CE 4353-001
DESIGN OF HYDRAULIC SYSTEMS

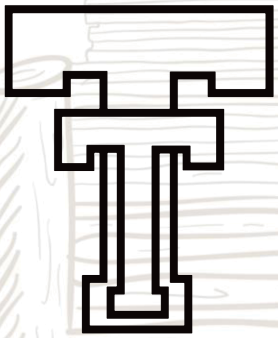
CULVERT INSERTION IN BUCKBRUSH WASH

NAME

SEMESTER

PROJECT BUCKBRUSH WASH

SUBMITTAL DATE



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1 SKETCHES

Using the data provided for the Buckbrush Wash, the sketches for the cross-sections were generated, which were used for the HEC-RAS analysis. Three different sketches were generated in total. Figure 1 shows the view of roadway and culvert combination between Station 3 and 38. Figure 2 shows the top view with cross sections of Station 36.6, 37, 38, and 38.1. Figure 3 shows the upstream view of the culvert orientation and the ineffective flow areas, and shows the downstream view of the culvert orientation and the ineffective flow areas.

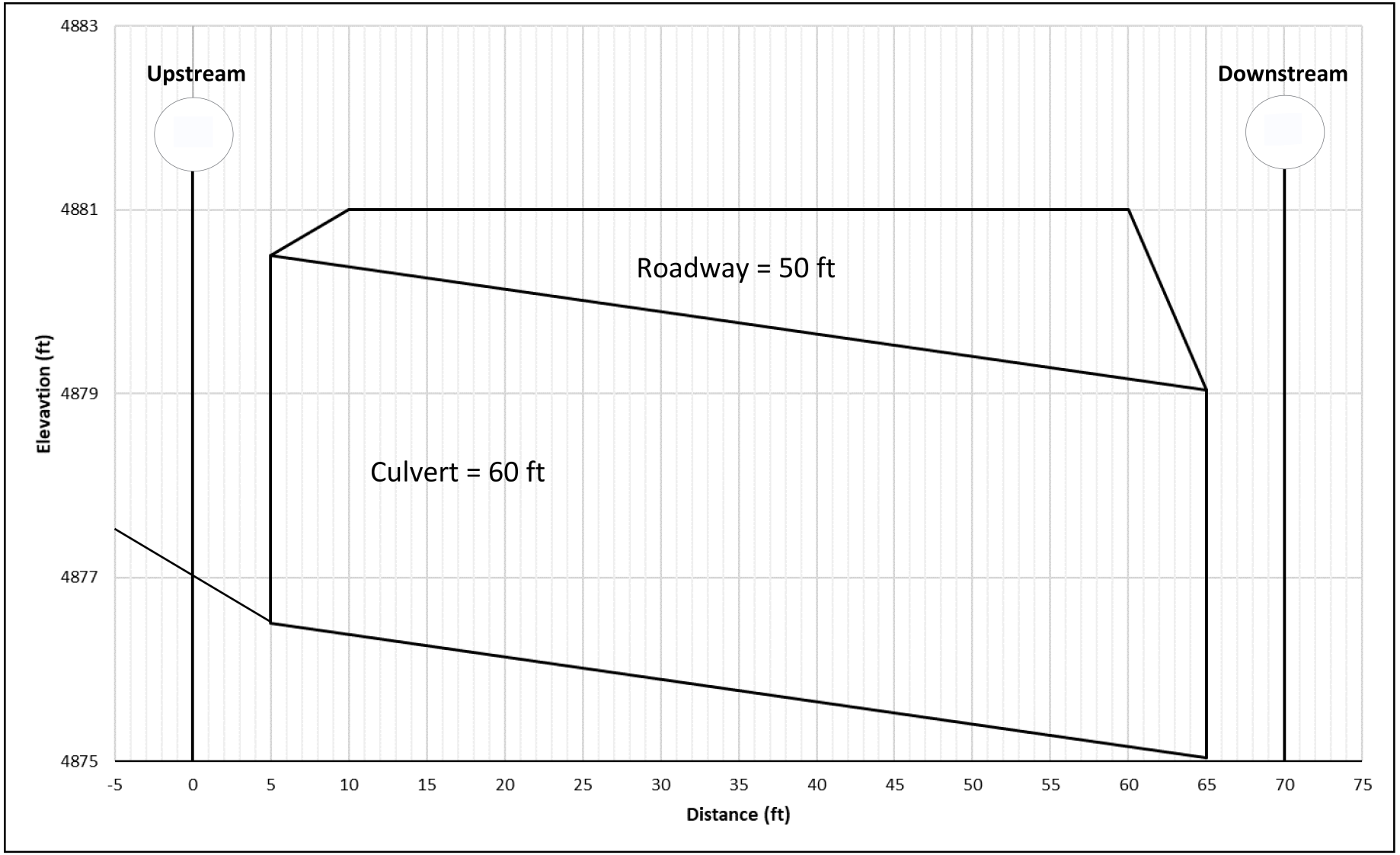


Figure 1: Side view of roadway and culvert combination

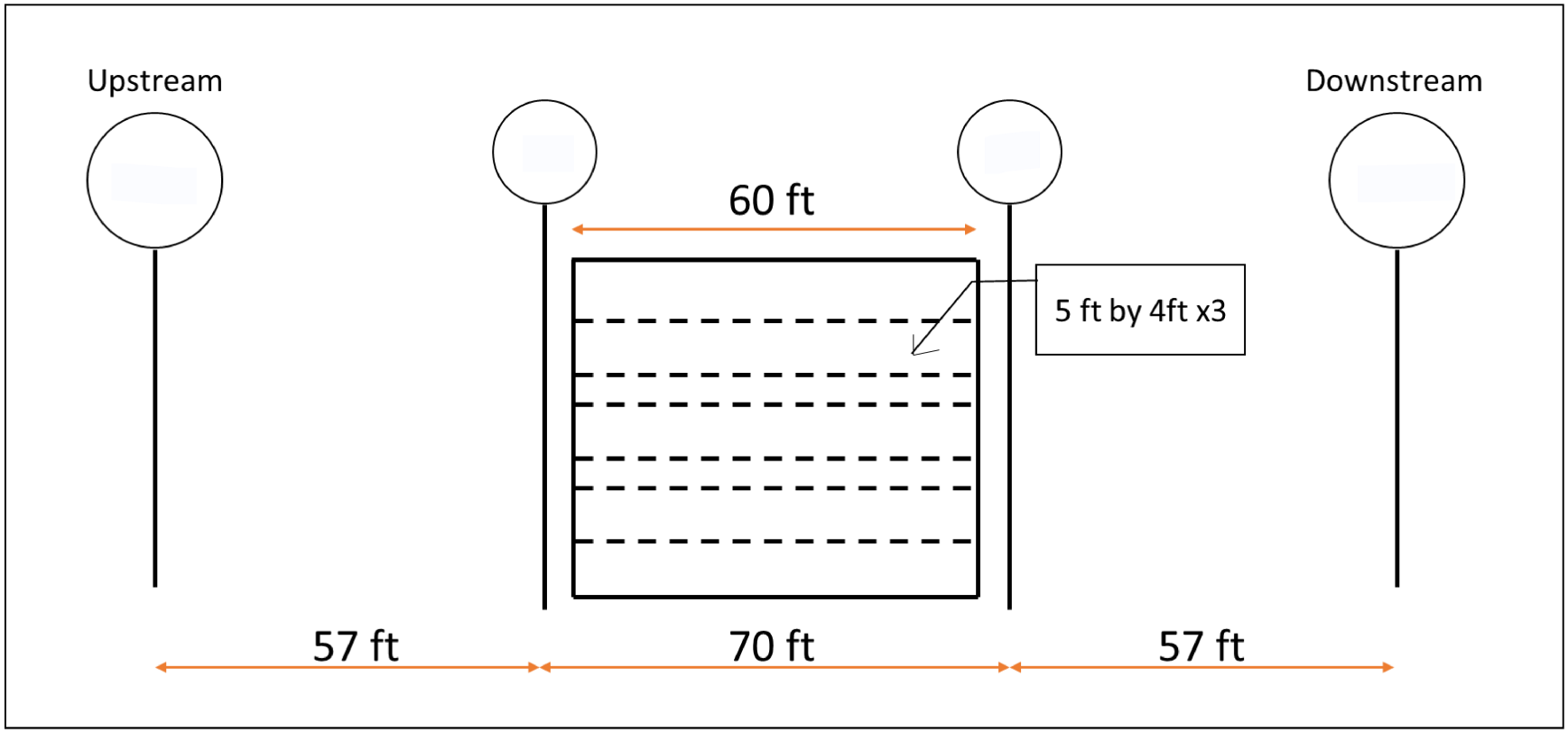


Figure 2: Top view with locations of the four cross-sections for culvert

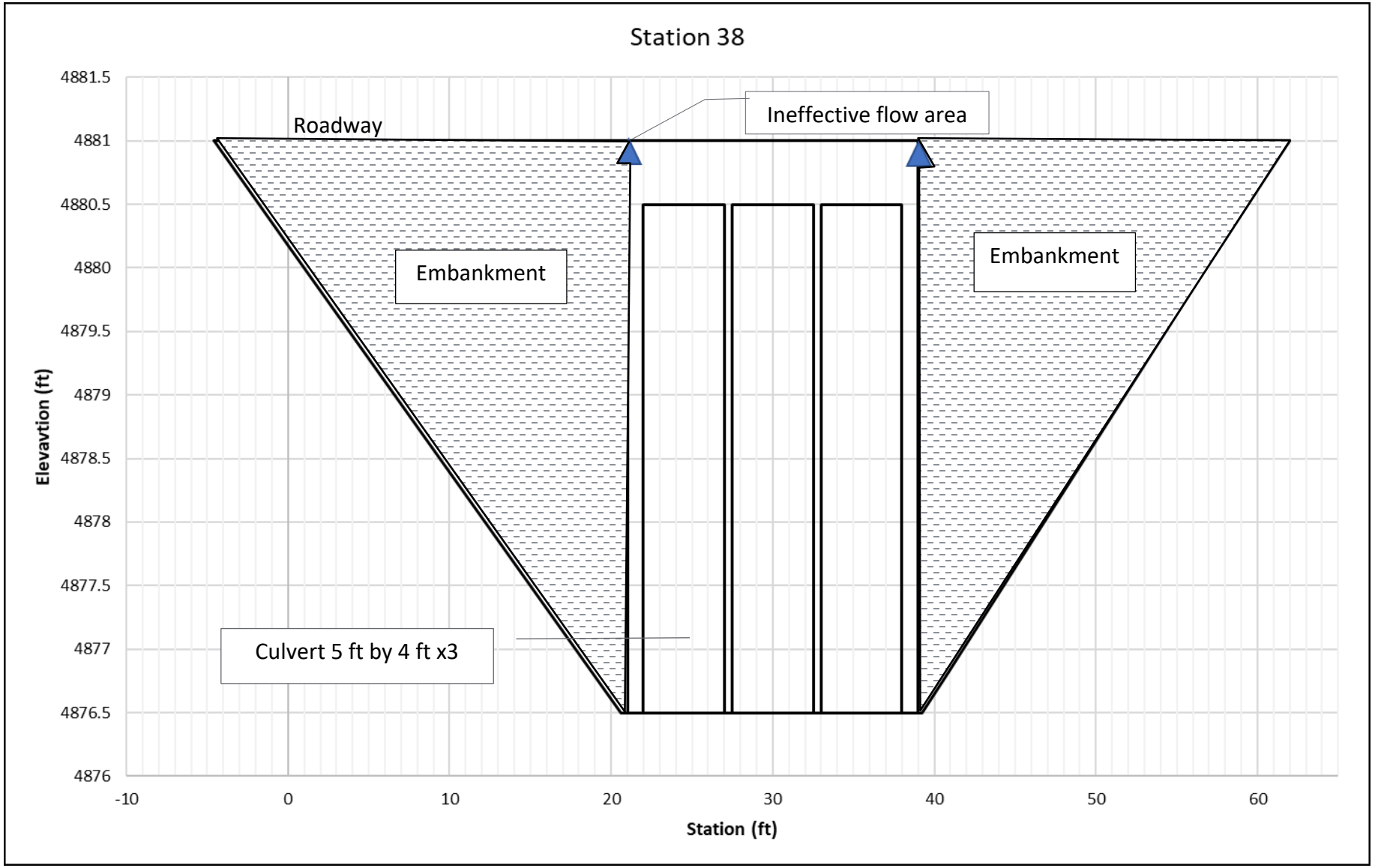


Figure 3: Upstream view of Station 38 showing culvert orientation and ineffective flow areas

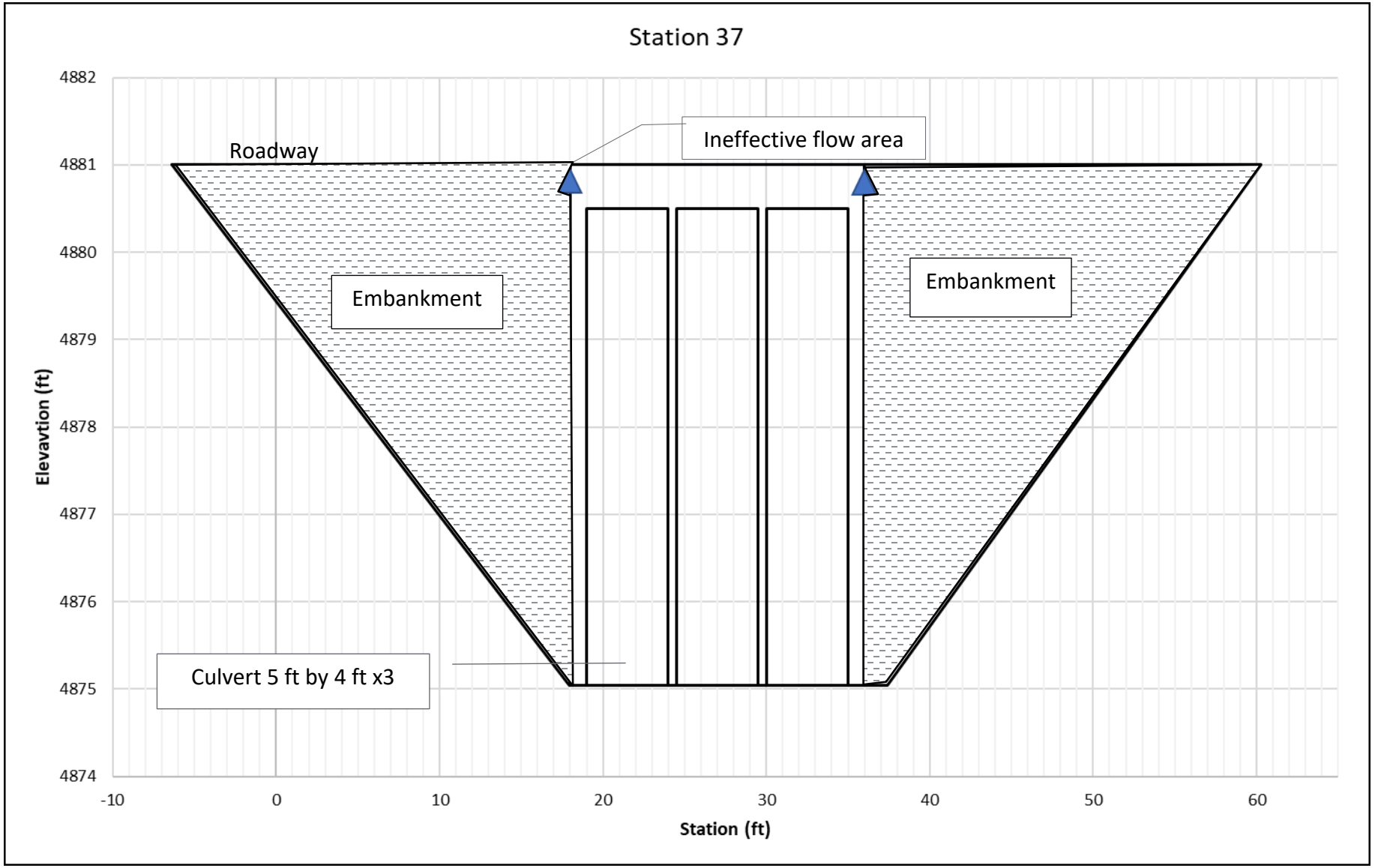


Figure 4: Downstream view of Station 37 showing culvert orientation and ineffective flow areas

2 INPUT DATA

2.1 CROSS-SECTIONS INTERPOLATION

The cross-sections between Stations 39 and 38 and between Stations 37 and 36 were interpolated using the cross-section interpolation function of HEC-RAS. Interpolation of cross-sections was needed to get an accurate result near the culvert. The cross-sections were required to allow for contraction and