Appendix E

Santa Clara River (SCR-3) Unsteady Flow Hydraulic Analysis

Michael Baker
INTERNATIONAL

TECHNICAL MEMORANDUM

To: Masood Jilani, Ventura County Watershed Protection District

From: John McCarthy P.E., Larry Tortuya P.E.

Date: April 5, 2016

Subject: Santa Clara River (SCR-3) Unsteady Flow Hydraulic Analysis

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Project Background

The Santa Clara River Levee (SCR-3) Improvements are located downstream of Union Pacific Railroad (UPRR) crossing along the southern bank of the Santa Clara River. The improvements are intended to improve the existing levee system to meet current Ventura County Watershed Protection District (District) requirements and FEMA standards. As a part of the project, the existing floodplain overflow paths along the south bank will be eliminated between the UPRR bridge crossing and the Bailard Landfill. While the project will reduce the flood hazard along the south side of the river, a result of this project will be that all of the tributary flow in the river will be contained in the river to downstream of the project limits. This will in effect increase the potential flood flow in the river downstream of the project. The purpose of this task was to perform a detailed unsteady flow hydraulic analysis for the reach of Santa Clara River from the Highway 101 crossing downstream to the ocean outlet. The analysis was performed for the baseline (existing) and project (SCR-3 only) conditions to determine the impacts to the floodplain limits and water surface elevations downstream of the project as a result of the elimination of the existing overflow paths along the southern bank. The analysis will also assess the potential increases in the channel flow velocities adjacent to the existing closed landfills (Santa Clara, Coastal, and Bailard) along the southerly bank of the river. Additionally, the analysis was performed for the baseline (existing) and a condition which includes the SCR-3, Olivas Park Drive, and Wagon Wheel levees (termed “ultimate”) to determine the possible cumulative impacts from all three projects.

The hydraulic analysis was developed from the detailed HEC-RAS model used for the project design, and includes key structural elements including Highway 101, the UPRR Bridge, Victoria Avenue Bridge, and Harbor Boulevard Bridge. For this study the analysis was prepared using an unsteady flow approach. The inflow hydrograph for the Santa Clara River was taken from the Aqua TERRA report “Hydrology Modeling of the Santa Clara Watershed with the U.S. EPA Hydrologic Simulation Program-FORTRAN (HSPF),” dated July 24, 2009. The hydrograph has a peak flow rate of 227,000 cfs. The inflow hydrograph was added to the unsteady model approximately 2,000 feet upstream of the Highway 101 crossing. Lateral weir structures were added in various locations along the river reach to model the existing overflow paths along the southern bank. The baseline condition model includes lateral weir structures along the south bank of the river at North Ventura Road and below the Bailard Landfill. The placement of the lateral weir structures is consistent with the FEMA floodplain and floodway model dated July, 2009.

In the project condition model, levees were added along the south bank for the proposed SCR-3 levee improvements. For the "ultimate" condition analysis, the proposed SCR-3, Olivas Park Drive, and Wagon Wheel levee improvements were added to the model. The Olivas Park Drive levee alignment was based on the configuration in the approved EIR. The overflow path along North Ventura Road was eliminated from the project and ultimate condition models as a result of the proposed improvements. The unsteady models were run for the existing, project, and ultimate conditions to determine the project impacts downstream of the Bailard landfill.

Baseline vs. Project Conditions

The results of the analysis of baseline vs. project conditions show the proposed project improvements will have a minor increase on the peak flow rates and water surface elevations in the river downstream of the project improvements. At the downstream limits of the project (HEC-RAS station 13774), the peak flow rate in the mainstem of the river is increased from 223,380 cfs to 225,308 cfs as a result of the project improvements. This is an increase of 1,928 cfs, or 0.86%. This flow rate increase has a corresponding water surface elevation increase of 0.05 feet at station 13774. The maximum increase in water surface elevation below the project site is 0.07 feet at a location approximately 8,000 feet downstream of the Bailard Landfill. The average increase in water surface elevation downstream of the project improvements is approximately 0.05 feet. The change in channel flow velocities is insignificant, with a maximum increase of 0.04 feet per second. It is anticipated that these increases will have a negligible impact on the downstream floodplain as a result of the project improvements. A summary of the model results are included in Table No. 1. See Figures 1 A/B and 2 A/B for the resulting floodplains and cross section locations for the baseline and project conditions.

