US Army Corps
of Engineers ®
Portland District

Tillamook Bay and Estuary, Oregon General Investigation Feasibility Report

APPENDIX C

MIKE11 to HEC-RAS Model Conversion

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for the
U.S. Army Corps of Engineers
Portland District

March 2004

Hydraulic Modeling of the Tillamook Bay and Estuary Study

MIKE11 to HEC-RAS Conversion

Provided to:

Portland District Corps of Engineers

Provided by:

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Introduction

This report documents the conversion of the Tillamook Bay 1-D hydraulic unsteady flow model from MIKE11 Version 2001 (DHI, 2001) to HEC-RAS Version 3.1.1 (USACE, 2002b) and subsequent modeling of alternatives. This work was conducted by WEST Consultants, Inc. (WEST) for the Portland District Corps of Engineers (District) under contract DACW57-99-D-0003.

The major tasks that WEST completed included:

- Importing into HEC-RAS the MIKE11 geometry and discharges used in the prior Tillamook Bay modeling simulations, creating a “base geometry” model.
- Modification and calibration of the HEC-RAS base geometry model to successfully run the November 1999, May 2001, November 2001, January 2002, and 100-year events.

- Updating to current conditions from the base geometry model. This is referred to as “Alternative 1”.
- Modification of Alternative 1 to create a saltwater marsh in the Blind Slough area and flood control storage to the south of this area. This is “Alternative 2”.
- Modification of Alternative 2 to include ecosystem restoration in Nolan Slough. This is “Alternative 4”.

Model Conversion of Base Geometry

The first task that WEST initiated was to import the existing MIKE11 model (WEST, 2004) into HEC-RAS using existing tools in Version 3.1.1 of the HEC-RAS software. We imported the alignment and cross-section geometry for the main channels, sloughs, and overbank reaches into HEC-RAS, while attempting to keep the reach names and river stationing as close as possible to those specified in the MIKE11 model. The changes that we did make included shortening some of the reach names (due to maximum number of character limits in HEC-RAS) and setting the HEC-RAS river stationing equal to negative values of those in MIKE11 (since the direction of the cross-section ordering is reversed between the two models). We created additional cross-sections in those imported reaches that had only one cross-section in the MIKE11 model since reaches must have more than one cross-section in HEC-RAS. This was limited to the reaches near the downstream end of the model. We set junction lengths and initial Manning’s ‘n’ values equal to those specified in MIKE11 (see the Calibration section for further detail on calibration of the Manning’s ‘n’ values).

WEST created HEC-RAS boundary condition files for the November 1999, May 2002, November 2001, January 2002, and 100-year events using the data specified in MIKE11. We later modified the initial data points leading into the event in this data set to help stabilize the model (see the Model Stability section). We included in the unsteady flow files the observed highwater marks and stage hydrographs, which were identical to those specified in the MIKE11 models, that would be later used in the calibration of the Nov 1999, May 2001, Nov 2001, and January 2002 events (discussed in the Calibration section).

WEST also added bridges and culverts to the HEC-RAS model at the same locations as in the original MIKE11 model. However, when we entered the bridge information, rather than use the combination of level/width bridge geometry and culvert data that was used to define bridges in MIKE11, we created the bridges using the original data source which included survey information, other HEC-RAS models, and bridge drawings (WEST, 2003). We took culvert specifications directly from the MIKE11 data files.

WEST added “lateral structures”, i.e., levees and equivalent to MIKE11 “link channels”, in the HEC-RAS model to create hydraulic connections between various portions of the model. The lateral structure geometry were all re-cut from the TIN using GeoRAS (HEC, 2002a) rather than using the level/width information in MIKE11. We extended the length of some of the lateral structures upstream to the nearest cross-section, this being longer than they existed in the MIKE11 model, as part of this process. This simplified the process of defining the lateral structure “distance to upstream cross-section” parameter in HEC-RAS and added more definition to the model. Additional lateral structures were also added later as part of the calibration process (see the Calibration section).

We changed for clarification the lateral structure naming convention in HEC-RAS, from that used in MIKE11. We named lateral structures using four letters to identify the main reach followed by two letters indicating which bank the lateral structure is on (e.g. LB for left bank, RB for right bank) and then a letter indicating the order (ascending from upstream to down) rather then the random numbering scheme in MIKE11. As the lateral structures were later divided into smaller pieces numbers and then letters were added on to the lateral structure name. For example, “Wils_LB_ E” is a lateral structure on the left bank of the Wilson River. It is downstream of “Wils_LB_D” and upstream of “Wils_LB_F”. Wils_LB_E was later further divided into “Wils_LB_E_01” and “Wils_LB_E_02” to separate where the overtopping flow was connected downstream.

HEC-RAS does not allow lateral structures to start or end at the extents of a reach so, when necessary, we copied cross-sections 1 m away, to add the lateral structures into HEC-RAS. For those cases where the lateral structures were longer than the HEC-RAS reach length (e.g., if the structure was located in the outside of a bend), the overbank reach length was extended in HEC-RAS so as it would not overlap onto a downstream lateral structure or different reach.

We have provided in this Model Conversion of Base Geometry section of the report an overview summary of the steps taken to import the MIKE11 data. Additional detail can be found in “MIKE11 to HEC-RAS Conversion, Technical Notes” (WEST, August 2003)”.

Model Stability

We ran simulations during various stages in the process of converting from MIKE11, e.g. first with only the three major rivers, then with the sloughs added, then with bridges added, etc., identifying stability issues along the way, rather than importing the entire model at once and having less of an idea on where to look for instabilities. We ran into numerous stability problems during the development of the model, some of which we fixed by working with the Hydrologic Engineering Center to perfect the HEC-RAS code. Some of the other more wide-ranging fixes for stability including modifying the default HTAB parameters defined by RAS and adding pilot channels.

We modified each of the boundary condition files to provide a period of a constant flow or stage during the initial steps of the simulation. This was necessary since the model was typically unstable at the initial time step if the low flow on the rising limb of the hydrograph was specified. The constant stages and flows were then tapered to the observed low flow condition leading into the rising limb of the hydrograph.

