved populations[5]?

   - **Example:** As a lesson learned from Hurricane Katrina, a recommendation is to formally coordinate with regional animal services and shelter organizations to improve messaging and logistics for evacuating with animals.

2. How can we assess the effectiveness of outreach to vulnerable and underserved populations, knowing that this is a very difficult population to assess by traditional survey methodology?

3. What networks can we build or enhance to improve our delivery of the flood risk reduction programs to vulnerable or historically underserved populations? What alternative mitigation options could be proposed for special needs, such as low-income, physical or developmental disabilities?
   - **Example:** While all flood risk reduction projects and acquisitions are prioritized on the basis of flood risk, regardless of income, race or language spoken, the Flood Elevation Program[6] is only available to those who can pay up to 25 percent, out of pocket, of the project cost ($70K-$120K) and any relocation costs needed if necessary. Additionally, property owners must pay for project costs up front and then be reimbursed by the county after project milestones are achieved. These requirements can make it difficult or impossible for residents without sufficient financial resources to participate in the elevation program.
   - **Suggestions:** Internships to provide training in the field and small business outreach.

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[4] **4.5.1** "The King County Flood Hazard Education and Flood Preparedness Program is designed to increase awareness of locally available resources and information to help citizens prepare for flood events and prevent, minimize, and recover from flood damage."

[5] Physically disabled; blind; deaf, deaf-blind, or hard of hearing; mentally ill; developmentally disabled; impoverished; seniors; children; immigrant communities; limited English or non-English proficient; undocumented persons; medically dependent or medically compromised; chemically dependent; homeless and shelter dependent; clients of criminal justice system; and emerging or transient special needs.

[6] Flood Buyout and Elevation Program - http://www.kingcounty.gov/environment/waterandland/flooding/buyout.aspx

2012 KING COUNTY FLOOD HAZARD MANAGEMENT PLAN UPDATE
June 2012

TOPIC:
Relocation of Residential and Commercial Tenants

STATEMENT OF ISSUE:

- When land is acquired for flood risk reduction purposes and tenants are displaced, what types of relocation assistance should be provided?
- Should any other steps be taken minimize disruptions to economic activity and mitigate possible impacts on economic development and local tax revenue?

BACKGROUND:
Property buyouts are one of the most effective tools at permanently reducing flood and channel migration risks, and are also often necessary to provide the space needed to set back levees or simply rebuild them to a wider and more stable geometry. In some situations the property owner rents or leases the home. In those situations the tenants are provided with relocation assistance as described below.

History: Congress passed the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, and amended it in 1987. The law is referred to as the Uniform Act and is followed by all Federal, State, and local government agencies.

Purpose: To provide uniform procedures in relocation assistance that will assure legal entitlements and provide fair, equitable, and consistent treatment to persons displaced by a government project.

The Law: Contained in Chapter 8.26 of the Revised Code of Washington (RCW) and the Washington Administrative Code (WAC) 468-100.

Process: The following outlines the general process:

- Coordinate tenant-contact information with onsite Property Manager and Owner;
- Send General Notice of Relocation Rights letter to tenants;
- Hold an Open House (presentation, questions and answer session, etc.);
- Contract with appraiser to complete individual appraisals for owner-occupied units;
- Meet with individual owners for interview and appraiser site inspection;
- Calculate benefits based on appraisal, comparables and present offer to residents;
- Send Notice of Relocation Eligibility, Entitlements, and 90-Day Assurance letter giving at least 90 days notice by which they will be required to vacate;

- Provide Relocation Advisory Services (i.e. transportation, referrals, minimize hardships, provide listings of replacement availabilities, inspect replacement housing for decent, safe, and sanitary acceptability and other special needs etc.)
- All residents have the right to appeal and the right to file for "Hardship" to be granted a stronger priority in the event they need to move earlier than scheduled.

Entitlements: Owner-Occupants, renting space, may be eligible to receive:

1. Fair Market Value for their home, as determined by an appraiser;
2. Replacement housing payment (Purchase Price Differential), as determined by the Relocation Advisor;
3. A Rent Supplement or Differential (if costs to rent other space including utilities exceed what they are paying currently) based on a comparable, for 42 months and paid in a lump sum, as determined by the Relocation Advisor;
4. Moving expense payment for self-move (based on room count) or a commercial move (based on 50-mile radius and a federal schedule) direct payment to mover) as determined by the Relocation Advisor. and
5. Relocation Advisory Services (see above definition).

Timeline: Based on prior experience with residential tenants, once appraisals have been completed (45-60 days), the residents can be re-located within an approximate 2-4 month period each. This timeframe would likely be greater for commercial space, as the process to find comparable locations is more complex.

ALTERNATIVES TO CONSIDER:

While relocation assistance is required under federal, state, and local laws, this should be clarified in the Flood Plan. Two significant differences between residential and commercial relocations are (1) the possibility of higher costs to relocate and re-establish businesses compared to homes, and (2) the possibility of a larger impact on local government revenue (assuming the commercial structure was occupied by a commercial tenant and generating sales tax and B&O tax. Efforts to mitigate these impacts would remove or reduce one of the tensions between short-term financial impacts and long-term reductions in flood risk as well as long-term investor confidence in commercial/industrial areas. In addition, business re-establishment costs are higher than relocation of residential tenants due to the need to move business equipment and in some situations make improvements to the new location.

1. Establish a policy that relocation efforts will focus within the same jurisdiction wherever possible.

PROS: Preserves local government revenue associated with business activity.

CONS: No guarantee that the business will indeed be relocated within the same political boundary. First responsibility under federal law is to find comparable locations to the displaced tenant, which may mean relocating elsewhere in the region.

2. Work with the appropriate local government(s) to communicate with the affected business community on plans and projects. Like with any major public works project, there are short-term and long-term impacts, and economic disruption can be minimized by clearly conveying the long-term objectives for flood risk reduction and the near-term priority actions to achieve these objectives.

ADDITIONAL RESOURCES:

Uniform Relocation Assistance and Real Property Acquisition Policies Act
http://uscode.house.gov/download/pls/42C61.txt

2012 KING COUNTY FLOOD HAZARD MANAGEMENT PLAN UPDATE
June 2012

TOPIC:
Capital project prioritization, sequencing approach, and eligibility criteria

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STATEMENT OF ISSUE:
The current capital project prioritization process evaluates the consequence, urgency, and severity of flooding and channel migration risks, and sequences project implementation based on factors such as readiness, partnerships, external funding opportunity, and legal responsibility. The fundamental purpose of these criteria is to ensure that limited funding is targeted at the highest priority flood and channel migration risks, and that the proposed solutions are consistent with the goals, objectives, and guiding principles in the Plan. With the benefit of the experience applying these criteria over five budget cycles and multiple mid-year revisions, the criteria and scoring system should be assessed with the following questions in mind:

- Do the prioritization scoring criteria adequately define eligible and ineligible projects?
- Do the criteria help decision-makers focus on long-term solutions and 'getting ahead of the next flood' rather than 'reacting to the last flood'?
- Do the prioritization criteria clearly identify when flood damage repairs are necessary to protect public safety and prevent a small problem from becoming larger and more expensive to fix?

BACKGROUND:
The proposed capital program continues to focus on high priority flood risk reduction needs through rehabilitation of flood facilities and the acquisition and removal of floodprone structures throughout King County. New projects proposed for the District's capital program are responsive to flood events, in the form of either high priority repairs or new projects that address flood hazards identified during the flood or through updated flood hazard maps. The addition of new projects does not result in the removal of any project adopted in the 6-year project list, although it may result in delays to other projects.

The *2006 King County Flood Hazard Management Plan* (FHMP) describes flood risks in King County; outlines a series of goals, objectives, and policies for managing these risks; and recommends basin-by-basin actions for reducing risks throughout the County. By adopting this planning document, the District's governing body—the Board of Supervisors—agreed with the suite of flood risk policies and strategies contained in the plan, and it follows that capital projects funded by the District should be implemented in accordance with FHMP guidance. The FHMP is considered under the RCW to be the comprehensive plan for the King County Flood Control District (KCFCD).

