Chapter 4.3
Flood Hazard Risk Assessment

Introduction

Floods in Thurston County are common. Nearly half (12 out of 25) of major federal disaster declarations for Thurston County are related in some part to impacts from flood hazards. The February 1996 flood cost uninsured private property owners an estimated $22 million in losses. Flood hazard management is complex and must protect life safety and property protection and preserve the ecological functions of rivers and flood plains. This chapter assesses the impacts and risks for the most common types of flooding that affect Thurston County communities.

Definition

In general, a flood is a temporary condition in which a normally dry area of land or infrastructure is inundated by excess standing or flowing water. Flooding is most common in the fall and winter months. This hazard profile characterizes flood risks for 50-, 100-, and 500-year special flood hazard area flood scenarios and high groundwater flooding. There are four principal sources of flooding that impact Thurston County communities:

1. Riverine (river and stream)
2. Groundwater
3. Tidal
4. Urban

1. Riverine Flooding

Rivers and their floodplains are dynamic systems that perform important ecological functions, benefitting both wildlife and humans. Flooding is a natural function of rivers, with its effects supporting productivity of wildlife and potentially increasing the fertility of farmlands within flood plains. Attempts to control floods by altering the physical characteristics of rivers and flood plains with dams, levees, or other flood control facilities, result in the loss, alteration, or significant reduction in the intrinsic ecological benefits these systems offer.

Communities must balance the need to preserve the natural functions of floodplains vs. the need to protect life safety, property, communities, and human activities. Understanding how, when, and where to expect flood impacts is a first step in developing a mitigation strategy to minimize losses from floods and to protect the environment.

Riverine flooding occurs when excess flow and volume of water crests a river channel's normal capacity. Floodwater consequently inundates areas within the river's floodway, flood plain, and other low-lying areas that may not be mapped as flood hazard areas.

Cause of Riverine Flooding

Two to three days of prolonged rainfall, averaging 2 to 5 inches per day, a rapidly melting snowpack, or a combination of these conditions trigger such floods. The actual duration and rainfall amount needed to cause flooding depends on the initial condition of the river or stream, and groundwater and runoff conditions. The Nisqually River and the Chehalis River's extensive watersheds are subject to events outside the county that influence flooding downstream in the county.

Thurston County hydrological research documents increased rainfall intensity in the region in the last two decades. The county continues to analyze stream flow and precipitation gauge data from its own network of monitoring stations, as well as the National Weather Service and USGS data. This research provides clues about the types of precipitation patterns that trigger small stream, riverine, and shallow groundwater basin flooding in the county. Initial findings reveal that six precipitation patterns appear to affect peak flood flow pulses in small Thurston County streams and shallow groundwater basins. These heavy rainfall scenarios have occurred within the previous two decades. The precipitation patterns also correlate with larger river flood events. The previous five decades of the Olympia rainfall record show only one, two or three of the identified scenarios per decade.

Atmospheric River events are common triggers of major flooding events in Thurston County. These storms are generated in the tropical Pacific Ocean and contain a vast amount of moisture that is transported by the jet stream directly to areas of the Pacific Northwest. They can be highly targeted and may have regional or watershed-specific effects depending on positioning of the guiding jet stream patterns and topographic features the moisture stream encounters on land. Many of the region's major floods events have occurred as a result of such storm systems. These storms are typically associated with warm, tropical air and are responsible for rain-on-snow events causing rapid snowmelt if they occur after snow has fallen. Very large atmospheric river events are known as ARkStorms.

Late wet season precipitation patterns seem to have the most significant effect on groundwater flooding and deep-seated landslide susceptibility. Saturation of the subsurface soils peaks in March. Any additional rainfall during this natural high-water season tends to rapidly overwhelm the remaining horizontal groundwater flow component in near-saturated soils.[1] Table 4.3.1 shows the precipitation patterns that cause major flood events on stream and rivers.

Table 4.3.1 Six Rainfall Patterns that influence Puget Sound Stream Flooding in Thurston County

<table>
<tr><th>Pattern</th><th>Description</th><th>Example</th></tr>
<tr><td>1</td><td>Early or late wet season rainfall (greater than 3-inch daily storm events) in October (Horton Overland Flow) or prolonged, above avg. rain in October or March and April</td><td>October 20, 2003: 4.14” storm event;
October 2, 1981: 3.56” storm event;
September – early October 2013 (September record rainfall);
March –April 2016 (prolonged well above average rainfall);
October –November 2016 (October record rainfall; November prolonged well-above average)</td></tr>
<tr><td>2</td><td>Five or six consecutive days of greater than 1-inch storm events punctuated by a greater than 2.5-inch storm event in the same series</td><td>November 2, 2006, 1.08”
November 3, 2006,1.02”
November 4, 2006, 1.5”
November 5, 2006, 1.88”
November 6, 2006, 4.31”
November 7, 2006, 1.02”</td></tr>
<tr><td>3</td><td>Two or more consecutive days of greater than 2.0-inch daily storm events</td><td>2007:
December 2, 2.2”;
December 3, 3.19”</td></tr>
<tr><td>4</td><td>Greater than 4-inch daily storm events (high landslide potential</td><td>January 7, 2009, 4.82 inches
November 6, 2006, 4.31 inches
October 20, 2003, 4.14 inches
November 19, 1962, 4.25 inches</td></tr>
<tr><td>5</td><td>Three or more consecutive months of at or greater than 11-inch monthly totals (larger potential for ground water flooding in key basins)</td><td>Monthly Totals
<table>
<tr><th>Years</th><th>Nov</th><th>Dec</th><th>Jan</th><th>Feb</th></tr>
<tr><td>1955 – 1956</td><td>12.18</td><td>12.59</td><td>10.75</td><td></td></tr>
<tr><td>1973 – 1974</td><td>12.95</td><td>11.61</td><td>10.57</td><td></td></tr>
<tr><td>1998 – 1999</td><td>15.28</td><td>12.99</td><td>12.25</td><td>15.5</td></tr>
<tr><td>2001 – 2002</td><td>13.01</td><td>11.86</td><td>11.42</td><td></td></tr>
</table></td></tr>
<tr><td>6</td><td>A greater than 15-inch monthly total</td><td>November, 2006, 19.68”
February, 1999, 15.5”
November, 1998, 15.28”
November, 1990, 15.06”
November, 1964, 15.00”
November, 1962, 15”
January, 1953, 19.84”</td></tr>
</table>

Extent of Riverine Flooding

Many factors influence the severity of riverine flooding such as the pre-existing condition of the ground water saturation levels, the topography and size of the watershed, freezing level, and the influence of human activity on the landscape (total amount of impervious surface, stormwater management, and other large-scale land uses such as logging). Thurston County Emergency Management issues three levels of flood severity to monitor flood stages and notify the public[2]:

1. **Minor flooding (or flood stage):** A river exceeds bank-full conditions at one or more locations, generally flooding fields and forests. Some roads may be covered but passable. There may be enhanced erosion of some river banks.
2. **Moderate flooding:** Individual residential structures are threatened and evacuation is recommended for selected properties. Some roads may be closed. Moderate damage may be experienced.
3. **Major flooding:** Neighborhoods and communities are threatened and evacuation is recommended for residents living on specified streets, in specified communities or neighborhoods, or along specified stretches of river. Major thoroughfares may be closed and major damage is expected.

Thurston County Emergency Management identifies flood severity thresholds based on stream flow rates and gauge heights for the Deschutes, Chehalis, Nisqually, and Skookumchuck rivers using select gauges in the region (no USGS gauges are established on the Black River). Rivers are dynamic and all channels are subject to dimensional changes over time due to factors such as sediment and coarse woody debris deposition, and channel migration and braiding. Therefore, a direct comparison of flood events between years or decades for any given river based on flood gauge heights will vary.

The principal factors affecting flood damage are flood depth and velocity. The deeper and faster flood flows become, the greater the potential for damage and adverse impacts. Shallow flooding with high velocities is also capable of causing damage, as is deep flooding with slow velocity. This is especially true when a channel migrates over a broad floodplain, redirecting high velocity flows and transporting debris and sediment. Flood severity is often evaluated by examining peak discharges. Table 4.3.2 lists peak flows FEMA uses to map the floodplains of the planning area.[3]

Table 4.3.2 Summary of Peak Discharges of Streams and Rivers within Thurston County

Source	Location	Drainage area (sq. mi.)	Discharge (cubic feet/second) 10-Year	50-Year	100-Year	500-Year
Black River	At County limits	124	2,820a	4,100a	4,940a	6,790
	Downstream of confluence with Beaver Creek	99	1,550	2,220	2,490	3,200
	Downstream of confluence with Waddell Creek	58.7	1,250	1,770	2,000	2,560
	Outlet of Black Lake - At Black Lake	5	210	303	342	431
Chehalis River	U.S. Geological Survey Gauge #12027500 near Grand Mound	895	38,600	50,100	55,000	66,600
Deschutes River	Downstream of Henderson Blvd.	160	5,990	7,960	8,800	10,800
	Upstream of confluence with Spurgeon Creek	127	5,630	7,450	8,230	10,100
	At Vail Loop Rd, Crossing	89.8	4,950	6,500	7,150	8,690
	Upstream of confluence with Mitchell Creek	44.1	2,690	3,590	3,980	4,900
	Upstream of limit of detailed study	33.3	2,120	2,860	3,180	3,930
Nisqually River	At Mouth	711	21,500	29,000	33,000	45,000
	Upstream of confluence with Horn Creek	488	21,000	28,000	32,000	44,000
	Upstream of Confluence with Tanwax Creek	446	20,500	27,000	31,000	43,000
Percival Creek	At Sapp Rd., SW	1.8	94	128	145	180
	At 54th Ave., SW	0.5	33	45	50	62
Scatter Creek	At downstream limit of detailed study	15.5	403	561	633	803
	At confluence with Scatter Creek tributary	11.0	314	436	492	622
	Upstream confluence with Scatter Creek tributary	4.6	167	230	258	324
	Scatter Creek Tributary - At confluence with Scatter Creek	6.4	212	293	330	415
	Scatter Creek Tributary - At State Route 507	10.3	66	90	102	126
Skookumchuck River	At State Route 507	113	6,990	9,100	9,980	12,100
	Upstream of Bucoda	90.2	6,400	8,290	9,060	10,900
	Upstream of confluence with Thompson Creek	65.9	5,790	7,440	8,110	9,700
Woodland Creek	At Pleasant Grade Rd., NE	24.6	151	205	228	284
Yelm Creek	From 1st St. to Centralia Canal	11.2	220	310	350	445
	From 103rd Ave. to 1st St.	9.8	200	285	325	410
	Upstream end of study reach, to 103rd Ave.	9.3	185	265	300	375

a= Includes effect of overflow from Chehalis River

Frequency of Riverine Floods

Floods are commonly described as having a 10-, 50-, 100-, and 500-year recurrence interval, meaning that floods of these magnitudes have (respectively) a 10, 2, 1, or 0.2 percent chance of occurring in any given year. The frequency and severity of flooding are measured using a discharge probability, which is the probability that a certain river discharge (flow) level will be equaled or exceeded in a given year. Flood studies use historical records to determine the probability of occurrence for the different discharge levels. The flood frequency equals 100 divided by the discharge probability. For example, the 100-year discharge has a one percent chance of being equaled or exceeded in any given year. The "annual flood" is the greatest flood event expected in a typical year.

Many agencies use the extent of flooding associated with a one percent annual probability of occurrence (the base flood or 100-year flood) as the regulatory boundary. Also referred to as the special flood hazard area (SFHA), this boundary serves as a convenient tool for assessing vulnerability and risk in flood-prone communities. Many communities' maps show the extent and likely depth of flooding for the base flood. Corresponding water-surface elevations describe the elevation of water resulting from a given discharge level, which is one of the most important factors used in estimating flood damage.

These measurements reflect statistical averages only; it is possible for two or more rare floods (with a 100-year or higher recurrence interval) to occur within a short time period. Assigning

Flood Definitions

Flood Plain: A strip of relatively smooth land bordering a stream, built of sediment carried by the stream and deposited in the slack water beyond the influence of the swiftest current.

100-Year Floodplain: Lands which are subject to a one percent chance of flooding in any year. These areas are mapped as the "A" zone on the Flood Insurance Rate Maps (FIRM) of the Federal Emergency Management Agency.

500-Year Floodplain: Lands which are subject to a 0.2 percent chance of flooding in any year. These areas are mapped as the "B" zone on the FIRM of the Federal Emergency Management Agency.

Flood Stage: The stage at which overflow of the natural streambanks begins to cause damage in the reach in which the elevation is measured. Flood stages for each USGS gaging station are usually provided by the National Weather Service.

Floodway: The portion of the floodplain adjoining and including the river channel which discharges the flood water and flow of the river. It does not include portions of the floodplain where water is just standing. These areas are mapped as "Floodway" on both the Floodway and the FIRM of the Federal Emergency Management Agency.

Special Flood Hazard Area (SFHA): The land area covered by the floodwaters of the base flood is the Special Flood Hazard Area (SFHA) on NFIP maps. The SFHA is the area where the National Flood Insurance Program's floodplain management regulations must be enforced and the area where the mandatory purchase of flood insurance applies. The SFHA includes Zones A, AO, AH, A1-30, AE, A99, AR, AR/A1-30, AR/AE, AR/AO, AR/AH, AR/A, VO, V1-30, VE, and V.

