TECHNICAL MEMORANDUM

DATE: August 16, 2012

TO: City of Palo Alto and EPA

FROM: Wen Chen and Mike Pugh – Nolte Vertical Five (NV5)

PROJECT: Newell Bridge Replacement over San Francisquito Creek

PROJECT #: SJB036700

SUBJECT: Bridge Hydraulics and Evaluation of Proposed Alternatives

Nolte (a subsidiary of NV5, Inc.) met with Santa Clara Valley Water District (SCVWD) and presented preliminary bridge hydraulic results on June 12, 2012. This technical memorandum documents the methodology of bridge hydraulic modeling and summarizes design alternatives. SCVWD has reviewed the memo and provided comments. Presented below is the revised technical memo.

PROJECT BACKGROUND

The City of Palo Alto intends to replace the Newell Road Bridge over San Francisquito Creek (SFC). The existing bridge links the City of Palo Alto (CPA) and City of East Palo Alto (EPA) as well as the Counties of Santa Clara (CPA side) and San Mateo (EPA side). The bridge along Newell Road in Palo Alto crosses over SFC and intersects with Woodland Avenue in East Palo Alto. The existing bridge is a 21.7' wide by 40' long, concrete reinforced through girder structure.

The proposed replacement bridge will be a 48 feet wide by 75 feet long structure containing two 11-foot lanes, a five-foot bike lane/shoulder on the east side and an approximately nine-foot-wide shared parking, bike lane, shoulder on the west side. Five-foot sidewalks on each side of the bridge are also proposed. The new span of 75 feet matches the distance between the top of the SFC banks, allowing the new abutments to be constructed outside of the creek channel.

In order to provide adequate clearance to convey the Q100 storm flow, the bridge soffit and road elevation will need to be raised. Raising the bridge profile elevation will result in modifications to the Newell Road approaches on either side of the replacement bridge. Modifications to Woodland Avenue will also be required within the vicinity of the Newell Road / Woodland Avenue intersection. The existing roadway profile of Woodland Avenue at the Newell Road intersection is essentially at grade with the adjacent properties. The new bridge and Newell Road vertical alignment will likely raise the Woodland Avenue vertical alignment on the order of 4 to 6 feet. NV5's bridge and road design will need to achieve a delicate balance between the soffit elevation of the replacement bridge and the finished roadway profile elevation. The revised roadway will need to conform to the existing grades as quickly as possible while utilizing a reasonable and safe vertical profile along each road alignment; Newell and Woodland.

SCVWD provided the SFC hydraulic models for the existing conditions. The scope of NV5's hydraulic analysis includes:

i. Review SCVWD hydraulic model
ii. Propose bridge replacement alternatives based on hydraulic modeling
iii. Evaluate bridge design alternatives compatible with future SFC improvements

SCVWD MODEL REVIEW

Both the creek and bridges at the lower reach of SFC from downstream of the Cal Train Bridge/El Camino Real Bridge to the Bay is incapable of carrying the 100-year flow. The results are in agreement with the 100-year floodplain delineation, which indicates that flow starts to spread out of the creek at the upstream of Middlefield Bridge on FEMA DFIRM Panel FM06085C0010H. According to the 2009 Nobel report, the flow capacity is up to 6,000 cfs, significantly less than the 50-year flow of 7,900 cfs and the 100-year flow of 9,200 cfs for the lower reach. Floodwalls were added to the existing model to contain the 100-year flow. As a result, the 100-year flood water surface elevations (WSELs) go up to 3 feet above the top of the banks. Floodwalls function as levee in the model. Title 44 CFR Section 65.10 requires a levee to have a minimum freeboard of 3 feet above the 100-year WSEL and an additional one foot above the minimum within 100 feet in either side of structures (such as bridges) riverward of the levee or wherever the flow is constricted. If floodwalls are installed for SFC flood protection improvements, the height of the floodwall is expected to be on the order of 6 feet.

METHODOLOGY

The SCVWD model reveals that neither the Newell Bridge nor the creek channel has adequate capacity to convey the base flood. One purpose of the replacement bridge is to increase flow conveyance capacity. At the June 12th meeting, SCVWD was interested in widening creek channel within the vicinity of the replacement bridge. NV5's methodology is to revise the existing model to propose bridge design options. The model is further revised to evaluate the creek channel widening option.

