Appendix B1. Sacramento River Flood Flow Hydraulic Modeling – HEC-RAS 2D (Final Draft)

1. Introduction and Purpose

The purpose of this technical memorandum (TM) is to document the results of the river hydraulic modeling used to evaluate the effects of flood flows on the Sacramento River water surface elevations and related flow characteristics resulting from installation of the proposed water intake facilities for the Delta Conveyance Project (Project).

1.1 Organization

This TM includes the following sections:

- Introduction and Purpose
- Background
- Flood Flows and Profiles – USACE and CVFPB
- Model Scenarios
- Model Baseline and Calibration
- Model Limits
- Model Development
- Model Results
- Conclusions
- References
- Attachment 1 – Figures
- Attachment 2 – Water Surface Superelevation Information
- Attachment 3 – River Flow Velocity Information

2. Background

The intake sites are located between the town of Clarksburg and Courtland along the portion of the Sacramento River designated as Reach 08 by the Central Valley Flood Protection Board (CVFPB). Potential intake sites were evaluated by the DCA and site selection was documented in the Concept Engineering Report (CER) Appendix B6 – *Intake Site Identification and Evaluation*. The Project includes two intake structures, C-E-3, and C-E-5, located at river mile (RM) 39.7 and 37.2 on the Sacramento River, each capable of conveying up to 3,000 cubic-feet-per-second (cfs) for a total Project flow capacity of 6,000 cfs.

2.1 Diversion Capacity

The capacity and associated size included in the hydraulic model for Intakes C-E-3 and C-E-5 would be 3,000 cfs. However, for worst case flood modeling, these intakes were assumed to not be diverting (i.e. not operating) during the modelled flood events. Therefore, there would be no decrease in river flow at the intakes for the analyses described in this TM. Additionally, modeling the intakes sized at these capacities would encroach on the existing river channel cross section and results demonstrate the maximum increase in river WSEL at the flood flows considered. Intakes with a smaller combination of capacities would result in less increase to the WSELs.

2.2 Intake Sites

The intake sites evaluated in the hydraulic modeling are shown on Figure G01 (included in Attachment 1 at the end of this TM). These include sites for Intakes C-E-3 and C-E-5. The nature of these water intake structures requires their placement along the bank of the Sacramento River, with the structure projecting a short distance into the flowing river to divert water. Such a projection into the river would constrict a portion of the channel cross-section along the respective length of each intake and would affect river hydraulics. The effect on river hydraulics is dependent on the combination of intakes used to achieve Project needs, the phase of construction for each intake, and the size of the structure (related to diversion capacity).

Table 1 lists the approximate river mile along Sacramento River Reach 08 for each intake site location.

Table 1. Intake Site Locations Along Sacramento River

Intake	Approximate River Mile at Center of Intake Facility
Intake C-E-3	39.7
Intake C-E-5	37.2

2.3 Fish Screen Type

Cylindrical tee screens were selected as the fish screen type as evaluated and documented in CER Appendix B7 *Intake Screen Sizing – North Delta Intakes*.

2.4 In-River Configuration

The finished, or proposed “as-built”, configuration of the intake structures is referred to as the “permanent” condition in this TM. During the construction phase, work at the intake structures requires the use of cofferdams to dewater the construction area and separate the work from the flowing river. The cofferdam footprint would project further into the river than the permanent condition. The construction phase configuration of the intake structures, including the cofferdams, is referred to as the “construction” condition in this TM. Both the permanent and construction conditions were evaluated for each flood flow scenario and each combination of intake sites.

3. Flood Flows and Profiles - USACE and CVFPB

The Sacramento River has overlapping jurisdictions across various federal and state agencies involved in flood management, including the United States Army Corps of Engineers (USACE) and the CVFPB. These agencies have different requirements for flood studies along the Sacramento River in terms of the flood flows to be evaluated. The flood flow scenarios that require evaluation are defined as follows:

- **1957 Design Flow**– The 1957 design flow is used by the USACE as a baseline design flood event for the Sacramento River Flood Control Project (SRFCP). The design flow capacity through Sacramento River Reach 08 (SAC R08) is 110,000 cfs. This design flow and water surface elevation profile was adapted from the SRFCP levee and channel profiles dated March 1957 (USACE, 1957).
- **Central Valley Flood Protection Plan (CVFPP) 2022 Update scaled-events (DWR, 2021 and DWR, 2022)** – The scaled-events listed below and water surface profiles provided by DWR are the closest approximation of the applicable return period events in the reach of the river included the 2D analysis presented in this TM. They are based on the assumptions used in the 2022 update of the CVFPP (DWR, 2022). The CVFPP analysis applies a probabilistic approach that ensembles a range of

scaled model runs to calculate the Annual Exceedance Probability at specific limited points within the flood control system for risk analysis and the scale-event selection will change from tributary to tributary, river mile to river mile.

- **Existing Condition Approximate 100-year Event (105% of 1997 event)** – This flow scenario is "Existing 100-year (yr) Event". The existing 100-yr event is used by the CVFPB as a baseline flood event that has 1 in 100 (1 percent) chance of being exceeded in any given year. The existing 100-yr event flow through SAC R08 is 113,434 cfs.
- **Existing Condition Approximate 200-year Event (115% of 1997 event)** –This flow scenario is "Existing 200-yr Event". The existing 200-yr event is used by the CVFPB as a baseline flood event that has 1 in 200 (0.5 percent) chance of being exceeded in any given year. The existing 200-yr event flow through SAC R08 is 117,099 cfs.
- **Future Condition Approximate 100-year Event (115% of 1997 event with Climate Change [CC] and Sea Level Rise [SLR])** –This flow scenario is "Future 100-yr Event". The future 100-yr event is used by the CVFPB as a future baseline flood event that has about a 1 in 100 (1 percent) chance of being exceeded in any given year and includes the future Median Climate Change Scenario, sea level rise (SLR), and increased river flows projected for future conditions (year 2072) as assumed in CVFPB's development of this event. The future 100-yr event flow through SAC R08 is 116,652 cfs.
- **Future Condition Approximate 200-year Event (135% of 1997 event with CC and SLR)** – This flow scenario is "Future 200-yr Event". The future 200-yr event is used by the CVFPB as a baseline flood event that has about a 1 in 200 (0.5 percent) chance of being exceeded in any given year and includes the future Median Climate Change Scenario, SLR, and increased river flows projected for future conditions (year 2072) as assumed in CVFPB's development of this event. The future 200-yr event flow through SAC R08 is 119,922 cfs.

A baseline WSEL profile was established through SAC R08 for each of the flood flow scenarios described above. For the USACE 1957 Design Flow, the WSEL profile was adapted from the SRFCP levee and channel profiles dated March 1957. The 1957 design profile was verified to match the same values presented by the CVFPB as part of the CVFPP.

Baseline profiles that reflect results from the CVFPB's 1D HEC-RAS modelling for the 2022 update of the CVFPP (DWR, 2022) were provided to DCA by DWR in October 2021 (DWR, 2021) for each of the non-USACE scaled-event flood flow scenarios described above. The CVFPB provided a set of DSS data files containing output from the HEC-RAS models for each condition, including water surface profiles along SAC R08.

The profiles provided for the CVFPP Future Conditions listed above assume a SLR of 3.68 feet at the Golden Gate, estimated for year 2072. Note that the SLR used for the CVFPP profiles is not the same as the SLR used for the Project EIR, but reflects the river hydrologic and hydraulic conditions by which the CVFPB will consider the impacts of the Project.

4. Model Scenarios

Table 2 lists the model scenarios evaluated and documented in this TM. The 13 models (or runs) listed below are organized into model types for model run management. Model Numbers (Nos.) 1 through 5 are the calibrated baseline models representing existing river conditions (topography and bathymetry) at the flows and profile information described above. The baseline models do not include the intake structures and provide the basis of comparison for all subsequent models running the same flow scenario. Models Nos. 14 through 21 are the model runs for the various combinations of proposed conditions (both existing and future, applicable). Model runs for construction conditions are only evaluated against the 1957 Design and the Existing 100-yr and 200-yr Event cases since the cofferdams would no longer be in place during future conditions. As noted above, model runs for construction and permanent cases do not include flow diversion at the intakes.

Table 2. Model Scenarios

Model (Run) Number	Model Type	Flow Scenario	Model Description and Comments
1	**Calibrated baseline models**	1957 Design 110,000-cfs	Baseline model, without intakes, for comparison.
2		Existing 100-YR Event 113,434-cfs	Baseline model, without intakes, for comparison.
3		Existing 200-YR Event 117,099-cfs	Baseline model, without intakes, for comparison.
4		Future 100-YR Event 116,652-cfs	Baseline model, without intakes, for comparison.
5		Future 200-YR Event 119,922-cfs	Baseline model, without intakes, for comparison.
14	**Model Type 014** Tee Screen Intakes C-E-3, C-E-5 Permanent Condition	1957 Design 110,000-cfs	Model includes tee screen intakes in the permanent condition at Intake locations C-E-3 and C-E-5.
15		Existing 100-YR Event 113,434-cfs	Model includes tee screen intakes in the permanent condition at Intake locations C-E-3 and C-E-5.
16		Existing 200-YR Event 117,099-cfs	Model includes tee screen intakes in the permanent condition at Intake locations C-E-3 and C-E-5.
17		Future 100-YR Event 116,652-cfs	Model includes tee screen intakes in the permanent condition at Intake locations C-E-3 and C-E-5.
18		Future 200-YR Event 119,922-cfs	Model includes tee screen intakes in the permanent condition at Intake locations C-E-3 and C-E-5.

Model (Run) Number	Model Type	Flow Scenario	Model Description and Comments
19	**Model Type 015** Tee Screen Intakes C-E-3, C-E-5 Construction Condition	1957 Design 110,000-cfs	Model includes tee screen intakes in the construction condition at Intake locations C-E-3 and C-E-5.
20		Existing 100-YR Event 113,434-cfs	Model includes tee screen intakes in the construction condition at Intake locations C-E-3 and C-E-5.
21		Existing 200-YR Event 117,099-cfs	Model includes tee screen intakes in the construction condition at Intake locations C-E-3 and C-E-5.

Notes:

Runs 6 thru 12 and Runs 22 thru 27 are not included in this analysis

5. Model Baseline and Calibration

5.1 Model Baseline

Calibrated baseline models were developed for each flow scenario using existing topographic and bathymetric conditions and do not include the Project intakes. These baseline models are used for comparison to model runs that include the various combinations of intakes under permanent and construction conditions. Each of these baseline models were calibrated against their respective WSEL profiles described above. The calibration profiles are listed as follows and included in Attachment 1 (included at the end of this TM):

- Figure C01 – USACE 1957 Design Flow WSEL and Baseline Calibration Profile
- Figure C02 – Existing Conditions 100-yr Event WSEL and Baseline Calibration Profile
- Figure C03 – Existing Conditions 200-yr Event WSEL and Baseline Calibration Profile
- Figure C04 – Future Conditions 100-yr Event WSEL and Baseline Calibration Profile
- Figure C05 – Future Conditions 200-yr Event WSEL and Baseline Calibration Profile

5.2 Model Calibration

The 2D baseline model was calibrated against the 1957 design profile and the CVFPP scale-events 1D model results files introduced above. Since the baseline conditions and technologies used to develop the 1957 design profile and the CVFPP 1D model profiles is different than those described for the 2D model in this TM, it is not reasonable to expect a precise profile match using current conditions and 2D modeling analyses. Notable differences include changes in conditions of the reach of river being studied over time (bathymetric changes, riverbank changes, etc.) and the difference in calculation methods between the 1957 design profile, the CVFPP 1D modeling, and the current 2D modeling. In acknowledgment of these differences, the goal of model calibration was to obtain the best fit for WSELs at key locations along the model reach to establish baseline 2D model runs that closely approximate the 1957 and CVFPP profiles. Those calibrated model runs would then be used to assess the relative impact on baseline WSELs and river velocities against the new companion 2D model runs that include the proposed the intake facilities.

The baseline model running the 1957 design profile flow (Model Number 1 in Table 2) was calibrated to fit against the 1957 design profile along river reach SAC R08 between Sutter Slough and the American River. A Manning's n of 0.025 was used throughout the 2D flow area for models running the USACE 1957 design flow. The calibration profile, Figure C01 (included in Attachment 1 at the end of this TM), illustrates the best fit between Sutter Slough and a point on the profile just upstream of the Freeport Bridge. The primary point of calibration was the point upstream of the Freeport Bridge with a point near I Street as a secondary point of calibration. The slope of the calibration profile is consistent with the slope of the 1957 design profile.

The baseline models running the Existing and Future 100-yr and 200-yr Events (Model Nos. 2 through 5 in Table 2) were calibrated to fit against the respective profiles provided by DWR. Model calibration was conducted to emulate these profiles, to the extent reasonable. A Manning's n of 0.022 was used throughout the two-dimensional (2D) flow area for models running the Existing and Future 100-yr and 200-yr Event flows since it provided the best match to the one-dimensional (1D) model results at the same Freeport and I Street calibration points described above for the 1957 design profile calibration. The calibration profiles, Figures C02 through C05 (included in Attachment 1 at the end of this TM), show profile slopes consistent with the 1D model results provided by DWR.

5.3 Model Sensitivity

A review of the full system 1D HEC-RAS model results and profiles provided by DWR shows the Manning's n values for the Sacramento River reach SAC R08 range from 0.033-0.040 for the main channel and 0.033-0.080 for the riverbanks. Multiple calibration sensitivity runs were developed using the 2D model with Manning's n values similar to those used in the 1D model runs. The resulting profiles from the 2D sensitivity runs show that WSELs did not match to the calibration points established at Freeport and I Street, as well as at other locations along the profile. The sensitivity runs also yielded water surface profiles with steeper slopes than the 1D results.

Due to the lack of consistency between 1D and 2D model results using the original 1D friction coefficients, 2D models running the 1957 design flow at Manning's n = 0.025 and 2D models running Existing and Future 100-yr and 200-yr Event flows at Manning's n = 0.022 were determined to most closely match the baseline profiles and were used for this analysis. The lower Manning's n in the 2D model relative to that used in the 1D model is not a concern, as the 2D model provides a good match to the respective USACE and CVFPP profiles. Also, since the 2D model has a better representation of the river channel geometry relative to the 1D model, it better accounts for geometry variations and does not require as high of a friction coefficient to represent the actual conditions.

6. Model Limits

6.1 Model Extents and Boundaries Conditions

The model extents and boundary condition locations are shown on Figure G01 (included in Attachment 1 at the end of this TM). The upstream boundary location is similar for all model runs and is located at the confluence of the Sacramento and American Rivers. The downstream boundary location was established near the town of Courtland at the confluence of the Sacramento River and Sutter Slough. Key boundary conditions are the river stage at the downstream boundary and river flow at the upstream boundary. These boundary conditions are used to compute the WSELs and related flow characteristics between the model limits. The model runs in this analysis use the peak steady state flow value, as define above and shown in Table 3, with no river inflows or outflows throughout the limits of the model. Modeled river conditions at the far upstream end of the model limits are generally not considered accurate for this type of 2D model analysis since that section does not have continuous upstream model domain and model results in this region reflect the modeling software converging on a solution for the remainder of the model domain. However, a short distance downstream, the model is more accurate. Model results up to about I Street are considered suitably accurate for this analysis.

Table 3 lists the boundary condition values for flow and stage used in the HEC-RAS model simulations. Note that the flows are those described above for each flood flow scenario and the downstream stage was adapted from the flood flow profiles provided for each flood flow scenario. Differences in the downstream boundary stage shown in Table 3 are primarily the result of different flow rates and the effect of SLR between existing and future conditions.

Table 3. Flow and Stage Boundary Conditions.

Flood Flow Scenario	Upstream Boundary Flow (cfs) at River Mile 60.41	Downstream Boundary Stage (elevation, feet) at River Mile 34.25
1957 Design Flow	110,000	20.71
Existing 100-yr Event	113,434	21.30

Flood Flow Scenario	Upstream Boundary Flow (cfs) at River Mile 60.41	Downstream Boundary Stage (elevation, feet) at River Mile 34.25
Existing 200-yr Event	117,099	21.49
Future 100-yr Event	116,652	21.97
Future 200-yr Event	119,922	22.45

6.2 Urban and Non-Urban Levees

Sacramento River Reach R08 is bordered by State Plan of Flood Control (SPFC) levees on both the left bank and right bank. These levees are categorized as either urban or non-urban levees by DWR. Figure G01 (included in Attachment 1 at the end of this TM) shows the extent of urban and non-urban levees along SAC R08. Levees categorized as either urban or non-urban have different flood protection requirements in terms of flow events. Urban levees use 200-yr event level of protection, while non-urban levees use 100-yr event level of protection. Along the right bank of SAC R08 the split between urban and non-urban levee occurs at river mile 51.7. Along the left bank the split between urban and non-urban levee occurs at river mile 45.6.

7. Model Development

The Sacramento River hydraulic model was developed using the USACE Hydrologic Engineering Center's River Analysis System (HEC-RAS) version 6.0 software (USACE, 2021). The model was developed as a 2D flow hydraulics model. This section discusses details and data sources used in the development of the 2D hydraulic model.

7.1 Coordinate System

The spatial coordinate system used for the hydraulic modeling is North American Datum (NAD) 1983 State Plane California II FIPS 0403 feet, which uses U.S. feet as the linear unit. The vertical datum used is the North American Datum of 1988 (NAVD 88) and uses U.S. feet as the linear unit.

7.2 Terrain and Bathymetric Data

Bathymetric surveys from 2019 were obtained in January 2020 from DWR (DWR, 2019) for the Sacramento River extending from the confluence with the American River downstream to Sutter Slough. The DWR bathymetric survey data included LiDAR information for the river side of the levees above the water line at the time of the survey. The bathymetric data was further supplemented by LiDAR data obtained from the Central Valley Floodplain Evaluation and Delineation Program (CVFED) to cover the land side levee portion of the terrain plus a 500-foot buffer further into the landside. The bathymetric survey data and the CVFED terrain data are a 1-foot grid cell resolution raster that cover the lateral extents of the Sacramento River within the limits described above. An existing conditions terrain surface was created using the combination of the DWR bathymetric data and CVFED data and was used to create the baseline 2D models in HEC-RAS. The method of including the intake structures into the HEC-RAS model is discussed below.

7.3 Model Domain - 2D Flow Area

The terrain surface and 2D flow areas are the main components of 2D models developed in HEC-RAS. The 2D flow area is made up of grid cells which HEC-RAS uses to perform hydraulic calculations on every grid cell face. HEC-RAS uses the cross section of terrain elevation along each cell face to calculate flow between adjoining cells at each model time step. The smaller the grid cell size the more calculations the software performs. For the river models described in this TM, a default grid cell size of 25-feet by 25-feet was used to develop the 2D flow area. Figure 1 shows the computational 2D mesh in the vicinity of Intake C-E-3. Note that the cell size along the intake structure uses a finer resolution to provide more detail at the structure and river interface. The 2D flow area extends from the left bank levee centerline to right bank levee centerline from the upstream boundary to the downstream boundary of the model domain.

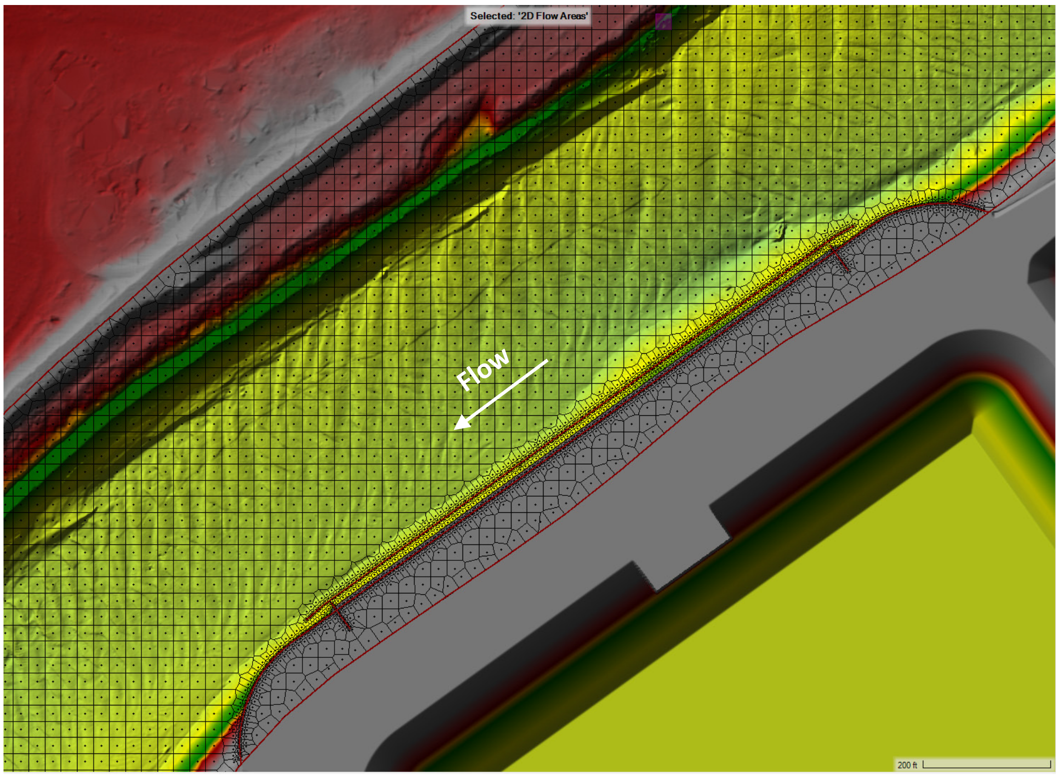

Figure 1. Computational 2D Mesh at Intake C-E-3

7.4 HEC-RAS 2D Flow Simulations

HEC-RAS performs 2D flow simulations and hydraulic calculations using a range of user-specified solution schemes that control the complexity of the numerical equations used to calculate hydraulic results. The Sacramento River along reach R08 has characteristics most compatible with use of the Full Momentum option within HEC-RAS given that the R08 reach of the Sacramento River is relatively flat and is tidally influenced. Therefore, the Full Momentum option was used in all models. The model water surface tolerance was set at 0.01-foot.

7.5 Intake Screens

The intake screens conceptual design and sizing is covered in CER Appendix B7. The sections below summarize the relevant information used to model the intake facilities in HEC-RAS.

7.5.1 Cylindrical Tee Screen Intake Structure

The cylindrical tee screen intake structure includes the following structural elements: the upstream and downstream wingwalls, the screen intake headwall (face of concrete structure), the 8-foot diameter cylindrical tee screens, a structural slab in front of the headwall and below the screens, and the log boom support piles. For the construction condition, the structure includes the cofferdam without the tee screen units installed and does not include the log boom piles.

The schematic sketch below (Figure 2) illustrates how the tee screen structure projects into the river in section view and how the screen units are represented in the model. The cylindrical screens extend about 11-feet beyond the intake structure headwall and 8-feet from top of screen to bottom of screen. Given the 2D nature of the model, the screens cannot be modeled with space under them. Therefore, the screens are represented in the model as an 11-foot wide rectangular step situated at the bottom of the headwall. The top of the screen unit was modeled with elevations depending on intake location. For modeling convenience, the rectangular step extends further to the bottom of the structural slab of the main intake structure, as shown in the sketch. Since the finished grades of the river bottom intersect the structure at the slab elevation, the additional depth of the screen step does not interact with the river and therefore has no effect on the results of the modeling. At Intakes C-E-3 and C-E-5 the tops were modeled at the screen centerline elevation of -9.0 feet and slab elevation of -17.0 feet.

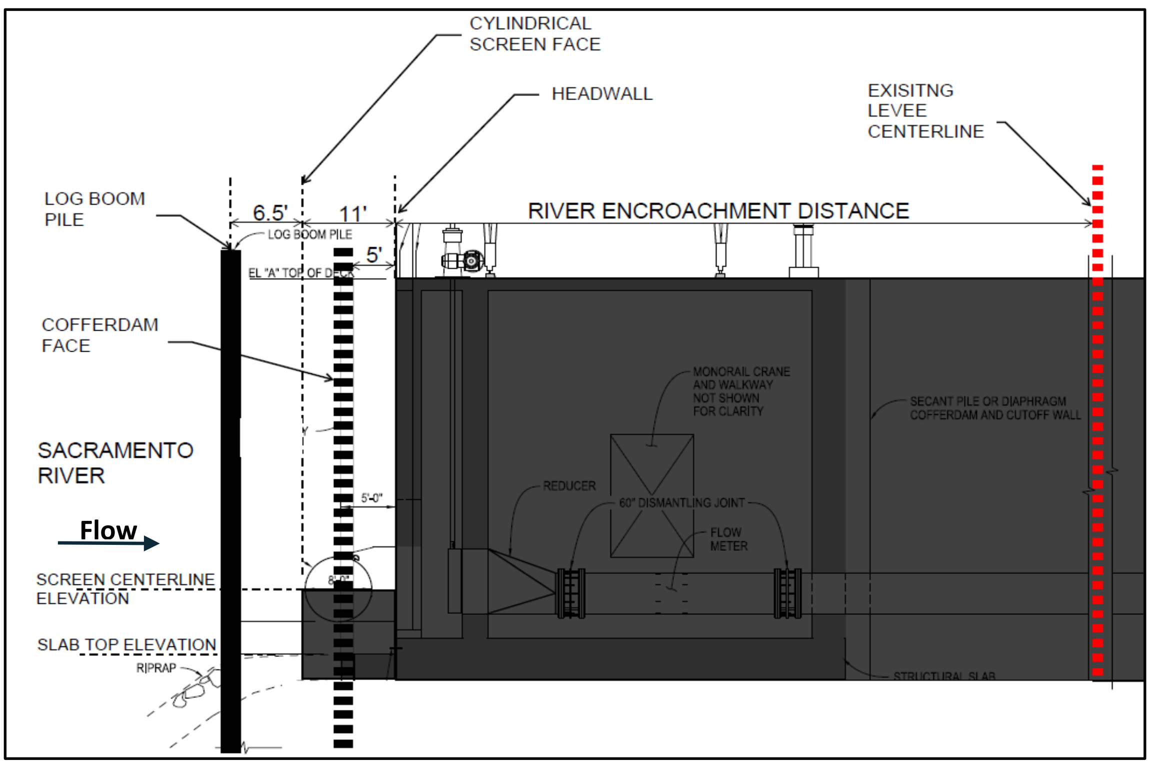

Figure 2. Schematic Profile Sketch of Cylindrical Tee Screen Intake Structure

7.5.2 Log Boom Piles and Cofferdam

The log boom support piles are aligned along the length of each intake structure, located 17.5 feet from the intake headwall to the pile centerline and spaced about 35 feet center-to-center. The log boom support piles are modeled in HEC-RAS by building each pile directly into the terrain for the permanent scenarios only. Piles would not be in place during construction phase flood seasons, so they are excluded from the construction conditions model runs. Pile geometry in the 2D models is tapered to allow inclusion in the terrain and results in about the equivalent of a 36-inch diameter pile (18-24-inch is actually planned). This configuration provides additional flow blockage to account for possible debris on the piles. For the construction conditions model runs, the cofferdam is modeled as a smooth wall face projecting 5-feet further into the river than the intake headwall. Frictional characteristics of the wall are the same as the overall model friction coefficient.

7.5.3 Modeling the Tee Screen Intake Structure

The overall cylindrical tee screen intake structure geometry was developed from CAD design files with a terrain surface developed to represent the intake structure footprint. The intake structure terrain surface was merged with the existing conditions terrain surface in HEC-RAS to create a proposed conditions "with-project" terrain for the tee screens. The images in the sketches below (Figures 3 and 4) illustrate the intake structure surface merged into the existing terrain for Intake C-E-3 and would be similar for Intake C-E-5. Merging the intake structure terrain with the existing conditions terrain for the permanent condition created areas within the river bathymetry model terrain in front of the intake structures that would need to be excavated in order for flows to enter the intake screens. These locations were corrected within the model terrain for permanent conditions runs by grading the elevated areas in the river bathymetry.

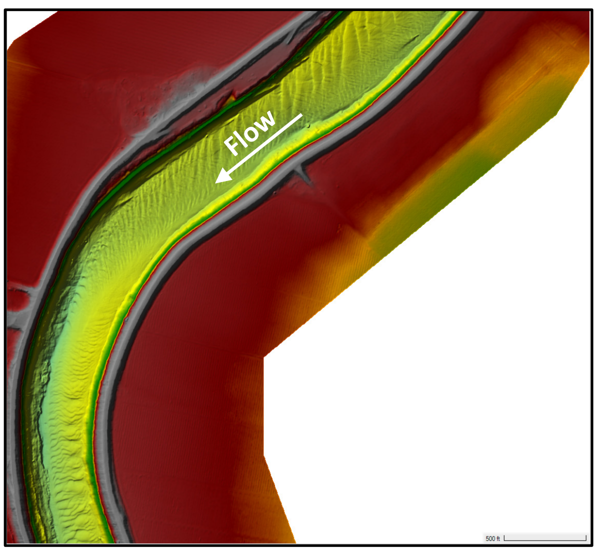

Figure 3. Existing Conditions at Intake C-E-3

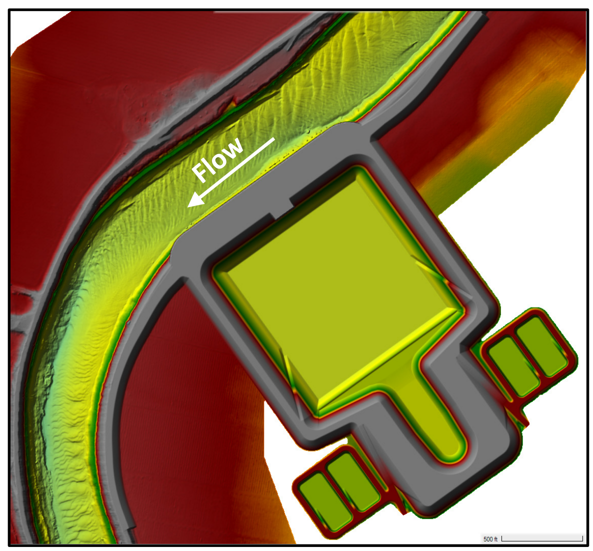

Figure 4. With-Project Conditions at Intake C-E-3

7.5.4 Typical Section of Cylindrical Tee Screen Intake Structure

The typical cross-section sketch below (Figure 5) is cut across the terrain surfaces used in HEC-RAS to represent the cylindrical tee screen intake structures. The sketch shows the existing conditions profile with the river levee as well as the permanent tee screens in the form of a step area near the bottom to represent the geometry of the tee screen cylinders as described above. Permanent in-river grading is also shown. That grading is included in the model geometry for the permanent cases and also includes assumed smooth transition grading to the existing levee on the upstream and downstream end of the structures. The cofferdam construction condition would not include in-river grading and is represented in the sketch by the cofferdam without in-river grading.

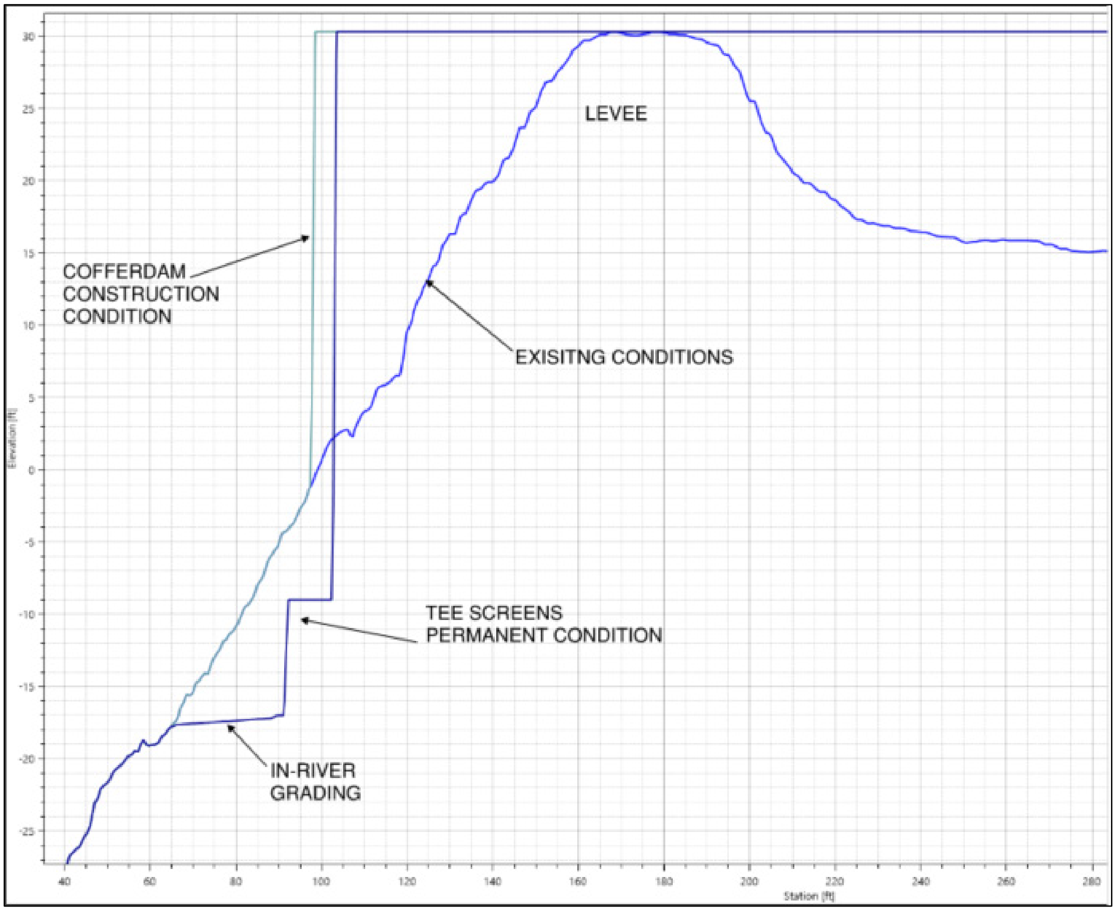

Figure 5. Typical Cross-Section Through Cylindrical Tee Screen Intake Structure

7.6 River Encroachment

CER Appendix B7 identified the typical plan layout for the tee screen intake structures. The major features of the intake structures that affect Sacramento River hydraulics are the intake training walls, the structural elements supporting the screens, the screens, and the log boom pile system. Figures 1 through 5 illustrate how the intake structures encroach into the Sacramento River. The lateral distance from the existing levee centerline to the face of the concrete structure supporting the screens is defined as the encroachment distance. During the construction phase the intake structure includes cofferdams that project 5 feet further into the river than the concrete structure. During the permanent operations phase the intake structure includes the tee screens that project about 11 feet further into the river than the concrete structure. Table 4 lists each intake structures' encroachment distance into the river for both the permanent and construction phase of the Project. The dimensions listed are approximate and vary along the length of the intake structure. Distances are measured from levee centerline along the lateral centerline of the intake structure to the river-side face of the concrete structure.

Table 4. Approximate River Encroachment Distance

Intake	River Station (RS)	River width Levee to Levee (ft)	Levee to Structure Encroachment Distance (ft)	Percent Blockage (Permanent)	Percent Blockage (Cofferdam)
Intake C-E-3	39.7	685	83	12.1%	12.8%
Intake C-E-5	37.2	764	112	14.7%	15.3%

8. Model Results

This section discusses the model scenarios with results described and tabulated below.

Results are summarized for:

- Water surface elevation differences over the model domain. The results for each model scenario showing WSEL difference profiles are described in Section 8.1 and included in Attachment 1 at the end of this TM.
- Water surface superelevation changes at key bend locations near the intake structures. The bend locations and bathymetric river cross sections at the bend location are included in Attachment 2 at the end of this TM. The results for each model scenario including water surface superelevation differences are described in Section 8.2 and tabulated in Attachment 2 at the end of this TM.
- Velocity and velocity differences in the vicinity of the intake structures. The results for each model scenario represented by velocity contour plots and velocity difference plots are described in Section 8.3 and included in Attachment 3 at the end of this TM.

8.1 Water Surface Elevation Differences

The WSEL difference profiles show the impacts on water levels along the Sacramento River resulting from the proposed Project. The profiles are organized by Model Type based on the combination of intakes and the buildout phase – permanent or construction – as shown in Table 2. The WSEL difference profiles were generated by subtracting the existing conditions WSEL profile from the proposed Project conditions WSEL profile. The resulting difference profile is the estimated water level impact along SAC R08 for that specific model scenario.

Each model type was evaluated based on the flood flow scenarios described above. The WSEL difference profiles are organized as listed below, and included in Attachment 1 at the end of this TM. The WSEL difference profiles for each Model Type are stacked in the graphs included in the figures.

- Figure D01: Model Type 014—Tee Screen Intakes C-E-3 and C-E-5 Permanent Condition
- Figure D02: Model Type 015—Tee Screen Intakes C-E-3 and C-E-5 Construction Condition

Review of the water surface difference profiles shows that water levels drop at each intake location resulting from the constricted river cross-section causing the river to slightly increase velocity and drop a small amount in WSEL. Water levels normalize upstream and downstream of each intake location.

8.1.1 Model Type 014—Tee Screen Intakes C-E-3 and C-E-5 Permanent Condition

This Model Type includes the cylindrical tee screen intake structures at Intake locations C-E-3 and C-E-5 in the permanent condition. A model for each of the five flood flow scenarios was developed and compared against its respective baseline condition. Table 5 and Figure D01 show the differences in WSELs between the proposed Project conditions and existing conditions for each of the five flood flow scenarios.

- Results from Model Type 014 indicate that the maximum impact on Sacramento River water level occurs near Intake C-E-3 with a maximum rise in water surface of approximately 0.05-feet under the Future 200-yr Event. The impacts taper to lower values of WSEL increase as the water surface difference profile moves upstream.
- Water level impacts caused by Intake C-E-5 and C-E-3 range from 0.02- to 0.03-feet of WSEL increase at each location.

Table 5. Maximum Difference in WSELs for Model Type 014—Tee Screen Intakes C-E-3 and C-E-5 Permanent Condition

Flood Flow Scenario	Urban Levee Right Bank Maximum WSEL Difference (feet)	Urban Levee Left Bank Maximum WSEL Difference (feet)	Non-Urban Levee Right Bank Maximum WSEL Difference (feet)	Non-Urban Levee Left Bank Maximum WSEL Difference (feet)
1957 Design Flow	0.02	0.03	0.04	0.04
Existing 100-yr Event	0.03	0.03	0.04	0.04
Existing 200-yr Event	0.03	0.04	0.04	0.04
Future 100-yr Event	0.03	0.04	0.04	0.04
Future 200-yr Event	0.04	0.04	0.05	0.05

Notes:

1. Positive WSEL difference is an increase.
2. Maximum impact along right bank urban levee is at RM 51.7.
3. Maximum impact along the left bank urban levee is at RM 45.6.
4. Maximum impact along the right bank and left bank non-urban levee is at RM 40.0.

8.1.2 Model Type 015 —Tee Screen Intakes C-E-3 and C-E-5 Construction Condition

This Model Type includes the cylindrical tee screen intake structures at Intake locations C-E-3 and C-E-5 in the construction condition. A model for the three applicable flood flow scenarios was developed and compared against its respective baseline condition. Table 6 and Figure D02 show the differences in WSELs between the proposed Project conditions and existing conditions for the three applicable flood flow scenarios.

- Results from Model Type 015 indicate that the maximum impact on Sacramento River water level occurs near Intake C-E-3 with a maximum increase in water surface of approximately 0.10-feet under the Existing 200-yr Event. The impacts taper to lower values of WSEL increase as the water surface difference profile moves upstream.
- Water level impacts caused by Intakes C-E-5 and C-E-3 range from 0.04 to 0.06-feet of WSEL increase at each location.

Table 6. Maximum Difference in WSELs for Model Type 015—Tee Screen Intakes C-E-3 and C-E-5 Construction Condition

Flood Flow Scenario	Urban Levee Right Bank Maximum WSEL Difference (feet)	Urban Levee Left Bank Maximum WSEL Difference (feet)	Non-Urban Levee Right Bank Maximum WSEL Difference (feet)	Non-Urban Levee Left Bank Maximum WSEL Difference (feet)
1957 Design Flow	0.06	0.08	0.09	0.09
Existing 100-yr Event	0.07	0.08	0.10	0.10
Existing 200-yr Event	0.07	0.08	0.10	0.10

Notes:
1. Positive WSEL difference is an increase.
2. Maximum impact along right bank urban levee is at RM 51.7.
3. Maximum impact along the left bank urban levee is at RM 45.6.
4. Maximum impact along the right bank and left bank non-urban levee is at RM 40.0.

8.2 Water Surface Superelevation Changes

Water surface superelevation and "with-Project" differences were evaluated for all model runs and results are tabulated in Attachment 2 at the end of this TM. The WSEL at river centerline (same location as used for the WSEL difference profiles in Attachment 1) and at both the right and the left bank were considered at four bend locations in the vicinity of the proposed intake facilities (specific locations are shown in Attachment 2). For all model runs, water surface superelevation changes reflect the slightly higher overall river WSEL change shown in Attachment 1 and described above (Section 8.1). Only negligible changes in the relative water surface elevations were evident between the left, center, and right bank when comparing the baseline superelevation to the "with-Project" superelevation. Because superelevation changes are negligible for all model runs at all locations, no special consideration is needed at this time.

8.3 Velocity and Velocity Differences in the Vicinity of the Intake Structures

River flow velocity and river flow velocity differences resulting from proposed construction and permanent conditions were evaluated for all model runs. River flow velocity and river flow velocity difference contour plots at each intake and for each model type and run are included in Attachment 3 at the end of this TM.

Existing maximum river flow velocities in the river near the intakes are depicted in Attachment 3 and range from about 5 feet per second (fps) to just over 6.5 fps. The location of the maximum velocities varies somewhat depending on the flood flow scenario and location along the river.

Review of the velocity information in Attachment 3 shows that river flow velocities are relatively unchanged in the main river channel with some evidence of nominally higher velocities occurring immediately in front of the intake structures. Flow velocity increases in the main river channel are minimal and do not result in "with-Project" maximum velocities higher than those evident for existing conditions in this reach of the river. However, small velocity increases are evident for a short distance immediately in front of each intake structure. These increases, depending on flood flow and intake location, range from about 0.2 to 0.7 fps in portions of the river channel and drop to less than 0.5 fps in all cases along the riverbank. The increases are due to the presence of the intake structures which slightly skews the cross-sectional velocity distribution toward the far (right) bank at each intake. These velocity changes are very low magnitude, evident for only a short length in front of the intakes, and maximum velocity is maintained within the baseline velocity range in this portion of the river. These changes are not expected to result in additional erosion along the river channel since they are consistent with the maximum baseline velocities along this reach of the river. The existing natural and man-made bank and bottom conditions would be expected to provide equivalent erosion protection.

