Nelson Dam Project/Power House Bridge Project
Task 4: Final Report

Yakima County

Task 4 Final Report
October 2011

Nelson Dam Project/Power House Bridge Project

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PURPOSE OF MEMORANDUM

The project goals were to evaluate the sensitivity of predicted maximum water surface elevations (WSE) on the Naches River in the vicinity of Nelson Dam to changes in infrastructure and removal of sediment and bed materials. This feasibility level study is meant to provide a comparative analysis of the hydraulic conditions of this reach of the Naches River during the 100YR flood discharges, under a variety of different conditions.

The WSE sensitivities were evaluated to determine if there is a feasible configuration of infrastructure improvements and increases in hydraulic conveyance by means of sediment removal that would sufficiently lower the predicted 100-year flood WSEs to allow the floodway to be confined to the main channel of the Naches River. Several modeling scenarios were evaluated to determine the changes in predicted WSE's due changes in infrastructure and changes in the cross-section geometry defined in the hydraulic model.

The purpose of this memorandum is to present the findings of the hydraulic analyses and report on and compare the observed changes in each scenario. The project objective of developing an alternative that would result in the 100-year flood being contained within the main channel of the Naches River and would remove necessary floodway conveyance area from the landward side of Highway 12 was not achieved. This memorandum will offer some explanation for the hydraulic constraints and control points that prevented this objective from being achieved and provide some ideas for additional analyses that could be performed towards containing the base flood and floodway conveyance areas to the main channel of the Naches River.

MODELED SCENARIOS

Several scenarios were modeled to evaluate the sensitivity of the water surface elevations to the removal of infrastructure and changes to cross-sectional geometries and conveyance areas that could potentially be achieved through the removal of sediment and bed material from the Naches River main channel. Figure 1 shows the locations of infrastructure in the study area. Figure 2 shows the location and alignment of lettered cross-sections within the study area. The project tasks and modeling scenarios executed under each task are summarized below.

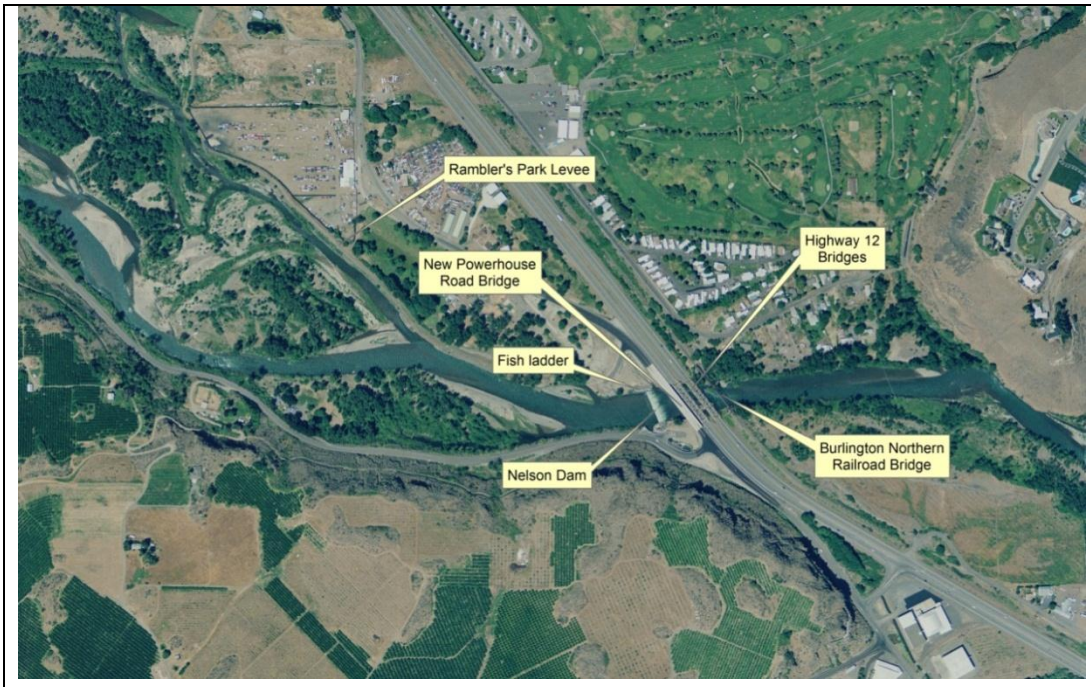

Figure 1 - Infrastructure Locations in Study Area

Figure 2 - Lettered Cross-Sections in Study Area

Task 1

The Task 1 model scenario was designed to represent the current existing conditions in the Naches River. The regulatory model, used for floodplain and floodway mapping was based on 2002 conditions. Since the development of the regulatory model, there have been changes to the infrastructure and topography in the mapped area. The most notable changes have been the removal of the old Power House Bridge, construction of the new Power House Road Bridge, and the ground surface elevation changes that were associated with the construction of the new road approaches and bridge abutments. Changes between the 2002 conditions and the current conditions are shown in Figure 3. The changes between the 2002 conditions and the current conditions will affect the hydraulics and predicted WSEs at higher flow events.

2002 Conditions

2008 Conditions

Figure 3 - Changes around Nelson Dam and Power House Road on the Naches River

Under Task 1, the regulatory model was updated to represent the current conditions. Within the study domain, the following features were identified as having changed since 2002: repairs made to the Ramblers Park Levee resulted in a change in its geometry, removal of the old Power House Bridge approaches, removal of the old Power House Bridge south abutment, access road, and construction of new Power House Bridge approaches and bridge abutments. The north abutment of the old Power House Road Bridge was not changed from the 2002 to the 2008 conditions; the north abutment has been left in place to protect the existing fish ladder. These changes were implemented in the Task 1 model to provide a new baseline of maximum WSEs predicted from the 100-year flood event. Appendix A provides a more detailed description of the Task 1 model edits.

Task 2 Scenario 1

The Task 2 Scenario 1 model runs were designed to evaluate the changes to predicted maximum WSEs for the 100-year flood event caused by the removal of infrastructure in the vicinity of the Powerhouse Road Bridge. The structures removed in the Task 2 Scenario 1 model edits are: Nelson Dam and the adjacent fish ladder, Westbound Highway 12 Bridge, Eastbound Highway 12 Bridge, Burlington Northern Railroad

Bridge, Ramblers Park Levee and the northern Old Powerhouse Road Bridge abutment. In addition to the removal of the listed structures, the impinging abutment materials from the removed bridges and low head Nelson Dam structures were also removed from the Task 2 Scenario 1 model. The rationale for this scenario was to examine the effects of removal of most of the infrastructure in the reach on conveyance of the 100 year flow. A more complete description of the model changes can be found in Appendix B – Task 2 Scenario 1 and Scenario 2 TM. These changes were implemented in the Task 2 Scenario 1 model to allow for an evaluation of the sensitivity of the modeled WSEs to the effects of the infrastructure.

Task 2 Scenario 2

The Task 2 Scenario 2 model runs were designed to evaluate the changes to predicted maximum WSEs for the 100-year flood event caused by the removal of sediment in the study area. Sediment removal was modeled to occur in the right overbank floodplain to return this area to a more natural floodplain elevation, and in the channel to reflect expected channel degradation if Nelson Dam were removed. The removal of sediment and bed materials from the Naches channel were implemented in the model by editing the cross-section geometries at the locations where the County defined sediment removal activities were likely to occur. Cross sections between model chainages 77572 and 81958 were edited. Figure 4 shows the location and alignment of the edited cross sections.

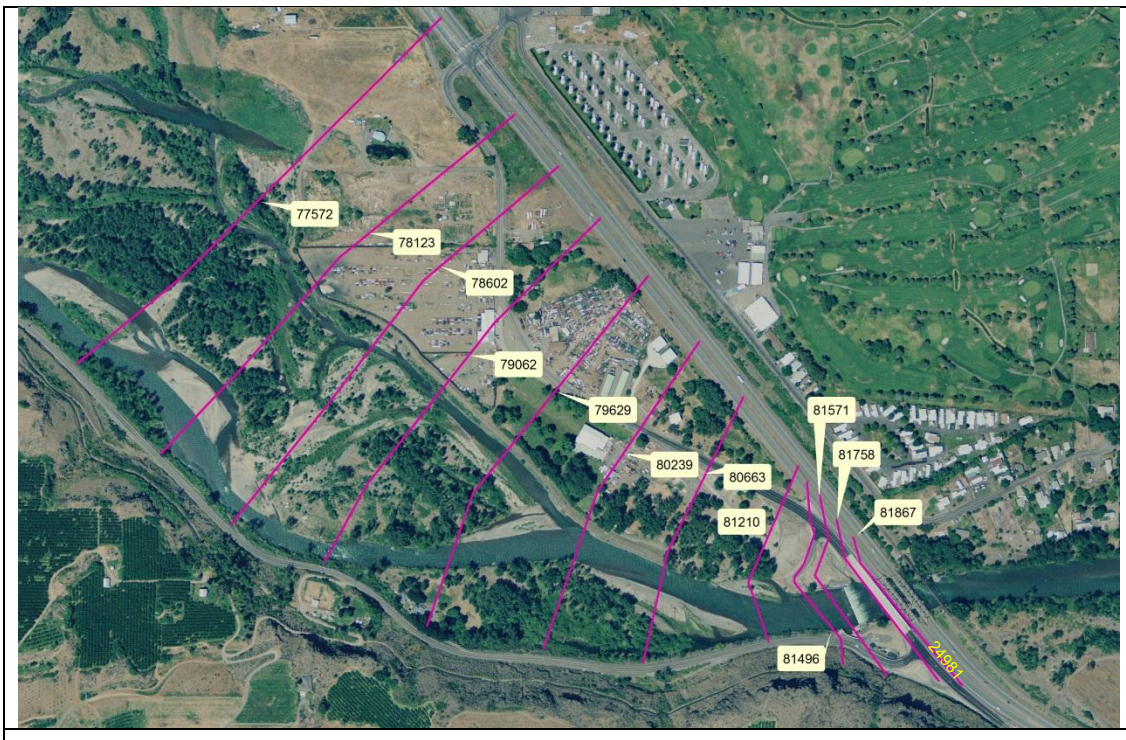

Figure 4- Cross section locations edited in the Task 2 Scenario 2 models

A more complete description of the model changes can be found in Appendix B – Task 2 Scenario 1 and Scenario 2 TM. These changes were implemented in the Task 2 Scenario 2 model to allow for an evaluation of the sensitivity of the modeled WSEs to the effects of an additional increase in hydraulic conveyance area upstream of the wider span of the new Powerhouse Road Bridge.

Task 2 Scenario 3

The Task 2 Scenario 3 model runs were designed to evaluate the changes to predicted maximum WSEs for the 100-year flood event caused by the removal of additional sediment and bed-materials in the study area. The rationale for this scenario is that channel conveyance has been reduced by aggradation of sediment in the channel, the County estimates roughly 30,000 cubic yards of sediment has contributed to channel aggradation. The current infrastructure configuration has contributed to aggradation through backwater and reduction in channel gradient, the removal of infrastructure would therefore initiate a channel response of bed degradation, and release of sediment downstream. This bed sediment could either be allowed to travel downstream, be removed by excavation or a combination of the two. Cross sections between model chainages 79062 and 81571 were edited. Figure 5 shows the location and alignment of the edited cross sections.

Figure 5 - Cross section locations edited in the Task 2 Scenario 3 models

A more complete description of the model changes can be found in Appendix C – Task 2 Scenario 3 TM. These changes were implemented in the Task 2 Scenario 3 model to allow for an evaluation of the sensitivity of the modeled WSEs to the effects of an increase in hydraulic conveyance area.

Task 3

The Task 3 model runs were designed to evaluate the changes to the predicted maximum WSEs for the 100-year flood event caused by the reinsertion of the Nelson Dam structure and the expected changes in cross-section geometries associated with the reintroduction of the low head dam. The MIKE 11 model was edited to update the cross section geometries between model chainages, 81210 and 81571. A more complete description of the model edits performed for Task 3 can be found in Appendix D – Task 3 TM.

Model Simulations

For each of the described project tasks, model simulations were performed to predict the water surface elevations for the base flood elevations conditions represented by unencroached cross sectional areas in the model, and the resulting water surface elevations from the floodway model runs represented by cross sectional areas that had been encroached to give a 1-foot rise compared to the without floodway baseline conditions.

For each task MIKE 11 model runs were performed to evaluate the change to the base flood elevations that would be expected during the 100-year flow event. Investigation of the floodway data table prepared for the FEMA flood mapping (DFIRM, effective September 2009) showed that in the study area there were 3 separate BFE's reported for the following conditions; Landward of Highway 12, Between Highway 12 and Left Levee, and Riverward of Levees. In order to compare the simulated BFEs from each task to the baseline regulatory conditions, these same three conditions were run for each task.

For the project tasks, two floodway simulations were run to determine the rise in the water surface elevation due to the encroachment of the conveyance area of the cross-sections. The first floodway simulation allowed overtopping of Highway 12 and floodway conveyance to the north of the highway. The second floodway simulation contained all flows within the main Naches River channel. The first floodway run was performed to evaluate any changes in water surface rise within the regulatory floodway, the second floodway scenario was performed to determine if the floodway could be confined to the main channel of the Naches River.

MODEL SIMULATION RESULTS

This section presents the model results within the project study domain for the simulated BFE and Floodway conditions.

Base Flood Elevation Simulations

The base flood elevation simulations represent the hydraulics from unencroached cross section geometries. In accordance with FEMA standards, three Base Flood Elevation (BFE) conditions were simulated, representing whether flood protection structures were assumed to have failed or not. There are three simulated conditions because there are two

land features that may provide flood protection in the study reach. The three simulated BFE conditions are:

Riverward of Levee – all land features that may provide flood protection are in place

Between Left Levee and Highway 12 – assumes Rambler's Park Levee has failed, but Highway 12 may still provide flood protection

Landward of Highway 12 – assumes both Rambler's Park Levee and Highway 12 have failed.

Each of these conditions is described in more detail below.

Simulated BFE Riverward of Levee

The simulated BFE Riverward of the Levee model condition assumes that, unless specifically removed as described in the model scenarios above, all structures are in place and have not failed. In those cases where the levee was removed, the BFE Riverward of Levee simulations were still performed; the result is the predicted water surface elevation may match the simulated BFE for the Between the Highway 12 and Left Levee simulation results. Consequently, the simulated BFE Riverward of the Levee is the most conservative condition and results in the highest prediction of water surface elevations. The model results for the Riverward Scenario from the different tasks are shown in tabular and graphical form in Table 1 and Figure 6, respectively. Table 2 shows the resulting base flood elevation differences from the Regulatory Model results for the Riverward Model simulations.

