TECHNICAL MEMO

Date: October 16, 2013

To: Kyle Heaton, Port of Centralia

From: John Howard and Henry Hu

RE: **Port of Centralia Floodplain Development Hydraulic Impact Analysis**

WEST Consultants, Inc. (WEST) is currently working on a floodplain hydraulic impact analysis for a proposed future development of Port of Centralia Park 3 (Park 3), which is located within the floodplain of the Chehalis River in Centralia, WA.

A. Executive Summary

This technical memo describes the hydraulic analysis for the existing and proposed conditions of the Chehalis River, and the effect of the proposed future development of the Park 3 project, Centralia Station, on flows and water surface elevations at the project site and in surrounding areas.

The 100- and 500- year flows from the preliminary FEMA FIS HEC-RAS model and the most recent geometry from the Baseline Conditions HEC-RAS model developed for the U.S. Army Corps of Engineers, the Chehalis River Basin Flood Authority, and WSDOT were used to develop the existing conditions model.

The modeling results show that there is no rise in the water surface elevation during a 100- or 500-year flood event from the proposed future development of the Park 3 project site, Centralia Station. Adjacent to the Park 3 storage area, the maximum increase in the water surface elevation is only 0.01 feet and there is nearly no change in the discharges at most locations.

B. Background Information regarding Flood Model

WEST began its floodplain hydraulic impact analysis by requesting the effective Flood Insurance Study (FIS) model for the Chehalis River from the FEMA Engineering Library. Unfortunately, FEMA was not able to provide any geometry data for the vicinity of Park 3.

WEST then turned to the unsteady-flow Hydrologic Engineering Center River Analysis System (HEC-RAS) Flood Insurance Study (FIS) model for the Chehalis River generated by Northwest Hydraulic Consultants (NHC) in 2009 for the portion of the Chehalis River from Doty to Porter. (NHC's preliminary FIS is currently on hold due to pending changes in FEMA's specifications and guidelines for modeling levees.)

WEST, Watershed Science and Engineering (WSE), and NHC made several updates and modifications to NHC's preliminary FIS model, including incorporating updated LiDAR (topographic) data from 2006. This work was a collaborative effort to update and expand the model for the Seattle District Corps of Engineers, the Chehalis River Basin Flood Authority, and the Washington State Department of Transportation (WSDOT). WEST and WSE developed a Baseline Conditions model, which incorporates WSDOT's work along I-5, known as I-5 Mellen Street to Blakeslee Junction Project, including a dike for flood control. The Baseline Conditions geometry represents the most complete, recent, and accurate representation of the Chehalis River system.

C. Analysis of the Effects of Potential Future Development of Park 3

To evaluate any potential hydraulic impacts from the proposed development of the Park 3 project, WEST developed an existing conditions unsteady-flow HEC-RAS model using NHC's preliminary FIS hydrology and the channel and overbank geometry from the Baseline Conditions model. The geometry in the Baseline Conditions model represents the existing conditions of the system. WEST then modified the existing conditions model to incorporate the proposed development of the Park 3 project using the grading plan provided by the Port of Centralia. WEST compared the existing conditions results of the 100- and 500-year floods to the conditions assuming development of the Park 3 project. WEST did not model conditions at less than the 100-year flood because under either existing conditions or developed conditions, floodwaters do not reach the Park 3 project site during a 10- or 50-year flood event.

1. Geometry

The Park 3 project site and surrounding area was modeled as storage in the HEC-RAS model (Storage Area 5, (SA 5)). The trapezoidal area shown in Figure 1 is bordered on the west by Interstate 5 (I-5), on the north by Alder Street, on the south by a dike, and, on the east by the continuation of the dike and the railroad grade. Under the existing conditions, during a major flood, such as the 100- and 500-year events, flood waters of the Chehalis River will spill into the right overbank and also into Salzer Creek, just upstream of Park 3, and then further split into the storage areas between Salzer Creek and the Chehalis River, including SA 5. If the water surface elevation in the storage area is high enough, it can then travel back into the Chehalis River to the west and other storage areas to the north. Therefore, the Park 3 storage area hydraulically functions like a pond. This was confirmed by John Howard of WEST during his field reconnaissance on July 27, 2012.

