Chehalis River Basin

Draft Comprehensive Flood Hazard Management Plan

June 2009

Prepared for:
Chehalis River Basin Flood Authority

Prepared by:
ESA Adolfson

CHEHALIS RIVER BASIN
FLOOD AUTHORITY

Table of Contents

List of Tables

List of Figures

ACRONYMS

AF	acre feet
BA	Biological Assessment
BE	Biological Evaluation
BMC	Bucoda Municipal Code
BMP	Best Management Practice
CEQ	Council on Environmental Quality
CFHMP	Comprehensive Flood Hazard Management Plan
CFR	Code of Federal Regulations
CFRP	Centralia Flood Reduction Project
cfs	cubic feet per second
CMC	Chehalis Municipal Code
COE	U.S. Army Corps of Engineers
Corps	U.S. Army Corps of Engineers
CMZ	Channel Migration Zone
CRS	Community Rating System
CTED	Community, Trade, and Economic Development
CWA	Clean Water Act
CWPO	Closed Without Payment
DOE	Department of Ecology
DST	Decision Support Tool
Ecology	Washington State Department of Ecology
EIS	Environmental Impact Statement
EO	Executive Order
EPA	Environmental Protection Agency
ER	Emergency Response
ESA	Endangered Species Act
ESSB	Engrossed Substitute Senate Bill
FCAAP	Flood Control Assistance Account Program
FEMA	Federal Emergency Management Association
FERC	Federal Energy Regulatory Commission
FIA	Federal Insurance Administration
FIRM	Flood Insurance Rate Map
FMA	Flood Mitigation Assistant grant program
FONSI	Finding of No Significant Impact
GI	General Investigation
GIS	Geographic Information System
GMA	Growth Management Act
HEC-RAS	Hydrologic Engineering Centers River Analysis System
HHS	Human Health & Safety
HPA	Hydraulic Project Approval
LCC	Lewis County Code
LiDAR	Light Detection and Ranging
LLC	Limited Liability Company

LWD	large woody debris
MI	Major Infrastructure
NEPA	National Environmental Policy Act
NF	North Fork
NFIP	National Flood Insurance Program
nhc	Northwest Hydraulics Consultants
NHMP	Natural Hazards Mitigation Plan
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resource Conservation Service
NSIP	National Streamflow Information Program
NWS	National Weather Service
OHWM	ordinary high water mark
OMC	Oakville Municipal Code
PCB	polychlorinated biphenyl
PUD	Lewis County Public Utility District
RCW	Revised Code of Washington
RM	River Mile
SaSI	Salmonid Stock Inventory
SBA	Small Business Administration
SEPA	State Environmental Policy Act
SFHA	Special Flood Hazard Area
SMA	Shoreline Management Act
SMP	Shoreline Master Program
SR	State Route
TCC	Thurston County Code
TMDL	Total Maximum Daily Load
USACE	U.S. Army Corps of Engineers
USC	U.S. Code
USFSW	U.S. Fish and Wildlife Services
USGS	United States Geological Survey
WDFW	Washington Department of Fish and Wildlife
WRDA	Water Resources Development Act
WRIA	Water Resource Inventory Area
WSDOT	Washington State Department of Transportation
WWTP	Wastewater Treatment Plant

CHAPTER 1 INTRODUCTION AND GOALS

Background

The Chehalis River Basin Flood Authority (Flood Authority) has prepared this Draft Comprehensive Flood Hazard Management Plan (CFHMP) for the Chehalis River basin to define flood problems in the basin and to propose solutions for those problems. The Flood Authority intends to finalize this Draft Plan in the next year. However, the Comprehensive Flood Hazard Management Plan will remain a work in progress and will be revised as the Flood Authority continues its efforts to develop solutions to flooding problems. The process for updating the plan is described in the Next Steps section at the end of this chapter.

Major Flooding Issues in the Basin

Flooding is a common, historical occurrence in the Chehalis River basin. Major flood events on the Chehalis River have affected Lewis, Thurston, and Grays Harbor Counties in the years 1972, 1975, 1986, 1990, 1996, 2007, and 2009. In the past 30 years Lewis County has experienced 16 federally declared disasters. Of these, 13 were either caused or exacerbated by flooding. These floods have caused millions of dollars of flood damage and the disruption of lives and commerce. The flooding closed Interstate 5 through Chehalis and Centralia for multiple days during the 1996, 2007, and 2009 floods.

Authority and Scope for the Chehalis River Basin CFHMP

The Flood Authority was formed in response to the 2007 flooding event throughout Lewis, Grays Harbor, and Thurston Counties and on the Chehalis Reservation. The Authority was formed by an Interlocal Agreement between eleven jurisdictions in the river basin in April 2008, to evaluate flooding issues throughout the Basin. House Bills 3374 and 3375 appropriated $2.5 million by the legislature for the Flood Authority to develop or participate in the development of flood hazard mitigation measures throughout the basin. The House Bills appropriated an additional $47.5 million in state general obligation bonds to the Office of Financial Management, working with and through other state agencies, the Flood Authority, and other local governments, to participate in flood hazard mitigation projects for the Chehalis River basin.

The Chehalis River Basin Flood Authority consists of eleven jurisdictions: Grays Harbor, Lewis, and Thurston Counties; the Confederated Tribes of the Chehalis; the cities of Aberdeen, Centralia, Chehalis, Montesano, and Oakville; and the towns of Bucoda and Pe Ell.

The purpose of the Flood Authority, according to the Interlocal Agreement, is to develop and participate in the development of flood hazard mitigation measures throughout the basin, and provide a formal and organized process to ensure:

- That flood control projects are identified and implemented that address the flood problems in the basin.

- That good public policy supports environmentally sensitive responses to protect communities and their residents from flooding, if the responses provide benefits which exceed costs, including costs associated with a no action response.
- That state and federal funding sources are well-informed of Basin Government options and needs.
- That the design for basin flood control projects incorporate options, features and betterments that may benefit the basin communities and the Basin Governments.
- That the Chehalis River Basin Flood Authority will oversee moving current and future Chehalis River Basin Flood reduction projects forward until such time as a Flood Control District is formed and adopted by the stakeholders' legislative authorities.

The Flood Authority also agreed to the following goals in the Interlocal Agreement:

- To create a Basin Flood Control District as soon as is practicable.
- To inform state and federal funding sources of project options and the needs of the basin communities.
- To work with the State of Washington to develop appropriate policy for a basin-wide flood control project.
- To seek adequate funding for the Basin Governments to identify, study and permit projects for localized problems.
- To disseminate information to residents about options and alternatives.
- To coordinate flood control activities, actions and responses.

The Flood Authority decided in November 2008 to develop a basin-wide Comprehensive Flood Hazard Management Plan as a means to identify and prioritize projects for Flood Authority funding under its state authorization.

Plan Development Process

The Flood Authority began preparing the Draft Comprehensive Flood Hazard Management Plan in January 2009. Existing CFHMPs for basin jurisdictions formed the basis for this Draft Plan. The Flood Authority also conducted a monthly series of work sessions from January through June 2009 to develop the plan.

This Draft CFHMP generally meets the guidelines of the State of Washington Flood Control Assistance Account Program (FCAAP) and the Federal Emergency Management Agency's Community Rating System (CRS).

Summary of Public Invovlement and Agency Coordination

The Flood Authority held two public workshops in February 2009, one in Chehalis on February 11 and one in Montesano on February 12. Approximately 200 people attended the workshop in Chehalis and approximately 40 people attended in Montesano. At the workshops, the Flood Authority introduced the planning process to members of the public then asked for feedback specifically on goals, flood problem areas, and recommended actions.

In March 2009, the Flood Authority commissioned Stuart Elway of Elway Research to perform a public values telephone survey of basin residents. The Flood Authority used the results of the survey to revise its goals at its work session on April 2, 2009.

Defining Goals

The Chehalis River Basin Flood Authority has adopted a set of nine goals to provide a framework for the development of the CFHMP as well as guidance for flood hazard mitigation.

Process

The Flood Authority began its CFHMP process with a workshop on goals held on January 15, 2009. For the purpose of the workshop, the Authority agreed to the following definitions of "goal," "objective," and "task" (originally developed by David Drucker):

Goal – A statement that provides clear direction and purpose but may not be fully attainable

Objective – A product or effort that moves toward the Goal, is attainable and is measurable, and has various discrete products

Task – A discrete product or effort that is possible, measurable, and contributes to the Objective

At the January 15 workshop, the Flood Authority agreed upon eight initial goals. After the workshop, the Board Advisory Committee further developed the language of the goals. In February 2009 the Authority conducted public workshops to gather citizen feedback on goals. In March 2009 the Authority conducted a public values telephone survey. The Authority held a goal revision workshop on April 2, 2009 to reconsider their goals in light of public feedback from the public workshops and the survey. The Authority agreed to revise one existing goal and add a new goal.

Goals

The nine goals adopted by the Chehalis River Basin Flood Authority are:

- Protect life and property basin-wide, including tributaries, by developing a mix of strategies that reduce flood damage.
- Promote the wise use of public and private resources.
- Enhance understanding of the hydrologic processes in the Chehalis River system.
- Ensure that land use plans and regulations protect floodplain functions.

- Ensure that flood reduction strategies protect, or enhance, the basin's natural resources.
- Increase public awareness and understanding of flooding.
- Assure that there are mechanisms in place to implement the recommendations in this plan.
- Protect the communities' interest in growth and economic sustainability.
- Protect property rights.

Related Plans

This Draft CFHMP is based on existing CFHMPs developed by jurisdictions within the Chehalis basin. Table 1-1 lists the existing CFHMPs that were used.

Table 1-1 Existing Comprehensive Flood Hazard Management Plans

Jurisdiction	Title	Year	Notes
Bucoda	Town of Bucoda Comprehensive Flood Hazard Management Plan	1999	The town is proposing to update the plan.
Centralia	City of Centralia Comprehensive Flood Management and Natural Hazards Mitigation Plan	2008	Flooding issues are the same as presented in the Lewis County CFHMP.
Chehalis Tribe	DRAFT Comprehensive Flood hazard Management Plan for Confederated Tribes of the Chehalis Reservation	2009	
Montesano	All Hazard Mitigation Plan Addendum 2	2007	Addendum to Natural Hazards Mitigation Plan for the Grays Harbor Region
Lewis County	Lewis County Comprehensive Flood Hazard Management Plan	2008	
Grays Harbor County	Grays Harbor County Comprehensive Flood Hazard Management Plan	2001	Adopted Resolution 01-161
Thurston County	Thurston County Flood Hazard Management Plan	1999	The County is proposing to update the plan.

Next Steps

This Draft Comprehensive Flood Hazard Management Plan is a working document for consideration by the Flood Authority. Because much of the plan is based on existing information from individual jurisdiction flood plans, there are gaps in the data. Additionally, much of the work needed to arrive at recommended actions has not yet been completed. Over the course of the next year, the Flood Authority will work to revise and finalize the plan. By June 2010, the Flood Plan will be ready to be adopted by the Flood Authority. Steps to be taken over the next year are included in individual chapters of the plan where appropriate. The Flood Authority will undertake following tasks by June 2010:

- Review the Draft Plan and recommend improvements;
- Identify gaps in the plan that the Authority would like to fill and strategize how to fill them;
- Undertake the Ripe and Ready studies identified in April 2009 and incorporate the results into the CFHMP;
- Support the work of the regulations work group approved in June 2009 and incorporate the findings into chapter 3 of the CFHMP;
- Work to further develop the project selection criteria and process and incorporate results into chapter 8 of the CFHNP;
- Identify how the actions eventually recommended by the CFHMP will be implemented and funded (for example, by a Flood District);
- Determine if and how the CFHMP should be adopted by individual jurisdictions;
- Determine how often and by what process the CFHMP will be revised in the future; and
- Adopt the Comprehensive Flood Hazard Management Plan.

CHAPTER 2 STUDY AREA CHARACTERISTICS

The study area for the Draft Comprehensive Flood Hazard Management Plan (CFHMP) includes the entire Chehalis River Basin (Figure 2-1). The basin is located in western Washington with the majority of the basin in Grays Harbor, Lewis, and Thurston Counties. Small portions of the basin are located in Cowlitz, Jefferson, Mason, Pacific, and Wahkiakum, Counties. The headwaters of the Chehalis River are in the southwest corner of the basin. The river flows generally northwest, discharging into Grays Harbor. Several tributaries drain into the Chehalis River in the study area. The main tributaries are the:

- Newaukum River (North Fork and South Fork)
- Skookumchuck River
- Black River
- Satsop River (East Fork, Middle Fork, and West Fork)
- Wynoochee River

The Chehalis River and its four main tributaries are discussed in the sections below.

General Description

Study Area

The mainstem Chehalis River and its tributaries form the Chehalis River Basin, which drains approximately 2,700 square miles. The basin is bounded by the Pacific Ocean to the west, the Deschutes River Basin to the east, the Olympic Mountains to the north, and the Willapa Hills and Cowlitz River Basin to the south. Elevations within the basin range from sea level at Grays Harbor to approximately 5,000 feet at Capitol Peak in the Olympic Mountains. Four major urban areas are located within the basin—Chehalis, Centralia, Aberdeen, and Hoquiam. The Confederated Tribes of the Chehalis Reservation are located within the basin. In the year 2000, total population in the Chehalis River Basin was approximately 141,000 (U.S. Census, 2000).

The Chehalis River Basin is the second largest basin in Washington, next to the Columbia River Basin. The basin is divided into two Water Resource Inventory Areas. Water Resource Area (WRIA) 22 contains the Upper Chehalis Basin upstream from the town of Porter. The Lower Chehalis Basin is located in WRIA 23 and is downstream from the town of Porter.

Forest and shrub cover dominate the Chehalis River Basin (approximately 87 percent). Other land use includes agriculture (7 percent), urban and industrial uses (4 percent), and waters and wetlands (2 percent). The Chehalis River Basin contains 180 lakes, ponds, and reservoirs and covers approximately 3,350 linear stream miles. Fish species documented in the Chehalis River include coho and fall Chinook salmon and steelhead. A variety of fish and wildlife species are supported by additional streams, lakes, ponds, and reservoirs in the basin.

The Chehalis River flows into the Grays Harbor Estuary on the Pacific coast. The estuary was created by sedimentation and erosion processes that occurred in the Chehalis River and the Pacific Ocean. Historically, this was a bar-built estuary dominated by eelgrass beds. Approximately 70 percent of the historic estuary is considered intact, and the majority of land converted from historic use is now dominated by urban development (Chehalis Basin Partnership, 2004).

Chehalis River

The Chehalis River flows for approximately 125 miles north-northwest through the Chehalis River Basin and discharges into Grays Harbor. In the headwater region in the southwest corner of the basin, the river flows adjacent to State Route (SR) 6. The river then turns north and parallels U.S. Highway 12, and finally turns west where it parallels U.S. Highway 101.

The Chehalis River can be divided into three main sections: Upper Chehalis, Middle Chehalis, and Lower Chehalis. The Upper Chehalis River extends from the headwaters in southwest Lewis County to the Centralia-Chehalis area and includes the South Fork and the Main Fork Chehalis Rivers. This portion of the basin drains approximately 428 square miles with an average annual discharge of approximately 1,600 cubic feet per second (cfs). The Middle Chehalis River flows from the Centralia-Chehalis area to the town of Porter. This segment of the river drains approximately 381 square miles with an average annual discharge of 4,560 cfs. The Lower Chehalis River flows from Porter to the west, eventually draining into Grays Harbor. The Lower Chehalis drains approximately 169 square miles. The average annual discharge for the river is 11,210 cfs.

Chehalis River Tributaries

The five major tributaries of the Chehalis River basin are the Newaukum River, Skookumchuck River, Black River, Satsop River, and the Wynoochee River (Figure 2-1). The North Fork and the South Fork Newaukum River tributaries flow west from the Cascade foothills into the Chehalis River near Chehalis. The Skookumchuck River is located in the western portion of the Mt. Baker-Snoqualmie Forest and drains into the Chehalis River at Centralia past the town of Bucoda. The Black River flows south from Black Lake and into the Chehalis River near the town of Oakville. The East Fork, Middle Fork, and West Fork Satsop River tributaries flow south from the foothills of the Olympic Mountains and into the mainstem Satsop River above the town of Satsop. The mainstem Satsop River joins the Lower Chehalis River near the town of Satsop. The Wynoochee River originates in the southern foothills of the Olympic Mountains and drains into the Lower Chehalis River near the town of Montesano. Characteristics of these major tributaries are provided in Table 2-1.

FILE NAME: Fig02-1_ChehalisBasin.ai
CREATED BY: JAB / DATE LAST UPDATED: 06/30/09

SOURCE: USGS, 2008; ESRI, 2008; National Weather Service (NWS), 2008; WA Dept. of Ecology, 2000; WDNR, 2008.

Chehalis River Basin Facilitation . 208379

Figure 2-1
Chehalis River Basin
Washington

Table 2-1 Characteristics of Major Chehalis River Tributaries

	Newaukum	Skookumchuck	Black	Satsop	Wynoochee
Confluence with Chehalis River (RM)	75.2	67	47	20.2	13.1
Drainage Area (square miles)	158	181	138	300	185
Average Annual Discharge (cfs)	506	540	330	1,968	1,316

RM=river mile; cfs=cubic feet per second

Additional tributaries to the Chehalis River include Cloquallum Creek, the Wishkah River, and the Hoquiam River. Cloquallum Creek is approximately 20 miles long and flows from the town of McCleary to join the Chehalis at RM 25.2. The Wishkah River drainage flows from the south end of the Olympic Mountains into the Chehalis River at RM 0.15. The Hoquiam River originates in the southern Olympic Mountains and joins the Chehalis River above the town of Hoquiam, near the mouth of the Chehalis River. The Humptulips River flows into Grays Harbor from the north. For purposes of this CFHMP, it is not considered part of the Chehalis River Basin

Physical Characteristics

Climate

The climate in the Chehalis River Basin is temperate throughout the year along with wet winter and dry summer months. Annual precipitation in the upper basin area ranges from approximately 40 inches near the City of Chehalis to 120 inches near the headwaters of the Chehalis River. Average annual precipitation in the lower basin area ranges from 55 inches near the town of Porter to 220 inches near the headwaters of the Wynoochee River. The majority of precipitation within the basin falls as rain. The surrounding mountain ranges receive snow accumulation during winter months, although snow generally does not accumulate for long periods. Most precipitation accumulates between the months of October and May. Peak river discharges generally occur between December and March. Average temperatures in the river basin range from 38° F to 40° F in January and from 59° to 64° F in July. The average frost-free period ranges from 163 days to more than 190 days.

Geology

The geology of the Chehalis River Basin is primarily derived from volcanic and sedimentary bedrock, glacial deposits, and alluvium. The Chehalis River system passes through three distinct ecoregions before draining into Grays Harbor near Aberdeen. First is the Cascade ecoregion, which includes the Olympic Mountains. This area contains mostly volcanic and sedimentary bedrock formations. Second is the Puget Lowland ecoregion, dominated by glacial and alluvial sediment. The glacial sediments are comprised of sand, silt, gravel, and clay and are deposited throughout the river valley by surface water. The Chehalis River system also flows through the Coast Range, which primarily contains volcanic and sedimentary bedrock.

The majority of the basin rests on top of volcanic material, overlain by sedimentary or glacial material. These bedrock formations are exposed on hill slopes and ridges. Sedimentary rock, found in the South Fork Chehalis and Lincoln Creek drainages, were formed during the Eocene/Oligocene epoch (55-24 million years ago). Younger sedimentary material, from the Miocene epoch (24 to 5 million years ago), is distributed between the Satsop and Wynoochee Rivers. Glacial deposits characterize most of the lower Chehalis River Basin. Alluvial deposits combine with glacial deposits throughout the river valleys, providing a vast source of unsorted material.

Upper Chehalis River Subbasin

Four key geologic formations occur in the Upper Chehalis subbasin. These include alluvial deposits of the Quaternary Age; alluvial terrace deposits of the late Tertiary (63 to 2 million years ago) to Quaternary Age (2 million years ago to present); volcanic flows and interbeds of the Tertiary Age; and sedimentary rocks of the Tertiary Age. Upland areas of the basin are comprised mostly of Tertiary-based volcanic flow and fine-grained sedimentary rock. These Tertiary Age formations are generally associated with small quantities of groundwater that contain high mineral content, and are therefore unsuitable for human consumption. River valleys within the basin are dominated by alluvial deposits of the Quaternary Age that contain silt, sand, and clay near the surface; and sand and gravel below. These alluvial formations are believed to have high porosity and permeability.

The Middle Chehalis River, within the Upper Chehalis subbasin, is generally comprised of lowland areas based in Quaternary Age outwash deposits of sand and gravel. These outwash deposits are very permeable and yield large quantities of high quality water, in contrast to the upland sedimentary deposits described above. The City of Centralia accesses these lowland aquifers for a portion of its water supply.

Lower Chehalis River Subbasins

The geology of the Lower Chehalis subbasin is primarily glacially influenced. Alluvial terrace deposits from the late Tertiary to Quaternary Age dominate exposed rock in the Newaukum subbasin. The Black River area lies atop approximately 100 feet of deposits from the southern terminus of the Vashon stade of the Fraser glaciation. No detailed geologic information is available for the Skookumchuck, Satsop, or Wynoochee Subbasins.

Topography

Upper Chehalis Subbasin

The Upper Chehalis River originates in the Willapa Hills, which comprise part of the Coastal Range. Elevations range from below 2,400 feet to 3,110 feet at Baw Faw Peak. The mainstem Chehalis flattens into an open river valley below Pe Ell and the South Fork Chehalis opens to a low-gradient river valley at the Lewis County/Cowlitz County line.

The Middle Chehalis River meanders through a flat river valley. The west side of the river is used primarily for agricultural purposes. The east side of the river has been developed into the Centralia, Chehalis, and Fords Prairie urban areas. The river narrows to approximately 150 feet wide and flows through a channel dominated by pool habitat with occasional riffle habitat. Deciduous forest covers the stream banks and upland forested areas are harvested for timber production. South of Grand Mound, the river flows through the coastal hills and the river valley separates the Doty and Willapa Hills to the south from the Black Hills, located to the north. Elevations range from approximately 100 feet to 2,700 feet at Larch Mountain, the tallest of the Black Hills.

Newaukum River Subbasin

The headwaters of the North and South Fork Newaukum River originate in steep hills and narrow river valleys. These tributaries flow west into the mainstem Newaukum, which is characterized by an open river valley. Overall, the river gradient is low and it averages approximately 30 to 75 feet in width. The stream substrate is predominately gravel and cobble, interspersed with shallow pools and riffles.

The North Fork Newaukum River has a steep gradient in the upstream areas and a moderate gradient below. Substrate generally consists of bedrock outcrops and gravel. Pool and riffle habitat supports salmonid use in the upper reaches. Downstream reaches contain a combination of gravel and rubble substrate and the stream channel averages about 60 feet in width.

The South Fork Newaukum River averages between 45 and 60 feet wide with a gravel and rubble substrate along with good pool and riffle habitat for salmonids. Riparian areas are vegetated with a combination of coniferous and deciduous forest and shrub habitat, providing shade and habitat for wildlife. The stream is generally confined along the entire reach. Upper reaches have a steep gradient with frequent outcroppings of bedrock. The lower reaches flow through a lower gradient area with deep pools and riffle habitat.

Skookumchuck River Subbasin

The Skookumchuck River originates in the western edge of the Snoqualmie National Forest and flows through the town of Bucoda prior to its confluence with the Chehalis River at Centralia. The Skookumchuck (TransAlta) Dam is located just upstream of the confluence with Bloody Run Creek. The gradient between the headwaters and Bucoda is approximately 19 feet per mile, as the river flows down into the river valley. The lower extent of the river has a gradient of approximately 5 feet per mile. In floodplain areas, the river channel extends from several hundred feet to approximately 0.5 mile in width.

Lower Chehalis River Subbasin

Areas located north of the Lower Chehalis River are characterized by open river valley. The south side of the river contains steeply rising hills. A portion of the open river valley to the north transitions into tributary river valleys; other areas transition into sloping hillsides.

Black River Subbasin

The Black River originates at Black Lake near the Black Hills of the Capital State Forest. It flows southwest through the Chehalis Indian Reservation to its confluence with the Chehalis River near the town of Oakville. The Black River has a very low gradient, dropping only 19 feet over its entire length, with alternating riffles and long pools in the lower nine miles (Washington State Conservation Commission, 2001).

A gas pipeline was excavated across the Black River in 1965, approximately 1.5 miles downstream from Black Lake, which left debris in the channel. This has since created a blockage for fish passage and contributed to the reversal of flow in wetlands associated with the upper Black River.

Satsop River Subbasin

The upper reaches of the Satsop River flow through moderately sloping hills characterized by second growth forest. Downstream areas flow through an open, flat river valley containing mostly deciduous riparian vegetation. The Satsop River substrate includes gravel and cobble. This low-gradient stream contains long pools and short riffles that support salmonids. Average channel width ranges from approximately 90 feet to 135 feet. The floodplain is interspersed with rural and agricultural land use. The Satsop Subbasin contains several lakes and three small reservoirs that feed into smaller tributaries.

The East Fork Satsop River flows southwest toward the Simpson State Salmon Hatchery, located at River Mile (RM) 17.5. This stream flows through an open, flat river valley vegetated with mixed coniferous and deciduous forest.

The Middle Fork Satsop River originates in the foothills of the Olympic Mountains. The upper reaches flow south along a steep gradient through canyons and steep valleys. The lower reaches transition to an open river valley. Old growth forest dominates the headwaters of the Middle Fork. Upstream areas contain mostly second-growth forest and the floodplain area mostly contains small farms.

The West Fork Satsop River also originates in the foothills of the Olympics. The upper portions of the stream have a steep gradient similar to the Middle Fork. From approximately RM 33 to the confluence with the mainstem Satsop River, this tributary flows through open river valley with rolling hills in the surrounding areas. Most of the West Fork river valley is managed under the 100-year Shelton Cooperative Sustained Yield Unit agreement between the US Department of Agriculture and the Simpson Timber Company. Small portions of this drainage system contain other private timber pursuits and some agricultural areas.

Wynoochee River Subbasin

The Wynoochee River headwaters are located on the steeply sloped, southern aspect of the Olympic Mountains. Wynoochee Dam lies at the transition from mountain streams to river valley, approximately 52 miles above the confluence with the Chehalis River. The dam was constructed by the Army Corps of Engineers (Corps) to provide flood control, water supply, and recreation for the valley. Wynoochee Lake serves as the reservoir for the dam. Below the dam, the river has changed course over the years as it meanders down from the mountains into the river valley.

Soils

The Chehalis River Basin floodplain contains five major soil associations (Table 2-2) (Chehalis Basin Partnership, 2004). These soils occur in flat or gently sloping terrain and include the major tributary systems within the basin. In floodplain fringes, cropland, and pasture areas, dominant vegetation includes western red cedar, red alder, black cottonwood, and willow species. Areas of moderate to well-drained soils contain some Douglas-fir trees.

Table 2-2 Major Soil Associations in the Chehalis River Floodplain

Major Soil Association	Characteristics
Ocasta	Very deep, poorly drained, nearly level soils; on floodplains and deltas protected from tidal overflow.
Grehalem-Rennie	Very deep, well drained and poorly drained, nearly level soils; on floodplains.
Chehalis-Skamo-Spanaway	Very deep, moderately well drained to somewhat excessively well drained, nearly level to gently sloping soils; on floodplains, terraces, and fans.
Chehalis-Newberg	Very deep, well drained, nearly level soils; on floodplains.
Reed-Chehalis	Very deep, poorly drained and well drained, level and nearly level soils that formed in alluvium; on floodplains and terraces.

The following sections describe the soils found in the Chehalis River floodplain. The soil series found in the basin are described in Table 2-3. These soil series are referenced in the basin and subbasin descriptions following the table.

Table 2-3 Major Soil Series in the Chehalis River Floodplain

Soil Name	Soil Description
Ocosta silty clay loam	Very deep, poorly drained, nearly level soils formed in alluvium deposited in coastal bays; located within Grays Harbor, at the mouth of the Chehalis River, and upriver towards Montesano on floodplains and deltas in flat or depressed areas; subject to tidal overflow unless protected.
Grehalem silt loam	Very deep, well drained soil formed in alluvium derived from basic igneous and sedimentary rocks; on nearly level floodplains usually subject to annual stream overflow at elevations of 0 to 100 feet with slopes of 0 to 3 percent.
Rennie silty clay loam	Very deep, poorly drained soil formed in mixed, clayey and silty alluvium; bottomlands, floodplains, and swales at elevations of 0 to 100 feet with a slope of 0 to 2 percent.
Maytown silt loam	Very deep, moderately well drained soil formed in mixed alluvium on floodplains and low terraces at elevations of 10 to 500 feet with slopes of 0 to 3 percent; slow runoff capacity and moderately slow permeability, subject to occasional brief flooding from November to March with a water table as high as 2.5 to 3.5 feet at times.
Chehalis silt loam	Very deep, moderately well drained to somewhat excessively drained, nearly level to gently sloping soils; on floodplains, terraces, and fans; moderate permeability and slow runoff and was formed in silty and loamy mixed alluvium; subject to occasional flooding for brief periods from November to April.
Skamo silt loam	Deep, moderately well drained, formed in alluvium and can be found on terraces and fans at elevations from 50 to 300 feet with 0 to 15 percent slopes
Spanaway gravelly sandy loam	Deep, somewhat excessively drained, and formed in glacial outwash and volcanic ash; terraces and plains at elevations of 100 to 400 feet with slopes of 0 to 15 percent.
Newberg fine sandy loam	Very deep, somewhat excessively drained soil formed in loamy and sandy alluvium from sedimentary and basic igneous rocks; Found on floodplains from 10 to 3,000 feet with 0 to 4 percent slope.
Reed silty clay loam	Very deep, poorly drained and well drained, level and nearly level soils formed in alluvium weathered from shale, sandstone, siltstone, and glacial drift; in depressions on low terraces adjacent to perennial streams with slopes of 0 to 3 percent.
Salkum silty clay loam	Well drained, formed in very strongly weathered ancient glacial drift; hills, terraces, and escarpments at 200 to 1000 feet with slopes of 0 to 65 percent.
Prather silty clay loam	Very deep, moderately well drained and formed in weathered glacial drift derived from igneous rock; terraces and plains with slopes of 0 to 30 percent at 200 to 1000 feet elevation; slow to medium runoff with moderate permeability and water stands within 1 to 3 feet of the surface during winter.
Lacamas silt loam	Very deep, poorly drained and was formed in mixed alluvium weathered from glacial and sedimentary sources; glacial terraces and footslopes with slopes of 0 to 8 percent; medium to ponded runoff with slow permeability and typically has a perched water table from surface to 0.5 feet between November and May unless drained.
Katula very cobbly loam	Moderately deep and well drained with moderate permeability formed in basalt and an admixture of volcanic ash; narrow ridges, shoulders and back slopes of mountainous areas with slopes of 5 to 90 percent.
Bunker loam	Deep, well drained soil weathered from colluvial basalt on foothills and mountains at slopes of 1 to 90 percent.
Melbourne loam	Very deep, and well drained, formed in residuum and colluvium weathered from siltstone and sandstone; forests between 200 and 1,200 to 1,800 feet with varying slopes between 0 to 90 percent.

Soil Name	Soil Description
Buckpeak silt loam	Very deep, and well drained, formed in residuum and colluvium from siltstone, shale, and fine grained sandstone; upland forests between 200 and 1,200 to 1,800 feet with varying slopes between 0 to 90 percent
Centralia loam	Very deep, and well drained, in residuum and colluvium weathered from sandstone; upland forests between 200 and 1,200 to 1,800 feet with varying slopes between 0 to 90 percent; moderate permeability and slow or medium runoff capacity.
Baumgard loam	Deep and well drained, formed in volcanic ash and residuum and colluvium from andesite; on forested foothills and mountains with slopes of 5 to 90 percent at elevations of about 50 to 1,800 feet, and.
Schneider very gravelly loam	Deep and well drained, formed in colluvium from basalt or andesite and volcanic ash; forested foothills and mountains with slopes of 5 to 90 percent at elevations of about 50 to 1,800 feet, and.
Olympic silty clay loam	Very deep, well drained, formed in residuum and colluvium weathered from basic igneous rocks; stable forested summits of foothills and mountains with slopes of 0 to 65 percent at elevations of 200 to 2,000 feet.
Pheeney gravelly ashy loam	Moderately deep and very deep, well drained soils, formed in andesite and breccia colluvium with an admixture of volcanic ash; forested ridge crests and slopes within the Snoqualmie National Forest at elevations of 1,500 to 2,800 feet with slopes of 5 to 90 percent.
Jonas gravelly medial silt loam	Moderately deep and very deep, well drained soils, formed in colluvium and residuum from andesite and breccia with an admixture of volcanic ash in the upper part; forested ridge crests and slopes within the Snoqualmie National Forest at elevations of 1,500 to 2,800 feet with slopes of 5 to 90 percent.
Stahl very gravelly medial silt	Moderately deep to deep, well drained, formed in residuum and colluvium from basic igneous rock with an admixture of volcanic ash and pumice; ridgetops and mountain slopes at elevations of 2,500 to 4,700 feet with slopes of 0 to 65 percent and 5 to 90 percent.
Reichel medial loam	Moderately deep to deep, well drained, formed in residuum and colluvium from andesite with a mixture of volcanic ash in the upper part; ridgetops and mountain slopes at elevations of 2,500 to 4,700 feet with slopes of 0 to 65 percent and 5 to 90 percent.
Hoquiam medial silt loam with 15 percent slope	Deep to cemented till, well drained soils that formed in old alluvium deposited over glacial drift; on ground moraine positions in uplands and have slopes ranging 1 to 65 percent.
Le Bar silt loam	Deep, well drained soils formed in loess and old alluvium derived from sandstone; on terraces and terrace escarpments with 0 to 65 percent slopes.
Nisqually ashy fine sandy loam	Very deep, somewhat excessively drained soil formed in glacial outwash found on terraces with slopes of 0 to 15 percent.
Vailton silt loam	Deep, well drained soil formed in volcanic ash and colluvium and residuum from siltstone and shale; found on mountains at elevations of 1,700 to 2,800 feet with slopes of 5 to 90 percent.
Mal clay loam	Deep, moderately well drained soil formed in tuffaceous marine siltstone and basaltic sandstone with an admixture of volcanic ash; on foothills and mountain slopes between 1,500 to 2,400 feet with slopes of 5 to 65 percent.
Wilkeson gravelly silt loam	Deep, well drained, formed in materials weathered from andesite and basalt; found on uplands and convex slopes in the foothills of the Cascade Mountains at elevations of 600 to 1,800 feet; medium to rapid runoff and moderate permeability.
Shelton very gravelly sandy loam	Deep, moderately well drained soil formed in glacial till; undulating to rolling glacial moraines at elevations of 100 to 800 feet with 15-30 percent slope.
Mukilteo muck (Mukilteo peat)	Deep, very poorly drained soils formed in deep organic deposits; depressional areas on glacial uplands or river valleys at elevation of 0 to 1,000 feet with 0 to 2 percent slopes.

