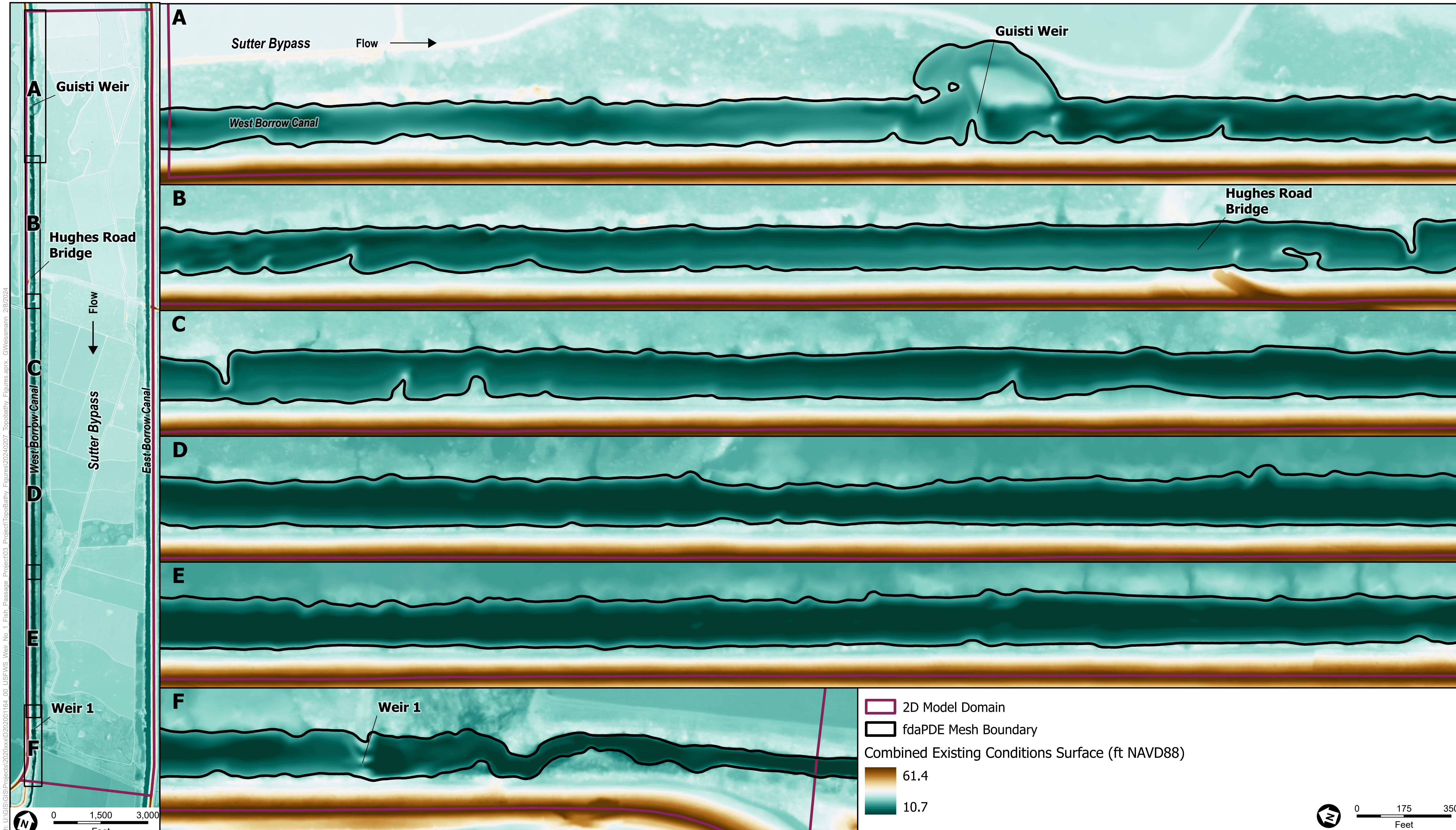

SOURCE: Existing Elevations (ESA 2023; Quantum Spatial 2021; PSOMAS 2020; CDFW 2020; ESA 2020; DWR 2010; Fugro Earth Data 2010; Photo Science 2009).

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Figure A-6
Existing Conditions Topobathymetry

ESA

3.3 Roughness

Landcover types and roughness values from the Tisdale Weir Fish Passage Improvement Project TUFLOW model were used within the 2D domain (**Table A-2** & **Figure A-7**). The WBC channel was modeled with a 0.03 roughness ("Toe Drains" landcover category), while the floodplains were modeled with a range of roughness values from 0.06 to 0.1 (**Table A-2**). The flows assessed with the model are primarily contained in the channel, though under the high passage flow (discussed below in section 2.4) there are several areas where adjacent floodplains are activated.