Figure 2 shows the grading and development plan. The proposed development of Park 3 consists of raising part of the storage area above the 100-year water surface elevations for development and creating one pond to the east of the fill area and one pond at a location south of the fill. Figure 1 shows the locations of these changes. Although the new ponds will provide some compensatory storage during a flood event, for purposes of a conservative analysis, WEST assumed no compensatory flood storage from the ponds. Additionally, the Park 3 storage area will continue to hydraulically function like a pond because the boundaries that surround the storage area will remain unchanged.

As a sensitivity analysis, WEST also considered partial failure of the center traffic barriers installed along I-5 (Figure 3). This actually occurred during the December 2007 flood event as shown in Figure 4. Flood water breached the traffic barriers and crossed I-5.

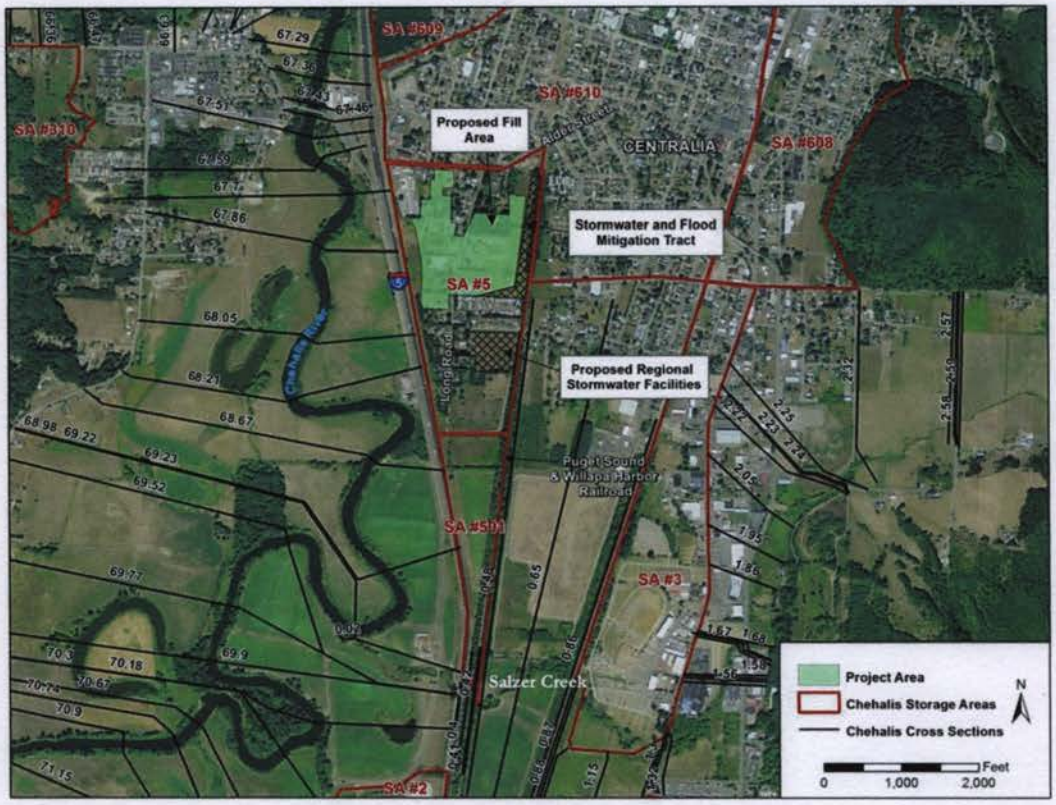

Figure 1. Proposed Park 3 development project location.