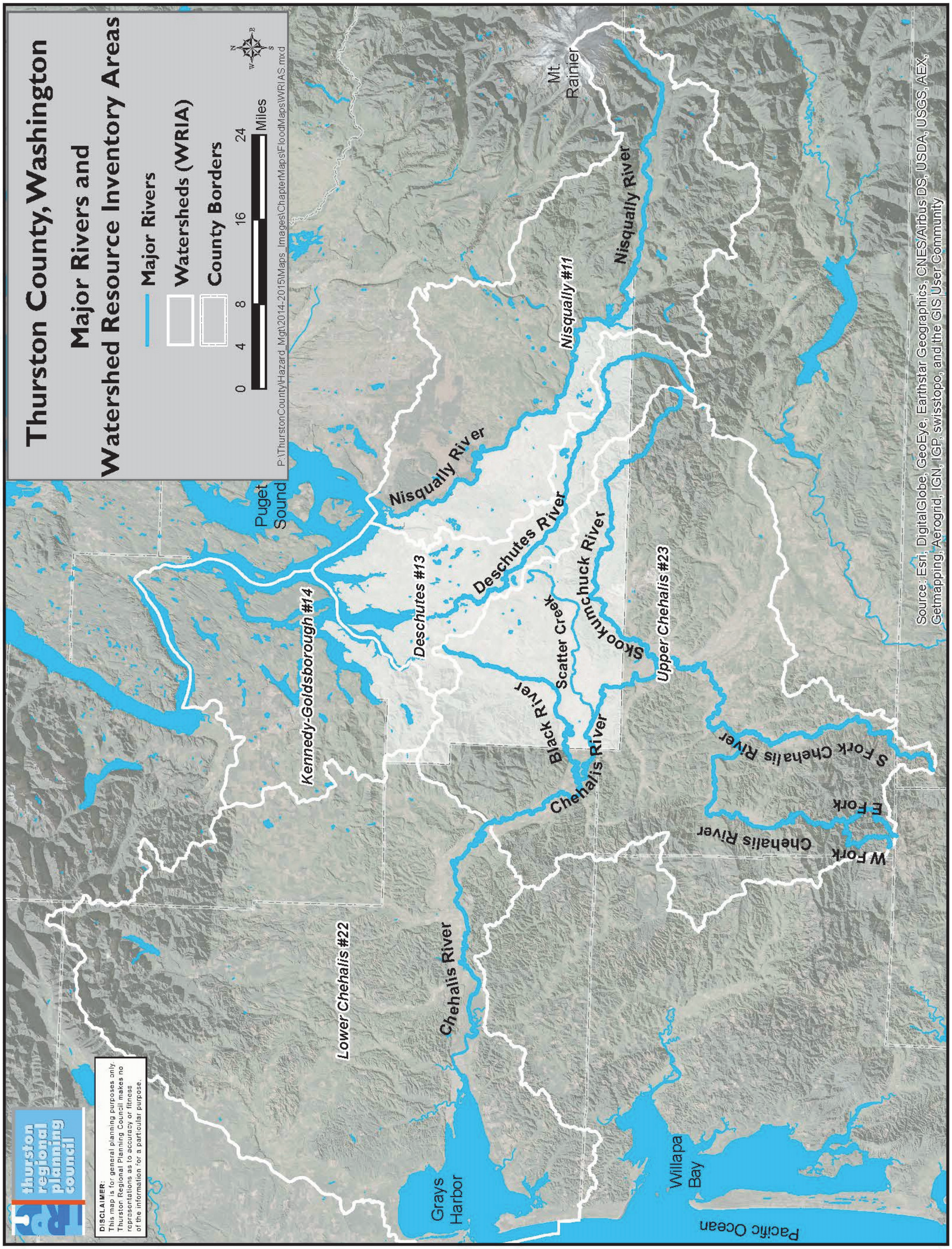
recurrence intervals to historical floods on different rivers can help indicate the intensity of a storm over a large area. For example, the 1996 flood event exceeded the flood with 100-year recurrence interval on the Chehalis River, while the recurrence interval of that event for tributaries to the Chehalis such as the Skookumchuck River was determined to be 75 years.[4] Recent history shows that Thurston County can expect an average of one episode of minor river flooding each winter. Large, damaging floods typically occur every 2 to 5 years.

Sources of Riverine Floods

Six rivers in Thurston County (Map 4.3.1) experience episodic flooding: 1) Black; 2) Chehalis; 3) Deschutes; 4) Nisqually; 5) Scatter Creek; and 6) Skookumchuck. All the rivers, except for the Nisqually River, are lowland rivers that are fed primarily by watershed precipitation and groundwater flows. FEMA has mapped the Special Flood Hazard Areas (SFHA) for each river (Map 4.3.2). Although not a major river, Scatter Creek also has a designated high risk flood zone and has historically produced major floodwaters in southwest Thurston County.
The top ten historic crests for the Nisqually, Deschutes, Skookumchuck, and Chehalis rivers are shown in table 4.3.3. The six river systems and their flood stages within the planning area are presented in the sections that follow.

Table 4.3.3 Top Ten Historic Crests for Thurston County Rivers[5]

	Nisqually at McKenna		Deschutes near Rainier		Skookumchuck near Bucoda		Chehalis near Grand Mound	
Rank	Gauge Ht	Date	Gauge Ht	Date	Gauge Ht	Date	Gauge Ht	Date
1	17.13	02/08/1996	17.01	01/09/1990	17.87	02/08/1996	20.23	12/04/2007
2	13.00	01/29/1965	15.74	02/08/1996	17.72	01/08/2009	19.98	02/09/1996
3	12.48	11/30/1995	15.68	01/15/1974	17.33	01/10/1990	19.34	01/10/1990
4	12.39	12/26/1980	15.28	01/21/1972	17.23	11/25/1990	18.41	11/25/1986
5	12.38	12/12/1955	14.29	12/29/1996	16.82	01/21/1972	18.39	12/29/1937
6	11.78	11/23/1959	14.10	01/08/2009	16.82	04/05/1991	18.21	01/21/1972
7	11.31	01/10/1990	13.76	04/05/1991	16.76	12/30/1996	18.18	01/09/2009
8	11.30	02/11/1951	13.75	12/03/2007	16.60	02/11/1990	18.12	11/25/1990
9	11.14	04/05/1991	13.55	11/26/1998	16.60	12/09/2015	17.73	12/05/1975
10	11.04	12/10/1953	13.42	12/28/1998	16.51	03/09/1977	17.66	04/06/1991



Map 4.3.1 Major Rivers and Watershed Resource Inventory Areas, Thurston County

Black River Basin

The Black River drains southwest from the south end of Black Lake into the Chehalis River near Oakville in Grays Harbor County. The Black River drainage is approximately 144 square miles, with 105 square miles in Thurston County. In general, the Black River is a slow flowing river with a broad floodplain. Most flooding along the main stem of the river is inundation flooding with low-velocity floodwaters.

The Black River drainage basin is divided in two parts. The west half of the basin drains the Capitol Forest area. The main tributaries in this section include Dempsey, Waddell, and Mima creeks. This area ranges in elevation from 2,659 feet at Capitol Peak to 200 feet at the Black River valley floor. The basin is subject to high-intensity, short-duration rain events that can produce flash flooding in these creeks.   In general, snowmelt alone does not cause flooding in this area, however snow can compound this flooding.

The east half of the basin drains the relatively flat area south of Tumwater, west of Offutt Lake and north of Tenino. The elevation difference here is approximately 200 feet. The Salmon and Beaver creeks and Bloom Ditch are the main streams that drain this basin. These very slow-flowing water systems tend to cause inundation flooding with no velocity. This side of the basin is susceptible to high-groundwater flooding during periods of extended rain.

Because of its flat topography, the Black River is also susceptible to flooding by waters backing up from the Chehalis River. This appears to be the situation when flooding on the Chehalis River is concurrent with high tides along the coast.

Black River Flood Stage Levels

In April 2005, the Washington State Department of Ecology established a river gauging station on the Black River where it crosses U.S. Highway 12 at River Mile 2. Unlike the gauging stations on the Chehalis at Prather Road Bridge and at Porter, this gauge has not been rated and is not modeled to forecast flood levels. Figure 4.3.1 shows the Thurston County Emergency Management summary for flood stages levels at this river gauge.

Figure 4.3.1 Black River Gauge Flood Stages and Historic Crests

Flood Stage	Gauge Height	Conditions and Previous Years of Occurrence
Action	6 Feet	At 6 feet, residents should be aware that the river is likely to flood. 2006, 2007, 2009, 2010, 2011, 2012, 2015
Flood	8 Feet	At 8 feet, the Black River has reached flood stage; the river will spill out of its banks into nearby fields and woods with limited water over a few spots on local roads. 2006, 2007, 2010, 2011, 2015
Moderate	10 Feet	At 10 feet, moderate flooding will occur. This stage corresponds to 15.5 feet at the Prather Road Bridge on the Chehalis River. At this level, the Chehalis River in Thurston County will flood several roads in Independence Valley with swiftly moving water, including U.S. Highway 12 and James, Independence, Moon and Anderson Roads. Floodwaters will cut off access to and from the Chehalis Reservation and inundate nearby farmlands. Some residential structures may be threatened. 2006, 2007, 2015
Major	12 Feet	Major flooding occurs when the Black River reaches 12 feet. During the December 2007 flood, the gauge on the Black River recorded a stage of 14.5 feet. 2007

Chehalis River Basin

The 174-mile long Chehalis River emerges from three forks in remote forest lands in Lewis and Pacific counties. The river is divided into two watersheds, the Upper Chehalis (WRIA #23) and the Lower Chehalis (WRIA # 22). The Chehalis River grows at the confluence of the West Fork Chehalis River and East Fork Chehalis River. From there, the Chehalis flows north and east, collecting tributary streams that drain the Willapa Hills and other lowland mountains in southwestern Lewis County. The South Fork Chehalis River joins the main river a few miles west of the City of Chehalis. The Newaukum River joins the Chehalis River at Chehalis, after which the river turns north, flowing by the city of Centralia, where the Skookumchuck River joins. Beyond Centralia, the Chehalis River flows north and west for a nine-mile course through the southwestern corner of Thurston County.

The Chehalis River flows into Thurston County (WRIA #23) approximately two miles west of Interstate 5 and flows north toward Grand Mound where it drains the Michigan Hill area and receives water from Prairie Creek and Scatter Creek. The river courses west through largely undeveloped rural lowlands scattered with small farms and gentle sloping forested hills. The river continues west and passes through the Confederated Tribes of the Chehalis Reservation before entering Grays Harbor County where it joins the mouth of the Black River.

Beyond Thurston County, the Chehalis River continues northwest where it joins the tributaries of the Satsop and Wynoochee rivers near the City of Montesano. The Chehalis River becomes increasingly affected by tides beyond this location and gradually widens into the Grays Harbor estuary where it is joined by several other rivers, becoming Grays Harbor.

Due to its large drainage area, the Chehalis River tends to rise slowly over a long period. Thurston County Emergency Management describes the three common scenarios for flooding on the Chehalis River within Thurston County:

- The most predictable scenario for the Chehalis occurs when rains fall over all southwestern Washington and all regional rivers and streams rise.
- The Chehalis River can also experience flooding when there is little or no rain in Thurston or Grays Harbor counties, but heavy rain in Lewis and Pacific counties. This causes flooding to occur later than normal.
- Flooding also occurs when heavy rain falls in Grays Harbor County, but not in Thurston or Lewis counties. Feeder streams can then fill the Chehalis and cause water to "back up" into Thurston County.

Chehalis River Flood Stage Levels

The flood of record is 20.23 feet from December 4, 2007. Figure 4.3.2 summarizes the flood impacts based on the Chehalis River flood stages at the gauge near Grand Mound at Prather Road Bridge, River Mile 59.9.

Figure 4.3.2 Chehalis River Flood Stages and Historic Crests at the Gauge near Grand Mound

Flood Stage	Gauge Height and Discharge	Conditions and Previous Years of Occurrence
Action	12.2 Feet or 16,600 CFS	At 12.2 feet, the Chehalis River will locally spill out of its banks into nearby fields and over a few roads. 1933, 1936, 1943, 1945, 1946, 1948, 1949, 1953, 1954, 1955, 1956, 1964, 1966, 1980, 1983, 1984, 2003, 2009, 2011, 2012, 2013, 2014, 2015
Flood	14 or 22,900 CFS	At 14 feet, the Chehalis River will flood several roads in Independence Valley, including James Road, Independence Road and Moon Road. Flood waters will also cover nearby farm lands. 1933, 1937, 1939, 1941, 1945, 1946, 1947, 1948, 1949, 1950, 1954, 1955, 1956, 1957, 1958, 1959, 1960, 1961, 1963, 1964, 1965, 1966, 1967, 1968, 1970, 1971, 1972, 1974, 1975, 1980, 1981, 1982, 1983, 1986, 1989, 1990, 1992, 1995, 1997, 1998, 1999, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2010, 2011, 2012, 2014, 2015
Moderate	15.5 Feet or 29,600 CFS	At 15.5 feet, the Chehalis River will flood several roads in Independence Valley with swiftly moving water, including SR-12 and James, Independence, Moon and Anderson Roads. Floodwaters will cut off access to and from the Chehalis Reservation and inundate nearby farm lands. Some residential structures may be threatened. 1934, 1936, 1949, 1953, 1954, 1955, 1962, 1964, 1966, 1970, 1976, 1977, 1982, 1986, 1987, 1994, 1996, 1997, 1999, 2001, 2006, 2015
Major	17 Feet or 38,800 CFS	At 17 feet, the Chehalis River will cause major flooding, inundating roads and farm lands in Independence Valley. Deep and swift floodwaters will cover SR-12 and James, Independence and Moon Roads. Flooding will occur all along the river, including headwaters, tributaries and other streams within and near the Chehalis River Basin. 1935, 1937, 1951, 1971, 1972, 1974, 1975, 1986, 1990, 1991, 1994, 1995, 1996, 1998, 1999, 2007, 2009, 2015

Deschutes River Basin

The Deschutes River is a 53-mile-long lowland river that gives rise within Mt. Baker-Snoqualmie National Forest in north Lewis County. The river is in the Deschutes Watershed (WRIA #13). The Deschutes lies west of the Nisqually River and flows in a parallel pattern. The Deschutes is the fastest rising and falling river in the county, responding quickly to local rainfall and runoff. The river's watershed encompasses a great majority of the land area for the cities of Lacey, Olympia, and Tumwater. As the Deschutes River enters the urban growth area and the City of Tumwater, the river bank and surrounding land use becomes more developed, with several residences in the Tumwater Valley around the periphery of the Tumwater Golf Course. A riprap bank and additional hard banking channels the river through the Tumwater Valley Golf Course and parts of Tumwater Falls Park before it discharges into Capitol Lake near the Historic Olympia Brewery in Tumwater, just south of Interstate 5.