One of the goals of this work was for WEST to create a geometry that could be used for numerous events, ranging from low to high flow. This added to the stability problems as the overbank channels transitioned between being "dry" (e.g., typically less than 1 cms in the pilot channel to keep it "wet" as is required by HEC-RAS) to when flow began to enter the channel, as well as transitions from narrow channel flow to the wider overbank flow. Additional complexity was also added as lateral structures (levees) were overtopped in the model. In all the simulations we increased the weir stability coefficients to help stabilize the model. We also converted some of the shorter overbank reaches, which appeared to have a level pool during most of the simulation, to storage areas. This helped to stabilize the simulations. Other changes to help stabilize the model included fitting a line to the upstream flow hydrographs, while maintaining the peak flow as best possible, where there were unrealistic jumps in the observed data. In the end, computation time steps of 5 or 15 sections were required to keep the model stable.

Some of the more significant and consistently troublesome spots include the Hall Do-RB 2090 reach, a small channel branching off from the upstream end of Hall Slough, the Hoqu RB 2.20 overbank reach, complicated by many overtopping lateral structures in a relatively short reach length, and the Tras RB 2.37 overbank reach, where the reach transitions from a well defined channel to no channel downstream of Highway 101. The Hall overbank area, downstream of Highway 101, originally modeled as a grouping of reaches, also caused significant stability issues as the lateral structures were overtopped. Preliminary results indicated that these reaches typically had a relatively uniform stage along the reach. Therefore, these reaches were converted to storage areas which especially improved the instability issues.

A numerical increase in the stage was created at the downstream end of the DoTr 0.85 reach in the simulation of the alternatives (alternatives are discussed in the Modeling Alternatives section) where it was connected to the Wetlands Acquisition storage area. An example is shown in Figure 1. This was due to the computation of the water surface being made during the transition from channel to overbank flow at the downstream end of the reach and the fact that the reach was connected at the downstream end to the Wetlands Acquisition storage area, which controlled the stage at this location. We modified the channel to make s smooth transition from channel to overbank flow which corrected for this phenomenon. Figure 1 shows that although the stage during the initial period of the simulation, when the model is transitioning from initial boundary conditions set for stability to the observed hydrograph, is different but that during the main event the results are identical except that the peak has been removed.

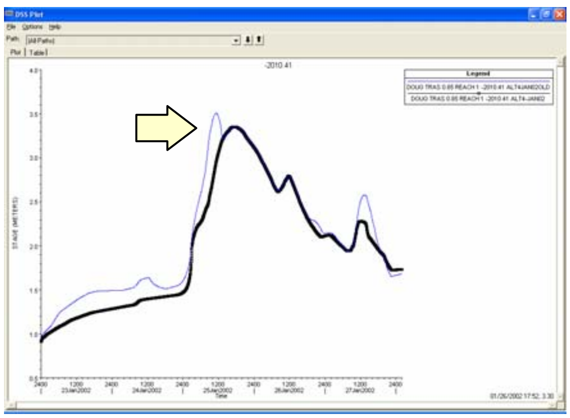

Figure 1. Example of the stage hydrograph rise calculated due to the calculation being made at the DoTr 0.85/Wetlands Acquisition storage area, with (heavy black line) and without (thin blue line) the correction for this phenomenon.

Of interest is a small oscillation in the flow that can be observed in numerous cross-sections in the lower portions of the model. The effect is typically only observed in the flow hydrograph when results are written at relatively small time steps (e.g., 2 minutes) since writing data at larger steps tends to mask these oscillations. This appears to be a numerical wave that is occurring based on the reflection of the tidal wave against the land boundary and the fixed downstream boundary condition, as best we could identify. We created a test case to help determine the root of this oscillation. An example of the oscillation from the test case is shown in Figure 2. We simplified the model to help eliminate potential causes, with the resulting test case being a single reach in HEC-RAS which including the Tillamook reaches and the Tillamook Bay reach form the base geometry. All bridges, lateral structures, culverts, storage areas, and storage area connections were removed. We set the upstream flow to a constant 60 cms and created a sinusoidal curve at the downstream boundary oscillating between 0 and 2 meters (Figure 3). We ran this test at 5 second time steps. The resulting simulation after this change still showed the oscillating flow (Figure 2) indicating that the oscillating downstream stage boundary was the cause. We could not dampen this effect during simulation of the events, however this change in flow is relatively small compared to the observed flows at the upstream boundary conditions.

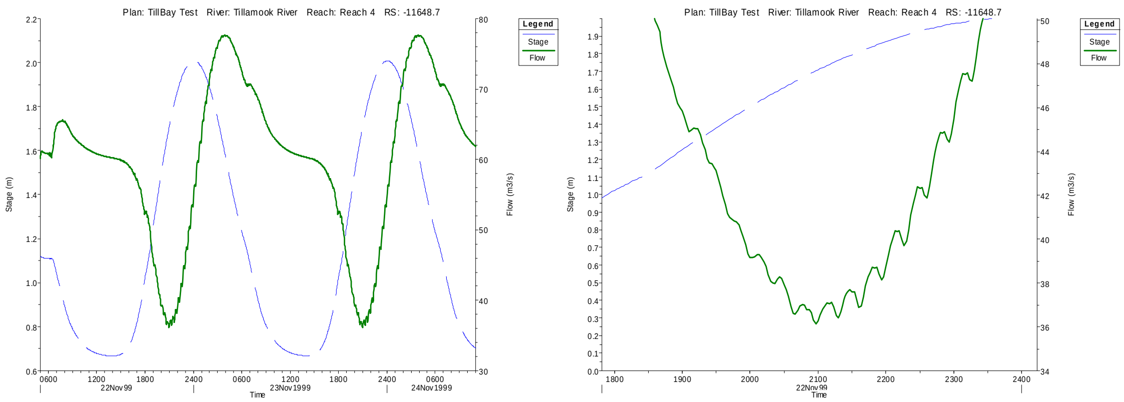

Figure 2. Example of small flow oscillations from the test case.

