US Army Corps
of Engineers
Los Angeles District

Los Angeles County Drainage Area
Upper Los Angeles River and Tujunga Wash
HEC-RAS Hydraulic Models

FINAL REPORT

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1. INTRODUCTION

Purpose

The purpose of this report is to present the hydraulic analyses for the Upper Los Angeles River and Tujunga Wash Study. In addition, the report establishes the regulatory water surface elevations that will be used as the basis against which all hydraulic impacts to the Upper Los Angeles River and Tujunga Wash are evaluated.

Scope

This report encompasses the development of hydraulic models for the Upper Los Angeles River (Owensmouth Ave. to Rio Hondo Channel) and Tujunga Wash (Hansen Dam to Upper Los Angeles River). Additional phases for modeling other tributaries on the Upper Los Angeles River may follow at a later date.

Background

The U.S. Army Corps of Engineers (USACE) initiated flood control studies in the Los Angeles drainage basin in the early 1930's. Since that time the USACE and the Los Angeles County Department of Public Works (LACDPW) have studied, designed, and constructed a variety of flood control structures and improvements within the drainage basin.

In December 2002, the U.S. Army Corps of Engineers and the Los Angeles County Department of Public Works agreed to develop a detailed HEC-RAS hydraulic model of the Los Angeles County Drainage Area to assess the impact of potential future increases in stormwater flow and/or physical modifications to the channel system. This initial study completed in July 2004, in support of the Department of Army and the Los Angeles County Flood Control District, Stormwater Management Plan - Phase I (Reference 1), created the hydraulic models of the Lower Los Angeles River and the Rio Hondo Channel at their confluence.

In April 2004, the USACE initiated the development of detailed HEC-RAS hydraulic models for the Upper Los Angeles River and Tujunga Wash channels to: (1) Establish present-day baseline hydraulic conditions, (2) Refine channel operation and maintenance procedures, (3) Evaluate permit requests for proposed changes to channel geometry, and (4) Evaluate future-use alternatives for this area of the Los Angeles County Drainage Area.

2. PROJECT DESCRIPTION

Project Location

The project location of the Upper Los Angeles River and the Tujunga Wash Study is shown on Plate 1.

River Reach/Subreach Assignments

For this study, the Upper Los Angeles River is divided into Reaches 1, 2, and 3 and Tujunga Wash is comprised of a single reach.

Subreach assignments for both the Upper Los Angeles River and Tujunga Wash were taken from the December 1975 USACE Los Angeles County Drainage Area Project, Operation and Maintenance Manual (Reference 2). The subreach assignments also correspond to the as-built construction plan designations.

Table 1. Upper Los Angeles River and Tujunga Wash Reach Assignments

River / Reach	Subreach	Station Start	Length (mi)
Upper Los Angeles River Reach 3	Owensmouth Ave - Corbin Ave	1421+43.46	2.02
	Corbin Ave - Reseda Blvd	1314+87.49	1.80
	Reseda Blvd - Sepulveda FCB	1219+92.03	1.67
Upper Los Angeles River Reach 2	Sepulveda FCB - Van Nuys Blvd	969+89.01	1.13
	Van Nuys Blvd - Fulton Ave	910+00.00	1.67
	Fulton Ave - Whisett Ave	822+00.00	1.14
	Whitsett Ave - Radford Ave	761+76.30	0.90
	Radford Ave - Lankershim Blvd	714+00.00	2.31
	Lankershim Blvd - Niagara St	592+00.00	1.70
	Niagara St - Mariposa St	502+00.00	1.06
	Mariposa St - Golden State Fwy (5)	446+00.00	1.29
	Golden State Fwy (5) - Doran St	378+00.00	0.76
	Doran St - Los Feliz Blvd	337+97.22	1.82
	Los Feliz Blvd - Hyperion Ave	242+00.00	0.99
	Hyperion Ave - Fletcher Dr	189+50.00	1.00
Upper Los Angeles River Reach 1	Fletcher Dr - Blimp St	1420+55.65	1.03
	Blimp St - Golden State Fwy (5)	1366+00.00	1.31
	Golden State Fwy (5) - Pasadena Fwy (110)	1297+00.00	0.45
	Pasadena Fwy (110) - North Broadway	1273+10.00	0.49
	North Broadway - Alhambra Ave	1247+00.00	0.63
	Alhambra Ave - Santa Ana Fwy (5)	1214+00.00	0.78
	Santa Ana Fwy (5) - 4th St	1173+00.00	0.59
	4th St - Olympic Blvd	1142+01.50	1.21
	Olympic Blvd - Washington Blvd	1078+00.00	0.63
	Washington Blvd - Soto St	1045+00.00	0.59
	Soto St - Downey Rd	1013+65.03	0.90
	Downey Rd - Atlantic Blvd	966+31.66	1.58
	Atlantic Blvd - Randolph St	883+10.00	1.35
	Randolph St - Florence Ave	812+00.00	0.80
	Florence Ave - Stewart & Gray Rd	770+00.00	1.61
	Stewart & Gray Rd - Rio Hondo Channel	685+00.00	0.89
Tujunga Wash	Hansen Dam - Beachy Ave	499+88.27	2.61
	Beachy Ave - Vanowen St	362+00.00	2.65
	Vanowen St - Magnolia Blvd	222+00.00	2.12
	Magnolia Blvd - LA River	110+00.00	1.95

Upper Los Angeles River

The Los Angeles River Watershed covers a land area of over 834 square miles from the eastern portions of Santa Monica Mountains to the San Gabriel Mountains in the west. The Los Angeles River flows from its headwaters in the mountains eastward to the northern corner of Griffith Park where the channel turns southward through the Glendale Narrows before it flows across the coastal plain and into the Pacific Ocean at Long Beach, California. The upper portion of the watershed, approximately 360 square miles, is covered by forest or open space, while the remaining watershed, nearly 474 square miles, is highly developed with commercial, industrial, or residential uses. The major tributaries to the Upper Los Angeles River include: Caballero Creek, Tujunga Wash, Burbank Western Channel, Burbank Eastern Channel, Verdugo Wash, Sycamore Wash, and the Arroyo Seco Channel.

Tujunga Wash

Tujunga Creek rises in the San Gabriel Mountains and flows west through rugged Tujunga Canyon and enters Hansen flood-control basin. Approximately 9.3 miles below Hansen Dam, Tujunga Wash intersects the Upper Los Angeles River at station 638+15. Tujunga Wash primarily serves as a flood control conduit through the largely urbanized eastern San Fernando Valley. The major tributary to Tujunga Wash is Pacoima Wash.

3. DEVELOPMENT OF HYDRAULIC MODELS

Field Verification

Field site visits were conducted to: (1) verify channel as-built construction plans, (2) verify and obtain bridge and pier measurements, and (3) photograph the study area. The bridge and pier data collected during the site visits are presented in Appendix A.

Channel Geometry

As-built construction plans were used to develop the HEC-RAS model geometry. Cross-sections were defined at major channel geometry changes (i.e. channel shape, transitions, invert slope change, etc.). Generally, the distance between sections is equal to the channel base width.

Interpolated cross-sections with variable spacing between the sections were added to accommodate specific geometric conditions, provide model stability, and additional water surface elevation data points. Interpolated sections in the study are identified with an asterisk (*) in the HEC-RAS Model Geometry File and the Summary Output Tables 4-7.

Skewed Bridges

Five bridges in Reach 1 of the Upper Los Angeles River were modeled with multiple bridge decks to simulate skewed bridge crossings (identified with an asterisk (*) footnote in Appendix A, Bridge Soffit Elevations table). This same procedure was used in the LACDA Stormwater Management Plan – Phase I Study where it yielded the closest results to the physical model study.