Capitol Lake is an artificial lake formed by a small dam at the north end of the lake in downtown Olympia. Sediments carried down river are slowly accumulating on the lake bottom and effectively decreasing the lake's capacity. Washington State Department of Enterprise Services regulates the dam, which creates a freshwater lake to complement the Capitol Campus. Percival Creek joins the Deschutes River in Capitol Lake's central basin, near Marathon Park, just north of Interstate 5. When the tides and lake water level conditions permit the opening of the dam's radial gate, Capitol Lake drains into Budd Inlet.

A multi-year and multi-stakeholder study was completed to evaluate how the mouth of the Deschutes River will ultimately interface with Budd Inlet and how it will be managed within a heavily developed urban environment. This study evaluated the environmental, social, and economic implications for a variety of long-term management alternatives. The Washington State Department of Enterprise Services is recommending the removal of the dam, which will allow Capitol Lake to revert to an estuary.

Deschutes River Flood Stage Levels

The flood of record is 17.01 feet from January 9, 1990. Figure 4.3.3 summarizes the flood impacts based on Deschutes River flood stages at the Rainier Vail Loop Bridge Gauge, River Mile 25.9.

Figure 4.3.3 Deschutes River Flood Stages and Historic Crests at the Rainier Vail Loop Bridge Gauge

Flood Stage	Gauge Height and Discharge	Conditions and Previous Years of Occurrence
Action	9 Feet or 2,570 CFS	At 9 feet, the Deschutes River locally spills over its banks into low fields and forested lands, mainly along Vail Cutoff Road and Reichel Road. 1949, 1950, 1951, 1952, 1953, 1954, 1955, 1956, 1957, 1958, 1959, 1960, 1961, 1962, 1964, 1965, 1966, 1967, 1968, 1970, 1972, 1974, 1975, 1977, 1979, 1982, 1989, 1990, 1991, 1992, 1994, 1995, 1996, 1997, 1998, 1999, 2001, 2002, 2007, 2009, 2011, 2015
Flood	11 or 3,950 CFS	At 11 feet, the Deschutes River will flood downstream in Tumwater Valley, including the golf course. Minor flooding will also occur in several residential areas, mainly Cougar Mountain and Driftwood Valley. Many roads and farm lands will also be flooded. 1949, 1953, 1955, 1957, 1960, 1962, 1963, 1964, 1966, 1967, 1970, 1971, 1972, 1975, 1977, 1982, 1987, 1988, 1990, 1994, 1996, 1997, 1998, 2001, 2003, 2006, 2011, 2012, 2014, 2015
Moderate	13.5 Feet or 5,970 CFS	At 13.5 feet, the Deschutes River will flood residential areas, especially Cougar Mountain, Driftwood Valley and Falling Horseshoe. Downstream flooding will occur in areas of Tumwater Valley, including the golf course. Many roads and farm lands will also be flooded. 1991, 1996, 1998, 2007, 2009
Major	15 Feet or 7,330 CFS	At 15 feet, the Deschutes River will cause major flooding, with swift and deep water flooding roads, farmlands and the residential areas of Cougar Mountain, Driftwood Valley, Falling Horseshoe and areas downstream in the Tumwater Valley. Flooding will occur all along the river including headwaters, tributaries and other streams within and near the Deschutes River Basin. 1972, 1974, 1990, 1996

The Nisqually River

The Nisqually River is the only river system within Thurston County that is fed primarily by melting snowpack and glacial ice. This 80-mile river is located within the Nisqually Watershed (WRIA #11). The river's headwaters begin on the southwestern slope of Mount Rainier at the base of the Nisqually Glacier in Mount Rainier National Park in Pierce County. The river flows west along the Pierce and Lewis County line until constrained by the Alder Dam; nearly halfway (river mile 44.2) to the river mouth at the Puget Sound. From Alder Reservoir, the Nisqually River forms a natural border for approximately 48 miles between Pierce and Thurston counties. The Nisqually River is particularly prone to atmospheric river flooding due to its alpine origins and susceptibility to rain-on-snow melting in the upper elevations near Mt. Rainier.

Alder Dam is a 330-foot-high concrete arch dam with a crest length of about 1,600 feet, with a spillway designed for a maximum discharge of 85,000 cubic feet per second (cfs). Alder Reservoir is about seven miles long with a 3,065-acre surface area and a 214,500-acre-foot total storage capacity. The LaGrande Dam, a gravity structure 212 feet high and about 710 feet long, is 1.7 miles downstream from Alder Dam. The dam's spillway was also designed for a maximum discharge of 85,000 cfs. The LaGrande Reservoir provides a total storage capacity of 2,676 acre-feet. Tacoma Power operates both dams for hydroelectric power generation.[6] The reservoirs of both dams are relatively small, and Tacoma Power is not required to provide flood control. Even so, Tacoma Power lowers the elevation of the lake, when possible, during winter months to enable some capture of high-water inflows from rainstorms and snow melt.

The Nisqually River resumes a mostly natural unrestricted flow as it traverses northwest away from the LaGrande Dam, passing a diversion dam owned by the City of Centralia. The diversion dam and a canal divert water from the Nisqually River to generate 12 megawatts of hydroelectric power during peak flows at a plant northwest of the city of Yelm. The dam provides no floodwater storage capacity. The river courses past scattered residences in unincorporated Thurston County before it passes the communities of McKenna, Yelm, the Nisqually Pines neighborhood, the Nisqually Indian Reservation, and the undeveloped range lands of Joint Base Lewis McChord. Several small farms and residences are in the Nisqually Valley in the vicinity around Interstate 5 and Old Pacific Highway. The river enters the Puget Sound near the Nisqually National Wildlife Refuge.

Nisqually River flooding relates largely to the amount of water released from Alder and LaGrande dams. Feeder streams such as Ohop, Yelm, and Tanwax creeks also influence flooding, as do high tides in the Nisqually Delta. Conservation efforts including dike removal and revegetation work was recently completed to restore ecological functions of the Nisqually Estuary. It is unknown how this restoration will affect floods in the lower reaches of the river, as major flooding has not occurred since this work was completed.

Nisqually River Flood Stage Levels

The flood of record is 17.13 feet from February 8, 1996. The National Weather Service issues a flood warning for the Nisqually River when forecast models indicate the river will reach a stage of 12 feet or higher at the McKenna Gauge at River Mile 21.8. Figure 4.3.4 summarizes the flood impacts based on Deschutes River flood stages at this gauge.

Figure 4.3.4 Nisqually River Flood Stages and Historic Crests at the McKenna Gauge

Flood Stage	Gauge Height and Discharge	Conditions and Previous Years of Occurrence
Action	8 Feet or 9,970 CFS	At 8 feet, residents should be aware that the river is likely to flood. 1967, 2011, 2014
Flood	10 or 14,700 CFS	At 10 feet, the Nisqually River will flood at the lower end near the mouth. High tide levels on Puget Sound may increase the amount of flooding. The Nisqually River will also spill over its banks between LaGrande and McKenna. 1951, 1953, 1955, 1959, 1961, 1964, 1977, 1980, 1982, 1990, 1991, 1994, 1995, 1997, 2003, 2006, 2009, 2015
Moderate	13 Feet or 23,300 CFS	At 13 feet, the Nisqually River will flood from LaGrande downstream through McKenna to the mouth. Swift waters will flood roads, farms and some residential areas, including the residential care facility in McKenna. Erosion will likely damage properties along river banks. 1991, 1996, 1998, 2007, 2009
Major	14 Feet or 26,500 CFS	At 14 feet, the Nisqually River will cause major flooding from LaGrande downstream through McKenna to the mouth. Deep and swift waters will flood roads, farms and residential areas, including the residential care facility in McKenna. Erosion may cause severe damage. Flooding will occur all along the river, including headwaters, tributaries and other streams within and near the Nisqually River Basin. 1972, 1974, 1990, 1996

Scatter Creek

Located in the Upper Chehalis Watershed (WRIA #23), Scatter Creek is approximately 20 miles long with an additional 9.5 miles of tributaries. The creek flows west-southwest from McIntosh Lake, east of Tenino, to the Chehalis River near Rochester.

The creek crosses lands chiefly composed of highly porous glacial outwash materials. After Scatter Creek passes through the City of Tenino, the river flows through mostly undeveloped small farmland with scattered residences through unincorporated Thurston County. The lower end of the creek passes through the Grand Mound area which is scattered with residences and light industrial plants and businesses. The lower six miles maintains a year-round flow of water due to pumped groundwater sourced from effluent from a commercial fish farm. Significant reaches of the creek up stream remain dry during the summer because of a lowering of the water table from a variety of active water rights and exempt wells within the watershed.

The Scatter Creek Aquifer system is like a "propped up bathtub" that feeds into the Chehalis (a high ground water gradient and velocity). Ground water flooding in Scatter Creek impacts the municipal well field which is shallow – only 90 feet below ground surface. Even in years where the Chehalis does not flood, the ground water comes to ground surface at the well field. Also, the LIDAR data reveals Scatter Creek as large ancestral flood channels, so the stream itself does not seem to overbank as dynamically as a normal flood plain in the upgradient areas. The river just follows the larger ancestral 'scours.'[7]

No permanent long-term stream flow gauges exist on this creek, so little is known about its long- term hydrography. In addition, very little flood history data is published for this riverine system. The Scatter Creek Habitat Conservation Plan states that from 1993 to 1999, the wet season flows typically ranged from 80 to 400 cfs, with less frequent peaks in the range of 400 to 1,400 cfs. The maximum mean daily discharge during this period was 1,362 cfs on February 14, 1996 (historically a very wet year, coinciding with record flood levels for the Skookumchuck River).

A long-term (> 20-year) stream flow gauge exists on this creek near the confluence with the Chehalis River at James Road which provides historical and near real-time data on flow levels. The Scatter Creek Habitat Conservation Plan states that from 1993 to 1999, the wet season flows typically ranged from 80 to 400 cfs, with less frequent peaks in the range of 400 to 1,400 cfs. The maximum mean daily discharge during this period was 1,362 cfs on February 14, 1996 (historically a very wet year, coinciding with record flood levels for the Skookumchuck River).The Scatter Creek Habitat Conservation Plan includes the following passage regarding flood flows[8]:

> …About 50 percent of the basin delivers stormflow runoff to the valley bottom from the hill portions of the basin. This flow is mostly delivered from seven tributary creeks that enter Scatter Creek and elevated groundwater return flow. If stormflow runoff enters from the tributaries after a dry summer, it takes a while to fill the local groundwater and channel areas. Stormflow onto wet basin conditions creates the largest stormflow peaks. There are insufficient years of recorded flows on Scatter Creek to determine the relationship between flood frequency and magnitude.

In 1996, Scatter Creek experienced major flooding, covering several county roads along its westward flow including Old Highway 99, Sargent Road, 183rd Avenue, State Route 12, and Denmark Street.[9]

The Skookumchuck River Basin

The Skookumchuck River is 43 miles long with headwaters originating within Mt. Baker- Snoqualmie National Forest in north Lewis County. Located in the Upper Chehalis Watershed (WRIA #23), the river is arch-shaped and arcs upward into Thurston County for nearly 26 miles before it returns to Lewis County. The river flows northwest into Thurston County through commercial forest lands with relatively steep forested valley slopes. The Skookumchuck Dam, located about ten miles east and upstream from the town of Bucoda, constrains the river as it traverses west. The dam - a rolled earthfill embankment with a crest length of 1,320 feet and a height above streambed of 160 feet – has a gross storage capacity of 35,000 acre-feet. The dam's spillway, an ungated concrete ogee section 130 feet long, can pass the Probable Maximum Flood of 32,500 cfs.[10] TransAlta operates the dam, with a primary function to provide a controlled release of cooling water at the Centralia Steam Electric Plant in Lewis County.

The Skookumchuck River emerges from the reservoir and passes through a relatively flat open valley comprised of scattered small farms and residences. As the River bends south toward Lewis County, the valley narrows as the river flows through the town of Bucoda. The river winds along the eastern edge of the town's core developed area. From here, the river flows southwest and runs roughly parallel with State Route 507 into Lewis County. The river continues south until it enters the more densely populated City of Centralia. The Skookumchuck River drains into the Chehalis River, in Centralia, just west of Interstate 5 and south of Harrison Avenue.

Skookumchuck River Flood Stage Levels

The flood of record is 17.87 feet from February 8, 1996. The National Weather Service issues a flood warning for the Skookumchuck River when forecasts indicate that the river will reach a stage of 13.5 feet at the gauge near Bucoda. Figure 4.3.5 summarizes the flood impacts based on Skookumchuck River flood stages at the gauge four miles downstream from Bucoda.

Figure 4.3.5 Skookumchuck River Flood Stages and Historic Crests at the Gauge near Bucoda

Flood Stage	Gauge Height and Discharge	Conditions and Previous Years of Occurrence
Action	11.5 Feet or 2,750 CFS	At 11.5 feet, residents should be aware that the river is likely to flood. 1968, 1970, 1972, 1977, 1980, 1982, 1986, 1987, 1994, 1997, 1998, 2001, 2006, 2007, 2010, 2012, 2014
Flood	13.5 Feet	At 13.5 feet, the Skookumchuck River will flood a few roads and low pasture lands near Bucoda. 1968, 1972, 1974, 1975, 1976, 1982, 1983, 1986, 1994, 1995, 1996, 1998, 1999, 2001, 2002, 2004, 2005, 2006, 2007, 2011
Moderate	15 Feet or 5,500 CFS	At 15 feet, the Skookumchuck River will flood several residential and business areas around Bucoda. Flood waters will cover many roads. 1971, 1972, 1974, 1975, 1977, 1986, 1987, 1990, 1991, 1995, 1996, 1998, 1999, 2001, 2003, 2006, 2014, 2015
Major	17 Feet or 8,650	At 17 feet, the Skookumchuck River will cause major flooding in the Bucoda area, with deep and swift flood waters inundating residential and business areas and numerous roads. Flooding will occur all along the river, including headwaters, tributaries and other streams within and near the Skookumchuck River Basin. 1990, 1996, 2009

2. Groundwater Flooding

Groundwater flooding occurs when there is a high-water table and persistent heavy rains in an area where an upper, thin layer of permeable soils overlays an impermeable layer of hard pan. As the ground absorbs more and more rainwater, the groundwater table rises and causes flooding where it is higher than the surface of the ground. Map 4.3.3 shows high groundwater hazard areas in Thurston County.