Soil Name	Soil Description
Grove very gravelly sandy loam	Deep, somewhat excessively drained soil formed in glacial outwash and located on terraces and terrace escarpments at elevations near 0 to 500 feet with slopes of 0 to 50 percent.
Lytell paragravelly medial silt loam	Deep, well drained soil formed in materials weathered from siltstone or very fine grained sandstone; hillsides and ridgetops from 0 to 1,700 feet with slopes of 5 to 90 percent.
Rough loam	Very shallow, somewhat excessively drained soils formed in residuum from shales, siltstones, and fine-grained sandstones on uplands; rocky outcrops in mountainous elevations from 900 to 3,600 feet with a slope range between 7 to 100 percent.
Astoria medial silt loam	Deep to very deep, well drained soil formed in colluvium and residuum weathered mostly from shale and siltstone; mountains from 100 to 2,000 feet with slopes of 0 to 90 percent.
Knappton medial silt loam	Deep and very deep, well drained soils formed in material weathered from basalt colluvium; ridgetops and mountainous uplands at 100 to 1,800 feet with slopes of 1 to 90 percent.
Halbert muck	Shallow, very poorly drained soil that formed in silty glaciolacustrine sediments over piedmont glacial outwash from the Olympic Mountains; depressions on glacial outwash terraces and till plains from 50 to 300 feet with 0 to 10 percent slope.
Willaby silt loam	Deep, moderately well drained soil formed in piedmont glacial drift in the Olympic Mountains; benches and terraces at elevation of 100 to 500 feet with 1 to 15 percent slope.

SOURCE: Soil Conservation, 1986 and no date

Upper Chehalis River Basin

The Upper Chehalis floodplain is characterized by Chehalis-Skamo-Spanaway, Newberg, and Reed series soils. Chehalis silt loam and Reed silty clay loam, are the dominant soils in the upper river basin region. Dominant soils originating from uplands and high elevation slopes include Salkum-Lacamas, Katula-Bunker, Melbourne-Buckpeak-Centralia, Baumgard-Schneider-Olympic, Pheeney-Jonas, and Stahl-Reichel associations (described in Table 2-3).

Newaukum River Subbasin

North Fork Newaukum

Soils in the North Fork Newaukum River Floodplain are comprised of Reed silty clay loam and Chehalis silt loam. Upland and headwater soils are primarily Salkum silty clay loam, Prather silty clay loam, Lacamas silt loam, Melbourne loam, Buckpeak silt loam, Centralia loam, Baumgard loam, Schneider very gravelly loam, Olympic silty clay loam, Pheeney gravelly ashy loam, and Jonas gravelly medial silt loam (described in Table 2-3).

South Fork Newaukum

Dominant soils in the South Fork floodplain are Reed silt loam and Chehalis silt loam. Upland and headwater soils are primarily Salkum silty clay loam, Prather silty clay loam, Lacamas silt loam, Melbourne loam, Buckpeak silt loam, Centralia loam, Pheeney gravelly ashy loam, Jonas gravelly medial loam, Stahl very gravelly medial loam, and Reichel medial loam (described in Table 2-3).

Skookumchuck River Subbasin

The Skookumchuck River floodplain soils primarily consist of Chehalis silt loam, Newberg fine sandy loam, Spanaway gravelly sandy loam and Nisqually ashy fine sandy loam. Upland and headwaters soils are dominated by Melbourne loam, Buckpeak silt loam, Centralia loam, Baumgard loam, Schneider very gravelly loam, Olympic silty clay loam, Pheeney gravelly ashy loam, Jonas gravelly medial silt loam, Stahl very gravelly medial loam, and Reichel medial loam, Vailton silt loam, Mal clay loam, and Wilkeson gravelly silt loam (described in Table 2-3).

Lower Chehalis River Subbasin

Lower Chehalis floodplain soils are dominated by the Ocosta and Chehalis-Skamo-Spanaway series soils. These include Ocosta silty clay loam, Chehalis silt loam, Skamo silt loam, and Spanaway very gravelly sandy loam. Soils on glacial uplands are primarily Hoquiam-Le Bar series soils (described in Table 2-3).

Satsop River Subbasin

East Fork Satsop

The East Fork Satsop River floodplain consists of Chehalis silt loam, Skamo silt loam, Spanaway gravelly sandy loam and Shelton very gravelly sandy loam. Upland and headwater soils within the East Fork Satsop River sub-basin include Shelton gravely sandy loam, Mukilteo muck, and Grove very gravelly sandy loam (described in Table 2-3).

Middle Fork Satsop

Mid-Fork Satsop River floodplain soils are dominated by Grahalem silt loam, Rennie silty clay loam, and Maytown silt loam. Upland and headwater soils consists of primarily Hoquiam medial silt loam, Le Bar silt loam, Lytell paragravelly medial silt loam, Astoria medial silt loam, and Rough series soils (described in Table 2-3).

West Fork Satsop

West Fork Satsop River floodplain soils consist of Grahalem silt loam, Rennie silty clay loam, Chehalis silt loam, Skamo silt loam, and Spanaway gravelly sandy loam.

Upland and headwater soils are dominated by Lytell paragravelly medial silt loam, Astoria medial silt loam, Hoquiam medial silt loam, Le Bar silt loam (described in Table 2-3) and Bunker-Knappton series soils. Bunker loam is a deep, well drained soil weathered from colluvial basalt on foothills and mountains. Bunker series soils are found on metastable side slopes, footslopes, benches, ridgetops, and hillsides at elevation of 100 to 2,200 feet with slopes of 1 to 90 percent. These soils are primarily forested and used for timber production, watershed, and recreation. Knappton medial silt loam is deep to very deep, well drained, and formed in material weathered from basalt colluvium. Knappton series soils are found on narrow ridgetops, and colluviual side slopes in mountainous uplands at elevations of 100 to 1,800 feet with slopes of 1 to 90 percent. They are primarily used in timber production, watershed, and recreation.

Wynoochee River Subbasin

Dominant soils within the Wynoochee River floodplain are Chehalis silt loam, Skamo silt loam, Spanaway gravelly sandy loam, Grahalem silt loam, and Rennie silty clay loam (described in Table 2-3).

Upland and headwater soils consist primarily of Hoquiam medial silt loam, Le Bar silt loam, Bunker loam, Knappton medial silt loam, Halbert muck, and Willaby silt loam.

Hydrology

Groundwater Hydrology

Groundwater movement in the Chehalis River Basin is determined by the complex geologic formations that shape the basin. The primary surficial aquifers within the basin are contained in the unconsolidated glacial and alluvial deposits, located in the river valleys and upland prairies. Bedrock formations provide low yields of local groundwater and are not generally associated with surficial aquifers within the basin. Surficial aquifers generally occur between several feet below ground surface and approximately 100 feet deep. Wells associated with the primary surficial aquifers can generate between 200 gallons and 3,000 gallons per minute. Groundwater flow generally spreads from upland recharge areas along aquifer perimeters toward natural discharge points along streams and tributaries. Groundwater movement also occurs downward in elevation to recharge regional aquifers.

Alluvial aquifers in the tributary system of the Chehalis River are much shallower, generally occurring within 20 feet of the ground surface. These aquifers provide a local water source for farms, private residences, and public water systems. Because of the shallow water table and hydraulic connection to other waterbodies, these aquifers are susceptible to groundwater contamination.

Surface Water Hydrology

Rainfall is a primary water source for the Chehalis River Basin. The majority of precipitation in the basin accumulates as rain. The surrounding mountains also receive snow accumulations during winter months. Discharge levels within the basin peak between December and March. Average annual discharge within the basin is approximately 11,210 cfs. Delayed runoff from snowmelt primarily impacts the Wynoochee and Satsop Rivers.

Few dams or diversion structures are located in the basin. Diversion structures are located on the Hoquiam and Wishkah Rivers to provide municipal and industrial water to the Hoquiam/Aberdeen area. These structures consistently divert approximately 2.5 cfs from the Hoquiam River and 10 cfs from the Wishkah River. The Wynoochee Dam, located on the Wynoochee River, provides a variety of opportunities for the City of Aberdeen. These include fish and wildlife habitat, irrigation, recreation, flood control, and a municipal and industrial water supply. Wynoochee Lake, which serves as the reservoir for the dam, has a maximum capacity of 70,000 acre-feet. The Skookumchuck Dam is located on the Skookumchuck River, just upstream of Bloody Run Creek, and primarily serves the Centralia Steam Electric plant, with a maximum discharge of 54 cfs. The North Fork of the Newaukum River is dammed to provide up to 7 cfs of municipal and industrial water supply to the nearby cities of Centralia and Chehalis. Several other, small dams are interspersed throughout the basin. These provide a local water source to rural areas.

Two splash dams were located on the Upper Chehalis River, one above Fisk Falls and the other below the confluence with Crim Creek. Splash dams are temporary wooden dams that were historically used to raise water levels so logs could easily be transported to downstream sawmills. These splash dams have resulted in channel incision, scouring, loss of gravel, and loss of large woody debris.

Upper Chehalis River Subbasin

Precipitation levels in the Upper Chehalis River Subbasin range from approximately 40 inches at Centralia to 120 inches in the Willapa Hills. Precipitation levels generally increase with elevation and along an east-west gradient. Seventy-seven percent of precipitation occurs during the months of October through March. In summer, dry spells can last between 30 and 60 days. Winter snowfall accumulations in the higher elevations can reach approximately 24 inches. Rain-on-snow events and snowmelt can lead to flooding and erosion hazards in this area of the subbasin.

Newaukum River Subbasin

Average annual precipitation levels in the Newaukum Subbasin range from approximately 30 inches to 60 inches. Table 2-1 provides additional information about tributary drainage features within the Chehalis River Basin.

Skookumchuck River Subbasin

Conditions within the Skookumchuck River Subbasin are comparable to those in the Newaukum Subbasin. However, the Skookumchuck River receives approximately 20 percent more precipitation than the Newaukum River.

Lower Chehalis River Subbasin

The primary water source in the Lower Chehalis River Subbasin is rainfall. This area is characterized by mild temperatures and overall moderate levels of rainfall. The coastal mountain ranges provide a rainshadow effect, so precipitation increases north and south of Grays Harbor. Average rainfall in the subbasin is approximately 71 inches.

Black River Subbasin

As with the other subbasins, the Black River Subbasin is primarily fed by rain and snow. Average annual precipitation in the Black Hills ranges as high as 90 inches (Daly et. al., 2003). The hydrology of the Black River has been severely altered due to the construction and subsequent excavation of the Black Lake Ditch in 1922, 1952, and 1976. Originally, Black Lake drained into the Black River, until the ditch was constructed on the north end of the lake to control flooding of private property along the lake boundary. However, as the ditch down-cut, it became the primary outlet for Black Lake. Since then, the wetlands near the upper Black River have slowly filled in, resulting in greatly decreased flows into the river, except during flooding (Hawkins, 2000; Washington State Conservation Commission, 2001). The ditch, along with the addition of the pipeline crossing in 1965 (discussed above), has changed the natural hydrology of the Black River and worsened summer low flow conditions. Although Black Lake no longer drains into the Black River, the two remain hydrologically connected via groundwater (Washington State Conservation Commission, 2001).

Satsop River Subbasin

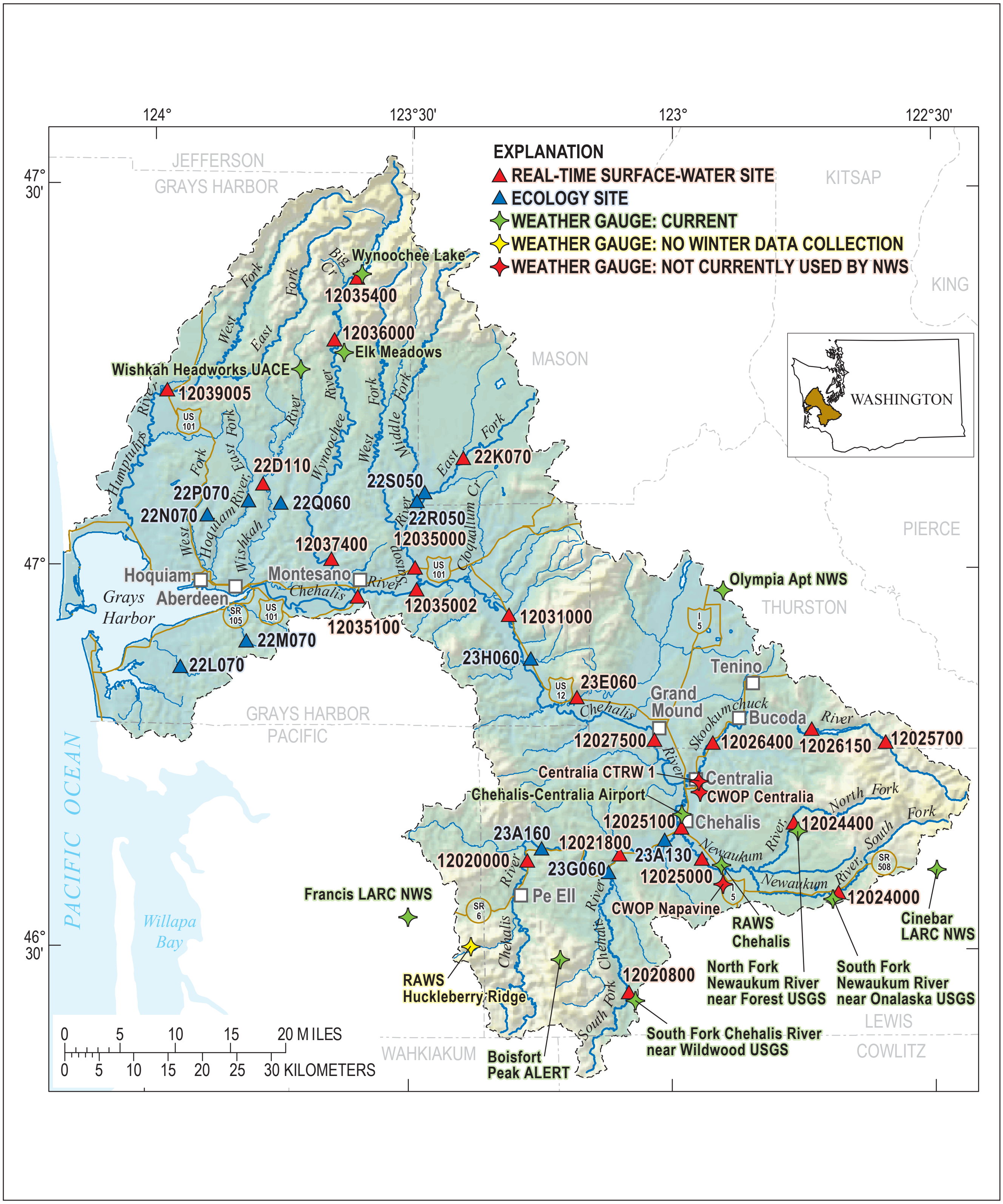
Water sources for the Satsop Subbasin stem from rainfall and snowmelt. Precipitation levels vary significantly from over 180 inches at the headwaters in the Olympic Mountains to approximately 80 inches at the confluence with the Chehalis River (Weyerhaeuser and Simpson Timber Co., 1995).

Wynoochee River Subbasin

Water sources for the Wynoochee drainage stem from rainfall and snowmelt. Precipitation levels increase dramatically from the lowlands to higher elevations at the south end of the Olympic Mountains. Average annual precipitation in the lowlands is approximately 75 inches and approximately 220 inches in the Olympic Mountains.

Stream Gauges

Figure 2-2 illustrates the location of precipitation and stream gauges in the Chehalis River Basin. These gauges are managed by a variety of agencies as indicated in Table 2-4 and 2-5. There are 35 active stream gauges in the Chehalis River Basin. The US Geological Survey manages 19 gauges; the National Weather Service manages two gauges; and Ecology manages 14 gauges in the basin. Data from all of the gauges managed by the USGS are reported in realtime and included in the USGS Flood Watch system. The National Weather Service reports some data in near realtime at the Newaukum River near Chehalis, the Chehalis River at Centralia, and the Skookumchuck River near Chehalis. All but three of the Ecology gauges are manual staff height gauges and are not appropriate for flood monitoring.



FILE NAME: Fig02-2_StreamGaugesBasin.ai
CREATED BY: JAB / DATE LAST UPDATED: 06/29/09

SOURCE: USGS, 2008; ESRI, 2008; National Weather Service (NWS), 2008; WA Dept. of Ecology, 2000; WDNR, 2008.

Figure 2-2
Chehalis River Basin Stream and Precipitation Gauges
Washington

Table 2-4 Chehalis River Basin Stream Gauges

Gauge Number	Location	River Mile	Drainage Area (mile2)	Date of Record	Managing/Funding Agency	Notes
12020000	Chehalis River near Doty	101.8	113	1939-present	USGS/Lewis County Public Works Department	Realtime data
12020800	South Fork Chehalis River near Wildwood	16.2	27	1998-present	USGS/Lewis County Public Works Department	Seasonal gage Realtime data
12021800	Chehalis River near Adna	86	340	1998-present	USGS/Lewis County Public Works Department	Seasonal gage Elevation/stage only station Realtime data
12024000	South Fork Newaukum River near Onalaska	22.8	42.4	1944-present	USGS/Lewis County Public Works Department	Seasonal gage Realtime data
12024400	NF Newaukum River above Bear Creek	7.7	29.6	1998-present	USGS/Lewis County Public Works Department	Seasonal gage Realtime data
12025000	Newaukum River near Chehalis	4.1	155	1929-present	USGS/Lewis County Public Works Department	Realtime data
12025100	Chehalis River at WWTP at Chehalis	74.3	618	2000-present	USGS/Lewis County Public Works Department	Realtime data Seasonal gage Elevation/stage only station
12025500	Chehalis River at Centralia	67.5	653	Pre-2000-present	National Weather Service	Realtime data
12025700	Skookumchuck River near Vail	28.8	40.0	1967-present	USGS/Skookumchuck Dam, LLC.	Realtime data
12026150	Skookumchuck River at Bloody Run Creek near Centralia	20.7	65.9	1969-present	USGS/Skookumchuck Dam, LLC.	Realtime data
12026400	Skookumchuck River near Bucoda	6.4	112	1967-present	USGS/Skookumchuck Dam, LLC. and Thurston County	Realtime data
12026600	Skookumchuck River at Centralia	2.5	170	Pre-2000-present	National Weather Service	Realtime data
12027500	Chehalis River near Grand Mound	59.9	895	1928-present	USGS/Ecology	Realtime data
12031000	Chehalis River at Porter	33.3	1,294	1952-present	USGS/Ecology	Realtime data
12035000	Satsop River near Satsop	2.3	299	1929-present	USGS/Ecology and USGS NSIP	Realtime data

Gauge Number	Location	River Mile	Drainage Area (mile2)	Date of Record	Managing/Funding Agency	Notes
12035002	Chehalis River near Satsop	18	1,760	1979-present	USGS/Energy Northwest	Realtime data Stage velocity readings Affected by tides and debris
12035100	Chehalis River near Montesano	13.2	1,780	2001-present	USGS/USGS NSIP	Realtime data Affected by tides
12035400	Wynoochee River near Grisdale	51.3	41.3	1965-present	USGS/City of Tacoma, Tacoma Public Utilities	Realtime data
12036000	Wynoochee River above Save Creek near Aberdeen	40.6	71.4	1925-present	USGS/City of Tacoma, Tacoma Public Utilities	Realtime data
12037400	Wynoochee River above Black Creek near Montesano	5.9	155.2	1956-present	USGS/City of Tacoma, Tacoma Public Utilities	Realtime data
12039005	Humptulips River below Highway 101 bridge near Humptulips	22.9	132	1933-present (most 2002-present)	USGS/Grays Harbor County	Realtime data
22R050	North Fork Satsop River at the Mouth	0.3	Not available	2005 to present	Ecology	Manual staff height
22D110	Wishkah River near Nisson	15.3	Not available	2005-present	Ecology	Telemetry
22K070	Bingham Creek at Hatchery	0.1	Not available	2000-present	Ecology	Telemetry
22L070	Johns River at Western	5.5	Not available	2005-present	Ecology	Manual staff height
22M070	Newskah Creek below Falls	4.1	Not available	2005-present	Ecology	Manual staff height
22N070	Middle Fork Hoquiam River near New London	Not avail-able	Not available	2005-present	Ecology	Manual staff height
22P080	East Fork Hoquiam River near Nisson	10.0	Not available	2005-present	Ecology	Manual staff height
22Q060	East Fork Wishkah River near mouth	0.9	Not available	2005-present	Ecology	Manual staff height
22S050	Decker Creek at mouth	0.1	Not available	2005-present	Ecology	Manual staff height
23A130	Chehalis River at Claquato	77.7	Not available	2005-present	Ecology	Manual staff height
23A160	Chehalis River at Dryad	96.9	Not available	1996-present	Ecology	Manual staff height

Gauge Number	Location	River Mile	Drainage Area (mile2)	Date of Record	Managing/Funding Agency	Notes
23E060	Black River at Highway 12	2.0	Not available	2005-present	Ecology	Telemetry
23G060	South Fork Chehalis River near mouth	0.6	Not available	2005-present	Ecology	Manual staff height
23H 070	Cedar Creek at Highway 12	1.3	Not available	2005-present	Ecology	Manual staff height
None	Black River at 128th Avenue Littlerock	N/A	Not available	1992-1999, 2006-present	Thurston County	
None	Scatter Creek at James Road	N/A	Not available	1995-1998, 2007-present	Thurston County	

Table 2-5 Precipitation Gauges in the Chehalis River Basin

Gauge Name/Location	Managing Agency	Notes
Huckleberry Ridge	RAWS	Does not operate during the winter at this time
Chehalis	RAWS	
Chehalis-Centralia Airport	National Weather Service	
Francis	LARC National Weather Service	Near the Chehalis River basin
Boisfort Peak	ALERT	
South Fork Chehalis River near Wildwood	USGS	
Cinebar	LARC National Weather Service	
South Fork Newaukum River near Onalaska	USGS	
North Fork Newaukum River near Forest	USGS	
Olympia Airport	National Weather Service	Near the Chehalis River basin
Wynoochee Lake		
Elk Meadows		
Wishkah Headworks	Corps of Engineers	
Citizen Weather Observer station Napavine[1]	APRS/CWOP[2]	
Citizen Weather Observer station Centralia[1]	APRS/CWOP[2]	
Hydrologic Remote Sensing Center Centralia[1]	USGS	At the Centralia stream gauge 12025500
WDFW Skookumchuck Dam Hatchery[1]	Thurston County	Under construction
Black River at 128th Ave, Littlerock[1]	Thurston County	At the Black River stream gauge (1989-present)
Scatter Creek at James Road[1]	Thurston County	At the Scatter Creek stream gauge (2006-present)

[1] Not used by the National Weather Service for forecasting
[2] Automated Position Reporting System/Citizen Weather Observer Position

Wetlands

Wetlands, as defined in RCW 36.070A.030, are those areas inundated or saturated by surface water or groundwater at a frequency and duration to support vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. They may also include wetlands artificially created as mitigation when wetlands were converted to other uses. Wetlands do not include artificial wetland areas that have been unintentionally created from irrigation, drainage ditches, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, or landscape amenities.

Wetlands are important to flood hazard management because they serve natural retention and detention functions. They store water above and below the ground surface, reducing the volume and velocity of floodwaters downstream and thus decreasing downstream erosion. Wetlands also improve water quality and provide habitat for a wide range of plants and animals. Maintaining wetlands, particularly those located in floodplains, is one of the most cost-effective ways to reduce the adverse effects of flooding and erosion and to support healthy ecosystems.

The Chehalis River contains a diverse wetland mosaic throughout the basin. Estuarine and tidal wetlands combine with forested, scrub-shrub, emergent, and riverine wetlands to create a complex wetland ecosystem at the mouth of the river in Grays Harbor. Between Montesano and Porter, most wetlands are restricted to the riparian areas and floodplain between the river and Highway 12 to the north. These also include a variety of emergent, forested, and scrub-shrub wetlands. At Porter, floodplain wetlands generally shift to the south and west side of the riverbed. These include forested, scrub-shrub, emergent, and riparian wetlands. Upstream from Porter to the headwaters, the floodplain is laced with forested, emergent, scrub-shrub, and riparian wetlands. These wetlands range from temporarily flooded to seasonally and permanently flooded. Most of the wetland vegetation is considered broad-leaved deciduous.

The East Fork Satsop Subbasin contains approximately 4 percent wetland and open water land use. The Wynoochee Subbasin contains approximately 1 percent of wetland and water land use. Approximately 6 percent of land use in the Lower Chehalis River Subbasin is designated wetlands/water use. Although the Grays Harbor area still contains an extensive wetland system, approximately one-third of the historic wetlands in this area have been lost to development and agricultural activities.

Important water storage, water quality, and flood control issues provided by existing wetlands in the basin have made wetland protection and mitigation priorities for the local jurisdictions. Restoration and creation of wetland habitat could be implemented basin-wide to compensate for impacts and to enhance natural processes that reduce the volume and duration of floodwaters. Funding is not currently available for these projects. A basin-wide inventory of potential mitigation sites would need to be completed to prioritize and plan wetland mitigation and restoration projects within the river basin.

Fish

Fish and wildlife presence in the Chehalis River Basin has been addressed in various, recent watershed planning documents (Chehalis Basin Partnership, 2008; Washington State Conservation Commission, 2001; WDFW, 2008). These issues have recently focused on the health of fish species that inhabit the river basin, due to their cultural, recreational, and economic importance.

The 180 lakes, reservoirs, ponds, and streams in the Chehalis River Basin provide a variety of habitats for fish species. Upland tributaries are generally cold, high elevation, and high velocity streams. These waterbodies transition into warmer, low elevation streams that meander through river valleys. The basin is host to significant tribal, sport, and commercial fisheries. Documented salmonid species in the basin include fall, spring, and summer Chinook; coho; fall chum; cutthroat trout; and summer and winter steelhead. Bull trout/Dolly Varden presence is documented from the mouth of the Chehalis River downstream of Centralia. Historic presence is documented on tributaries near the mouth of the river.

Cutthroat trout presence is documented in most perennial tributaries and mainstem reaches of the Chehalis River Basin in one or more of their life history forms. Anadromous and fluvial cutthroat trout inhabit mainstem and accessible tributary reaches and the resident form is found above and below anadromous barriers. In areas below fish barriers, this species mixes with anadromous fish. Adfluvial (fish that live in lakes and migrate into rivers or streams to spawn) cutthroat trout inhabit many lakes in the Chehalis River system. Current status is unknown but considered abundant and widely distributed throughout the basin.

Upper Chehalis River Subbasin

Fall Chinook and Spring Chinook spawning is documented between Porter and Centralia in the Lower Chehalis River. In the Upper Chehalis River, Fall Chinook and Spring Chinook presence is documented between Centralia and Chehalis. Fall Chinook spawning is documented between the City of Chehalis and the mainstem river near the confluence with Hull Creek. Spring Chinook spawning is documented on the mainstem between Chehalis and the confluence with Thrash Creek. Upstream of these areas along the mainstem, presence is documented. Fall Chinook and Spring Chinook spawning is documented along the entire reach of the South Fork Chehalis River. Presence and spawning of coho salmon are documented from Porter to the headwaters of the South Fork and mainstem Chehalis River. Fall chum spawning is documented along the Lower Chehalis River between Porter and the confluence with the Black River. Presence of bull trout/Dolly Varden is documented from Grays Harbor to just downstream of the confluence with Independence Creek on the Lower Chehalis River. Winter steelhead presence, rearing, and spawning are documented from Porter to headwaters of the South Fork and mainstem Chehalis River (WDFW, 2008). Cutthroat trout presence is also documented along the Upper Chehalis River (Chehalis Basin Partnership, 2008).

Newaukum River Subbasin

Fall Chinook spawning is documented along the entire reach of the Newaukum mainstem, from the confluence with the Chehalis River to the headwaters of the North and South Fork tributaries. Spring Chinook spawning is documented along the entire mainstem Newaukum; spawning and presence are documented along the Newaukum River tributaries (WDFW, 2008). According to some studies, fall, spring, and summer Chinook use the mainstem for spawning, rearing, and migration; coho and steelhead trout use the mainstem for rearing and migration; and cutthroat trout are present throughout the subbasin (Chehalis Basin Partnership, 2008).

North Fork Newaukum River

Fall Chinook, spring Chinook, and coho salmon spawning are documented along the entire reach of the North Fork Newaukum River (WDFW, 2008). Steelhead trout have also been documented along this tributary (Chehalis Basin Partnership, 2008).

South Fork Newaukum River

Fall Chinook spawning is documented along the entire reach of the South Fork Newaukum River. Spring Chinook spawning is documented from the confluence with the mainstem just south of the headwaters, where presence is documented. Spawning, rearing, and presence of coho salmon are documented along the South Fork Newaukum tributary.

Skookumchuck River Subbasin

Fall Chinook and spring Chinook spawning is documented from the confluence of the Skookumchuck River with the Chehalis River to just west of the Skookumchuck Reservoir. Fall Chinook rearing habitat is documented directly west of the reservoir. Coho salmon spawning is documented from the confluence with the Chehalis River to the Skookumchuck Reservoir. Historic presence of coho salmon is documented from the reservoir to the headwaters (WDFW, 2008). Winter steelhead and cutthroat trout presence is also documented within the Skookumchuck watershed (Chehalis Basin Partnership, 2008).

Lower Chehalis River Subbasin

Fall Chinook rearing and spawning is documented from the town of Porter to the mouth of Grays Harbor. Spring Chinook and winter steelhead presence and rearing is documented between Grays Harbor and Porter. Summer Chinook presence is documented between Grays Harbor upstream of the confluence with the Satsop River. Coho salmon rearing is documented between the mouth of the Chehalis River at Grays Harbor and Porter. Fall chum presence and spawning is documented from the mouth of the Chehalis to Porter in the Lower Chehalis subbasin. Presence of bull trout/Dolly Varden is documented from Grays Harbor to Porter. Summer steelhead presence is documented between the mouth of the Chehalis River to the confluence with the Wynoochee River (WDFW, 2008). Cutthroat trout are also present along this reach of the mainstem and continue into the Upper Chehalis subbasin (Chehalis Basin Partnership, 2008).

Black River Subbasin

Coho, fall Chinook, and chum salmon, as well as winter steelhead trout, are present in the Black River Subbasin. Coho salmon spawning is widely distributed in the tributaries to the Black River (Washington State Conservation Commission, 2001). Chinook spawning has been documented in the lower mile of Waddell Creek and throughout the mainstem (WDFW, 2000). Winter steelhead spawning has been documented in the lower seven miles of the mainstem and in many of the tributaries. Chum salmon were once very abundant in the Black River, but their numbers dropped significantly in the 1970s for unknown reasons (Phinney and Bucknell, 1975 in Washington State Conservation Commission, 2001). Chum salmon have since been documented in the lower 10 miles of the Black River.

Satsop River Subbasin

Fall Chinook, Summer Chinook, fall chum, and winter steelhead spawning are documented along the mainstem Satsop River, from the confluence with the Chehalis River to the headwaters of the East, Middle, and West Fork tributaries. Coho rearing and spawning are documented along the mainstem from the confluence with the Chehalis River to the East, Middle, and West Fork tributaries. Historic presence of bull trout/Dolly Varden is documented from the confluence with the Chehalis River to the headwaters of the West Fork tributary (WDFW, 2008). Cutthroat trout also occur in the Satsop Subbasin (Chehalis Basin Partnership, 2008).

East Fork Satsop

Fall Chinook and fall chum salmon spawning is documented along the entire reach of the East Fork Satsop River. Summer Chinook and coho spawning and presence are documented along the East Fork and its tributaries. Presence, spawning, and rearing of winter steelhead are documented along the East Fork Satsop River.

Middle Fork Satsop

Fall Chinook, fall chum, and winter steelhead spawning is documented along the entire reach of the Middle Fork Satsop River. Summer Chinook presence is documented along the Middle Fork. Spawning and presence of coho salmon are documented along this tributary system.

West Fork Satsop

Fall Chinook and fall chum salmon spawning is documented along the entire reach of the West Fork Satsop River. Summer Chinook and coho rearing and spawning are documented along the West Fork. Historic presence of bull trout/Dolly Varden is documented on the West Fork tributary. Winter steelhead presence, rearing, and spawning are documented along the West Fork Satsop tributary.

Wynoochee River Subbasin

Fall Chinook spawning is documented along the Wynoochee River from the confluence with the Chehalis River to the south end of Wynoochee Lake. Between Wynoochee Lake and the headwaters, fall Chinook presence is documented. Coho, fall chum, and winter steelhead spawning and rearing is documented from the confluence with the Chehalis River to the headwaters of the Wynoochee River. Historic presence of bull trout/Dolly Varden is documented along the Wynoochee River. Presence of summer steelhead is documented from the confluence with the Chehalis River and potential presence is documented from south of Wynoochee Lake to the headwaters (WDFW, 2008). Cutthroat trout are also present in the Wynoochee watershed (Chehalis Basin Partnership, 2008).

Endangered Species Act Issues

The Chehalis River watershed is high in fish species richness and diversity. Bull trout/Dolly Varden is the only species listed on the Endangered Species List in WRIA 22/23. The Olympic Peninsula Bull trout/Dolly Varden population was listed as federally threatened by the U.S. Fish and Wildlife Service (USFWS) in November 1999. Bull trout/Dolly Varden is considered a species of concern by WDFW. Several salmonid stocks are listed as depressed in the WDFW 2002 draft Salmonid Stock Inventory (SaSI): Satsop summer Chinook, Wynoochee fall Chinook, Hoquiam winter steelhead, and Humptulips fall Chinook.

