

**SANTA ANA RIVER  
WASTE LOAD ALLOCATION  
MODEL UPDATE**

**TM-2: WLAM Update  
and Recalibration**

**DRAFT**

**PREPARED FOR:**

**Santa Ana Watershed Project Authority**

**April 13, 2018**

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## SANTA ANA RIVER WASTE LOAD ALLOCATION MODEL UPDATE

### TECHNICAL MEMORANDUM 2: WLAM UPDATE AND RECALIBRATION

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## APPENDIX

Ltr.	Description
A	Comments Received and GEOSCIENCE Responses for Draft WLAM TM-2 (19-Sep-2017)

### ACRONYMS, ABBREVIATIONS, and INITIALISMS

Abbrev.	Description
2004 WLAM	Waste Load Allocation Model Developed by WEI in 2002-2003 and included in the 2004 Basin Management Plan.
2008 WLAM	Waste Load Allocation Model Developed by WEI in 2008-2009. Note: Scenario 8 was completed in 2015.
2017 WLAM HSPF	Waste Load Allocation Model Developed by GEOSCIENCE as part of the current WLAM update (2018).
BMP	best management practice
cfs	cubic feet per second
CIMIS	California Irrigation Management Information System
CIWQS	California Integrated Water Quality System
CONS	HSPF section of Module RCHRES that simulates the behavior of conservative constituents (i.e., do not decay with time or leave RCHRES by any mechanism other than advection)
EMWD	Eastern Municipal Water District
ET	evapotranspiration
EVMWD	Elsinore Valley Municipal Water District
ft	feet
GEOSCIENCE	GEOSCIENCE Support Services, Inc.
GMZ	groundwater management zone
hr	hour
HSPF	Hydrological Simulation Program – Fortran

### ACRONYMS, ABBREVIATIONS, and INITIALISMS (continued)

Abbrev.	Description
IEUA	Inland Empire Utilities Agency
in.	inches
IQUAL	HSPF module that simulates water quality constituents (e.g., TDS/TIN) in the outflows from impervious land segments
LID	low-impact development
MWD	Metropolitan Water District
MWDOC	Metropolitan Water District of Orange County
MGD	million gallons per day
mg/L	milligrams per liter
MS4	municipal separate storm sewer system
NCDC	National Climatic Data Center
NPDES	National Pollutant Discharge Elimination System
NSE	Nash-Sutcliffe Efficiency
NWIS	National Water Information System
OCPW	Orange County Public Works
OCWD	Orange County Water District
POTW	publically owned treatment work
PQUAL	HSPF module that simulates water quality constituents (e.g., TDS/TIN) in the outflows from pervious land segments
QA/QC	quality assurance/quality control

### ACRONYMS, ABBREVIATIONS, and INITIALISMS (continued)

Abbrev.	Description
QUALIF	HSPF subroutine of PQUAL that simulates water quality constituents associated with interflow
QUALOF	HSPF subroutine of PQUAL that simulates water quality constituents associated with overland flow
R <sup>2</sup>	coefficient of determination (representing the goodness-of-fit)
RCFCWCD	Riverside County Flood Control and Water Conservation District
RCHRES	HSPF module that simulates the processes which occur in a single reach of open or closed channel
RFM	Recharge Facilities Model (operated by OCWD)
RIX	Rapid Infiltration and Extraction
RMSE	root mean square error
RP	regional plant
RQUAL	HSPF section of Module RCHRES that simulates the behavior of constituents involved in biochemical transformations (e.g., TIN)
RWAP	regional wastewater authority plant
RWQCP	regional water quality control plant
SAR	Santa Ana River
SAWPA	Santa Ana Watershed Project Authority
SBC	San Bernardino County
SBCFCD	San Bernardino County Flood Control District
SBVMWD	San Bernardino Valley Municipal Water District (also known as Valley District)

**ACRONYMS, ABBREVIATIONS, and INITIALISMS (continued)**

<b>Abbrev.</b>	<b>Description</b>
SCAG	Southern California Association of Governments
SNRC	Sterling Natural Resources Center
SSURGO	Soil Survey Geographic
Task Force	Basin Monitoring Program Task Force
TDS	total dissolved solids
TIN	total inorganic nitrogen
TM	technical memorandum
U.C.	University of California
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
Valley District	San Bernardino Valley Municipal Water District
WEI	Wildermuth Environmental, Inc.
WLAM	Waste Load Allocation Model
WMWD	Western Municipal Water District
WRF	water recycling facility or water reclamation facility
WRP	water reclamation plant
WWRF	wastewater reclamation facility
WWTP	wastewater treatment plant

### ACRONYMS, ABBREVIATIONS, and INITIALISMS (continued)

Abbrev.	Description
YVWD	Yucaipa Valley Water District

## **SANTA ANA RIVER WASTE LOAD ALLOCATION MODEL UPDATE**

### **TECHNICAL MEMORANDUM 2: WLAM UPDATE AND RECALIBRATION**

#### **1.0 INTRODUCTION**

##### **1.1 Purpose and Scope**

The tributaries of the Santa Ana River (SAR) begin in the San Bernardino, San Gabriel, San Jacinto, and Santa Ana Mountains. The tributaries merge with the SAR, which flows to the Pacific Ocean. The SAR Watershed includes portions of San Bernardino County, Riverside County, Orange County, and a small portion of Los Angeles County. SAR stream reaches and associated groundwater management zones (GMZs) are shown on Figure 1.

The Santa Ana Watershed Project Authority (SAWPA) and Basin Monitoring Task Force retained GEOSCIENCE Support Services, Inc. (GEOSCIENCE) to update the Waste Load Allocation Model (WLAM) by developing and calibrating a watershed model using the Hydrological Simulation Program - Fortran (HSPF) computer code. During the course of developing this watershed model, referred to as the 2017 WLAM HSPF, the previous WLAM boundary was also expanded to include additional reaches of the SAR within Orange County (see Figure 2 for the 2017 WLAM HSPF boundary). The 2017 WLAM HSPF will then be used to estimate the projected total dissolved solids (TDS) and total inorganic nitrogen (TIN) concentrations of the SAR recharge water and discharge at Prado Dam. This effort satisfies monitoring and analysis requirements in the Water Quality Control Plan for the Santa Ana River Basin (Basin Plan).

The scope of work for this WLAM update includes:

- Task 1 — Update the Data Used in the Waste Load Allocation Model (WLAM)
- Task 2 — Update and Recalibrate the WLAM
- Task 3 — Evaluate Waste Load Allocation Scenarios for Major Stream Segments
- Task 4 — Develop WLAM for Managed Recharge in Percolation Basins (cancelled)
- Task 5 — Estimate Off-Channel Recharge from Natural Precipitation
- Task 6 — Run the WLAM in Retrospective Mode, using Historical Discharge Data, to Estimate the Quantity and Quality of Recharge that Actually Occurred
- Task 7 — Compile the WLAM into a Run-Time Software Simulation Package

- Task 8 — Draft Task Reports, Draft and Final Report
- Task 9 — Monthly Project Meetings
- Task 10 — Pilot Evaluation of the Doppler Data Compared to Precipitation Gauge Data

A draft Technical Memorandum No. 2 (TM-2), summarizing the results of Task 2 – Update and Recalibrate the WLAM, was issued on September 19, 2017. This TM represents a revised draft that incorporates responses to comments received on the draft TM-2 (Appendix A).

## 1.2 Model Background

The TIN/TDS Task Force, consisting of representatives from water, wastewater, and groundwater agencies in the SAR Watershed, was established in 1995 to evaluate the impact of TDS/TIN on water resources. To do so, Wildermuth Environmental, Inc. (WEI) was contracted to perform a multi-phase TIN/TDS Study. Phase 1A of the study defined watershed hydrology and developed water quality objectives. Phase 1B evaluated analytical methodologies to investigate watershed hydrology. Phase 2A of the study was geared at developing a nitrogen loss rate for surface water recharge, developing a new monitoring plan, updating groundwater management zones and groundwater quality objectives, and estimating TIN/TDS concentrations in groundwater. Phase 2B included the development of a surface water WLAM and the Santa Ana Watershed Data Collection and Management Program.

Regional Basin Plans are required by the California Water Code (Section 13240) to protect the beneficial use of surface and groundwater resources within the basin, establish water quality objectives, and implement management plans to meet those objectives. The SAR Watershed Basin Plans include waste load allocations for discharges to the SAR. As part of the 2004 Basin Plan, WEI performed the waste load allocation analysis for both TIN and TDS using the surface water WLAM developed as part of the TIN/TDS Study Phase 2B (WEI, 2002 and 2003). Known as the 2004 WLAM, it was officially adopted into the Basin Plan by the California Regional Water Quality Control Board, Santa Ana Region (Regional Board) through Resolution No. R8-2004-0001. As of the date of this TM, the 2004 WLAM is the only WLAM to have gone through a formal review process and be approved by the Regional Board.

The 2004 WLAM is based on work conducted in the Chino Basin for the Chino Basin Watermaster, and uses in-house computer codes developed by WEI. These codes (RUNOFF and ROUTER) estimate surface runoff and route it through the watershed. TIN/TDS concentrations are also tracked by the computer codes using a water quality component. The 2004 WLAM was calibrated to observed streamflow and water quality data (TIN and TDS) for the period from Water Year 1995 through 1999. The calibrated model was then used to evaluate 50-year scenarios using future (2010) publically owned treatment work (POTW) discharge assumptions and hydrology from Water Year 1950 through 1999.

Shortly after the completion of the 2004 WLAM, the Basin Monitoring Task Force was established. As an extension of the TIN/TDS Task Force, the Basin Monitoring Task Force (hereafter referred to as “Task Force”) facilitates the implementation of Basin Plan Amendments and oversees the collection and evaluation of water quality data to ensure compliance with surface water and groundwater quality objectives. In 2008, the Task Force contracted with WEI to update the 2004 WLAM in order to account for changing plans and conditions in the watershed (e.g., land use). The 2008 WLAM was calibrated to observed streamflow and water quality data (TIN and TDS) for Water Years 1995 through 2006. Six 50-year scenarios (Water Years 1950 through 1999) were modeled with the calibrated 2008 WLAM for various future (2010 and 2020) discharge and Seven Oaks Dam operating assumptions. Following issuance of the 2008 WLAM model report (WEI, 2009), WEI was tasked with running an additional model scenario (Scenario 7) with the 2008 WLAM. When the Seven Oaks Dam operating assumptions were questioned, WEI ran another scenario (Scenario 8) with updated assumptions and hydrology from Water Year 1950 through 2012. The results of this scenario were presented in an addendum report to the 2008 WLAM (WEI, 2015). While the 2008 WLAM was submitted to the Regional Board for review, it was never formally approved.

In order to further update the WLAM, GEOSCIENCE constructed and calibrated the 2017 WLAM HSPF from October 1, 2006 through September 30, 2016 (Water Years 2007 through 2016). The 2017 WLAM HSPF was expanded from the existing 2008 WLAM model area to include additional reaches of the SAR within Orange County (see Figure 2). The development of the HSPF model and calibration process are discussed in the following sections.

## 2.0 WASTE LOAD ALLOCATION MODEL UPDATE

### 2.1 2017 WLAM HSPF Development

The 2017 WLAM HSPF area was divided into 568 sub-watersheds, including 526 sub-watersheds for the 2008 WLAM area and 42 sub-watersheds for the expanded model area (see Figure 3). Delineation of each sub-watershed was based on topography, drainage pattern, type of stream channel, and location of streamflow gaging stations.

Each sub-watershed consists of a stream segment and either pervious, impervious, or a combination both land surfaces. Sub-watersheds, or elements, are areas that are assumed to have similar hydrogeologic characteristics. They were created for the 2017 WLAM HSPF with the United States Environmental Protection Agency (USEPA) BASINS 4.1 program. The program segments the watershed into sub-watersheds and stream reaches using a delineation tool and a United States Geological Survey (USGS) 10-meter-by-10-meter digital elevation model (DEM), as well as user-specified outlet locations. The location of these outlets was based on the change in channel type (e.g., lined, unlined, etc.) and geography.

#### 2.1.1 Model Code

The 2017 WLAM HSPF uses the Hydrologic Simulation Program – Fortran (HSPF) computer code. This is different from the model computer code that was used for the 2004 and 2008 WLAMs. Benefits for migrating to the HSPF model code include:

- HSPF is a comprehensive and physically based watershed model that can simulate all water cycle and water quality components with a time step of less than one day. The simulated components include rain, vegetation interception, evaporation of rain, evapotranspiration from plants, infiltration of applied water into the upper soil zone, percolation to groundwater, interflow of water through the upper soil layer to a stream channel, stream channel losses to groundwater, and stream channel gains from groundwater. Figure 4 is a schematic diagram showing the water cycle component simulated by the HSPF.
- HSPF is supported and maintained by federal agencies. HSPF is jointly supported and maintained by both the USEPA and the USGS – a rare occurrence where two federal agencies agree on support of a single modeling system. HSPF has enjoyed widespread usage and acceptance since its initial release in 1980, as demonstrated through hundreds of applications across the United

States and abroad. This widespread usage and support has helped ensure the continued availability and maintenance of the code for more than two decades.

- HSPF has an established standard and guideline for model calibration (USEPA, 2000). The calibration process involves adjusting model parameters so that the model-simulated flow and water quality match observed data. The USEPA and its consultant have established model calibration performance criteria. In addition, typical and reasonable ranges of the model parameters are provided by the USEPA as a guideline for model calibration.
- HSPF is a windows-based interface with powerful pre- and post- processors. WinHSPF provides a windows-based interface for data input into the HSPF. WinHSPF also assists the user to view, understand, and modify the model representation of a watershed. In addition, the pre-processor included in the BASINS interfaces through GIS, allowing spatial data to be brought together easier. All HSPF software is free and includes comprehensive user's manuals<sup>1</sup>.

## 2.2 Data Needs for the 2017 WLAM HSPF

Watershed hydrologic modeling requires a variety of data to characterize the water balance and hydrologic processes that occur in a watershed. These data include:

- Land surface elevations,
- Soil types,
- Land use,
- Precipitation,
- Evaporation,
- Streamflow,
- Stream Channel Characteristics, and
- TDS and TIN concentrations.

Data for the construction and calibration of the 2017 WLAM HSPF were collected for the period from Water Year 2007 through 2016. Data collection and quality assurance/quality control (QA/QC) procedures are presented in TM-1 (refer to GEOSCIENCE, 2018). It was assumed that data from previous versions of the WLAM had already undergone a QA/QC process. Therefore, these prior data (which will be used for model simulations) were not reevaluated.

<sup>1</sup> The User's Manual for Hydrological Simulation Program – Fortran (HSPF) is available from the USEPA's National Service Center for Environmental Publications at: <https://www.epa.gov/nscep>.

### 2.2.1 Land Surface Elevations

Land surface elevations were obtained by using a USGS 10-meter-by-10-meter DEM in ESRI ArcMap 10. The DEMs are used to evaluate surface water runoff patterns, and in turn to delineate the watershed and sub-watershed boundaries.

### 2.2.2 Soil Types

Soil type and distribution affects infiltration, surface runoff, interflow, groundwater storage, and deep groundwater losses. Information on both type and distribution of soil types in the study area is available from an ESRI shapefile of Soil Survey Geographic (SSURGO) Database hydrologic soil group information (Soil Survey Staff et al., 2011) (see Figure 5). There are four basic types of soils under this classification system (Group A through D), which are based on soil texture and properties. SSURGO describes each type as the following:

- Group A soils have a high infiltration rate (low runoff potential) when thoroughly wet. They consist mainly of deep, well drained to excessively drained sands or gravelly sands and have a high rate of water transmission. Examples include sand, loamy sand, or sandy loam types of soils.
- Group B soils have a moderate infiltration rate when thoroughly wet. They consist mainly of moderately deep or deep, moderately drained soils that have moderately fine texture to moderately coarse texture and have a moderate rate of water transmission. This includes the silt loam and loam soils.
- Group C soils have a slow infiltration rate when thoroughly wet. They consist mainly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. They have a slow rate of water transmission. The predominant soil in this group is a sandy clay loam.
- Group D soils have a very slow infiltration rate (high runoff potential) when thoroughly wet. They consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. Therefore, they have a very slow rate of water transmission. This includes clay loam, silty clay loam, sandy clay, silty clay or clay type soils. Bedrock is also included in this group due to its very low infiltration rate.

A relative infiltration rate is associated with each soil group, ranging from soils with a high infiltration rate characteristic of coarser sediments (Group A) to a very low infiltration rate characteristic of finer grained materials (Group D). Each sub-watershed is given an average infiltration index based on the

percentage of the various soil types within its borders. The infiltration rate was assigned initially based on the calculated infiltration index and adjusted during model calibration. Table 1 shows the initial and model-calibrated infiltration rates for each sub-watershed.

### 2.2.3 Land Use

Land use and development affect how water enters or leaves a system by altering infiltration, surface runoff, runoff location, degree of evapotranspiration, and where water is applied in the form of irrigation. Since the 2017 WLAM HSPF period covers water years 2007 through 2016, 2012 land use information from Southern California Association of Governments (SCAG) was used to locate and designate areas as being pervious or impervious within the model boundary during the simulation period (see Figure 6). Six main land use categories were used for the purpose of identifying perviousness:

- Agriculture/Golf Course/Parks,
- Commercial/Industrial/Public Facility<sup>2</sup>,
- Open Space/Dry Agriculture/Water Body,
- Residential Low Density,
- Residential Medium Density, and
- Residential High Density.

The 2012 acreages of each land use category are shown in Table 2.

The land use category determines to what degree areas are pervious or impervious. Even urban areas are assumed to have a percentage of perviousness associated with them (i.e., landscaping). The assumed pervious percentages in the 2017 WLAM HSPF were taken from an Aqua Terra modeling study conducted in Ventura County (Aqua Terra, 2005). These pervious percentages also fall within the ranges suggested by the Riverside County Flood Control and Water Conservation District (RCFCWCD) and San Bernardino County (SBC) Hydrology Manuals (RCFCWCD, 1978; Williamson and Schmid, 1986). Table 2-1 below summarizes the pervious percentages for different land use categories. The recommended percentages from the RCFCWCD and SBC Hydrology Manuals, as well as those used in the 2004 and 2008 versions of the WLAM, are included for comparison.

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<sup>2</sup> Agricultural processing was assigned as “industrial” for the purpose of assigning a pervious percentage.

**Table 2-1. Assumed Pervious Percentages for Land Use**

Land Use Category	% Pervious				
	RCFCWCD	SBC	2004 WLAM	2008 WLAM	2017 WLAM HSPF
Agriculture/Golf Courses/Parks	90-100	75-100	95-98	98-100, 20 <sup>1</sup>	<b>100</b>
Open Space/Dry Agriculture/Water	90-100	100	98-100	98	<b>100</b>
Commercial/Industrial/Public Facilities	0-20	0-20	0-100	10	<b>20</b>
Residential Low Density	75-90	75-95	60	70	<b>90</b>
Residential Medium Density	55-70	50-80	40	50	<b>50</b>
Residential High Density	10-55	10-65	20	25	<b>40</b>

<sup>1</sup> 20% pervious area used for parks and schools

#### 2.2.4 Precipitation

Precipitation data is available from a multitude of precipitation gaging stations within the 2017 WLAM HSPF model boundary. As discussed in TM-1 (GEOSCIENCE, 2018), daily precipitation was collected from over 81 stations. However, many of the precipitation stations showed large data gap periods or were no longer active – in some cases having ceased data collection many years ago. Rather than interpolate precipitation data for the missing periods, only 19 of the evaluated stations were ultimately chosen based on the completeness of their record (greater than 95% complete). The locations of these stations are shown on Figure 7. While this resulted in fewer precipitation stations than those used in previous versions of the WLAM (43 precipitation stations were used in the 2004 and 2008 WLAMs), it provided a more complete data set that required fewer assumptions for days with missing data. For the few days for which data were missing in the 2017 WLAM HSPF precipitation data set, daily precipitation was estimated based on the correlation (ratio) of average annual precipitation at the station in question to average annual precipitation at the San Bernardino County Hospital gage (2146AUTO). The San Bernardino County Hospital gage was selected for its complete data set. The ratio correlating precipitation at the gage with missing data and the San Bernardino County Hospital gage and was then used to calculate the missing day(s) of precipitation based on the reading at the San Bernardino County Hospital gage.

In order to distribute the observed daily precipitation from the 19 precipitation stations throughout the model domain, precipitation adjustment factors were developed based on long-term average annual precipitation. Gridded historical average annual precipitation from 1981 through 2010 was used from

the PRISM Climate Group (2017), which covers a variety of hydrologic conditions (i.e., wet, dry, and average). These long-term average contours also account for increased precipitation at higher elevations and allows for the application of higher precipitation in mountainous sub-watersheds instead of relying on direct values from precipitation stations in valley areas. The process of calculating the precipitation adjustment factors for each sub-watershed involved the following steps:

- An average annual precipitation value was calculated for each sub-watershed based on isohyetal contours of gridded PRISM historical average annual precipitation (1981-2010) in the 2017 WLAM HSPF area (see Figure 7).
- The average annual precipitation value from the isohyetal contours was noted for each precipitation station.
- The average annual precipitation values within each sub-watershed were compared to the average precipitation at each precipitation station. The station with an average annual precipitation value closest to that at individual sub-watersheds in the vicinity was used to assign daily values (typically coinciding with Thiessen polygon boundaries).
- A precipitation adjustment factor was then calculated by dividing the average annual precipitation value for each sub-watershed by the average precipitation value of the station that was designated as being the closest match in terms of long-term average precipitation (from PRISM isohyetal contours).
- Historical daily precipitation values for each station were then multiplied by the precipitation adjustment factor to determine daily precipitation within each sub-watershed.

Precipitation adjustment factors and designated precipitation stations are shown on Figure 7. As an example, the average PRISM precipitation for Sub-Watershed A-71, located just southwest of the Indian Hills precipitation station (#265), is 9.86 inches. The average PRISM precipitation at the Indian Hills station is 10.44 inches. This results in a precipitation adjustment factor of 94% ( $9.86 \text{ inches} / 10.44 \text{ inches} = 0.94$ ). Therefore, daily precipitation for Sub-Watershed A-71 represents 94% of the daily precipitation recorded at the Indian Hills gage (on 3/8/16, 0.42 inches of precipitation were recorded at Indian Hills gage and 0.39 inches were applied to Sub-Watershed A-71).

### 2.2.5 Evapotranspiration

Evapotranspiration (ET) represents a significant outflow term and is included in the 2017 WLAM HSPF using the following methodology:

- Monthly average reference ET (ET<sub>o</sub>) was collected for California Irrigation Management Information System (CIMIS) ET<sub>o</sub> Zones 6, 9, and 14 (refer to Figure 8 for zone locations).
- Hourly ET rates were collected from CIMIS stations at the University of California, Riverside (UC Riverside #44; data available from 6/2/1985) and Pomona (Pomona #78; data available from 3/14/1989), located in CIMIS Zones 6 and 9, respectively. The locations of these evaporation stations are also shown on Figure 8. Assumed values for missing hourly data were calculated based on average daily ET at that station or interpolated from recordings on either side of the missing data.
- Adjustment factors were developed for ET<sub>o</sub> Zones 6 and 9 based on average annual ET rates and data from the CIMIS ET stations. The adjustment factor is equal to the ET<sub>o</sub> Zone average annual ET divided by the CIMIS station average annual ET.
- The adjustment factors were then used to apply hourly ET rates from the CIMIS station in a given zone to each sub-watershed within that same zone (ET for a given sub-watershed = corresponding ET<sub>o</sub> Zone CIMIS station hourly ET x adjustment factor). Hourly ET rates were also developed for sub-watersheds within CIMIS ET<sub>o</sub> Zone 14 based on the monthly average reference ET for that zone. For CIMIS Zone 14, daily evapotranspiration values were assumed to be constant within each month.

## 2.2.6 Streamflow

### 2.2.6.1 External Inflow

External inflow into the model area is represented by streamflow from tributaries flowing into the 2017 WLAM HSPF area. The amount of streamflow was quantified based on daily historical gaged data. Figure 9 shows the location of these gaging stations, located in Cucamonga, Lytle, Cajon, Devil Canyon, East Twin, City, Plunge, Mill, Carbon, and Santiago Creeks.

Streamflow from Seven Oaks Dam outflow (i.e., Santa Ana Canyon) to the SAR is also one of the external sources of streamflow for the 2017 WLAM HSPF. These discharges were accounted for in the gaged streamflow at the downstream Santa Ana River near Mentone, CA gage. Conversations with the San Bernardino Valley Municipal Water District (Valley District) have indicated that for now, the existing control manual (covering discharges) is the underlying assumption for future conditions. However, it should be noted that the United States Army Corps of Engineers (USACE) does not always follow formal operating rules and there is no way to predict these deviations in 2017 WLAM HSPF future model scenarios (this will be discussed in the predictive scenarios TM). The same is true of operations at Prado Dam.

### 2.2.6.2 Discharges

Wastewater discharge from POTWs represents a significant source of streamflow in the 2017 WLAM HSPF area. Wastewater facilities within the model area that discharge into the SAR and its tributaries include:

- Beaumont Wastewater Treatment Plant (WWTP),
- Carbon Canyon WRF,
- Colton WWTP,
- Corona WWTP,
- Eastern Municipal Water District (EMWD) Regional Water Reclamation Facilities (WRFs),
- Elsinore Valley Municipal Water District (EVMWD) Regional Wastewater Reclamation Facility (WWRF),
- IEUA Regional Plants (RPs),
- Rialto WWTP,
- Riverside Regional Water Quality Control Plant (RWQCP),
- San Bernardino/Colton Rapid Infiltration and Extraction (RIX) Facility (including direct discharges during extreme wet weather conditions),
- San Bernardino Water Reclamation Plant (WRP),
- Temescal Valley WRF (formerly Lee Lake Water District WWTP),
- Western Riverside County Regional Wastewater Authority Plant (RWAP), and
- YVWD Henry N. Wochholz Water Recycling Facility (WRF).

Additional discharges incorporated in the 2017 WLAM HSPF include:

- San Bernardino Geothermal Plant,
- Arlington Desalter, and
- OCWD's turnout OC-59.

Historically, Valley District has also operated a dewatering discharge of approximately 6.3 cfs. While this discharge was included in the 2008 WLAM, no dewatering discharges were made by Valley District during the 2017 WLAM HSPF calibration period. The same is true of Lake Elsinore storm water discharges. Discharge locations are shown on Figure 10 and average monthly discharges are provided in Table 3.

### 2.2.6.3 Stormwater Recharge

Streamflow diversions for stormwater recharge were accounted for in the 2017 WLAM HSPF by removing stormwater recharge volumes from the streamflow in the channel. Monthly stormwater recharge values were provided by the Chino Basin Watermaster. Daily stormwater recharge (and therefore diversion) was assumed to be constant within each month. Recharge basin locations are shown on Figure 11.

### 2.2.6.4 Prado Wetlands

The Prado Wetlands, operated by OCWD, receives approximately fifty percent (50%) of SAR discharge (up to 100 cfs). This water is diverted into a series of wetland ponds for the removal of nitrate and other pollutants and flows out of the ponds into Chino Creek. In order to account for additional ET losses that occur for river flows diverted through these ponds, a separate, discrete impoundment was created for the 2017 WLAM HSPF using a spreadsheet model.

The OCWD Prado Wetlands spreadsheet model was developed based on the pond schematic and descriptions provided by OCWD. Inflow into the wetlands through the SAR diversion channel represents 50% of model-calculated flow in the SAR at the diversion point, up to 100 cfs. Flow is then routed through the wetland ponds by the spreadsheet model through a series of weirs and channels according to the flow diagram provided as Figure 12. The spreadsheet model tracks pond storage and flow depending on the elevation of each pond zone and outflow weir. Model-calculated flow from the spreadsheet model is added into the 2017 WLAM HSPF at the discharge location in Chino Creek.

Limited percolation is thought to occur in the wetland ponds due to the presence of fine-grained sediments<sup>3</sup>. Therefore, percolation in the Prado Wetlands spreadsheet model was assumed to be zero. Los Angeles County pan evaporation rates from Puddingstone Reservoir were used to calculate ET in the wetlands for freshwater marsh and open water habitat, according to the method outlined in the “Evaporation Analysis of the Prado Basin, Santa Ana River, California” by Merkel & Associates, Inc. (2007). The spreadsheet model was run for the period from Water Year 1995 through 2016 to avoid artificial, transient effects from initial filling of the model prior to the 2017 WLAM HSPF model calibration period (Water Year 2007 through 2016).

<sup>3</sup> Greg Woodside (Executive Director of Planning and Natural Resources, OCWD), personal communication.

#### 2.2.6.5 OCWD Operations at and below Prado Dam

Within the expanded 2017 WLAM HSPF model area in Orange County, the OCWD Recharge Facilities Model (RFM) was used to account for operations at Prado Dam and OCWD diversions from the SAR to recharge spreading facilities in the cities of Anaheim and Orange. The RFM was created by CH2M Hill using GoldSim software (CH2M Hill, 2009). GoldSim is a software developed by GoldSim Technology Group for simulating complex systems in engineering, business, and science through a series of user-defined equations and data input into a visual spreadsheet. GoldSim is capable of performing dynamic, probabilistic simulations and predicting system responses to changing conditions. The OCWD RFM incorporates OCWD operational practices and was calibrated to available diversion, storage, and percolation data from July 2002 through June 2008. CH2M Hill provides a full overview of the model in their 2009 OCWD RFM technical memorandum.

The 2017 WLAM HSPF and the RFM were used in a two-way coupling fashion. The RFM is used only as an accounting tool to track diversions from the SAR and does not estimate runoff from adjacent land areas. Therefore, the 2017 WLAM HSPF was run to calculate local run-off in the watershed areas upstream of and surrounding the stretch of the SAR for which the RFM operates (Reach 2 of the SAR, shown in green on Figure 13). This model-calculated runoff, along with Prado Dam calculated inflow, was used as RFM input. The RFM was then run to calculate diversions to OCWD recharge spreading facilities and discharge at the RFM outlet (see Figure 13). The 2017 WLAM HSPF was then run to calculate run-off in the watershed area below the RFM (area shown in gray on Figure 13) and streamflow at the SAR at Santa Ana gage, using the RFM-calculated discharge as inflow.

#### 2.2.7 Stream Channel Characteristics

As part of the 2012 Basin Plan amendment for bacteria standards, the Counties were required to submit information on channel characteristics to the Regional Board. These stream channel characteristics (e.g., lined or unlined) were used to determine the degree to which streamflow is able to infiltrate in stream reaches within the model area. Figure 11 shows stream channel types. The type of stream channel for each stream reach segment was analyzed to determine the hydraulic behavior through the use of an FTABLE (hydraulic table). FTABLEs determine the infiltration volume of stream reaches by using the HSPF best management practice (BMP) Toolkit created by the USEPA, which takes into account the lining type, slope, Manning's Roughness Coefficient (used for flow calculations), and the length of the stream reach. Each sub-watershed was assigned model parameter values based on the available data in the area. Where stream segments are unlined, the assigned streambed percolation rate was adjusted during model calibration.

### 2.2.8 Rising Water

Rising water discharges to the SAR at Riverside Narrows and in the vicinity of Prado Basin (refer to Figure 14 for locations). A recent study by WEI (2017) has also identified rising water in Temescal Creek upstream of the Main Street gage. In natural systems, the amount of rising water fluctuates depending on groundwater elevations relative to stream stage. Since groundwater elevation was not modeled by the 2017 WLAM HSPF, discharge from the groundwater system to the surface water system in the form of rising groundwater was not automatically modeled in response to water levels. Rising water was accounted for in the 2017 WLAM HSPF in two ways. In Temescal Creek upstream of the Main Street gaging station, an assumed flow with associated TDS/TIN concentrations was added to the watershed model, based on the Salt and Nutrient Management Plan for the Upper Temescal Valley (WEI, 2017). This flow is shown on Figure 15. TDS and TIN concentrations of rising water are discussed in Section 2.2.9.3.

In the 2017 WLAM HSPF, rising water in the SAR upstream of MWD Crossing was based on model-calculated rising water from the WRIME groundwater flow model for the Riverside-Arlington Groundwater Basin (WRIME, 2010; currently being updated by GEOSCIENCE as part of the Integrated SAR Model). Rising water in the vicinity of Prado Basin was based on model-calculated rising water from the Chino Basin groundwater flow model developed by GEOSCIENCE in 2014. In order to account for this model-calculated flow, streambed percolation was adjusted so the model can closely simulate the observed flow in the SAR at MWD Crossing and at Prado Dam. The amount of rising water modeled at Riverside Narrows and Prado vicinity is shown on Figures 16 and 17, respectively.

The approach of modifying streambed percolation in the 2017 WLAM HSPF to effectively reproduce the amount of rising water seen in groundwater flow modeling results represents a significant departure from previous versions of the WLAM. Both the 2004 WLAM and 2008 WLAM treated rising water as an additional flow source by assigning an assumed flow rate and concentration into the surface water model at the location of rising water. In the 2004 WLAM, a seasonally varying amount of rising groundwater at Prado Basin was determined through model calibration and was added to the model (WEI, 2002). A constant rising water volume with assumed TDS/TIN concentrations was also applied at the Riverside Narrows in the 2004 WLAM (WEI, 2002) and at both Prado Basin and the Riverside Narrows in the 2008 WLAM (WEI, 2009). Neither the 2004 WLAM nor the 2008 WLAM included rising water in Temescal Creek.

While both methods used for the 2004/2008 WLAM and 2017 WLAM HSPF produce acceptable levels of calibration at downstream gages (SAR at MWD Crossing and Prado Dam), the method used for the 2017 WLAM HSPF was chosen for the flexibility it affords. While this method artificially reduces streambed

percolation (not reflective of actual hydraulic conductivity of streambed sediments in these locations), little percolation tends to occur in areas of rising water given the gaining stream conditions that are typically present. In addition, rising water varies in response to hydrologic conditions (greater rainfall and recharge generally results in higher groundwater levels, resulting in greater amounts of rising water). By setting the model up to react dynamically to surface water flow, the 2017 WLAM HSPF is able to respond to and accommodate changes in hydrology during the calibration period and in future model simulations.

### 2.2.9 TDS and TIN

In order to estimate average daily and monthly TDS/TIN concentrations in major stream segments, the 2017 WLAM HSPF was calibrated to observed TDS and TIN data in the SAR at MWD Crossing, below Prado Dam, and at Imperial Highway near Anaheim (see Figure 9 for station locations). The TDS/TIN concentrations at these locations are a product of multiple contributing sources, including runoff, discharges to streamflow, and rising groundwater. Each source has an associated concentration. TDS/TIN concentrations were collected for each discharging agency and the three water quality streamflow gages used for calibration (refer to TM-1 for data collection). TIN measurements were augmented by including measurements of Ammonia + Nitrate + Nitrite<sup>4</sup>. TDS data were provided in mg/L.

Various modules in HSPF were used to simulate TDS and TIN. The PQUAL module simulates the accumulation of TDS/TIN on the pervious land surface and its removal by a constant unit rate and by overland flow (subroutine QUALOF), as well as the occurrence of TDS/TIN in interflow (subroutine QUALIF). For impervious land, the HSPF module IQUAL was used, which simulates TDS/TIN in the outflows from an impervious land segment. Since TDS is considered conservative in nature (i.e., does not interact with other water quality parameters or decay with time), the CONS section of HSPF module RCHRES was used. The subroutines utilized by this section simulate the normal longitudinal advection of TDS. TIN, which is a non-conservative constituent (i.e., chemically reactive), was simulated using the RQUAL section of HSPF module RCHRES. The subroutines in this section simulate the reduction of nitrate by anaerobic bacteria (i.e., denitrification). Schematic diagrams of HSPF TDS and TIN simulation are provided as Figures 18 and 19, respectively.

<sup>4</sup> Nitrite is not critical for the computation of TIN since the contribution is typically very small.