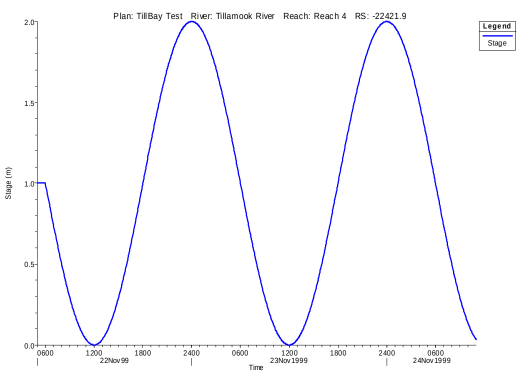

Figure 3. Downstream boundary for testing the cause of small flow oscillations.

Calibration

WEST began the calibration once we had created a stable model for each of the four calibration events (November 1999, May 2001, November 2001, and January 2002). We initially used the Manning's 'n' values specified in the MIKE11 simulation and then modified them to match the simulated stages to highwater marks and observed stage hydrographs. We first calibrated the Manning's 'n' values in the rivers and sloughs for the in-channel events and then, while keeping these values fixed, calibrated the overbank Manning's 'n' values for the larger events. However, we found it difficult to select one set of parameters to adequately model all events, and ended up modifying the Manning's 'n' value in the rivers and sloughs for the out-of-bank events. We observed that during the calibration of the out-of-bank events that the amount of flow over the lateral structures had a considerable effect on the results. The amount of flow over the lateral structures was most affected by 1) the Manning's 'n' value in the channel, which would changes the stage and therefore the head driving flow over the lateral structures, 2) the weir coefficient (Cd), 3) the amount of lateral structure submergence, and 4) the geometry defining the lateral structure geometry. WEST found that during calibration of the out-of-bank events that initially too much flow was overtopping the lateral structures as there was not enough flow in the main channels to match the high watermarks. The weir coefficient was typically lowered to 0.55 (1.0 in English units) to reduce the amount of flow leaving main channels. In addition, throughout the study area the TIN had significant deficiencies in definition of the levee elevation frequently showing "gaps" in locations were levees are known to exist (Figure 4). The "filling" of these gaps reduced the amount of flow leaving the main channels and improved the calibrated results.

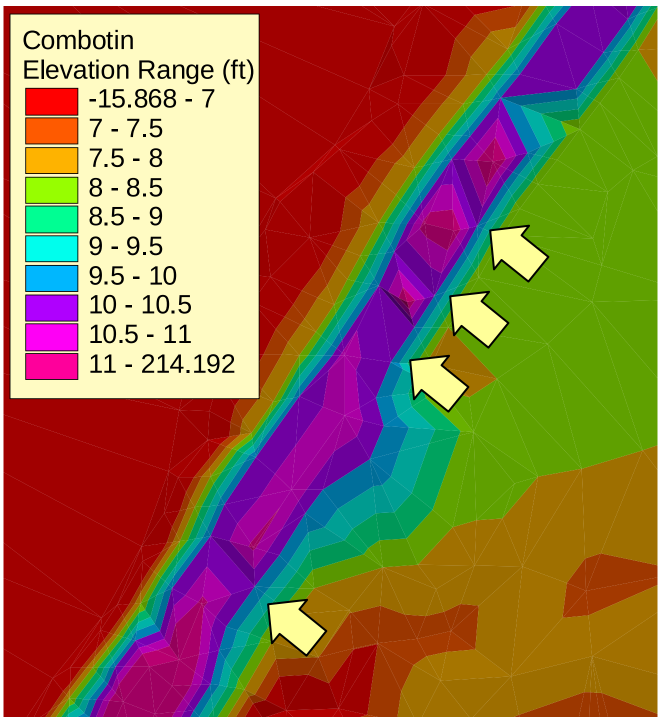

Figure 4. Example of "gaps" (indicated by arrows) in the TIN definition of the levee geometry.

The final calibrated Manning's 'n' values and comparison of simulated results to both high water marks and observed stage hydrographs are shown in Table 1, Table 2, and Figure 5 through Figure 9. Overall the results are good, with highwater marks typically being within ±0.4 meters and the timing and the shape of the hydrographs matching well. However, there are some high excursions during specific events, but improvement could not be made without drastically affecting other events. For example, the simulated stage is high (0.97 meters) for the November 2001 event at river station -10193 on the Tillamook River, yet much better for the May 2001 and November 1999 events upstream and downstream of this location. This may be due to an error in the November 2001 highwater mark as this stage is lower than the observed stage at the downstream boundary condition. Another example is Hall RB 3.00, which is 1.26 meters too low for the November 2001 event, yet the difference between observed and simulated at the same location is 0.03 meters for the November 1999 event. Dougherty Slough which is high at the upstream end for the May 2001 event yet low, and much closer, for the other three events. Looking across all events typically shows some events being high and others low for the same location. Another example is the Hall at RS -3100.7 being high for the May 2001 event (0.13 meters) and low for the November 1999 event (-0.21).

The upstream end of the Wilson River (reach 8a) is consistently high for all four calibration events, however downstream (reach 7) the values are equal or below the observed high water marks. The Manning's 'n' value is consistent through these reaches and no rational could be determined for decreasing the Manning's 'n' value in an upstream direction (the system typically shows an increase in Manning's 'n' value moving in an upstream direction). Modifying the lateral structure coefficients, downstream connections, adding additional lateral structures, etc. to try to adjust the flow distribution in the left bank of the Wilson River, near the Wils-Doug 690 reach area, helped to improve the calibration in this area. Additional refinement might further improve the calibration.

The upstream end of the Till OldT 0_30 at river station -258 is too low (-1.1 meters), but nearly perfect, 0.03 meters, downstream. This is likely due to not enough division in the lateral structures as there are no lateral structures connected to the reach in this area or upstream of this location.

On last general note is that the May 2001 event has times associated with the highwater marks (i.e., they may not be the maximum stage for the event). If the simulated timing is off slightly for this event it can obviously affect the comparison to simulated results.

Table 1. Range of Manning's 'n' values used in the HEC-RAS simualations.