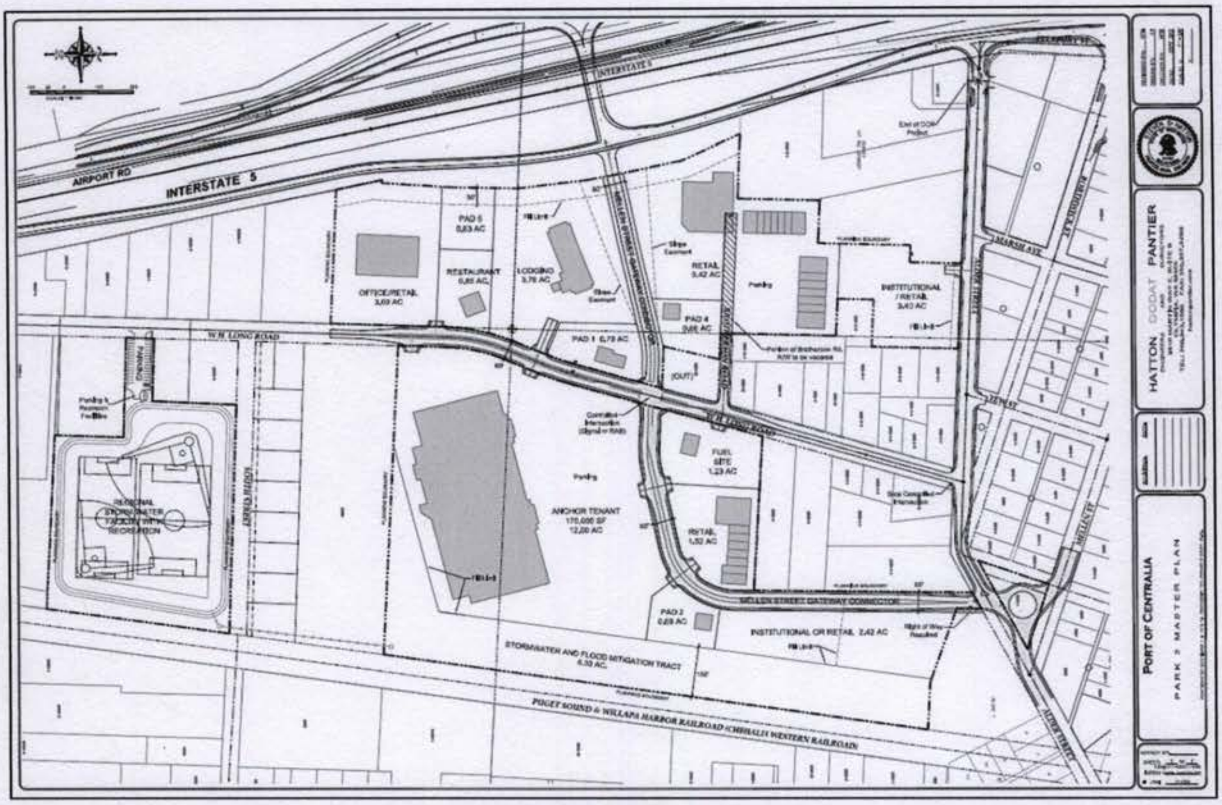

Figure 2. Grading plan of Park3 development project.