Greater velocity changes can occur at the interface between the river flow and the intake structures, with the most attention normally focused on the leading and trailing edges of the structure. Review of the velocity information in Attachment 3 shows that river flow velocities are actually predicted by the modeling to decrease at these interface locations. This decrease is due to the additional friction imposed by the structures at these locations. However, the depth averaged velocity analysis and grid size represented by 2D HEC-RAS modeling is not sensitive enough to define the actual scour potential at these interfaces. More detailed analysis would be conducted to specifically consider scour potential in support of future implementation phases of the work. Experience with this type of intake structure, suggests that some nominal level of scour force would be expected at these interfaces. However, given the relatively low overall river flow velocity and the small encroachment of these structures into the river, riprap slope protection planned for the intake structures would be expected to easily protect the river bottom and levee slope from the magnitude of the potential scour force.

Some of the velocity plots also show that the flow profile has a small potential for rotational flow (flow eddy areas), primarily just upstream and just downstream of the structures. Rotational flow would occur fully within the area proposed for riprap slope protection. These rotational flow areas are characterized by very low velocities (less than 3 fps for any model run) and are lower than baseline velocity conditions. Riprap slope protection planned for the intake structures would be expected to easily protect the river bottom and levee slope from the negligible scour forces suggested by this low magnitude rotational flow.

9. Conclusions

Review of the model development and results supports the following conclusions regarding the 2D HEC-RAS modeling of the Project.

Results show that for all model runs, the water surface superelevation changes relative to baseline conditions at four bends in the vicinity the intake facilities are negligible, and no special consideration is necessary at this time.

Results show that for all model runs, the river flow velocity and velocity changes relative to baseline conditions are consistently small enough to be effectively managed by the existing condition of the river bank and bottom or the proposed riprap slope protection included in the conceptual configuration of the intakes. Scour analysis and riprap design would be further evaluated during future design, and construction phases and no special consideration is necessary at this time.

9.1 Water Surface Elevation Changes

Model results for the permanent condition (Model Type 014) show WSEL increases less than 0.1 feet for all flood flow scenarios in both the urban and non-urban levee sections.

Model results for the construction condition (Model Type 015) show WSEL increases less than, or equal to, 0.1 feet for all applicable flood flow scenarios in both the urban and non-urban levee sections.

9.2 Other Considerations

In addition to revising the 2D HEC-RAS modeling after more design development, river modelling including scour analyses would be conducted to support riprap design and construction. Note that the minimal velocity changes described in the results above suggest that riprap scour protection will be feasible.

Also, during future design development, sediment transport modeling would be conducted to consider sediment movement and deposition and further define expected sediment behavior both before and after the installation of the intakes. Note that experience with similar intakes in the Sacramento River and the position of the intake sites along the river suggests that significant sediment deposition changes due to the new structures would not be expected.

Other analyses and modeling related to aquatic resources, detailed intake hydraulic design, river levee design, and other related features would also be conducted to support future implementation of the Project.

10. References

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U.S. Army Corp of Engineers, Institute for Water Resources Hydrologic Engineering Center. 2021. HEC-RAS River Analysis System, User’s Manual. Version 6.0. May.

United States Army Corp of Engineers (USACE), Sacramento District. 1957. Levee and Channel Profiles. Sacramento River Flood Control Project, California. File No. 50-10-3334.

Attachment 1
Figures

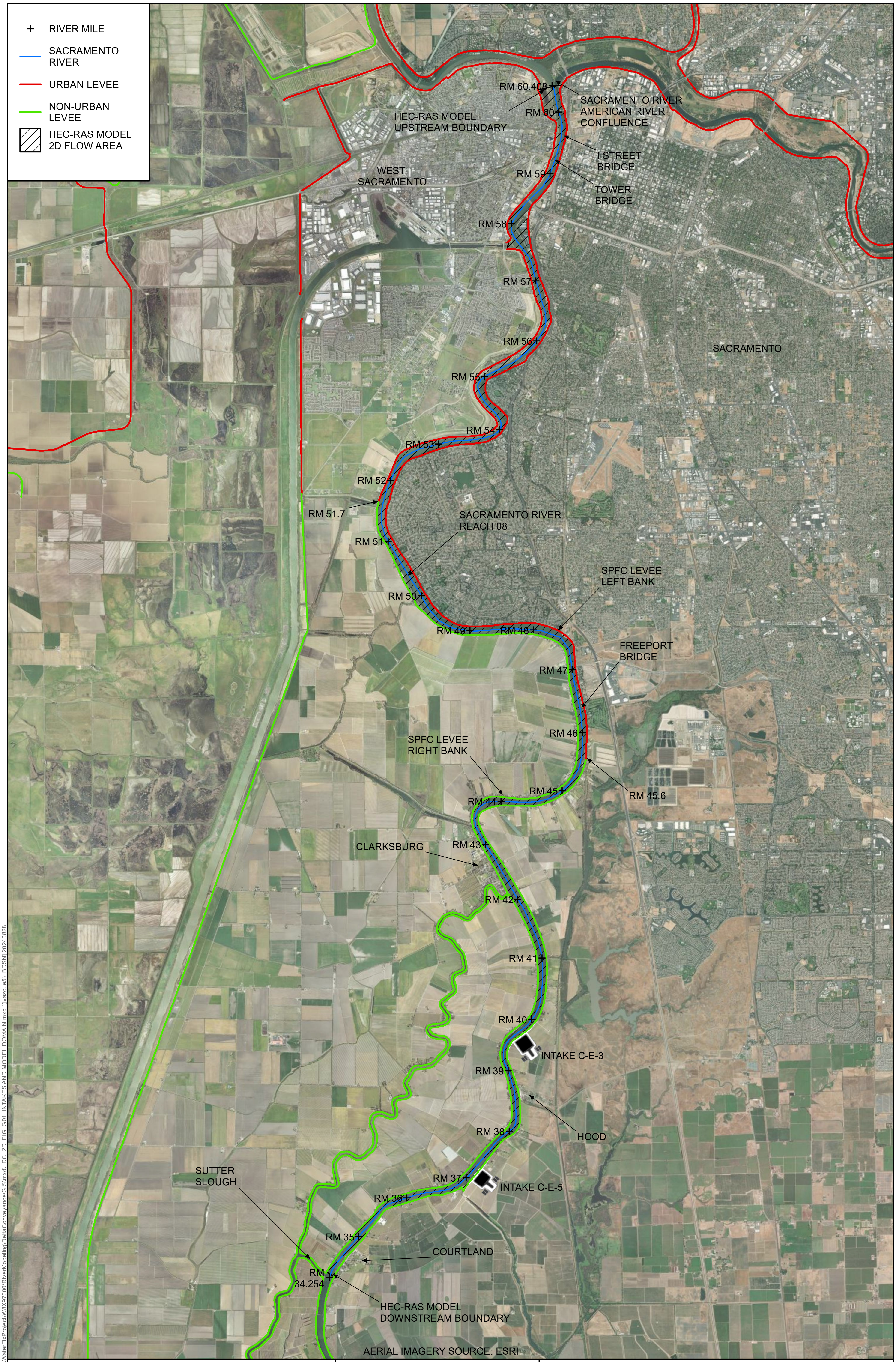
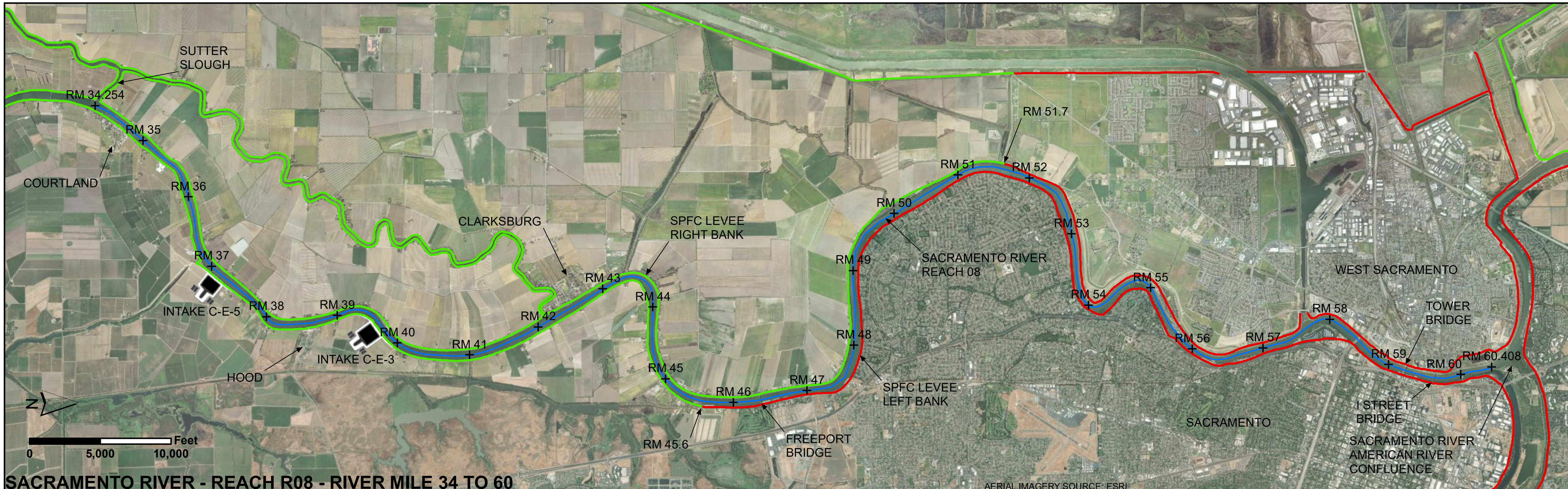


FIGURE G01
INTAKE LOCATIONS AND MODEL DOMAIN

DCA DELTA CONVEYANCE DESIGN & CONSTRUCTION AUTHORITY

Data Source: DCA, DWR



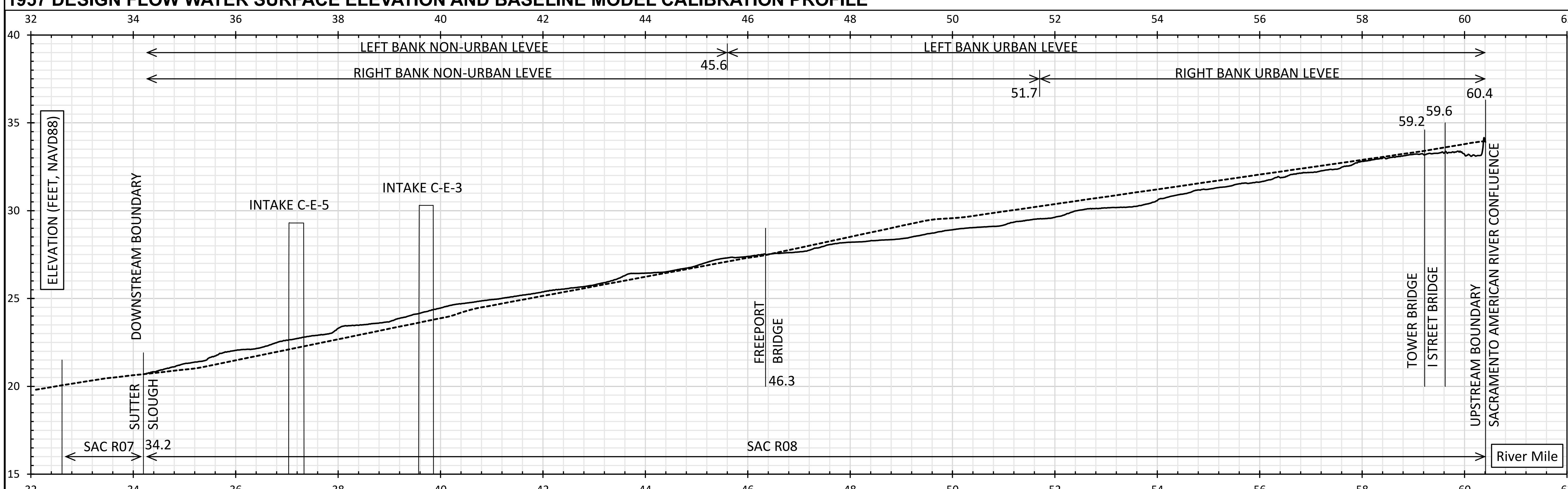
SACRAMENTO RIVER - REACH R08 - RIVER MILE 34 TO 60

PLAN LEGEND

- + RIVER MILE
- SACRAMENTO RIVER
- URBAN LEVEE
- NON-URBAN LEVEE

VICINITY MAP

1957 DESIGN FLOW WATER SURFACE ELEVATION AND BASELINE MODEL CALIBRATION PROFILE



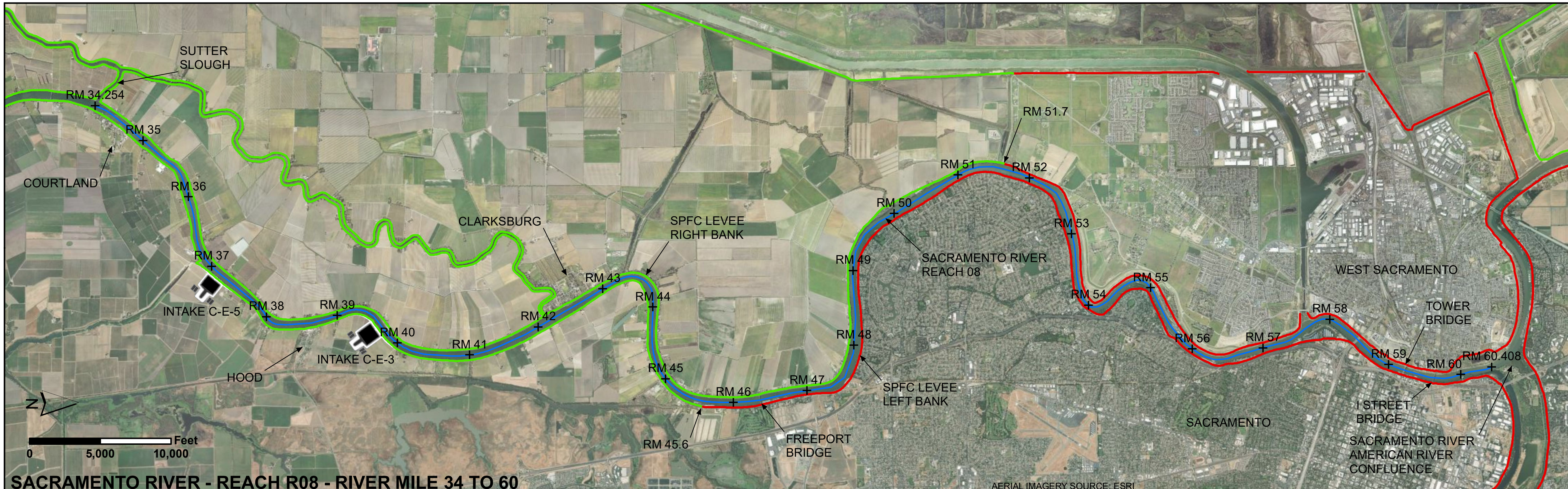
PROFILE LEGEND

- USACE 1957 BASELINE MODEL CALIBRATION
- 1957 DESIGN PROFILE

TITLE

1957 DESIGN FLOW WSE AND BASELINE MODEL CALIBRATION PROFILE

FIGURE C01

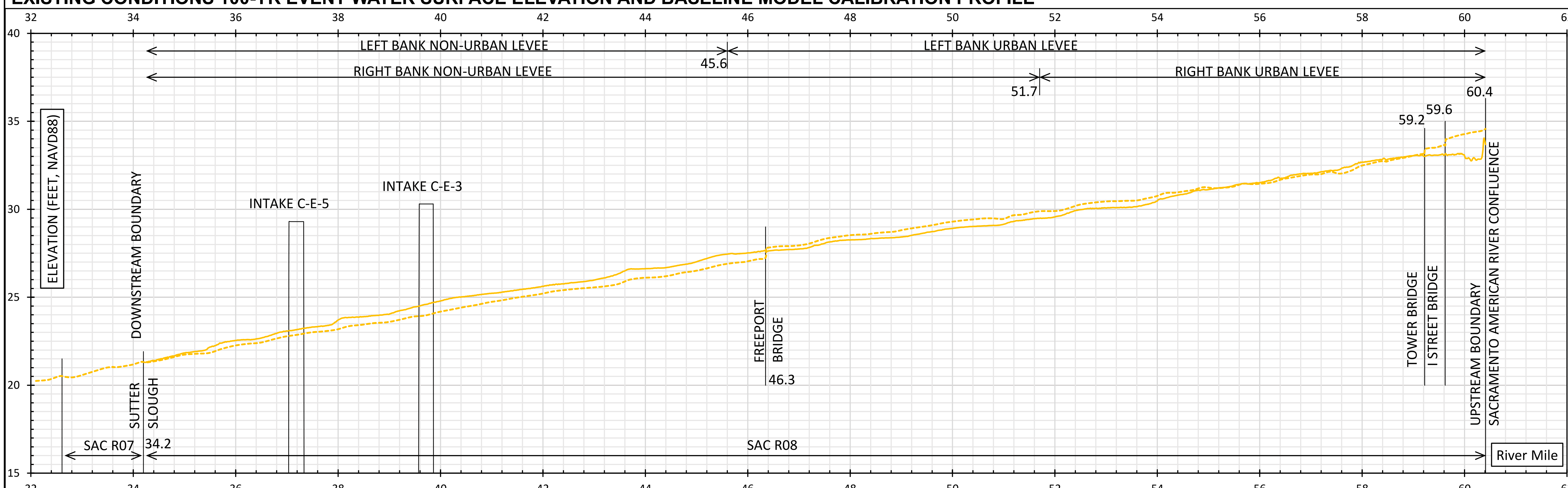


PLAN LEGEND

- + RIVER MILE
- SACRAMENTO RIVER
- URBAN LEVEE
- NON-URBAN LEVEE

VICINITY MAP

EXISTING CONDITIONS 100-YR EVENT WATER SURFACE ELEVATION AND BASELINE MODEL CALIBRATION PROFILE



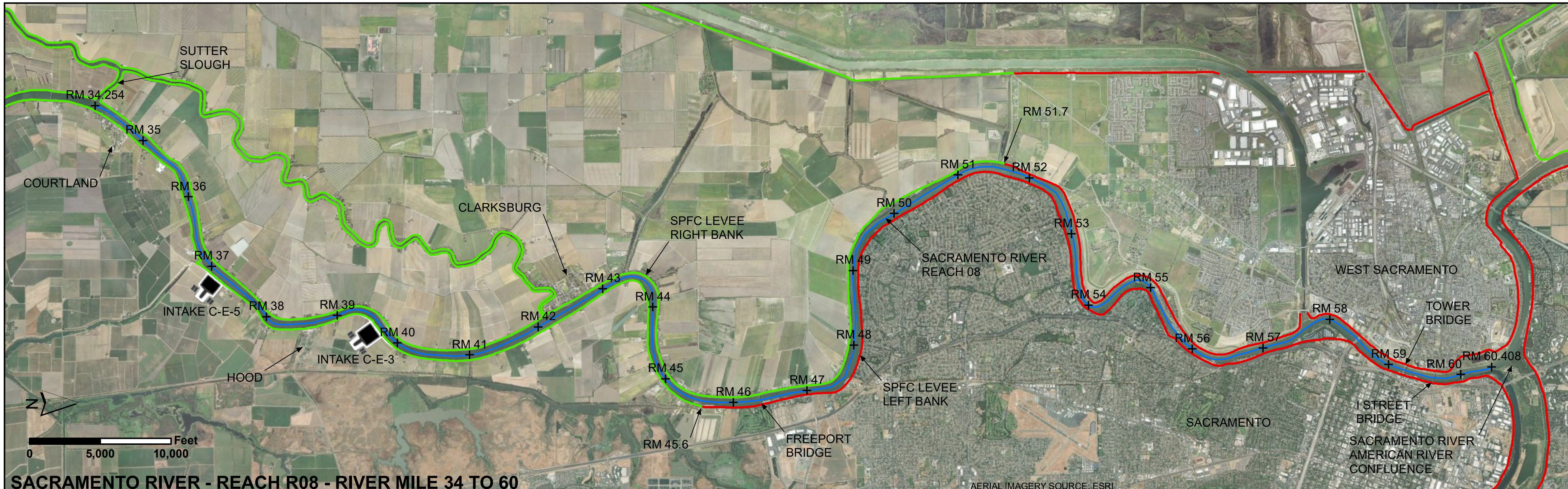
PROFILE LEGEND

- EXISTING 100-YR EVENT BASELINE MODEL CALIBRATION
- EXISTING 100-YR EVENT

TITLE

EXISTING CONDITIONS 100-YR EVENT WSE AND BASELINE MODEL CALIBRATION PROFILE

FIGURE C02

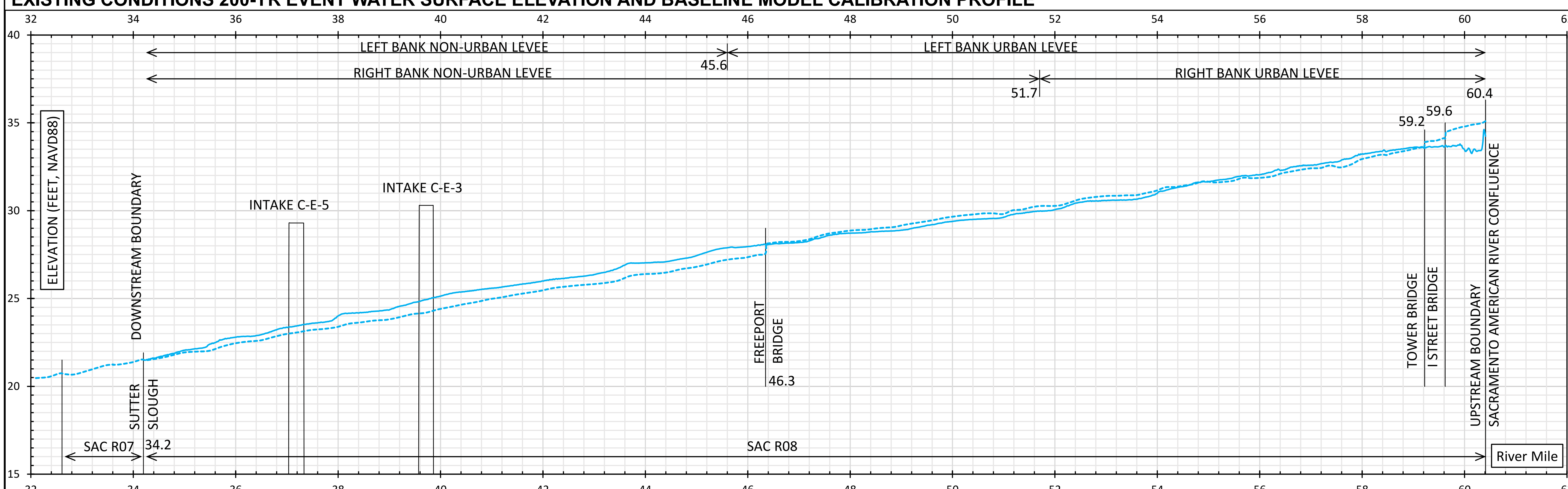


PLAN LEGEND

- + RIVER MILE
- SACRAMENTO RIVER
- URBAN LEVEE
- NON-URBAN LEVEE

VICINITY MAP

EXISTING CONDITIONS 200-YR EVENT WATER SURFACE ELEVATION AND BASELINE MODEL CALIBRATION PROFILE



PROFILE LEGEND

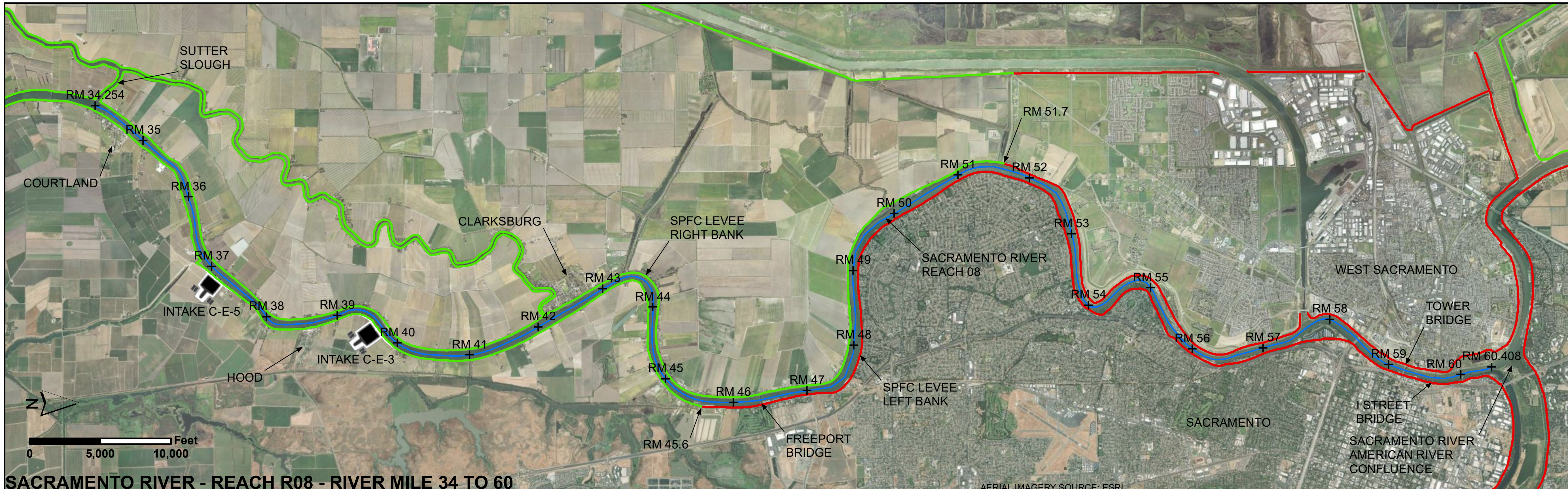
- EXISTING 200-YR EVENT BASELINE MODEL CALIBRATION
- EXISTING 200-YR EVENT

TITLE

EXISTING CONDITIONS 200-YR EVENT WSE AND BASELINE MODEL CALIBRATION PROFILE

FIGURE C03

Document Path: \\odin\Proj\DWR\DCA\WaterFixProject\W8X97000\RiverModeling\DeltaConveyance\GIS\mxd_DC_2D_FIG_C03_WSE_CALIBRATION_BethanyUpdate08282024.mxd

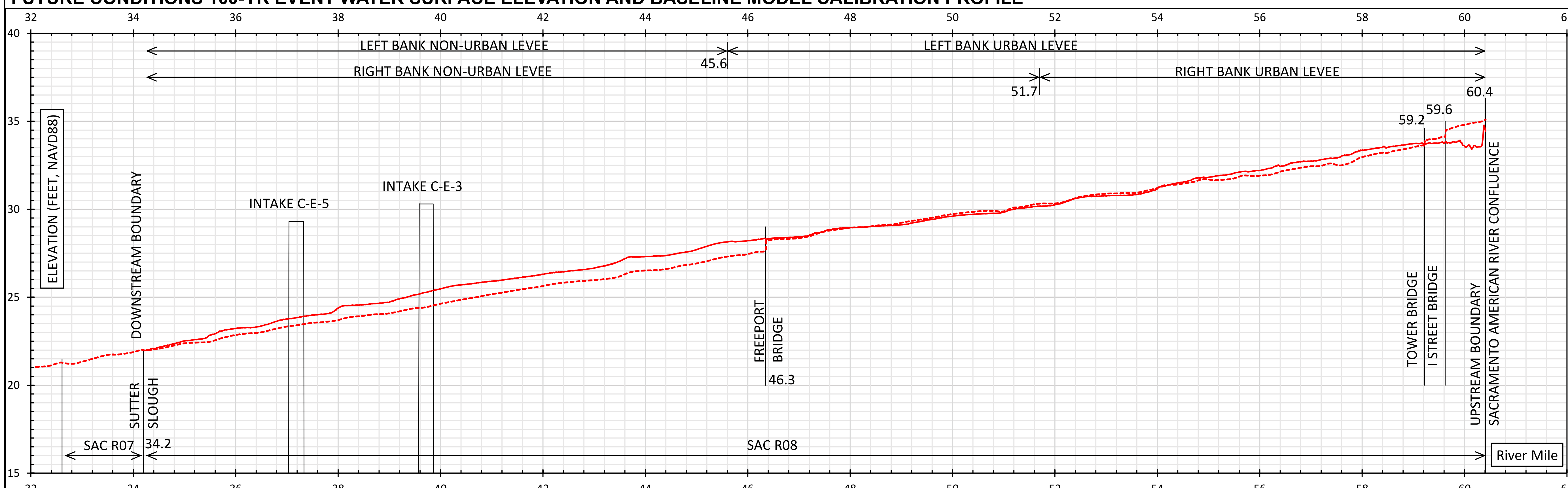


PLAN LEGEND

- RIVER MILE
- SACRAMENTO RIVER
- URBAN LEVEE
- NON-URBAN LEVEE

VICINITY MAP

FUTURE CONDITIONS 100-YR EVENT WATER SURFACE ELEVATION AND BASELINE MODEL CALIBRATION PROFILE



PROFILE LEGEND

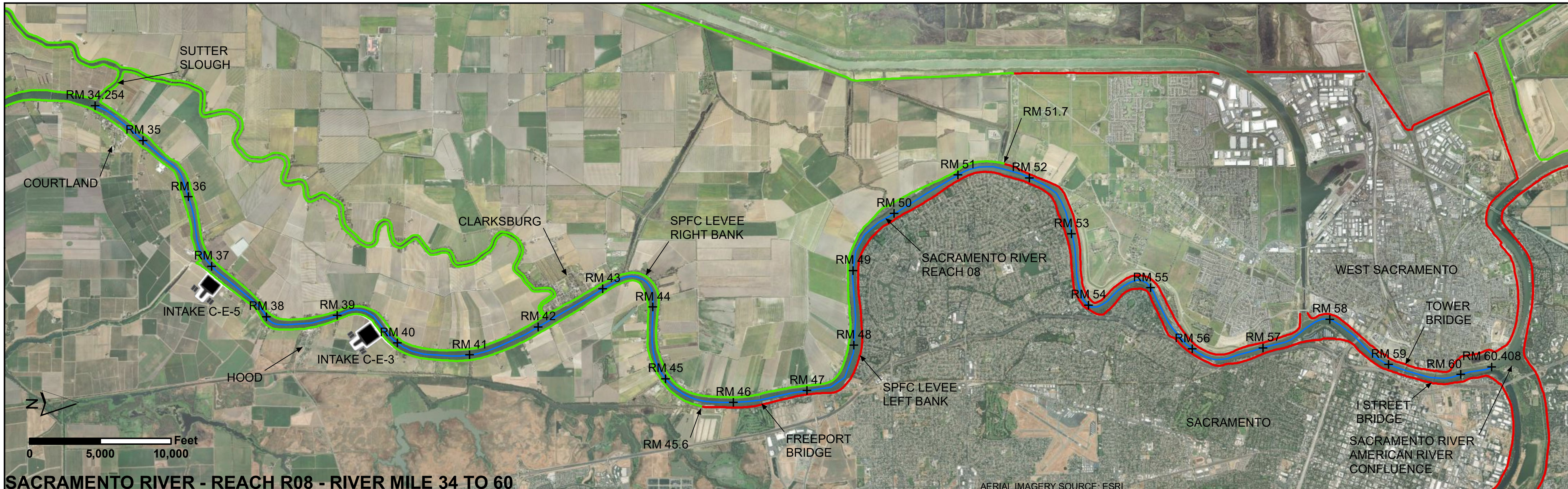
- FUTURE 100-YR EVENT BASELINE MODEL CALIBRATION
- FUTURE 100-YR EVENT

TITLE

FUTURE CONDITIONS 100-YR EVENT WSE AND BASELINE MODEL CALIBRATION PROFILE

FIGURE C04

Document Path: \\odin\Proj\DWR\DCA\WaterFixProject\W8X97000\RiverModeling\DeltaConveyance\GIS\mxd_DC_2D_FIG_C04_WSE_CALIBRATION_BethanyUpdate08282024.mxd

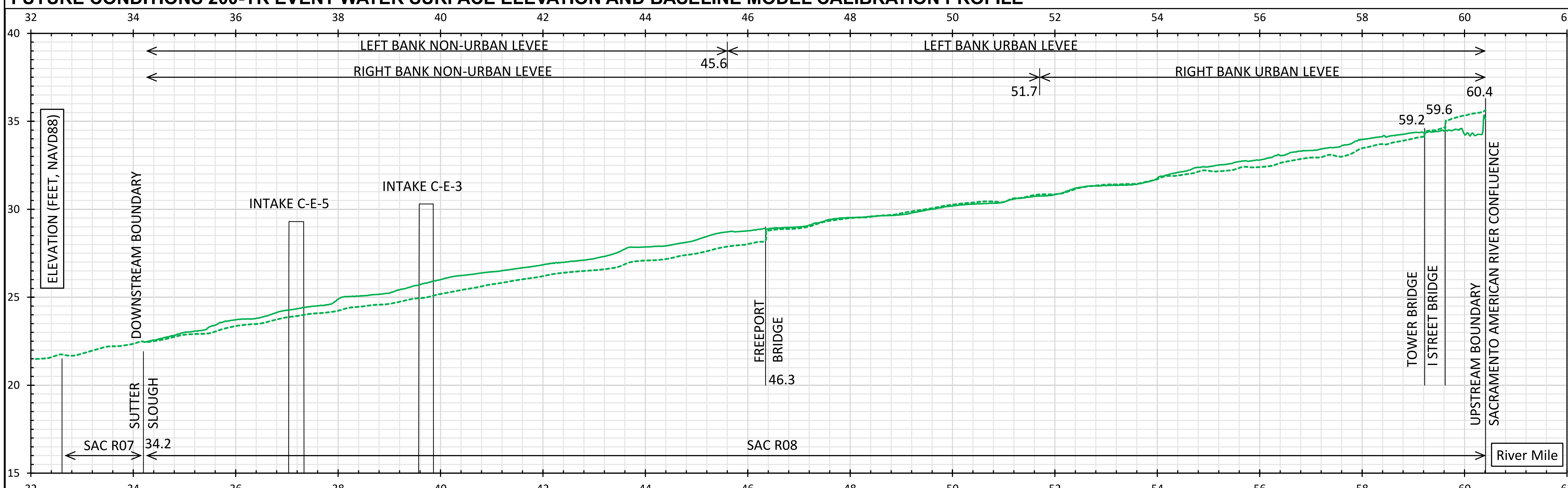


PLAN LEGEND

- + RIVER MILE
- SACRAMENTO RIVER
- URBAN LEVEE
- NON-URBAN LEVEE

VICINITY MAP

FUTURE CONDITIONS 200-YR EVENT WATER SURFACE ELEVATION AND BASELINE MODEL CALIBRATION PROFILE



PROFILE LEGEND

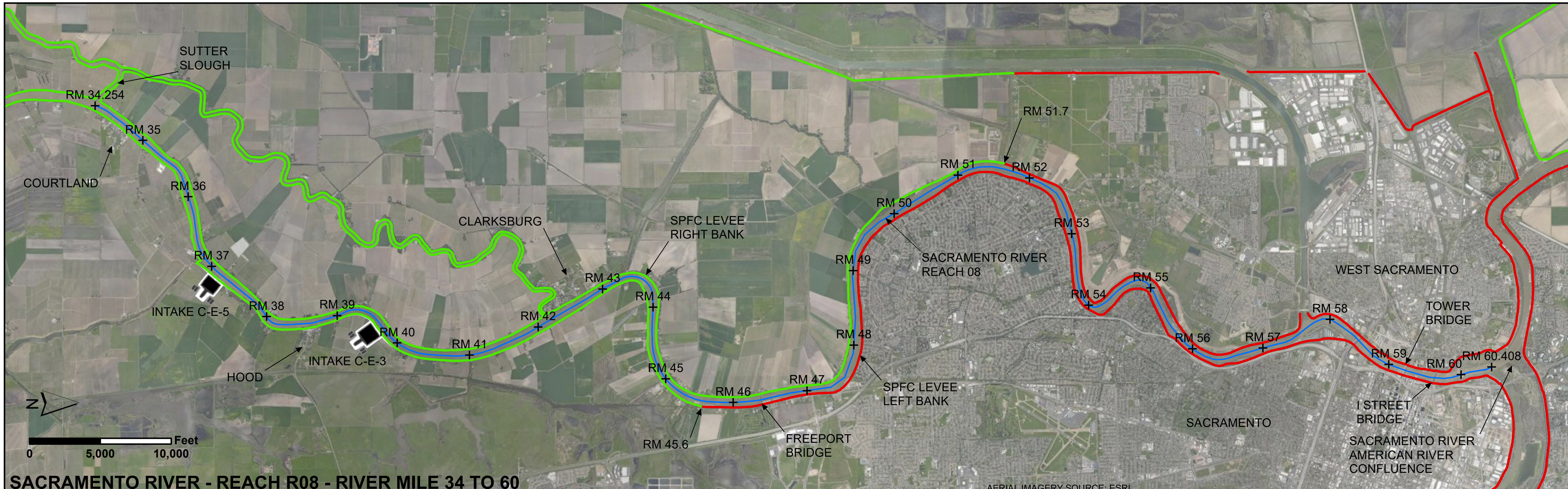
- FUTURE 200-YR EVENT BASELINE MODEL
- FUTURE 200-YR EVENT

TITLE

FUTURE CONDITIONS 100-YR EVENT WSE AND BASELINE MODEL CALIBRATION PROFILE

FIGURE C05

Document Path: \\odin\Proj\DWR\DCA\WaterFixProject\W8X97000\RiverModeling\DeltaConveyance\GIS\mxd_DC_2D_FIG_C05_WSE_CALIBRATION_BethanyUpdate08282024.mxd

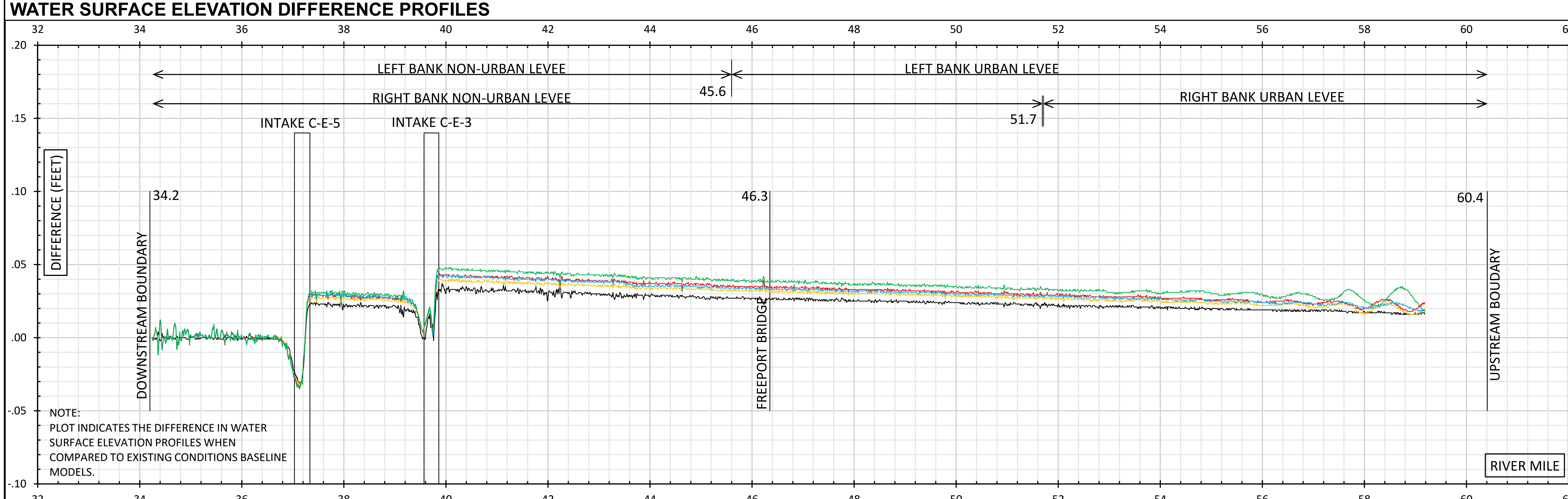


PLAN LEGEND

- + RIVER MILE
- SACRAMENTO RIVER
- URBAN LEVEE
- NON-URBAN LEVEE

VICINITY MAP

014 MODEL TYPE - TEE SCREEN INTAKES C-E-3, AND C-E-5, PERMANENT CONDITION
WATER SURFACE ELEVATION DIFFERENCE PROFILES



NOTE:
PLOT INDICATES THE DIFFERENCE IN WATER SURFACE ELEVATION PROFILES WHEN COMPARED TO EXISTING CONDITIONS BASELINE MODELS.

