

FINAL HYDRAULIC MODELING RESULTS TECHNICAL MEMORANDUM

WHITE RIVER AT COUNTYLINE LEVEE SETBACK PROJECT

Prepared for
King County Department of Natural
Resources and Parks
Water and Land Resources Division
River and Floodplain Management Section

Prepared by
Herrera Environmental Consultants, Inc.



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201 South Jackson Street, Suite 600
Seattle, Washington 98104

Prepared by
Herrera Environmental Consultants, Inc.
2200 Sixth Avenue, Suite 1100
Seattle, Washington 98121
Telephone: 206/441-9080

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INTRODUCTION

The White River at Countyline Levee Setback (Countyline) project is a salmon recovery and flood risk reduction project located on the left (east) bank of the White River between river mile (RM) 5.00 and RM 6.33. Implementation of the Countyline project will reconnect approximately 115 acres of forested wetland and historical floodplain to the main stem of the White River by removing the existing left bank levee and constructing a new setback levee and biorevetment along the eastern edge of the project boundary. The reconnection of the historical floodplain to the White River will alter flood flow patterns and water depths within the project reach and downstream of the project site. The hydraulic effects of the proposed project are expected to vary through time depending on the magnitude, frequency, and duration of future river flows and in relation to likely sediment deposition in the river channel and the reconnected floodplain. In partial fulfillment of Task 200 of Herrera's contract with King County for analysis and design of the proposed project (Contract #E00187E10), this memorandum presents the methods and results of hydraulic modeling of existing and proposed (post-project) conditions at the 60% project design level. This memorandum documents all of the simulation results specific to off-site impacts and the flood-reduction benefits of the proposed project. A Geomorphic Assessment memorandum (Herrera 2012c) prepared under Task 300.3 of this same contract summarizes the geomorphic ramifications of the final, limited-domain model results discussed herein. The final hydraulic results were not available at the time the geomorphic assessment was written, but the differences between the limited-domain-model results and the final expanded-domain-model results are not significant from a geomorphic or hydraulic point-of-view. The model results presented herein were used to guide the project design and to assess potential project impacts related to flooding and erosion.

Project Site and Study Area

The proposed project site is located on the left bank of the White River between the A Street Bridge in Auburn and the 8th Street E Bridge in Sumner. The project site lies within the City of Pacific and also extends into the City of Sumner in Pierce County, with a small portion of the project site lying in an unincorporated area of Pierce County (Figure 1).

The study area, which in the case of a modeling project is the model domain, varies for the types of simulation performed. Those simulations that focused on implications within the project site (e.g., those that intended to quantify the hydraulic impact on the wood structures and those that were used to size the height of the setback levee) used the original or limited-domain-model extents (see Figure 1 - "limited domain"), which are bounded by approximately RM 4.4 and RM 6.7.

For the final model runs focused on more fully understanding project impacts in the right bank floodplain and downstream of the site, the domain was extended in several directions. It was extended laterally to the railroad tracks on the west (owned by Union Pacific Railroad [UP]) and the east (owned by Burlington-Northern Santa Fe Railway [BNSF]) sides of the

valley. The downstream boundary condition was extended much further downstream to near RM 2.5, which is near an artificial constriction in the valley formed by recent fill pads, downstream of the Lake Tapps diversion return. The upstream boundary of the domain was also extended north to include nearly all areas between the two railroads south of 1st Avenue SE (Figure 1).

Objectives

The hydraulic analysis for the proposed project focuses on the determination of likely geomorphic changes that can be expected as a result of constructing the project and the associated effects on flooding characteristics in the study area. It also supports evaluating the consequences of no action (i.e., no project implementation) on the future flooding characteristics in the study area.

It is well established that the study area is a locus for sediment deposition ((Banks 1907; Roberts 1920; Herrera 2010, 2011a, 2011b, 2012c; Czuba et al. 2010; Collins and Montgomery 2011). Given the dynamic sediment deposition that occurs in the study area, the extent of development surrounding the project site, and the County's desire to design project elements that serve their intended functions for a long design life, the objectives of the hydraulic modeling were to:

1. Estimate the extent of floodplain inundation under existing and proposed conditions under a suite of scenarios that simulate both short- and long-term expected changes.
2. Determine the maximum range of probable flow velocities and depths near the proposed levee setback infrastructure (i.e., the proposed biorevetment and engineered log jams [ELJs] in the reconnected floodplain).
3. Identify possible consequences and design refinements necessary to successfully complete the proposed levee setback project.

An earlier memorandum (prepared under Task 200.9) summarized preliminary results for the model simulations used to support the preliminary project design work (Herrera 2012d). That memorandum did not include simulations to test the hydraulic stresses on selected design components (i.e., the ELJs and biorevetment), to estimate conditions at the end of the project's service life, and to address initial concerns about the model's ability to simulate conditions south of 8th Street E.

This memorandum relies heavily on earlier documentation that describes previous modeling work in the project area (Herrera 2011a, 2011b, 2012a, 2012b, 2012d), particularly as they relate to the way the model was set up and implemented.

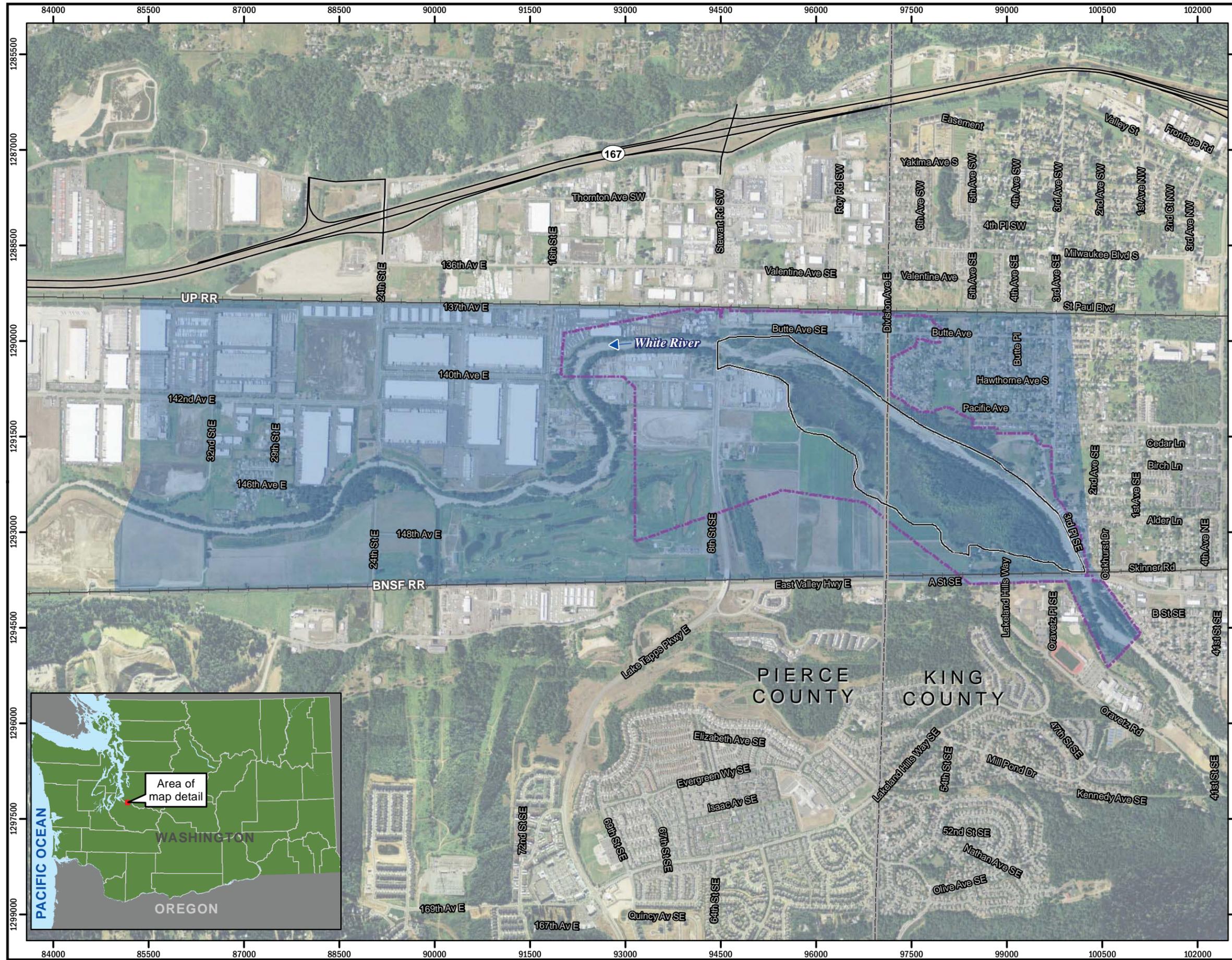
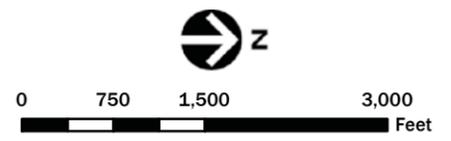


Figure 1.
Vicinity Map of the White River at
Countyline Project Site and Study Area.

Legend

-  Project area
-  Limited model domain
-  Extended model domain
-  County boundary
-  Railroad



Prepared for King County by Herrera
Aerial: USDA (2011)

Produced by: GIS (rd)
File path: K:\Projects\09-04375-140\ProjectSite_Map.mxd

METHODOLOGY

The methodology for the hydraulic modeling work performed for the project is described in large part in a series of previous documents, including Herrera (2011a, 2011b, 2012a, 2012b, 2012d). Updates to the approach outlined in those documents are summarized here along with relevant background information.

Numerical models require a set of boundary conditions for each simulation that consist of discharge (inflow) at the upstream end of the computational mesh, a water surface elevation or an elevation-discharge rating curve at the downstream end of the computational mesh, and a topographic surface over which the flows are run. The boundary conditions and other input data developed for the project models are described in this section. Figure 1 shows the RiverFLO-2D model domain, along with many other key locations and features discussed in the following sections.

Model Overview

The software used to perform hydraulic modeling for this project is RiverFLO-2D Version 99g, though the extended model domain simulations use an updated version (Version 3.0). Regardless of the version, RiverFLO-2D is a hydrodynamic and mobile-bed model specifically developed for rivers. It is a two-dimensional, finite-element model for routing flood flows that enables high-resolution flood hydraulic analysis. A flexible triangular mesh refines the flow field around key features of interest in complex river environments. RiverFLO-2D has been applied on a number of river projects worldwide, including several in King County. RiverFLO-2D uses the shallow-water equations for depth-averaged, free-surface flow that allow simulation of water surface elevations, and two components of the velocity (Garcia et al. 2006), resulting in resolution of detailed two-dimensional channel hydraulics and overbank flooding characteristics. RiverFLO-2D version 3.0 can also simulate flow through culverts and around buildings, which are important features in the extended model domain.

The RiverFLO-2D user interface is based upon the Argus Open Numerical Environment (Argus ONE) platform. This GIS-integrated software system provides interactive functions to generate and refine the finite-element mesh representing the topographic and bathymetric surface over which flood flow is routed. It also facilitates assigning boundary conditions and roughness values. Finally, it serves as the means to export model results to GIS-based platforms.

Modeling Approach

To achieve the project objectives described above, Herrera and King County defined a series of scenarios and timeframes that would simulate the range of conditions both due to the project and in the absence of the project. Much of the explanation of the modeled scenarios is provided in Herrera (2012d). Each scenario refers to an assumed set of circumstances that are tracked through time. Because of this, the earlier model results guided the determination

of the topographic surface to use in subsequent modeled scenarios, but necessarily confined the results to the preceding scenario assumptions.

Table 1 summarizes the model scenarios and simulations performed on the limited domain (shown graphically in Figure 1). The preliminary results of the model runs displayed in gray in the table are described in detail in Herrera (2012d) and final “reckoned” simulations are included in Attachment A to this memorandum. Table 1 is the same as Table 1 presented in Herrera (2012d), with inclusion of the S1d, S5a, and S6a simulations, which were recommended by Herrera (2012d).

Table 1. Summary of the Model Simulations.				
Scenario	Year Zero ^a	Short-term ^b	Fully Evolved ^c	Service Life ^d
Without Project (S4)	S4a, S4ax	S4b	S4c	N/A
With Project (S1)	S1a, S1ax	S1b	S1c	S1d
With Project, Avulsion at Pacific Park (S2)	N/A	S2b	N/A	N/A
With Project, Avulsion at County Boundary Line (S3)	N/A	S3b	N/A	N/A
Without Project With Scour at the 8th Street E Bridge (S5)	S5a	N/A	N/A	N/A
With Project with Scour at the 8th Street E Bridge (S6)	S6a	N/A	N/A	N/A
With Project and Including Proposed Right Bank Improvements (S1aa)	S1aax	N/A	N/A	N/A

^a Time immediately following construction for scenarios simulating effects of project construction.

^b Approximately 3 years following construction.

^c 13.8 years following the construction of the project when the main channel under existing conditions is expected to completely fill to the height of the existing levee.

^d Assumed to be approximately 30 years, when sediment aggradation impacts 3-foot freeboard.

x refers to extended model domain simulations.

N/A = Runs were not performed because they are not applicable or not appropriate.

Reckoned, Limited-Domain Simulations

The purpose of the reckoned simulations was to perform all limited-domain-model simulations with an identical mesh (topographic surface) to make point-by-point comparisons possible. The process of reckoning is well described in the modeling approach memorandum (Herrera 2012d). It entails implementing all of the limited-domain-model refinements together (e.g., using the higher-resolution meshes around the modeled avulsion areas) following the completion of all of the preliminary simulations. The boundary conditions, hydrographs, and general approach to the preliminary simulations (i.e., those simulations shaded in grey in Table 1) are summarized well in Herrera (2012d).

Service Life Simulation

Previous modeling was done primarily for comparison purposes to document the future benefits of the project long after construction; however, the value of modeled conditions in the future is fundamentally limited by the fact that the river channel is expected to

completely fill in with sand, gravel, and cobbles and necessarily avulse at the county boundary line in approximately 14 years if the project is not constructed. Because it is not possible to make a sensible comparison with an avulsed river as existing conditions, a separate proposed-conditions-only surface was developed and modeled to estimate the longevity of the design condition (primarily the levee height). In this simulation (denoted as Simulation S1d in Table 1), deposition rates estimated to occur in the time period between the short-term and fully evolved conditions following project construction were assumed to persist until approximately 30 years following construction.

Worst-Case Scenario Simulations

To properly design the biorevetment to resist the potential for the river to entrain itself against the structure, two different scenarios were developed that specifically tested geomorphic “worst-case” scenarios that could occur following project construction. These scenarios assumed that geomorphic processes would direct the entire flow of the river directly at and perpendicular to the biorevetment structures. This would produce the largest possible hydraulic forcing on the structures. Because it is unlikely that these scenarios would occur (though they cannot be entirely ruled out), these simulations have been called the worst-case scenario simulations.

For the purposes of having discrete simulations, it was determined in coordination with the County that two such unusual avulsion scenarios would have the most detrimental impact to the proposed infrastructure. These scenarios are:

- **Avulsion at Pacific Park (S2)** - This scenario assumed that a debris jam would form in the existing main channel downstream of the tip of the existing levee that is to remain following construction and thereby divert all of the mainstem flow into the reconnected floodplain. To simulate the scenario, the proposed short-term surface was altered by raising both the ground surface within the main channel and a portion of the reconnected floodplain to the elevation of the top of the existing levee. This scenario was selected because it is the best test of the upper (northern) end of the biorevetment.
- **Avulsion at County Boundary Line (S3)** - This scenario assumed that the main channel would remain unobstructed until the point where it crosses the county boundary line, at which a debris dam would form and block the channel and direct flow towards the proposed biorevetment. To simulate the scenario, a barrier was placed in the main channel at the county boundary line with a top elevation equal to the height of the right bank. This scenario was selected because it tests the potentially most-vulnerable portion of the proposed biorevetment that extends westerly toward the main channel.

8th Street E Bridge Area Scour Scenario Simulations

Because the project is designed to contain the 100-year flood flow of the White River along the left bank approaching the 8th Street E Bridge (Herrera 2012d), peak flow velocities will almost certainly increase through the bridged portion of the river channel. River bed scour associated with increased flow velocities could have the potential to ameliorate the impacts that would otherwise occur due to increased water surface elevations during flood events. Total scour depths were calculated by King County using the HEC-18 CSU Equation with K4

correction (Federal Highway Administration 2001), using information from recent surveys and the 1952 design drawings of the 8th Street E Bridge. The scour depths were expressed in the model as pyramids that radiate away from the bridge foundation piers at 1V:4H (vertical to horizontal) slopes in the downstream direction and 1V:2H slopes in the lateral and upstream directions. The model resolution was subsequently increased near the piers to fully resolve these bathymetric differences. However, the piers themselves were not included in the model. They were deemed too small relative to the width of the hydraulic opening beneath the bridge to be accurately represented in the model, and the complicated fluid dynamics associated with them is not encapsulated in the governing equations of the model.

Extended Domain Simulations

The extended domain simulations (S4ax, S1ax, and S1aax) effectively extended the model to the point where the full extent of flood water inundation potentially affected by the project could be simulated. Another goal of these simulations was to sufficiently separate the downstream boundary condition from areas affected by the project. As discussed at length in Herrera (2012d), simulated flow conditions in areas immediately adjacent to the downstream boundary condition can be inaccurate due to water-surface elevations imposed during model calibration by results from a less-accurate and spatially explicit, one-dimensional HEC-RAS hydraulic model that was used by King County for floodplain mapping purposes several years ago (i.e., 2009).

Expanding the domain also provided the opportunity to reassess the version of RiverFLO-2D used to evaluate the project. As a result, a decision was made in consultation with County staff to use RiverFLO-2D Version 3.0 for the extended domain model runs. This version allows for modeling of the effects of more structures and culverts, has improved speed of input and output, and provides more and better tools to assess continuity. All of these model attributes were helpful for quickly, accurately, and effectively assessing the effects of the project.

Topographic Surfaces

The extended domain topographic surface incorporated all of the numerical model sensitivities and site-specific model responses interpreted from the results of the limited-domain-model simulations summarized in Herrera (2012d). The existing conditions topographic surface itself used the limited-domain model upstream of RM 4.45, which was compiled from lidar flown by King County in March 2011, channel and wetland bathymetry surveyed by King County in May 2011, and the HESCO barrier surveyed in 2010, supplemented with additional topographic data. The additional data included 2012 lidar flown by King County on the eastern two-thirds of the valley floor through the City of Sumner. The western third of the valley floor not included in the 2012 lidar flight was compiled from 2010 lidar provided by Pierce County. King County extended the channel bathymetry downstream of RM 4.45 to the downstream boundary condition at RM 2.5 by interpolating between 14 cross-sections surveyed by the USGS and King County in 2001-2002. The 2001-2002 cross-section locations were re-surveyed in 2012, but these data were not available in time for incorporation into the extended domain model. In addition, the surface included culverts that convey the flow of Government Canal into the White River, which were found in preliminary extended domain simulations to be an important variable in estimating the flooding extents on the right bank upstream of the 8th Street E

Bridge. Key culvert dimensions used for model input were measured in the field by Herrera staff.

The proposed conditions surfaces are based upon an alteration of the original model surface (based upon April 2011 lidar and survey) to reflect the proposed changes represented by the 60% complete project design plans (i.e., design refinements that included extending the setback levee north to the BNSF railroad embankment and the most up-to-date alignment of the proposed setback levee). The extended-domain-model surface also re-defined the boundary condition along the right bank. In the limited-domain model, both the existing-condition scenario (S4) and the proposed-conditions scenario (S1) assumed that the temporary HESCO barriers were in place, whereas they were not included in the S4 and S1 scenarios in the extended-domain model. The extended-domain-model surface did not include the effects of scour at the bridge piers because the scour simulations significantly increased the number of nodes, but only captured changes in an extremely localized (within the main channel around the piers themselves) area. For a full discussion of the impacts of scour, see the results section discussing these simulations below.

Boundary Roughness

The hydraulic roughness values assigned in the extended model domain were generally the same as used in the earlier models (described in detail in Herrera [2012d]), with the exception of the portion of 3rd Place SE. Roughness was lowered in this area because the primary roughness elements, which are buildings, were explicitly included in the model as impermeable areas. Large buildings elsewhere were also included (i.e., blocked out as impermeable areas), though only in areas where earlier preliminary modeling showed that the building would likely be engaged with flow at least partially during the largest flood events. Figure 2 (Sheets A through H) illustrates the buildings that were explicitly accounted for and the roughness values used in the extended model domain.

It is important to mention that two-dimensional models are generally less sensitive to roughness coefficients than one-dimensional models like HEC-RAS. Also because two-dimensional models explicitly account for expansion, contraction and flow curvature (common sources of “roughness” in one-dimensional models) in the equations that they solve, roughness coefficients in two-dimensional models have a tendency to be smaller than those in one-dimensional models.

Upstream Boundary Condition

The upstream boundary condition is set by hydrographs developed in earlier phases of the project. This included hydrographs for the 2-, 10-, 50-, 100-, and 500-year recurrence events and the mean annual flow simulation. The 10-year recurrence hydrograph is described in Herrera (2011a). The 50-year hydrograph was created from the 100-year hydrograph, scaled by the ratio of the respective peak flows (50-year and 100-year) determined from the original hydrologic analysis (Herrera 2011a). The extended domain includes the Lake Tapps return channel at Dieringer near the downstream end of the model. Historical records indicate that the volumetric flow rate in this return flow would be insignificant compared to overbank White River flood flows, so inflow at this location was assumed to be zero in both existing and proposed conditions.

Downstream Boundary Conditions

Because of the extensive downstream expansion of the model domain, it was possible to select a downstream boundary condition that performs much better than the limited-domain simulations described by Herrera (2012d). The downstream boundary condition was constructed near RM 2.5 by the model itself using local channel slope determined from existing lidar and bathymetry. By extension to earlier calibration efforts, this new boundary condition is capable of accurately depicting high water marks across the project site under existing conditions. Very close to this boundary condition the results are not necessarily reliable and these areas were eliminated from the difference plots shown in the results section of this memorandum.

Lateral Boundary Conditions

Unlike the modeling runs with the limited domain, the extended domain model runs extended the lateral boundary conditions to the railroad embankments (i.e., UP to the west and BNSF to the east) and farther north on the right bank. The model domain extents in both scenarios were identical. Because of the way boundaries are handled in RiverFLO-2D, the lateral sides of the model domain function as vertical walls.

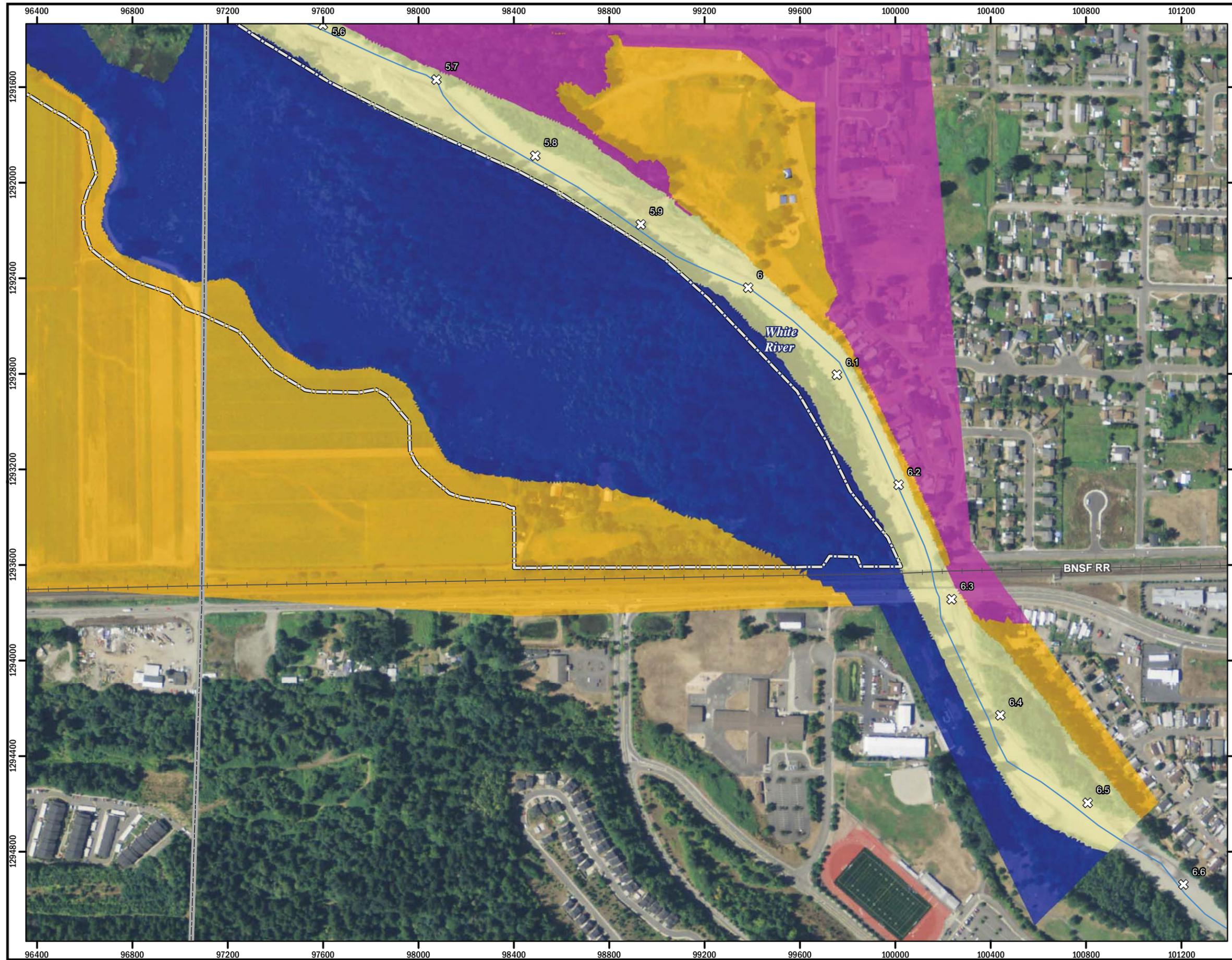


Figure 2. Sheet A.
Roughness Map Including
Impermeable Buildings in the
Extended Domain Simulations.

- Legend**
- Roughness value**
- 0.025
 - 0.025 to 0.03
 - 0.03 to 0.1
 - 0.1 to 0.15
- River mile
 - Railroad
 - Project area
 - County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&M_Modeling_Figures\figure2_mannings_n_values.mxd (8/19/2013)

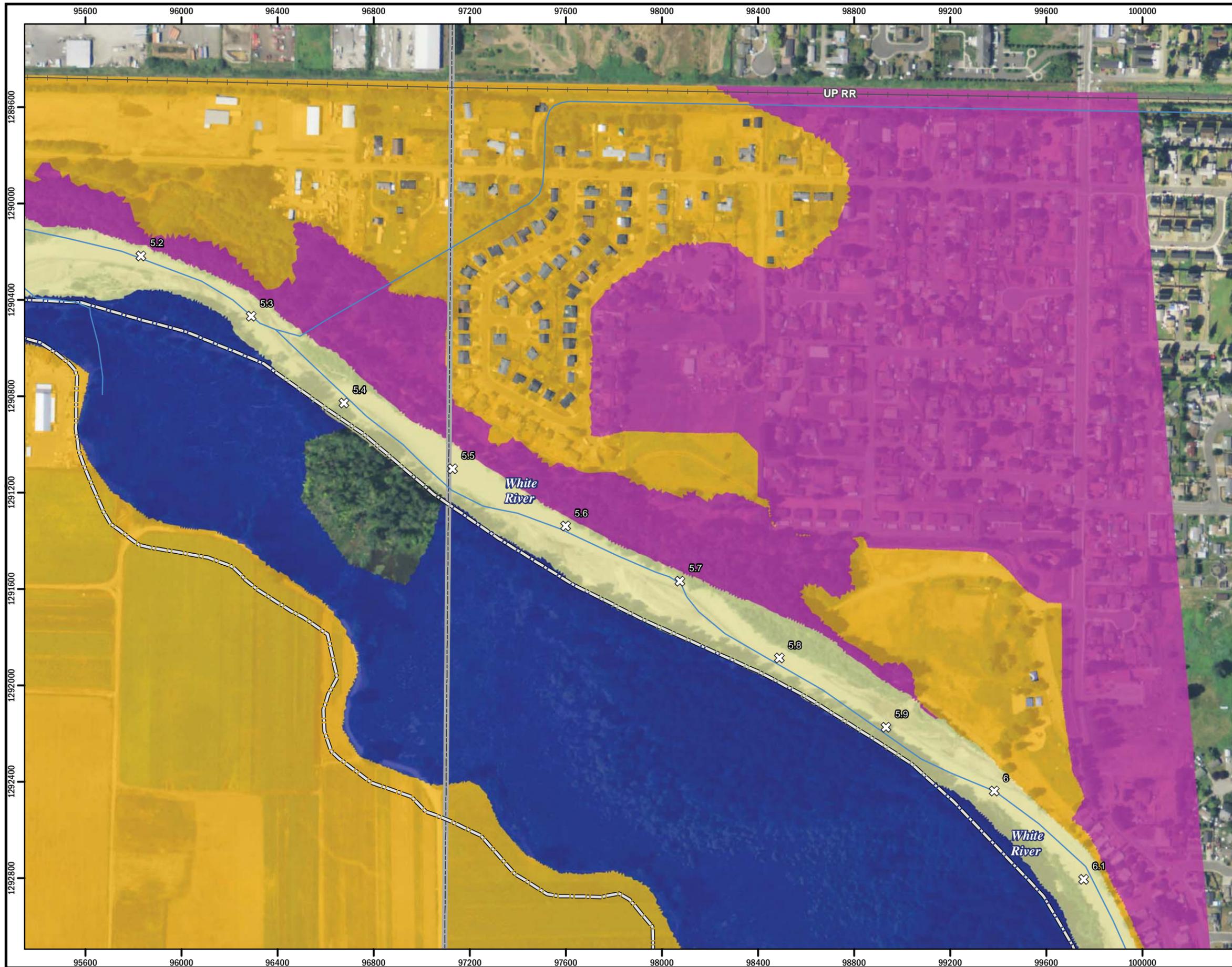
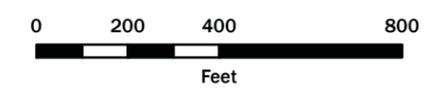


Figure 2. Sheet B.
Roughness Map Including
Impermeable Buildings in the
Extended Domain Simulations.

- Legend**
- Roughness value**
 - 0.025
 - 0.025 to 0.03
 - 0.03 to 0.1
 - 0.1 to 0.15
 - River mile
 - Railroad
 - Project area
 - County boundary



King County

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 State Plane North (ft)

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Figure 2. Sheet C.
Roughness Map Including
Impermeable Buildings in the
Extended Domain Simulations.

Legend

Roughness value

- 0.025
- 0.025 to 0.03
- 0.03 to 0.1
- 0.1 to 0.15

⊗ River mile

—+— Railroad

⎓ Project area

— County boundary



King County
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 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&H_Modeling_Figures\figure2_mannings_n_values.mxd (8/19/2013)

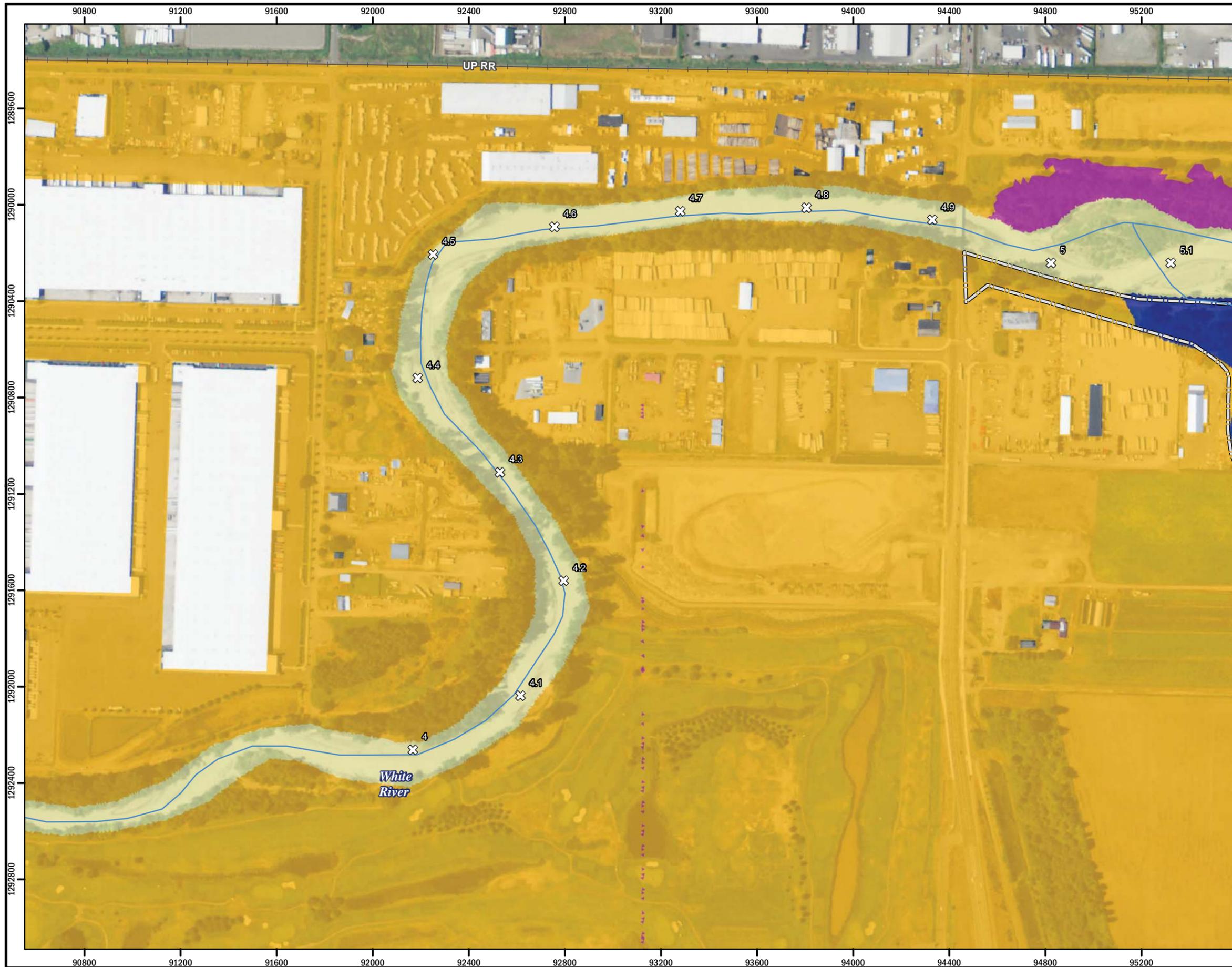


Figure 2. Sheet D.
Roughness Map Including
Impermeable Buildings in the
Extended Domain Simulations.

Legend

Roughness value

- 0.025
- 0.025 to 0.03
- 0.03 to 0.1
- 0.1 to 0.15

- River mile
- Railroad
- Project area
- County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&H_Modeling_Figures\figure2_mannings_n_values.mxd (8/19/2013)

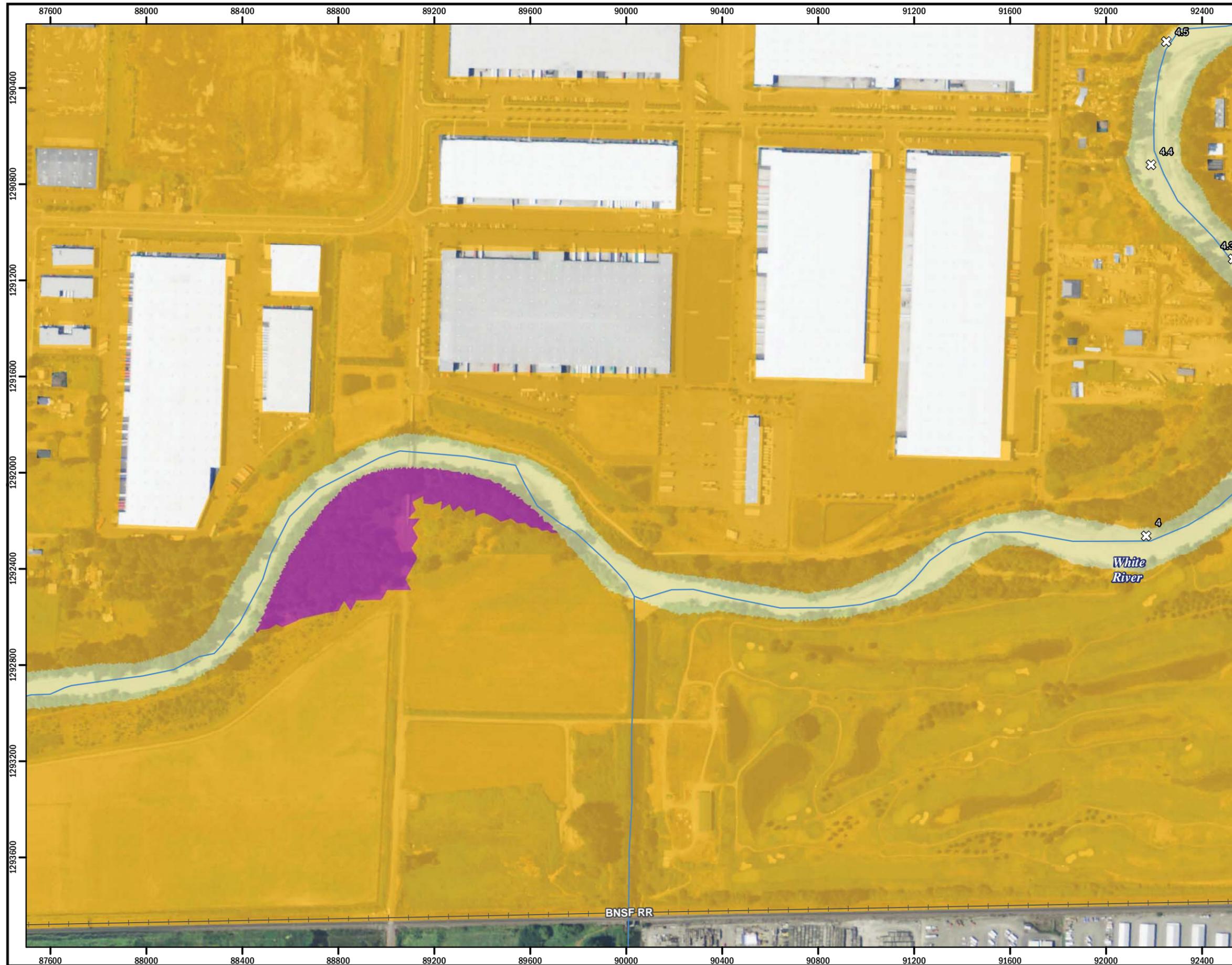


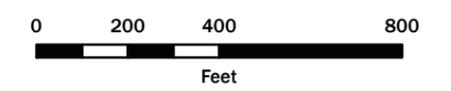
Figure 2. Sheet E.
Roughness Map Including
Impermeable Buildings in the
Extended Domain Simulations.

Legend

Roughness value

- 0.025
- 0.025 to 0.03
- 0.03 to 0.1
- 0.1 to 0.15

- River mile
- Railroad
- Project area
- County boundary



Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

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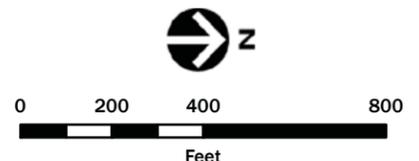
Figure 2. Sheet F.
Roughness Map Including
Impermeable Buildings in the
Extended Domain Simulations.

Legend

Roughness value

- 0.025
- 0.025 to 0.03
- 0.03 to 0.1
- 0.1 to 0.15

- River mile
- Railroad
- Project area
- County boundary



King County
 Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&H_Modeling_Figures\figure2_mannings_n_values.mxd (8/19/2013)



Figure 2. Sheet G.
Roughness Map Including
Impermeable Buildings in the
Extended Domain Simulations.

- Legend**
- Roughness value**
- 0.025
 - 0.025 to 0.03
 - 0.03 to 0.1
 - 0.1 to 0.15
- River mile
 - Railroad
 - Project area
 - County boundary



Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&M_Modeling_Figures\figure2_mannings_n_values.mxd (8/19/2013)



Figure 2. Sheet H.
Roughness Map Including
Impermeable Buildings in the
Extended Domain Simulations.

Legend

Roughness value

- 0.025
- 0.025 to 0.03
- 0.03 to 0.1
- 0.1 to 0.15

River mile

Railroad

Project area

County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&H_Modeling_Figures\Figure2_mannings_n_values.mxd (8/19/2013)

RESULTS

The discussion of hydraulic modeling results presented in this section includes the final results from all nine limited-domain simulations described in Herrera (2012a) and summarized in Table 1 and the three extended model domain simulations described herein and also summarized in Table 1. All model results are presented specifically for the 100-year flood event using a common mesh (topographic surface) for each model domain to enable direct comparisons of results at specific locations from the existing and proposed conditions model runs. Previous model simulations on earlier topographic surfaces and for earlier engineering design plan configurations are summarized in Herrera (2011b, 2012b, 2012d). Those simulations provided the broad basis for understanding the general hydraulic characteristics of the study area, which informed model refinements described in this memorandum. The model results described below reflect improved performance of the model and repeatability of model results.

Reckoned, Limited–Domain Simulations

The reckoned simulation results for the limited-domain simulations are plotted in Attachment A. There were no striking differences seen in the results that were not adequately documented previously in Herrera (2012d).

Service Life Simulation

The design service life simulation results (simulation S1d) are shown in Figure 3. These results can be compared to the simulated conditions immediately following construction (scenario S1a, see Attachment A) based upon the topographic information extracted from the 40% complete design plans and the design refinements described earlier in this memorandum. In general the main differences are those associated with the predicted amount of sediment deposition in the reconnected floodplain on the left bank. The ground surface in the service life simulation was set approximately 1.5 feet above existing conditions in the reconnected floodplain based on historical rates of sediment aggradation, resulting in higher water-surface elevations in the model output as compared to conditions immediately following construction, for which the modeled ground surface in the reconnected floodplain was assumed to be equivalent to the existing ground surface.

Worst-Case Scenario Simulations

The results of the worst-case scenario simulations (simulations S2b and S3b) depicting the water surface elevations and flow velocities during the 100-year flood event are shown in Figures 4 through 7. As can be seen in Figures 5 and 7, the model run for the avulsion simulation S2b yielded higher flow velocities within the reconnected floodplain compared to simulation S3b (avulsion at county boundary line). As a result, the model results for avulsion simulation S2b were used for all of the biorevetment and ELJ design calculations. Table 2

summarizes the flow velocity and depth information from this scenario that were used for design development.

Design Element	Design Flow Velocity (feet per second)	Design Flow Depth (feet)
Inlet (Small Apex) ELJ Structures	8	10
Bank Deflector ELJs	8	14
Large Apex ELJ Structure	8	14
Biorevetment	8	14

8th Street E Bridge Area Scour Simulations

The model results comparison between the original model result without scour (S1a) and the simulation in which channel bed scour was assumed in the vicinity of the 8th Street E Bridge (S6a) is presented in Figures 8 and 9. The differences are calculated as the modeled water surface elevation and flow velocity with scour minus those without scour for proposed conditions (i.e., S1a minus S6a). Scour for the existing conditions is less and will therefore necessarily produce smaller differences. As can be seen in these figures, the primary difference is focused around the bridge foundation piers, which are not explicitly included in the simulations. There are no predicted changes beyond the area close to the bridge crossing shown in these figures. The reduction of the water surface elevation during the 100-year flood due to the inclusion of scour does not extend to the banks. Although proposed conditions will produce more channel bed scour at the bridge crossing than in existing conditions due to increased flow rates through the crossing, the results in Figures 8 and 9 indicate that the differences in water surface elevations and flow velocities due to scour in this area following project construction will be negligible upstream and downstream of the bridge; however, geomorphic changes expected to occur over many years associated with generally greater flow rates in the bridge crossing area may be more significant than assumed in the mesh refinements made for scenarios S5a and S6a. These changes are much more difficult to predict, and were therefore not accounted for in this analysis. With that said, the infrequent erosion around the piers during large events is expected to be less over time than the steady deposition documented well by previous sediment transport analyses (Herrera 2010).

Extended Domain Simulations

Figures 10 through 12 depict the simulated differences in 100-year water surface elevations and flow velocities between existing conditions (simulation S4ax), immediately following construction of the Countyline project (simulation S1ax), and after construction of both the Countyline and the future right bank project (scenario S1aax) in the extended model domain. The greatest change in water-surface elevation resulting from the project is predicted to occur within the existing wetland of the left bank floodplain, where post-project water-surface elevations are predicted to rise between 2 and 5 feet at the peak of the 100-year

Figure 3. Sheet A.
Service Life (S1d) Simulation Water
Surface Elevation Results for the
100-year Flood Event



Legend

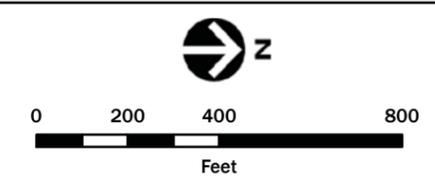
Water surface elevation (feet)

	< 65
	65 to 70
	70 to 75
	75 to 80
	80 to 85
	85 to 90
	90 to 95
	> 95

River mile

Project area

County boundary



King County
 Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&M_Modeling_Figures\fig3_s1d_100yr_wse.mxd (8/19/2013)

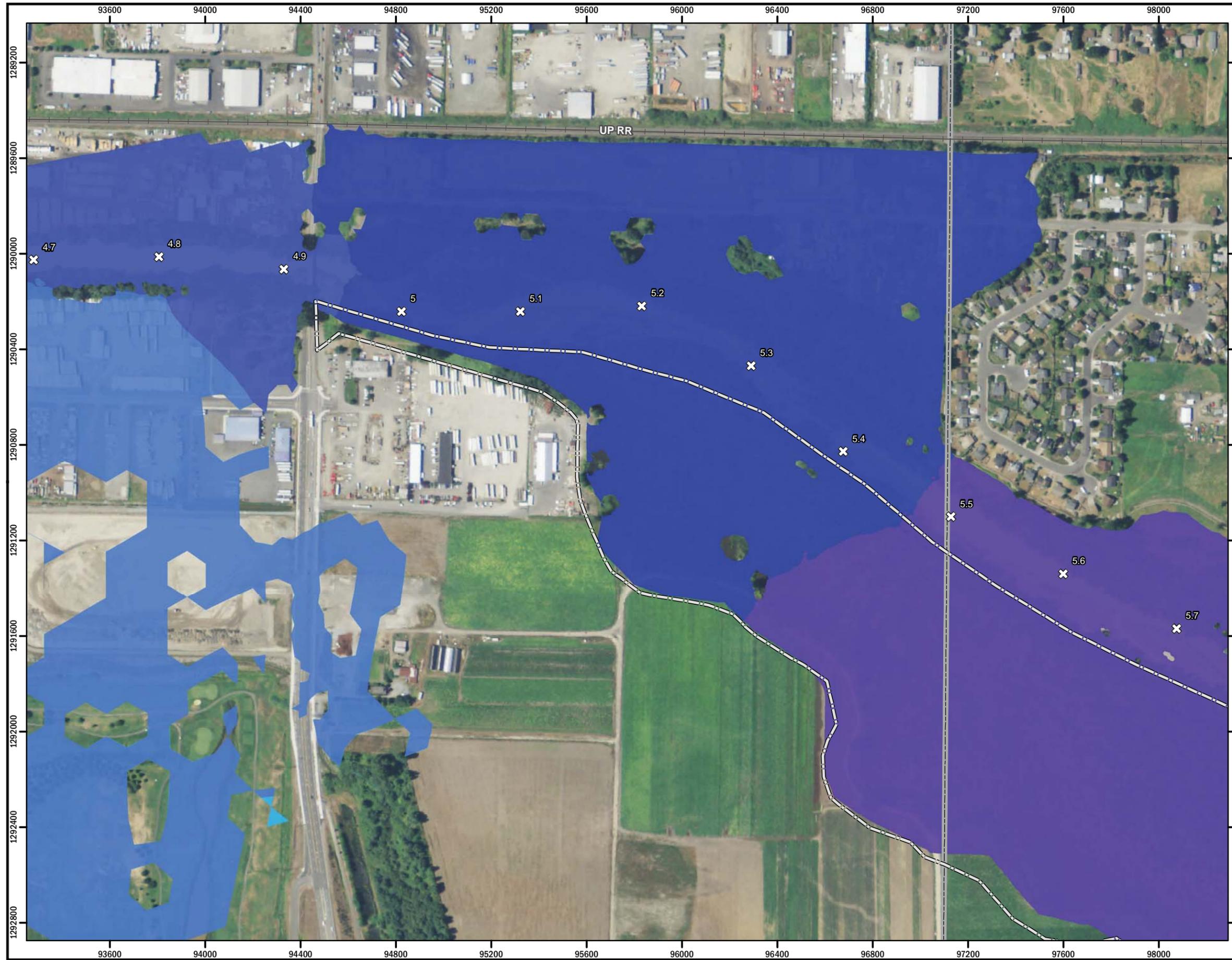


Figure 3. Sheet B.
Service Life (S1d) Simulation Water Surface Elevation Results for the 100-year Flood Event

Legend

Water surface elevation (feet)

	< 65
	65 to 70
	70 to 75
	75 to 80
	80 to 85
	85 to 90
	90 to 95
	> 95

River mile

Project area

County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&H_Modeling_Figures\fig3_s1d_100yr_wse.mxd (8/19/2013)



Figure 4. Sheet A.
Full Avulsion (S2b) Simulation
Water Surface Elevation Results
for the 100-year Flood Event.