Modes of Groundwater Flooding in Thurston County[11]

Combined local and National Oceanic and Atmospheric Administration data reveal two types of weather patterns that trigger groundwater flood events:

Type 1: Intense – Short Duration Successional Storms: ARkStorm systems are driven by the Pacific jet stream that draw sub-tropical moisture from the Pacific Ocean and release abundant rainfall as they reach land in the Pacific Northwest. They are characterized by warmer than normal temperatures and intense steady rainfall lasting for 1-3 days. Groundwater flooding occurs with two separate but successive storm events within a month, or if an atmospheric river system arrives later in the season after normal winter rains have "primed" the groundwater levels to near maximum. Normal high groundwater levels occur in mid- to late March, so if an atmospheric river system coincides with this normal peak, the capacity of the soils is exceeded and groundwater flooding occurs. This pattern appears to be increasing in frequency and intensity. Type 1 storm events also contribute to urban and stream flooding and landslides.

Type 2: Persistent Low-intensity Precipitation Pattern: This weather pattern is less common, but produces similar groundwater flooding effects. Type 2 patterns are characterized by weeks of persistent low intensity daily rainfall measuring less than an inch per day that gradually topples the groundwater table. In most cases, this weather pattern causes more widespread flooding throughout the County, both in areas that routinely flood and in those not generally susceptible to groundwater flooding. The county has only experienced this pattern twice in the last two decades – in 2002-2003 and in 2006-2007. In both instances, groundwater flooding was widespread and included areas not previously identified as susceptible to routine groundwater flooding. This implies that Type 2 events generate more widespread flooding than Type 1 events. Type 2 events do not appear to cause riverine flooding or landslides, but the data is insufficient to be certain of this conclusion.

Area of Impact of Groundwater Flooding

Nearly 54 square miles or 34,363 acres countywide (around 7 percent) have experienced groundwater flooding. Areas that experience such flooding are scattered throughout the lowlands in Thurston County (Map 4.3.3), but it is most prevalent around the western and southern end of the Olympia Regional Airport, near Littlerock Road, and south of Tumwater along Case Road. Although groundwater flooding occurs sporadically throughout Thurston County, the geologic conditions present in the Salmon Creek Basin south of Tumwater create the "worst case scenario" for such flooding here.

Since 1999, this basin has experienced floods four more times, though none were as severe as in 1999. The combination of increasing storm severity and intensity in the past decade, coupled with population increases in the County, have brought people and floods ever closer together in developing areas of the county. Other affected areas are in the Scatter Creek/lower Black system near Grand Mound and Rochester, eastern portions of the Lacey UGA, Beaver Creek, the Spurgeon Creek systems, and in the Yelm UGA.[12]

Extent of Groundwater Flooding

Since areas of high groundwater are relatively flat, flood waters can remain standing for several months, resembling ponds or lake like conditions. The Salmon Creek Basin experienced significant flooding in 1999, resulting in contiguous bodies of standing flood waters ranging from small puddles to 113 acres. Depths ranged from near ground surface to over 12 feet deep. The volume of flood water above the surface of the ground in the basin was equivalent to 603 football fields covered with four feet of water. This amount combined with the volume of groundwater below the surface at the septic drain field level would be equal to 977 football fields or 28,655 acre-feet.[13]

Historic groundwater flooding has been most severe in the second and subsequent years of consecutive wet years. According to the U.S. Army Corps of Engineer's post event report on the winter storm of 1996-1997, the frequency of a groundwater flooding disaster in Thurston County is probably on the order of every 25 years. This first widespread groundwater flood event since 1972 and the worst on record until the winter of 1998-1999. The 1998-1999 flood is now the "event of record." This event set the benchmark for high groundwater flood hazard requirements implemented by Thurston County.

3. Tidal Flooding

Spring tides, the highest tides during any month, occur with each full and new moon. When these coincide with a northerly wind piling water in south Puget Sound, tidal flooding can occur. Tidal flooding can also occur without the effect of storm surge. The tides can also enhance flooding in delta areas when rivers or creeks are at or near flood stage.

Photo courtesy of West Thurston Fire District.

Area of Impact of Tidal Flooding

The downtown Olympia waterfront, including Port of Olympia properties, face the greatest risk from tidal flooding. Localized flooding is common along 4th and 5th Avenues near the isthmus between Capitol Lake and Budd Inlet and nuisance tidal flooding occurs downtown at 17 feet mean lower low water. Low-lying farmlands in the Nisqually Valley and along McLane Creek near Mud Bay are at risk. Tidal flood impacts are also a concern in delta areas when rivers are at flood stage and high tide exacerbates the situation. Sea level rise will increase the extent of inundation during tidal flooding.

Extent of Tidal Flooding

Puget Sound marine flooding by itself does not produce major flooding in the region. However, such flooding will become more frequent and present more adverse impacts in the second half of the 21st Century as sea levels rise.[14] Tidal flooding generally subsides as tides recede. Presently, tidal floods are short, often lasting only one to two hours. Chapter 4.5 Sea Level Rise Hazard Risk Assessment includes more information about coastal/tidal flooding and its extent for Downtown Olympia and unincorporated Thurston County.

4. Urban Flooding

Urban flooding occurs when excess precipitation is not readily absorbed by the ground and stormwater runoff exceeds the ability of stormwater facilities' capacity to safely convey and divert water within suburban and urban environments. As a result, streets, parking lots, homes, and businesses may experience localized flooding.

Excess water accumulation flowing off and over impervious surfaces from heavy rainfall or melting snow over a short period is the most common cause of urban flooding in the cities and developed areas of the county. Leaves, branches, snow or ice, and other debris that clogs stormwater drains compounds the problem. Other forms of urban flooding occur in residential neighborhoods constructed with insufficient stormwater conveyance capacity. Until flooding reveals the problem, residents or municipalities may be unaware of deficient drainage systems in newer developments. New urban development or neighborhoods with faulty stormwater systems may adversely impact adjacent neighborhoods that previously did not experience stormwater flooding.

Area of Impact of Urban Flooding

Although it occurs throughout every city in Thurston County, urban flooding has historically impacted west Olympia and downtown Olympia more than other communities.

Extent of Urban Flooding

In general, properties impacted by urban flooding are not widespread and flood conditions are often localized. However, the impacts to transportation networks can be great. Downtown Olympia is vulnerable to urban flooding when extreme high tides coincide with persistent heavy rainfall and major flooding on the Deschutes River. The city can easily mitigate some stormwater flooding through regular cleaning and maintenance of stormwater conveyance systems.

Effects of Climate Change on Flooding

Research and climate forecasts offer evidence that long-term climate change will have a measurable impact on the frequency and severity of flooding. The University of Washington Climate Impacts Group (UWCIG) published a detailed report on the state of science on climate change and its effects within the region titled, “State of Knowledge: Climate Change in the Puget Sound.” The report identifies several factors that will influence flooding for these communities. Thurston County is currently conducting long term analysis to quantify climate change impacts recorded in the vast quantities of hydrologic data collected by the County since 2000.

Air temperatures are increasing in the Puget Sound Region, and are projected to warm rapidly during the 21st century, especially during the summer. By mid-century, warming will be outside of the range of historical variations. Because of warmer winters, watersheds will become increasingly rain dominant with streamflow projected to peak earlier in winter and decrease in spring and summer. Winter streamflow is projected to increase by 28 to 34 percent on average by the 2080s.

Overall annual precipitation levels are forecast to remain the same, but with greater seasonal variation. Summers will become drier and winters wetter. The frequency of the region’s peak 24-hour rain events is expected to more than triple by the end of the 21st century. Such heavy storms are also expected to become more intense, with greater rainfall occurring in shorter periods of time.

Climate Change on the Region’s Hydrology

Changes in temperature and precipitation will continue to decrease snowpack, affecting stream flow and water quality throughout the Pacific Northwest. Warmer temperatures will result in more winter precipitation falling as rain rather than snow, particularly in mid-elevation basins where average winter temperatures are near freezing. This change will result in less winter snow accumulation and higher winter stream flows. The Nisqually River, fed by snowmelt, will likely see earlier peak spring stream flow and lower summer stream flows.

The decline of the region’s snowpack is predicted to be greatest at low and middle elevations due to increases in air temperature and less precipitation falling as snow. The average decline in snowpack in the Cascade Mountains, for example, was about 25 percent over the last 40 to 70 years, with most of the decline due to the 2.5°F increase in cool season air temperatures over that period. As a result, seasonal stream flow timing will likely shift significantly in sensitive watersheds.

Thurston County’s rivers are less impacted by snowpack than other rivers in western Washington, so would see less impact from changes to snowpack. However, any change in hydrograph associated with more concentrated, intense rainfall would greatly impact Thurston County’s rivers.

Rivers with dams could experience significant impacts from a changed hydrograph, since dams are designed partly based on assumptions about a river's flow behavior, expressed as hydrographs. Changes in weather patterns can have significant effects on the hydrograph used for the design of a dam. If the hygrograph changes, it is conceivable that the dam can lose some or all its designed margin of safety, also known as freeboard. If freeboard is reduced, dam operators may be forced to release increased flows earlier in a storm cycle to maintain required margins of safety. Such early releases of flow can increase flood potential downstream. Throughout the western United States, communities downstream of dams are already experiencing increases in stream flows caused by earlier releases from dams.

Use of historical hydrologic data has long been the standard of practice for designing and operating water supply and flood protection projects. For example, historical data are used for flood forecasting models and to forecast snowmelt runoff for water supply. This method assumes that the climate of the future will be like that of the period of historical record. However, the hydrologic record cannot be used to predict changes in frequency and severity of extreme climate events such as floods. Going forward, model calibration or statistical relation development must happen more frequently, new forecast-based tools must be developed, and a standard of practice that explicitly considers climate change must be adopted.

Climate change is already impacting water resources, and resource managers have observed the following:

- Historical hydrologic patterns can no longer be solely relied upon to forecast the water future.
- Precipitation and runoff patterns are changing, increasing the uncertainty of water supply and quality, flood management, and ecosystem functions.
- Extreme climatic events will become more frequent, necessitating improvement in flood protection and emergency response.
- Drought is likely to become an annual summer event causing impacts to agriculture, aquatic species survivability, and increasing wildfire danger.

The UWCIG provides climate forecast projections for the percent change in the magnitude of streamflow on the day of the year with the most streamflow (Table 4.3.4).[15]

Table 4.3.4 Percentage of Stream Lengths in Thurston County – Percent Change in Annual Maximum Streamflow[1]

Scenarios	Over 100	70 to 100	50 to 70	30 to 50	10 to 30	-10 to 10
1980-2009						
Historical Baseline	0	0	0	0	0	100
2020-2049						
Higher Scenario (RCP 8.5)	0	0	0	0	21.8	78.2
Lower Scenario (RCP 4.5)	0	0	0	0	22.1	77.9
2030-2059						
Higher Scenario (RCP 8.5)	0	0	0	0	90.1	9.9
Lower Scenario (RCP 4.5)	0	0	0	0	43.5	56.5
2040-2069						
Higher Scenario (RCP 8.5)	0	0	0	4.9	94.9	0.2
Lower Scenario (RCP 4.5)	0	0	0	0	69.5	30.5
2050-2079						
Higher Scenario (RCP 8.5)	0	0	0	21.8	78	0.2
Lower Scenario (RCP 4.5)	0	0	0	0	87.4	12.6
2060-2089						
Higher Scenario (RCP 8.5)	0	0	0	21.8	78	0.2
Lower Scenario (RCP 4.5)	0	0	0	0	72.4	27.6
2070-2099						
Higher Scenario (RCP 8.5)	0	0	0	0	99.8	0.2
Lower Scenario (RCP 4.5)	0	0	0	0	99.8	0.2

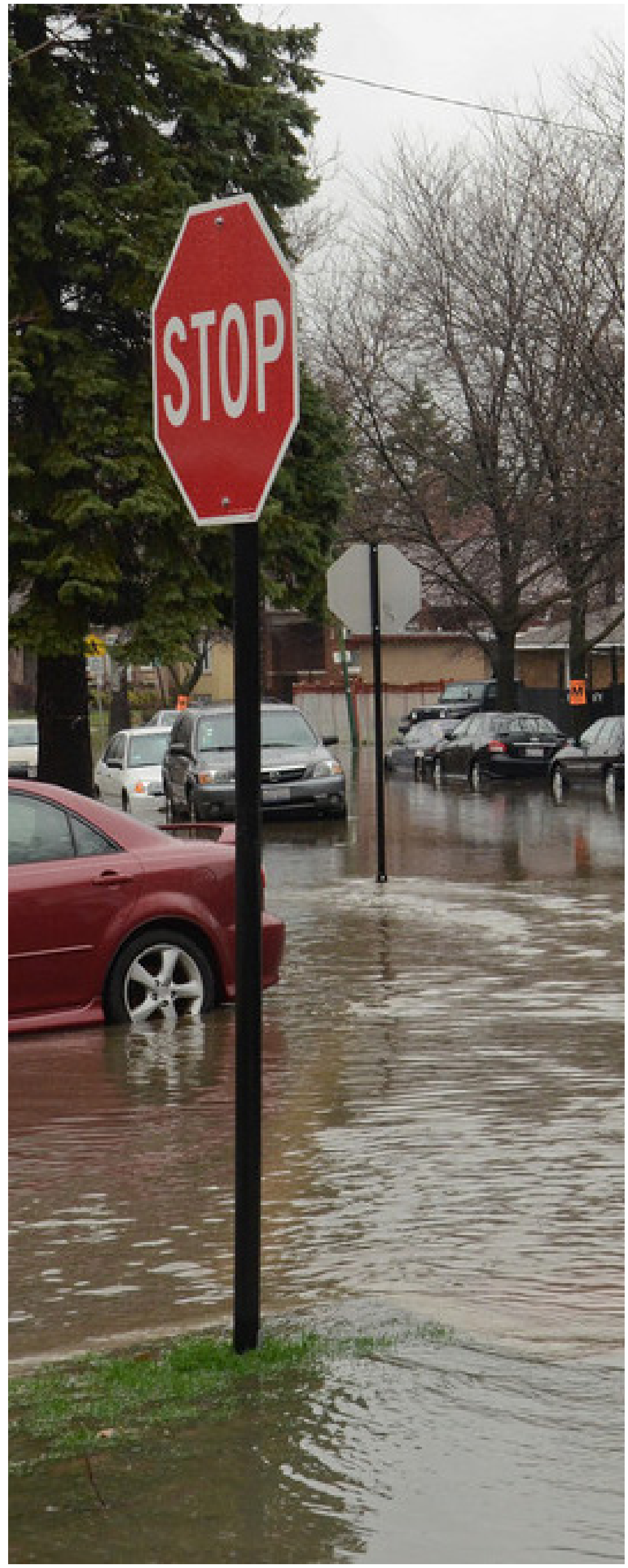
[1]Representation concentration pathways, or RCPs are climate model scenarios for the 21st century. RCP 4.5 — a "low" scenario that assumes greenhouse gas emissions (GHG) stabilize by mid-century and fall sharply thereafter; and RCP 8.5 — a "high" scenario that assumes substantial GHG increases until the end of the 21st century.

