LOMR SUBMITTAL
LOWER NEHALEM RIVER
TILLAMOOK COUNTY, OREGON

Prepared for:

TILLAMOOK COUNTY
DEPARTMENT OF COMMUNITY DEVELOPMENT
1510-B THIRD STREET
TILLAMOOK, OR 97141

Prepared by:

10300 SW GREENBURG ROAD, SUITE 470
PORTLAND, OR 97223

June 4, 2014

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF EXHIBITS

1. INTRODUCTION

Tillamook County, Oregon (County) was recently directed by Federal Management Emergency Agency (FEMA), Region X, to re-analysis the lower reach of the Nehalem River. As a result, the County contracted WEST Consultants, Inc. (WEST) to re-analyze the reach of the Nehalem River between FEMA Cross Sections A through K and to prepare a Letter of Map Revision (LOMR) submittal package in support of the re-analysis (Note: The upstream limit of the model is at FEMA Cross Section O in order to meet FEMA's tie-in requirements). Figure 1 shows a map of the study area.

The re-analysis involved conducting a hydraulic analysis to determine the revised based flood elevations (BFEs – water surface elevations associated with the 1% annual chance event) and floodway elevations for the study reach. The hydraulic analysis utilized new topography data for the overbank area. This report, along with supporting documentation, will be submitted to FEMA as a LOMR application to request a revision to the current effective Flood Insurance Rate Map (FIRM) panels. Exhibit A includes the FEMA forms for this LOMR submittal.

Pertinent information about the request is summarized as follows:

Identifier:	Lower Nehalem River (Cross Sections A through O)
Flooding Source:	Nehalem River
Community:	Tillamook County, Oregon
Community No.:	410196
FIRM Panels Affected:	4101960015B and 4101960020A

Unless otherwise stated, all elevations within this report are referenced to the North American Vertical Datum of 1988 (NAVD88).

2. RESEARCH

A FEMA Flood Insurance Study (FIS) is available for Nehalem Creek (FEMA, 2002). The flood boundaries for the study reach of the Nehalem River is available on Panels 15B and 20A for Community 410196, i.e., FIRM panel 4101960015B and 4101960020A. The floodway boundaries for the study reach is available on the Flood Boundary and Floodway Map (FBFM) panels 4101960015 and 4101960020. WEST obtained the effective HEC-2 model from the FEMA library. Digital versions of the Tillamook County, Oregon and Unincorporated Areas FIS (FEMA, 2002), FIRM panels, and DFIRM ArcGIS shape files were obtained from the FEMA Map Service Center website. The effective FIRM, FBFM, flood profile, and floodway data table are provided in Exhibit B.

There are two bridges located within the study reach that was updated as part of this submittal: (1) Highway 101 over the Nehalem, and (2) Necanicum Highway over the Nehalem (plans refer to the Nehalem as the South Fork Nehalem). Bridge plans were obtained from Oregon Department of Transportation (ODOT). Selected plan sheets are provided in Exhibit C. The model was exteneded to FEMA Cross Section O to meet FEMA's tie-in requirements. The model data for

