Floods of November 1990 in Western Washington

By Larry L. Hubbard

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[In pocket]

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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
inch (in)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
cubic foot (ft^3)	0.02832	cubic meter
cubic foot per second (ft^3/s)	0.02832	cubic meter per second

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

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ABSTRACT

During November 7-11, a moisture-laden warm front created heavy rains and melting snows which resulted in appreciable flooding in northwestern Washington and in the Wenatchee River basin that drains the east slopes of the Cascade Range. The Skagit Basin on the west slope of the Cascade Range was affected the most during this storm. After this storm, cool, wet weather lasted until November 21 and resulted in another low-elevation mountain snowpack. A second warm, wet front arrived on November 21 and lasted through November 25, resulting in extreme flooding; a larger area was affected by this storm. The most extensive flooding from these storms occurred in the Duwamish, Lake Washington, Snohomish, and Wenatchee River basins. Record peak flows were recorded at 11 gaging stations. At six gaging stations, the peak flows are estimated to have recurrence intervals of about 100 years.

Two lives were lost in the second flood (November 23-26, 1990) when thousands of people were evacuated from their homes to escape floodwaters. Some residents of Fir Island, near the mouth of the Skagit River, were evacuated from their homes during both of the floods. In both floods, heavy damages were sustained. The floodwaters destroyed homes, roads, bridges, levees, farm crops, and livestock. Estimated damages were about 42 million dollars for the November 9-11 flood, and about 100 million dollars for the flood of November 23-26.

INTRODUCTION

Above-average precipitation, during October and early November 1990, saturated soils and created a low-elevation mountain snowpack that set the stage for the floods that followed. The flooding described in this report covered most of western Washington and the Chelan and Wenatchee River Basins (pl. 1). The Chelan and Wenatchee River Basins drain the east slopes of the Cascade Range and are not considered part of western Washington. Western Washington is defined as all parts of the State west of the crest of the Cascade Range. The extreme southern portion of western Washington experienced relatively mild flooding and is not included in this study. Major floods in western Washington typically occur during the winter months and are usually caused by eastward moving storms (from the Pacific Ocean) embedded in frontal systems. When these winter storms are accompanied by warm temperatures and the rain falls on a heavy snowpack on the west slopes of the Cascade Range, flooding is greatly intensified. Flooding on the east slopes of the Cascade Range can result directly from these winter storms, spring snowpack runoff, or convection storms.

The purpose of this report is to document the flooding that occurred in November of 1990, and to describe the storms, the flooding, and the flood damages. A map (pl. 1) showing the location of flood measuring sites and location of selected precipitation measuring stations also is included in this report. Flood peak stages and discharges of the affected streams and those of previous floods of record are tabulated. Total rainfall for November 8-11, 1990, and November 19-27, 1990 is shown for 10 sites. Daily precipitation at two weather stations and flood discharges for 46 stream-gaging stations are included.

Three separate major flood events occurred in Washington during the 1990 calendar year. The peak flows of January 1990 were reported by Hubbard (1991) and are not described in this report.

DETERMINATION OF FLOOD STAGES AND DISCHARGES

Peak stages and discharges were obtained and compiled using standard procedures of surface-water investigations used by the USGS. The usual method of determining stream discharge is the application of a stage-discharge relation to a known stage. That relation at a station is usually defined by current-meter measurements through as much of the range in stage as possible. If the peak discharge is above the range of the measured discharge, the stage-discharge relation may be extended by logarithmic extrapolation, by velocity-area studies, or by the use of other hydraulic techniques. Peak discharges that are far beyond the range of the stage-discharge relation at the gaging stations may be determined by various types of indirect measurements. During major floods, such as the November 1990 floods in western Washington, adverse conditions often make it impossible to obtain current-meter measurements near flood peaks at some sites. Peak discharges at a few of the sites in flooded areas were determined by indirect methods based on detailed surveys of selected channel reaches after the flood had subsided. Descriptions of the indirect measurement methods used by the USGS are given in a series of publications titled "Techniques of Water-Resources Investigations of the United States Geological Survey, Book 3."