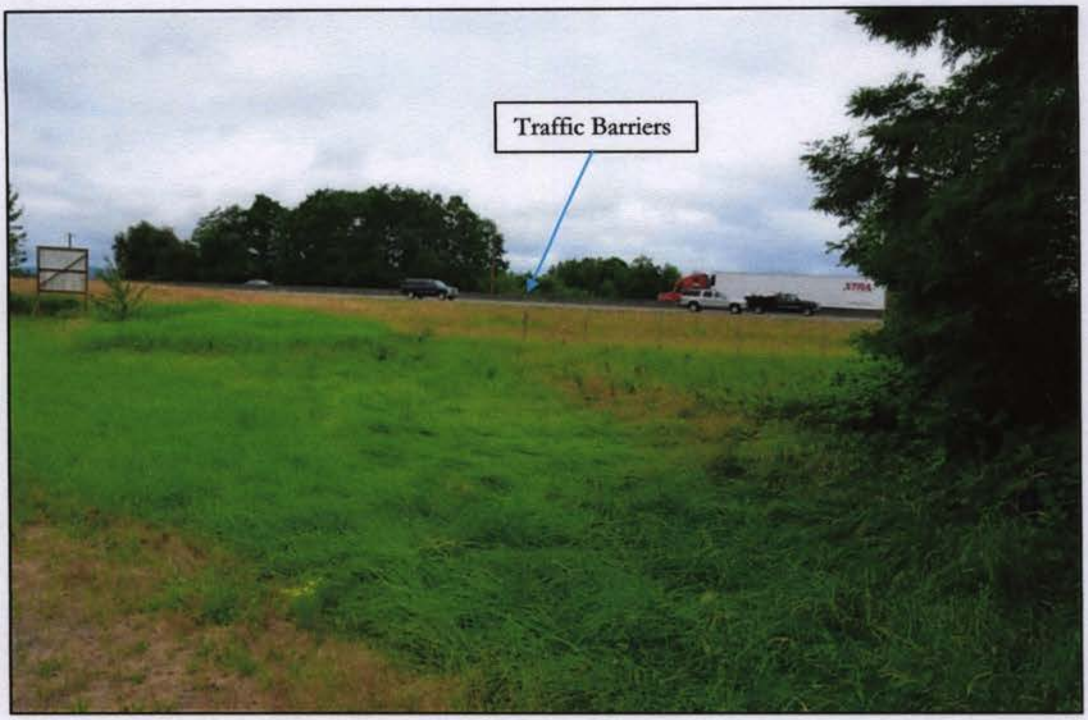

Figure 3. Center barriers along I-5.

Figure 4. Barrier breach during December 2007 flood event.

2. Hydraulic Results

The model results for the existing and proposed conditions were compared to evaluate project impacts from the proposed development of the Park 3 project. The impacts evaluated include the maximum water surface elevations and discharges within and adjacent to the project area for the 100- and 500-year flood events. In addition, flow velocity in the area adjacent to the proposed fill area was also evaluated for the 100-year proposed conditions.

2.1 Water Surface Elevations and Discharges

Figure 5 through Figure 8 show the maximum net inflow to Storage Area 5 and water surface elevations in the vicinity of Storage Area 5 for the existing and proposed conditions. The arrows indicate the direction of flow. If there is an increase in flow or stage from the existing to proposed conditions, the amount of change is noted in parentheses. Note that the results with the traffic barriers both in place and breached are presented.

Table 1 summarizes the maximum water surface elevations in Storage Area 5 for various scenarios. Table 2 and Table 3 summarize the existing and proposed conditions maximum water surface elevations and maximum flows in the surrounding area during the 100- and 500-year flood events. The locations reported in Table 2 and Table 3 are shown in Figure 9, and include the storage areas, lateral structures (LS), connectors (CON), and river stations (RS) along the Chehalis River and the right (looking downstream) overbank of Salzer Creek that are adjacent to the Park 3 storage area. The results show that there is no rise in the water surface elevations in Storage Area 5 for any modeling scenarios. Outside Storage Area 5, the greatest increase in the water surface elevations is 0.01 feet and there is nearly no change in the discharges at most locations. The greatest increase in the discharge is about 7 %, which occurred at RS 0.65 for the 100-year flood event assuming the failure of the traffic barriers.

Table 1. Changes in Peak Stages and Net Inflow in the Park 3 Storage Area

Event	Scenario	Peak Stage (feet, NAVD88)			Peak Net Inflow (cfs)		
		Existing	Proposed	Change	Existing	Proposed	Change
100-Year	Traffic barriers in place	178.62	178.62	0.0	1,131	861	-270
	Traffic barriers breached	178.70	178.70	0.0	1,183	878	-305
500-Year	Traffic barriers in place	183.56	183.56	0.0	2,084	2,194	110
	Traffic barriers breached	183.63	183.63	0.0	2,272	1,842	-430

Table 2. 100-year Peak Stage and Net Inflow/Discharge outside the Park 3 Storage Area

Location	Scenario	Peak Stage (feet, NAVD88)			Peak Flow/Net Inflow (cfs)			
		Existing	Proposed	Change	Existing	Proposed	Change	%Change
RS 69.23	Traffic barriers in place	181.01	181.01	0	68,770	68,754	-16	-0.023
RS 68.98	Traffic barriers in place	180.97	180.97	0	68,682	68,681	-1	-0.001
RS 68.67	Traffic barriers in place	180.90	180.90	0	68,635	68,635	0	0.000
RS 68.21	Traffic barriers in place	180.80	180.81	0.01	68,599	68,601	2	0.003

