Hydraulic Modeling of Novato Creek Sediment Dredging Scenarios

Stetson Engineers Inc.
5/4/2020

1. Introduction

About 1.5 miles of creek bed were dredged each year in 2008, 2012, and 2016 (every four years) from the Novato Fair Shopping Center creek crossing (the Drive Way Bridge shown in Figure 1) down to about 530 ft downstream of the SMART Railroad Bridge, including the lower reaches of the two tributaries; Warner Creek and Arroyo Avichi Creek. This dredging option is called "full sediment removal" and it is intended to improve creek hydraulic capacity and reduce flooding.

The County is planning sediment removal for the next 2020 cycle. The purpose of this analysis is to evaluate the effectiveness of the following two different dredging limits scenarios in lowering the 50-year water surface elevation (see Figure 1 for the two different dredging limits scenarios):

<u>Full Sediment Removal Limits:</u>

- Novato Creek: From the downstream side of the Novato Fair Shopping Center Bridge
- to 500 ft downstream of the SMART Railroad Bridge
- Warner Creek: From the downstream side of the Diablo Ave Bridge to the confluence with Novato Creek
- Arroyo Avichi Creek: from the downstream side of the Novato Blvd bridge to the confluence with Novato Creek

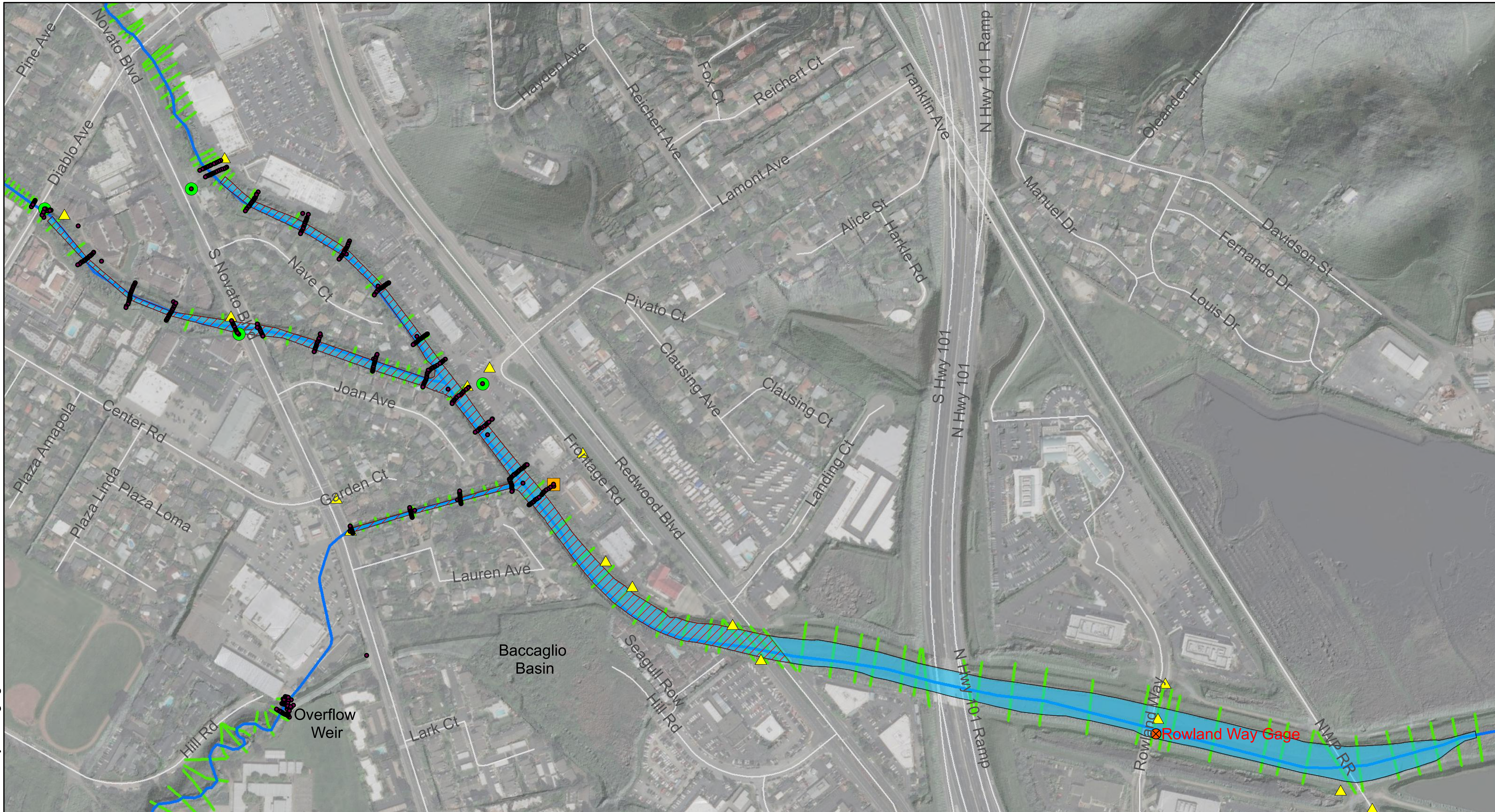
<u>Partial Sediment Removal Limits:</u>

- Novato Creek: From the downstream side of the Novato Fair Shopping Center Bridge
- to the downstream face of the Redwood Blvd Bridge
- Warner Creek: Same as the full dredge
- Arroyo Avichi Creek: Same as the full dredge

There is an existing HEC-RAS 1D/2D unsteady-state hydraulic model for the Novato Creek watershed that was originally developed by Schaaf &Wheeler (2018) and then modified and used by Stetson for the recent Novato Creek levee evaluation project (Stetson, 2019). This HEC-RAS 1D/2D model had incorporated the 2018 bathymetric survey data for the Novato Creek below the Warner Creek confluence.

Stetson first updated the existing HEC-RAS hydraulic model and then utilized the updated model as a tool for this hydraulic modeling analysis.

