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Memorandum

To: Chehalis River Basin Flood Authority

From: Bob Elliot and Larry Karpack, WATERSHED Science & Engineering (WSE)

Date: March 13, 2012

Re: **Newaukum River Model Extension and Refinement**

WATERSHED Science & Engineering (WSE) and WEST Consultants (WEST) are currently working with the Chehalis River Basin Flood Authority to develop a hydraulic model of the Lower Chehalis River (from Grand Mound to Aberdeen). This model will be used to evaluate the effects of potential flood relief alternatives in the basin. In addition to work on the main stem hydraulic model, the Flood Authority authorized WSE to collect data and/or refine portions of the model on significant Chehalis River tributaries, including the Newaukum River. Lewis County has indicated that an improved hydraulic model of the Newaukum River would be beneficial to their flood damage reduction planning efforts.

The FEMA "Twin Cities" model of the Chehalis basin included the Newaukum River from its mouth upstream to approximately River Mile (RM) 4.1 at Labree Road, as well as the lower 3.45 miles of Dillenbaugh Slough, which receives overflows from the Newaukum River both upstream and downstream of Labree Road. Modeling conducted for the Corps of Engineers in the 1990s by Pacific International Engineering (PIE) using the UNET model, and more recently in 2001 by Northwest Hydraulic Consultants (NHC) using HEC-RAS, included the entire main stem of the Newaukum River including upstream of Labree Road to RM 10.63 (just below the North Fork confluence) . NHC used data from various sources but primarily the UNET model developed by PIE. Neither the PIE nor the NHC model was geo-referenced (e.g. tied to a fixed horizontal coordinate system); however, AutoCAD files from PIE are available to show the location and alignment for the UNET cross-sections.

This memorandum summarizes current work by WSE along the upper reach of the Newaukum River, upstream of Labree Road from RM 4.11 to RM 10.63, to geo-reference, refine, and extend the Flood Authority HEC-RAS model being developed jointly by WSE and WEST. The floodplain portions of all cross-sections were re-cut using 2002 LiDAR data obtained from the Puget Sound LiDAR Consortium (PSLC) and merged with the main channel data from the NHC model. Cross-sections in the NHC model that were not shown on the PIE AutoCAD drawings were located along the channel by their reach lengths, then extended appropriately across the floodplain and cut from the LiDAR data.

Geo-referencing cross-section locations

The original NHC hydraulic model for this reach of the Newaukum River includes forty three (43) cross-sections upstream of RM 4.1. None of these cross-sections were geo-referenced in the NHC model. For the current work the location of forty (40) of the cross-sections was established from the original PIE cross-section lines shown in AutoCAD. NHC also added three cross-sections to the earlier PIE model at approximately RMs 6.87, 7.54, and 9.84. The locations of these sections were estimated by WSE based upon modeled reach lengths, and extended onto the floodplain considering anticipated flood flow hydraulic conditions. The overbanks were also re-aligned and improved at four other model cross-sections that had been extended or otherwise modified by NHC (RMs 7.1, 7.12, 7.21, and 7.91). The new alignments were established by WSE in consideration of hydraulic conditions as interpreted from the 2002 LiDAR data. Figure 1 shows a comparison between the original cross section alignments from the NHC model and the cross sections alignments for the refined WSE model. These cross sections were geo-referenced and incorporated into the hydraulic model utilizing HEC-GeoRAS (USACE, 2011).

Re-cutting cross-sections with 2002 PSLC LiDAR

Utilizing HEC-GeoRAS (USACE, 2011), the geo-referenced cross-sections were repopulated with elevation data from the 2002 PSLC LiDAR. The two sets of cross-sections, one with the original surveyed elevations in the channel and one with floodplain elevations based on the available LiDAR, were merged within HEC-RAS such that the channel portion of each cross section retained the original survey data, and the overbank portion used the new LiDAR elevations. A vertical datum shift of 3.4 ft was applied to the original channel elevations to account for the difference between the datum of the survey (NGVD 29) and the datum of the current model (NAVD 88).