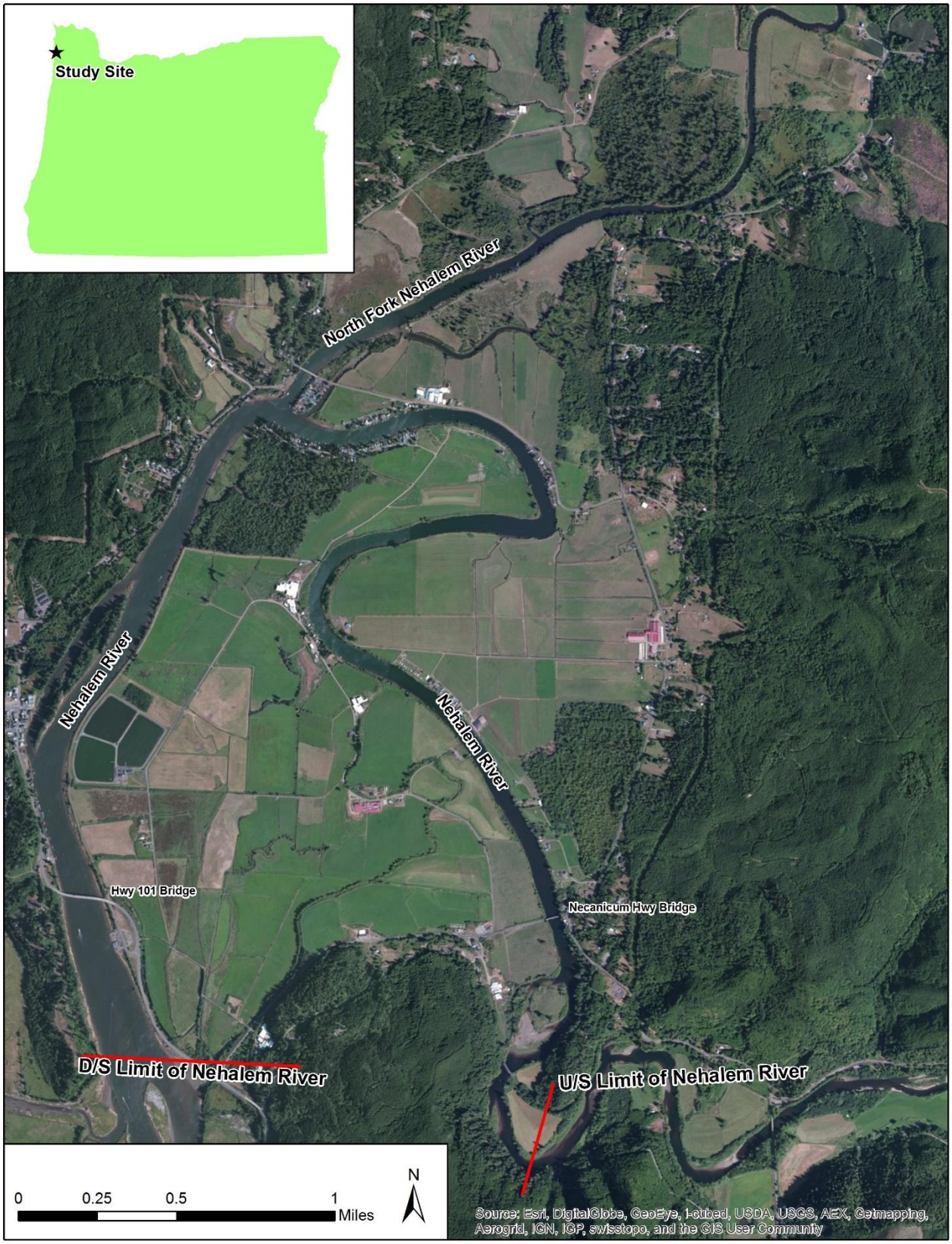

Figure 1. Project location map

the reach between Cross Section K and O is based on the effective FIS model. There is one

bridge within this reach.

LiDAR data from the Oregon Department of Geology and Mineral Industries (DOGAMI 2009) is the main topography data available for the study area. Electronic files of the topography data are included on the CD in Exhibit J.

3. HYDROLOGY

The hydrology for this LOMR submittal is based on the hydrology defined in the effective FIS (FEMA, 2002). As discussed in the FIS, the hydrology for Nehalem River was developed by U.S. Army Corps of Engineers using a hydrologic model that was calibrated to measured data at USGS stream gage 14301000, *Nehalem River near Foss, OR*. The peak discharges of Nehalem River for various annual chance flood events are summarized in Table 1.

Table 1. Peak Discharges for Various Annual Chance Flood Events

Location	Drainage Area (mi^2)	Peak Discharge (cfs) per Annual Chance Flood Event			
		10%	2%	1%[(1)]	0.2%
Mouth	847	57,300	66,200	74,000	87,400
Confluence with North Fork	746	37,950	48,050	52,900	63,350
Necanicum Highway	743.2	39,250	49,700	54,700	62,650

Notes:

1. The peak discharges in the above table take into account the attenuation of the overbank areas. The discharge considered for the floodway analysis accounts for the increase in discharge associated with the loss of storage.

4. HYDRAULICS

Information used to develop the various hydraulic models required for the LOMR submittal is provided in the following paragraphs.

4.1 Duplicate Effective Model (DEM)

The Duplicate Effective Model (DEM) is a copy of the model used in the hydraulic analysis of the effective FIS, referred to as the effective model. The effective model was obtained and reproduced by WEST Consultants. This is required to ensure the effective model: (1) has been transferred correctly to WEST's equipment, and (2) has been revised with new data in order to provide a continuous effective model both upstream and downstream of the specific reach of interest.