Pier Debris

Two feet of floating debris was added to each side of all sloping piers that measure 6 ft or less in width (transverse dimension). The debris depth was set to 6 ft below the water surface elevation. Floating debris was not added to piers greater than 6 ft in width. This practice is based on (a) experience from recent floods and (b) physical model studies that indicate sloping pier extensions in high velocity flows are quite effective in moving debris up the slope out of the water and thereby preventing significant debris accumulation.

Georeference HEC-RAS Models

The HEC-RAS model data for all reaches were georeferenced, i.e. registered, using MicroStation, Inroads, and ArcView 3.2 GIS (References 3-5). The horizontal and vertical data are California State Plane 1983, Zone V, and Mean Sea Level (MSL), respectively.

Existing digital horizontal alignment files and channel as-built construction plans were used to construct the stream centerlines of the Los Angeles River and Tujunga Wash. In addition, topographic maps and aerial photographs of the study area were used to verify the location of the stream centerlines and channel cross-sections.

Note that at some locations, the stream centerlines deviate from the aerial photographs, especially upstream of the Verdugo Wash confluence with the Los Angeles River. The main reason is that the Inroads software cannot replicate the "modified" spiral curves used in the original channel as-built construction plans horizontal alignment. At these locations, the "standard" spiral curve alignment available to Inroads was used instead to draw the horizontal alignment. This alignment was then manually adjusted using the aerial photos.

Although there are disparities in the horizontal alignment, the numerical model results will not be affected by these differences.

4. METHOD OF ANALYSIS

Numerical Model

The U.S. Army Corps of Engineers Hydrologic Engineering Center's River Analysis System HEC-RAS (Reference 6) was used to complete the hydraulic models. The software allows the user to perform one-dimensional, steady and unsteady flow river hydraulics calculations. The system is comprised of a graphical user interface (GUI), separate hydraulic analysis components, data storage and management capabilities and graphic output capabilities.

Analysis Assumptions

In applying the numerical model, the flow is in a one-dimensional, uniform, steady state. The one-dimensional assumption is applicable since during high flows most of the flow travels downstream along the channel allowing the model to be analyzed in one direction. The uniform flow statement is reasonable since in most particular situations flow is gradually changing. Steady flow states the change in depth is constant as a function of time.

The steady state assumption is reasonable for most of our reaches except during abrupt changes in cross sectional flow; examples include hydraulic jumps, abrupt channel bends and changes in bed slope.

Design Discharges

Design discharges were obtained using the hydraulic pertinent data tables (Reference 7) from the Hydrology & Hydraulics Section permit manual. The purpose of the pertinent data tables is to evaluate hydraulics information during permit requests. Table 2 summarizes the Design Discharges for the Upper Los Angeles River and Tujunga Wash.

Table 2. Design Discharges

River / Reach	Subreach	Subreach Stations (ft)	Design Discharge (cfs)
Upper Los Angeles River Reach 3	Owensmouth Ave - Corbin Ave	1421+43.40	24,000
		1408+35.00	24,600
		1355+88.70	36,000
	Corbin Ave - Reseda Blvd	1314+87.40	36,000
		1225+48.10	48,000
	Reseda Blvd - Sepulveda FCB	1219+92.00	48,000
		1181+00.00	53,000
Upper Los Angeles River Reach 2	Sepulveda FCB - Van Nuys Blvd	969+89.01	17,000
		934+36.09	17,500
	Van Nuys Blvd - Fulton Ave	910+00.00	17,500
		908+95.58	19,000
		874+51.30	19,500
		854+76.70	20,500
		825+80.92	21,000
	Fulton Ave - Whisett Ave	822+00.00	21,000
		790+56.70	21,500
	Whitsett Ave - Radford Ave	761+76.30	21,500
	Radford Ave - Lankershim Blvd	714+00.00	24,000
		702+26.77	52,000
		618+57.00	55,000
	Lankershim Blvd - Niagara St	592+00.00	55,000 *
		553+13.01	57,000 *
		502+00.00	40,000
	Niagara St - Mariposa St	502+00.00	40,000
	Mariposa St - Golden State Fwy (5)	446+00.00	40,000
		406+00.00	40,000
	Golden State Fwy (5) - Doran St	378+00.00	40,000
		336+25.00	78,000
	Doran St - Los Feliz Blvd	337+97.22	78,000
	Los Feliz Blvd - Hyperion Ave	242+00.00	78,000
	Hyperion Ave - Fletcher Dr	189+50.00	78,000

Table 2. Design Discharges
(continued)

River / Reach	Subreach	Subreach Stations (ft)	Design Discharge (cfs)
Upper Los Angeles River Reach 1	Fletcher Dr - Blimp St	1420+55.60	78,000
		1403+50.00	83,700
	Blimp St - Golden State Fwy (5)	1366+00.00	83,700
	Golden State Fwy (5) - Pasadena Fwy (110)	1297+00.00	83,700
	Pasadena Fwy (110) - North Broadway	1273+10.00	104,000
	North Broadway - Alhambra Ave	1247+00.00	104,000
	Alhambra Ave - Santa Ana Fwy (5)	1214+00.00	104,000
	Santa Ana Fwy (5) - 4th St	1173+00.00	104,000
	4th St - Olympic Blvd	1142+01.50	104,000
	Olympic Blvd - Washington Blvd	1078+00.00	104,000
	Washington Blvd - Soto St Soto St - Downey Rd	1045+00.00	104,000
		999+00.00	109,500
	Downey Rd - Atlantic Blvd	966+31.66	109,500
	Atlantic Blvd - Randolph St Randolph St - Florence Ave Florence Ave - Stewart & Gray Rd	883+10.00	109,500
	Stewart & Gray Rd - Rio Hondo Channel	685+00.00	120,000
Tujunga Wash	Hansen Dam - Beachy Ave	499+88.27	22,000
	Beachy Ave - Vanowen St	362+00.00	22,000
		351+88.66	29,000
		350+17.68	29,000
	Vanowen St - Magnolia Blvd	222+00.00	29,000
		123+00.00	30,000
	Magnolia Blvd - LA River	110+00.00	30,000

* 1947 revised estimate that increases flow rate based on additional hydrologic information – see Reference 8.

Roughness Values

The Manning's roughness coefficients used for the Upper Los Angeles River and Tujunga Wash models are shown in the HEC-RAS Summary Output tables. These roughness values were derived from the pertinent data tables for design conditions. Certain reaches along the Upper Los Angeles River do not depict the design roughness conditions.

Boundary Conditions

The following table summarizes the boundary conditions (starting water surface at the upstream and downstream ends of the river system reaches) for the Upper Los Angeles River and Tujunga Wash. In the table, "mixed" flow regime indicates the occurrence of both subcritical and supercritical flow within the reach.

Table 3: Boundary Conditions

River	Reach	Flow Regime	Station (ft)	Flow (cfs)	WSEL (ft) MSL
Upper Los Angeles	Reach 3	Mixed	1421+43.46 1131+69.50	24,000 53,000	785.92 702.25
Upper Los Angeles	Reach 2	Mixed	969+89.01 136+57.90	17,000 78,000	671.36 356.84
Upper Los Angeles	Reach 1	Mixed	1420+55.65 638+15.00	78,000 120,000	356.84 109.06
Tujunga Wash	Tujunga Wash	Supercritical	499+88.27 7+00.00	22,000 30,000	962.80 583.77

Coefficients Of Contraction/Expansion

Per guidance in the HEC-RAS Reference Manual (Reference 6), it is recommended that the contraction and expansion coefficients be set to zero for constructed trapezoidal and rectangular channels designed for supercritical flow. This is especially true for reaches where the cross-sectional geometry is not changing shape. For subcritical flow, typical values for the coefficients can range from 0.0 to 0.8 depending on bridge transition losses and the degree of change in cross-sectional geometry.