Proposed projects are reviewed and prioritized by the Basin Technical Committees, along with a discussion of project sequencing over the 6-year Capital Improvement Program (CIP). Project prioritization and sequencing is guided by the policies contained in the District's adopted comprehensive plan (the 2006 FHMP). Projects are reviewed and scored against flood risk reduction factors (consequence, severity, and urgency) to prioritize projects across the county;

implementation factors such as readiness and leveraging are then evaluated to determine how to sequence high-priority projects over the 6-year CIP timeframe. By evaluating flood risk reduction and implementation factors, appropriate strategies can be developed to ensure that high priority projects are implemented and any implementation constraints are identified and addressed.

The goals of the capital project prioritization and evaluation process are as follows:

- Identify flood risk reduction projects on an annual basis that would be eligible for potential inclusion and prioritization in the KCFCD's 6-year CIP
- Provide an objective and transparent method for prioritizing and sequencing flood risk reduction projects throughout King County
- Provide an objective method for evaluating project eligibility an ineligibility
- Familiarize other agencies within the project evaluation criteria to be considered by the District when identifying and prioritizing capital projects for inclusion in the KCFCD's 6-year CIP
- Provide a mechanism for transparently redistributing funds in the KCFCD's 6-year CIP in response to unanticipated events which may impact the 6-year CIP

Current project prioritization policies that form the foundation for project identification and evaluation are described in Chapter 2 of the 2006 FHMP. Key policies, provided as supplementary material, include: Policy G-2: Flood Risks; Policy G-3: Comprehensive River and Flood Hazard Management; Policy G-9: Multi-Objective Management; Policy G-10: Protecting Natural Functions and Values; PROJ-1: Prioritizing Flood Hazard Risks; and Policy PROJ-6: Flood Protection Facility Design and Maintenance Objectives. These policies outline the criteria that King County should use in prioritizing projects to address flood and channel migration risks; in particular, G-2 and PROJ-1 directly address prioritization approaches to evaluating project proposals.

Projects are evaluated based on these key policies and against a set of criteria approved by the District's Board, which falls into two categories – flood risk and implementation opportunity. Each criterion is numerically scored. The prioritization scoring system provides a relative comparison of capital projects to guide decision-makers; definitive quantitative thresholds between prioritization categories are neither intended nor implied.

Expenditure of public funds to reduce flood hazards may be more appropriate for some types of projects than others. Capital projects funded by the KCFCD should be implemented in accordance with FHMP guidance; policy should be strengthened and brought into alignment with best practices to better reflect how the prioritization and eligibility criteria have evolved over the past five years of project implementation. Ensuring consistency with the FHMP, and appropriately directing public funding toward the most relevant and highest priority projects that provide long-term solutions aimed at reducing flood hazard risks will enable the most effective projects to be implemented.

In the end, the District needs a transparent and consistent way to measure the effectiveness of a proposed solution to a given flooding problem, and incorporating the FHMP's policies in the project evaluation process presents an opportunity to accomplish this objective. This paper does not intend to recommend one approach over another, yet the hope is that it generates discussion that leads to an improved process.

Project Eligibility

The District's capital project evaluation criteria were developed with the numerous FHMP project proposals in mind, and as a result, the present evaluation process assumes project proposals are consistent with FHMP policies. However, the District has received project proposals from individual jurisdictions within King County, and for these proposals, there is no clear mechanism in place to determine whether a new project proposal meets FHMP policies. For this reason, the criteria and evaluation process may require refinement to ensure that approved projects, regardless of their origin, are consistent with the adopted policies in the FHMP and meet minimum eligibility requirements.

Selecting the Most Appropriate Solution to a Problem

The current system works well to identify the problems, but lacks an explicit step in determining whether a proposed project is the best solution for the problem. The flood risk criteria are focused on the severity, consequences, and urgency of the problem but do not evaluate how effectively the proposed solution addresses the problem. This is a deficiency in the present system that does not allow for a clear and transparent assessment of whether proposed projects are consistent with FHMP goals, objectives, and policies. Further, an evaluation of a proposed project design should be conducted when considering the suitability of a solution. The proposed implementation criteria are straight-forward and complement the criteria focused on addressing the flood risk. These implementation criteria address the project's effectiveness in addressing the problem, the benefit of implementing the project and the readiness of a proposed solution to a flood risk problem.

ALTERNATIVES TO CONSIDER:

Currently, broad policy is in place regarding prioritization and sequencing approaches to project implementation. Modifying the project evaluation process can help to ensure that all projects put forth for consideration by the District are consistent with the fundamental tenets of the District's FHMP. In order to keep focused, and target spending toward the most effective projects, the following policy changes are proposed for consideration.

1. While the 2006 FHMP includes policy regarding project prioritization and sequencing, it does not include explicit eligibility criteria for project funding. Should the FHMP update better define eligibility and ineligibility requirements for project funding and implementation through enhancement of FHMP policy to include an eligibility filter (a project, to the degree possible, must be consistent with the elements of this policy in order to be evaluated or prioritized)? Projects that do not meet the elements of the policy or a specified subset of the elements do not receive further consideration. Examples of minimum eligibility criteria could include:
   - Jurisdictions submitting the project must have adopted a planning document that includes capital projects intended to address flood hazard risks (e.g., comprehensive stormwater plan, basin plan, coastal zone management plan, flood hazard reduction plan), AND

- Jurisdiction must be in good standing with the National Flood Insurance Program, AND
- Project must be located in a mapped floodplain, special flood hazard area (SFHA), channel migration zone, or reduce flood and channel migration risks in these area.

PRO: Using the Plan to define eligibility criteria eliminates ambiguity about whether a project is consistent with the District's goals, objectives, and guiding principles by making very explicit the link between a project proposal and the adopted FHMP policies.

CON: This option has the potential to generate conflict between the District and individual jurisdictions should a proposed project fail to move to the evaluation and prioritization stage.

2. Should the Plan update provide enhanced criteria that clearly identify when flood damage repairs are necessary? The policy change would enable the District to:
    a. Evaluate repair projects against the broader strategy to ensure choosing the most appropriate projects that adequately address the problem and prepare for the next flood rather than reacting to the last flood.
    b. Ensure consistency with strategies for long-term maintenance and cost reduction. If a project is not consistent with the strategy, an extra level of review would be needed.
    c. Evaluate effectiveness of the solution as part of the prioritization scheme.

    PRO: Defining criteria around when to repair flood facilities would help decision-makers focus on longer-term solutions and getting ahead of the flood rather than reacting to the last flood event?

    CON: Flood damages are unpredictable and highly variable. If criteria and requirements are too stringent it may limit our ability to respond to unanticipated conditions that require action to protect public safety.

3. The current capital project prioritization process evaluates the consequence, urgency, and severity of flooding and channel migration risks, and sequences project implementation based on factors such as readiness, legal responsibility and opportunity. Should the FHMP update strengthen the project prioritization and sequencing process criteria so that all project proposals are evaluated and screened against pertinent FHMP policies, receiving points if specified plan policy components are met and to better reflect the current annual CIP criteria which have evolved over the past four years since the KCFCD was established?

    PRO: All project proposals are evaluated in the same fashion against a standard set of criteria, thus allowing the scoring to determine which projects move forward.