expansion losses. The distance between Stations 39 and 38 is 570 ft. Hence, Stations 39 and 38 were interpolated at 57 ft interval. Stations 39 and 38 accounted for contraction losses. On the other hand, Stations 37 and 36 was 170 ft in length. Like Stations 38 and 39, Stations 37 and 36 were interpolated at 57 feet interval as well. Stations 37 and 36 were accounted for expansion losses. The table below summarizes the cross-sections interpolation.

Table 1: Summary of Cross-Sections Interpolation

Stations	Length (ft)	Interpolated Length (ft)	Losses Accounted For
39 to 38	570		Contraction
37 to 36	170		Expansion

Figure 5 shows the input data used in HEC-RAS for the interpolation of the cross-sections. The input data was screen captured from HEC-RAS.

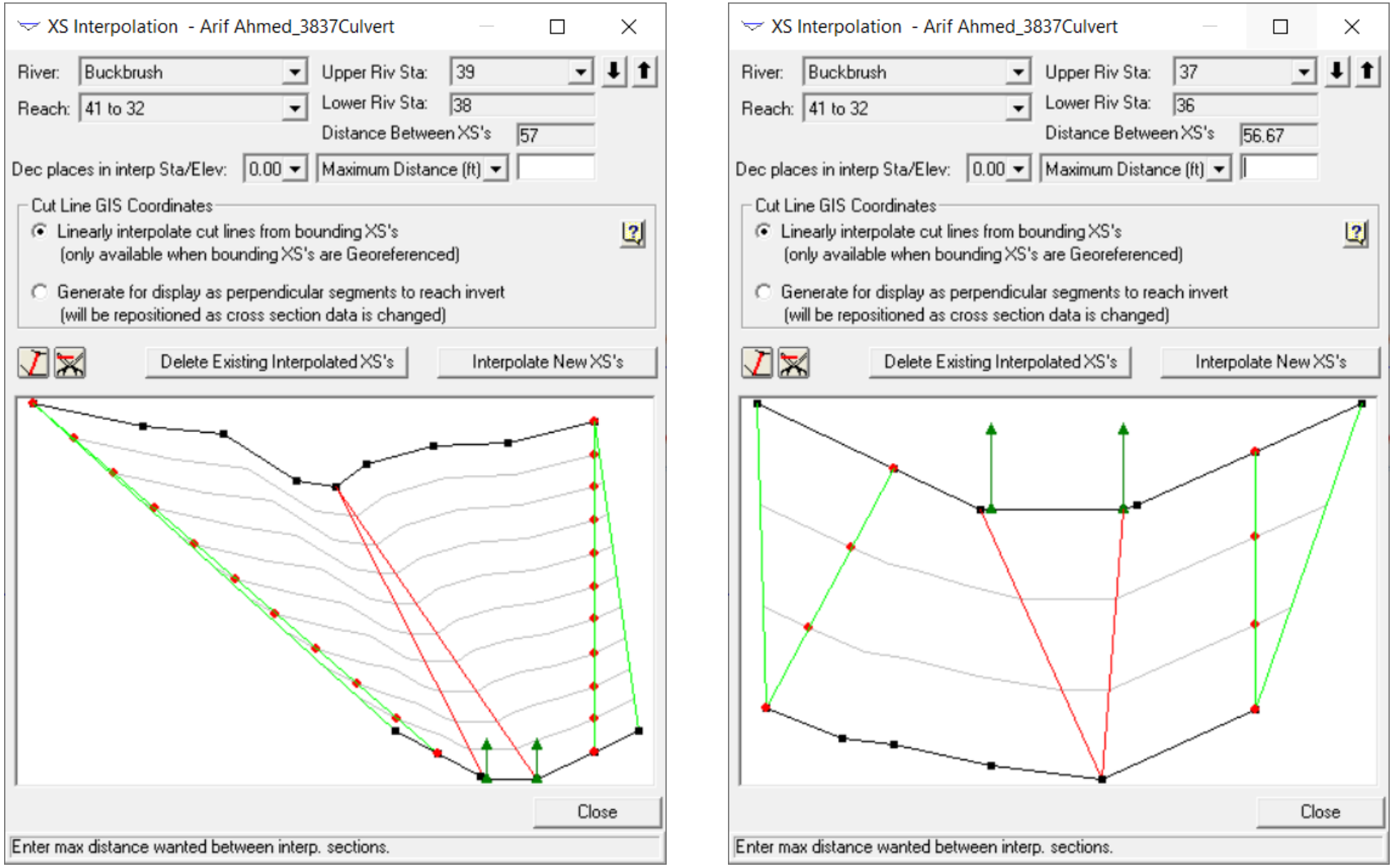


Figure 5: Screen capture from HEC-RAS for cross-sections interpolation between Stations 39 & 38 and Stations 37 & 36

2.2 ADJUSTMENTS TO CROSS SECTIONS 37 & 38

To place the culvert for the project some adjustments had to made to the cross sections 37 and 38. The bottom of the two cross-sections were flattened out which would help to place the culvert inverts on flat surface. The calculations of the flattening process are shown in the Appendix. The edges of the cross-sections were also extended for both the cross-sections. This would help to see the rise of the water level to test out various culvert sizes. Figure 6 compares the cross sections 37 before and after adjustments were made, and Figure 7 compares the adjustments of cross sections 38. Figure 8 shows the adjustment data for cross sections 37 and 38.