River	Manning's 'n' value
Tillamook Bay	0.02
Wilson River	0.04 - 0.07
Hall	0.07
Dougherty Slough	0.09 - 0.15
Hoquarten Slough	0.07
Trask River	0.034 -0.07
Tillamook River	0.04 - 0.07
Old Trask River	0.04
Overbank reaches	0.07 - 0.09

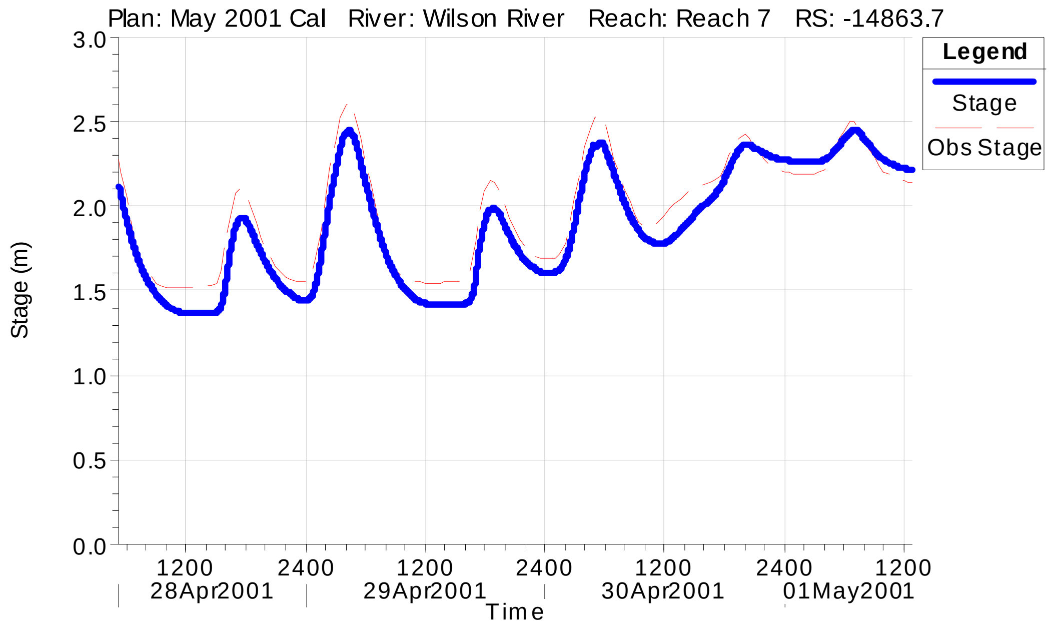

Figure 5. Simulated (solid blue) and observed (dashed red) at Geinger Farm during May 2001.

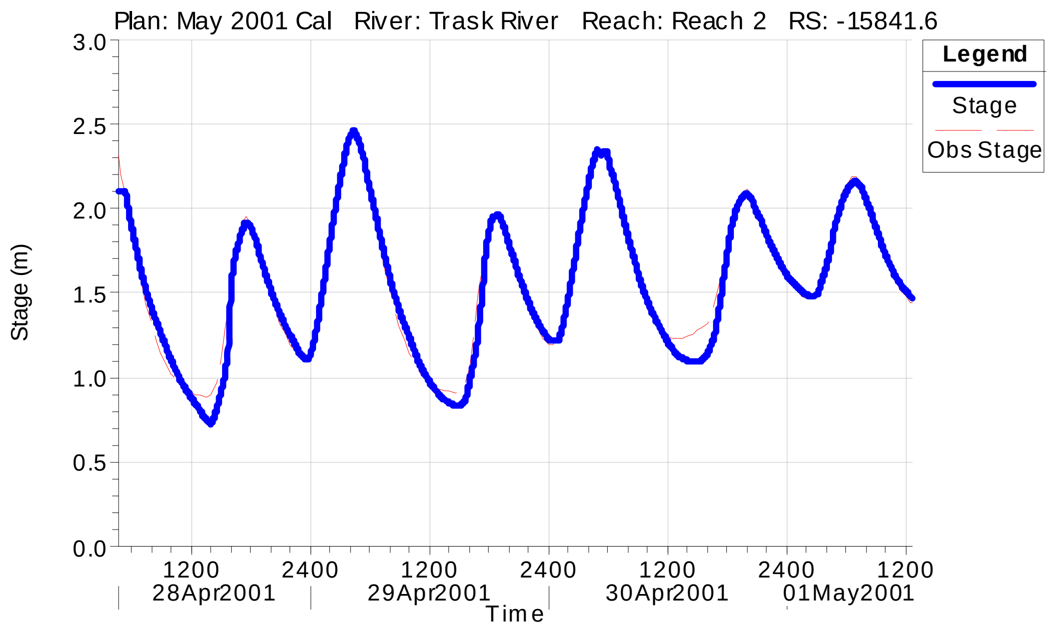

Figure 6. Simulated (solid blue) and observed (dashed red) at Carnahan tide gage during May 2001.