Legend

Water surface elevation (feet)

	< 65
	65 to 70
	70 to 75
	75 to 80
	80 to 85
	85 to 90
	90 to 95
	> 95

River mile

Project area

County boundary

0 200 400 800
 Feet

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&M_Modeling_Figures\Fig4_s2_100yr_wse.mxd (6/10/2013)

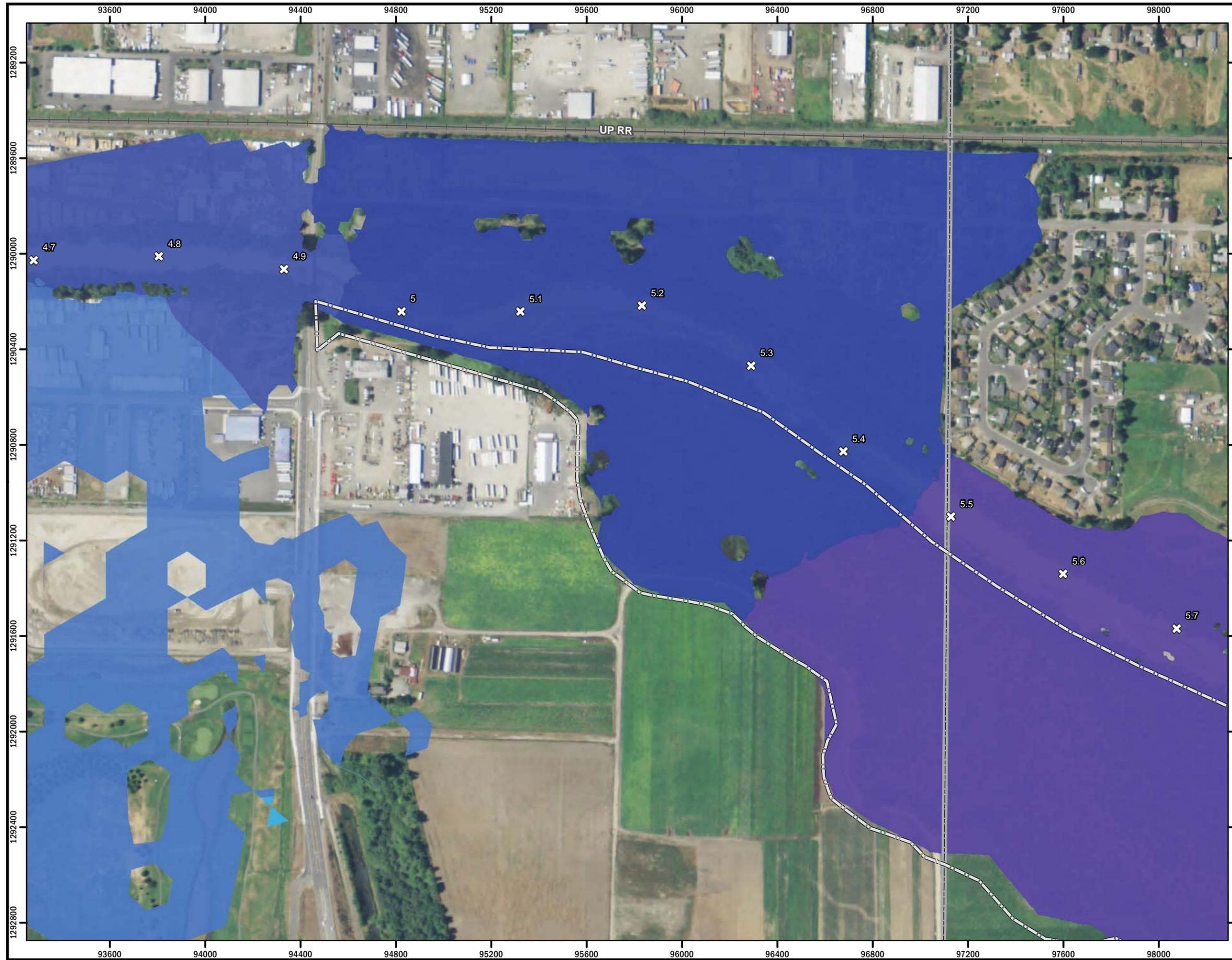


Figure 4. Sheet B.
Full Avulsion (S2b) Simulation
Water Surface Elevation Results
for the 100-year Flood Event.

Legend

Water surface elevation (feet)

	< 65
	65 to 70
	70 to 75
	75 to 80
	80 to 85
	85 to 90
	90 to 95
	> 95

River mile

Project area

County boundary

0 200 400 800
 Feet

King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&H_Modeling_Figures\Fig4_s2_100yr_wse.mxd (6/10/2013)

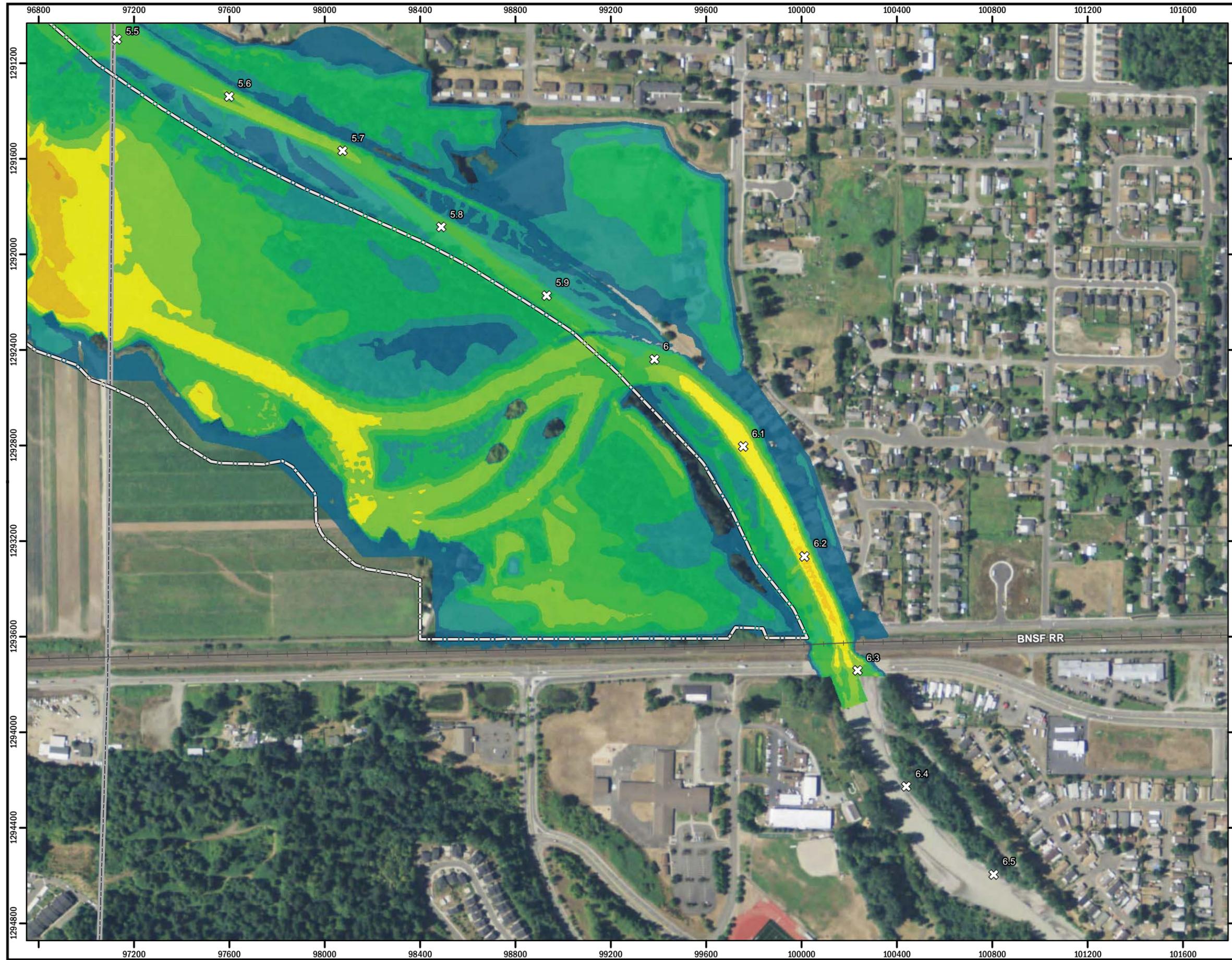


Figure 5. Sheet A.
Full Avulsion (S2b) Simulation
Water Velocity Results for the
100-year Flood Event.

Legend

Water velocity (ft/sec)

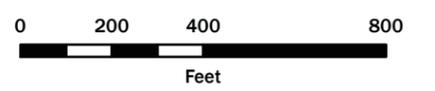
0.05 to 2
2 to 4
4 to 6
6 to 8
8 to 10
10 to 12
12 to 14
14 to 16
16 to 18
> 18

⊗ River mile

—+— Railroad

⊠ Project area

— County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&M_Modeling_Figures\Fig5_s2_100yr_vel.mxd (5/20/2013)

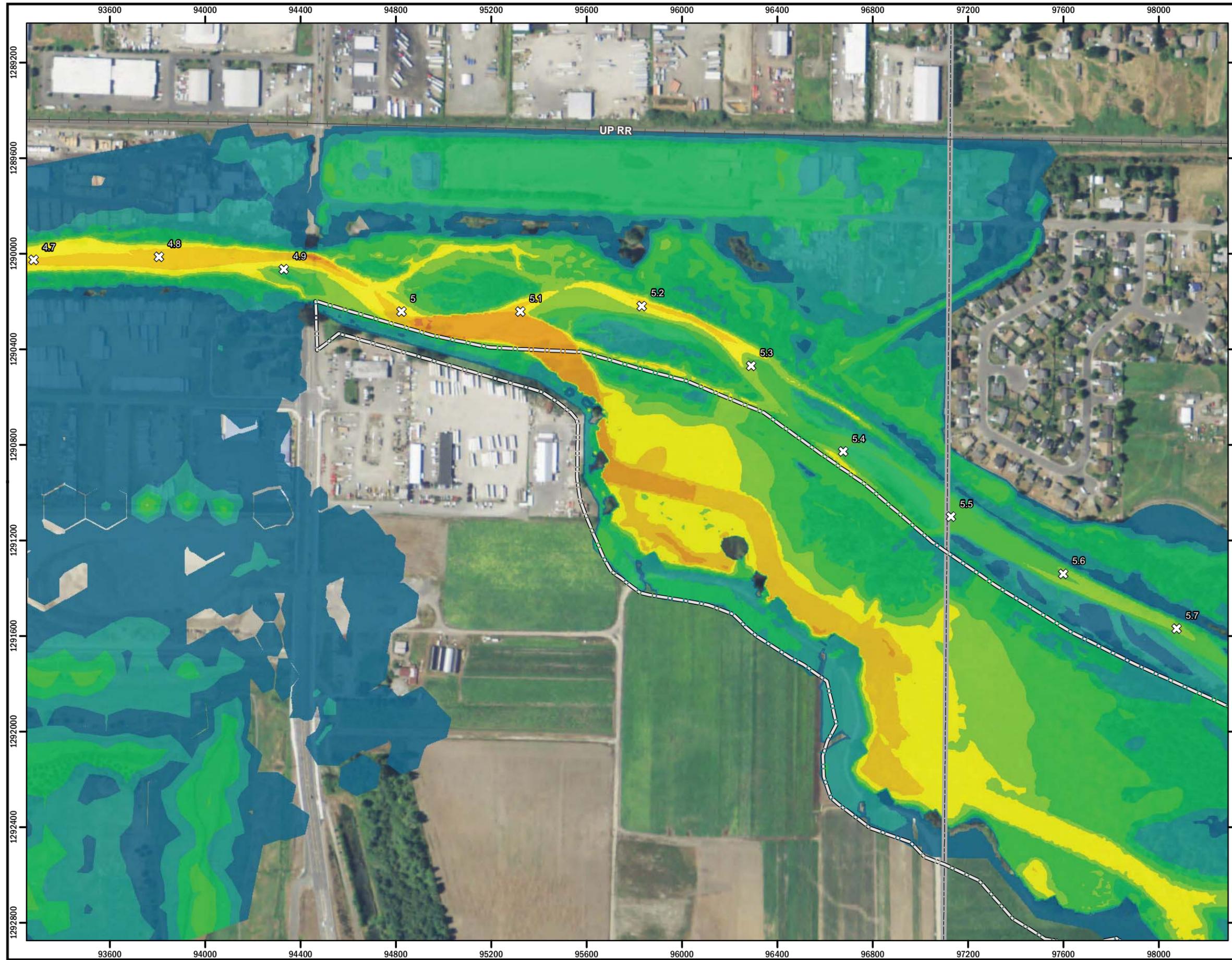


Figure 5. Sheet B.
Full Avulsion (S2b) Simulation
Water Velocity Results for the
100-year Flood Event.

Legend

Water velocity (ft/sec)

	0.05 to 2
	2 to 4
	4 to 6
	6 to 8
	8 to 10
	10 to 12
	12 to 14
	14 to 16
	16 to 18
	> 18

River mile

Railroad

Project area

County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&H_Modeling_Figures\fig5_s2_100yr_vel.mxd (5/20/2013)



Figure 6. Sheet A.
Avulsion at County Line (S3b)
Simulation Water Surface Elevation
Results for the 100-year Flood Event.

Legend

Water surface elevation (feet)

	< 65
	65 to 70
	70 to 75
	75 to 80
	80 to 85
	85 to 90
	90 to 95
	> 95

River mile

Project area

County boundary

0 200 400 800
 Feet

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&M_Modeling_Figures\Fig6_s3_100yr_wse.mxd (5/26/2013)



Figure 6. Sheet B.
Avulsion at County Line (S3b)
Simulation Water Surface Elevation
Results for the 100-year Flood Event.

Legend

Water surface elevation (feet)

	< 65
	65 to 70
	70 to 75
	75 to 80
	80 to 85
	85 to 90
	90 to 95
	> 95

River mile

Project area

County boundary

0 200 400 800
 Feet

King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&M_Modeling_Figures\Fig6_s3_100yr_wse.mxd (5/26/2013)

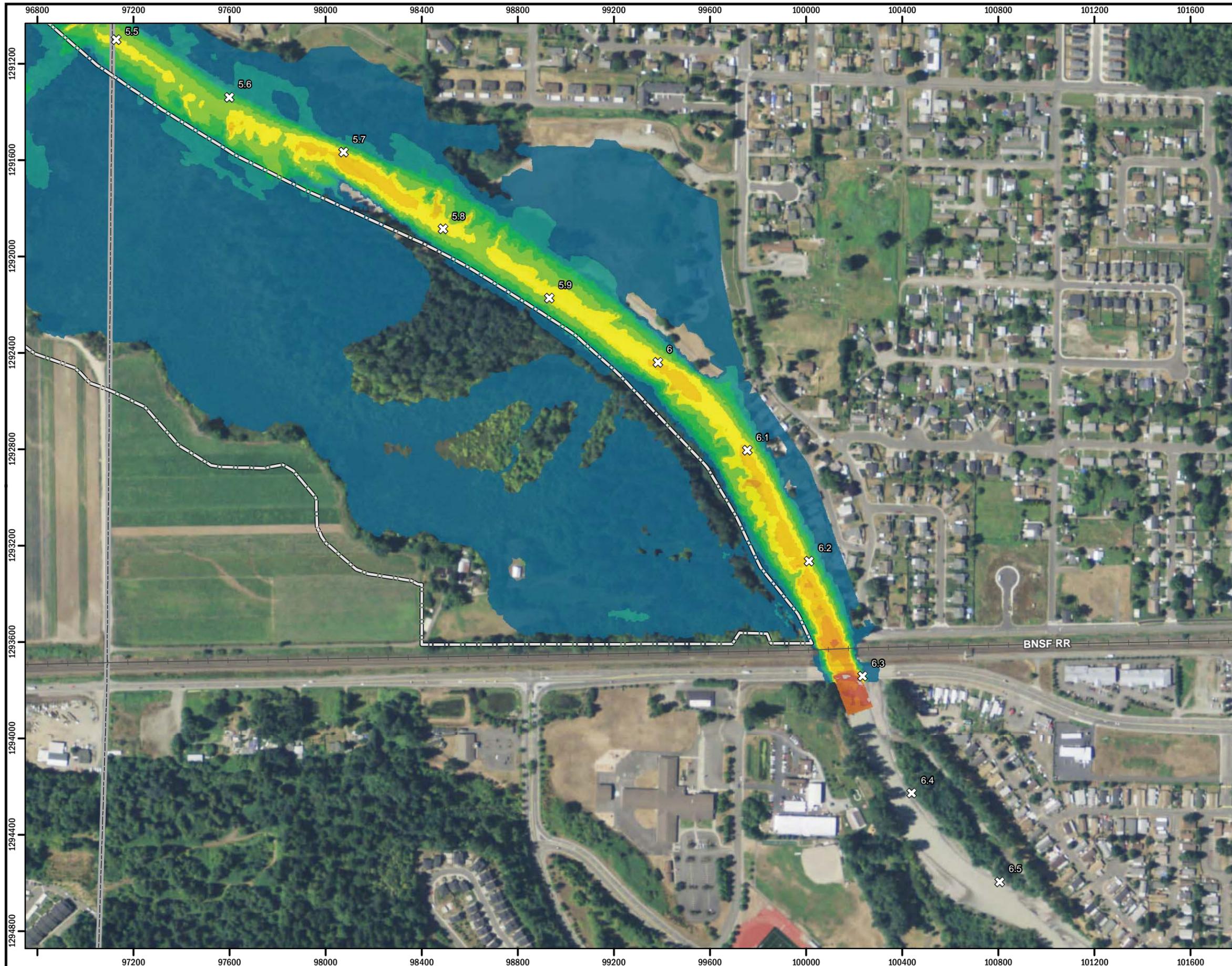


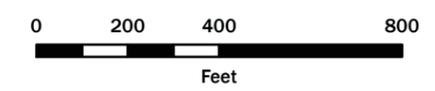
Figure 7. Sheet A.
Avulsion at County Line (S3b)
Simulation Water Velocity Results
for the 100-year Flood Event.

Legend

Water velocity (ft/sec)

- 0.05 to 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- 10 to 12
- 12 to 14
- 14 to 16
- 16 to 18
- > 18

- River mile
- Railroad
- Project area
- County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&M_Modeling_Figures\fig7_s3_100yr_vel.mxd (5/26/2013)

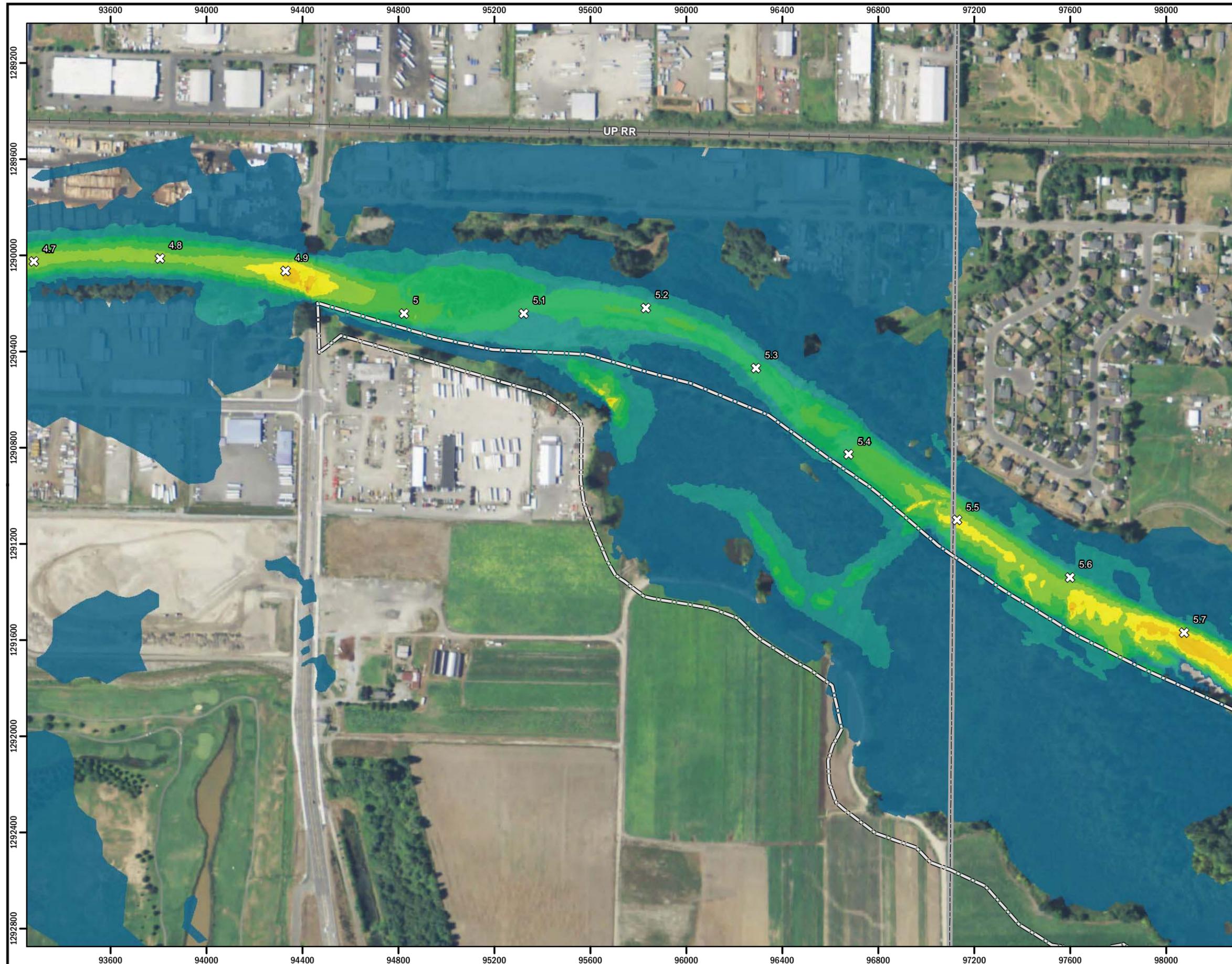


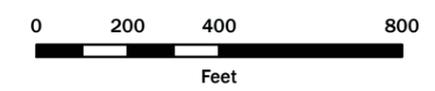
Figure 7. Sheet B.
Avulsion at County Line (S3b)
Simulation Water Velocity Results
for the 100-year Flood Event.

Legend

Water velocity (ft/sec)

-  0.05 to 2
-  2 to 4
-  4 to 6
-  6 to 8
-  8 to 10
-  10 to 12
-  12 to 14
-  14 to 16
-  16 to 18
-  > 18

-  River mile
-  Railroad
-  Project area
-  County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&M_Modeling_Figures\Fig7_s3_100yr_vel.mxd (5/26/2013)

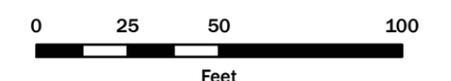


Figure 8.
Water Surface Elevation Difference
for the 100-year Flood Event
With and Without Scour
at the 8th Street E Bridge (S6a-S1a).

Legend

Change in water surface elevation (feet)
(with scour minus without scour)

- < -5
- 5 to -2
- 2 to -1.5
- 1.5 to -1
- 1 to -0.5
- 0.5 to -0.3
- 0.3 to 0.3
- 0.3 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- 2 to 5
- > 5
- River mile
- Railroad
- Project area
- County boundary



Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&H_Modeling_Figures\Fig8_scour_comparison_wse.mxd (9/12/2013)



Figure 9.
Water Surface Elevation Difference
for the 100-year Flood Event
With and Without Scour at the
8th Street E Bridge (S4a-S5a).

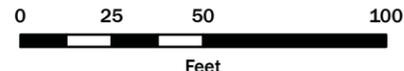
Legend

Change in velocity (ft/sec)
(with scour minus without scour)

- > 2
- 1 to 2
- 0.5 to 1
- 0.25 to 0.5
- 0.25 to 0.25
- 0.5 to -0.25
- 1 to -0.5
- 2 to -1
- < -2

- River mile
- Railroad
- Project area
- County boundary





0 25 50 100
Feet



King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&M_Modeling_Figures\fig9_scour_comparison_vel.mxd (8/19/2013)

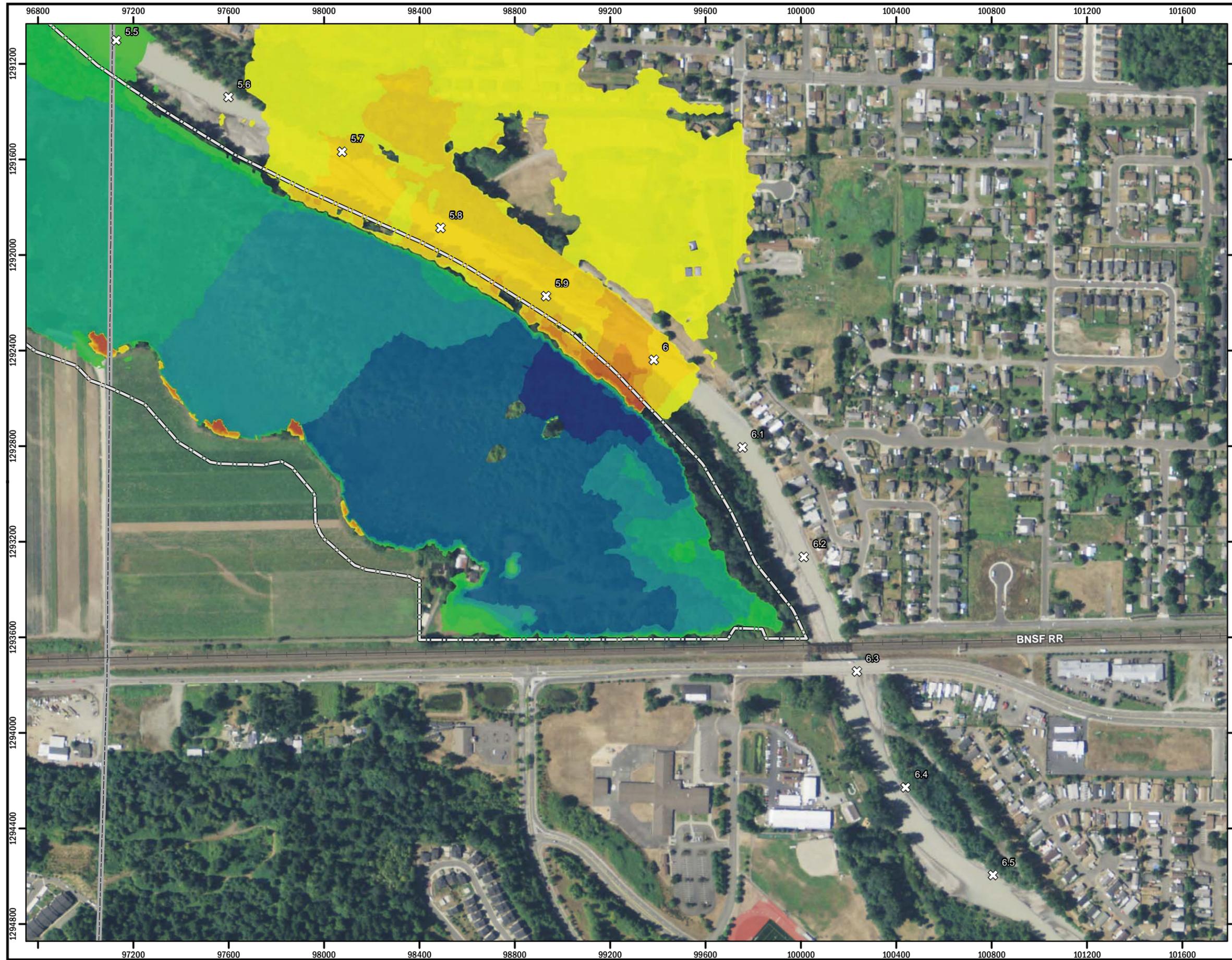


Figure 10. Sheet A.
Comparison of Existing (Without Project: S4ax) and Proposed (With Project Not Including Right Bank Improvements: S1ax) Water Surface Elevations for the 100-year Event in the Extended Domain Simulations.

Legend

Change in water surface elevation (feet)

[Red]	< -5
[Orange-Red]	-5 to -4
[Orange]	-4 to -3
[Yellow-Orange]	-3 to -2
[Yellow]	-2 to -1
[Light Yellow]	-1 to -0.5
[White]	-0.5 to 0.5
[Light Green]	0.5 to 1
[Green]	1 to 2
[Teal]	2 to 3
[Blue-Teal]	3 to 4
[Blue]	4 to 5
[Dark Blue]	> 5

River mile
 Railroad
 Project area
 County boundary

0 200 400 800
 Feet

King County
 Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&M_Modeling_Figures\fig10_s1a_minus_s4a_wse.mxd (9/5/2013)

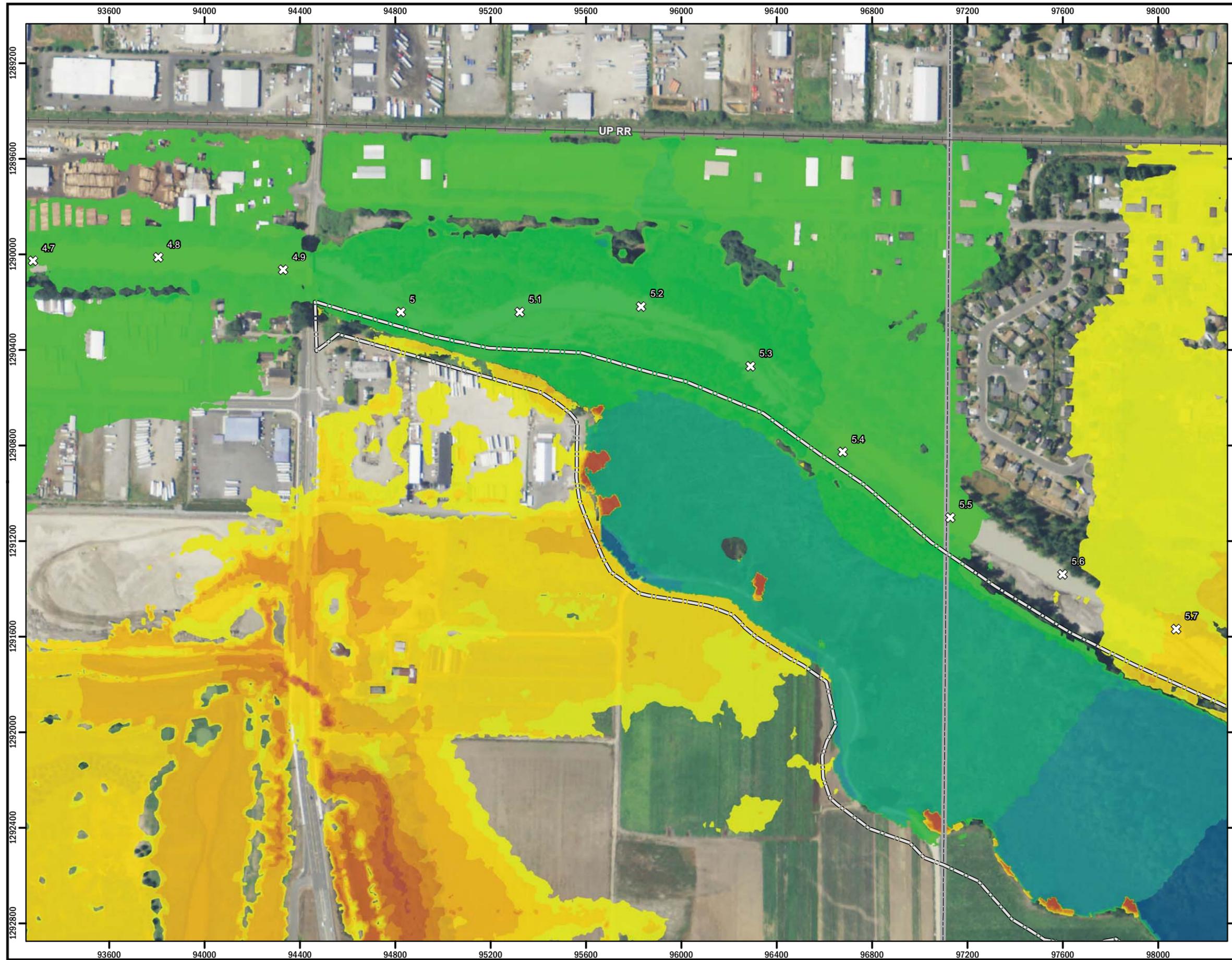


Figure 10. Sheet B.
Comparison of Existing (Without Project: S4ax) and Proposed (With Project Not Including Right Bank Improvements: S1ax) Water Surface Elevations for the 100-year Event in the Extended Domain Simulations.

Legend

Change in water surface elevation (feet)

[Red]	< -5
[Dark Orange]	-5 to -4
[Orange]	-4 to -3
[Light Orange]	-3 to -2
[Yellow-Orange]	-2 to -1
[Yellow]	-1 to -0.5
[White]	-0.5 to 0.5
[Light Green]	0.5 to 1
[Green]	1 to 2
[Teal]	2 to 3
[Dark Teal]	3 to 4
[Blue-Teal]	4 to 5
[Dark Blue]	> 5

River mile
 Railroad
 Project area
 County boundary

N

0 200 400 800
 Feet

King County
 Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&M_Modeling_Figures\Fig10_s1a_minus_s4a_wse.mxd (9/5/2013)



Figure 10. Sheet C.
Comparison of Existing (Without Project: S4ax) and Proposed (With Project Not Including Right Bank Improvements: S1ax) Water Surface Elevations for the 100-year Event in the Extended Domain Simulations.

Legend

Change in water surface elevation (feet)

[Red]	< -5
[Orange-Red]	-5 to -4
[Orange]	-4 to -3
[Yellow-Orange]	-3 to -2
[Yellow]	-2 to -1
[Light Yellow]	-1 to -0.5
[White]	-0.5 to 0.5
[Light Green]	0.5 to 1
[Green]	1 to 2
[Teal-Green]	2 to 3
[Teal]	3 to 4
[Blue-Teal]	4 to 5
[Dark Blue]	> 5

River mile
 Railroad
 Project area
 County boundary

0 200 400 800
 Feet

King County
 Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&H_Modeling_Figures\fig10_s1a_minus_s4a_wse.mxd (9/5/2013)

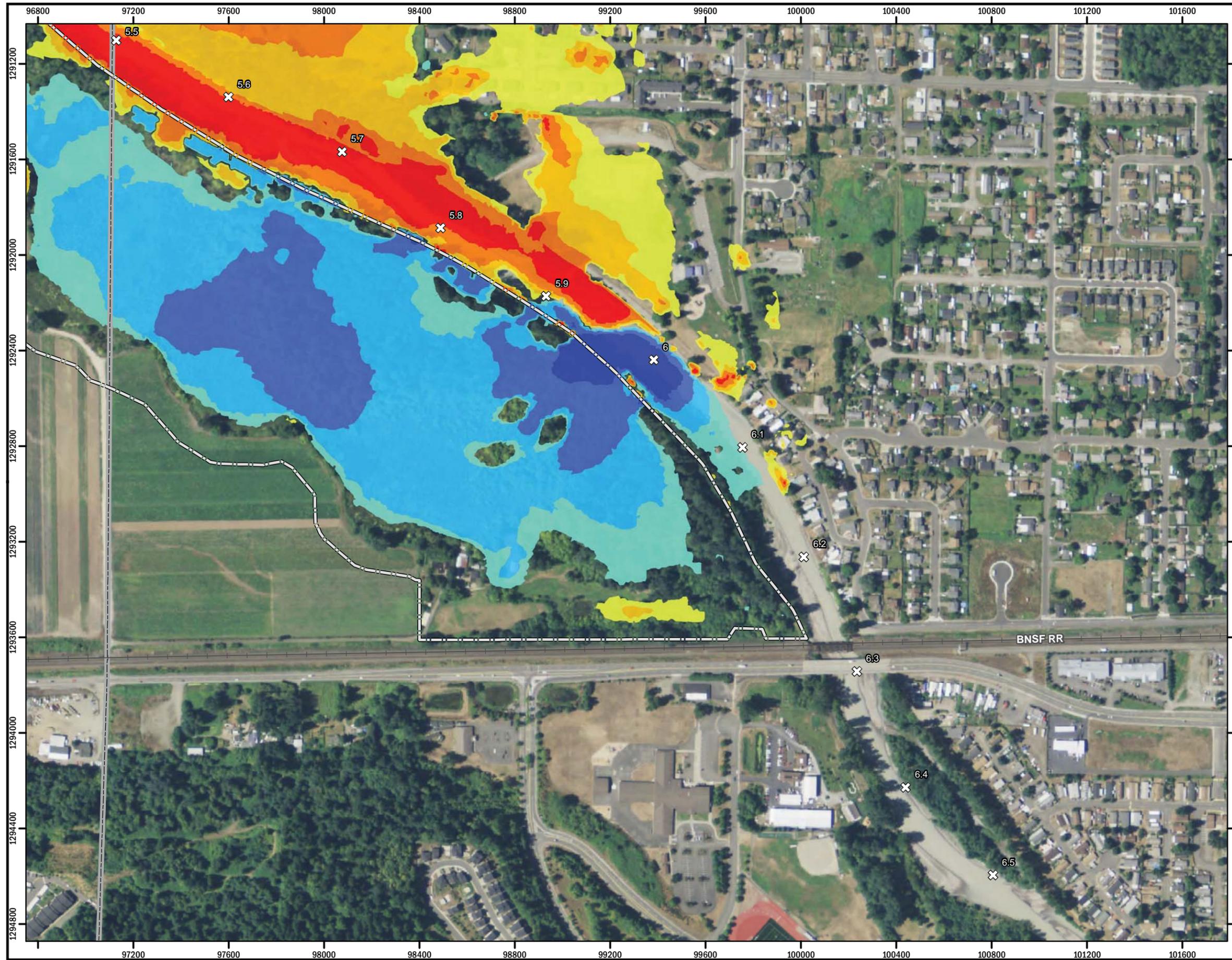


Figure 11. Sheet A.
Comparison of Existing (Without Project: S4ax) and Proposed (With Project Not Including Right Bank Improvements: S1ax) Water Surface Elevations for the 100-year Event in the Extended Domain Simulations.

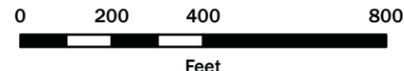
Legend

Change in water velocity (ft/sec)

- > 2
- 1 to 2
- 0.5 to 1
- 0.25 to 0.5
- 0.25 to 0.25
- 0.5 to -0.25
- 1 to -0.5
- 2 to -1
- < -2

- River mile
- Railroad
- Project area
- County boundary





0 200 400 800
Feet



King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&H_Modeling_Figures\fig11_s1a_minus_s4a_velocity.mxd (9/5/2013)

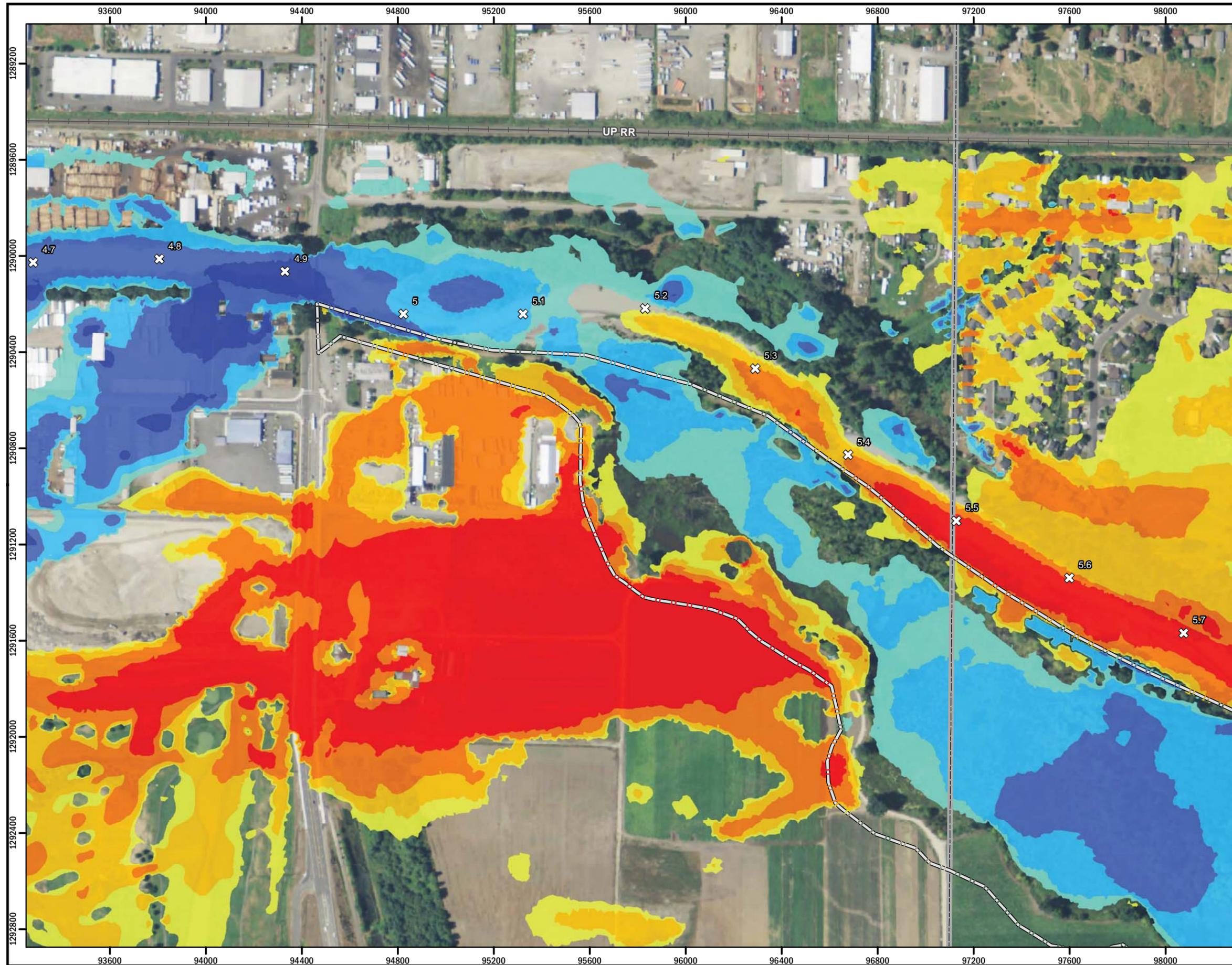


Figure 11. Sheet B.
Comparison of Existing (Without Project: S4ax) and Proposed (With Project Not Including Right Bank Improvements: S1ax) Water Surface Elevations for the 100-year Event in the Extended Domain Simulations.

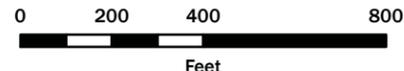
Legend

Change in water velocity (ft/sec)

- > 2
- 1 to 2
- 0.5 to 1
- 0.25 to 0.5
- 0.25 to 0.25
- 0.5 to -0.25
- 1 to -0.5
- 2 to -1
- < -2

- River mile
- Railroad
- Project area
- County boundary





0 200 400 800
Feet



King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&H_Modeling_Figures\fig11_s1a_minus_s4a_velocity.mxd (9/5/2013)

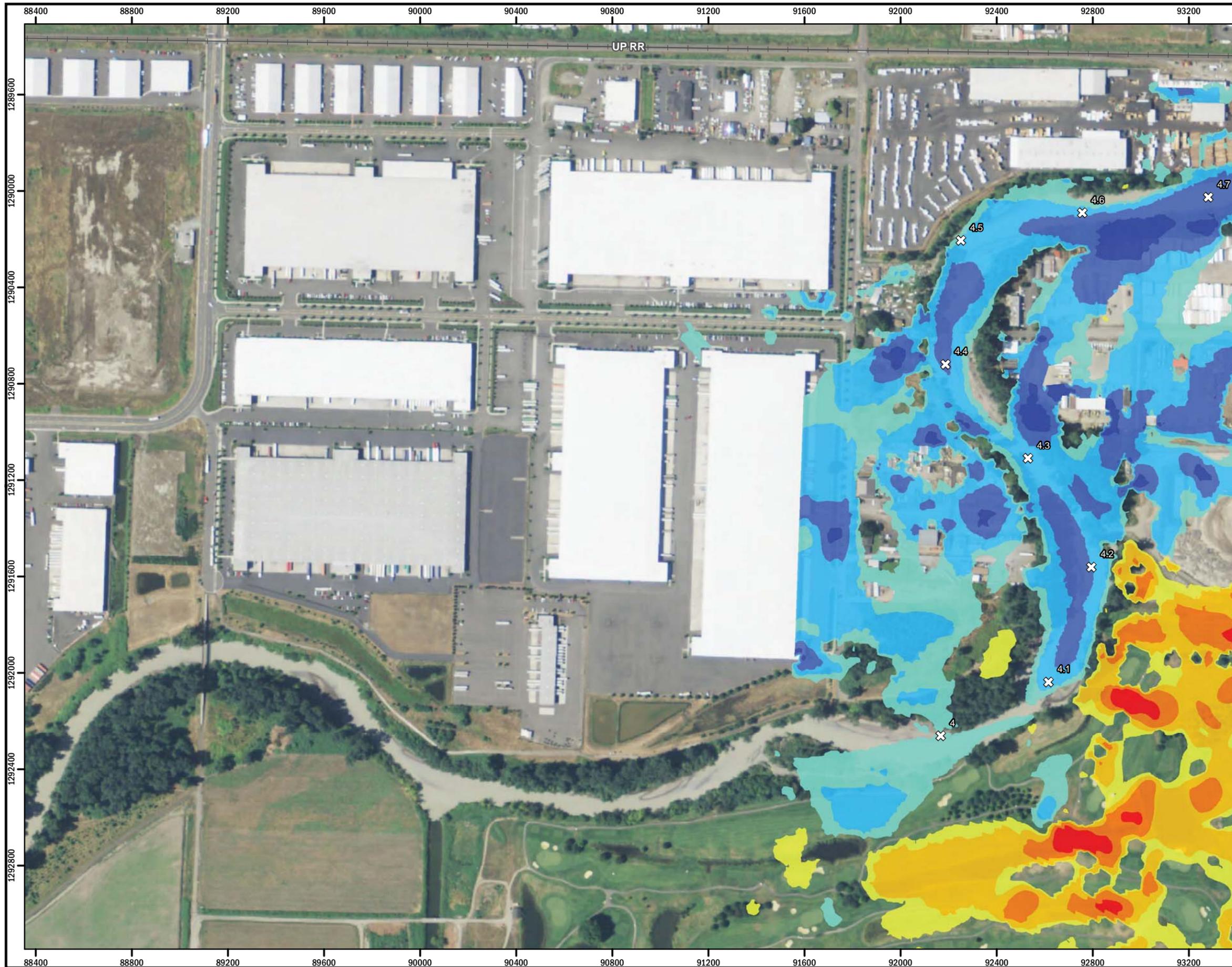


Figure 11. Sheet C.
Comparison of Existing (Without Project: S4ax) and Proposed (With Project Not Including Right Bank Improvements: S1ax) Water Surface Elevations for the 100-year Event in the Extended Domain Simulations.

