Pacific Northwest Flood Event of Jan 15-19, 2011

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Overview of the Pacific Northwest Storm Jan 15– Jan 19:

Widespread flooding was experienced across the Pacific Northwest during the period of January 15-19, 2011. The flooding was initiated by two days (January 15-16) of warm, heavy precipitation and strong winds that produced rainfall and snowmelt across the Pacific Northwest. In all, 55 floods were observed at official NWRFC flood forecast locations. The extent of flooding (Figure 1) was unusual with floods occurring in seven of the nine WFOs serviced by the NWRFC.

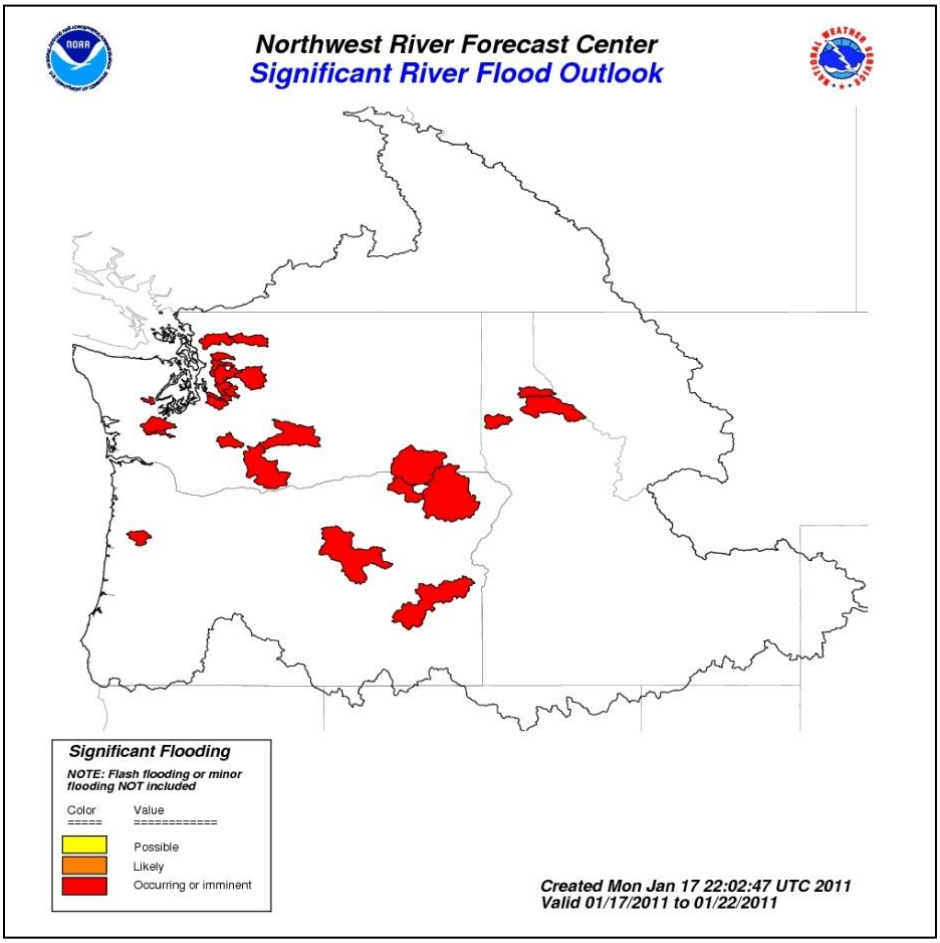
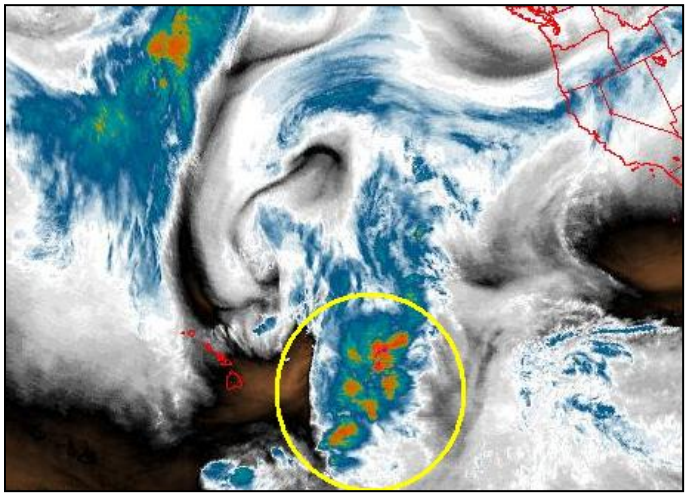


Figure 1. Graphic depicting the wide spread nature of flooding on the morning of Jan 17, 2011.

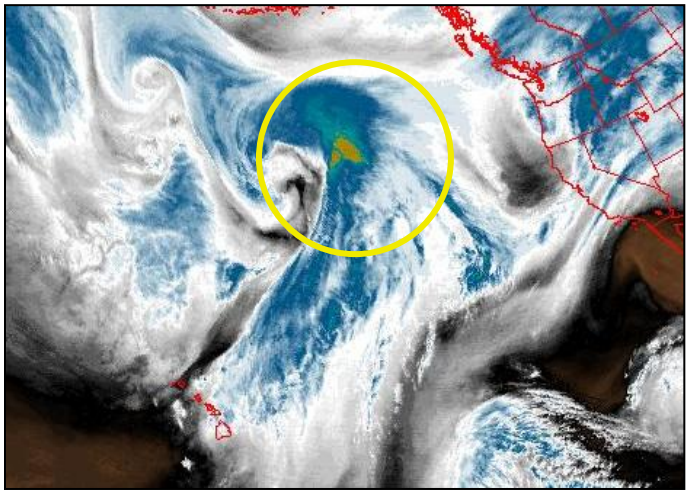
Flood damage was reported by most of WFOs and included numerous road closures, home evacuations, and the inundation of low-lying lands. Flooding in the Spokane River basin was estimated at $255,000 dollars and the area was declared a disaster by the State of Washington.