The hydraulic analysis for the effective FIS for the Nehalem River was completed using the HEC-2 program. The HEC-2 model was converted to an HEC-RAS model (designated as the DEM). The DEM was developed for the reach from FEMA cross section B at the downstream end to FEMA cross section O approximately 6.8 miles upstream from the mouth. The DEM consists of 27 cross sections and 3 bridge structures that were modeled using the "Normal

Bridge" approach.

The 1% annual chance water surface elevations (WSELs) for with and without the floodway computed using the DEM are summarized in Table 2. The WSELs in the table are based on NAVD88. The elevations in the effective FIS model are based on National Geodetic Vertical Datum of 1929 (NGVD29). The DEM model was initially developed in NGVD29 and the results were compared to the effective FIS model. After the comparison, HEC-RAS was utilized to

Table 2. Duplicate Effective Model Results

Model RS	FIS Cross Section	Base Flood Water Surface Elevations					
		Without Floodway			With Floodway		
		Effective FIS WSEL (ft, NAVD88)	DEM WSEL (ft, NAVD88)	Delta (ft)	Effective FIS WSEL (ft, NAVD88)	DEM WSEL (ft, NAVD88)	Delta (ft)
0.45	B	13.11	13.11	0.00	13.45	13.45	0.00
0.994	C	13.47	13.46	-0.01	13.87	13.88	0.01
1.02		13.47	13.49	0.02	13.90	13.9	0.00
1.021		13.43	13.43	0.00	13.83	13.83	0.00
1.023		13.44	13.36	-0.08	13.84	13.75	-0.09
1.024		13.59	13.73	0.14	14.02	14.09	0.07
1.05	D	13.61	13.75	0.14	14.05	14.11	0.06
2.01	E	14.67	14.79	0.12	15.26	15.5	0.24
2.92	F	15.57	15.68	0.11	16.33	16.53	0.20
3.66	G	16.26	16.35	0.09	17.27	17.45	0.18
4.78	H	17.30	17.37	0.07	18.30	18.43	0.13
5.65	I	17.68	17.73	0.05	18.59	18.69	0.10
5.951	J	17.74	17.8	0.06	18.54	18.64	0.10
5.989		17.57	17.63	0.06	18.35	18.45	0.10
5.99		17.53	17.59	0.06	18.30	18.4	0.10
5.994		17.56	17.61	0.05	18.33	18.43	0.10
5.995		17.68	17.74	0.06	18.47	18.56	0.09
6.01	K	17.60	17.66	0.06	18.45	18.54	0.09
6.25	L	19.70	19.73	0.03	20.11	20.17	0.06
6.559	M	20.55	20.46	-0.09	21.25	21.34	0.09
6.578		20.64	20.66	0.02	21.62	21.53	-0.09
6.579		20.63	20.65	0.02	21.61	21.51	-0.10
6.583		20.66	20.67	0.01	21.64	21.53	-0.11
6.584		20.81	20.8	-0.01	21.76	21.66	-0.10
6.61	N	20.77	20.7	-0.07	21.71	21.57	-0.14
6.80	O	23.85	23.8	-0.05	24.34	24.26	-0.08

convert the DEM model was developed in HEC-RAS then converted to NAVD88 by using a conversion factor of 3.54 feet. As shown in the table, the WSELs computed using the DEM are within the 0.5 foot tolerance specified by FEMA for applying a different hydraulic model. A hardcopy of the DEM is provided in Exhibit D, and an electronic version of this model is included on the CD in Exhibit J.

4.2 Corrected Effective Model (CEM)

The Corrected Effective Model (CEM) is the model that corrects any errors that occur in the DEM, adds any additional cross sections to the DEM, or incorporates more detailed topographic information than that used in the effective FIS model. The CEM must not reflect any man-made physical changes since the date of the effective model. An error could be a technical error in the modeling procedures, or any construction in the floodplain that occurred prior to the date of the effective model, but was not incorporated into the effective model.