As a start point, NV5 removed the existing Newell Bridge from the SCVWD model and established the 50-year and 100-year WSELs at the bridge location at Station 112+23. The 100-year WSEL was then set as the soffit elevation of the new bridge with a clear span of 75 feet. As an alternative, the bridge soffit set at the 50-year WSEL with a clear span was also modeled. This alternative will raise the existing Woodland Avenue vertical alignment to a lesser extent than the 100-year WSEL option. Lastly, creek cross sections located within approximately 800 feet upstream and downstream of the replacement bridge were widened with 1:1 slope. The changes were incorporated into the two bridge models to determine the ultimate WSELs. To be consistent for comparison, all other hydraulic elements set in the SCVWD model such as levees, ineffective flows, Manning's n-values, channel stations, channel spacing, etc. remain unchanged.

Table below lists scenarios developed in the task.

Scenario	Description	HEC-RAS ShortID
1	SCVWD Existing Model	EXST
2	Newell Bridge Removed	BrRmv
3	Newell Bridge Replacement soffit at 100-year WSEL	soffit@31.7ft
4	Newell Bridge Replacement soffit at 50-year WSEL	soffit@30.2ft
5	Newell Bridge Replacement soffit at 100-year WSEL with channel widening	100Sf_US_DS_Wd
6	Newell Bridge Replacement soffit at 50-year WSEL with channel widening	50Sf_US_DS_Wd

RESULTS AND DISCUSSIONS

The modeling results are presented below.