Main channel data

All of the channel data used in the model are quite old, most originating from old Corps of Engineers backwater modeling and/or HEC-2 models provided by FEMA. The dates of these original models and their channel bathymetry are somewhat uncertain, but are believed to be from the 1980s if not late 1970s. Based upon comments in the NHC model input, the following cross-sections in the upper reach incorporate channel data taken from “Corps” surveys of summer 1998, which is likely Duane Hartman and Associates (DHA) surveys collected to develop the PIE model: RMs 8.82, 9.26, and 10.63. Portions of the main channel for the following cross-sections defining the Rush Road and Interstate 5 bridge openings are based upon NHC surveys collected during 1997: RMs 7.11, 7.12, 7.45, and 7.46. Updated cross-sections, at least at each of the bridges, would help validate the bridge modeling and provide an indication as to how much the river channel itself has changed. Bridge data in the current modeling effort was not updated from the NHC modeling. Slight adjustments, however, were required such that the bridge geometry properly “fit” within the new cross-sections. It would be beneficial for these data to be verified in the field, especially if the bridges are near or within any reaches that may be evaluated further (e.g. Lewis County flood reduction alternatives).

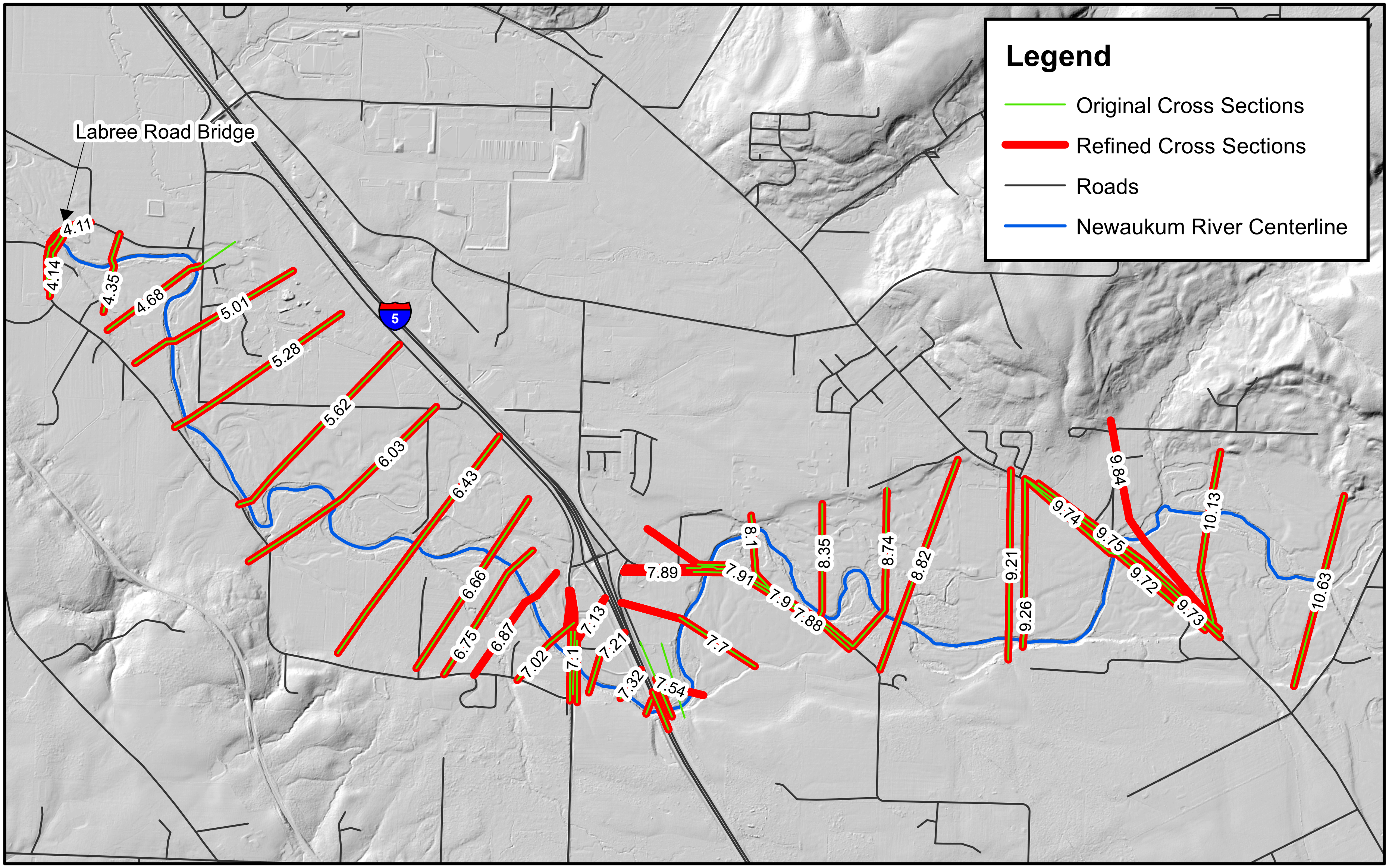
Lateral weirs

The original PIE UNET model included a separate northerly split flow path at Interstate 5. Specifically, it was configured to take flood overflows from the Kirkland Road area upstream of the freeway, convey them through the freeway underpass and across Rush Road, before rejoining the main stem Newaukum downstream of Rush Road. However, the UNET model DSS results for the February 1996 flood event (approximate 100-year event) indicate only minor overtopping and flow through the freeway overpass reach, less than 150 cfs. Because the predicted overflow is insignificant and to maintain model simplicity, NHC did not include this reach in their 2001 modeling. Likewise, this potential flow path is also not included in the current extension of the Flood Authority model for the Newaukum River.