Table 1 - Base Flood Elevations, Riverward Model Simulations

FLOODING SOURCE			BASE FLOOD ELEVATIONS (NAVD88 ft) - RIVERWARD CONDITION					
FIS Cross Section	FIS Distance (ft)	Model Chainage (ft)	Regulatory Model	Task 1	Task 2 Scenario 1	Task 2 Scenario 2	Task 2 Scenario 3	Task 3
N	17,254	84,567	1163.4	1163.4	1163.4	1163.4	1163.4	1163.4
O	19,219	82,602	1170.3	1170.3	1170.3	1170.3	1170.3	1170.3
P	19,695	82,126	1173.3	1173.3	1173.3	1173.3	1173.3	1173.3
Q	19,863	81,958	1175.9	1175.8	1174.0	1174.0	1174.0	1174.0
R	19,954	81,867	1177.4	1177.4	1174.2	1174.2	1174.2	1174.2
S	20,063	81,758	1178.3	1178.9	1175.8	1175.8	1175.8	1175.8
T	20,250	81,571	1179.2	1179.9	1176.0	1176.0	1176.3	1178.4
U	20,611	81,210	1181.0	1181.0	1178.1	1178.0	1177.9	1179.5
V	21,582	80,239	1185.6	1184.2	1183.5	1183.5	1183.0	1183.3
W	22,759	79,062	1190.4	1189.5	1188.4	1187.9	1187.2	1187.2
X	24,249	77,572	1197.5	1197.4	1197.0	1196.0	1196.0	1196.0
Y	25,637	76,184	1205.0	1205.0	1205.0	1204.4	1204.4	1204.4
Z	26,838	74,983	1210.2	1210.1	1210.1	1208.5	1208.5	1208.5
AA	27,566	74,255	1214.8	1214.8	1214.8	1212.9	1212.9	1212.9
AB	30,876	70,945	1233.7	1233.7	1233.7	1233.7	1233.7	1233.7
AC	32,107	69,714	1240.8	1240.8	1240.8	1240.8	1240.8	1240.8

Table 2 - Base Flood Elevation Differences, Riverward Model Simulations

FLOODING SOURCE			BASE FLOOD ELEVATION DIFFERENCES (NAVD88 ft) - RIVERWARD CONDITION					
FIS Cross Section	FIS Distance (ft)	Model Chainage (ft)	Regulatory Model	Task 1	Task 2 Scenario 1	Task 2 Scenario 2	Task 2 Scenario 3	Task 3
N	17,254	84,567	--	0.0	0.0	0.0	0.0	0.0
O	19,219	82,602	--	0.0	0.0	0.0	0.0	0.0
P	19,695	82,126	--	0.0	0.0	0.0	0.0	0.0
Q	19,863	81,958	--	-0.1	-1.9	-1.9	-1.9	-1.9
R	19,954	81,867	--	0.0	-3.2	-3.2	-3.2	-3.2
S	20,063	81,758	--	0.6	-2.5	-2.5	-2.5	-2.5
T	20,250	81,571	--	0.7	-3.2	-3.2	-2.9	-0.8
U	20,611	81,210	--	0.0	-2.9	-3.0	-3.1	-1.5
V	21,582	80,239	--	-1.4	-2.1	-2.1	-2.6	-2.3
W	22,759	79,062	--	-0.9	-2.0	-2.5	-3.2	-3.2
X	24,249	77,572	--	-0.1	-0.5	-1.5	-1.5	-1.5
Y	25,637	76,184	--	0.0	0.0	-0.6	-0.6	-0.6
Z	26,838	74,983	--	-0.1	-0.1	-1.7	-1.7	-1.7
AA	27,566	74,255	--	0.0	0.0	-1.9	-1.9	-1.9
AB	30,876	70,945	--	0.0	0.0	0.0	0.0	0.0
AC	32,107	69,714	--	0.0	0.0	0.0	0.0	0.0

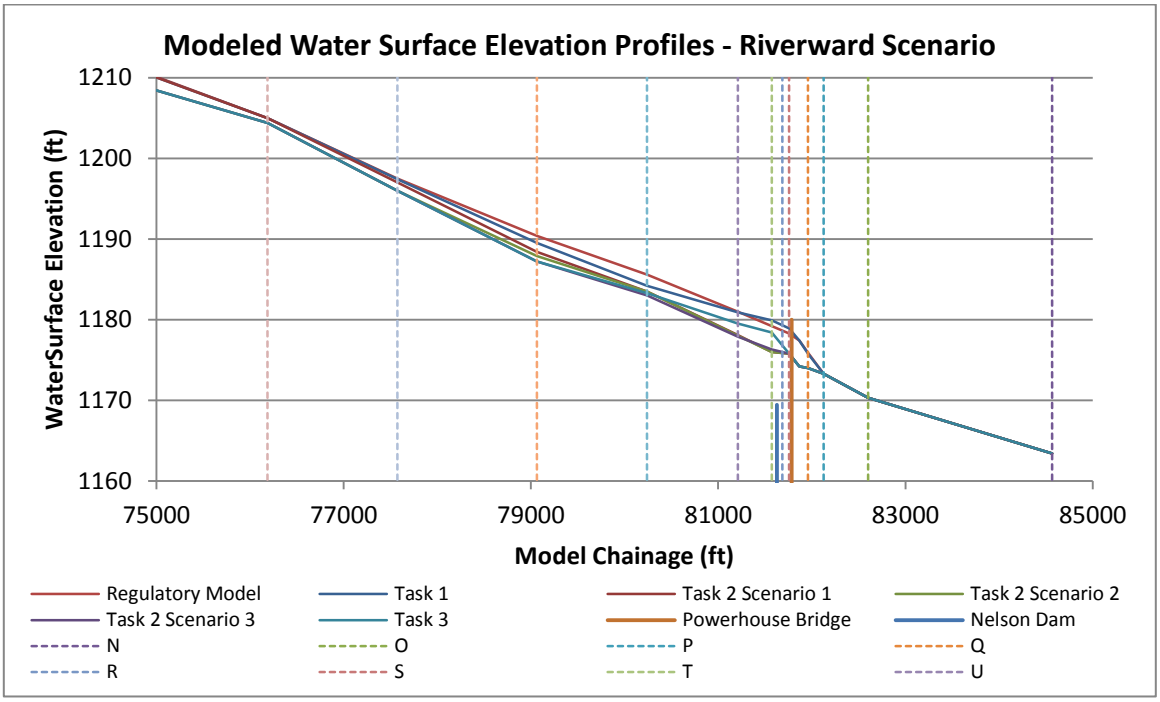

Figure 6 - Water Surface Elevation Profiles, Riverward Model Simulations

The Riverward condition results in overtopping of Highway 12 at two locations. The downstream overtopping location is near the new Powerhouse Road and Highway 12 bridge crossings. The upstream overtopping location is near lettered cross section AC approximately six miles upstream of the Naches River's confluence with the Yakima River. The predicted water surface elevations at the upstream and downstream overtopping locations each of the different simulated scenarios is shown in Figure 7 and Figure 8, respectively.

Figure 9 and Figure 10 show the difference in the predicted base flood elevation for the different conditions that were modeled and the elevation of the top of road for Highway 12. Where the water surface elevation difference is positive, Highway 12 is overtopped and flooding would be expected to occur to the north of the highway. Where the water surface elevation differences are negative, Highway is not predicted to be overtopped.