### 2.2.9.1 TDS and TIN in Runoff

TDS and TIN in runoff is modeled by HSPF through dry deposition, which includes contributions from rainfall, agricultural irrigation, and urban irrigation. The average amount of dry deposition (mass per area per time) suggested by the USEPA was used as an initial concentration in the 2017 WLAM HSPF. This rate was then adjusted during model calibration within the limits established in USEPA BASINS Technical Note 6 (2000) to produce TDS and TIN concentrations in runoff that follow the relationships developed by WEI in the 2004 WLAM (WEI, 2002).

### 2.2.9.2 TDS and TIN in Discharges

TDS and TIN measurements for discharges to the SAR and its tributaries are typically taken periodically; they do not represent daily data. If monthly data were provided (i.e., one measurement per month), the concentration of the daily discharge was assumed to be constant for the whole month. In months where several data points were available, daily discharge was assumed to have a concentration equal to the average measured concentration for each month. However, some discharge locations provided decent coverage (i.e., approximately 15 or more measurements per month). When this density of data was available (e.g., IEUA RP-1), daily concentrations were assumed to be constant between readings.

### 2.2.9.3 TDS and TIN in Rising Groundwater

In the 2017 WLAM HSPF, rising water occurs in the Riverside Narrows, Prado Basin (Prado Vicinity), and in Temescal Creek upgradient of Main Street. The TDS/TIN concentrations associated with this rising water were incorporated into the model in one of two ways. In Temescal Creek, average TDS and TIN concentrations were assigned to the rising water based on the Salt and Nutrient Management Plan for the Upper Temescal Valley (WEI, 2017). At Riverside Narrows and in Prado Basin, a separate spreadsheet model was used to calculate the TDS and TIN concentrations associated with rising water, based on the amount of flow calculated by the Riverside-Arlington and Chino Basin Models. The additional mass calculated by the spreadsheet model was then added to the system. Average concentrations of rising water are summarized in the following table.

**Table 2-2. Average TDS and TIN Concentrations of Rising Water**

Area	2004 WLAM		2008 WLAM		2017 WLAM HSPF	
	TDS	TIN	TDS	TIN	TDS	TIN
	[mg/L]					
Riverside Narrows	900	11	900	11	822	11
Prado Vicinity	1,100	11	1,100	11	977	5
Temescal Creek	-	-	-	-	775	6

#### 2.2.9.4 TDS and TIN in Prado Wetlands Effluent

As mentioned in Section 2.2.6.4, the Prado Wetlands are used to treat some of the SAR discharge for nitrate and other pollutants. Communications with OCWD staff have revealed that nitrate removal in the wetlands varies seasonally (higher in summer, lower in winter). OCWD recommends an effluent nitrate concentration of 1 mg/L be applied from May through October and a concentration of 4 mg/L be applied from November through April. The wetlands effluent also has slightly increased TDS concentrations due to the removal of flow through the additional ET calculated by the spreadsheet model.

#### 2.2.9.5 Nitrogen Reaction Rate Coefficients

The nitrogen reaction rate coefficient, or nitrogen loss coefficient, simulates the loss of nitrogen in surface flow due to the reduction of nitrate by facultative anaerobic bacteria (i.e., denitrification). The initial reaction rate coefficients for nitrogen loss in surface discharge were 0.1 day<sup>-1</sup> upstream of Riverside Narrows, 0.25 day<sup>-1</sup> from Riverside Narrows to Prado Dam, and 0.1 day<sup>-1</sup> downstream of Prado Dam. During model calibration, these coefficients were found to provide satisfactory results between model-calculated and observed TIN concentrations.

### 2.3 WLAM Differences

The 2017 WLAM HSPF represents a departure from the previous modeling used for the 2004 and 2008 WLAMs. Some of the key differences are summarized in the following table.

**Table 2-3. Key Similarities and Differences between WLAM Versions**

Item	2004 WLAM	2008 WLAM	2017 WLAM HSPF
Computer Code	<p>RUNOFF &amp; ROUTER</p> <ul style="list-style-type: none"> <li>• WEI proprietary software</li> <li>• Water left unaccounted for after individual modules are combined (infiltration included in the initial abstraction was not accounted for in the soil moisture calculation)</li> <li>• Field data not always honored</li> <li>• Limited capability: relies on Arc GIS to prepare model input and is executed through DOS</li> </ul>	<p>RUNOFF &amp; ROUTER</p> <ul style="list-style-type: none"> <li>• WEI proprietary software</li> <li>• Water left unaccounted for after individual modules are combined (infiltration included in the initial abstraction was not accounted for in the soil moisture calculation)</li> <li>• Field data not always honored</li> <li>• Limited capability: relies on Arc GIS to prepare model input and is executed through DOS</li> </ul>	<p>HSPF (<b>NEW</b>)</p> <ul style="list-style-type: none"> <li>• Supported and maintained by Federal agencies (USEPA and USGS)</li> <li>• Publically available</li> <li>• Comprehensive and physically based – accounts for all water cycle components</li> <li>• Established standards and guidelines</li> <li>• Windows-based interface with powerful pre- and post-processors</li> </ul>
Sub-Watersheds (or Hydrologic Simulation Areas)	<p>Not Provided</p> <p>Includes SAR Watershed area from Seven Oaks Dam to Prado Dam</p>	<p>220</p> <p>Includes SAR Watershed area from Seven Oaks Dam to Prado Dam</p>	<p>568</p> <p>Includes SAR Watershed area from Seven Oaks Dam to Prado Dam and downstream of Prado Dam to the SAR at Santa Ana gage in Orange County (<b>NEW</b>)</p>
Soil Data	<ul style="list-style-type: none"> <li>• Soil Conservation Service (SCS) surveys in: <ul style="list-style-type: none"> <li>– Pasadena (1917),</li> <li>– Riverside (1971), and</li> <li>– San Bernardino County (1977).</li> </ul> </li> <li>• San Bernardino County Hydrology Manual (Williamson and Schmid, 1986)</li> </ul>	<ul style="list-style-type: none"> <li>• Soil Conservation Service (SCS) surveys in: <ul style="list-style-type: none"> <li>– Pasadena (1917),</li> <li>– Riverside (1971), and</li> <li>– San Bernardino County (1977).</li> </ul> </li> <li>• San Bernardino County Hydrology Manual (Williamson and Schmid, 1986)</li> </ul>	<ul style="list-style-type: none"> <li>• SSURGO Database (Soil Survey Staff et al., 2011) (<b>NEW</b>)</li> </ul>
Land Use	<p>1993 (SCAG)</p>	<p>2005 (SCAG)</p>	<p>2012 (SCAG) (<b>NEW</b>)</p>
Precipitation Stations	<p>Collected all available precipitation data in model area. Interpolated missing data at each station and applied daily data to hydrologic simulation areas based on Thiessen polygons.</p> <p>43 precipitation stations used:</p> <ul style="list-style-type: none"> <li>• Mira Loma Space Center (1021AUTO)</li> <li>• Ontario Fire Station (1026)</li> <li>• San Bern. City – Devil (2071)</li> <li>• Lytle Cr at Foothill Blvd (2159AUTO)</li> <li>• San Bern. City – Newmark (2166)</li> <li>• San Bern. City – Lytle Cr (2198)</li> <li>• Oak Glen (3014AUTO)</li> <li>• Loma Linda (V.G.C) (3273)</li> </ul>	<p>Collected all available precipitation data in model area. Interpolated missing data at each station and applied daily data to hydrologic simulation areas based on Thiessen polygons. (Note: more than half of the stations were without data for the calibration period)</p> <p>43 precipitation stations used:</p> <ul style="list-style-type: none"> <li>• Mira Loma Space Center (1021AUTO)</li> <li>• Ontario Fire Station (1026)</li> <li>• San Bern. City – Devil (2071)</li> <li>• Lytle Cr at Foothill Blvd (2159AUTO)</li> <li>• San Bern. City – Newmark (2166)</li> <li>• San Bern. City – Lytle Cr (2198)</li> </ul>	<p>Collected all available precipitation data in model area. Used only precipitation stations with good records (over 95% complete). Used adjustment factors based on PRISM 30-year average precipitation to apply daily data to sub-watersheds.</p> <p>19 precipitation stations used:</p> <ul style="list-style-type: none"> <li>• Mira Loma Space Center (1021AUTO)</li> <li>• Lytle Cr at Foothill Blvd (2159AUTO)</li> <li>• Oak Glen (3014AUTO)</li> <li>• Loma Linda (V.G.C) (3273)</li> <li>• Declez (2005B)</li> <li>• Del Rosa Ranger Stn (2015AUTO)</li> <li>• Fontana 5N (Getchell)</li> </ul>

Item	2004 WLAM	2008 WLAM	2017 WLAM HSPF
	<ul style="list-style-type: none"> <li>• Chino – Imbach (1079)</li> <li>• San Antonio Heights CDF (1085)</li> <li>• Yucaipa CDF (3129)</li> <li>• Claremont Pomona College (1034)</li> <li>• Chino Substation – Edison (1067)</li> <li>• Alta Loma Forney (1175)</li> <li>• Declez (2005B)</li> <li>• Reche Canyon – Manton (2009A)</li> <li>• Del Rosa Ranger Stn (2015AUTO)</li> <li>• Fontana 5N (Getchell) (2017AUTO)</li> <li>• Lytle Cr Ranger Stn (2037AUTO)</li> <li>• San Bern. Co. Hospital (2146AUTO)</li> <li>• Fontana Union Water Co (2194)</li> <li>• San Bern. City – Hanford (2286AUTO)</li> <li>• Santa Ana PH #3 (3162AUTO)</li> <li>• Upland – Chapel (1019AUTO)</li> <li>• Mentone – Blue Goose (3058)</li> <li>• Beaumont (13)</li> <li>• Chase &amp; Taylor (35)</li> <li>• Elsinore (67)</li> <li>• Temescal Cyn Ws (75)</li> <li>• Riverside East (177)</li> <li>• Riverside North (178)</li> <li>• Riverside South (179)</li> <li>• Wildomar (246)</li> <li>• Arlington (7)</li> <li>• Calimesa (31)</li> <li>• Cherry Valley (36)</li> <li>• Corona North (44)</li> <li>• La Sierra (100)</li> <li>• Lake Mathews (102)</li> <li>• Santiago Peak (202)</li> <li>• Woodcrest (250)</li> <li>• Gavilan Springs (71)</li> <li>• Indian Hills (265)</li> </ul>	<ul style="list-style-type: none"> <li>• Oak Glen (3014AUTO)</li> <li>• Loma Linda (V.G.C) (3273)</li> <li>• Chino – Imbach (1079)</li> <li>• San Antonio Heights CDF (1085)</li> <li>• Yucaipa CDF (3129)</li> <li>• Claremont Pomona College (1034)</li> <li>• Chino Substation – Edison (1067)</li> <li>• Alta Loma Forney (1175)</li> <li>• Declez (2005B)</li> <li>• Reche Canyon – Manton (2009A)</li> <li>• Del Rosa Ranger Stn (2015AUTO)</li> <li>• Fontana 5N (Getchell) (2017AUTO)</li> <li>• Lytle Cr Ranger Stn (2037AUTO)</li> <li>• San Bern. Co. Hospital (2146AUTO)</li> <li>• Fontana Union Water Co (2194)</li> <li>• San Bern. City – Hanford (2286AUTO)</li> <li>• Santa Ana PH #3 (3162AUTO)</li> <li>• Upland – Chapel (1019AUTO)</li> <li>• Mentone – Blue Goose (3058)</li> <li>• Beaumont (13)</li> <li>• Chase &amp; Taylor (35)</li> <li>• Elsinore (67)</li> <li>• Temescal Cyn Ws (75)</li> <li>• Riverside East (177)</li> <li>• Riverside North (178)</li> <li>• Riverside South (179)</li> <li>• Wildomar (246)</li> <li>• Arlington (7)</li> <li>• Calimesa (31)</li> <li>• Cherry Valley (36)</li> <li>• Corona North (44)</li> <li>• La Sierra (100)</li> <li>• Lake Mathews (102)</li> <li>• Santiago Peak (202)</li> <li>• Woodcrest (250)</li> <li>• Gavilan Springs (71)</li> <li>• Indian Hills (265)</li> </ul>	<ul style="list-style-type: none"> <li>• (2017AUTO)</li> <li>• San Bern. Co. Hospital (2146AUTO)</li> <li>• Santa Ana PH #3 (3162AUTO)</li> <li>• Beaumont (13)</li> <li>• Chase &amp; Taylor (35)</li> <li>• Elsinore (67)</li> <li>• Riverside North (178)</li> <li>• Riverside South (179)</li> <li>• Lake Mathews (102)</li> <li>• Woodcrest (250)</li> <li>• Indian Hills (265)</li> <li>• Santana (OC SANTANA) (<b>NEW</b>)</li> <li>• Villapark (OC VILLAPARK) (<b>NEW</b>)</li> </ul>
Evapotranspiration Stations	<ul style="list-style-type: none"> <li>• LA County Evaporation Station at Puddingstone Reservoir</li> </ul>	<ul style="list-style-type: none"> <li>• CIMIS Station Pomona #78 (included in model files but not mentioned in report)</li> <li>• CIMIS Station UC Riverside #44 (included in model files but not mentioned in report)</li> <li>• LA County Evaporation Station at Puddingstone Reservoir</li> </ul>	<ul style="list-style-type: none"> <li>• CIMIS Station Pomona #78</li> <li>• CIMIS Station UC Riverside #44</li> <li>• LA County Evaporation Station at Puddingstone Reservoir</li> </ul>

Item	2004 WLAM	2008 WLAM	2017 WLAM HSPF
Streamflow Gaging Stations	<p>Boundary Inflow (12):</p> <ul style="list-style-type: none"> <li>• SAR nr Mentone (11051500)</li> <li>• SAR nr Mentone + Canals (11051501)</li> <li>• Mill Ck nr Yucaipa (11054000)</li> <li>• Plunge Ck nr E Highlands (11055500)</li> <li>• Plunge Ck nr E Highlands + Canals (11055500)</li> <li>• City Ck nr Highland (11055800)</li> <li>• E Twin Ck nr Arrowhead Springs (11058500)</li> <li>• Lytle Ck nr Fontana (11062000)</li> <li>• Cajon Ck below Lone Pine Ck nr Keenbrook (11063510)</li> <li>• Devil Cyn Ck nr San Bernardino (11063680)</li> <li>• Day Ck nr Etiwanda (11067000)</li> <li>• Cucamonga Ck nr Upland (11073470)</li> </ul> <p>Flow Calibration (7):</p> <ul style="list-style-type: none"> <li>• San Timoteo Ck nr Loma Linda (11057500)</li> <li>• SAR at E St (11059300)</li> <li>• SAR at MWD Crossing (11066460)</li> <li>• Temescal Ck at Main St (11072100)</li> <li>• Chino Ck at Schaefer Ave (11073360)</li> <li>• Cucamonga Ck nr Mira Loma (11073495)</li> <li>• SAR Inflow to Prado Dam (USACE calculation)</li> </ul>	<p>Boundary Inflow (12):</p> <ul style="list-style-type: none"> <li>• SAR nr Mentone (11051500)</li> <li>• SAR nr Mentone + Canals (11051501)</li> <li>• Mill Ck nr Yucaipa (11054000)</li> <li>• Plunge Ck nr E Highlands (11055500)</li> <li>• Plunge Ck nr E Highlands + Canals (11055500)</li> <li>• City Ck nr Highland (11055800)</li> <li>• E Twin Ck nr Arrowhead Springs (11058500)</li> <li>• Lytle Ck nr Fontana (11062000)</li> <li>• Cajon Ck below Lone Pine Ck nr Keenbrook (11063510)</li> <li>• Devil Cyn Ck nr San Bernardino (11063680)</li> <li>• Day Ck nr Etiwanda (11067000)</li> <li>• Cucamonga Ck nr Upland (11073470)</li> </ul> <p>Flow Calibration (7):</p> <ul style="list-style-type: none"> <li>• San Timoteo Ck nr Loma Linda (11057500)</li> <li>• SAR at E St (11059300)</li> <li>• SAR at MWD Crossing (11066460)</li> <li>• Temescal Ck at Main St (11072100)</li> <li>• Chino Ck at Schaefer Ave (11073360)</li> <li>• Cucamonga Ck nr Mira Loma (11073495)</li> <li>• SAR Inflow to Prado Dam (USACE calculation)</li> </ul>	<p>Boundary Inflow (13):</p> <ul style="list-style-type: none"> <li>• SAR nr Mentone + Canals (11051501)</li> <li>• Mill Ck + Canals nr Yucaipa (11054001)</li> <li>• Plunge Ck + Canals nr E Highlands (11055501)</li> <li>• City Ck &amp; City Ck Water Co's Canal nr Highland (11055801)</li> <li>• E Twin Ck nr Arrowhead Springs (11058500)</li> <li>• Lytle Cr, SCE Co's Lytle Ck Conduit, and Fontana Water Co's Infiltration Line Diversion nr Fontana (11062001)</li> <li>• Cajon Ck below Lone Pine Ck nr Keenbrook (11063510)</li> <li>• Devil Cyn Ck nr San Bernardino (11063680)</li> <li>• Day Ck nr Etiwanda (11067000)</li> <li>• Temescal Ck at Corona Lake nr Corona (11071900) <b>(NEW)</b></li> <li>• Cucamonga Ck nr Upland (11073470)</li> <li>• Carbon Ck below Carbon Cyn Dam (11075720) <b>(NEW)</b></li> <li>• Santiago Ck at Santa Ana (11077500) <b>(NEW)</b></li> </ul> <p>Flow Calibration (9):</p> <ul style="list-style-type: none"> <li>• San Timoteo Ck nr Loma Linda (11057500)</li> <li>• Warm Ck nr San Bernardino (11060400)</li> <li>• SAR at E St (11059300)</li> <li>• SAR at MWD Crossing (11066460)</li> <li>• Temescal Ck at Main St (11072100)</li> <li>• Chino Ck at Schaefer Ave (11073360)</li> <li>• Cucamonga Ck nr Mira Loma (11073495)</li> <li>• SAR Inflow to Prado Dam (USACE calculation)</li> <li>• SAR at Santa Ana (11078000) <b>(NEW)</b></li> </ul>
TIN/TDS from Streamflow Gaging Stations	<ul style="list-style-type: none"> <li>• SAR at MWD Crossing (11066460)</li> <li>• SAR below Prado Dam (11074000)</li> </ul>	<ul style="list-style-type: none"> <li>• SAR at MWD Crossing (11066460)</li> <li>• SAR below Prado Dam (11074000)</li> </ul>	<ul style="list-style-type: none"> <li>• SAR at MWD Crossing (11066460)</li> <li>• SAR below Prado Dam (11074000)</li> <li>• SAR at Imperial Hwy nr Anaheim (11075600) <b>(NEW)</b></li> </ul>

Item	2004 WLAM	2008 WLAM	2017 WLAM HSPF
POTW and Other Discharges	<p>Recycled Water Discharges:</p> <ul style="list-style-type: none"> <li>Beaumont WWTP</li> <li>Colton WWTP</li> <li>Corona WWTP</li> <li>EMWD Temescal Discharge</li> <li>EVMWD</li> <li>IEUA Carbon Canyon WRF</li> <li>IEUA RP1 001</li> <li>IEUA RP1 002</li> <li>IEUA RP2</li> <li>LLWD WWTP</li> <li>Rialto WWTP</li> <li>Riverside Discharge</li> <li>RIX</li> <li>San Bernardino WWTP</li> <li>Western Riv Co. RWA WTP</li> <li>YVWD WWTP</li> </ul> <p>Other Discharges:</p> <ul style="list-style-type: none"> <li>Arlington Desalter</li> <li>OC-59</li> <li>SBVMWD Exchange (dewatering)</li> <li>Lake Elsinore Storm Water Discharge</li> </ul>	<p>Recycled Water Discharges:</p> <ul style="list-style-type: none"> <li>Beaumont WWTP</li> <li>Colton WWTP</li> <li>Corona WWTP #1</li> <li>EMWD Temescal Discharge</li> <li>EVMWD Regional WWRP</li> <li>IEUA Carbon Canyon WRP</li> <li>IEUA RP1 001</li> <li>IEUA RP1 002 Cucamonga and RP4</li> <li>IEUA RP2</li> <li>LLWD WWTP</li> <li>Rialto WWTP</li> <li>Riverside RWQCP</li> <li>RIX Facility</li> <li>San Bernardino WWTP</li> <li>Western Riv Co. RWA WTP</li> <li>YVWD H.N. Wochholz WTP</li> </ul> <p>Other Discharges:</p> <ul style="list-style-type: none"> <li>Arlington Desalter</li> <li>OC-59</li> <li>SBVMWD Exchange (dewatering)</li> <li>Lake Elsinore Storm Water Discharge</li> </ul>	<p>Recycled Water Discharges:</p> <ul style="list-style-type: none"> <li>Beaumont WWTP</li> <li>Colton WWTP</li> <li>Corona WWTP #1 and #3 <b>(NEW)</b></li> <li>EMWD Regional WRFs</li> <li>EVMWD Regional WWRP</li> <li>IEUA Carbon Canyon WRF</li> <li>IEUA RP1 001 Prado</li> <li>IEUA RP1 002 Cucamonga and RP4</li> <li>IEUA RP2</li> <li>IEUA RP5 <b>(NEW)</b></li> <li>Temescal Valley WRF (formerly LLWD WWTP)</li> <li>Rialto WWTP</li> <li>Riverside RWQCP</li> <li>RIX Facility</li> <li>San Bernardino WRP</li> <li>Western Riv Co. RWAP</li> <li>YVWD H.N. Wochholz WRF</li> </ul> <p>Other Discharges:</p> <ul style="list-style-type: none"> <li>Arlington Desalter</li> <li>OC-59</li> <li>San Bernardino Geothermal Plant <b>(NEW)</b></li> </ul> <p>Note: Valley District dewatering, and Lake Elsinore storm water discharges not included since none occurred during the calibration period.</p>
Rising Water (Flow)	<p>Assumed flow at:</p> <ul style="list-style-type: none"> <li>Riverside Narrows</li> <li>Prado Vicinity</li> </ul>	<p>Assumed flow at:</p> <ul style="list-style-type: none"> <li>Riverside Narrows</li> <li>Prado Vicinity</li> </ul>	<p>Decreased percolation to match groundwater flow model-calculated rising water volumes at:</p> <ul style="list-style-type: none"> <li>Riverside Narrows</li> <li>Prado Vicinity</li> </ul> <p>Assumed flow at:</p> <ul style="list-style-type: none"> <li>Temescal Creek upstream of Main St. <b>(NEW)</b></li> </ul>
Rising Water (TDS/TIN)	<p>Assumed TDS concentration at:</p> <ul style="list-style-type: none"> <li>Riverside Narrows = 900 mg/L</li> <li>Prado Vicinity = 1,100 mg/L</li> </ul> <p>Assumed TIN concentration at:</p> <ul style="list-style-type: none"> <li>Riverside Narrows = 11 mg/L</li> <li>Prado Vicinity = 11 mg/L</li> </ul>	<p>Assumed TDS concentration at:</p> <ul style="list-style-type: none"> <li>Riverside Narrows = 900 mg/L</li> <li>Prado Vicinity = 1,100 mg/L</li> </ul> <p>Assumed TIN concentration at:</p> <ul style="list-style-type: none"> <li>Riverside Narrows = 11 mg/L</li> <li>Prado Vicinity = 11 mg/L</li> </ul>	<p>Assumed TDS concentration at:</p> <ul style="list-style-type: none"> <li>Riverside Narrows = 822 mg/L</li> <li>Prado Vicinity = 877 mg/L</li> <li>Temescal Creek = 775 mg/L <b>(NEW)</b></li> </ul> <p>Assumed TIN concentration at:</p> <ul style="list-style-type: none"> <li>Riverside Narrows = 11 mg/L</li> <li>Prado Vicinity = 5 mg/L</li> <li>Temescal Creek = 6 mg/L <b>(NEW)</b></li> </ul>

Item	2004 WLAM	2008 WLAM	2017 WLAM HSPF
Nitrogen Reaction Rate Coefficients	0.1 upstream of Riverside Narrows, 0.25 downstream of Riverside Narrows	0.1 upstream of Riverside Narrows, 0.25 downstream of Riverside Narrows	0.1 upstream of Riverside Narrows, 0.25 from Riverside Narrows to Prado Dam, 0.1 downstream of Prado Dam <b>(NEW)</b>
Calibration Period	WY 1995-1999	WY 1995-2006	WY 2007-2016 <b>(NEW)</b>
Calibration Methodology	<p>Flow*:</p> <ul style="list-style-type: none"> <li>Adjusted Curve Number</li> <li>Adjusted channel percolation rates</li> <li>Adjusted rising water estimates</li> </ul> <p>TDS/TIN:</p> <ul style="list-style-type: none"> <li>Adjusted concentrations for runoff</li> <li>Adjusted assumed concentrations of rising water</li> <li>Adjusted nitrogen reaction rate coefficients</li> </ul> <p>*Note: original model files were not available. Therefore, this summary relies on information provided in the 2004 WLAM report (WEI, 2002 and 2003).</p>	<p>Flow:</p> <ul style="list-style-type: none"> <li>Adjusted Curve Number</li> <li>Adjusted channel percolation rates</li> <li>Adjusted rising water estimates</li> <li>Adjusted precipitation</li> </ul> <p>TDS/TIN:</p> <ul style="list-style-type: none"> <li>Adjusted concentrations for runoff</li> <li>Adjusted assumed concentrations of rising water</li> <li>Adjusted nitrogen reaction rate coefficients</li> </ul>	<p>Flow:</p> <ul style="list-style-type: none"> <li>Adjusted HSPF model parameters within limits defined in USEPA BASINS Technical Note 6 (e.g., soil storage, ET parameters, channel geometry and infiltration, etc. For details, refer to Section 3.1)</li> </ul> <p>TDS/TIN:</p> <ul style="list-style-type: none"> <li>Adjusted dry deposition for runoff concentrations</li> <li>Adjusted assumed concentrations/mass of rising water</li> <li>Adjusted nitrogen reaction rate coefficients</li> </ul>
Methods used to Account for Flow at Select Locations	Not Applicable (model files unavailable)	<ul style="list-style-type: none"> <li>Added flow at San Timoteo Creek near Loma Linda and Chino Creek at Schaefer Avenue</li> <li>Applied discharge from Corona WWTP #1 above Temescal Creek at Main Street gage instead of below</li> </ul> <p>Refer to Section 3.3 for details</p>	<ul style="list-style-type: none"> <li>Model-simulated</li> </ul>
Calibration Criteria	<p>Flow (monthly):</p> <ul style="list-style-type: none"> <li><math>R^2</math></li> <li>Percent Error</li> </ul> <p>TDS/TIN:</p> <p>None (not enough data)</p>	<p>Flow (monthly):</p> <ul style="list-style-type: none"> <li><math>R^2</math></li> <li>Root mean square error (RMSE)*</li> <li>RMSE Percent of Average Flow</li> <li>Nash-Sutcliffe Efficiency (NSE)</li> </ul> <p>TDS/TIN:</p> <p>None (not enough data)</p> <p>*Note: RMSE formula was applied incorrectly (using measured data instead of squared residuals) – leading to an underestimation of the residuals.</p>	<p>Flow (monthly and <b>daily</b>):</p> <ul style="list-style-type: none"> <li><math>R^2</math></li> <li>Average Residual <b>(NEW)</b></li> <li>Average Residual Percentage of Observed <b>(NEW)</b></li> <li>RMSE</li> <li>RMSE as Percentage of Range of Observed</li> </ul> <p>TDS/TIN <b>(NEW)</b>:</p> <ul style="list-style-type: none"> <li>Average Residual</li> <li>Average Residual Percentage of Observed</li> <li>Standard Deviation</li> <li>RMSE</li> </ul>

### 2.3.1 Initial Comparison of 2008 WLAM and HSPF

One of the initial steps taken for the WLAM update was to compare streamflow results from the 2017 WLAM HSPF to the 2008 WLAM for the period from Water Year 1995 through 2006. To do so, model input data from the 2008 WLAM (including 2005 land use) was applied to the 2017 WLAM HSPF after its initial construction. Model-calculated streamflow was then compared at several key gaging stations.

The performance of the model calibration in regards to streamflow was also evaluated quantitatively using the goodness of fit (i.e.,  $R^2$  value) between measured and model-simulated streamflow. Figures 20 through 23 show scatterplots of measured and model-simulated daily streamflow for selected gaging stations from the 2008 WLAM and 2017 WLAM HSPF for Water Years 1995 through 2006 under 2005 land use conditions. Scatterplots of measured and model-simulated monthly streamflow are shown on Figures 34 through 27. For a perfect calibration, all points (observed along the x-axis and model-simulated along the y-axis) would fall on the diagonal line with a  $R^2$  value of 1. Greater deviation of points from the diagonal line correspond with lower the  $R^2$  values and poorer model calibration performance.

The following table summarizes calibration performance criteria from Donigian (2002), which were used to assess the results.

**Table 2-4. Streamflow Calibration Performance Criteria**

Type of Flow Data	$R^2$ (Goodness-of-Fit)	Calibration Performance
Daily Flow	$R^2 < 0.60$	Poor
Daily Flow	$0.60 < R^2 < 0.70$	Fair
Daily Flow	$0.70 < R^2 < 0.80$	Good
Daily Flow	$R^2 > 0.80$	Very Good
Monthly Flow	$R^2 < 0.65$	Poor
Monthly Flow	$0.65 < R^2 < 0.75$	Fair
Monthly Flow	$0.75 < R^2 < 0.85$	Good
Monthly Flow	$R^2 > 0.85$	Very Good

The results of the initial comparison between the 2008 WLAM and 2017 WLAM HSPF are summarized in the following tables.

**Table 2-5. 2008 WLAM and 2017 WLAM HSPF Initial Comparison: Daily Simulated Streamflow Performance (Water Year 1995-2006 and 2005 Land Use)**

Gaging Station	2008 WLAM		2017 WLAM HSPF	
	R <sup>2</sup>	Calibration Performance	R <sup>2</sup>	Calibration Performance
San Timoteo Ck near Loma Linda	0.72	Good	0.97	Very Good
Warm Ck near San Bernardino	0.62	Fair	0.71	Good
Santa Ana River at E Street	0.72	Good	0.74	Good
Santa Ana River at MWD Crossing	0.68	Fair	0.73	Good

**Table 2-6. 2008 WLAM and 2017 WLAM HSPF Initial Comparison: Monthly Simulated Streamflow Performance (Water Year 1995-2006 and 2005 Land Use)**

Gaging Station	2008 WLAM		2017 WLAM HSPF	
	R <sup>2</sup>	Calibration Performance	R <sup>2</sup>	Calibration Performance
San Timoteo Ck near Loma Linda	0.84	Good	0.99	Very Good
Warm Ck near San Bernardino	0.70	Fair	0.79	Good
Santa Ana River at E Street	0.93	Very Good	0.89	Very Good
Santa Ana River at MWD Crossing	0.91	Very Good	0.86	Very Good

As seen in Tables 2-5 and 2-6 above, the 2017 WLAM HSPF performs similarly to or slightly better than the 2008 WLAM.

The updated data compiled for the 2017 WLAM HSPF (Water Years 2007 through 2016) were then used as model input, along with 2012 land use, for the 2008 WLAM. Both models were rerun with this input data for comparison. Figures 28 through 31 show scatterplots of measured and model-simulated daily streamflow for each gaging station from the 2008 WLAM and 2017 WLAM HSPF for Water Years 2007 through 2016 under 2012 land use conditions. Scatterplots of measured and model-simulated monthly streamflow are shown on Figures 32 through 35. The results are summarized in the following tables.

**Table 2-7. 2008 WLAM and 2017 WLAM HSPF Initial Comparison: Daily Simulated Streamflow Performance (Water Year 2007-2016 and 2012 Land Use)**

Gaging Station	2008 WLAM		2017 WLAM HSPF	
	R <sup>2</sup>	Calibration Performance	R <sup>2</sup>	Calibration Performance
San Timoteo Ck near Loma Linda	0.73	Good	0.94	Very Good
Warm Ck near San Bernardino	0.50	Poor	0.70	Good
Santa Ana River at E Street	0.90	Very Good	0.95	Very Good
Santa Ana River at MWD Crossing	0.93	Very Good	0.88	Very Good

**Table 2-8. 2008 WLAM and 2017 WLAM HSPF Initial Comparison: Monthly Simulated Streamflow Performance (Water Year 2007-2016 and 2012 Land Use)**

Gaging Station	2008 WLAM		2017 WLAM HSPF	
	R <sup>2</sup>	Calibration Performance	R <sup>2</sup>	Calibration Performance
San Timoteo Ck near Loma Linda	0.62	Poor	0.98	Very Good
Warm Ck near San Bernardino	0.80	Good	0.91	Very Good
Santa Ana River at E Street	0.88	Very Good	0.98	Very Good
Santa Ana River at MWD Crossing	0.96	Very Good	0.97	Very Good

As shown, the 2017 WLAM HSPF performs as good as or slightly better than the 2008 WLAM. This initial comparison indicates that the HSPF code is adequate to use for the purposes of the WLAM.

### 3.0 2017 WLAM HSPF CALIBRATION

#### 3.1 Calibration Process

Model calibration is a trial-and-error process which consists of iteratively adjusting model parameters, within acceptable ranges, until the model provides a reasonable match between the model-simulated and measured data. Proper calibration is important in order to reduce uncertainty in the model results (Engel et al., 2007). The accuracy of data simulated by the calibrated model is evaluated using the techniques recommended by the one of authors for HSPF (Donigian, 2002).

After the 2017 WLAM HSPF was constructed, it was calibrated against measured streamflow and TDS/TIN data for the period from October 1, 2006 through September 30, 2016 (Water Years 2007 through 2016). This calibration period represents an appropriate time period for calibration to 2012 land use. In addition, this calibration period includes dry, wet, and average hydrologic conditions.

Streamflow data from nine gaging stations (see Figure 9 for locations) were used during the calibration process. The period of record, including data gaps, are presented in TM-1 (GEOSCIENCE, 2018). The streamflow gages used for flow calibration include:

• San Timoteo Creek near Loma Linda	USGS Gage 11057500	[34.061402, -117.267542]
• Warm Creek near San Bernardino	USGS Gage 11060400	[34.078346, -117.300321]
• Santa Ana River at E Street	USGS Gage 11059300	[34.065013, -117.300321]
• Santa Ana River at MWD Crossing	USGS Gage 11066460	[33.968626, -117.448381]
• Temescal Creek at Main Street	USGS Gage 11072100	[33.889182, -117.562827]
• Chino Creek at Schaefer Avenue	USGS Gage 11073360	[34.003901, -117.727001]
• Cucamonga Creek near Mira Loma	USGS Gage 11073495	[33.982791, -117.599497]
• Santa Ana River into Prado Dam	Calculated by the USACE	[33.890293, -117.640885]
• Santa Ana River at Santa Ana	USGS Gage 11078000	[33.751128, -117.908391]

As indicated by the list above, model calibration in the Prado Vicinity was conducted using the USACE-calculated inflow to Prado Dam. While there is a USGS gage with measured flow data below the gage, this flow is controlled by releases from Prado Dam. The calculated inflow, which is based on stage measurements and storage relationships, allows for a better comparison between model-simulated streamflow and natural flow in the SAR before it becomes storage behind the dam.