Scenario #1 – Existing Condition

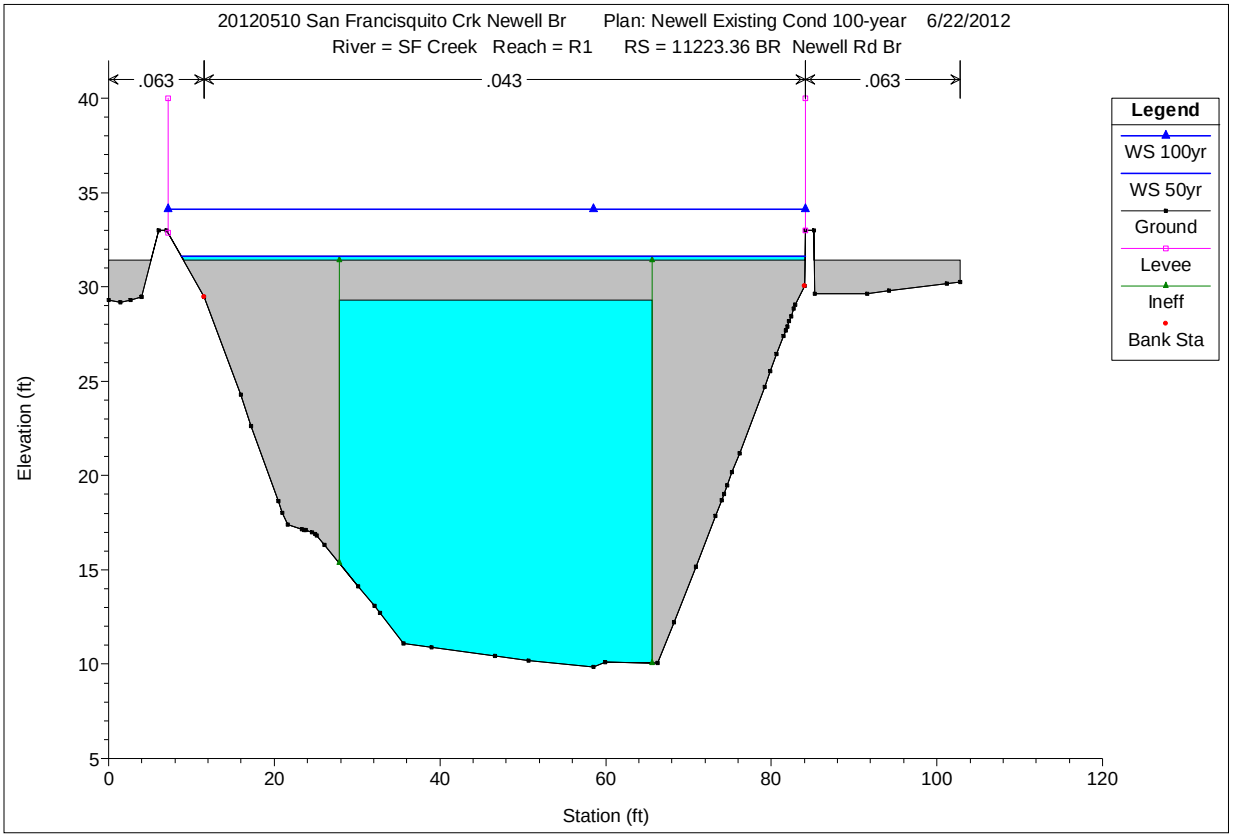


Figure 1. Newell Bridge hydraulic performance in the 50- and 100-year events under the existing condition

Under the existing condition, the bridge will be overtopped in the 50-year and 100-year storm events. The existing roadway profile is set at 31.4 feet (NAVD88) and bridge soffit is set at 29.3 feet.
The WSELs for the 50-year and 100-year events are 31.6 feet and 34.1 feet, respectively. It is expected there will be 2.7 feet of water on the bridge roadway.