Section 1. Meteorology

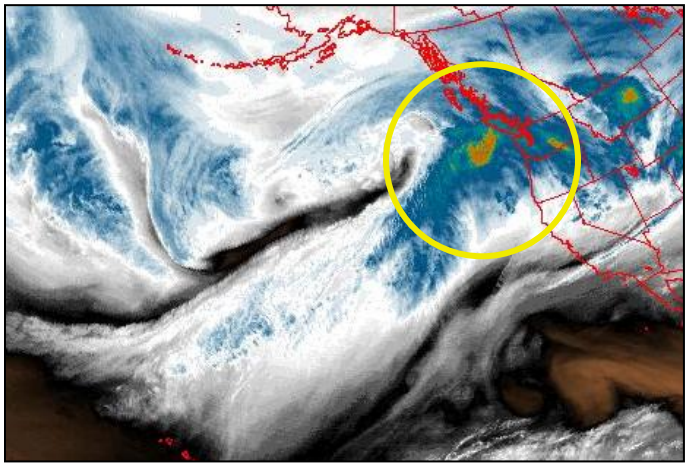
***Storm Analysis*:**



One week before the flood event in the Pacific Northwest, a large area of convection was observed southeast of the Hawaiian Islands. Moisture continued to pool in this area for several days as it gradually lifted north.

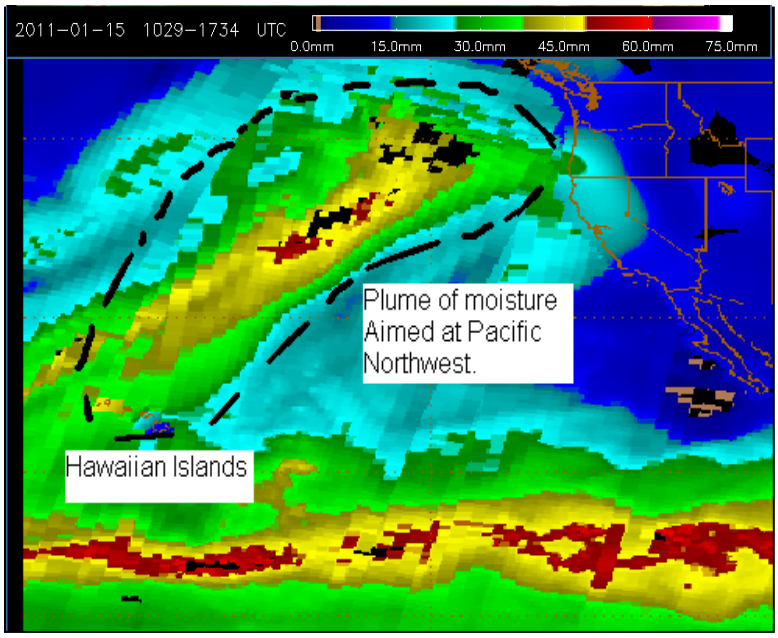


Three days before the flood event, the area of convection had weakened and lifted north. Moisture continued to slowly drift northward ahead of a well developed low pressure system located midway between the Aleutian Islands, The Hawaiian Islands and the Continental United States.



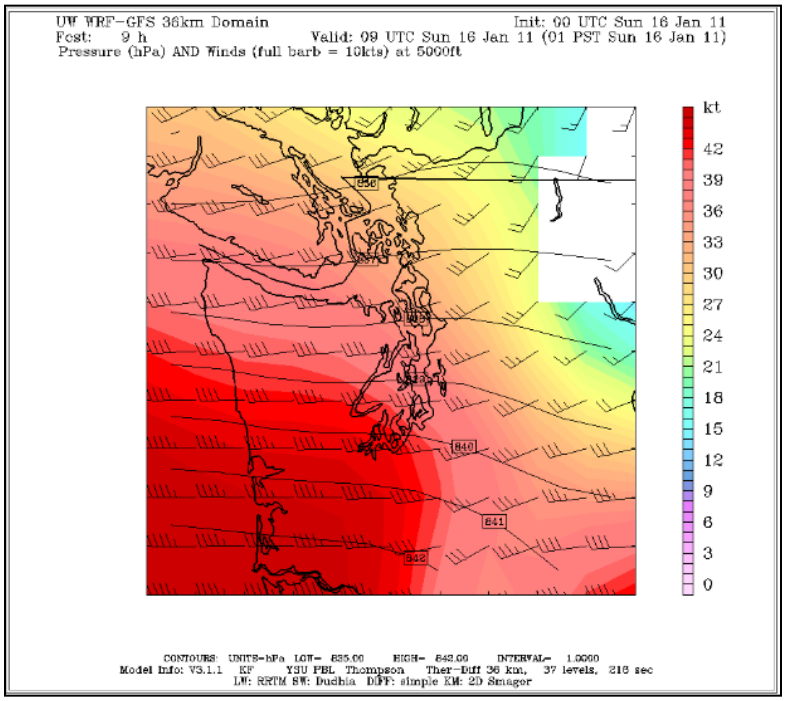
By the morning of the event, a strong conveyor of warm, moist air dominated most of the Pacific Northwest. A long trailing plume of moisture stretched to near the Hawaiian Islands with a trajectory aimed the Pacific Northwest.

Total Precipitable Water Image, January 15, 2011.



The total precipitable water image taken Saturday morning just before the heavy rainfall moved across the Pacific Northwest. The maximum values in the plume of moisture show amounts around 2.50 inches. The image also reveals the tropical connection with a source region near the Hawaiian Islands.