TABLE A-2
MANNING'S ROUGHNESS FOR HYDRAULIC MODEL

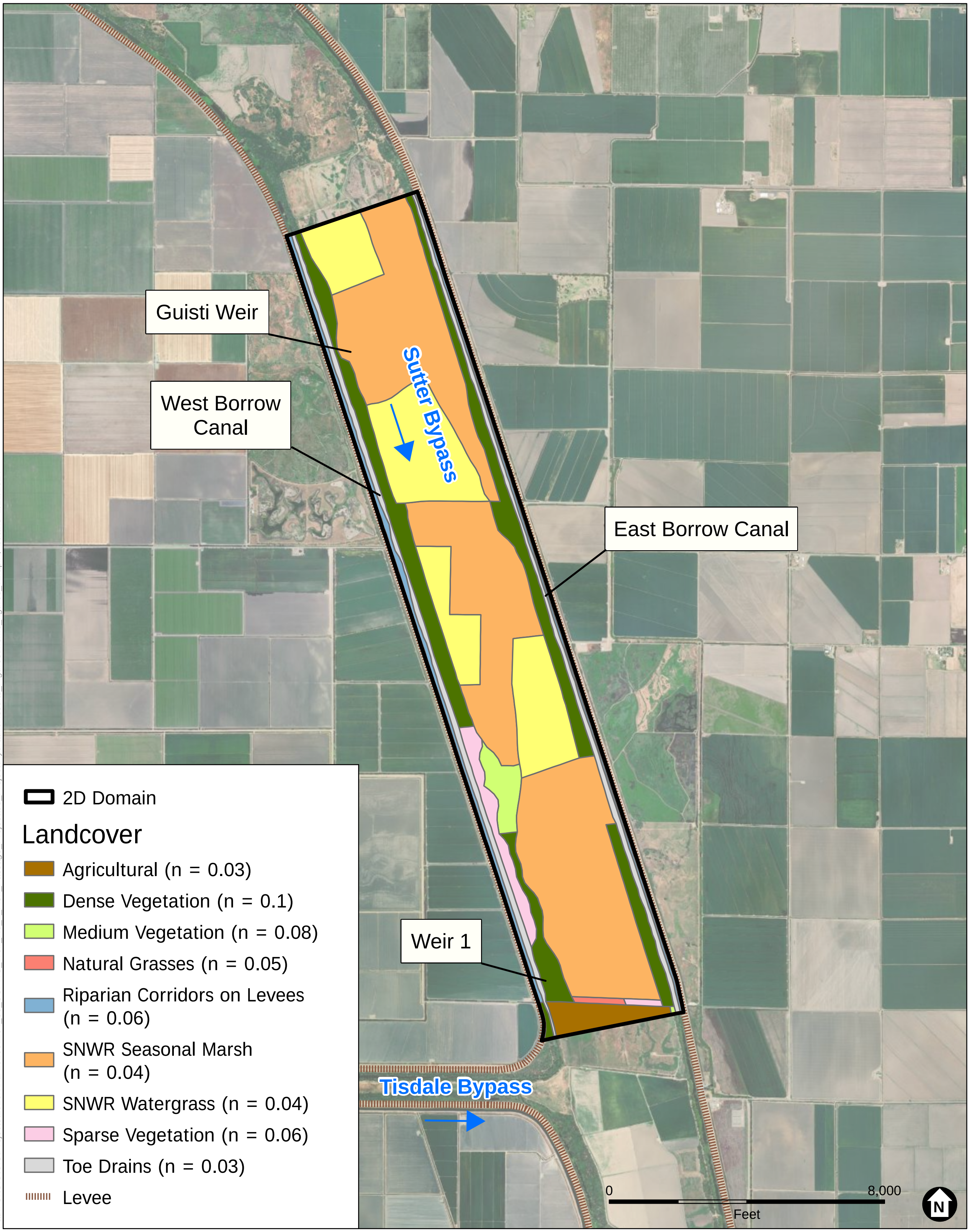
Landcover	Manning's Roughness
Agricultural	0.03
Dense Vegetation	0.1
Medium Vegetation	0.08
Natural Grasses	0.05
Riparian Corridors on Levees	0.06
SNWR Seasonal Marsh	0.04
SNWR Watergrass	0.04
Sparse Vegetation	0.06
Toe Drains	0.03

3.4 Model Verification

Due to data limitations within the West Borrow Canal and the scope of this study, the HECRAS model was not calibrated against real-time data. However, in the absence of calibration the model was verified using the TUFLOW model results and was determined to produce reasonably sufficient results for a comparative analysis of fish passage conditions under the various alternatives.