ADDITIONAL RESOURCES:

Relevant Policies and Recommendations from the 2006 FHMP:
http://your.kingcounty.gov/dnrp/library/water-and-land/flooding/0701-flood-hazard-mgt-plan/fhmp2006-chapter-2.pdf

Current King County Flood Control District Project Prioritization Criteria:
http://your.kingcounty.gov/dnrp/wlr/flood/flood-control-zone-district/advisory-committee-docs/pdf/070720-meeting/13-prioritization-criteria-regional.pdf

2012 KING COUNTY FLOOD HAZARD MANAGEMENT PLAN UPDATE
July 2012

TOPIC:

Design Guidelines and Bioengineering Approaches to Levees and Revetments

STATEMENT OF ISSUE:

Bioengineering approaches have been applied on King County levee and revetment projects over the past 20 years. Flood risk reduction, ecological objectives, and long-term maintenance, recreational safety and repair costs are taken into account when determining the best approach to levee and revetment repair projects. This paper explains why King County employs bioengineering approaches to levee and revetment projects and why we need to update our design guidelines. However, we have been asked:

- Should King County continue to employ bioengineering techniques and use large wood as a structural element of river projects given concern about recreational safety?
- Can bioengineering techniques and large wood be incorporated into projects and can public safety be addressed in the design and/or operations of the projects?

BACKGROUND:

King County employs bioengineering approaches to levee and revetment repairs, with the objectives of increasing the resiliency of the structure, reducing maintenance costs over time, and promoting multiple floodplain objectives for habitat, open space, and recreation along our river corridors. By incorporating bioengineering techniques into levee and revetment repair projects permitting agency requirements to provide habitat mitigation can be incorporated on-site using large wood and habitat structures in the project design. This can also reduce permitting time. Including bioengineering techniques may require more time for design and implementation, and an increase in funding needs but this depends on the project location and options for meeting the habitat mitigation requirements. An alternative to incorporating bioengineering techniques into a project would be to construct an off-site mitigation project, which may or may not require additional time and increases costs. Project specific circumstances must be investigated during the planning and predesign phase.

King County modifies rivers through capital projects to achieve flood risk reduction and other regional goals. The approach to these projects generally reconnects river channels to their floodplains, thereby encouraging more dynamic processes to increase flow capacity and better handle floods. Projects can produce substantial changes in river environments, sometimes suddenly occurring during a large flood event, or more incrementally over time. Physical changes resulting from river projects may affect in-river recreationalists that have previously used less complex and dynamic channels. Though these changes are viewed differently by different user groups, some in-river recreationalists may face possible increases in hazards due to changed river conditions. Further, when river channels shift, banks can be undercut, posing possible unseen hazards to riverside recreationalists. It is important to note that these processes and potential hazards are routinely created in dynamic river systems, whether or not any projects are done by King County. King County wants to design, construct, and operate its projects to address recreational safety. Further, King County needs to monitor projects over time to address any safety concerns that come up post project.

The recent MWH report (*Independent Expert Panel Review of Water and Land Resources Division's Project Scoping and Implementation Practices*) evaluated King County's approach to capital project identification and implementation, and stated the following:

> There is increasing awareness in recent decades of the interconnection and mutual influence among different objectives and associated actions for river and floodplain management. Therefore, project formulation and implementation has shifted from the traditional single purpose project, with necessary compensatory mitigations, to a multi-objective approach to incorporate features that promote public safety, flood management, ecosystem restoration and recreation. While traditional river management involves strategies to control a river through channelization or hardening embankments, the more integrated approach seeks opportunities to allow river meandering for transitory storage and potential restoration of critical floodplain functions. This multi-objective approach, especially when applied on a system wide level, allows more flexible management strategies, improved prioritization and effectiveness in using limited resources, and more sustainable outcomes … (King County) uses scientifically accepted principles for managing floodplains within the context of balancing other stated policy objectives" and that "… no consistent or systemic design or siting failures invalidate the new approaches to floodplain management or urge a moratorium on additional projects.

To date, project design has been guided by a collection of design guidelines that are either dated, such as "Guidelines for Bank Stabilization Projects in the Riverine Environments of King County" (Johnson and Stypula 1993) or from other sources, such as the Department of Fish and Wildlife's and the Army Corps of Engineers "Guidelines for the Construction of Levees." However, the Flood District and King County do not have established, county-specific guidelines for project design, construction, and maintenance.

The MWH report "recommended establishing design guidelines and specifications appropriate for integrating public safety and ecological objectives into King County's floodplain management strategies." Further supporting the development of county-specific guidelines, the MWH Report identified the need for the development of a formal process for reviewing project selections and design approaches. One of the primary findings from the MWH Report was the need for King County to clearly describe strategies in the shift from "hard engineering" to "ecological/dynamic" floodplain management strategies and to show how individual projects meet strategic goals or fit with current scientific theory and practice. The Flood Hazard Management Plan update includes policy language that recommends establishing such design guidelines and in each basin's vision and strategy, we will better coordinate and align projects and identify work program needs to develop an integrated river management strategy more clearly linking projects to the overall goals of the Flood Plan.

In response to the MWH report recommendations, King County has conducted recreational use and large wood surveys on the Cedar River, hosted a public workshop on upcoming projects along the Cedar River, documented and strengthened the project prioritization and sequencing criteria, strengthened connections between the Flood Hazard Management Plan with the WRIA salmon habitat plans and 3-year habitat work programs, conducted placed wood public meetings to encourage stakeholder involvement in project design, and established internal basin coordination teams for each basin.

In addition to the items already implemented, King County is currently putting into practice a number of other recommendations from the MHW report which include: updating its project and construction management manuals, initiating studies to evaluate large wood, recreation, channel changes and sediment transport; conducting a landscape analysis for the Lower Snoqualmie (fish, flood, farm, floaters); developing an integrated river management strategy for each major river basin to be phased in over a 2-3 year period; developing a Lower Green River corridor conceptual approach; and enhancing outreach to stakeholders and the general public through several methods such as a web-based CIP mapping tool, posting project summary documents on the Web, and holding annual public meetings in each basin to discuss basin-wide strategies, goals, and objectives, along with project specific progress.

King County will incorporate recreation into monitoring protocols, as appropriate, and identify additional methods to obtain recreational use information and recreational user input into the design of monitoring approaches. All County projects to re-establish natural river processes now evaluate and plan for a range of likely potential outcomes, acknowledge areas of uncertainty, and identify and plan for mitigation of resulting risks. Further, capital projects will continue to consider river recreation in the planning and implementation of flood risk reduction and habitat improvement projects, and will invest in building public awareness and understanding of river hazards and recreational safety to minimize the potential for personal injury.

Bioengineering Approach
Historically, major maintenance activities on levees consisted primarily of replacing riprap eroded by the river, and clearing vegetation along river channels that were often constrained. This approach often did not address the causes of damage, or normal wear of the levee system. The high cost of frequent maintenance could not be sustained with limited revenue.

As a result of these temporary fixes, which did not fully address the cause of the repeated damage, King County has shifted toward a more systemic solution, increasing the use of bioengineering techniques as the basis for nearly all repairs and retrofits on existing levees and revetments along major rivers and streams. These changes aim to reduce maintenance costs, are more readily permitted to enable the project to be designed and constructed in a timely manner. The 1993 Flood Hazard Reduction Plan (FHRP) incorporated guidelines for the design, construction, and maintenance of structural capital improvement projects (CIPs) for flood reduction and flood control along the major rivers in King County stressing bioengineering approaches to bank stabilization.

This approach emphasized more environmentally friendly bioengineering methods (soil biostabilization) such as vegetative brush layering to stabilize riverbank and levee slopes, and toe-buttress construction with large stone and firmly anchored large wood emplacements at the base of a facility. These actions are designed to address instream habitat along the toe of the facility and to minimize the potential for flood-flow undercutting, erosion, and sloughing of the face of the facility.

The 2006 Flood Hazard Management Plan (FHMP) continues to put forward bioengineering as a design approach for levees and revetments; bioengineering is an available alternative for managing King County's flood protection facilities. Bioengineering mimics natural river bank stabilization techniques by incorporating live plants and engineered log jams (fallen trees lodge in the river channel's bed and banks, riparian vegetation lines the banks helping to slow localized flow velocities while the roots help bind the soil) into the fabric of the flood protection facility and as instream structures, reducing the potential for bank erosion and providing multiple valuable habitat objectives (protective cover from predation, shade, and food).