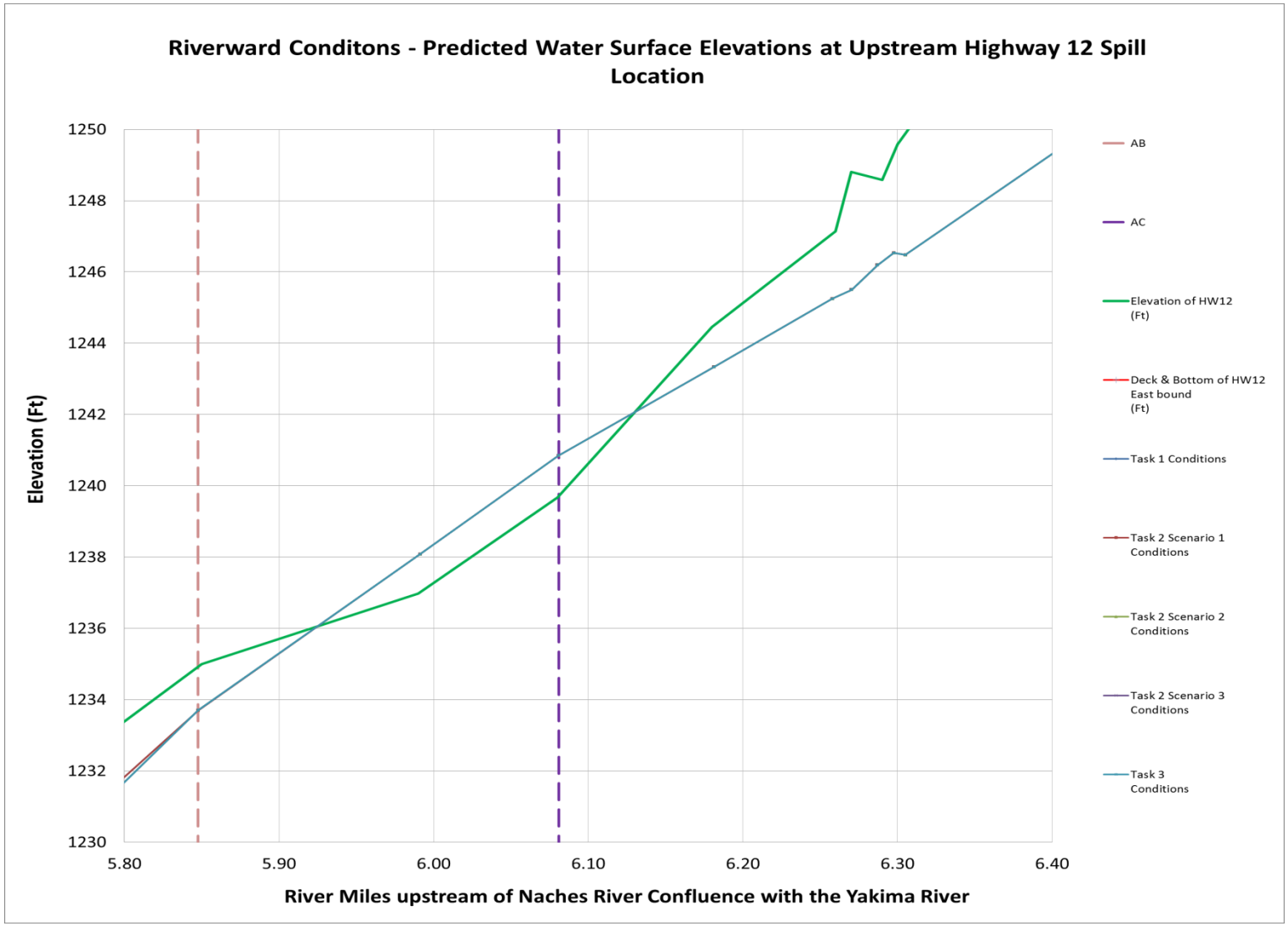

Figure 7 - Highway 12 Upstream Spill Location, Riverward Conditions

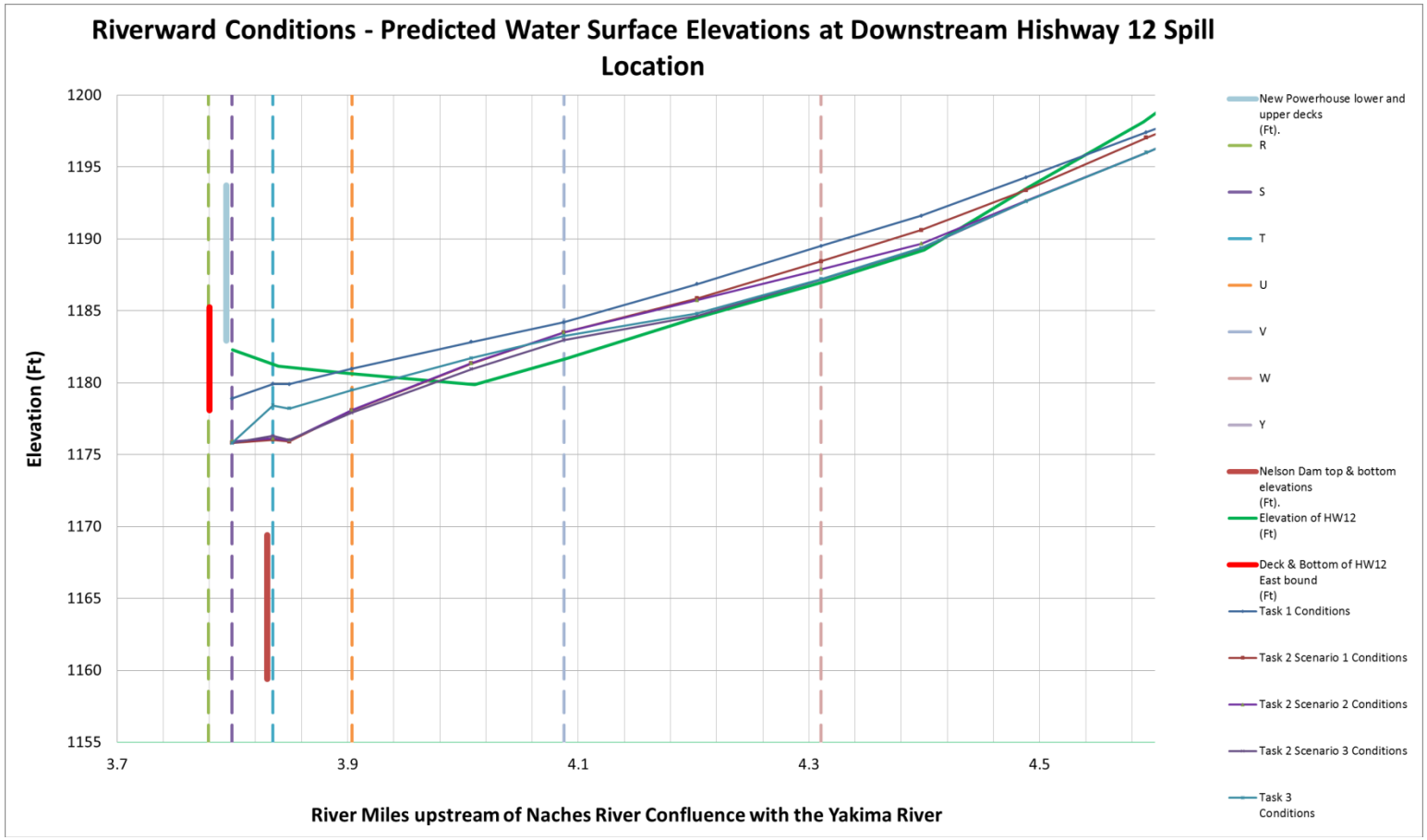

Figure 8 - Highway 12 Downstream Spill Location, Riverward Conditions

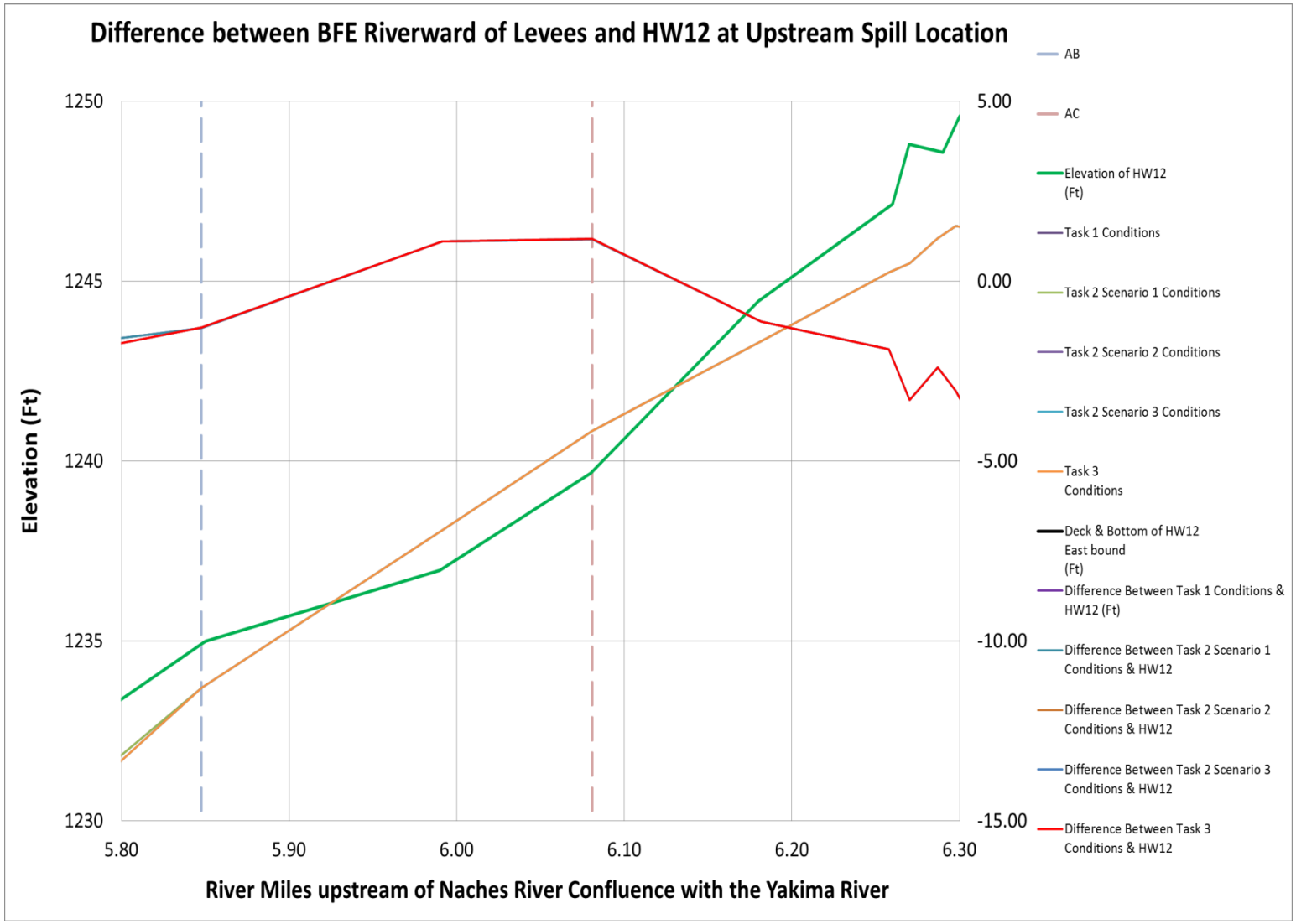

Figure 9- Differences between BFE Riverward of Levees and HW12, Upstream Spill Location

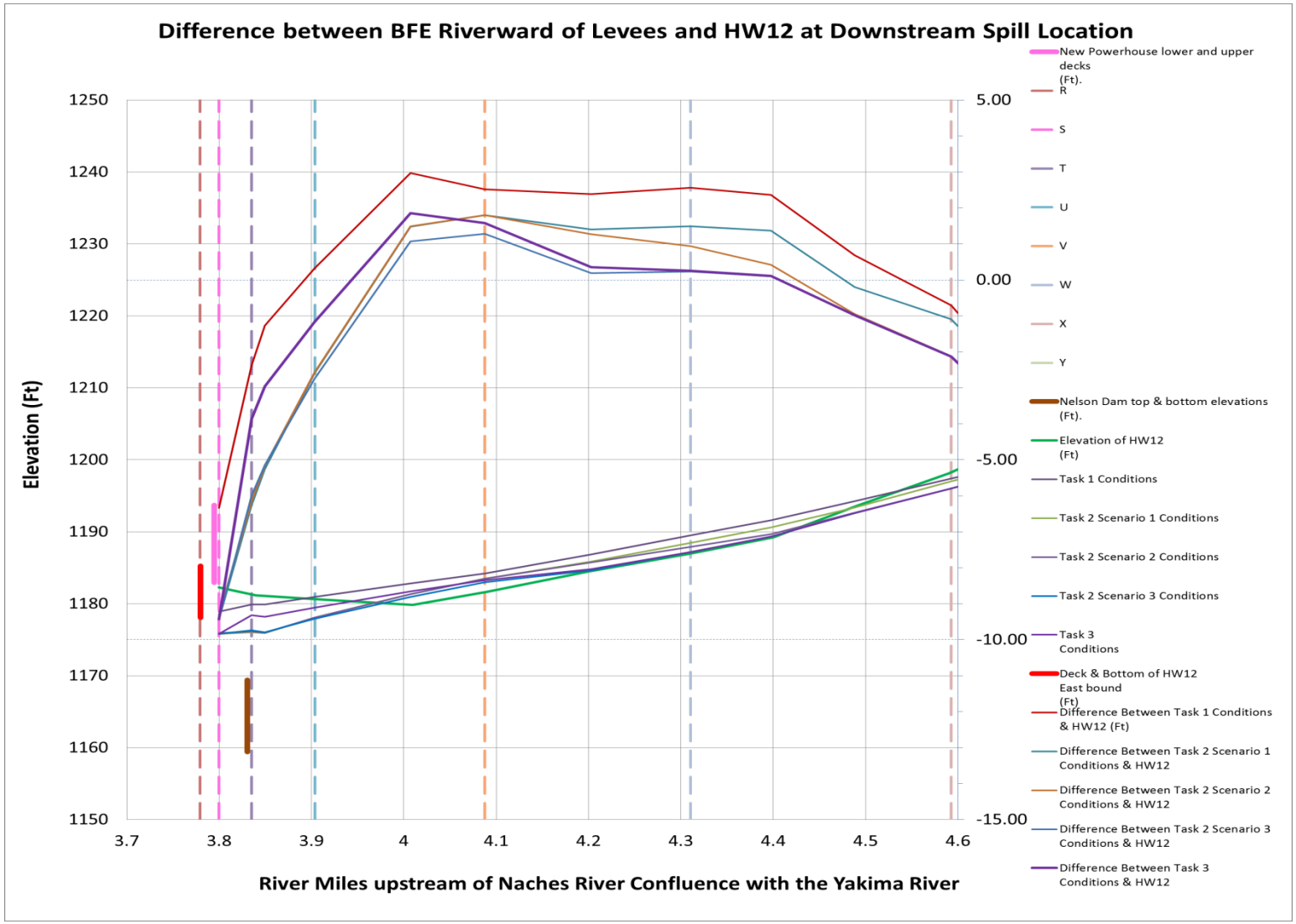

Figure 10 - Differences between BFE Riverward of Levees and HW12, Downstream Spill Location

Between Highway 12 and Left Levee – BFE Simulation

The Between Highway 12 and Left Levee condition assumes that the levees on the left bank of the river have failed, but that Highway 12 is still in place. As there is extra conveyance area between the left levee and Highway 12, the resulting water surface elevations are reduced as compared to the Riverward condition. The model results for the Between Highway 12 and Left Levee BFE simulations from the different tasks are shown in tabular and graphical form in Table 3 and Figure 11, shown below, respectively. Table 4 shows the resulting base flood elevation difference from the Regulatory Model results for the Between Highway 12 and Left Levee Condition model simulations.

Table 3 - Base Flood Elevations, Between Highway 12 and Left Levee Condition

FLOODING SOURCE			BASE FLOOD ELEVATIONS (NAVD88 ft) - BETWEEN LEFT LEVEE AND HIGHWAY 12 CONDITION					
FIS Cross Section	FIS Distance (ft)	Model Chainage (ft)	Regulatory Model	Task 1	Task 2 Scenario 1	Task 2 Scenario 2	Task 2 Scenario 3	Task 3
N	17,254	84,567	1,163.4	1163.4	1163.4	1163.4	1163.4	1163.4
O	19,219	82,602	1,170.3	1170.3	1170.3	1170.3	1170.3	1170.3
P	19,695	82,126	1,173.3	1173.3	1173.3	1173.3	1173.3	1173.3
Q	19,863	81,958	1,175.9	1175.8	1174.0	1174.0	1174.0	1174.0
R	19,954	81,867	1,177.4	1177.4	1174.2	1174.2	1174.2	1174.2
S	20,063	81,758	1,178.3	1178.9	1175.8	1175.8	1175.8	1175.8
T	20,250	81,571	1,179.2	1179.9	1176.1	1176.0	1176.3	1178.4
U	20,611	81,210	1,181.0	1181.0	1178.0	1178.1	1177.9	1179.1
V	21,582	80,239	1,184.9	1184.2	1183.5	1183.5	1183.0	1183.2
W	22,759	79,062	1,187.8	1188.5	1188.4	1187.9	1187.2	1187.2
X	24,249	77,572	1,196.4	1197.0	1197.0	1196.0	1196.0	1196.0
Y	25,637	76,184	1205.0	1205.0	1205.0	1204.5	1204.5	1204.5
Z	26,838	74,983	1210.2	1210.1	1210.1	1208.6	1208.6	1208.6
AA	27,566	74,255	1214.8	1214.8	1214.8	1213.0	1213.0	1213.0
AB	30,876	70,945	1,232.1	1232.1	1232.1	1232.1	1232.1	1232.1
AC	32,107	69,714	1,240.0	1240.5	1240.5	1240.5	1240.5	1240.5

Table 4 - Base Flood Elevation Differences, Between Highway 12 and Left Levee Condition

FLOODING SOURCE			BASE FLOOD ELEVATION DIFFERENCES (NAVD88 ft) - BETWEEN LEFT LEVEE AND HIGHWAY 12 CONDITION					
FIS Cross Section	FIS Distance (ft)	Model Chainage (ft)	Regulatory Model	Task 1	Task 2 Scenario 1	Task 2 Scenario 2	Task 2 Scenario 3	Task 3
N	17,254	84,567	--	0.0	0.0	0.0	0.0	0.0
O	19,219	82,602	--	0.0	0.0	0.0	0.0	0.0
P	19,695	82,126	--	0.0	0.0	0.0	0.0	0.0
Q	19,863	81,958	--	-0.1	-1.9	-1.9	-1.9	-1.9
R	19,954	81,867	--	0.0	-3.2	-3.2	-3.2	-3.2
S	20,063	81,758	--	0.6	-2.5	-2.5	-2.5	-2.5
T	20,250	81,571	--	0.7	-3.1	-3.2	-2.9	-0.8
U	20,611	81,210	--	0.0	-3.0	-2.9	-3.1	-1.9
V	21,582	80,239	--	-0.7	-1.4	-1.4	-1.9	-1.7
W	22,759	79,062	--	0.7	0.6	0.1	-0.6	-0.6
X	24,249	77,572	--	0.6	0.6	-0.4	-0.4	-0.4
Y	25,637	76,184	--	0.0	0.0	-0.5	-0.5	-0.5
Z	26,838	74,983	--	-0.1	-0.1	-1.6	-1.6	-1.6
AA	27,566	74,255	--	0.0	0.0	-1.8	-1.8	-1.8
AB	30,876	70,945	--	0.0	0.0	0.0	0.0	0.0
AC	32,107	69,714	--	0.0	0.5	0.5	0.5	0.5

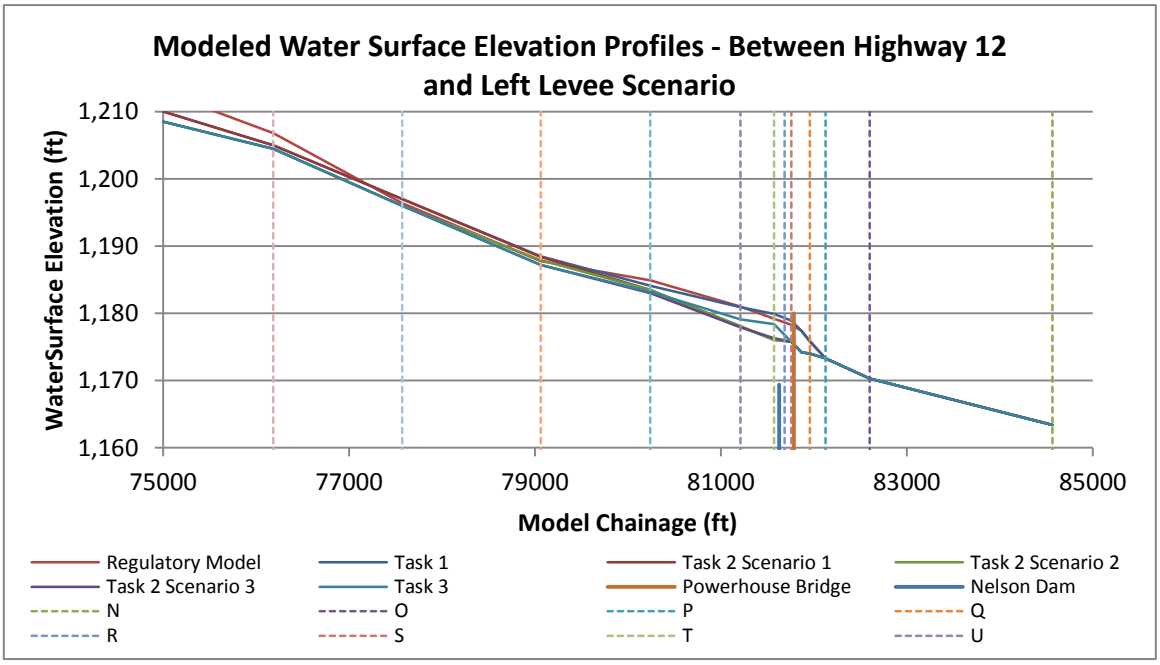

Figure 11 - Water Surface Elevation Profiles, Between Highway 12 and Left Levee Simulations

Like the Riverward condition, the Between Highway 12 and Left Levee condition also results in overtopping of Highway 12 at two locations. The downstream overtopping location is near the new Powerhouse Road and Highway 12 bridge crossings. The upstream overtopping location is near lettered cross section AC approximately six miles upstream of the Naches River's confluence with the Yakima River. The predicted water surface elevations at the upstream and downstream overtopping locations each of the different simulated scenarios is shown in Figure 12and Figure 13, respectively.