PROFILE LEGEND

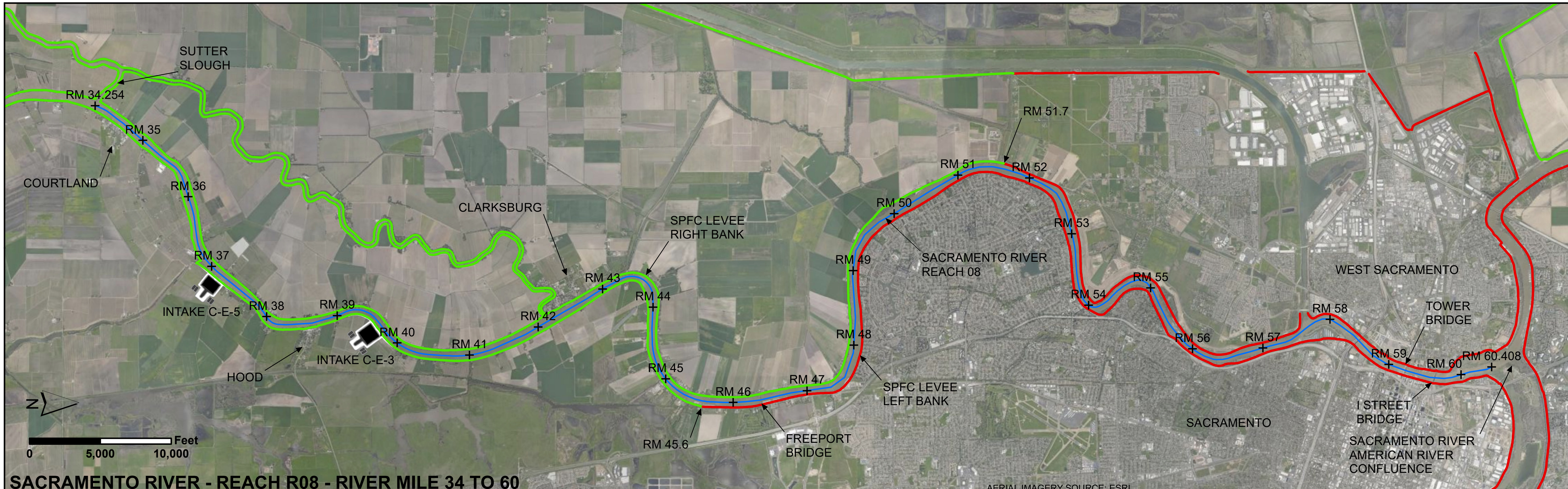
- 1957 DESIGN FLOW
- EXISTING 100-YR EVENT
- EXISTING 200-YR EVENT
- FUTURE 100-YR EVENT
- FUTURE 200-YR EVENT

TITLE

014 MODEL TYPE
TEE SCREEN
INTAKES C-E-3, AND C-E-5
PERMANENT CONDITION
WSE DIFFERENCE
PROFILES

FIGURE D01

Document Path: \\odin\Proj\DWR\DCA\WaterFixProject\W8X97000\RiverModeling\DeltaConveyance\GIS\mxd_DC_2D_FIG_D03_WSE_DIFFERENCE.mxd

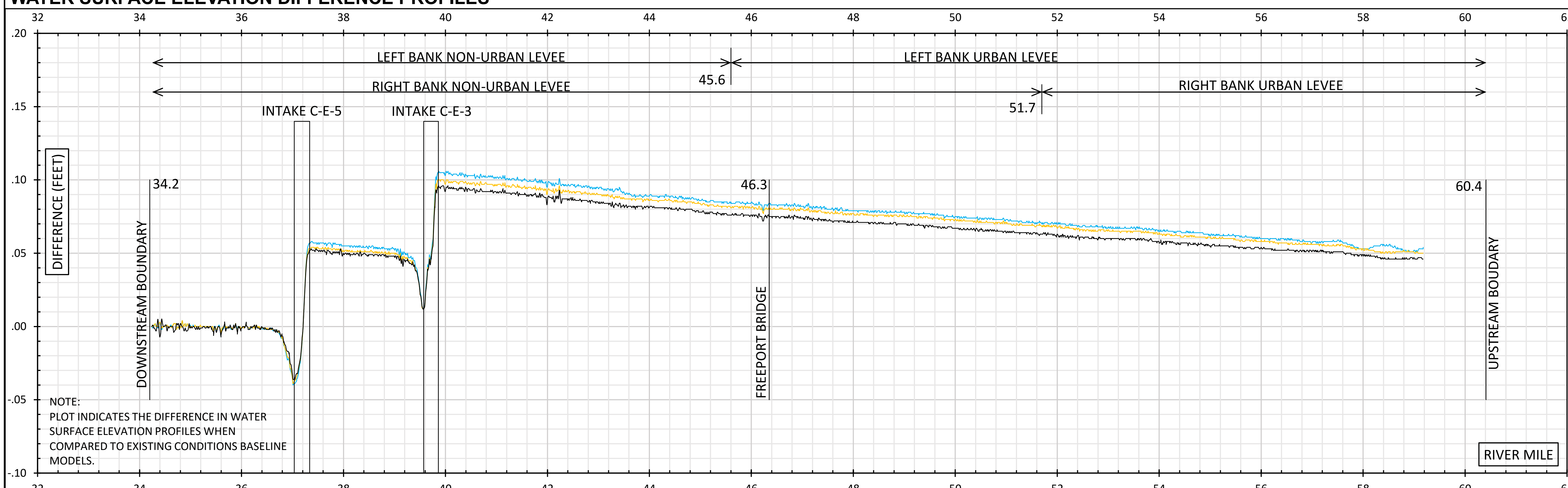


PLAN LEGEND

- + RIVER MILE
- SACRAMENTO RIVER
- URBAN LEVEE
- NON-URBAN LEVEE

VICINITY MAP

015 MODEL TYPE - TEE SCREEN INTAKES C-E-3, AND C-E-5, CONSTRUCTION CONDITION
WATER SURFACE ELEVATION DIFFERENCE PROFILES



PROFILE LEGEND

- 1957 DESIGN FLOW
- EXISTING 100-YR EVENT
- EXISTING 200-YR EVENT

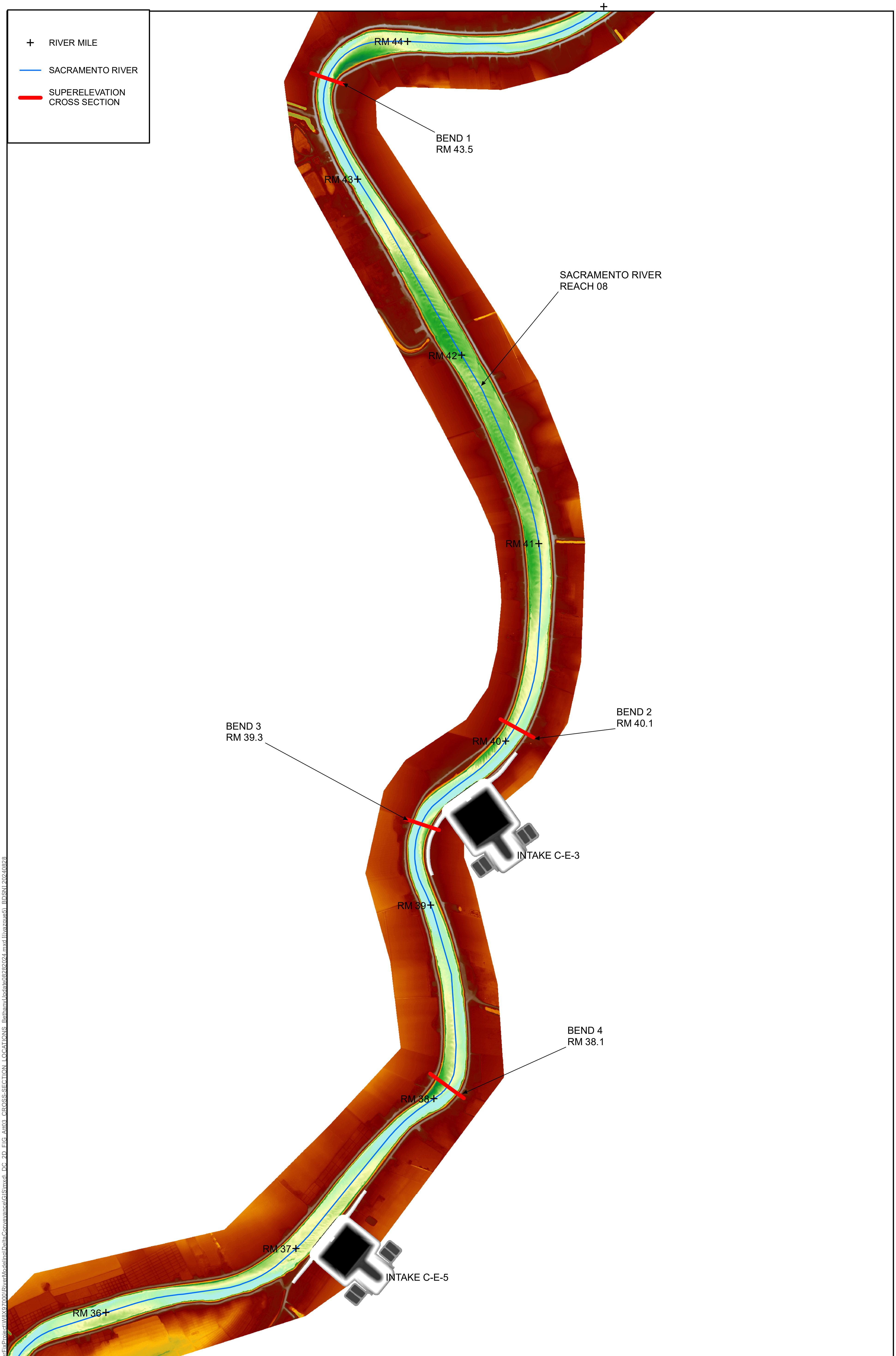
TITLE

015 MODEL TYPE
TEE SCREEN
INTAKES C-E-3, AND C-E-5
CONSTRUCTION CONDITION
WSE DIFFERENCE
PROFILES

FIGURE D02

Document Path: \\odin\Proj\DWR\DCA\WaterFixProject\W8X97000\RiverModeling\DeltaConveyance\GIS\mxd_DC_2D_FIG_D04_WSE_DIFFERENCE.mxd

Attachment 2
Water Surface Superelevation Information



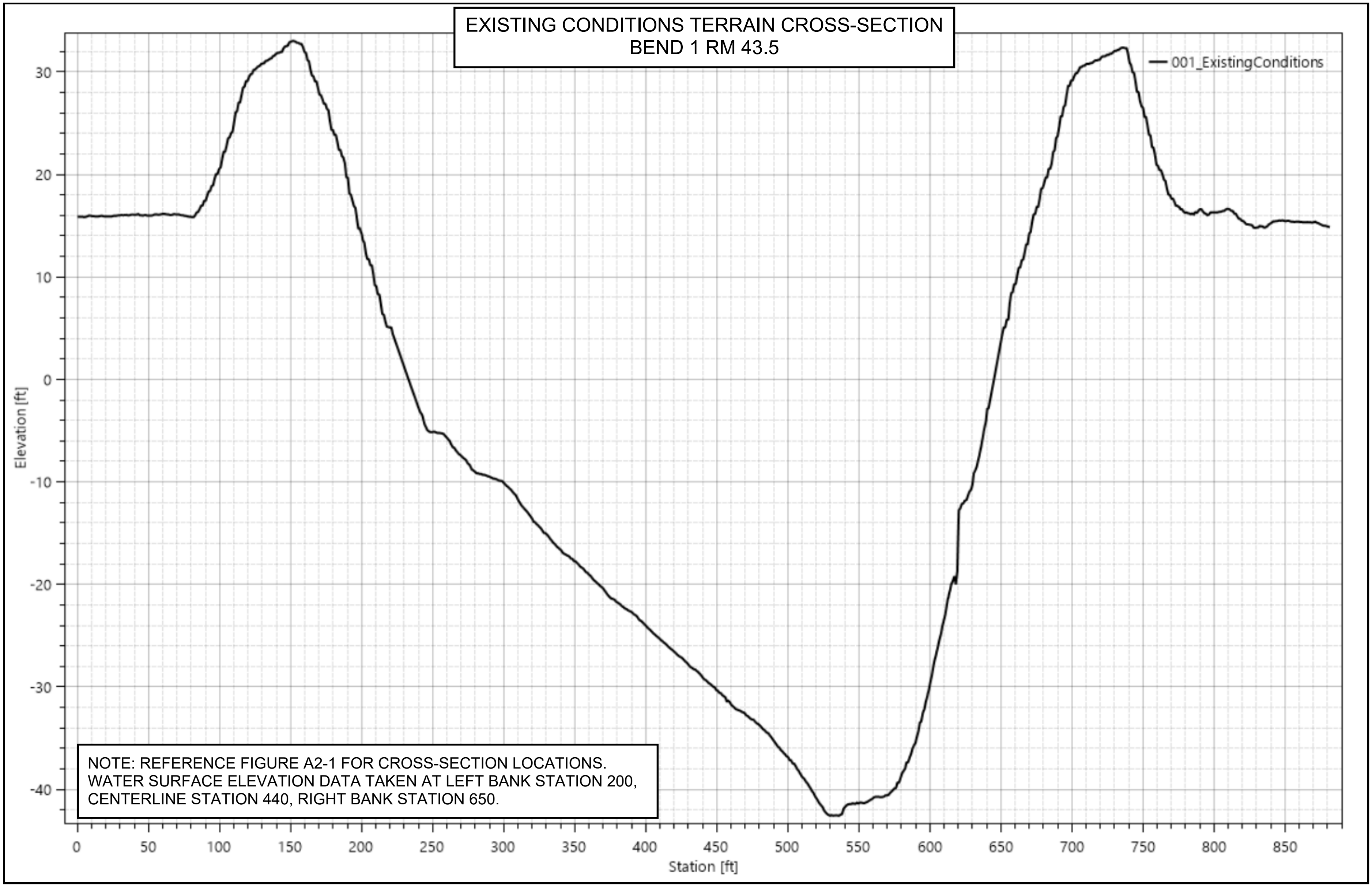
N

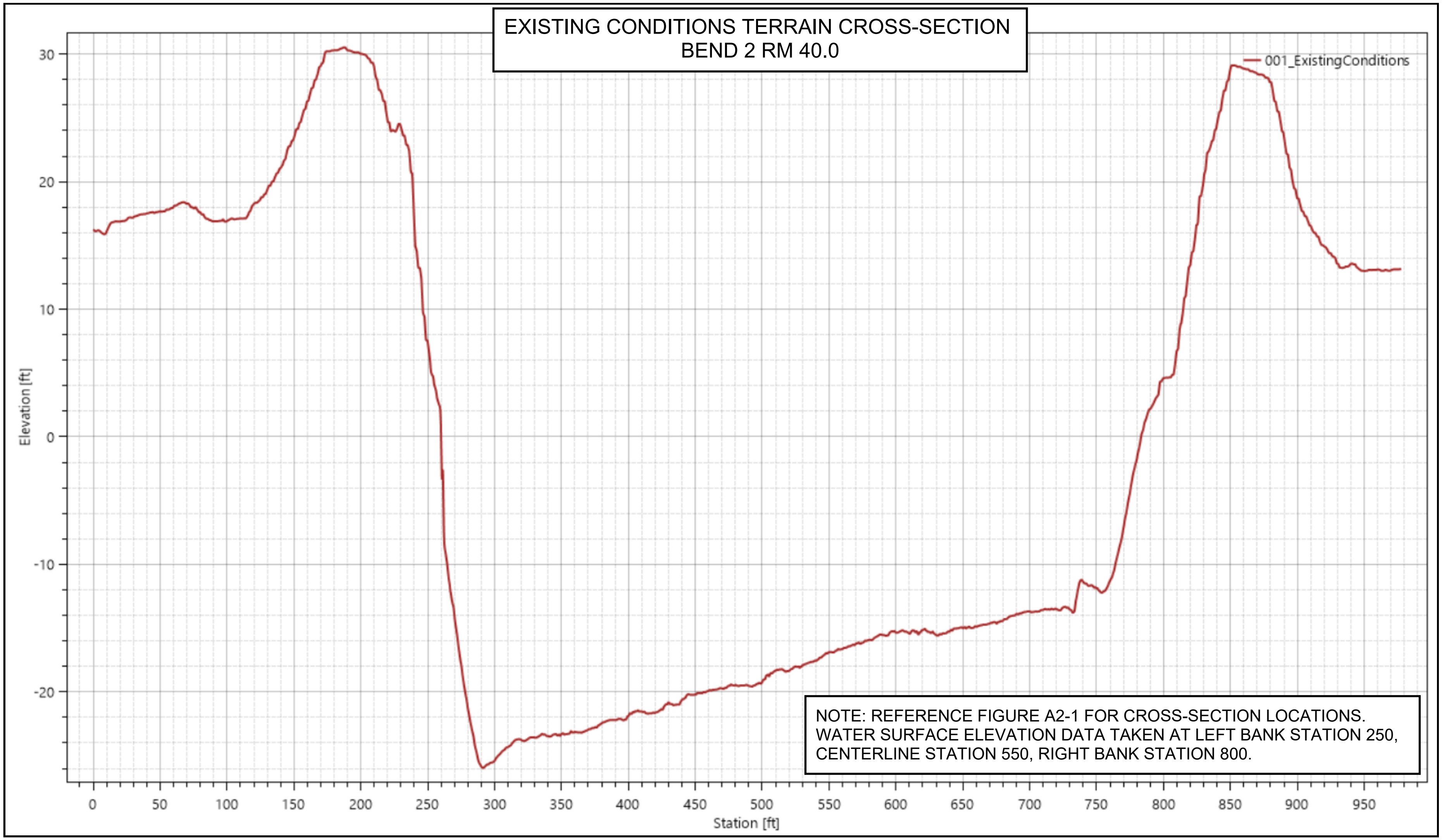
0 1,000 2,000 Feet

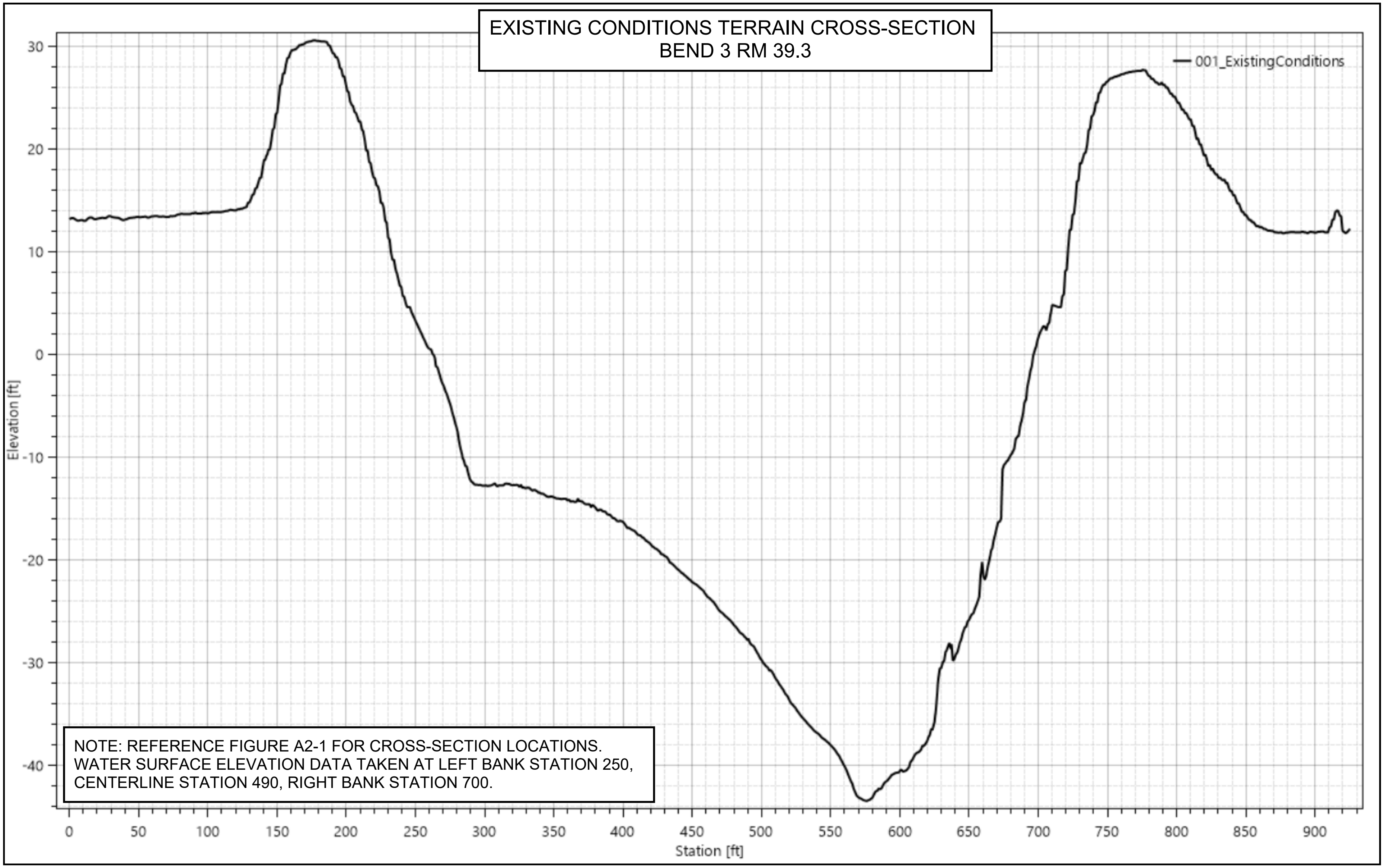
FIGURE A2-1
SUPERELEVATION CROSS-SECTION LOCATIONS

DCA DELTA CONVEYANCE DESIGN & CONSTRUCTION AUTHORITY

Data Source: DCA, DWR


EXISTING CONDITIONS TERRAIN CROSS-SECTION
BEND 1 RM 43.5
001_ExistingConditions
Elevation [ft]
30
20
10
0
-10
-20
-30
-40
Station [ft]
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
NOTE: REFERENCE FIGURE A2-1 FOR CROSS-SECTION LOCATIONS.
WATER SURFACE ELEVATION DATA TAKEN AT LEFT BANK STATION 200,
CENTERLINE STATION 440, RIGHT BANK STATION 650.


EXISTING CONDITIONS TERRAIN CROSS-SECTION
BEND 2 RM 40.0
001_ExistingConditions
Elevation [ft]
30
20
10
0
-10
-20
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
Station [ft]
NOTE: REFERENCE FIGURE A2-1 FOR CROSS-SECTION LOCATIONS.
WATER SURFACE ELEVATION DATA TAKEN AT LEFT BANK STATION 250,
CENTERLINE STATION 550, RIGHT BANK STATION 800.


EXISTING CONDITIONS TERRAIN CROSS-SECTION
BEND 3 RM 39.3
001_ExistingConditions
Elevation [ft]
Station [ft]
30
20
10
0
-10
-20
-30
-40
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
NOTE: REFERENCE FIGURE A2-1 FOR CROSS-SECTION LOCATIONS.
WATER SURFACE ELEVATION DATA TAKEN AT LEFT BANK STATION 250,
CENTERLINE STATION 490, RIGHT BANK STATION 700.

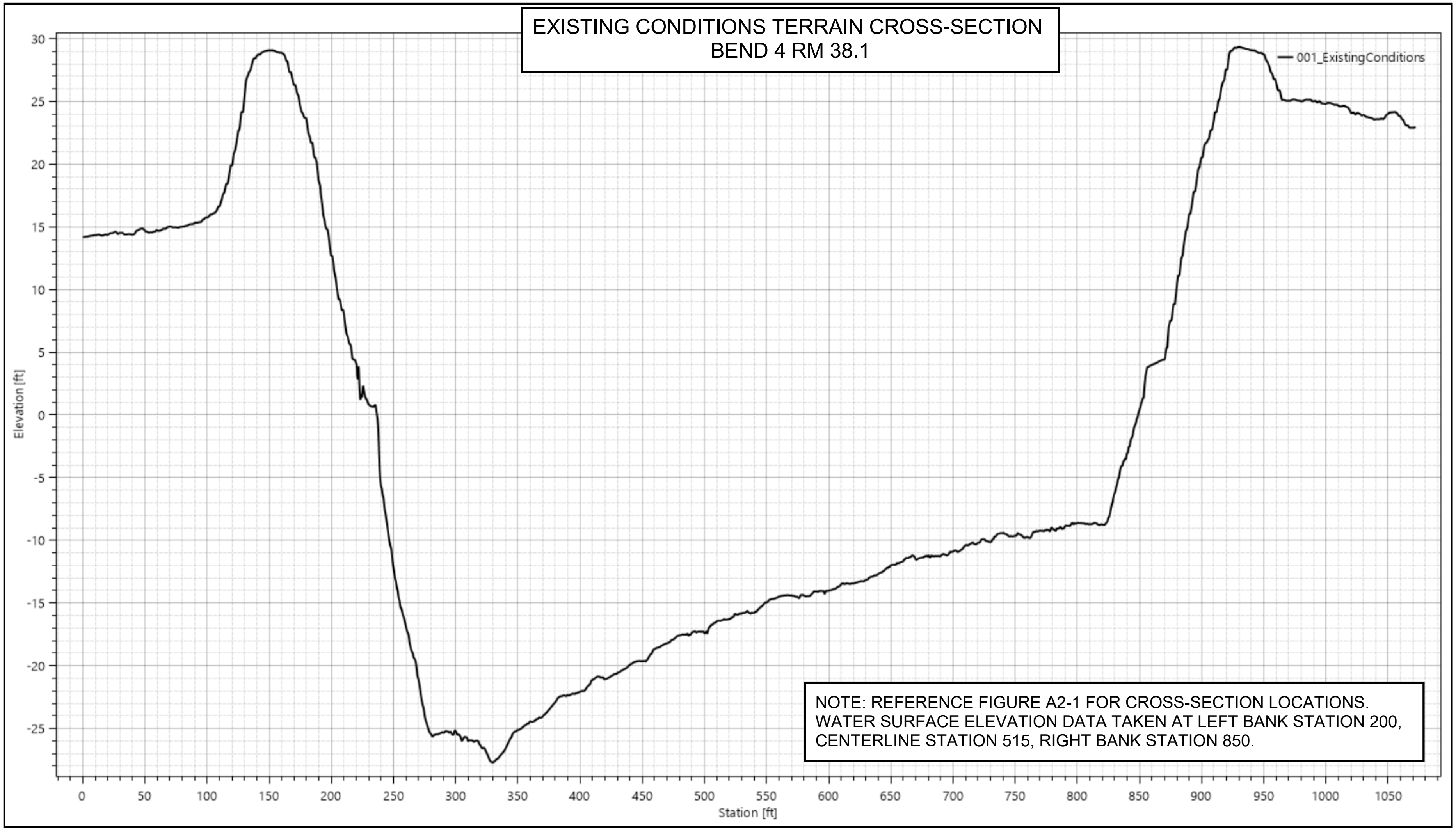

EXISTING CONDITIONS TERRAIN CROSS-SECTION
BEND 4 RM 38.1
001_ExistingConditions
Elevation [ft]
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
Station [ft]
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
1050
NOTE: REFERENCE FIGURE A2-1 FOR CROSS-SECTION LOCATIONS.
WATER SURFACE ELEVATION DATA TAKEN AT LEFT BANK STATION 200,
CENTERLINE STATION 515, RIGHT BANK STATION 850.

Table A2-3. Sacramento River Superelevation Analysis
Existing Conditions vs Model Type 014 – Tee Screen Intakes C-E-3, C-E-5 Permanent Condition

Model (Run) Number[1]	Bend[2]	Existing Condition Model			Model Type 014 Results						
		Left Bank WSE	Centerline WSE	Right Bank WSE	Left Bank WSE	WSE Difference	Centerline WSE	WSE Difference	Right Bank WSE	WSE Difference
14 Compared Against 01	1	25.95	26.18	26.28	25.98	0.03	26.21	0.03	26.31	0.03
	2	24.58	24.50	24.46	24.62	0.04	24.54	0.04	24.49	0.03
	3	23.90	24.02	24.08	23.93	0.03	24.04	0.02	24.10	0.02
	4	23.50	23.41	23.24	23.53	0.03	23.43	0.02	23.26	0.02
15 Compared Against 02	1	26.12	26.38	26.48	26.16	0.04	26.41	0.03	26.51	0.03
	2	24.91	24.83	24.78	24.95	0.04	24.87	0.04	24.82	0.04
	3	24.25	24.37	24.43	24.27	0.02	24.39	0.02	24.45	0.02
	4	23.90	23.81	23.62	23.93	0.03	23.84	0.03	23.65	0.03
18 Compared Against 03	1	26.51	26.78	26.89	26.55	0.04	26.82	0.04	26.92	0.03
	2	25.27	25.18	25.13	25.31	0.04	25.23	0.05	25.17	0.04
	3	24.58	24.70	24.77	24.60	0.02	24.72	0.02	24.79	0.02
	4	24.22	24.12	23.93	24.25	0.03	24.15	0.03	23.95	0.02
19 Compared Against 04	1	26.79	27.06	27.17	26.83	0.04	27.10	0.04	27.20	0.03
	2	25.60	25.52	25.46	25.64	0.04	25.56	0.04	25.51	0.05
	3	24.93	25.05	25.11	24.95	0.02	25.07	0.02	25.13	0.02
	4	24.58	24.49	24.3	24.61	0.03	24.52	0.03	24.33	0.03
20 Compared Against 05	1	27.33	27.61	27.72	27.37	0.04	27.65	0.04	27.76	0.04
	2	26.13	26.04	25.99	26.17	0.04	26.09	0.05	26.04	0.05
	3	25.44	25.57	25.63	25.47	0.03	25.59	0.02	25.66	0.03
	4	25.10	25.00	24.80	25.13	0.03	25.03	0.03	24.83	0.03

Notes:

1. Model runs are compared against existing conditions models using the same flow rate. Example: model run 14 is compared against model run 01.
2. Water surface elevation data is taken at cross-section stationing as follows: Bend 1 cross-section is located at Rive Mile 43.5. LB STA 200, CL STA 440, RB STA 650. Bend 2 cross-section is located at Rive Mile 40.0. LB STA 250, CL STA 550, RB STA 800. Bend 3 cross-section is located at Rive Mile 39.3. LB STA 250, CL STA 490, RB STA 700. Bend 4 cross-section is located at Rive Mile 38.1. LB STA 200, CL STA 515, RB STA 850.

Table A2-4. Sacramento River Superelevation Analysis
Existing Conditions vs Model Type 015 —Tee Screen Intakes C-E-3, C-E-5 Construction Condition

Model (Run) Number[1]	Bend[2]	Existing Condition Model			Model Type 015 Results					
		Left Bank WSE	Centerline WSE	Right Bank WSE	Left Bank WSE	WSE Difference	Centerline WSE	WSE Difference	Right Bank WSE	WSE Difference
19 Compared against 01	1	25.95	26.18	26.28	26.03	0.08	26.27	0.09	26.36	0.08
	2	24.58	24.50	24.46	24.68	0.10	24.60	0.10	24.55	0.09
	3	23.90	24.02	24.08	23.95	0.05	24.06	0.04	24.12	0.04
	4	23.50	23.41	23.24	23.55	0.05	23.46	0.05	23.29	0.05
20 Compared against 02	1	26.12	26.38	26.48	26.21	0.09	26.47	0.09	26.57	0.09
	2	24.91	24.83	24.78	25.01	0.10	24.93	0.10	24.88	0.10
	3	24.25	24.37	24.43	24.30	0.05	24.41	0.04	24.47	0.04
	4	23.90	23.81	23.62	23.96	0.06	23.86	0.05	23.67	0.05
21 Compared against 03	1	26.51	26.78	26.89	26.60	0.09	26.87	0.09	26.98	0.09
	2	25.27	25.18	25.13	25.37	0.10	25.29	0.11	25.24	0.11
	3	24.58	24.70	24.77	24.63	0.05	24.75	0.05	24.81	0.04
	4	24.22	24.12	23.93	24.27	0.05	24.18	0.06	23.98	0.05

Notes:

1. Model runs are compared against existing conditions models using the same flow rate. Example: model run 19 is compared against model run 01.
2. Water surface elevation data is taken at cross-section stationing as follows: Bend 1 cross-section is located at Rive Mile 43.5. LB STA 200, CL STA 440, RB STA 650. Bend 2 cross-section is located at Rive Mile 40.0. LB STA 250, CL STA 550, RB STA 800. Bend 3 cross-section is located at Rive Mile 39.3. LB STA 250, CL STA 490, RB STA 700. Bend 4 cross-section is located at Rive Mile 38.1. LB STA 200, CL STA 515, RB STA 850

Attachment 3
River Flow Velocity Information

HECRAS Flood Flow Model Output

INDEX

NOTES:

1. VELOCITY DIFFERENCE CONTOUR PLOTS ARE CREATED BY SUBTRACTING THE EXISTING CONDITIONS MODEL VELOCITY LAYER FROM THE PROPOSED CONDITIONS MODEL VELOCITY LAYER.

2. THE PAGE ORGANIZATION OF THE VELOCITY AND VELOCITY DIFFERENCE PLOTS BEGINNING ON PAGE PDF PG 35 INCLUDES; 1) EXISTING CONDITIONS VELOCITY CONTOUR PLOT, 2) PROPOSED CONDITIONS VELOCITY CONTOUR PLOT, AND 3) VELOCITY DIFFERNCE CONTOUR PLOT. THIS PAGE ORGANIZATION IS DONE AT EACH INTAKE LOCATION FOR EACH MODEL RUN AND FACILITATES COMPARISON OF EXISITNG CONDITIONS VERSUS PROPOSED CONDITIONS.

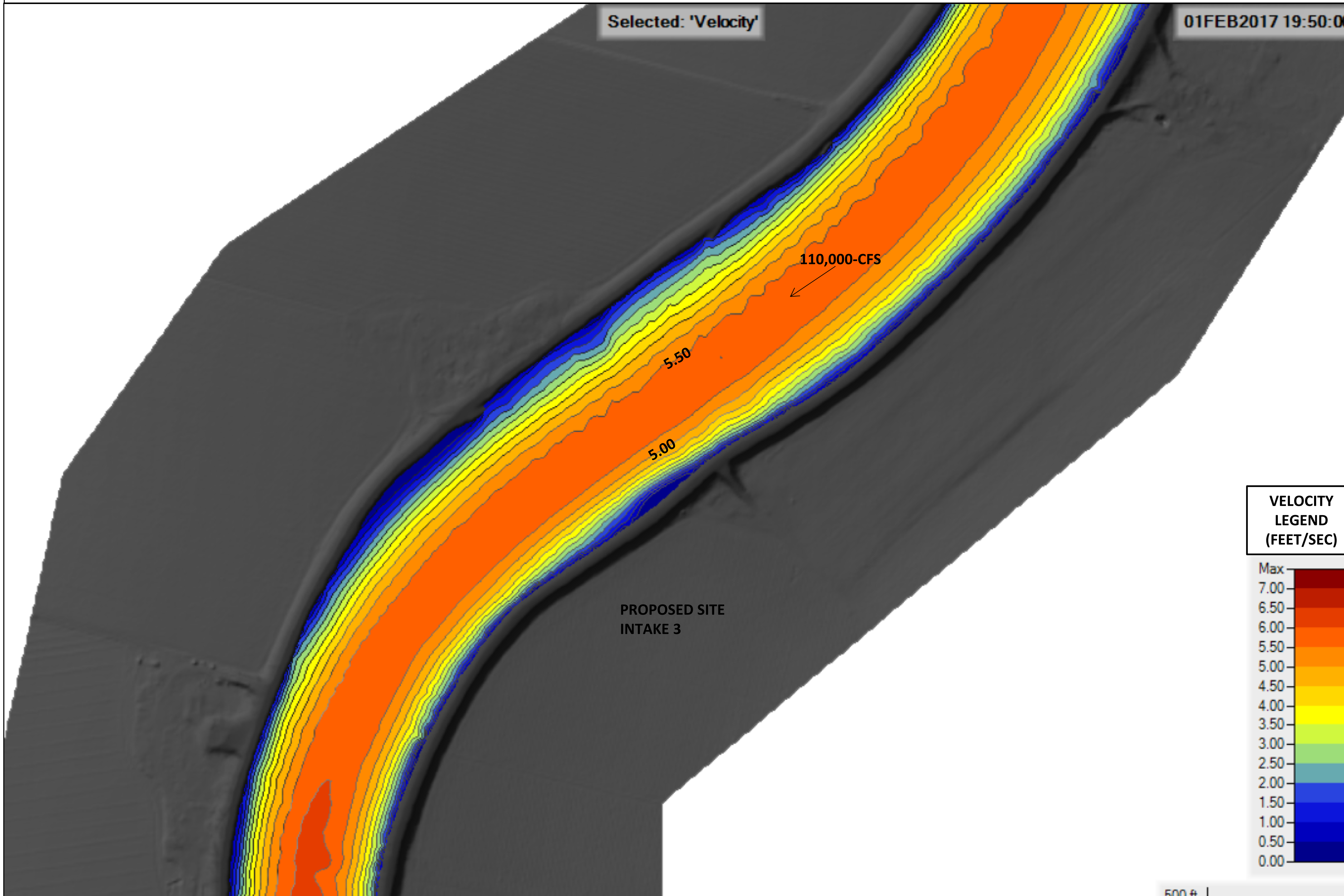
Velocity Contour Plots
Model TYPE 001
Existing Condition

Model No. 1

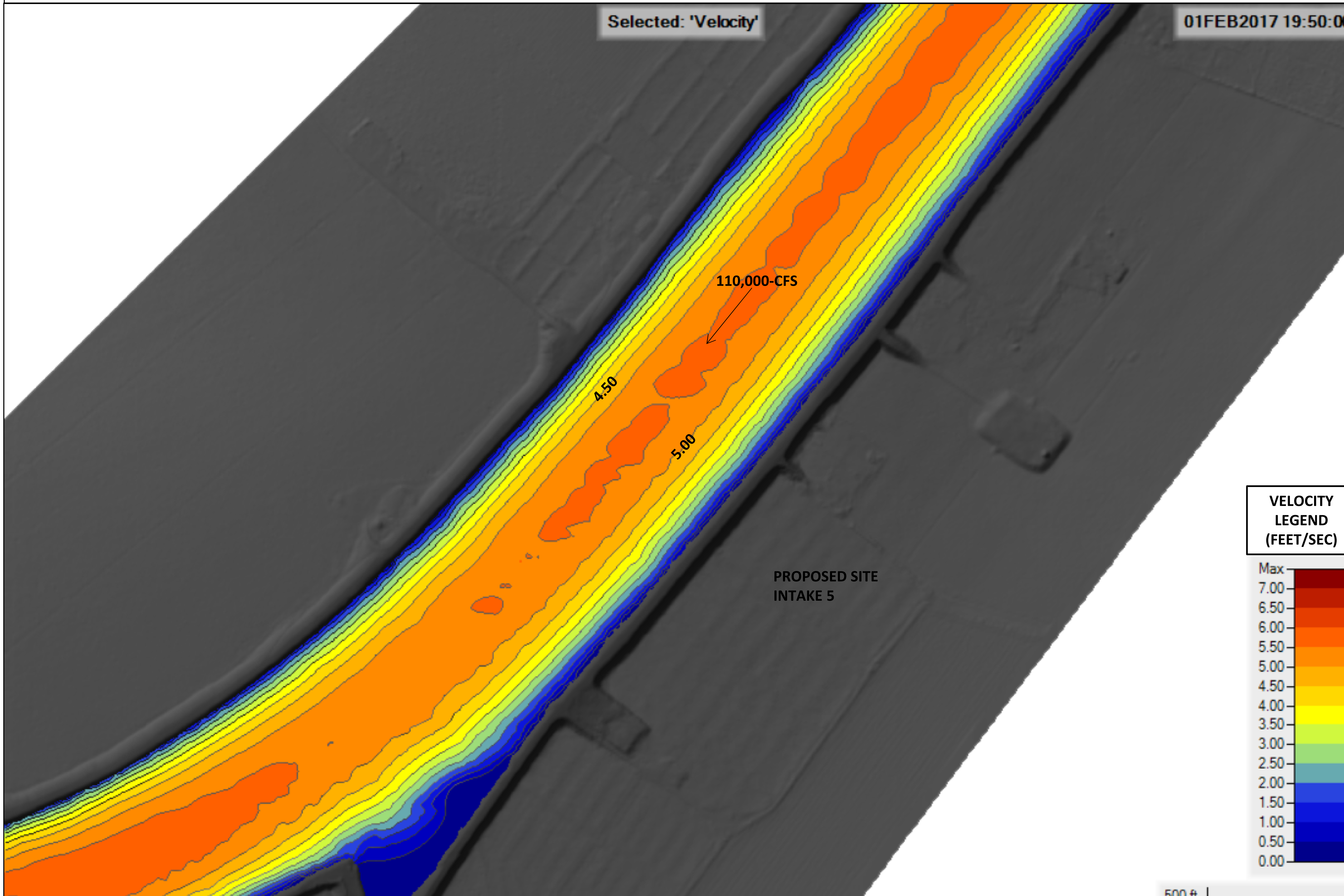
1957 Design – 110,000-cfs

RUN 01 - INTAKE C-E-3 (B) – VELOCITY CONTOUR PLOT

MODEL SCENARIO EXISTING CONDITIONS – 1957 DESIGN FLOW



RUN 01 - INTAKE C-E-5 (C) – VELOCITY CONTOUR PLOT
MODEL SCENARIO EXISTING CONDITIONS – 1957 DESIGN FLOW



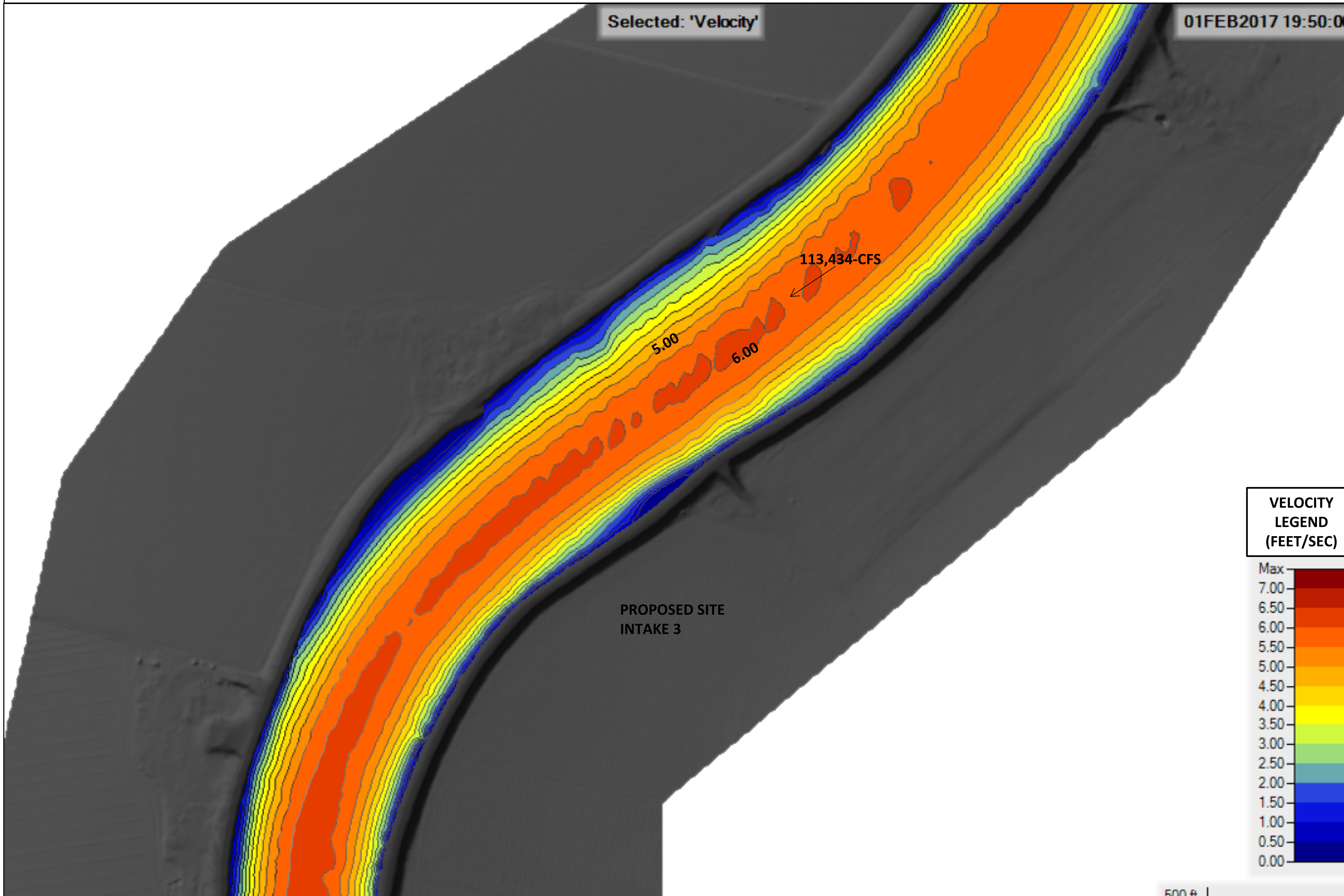
Velocity Contour Plots
Model TYPE 001
Existing Condition