EXPLANATION OF DATA

Peak stages and discharges for the November 1990 floods are listed in table 1. The first major division of columns in table 1 under "Maximum floods" provides information on known floods prior to those of November 1990 and includes period of record, gage heights, and discharges for maximum floods for each measurement location. More than one period of record is shown for some stations. The second major division under "Maximum floods" includes information on date, gage height, discharge, and recurrence interval for the November 1990 floods.

The recurrence interval is the average interval, in years, in which a flood of a given magnitude will be equalled or exceeded once. A flood having a recurrence interval of 50 years can be expected to occur, on the average, once in 50 years, or it can be described as one that has a 2-percent chance of being equalled or exceeded in any one year. All recurrence intervals in the tables were determined using guidelines for determining flood frequency as shown in a report by the U.S. Water Resources Council (1981).

THE STORM SYSTEMS

Above-average precipitation in October and early November resulted in saturated soils that contributed to the flooding potential when the major storms arrived during the periods of November 7-11 and 21-25, 1990. The daily precipitation record for the National Weather Service climatological station at Mud Mountain Dam (climatological station number 5) illustrates the large quantity of precipitation during October and November (fig. 1). The above-normal precipitation in western Washington during October and November 1990 is documented by the 1990 annual records of the U.S. National Oceanic and Atmospheric Administration (1990c). For example, the total precipitation for October and November at Mud Mountain Dam was 23.42 inches. This precipitation was 12.05 inches greater than the normal precipitation of 11.36 inches for this period (about 200 percent of normal) and was similar to the precipitation that occurred at other sites in the area. For the same period, recorded precipitation at Grays River Hatchery (climatological station number 1) was about 140 percent of normal; and Lake Wenatchee, the easternmost climatological station (number 9), recorded about 250 percent of normal precipitation.

Table 1. Flood stages and discharges, November 9-11 and 23-26, 1990, in Washington

[mi^2 = square miles, ft^3/s = cubic feet per second, > = greater than, -- = missing data, e = estimated]

Number			Maximum floods								
			Known before November 1990					November 1990			
Map	Station	Stream and place determination	Drainage area (mi^2)	Period of record	Year	Gage height (feet)	Discharge (ft^3/s)	Date	Gage height (feet)	Discharge (ft^3/s)	Recurrence interval (years)
				Naselle River Basin							
1	12010000	Naselle River near Naselle, Washington	54.8	1929-90	1935	--	11,100	Nov. 24	18.45	11,300	50
				Willapa River Basin							
2	12013500	Willapa River near Willapa, Washington	130	1948-54	1949	--	11,400	Nov. 24	24.21	11,800	15
				1957-58	1958	--	7,360				
				1961-90	1990	--	11,700				
				Chehalis River Basin							
3	12020000	Chehalis River near Doty, Washington	113	1939-90	1990	19.96	27,500	Nov. 24	17.45	20,600	25
4	12025000	Newaukum River near Chehalis, Washington	155	1942-90	1986	12.76	10,700	Nov. 24	12.73	10,300	25
5	12025700	Skookumchuck River near Vail, Washington	40.0	1967-90	1972	10.93	6,900	Nov. 24	10.30	5,820	20
6	12027500	Chehalis River near Grand Mound, Washington	895	1928-90	1990	19.34	68,700	Nov. 25	18.12	48,000	20
7	12031000	Chehalis River at Porter, Washington	1,294	1952-72	1972	23.88	55,600	Nov. 26	23.17	43,000	10
				1974-84	1975	23.36	48,100				
				1986-90	1990	24.52	60,400				
8	12035000	Satsop River near Satsop, Washington	299	1929-90	1935	38.9	46,600	Nov. 24	35.75	38,200	10
				Quinault River Basin							
9	12039500	Quinault River at Quinault Lake, Washington	264	1911-90	1955	20.51	50,200	Nov. 10	18.35	41,400	15
								Nov. 24	18.15	40,600	15
				Queets River Basin							
10	12040500	Queets River near Clearwater, Washington	445	1930-67	1935	27.0	130,400	Nov. 10	24.19	99,000	10
				1974-90	1986	24.40	101,000	Nov. 23	25.44	112,000	25
				Hoh River Basin							
11	12041200	Hoh River at U.S. Highway 101, Washington	253	1960-90	1979	19.08	51,600	Nov. 10	18.18	47,300	7
								Nov. 24	19.61	54,500	15
				Quillayute River Basin							
12	12043000	Calawah River near Forks, Washington	129	1897-01							
				1976-80	1979	18.98	28,900	Nov. 10	18.12	25,900	7
				1984-90	1986	18.73	27,900	Nov. 23	20.58	34,500	20
				Elwha River Basin							
13	12045500	Elwha River at McDonald Bridge near Port Angeles, Washington	269	1897-01	1897	--	41,600	Nov. 23	23.71	28,700	15
				1918-90	1949	24.20	30,000				