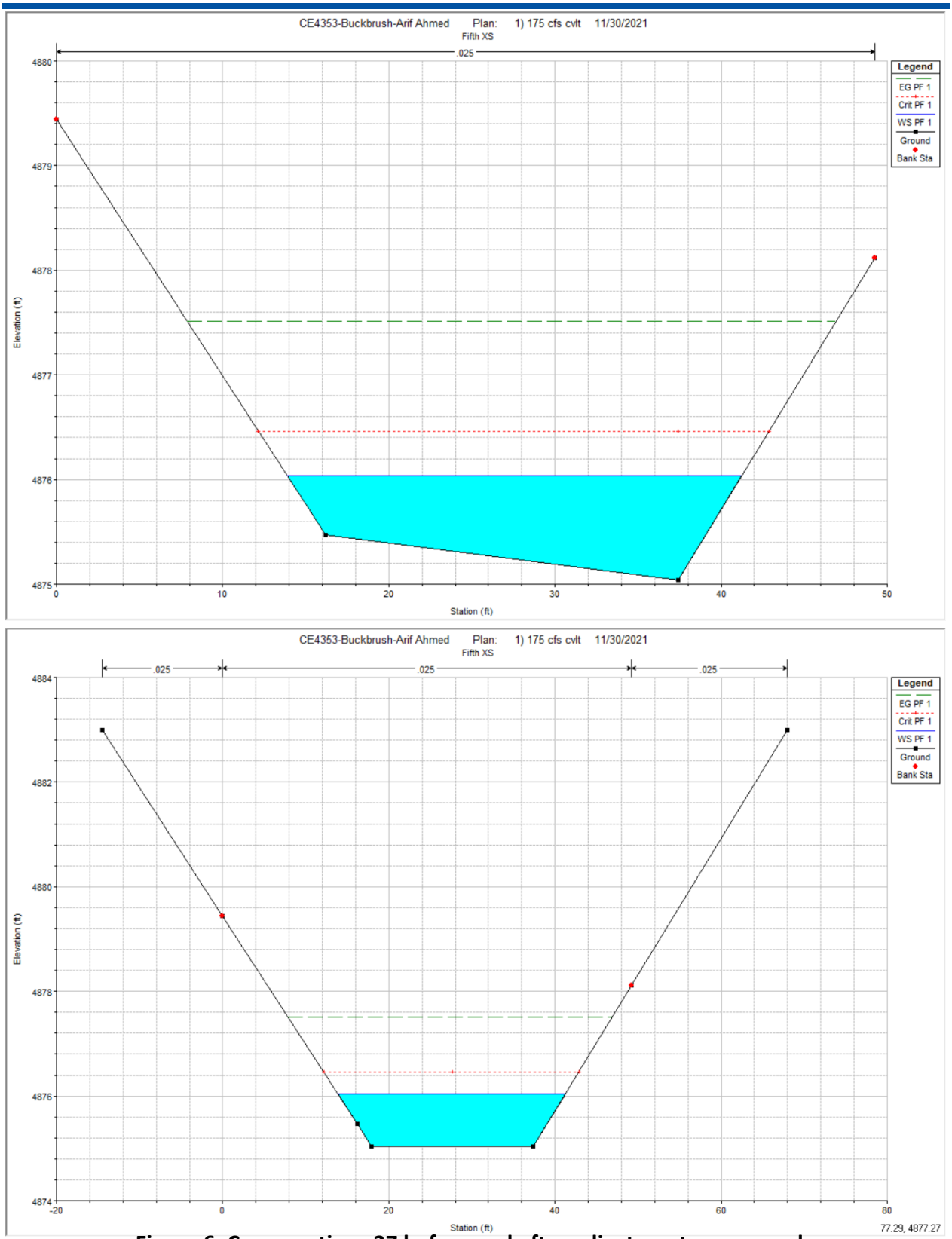


Figure 6: Cross sections 37 before and after adjustments were made

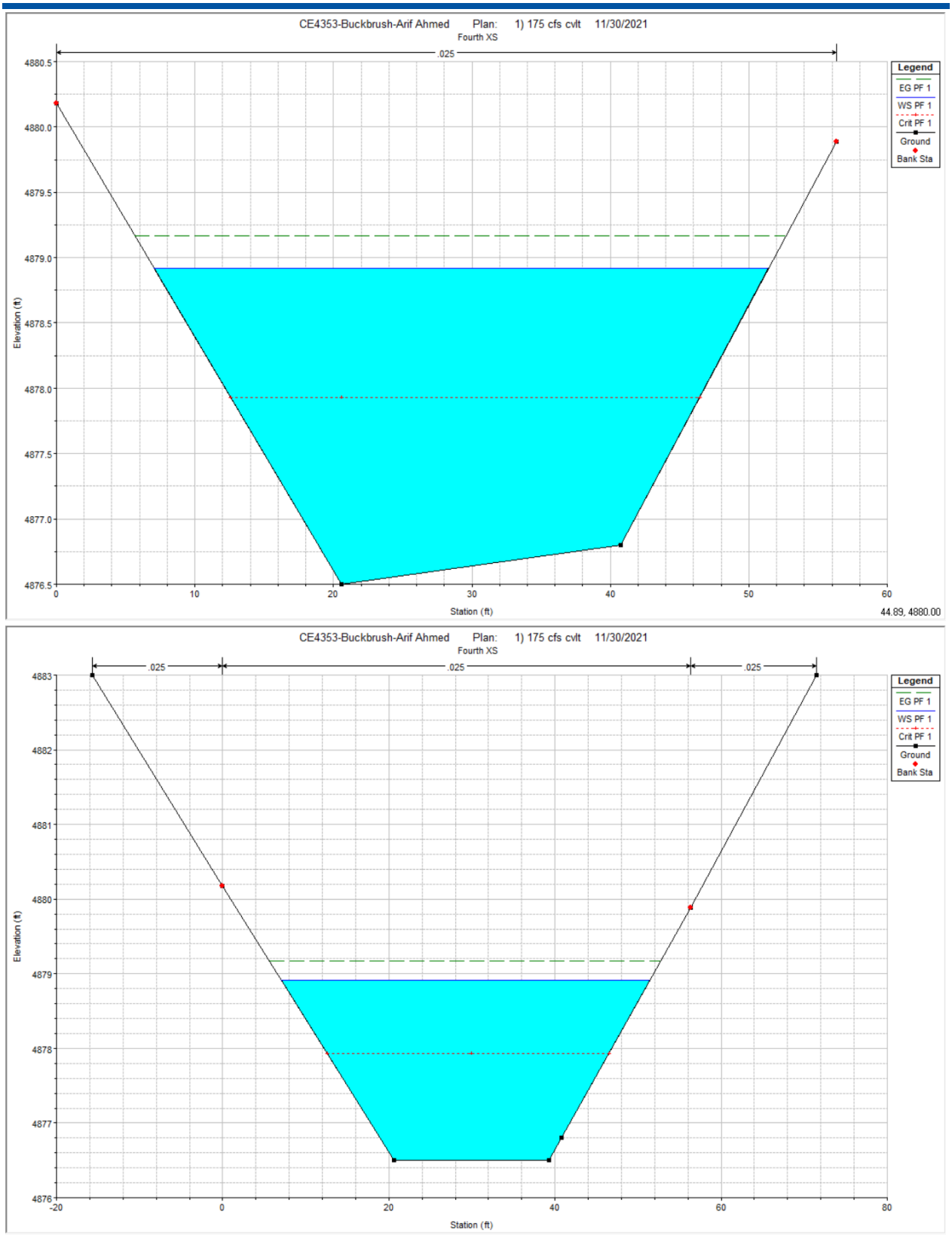


Figure 7: Cross sections 38 before and after adjustments were made

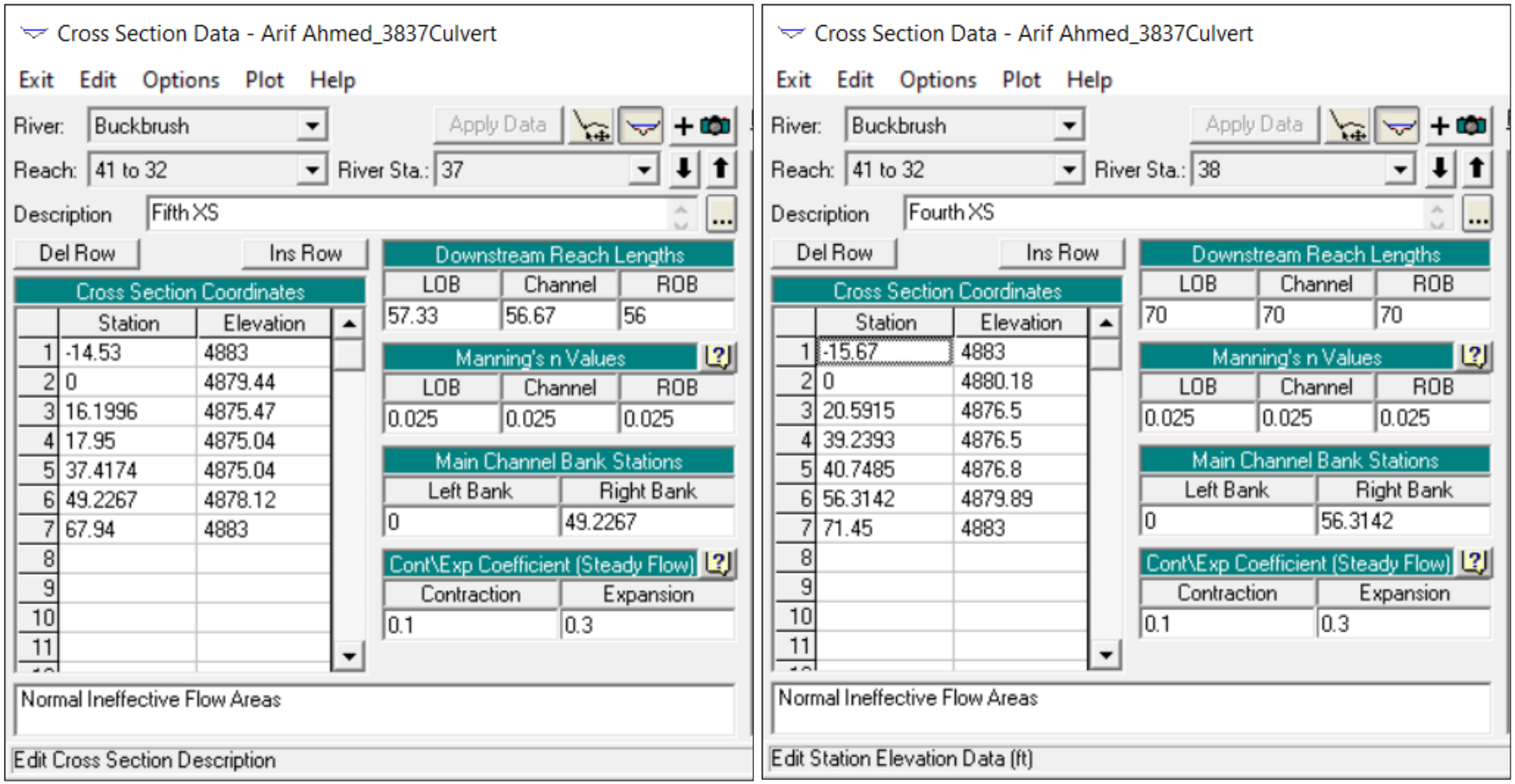


Figure 8: Adjustment data for cross sections 37 and 38

2.3 CULVERT DATA

The goal of the project was not to have water level 2 ft below the roadway, which was located at an elevation of 4881 ft. After several trial and error, the culvert that performs the best was box concrete culvert 3 barrels with each barrel sized at 5 ft by 4 ft. The total length of the culvert was design for 60 ft and was placed at cross section 37.5. The distance between the upstream section 38 section and the downstream section 37 was 70 ft. The roadway was 50 ft wide and was at an elevation of 4881 ft. Figure 9 shows the dimension of the culvert. Figure 10 shows the screen capture from HEC-RAS for culvert and roadway data input.