Legend

Change in water velocity (ft/sec)

- > 2
- 1 to 2
- 0.5 to 1
- 0.25 to 0.5
- 0.25 to 0.25
- 0.5 to -0.25
- 1 to -0.5
- 2 to -1
- < -2

- River mile
- Railroad
- Project area
- County boundary



0 200 400 800
Feet

King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&H_Modeling_Figures\fig11_s1a_minus_s4a_velocity.mxd (9/5/2013)

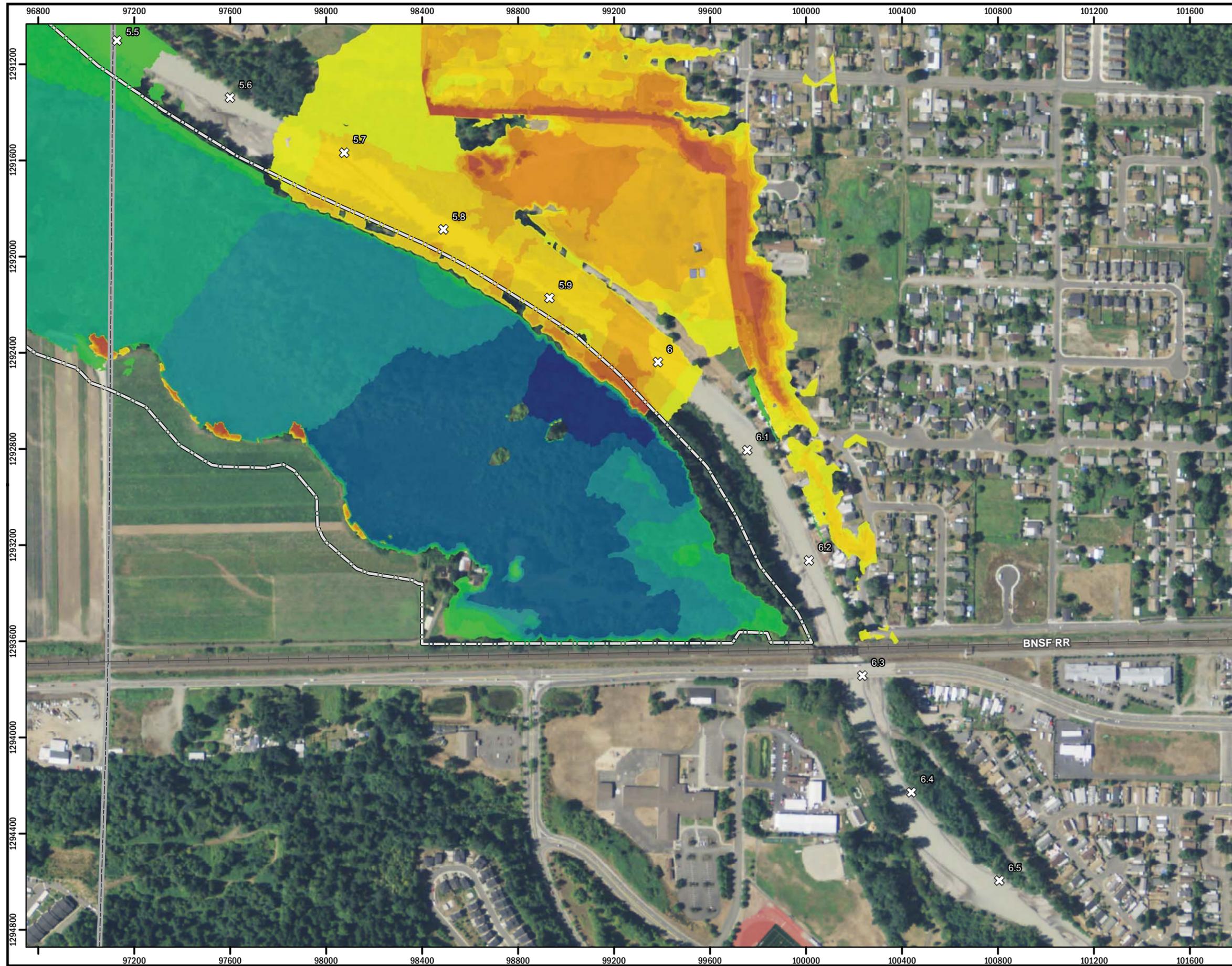


Figure 12. Sheet A.
Comparison of Existing (Without Project: S4ax) and Proposed (With Project Including Right Bank Improvements: S1aax) Water Surface Elevations for the 100-year Event in the Extended Domain Simulations.

Legend

Change in water surface elevation (feet)

Dark Red	< -5
Red-Orange	-5 to -4
Orange	-4 to -3
Yellow-Orange	-3 to -2
Yellow	-2 to -1
Light Yellow	-1 to -0.5
White	-0.5 to 0.5
Light Green	0.5 to 1
Green	1 to 2
Teal	2 to 3
Blue-Teal	3 to 4
Blue	4 to 5
Dark Blue	> 5

River mile
 Railroad
 Project area
 County boundary

King County
 Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&M_Modeling_Figures\fig12_s1aBB_minus_s4a_wse.mxd (9/5/2013)

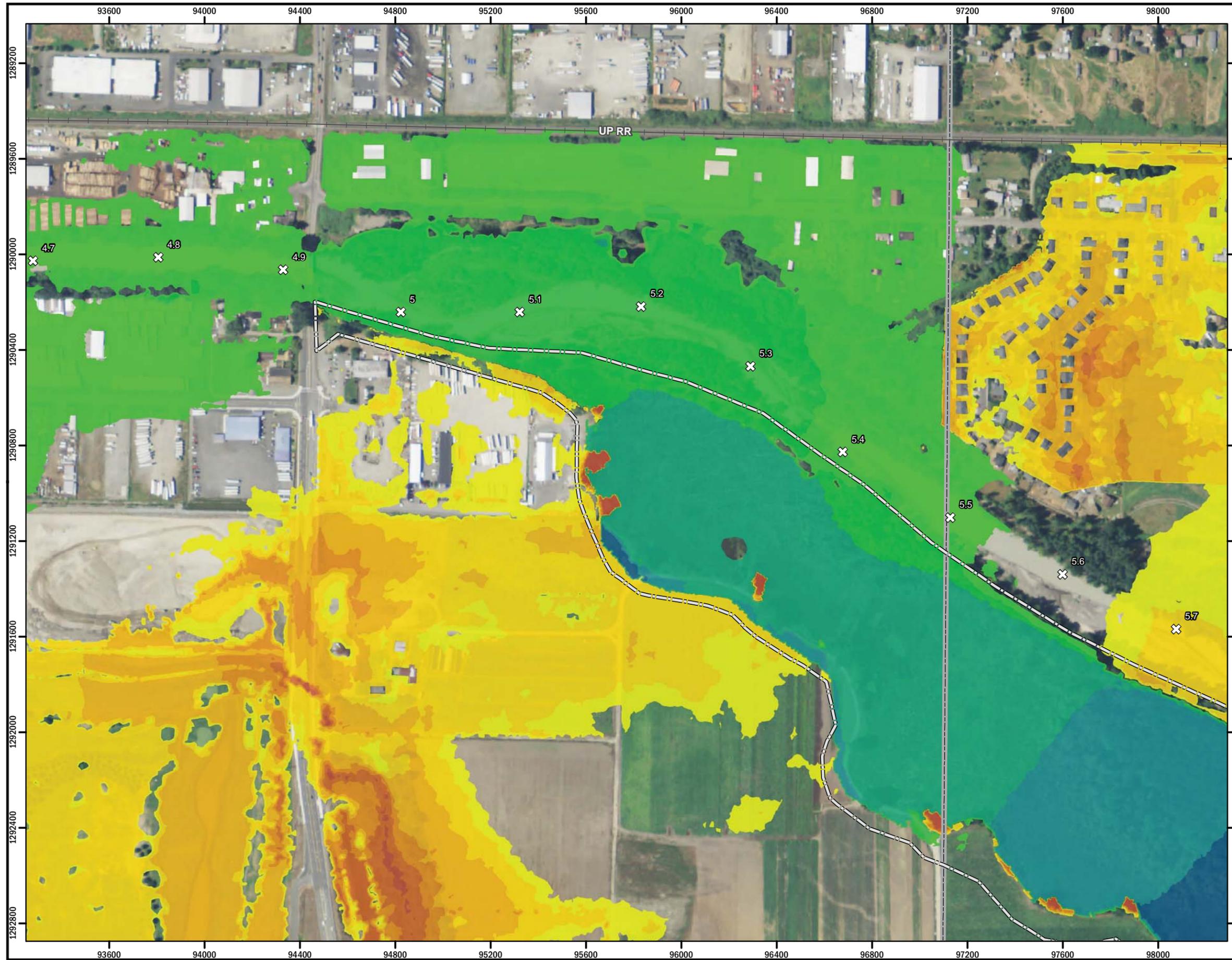


Figure 12. Sheet B.
Comparison of Existing (Without Project: S4ax) and Proposed (With Project Including Right Bank Improvements: S1aax) Water Surface Elevations for the 100-year Event in the Extended Domain Simulations.

Legend

Change in water surface elevation (feet)

[Red]	< -5
[Dark Orange]	-5 to -4
[Orange]	-4 to -3
[Light Orange]	-3 to -2
[Yellow]	-2 to -1
[Light Yellow]	-1 to -0.5
[White]	-0.5 to 0.5
[Light Green]	0.5 to 1
[Green]	1 to 2
[Teal]	2 to 3
[Dark Teal]	3 to 4
[Blue-Teal]	4 to 5
[Dark Blue]	> 5

River mile
 Railroad
 Project area
 County boundary

0 200 400 800
Feet

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&M_Modeling_Figures\fig12_s1aBB_minus_s4a_wse.mxd (9/5/2013)



Figure 12. Sheet C.
Comparison of Existing (Without Project: S4ax) and Proposed (With Project Including Right Bank Improvements: S1aax) Water Surface Elevations for the 100-year Event in the Extended Domain Simulations.

Legend

Change in water surface elevation (feet)

Dark Red	< -5
Red-Orange	-5 to -4
Orange	-4 to -3
Yellow-Orange	-3 to -2
Yellow	-2 to -1
Light Yellow	-1 to -0.5
White	-0.5 to 0.5
Light Green	0.5 to 1
Green	1 to 2
Teal	2 to 3
Blue-Teal	3 to 4
Blue	4 to 5
Dark Blue	> 5

River mile
 Railroad
 Project area
 County boundary

0 200 400 800
 Feet

King County
 Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&M_Modeling_Figures\fig12_s1aBB_minus_s4a_wse.mxd (9/5/2013)

flood (see Figure 10, Sheets A and B). This predicted increase in water-surface elevation is contained entirely within the reconnected floodplain by means of the setback levee. Because of the expansion of the available flow area into this reconnected floodplain, there are decreases in the inundation depth and flow velocity in the main channel and in right bank floodplain areas in the City of Pacific. The model results indicate the elimination of inundation for large areas of the right bank floodplain.

Another major difference observed in the simulation results for conditions immediately following project construction is the elimination of flow over 8th Street E, southeast of the project site (see Figure 10, Sheet B). In existing conditions, the flow rate over 8th Street E is predicted to be significant during the 100-year flood event. The existing conditions model predicts that approximately 5,450 cubic feet per second, or 35 percent of the total peak discharge of the White River, will flow over 8th Street E east of the bridge during the 100-year event. Most of the water in the floodplain in this area is predicted to reenter the river in the large meander south of 8th Street E.

Downstream of the westward turn in the proposed setback levee, just south of the county boundary line (i.e., 1,200 feet upstream of the 8th Street E Bridge), the S1a simulation (proposed conditions immediately after construction) model results show a temporary increase in water surface elevations in the river channel and adjacent floodplain areas (Figure 10) primarily because the setback levee will eliminate the split flow overtopping the left bank wetland area and 8th Street E. The simulated water surface elevation differences between existing and proposed conditions immediately after construction are largest immediately upstream of the 8th Street E Bridge, since water will accumulate here and be forced to flow under the bridge after project construction is complete. Some of the increased accumulation of flood water can be accommodated in the reconnected floodplain on the left bank, but not all of it. The predicted increase in water surface elevation during the 100-year flood event following project construction extends into the main channel from the county line to the beginning of the meander downstream of the 8th Street E Bridge. Compared to existing conditions, the water surface elevations in the main channel are predicted to be up to 2 feet higher upstream of the 8th Street E Bridge to less than 0.5 feet higher downstream of the bridge in the timeframe immediately following project construction. These increases also drive more flow into the floodplain in this reach, though water surface elevation increases in the adjacent floodplain areas are predicted to be generally less than 1 foot at the peak of the 100-year flood event. The greatest increases outside of the channel will occur near the river in a mitigation wetland owned by Pierce County on the right bank. The model results indicate that the project is not expected to increase the extent of existing flooding or inundate properties that do not currently flood. The modeling results in this area of the right bank floodplain indicate that flow patterns here are complex due to reverse flow up Government Canal, which allows flood waters to inundate areas along Butte Avenue; however, the downstream extent of this area along Butte Avenue is hydraulically disconnected from the river due to topographic barriers imposed by dredge spoil mounds east of Butte Avenue, the Union Pacific Railroad embankment to the west, and the 8th Street E road prism to the south, which thereby exacerbate and extend the duration of flooding in this area under existing conditions.

The relative increases in water-surface elevations described above for residential properties located on the right bank along Butte Avenue are expected to diminish to within the resolution of the hydraulic model (inches) within 10 to 15 years following project construction (Herrera 2012d). The reason for this reduction in flood impact over time is two-fold. First, the project will reduce the rate of sediment accumulation in the main channel by opening up 80 to 100 acres of reconnected floodplain for sediment deposition and storage. Second, the filling of floodplain areas downstream of the project for permitted land development within the City of Sumner is currently underway. This floodplain fill occurred soon after topographic surface data were obtained for the project hydraulic modeling, hence the model does not account for the effects of these newly added fill areas. Also not included in the baseline conditions is temporary fill (sand bags) placed during flood events to protect existing private development (as was done in January 2009 and is planned by multiple agencies during future flood fights). The cumulative impact of these actions is to reduce split flow to the left bank wetland and over 8th Street E and increase baseline flood elevations on the right bank south of Government Canal. These actions, not included in the modeling, consequently reduce the relative modeled impacts imposed in this area by the Countyline project. Because the hydraulic models do not account for the recent fill in the area of the split flow or future flood-fight fill, the potential impacts described above are considered conservative estimates.

The additional flow that can be contained in the reconnected floodplain relative to existing conditions will also increase flow velocities in the river channel in the vicinity of the 8th Street E Bridge (see Figure 11, Sheets B and C). Increases in flow velocity in this area will also likely cause increased scour of the river bed at the bridge during large floods. Scour calculations conducted by King County (2013) indicate that maximum scour for the 100-year event will increase by approximately 2 to 3 feet immediately after construction. Because the thalweg (the deepest part of the river) at the bridge has aggraded approximately 2 feet since the bridge was constructed in 1952, and because the 100-year peak flow at that time was approximately 3,500 cfs greater, the additional 2 to 3 feet of scour is not expected to increase the risk to the bridge above what existed in the past.

The model results for proposed conditions immediately following construction also show increased flow velocities in the large meander south of the bridge and in the floodplain on both banks immediately adjacent to the meander (see Figure 11, Sheet C). Once water returns to the channel at the downstream end of the meander from these adjacent floodplain areas, the predicted differences in water surface elevations and flow velocities between existing and proposed conditions vanish. This is an expected finding because this is the same general location along the river where flow overtopping 8th Street E in major floods will reenter the river in the existing condition.

Figures 12 and 13 present the simulated differences in water surface elevations and flow velocities, respectively, during the 100-year flood event between existing (S4ax) and proposed (S1aax) conditions with inclusion of the proposed right bank floodplain improvements upstream of the 8th Street E bridge (a future King County project). The model results are roughly the same as without the right bank floodplain improvements, with the obvious and important exception that riverward of the proposed right bank setback levee all flooding is eliminated in the proposed conditions case. The water surface elevation increases predicted around the

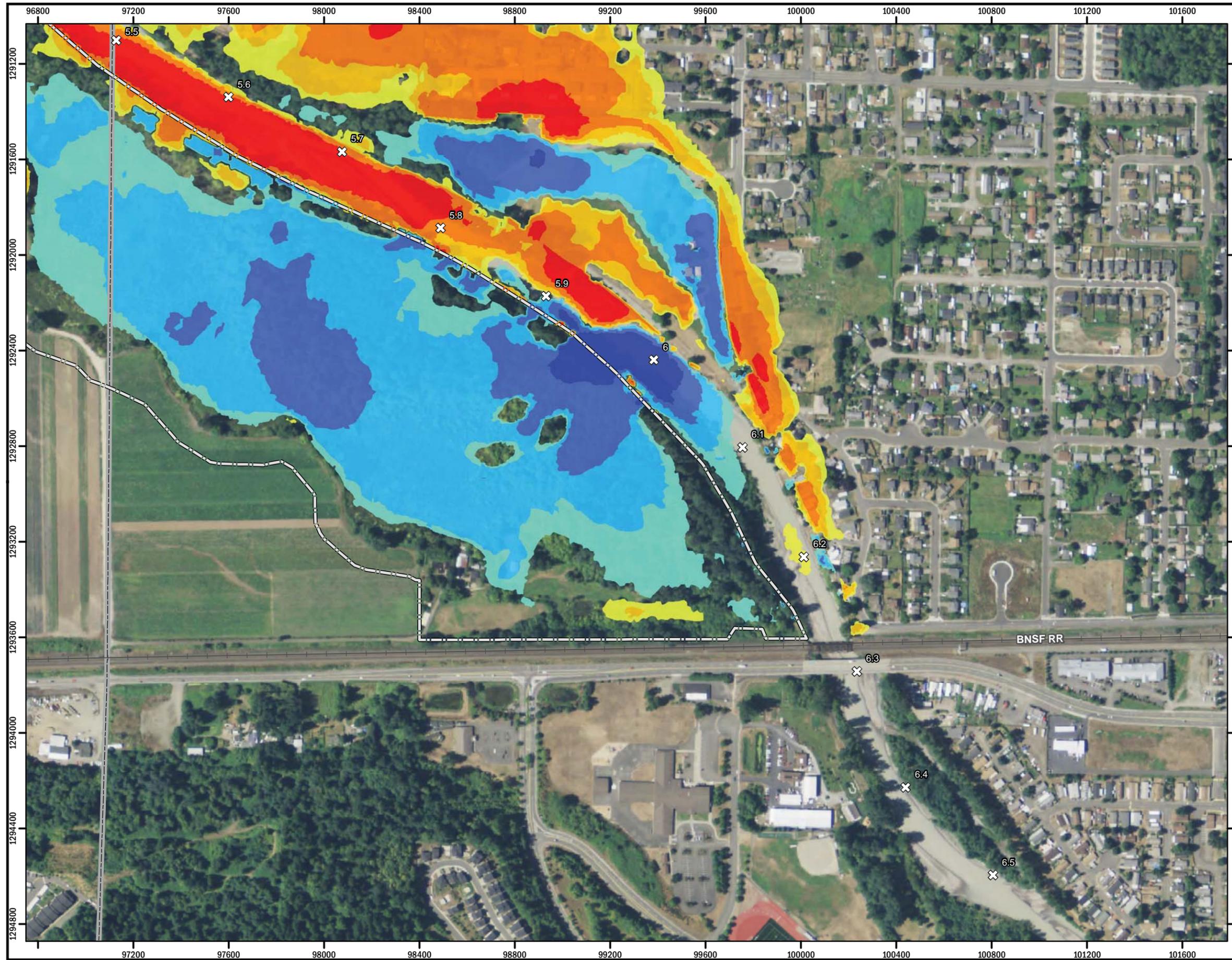


Figure 13. Sheet A.
Comparison of Existing (Without Project: S4ax) and Proposed (With Project Including Right Bank Improvements: S1aax) Water Surface Elevations for the 100-year Event in the Extended Domain Simulations.

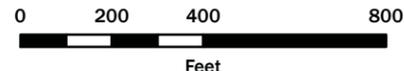
Legend

Change in water velocity (ft/sec)

- > 2
- 1 to 2
- 0.5 to 1
- 0.25 to 0.5
- 0.25 to 0.25
- 0.5 to -0.25
- 1 to -0.5
- 2 to -1
- < -2

- River mile
- Railroad
- Project area
- County boundary





0 200 400 800
Feet



King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&M_Modeling_Figures\fig13_s1aBB_minus_s4a_v01.mxd (9/5/2013)

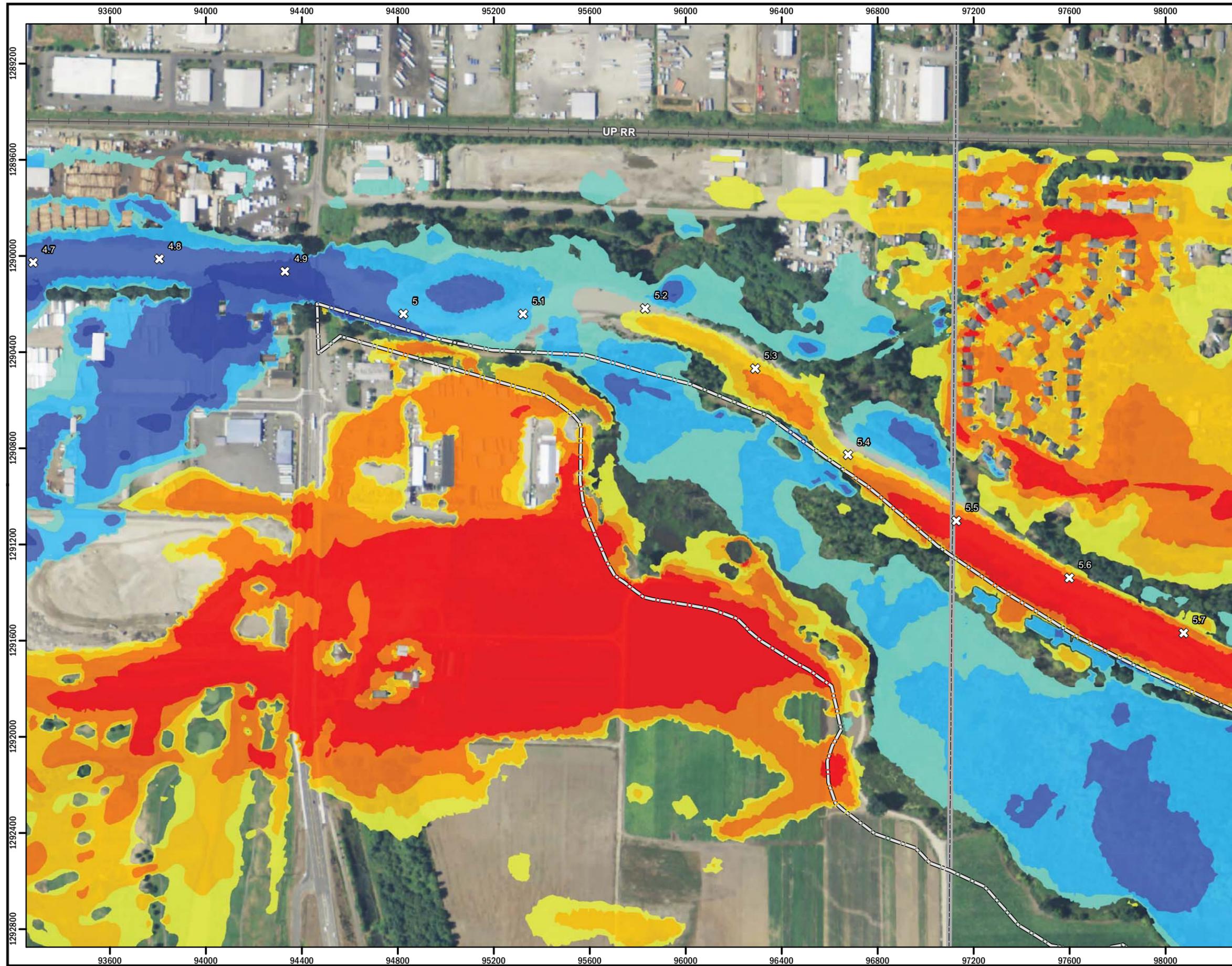


Figure 13. Sheet B.
Comparison of Existing (Without Project: S4ax) and Proposed (With Project Including Right Bank Improvements: S1aax) Water Surface Elevations for the 100-year Event in the Extended Domain Simulations.

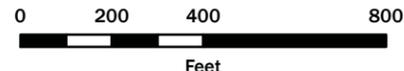
Legend

Change in water velocity (ft/sec)

- > 2
- 1 to 2
- 0.5 to 1
- 0.25 to 0.5
- 0.25 to 0.25
- 0.5 to -0.25
- 1 to -0.5
- 2 to -1
- < -2

- River mile
- Railroad
- Project area
- County boundary





0 200 400 800
Feet



King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&M_Modeling_Figures\fig13_s1aBB_minus_s4a_v01.mxd (9/5/2013)

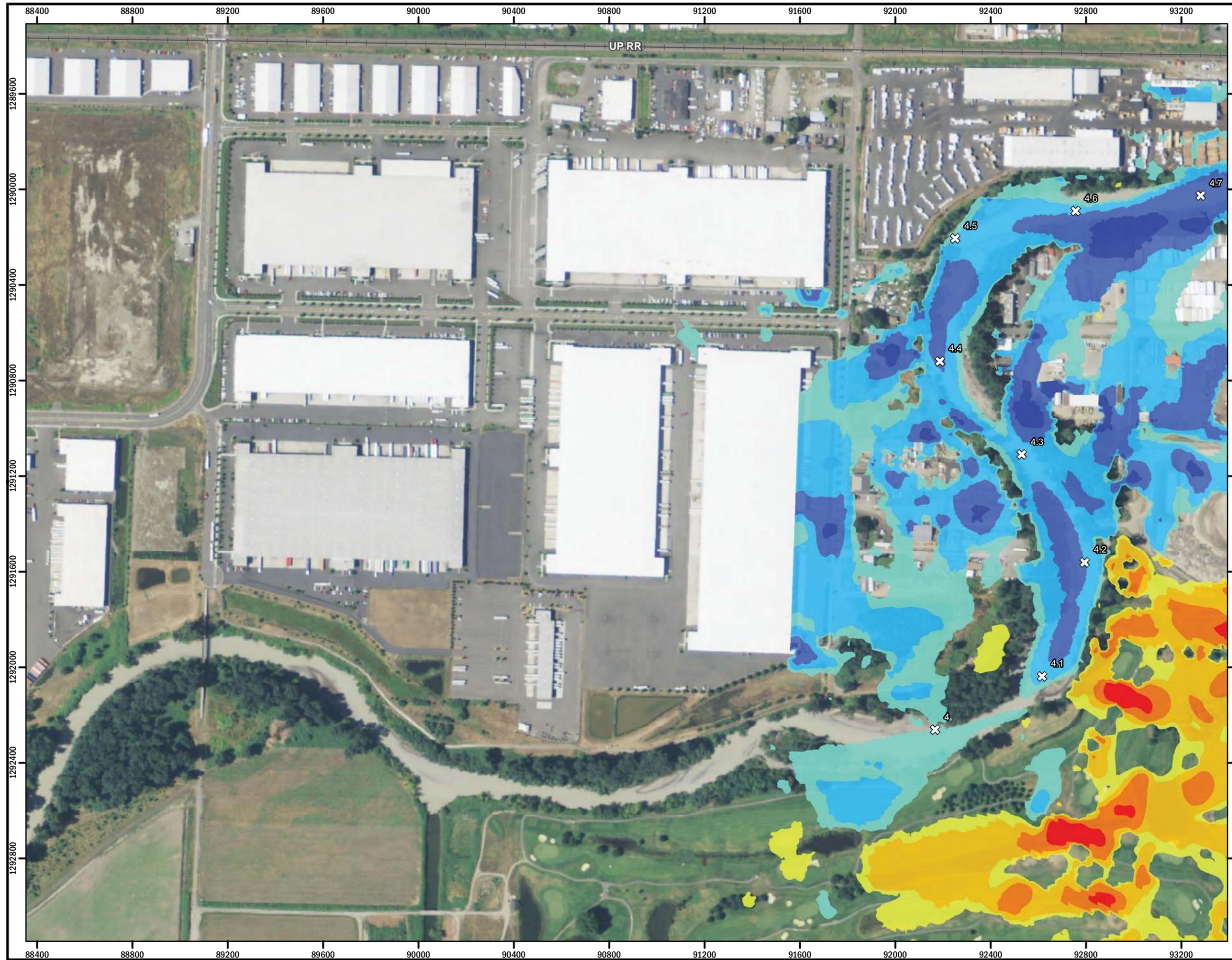


Figure 13. Sheet C.
Comparison of Existing (Without Project: S4ax) and Proposed (With Project Including Right Bank Improvements: S1aax) Water Surface Elevations for the 100-year Event in the Extended Domain Simulations.

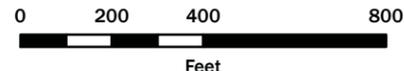
Legend

Change in water velocity (ft/sec)

- > 2
- 1 to 2
- 0.5 to 1
- 0.25 to 0.5
- 0.25 to 0.25
- 0.5 to -0.25
- 1 to -0.5
- 2 to -1
- < -2

- River mile
- Railroad
- Project area
- County boundary





0 200 400 800
Feet



King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\H&M_Modeling_Figures\fig13_s1aBB_minus_s4a_ve1.mxd (9/5/2013)

8th Street E Bridge following construction of proposed right bank floodplain improvements are also broadly similar to the simulation (scenario S1a) without the right bank floodplain improvements. This is likely because the area inundated in the City of Pacific under existing conditions provides relatively little flood flow conveyance and storage compared to the total flow in the main channel and in the proposed left bank setback floodplain.

Quality Control

As discussed at length in Herrera (2012d), the initial model runs with a smaller model domain failed to consistently conserve mass. Two primary reasons were cited for this in Herrera (2012d). First, the model “produced” flow due to inaccuracies in calculation of flow near and around 8th Street E, primarily in the existing conditions simulations due to the adverse slope associated with water flowing over the road prism. The other possibility for error was that the boundary conditions employed were highly simplified in the downstream end of the left bank floodplain and could have forced model errors. It was unclear from the results at that time which was more important. Therefore, it was recommended to expand the model domain to completely resolve the flow in the left bank floodplain.

From subsequent testing with RiverFLO-2D Version 3.0 and the extended model domain, it was found that both sources of error likely contributed to the continuity problems, especially in the existing conditions simulations where significant flow is predicted over 8th Street E. In addition, the wetting-drying method used in RiverFLO-2D (i.e., how the model simulates wetting and drying of individual elements at small geographic scale in the mesh) also played a role. The wetting-drying method in the program changed over the course of the project modeling work based upon different issues encountered over time. Originally, Method A was used to determine wetting and drying (see the discussion in Herrera 2011a and 2011b). Method A was abandoned in the ensuing simulations documented in Herrera (2012d), and Method B was thereafter used exclusively because earlier simulations found that Method A produced anomalous “numerical piping” through the left bank levee immediately downstream of the A Street Bridge; however, after further analysis it was determined that the primary source of “numerical piping” was eliminated through the inclusion of a second breakline in the mesh at the top of the levee. Based on that finding, Method A was subsequently reused without these effects, while better conserving mass. The final extended domain results, which are used as the primary basis for understanding off-site impacts, were developed using Method B and conserved mass within 5 percent, which is sufficiently small as to be considered reasonable and not an indication that further testing of the wetting and drying method is needed.

It is important to note that although the simulations with the extended model domain did not produce the exact same water surface elevations and flow velocities as the earlier simulations with the limited domain, in a broad sense they captured all of the same flow features as the smaller domain results. In all of the comparative simulations, significant flood reduction benefits are expected to be achieved north of the Government Canal confluence as a result of project implementation, with those benefits diminishing in the upstream direction to a point at or near the A Street Bridge. Further, simulations with both the original model domain and the extended model domain indicate that temporary water surface elevation increases can be expected following project construction from the confluence of Government

Canal with the mainstem river to a point approximately 1,000 feet downstream of the 8th Street E Bridge. In all of the scenarios that were modeled, this effect is due to the elimination of large volumes of split flow over 8th Street E in the existing condition simulations.

These impacts are expected to diminish over time due to increase relocation of sedimentation from the main channel to the left bank wetland. In the without-project case, deposition will continue to be concentrated in the constrained main channel until the channel bed exceeds the elevation of the left bank levee, at which time all of the flow will leave the channel even during drier periods. With the project, it is expected that sediment will be deposited preferentially in the lower left bank wetland. This action will maintain conveyance in the main channel for at least the design life of the proposed project (30 years), maintaining flood levels near immediately post-construction levels.

Because of concern about the continuity problems, a procedure was subsequently developed to assess the quality and repeatability of the modeling results and is recommended in any future large modeling effort conducted by King County and others. The procedure is as follows:

- Perform steady-state simulations to determine if the flow rate remains constant through several cross sections scattered throughout the model domain.
- If there are large discrepancies, increase the model resolution in the vicinity of those sections, particularly in areas where flow velocities or velocity gradients are large.
- Once the steady state runs satisfy continuity throughout the model domain, commence modeling with unsteady flows to assess proposed channel and floodplain conditions.

Although calibration was completed on the hydraulic model only for the January 2009 event (Herrera 2011a), and then only on a post-2009-flood surface, smaller floods in the intervening time were examined to determine the continued accuracy of the model given the changes known to have occurred on site. For example, the model indicates that the 3-foot dirt berm at south end of wetland will overtop at approximately 7,500 cfs. On February 23, 2012, a peak flow of 7,280 cfs was observed. At this time, the berm was “within inches of overtopping” (Chris Brummer, personal communication), consistent with the current model estimates.

There are large differences between the results presented herein and other model estimates (e.g., King County [2013]). These differences are directly related to topographic changes within the project site. For instance, the average bed change was approximately 4 inches per year in the channel between 2007 and 2011 based upon an analysis of the two topographic data sets used during the design process. These changes are well known and documented in the project literature (Herrera [2010]) and the peer-reviewed literature (Collins and Montgomery [2011]). Therefore it is expected that the model is accurately predicting current flood conditions considerably better than other flood models in the vicinity of the project site with older topography.

Assumptions and Limitations

Like all modeling analyses, there are numerous assumptions that can limit the applicability and accuracy of the forecast of future conditions. Some key assumptions and the limitations associated with them for this project are:

- All of the hydraulic modeling performed to date was for meteorological (“clear water”) floods only. The entire study area is within a documented lahar zone of Mount Rainier (Washington State Department of Natural Resources 2013). Lahars produce mud and debris that could be carried by the White River into the study area. This phenomenon was not considered in this analysis.
- The latest available topographic surface information was used to model the conditions documented herein (April 2011 lidar and survey). However, known topographic changes have occurred since that time. Newly placed fill in the floodplain may have unknown impacts on the flood conditions reported herein and may exacerbate existing flooded areas or trigger flooding in areas not currently predicted to be inundated.
- The existing conditions model does not assume any informal, ad hoc flood fighting activities. The model results for existing conditions indicate that large areas of development would be inundated in a moderate (5- to 10-year recurrence interval) flood event. Flood fighting of any kind may direct flood waters to areas that are not shown to be inundated in the model results figures in this document. These actions may also initiate geomorphic changes which were not considered here.
- The buildings included as obstructions to (and displacement of) flow in the right bank floodplain were those that could be identified in the 2011 aerial photographs that accompanied the lidar survey. Recently permitted structures within flooded areas may change flooding patterns and flow velocities in comparison to the results presented for the extended domain model results.

SUMMARY OF FINDINGS

The following summary statements are based upon the model results discussed in this memorandum:

- The findings are based on the projection of recent trends in sediment deposition within the project reach and assume that both the Countyline (left bank) project and the future right bank project (or temporary flood protection measures) will be constructed to provide 100-year flood protection with 3 feet of freeboard throughout the service life of the project.
- The extended domain model simulations produced results that satisfied continuity and were physically realistic for all of the conditions simulated between the A Street Bridge and the White River near the Lake Tapps diversion return.
- The proposed Countyline project will lower flood water surface elevations by several feet along the right bank of the White River in the City of Pacific for all time periods examined. The greatest flood reduction benefit appears to be in the vicinity of Pacific City Park, where modeled flood water surface elevation reductions of up to 5 feet are predicted immediately following project construction.
- For floodplain areas downstream of Government Canal, nearly all of the differences in flood water surface elevations and flow velocities simulated between existing and proposed conditions are because the project will eliminate flow over 8th Street E (a major arterial) for all flows greater than 7,500 cfs (which is less than the 2-year event) and instead send all of water through the 8th Street E Bridge crossing. Temporary water surface elevations increases are expected immediately after construction in the right bank floodplain along Butte Avenue upstream of the 8th Street E Bridge due to the backwater effects from the bridge and associated fill. Temporary water surface elevation increases are also expected in major floods in the right bank floodplain downstream of this bridge. The model results indicate that water surface elevations in the floodplain outside of the channel in these areas can be expected to increase by up to 1 foot upstream of the bridge and by less than 0.5 feet downstream of the bridge immediately after construction and will decline relative to future conditions if the project was not constructed. Both areas of estimated water surface elevation increase are within the present-day, 100-year flood zone. Because these increases in flood elevations are temporary relative to future conditions without the project, the increased risk would only be realized if a major flood event occurs during the first 10 to 15 years after construction.
- Differences in channel bed scour around the 8th Street E Bridge foundation piers between existing and proposed conditions are not expected to have a significant impact on flood water surface elevations upstream or downstream of the bridge or on the structural integrity of the bridge.

- The simulated differences between the existing and proposed conditions models (with extended domain) vanish at the south end of the Sumner Meadows Golf Course and near the Lake Tapps diversion return, where the left overbank floodplain flow over 8th Street E would return to the main channel in existing conditions.

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ATTACHMENT A

Reckoning Simulation Results



Figure A-1. Sheet A.
Without Project Year Zero (S4a)
Simulation Water Surface Elevation
Results for the 2-year Flood Event.

Legend

Water surface elevation (feet)

	< 65
	65 to 70
	70 to 75
	75 to 80
	80 to 85
	85 to 90
	90 to 95
	> 95

River mile

Project area

County boundary

0 200 400 800
 Feet

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HMA_Modeling_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

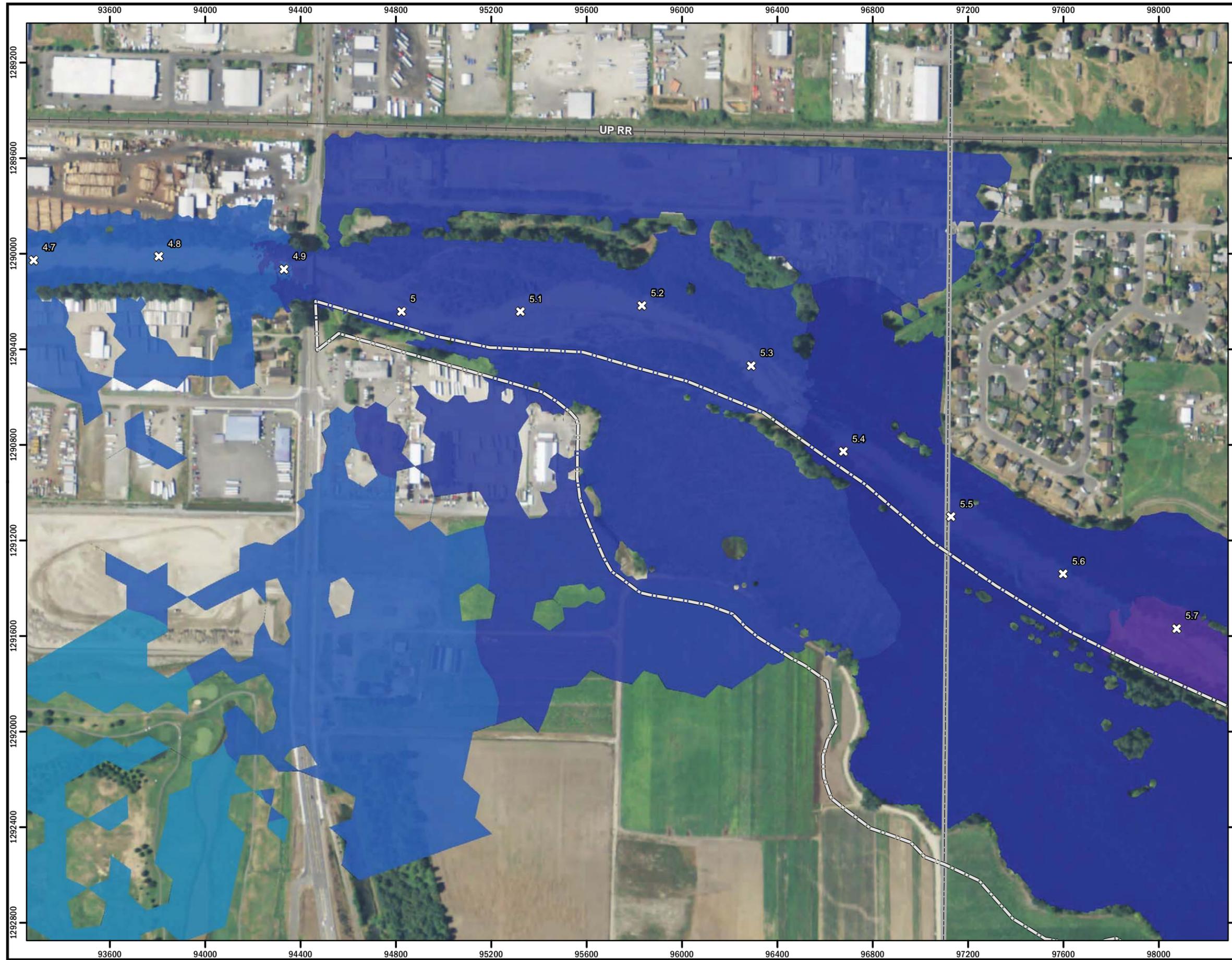


Figure A-1. Sheet B.
Without Project Year Zero (S4a)
Simulation Water Surface Elevation
Results for the 2-year Flood Event.

Legend

Water surface elevation (feet)

	< 65
	65 to 70
	70 to 75
	75 to 80
	80 to 85
	85 to 90
	90 to 95
	> 95

River mile

Project area

County boundary

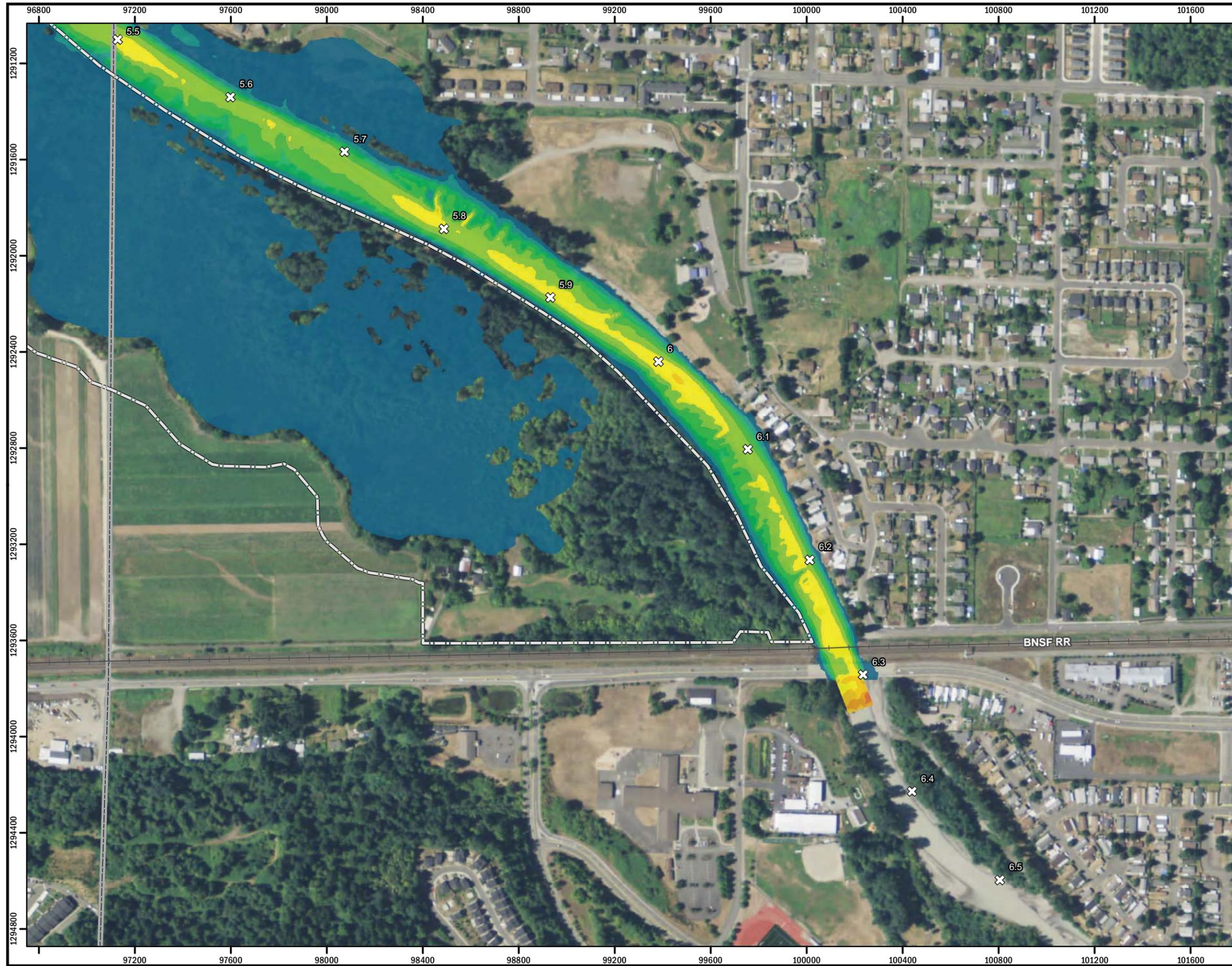
0 200 400 800
 Feet

King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project: K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

Figure A-2. Sheet A.
Without Project Year Zero (S4a)
Simulation Water Velocity Results
for the 2-year Flood Event.



Legend

Water velocity (ft/sec)

0.05 to 2
2 to 4
4 to 6
6 to 8
8 to 10
10 to 12
12 to 14
14 to 16
16 to 18
> 18

⊗ River mile

—+— Railroad

⎓ Project area

— County boundary



0 200 400 800
 Feet

 **King County**

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\reconned_delta_velocity_appendix_figures.mxd (6/13/2013)

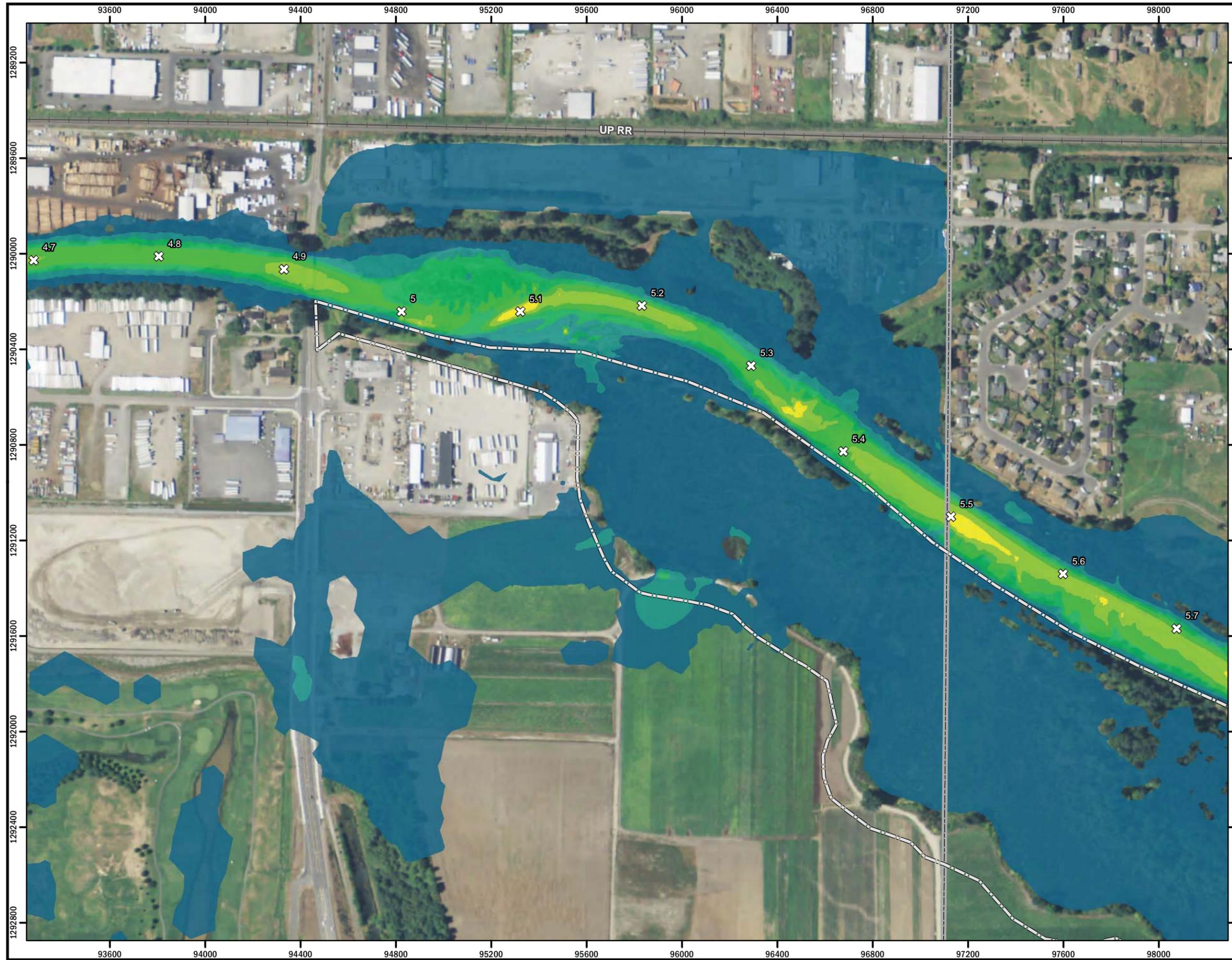


Figure A-2. Sheet B.
Without Project Year Zero (S4a)
Simulation Water Velocity Results
for the 2-year Flood Event.

Legend

Water velocity (ft/sec)

	0.05 to 2
	2 to 4
	4 to 6
	6 to 8
	8 to 10
	10 to 12
	12 to 14
	14 to 16
	16 to 18
	> 18

River mile

Railroad

Project area

County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\reconned_delta_velocity_appendix_figures.mxd (6/13/2013)

Figure A-3. Sheet A.
Without Project Year Zero (S4a)
Simulation Water Surface Elevation
Results for the 100-year Flood Event.