Location	Scenario	Peak Stage (feet, NAVD88)			Peak Flow/Net Inflow (cfs)			
		Existing	Proposed	Change	Existing	Proposed	Change	%Change
RS 68.05	Traffic barriers in place	180.75	180.75	0	68,568	68,570	2	0.003
RS 67.86	Traffic barriers in place	180.32	180.32	0	68,511	68,515	4	0.006
RS 67.7	Traffic barriers in place	180.01	180.01	0	68,488	68,492	4	0.006
RS 67.59	Traffic barriers in place	179.73	179.73	0	68,471	68,476	5	0.007
RS 67.51	Traffic barriers in place	179.21	179.21	0	68,463	68,468	5	0.007
RS 67.46	Traffic barriers in place	178.48	178.48	0	68,460	68,465	5	0.007
RS 67.43	Traffic barriers in place	178.36	178.37	0.01	68,460	68,465	5	0.007
SA 610	Traffic barriers in place	177.93	177.94	0.01	13,680	13,724	44	0.322
SA 501	Traffic barriers in place	181.72	181.72	0	614	614	0	0.000
CON 55	Traffic barriers in place	--	--	--	0	0	0	0.000
CON 39	Traffic barriers in place	178.62	178.62	0	3,763	3,778	15	0.399
LS 0.8	Traffic barriers in place	181.74	181.74	0	2,780	2,784	4	0.144
LS 0.475	Traffic barriers in place	181.75	181.75	0	3,778	3,788	10	0.265
LS 68.5	Traffic barriers in place	--	--	--	--	--	--	--
LS 68.13	Traffic barriers in place	--	--	--	--	--	--	--
LS67.955	Traffic barriers in place	--	--	--	--	--	--	--
RS 0.48	Traffic barriers in place	181.75	181.75	0	2,862	2,866	4	0.140
RS 0.65	Traffic barriers in place	181.74	181.74	0	3,252	3,295	43	1.322
RS 69.23	Traffic barriers breached	180.99	180.99	0	68,876	68,793	-83	-0.121
RS 68.98	Traffic barriers breached	180.95	180.95	0	68,791	68,732	-59	-0.086
RS 68.67	Traffic barriers breached	180.88	180.88	0	68,744	68,683	-61	-0.089
RS 68.21	Traffic barriers breached	180.79	180.78	-0.01	68,417	68,355	-62	-0.091
RS 68.05	Traffic barriers breached	180.73	180.73	0	68,387	68,325	-62	-0.091
RS 67.86	Traffic barriers breached	180.31	180.30	-0.01	68,332	68,269	-63	-0.092
RS 67.7	Traffic barriers breached	180.00	179.99	-0.01	68,309	68,245	-64	-0.094
RS 67.59	Traffic barriers breached	179.71	179.71	0	68,293	68,229	-64	-0.094
RS 67.51	Traffic barriers breached	179.20	179.20	0	68,285	68,221	-64	-0.094
RS 67.46	Traffic barriers breached	178.47	178.47	0	68,282	68,218	-64	-0.094
RS 67.43	Traffic barriers breached	178.36	178.36	0	68,282	68,218	-64	-0.094
SA 610	Traffic barriers breached	178.01	178.00	-0.01	14,108	14,072	-36	-0.255
SA 501	Traffic barriers breached	181.71	181.70	-0.01	614	613	-1	-0.163
CON 55	Traffic barriers breached	--	--	--	--	--	--	--
CON 39	Traffic barriers breached	178.70	178.70	0	4,032	4014	-18	-0.446
LS 0.8	Traffic barriers breached	181.73	181.73	0	2,770	2,762	-8	-0.289
LS 0.475	Traffic barriers breached	181.74	181.73	-0.01	3,752	3,730	-22	-0.586
LS 68.5	Traffic barriers breached	180.85	180.84	-0.01	295	293	-2	-0.678
LS 68.13	Traffic barriers breached	--	--	--	--	--	--	--
LS67.955	Traffic barriers breached	--	--	--	--	--	--	--
RS 0.48	Traffic barriers breached	181.74	181.73	-0.01	2,867	2,833	-34	-1.186
RS 0.65	Traffic barriers breached	181.73	181.73	0	3,168	3,380	212	6.692

Table 3. 500-year Peak Stage and Net Inflow/Discharge outside the Park 3 Storage Area