Previous Incidents

Several major floods have impacted the Thurston County region over the last several decades resulting in 12 major federal disaster declarations. The following accounts describe the range of flood impacts to community assets including people, structures and systems, natural, cultural and historic resources, and activities. The impacts reveal potential vulnerabilities from future floods.

December 26, 2021 – January 15, 2022, Severe Winter Storms, Straight-Line Winds, and Flooding. DR 4650.

Winter storms, snow, and heavy rains caused major flooding on the Chehalis and Skookumchuck rivers. On January 6, the Thurston County Emergency Coordination Center activated to a Level 2 partial activation due to anticipated major flooding. On January 7, the Chehalis River near Grand Mound crested at 145 feet and the Skookumchuck River near Bucoda crested at 216 feet, both reached major flood stage. Evacuation advisements were issued for residents in affected areas. Several rescues were performed in the West Thurston Fire District. 35 county roads were closed, and 113 additional roads were signed for roadway flooding. A surge in demand to dispose of residential debris from the winter storm combined with road closures created a backlog of waste at disposal sites.



97 residents reported over $556,000 in uninsured losses. Flooding caused damage to crawl space HVAC systems, first floor structures and contents, and damaged or destroyed outbuildings and septic systems. The flooding resulted in a combined local government assessment of $701,433 in public assistance needs.[16]

January 20 – February 10, 2020, Severe Storms, Flooding, Landslides, and Mudslides. DR 453917

A period of abnormally wet weather began in late December and persisted through early February across the Pacific Northwest. An area of strong, persistent low pressure over the eastern Pacific generated a series of strong atmospheric river events that hit in quick succession resulting in overlapping storms. Water vapor transport into Washington State was 200 to 250 percent of normal during the period. These events led to widespread sustained riverine flooding and other winter storm impacts across Washington State.

Weeks of heavy rain and snow resulted in significantly higher than normal flows on the Nisqually River. To prevent the pooled reservoir from overtopping the La Grande Dam, Tacoma Power increased the dam flow from approximately 2,200 cfs to 17,000 cfs, peaking on February 6 and continuing through February 7, 2020. The sustained release of water had major implications on downstream communities, especially for hundreds of Thurston County residents, businesses and Nisqually Indian tribal members residing in the Lower Nisqually Valley area.

Thurston County Department of Emergency Management activated their Emergency Operations Center and issued evacuation orders beginning February 6 for approximately 700-1,000 individuals living in the low-lying areas along the river. The Thurston County Sheriff's department and dive/swift water search and rescue teams assisted with the evacuations of people, pets, and domestic livestock. The County assisted with emergency sandbagging operations and public messaging. The rapid rate of rising water in communities along the Nisqually River required life-saving decisions for several evacuating residents at the time of the flooding. There was major flood damage reported to garages, sheds, personal property, and homes in neighborhoods with a high number of very low-income families.

The Red Cross operated a shelter in Lacey from February 6 to February 11, 2020, in response to the evacuation and flooding impacts. The evacuation advisory remained in place for four days. The Riverside Manor Apartments in Nisqually were flooded as the river overtopped its banks, resulting in several units with reported flood damage. Dozens of other homes and businesses in the area were also impacted by the flooding. Data from a 2016 American Community Survey (ACS) identifies nearly 16 percent of families living in the Nisqually Valley to be below the poverty line, and an estimated 18.1 percent of the population is living with a disability. The primary impact of the flooding directly affected an estimated 2,669 individuals, 43 percent of which were over the age of 60, and 40 percent were families receiving supplemental or cash public assistance. The impacted individuals faced major challenges finding alternate affordable housing options in the area due to their economic constraints. Another major challenge impacting residents' ability to recover from this flooding was the widespread and ongoing response to the COVID-19 pandemic.

The severe winter weather damaged roads, recreational sites, private and commercial fishing facilities, downed large trees on top of power lines and other critical infrastructure and caused widespread damage to homes and businesses. Schools cancelled classes and bus routes were interrupted due to the flooding. The Nisqually Indian Tribe's Wa He Lute Indian School also sustained major flood damages from this severe winter storm system. Strong winds and heavy rains toppled trees across the County, knocking down utility lines and eroding and destroying popular hiking trails in the area. A large tree fell on a pedestrian bridge over Percival Creek, destroying the bridge and severing a watermain, sewer line and conduit containing private utility communications lines. Approximately 30,000 gallons of untreated sewage flowed directly into the creek, Capitol Lake, and the Lower Budd Inlet. The bridge supports sewer, water, and utility infrastructure lines serving thousands of residents in multiple counties. Approximately 765 residential units and 42 commercial accounts including the Thurston County Courthouse were impacted by the broken sewer main line and approximately 2,100 residential units and 64 commercial accounts were impacted by the broken water main. The embankment around the structure also suffered major erosion damage. A 53-foot span of the bridge will need to be replaced to support replacement of the utilities at an estimated cost of $2.5 million.

The Washington Department of Fish and Wildlife (WDFW) reported damage to its facilities after the Nisqually River flooded approximately five feet over its banks, damaging a juvenile fish trap site. The historic flows broke the anchor line, damaging the trap, flooding hatchery facilities, and severely eroded the parking lot and access area. Hatchery operations are a crucial economic driver for the state, serving as an important asset to the tourist and recreation fishing industry. The loss of a normal cycle of fish into the rivers disrupts the return of fish to the waters on schedule, adversely impacting the entire state economy.

The Nisqually Indian Reservation community also relies heavily on the abundance of salmon in the region for economic and cultural reasons. As a result of the historic flows, an estimated 600,000 Coho salmon, 500,000 Chinook salmon, and 500,000 Chum salmon were affected by the flooding to the Tribe's salmon hatchery. Erosion occurred around the fish ladder, upper site intake dam and along the roadway at the Kalama Creek Hatchery Facility resulting in major damages. Floodwater contaminated with sediment, sewage, and petroleum products inundated containment tanks holding hundreds of thousands of Coho and Chinook salmon. The full extent of the loss is still being calculated at this time, but the compounding adverse effects on the economy, environment and livelihoods of the community may be felt for years to come.

Representatives from FEMA and Washington State Emergency Management Division met with the Nisqually Indian Tribe on February 27 to discuss the flooding impacts to their hatchery operations and community at large. The Tribe reiterated and stressed the cultural, economic, and environmental implications of the threatened salmon habitat and the adverse impacts because of this disaster.

January 6-16, 2009, Severe Winter Storms, Landslides, Mudslides, and Flooding. DR-1817.

An atmospheric river storm raised temperatures and dropped heavy rains throughout western Washington following one of the worst Pacific Northwest snowstorms in decades. Severe flooding occurred throughout western Washington, including the Chehalis, Skookumchuck, Deschutes, Nisqually, and Black rivers. The Skookumchuck River crested at 17.72 feet on January 8, making it the second worst flood in the river's recorded history. The Chehalis River crested at 18.18 feet near Grand Mound causing major flooding in the Chehalis River Basin only 13 months after the December 2007 floods.

Interstate 5 was closed for 20 miles for nearly two days. State Route 12, State Route 8 and Highway 101 were also closed for a period, some for multiple days. During the height of the flood event, 49 county roads were closed. Over 200 homes were isolated in the Bald Hills Road/Clearwood area, and likely over 100 in the Rochester, Grand Mound, and Gate communities, and likely another 50 homes had access issues in the area around Bucoda.

Damage to homes throughout Thurston County was estimated at $3 million. Damage was concentrated in and around the town of Bucoda, the Rochester community, and along the Deschutes River outside of Yelm. Damage to public facilities and roads around Thurston County and the overtime cost for city and county officials to respond to the flooding cost $2.5 million.

Volunteer firefighters went door to door in Bucoda warning residents of imminent flooding before floodwaters swallowed a nine-block stretch of the town (the town's worst flood event since 1996). Residents were forced to evacuate, and a Thurston County dive team was deployed to assist residents. At least two households required rescue assistance. One home was identified as too dangerous to inhabit and 12 homes were deemed moderately damaged and only accessible during the daytime. The Intersection of 3rd Avenue and North Nenant Street incurred damages exceeding $12,000. Extensive road damage along five blocks of Market Street also occurred. At least one municipal well was forced to shut down due to possible contamination. The town-owned RV park restroom was also contaminated by floodwaters and required extensive clean up.

On January 8, the City of Lacey shut down two streets for the first time in at least nine years due to urban flooding. Crews closed Rainier Road at the south end of city limits around the Burlington Northern Santa Fe (BNSF) railroad trestle. The city also closed 32nd Avenue Northeast off Marvin Road in the Hawks Prairie area. The heavy rains entering the sewer system in Olympia forced the LOTT Alliance to discharge 6.3 million gallons of partially treated wastewater from its Budd Inlet Sewer Treatment Plant via its emergency outfall at the Fiddlehead Marina.

December 1-7, 2007, Federal Disaster 1734: Severe Winter Storms, Flooding, Landslides, and Mudslides18

Snow followed by an atmospheric river on December 2 and 3 caused major flooding throughout southwest Washington. Heavy rainfall and melting snow resulted in record flooding on the Chehalis River, which crested at 20.23 feet, six feet over flood stage at the Grand Mound gauge. Some sites in the Willapa Hills area collected 14 to 18 inches of rain over the two-day period. Widespread flooding occurred in southwest Thurston County heavily impacting the Rochester community, Grand Mound, and the Independence Valley area. Lewis County was especially hard hit, particularly around the cities of Centralia and Chehalis and the farms around Adna and the Boistfort Valley.

The Deschutes and Black rivers also rose above their banks. The Deschutes River crested 2.75 feet above flood stage near Rainier and flooded residential areas and the Tumwater Valley. The region also experienced stream and urban flooding and flash flood conditions in the Capitol Forest, resulting in washouts and landslides (see landslide hazard profile for other details on this event).

On December 4, Rochester Fire Department developed a command post for evacuation and rescue. They partnered with the Thurston County Sheriff's Office Dive Team, local search and rescue volunteer groups, and the Washington State National Guard and rescued 63 people - 17 by helicopter. Nearly 300 people were rescued or forced to evacuate in Lewis County – some seeking refuge in local area shelters. Thurston County opened a flood relief center at the Rochester Community Center to assist affected residents.

Thurston County documented 44 county roads and bridges that closed from storm and flood damage. The county and cities carried out round-the-clock road repair and maintenance. Estimates reflect that over 400 homes in the area were affected by the road closures in the southwest Thurston County. Interstate 5 closed for 20 miles between Chehalis and Grand Mound for five days. Some portions of Interstate 5 were covered with 10 feet of water. The Washington State Department of Transportation estimated that the closure resulted in $47 million in lost of economic output statewide.[19] Additional closures along Highway 101 and Highway 8 disrupted traffic for thousands of people who live or work in Thurston County, or who were passing through. A railroad bridge over the Nisqually River suffered significant damage due to debris collection against the bridge, resulting in a disruption of statewide rail traffic. West coast rail traffic was also shut down for several days due to flooding.

Nearly 10 inches of rain fell on the City of Olympia's west side resulting in the worst urban flooding ever experienced in that area. On December 3, 2007 during the morning peak commute period, the west side of Olympia experienced major traffic backups for hours due to road closures. One of the highest traffic volume intersections in the region, Cooper Point Road and Black Lake Boulevard off Highway 101, experienced major flooding resulting in permanent damage to the signal controller. Several motorists attempted to drive through the water only to become stranded and forced to abandon their vehicles. Some vehicles were eventually completely submerged. Inundation forced the closure of the Percival Creek Bridge on Cooper Point Road. Several businesses on Olympia's west side were affected by floodwaters and power outages. Puget Sound Energy turned off power as a safety precaution requiring businesses to temporarily close their doors. The Woodshed, a furniture retailer, lost their entire inventory to three feet of water. Replacement cost was estimated at $250,000.

On December 3, the enormous volume of rainfall and runoff caused LOTT Alliance's Budd Inlet Sewer Treatment Plant to discharge untreated wastewater into Budd Inlet. At its peak, an estimated 1 million gallons per hour bypassed treatment processes and was sent through the emergency outfall near Fiddlehead Marina. After the flooding, many wells and water supplies were contaminated and non-functional in the unincorporated areas of the county. Public health advisories were issued to flood affected areas to inform the public to boil their water or consume only bottled water.

Preliminary cost estimates for the response, preventive measures, and the damage to public facilities exceeded $4.6 million throughout Thurston County. In many ways, the dollar figures reported for response costs only reflect a fraction of the actual response costs to local governments. For example, the estimates may not include volunteers, such as the local fire districts' volunteer firefights who provided emergency response. Damage to Thurston County roads and bridges for non-federal aid routes was $2.7 million. Three sites of federal aid roads incurred over $32,000 in damages.

For this disaster, nearly 267 Thurston County residents applied to FEMA for assistance with over $6 million claims in property damages. FEMA awarded $544,928 in aid and the Small Business Administration granted $1.7 million to 30 homeowners and 2 businesses.

