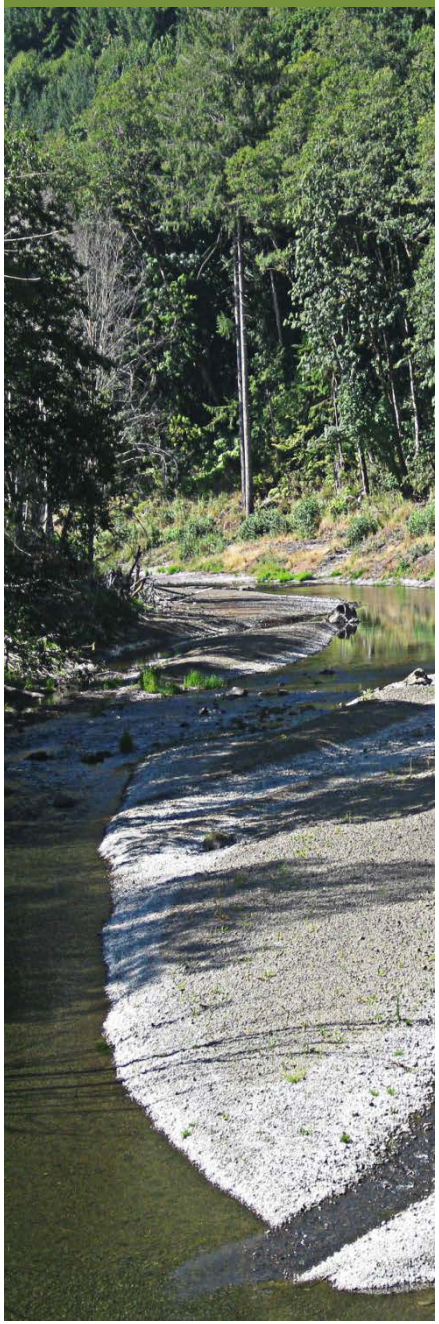
Review of Statistical Hydrologic Analysis

Technical Workshop

Lacey Community Center

October 30, 2013



Task Description

Task 1.3.5 Re-evaluate Statistical Hydrology

Recent work by the USACE has developed statistical hydrology data for the entire Chehalis River Basin. The approach used to develop these data was vetted with basin stakeholders and agencies and deemed appropriate for the previous work. However, there remains some concern that the "one size fits all" hydrologic data does not fully capture the range of flood events that may be seen in the Chehalis Basin. The purpose of this task is to re-evaluate the historical record of flood events in detail to ensure that all significant flood patterns represented in the historical data are adequately captured by the simulation of the observed events of February 1996, December 2007, and January 2009, together with the theoretical design storms. In particular, this task will address the question of whether there is a reasonable possibility of extreme flood events that are focused in the Cascades or Black Hills with only minor contributions from the Upper Chehalis River basin. This evaluation will improve the understanding of possible storm patterns (both spatially and temporally) in the basin and may lead to the development of additional hydraulic model inputs. The findings of this task will also be used in the development of the dam operations plan.

Statistical Hydrology

What design events should be used for this project?

How should they be created?

Reminder:

Economic analysis based on 10-, 25-, 100-, and 500-year flood events, focused on main stem Chehalis River (at Grand Mound)

Actual event simulations (Dec 2007, Feb 1996, Jan 2009) used for other purposes (calibration, evaluation of benefits and impacts of specific project, etc.)

Chehalis River at Grand Mound

Percent Chance Exceedence	Return Interval	Flow (cfs)
0.2	500	100,300
0.5	200	85,200
1	100	74,700
2	50	64,900
4	25	55,800
10	10	44,600
20	5	36,500
50	2	25,600

Previous Analyses (FEMA and Flood Authority)

		100-year Discharge or Percent of estimated 100-year flow at USGS gage				
	River Mile	WSE Hydrology [a]	Flood Authority Model		FEMA model	
Chehalis at Doty	101.549/101.8	39,000	36,177[b]	92%	39,353	101%
SF Chehalis at Boistfort	5.84	15,200	15,673	103%	15,744	104%
Newaukum near Chehalis	4.11	14,400	13,123[c]	91%	10,905[c]	76%
Skookumchuck near Bucoda	6.42/6.38	12,900	13,705	106%	9,632	75%
Chehalis near Grand Mound	59.909/59.89	75,000	76,863	102%	82,731	110%

[a] Based on new flow frequency analysis by WSE using USGS data through Water Year 2012. These analyses are still in review but are similar to previous analyses and therefore not expected to change much.