Table 1. Flood stages and discharges, November 9-11 and 23-26, 1990, in Washington—Continued

Number			Maximum floods								
			Known before November 1990					November 1990			
Map	Station	Stream and place determination	Drainage area (mi^2)	Period of record	Year	Gage height (feet)	Discharge (ft^3/s)	Date	Gage height (feet)	Discharge (ft^3/s)	Recurrence interval (years)
				Dungeness River Basin							
14	12048000	Dungeness River near Sequim, Washington	156	1923-30	1924	--	6,340	Nov. 24	8.35	7,120	25
				1937-90	1949	8.58	6,820				
				Duckabush River Basin							
15	12054000	Duckabush River near Brinnon, Washington	66.5	1938-90	1949	10.06	8,960	Nov. 10	7.26	4,460	2
								Nov. 23	8.04	5,500	5
				Nisqually River Basin							
16	12082500	Nisqually River near National, Washington	133	1942-90	1977	11.96	17,100	Nov. 24	10.23	11,000	10
17	12083000	Mineral Creek near Mineral, Washington	75.2	1942-90	1990	13.56	13,800	Nov. 24	12.78	10,000	25
				Puyallup River Basin							
18	12093500	Puyallup River near Orting, Washington	172	1931-90	1962	11.82	15,300	Nov. 24	10.19	10,300	5
19	12095000	South Prairie Creek at South Prairie, Washington	79.5	1950-71	1955	--	6,850	Nov. 24	32.45	5,560	10
				1988-90	1990	33.55	8,330				
20	12099600	Boise Creek at Buckley, Washington	15.4	1977-81	1979	3.25	545	Nov. 24	3.38	571	2
				1981-90	1984	5.18	972				
21	12101500	Puyallup River at Puyallup, Washington	948	1914-90	1933	--	57,000	Nov. 24	27.19	41,900	15
				Duwamish River Basin							
22	12112600	Big Soos Creek above Hatchery near Auburn, Washington	66.7	1960-90	1990	7.55	1,750	Nov. 25	7.16	1,570	30
				Lake Washington Basin							
23	12117500	Cedar River near Landsburg, Washington 1990	121	1895-1990	1911	--	14,200	Nov. 24	10.38	10,800	70
24	12119000	Cedar River at Renton, Washington	184	1945-90	1975	14.14	8,800	Nov. 24	17.13	10,600	100
25	12121600	Issaquah Creek near mouth near Issaquah, Washington	56.6	1963-90	1990	13.50	3,200	Nov. 24	13.43	2,410	5
				Snohomish River Basin							
26	12134500	Skykomish River near Gold Bar, Washington	535	1928-90	1980	21.38	90,100	Nov. 10	21.01	86,800	20
								Nov. 24	22.49	102,000	50
27	12141300	M.F. Snoqualmie River near Tanner, Washington	154	1961-90	1959	18.7	49,000	Nov. 10	12.76	21,000	<5
								Nov. 24	14.97	30,100	25
28	12142000	N.F. Snoqualmie River near Snoqualmie Falls, Washington	64.0	1929-90	1932	--	15,800	Nov. 9	11.32	10,400	5
								Nov. 24	12.05	12,000	10
29	12143400	S.F. Snoqualmie River near Garcia, Washington	41.6	1960-90	1986	--	8,450	Nov. 9	17.18	6,240	5
								Nov. 24	18.26	8,000	15

Table 1. Flood stages and discharges, November 9-11 and 23-26, 1990, in Washington—Continued