Incorporating natural elements for bank stabilization through bioengineering methods offer multiple benefits to the system creating more stable riverbanks and reducing long term maintenance and costs than those armored with rock riprap. Through recruitment of vegetation and additional woody debris during flooding, adding roughness to the channel (increasing flow resistance and slowing the river), and allowing vegetation in the project site to become established and form a cohesive matrix of interlocking plant root structures, the bank becomes naturally stronger and more resistant to erosion. At the same time, these methods improve fish and wildlife habitat. These projects provide an environmentally sensitive, low maintenance solution with lower long-term costs. Rather than deteriorating and requiring continual and costly maintenance, these structures grow stronger over time.

However, under certain conditions, bioengineering techniques may not be appropriate, or may need careful consideration when designing a project. A very confined section of a river, with levees on both sides, for example, may not be the optimal choice for applying bioengineering methods. A high energy system with high risk potential also may not be an appropriate location for bioengineering techniques; allowing the time needed for plant roots and wood structures to establish could leave a levee at risk for erosion and potentially increase the risk from flooding. Use of rock is a normal feature of levee project design, particularly in the toe of the levee, below ordinary high water. Wood features can help protect the toe, but bioengineering techniques exclusively do not create a stable toe; there is always an element of rock in the lower bank. County-specific design guidelines that include bioengineering techniques are needed and will increase consistency and provide an objective, transparent mechanism for design considerations and implementation. Updated guidelines will better direct the most appropriate design technique for the site.

Since adoption of the 2006 FHMP, Public Rule "Procedures for considering Public Safety when Placing Large Wood in King County Rivers" was approved to:

1) Consider public safety issues in the design of projects involving the placement of large wood in King County rivers and streams.
2) Evaluate strategies for design of wood placements that will maximize project benefits and minimize risks to public safety.
3) Make available to the public the opportunity to provide input on proposed projects utilizing large wood.

The Public Rule states that at 30% design, King County will document how public safety considerations have been addressed in the design, conduct public outreach in an effort to reach a broad spectrum of the community and incorporate safety features into project design. Further underscoring public safety issues, the MWH Report recommended that King County consider a dedicated "Office of River Public Use" to support engineers in designing safe projects. We have secured contracts to provide professional expertise in project design to ensure we are addressing public safety issues. Until county-specific guidelines are available, King County will follow Public Rule procedures.

ALTERNATIVES TO CONSIDER:

While King County and the Flood Control District have been employing bioengineering approaches to levee and revetment repairs over the past 20 years, current design guidelines are dated. Bioengineering approaches can create resilient structures and reduce maintenance costs over time. Bioengineered structures slow erosive flows, direct higher velocity flows away from banks, and provide multiple objectives such as habitat benefits. When applied as part of an integrated system, this approach allows for a more resilient and sustainable flood risk reduction system.

The MWH report confirms King County is using the right scientific approach but we need updated, county-specific design guidelines that include bioengineering techniques. We are establishing a set of design guidelines that will direct design alternatives to consider appropriateness of scale (i.e. small streams vs. large rivers) and context (i.e. adjacent land uses, inside bend vs. outside bend, river use) for a project while taking into consideration the project location.

The design guidelines will also address how to evaluate recreation impacts (positive or negative) and address public safety either through design, closures, education or other means appropriate for the situation.

ADDITIONAL RESOURCES:

Engineering with Nature (FEMA)
http://www.fema.gov/pdf/about/regions/regionx/Engineering_With_Nature_Web.pdf

Integrated Stream Protection Guidelines (WDFW)
Integrated Streambank Protection Guidelines - WDFW Publications | Washington Department of Fish & Wildlife

Guidelines for Bank Stabilization Projects in the Riverine Environments of King County
http://www.kingcounty.gov/environment/waterandland/flooding/bank-stabilization-projects/guidelines.aspx?print=1

2012 Independent Expert Panel Review of Water and Land Resources Division's Project Scoping and Implementation Practices http://your.kingcounty.gov/dnrp/library/water-and-land/rivers/1201-wlrd-project-practices-review.pdf
King County Rivers Program Programmatic Biological Effects Analysis
http://www.kingcounty.gov/environment/waterandland/flooding/documents/biological-effects.aspx

2011 King County River Management Survey:
http://www.kingcounty.gov/environment/wlr/sections-programs/river-floodplain-section/river-survey-2011.aspx

2010 Cedar River Recreational Study: http://www.kingcounty.gov/environment/wlr/sections-programs/river-floodplain-section/cedar-recreation-study.aspx

2009 Large Wood Stakeholder Committee http://your.kingcounty.gov/dnrp/library/water-and-land/flooding/0912-large-wood-safety-rule/Large_Wood_Stakeholder_Committee_Final_Transmittal.pdf

2010 Placed Wood Public Rule:
http://www.kingcounty.gov/operations/policies/rules/LandUse/lud121pr.aspx

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KING COUNTY FLOOD PLAN UPDATE
June 2012

TOPIC:

Gravel removal and sediment management for flood risk reduction purposes.

STATEMENT OF ISSUE:

Sediment accumulation in river channels can increase flood hazard and flood risk in King County. The 2006 King County Flood Hazard Management Plan (Flood Plan) established a comprehensive sediment management program, which can include gravel removal (dredging), to reduce the flood risk. This issue paper describes implementation of the sediment management program in specific King County rivers since 2006 and also identifies recent actions at the countywide or regional scale regarding sediment management. One such recent countywide action warrants a minor revision in this Flood Plan update. Other than this one revision, it is proposed that the existing King County sediment management program be continued as it is in the 2006 Flood Plan.

BACKGROUND:

Gravel Removal and the King County Sediment Management Program in the 2006 Flood Plan

The Flood Plan recognizes gravel removal as a potential flood risk reduction strategy that can be considered on a case-by-case basis, as long as its flood risk reduction effectiveness, potential impacts and priority relative to other projects also are considered. Flood Plan Policy RCM-3 on Gravel Removal states that "King County should remove gravel from rivers and streams for flood hazard management purposes" only when a set of six conditions can be met. Policy RCM-3 is consistent with state and federal policies and regulations. No revisions to Policy RCM-3 are proposed.

The King County sediment management program, described in Flood Plan Section 4.3.1 and depicted in Figure 4-6, identifies two main program components: channel monitoring and sediment management actions. Channel monitoring includes the periodic survey of in-channel sediment levels to document trends in sediment accumulation. Channel monitoring also includes hydraulic modeling of flood water surface elevations in response to changes in sediment levels. In these monitoring analyses, persistent increases in sediment levels along with corresponding increases in modeled flood water surface elevations typically indicate that flood hazard has increased due to sedimentation. Channel monitoring results are used to inform decisions on sediment management actions; they also would be required for permit applications on any gravel removal project.

Channel monitoring is conducted in King County on eight river segments: the South Fork Snoqualmie and the Middle Fork Snoqualmie Rivers (both near North Bend), Snoqualmie River along Fall City, Snoqualmie River along Carnation, Lower Tolt River, Lower Raging River, Lower Cedar River (where the City of Renton conducts the monitoring) and the Lower White River (where King County cooperates with City of Auburn in collection of survey data).

The sediment management actions part of the program applies to these same monitored river channels and includes evaluation of the channel monitoring data relative to an identified flood risk reduction objective. If that objective is not being met and it can be demonstrated that there is an increased flood risk that is attributable to sediment accumulation, then potential sediment management action alternatives can be considered, including:

- Short term: gravel removal; install temporary flood barrier
- Long term: elevate, or purchase and remove at-risk structures; set back levee(s)

The primary criteria that are used to evaluate potential sediment management alternatives are based on the three main goals of the Flood Plan (Section 1.2):

1. Reduce risks from flood and channel migration hazards.
2. Avoid or minimize the environmental impacts of flood hazard management.
3. Reduce the long-term costs of flood hazard management.

The intent is that such criteria, or others based on these same goals, be used to select a preferred sediment management or flood risk reduction project. Examples that illustrate the use of such criteria to evaluate and select preferred alternatives in implementation of the King County sediment management program are described below.