FIGURE 1



C:\DATA\2738\GIS\F1 XS Survey, Dredging Reach Limit, etc.mxd
4/8/2020

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NOVATO CREEK
CONTROL POINTS & FIELD SURVEY
AT THE NAVE GARDENS NEIGHBORHOOD
(Survey Date: 1/13/2020 - 1/14/2020)

Legend

- Stetson Survey (Jan 13, 2020)
- Gage
- Partial dredge limit
- Full dredge limit
- Creek
- Model XS

Control Points

- Not found
- Good accuracy (error about 1 in)
- High accracy

N

0 250 500 Feet

2. HEC-RAS Model Update and Calibration

Review of the existing HEC-RAS model identified the following updates needed for the purpose of this hydraulic modeling analysis:

- The existing model represented Arroyo Avichi Creek as a 1D channel and Warner Creek as a 2D flow area -- there is a need to reconfigure Warner Creek as a 1D channel to more reliably simulate the channel hydraulics;
- The existing model did not have specific representation of the Arroyo Avichi diversion channel and side weir (see the photos on the next page for the diversion structures) -- there is a need to add these structures to more reliably simulate the diversion channel hydraulics and the diverted amount of flow;
- The existing model did not have representation of buildings -- there is a need to represent buildings in the model and simulate the hydraulic effects of buildings;
- The existing model used the 2010 LiDAR data for the floodplain topography -- the 2019 LiDAR data is available now and there is a need to update the floodplain DEM with the most recent topographic data;
- The channel geometry data in the existing model for the Novato Creek upper sedimentation reach (upstream of Warner Creek confluence) and the Arroyo Avichi Creek appeared to be from the post-2012 dredging survey with little deposited sediment -- there is a need to further examine the data and, if needed, reconstruct the channel geometry for the Baseline using the pre-2016 dredging survey data as surveyed in 2015. For the reconfigured 1D channel for Warner Creek, also use the pre-2016 dredging survey data for the Baseline channel geometry.
- It is our understanding that there was no calibration for the existing model -- there is a need to perform a model calibration to establish the reliability of the updated model. Section 2.1 below describes the details of the model update and Section 2.2 describes the model calibration.

For the fifth bullet above, using the pre-2016 dredging survey data as surveyed in 2015 to update the channel geometry for the sedimentation reaches was the original work plan. However, examination of the pre-2016 dredging survey data found that the 2015 survey was mostly limited to the channel bed, with just a few cross sections surveyed to the top of banks. In order to more accurately represent the channel geometry and simulate the hydraulics, the County commissioned Stetson to conduct a new survey. Stetson prepared a survey plan and performed the new survey during the two days of January 13 - 14, 2020. Control points for this survey were provided by the County. The surveyed cross sections and the control points used for the survey are shown in Figure 1.

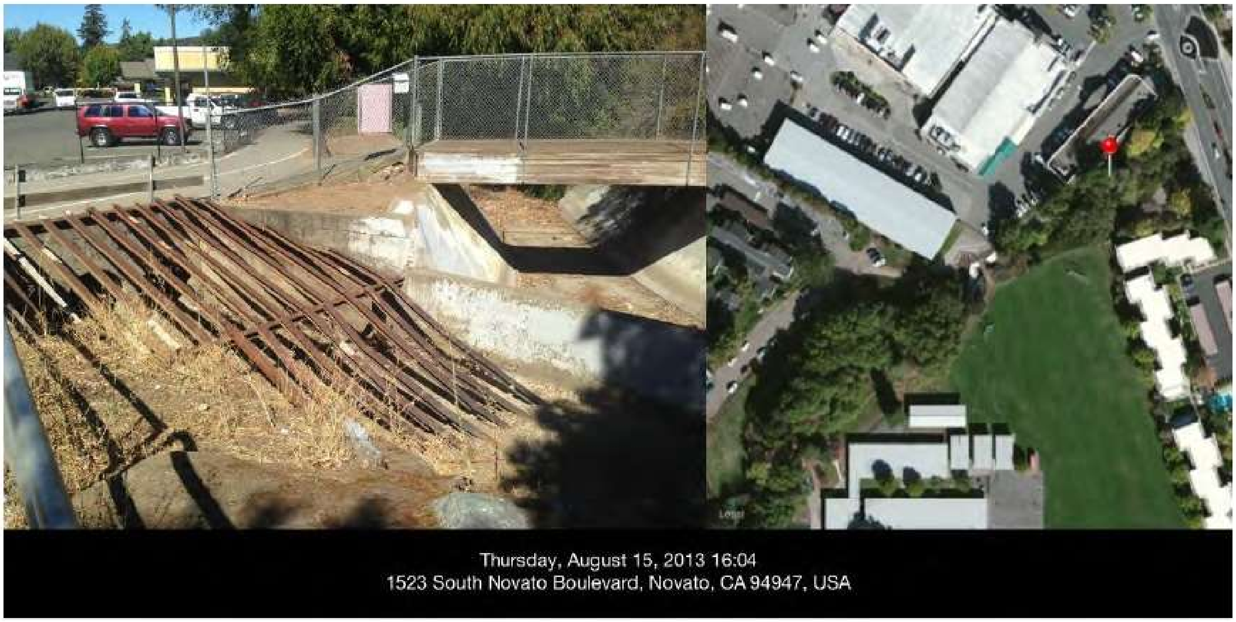


Photo of Arroyo Avichi Overflow Weir and Diversion Channel

Photo of Arroyo Avichi Culvert Inlet Structure (Three Culverts with Trash Rack)

2.1. Model Update

The data used to update the model geometry included the latest 2019 LiDAR data for the floodplain, and the recent channel survey for Warner Creek, Arroyo Avichi Creek, and Novato Creek in the Nave Gardens neighborhood.

The latest LiDAR data was obtained from Marin County in the format of high resolution DEM (0.5 m grids). The LiDAR was flown between 12/22/2018 – 03/15/2019 by Quantum Spatial, Inc for the Golden Gate National Parks Conservancy (GGNPC).