Figure 14 and Figure 15 show the difference in the predicted base flood elevation for the different scenarios that were modeled and the elevation of the top of road for Highway 12 for the Between Highway 12 and Left Levee conditions. Where the water surface elevation difference is positive, Highway 12 is overtopped and flooding would be expected to occur to the north of the highway. Where the water surface elevation differences are negative, Highway is not predicted to be overtopped

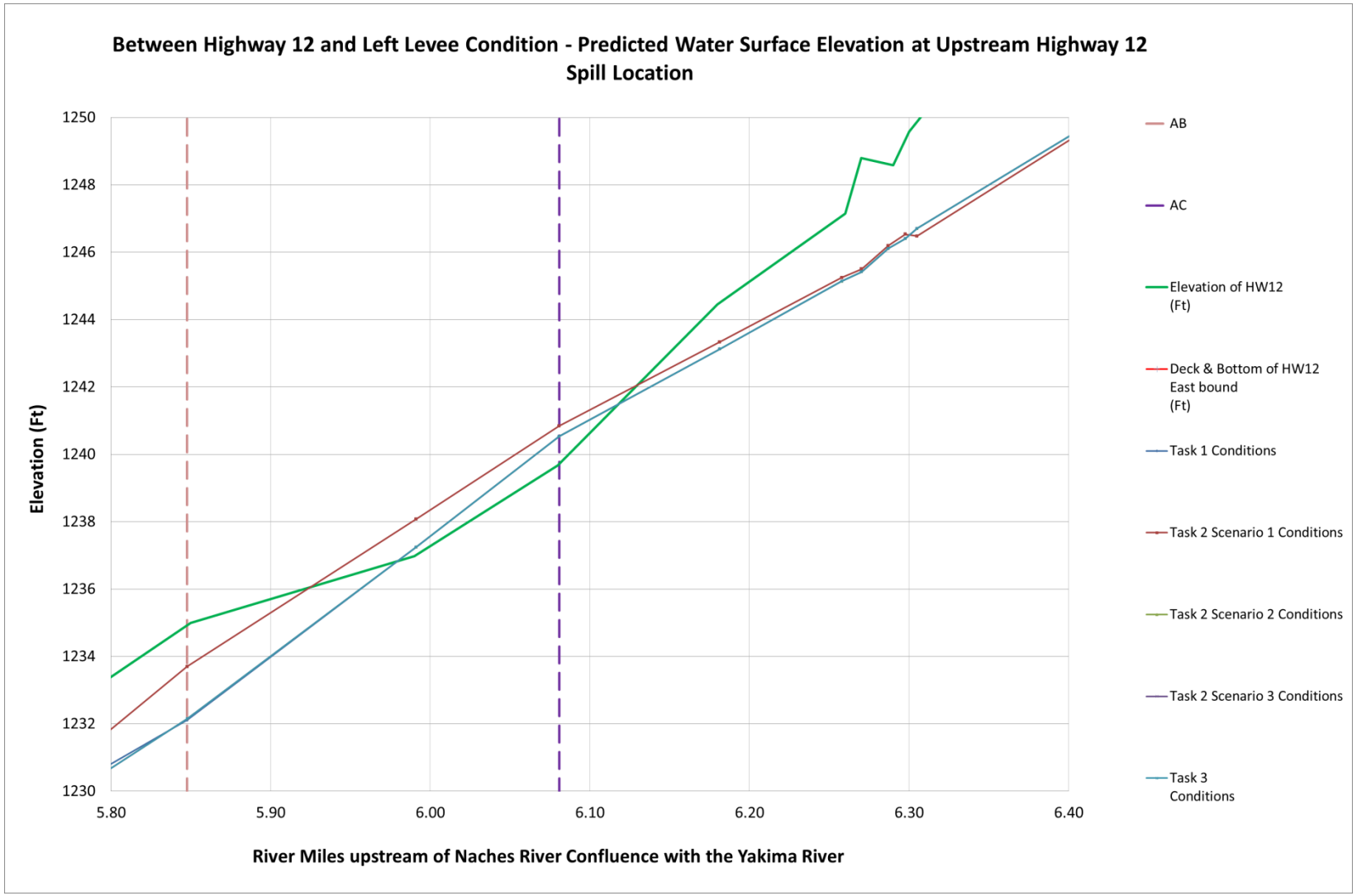

Figure 12 - Highway 12 Upstream Spill Location, Between Highway 12 and Left Levee Conditions

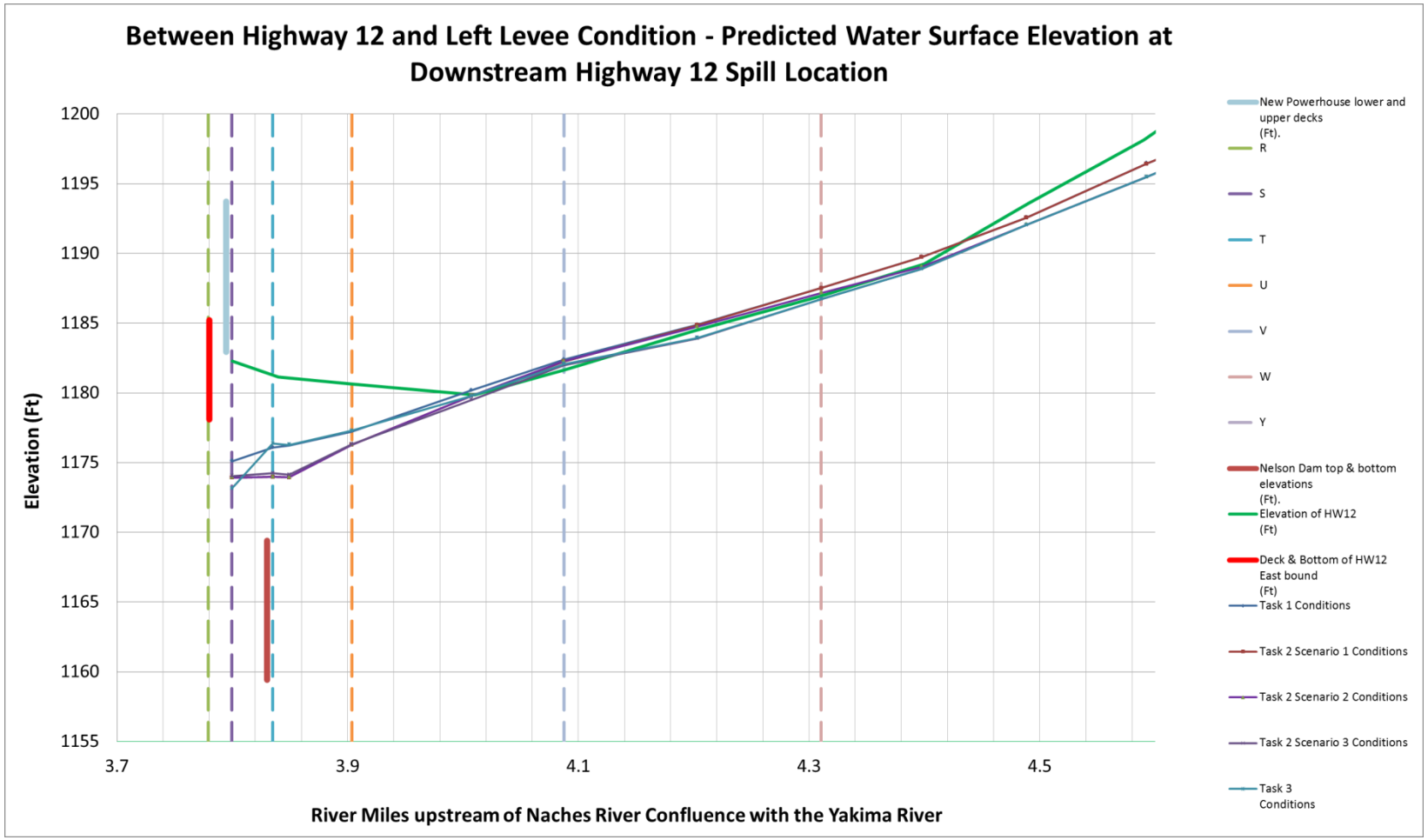

Figure 13 - Highway 12 Downstream Spill Location, Between Highway 12 and Left Levee Conditions

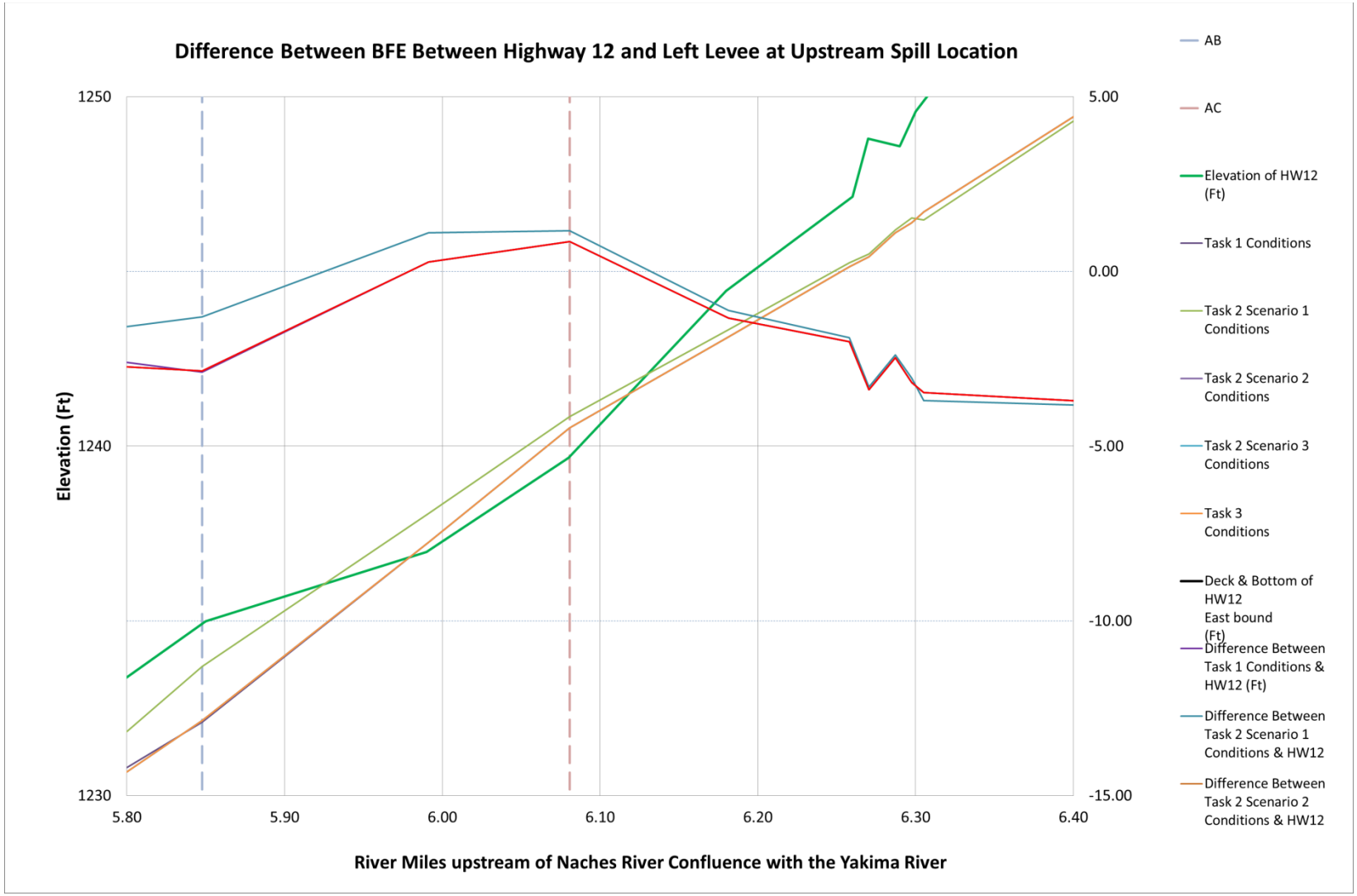

Figure 14 - Differences between BFE for Between Highway 12 and Left Levee Conditions and HW12, Upstream Spill Location

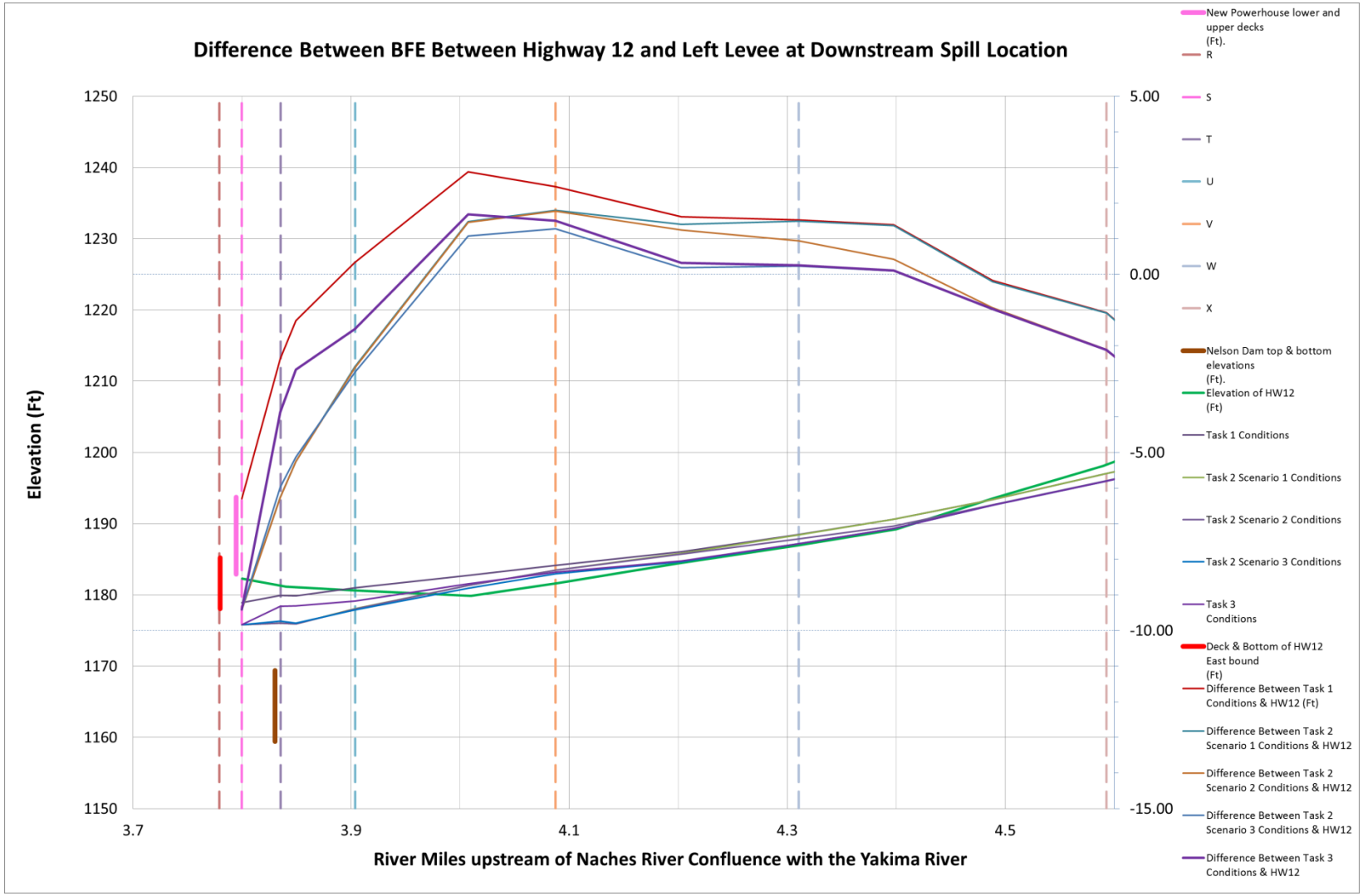

Figure 15 - Differences between BFE for Between Highway 12 and Left Levee Conditions and HW12, Downstream Spill Location

Landward– BFE Simulation

The Landward condition assumes that the levees on the left bank of the river have failed and that Highway 12 has also failed. This condition represents the maximum conveyance area, and therefore the lowest water surface elevations. The model results for the Landward BFE simulations from the different tasks are shown in tabular and graphical form in Table 5 and Figure 16, shown below, respectively. Table 6 shows the resulting base flood elevation difference from the Regulatory Model results for the Landward Condition model simulations.