Table No. 1 – Summary of floodplain hydraulics (Baseline vs Project)

River Station	Location	Flow (cfs)			Water Surface Elevation (ft)		
		Baseline	Project	Delta	Baseline	Project	Delta
24165.9	UPRR						
24142		224553.9	226736.2	2182.3	71.82	71.9	0.08
23763		224518.2	226698.7	2180.5	70.93	71.01	0.08
23371		224475.5	226653.9	2178.4	69.64	69.72	0.08
23100	Begin lateral overflow structure (weir) along North Ventura Road						
22978		224431.5	226607.9	2176.4	68.87	68.95	0.08
22554		224384.6	226559.0	2174.4	68.60	68.68	0.08
22125		224335.5	226507.8	2172.3	68.26	68.34	0.08
21663		224279.1	226449.1	2170.0	67.86	67.94	0.08
21214		224222.5	226390.1	2167.6	67.51	67.60	0.09
20839		224172.2	226337.4	2165.2	66.78	66.86	0.08
20454		224127.0	226290.2	2163.2	65.58	65.66	0.08
20004		224083.4	226244.5	2161.1	63.28	63.35	0.07
19569		224050.5	226209.9	2159.4	62.03	62.10	0.07
19169		224013.9	226171.1	2157.2	59.89	59.96	0.07
18771		223974.9	226129.9	2155.0	59.89	59.96	0.07
18374		223936.7	226089.5	2152.8	58.86	58.93	0.07
17980		223896.2	226046.9	2150.7	57.82	57.89	0.07
17571		223850.2	225998.3	2148.1	57.13	57.20	0.07
17177		223798.5	225944.1	2145.6	56.03	56.11	0.08

River Station	Location	Flow (cfs)			Water Surface Elevation (ft)		
		Baseline	Project	Delta	Baseline	Project	Delta
16764		223737.4	225880.2	2142.8	55.31	55.39	0.08
16353		223671.7	225811.7	2140.0	54.17	54.25	0.08
15928		223604.4	225741.7	2137.3	53.36	53.44	0.08
15547		223550.3	225685.0	2134.7	51.53	51.6	0.07
15446	Victoria Avenue						
15346		223550.3	225685.0	2134.7	47.95	48.00	0.05
14945		223512.4	225645.3	2132.9	46.92	46.96	0.04
14543		223471.6	225602.6	2131.0	46.84	46.89	0.05
14164		223429.0	225558.1	2129.1	46.20	46.25	0.05
13774		223380.1	225308.3	1928.2	45.60	45.65	0.05
13370		223174.5	225308.0	2133.5	44.82	44.88	0.06
12977		223173.7	225306.8	2133.1	44.00	44.06	0.06
12571		223172.0	225304.7	2132.7	42.92	42.98	0.06
12158		223168.3	225300.3	2132.0	41.77	41.83	0.06
11756		223126.7	225239.9	2113.2	37.35	37.38	0.03
11600	Begin lateral overflow structure (weir) downstream of Bailard Landfill						
11371		223165.4	225297.0	2131.6	37.73	37.77	0.04
10939		223161.9	225293.1	2131.2	36.71	36.75	0.04
10498		223157.3	225288.0	2130.7	35.93	35.97	0.04
10079		223151.9	225282.2	2130.3	35.08	35.13	0.05
9574		223144.4	225274.1	2129.7	34.05	34.10	0.05
9167		223135.6	225264.7	2129.1	33.36	33.41	0.05
8755		223125.7	225254.1	2128.4	32.15	32.20	0.05
8360		223114.8	225242.4	2127.6	31.11	31.16	0.05
7974		223102.8	225229.6	2126.8	30.10	30.15	0.05
7598		222893.7	225003.3	2109.6	29.64	29.69	0.05
7203		221828.6	223856.7	2028.1	28.89	28.95	0.06
6804		221791.1	223809.3	2018.2	28.25	28.31	0.06
6366		221769.4	223786.2	2016.8	27.65	27.71	0.06
5945		221746.1	223761.6	2015.5	27.01	27.06	0.05
5525		221720.9	223734.9	2014.0	26.32	26.38	0.06
5137		221697.3	223709.9	2012.6	25.84	25.90	0.06
4727		220965.7	222925.4	1959.7	25.22	25.28	0.06
4308		220010.0	221899.7	1889.7	24.70	24.76	0.06
3840		219950.2	221824.6	1874.4	24.25	24.31	0.06
3410		219155.9	220937.0	1781.1	23.87	23.94	0.07
3106		218963.4	220720.6	1757.2	21.89	21.95	0.06
3023	Harbor Boulevard						
2941		218963.4	220720.6	1757.2	19.54	19.58	0.04
2281		218940.6	220696.9	1756.3	18.60	18.64	0.04
1903		218917.1	220672.3	1755.2	17.60	17.63	0.03
1551		218893.8	220648.0	1754.2	16.09	16.13	0.04
1113		218868.0	220621.0	1753.0	15.18	15.21	0.03

Shaded cells are cross sections downstream of the project limits.