The recent channel cross sections survey in the Nave Gardens neighborhood was described in the previous section and shown in Figure 1.

With the above data, the details of the model update included the following:

- Converted HEC-RAS model version from 5.0.6 to 5.0.7
- Added Warner Creek 1D in-channel model
- Added overflow weir/channel from Arroyo Avichi Creek to Baccaglio Basin based on the as-built designs
- Updated channel cross sections with the Stetson 2020 channel survey
- Updated floodplain terrain data with the 2019 LiDAR DEM
- Reconfigured 2D floodplain model domain, and refined 2D model grid cells
- Added representation of building footprints in the 2D domain
- Added spatially varying Manning’s n layer for the 2D domain with different Manning’s n for the following categories:
    - Building footprints
    - Road surfaces
    - Commercial property parcels
    - Residential property parcels
- Updated 1D/2D lateral links as needed

2.2. Model Calibration

Appropriate flow data is needed to calibrate the model. Three gages were examined: the USGS streamflow gage near the Novato Library (USGS Gage #11459500) and the Marin OneRain stage gages at the Rowland Way Bridge and at the Novato Creek estuary.

The 1/16/2019 storm event was chosen for the model calibration, as it is the largest event since the Rowland gage started recording water levels. Based on the USGS Gage #11459500, the peak discharge for the 1/16/2019 event was 1,870 cfs at the USGS gage (Figure 2), which is an approximate 8.5-year flood event.

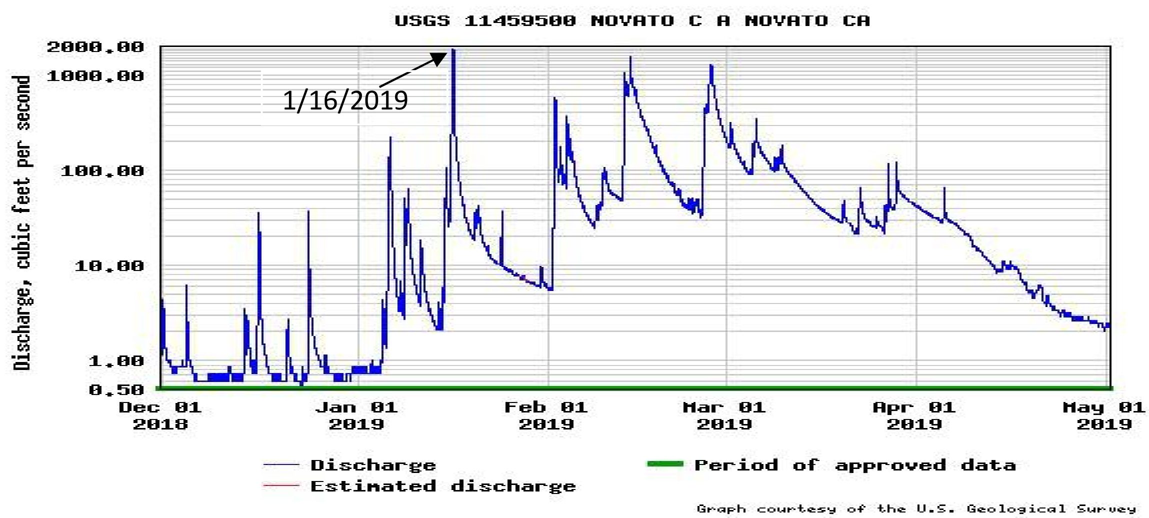


Figure 2 Flow hydrograph recorded at USGS Gage #11459500

To calibrate the model to the 1/16/2019 storm event, the original 50-year flow input hydrographs in the existing model (i.e., the HEC-HMS hydrologic model-simulated 50-year flood hydrographs with a peak discharge of 3,865 cfs at the USGS gage that were provided by the County) were scaled down with a ratio, so that the HEC-RAS model routed peak discharge at the USGS gage matched the gage recorded peak discharge of 1,870 cfs for the 1/16/2019 event. The scaling ratio was found to be 0.48.

Meanwhile, the downstream boundary condition at the Novato Creek estuary was set to the Marin OneRain gage-recorded tide hydrograph at the estuary during the same 1/16/2019 storm event.

The model was run iteratively by adjusting the channel roughness (i.e., Manning's n), until the model simulated peak water surface elevation at the Rowland Way gage matched the gage-recorded peak water level for the 1/16/2019 event (Figure 3). The calibrated Manning's n ranged from 0.025 – 0.04, which are within literature recommended ranges.