However, lateral weirs were added in the model immediately upstream of Labree Road, to allow overflows to spill into Dillenbaugh Creek. The geometric data and tailwater connectivity for these weirs were based upon the PIE UNET modeling. WSE also modified the lateral weirs between Labree Road and the BNSF railroad bridge (RM 1.48) to be consistent with the original UNET modeling. WSE cannot verify the accuracy of the weir data, nor do we have information showing the cut lines or survey that defined the original weir profiles. However, the resulting model calibrates reasonably well for the 1996, 2007, and 2009 flood simulations. See Figure 2 which compares for January 2009, the maximum water surface profile along the Newaukum River to observed high water marks downstream from Kirkland Road, extracted from USGS Scientific Investigations Report 2010-5177, Plate 1. Figure 3 compares the simulated hydrograph to the USGS recording at the Labree Road gage.

Upstream boundary condition

The USGS operated streamflow gage at Labree Road coincides with the upstream end of the "Twin Cities" FEMA model (RM 4.1). The FEMA model used the USGS gage data directly to provide inflow hydrographs to the model. Extending the model upstream to RM 10.63 requires shifting the USGS hydrograph back in time to account for the flood wave travel time over the 6.5 mile reach. Several assumed shifts were tested, and it was found that a 3 hour shift most closely replicates the measured hydrograph at Labree Road for each of the three simulated floods (see Figure 4 depicting the 2009 flood). Lateral inflows were not added within the upstream extended reach, since that would result in too much volume in the system at RM 4.1 (since the model is using the actual measured hydrograph from RM 4.1 as its upstream input at RM 10.63).



