Appendix F

SCR-3 Alternatives Analysis
Supplementary Evaluation

Michael Baker
INTERNATIONAL

MEMORANDUM

To: Masood Jilani / Angela Bonfiglio **JN** 136628

From: John McCarthy

Date: July 10, 2015

Subject: SCR-3 Alternatives Analysis Supplementary Evaluation

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Purpose

A report titled "Santa Clara River Levee System (SCR-3) Alternatives Analysis, Summary Memorandum" was prepared by RBF Consulting (RBF), dated March 2014. The report identified and evaluated alternatives for the development of a levee and floodwall system along the SCR-3 project reach.

A public pre-scoping meeting was held for the project on June 4, 2014 in the City of Oxnard. The levee modification alternatives were presented at the meeting and feedback was obtained from those in attendance and subsequently via comments provided to the Ventura County Watershed Protection District (District). Upstream flood detention and attenuation techniques were identified at the meeting and in subsequent written comments submitted to the District as potential methods to provide flood protection in lieu of the proposed SCR-3 project alternatives. Similar comments were received at the public scoping meeting held March 4, 2015.

The purpose of this memorandum is to identify and evaluate the feasibility of utilizing upstream flood detention and attenuation techniques to obtain the same flood protection goals that would be provided by a levee and floodwall system along the SCR-3 project reach.

Upstream Flood Detention and Attenuation Techniques

During the pre-scoping and scoping meetings, the public requested that upstream flood detention and attenuation techniques be considered in lieu of constructing a levee and floodwall system along the SCR-3 project reach. The general goal of the techniques would be to reduce runoff flow rates and volume from the watershed so that additional flood protection along the SCR-3 project reach would not be required. The desired benefits of upstream flood detention and attenuation techniques are storm water retention to promote recharge of the underlying groundwater basin(s), preservation of existing undeveloped 100-year floodplain, preservation of existing riparian habitat, minimization of flood control structures such as levees and floodwalls along the south bank of the Santa Clara River, and recreational access.

The upstream flood detention and attenuation techniques can generally be classified into the following three approaches:

1. Upstream storm water detention
2. Low Impact Development (LID)
3. Natural floodplain attenuation

Prior to evaluating the alternatives, an overview of the Santa Clara River watershed is provided to understand the conditions and flood protection goals for the SCR-3 project.

The SCR-3 flood protection project is located on the lower reach of the river and extends from approximately 1,500 feet west (downstream) of Victoria Avenue to the upstream side of the Union Pacific Railroad (UPRR) crossing, a reach of 2 miles. The Santa Clara River is one of the largest river systems in Southern California that remains in a relatively natural state (Aqua TERRA 2009). The total watershed area tributary to the project reach is approximately 1620 square miles. Based on previous studies (Aqua TERRA 2009 and Stillwater 2007), the watershed is predominately undeveloped open-space with a developed area of less than 8% of the total watershed area (Figure 1).

The hydrologic analysis of the Santa Clara River watershed is summarized in the *Hydrology Modeling of the Santa Clara River Watershed with the U.S. EPA Hydrologic Simulation Program – FORTRAN (HSPF)* report (Hydrology Modeling study) prepared by Aqua TERRA Consultants (Aqua TERRA, 2009). The report calculated that the river has an estimated 100-year (1% chance) peak flow rate for the current (existing) watershed condition of 226,000 cubic feet per second (cfs) at the Highway 101 crossing, with a 24-hour storm runoff volume of 331,000 acre-feet. An illustration of the watershed area is shown in Figure 1a. The peak flow rates along the river and its major tributaries is shown in Figure 1b. It is important to note that the Sespe Creek and Santa Paula Creek tributaries are the major contributors (135,000 cfs and 38,000 cfs respectively) to the peak flow rates in the Santa Clara River and that these watershed remain in a substantially undeveloped condition.

The design flow rate for the improvements along the SCR-3 project reach was established to be 250,000 cfs to account for the potential effects of climate change and future development within the watershed. Hydraulic modeling of the river indicates that the existing system can convey a peak flow rate of approximately 175,000 cfs along the SCR-3 project reach before it begins to flood the developed overbank areas downstream of the UPRR crossing.

Based on this information, an evaluation was prepared for each of the three general watershed categories and is summarized below.

***Figure 1a**. Santa Clara River Watershed, Municipalities, and Major Waterbodies (Reference Aqua TERRA Consultants, 2009)*