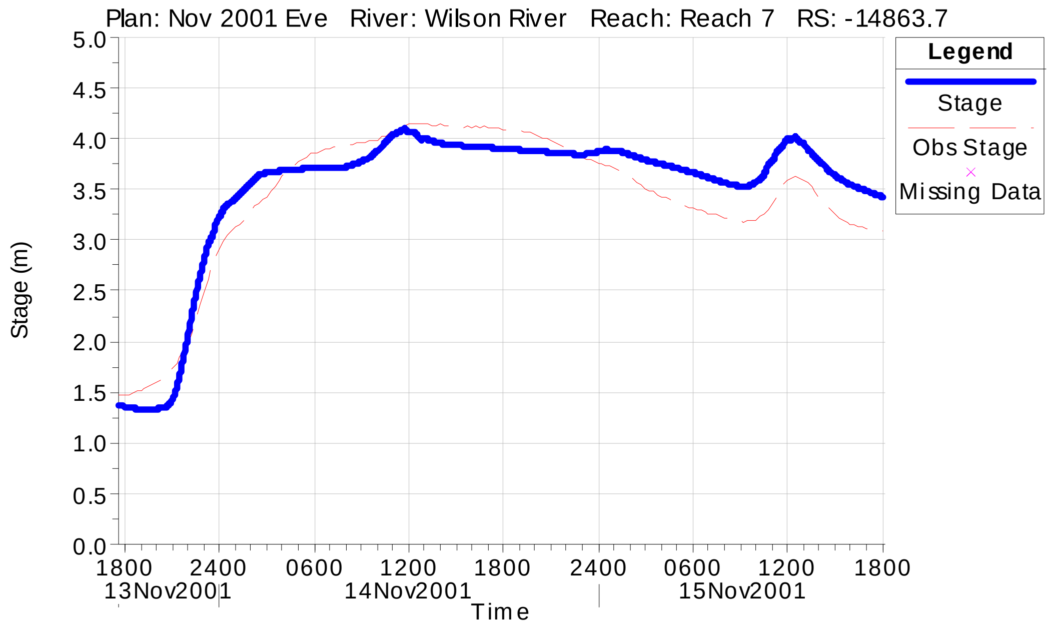

Figure 7. Simulated (solid blue) and observed (dashed red) at Geinger Farm during November 2001.

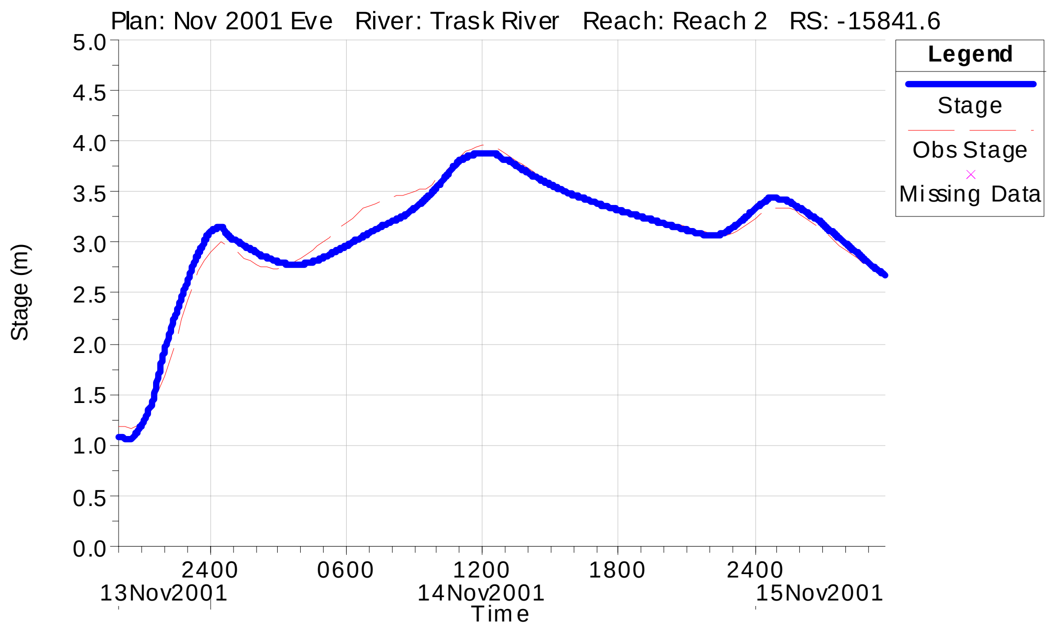

Figure 8. Simulated (solid blue) and observed (dashed red) at Carnahan during November 2001.

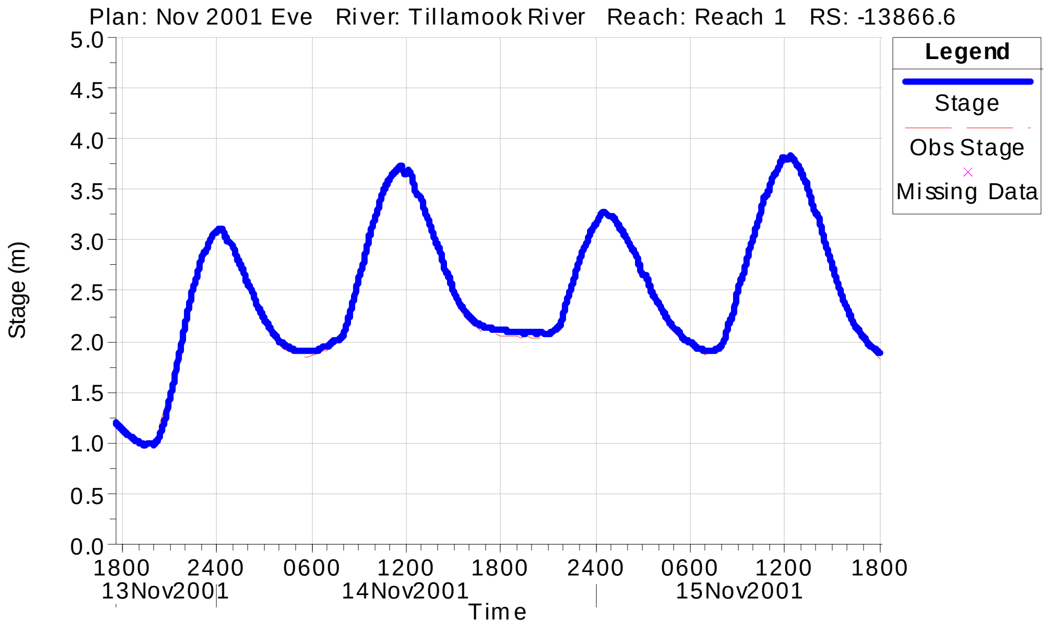

Figure 9. Simulated (solid blue) and observed (dashed red) at Dick Point during November 2001.