Verification of the hydraulic model was performed by comparing the 2D HEC-RAS model results with the TUFLOW model time-series results for a flood event from March 4th 2014 to March 21st 2014. This flood event was chosen because of the range of flow includes the passage flows (Table A-1) and flows that are expected to inundate adjacent wetlands.

Water surface elevations were compared for several locations (Figure A-4), upstream and downstream, of Weir 1 between the 2D HECRAS and TUFLOW model results (**Figure A-8** & **Figure A-9**). In general, the 2D HECRAS model underpredicted the water surface upstream of the weir by approximately one foot, and overpredicted the water surface downstream of the weir by approximately one-quarter to one-half of a foot.



Path: U:\GIS\GIS\Projects\2020xxx\D202001164_00_USFWS_Weir_No_1_Fish_Passage_Project\03_Project\HydraulicResults_Figures\memo_figures_v2.aprx, bdavis 2/21/2024

SOURCE: Levees (DWR 2012)

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Figure A-7
Two-dimensional HEC-RAS Model Landcover and Roughness

ESA

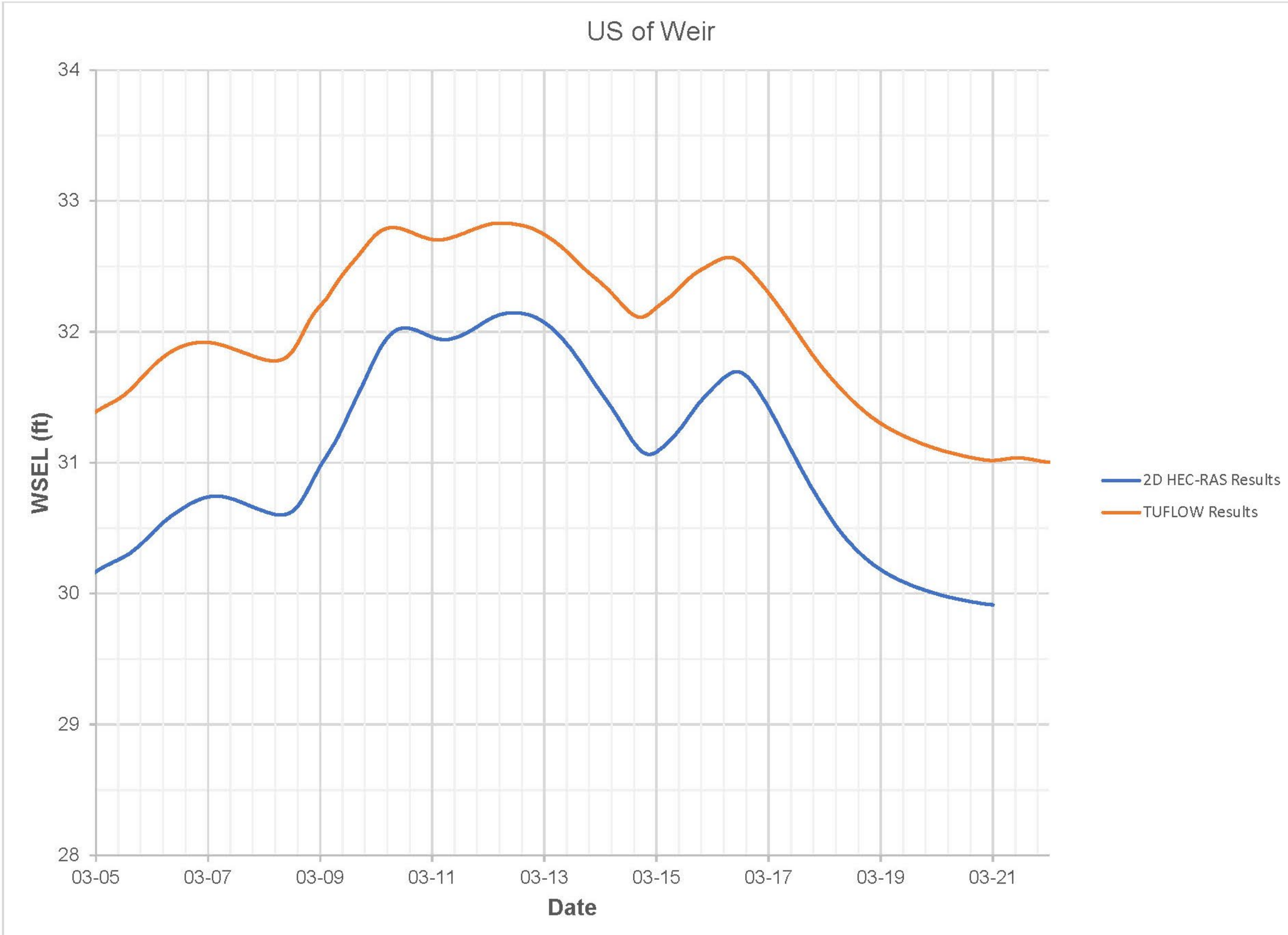

Figure A-8
Two-dimensional HEC-RAS Model Verification Upstream of Weir 1

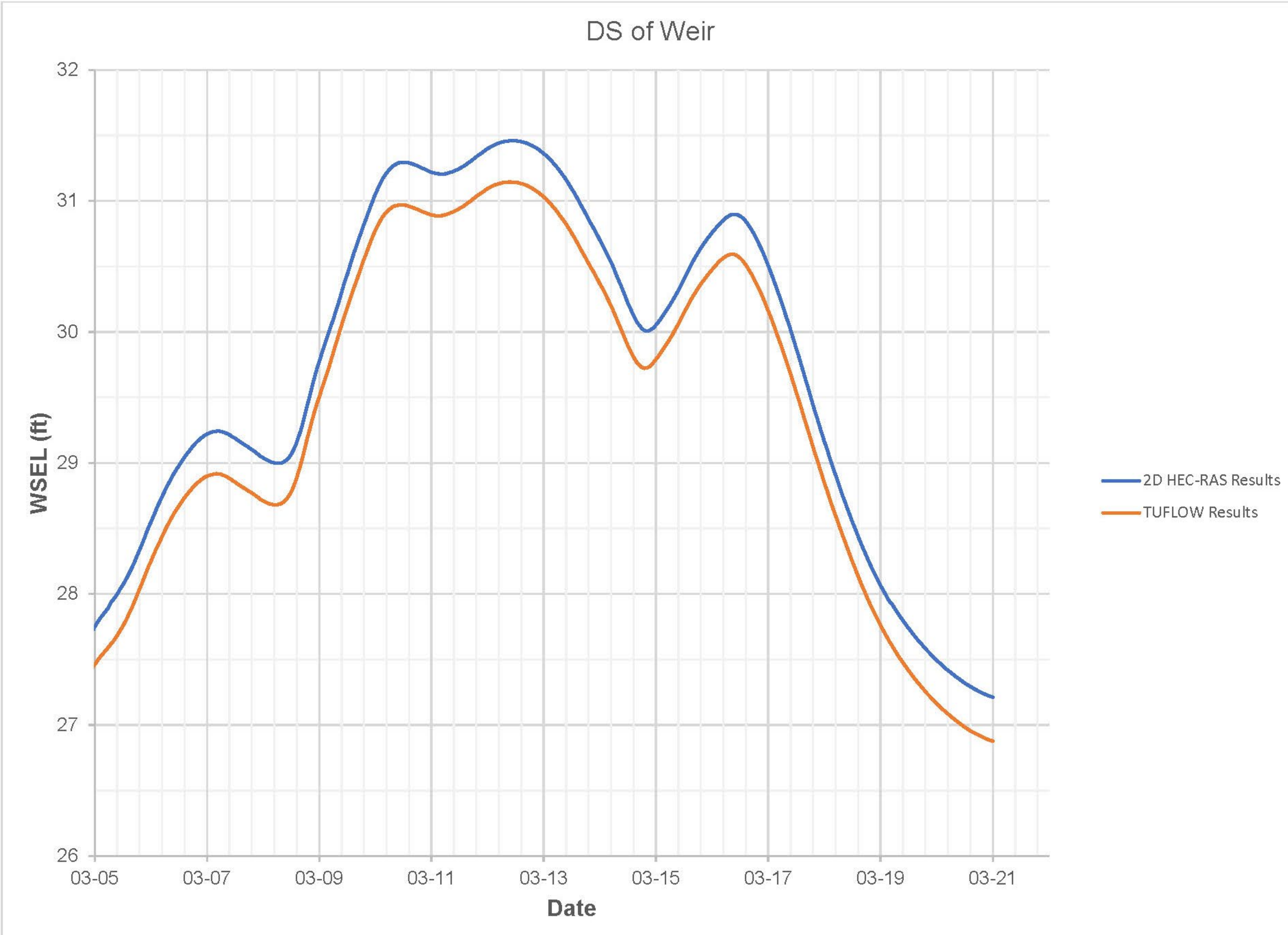

Figure A-9
Two-dimensional HEC-RAS Model Verification Downstream of Weir 1