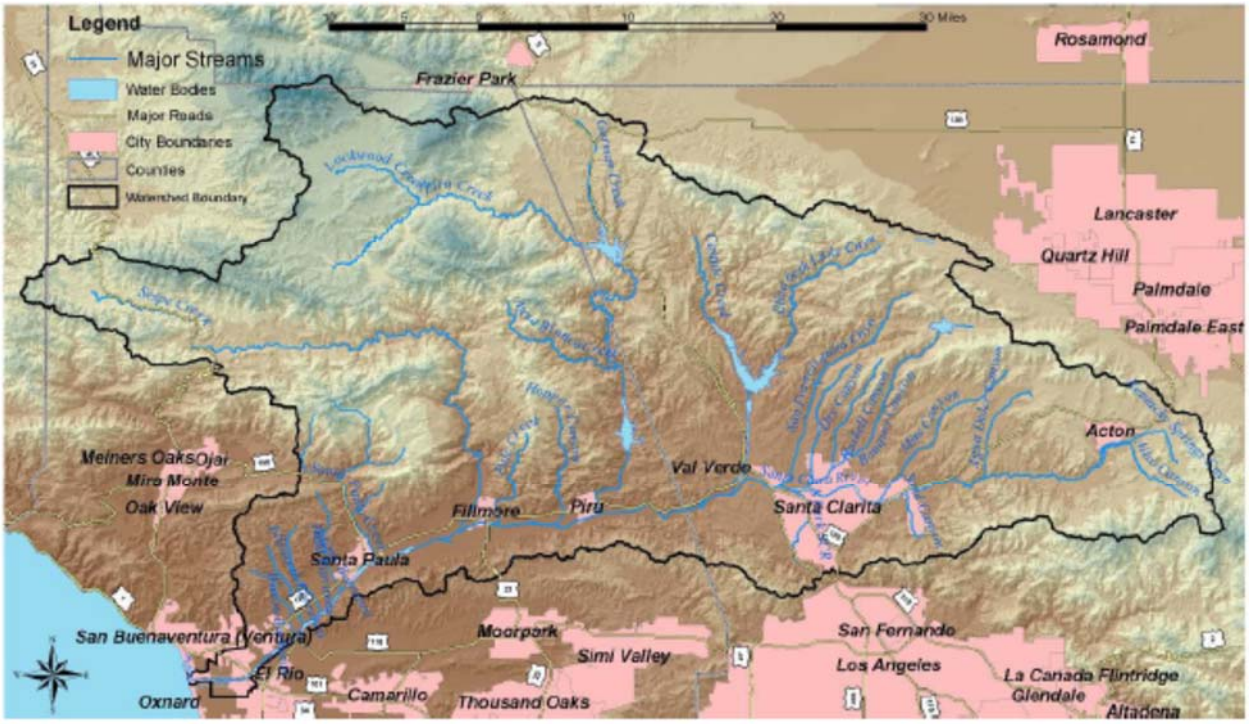
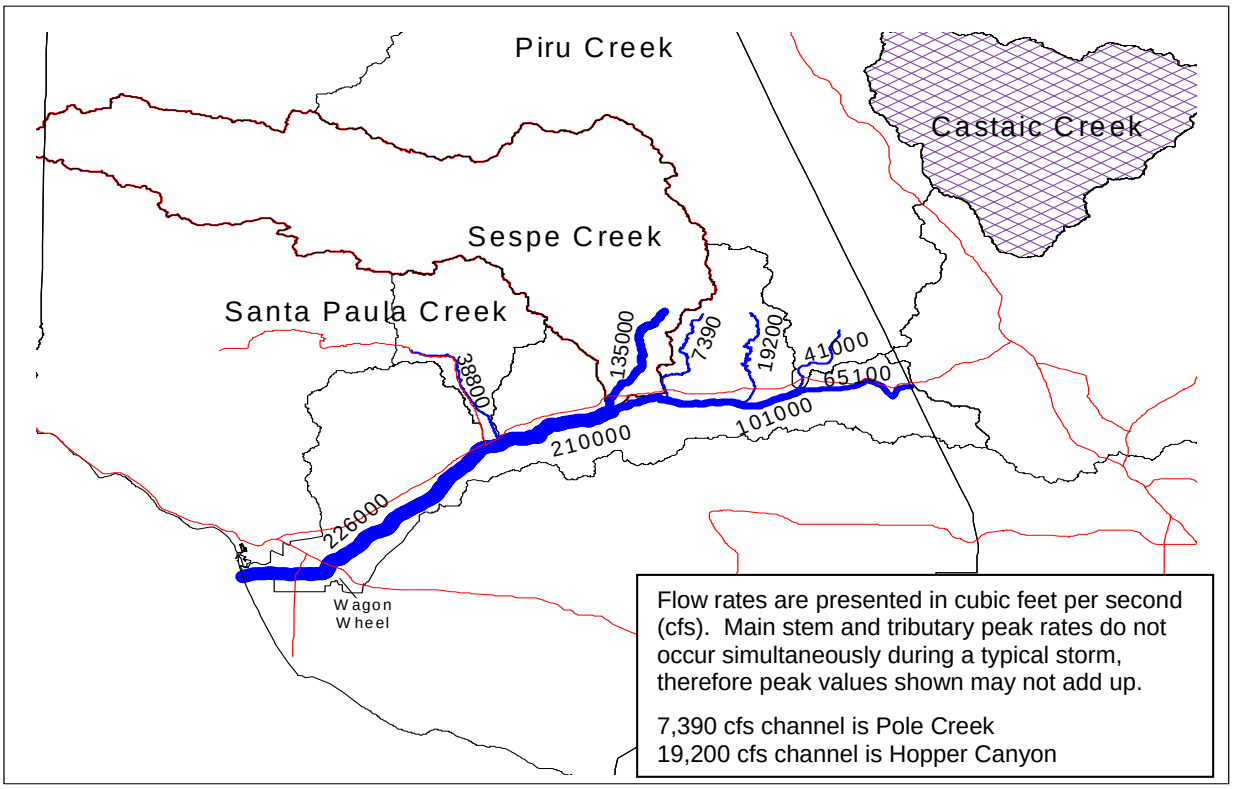


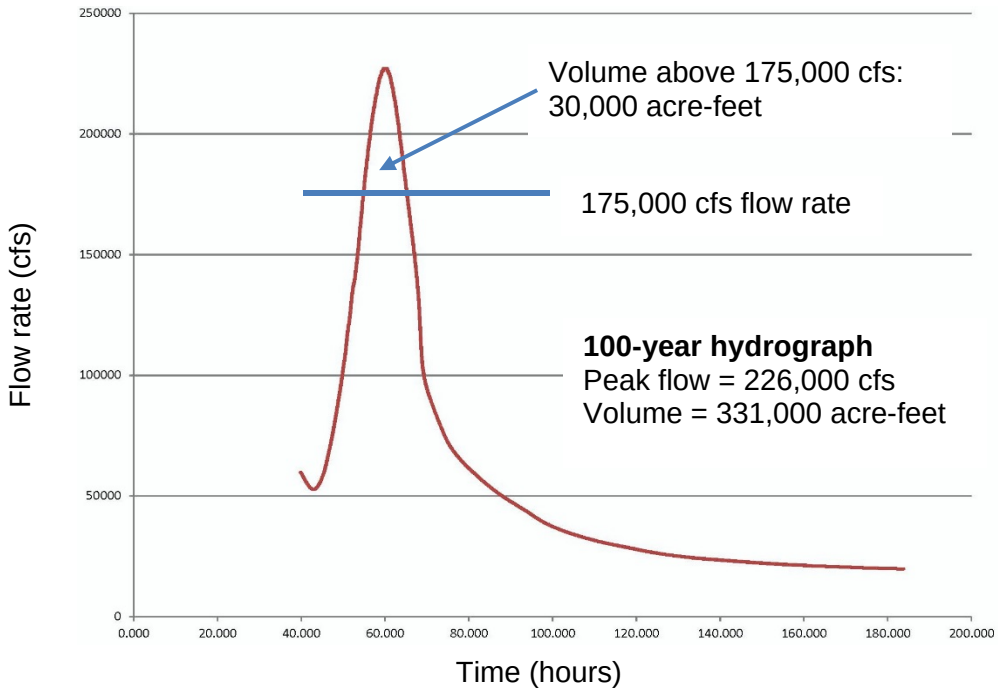
***Figure 1b**. Santa Clara River Watershed, Peak flow rates for mainstem and major tributaries*



Technique No. 1 – Upstream Detention Basins. This alternative for upstream storm water detention was identified as an approach to reduce the peak flow rates in the Santa Clara River to a level that would not require additional flood protection for the existing approximately 3,800 threatened structures along the SCR-3 project reach. Storm water detention basins could be placed on existing agricultural lands adjacent to the river.