Table 5 - Base Flood Elevations, Landward Conditions

FLOODING SOURCE			BASE FLOOD ELEVATIONS (NAVD88 ft) - LANDWARD CONDITIONS					
FIS Cross Section	FIS Distance (ft)	Model Chainage (ft)	Regulatory Model	Task 1	Task 2 Scenario 1	Task 2 Scenario 2	Task 2 Scenario 3	Task 3
N	17,254	84,567	1,163.4	1163.4	1163.4	1163.4	1163.4	1163.4
O	19,219	82,602	1,170.3	1170.3	1170.3	1170.3	1170.3	1170.3
P	19,695	82,126	1,173.3	1171.0	1171.9	1171.9	1172.0	1171.3
Q	19,863	81,958	1,173.1	1172.6	1172.6	1172.6	1172.7	1172.0
R	19,954	81,867	1,173.9	1173.6	1172.7	1172.7	1172.8	1172.1
S	20,063	81,758	1,174.8	1175.1	1173.9	1173.9	1174.0	1173.1
T	20,250	81,571	1,176.0	1176.1	1174.0	1174.0	1174.2	1176.4
U	20,611	81,210	1,177.4	1177.2	1176.3	1176.3	1176.3	1177.3
V	21,582	80,239	1,182.8	1182.4	1182.3	1182.3	1182.0	1182.1
W	22,759	79,062	1,188.1	1187.5	1187.5	1187.2	1186.7	1186.7
X	24,249	77,572	1,196.3	1196.4	1196.4	1195.5	1195.5	1195.5
Y	25,637	76,184	1,206.8	1204.4	1204.4	1204.0	1204.0	1204.0
Z	26,838	74,983	1,213.0	1209.7	1209.7	1208.0	1208.0	1208.0
AA	27,566	74,255	1,216.9	1214.4	1214.4	1212.5	1212.5	1212.5
AB	30,876	70,945	1,231.1	1231.7	1231.7	1231.7	1231.7	1231.7
AC	32,107	69,714	1,239.7	1240.2	1240.2	1240.2	1240.2	1240.2

Table 6 - Base Flood Elevation Differences, Landward Condition

FLOODING SOURCE			BASE FLOOD ELEVATION DIFFERECES (NAVD88 ft) - LANDWARD CONDITIONS					
FIS Cross Section	FIS Distance (ft)	Model Chainage (ft)	Regulatory Model	Task 1	Task 2 Scenario 1	Task 2 Scenario 2	Task 2 Scenario 3	Task 3
N	17,254	84,567	--	0.0	0.0	0.0	0.0	0.0
O	19,219	82,602	--	0.0	0.0	0.0	0.0	0.0
P	19,695	82,126	--	-2.3	-1.4	-1.4	-1.3	-2.0
Q	19,863	81,958	--	-0.5	-0.5	-0.5	-0.4	-1.1
R	19,954	81,867	--	-0.3	-1.2	-1.2	-1.1	-1.8
S	20,063	81,758	--	0.3	-0.9	-0.9	-0.8	-1.7
T	20,250	81,571	--	0.1	-2.0	-2.0	-1.8	0.4
U	20,611	81,210	--	-0.2	-1.1	-1.1	-1.1	-0.1
V	21,582	80,239	--	-0.4	-0.5	-0.5	-0.8	-0.7
W	22,759	79,062	--	-0.6	-0.6	-0.9	-1.4	-1.4
X	24,249	77,572	--	0.1	0.1	-0.8	-0.8	-0.8
Y	25,637	76,184	--	-2.4	-2.4	-2.8	-2.8	-2.8
Z	26,838	74,983	--	-3.3	-3.3	-5.0	-5.0	-5.0
AA	27,566	74,255	--	-2.5	-2.5	-4.4	-4.4	-4.4
AB	30,876	70,945	--	0.6	0.6	0.6	0.6	0.6
AC	32,107	69,714	--	0.5	0.5	0.5	0.5	0.5

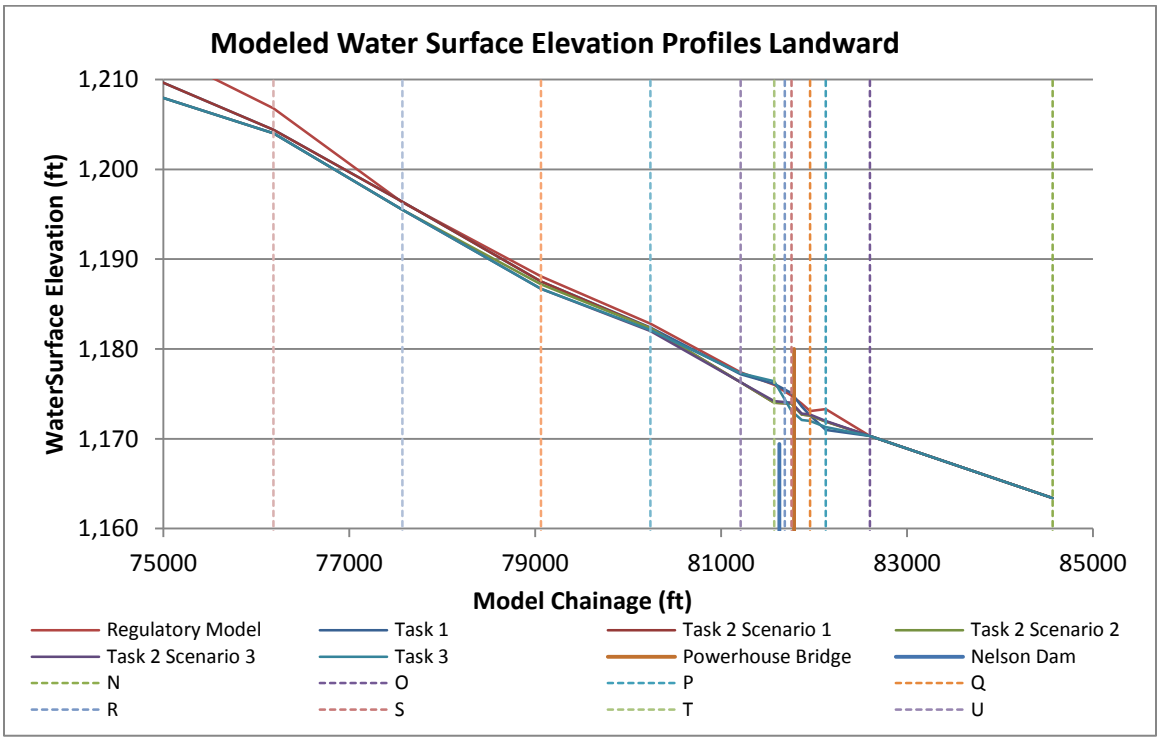

Figure 16 - Water Surface Elevation Profiles, Landward Simulations

The Landward Conditions resulted in overtopping of Highway 12 at two locations. The downstream overtopping location is near the new Powerhouse Road and Highway 12 bridge crossings. The upstream overtopping location is near lettered cross section AC approximately six miles upstream of the Naches River's confluence with the Yakima River. The predicted water surface elevations at the upstream and downstream overtopping locations each of the different simulated scenarios is shown in Figure 17 and Figure 18, respectively.

Figure 19and Figure 20 show the difference in the predicted base flood elevation for the different scenarios that were modeled and the elevation of the top of road for the Landward conditions. Where the water surface elevation difference is positive, Highway 12 is overtopped and flooding would be expected to occur to the north of the highway. Where the water surface elevation differences are negative, Highway is not predicted to be overtopped

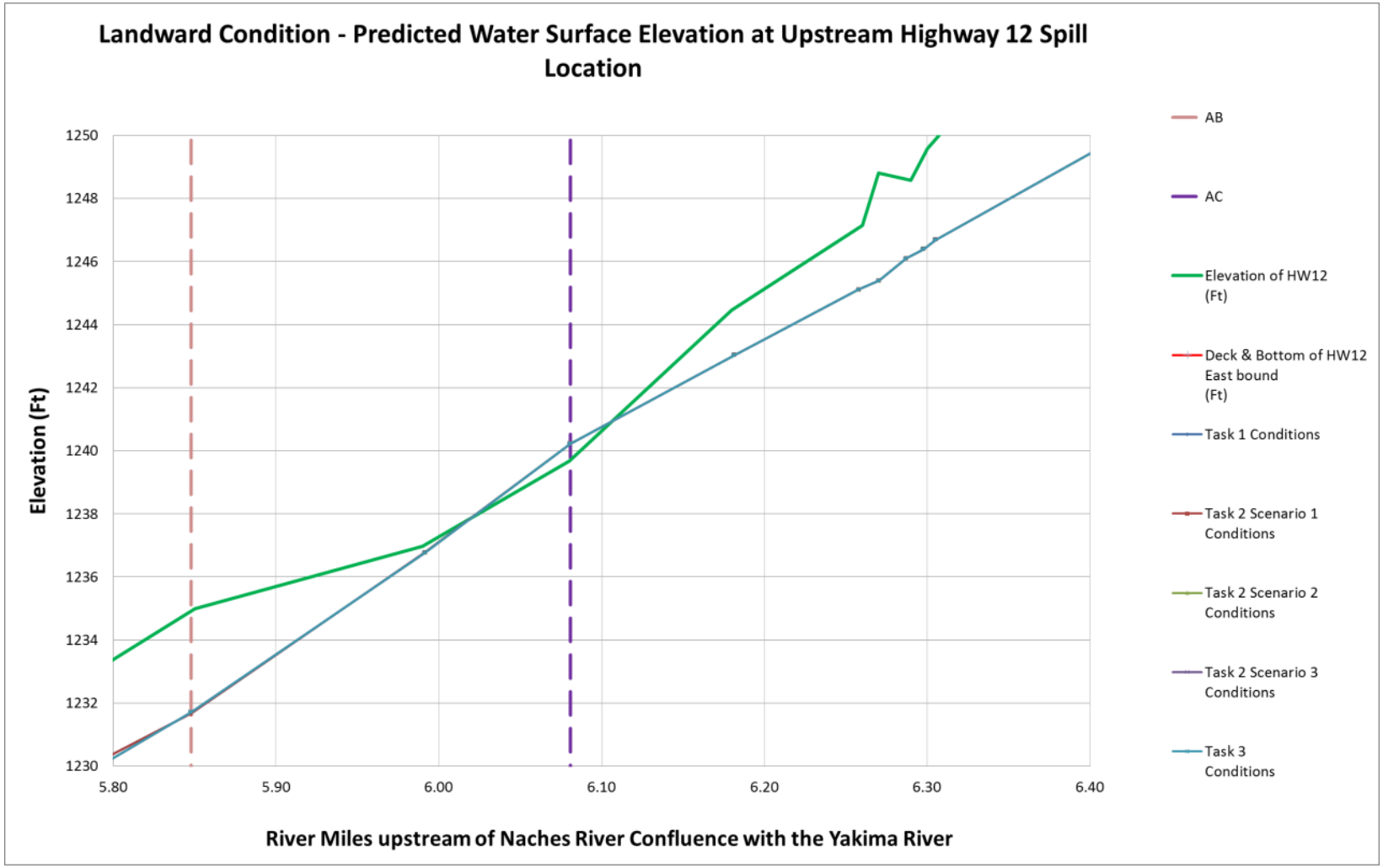

Figure 17 - Highway 12 Upstream Spill Location, Landward Conditions

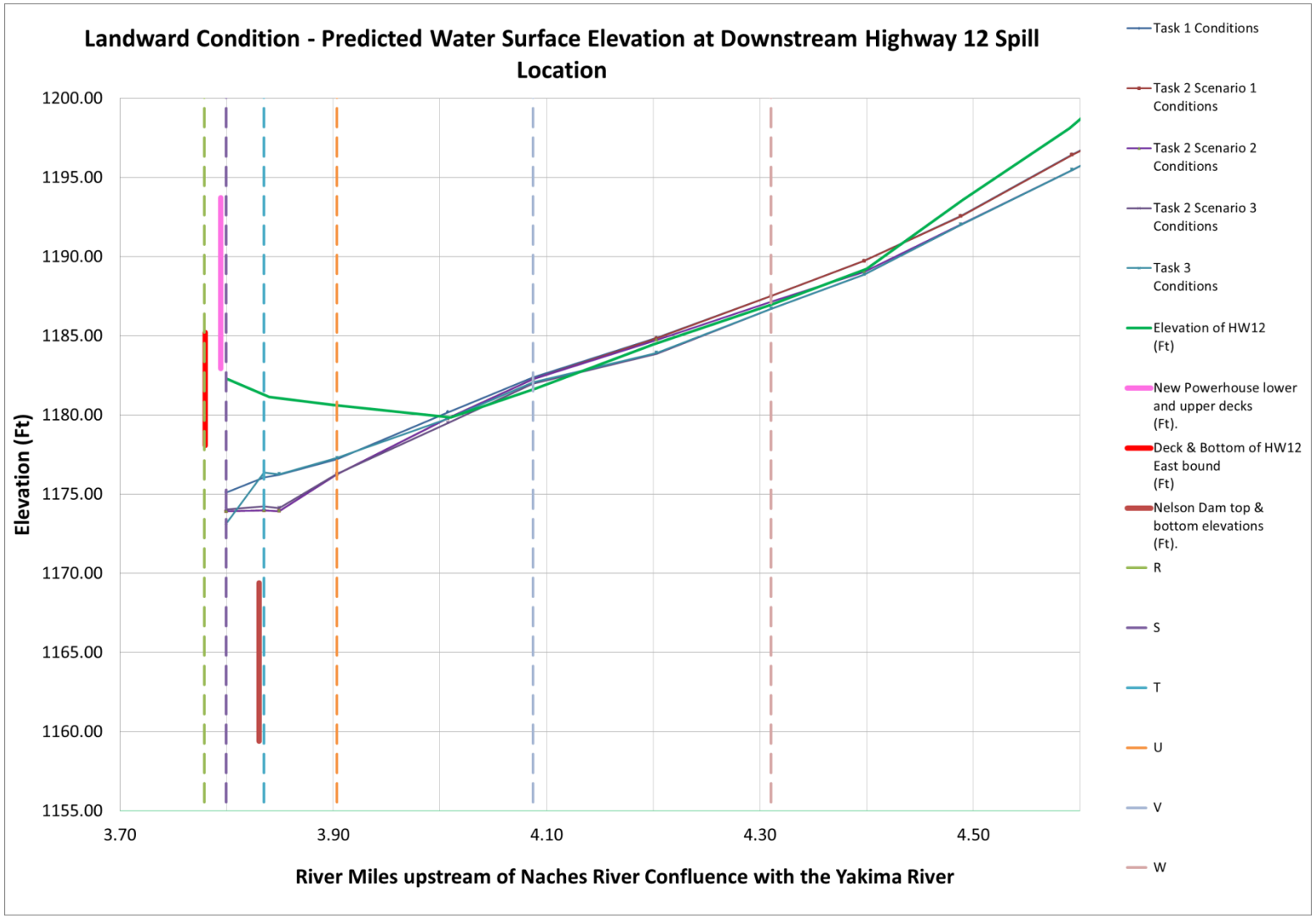

Figure 18 - Highway 12 Downstream Spill Location, Landward Conditions

Figure 19 - Differences between BFE for Landward Conditions and HW12, Upstream Spill Location