Implementation of the King County Sediment Management Program in King County Rivers:

South Fork Snoqualmie River Gravel Removal Study and Levee Improvement Project:
The South Fork Snoqualmie River decreases in channel gradient within a leveed river segment along the City of North Bend; ongoing sedimentation is a flood hazard concern in this area. Flooding in 1990 was followed by gravel removal in 1991 and 1994. Channel monitoring results since the 1990s identified areas and rates of sedimentation and associated increases in flood water surface elevations, and determined that an identified flood reduction objective was not being met along part of the South Fork Snoqualmie. The South Fork Snoqualmie River gravel removal study, completed in 2011, evaluated three gravel removal scenarios for flood hazard reduction effectiveness, potential adverse impacts and planning-level cost estimates using criteria based on the three main Flood Plan goals listed above. Study findings indicated that two of the gravel removal scenarios would result in moderate decreases in flood hazard that could persist for about a decade at one critical location where overtopping has occurred in the past. Potential adverse impacts (to salmonid habitat, levee stability, or downstream flooding) were characterized generally, and planning-level costs were estimated at $1.5M to $3.6M, depending on the gravel removal scenario.

Another notable finding of this study was that gravel removal would be ineffective in decreasing flood hazard in the area affected by Bendigo Blvd Bridge backwater conditions. This finding corroborates the results of an earlier hydraulic study and suggests that the most effective approach to decreasing the flood hazards at this particular location would be a capital project to modify the Bendigo Blvd Bridge, e.g., by widening its opening.

The South Fork Snoqualmie River gravel removal study identified one scenario that would be most appropriate if it is decided that gravel removal is going to be pursued as a project on this river. Because no other flood risk reduction/sediment management alternatives have been evaluated yet, no recommendations were made in that study. Instead, findings from the South Fork Snoqualmie River gravel removal study are being used in the South Fork Snoqualmie River Levee Improvement study, now in progress, which is evaluating a set of flood risk reduction alternatives such as levee setback, home elevations, property acquisitions, levee reconstruction and elevation as well as gravel removal. A preferred alternative, or combination of alternatives, will be selected based on the results of the South Fork Snoqualmie River Levee Improvement study using selection criteria that will be similarly based on the three main Flood Plan goals.

City of Pacific Flood Risk Reduction Options (Lower White River):
The Lower White River along the Cities of Auburn, Pacific and Sumner is located at the downstream end of a sediment-rich basin in an area of natural deposition. Also, in-channel sediment accumulation probably is accelerated due to the channelization and confinement in the early 1900s of a previously dispersed network of distributary channels. The historical response to aggradation since channelization typically was persistent and widespread dredging. Channel monitoring data indicate that ongoing aggradation has occurred since cessation of channel dredging in the late-1980s, and hydraulic studies show associated decreases in channel conveyance capacity to a point where the identified flood reduction objective is no longer being met. Sediment accumulation in the Lower White River channel exacerbated overbank flooding in January 2009 within the City of Pacific. In response, a number of actions have been or are being implemented over different time scales.

Because of the direct connection between channel sedimentation and the 2009 flood damages, and the high likelihood that such flooding and damage would be repeated, a short-term flood protection measure was rapidly deployed. In October 2010, King County installed (and continues to maintain) more than 4,000 lineal feet of HESCO © structures, with supporting pumps, as a temporary flood barrier along the area of January 2009 flooding. Even as an urgent short-term action, this flood barrier was evaluated for it flood reduction effectiveness (by hydraulic modeling), for potential impacts (as part of permit requirements) and for cost effectiveness (relative to potentially repeated flood damages).

In addition, King County purchased and removed 11 at-risk residential structures and purchased a 7-acre undeveloped riverside parcel within the area of January 2009 flooding. This project was implemented relatively quickly, with completion in 2011, even though acquisition and removal projects have longer-term flood risk reduction benefits. Because such acquisition projects so consistently have been demonstrated to be a preferred and effective long-term flood risk reduction strategy and due to the urgency of the situation, a standard evaluation of potential alternatives against selection criteria was not conducted. However, this project is consistent with Lower White River Flood Hazard Management Objectives and Strategies identified in Section 5.10.10 of the Flood Plan (to acquire properties and follow up with levee modification to reconnect the river to its floodplain) and with the provisions and objectives of the sediment management program.

For longer-term flood risk reduction on the river reach scale, King County is preparing detailed project design for the Countyline levee setback and floodplain reconnection project along the left (east) riverbank. This project was proposed with equal purposes of habitat restoration and flood risk reduction, and was conceptualized well before the recently more direct effect of sedimentation on flood hazards became evident. Its alternatives analysis used evaluation criteria based on the three main Flood Plan goals, but did not explicitly consider gravel removal as a project alternative due mainly to its broader purpose of floodplain reconnection. However, a recent US Geological Survey (USGS) study documents decreased channel flood capacity below an identified flood objective and evaluates sediment management options for this same river reach. It found that a levee setback project would be much more effective than gravel removal in reducing flood hazards, which is considered sufficient substantiation that a levee setback is the appropriate preferred project alternative in this river reach. A more detailed and updated evaluation of gravel removal will be included as part of the advanced design and review process for the project. A planning-level cost estimate for the Countyline levee setback and floodplain reconnection project is $9M.

Even as short-term and longer-term flood risk reduction/sediment management projects are considered, designed and implemented, the channel monitoring portion of the program continues on the Lower White River, with periodic resurvey of channel topography. In addition, King County is cooperating with the USGS to better understand Lower White River sedimentation through two new efforts: a basin-scale analysis of sediment production, transport and deposition, the findings of which will inform long-term sediment management efforts and the design of capital projects in the Lower White River; the installation of four additional river stage gages to monitor flood flow levels in greater detail through this part of Lower White River.

Cedar River Gravel Removal Project:
In 1912, the Lower Cedar River was redirected to its present course into Lake Washington via 1.4 miles of constructed channel. Because of its very low gradient, the constructed channel experiences sediment deposition and the sediment deposition results in a corresponding reduction in channel flood capacity. Consequently, the constructed channel has been dredged periodically to reestablish flood capacity, most recently in 1998. Dredging of the lower 1.25 miles of the Cedar River is identified in the 2006 Flood Plan as the Cedar River Gravel Removal Project, which is proposed for implementation in the near future.

In 1998, the US Army Corps of Engineers implemented the Cedar River 205 Flood Control Project with the City of Renton as the local sponsor. That project included dredging and construction of levees and floodwalls along the lower 1.25 miles of the constructed channel. Its stated objective was to reduce flood damages within the Renton area of the Cedar River in a cost effective manner and with minimal impacts to fish and wildlife habitat, with the intent to provide protection against the 100-year flood. Analysis and design of the 1998 project, including preparation of an EIS, evaluated a set of project alternatives against several criteria in the categories of flood damage reduction effectiveness, cost effectiveness, environmental quality, regional development and other social effects. Potential project alternatives included modification to Chester Morse Dam operations, a setback levee upstream of Renton, channel widening within Renton, a sediment trap, floodwall and levees, channel dredging and others. A combination of constructed levee/floodwalls, modification to a bridge near the river mouth, channel dredging and other features was identified as the preferred alternative.

The Army Corps required future maintenance dredging as part of the 205 Project to maintain its flood protection benefits. Also, because this 205 Project is federally certified, the required maintenance dredging was accredited in the federal flood hazard mapping of this portion of the Cedar River. Annual channel monitoring by the City of Renton demonstrates that ongoing deposition in the constructed channel is decreasing flood capacity below the identified flood protection objective and therefore maintenance dredging is needed. This maintenance dredging would be implemented as a part of the King County Flood District's 6-year Capital Improvement Project list, with the City of Renton as local sponsor. Implementation of dredging is targeted to commence in 2013, subject to obtaining all required permits. A planning-level cost estimate for the total Cedar River dredging project is $5.7M.