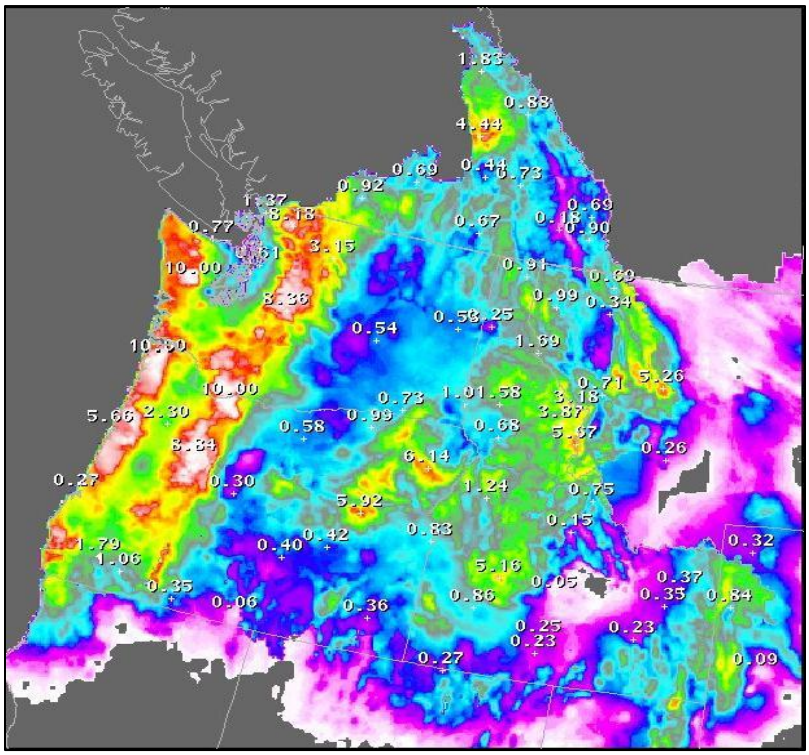
Image depicting the UW WRF-GFS Pressure and Wind Forecast at 5000 ft on the evening of Jan 15, 2011.



850 mb winds of around 50 knots moved east across south Washington and north Oregon during the overnight hours of Saturday night into Sunday morning. Orographic lift was a factor in the heavy rainfall that occurred over higher terrain. These wind speeds gradually decreased near the Idaho panhandle and western Montana. High freezing levels combined with large wind speeds contributed to melting snowpack in many eastside basins.

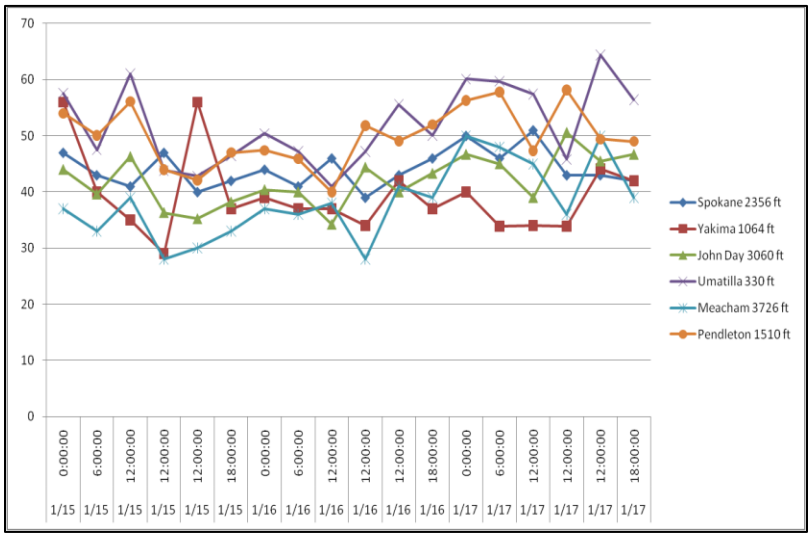
Summary of Observations

Observed Storm Total Precipitation, Jan 15-16, 2011.



The observed storm total precipitation graphic illustrates the wide spread nature of the storm event. 48 hour precipitation amounts for the period of Jan 15-16, 2011 indicate amounts from 5-10 inches in the mountains of western Oregon and Washington and over 5 inches the mountainous areas of eastern Oregon, Idaho, and western Montana.

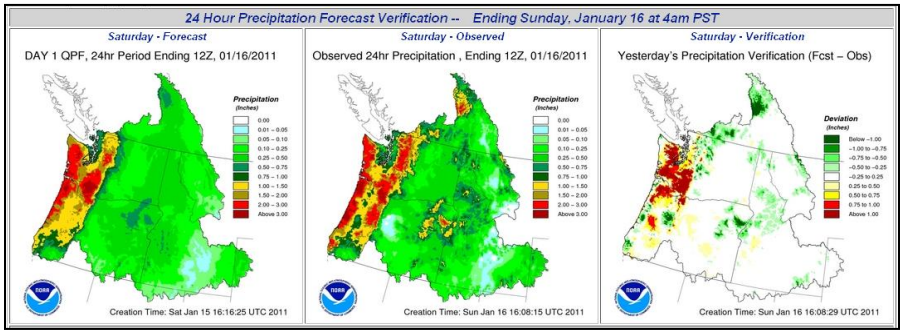
Observed temperature series for selected eastside gages.



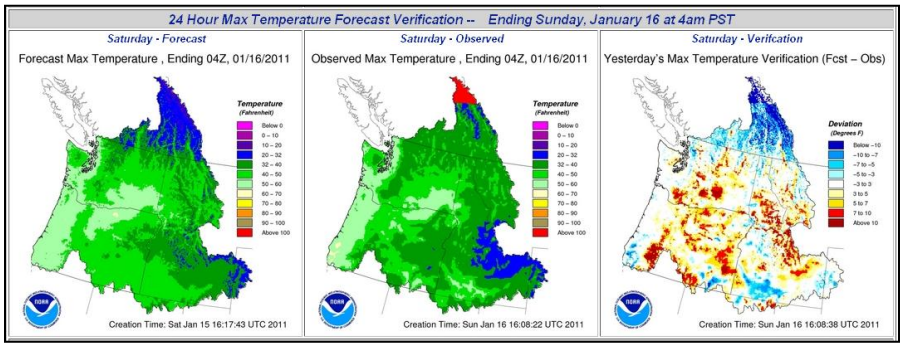
Observed temperatures for eastside locations were largely between 40-60 degrees Fahrenheit during the peak of the storm. Given the warm nature of the event, most of the precipitation fell as rainfall rather than snow. Warm temperatures and high freezing levels allowed existing low and mid level snowpack to melt, enhancing runoff during the event.