The contraction and expansion coefficients for this study were set to 0.0. Physical model study results from the Stormwater Management Plan, Phase I verified that contraction and expansion of 0.0 should be used for concrete, prismatic channels such as the Upper Los Angeles River and Tujunga Wash.

Pressure Flow

Initial analysis results indicated pressure flow conditions for a number of bridges in the Tujunga Wash reach. Given that all bridges in the reach are clear-span structures constructed with soffit elevations at the top of channel wall or above, it was decided to rerun the analysis with all Tujunga Wash bridge decks artificially raised 10 feet. This analysis indicates that the flow is contained within the channel well below the top of channel walls. Refer to Plate 145, Tujunga Wash water surface profile. Pressure flow was not observed in the study's other reaches.

Bridge Soffit Elevations

Appendix A summarizes the approximate bridge soffit elevations for all reaches of the study. Elevations were determined from plan and profile drawings and from field measurements. A field survey would be required to establish exact soffit elevations. During several site visits to the Upper Los Angeles River it was observed that a number of bridges contained soffit elevations several feet above the top of channel bank. For these bridges, the soffit elevations were estimated since the flow would eventually spillover the channel banks before reaching the soffit elevation.

Bridge Modeling Approach

The bridge modeling approach for bridges without piers was set to the Energy Only (Standard Step) computational method. For bridges with piers, the highest energy solution between: (1) Energy Only (Standard Step), (2) Momentum, and (3) Yarnell (Class A only) was selected.

Divided Flow

Divided flow bridge modeling was used to capture the high friction losses of the long piers in Reach 2 for: (a) Ventura Freeway (134) at the confluence of the Upper Los Angeles River and Verdugo Wash, and (b) North Glendale Boulevard and Hyperion Avenue. The pier geometry for these bridges was coded directly into the channel cross-sectional geometry.

5. METHODOLOGY FOR EVALUATING PROPOSED CHANGES TO CHANNELS

A procedure for evaluating proposed changes in the channel using the HEC-RAS models was developed. This procedure is based on the current Los Angeles District permit process. In addition, it is encouraged that the HEC-RAS model results derived from this report be used concurrently with the existing hydraulic pertinent data tables within the LACDA project reach to ensure hydraulic model output results are reliable. The procedure consists of:

- Assessing if HEC-RAS is the appropriate model to use,
- Assessing if the design water surface increased or flow conveyance characteristics changed,
- Determining if any mitigation is necessary,
- Documenting the changes in the HEC-RAS models.

The logic diagram shown on Plate 164 in Appendix B best illustrates this procedure.

In general, any proposed channel impacting structure that has a potential to raise the original design water surface and/or significantly change the associated conveyance conditions in the subject project reach shall be accompanied by commensurate offsetting mitigation measures.

Should the applicant request a waiver in any portion of the above requirement, then a detailed hydraulic analysis report shall be submitted to the USACE Engineering Evaluation Section (CESPL-CO-OE) for further review and assessment.

To keep track of the changes, a new Plan file (along with the corresponding Geometry and Flow files) shall be created within the HEC-RAS models. The date and description of changes shall be included in the comment block of the Steady Flow Analysis dialogue box.

The changes to the HEC-RAS models will be official when the permit is issued. The USACE and LACDPW will be the bearer of the current models of record.

6. HEC-RAS ANALYSIS RESULTS

Upper Los Angeles River – Reach 3

The HEC-RAS Reach 3 water surface profile is shown on Plate 11. Typical cross-sections are shown on Plates 12-20 and summary output data is presented in Table 4. A comparison of HEC-RAS results with Pertinent Data and Stream Gage Measurements are presented in Appendices C and D, respectively.

Occurrences of channel overtopping in Reach 3 were closely analyzed in an attempt to explain the causes for overtopping. The following paragraphs describe the location of overtopping and give an explanation on what factors were considered to be the cause.

Location: Between Canoga Ave Bridge and Pedestrian (formerly SPRR) Bridge
Channel overtopping occurs just downstream of Canoga Ave Bridge and just upstream of Pedestrian Bridge from River Station 1407+93 to River Station 1408+00. Both bridges have one sloping nose pier of width 2.5 feet. There is actually one continuous pier that runs through and is shared by both bridges. For modeling purposes though, each deck was modeled as a separate bridge. Both bridge decks sit at the top of wall of the channel. A test run was performed raising the bridge decks by 10 feet, well above the top of channel wall, to determine if the bridges were the cause for overtopping. Results showed that overtopping still occurred regardless. The cause of channel overtopping due to the bridges was ruled out.

The channel shape for this portion is trapezoidal with a base width that is gradually contracting. The channel invert is at a constant slope of approximately 0.003 ft/ft. The channel contraction is gradual and is not believed to be the cause of channel overtopping.

There is a flow rate change from 24,000 cfs to 24,600 cfs occurring at River Station 1408+35. This station is immediately upstream of River Station 1408+00.

A test run was performed where this flow rate change was deleted and the analysis showed that this had no effect on the water surface profile. It was concluded that the flow rate change was not the cause of channel overtopping.

Since the piers are of the sloping nose type, 2 feet of debris were modeled on each side of the pier. A test run was performed were no debris was simulated and the results showed that the water surface profile was below the top of channel wall. It was concluded that the modeling of pier debris was causing the channel overtopping for this area.

Location: Upstream of Amigo Ave Pedestrian Bridge
Channel overtopping also occurs upstream of the Amigo Ave Pedestrian Bridge from River Station 1225+69 to River Station 1226+13. The bridge has two sloping nose piers of width 2.5 feet each. The bridge deck sits at the top of wall of the channel. A test run was performed raising the bridge deck by 10 feet, well above the top of channel wall, to determine if the bridge was the cause for overtopping. Results showed that overtopping still occurred. The cause of channel overtopping due to the bridge was ruled out.

The channel shape for this portion is trapezoidal with a base width that is mainly constant. The channel invert is at a constant slope of approximately 0.003 ft/ft. The channel geometry is not believed to be the cause of channel overtopping.

There is a flow rate change from 36,000 cfs to 48,000 cfs occurring at River Station 1225+48.10. This station is immediately downstream of River Station 1225+69. A test run was performed where this flow rate change was deleted and the analysis showed that the backwater effect was less severe and the water surface profile was below the top of channel wall. It was concluded that due to the large flow rate change, a backwater effect is the primary cause of overtopping in the River Stations mentioned previously.

Since the piers are of the sloping nose type, 2 feet of debris were modeled on each side of the piers. A test run was performed were no debris was simulated and the results showed that the water surface profile was slightly lower but still overtopping the channel wall. Also, the Amigo Ave Pedestrian Bridge is a fairly large distance from where the overtopping is occurring. Due to this large distance, the effects of the piers on the water surface profile will be negligible. Therefore, it was concluded that the modeling of pier debris was not causing the channel overtopping.

Upper Los Angeles River – Reach 2

The HEC-RAS Reach 2 water surface profile is shown on Plate 21. Typical cross-sections are shown on Plates 22-66 and summary output data is presented in Table 5. A comparison of HEC-RAS results with Pertinent Data and Stream Gage Measurements are presented in Appendices C and D, respectively.

As with Reach 3, occurrences of channel overtopping in Reach 2 were closely analyzed in an attempt to explain the causes for overtopping. The following paragraphs describe the location of overtopping and give an explanation on what factors were considered to be the cause.

Location: Upstream of Van Nuys Blvd Bridge
Channel overtopping occurs just upstream of Van Nuys Blvd Bridge from River Station 909+23.65 to River Station 914+71.85. The Van Nuys Blvd Bridge is clear span and therefore has no piers modeled.
The bridge deck is well above the top of the channel wall. The cause of channel overtopping due to the bridge was ruled out.