Number		Stream and place determination	Maximum floods								
			Known before November 1990					November 1990			
Map	Station		Drainage area (mi^2)	Period of record	Year	Gage height (feet)	Discharge (ft^3/s)	Date	Gage height (feet)	Discharge (ft^3/s)	Recurrence interval (years)
				Snohomish River Basin—Continued							
30	12144500	Snoqualmie River near Snoqualmie, Washington	375	1958-90	1959	19.78	61,000	Nov. 10	18.23	49,100	5
								Nov. 24	21.55	78,800	50
31	12145500	Raging River near Fall City, Washington	30.6	1945-90	1986	6.27	5,330	Nov. 10	5.72	3,900	15
								Nov. 24	6.56	6,220	100
32	12149000	Snoqualmie River near Carnation, Washington	603	1928-90	1932	59.88	59,500	Nov. 10	59.48	53,000	10
								Nov. 24	60.70	65,200	25
33	12150800	Snohomish River near Monroe, Washington	1,537	1921	1921	--	180,000e	Nov. 10	21.65	100,000	15
				1963-90	1975	22.92	115,000	Nov. 25	25.30	150,000	100
				Skagit River Basin							
34	12186000	Sauk River near Darrington, Washington	152	1917-22				Nov. 10	11.90	22,000	15
				1928-90	1980	16.03	40,100	Nov. 24	12.56	24,600	20
35	12189500	Sauk River near Sauk, Washington	714	1928-90	1980	18.24	98,600	Nov. 10	15.64	69,800	20
								Nov. 24	16.99	83,400	40
36	12194000	Skagit River near Concrete, Washington	2,737	1815	1815	69.3	500,000	Nov. 10	40.20	149,000	30
				1924-90	1949	40.80	154,000	Nov. 24	39.89	146,000	25
37	12200500	Skagit River near Mt. Vernon, Washington	3,093	1906	1906	37.0	180,000	Nov. 11	36.61	142,000	50
				1940-90	1951	36.85	144,000	Nov. 25	37.37	152,000	75
				Nooksack River Basin							
38	12210500	Nooksack River at Deming, Washington	584	1932	1932	16.8	49,300	Nov. 10	15.40	37,900	10
				1935-90	1951	15.69	43,200	Nov. 24	14.87	35,100	<10
				Chelan River Basin							
39	12451000	Stehekin River near Stehekin, Washington	321	1910-15				Nov. 10	26.61	12,800	5
				1926-90	1948	29.00	18,900	Nov. 24	27.45	14,700	10
				Wenatchee River Basin							
40	12457000	Wenatchee River at Plain, Washington	591	1910-79	1948	12.48	22,700	Nov. 11	10.52	17,000	10
				1989-90				Nov. 25	14.39	33,200	>100
41	12459000	Wenatchee River at Peshastin, Washington	1,000	1929-90	1948	15.88	32,300	Nov. 11	11.87	20,000	5
								Nov. 25	17.58	40,000	>100
42	12462500	Wenatchee River at Monitor, Washington	1,301	1962-90	1980	27.23	29,600	Nov. 11	25.42	21,500	15
								Nov. 25	29.80	45,900	>100
				Cowlitz River Basin							
43	14226500	Cowlitz River near Packwood, Washington	287	1929-90	1933	13.00	36,600	Nov. 24	12.48	28,700	15
44	14232500	Cispus River near Randle, Washington	321	1929-90	1974	12.58	21,700	Nov. 25	10.21	11,500	5
45	14233400	Cowlitz River near Randle, Washington	1,030	1947-90	1977	26.54	89,300	Nov. 25	23.60	66,300	25
46	14236200	Tilton River above Bear Canyon Creek near Cinebar, Washington	141	1956-90	1977	17.00	22,500	Nov. 24	14.44	17,600	10