TDS/TIN data from three gaging stations were also used during the calibration process. These stations were chosen based on data availability and include:

- |  |                    |                          |
|--|--------------------|--------------------------|
| • Santa Ana River at MWD Crossing                  | USGS Gage 11066460 | [33.968626, -117.448381] |
| • Santa Ana River below Prado                      | USGS Gage 11074000 | [33.883349, -117.64533]  |
| • Santa Ana River at Imperial Highway near Anaheim | USGS Gage 11075600 | [33.856404, -117.790611] |

Model calibration was performed in accordance with guidelines provided by the USEPA (2000). The major parameters adjusted during calibration of the 2017 WLAM HSPF included the following:

- Lower zone nominal soil moisture storage,
- Upper zone nominal soil moisture storage,
- Interception storage,
- Interflow inflow parameter,
- Base groundwater recession,
- Fraction of groundwater inflow to deep recharge,
- Fraction of remaining ET from baseflow,
- ET by riparian vegetation,
- Lower zone ET parameter,
- Dry deposition,
- Function tables (FTABLE) which include physical information (shape, depth, width, slope, length, Manning Factor, and materials), and infiltration rates for reaches of each sub-watershed, and
- Nitrogen reaction rate coefficient.

These parameters were altered either on the stream reach level (including sub-watersheds contributing to flow within that reach) or globally, within the limits outlined in USEPA BASINS Technical Note 6 (2000).

### 3.2 Calibration Criteria

As mentioned above, the 2017 WLAM HSPF was calibrated against measured streamflow at nine gaging stations and measured TDS/TIN at three gaging stations for the period from October 1, 2006 through September 30, 2016 (Water Years 2007 through 2016). The qualitative calibration results are shown as:

- Hydrographs of measured and model-simulated daily streamflow;
- Hydrographs of measured and model-simulated monthly streamflow;
- Scatterplots of measured versus model-simulated daily streamflow;
- Scatterplots of measured versus model-simulated monthly streamflow; and

- Chemographs of measured versus model-simulated TDS/TIN concentrations.

In addition to the qualitative calibration results listed above, the following quantitative measures of calibration performance were used:

- **R<sup>2</sup> (flow)**. Indicates the “goodness of fit” between measured and model-simulated streamflow values. Examined in accordance with the performance criteria suggested by Donigian (2002). For a perfect calibration, all points (observed along the x-axis and model-simulated along the y-axis) would fall on the diagonal line (regression line) with a R<sup>2</sup> value of 1. A greater deviation of points from the diagonal line corresponds with lower R<sup>2</sup> values and poorer model calibration performance. Due to the scarcity of water quality data, R<sup>2</sup> values for TDS/TIN calibration were not calculated.
- **Average Residual** (flow and concentration). Equal to the observed value minus the model-simulated value. Represents a measure of how far model-simulated values are from the regression line. One of the goals of model calibration is to minimize residuals between model-calculated and observed values. In general, lower residuals (i.e., closer to zero) indicate a calibration that is more representative of observed data. Positive residuals indicate model underestimation, negative residuals indicate model overestimation.
- **Average Residual Percentage of Observed** (flow and concentration).
- **Root Mean Square Error (RMSE)** (flow and concentration). Equal to the standard deviation of the residuals. Represents a measure of how spread out the residuals are. In general, a lower RMSE (i.e., closer to zero) indicates a calibration that is more representative of observed data.
- **RMSE as percentage of the range of observed** (flow).
- **Standard Deviation** (concentration). Represents a measure of how spread out the residuals are from the observed average.

2017 WLAM HSPF calibration results are presented below along with 2008 WLAM calibration results<sup>5</sup> as a general comparison and indication of previous acceptable levels of calibration. However, these models

<sup>5</sup> Notes regarding the 2008 WLAM calibration results shown in this TM:

2008 WLAM daily flow statistics were not provided in the model report (WEI, 2009). The values shown here were calculated using the 2008 WLAM model output files.

RMSE values shown in this TM also vary from those reported in the 2008 WLAM report due to a difference in units and an error found in the original calculation of RMSE (measured data was used instead of squared residuals). This resulted in an underestimation of the residuals.

do not have the same calibration period (WY 2007-2016 vs. WY 1995-2006) so should not be compared directly.

### 3.3 Streamflow Calibration Results

Hydrographs showing model-simulated and measured daily and monthly streamflow for the nine gaging stations from October 1, 2006 through September 30, 2016 were plotted to evaluate model calibration performance (see Figures 36 through 44 for daily and Figure 45 through 53 for monthly). Model calibration results for the period from October 1, 1994 through September 30, 2006 from the 2008 WLAM were also shown in the hydrographs for comparison purposes and to ensure that model calibration performance is consistent with previous work. As shown, there are similar temporal dynamics in both model-simulated and measured daily and monthly streamflow at the nine gaging stations for both the 2008 WLAM and the 2017 WLAM HSPF.

As with the initial comparison made at the onset of the WLAM update (Section 2.3.1), the performance of the model calibration in regards to streamflow was also evaluated quantitatively using the goodness of fit (i.e.,  $R^2$  value) between measured and model-simulated streamflow. Figures 54 through 62 show scatterplots of measured and model-simulated daily streamflow for each gaging station from the 2008 WLAM (Water Years 1995 through 2006) and 2017 WLAM HSPF (Water Years 2007 through 2016). Scatterplots of measured and model-simulated monthly streamflow are shown on Figure 63 through 71.

Calibration performance criteria from Donigian (2002), which were used to assess calibration results, are presented in Table 2-4. It should be noted that daily flow calibration performance is allowed a lower range of  $R^2$  values than monthly flow. This is due to sources of uncertainty related to daily data, including lag time between precipitation events and increased flow at stream gages, daily variations in discharge, and stream gage accuracy (refer to Section 4.0 for more information). However, given that the primary use of the 2017 WLAM HSPF is to protect groundwater quality in the SAR Groundwater Basin, calibration to a monthly time step is more than adequate to implement Basin Plan objectives<sup>6</sup>.

The results of the 2008 WLAM and 2017 WLAM HSPF model calibrations are summarized in the following tables.

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<sup>6</sup> Groundwater objectives are calculated as a 20-year average and recharge compliance is computed using a 10-year average.

**Table 3-1. WLAM Calibration Results – Daily Simulated Streamflow Performance**

Gaging Station	2008 WLAM WY 1995-2006	2017 WLAM HSPF WY 2007-2016
<b>San Timoteo Ck near Loma Linda</b>		
$R^2$	0.72	0.68
Calibration Performance	Good	Fair
Average Residual, cfs	-2.2	-1.4
Average of Observed, cfs	5.4	8.2
Average Residual Percentage of Observed, %	-40%	-17%
RMSE	44.1	25.7
RMSE as Percentage of Range of Observed, %	4%	3%
<b>Warm Ck near San Bernardino</b>		
$R^2$	0.62	0.73
Calibration Performance	Fair	Good
Average Residual, cfs	4.9	-1.3
Average of Observed, cfs	6.4	3.5
Average Residual Percentage of Observed, %	77%	-37%
RMSE	14.9	9.8
RMSE as Percentage of Range of Observed, %	4%	2%
<b>Santa Ana River at E Street</b>		
$R^2$	0.72	0.95
Calibration Performance	Good	Very Good
Average Residual, cfs	12.8	-6.4
Average of Observed, cfs	69.3	26.2
Average Residual Percentage of Observed, %	19%	-24%
RMSE	194.2	96.1
RMSE as Percentage of Range of Observed, %	2%	1%

Gaging Station	2008 WLAM WY 1995-2006	2017 WLAM HSPF WY 2007-2016
<b>Santa Ana River at MWD Crossing</b>		
R <sup>2</sup>	0.68	0.91
Calibration Performance	Fair	Very Good
Average Residual, cfs	33.1	-12.0
Average of Observed, cfs	182.5	97.2
Average Residual Percentage of Observed, %	18%	-12%
RMSE	382.9	147.0
RMSE as Percentage of Range of Observed, %	2%	1%
<b>Temescal Ck at Main Street</b>		
R <sup>2</sup>	0.42	0.75
Calibration Performance	Poor	Good
Average Residual, cfs	-1.2	-0.7
Average of Observed, cfs	33.7	17.2
Average Residual Percentage of Observed, %	-4%	-4%
RMSE	155.7	42.5
RMSE as Percentage of Range of Observed, %	7%	1%
<b>Chino Ck at Schaefer Avenue</b>		
R <sup>2</sup>	0.69	0.80
Calibration Performance	Fair	Very Good
Average Residual, cfs	1.8	-2.3
Average of Observed, cfs	24.4	9.0
Average Residual Percentage of Observed, %	7%	-25%
RMSE	40.7	32.5
RMSE as Percentage of Range of Observed, %	3%	4%

Gaging Station	2008 WLAM WY 1995-2006	2017 WLAM HSPF WY 2007-2016
<b>Cucamonga Ck near Mira Loma</b>		
$R^2$	0.48	0.87
Calibration Performance	Poor	Very Good
Average Residual, cfs	9.4	-0.2
Average of Observed, cfs	64.5	37.3
Average Residual Percentage of Observed, %	15%	0%
RMSE	113.2	37.5
RMSE as Percentage of Range of Observed, %	2%	2%
<b>Santa Ana River into Prado Dam</b>		
$R^2$	0.66	0.92
Calibration Performance	Fair	Very Good
Average Residual, cfs	11.4	-1.3
Average of Observed, cfs	396.3	223.0
Average Residual Percentage of Observed, %	3%	-1%
RMSE	681.9	199.7
RMSE as Percentage of Range of Observed, %	3%	1%
<b>Santa Ana River at Santa Ana</b>		
$R^2$	NA	0.55
Calibration Performance	NA	Poor
Average Residual, cfs	NA	0.2
Average of Observed, cfs	NA	49.7
Average Residual Percentage of Observed, %	NA	0%
RMSE	NA	299.3
RMSE as Percentage of Range of Observed, %	NA	3%

Note: Residual = Observed – Model-Simulated (positive numbers indicate model underestimation, negative numbers indicate model overestimation)

**Table 3-2. WLAM Calibration Results – Monthly Simulated Streamflow Performance**

Gaging Station	2008 WLAM WY 1995-2006	2017 WLAM HSPF WY 2007-2016
<b>San Timoteo Ck near Loma Linda</b>		
$R^2$	0.84	0.68
Calibration Performance	Good	Fair
Average Residual, cfs	-2.2	-1.4
Average of Observed, cfs	5.5	8.2
Average Residual Percentage of Observed, %	-41%	-17%
RMSE	9.2	12.4
RMSE as Percentage of Range of Observed, %	7%	16%
<b>Warm Ck near San Bernardino</b>		
$R^2$	0.70	0.91
Calibration Performance	Fair	Very Good
Average Residual, cfs	4.9	-1.3
Average of Observed, cfs	6.4	3.5
Average Residual Percentage of Observed, %	77%	-37%
RMSE	8.0	3.4
RMSE as Percentage of Range of Observed, %	15%	7%
<b>Santa Ana River at E Street</b>		
$R^2$	0.93	0.97
Calibration Performance	Very Good	Very Good
Average Residual, cfs	12.8	-6.3
Average of Observed, cfs	69.8	26.3
Average Residual Percentage of Observed, %	18%	-24%
RMSE	45.0	40.8
RMSE as Percentage of Range of Observed, %	4%	5%

Gaging Station	2008 WLAM WY 1995-2006	2017 WLAM HSPF WY 2007-2016
<b>Santa Ana River at MWD Crossing</b>		
$R^2$	0.91	0.97
Calibration Performance	Very Good	Very Good
Average Residual, cfs	32.9	-12.1
Average of Observed, cfs	183.3	97.2
Average Residual Percentage of Observed, %	18%	-12%
RMSE	110.1	37.4
RMSE as Percentage of Range of Observed, %	5%	2%
<b>Temescal Ck at Main Street</b>		
$R^2$	0.77	0.84
Calibration Performance	Good	Good
Average Residual, cfs	-1.3	-0.7
Average of Observed, cfs	34.1	17.3
Average Residual Percentage of Observed, %	-4%	-4%
RMSE	32.4	13.2
RMSE as Percentage of Range of Observed, %	8%	6%
<b>Chino Ck at Schaefer Avenue</b>		
$R^2$	0.84	0.83
Calibration Performance	Good	Good
Average Residual, cfs	1.8	-2.3
Average of Observed, cfs	24.5	9.0
Average Residual Percentage of Observed, %	7%	-25%
RMSE	14.9	11.4
RMSE as Percentage of Range of Observed, %	7%	12%

Gaging Station	2008 WLAM WY 1995-2006	2017 WLAM HSPF WY 2007-2016
<b>Cucamonga Ck near Mira Loma</b>		
R <sup>2</sup>	0.76	0.94
Calibration Performance	Good	Very Good
Average Residual, cfs	9.6	-0.2
Average of Observed, cfs	64.9	37.4
Average Residual Percentage of Observed, %	15%	-1%
RMSE	28.6	11.3
RMSE as Percentage of Range of Observed, %	7%	3%
<b>Santa Ana River into Prado Dam</b>		
R <sup>2</sup>	0.93	0.97
Calibration Performance	Very Good	Very Good
Average Residual, cfs	11.5	-1.3
Average of Observed, cfs	399.0	223.6
Average Residual Percentage of Observed, %	3%	-1%
RMSE	123.5	54.2
RMSE as Percentage of Range of Observed, %	4%	2%
<b>Santa Ana River at Santa Ana</b>		
R <sup>2</sup>	NA	0.77
Calibration Performance	NA	Good
Average Residual, cfs	NA	0.1
Average of Observed, cfs	NA	49.7
Average Residual Percentage of Observed, %	NA	0%
RMSE	NA	107.0
RMSE as Percentage of Range of Observed, %	NA	7%

Note: Residual = Observed – Model-Simulated (positive numbers indicate model underestimation, negative numbers indicate model overestimation)

As seen in Tables 3-1 and 3-2 above, model calibration for the 2017 WLAM HSPF shows good to very good performance at the majority of the streamflow gages from Water Year 2006 through Water Year 2016. In addition, the 2017 WLAM HSPF performs equal to or better than the 2008 WLAM for all gages,

except for daily and monthly streamflow at the San Timoteo Creek near Loma Linda gaging station and monthly streamflow at the Chino Creek at Schaefer Avenue gaging station.

The observed streamflow at San Timoteo Creek near Loma Linda proved difficult to calibrate the 2017 WLAM HSPF to, resulting in a “fair” model performance for both daily and monthly simulated streamflow (Figures 36 and 45). It is believed that much of the discrepancy seen in the calibration data at this location is due to channel conditions upstream that are not taken into account by the model. In particular, basin modifications such as the San Timoteo Sediment Basins alter flow and affect timing in San Timoteo Creek. These details were not able to be captured by the 2017 WLAM HSPF. The 2008 WLAM was able to produce better calibration results at the San Timoteo Creek near Loma Linda gage. According to the model files for the 2008 WLAM, additional flow was added at this location. No explanation for this assumption is provided in the modeling report.

Observed streamflow at the Chino Creek at Schaefer Avenue gaging station indicates that there is a consistent, low baseflow at this location which is likely caused by urban runoff (Figures 41 and 50). In addition, the decommissioning of IEUA’s RP-2 in 2002, which discharged into Chino Creek, likely altered subsequent streambed percolation rates. This loss of perennial flows may also contribute to some calibration discrepancies at this location. While the 2017 WLAM does not reproduce the observed baseflow, the 2008 WLAM does (Figure 50). The 2008 WLAM establishes a minimum flow of 2.1 cfs at this location in Chino Creek. The 2017 WLAM HSPF does not make this assumption and no explanation is provided in the 2008 WLAM report regarding it. However, it should be noted that while the baseflow from urban runoff is fairly constant throughout the 2008 WLAM calibration period (Water Years 1995 through 2006), the baseflow drops off during the 2017 WLAM HSPF model period – likely due to water conservation measures.

Both the 2008 WLAM and 2017 WLAM HSPF show good calibration performance at the Temescal Creek at Main Street gaging station (Figure 49). In the 2017 WLAM HSPF, this good calibration is facilitated by the addition of rising water upstream of the gaging station (refer to Figure 14). However, this rising water was unknown at the time the 2008 WLAM was constructed and calibrated. An examination of the model input files shows that discharge from the Corona WWTP #1 was misplaced in the 2008 WLAM; instead of discharging below the gaging station, the discharge was added upstream and was therefore represented in the model-simulated flow at the Main Street gage. This extra flow allowed the 2008 WLAM to produce good monthly calibration results at the Temescal Creek at Main Street gage without taking into account the additional rising water that has been found to occur upstream.

Daily streamflow calibration performance in the 2017 WLAM HSPF is “poor” at the SAR at Santa Ana gaging station (Figure 44). Model-simulated streamflow at this location is largely dependent on the results of the OCWD RFM, which simulates Prado Dam operations and OCWD diversions. However,

actual releases from Prado may be different since the USACE does not always follow their own operating rules. This is especially true for wet years (e.g., Water Year 2011). These deviations are not accounted for in the modeling, which can lead to discrepancies between model-calculated and observed streamflow at the Santa Ana River at Santa Ana gaging station. This is especially true for daily model-simulated streamflow. As seen in Table 3-2 and on Figure 53, the 2017 WLAM HSPF produces good calibration results for monthly model-simulated streamflow at this same location. Model calibration results at this stream gage also improve significantly when high flow values during very wet periods (representing times when USACE may have deviated from normal Prado Dam operations) are removed (see Figures 62 and 71).

### 3.3.1 Streamflow Outlier Analysis

At the request of the Task Force, an outlier analysis was conducted on the 2017 WLAM HSPF model-simulated streamflow. The purpose of this analysis is to determine the effect that extreme deviations (outliers) in model-simulated streamflow have on calibration performance. Points were designated outliers if model-calculated and observed streamflow differed by more than two orders of magnitude. These points were excluded from scatterplots of measured and model-simulated daily streamflow for each gaging station, except for Santa Ana River at MWD Crossing and Santa Ana River into Prado Dam gages where no outliers were found. Outliers were also not found for monthly model-simulated streamflow at the San Timoteo near Loma Linda, Temescal Creek at Main Street, and Cucamonga Creek near Mira Loma. Tables 3-3 and 3-4 below show a comparison of daily and monthly simulated streamflow performance, respectively, with outliers included (as presented above) and removed.

**Table 3-3. Outlier Analysis – Daily Simulated Streamflow Performance**

Gaging Station	R <sup>2</sup>		Average Residual, cfs	
	2017 WLAM HSPF WY 2007-2016	Outliers Removed	2017 WLAM HSPF WY 2007-2016	Outliers Removed
San Timoteo Ck near Loma Linda	0.68	0.68	-1.36	-1.33
Warm Ck near San Bernardino	0.73	0.74	-1.32	-1.19
Santa Ana River at E Street	0.95	0.95	-6.36	-6.40
Santa Ana River at MWD Crossing	0.91	0.91	-12.02	-12.02
Temescal Ck at Main Street	0.75	0.75	-0.72	-0.78
Chino Ck at Schaefer Avenue	0.80	0.80	-2.27	-2.35
Cucamonga Ck near Mira Loma	0.87	0.88	-0.16	-0.28
Santa Ana River into Prado Dam	0.92	0.92	-1.33	-1.33
Santa Ana River at Santa Ana	0.55	0.56	0.18	-0.31

**Table 3-4. Outlier Analysis – Monthly Simulated Streamflow Performance**

Gaging Station	R <sup>2</sup>		Average Residual, cfs	
	2017 WLAM HSPF WY 2007-2016	Outliers Removed	2017 WLAM HSPF WY 2007-2016	Outliers Removed
San Timoteo Ck near Loma Linda	0.68	0.68	-1.38	-1.38
Warm Ck near San Bernardino	0.91	0.91	-1.31	-1.31
Santa Ana River at E Street	0.97	0.97	-6.32	-6.22
Santa Ana River at MWD Crossing	0.97	0.97	-12.09	NA
Temescal Ck at Main Street	0.84	0.84	-0.69	NA
Chino Ck at Schaefer Avenue	0.83	0.83	-2.27	-2.32
Cucamonga Ck near Mira Loma	0.94	0.94	-0.22	-0.22
Santa Ana River into Prado Dam	0.97	0.97	-1.26	-1.26
Santa Ana River at Santa Ana	0.77	0.77	0.13	0.16

As shown,  $R^2$  values remain the same or improve slightly by removing outlier points. The value of average residual slightly increased or decreased depending on the distribution of the outlier points.

### 3.4 TDS and TIN Calibration

Chemographs showing daily model-simulated and measured TDS and TIN for the three gaging stations from October 1, 2006 through September 30, 2016 (Water Years 2007 through 2016) are provided as Figures 72 through 74 for TDS and Figures 75 through 77 for TIN. Monthly average TDS and TIN concentrations are provided as Figures 78 through 80 and Figures 81 through 83, respectively. For comparison purposes, model calibration results for the period from October 1, 1994 through September 30, 2006 (Water Years 1995 through 2006) from the 2008 WLAM were also shown in the applicable chemographs. However, these results are not shown on the chemographs for the SAR at Imperial Highway near Anaheim, as this station was not used for 2008 WLAM calibration. The chemographs similar temporal dynamics in both model-simulated and measured TDS concentrations at the gaging stations for both the 2008 WLAM and the 2017 WLAM HSPF.

The following tables summarize TDS and TIN residuals for the 2008 WLAM and 2017 WLAM HSPF. It should be noted that the 2008 WLAM did not attempt to optimize model-calculated water quality by maximizing  $R^2$  or minimizing the RMSE due to an insufficient amount of data.

**Table 3-5. WLAM Calibration Results – Daily Simulated TDS and TIN Performance**

Gaging Station	TDS		TIN	
	2008 WLAM WY 1995-2006	2017 WLAM HSPF WY 2007-2016	2008 WLAM WY 1995-2006	2017 WLAM HSPF WY 2007-2016
<b>Santa Ana River at MWD Crossing</b>				
Average Residual, mg/L	16.4	0.6	-0.45	-0.14
Average of Observed, mg/L	591	587	6.14	8.45
Average Residual Percentage of Observed, %	2.8%	0.1%	-7.4%	-1.7%
Standard Deviation, mg/L	75.5	74.6	2.38	1.24
RMSE	77.3	74.5	2.42	1.24
<b>Santa Ana River below Prado Dam</b>				
Average Residual, mg/L	20.7	0.1	-0.07	-0.54
Average of Observed, mg/L	535	615	5.13	3.92
Average Residual Percentage of Observed, %	3.9%	0.0%	-1.4%	-13.9%
Standard Deviation, mg/L	74.7	101.5	1.61	1.22
RMSE	77.4	101.5	1.61	1.34
<b>Santa Ana River at Imperial Highway near Anaheim</b>				
Average Residual, mg/L	NA	-0.6	NA	-0.17
Average of Observed, mg/L	NA	640	NA	3.09
Average Residual Percentage of Observed, %	NA	-0.1%	NA	-5.6%
Standard Deviation, mg/L	NA	84.4	NA	1.01
RMSE	NA	84.2	NA	1.03

Note: Residual = Observed – Model-Simulated (positive numbers indicate model underestimation, negative numbers indicate model overestimation)

**Table 3-6. WLAM Calibration Results – Monthly Simulated TDS and TIN Performance**

Gaging Station	TDS		TIN	
	2008 WLAM WY 1995-2006	2017 WLAM HSPF WY 2007-2016	2008 WLAM WY 1995-2006	2017 WLAM HSPF WY 2007-2016
<b>Santa Ana River at MWD Crossing</b>				
Average Residual, mg/L	-15.6	1.0	-0.47	-0.16
Average of Observed, mg/L	548	587	6.31	8.42
Average Residual Percentage of Observed, %	-2.8%	0.2%	-7.4%	-1.9%
Standard Deviation, mg/L	71.6	55.0	2.54	0.93
RMSE	73.0	54.8	2.56	0.93
<b>Santa Ana River below Prado Dam</b>				
Average Residual, mg/L	21.3	0.2	-0.23	-0.50
Average of Observed, mg/L	536	613	5.21	3.96
Average Residual Percentage of Observed, %	4.0%	0.0%	-4.4%	-12.6%
Standard Deviation, mg/L	48.6	51.1	1.49	0.97
RMSE	52.9	50.9	1.51	1.08
<b>Santa Ana River at Imperial Highway near Anaheim</b>				
Average Residual, mg/L	NA	-0.8	NA	-0.17
Average of Observed, mg/L	NA	637	NA	3.19
Average Residual Percentage of Observed, %	NA	-0.1%	NA	-5.3%
Standard Deviation, mg/L	NA	88.3	NA	1.08
RMSE	NA	87.9	NA	1.09

Note: Residual = Observed – Model-Simulated (positive numbers indicate model underestimation, negative numbers indicate model overestimation)

As seen in Tables 3-5 and 3-6 above, model calibration for the 2017 WLAM HSPF produces low TDS/TIN residuals from Water Year 2006 through Water Year 2016. In addition, residuals from the 2017 WLAM HSPF are lower than the 2008 WLAM for all gages, except for TIN at the Santa Ana River below Prado Dam. However, the 2017 WLAM HSPF produces a standard deviation and RMSE for TIN that is less than those produced by the 2008 WLAM at this location.

### 3.5 Water Budgets and Mass Balance

The amount of model-calculated streambed percolation and the associated TDS/TIN concentrations for each GMZ within the 2017 WLAM HSPF area are summarized in the following table.

**Table 3-7. Average Annual Streambed Percolation and TDS/TIN Mass (Water Years 2007 through 2016)**

GMZ	Streambed Percolation [acre-ft/yr]	TDS Mass [tons/yr]	TIN Mass [tons/yr]
Bunker Hill-B (SAR Reach 5)	12,650	2604	29
Colton (SAR Reach 4)	1,370	245	2
Riverside-A (SAR Reaches 3 & 4)	39,594	34,323	463
Chino-South (SAR Reach 3)	39,867	21,179	266
Prado Basin (SAR Reach 3)	7,856	6,060	69
Orange County (SAR Reach 2)	12,310	3,724	15

Annual flow and TDS and TIN mass balances for each GMZ and associated SAR reach are provided in Tables 4 through 15. In addition, the average mass balances (by source) for each major stream segment are summarized below, based on the flow-weighted annualized average (see Table 16 for annual streambed percolation).

**Table 3-8. Mass Balance (by Source) for Reach 5 of the Santa Ana River overlying the Bunker Hill-B GMZ (Water Years 2007 through 2016)**

Source	Flow [acre-ft/yr (% of total)]	TDS [tons/yr (% of total)]	TIN [tons/yr (% of total)]
Direct Precipitation and Atmospheric Deposition	30 (0%)	0 (0%)	0 (0%)
Surface Runoff	35,810 (99%)	7,220 (96%)	90 (92%)
San Bernardino WRP	460 (1%)	320 (4%)	10 (8%)
<b>TOTAL</b>	<b>36,300 (100%)</b>	<b>7540 (100%)</b>	<b>100 (100%)</b>

**Table 3-9. Mass Balance (by Source) for Reach 4 of the Santa Ana River overlying the Colton GMZ (Water Years 2007 through 2016)**

Source	Flow [acre-ft/yr (% of total)]	TDS [tons/yr (% of total)]	TIN [tons/yr (% of total)]
Direct Precipitation and Atmospheric Deposition	140 (0%)	10 (0%)	0 (0%)
Surface Runoff	30,910 (100%)	5,440 (100%)	60 (100%)
<b>TOTAL</b>	<b>31,050 (100%)</b>	<b>5,450 (100%)</b>	<b>60 (100%)</b>

**Table 3-10. Mass Balance (by Source) for Reach 3 & 4 of the Santa Ana River overlying the Riverside-A GMZ (Water Years 2007 through 2016)**

Source	Flow [acre-ft/yr (% of total)]	TDS [tons/yr (% of total)]	TIN [tons/yr (% of total)]
Direct Precipitation and Atmospheric Deposition	110 (0%)	10 (0%)	0 (0%)
Surface Runoff	47,660 (41%)	7,220 (12%)	70 (8%)
Colton WWTP	0 (0%)	0 (0%)	0 (0%)
Rialto WWTP	6,800 (6%)	3,710 (6%)	80 (9%)
RIX Facility	37,760 (33%)	25,280 (40%)	390 (44%)
Rising Water	23,460 (20%)	26,230 (42%)	340 (39%)
<b>TOTAL</b>	<b>115,790 (100%)</b>	<b>62,450 (100%)</b>	<b>880 (100%)</b>

**Table 3-11. Mass Balance (by Source) for Reach 3 of the Santa Ana River overlying the Chino South GMZ (Water Years 2007 through 2016)**

Source	Flow [acre-ft/yr (% of total)]	TDS [tons/yr (% of total)]	TIN [tons/yr (% of total)]
Direct Precipitation and Atmospheric Deposition	90 (0%)	10 (0%)	0 (0%)
Surface Runoff	100,350 (75%)	44,200 (62%)	580 (63%)
Riverside RWQCP	32,840 (25%)	27,640 (38%)	340 (37%)
<b>TOTAL</b>	<b>133,280 (100%)</b>	<b>71,850 (100%)</b>	<b>920 (100%)</b>

**Table 3-12. Mass Balance (by Source) for Reach 3 of the Santa Ana River overlying the Prado Basin GMZ (Water Years 2007 through 2016)**

Source	Flow [acre-ft/yr (% of total)]	TDS [tons/yr (% of total)]	TIN [tons/yr (% of total)]
Direct Precipitation and Atmospheric Deposition	140 (0%)	10 (0%)	0 (0%)
Surface Runoff	177,340 (87%)	84,790 (74%)	900 (86%)
Western Riverside County RWAP	6,480 (3%)	4,700 (4%)	20 (2%)
Corona WWTP-1	3,350 (2%)	3,240 (3%)	30 (2%)
Rising Water	15,850 (8%)	22,000 (19%)	100 (10%)
<b>TOTAL</b>	<b>203,160 (100%)</b>	<b>114,740 (100%)</b>	<b>1,050 (100%)</b>

**Table 3-13. Mass Balance (by Source) for Reach 2 of the Santa Ana River overlying the Orange County GMZ (Water Years 2007 through 2016)**

Source	Flow [acre-ft/yr (% of total)]	TDS [tons/yr (% of total)]	TIN [tons/yr (% of total)]
Direct Precipitation and Atmospheric Deposition	410 (0%)	40 (0%)	0 (0%)
Surface Runoff	188,050 (100%)	88,390 (100%)	700 (100%)
<b>TOTAL</b>	<b>188,460 (100%)</b>	<b>88,430 (100%)</b>	<b>700 (100%)</b>

#### 4.0 SOURCES OF UNCERTAINTY AND ERROR

The 2017 WLAM HSPF is a useful tool for evaluating streamflow and TDS/TIN concentrations in surface water. However, it is a simplified approximation of a complex hydrogeologic system and has been designed with certain built-in assumptions. HSPF watershed modeling has very extensive data requirements (Skahill, 2004). A reliable watershed model depends upon accurate and abundant sources of measured data and a satisfactory calibration period. Often, in absence of complete or accurate records, model input represents estimated and/or averaged values. Future use of an extended data set and calibration period should continue to improve the accuracy and reliability of the model.

Sources of uncertainty and areas of significant model limitation were found to be:

- Uncertainty in data from streamflow gages typically increases with decreased flow. At low flow rates, the water in the channel may not reach the gage due to gage detection limits (e.g., 0.1 cfs – 1.0 cfs) or flow by-passing the gage. Therefore, some of the variability between model-calculated and observed streamflow at low flow rates may be attributed to gage sensitivity and precision of gage detection limits.
- USGS gaged data is used to calibrate model-calculated streamflow. However, stream gage accuracy, as defined in the USGS Water-Year Summaries for each gaging station (reported in TM-1; GEOSCIENCE, 2018), varies each year. In many of the years, stream gage accuracy has been classified as “poor” – indicating that less than 95% of the daily discharge values are within 15% of the true value.
- Model-calculated flow downstream of Prado Dam is largely dependent on the results from the OCWD RFM, which simulates Prado Dam operations and OCWD diversions. However, actual releases from Prado may be different since the USACE does not always follow their own operating rules. This is especially true for wet years (e.g., Water Year 2011). These deviations are not accounted for in the modeling, which can lead to discrepancies between model-calculated and observed streamflow at the Santa Ana River at Santa Ana gaging station.
- Flow from the SAR is diverted to the Prado Wetlands using a sand dike. During high flow events associated with stormwater runoff conditions, this dike has been known to wash out and may not be rebuilt for several weeks. This is a detail that the 2017 WLAM HSPF is not able to take into account.
- Dry weather urban runoff from return flow and landscape irrigation is not explicitly accounted for in the 2017 WLAM HSPF. While there is a long-term declining trend in urban runoff due to water conservation efforts, the unaccounted for flow from this runoff may explain some of the

discrepancy between model-calculated and observed values, particularly in dry weather, low flow conditions.

- Channel conditions are not constant. For example, significant channel improvements have been made to San Timoteo Creek during the model calibration period. These improvements have included lined channel sections, sediment control basins, earthen low-flow channels, and landscaping treatments (FEMA, 2007). Changes in streambeds can alter flow, detection limits of streamflow, and timing.
- IEUA's RP-2, which discharged into Chino Creek, was decommissioned in 2002. The loss of perennial flows likely altered subsequent streambed percolation rates in Chino Creek, which may contribute to some calibration discrepancies at this location.
- There are unavoidable discrepancies associated with delays between rainfall events and the arrival of runoff at a streamflow gage. In natural ephemeral stream systems, increased flow from a rainfall event may not appear at a downstream gage that same day. For this reason, model-calculated monthly streamflow typically shows better calibration performance than daily streamflow.
- Daily discharge and diversion values are not always available (e.g., Temescal Valley WRP discharge, OC-59 discharge, stormwater recharge). Daily discharge and diversions at locations for which only monthly data are available was therefore assumed to be constant throughout the month. This modeling assumption may also contribute to some of the discrepancy between model-calculated and observed daily streamflow.

## 5.0 SUMMARY

The 2017 WLAM HSPF for the SAR watershed was constructed and calibrated to provide an updated tool for predicting future conditions. The 2017 WLAM HSPF uses the HSPF computer code and includes an expanded area over the 2008 WLAM model boundary to incorporate additional reaches of the SAR within Orange County. HSPF is a publically available, federally-supported software system capable of simulating all water cycle and water quality components with small time steps (i.e, less than one day).

The 2017 WLAM HSPF was constructed using recent data and calibrated from October 1, 2006 through September 30, 2016 (Water Years 2007 through 2016). Streamflow data from nine gaging stations and TDS/TIN measurements from three gaging stations were used for model calibration. The calibration results show:

- Similar temporal dynamics in model-simulated and measured daily and monthly streamflow and TDS/TIN concentrations.
- Good to very good performance at the majority of the streamflow gages from Water Year 2006 through Water Year 2016.
- The calibration performance of the 2017 WLAM HSPF is equal to or better than that of the 2008 WLAM at nearly all gages.
- TDS/TIN residuals from the 2017 WLAM HSPF calibration are lower than the 2008 WLAM residuals for nearly all gages.
- The results indicate a satisfactory model calibration.

The 2017 WLAM HSPF is a useful tool for evaluating streamflow and TDS/TIN concentrations in surface water. However, it is a simplified approximation of a complex hydrogeologic system and has been designed with certain built-in assumptions. In the next phase of this study, the 2017 WLAM HSPF will be used to run predictive scenarios based on current and future projections of recycled water and non-tributary discharge.