QPF Verification

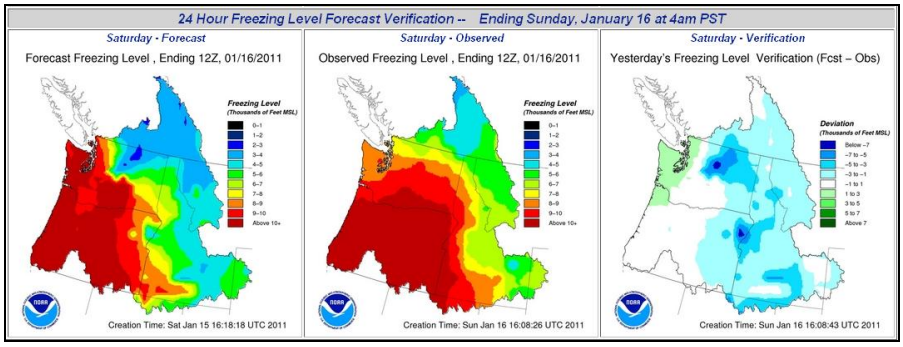
Verification plots for the Jan 15 Day 1 HAS Forecast:



Verification of the precipitation forecast for Saturday indicates that QPF was overdone for westside basins. For the eastside, the largest rainfall amounts were under forecast.

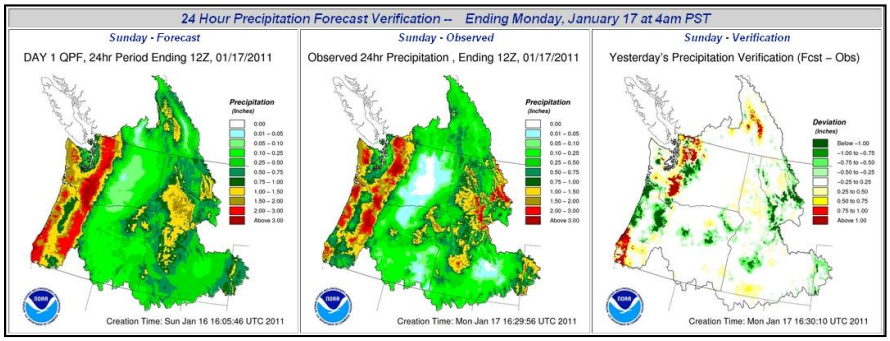


Temperature forecasts verified across the westside, but were too warm for much of the region east of the Cascade Mountains except for the northern tier and upper Snake basins where they were too low.

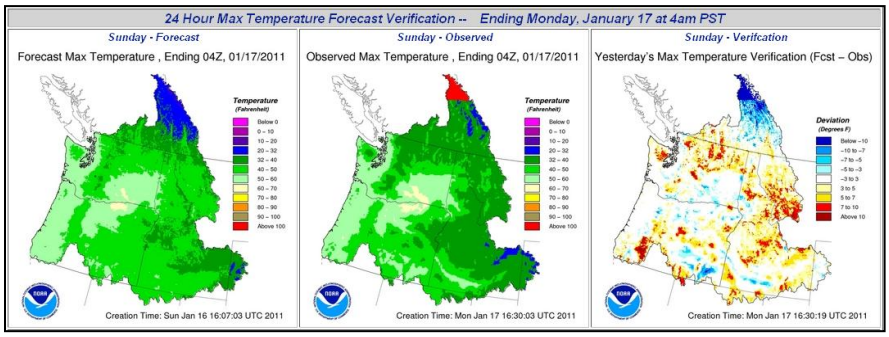


Forecasted freezing levels were high for much of the region, but not as high as the observations.

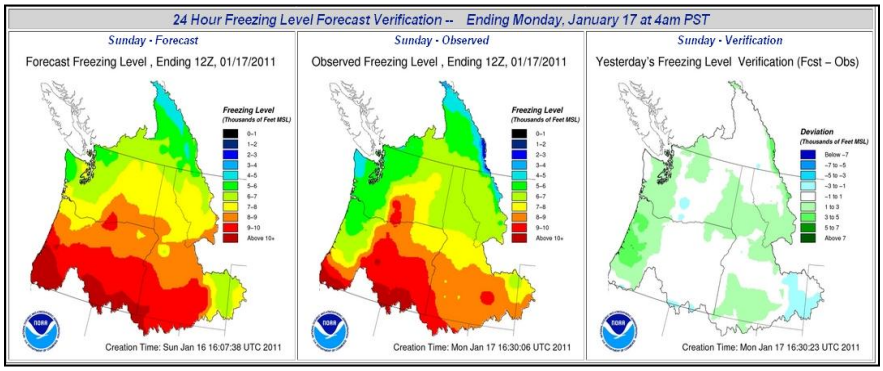
Verification plots for the January 16 Day 1 HAS Forecast:



The heaviest rainfall was generally under forecast for Oregon, Idaho, and western Montana. QPF was too high in the western Washington Cascades and in SW Oregon.



The temperature forecast for much of the region showed a warm bias.



Forecasted freezing levels were too high west of the Cascades and the Idaho panhandle. This suggests the cold front was moving faster than was forecast, thereby accelerating the delivery of heavy rainfall to the region.