Analysis of the limiting factors affecting bull trout has been performed for the Chehalis River and the four major subbasins. Grays Harbor, the Chehalis River upstream to and including the Satsop River, and portions of the Wishkah, Wynoochee, and Humptulips Rivers used by salmon and steelhead, have been identified as current or potential habitat for bull trout foraging, migration, and overwintering. This habitat is important for bull trout recovery in the Olympic Peninsula. Limiting factors identified within the basin pertain to riparian conditions (i.e., channel incision, sedimentation, riparian loss or conversion); water quality issues; reduction in stream flow; elevated water temperature; and low dissolved oxygen levels (Chehalis Basin Partnership, 2008).

Upper Chehalis River Subbasin

The entire Upper Chehalis subbasin has been impacted by timber production as a predominant land use combined with high road densities that were established prior to forest practices regulations. Two splash dams constructed on the Upper Chehalis led to channel incision and scouring, loss of gravel beds, and loss of large woody debris.

Sedimentation is an issue in this subbasin in areas with moderate to steep slopes and in areas with high road densities. Landslides are a primary source of sedimentation in this area and tend to occur in conjunction with storm events and timber harvesting.

Riparian and floodplain conditions have degraded due to vegetation removal, agricultural land use, timber harvesting, and channel incision. Significant riparian vegetation loss has occurred along the mainstem between the confluence with the South Fork Chehalis and

Pe Ell. Floodplain connectivity is limited in some areas because of riprap that has been placed on the channel banks.

Large woody debris presence is an ongoing issue in this subbasin due to removal of riparian vegetation (mostly from timber harvesting) and agricultural practices that have reduced channel width. Some reaches contain narrow corridors of larger trees and provide opportunities for large woody debris recruitment along the mainstem.

A major limiting factor for salmonid production in the Upper Chehalis subbasin is a lack of summer rearing habitat. Quantity and spacing of pools is generally poor, and existing pools have been found overall to be shallow and lacking in sufficient cover and LWD. Timber harvesting and increased runoff are leading causes of increased flows that have reduced pool habitat in the subbasin.

Newaukum River Subbasin

Land use along the Newaukum River is dominated by agriculture with surrounding timber harvesting. A dam on the North Fork Newaukum blocked fish passage until 1970. This dam currently serves the City of Chehalis to augment their water supply.

Riparian conditions along the mainstem Newaukum are degraded, with little to no riparian vegetation present. Current conditions consist of open/hardwood or non-forested habitat, as the river valley has largely been converted to agricultural and rural residential use. The headwater regions of the North and South Fork tributaries are considered to be in good condition. The middle and lower regions of these two tributaries are considered to be in fair to poor condition. The Middle Fork Newaukum contains fair to poor riparian conditions due to the same land use changes in the watershed.

Base flows requirements are not met on average 59 days per year at the gauging station near Chehalis, and peak flows have increased within the subbasin. Contributing factors include water withdrawals, changes in land use, and loss of wetland habitat.

Fish access is restricted by culverts at road crossings on tributaries, and many culverts are undersized. Upstream flows frequently occur at high velocities or at perched outfalls inaccessible to fish.

Floodplain habitat and meandering channels are reduced by riprap and construction of dikes and roads in the floodplain. Loss of wetlands has reduced water storage capacity within the floodplain as well. Beaver activity has declined, which has resulted in a loss of floodplain connectivity with stream and tributary habitat. In addition, gravel removal operations during construction of Interstate 5 may have contributed to channel incision along the Newaukum River. The Interstate acts as a dike along the lower reaches of the river.

High levels of sediment input are caused by high road densities, associated landslides, and bank erosion issues. Additional data are needed to quantify sediment issues in the Newaukum Subbasin.

The Newaukum Subbasin has not been inventoried for large woody debris quantities, although levels are expected to be low due to historic practices of instream wood removal and low recruitment potential from a lack of riparian vegetation.

Skookumchuck River Subbasin

Fish habitat in the Skookumchuck subbasin has been affected by timber harvesting and historic presence of three splash dams that were constructed in the 1920s. The splash dams were interspersed along the Skookumchuck River. They blocked approximately 50 to 90 percent of upstream fish access. In addition, the dams contributed to channel incision and a reduction of off-channel habitat for fish.

Loss of floodplain function in the Skookumchuck subbasin can be attributed to several factors. Ditching and channel realignment, particularly in the lower watershed, have reduced the potential for water storage. Construction of roads and other developments within the floodplain have limited river mobility and floodplain connectivity. Placement of riprap has led to channel confinement and flooding issues in some areas.

Riparian conditions along the Skookumchuck are considered poor and large woody debris recruitment potential is low. Primary causes in the lower reaches include agricultural land use, urban and suburban development, and timber harvesting in the lower Skookumchuck and its tributaries. In the upper watershed, conversion from coniferous to hardwood and open canopy forest has resulted in degraded riparian conditions.

The Skookumchuck Dam is the primary fish access barrier in the watershed, which blocks approximately 3.6 miles of Chinook and 8 miles of coho habitat. Steelhead trout are trucked above the dam. Smaller barriers, such as culverts, are located throughout the subbasin. Undersized stream culverts limit upstream fish access in some portions of the watershed.

Summer low flows are an issue on the Skookumchuck, largely due to the Skookumchuck Dam. The dam removes water for industrial purposes; additional water rights along the river include irrigation, mining, gravel, and livestock watering. Instream flows are not met along the Skookumchuck approximately 33 days each year.

Sediment levels in the Skookumchuck watershed are estimated to be high. Contributing factors include high road densities of 5.4 miles of road per square mile of drainage (Chehalis Basin Partnership, 2008). In addition, fine sediments and gravels are obstructed from reaching downstream areas of the watershed beyond the Skookumchuck Dam.

Large woody debris levels are low throughout the subbasin and recruitment potential is low because of poor riparian conditions. Large woody debris is collected and removed at Skookumchuck Dam.

Chehalis River Mainstem and Lower Chehalis Subbasin

Over 100 miles of the Chehalis River mainstem riparian habitat has reduced shading caused by the predominance of agricultural land use. In the lower Chehalis Subbasin and the Chehalis-Centralia reach, urbanization is the leading cause of vegetation loss along the river.

Between RM 1 and RM 11, floodplain habitat is rated good. Some off-channel habitat has been lost between RM 13 to 20. Some channel incision has occurred between Satsop and Grand Mound (RM 20 to 57), although this issue is more severe upstream (RM 57 to 79). The upstream area is incised and disconnected from the floodplain and off-channel habitat. Causes of channel incision include historic presence of splash dams on the mainstem, historic removal of large woody debris, and low recruitment of large woody debris. Large woody debris presence and recruitment are generally low along the mainstem, although more data is needed.

Poor water quantity conditions are reported at the Porter and Grand Mound gauges. According to 2001 records, water rights along the mainstem exceeded summer instream flows by 400 percent. In addition, aquifer recharge opportunities are lacking due to high levels of impervious surface within the basin. This is critical because groundwater is the primary water source in the basin, particularly during the summer months.

Sediment transport is a concern along the mainstem channel, primarily because of high sediment loading from tributaries and a lack of large woody debris. The majority of sediment loading comes from the Satsop River, Wynoochee River, Newaukum River, South Fork Chehalis River, and the mainstem Chehalis River above Doty. Shallow, rapid landslides, particularly associated with tributaries and clearcut regions on steep slopes, also contribute to sedimentation. Lack of riparian vegetation, combined with urbanization and agricultural land use also cause sediment issues.

Black River Subbasin

Salmon and steelhead spawning habitat in the Black River drainage is primarily in tributaries because the majority of the mainstem has a mud or fine sediment bottom due to the extremely low gradients. It is somewhat different in character from many Olympic Peninsula rivers in that it flows through large expanses of swamp, marsh, and sloughs surrounded by relatively undisturbed riparian habitat (Washington Department of Game, 1980 in Washington State Conservation Commission, 2001). The Black River has a relatively low sediment yield. The average annual suspended sediment yield for the Black River near Oakville was 20 tons per year (Chehalis Tribe, 2009). Sediment input is mainly from bank erosion due to roads and other related development nearshore.

Much of the off-channel and floodplain habitat has been filled, drained, or channelized in the lower reaches of the Black River and its tributaries for residential and agricultural development. The eastern tributaries of the Black River have been channelized for irrigation, and there has been some confinement of stream channels from roads and a railroad line. The artificial fill embankments and approaches associated with the three bridges that span the Black River constrict the floodplain to various degrees. Levees constructed at two locations also serve to constrain the channel. Riprap is located in 42 sites within the lower Subbasin (Washington State Conservation Commission, 2001).

The lower and upper middle portions of the Black River mainstem flow through residential and agricultural lands with only a narrow buffer of trees. Riparian conditions in these areas are considered "poor." The lower middle and upper portions of the Black River mainstem flow through native wetland and marsh habitat where riparian conditions are considered "good."

Water quality conditions in the Black River vary along the mainstem with the different levels of vegetation and development. The water quality of Black Lake has historically been very degraded, though improvements have been made in recent years. Because of the preponderance of water quality and flow problems in the Black River, the Black Lake drainage issue is very important to the fish resources in the Black River.

The Black River and some of its tributaries are closed to further consumptive water appropriations in the dry season (Ecology, 1998). For these reasons, water quantity conditions in the Black River are rated "poor."

Satsop River Subbasin

The mainstem Satsop River has experienced channel incision due, in part, to gravel and timber harvesting in the riparian corridor. Large amounts of riprap occur in the lower portion of the mainstem Satsop River, which contribute to channel incision and channelization.

Overall, the riparian conditions are considered poor along the mainstem. Approximately 79 percent of the mainstem Satsop is lacking riparian vegetation or is dominated by hardwoods as a result of agricultural and forest management practices. The upper reaches of the West Fork Satsop are rated as good riparian habitat due to coniferous habitat and large woody debris recruitment. Downstream reaches of the tributary contain hardwoods or lack riparian vegetation and are rated as poor habitat. The Middle Fork Satsop contains poor riparian habitat conditions and does not significantly contribute large woody debris. Significant riparian habitat loss is present in the middle and lower reaches of the tributary. Riparian conditions along the East Fork Satsop are also considered poor.

Undersized stream crossing structures in the subbasin have compromised fish access to upstream areas of the subbasin due to water velocity and perched outfall issues. These structures also inhibit downstream movement of streambed material, which contributes to channel scour.

The Satsop Subbasin has not been inventoried for large woody debris quantities. However, large woody debris levels are estimated to be low because of historic splash dams, large woody debris removal from streams, and poor large woody debris recruitment potential in the subbasin. Riparian corridors in the middle and lower West Fork tributary have largely been converted from coniferous habitat to deciduous habitat, contributing to low levels of large woody debris.

Sedimentation is one of the primary concerns in the Satsop Subbasin. Leading causes include high road densities in the watershed, sediment transport from the east, middle, and west fork tributaries, and extensive logging. The West Fork Satsop receives high levels of sediment input from landslides and impervious surfaces. The West Fork is listed as threatened by Ecology for siltation and suspended solids. This tributary also lacks sufficient large woody debris to retain and sort stream substrate suitable for spawning habitat. In the Middle Fork Satsop, a high number of debris torrents and high road densities contribute to sediment issues, as well as instream vehicle activity. The East Fork Satsop has been listed as threatened by Ecology for sediment and siltation. Contributing factors include high road densities and vehicle activities in stream channels; however, more data are needed to quantify sedimentation sources.

Water quantity issues within the subbasin include both summer low flows and high peak flows, which are a result of land use practices (forestry, agriculture, and rural residential). The Satsop River has not met established base flows for approximately 63 days per year in recent years (Chehalis Basin Partnership, 2008). However, more data are needed to clarify the source of these issues.

Wynoochee River Subbasin

Fish access to upstream areas of the Wynoochee watershed is limited by the number of barrier culverts (225) and others that provide unknown upstream accessibility (55). Timber harvesting practices have led to high road densities, and old roads have been reopened leaving barrier culverts. In addition, fish passage along the Wynoochee River is impeded at the Wynoochee Dam (RM 47.8), which marks the uppermost extent of natural fish migration along the river.

Timber harvesting and agricultural land use have degraded riparian conditions in the watershed. Livestock access in lower portions of the watershed has also contributed to degraded habitat. Overall riparian conditions range from fair to poor in the subbasin.

Shoreline armoring and diking used to protect farmlands and residential development in the lower reaches has reduced floodplain connectivity. Channel incision and scouring have also reduced floodplain conditions, due in part to historic floodplain mining and ongoing timber harvesting. Severe flooding, dam operations, and gravel scouring associated with farming and logging land uses have resulted in loss of off-channel habitat.

The Wynoochee River is the second largest contributor of sediment to the Chehalis River in the basin. Agricultural land use and livestock access to streams have contributed to sediment loading. Other sources include side roads failing and blocked or undersized culverts creating saturated fill slopes. Juvenile salmonids are subject to excessive predation in the Wynoochee drainage, caused in part by sports fishermen who travel at high speeds along shorelines and stir up sediment where juvenile salmonids occur. This causes the juveniles to venture into deeper waters where they become prey for larger fish. The Wynoochee Subbasin is naturally prone to landslides because of steep slopes and shallow soils, but timber harvesting, road construction, and agricultural practices have left slopes less stable by removing riparian vegetation and large woody debris, accelerating flows, reducing gravel retention, and causing channel incision.

Large woody debris presence and recruitment in the subbasin are considered poor. This contributes to accelerated substrate transport, channel incision, lack of channel complexity, and gravel retention in upstream areas. Reaches just below Wynoochee Dam are heavily managed for timber harvesting and provide little opportunity for large woody debris recruitment. Downstream reaches are dominated by agricultural land use, where large woody debris presence is limited due to conversion of conifers to hardwoods and open canopy forest.

Water quantity conditions are considered poor overall for the Wynoochee drainage. Low summer flows are associated with increased runoff from logging operations and dam operations, which maintain flow levels across seasons.

Water Quality

The Department of Ecology (Ecology), under authority of state law and direction of the federal Clean Water Act (CWA), is responsible for determining appropriate water quality standards and classifying water bodies. These surface water quality standards are intended to protect the beneficial water uses of the state waters such as swimming, fishing, aquatic life habitat, and agricultural and domestic water supplies. The water quality standards establish water quality goals for lakes, rivers, and marine waters.

Ecology implements water quality standards under Section 303 of the CWA, which requires it to identify the state's polluted water bodies and submit a list of these water bodies to EPA every two years. Ecology uses monitoring data to identify locations where water quality standards are being violated. From this data, Ecology makes a determination about the severity and potential causes of water quality violation and prepares the 303(d) list. The 303(d) list identifies the locations of impaired water bodies and tells which water quality standards each exceeds, and by how much. The 2008 303(d) list was released in January 2009.

Upper Chehalis River Subbasin

The Upper Chehalis River includes several reaches that contain water quality issues identified on the 303(d) list of impaired waters. Between RM 102.6 and 104.3, the Chehalis River is listed for dioxin (Lewis County). This reach of the Chehalis was listed previously on the 2004 303(d) list of impaired waters. Between RM 104.3 and RM 106.9, the Chehalis River is listed for elevated PCB levels (Lewis County). This reach along the Chehalis was previously listed for the PCB parameter in 1996, 1998, and 2004. The Chehalis River was also listed on the 2004 and 2008 303(d) lists for high turbidity between RM 123.2 and RM 124.7 (Lewis County).

In 2000, Ecology conducted aquatic surveys along the Chehalis River and found two invasive, aquatic species of vegetation: Brazilian elodea (*Egeria densa*) and parrotfeather (*Myriophyllum aquaticum*). The two species were observed between RM 100.8 and RM 102.3 in Lewis County. Presence of these two species merited a Category 4C listing in

2004 and 2008 for Invasive Exotic Species. Category 4C Waters are defined as follows: "Waters where some characteristic uses of a waterbody segment may be impaired due to aquatic habitat degradation that is not the result of a pollutant."

Additional water quality issues occur in the Upper Chehalis watershed but do not merit listing by Ecology on the 303(d) list of impaired waters. Warm water temperatures and low dissolved oxygen levels have been documented in the Upper Chehalis. These are likely caused by loss of riparian vegetation, conversion of habitat, livestock waste, sedimentation, decreased streamflow, industrial inputs, and urban stormwater runoff. Wetland loss has also contributed to a reduction in water quality in this subbasin but the extent has not been quantified.

Newaukum River Subbasin

The Middle Fork Newaukum River has been listed on the 2008 303(d) list of impaired waters for dissolved oxygen between RM 1.4 and RM 3.2. Poor riparian conditions are present in the watershed, particularly a lack of riparian vegetation. However, additional data are needed to quantify the source of water quality issues along this waterbody.

Other water quality issues are present along the mainstem Newaukum and the North and South Fork tributaries. These do not merit listing on the 303(d) list of impaired waters but do warrant further attention. Elevated stream temperatures and fecal coliform issues along the mainstem Newaukum have been caused by lacking canopy cover, livestock access to streams, and failing septic systems. In the North and South Fork tributaries, elevated summer stream temperatures are likely caused by lack of riparian canopy cover and low summer flows. High turbidity within the North Fork Newaukum is caused by a combination of livestock access to streams, high road densities, landslides, and erosion.

Skookumchuck River Subbasin

The Skookumchuck Subbasin is not currently listed on the 303(d) list of impaired waters. However, several water quality issues have been identified that affect instream and riparian habitat in the watershed. The lower Skookumchuck River contains elevated temperatures, pH, and fecal coliform levels near the mouth of the river. Likely causes include loss of riparian habitat, livestock access, stormwater runoff, and sedimentation.

Chehalis River Mainstem and Lower Chehalis River Subbasin

The Chehalis River has been listed for the PCB and mercury parameters on the 2008 303(d) list of impaired waters between RM 24.5 and RM 25.8 in Grays Harbor County. Additional water quality issues in the Lower Chehalis watershed that do not merit a listing under the Clean Water Act are discussed below.

Primary causes of water quality issues along the mainstem Chehalis River stem from riparian degradation and loss, leading to high water temperature levels. In addition, high sediment loads have resulted in poor width-to-depth ratios. Low dissolved oxygen has been an ongoing issue, likely caused by livestock waste, urban stormwater runoff, food processing plants, upstream dairies, and sewage discharge.

Black River Subbasin

The combination of low water velocity, high nutrient concentrations, high productivity, and stratified pools creates naturally low dissolved oxygen levels in the Black River. This condition has been magnified from land use practices along the river, such as agriculture and aquiculture (Ecology, 1989). There is also a lack of LWD in the downstream segments of the river. Other contributing factors include urban stormwater and fertilizers.

Although clean-up programs in the 1990s have improved water quality problems associated with dairy farms along the river, the Black River continues to be listed on the 2008 303(d) List for warm water temperature, fecal coliform, and dissolved oxygen (Ecology, 2009).

Satsop River Subbasin

The Satsop River is not currently listed by Ecology on the 303(d) list of impaired waters. Several water quality issues have been identified along the mainstem and tributary streams in the Satsop watershed that may impact instream and riparian conditions. Siltation and suspended solids have been identified as water quality issues in the Satsop River Subbasin and are caused by unspecified nonpoint sources.

The West Fork tributary is listed as threatened by Ecology for siltation and suspended solids. This tributary receives high levels of sedimentation from landslides and roads. This area of the watershed also lacks sufficient LWD to sort and retain course stream substrate for spawning habitat. High water temperatures occurring along the West Fork Satsop are due to the conversion of coniferous to hardwood forest in lower portions of the watershed, and from forest habitat to agricultural and rural residential land use in the lower watershed areas.

Rabbit Creek, a tributary to the Middle Fork Satsop, was previously listed for elevated water temperature. This is likely due to riparian conditions in the subbasin, such as lack of riparian vegetation.

The East Fork tributary is listed by Ecology as threatened for siltation and suspended solids. The primary source has been identified as unspecified nonpoint sources, although additional data are needed.

Wynoochee River Subbasin

Ecology has not listed the Wynoochee River drainage on the 303(d) list of impaired waters. However, elevated temperatures and sediment pose water quality issues for the Wynoochee River Subbasin. Primary causes include dam operations, livestock access, and timber harvesting.

SOCIOECONOMIC CHARACTERISTICS

History

The Chehalis River Basin was historically inhabited by Salish-speaking indigenous tribes and then home to European settlers who lived and worked the land within the basin in the 1800s (Chehalis Basin Partnership, 2004). The Chehalis River and its tributaries provided a vast amount of food in salmon and other fish, seals, and shellfish, the forests provided deer, elk, and berries, and the meadows provided tubers, and roots. Most travel was on foot or by canoe. Historically Grays Harbor has provided access to cities and ports up the Chehalis River for commercial shipping.

European settlers brought small farm agriculture practices to the floodplains and valleys. They drained wetlands, cut riparian forests, and grew crops for food or livestock feed. Farmers built small dams on creeks for irrigation and employed slash and burn techniques in order to clear forested areas for livestock grazing. Most early European residents were subsistence farmers.

Forests were harvested by early settlers and timber companies using streams and rivers as primary transport. Splash dams caught freshly cut timber and once back filled the water was released sending the logs down river, frequently demolishing stream banks and riparian habitat. Railroads were built throughout the region to transport milled timber and other goods.

Land Use

The majority of the Chehalis Basin (87 percent) is forestland. Most forested acres are private or government-owned lands. These forests are an important factor in preserving watershed integrity because harvest practices within the basin have direct impact on Chehalis River water quality and flood management. Development is primarily clustered within floodplains and valleys. Forty-two percent of all developed land within the basin lies within one mile of the major Chehalis Rivers. Land uses include agriculture, urban, or industrial development. Developed segments of these water bodies account for almost half the length of the major rivers in the basin. Industrial development is focused around the Chehalis/Centralia and Aberdeen/Hoquiam areas as well as the coal mine/power plant site south of Bucoda. The main use of industrial water is in the manufacturing of wood, pulp, and paper product (Chehalis Basin Partnership, 2004).

Agriculture makes up 7 percent of land use in the basin. Dairy, livestock, and crop farms are located mainly in the low-lying valleys adjacent to the Chehalis River and its major tributaries. Most common crops include hay and silage, vegetables and small grains, as well as pasture (Chehalis Basin Partnership, 2004).

Table 2-6 summarizes the major land uses within the subbasins of the Chehalis River Basin (Chehalis Basin Partnership, 2004).

Table 2-6 Three Major Land Uses within the Chehalis River Basin

Major Land Use by Sub-basin						
Name	**Primary Use**		**Secondary Use**		**Tertiary Use**	
Upper Chehalis	Forest	82%	Agriculture	17%	Urban/Industrial	1%
Middle Chehalis #1	Forest	69%	Agriculture	21%	Urban/Industrial	9%
Middle Chehalis #2	Forest	78%	Agriculture	15%	Urban/Industrial	6%
Lower Chehalis #1	Forest	79%	Urban/Industrial	15%	Agriculture	6%
Lower Chehalis #2	Forest	66%	Urban/Industrial	24%	Wetlands/Water	6%
North Fork Newaukum	Forest	95%	Agriculture	5%		
South Fork Newaukum	Forest	91%	Agriculture	6%		
Skookumchuck	Forest	88%	Agriculture	8%	Urban/Industrial	2%
East Fork Satsop	Forest	96%	Wetlands/Water	4%		
Middle Fork Satsop	Forest	99%				
West Fork Satsop	Forest	94%	Agriculture	3%	Urban/Industrial	1%
Wynoochee	Forest	95%	Agriculture	3%	Wetlands/Water	1%

The most populated portions of the basin are located in the Lower Chehalis River subbasin. Major population centers in the upper basin include the cities of Chehalis and Centralia with populations of approximately 6,000 and 12,000, respectively, and at the mouth of the Chehalis the cities of Aberdeen and Hoquiam with populations of approximately 16,000 and 9,700, respectively (Chehalis Basin Partnership, 2004).

CHAPTER 3 REGULATORY OVERVIEW

This chapter provides an overview of existing federal, state, and local regulatory and permitting requirements that relate to flood hazard management, surface water management, water quality, and wetlands protection. It summarizes local regulations for each of the jurisdictions in the Chehalis River Basin Flood Authority.

Summary of Existing Regulations

Many laws that address flood hazard management directly or indirectly have been enacted at the federal, state, and local levels. Table 3-1 lists federal and state laws in the categories of flood hazard management, stormwater management, sensitive areas.

Most federal laws are implemented at the state and local levels. For example, the federal Clean Water Act regulates stormwater discharge, but the EPA has delegated the responsibility of administering the program to the Washington State Department of Ecology (Ecology). The National Flood Insurance Program, which offers affordable flood insurance to private property owners, is a national program administered by the Federal Emergency Management Agency (FEMA), but requires cities and counties to adopt floodplain regulations.

With the exception of the National Flood Insurance Program and the Endangered Species Act, the laws most relevant to flood hazard management originate at the state level. Most of these begin with state legislation that enables local governments to adopt regulations promoting public health, safety, and general welfare. Environmental laws that affect flood hazard management through habitat, shoreline, and other critical-area protection measures also exist at the state level, but enforcement is increasingly becoming the responsibility of local governments. State growth management requirements contain additional recommendations regarding land use and development near wetlands and in frequently flooded areas, with regulatory implementation largely in the hands of local jurisdictions.

Table 3-1. Overview of Major Federal and State Surface Water Management Regulations

Regulation	Implementing Agency	Purpose	Jurisdiction	Required Approval, Permit, or Plan	Applicability to Flood Hazard Management
FEDERAL					
Clean Water Act, Section 401	State agencies empowered by EPA (i.e., Ecology)	Ensures that federally permitted activities comply with the Clean Water Act, state water quality laws, discharge limitations, and other state regulations	Waters of the U.S.	Water Quality Certification or Modification	Structural measures affecting surface water will require Water Quality Certification or Modification
Clean Water Act, Section 402	State agencies empowered by EPA (i.e., Ecology)	Establishes permit application requirements for stormwater discharges under National Pollutant Discharge Elimination System (NPDES)	All stormwater discharge associated with industrial activity and from municipal storm sewer systems	Stormwater Discharge Permits	NPDES stormwater permit is required for jurisdictions applying for an individual NPDES permit
Clean Water Act, 404	COE	Regulates the discharge of dredged or fill material in rivers, streams, and wetlands	Waters of the U.S. including wetlands	Individual or Nationwide Permits	Dredging or filling in wetlands or the Yakima River will require permit
National Flood Insurance Act	FEMA	Offers affordable flood insurance to communities that adopt approved floodplain management regulations	Floodplains of the U.S.	Flood Insurance Study and approval letter from FEMA	Participation in NFIP requires minimum floodplain management regulations
Flood Disaster Protection Act	FEMA	Provides incentive to communities to join the NFIP by increasing amounts of flood insurance available and providing penalties for communities and individuals that do not join the NFIP and are subsequently flooded	Floodplains of the U.S.	Approval by FEMA	Requires purchase of flood insurance for funding by federally backed lending institutions for purchase of property in floodplains
National Environmental Policy Act	Varies (usually the federal agency issuing the permit)	Requires full disclosure of potential impacts associated with proposed actions and mitigative measures	All federal actions	Environmental Assessment and EIS	Regulates actions that may result in significant adverse environmental impacts
River and Harbor Act, Section 10	COE	Preserves the navigability of the nation's waterways	U.S. navigable waters	Section 10 permit	Regulates activities within the ordinary high water mark (OHWM) on navigable waters
Executive Order 11988	Federal Agencies	Protects floodplain from development by federal agencies	Federal projects	None	Enhances existing floodplain management regulations
Endangered Species Act	Federal Agencies	Protection of fish and wildlife habitat and evaluation of species health	Nationwide	Approval	Regulates activities in endangered species habitat
Executive Order 11990	Federal Agencies	Protects wetlands and evaluates impacts of proposed actions on wetlands	Federal projects, federally funded activities, or other activities licensed or regulated by federal agencies	None	Enhances existing wetland protection regulations
STATE					
SEPA	Varies (usually the local agency issuing the permit); circulation to state and federal agencies for review	Requires full disclosure of the likely significant adverse impacts associated with a proposed action and identification of mitigative measures	All proposed actions that require permits	Environmental Checklist or EIS	Requires environmental review of any project with potential adverse environmental impacts
Shoreline Management Act	Ecology; local jurisdictions when state approved	Manages uses of the shorelines of the state for protection of public interests and natural environment	All shorelines of the state (including all marine waters, lakes >20 acres, reservoirs, streams and rivers >20 cfs mean annual flow, and associated wetlands)	State or state-approved local shoreline permit	Applies to activities within the Chehalis River system, adjacent lands within 200 feet of the floodway or within the 100-year floodplain (whichever is less) and all associated wetlands
Senate Bill 5411 (ESSB 5411); Flood Control by Counties (RCW 86.12)	Counties	RCW 86.12 gives county governments the power to levy taxes, exercise eminent domain and take action to control and prevent flood damage. ESSB 5411 provides a greatly expanded role for counties in formulating and adopting drainage basin plans to address flooding and land use regulations	All drainage basins located wholly or partially within the County	Comprehensive Flood Hazard Management Plan	Allows for development of CFHMPs
Floodplain Management Program (RCW 86.16)	Ecology	Reduces flood damages and protects human health and safety. Department oversees local implementation of floodplain regulations required for participation in the NFIP.	All floodplains within the state	State approval of floodplain management programs and regulations	Provides eligibility for national flood insurance and for state matching funds to construct flood control facilities
State Participation in Flood Control Maintenance	Ecology	Assists local jurisdictions in comprehensive planning and flood control maintenance efforts	All flood hazard management activities of local jurisdictions as approved by Ecology	FCAAP grant application, approved CFHMP for maintenance grants	FCAAP funds available for preparation of CFHMPs, flood control maintenance projects, and emergency flood control projects
Water Pollution Control Act	Ecology	Empowers the state to develop, maintain, and administer the federal statutes and programs required by the federal Clean Water Act	All receiving waters of the state	Water Quality Certification/Modification	Regualtes activities that violate state water quality standards per the Clean Water Act
Hydraulic Code	WDFW	Protects fish, fish habitat, and wildlife habitat from damage by construction and other activities	All marine and fresh waters of the state and drainage corridors	Hydraulic Project Approval (HPA)	HPA is required for all activities within the OHWM of streams and along natural drainage corridors
Growth Management Act (GMA) (RCW 36.70A)	CTED	Requires comprehensive plans to include surface water considerations and facilities (quantity and quality).	Selected high-growth counties and their cities.	Comprehensive Plan	Requires adoption of development regulations and comprehensive plans
		Requires designation and regulation of critical areas, including wetlands and frequently flooded areas.	All Washington counties and cities.	Critical areas and resource lands designation.	Requires adoption of critical areas and resource lands ordinances regulating development in designated areas
Executive Order 90-04, Protection of Wetlands/Model Wetlands Protection Ordinance	Ecology	Provides guidance to local governments to achieve no net loss of wetland functions and values	State wetland buffers	None	Provides voluntary technical assistance to the local jurisdiction to regulate activities that affect wetlands

Key Federal Regulations

National Flood Insurance Program

In 1968, the U.S. Congress initiated the National Flood Insurance Program (NFIP) (Chapter 44 CFR) under the National Flood Insurance Act to relieve the burden of disaster relief on the national treasury, state and local tax bases. The NFIP is administered by the Federal Insurance Administration (FIA), which is part of FEMA. The NFIP makes available affordable flood insurance to communities that adopt approved community-wide floodplain management regulations. Communities that do not participate in the NFIP do not qualify for certain flood disaster relief.

Congress added several provisions to the NFIP under the Flood Disaster Protection Act of 1973 in order to strengthen the program. The 1973 act provided additional incentives to communities to join the NFIP by substantially increasing the amount of flood insurance coverage available and providing penalties for communities and individuals that choose not to join the NFIP. Specific new requirements include the following:

- Any acquisition or construction undertaken in identified special flood hazard areas requires purchase of federal flood insurance, if available.
- Purchase of properties in the floodplain to be secured under mortgages from a federally related lender require purchase of federal flood insurance, if available.
- Communities identified by FEMA as flood-prone have one year from the time of designation to enroll in the NFIP; otherwise disaster-assistance funds and federal financial assistance for acquisition or construction of property in flood hazard areas will be denied.

A community enters the regular NFIP program upon adoption of an ordinance approved by FEMA. A detailed flood insurance study that involves hydrologic and hydraulic analyses is normally performed and is referenced in the ordinance as the basis for the regulatory program. The products of the study are the Flood Insurance Rate Map (FIRM) and the Flood Insurance Study.

The Flood Insurance Study provides data on the width of the floodway and floodplain, the cross-sectional area, and the floodwater velocity at given points in the stream. FIRMs delineate areas adjacent to rivers and coastlines that are subjected to flood risks and an insurance rate is determined for each area. New FIRMs delineate flood insurance rate zones; limits of the 100-year floodway, 100-year floodplain; and 500-year floodplain. FIRMS also delineate areas of coastline flooding. FIRMs and associated insurance studies are available online and from FEMA.

The 100-year flood determines the geographic jurisdiction of NFIP-related programs. The 100-year flood is frequently called the “base flood” and is defined as the discharge that has a 1 percent chance of occurring or being exceeded in a given year. The 100-year floodplain is the area that would become inundated by water during the 100-year flood.

The floodway is an engineering concept incorporated into the NFIP floodplain management criteria. A floodway is the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to convey the base flood without cumulatively increasing the water surface elevation more than a certain amount (1 foot for NFIP). Floodways are calculated by FEMA for the 100-year base flood for major rivers and streams as part of the flood insurance study undertaken for a community.

Since 1990, communities that have adopted programs or regulations to reduce flood-related damages have been eligible to receive reduced insurance rates under the Community Rating System (CRS). The CRS is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. Communities must apply to FEMA to be certified for a rate reduction before policy holders within the community can receive a rate reduction. Flood insurance premium rates are discounted to reflect the reduced flood risk resulting from community actions

For CRS participating communities, flood insurance premium rates are discounted in increments of 5 percent; i.e., a Class 1 community would receive a 45 percent premium discount, while a Class 9 community would receive a 5 percent discount (a Class 10 is not participating in the CRS and receives no discount). The CRS classes for local communities are based on 18 creditable activities, organized under four categories:

- Public Information,
- Mapping and Regulations,
- Flood Damage Reduction, and
- Flood Preparedness.