Legend

Water surface elevation (feet)

	< 65
	65 to 70
	70 to 75
	75 to 80
	80 to 85
	85 to 90
	90 to 95
	> 95

River mile

Project area

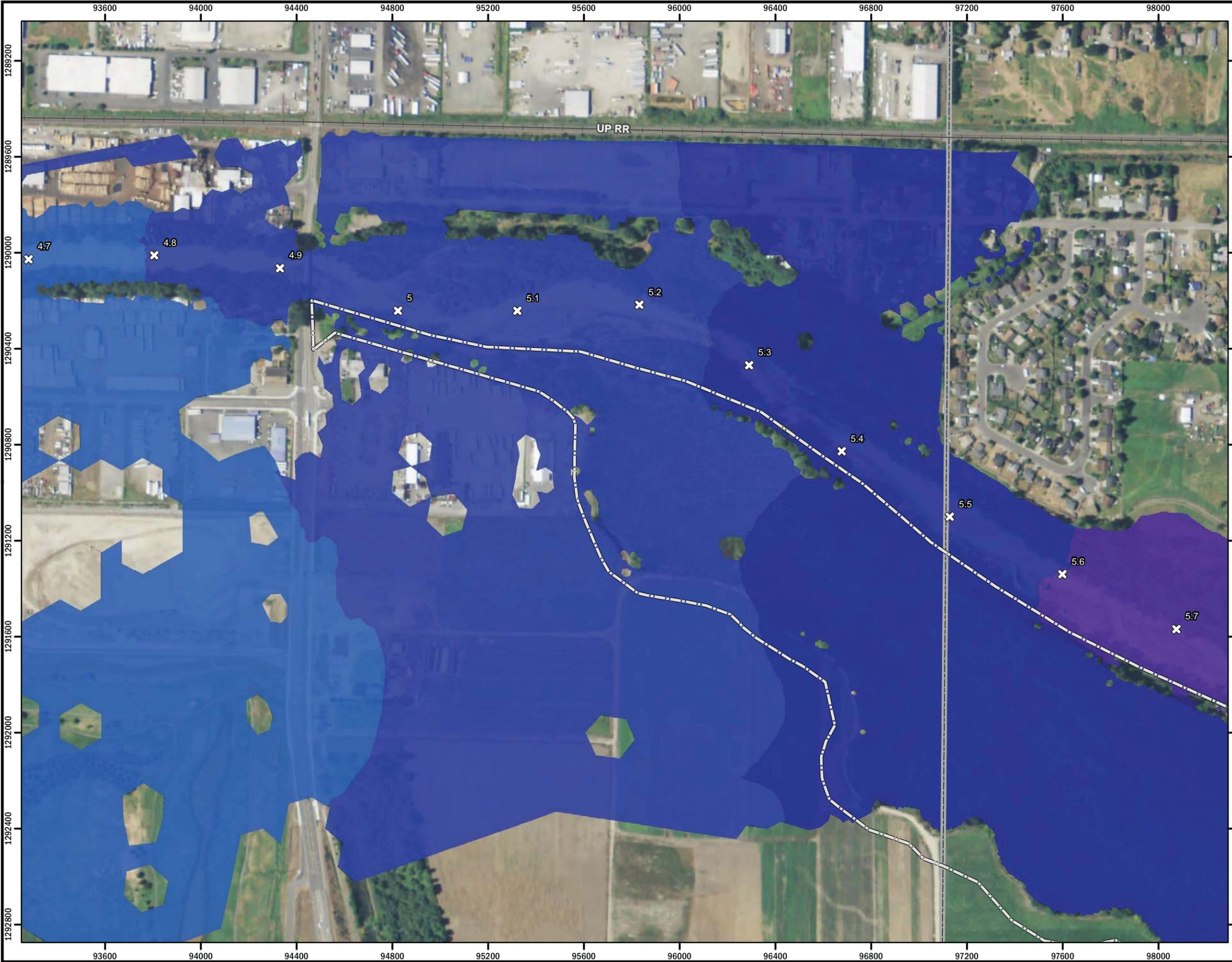
County boundary

0 200 400 800
 Feet

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HMA_Modeling_Figures\rechecked_domain_WSE_appendix_figures.mxd (6/13/2013)

Figure A-3. Sheet B.
 Without Project Year Zero (S4a)
 Simulation Water Surface Elevation
 Results for the 100-year Flood Event.

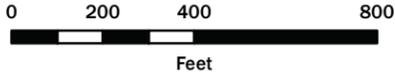


Legend

Water surface elevation (feet)

- < 65
- 65 to 70
- 70 to 75
- 75 to 80
- 80 to 85
- 85 to 90
- 90 to 95
- > 95

- River mile
- Project area
- County boundary



Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project: K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

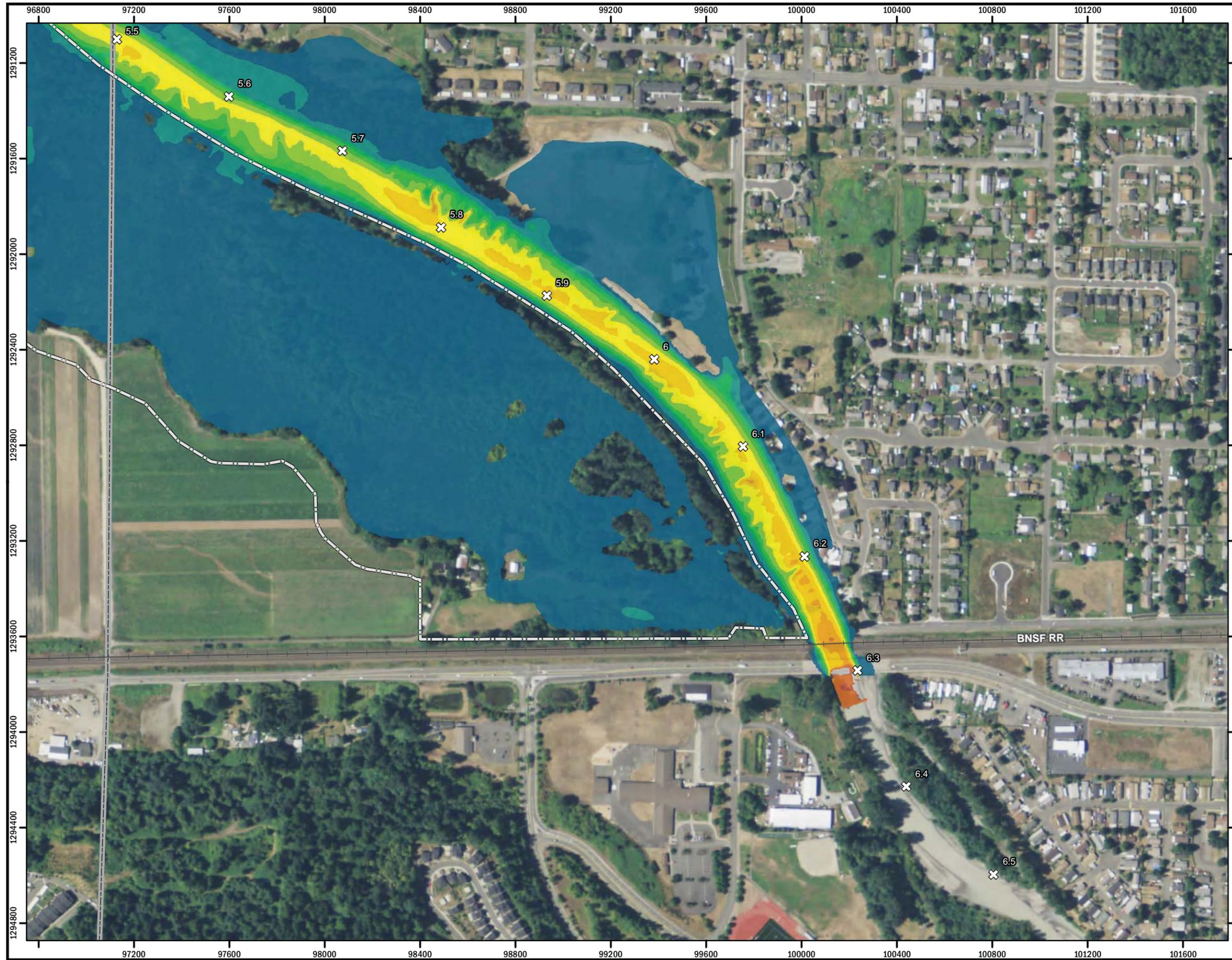


Figure A-4. Sheet A.
Without Project Year Zero (S4a)
Simulation Water Velocity Results
for the 100-year Flood Event.

Legend

Water velocity (ft/sec)

	0.05 to 2
	2 to 4
	4 to 6
	6 to 8
	8 to 10
	10 to 12
	12 to 14
	14 to 16
	16 to 18
	> 18

River mile

Railroad

Project area

County boundary

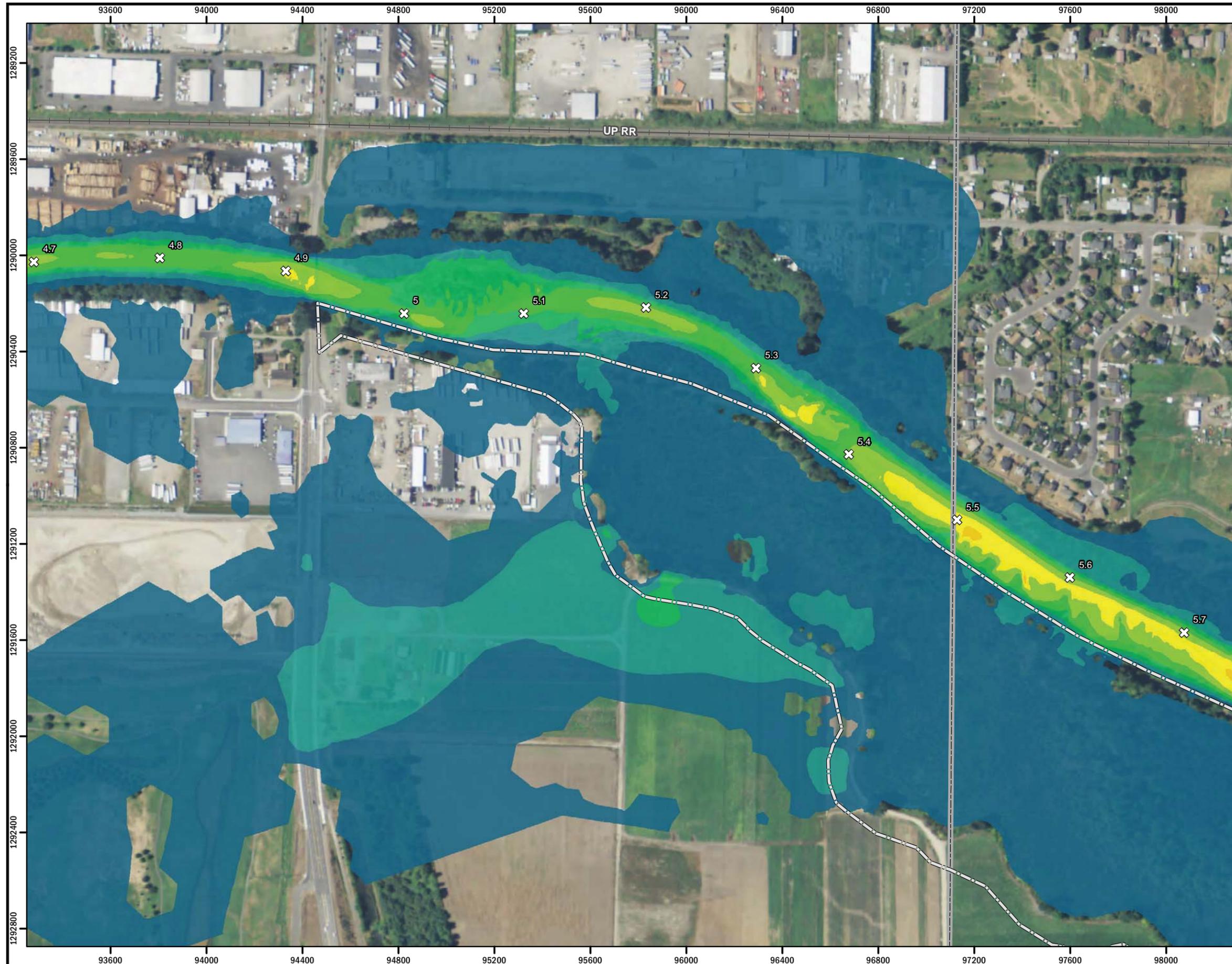
0 200 400 800
 Feet

King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\rechecked_delta_velocity_appendix_figures.mxd (6/13/2013)

Figure A-4. Sheet B.
Without Project Year Zero (S4a)
Simulation Water Velocity Results
for the 100-year Flood Event.

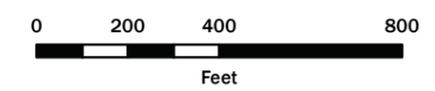


Legend

Water velocity (ft/sec)



- River mile
- Railroad
- Project area
- County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project: K:\Projects\130-04770-000\Project\HAM_Mapping_Figures\rechecked_delta_in_velocity_appendix_figures.mxd (6/13/2013)



Figure A-5. Sheet A.
Without Project Year Zero (S4a)
Simulation Water Surface Elevation
Results for the 500-year Flood Event.

Legend

Water surface elevation (feet)

	< 65
	65 to 70
	70 to 75
	75 to 80
	80 to 85
	85 to 90
	90 to 95
	> 95

River mile

Project area

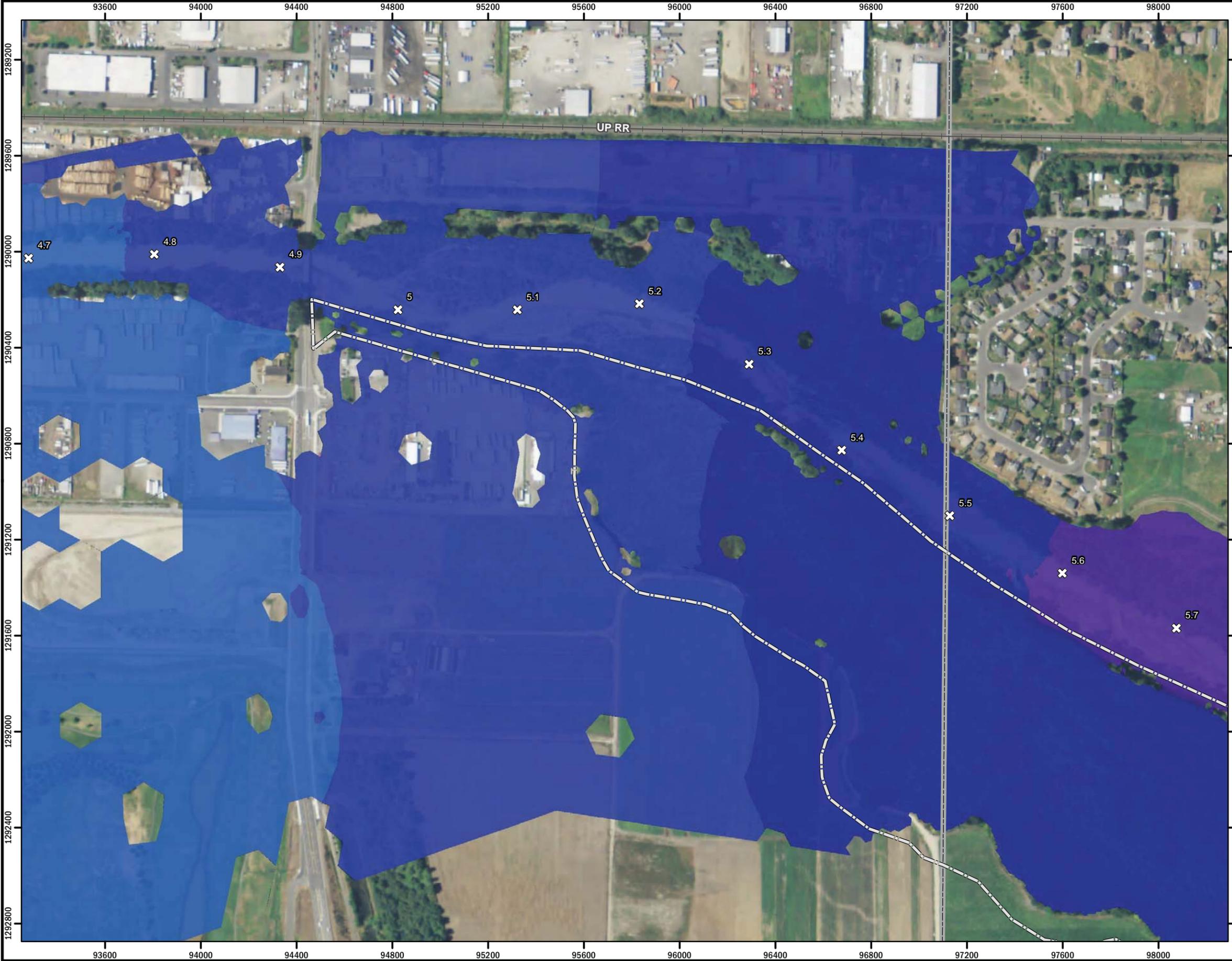
County boundary

0 200 400 800
 Feet

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

Figure A-5. Sheet B.
Without Project Year Zero (S4a)
Simulation Water Surface Elevation
Results for the 500-year Flood Event.

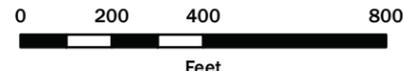


Legend

Water surface elevation (feet)

- < 65
- 65 to 70
- 70 to 75
- 75 to 80
- 80 to 85
- 85 to 90
- 90 to 95
- > 95

- River mile
- Project area
- County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project: K:\Projects\130-04770-000\Project\HAM_Mapping_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

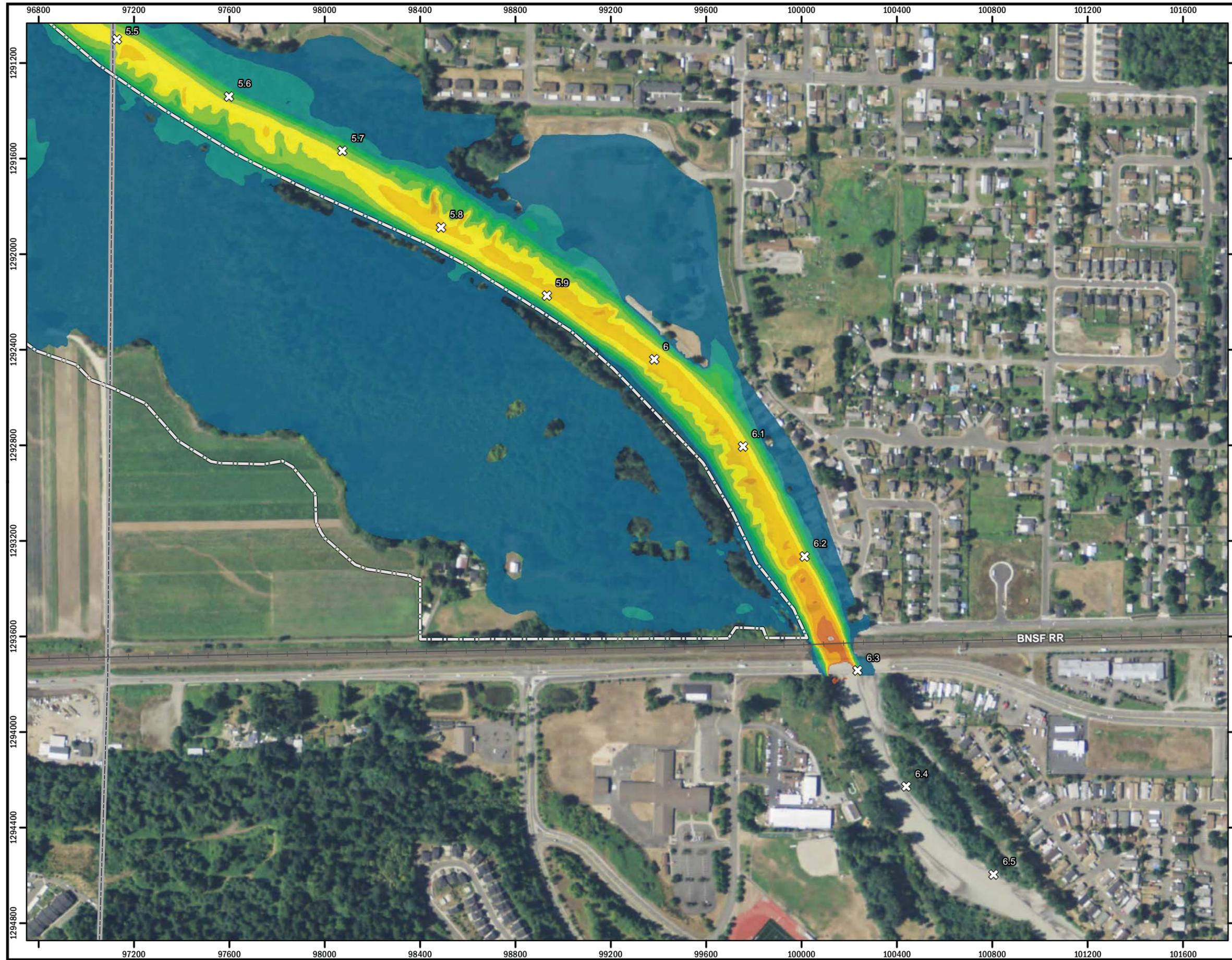


Figure A-6. Sheet A.
Without Project Year Zero (S4a)
Simulation Water Velocity Results
for the 500-year Flood Event.

Legend

Water velocity (ft/sec)

0.05 to 2
2 to 4
4 to 6
6 to 8
8 to 10
10 to 12
12 to 14
14 to 16
16 to 18
> 18

⊗ River mile

—+— Railroad

⎓ Project area

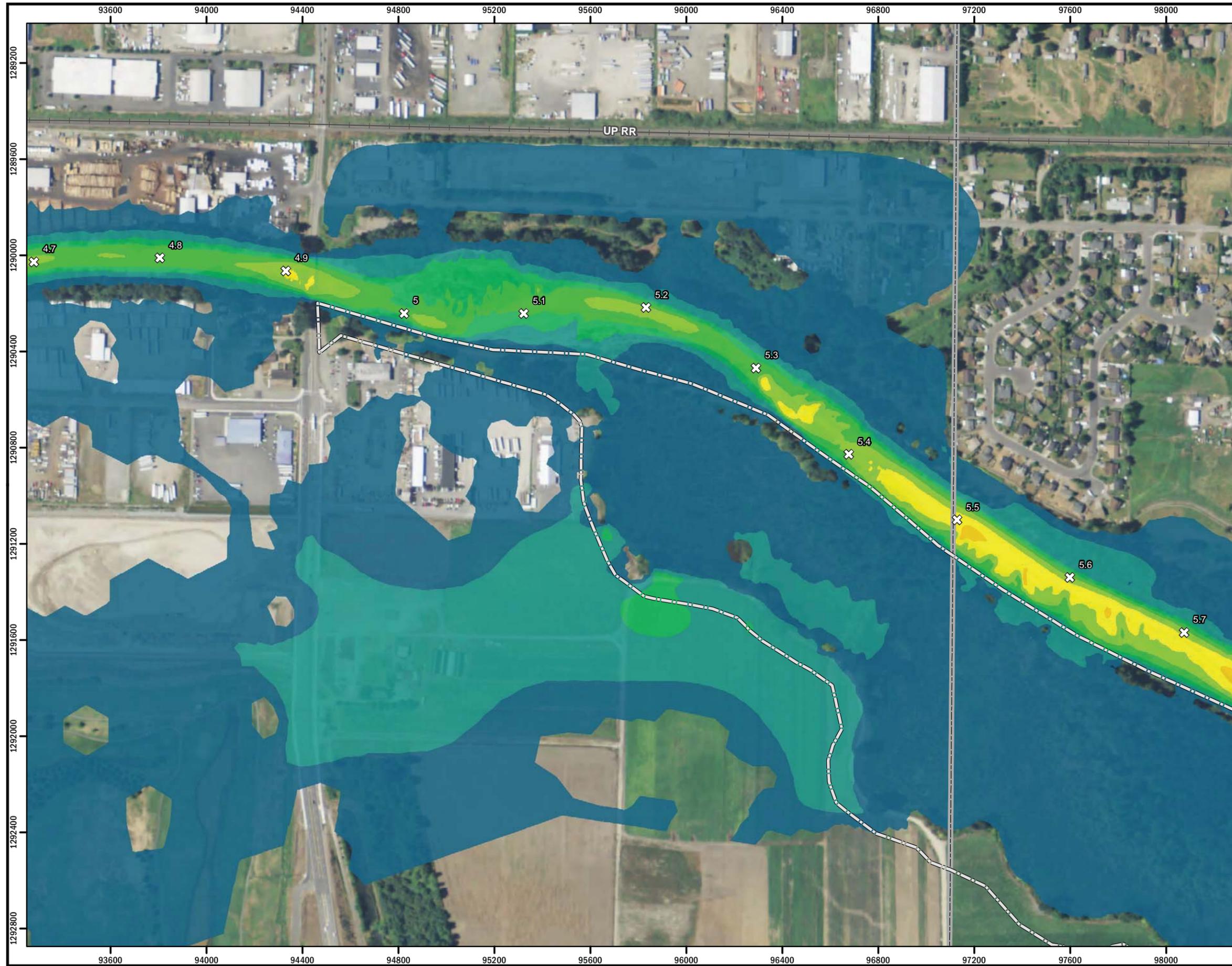
— County boundary

0 200 400 800
 Feet

King County
 Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\rechecked_delta_velocity_appendix_figures.mxd (6/13/2013)

Figure A-6. Sheet B.
Without Project Year Zero (S4a)
Simulation Water Velocity Results
for the 500-year Flood Event.



Legend

Water velocity (ft/sec)

	0.05 to 2
	2 to 4
	4 to 6
	6 to 8
	8 to 10
	10 to 12
	12 to 14
	14 to 16
	16 to 18
	> 18

River mile

Railroad

Project area

County boundary

0 200 400 800
 Feet

King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\130-04770-000\Project\HAM_Mapping_Figures\reckoned_delta_velocity_appendix_figures.mxd (6/13/2013)

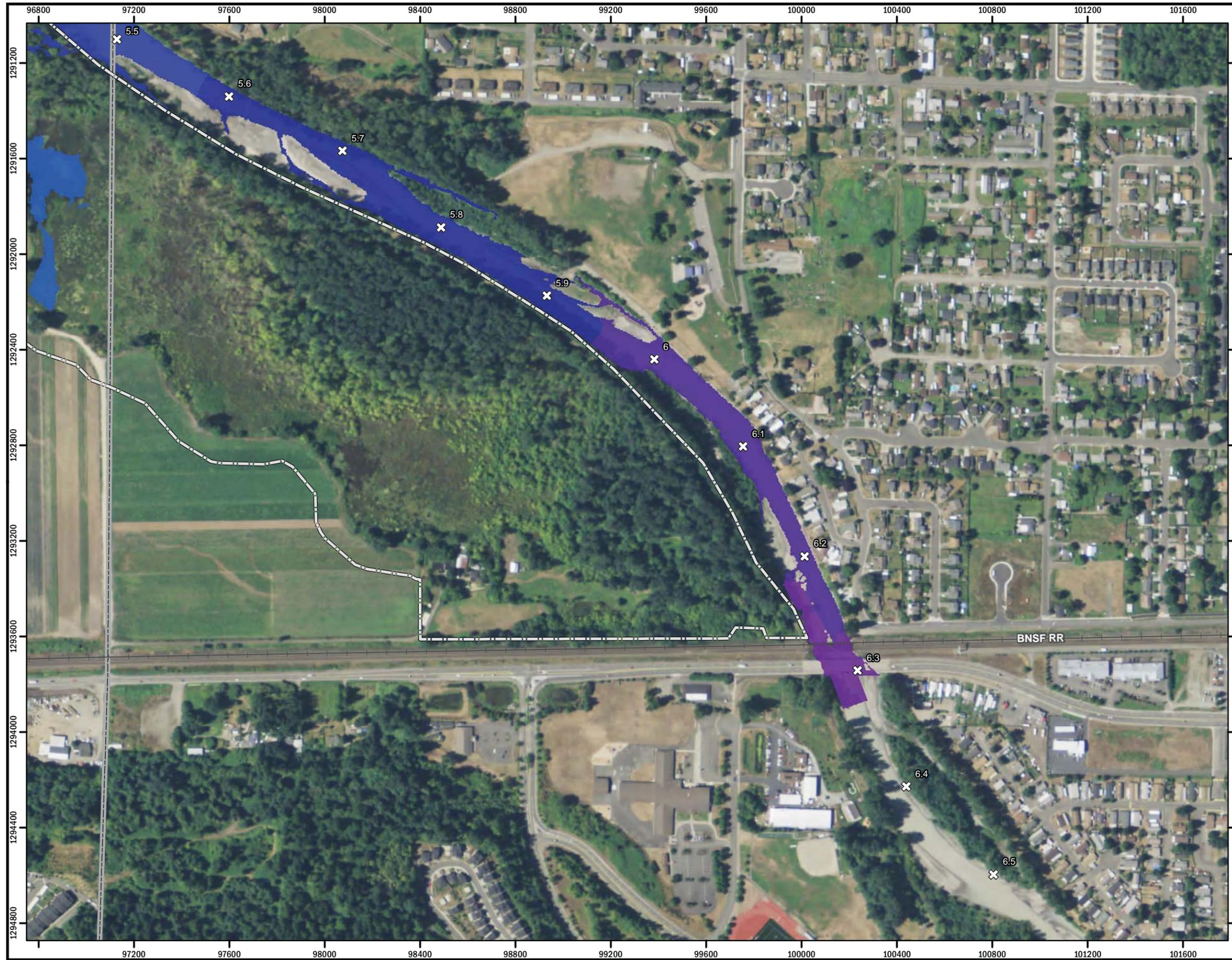


Figure A-7. Sheet A.
Without Project Year Zero (S4a)
Simulation Water Surface Elevation
Results for Mean Annual Flow.

Legend

Water surface elevation (feet)

- < 65
- 65 to 70
- 70 to 75
- 75 to 80
- 80 to 85
- 85 to 90
- 90 to 95
- > 95

- River mile
- Project area
- County boundary





0 200 400 800
Feet



King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HMA_Modeling_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

Figure A-7. Sheet B.
Without Project Year Zero (S4a)
Simulation Water Surface Elevation
Results for Mean Annual Flow.

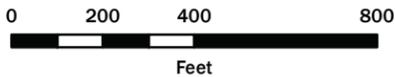


Legend

Water surface elevation (feet)

- < 65
- 65 to 70
- 70 to 75
- 75 to 80
- 80 to 85
- 85 to 90
- 90 to 95
- > 95

- River mile
- Project area
- County boundary



Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project: K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)



Figure A-8. Sheet A.
Without Project Year Zero (S4a)
Simulation Water Velocity Results
for Mean Annual Flow.

Legend

Water velocity (ft/sec)

0.05 to 2
2 to 4
4 to 6
6 to 8
8 to 10
10 to 12
12 to 14
14 to 16
16 to 18
> 18

⊗ River mile

—+— Railroad

⎓ Project area

— County boundary

0 200 400 800
 Feet

King County
 Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\rechecked_delta_velocity_appendix_figures.mxd (6/13/2013)



Figure A-8. Sheet B.
Without Project Year Zero (S4a)
Simulation Water Velocity Results
for Mean Annual Flow.

Legend

Water velocity (ft/sec)

Blue	0.05 to 2
Light Blue	2 to 4
Green	4 to 6
Light Green	6 to 8
Yellow-Green	8 to 10
Yellow	10 to 12
Orange-Yellow	12 to 14
Orange	14 to 16
Red-Orange	16 to 18
Red	> 18

⊗ River mile

—+— Railroad

⬡ Project area

— County boundary


 0 200 400 800
 Feet


 Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\rechecked_delta_velocity_appendix_figures.mxd (6/13/2013)



Figure A-9. Sheet A.
Without Project Short-Term (S4b)
Simulation Water Surface Elevation
Results for the 2-year Flood Event.

Legend

Water surface elevation (feet)

	< 65
	65 to 70
	70 to 75
	75 to 80
	80 to 85
	85 to 90
	90 to 95
	> 95

River mile

Project area

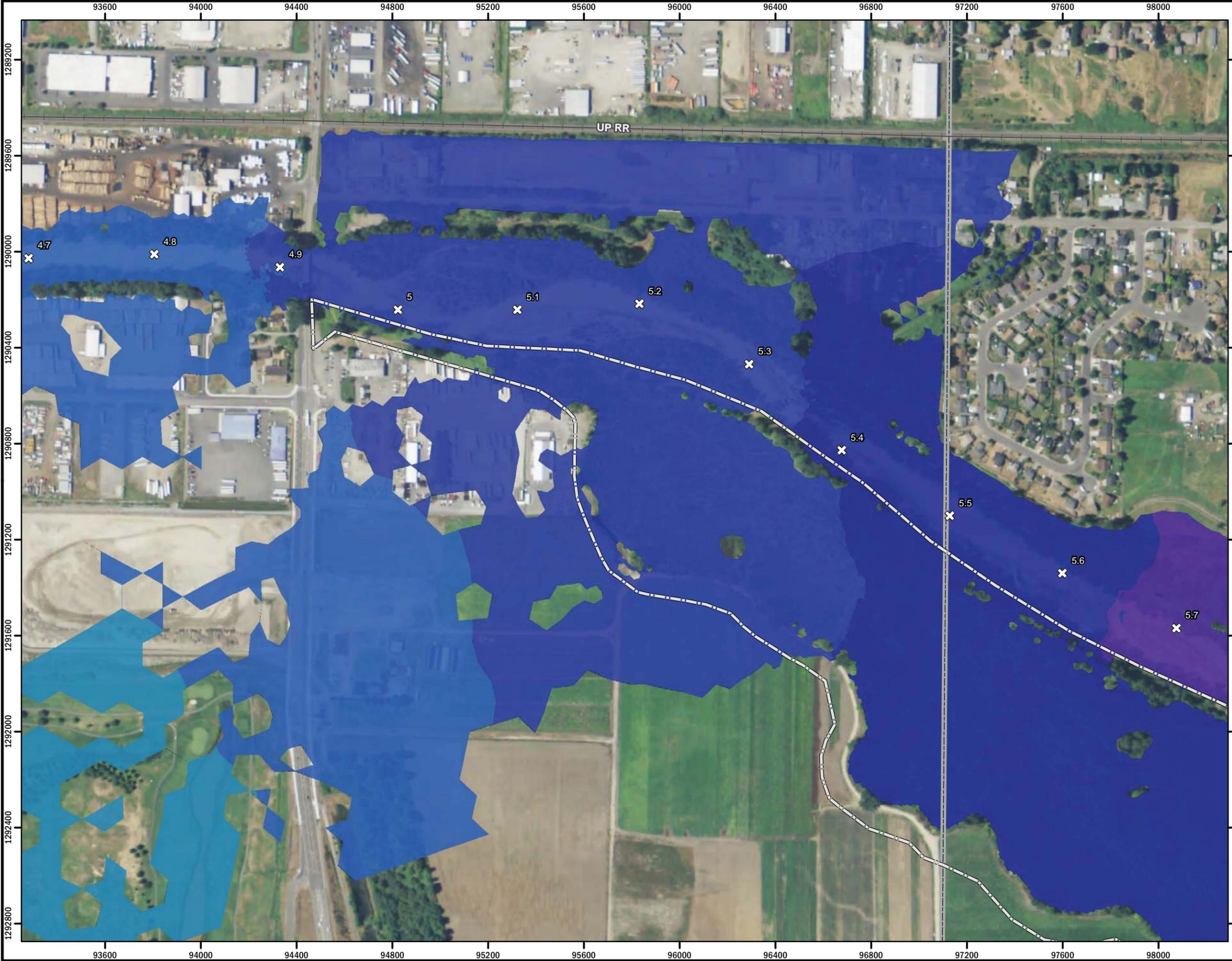
County boundary

0 200 400 800
 Feet

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

Figure A-9. Sheet B.
Without Project Short-Term (S4b)
Simulation Water Surface Elevation
Results for the 2-year Flood Event.

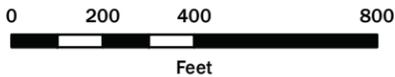


Legend

Water surface elevation (feet)

- < 65
- 65 to 70
- 70 to 75
- 75 to 80
- 80 to 85
- 85 to 90
- 90 to 95
- > 95

- River mile
- Project area
- County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project: K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

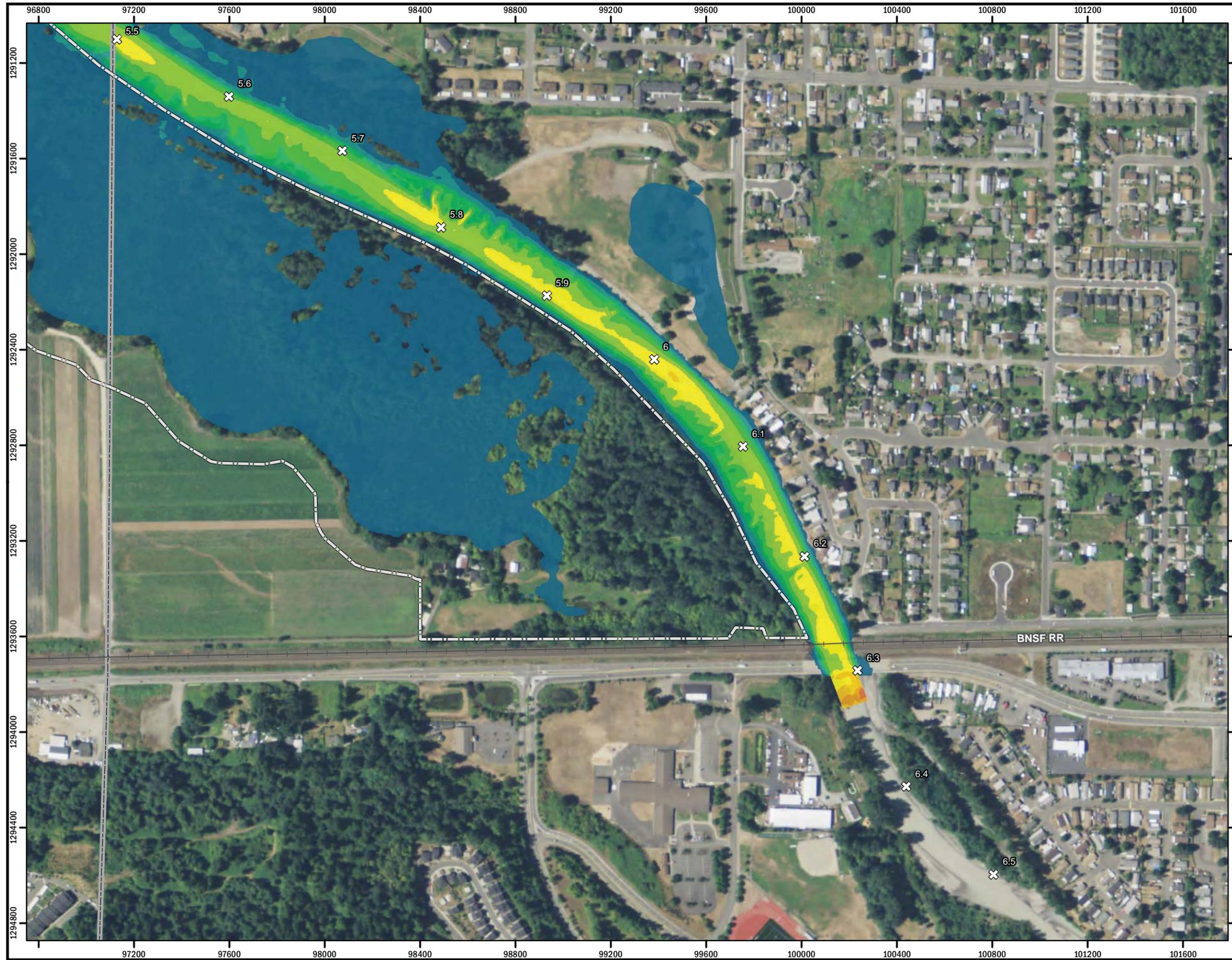


Figure A-10. Sheet A.
Without Project Short-Term (S4b)
Simulation Water Velocity Results
for the 2-year Flood Event.

Legend

Water velocity (ft/sec)

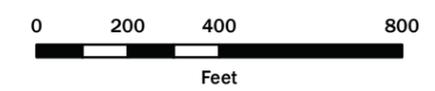
0.05 to 2
2 to 4
4 to 6
6 to 8
8 to 10
10 to 12
12 to 14
14 to 16
16 to 18
> 18

⊗ River mile

—+— Railroad

⊠ Project area

— County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\rechecked_delta_velocity_appendix_figures.mxd (6/13/2013)

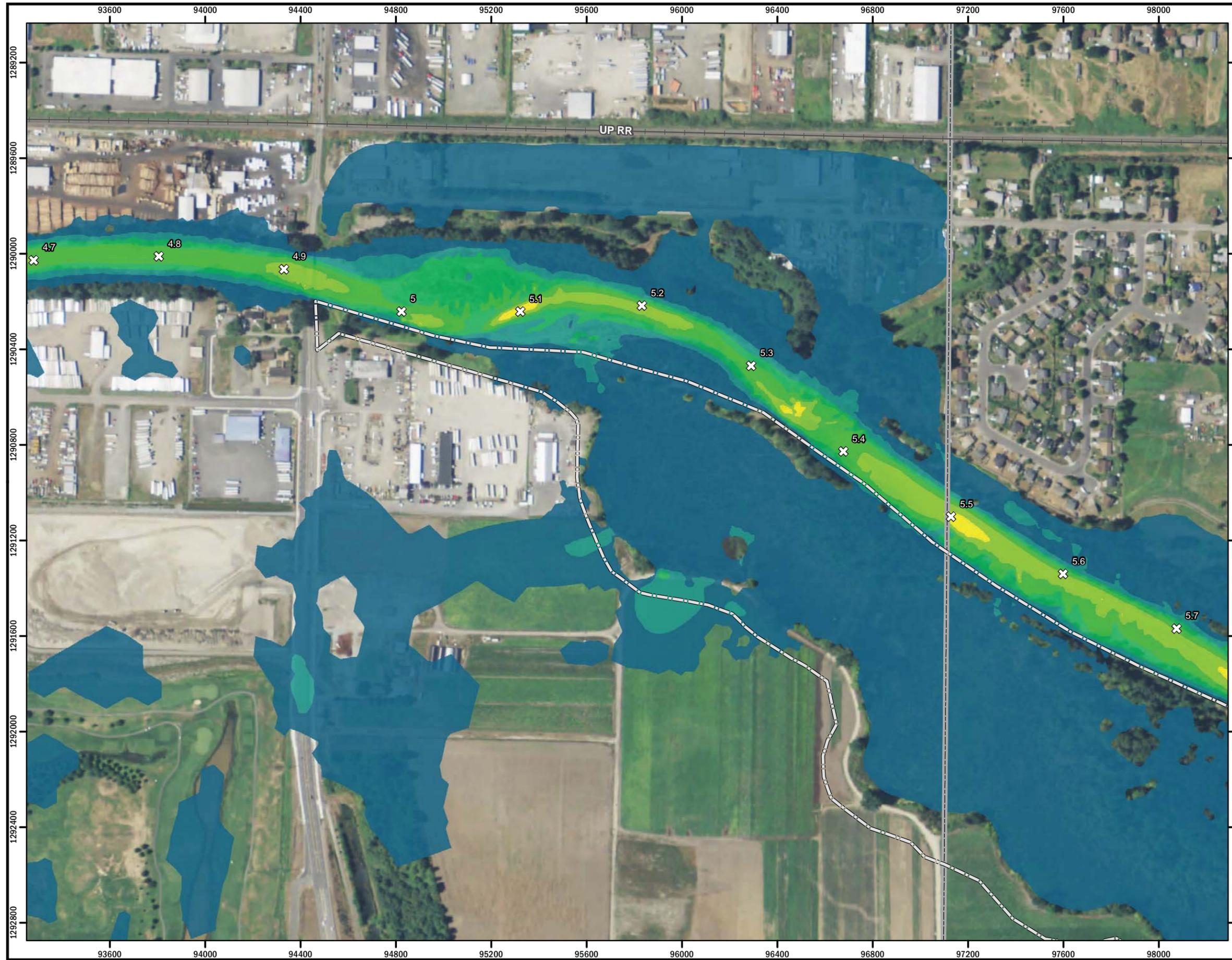


Figure A-10. Sheet B.
Without Project Short-Term (S4b)
Simulation Water Velocity Results
for the 2-year Flood Event.

Legend

Water velocity (ft/sec)

0.05 to 2
2 to 4
4 to 6
6 to 8
8 to 10
10 to 12
12 to 14
14 to 16
16 to 18
> 18

⊗ River mile

—+— Railroad

⎓ Project area

— County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\130-04770-000\Project\HAM_Mapping_Figures\reconned_delta_velocity_appendix_figures.mxd (6/13/2013)



Figure A-11. Sheet A.
Without Project Short-Term (S4b)
Simulation Water Surface Elevation
Results for the 100-year Flood Event.

Legend

Water surface elevation (feet)

- < 65
- 65 to 70
- 70 to 75
- 75 to 80
- 80 to 85
- 85 to 90
- 90 to 95
- > 95

River mile

Project area

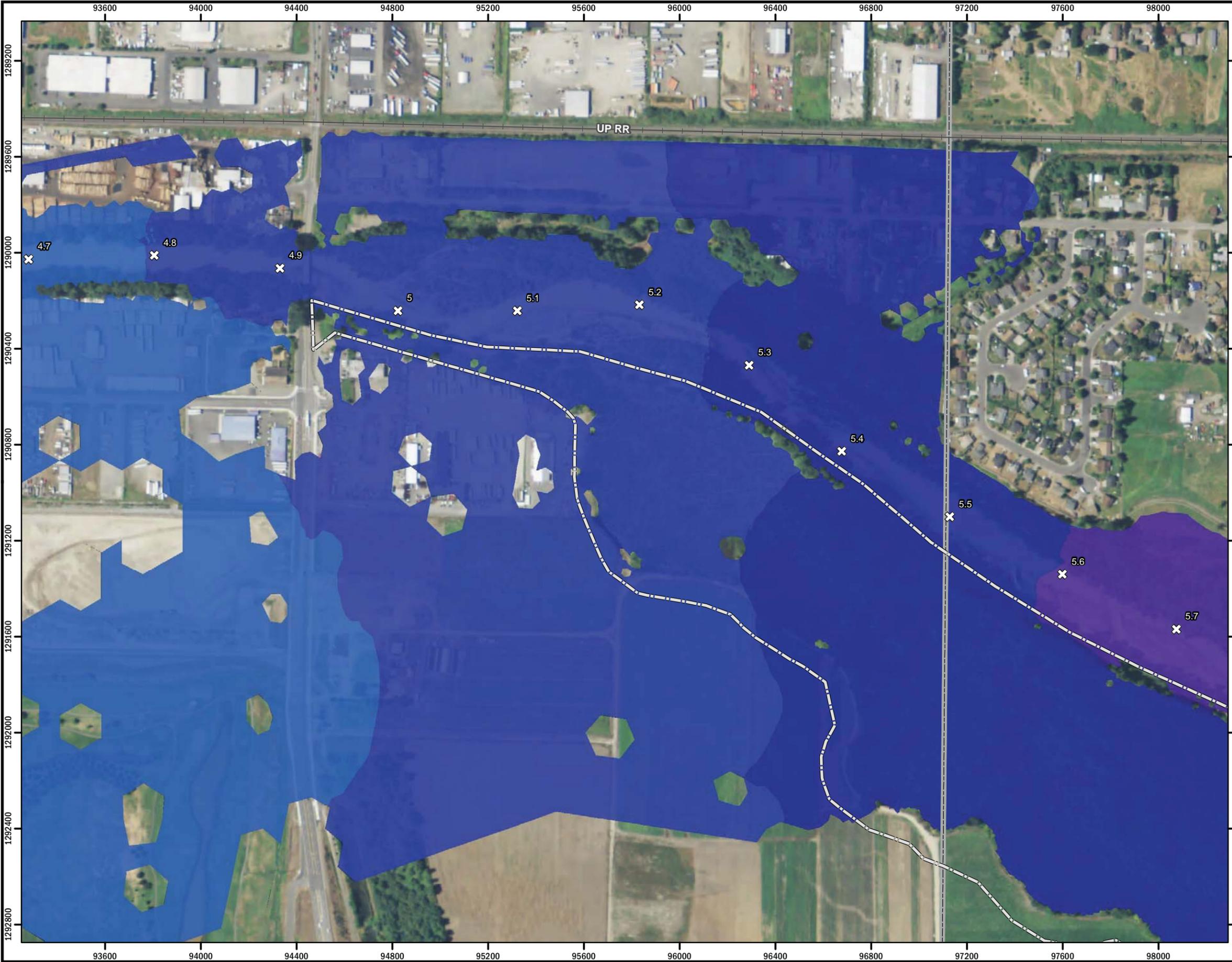
County boundary

0 200 400 800
 Feet

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HMA_Modeling_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

Figure A-11. Sheet B.
Without Project Short-Term (S4b)
Simulation Water Surface Elevation
Results for the 100-year Flood Event.