Scenario #2 – Bridge Removal

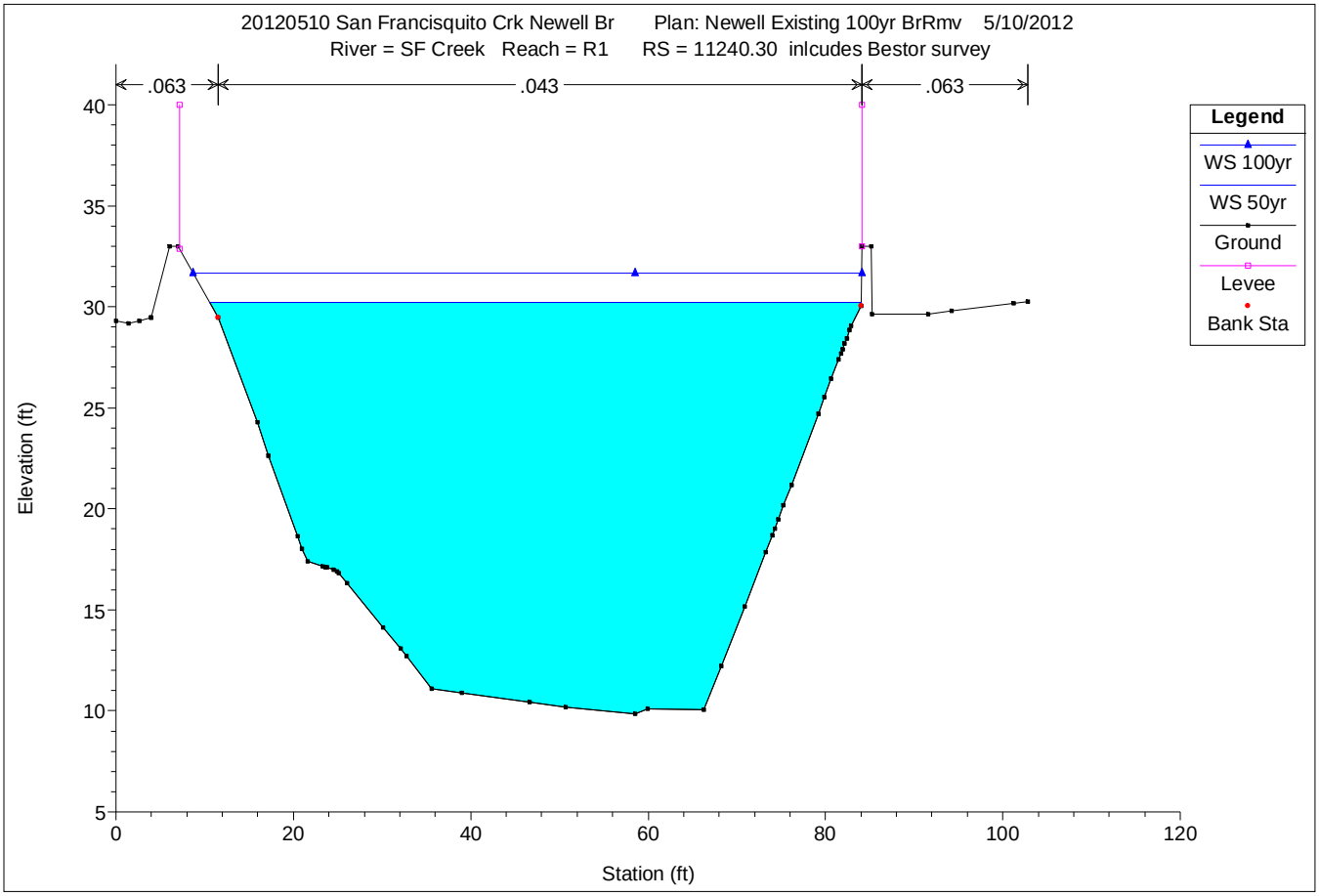


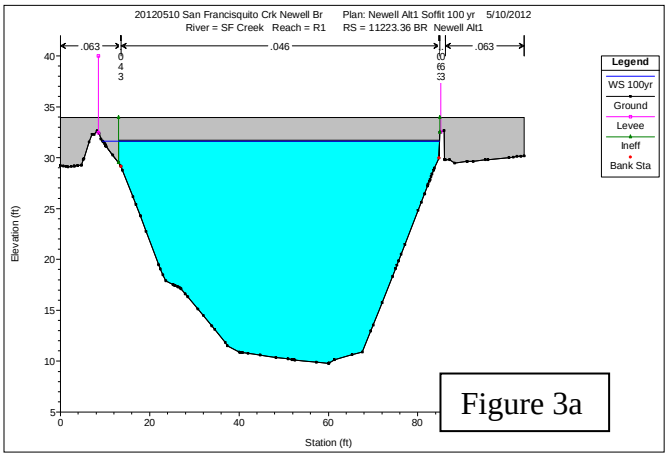
Figure 2. Hydraulic performance at Newell Bridge location in the 50- and 100-year events under bridge removal condition

When the existing Newell Bridge is removed, both the 50-year and 100-year flows are contained within the bridge cross section and WSELs decrease by 1.4 and 2.4 feet, respectively. A comparison of the WSELs at the bridge location is presented below:

	50-year flood	100-year flood
Discharge (cfs)	7,900	9,200
WSEL (ft, NAVD), Existing Condition	31.6	34.1
WSEL (ft, NAVD), Bridge Removal	30.2	31.7
WSEL Drop (ft)	1.4	2.4

The WSELs of 31.7 feet and 30.2 feet from the bridge removal scenario were set as the soffits for bridge alternative designs in Scenarios #3 and #4.

Scenarios #3 & 4 - Newell Bridge replacement design alternatives



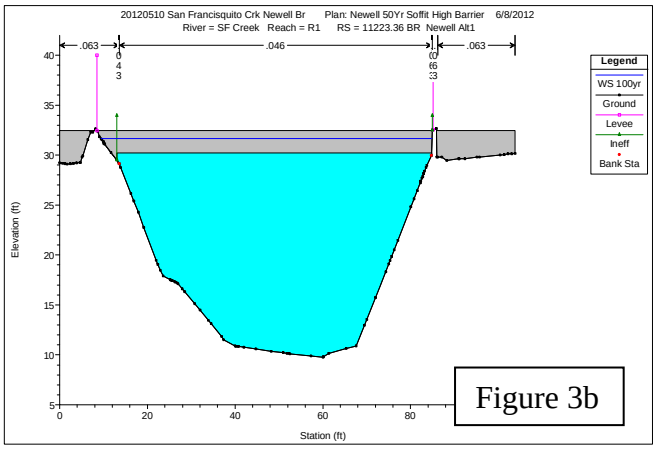


Figure 3a. Newell bridge replacement hydraulic performance in the 100-year event with soffits 31.7 feet
Figure 3b. Newell bridge replacement hydraulic performance in the 100-year event with soffits 30.2 feet

As shown in Figure 3a, under scenario #3 the soffit is set at 31.7 feet (equivalent to the 100-year WSEL without bridge in Scenario #2), and the Newell bridge replacement will pass the 100-year flow without pressure. As shown in Figure 3b, under scenario #4 the soffit is set at 30.2 feet (equivalent to the 50-year WSEL without bridge in Scenario #2), and the Newell bridge replacement will pass the 100-year flow with pressure, but no overtopping of the bridge will occur.