Clean Water Act

The Clean Water Act of 1977 and the Water Quality Act of 1987 (amendments to the Federal Water Pollution Control Act) provide the backbone for national water quality policy and action. The goal is to eliminate pollutant discharges into “waters of the U.S.” Sections 401, 402, and 404 of the Clean Water Act (33 USC 1251 et seq., as amended by Public Law 92-500) are pertinent to surface water management activities.

CWA Section 401 - Water Quality Certification

Section 401 (40 CFR 121) ensures that activities requiring a federal permit (such as Corps Section 404 permit for filling of a wetland) comply with the Clean Water Act, state water quality laws, and other appropriate state regulations (e.g., the Hydraulic Code, Water Pollution Act). Compliance with Section 401 is required for any structural measures resulting in a discharge of dredge or fill material to all waters of the U.S. or non-isolated wetlands.

Section 401 is implemented through a certification process implemented by each state. Section 401 approvals are granted through a Water Quality Certification issued by a state agency. The certification ensures that federally permitted activities comply with water quality standards and discharge limitations. The implementing state agency has final authority on approval, denial, or development of special conditions for certification. The Certification is similar to a permit and is a prerequisite requirement for obtaining a Corps permit, a Federal Energy Regulatory Commission (FERC) license, or other federal permit.

CWA Section 402 - National Pollution Discharge Elimination System

Section 402 of the Clean Water Act established the system for permitting wastewater discharges, known as the National Pollutant Discharge Elimination System (NPDES). Under NPDES, all facilities which discharge pollutants from any point source into waters of the United States are required to obtain a permit. NPDES permits are issued by states that have obtained Environmental Protection Agency (EPA) approval to issue permits or by EPA Regions in states without such approval. The Water Quality Act of 1987 amended Section 402 with a new subsection regulating stormwater discharges. In Washington, the Department of Ecology (Ecology) issues NPDES permits.

There are two basic types of NPDES permits, individual and general permits. An individual permit is a permit specifically tailored to an individual facility. Once a facility submits the appropriate application(s), the permitting authority develops a permit for that particular facility based on the information contained in the permit application (e.g., type of activity, nature of discharge, receiving water quality). The authority issues the permit to the facility for a specific time period (not to exceed five years) with a requirement that the facility reapply prior to the expiration date.

A general permit covers multiple facilities within a specific category. A general NPDES stormwater permit is called a municipal permit. Under the 1987 revisions, NPDES permits were required for municipal stormwater discharges to surface waters. EPA developed rules to implement the new stormwater requirements in two phases. In Phase I, NPDES permits were required for stormwater discharges from cities and counties with populations greater than 100,000. In Phase II, communities with populations of at least 10,000 or designated as an “urbanized area” by the U.S. Census Bureau are also required to obtain permits.

For both Phase I and Phase II jurisdictions, the EPA rules require operators of municipal separate storm sewer systems to develop and implement a stormwater management program that: 1) Reduces the discharge of pollutants to the “maximum extent practicable”; 2) Protects water quality; and 3) Satisfies appropriate requirements of the Clean Water Act.

EPA's rules identify six minimum control measures which must be included in a Phase II stormwater program to protect water quality:

1. Public Education and Outreach;
2. Public Participation/Involvement;
3. Illicit Discharge Detection and Elimination
4. Construction Site Runoff Control
5. Post-Construction Runoff Control
6. Pollution Prevention/Good Housekeeping

The federal rules identify two additional standards with which an operator of a regulated municipal separate storm sewer system must comply:

7. Fulfillment of requirements of an approved TMDL (water-cleanup plan),
8. Record keeping, evaluation and reporting the progress of the program.

CWA Section 404 - Dredge and Fill Requirements

Section 404 of the Clean Water Act (USC 1394) regulates the discharge of dredged or fill material into waters of the United States. Any project that proposes discharging dredged or fill material into the waters of the United States, including special aquatic sites such as wetlands (non-isolated), must get a Section 404 permit. The U.S. Army Corps of Engineers (Corps) can authorize activities by a standard individual permit, letter-of-permission, nationwide permit, or regional permit. The Corps makes the determination on what type of permit is needed.

Nationwide Permits are a type of general permit issued by the Corps on a nationwide basis for smaller projects or activities that will have minimal impacts. The nationwide permits authorize specific categories of work, such as stormwater management facilities, bank stabilizations, mooring buoys, or maintenance of flood control facilities. An activity may be authorized under a Nationwide Permit only if it satisfies all of the Nationwide Permit terms and conditions. If the Corps finds that the proposed activity would have more than minimal individual or cumulative net adverse impacts on the environment, or may be contrary to the public interest, an applicant will be required to modify the proposal or apply for an individual permit.

Standard Individual Permits are required for wetland proposals that do not fit within the specific criteria of a nationwide permit. The individual permit review process includes an analysis by the Corps of whether the project's benefits outweigh predicted environmental impact. Completion of an Environmental Impact Statement (EIS) may be necessary for some projects. In addition, there is a 30-day period during which the proposal is available for review by federal, state, and local agencies, Native American groups, interest groups, and the general public. On average, individual permit decisions are made within two to six months from receipt of a completed application. Applications requiring an EIS (less than one percent) average about three years to process. In emergencies, decisions can be made in a matter of hours.

Letters of Permission are a type of permit normally used for activities in navigable waters where objections are unlikely, and the activity does not qualify for a General Permit. The letters are issued through an abbreviated processing procedure that includes coordination with federal and state environmental agencies and a public interest evaluation. They do not require the publishing of an individual public notice.

Regional General Permits are issued on a regional (limited geographic scope) basis for a category of activities that are substantially similar in nature and cause only minimal individual and cumulative impacts on the aquatic environment. Each Regional General Permit has a number of terms and conditions that must be met in order for an applicant to use a Regional General Permit.

Proposed wetland activities may be subject to other laws in addition to or in association with a Section 404 permit. For example, in Washington, Ecology has the right to place conditions on or request denial of a Section 404 permit if a proposed project does not comply with state water quality laws. The Corps cannot issue a Section 404 permit if the state has denied water quality certification. Furthermore, if any local agency permit is denied, the Corps will deny the 404 permit.

River and Harbor Act, Section 10

The River and Harbor Act was enacted in 1899 to preserve the navigability of the nation's waterways. Section 10 (33 USC 403) prohibits the unauthorized obstruction or alteration of any navigable water of the United States. Section 10 of the Rivers and Harbors Act of 1899 requires approval prior to accomplishment of any work in, over, under or near waters of the U.S. or special aquatic sites, including wetlands. Typical activities requiring Section 10 permits are:

- Construction or installation of piers, wharves, bulkheads, dolphins, marinas, ramps, floats, overhanging decks, buoys, boat lifts, jet ski lifts, intake structures, outfall pipes, marine waterways, overhead transmission lines, and cable or pipeline crossings, etc.; or
- Dredging and excavation.

Provisions of Section 10 are implemented by the Corps through a permit process that includes consideration of navigation, flood control, fish and wildlife management, and environmental impact. Compliance with the National Environmental Policy Act (NEPA) is required. Section 10 reviews often occur simultaneously with Section 404 permit processing. Under section 10 activities receive a standard individual permit, a letter of permission, a nationwide permit, or a regional permit.

Executive Order 11988

Executive Order (EO) 11988, issued in 1977, directs federal agencies to avoid, to the extent possible, the long and short term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct or indirect support of floodplain development wherever there is a practicable alternative. The Order directs each agency to "provide leadership and take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out its responsibilities for (1) acquiring, managing. and disposing of federal lands and facilities; (2) providing federally undertaken, financed, or assisted construction and improvements; and (3) conducting federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities."

The guidelines address an eight-step process that agencies should carry out as part of their decision-making on projects that have potential impacts to or within the floodplain. The eight steps, which are summarized below, reflect the decision-making process required in Section 2(a) of the Order.

1. Determine if a proposed action is in the base floodplain (that area which has a one percent or greater chance of flooding in any given year).
2. Conduct early public review, including public notice.
3. Identify and evaluate practicable alternatives to locating in the base floodplain, including alterative sites outside of the floodplain.
4. Identify impacts of the proposed action.
5. If impacts cannot be avoided, develop measures to minimize the impacts and restore and preserve the floodplain, as appropriate.
6. Reevaluate alternatives.
7. Present the findings and a public explanation.
8. Implement the action.

Executive Order 11990

In 1977, Executive Order 11990 directed federal agencies to avoid the unnecessary alteration or destruction of wetlands. The purpose of Executive Order 11990 is to "minimize the destruction, loss or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands." To meet these objectives, the Order requires federal agencies, in planning their actions, to consider alternatives to wetland sites and limit potential damage if an activity affecting a wetland cannot be avoided. The Order applies to:

- Acquisition, management, and disposition of federal lands and facilities construction and improvement projects which are undertaken, financed or assisted by federal agencies; and
- Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulation, and licensing activities.

Each federal agency is responsible for preparing implementing procedures for carrying out the provisions of the Order. The order requires federal agencies to provide leadership and take action to minimize the destruction, loss, or degradation of wetlands affected by any federal project or project that receives federal funding. Federal agencies must also address impact on wetlands and mitigate any unavoidable impact. The order establishes wetland protection as the official policy of all federal agencies.

While the order does not regulate wetlands per se, it does establish wetland protection as the official policy of all federal agencies. Many state policies and regulations reflect this policy.

Endangered Species Act

The Endangered Species Act (ESA), passed, in 1973 provides for the conservation of species that are endangered or threatened throughout all or a significant portion of their range, and the conservation of the ecosystems on which they depend. A species is considered endangered if it is in danger of extinction throughout all or a significant portion of its range. A species is considered threatened if it is likely to become an endangered species within the foreseeable future. There are approximately 1,880 species listed under the ESA.

All projects that have the potential to directly or indirectly impact wildlife species listed as endangered or threatened under ESA are subject to environmental review by the U.S. Fish and Wildlife Service (USFWS) or the National Oceanic and Atmospheric Administration Fisheries (NOAA Fisheries). The USFWS oversees terrestrial and freshwater fish species and NOAA Fisheries oversees marine and anadromous species. These agencies review projects to determine the extent of the impacts and the proper mitigation and conservation measures to be implemented to eliminate or limit these impacts. The ESA applies to all projects that meet any of the following criteria:

- Projects requiring a permit from a federal agency, such as the Corps of Engineers;
- Projects on federal lands;
- Federally funded projects; or
- Projects that may cause either direct injury to the listed species, alteration of habitat, or significant disturbance to the habitat.

The first three types of projects listed above are covered under Section 7 of the ESA, which requires agency consultation. The last category is covered under Section 9, which defines prohibited acts. Under both categories, applicants must show either that the project would have negligible impact on any listed species or that the project includes mitigation or conservation measures to sufficiently negate any potential impacts.

Initially, a local agency works with the applicant and the federal authority (USFWS or NOAA Fisheries) to determine which species reside in the project area and the probable extent of the impact. The applicant submits a brief assessment, called a Biological Evaluation (BE), to the local and federal agencies describing the scope of the project, the listed species determined to reside in the project area, and the probable project impacts on the species or its habitat.

If the impacts are determined to be negligible, then the federal agency issues a letter or notification of "no effect" and the project may proceed without additional permitting from USFWS or NOAA fisheries. If potential significant impacts on the listed species or its habitat are identified, the applicant must hire a biologist to complete a Biological Assessment (BA). In a BA, the biologist conducts a field investigation, collects pertinent biological information, and interviews local specialists to assess potential impacts on the listed species and its habitat. The BA is submitted to the federal agency, along with a request for a "formal consultation," and is used as the technical reference whereby the federal agency determines the project's level of impact. The agency issues one of two biological opinions:

- No Jeopardy/No Adverse Modification - The project can proceed without additional permitting from USFWS or NOAA Fisheries; or
- Jeopardy/Adverse Modification - The applicant can implement reasonable and prudent alternatives approved by the agency and proceed with the project or seek an exemption from the opinion. Otherwise, the project must be abandoned. The USFWS or NOAA Fisheries may also issue an incidental take permit, which allows limited take of a species as long as the activity is otherwise legal ("take" consists of a number of potential impacts on the species as defined in the ESA).

National Environmental Policy Act

The National Environmental Policy Act (NEPA) (42 USC 4321 et seq.) requires federal agencies to review the potential environmental impact of all federal actions (including agency-sponsored development projects and agency decisions on permits and approvals for privately-sponsored development projects). The NEPA process requires evaluation of probable environmental consequences of a proposal before decisions are made by a federal agency. NEPA also requires identification of alternatives and mitigation that avoids or minimizes environmental impacts.

Guidance for implementation of NEPA is provided by the Council on Environmental Quality (CEQ). The CEQ Regulations (40 CFR 1500-1508) place significant emphasis on the consideration of alternatives, including ways to mitigate harmful environmental effects. Generally, the NEPA process occurs concurrently with Corps Section 404 reviews. Most federal agencies have adopted their own regulations for implementing NEPA requirements.

NEPA requires the preparation of an environmental impact statement (EIS) for any federal action that would have significant adverse environmental impact. The EIS must thoroughly evaluate any adverse environmental impact of the proposed action and its alternatives. Permits issued by a federal agency (such as Section 404 permits) are among the federal actions that may require an EIS.

To determine whether a proposal would have significant adverse environmental impact, the agency may prepare an environmental assessment (EA). A permit applicant often provides much of the information and analysis used to prepare the EA. The EA contains sufficient evidence and analysis to determine whether an EIS is required. If an EIS is not required, a Finding of No Significant Impact (FONSI) document is prepared by the federal agency to explain why an EIS is not required. Compliance with NEPA is achieved upon completion of the FONSI or EIS.

Key State Regulations

Floodplain Management Program

Washington State's Floodplain Management Program (RCW 86.16) requires that local flood-prone jurisdictions adopt a flood damage prevention ordinance based on federal standards contained in the NFIP. However, state regulations go beyond federal standards in prohibiting new or substantially improved residential construction in designated floodways.

The state Floodplain Management Program also provides technical and financial assistance to local communities. The CFHMP for Thurston County and for the Chehalis Tribe are partially funded by the State Floodplain Management Program through the Flood Control Assistance Account Program (FCAAP).

Hydraulic Code

The Washington State Hydraulic Code (RCW 75.20.100-140) regulates activities affecting the state's salt and fresh waters. The purpose of the Hydraulic Code is to reserve fish and wildlife habitat in and around the waters of the state. The Washington State Department of Fish and Wildlife (WDFW) administers the Hydraulic Code.

Any work that falls within the definition of a hydraulic project requires a Hydraulic Project Approval (HPA) from WDFW. Hydraulic projects are defined as work that will use, divert, obstruct, or change the natural flow or bed of any waters of the state. Most structural flood hazard reduction projects require an HPA.

Other State Programs Implemented at the Local level

The following state laws relevant to flood hazard management are implemented at the county or city level:

- Shoreline Management Act (SMA)
- Growth Management Act (GMA)
- State Environmental Policy Act (SEPA).

State involvement in these programs is limited to oversight and technical assistance.

The Shoreline Management Act requires local jurisdictions to develop a Shoreline Master Program to regulate activities in the shoreline zone (within 200 feet) of streams or rivers with flows greater than 20 cfs and lakes greater than 20 acres. The Shoreline Master Program regulations are intended to protect the actual shoreline by limiting what can be constructed on the shoreline and in the shoreline zone. Regulations typically cover shoreline armoring, docks, vegetation removal, construction of roads and structures, and utility installation. The Shoreline Management Act is also intended to provide public access to areas of the shoreline. The Shoreline Management Act has no specific flood protection role, but indirectly helps reduce flood damages by regulating what can be constructed within the shoreline zone.

The Growth Management Act regulates development in cities and counties of the state. The Growth Management Act includes a requirement for jurisdictions to adopt critical (or sensitive) areas regulations to protect wetlands, fish and wildlife habitat, geologic hazard areas, critical aquifer recharge areas, and flood hazard areas. In addition to the direct flood regulations in flood hazard areas, protection of wetlands and streams helps protect the floodplain. The general protection mechanism is the requirement for buffers around wetlands (often located in the floodplain) and streams. These buffers restrict construction in those areas.

The State Environmental Policy Act does not include any specific regulations, but is a procedural requirement that jurisdictions conduct an environmental analysis of the potential impacts of developments that meet certain requirements. The environmental analysis can help identify potential impacts of developing in a floodplain and can identify ways to mitigate development.

Flood Authority Regulatory Summary

All of the member jurisdictions of the Chehalis River Basin Flood authority have adopted floodplain regulations that have been approved by the state. Although all the regulations meet the state's minimum requirements, there is no standard regulation. There is considerable variability between jurisdictions in the level of protection provided.

Most jurisdictions in the Chehalis River basin have adopted critical or sensitive areas regulations, although some are still in the process of adoption. Although there is some variability in the regulations, most provide sizable buffers around wetlands and streams. Jurisdictions in the Chehalis River basin adopted their Shoreline Master Programs in the 1970s shortly after the Shoreline Management Act passed. Those programs have not been updated since the 1970s, but will be required to be revised within the next 5 years under amendments to the Shoreline Management Act.

Next Steps

Flood Authority members and the public have expressed concerns about development impacts on flooding and the adequacy of existing local regulations. The Flood Authority has developed a process to evaluate existing regulations and to recommend improvements. That process is described here.

At its June 18, 2009 business meeting, the Flood Authority authorized a work group on regulatory programs. The work group will develop an inventory of flooding-related regulations throughout the basin, which will be included in future versions of this chapter. The work group will also undertake the following tasks:

1. Evaluate regulatory approaches to development in the floodplain from the perspective of:
   a. Risk to proposed structures,
   b. Risk to existing structures and properties,
   c. Ecological risks (including habitat, water quality, and wetland impacts), and
   d. Emergency management costs.

2. Review local jurisdictions' options for credit from the Community Rating System (CRS) to reduce flood insurance premiums under Activity 430, Higher Regulatory Standards.

3. Develop findings and options for presentation to the Flood Authority, including:
   a. Best management practices and model regulations for local jurisdictions to consider, and
   b. Pros and cons of various practices and approaches.

The Flood Authority will use these findings to develop a recommended set of consistent best land use practices and regulations to achieve flood damage protection and reduction. This set of recommended practices will be added to this chapter of the flood plan.

CHAPTER 4 PREVIOUS STUDIES

Many different entities have studied flood problems in the Chehalis River Basin. These include the Army Corps of Engineers (Corps), Federal Emergency Management Agency (FEMA), Natural Resource Conservation Service (formerly Soil Conservation Service), and the U.S. Bureau of Reclamation (Reclamation). The Corps has been conducting studies of the basin off and on since the 1930s. The early studies did not identify projects that justified the expense under benefit cost analysis guidelines. The Corps is currently conducting new studies in response to recent flood events. Reclamation investigated multipurpose land and water resource development potentials of the Upper Chehalis River Basin in the 1960s. The Natural Resource Conservation Service conducted flood analyses for tributaries in the basin in the 1970s.

These projects are described in more detail below. This chapter also includes a brief description of the existing flood hazard management plans developed by jurisdictions in the Chehalis River Basin and the Chehalis Watershed Management Plan.

U.S. Army Corps of Engineers Activities

This section describes projects undertaken by the Corps since the early 1930s as well as the current Corps projects. This section is based largely on information provided in the 2008 Lewis County Comprehensive Flood Hazard Management Plan.

1930-1976

- In 1931, the Corps investigated improvements on the Chehalis River for navigation, flood control, power development, and irrigation, but concluded that no improvements were justified at that time.
- In 1935, a Preliminary Examination (not published as a congressional document) the Corps concluded that a flood control reservoir or channel improvements at Centralia, Galvin, Oakville, Malone, and Potter were not economically justified.
- In 1944 House Document 494 discussed a preliminary examination and survey for flood control on the Chehalis River and its tributaries. The Corps considered construction of a levee system to protect Aberdeen, Cosmopolis, and Hoquiam, but concluded that any additional flood control in the basin was not economically feasible. Despite this conclusion, a levee system was subsequently authorized by Congress in 1944. However, the authorization expired in 1952 with no levees constructed.
- Between 1946 and 1949, the Corps analyzed the concept of multiple reservoirs on the upper Chehalis River, but determined that they were not feasible at that time. Later, the Corps conducted a more localized evaluation of the flood problems along Lum Road in Centralia and recommended channel clearing on 1,660 feet of Coffee Creek. This evaluation was completed in March 1966.
- Between 1966 and 1971, the Corps study efforts concentrated on identifying flood problem areas and possible solutions. Flood damage was occurring in the urban areas of the Aberdeen/ Hoquiam/ Cosmopolis region, Oakville, and Centralia-

Chehalis region, and in rural areas along the Chehalis, Skookumchuck, and Newaukum Rivers. These studies indicated that large multiple-purpose storage projects in the Chehalis River basin were not economically justified and that levee and/or channel modifications, along with small headwater dams, should be studied further. Enlargement of Skookumchuck Dam to provide flood control storage was considered and found to not be economically justified at that time.

- In 1968, the Corps published two informational documents.
  - *Flood Plain Information-- Skookumchuck River, Bucoda, Washington* (Corps, 1968a) delineated the floodplain along the Skookumchuck River, from the Lewis/Thurston County line to about 1 mile upstream of Bucoda.
  - *Flood Plain Information-- Chehalis and Skookumchuck Rivers, Centralia Chehalis, Washington* (Corps, 1968b) delineated the floodplain along the Chehalis River from the Lewis/Thurston County line to Chehalis and along the Skookumchuck River from the mouth to the Lewis/Thurston County line.
- A 1974 report, Special Study, Suggested Hydraulic Floodway-- Chehalis and Skookumchuck Rivers (Corps, 1974), delineated the suggested hydraulic floodway for the area covered by the 1968 floodplain information report. The Corps published another report in this series in 1976, Special Study-- Suggested Hydraulic Floodway, Chehalis and Newaukum Rivers, that delineated the floodplain and suggested a hydraulic floodway for the Chehalis River from Chehalis to Adna, and for the Newaukum River from its mouth to the Interstate-5 bridge.

1972-1982

During the period from 1972 to 1982, the basin study was divided into four interim reports, each covering a specific area. These areas included the following locations on the Chehalis River: 1) at South Aberdeen and Cosmopolis; 2) near Centralia; 3) at the Wynoochee Hydropower/Fish Hatchery facility; and 4) surrounding Aberdeen and Hoquiam.

Centralia, Washington, Flood Damage Reduction Interim Feasibility Report and Environmental Impact Statement

The objective of the planning effort in Lewis County was to reduce flood damages within both the flood problem area near the cities of Centralia and Chehalis and throughout the planning area covering the Skookumchuck Valley. Preliminary evaluation of potential flood damage reduction measures considered multiple-purpose storage dams, small headwater dams, watershed management, channel clearing, channel excavation, urban levees, and non-structural measures. The urban levee system was the only alternative that initially appeared to be economically justified.

Subsequent feasibility studies focused on the urban levee alternative. These studies resulted in a tentative recommendation for a levee system providing a 200-year level of protection for 2,080 acres in Centralia. Levees to protect Fords Prairie, Galvin, and

Chehalis were determined to not be economically justified. On August 5, 1980, Centralia expressed support for the levee system and agreed to serve as local sponsor, but recommended that prior to proceeding with the levee, the Corps review the potential for modifying the private Skookumchuck Dam to provide flood control. Based on its subsequent analysis, the Corps recommended modification of Skookumchuck Dam as the preferred flood control alternative in the *Centralia, Washington, Flood Damage Reduction Interim Feasibility Report and Environmental Impact Statement* (Corps, 1982). The Corps prepared basic hydrologic, hydraulic, and economic studies that were updated from the previous reports and preliminary spillway design layouts and cost estimates. The Corps suspended design work after studies indicated that the recommended plan lacked economic justification.

Modification of Skookumchuck Dam, 1982

Prompted by the City of Centralia's 1980 request, the Corps initiated feasibility studies for modifying the existing private water supply dam on the Skookumchuck River, about 20 miles upstream from Centralia. The Corps' study results indicated that it would be a better solution, both economically and environmentally, than an urban levee system. Although a 1968 Corps analysis had shown that using the dam for flood control was not feasible, subsequent coordination with the dam owner, Pacific Power and Light, indicated that flood control could be feasible. Based on the experience it had gained in a decade of dam operation, Pacific Power and Light believed that it would be possible to use part of its existing water supply storage for flood control storage during winter months. Hydrologic studies by the Corps showed that 17,000 acre-feet of flood control storage could be provided at the dam. This storage would reduce the 100-year flood on the Skookumchuck River in Centralia from 13,300 to 6,700 cubic feet per second (cfs), a reduction of 2 to 5 feet in flood height. The reliability of the existing and future water supply requirements would also be maintained.

The *Centralia, Washington, Flood Damage Reduction Interim Feasibility Report and Environmental Impact Statement* (Corps, 1982) recommended modifying the dam to provide a low level flood control outlet (12-foot-diameter tunnel) and to raise the controlled reservoir (15-foot-high spillway gate) to provide flood control storage during winter months. The project would reduce flooding on 4,600 acres in the Skookumchuck River valley and on 17,500 acres in the Chehalis River valley. Total cost for this project was projected at $18.2 million (October 1982 prices) and would result in annual average flood damage reduction benefits of $2.5 million in the Skookumchuck and Chehalis River valleys, primarily in the Centralia urban area. The average annual costs were estimated to be $1,654,000 and the benefit to cost ratio for this plan was 1.5 to 1. Structural modifications to the dam would have been performed by the Corps and included gating of the existing spillway along with constructing a 12-foot-diameter flood control tunnel with related intake and exit structures.

Once modifications were complete, Pacific Power and Light would continue to operate the dam. Operational changes would involve maintaining a lower reservoir pool level during the early winter, to provide floodwater storage, with a programmed refill period between January 1 and March 1 to return the reservoir to the spillway crest (elevation 477 feet) before the summer dry season.

The Corps believed that, with planned mitigation features, adverse environmental impacts associated with the plan would not be major. Principal anticipated adverse impacts included alteration of wetland and riparian areas associated with the Skookumchuck River, with reductions in habitat values and impacts to dependent wildlife populations; reduction in available waterfowl habitat in the reservoir; and loss of a small number of fur-bearers (beavers and muskrats) in the Skookumchuck Reservoir. Beneficial impacts included significant flood damage reduction for the Skookumchuck River valley and the communities of Centralia and Bucoda, a minor amount of flood damage reduction for the Chehalis River floodplain downstream of Centralia, and an anticipated improvement of spawning conditions for anadromous fish in the Skookumchuck River.

1990s-Present

In response to flooding on the Chehalis River in the 1990s, the Corps initiated several flood damage reduction studies. While no action occurred as a result of these analyses, severe flooding in 2007 refocused the attention of regional stakeholders on appropriate structural solutions.

1990-Follow-up Evaluations of the Skookumchuck Dam Modifications

In May 1990, the Corps studies resulted in reduction of construction cost estimates for the Skookumchuck Dam modification from $24.8 million to $15.8 million. However, the new economic analysis also reduced the estimate of average annual flood damages. The new damage estimate appeared sufficient to justify only a $6 to $8 million project. In September 1990, further analysis of costs and benefits raised the benefit to cost ratio to 0.69 to 1, which was still well below economic feasibility. The Corps sent a negative report to the Division Office in September; the report recommended cessation of further study of Skookumchuck Dam modification by the Corps.

1998-Centralia Flood Damage Reduction Project

After the 1996 flood event, the Flood Action Council, a group of economic development, business activist, and commercial interests, developed a preliminary plan of modifying the Skookumchuck Dam and providing additional flood storage with overbank excavation of the Chehalis River (called the Centralia Flood Damage Reduction Project). A special flood control district was proposed to implement this plan, but it was rejected by the Lewis County Board of Commissioners because it did not meet the legal criteria for creation.

The Lewis County Board of Commissioners took the lead by establishing a countywide flood control district zone, and used local and state funding to study modifications to the 1984 Authorized Project (Skookumchuck Dam). The Skookumchuck Dam project had evolved to the point of having the Corps conduct Preconstruction Engineering and Design work from February 1988 through August 1990. Prior to the Preconstruction Engineering and Design, the Washington State Department of Transportation had plans to widen and raise segments of Interstate-5 near Centralia and Chehalis. These post-1996 local flood studies were made to also develop a flood hazard management alternative for flood relief other than raising Interstate 5 (I-5).

Lewis County asked that the Corps resume work on its Preconstruction Engineering and Design work on July 7, 1998, and to consider additional measures with the authorized dam modification element for a flood hazard reduction plan for the Centralia-Chehalis urban area. Although the City of Centralia was the project sponsor through the feasibility phase, Lewis County assumed sponsor responsibilities for project construction and to provide the appropriate cost sharing. The Corps resumed work in July 1998.

The study area for the authorized project includes the mainstem Chehalis River, its floodplain and tributaries from the South Fork Chehalis River confluence to Grand Mound, the Cities of Centralia and Chehalis, surrounding areas in Lewis and Thurston Counties, the Town of Bucoda, and along the Skookumchuck River to a point above the Skookumchuck Dam. Tributaries in the study area include the Skookumchuck and Newaukum Rivers, and several smaller creeks (Hanaford, China, Salzer, Coal, Dillenbaugh, and Berwick).

The Corps began the scoping process for the Environmental Impact Study (EIS) by holding two public meetings on September 28 and 29, 1999, in Chehalis and Rochester, respectively. Supplemental studies were completed to address concerns raised during the scoping and project development processes. The Corps conducted a Post Authorization Study, the Chehalis River General Reevaluation Study. This study is a reanalysis of a previously completed and authorized study using current planning criteria and policies, which is required because of changed conditions/assumptions. The results may affirm the prior study, reformulate or modify it, or find that no plan is currently justified. The results for this General Reevaluation Study is summarized in the Corps July 2002 *Draft Environmental Impact Statement (EIS), Centralia Flood Damage Reduction Project*.

The EIS evaluated seven alternatives. The preferred alternative is a series of setback levees with modifications to the Skookumchuck Dam to increase flood storage and non-structural features to be included in the local sponsor's revised floodplain management plan. The new plan for the project is to be in compliance with Executive Order 11988, which directs federal agencies to avoid impacts associated with floodplain development (see Chapter 3 for additional information on Executive Order 11988). The project has not yet been implemented.

1988-Salzer Creek Flood Damage Reduction Study

In response to a March 1988 request by the City of Centralia for assistance with flooding along Salzer Creek, the Corps conducted a reconnaissance study under authority of Section 205 of the 1948 Flood Control Act.

Flooding in the lower Salzer Creek basin causes damage within the Cities of Centralia and Chehalis, and in unincorporated Lewis County. Flooding within the Salzer Creek basin can occur from two different sources: high flows in the Chehalis River that back up water Salzer Creek, or high flows on Salzer Creek itself. The most serious floods occur with backwater flooding. For most events, Salzer Creek can be expected to peak about 6 to 8 hours before the Chehalis River. Studies indicate that when Salzer Creek experiences a 100-year flood, the Chehalis River would approximate the 75-year flood level. In addition to creating a backwater effect on Salzer Creek, water surface elevations on the Chehalis River with discharges in excess of about a 25-year frequency event overtop Intestate-5 both upstream and downstream from the Salzer Creek confluence, resulting in flooding conditions in both Chehalis and Centralia. The Skookumchuck River overflow may also contribute to the flooding near the mouth of Salzer Creek. No attempt was made by the Corps to analyze the effect of overland flow from the Skookumchuck River in this level of investigation.

The Corps determined the most feasible flood damage reduction alternative to be a closure structure and small levee across Salzer Creek in the vicinity of I-5 to prevent backwater flooding from the Chehalis River, and a pump (or pumps) to convey ponded Salzer Creek water across the closure structure. The project would protect not only improvements along Salzer Creek, but also a portion of Intestate-5 that is subject to flooding and the Centralia-Chehalis airport.

The project would consist of the following main elements:

- A short levee segment and a closure structure with a pump plant across lower Salzer Creek just west (downstream) of the Intestate-5 bridge over the creek. The levee would stretch from I-5 east to high ground and would protect the right bank only. It would have 3:1 (horizontal: vertical) side slopes, a 12-foot top width, and vary from 8 to 16 feet in height. The levee would be designed with a top elevation that allows 3 feet of freeboard over the 100-year water surface elevation.
- Raising and improving the airport dike to provide appropriate flood protection.
- Two new short levee segments to tie the airport dike to the I-5 embankment.
- Designation of a ponding area and channel improvement along Salzer Creek to improve conveyance.

The City of Centralia signed the Feasibility Cost Sharing Agreement in September 1990, and has been seeking cost-sharing funds since that time. The estimated feasibility study cost is $650,000 (sponsor to pay half of this), and estimated construction cost is $3 million (sponsor to pay roughly one quarter). The City of Centralia is the main sponsor. Participating sponsors are the City of Chehalis and Lewis County. In April 1993, affected property owners in the Salzer Creek basin did not approve the formation of a special district to fund this project. Instead, they approved construction of a levee that would provide a 45-year design level of protection. This project is called the “Long Road Levee” and was completed in September 2000. The levee is maintained and funded by the Lewis County Flood Control District No. 2, which was formed in 1991.

1988-Section 205 Initial Reconnaissance Report on China Creek at Centralia

In response to a March 1988 request by the City of Centralia for help with flooding along China Creek, the Corps conducted an initial reconnaissance study under authority of Section 205 of the 1948 Flood Control Act.

China Creek is a tributary to the Chehalis River and has a drainage area of 5.32 square-miles at its mouth. The lower reach of the basin, below the Burlington Northern Railroad crossings (drainage area 0.87 square-mile), is well developed and highly channelized with numerous constricted and covered sections. The upper portion of the basin is relatively undeveloped and wooded, and is surrounded by low-lying hills having a maximum elevation of about 600 feet. Stream gradients are mild to relatively flat from the confluence with the Chehalis River to 1 to 2 miles upstream of the Burlington Northern Railroad.

Flood-producing streamflows occur from October through March and are generated primarily from maritime rainstorms with little or no snowmelt. Flooding near the mouth of China Creek is affected by backwater from the Chehalis River. Flooding in the project area can also result from overflows from Skookumchuck River entering China Creek near the Burlington Northern Railroad during periods of high discharge. No streamflow records are available for China Creek. The 10- and 100-year frequency floods on China Creek are estimated to be 235 and 480 cfs, respectively.