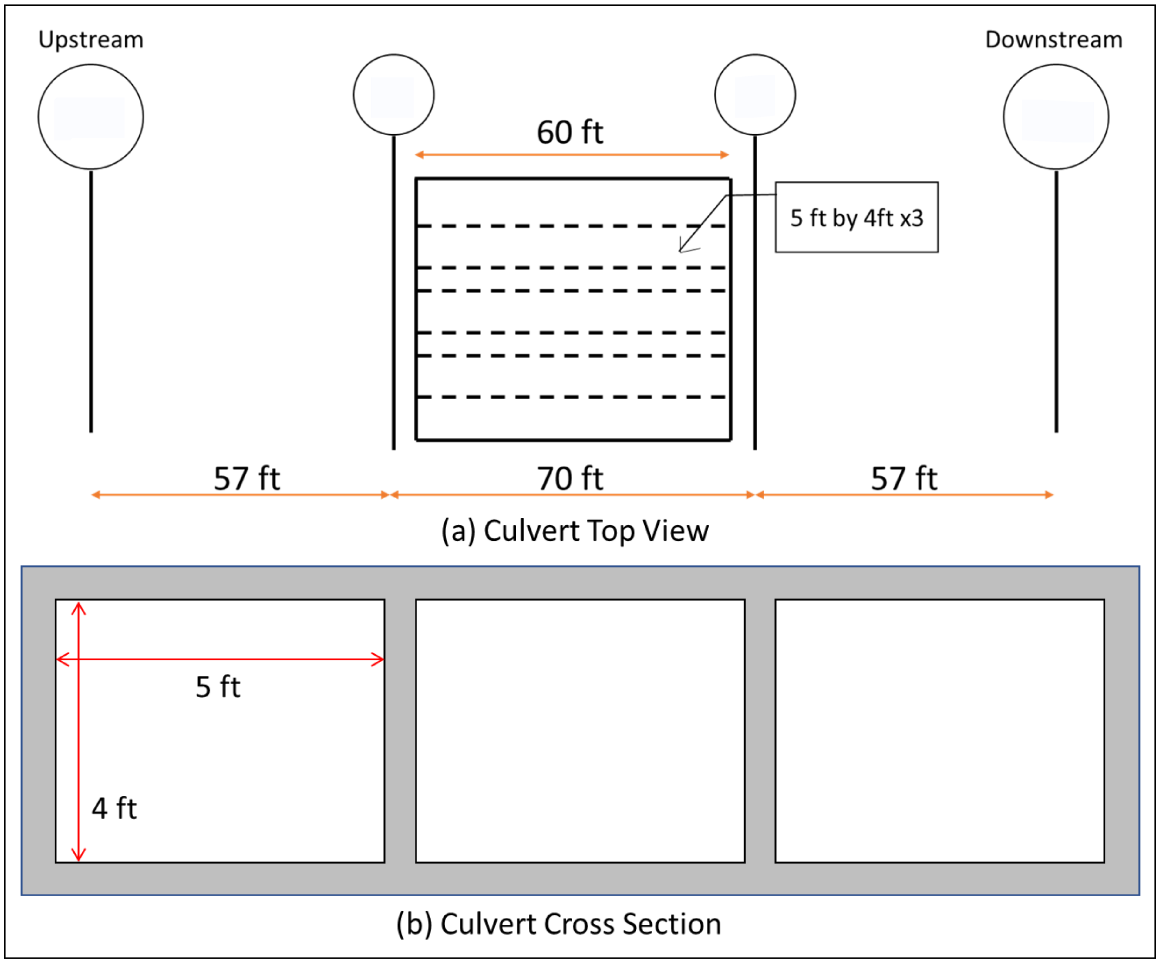


Figure 9: Culvert top view and cross section with dimensions

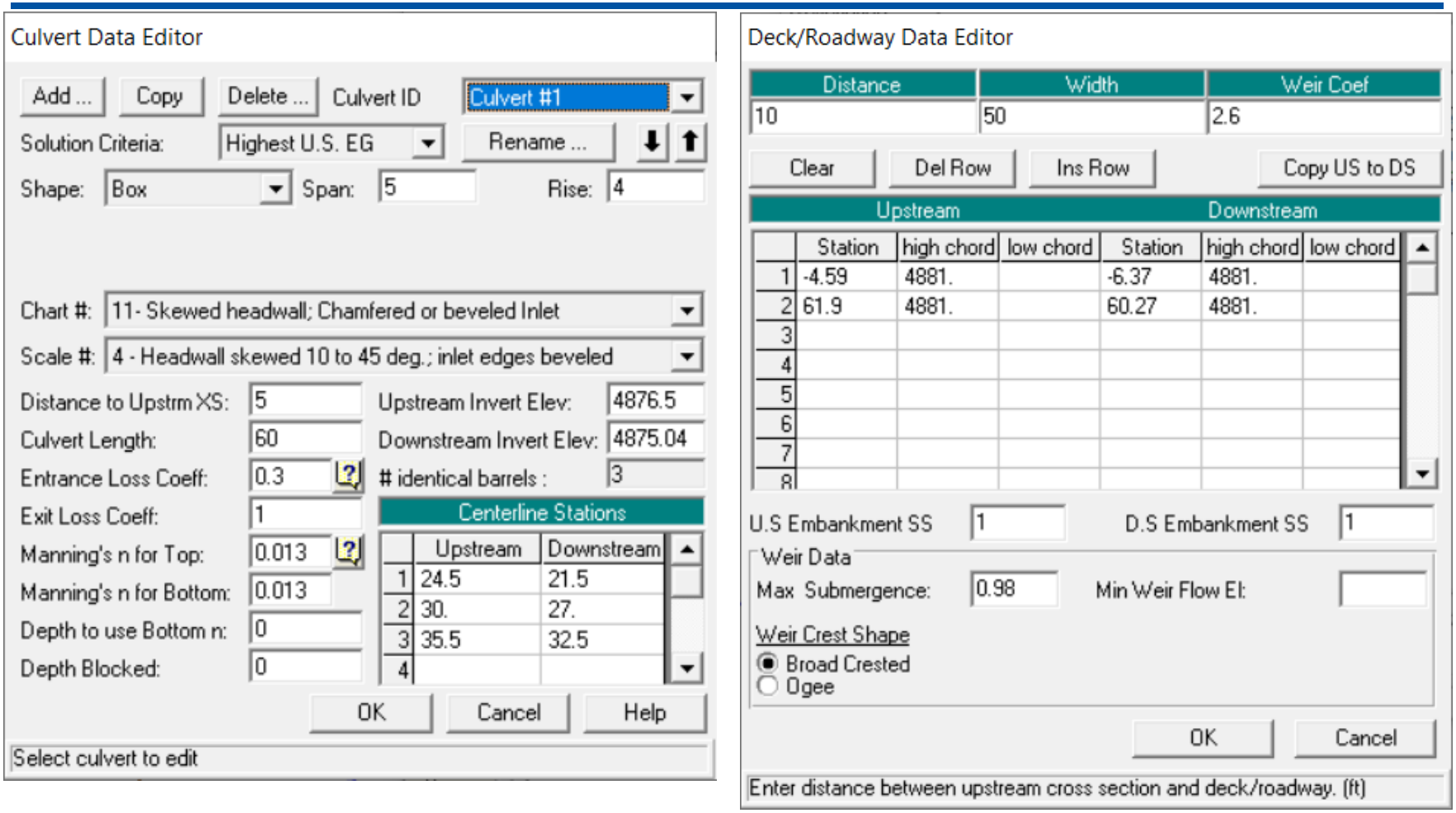


Figure 10: Screen capture from HEC-RAS for culvert and roadway data input

3 RESULTS

3.1 WITHOUT CULVERT

Using HEC-RAS, the steady state flows for the model were simulated without the culvert initially. Two different flows were simulated – 175 cfs and 625 cfs. The boundary conditions were set to Normal Depth with upstream bed slope of 0.02155 ft/ft and downstream bed slope of 0.027 ft/ft. The calculations of the bed slopes can be found in the Appendix. To simulate the steady flows, the mixed flow regime was assumed. Figure 11 shows the flow profiles at 175 cfs without any culvert. Figure 12 shows the flow profiles at 625 cfs without any culvert.