Loca-	Scenario	Peak Stage (feet, NAVD88)	Peak Flow/Net Inflow (cfs)

tion		Existing	Proposed	Change	Existing	Proposed	Change	%Change
RS 69.23	Traffic barriers in place	184.24	184.24	0	80,847	80,817	-30	-0.037
RS 68.98	Traffic barriers in place	184.20	184.21	0.01	84,219	84,209	-10	-0.012
RS 68.67	Traffic barriers in place	184.14	184.14	0	88,288	88,287	-1	-0.001
RS 68.21	Traffic barriers in place	184.06	184.07	0.01	85,137	85,131	-6	-0.007
RS 68.05	Traffic barriers in place	184.02	184.02	0	84,960	84,954	-6	-0.007
RS 67.86	Traffic barriers in place	183.63	183.63	0	84,322	84,318	-4	-0.005
RS 67.7	Traffic barriers in place	183.36	183.36	0	84,172	84,169	-3	-0.004
RS 67.59	Traffic barriers in place	183.10	183.11	0.01	84,062	84,059	-3	-0.004
RS 67.51	Traffic barriers in place	182.61	182.61	0	84,000	83,998	-2	-0.002
RS 67.46	Traffic barriers in place	181.77	181.77	0	83,974	83,972	-2	-0.002
RS 67.43	Traffic barriers in place	181.22	181.22	0	83,974	83,972	-2	-0.002
SA 610	Traffic barriers in place	183.42	183.42	0	63,074	63,105	31	0.049
SA 501	Traffic barriers in place	184.35	184.35	0	640	645	5	0.781
CON 55	Traffic barriers in place	184.35	184.35	0	4,372	4375	3	0.069
CON 39	Traffic barriers in place	183.56	183.56	0	28,028	28,049	21	0.075
LS 0.8	Traffic barriers in place	184.41	184.42	0.01	7,569	7,573	4	0.053
LS 0.475	Traffic barriers in place	184.42	184.42	0	16,604	16611	7	0.042
LS 68.5	Traffic barriers in place	184.11	184.11	0	6,807	6,812	5	0.073
LS 68.13	Traffic barriers in place	184.06	184.07	0.01	13	13	0	0.000
LS67.955	Traffic barriers in place	184.02	184.02	0	457	445	-12	-2.626
RS 0.48	Traffic barriers in place	184.42	184.42	0	3,098	3,092	-6	-0.194
RS 0.65	Traffic barriers in place	184.41	184.42	0.01	6,188	6,185	-3	-0.048
RS 69.23	Traffic barriers breached	184.17	184.17	0	81,690	81,666	-24	-0.029
RS 68.98	Traffic barriers breached	184.14	184.14	0	85,266	85,239	-27	-0.032
RS 68.67	Traffic barriers breached	184.08	184.08	0	89,223	89,204	-19	-0.021
RS 68.21	Traffic barriers breached	184.00	184.00	0	84,472	84,449	-23	-0.027
RS 68.05	Traffic barriers breached	183.95	183.95	0	84,273	84,255	-18	-0.021
RS 67.86	Traffic barriers breached	183.57	183.57	0	83,623	83,612	-11	-0.013
RS 67.7	Traffic barriers breached	183.31	183.31	0	83,453	83,447	-6	-0.007
RS 67.59	Traffic barriers breached	183.05	183.06	0.01	83,328	83,326	-2	-0.002
RS 67.51	Traffic barriers breached	182.56	182.57	0.01	83,259	83,259	0	0.000
RS 67.46	Traffic barriers breached	181.74	181.74	0	83,231	83,232	1	0.001
RS 67.43	Traffic barriers breached	181.21	181.21	0	83,231	83,232	1	0.001
SA 610	Traffic barriers breached	183.48	183.49	0.01	63,874	63,898	24	0.038
SA 501	Traffic barriers breached	184.30	184.30	0	676	668	-8	-1.183
CON 55	Traffic barriers breached	184.30	184.30	0	4,240	4,244	-4	-0.094
CON 39	Traffic barriers breached	183.63	183.63	0	28,801	28,817	16	0.056
LS 0.8	Traffic barriers breached	184.38	184.37	-0.01	7,394	7,398	4	0.054
LS 0.475	Traffic barriers breached	184.38	184.38	0	16,245	16,251	6	0.037
LS 68.53	Traffic barriers breached	184.05	184.05	0	8,085	8,090	5	0.062
LS 68.13	Traffic barriers in place	184.00	184.00	0	5	5	0	0.000
LS67.955	Traffic barriers breached	183.95	183.95	0	400	401	1	0.250
RS 0.48	Traffic barriers breached	184.38	184.38	0	3,088	3,088	0	0.000
RS 0.65	Traffic barriers breached	184.37	184.37	0	5,744	5,744	0	0.000