Lewis County, WA

Extended Newaukum River HEC-RAS
Model Cross Sections

N

0 1,250 2,500
Feet

Scale: 1:29,705
NAD 1983 HARN StatePlane
Washington North FIPS 4601 Feet

13 Mar 2012

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Figure 1

Computed Newaukum Water Surface Profile versus Observed High Water Marks, January 2009 Flood

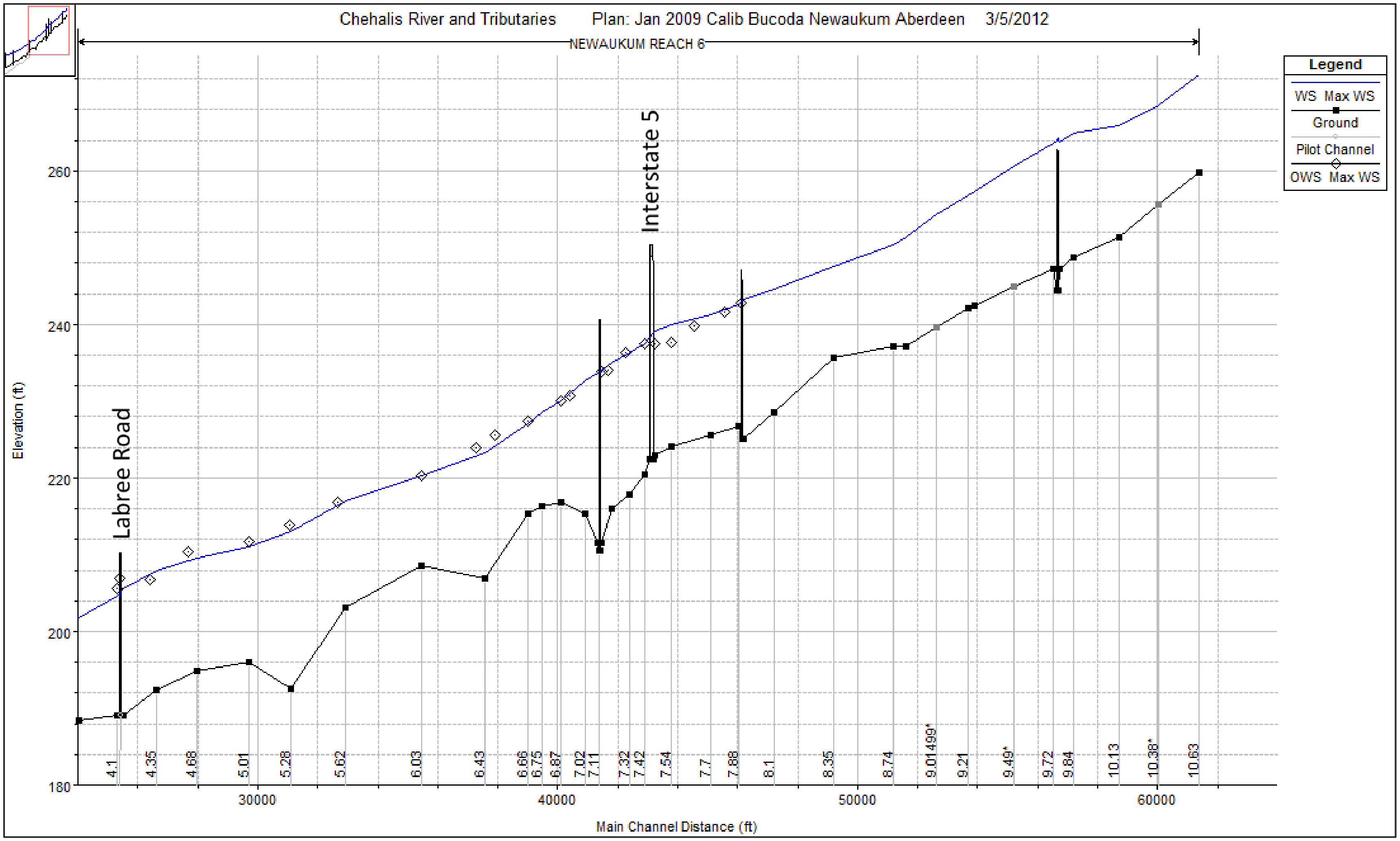

Figure 2

Computed versus Measured State at Labree Road USGS Gage, Newaukum River, January 2009 Flood