Model No. 2

Existing 100-Year Event – 113,434-cfs

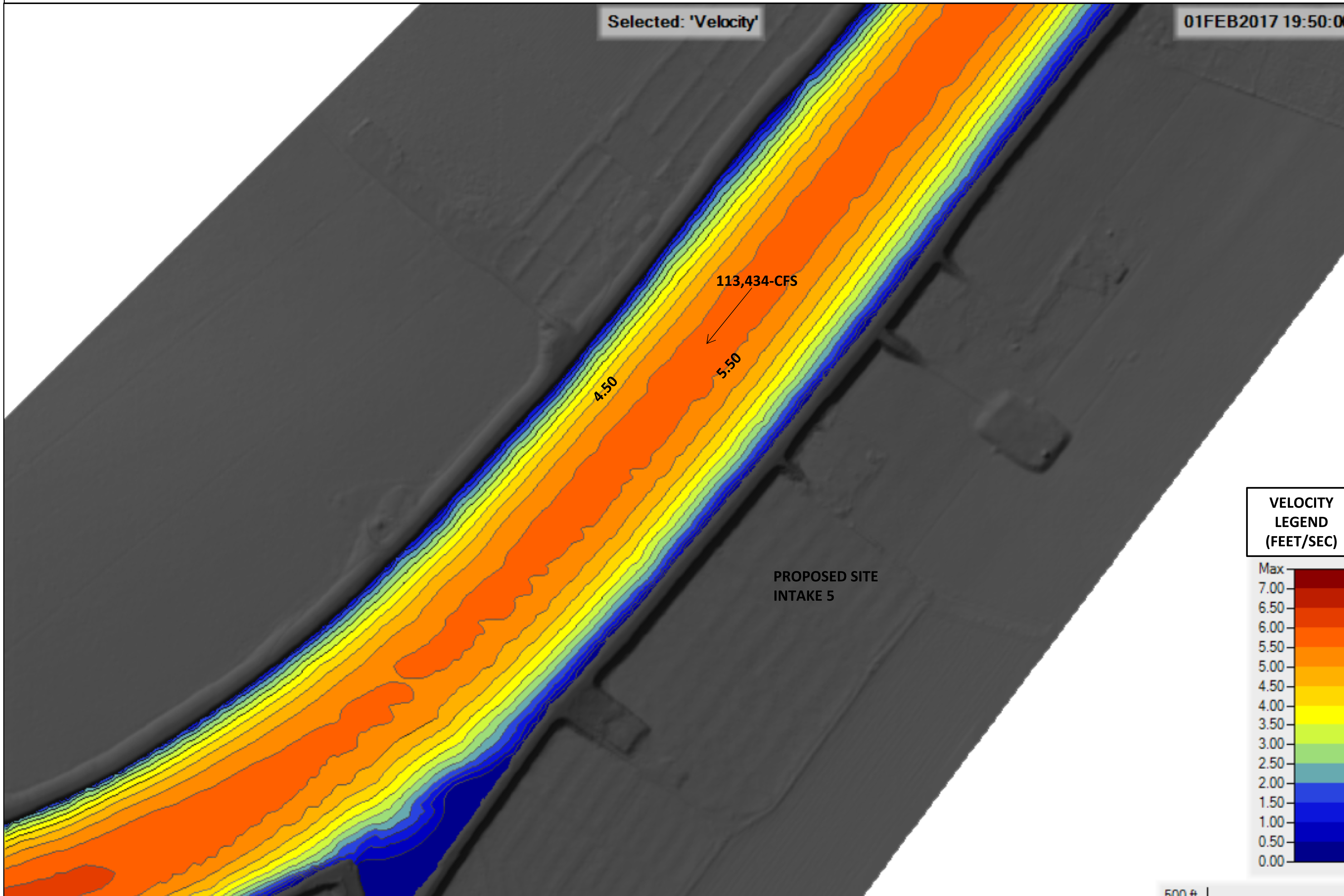
RUN 02 - INTAKE C-E-3 (B) – VELOCITY CONTOUR PLOT

MODEL SCENARIO EXISTING CONDITIONS – EXISTING 100-YR FLOW



RUN 02 - INTAKE C-E-5 (C) – VELOCITY CONTOUR PLOT

MODEL SCENARIO EXISTING CONDITIONS – EXISTING 100-YR FLOW



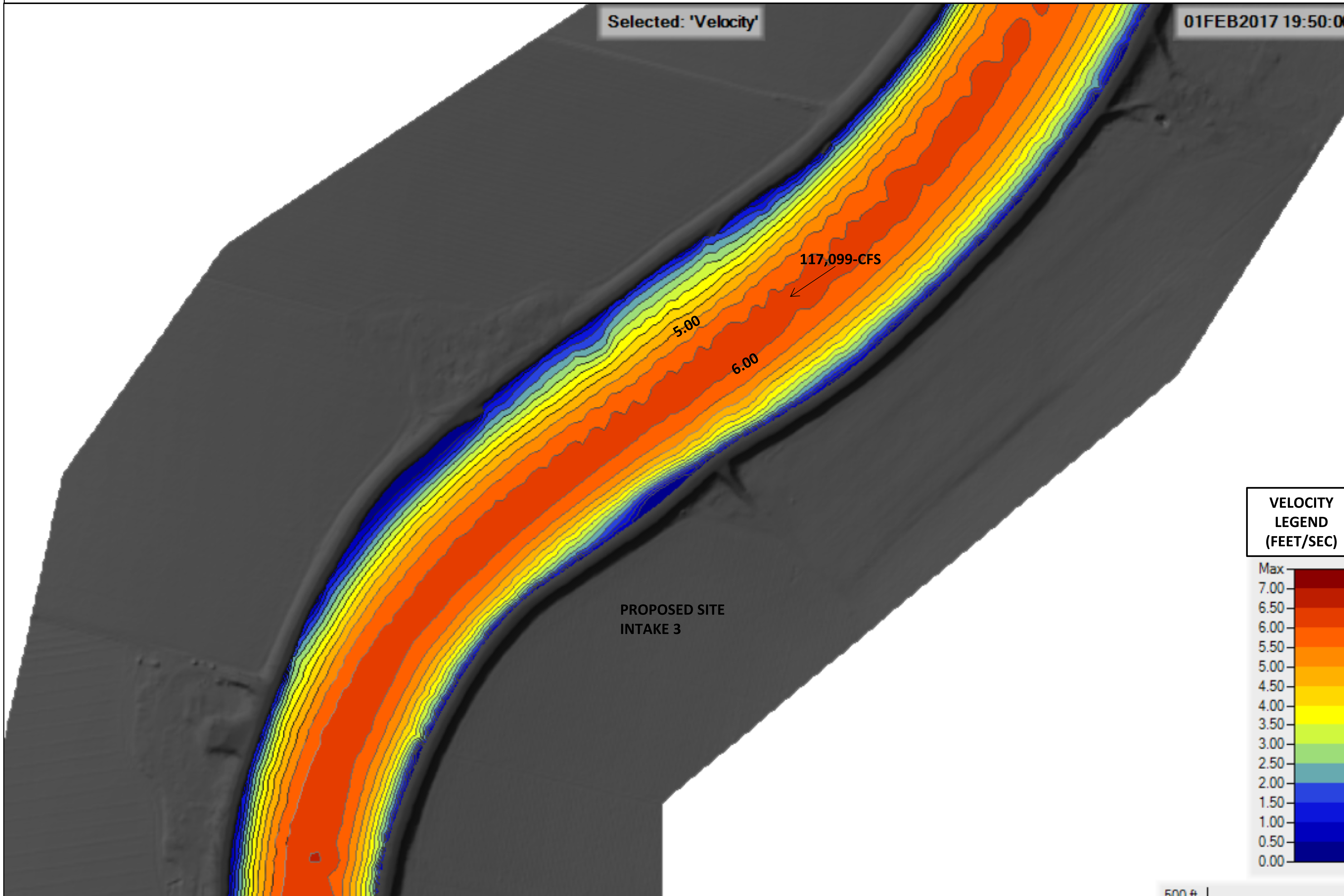
Velocity Contour Plots
Model TYPE 001
Existing Condition

Model No. 3

Existing 200-Year Event – 117,099-cfs

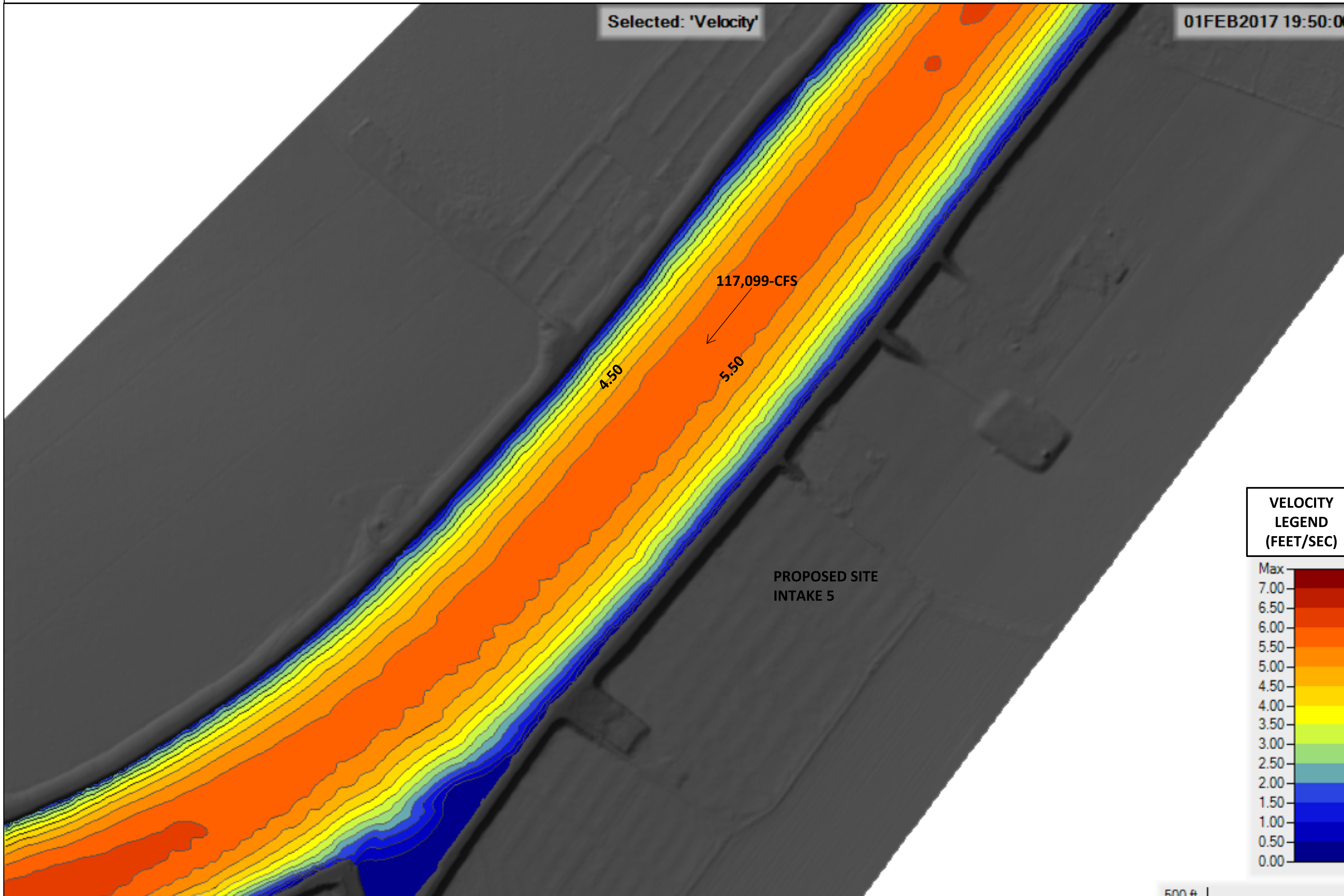
RUN 03 - INTAKE C-E-3 (B) – VELOCITY CONTOUR PLOT

MODEL SCENARIO EXISTING CONDITIONS – EXISTING 200-YR FLOW



RUN 03 - INTAKE C-E-5 (C) – VELOCITY CONTOUR PLOT

MODEL SCENARIO EXISTING CONDITIONS – EXISTING 200-YR FLOW

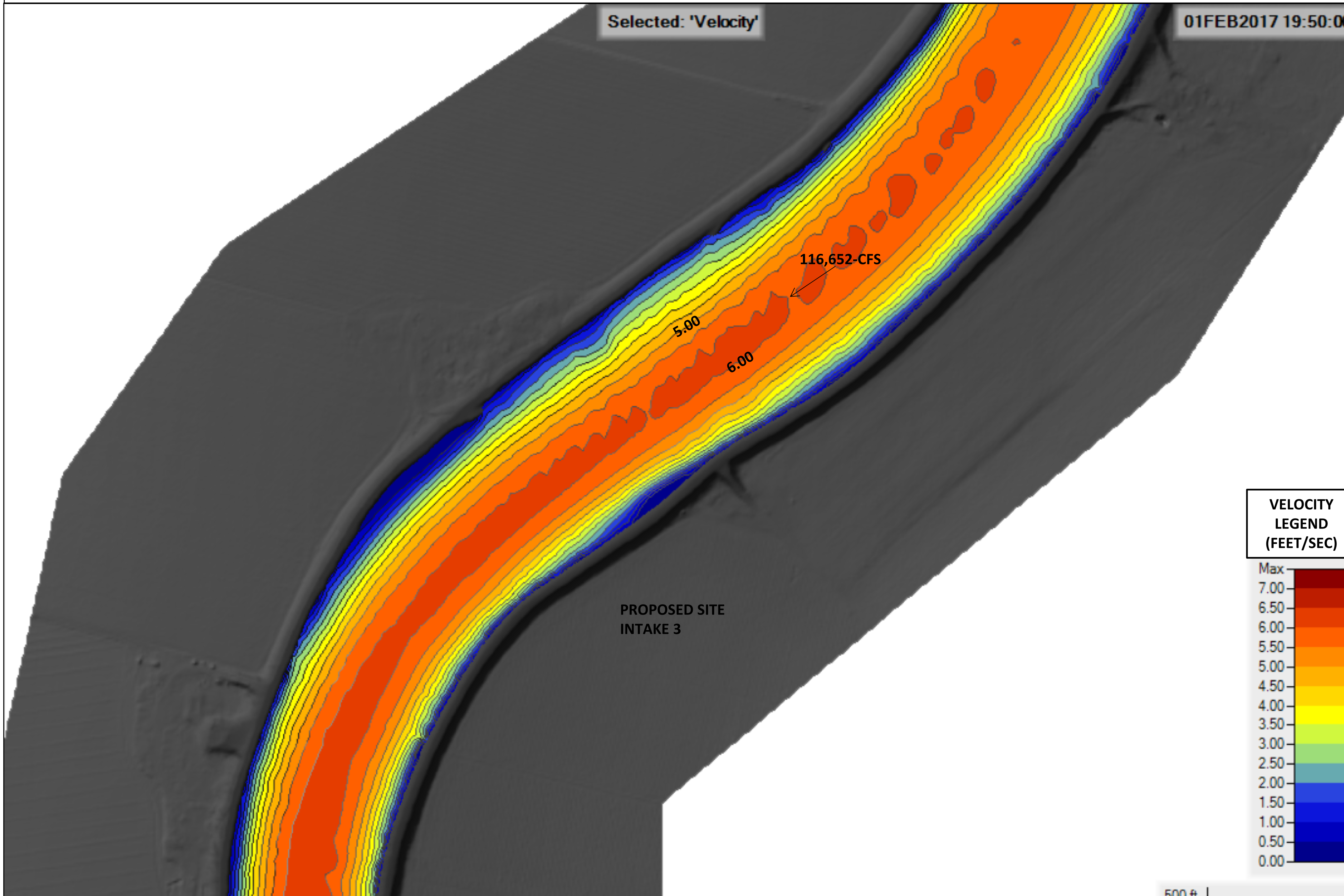


Velocity Contour Plots
Model TYPE 001
Existing Condition

Model No. 4
Future 100-Year Event – 116,652-cfs

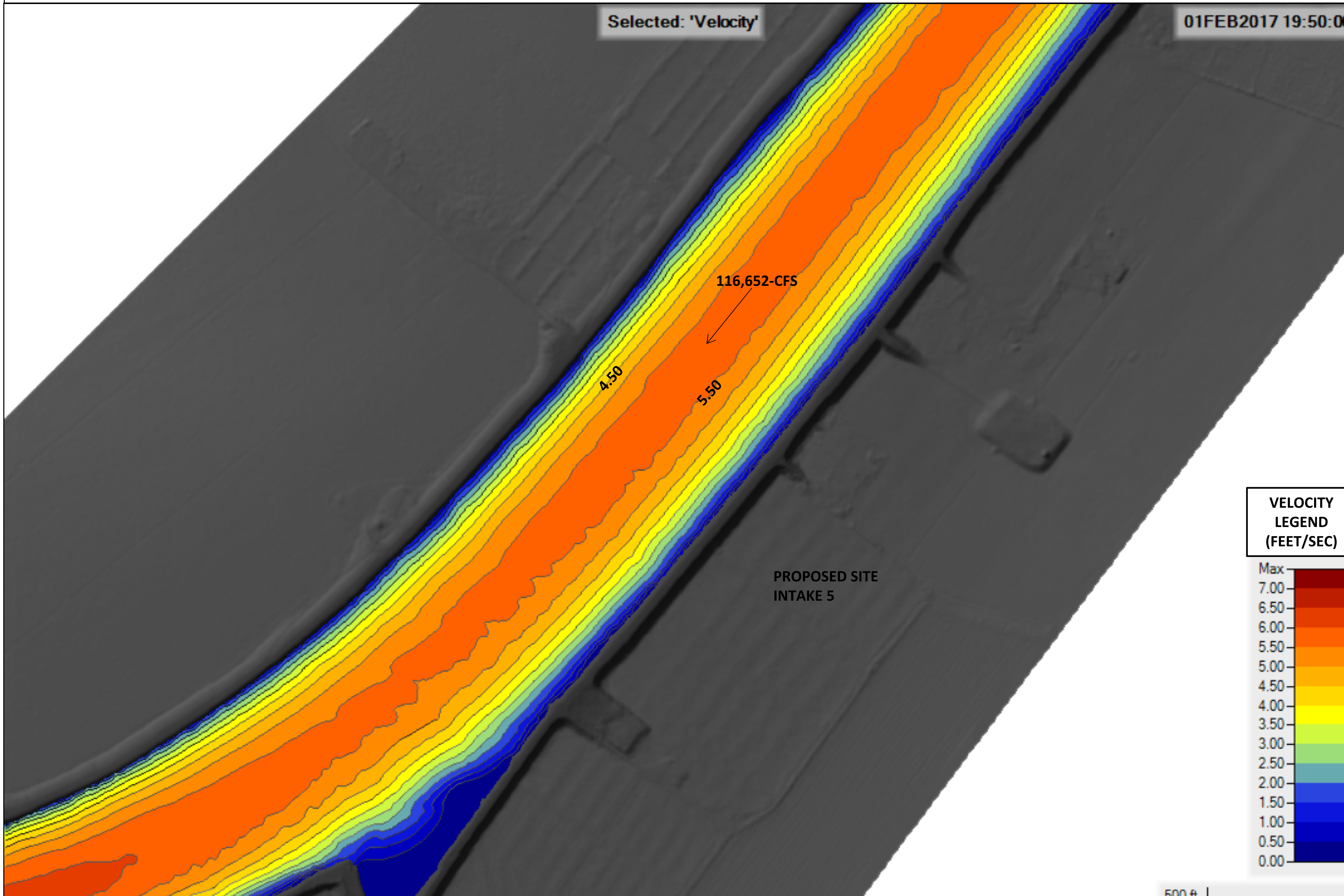
RUN 04 - INTAKE C-E-3 (B) – VELOCITY CONTOUR PLOT

MODEL SCENARIO EXISTING CONDITIONS – FUTURE 100-YR FLOW



RUN 04 - INTAKE C-E-5 (C) – VELOCITY CONTOUR PLOT

MODEL SCENARIO EXISTING CONDITIONS – FUTURE 100-YR FLOW

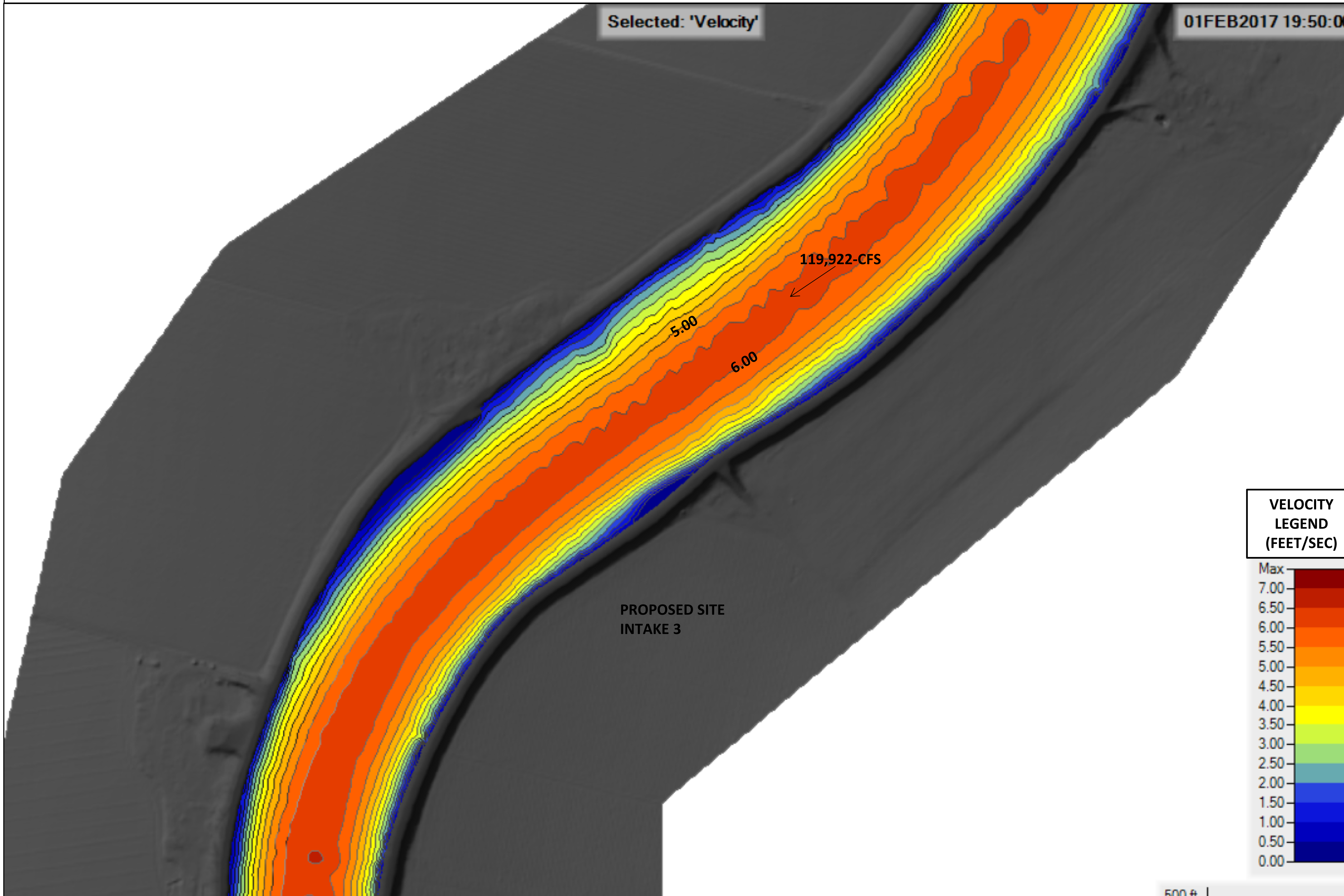


Velocity Contour Plots
Model TYPE 001
Existing Condition

Model No. 5
Future 200-Year Event – 119,9222-cfs

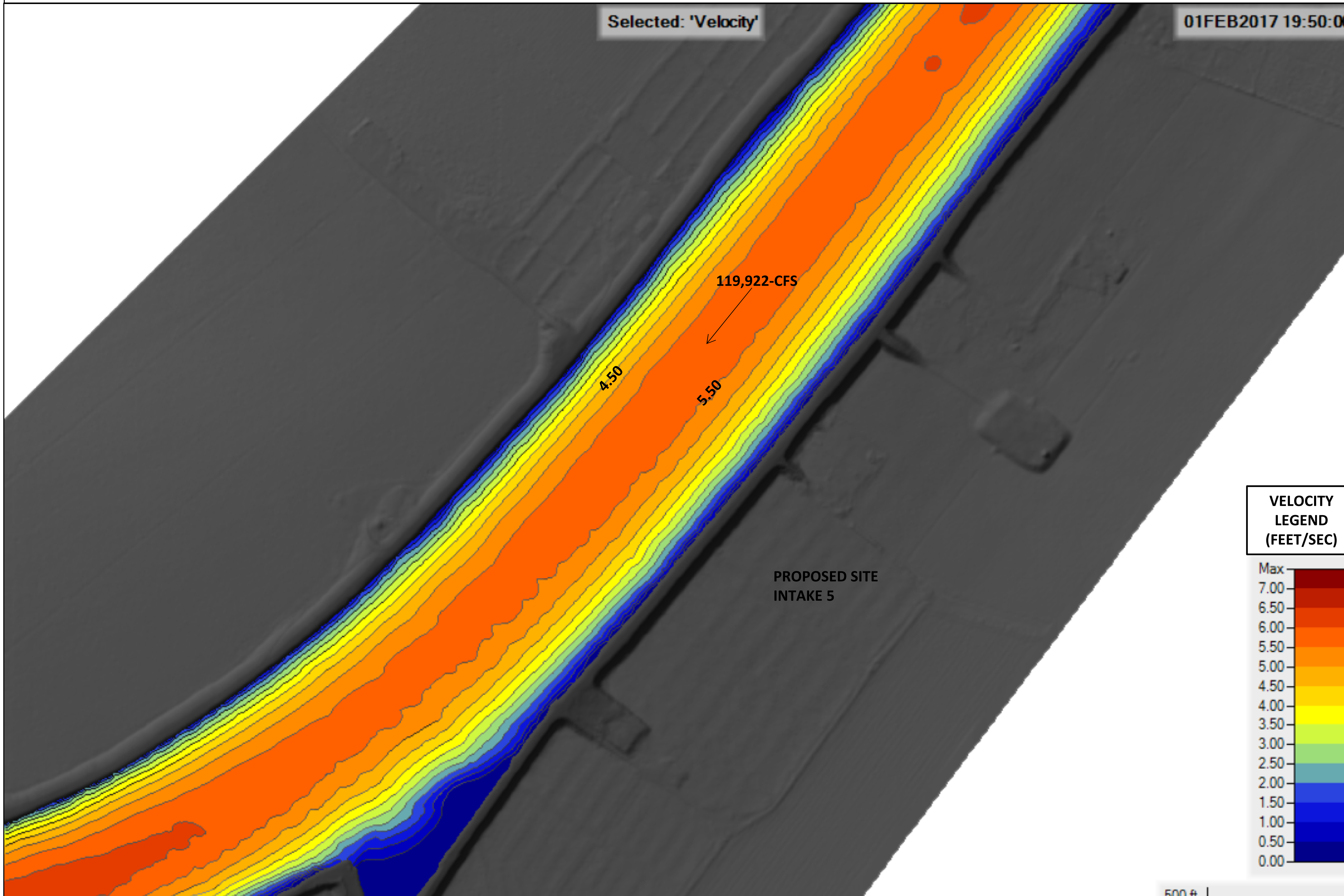
RUN 05 - INTAKE C-E-3 (B) – VELOCITY CONTOUR PLOT

MODEL SCENARIO EXISTING CONDITIONS – FUTURE 200-YR FLOW



RUN 05 - INTAKE C-E-5 (C) – VELOCITY CONTOUR PLOT

MODEL SCENARIO EXISTING CONDITIONS – FUTURE 200-YR FLOW



Velocity Contour and Difference Plots
Model TYPE 014

Tee Screen

Intakes C-E-3, C-E-5

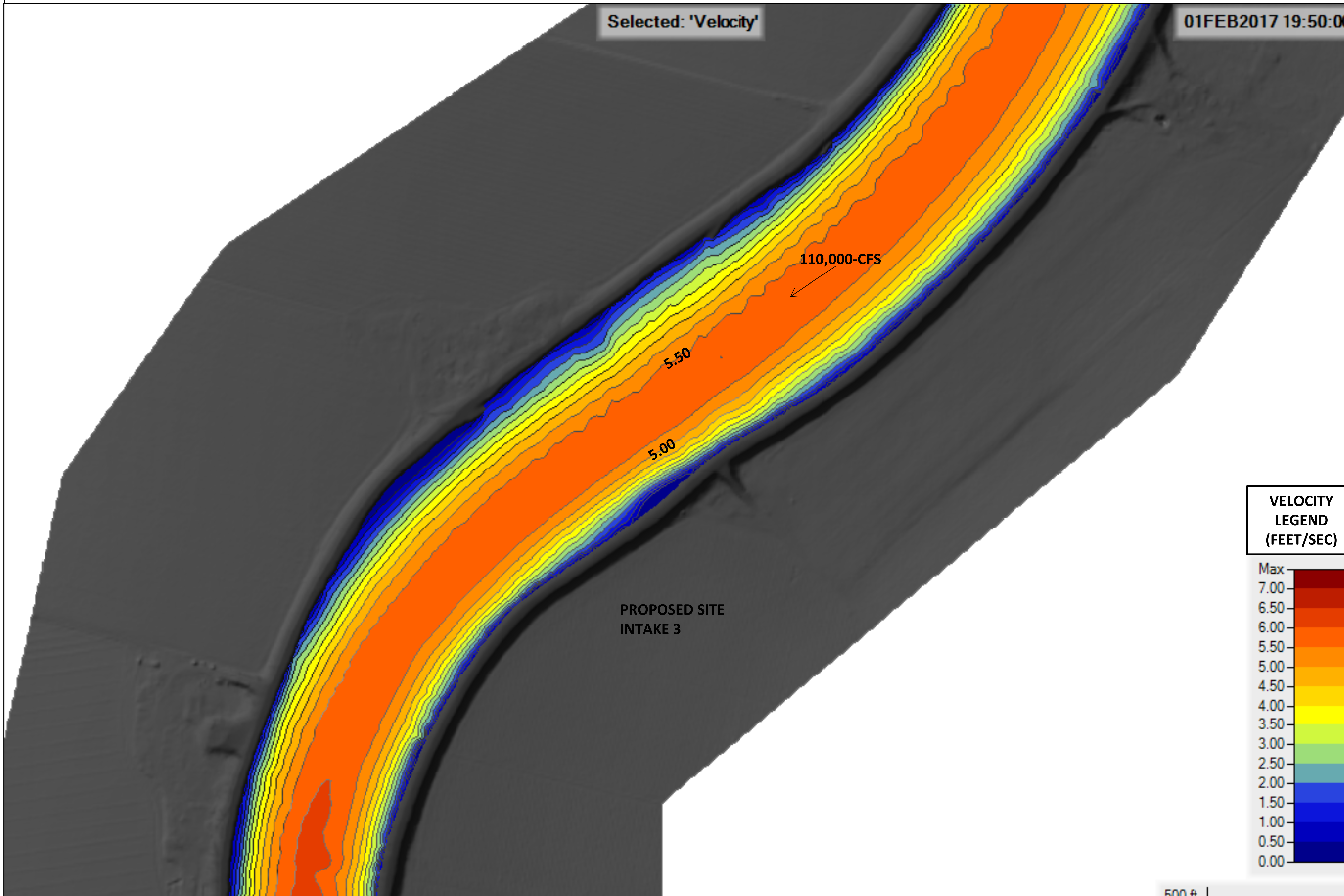
Permanent Condition

Model No. 14

1957 Design – 110,000-cfs

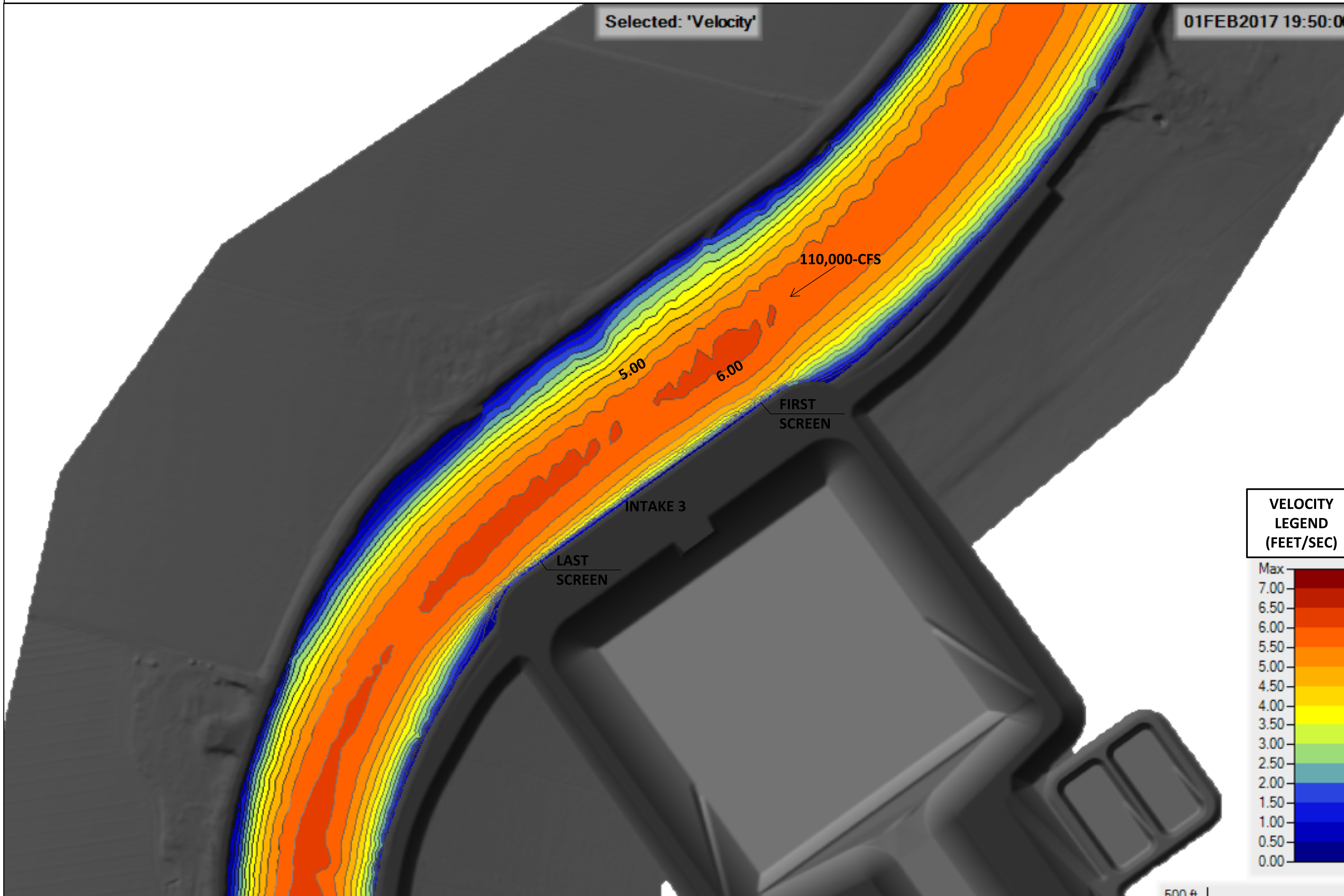
RUN 01 - INTAKE C-E-3 (B) – VELOCITY CONTOUR PLOT

MODEL SCENARIO EXISTING CONDITIONS – 1957 DESIGN FLOW



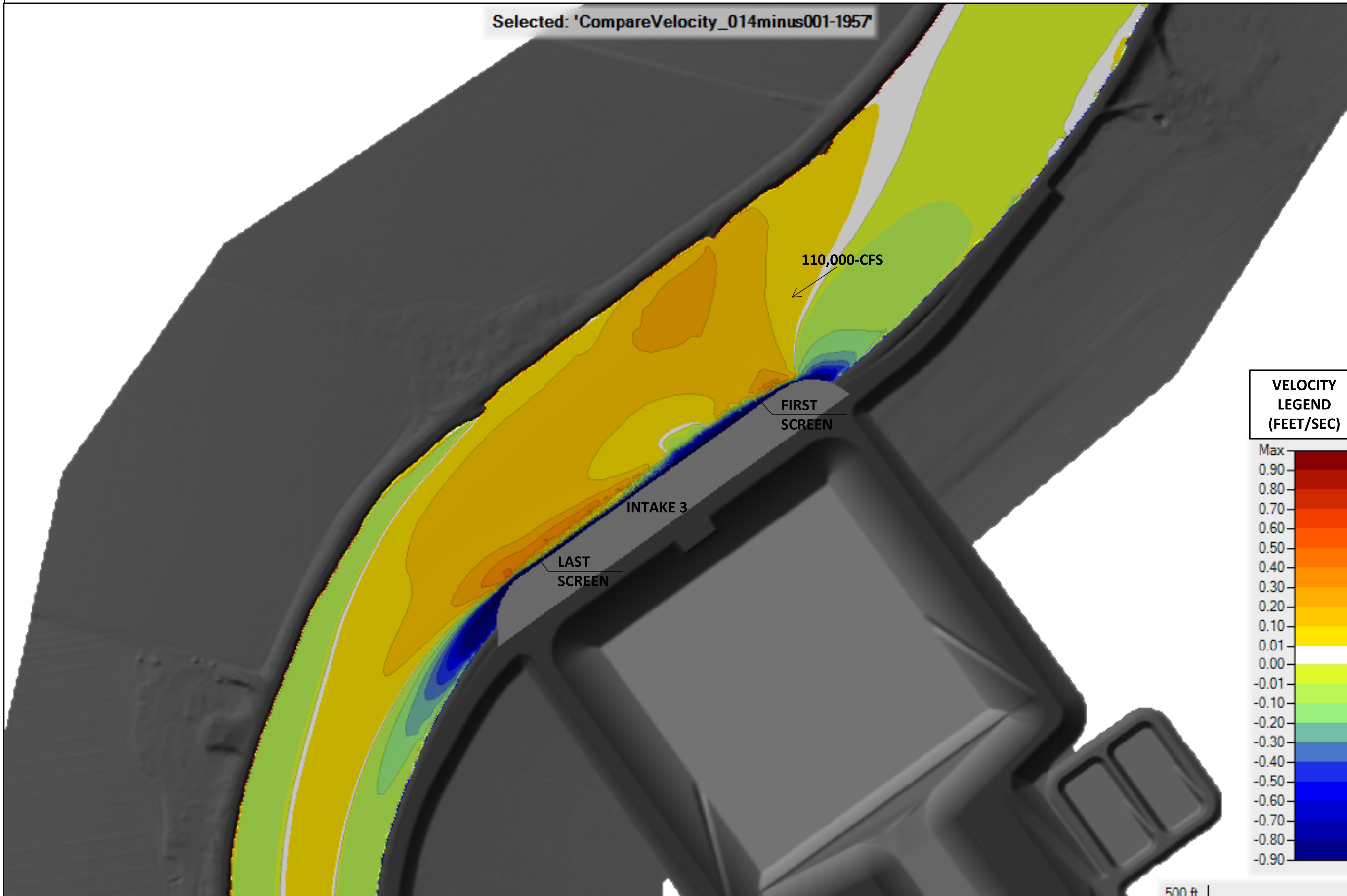
RUN 14 - INTAKE C-E-3 (B) – VELOCITY CONTOUR PLOT