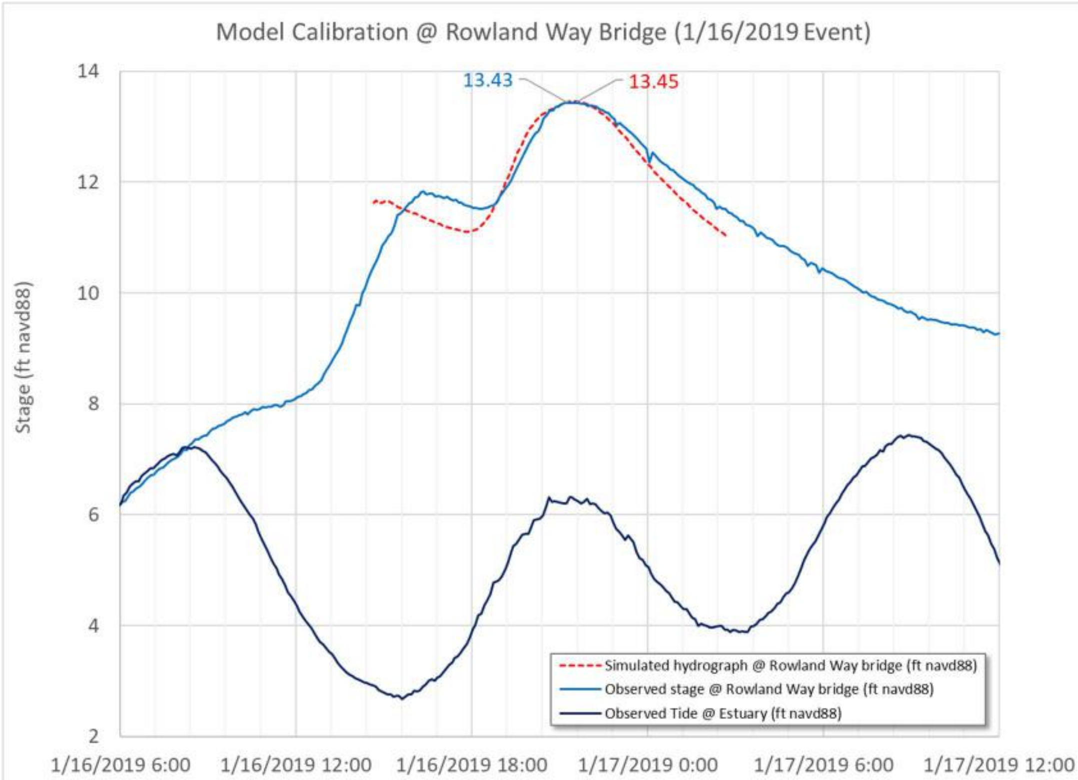


Figure 3 Model calibration at Rowland Way bridge

3. Simulation of Sediment Dredge Scenarios

A total of three channel conditions were simulated: the existing condition, the full dredge condition, and the partial dredge condition. The limits of the full dredging and partial dredging conditions are defined as follows (Figure 1):

Full Dredge:

- Novato Creek: From the downstream side of the Novato Fair Shopping Center Bridge
- to 500 ft downstream of the SMART Railroad Bridge
- Warner Creek: From the downstream side of the Diablo Ave Bridge to the confluence with Novato Creek
- Arroyo Avichi Creek: from the downstream side of the Novato Blvd bridge to the confluence with Novato Creek

Partial Dredge:

- Novato Creek: From the downstream side of the Novato Fair Shopping Center Bridge
- to the downstream face of the Redwood Blvd Bridge
- Warner Creek: Same as the full dredge
- Arroyo Avichi Creek: Same as the full dredge

To simulate the dredging conditions, the existing condition model geometry was modified to reflect the dredging condition as depicted by the DEM provided by the County. Each of the conditions was then run with three different flood events: 10-year, 50-year, and 100-year. The longitudinal WSE profiles and the WSE change maps for the 50-year flood event are shown in Figures 4 - 9.

The figures show that the WSE changes and the WSE differences between the partial dredge and the full dredge is small. The reason for the small difference is because that the reach between the Redwood Blvd Bridge and the SMART Train Bridge is mainly a tidal affected reach with relatively low channel grade and flat WSE profiles.