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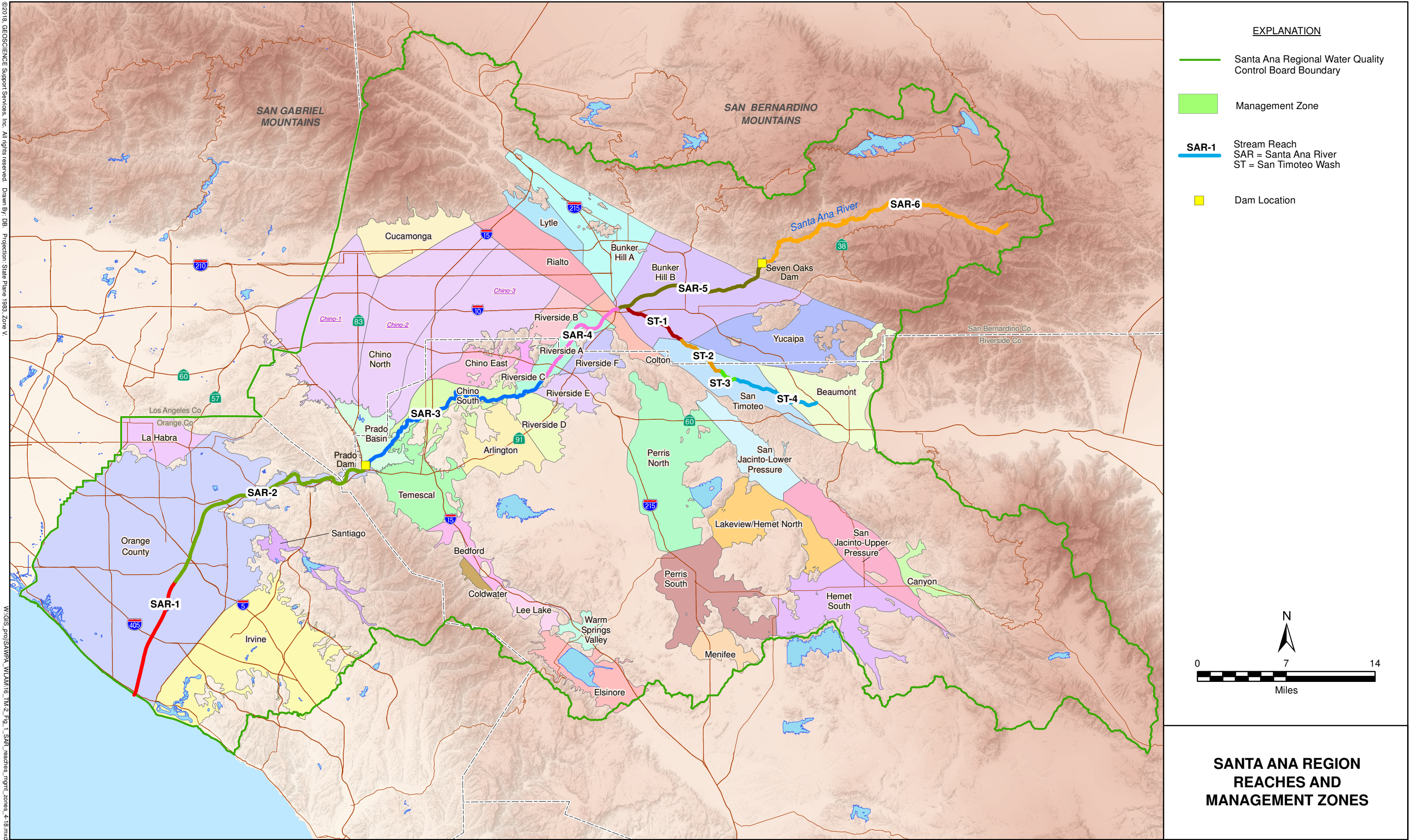
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## FIGURES

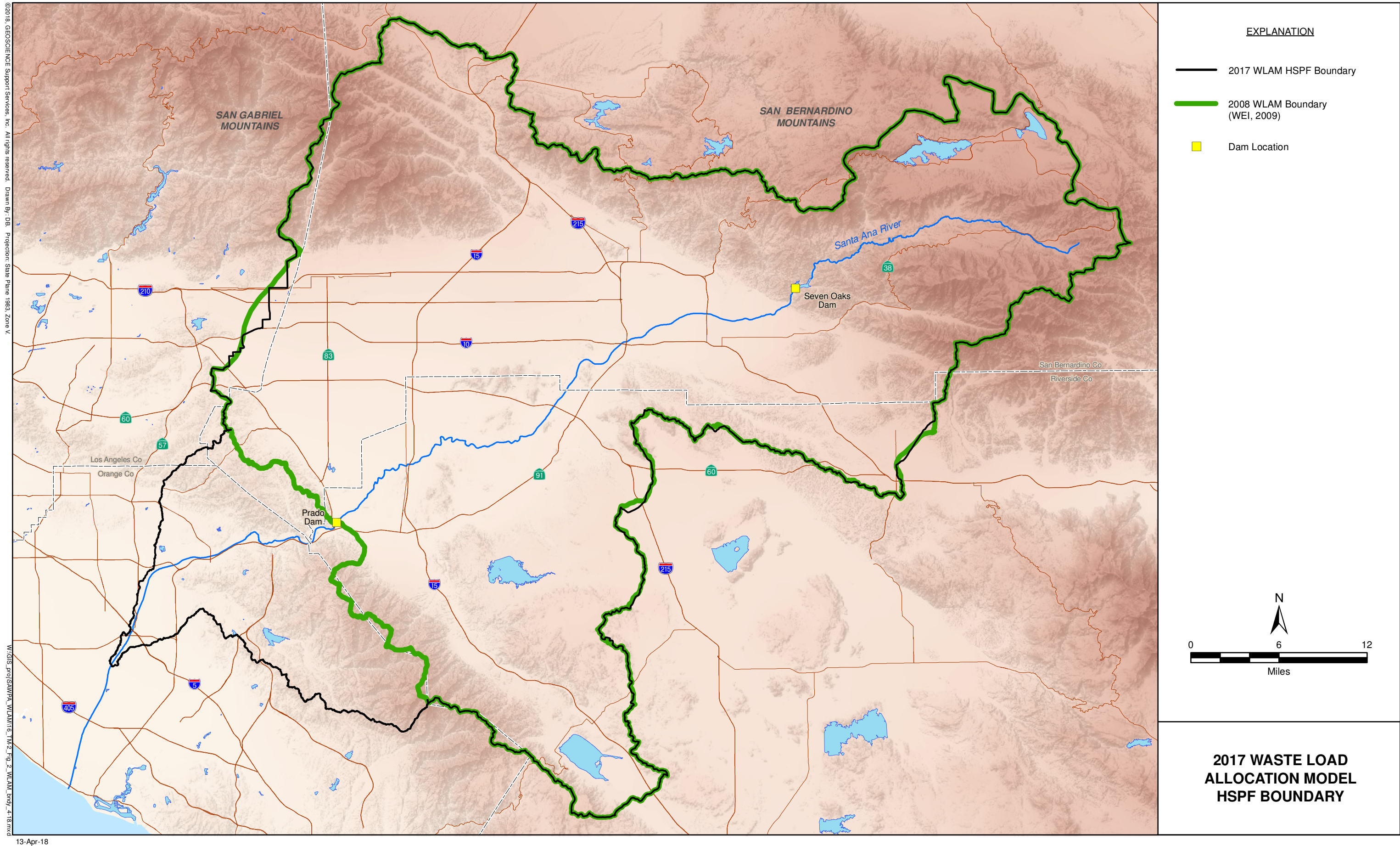
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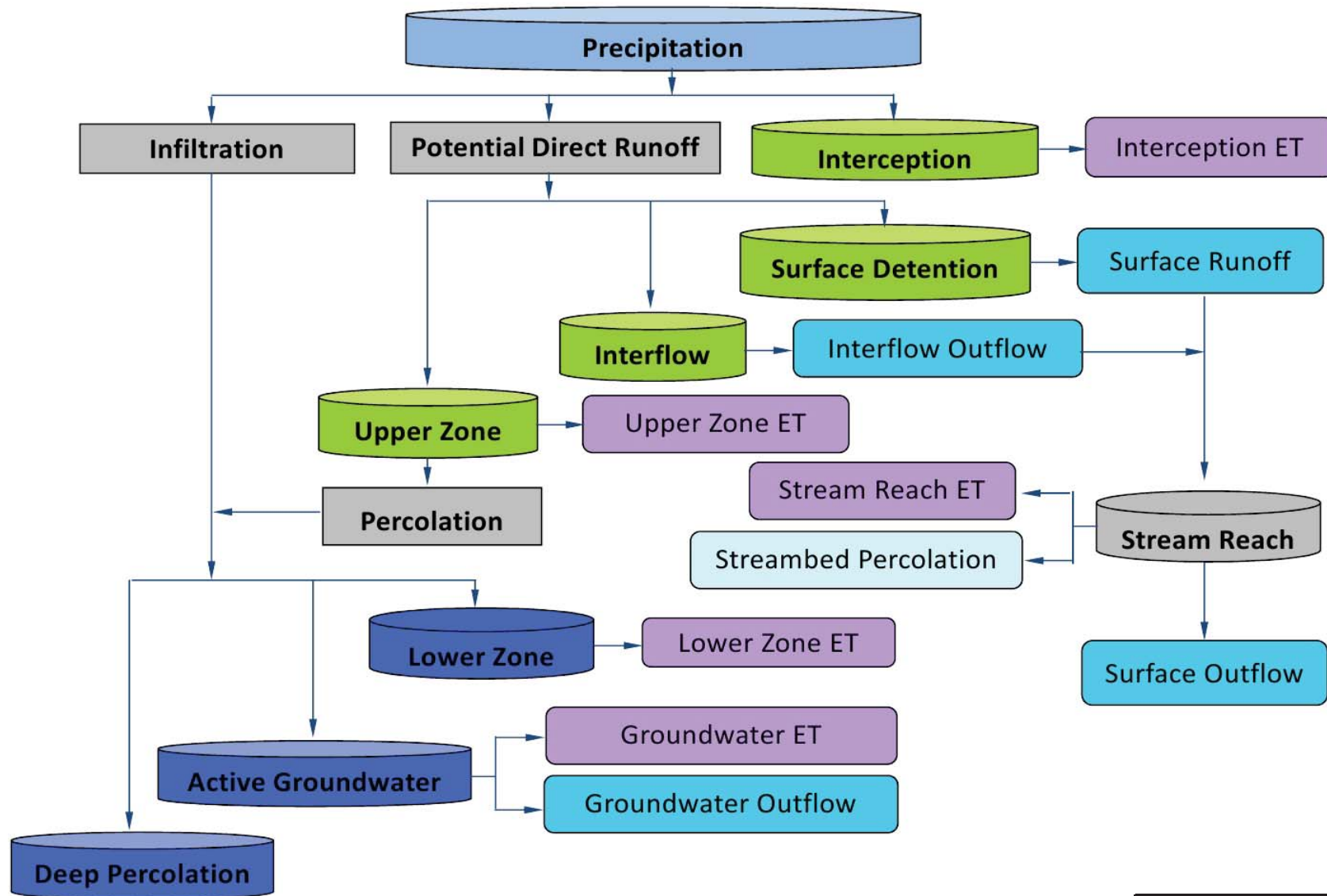


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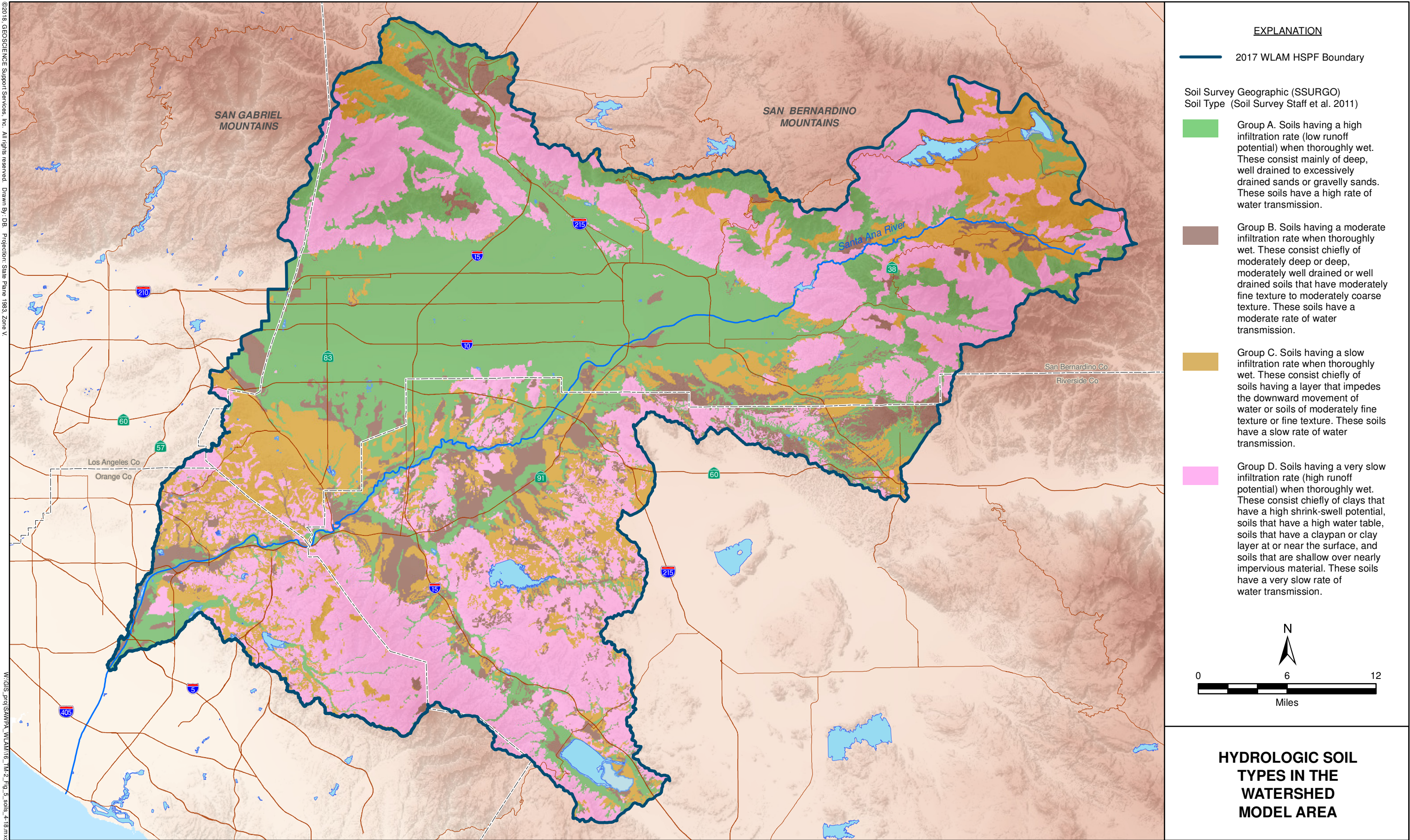
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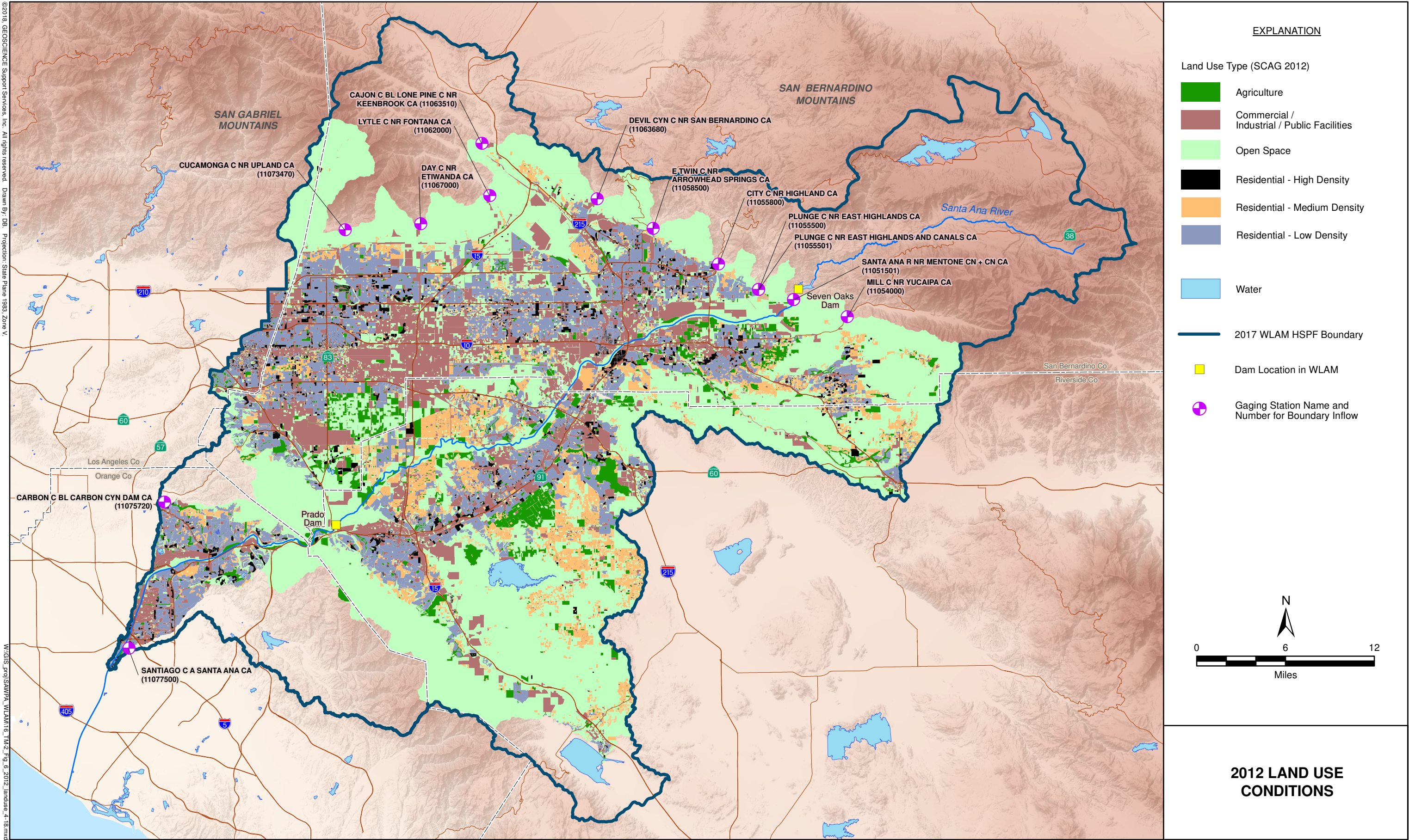
HSPF SCHEMATIC DIAGRAM



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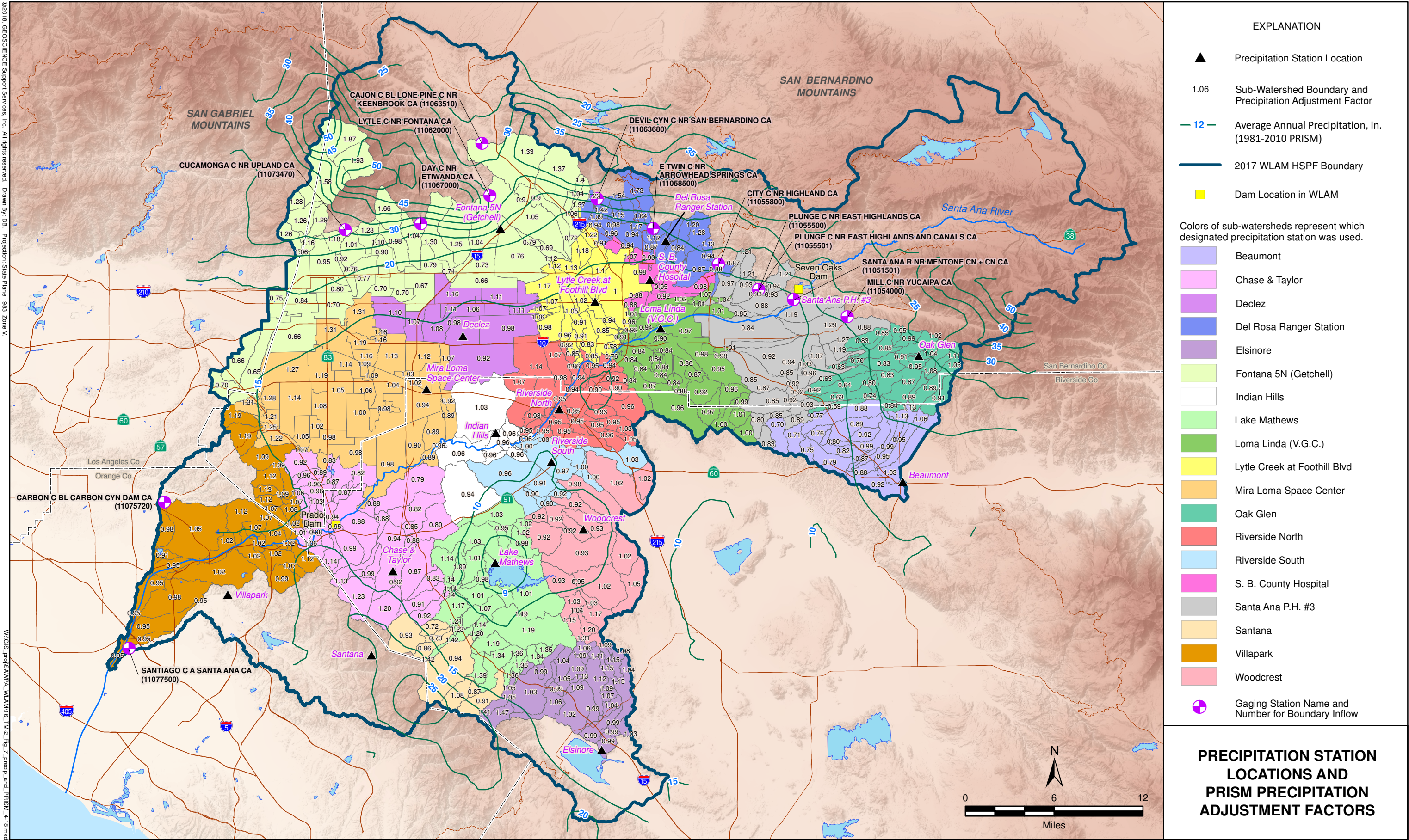
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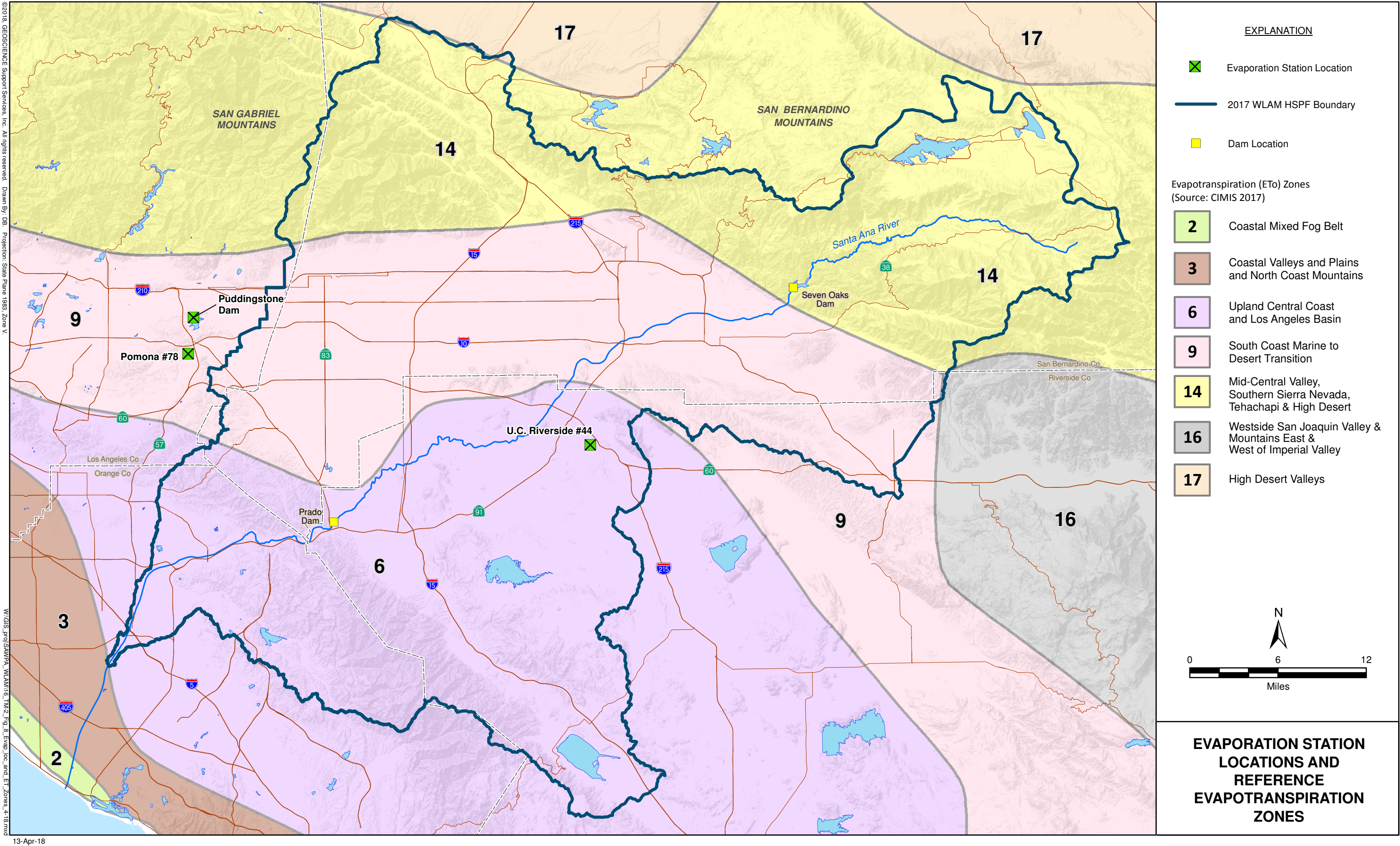


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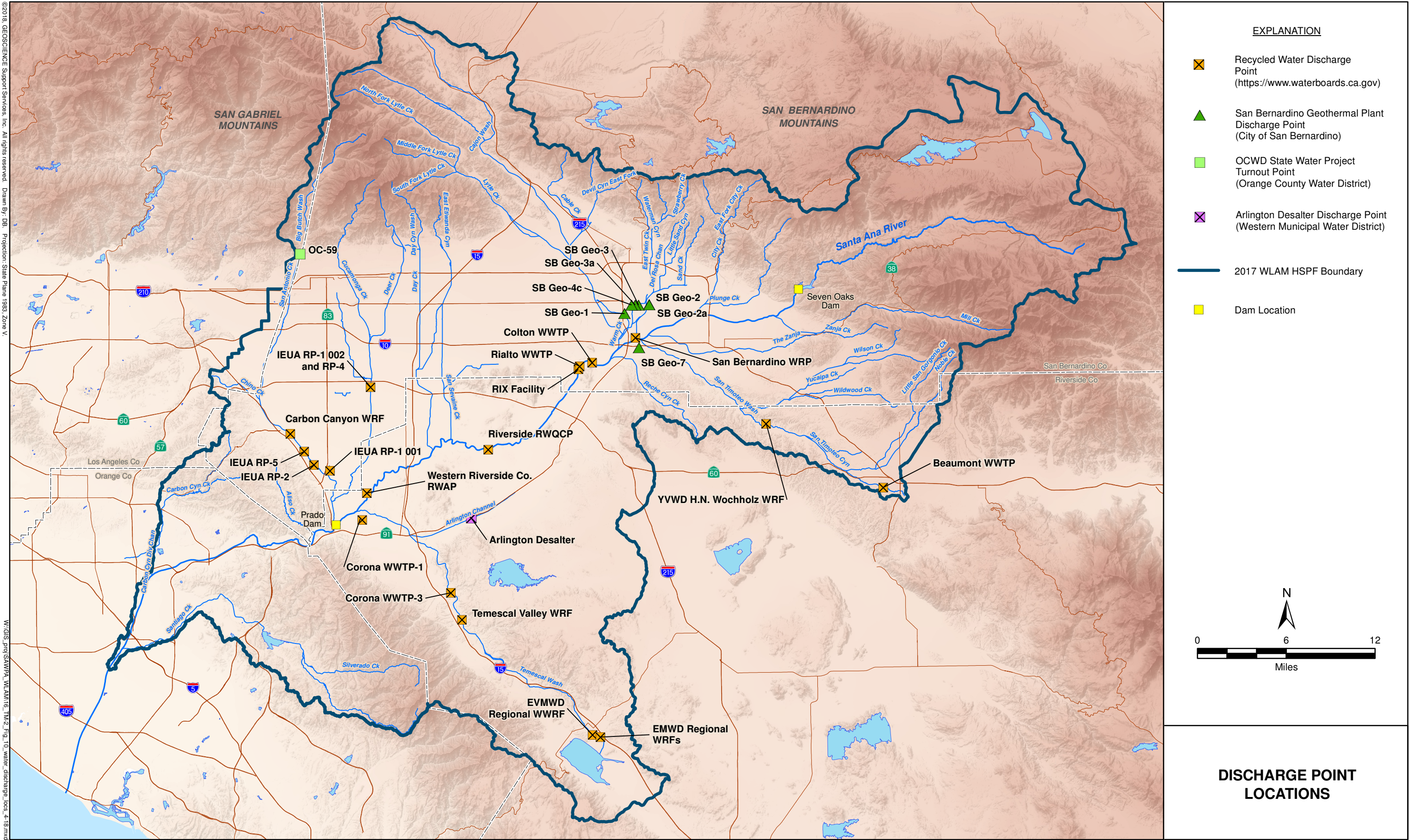
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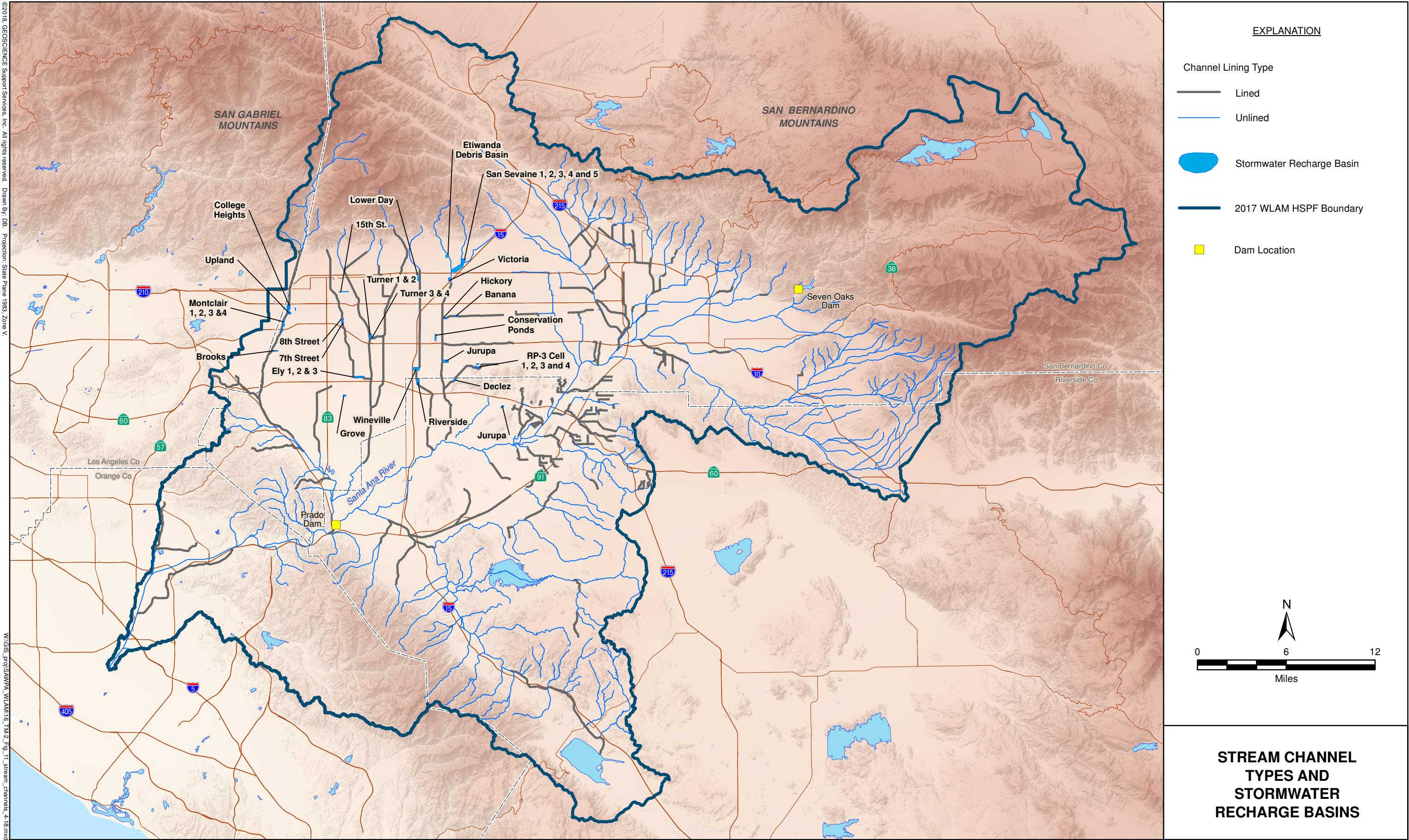