MODEL TYPE 014 – 1957 DESIGN FLOW



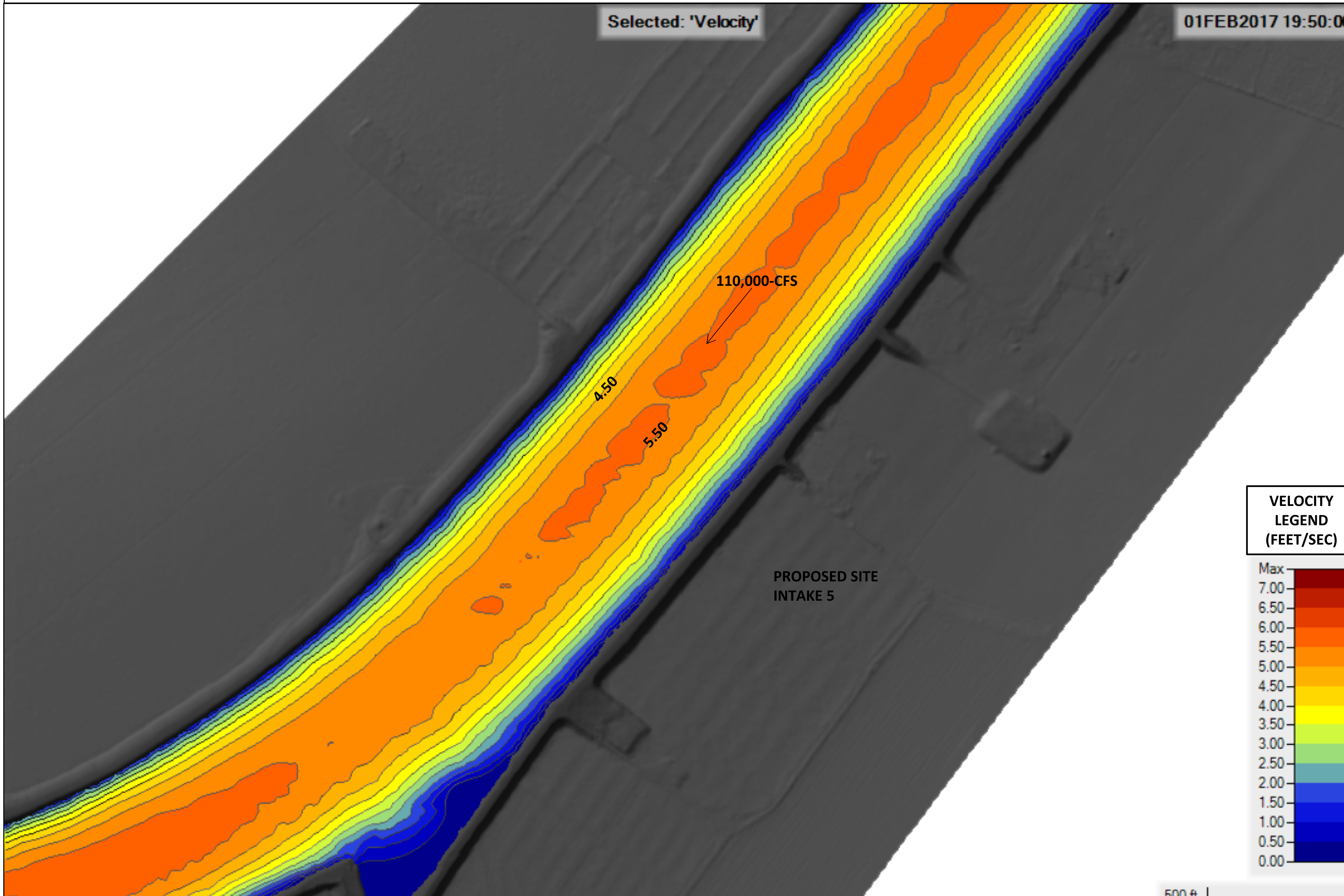
RUN 14 - INTAKE C-E-3 (B) – VELOCITY DIFFERENCE CONTOUR PLOT

MODEL TYPE 014 vs EXISTING CONDITIONS – 1957 DESIGN FLOW



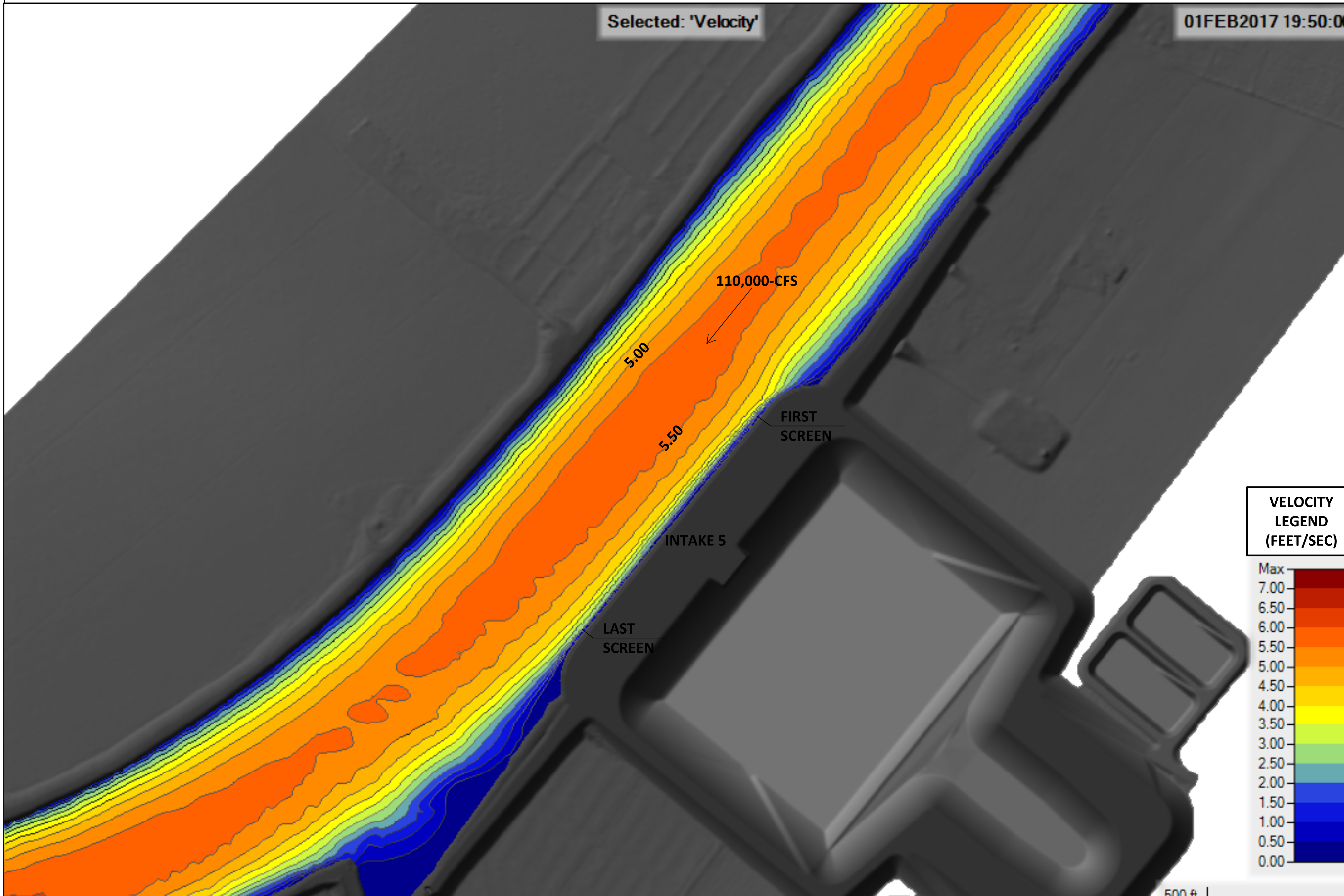
RUN 01 - INTAKE C-E-5 (C) – VELOCITY CONTOUR PLOT

MODEL SCENARIO EXISTING CONDITIONS – 1957 DESIGN FLOW



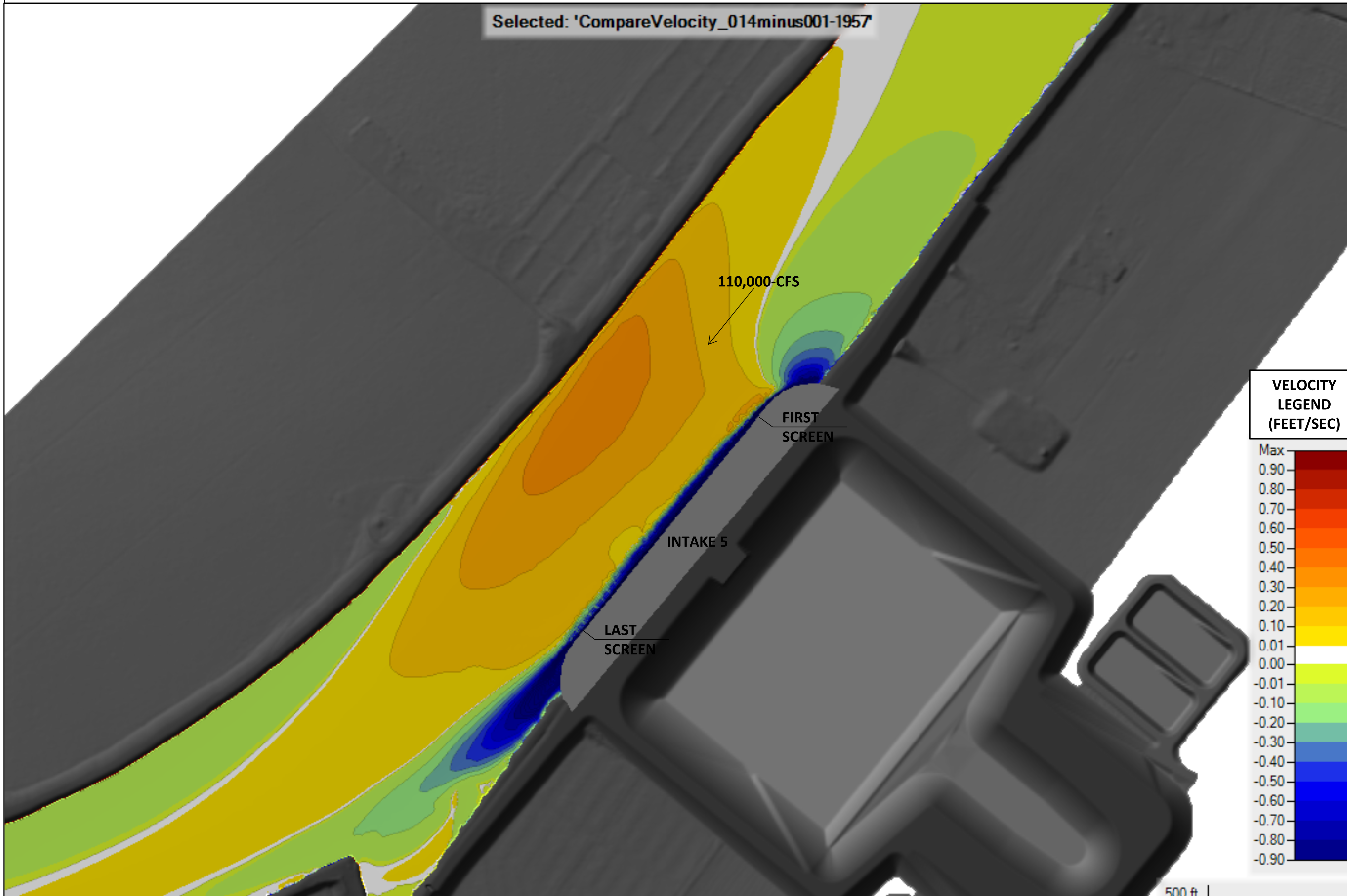
RUN 14 - INTAKE C-E-5 (C) – VELOCITY CONTOUR PLOT

MODEL TYPE 014 – 1957 DESIGN FLOW



RUN 14 - INTAKE C-E-5 (C) – VELOCITY DIFFERENCE CONTOUR PLOT

MODEL TYPE 014 vs EXISTING CONDITIONS – 1957 DESIGN FLOW



Velocity Contour and Difference Plots
Model TYPE 014

Tee Screen

Intakes C-E-3, C-E-5

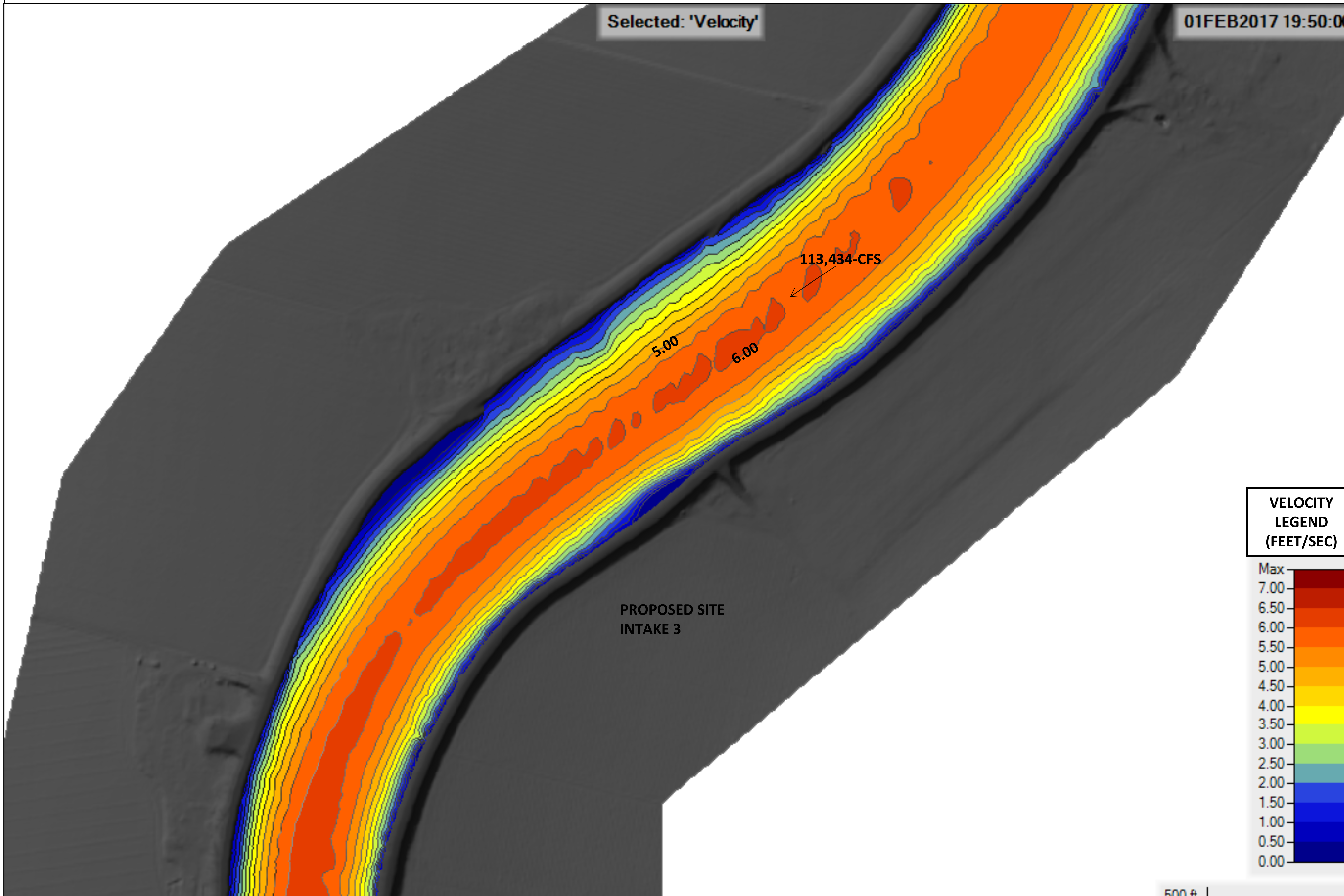
Permanent Condition

Model No. 15

Existing 100-Year Event – 113,434-cfs

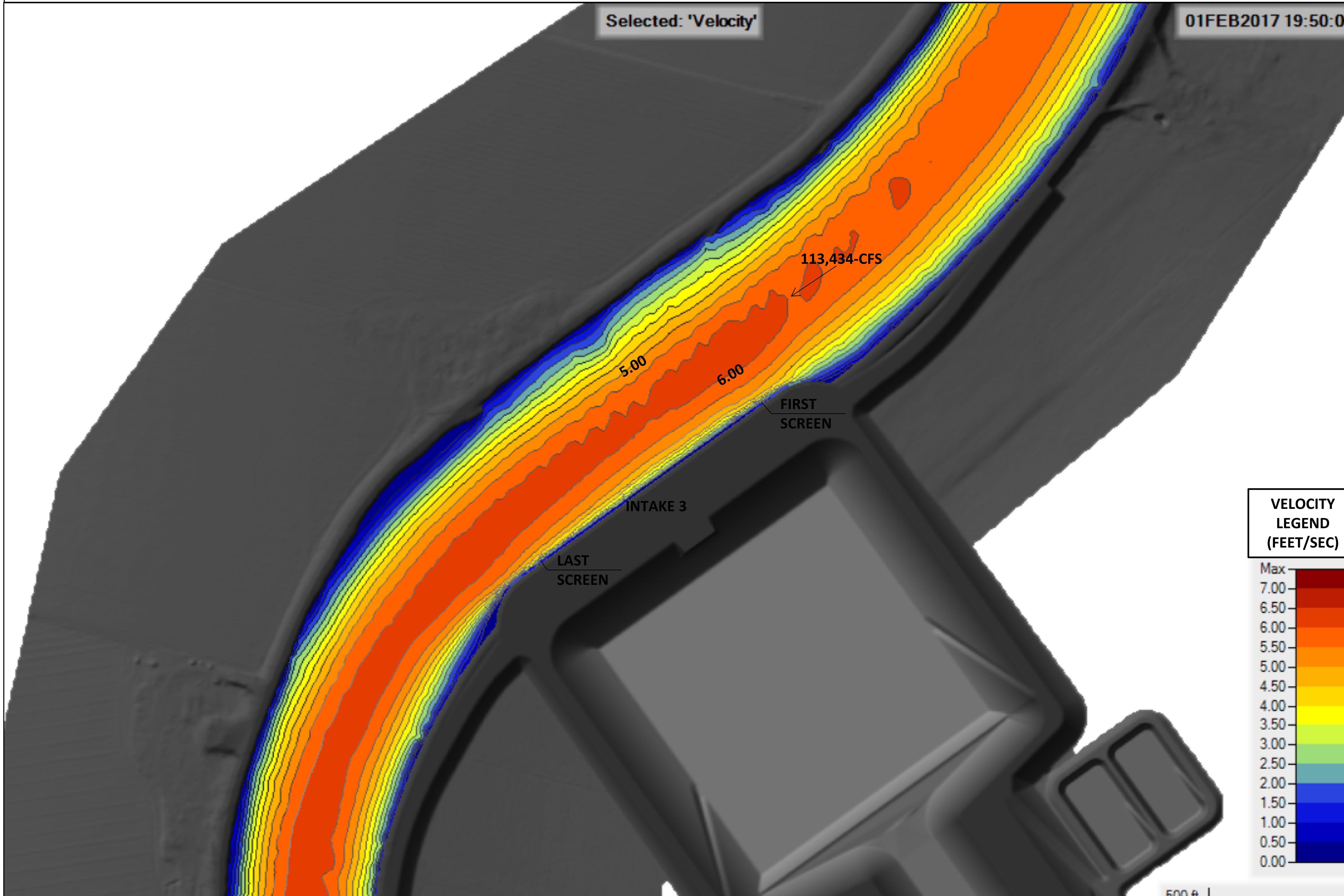
RUN 02 - INTAKE C-E-3 (B) – VELOCITY CONTOUR PLOT

MODEL SCENARIO EXISTING CONDITIONS – EXISTING 100-YR FLOW



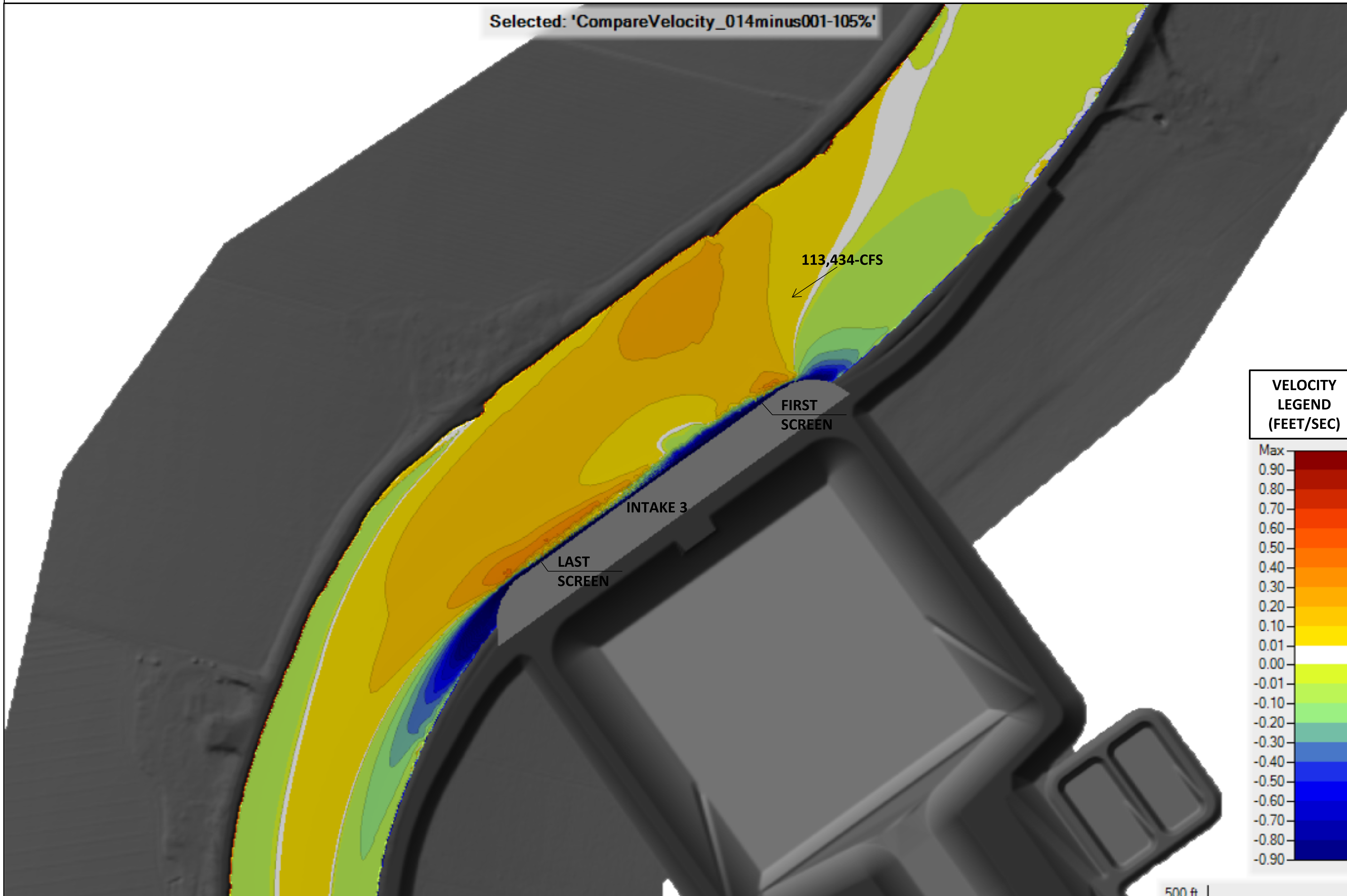
RUN 15 - INTAKE C-E-3 (B) – VELOCITY CONTOUR PLOT

MODEL TYPE 014 – EXISTING 100-YR FLOW

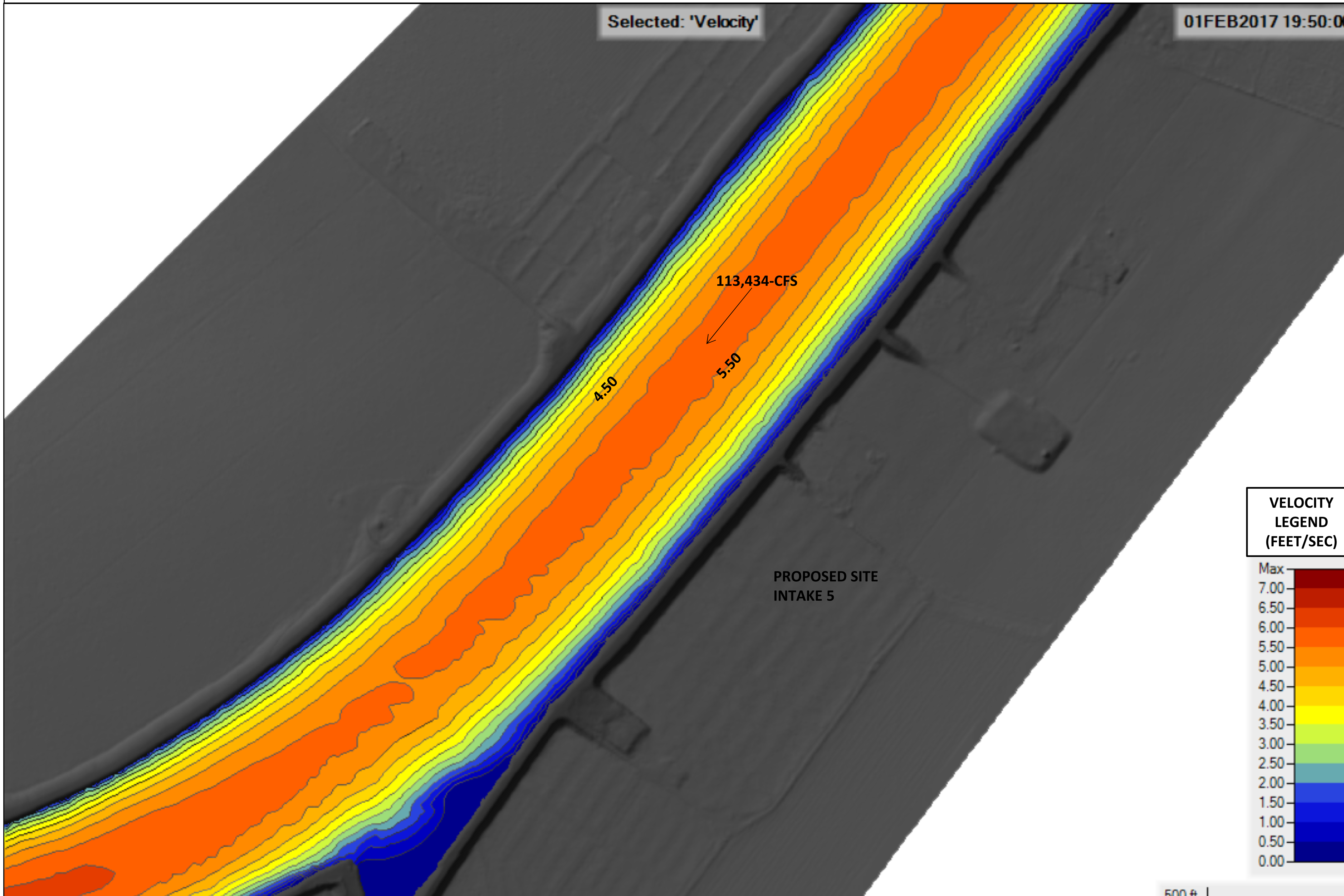


RUN 15 - INTAKE C-E-3 (B) – VELOCITY DIFFERENCE CONTOUR PLOT

MODEL TYPE 014 vs EXISTING CONDITIONS – EXISTING 100-YR FLOW

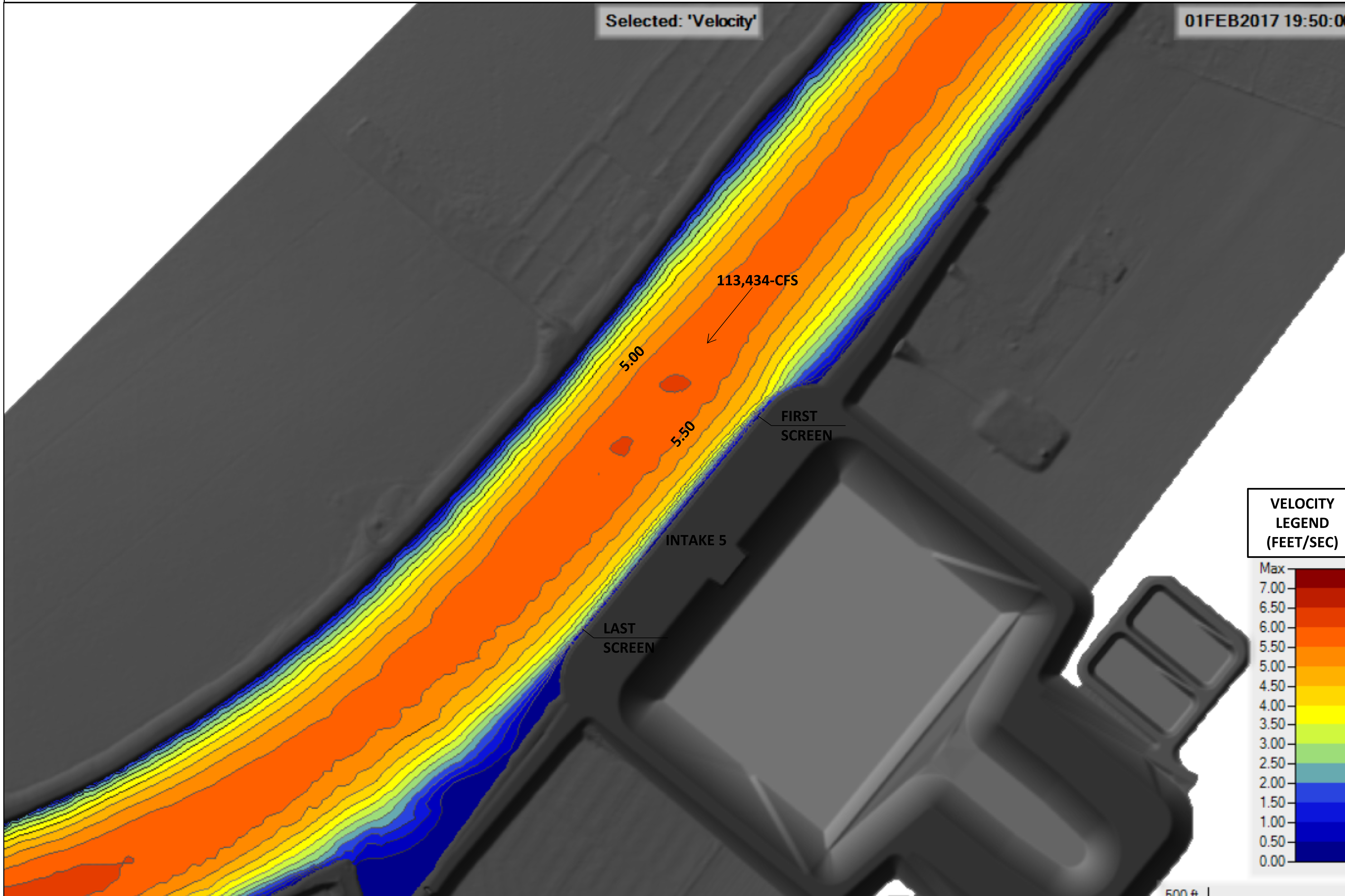


RUN 02 - INTAKE C-E-5 (C) – VELOCITY CONTOUR PLOT
MODEL SCENARIO EXISTING CONDITIONS – EXISTING 100-YR FLOW



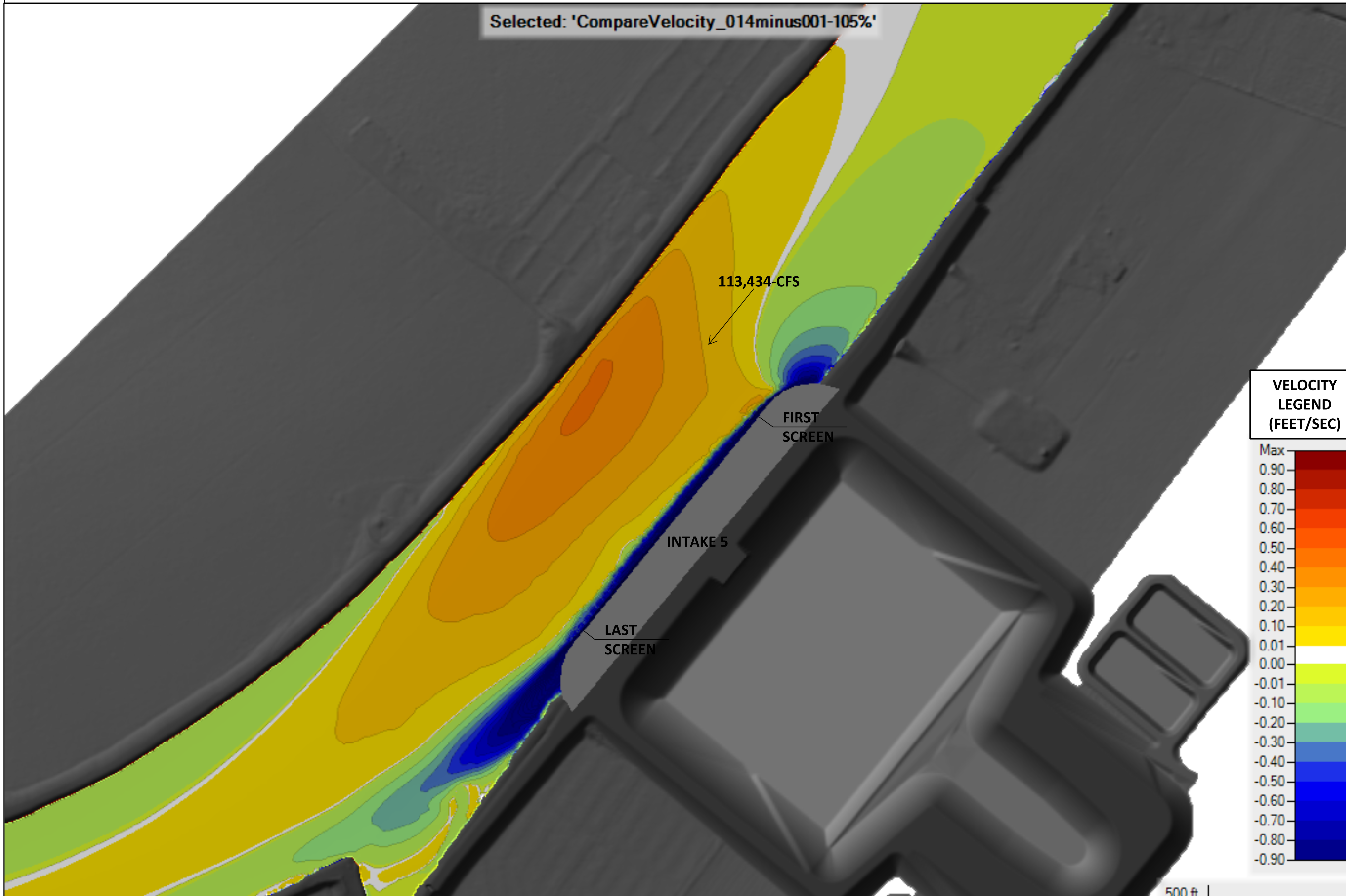
RUN 15 - INTAKE C-E-5 (C) – VELOCITY CONTOUR PLOT

MODEL TYPE 014 – EXISTING 100-YR FLOW



RUN 15 - INTAKE C-E-5 (C) – VELOCITY DIFFERENCE CONTOUR PLOT

MODEL TYPE 014 vs EXISTING CONDITIONS – EXISTING 100-YR FLOW



Velocity Contour and Difference Plots
Model TYPE 014

Tee Screen

Intakes C-E-3, C-E-5

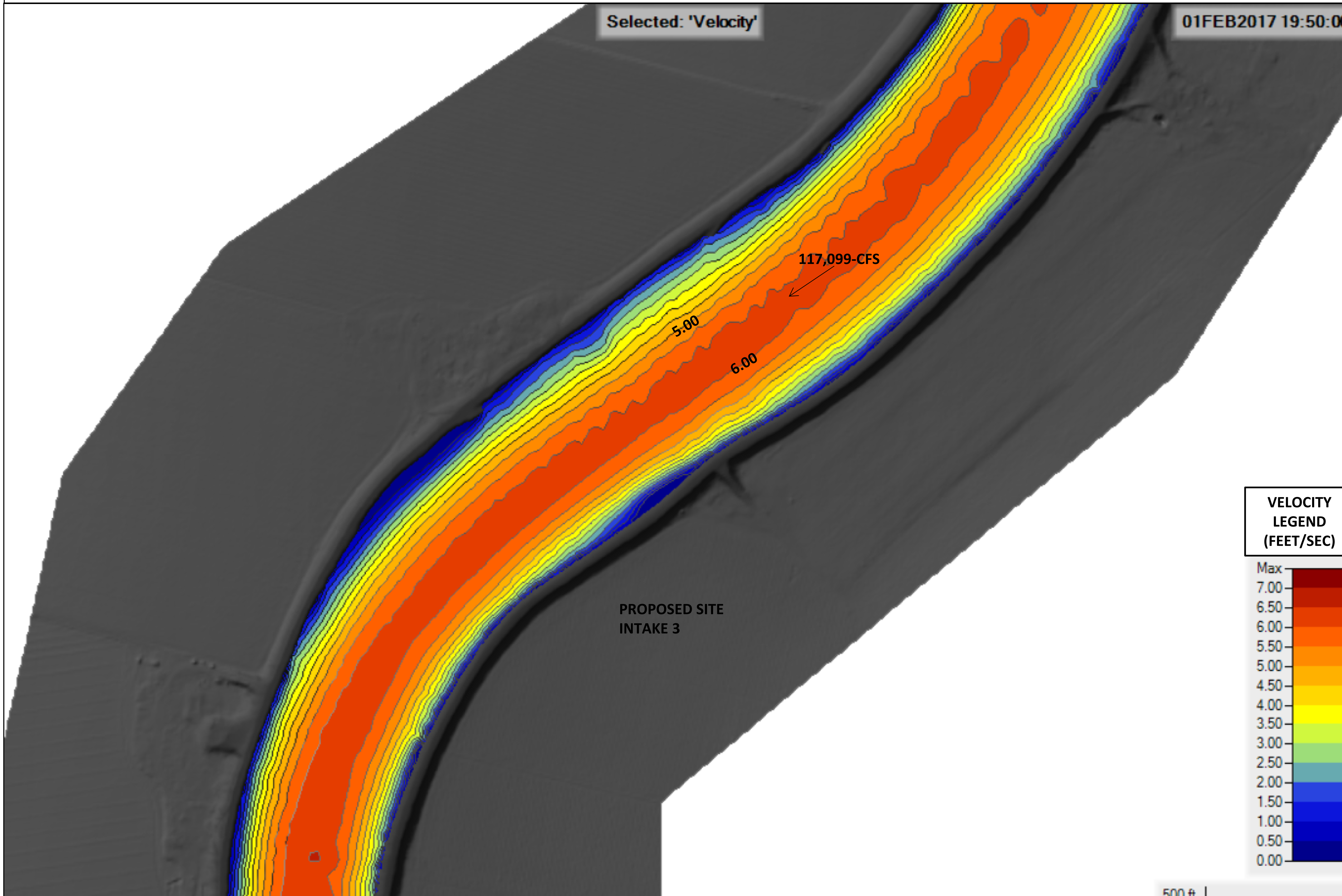
Permanent Condition

Model No. 16

Existing 200-Year Event – 117,099-cfs

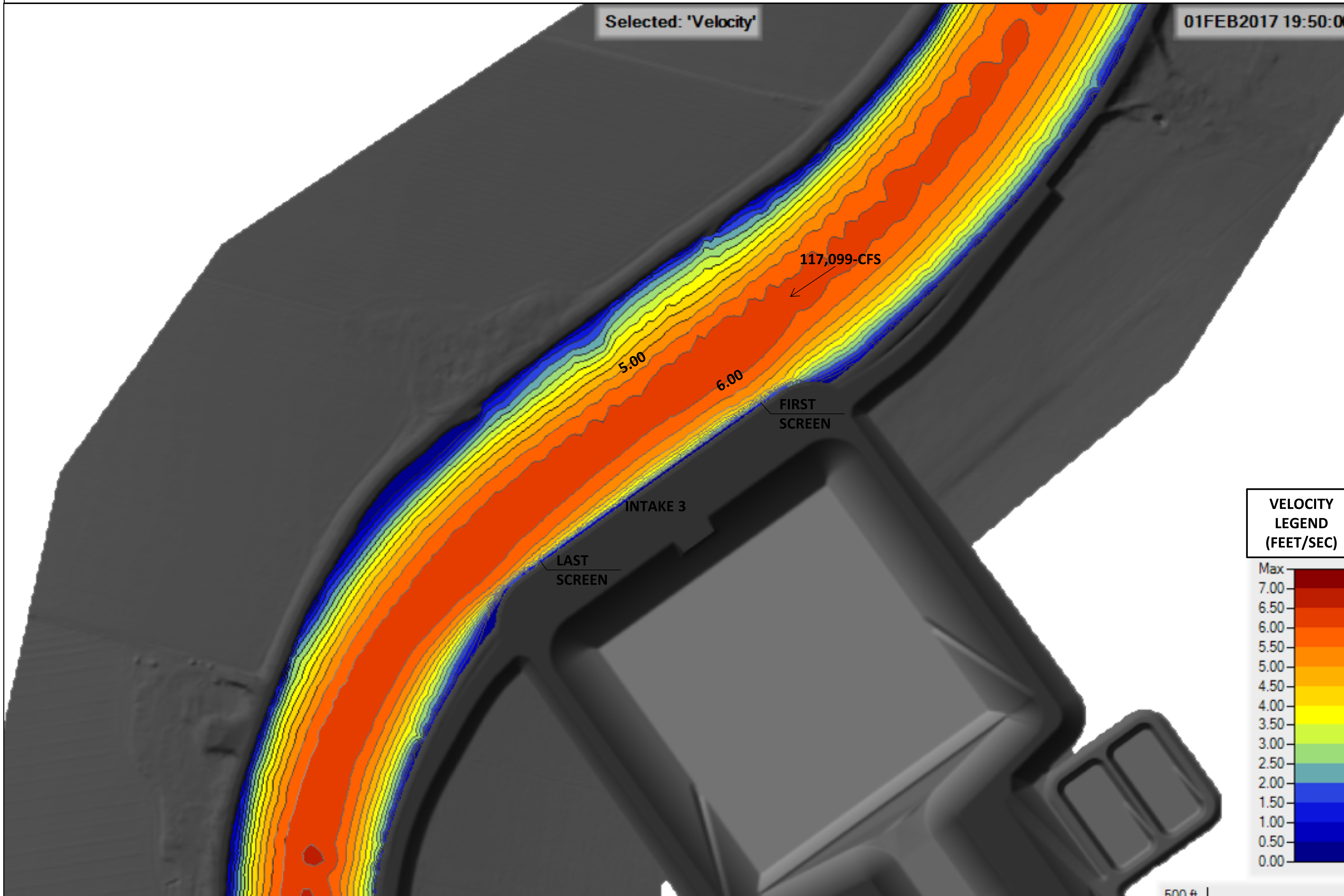
RUN 03 - INTAKE C-E-3 (B) – VELOCITY CONTOUR PLOT

MODEL SCENARIO EXISTING CONDITIONS – EXISTING 200-YR FLOW



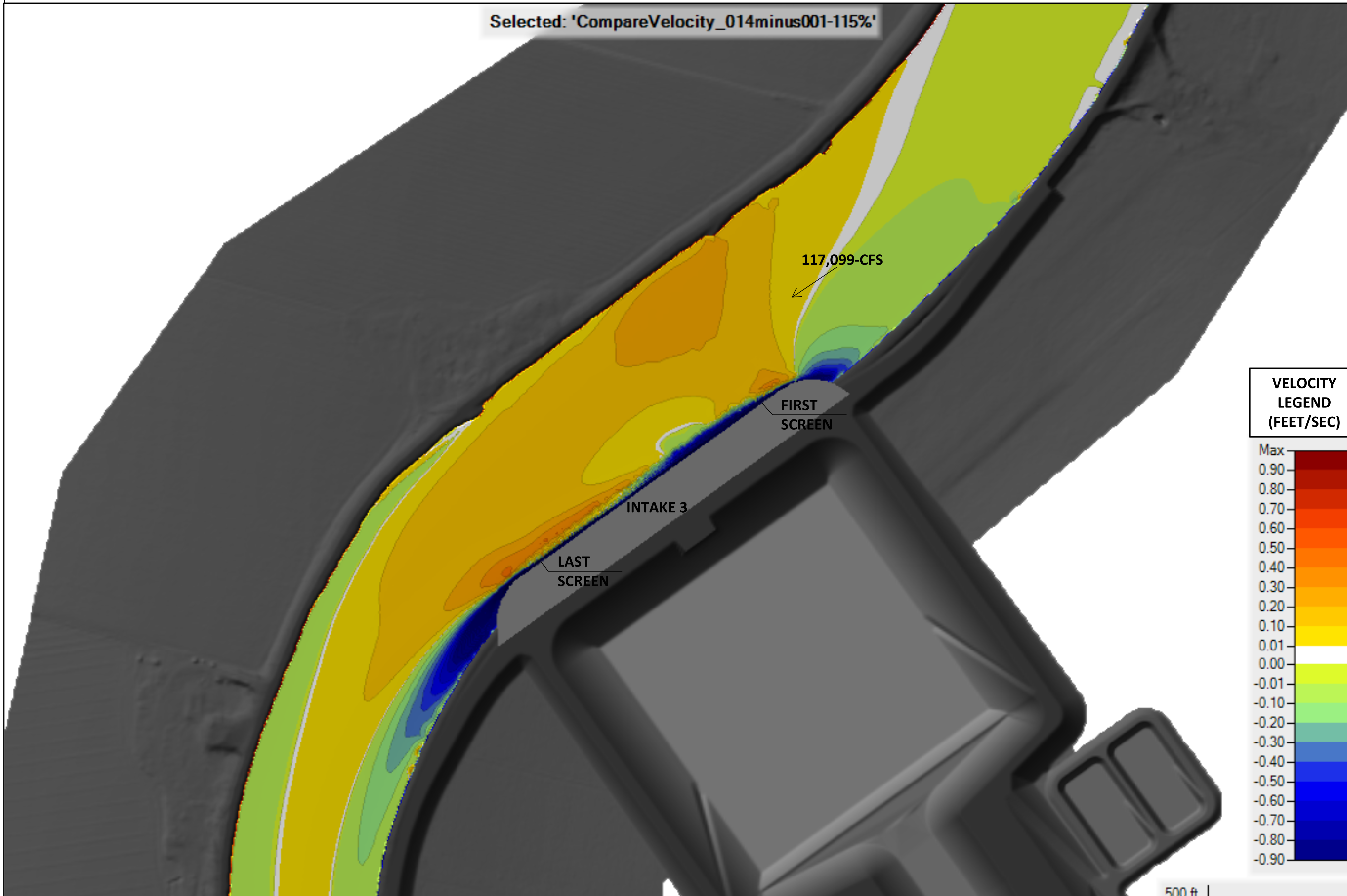
RUN 16 - INTAKE C-E-3 (B) – VELOCITY CONTOUR PLOT