The CEM was developed by updating the existing cross section with LiDAR data (DOGAMI, 2009) and adding additional cross sections for the reach between FEMA cross sections B through K. A plan view showing the location of the cross sections is shown in Figure 2. As shown in the figure, the existing and new cross sections extend across the southern floodplain, which was modeled as ineffective flow area (2-dimensional modeling of the area indicated that the southern floodplain functions as storage area with minimal flow velocity in the downstream direction). The main channel of Nehalem River within the study reach is comprised of silts and sand sized bed material with vegetated banks. A roughness coefficient of 0.026 was assumed for the reach downstream of the confluence with the North Fork Nehalem River and 0.028 was assumed for the reach upstream of the confluence. The overbank areas consist of grasses with moderate to heavy brush or densely vegetated trees and brush. A roughness coefficient of 0.06 was assumed for the grasses with brush area and 0.12 to 0.15 for the densely vegetated areas. Revisions to the cross sections extracted from the LiDAR data were made to eliminate all man-made physical changes completed since the date of the effective model. Minor changes were made to the effective floodway width to prevent the encroachment of the floodway within the active main channel. Table 3 shows a comparison of the DEM and CEM floodway widths. The changes in the floodway are minor and they result in a slight widening of the floodway.

The 1% annual chance flood WSELs for with and without floodway computed using the CEM are summarized in Table 4. This table also includes the WSELs computed using the DEM, and the difference in the WSELs between the two models. A hardcopy of the CEM is provided in Exhibit E, and an electronic version of this model is included on the CD in Exhibit J.