Other factors affecting the Cedar River project also provide context. The Lower Cedar River in this project area is a constructed channel that was redirected from its original location. It now flows through densely developed areas of municipal and industrial infrastructure that includes downtown Renton, the Renton Municipal Airport and the Renton Boeing Plant. These areas have regional economic significance and maintenance dredging is intended to avoid extensive flood damage to these areas. Also, available information indicates that the planning and permit process for a project such as the proposed Cedar River dredging can require extensive time and effort to ensure appropriate project implementation and mitigation of impacts. Compensatory mitigation measures will be required to offset project impacts, including adverse effects on regulated wetlands or salmonid habitat of species listed under the Endangered Species Act.

These projects on three river segments on the South Fork Snoqualmie, Lower White and Lower Cedar Rivers, demonstrate how the King County sediment management program is being implemented through all of its intended components. In each river segment, a flood reduction objective has been identified, channel monitoring results are compared to that objective, and, if appropriate, flood risk reduction/sediment management alternatives are identified, analyzed and evaluated against criteria that are based on the three main Flood Plan goals. Application of this alternatives analysis and evaluation process has resulted in selection of different preferred alternatives in two of the river segments: channel dredging on the Lower Cedar River and a levee setback project on the Lower White River. The selection of a preferred alternative(s) is yet to be determined on the South Fork Snoqualmie River.

On five other river segments, the channel monitoring component of the sediment management program is being implemented: the Lower Raging and Lower Tolt Rivers, the Snoqualmie River along Fall City and Carnation, and the Middle Fork Snoqualmie River. This channel monitoring information will be used to analyze the effectiveness of gravel removal in these river reaches, as appropriate. Consideration of flood risk reduction/sediment management alternatives are yet to be conducted in these five segments. Evaluation of gravel removal along with other potential project alternatives against the evaluation criteria similarly based on the three main Flood Plan goals would occur as part of basin-scale capital project planning efforts by King County.

Recent Countywide or Regional Actions Regarding Sediment Management:

Terminology:

Use of the term "gravel removal" in King County Code (KCC) has been questioned. The proposed remedy is to replace it with the term "dredging", whose definition in the Washington Administrative Code is consistent with the provisions intended by "gravel removal" in the current KCC and 2006 Flood Plan. This correction in the term has no effect on the associated development standards specified in the KCC.

Draft 2012 Pierce County Flood Plan:
King County staff recently reviewed and commented on the Draft Pierce County Flood Plan with regard to gravel removal and sediment management, as part of ongoing coordination between Pierce County and King County on flooding issues. The Draft Pierce County Flood Plan also proposes two gravel removal pilot projects on the Puyallup River, the progress of which King County staff will follow for its informative value.

Sediment Management Group:
A Sediment Management Issues Group (SMIG) was formed by the Washington Association for Floodplain Management (WAFM; now part of the Northwest Regional Floodplain Management Association; NORFMA). The SMIG is composed of scientists, engineers, agency staff and other practitioners who meet regularly to share information on sediment management evaluations and projects particular to this region. King County staff attends the meetings and participates in a sub-committee that is preparing a searchable library of articles and documents relevant to sediment management.

SUMMARY STATEMENTS:

Projects on three river segments demonstrate the implementation of all components of the King County sediment management program. Implementation of the channel monitoring component of the program continues in five river segments, with analysis and evaluation of gravel removal and other project alternatives yet to be conducted. Evidence from these examples, plus feedback from other agencies indicate that the King County sediment management program is appropriate in its approach, scope and provisions because it includes documentation of existing conditions, evaluation of a range of potential action alternatives, and consideration of potential impacts and long-term costs in selecting a sediment management (or flood risk reduction) action.

One specific, proposed revision is that terminology be revised in the Flood Plan update and in King County Code so that the term "gravel removal" is replaced with the term "dredging".

Other than the one revision to terminology, King County proposes to continue to implement the existing sediment management program as described in Flood Plan Section 4.3.1, with minor edits to update it. Gravel removal for flood risk reduction purposes will continue to be considered on a case-by-case basis, along with other potential sediment management/flood risk reduction actions.

King County Flood Hazard Management Plan Update
Citizens Committee Report

September 2012

Introduction

The King County Flood Control District adopted the King County Flood Hazard Management Plan as their comprehensive planning document to provide policy guidance and identify capital improvement needs and priorities. The federal Disaster Mitigation Act and the Community Rating System under the National Flood Insurance Program both require updating the plan every five years. Motion FCD11-03 established a Citizens Committee to serve as a sounding board at key milestones in the plan update process.

The Citizens Committee was convened in December 2011 and has met seven times to review new information on the public safety and economic importance of flood risk reduction for the county and state, including commercial, agricultural, environmental, and residential data; current flood and channel migration studies and mapping; damage and changed conditions due to flood events; risk assessment; the 10-year capital improvement plan; and issue papers on specific topics identified in Motion FCD11-03. This report summarizes the feedback received from the Citizens committee.

Levee Certification, Accreditation and Flood Risk Reduction "Levels of Service"

Statement of Issue:
In response to a request from the mayors of the four Green River valley cities in March 2011, the Board of Supervisors for the Flood Control District adopted a motion stating its intent to assume levee maintenance and operations responsibilities for FEMA accreditation efforts under specific conditions. The 2006 King County Flood Hazard Management Plan does not include policy language regarding levee certification and accreditation. The suitability of the 100-year standard for levee certification and accreditation has been questioned resulting in a debate at the national level on whether a higher standard should be used. In addition, certified and accredited levees often result in a misperceived safety standard for people and property located behind those levees.

Summary of Committee feedback:
One Committee member stated strongly that the insurance industry is ignoring FEMA's mapping that shows areas behind certified and accredited levees are not at risk by mapping those areas out of the floodplain. The private commercial insurance industry uses a two-tiered system using the 100-year and 500-year flood elevations and then making sure the levee is constructed to US Army Corps of Engineers standards before they would recognize a levee for insurance purposes. Considering a levee as "accredited" by FEMA is not adequate; the private commercial insurance industry does not recognize any of the levees in King County, regardless of their FEMA status. The Committee suggested looking at the recent revisions to the National Flood Insurance Program which includes requirements for agreement among affected parties on what the standard should be as well as public outreach to people behind accredited levees. According to the Boeing

Company representative, the company did not previously consider flood events that might exceed the 100-year flood because they were confident Howard Hanson could provide that level of protection. Now they have to rethink that assumption if the discharge from the Dam could exceed 100-year flows. It is hard for Boeing to make a decision about certification and accreditation because the question is presented as an "either/or" scenario (accreditation or not accreditation) rather than debating a specific levee design standard based on the risk. According to one Committee member, there is a fair bit of consensus in the professional engineering community, reflected in the American Society of Civil Engineers' Policy Statement 529, that certification is something professional engineers don't have a lot of confidence in. The King County Flood Control District should only take on the operation and maintenance of structures they have some confidence will meet a specific risk-reduction standard. As for "performance-based standards," they can offer some benefits in savings in engineering and construction, but there needs to be the recognition that the savings come with a tolerance for some impacts and damages. In the context of flood engineering, there are regional scale problems that require consensus among all the stakeholders, which is different from an individual property owner or business taking on the risk for their own building, as in earthquake performance-based engineering.

Levee vegetation and eligibility for US Army Corps of Engineers (Corps) levee repair funding

Statement of Issue:

Local governments in the Puget Sound region continue to be caught between conflicting federal mandates that require degradation of riparian areas identified as critical habitat for federally listed species in order to retain eligibility for federal PL 84-99 funding for critical public safety projects. To qualify for one federal program that provides funding for levee repairs resulting from flood events, King County must risk violating both the Endangered Species and Clean Water Acts because the federal PL 84-99 Program standards require significant removal of vegetation on levees. This vegetation provides needed riparian habitat for Endangered Species Act-listed species as well as shade to meet Clean Water Act water temperature standards.