Alternatives were identified for flood damage reduction, including levees, flood-proofing, channel modification, detention storage, and diversion. Extensive development around and over the channel eliminated most of these alternatives, including levees and channel modification. An alternative that provides detention storage and diversion of floodwaters upstream from the Burlington Northern Railroad may be the most effective solution to reducing flood damages from China Creek. A program of periodic channel maintenance by Centralia would also help reduce the potential for flood damage.

The recommended alternatives are not eligible for federal participation because the 10-year discharge on China Creek in the project area is estimated to be only 235 cfs. Federal participation criteria require the 10-year flood to be greater than 800 cfs. The Corps recommended that no further studies of the flood problems from China Creek at Centralia be undertaken using the authority of Section 205 of the 1948 Flood Control Act, as amended.

1990-Centralia Chehalis Flood Warning and Flood Response Study

In January 1990, the Chehalis River at Centralia experienced a 100-year flood, and the greater Centralia-Chehalis area found it difficult to respond to this disaster. Property damage was estimated at $15 million, and three lives were lost. In March 1990, Lewis County asked the Corps to perform a non-structural study, and to work with the County and the Cities of Centralia and Chehalis to improve their flood warning and flood response plan. The Corps completed a reconnaissance report in August 1990 that indicated that substantial flood damage reduction and safety benefits could accrue from improving flood warnings, public awareness of the flood problem, and the government's flood response plan. In early 1991 the Seattle District Corps received $40,000 to complete the non-cost shared feasibility phase.

During the feasibility phase, the following products were completed: 1) a public brochure that advises Centralia and Chehalis citizens what to do before, during, or after the flood; 2) a flood warning map that predicts what areas of Centralia and Chehalis would be flooded based on information received from upstream river gauges; and 3) a flood warning checklist that alerts City and County officials which of their facilities may be threatened during a flood. No construction project was identified in the feasibility phase.

The Corps has investigated flood damages in the Centralia-Chehalis valley and based on historical records, has identified water levels at selected gauges that cause both zero damage and major damage in the valley. These gauge heights provide a reference for quickly assessing the severity of anticipated floods, and triggering emergency flood response operations in Lewis County.

The Corps developed a Flood Phases Guidelines Manual in 1993 that includes the flood phase warning map for the Centralia-Chehalis valley. This map was developed prior to the 1996 flood of record, but the four flood phases in the flood warning map are still accurate and used for local alerts and flood emergency preparedness. Reproductions of the map are inserted annually in the local newspapers. Large wall maps are posted in County and city offices along with a graphic and narrative description of each of the four flood phases.

1989-Newaukum River at Chehalis Flood Reduction Study

In1989, under Corps Section 205 authority, the Seattle District Corps investigated flood solutions to the flooding problem centered on the Chehalis Avenue Apartments in Chehalis. The solution proposed by the Corps was an approximately 1,000-foot-long levee and pump plant to the south of the apartments. The potential project had a benefit to cost ratio of only 0.2 to 1, and further consideration of the project ceased in November 1989. Flood-proofing by home, apartment, and business owners was encouraged by the Corps.

2007 Project Authorization

The Centralia Flood Damage Reduction General Reevaluation Report and EIS were completed in April 2004. A Record of Decision was issued in January 2006 and project authorization was received in Section 1001(46) of the Water Resource Development Act of 2007. The 2007 Water Resources Development Act authorized the Corps, in cooperation with the non-federal sponsor to pursue three options—Water Resource Development Act 2007 Approved Plan, National Economic Development Plan, and Locally Preferred Plan. These are described below:

Water Resource Development Act 2007 Approved Plan:

- Construction of a 100-year level of protection levee system along the Chehalis River from approximately river mile (RM) 75 to RM 64 and along most of the lower 2 miles of both Dillenbaugh Creek and Salzer Creek;
- Construction of a levee along the lower approximately 2 miles of the Skookumchuck River to the confluence with Coffee Creek that would provide 100-year level of protection;
- Raising in elevation approximately eight structures that would incur induced damages from increased inundation as a result of the project;
- Modification of Skookumchuck Dam to allow 11,000 acre-fee of flood control storage.

National Economic Development Plan:

- Construction of a 100-year level of protection levee system along the Chehalis River from approximately river mile (RM) 75 to RM 64 and along most of the lower 2 miles of both Dillenbaugh Creek and Salzer Creek;
- Construction of a 2-foot below 100-year water surface elevation levee along the lower approximately 2 miles of Skookumchuck River to the confluence with Coffee Creek;
- Raising in elevation approximately eight structures that would incur induced damages from increased inundation as a result of the project;
- Modification of Skookumchuck Dam to allow 11,000 acre-feet of flood control storage.

Locally Preferred Plan:

- Construction of a 100-year level of protection levee system along the Chehalis River from approximately river mile (RM) 75 to RM 64 and along most of the lower 2 miles of both Dillenbaugh Creek and Salzer Creek;
- Construction of a levee along the lower approximately 2 miles of Skookumchuck River to the confluence with Coffee Creek that would provide 100-year level of protection (based on 20,000 acre-feet of storage at Skookumchuck Dam);
- Raising in elevation approximately eight structures that would incur induced damages from increased inundation as a result of the project.
- Requires further federal evaluation.

Corps Twin Cities Flood Damage Reduction Project

The Corps with State of Washington, the local sponsor, are conducting an evaluation of flood damage reduction projects in the Chehalis-Centralia area. These projects include the levee system along the Chehalis River, a control structure on Salzer Creek, and modifications to Skookumchuck Dam as well as other local improvements. The project is being conducted in two parts. Part 1 is an evaluation and update of the existing design based on the 2007 flood. Part 2 will be the design phase. The Corps anticipates beginning construction in 2014.

2009-Chehalis River Basin General Investigation

The Corps is initiating the process of conducting a General Investigation for the entire Chehalis River Basin. The investigation will include a comprehensive study evaluating water resource needs.

FEMA Region X Interagency Hazard Mitigation Team

The FEMA Region X Interagency Hazard Mitigation Team is composed of numerous federal, state, and local agencies. The Supplemental Flood Hazard Mitigation Report (FEMA, 1991), prepared by the Region X Interagency Hazard Mitigation Team after the November 1990 floods, made recommendations concerning the recurring flooding in the Centralia-Chehalis area. Current flood control structural proposals identified in the area included: 1) a dam on the Skookumchuck River that would provide incidental flood control benefits for Centralia; 2) a levee segment on the Skookumchuck River that would protect a portion of Centralia; and 3) a levee that would protect the Chehalis-Centralia airport.

The following recommendations were made by the Interagency Hazard Mitigation Team (FEMA, 1991) and were identified as being interdependent and best implemented simultaneously:

- State government with FEMA support should provide leadership to encourage all home and business owners who receive flood damage to flood-proof their homes and businesses. Flood audits should be performed on selected structures.
- The federal government should aid the local governments and individuals in improving their flood warning and flood response system.
- All potentially feasible structural projects should be investigated and their costs, benefits, and impacts thoroughly researched.

Natural Resource Conservation Service

The Soil Conservation Service (now Natural Resource Conservation Service) conducted a series of flood hazard analyses for tributaries of the Chehalis River in the 1970s. Flood hazard analyses by the Natural Resource Conservation Service are conducted according to recommendations in a report by the 1966 Task Force on Federal Flood Control Policy, especially recommendation 9(c), "Regulation of Land Use," which requires that preliminary reports be issued where guidance may be needed before a complete flood hazard information report can be prepared, or when a full report is not scheduled.

1978-Flood Hazard Analysis of Coffee Creek

This study was requested by the City of Centralia. The objective was to conduct a detailed flood hazard analysis of the Coffee Creek floodplain in and adjacent to the north portion of Centralia. Coffee Creek is a tributary of the Skookumchuck River, with headwaters in Thurston County flowing south through Zenkner Valley to the Skookumchuck River just north of Centralia. The NRCS report addressed the lower 3.4 miles of the watershed.

The NRCS flood hazard study developed information needed to show portions of the Coffee Creek floodplain subject to inundation by select frequency floods. A total of 395 acres is subject to inundation by the 100-year flood in the study area. The study did not address flooding in the Coffee Creek basin caused by overland flow from the Skookumchuck River. Additional information on the Coffee Creek Flood Hazard Analysis can be found in the 2008 Lewis County Comprehensive Flood Hazard Management Plan.

1977-Flood Hazard Analysis of China Creek

An analysis of flooding on China Creek was requested by the City of Centralia in 1974. The objective was to conduct a detailed flood hazard analysis of the China Creek floodplain in and adjacent to Centralia.

The NRCS study provided peak discharges, water surface elevations and profiles, and flood boundary and floodway information for select frequency floods. The study did not consider any structural changes on the streams. The results of this study were presented as a base from which Lewis County and the City of Centralia may compare the effects of future alternatives for development. The NRCS did, however, recommend that clearing the bridges and channels of sediment and debris and heavy vegetation would reduce floodwater elevations, especially for smaller floods. The study also emphasized that land use and development trends within the watershed, coupled with the outside influence of the Chehalis and Skookumchuck drainages, have a direct effect on future flooding potential. Additional information on the China Creek Flood Hazard Analysis can be found in the 2008 Lewis County Comprehensive Flood Hazard Management Plan.

1975-Flood Hazard Analysis, Salzer-Coal Creeks

An analysis of flood hazard for Salzer-Coal Creeks was requested by the Lewis County Commissioners in 1973. The objective of this study was to conduct a detailed flood hazard analysis of the Salzer Coal Creek floodplain in and adjacent to Centralia. Information on the Salzer-Coal Creeks Flood Hazard Analysis can be found in the 2008 Lewis County Comprehensive Flood Hazard Management Plan.

U.S. Bureau of Reclamation

In its publication *Upper Chehalis River Basin Reconnaissance Report* (Reclamation, 1965), Reclamation investigated the multipurpose land and water resource development potentials of the upper Chehalis River basin. Multipurpose development considered in this report included irrigation, flood control, fish and wildlife, and recreation. Water quality control, municipal and industrial water, navigation, and power generation were evaluated, but would not be involved in a development plan. The study area included only the upper part of the Chehalis River basin, which was defined as that portion of the basin lying upstream from the confluence of the Chehalis and Black Rivers in Grays Harbor County near Oakville.

A reconnaissance land classification survey made by Reclamation in 1960 and 1961 covered a total of 282,000 acres. Reclamation determined that the upper Chehalis River basin contains about 120,000 acres of arable land, of which about 85,000 acres, or 70 percent, are suitable for irrigation under long-range development plans.

The following plans for irrigation development in the Chehalis River basin were analyzed:

- Storage at the Doty site on Elk Creek to serve lands in the Adna area, and at the Alpha site on South Fork of Newaukum River to serve lands in the Newaukum area
- Alternatives to Doty storage at the Pe Ell, Dryad, Meskill, and Ruth sites on the Chehalis River, Boistfort and Point Hill sites on the South Fork Chehalis River, and alternatives to Alpha storage at the Logan Hill, Middle Fork, and Bear Creek sites on the North Fork Newaukum River and Onalaska site on the South Fork Newaukum River

- Bloody Run site on the Skookumchuck River

The first plan was superior in providing storage and facilities within the range of requirements for multiple purposes considered in the plan formulation. Alternative 2 storage sites were eliminated for cost or geologic reasons.

The plan was presented as having an engineering feasibility and a benefit cost ratio of 1.22 to 1. Financial assistance to the water users would be necessary. The plan would provide full-scale irrigation development for an almost solid area or block of land.

Reservoir operation for flood control was provided for in the development plan to the extent feasible. It was projected that flood damages could be reduced by the project primarily below the confluence of the Newaukum and Chehalis Rivers.

No further work was done on this project.

Existing Comprehensive Flood Hazard Management Plans

Several jurisdictions in the Chehalis River Basin have developed Comprehensive Flood Hazard Management Plans. These plans have provided background information for the development of this basin-wide Comprehensive Flood Hazard Management Plan.

Chehalis Tribe Comprehensive Flood Hazard Management Plan, 2008

The Chehalis Tribe completed its Comprehensive Flood Hazard Management Plan for the Chehalis Reservation in March 2009. Approximately 75 percent of the Reservation is in the active floodplain and the portions of the Reservation are isolated by floods for several days. The long-term goals of the Chehalis Tribe CFHMP are:

- Protect and preserve the lives, health, safety and well-being of the people living on the Chehalis Reservation.
- Reduce repetitive damages and costs associated with flooding.
- Protect the Reservation from negative impacts of upstream floodplain development.

Short-term goals of the CFHMP are intended to address the previous lack of 1) a science-based 100-year recurrence interval flood map for the entire Chehalis Reservation (update the 1977 USGS flood map), and 2) written record of hazard areas associated with flooding, and flood-related processes such as channel migration within and adjacent to the Chehalis Reservation. The product of this short-term goal will be the 100-year flood inundation surface map with hazard areas indicated. The flood map will be used as a tool for planning and permitting by the Chehalis Tribe.

The CFHMP includes a number of structural and nonstructural mitigation measures that were evaluated and prioritized for the CFHMP. The structural measures include culvert and bridge improvements to reduce access limitations during flooding events. The nonstructural measures include emergency response and preparedness measures, as well as elevating or removing structures from the floodplain. The Chehalis CFHMP also identifies studies needed to implement the mitigation measures and meet the CFHMP goals.

Grays Harbor County Comprehensive Flood Hazard Management Plan, 2001

Grays Harbor County received funding for comprehensive flood hazard management planning from Ecology's FCAAP grant program and FEMA's flood mitigation assistant (FMA) grant program administered by the State Emergency Management Department. The Grays Harbor County Comprehensive Flood Hazard Management Plan (CFHMP) covers a large portion of Grays Harbor County, with special focus on the Humptulips, Wynoochee, and Satsop Rivers. The plan addresses the watersheds contributing to Grays Harbor County and evaluates the potential for flooding and its impacts. It also proposes possible structural and alternative management solutions to reduce flood hazards.

The Grays Harbor County CFHMP short and long term project goals include: improving the protection of public health and safety from flooding events; providing practical, cost-effective solutions that will result in measurable reductions in flood frequency, flood duration, and the amount of damage that occurs in frequently flooded areas. In addition, the CFHMP goals seek to identify and assess county wide problem areas through public meetings and existing FEMA mapping, develop a community-driven plan with positive working relationships among the community and governmental agencies. The CFHMP also seeks to ensure that all parties are aware of the issues, processes, and implications of a CFHMP, and reach public and agency consensus on solutions and funding. Other goals include documenting recommendations consistent with Ecology's FCAAP to permit further grant funding opportunities for plan implementation, as well as developing a plan consistent with FEMA Flood Hazard Mitigation Planning so that the County can be eligible for flood hazard mitigation assistance for the projects detailed in the plan. Instrumental in implementation of this CFHMP goals and objectives, the Flood Control Assistance Account Program (FCAAP), administered by Ecology's shoreland and coastal zone management program, promotes a watershed approach to minimizing flood hazards. To be eligible for funding, jurisdictions must participate in the National Flood Insurance Program.

Flood hazard management measures recommended in the CFHMP are categorized as nonstructural or structural. Key nonstructural approaches to flood hazard management include the following: Land use regulations/permitting, accurate floodplain mapping, inter-jurisdictional coordination, floodplain conservation easements, educational materials on flood hazard management, flood warning system, new standards for design, construction, and maintenance, and a NFIP community rating program. Nonstructural alternatives also include measures that homeowner's can take to protect their homes from flood damage such as floodproofing, elevation, relocation, or buyout and demolition of affected structures. Structural management measures include levees, setback levees, floodplain excavation, flood control reservoir, overflow culverts and channels, onsite detention and retention, and biostabilization and other engineered solutions.

Lewis County Comprehensive Flood Hazard Management Plan, 2008

A Project Advisory Committee guided development of the Lewis County CFHMP, and included members from the County, Ecology, cities and utilities. The policies laid out in the CFHMP include hazard identification, education and outreach, planning, regulations and development standards, corrective/mitigation actions, infrastructure, and emergency services. To address flood control issues in Lewis County, the CFHMP recommends Berwick and China Creek Drainage Basin Plans to identify structural and non-structural actions that will minimize peak flow increases, channel migration zone mapping, update hazards data sets and maps, identify and collect missing data sets. Other recommended projects in the CFHMP are the Regional Flood Alleviation Project along I-5 consisting of levee construction and implementation of flow control facilities that minimize impacts to downstream populations, regional flood detention facilities, regional stormwater detention facilities, Salzer Creek Backwater Control, a technical assistance program for bank stabilization and debris removal. The CFHMP also identifies coordinating with the Corps on its study of using the Skookumchuck dam for flood control and creating flood district boundaries.

The Lewis County CFHMP recommends new flood hazard management policies to minimize future impacts of flooding. The policies are divided into seven categories:

- Hazard identification,
- Education and outreach,
- Planning,
- Regulations and development standards,
- Correction (mitigation) Actions/Repetitive Loss,
- Infrastructure, and
- Emergency Services.

The plan includes policy statements and recommended actions for each category.

Thurston County Comprehensive Flood Hazard Management Plan, 1999

Funding for the Thurston County CFHMP was provided by Ecology through the Flood Control Assistance Account Program (FCAAP). The County CFHMP synthesizes several basin specific stormwater plans and addresses community interests in each of the four Thurston County Water Resource Inventory Area (WRIA) systems.

The FHMP outlines 27 “Flood Plan Recommendations” that included guidance for county-wide Flood Plan implementation measures, public information, mapping and regulations, flood damage reduction, and flood preparedness. Recommendations given for implementation include applying to FEMA for inclusion in the Community Rating System (CRS Program) as part of the National Flood Insurance Program, to secure funding for the flood related project within the Stormwater Capital Facilities Plan, and expansion of the Thurston County Stormwater Utility rate boundary to include all unincorporated areas. Public information recommendations consist of installing flood elevation poles and staff gauges along major rivers, creating a countywide Water Resources Database, and developing a system to track flood elevation certificates for individual homes. Also included in public information recommendations are the preparation of a public information program that focuses on flood consequences, providing a set of all flood management documents for each Timberland library within the county, and the distribution of flood insurance information to residents and property owners who live in a floodplain, as well as real estate offices.

Recommendations for mapping and regulations included the remapping of floodplains and locations of streams using new 2-foot contour data for submission to FEMA for revisions, remapping high quality riparian habitat and extent of historic meander along the Nisqually River, and mapping 190 square miles of wetlands in Nisqually, Chehalis, Black and Skookumchuck watersheds. Primary mapping and regulations recommendations also included reevaluating land uses and zoning based on new floodplain maps, adopting development regulations for high groundwater areas, revising shoreline regulations, determining width and conditions of forested corridors along rivers and streams, and drafting a Comprehensive Plan policy to encourage the creation and use of wetland mitigation bank. To address flood damage reduction the CFHMP recommends the creation of a prioritized list of floodplain residences for buyout or elevation above the 100 year floodplain, if state or federal funds are available, working with landowners and others to establish reforested riparian buffers, and encouraging research into bioengineering and other techniques for streambank protection and improved fisheries habitat through large woody debris recruitment. The FHMP recommends developing a flood warning system for the Skookumchuck River dam in collaboration with the Department of Ecology, the downstream communities and the Skookumchuck Valley residents.

Since adoption of the CFHMP in 1999, Thurston County has completed the majority of the projects recommended in the plan. The County is currently proposing to update its CFHMP.

Bucoda Comprehensive Flood Hazard Management Plan, 1999

The Town of Bucoda prepared its CFHMP under a grant from the Flood Control Assistance Account Program within the Department of Ecology. Bucoda is periodically inundated by floodwaters from the Skookumchuck River which result largely from upstream activities. This plan recommends steps the Town can take action on within their jurisdiction. Plan goals include prevention of harm to life and property, preservation of water quality, protection of fish and wildlife habitat, and minimization of cost.

Recommendations within Selected Alternatives section of the Bucoda CFHMP included structural and non-structural actions. Structural projects include building an overtopping levee at the north end of town, and the installation of a twin 18-inch culvert under Main Street at 11th Ave to allow areas of town to drain rapidly following flood. Other structural recommendations are streambank stabilization with habitat rehabilitation, house raising, and regrading Market Street. Non-structural projects listed are overall cooperation with the flood control program on the Chehalis River, largely focused upon retrofit of the Skookumchuck Dam, improvement of the flood notification and response program, and adoption of a filling ordinance to restrict filling within the secondary overflow boundary.

City of Centralia Comprehensive Flood Hazard Management and Natural Hazards Management Plan, 2008

The City of Centralia is in the process of adopting a Comprehensive Flood Hazard Management and Natural Hazards Management Plan and has made the draft plan available. Concern over major flooding events, evolution of the US Army Corps of Engineers' proposed flood control project in the Chehalis River Basin, and a lack of clearly articulated flood hazard management policies prompted the City to develop this new plan. The Action Plan section lists activities appropriate to the community's resources, hazards, and vulnerable properties. The action plan identifies who does what, when it will be done, and how it will be financed.

Proposed actions include preventative activities such as zoning, stormwater management regulations, building codes, and preservation of open space and the effectiveness of current regulatory and preventative standards and programs. The Plan lists property protection actions such as acquisition, retrofitting, and insurance, as well as activities to protect the natural and beneficial functions of the floodplain, such as wetlands protection. Also listed are the development and maintenance of a specific flood warning and evacuation program for the City, retrofitting and updating of current infrastructure and emergency services, and structural projects such as reservoirs and channel modifications. The China Creek Drainage Basin Plan, Centralia Flood Reduction Project (CFRP), construction of regional stormwater and flood detention facilities, Salzer Creek Backwater Control, and construction of a levee system along the Chehalis River in the City of Centralia are all specific actions listed in the Plan.

City of Montesano All Hazard Mitigation Plan: Addendum 2, 2007

In response to the Grays Harbor County Natural Hazards Mitigation planning process, the City of Montesano developed and integrated its own Natural Hazards Mitigation Plan (NHMP) with that of the County's. The NHMP identifies vulnerabilities for future disasters and proposes the mitigation initiatives necessary to avoid or minimize those vulnerabilities. The NHMP outlines specific mitigation initiatives for the City that are expected to be implemented by the year 2025.

A risk assessment was performed for several hazard events including earthquake, storm, flood, landslide, tsunami, wildlife, volcano ash fallout, and hazardous materials releases. The assessment concluded the City is vulnerable to all of the hazards outlined in the plan. The NHMP makes the following mitigation initiatives: installation of a city-owned natural gas/propane generator at City Hall to avoid disruption to the Emergency Operations Center, and construction of a 750,000 gallon reservoir on City Property as backup to the city's vulnerable primary water source. Additionally long-term bank stabilization on the Wynoochee River should be implemented to repair bank erosion which endangers the integrity of the city's sewage treatment plant and holding lagoons.

Chehalis Basin Watershed Management Plan, 2004

The Chehalis Basin Watershed Management Plan provides the collective vision of citizens, utilities, federal, state, tribal, and local governments within the Chehalis Basin Partnership. The Plan is a framework for water resource management, examining water quantity, water quality, instream flow, habitat, and water rights issues in the Basin.

- In order to address water quantity the Partnership recommends conducting a groundwater study that provides necessary information to decision-makers to address hydraulic continuity and better evaluate whether an individual water right application would impact stream flows. They also recommend that a "tool box" of alternative approaches for those seeking water supply, water rights and tracking, and enforcement be evaluated and considered for the basin. Exempt wells should be evaluated to assess their real cumulative impact in the Chehalis Basin and its subbasins. The Partnership also makes various general and specific recommendations for water conservation. In order to address water quality, the Partnership recommends a basin-wide water quality monitoring program, and exploration of a range of approaches to improve communication, coordination and consolidation of all habitat efforts in the Chehalis Basin. The Partnership's Plan also recommends that minimum instream flows established in 1976 at sites within the Basin be reevaluated using updated scientific information.

CHAPTER 5 BASIN FLOOD CHARACTERISTICS

Flooding is a common, historical occurrence in the Chehalis River basin. Major flood events on the Chehalis River have affected Lewis, Thurston, and Grays Harbor Counties in the years 1972, 1975, 1986, 1990, 1996, 2007, and 2009. This chapter reviews historical information on previous flood events, including flood damage reports and historical flood flows, and focuses on key physical factors that affect flooding in the Chehalis River Basin.

The information presented in this chapter is based on flood history sections of existing Comprehensive Flood Hazard Management Plans in the Chehalis River basin, especially the Lewis County Comprehensive Flood Hazard Management Plan (2008). Because the most current information is available from the Lewis County plan, the information presented here focuses primarily on the Lewis County portion of the basin. As information is collected for the lower basin, it will be added to future iterations of this plan.

These reports were in preparation prior to the 2007 and 2009 flood events, so information about these floods has yet to be fully incorporated into some of the tables in this chapter. Other primary sources of information included: Comprehensive Flood Hazard Management Plans developed by the Chehalis Tribe (2009) and Grays Harbor County (2001), meteorologic and hydrologic data collected by the National Weather Service and the U.S. Geological Survey (USGS), and the U.S. Army Corps of Engineers General Reevaluation Study for the Centralia Flood Control Project (2003).

Factors Affecting Flooding

The extent and severity of flood damage in the Chehalis River Basin is determined by several factors, including time of year, flood magnitude and duration, sediment transport and deposition, the amount and type of development in the floodplain, and natural obstructions in the channel.

Seasonal Conditions

Flooding in the Chehalis River Basin typically occurs during the fall and early winter months. Heavy rainfall, rapidly melting snowpack, or a combination of these factors can result in river and stream flood conditions. Recent major floods have occurred between November and March.

Flood Magnitude and Duration

The Chehalis River Basin is a large, relatively low elevation area with a relatively high drainage density. The basin responds primarily to precipitation events, and to a lesser degree to rain-on-snow events. The magnitude and duration of these types of floods can vary significantly depending on the type, spatial extent, and duration of storm events.

Flows within the mainstem of the Chehalis River respond to contributions from the major tributary channels. This response can be additive if the timing and spatial extent of precipitation is similar over the watershed. The response in the mainstem can also be driven by a limited number of tributaries, as seen in the 2007 event, when intense rain in the Willapa Hills resulted in very high flows in the upper mainstem and South Fork of the Chehalis River and flood flows downstream to the mouth.

All flow from the upper tributaries is routed through the lower valley, including a narrow portion of the valley downstream of Grand Mound. These flows can then combine with flows from the lower tributaries such as the Satsop, Wynoochee, and Wishkah Rivers. The lower valley is typically wider than the upper valley, with less structural modification (e.g., levees, bridges) than in the Chehalis and Centralia (Twin Cities) area. In past events, storms appear to have been more significant in either the upper or the lower basin. According to flood peak data maintained by the National Weather Service, the ranking of flood peaks in the lower basin is different than in the upper basin. For example, the 2007 event is ranked number eight on the list for the Satsop River, and is not in the top ten peak flows for the Wynoochee River.

In the lower basin, flood stage becomes increasingly influenced by tides as the river gets closer to its mouth at Grays Harbor. Flood peaks below Elma are likely modified by tide stage, but there are no studies that detail this process.

In general, precipitation-driven flooding has distinct peaks associated with specific storm events, which limits the overall duration of flooding. The 1996, 2007 and 2009 flood events in the upper basin occurred in a time frame of a week or less, according to data from the Grand Mound USGS gauge. The duration of flooding will be influenced by soil saturation and other conditions prior to the storm event, as well as the length of the storm event itself.

Sediment Transport and Deposition

The generation, transport, and storage of sediment are major functions of the Chehalis and its tributaries. Sediment sources in the upper watershed include weathered bedrock, glacial sediments, and alluvial deposits (Chehalis Tribe, 2009). These sources can deliver sediment to channels on an ongoing basis, and on an episodic basis as a result of landslides or significant channel change. Channel migration will also result in localized erosion and deposition of sediments.

Sediment processes can influence flooding in a number of ways. Increasing sediment loads can result in deposition within active channels, reducing conveyance capacity. Discrete events, such as landslides, can block channels and divert flow. Deposition on the floodplain can also influence flood flows. This deposition typically includes sand or finer materials, since the transport capacity of flows on the floodplain are typically lower than in the channel.

There is limited information available regarding sediment transport processes within the Chehalis Basin. The USGS performed a study that investigated sediment transport within the Chehalis Basin for the water years 1961 to 1965 (Glancy, 1971). This study identified the Wynoochee River and the Middle and West Forks of the Satsop River as having the highest unit yields of sediment production and transport. Within the upper basin above Porter, the streams that drain the Willapa Hills to the west were found to have larger sediment yields than the streams that drain the eastern portion of the contributing basin. The upper mainstem had the highest sediment yield and the Black River had the lowest (Glancy, 1971). There do not appear to be any recent studies of sediment transport in the Chehalis basin.

Obstructions

Obstructions to flood flows can be structural elements (e.g., levees, bridges, roads), or they can form during the flood as debris collects. During flood events in the Chehalis basin, downed trees and other debris can deposit and form blockages that can divert significant volumes of flow. These obstructions can also hold back volumes of water until they break, sending a wave downstream.

There are structural elements that could impact flood flows throughout the Chehalis basin. In the upper basin, there are at least 21 bridge crossings (Corps, 2003). In the lower basin, there are similar crossings. The Sickman-Ford Bridge on the Chehalis Tribe Reservation and associated approaches reduces the floodplain width, resulting in a backwater condition during high flows (Chehalis Tribe, 2009). The airport levee near Chehalis was observed to trap overbank flows during the 2007 event. Newspaper reports during the flooding indicate that the airport levee was breeched during the event, to hasten the recession of water from over major roads. Other bridges and obstructions exist in the Chehalis basin, but are not discussed in detail in this chapter.

Flood Damages

Floods are among the most frequent and costly natural disasters in terms of human hardship and economic loss. Flood damage costs are a way to compare the impacts of different size floods. This flood damage summary is taken from Lewis County's 2008 Comprehensive Flood Hazard Management Plan.

Flood damage information was obtained by the Corps of Engineers (Corps) from field investigations, damage survey reports, and personal interviews with homeowners, farmers, businessmen, and federal, state, county, city, and public utility officials. Eyewitness accounts of flooding and reports of damage in local newspapers were also used in identifying and quantifying flood damages.

In the past 30 years Lewis County has experienced 16 federally declared disasters. Of these, 13 were either caused or exacerbated by flooding. Table 5-1 is from the Lewis County Hazard Identification and Vulnerability Analysis and lists floods that resulted in a Presidential Declaration of Disaster. Care should be used in viewing the damage costs listed in Table 5-1. It should be noted that this table represents damages in Lewis County only and includes some damages from the Cowlitz, outside the Chehalis River basin. These damage costs are approximate, and of primary and significant structures and businesses. Information about damages is collected by different agencies, and does not include all damages. The information is further confused when initial estimates of damage are refined. This can result in a higher or lower value. At best, the primary damage was erosion of public infrastructures (riverbanks, roads, bridges, and revetments). Costs for public damages are based on actual costs or cost estimates reviewed by FEMA. Private costs are based on information provided by victims, Red Cross, and FEMA, and do not include any reduction in property values.

Table 5-1. Flood Damages in Lewis County

Federal Declaration No.	Date	River/Area	Reported Public Damages ($)
DR-1734	Dec-07	Chehalis	*
DR-1172	Mar-97	Cowlitz	9,400,000**
DR-1159	Dec 96 – Jan 97	Chehalis, Cowlitz	3,255,900
DR-1100	Feb-96	Chehalis, Cowlitz	30,000,000
-	Dec-94	Chehalis	40,000
DR-0883	Nov-90	Chehalis	1,050,000
-	Feb-90	Chehalis	200,000
DR-0852	Jan-90	Chehalis	1,439,380
DR-784	Nov-86	Chehalis	3,926,250
DR-322	Jan-72	Chehalis	2,060,250
-	Jan-71	Chehalis	446,570

Source: Lewis County Comprehensive Flood Hazard Management Plan (2008)
**Information pending.*
*** Amount of Stafford Act and Small Business Administration disaster loans approved*

Precise information on private property damage is, for the most part, unavailable. FEMA collects several types of data for private property: human resources claims, and requests for short-term assistance and claims through the NFIP and the Small Business Administration (SBA). Human resource claims data and the damage reported in the newspapers are not necessarily alike. Human resource data are aggregated by zip code to protect the privacy of applicants, which makes it difficult to identify localized flood problems, trends, and causes.

Another factor to consider is the unreported private property damages. Flood insurance claims were either not filed because of lapsed flood insurance policies, or fear of increased rates. This is a common misconception; however, rates do not increase because a claim may have been submitted. In any case, the actual damages are likely understated and do not reflect the true magnitude of the problem.

The scope of the flood damages is related to the magnitude of the flood and location. Low-lying areas, especially river valleys, have flooded regularly for hundreds of years. The 1996 flood event was the most severe and it affected interstate travel, thus making the associated damage costs (estimated up to $100 million) the highest to date. Cost estimates for damages from the 2007 and 2009 floods are not yet available.

Table 5-2 shows National Flood Insurance Program (NFIP) loss statistics for jurisdictions in the Chehalis River basin between January 1, 1978 and June 30, 2008. This information is based on data from FEMA.

Table 5-2. NFIP Loss Statistics from January 1, 1978 to June 30, 2008					
	Total Losses	Closed Losses	Open losses	CWPO[1] Losses	Total Payments
Gray's Harbor County	145	127	3	15	$2,997,500.98
Lewis County	641	547	21	73	$20,157,084.63
Thurston County	192	150	4	38	$3,086,335.82
Aberdeen	215	141	0	74	$676,508.63
Bucoda	30	27	0	3	$179,624.46
Centralia	663	610	7	46	$22,907,358.98
Chehalis	427	364	15	48	$23,227,221.31
Montesano	10	9	0	1	$99,745.89
Oakville	5	4	1	0	$184,142.96
Pe Ell	1	1	0	0	$37,770.81
Total	2,329	1,980	51	298	$73,553,294.47

[1]Closed Without Payment
Source: FEMA, 2008.

Historical Flow Records

Flow data have been collected on the Chehalis River and two of its major tributaries, the Newaukum and Skookumchuck Rivers, by the National Weather Service andUSGS. The National Weather Service stations record only water levels, while the USGS stations record water levels and flow. The stream gauging network in the Chehalis River basin is described in Chapter 2. This historical flow record summary is taken from Lewis County's 2008 Comprehensive Flood Hazard Management Plan.