MODEL TYPE 014 – EXISTING 200-YR FLOW



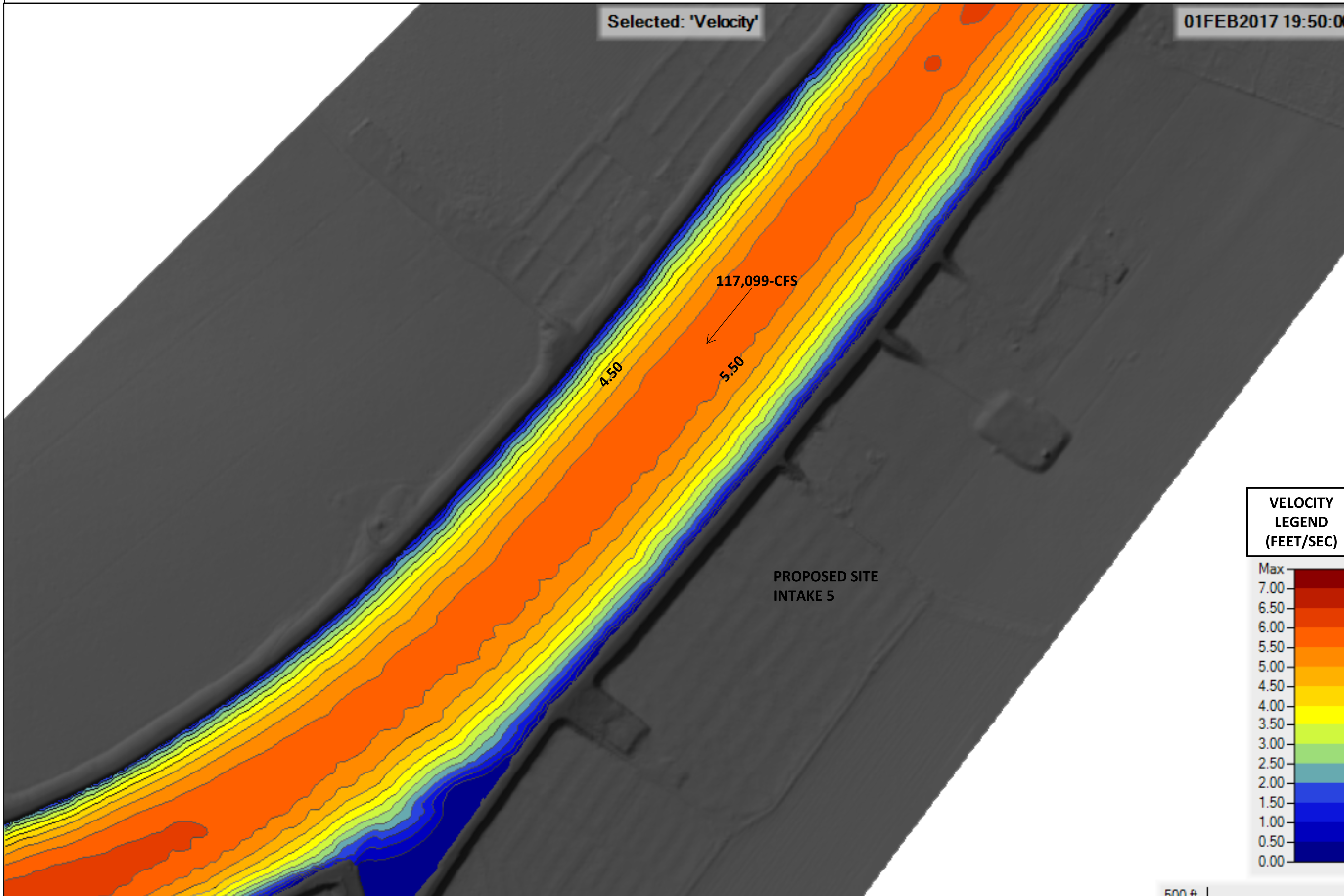
RUN 16 - INTAKE C-E-3 (B) – VELOCITY DIFFERENCE CONTOUR PLOT

MODEL TYPE 014 vs EXISTING CONDITIONS – EXISTING 200-YR FLOW



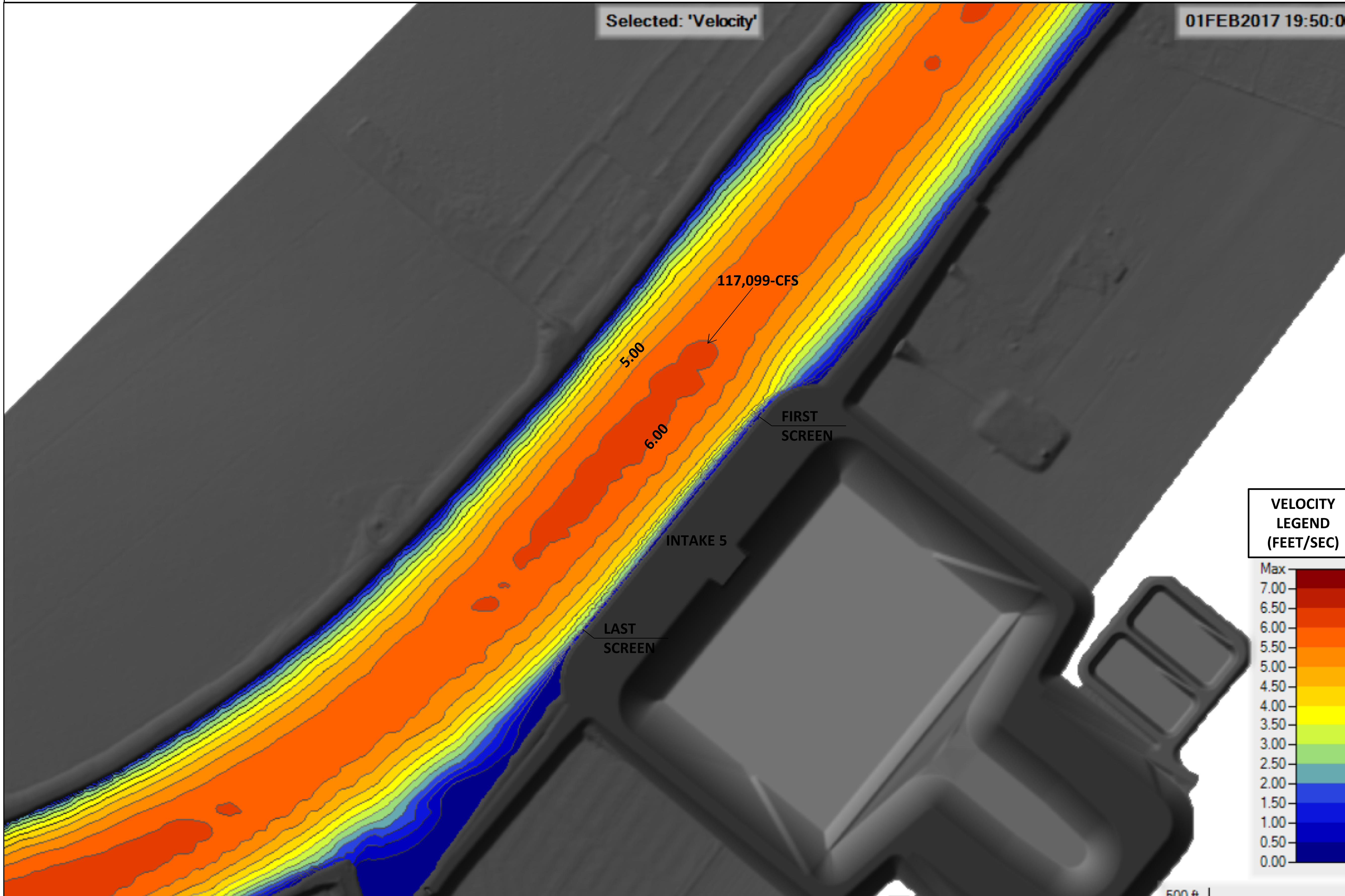
RUN 03 - INTAKE C-E-5 (C) – VELOCITY CONTOUR PLOT

MODEL SCENARIO EXISTING CONDITIONS – EXISTING 200-YR FLOW



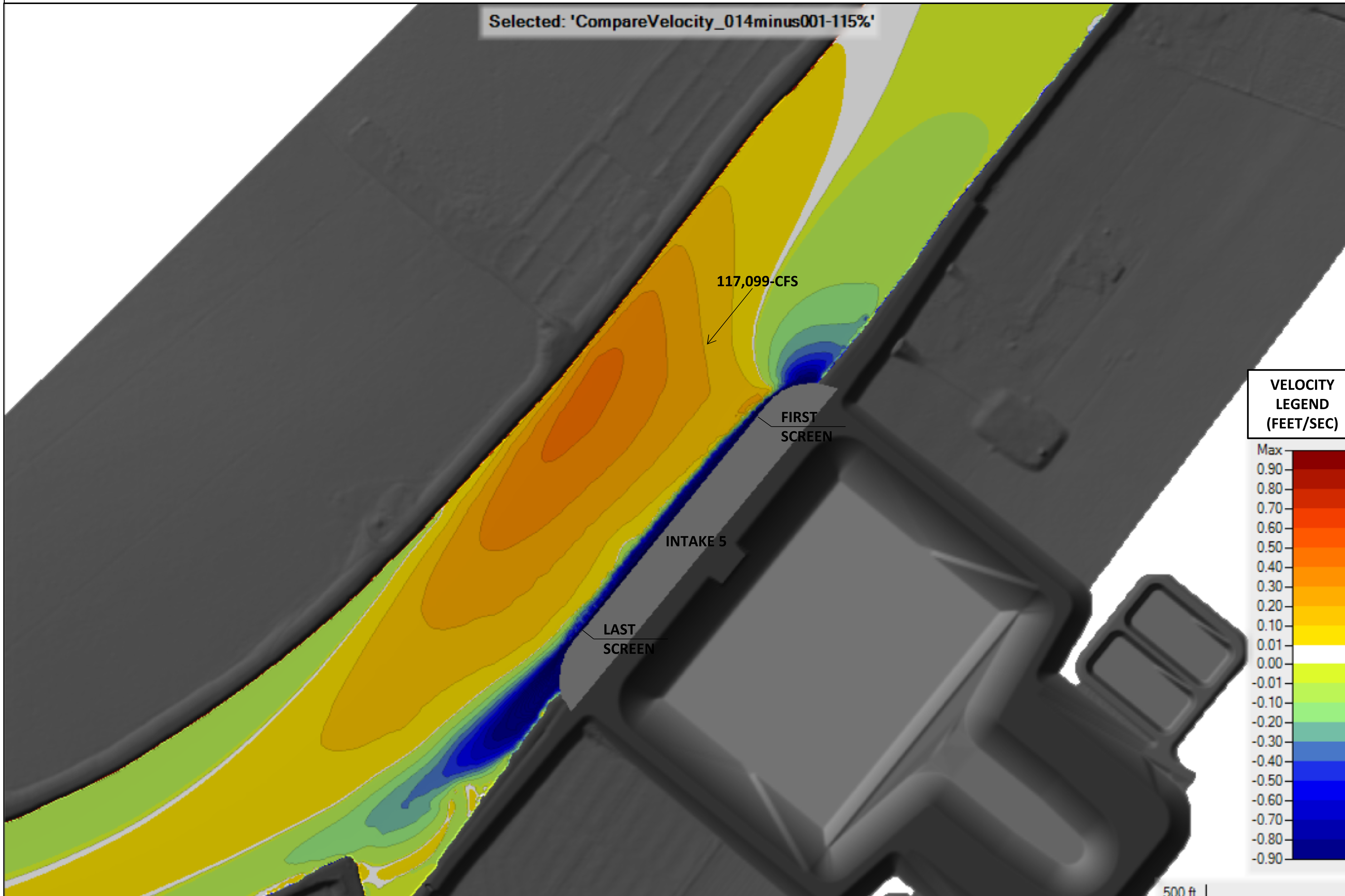
RUN 16 - INTAKE C-E-5 (C) – VELOCITY CONTOUR PLOT

MODEL TYPE 014 – EXISTING 200-YR FLOW



RUN 16 - INTAKE C-E-5 (C) – VELOCITY DIFFERENCE CONTOUR PLOT

MODEL TYPE 014 vs EXISTING CONDITIONS – EXISTING 200-YR FLOW



Velocity Contour and Difference Plots
Model TYPE 014

Tee Screen

Intakes C-E-3, C-E-5

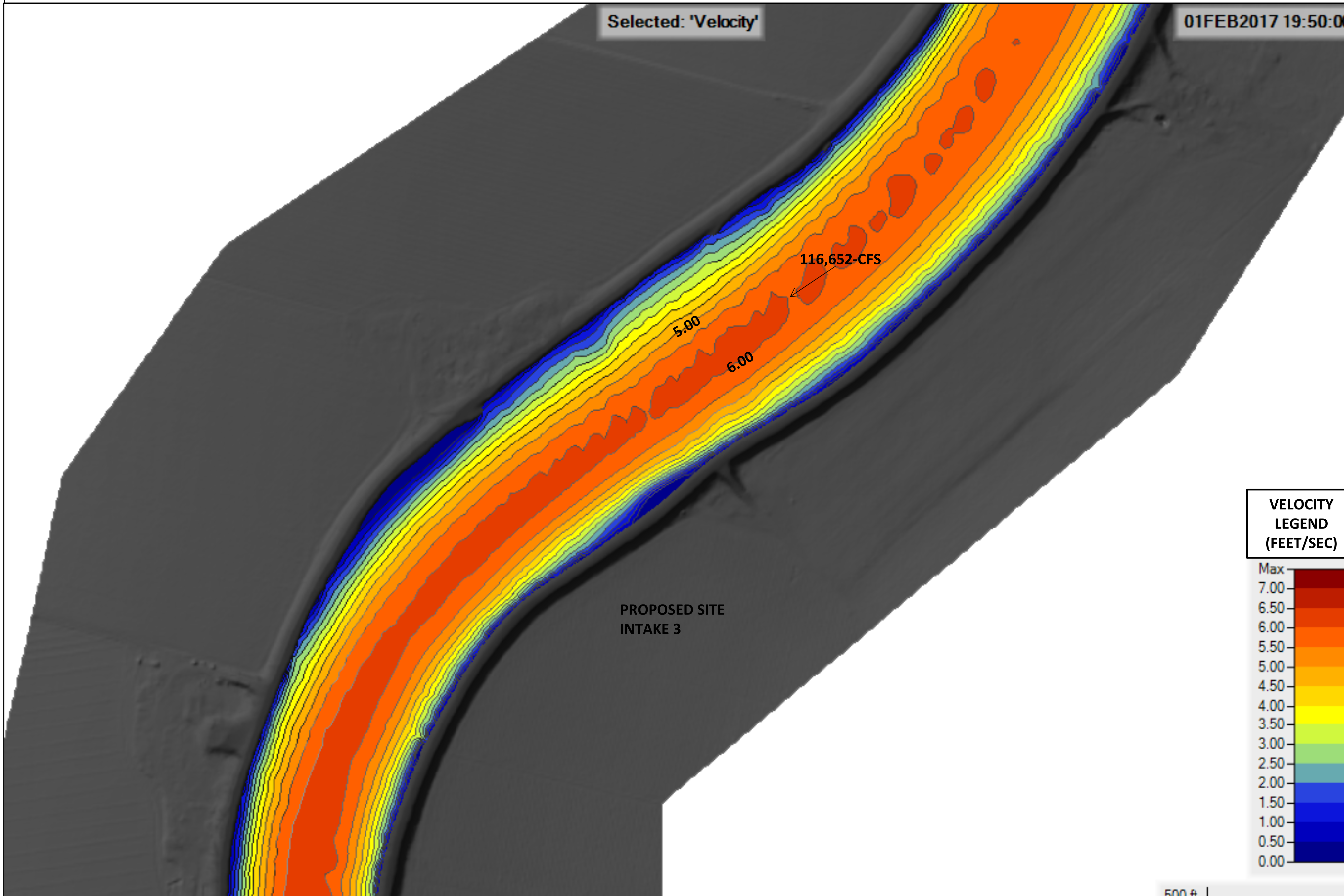
Permanent Condition

Model No. 17

Future 100-Year Event – 116,652-cfs

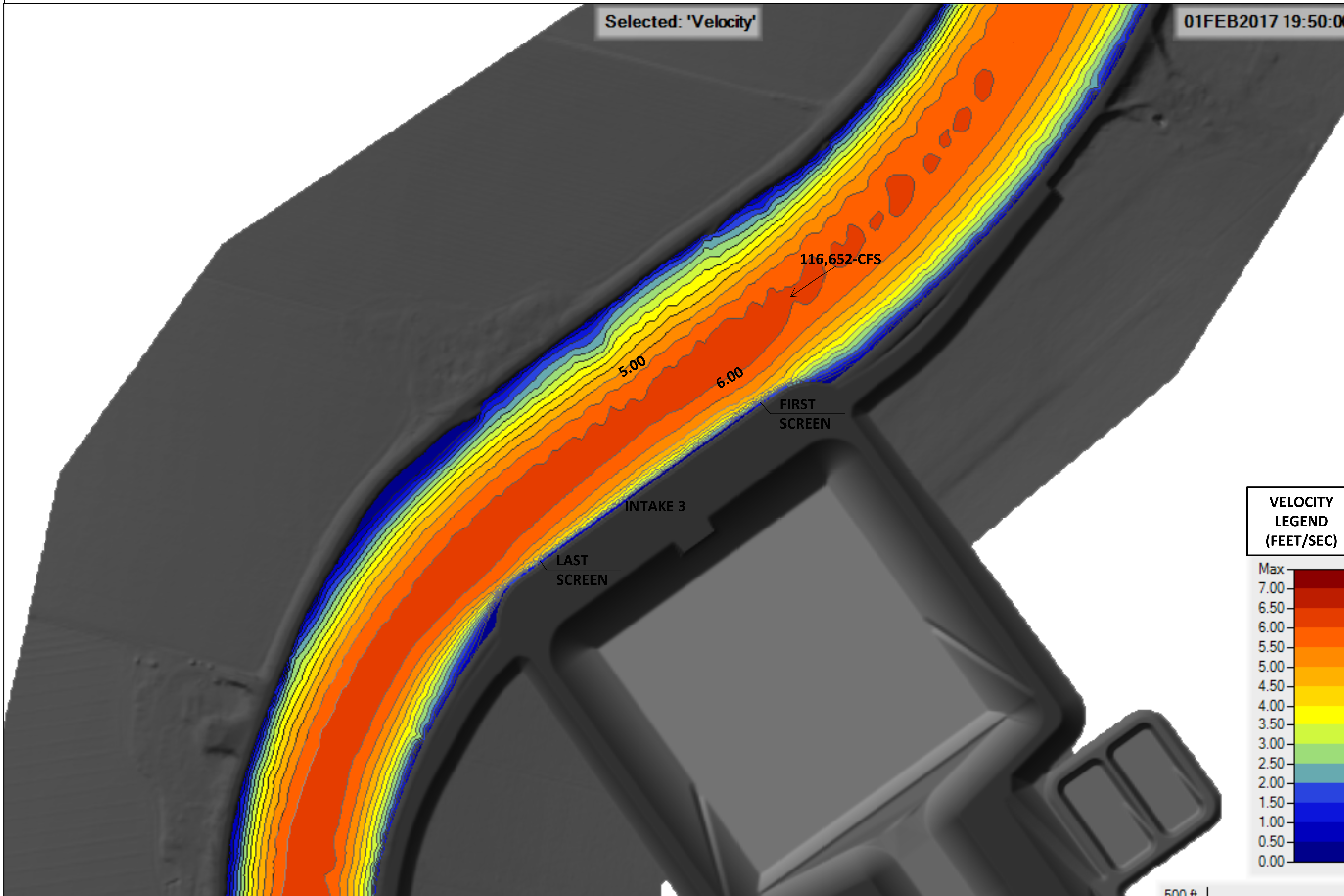
RUN 04 - INTAKE C-E-3 (B) – VELOCITY CONTOUR PLOT

MODEL SCENARIO EXISTING CONDITIONS – FUTURE 100-YR FLOW



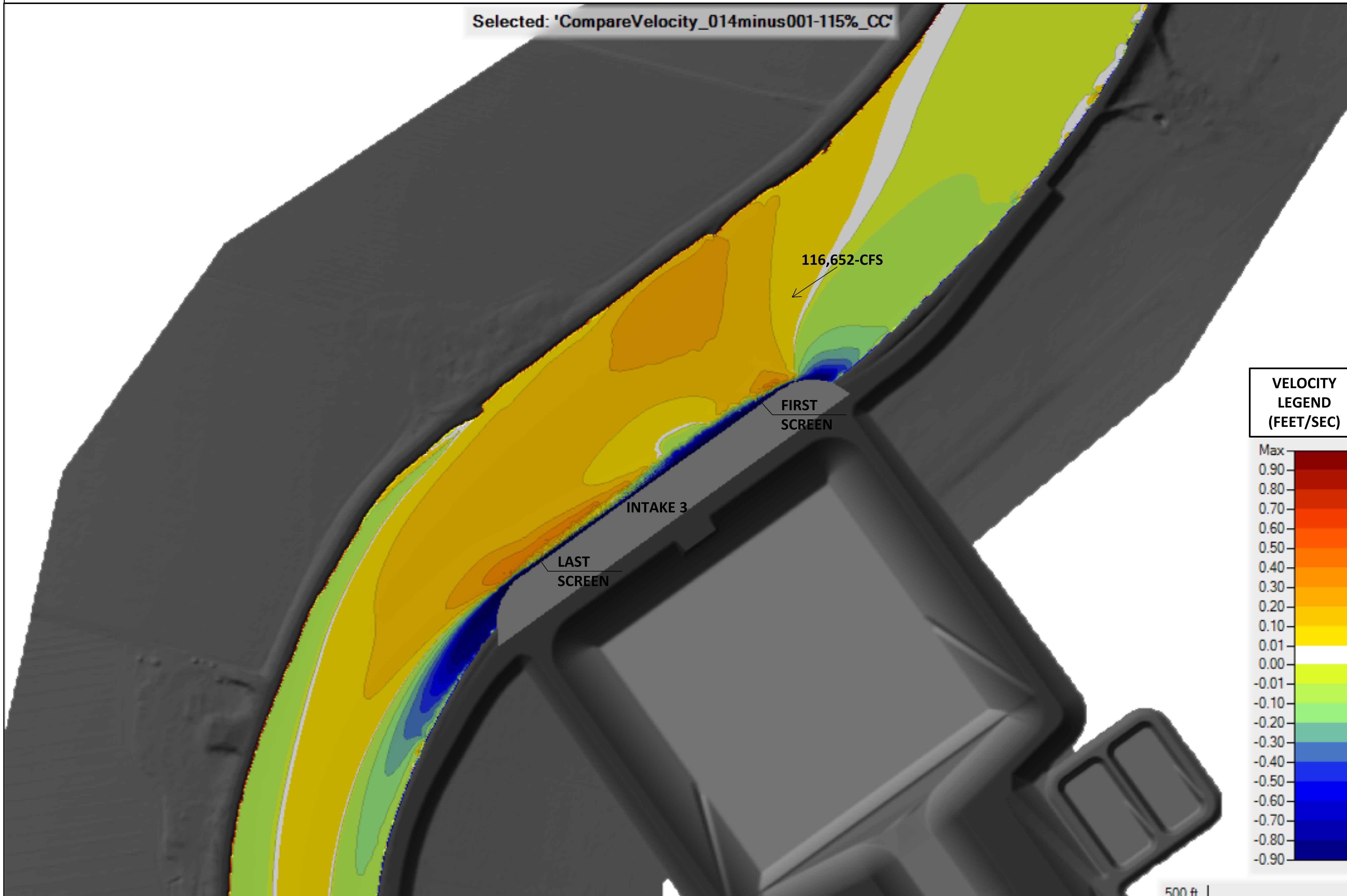
RUN 17 - INTAKE C-E-3 (B) – VELOCITY CONTOUR PLOT

MODEL TYPE 014 – FUTURE 100-YR FLOW



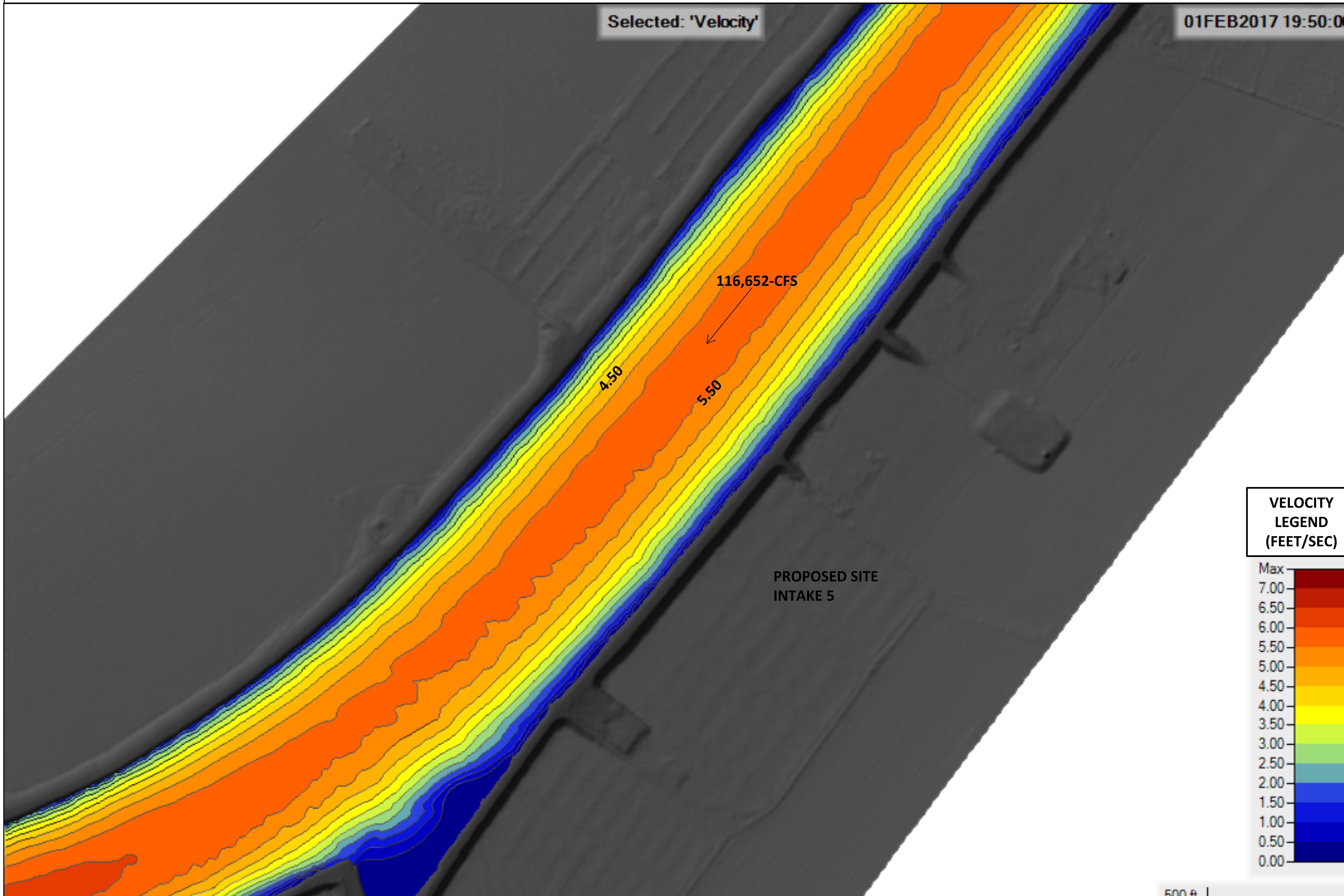
RUN 17 - INTAKE C-E-3 (B) – VELOCITY DIFFERENCE CONTOUR PLOT

MODEL TYPE 014 vs EXISTING CONDITIONS – FUTURE 100-YR FLOW

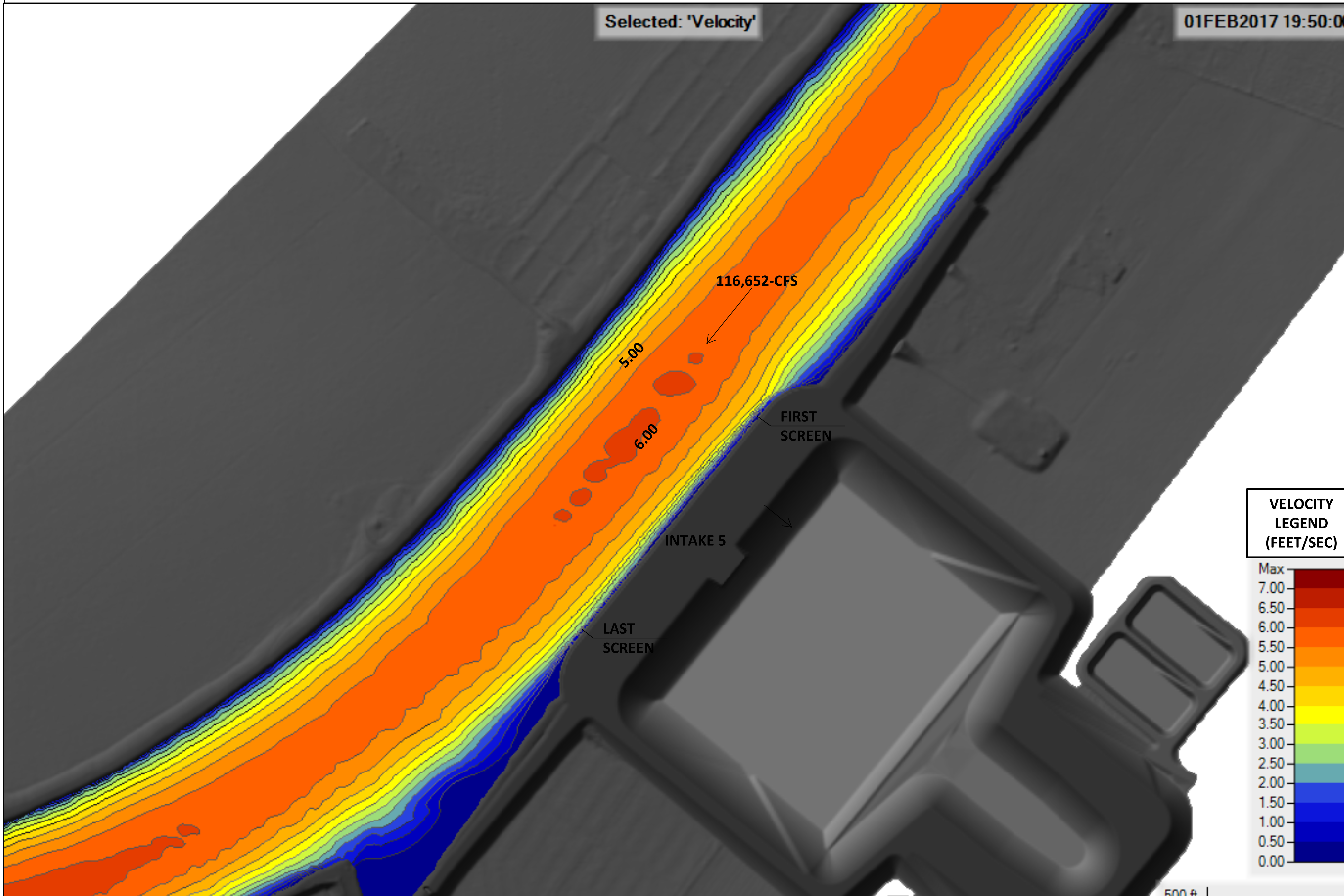


RUN 04 - INTAKE C-E-5 (C) – VELOCITY CONTOUR PLOT

MODEL SCENARIO EXISTING CONDITIONS – FUTURE 100-YR FLOW

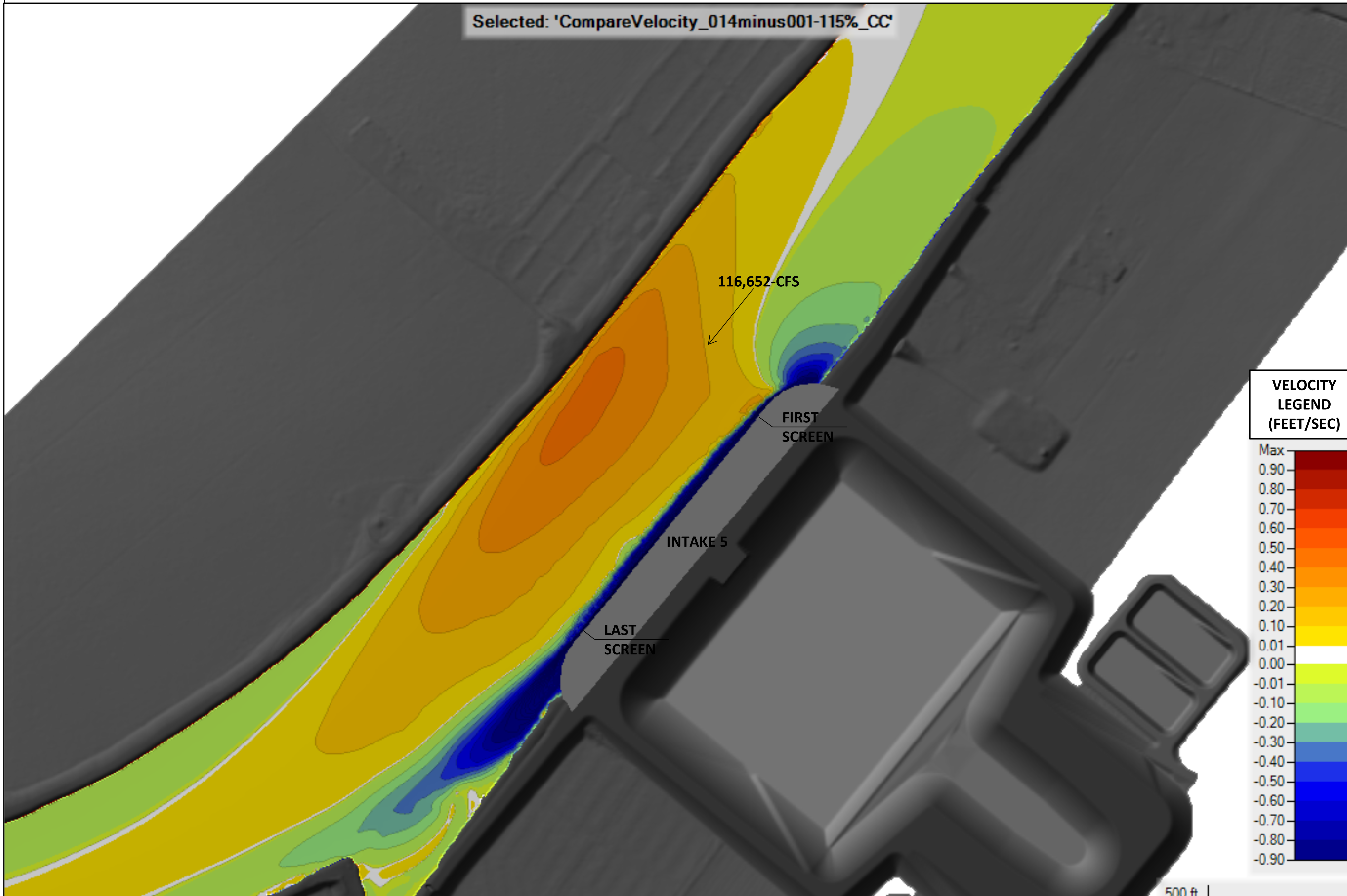


RUN 17 - INTAKE C-E-5 (C) – VELOCITY CONTOUR PLOT
MODEL TYPE 014 – FUTURE 100-YR FLOW



RUN 17 - INTAKE C-E-5 (C) – VELOCITY DIFFERENCE CONTOUR PLOT

MODEL TYPE 014 vs EXISTING CONDITIONS – FUTURE 100-YR FLOW



Velocity Contour and Difference Plots
Model TYPE 014

Tee Screen

Intakes C-E-3, C-E-5

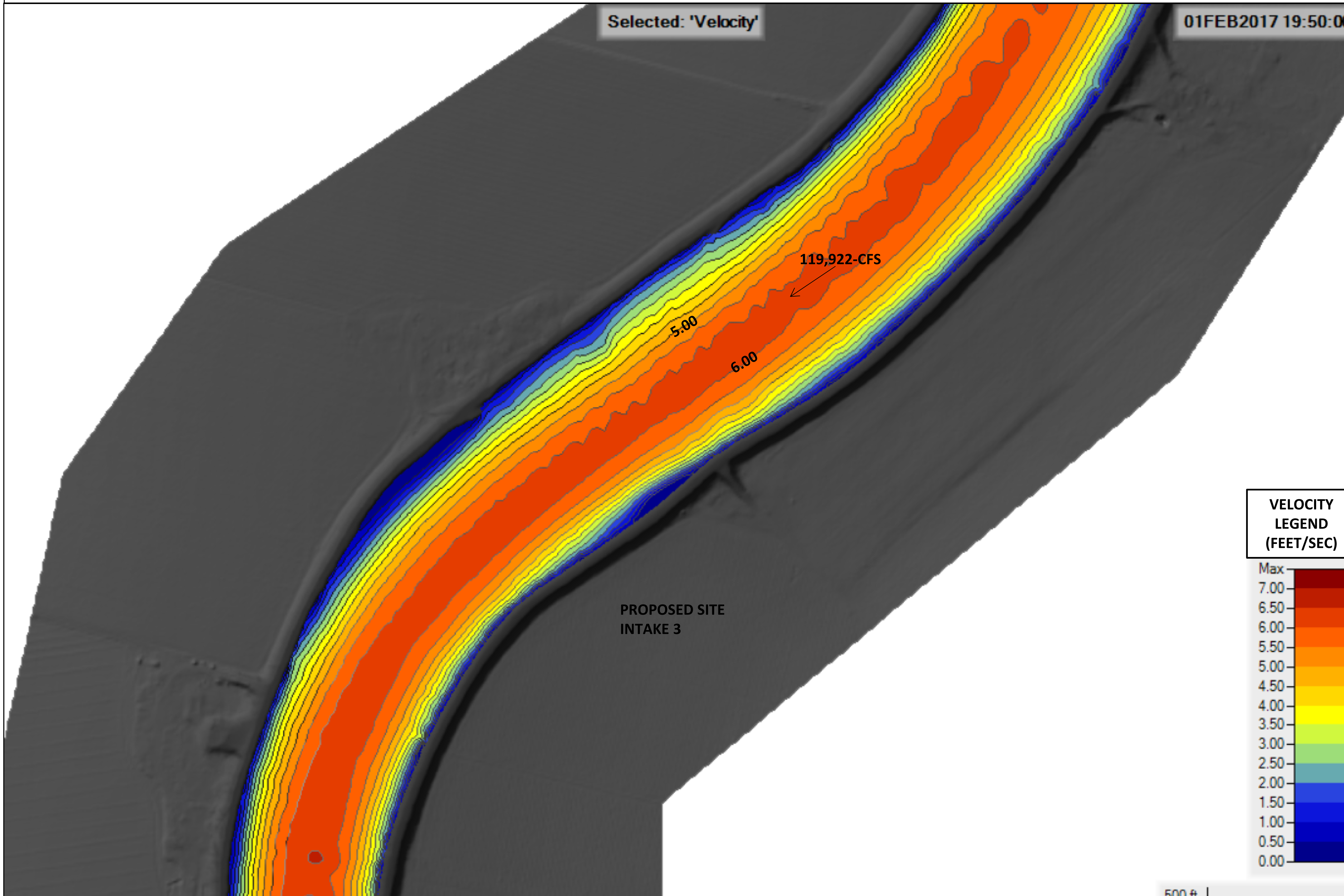
Permanent Condition

Model No. 18

Future 200-Year Event – 119,922-cfs

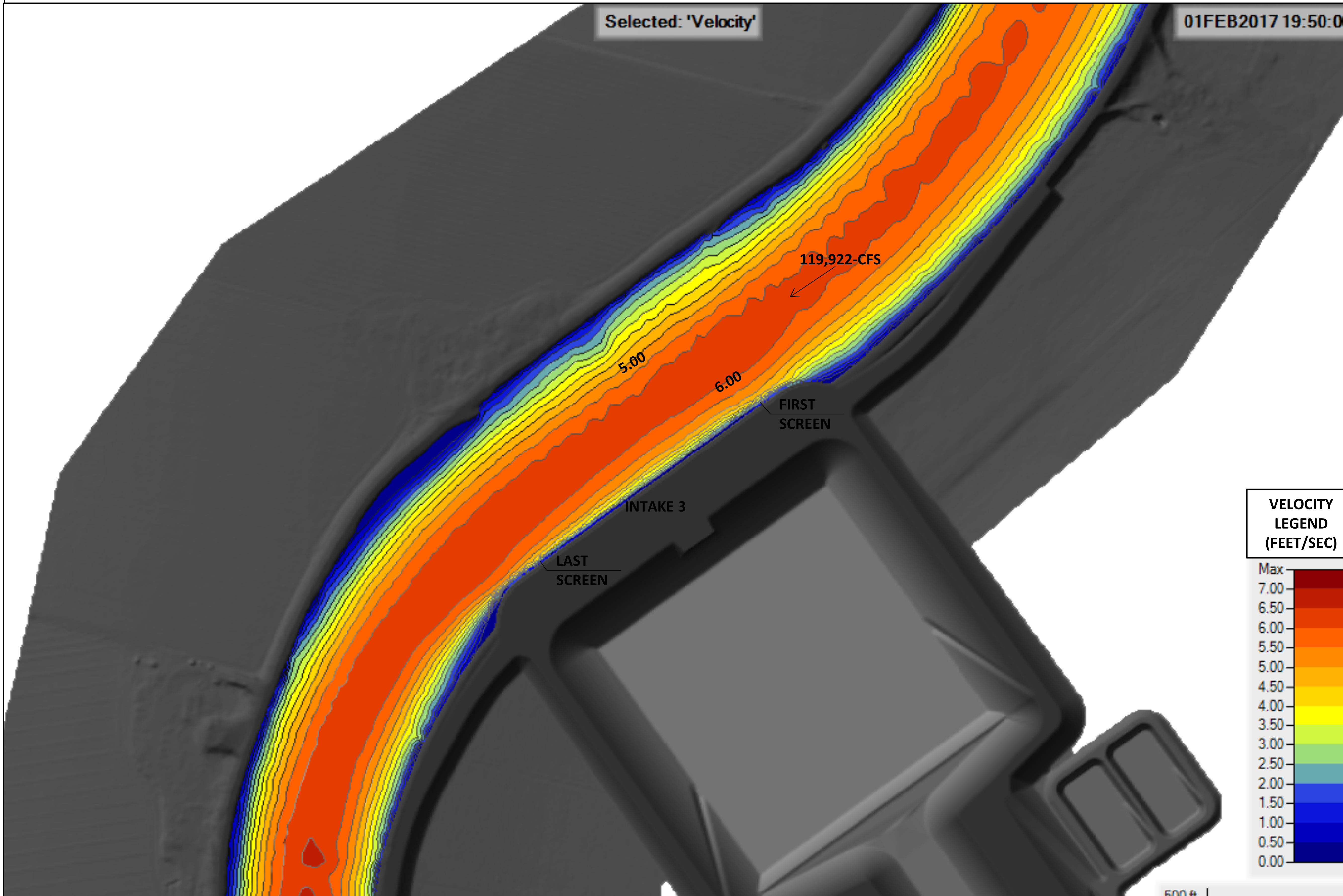
RUN 05 - INTAKE C-E-3 (B) – VELOCITY CONTOUR PLOT