Section 2. Hydrology

Description of Flood Event

The weeks leading up to the January flood event featured a number of weather systems that left much of western Oregon and western Washington with saturated soils, healthy snow packs, and rivers that were at high levels. During the week of December 8-13, heavy rain and flooding hit all streams in western Washington with many rivers reaching major flood level. In early January, a rain event brought moderate river rises to the same area. During January 8-13, a cold storm event built a snowpack in mid and lower elevation basins in western Washington. On the eastside, above normal snowpack was observed and was strongest in eastern Oregon. Two to four inches of snow water equivalent (SWE) covered the lower areas of many basins across the entire region. The result was a set of antecedent conditions that, when combined with the January 15-16 storm, produced unusually widespread flooding across many rivers of the Pacific Northwest.

Seattle Hydrologic Service Area (HSA)

Nooksack River. Heavy rain and snowmelt produced sharp rises on the Nooksack. Storm rainfall varied from 4 to over 10 inches. Several inches of SWE enhanced the runoff. The Cedarville and Ferndale gages crested above flood stage. Forecasts issued 24 hours in advance of the peak flow were well below the actual observations for these locations.

Skagit River. Rises above flood stage were observed on the Skagit River at Concrete and at Mt. Vernon. Mt. Vernon crested above major flood level on January 18th. River forecasts for the Skagit were reasonable and provided 2-3 days of lead time before flooding was observed.

Stillaguamish, Skykomish, and Snoqualmie Rivers. A period of heavy rainfall augmented by snow melt produced sharp river responses and produced floods on these rivers beginning on January 16th. Shortly after, another band of heavy rain hit the same areas producing a higher secondary peak at some locations. Major flood level was observed for the Snoqualmie River at Carnation and for the Snohomish River at Monroe and Snohomish, WA. Lead time for Carnation was nearly 1.5 days and nearly 3 days for Monroe.

SEATTLE Northern Cascades	FS (ft)	Time of First Flood Fcst	Time of Flood	Time of Peak	Peak (ft)	Lead Time (hrs)
Snoqualmie River at Snoqualmie Falls, WA						
SQUW1	13	1/13 18:36	1/16 13:15	1/17 03:45	17.1	66.7
Skykomish River At Gold Bar, WA						
GLBW1	15	1/15 01:04	1/16 16:00	1/17 10:45	18.6	38.0
Snoqualmie River near Carnation, WA						
CRNW1	54	1/13 18:36	1/16 17:00	1/17 23:30	59.3	70.0
Tolt River near Carnation, WA						
TOLW1	9.04	1/15 08:39	1/16 18:30	1/16 21:15	9.1	33.9
Snohomish River at Snohomish, WA						
SNAW1	25	1/13 18:36	1/16 23:30	1/18 13:00	30.9	76.9
Snohomish River At Monroe, WA						
MROW1	15	1/14 00:59	1/17 01:00	1/18 06:00	19.2	72.0
Skookumchuck River At Bucoda, WA						
BCDW1	13.5	1/15 10:05	1/17 02:30	1/17 07:15	13.9	40.4
Skagit River At Concrete, WA						
CONW1	28	1/15 08:14	1/17 07:30	1/17 18:30	30.1	47.0
Nooksack Riverat North Cedarvillle, WA						
NRKW1	146.5	1/15 07:47	1/17 11:15	1/17 17:00	147.8	51.5
Skagit River At Mt Vernon, WA						
MVEW1	28	1/15 08:14	1/17 13:00	1/18 08:30	30.9	52.8
Stillaguamish River At Arlington, WA						
ARLW1	14	1/16 05:06	1/17 13:24	1/17 19:24	17.6	32.3
North Fork Stillaguamish River near Arlington, WA						
ARGW1	13	1/16 05:06	1/17 16:15	1/17 18:15	13.3	35.2
Nooksack River at Ferndale, WA						
NKSW1	19	1/15 07:47	1/18 03:45	1/18 10:30	20.1	68.0

Cedar and Green Rivers. The Cedar and Green basins had some of the largest precipitation catches for the storm event. The Corps of Engineers Seattle District Office reported that inflows to Howard Hanson and Mud Mountain dams peaked near 20,000 and 25,000 cfs, respectively. Sharp river rises were observed near Landsburg and at Renton. River forecasts under-predicted flood rises, in part due to managed releases from the reservoir in the upper Cedar basin. On the Green River, the gage at Auburn crested above flood stage and had a flood forecast lead time of over 72 hours.

Puyallup, Nisqually, and Cowitz Rivers. Rises above flood stage were observed on the Puyallup River near Orting and the Nisqually River near National. On the upper Cowlitz River at Packwood, storm total rainfall was in the four to six inch range causing the gage near Randle to

crest above major flood level. Forecast peaks for The Puyallup and Cowlitz rivers were generally higher than was observed.

SEATTLE Middle Cascades	FS (ft)	Time of First Flood Fcst	Time of Flood	Time of Peak	Peak (ft)	Lead Time (hrs)
Puyallup River At Orting, WA						
ORTW1	7.84	1/11 18:01	1/16 08:30	1/16 21:00	9.4	110.5
Nisqually River near National, WA						
NISW1	10.8	1/15 09:29	1/16 18:30	1/16 19:45	11.1	33.0
Carbon River near Fairfax, WA						
FFXW1	13.5	1/16 01:47	1/16 21:15	1/16 21:15	13.5	19.5
Green River At Auburn, WA						
AUBW1	61.7	1/13 17:15	1/16 23:00	1/19 09:00	63.0	77.8
Cedar River At Landsburg, WA						
LNDW1	5	1/17 07:28	1/17 10:00	1/18 05:00	6.0	2.5
Cedar River at Renton, WA						
RNTW1	12	1/17 06:20	1/17 10:15	1/19 01:15	13.5	3.9
Cowlitz River at Randle, WA						
RAWW1	18	1/14 17:16	1/16 17:15	1/17 12:30	22.4	48.0
Cowlitz River At Packwood, WA						
PACW1	10.5	1/16 02:21	1/16 19:15	1/16 21:45	10.8	16.9

Skokomish and Chehalis Rivers. Sharp rises and river flooding began in the Skokomish River area on January 15 where Potlatch crested one half foot above flood. On the Chehalis River only minor flooding was observed at Grand Mound and Porter. Minor flooding was observed on the Satsop River near Satsop. Peak forecasts for the upper Chehalis where higher than was observed. The lower Chehalis River at Porter and the Skokomish River at Potlatch had forecasts peaks that were within 10% of the observed peak flow.