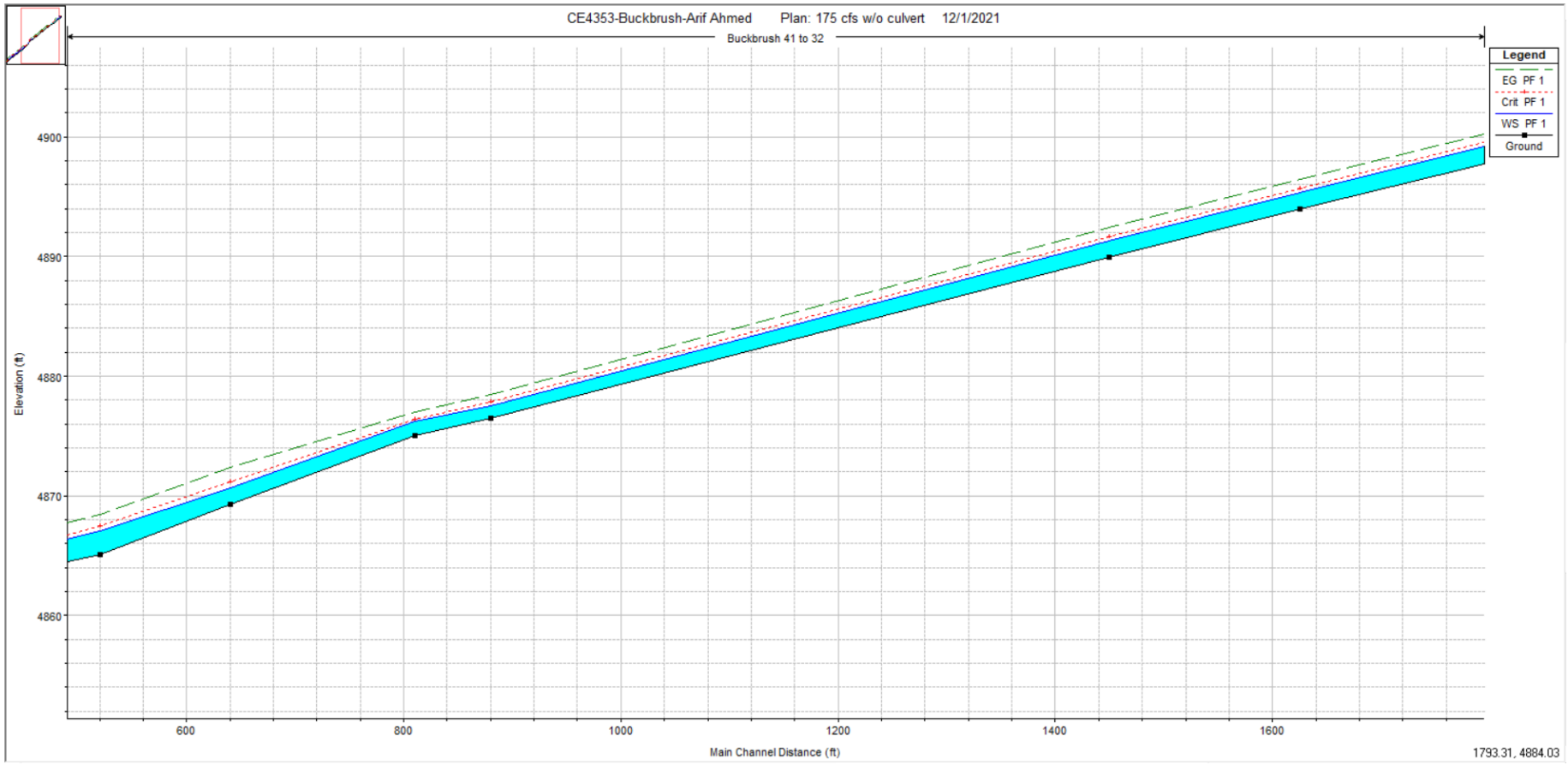


Figure 11: The flow profiles at 175 cfs without any culvert

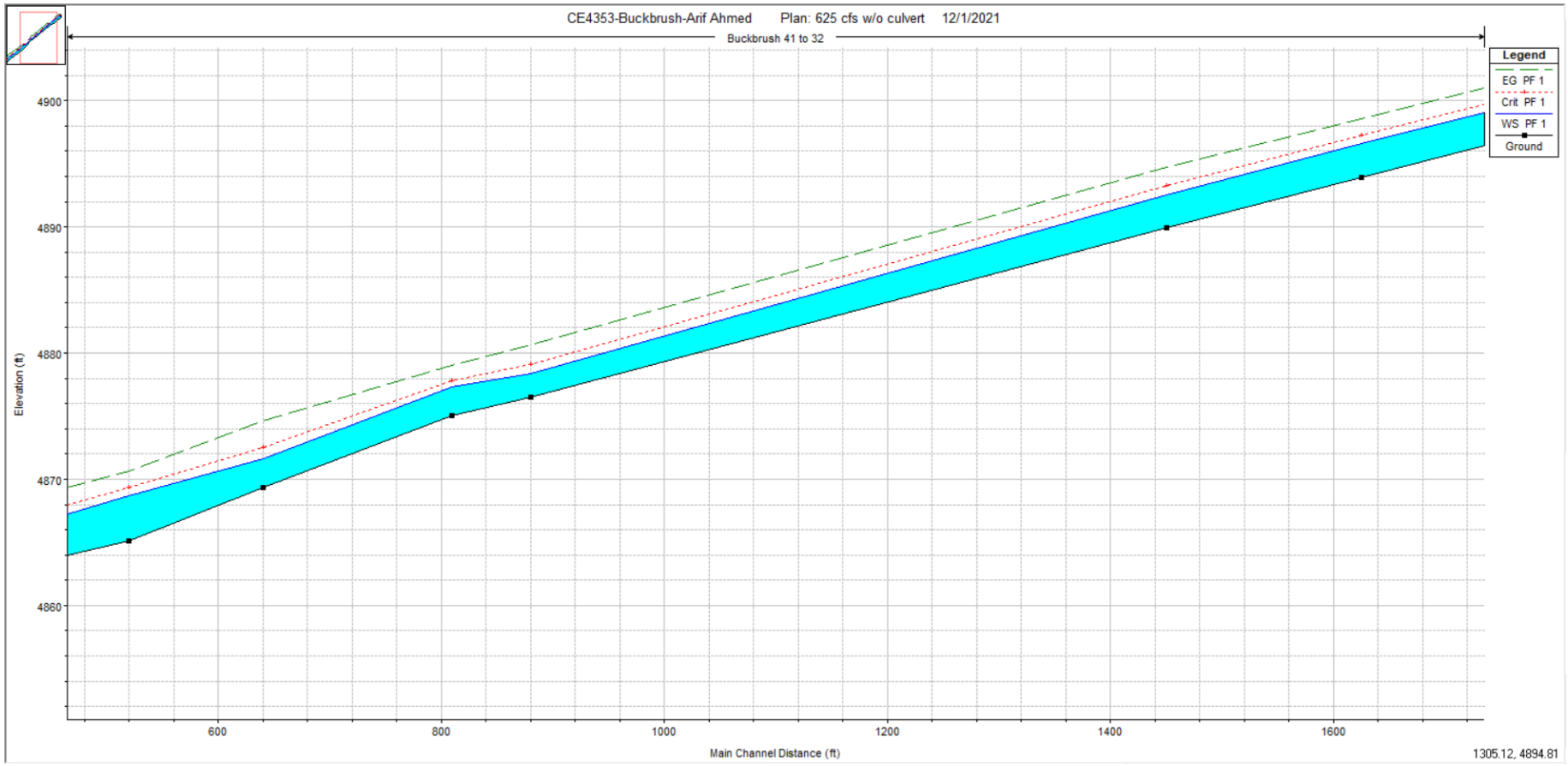


Figure 12: the flow profiles at 625 cfs without any culvert

3.2 WITH CULVERT

Using HEC-RAS, the steady state flows for the model were simulated with the culvert. The same 175 cfs and 625 cfs flows were used for the simulation. For the 175 cfs, the objective was to have the water level at or below 4789 ft for sections 38 and 37. The roadway elevation was at 4881 ft with 2 ft freeboard. The 3-barrel 5 ft by 4 ft box concrete culvert was able to keep the water below 4879 ft. The maximum water elevation reached in Section 38 was 4878.92. When the flow was set to 625 cfs, the maximum water elevation reached in Section 38 was 4880.80. Therefore, when the water flow reaches 625 cfs, the road between Sections 38 will have about 10 inches of water. Figure 13 shows the flow profiles at 175 cfs with the culvert. Figure 14 shows the flow profiles at 625 cfs with the culvert. Figure 15 and Figure 16 show the cross section of Section 38 when the flow is at 175 cfs and 625 cfs respectively. Figure 17 and Figure 18 show the cross section of the culvert at upstream and downstream end when the flow is at 175 cfs and 625 cfs respectively. Figure 19 shows the cross section of Section 37 when flow is 175 cfs and 625 cfs respectively.

3.3 DISCUSSION

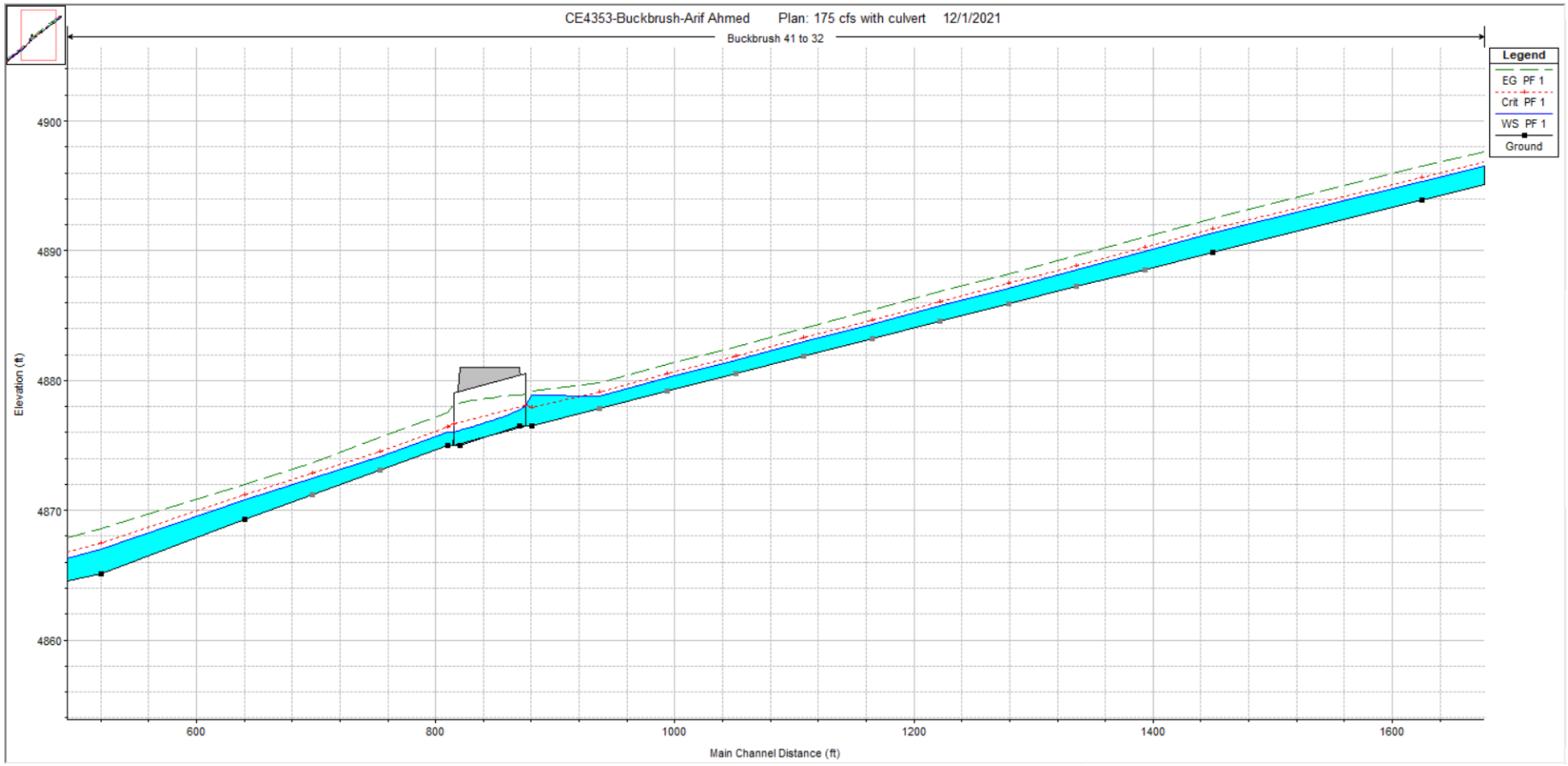


Figure 13: The flow profiles at 175 cfs with the culvert between Section 38 and 37