MODEL SCENARIO EXISTING CONDITIONS – FUTURE 200-YR FLOW



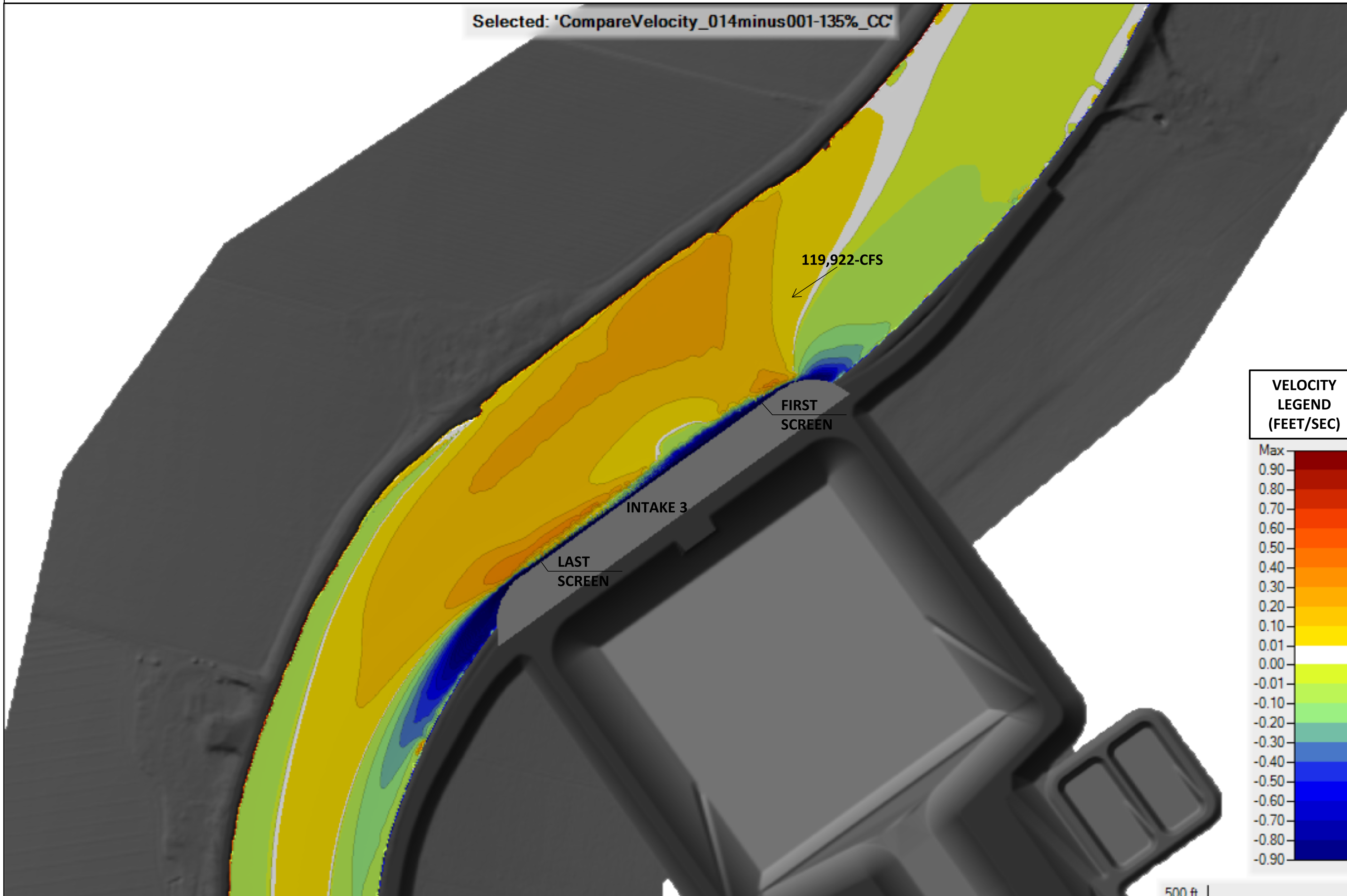
RUN 18 - INTAKE C-E-3 (B) – VELOCITY CONTOUR PLOT

MODEL TYPE 014 – FUTURE 200-YR FLOW



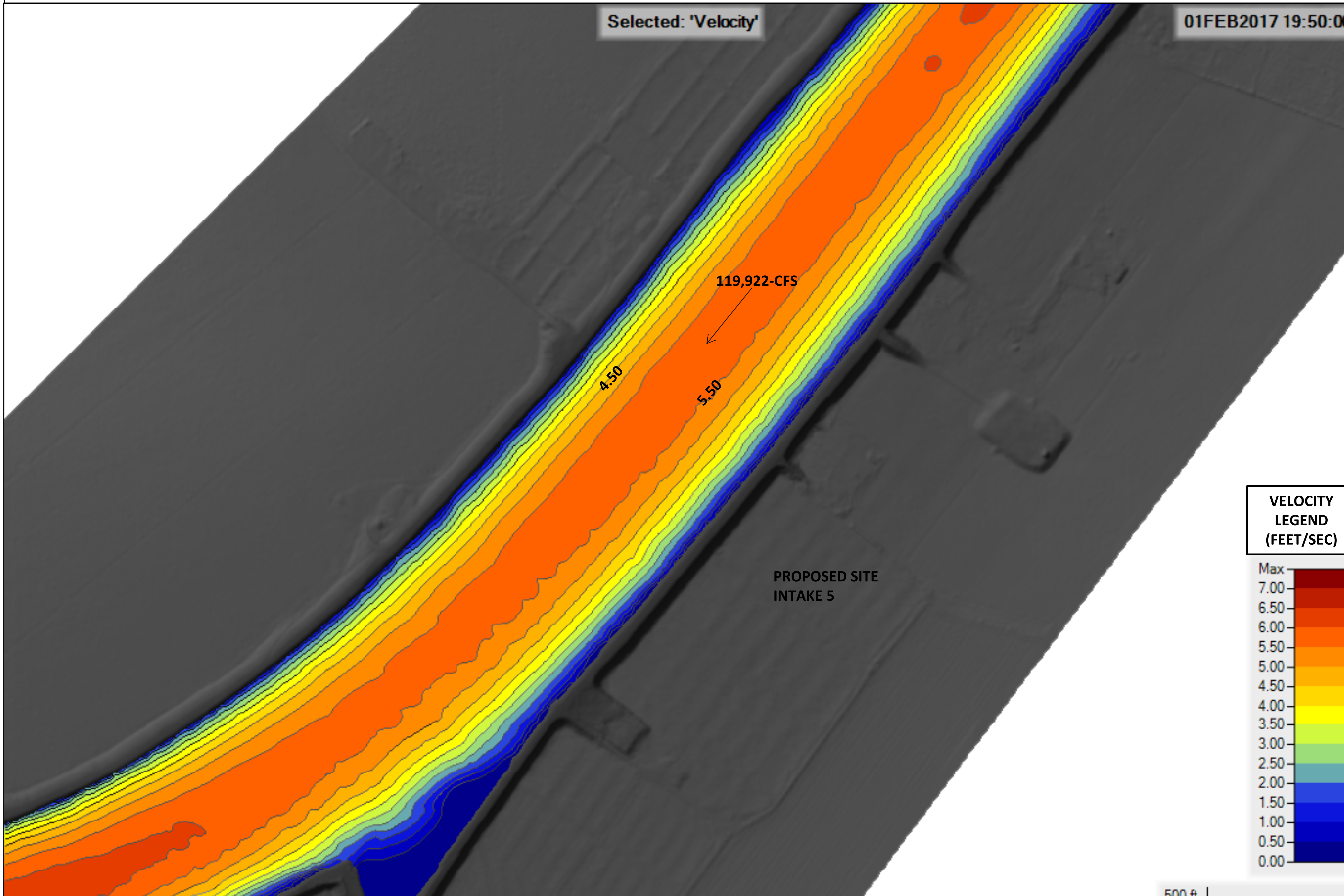
RUN 18 - INTAKE C-E-3 (B) – VELOCITY DIFFERENCE CONTOUR PLOT

MODEL TYPE 014 vs EXISTING CONDITIONS – FUTURE 200-YR FLOW



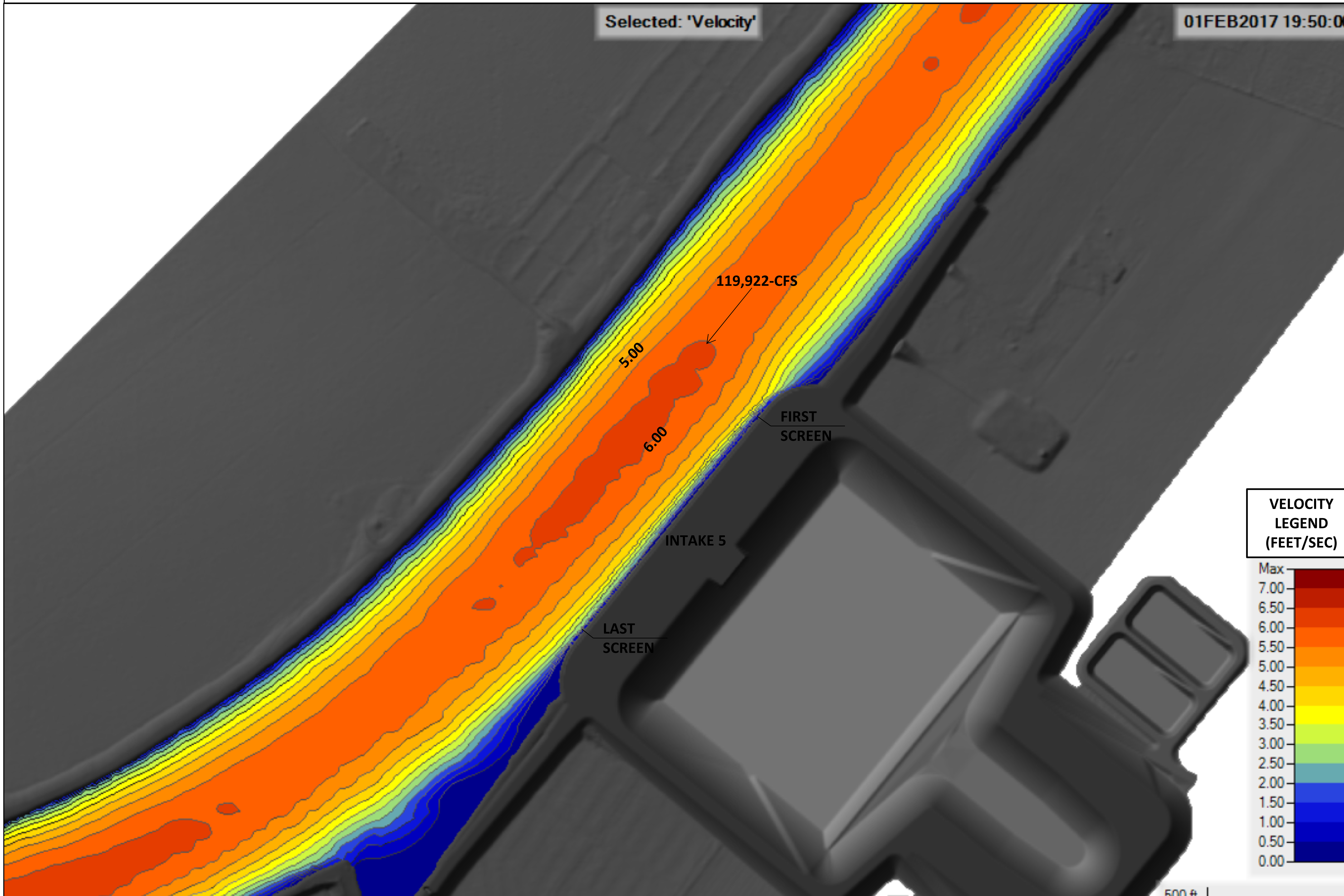
RUN 05 - INTAKE C-E-5 (C) – VELOCITY CONTOUR PLOT

MODEL SCENARIO EXISTING CONDITIONS – FUTURE 200-YR FLOW



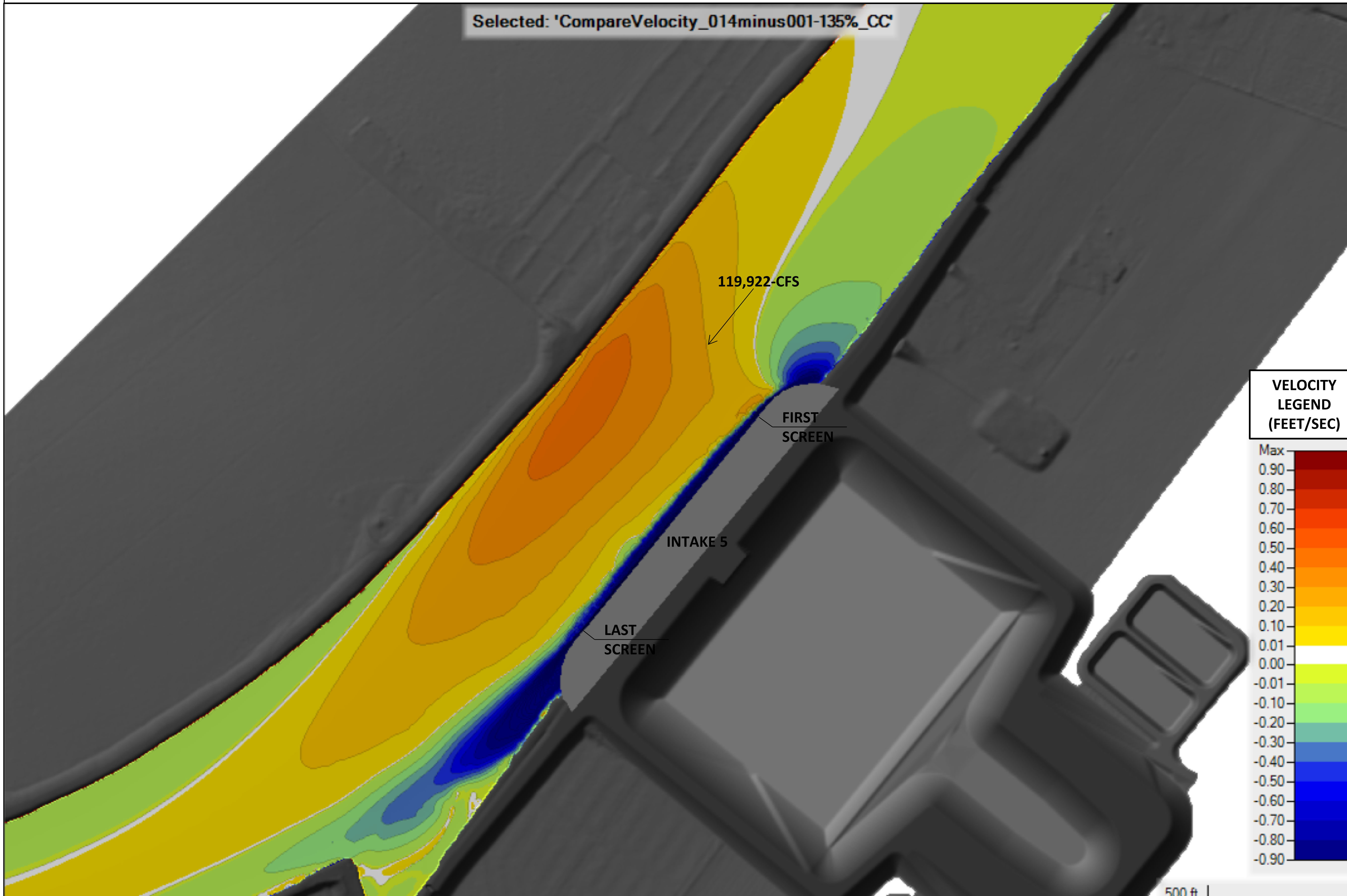
RUN 18 - INTAKE C-E-5 (C) – VELOCITY CONTOUR PLOT

MODEL TYPE 014 – FUTURE 200-YR FLOW



RUN 18 - INTAKE C-E-5 (C) – VELOCITY DIFFERENCE CONTOUR PLOT

MODEL TYPE 014 vs EXISTING CONDITIONS – FUTURE 200-YR FLOW



Velocity Contour and Difference Plots
Model TYPE 015

Tee Screen

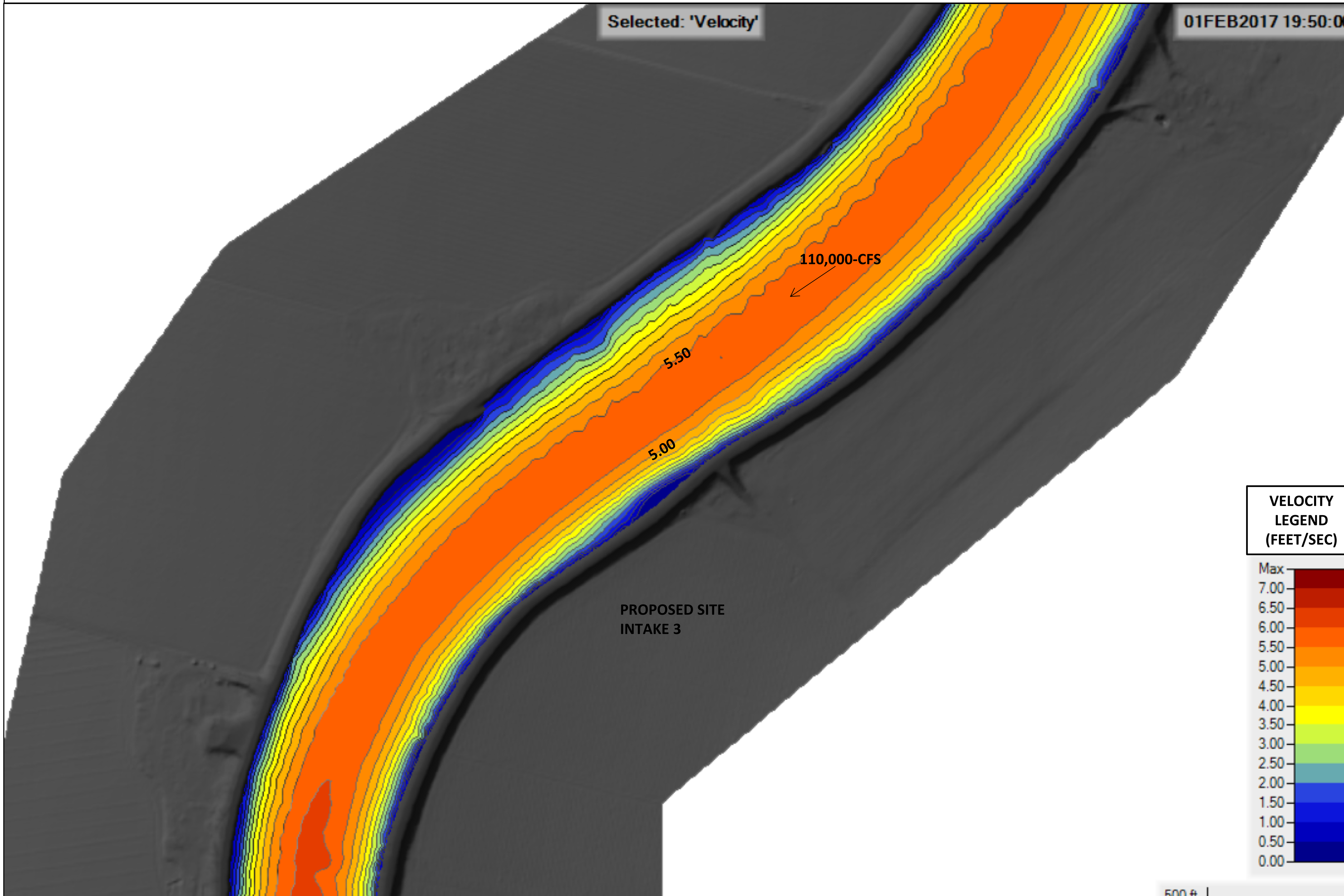
Intakes C-E-3, C-E-5

Construction Condition

Model No. 19

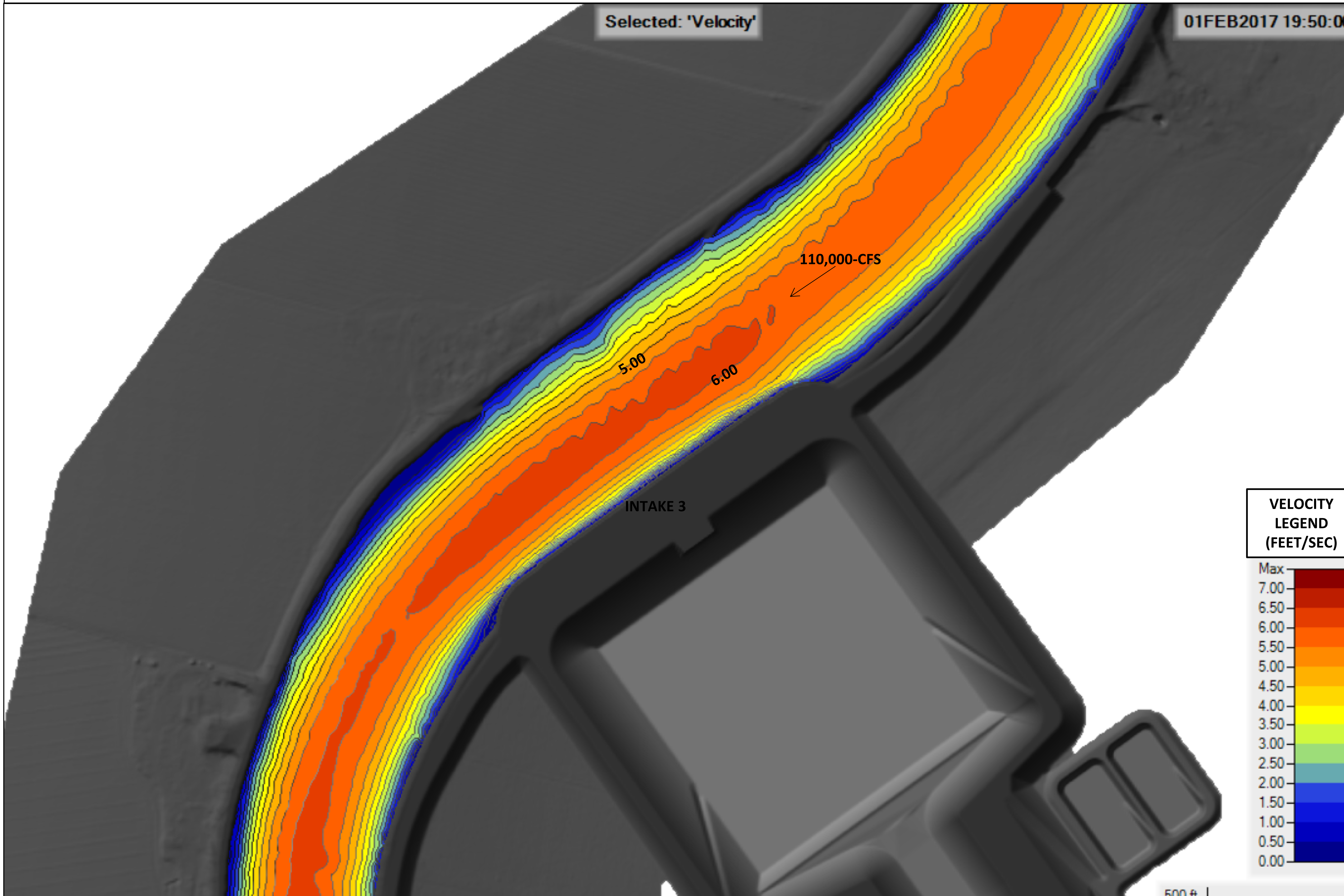
1957 Design – 110,000-cfs

RUN 01 - INTAKE C-E-3 (B) – VELOCITY CONTOUR PLOT
MODEL SCENARIO EXISTING CONDITIONS – 1957 DESIGN FLOW



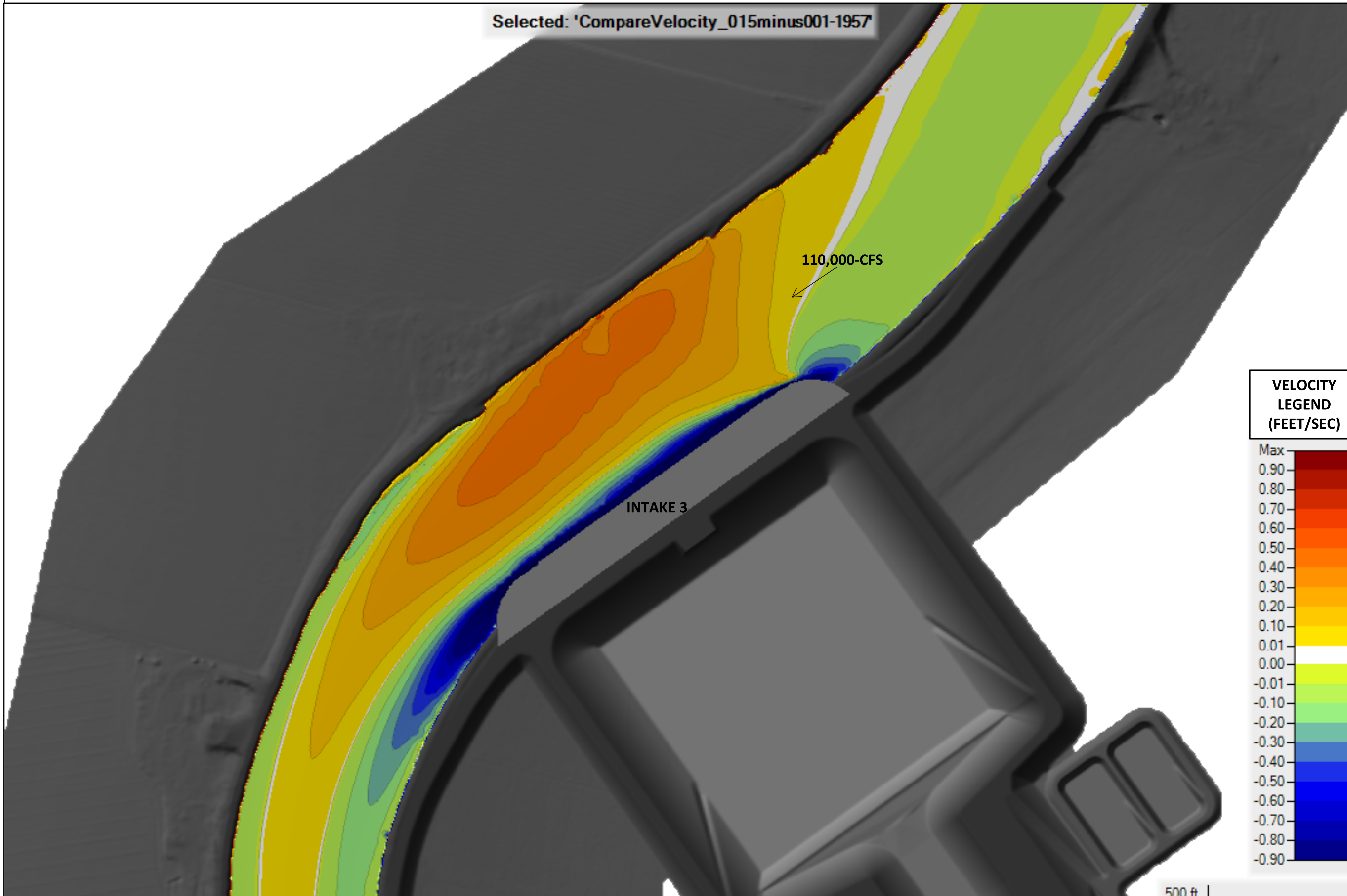
RUN 19 - INTAKE C-E-3 (B) – VELOCITY CONTOUR PLOT

MODEL TYPE 015 – 1957 DESIGN FLOW



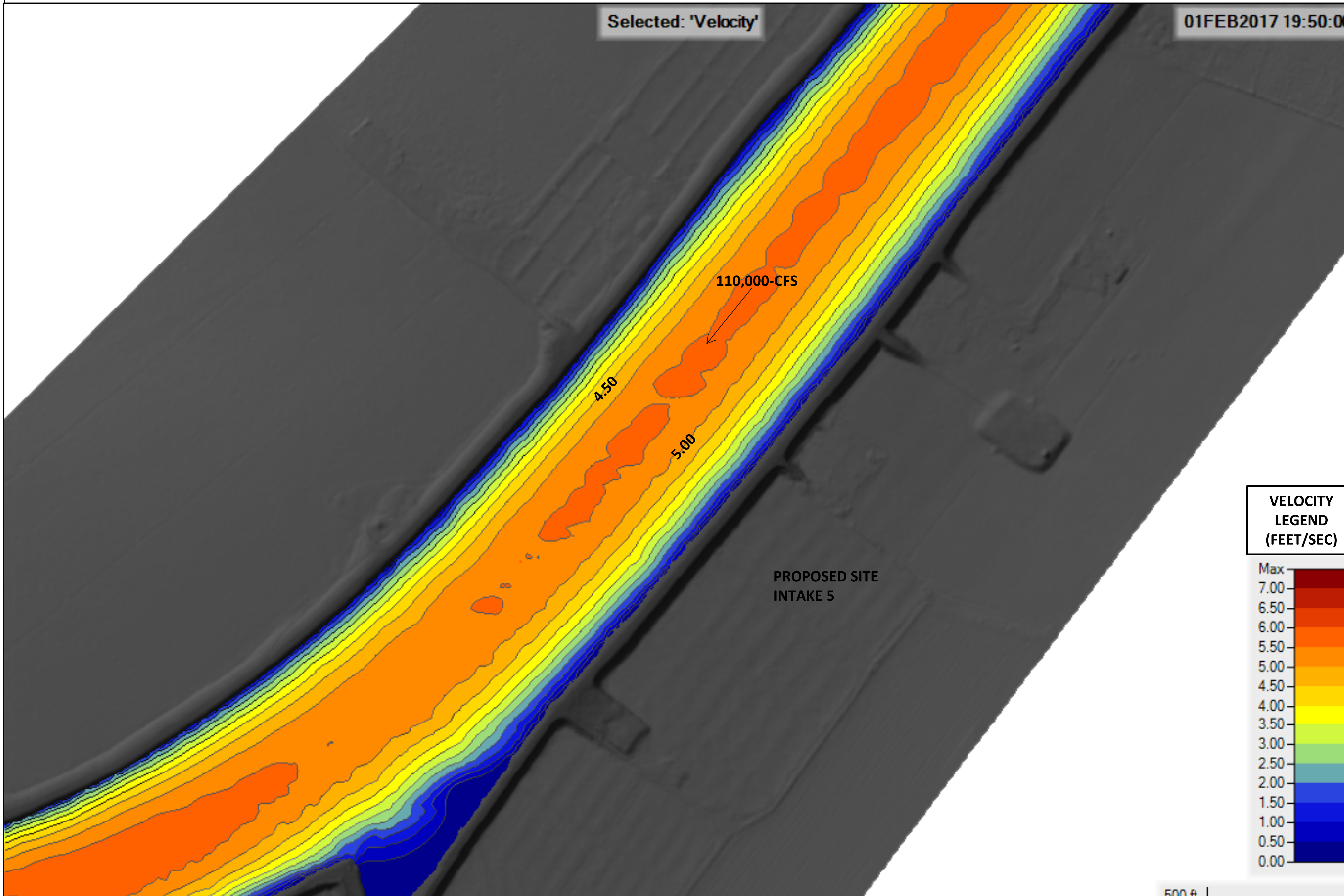
RUN 19 - INTAKE C-E-3 (B) – VELOCITY DIFFERENCE CONTOUR PLOT

MODEL TYPE 015 vs EXISTING CONDITIONS – 1957 DESIGN FLOW



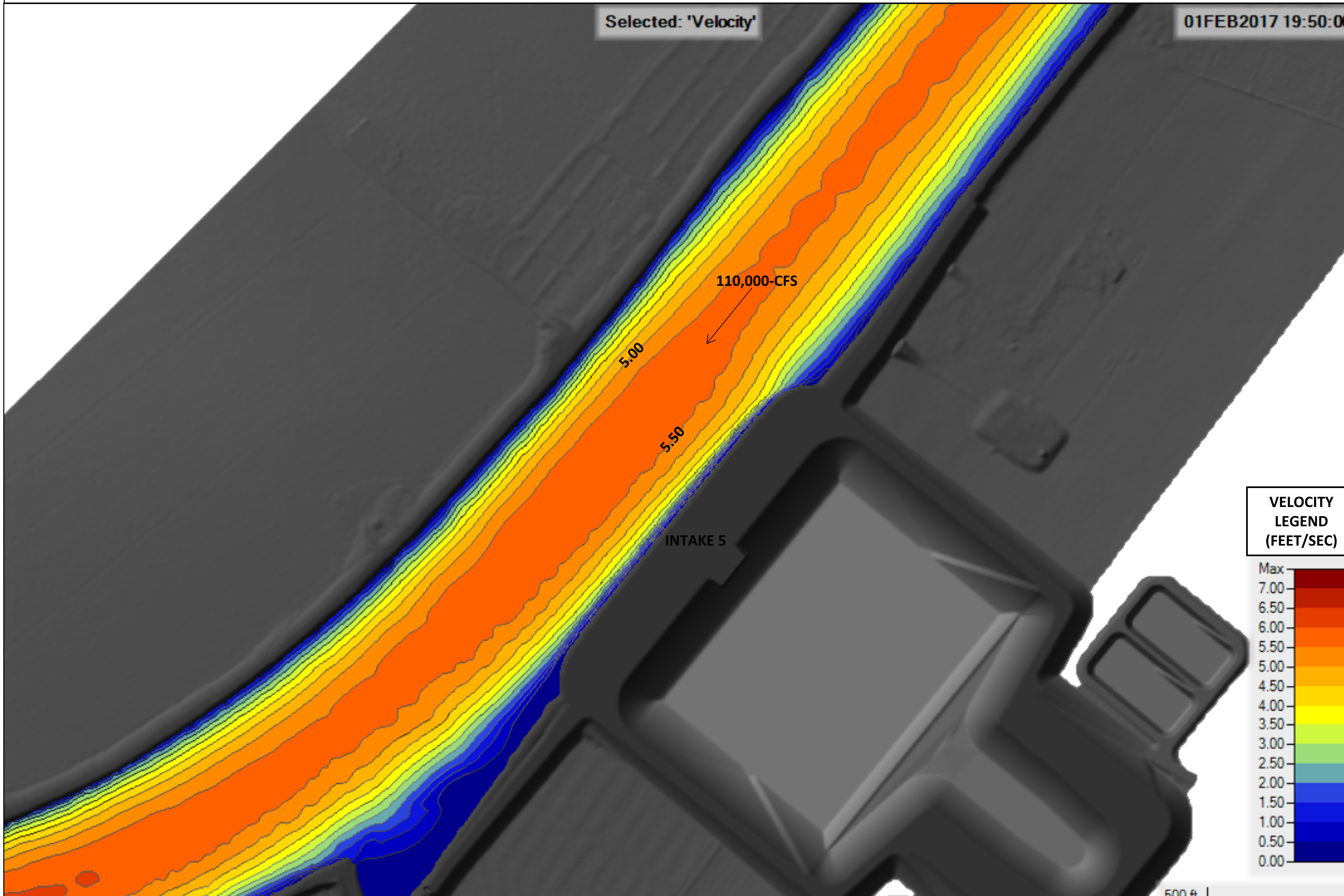
RUN 01 - INTAKE C-E-5 (C) – VELOCITY CONTOUR PLOT

MODEL SCENARIO EXISTING CONDITIONS – 1957 DESIGN FLOW



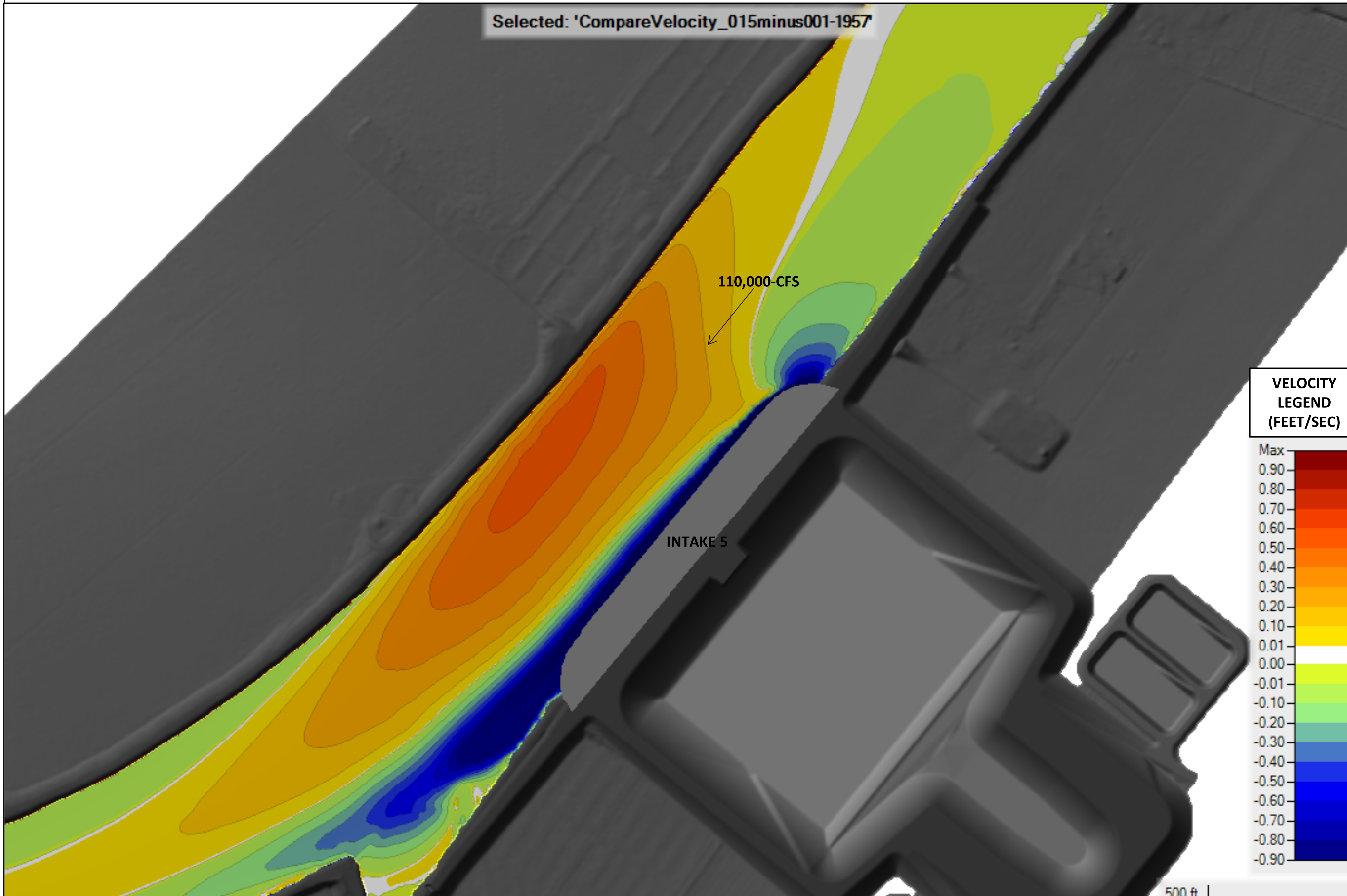
RUN 19 - INTAKE C-E-5 (C) – VELOCITY CONTOUR PLOT