Baseline vs. Ultimate Conditions

The results of the analysis of baseline vs. ultimate conditions show the proposed ultimate improvements will also only result in a minor increase on the peak flow rates and water surface elevations in the river downstream of the project improvements. At the downstream limits of the project (HEC-RAS station 13774), the peak flow rate in the mainstem of the river is increased from 223,380 cfs to 225,825 cfs as a result of the ultimate improvements. This is an increase of 2,445 cfs, or 1.09%. This flow rate increase has a corresponding water surface elevation increase of 0.06 feet at station 13774. The maximum increase in water surface elevation below the project site is 0.07 feet at a location approximately 7,000 feet downstream of the Bailard Landfill. The average increase in water surface elevation downstream of the project improvements is approximately 0.06 feet. The change in channel flow velocities is also insignificant, with a maximum increase of 0.04 feet per second. It is also anticipated that these increase will have a negligible impact on the downstream floodplain as a result of the project improvements. A summary of the model results are included in Table No. 2. See Figures 1 A/B and 3 A/B for the resulting floodplains and cross section locations for the baseline and ultimate conditions.

Table No. 2 – Summary of floodplain hydraulics (Baseline vs Ultimate)

River Station	Location	Flow (cfs)			Water Surface Elevation (ft)		
		Baseline	Ultimate	Delta	Baseline	Ultimate	Delta
24165.9	UPRR						
24142		224553.9	226784.6	2230.7	71.82	73.06	1.24
23763		224518.2	226754.8	2236.6	70.93	72.05	1.12
23371		224475.5	226725.9	2250.4	69.64	70.97	1.33
23100	Begin lateral overflow structure (weir) along North Ventura Road						
22978		224431.5	226696.1	2264.6	68.87	70.22	1.35
22554		224384.6	226665.9	2281.3	68.60	69.74	1.14
22125		224335.5	226637.5	2302	68.26	69.26	1
21663		224279.1	226607.3	2328.2	67.86	68.83	0.97
21214		224222.5	226577.3	2354.8	67.51	68.12	0.61
20839		224172.2	226549.1	2376.9	66.78	67.27	0.49
20454		224127.0	226520.2	2393.2	65.58	66.1	0.52
20004		224083.4	226488.1	2404.7	63.28	63.55	0.27
19569		224050.5	226458	2407.5	62.03	62.53	0.5
19169		224013.9	226433	2419.1	59.89	59.28	-0.61
18771		223974.9	226409.9	2435	59.89	59.83	-0.06
18374		223936.7	226376.9	2440.2	58.86	58.9	0.04
17980		223896.2	226337.8	2441.6	57.82	57.9	0.08
17571		223850.2	226291.9	2441.7	57.13	57.21	0.08
17177		223798.5	226240.4	2441.9	56.03	56.12	0.09
16764		223737.4	226179.6	2442.2	55.31	55.41	0.1
16353		223671.7	226114.4	2442.7	54.17	54.27	0.1
15928		223604.4	226047.8	2443.4	53.36	53.45	0.09
15547		223550.3	225993.5	2443.2	51.53	51.62	0.09
15446	Victoria Avenue						
15346		223550.3	225993.5	2443.2	47.95	48.01	0.06
14945		223512.4	225956.3	2443.9	46.92	46.97	0.05
14543		223471.6	225916.2	2444.6	46.84	46.90	0.06
14164		223429.0	225873.9	2444.9	46.20	46.26	0.06
13774		223380.1	225825.1	2445.0	45.60	45.66	0.06