The drop of the soffit elevation by 1.5 feet is particularly meaningful to Woodland Avenue vertical alignment because the existing roadway profile of Woodland Avenue at the Newell Road intersection is essentially at grade with the adjacent properties. The drop of bridge soffit will increase the 100-year WSEL by 0.8 feet. A comparison of the two options is presented below.

	Soffit Elevation (ft)	Roadway Elevation (ft)	100-year WSEL (ft)
Scenario #3 (Alt 1)	31.7	34.0	31.6
Scenario #4 (Alt 2)	30.2	32.5	32.4
Difference between alternatives	1.5	1.5	0.8

Scenarios #5 & 6 – Newell bridge replacement design with channel widening

Cross sections from STA 120+28 to 104+24 were designed at 1:1 slope, approximately 800 feet upstream and downstream of the replacement bridge. The channel widening option was evaluated with the two proposed bridge alternatives.

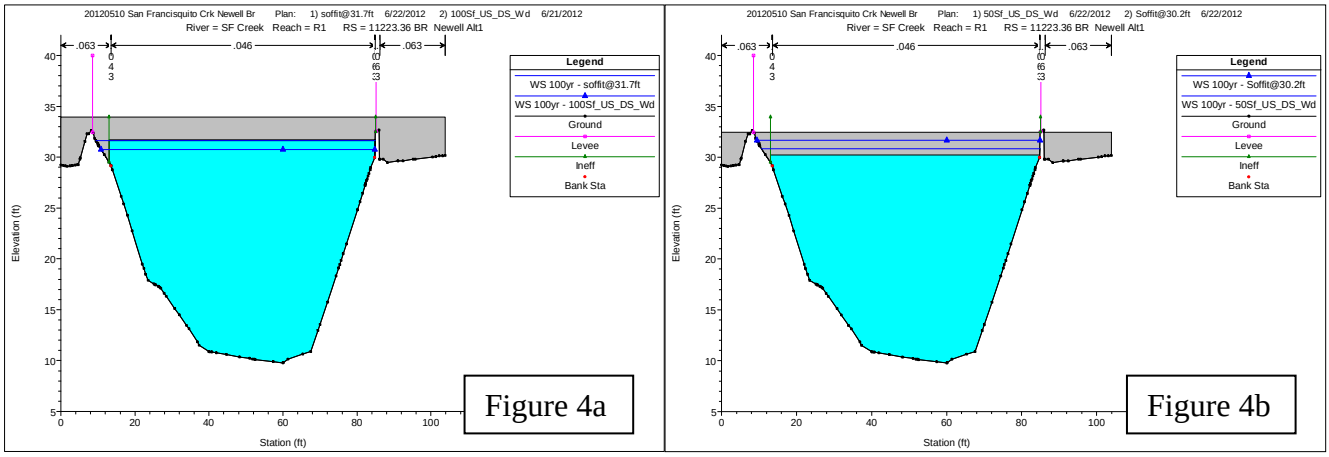


Figure 4a. Comparison of with and without channel widening for Newell bridge replacement with soffits @ 31.7 feet
Figure 4b. Comparison of with and without channel widening for Newell bridge replacement with soffits @ 30.2 feet

As shown in Figure 4a, the 100-year WSEL will drop by 0.8 feet with channel widening as compared to the option without when the bridge soffit elevation is set at 31.7 feet. Similarly, as shown in Figure 4b, the 100-year WSEL will drop by 1 foot with channel widening as compared to the option without when the bridge soffit elevation is set at 30.2 feet. A comparison of channel widening to the two bridge alternative design is presented below.

	Soffit @ 31.7 ft	Soffit @ 30.2 ft
100-year WSEL without channel widening (ft)	31.6	32.0
100-year WSEL with channel widening (ft)	30.8	31.0
Difference between with and without widening (ft)	0.8	1.0

The 100-year WSELs also drop along the widened cross sections. Under bridge replacement alternative #1 (soffit set at 31.7 ft), the maximum decrease of WSEL of 1.3 feet was seen at cross section 12126.96, upstream of the bridge, and the maximum decrease of WSEL of 1.06 feet was seen at cross section 11023.69, downstream of the bridge. For the bridge replacement alternative #2 (soffit set at 30.2 ft), similar decreases were observed.

The required floodwall heights to meet FEMA requirements under the existing, the bridge replacement options, and bridge replacement with channel widening conditions are presented in Tables below.