MODEL TYPE 015 – 1957 DESIGN FLOW



RUN 19 - INTAKE C-E-5 (C) – VELOCITY DIFFERENCE CONTOUR PLOT

MODEL TYPE 015 vs EXISTING CONDITIONS – 1957 DESIGN FLOW



Velocity Contour and Difference Plots
Model TYPE 015

Tee Screen

Intakes C-E-3, C-E-5

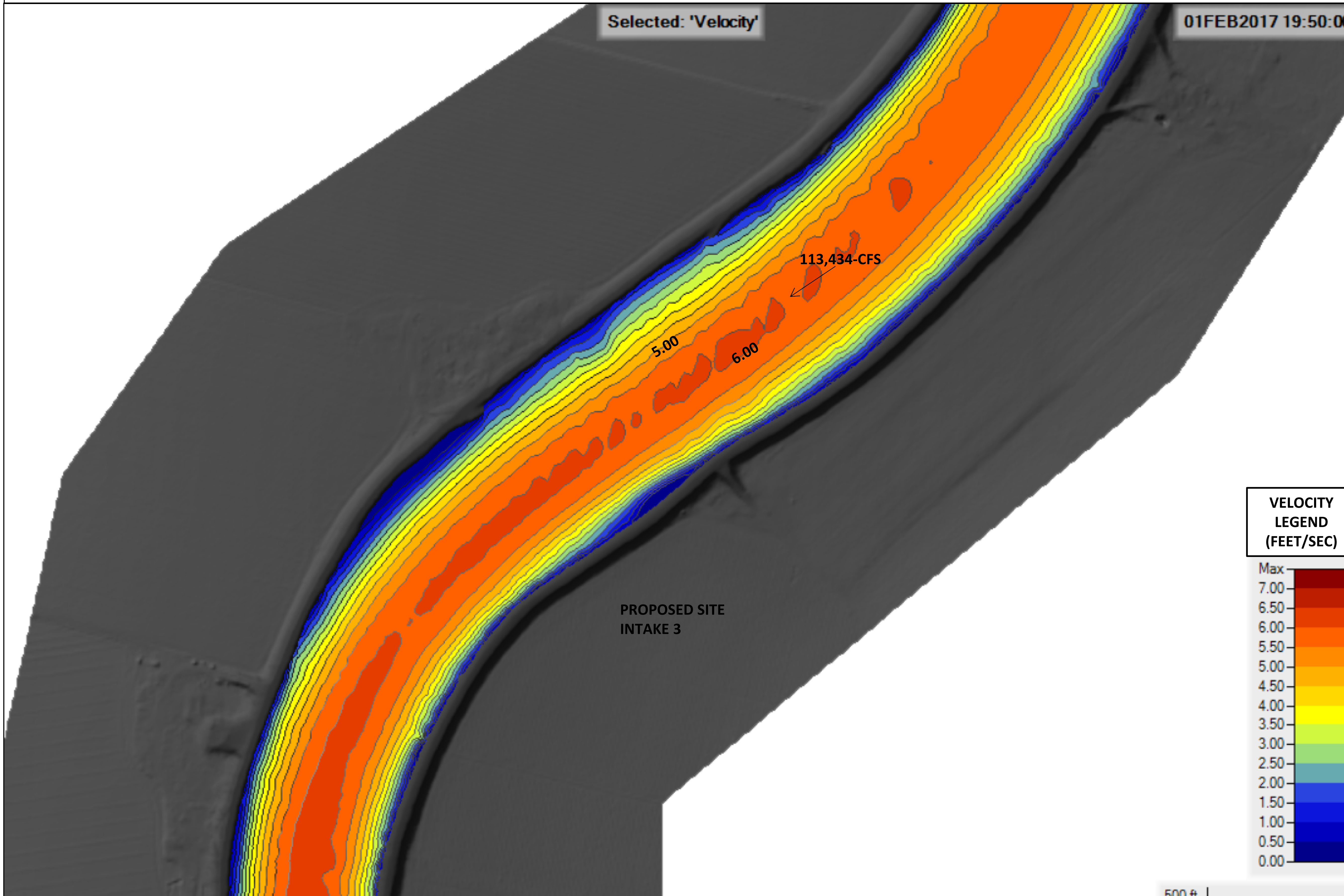
Construction Condition

Model No. 20

Existing 100-Year Event – 113,434-cfs

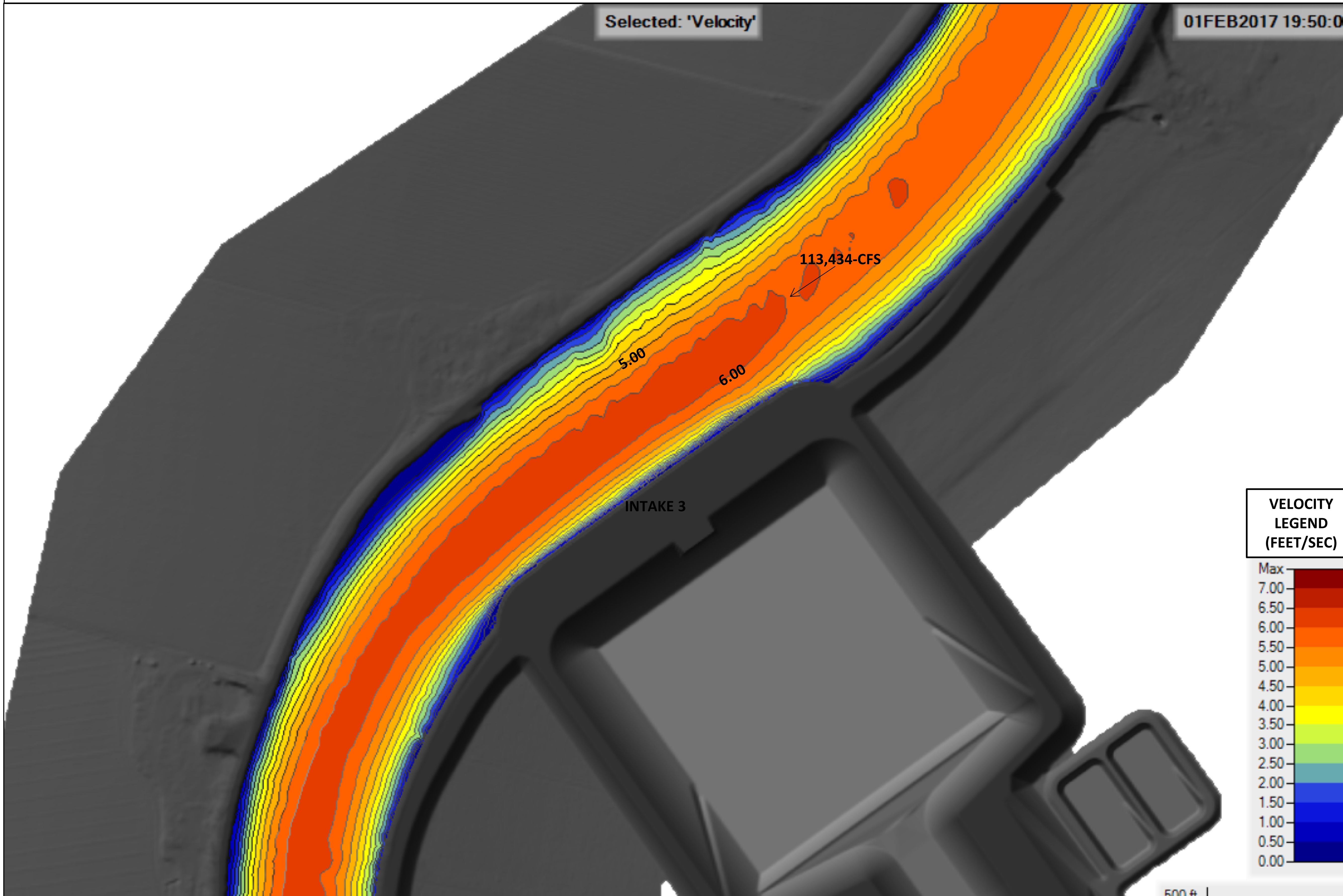
RUN 02 - INTAKE C-E-3 (B) – VELOCITY CONTOUR PLOT

MODEL SCENARIO EXISTING CONDITIONS – EXISTING 100-YR FLOW



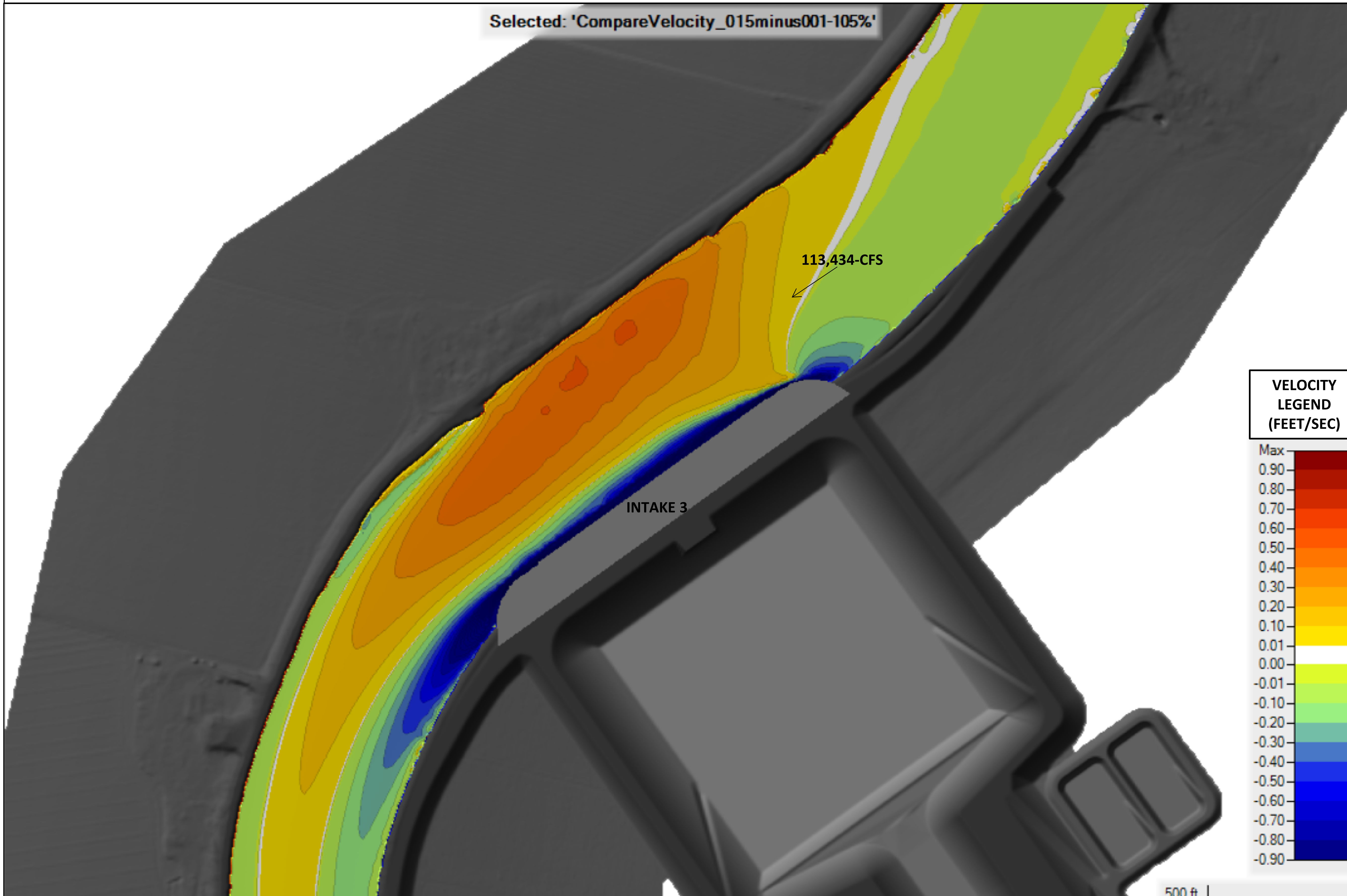
RUN 20 - INTAKE C-E-3 (B) – VELOCITY CONTOUR PLOT

MODEL TYPE 015 – EXISTING 100-YR FLOW



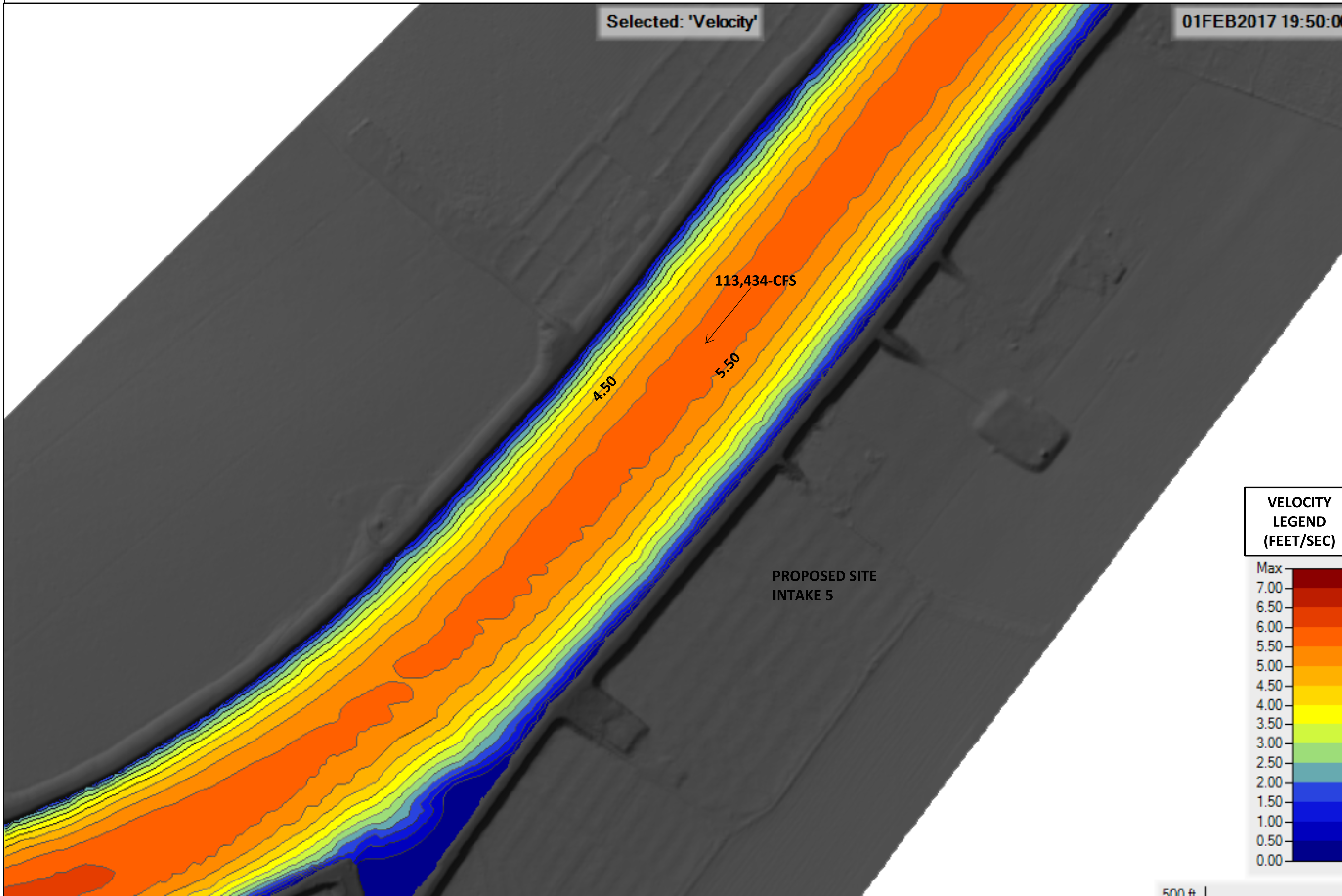
RUN 20 - INTAKE C-E-3 (B) – VELOCITY DIFFERENCE CONTOUR PLOT

MODEL TYPE 015 vs EXISTING CONDITIONS – EXISTING 100-YR FLOW



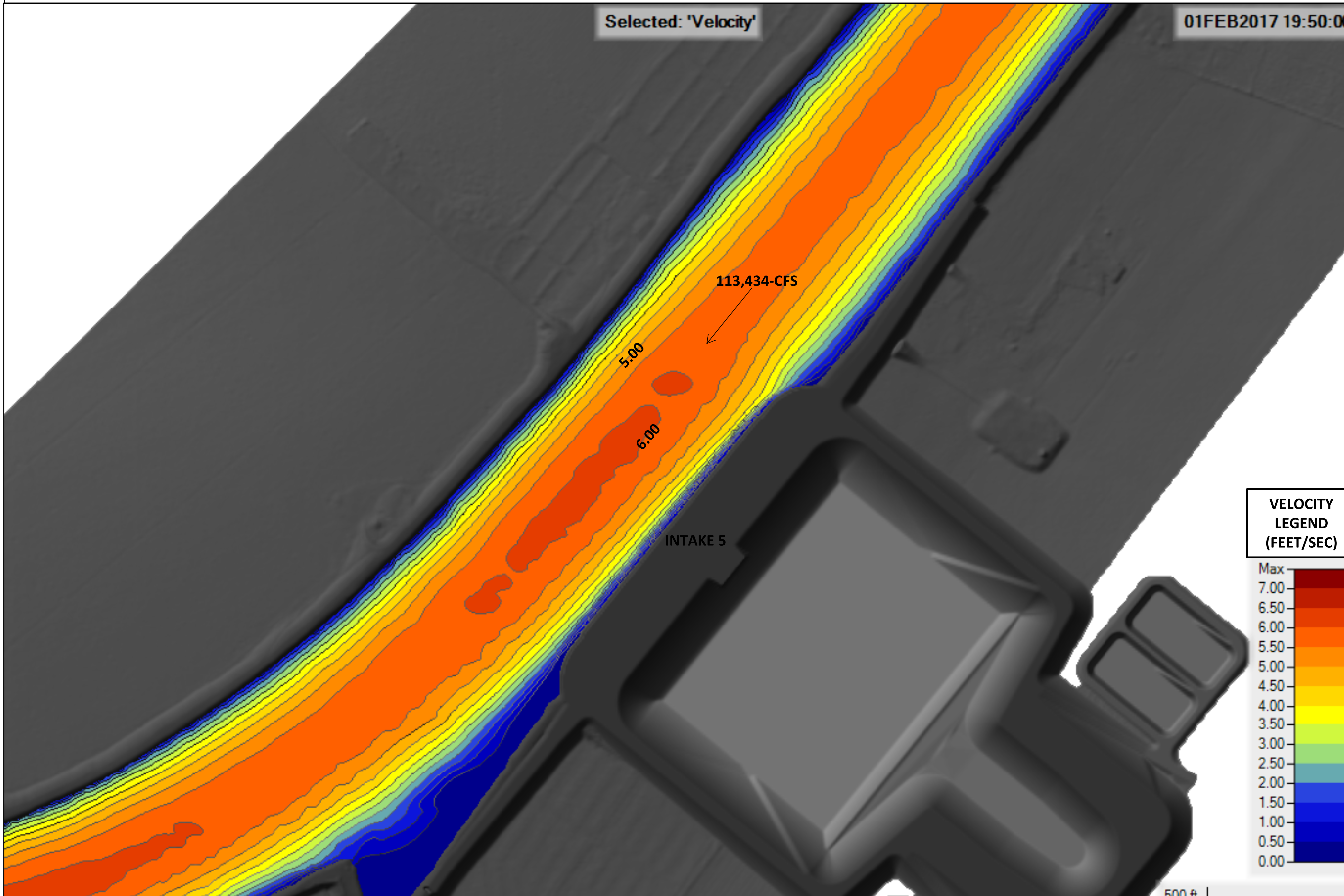
RUN 02 - INTAKE C-E-5 (C) – VELOCITY CONTOUR PLOT

MODEL SCENARIO EXISTING CONDITIONS – EXISTING 100-YR FLOW



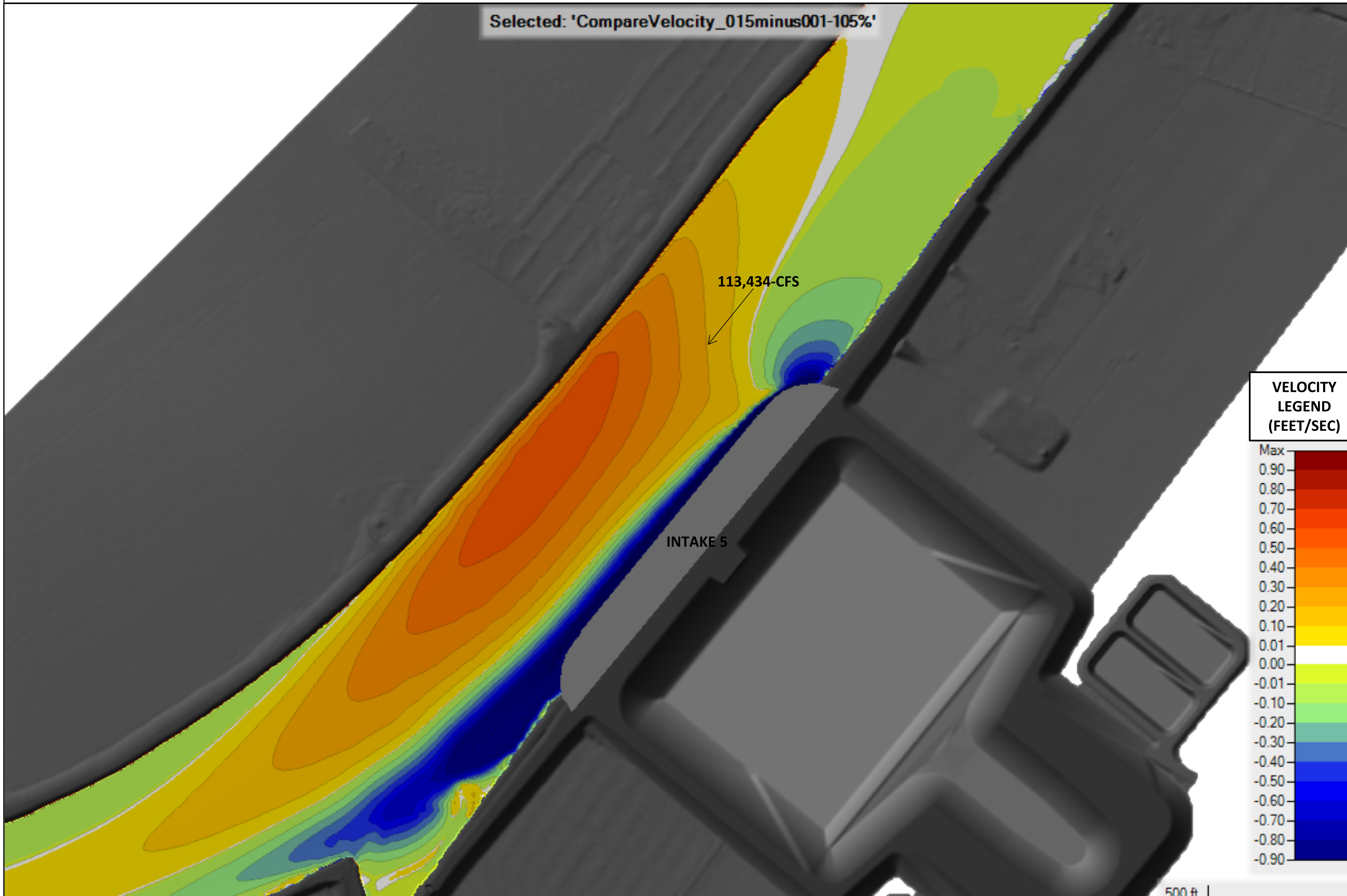
RUN 20 - INTAKE C-E-5 (C) – VELOCITY CONTOUR PLOT

MODEL TYPE 015 – EXISTING 100-YR FLOW



RUN 20 - INTAKE C-E-5 (C) – VELOCITY DIFFERENCE CONTOUR PLOT

MODEL TYPE 015 vs EXISTING CONDITIONS – EXISTING 100-YR FLOW



Velocity Contour and Difference Plots
Model TYPE 015

Tee Screen

Intakes C-E-3, C-E-5

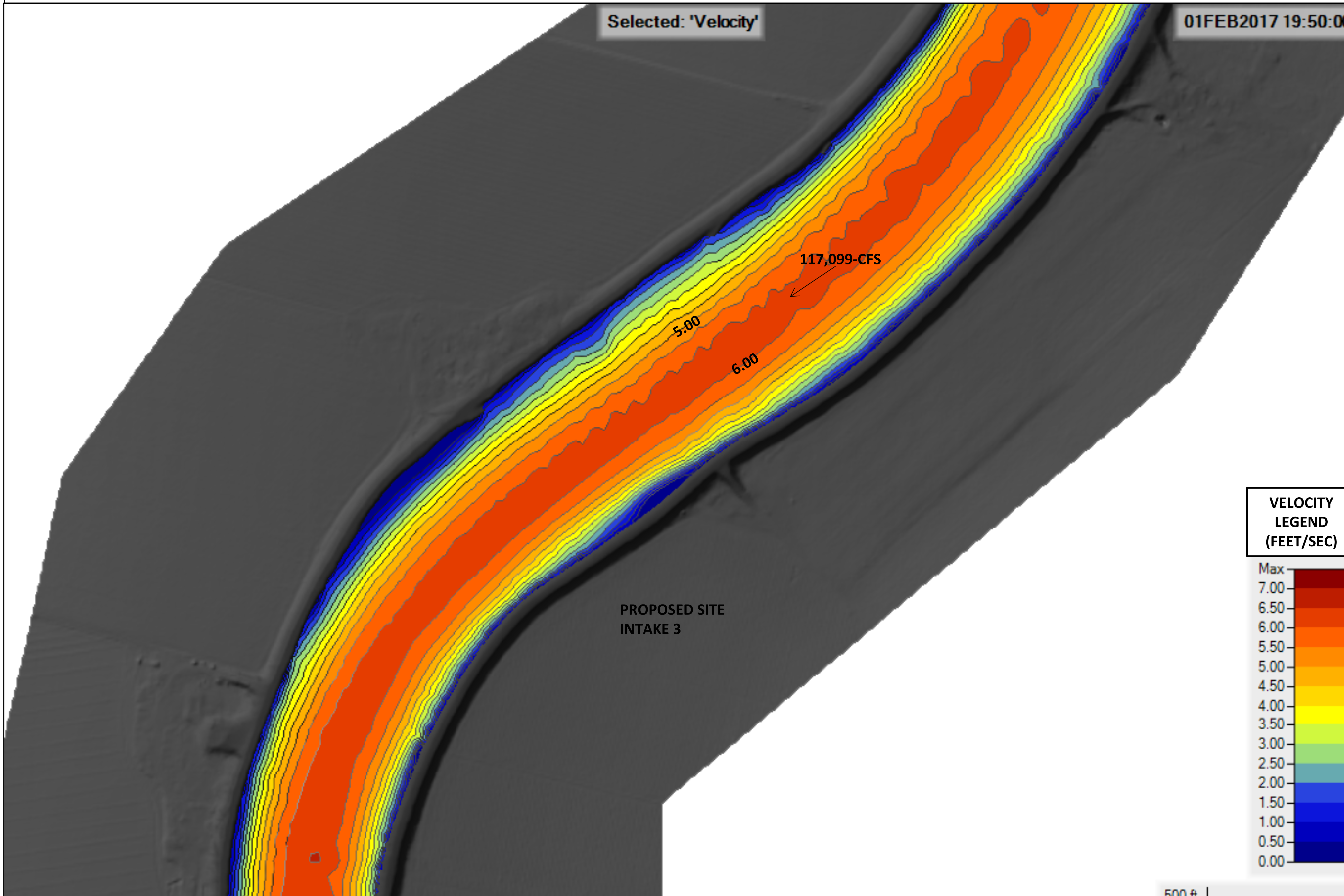
Construction Condition

Model No. 21

Existing 200-Year Event – 117,099-cfs

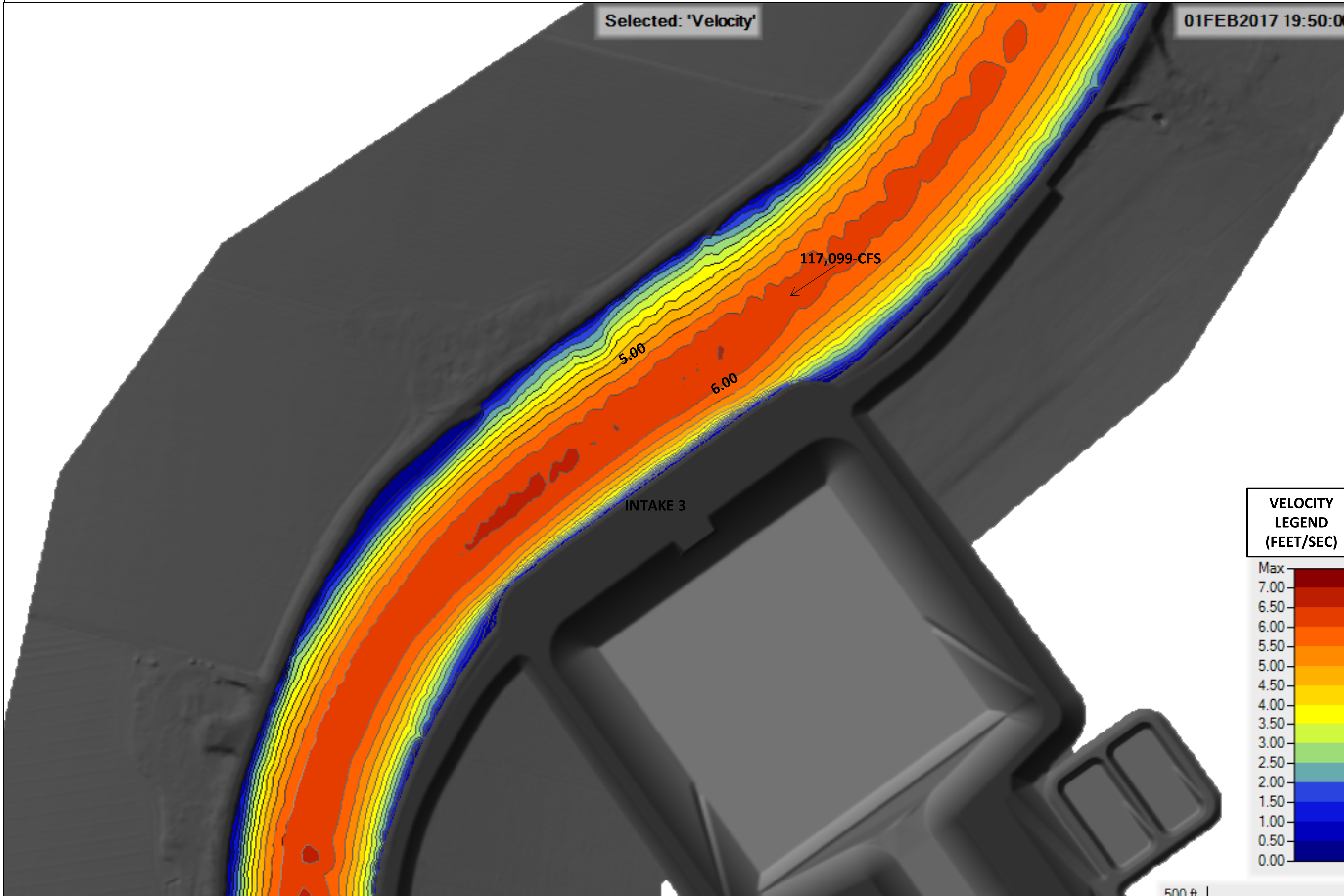
RUN 03 - INTAKE C-E-3 (B) – VELOCITY CONTOUR PLOT

MODEL SCENARIO EXISTING CONDITIONS – EXISTING 200-YR FLOW



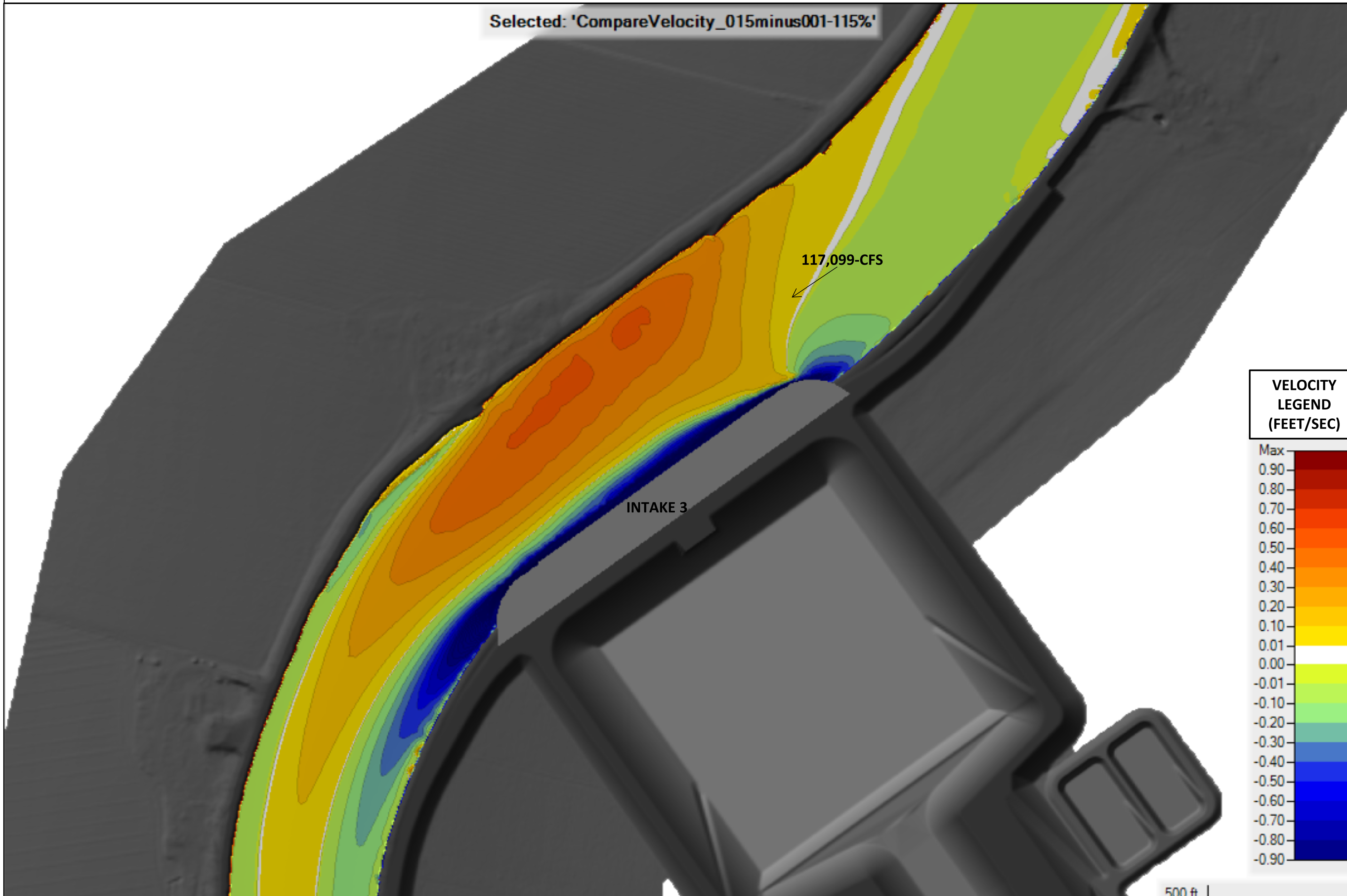
RUN 21 - INTAKE C-E-3 (B) – VELOCITY CONTOUR PLOT

MODEL TYPE 015 – EXISTING 200-YR FLOW



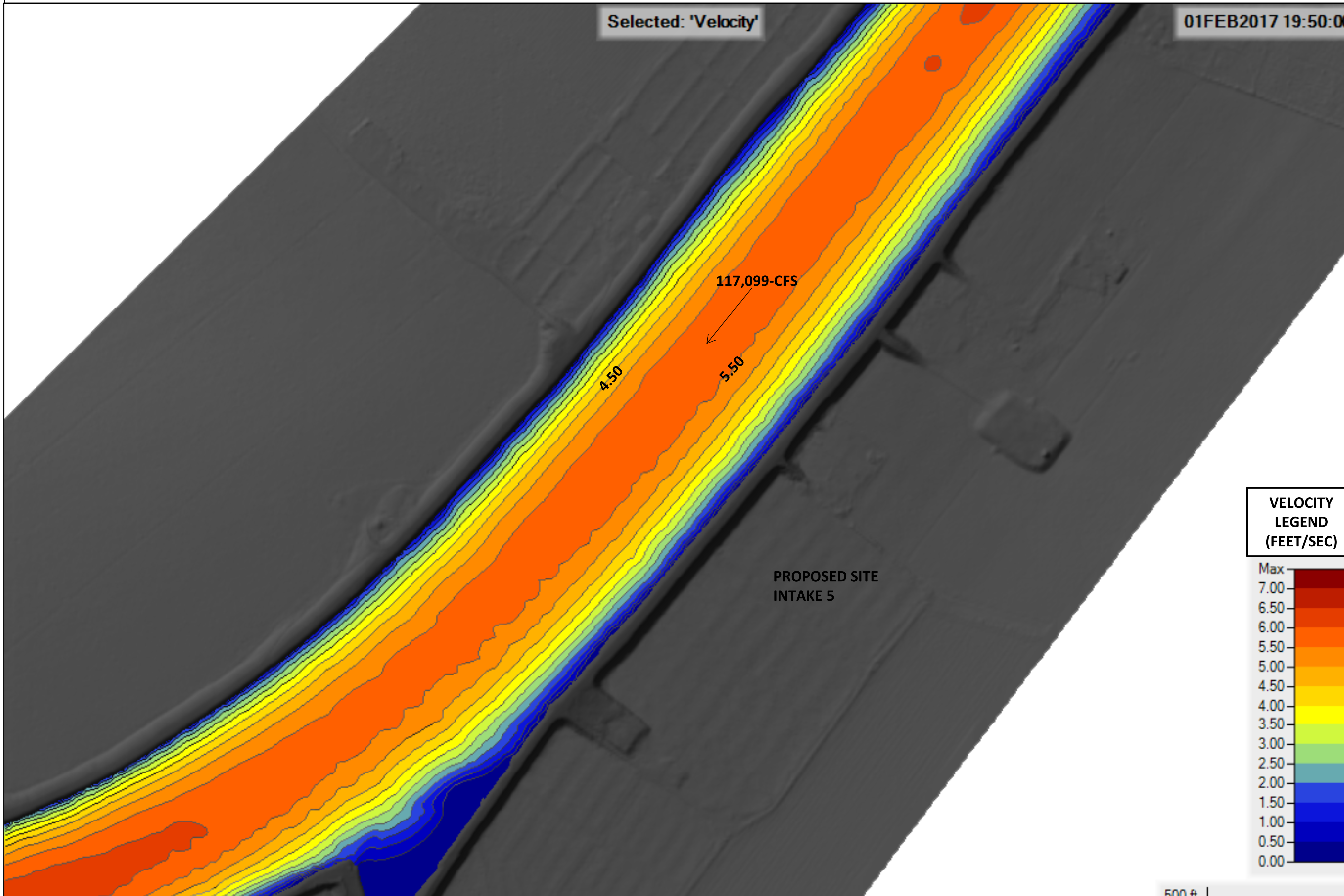
RUN 21 - INTAKE C-E-3 (B) – VELOCITY DIFFERENCE CONTOUR PLOT

MODEL TYPE 015 vs EXISTING CONDITIONS – EXISTING 200-YR FLOW



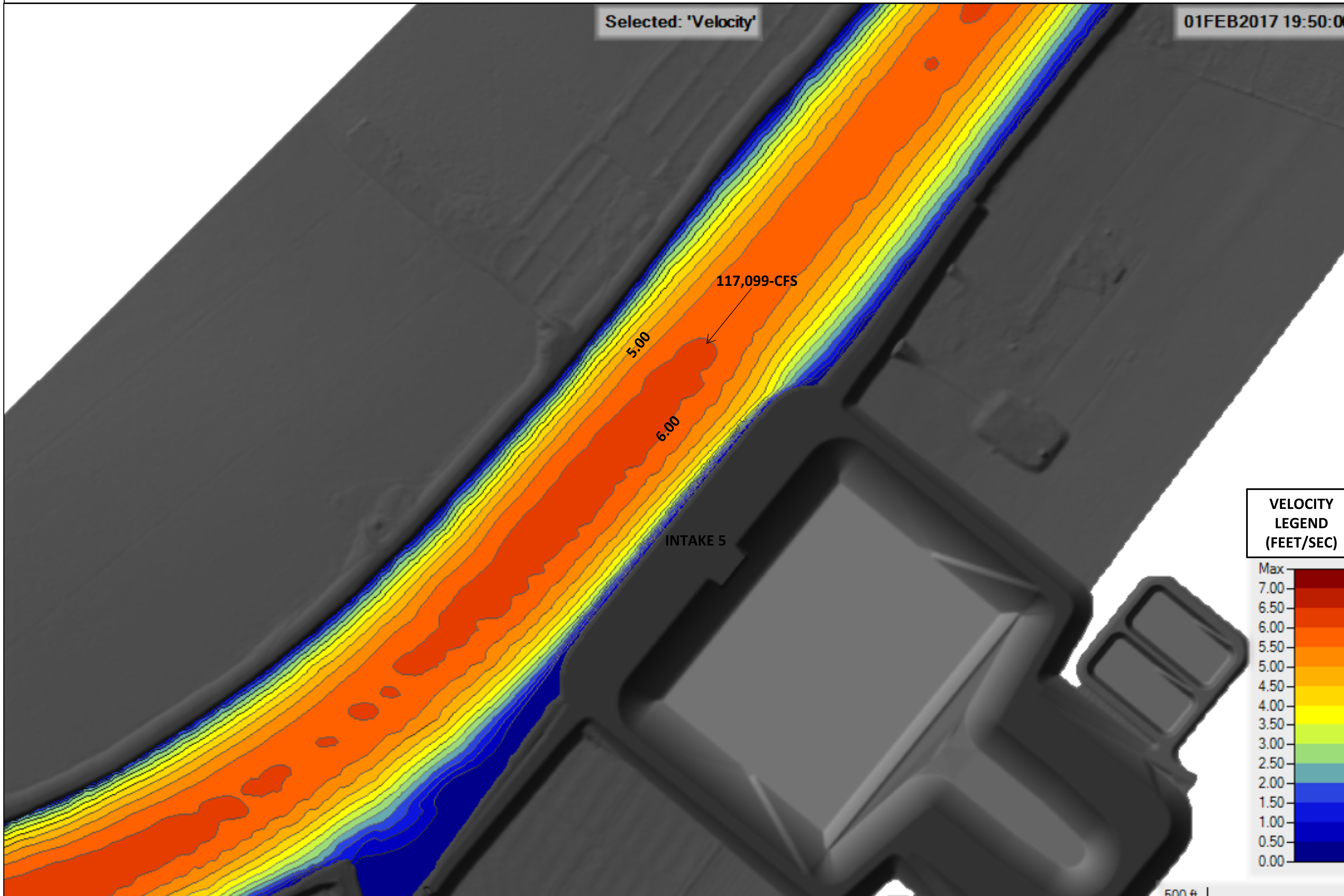
RUN 03 - INTAKE C-E-5 (C) – VELOCITY CONTOUR PLOT

MODEL SCENARIO EXISTING CONDITIONS – EXISTING 200-YR FLOW



RUN 21 - INTAKE C-E-5 (C) – VELOCITY CONTOUR PLOT

MODEL TYPE 015 – EXISTING 200-YR FLOW



RUN 21 - INTAKE C-E-5 (C) – VELOCITY DIFFERENCE CONTOUR PLOT

MODEL TYPE 015 vs EXISTING CONDITIONS – EXISTING 200-YR FLOW