Flood impacts in the Seattle HSA were mainly limited to road closures and home evacuations in the flood plain of the Snoqualmie and Snohomish rivers.

SEATTLE SW WA/Olympics	FS (ft)	Time of First Flood Fcst	Time of Flood	Time of Peak	Peak (ft)	Lead Time (hrs)
Skokomish River At Potlatch, WA						
SRPW1	16.5	1/14 17:44	1/16 17:00	1/17 12:00	16.9	47.3
Satsop River At Satsop, WA						
SATW1	34	1/15 18:03	1/16 23:00	1/17 04:15	34.4	29.0
Newaukum River At Chehalis, WA						
NEWW1	10.5	1/15 10:05	1/16 23:15	1/17 04:00	11.1	37.0
Chehalis River At Grand Mound, WA						
CGMW1	14	1/14 18:40	1/17 11:30	1/17 19:30	14.2	64.8
Chehalis River At Porter, WA						
CRPW1	21	1/14 18:00	1/18 00:00	1/18 10:15	21.2	78.0

Portland HSA

Willamette River Basin. High freezing levels and heavy rainfall (three to five inches) produced high stream flows which were enhanced by snowmelt. Three to six inches of mid level SWE were melted off during the storm. Rises above flood stage were observed on the Luckiamute, Santiam, Clackamas and Pudding Rivers. The sharpest rises were on the Santiam River where forecasts were underdone and there was little to no lead time. On the Clackamas River rises were well forecasted with more than two days of lead time but were over forecast for the headwater locations.

PORTLAND Willamette Basin	FS (ft)	Time of First Flood Fcst	Time of Flood	Time of Peak	Peak (ft)	Lead Time (hrs)
Clackamas River near Estacada, OR						
ESTO3	20	1/14 18:36	1/16 16:45	1/17 04:45	23.8	46.2
Clackamas River above Three Lynx Creek, OR						
TLYO3	12	1/14 18:36	1/17 00:00	1/17 02:00	12.8	53.4
Clackamas River near Oregon City, OR						
COCO3	39	1/14 18:36	1/17 01:00	1/17 07:00	42.5	54.4
N Santiam River At Mehama, OR						
MEHO3	11	1/16 22:24	1/16 22:30	1/17 01:00	11.7	0.1
Santiam River At Jefferson, OR						
JFFO3	15	1/17 09:03	1/17 08:15	1/17 11:30	15.4	0.0
Luckiamute River At Suver, OR						
SUVO3	27	1/14 18:52	1/17 09:15	1/17 17:45	28.8	62.0

Coastal Rivers. On the Oregon coast, minor flooding was observed on the Nehalem, Wilson and Siletz rivers. Two to four inches of rain was augmented by low level snow melt to produce flooding. Floods were forecast for the Naselle and Willapa Rivers, but neither location verified.

Lower Cowlitz River. The Cowlitz River at Kelso briefly touched flood stage during the evening of Jan 16th. Initial forecasts were on track, however as the peak approached, several unrealistic forecasts were issued that forecast the stage to go well above flood.

Hood River. The headwaters of the Hood River on east flank of Mt. Hood caught five inches of rainfall. Several inches of SWE contributed to high runoff. The Hood River crested about a foot above flood stage on January 16th.

Flood impacts in the Portland HSA included road closures, low land flooding, and a few structures that experienced floodwater damage. The exception to this was fairly severe flooding on the upper Sandy River near Zigzag where the river washed out part of Lolo Pass road and destroyed several homes in that area.

PORTLAND Coastal and Other	FS (ft)	Time of First Flood Fcst	Time of Flood	Time of Peak	Peak (ft)	Lead Time (hrs)
Siletz River at Siletz, OR						
SILO3	16	1/16 00:19	1/16 17:00	1/17 02:00	20.6	16.7
Wilson River At Tillamook, OR						
TLMO3	12	1/16 00:19	1/16 17:30	1/16 23:30	13.9	17.2
Nehalem River near Foss, OR						
FSSO3	14	1/14 18:25	1/16 18:00	1/17 03:00	15.9	47.6
Cowlitz River at Kelso, WA						
KELW1	21.5	1/15 21:04	1/17 04:16	1/17 04:16	21.5	31.2
Hood River At Hood River, OR						
HODO3	13	1/16 08:07	1/16 20:50	1/17 02:40	14.3	12.7

Medford HSA

Umpqua and Coquille Rivers. The January 15-19 storm extending into the Medford HAS, bringing strong river rises, but no flooding to the area. The Umpqua River near Elkton and the Coquille River at Coquile both crested near, but just below flood stage.

Pendleton HSA

Yakima River Basin. Heavy rain and warm temperatures impacted the upper reaches of the Yakima and Naches Rivers. WFO Pendleton put out a flood potential statement well before the storm, correctly identifying the areas of concern. Storm rainfall in this area varied from four to eight inches with several inches of melted SWE adding to the river flows.

Rises above flood stage were observed on the upper Yakima River at Easton, Horlick and Umtanum. In the Naches drainage, the upstream gage at Clifdel crested just below flood stage on January 17th. Downstream, the Naches River near Naches crested one foot above flood stage. On the lower Yakima River, Parker crested just above major flood level and Kiona crested 1.8 feet above flood stage. River forecasts in this basin on generally track for the upper Yakima, but were under forecast at Parker and Horlick.