River Station	Location	Flow (cfs)			Water Surface Elevation (ft)		
		Baseline	Ultimate	Delta	Baseline	Ultimate	Delta
13370		223174.5	225771.5	2597.0	44.82	44.89	0.07
12977		223173.7	225716.8	2543.1	44.00	44.07	0.07
12571		223172.0	225663.0	2491.0	42.92	42.99	0.07
12158		223168.3	225316.4	2148.1	41.77	41.83	0.06
11756		223126.7	225565.8	2439.1	37.35	37.38	0.03
11600	Begin lateral overflow structure (weir) downstream of Bailard Landfill						
11371		223165.4	225524.9	2359.5	37.73	37.77	0.04
10939		223161.9	225318.0	2156.1	36.71	36.75	0.04
10498		223157.3	225316.9	2159.6	35.93	35.97	0.04
10079		223151.9	225314.8	2162.9	35.08	35.13	0.05
9574		223144.4	225311.2	2166.8	34.05	34.10	0.05
9167		223135.6	225306.3	2170.7	33.36	33.41	0.05
8755		223125.7	225300.1	2174.4	32.15	32.21	0.06
8360		223114.8	225292.7	2177.9	31.11	31.16	0.05
7974		223102.8	225283.8	2181.0	30.10	30.15	0.05
7598		222893.7	225061.0	2167.3	29.64	29.69	0.05
7203		221828.6	223915.8	2087.2	28.89	28.95	0.06
6804		221791.1	223872.5	2081.4	28.25	28.31	0.06
6366		221769.4	223854.5	2085.1	27.65	27.71	0.06
5945		221746.1	223835.2	2089.1	27.01	27.07	0.06
5525		221720.9	223813.8	2092.9	26.32	26.38	0.06
5137		221697.3	223793.7	2096.4	25.84	25.90	0.06
4727		220965.7	223012.3	2046.6	25.22	25.29	0.07
4308		220010.0	221989.5	1979.5	24.70	24.77	0.07
3840		219950.2	221921.2	1971.0	24.25	24.31	0.06
3410		219155.9	221036.2	1880.3	23.87	23.94	0.07
3106		218963.4	220823.4	1860.0	21.89	21.96	0.07
3023	Harbor Boulevard						
2941		218963.4	220823.4	1860.0	19.54	19.58	0.04
2281		218940.6	220803.3	1862.7	18.60	18.65	0.05
1903		218917.1	220782.4	1865.3	17.60	17.63	0.03
1551		218893.8	220761.8	1868.0	16.09	16.13	0.04
1113		218868.0	220738.8	1870.8	15.18	15.22	0.04

Shaded cells are cross sections downstream of the project limits.

Velocity Assessment

An assessment of the impacts along the existing closed landfills on the southerly bank of the river was evaluated to determine if the increased flow in the channel would have an adverse effect on the velocities adjacent to the existing landfills. The change in flow velocities was evaluated along the reaches of the river where the existing landfills are potentially exposed to river floodwaters exceeding the channel banks. The same unsteady flow models were used for the analysis, and the velocities along the southerly (left) channel overbank were compared for all three conditions (baseline, project, and ultimate).

The results of the analysis indicate that the project improvements will have an insignificant impact on the overbank velocities adjacent to the landfills, with a maximum change in velocity of 0.05 feet per second adjacent to the Santa Clara landfill. The results of the analysis are summarized in Table No. 3, which includes overbank flow adjacent to the Santa Clara and Coastal landfills. There is no overbank flow downstream of Victoria Avenue adjacent to the Bailard landfill and therefore no comparison for this

reach is included in the table.

Table No. 3 – Average Flow Velocity (Southerly Overbank) Comparison

River Station	Location	Flow Velocity (feet per second)					
		Baseline	Project	Delta	Baseline	Ultimate	Delta
21250	Santa Clara Landfill (eastern limit)						
21214		1.19	1.23	0.04	1.19	1.26	0.07
20839		1.53	1.58	0.05	1.53	2.00	0.47
20454		4.41	4.44	0.03	4.41	4.66	0.25
20004		4.71	4.75	0.04	4.71	4.93	0.22
19569		6.60	6.64	0.04	6.60	6.68	0.08
19169		5.34	5.38	0.04	5.34	5.69	0.35
18771		3.66	3.68	0.02	3.66	3.80	0.14
18374		3.25	3.26	0.01	3.25	3.30	0.05
17980		4.56	4.57	0.01	4.56	4.58	0.02
17571		4.58	4.60	0.02	4.58	4.60	0.02
17177	Coastal Landfill						
16764		4.91	4.92	0.01	4.91	4.92	0.01
16353		4.85	4.87	0.02	4.85	4.87	0.02
15928		6.65	6.67	0.02	6.65	6.67	0.02
15547	*Proposed levee improvements – no overbank flow adjacent to landfill cap*						
15446	Victoria Avenue						
14164	Bailard Landfill (eastern limit)						
	Flow contained in channel banks, no overbank flow adjacent to landfill cap						
11371	Bailard Landfill (western limit)						

Shaded cells represent the project condition impacts.