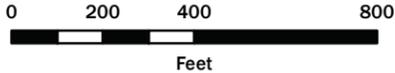


Legend

Water surface elevation (feet)

- < 65
- 65 to 70
- 70 to 75
- 75 to 80
- 80 to 85
- 85 to 90
- 90 to 95
- > 95

- River mile
- Project area
- County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

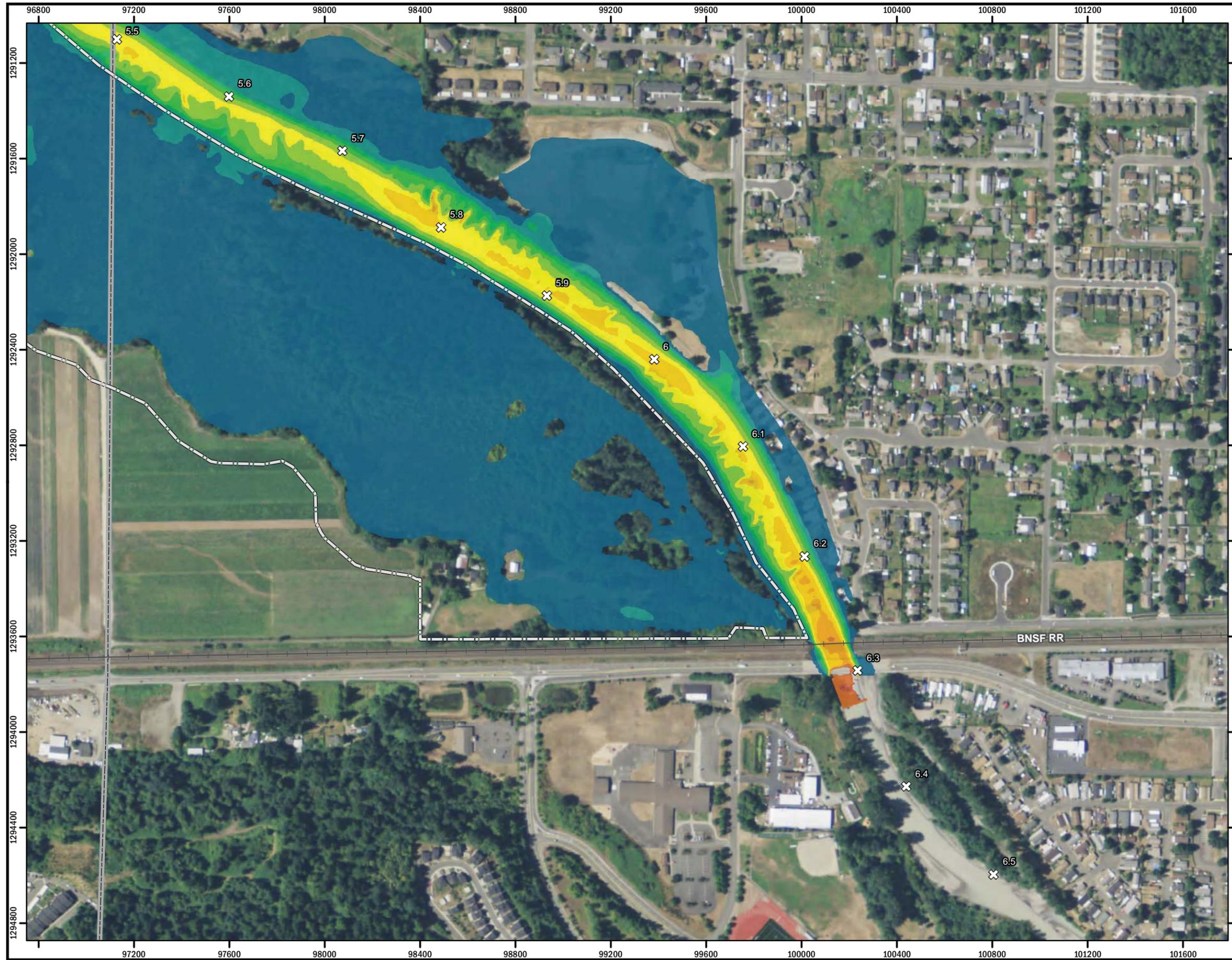


Figure A-12. Sheet A.
Without Project Short-Term (S4b)
Simulation Water Velocity Results
for the 100-year Flood Event.

Legend

Water velocity (ft/sec)

0.05 to 2
2 to 4
4 to 6
6 to 8
8 to 10
10 to 12
12 to 14
14 to 16
16 to 18
> 18

⊗ River mile

—+— Railroad

⎓ Project area

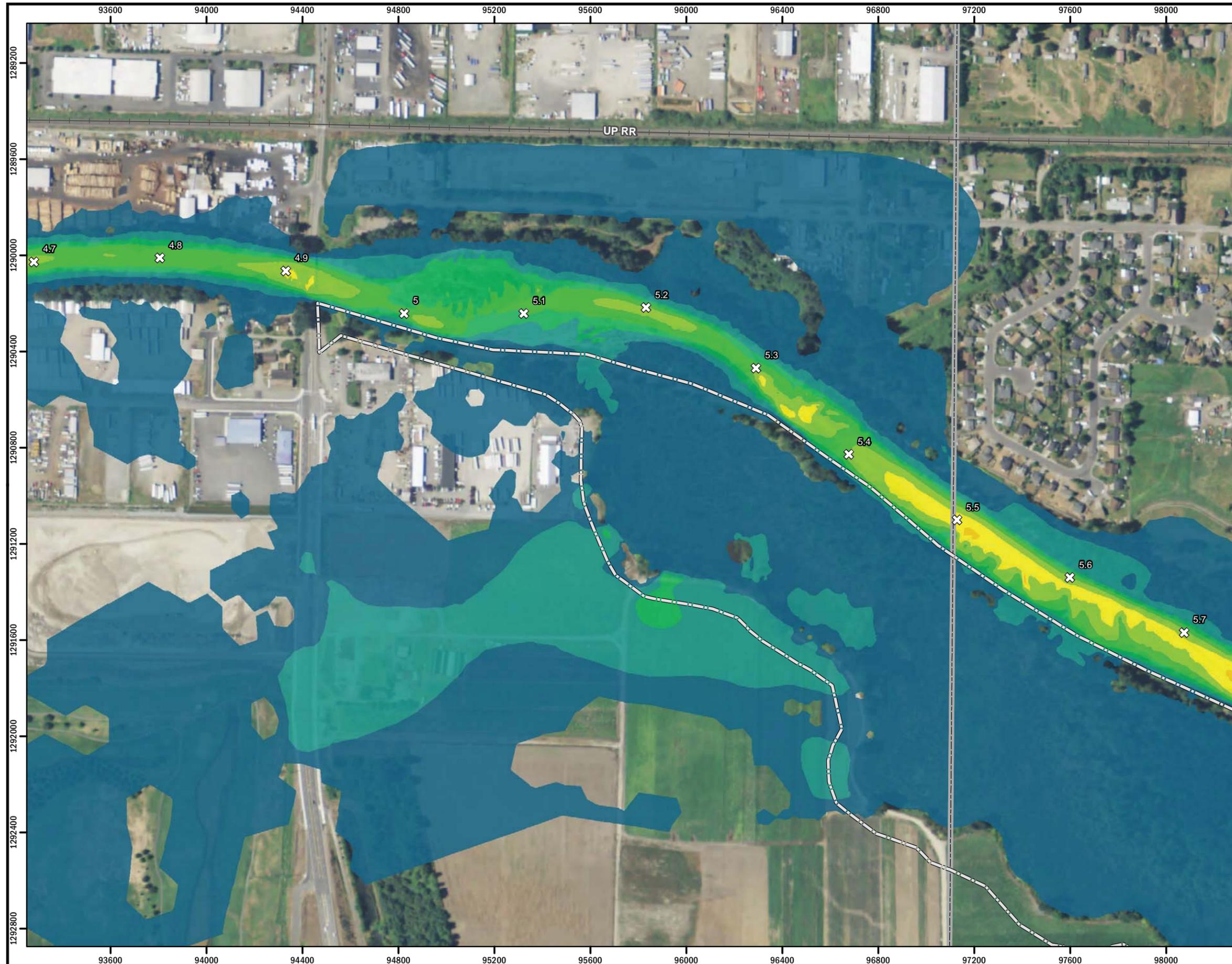
— County boundary


 0 200 400 800
 Feet


King County
 Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\rechecked_delta_velocity_appendix_figures.mxd (6/13/2013)

Figure A-12. Sheet B.
Without Project Short-Term (S4b)
Simulation Water Velocity Results
for the 100-year Flood Event.

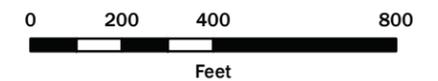


Legend

Water velocity (ft/sec)



- River mile
- Railroad
- Project area
- County boundary



Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project: K:\Projects\130-04770-000\Project\HAM_Mapping_Figures\rechecked_delta_velocity_appendix_figures.mxd (6/13/2013)

Figure A-13. Sheet A.
Without Project Short-Term (S4b)
Simulation Water Surface Elevation
Results for the 500-year Flood Event.



Legend

Water surface elevation (feet)

- < 65
- 65 to 70
- 70 to 75
- 75 to 80
- 80 to 85
- 85 to 90
- 90 to 95
- > 95

River mile

Project area

County boundary



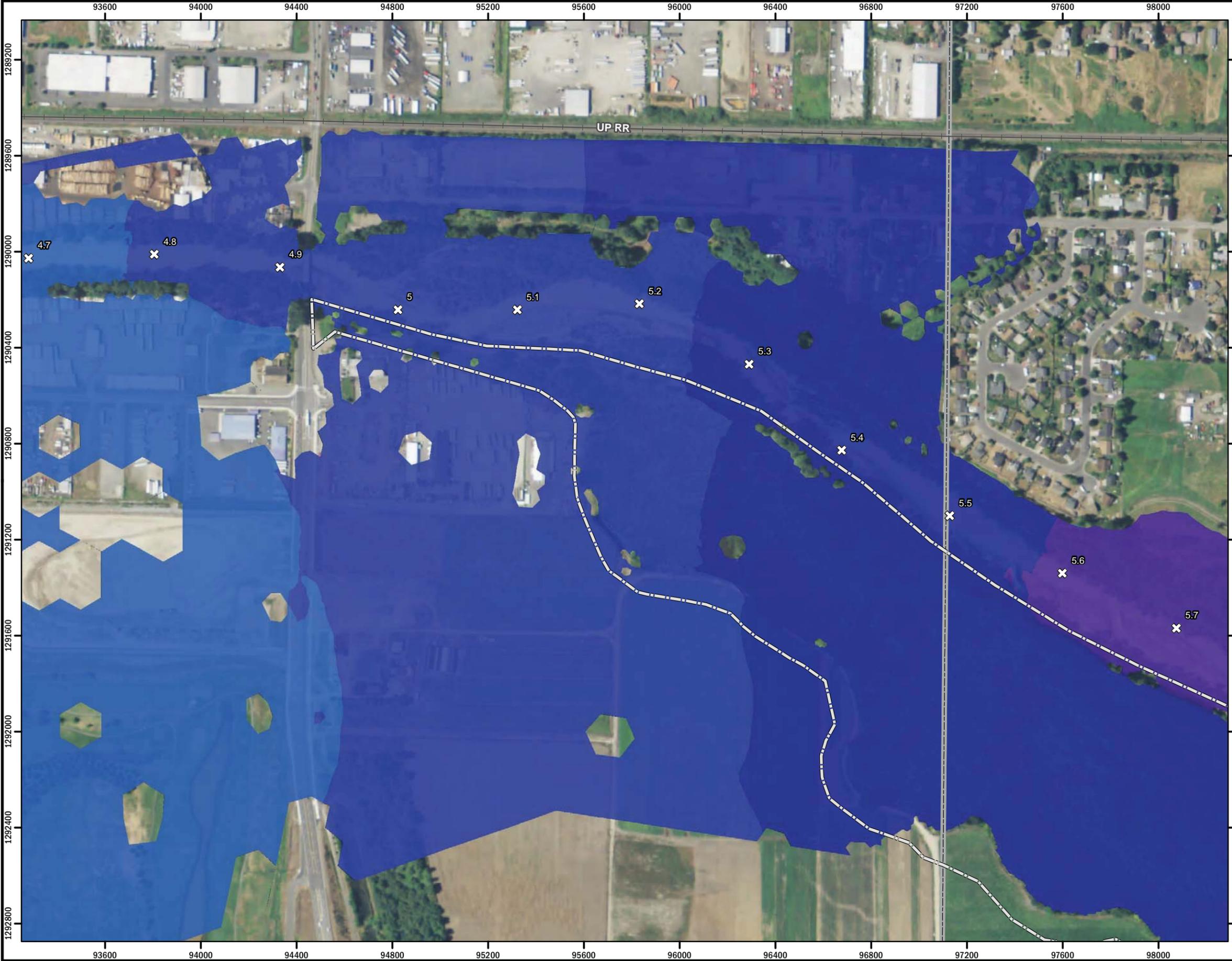
0 200 400 800
 Feet

 **King County**

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\130-04770-000\Project\HMA_Modelling_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

Figure A-13. Sheet B.
Without Project Short-Term (S4b)
Simulation Water Surface Elevation
Results for the 500-year Flood Event.

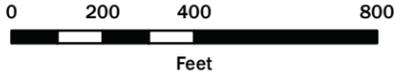


Legend

Water surface elevation (feet)

- < 65
- 65 to 70
- 70 to 75
- 75 to 80
- 80 to 85
- 85 to 90
- 90 to 95
- > 95

- River mile
- Project area
- County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project: K:\Projects\130-04770-000\Project\HAM_Mapping_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

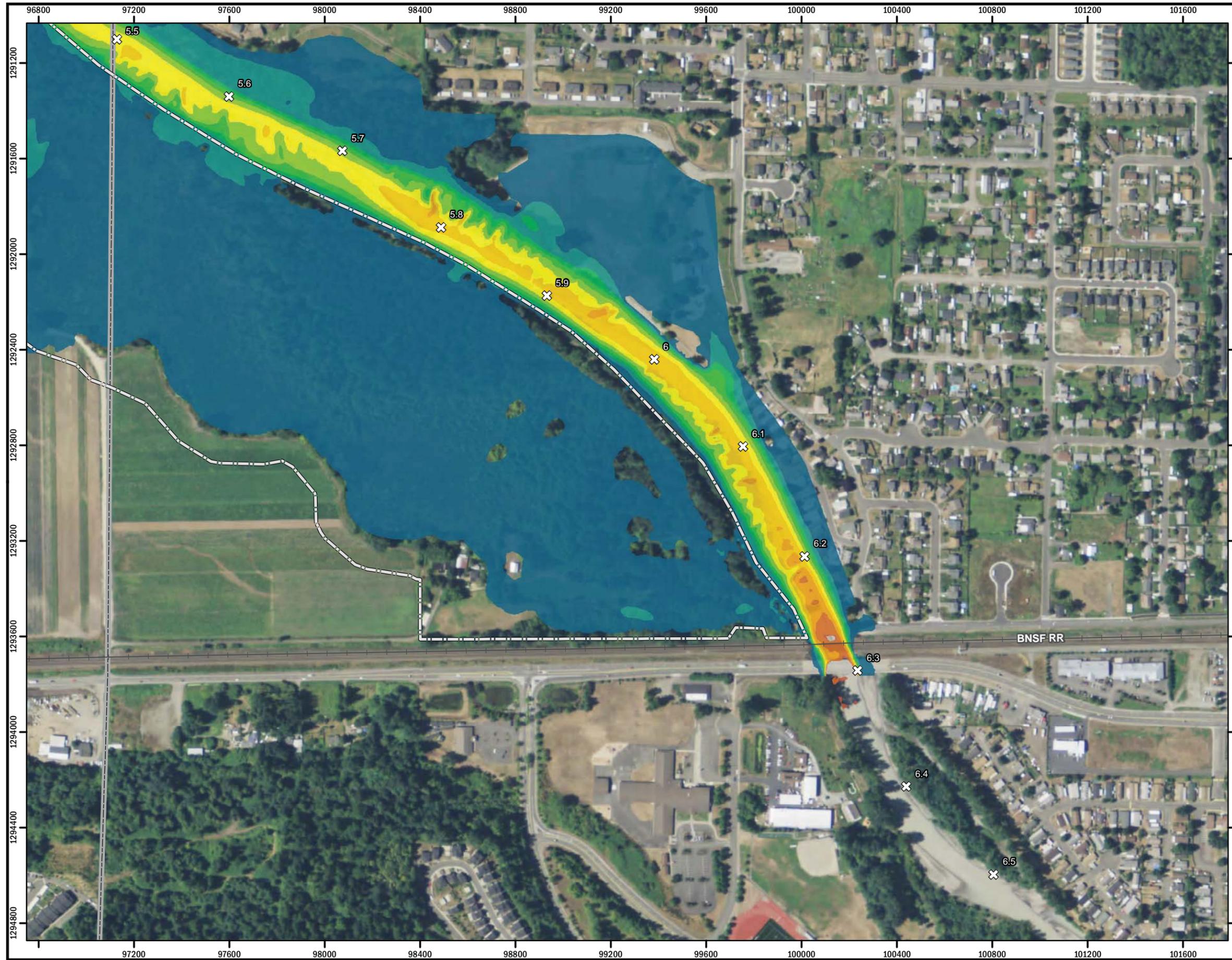


Figure A-14. Sheet A.
Without Project Short-Term (S4b)
Simulation Water Velocity Results
for the 500-year Flood Event.

Legend

Water velocity (ft/sec)

0.05 to 2
2 to 4
4 to 6
6 to 8
8 to 10
10 to 12
12 to 14
14 to 16
16 to 18
> 18

⊗ River mile

—+— Railroad

⊠ Project area

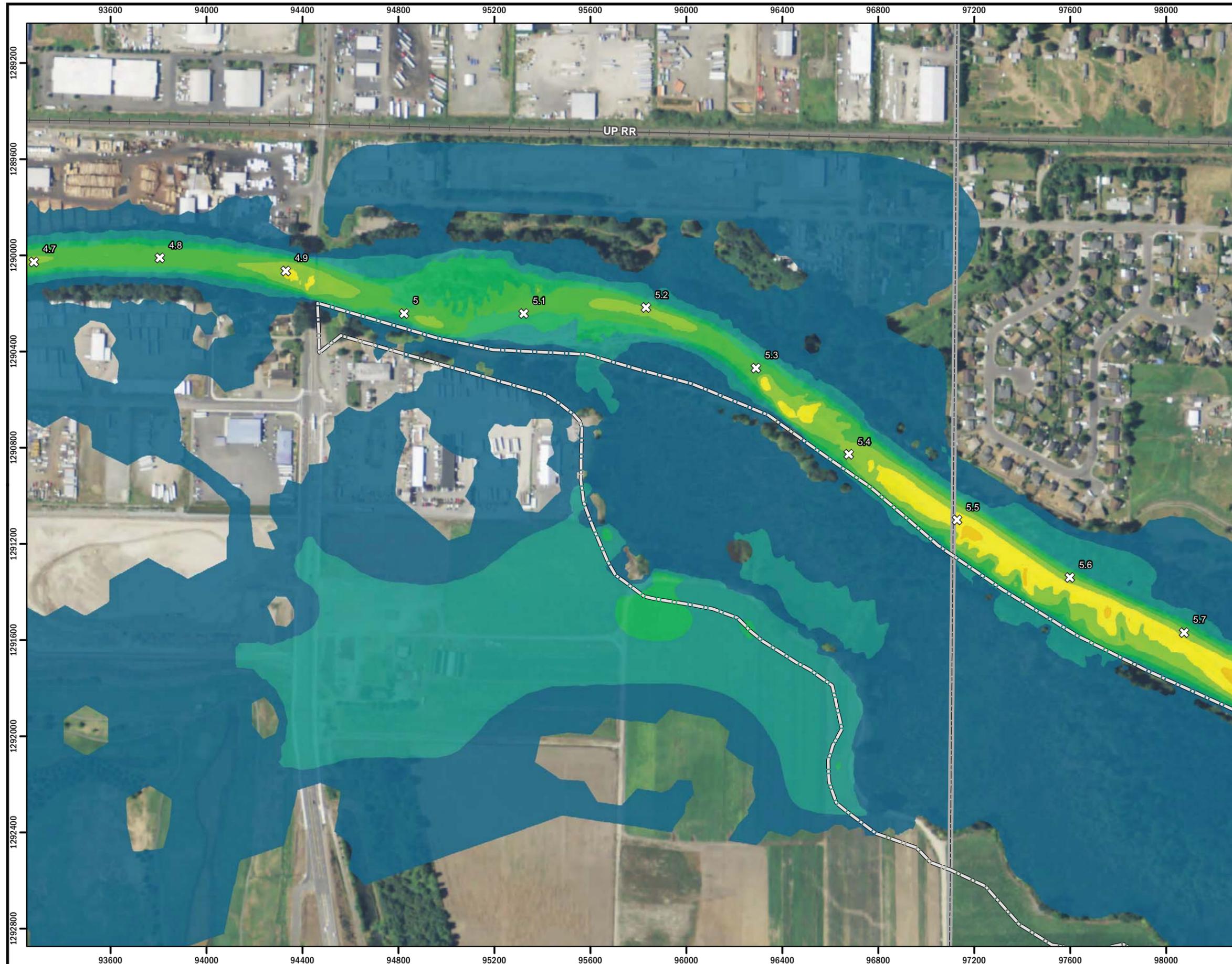
— County boundary

0 200 400 800
 Feet

King County
 Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\rechecked_delta_velocity_appendix_figures.mxd (6/13/2013)

Figure A-14. Sheet B.
Without Project Short-Term (S4b)
Simulation Water Velocity Results
for the 500-year Flood Event.

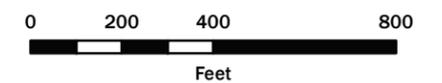


Legend

Water velocity (ft/sec)



- River mile
- Railroad
- Project area
- County boundary



Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project: K:\Projects\130-04770-000\Project\HAM_Mapping_Figures\rechecked_delta_in_velocity_appendix_figures.mxd (6/13/2013)

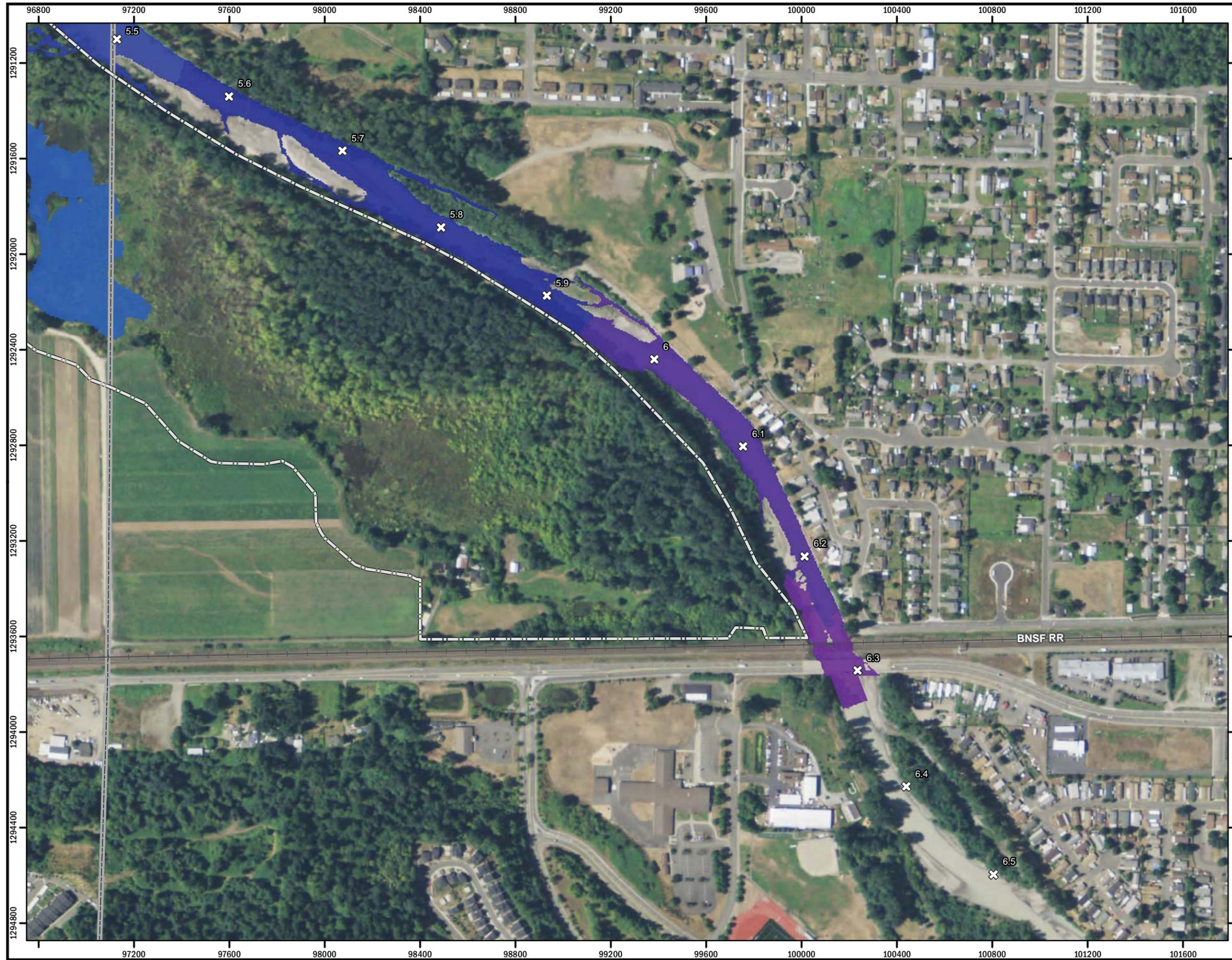


Figure A-15. Sheet A.
Without Project Short-Term (S4b)
Simulation Water Surface Elevation
Results for Mean Annual Flow.

Legend

Water surface elevation (feet)

	< 65
	65 to 70
	70 to 75
	75 to 80
	80 to 85
	85 to 90
	90 to 95
	> 95

River mile

Project area

County boundary

0 200 400 800
 Feet

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)



Figure A-15. Sheet B.
Without Project Short-Term (S4b)
Simulation Water Surface Elevation
Results for Mean Annual Flow.

Legend

Water surface elevation (feet)

	< 65
	65 to 70
	70 to 75
	75 to 80
	80 to 85
	85 to 90
	90 to 95
	> 95

River mile

Project area

County boundary

0 200 400 800
 Feet

King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project: K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)



Figure A-16. Sheet A.
Without Project Short-Term (S4b)
Simulation Water Velocity Results
for Mean Annual Flow.

Legend

Water velocity (ft/sec)

0.05 to 2
2 to 4
4 to 6
6 to 8
8 to 10
10 to 12
12 to 14
14 to 16
16 to 18
> 18

⊗ River mile

—+— Railroad

⎓ Project area

— County boundary



0 200 400 800
 Feet

 **King County**

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\reconned_delta_velocity_appendix_figures.mxd (6/13/2013)



Figure A-16. Sheet B.
Without Project Short-Term (S4b)
Simulation Water Velocity Results
for Mean Annual Flow.

Legend

Water velocity (ft/sec)

0.05 to 2
2 to 4
4 to 6
6 to 8
8 to 10
10 to 12
12 to 14
14 to 16
16 to 18
> 18

⊗ River mile

—+— Railroad

⬡ Project area

— County boundary

0 200 400 800
 Feet

King County
 Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\rechecked_delta_in_velocity_appendix_figures.mxd (6/13/2013)



Figure A-17. Sheet A.
Without Project Fully Evolved (S4c)
Simulation Water Surface Elevation
Results for the 2-year Flood Event.

Legend

Water surface elevation (feet)

	< 65
	65 to 70
	70 to 75
	75 to 80
	80 to 85
	85 to 90
	90 to 95
	> 95

River mile

Project area

County boundary

0 200 400 800
 Feet

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

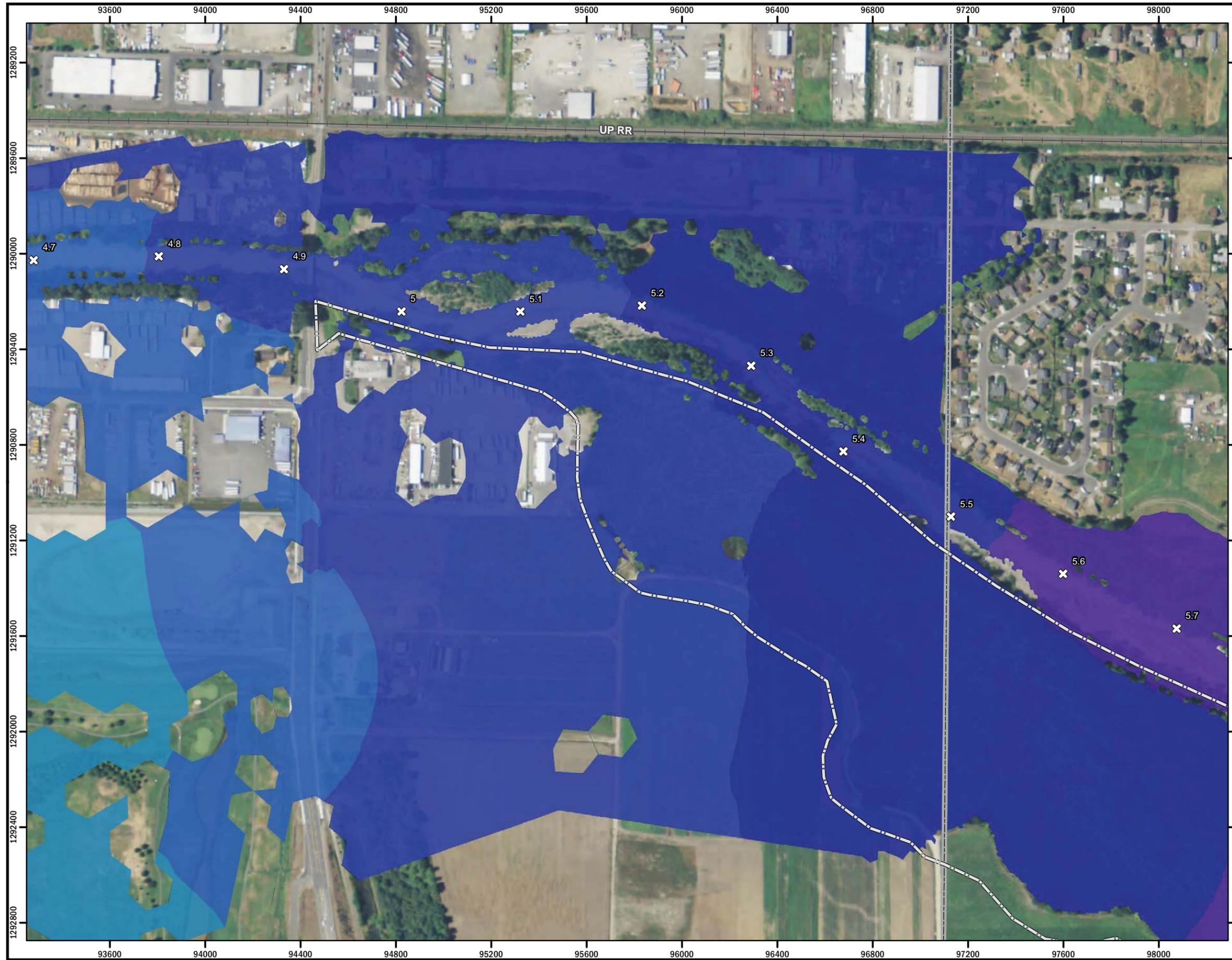


Figure A-17. Sheet B.
Without Project Fully Evolved (S4c)
Simulation Water Surface Elevation
Results for the 2-year Flood Event.

Legend

Water surface elevation (feet)

	< 65
	65 to 70
	70 to 75
	75 to 80
	80 to 85
	85 to 90
	90 to 95
	> 95

River mile

Project area

County boundary

0 200 400 800
 Feet

King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project: K:\Projects\130-04770-000\Project\HAM_Mapping_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

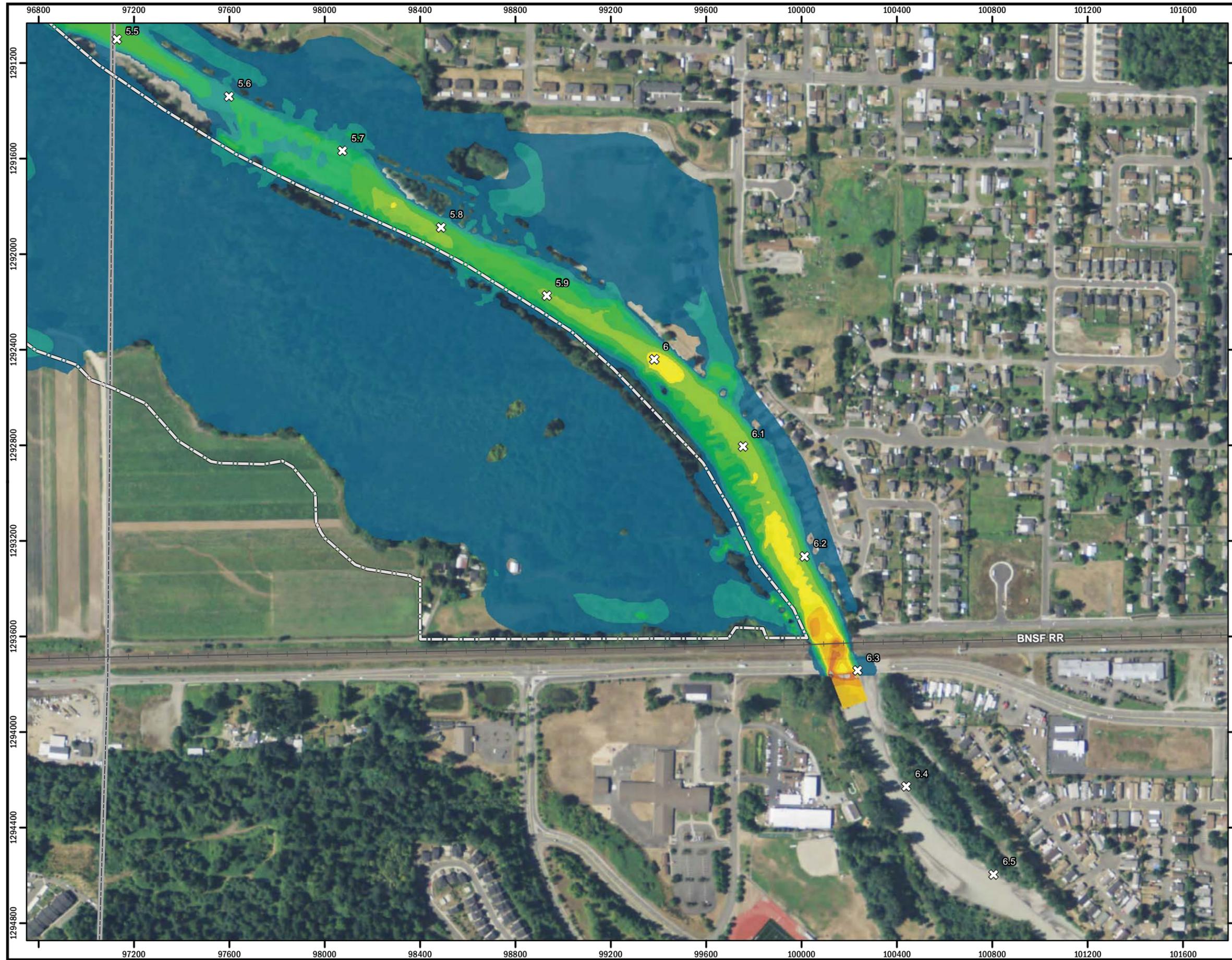


Figure A-18. Sheet A.
Without Project Fully Evolved (S4c)
Simulation Water Velocity Results
for the 2-year Flood Event.

Legend

Water velocity (ft/sec)

0.05 to 2
2 to 4
4 to 6
6 to 8
8 to 10
10 to 12
12 to 14
14 to 16
16 to 18
> 18

⊗ River mile

—+— Railroad

⎓ Project area

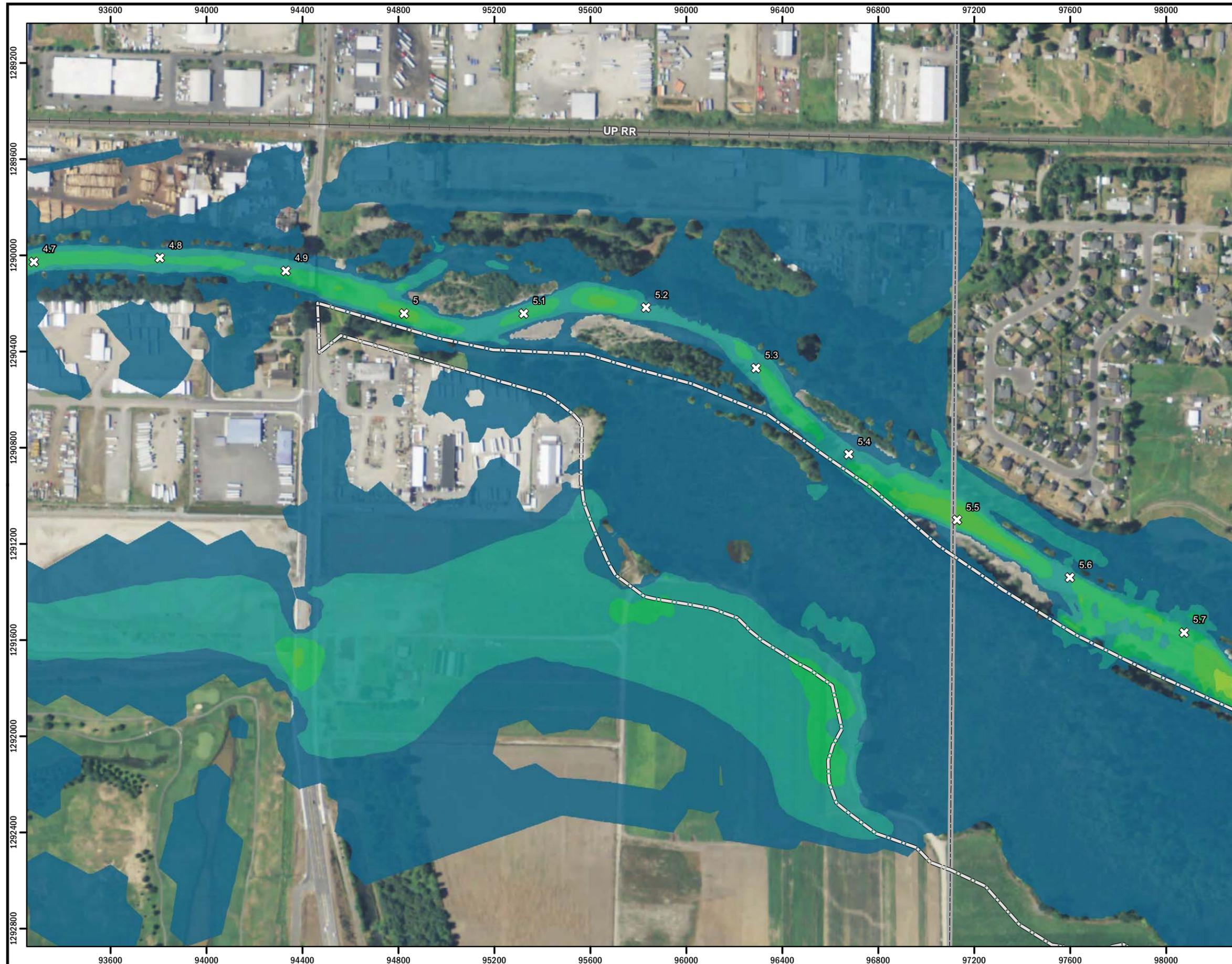
— County boundary

0 200 400 800
 Feet

King County
 Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

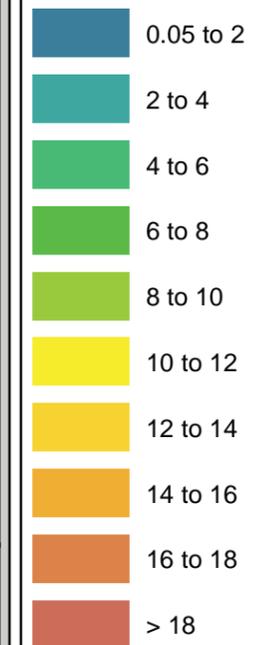
Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\reworked_delta_velocity_appendix_figures.mxd (6/13/2013)

Figure A-18. Sheet B.
Without Project Fully Evolved (S4c)
Simulation Water Velocity Results
for the 2-year Flood Event.

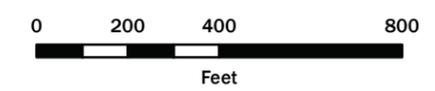


Legend

Water velocity (ft/sec)



- River mile
- Railroad
- Project area
- County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\reconned_delta_velocity_appendix_figures.mxd (6/13/2013)

Figure A-19. Sheet A.
Without Project Fully Evolved (S4c)
Simulation Water Surface Elevation
Results for the 100-year Flood Event.



Legend

Water surface elevation (feet)

- < 65
- 65 to 70
- 70 to 75
- 75 to 80
- 80 to 85
- 85 to 90
- 90 to 95
- > 95

River mile

Project area

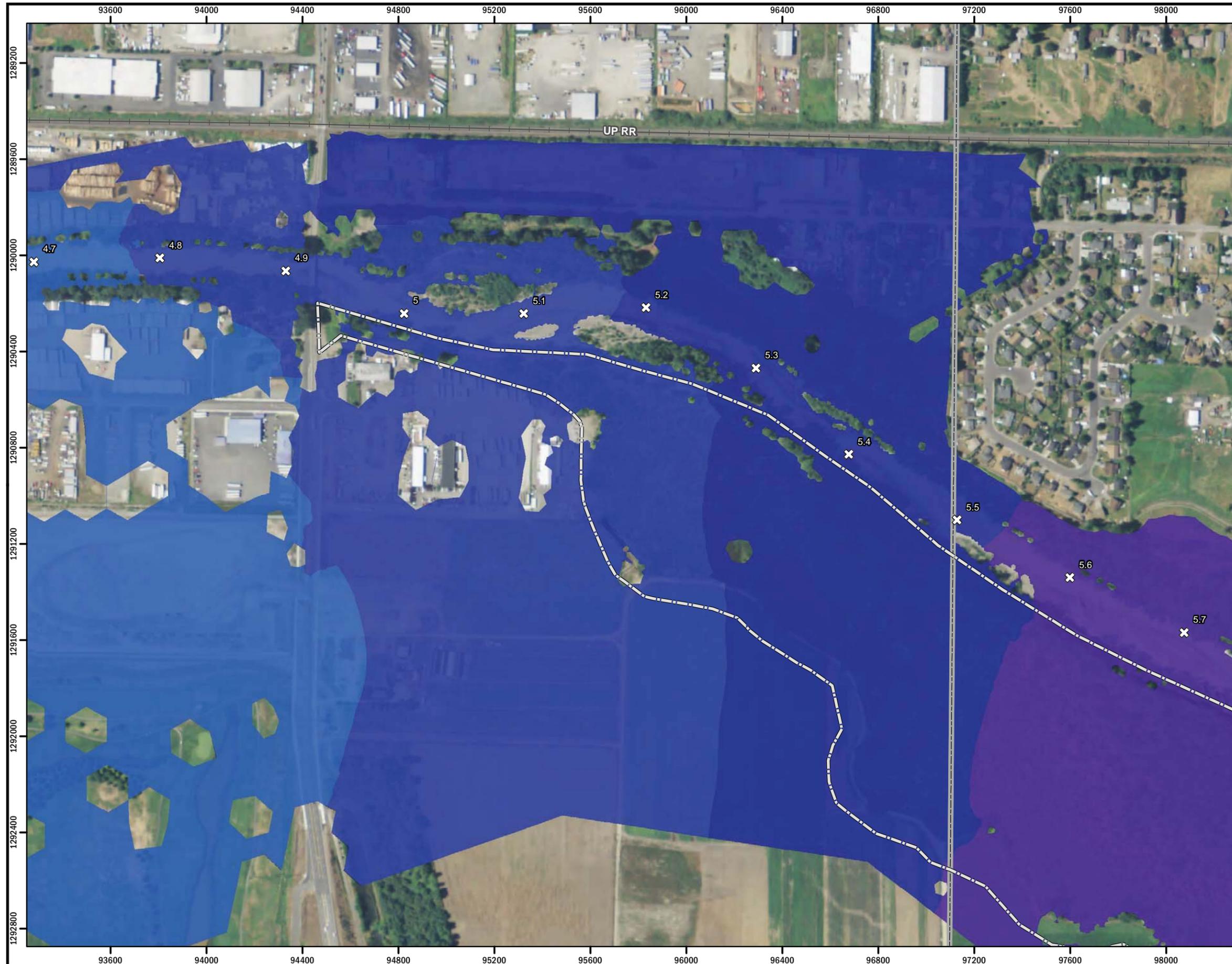
County boundary

0 200 400 800
 Feet

King County
 Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\recloned_domain_WSE_appendix_figures.mxd (6/13/2013)

Figure A-19. Sheet B.
Without Project Fully Evolved (S4c)
Simulation Water Surface Elevation
Results for the 100-year Flood Event.



Legend

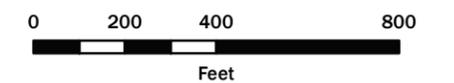
Water surface elevation (feet)

-  < 65
-  65 to 70
-  70 to 75
-  75 to 80
-  80 to 85
-  85 to 90
-  90 to 95
-  > 95

 River mile

 Project area

 County boundary



Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

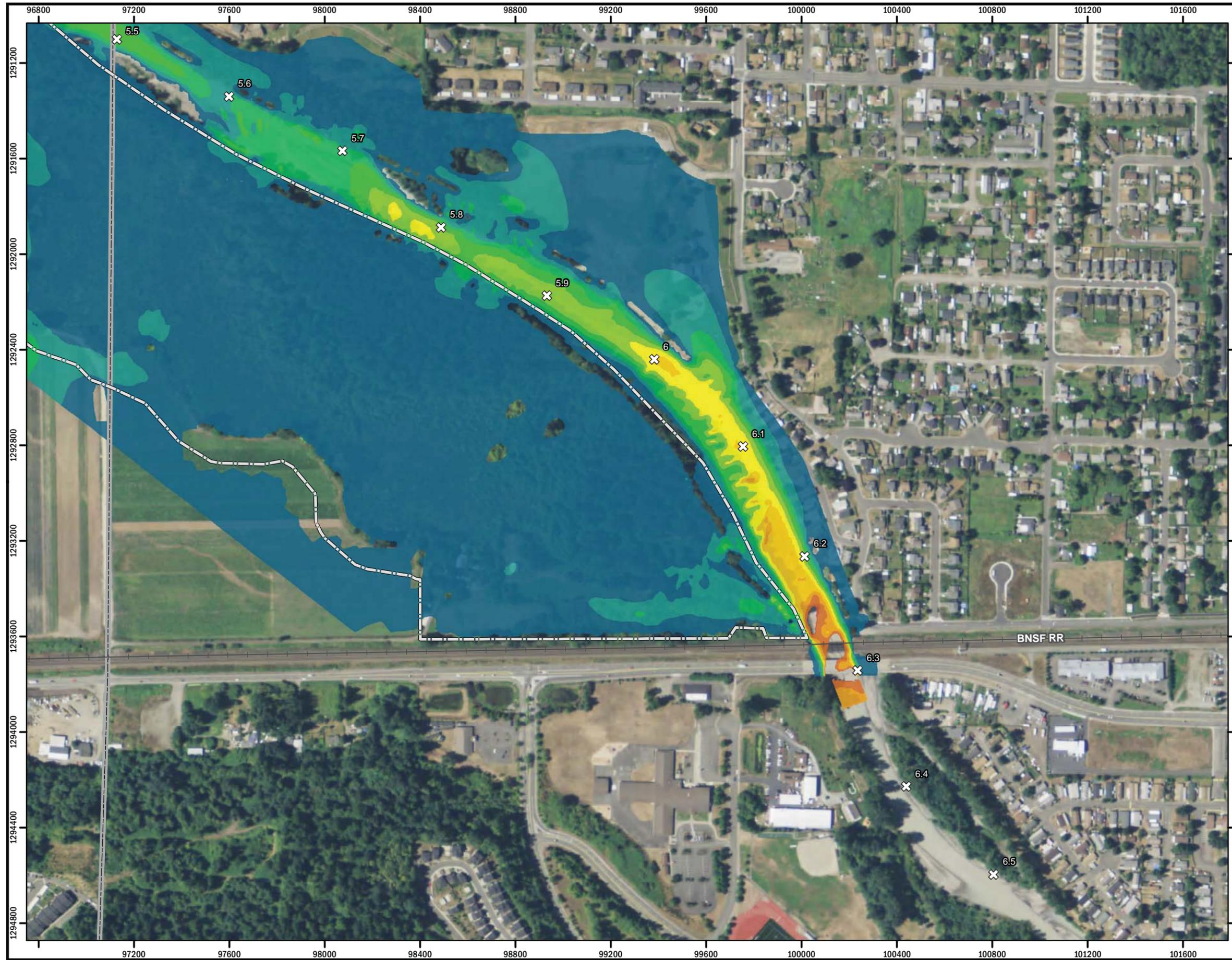


Figure A-20. Sheet A.
Without Project Fully Evolved (S4c)
Simulation Water Velocity Results
for the 100-year Flood Event.