Flood damages in the upper Yakima area above Horlick were substantial. Roads were washed out and 30 homes were impacted. A dozen families were evacuated from their properties. Flood damage on the Naches River and lower Yakima were minor with only low lying roads and a golf course impacted.

PENDLETON Yakima Basin	FS (ft)	Time of First Flood Fcst	Time of Flood	Time of Peak	Peak (ft)	Lead Time (hrs)
Yakima River at Easton, WA						
EASW1	51.3	1/16 16:41	1/16 19:15	1/17 07:00	53.3	2.6
Naches River At Naches, WA						
NACW1	17	1/16 18:13	1/17 00:00	1/17 12:00	18.3	5.8
Yakima River At Horlick, WA						
HLKW1	35.6	1/16 23:32	1/17 08:30	1/17 17:00	37.0	9.0
Yakima River At Parker, WA						
PARW1	10	1/16 16:41	1/17 16:00	1/18 10:30	12.2	23.3
Yakima River At Umtanum, WA						
UMTW1	35.5	1/16 23:32	1/17 23:15	1/18 07:00	36.7	23.7
Yakima River At Kiona, WA						
KIOW1	13	1/16 16:41	1/19 02:30	1/20 03:15	14.8	57.0

Umatilla, John Day, Walla Walla, and Klickitat Rivers. Approximately two inches storm total rainfall was observed in the Umatilla and John Day basins. Again, several inches of SWE augmented the flow. Flooding was observed on the Umatilla, John Day, Walla Walla, and Klickitat Rivers. These sites crested from a half foot to over two feet above flood stage. Forecasted peaks issued 24 hours in advance of the observed crest were underdone, except for the Walla Walla River. For the John Day River near John Day, the NWRFC failed to issue a forecast reflecting a rise above flood until after a flood was observed at the gage.

The flood impacts in this area were fairly minor with road closures and agricultural flooding in several places. On the Lower Umatilla several homes and a mobile home park were threatened by flood waters. Sand bags were used to protect the structures.

PENDLETON	FS (ft)	Time of First Flood Fcst	Time of Flood	Time of Peak	Peak (ft)	Lead Time (hrs)
Umatilla River At Gibbon, OR						
GIBO3	7	1/16 17:21	1/16 19:00	1/17 05:45	7.7	1.7
Umatilla River near Pendleton, OR						
PDTO3	7.8	1/16 08:07	1/16 22:45	1/17 11:15	10.3	14.6
John Day River At John Day, OR						
JHNO3	8	1/17 03:22	1/17 03:15	1/17 05:30	8.4	0.0
John Day River at Service Creek, OR						
SERO3	11.5	1/16 17:21	1/17 10:00	1/17 23:30	13.7	16.7
Grande Ronde River At Troy, OR						
TRYO3	10	1/17 13:40	1/17 13:30	1/17 18:30	10.3	0.0
Walla Walla River near Touchet, WA						
TCHW1	13	1/15 17:44	1/17 13:45	1/17 22:15	13.5	44.0
Klickitat River At Pitt, WA						
PITW1	9	1/15 17:44	1/16 22:15	1/17 18:15	10.3	28.5

Spokane HSA

The January 15-19 storm heavily impacted the Spokane River and its tributaries. Storm total rainfall ranged from two to over five inches in the headwaters areas. At elevations below 4500 feet several inches of SWE melted during the storm. The Spokane WFO issued a flood potential statement well before the storm. However, NWRFC guidance did not indicate flooding on rivers in the Spokane HSA until 8 to 14 hours before flooding began.

SPOKANE	FS (ft)	Time of First Flood Fcst	Time of Flood	Time of Peak	Peak (ft)	Lead Time (hrs)
Palouse River At Potlatch, ID						
PLOI1	15	1/16 17:33	1/17 02:30	1/17 10:30	16.5	9.0
Coeur D'Alene River at Cataldo, ID						
CTLI1	43	1/16 17:31	1/17 07:30	1/18 06:30	46.0	14.0
St Joe River at St Maries						
SJMI1	32.5	1/17 06:15	1/17 14:23	1/18 17:05	36.0	8.1
St Joe River At Calder, ID						
CLDI1	13	1/17 06:15	1/17 18:45	1/18 00:45	13.2	12.5

Palouse River. On the Palouse River the gage near Potlatch crested 1.5 feet above flood stage on January 17th. 9 hours of lead time was given and the peak forecast was within 10% of the observed crest.

Coeur D' Alene River. The flood crests on the Coeur D' Alene River were just below flood stage at Enaville, but three feet above flood stage at Cataldo. The difference in flood peaks at these locations is the result of low-level snow melt draining into the local drainage between Enaville and Caltaldo. The Cataldo peak was underdone in forecasts issued 24 hours in advance of the crest.

St Joe River. Calder crested just above flood stage on January 17th. Downstream, the St. Joe River at St. Maries crested 3.5 feet above flood level. All forecasts for the St. Joe were too low until 12 hours before the peak. Peak forecasts for the St Joe River were significantly underdone.

Flood impacts in the Spokane drainage included roads closed near Cataldo and evacuations of residents on the North Fork Coeur D'Alene. On the St. Joe River one flood gate was closed to prevent flooding. One home was completely surrounded by water and elsewhere basement flooding was reported. Near Cataldo, $7-8,000 dollars was spent in order to pump flood waters away from impacted areas. Infrastructure and property damage was estimated at $255,000 dollars. The area was declared a disaster by the State of Washington.

Boise HSA

Weiser, Powder and Malheur Rivers. Up to 1.5 inches of rainfall fell in the middle Snake region and temperatures at that time were in the 40 to 50 degree range. The Weiser, Powder and Malheur Rivers were all forecast to exceed flood stage, however only the Malheur River near Vale crested above flood. Bad data at the Powder and Weiser gages contributed to the over forecasts where bad observed data misled forecasters. On the Malheur River a sharp rise was forecast early in the storm, but river was not expected to reach flood stage. No flood forecast was issued until slightly after observed data indicated that the river was in flood. A later forecast update called for a crest about three feet over flood stage. Damage in the Boise HSA was limited to road closures.