Table 1a. Required Levee Heights under the Existing Condition

						Existing Condition	
Cross Section	Discharge (cfs)	100-Year WSEL (ft)	TOB Left (ft)	TOB Right (ft)	Freeboard Requirements if WSEL > TOB (ft)	Required Left Levee Height (ft)	Required Right Levee Height (ft)
12028.15	9200	35.81	32.22	31.6	3	6.59	7.21
11925.53	9200	35.72	31.93	32.2	3	6.79	6.52
11823.48	9200	35.34	31.7	31.7	3	6.64	6.64
11723.45	9200	35.09	31.3	30.8	3	6.79	7.29
11623.02	9200	34.06	30.7	30.2	3	6.36	6.86
11522.5	9200	34.23	30.5	30	3	6.73	7.23
11423.17	9200	34.14	30.4	29.9	3	6.74	7.24
11323.51	9200	33.99	30.4	30.9	4	7.59	7.09
11240.3	9200	34.1	33	33	4	5.1	5.1
11223.36	Bridge						
11206.09	9200	31.53	33	33			
11124.28	9200	31.46	30.1	30.2	4	5.36	5.26
11023.69	9200	30.95	30	29.7	3	3.95	4.25
10923.69	9200	29.8	29.6	29.9	3	3.2	
10824.08	9200	29.54	29.7	29.9			
10624.24	9200	28.88	28.6	28.7	3	3.28	3.18
10423.93	9200	27.81	27.6	28.3	3	3.21	
				Average Levee Height Required:		5.60	6.16

Table 1b. Required Levee Heights under the Option of Replacement Bridge Soffit @ 31.7 ft

						Newell Replacement Bridge Soffit @ 31.7 ft	
Cross Section	Discharge (cfs)	100-Year WSEL (ft)	TOB Left (ft)	TOB Right (ft)	Freeboard Requirements if WSEL > TOB (ft)	Required Left Levee Height (ft)	Required Right Levee Height (ft)
12028.15	9200	34.33	32.22	31.6	3	5.11	5.73
11925.53	9200	34.2	31.93	32.2	3	5.27	5
11823.48	9200	33.69	31.7	31.7	3	4.99	4.99
11723.45	9200	33.34	31.3	30.8	3	5.04	5.54
11623.02	9200	31.75	30.7	30.2	3	4.05	4.55
11522.5	9200	31.97	30.5	30	3	4.47	4.97
11423.17	9200	31.81	30.4	29.9	3	4.41	4.91
11323.51	9200	31.48	30.4	30.9	4	5.08	4.58
11240.3	9200	31.64	33	33			
11223.36	Bridge						
11206.09	9200	31.52	33	33			
11124.28	9200	31.46	30.1	30.2	4	5.36	5.26
11023.69	9200	30.95	30	29.7	3	3.95	4.25
10923.69	9200	29.8	29.6	29.9	3	3.2	
10824.08	9200	29.54	29.7	29.9			
10624.24	9200	28.88	28.6	28.7	3	3.28	3.18
10423.93	9200	27.81	27.6	28.3	3	3.21	
			Average Levee Height Required:			4.42	4.81

Table 1c. Required Levee Heights under the Option of Replacement Bridge Soffit @ 30.2 ft

						Newell Replacement Bridge Soffit @30.2 ft	
Cross Section	Discharge (cfs)	100-Year WSEL (ft)	TOB Left (ft)	TOB Right (ft)	Freeboard Requirements if WSEL > TOB (ft)	Required Left Levee Height (ft)	Required Right Levee Height (ft)
12028.15	9200	34.75	32.22	31.6	3	5.53	6.15
11925.53	9200	34.64	31.93	32.2	3	5.71	5.44
11823.48	9200	34.17	31.7	31.7	3	5.47	5.47
11723.45	9200	33.86	31.3	30.8	3	5.56	6.06
11623.02	9200	32.49	30.7	30.2	3	4.79	5.29
11522.5	9200	32.69	30.5	30	3	5.19	5.69
11423.17	9200	32.56	30.4	29.9	3	5.16	5.66
11323.51	9200	32.3	30.4	30.9	4	5.9	5.4
11240.3	9200	32.44	33	33	4	3.44	3.44
11223.36	Bridge						
11206.09	9200	31.52	33	33			
11124.28	9200	31.46	30.1	30.2	4	5.36	5.26
11023.69	9200	30.95	30	29.7	3	3.95	4.25
10923.69	9200	29.8	29.6	29.9	3	3.2	
10824.08	9200	29.54	29.7	29.9			
10624.24	9200	28.88	28.6	28.7	3	3.28	3.18
10423.93	9200	27.81	27.6	28.3	3	3.21	
				Average Levee Height Required:		4.70	5.11