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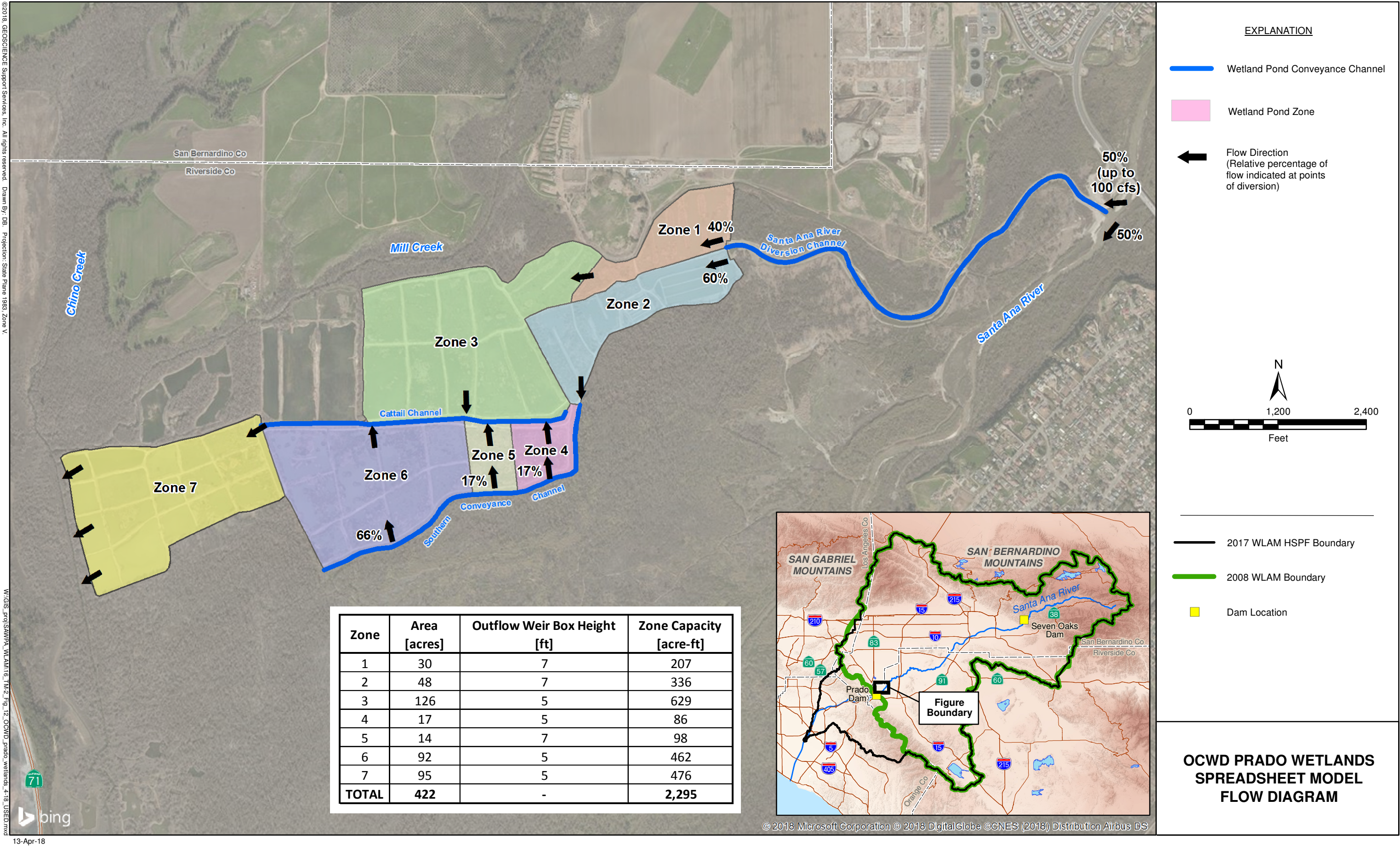
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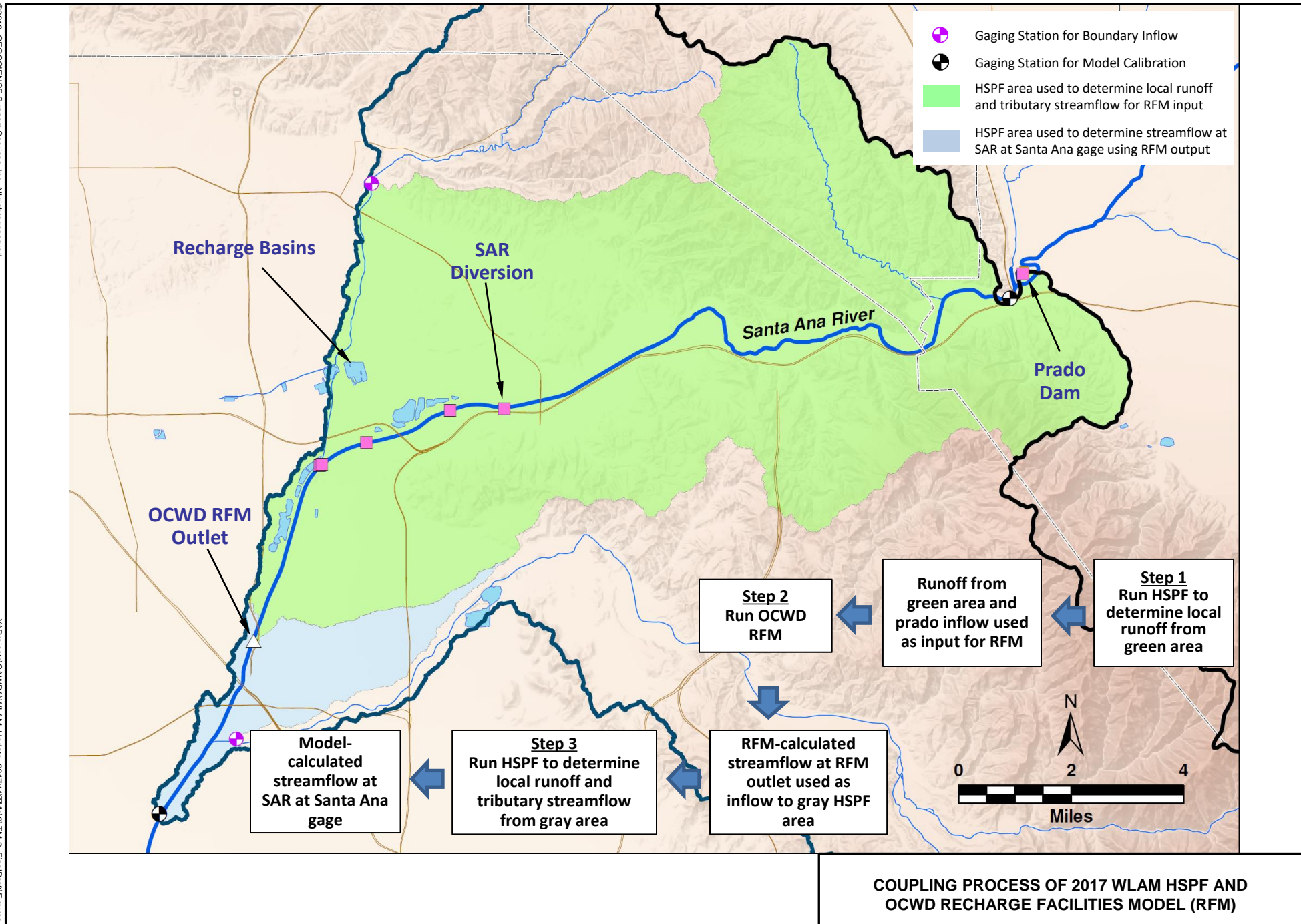


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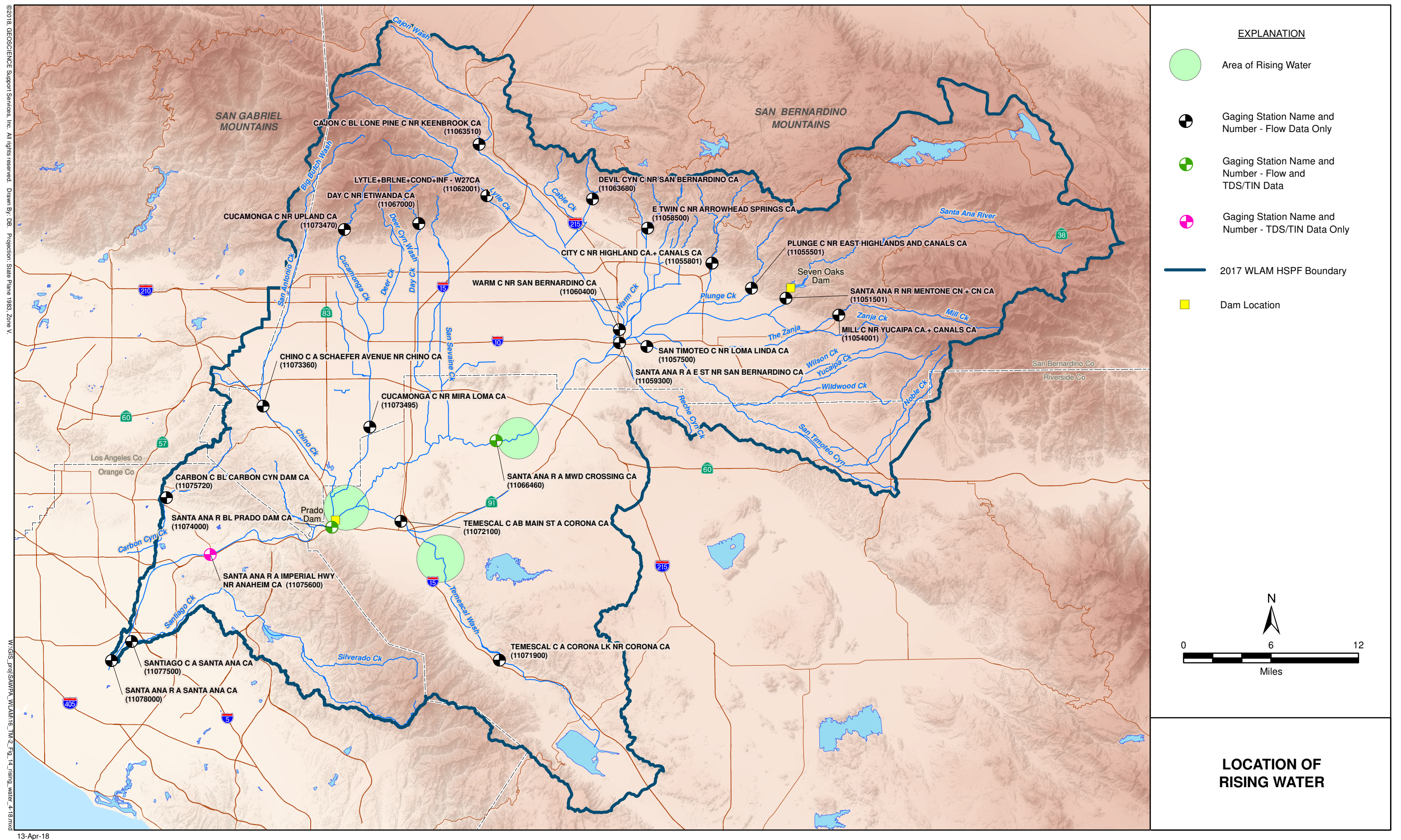
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Annual Rising Water from Upper Temescal Valley to Temescal Basin

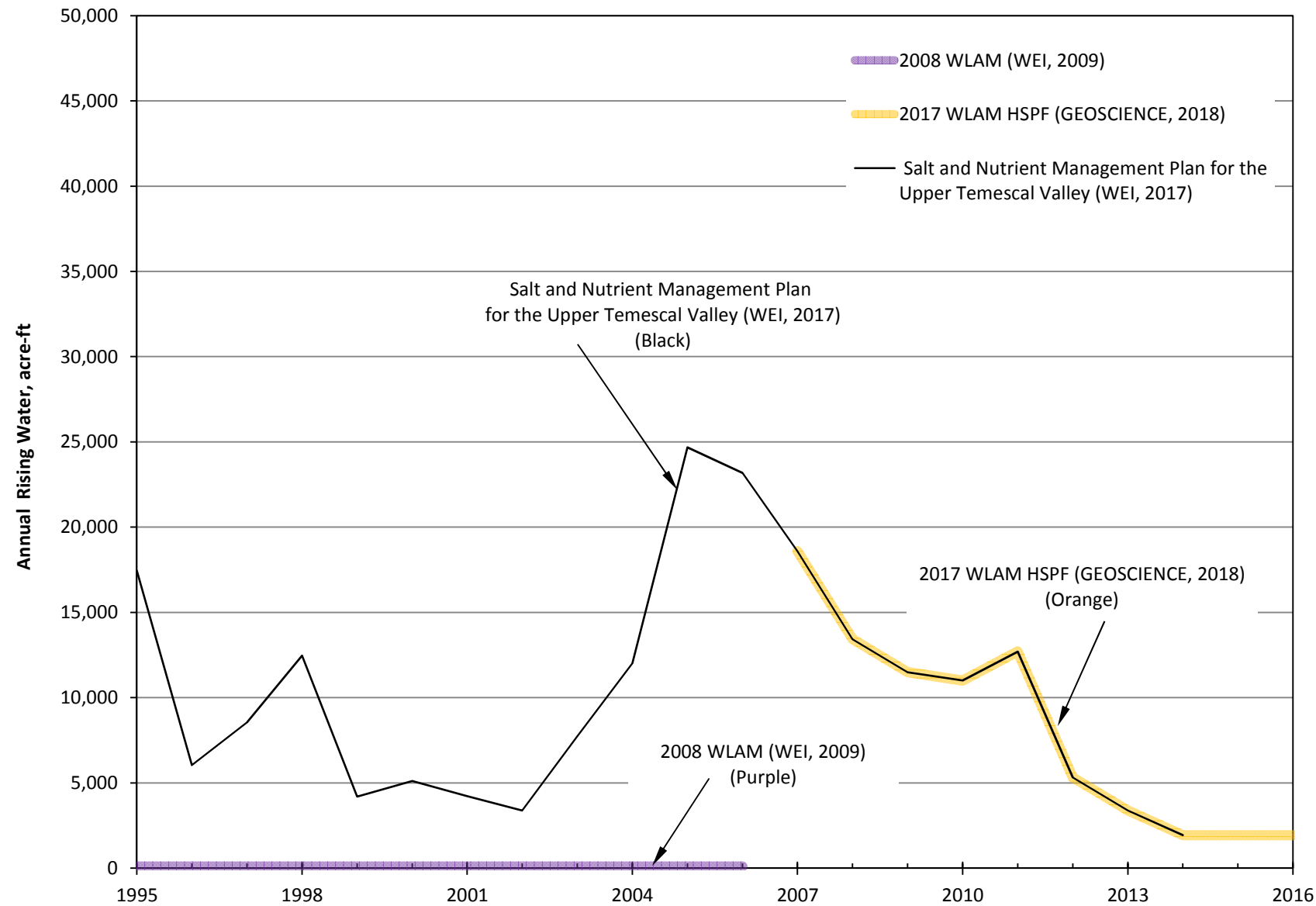


Figure 15

Annual Rising Water in Riverside Narrows

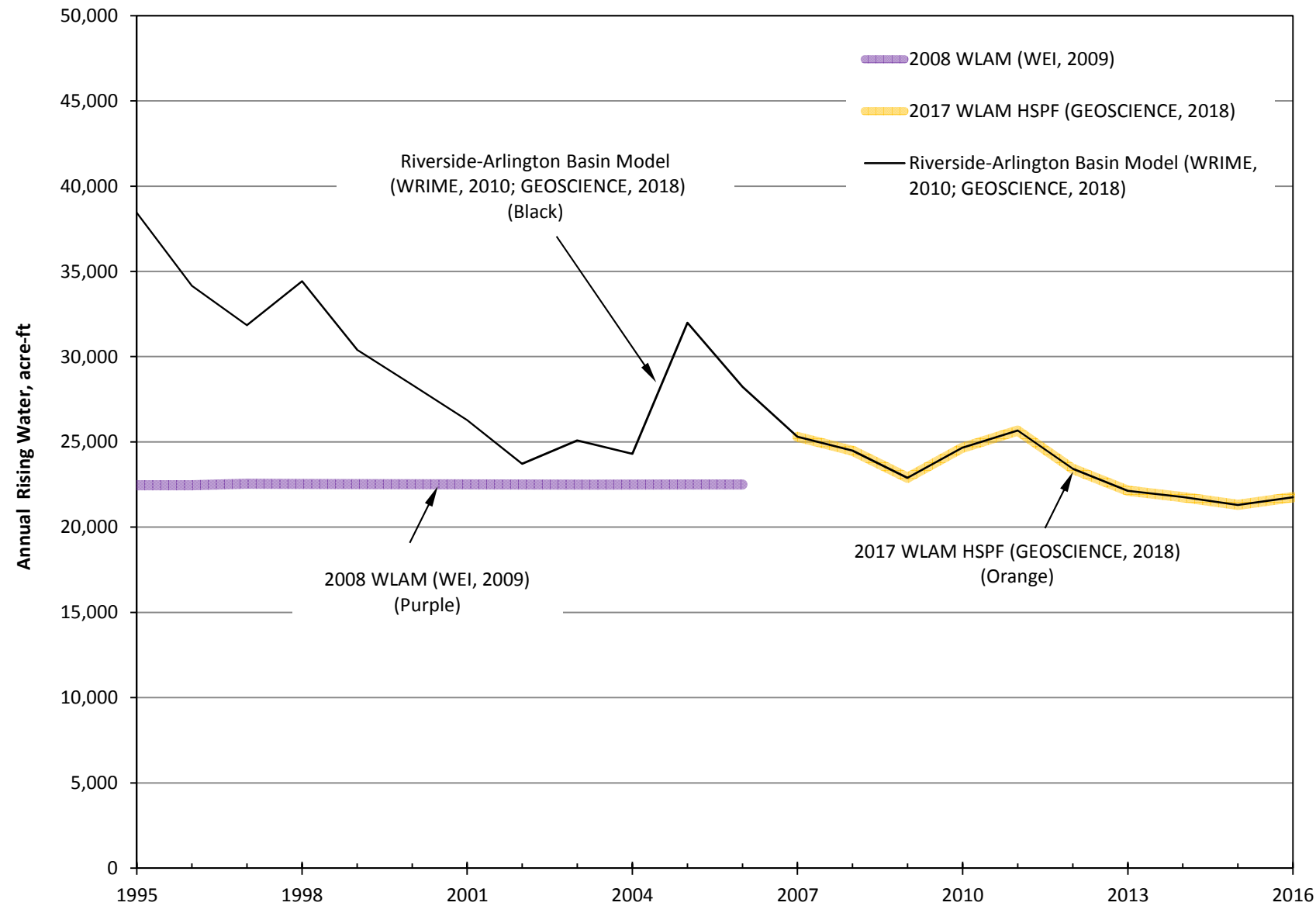


Figure 16

Annual Rising Water in Prado Vicinity

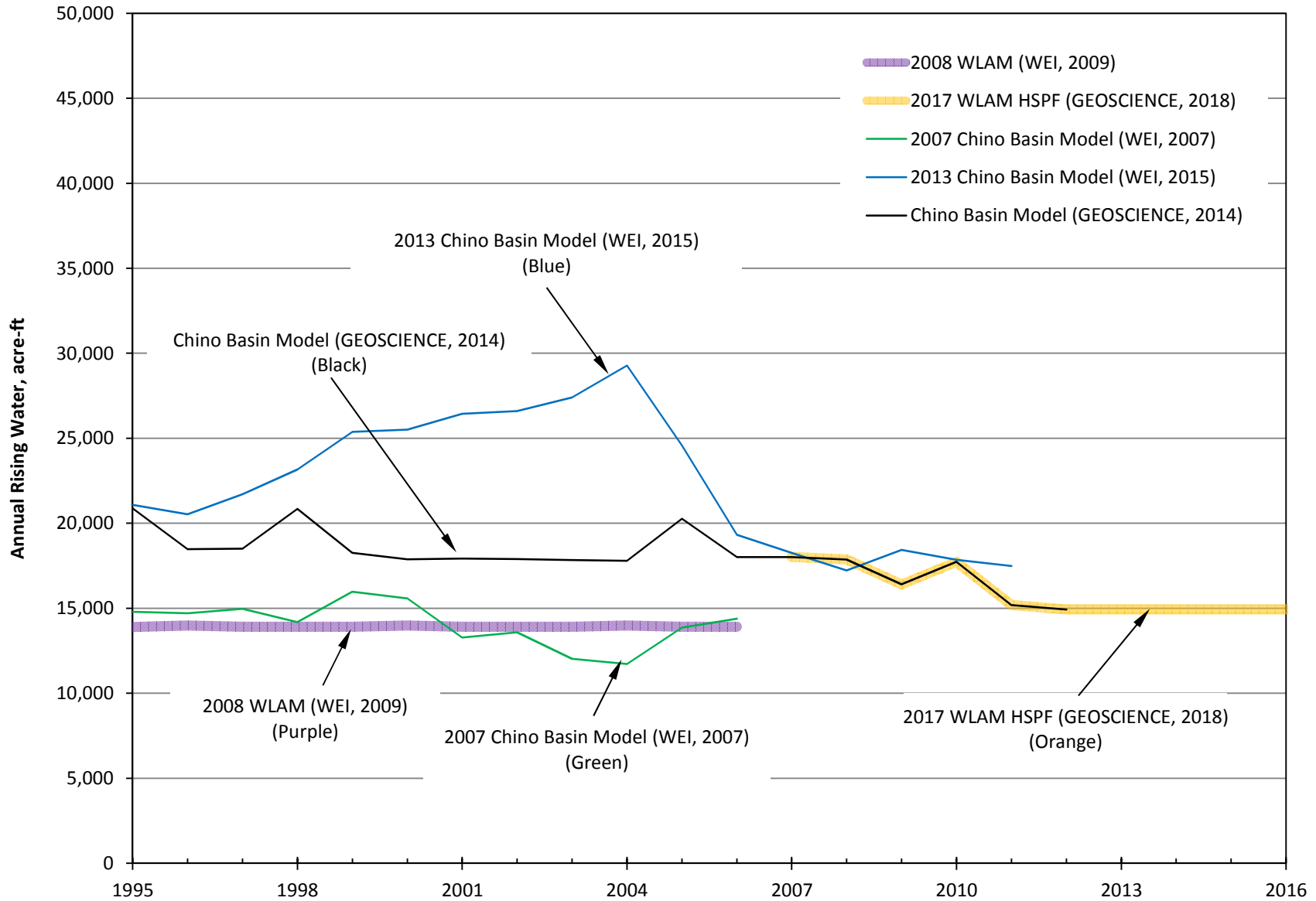
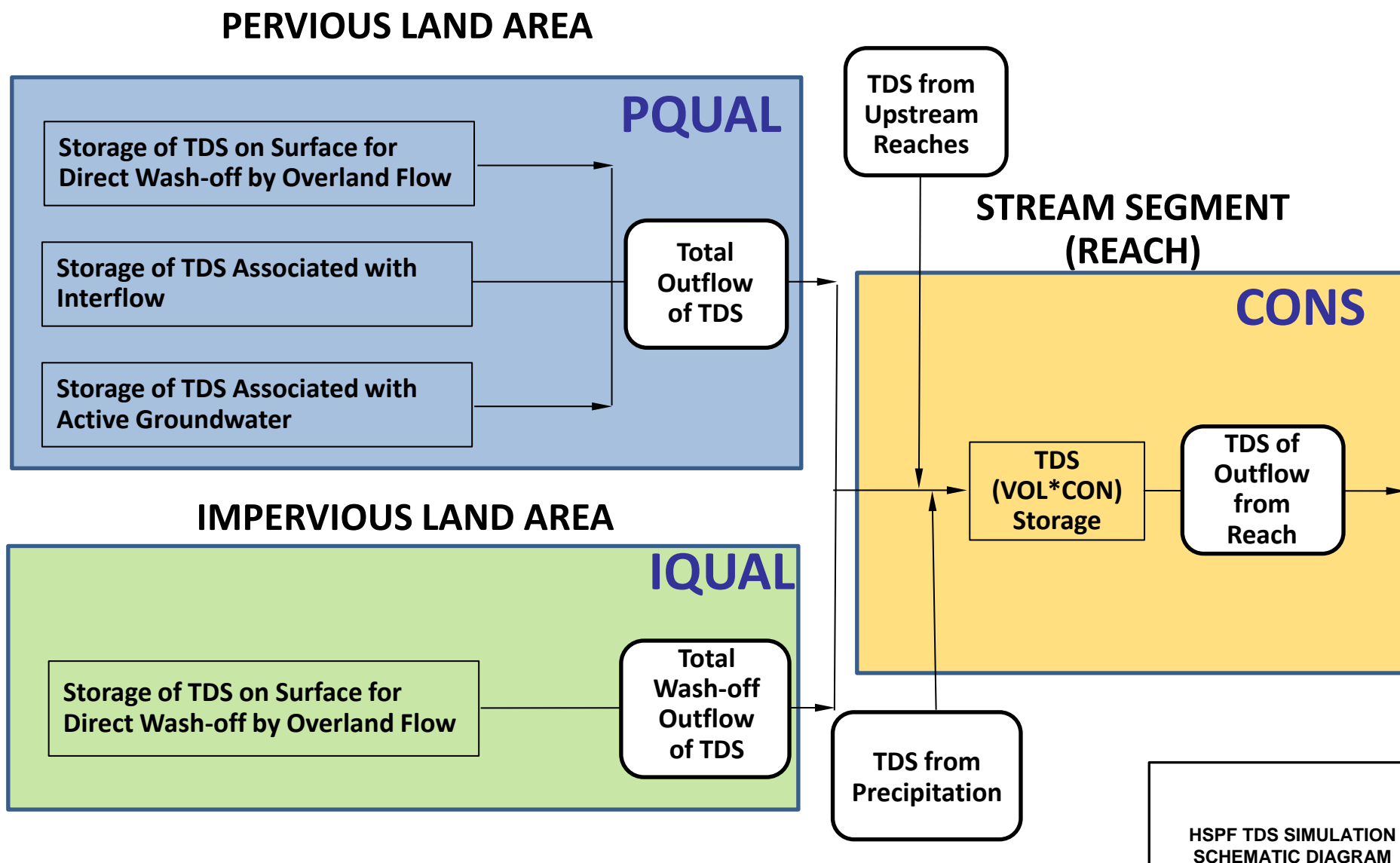
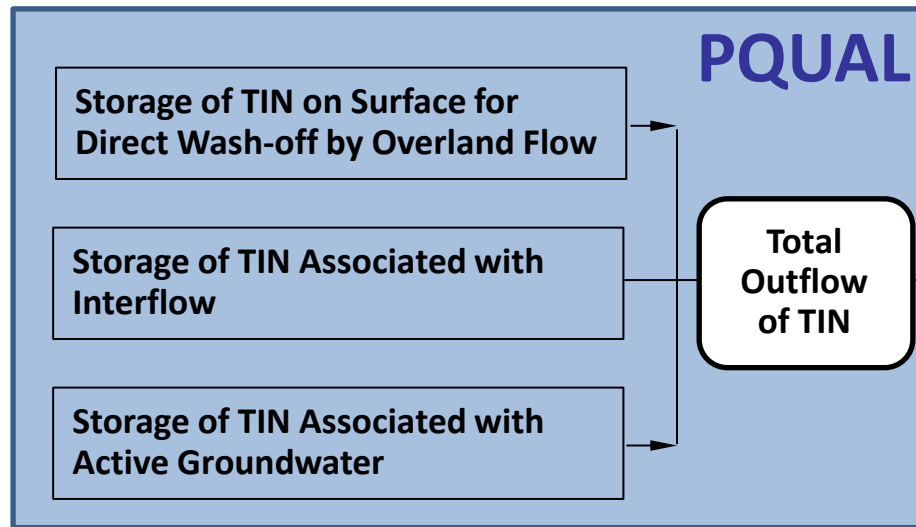


Figure 17

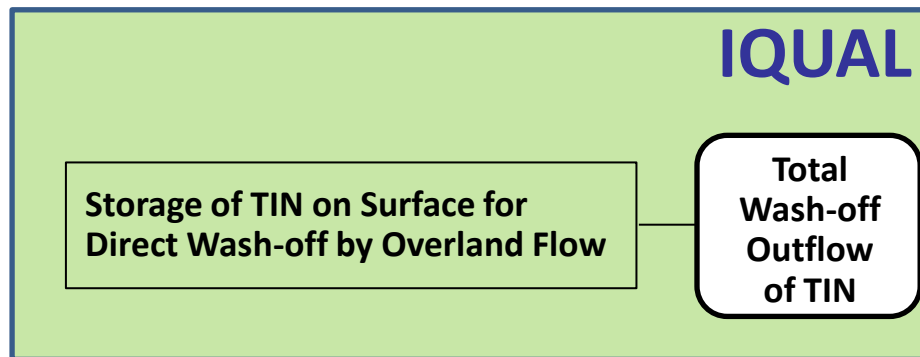


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## PERVIOUS LAND AREA

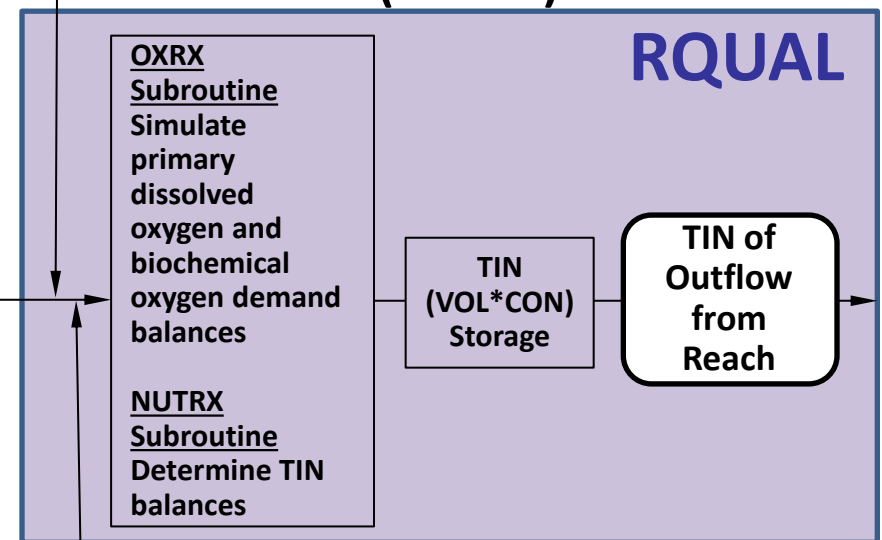


## IMPERVIOUS LAND AREA



TIN from Upstream Reaches

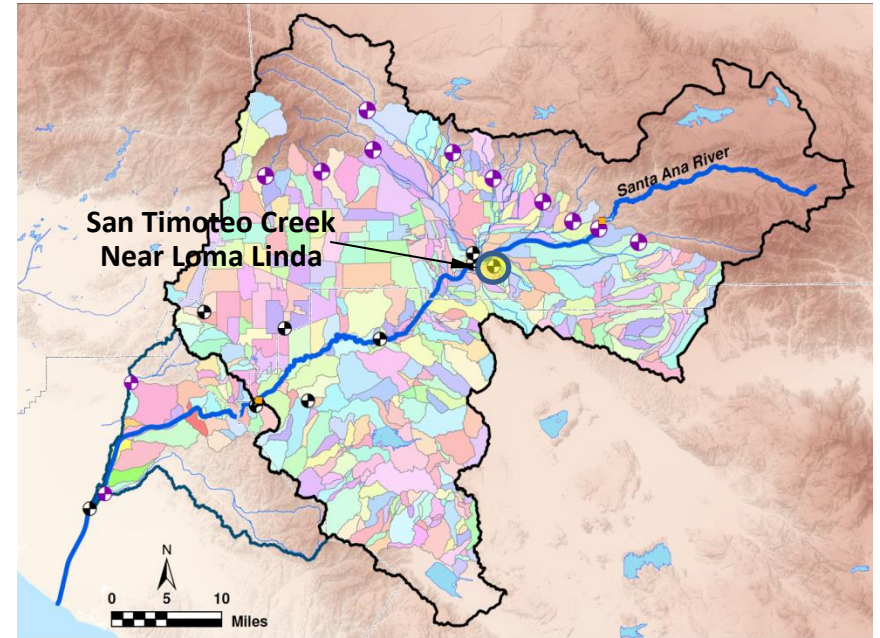
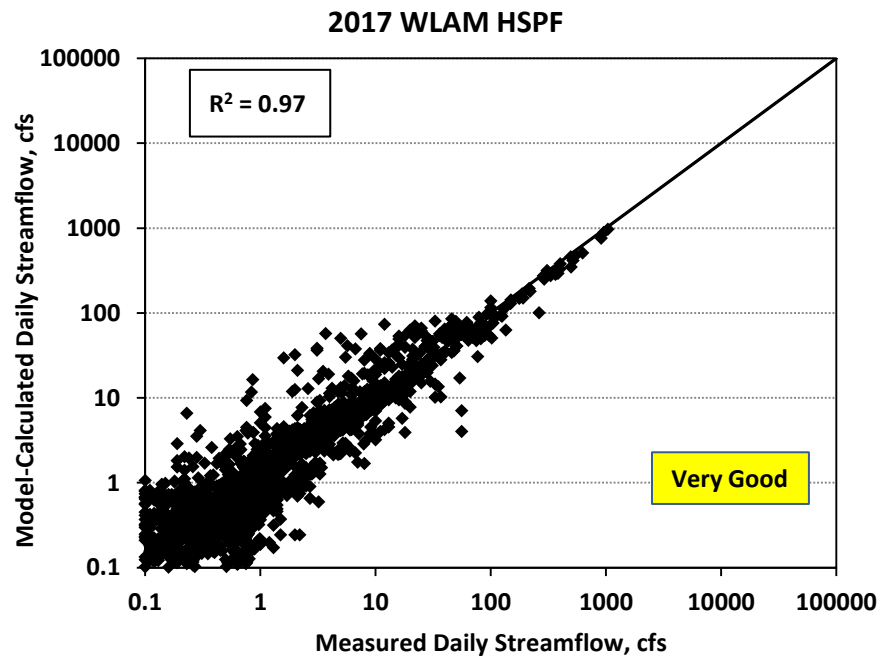
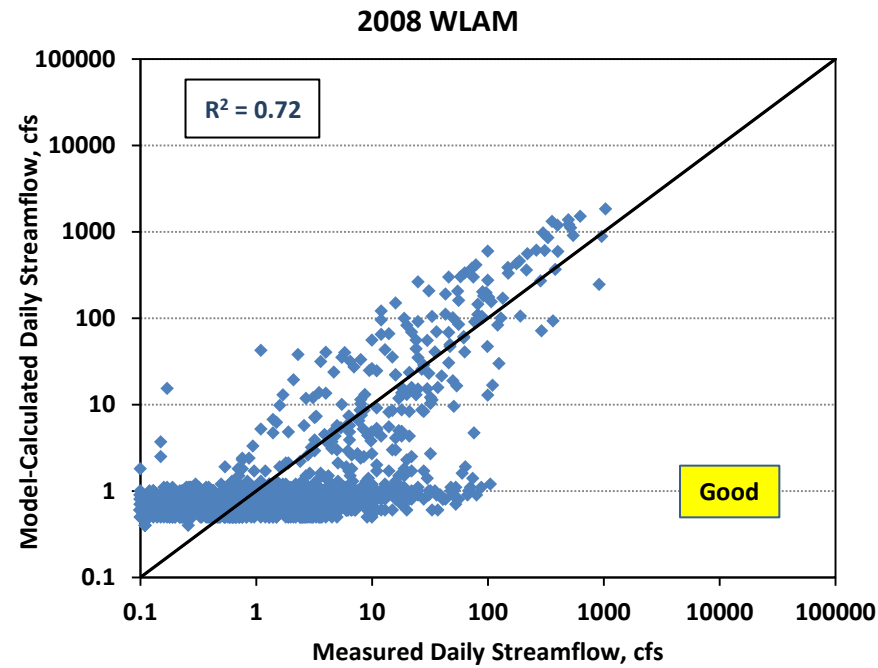
## STREAM SEGMENT (REACH)



TIN from Precipitation

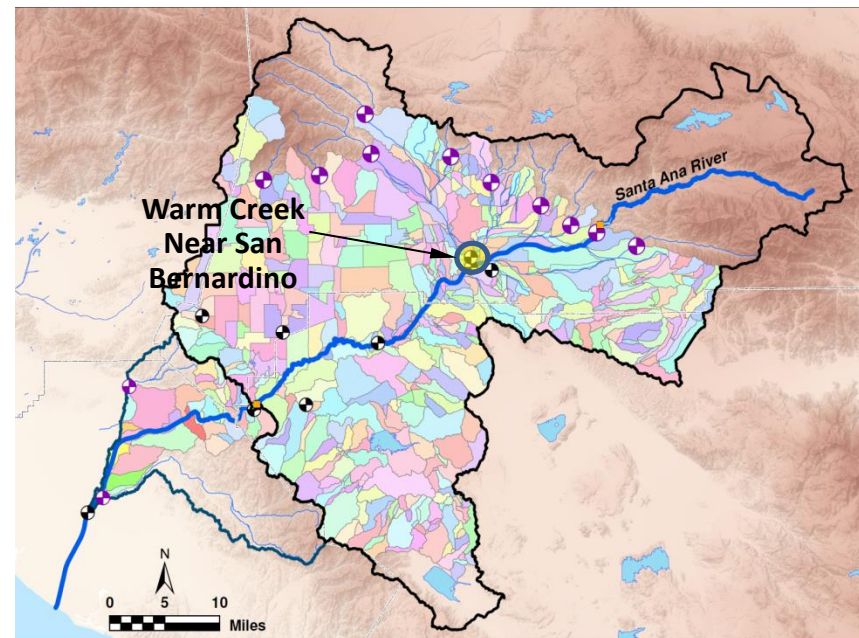
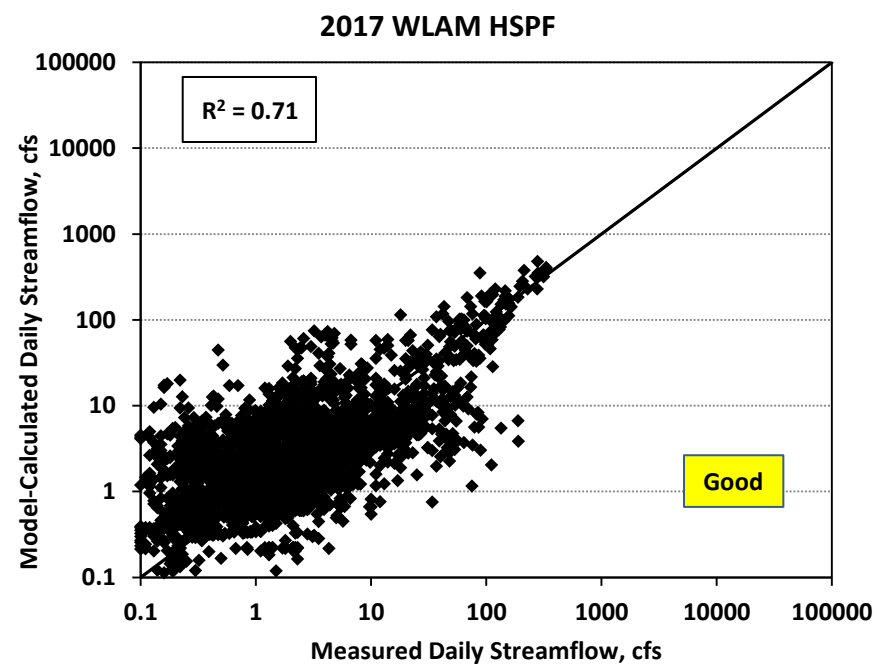
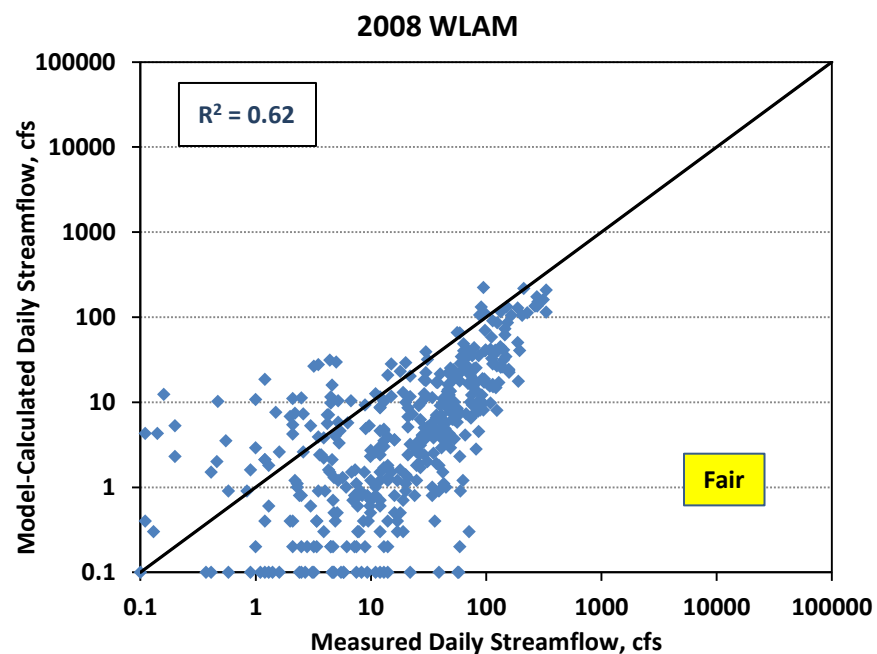
HSPF TIN SIMULATION SCHEMATIC DIAGRAM