A hydraulic analysis of the river along the SCR-3 reach was prepared using the HEC-RAS computer model to determine the maximum allowable flow rate. The model was run for the existing condition, and the peak flow rate was adjusted by trial and error to determine the maximum flow rate in the river that would not exceed the height of the existing river banks on the City of Oxnard (southerly) side of the river within the SCR-3 project reach. The maximum flow rate was determined to be 175,000 cfs. The 100-year peak flow rate for the river at this location is 226,000 cfs. Therefore, the storm water detention basins would be required to reduce the peak flow rate by about 51,000 cfs. The required volume of the detention basins was estimated by assuming that the storm runoff above 175,000 cfs could be diverted off of the river to an adjacent series of basins. The volume was then estimated from the 100-year storm hydrograph as the area above the flow rate of 175,000 cfs (Figure 2). The required storage volume was calculated to be approximately 30,000 acre-feet (less than 10% of the total storm runoff volume).

Figure 2*. Santa Clara River 100-year flood hydrograph at Highway 101 (Ref: Aqua TERRA 2009)*



Assuming a maximum depth of 10-feet, the required surface area for the basins would be in excess of 3,000 acres. Additional acreage would be required if the basins were allowed to grow and maintain vegetation for habitat restoration. Using a market value of $150,000 per acre for agricultural land, the estimated land cost alone is $450,000,000 (project design, permitting, mitigation, and construction costs

would need to be added to this value). This cost is more than 20 times the cost of the levee and floodwall alternatives. This alternative would also have significant impacts regarding the loss of agricultural land, and air and noise quality impacts associated with the necessary grading and export of over 5 million cubic yards (CY) of earthen material, as compared to 72,000 CY for the levee and floodwall alternatives. To ensure excess flows reach the detention basins from the Santa Clara River, a diversion and conveyance system would be required. Regulatory feasibility would be uncertain due to potential entrapment of federally endangered steelhead trout in this diversion and detention basin system. Additionally, it may be necessary to construct flood protection for this system of detention basins as they would likely be located within the Santa Clara River 100-year floodplain.

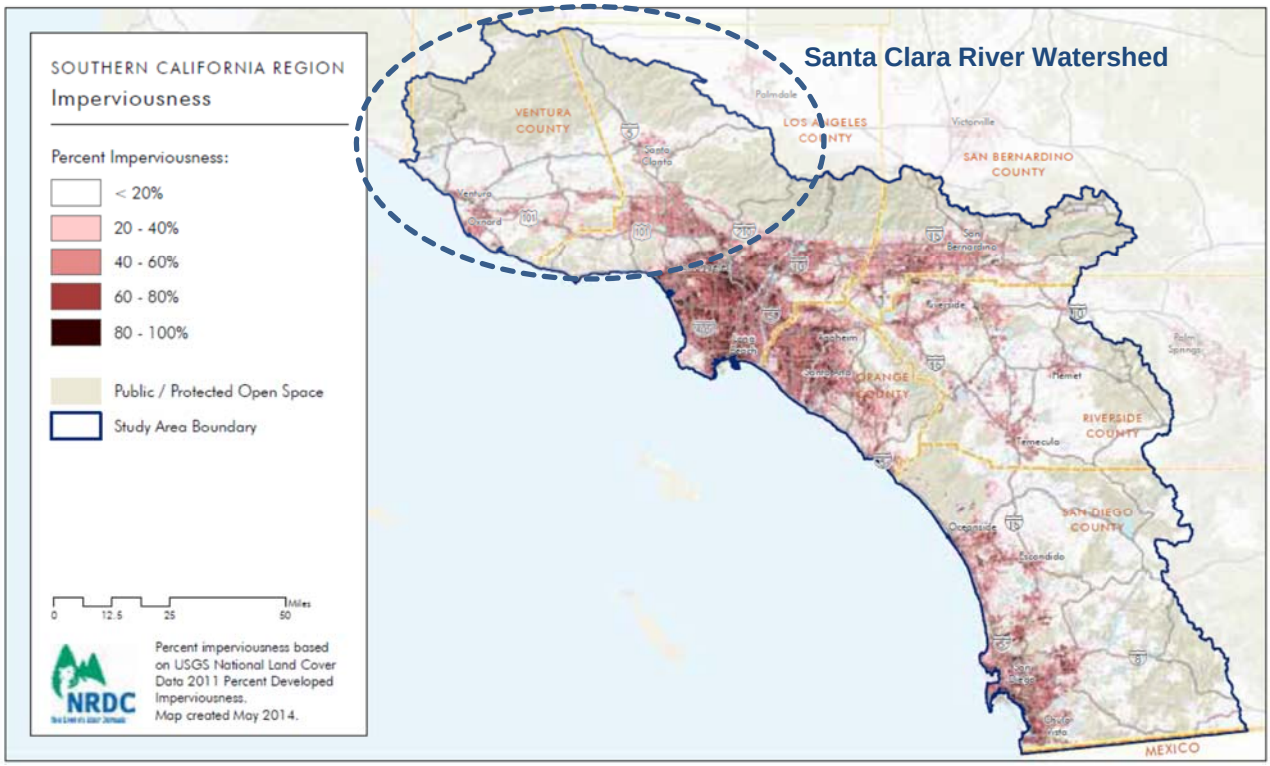
Finally, in the event of successive large flow events, the flood protection intended by detention basins could be minimized. For example, in 1969, a significant storm was documented January 18-22 and immediately followed by another from January 23-27. "During this [January 23-27] period, intense rainfall occurred which fell on watersheds soaked by the previous [January 18-22] storm, and resulted in record breaking runoff and severe flood damages over much of Ventura County" (Ventura County Flood Control District (VCFCD), 1969). If full detention basins cannot be emptied in time to receive runoff from a subsequent storm event generating flow greater than 175,000 cfs, residential, commercial, and public structures along the SCR-3 levee would remain vulnerable to flooding.

Because sediment transport in this steep, predominantly natural watershed can be substantial during large flood events, the detention basins would require periodic maintenance to remove accumulated sediments and preserve the flood capacity required to protect the structures along the SCR-3 levee. If riparian vegetation were to grow on these sediments, recurring mitigation would likely be required to offset its loss during sediment removal maintenance episodes. To avoid recurring mitigation costs, annual operations would include removal of all vegetation on the 3,000-acre basin.