Table 1d. Required Levee Heights under the Option of Replacement Bridge Soffit @ 31.7 ft with Channel Widening

						Newell Replacement Bridge Soffit @31.7 ft with US/DS Widening	
Cross Section	Discharge (cfs)	100-Year WSEL (ft)	TOB Left (ft)	TOB Right (ft)	Freeboard Requirements if WSEL > TOB (ft)	Required Left Levee Height (ft)	Required Right Levee Height (ft)
12028.15	9200	33.33	32.22	31.6	3	4.11	4.73
11925.53	9200	33.06	31.93	32.2	3	4.13	3.86
11823.48	9200	32.62	31.7	31.7	3	3.92	3.92
11723.45	9200	32.51	31.3	30.8	3	4.21	4.71
11623.02	9200	31.36	30.7	30.2	3	3.66	4.16
11522.5	9200	31.4	30.5	30	3	3.9	4.4
11423.17	9200	30.96	30.4	29.9	3	3.56	4.06
11323.51	9200	31.02	30.4	30.9	4	4.62	4.12
11240.3	9200	30.76	33	33			
11223.36	Bridge						
11206.09	9200	30.62	33	33			
11124.28	9200	30.54	30.1	30.2	4	4.44	4.34
11023.69	9200	29.89	30	29.7	3		3.19
10923.69	9200	29.43	29.6	29.9			
10824.08	9200	29.3	29.7	29.9			
10624.24	9200	28.93	28.6	28.7	3	3.33	3.23
10423.93	9200	28.29	27.6	28.3	3	3.69	
			Average Levee Height Required:			3.96	4.07

Table 1e. Required Levee Heights under the Option of Replacement Bridge Soffit @ 30.2 ft with Channel Widening

						Newell Replacement Bridge Soffit @30.2 ft with US/DS Widening	
Cross Section	Discharge (cfs)	100-Year WSEL (ft)	TOB Left (ft)	TOB Right (ft)	Freeboard Requirements if WSEL > TOB (ft)	Required Left Levee Height (ft)	Required Right Levee Height (ft)
12028.15	9200	33.77	32.22	31.6	3	4.55	5.17
11925.53	9200	33.52	31.93	32.2	3	4.59	4.32
11823.48	9200	33.12	31.7	31.7	3	4.42	4.42
11723.45	9200	33.03	31.3	30.8	3	4.73	5.23
11623.02	9200	31.99	30.7	30.2	3	4.29	4.79
11522.5	9200	32.03	30.5	30	3	4.53	5.03
11423.17	9200	31.65	30.4	29.9	3	4.25	4.75
11323.51	9200	31.71	30.4	30.9	4	5.31	4.81
11240.3	9200	31.49	33	33			
11223.36	Bridge						
11206.09	9200	30.62	33	33			
11124.28	9200	30.54	30.1	30.2	4	4.44	4.34
11023.69	9200	29.89	30	29.7	3		3.19
10923.69	9200	29.43	29.6	29.9			
10824.08	9200	29.3	29.7	29.9			
10624.24	9200	28.93	28.6	28.7	3	3.33	3.23
10423.93	9200	28.29	27.6	28.3	3	3.69	
				Average Levee Height Required:		4.38	4.48

SUMMARY

Design options were proposed to replace the existing Newell Bridge over SFC and modeled in the HEC-RAS program. The following summarizes the study that has been conducted and our conclusions presented in the technical memo:

- Under the existing condition, the required height of floodwalls is on the order of 6 feet.
- WSELs upstream of the existing Newell Bridge will decrease by up to 2.5 feet with a bridge replacement.
- Up to additional one (1) foot drop of the WSELs will be achieved along cross sections that are widened.
- With both options implemented, the WSELs are still above the top elevation of the banks except for a few cross sections that contain the 100-year flow.
- Floodwalls are mostly needed for the 100-year flow to be contained in the creek. With improvements, the height of floodwalls can be dropped on the order of 4 feet to meet FEMA's levee requirements.