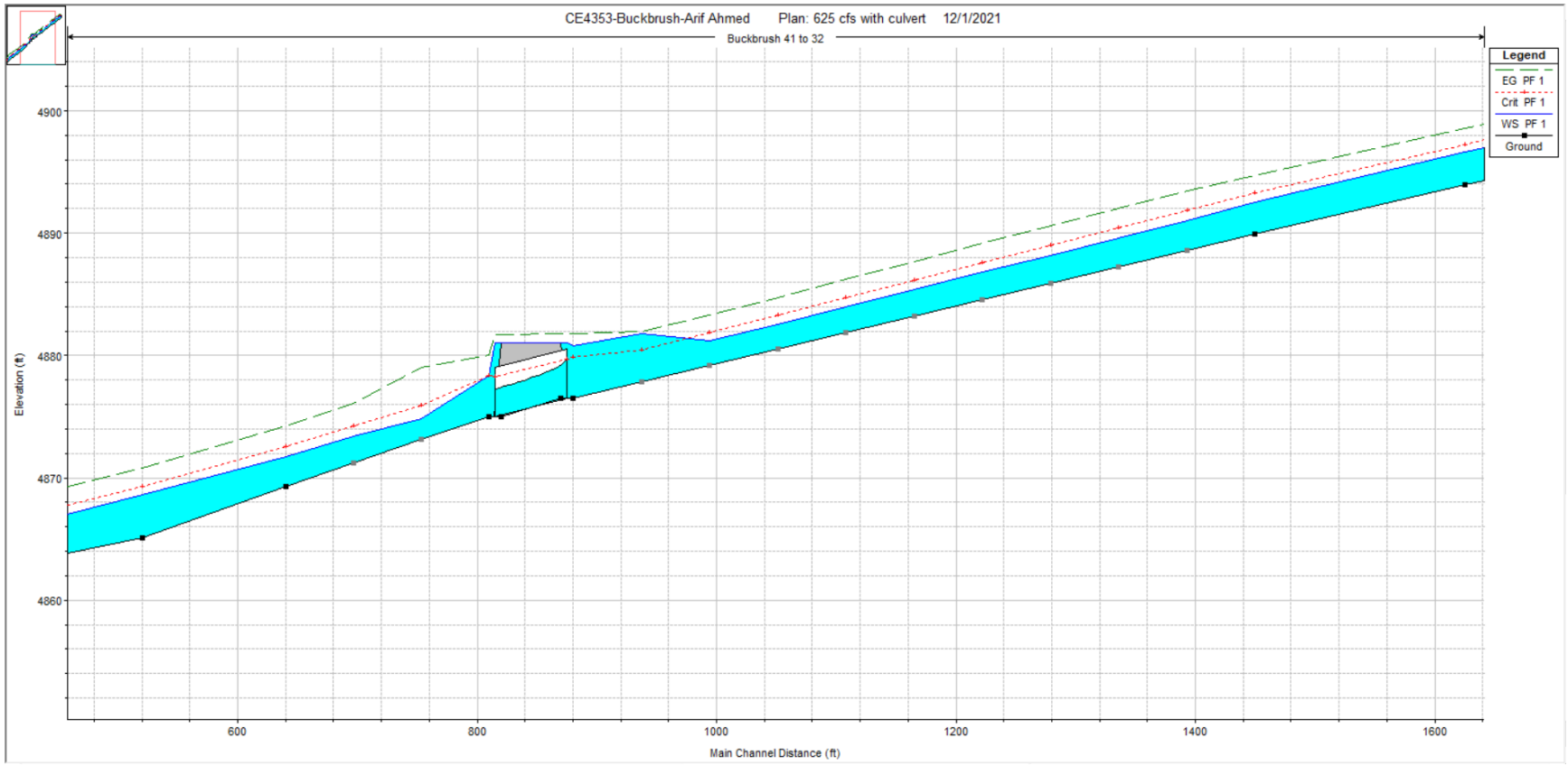


Figure 14: The flow profiles at 625 cfs with the culvert between Section 38 and 37

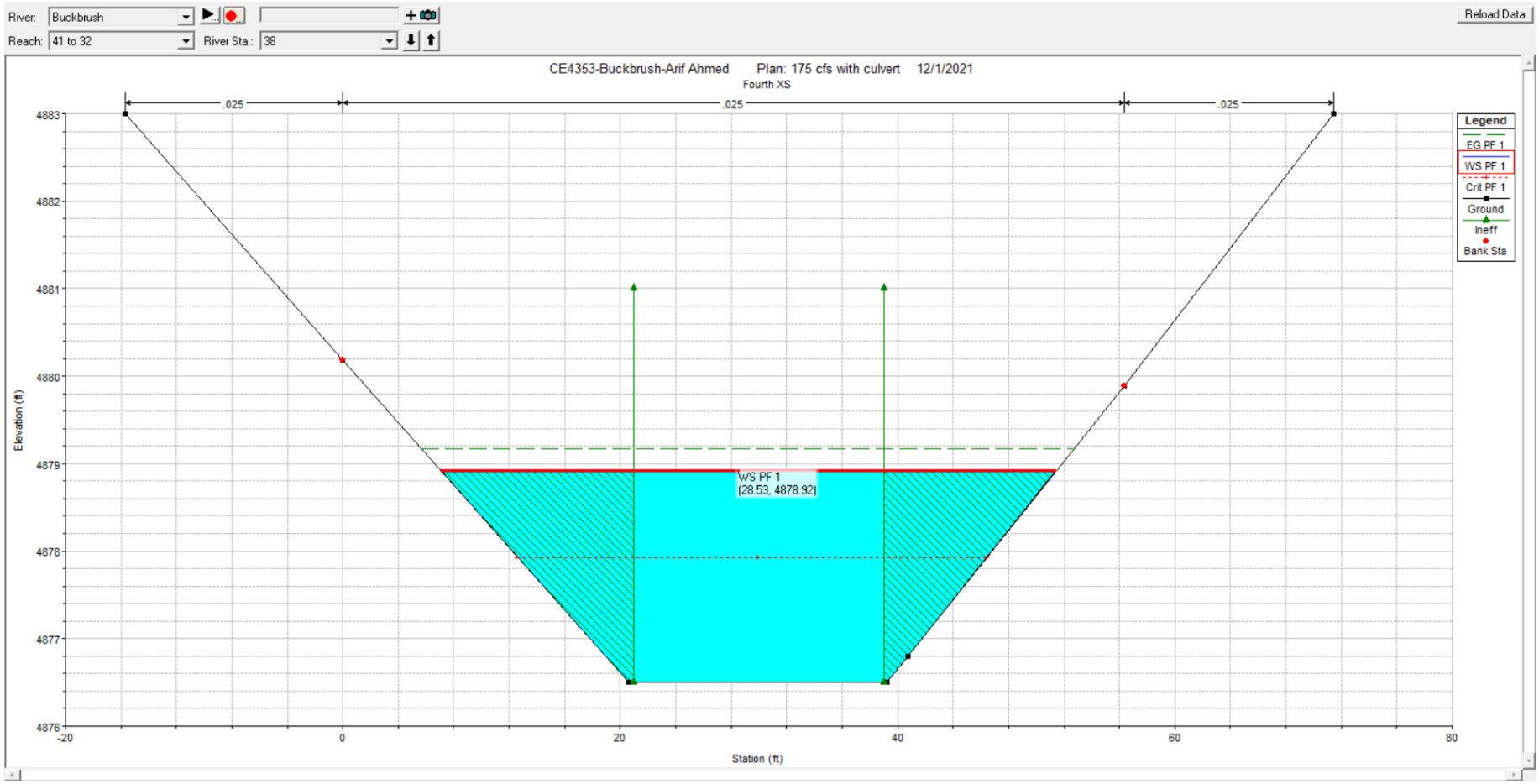


Figure 15: The cross section of Section 38 when the flow is at 175 cfs with culvert