Table 2. Observed vs. Simulated Highwater Marks

				May-01				Nov-01				Nov-99				Jan-02		
River	Reach	River Sta	Obs WS (m)	Simulated (m)	Diff (m)	Diff (ft)	Obs WS (m)	Simulated (m)	Diff (m)	Diff (ft)	Obs WS (m)	Simulated (m)	Diff (m)	Diff (ft)	Obs WS (m)	Simulated (m)	Diff (m)	Diff (ft)
Wilson River	Reach 8a	-1299.9	13.1	13.28	0.18	0.59	16.06	16.46	0.40	1.31	17.53	17.75	0.22	0.72	16.09	16.49	0.40	1.31
Wilson River	Reach 8a	-1650.7	12.41	12.67	0.25	0.84	15.51	15.82	0.31	1.02								
Wilson River	Reach 8a	-5010.1					11.26	11.58	0.32	1.05								
Wilson River	Reach 7	-8908.9					8.82	8.82	0.00	0.00	8.99	9.15	0.16	0.52	8.87	8.83	-0.04	-0.13
Wilson River	Reach 7	-8942.9	4.42	4.77	0.35	1.15												
Wilson River	Reach 7	-11294.6					7.08	6.71	-0.37	-1.21	7.14	6.84	-0.30	-0.98	7.09	6.72	-0.37	-1.21
Wilson River	Reach 7	-11336.5	3.24	3.43	0.19	0.62												
Wilson River	Reach 7	-12445.1	2.87	3.12	0.25	0.82	6.42	6.16	-0.26	-0.85	6.45	6.24	-0.21	-0.69	6.36	6.16	-0.20	-0.66
Wilson River	Reach 7	-12759.2					5.69	5.84	0.15	0.49								
Wilson River	Reach 7	-14341.9	2.35	2.56	0.21	0.69												
Hall	Reach 1	-1275.1					4.5	4.49	-0.01	-0.03								
Hall	Reach 1	-2245.1									4.2	4.15	-0.05	-0.16				
Hall	Reach 1	-3100.7	2.03	2.16	0.13	0.43					4.27	4.06	-0.21	-0.69				
Hall RB 3.00	Reach 1	-345.2					5.04	3.78	-1.26	-4.13	4.1	4.11	0.01	0.03				
Dougherty Slough	Reach 1a	0	4.83	5.29	0.46	1.51												
Dougherty Slough	Reach 1a	-172	4.61	4.94	0.33	1.08												
Dougherty Slough	Reach 3	-690.6	4.02	4.33	0.31	1.02	7.96	7.92	-0.04	-0.13	8.42	8.38	-0.04	-0.13	8.1	7.95	-0.15	-0.49
Dougherty Slough	Reach 3	-2157.0					6.03	6.03	0.00	0.00								
Dougherty Slough	Reach 3	-2184.3									6.52	6.3	-0.22	-0.72	6.26	5.97	-0.29	-0.95
Dougherty Slough	Reach 1	-4170.2	1.94	1.96	0.02	0.07												
Dougherty Slough	Reach 1	-4684.9	2.01	2.00	-0.01	-0.03	3.76	4.01	0.25	0.82								
Dougherty Slough	Reach 1	-4730.6					3.86	3.97	0.11	0.36								
Hoquarten Slough	Reach 3	-6234.9	1.95	1.88	-0.07	-0.23					4.78	4.78	0.00	0.00				
Wetlands	Storage																	
Trask River	Reach 3	-3231	13.06	13.08	0.02	0.07												
Trask River	Reach 3	-6374									11.86	11.8	-0.06	-0.20	10.61	10.48	-0.13	-0.43
Trask River	Reach 3	-6385.95	7.16	7.26	0.09	0.31												
Trask River	Reach 3	-9164.6	4.48	4.59	0.11	0.36					9.6	9.33	-0.27	-0.89				
Trask River	Reach 3	-10930.5	2.74	2.63	-0.12	-0.38												
Trask River	Reach 3	-10954.3									8.14	8.07	-0.07	-0.23				
Trask River	Reach 3	-12965.6	2.04	2.00	-0.04	-0.13												
Trask River	Reach 3	-14070.4	1.83	1.78	-0.05	-0.16												
Trask River	Reach 3	-14078.5									5.78	5.6	-0.18	-0.59				
Trask River	Reach 2	-15841.6									4.51	4.43	-0.08	-0.26	4.5	3.91	-0.59	-1.94
Trask River	Reach 2	-15873.6	1.49	1.48	-0.01	-0.03	3.96	3.89	-0.07	-0.23								
Old Trask River	Reach 1	-2796.6					3.14	3.68	0.54	1.77								
Tillamook River	Reach 4	-28.2	4.76	4.68	-0.08	-0.26												
Tillamook River	Reach 4	-2605.7									4.3	4.22	-0.08	-0.26				
Tillamook River	Reach 4	-2658.5	2.04	2.08	0.04	0.13												
Tillamook River	Reach 4	-3532.8	1.94	1.92	-0.02	-0.07												
Tillamook River	Reach 4	-5060.3	1.99	1.95	-0.04	-0.13					4.25	4.18	-0.07	-0.23				
Tillamook River	Reach 4	-6775.5	2.04	1.91	-0.13	-0.43												
Tillamook River	Reach 4	-8402.1	1.98	1.88	-0.10	-0.33												
Tillamook River	Reach 3a	-10193					2.75	3.72	0.97	3.18	3.75	3.87	0.12	0.39				
Tillamook River	Reach 2	-12823.8									2.96	3.08	0.12	0.39				
Till oldt 0_30	Reach 2	-258									5.5	4.4	-1.10	-3.61				
Till oldt 0_30	Reach 2	-1045									4.3	4.33	0.03	0.10				
Tras rb 2.37	Reach 1	-2919.4									6.1	6.11	0.01	0.03				

Modeling Alternatives

WEST modeled three alternatives, which included:

- Alternative 1: Updating to existing conditions from the base geometry model.
- Alternative 2: Modification of Alternative 1 to create a saltwater marsh in the Blind Slough area and flood control storage to the south of this area (Figure 10).
- Alternative 4: Modification of Alternative 2 to include ecosystem restoration in Nolan Slough (Figure 10).

We modeled two flows, the January 2002 and 100-year events as selected by the District, for these alternatives. The modifications WEST made to for Alternatives 2 and 4 were to achieve no-rise, defined as a water surface increase above 0.0015 meters (0.005 feet), in areas with existing structures, especially near Highway 101, for the two events. Any changes that WEST made during modeling of any of these alternatives, e.g. copying additional cross-sections, further division of lateral structures, etc. were made to all geometry files in the HEC-RAS model to ensure equivalent comparisons could be made between results.