The difference in WSE between the TUFLOW and 2D HEC-RAS could be attributed to several factors. Namely, the representation of the weir in a two-dimensional verses a one-dimensional hydraulic model (i.e. terrain feature vs. explicit weir equations) and the downstream boundary conditions for each model. The 2D HEC-RAS model uses a rating curve as the downstream boundary conditions that was developed from the TUFLOW model results. In the development of the rating curve a best-fit line was used (Figure A-3), therefore variations in downstream stage between the 2D HEC-RAS model and the TUFLOW model are expected and are likely to influence the stage directly downstream of Weir 1.

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4 HYDRAULIC ANALYSIS – ALTERNATIVES A, B, AND C

Proposed hydraulic conditions for Alternatives A, B, and C were evaluated using the 2D HEC-RAS model. The model terrain input for each alternative was adapted from the existing conditions terrain model and modified to reflect the proposed improvements. Section 1 summarizes key design elements for each of the respective alternatives. Additional break lines were added for each alternative terrain to reinforce the computational mesh and reflect key grading features. Alternatives 0 and D were assessed on a comparative basis, as their geometries are comparable to several of the modeled alternatives (i.e. the no action alternative is the existing conditions scenario, and an operable weir will have similar hydraulics to the full weir removal scenario when the weir is down and existing conditions when the weir is raised). Appendix C provides an overview of each alternative's specific geometry and grading footprints.

4.1 Terrain

Alternative Conditions Surfaces

To model proposed conditions, the respective alternative terrain surfaces were creating using the grading tools in Autodesk Civil 3D software and then imported and merged with the existing conditions surface using the RAS Mapper module within the HEC-RAS software. Proposed conditions terrain surfaces were created for alternatives A, B, and C (**Figure A-10**). A proposed conditions surface was not developed for Alternative D.

4.2 Roughness

Hydraulic roughness for roughened channel (Alternative B) and rock ramp (Alternative C) features were set to a value of 0.05 based on Manning's n for cobbles and large boulders in mountain streams (Chow 1959). The extent of the increased roughness can be seen in **Figure A-10**. No additional changes to roughness values were made for the alternative conditions surfaces.

4.3 Channel Bed Sediments

As described in Section 1, Alternative A proposes to remove the weir and fish ladder structures and smooth the channel bed between upstream and downstream bed elevations allowing for unimpeded fish passage. A primary concern with this alternative is that because of the difference in grade between upstream and downstream, the channel may become unstable, incising and widening in response. To assess the potential for channel instability, a characterization of bed sediments in the WBC was required.