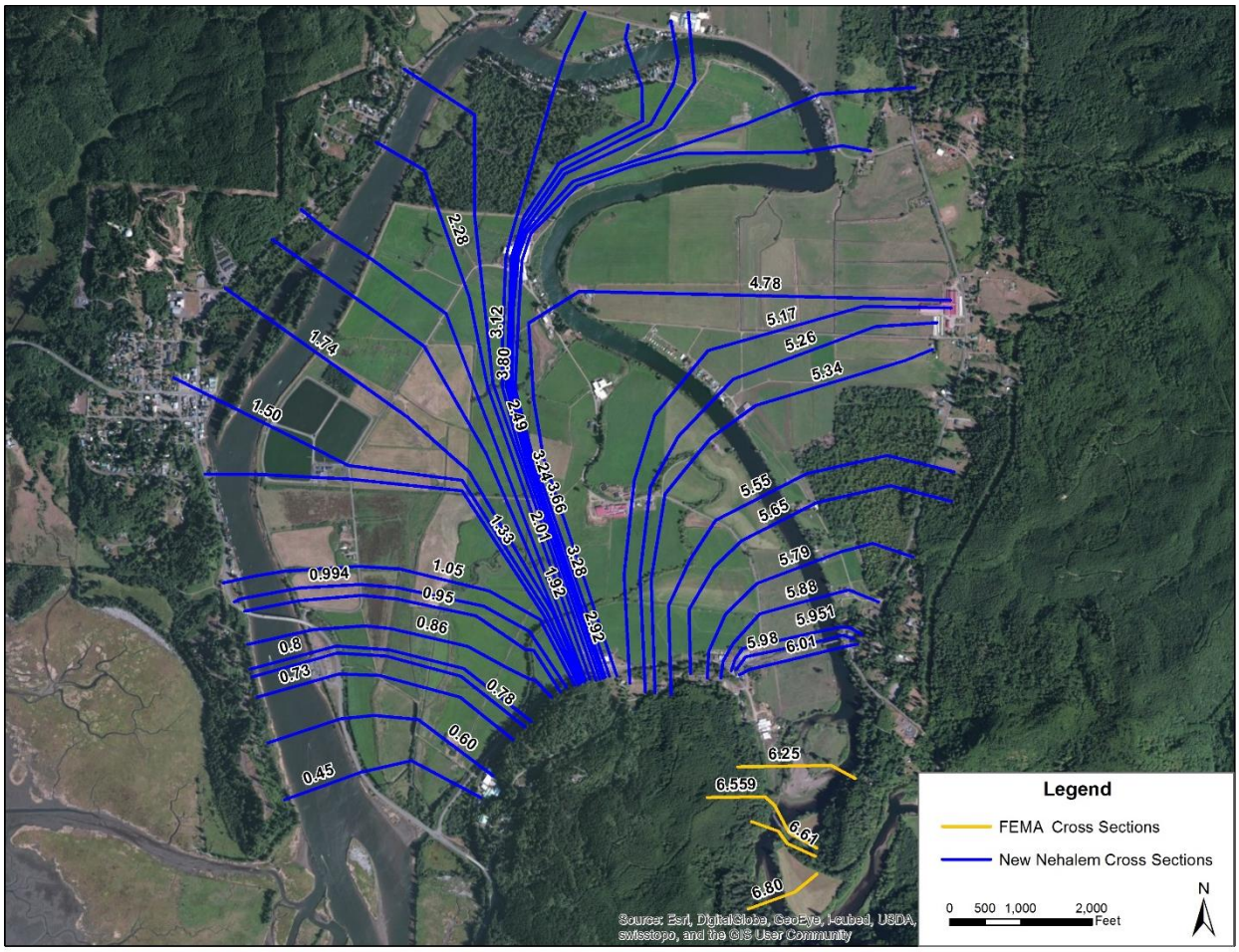

Figure 2. Layout of hydraulic model cross sections

Table 3. Revised Floodway Widths

RS	FIS Cross Section	Effective Floodway Width (ft)[1]	Mapped Floodway Width (ft)	Revised Floodway Width (ft)	Difference (ft)
0.45	B	1,025 (1,025)	1,025	1,066	41
0.60		-	930	930	0
0.73		-	851	851	0
0.78		-	816	816	0
0.80		-	805	812	7
0.86		-	766	811	45
0.95		-	702	702	0
0.994	C	643 (643)	660	675	15
1.05	D	618 (618)	620	620	0
1.33		-	593	593	0
1.50		-	778	804	25
1.74		-	928	928	0
1.92		-	904	929	25
2.01	E	716 (716)	715	739	24
2.28		-	460	481	21
2.49		-	674	674	0
2.92	F	580 (580)	570	570	0
3.12		-	887	887	0
3.24		-	1,219	1,219	0
3.28		-	1,404	1,404	0
3.66	G	2,500 (2,500)	2,480	2,480	0
3.80		-	2,383	2,383	0
4.78	H	4,432 (4,432)	4,415	4,415	0
5.17		-	2,979	2,979	0
5.26		-	2,720	2,720	0
5.34		-	2,507	2,507	0
5.55		-	2,192	2,192	0
5.65	I	1,902 (1,902)	1,985	1,985	0
5.79		-	1,429	1,429	0
5.88		-	824	824	0
5.951	J	375 (375)	379	379	0
5.98		-	279	288	9
6.01	K	282 (282)	266	277	11
6.25	L	734 (734)	-	734	0
6.559	M	670 (655)	-	655	0
6.578		(655)	-	655	0
6.579		(655)	-	655	0
6.583		(655)	-	655	0
6.584		(656)	-	656	0
6.61	N	490 (380)	-	380	0
6.80	O	310 (310)	-	310	0

Notes:

1. Two values provided are provided for the effective floodway width: (1) the first value is from the FIS, and (2) the second value, provided in the parenthesis, is from the effective hydraulic model.

Table 4. Corrected Effective Model Results

RS	FIS Cross Section	Base Flood Water Surface Elevations					
		Without Floodway			With Floodway		
		DEM WSEL (ft)[1]	CEM WSEL (ft)	Delta (ft)	DEM WSEL (ft)	CEM WSEL (ft)	Delta (ft)
0.45	B	13.11	13.11	0.00	13.45	13.45	0.00
0.60		13.21	13.32	0.11	13.57	13.61	0.04
0.73		13.29	13.36	0.07	13.67	13.65	-0.02
0.78		13.33	13.40	0.07	13.72	13.70	-0.02
0.80		13.34	13.50	0.16	13.73	13.80	0.07
0.86		13.38	13.55	0.17	13.78	13.86	0.08
0.95		13.44	13.63	0.19	13.85	13.94	0.09
0.994	C	13.46	13.68	0.22	13.88	14.00	0.12
1.05	D	13.75	13.7	-0.05	14.11	14.01	-0.10
1.33		14.05	13.88	-0.17	14.51	14.20	-0.31
1.50		14.23	14.04	-0.19	14.75	14.36	-0.39
1.74		14.48	14.31	-0.17	15.09	14.64	-0.45
1.92		14.67	14.74	0.07	15.34	15.13	-0.21
2.01	E	14.79	14.84	0.05	15.50	15.26	-0.24
2.28		15.06	14.95	-0.11	15.82	15.35	-0.47
2.49		15.26	15.15	-0.11	16.05	15.53	-0.52
2.92	F	15.68	15.52	-0.16	16.53	15.87	-0.66
3.12		15.87	15.69	-0.18	16.79	16.13	-0.66
3.24		15.98	15.75	-0.23	16.94	16.24	-0.70
3.28		16.02	15.78	-0.24	17.00	16.31	-0.69
3.66	G	16.35	16.21	-0.14	17.45	16.95	-0.50
3.80		16.47	15.97	-0.50	17.57	16.77	-0.80
4.78	H	17.37	17.51	0.14	18.43	18.32	-0.11
5.17		17.54	17.59	0.05	18.55	18.40	-0.15
5.26		17.58	17.61	0.03	18.58	18.43	-0.15
5.34		17.61	17.65	0.04	18.60	18.46	-0.14
5.55		17.70	17.53	-0.17	18.67	18.37	-0.30
5.65	I	17.73	17.49	-0.24	18.69	18.33	-0.36
5.79		17.76	17.85	0.09	18.67	18.69	0.02
5.88		17.78	18.08	0.30	18.65	18.86	0.21
5.951	J	17.80	17.98	0.18	18.64	18.74	0.10
5.98		17.74	18.03	0.29	18.60	18.79	0.19
6.01	K	17.66	18.20	0.54	18.54	18.96	0.42
6.25	L	19.73	20.30	0.57	20.17	20.69	0.52
6.559	M	20.46	20.96	0.50	21.34	21.72	0.38
6.578		20.66	21.14	0.48	21.53	21.89	0.36
6.579		20.65	21.13	0.48	21.51	21.88	0.37
6.583		20.67	21.15	0.48	21.53	21.90	0.37
6.584		20.80	21.28	0.48	21.66	22.02	0.36
6.61	N	20.70	21.18	0.48	21.57	21.93	0.36
6.80	O	23.80	24.08	0.28	24.26	24.47	0.21