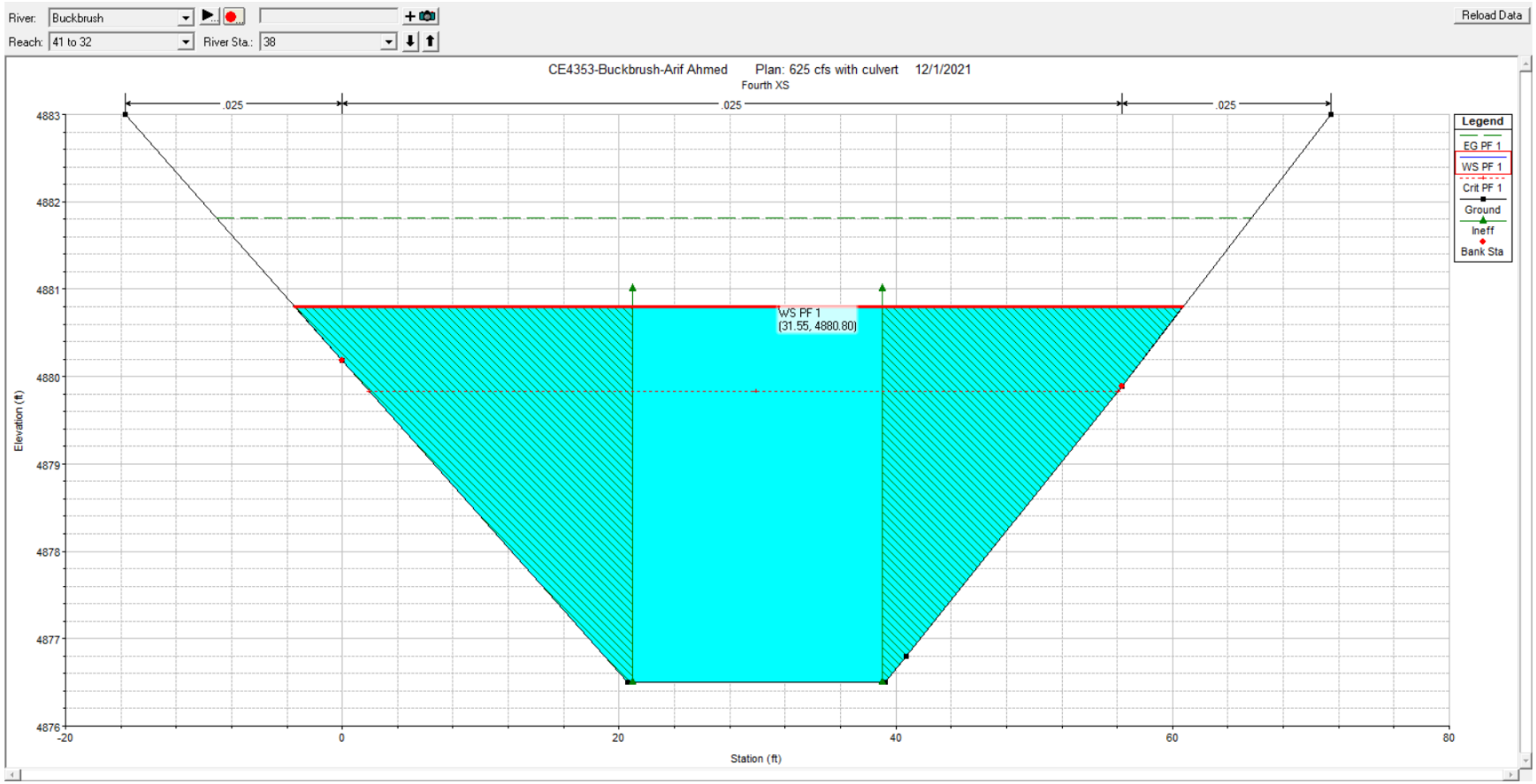
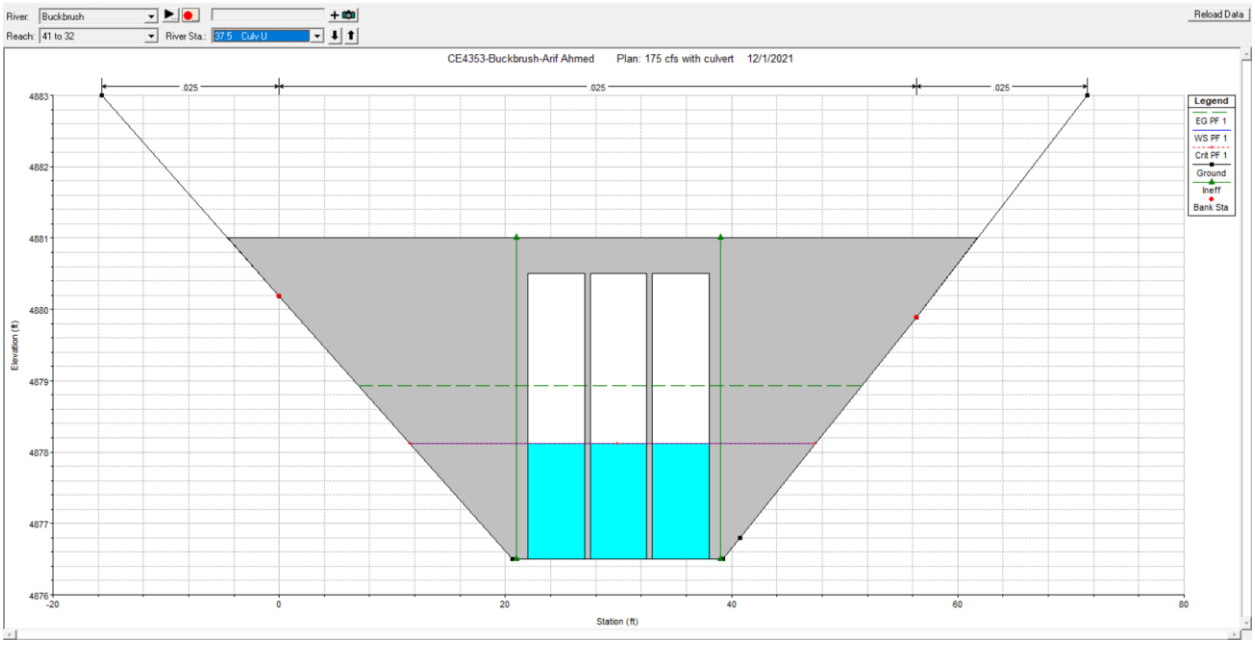
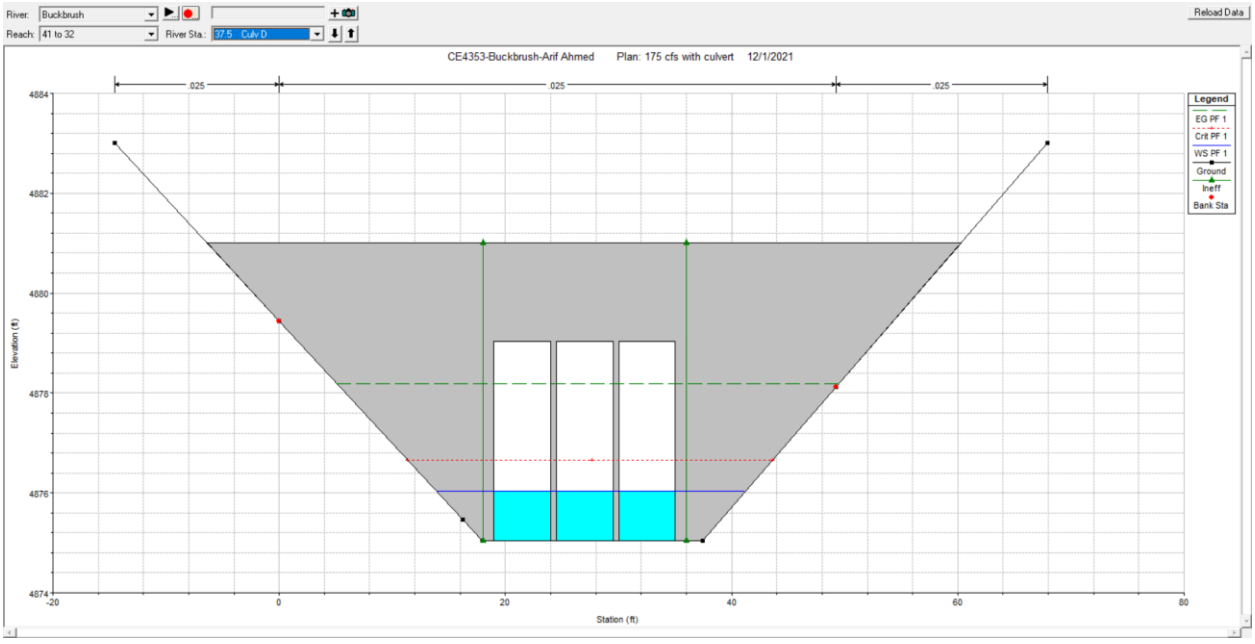


Figure 16: The cross section of Section 38 when the flow is at 625 cfs with culvert

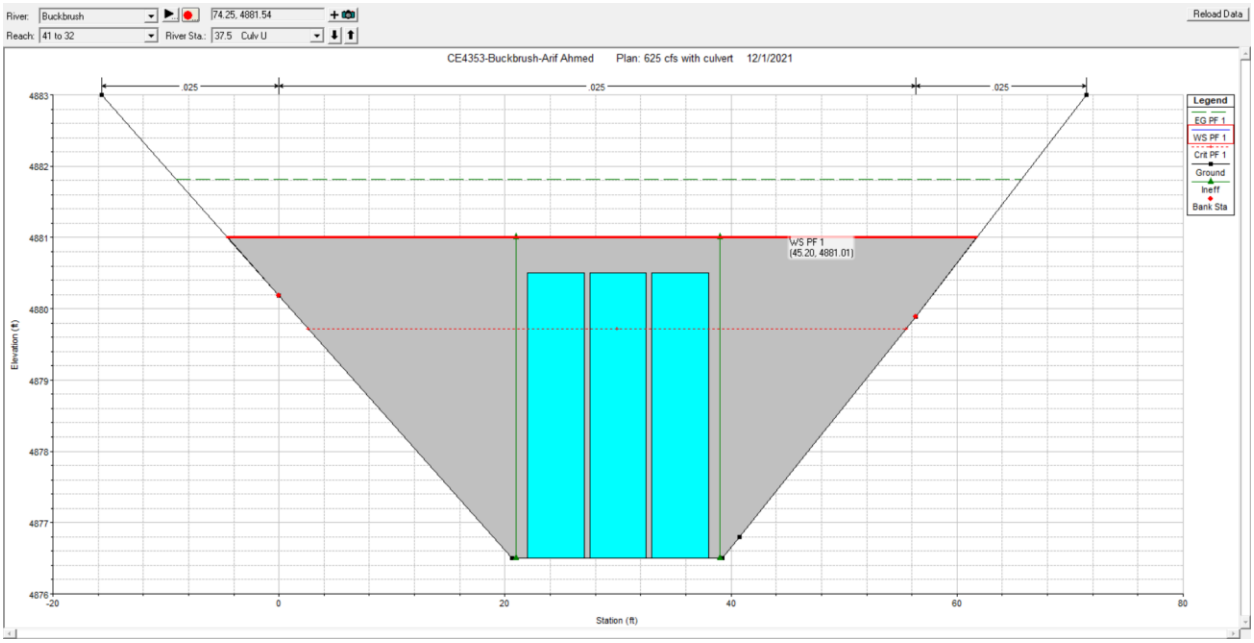


(a) Upstream

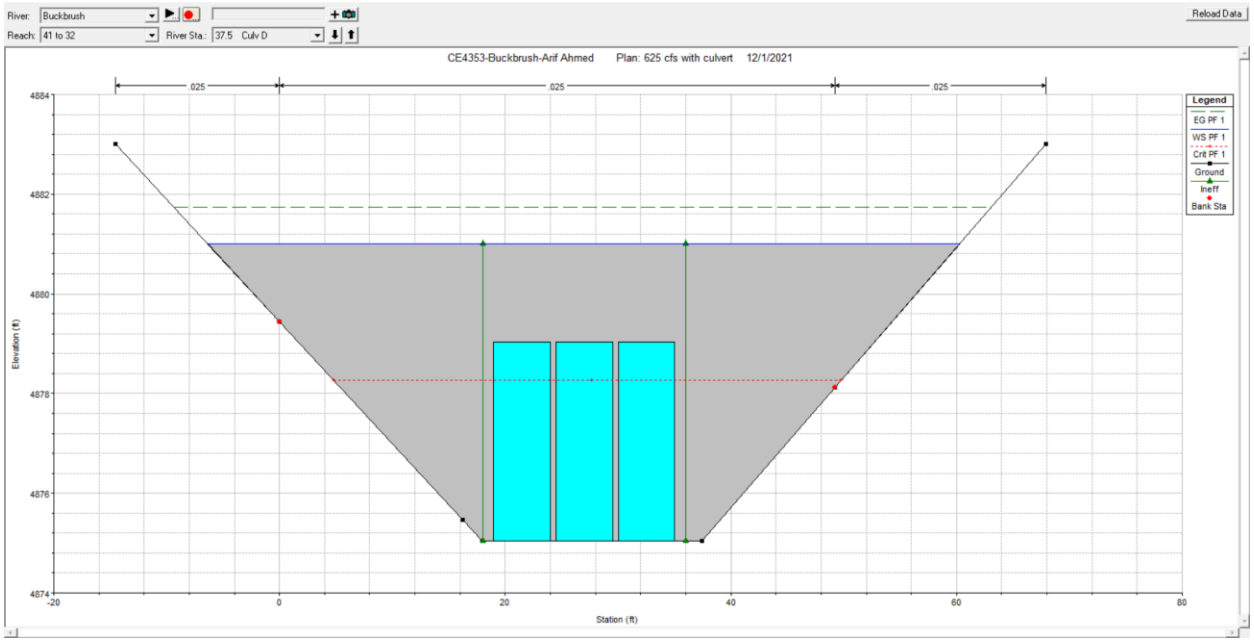


(b) Downstream

Figure 17: The cross section of the culvert at upstream and downstream end when the flow is at 175 cfs