Legend
- HEC-RAS Cross Sections
- 5137 HEC-RAS Cross Section Number
- Limit of Study
- Stream Centerline
- Lateral Weir Structures
- 10-ft Contours
- 100-Year Flood Plain

Harbor Blvd
Olivas Park Dr
Victoria Ave
Harbor Blvd

5137 5525 5945 6366 6804 7203 7598 7974 8360 8755 9167 9574 10079 10498 10939 11371 11756 12158 12571 12977 13370 13774 14164 14543 14945 15345 15547

1113 1551 1903 2281 3941 3106 3410 3840 4308 4727

Sheet A
Sheet B
El Rio
River Ridge Golf Club
W Gonzales Rd
E Gonzales Rd
Telephone Rd
Olivas Park Dr
Santa Paula Fwy
Victoria Ave
Oxnard Blvd

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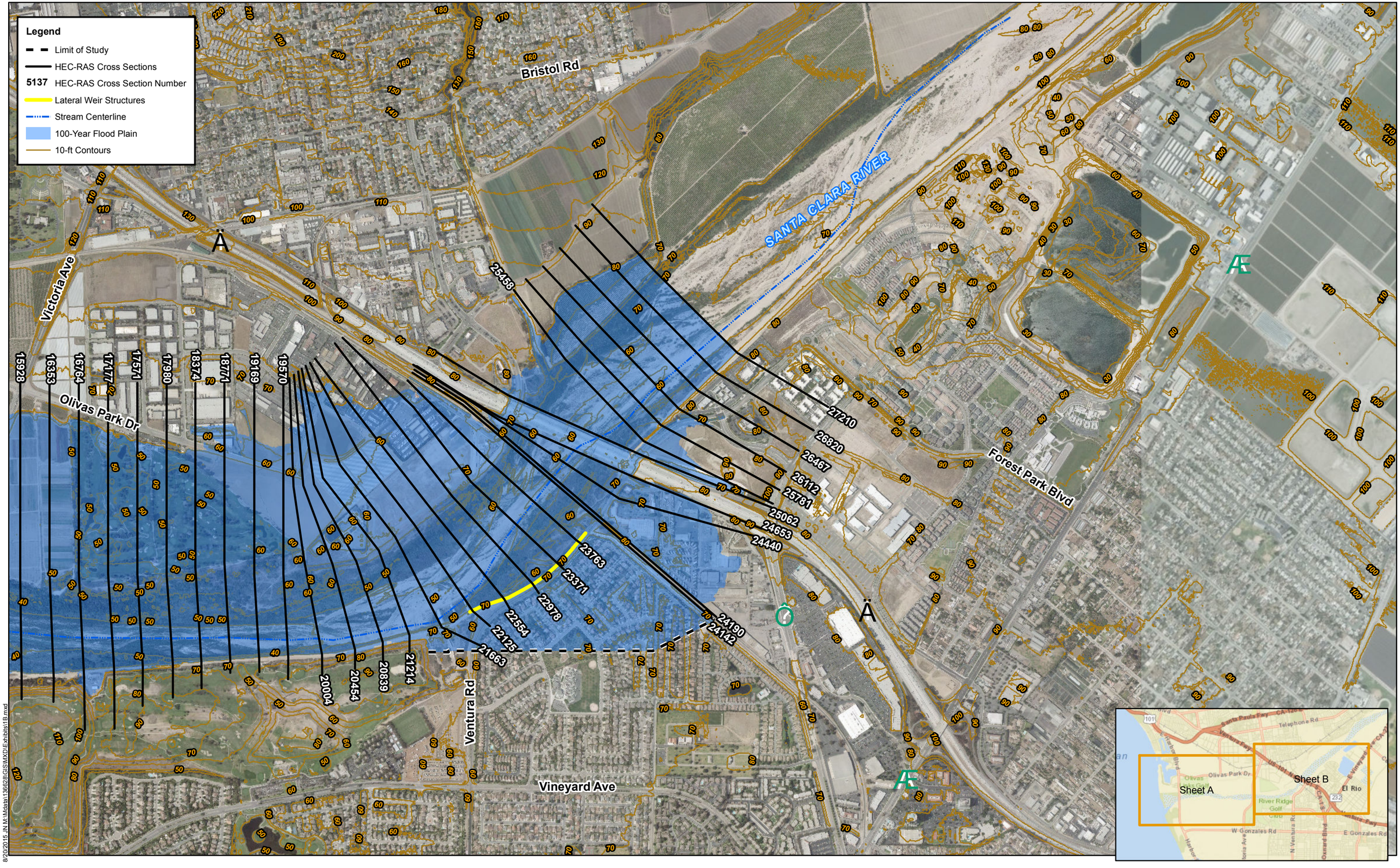
0 6001,200 2,400 Feet