The channel shape for this portion is rectangular with a constant base width of 50 feet. The channel invert is at a constant slope of approximately 0.003 ft/ft. There are no sudden changes in channel geometry to warrant channel overtopping.

There is a flow rate change from 17,500 cfs to 19,000 cfs occurring at River Station 908+95.58. This River Station is just downstream of River Station 909+23.65. A test run was performed where this flow rate change was deleted and the analysis showed that the backwater effect was eliminated and the water surface profile was below the top of channel wall. It was concluded that due to the flow rate change, a backwater effect is causing channel overtopping in the River Stations mentioned previously.

Location: Near Radford Ave Bridge
Channel overtopping occurs just downstream and just upstream of Radford Ave Bridge from River Station 714+00 to River Station 719+24.98. The Radford Ave Bridge is clear span and therefore has no piers modeled. The bridge deck sits at the top of wall of the channel. A test run was performed raising the bridge deck by 10 feet, well above the top of channel wall, to determine if bridge was the cause for overtopping. Results showed that overtopping still occurred. The cause of channel overtopping due to the bridge was ruled out.

The channel shape for this portion is rectangular with a constant base width of 60 feet. The channel invert is at a constant slope of approximately 0.003 ft/ft. The channel is super-elevated just as it approaches Radford Ave Bridge. The super-elevation is gradual and is not believed to be the cause of channel overtopping.

There is a flow rate change from 21,500 cfs to 24,000 cfs occurring at River Station 714+00. A test run was performed where this flow rate change was deleted and the analysis showed that no backwater effect occurred and the water surface profile was below the top of channel wall. It was concluded that due to the flow rate change, a backwater effect is causing channel overtopping in the River Stations mentioned previously.

Upper Los Angeles River – Reach 1

The HEC-RAS Reach 1 water surface profile is shown on Plate 67. Typical cross-sections are shown on Plates 68-144 and summary output data is presented in Table 6. A comparison of HEC-RAS results with Pertinent Data and Stream Gage Measurements are presented in Appendices C and D, respectively. No occurrences of channel overtopping were observed for Reach 1.

Tujunga Wash

The HEC-RAS Tujunga Wash water surface profile is shown on Plate 145. Typical cross-sections are shown on Plates 146-163 and summary output data is presented in Table 7. A comparison of HEC-RAS results with Pertinent Data and Stream Gage Measurements are presented in Appendices C and D, respectively. No occurrences of channel overtopping were observed for Tujunga Wash.

General

Negative Freeboard

Analysis results for the study show negative freeboard elevations for several subreaches along the Upper Los Angeles River (refer to Summary Output Tables 4-7). Negative freeboard indicates a water surface elevation above the top of channel bank.

Channel Superelevation

Certain areas in the project were constructed with curved, and in some cases, superelevated cross-sectional geometry. For superelevated locations, HEC-RAS water surface profile plots will graphically depict the channel invert as a rising/falling, saw-tooth line ("minimum" channel elevation) and not the channel as-constructed centerline slope.

Appendix E provides a summary of the rise in water surface elevation between a theoretical level water surface at the channel centerline and the outside water surface elevation at the channel walls due to superelevation. The data was calculated per guidance from USACE Engineer Manual, EM 1110-2-1601, Hydraulic Design of Flood Control Channels (Reference 9).

REFERENCES

1. U.S. Army Engineer District, Los Angeles, 2004. *Los Angeles County Drainage Area, Stormwater Management Plan, Phase I, HEC-RAS Hydraulic Models, Rio Hondo Channel and Lower Los Angeles River*.

2. U.S. Army Engineer District, Los Angeles, 1975. *Los Angeles County Drainage Area Project, Operation and Maintenance Manual.*

3. Bentley Systems, Inc., 2001. *MicroStation, Version 07.02.04.20*

4. Bentley Systems, Inc., 2001. *InRoads SelectCAD, Version 08.02.00.00*

5. Environmental Systems Research Institute, Inc., 1999. *ArcView GIS, Version 3.2*

6. U.S. Army Corps of Engineers, Hydrologic Engineering Center, 2003. *HEC-RAS River Analysis System, Version 3.1.1*.

7. U.S. Army Engineer District, Los Angeles, 1991. *Pertinent Data For Permit Requests.*

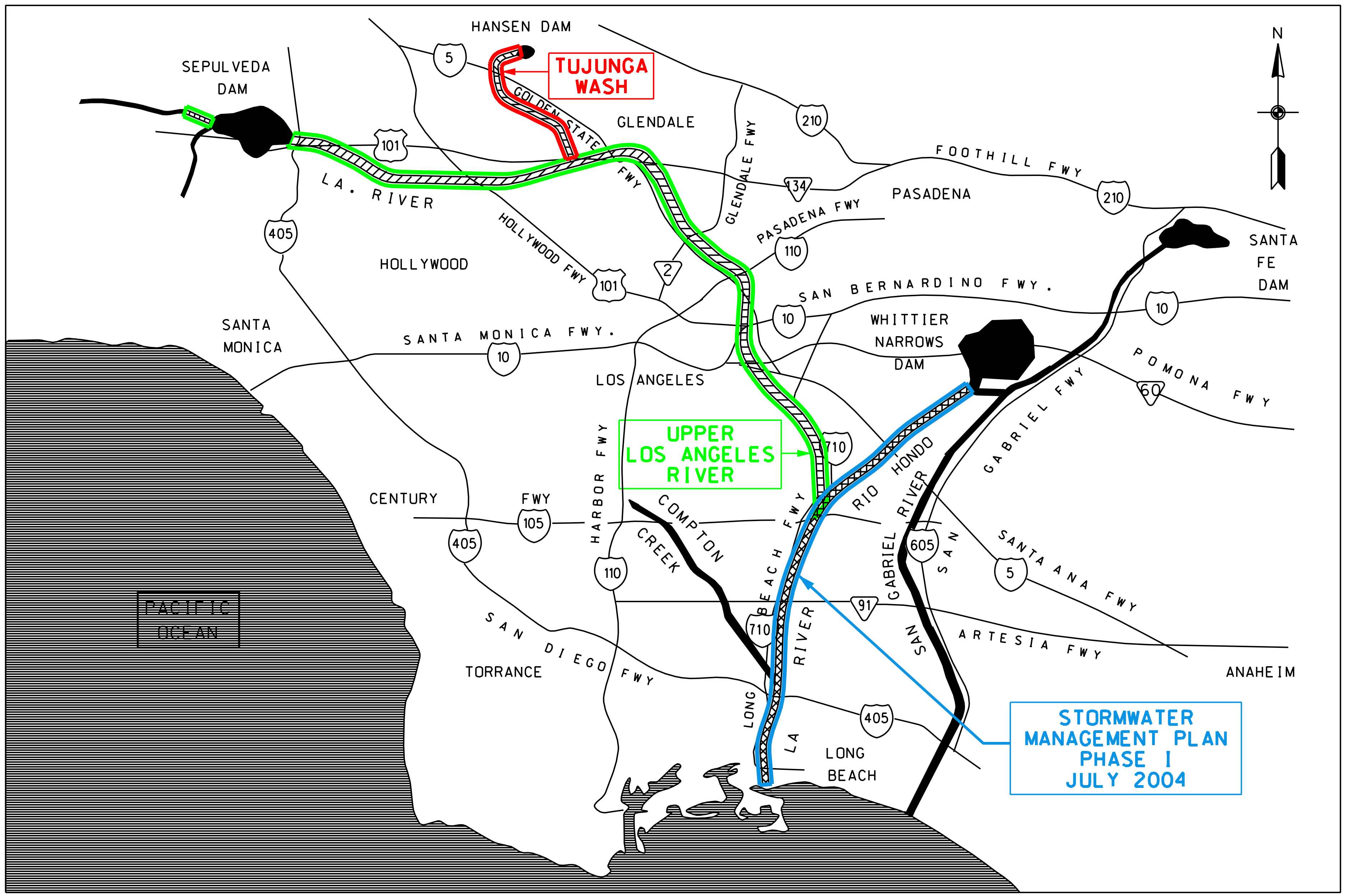
8. U.S. Army Engineer District, Los Angeles, 1947. *Analysis Of Design On Los Angeles River Improvement, Niagara St. To Lankershim Blvd.*