Notes:

1. Values provided in the shaded cells are interpolated values.

4.3 Existing Conditions Model

The Existing Conditions Model is a modification of the DEM or CEM to reflect any modifications that have occurred within the floodplain since the date of the effective model but prior to the floodway revision being requested. The Existing Conditions model was developed by incorporating the land changes and structures built after the effective model was completed. No changes were made to the floodway boundaries. The 1% annual chance WSELs for with and without the floodway computed using the Existing Conditions model are summarized in Table 5. This table also includes the WSELs computed using the CEM, and the difference in the WSELs between the two models.

A hardcopy of the Existing Conditions model is provided in Exhibit F, and an electronic version of this model is included on the CD in Exhibit J.

4.4 Proposed Conditions Model

A Proposed Conditions Model was not developed for this submittal.

5. FEMA FORMS

As previously mentioned, completed FEMA MT-2 forms are included in Exhibit A.

6. SUMMARY

A hydraulic analysis of Nehalem River was completed for the reach between FEMA cross section B (RS 0.45) and O (RS 6.80) in the Tillamook County, Oregon. Model revisions were made only for the reach downstream of FEMA cross section K (RS 6.01) with the upper reach being need to meet FEMA's requirements for tying into the effective hydraulic model. The hydraulic analysis was completed in support of this LOMR submittal required by FEMA for development that has occurred within the floodway boundaries since the effective hydraulic model was completed. The revised floodplain boundaries are included in revised FIRM panel included in Exhibit G and work map included in Exhibit H. The results of the analysis indicate that there will be a reduction in the BFEs for the reach immediately upstream of the Highway 101 bridge and an increase in the BFEs for the reach downstream of the Highway 101 bridge and near the Necanicum Highway bridge.

Minor changes were made to the effective floodway width to eliminate the floodway encroachment into the active main channel. The changes in the floodway are considered minor (average of about 3.4%) and they result in a slight widening of the floodway.