Source: ArcGIS Online

SANTA CLARA RIVER (SCR-3) LEVEE

River Hydraulics – BaseLine Condition

Figure 1A



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0 6001,200 2,400 Feet

Source: ArcGIS Online

SANTA CLARA RIVER (SCR-3) LEVEE

River Hydraulics – BaseLine Condition

Figure 1B

Legend
- Limit of Study
- HEC-RAS Cross Sections
- 5137 HEC-RAS Cross Section Number
- Lateral Weir Structures
- SCR-3 Levee
- Stream Centerline
- Project Condition Floodplain
- 10-ft Contours

Harbor Blvd
Olivas Park Dr
Victoria Ave
Harbor Blvd
5137 5525 5945 6366 6804 7203 7598 7974 8360 8755 9167 9574 10079 10498 10939 11371 11756 12158 12571 12977 13370 13774 14164 14543 14945 15345 15547
1113 1551 1903 2281 3941 3106 3410 3840 4308 4727
Sheet A
Sheet B
Santa Paula Fwy
Telephone Rd
Olivas Park Dr
El Rio
River Ridge Golf Club
W Gonzales Rd
E Gonzales Rd
N Ventura Rd
Oxnard Blvd
Victoria Ave

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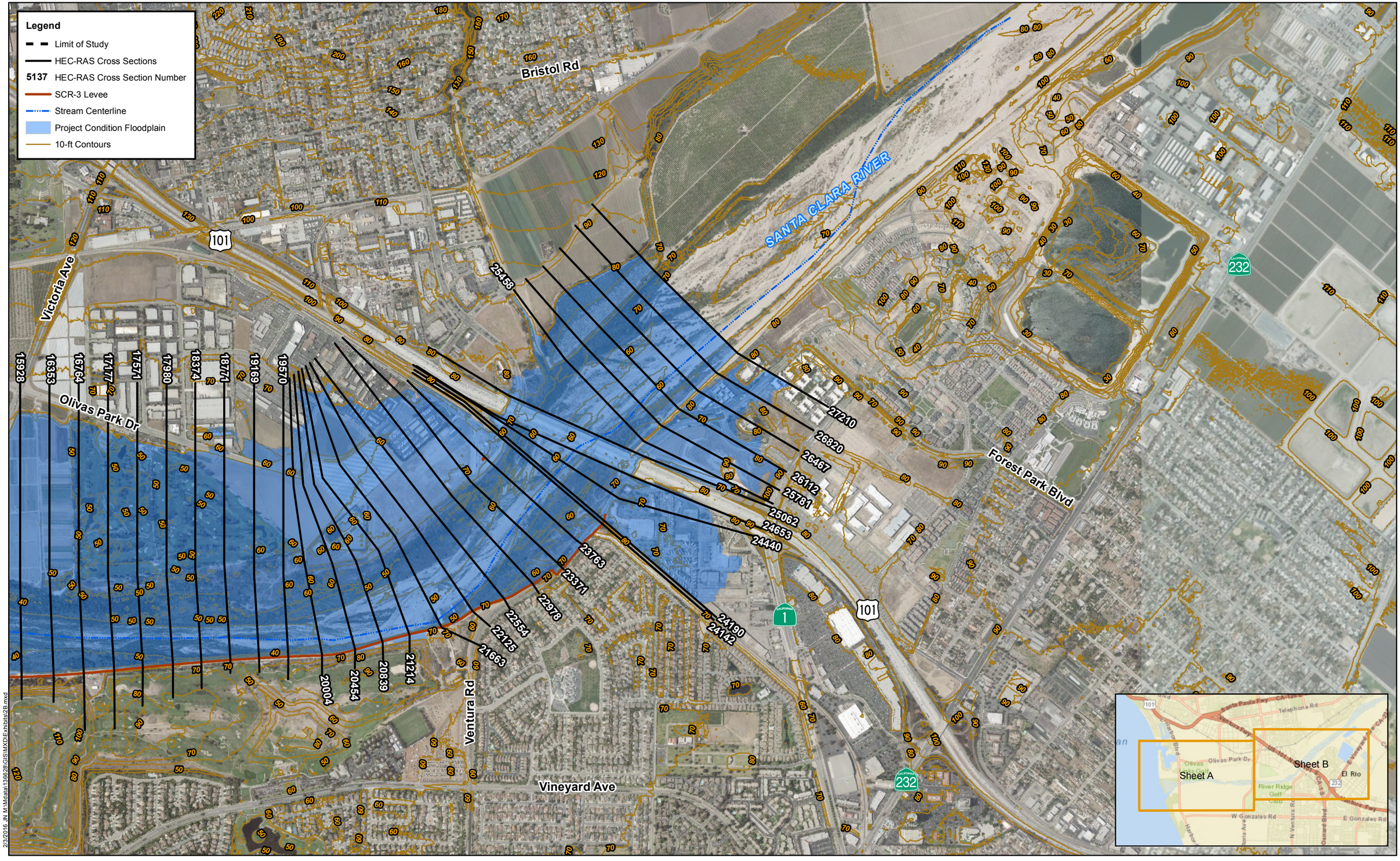
0 6001,200 2,400 Feet