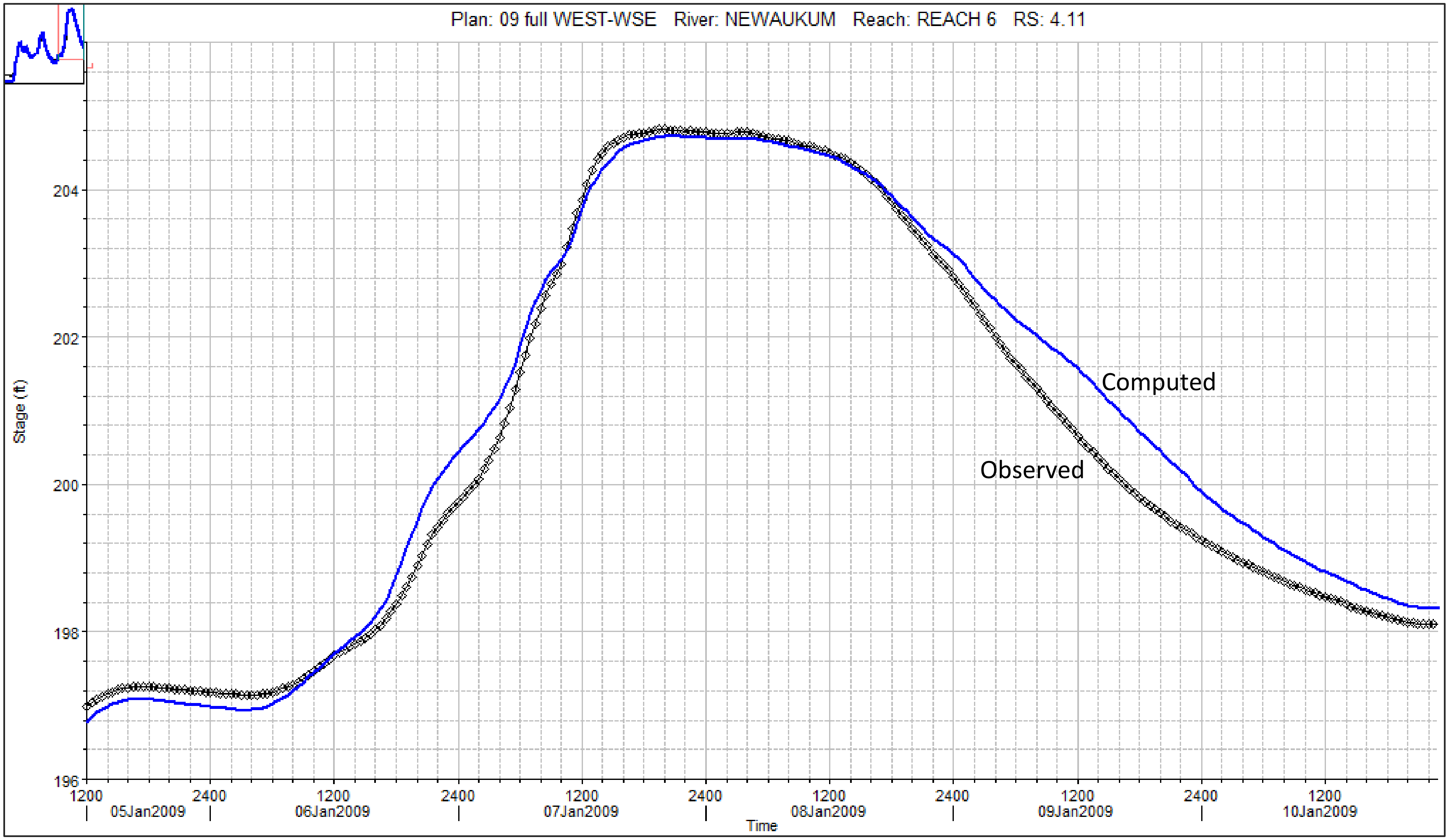

Figure 3

Computed versus Measured Discharge at Labree Road USGS Gage, Newaukum River, January 2009 Flood