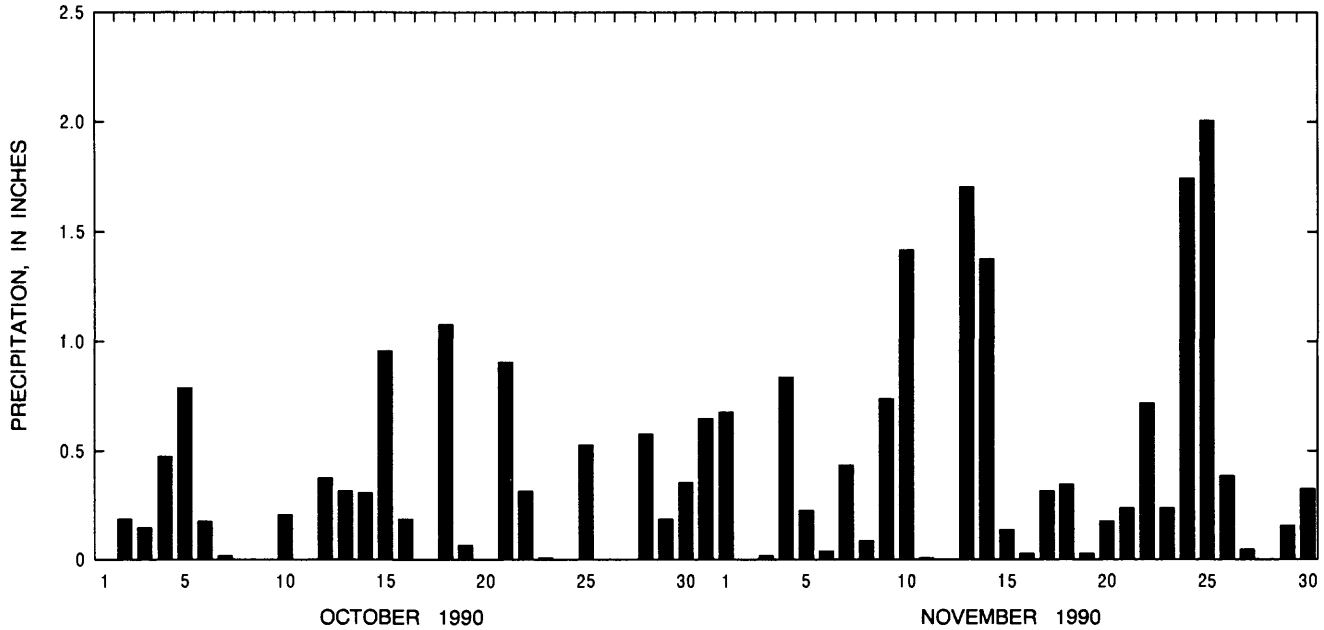

Figure 1. Daily precipitation at Mud Mountain Dam, Washington, October-November 1990.

Throughout most of western Washington, the largest quantities of precipitation fell during the second storm period of November 21-25. The Skagit River Basin may be an exception. The climatological station at Diablo Dam in the Skagit River Basin recorded 15.44 inches during the second 4-day storm (table 2, site 10), but the most intense rain was recorded November 10 when 7.32 inches fell in the 24-hour period at Diablo Dam (fig. 2).

During the period between the major storms, wet weather accompanied by cool temperatures continued and snow levels descended to about the 1,000 feet elevation. By November 21, 1990, snow depths in the Cascades averaged 6 inches at elevations of 1,000 to 2,000 feet; 12 inches at 2,000 to 3,000 feet; and 12 to 18 inches at 3,000 to 4,000 feet. The water content of the snow was generally 10 percent or higher. As a warm front moved through western Washington on Wednesday, November 21, snow changed to rain and temperatures rose. The warm front caused melting of snow to elevations of 7,500 feet in the northern Cascade Range and to about 5,500 feet in the Cascade Range at the southern end of the state. Over the next 3 days, intense rain fell on drainages where rivers were already swollen with snowmelt runoff; disastrous flooding resulted. A cold front that moved in from the north on November 26, 1990, lowered freezing levels and diminished precipitation, finally ending the severe flooding.

THE FLOODS

As a result of the October-November 1990 storms, the western half of Washington experienced two major floods during November. The November 9-11 flooding affected streams in most of the northern half of western Washington on Veteran's Day weekend. The November 23-25 (during the week of Thanksgiving) floods affected streams in most of western Washington. The largest peaks ever observed in the Wenatchee River drainage on the east slopes of the Cascade Range were recorded November 25. With the exception of some rivers in the Skagit and Nooksack River Basins, most rivers in western Washington and the east slope of the Cascade Range experienced the most severe flooding during November 23-25.