9. U.S. Army Corps of Engineers, Engineering and Design, 1991. *Engineer Manual, EM 1110-2-1601, Hydraulic Design of Flood Control Channels.*

LOS ANGELES COUNTY DRAINAGE AREA, CALIFORNIA

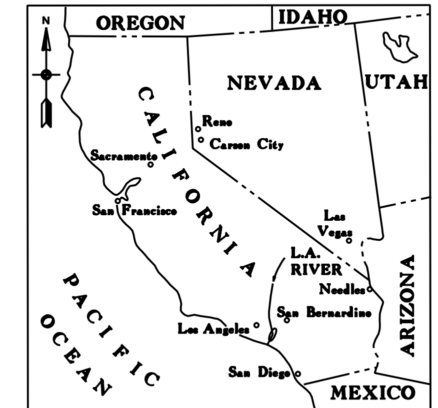
UPPER LOS ANGELES RIVER AND TUJUNGA WASH STUDY

HEC-RAS HYDRAULIC MODELS



GENERAL PROJECT LOCATION

NTS



VICINITY MAP

SCALE 150 75 0 150 300 MILES

LEGEND

10	INTERSTATE HIGHWAY
101	FEDERAL HIGHWAY
2	STATE HIGHWAY
	EXIST. RIVERS
	UPPER LOS ANGELES RIVER AND TUJUNGA WASH
	LOWER LOS ANGELES RIVER AND RIO HONDO CHANNEL

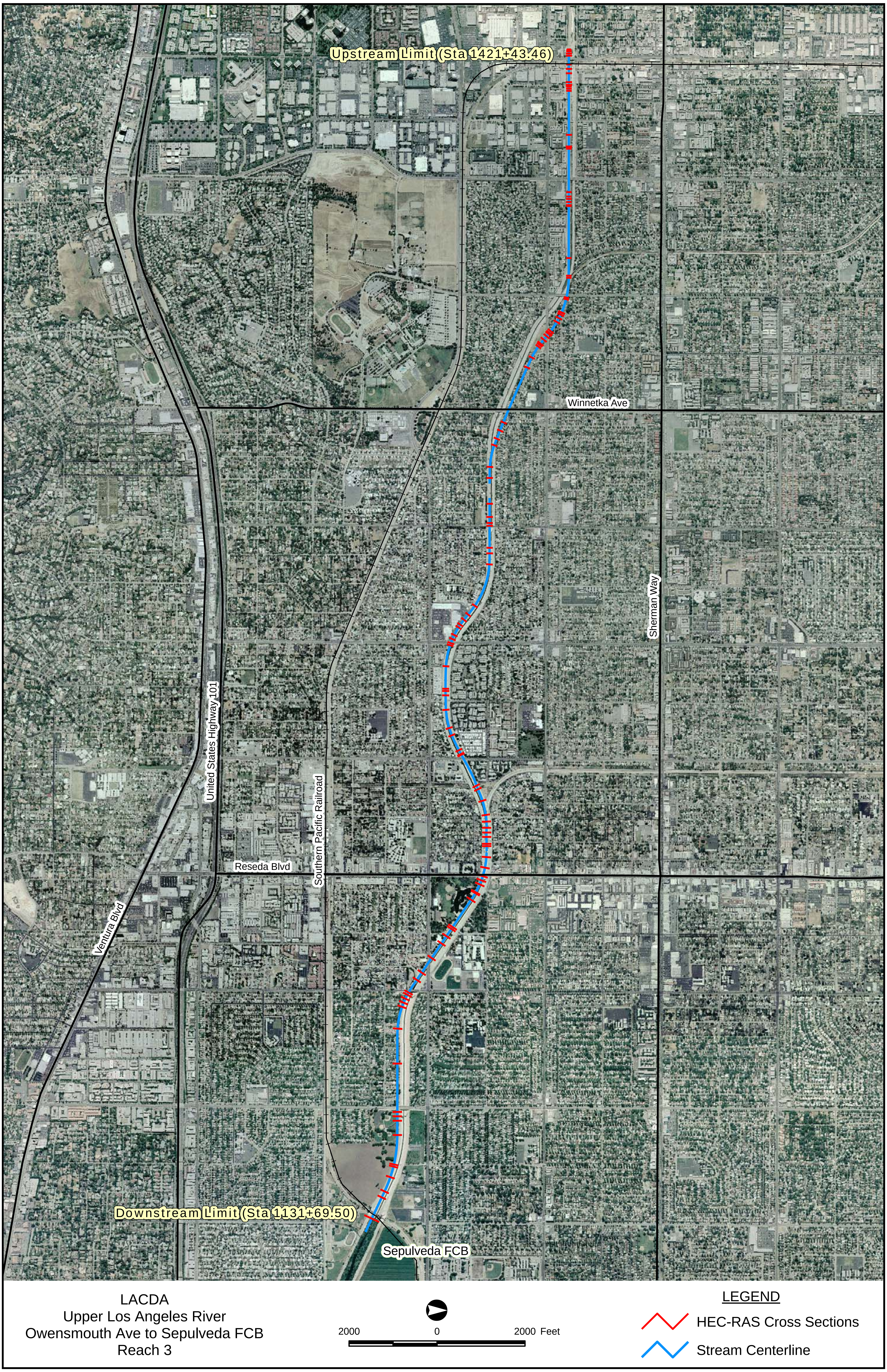
U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

LOS ANGELES COUNTY DRAINAGE AREA, CALIFORNIA
LOS ANGELES RIVER AND TUJUNGA WASH FROM SEPULVEDA AND HANSEN DAM TO PACIFIC OCEAN