Streamflow data are summarized in Table 5-3 for three USGS stations: the Chehalis River near Grand Mound, approximately 7 miles downstream from the Skookumchuck River confluence; the Newaukum River near Chehalis; and the Skookumchuck River near Bucoda. The data show that the monthly distribution of flow is similar for the mainstem of the Chehalis River and two major tributaries flowing through the Centralia-Chehalis valley (Figure 6-1 in Lewis County, 1994). The largest monthly flows occur from December through February, with this period accounting for over half of the annual runoff volume. The smallest mean monthly flows occur from July through September, when monthly flows range from only 1 to 3 percent of the annual runoff.

Table 5-3. Summary of Mean Monthly Flows									
	Chehalis River Near Grand Mound			Newaukum River Near Chehalis			Skookumchuck River Near Bucoda		
Period of record	1928-2007			1929- 2007			1967- 2007		
Drainage Area (mi²)	895			155			112		
Month	Flow (cfs)	Percentage of Annual Flow (%)	Flow per Unit Area (cfs/mi²)	Flow (cfs)	Percentage of Annual Flow (%)	Flow per Unit Area (cfs/mi²)	Flow (cfs)	Percentage of Annual Flow (%)	Flow per Unit Area (cfs/mi²)
January	6,428	19	7.1	1,110	18	6.9	783	18	7.0
February	5,769	17	6.5	970	16	6.4	670	16	6.1
March	4,501	13	5.1	768	13	5.0	542	13	5.0
April	2,929	9	3.3	540	9	3.5	395	9	3.7
May	1,382	4	1.5	294	5	1.8	219	5	1.9
June	810	2	0.9	183	3	1.2	151	4	1.4
July	378	1	0.4	89	1	0.6	95	2	0.9
August	243	1	0.3	56	1	0.3	79	2	0.7
September	340	1	0.4	71	1	0.5	120	3	1.1
October	918	3	1.0	181	3	1.2	141	3	1.3
November	3,862	11	4.3	748	12	1.5	346	8	3.1
December	6,389	19	6.8	1,070	18	6.5	717	17	6.0
Annual Average	2,829	100	3.1	507	100	3.2	355	100	3.2

Peak annual flood data are summarized from greatest to lowest in Table 5-4. This table does not include 2009 data for the Newaukum or Sookumchuck Rivers.

Table 5-4. Summary of Peak Annual Floods								
Chehalis River near Grand Mound			Newaukum River near Chehalis			Skookumchuck River near Bucoda		
1929- 2007			1929- 2007			1968- 2007		
Year	Date	Maximum Flow (cfs)	Year	Date	Maximum Flow (cfs)	Year	Date	Maximum Flow (cfs)
2007	Dec. 4, 2007	79,000 [1]	1996	Feb. 08, 1996	13,300	1996	Feb. 08, 1996	11,300
1996	Feb. 09, 1996	74,800	1996	Feb. 08, 1996	13,300	1996	Feb. 08, 1996	11,300
1990	Jan. 10, 1990	68,700	1987	Nov. 24, 1986	10,700	1990	Jan. 10, 1990	8,540
1987	Nov. 25, 1986	51,600	1990	Jan. 09, 1990	10,400	1991	Nov. 25, 1990	8,400
1972	Jan. 21, 1972	49,200	2007	Dec. 3, 2007	10,300	1997	Dec. 30, 1996	8,380
2009	Jan. 4, 2009	48,800[1]	1978	Dec. 02, 1977	10,300	1972	Jan. 21, 1972	8,190
1938	Dec. 29, 1937	48,400	1991	Nov. 24, 1990	10,300	1978	Dec. 02, 1977	7,170
1991	Nov. 25, 1990	48,000	1999	Nov. 26, 1998	10,000	2006	Jan. 30, 2006	6,640
1934	Dec. 21, 1933	45,700	1972	Jan. 21, 1972	9,770	1971	Jan. 26, 1971	6,630
1976	Dec. 05, 1975	44,800	1997	Dec. 29, 1996	9,700	1987	Feb. 01, 1987	6,470
1971	Jan. 26, 1971	40,800	2003	Jan. 31, 2003	8,940	1976	Dec. 04, 1975	6,110
1997	Dec. 30, 1996	38,700	2006	Jan. 30, 2006	8,720	2002	Dec. 17, 2001	6,060
1935	Jan. 23, 1935	38,000	1974	Jan. 15, 1974	8,440	2003	Feb. 01, 2003	5,990
1951	Feb. 10, 1951	38,000	1971	Jan. 26, 1971	8,390	1974	Jan. 16, 1974	5,950
2006	Jan. 31, 2006	37,900	2000	Dec. 16, 1999	8,100	1982	Jan. 24, 1982	5,250

Table 5-4. Summary of Peak Annual Floods								
Chehalis River near Grand Mound			Newaukum River near Chehalis			Skookumchuck River near Bucoda		
1929- 2007			1929- 2007			1968- 2007		
Year	Date	Maximum Flow (cfs)	Year	Date	Maximum Flow (cfs)	Year	Date	Maximum Flow (cfs)
1974	Jan. 17, 1974	37,400	1976	Dec. 04, 1975	8,020	2000	Dec. 16, 1999	5,150
1949	Feb. 18, 1949	36,500	1964	Jan. 25, 1964	7,970	1999	Dec. 28, 1998	5,010
1978	Dec. 03, 1977	36,500	1986	Feb. 23, 1986	7,960	2005	Jan. 18, 2005	5,000
1999	Nov. 26, 1998	36,500	2002	Dec. 17, 2001	7,920	1968	Feb. 04, 1968	4,850
1936	Jan. 15, 1936	36,300	1954	Dec. 09, 1953	7,880	1986	Feb. 24, 1986	4,650
1995	Dec. 21, 1994	35,900	1983	Dec. 04, 1982	7,820	1975	Jan. 14, 1975	4,610
1964	Jan. 26, 1964	35,700	2005	Jan. 18, 2005	7,740	1983	Jan. 05, 1983	4,570
1956	Dec. 22, 1955	35,100	2004	Jan. 30, 2004	7,460	1998	Jan. 15, 1998	4,340
1954	Jan. 06, 1954	34,700	1975	Jan. 14, 1975	7,400	1995	Feb. 20, 1995	4,100
1967	Dec. 14, 1966	34,400	1979	Feb. 07, 1979	7,280	1981	Dec. 26, 1980	3,980
1986	Jan. 20, 1986	32,100	1956	Dec. 12, 1955	7,200	2004	Jan. 30, 2004	3,900
2002	Dec. 18, 2001	31,900	1963	Nov. 20, 1962	6,960	1970	Jan. 14, 1970	3,810
2000	Dec. 17, 1999	31,000	1949	Feb. 17, 1949	6,950	1969	Dec. 04, 1968	3,680
1963	Nov. 21, 1962	29,800	1984	Jan. 25, 1984	6,760	1984	Nov. 18, 1983	3,260
1982	Jan. 25, 1982	27,300	1931	Apr. 01, 1931	6,750	1988	Mar. 27, 1988	2,820
1945	Feb. 09, 1945	27,000	1998	Jan. 14, 1998	6,580	2007	Dec. 5, 2007	2,810
1961	Feb. 22, 1961	27,000	1965	Dec. 23, 1964	6,500	1994	Mar. 03, 1994	2,770
1942	Dec. 20, 1941	26,900	1961	Nov. 20, 1960	6,460	1980	Dec. 18, 1979	2,740
1975	Jan. 15, 1975	26,900	1947	Dec. 11, 1946	6,350	1992	Jan. 29, 1992	2,620
1950	Feb. 26, 1950	26,300	1973	Dec. 21, 1972	6,330	1979	Feb. 07, 1979	2,000
1965	Dec. 24, 1964	26,200	1959	Nov. 12, 1958	6,290	1973	Dec. 21, 1972	1,770
1983	Dec. 05, 1982	25,600	1945	Feb. 08, 1945	6,080	1993	Apr. 11, 1993	1,760
1933	Dec. 03, 1932	24,900	1995	Dec. 27, 1994	6,040	1985	Nov. 29, 1984	1,620
1939	Feb. 16, 1939	24,800	1960	Nov. 21, 1959	5,950	1989	Mar. 13, 1989	1,550
1968	Feb. 05, 1968	24,800	1946	Feb. 06, 1946	5,900	2001	May 2, 2001	905
1960	Nov. 24, 1959	24,700	1950	Feb. 24, 1950	5,720	1977	Mar. 09, 1977	764
1937	Apr. 15, 1937	24,300	1948	Mar. 22, 1948	5,630			
1947	Jan. 26, 1947	24,200	1988	Dec. 10, 1987	5,500			
1981	Dec. 27, 1980	24,000	1981	Dec. 26, 1980	5,490			
1932	Feb. 27, 1932	23,500	1967	Jan. 20, 1967	5,450			
1970	Jan. 28, 1970	23,300	1970	Jan. 14, 1970	5,300			
1946	Dec. 30, 1945	23,100	1951	Feb. 09, 1951	5,240			
2003	Feb. 01, 2003	23,100	1980	Jan. 12, 1980	5,020			
1940	Dec. 17, 1939	22,700	1943	Nov. 23, 1942	4,990			
1959	Nov. 13, 1958	22,500	1968	Feb. 19, 1968	4,810			
1966	Jan. 07, 1966	21,900	1955	Feb. 08, 1955	4,780			
1973	Dec. 28, 1972	21,900	1953	Jan. 23, 1953	4,540			
1998	Jan. 15, 1998	21,400	1966	Jan. 06, 1966	4,520			
1957	Feb. 27, 1957	20,900	1944	Dec. 03, 1943	4,500			
2005	Jan. 19, 2005	20,700	1957	Dec. 10, 1956	4,300			
1953	Jan. 10, 1953	20,500	1969	Dec. 04, 1968	4,300			

Table 5-4. Summary of Peak Annual Floods								
Chehalis River near Grand Mound			Newaukum River near Chehalis			Skookumchuck River near Bucoda		
1929- 2007			1929- 2007			1968- 2007		
Year	Date	Maximum Flow (cfs)	Year	Date	Maximum Flow (cfs)	Year	Date	Maximum Flow (cfs)
2004	Jan. 31, 2004	20,400	1992	Jan. 28, 1992	3,990			
1943	Feb. 07, 1943	20,200	1952	Feb. 04, 1952	3,980			
1948	Jan. 03, 1948	20,000	1962	Dec. 24, 1961	3,820			
1992	Jan. 30, 1992	19,600	1993	Apr. 11, 1993	3,730			
1931	Apr. 01, 1931	19,400	1985	Nov. 04, 1984	3,630			
1984	Jan. 26, 1984	19,200	1958	Dec. 26, 1957	3,590			
1980	Jan. 13, 1980	19,000	1989	Dec. 30, 1988	3,570			
1941	Jan. 19, 1941	18,800	1994	Jan. 05, 1994	3,170			
1952	Feb. 05, 1952	18,800	1929	Mar. 27, 1929	3,090			
1958	Dec. 27, 1957	18,500	1930	Mar. 24, 1930	16-Jun			
1979	Feb. 08, 1979	18,300	1977	Mar. 09, 1977	13-Jan			
1955	Feb. 09, 1955	18,100	2001	Apr. 11, 2001	22-Jul			
1985	Nov. 29, 1984	18,000						
1969	Feb. 12, 1969	17,500						
1944	Dec. 04, 1943	16,400						
1988	Dec. 11, 1987	16,400						
1962	Dec. 21, 1961	15,900						
1977	Mar. 09, 1977	15,200						
1989	Dec. 31, 1988	14,400						
1929	Mar. 27, 1929	13,700						
1994	Mar. 04, 1994	13,100						
1930	Feb. 08, 1930	12,200						
1993	Apr. 12, 1993	10,400						
2001	Feb. 05, 2001	5,750						

[1] *Flows are preliminary*

Flood data in Table 5-4 show that almost all annual floods occurred during the fall/winter period from November through February. For this period of record on the Chehalis River near Grand Mound, only five of the peak annual floods occurred outside of this period. Of the remaining four, two occurred in March and two in April. Similarly, most peak annual floods on the Newaukum and Skookumchuck Rivers also occurred during the November through February period.

Examination of the flood data in Table 5-4 reveals some interesting trends. First, recent years have experienced some of the largest floods on record. For example, the 1980, 1990 and 1986 floods rank in the top five all on three rivers. These flood data support the perception that flooding has been worse in recent years. In fact, floods in recent years have been some of the largest to occur during the past 63 years.

Table 5-5 is a summary and ranking of the top 10 peak flows in the upper Chehalis River Basin (Water Resource Inventory Area 23 (WRIA 23). The February 1996 flood is considered the flood of record for the WRIA 23. Flow data for the 2007 flood is only available for the Chehalis River near Grand Mound. Data for the 2009 flood were not yet available. Recorded flows in WRIA 23 show numerous peak flows from the period 1971 to 1996.

Table 5-5. Summary of Ten Peak Annual Flows			
WRIA 23 Chehalis Near Grand Mound		WRIA 23 Newaukum at Chehalis	
Date	Flow (cfs)	Date	Flow (cfs)
Dec-07	79,000[2]	Feb-96	13,300
Feb-96	74,800	Nov-86	10,700
Jan-90	68,700	Jan-90	10,400
Nov-86	51,600	Dec-77	10,300
Jan-72	49,200	Nov-90	10,300
Jan-09	48,800[2]	Nov-98	10,000
Dec-37	48,400	Jan-72	9,770
Nov-90	48,000	Dec-96	9,700
Dec-33	45,700	Jan-03	8,940
Dec-75	44,800	Jan-06	8,720

[1] *Flows after 1963 are affected by diversion*

[2] *Flows are preliminary*

As part of a Flood Insurance Study, FEMA (1981) estimated flood magnitudes at various locations in the Chehalis River basin for return periods ranging from 10 to 500 years. These flood estimates are summarized in Table 5-6. For the extreme flood event in January 1990, the USGS (Hubbard, 1991) estimated the return period of the peak flow on the Chehalis River near Grand Mound to be about 100 years; in layman terms, this flow has a 1 percent chance of occurring in any given year. The return periods of the peak flows at this time on major tributaries were less, estimated to be 30 years (3.3 percent probability) on the Newaukum River and 45 years (2.2 percent probability) on the Skookumchuck River. The USGS is expected to create new flood frequency returns in response to the recent flood events.

Table 5-6. Magnitude and Frequency of Floods within the Chehalis River Basin						
Location		Drainage area (mi²)	Peak flood (cfs)			
Chehalis River			10-year	50-year	100-year	500-year
Chehalis River mainstem	at Grand Mound	895	38,700	51,600	56,000	70,000
	downstream of confluence with Skookumchuck River	834	38,600	51,600	55,780	70,000
	upstream of confluence with Skookumchuck River	653	32,500	42,000	45,000	59,200
	downstream of confluence with Newaukum River	593	32,100	38,500	42,500	58,700
	downstream of confluence with South Fork Chehalis River	332	24,600	32,000	35,220	43,800
	at Pe Ell	95	15,200	20,000	23,000	28,000
Tributaries to Chehalis River						
Skookumchuck River	at confluence with Chehalis River	181	8,750	11,000	13,000	17,900
	Coffee Creek at confluence with Skookumchuck River	7	150	275	234	510
	Hanaford Creek at confluence with Skookumchuck River	58	2,100	3,150	3,700	4,800
China Creek	at confluence with Chehalis River	6	120	220	290	*1
Salzer Creek	at confluence with Chehalis River	25	600	1,070	1,360	
	Coal Creek at confluence with Salzer Creek	9	230	420	530	790
	South Fork Salzer Creek at confluence with Salzer Creek	8	250	450	580	*1
	Middle Fork Salzer Creek at confluence with Salzer Creek	2	190	340	440	*1
	North Fork Salzer Creek at confluence with Middle Fork Salzer Creek	3	180	320	410	*1
Dillenbaugh Creek	at confluence with Chehalis River	12	440	560	630	800
	Berwick Creek at confluence with Dillenbaugh Creek	5	130	180	220	280
Newaukum River	at confluence with Chehalis River	155	7,860	10,750	11,500	13,640
South Fork Newaukum River	North Fork Newaukum River at confluence with Newaukum River	69	4,400	6,350	7,400	9,400
	Middle Fork Newaukum River at confluence with North Fork Newaukum River	19	660	1,000	1,250	1,700
South Fork Chehalis	at confluence with Chehalis River	123	9,300	12,860	14,800	18,600

[1]Data not available
Source: FEMA 1981

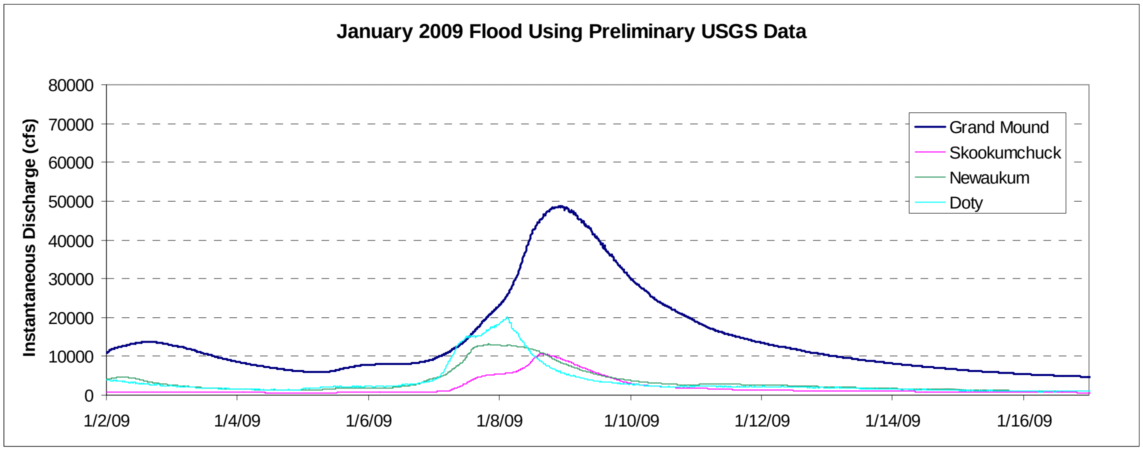
Recent Significant Flood Events

January 2009

The Chehalis River was above the National Weather Service flood stage at the USGS gauge at Grand Mound between January 7 and January 10, 2009. This event resulted in a two day closure of Interstate 5 through Centralia-Chehalis. Preliminary flow data from the USGS indicates the peak discharge at Grand Mound was 48,800 cfs (Figure 5-1).

The January 2009 event was generated by significant precipitation (6 to 15 inches over the preceding week) over snow at low elevations (USGS, 2009).

Figure 5-1 Hydrographs of the January 2009 Flood Event



Source: USGS, 2009.

The peak flow crests for the January 2009 event were within the top five of measured events at the Chehalis River at Porter, the Chehalis River at Centralia, and the Skookumchuck River USGS gauges. The event was in the top ten for the Chehalis at Grand Mound, the Chehalis River at Chehalis, and the Chehalis River at Doty gauges. The event was not in the top ten for the Newaukum River or the Wynoochee gauges. The 2009 flood event appears to have been a result of more evenly-distributed precipitation, compared to the 2007 event (National Weather Service data from the Advanced Hydrologic Prediction System.

There is evidence that storage available within the Skookumchuck Dam may have played a role in reducing the downstream flood peak. The Skookumchuck Dam had been drawn down, and had more available storage volume than would typically be the case.

December 2007

The most significant recent flooding in the Chehalis Basin occurred in December 2007. This event resulted in substantial flooding throughout the basin, including a four-day closure of a 20 mile section of Interstate 5 at Chehalis.

The December 2007 flooding occurred after substantial precipitation associated with a climatic event known as an atmospheric river. An atmospheric river forms when atmospheric conditions allow for a significant movement of subtropical moist air to northern latitudes. This type of event is often referred to as a “pineapple express,” because the moist subtropical air often passes Hawaii on the way to the West Coast. The December 2007 event had a disproportionate affect on the upper Chehalis basin, resulting in significant precipitation over the Willapa Hills that feed the upper mainstem Chehalis and South Fork Chehalis Rivers. Rainfall data summarized by the Office of Washington State Climatologist suggest that the December 1 to 4, 2007 rainfall totals for the upper portion of the Willapa Hills exceeded 14 inches, while the surrounding area received between 3 and 8 inches during the same time period (Mote et al., 2008). Heavy precipitation in the southwestern portion of the basin (the Willapa Hills) resulted in the flood of record at the USGS stream gauge at Doty. The gauge telemetry system transmitted an instantaneous discharge of 51,100 cfs with the flows still rising when the gauge was destroyed. Post-event measurements using high water marks were used by the USGS to estimate that the peak flow reached 63,100 cfs at the Doty gauge. These flows are substantially larger than the previous record flow of 28,900 cfs measured during the 1996 flood event (USGS, 2008).

The USGS Gauge at Grand Mound also recorded what is the record peak for the 2008 water year. The December 2007 instantaneous maximum discharge at Grand Mound was about 79,000 cfs, exceeding the past peak of 74,800 cfs recorded in 1996. The daily average discharge for the 2007 event was lower than the 1996 event, indicating that the 2007 event had a more distinct peak (Mote et al., 2008).

The storm resulted in widespread damages across the Chehalis River basin (Lewis County, 2008). Numerous landslides occurred, levees broke, and dikes were overtopped. Late in the afternoon on December 3, flooding of the Chehalis River forced the closure of Interstate 5 in the Chambers Way area, and by the next day a 20-mile stretch of the freeway was covered by as much as 10 to 15 feet of water in some locations. The floodwaters did not start receding until December 5. Late in the evening on December 6, the Washington State Department of Transportation reopened one lane for commercial truck traffic, followed the next day by the reopening of all lanes of traffic. The economic cost of the Interstate 5 closure was estimated at approximately $4 million dollars a day (City of Centralia, 2009).

On December 3, Governor Chris Gregoire, declared a state of emergency for the entire state citing rains, flooding, landslides, road closures, and extensive property damage.. Grays Harbor, Lewis, and Thurston Counties were part of a federal disaster declaration made on December 8, 2007.

Anecdotal accounts indicate this flood was more damaging than the one in 1996. The water rose faster, and it flooded places that no one remembered being inundated before. Floodwater high up the Chehalis River caused landslides and loads of silt and timber were deposited in streams. In some areas, log jams may have acted like small dams, temporarily holding back water until they toppled over or breached. Water swamped homes, garages and barns to depths of up to 12 feet in some upriver communities. Near downtown Centralia, 20 square blocks were flooded.

Damage to the Chehalis Reservation from the December 2007 flood has been documented in the Chehalis Tribe's Comprehensive Flood Hazard Management Plan (Chehalis Tribe, 2009). During the flood, homes in the central area of the Chehalis Reservation were inundated with up to 4 feet of water. The water moved swiftly and covered the reservation to record water depths within 24 hours of notification of flooding. At the east end of the Chehalis Reservation, water overtopped Anderson Road. Up to 2 feet of water overtopped U.S. Highway 12 and flowed into the Black River east of Anderson Road. Southeast of the Reservation, Independence Road was overtopped near the bridge and a section of the Chehalis River channel migrated south and eroded a portion of the abandoned railroad grade. The central portion of the Chehalis Reservation, at the confluence of the Chehalis and Black Rivers, was flooded from U.S. Highway 12 south to the abandoned railroad grade. Floodwater ponded upstream of the western glacial terrace and rose high enough to overtop Blockhouse Road and flow down Harris Creek. Between the glacial terrace and Oakville, bridges and culverts were overtopped, road pavement was damaged, and houses were flooded. At the west end of the Reservation, portions of Balch Road were damaged and the east approach to the Sickman-Ford Bridge was overtopped and damaged. Elsewhere within the Chehalis Reservation, gravel driveways and rural roads were scoured clean of gravel. Wells and septic systems were swamped and well heads were overtopped.

December 1999

Significant flooding occurred throughout the lower basin, including the Wynoochee and Satsop River basins during December 1999. This event was not a federally-declared disaster, but did result in approximately $1.3 million of reported losses in Grays Harbor County (Grays Harbor County, 2001).

March 1997

Heavy rainfall and low-elevation mountain snowmelt caused flooding in Grays Harbor County. The recorded peak flow on the Wynoochee River above Black Creek (USGS gauge 12037400) was 25,600 cfs, which is the highest recorded flow at this gauge since the Wynoochee Dam was competed in 1973. Similarly for the Satsop River, the peak flow in 1997 was 63,600 cfs, rated as greater than 100 year recurrence interval event (Grays Harbor County, 2001).

December 1996 – January 1997

Saturated ground combined with snow, freezing rain, rain, rapid warming and high winds within a 5-day period were the causes of flooding. Impacted counties included Grays Harbor, Lewis, and Thurston Counties. The recurrence intervals of the Chehalis River in Grays Harbor County and the Skookumchuck River in Lewis County were projected at 10 years. The recurrence level of the Newaukum River in Lewis County was projected at 100 years. (Washington State Military Department Emergency Management Division, 2007).

February 1996

The February 1996 flood is the flood of record on many major drainages in WRIA 23 (Lewis County, 2008). Heavy rainfall, mild temperatures and low-elevation snowmelt caused flooding in many Washington counties, including Grays Harbor, Lewis, and Thurston. Record floods occurred on the Chehalis and Skookumchuck Rivers. The recurrence interval of the Newaukum River in Lewis County is projected at 90 years. The recurrence interval of the Chehalis River in Thurston and Lewis Counties is projected at 90 to 100 years. The maximum flow recorded at the Grand Mound gauge was 73,900 cfs on February 6 (Washington State Military Department Emergency Management Division, 2007).

Several antecedent conditions were in place before the February 6, 1996, flood of record. The ground throughout the basin was at or near saturation. Recent snowfall had occurred as low as 500 feet above sea level. Warm, moist subtropical air was transported from the Pacific Ocean into the Pacific Northwest with a freezing level above 8,000 feet. There was also a strong polar jet stream with maximum core wind speeds in excess of 150 knots (172.6 miles per hour). Storms fed upon the jet stream, and this powerful jet stream sustained and strengthened the storms as they moved in off the eastern Pacific Ocean. Local atmospheric conditions had set up a blocking pattern, which meant the major troughs and ridges around the Northern Hemisphere were stationary. There was a major trough to the west of the Pacific Northwest and a major ridge to the east. This pattern makes ideal conditions for weather systems to be at maximum strength. The atmosphere remained in this pattern for at least 96 hours, maximizing precipitation amounts. Large quantities of water were released from the heavy amounts of rain and snowmelt (Lewis County, 2008).

The 1996 flood covered 75 percent of the Chehalis Reservation with measured flood depths up to 10 feet. All access routes, including Howanut Road, Anderson Road, and Moon Road were under 1 to 4 feet of fast-moving water. U.S. Highway 12, which provides access to many secondary roads, also was flooded, and Interstate 5 was flooded and closed for several days. (Chehalis Tribe, 2009).

January 1990

Flooding occurred on the Chehalis and Skookumchuck Rivers as heavy rainfall and severe storms affected Grays Harbor, Lewis, and Thurston Counties. Maximum flow at the Grand Mound gauge was 68,700 cfs recorded on January 10, 1990. The recurrence interval was projected at 70 years (Washington State Military Department Emergency Management Division, 2007)

Floodwater affected the cities of Centralia, Chehalis, Montesano, Elm, Bucoda, and Oakville (Lewis County, 1994). Hundreds of people were evacuated and several hundred homes and businesses were damaged or destroyed. The Chehalis hospital was isolated by floodwaters and several nursing homes were evacuated. Interstate 5 in Chehalis closed for several days, covered by 3 to 5 feet of water. (Washington State Military Department Emergency Management Division, 2007). The dikes around the Chehalis-Centralia Airport and Lewis County Fairgrounds failed or were overtopped. Wastewater treatment plants in Chehalis and Centralia were out of service and the Centralia landfill was inundated. Approximately 10,000 acres of agricultural land was flooded and cattle and chickens were killed.

The flood was caused by a stalled, southwesterly weather system over the region (Lewis County, 1994). The 2-day storm rainfall was about 5.3 inches on average with the average basin runoff at 5.1 inches. Ground conditions were saturated, resulting in minimal infiltration and high runoff.

November 1986

Heavy rainfall, mild temperatures, and low-elevation snowmelt generated major floods on the Chehalis and Skookumchuck Rivers. Less severe flooding occurred on the Satsop River. Two-hundred eighty homes and businesses flooded in Lewis County; impacts included a major hazardous materials spill (pentachlorophenol) from an underground storage tank. The Lewis County fairgrounds were under 9 feet of water. Numerous levees overtopped and damaged throughout flooded counties. The recurrence interval of the Chehalis River in Grays Harbor County was projected at 45 to 50 years. At Grand Mound the maximum flow was 51,600 cfs. The recurrence interval of the Chehalis River at Grand Mound was projected at 20 years. (Washington State Military Department Emergency Management Division, 2007).

Other Floods

Other significant floods occurred in the Chehalis River basin in 1975 and 1972. The maximum flow at Grand Mound during the 1972 flooding event was 49,200 cfs. The flood recurrence interval at Grand Mound was projected at 15 years (Washington State Military Department Emergency Management Division, 2007). No other information is readily available for these floods.

Chapter 6 FLOOD PROBLEM AREAS

Problem Identification

Flood problem areas occur throughout the Chehalis River Basin. As discussed in previous chapters, flooding occurs to some extent in most years, and can be dramatically different in the upper or lower basins. To frame a discussion of flood problem areas, general flooding problems are presented, followed by a partial listing of specific flood problem areas throughout the Flood Authority's study area. The specific flood problem areas were developed by reviewing existing Comprehensive Flood Hazard Management Plans for jurisdictions in the area, soliciting comments from the public at the Authority's public meetings, reviewing the hard copy of recent detailed hydraulic modeling, and a basic Geographic Information System (GIS) analysis.

This discussion is intended to support the development of solutions to these known flooding problems. In the Flood Authority's previous deliberations, several overarching problems have been identified, and initial steps (known as "ripe and ready" projects) have been identified and targeted for support. These projects are identified throughout this chapter as appropriate.

General Flooding Issues

General flooding issues in the Chehalis River basin include understanding the sources, potential extent, and potential consequences of flooding; communicating flood hazard information; response to flood events; and impacts of flood waters. These general flooding issues are described in the following sections.

Understanding the Sources, Potential Extent, and Potential Consequences of Flooding

Initial scientific and engineering hydrologic and hydraulic investigations are an essential element of planning for flood events. These studies can help show the potential extent of flooding, and can suggest the consequences of flooding outside the inundated area. For the Chehalis Basin, initial flood studies have been completed along most of the major channels. The resolution of these studies varies significantly throughout the study area, with more detailed models available in the upper basin (generally upstream of Grand Mound), and less detailed models available for the lower basin.

The Flood Authority is addressing the variable level of detail of the studies through the authorization, in April 2009, of funding for several ripe and ready projects. Those projects include:

- Extending LiDAR[1] coverage throughout the entire study area to establish a consistent, high quality representation of floodplain surface topography.
- Developing an unsteady HEC-RAS[2] model for the lower basin, to match the resolution of the existing model in the upper basin.
- Augmenting the existing precipitation and stream gauge network.

Communicating Flood Hazard Information

Information about flood hazards needs to be conveyed to all residents of the Chehalis River basin. Flood hazard information is available in three phases: prior to flood events, during flood events, and post-event. Prior to flood events, it is important that the public understand that floods can and will occur, both to support decisions about property acquisition, insurance, and development and to prepare for future events. Challenges with communicating flood hazards include:

- Lack of public understanding of river system behavior and flood hazards;
- The real-time nature of these events; and
- Highly variable levels of understanding of, and tolerance for, risk.

Communication is vital during flood events to ensure that information is disseminated to all affected residents in a way that provides adequate warning. Post-event communication focuses on informing and reminding people of proper clean up and sanitary measures.
A flood warning system exists for the Chehalis River basin, based primarily on the National Weather Service's Advanced Hydrologic Prediction System. This system is available on the web, and provides measured and predicted hydrographs at established USGS stream gauges. This system provided advance warning of flooding in both 2007 and 2009, and provided a reasonable level of accuracy for both events.

Public comments given at public workshops suggest that this system may not provide the level of detail necessary to achieve the overall goal of providing clear warning to residents throughout the basin. The National Weather Service information is often interpreted through media outlets, which can influence the impact of the information.

To address this potential gap, the Flood Authority has authorized funding for a Ripe and Ready project to evaluate the adequacy of the existing warning system and make recommendations for augmenting existing systems and improving communication tools.

---

[1] LiDAR = Light Detection and Ranging – a remote sensing technology that measures properties of scattered light to find range and/or other information of a distant target.
[2] HEC-RAS = Hydrologic Engineering Centers River Analysis System – a hydraulic model of water flow through rivers and other channels developed by the Corps of Engineers.

Response to Flood Events - Emergency Management

The quality of response to flood events is tied to advance planning, preparation of materials, and broad understanding of plan implementation. Key factors for emergency management include:

- Adequate warning of flood events;
- Established circulation/access routes;
- Established coordination protocols;
- Access to flood fighting materials; and
- Access to hospitals and emergency headquarters.

Specific emergency response issues have included the lack of access from one side of the flooded valley to the other, loss of local radio station, impaired access to a major hospital. The Flood Authority has authorized a project to evaluate the existing warning system in the basin and develop recommendations for improvements.

Impacts of Flood Waters

The direct impacts of flood waters extend across the floodplain, and include temporary and long term impacts. These impacts include:

- Inundation during the flood event;
- Loss of property due to bank erosion and channel migration;
- Sedimentation;
- Water quality impacts, including domestic well contamination;
- Damage to buildings, machinery, or roads; and
- Compromising vital infrastructure, including wastewater treatment plants.

Table 6-1 summarizes the flooding issues in the basin and identifies Ripe and Ready projects that the Flood Authority has authorized to further evaluate the issues.