November 9-11 Floods

The November 9-11 flooding was prevalent in the northern parts of western Washington. Severe flooding occurred in the Quinault, Queets, Snohomish, Skagit, and

Table 2. Precipitation totals for period November 7-11 and 21-25, 1990, at selected climatological stations in western Washington

Site number	Station	Precipitation, in inches	
		November 7-11	November 21-25
1	Grays River Hatchery	3.12	8.10
2	Centralia	1.15	6.06
3	Clearwater	6.59	8.05
4	Rainier Ohanapecosh	2.59	4.51
5	Mud Mountain Dam	2.70	4.96
6	Tolt South Fork Reservoir	6.24	7.30
7	Arlington	2.41	4.86
8	Stevens Pass	8.75	14.40
9	Lake Wenatchee	3.16	7.53
10	Diablo Dam	13.25	15.44

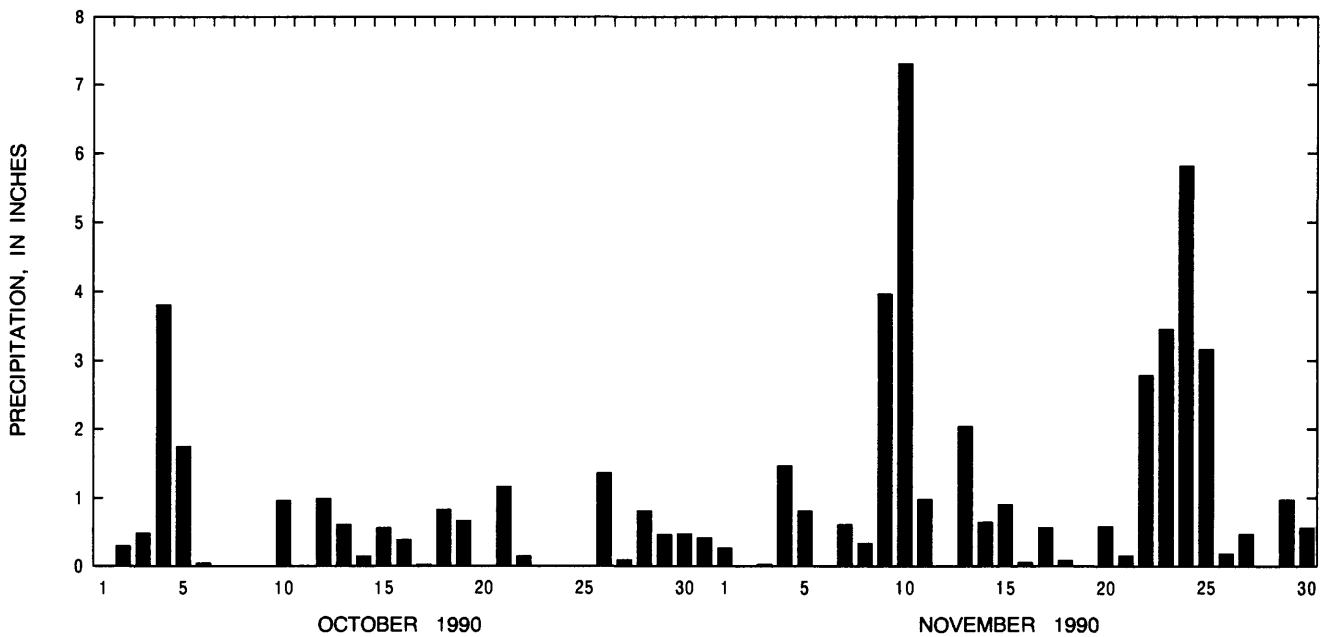

Figure 2. Daily precipitation at Diablo Dam, Washington, October-November 1990.

Nooksack Basins. The recurrence intervals for floods in these basins generally ranged from 10 to 30 years; The recurrence intervals for peak discharges at Skagit River Basin stations ranged from 15 to 50 years. On November 10, the peak flow for the Nooksack River at Deming was 37,900 ft^3/s (cubic feet per second) [fig. 3].

Major flooding occurred on rivers that drain the east and west slopes of the Olympic Mountains in the coastal range. Recurrence intervals for floods on these rivers ranged from 5- to 25-year-flood events. The flood peak on the Quinault River slightly exceeded the November 24 flood event.