UPPER LOS ANGELES RIVER AND TUJUNGA WASH STUDY

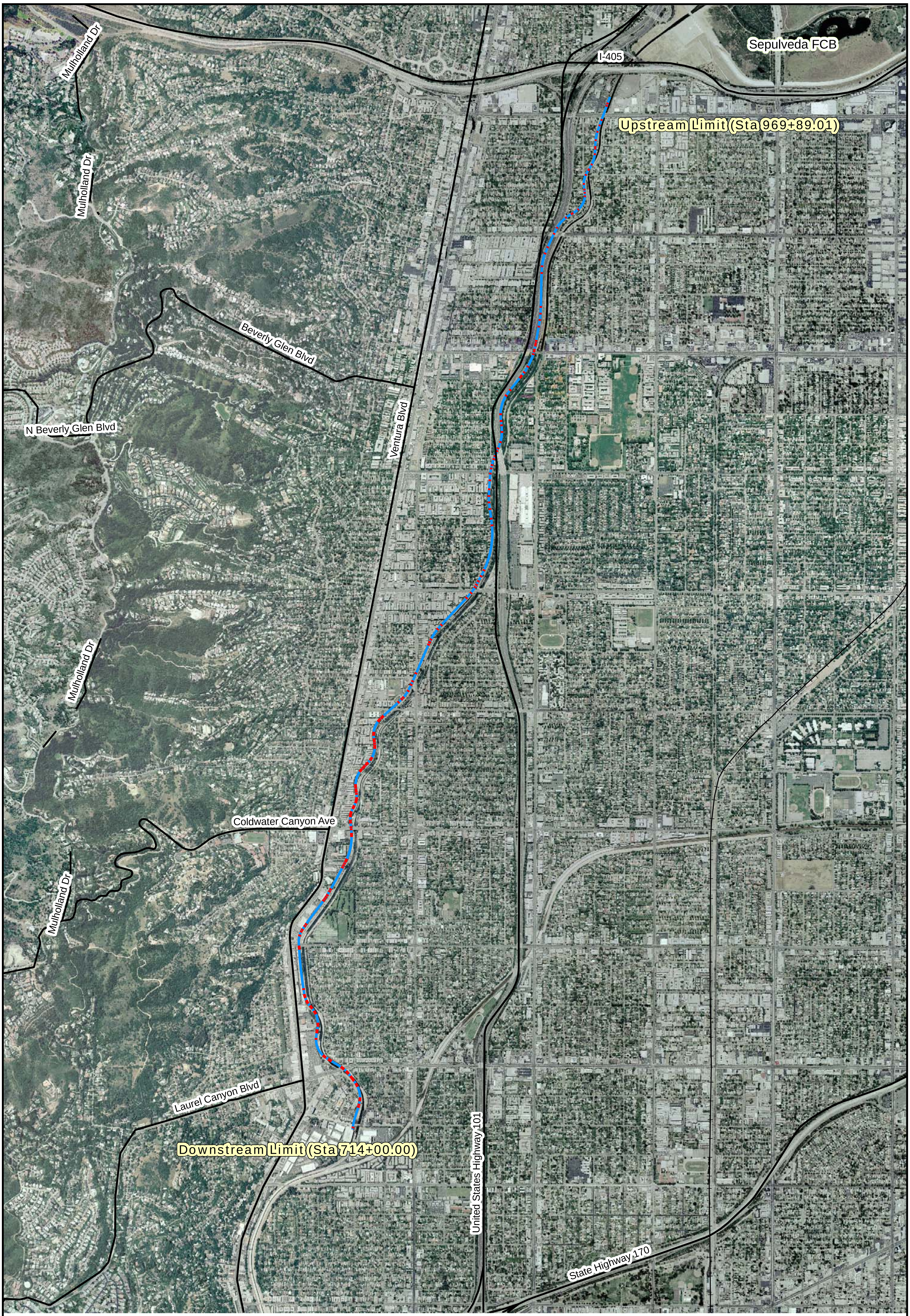
HEC-RAS HYDRAULIC MODELS

PLATE 1



LACDA
Upper Los Angeles River
Owensmouth Ave to Sepulveda FCB
Reach 3

PLATE 2



LACDA
Upper Los Angeles River
Sepulveda FCB to Radford Ave.
Reach 2

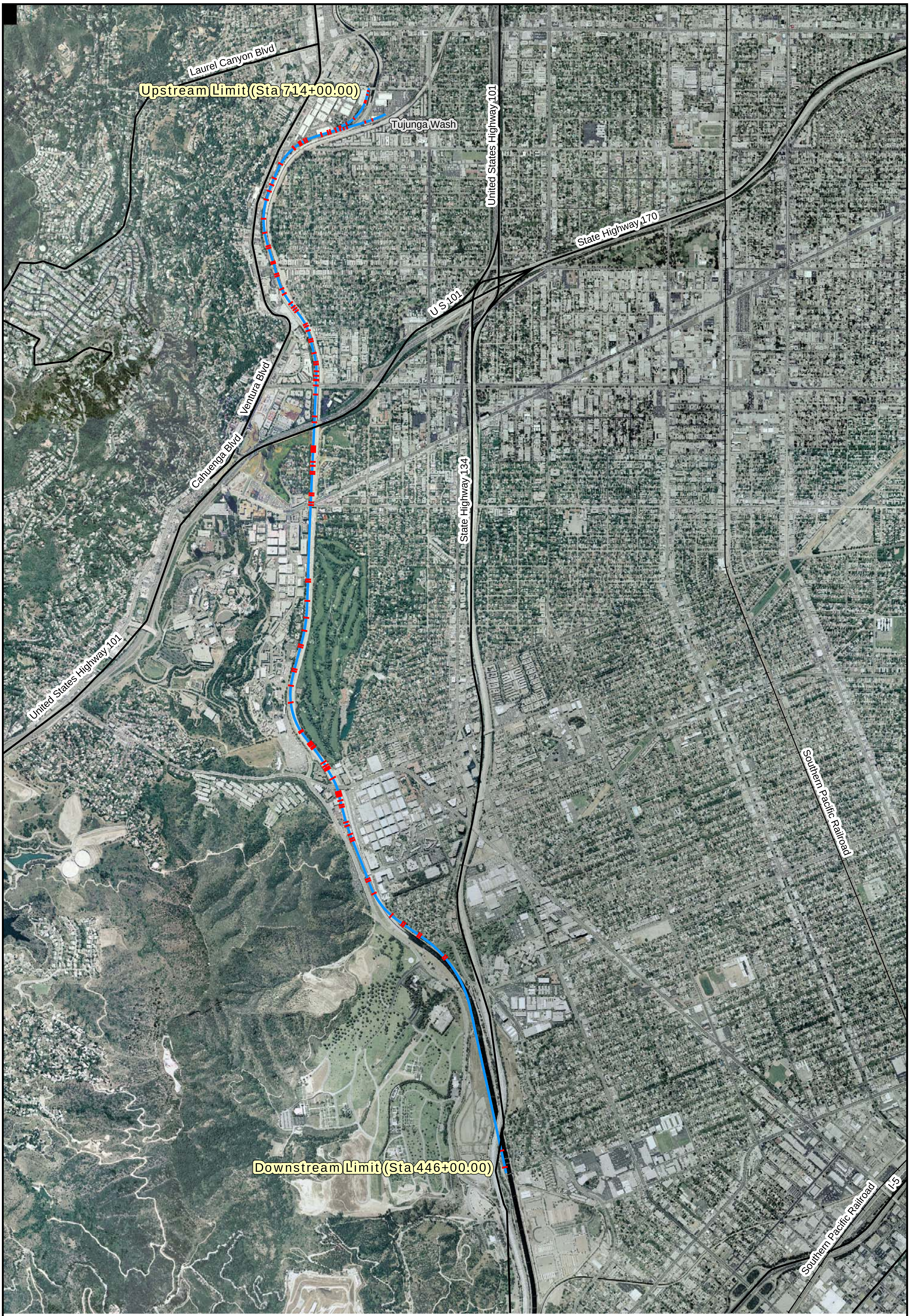
2000 0 2000 Feet

LEGEND

HEC-RAS Cross Sections

Stream Centerline

PLATE 3

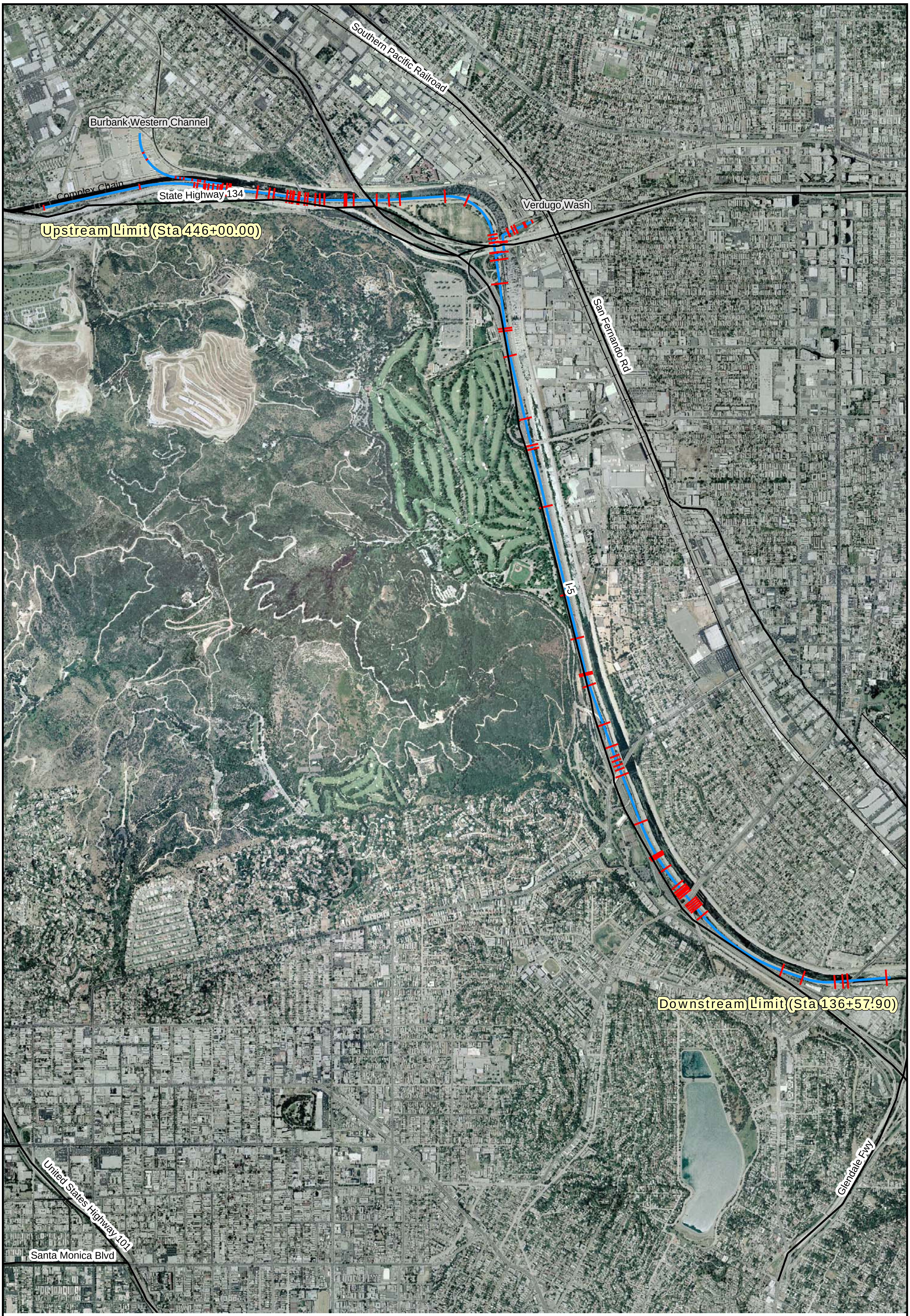


LACDA
Upper Los Angeles River