Legend

Water velocity (ft/sec)

	0.05 to 2
	2 to 4
	4 to 6
	6 to 8
	8 to 10
	10 to 12
	12 to 14
	14 to 16
	16 to 18
	> 18

River mile

Railroad

Project area

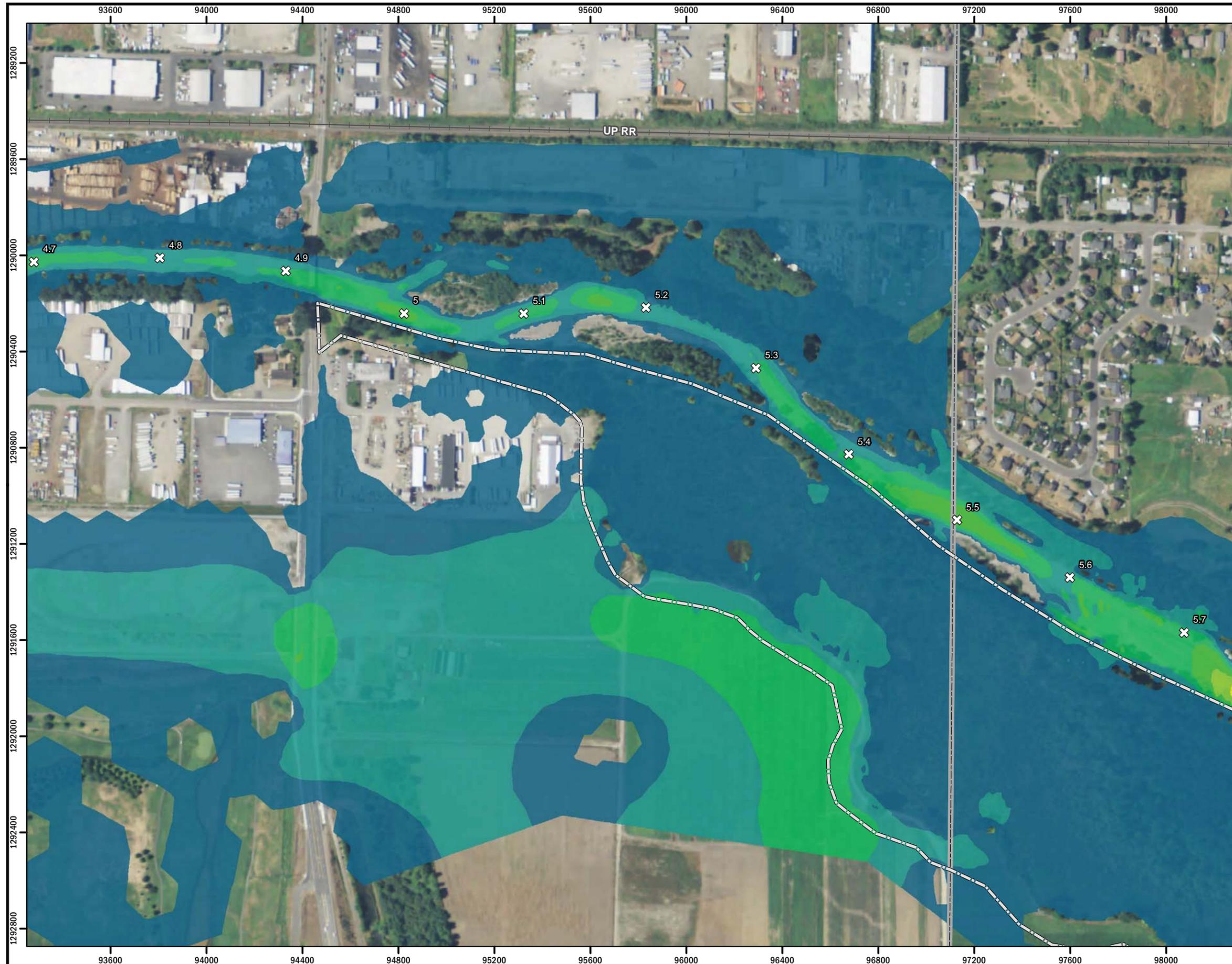
County boundary

0 200 400 800
 Feet

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

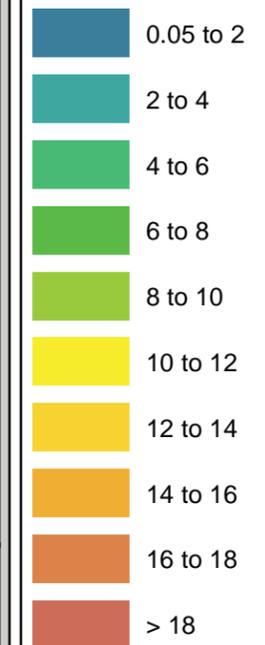
Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\rechecked_delta_to_velocity_appendix_figures.mxd (6/13/2013)

Figure A-20. Sheet B.
 Without Project Fully Evolved (S4c)
 Simulation Water Velocity Results
 for the 100-year Flood Event.

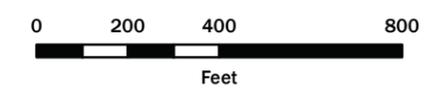


Legend

Water velocity (ft/sec)



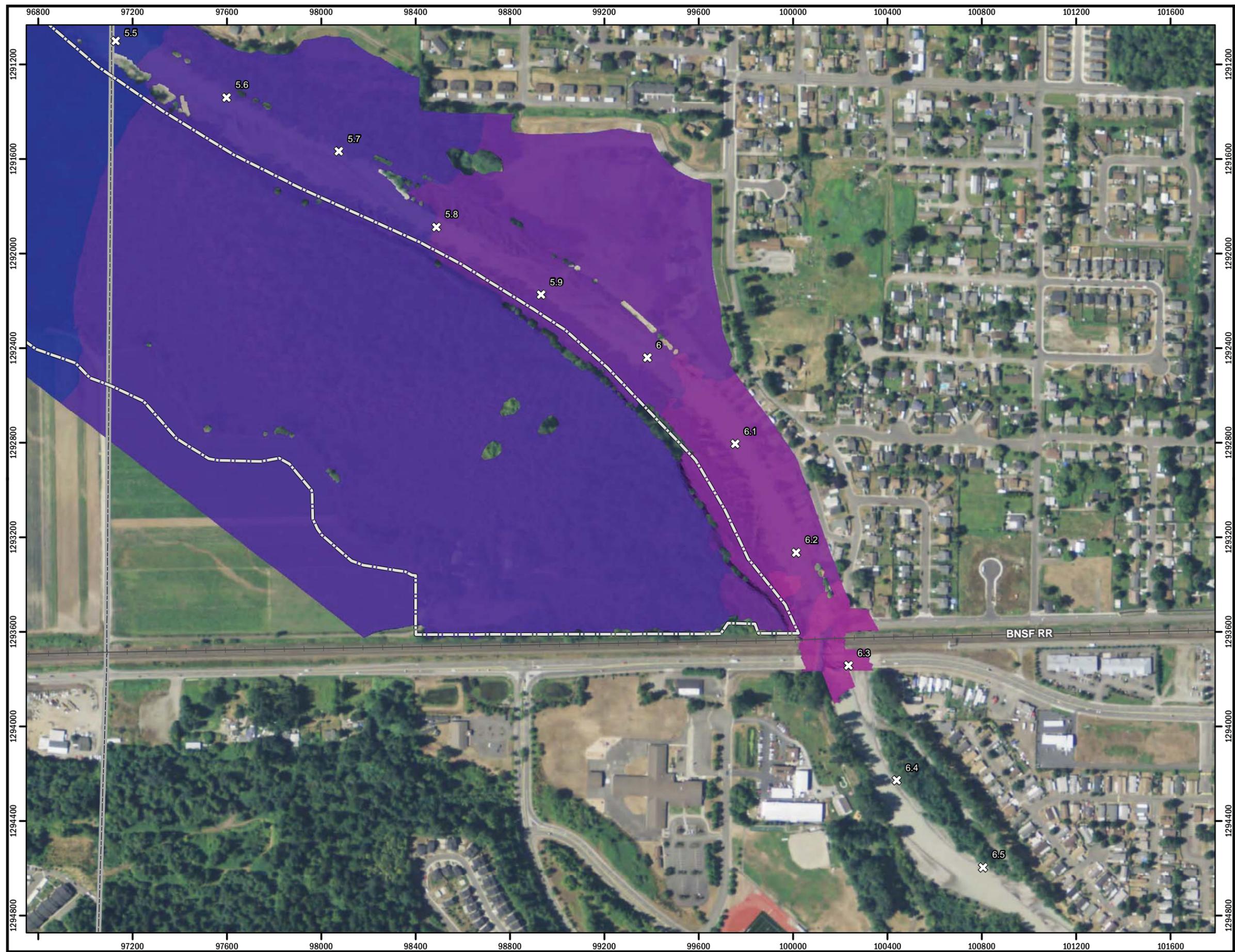
- River mile
- Railroad
- Project area
- County boundary



Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\130-04770-000\Project\HAM_Mapping_Figures\rechecked_delta_velocity_appendix_figures.mxd (6/13/2013)

Figure A-21. Sheet A.
Without Project Fully Evolved (S4c)
Simulation Water Surface Elevation
Results for the 500-year Flood Event.



Legend

Water surface elevation (feet)

- < 65
- 65 to 70
- 70 to 75
- 75 to 80
- 80 to 85
- 85 to 90
- 90 to 95
- > 95

- River mile
- Project area
- County boundary





0 200 400 800
Feet

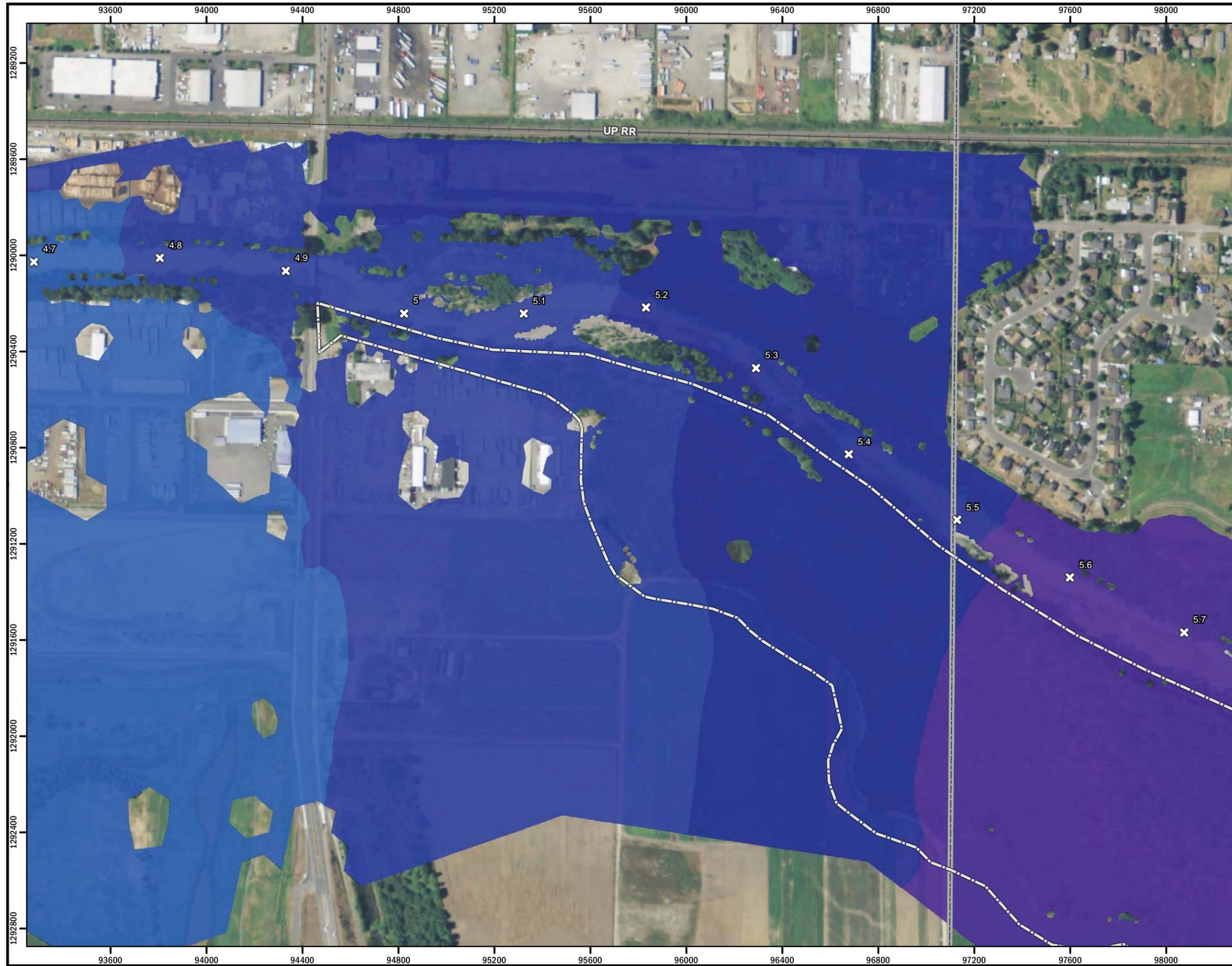


King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\recloned_domain_WSE_appendix_figures.mxd (6/13/2013)

Figure A-21. Sheet B.
Without Project Fully Evolved (S4c)
Simulation Water Surface Elevation
Results for the 500-year Flood Event.



Legend

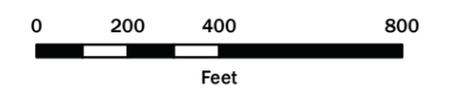
Water surface elevation (feet)

- < 65
- 65 to 70
- 70 to 75
- 75 to 80
- 80 to 85
- 85 to 90
- 90 to 95
- > 95

River mile

Project area

County boundary



Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project K:\Projects\130-04770-000\Project\HAM_Mapping_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

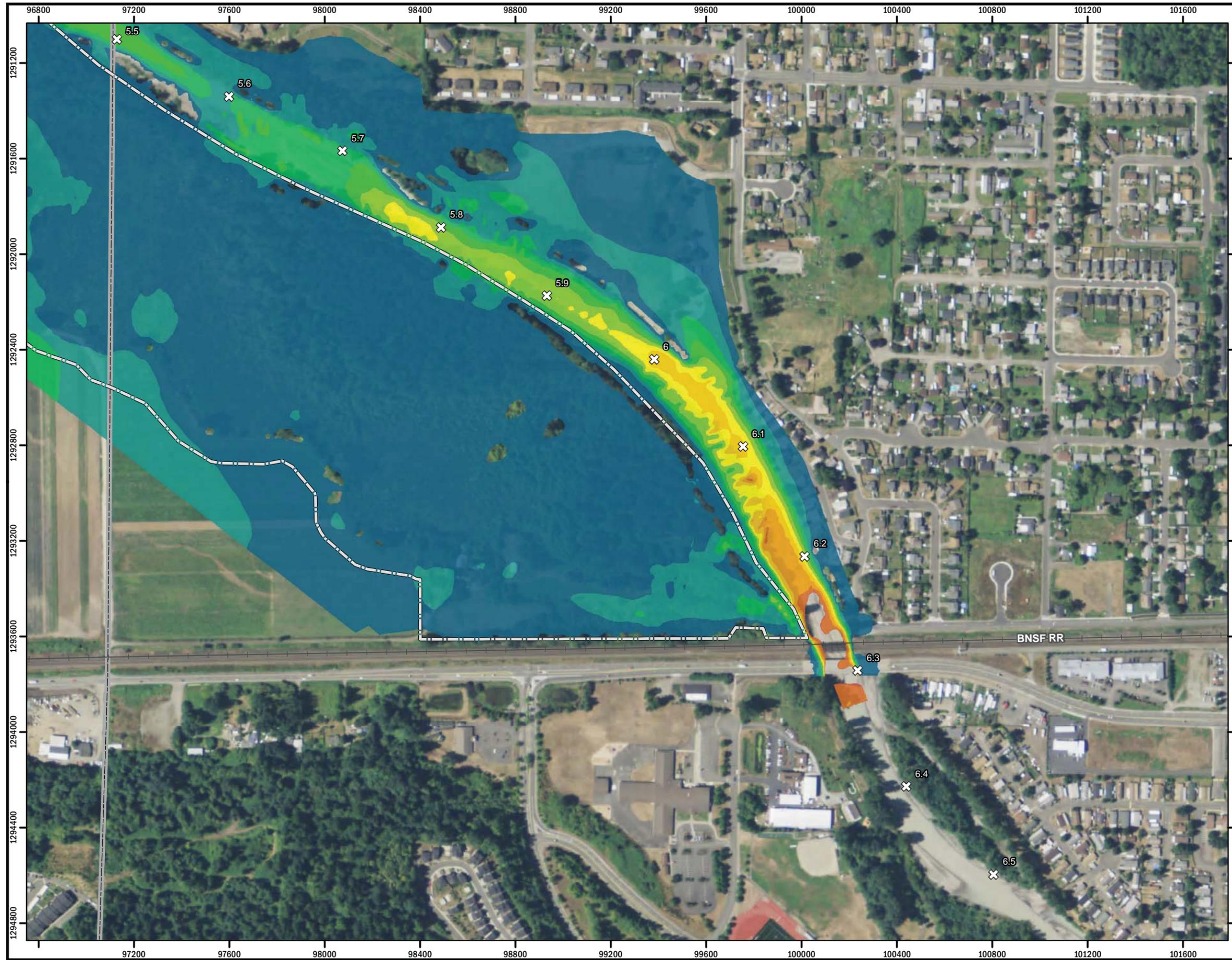


Figure A-22. Sheet A.
Without Project Fully Evolved (S4c)
Simulation Water Velocity Results
for the 500-year Flood Event.

Legend

Water velocity (ft/sec)

0.05 to 2
2 to 4
4 to 6
6 to 8
8 to 10
10 to 12
12 to 14
14 to 16
16 to 18
> 18

⊗ River mile

—+— Railroad

⎓ Project area

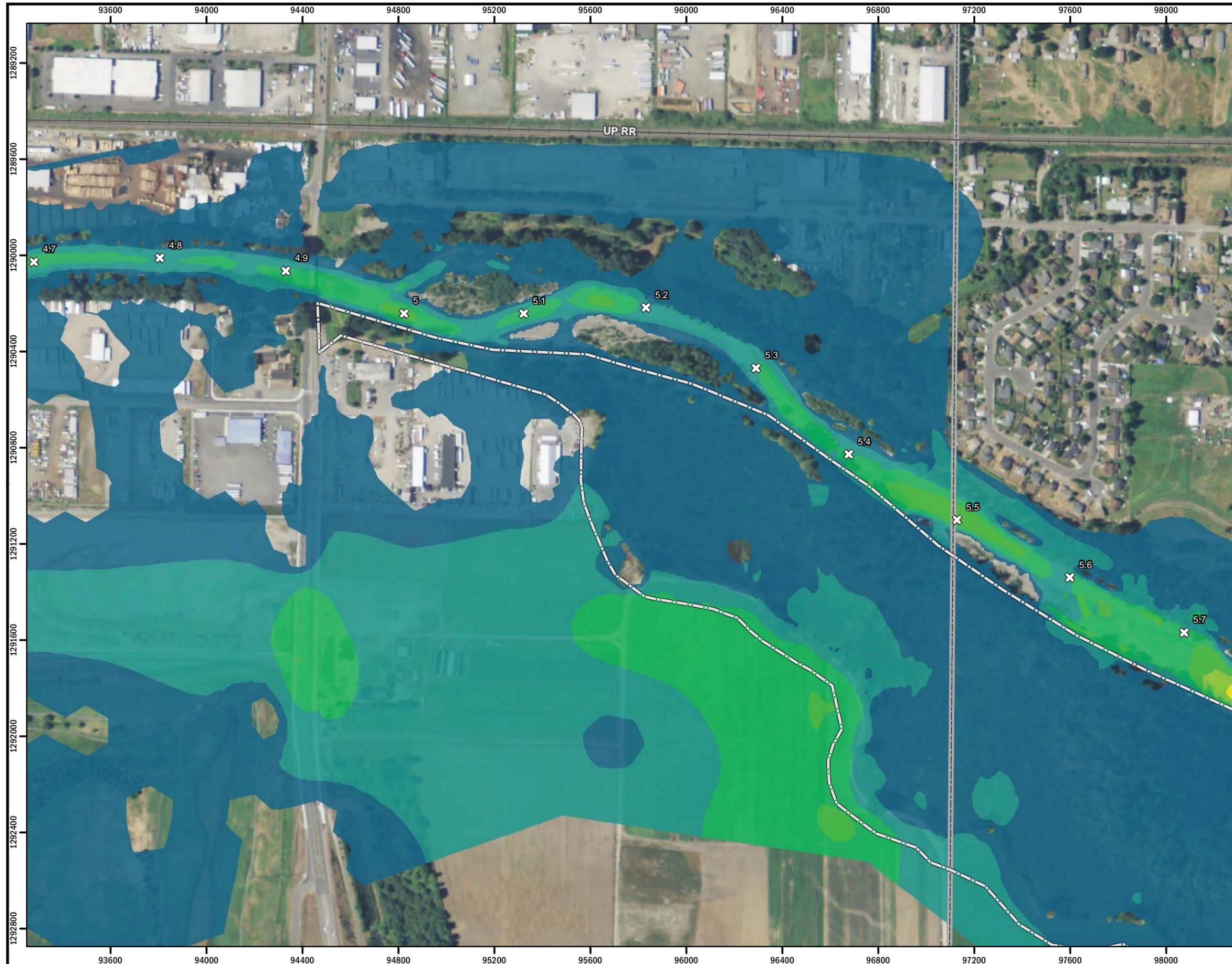
— County boundary

0 200 400 800
 Feet

King County
 Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

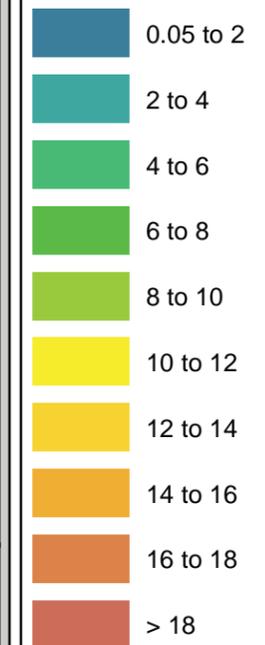
Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\rechecked_delta_velocity_appendix_figures.mxd (6/13/2013)

Figure A-22. Sheet B.
Without Project Fully Evolved (S4c)
Simulation Water Velocity Results
for the 500-year Flood Event.

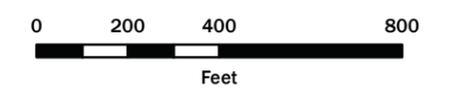


Legend

Water velocity (ft/sec)



- River mile
- Railroad
- Project area
- County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project: K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\reconned_delta_velocity_appendix_figures.mxd (6/13/2013)



Figure A-23. Sheet A.
Without Project Fully Evolved (S4c)
Simulation Water Surface Elevation
Results for Mean Annual Flow.

Legend

Water surface elevation (feet)

	< 65
	65 to 70
	70 to 75
	75 to 80
	80 to 85
	85 to 90
	90 to 95
	> 95

River mile

Project area

County boundary

0 200 400 800
 Feet

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HMA_Modeling_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

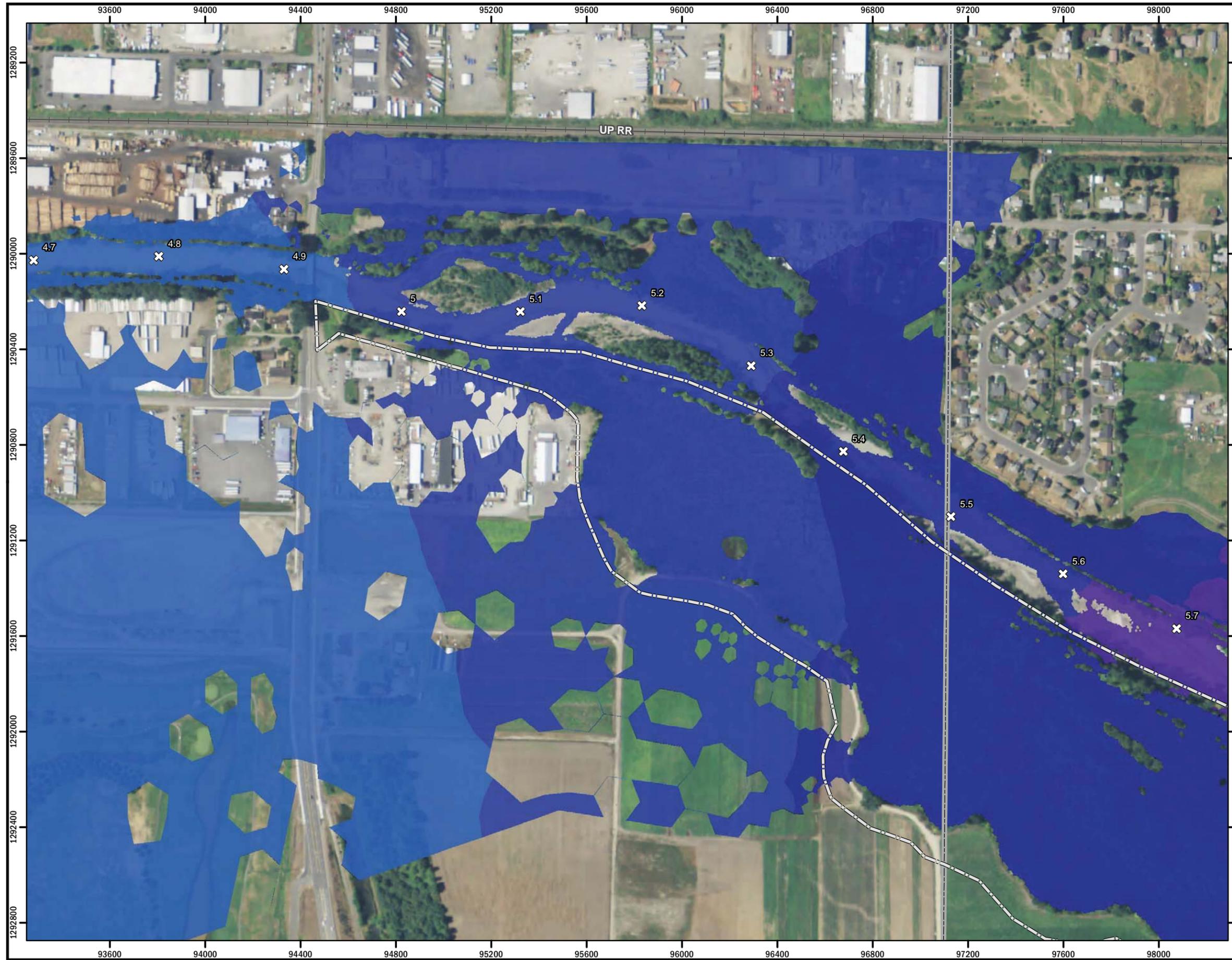


Figure A-23. Sheet B.
Without Project Fully Evolved (S4c)
Simulation Water Surface Elevation
Results for Mean Annual Flow.

Legend

Water surface elevation (feet)

	< 65
	65 to 70
	70 to 75
	75 to 80
	80 to 85
	85 to 90
	90 to 95
	> 95

River mile

Project area

County boundary

0 200 400 800
 Feet

King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

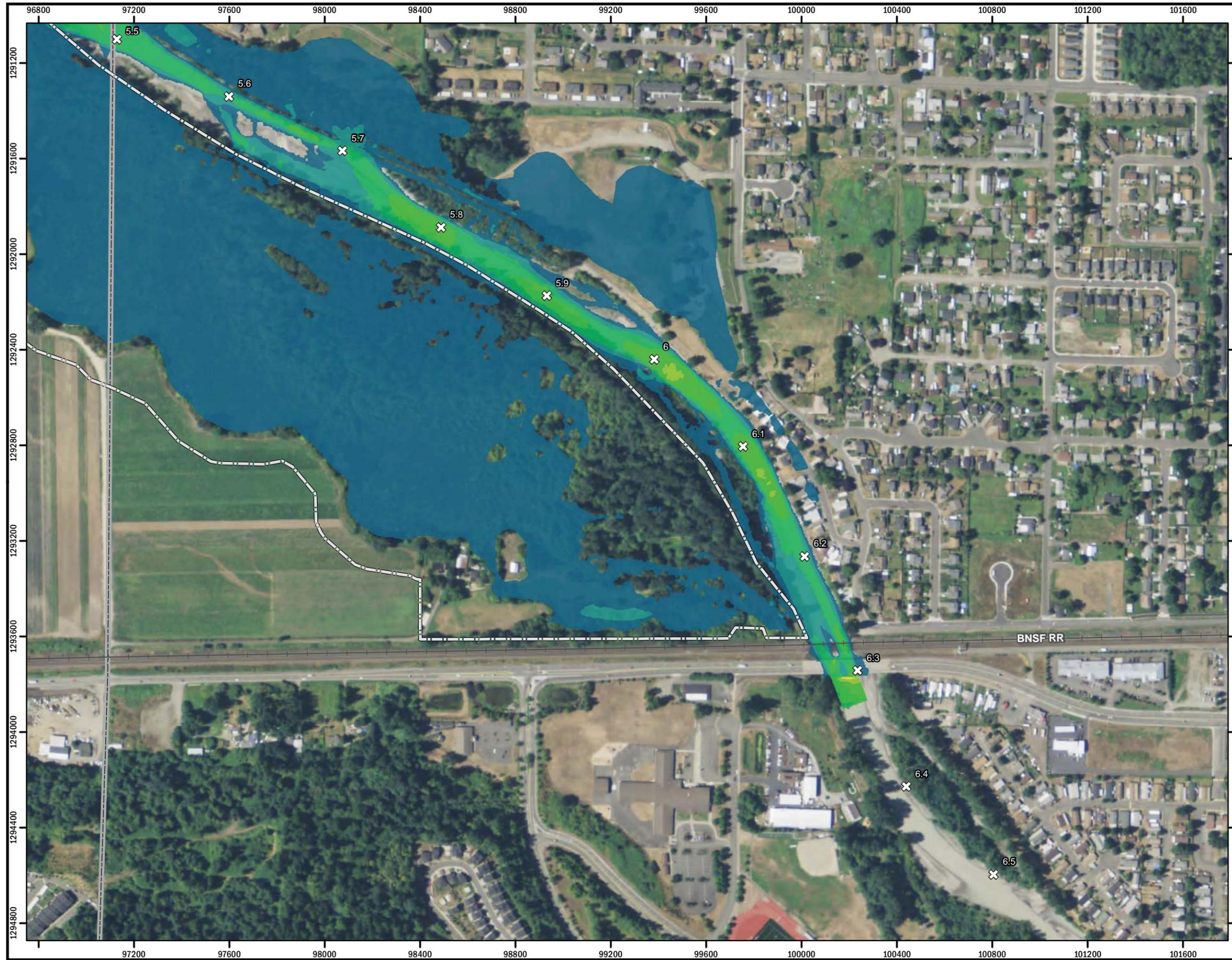


Figure A-24. Sheet A.
Without Project Fully Evolved (S4c)
Simulation Water Velocity Results
for Mean Annual Flow.

Legend

Water velocity (ft/sec)

0.05 to 2
2 to 4
4 to 6
6 to 8
8 to 10
10 to 12
12 to 14
14 to 16
16 to 18
> 18

⊗ River mile

—+— Railroad

⊠ Project area

— County boundary

0 200 400 800
 Feet

King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Mapping\Figures\rechecked_delta_velocity_appendix_figures.mxd (6/13/2013)

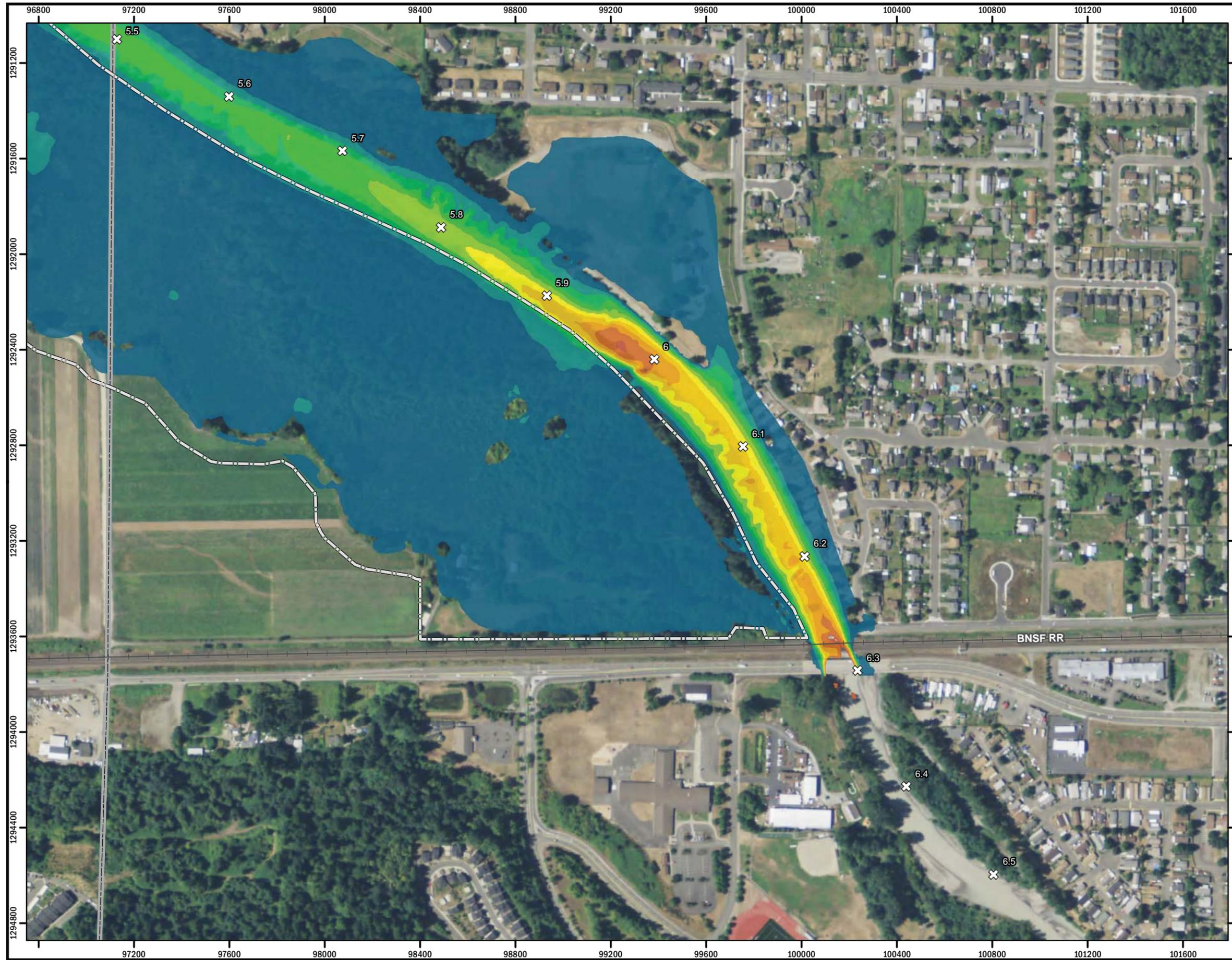


Figure A-30. Sheet A.
With Project Year Zero (S1a)
Simulation Water Velocity Results
for the 500-year Flood Event.

Legend

Water velocity (ft/sec)

	0.05 to 2
	2 to 4
	4 to 6
	6 to 8
	8 to 10
	10 to 12
	12 to 14
	14 to 16
	16 to 18
	> 18

River mile

Railroad

Project area

County boundary

0 200 400 800
 Feet

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\rechecked_delta_velocity_appendix_figures.mxd (6/13/2013)

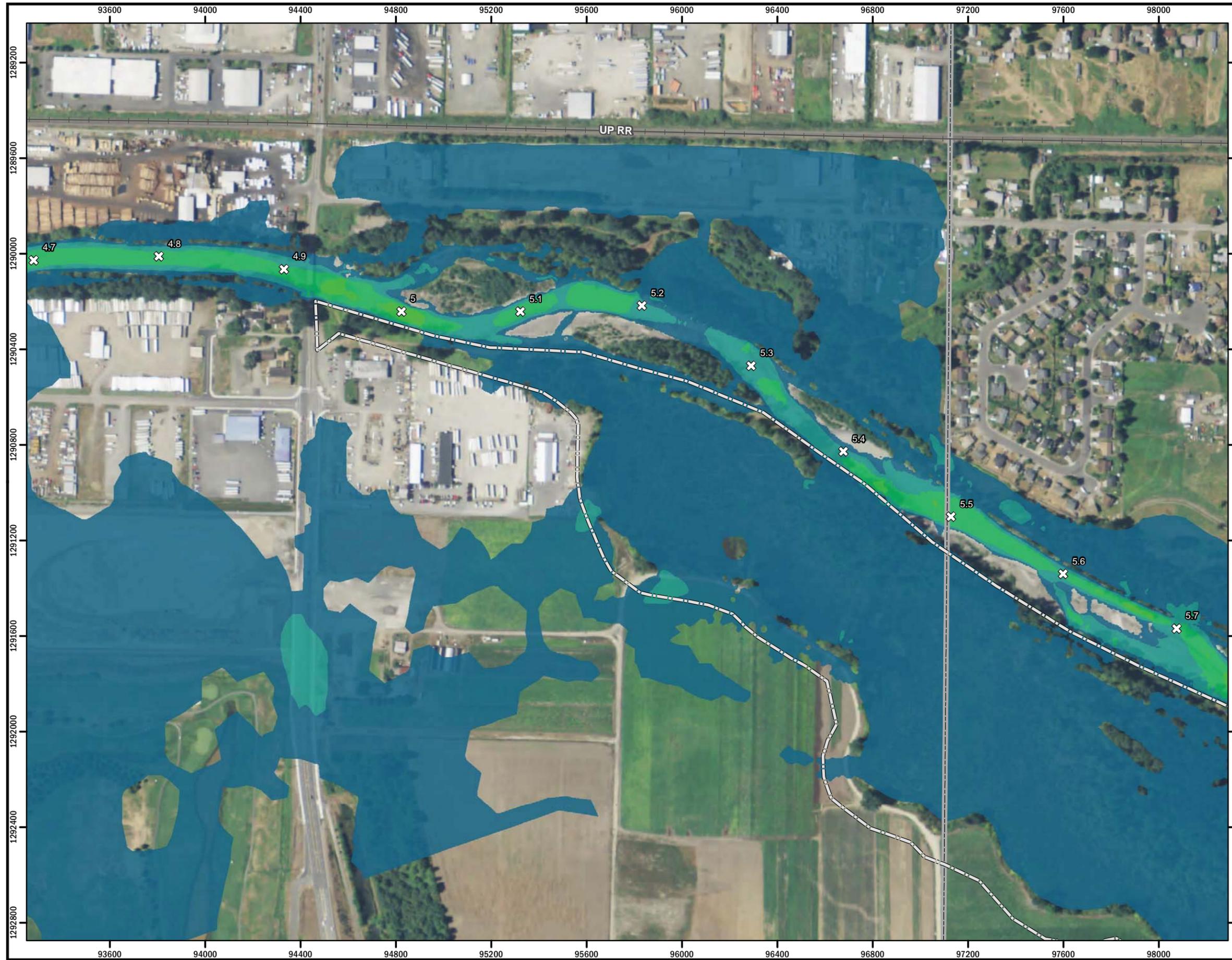


Figure A-24. Sheet B.
Without Project Fully Evolved (S4c)
Simulation Water Velocity Results
for Mean Annual Flow.

Legend

Water velocity (ft/sec)

	0.05 to 2
	2 to 4
	4 to 6
	6 to 8
	8 to 10
	10 to 12
	12 to 14
	14 to 16
	16 to 18
	> 18

River mile

Railroad

Project area

County boundary

0 200 400 800
 Feet

King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\reconned_delta_velocity_appendix_figures.mxd (6/13/2013)

Figure A-25. Sheet A.
With Project Year Zero (S1a)
Simulation Water Surface Elevation
Results for the 2-year Flood Event.



Legend

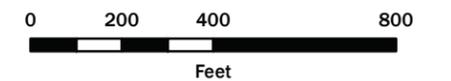
Water surface elevation (feet)

- < 65
- 65 to 70
- 70 to 75
- 75 to 80
- 80 to 85
- 85 to 90
- 90 to 95
- > 95

River mile

Project area

County boundary



Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HMA_Modelling_Figures\rechecked_domain_WSE_appendix_figures.mxd (6/13/2013)

Figure A-25. Sheet B.
 With Project Year Zero (S1a)
 Simulation Water Surface Elevation
 Results for the 2-year Flood Event.



Legend

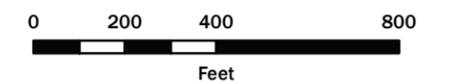
Water surface elevation (feet)

-  < 65
-  65 to 70
-  70 to 75
-  75 to 80
-  80 to 85
-  85 to 90
-  90 to 95
-  > 95

 River mile

 Project area

 County boundary



Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project: K:\Projects\130-04770-000\Project\HAM_Mapping_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

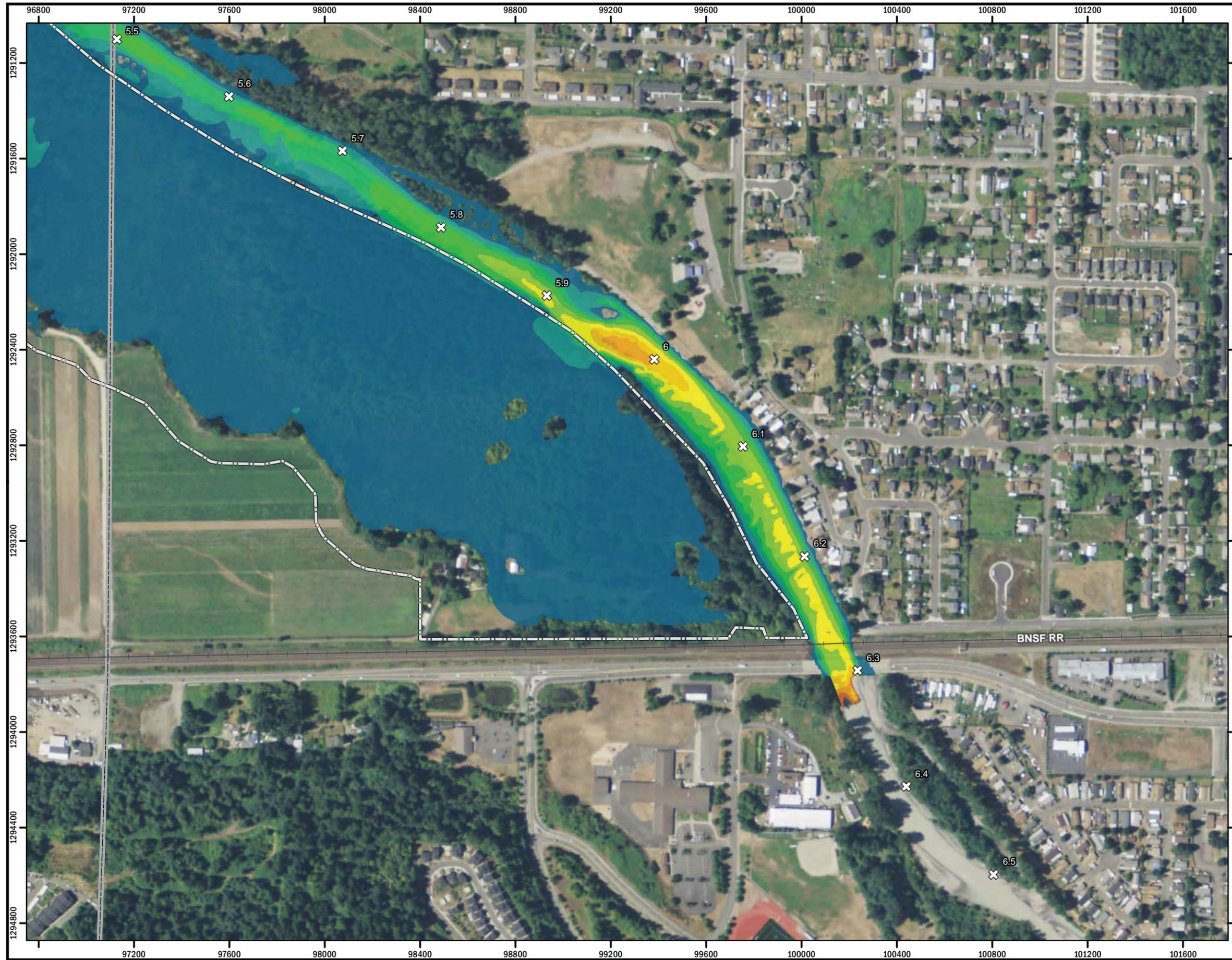


Figure A-26. Sheet A.
With Project Year Zero (S1a)
Simulation Water Velocity Results
for the 2-year Flood Event.

Legend

Water velocity (ft/sec)

0.05 to 2
2 to 4
4 to 6
6 to 8
8 to 10
10 to 12
12 to 14
14 to 16
16 to 18
> 18

⊗ River mile

—+— Railroad

⎓ Project area

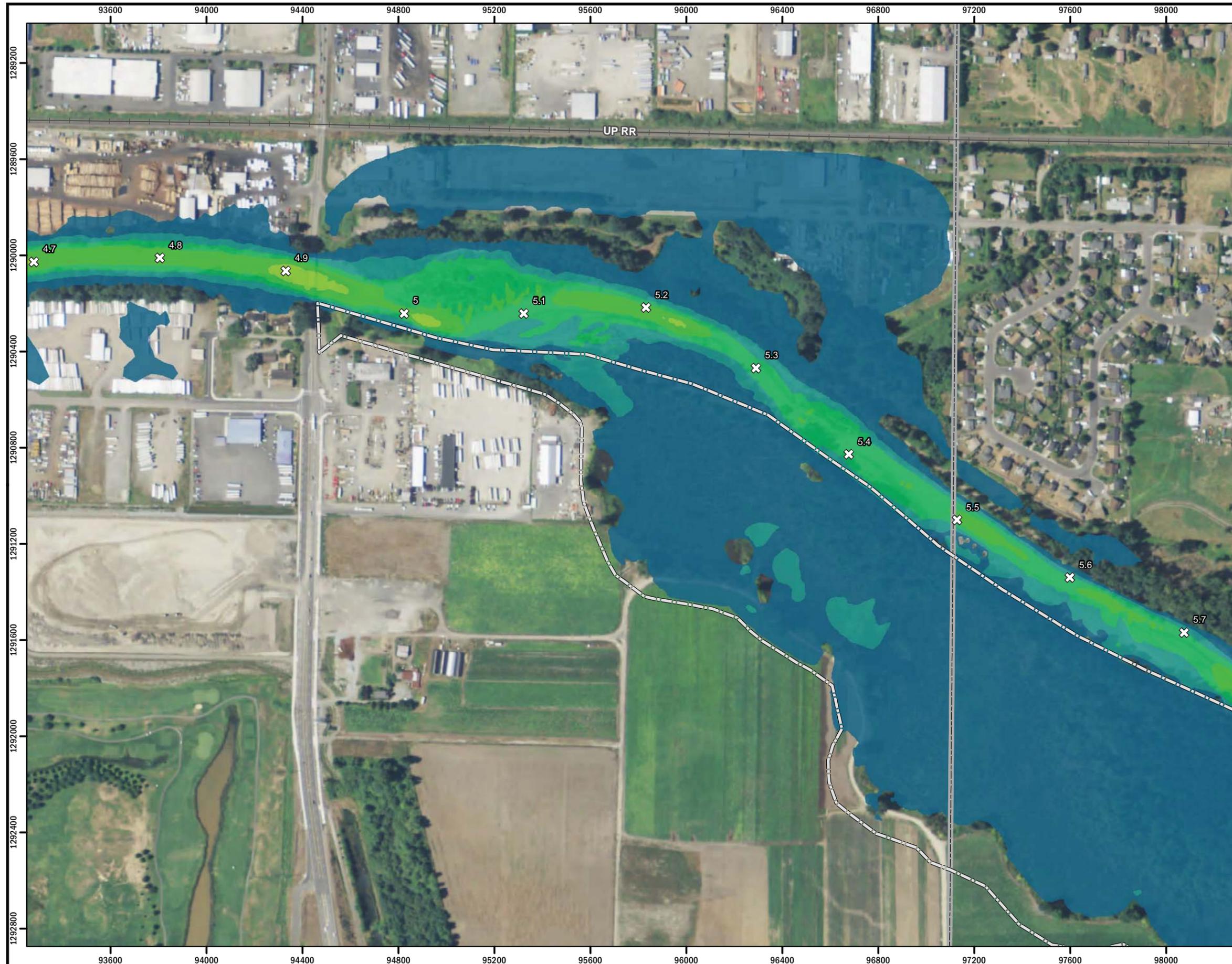
— County boundary


 0 200 400 800
 Feet


 Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\rechecked_delta_velocity_appendix_figures.mxd (6/13/2013)

Figure A-26. Sheet B.
With Project Year Zero (S1a)
Simulation Water Velocity Results
for the 2-year Flood Event.