Summary of Committee feedback:

The Committee members generally agreed that simply walking away from the PL 84-99 Program was not the answer nor was it wise to follow the nation-wide US Army Corps of Engineers standards. Concern was raised that by disengaging with the Corps would send a message to floodplain residents and businesses that the levee systems are not safe. The Committee felt it made sense to try and either develop a new regional variance for a modified levee vegetation standard or work through the System-Wide Improvement Framework process. However several Committee members felt very strongly that King County should not participate in the PL 84-99 program. There was general support for finding opportunities for levee setbacks to allow more room for the rivers. One creative suggestion was to route water through the adjacent floodplain, such as along streets, during extremely high flows. A Committee member who was a member of the national engineering team reviewing the performance of the New Orleans levee system stated there is no scientific evidence that vegetation on levees compromises the levees integrity – quite the opposite. It was recommended that an independent group, such as the American Society of

Civil Engineers, could help to mediate the issue with the Corps because that Society is seen as a neutral party of experts.

Capital project funding for coastal flood and erosion risks

Statement of Issue:
The geographic scope of the 2006 King County Flood Hazard Management Plan includes the unincorporated and incorporated areas of King County, with a 'focus' on the major river floodplains and their significant tributaries. The 2006 Plan includes a recommendation to cost-share hazard mapping studies with FEMA for marine shorelines. The state authorization for flood districts does allow for improvements that include "the extension, enlargement, construction, or acquisition of dikes and levees, drain and drainage systems, dams and reservoirs, or other flood control or storm water control improvements; widening, straightening, or relocating of stream or water courses; and the acquisition, extension, enlargement, or construction of any works necessary for the protection of stream and water courses, channels, harbors, life, and property" (RCW 86.15.100). Should the Flood Control District's capital program include funding for coastal flood and erosion risk reduction projects?

Summary of Committee feedback:
The Committee's feedback was to continue to focus capital funding on river and stream flooding and to not divert funding for future coastal projects that are not already adopted by the Board. There was concern that using capital funding on coastal projects is not consistent with the 2006 Flood Hazard Management Plan, and there was little support to update the Plan to supporting coastal flood risk reduction projects since the there appeared to be agreement that the main flood risk in King County comes from river flooding.

Urban Flooding and Small Streams

Statement of Issue:
The geographic scope of the 2006 King County Flood Hazard Management Plan includes the unincorporated and incorporated areas of King County, but the plans calls for a 'focus' on the major river floodplains and their significant tributaries. How should flood district funds be allocated for urban flooding and small streams that are not the 'focus' of the 2006 FHMP?

Summary of Committee feedback:
In general, the Committee appeared to think the Board made the right decision initially in allocating 10% of the funding for an opportunity fund that the cities could use for any program or project that is consistent with RCW 86.15. There was no support for increasing that percentage. Some Committee members liked the idea of allocating that 10% through a competitive process based on risk rather than just an automatic allocation to the cities. There was also some support for allocating the opportunity fund to cities that agree to adopt strong floodplain management land use policies and regulations that exceed the minimum National Flood Insurance Program requirements, but this was not the opinion of all Committee members.

Equity and Social Justice: Outreach to Vulnerable and Underserved Populations

Statement of Issue:
The King County Equity and Social Justice Initiative (ESJI) directs all King County government services be done in a fair and just manner – ensuring that those without traditional access to resources are being served – and to view the development of all policy, procedures and communication through this lens. King County also has an Executive Order, establishing criteria for a Written Language Translation process that requires a reasonable effort be made to provide all print materials in the languages spoken by the target audience. Lastly, the King County Flood Control District has directed the River and Floodplain Management Program to ensure that we are reaching vulnerable populations in our public outreach and education efforts. How should the King County Flood Hazard Management Plan be used to ensure that the River and Floodplain Management program is providing these services equitably throughout King County?

Summary of Committee feedback:
The Committee asked for some clarification on terminology used when discussing vulnerable and underserved populations. There was interest in how to track the effectiveness of the outreach efforts. In addition to web site hits, a suggestion was made for a more qualitative assessment using focus groups. The Committee was most interested in the idea of equity. County staff clarified that reasonable efforts need to be made to make services available, and in some cases it may not be reasonable to provide services to every single person. Several excellent suggestions were offered, including partnering with the local Housing Authorities, working with tech-savvy teens, identifying community leaders, and educating primary caregivers for the young and disabled on flood response. Another recommendation was to include information in outreach materials about the benefits and opportunities created by flooding. Finally, a paper by Louise Comfort was brought to the attention of the Committee which points out information in and of itself doesn't result in action. What results in action depends on who says it, which reinforces the suggestion to identify community leaders.

Relocation of Residential and Commercial Tenants

Statement of Issue:
When land is acquired for flood risk reduction purposes, tenants are displaced. The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 provides relocation assistance for tenants to relocate to comparable or better housing or buildings when displaced by federal projects. Two significant differences between residential and commercial relocations are (1) the possibility of higher costs to relocate and re-establish businesses compared to homes, and (2) the possibility of a larger impact on local government revenue by the relocation of a commercial tenant that is generating sales tax and B&O tax. Should the Flood Plan include policy guidance to minimize disruptions to economic activity and mitigate possible impacts on economic development and local tax revenue?

Summary of Committee feedback:
The Committee asked for clarification on the relocation issue to understand that there are federal, state, and local regulations to provide assistance, but no guidance on working with cities to maintain the existing tax base that would be impacted if properties and businesses are purchased

in their jurisdictions. One Committee member asked if there has been any assessment on the impact on the tax base for properties that have already been purchased. It was pointed out that taxes removed from one property ends up getting paid by others, so in general, there is no net loss of property taxes, but who pays and the jurisdictions benefiting from the tax revenue might change. The Committee supported providing relocation assistance to commercial tenants that relocate outside the floodplain. However the Committee did not provide any specific guidance on whether the Flood Plan should address the loss of tax base if commercial floodplain property is acquired and businesses are closed or relocated outside the jurisdiction where they were previously located.

Capital project prioritization, sequencing approach, and eligibility criteria

Statement of Issue:
The current capital project prioritization process evaluates the consequence, urgency, and severity of flooding and channel migration risks, and sequences project implementation based on factors such as readiness, partnerships, external funding opportunity, and legal responsibility. With the benefit of the experience applying these criteria over five budget cycles and multiple mid-year revisions, the criteria and scoring system should be assessed with the following questions in mind:

1. Do the prioritization scoring criteria adequately define eligible and ineligible projects?
2. Do the criteria help decision-makers focus on long-term solutions and 'getting ahead of the next flood' rather than 'reacting to the last flood'?
3. Do the prioritization criteria clearly identify when flood damage repairs are necessary to protect public safety and prevent a small problem from becoming larger and more expensive to fix?

Summary of Committee feedback:
In general, the Committee felt the criteria used to select projects was working, but several people expressed more emphasis being placed on considering the ecological value of natural resources, such as the value of protecting a wetland for flood storage. Committee members expressed concern about "mission creep" or "scope creep" that could jeopardize the ability for the Flood Control District to complete the high priority flood risk reduction projects if money gets diverted for other purposes, or for flood risk reduction projects that are lower priority based on risk. There appeared to be support for using some of the District funding to support the work of the WRIAs because of the nexus between salmon recovery and flood risk reduction, although not all Committee members agreed. Several Committee members supported funding actions outside floodplains, such as purchasing development rights in the upper watersheds, as a viable tool for reducing flooding. A suggestion was made to consider using performance-based measures for selecting projects similar to what is used in earthquake planning. Concern was raised that a lot of new projects are being added when the projects identified in the 2006 Flood Plan had not all been completed. The Committee did not seem to support using compliance with FEMA's Biological Opinion, prepared to set standards for implementing the National Flood Insurance Program in the Puget Sound region, as criteria for jurisdictions to receive funding for flood risk reduction projects. The Committee wanted to maintain focus on rivers and streams; if the criteria could help maintain this focus, there was support.