October 15-23, 2003, Federal Disaster 1499: Severe Storms and Flooding

At least 11 people reported flood damage within Thurston County, with at least two structures possibly incurring damage exceeding their replacement value. Thurston County was not seriously impacted by this storm event and received a disaster declaration because it bordered counties that experienced more severe flooding (Mason, Pierce, and Grays Harbor counties).

February 1999 High Ground Water Flooding

Higher than normal rainfall caused major groundwater flooding and urban stormwater flooding throughout Thurston County and its communities. Although no federal disaster was issued, major flooding affected over 200 properties in Lacey, Olympia, Tumwater, and Thurston County. (See landslide hazard profile for more on landslide impacts during this event).

December 1996 (Federal Disaster 1159) to February 1997 Winter Storm and Flooding

1996 was the third wettest year of the 20th Century. December was especially wet, receiving over twice its normal monthly rainfall. During this time:

- 200 homes countywide were flooded
- 200 drinking water wells were contaminated
- Septic system failures occurred throughout the county
- Response and recovery efforts cost Thurston County government over $340,000
- Response, recovery, and repair costs for other government entities and utilities exceeded $750,000
- Private property owners incurred over $1.75 million in uninsured losses

February 1996, Federal Disaster 1100: Flooding

The February 1996 flood is one of the most devastating floods on record for Thurston County. Every major river and stream crested their banks. Record flooding occurred on the Nisqually River near McKenna when the river crested at 17.13 feet, seven feet over flood stage on February 8, 1996. Record flooding also occurred on the Skookumchuck River near Bucoda when the river crested at 17.87 feet, four feet over flood stage. Major flooding also occurred on the Deschutes and Chehalis rivers. The 1996 flood resulted in the following impacts:

- Inspections declared 190 homes uninhabitable
- 47 homes were destroyed in the Nisqually Valley; over two dozen homes were destroyed elsewhere
- Nearly 1,000 people evacuated their homes
- 300 people required rescuing
- More than 300 sections of the county road system were damaged
- Wa He Lut, a contract U.S. Bureau of Indian Affairs School, was destroyed by the Nisqually River
- I-5 was closed between Chehalis and Thurston County
- The main north-south railroad line at the Pierce County line was closed
- Response and recovery efforts cost Thurston County government over $2 million
- Response, recovery, and repair costs for other government entities and utilities exceeded $20 million
- Private property owners incurred over $22 million in uninsured losses.

January 1990, Federal Disaster 852: Severe Storm and Flooding

The Deschutes River at Rainier crested at 17.01 feet, six feet over flood stage – setting the flood record. Major flooding also occurred on the Nisqually, Deschutes, Skookumchuck, and Chehalis rivers. The Thurston Region experienced the following impacts:

- Flood waters in Lewis County killed two people
- I-5 closed for several days between Chehalis and Thurston County
- 83 elderly residents from the Nisqually Valley Care Center in McKenna were evacuated to a Red Cross Shelter at the Yelm High School gymnasium
- Floodwaters reached four feet deep on Bucoda streets and prompted nearly 600 residents to evacuate; one elderly man died from natural causes during the evacuation
- Lowland Nisqually Valley residents were urged to evacuate their homes
- Portions of downtown Olympia experienced urban flooding

Probability of Occurrence

Probability of Riverine Flooding

Because rivers and streams cause nuisance flooding annually, and major riverine flooding occurs about every 2 to 5 years in Thurston County, there is a high probability of occurrence.

Probability of Groundwater Flooding

Statistically, the U.S. Army Corps of Engineers estimates an approximately 70 percent chance that the county will equal or exceed the 1996-1997 flooding at least once during a 30-year mortgage cycle. The Corps estimates that the frequency of a groundwater flooding disaster in Thurston County is probably on the order of every 25 years. In the past decade, Thurston County's precipitation and groundwater monitoring is showing that large rainfall events have increased, and climate models indicate that this trend will continue. The probability for groundwater flooding is high.

Probability of Tidal Flooding

Olympia experiences nuisance tidal flooding one to two times a year. King tides combined with even moderate levels of sea level rise will increase the frequency of tidal floods. The probability of tidal flooding is high. The most recent tidal flooding occurred during the December 2022 King tides. Low atmospheric pressure further contributed to portions of Downtown Olympia experiencing floodwater over city streets.

Probability of Urban Flooding

Some level of minor to moderate urban flooding coincides with major flooding on the Deschutes River; about every four and a half years. This frequency suggests a high probability of occurrence.

Vulnerabilities and Impacts

Impacts to People

People caught unprepared and isolated by swift moving flood waters can die from drowning, hypothermia, or trauma. Flood waters can rise quickly and strand people who are unable or unprepared to evacuate on their own. People with disabilities, the elderly, and people who lack transportation are vulnerable to floods as they require assistance to evacuate.

Estimates of People Exposed to Flood Hazards

Flood Modeling and GIS exposure analysis estimated the number of people who live in areas that are prone to flooding. Over 50 percent of the Town of Bucoda's population lives in the 100-year special flood hazard area. Table 4.3.5 shows the percent of communities population that are potentially exposed to flood hazards.

Table 4.3.5 Thurston County Population Exposed to Flood Risks

		% Population Exposed			
Jurisdiction	Total Population	50-Year	100-Year	500-Year	High Groundwater
Bucoda	610	47.3	53.2%	59.5%	0.0%
Lacey	58,180	0.0%	0.0%	0.0%	0.3%
Olympia	56,370	0.0%	0.2%	0.2%	0.0%
Rainier	2,510	0.0%	0.0%	0.0%	0.1%
Tenino	2,030	0.2%	0.2%	0.2%	0.0%
Tumwater	26,360	0.1%	0.1%	0.1%	0.1%
Yelm	10,680	0.5%	0.6%	0.9%	0.1%
Unincorporated Thurston County	143,760	0.9%	1.7%	2.0%	0.1%
Total Planning Area	**300,500**	**0.6%**	**1.0%**	**1.1%**	**0.1%**

Flood damage makes homes and businesses unsafe for occupancy, displacing individuals and families. Sheltering facilities are crucial for socially vulnerable individuals. Homes or structures that aren't inundated may be surrounded by floodwater depths and make it difficult for people to enter and leave their properties. People suffer immense financial losses from damaged homes and vehicles, lost possessions, lost pets and livestock, spoiled food, and other property damage.

Estimates of People Displaced or Requiring Shelter

Table 4.3.6 shows modeled estimates of the number of individuals who could be displaced or require short-term sheltering for 50-, 100-, and 500-year flood events.

Table 4.3.6 Number of Individuals Displaced and Individuals Needing Shelter due to Flooding[2]

	50-Year Flood		100-Year Flood		500-Year Flood	
Jurisdiction	Displaced Individuals	Individuals Needing Shelter	Displaced Individuals	Individuals Needing Shelter	Displaced Individuals	Individuals Needing Shelter
Bucoda	143	2	174	6	203	10
Lacey	0	0	0	0	0	0
Olympia	0	0	2	1	18	0
Rainier	0	0	0	0	0	0
Tenino	0	0	0	0	0	0
Tumwater	0	0	0	0	10	0
Yelm	1	0	2	0	11	0
Unincorporated Thurston County	24	0	79	16	191	27
Total Planning Area	**168**	**2**	**257**	**23**	**434**	**37**

[2]Estimates of household displacement and sheltering needs are unavailable for high groundwater flooding.

Public Health and Safety

Floods and their aftermath present threats to public health and safety to victims and people assisting with recovery. The following health and safety risks are commonly associated with flood events.

Mental Health Impacts

The recovery period is stressful and disruptive for flood victims. Children miss school days, people lose income absent emergency leave from their employer, and businesses that are forced to close lose revenue. Individuals may experience mental stress or fatigue. The expense and effort required to repair flood-damaged homes places severe financial and psychological burdens on the people affected, especially for the unprepared and uninsured. Post-flood recovery—especially when it becomes prolonged, causes mental disorders, anxiety, anger, depression, lethargy, hyperactivity, sleeplessness, and, in an extreme case, suicide. Behavior changes may also occur in children. There is also a long-term concern among the affected that their homes can be flooded again in the future.

Post-Flood Hazards

Hazards can persist during cleanup and recovery. Flooded buildings can pose significant health hazards after floodwaters recede. Electrical power systems, including fallen power lines, can cause electrocution. Gas leaks from pipelines or propane tanks can trigger fires and explosions. Flood debris, such as broken glass and other sharp objects can cause injuries. Unstable structures could collapse and cause injuries during demolition. Containers of hazardous chemicals, including pesticides, insecticides, fertilizers, car batteries, propane tanks and other industrial chemicals, may be hidden or buried under flood debris.

Contaminated Drinking Water

Flooding contaminates clean water resources with pollutants. Direct and indirect contact with the contaminants can result in waterborne illnesses and infectious disease. Pollutants can infiltrate to groundwater or infiltrate into waterlines in areas with low water pressure. Wastewater treatment plants, if flooded and caused to malfunction, can be overloaded with polluted runoff waters and sewage beyond their operating capacity, resulting in backflows of raw sewage to receiving waters and nearby low-lying areas. Wells can be contaminated or damaged. Lack of potable water sources coupled with lack of adequate sewage treatment, can lead to disease outbreaks.

Vector-Borne Disease and Mold Infestation

Floodwaters provide breeding grounds for mosquitoes and can lead to an increase in the number of mosquito-borne diseases. Molds can spread within 24 to 48 hours in wet and damp areas of buildings and homes that have not been cleaned after flooding. Mold spores can be easily inhaled by humans and, in large enough quantities, cause allergic reactions, asthma episodes, and other respiratory problems. Excessive exposure to molds and mildews can cause flood victims, especially those with chronic respiratory problems, to contract upper respiratory diseases. Infants, children, the elderly, and pregnant women are most vulnerable to mold-induced health problems. Fast rising flood waters place livestock and pets at risk. Public health risks may arise if animal carcasses are not properly disposed.

Impacts to Structures and Systems

Flood waters can damage or destroy buildings, homes, and their contents. Electric, gas, water, and communication utilities are also at risk for damage and disruption. Table 4.3.7 shows the number of buildings that are exposed to flooding in the 50-, 100-, and 500-year Special Flood Hazard Areas. Swift moving floodwaters can cause erosion and damage or destroy infrastructure including electric, gas, water, and communications utilities. Bridges, roads, and railroads are also vulnerable. Major and moderate flooding frequently inundates low lying roads around Thurston County, resulting in area-wide transportation disruptions. As flood waters recede, woody debris and other objects left behind can pose hazards to travelers. Floodwaters have forced the closure of State Route 12 near Rochester and Interstate 5 near Centralia, snarling traffic in both directions, multiple times due to major flooding. In urban areas, flooding can cause power outages or disable traffic signal controllers resulting in traffic signal blackouts. Map 4.3.3 shows roads in Thurston County Communities vulnerable to flood water inundation.

During extreme high tide events, low lying areas are vulnerable to marine flooding. Numerous downtown Olympia stormwater outlets to Budd Inlet lack valves or flood gates and will back up, causing stormwater drains to overflow. High tides influence the timing of dam water release from Capitol Lake near 5th Avenue in downtown Olympia. During the re-construction of portions of Heritage Park, an earthen berm was installed around the north and eastern perimeter of Heritage Park to prevent major flood waters from flowing into downtown from Capitol Lake. However, if the Deschutes River experiences major flooding and a high tide prohibits discharge of lake water into Budd Inlet, floodwaters could crest the lake bank at the southeast end of the north basin and flow into downtown Olympia along the utility road between the Capitol Campus Steam Plant and Water Street.[20] Such flood conditions have not occurred since the berm was constructed.

Table 4.3.7 Estimates of Buildings Exposed in 50-, 100-, and 500-Year Special Flood Hazard Areas

		50-Year Flood		100-Year Flood		500-Year Flood	
Jurisdiction	Total Buildings	Buildings Exposed	% Buildings Exposed	Buildings Exposed	% Buildings Exposed	Buildings Exposed	% Buildings Exposed
Bucoda	245	113	46%	128	52%	145	59%
Lacey	18,985	0	0.0%	1	0.1%	1	0.1%
Olympia	18,242	0	0.0%	77	0.4%	125	0.7%
Rainier	875	0	0.0%	0	0%	0	
Tenino	751	1	0.1%	1	0.1%	1	0.1%
Tumwater	9,513	5	0.1%	16	0.1%	23	0.2%
Yelm	3,139	19	0.6%	17	0.6%	29	0.2%
Unincorporated Thurston County	53,104	515	0.9%	908	1.7%	1,069	2%
Total Planning Area	104,854	653	0.6%	1,148	1.1%	1,393	1.3%

Estimates of Flood Structural and Content Damage

Hazus modeling for flood scenarios estimates there will be nearly $36 million in combined structural and content losses countywide for a 100-year flood event and over $44 million in losses countywide for a 500-year flood (Table 4.3.8). A combined 145 structures and their contents, valued over $46 million, are exposed to high groundwater flood hazards (Tables 4.3.9 and 4.3.10).