Figure 4 Simulated 50-Year WSE Profiles of Novato Creek

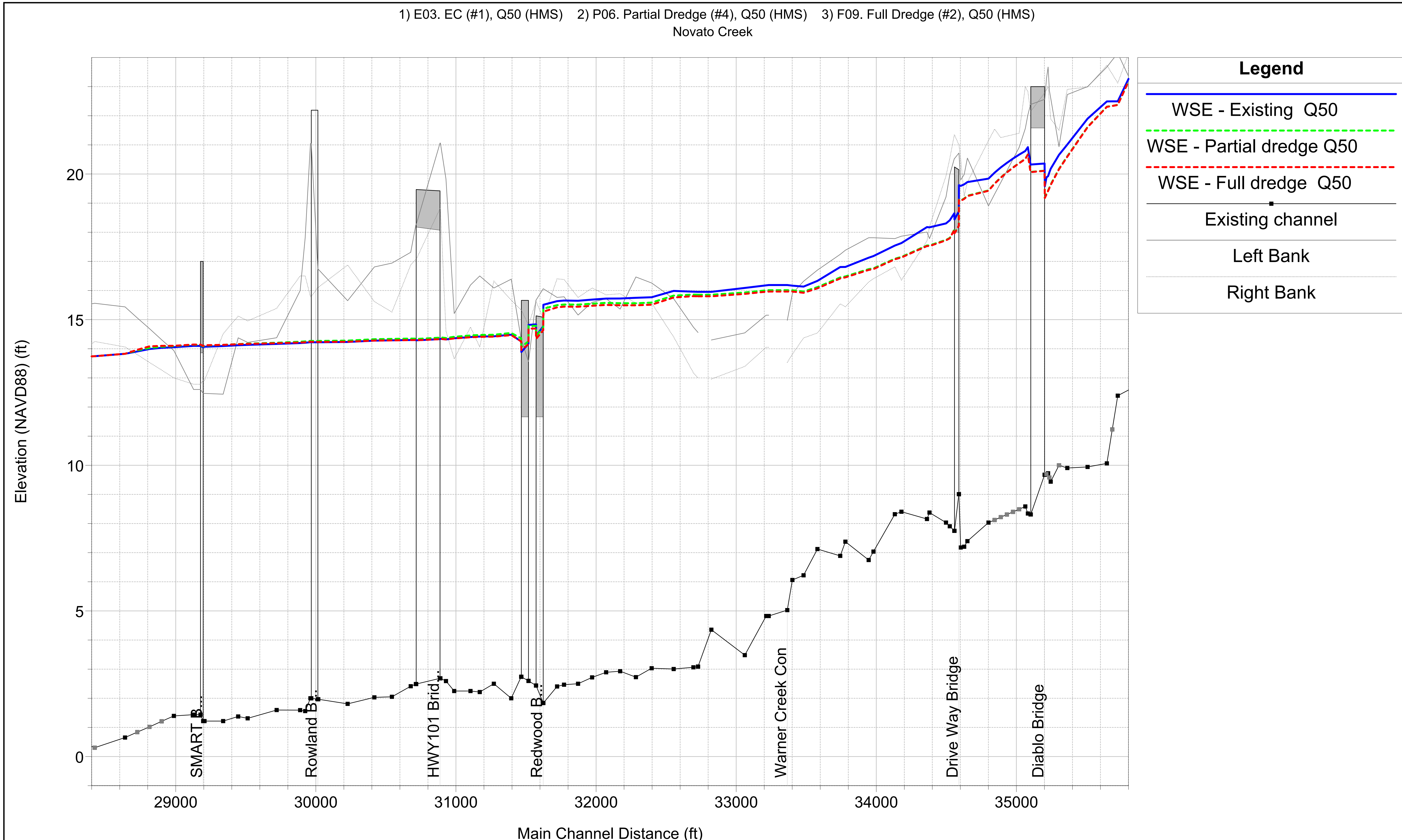


Figure 5 Simulated 50-Year WSE Profiles of Warner Creek