Technique No. 2 – Low Impact Development. This approach was considered as a method to modify existing watershed development to reduce impervious areas and lower storm water runoff to mimic the existing (pre-development) conditions. As identified in Technique No. 1, the peak runoff in the river needs to be lowered by 51,000 cfs to avoid flooding impacts to the properties along the SCR-3 reach. Low impact development (LID) can be used as an effective method to reduce the impacts of a development project and attempt to mimic the natural hydrology of a watershed area. However, LID techniques are most beneficial for reducing peak runoff associated with development for the more frequent storms such as the 2-, 5-, and 10-year events. Planning for larger storm events (i.e. 100-year event being used for a levee system design) conservatively assumes that the ground conditions are mostly saturated as a result of preceding storm events. Therefore, LID methods to reduce impervious areas and promote infiltration are less effective in reducing runoff from developed areas since the ground conditions are assumed to be already saturated, cancelling their ability to provide flood storage during a 100-year event. As identified in previous studies, the majority of the watershed (92 percent) remains in a natural condition, therefore only a small portion of the watershed could potentially be re-converted to pervious areas.

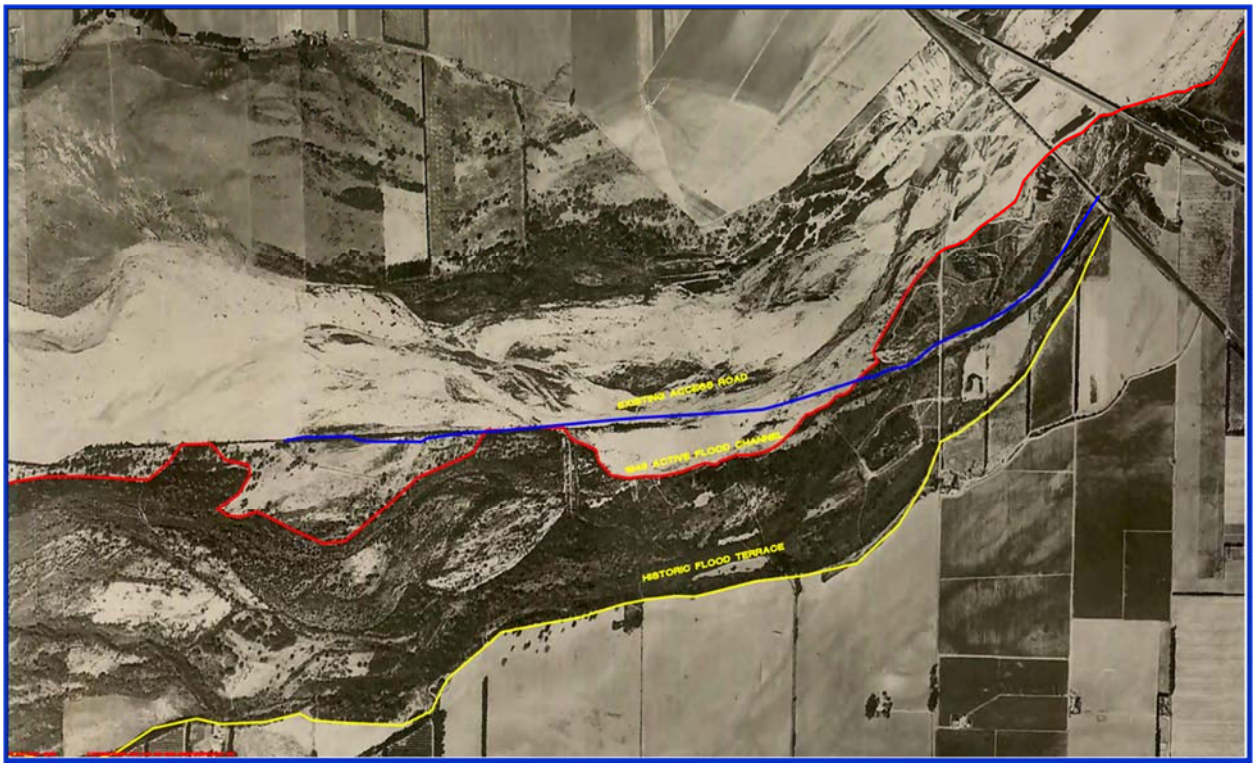
Figure 3 illustrates the percent of impervious cover within the watershed area and the Southern California region (Natural Resources Defense Council (NRDC), 2014).

Figure 3 *Map of impervious surface cover within the Southern California study area (Reference NRDC, 2014)*



The Santa Clara River has historically exceeded its meandering channel banks and flooded the Oxnard Plain along the project reach during larger storm events. Aerial photography from 1945 clearly shows an active flood terrace in the areas proposed to be protected by the SCR-3 levee system (Figure 4). The limits of the flood terrace are shown in yellow on the figure. The location of the SCR-3 project improvements is shown in blue. Watershed development within the Santa Clara River watershed at the time of the 1945 photograph was substantially less than it is currently; the developed area is only 8% of the total watershed area as of 2015.