[b] The 100-year flow estimate for the Chehalis River at Doty used in the Flood Authority project assumed that the december 2007 flood was a historic event for a longer period than the actual Doty record. This resulted in a slighhtly lower estimate of the 100-year discharge which was then used in the Flood Authority modeling. The FEMA peak discharge estimate, and the current analysis by WSE, did not assume the December 2007 event was a historic peak flow for this analysis.

[c] Subject to upstream flow splits to Dillenbaugh Creek - the USGS has indicated that the Newaukum gage record includes these flow splits which may be approximately 550 cfs in the 100-year event (i.e. the modeled discharges just upstream of the flow splits are 500 cfs higher than reported here)

Historical Peak Flood data (see Excel)

Gage No.	12027500				12020000					12021000					12025000					12026400				
Gage Name	CHEHALIS RIVER NEAR GRAND MOUND, WA				CHEHALIS RIVER NEAR DOTY, WA					SOUTH FORK CHEHALIS RIVER AT BOISTFORT, WA					NEWAUKUM RIVER NEAR CHEHALIS, WA					SKOOKUMCHUCK RIVER NEAR BUCODA, WA				
100-yr Flow	100-year Q	75,000			100-year Q	38,900				100-year Q	15,200				100-year Q	14,400				100-year Q	12,900			
Water Year	Date	Peak flow (cfs)	Rank	Percentile	Date	Peak flow (cfs)	Rank	Percentile	0.15	Date	Peak flow (cfs)	Rank	Percentile	0.15	Date	Peak flow (cfs)	Rank	Percentile	0.15	Date	Peak flow (cfs)	Rank	Percentile	0.15
2008	04-Dec-07	79,100	1	100%	03-Dec-07	52,660	1	100%		03-Dec-07	20713	1	100%		03-Dec-07	12,900	3	97%		03-Dec-07	3,600	24	48%	A
1996	09-Feb-96	74,800	2	99%	08-Feb-96	28,900	2	99%		08-Feb-96	9542	3	96%		08-Feb-96	13,300	1	100%		08-Feb-96	11,300	1	100%	
1990	10-Jan-90	68,700	3	98%	09-Jan-90	27,500	3	97%							09-Jan-90	10,400	6	93%		10-Jan-90	8,540	3	95%	
1987	25-Nov-86	51,600	4	96%	24-Nov-86	17,900	9	89%							24-Nov-86	10,700	5	94%		24-Nov-86	3,379	25	45%	A
2009	08-Jan-09	50,700	5	95%	08-Jan-09	20,100	7	92%		08-Jan-09	11664	2	98%		07-Jan-09	13,000	2	99%		08-Jan-09	10,500	2	98%	
1972	21-Jan-72	49,200	6	94%	20-Jan-72	22,800	4	96%		20-Jan-72	6540	8	86%		21-Jan-72	9,770	10	87%		21-Jan-72	8,190	6	89%	
1938	29-Dec-37	48,400	7	93%																				
1991	25-Nov-90	48,000	8	92%	24-Nov-90	20,600	6	93%							24-Nov-90	10,300	7	90%		25-Nov-90	8,400	4	93%	
1934	21-Dec-33	45,700	9	90%																				
1976	05-Dec-75	44,800	10	89%	04-Dec-75	17,400	10	88%		04-Dec-75	6593	7	88%		04-Dec-75	8,020	17	77%		04-Dec-75	6,110	10	80%	
1971	26-Jan-71	40,800	11	88%	26-Jan-71	9,612	28	63%	A	26-Jan-71	3526	21	60%	A	26-Jan-71	8,390	15	80%		26-Jan-71	6,630	9	82%	
1997	30-Dec-96	38,700	12	87%	30-Dec-96	9,964	26	65%	A						29-Dec-96	9,700	11	86%		30-Dec-96	8,380	5	91%	
1935	23-Jan-35	38,000	13	84%																				
1951	10-Feb-51	38,000	14	84%	09-Feb-51	15,700	13	83%		09-Feb-51	3690	19	64%	A	09-Feb-51	5,240	49	32%	A					
2006	31-Jan-06	37,900	15	83%	30-Jan-06	16,000	12	85%		30-Jan-06	7080	6	90%		30-Jan-06	8,720	13	83%		30-Jan-06	6,640	8	84%	
1974	17-Jan-74	37,400	16	82%	15-Jan-74	8,230	47	36%	A	15-Jan-74	3339	25	52%	A	15-Jan-74	8,440	14	82%		16-Jan-74	5,950	13	73%	
1949	18-Feb-49	36,500	17	78%	22-Feb-49	12,800	21	72%		17-Feb-49	4920	12	78%		17-Feb-49	6,950	26	65%						
1978	03-Dec-77	36,500	18	78%	02-Dec-77	8,130	50	32%	A	02-Dec-77	2782	35	32%	A	02-Dec-77	10,300	7	90%		02-Dec-77	7,170	7	86%	
1999	26-Nov-98	36,500	19	78%	25-Nov-98	14,726	17	78%		25-Nov-98	7419	5	92%		26-Nov-98	10,000	9	89%		26-Nov-98	3,328	29	36%	A