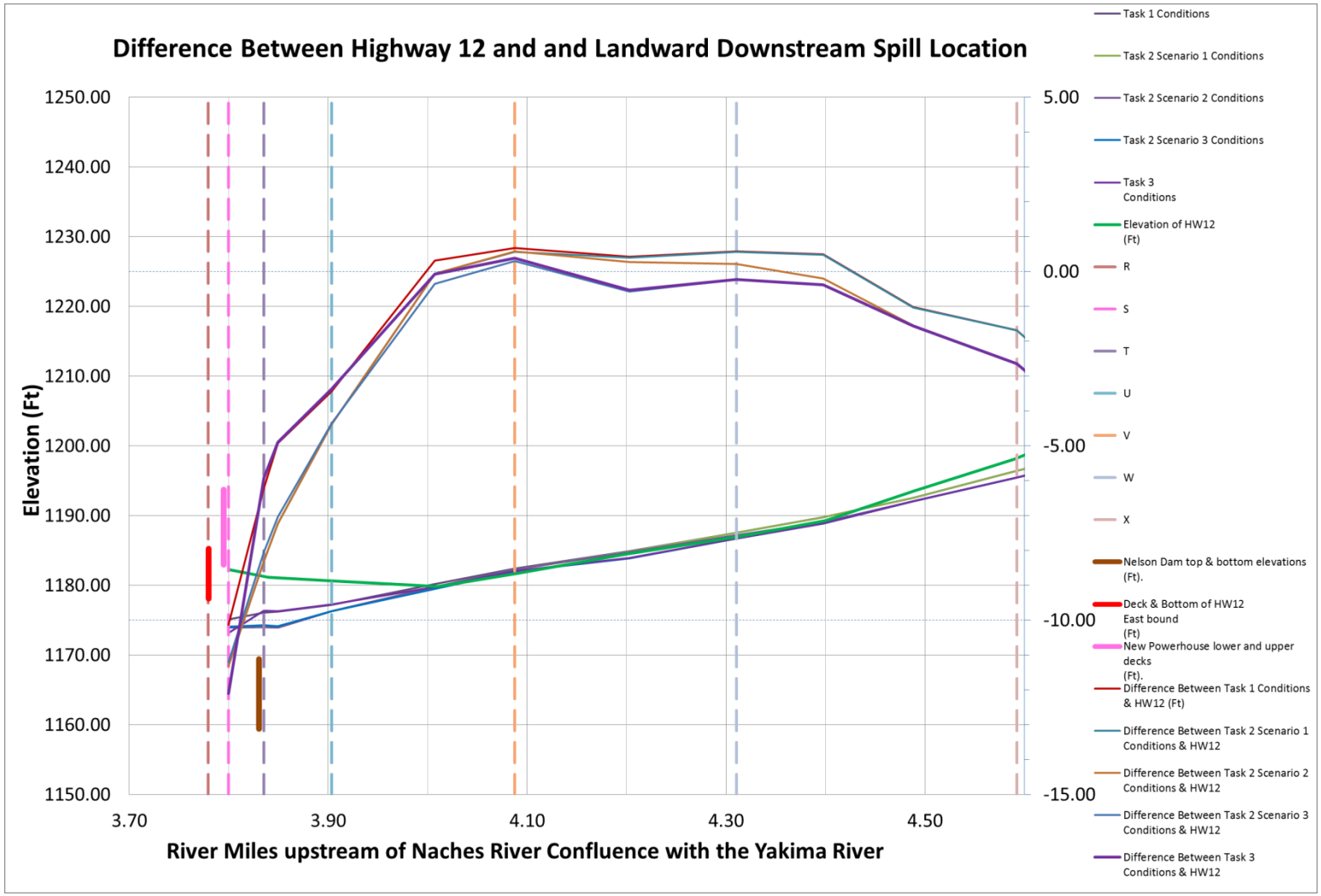

Figure 20 - Differences between BFE for Landward Conditions and HW12, Downstream Spill Location

WSE Sensitivity - Base Flood Elevation Simulation

The water surface elevations from Task 1 establish the new baseline conditions that represent the current Naches River conditions. In the Task 2 model simulations, the removal of the Nelson Dam and Highway 12 bridges reduces the backwater curve upstream of the bridge locations and results in an overall lowering of the predicted water surface elevation. The extent of the reduction of the backwater curve is also affected by the sediment removal represented in the individual tasks.

The Task 2 model results show a significant drop in the base flood elevations. For the most conservative scenario, the Riverward simulations, the water surface elevation for the base flood simulations were decreased by nearly four feet for the Task 2 simulations immediately upstream of Nelson Dam. The decrease in the water surface elevation observed in the Task 2 simulations is the result of the removal of the low head dam and the Highway 12 twin bridges. The low head dam introduces additional headlosses at high flows. The Highway 12 twin bridges represent a significant hydraulic bottleneck, the conveyance area through the bridge opening is smaller than the upstream and downstream conveyance areas, the contraction and expansion of flows introduces a headloss and results in a backwater curve that can be seen from the Task 1 model results and water surface profile plots. The backwater curve can be seen as the sharp increase in water surface elevation directly upstream of model chainage 82,000 feet in Tables 1 -3 and Figures 4-6. When the low head dam and Highway 12 bridge structures were removed, the water surface elevation was significantly reduced.

In Task 3, the Nelson Dam structure is re-inserted into the model; this low head dam re-introduces an energy loss and results in a backwater curve that can be observed in each of the water surface profiles for each modeled condition. From the BFE simulations it can be seen that the existing infrastructure and conveyance area represent a hydraulic constriction on the Naches River Channel during high flow events. By removing these infrastructure or providing more conveyance area by removing sediment and bed materials, the water surface elevations can be lowered.

Effects of Infrastructure Removal

While the previous section compared the simulated BFE between modeled scenarios, it can also be useful to compare the model results from within a single scenario to assess the impacts to the simulated water surface elevations due to changes in infrastructure and removal of sediment materials.

Comparison of Task 1 BFE Simulations

Task 1 was designed to provide an updated baseline BFE's of the expected water surface elevations for the current conditions. Table 7 shows the Task 1 BFE simulation model results.

Table 7 - Task 1 BFE Simulation Results

FLOODING SOURCE			BASE FLOOD ELEVATIONS (ft) - Task 1 BFE Simulations						
FIS Cross Section	FIS Distance (ft)	Model Chainage (ft)	Regulatory Model	Riverward	Riverward Differences	Between Highway 12 and Levee	Between Highway 12 and Levee Differences	Landward	Landward Differences
N	17,254	84,567	1,163.4	1163.4	0.0	1163.4	0.0	1163.4	0.0
O	19,219	82,602	1,170.3	1170.3	0.0	1170.3	0.0	1170.3	0.0
P	19,695	82,126	1,173.3	1173.3	0.0	1173.3	0.0	1171.0	-2.3
Q	19,863	81,958	1,173.1 / 1,175.9[2]	1175.8	-0.1	1175.8	-0.1	1172.6	-0.5
R	19,954	81,867	1,173.9 / 1,177.4[2]	1177.4	0.0	1177.4	0.0	1173.6	-0.3
S	20,063	81,758	1,174.8 / 1,178.3[2]	1178.9	0.6	1178.9	0.6	1175.1	0.3
T	20,250	81,571	1,176.0 / 1,179.2[2]	1179.9	0.7	1179.9	0.7	1176.1	0.1
U	20,611	81,210	1,177.4 / 1,181.0[2]	1181.0	0.0	1181.0	0.0	1177.2	-0.2
V	21,582	80,239	1,182.8 / 1,184.9 / 1,185.6[3]	1184.2	-1.4	1184.1	-0.8	1182.4	-0.4
W	22,759	79,062	1,188.1 / 1,187.8 / 1,190.4[3]	1189.5	-0.9	1188.5	0.7	1187.5	-0.6
X	24,249	77,572	1,196.3 / 1,196.4 / 1,197.5[3]	1197.4	-0.1	1197.0	0.6	1196.4	0.1
Y	25,637	76,184	1,206.8 / 1,205.0[2]	1205.0	0.0	1205.0	0.0	1204.4	-2.4
Z	26,838	74,983	1,213.0 / 1,210.2[2]	1210.1	-0.1	1210.1	-0.1	1209.7	-3.3
AA	27,566	74,255	1,216.9 / 1,214.8[2]	1214.8	0.0	1214.8	0.0	1214.4	-2.5
AB	30,876	70,945	1,231.1 / 1,232.1 / 1,233.7[3]	1233.7	0.0	1232.1	0.0	1231.7	0.6
AC	32,107	69,714	1,239.7 / 1,240.0 / 1,240.8[3]	1240.8	0.0	1240.5	0.5	1240.2	0.5

[2]Landward of Highway 12 / Riverward of levees

[3]Landward of Highway 12 / Between Highway 12 and left levee / Riverward of levees

Comparison of Task 2 Scenario 1 BFE Simulations

Task 2 Scenario 1 was designed to provide updated baseline BFE's of the expected water surface elevations caused by the removal of infrastructure in the vicinity of the Powerhouse Road Bridge. Table 8 shows the Task 2 Scenario 1 BFE simulation model results.

Table 8 - Task 2 Scenario 1 BFE Simulation Results

FLOODING SOURCE			BASE FLOOD ELEVATIONS (ft) - Task 2 Scenario 1 BFE Simulations						
FIS Cross Section	FIS Distance (ft)	Model Chainage (ft)	Regulatory Model	Riverward	Riverward Differences	Between Highway 12 and Levee	Between Highway 12 and Levee Differences	Landward	Landward Differences
N	17,254	84,567	1,163.4	1163.4	0.0	1163.4	0.0	1163.4	0.0
O	19,219	82,602	1,170.3	1170.3	0.0	1170.3	0.0	1170.3	0.0
P	19,695	82,126	1,173.3	1173.3	0.0	1173.3	0.0	1171.9	-1.4
Q	19,863	81,958	1,173.1 / 1,175.9[2]	1174.0	-1.9	1174.0	-1.9	1172.6	-0.5
R	19,954	81,867	1,173.9 / 1,177.4[2]	1174.2	-3.2	1174.2	-3.2	1172.7	-1.2
S	20,063	81,758	1,174.8 / 1,178.3[2]	1175.8	-2.5	1175.8	-2.5	1173.9	-0.9
T	20,250	81,571	1,176.0 / 1,179.2[2]	1176.0	-3.2	1176.1	-3.1	1174.0	-2.0
U	20,611	81,210	1,177.4 / 1,181.0[2]	1178.1	-2.9	1178.0	-3.0	1176.3	-1.1
V	21,582	80,239	1,182.8 / 1,184.9 / 1,185.6[3]	1183.5	-2.1	1183.5	-1.4	1182.3	-0.5
W	22,759	79,062	1,188.1 / 1,187.8 / 1,190.4[3]	1188.4	-2.0	1188.4	0.6	1187.5	-0.6
X	24,249	77,572	1,196.3 / 1,196.4 / 1,197.5[3]	1197.0	-0.5	1197.0	0.6	1196.4	0.1
Y	25,637	76,184	1,206.8 / 1,205.0[2]	1205.0	0.0	1205.0	0.0	1204.4	-2.4
Z	26,838	74,983	1,213.0 / 1,210.2[2]	1210.1	-0.1	1210.1	-0.1	1209.7	-3.3
AA	27,566	74,255	1,216.9 / 1,214.8[2]	1214.8	0.0	1214.8	0.0	1214.4	-2.5
AB	30,876	70,945	1,231.1 / 1,232.1 / 1,233.7[3]	1233.7	0.0	1232.1	0.0	1231.7	0.6
AC	32,107	69,714	1,239.7 / 1,240.0 / 1,240.8[3]	1240.8	0.0	1240.5	0.5	1240.2	0.5

[2]Landward of Highway 12 / Riverward of levees

[3]Landward of Highway 12 / Between Highway 12 and left levee / Riverward of levees

Comparison of Task 2 Scenario 2 BFE Simulations

The Task 2 Scenario 2 model runs were designed to evaluate the changes to predicted maximum WSEs for the 100-year flood event caused by the removal of sediment in the study area. Table 9 shows the Task 2 Scenario 2 BFE simulation model results.