***Figure 4**. Santa Clara River Profiles: 1945 (Reference: Ventura County Watershed Protection District)*

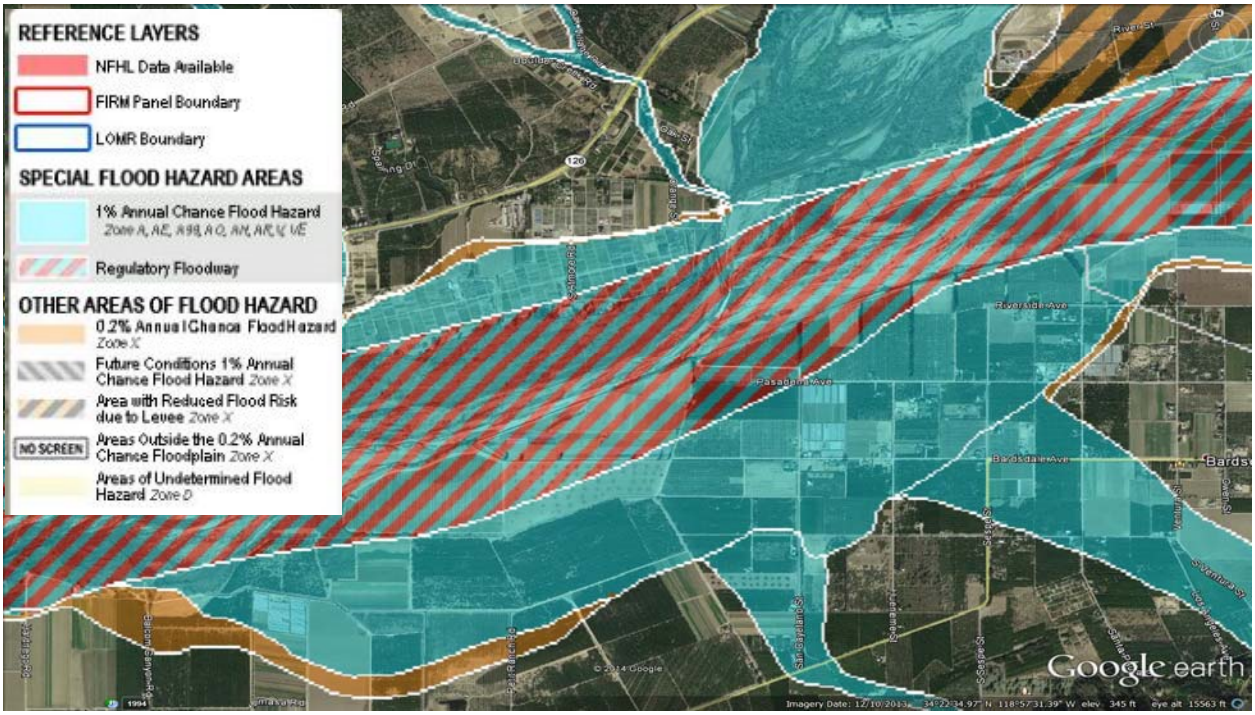


This information suggests that the Santa Clara River along the SCR-3 project reach has historically flooded its overbank areas during large storm events under pre-watershed development conditions, and that LID approaches to reduce or eliminate impervious areas within the watershed may have some limited impact on a reduction to the peak flow rate, but would not be sufficient to reduce the peak flow rates along the project reach to mitigate the existing flood hazard. Additionally, it is not reasonable to assume that all of the existing impervious surfaces within the watershed could be mitigated using LID techniques – particularly for the rare storm events associated with watershed scale flooding. Since the majority of the runoff in the river is from the natural undeveloped watershed areas as documented in the Hydrology Modeling study (Aqua TERRA, 2009), the use of LID techniques would not be sufficient to mitigate the existing flooding problems on the lower reaches.

Technique No. 3 – Natural Floodplain Attenuation. Studies have been completed on the natural and beneficial functions of floodplains. The concept is to allow a river's overbank areas (floodplains) to provide a natural benefit for peak flow attenuation and flood risk reduction through storage of runoff volume. The Santa Clara River currently benefits from this natural function by allowing the river to overflow its banks for much of the reach from the Ventura County line downstream to the Freeman Diversion structure. Many of the existing overbank areas along this reach are maintained as agricultural areas and allowed to flood during extreme events. A depiction of the FEMA 100-year floodplain along the river downstream of the City of Fillmore and the Sespe Creek confluence is shown in Figure 5. The light blue areas illustrate the approximate limits of flooding during a 100-year event on overbank areas outside the

river channel. It can be seen from this figure that these overbank areas are currently maintained as open-space and provide some natural flood attenuation.

***Figure 5**. Map of Santa Clara River floodplain and floodway below the Sespe Creek confluence (Reference FEMA FIRM Nos. 06111C0640E & 06111C0805E, effective January 20, 2010)*



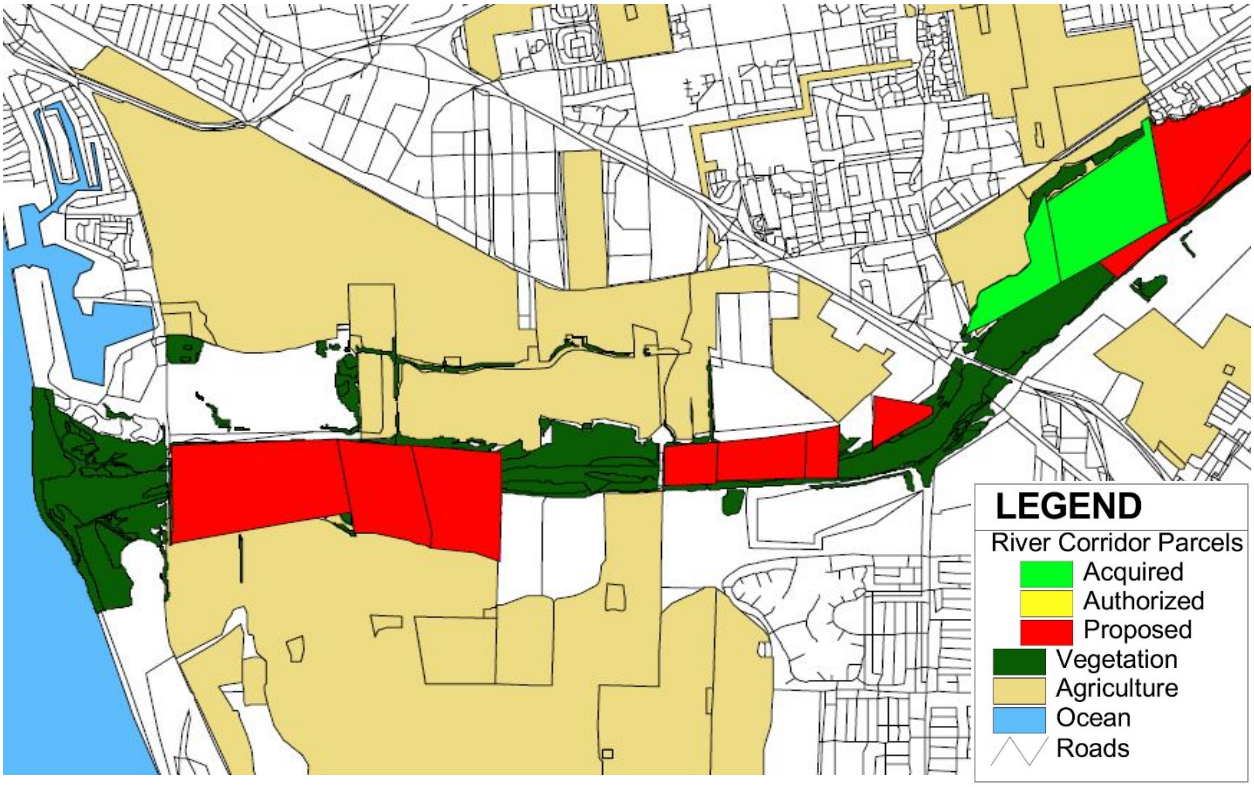
Preservation of these natural benefits upstream of SCR-3 will not address the current flood hazards along the lower reach of the river. However, it is important to note that these natural and beneficial functions must be protected to avoid having to construct additional structural improvements along the river in the future.