BOISE	FS (ft)	Time of First Flood Fcst	Time of Flood	Time of Peak	Peak (ft)	Lead Time (hrs)
Malheur River At Vale, OR						
VALO3	9.5	1/17 19:49	1/17 18:30	1/18 12:45	12.6	0.0

Missoula HSA

No floods were observed at official NWS flood locations in the Missoula HSA. However, a serious event related to an ice jam flooded the town of Libby, MT. Approximately 20 homes were damaged and Highway 2 was closed for a short time.

Flood Analysis and Verification

During a typical workday (non-event), the NWRFC issues 42 short term river forecast products (RVF's). These products contain 773 individual forecasts for stage, flow, and reservoir pool levels. Of these, 197 are for locations with official NWS flood stages. During this event, 55 of those locations exceeded flood stage during a 48 hour period. 38 of these occurred on the western rivers and 17 were on the eastern rivers.

The volume of issued forecasts dramatically increased during the peak of the event as staff produced updated forecasts through the evening and overnight hours. On Jan 16, 92 RVF's (1470 individual forecasts) were issued and on Jan 17, that number peaked at 97 products (1480 individual forecasts). This represents a doubling of the typical daily forecast output for the NWRFC.

In contrast, during the recent major flood event of Dec 10-14, 2010, the peak number of RVF products issued during a single day was 77 (1293 individual forecasts). During that event, 20 locations flooded, all of which were located in the Seattle HSA. Compared to the December flood episode, the January event experienced more than twice the number floods and a total of 7 WFOs were impacted by flooding.

The increase in forecasts is directly related to the number of updates that are issued for, or in support of, locations with official NWS flood stages. For instance, forecasts for the Green River near Auburn were issued 3 to 4 times per day from during the period Jan 14-17 and forecasts for the St. Joe River at Saint Maries were updated 5 times on Jan 17 alone.

Table 1 (page 15) summarizes observations and forecasts for rivers that flooded during the January 2011 episode. The table is presented as a timeline showing when rivers went above flood stage and the number of floods experience by each WFO. Average lead time is given for each WFO for each 6 hour period. Volumetric forecast error is indicated as well.

The average lead time for all the flood forecasts was 34 hours. The median for the 55 events was 33 hours. Several locations in western Washington and Oregon had lead times of over 72 hours. Five locations had lead times of 1 hour or less. Four of these locations (JFFO3, JHNO3, TRYO3, VALO3) did not have a flood forecast issued before a flood was observed.

24 hour lead time verification of the peak flood flows indicates a negative bias for eastern rivers (the peak forecasts were often lower than what was observed). On the west side, forecasts showed little bias with forecasts being too high about as often as they were too low.

Table 2 (page 17) lists the 15 locations where floods were forecast, but not observed. 12 of these are on the west side, including one that was forecast to hit major flood.

Table 3 (page 17) summarizes the 5 locations in the Seattle HSA that experienced Major Flood status.

Table 1. Chronology of Flood Events (Showing Time River Reached Flood Stage)

Fcst Error Peak Flow 24 hr Lead	RED UNDERLINE < -25%		RED -25 to -10%		BLUE -10 to 10%		BLUE UNDERLINE > 25%	
Time (GMT)	17-Jan 06-12Z	17-Jan 12-18Z	17-Jan 18-00Z	18-Jan 00-06Z	18-Jan 06-12Z	18-Jan 12-18Z	18-Jan 18-00Z	19-Jan 00-06Z
SEW	ORTW1	SQUW1 GLBW1 CRNW1 SRPW1 RAWW1	NISW1 TOLW1 PACW1 FFXW1 AUBW1 SATW1 NEWW1 SNAW1	MROW1 BCDW1	CONW1 LNDW1 RNTW1 NRKW1 CGMW1	MVEW1 ARLW1 ARGW1		CRPW1 NKSW1
Ave Lead Time (hrs)	111	54	41	56	34	40		73
PQR		ESTO3 SILO3 TLMO3	FSSO3 HODO3 MEHO3	TLYO3 COCO3 KELW1	JFFO3 SUVO3			
Ave Lead Time (hrs)		27	20	46	31			
OTX				PLOI1	CTLI1	SJMI1	CLDI1	
Ave Lead Time (hrs)				9	14	8	13	
PDT			GIBO3 EASW1 PITW1 PDTO3	NACW1 JHNO3	HLKW1 SERO3	TRYO3 TCHW1 PARW1	UMTW1	KIOW1
Ave Lead Time (hrs)			12	3	13	22	24	57
BOI							VALO3	
Ave Lead Time (hrs)							0	
# FLOODS	1	8	15	8	10	7	3	3
Ave Lead Time (hrs)	111	44	29	33	27	28	12	68

Table 2. Flood Forecasts for Non-Floods

WFO	Location	Notes
SEW	NSSW1	
SEW	GFLW1	
SEW	DSRW1	
SEW	CASW1	
SEW	DOTW1	
SEW	CENW1	
SEW	CGMW1	MF forecast
PDX	WILW1	
PDX	MPLO3	
PDX	PHIO3	
PDX	DLLO3	
PDX	FRMO3	
PDT	CLFW1	
BOI	WSRI1	ICE affected
BOI	PWDO3	ICE affected

Table 3. Forecast Locations reaching Major Flood Stage

WFO	Location	MF	Obs. Peak
SEW	MVEW1	30.0	30.9
SEW	CRNW1	58.0	59.3
SEW	MROW1	17.0	19.2
SEW	SNAW1	29.0	30.9
SEW	RAWW1	22.0	22.4