Table 5. Existing Conditions Model Results

RS	FIS Cross Section	Base Flood Water Surface Elevations						
		Without Floodway			With Floodway			
		CEM WSEL (ft)	Existing WSEL (ft)	Delta (ft)	CEM WSEL (ft)	Existing WSEL (ft)	Delta (ft)	Surcharge (ft)
0.45	B	13.11	13.11	0.00	13.45	13.45	0.00	0.34
0.60		13.32	13.32	0.00	13.61	13.61	0.00	0.29
0.73		13.36	13.36	0.00	13.65	13.65	0.00	0.29
0.78		13.40	13.40	0.00	13.70	13.70	0.00	0.30
0.80		13.50	13.50	0.00	13.80	13.80	0.00	0.30
0.86		13.55	13.55	0.00	13.86	13.86	0.00	0.31
0.95		13.63	13.63	0.00	13.94	13.94	0.00	0.31
0.994	C	13.68	13.68	0.00	14.00	14.00	0.00	0.32
1.05	D	13.70	13.70	0.00	14.01	14.01	0.00	0.31
1.33		13.88	13.88	0.00	14.20	14.20	0.00	0.32
1.50		14.04	14.04	0.00	14.36	14.36	0.00	0.32
1.74		14.31	14.31	0.00	14.64	14.64	0.00	0.33
1.92		14.74	14.74	0.00	15.13	15.13	0.00	0.39
2.01	E	14.84	14.84	0.00	15.26	15.26	0.00	0.42
2.28		14.95	14.95	0.00	15.35	15.35	0.00	0.40
2.49		15.15	15.15	0.00	15.53	15.53	0.00	0.38
2.92	F	15.52	15.53	0.01	15.87	15.89	0.02	0.36
3.12		15.69	15.68	-0.01	16.13	16.12	-0.01	0.44
3.24		15.75	15.75	0.00	16.24	16.25	0.01	0.50
3.28		15.78	15.79	0.01	16.31	16.33	0.02	0.54
3.66	G	16.21	16.22	0.01	16.95	16.96	0.01	0.74
3.80		15.97	15.98	0.01	16.77	16.77	0.00	0.79
4.78	H	17.51	17.53	0.02	18.32	18.34	0.02	0.81
5.17		17.59	17.60	0.01	18.40	18.41	0.01	0.81
5.26		17.61	17.63	0.02	18.43	18.45	0.02	0.82
5.34		17.65	17.66	0.01	18.46	18.48	0.02	0.82
5.55		17.53	17.54	0.01	18.37	18.39	0.02	0.85
5.65	I	17.49	17.50	0.01	18.33	18.34	0.01	0.84
5.79		17.85	17.86	0.01	18.69	18.70	0.01	0.84
5.88		18.08	18.09	0.01	18.86	18.87	0.01	0.78
5.951	J	17.98	17.98	0.00	18.74	18.74	0.00	0.76
5.98		18.03	18.04	0.01	18.79	18.80	0.01	0.76
6.01	K	18.20	18.21	0.01	19.02	18.97	-0.05	0.76
6.25	L	20.30	20.31	0.01	20.74	20.70	-0.04	0.39
6.559	M	20.96	20.96	0.00	21.75	21.72	-0.03	0.76
6.578		21.14	21.15	0.01	21.93	21.90	-0.03	0.75
6.579		21.13	21.13	0.00	21.91	21.88	-0.03	0.75
6.583		21.15	21.16	0.01	21.93	21.90	-0.03	0.74
6.584		21.28	21.28	0.00	22.05	22.02	-0.03	0.74
6.61	N	21.18	21.19	0.01	21.97	21.94	-0.03	0.75
6.80	O	24.08	24.08	0.00	24.49	24.47	-0.02	0.39

Note: The "Delta" in the above table corresponds to the difference between the Proposed and Existing Conditions, and the "Surcharge" corresponds to the increase in the water surface elevation associated with the Proposed Conditions floodway boundaries.

Because the BFEs need to be revised, the Tillamook County, OR, in accordance with Part 65.12

of the National Flood Insurance Program (NFIP) regulations, will have to provide additional evidence before the effective FIRM is revised. As part of this submittal package, the following documents will be submitted by the Tillamook County, OR (furnished in Exhibit I):

1. Letter from the Tillamook County, OR stating that the County will adopt and enforce the modified floodplain and floodway.

2. Certification that no structures are located in the areas that would be impacted by the modified floodplain and floodway.

3. Documentation of individual legal notice to all impacted property owners within and outside the community explaining the impact of the revised floodplain and floodway.

7. REFERENCES

Federal Emergency Management Agency, *DFIRM Database, Tillamook County, Oregon*, 2010.

Federal Emergency Management Agency, *FIRM Panel 4101960015B, Tillamook County, Oregon*, September 1990.

Federal Emergency Management Agency, *FIRM Panel 4101960020A, Tillamook County, Oregon*, August 1978.

Federal Emergency Management Agency (FEMA), *Flood Insurance Study, Tillamook County, Oregon, Unincorporated Areas*, August 2002.

Oregon Department of Geology and Mineral Industries (DOGAMI), *LiDAR data, BE45123-F7 and BE45123-F8,* July 2009.

U.S. Army Corps of Engineers (USACE), *HEC-RAS River Analysis System User's Manual, Version 4.1*, January 2010.