Design Guidelines and Bioengineering Approaches to Levees and Revetments

Statement of Issue:
Bioengineering approaches have been applied on King County levee and revetment projects over the past 20 years. Flood risk reduction, ecological objectives, and long-term maintenance, recreational safety and repair costs are taken into account when determining the best approach to levee and revetment repair projects. Concern has been raised that incorporating large wood as a structural element of a flood risk reduction project creates recreational safety concerns.

Summary of Committee feedback:
One Committee member summarized her concerns as: need to use rock at the toe; the County does not monitor well for safety resulting in the need to alter the County's Guidelines for Bank Stabilization document; not sure rip-rap is more expensive than wood; bioengineering is experimental resulting in three designs for Cedar Rapids project; wood does not increase flow resistance; wood rots and has limited lifespan; and recommends using the Stream Habitat Restoration Guidelines document published by Washington Department of Fish and Wildlife in April 2012. Another Committee member, who lived on the Cedar River for over ten years, said he saw the wood in projects break loose during flood events. He agreed that bioengineering is experimental and needs more time to see what works and what does not work. The majority of Committee members weighing in were supportive of updating the County's Guidelines for Bank Stabilization document to address both the most current science on this use of large wood as well as the impact on recreational safety.

Gravel removal and sediment management for flood risk reduction purposes

Statement of Issue:
Sediment accumulation in river channels can increase flood hazard and flood risk in King County. The 2006 King County Flood Hazard Management Plan (Flood Plan) established a comprehensive sediment management program, which can include gravel removal (dredging), to reduce the flood risk. For purposes of implementing the sediment management program, the term "sediment removal" is recommended to be changed to "dredging," which is a more defined term in state law. Other than this one revision, it is proposed that the existing King County sediment management program be continued as it is in the 2006 Flood Plan.

Summary of Committee feedback:
Committee members had strong reaction against the proposal to change the term "sediment removal" to "dredging" because dredging is a very politically-charged word. There appeared to be general support for sediment monitoring, but a suggestion was made to include monitoring smaller streams as well since sediment build-up in the stream is also impacting property owners. There was debate about whether sediment removal should be considered a short-term solution or long-term solution. Committee members seem to understand that sediment build-up is a natural process, but some argued if routine sediment removal is conducted, the action should be

considered a long-term solution. Others argued the frequent need for sediment removal makes it a short-term solution because the action needs to be repeated. Committee members discussed the costs associated with gravel removal and how that compared with other flood risk reduction actions, such as building higher levees, setting back levees, or home buy-outs. In general, Committee members believe gravel removal is a tool that has been underutilized and King County should re-evaluate when it might be the appropriate solution. One Committee member felt transfer of development rights should also be considered to address the impacts from sediments build-up and resultant flooding. King County should notify cities that might be impacted by gravel accumulation in rivers. However Committee members felt a better solution would be to restrict development in areas that are, or could be, impacted by sediment accumulation.

South Fork Skykomish River and Snoqualmie River Risk Assessment and Action Plans

Statement of Issue:
Has King County adequately identified the flooding and erosion hazards on the South Fork Skykomish and Snoqualmie Rivers and developed a reasonable strategy and set of actions to address those hazards?

Summary of Committee feedback:
A Committee member pointed out that if buildings and other infrastructure are protected in some fashion, such as elevating the buildings, flooding can be a good thing from a biological standpoint as flooding provides natural functions and values that are a benefit to the ecosystem. It is worse on the environment to try and keep all the water in the channel during a flood event than to allow it to inundate the floodplain in a more natural manner. There is also a tremendous cost to trying to keep all the water in the channels, so there are costs in expenditures for building and maintaining levees as well as the ecological cost related to the loss of floodplain functions and values. A Committee member asked if gravel removal is going to be part of the strategy for addressing flooding in this river basin. A recommendation was made to look at acquisitions more broadly by considering the benefit of land for flood storage in addition to, or even as an alternative to acquiring property only because a structure is at risk. The Committee appreciated that the County is looking at a wide range of tools – elevations, buyouts, gravel removal, levees – to address the risk from flooding. A suggestion was offered to use the streams more effective for both transporting water as well as storing water for release during the dry season. A request was made to look at the opportunities for recreational use county-wide, not just on some river systems. Finally, a Committee member asked if the County ever considered relocating some roads, such as Jones Road (on the Cedar River).

Sammamish River, Issaquah Creek and Cedar River Risk Assessment and Action Plans

Statement of Issue:
Has King County adequately identified the flooding and erosion hazards on the Sammamish River, Issaquah Creek, and Cedar River and developed a reasonable strategy and set of actions to address those hazards?

Summary of Committee feedback:

Committee members asked for clarification about city and county coordination and were told the cities generally implement the projects within their jurisdiction while the Flood District helps with funding. Questions were asked about whether dredging would be an option to consider for the Cedar River given the concerns from state agencies over the impacts to habitat. A Committee member wanted verification that the County was actually going to do work on the Lake Sammamish weir and whether maintaining weirs are covered under the Flood Plan. Will the Plan include the Pacific Fish Management Council recommendation to have 80 trees per mile of river in Western Washington, as well as clarify that hydraulic project approvals have to be issued by Washington Department of Fish and Wildlife before the County can do work?

Green River Risk Assessment and Action Plans

Statement of Issue:
Has King County adequately identified the flooding and erosion hazards on the Green River and developed a reasonable strategy and set of actions to address those hazards?

Summary of Committee feedback:
The Committee sought clarification on the release rates for the Howard Hanson Dam and the required design standard for the levees. They asked what the probability was that these levees will meet the conditions contained in the Motion that has been adopted related to the District taking on the role of Operations and Maintenance. Further clarification was asked about how risk-based maintenance compared to the Operations and Maintenance standards required for accreditation. One Committee member asked if King County and the City of Kent were on the same page on this issue or at odds. It was pointed out that the agreement for Howard Hanson dam was to put wood and gravel in the river downstream of the dam for a period of 50 years, and asked this be reflected in the minutes. Will the Plan recommend seeking accreditation for all the levees on the Green River? A Committee member stated that between the FEMA mapping and the Biological Opinion for the National Flood Insurance Program, a lot of the industries on the Green River have contingency plans to move to other locations, which is not a better environmental decision. Finally, clarification was asked about plans for river mile 41 to 44 at Flaming Geyser Park of which there is nothing proposed in that location.

White River Risk Assessment and Action Plans

Statement of Issue:
Has King County adequately identified the flooding and erosion hazards on the White River and developed a reasonable strategy and set of actions to address those hazards?

Summary of Committee feedback:
The Committee comments focused on several topics: how to manage flood waters, gravel removal, floodplain development regulations, and management of open space. One Committee member offered an approach to managing flood waters where the 10-year or 20-year floods would be allowed to inundate the floodplain rather than trying to keep those low flows in the river channel. This approach also recommended the placement of "friction devices" in the floodplain to help with the erosional forces of overbank flooding. Staff pointed out that the US Army Corps of Engineers is exploring the placement of log jams within the River channels of the

White River, which would serve the same purpose for reducing flood velocities. A lot of the Committee discussion focused on gravel removal with questions regarding whether King County would consider gravel removal on the White River. The Committee was reminded of the presentation at the previous meeting that outlined King County's Sediment Management Program that would inform decisions related to when the County might consider gravel removal. A Committee member pointed out that times have changed and gravel removal cannot be conducted like it had been in the past without consideration of the impact on listed species and their habitat. The County should provide additional education to those who believe the County can return to the old practices of gravel removal. It was suggested that buyout of homes from willing sellers was preferable to large public works projects. Questions were asked about subdividing property and were told that floodplain regulations require at least 5,000 square feet of land outside the floodplain for all new lots created. A question was asked about the management of Lake Tapps and whether that lake can play a larger role in providing flood storage. Finally, how is floodplain property that is purchased managed? One Committee member believes King County manages the open space primarily for habitat with little opportunity for the general public to actively use the land.