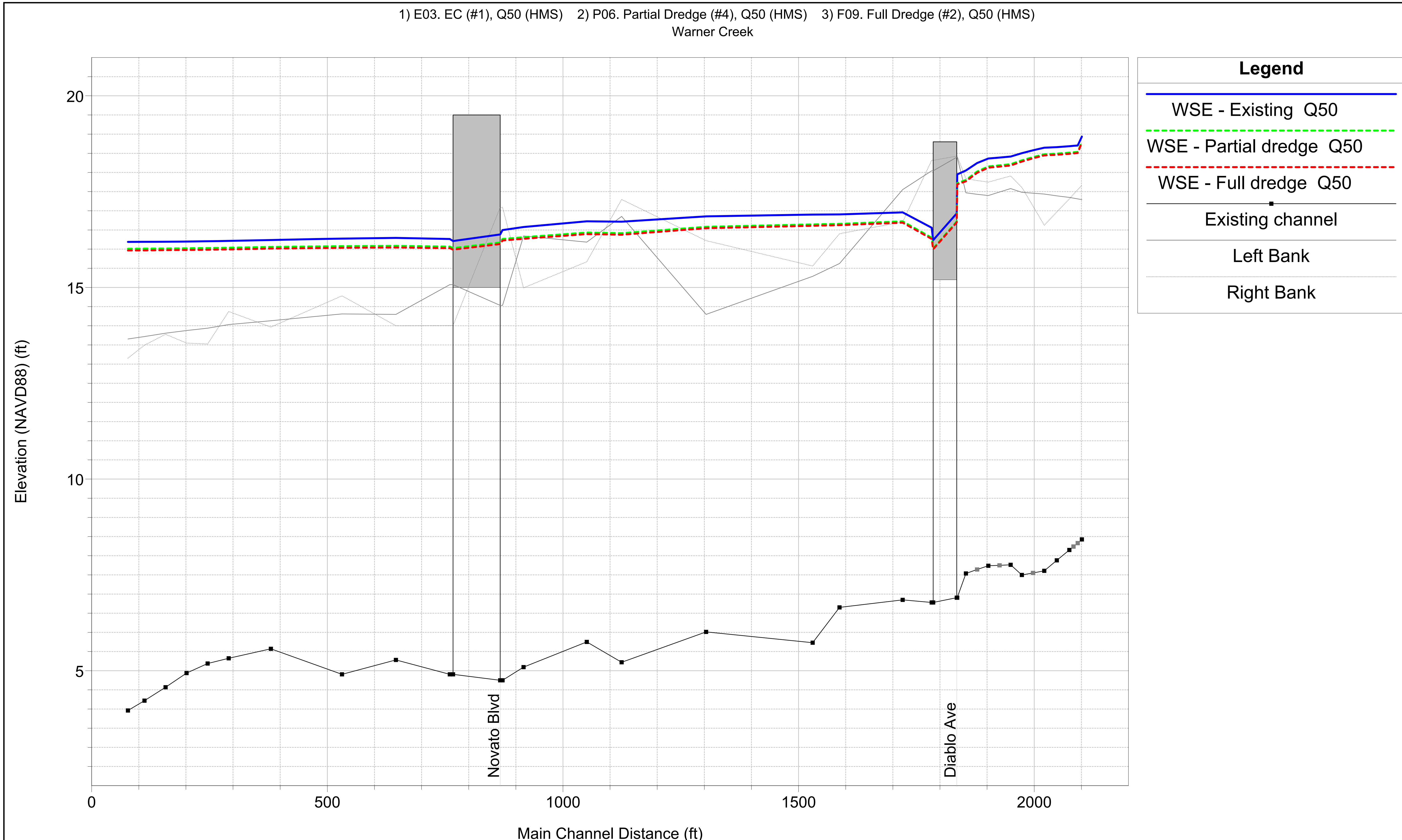
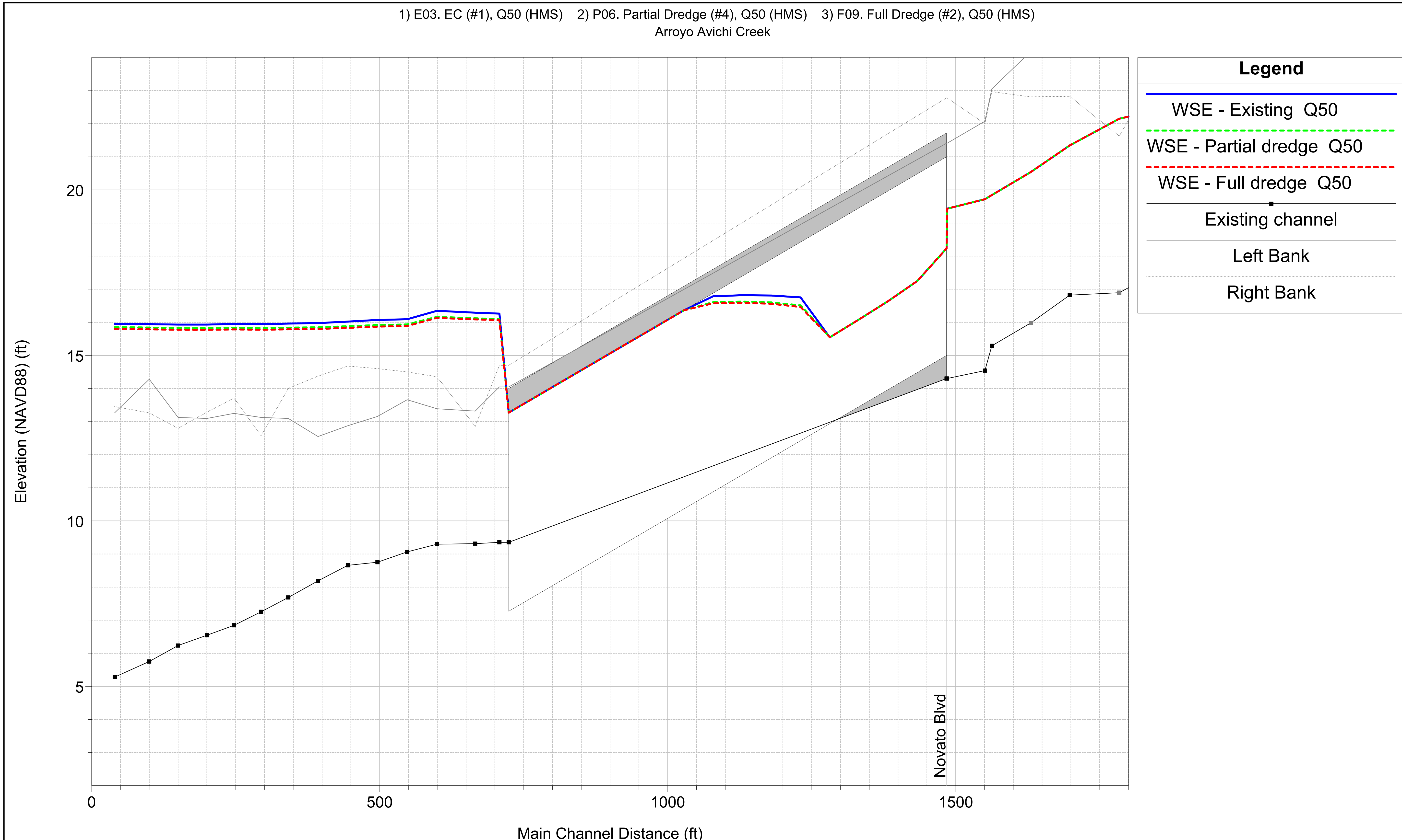
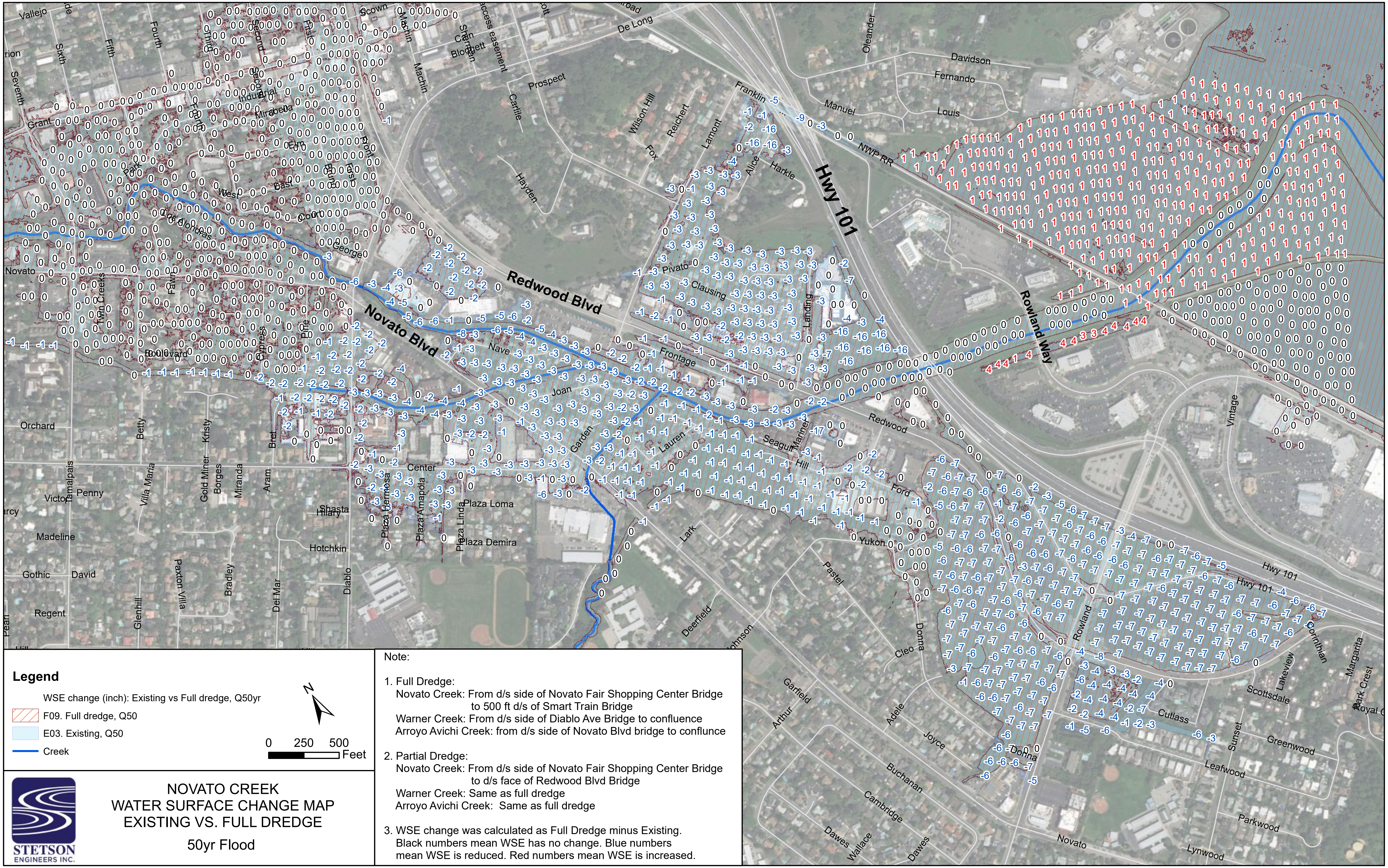