Source: ArcGIS Online

SANTA CLARA RIVER (SCR-3) LEVEE

River Hydraulics – Project Condition

Figure 2A



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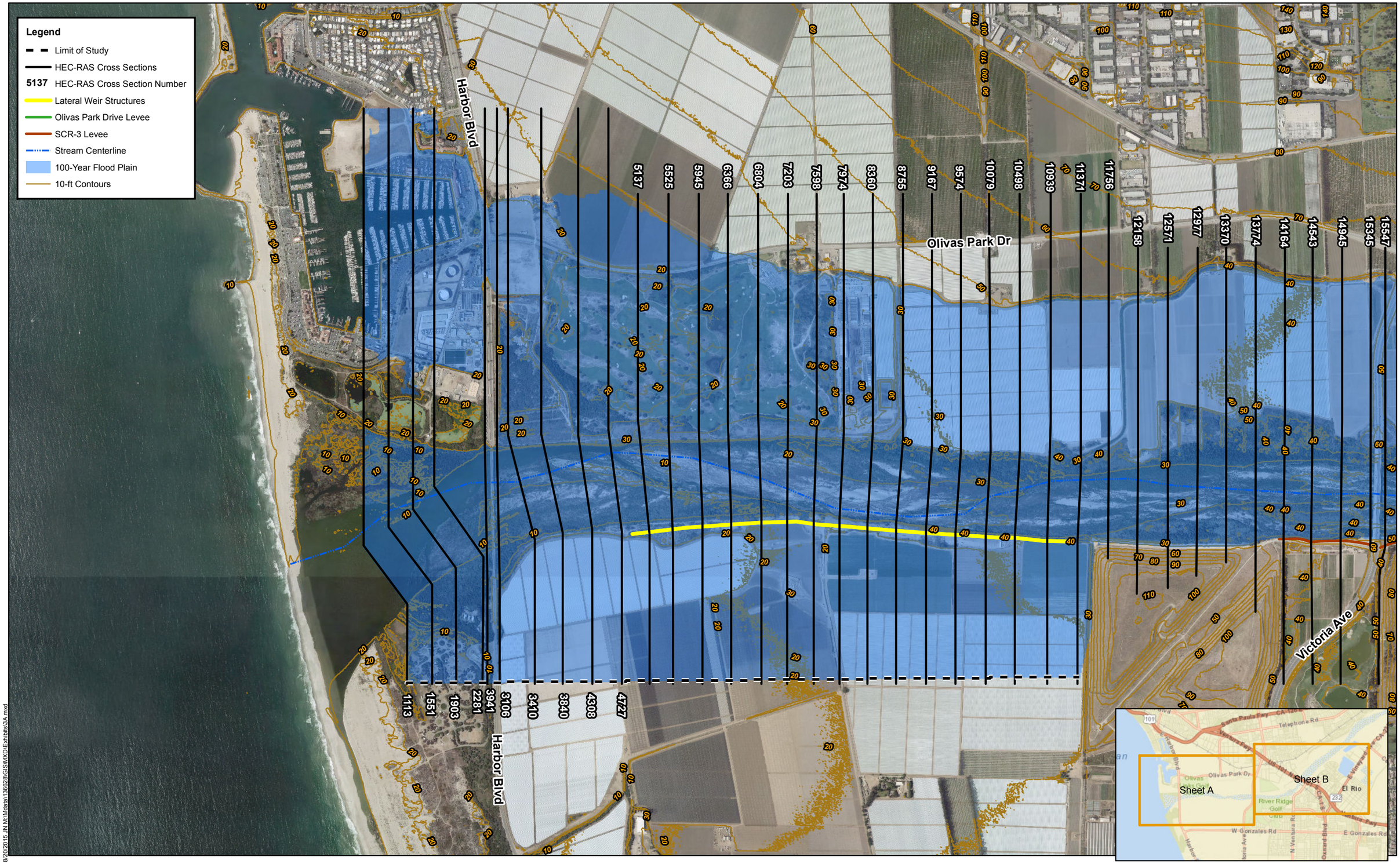
0 1,200 2,400 Feet