Table 9 - Task 2 Scenario 2 BFE Simulation Results

FLOODING SOURCE			BASE FLOOD ELEVATIONS (ft) - Task 2 Scenario 2 BFE Simulations						
FIS Cross Section	FIS Distance (ft)	Model Chainage (ft)	Regulatory Model	Riverward	Riverward Differences	Between Highway 12 and Levee	Between Highway 12 and Levee Differences	Landward	Landward Differences
N	17,254	84,567	1,163.4	1163.4	0.0	1163.4	0.0	1163.4	0.0
O	19,219	82,602	1,170.3	1170.3	0.0	1170.3	0.0	1170.3	0.0
P	19,695	82,126	1,173.3	1173.3	0.0	1173.3	0.0	1171.9	-1.1
Q	19,863	81,958	1,173.1 / 1,175.9[2]	1174.0	-1.9	1174.0	-1.9	1172.6	-0.5
R	19,954	81,867	1,173.9 / 1,177.4[2]	1174.2	-3.2	1174.2	-3.2	1172.7	-1.2
S	20,063	81,758	1,174.8 / 1,178.3[2]	1175.8	-2.5	1175.8	-2.5	1173.9	-0.9
T	20,250	81,571	1,176.0 / 1,179.2[2]	1176.0	-3.2	1176.0	-3.2	1174.0	-2.0
U	20,611	81,210	1,177.4 / 1,181.0[2]	1178.0	-3.0	1178.1	-2.9	1176.3	-1.1
V	21,582	80,239	1,182.8 / 1,184.9 / 1,185.6[3]	1183.5	-2.1	1183.5	-1.4	1182.3	-0.5
W	22,759	79,062	1,188.1 / 1,187.8 / 1,190.4[3]	1187.9	-2.5	1187.9	0.1	1187.2	-0.9
X	24,249	77,572	1,196.3 / 1,196.4 / 1,197.5[3]	1196.0	-1.5	1196.0	-0.4	1195.5	-0.8
Y	25,637	76,184	1,206.8 / 1,205.0[2]	1204.4	-0.6	1204.5	-0.5	1204.0	-2.8
Z	26,838	74,983	1,213.0 / 1,210.2[2]	1208.5	-1.7	1208.6	-1.6	1208.0	-5.0
AA	27,566	74,255	1,216.9 / 1,214.8[2]	1212.9	-1.9	1213.0	-1.8	1212.5	-1.4
AB	30,876	70,945	1,231.1 / 1,232.1 / 1,233.7[3]	1233.7	0.0	1232.1	0.0	1231.7	0.6
AC	32,107	69,714	1,239.7 / 1,240.0 / 1,240.8[3]	1240.8	0.0	1240.5	0.5	1240.2	0.5

[2]Landward of Highway 12 / Riverward of levees

[3]Landward of Highway 12 / Between Highway 12 and left levee / Riverward of levees

Comparison of Task 2 Scenario 3 BFE Simulations

The Task 2 Scenario 3 model runs were designed to evaluate the changes to predicted maximum WSEs for the 100-year flood event caused by the removal of additional sediment and bed-materials in the study area. Table 10 shows the Task 2 Scenario 1 BFE simulation model results.

Table 10 - Task 2 Scenario 3 BFE Simulation Results

FLOODING SOURCE			BASE FLOOD ELEVATIONS (ft) - Task 2 Scenario 3 BFE Simulations						
FIS Cross Section	FIS Distance (ft)	Model Chainage (ft)	Regulatory Model	Riverward	Riverward Differences	Between Highway 12 and Levee	Between Highway 12 and Levee Differences	Landward	Landward Differences
N	17,254	84,567	1,163.4	1163.4	0.0	1163.4	0.0	1163.4	0.0
O	19,219	82,602	1,170.3	1170.3	0.0	1170.3	0.0	1170.3	0.0
P	19,695	82,126	1,173.3	1173.3	0.0	1173.3	0.0	1172.0	-1.3
Q	19,863	81,958	1,173.1 / 1,175.9[2]	1174.0	-1.9	1174.0	-1.9	1172.7	-0.4
R	19,954	81,867	1,173.9 / 1,177.4[2]	1174.2	-0.2	1174.2	-3.2	1172.8	-1.1
S	20,063	81,758	1,174.8 / 1,178.3[2]	1175.8	-2.5	1175.8	-2.5	1174.0	-0.8
T	20,250	81,571	1,176.0 / 1,179.2[2]	1176.3	-2.9	1176.3	-2.9	1174.2	-1.8
U	20,611	81,210	1,177.4 / 1,181.0[2]	1177.9	-3.1	1177.9	-3.1	1176.3	-1.1
V	21,582	80,239	1,182.8 / 1,184.9 / 1,185.6[3]	1183.0	-2.6	1183.0	-1.9	1182.0	-0.8
W	22,759	79,062	1,188.1 / 1,187.8 / 1,190.4[3]	1187.2	-3.2	1187.2	-0.6	1186.7	-1.4
X	24,249	77,572	1,196.3 / 1,196.4 / 1,197.5[3]	1196.0	-1.5	1196.0	-0.4	1195.5	-0.8
Y	25,637	76,184	1,206.8 / 1,205.0[2]	1204.4	-0.6	1204.5	-0.5	1204.0	-2.8
Z	26,838	74,983	1,213.0 / 1,210.2[2]	1208.5	-1.7	1208.6	-1.6	1208.0	-5.0
AA	27,566	74,255	1,216.9 / 1,214.8[2]	1212.9	-1.9	1213.0	-1.8	1212.5	-4.4
AB	30,876	70,945	1,231.1 / 1,232.1 / 1,233.7[3]	1233.7	0.0	1232.1	0.0	1231.7	0.6
AC	32,107	69,714	1,239.7 / 1,240.0 / 1,240.8[3]	1240.8	0.0	1240.5	0.5	1240.2	0.5

[2]Landward of Highway 12 / Riverward of levees

[3]Landward of Highway 12 / Between Highway 12 and left levee / Riverward of levees

Comparison of Task 3 BFE Simulations

The Task 3 model runs were designed to evaluate the changes to the predicted maximum WSEs for the 100-year flood event caused by the reinsertion of the Nelson Dam structure and the expected changes in cross-section geometries associated with the reintroduction of the low head dam. Table 11 shows the Task 3 BFE simulation model results.

Table 11 - Task 3 BFE Simulation Results

FLOODING SOURCE			BASE FLOOD ELEVATIONS (ft) - Task 3 BFE Simulations						
FIS Cross Section	FIS Distance (ft)	Model Chainage (ft)	Regulatory Model	Riverward	Riverward Differences	Between Highway 12 and Levee	Between Highway 12 and Levee Differences	Landward	Landward Differences
N	17,254	84,567	1,163.4	1163.4	0.0	1163.4	0.0	1163.4	0.0
O	19,219	82,602	1,170.3	1170.3	0.0	1170.3	0.0	1170.3	0.0
P	19,695	82,126	1,173.3	1173.3	0.0	1173.3	0.0	1171.3	-2.0
Q	19,863	81,958	1,173.1 / 1,175.9[2]	1174.0	-1.9	1174.0	-1.9	1172.0	-1.1
R	19,954	81,867	1,173.9 / 1,177.4[2]	1174.2	-3.2	1174.2	-3.2	1172.1	-1.8
S	20,063	81,758	1,174.8 / 1,178.3[2]	1175.8	-2.5	1175.8	-2.5	1173.1	-1.7
T	20,250	81,571	1,176.0 / 1,179.2[2]	1178.4	-0.8	1178.4	-0.8	1176.4	0.4
U	20,611	81,210	1,177.4 / 1,181.0[2]	1179.5	-1.5	1179.1	-1.9	1177.3	-0.1
V	21,582	80,239	1,182.8 / 1,184.9 / 1,185.6[3]	1183.3	-2.3	1183.2	-1.7	1182.1	-0.7
W	22,759	79,062	1,188.1 / 1,187.8 / 1,190.4[3]	1187.2	-3.2	1187.2	-0.6	1186.7	-1.4
X	24,249	77,572	1,196.3 / 1,196.4 / 1,197.5[3]	1196.0	-1.5	1196.0	-0.4	1195.5	-0.8
Y	25,637	76,184	1,206.8 / 1,205.0[2]	1204.4	-0.6	1204.5	-0.5	1204.0	-2.8
Z	26,838	74,983	1,213.0 / 1,210.2[2]	1208.5	-1.7	1208.6	-1.6	1208.0	-5.0
AA	27,566	74,255	1,216.9 / 1,214.8[2]	1212.9	-1.9	1213.0	-1.8	1212.5	-4.4
AB	30,876	70,945	1,231.1 / 1,232.1 / 1,233.7[3]	1233.7	0.0	1232.1	0.0	1231.7	0.6
AC	32,107	69,714	1,239.7 / 1,240.0 / 1,240.8[3]	1240.8	0.0	1240.5	0.5	1240.2	0.5

[2]Landward of Highway 12 / Riverward of levees

[3]Landward of Highway 12 / Between Highway 12 and left levee / Riverward of levees

From Table 7 through Table 11 the impacts of the removal or failure of the Rambler's Park levee can be seen by comparing the Riverward and the Between Highway 12 and Levee water surface elevations around approximate model chainages 80,000 and 77,000 feet. The impacts of the activation of conveyance area on the landward side of Highway 12 can be seen in the lower predicted BFEs for the Landward conditions between lettered cross sections O and AB.

Floodway Simulations

For each of the project tasks, floodway simulations were performed to asses rise and the ability to contain floodway (one foot rise only) riverward of Highway 12. For each task, two floodway conditions were simulated, a floodway condition with conveyance on the north side of Highway 12, and a floodway condition with no conveyance on the north side of Highway 12. For the floodway conditions, the cross-section encroachment previously developed for the FEMA regulatory model was used. The resulting increase in water surface elevation between the baseline and floodway conditions for each project task simulation are shown in Table 12 below. The baseline condition considers that levees and other flood control structures are not providing flood protection, therefore in the baseline condition flood control structures are considered to not be present. Further the baseline condition changes for each modeled task; as the cross-section geometries were changed to represent channel dredging or degradation upon removal of infrastructure, the conveyance area also changed. The change in conveyance area results in a new baseline flood elevation being established for each simulated condition and task. Water surface elevation differences from the floodway simulations are shown in Table 13.

Table 12 - Water Surface Elevations for Task Floodway Test Simulations

FLOODING SOURCE			Task 1			Task 2 Scenario 1			Task 2 Scenario 2			Task 2 Scenario 3			Task 3		
			Revised Baseline	Floodway Encroachment Test		Revised Baseline	Floodway Encroachment Test		Revised Baseline	Floodway Encroachment Test		Revised Baseline	Floodway Encroachment Test		Revised Baseline	Floodway Encroachment Test	
CROSS SECTION	FIS DISTANCE (ft)	MODEL CHAINAGE (ft)	Baseline 1	With floodway HWY12 active	With floodway HWY12 inactive	Baseline 2.1	With floodway HWY12 active	With floodway HWY12 inactive	Baseline 2.2	With floodway HWY12 active	With floodway HWY12 inactive	Baseline 2.3	With floodway HWY12 active	With floodway HWY12 inactive	Baseline 3	With floodway HWY12 active	With floodway HWY12 inactive
			FEET (NAVD)			FEET (NAVD)			FEET (NAVD)			FEET (NAVD)			FEET (NAVD)		
N	17,254	84,567	1163.4	1164.2	1164.2	1163.4	1164.2	1164.2	1163.4	1164.2	1164.2	1163.4	1164.2	1164.2	1163.4	1164.2	1164.2
O	19,219	82,602	1170.3	1171.1	1171.1	1170.3	1171.1	1171.1	1170.3	1171.1	1171.1	1170.3	1171.1	1171.1	1170.3	1171.1	1171.1
P	19,695	82,126	1171.0	1171.9	1173.8	1171.9	1172.8	1173.8	1171.9	1172.8	1173.8	1171.9	1172.9	1173.8	1171.3	1172.4	1173.8
Q	19,863	81,958	1172.6	1173.4	1176.1	1172.6	1173.6	1174.7	1172.6	1173.6	1174.7	1172.7	*1173.7*	1174.7	1172.0	1173.1	1174.7
R	19,954	81,867	1173.6	1174.4	1177.6	1172.8	1173.7	1174.9	1172.7	1173.7	1174.9	1172.1	*1173.9*	1174.9	1172.1	1173.2	1174.9
S	20,063	81,758	1175.1	1175.6	1179.1	1174.0	1174.5	1175.8	1174.0	1174.5	1175.8	1174.1	*1174.6*	1175.8	1173.2	1174.1	1175.8
T	20,250	81,571	1176.1	1176.8	1179.9	1173.9	1174.4	1175.7	1174.0	1174.6	1175.9	1174.3	*1174.9*	1176.2	1176.4	1176.8	1178.4
U	20,611	81,210	1177.2	1178.0	1181.0	1176.3	1176.8	1178.0	1176.3	1176.8	1178.0	1176.3	*1176.9*	1177.9	1177.3	1177.9	1178.8
V	21,582	80,239	1182.4	1183.2	1184.2	1182.3	1183.0	1183.5	1182.3	1183.0	1183.5	1182.0	1182.5	1183.0	1182.1	1182.7	1183.1
W	22,759	79,062	1187.9	1188.3	1188.5	1187.9	1188.3	1188.4	1187.4	1187.8	1187.9	1186.9	1187.1	1187.2	1186.9	1187.1	1187.2
X	24,249	77,572	1197.0	1197.3	1197.3	1197.0	1197.3	1197.3	1196.0	1196.2	1196.2	1196.0	1196.2	1196.2	1196.0	1196.2	1196.2
Y	25,637	76,184	1205.0	1205.4	1205.4	1205.0	1205.4	1205.4	1204.5	1205.1	1205.1	1204.5	1205.1	1205.1	1204.5	1205.1	1205.1
Z	26,838	74,983	1210.1	1210.7	1210.7	1210.1	1210.7	1210.7	1208.6	1209.1	1209.1	1208.6	1209.1	1209.1	1208.6	1209.1	1209.1
AA	27,566	74,255	1214.8	1215.4	1215.4	1214.8	1215.4	1215.4	1213.1	1213.4	1213.4	1213.1	1213.4	1213.4	1213.1	1213.4	1213.4
AB	30,876	70,945	1232.1	1232.7	1232.7	1232.1	1232.7	1232.7	1232.1	1232.6	1232.6	1232.1	1232.6	1232.6	1232.1	1232.6	1232.6
AC	32,107	69,714	1240.5	1241.2	1241.2	1240.5	1241.2	1241.2	1240.5	1241.2	1241.2	1240.5	1241.2	1241.2	1240.5	1241.2	1241.2

Table 13 - Water Surface Elevation Gains from Task Baseline for Floodway Test Simulations

FLOODING SOURCE			WSE Differences (ft)									
			Task 1		Task 2 Scenario 1		Task 2 Scenario 2		Task 2 Scenario 3		Task 3	
FIS CROSS SECTION	FIS DISTANCE (ft)	MODEL CHAINAGE (ft)	ΔWSE with HWY12 active	ΔWSE with HWY12 inactive	ΔWSE with HWY12 active	ΔWSE with HWY12 inactive	ΔWSE with HWY12 active	ΔWSE with HWY12 inactive	ΔWSE with HWY12 active	ΔWSE with HWY12 inactive	ΔWSE with HWY12 active	ΔWSE with HWY12 inactive
			FEET (NAVD)		FEET (NAVD)		FEET (NAVD)		FEET (NAVD)		FEET (NAVD)	
N	17,254	84,567	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
O	19,219	82,602	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
P	19,695	82,126	0.9	2.8	0.9	1.9	0.9	1.9	1.0	1.9	1.1	2.5
Q	19,863	81,958	0.8	3.5	1.0	2.1	1.0	2.1	1.0	2.0	1.1	2.7
R	19,954	81,867	0.8	4	0.9	2.1	1.0	2.2	1.1	2.1	1.1	2.8
S	20,063	81,758	0.5	4	0.5	1.8	0.5	1.8	0.5	1.7	0.9	2.6
T	20,250	81,571	0.7	3.8	0.5	1.8	0.6	1.9	0.6	1.9	0.4	2.0
U	20,611	81,210	0.8	3.8	0.5	1.7	0.5	1.7	0.6	1.6	0.6	1.5
V	21,582	80,239	0.8	1.8	0.7	1.2	0.7	1.2	0.5	1.0	0.6	1.0
W	22,759	79,062	0.4	0.6	0.4	0.5	0.4	0.5	0.2	0.3	0.2	0.3
X	24,249	77,572	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2
Y	25,637	76,184	0.4	0.4	0.4	0.4	0.6	0.6	0.6	0.6	0.6	0.6
Z	26,838	74,983	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5
AA	27,566	74,255	0.6	0.6	0.6	0.6	0.3	0.3	0.3	0.3	0.3	0.3
AB	30,876	70,945	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5
AC	32,107	69,714	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7

Red text indicates where values exceed 1 foot, to show areas where encroachment is above FEMA standards.