Figure 6 Simulated 50-Year WSE Profiles of Arroyo Avichi Creek





Legend

WSE change (inch): Existing vs Full dredge, Q50yr

- F09. Full dredge, Q50
- E03. Existing, Q50
- Creek

N

0 250 500 Feet

NOVATO CREEK
WATER SURFACE CHANGE MAP
EXISTING VS. FULL DREDGE

50yr Flood

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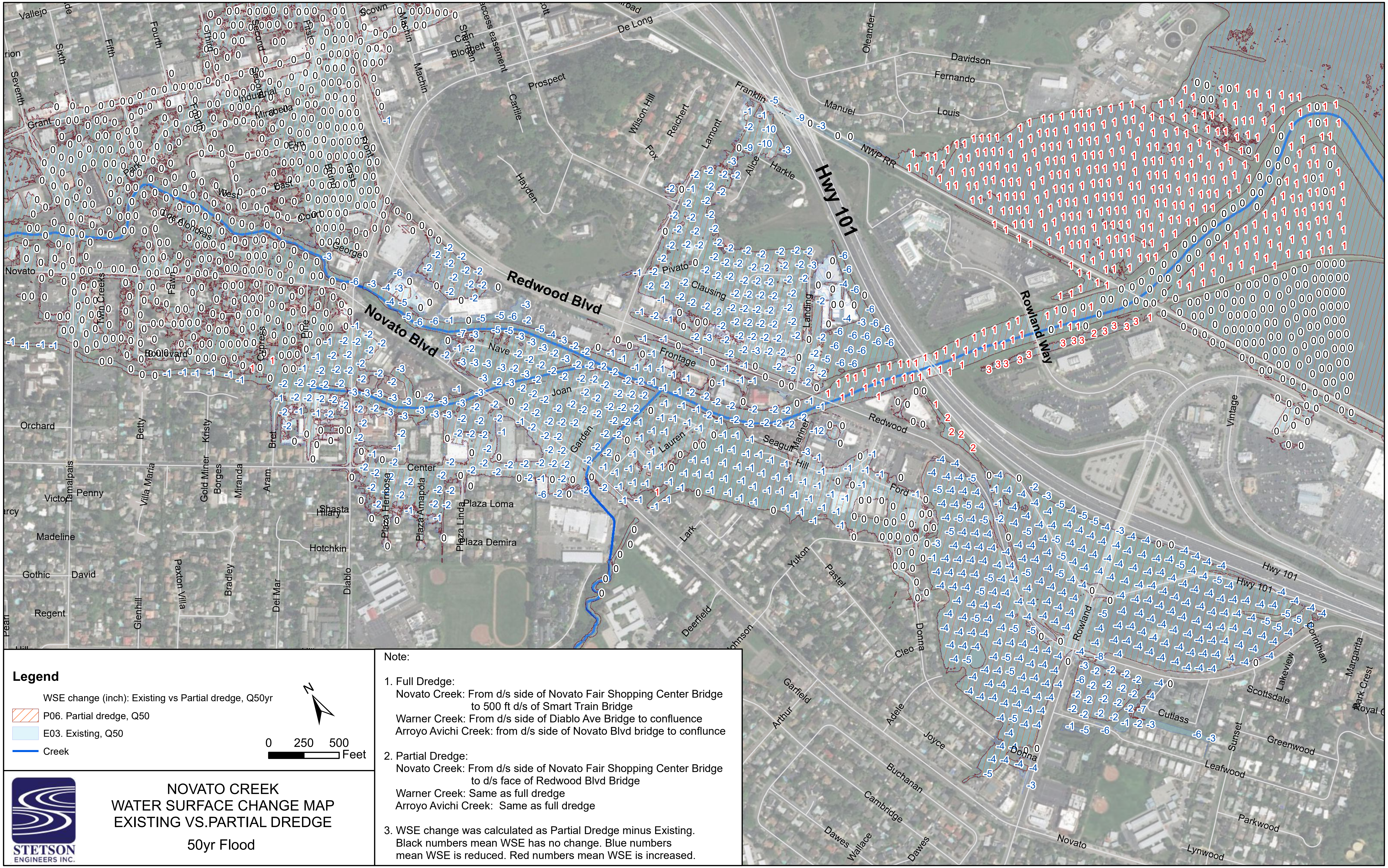
Note:

1. Full Dredge:
   Novato Creek: From d/s side of Novato Fair Shopping Center Bridge to 500 ft d/s of Smart Train Bridge
   Warner Creek: From d/s side of Diablo Ave Bridge to confluence
   Arroyo Avichi Creek: from d/s side of Novato Blvd bridge to confluence
2. Partial Dredge:
   Novato Creek: From d/s side of Novato Fair Shopping Center Bridge to d/s face of Redwood Blvd Bridge
   Warner Creek: Same as full dredge
   Arroyo Avichi Creek: Same as full dredge
3. WSE change was calculated as Full Dredge minus Existing. Black numbers mean WSE has no change. Blue numbers mean WSE is reduced. Red numbers mean WSE is increased.