Radford Ave. to Mariposa St.
Reach 2

2000 0 2000 Feet

LEGEND
HEC-RAS Cross Sections
Stream Centerline

PLATE 4



LACDA
Upper Los Angeles River
Mariposa St. to Fletcher Dr.
Reach 2

2000 0 2000 Feet

LEGEND

HEC_RAS Cross Sections

Stream Centerline

LACDA
Upper Los Angeles River
Fletcher Dr. to 4th St.
Reach 1

2000 0 2000 Feet

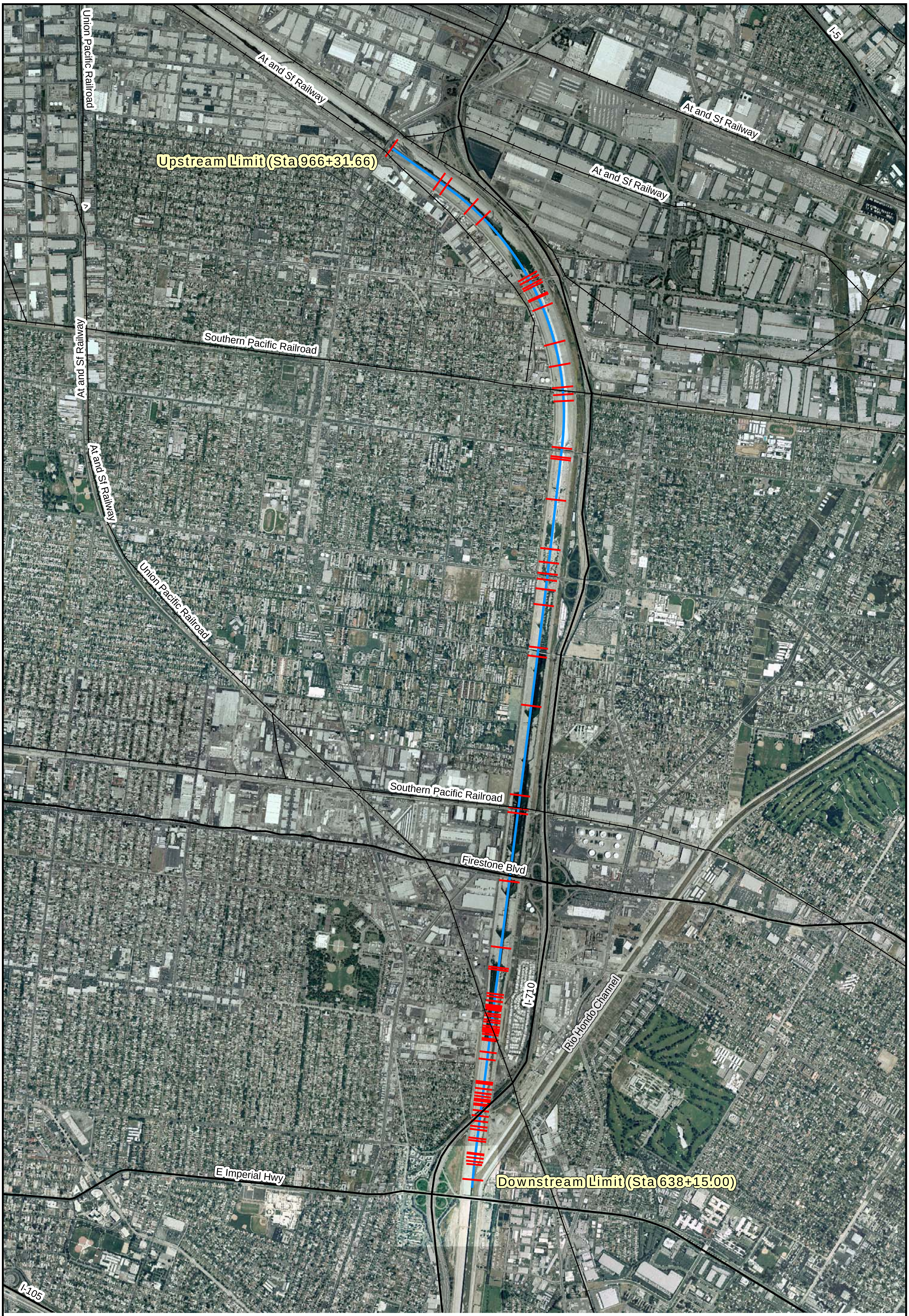
LEGEND

HEC-RAS Cross Sections

Stream Centerline

LACDA
Upper Los Angeles River
4th St. to Atlantic Blvd.