The California State Coastal Conservancy in conjunction with the Nature Conservancy (TNC), Friends of the Santa Clara River, private landowners, and local governments are working to identify and purchase key parcels along the Santa Clara River to help preserve these natural benefits. In 2009, the District, Ventura County Resource Conservation District, Farm Bureau of Ventura County, and TNC signed a Memorandum of Understanding (MOU) "to work together as the Steering Committee of the Ventura County Floodplain Conservation Working Group. In March 2013, the District and TNC signed a Memorandum of Agreement for Coordination of Land Protection and Habitat Restoration Activities in Ventura County. The floodplain along the Santa Clara River from the County line to the Pacific Ocean is shown in Figures 6a, 6b, and 6c along with the parcels currently preserved by TNC (Figures 6a-c appear at the back of this document). This includes two parcels purchased by the District and turned over to TNC (Figure 6a): one 42-acre parcel upstream of Victoria Avenue ($9,200 for purchase and $111,777 for long-

term management) and one nearly 100-acre parcel immediately upstream of and abutting Interstate 101 ($84,950 for purchase and $159,235 for long-term management).

The *Santa Clara River Parkway, Floodplain Restoration Feasibility Study* and the *Levee Setback Assessment of the Lower Santa Clara River, Ventura County, California – Implications for Flood Risk Management and Ecologic Benefit* prepared for the California State Coastal Conservancy (Stillwater, 2007 and Stillwater, 2011) identify floodplain overbank areas along the river proposed to be maintained for flood management and ecological benefit. The following exhibit from the Santa Clara River Parkway (Figure 7) illustrates the parcels in the vicinity of the SCR-3 project that have been purchased or are proposed to be purchased for flood hazard management and habitat preservation by the Coastal Conservancy. The proposed levee and floodwall alternatives are consistent with the recommendations in the Parkway plan for preservation of floodplain overbank areas.

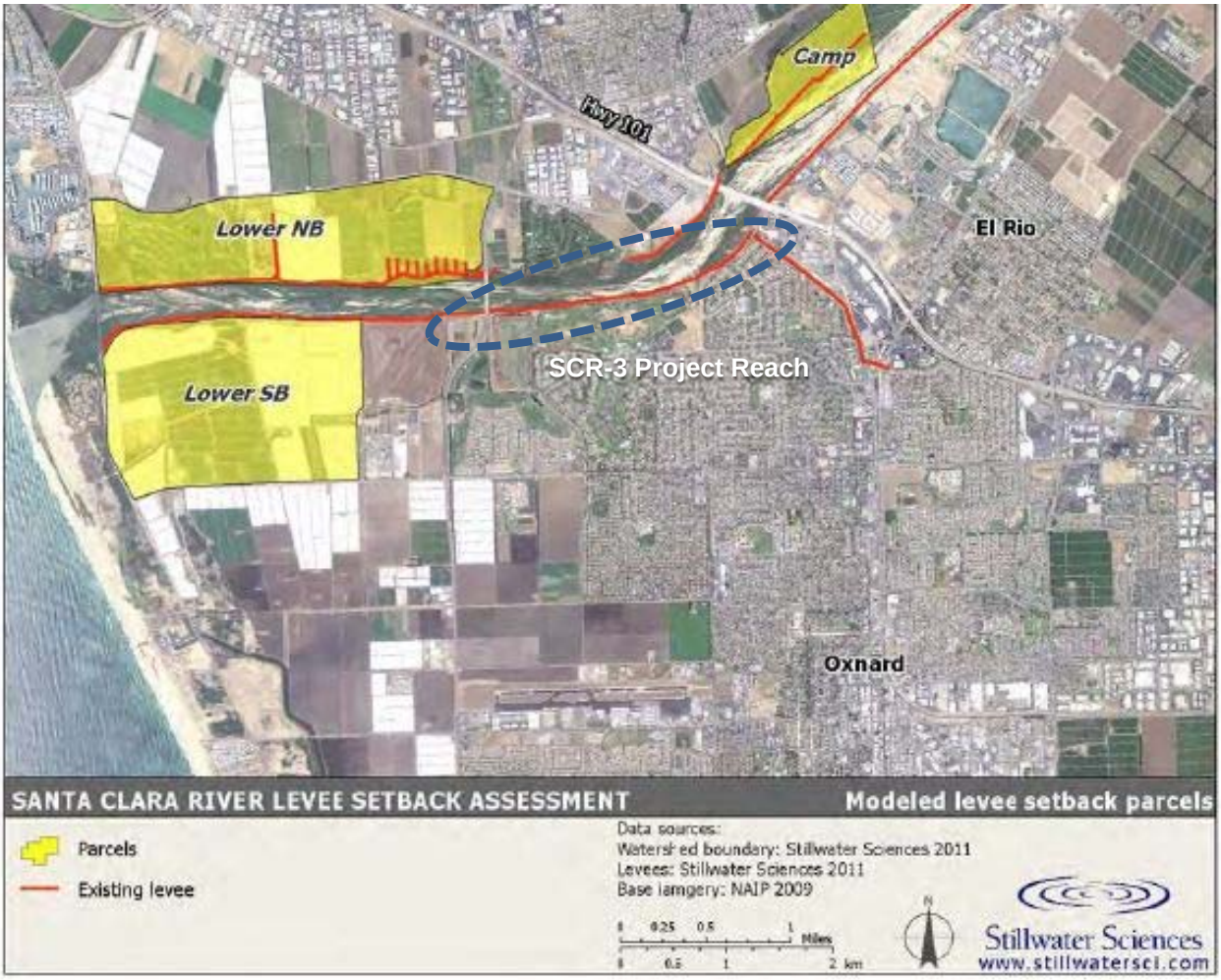
***Figure 7**. Santa Clara River Parkway – River Corridor Parcels*



The Levee Setback Assessment (Stillwater 2011) also evaluated locations along the lower Santa Clara River where levee setbacks were possible. The study investigated the potential benefits associated with levee setbacks during an extreme event (100-year flood) and a more frequent event (25-year storm). The results of the analysis identified potential setback areas along the Santa Clara River in the vicinity of the SCR-3 project location. The locations of the recommended setback areas (yellow shading) and the SCR-3 project reach are shown on Figure 8. These exhibits indicate that the proposed project to improve the conditions

of the existing levees along the SCR-3 project reach are consistent with the Santa Clara River Parkway planning efforts currently being implemented along the Santa Clara River.

***Figure 8**. Lower Santa Clara River Levee Setback Locations (Ref: Stillwater 2011)*



Note: El Rio Drain as shown on the Stillwater Sciences figure is not considered a levee system.