Source: ArcGIS Online

SANTA CLARA RIVER (SCR-3) LEVEE

River Hydraulics – Project Condition

Figure 2B



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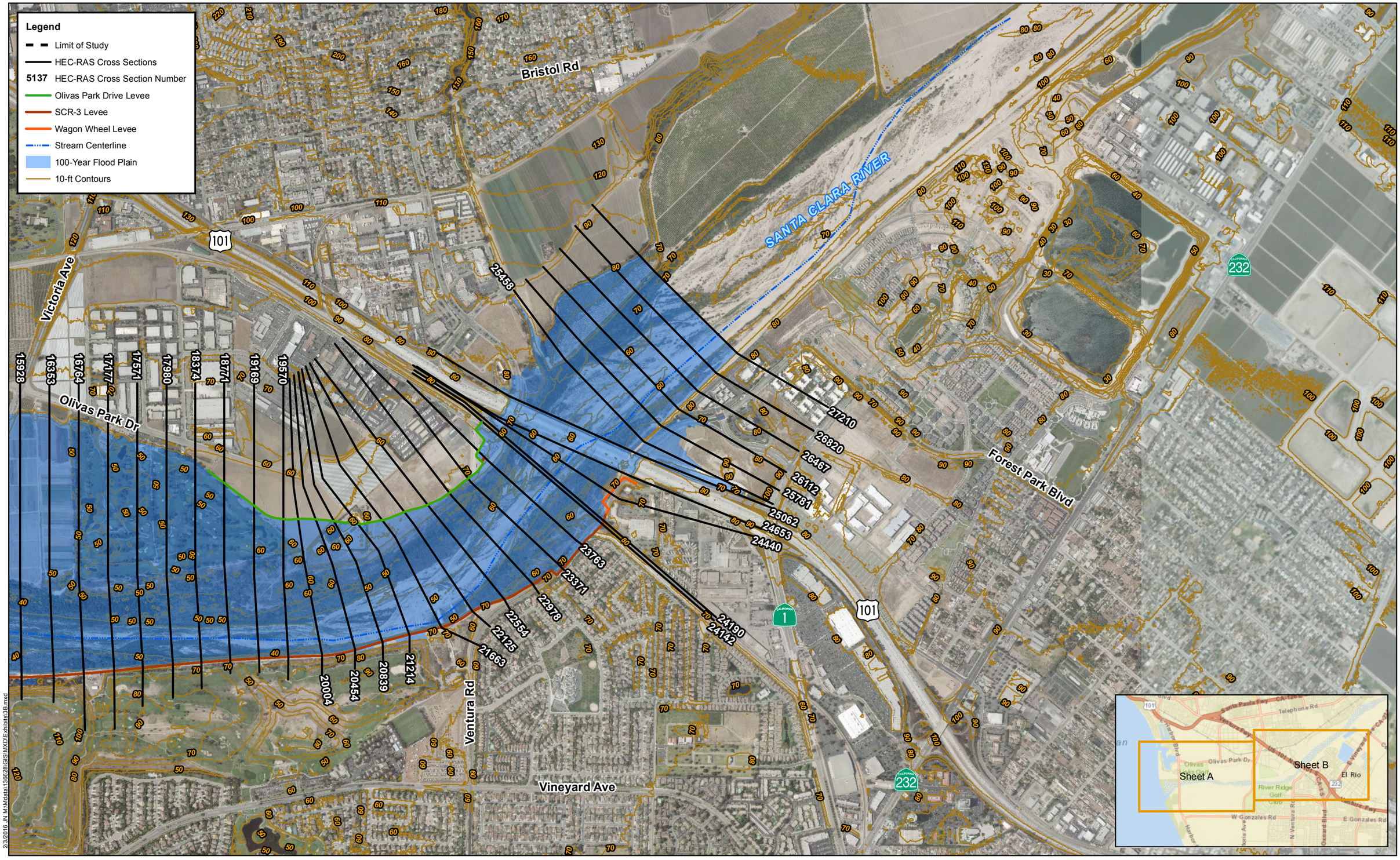
0 6001,200 2,400 Feet

Source: ArcGIS Online

SANTA CLARA RIVER (SCR-3) LEVEE

River Hydraulics – Project, Olivas, and Wagon Wheel Levee Condition

Figure 3A



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0 1,200 2,400 Feet

Source: ArcGIS Online

SANTA CLARA RIVER (SCR-3) LEVEE

River Hydraulics – Project, Olivas, and Wagon Wheel Levee Condition

Figure 3B