Historical Peak Flood data (see Excel)

Gage No.	12027500			
Gage Name	CHEHALIS RIVER NEAR GRAND MOUND, WA			
100-yr Flow	100-year Q	75,000		
Water Year	Date	Peak flow (cfs)	Rank	Percentile
2008	04-Dec-07	79,100	1	100%
1996	09-Feb-96	74,800	2	99%
1990	10-Jan-90	68,700	3	98%
1987	25-Nov-86	51,600	4	96%
2009	08-Jan-09	50,700	5	95%
1972	21-Jan-72	49,200	6	94%
1938	29-Dec-37	48,400	7	93%
1991	25-Nov-90	48,000	8	92%
1934	21-Dec-33	45,700	9	90%
1976	05-Dec-75	44,800	10	89%
1971	26-Jan-71	40,800	11	88%
1997	30-Dec-96	38,700	12	87%
1935	23-Jan-35	38,000	13	84%
1951	10-Feb-51	38,000	14	84%
2006	31-Jan-06	37,900	15	83%
1974	17-Jan-74	37,400	16	82%
1949	18-Feb-49	36,500	17	78%
1978	03-Dec-77	36,500	18	78%
1999	26-Nov-98	36,500	19	78%

Combined Flows from gages			
Doty + SF Chehalis		Skook + Newaukum	
Flow	ratio	Flow	ratio
73370	82%	16500	18%
38440	61%	24600	39%
31760	57%	23500	43%
29340	62%	17960	38%
23990	63%	14130	37%
13140	47%	15020	53%
23080	60%	15360	40%
11570	45%	14390	55%
10910	38%	17470	62%
22150	62%	13330	38%