2.2 Velocity Distribution for the Proposed Condition

As shown in Figure 1 and Figure 2, a significant portion of the floodplain in the storage area will be filled above the 100-year water surface elevations. Under the existing conditions, during the 100-year flood event, flood water will enter the storage area from the southeast and fill up the area. When the elevation in the storage reaches the lowest ground elevation at the north end along Alder Street, water starts to spill over Alder Street to the north. The velocities for the existing conditions in the storage area would vary between 0.6 to 1.5 feet per second. For the proposed conditions, to maintain a similar flow pattern through the Park 3 development site, there are two vegetated paths through which the floodplain surrounding the fill area will be connected, including:

a. Between I-5 and west side of the fill, and
b. Adjacent to Puget Sound & Willapa Harbor Railroad.

Figure 5 shows that the maximum flow across Alder Street from Storage Area 5 to Storage Area 610 is 3,778 cfs for the 100-year proposed conditions. Using the flow area of the path adjacent to the railroad track, the discharge of 3,778 cfs, and the water surface elevation of 178.62 feet in the storage area, WEST estimated the flow velocity in the eastern flow path. The mild velocities for this flow path range from 1.22 to 3.37 feet per second. Vegetation-lined channels or fields are adequate to prevent erosion at these mild velocities (King County, 2009).

Because the natural ground elevations at the north end of the western flow path between I-5 and the west side of the fill area are at about or even higher than the maximum water surface elevation of 178.62 feet, the flow path along I-5 functions like a storage area, not a conveyance reach. Therefore, the velocities along the west path are very low and should be smaller than those for the existing conditions.

D. <u>Summary</u>

The 100- and 500-year flows from the preliminary FEMA FIS HEC-RAS model and the most recent geometry from the Baseline Conditions HEC-RAS model developed for the U.S. Army Corps of Engineers, the Chehalis River Basin Flood Authority, and WSDOT were used to develop the existing conditions model. The Park 3 project site and surrounding area was modeled as a storage area in the HEC-RAS model as it functions like a pond. The only difference between the existing and proposed conditions models is the volume-elevation curves for the storage in the Park 3 area. The fill volume for the proposed conditions removes about 18 % of the capacity of the storage area at the base flood elevation of 178.62 feet. Because the amount of water entering and leaving the storage area is controlled by the boundaries that surround the storage area and these boundaries remain unchanged, the changes in the hydraulic results from the existing to proposed conditions are not expected to be significant.

The modeling results confirm that the impact from the proposed future development of the Park 3 area within and adjacent to the project area is negligible. There is no rise in the water surface elevation within the project area during the 100- or 500-year flood event as a result of the proposed future development of the Park 3 area. Adjacent to the project area, the maximum increase in the water surface elevation is only 0.01 feet and there is nearly no change in the discharges at most locations. In addition, for the proposed conditions, flood water would go through and exit the storage area in a pattern similar to the existing conditions. For the 100-year flood event, the velocities through the eastern conveyance path are less than 3.5 feet per second and likely smaller than existing conditions for the western path. Erosion is not expected for these vegetation-lined areas.

E. References

King County (2009). Surface Water Design Manual. Department of Natural Resources and Parks, January 9, 2009.

Figure 5. Hydraulic results for the 100-year event assuming traffic barriers in place.

Figure 6. Hydraulic results for the 100-year event assuming traffic barriers breached.

Figure 7. Hydraulic results for the 500-year event assuming traffic barriers in place.

Figure 8. Hydraulic results for the 500-year event assuming traffic barriers breached.

Figure 9. Modeled hydraulic features.