C:\DATA\2738\GIS\FIG 2 WSE Change Map - Existing vs Full Dredge, Q50.mxd 4/1/2020

FIGURE 8



Legend

WSE change (inch): Existing vs Partial dredge, Q50yr

P06. Partial dredge, Q50

E03. Existing, Q50

Creek

0 250 500 Feet

Note:

1. Full Dredge:
   Novato Creek: From d/s side of Novato Fair Shopping Center Bridge to 500 ft d/s of Smart Train Bridge
   Warner Creek: From d/s side of Diablo Ave Bridge to confluence
   Arroyo Avichi Creek: from d/s side of Novato Blvd bridge to confluence

2. Partial Dredge:
   Novato Creek: From d/s side of Novato Fair Shopping Center Bridge to d/s face of Redwood Blvd Bridge
   Warner Creek: Same as full dredge
   Arroyo Avichi Creek: Same as full dredge

3. WSE change was calculated as Partial Dredge minus Existing. Black numbers mean WSE has no change. Blue numbers mean WSE is reduced. Red numbers mean WSE is increased.

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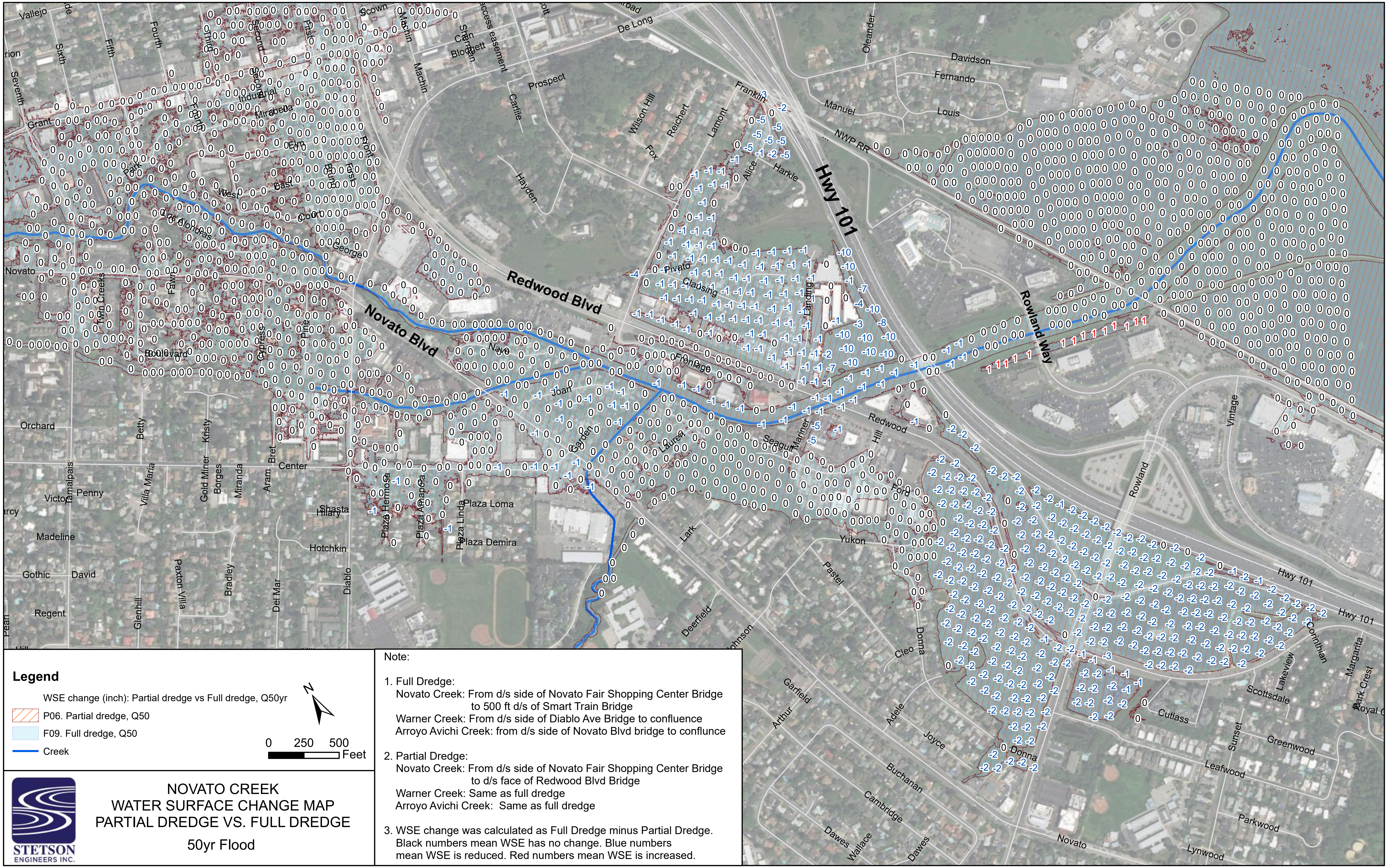
NOVATO CREEK
WATER SURFACE CHANGE MAP
EXISTING VS.PARTIAL DREDGE

50yr Flood

C:\DATA\2738\GIS\FIG 1 WSE Change Map - Existing vs Partial Dredge, Q50.mxd 4/1/2020

FIGURE 9



Legend

WSE change (inch): Partial dredge vs Full dredge, Q50yr

P06. Partial dredge, Q50

F09. Full dredge, Q50

Creek

Note:

1. Full Dredge:
   Novato Creek: From d/s side of Novato Fair Shopping Center Bridge to 500 ft d/s of Smart Train Bridge
   Warner Creek: From d/s side of Diablo Ave Bridge to confluence
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   Warner Creek: Same as full dredge
   Arroyo Avichi Creek: Same as full dredge
3. WSE change was calculated as Full Dredge minus Partial Dredge. Black numbers mean WSE has no change. Blue numbers mean WSE is reduced. Red numbers mean WSE is increased.

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NOVATO CREEK
WATER SURFACE CHANGE MAP
PARTIAL DREDGE VS. FULL DREDGE
50yr Flood

C:\DATA\2738\GIS\FIG 3 WSE Change Map - Partial vs Full Dredge, Q50.mxd 4/1/2020