Table 6-1 General Flooding Issues

Issue	Ripe and Ready Project(s)
Understanding the Sources, Potential Extent, and Potential Consequences of Flooding	• LiDAR • Unsteady HEC-RAS model • Stream and rain gauge program • Study of ecosystem services • Decision Support Tool
Communicating Flood Hazards • Lack of public understanding of river system behavior and flood hazards • The real-time nature of these events • Highly variable levels of understanding of, and tolerance for, risk	• Early Warning System
Response to Flood Events – Emergency Management • Adequate warning of flood events • Established circulation/access routes • Established coordination protocols • Access to flood fighting materials • Access to hospitals and emergency headquarters	• Early Warning System
Impacts of Flood Waters • Inundation during the event • Loss of property due to bank erosion and channel migration • Sedimentation • Water quality impacts, including domestic well contamination • Damage to buildings, machinery, or roads • Compromised vital infrastructure, including wastewater treatment plants	• Early Warning System • Unsteady HEC-RAS model • Decision Support Tool • PUD Storage Study

Site Specific Flood Issues

The following sources were used to develop a list of site specific flooding issues:

- Existing Comprehensive Flood Hazard Management Plans for jurisdictions in the Chehalis basin;
- Public comments solicited at public meetings held on February 11, 2009 in Chehalis and February 12, 2009 in Montesano;
- Contacting floodplain and emergency managers at member communities; and
- A general mapping analysis of the basin comparing major transportation infrastructure to mapped special flood hazard zones.

The existing CFHMPs are described in Table 1-1 in Chapter 1. These plans provided the basis for identifying flood problem areas in the basin.
The Flood Authority conducted public meetings in Chehalis on February 11 and Montesano on February 12, 2009. At the meetings, the Flood Authority solicited public input on flood-related problems, potential solutions, and recommended goals for the Authority. The problems identified by members of the public are listed below. The problems are presented as a list of actual comments made by the public and no attempt has been made to edit or categorize them.

Problems identified by the public at the public meeting in Chehalis on February 11:

- Restricted flow of the Chehalis River at Galvin Road
- Water built up at Mellen Street, goes into Chehalis and Centralia
- Water backing up over Highway 6 / Closure of Highway 6
- Residential flooding along Highway 6
- Flooding in West Adna
- Residential flooding 3 to 4 miles up Salzer Creek
- Bridges washed out
    - Dryad
    - Meskill
    - Rainbow Falls State Park
- Extensive flooding on Bunker Creek – loss of livestock and feed, major property damage, river changed course
- Flooding on Scheuber Road – across from Airport
- Flood on Newaukum, Rice Road area
- Flooding on Sylvenus Street – across from Riverside
- Lack of forest duff causes faster runoff
- Flooding in homes near Veteran’s Memorial Museum in Chehalis
- Lack of flood prediction and gauges near Veteran’s Memorial Museum
- South Street area of Chehalis, by Salzer Valley Creek, floods between the landfill and the tracks
- Emotional trauma related to flooding of homes
- Flooding along River St. in Chehalis
- Long Road dike area
- Long Road dike breach (2007), impact on houses
- Residential flooding in Curtis
- Flooding in China Creek
- Retail business losses due to flooding
- Debris and mud flow contributing to property damage
- Inability to travel

- Inability to develop
- Stalled process
- Lack of responsiveness from Corps
- Levees push water into houses
- Consequences of filling runoff spots (wetlands)
- Communications break down in 2007 flood
- Not enough stormwater drains, or they back up (near Veteran's Memorial Museum)
- Poor predictions
- "Best" practices that are not
- River does not have enough capacity
- Roads acting as a dike or levee, particularly as a result of road repairs
- Projects that contribute to what they are supposed to fix
- Bureaucracy
- Waiting too long for solutions
- Steep-slope clear-cutting / logging practice - rotation lengths that are too short
- Unclear rules on rebuilding permits
- State sales tax on rebuilding
- Impacts on business/commerce
- Need better flood notification to neighborhoods
- Need for better flood cleanup, should involve community
- Environmentalists in the way
- Some folks are trapped
- Difficulty with government processes – billing, requirements, permitting
- Corps cannot be trusted
- Inadequate flood fighting
- Water super tunnels
- Levee failure / levees get overtopped often
- Inadequate levee repair
- Levees displace people

Problems identified by the public at the public meeting in Montesano on February 12:

- Mismanagement of the lake level on the Wynoochee Dam
- Log jams in the rivers
- Erosion of farm lands – mile long stretches
- Flooding of Oakville
- Water from Capital Forest

- Loggers and property owners cut down trees before they get to 30 inches and that causes more water runoff and more soil erosion in a flood
- Lost livestock
- Loss of three dairies – each dairy loses $1 million a year during floods
- Bank erosion on the lower Satsop – there are 250,000 cubic yards of dirt that went into the river
- Barometric pressure of water coming out of the ground
- Difficulty for citizens to predict flooding on their property from available information
- Anderson Road (Chehalis Reservation) acts as dam
- Black River Bridge acts as a dam
- Highway 12 acts as a dam
- Moon Road (Chehalis Reservation) gets closed every flood
- Levees just cause someone else to get flooded
- 100-year floods happen more often than every 100 years
- Dams only work during unique situations planned for by hydrologists.
- Erosion in Boistfort – soils end up downstream

A general GIS analysis was performed to identify other potential flood problem areas not identified in existing CFHMPs or by public comment. The analysis used the Washington State Department of Transportation (WSDOT) ”major roads” layer and the mapped 1 percent annual chance flood. The 1 percent annual chance flood mapping used was the FEMA Q3 data for Lewis and Grays Harbor Counties, and a data layer developed by Thurston County in that area. The major roads layer and the 1 percent annual chance flood area were combined to identify infrastructure at risk for flooding. The results were then inspected to identify long stretches of major road that have the potential to be overtopped in a major flood. If these areas provided what appeared to be regionally-important access (e.g., connecting a more rural portion of the area to an urban center), they were included in the mapping. This mapping has not been confirmed or verified.

More recent flood mapping developed by Northwest Hydraulics Consultants (nhc) for the Lewis County prosecutor’s office was also inspected to identify areas with significant flooding. This mapping is based on an unsteady HEC-RAS model that has been developed to show the approximate extent of the 2007 flood event. While the general flood mapping is similar to the FEMA Q3 mapping described above, the Northwest Hydraulics Consultants mapping is more resolved in many areas, and also is set up to depict the depth of flooding.

To simplify the discussion of site-specific flood issues, the issues were categorized into three areas:

- Major Infrastructure (MI),
- Human Health and Safety (HHS), or
- Emergency Response (ER).

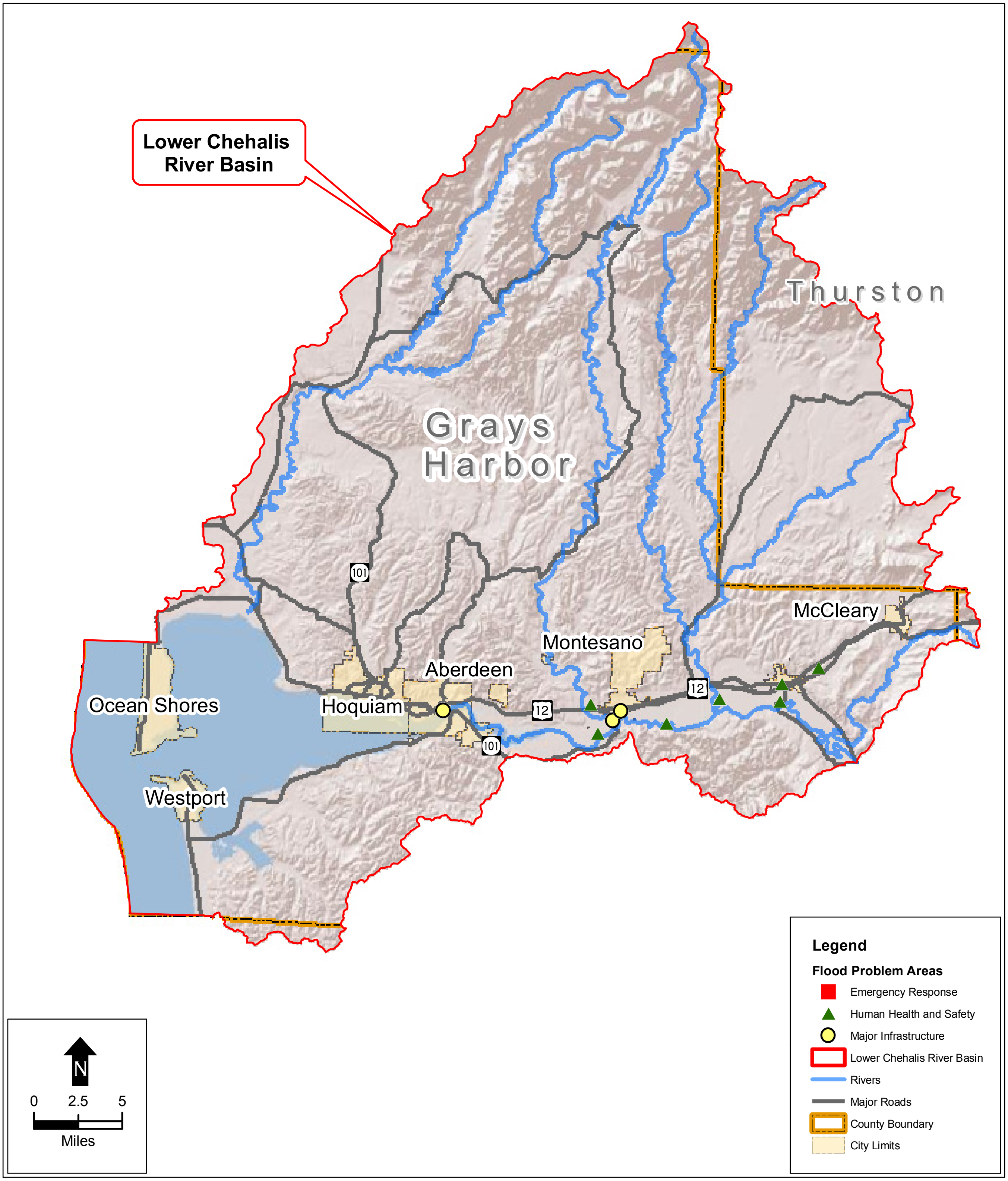
Major Infrastructure issues include major items such as interstate highways and wastewater treatment plants that are threatened by flood events. Human Health and Safety includes flooding of private property, secondary roads, and other public infrastructure. The Emergency Response category is intended to capture key elements of the emergency response network that have been damaged or cut off during floods, when they are needed most. Table 6-2 lists the identified flood issues. All site-specific flood issues are mapped in Figures 6-1 (upper basin) and 6-2 (lower basin).

Table 6-2 Site-Specific Flood Issues

Location	Type[1]	Information Source	Flooding Source(s)
I-5 at Dillenbaugh Creek Confluence	MI	GIS	Mainstem Chehalis and Dillenbaugh Creek
Highway 6	MI	GIS and Public Comment	Mainstem Chehalis and Newuakum
I-5 at Chehalis	MI	GIS, nhc map	Mainstem Chehalis
Mellen Street Wastewater Treatment Plant	MI	Lewis County CFHMP	Mainstem Chehalis
Centralia Central Business District at China Creek	MI	Lewis County CFHMP	Mainstem Chehalis, China Creek, Skookumchuck River
Montesano Wastewater Treatment Plant Lagoons	MI	Montesano Hazard Plan	Mainstem Chehalis, Tidal Action
Highways 105 and 107 at Montesano	MI	GIS	Mainstem Chehalis
US Highway 12 at Elma	MI	GIS	Mainstem Chehalis
Chehalis River at Aberdeen	MI	GIS	Mainstem Chehalis, Tidal Action
Long Road	HHS	GIS and Public Comment	Mainstem Chehalis
Stearns Creek Confluence	HHS	nhc mapping	Stearns Creek, Mainstem Chehalis
SF – Mainstem Confluence	HHS	nhc mapping	South Fork, Mainstem Chehalis
Salzer Creek/Fairgrounds	HHS	Lewis County CFHMP	Salzer Creek,
Dillenbaugh Creek Industrial Area	HHS	Lewis County CFHMP	Dillenbaugh Creek, Mainstem Chehalis
Lower Coffee Creek	HHS	Lewis County CFHMP	Coffee Creek, Skookumchuck River
Galvin	HHS	Lewis County CFHMP	Mainstem Chehalis, Lincoln Creek
Bucoda	HHS	Bucoda CFHMP	Skookumchuck River
Adna	HHS	Public Comment	Mainstem Chehalis
Residential flooding on Salzer Creek	HHS	Public Comment	Salzer Creek
Newaukum at Rice Road	HHS	Public Comment	Newaukum River
Curtis	HHS	Public Comment	South Fork Chehalis
Bridge failures at Dryad and Rainbow Falls State Park	HHS	Public Comment	Mainstem Chehalis
Bridge failure at Meskill	HHS	Public Comment	Mainstem Chehalis
Highway 507	HHS	GIS	Skookumchuck, China Creek
Wakefield Road near Elma	HHS	GIS	Mainstem Chehalis

Location	Type[1]	Information Source	Flooding Source(s)
Oakville	HHS	Chehalis Tribe CFHMP	Mainstem Chehalis
Sickman Ford Bridge Approach	HHS	Chehalis Tribe CFHMP	Mainstem Chehalis
Upper Falls Creek	HHS	Grays Harbor CFHMP	Upper Falls Creek
Elma	HHS	Grays Harbor CFHMP	Mainstem Chehalis
Road near Satsop – Chehalis Confluence	HHS	Grays Harbor CFHMP	Mainstem Chehalis, Satsop River
Chehalis downstream of Satsop-Chehalis Confluence	HHS	Grays Harbor CFHMP	Mainstem Chehalis, Satsop River
Chehalis near Arland Road	HHS	Grays Harbor CFHMP	Mainstem Chehalis
Wynoochee River near Montesano	HHS	Grays Harbor CFHMP	Wynooche, Mainstem Chehalis
Hospital on Crooks Hill Road	ER	Lewis County CFHMP	Mainstem Chehalis
Moon Road at Chehalis Tribe	ER	Chehalis Tribe CFHMP	Mainstem Chehalis, Black River
Anderson Road at Chehalis Tribe	ER	Chehalis Tribe CFHMP	Mainstem Chehalis
Howanut Road	ER	Chehalis Tribe CFHMP	Mainstem Chehalis, Black River

1 MI = Major Infrastructure, HHS = Human Health and Safety, ER = Emergency Response



SOURCE: ESRI, 2008; Regional CFMHPS, 2007; WSDOT, 2008, Department of Ecology; 2007

Chehalis River Basin Facilitation . 208379

Figure 6-1
Lower Chehalis River Basin
Flood Problem Areas
Lewis County, Washington

G:\WATER RESOURCES\2008 Projects\208379 Chehalis River Basin Facilitation\05_Graphics_GIS_Modeling\GIS\Fig01_Flood_problems\Fig02_FloodProblemAreas_LowerBasin.mxd (MJL; 3/17/09)

SOURCE: ESRI, 2008; Regional CFMHPS, 2007; WSDOT, 2008, Department of Ecology; 2007

Chehalis River Basin Facilitation . 208379

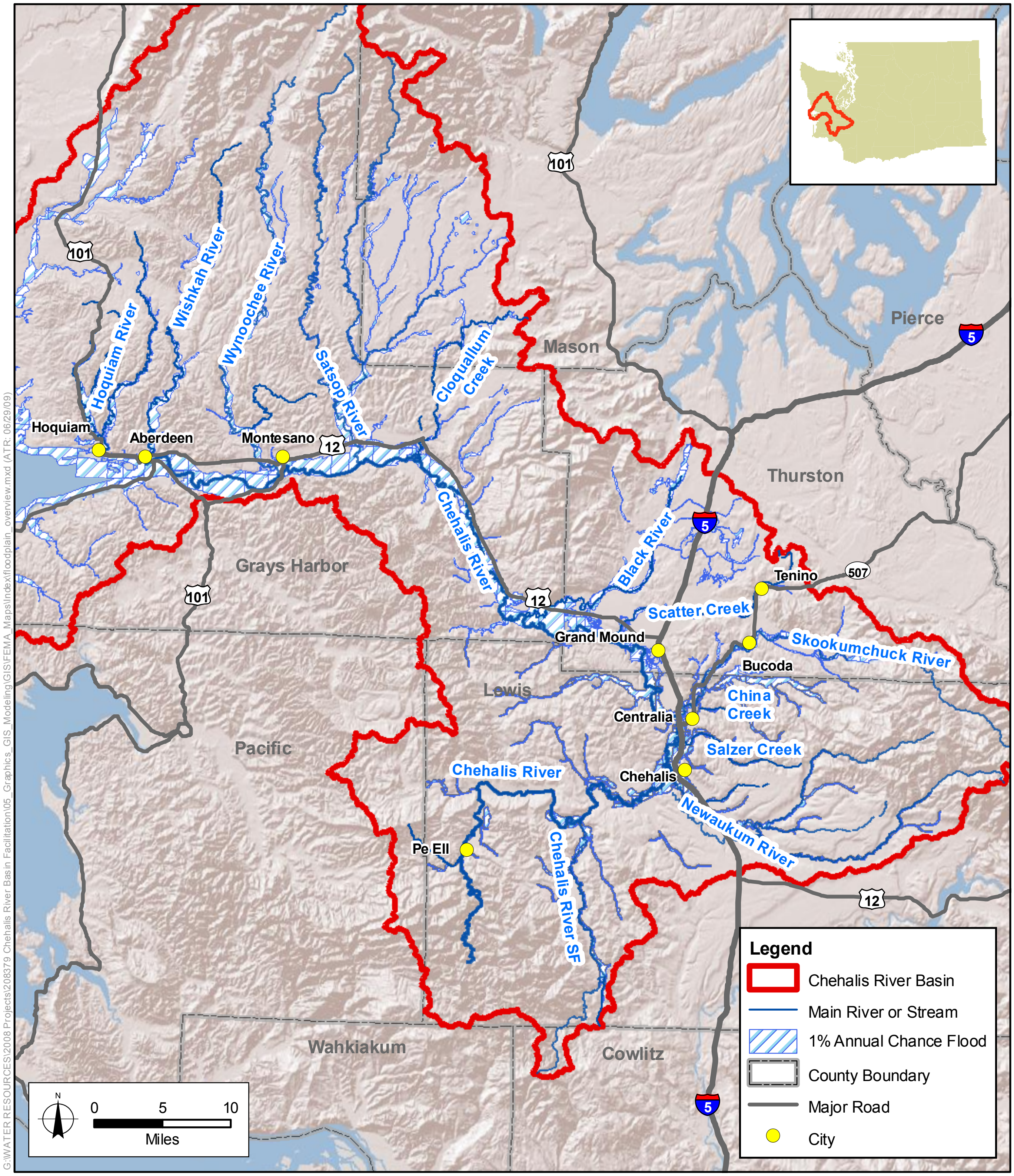
Figure 6-2
Upper Chehalis River Basin
Flood Problem Areas
Lewis County, Washington

FEMA Mapping

FEMA has mapped the floodplain for the Chehalis River basin. This Draft CFHMP includes a Map Folio of the floodplain maps as a CD attachment. The coverage of the floodplain mapping is illustrated in Figure 6-3. A detailed map overlain on an aerial photograph is available on the CD for each individual panel shown on Figure 6-3.

The Chehalis River Basin Map Folio maps the 1 Percent Annual Chance Flood extent for the Chehalis River and its main tributaries. The source data for the 1 Percent Annual Chance Flood dataset is provided by FEMA and is available via their Digital Q3 library. The Q3 Flood data represents FEMA's most current floodplain data. The aerial imagery is provided by ESRI, the Geographic Information System (GIS) software company and dates from 2006.

The Map Folio is organized by major river and/or tributary and includes index maps and accompanying internal links to aid users as they navigate and locate maps associated with certain geographic areas. The maps are presented at one of three scales (from larger to smaller): 1:5,280; 1:7,920; and 1:15,840. The scale used for a given map is dependent upon the relative density of development for a given extent. In general, more urbanized and developed areas are mapped at larger scales (more detail) while more natural and less developed areas are mapped at smaller scales (less detail).



SOURCE: ESRI, 2005, 2008; FEMA (Q3 Flood); WDNR, 2008

Chehalis River Basin Facilitation . 208379.01

Figure 6.3
Flood Map Overview
Chehalis River Basin, Washington

CHAPTER 7 DEVELOPMENT OF MITIGATION ALTERNATIVES

Options for addressing flooding concerns include engineered projects, public information programs, regulations, planning measures, and environmental protection and enhancement measures. Comprehensive flood hazard management emphasizes selecting a mix of approaches to minimize flooding impacts. This chapter presents and defines the general types of alternatives commonly used in floodplain management.

General Categories of Solutions

Flood hazard management measures are commonly classified as structural or nonstructural. Structural measures involve physical activities in or near the stream such as excavation, placement of bank protection materials, and other engineering and construction activities. Nonstructural measures include stormwater and land use regulations, flood preparedness programs, public awareness programs, floodproofing, and maintenance programs. The federal government encourages the use of cost-effective, long-term nonstructural alternatives. Tables 8-1 and 8-2 summarize typical nonstructural and structural solutions, respectively.

Figure 7-1 Typical Nonstructural Flood Hazard Management Solutions

Measure	Description	Typical Activities
Public Information	Public information activities to advise people of the risks associated with flood hazards, about flood insurance, and ways to reduce flood damage	• Public outreach projects • Flood protection library • Flood preparedness programs • Elevation certification • Hazard disclosure • Public workshops or meetings
Regulation	Regulatory measures to provide protection for existing structures and new development through land use regulation	• High regulatory standards • Low-density zoning • Open space preservation • Regulatory consistency • Building codes • Stormwater management
Planning and Data Collection	Activities to develop accurate floodplain information and flood data and increase the understanding of the river's flood characteristics	• Floodplain and channel meander zone (CMZ) mapping • Flood data maintenance (GIS, databases) • Engineering studies • Modeling
Reduce Damage to Existing Structures	Measures addressing flood damage to existing structures (buildings, roads, bridges, levees, etc.)	• Acquiring or relocating floodprone structures • Floodproofing • Developing repetitive loss plans • Elevating buildings and roadways • Flood insurance

Measure	Description	Typical Activities
Emergency Response and Preparedness	Actions to minimize the effects of flooding on people, property, and the contents of buildings	• Individual action plans • Comprehensive planning • Flood warning systems • Stream and precipitation gauge monitoring • Flood facility maintenance programs • Emergency response plans • Critical facilities protection • Post-distaster mitigation
Natural Resource Protection Projects	Measures to preserve or restore natural areas or the natural functions of floodplain and watershed areas	• Wetland protection • Habitat protection • Erosion and sediment control • Forestry practices

Figure 7-2 Typical Structural Flood Hazard Management Solutions

Measure	Description	Typical Activities
Floodplain Protection	Measures that reduce flood hazards for property, structures and occupants in the floodplain. Protection from inundation, floating debris, sediments, and the force of water flowing in the floodplain.	• Setback levees • Dikes • Elevating roads • Redesigning and replacing bridges • Constructing/expanding storage reservoirs
Bank Protection	Measures design to produce a stable, durable streambank that can withstand flood waters	• Reestablishing riparian vegetation • Constructing approach dikes • Installing gabions (wire cages filled with rocks to stabilize the bank) • Constructing windrow revetments (a line of stone placed on the edge of a bank) • Reducing bank slope • Riprap
Conveyance Capacity	Increasing channel bed slope or cross-sectional area or decreasing channel roughness in order to increase the amount of flow that a stream can carry; increasing off-channel storage or floodplain storage	• Constructing overflow/secondary channels • Removing vegetation and debris • Widening or deepening the channel • Controlling growth of vegetation in the channel • Increasing floodplain storage by removing levees or moving roads

Next Steps

This chapter has presented a simple description of potential mitigation alternatives both structural and nonstructural. The next iteration of this CFHMP will include more detailed descriptions of mitigation alternatives, especially of those that are appropriate for the Chehalis River basin.

CHAPTER 8 ALTERNATIVE ANALYSIS APPROACH/RECOMMENDED ACTIONS

Introduction

This chapter presents a description of all structural and nonstructural alternatives that were identified as potential ways to reduce flooding impacts in the Chehalis River basin. The chapter includes projects that have been recommended to reduce flood problems in the Chehalis basin and describes the process the Flood Authority will use for selecting projects in the future.

The flood mitigation alternatives presented in this chapter were identified in a number of ways. First, project lists were compiled from existing Comprehensive Flood Hazard Management Plans for jurisdictions within the Chehalis basin. Second, the public was asked to recommend projects at the public workshops held in February 2009. The Flood Authority also requested project recommendations from member jurisdictions and others.

Flood mitigation strategies for the Chehalis River basin are classified in three categories:

- Major regional capital projects,
- Local capital projects, and
- Nonstructural programmatic actions.

The sections below describe the potential projects that have been recommended in each category and identify which are being recommended at this point in the Draft Plan process.

Selection Criteria and Ranking Process

The Flood Authority began developing its process for ranking projects at its May 2009 work session. At that meeting the Flood Authority reviewed draft project considerations and discussed a system for ranking projects. The Flood Authority will continue to develop the process at future work sessions, starting in July 2009.

Draft Project Considerations

The Flood Authority reviewed and commented on draft considerations for evaluating projects at the May 2009 work session. Those considerations have been revised and are presented here.

- **Definition of the Project.** Has the project been sufficiently defined and scoped to be considered and evaluated as a potential project by the Flood Authority? What is the intent of the project? Who will benefit?
- **Implementing Agency**. Is there an identified agency or jurisdiction who will take the lead on the project? Is there an identified agency or jurisdiction who will be in charge of maintenance on the project?
- **Ability to Meet Goals**. Does the project meet the goals outlined in the Chehalis River Basin Comprehensive Flood Hazard Management Plan?

- **Effectiveness of Mitigation.** What flood hazard problems does the project solve? Is it a permanent or temporary solution? Is it a complete or partial solution? How much of the basin would be affected? Does the project consider upstream and downstream effects?
- **Feasibility**. Are there technical obstacles that would prevent the project being constructed?
- **Cost and Funding Sources**. How expensive is the project and who will bear the cost? Are funding sources available, both in the short-term and long-term?
- **Cost-effectiveness**. How much benefit does the project deliver per dollar invested?
- **Environmental Impacts**. Does the project have significant environmental impacts or can adverse impacts be mitigated?
- **Permitting Ease**. What approvals or permits will be required? Are those approvals or permits likely to be granted?
- **Timeliness**. How long will it take to implement the project? Are there other projects that must be completed before this project can begin?
- **Acceptability**. Is the project acceptable to the stakeholders in the Chehalis basin?

Ranking Process

The Flood Authority proposes to evaluate and rank potential projects using the draft considerations. The draft considerations will be developed into a numerical, weighted ranking system.

Major Regional Capital Projects

Major regional capital projects are those projects that would address flood issues on a broad or regional basis. These include projects such as levee construction, flood storage, and dam modifications. Several major regional capital projects have been recommended for the Chehalis River basin and some of those projects are currently being studied. However, the projects are not yet ready for implementation. These projects are described in Table 8-2 (located at the end of this chapter). The Flood Authority has decided to fund studies that will support decision-making on these major regional projects as part of its Nonstructural Programmatic Actions described below.

Several of the studies the Flood Authority has chosen to fund relate to a specific major regional capital project. These studies, such as the Upstream Storage Feasibility Phase II Analysis and the Skookumchuck Dam Modification Feasibility Analysis, will develop the information necessary to answer to the Flood Authority’s project considerations. Though not funded by the Flood Authority, completion of project design for the Twin Cities project will fill a similar role for that project. Other funded studies, such as the Decision Support Tool (DST), the HEC-RAS hydraulic model, and the Ecosystem Services analysis, will provide information necessary to evaluate all major regional capital projects. Once these studies are complete, the Flood Authority will be able to use its established project considerations and ranking process to make decisions about which projects to support. This process is detailed in Figure 8-1. See Figure 8-2 for a timeline of estimated completion dates for studies and other efforts related to decision-making on major regional capital projects.

Local Capital Projects

Local capital projects are ones that address specific, local flood problems. Many of the projects identified in existing Comprehensive Flood Hazard Management Plans for jurisdictions in the basin fall into this category. Local capital projects are described in Table 8-3 (at the end of this chapter). Most of these projects are ones that could most appropriately be undertaken by local jurisdictions. However, it might be appropriate for the Flood Authority to support some of these projects either through direct funding or by providing match money for grants.

Because the local capital projects are different in scale than major regional projects, the Flood Authority would apply a different ranking system to evaluate them. The Flood Authority discussed draft considerations, listed below, for evaluating local projects at its May 2009 work session. The Flood Authority considered the following considerations for evaluating local capital projects, but has not yet determined whether to support such projects.

- Address the general project considerations,
- Can be implemented at a relatively low cost,
- Can be accomplished in the next year or two,
- Provide relief from flood damage,
- Are potentially eligible for funding partnerships in the near future,
- May not have other funding sources,
- Provide an immediate benefit,
- Do not adversely affect others, and
- Will not preclude any future actions.

Nonstructural Programmatic Actions

Nonstructural programmatic actions are projects that attempt to prevent or reduce flood damage through nonstructural means. Typical programmatic actions include:

- Regulatory programs,
- Planning and data collection,
- Education and public information,
- Emergency response,
- Reducing damage to existing structures,
- Natural resource protect, and
- Forest practices.

Table 8-4 (at the end of this chapter) describes the nonstructural programmatic actions that have been identified in the Chehalis basin. The actions in the table are classified by the categories above.

The Flood Authority has approved an approach for considering regulatory approaches to flood control and has agreed to fund several planning and data collection projects through its Ripe and Ready Studies program. These are described in the following sections. The Flood Authority will evaluate other nonstructural programmatic actions in the next stage of its flood planning process.

Consideration of Regulatory Approaches

In response to concerns and questions about development impacts on flooding and the adequacy of existing local regulations, the Flood Authority agreed to evaluate existing regulations in the basin. At its June 2009 business meeting, the Flood Authority authorized an approach to considering regulatory programs. The purpose of the project is to make recommendations for improvements to regulatory programs in the basin. The approach for the project is presented below.

The Flood Authority will authorize a Work Group consisting of the Board Advisory Committee and representatives from the basin jurisdictions' planning and building departments to develop findings and options for building and land use regulations to achieve flood damage reduction. This Work Group will undertake the following steps:

- Evaluate regulatory approaches to development in the floodplain from the perspective of:
    - Risk to proposed structures,
    - Risk to existing structures and properties,
    - Ecological risks (including habitat, water quality, and wetland impacts), and
    - Emergency management costs.

- Review local jurisdictions options for credit from the Community Rating System (CRS) to reduce flood insurance premiums under Activity 430, Higher Regulatory Standards.
- Develop findings and options for presentation to the Flood Authority, including:
    - Best management practices and model regulations for local jurisdictions to consider, and
    - Pros and cons of various practices and approaches.

The Flood Authority will use these findings to develop a recommended set of consistent best land use practices and regulations to achieve flood damage protection and reduction.

This project is scheduled to begin in July 2009.

Ripe and Ready Studies

An early interest of the Flood Authority was implementing some flood risk reduction projects as soon as possible. These projects were identified as ones that could provide an immediate benefit, would not adversely affect others, and would not preclude any future actions. These have been referred to as "Ripe and Ready" projects. Under the category of ripe and ready studies, the Flood Authority has chosen to support a number of studies that would support decision-making on major capital projects in the basin.

Table 8-1 summarizes the ripe and ready studies being pursued by the Flood Authority.

Table 8-1 Ripe and Ready Studies

Study	Update
PUD Flood Storage Phase 2	The Flood Authority has contributed funding for Phase II studies of upstream storage.
Skookumchuck Dam Modification Feasibility	TransAlta is studying alternatives and analyzing the feasibility of modifying the discharge system of the Skookumchuck Dam to allow for faster drawdown and more effective use of the facility for flood control.
Early Warning Program	The Flood Authority has studied the existing precipitation and stream gauge system in the basin and solicited recommendations for new gauges. The Flood Authority is in the process of releasing a Request for Qualifications for a firm to design an improved flood warning system for the basin.
Ecosystem Services	This project will provide an analysis and valuation of flood protection and other ecosystem services in the Chehalis Watershed. The Flood Authority is expected to approve the contract with Earth Economics in June 2009.
Lower-basin Hydraulic Model	This project would produce a calibrated 1D hydraulic model for the lower basin, similar to the existing unsteady HEC-RAS model used by Northwest Hydraulic Consultants **(nhc)** and the Corps for the upper basin. The Flood Authority is coordinating with FEMA on potential partnership.
Seamless LiDAR	Light Detection and Ranging (LIDAR) data exist for some, but not all of the basin. This project would acquire a seamless LIDAR surface of the entire basin. The Flood Authority is coordinating with Puget Sound LIDAR Consortium to acquire this data.
Decision Support Tool (DST)	The Decision Support Tool (DST) is a USGS calibrated rainfall-runoff model for gauged and ungauged streams throughout the basin. The Flood Authority is reviewing a scope of work for the project.

Next Steps

Before the Flood Authority is able to make decisions on recommended actions, it needs to finish developing the selection criteria and ranking process, determine when and how it will fund local capital projects, and gather information about proposed projects. The Flood Authority will work on the selection criteria and ranking process and discuss its role in funding projects at the July 2009 work session. Future versions of this plan will include the final process as approved by the Flood Authority. The Flood Authority will also continue to undertake the Ripe and Ready studies and consideration of regulatory approaches identified above. Information and recommendations gathered through these efforts will be incorporated into this and other chapters of the CFHMP. Data gathered from the Ripe and Ready studies will also be used to evaluate major regional capital projects and other actions considered by the Flood Authority. When the Ripe and Ready studies are complete, the Flood Authority will use their established selection criteria and process to decide which projects to pursue, and these projects will constitute the recommended actions.

Table 8-2 Major Regional Capital Projects

Project Name	Proposer	Geographic Area	Project Description	Problems Mitigated	Alternatives Examined	Proposed Implementer	Schedule for Implementation	Permit Issues	Estimated Cost	Potential Funding Sources
Twin Cities Project	Corps of Engineers	Centralia and Chehalis, Skookumchuck River, with impacts downstream	A series of levees in Centralia and Chehalis. Potential modifications to the Skookumchuck dam.	Flooding in the Twin Cities and vicinity. Flooding of I-5 near Chehalis.		Corps of Engineers	Design complete in Nov. 2011. Construction begins Oct. 2013, ends in 2020.		Refined cost estimate will be available in January 2010 at 35% design	WRDA bill, Flood Authority state funding authority as local match
Upstream Storage	Lewis County PUD	Upstream on the Chehalis River and South Fork, with benefits downstream	Two dams, one on the Upper Chehalis and one on the South Fork Chehalis.	Flooding downstream of the dams.		Lewis County PUD			$336 million	Potential for federal funding
Skookumchuck Dam Modifications	TransAlta	Skookumchuck River, with impacts in Chehalis and downstream	Modify the Skookumchuck Dam to allow increased release of water and therefore increased capacity for flood storage	Flooding downstream of the Skookumchuck Dam		TransAlta and Flood Authority				Flood Authority, grants, or the Twin Cities project.