November 23-26 Floods

Severe flooding in Washington occurred November 23-26 in the Duwamish, Lake Washington, Snohomish, and Wenatchee River Basins. These floods were generally larger and more widespread than those earlier in the month, particularly in the Wenatchee River Basin (fig. 4). Flood peaks on the Snohomish River near Monroe and on three rivers in the Wenatchee Basin equalled or exceeded the 100-year-flood event. The flood flow of the Wenatchee River at Plain was 1.3 times greater than the magnitude of the 100-year flood event. The flood peaks recorded November 24 or 25 were the highest ever observed at the following 11 gaging stations: Naselle River near Naselle (11,300 ft^3/s), Willapa River near Willapa (11,800 ft^3/s), Dungeness River near Sequim (7,120 ft^3/s), Cedar River at Renton (10,600 ft^3/s), Skykomish River near Gold Bar (102,000 ft^3/s) , Snoqualmie River near Snoqualmie (78,800 ft^3/s), Raging River near Fall City (6,220 ft^3/s), Snoqualmie River near Carnation (65,200 ft^3/s), Wenatchee River at Plain ((33,200 ft^3/s), Wenatchee River at Peshastin (40,000 ft^3/s), and the Wenatchee River at Monitor (45,900 ft^3/s).

THE DAMAGES

No final damage figures were available for the November flooding. All damage figures shown are based on preliminary estimates as presented by the U.S. National Oceanic and Atmospheric Administration (1991).

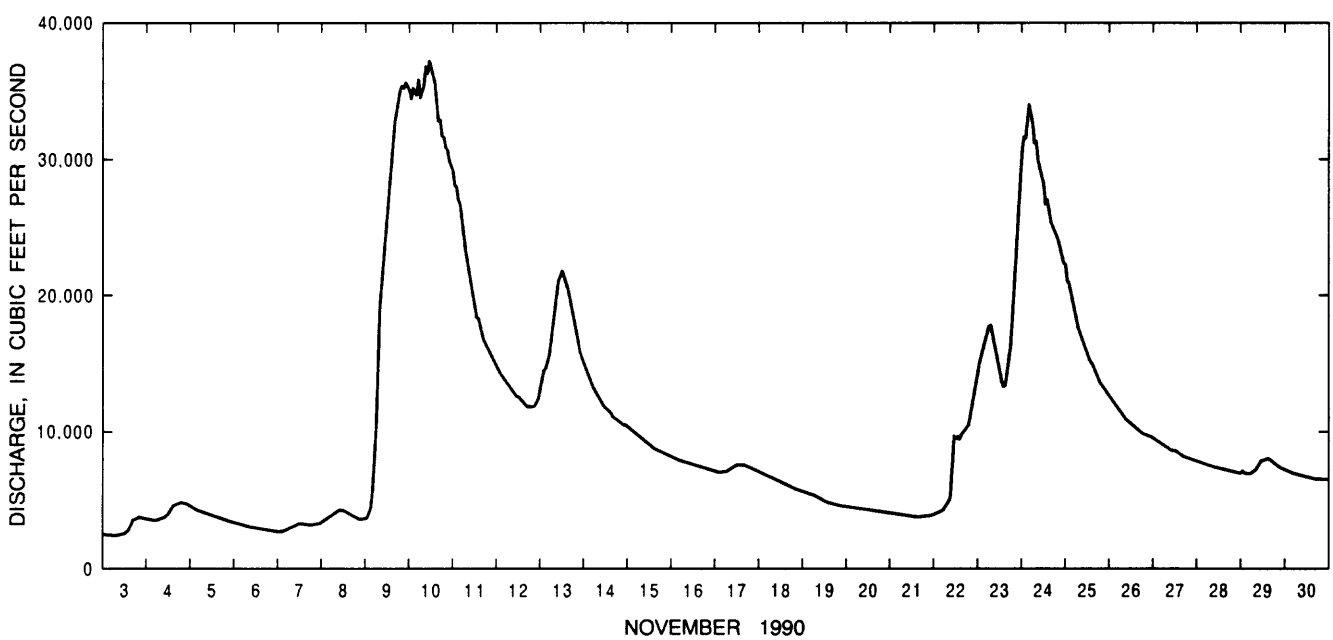

Figure 3. Discharge of Nooksack River at Deming, Washington, November 3-30, 1990.