Historical Mean Daily Flows

A	CHEHALIS RIVER			CHEHALIS RIVER					SOUTH FORK CHEHALIS RIVER					NEWAUKUM RIVER					SKOOKUMCHUCK RIVER				
B	GRAND MOUND, WA			DOTY, WA					BOISTFORT, WA					CHEHALIS, WA					BUCODA, WA				
C	FLOW			FLOW					FLOW					FLOW					FLOW				
E																							
F	USGS - WY			USGS - WY					USGS - WY					USGS - WY					USGS - WY				
Units	cfs			cfs					cfs					cfs					cfs				
Type	INST-VAL	Rank	Percentile	INST-VAL	% of GM	Rank	Percentile	0.15	INST-VAL	% of GM	Rank	Percentile	0.15	INST-VAL	% of GM	Rank	Percentile	0.15	INST-VAL	% of GM	Rank	Percentile	0.15
10Feb1996 0000	64200	1	1.000	19200	30%	2	0.986							10200	16%	4	0.958		8560	13%	1	1	
05Dec2007 0000	61900	2	0.988	27500	44%	1	1		13790	22%	1	1		10300	17%	3	0.972		2810	5%	55	0.285	A
11Jan1990 0000	58500	3	0.976	16400	28%	3	0.972							7170	12%	12	0.847		7120	12%	7	0.922	
30Dec1937 0000	46300	4	0.964																				
26Nov1986 0000	46000	5	0.952	11400	25%	10	0.876							9720	21%	5	0.944		4530	10%	25	0.688	A
22Dec1933 0000	45000	6	0.940																				
10Jan2009 0000	41600	7	0.928	12700	31%	6	0.931		8510	20%	2	0.974		11200	27%	1	1		8130	20%	2	0.987	
23Jan1972 0000	41100	8	0.916	14700	36%	4	0.958		4230	10%	8	0.82		7220	18%	11	0.861		7170	17%	6	0.935	
06Dec1975 0000	39100	9	0.904	10300	26%	14	0.794		4430	11%	7	0.846		7020	18%	13	0.833		5790	15%	11	0.87	
26Nov1990 0000	38400	10	0.892	13400	35%	5	0.945							7350	19%	10	0.875		7190	19%	5	0.948	
24Jan1935 0000	36300	11	0.880																				
27Jan1971 0000	36100	12	0.869	6530	18%	38	0.493	A	3000	8%	14	0.666	A	6690	19%	14	0.819		6090	17%	9	0.896	
01Feb2006 0000	35500	13	0.857	11200	32%	11	0.849		4890	14%	5	0.897		7750	22%	8	0.902		4910	14%	19	0.766	
18Jan1974 0000	35000	14	0.833	7440	21%	27	0.643	A	2680	8%	18	0.538	A	6230	18%	18	0.763		5250	15%	12	0.857	
01Jan1997 0000	35000	14	0.833	6790	19%	33	0.561	A						7390	21%	9	0.888		7430	21%	4	0.961	
24Feb1949 0000	34800	16	0.821	10800	31%	13	0.835		2590	7%	20	0.512	A	5450	16%	25	0.666	A	5050	15%	17	0.792	
22Dec1994 0000	33400	17	0.809	11500	34%	9	0.89							3200	10%	59	0.166	A	3580	11%	40	0.493	A
11Feb1951 0000	33100	18	0.797	12600	38%	7	0.917							4200	13%	45	0.388	A	4760	14%	21	0.74	
27Jan1964 0000	32800	19	0.785	7950	24%	23	0.698		3740	11%	11	0.743		6530	20%	15	0.805		7740	24%	3	0.974	A

Historical Mean Daily Flows

	A	CHEHALIS RIVER							
	B	GRAND MOUND, WA							
	C	FLOW							
	E								
	F	USGS - WY				Combined Flows from gages			
	Units	cfs				Doty + SF Chehalis		Skook + Newaukum	
	Type	INST-VAL	Rank	Percentile		Flow	ratio	Flow	ratio
10Feb1996	0000	64200	1	1.000					
05Dec2007	0000	61900	2	0.988		41290	76%	13110	24%
11Jan1990	0000	58500	3	0.976					
30Dec1937	0000	46300	4	0.964					
26Nov1986	0000	46000	5	0.952					
22Dec1933	0000	45000	6	0.940					
10Jan2009	0000	41600	7	0.928		21210	52%	19330	48%
23Jan1972	0000	41100	8	0.916		18930	57%	14390	43%
06Dec1975	0000	39100	9	0.904		14730	53%	12810	47%
26Nov1990	0000	38400	10	0.892					
24Jan1935	0000	36300	11	0.880					
27Jan1971	0000	36100	12	0.869		9530	43%	12780	57%
01Feb2006	0000	35500	13	0.857		16090	56%	12660	44%
18Jan1974	0000	35000	14	0.833		10120	47%	11480	53%
01Jan1997	0000	35000	14	0.833					
24Feb1949	0000	34800	16	0.821		13390	56%	10500	44%
22Dec1994	0000	33400	17	0.809					
11Feb1951	0000	33100	18	0.797					
27Jan1964	0000	32800	19	0.785		11690	45%	14270	55%

Basin Areas

Basin	Area (sq. mi.)	Gage No. (if applicable)
Chehalis at Doty	114	12020000
Elk Creek	47	12020500
SF Chehahlis at Wildwood	27	12020800
SF Chehalis at Boistfort	48	12021000
Newaukum near Chehalis	156	12025000
Salzer Creek near Centralia	13	12025300
Skookumchuck near Bucoda	112	12026400
Chehalis near Grand Mound	898	12027500
Rock Creek at Cedarville	25	12030000
Chehalis at Porter	1,298	12031000
Cloquallum Creek at Elma	66	12032500
Satsop River	297	12035000
Wynochee River above Black Creek	154	12037400
Chehalis River at Mouth	2,117	N/A
Proposed Dam Site	69	N/A
Chehalis below Thrash Creek	40	N/A
Chehalis above Rogers	44	N/A
Thrash Creek	7	N/A
Lester AND Crim Creek	12	N/A