Table 14 - Water Surface Elevation Differences for Floodway Simulations vs. Landward BFE

FLOODING SOURCE			WSE Differences (ft)									
			Task 1		Task 2 Scenario 1		Task 2 Scenario 2		Task 2 Scenario 3		Task 3	
FIS CROSS SECTION	FIS DISTANCE (ft)	MODEL CHAINAGE (ft)	Difference between (Floodway Encroachment when HW12 active –BFE)	Difference between (Floodway Encroachment when HW12 inactive – BFE)	Difference between (Floodway Encroachment when HW12 active –BFE)	Difference between (Floodway Encroachment when HW12 inactive – BFE)	Difference between (Floodway Encroachment when HW12 active –BFE)	Difference between (Floodway Encroachment when HW12 inactive – BFE)	Difference between (Floodway Encroachment when HW12 active –BFE)	Difference between (Floodway Encroachment when HW12 inactive – BFE)	Difference between (Floodway Encroachment when HW12 active –BFE)	Difference between (Floodway Encroachment when HW12 inactive – BFE)
			FEET (NAVD)		FEET (NAVD)		FEET (NAVD)		FEET (NAVD)		FEET (NAVD)	
N	17,254	84,567	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
O	19,219	82,602	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
P	19,695	82,126	0.9	2.8	0.9	1.9	0.9	1.9	0.9	1.8	1.1	2.5
Q	19,863	81,958	0.8	3.5	1.0	2.1	1.0	2.1	1.0	2.0	1.1	2.7
R	19,954	81,867	0.8	4.0	1.0	2.2	1.0	2.2	1.1	2.1	1.1	2.8
S	20,063	81,758	0.5	4.0	0.6	1.9	0.6	1.9	0.6	1.8	1.0	2.7
T	20,250	81,571	0.7	3.8	0.4	1.7	0.6	1.9	0.7	2.0	0.4	2.0
U	20,611	81,210	0.8	3.8	0.5	1.7	0.5	1.7	0.6	1.6	0.6	1.5
V	21,582	80,239	0.8	1.8	0.7	1.2	0.7	1.2	0.5	1.0	0.6	1.0
W	22,759	79,062	0.8	1.0	0.8	0.9	0.6	0.7	0.4	0.5	0.4	0.5
X	24,249	77,572	0.9	0.9	0.9	0.9	0.7	0.7	0.7	0.7	0.7	0.7
Y	25,637	76,184	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1
Z	26,838	74,983	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1
AA	27,566	74,255	1.0	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9
AB	30,876	70,945	1.0	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9
AC	32,107	69,714	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Table 15 - Water Surface Elevation Differences for Floodway Simulations vs. Riverward BFE

FLOODING SOURCE			WSE Differences (ft)									
			Task 1		Task 2 Scenario 1		Task 2 Scenario 2		Task 2 Scenario 3		Task 3	
FIS CROSS SECTION	FIS DISTANCE (ft)	MODEL CHAINAGE (ft)	Difference between (Floodway Encroachment when HW12 active –BFE)	Difference between (Floodway Encroachment when HW12 inactive – BFE)	Difference between (Floodway Encroachment when HW12 active –BFE)	Difference between (Floodway Encroachment when HW12 inactive – BFE)	Difference between (Floodway Encroachment when HW12 active –BFE)	Difference between (Floodway Encroachment when HW12 inactive – BFE)	Difference between (Floodway Encroachment when HW12 active –BFE)	Difference between (Floodway Encroachment when HW12 inactive – BFE)	Difference between (Floodway Encroachment when HW12 active –BFE)	Difference between (Floodway Encroachment when HW12 inactive – BFE)
			FEET (NAVD)		FEET (NAVD)		FEET (NAVD)		FEET (NAVD)		FEET (NAVD)	
N	17,254	84,567	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
O	19,219	82,602	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
P	19,695	82,126	-1.4	0.5	-0.5	0.5	-0.5	0.5	-0.4	0.5	-0.9	0.5
Q	19,863	81,958	-2.4	0.3	-0.4	0.7	-0.4	0.7	-0.3	0.7	-0.9	0.7
R	19,954	81,867	-3.0	0.2	-0.5	0.7	-0.5	0.7	-0.3	0.7	-1.0	0.7
S	20,063	81,758	-3.3	0.2	-1.3	0.0	-1.3	0.0	-1.2	0.0	-1.7	0.0
T	20,250	81,571	-3.1	0.0	-1.6	-0.3	-1.4	-0.1	-1.4	-0.1	-1.6	0.0
U	20,611	81,210	-3.0	0.0	-1.3	-0.1	-1.2	0.0	-1.0	0.0	-1.6	-0.7
V	21,582	80,239	-1.0	0.0	-0.5	0.0	-0.5	0.0	-0.5	0.0	-0.6	-0.2
W	22,759	79,062	-1.2	-1.0	-0.1	0.0	-0.1	0.0	-0.1	0.0	-0.1	0.0
X	24,249	77,572	-0.1	-0.1	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2
Y	25,637	76,184	0.4	0.4	0.4	0.4	0.7	0.7	0.7	0.7	0.7	0.7
Z	26,838	74,983	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
AA	27,566	74,255	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5
AB	30,876	70,945	-1.0	-1.0	-1.0	-1.0	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1
AC	32,107	69,714	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

Table 16 - Water Surface Elevation Differences for Floodway Simulations vs. Between Highway 12 and Left Levee BFE

FLOODING SOURCE			WSE Differences (ft)									
			Task 1		Task 2 Scenario 1		Task 2 Scenario 2		Task 2 Scenario 3		Task 3	
FIS CROSS SECTION	FIS DISTANCE (ft)	MODEL CHAINAGE (ft)	Difference between (Floodway Encroachment when HW12 active –BFE)	Difference between (Floodway Encroachment when HW12 inactive – BFE)	Difference between (Floodway Encroachment when HW12 active –BFE)	Difference between (Floodway Encroachment when HW12 inactive – BFE)	Difference between (Floodway Encroachment when HW12 active –BFE)	Difference between (Floodway Encroachment when HW12 inactive – BFE)	Difference between (Floodway Encroachment when HW12 active –BFE)	Difference between (Floodway Encroachment when HW12 inactive – BFE)	Difference between (Floodway Encroachment when HW12 active –BFE)	Difference between (Floodway Encroachment when HW12 inactive – BFE)
			FEET (NAVD)		FEET (NAVD)		FEET (NAVD)		FEET (NAVD)		FEET (NAVD)	
N	17,254	84,567	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
O	19,219	82,602	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
P	19,695	82,126	-1.4	0.5	-0.5	0.5	-0.5	0.5	-0.4	0.5	-0.9	0.5
Q	19,863	81,958	-2.4	0.3	-0.4	0.7	-0.4	0.7	-0.3	0.7	-0.9	0.7
R	19,954	81,867	-3.0	0.2	-0.5	0.7	-0.5	0.7	-0.3	0.7	-1.0	0.7
S	20,063	81,758	-3.3	0.2	-1.3	0.0	-1.3	0.0	-1.2	0.0	-1.7	0.0
T	20,250	81,571	-3.1	0.0	-1.7	-0.4	-1.4	-0.1	-1.4	-0.1	-1.6	0.0
U	20,611	81,210	-3.0	0.0	-1.2	0.0	-1.3	-0.1	-1.0	0.0	-1.2	-0.3
V	21,582	80,239	-0.9	0.1	-0.5	0.0	-0.5	0.0	-0.5	0.0	-0.5	-0.1
W	22,759	79,062	-0.2	0.0	-0.1	0.0	-0.1	0.0	-0.1	0.0	-0.1	0.0
X	24,249	77,572	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2
Y	25,637	76,184	0.4	0.4	0.4	0.4	0.6	0.6	0.6	0.6	0.6	0.6
Z	26,838	74,983	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5
AA	27,566	74,255	0.6	0.6	0.6	0.6	0.4	0.4	0.4	0.4	0.4	0.4
AB	30,876	70,945	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5
AC	32,107	69,714	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7

As compared to Task 1, which represents the existing conditions, there is a general trend of lowering the absolute water surface elevations for the baseline and floodway simulations upstream of the new Powerhouse Road Bridge. There is a slight increase in the predicted maximum water surface elevation downstream of the Highway 12 twin bridges for the Task 2 Scenario 3 and Task 3 model simulations. This slight increase in the predicted water surface elevation is the result of the lessening of the hydraulic constriction through the Powerhouse Road Bridge area; in essence the larger upstream conveyance allows a higher flow to reach these cross sections, which in turn, results in an elevated maximum water surface elevation.

There is also a general trend of decreasing the differential in predicted water surface elevations between the baseline conditions and the floodway simulations where the conveyance to the north of Highway 12 has been inactivated. From Task 1 to Task 2 Scenario 3 the difference in water surface elevations predicted by the baseline condition and the floodway simulations where the Highway 12 conveyance area has been inactivated decreases. The trend of decreasing differential between the baseline condition and the floodway with Highway 12 inactive condition can be explained by the additional conveyance area in the main channel of the Naches River for each subsequent task. The additional conveyance area in the Naches results from the removal of infrastructure and bed materials. The larger conveyance area allows more of the flood waters to remain on the Naches River side of Highway 12. In Task 3, the difference in water surface elevation between the baseline condition and the floodway with Highway 12 inactive is slightly larger than in Task 2 Scenario 3. The re-insertion of the Nelson Dam for the Task 3 model simulations cause the floodway rises to increase slightly for that scenario.

SUMMARY AND CONCLUSIONS

As previously stated, the project goals were to evaluate the sensitivity of predicted maximum water surface elevations (WSE) on the Naches River in the vicinity of Nelson Dam to changes in infrastructure and removal of sediment and bed materials. Further the project sought to try to determine if there is a feasible configuration of infrastructure improvements and increases in hydraulic conveyance that would sufficiently lower the predicted 100-year flood WSEs to confine the floodway extents within the main channel of the Naches River.

Through the systematic removal of the infrastructure and sediment in the vicinity of Nelson Dam and the new Powerhouse Road Bridge, the effects on the water surface elevations were evaluated. As previously explained, the resulting water surface elevations predicted by the model do share a fairly significant sensitivity to the infrastructure and conveyance area in the vicinity of Nelson Dam and the new Powerhouse Road Bridge. By increasing the conveyance area through sediment removal activities, increasing the hydraulic efficiency of the existing infrastructure, or a combination of the two, the predicted water surface elevations at the 100-year flood event are significantly reduced.

These improvements would reduce the risk to flooding in the area and likely take some pressure off the existing levee systems and roadway embankments during a flood event.

The project objective of confining the floodway to the main channel of the Naches River was not achieved. The Task 2 simulations came closest to achieving the objective, but a water surface elevation rise of 2-feet was still observed when the Highway 12 conveyance was inactivated. The inability to confine the floodway is partially due to how FEMA defines the floodway. The floodway is defined as the encroached conveyance area that results in a one-foot rise above the BFE; therefore during the Task 2 simulations, each time the base flood elevation was lowered, this created a new benchmark from which to evaluate the floodway against. While the floodway elevations determined for the Task 2 and Task 3 simulations were within the allowable 1-foot rise when compared to the Task 1 BFE, they were greater than the allowable 1-foot rise when compared to the BFE from the like scenario model results. The lowering of the predicted rise for the floodway simulations with the Highway 12 conveyance inactivated in Tasks 2 and 3 does indicate that a smaller regulatory floodway could be developed on the landward side of Highway 12 if improvements were made to the conveyance area and hydraulic efficiency of structures in the Nelson Dam and Powerhouse Road Bridge reach of the Naches River. Detailed mapping of the potential changes in the floodway area with the described improvements could be performed, but this effort was beyond the scope and objectives of this analysis.

RECOMMENDATIONS FOR ADDITIONAL MODEL ANALYSES

During the execution of this project, some potential modifications to the numerical analyses were noted that could affect the predicted water surface elevation and floodway conveyance zones. These observations are summarized below for the County's consideration.

The hydraulic analysis conducted for the regulatory modeling and for this project uses a steady state discharge through the system. This approach assumes that the flood event is independent of the routed volume; this approach may be acceptable for reaches that have very long and sustained flooding events but can be overly conservative for riverine systems that exhibit a more transient flooding pattern. The steady state analysis can be overly conservative in that it does not provide any credit to the flood storage capacity within the system and the potential attenuation of the flood wave as it is routed through the system. A hydrodynamic analysis, where the flood hydrograph is routed through the system, accounts for the volumetric affects during a flood and may produce a less conservative maximum water surface elevation.

For the Task 2 scenarios, all infrastructure in the vicinity of Nelson Dam were removed, save the New Powerhouse Road Bridge. Under these conditions, the model results still predicted that the floodway could not be constrained to the main channel of the Naches River. Additional analysis could be performed to investigate the impacts of adding

additional conveyance area through the New Powerhouse Road Bridge. Additional conveyance could be modeled as a larger span, or as culverts placed under the roadway.

Another factor that can influence the predicted water surface elevation is the resistance to flow, usually represented by an estimate of the Manning's number. The Manning numbers applied in the Naches model were found to be within the expected minimum and maximum values accepted by the engineering community. It was observed in the MIKE 11 model that the applied Manning number was transversally distributed along the cross-section, with the main channel having a lower resistance to flow than the overbank areas. The transversal distribution of bed resistance is also commonly applied in hydraulic modeling. In the Naches River model, the lower resistance was only applied in the low flow channel, while review of aerial photography shows areas of transient inundation where there is little vegetation. In these areas of transient flow and low vegetation, a higher Manning number is applied than what recent aerial photographs show. This could be an artifact of the ever changing nature of the Naches River channel, but if the current conditions are found to be different than the prevailing conditions when the model was developed, and are also expected to remain into the near to medium term, the model performance could potentially be improved by revisiting the model parameters and revising them to more representative of the actual conditions.

APPENDIX A – TASK 1 TM

APPENDIX B – TASK 2 SCENARIO 1 AND SCENARIO 2 TM

APPENDIX C– TASK 2 SCENARIO 3 TM

APPENDIX D – TASK 3 TM