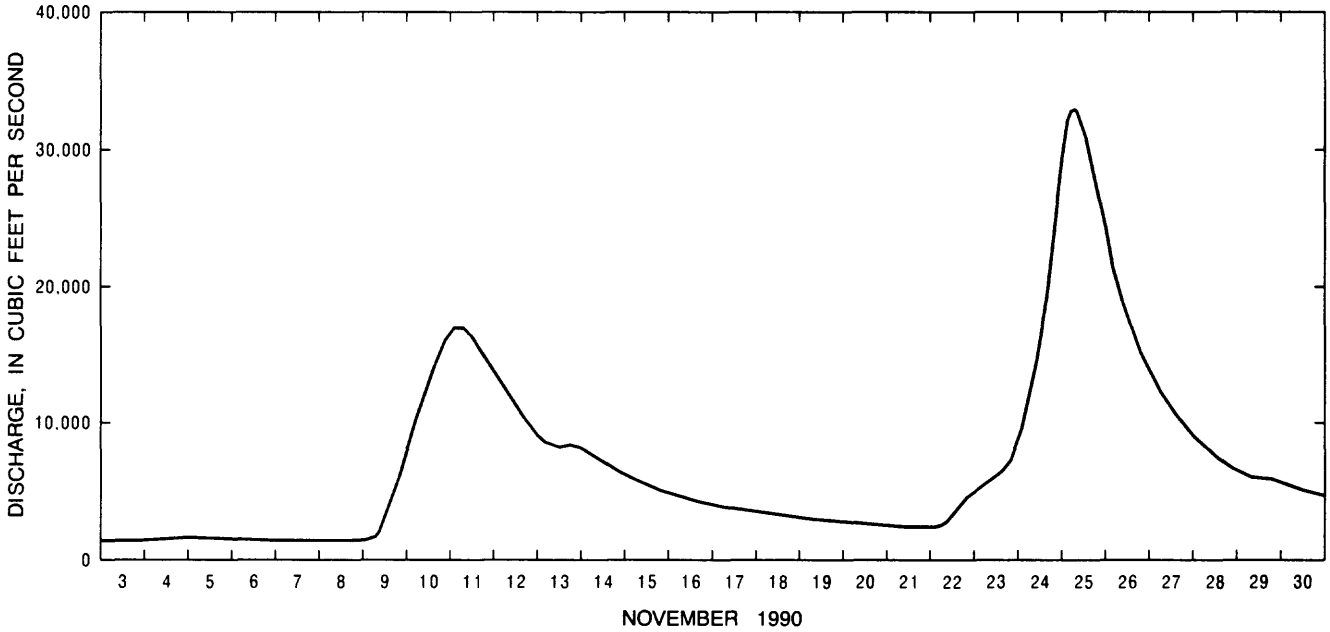

Figure 4. Discharge of Wenatchee River at Plain, Washington, November 3-30, 1990.

November 9-11

Extensive damages occurred as a result of the flooding. The Governor of Washington declared a state of emergency in Grays Harbor, King, Skagit, Snohomish, and Whatcom Counties. The flood waters of the Skagit River breached levees on Fir Island at the mouth of the river; approximately 500 people were evacuated and about 170 homes and farms were flooded. In Snohomish County, about 200 people were displaced from their homes. In Whatcom County, over 1,000 people on Gooseberry point and Lummi Island were isolated for a week. Estimated total flood damages were about 42 million dollars. Total damages to homes in Skagit, Snohomish, and Whatcom Counties were 14 million dollars, and damage to public works was about 24 million dollars. Damages to homes in Skagit County were about 8 million dollars and in Whatcom County about 4 million dollars.

November 23-26

Two lives were lost as a direct result of the flooding. Large amounts of resources were expended for rescuing and evacuating about 2,000 residents from flooded areas. Some residents of Fir Island on the Skagit River were evacuated to escape rising floodwaters for the second time in the month of November. Thousands of homes were flooded in the affected areas; 42 homes were destroyed. Early estimates of damages to homes, farm structures, farm crops, livestock, roads, dikes, highway structures and other utilities were 100 million dollars.

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