13-Apr-18



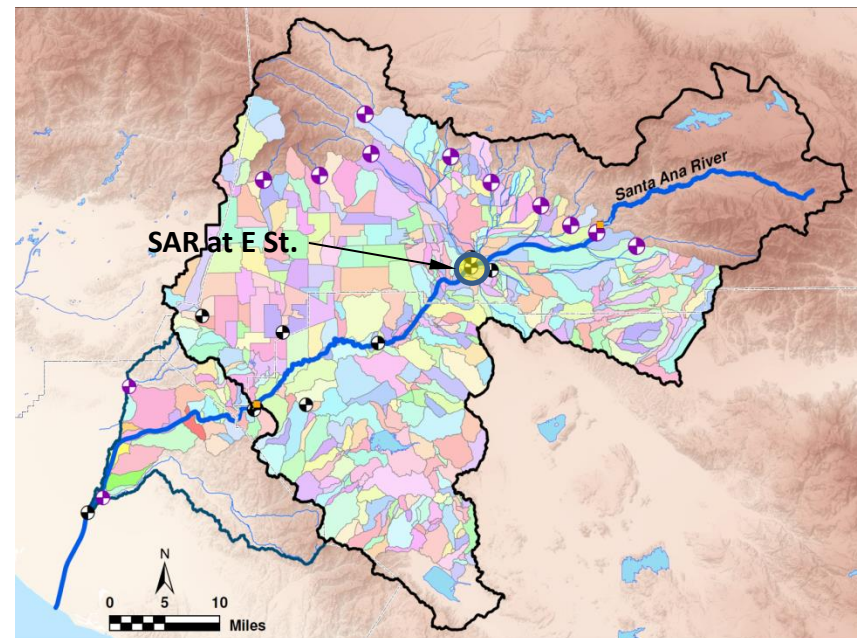
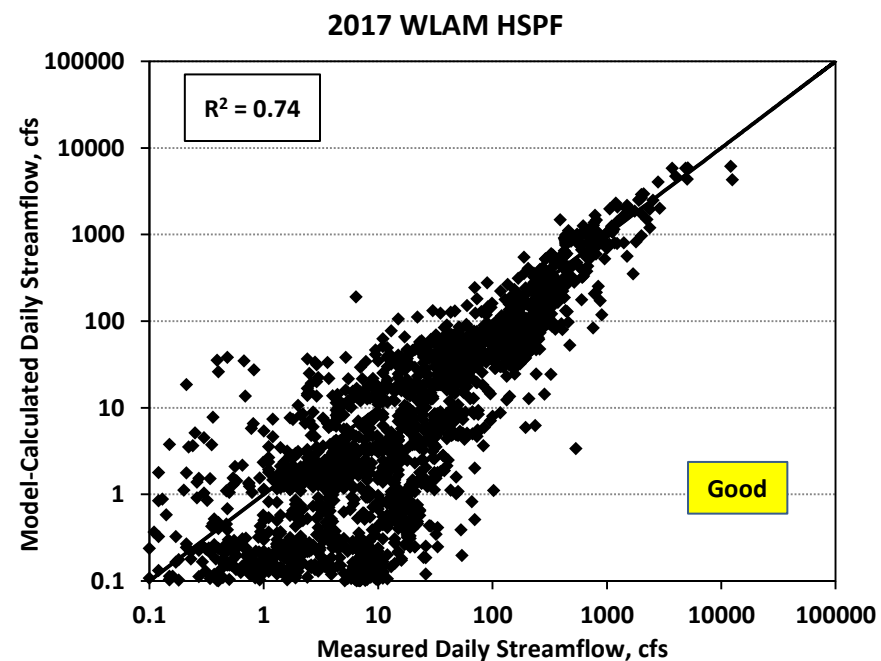
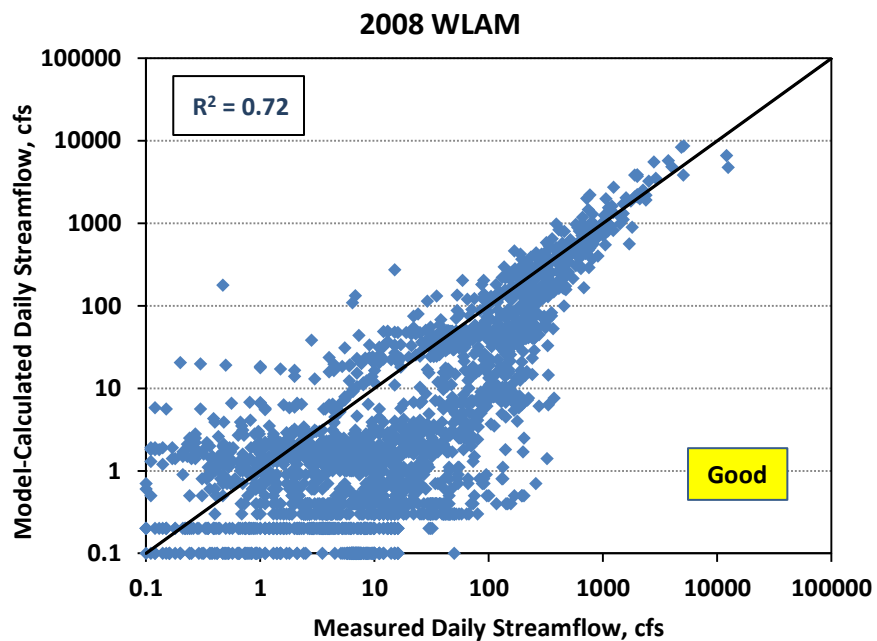
**2008 WLAM AND 2017 WLAM HSPF INITIAL COMPARISON:  
SCATTERPLOTS OF MEASURED AND MODEL-SIMULATED DAILY  
STREAMFLOW AT THE SAN TIMOTEO CREEK NEAR LOMA LINDA  
WATER YEARS 1995 TO 2006 AND 2005 LAND USE**

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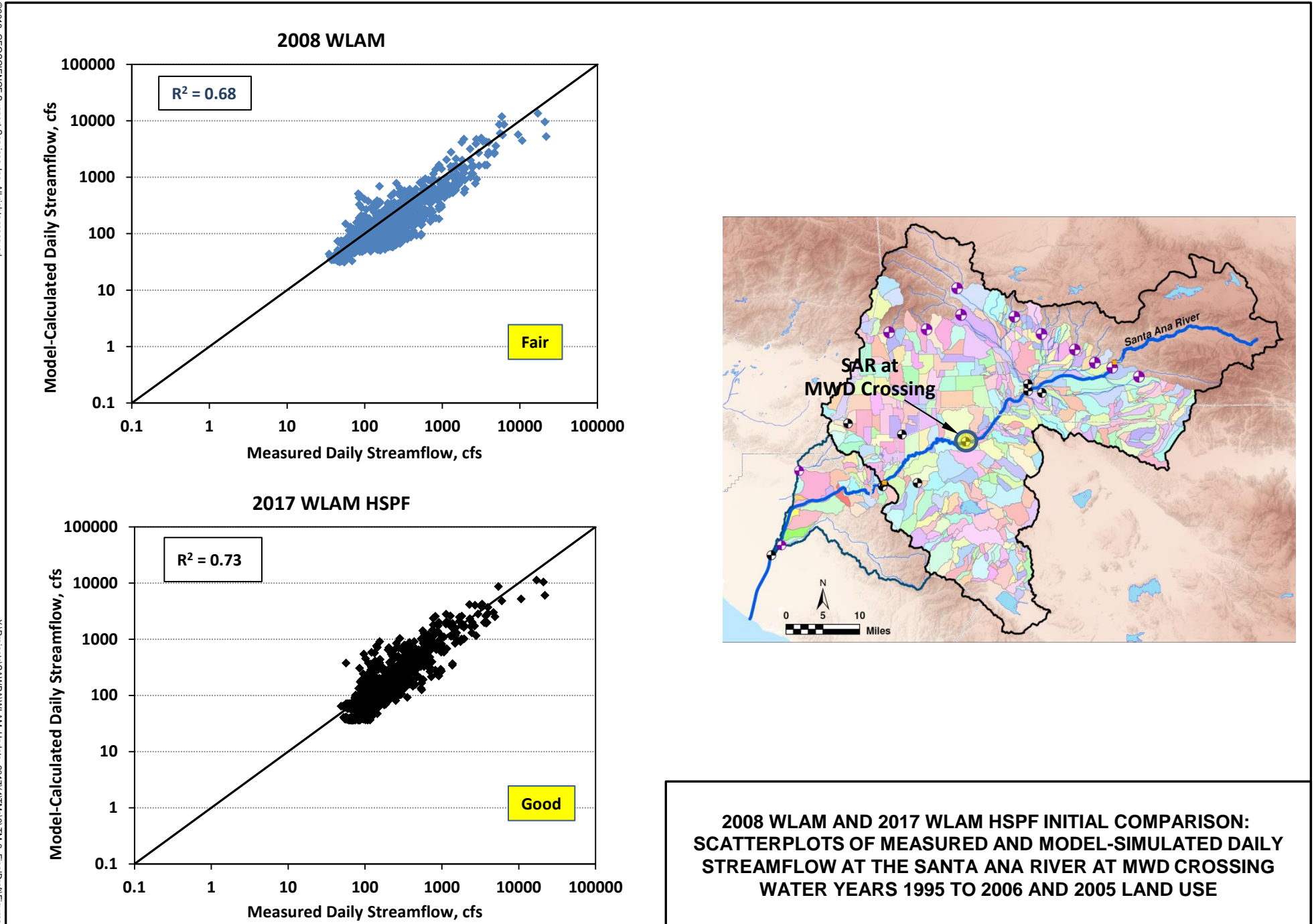
**2008 WLAM AND 2017 WLAM HSPF INITIAL COMPARISON:  
SCATTERPLOTS OF MEASURED AND MODEL-SIMULATED DAILY  
STREAMFLOW AT THE WARM CREEK NEAR SAN BERNARDINO  
WATER YEARS 1995 TO 2006 AND 2005 LAND USE**

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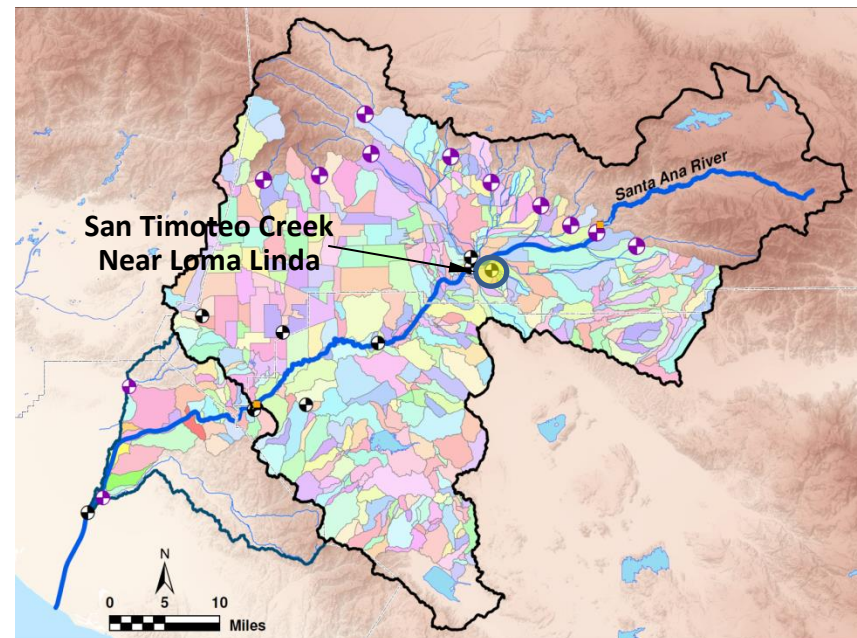
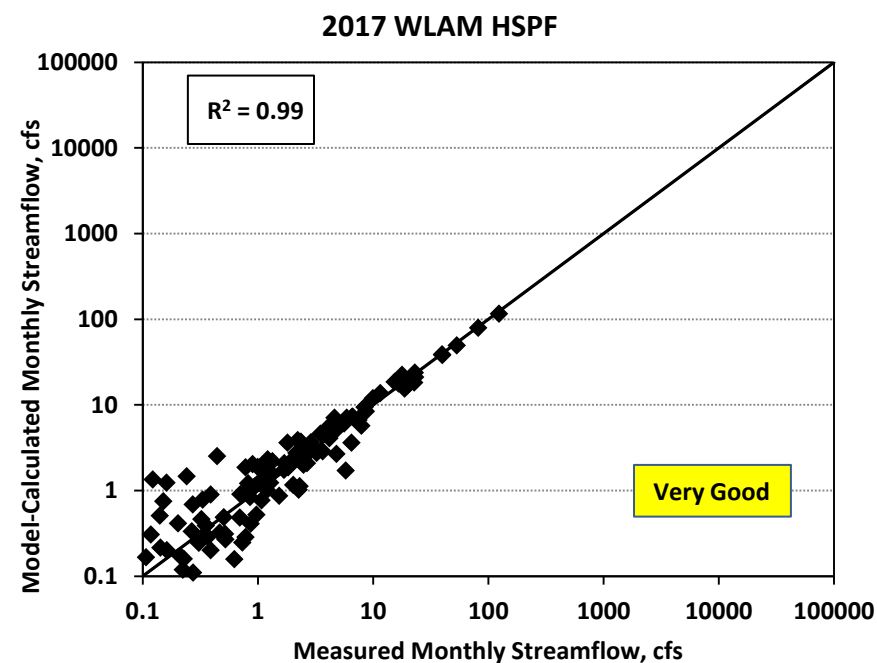
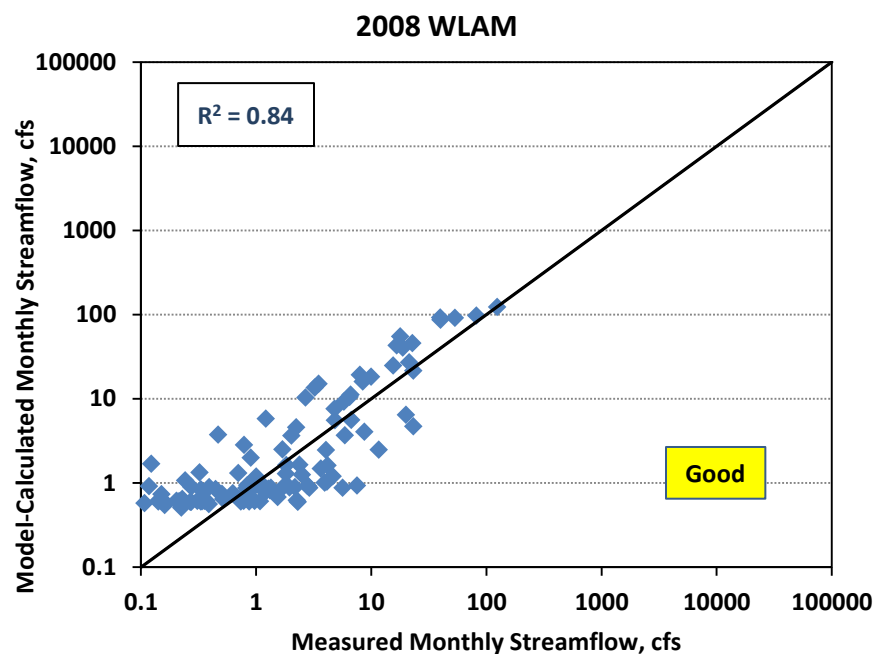


**2008 WLAM AND 2017 WLAM HSPF INITIAL COMPARISON:  
SCATTERPLOTS OF MEASURED AND MODEL-SIMULATED DAILY  
STREAMFLOW AT THE SANTA ANA RIVER AT E STREET  
WATER YEARS 1995 TO 2006 AND 2005 LAND USE**

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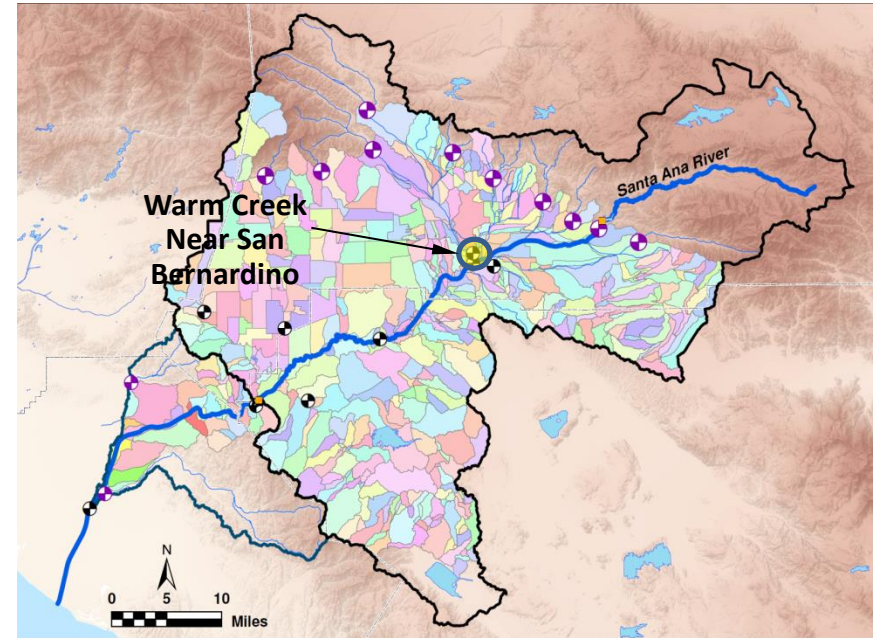
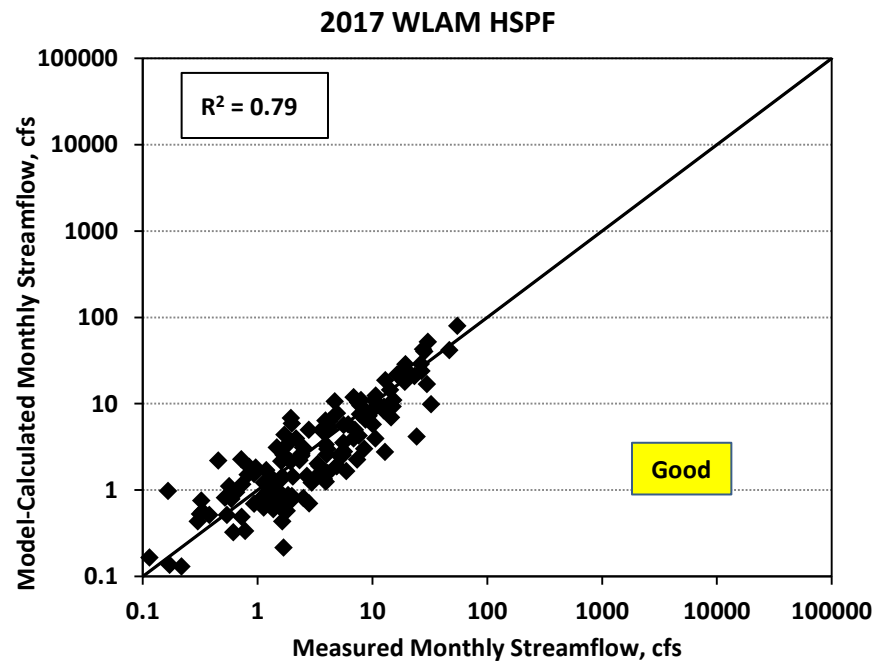
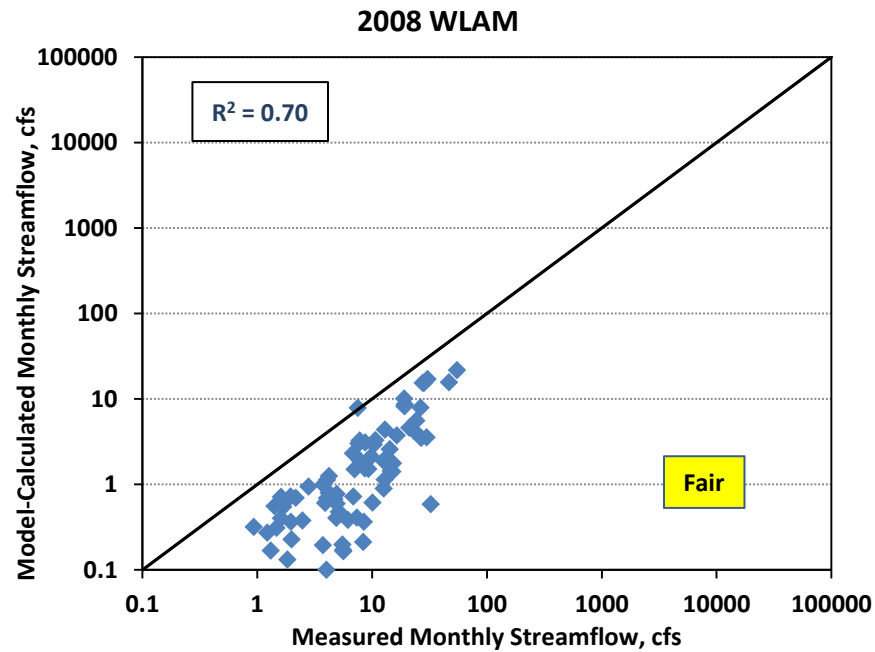


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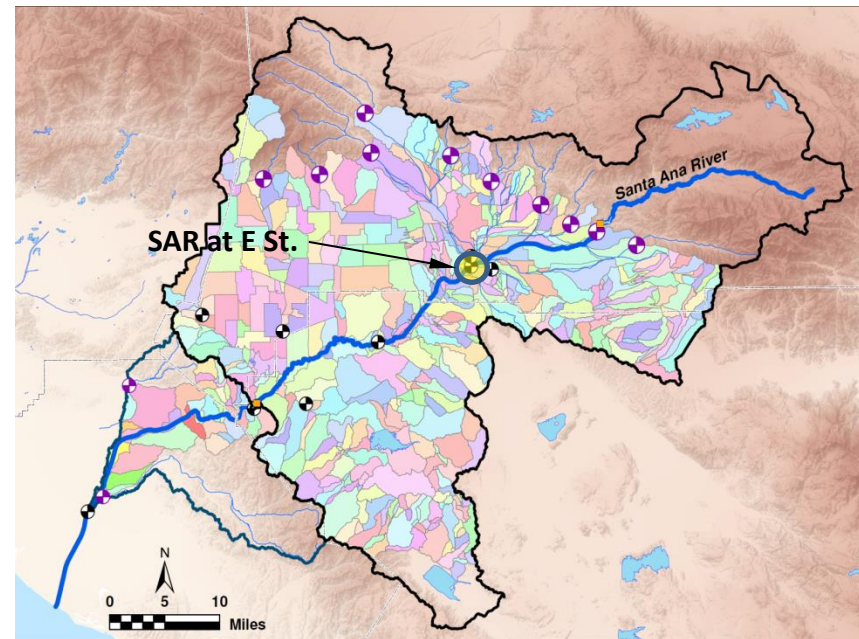
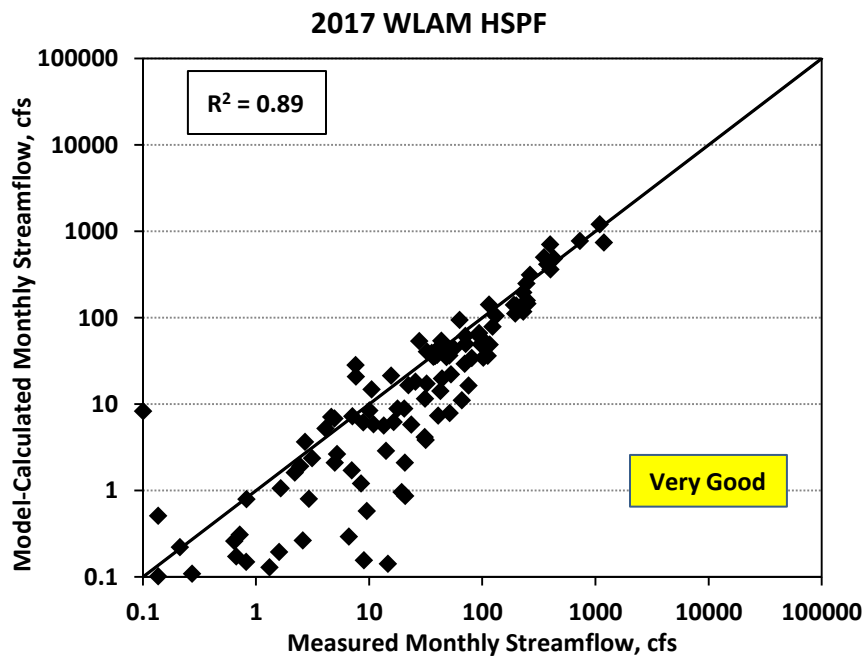
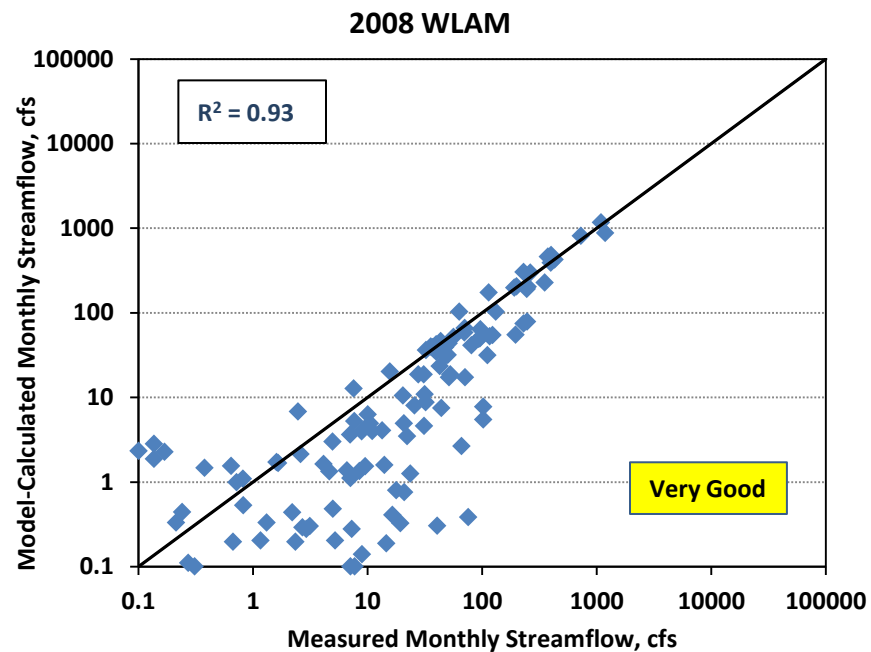
**2008 WLAM AND 2017 WLAM HSPF INITIAL COMPARISON:  
SCATTERPLOTS OF MEASURED AND MODEL-SIMULATED MONTHLY  
STREAMFLOW AT THE SAN TIMOTEO CREEK NEAR LOMA LINDA  
WATER YEARS 1995 TO 2006 AND 2005 LAND USE**

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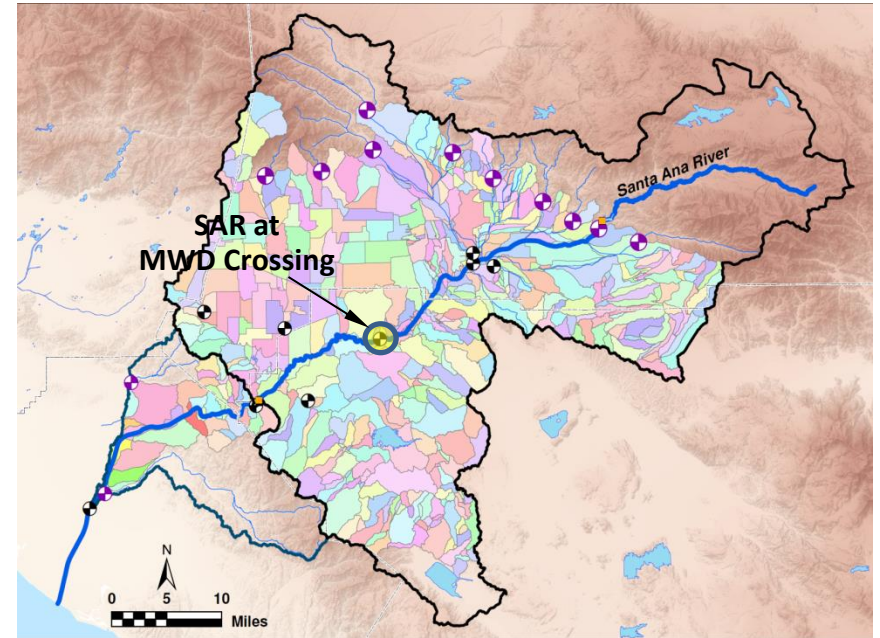
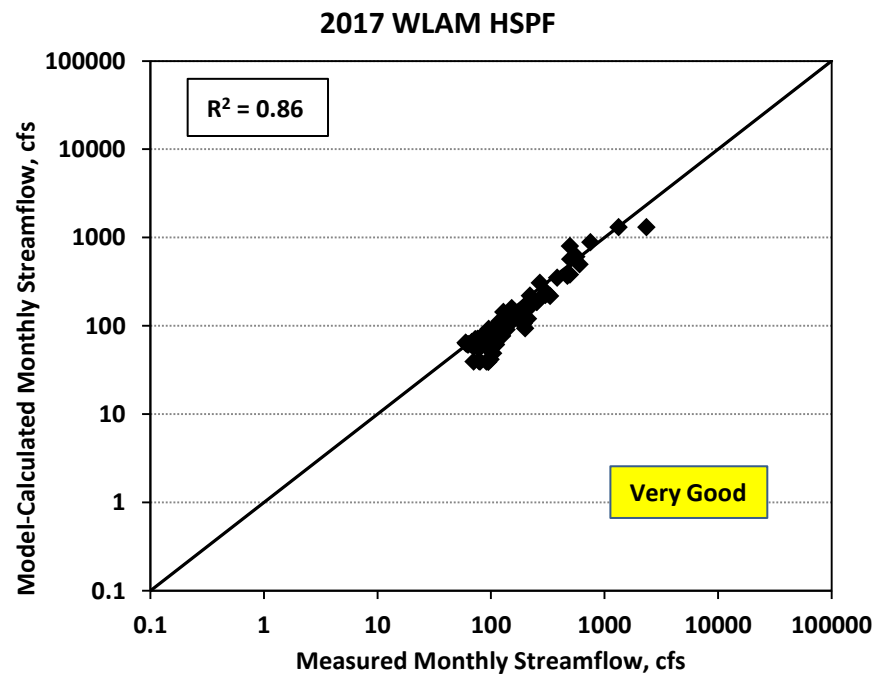
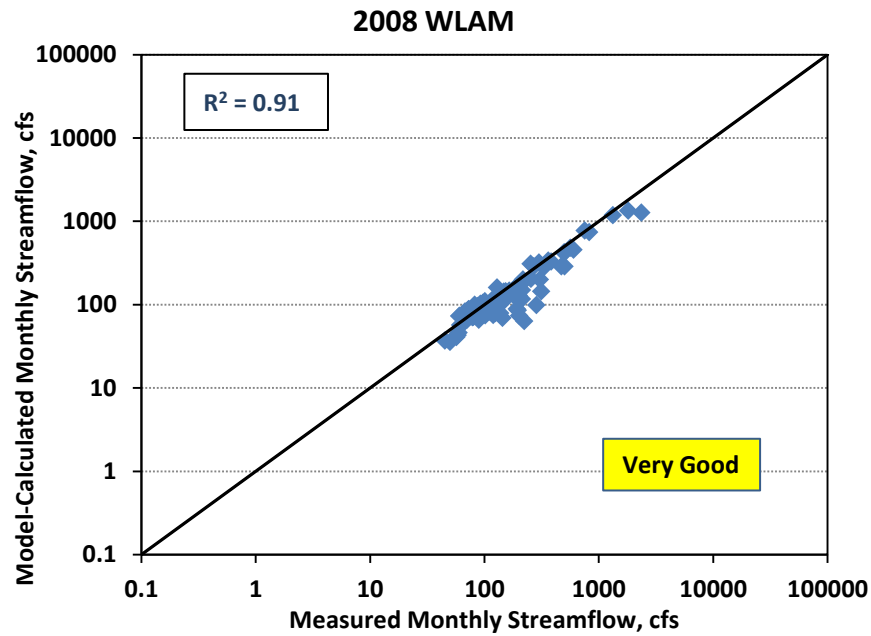
**2008 WLAM AND 2017 WLAM HSPF INITIAL COMPARISON:  
SCATTERPLOTS OF MEASURED AND MODEL-SIMULATED MONTHLY  
STREAMFLOW AT THE WARM CREEK NEAR SAN BERNARDINO  
WATER YEARS 1995 TO 2006 AND 2005 LAND USE**