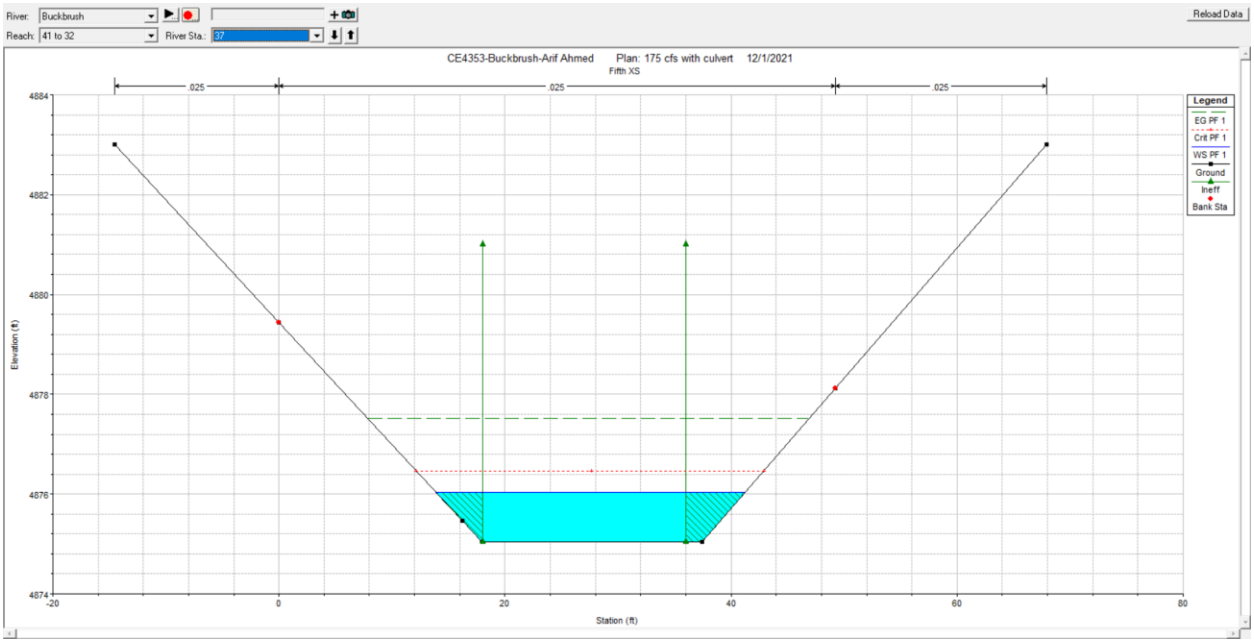


(a) Upstream

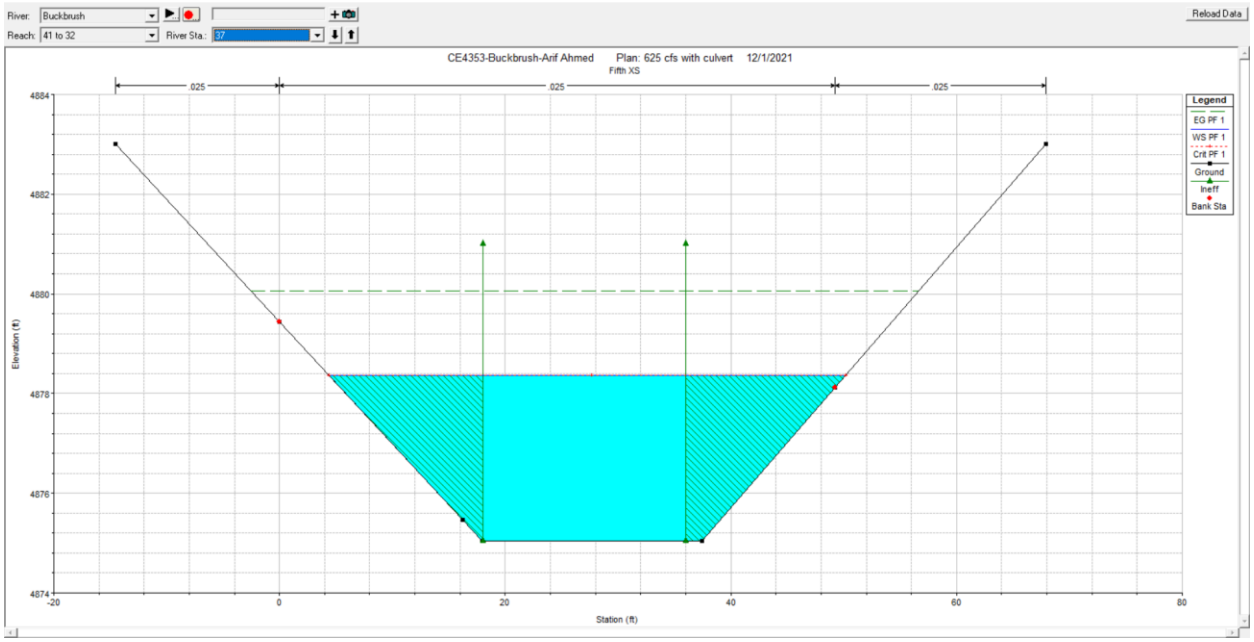


(b) Downstream

Figure 18: The cross section of the culvert at upstream and downstream end when the flow is at 625 cfs



(a) 175 cfs



(b) 625 cfs

Figure 19: The cross section of Section 37 when flow is 175 cfs and 625 cfs

4 APPENDIX

- Calculation of bed slope for upstream and downstream section
- Extension of the edges and the flattening the bottom of Section 38
- Extension of the edges and the flattening the bottom of Section 37

Slope Calculation

- So, upstream = $\frac{EL, LP41 - EL, LP40}{\text{Distance b/w. 41 \& 40}}$

$$= \frac{(4898.44 - 4894.13)\text{ ft}}{200\text{ ft}}$$

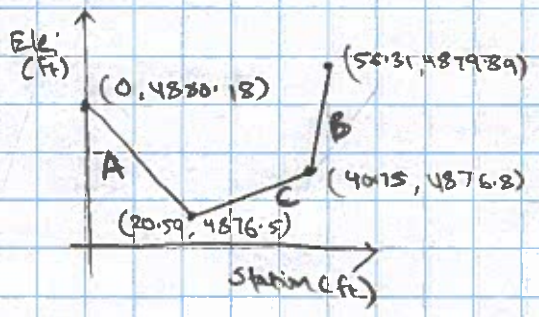
$$= 0.02155\text{ ft/ft}$$

- So, downstream = $\frac{EL, LP32 - EL, LP31}{\text{Distance b/w 32 \& 31}}$

$$= \frac{4855.06 - 4852.90}{80}$$

$$= 0.027\text{ ft/ft}$$

Extension of the edges & flattening the bottom of section 38



Equation of a line: $\frac{x - x_1}{x_2 - x_1} = \frac{y - y_1}{y_2 - y_1}$

Equation of line A: $\frac{x - 0}{20.59 - 0} = \frac{y - 4880.18}{4876.5 - 4880.18}$

$$\therefore y_A = -0.18x + 4880.18$$

$\therefore$ The value of x when $y_A = 4883$ ft

$$x = -15.67\text{ ft}$$

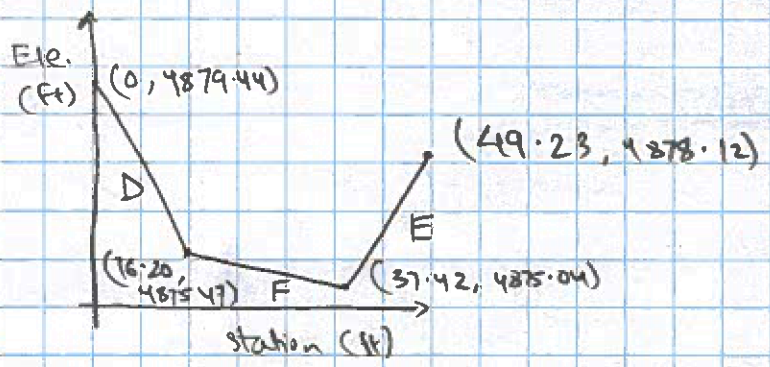
Equ of line B: $\frac{x - 56.31}{40.75 - 56.31} = \frac{y - 4879.89}{4876.8 - 4879.89}$

$$y_B = 0.20x + 4868.71$$

$\therefore$ The value of x when $y_B = 4883$ ft, $x = 71.145$ ft

$\therefore$ The value of x when $y_B = 4876.5$ ft, $x = 39.2393$ ft

Extension of the edges & flattening the bottom of solution 37



Eqn. of a straight line:

$$\frac{x - x_1}{x_2 - x_1} = \frac{y - y_1}{y_2 - y_1}$$

Using line D

When $y_D = 4883$ ft, $x = ?$

$$\frac{x - 0}{16.20 - 0} = \frac{4883 - 4879.44}{4875.47 - 4879.44} \Rightarrow x = -14.53 \text{ ft}$$

When $y_D = 4875.04$, $x =$

$$\frac{x - 0}{16.2 - 0} = \frac{4875.04 - 4879.44}{4875.47 - 4879.44} \Rightarrow x = 17.95$$

Using line E

When $y_E = 4883$ ft, $x =$

$$\frac{x - 49.23}{37.42 - 49.23} = \frac{4883 - 4878.12}{4875.04 - 4878.12} \Rightarrow x = 67.94$$