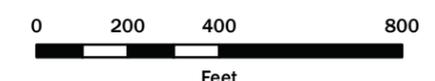


Legend

Water velocity (ft/sec)



- River mile
- Railroad
- Project area
- County boundary

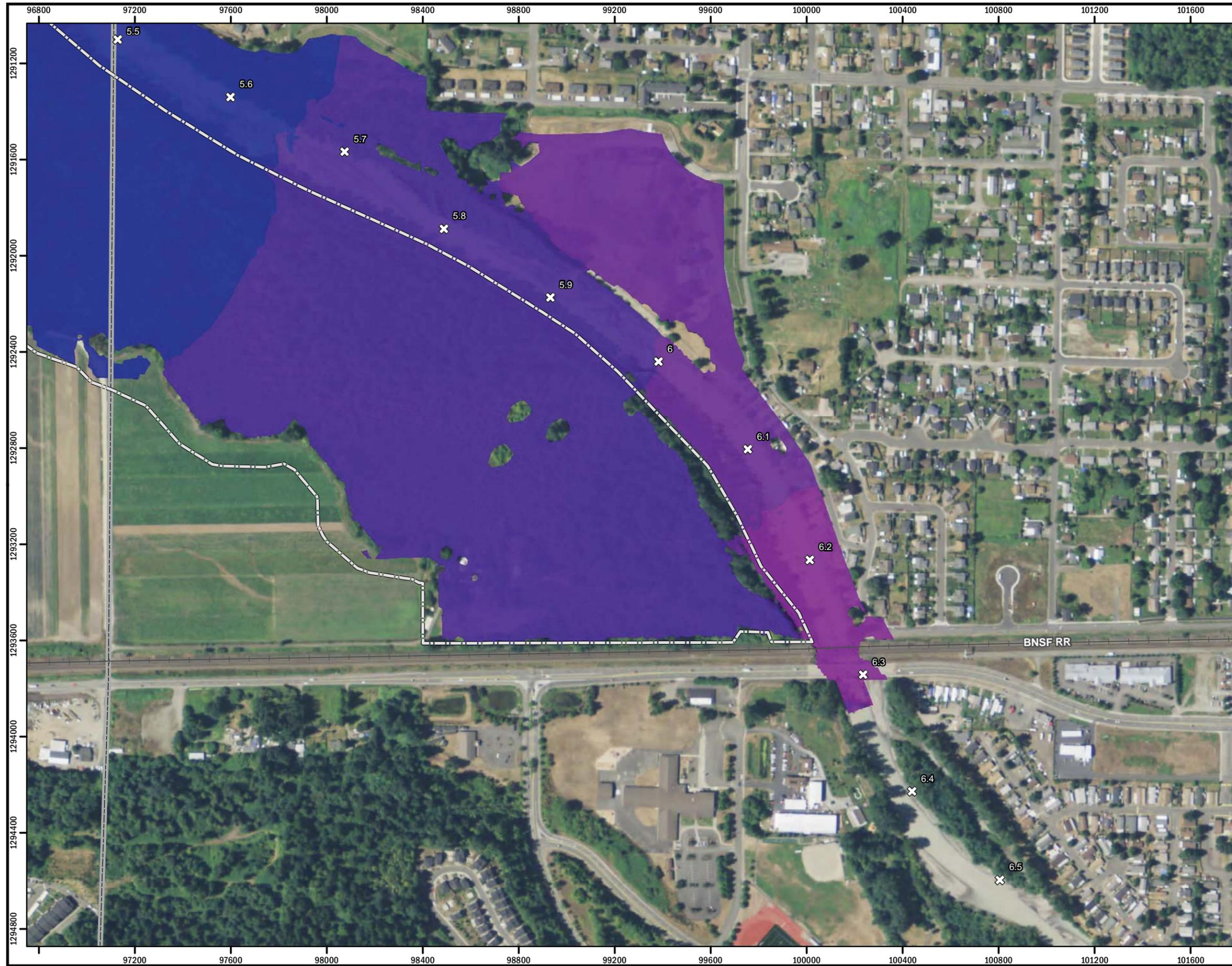


King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project: K:\Projects\130-04770-000\Project\HAM_Mapping_Figures\rechecked_delta_velocity_appendix_figures.mxd (6/13/2013)

Figure A-27. Sheet A.
With Project Year Zero (S1a)
Simulation Water Surface Elevation
Results for the 100-year Flood Event.



Legend

Water surface elevation (feet)

	< 65
	65 to 70
	70 to 75
	75 to 80
	80 to 85
	85 to 90
	90 to 95
	> 95

River mile

Project area

County boundary

0 200 400 800
 Feet

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HMA_Modeling_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

Figure A-27. Sheet B.
 With Project Year Zero (S1a)
 Simulation Water Surface Elevation
 Results for the 100-year Flood Event.



Legend

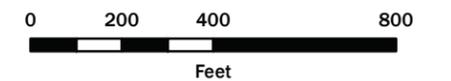
Water surface elevation (feet)

- < 65
- 65 to 70
- 70 to 75
- 75 to 80
- 80 to 85
- 85 to 90
- 90 to 95
- > 95

River mile

Project area

County boundary



Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

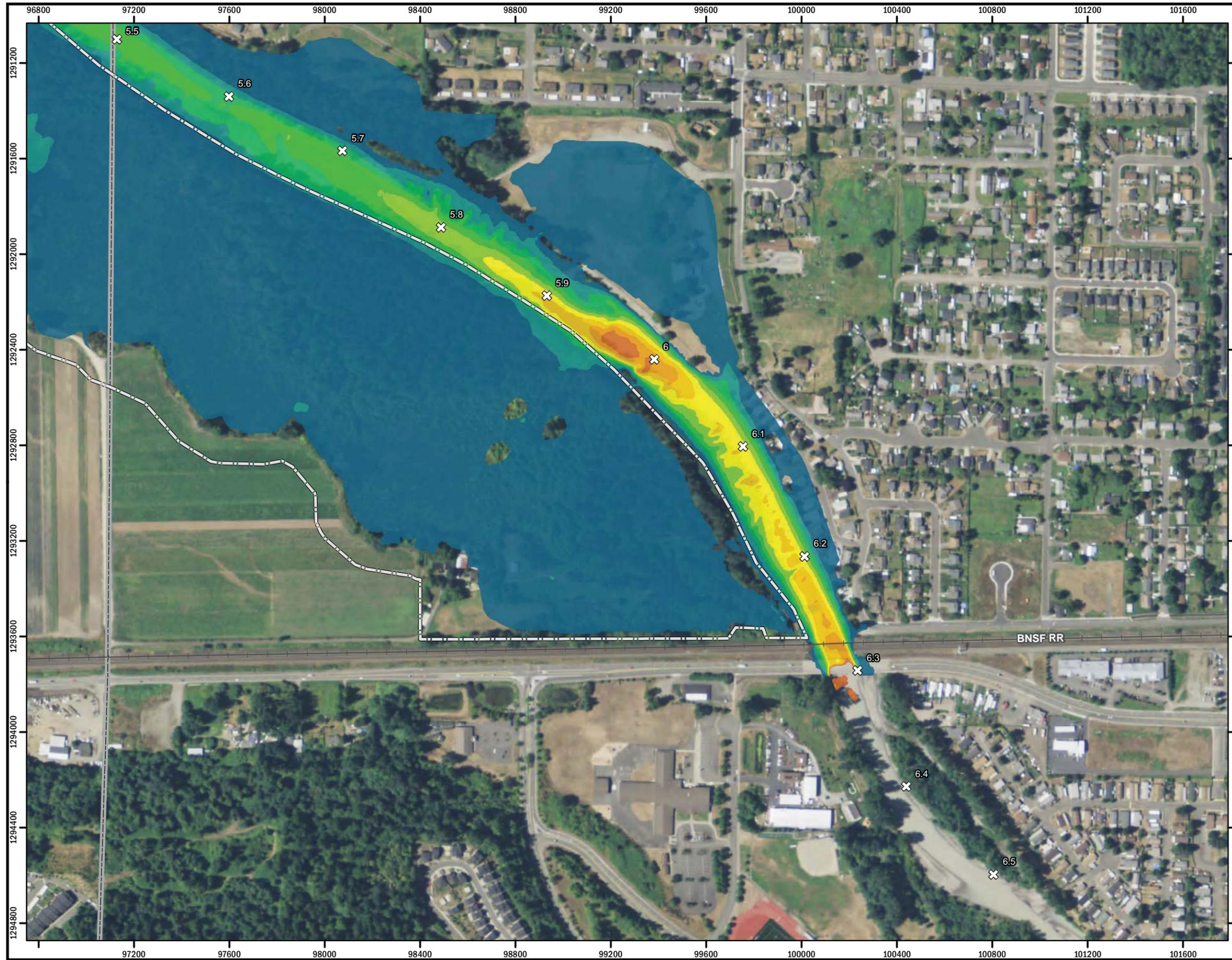


Figure A-28. Sheet A.
With Project Year Zero (S1a)
Simulation Water Velocity Results
for the 100-year Flood Event.

Legend

Water velocity (ft/sec)

	0.05 to 2
	2 to 4
	4 to 6
	6 to 8
	8 to 10
	10 to 12
	12 to 14
	14 to 16
	16 to 18
	> 18

River mile

Railroad

Project area

County boundary

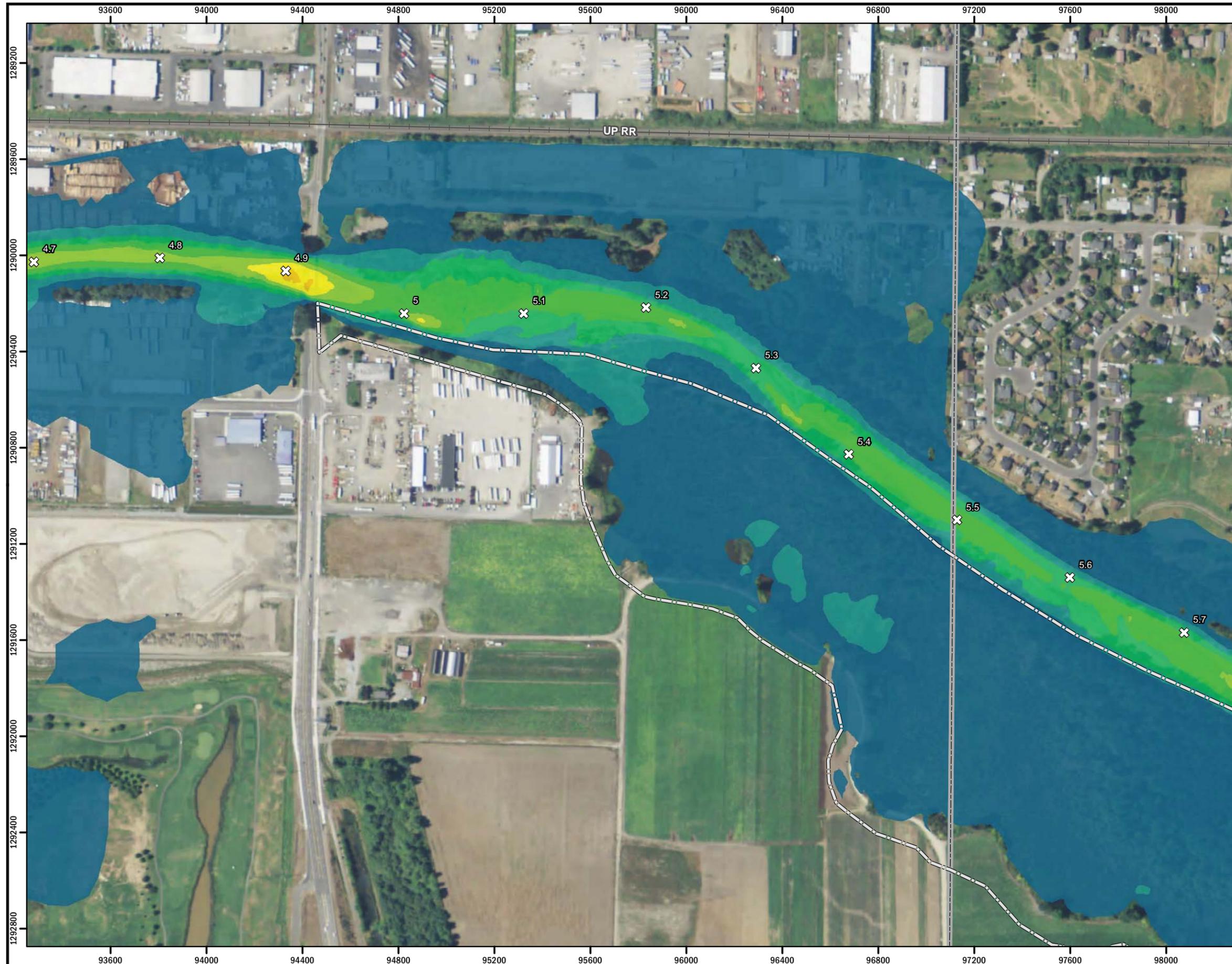
0 200 400 800
 Feet

King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

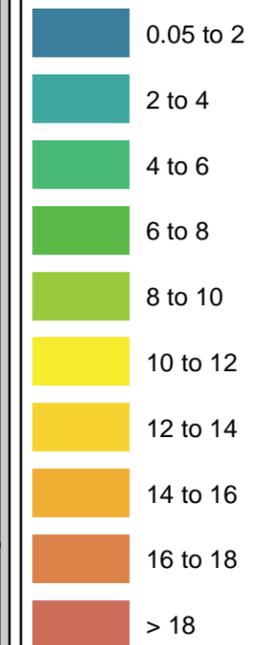
Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Mapping\Figures\rechecked_delta_velocity_appendix_figures.mxd (6/13/2013)

Figure A-28. Sheet B.
With Project Year Zero (S1a)
Simulation Water Velocity Results
for the 100-year Flood Event.

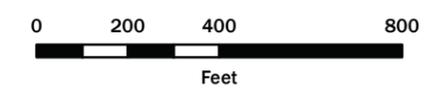


Legend

Water velocity (ft/sec)



-  River mile
-  Railroad
-  Project area
-  County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project: K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\rechecked_delta_velocity_appendix_figures.mxd (6/13/2013)

Figure A-29. Sheet A.
With Project Year Zero (S1a)
Simulation Water Surface Elevation
Results for the 100-year Flood Event.



Legend

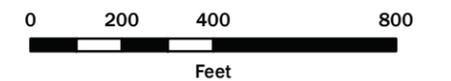
Water surface elevation (feet)

- < 65
- 65 to 70
- 70 to 75
- 75 to 80
- 80 to 85
- 85 to 90
- 90 to 95
- > 95

River mile

Project area

County boundary



Prepared for King County by Herrera
Aerial: USDA (2009)
Coordinates: NAD 1983 Washington
State Plane North (ft)

Produced By: GIS
Project K:\Projects\10-04770-000\Project\HMA_Modeling_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

Figure A-29. Sheet B.
 With Project Year Zero (S1a)
 Simulation Water Surface Elevation
 Results for the 100-year Flood Event.



Legend

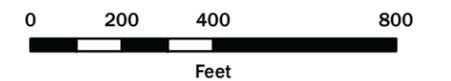
Water surface elevation (feet)

- < 65
- 65 to 70
- 70 to 75
- 75 to 80
- 80 to 85
- 85 to 90
- 90 to 95
- > 95

River mile

Project area

County boundary



Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project: K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

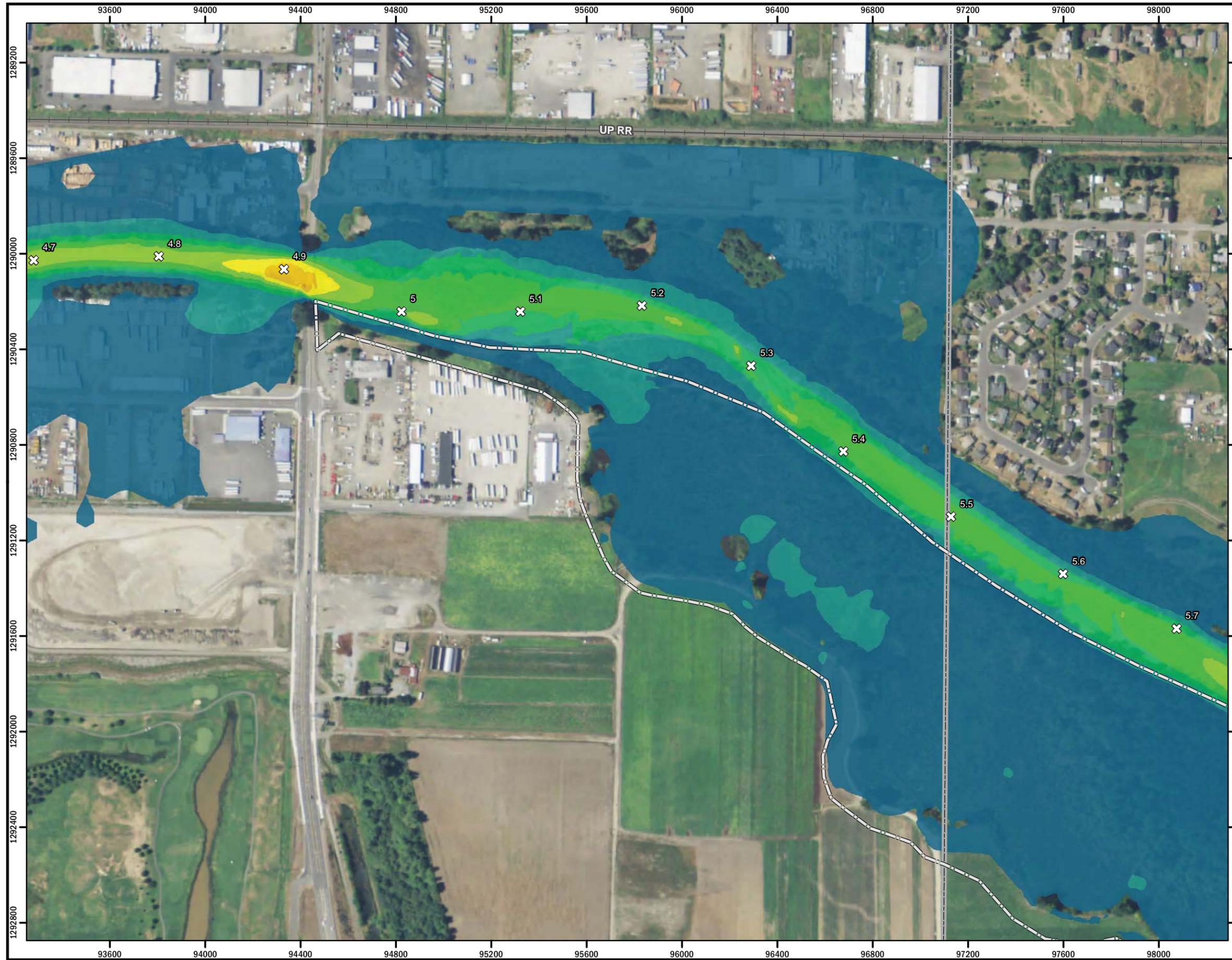


Figure A-30. Sheet B.
With Project Year Zero (S1a)
Simulation Water Velocity Results
for the 500-year Flood Event.

Legend

Water velocity (ft/sec)

0.05 to 2
2 to 4
4 to 6
6 to 8
8 to 10
10 to 12
12 to 14
14 to 16
16 to 18
> 18

⊗ River mile

—+— Railroad

⬡ Project area

— County boundary

0 200 400 800
 Feet

King County
 Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\reconned_delta_velocity_appendix_figures.mxd (6/13/2013)

Figure A-31. Sheet A.
 With Project Year Zero (S1a)
 Simulation Water Surface Elevation
 Results for Mean Annual Flow.



Legend

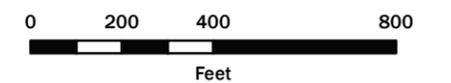
Water surface elevation (feet)

- < 65
- 65 to 70
- 70 to 75
- 75 to 80
- 80 to 85
- 85 to 90
- 90 to 95
- > 95

River mile

Project area

County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HMA_Modeling_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

Figure A-31. Sheet B.
 With Project Year Zero (S1a)
 Simulation Water Surface Elevation
 Results for Mean Annual Flow.



Legend

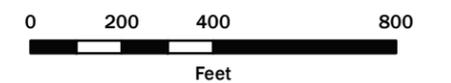
Water surface elevation (feet)

- < 65
- 65 to 70
- 70 to 75
- 75 to 80
- 80 to 85
- 85 to 90
- 90 to 95
- > 95

River mile

Project area

County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project: K:\Projects\130-04770-000\Project\HAM_Mapping_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

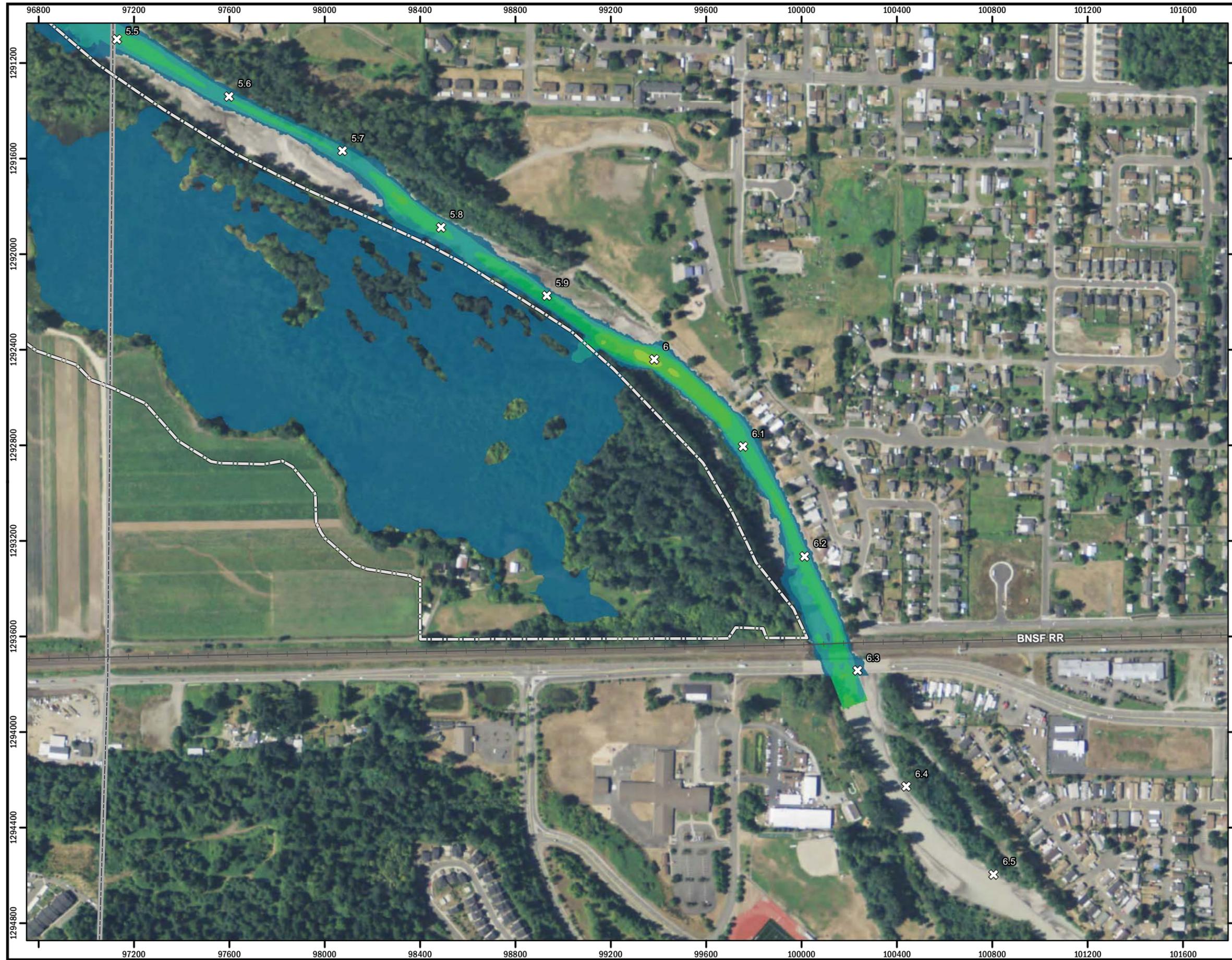


Figure A-32. Sheet A.
With Project Year Zero (S1a)
Simulation Water Velocity Results
for Mean Annual Flow.

Legend

Water velocity (ft/sec)

0.05 to 2
2 to 4
4 to 6
6 to 8
8 to 10
10 to 12
12 to 14
14 to 16
16 to 18
> 18

⊗ River mile

—+— Railroad

⊠ Project area

— County boundary

0 200 400 800
 Feet

King County
 Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\rechecked_delta_velocity_appendix_figures.mxd (6/13/2013)



Figure A-32. Sheet B.
With Project Year Zero (S1a)
Simulation Water Velocity Results
for Mean Annual Flow.

Legend

Water velocity (ft/sec)

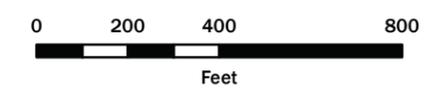
0.05 to 2
2 to 4
4 to 6
6 to 8
8 to 10
10 to 12
12 to 14
14 to 16
16 to 18
> 18

⊗ River mile

—+— Railroad

⬡ Project area

— County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project: K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\rechecked_delta_in_velocity_appendix_figures.mxd (6/13/2013)

Figure A-33. Sheet A.
With Project Short-Term (S1b)
Simulation Water Surface Elevation
Results for the 2-year Flood Event.



Legend

Water surface elevation (feet)

- < 65
- 65 to 70
- 70 to 75
- 75 to 80
- 80 to 85
- 85 to 90
- 90 to 95
- > 95

River mile

Project area

County boundary

0 200 400 800
 Feet

King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HMA_Modeling_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)



Figure A-33. Sheet B.
With Project Short-Term (S1b)
Simulation Water Surface Elevation
Results for the 2-year Flood Event.

Legend

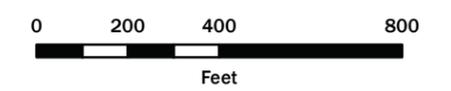
Water surface elevation (feet)

	< 65
	65 to 70
	70 to 75
	75 to 80
	80 to 85
	85 to 90
	90 to 95
	> 95

River mile

Project area

County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project K:\Projects\130-04770-000\Project\HAM_Mapping_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

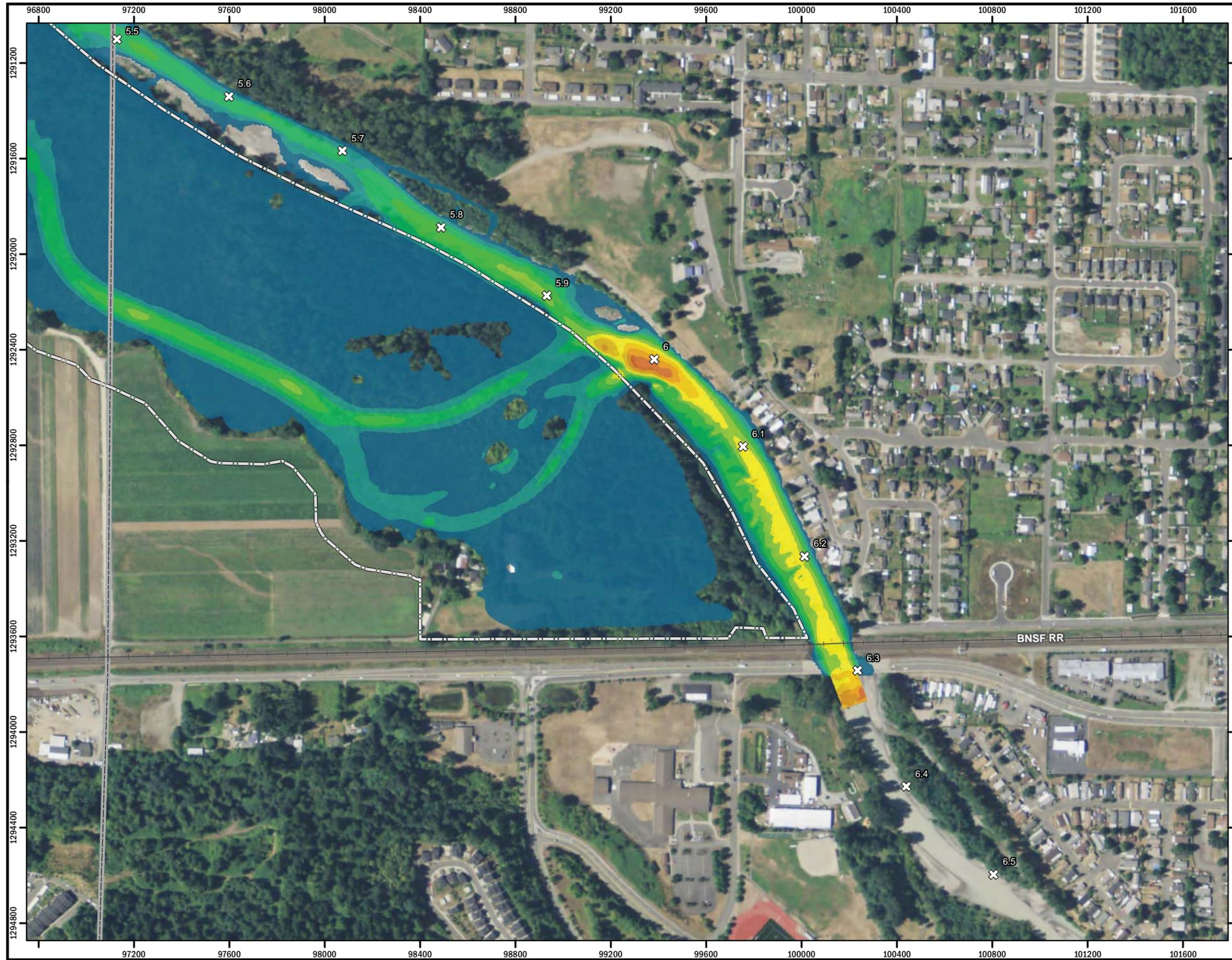


Figure A-34. Sheet A.
With Project Short-Term (S1b)
Simulation Water Velocity Results
for the 2-year Flood Event.

Legend

Water velocity (ft/sec)

0.05 to 2
2 to 4
4 to 6
6 to 8
8 to 10
10 to 12
12 to 14
14 to 16
16 to 18
> 18

⊗ River mile

—+— Railroad

⊠ Project area

— County boundary

0 200 400 800
 Feet

King County
 Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\reworked_delta_velocity_appendix_figures.mxd (6/13/2013)

Figure A-34. Sheet B.
With Project Short-Term (S1b)
Simulation Water Velocity Results
for the 2-year Flood Event.

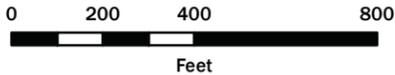


Legend

Water velocity (ft/sec)

-  0.05 to 2
-  2 to 4
-  4 to 6
-  6 to 8
-  8 to 10
-  10 to 12
-  12 to 14
-  14 to 16
-  16 to 18
-  > 18

-  River mile
-  Railroad
-  Project area
-  County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project: K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\rechecked_delta_velocity_appendix_figures.mxd (6/13/2013)



Figure A-35. Sheet A.
With Project Short-Term (S1b)
Simulation Water Surface Elevation
Results for the 100-year Flood Event.

Legend

Water surface elevation (feet)

	< 65
	65 to 70
	70 to 75
	75 to 80
	80 to 85
	85 to 90
	90 to 95
	> 95

River mile

Project area

County boundary

0 200 400 800
 Feet

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HMA_Modeling_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

Figure A-35. Sheet B.
With Project Short-Term (S1b)
Simulation Water Surface Elevation
Results for the 100-year Flood Event.



Legend

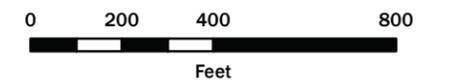
Water surface elevation (feet)

- < 65
- 65 to 70
- 70 to 75
- 75 to 80
- 80 to 85
- 85 to 90
- 90 to 95
- > 95

River mile

Project area

County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

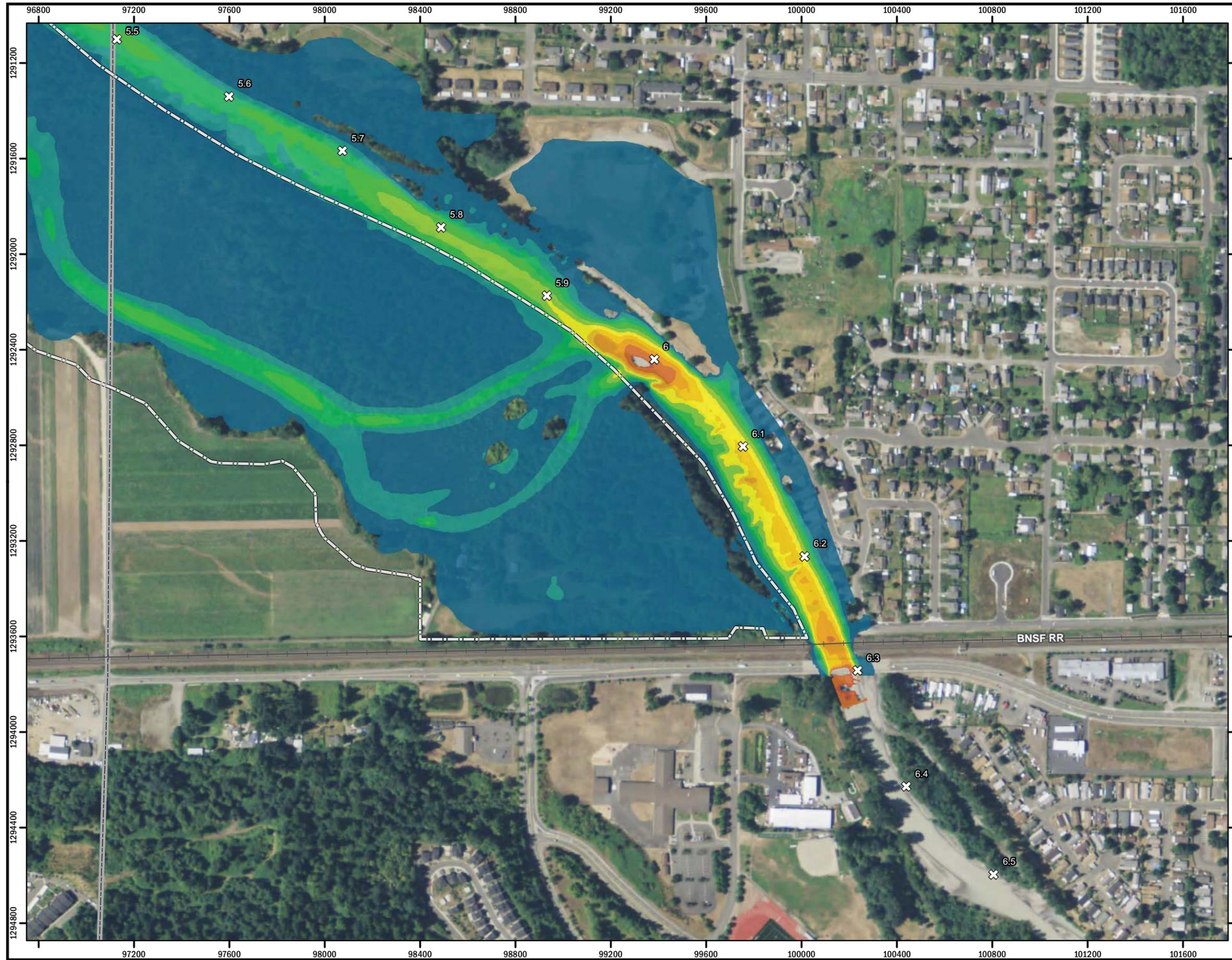


Figure A-36. Sheet A.
With Project Short-Term (S1b)
Simulation Water Velocity Results
for the 100-year Flood Event.

Legend

Water velocity (ft/sec)

0.05 to 2
2 to 4
4 to 6
6 to 8
8 to 10
10 to 12
12 to 14
14 to 16
16 to 18
> 18

⊗ River mile

—+— Railroad

⎓ Project area

— County boundary

0 200 400 800
 Feet

King County
 Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\rechecked_delta_velocity_appendix_figures.mxd (6/13/2013)



Figure A-36. Sheet B.
With Project Short-Term (S1b)
Simulation Water Velocity Results
for the 100-year Flood Event.

Legend

Water velocity (ft/sec)

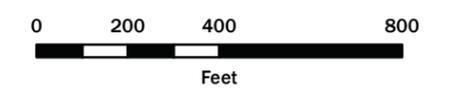
	0.05 to 2
	2 to 4
	4 to 6
	6 to 8
	8 to 10
	10 to 12
	12 to 14
	14 to 16
	16 to 18
	> 18

River mile

Railroad

Project area

County boundary

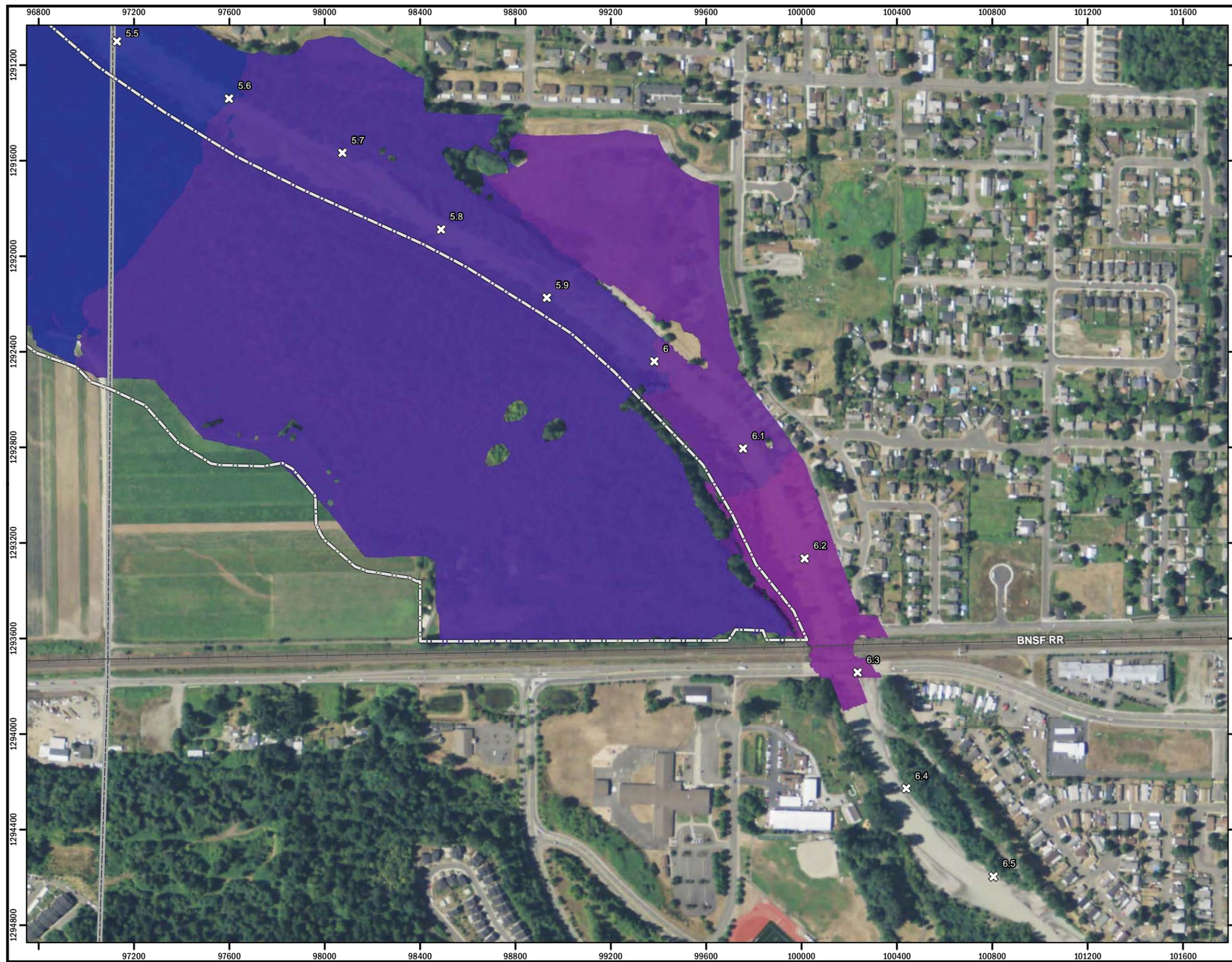


King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\rechecked_delta_velocity_appendix_figures.mxd (6/13/2013)

Figure A-37. Sheet A.
With Project Short-Term (S1b)
Simulation Water Surface Elevation
Results for the 500-year Flood Event.



Legend

Water surface elevation (feet)

- < 65
- 65 to 70
- 70 to 75
- 75 to 80
- 80 to 85
- 85 to 90
- 90 to 95
- > 95

River mile

Project area

County boundary

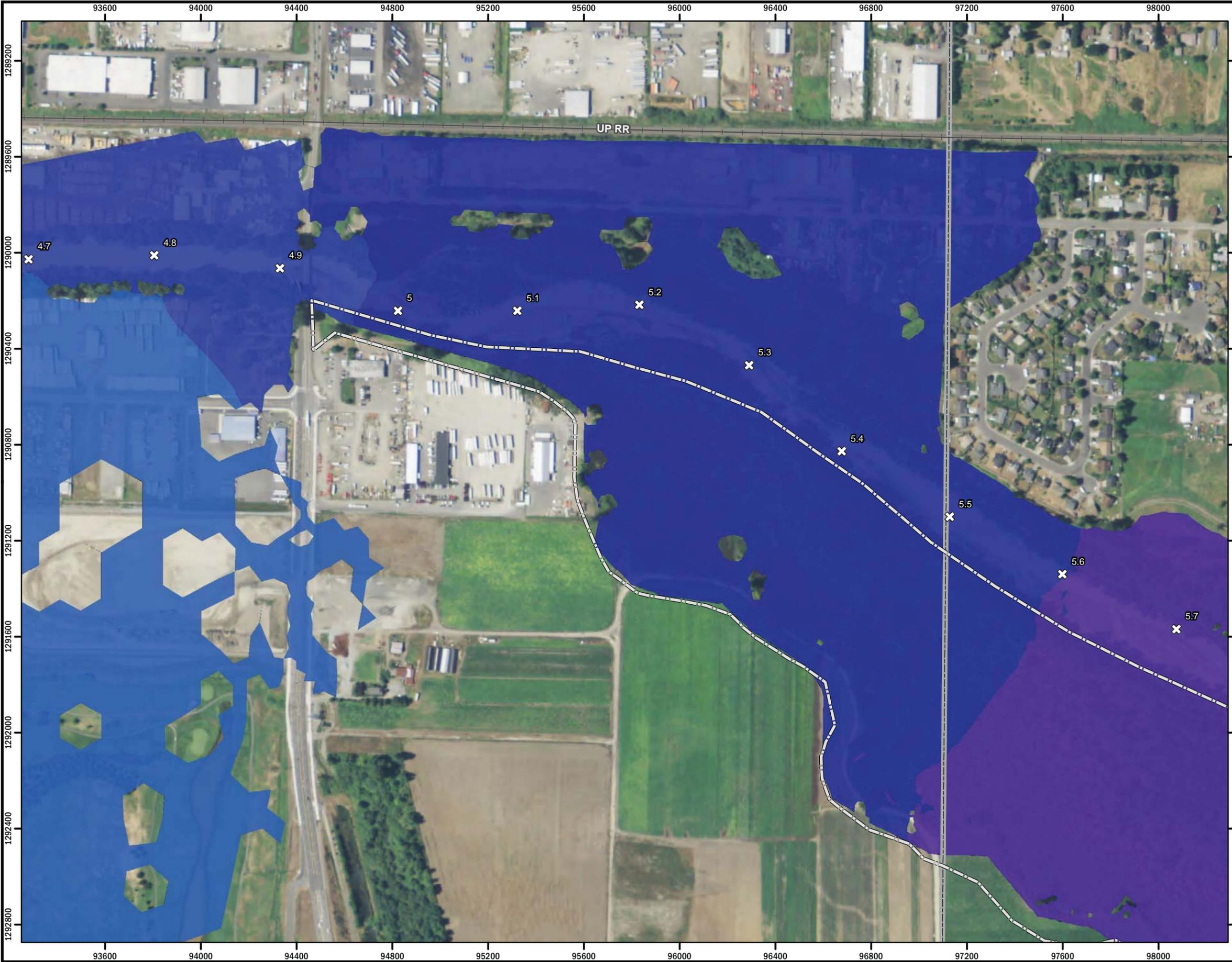
0 200 400 800

Feet

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HMA_Modelling_Figures\rechecked_domain_WSE_appendix_figures.mxd (6/13/2013)

Figure A-37. Sheet B.
 With Project Short-Term (S1b)
 Simulation Water Surface Elevation
 Results for the 500-year Flood Event.

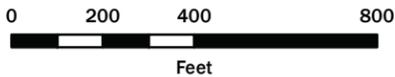


Legend

Water surface elevation (feet)

- < 65
- 65 to 70
- 70 to 75
- 75 to 80
- 80 to 85
- 85 to 90
- 90 to 95
- > 95

- River mile
- Project area
- County boundary



Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project K:\Projects\130-04770-000\Project\HAM_Mapping_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

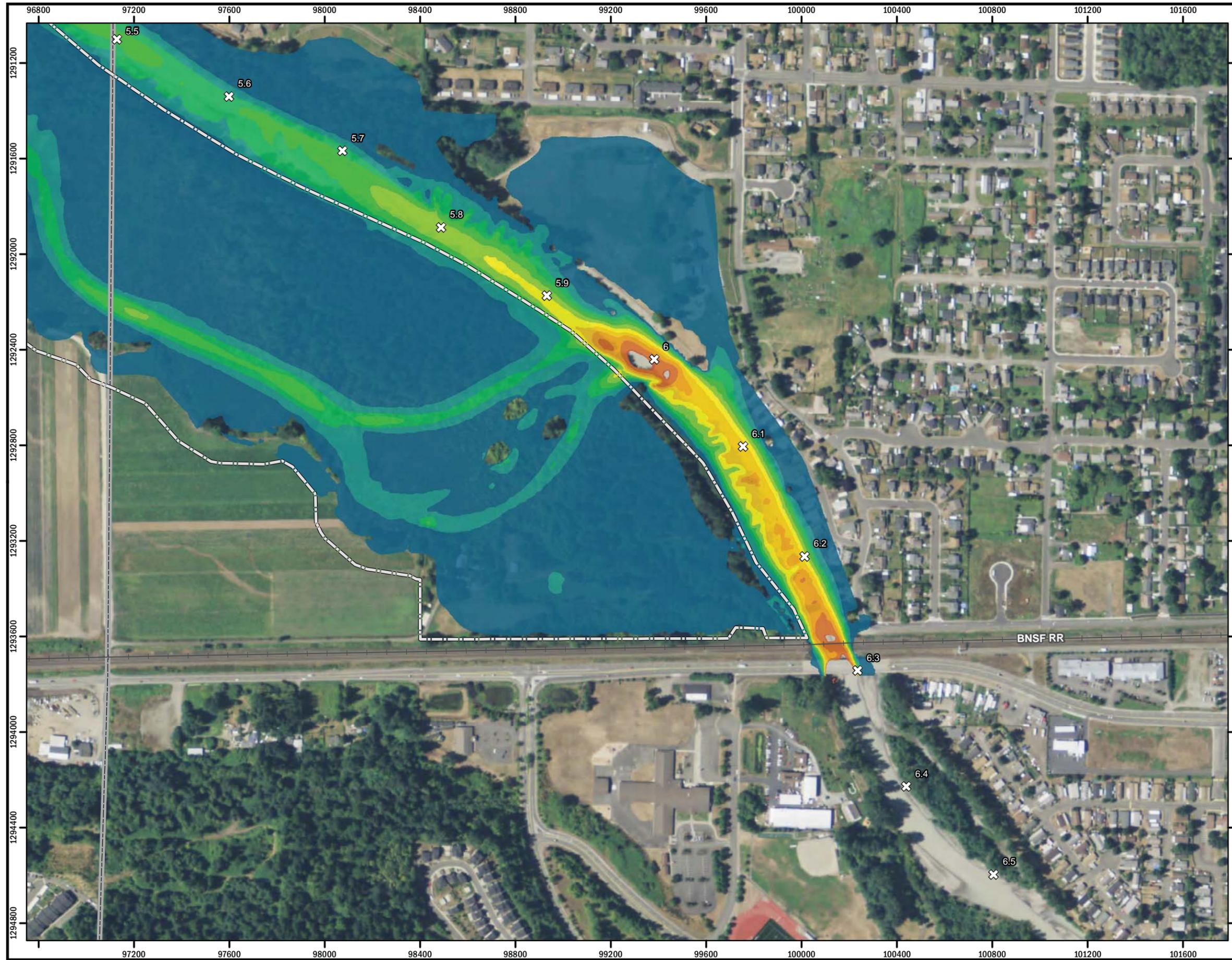


Figure A-38. Sheet A.
With Project Short-Term (S1b)
Simulation Water Velocity Results
for the 500-year Flood Event.