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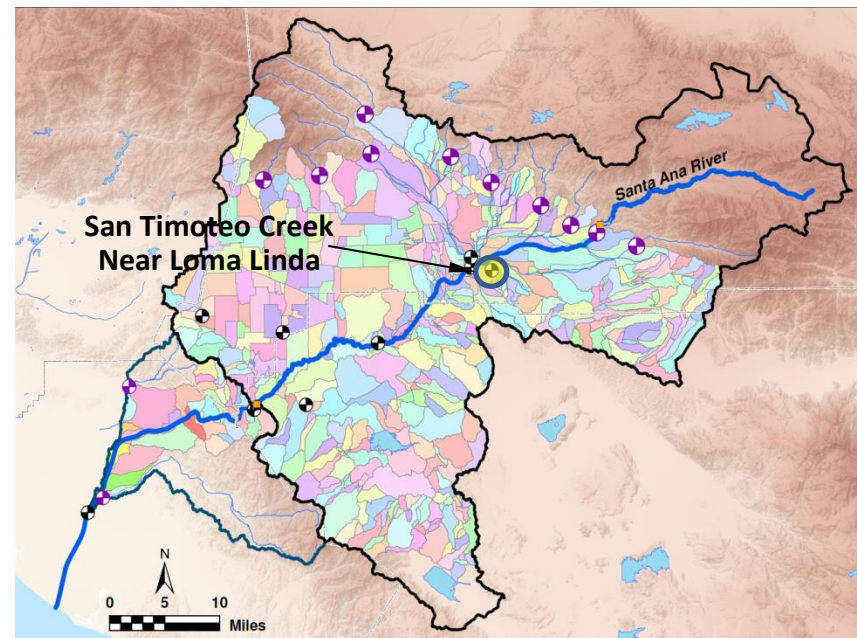
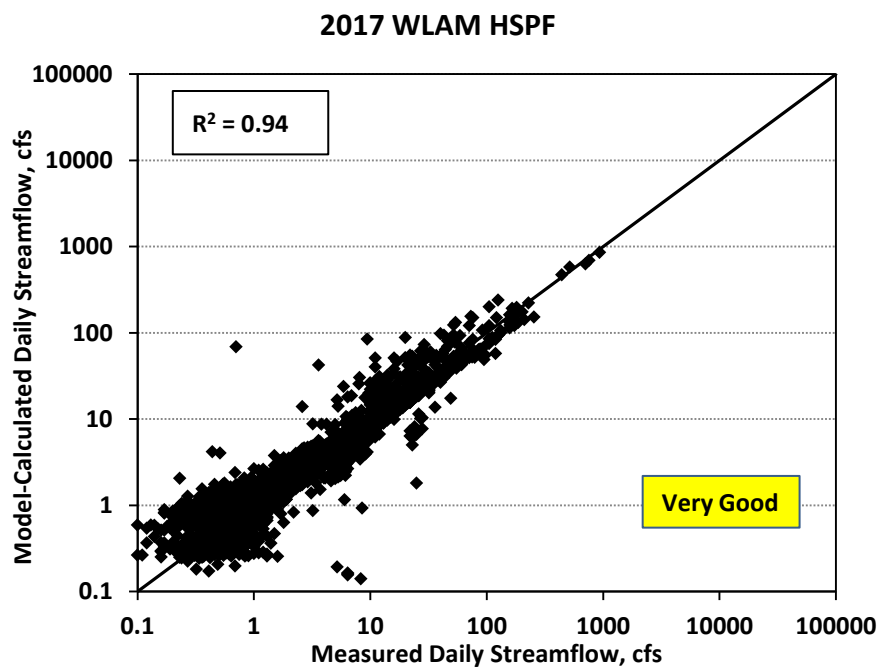
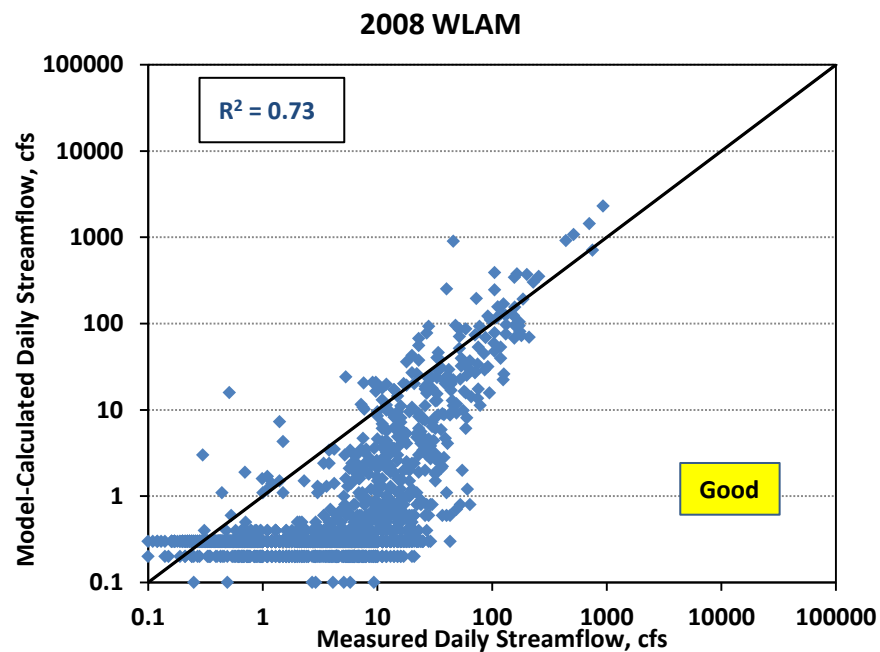
**2008 WLAM AND 2017 WLAM HSPF INITIAL COMPARISON:  
SCATTERPLOTS OF MEASURED AND MODEL-SIMULATED MONTHLY  
STREAMFLOW AT THE SANTA ANA RIVER AT E STREET  
WATER YEARS 1995 TO 2006 AND 2005 LAND USE**

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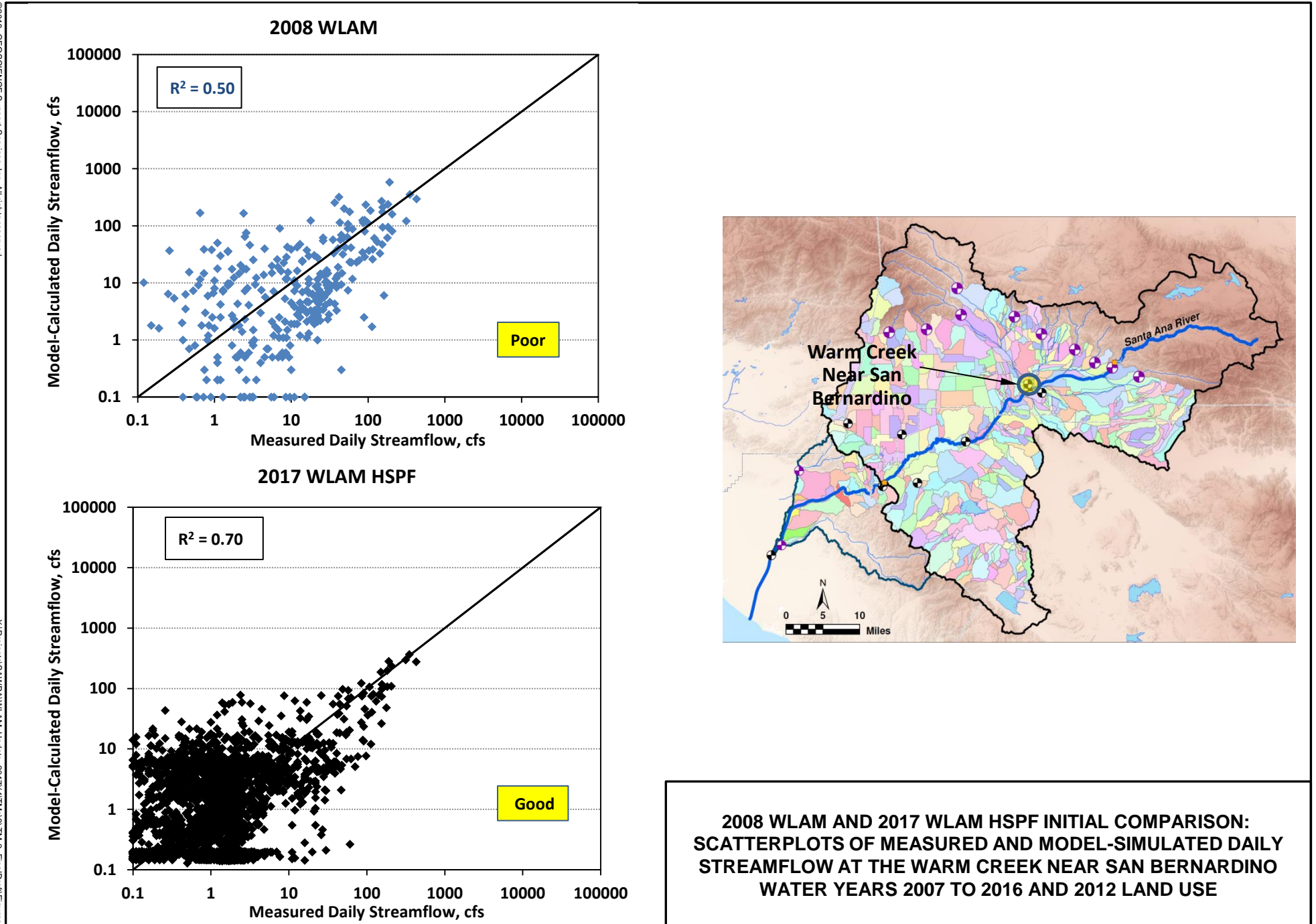
**2008 WLAM AND 2017 WLAM HSPF INITIAL COMPARISON:  
SCATTERPLOTS OF MEASURED AND MODEL-SIMULATED MONTHLY  
STREAMFLOW AT THE SANTA ANA RIVER AT MWD CROSSING  
WATER YEARS 1995 TO 2006 AND 2005 LAND USE**

13-Apr-18

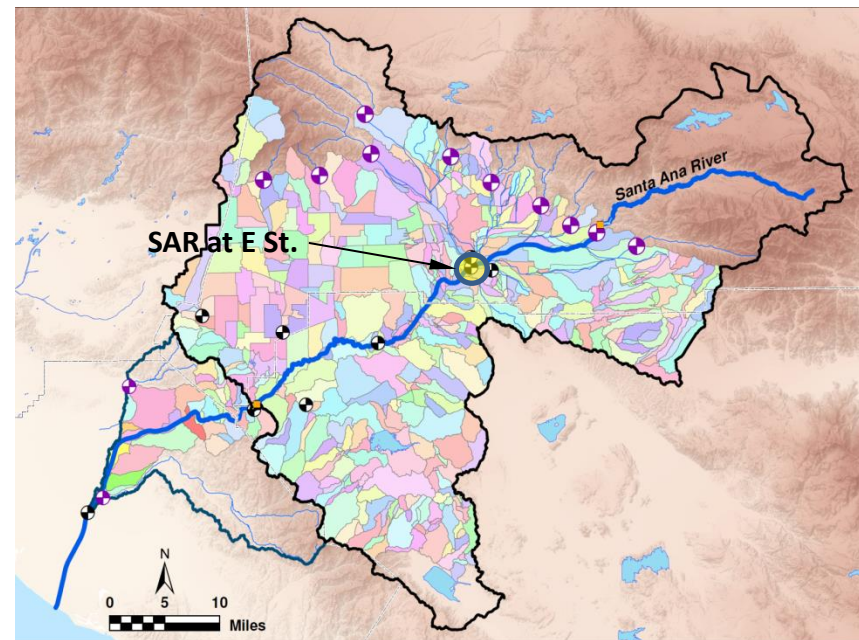
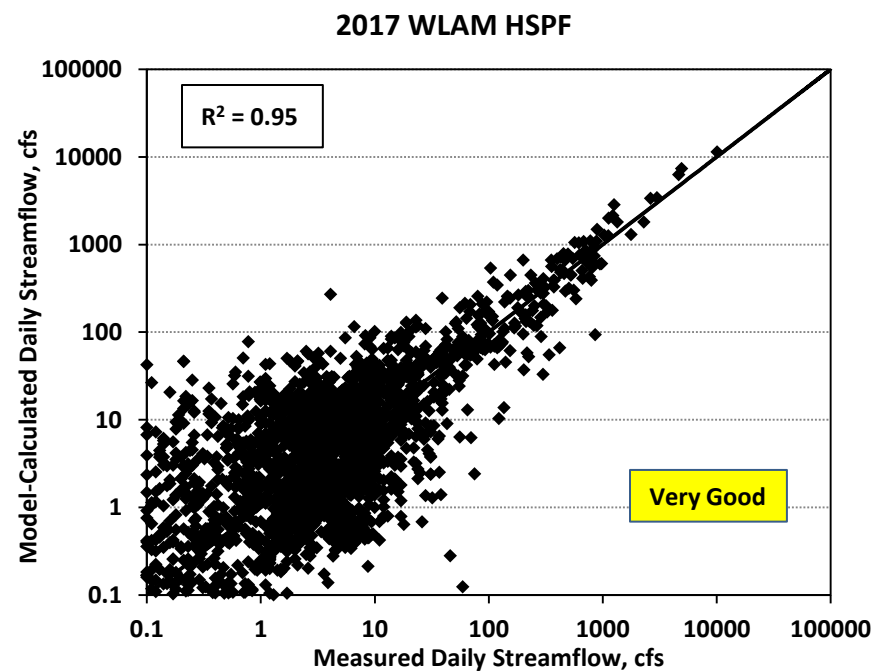
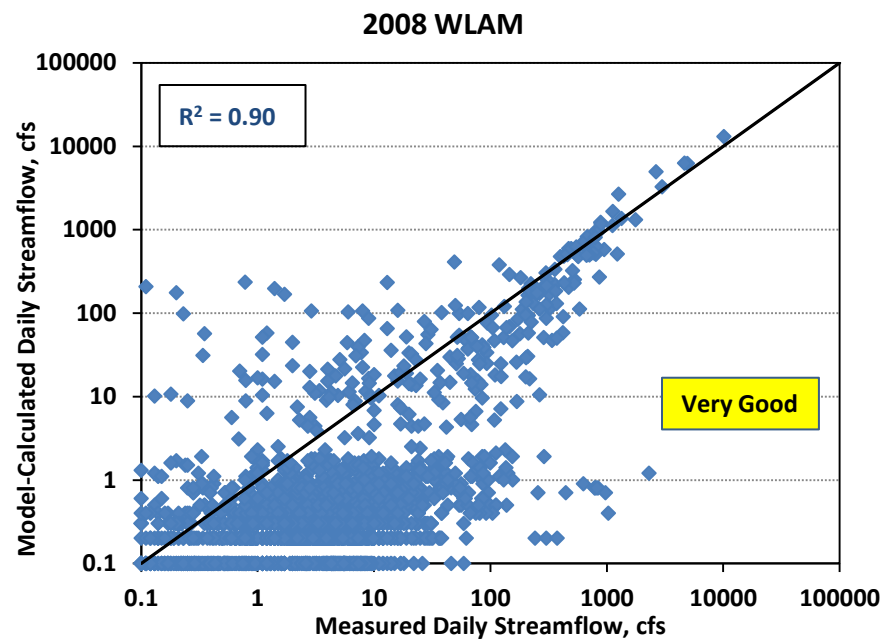


**2008 WLAM AND 2017 WLAM HSPF INITIAL COMPARISON:  
SCATTERPLOTS OF MEASURED AND MODEL-SIMULATED DAILY  
STREAMFLOW AT THE SAN TIMOTEO CREEK NEAR LOMA LINDA  
WATER YEARS 2007 TO 2016 AND 2012 LAND USE**

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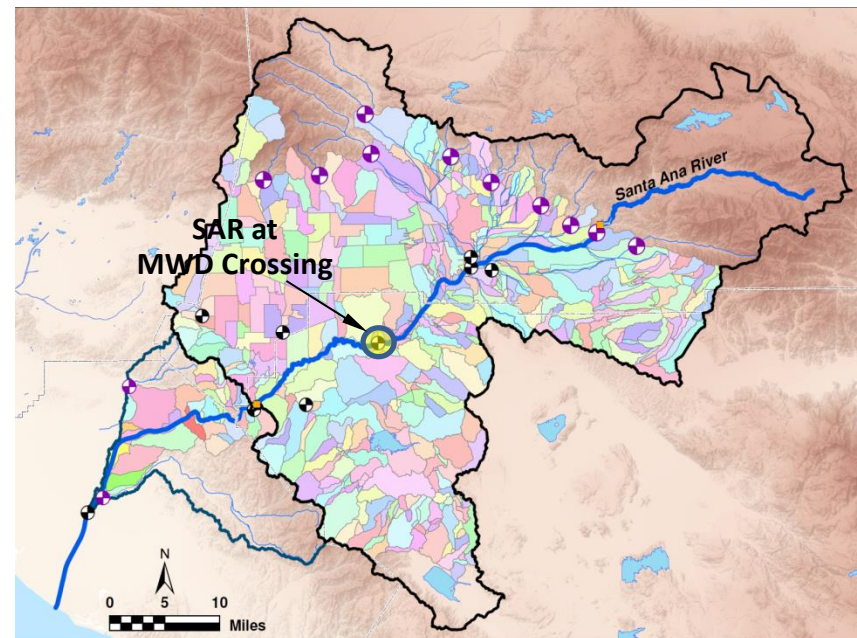
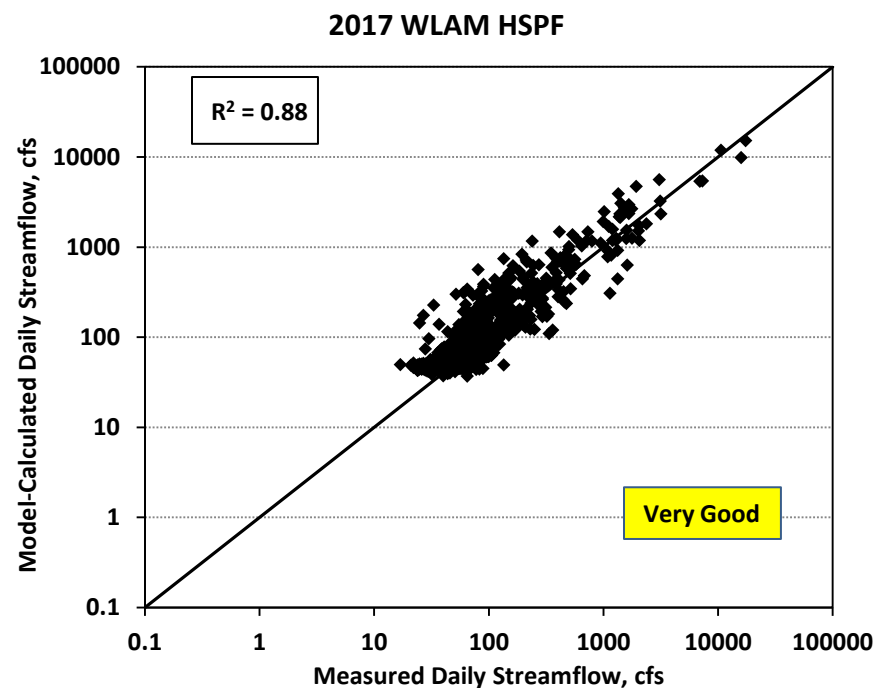
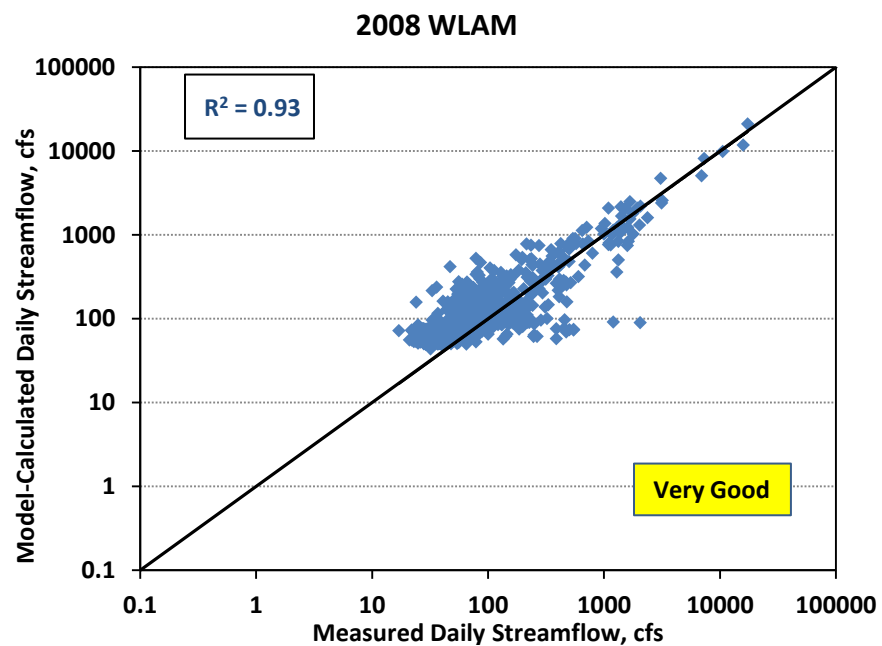


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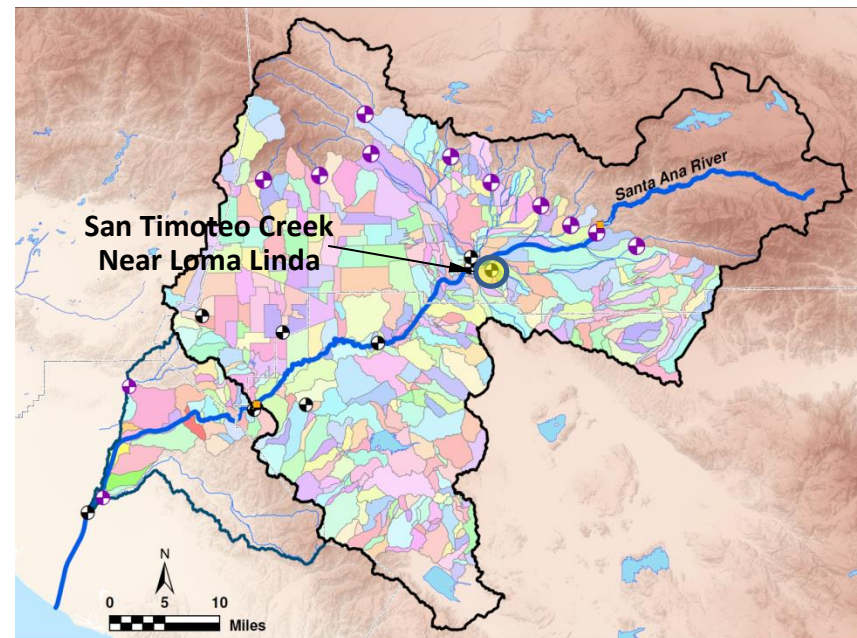
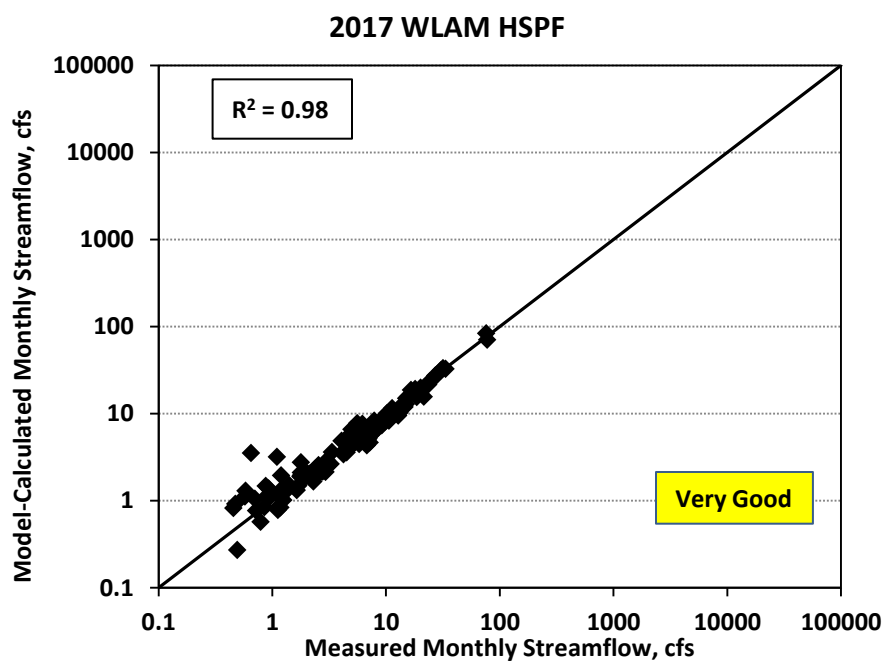
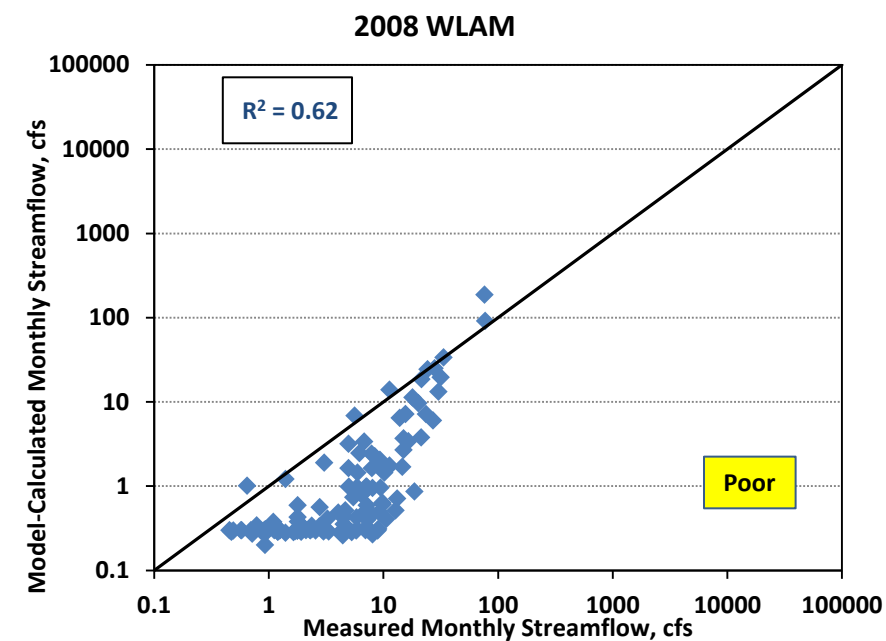
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STREAMFLOW AT THE SANTA ANA RIVER AT E STREET  
WATER YEARS 2007 TO 2016 AND 2012 LAND USE**

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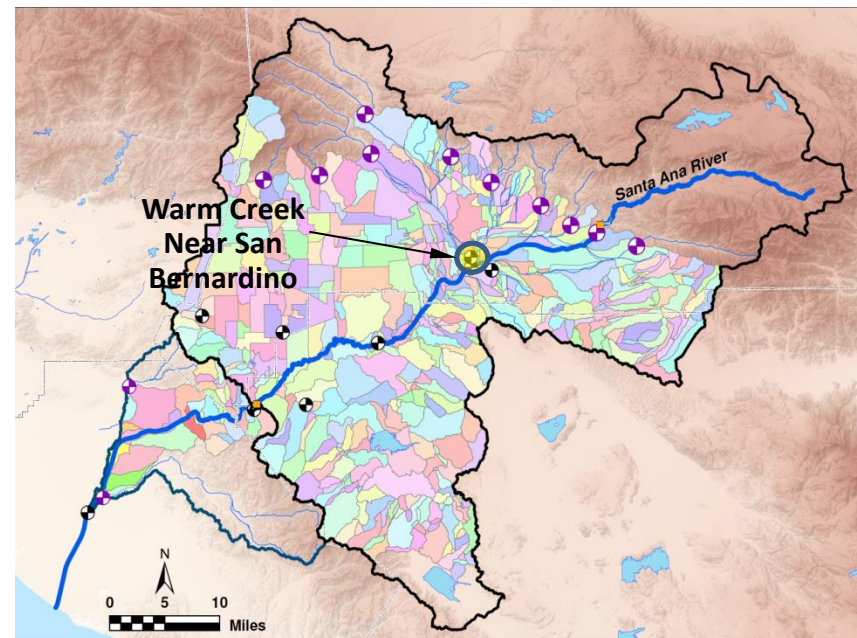
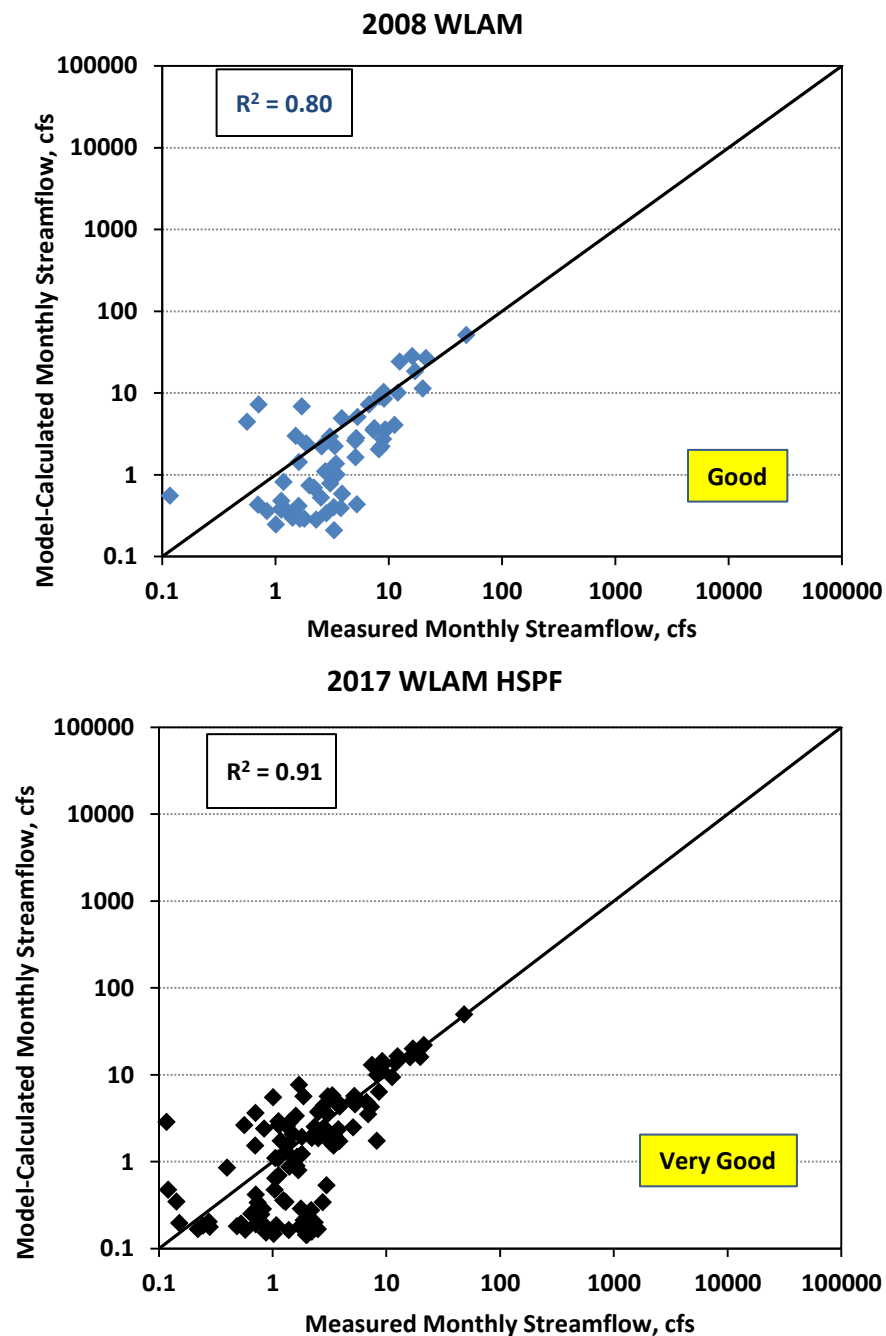
**2008 WLAM AND 2017 WLAM HSPF INITIAL COMPARISON:  
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STREAMFLOW AT THE SANTA ANA RIVER AT MWD CROSSING  
WATER YEARS 2007 TO 2016 AND 2012 LAND USE**

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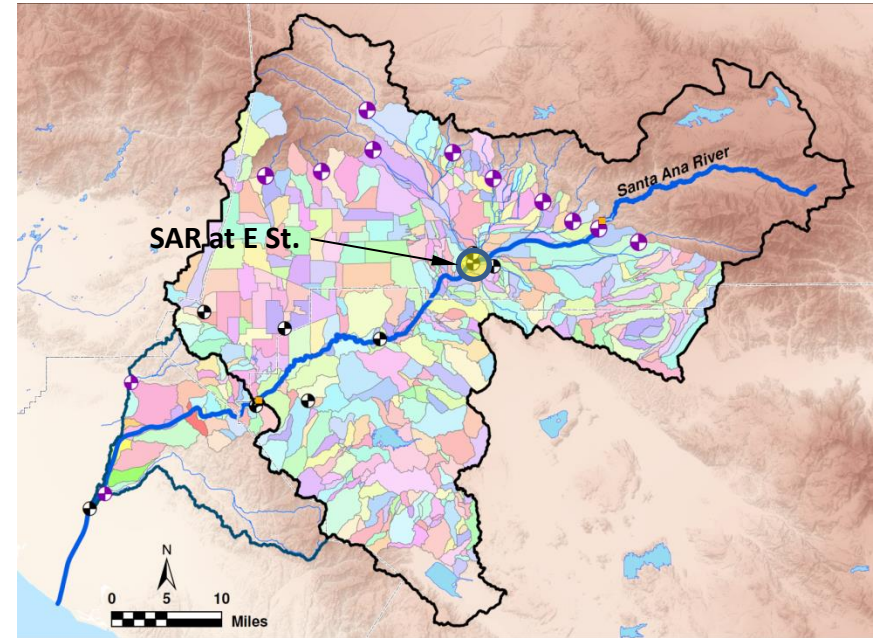
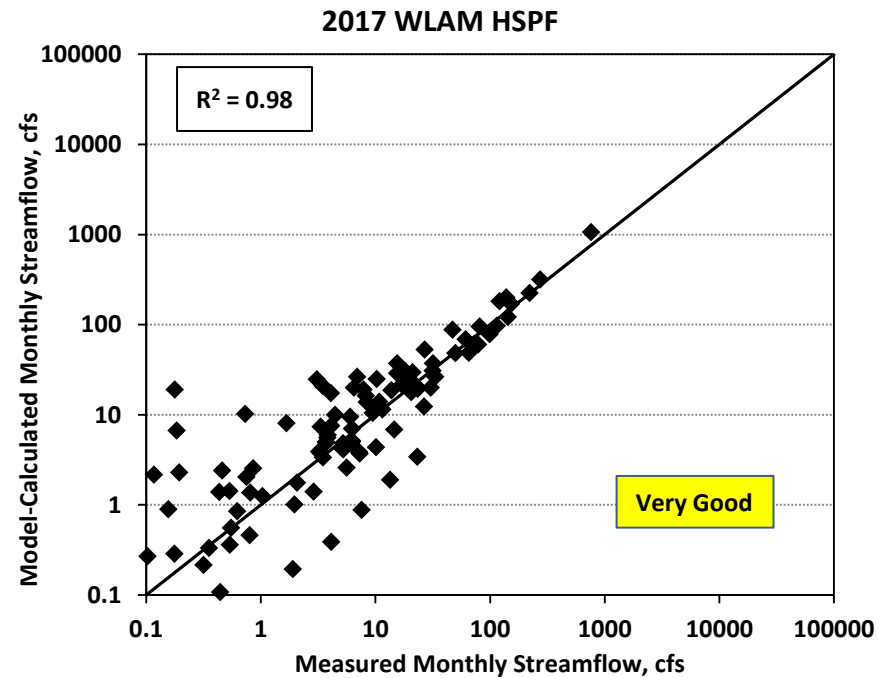
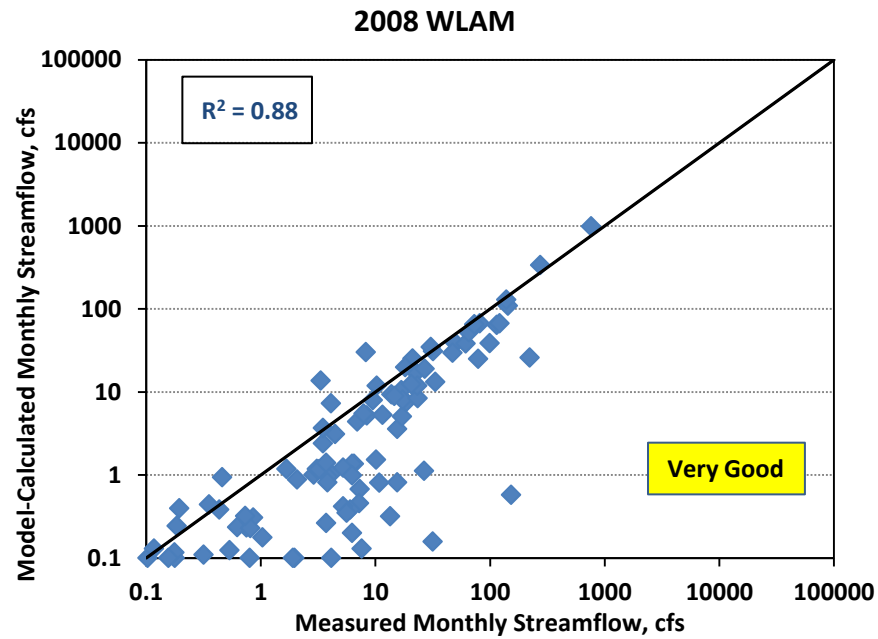
**2008 WLAM AND 2017 WLAM HSPF INITIAL COMPARISON:  
SCATTERPLOTS OF MEASURED AND MODEL-SIMULATED MONTHLY  
STREAMFLOW AT THE SAN TIMOTEO CREEK NEAR LOMA LINDA  
WATER YEARS 2007 TO 2016 AND 2012 LAND USE**