Base geometry to Alternative 1

A number of modifications were made to the base geometry to update it to existing conditions under direction from the District. This included raising the Wilson River lateral structures at river stations -10412 and -11088 so that they were not overtopped (raised an arbitrary 1 meter), removing the Jones cross-levee (at river station -1817.81 on the Doug Tras 0.85 reach) and replacing it with data provided by the District, and updating Dougherty Slough geometry with new cross-section data (at river stations -3467, -3468, and -3477.1).

Alternative 1 Conversion to Alternative 2

Alternative 2 modified Alternative 1, under guidance from the District, to create a saltwater marsh in the Blind Slough area and flood control storage to the south of this (Figure 10). We breached lateral structures to reconnect the main channel to blocked off sloughs in the overbanks. We set the width of the breaches to approximately match the slough widths, and the side slopes of the breaches were set at 2:1 slopes. Table 3 lists a summary of the levee breaches added for Alternative 2.

Table 3. Breaches in the lateral structures made for Alternative 1.

River	River Station	Breach Width (m)	Breach Station (m)
Wilson River	-15616	4	262
Wilson River	-16541	4.5	400
Wilson River	-16541	16	522
Hall Slough	-3855	10	872
Blind Slough (DO TR Wils 0.73)	-504	15	433.5
Blind Slough (DO TR Wils 0.73)	-504	10	866

We removed the inline structure (at river station -1225) on the Blind Slough reach (DO TR Wils 0.73) for Alternative 2 and added three 1.5 meter diameter culverts (with flap gates) to the lateral structure that connects the upstream end of Blind Slough (at river station -383) to the Wetlands Acquisition Storage Area. We divided the Wetlands Acquisition Storage Area in Alternative 1 into two storage areas with a 1,551 meter long levee that linearly varied in elevation from 3.8 to 3.82 meters and contained three 1.83 meter diameter culverts (with flap gates). The northernmost of these two new storage areas was hydraulically connected to the main river channel by the previously mentioned laterals structure breaches.

We also included tide gates in the lateral structure that connects the Wetlands Acquisition area to the Tillamook River (at river station -12200 3). This is the same lateral structure that contains the eleven existing flood control culverts. We assigned arbitrary dimensions to these three gates of 6.5 meter width, 1.83 meter height, and invert elevation of 1.3 meters. We specified that these gates be closed throughout the Alternative 2 simulations, since an endless number of time series gate opening could be defined in an attempt to cause no rise in the 100-year and January 2002 events and the culverts, with tide gates, left in place. In addition, tidal flaps cannot be added to gates in HEC-RAS which would have complicated even further setting an appropriate time series. The final gate design and operations could be defined to mimic the flow through the culverts for the Alternative 2 simulations.

Finally, a swale was added in the Doug Tras 0.85 overbank reach from river stations -1240 to -2529.71. We made two “cuts” for this swale at elevations directed by the District; one that was 21 meters wide at a bottom elevation of 1.8 meters, and one that was 1.8 meters wide at a bottom elevation of 1.5 meters.

The January Alternative 2 results initially showed an undesirable rise in the downstream portion of the DoTr 0.85 overbank reach. Two additional culverts with the tidal flaps (which the gate time series would also need to replicate for this simulation) were added to the lateral structure to help alleviate this increase.

The resulting Alternative 2 water surface elevation shows no-rise in the January 2002 water surface elevation (Table 4). The 100-year event, with identical geometry to the January 2002 event except that these additional two culverts were not added, showed a rise only in areas that met the approval of the District; at the Blind Slough/Wilson River confluence, in the southernmost of the two new Wetlands Acquisition storage areas, and at the downstream end of the Doug Tras 0.85 overbank reach where is connects with southern storage area.

Alternative 2 Conversion to Alternative 4

WEST modified Alternative 2 to include ecosystem restoration in Nolan Slough for Alternative 4 (Figure 10). We created a new Nolan Slough reach for this alternative, and reduced the volume of the southern Wetlands Acquisition area accordingly. New levees were added to separate Nolan Slough from the Wetlands Acquisition storage area and the Doug Tras 0.85 reach so that it would not be overtopped during typical tidal flows. A 1.83 meter culvert with a tidal flap was placed in each of the two new levees. We breached the lateral structure connecting the upstream end of Nolan Slough with the Houquarten Slough (at river station -9017) with two 10 meter wide breaches starting at bottom elevations of 1.83 meters and having 2:1 side slopes. We also breached the lateral structures connecting to the Trask River near the downstream end of Nolan Slough (at river station -16998 [station 130] and at river station -17437 [station 500]). We used the same dimensions as at the upstream breaches except that the bottom elevation was set to 0 meters for the most downstream breach.

WEST also lowered, by 0.3 meters for a distance of 288 meters, a lateral structure connecting Dougherty Slough (river station -4731 from station 1365 to 1653) to the DoTr 0.85 reach to assist in reducing peak stages. Other differences between the Alternative 2 geometry to ensure that no rise in undesirable location included setting the lateral structure height between the two Wetlands Acquisition storage areas at 3.81 meters and using a 1.5m diameter culvert, not including the additional two culverts that were added in the Tillamook lateral structure for the January 2002 Alternative 2 simulation, and increasing the breach width to 20m from 16m in the Wilson River lateral structure at river mile -16541 (station 400).

Table 4 shows that Alternative 4 creates a rise only at the Blind Slough/Wilson River confluence for the January 2002 event, which met with approval by the District, and no rise for the 100-year event.