Legend

Water velocity (ft/sec)

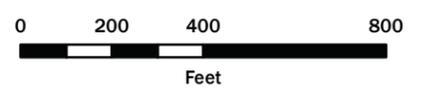
0.05 to 2
2 to 4
4 to 6
6 to 8
8 to 10
10 to 12
12 to 14
14 to 16
16 to 18
> 18

⊗ River mile

—+— Railroad

⊠ Project area

— County boundary

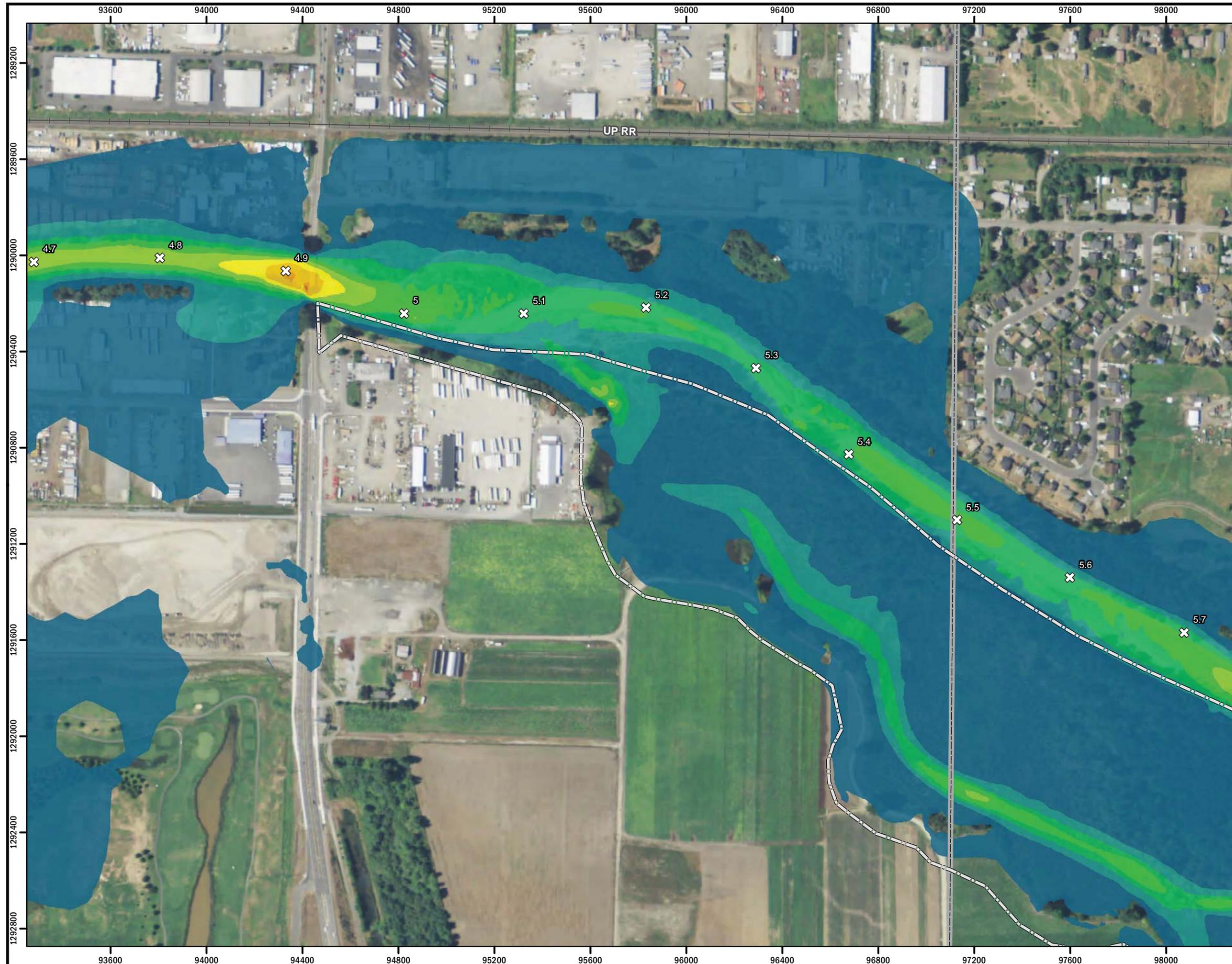


King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\rechecked_delta_velocity_appendix_figures.mxd (6/13/2013)

Figure A-38. Sheet B.
With Project Short-Term (S1b)
Simulation Water Velocity Results
for the 500-year Flood Event.



Legend

Water velocity (ft/sec)

	0.05 to 2
	2 to 4
	4 to 6
	6 to 8
	8 to 10
	10 to 12
	12 to 14
	14 to 16
	16 to 18
	> 18

River mile

Railroad

Project area

County boundary

0 200 400 800

Feet

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\HAM_Mapping\Figures\rechecked_delta_velocity_appendix_figures.mxd (6/13/2013)



Figure A-39. Sheet A.
With Project Short-Term (S1b)
Simulation Water Surface Elevation
Results Mean Annual Flow.

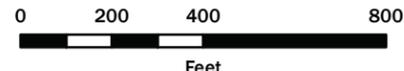
Legend

Water surface elevation (feet)

- < 65
- 65 to 70
- 70 to 75
- 75 to 80
- 80 to 85
- 85 to 90
- 90 to 95
- > 95

- River mile
- Project area
- County boundary





0 200 400 800
Feet



King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)



Figure A-39. Sheet B.
With Project Short-Term (S1b)
Simulation Water Surface Elevation
Results Mean Annual Flow.

Legend

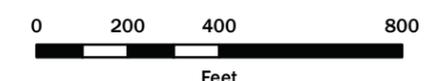
Water surface elevation (feet)

-  < 65
-  65 to 70
-  70 to 75
-  75 to 80
-  80 to 85
-  85 to 90
-  90 to 95
-  > 95

 River mile

 Project area

 County boundary



Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project: K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

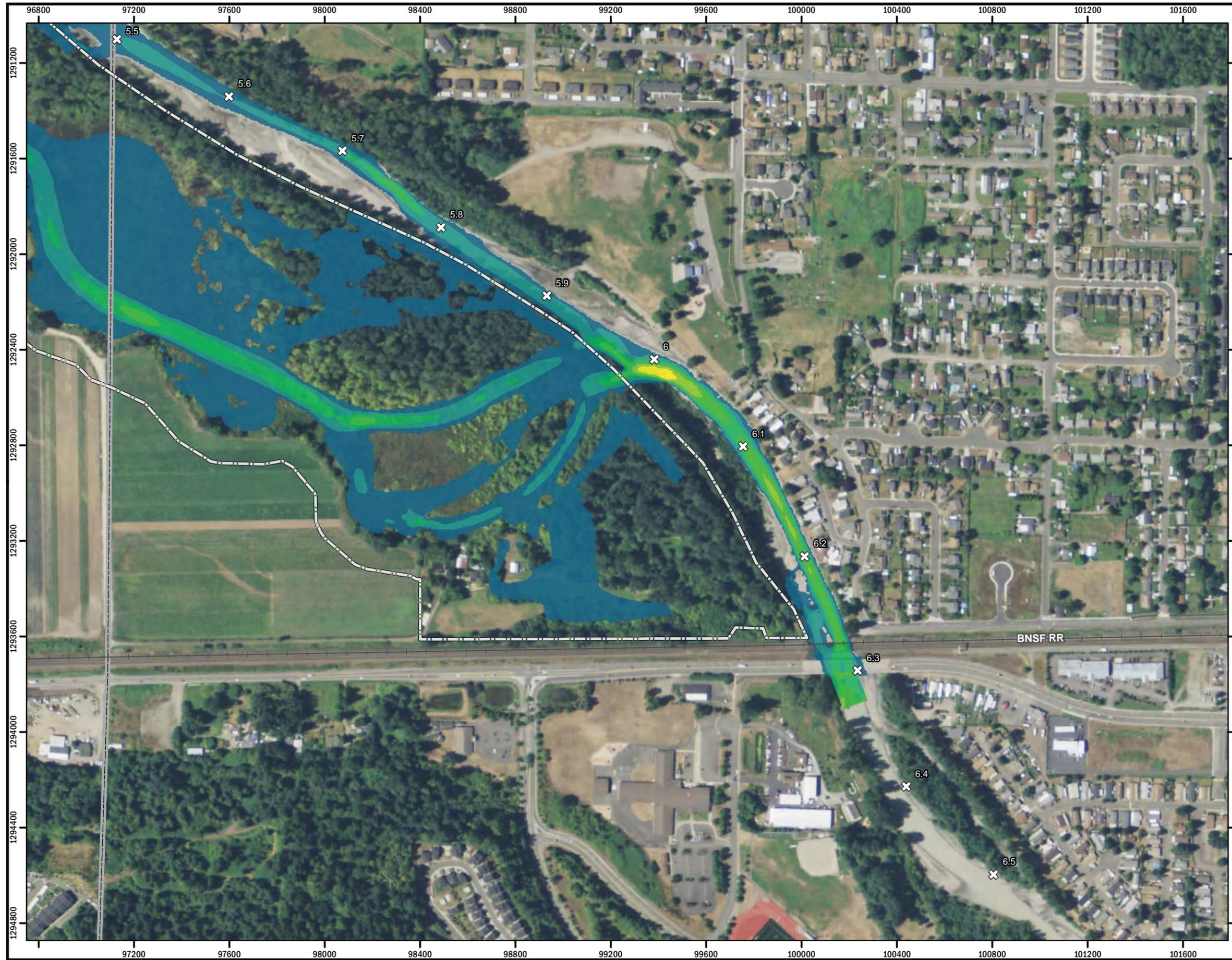


Figure A-40. Sheet A.
With Project Short-Term (S1b)
Simulation Water Velocity Results
for Mean Annual Flow.

Legend

Water velocity (ft/sec)

	0.05 to 2
	2 to 4
	4 to 6
	6 to 8
	8 to 10
	10 to 12
	12 to 14
	14 to 16
	16 to 18
	> 18

River mile

Railroad

Project area

County boundary

0 200 400 800
 Feet

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\rechecked_delta_velocity_appendix_figures.mxd (6/13/2013)



Figure A-40. Sheet B.
With Project Short-Term (S1b)
Simulation Water Velocity Results
for Mean Annual Flow.

Legend

Water velocity (ft/sec)

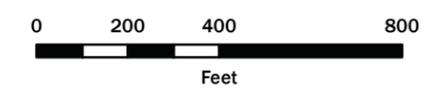
Blue	0.05 to 2
Teal	2 to 4
Light Green	4 to 6
Green	6 to 8
Light Yellow-Green	8 to 10
Yellow	10 to 12
Orange-Yellow	12 to 14
Orange	14 to 16
Red-Orange	16 to 18
Red	> 18

⊗ River mile

—+— Railroad

⎓ Project area

⎓ County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\rechecked_delta_in_velocity_appendix_figures.mxd (6/13/2013)

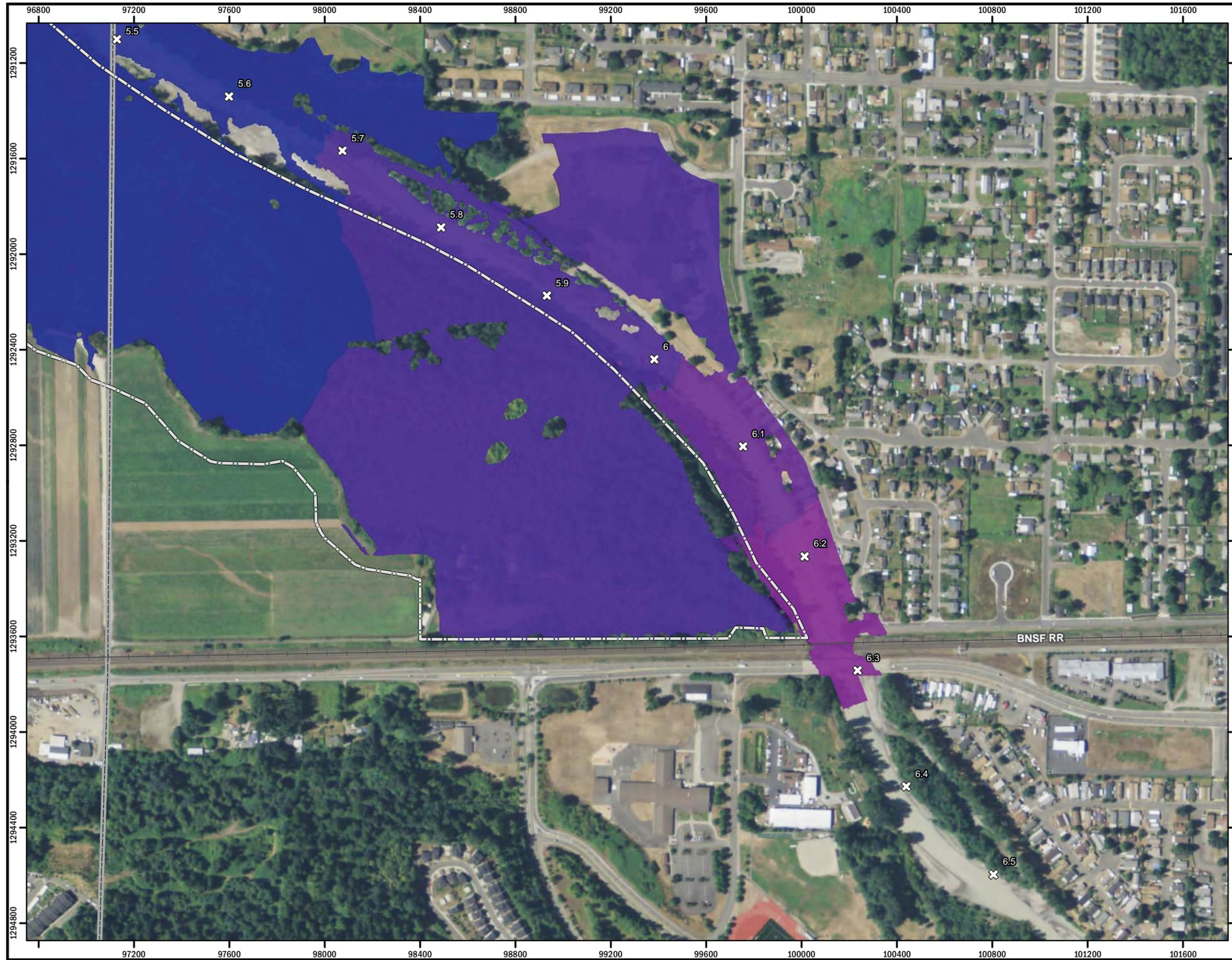


Figure A-41. Sheet A.
With Project Fully Evolved (S1c)
Simulation Water Surface Elevation
Results for the 2-year Flood Event.

Legend

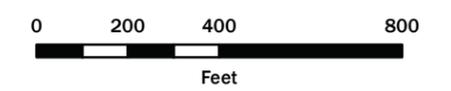
Water surface elevation (feet)

- < 65
- 65 to 70
- 70 to 75
- 75 to 80
- 80 to 85
- 85 to 90
- 90 to 95
- > 95

River mile

Project area

County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HMA_Modeling_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)



Figure A-41. Sheet B.
With Project Fully Evolved (S1c)
Simulation Water Surface Elevation
Results for the 2-year Flood Event.

Legend

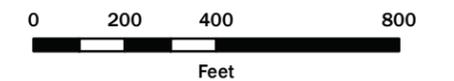
Water surface elevation (feet)

-  < 65
-  65 to 70
-  70 to 75
-  75 to 80
-  80 to 85
-  85 to 90
-  90 to 95
-  > 95

 River mile

 Project area

 County boundary



Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project K:\Projects\130-04770-000\Project\HAM_Mapping_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

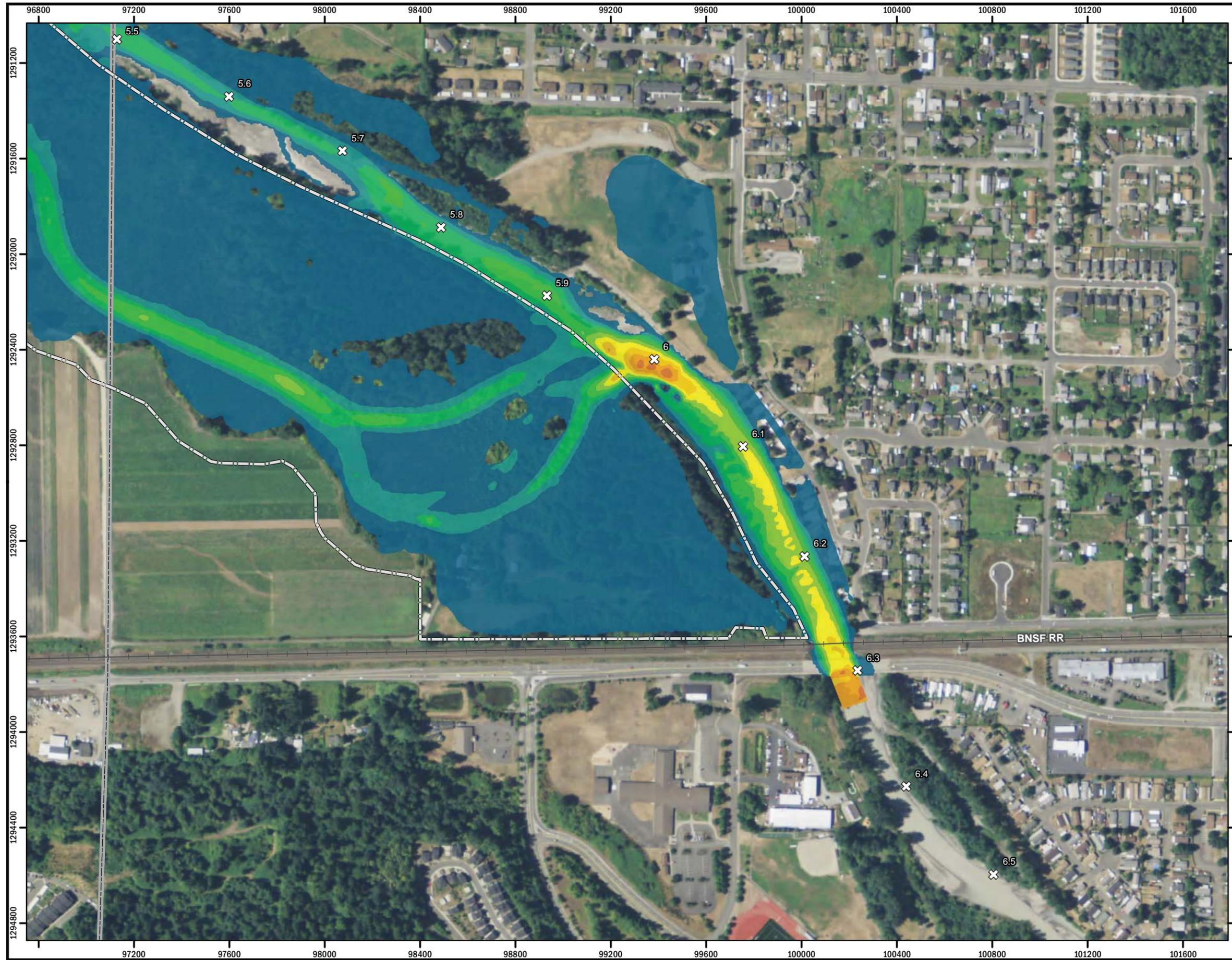


Figure A-42. Sheet A.
With Project Fully Evolved (S1c)
Simulation Water Velocity Results
for the 2-year Flood Event.

Legend

Water velocity (ft/sec)

	0.05 to 2
	2 to 4
	4 to 6
	6 to 8
	8 to 10
	10 to 12
	12 to 14
	14 to 16
	16 to 18
	> 18

River mile

Railroad

Project area

County boundary

0 200 400 800
 Feet

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\reconned_delta_velocity_appendix_figures.mxd (6/13/2013)



Figure A-42. Sheet B.
With Project Fully Evolved (S1c)
Simulation Water Velocity Results
for the 2-year Flood Event.

Legend

Water velocity (ft/sec)

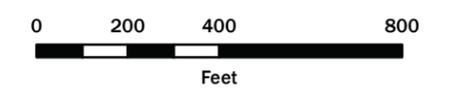
	0.05 to 2
	2 to 4
	4 to 6
	6 to 8
	8 to 10
	10 to 12
	12 to 14
	14 to 16
	16 to 18
	> 18

River mile

Railroad

Project area

County boundary

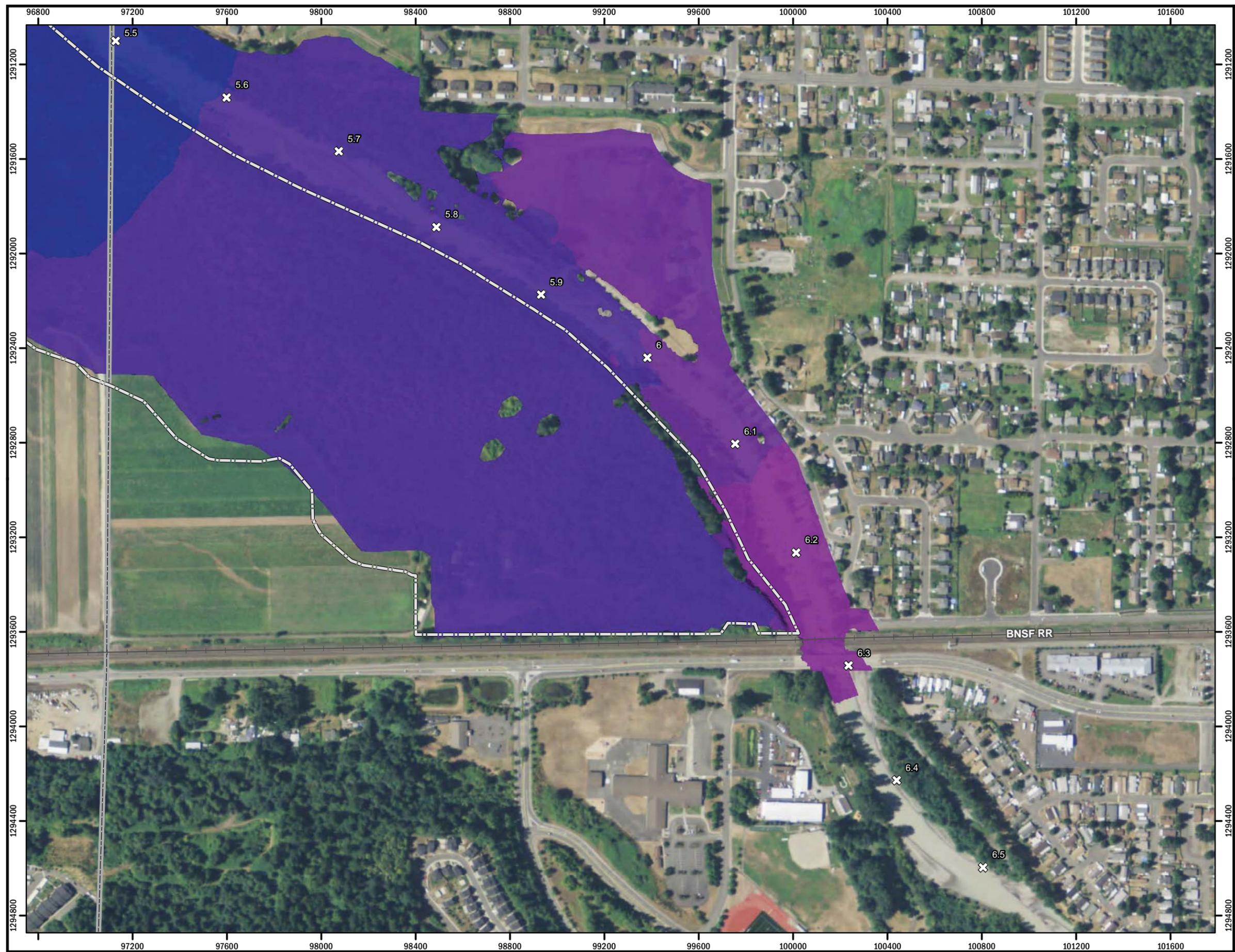


King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\rechecked_delta_in_velocity_appendix_figures.mxd (6/13/2013)

Figure A-43. Sheet A.
With Project Fully Evolved (S1c)
Simulation Water Surface Elevation
Results for the 100-year Flood Event.



Legend

Water surface elevation (feet)

- < 65
- 65 to 70
- 70 to 75
- 75 to 80
- 80 to 85
- 85 to 90
- 90 to 95
- > 95

River mile

Project area

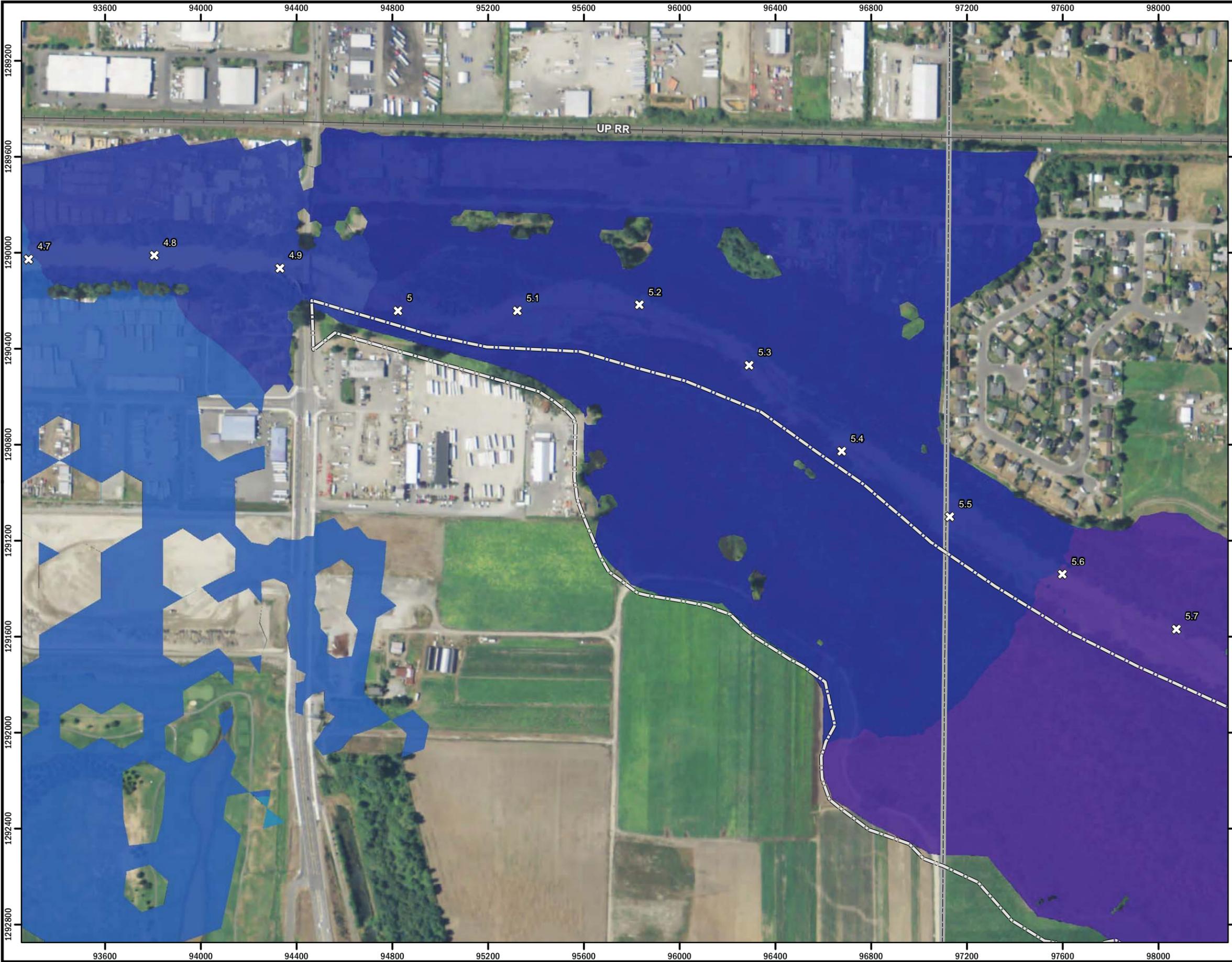
County boundary

0 200 400 800
 Feet

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\rechecked_domain_WSE_appendix_figures.mxd (6/13/2013)

Figure A-43. Sheet B.
With Project Fully Evolved (S1c)
Simulation Water Surface Elevation
Results for the 100-year Flood Event.

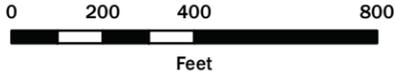


Legend

Water surface elevation (feet)

- < 65
- 65 to 70
- 70 to 75
- 75 to 80
- 80 to 85
- 85 to 90
- 90 to 95
- > 95

- River mile
- Project area
- County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project K:\Projects\130-04770-000\Project\HAM_Mapping_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

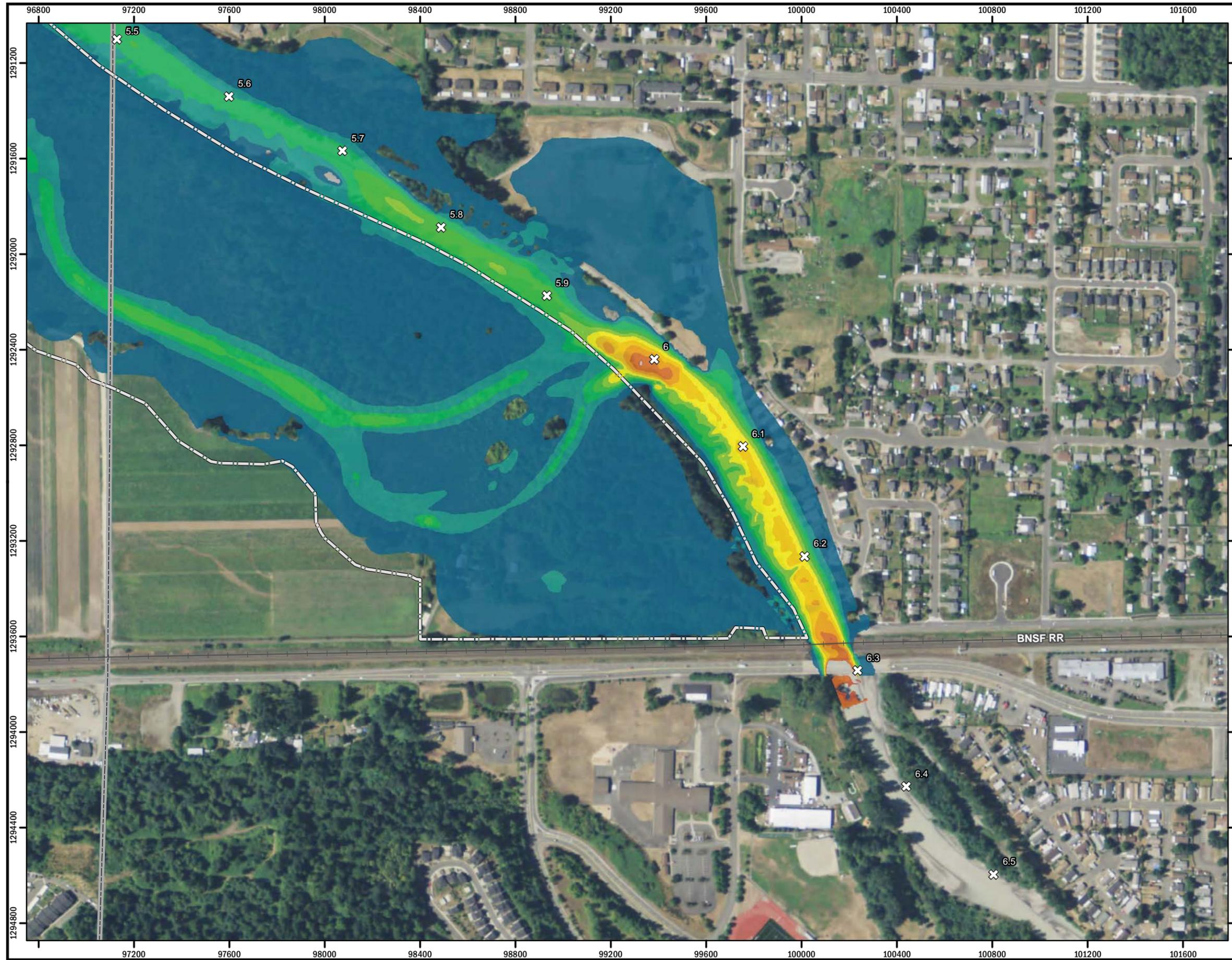


Figure A-44. Sheet A.
With Project Fully Evolved (S1c)
Simulation Water Velocity Results
for the 100-year Flood Event.

Legend

Water velocity (ft/sec)

0.05 to 2
2 to 4
4 to 6
6 to 8
8 to 10
10 to 12
12 to 14
14 to 16
16 to 18
> 18

⊗ River mile

—+— Railroad

⎓ Project area

— County boundary





Feet


King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\rechecked_delta_velocity_appendix_figures.mxd (6/13/2013)

Figure A-44. Sheet B.
With Project Fully Evolved (S1c)
Simulation Water Velocity Results
for the 100-year Flood Event.

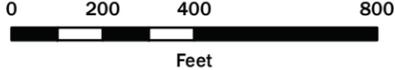


Legend

Water velocity (ft/sec)

-  0.05 to 2
-  2 to 4
-  4 to 6
-  6 to 8
-  8 to 10
-  10 to 12
-  12 to 14
-  14 to 16
-  16 to 18
-  > 18

-  River mile
-  Railroad
-  Project area
-  County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Mapping\Figures\rechecked_delta_velocity_appendix_figures.mxd (6/13/2013)

Figure A-45. Sheet A.
With Project Fully Evolved (S1c)
Simulation Water Surface Elevation
Results for the 500-year Flood Event.

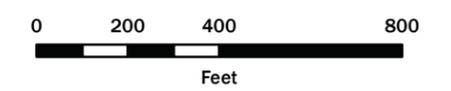


Legend

Water surface elevation (feet)

- < 65
- 65 to 70
- 70 to 75
- 75 to 80
- 80 to 85
- 85 to 90
- 90 to 95
- > 95

- River mile
- Project area
- County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project K:\Projects\10-04770-000\Project\Map_Monitoring_Figures\reworked_domain_WSE_appendix_figures.mxd (6/13/2013)

Figure A-45. Sheet B.
 With Project Fully Evolved (S1c)
 Simulation Water Surface Elevation
 Results for the 500-year Flood Event.



Legend

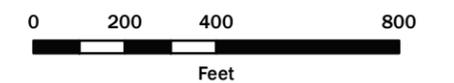
Water surface elevation (feet)

-  < 65
-  65 to 70
-  70 to 75
-  75 to 80
-  80 to 85
-  85 to 90
-  90 to 95
-  > 95

 River mile

 Project area

 County boundary



Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

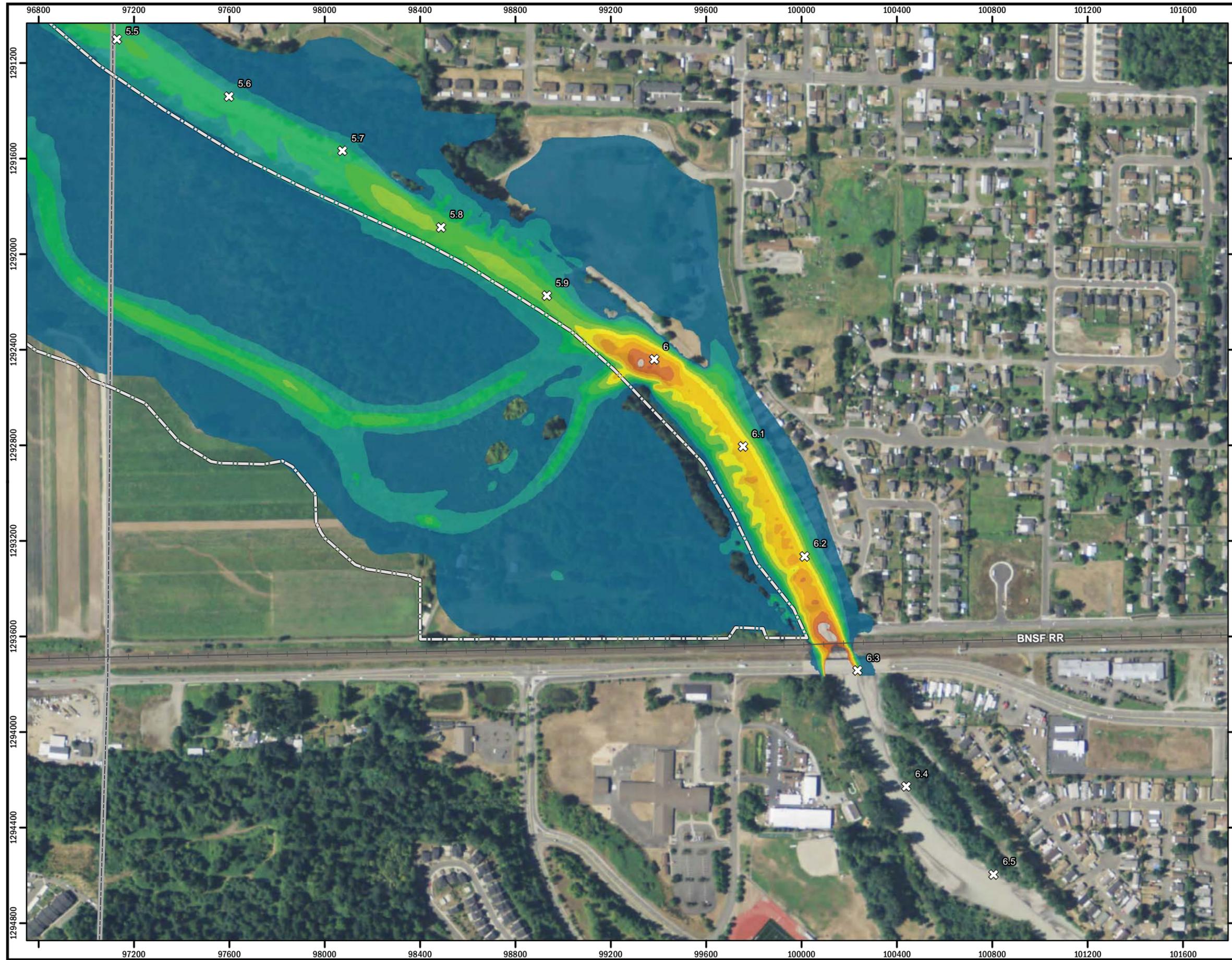


Figure A-46. Sheet A.
With Project Fully Evolved (S1c)
Simulation Water Velocity Results
for the 500-year Flood Event.

Legend

Water velocity (ft/sec)

0.05 to 2
2 to 4
4 to 6
6 to 8
8 to 10
10 to 12
12 to 14
14 to 16
16 to 18
> 18

⊗ River mile

—+— Railroad

⎓ Project area

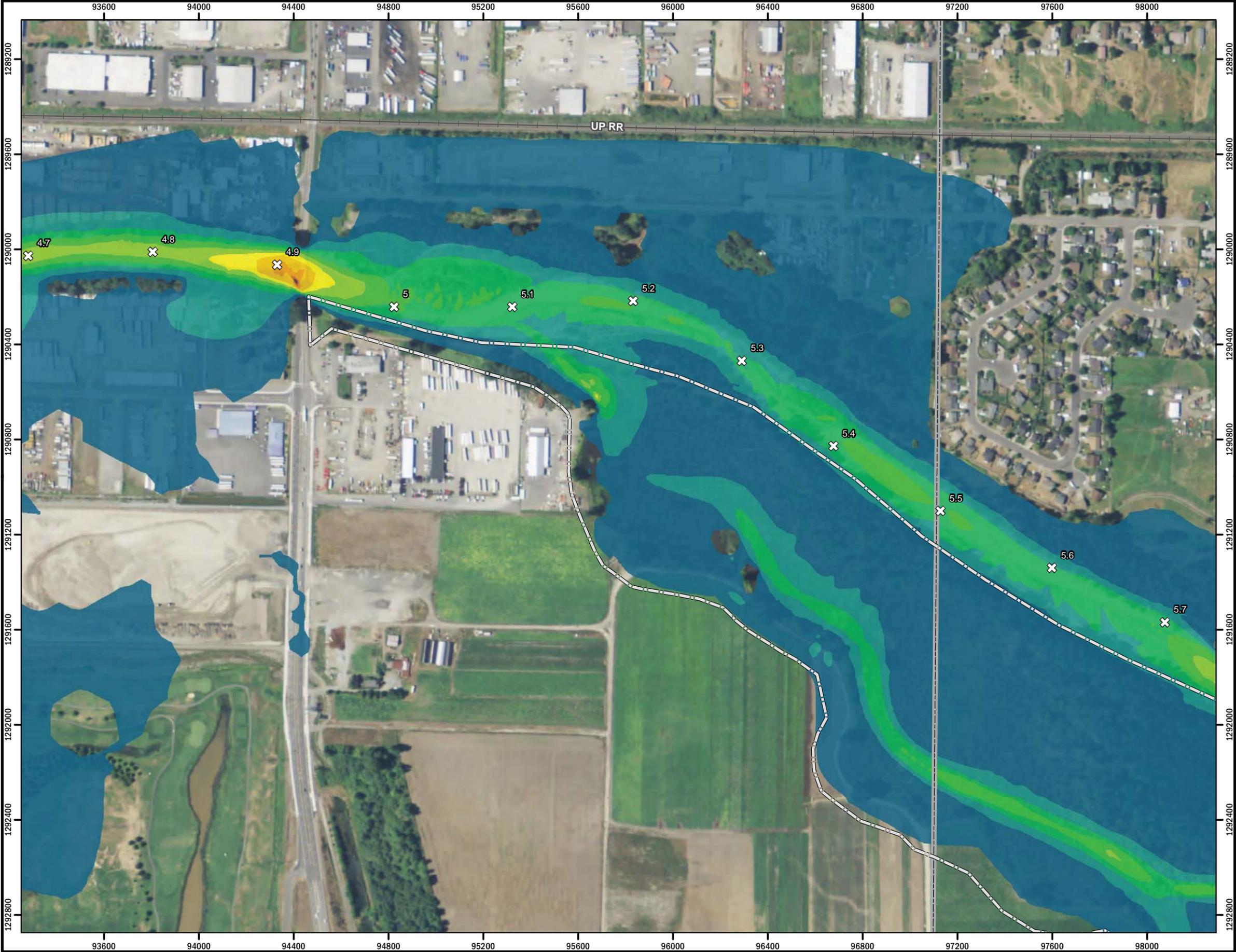
— County boundary

0 200 400 800
 Feet

King County
 Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\rechecked_delta_velocity_appendix_figures.mxd (6/13/2013)

Figure A-46. Sheet B.
With Project Fully Evolved (S1c)
Simulation Water Velocity Results
for the 500-year Flood Event.

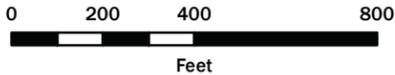


Legend

Water velocity (ft/sec)

-  0.05 to 2
-  2 to 4
-  4 to 6
-  6 to 8
-  8 to 10
-  10 to 12
-  12 to 14
-  14 to 16
-  16 to 18
-  > 18

-  River mile
-  Railroad
-  Project area
-  County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\rechecked_delta_velocity_appendix_figures.mxd (6/13/2013)



Figure A-47. Sheet A.
With Project Fully Evolved (S1c)
Simulation Water Surface Elevation
Results for Mean Annual Flow.

Legend

Water surface elevation (feet)

	< 65
	65 to 70
	70 to 75
	75 to 80
	80 to 85
	85 to 90
	90 to 95
	> 95

River mile

Project area

County boundary

0 200 400 800
 Feet

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)



Figure A-47. Sheet B.
With Project Fully Evolved (S1c)
Simulation Water Surface Elevation
Results for Mean Annual Flow.

Legend

Water surface elevation (feet)

	< 65
	65 to 70
	70 to 75
	75 to 80
	80 to 85
	85 to 90
	90 to 95
	> 95

River mile

Project area

County boundary

0 200 400 800
 Feet

King County

Prepared for King County by Herrera
 Aerial: USDA (2009)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced by: GIS
 Project: K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\reconned_domain_WSE_appendix_figures.mxd (6/13/2013)

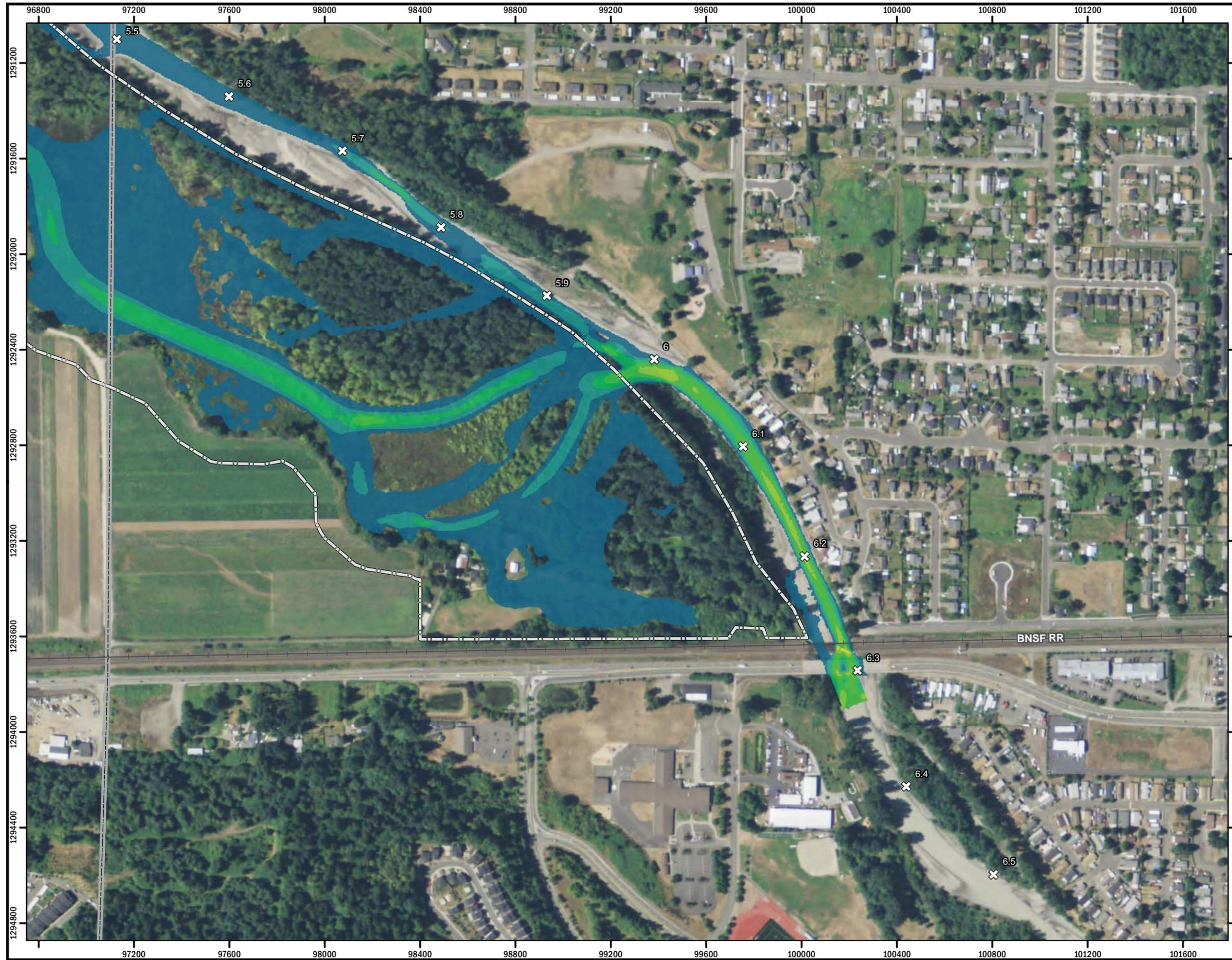


Figure A-48. Sheet A.
With Project Fully Evolved (S1c)
Simulation Water Velocity Results
for Mean Annual Flow.

Legend

Water velocity (ft/sec)

	0.05 to 2
	2 to 4
	4 to 6
	6 to 8
	8 to 10
	10 to 12
	12 to 14
	14 to 16
	16 to 18
	> 18

River mile

Railroad

Project area

County boundary

0 200 400 800
 Feet

King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project: K:\Projects\10-04770-000\Project\HAM_Modeling_Figures\rechecked_delta_in_velocity_appendix_figures.mxd (6/13/2013)



Figure A-48. Sheet B.
With Project Fully Evolved (S1c)
Simulation Water Velocity Results
for Mean Annual Flow.

Legend

Water velocity (ft/sec)

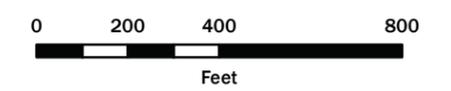
0.05 to 2
2 to 4
4 to 6
6 to 8
8 to 10
10 to 12
12 to 14
14 to 16
16 to 18
> 18

⊗ River mile

—+— Railroad

⎓ Project area

— County boundary



King County

Prepared for King County by Herrera
 Aerial: USDA (2011)
 Coordinates: NAD 1983 Washington
 State Plane North (ft)

Produced By: GIS
 Project K:\Projects\10-04770-000\Project\HAM_Mapping_Figures\rechecked_delta_in_velocity_appendix_figures.mxd (6/13/2013)