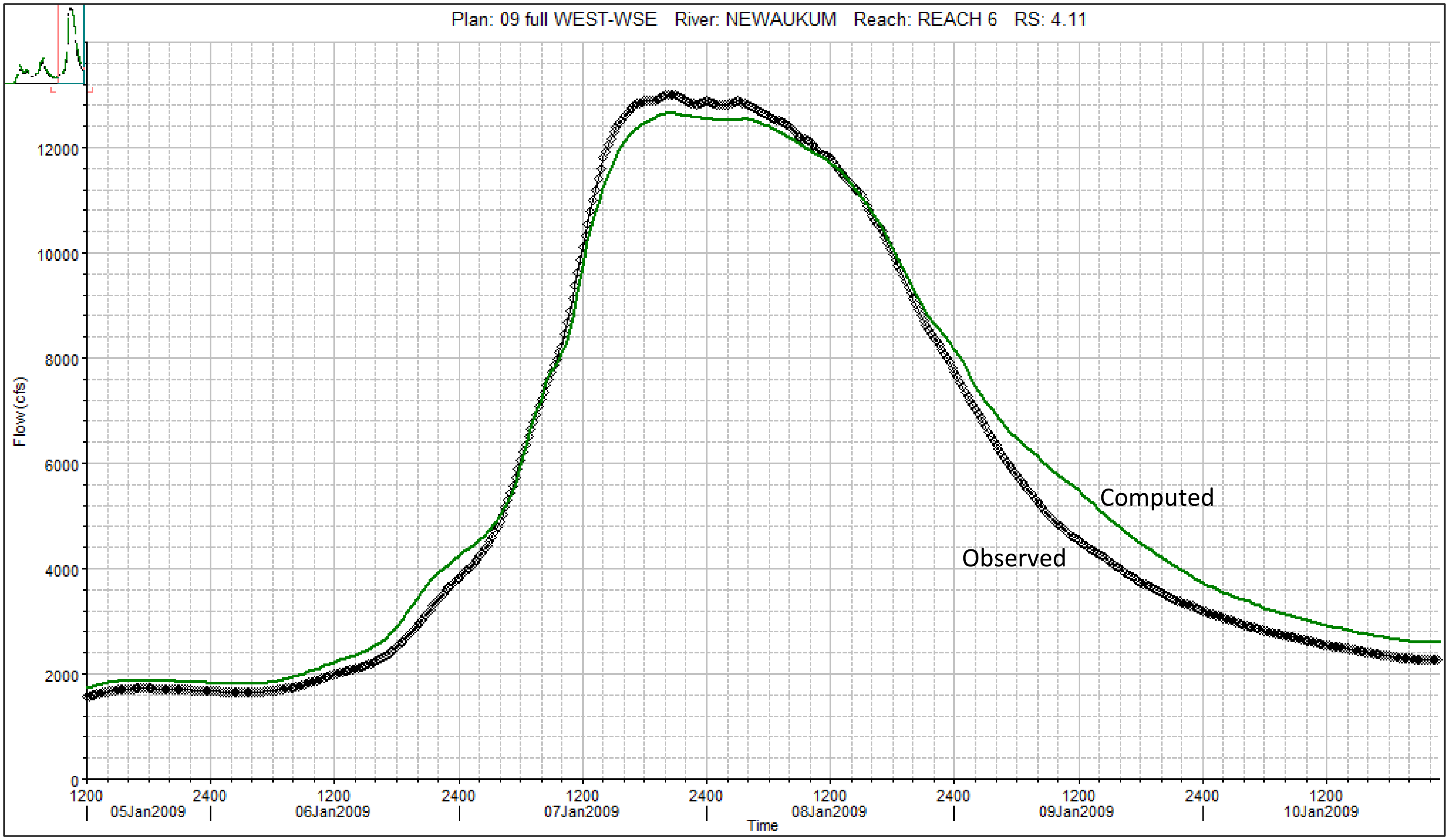

Figure 4