Figure 8-1 Process for Gathering Information and Making Decisions on Major Regional Projects

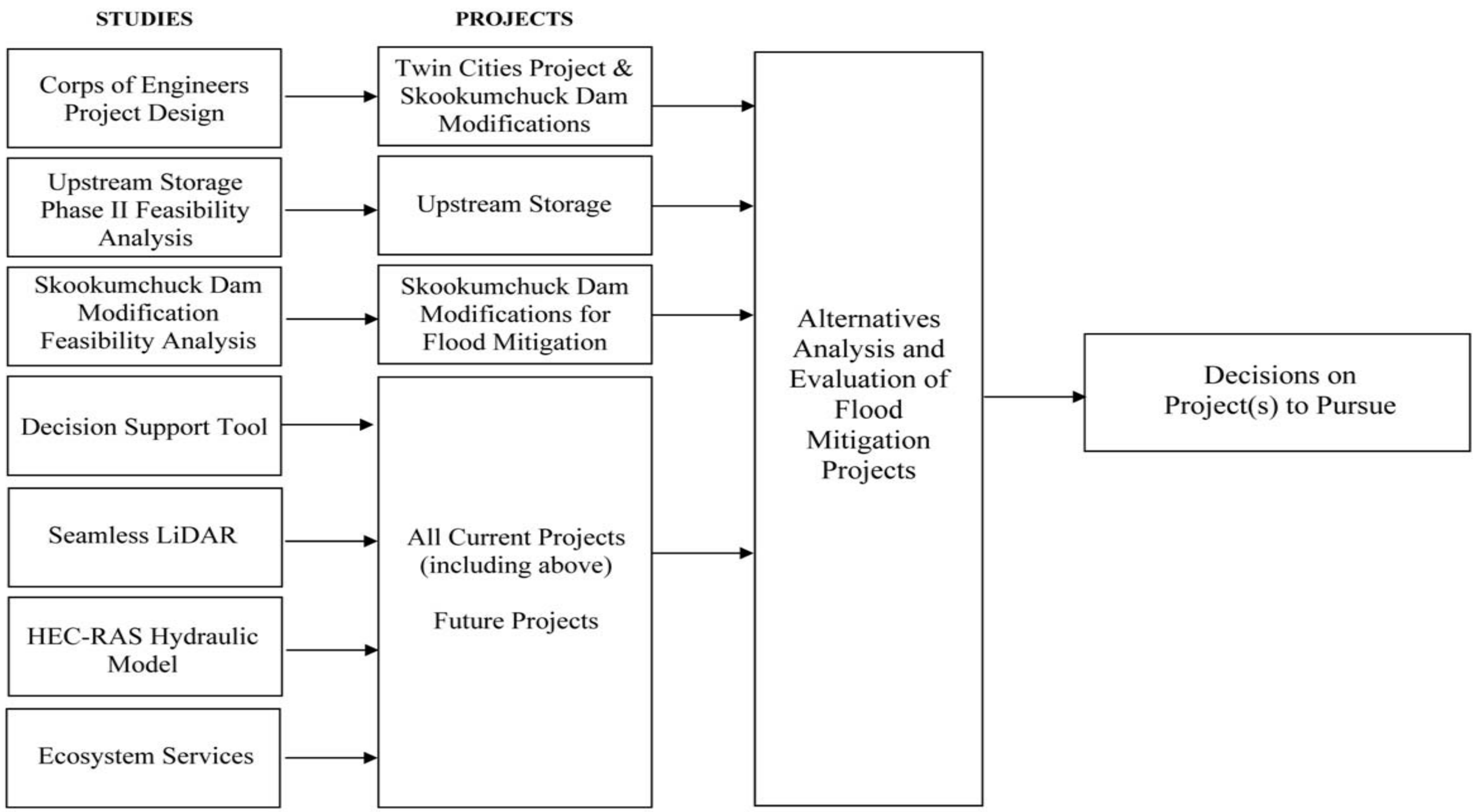


Figure 8-2. Timeline of Flood Authority and Related Studies and Analyses

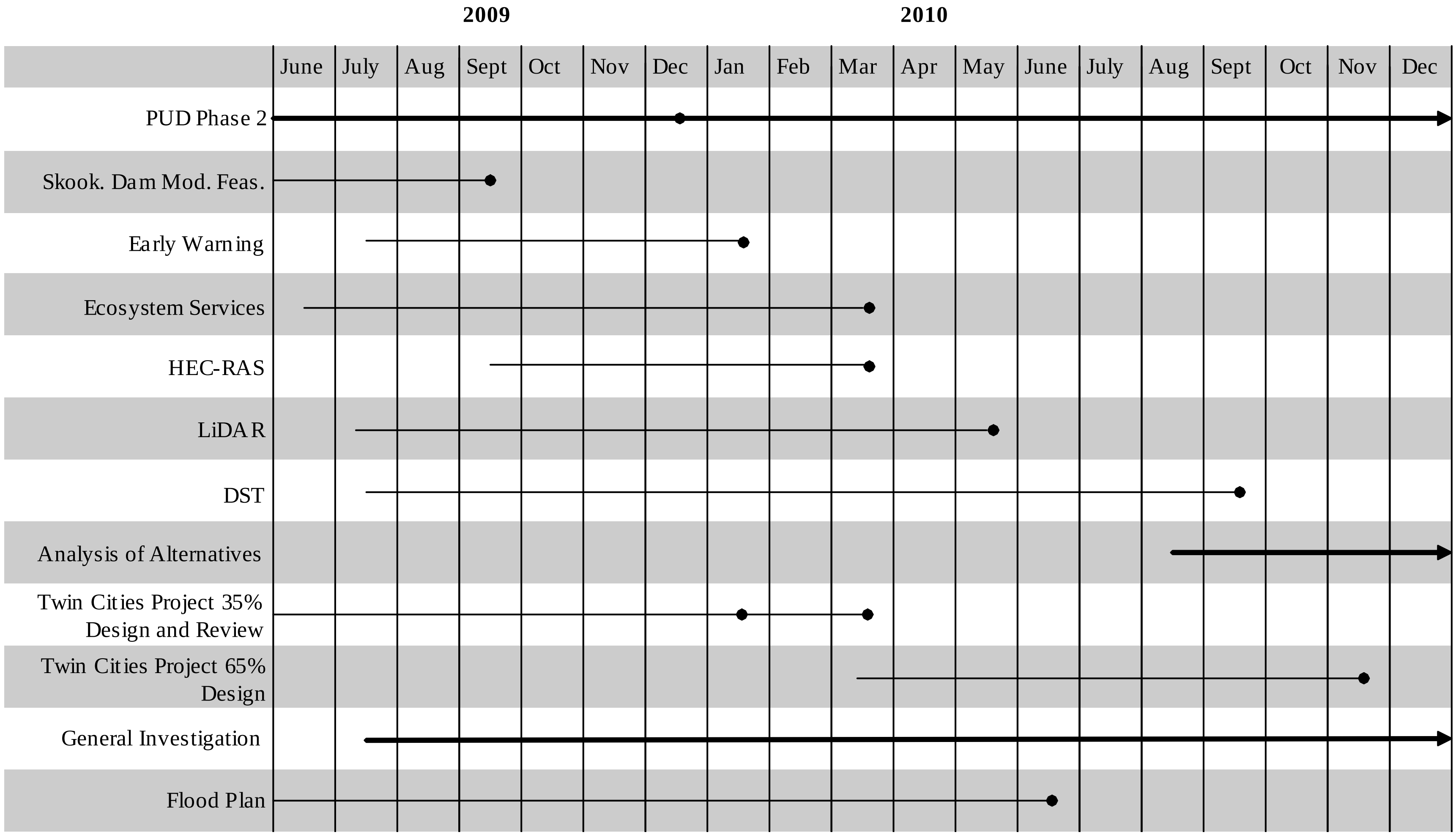


Table 8-3 Local Capital Projects

Project Name	Proposer	Category	Geographic Area	Project Description	Problems Mitigated	Alternatives Examined	Proposed Implementer	Schedule for Implementation	Permit Issues	Estimated Cost	Potential Funding Sources
Salzer Creek backwater control	Lewis County and Chehalis CFHMP	Floodplain Protection									
Provide increased on-site detention and retention	Grays Harbor County CFHMP	Floodplain Protection									
Build an overtopping levee at the north end of town	Bucoda CFHMP	Floodplain Protection	Within the town of Bucoda								
Install twin 18-inch culverts under Main Street at 11th	Bucoda CFHMP	Floodplain Protection	Within the town of Bucoda								
Relief Culvert for North Side Runoff	Oakville	Floodplain Protection	Within the city of Oakville	Improve, and lengthen, the drainage system that transports the runoff from the north side of the city in the south side. Install new drainage inlets along near the railroad track and improve the existing system that carries the stormwater to the south side of the city.	Presently this runoff flows east, along the north side of Highway 12, and flows under the Highway just east of the city limits. This runoff eventually overwhelms the Highway ditch and starts flooding the surrounding area. This flooding has occurred more frequent within the last several years and is starting to inundate local roads and damage homes. Installation of this culvert will reroute the runoff to the west side of State Street, which acts like a natural levee, and should reduce the impact of the stormwater flooding on the public.		City of Oakville		Easement for culvert under railroad tracks Easement for crossing of State highway (US12)		
Harris Creek Fish Enhancement	Oakville	Floodplain Protection	Within the city of Oakville	Replace the existing culvert under State Street, at Harris Creek, and replace them with a three-sided structure.	This project would allow for high flows to pass under State Street and reduce the possible of flooding. During the last two winters water has overtopped the roadway in this location cutting off emergency access to a number of residents.	None	City of Oakville & Chehalis Indian Tribe	Summer 2009 or 2010, fish window	Corps of Engineer Permit, HPA, Shoreline exemption	$330,000, estimate done in 2009	
Sickman-Ford Bridge Culvert	Oakville	Floodplain Protection	Within the City of Oakville	Install four three-sided structures in the northerly approach to the Sickman-Ford Bridge	This project would help reduce the hydraulic gradient that is evident during high water events. This gradient causes severe flooding in both the Black River Basin as well as the Chehalis Basin	None	City of Oakville and Chehalis Indian Tribe	Summer of 2010	Corps of Engineers Permit, HPA, Shoreline exemption	$624,454, estimate done in 2009	Basin wide flood control
River braiding	Grays Harbor at 2/19 workshop	Floodplain Protection	Wynoochee and Satsop rivers	Open old migration channels							
Culvert projects on Hiram Hill	Grays Harbor at 2/19 workshop	Floodplain Protection	Hiram Hill in Grays Harbor County								
Montesano	Montesano at	Floodplain	Montesano	Raise the height of dikes							

Project Name	Proposer	Category	Geographic Area	Project Description	Problems Mitigated	Alternatives Examined	Proposed Implementer	Schedule for Implementation	Permit Issues	Estimated Cost	Potential Funding Sources
WWTP	2/19 workshop	Protection		around, or otherwise protect, the Montesano WWTP							
Adna Levee Improvement	Corps of Engineers	Floodplain Protection	Adna	The Adna levee is a railroad grade that does not currently function as a flood protection levee. This project would improve the railroad grade to provide flood control. To become a flood control structure, the following improvements must be made: A. Determine a public sponsor and acquire easements; B. Add interior drainage; C. Clear the embankment of overgrown vegetation and develop an annual vegetation maintenance program; D. The slope must be repaired to a minimum 2H:1V slope; E. Additional post flood repair work including grading, slope work and crown work Once these improvements have been made, the structure will be eligible for the PL 84-99 program if a sponsor can be found.	The structure is not currently considered a levee. It impounds water on the landward side, and in significant events, overtops and/or breaches, introducing damaging flows to the Adna community. Additional data is required to determine the storm frequency that impounds flow and whether flow is from rain events and/or a result of overbank flow upstream. This railroad grade could potentially be turned into an effective flood control system.		Corps of Engineers				Section 205 could provide a source of funding. The Corps of Engineers needs a nonfederal sponsor to initiate a study under Section 205 and neither the Flood Authority nor Adna qualify. Potential sponsors are the State of Washington or Lewis County. Alternately, the Town of Adna could form a diking district to serve as sponsor.
Tilley Road Culvert Replacement	Thurston County	Floodplain Protection	Thurston County		Tilley Road South of 143rd is closed to traffic on about an annual occurrence. There are fairly large wetlands both east and west of Tilley Road the drainage is from east to the westerly wetland. The higher easterly wetland's flow is impacted by beaver dams.					$250,000	
Develop a technical assistance program for bank stabilization and/or debris removal	Lewis County CFHMP	Bank Protection	Basin-wide.								
Incorporate biostabilization and other engineered solutions to stabilize banks	Grays Harbor County CFHMP	Bank Protection	Basin-wide.								
Provide long-term stabilization of the Wynoochee River banks to protect	Montesano CFHMP	Bank Protection	Montesano.								

Project Name	Proposer	Category	Geographic Area	Project Description	Problems Mitigated	Alternatives Examined	Proposed Implementer	Schedule for Implementation	Permit Issues	Estimated Cost	Potential Funding Sources
City sewage facilities											
Streambank Stabilization	Bucoda CFHMP	Bank Protection									
Mary's River Lumber bank protection	Montesano at 2/19 workshop	Bank Protection	¼-mile of Chehalis River in Montesano	Steel plate protection or rip-rap protection						Approx. $1 million	
Independence Road Bank Protection Project	Thurston County	Bank Protection	Independence Road between Michigan Hill and 201st Street in Thurston County.	Feasibility Study to realign Independence Road between Michigan Hill Road and south of 201st Street and buy private properties impacted by loss of access. The realignment would be put of the flood plain and the active channel meander zone of the Chehalis River.	The project would eliminate the loss of public access on this section of Independence Road, which is subject to erosion from river channel migration. The flooding of adjacent residents would be eliminated if the project included purchase of property and access rights.	The alternative is to continue to address Chehalis River migration and related loss of Independence Road through bank stabilization and required mitigation of associated environmental impacts.	Thurston County Public Works	2015	Many+	$1 million (very preliminary cost estimate)	?
Open Migration Zone of the Satsop	Grays Harbor at 2/19 workshop	Conveyance Capacity	Satsop River	Remove or mitigate man-made obstacles in the Satsop River							
Dredge Lake Sylvia	Montesano at 2/19 workshop	Conveyance Capacity	Lake Sylvia, near Montesano								

Table 8-4 Programmatic Actions

Project Name	Proposer	Category	Geographic Area	Project Description	Problems Mitigated	Alternatives Examined	Proposed Implementer	Schedule for Implementation	Permit Issues	Estimated Cost	Potential Funding Sources
Develop floodplain conservation easement program	Grays Harbor County CFHMP	Regulatory Programs	Basin-wide.								
Improve floodplain and stormwater regulations	Centralia CFHMP	Regulatory Programs	Centralia.								
Tax breaks	Grays Harbor at 2/19 workshop	Regulatory Programs	Entire basin	Give tax breaks to people who remove structures and fill from the floodplain							
Penalization	Chehalis Tribe at 2/19 workshop	Regulatory Programs	Entire basin	Penalize people who build or fill in the floodplain							
Thurston County Critical Areas Ordinance	Thurston County	Regulatory Programs	100-year floodplains	100-year floodplains are considered as critical area.							
Thurston County High Groundwater Areas	Thurston County	Regulatory Programs	High Groundwater Areas	Remap High Groundwater Areas							
Channel Migration Zone Mapping	Lewis County	Planning and Data Collection - Mapping/ Modeling (Local)									
Channel Migration Zone Mapping	Centralia	Planning and Data Collection - Mapping/ Modeling (Local)									
Channel migration analysis	Chehalis Tribe	Planning and Data Collection - Mapping/ Modeling (Local)		Conduct a channel migration analysis for the Chehalis River form the city of Centralia to the Grays Harbor County line							
Comprehensive Flood Plan Augmentation	Chehalis Tribe	Planning and Data Collection - Mapping/ Modeling (Local)		Augment the Chehalis Tribe Comprehensive Flood Plan with 2-, 5-, and 10-year recurrence interval flood surface maps.							
Survey of river cross-sections	Public comment	Planning and Data Collection - Mapping/ Modeling (Regional)									
Remap floodplains	Thurston County	Planning and Data Collection - Mapping/ Modeling (Regional)		Remap floodplains using new 2-foot contour data for all rivers; submit changes to FEMA for map revisions							
Berwick Creek Drainage Plan	Lewis County and Chehalis	Planning and Data Collection - Plans (Local)									
China Creek Drainage Plan	Lewis County and Chehalis	Planning and Data Collection - Plans (Local)									
Rochester Stormwater Plan	Thurston County	Planning and Data Collection - Plans (Local)									
Revise Thurston County's	Thurston County	Planning and Data Collection - Plans									

Project Name	Proposer	Category	Geographic Area	Project Description	Problems Mitigated	Alternatives Examined	Proposed Implementer	Schedule for Implementation	Permit Issues	Estimated Cost	Potential Funding Sources
Comprehensive Flood Hazard Management Plan		(Local)									
Revise Town of Bucoda's Comprehensive Flood Hazard Management Plan	Bucoda	Planning and Data Collection - Plans (Local)									
Reevaluate land uses and zoning based on the new floodplain maps	Thurston County	Planning and Data Collection - Plans (Regional)									
Study of woody debris and aggregates	Grays Harbor County	Planning and Data Collection - Plans (Regional)									
Evaluate channel response to sediment	Chehalis Tribe	Planning and Data Collection - Studies (local)		Evaluate river channel responses to influx and deposition of sediment in the vicinity of the Chehalis Reservation							
Study of failed riprap	Chehalis Tribe	Planning and Data Collection - Studies (local)		Conduct a study to determine volume, placement, and potential impacts of flood on failed riprap placed by Thurston County on the Chehalis River bank adjacent to Independence Road							
Study of proposed mitigation strategies	Chehalis Tribe	Planning and Data Collection - Studies (local)		Identify and conduct studies that would need to be accomplished in order to design the proposed mitigation strategies (such as raising Moon Road)							
Investigate conditions near Wickett levee	Chehalis Tribe	Planning and Data Collection - Studies (local)		Investigate local conditions in the vicinity of the pushup levee near Wickett properties to assess site specific and downstream impacts during flooding							
Study of water backup over HWY 6	Public comment	Planning and Data Collection - Studies (local)		Determine what is causing water backup over Highway 6							
Study of fill adjacent to Harris Creek	Chehalis Tribe	Planning and Data Collection - Studies (local)		Conduct a study to determine the type and volume of fill adjacent to Harris Creek and evaluate if it would be beneficial to remove the fill							
Independence Road Bank Realignment Feasibility Study	Thurston County	Planning and Data Collection - Studies (local)		Feasibility Study – Independence Road Bank Realignment out of Flood Plain							
Skookumchuck River scour potential study	Thurston County	Planning and Data Collection - Studies (local)		Skookumchuck River scour potential with dam modifications							
Dynamic model of middle basin	Chehalis Tribe	Planning and Data Collection - Studies (local)		Coordinate with the Flood Authority to develop a dynamic model of the middle basin to assess effects of future basin development on the flood hydrology at the Chehalis Reservation							
2-D flow model	Chehalis Tribe	Planning and Data Collection - Studies (local)		Construct a two-dimensional flow model for the floodplain with Chehalis Reservation boundaries							
Sickman-Ford Bridge Approach	Chehalis Tribe	Planning and Data Collection - Studies (local)		Model the effects of removing/modifying the Sickman-Ford bridge approach and Balch Road							
Cumulative downstream flood impact analysis	Chehalis Tribe	Planning and Data Collection - Studies (regional)		Conduct a detailed cumulative downstream flood impacts analysis							

Project Name	Proposer	Category	Geographic Area	Project Description	Problems Mitigated	Alternatives Examined	Proposed Implementer	Schedule for Implementation	Permit Issues	Estimated Cost	Potential Funding Sources
Monitoring program on channel conditions and dimensions	Chehalis Tribe	Planning and Data Collection - Studies (regional)		Develop a semi-annual monitoring program focused on documenting changes in Chehalis River channel conditions and dimensions							
Study of impact of recent trucking and warehouse facilities	Public comment	Planning and Data Collection - Studies (regional)		Study the surface water and runoff impact of recent large trucking and warehouse facilities built in the Basin							
Study of groundwater flooding	Public comment	Planning and Data Collection - Studies (regional)		Study how groundwater flooding impacts flood events							
Study groundwater/surface water interaction	Grays Harbor at 2/19 workshop	Planning and Data Collection - Studies (regional)									
Inventory high quality riparian habitat along river reaches	Thurston County	Planning and Data Collection - Studies (regional)									
FloodPath Warning Model	USGS/ FEMA	Planning and Data Collection - Studies (regional)									
Floodplain Property Acquisition Program	Lewis County Public Works	Planning and Data Collection - Studies (regional)									
Identification of grant opportunities	ESA Adolfson	Planning and Data Collection - Studies (regional)									
Provide educational materials on flood hazard management	Grays Harbor County CFHMP	Education and Public Information	Basin-wide.								
Provide floodproofing guidance to residents	Grays Harbor County CFHMP	Education and Public Information	Basin-wide.								
Flood Awareness Week	Thurston County	Education and Public Information	Entire basin								
Flood District Formation	Proposed at 2/19 workshop	Governance and Management	Entire basin	Develop a Flood Control District for the entire watershed to plan and implement projects throughout the basin.							
Flood Warning Systems	Lewis County CFHMP	Emergency Response & Preparedness		Evaluate opportunities for flood warning systems							
Flood Hazard Warning Policies	Grays Harbor County CFHMP	Emergency Response & Preparedness		Establish policies to ensure that flood hazard warnings are posted during flood events and that flood elevation poles are placed near rivers to show high water marks from previous floods							
Gauges	Grays Harbor County CFHMP	Emergency Response & Preparedness		Install new gauges and upgrade existing gauges. Install flow gauge on Humptulips River. Install stage gauges on the Satsop River, Chehalis River at the Harbor, and Upper Humptulips River							
City Hall Generator	Montesano CFHMP	Emergency Response & Preparedness		Install generator at City Hall for Emergency Operations Center							

Project Name	Proposer	Category	Geographic Area	Project Description	Problems Mitigated	Alternatives Examined	Proposed Implementer	Schedule for Implementation	Permit Issues	Estimated Cost	Potential Funding Sources
Drinking water reservoir	Montesano CFHMP	Emergency Response & Preparedness		Construct drinking water reservoir on city property							
Improve flood notification and response program	Bucoda CFHMP	Emergency Response & Preparedness									
Develop and maintain a specific flood warning and evaluation program for the city	Centralia CFHMP	Emergency Response & Preparedness									
Manage Wynoochee and Skookumchuck dams for flood control	Grays Harbor and TransAlta at 2/19 workshop	Emergency Response & Preparedness	Wynoochee and Skookumchuck dams								
Generator at Grays Harbor Fairgrounds	Grays Harbor at 2/19 workshop	Emergency Response & Preparedness	Grays Harbor Fairgrounds		Grays Harbor Fairgrounds serves as an evacuation site. It typically loses power in flood events.						
Address loss of power and cell phone coverage	Lewis County at 2/19 workshop	Emergency Response & Preparedness	Entire basin								
Critter pads	Lewis County at 2/19 workshop	Emergency Response & Preparedness			Addresses livestock loss						
Join the NFIP Community Rating System	Grays Harbor County CFHMP	Reduction of Damage to Existing Structures	All communities.		Reduces cost of flood insurance.						
Develop a home elevation and buyout program	Grays Harbor County CFHMP	Reduction of Damage to Existing Structures	Basin-wide.		Eliminates damages to structures.						
Regrade Main Street	Bucoda CFHMP	Reduction of Damage to Existing Structures	Bucoda								
Raise houses	Bucoda CFHMP	Reduction of Damage to Existing Structures	Duplicated.								
Participate in NFIP Community Rating System	Centralia CFHMP	Reduction of Damage to Existing Structures	Duplicated.								

Project Name	Proposer	Category	Geographic Area	Project Description	Problems Mitigated	Alternatives Examined	Proposed Implementer	Schedule for Implementation	Permit Issues	Estimated Cost	Potential Funding Sources
Moon Road / Easton 188th Roadway Raise in Elevation	Thurston County	Reduction of Damage to Existing Structures		Raise the elevation of the lower spots along Moon Road south of State Route 12 and the east end of 188th Ave SW. This project is in the Draft CFHMP for the Confederated Tribes of the Chehalis Reservation. Thurston County's understanding to date is that the elevation change would be on only the existing lower spots that food frequently. The raise in elevation would not be like the larger project that was accomplished on parallel Anderson Road. Some form of culverts may also be needed.	Frequent flooding of the most direct access to the easterly end of the Confederated Tribes of the Chehalis Reservation including the Lucky Eagle Casino and motel.	This project is in the Draft Comprehensive Flood Management Plan for the Confederated Tribes of the Chehalis Reservation.	Confederated Tribes of the Chehalis Reservation/Thurston County	Thurston County Six Year Transportation program needs to be amended to include this project. The priority of the county still needs to be established.	SEPA, Shorelines and Tribal Permits	Unknown	Unknown
Elevating homes in the Chehalis Basin	Thurston County	Reduction of Damage to Existing Structures	Thurston County (potentially Entire basin) Duplicated.	Elevating homes in the Chehalis Basin. This may also include the Skookumchuck and Black River flood plains that are part of the Chehalis Basin.	Flooded private residents and commercial improvements.		Thurston County			Unknown	Unknown
Lincoln Creek Floodplain Purchase	Lewis County	Reduction of Damage to Existing Structures	Lincoln Creek Road area between Cooks Hill and Matson Roads	Purchase properties to reduce safety impacts, provide floodplain storage, reduce long-term flood related financial impacts to the county, use as wetland banking, avoid the public subsidy of private development, and protect emergency responders from flood related hazards.	Generally, land development in floodplains place obstructions to flood flow paths, which takes a toll on county roads. The impacts to county road maintenance is manifested in the following ways: 1. More frequent repairs of eroding embankments, road surfaces, and culverts. 2. Need to clear and monitor debris from culverts and bridges during heavy storms and high flow events. 3. Upsize culverts and bridges to handle unmitigated, higher flows. 4. Closure and monitor of inundated roadways. Strategic purchase of floodplains will also help the waning of floodwaters, thus allowing access to public roads. Another benefit of this project is emergency response. By keeping passage open, access is provided for emergency vehicles and for evacuation.	The properties have great potential for wetland banking to mitigate for the impacts from new county road construction, and for a countywide recreational trail. Other uses are to lease the properties for seasonal farming or grazing. This project meets all eight goals of Lewis County's CFHMP, which was approved in September 2008.	Lewis County Public Works.	If project is wholly funded, it can begin immediately.	Demolition permits.	$350,000 for minimal area, and $500,000 for a larger area.	Chehalis River Basin Flood Authority Public Works Road Fund
Floodplain	Lewis	Reduction of	Entire basin	A project to acquire property in the							

Project Name	Proposer	Category	Geographic Area	Project Description	Problems Mitigated	Alternatives Examined	Proposed Implementer	Schedule for Implementation	Permit Issues	Estimated Cost	Potential Funding Sources
Property Acquisition Project	County	Damage to Existing Structures	Duplicated	floodplain. The project would include developed criteria to determine feasibility, priority, and value of potential properties							
Protect access to Satsop Development Park	Grays Harbor County	Reduction of Damage to Existing Structures	Grays Harbor County								
Protect and restore critical areas	Centralia CFHMP	Natural Resource Protection									
Provide habitat for wildlife and fish	Centralia CFHMP	Natural Resource Protection									
Camp Creek drainage improvements	Montesano & Grays Harbor at 2/19 workshop	Natural Resource Protection									

CHAPTER 9 References

Chehalis Basin Partnership. 2004. Chehalis Basin Watershed Management Plan.

Chehalis Basin Partnership Habitat Working Group. 2008. The Chehalis Basin Salmon Habitat Restoration and Preservation Work Plan for WRIA 22 and 23. Available on-line at: http://www.co.grays-harbor.wa.us/info/pub_svcs/ChehalisBasin/Docs/WRIA20080922-23.pdf.

City of Centralia. 2008. City of Centralia Comprehensive Flood Management and Natural Hazards Mitigation Plan.

City of Montesano. 2007. All Hazard Mitigation Plan Addendum 2.

Confederated Tribes of the Chehalis Reservation (Chehalis Tribes). 2009. Comprehensive Flood Hazard Management Plan. Prepared by GeoEngineers, Inc. and Herrera Environmental Consultants, Inc. March 17, 2009.

Daly, C., W. Gibson and G. Taylor. 2003. United States Average Monthly or Annual Mean Temperature, 1971-2000. Spatial Climate Analysis Service, Oregon State University, Corvallis, Oregon, USA.

Federal Emergency Management Agency (FEMA). 1991. Region X Interagency Hazard Mitigation Team. Supplemental Flood Hazard Mitigation Report: FEMA-883-DR-WA.

Federal Emergency Management Agency (FEMA). 2008. National Flood Insurance Loss Statistics. Available at: http://bsa.nfipstat.com/reports/1040.htm#53.

Glancy, P.A. 1971. Sediment Transport by Streams in the Chehalis River Basin, Washington, October 1961 to September 1965. Geological Survey Water-Supply Pater 1798-H. Prepared in cooperation with the Washington State Department of Water Resources. United States Government Printing Office, Washington.

Grays Harbor County. 2001. Grays Harbor County Comprehensive Flood Hazard Management Plan. Prepared by CH2M Hill. June 2001.

Hawkins, C. 2000. Black River: past and future. South Sound Green Pages.

Hubbard, L.L. 1991. Floods of January 9-11, 1990 in northwest Oregon and southwest Washington: U.S. Geological Survey Open-File Report 91-172. 1991.

Lewis County. 2008. Lewis County Comprehensive Flood Hazard Management Plan.

Lewis County Department of Public Services. 1994. Comprehensive Flood Hazard Management Plan for Lewis County. Prepared by ENSR Consulting and Engineering in association with KCM, Inc., Applied Environmental Services, Inc., and Sharpiro and Associates, Inc. December 1994.

Mote, P., Mault, J., and V. Duliere. 2008. The Chehalis River flood of December 3-4, 2007. White Paper. Office of Washington State Climatologist, University of Washington.

Thurston County. 1999. Thurston County Flood Hazard Management Plan. Prepared by Thurston Regional Planning Council.

Town of Bucoda. 1999. Town of Bucoda Comprehensive Flood Hazard Management Plan. Prepared by Gray & Osborne, Inc. June 1999.

U.S. Army Corps of Engineers. 1968a. Flood plain information, Chehalis and Skookumchuck Rivers, Bucoda, Washington.

U.S. Army Corps of Engineers. 1968b. Flood plain information, Chehalis and Skookumchuck Rivers, Centralia-Chehalis, Washington.

U.S. Army Corps of Engineers. Seattle District. 1974. Special Study Suggested Hydraulic Floodway-- Chehalis and Skookumchuck Rivers Vicinity of Chehalis Lewis County, Washington. Prepared for the Washington Department of Ecology.

U.S. Army Corps of Engineers. Seattle District. 1976. Special Study Suggested Hydraulic Floodway Chehalis and Newaukum Rivers Vicinity of Chehalis Lewis County, Washington. Prepared for the Washington Deptartment of Ecology.

U. S. Army Corps of Engineers. 1982. Interim Feasibility Report and Environmental Impact Statement, Centralia, Washington Flood Damage Reduction. Seattle District, Seattle, Washington.

U.S. Army Corps of Engineers – Seattle District (Corps). 2003. Centralia Flood Damage Reduction Project Chehalis River, Washington General Reevaluation Study. Final General Reevaluation Report, June 2003.

U.S. Department of the Interior, Bureau of Reclamation. 1965. Region 1, Upper Chehalis River Basin Reconnaissance Report.

U.S. Department of Commerce, Bureau of the Census (Census). 2000. Census 2000. American Factfinder data sets. Accessed at: http://factfinder.census.gov/servlet/DatasetMainPageServlet?_program=DEC&_submenuId=&_lang=en&_ts=.

U.S. Geological Survey (USGS). 2008. USGS News Release. Available at: http://wa.water.usgs.gov/news/2008/news.chehalis.newpeak.htm.

U.S. Geological Survey (USGS). 2009. USGS News Summary. Available at: http://wa.water.usgs.gov/news/flood/summary/.

U.S. Soil Conservation Service (SCS). 1986. Soil Survey of Gays Harbor County Area, Pacific County, and Wahkiakum County, Washington.

U.S. Soil Conservation Service (SCS). No date. Soil Survey of Lewis County Area, Washington.

Washington Department of Game. 1980. Inventory of vegetative communities and associated wildlife of Black River drainage.

Washington Military Department Emergency Management Division. 2007. Washington State Hazard Mitigation Plan. June 2007. Available at: http://www.emd.wa.gov/plans/washington_state_hazard_mitigation_plan.shtml

Washington State Department of Ecology (Ecology). 1998. Setting instream flows in Washington State. Publication #98-1813-WR.

Washington State Department of Ecology (Ecology). 2009. 2008 Water Quality Assessment for Washington, 303(d) List. Accessed April 2009 from http://www.ecy.wa.gov/programs/wq/303d/2008/index.html.

Washington Department of Fish and Wildlife (WDFW). 2008a. Streamnet. Available at: http://www.streamnet.org.

Washington Department of Fish and Wildlife (WDFW). 2008b. SalmonScape. Accessed online January 2009 at http://wdfw.wa.gov/mapping/salmonscape/.

Washington State Conservation Commission (WCC). 2001. Salmon and Steelhead Limiting Factors. Chehalis Basin and Nearby Drainages. Water Resource Inventory Areas 22 and 23. May 2001.

Weyerhaeuser and Simpson Timber Company. 1995. West Fork Satsop Watershed Analysis. Weyerhaeuser Company, Federal Way, Washington and Simpson Timber Company, Shelton, Washington.