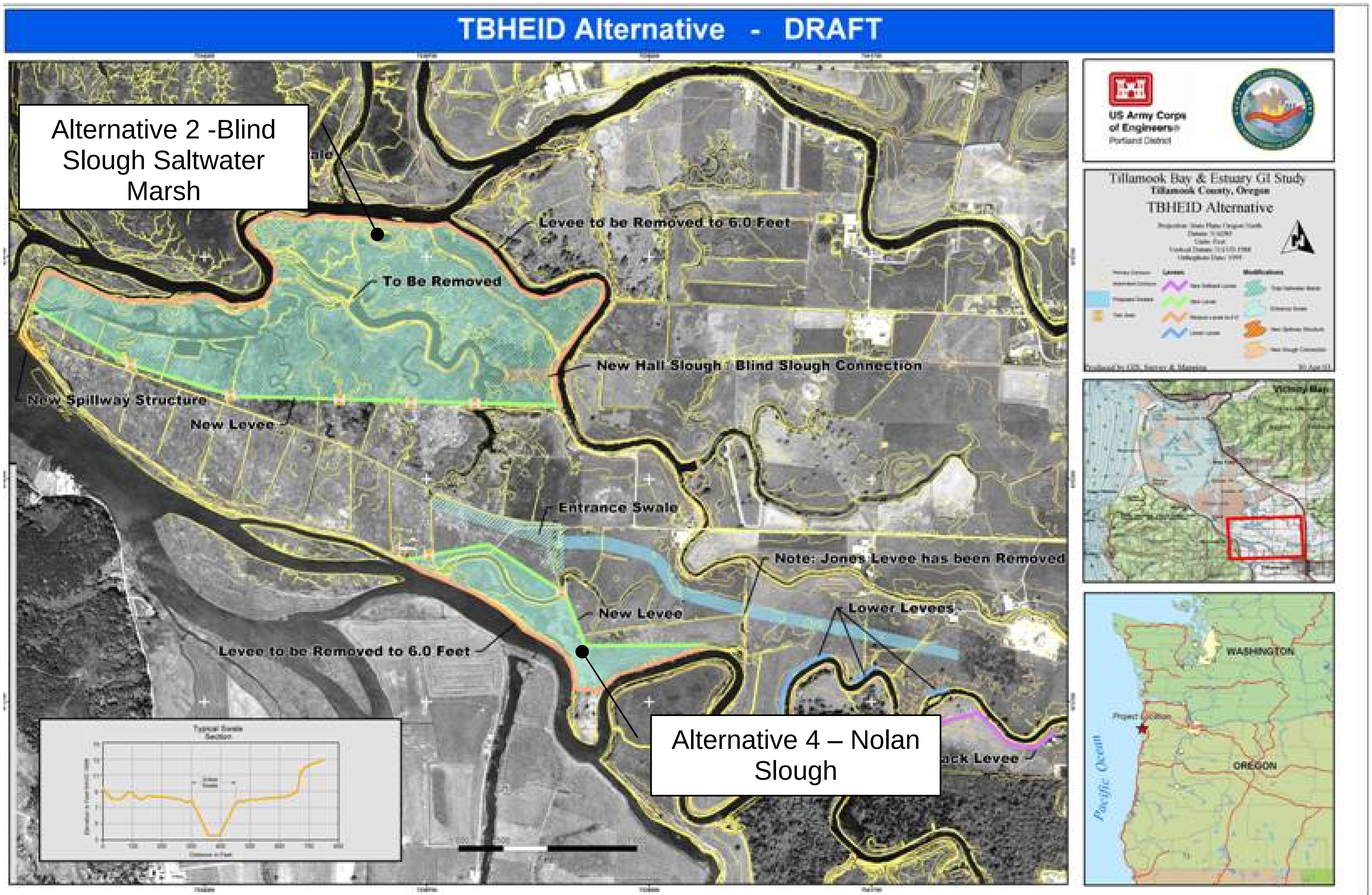

Figure 10. Schematic of Alternative 2 and Alternative 4.

Table 4. Increase in January 2002 and 100-year simulations for Alternative 2 and Alternative 4.

Simulation	Location			Stage (m)	Increase greater than 0.0015 (m)	Notes
	Reach	River	Station			
Alt2 Jan02	*N/A*	*N/A*	*N/A*	*N/A*	0.0000	No rise greater than 0.0015m
Alt2 100yr	Wilson River	Reach 4a	-16260	3.6122	0.0085	Blind Slough/Wilson R. Confluence
	Wilson River	Reach 4a	-16261	3.6119	0.0085	Blind Slough/Wilson R. Confluence
	Wilson River	Reach 4b	-16538.4	3.6119	0.0085	Blind Slough/Wilson R. Confluence
	Wilson River	Reach 4b	-16539.4	3.6104	0.0089	Blind Slough/Wilson R. Confluence
	Hall RB 3.00	Reach 1	-39.9	4.6622	0.0094	Water surface elevation is in pilot channel
	Doug tras 0.85	Reach 1	-2529	4.0139	0.0088	Junction with wetlands acquisition storage area
	Doug tras 0.85	Reach 1	-2529.71	4.0136	0.0091	Junction with wetlands acquisition storage area
	Do-Tr Wils 0.73	Reach 1	-1556.62	3.6119	0.0085	Blind Slough/Wilson R. Confluence
	Wetland Aqu SA S	*N/A*	*N/A*	4.013	0.0091	Storage Area
Alt4 Jan02	Wilson River	Reach 4a	-16260	3.2662	0.0024	Blind Slough/Wilson R. Confluence
	Wilson River	Reach 4a	-16261	3.2659	0.0024	Blind Slough/Wilson R. Confluence
	Wilson River	Reach 4b	-16538.4	3.2659	0.0024	Blind Slough/Wilson R. Confluence
	Wilson River	Reach 4b	-16539.4	3.2656	0.0027	Blind Slough/Wilson R. Confluence
	Do-Tr Wils 0.73	Reach 1	-1556.62	3.2659	0.0024	Blind Slough/Wilson R. Confluence
Alt4 100yr	Hall RB 3.00	Reach 1	-39.9	4.6634	0.0106	Water surface elevation is in pilot channel

Note: This data presents the results where HEC-RAS shows a rise above 0.0015 meters in the maximum water surface elevation. The stage shown for the upstream end of the Hall RB 3.00 overbank reach for the two 100-year simulation is within the pilot channel, and not above the ground geometry. Therefore, it would not result in an observed rise at the surface and is not included as a rise in the discussion of this report.

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