Table 4.3.8 Thurston County Estimated Value of Flood Structural and Content Damage for 50-, 100-, and 500-Year Special Flood Hazard Areas

	50-Year Flood		100-Year Flood		500-Year Flood	
Jurisdiction	Structure Damage Value	Contents Damage Value	Structure Damage Value	Contents Damage Value	Structure Damage Value	Contents Damage Value
Bucoda	$123,924	$86,399	$223,241	$177,927	$1,351,160	$1,449,167
Lacey	$0	$0	$0	$0	$0	$0
Olympia	$0	$0	$2,656,715	$5,873,652	$2,900,374	$6,684,489
Rainier	$0	$0	$0	$0	$0	$0
Tenino	$30,450	$17,164	$37,083	$20,770	$53,044	$29,308
Tumwater	$0	$0	$42,427	$81,452	$54,419	$2,027,259
Yelm	$11,938	$4,793	$16,783	$6,123	$64,075	$56,956
Unincorporated Thurston County	$7,249,832	$8,084,559	$12,928,749	$13,865,202	$13,564,185	$16,220,072
Total Planning Area	$7,416,145	$8,192,915	$15,904,998	$20,025,126	$17,987,258	$26,467,250

Table 4.3.9 Number of Structures in the High Groundwater Flood Hazard Areas

Jurisdiction	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Bucoda	0	0	0	0	0	0	0	0
Lacey	61	0	0	0	0	0	0	61
Olympia	0	1	0	0	0	0	0	1
Rainier	1	0	0	0	0	0	0	1
Tenino	0	0	0	0	0	0	0	0
Tumwater	6	2	1	0	0	0	0	9
Yelm	2	0	0	0	0	0	0	2
Unincorporated Thurston County	71	0	0	0	0	0	0	71
Total	141	3	1	0	0	0	0	145

Table 4.3.10 Value of Structures and Contents in the High Groundwater Flood Hazard Areas

Jurisdiction	Total Buildings	Total Residential Buildings	Total Building and Contents Value	Buildings Exposed	Total Building & Contents Exposed	% Total Value
Bucoda	245	237	$63,726,655	0	$0	0.0%
Lacey	18,985	17,637	$17,357,526,547	61	$11,420,250	0.1%
Olympia	18,242	16,257	$19,116,213,011	1	$804,710	0.0%
Rainier	875	814	$393,003,023	1	$86,917	0.0%
Tenino	751	651	$404,778,123	0	$0	0.0%
Tumwater	9,513	8,408	$9,362,171,728	9	$3,831,565	0.0%
Yelm	3,139	2,827	$2,077,637,133	2	$650,731	0.0%
Unincorporated	53,104	51,429	$24,765,596,428	71	$29,687,929	0.1%
Total Planning Area	104,854	98,260	$73,540,652,648	141	$46,482,102	0.1%

Estimates of Flood Damage Structural Debris

Flood Hazus modeling estimates the tons of structural debris that will be generated by major flood events. Countywide, a 100-year flood will produce over 15,400 tons of debris and a 500-year flood will generate over 16,500 tons. Table 4.3.11 shows estimated debris generation for each flood scenario by jurisdiction.

Table 4.3.11 Thurston County Estimated Flood Structure Debris for 50-, 100-, and 500-Year Special Flood Hazard Areas

	Structure Debris (tons)		
Jurisdiction	50-Year Flood	100-Year Flood	500-Year Flood
Bucoda	400	458	731
Lacey	0	143	216
Olympia	0	1,833	1,840
Rainier	0	1	1
Tenino	60	63	148
Tumwater	608	738	995
Yelm	336	369	441
Unincorporated Thurston County	7,471	11,867	12,211
Total Planning Area	8,876	15,472	16,583

Estimates of Lifeline Exposure

Over 1,200 community lifeline assets were evaluated for exposure to flood hazards. Estimates of flood damage are calculated by the Hazus model. The Hazus flood model scenarios provide estimates of the level of damage that facilities would experience for each jurisdiction. Tables 4.3.12 through 4.3.17 show lifeline estimates for each flood scenario. High groundwater flood exposure analysis reveals a stormwater facility in Lacey is within a high groundwater flood hazard area.

Table 4.3.12 Community Lifelines located in the 50-Year Special Flood Hazard Area

Location in Planning Area	Comm-unications	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Trans-portation	Total
Bucoda	0	0	2	0	0	1	0	3
Lacey	0	0	0	0	0	0	0	0
Olympia	0	0	0	0	0	0	0	0
Rainier	0	0	0	0	0	0	0	0
Tenino	0	0	0	0	0	0	0	0
Tumwater	0	0	0	0	0	0	0	0
Yelm	0	0	0	1	0	0	1	2
Unincorporated Thurston County	0	1	4	0	0	2	14	21
Total Planning Area	0	1	6	1	0	3	15	26

Table 4.3.13 Damage Estimates of Community Lifelines for a 50-Year Flood Event

Lifelines	Number of Facilities Affected	Average % of Total Value Damaged	
		Structure	Content
Safety and Security	1	5.5%	10.2%
Food, Water and Sheltering	1	8.6%	22.0%
Health and Medical	0	N/A	N/A
Energy	1	0.2 %	0.00
Communications	0	N/A	N/A
Transportation	1	1.3%	N/A
Hazardous Material	1	N/A	N/A
Total/Average	5	3.9%	10.7%

Table 4.3.14 Community Lifelines located in the 100-Year Special Flood Hazard Area

Location in Planning Area	Comm-unications	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Trans-portation	Total
Bucoda	0	0	3	0	0	2	0	5
Lacey	0	0	0	0	0	0	0	0
Olympia	4	0	1	0	3	0	4	12
Rainier	0	0	0	0	0	0	0	0
Tenino	0	0	0	0	0	0	0	0
Tumwater	0	0	0	0	0	0	0	0
Yelm	0	0	0	0	0	0	1	1
Unincorporated Thurston County	0	3	4	0	0	2	14	23
Total Planning Area	4	3	8	0	3	4	19	41

Table 4.3.15 Damage Estimates of Community Lifelines for a 100-Year Flood Event

Lifelines	Number of Facilities Affected	Average % of Total Value Damaged	
		Structure	Content
Safety and Security	2	5.9%	22.5%
Food, Water and Sheltering	1	8.6%	21.0%
Health and Medical	1	5.8%	16.7%
Energy	1	19.6%	27.7%
Communications	1	1.1%	5.0%
Transportation	1	2.5%	N/A
Hazardous Material	0	N/A	N/A
Total/Average	7	7.2%	18.6%

Table 4.3.16 Community Lifelines located in the 500-Year Special Flood Hazard Area

Location in Planning Area	Comm-unications	Energy	Food, Water, Shelter	Hazardous Material	Health & Medical	Safety & Security	Trans-portation	Total
Bucoda	0	0	3	0	0	3	0	6
Lacey	0	0	0	0	0	0	0	0
Olympia	4	1	2	0	4	0	8	19
Rainier	0	0	0	0	0	0	0	0
Tenino	0	0	0	0	0	0	0	0
Tumwater	0	0	3	0	0	0	0	3
Yelm	0	0	0	0	0	0	1	1
Unincorporated Thurston County	0	3	4	0	0	2	14	23
Total Planning Area	4	4	12	0	4	5	23	52

Table 4.3.17 Damage Estimates of Community Lifelines for a 500-Year Flood Event

Lifelines	Number of Facilities Affected	Average % of Total Value Damaged Structure	Content
Safety and Security	2	8.6%	33.5%
Food, Water and Sheltering	1	6.0%	18.0%
Health and Medical	2	5.8%	16.7%
Energy	1	20.2%	28.7%
Communications	1	1.1%	5.0%
Transportation	1	2.5%	N/A
Hazardous Material	1	N/A	N/A
Total/Average	9	7.4%	20.4%

Impacts to Natural, Cultural, and Historic Resources

Flooding can impact the environment in negative ways — especially when human development is factored in. Migrating fish can wash over streambanks and dikes and into flooded roads and fields. Oily road runoff and hazardous materials can be swept up by flood waters and then wash into waterways and seep into farm fields. Bridge abutments can exacerbate streambank erosion and cause rivers to migrate into non-natural courses.

Many species of mammals, birds, reptiles, amphibians and fish are dependent upon such riparian streambanks, as well as streams, wetlands and marshes — which, collectively, provide important ecosystem services beyond habitat. Changes in hydrologic conditions, as well as human disturbance of riparian areas, can alter the plant community and thus reduce vital access to food, shelter and water. Mammals depend upon a supply of water to survive. Riparian communities have a greater diversity and structure of vegetation than other upland areas.

Despite the many adverse impacts from floods, river flooding is a natural process that can also benefit a variety of wildlife and natural resources. Flood waters can force rivers to change their course. The natural processes of erosion, stream braiding, sediment deposits, and channel migration are critical to the long-term viability of fish and wildlife habitat. The formation of oxbow lakes provides important habitat to amphibians, birds, mammals, and fish. Deposits of gravel and sediments can foster the growth of alders, willows, and other vegetation and establish new riparian habitat. Trees that fall into rivers from bank erosion can entangle with other trees and coarse woody debris to form fish habitat. The deposition of upland sediments onto floodplains enhances the fertility of valley floors and further supports agriculture.

Protection of biological resources is very important to Thurston County communities. Equipped with planning tools and data, the region is establishing a diverse inventory of preserve areas that maintain the natural and beneficial functions of the floodplain. This is occurring through proactive land use regulations, and property acquisitions that are identifying critical habitat to be preserved. The combination of these two tools is resulting in a floodplain that is predominantly free of high-density development.

Impacts to Activities

Major flooding disrupts daily routines for areas of the region that are affected. Floods close schools, businesses, and other public and private sector services located in affected areas. Flood waters can impact all surface transportation modes and impact all trip types. Closures to I-5 and State Route 12 create major disruptions to the movement of freight, people, goods, and services. Transportation disruptions have significant impacts on the economy.

Risk Ratings

Social Vulnerability Rating and National Risk Index

Social vulnerability is the susceptibility of social groups to the adverse impacts of natural hazards, including disproportionate death, injury, loss, or disruption of livelihood. As a consequence enhancing risk component of the National Risk Index, a Social Vulnerability score and rating represent the relative level of a community's social vulnerability compared to all other communities at the same level. A community's Social Vulnerability score measures its national rank or percentile. A higher Social Vulnerability score results in a higher Risk Index score. Map 4.4.4 shows assets in Thurston County that are located in the 100-year special flood hazard area with census tract social vulnerability ratings.

The Federal Emergency Management Agency National Risk Index (NRI) for flood in Thurston County is 17.3 (very low). The rating represents a community's relative risk for flood when compared to the rest of the United States. For comparison, Pierce County's NRI for flood is 46.2 (relatively low). The NRI reports an estimated flood hazard annual loss of $53,000 for Thurston County.

Community Hazard Risk Ratings for Special Flood Hazard Area Scenarios and High Groundwater Flood Hazard Areas

The countywide 50-, 100-, and 500-year flood risk are medium, medium, and low, respectively. All special purpose districts' risk ratings for each flood scenario are a low rating. Tables 4.3.18 and 4.3.19 show community and special purpose special flood hazard area risk ratings. Tables 4.3.20 and 4.3.21 show high groundwater flood hazard risk ratings. The details of the flood hazard risk assessment calculations are shown in Appendix C.

Table 4.3.18 Community Hazard Risk Ratings for 50-, 100-, and 500-Year Special Flood Hazard Areas

	50-Year Flood		100-Year Flood		500-Year Flood	
Municipal Plan Participants	Risk Ranking Score	Risk Rating	Risk Ranking Score	Risk Rating	Risk Ranking Score	Risk Rating
Bucoda	48	High	48	High	32	Medium
Lacey	0	Low	0	Low	0	Low
Olympia	0	Low	0	Low	12	Low
Rainier	0	Low	0	Low	0	Low
Tenino	18	Medium	18	Medium	12	Low
Tumwater	15	Low	15	Low	12	Low
Yelm	15	Low	15	Low	10	Low
Unincorporated Thurston County	18	Medium	18	Medium	12	Low
Total Planning Area	18	Medium	18	Medium	12	Low

Table 4.3.19 Special Purpose District Hazard Risk Ratings 50-, 100-, and 500-Year Special Flood Hazard Areas

	Cascadia M9.3		Nisqually M7.2		Seattle M7.2	
Special Purpose District Plan Participants	Risk Ranking Score	Risk Ranking Score	Risk Ranking Score	Risk Rating	Risk Ranking Score	Risk Rating
East Olympia Fire District	9	Low	9	Low	6	Low
Intercity Transit	0	Low	0	Low	0	Low
Lacey Fire District	9	Low	9	Low	6	Low
McLane Black Lake Fire District	0	Low	9	Low	6	Low
Olympia School District	0	Low	9	Low	6	Low
SE Thurston Fire Authority	9	Low	9	Low	6	Low
South Bay Fire District	0	Low	9	Low	6	Low
The Evergreen State College	0	Low	0	Low	0	Low
Thurston PUD	18	Medium	15	Low	12	Low
West Thurston Regional Fire Authority	9	Low	9	Low	6	Low

Table 4.3.20 Community High Groundwater Flooding Hazard Risk Ratings

Municipal Plan Participants	Sea Level Rise Hazard Risk Ranking Score	Risk Rating
Bucoda	0	Low
Lacey	12	Low
Olympia	0	Low
Rainier	10	Low
Tenino	0	Low
Tumwater	12	Low
Yelm	10	Low
Unincorporated Thurston County	12	Low
Total Planning Area	12	Low

Table 4.3.21 Special Purpose District High Groundwater Flooding Hazard Risk Ratings

Special Purpose District Plan Participants	Sea Level Rise Hazard Risk Ranking Score	Risk Rating
East Olympia Fire District	6	Low
Intercity Transit	0	Low
Lacey Fire District	6	Low
McLane Black Lake Fire District	6	Low
Olympia School District	6	Low
SE Thurston Fire Authority	6	Low
South Bay Fire District	6	Low
The Evergreen State College	0	Low
Thurston PUD	6	Low
West Thurston Regional Fire Authority	6	Low

Changes in Flood Hazard Risks Since Last Plan Update

A different methodology was used to estimate hazard risks and the vulnerability of community assets since the plan was last updated. It is not possible to perform a regional assessment of any changes in flood hazard risks since the previous plan was adopted.