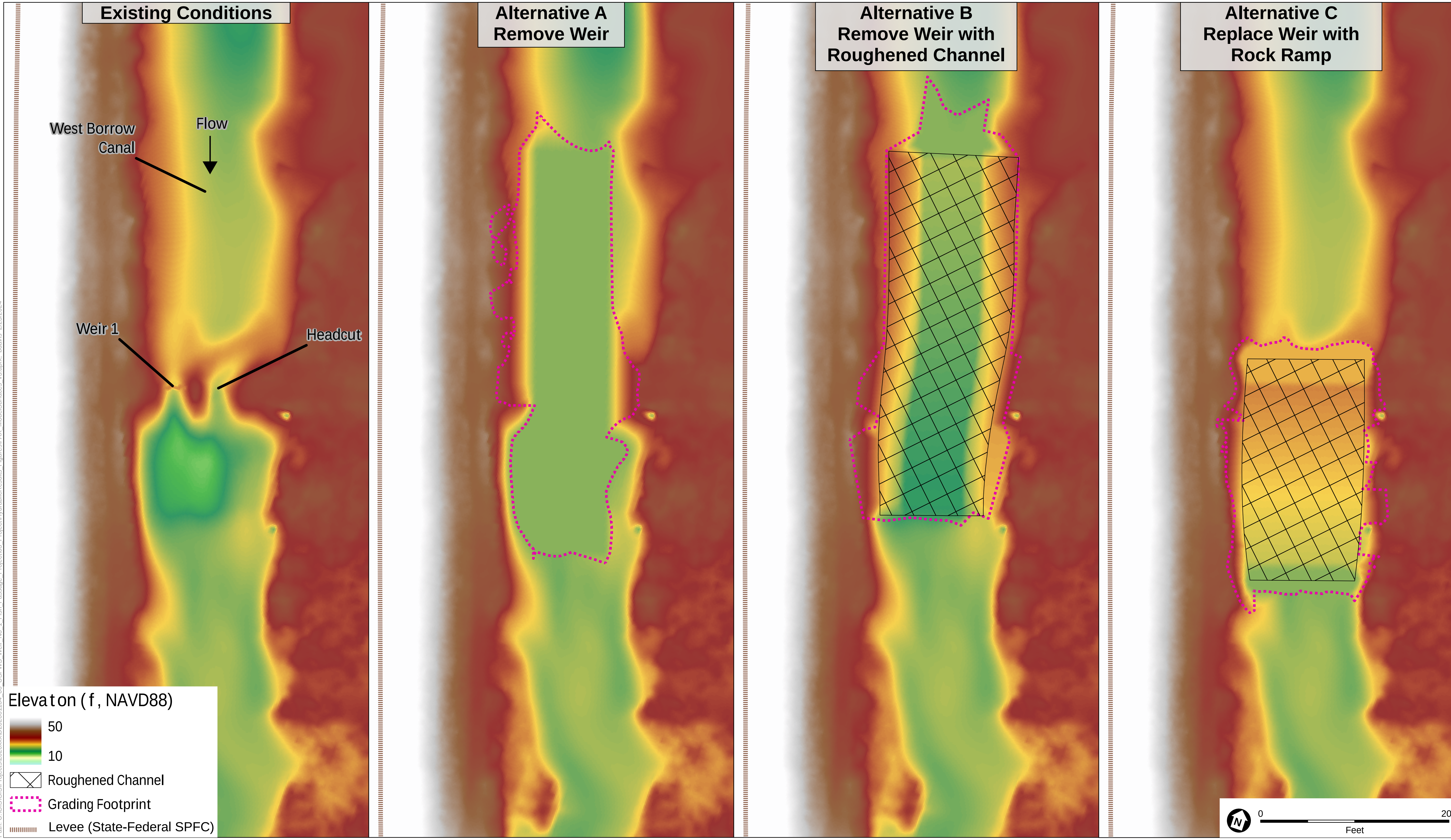
On August 23, 2024, ESA collected a series of 5 sediment samples from the bed of the WBC, between Hughes Road to the north and Weir 1 to the south (**Figure A-11**). Sediment samples were collected via a canoe using a Petite Ponar sampler, which uses a spring loaded, mechanical jaw that snaps shut, capturing loose sediments, once it is dropped onto the channel bed. Sampling in the WBC was complicated by the presence of consolidated "hardpan" sediments, but the field team was able to collect more recent deposits on top of the hardpan. Two sediment samples were collected at WB3 due to a departure in sediment characteristics relative to other sampling locations.

As seen in **Figure A-12 & Table A-3**, sediment gradations from the WBC were combined into two groupings: Group 1 comprises the sediments collected from WB1, WB2, and WB4, while Group 2 includes sediments from WB3A and WB3B. These groupings confirm our field observations regarding a change in sediment character at the WB3. Sediments from Group 1 were classified as "silty sand" with a median size class conforming to "medium sand". Sediments from Group 2 were classified as "silt with sand" with a median size class conforming to "fine silt". The hardpan bed sediment wasn't sampled directly, but it's likely comprised of the fine sediments (silts and clays) observed within these sediment samples, that have settled and consolidated over time.

TABLE A-3
SEDIMENT GRADATION AND CLASSIFICATION

Percentile	Group 1 Size (mm)	Group 1 Size Class	Group 2 Size (mm)	Group 2 Size Class
D90	0.81	coarse sand	0.21	fine sand
D85	0.68	coarse sand	0.13	fine sand
D60	0.44	medium sand	0.02	medium silt
D50	0.39	medium sand	0.01	fine silt
D30	0.29	medium sand	0.003	clay
D15	0.13	fine sand		
D10	0.04	coarse silt		

NOTES: Group 1 (silty sand) = WB1, WB2, and WB4; Group 2 (silt with sand) = WB3A and WB3B



SOURCE: Levees (DWR 2012)

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Figure A-10
Two-dimensional HEC-RAS Model Terrains

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