Summary

The results of this preliminary analysis and evaluation indicate that upstream flood detention and attenuation techniques would not be effective in addressing the current flood risk along the lower reaches of the river. The Santa Clara River is one of the largest river systems in Southern California that remains in a relatively natural state; therefore, modification of the existing development within the watershed is not sufficient to mitigate the existing flood hazard along the SCR-3 project reach. However, these techniques are an important consideration in the planning and construction of any new development within the Santa Clara River watershed. Unchecked development within the watershed would have the potential to increase impervious areas and encroach onto the natural river floodplain. These actions would increase storm water runoff and reduce the natural attenuation, potentially resulting in the need

for additional structural improvements to protect the existing downstream communities. The proposed SCR-3 project to improve the existing levee structures along the south bank of the Santa Clara River is consistent with current watershed scale planning for flood hazard management, habitat preservation, and ecological restoration along the Lower Santa Clara River.

References

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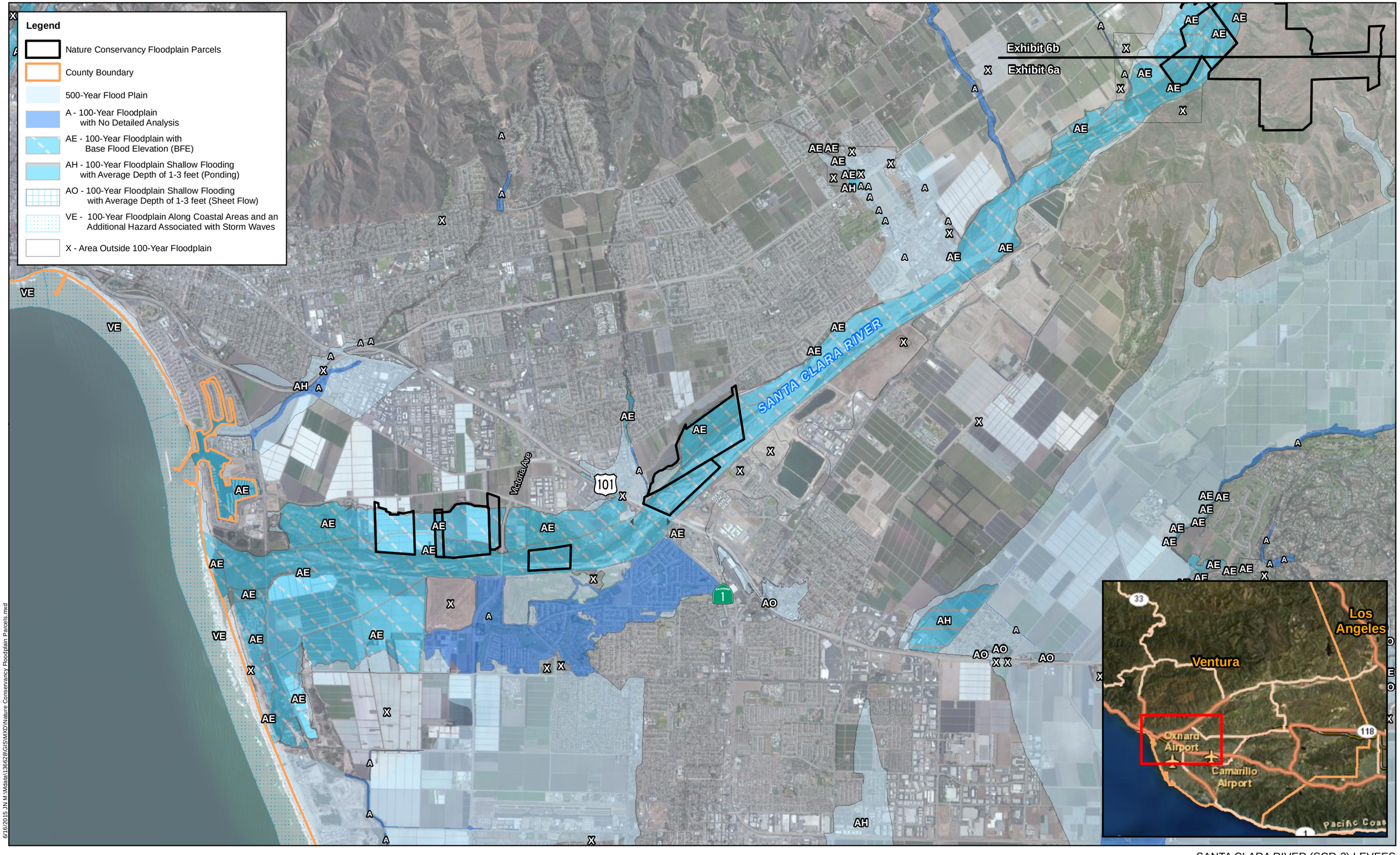