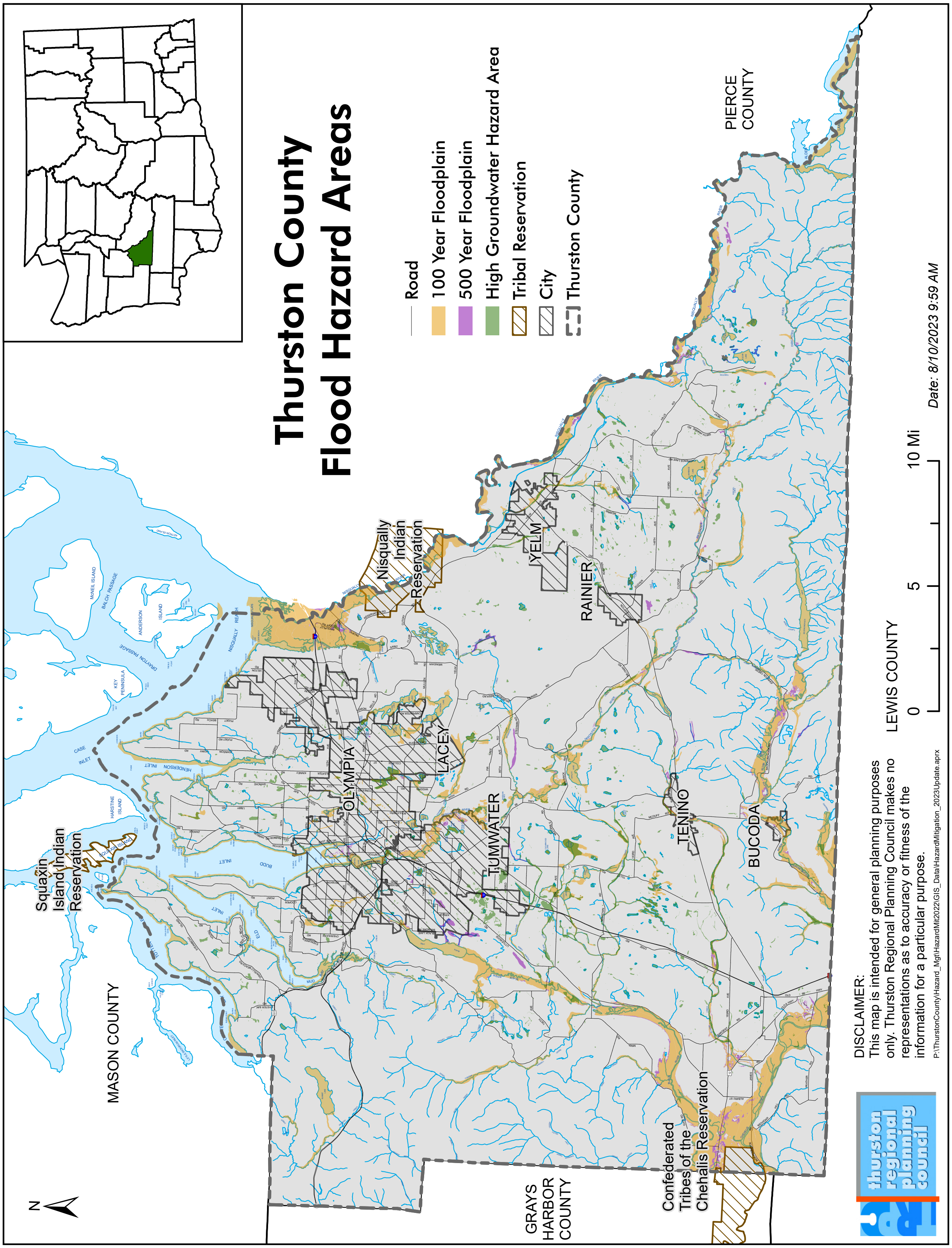
Addressing Flood Risk in the Regional Mitigation Strategy

Flood risk is a high concern for Thurston County due to the frequency of flood incidents and the history of federal disaster declarations. Thurston County is a Class 2 National Flood Insurance Program Community Rating System (CRS) Participant. Within the CRS Program, Thurston County maintains and updates a separate Flood Hazard Mitigation Plan.

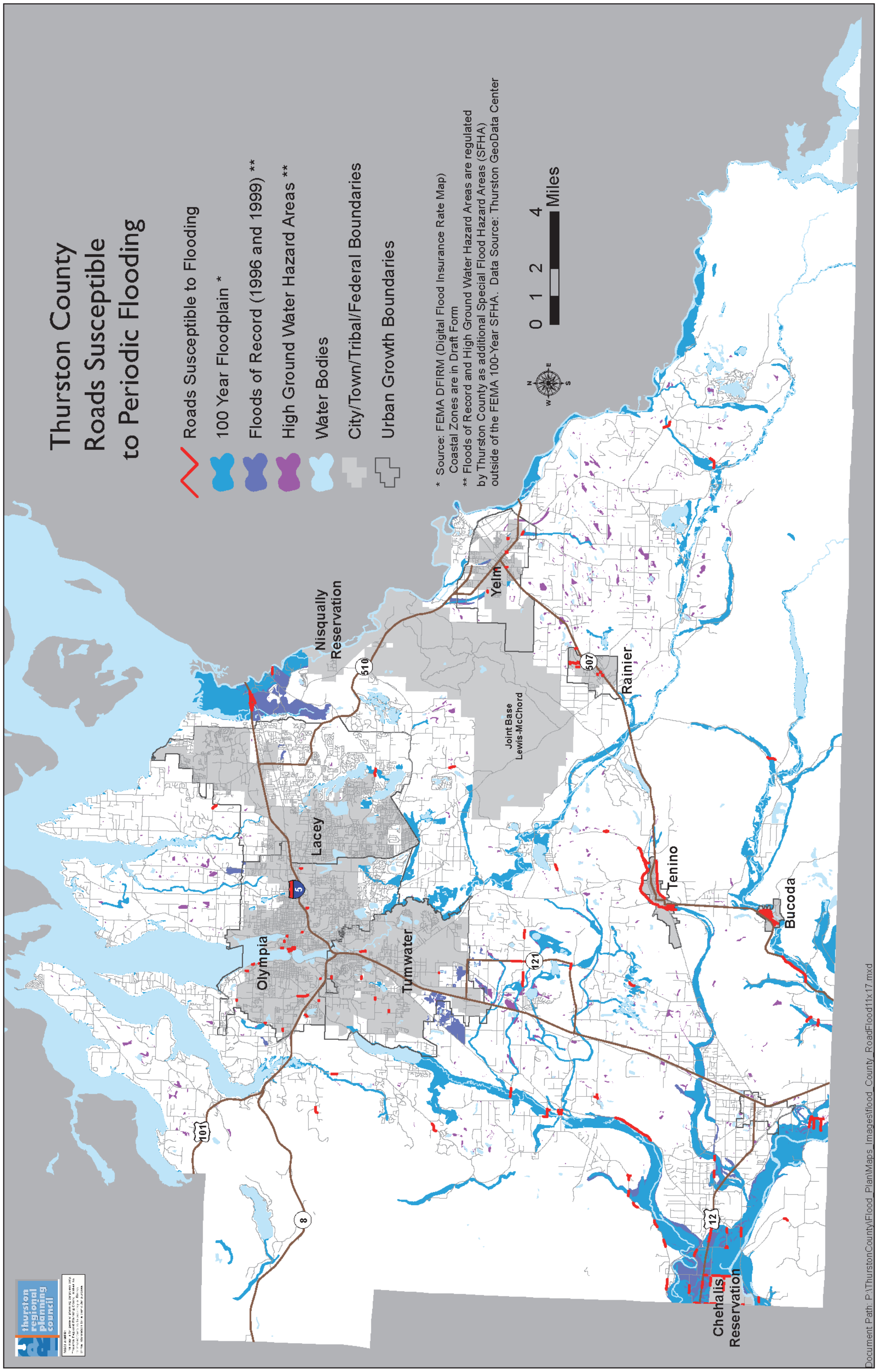
The 2022 "Thurston County Communities Natural Hazards and Resiliency Survey" region wide and unincorporated county results both show that respondents ranked flood as the sixth highest-rated hazard of concern. Although floods have caused more damage and have displaced more residents than any other hazard, survey respondents rank concerns about flood hazards as relatively low. Flood hazard education and preparedness for community residents remains a high priority. Flood hazard information will be included through Regional Hazard Mitigation Public Outreach Strategy initiative including the annual Fall Flood Bulletin.

The region's planning partners recognize that more work is necessary to broaden the inventory and documentation of the location, characteristics, and vulnerabilities of the region's lifelines and critical infrastructure. To this end, the Critical Infrastructure Inventory initiative will help inform and prioritize investments in strengthening communities' vital assets. The Hazard Modeling and Loss Estimation Capacity Building initiative will build local knowledge and technical skills to develop, operate, and maintain community-specific GIS-based hazard modeling tools that include local data. Local modeling tools can inform planning and decision making for hazard mitigation, emergency management, disaster recovery, and training. The Lifeline Transportation Resiliency Plan initiative will identify priority transportation projects to strengthen bridges, roads, and other multimodal transportation assets so they are less prone to floodwater inundation and closures.

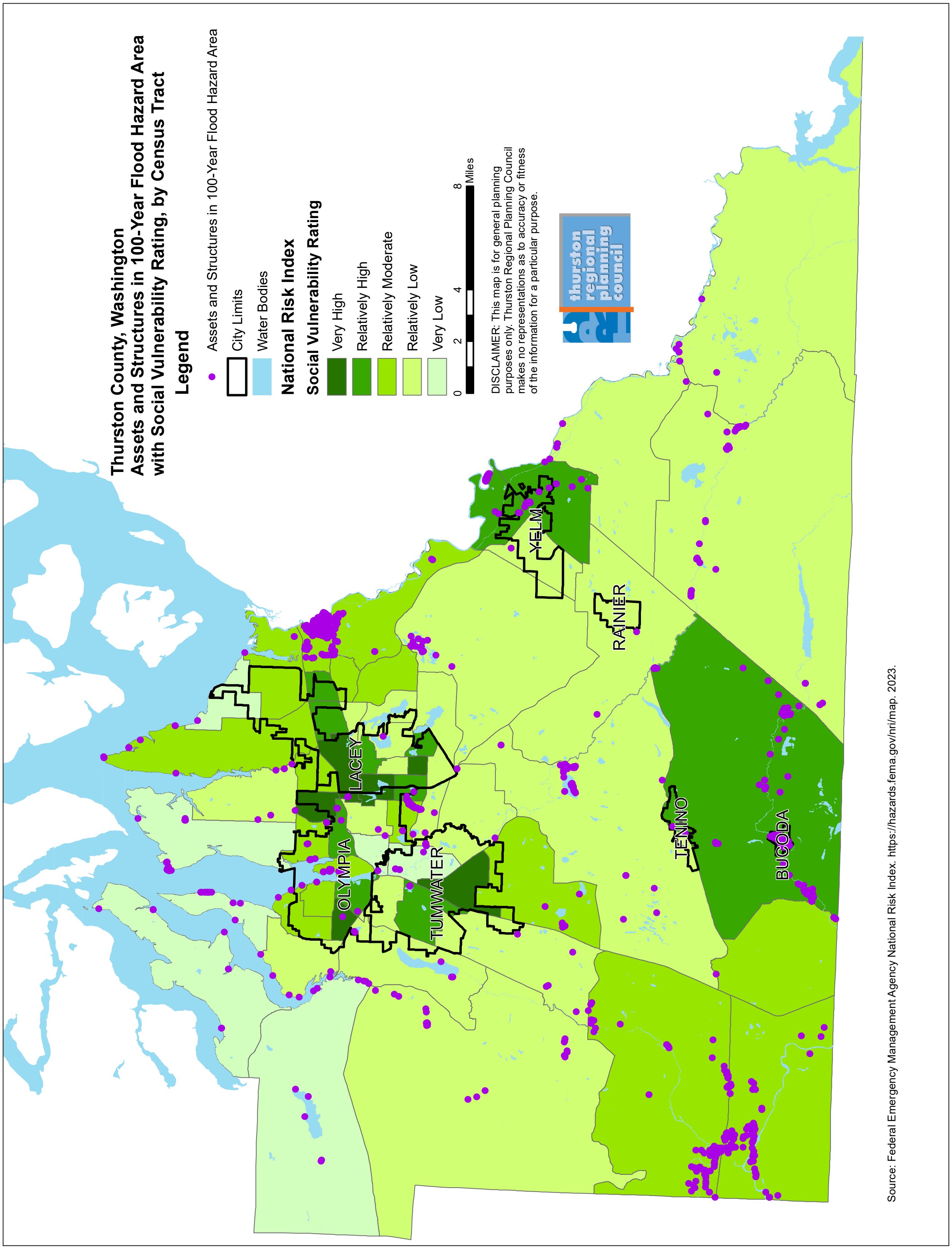
Map 4.3.2 Flood Hazard Areas of Thurston County



Map 4.3.3 Thurston County Region Roads Susceptible to Flood Inundation



Map 4.3.4 Exposed Assets and Structures in the 100-Year Special Flood Hazard Areas and Thurston County Social Vulnerability Index Rating by Census Tract



Endnotes

[1]Thurston County Water and Waste Management. 2017. Unpublished Data, Courtesy of Mark Biever, Thurston County Environmental Monitoring Program Supervisor

[2]Thurston County Emergency Management. 2017. River Flood Stage Levels. http://www.co.thurston.wa.us/em/Rivers/Rivers.htm

[3]Thurston County. 2013. Thurston County Flood Hazard Mitigation Plan.

[4]Ibid

[5]United States Geological Survey. 2023. National Water Information System: Web Interface, USGS Water Data for Washington, Surface Water Data. http://waterdata.usgs.gov/wa/nwis/

[6]Tacoma Power. 2016. Emergency Action Plan for the Nisqually Hydroelectric Project FERC Project No. 1862

[7]Contributed by Nadine Romero, Hydrogeologist, Thurston County Environmental Health. April 22, 2009.

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[9]Thurston County Development Services. 2009. Unpublished Data, Thurston County Flood of Record Reference Monument Locations. Courtesy of Joe Butler.

[10]TransAlta Centralia Generation LLC. 2007. Emergency Action Plan: Skookumchuck Hydroelectric Project FERC Project No. 4441 NATDAM No. WA00153. Revision H, December 2007.

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[13]Thurston County. 2004. Salmon Creek Comprehensive Drainage Basin Plan.

[14]Mauger, G.S., et.al. 2015. State of Knowledge: Climate Change in Puget Sound. Report prepared for the Puget Sound Partnership and the National Oceanic and Atmospheric Administration. Climate Impacts Group, University of Washington, Seattle.

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[18]Thurston County Emergency Management. 2007. Supplemental Justification Report. December 2-7, 2007 Severe Storm.

[19]Washington State Department of Transportation. 2008. Storm-Related Closures of I-5 and I-90: Freight Transportation Economic Impact Assessment Report Winter 2007-2008.

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