Reach 1

PLATE 7



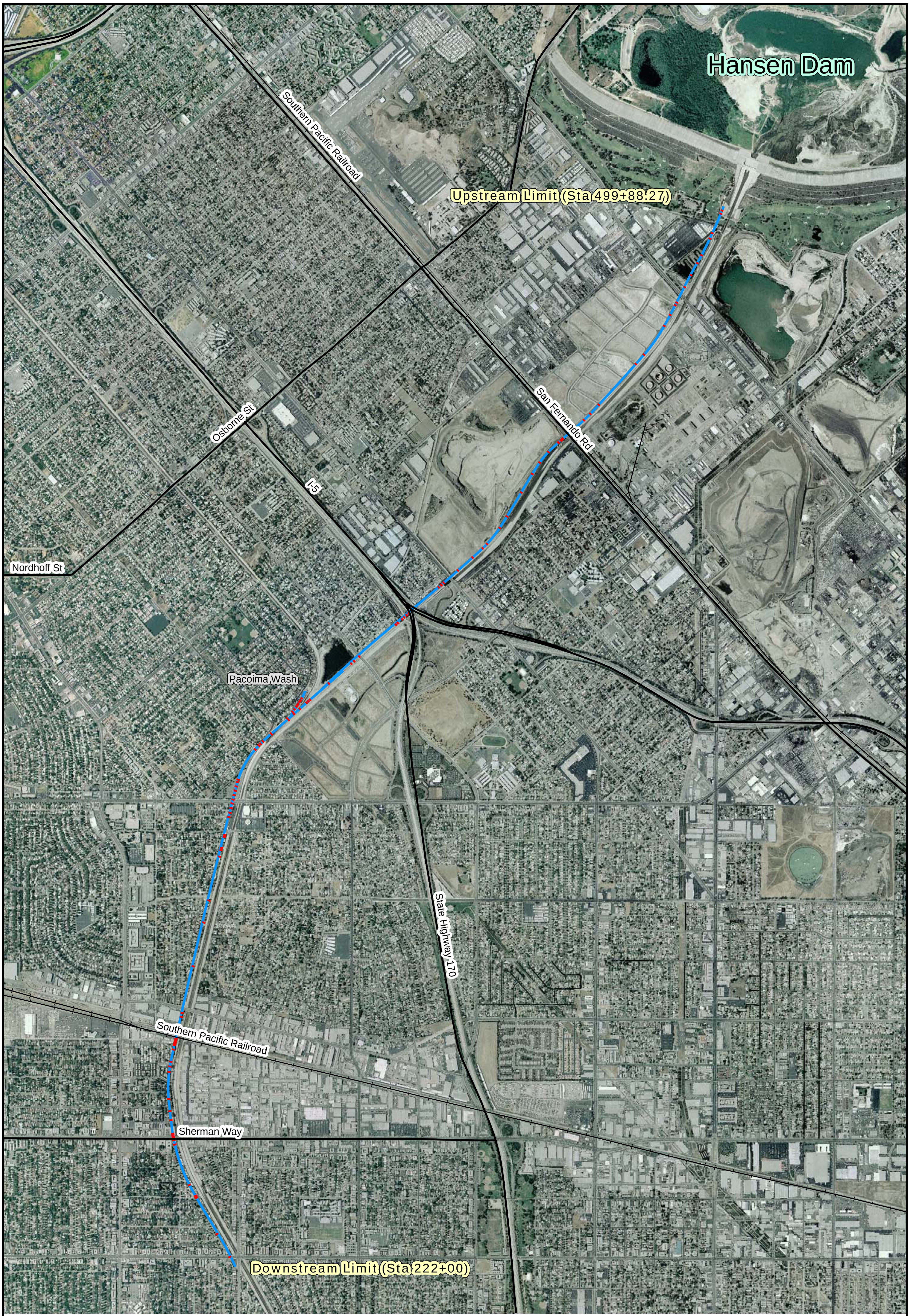
LACDA
Upper Los Angeles River
Downey Rd to Rio Hondo
Reach 1

2000 0 2000 Feet

LEGEND

HEC-RAS Cross Sections

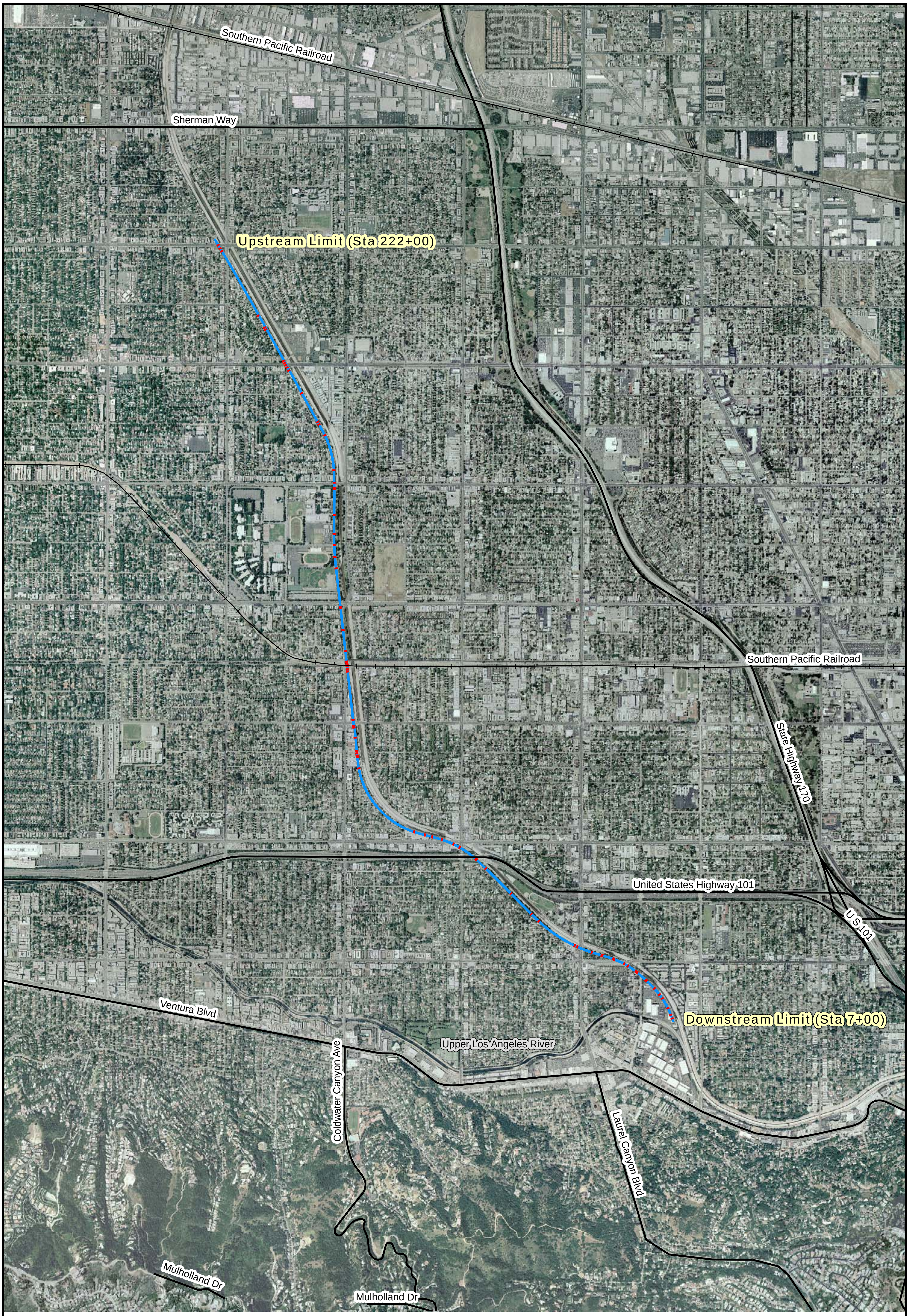
Stream Centerline



LACDA
Tujunga Wash
Hansen Dam to Vanowen St

2000 0 2000 Feet

LEGEND
HEC-RAS Cross Sections
Stream Centerline



LACDA
Tujunga Wash
Vanowen St to LA River

2000 0 2000 Feet

LEGEND

HEC-RAS Cross Section

Stream Centerline