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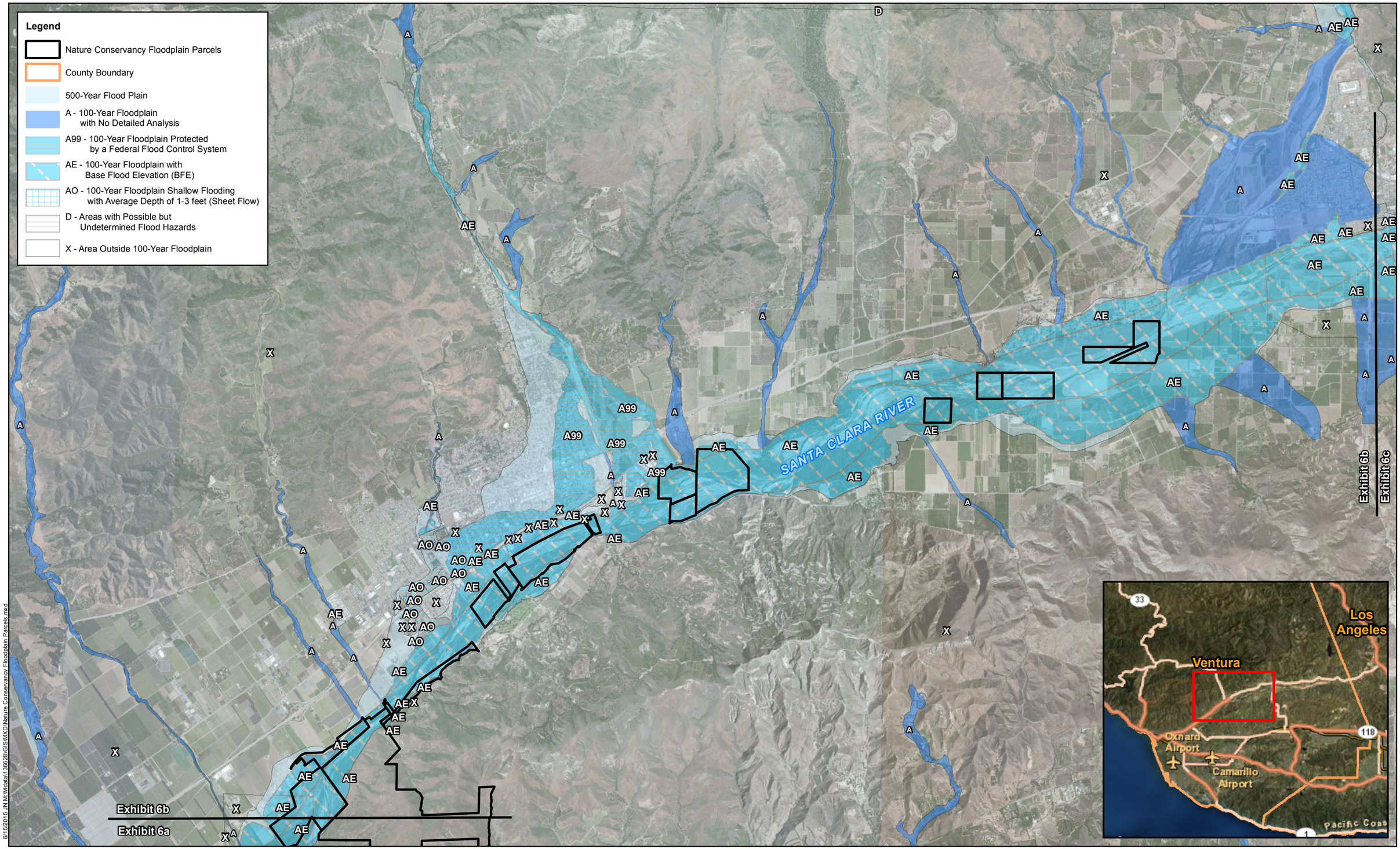
0 2,250 4,500 Feet

Source: FEMA 01/20/2010, ArcGIS Online

SANTA CLARA RIVER (SCR-3) LEVEES

Nature Conservancy Floodplain Parcels

Exhibit 6a



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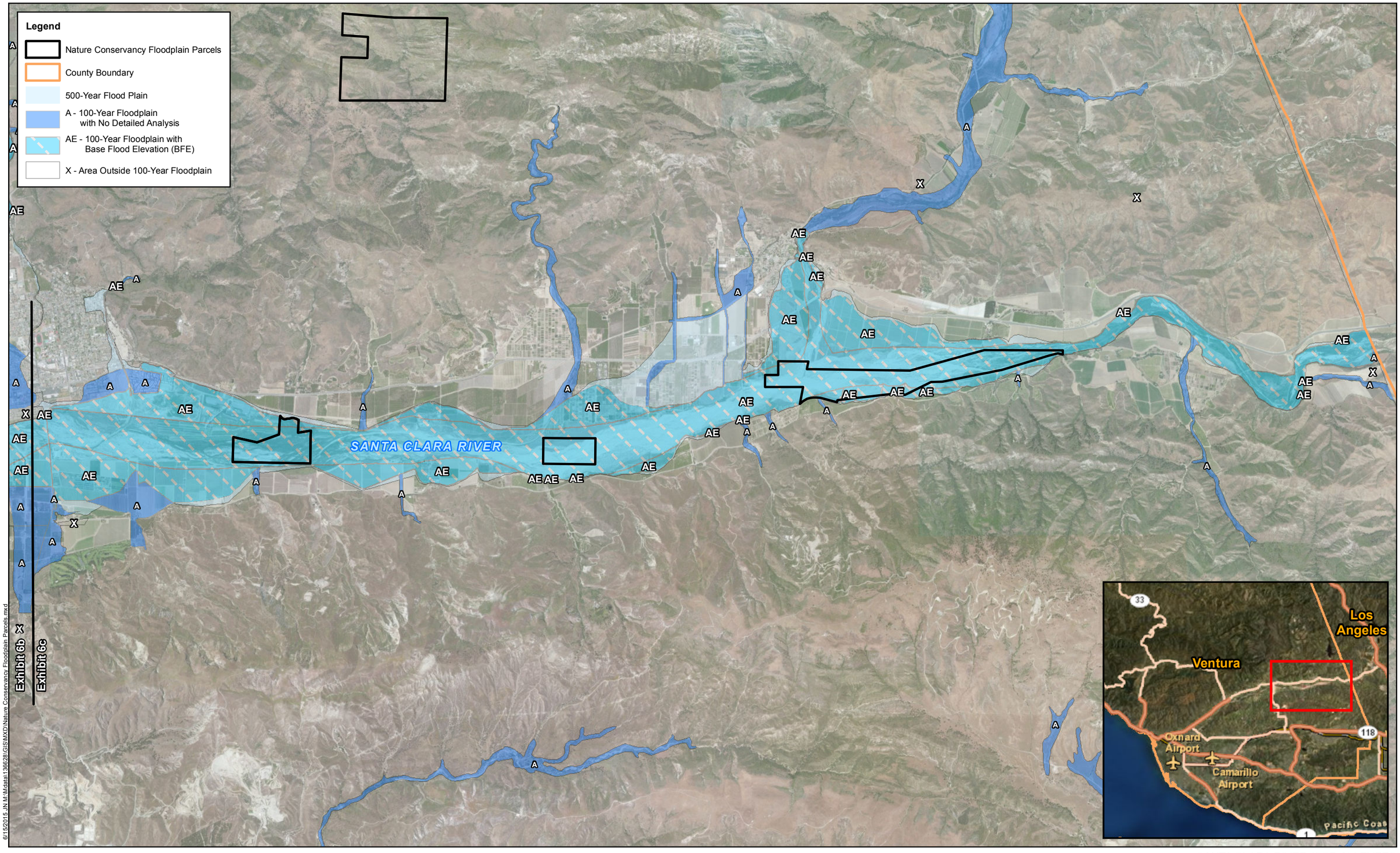
Source: FEMA 01/20/2010, ArcGIS Online

SANTA CLARA RIVER (SCR-3) LEVEES

Nature Conservancy Floodplain Parcels

Exhibit 6b



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Source: FEMA 01/20/2010, ArcGIS Online

SANTA CLARA RIVER (SCR-3) LEVEES

Nature Conservancy Floodplain Parcels

Exhibit 6c