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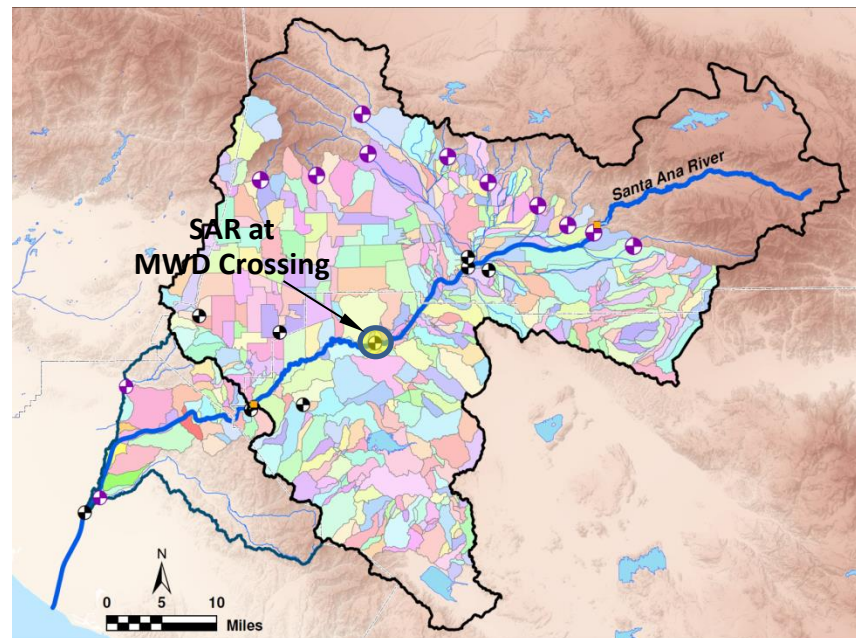
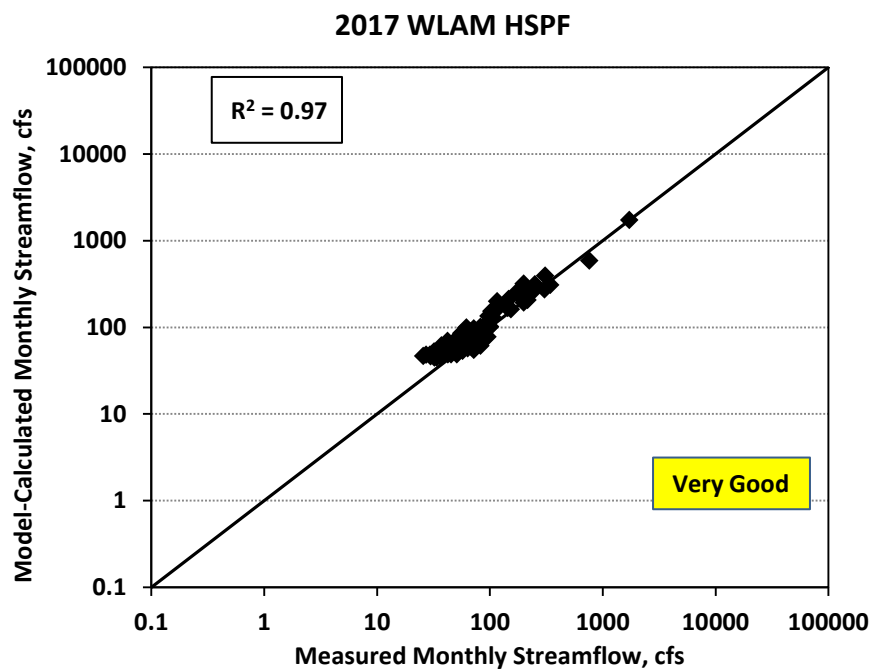
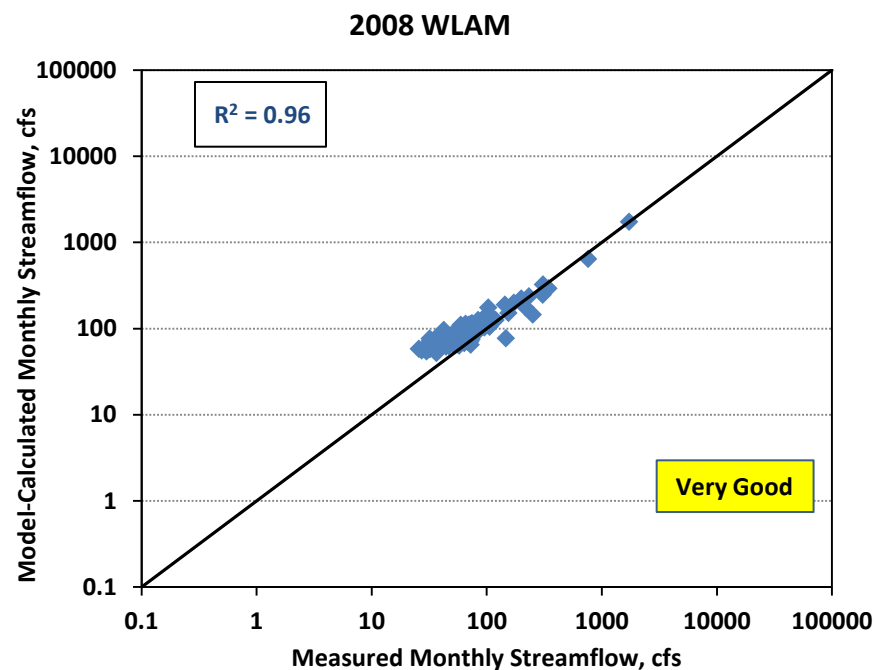
**2008 WLAM AND 2017 WLAM HSPF INITIAL COMPARISON:  
SCATTERPLOTS OF MEASURED AND MODEL-SIMULATED MONTHLY  
STREAMFLOW AT THE WARM CREEK NEAR SAN BERNARDINO  
WATER YEARS 2007 TO 2016 AND 2012 LAND USE**

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**2008 WLAM AND 2017 WLAM HSPF INITIAL COMPARISON:  
SCATTERPLOTS OF MEASURED AND MODEL-SIMULATED MONTHLY  
STREAMFLOW AT THE SANTA ANA RIVER AT E STREET  
WATER YEARS 2007 TO 2016 AND 2012 LAND USE**

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**2008 WLAM AND 2017 WLAM HSPF INITIAL COMPARISON:  
SCATTERPLOTS OF MEASURED AND MODEL-SIMULATED MONTHLY  
STREAMFLOW AT THE SANTA ANA RIVER AT MWD CROSSING  
WATER YEARS 2007 TO 2016 AND 2012 LAND USE**

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**Hydrographs of Measured and Model-Simulated Daily Streamflow at the San Temoteo Creek near Loma Linda – Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (2017 WLAM HSPF)**

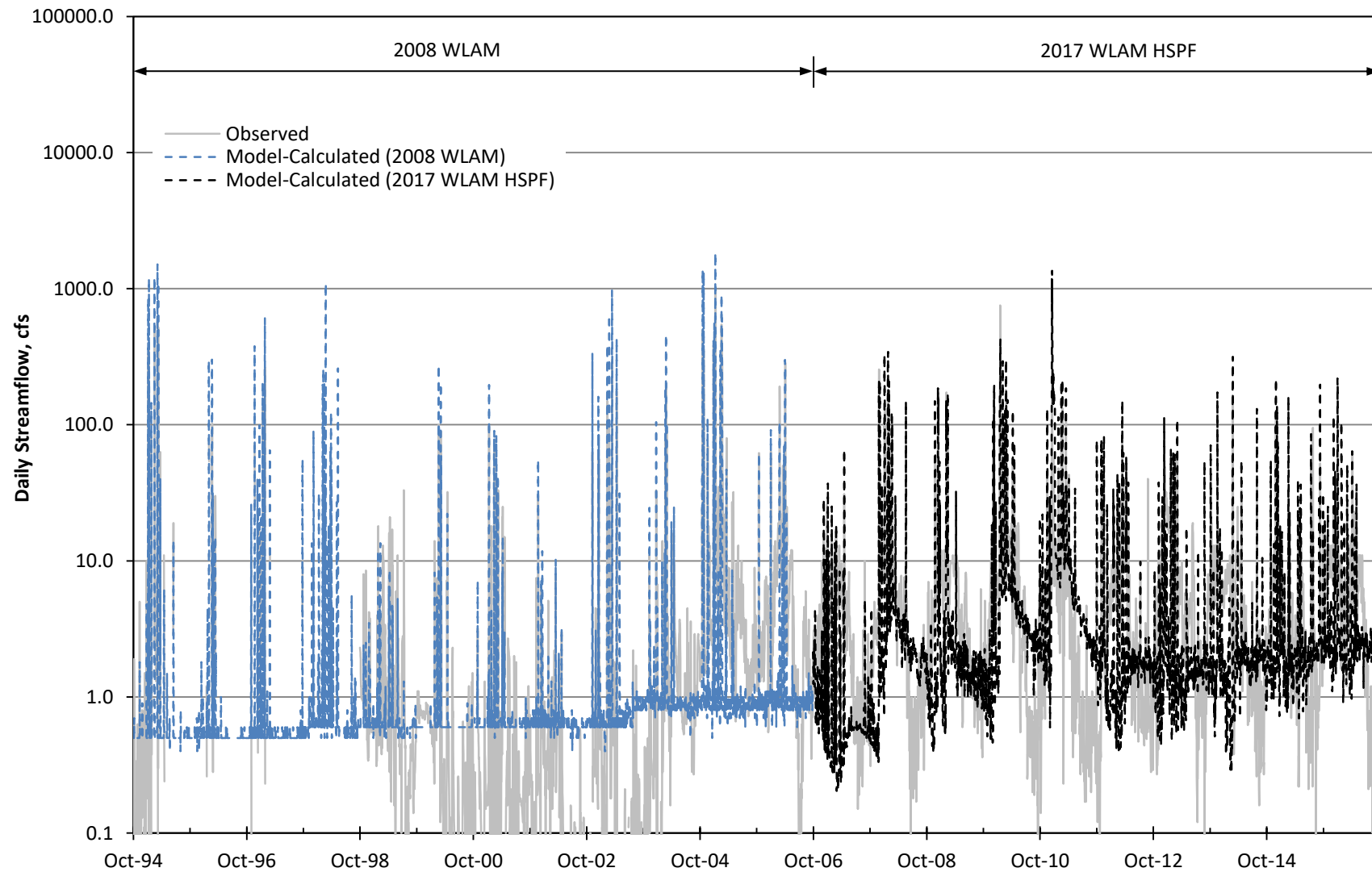


Figure 36

**Hydrographs of Measured and Model-Simulated Daily Streamflow at the Warm Creek near San Bernardino  
Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (2017 WLAM HSPF)**

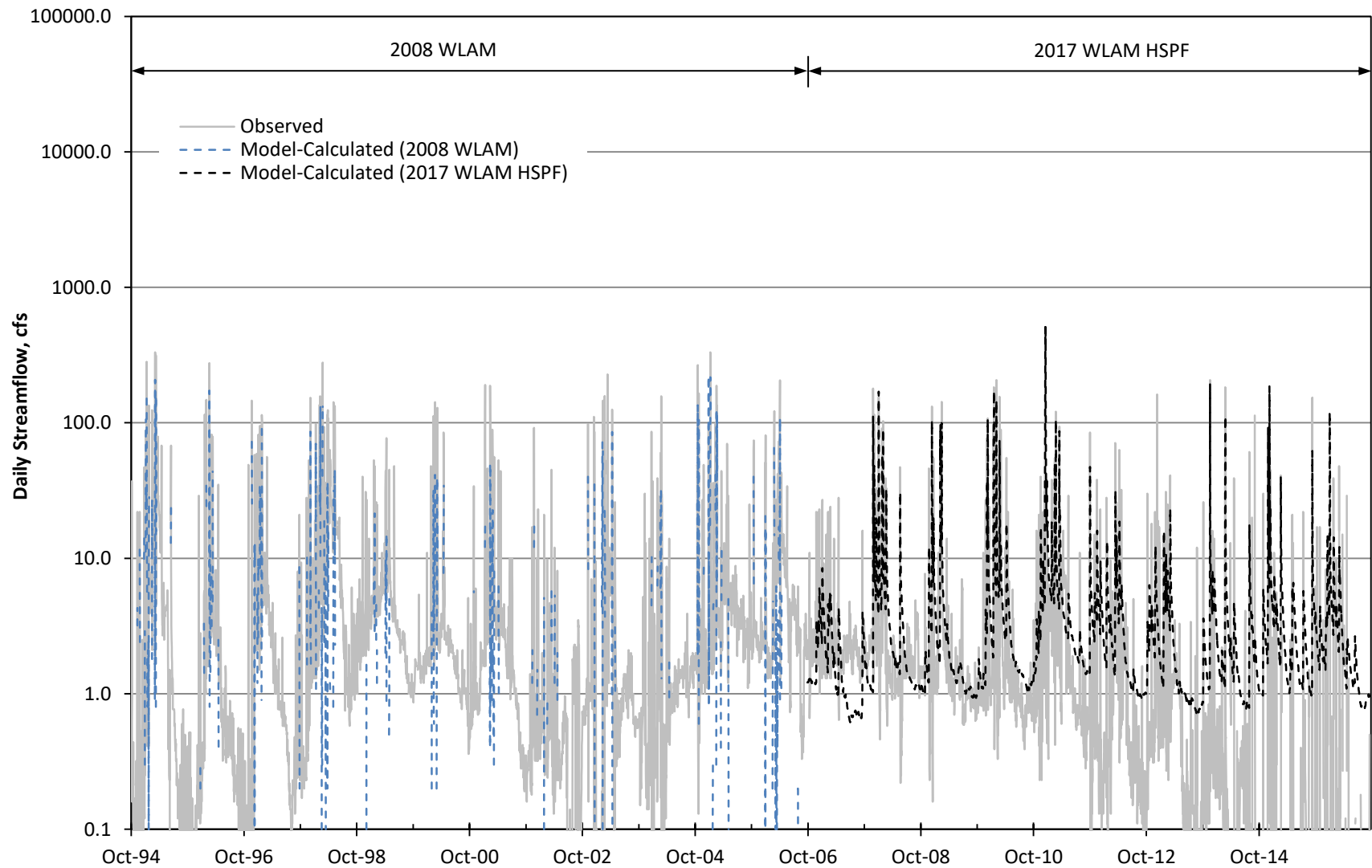


Figure 37

**Hydrographs of Measured and Model-Simulated Daily Streamflow at the Santa Ana River at E Street  
Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (2017 WLAM HSPF)**

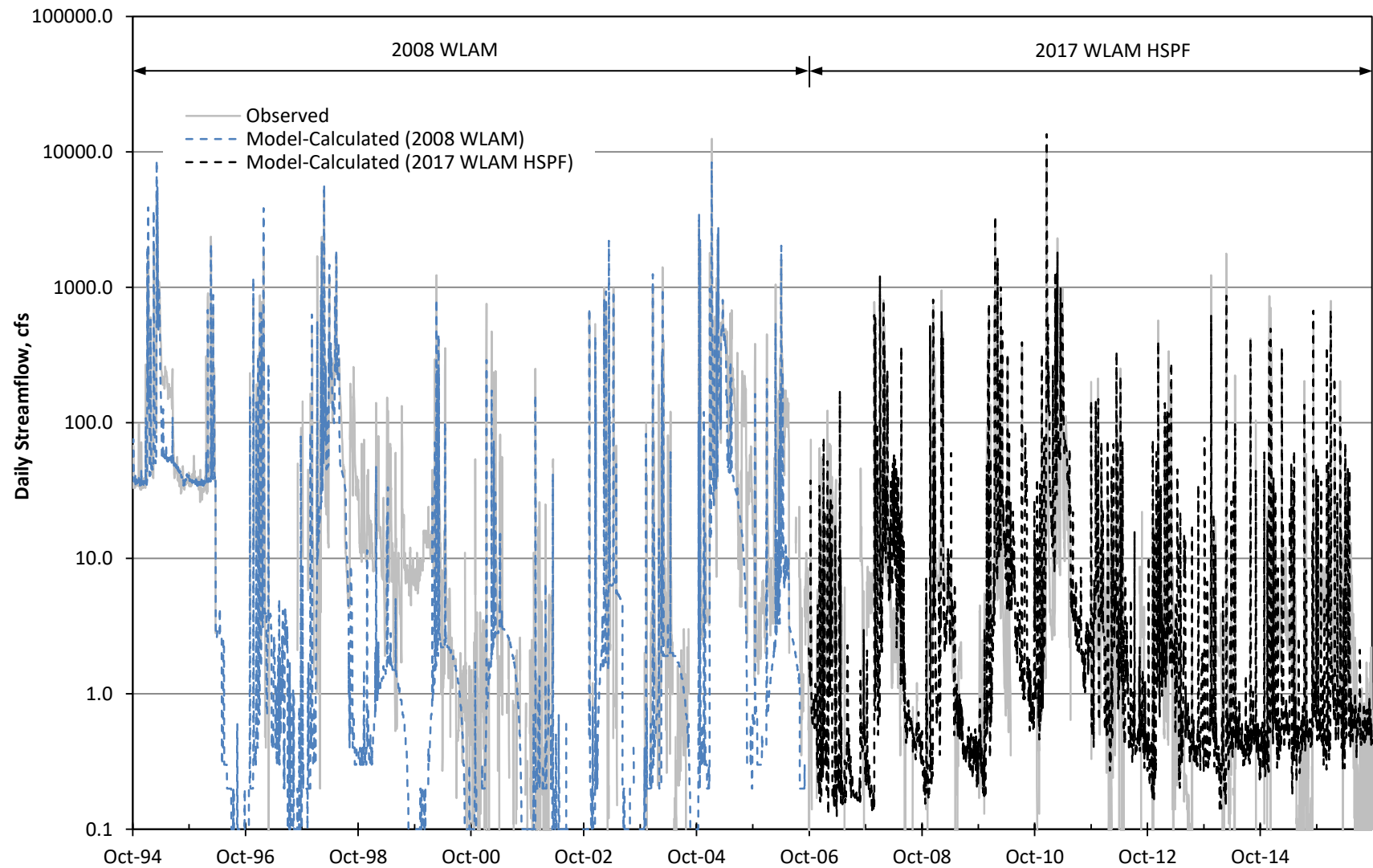


Figure 38

**Hydrographs of Measured and Model-Simulated Daily Streamflow at the Santa Ana River at MWD Crossing  
Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (2017 WLAM HSPF)**

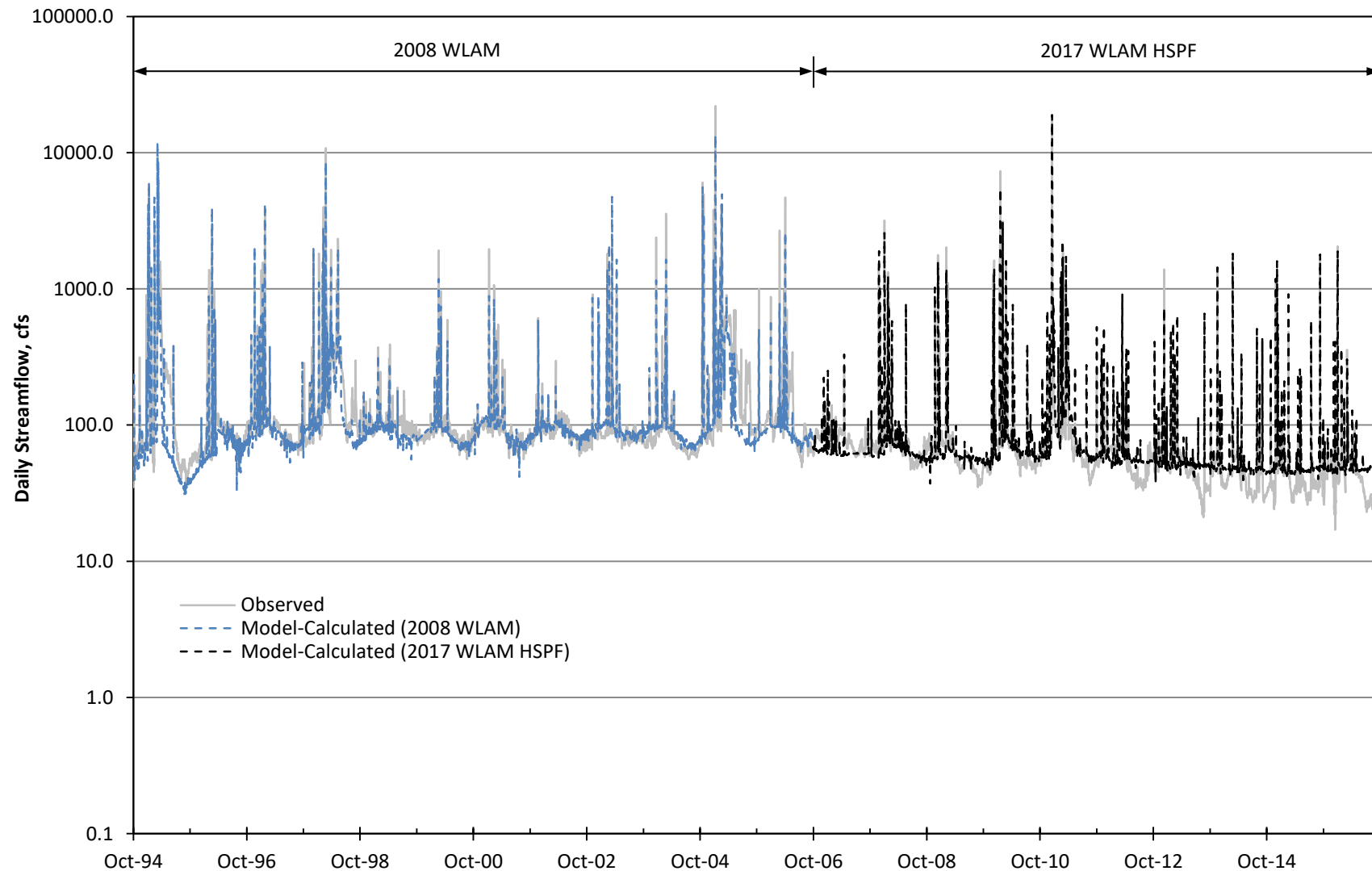


Figure 39

**Hydrographs of Measured and Model-Simulated Daily Streamflow at the Temescal Creek at Main Street  
Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (2017 WLAM HSPF)**

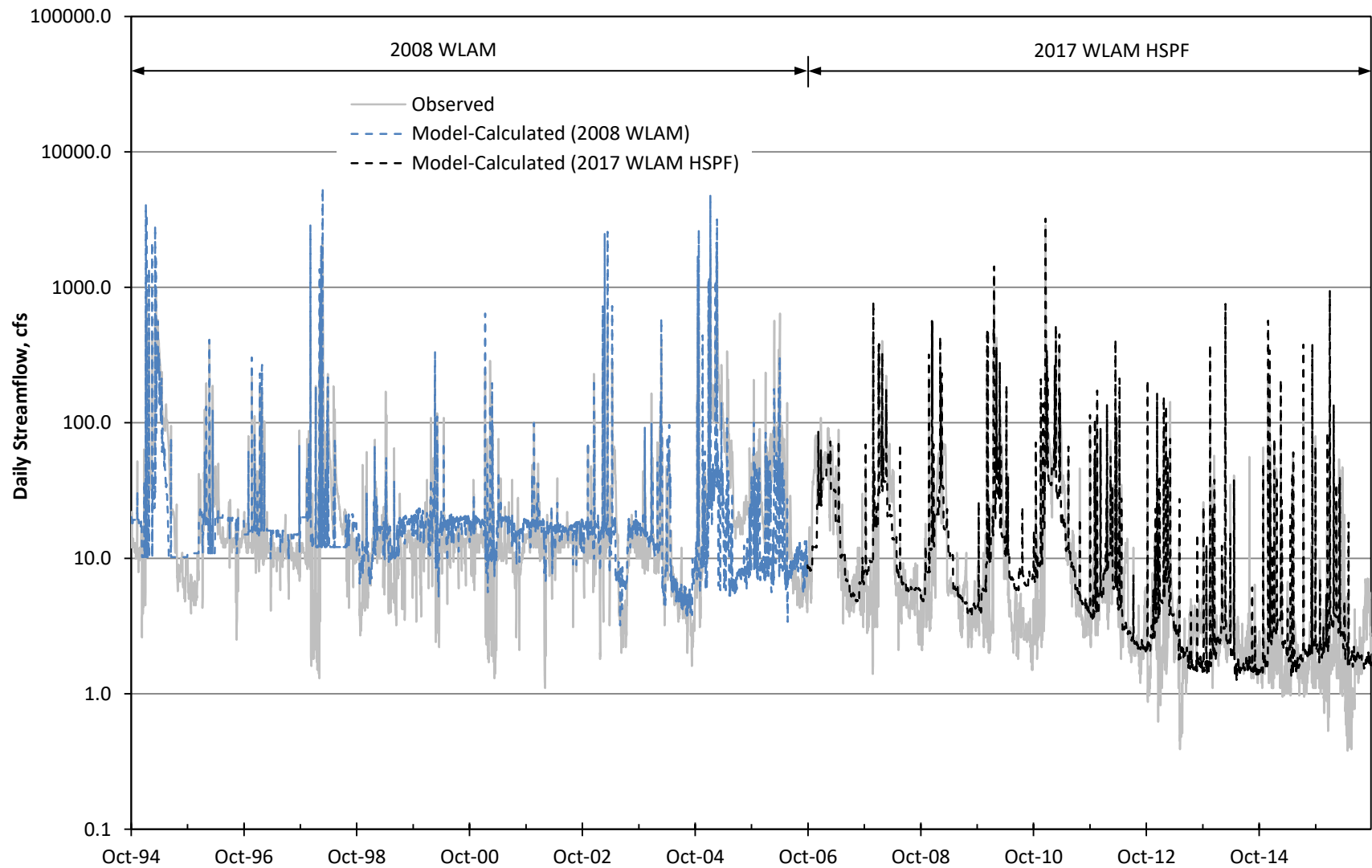


Figure 40

**Hydrographs of Measured and Model-Simulated Daily Streamflow at the Chino Creek at Schaefer Avenue  
Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (2017 WLAM HSPF)**

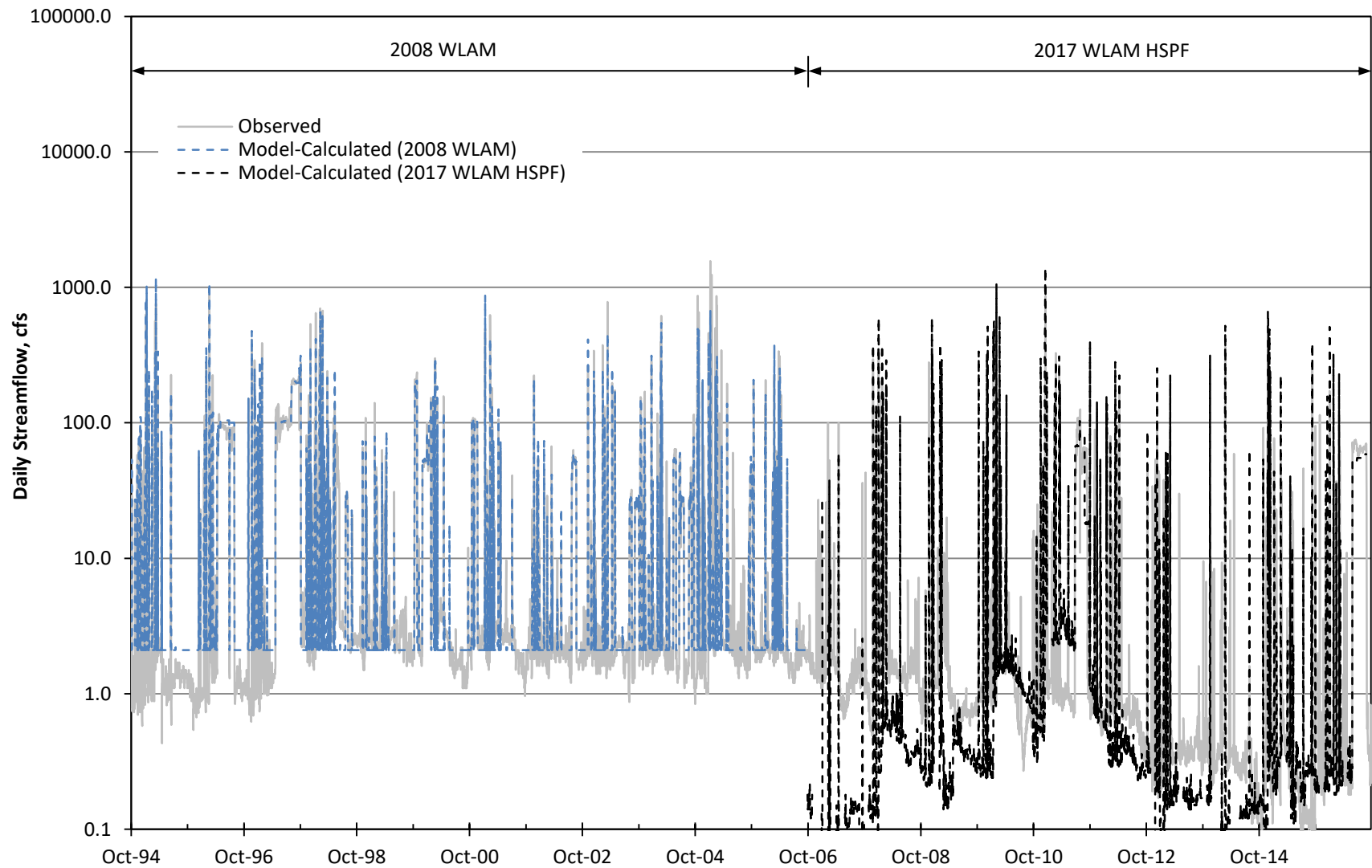


Figure 41

**Hydrographs of Measured and Model-Simulated Daily Streamflow at the Cucamonga Creek near Mira Loma  
Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (2017 WLAM HSPF)**

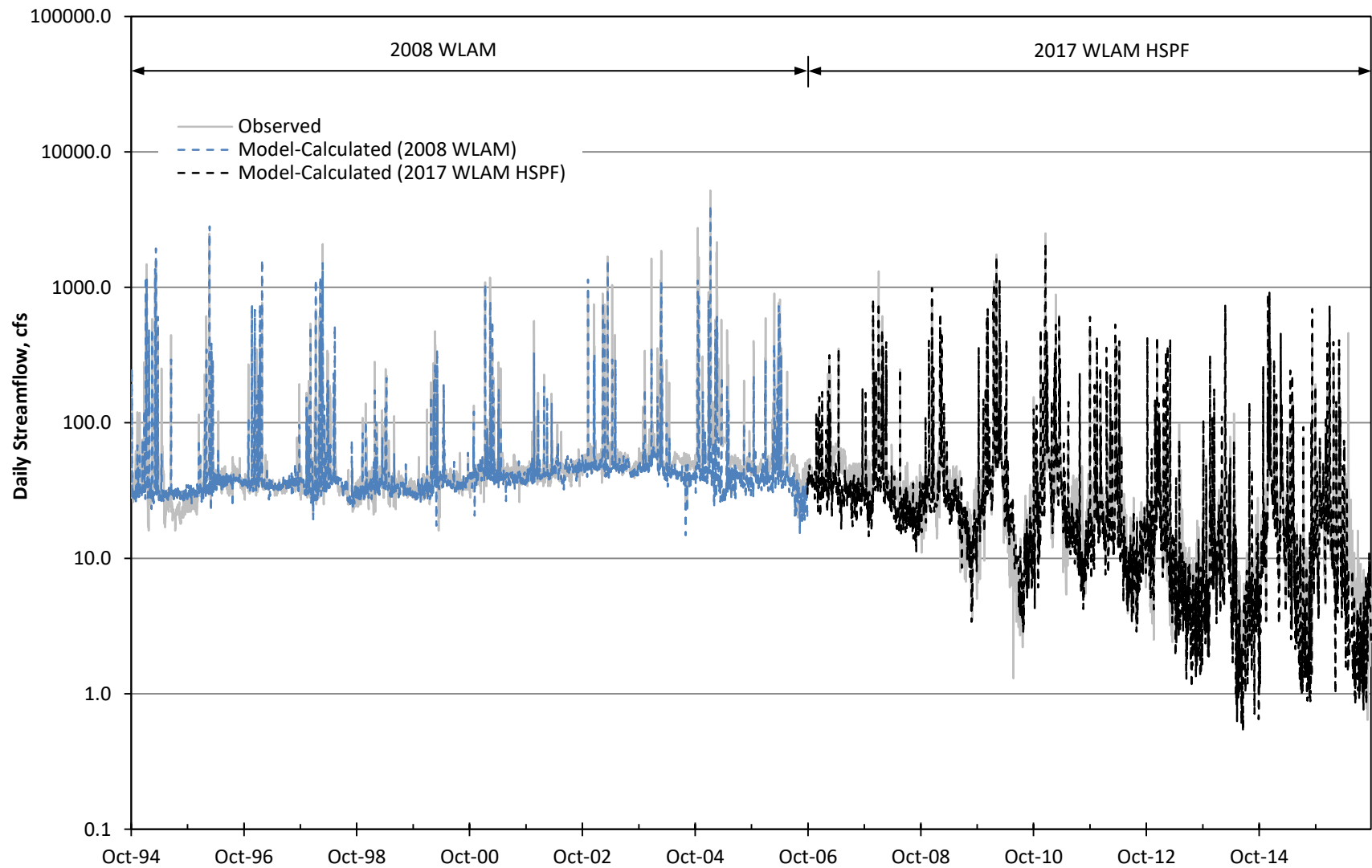


Figure 42

**Hydrographs of Measured and Model-Simulated Daily Streamflow at the Santa Ana River Inflow to Prado  
Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (2017 WLAM HSPF)**

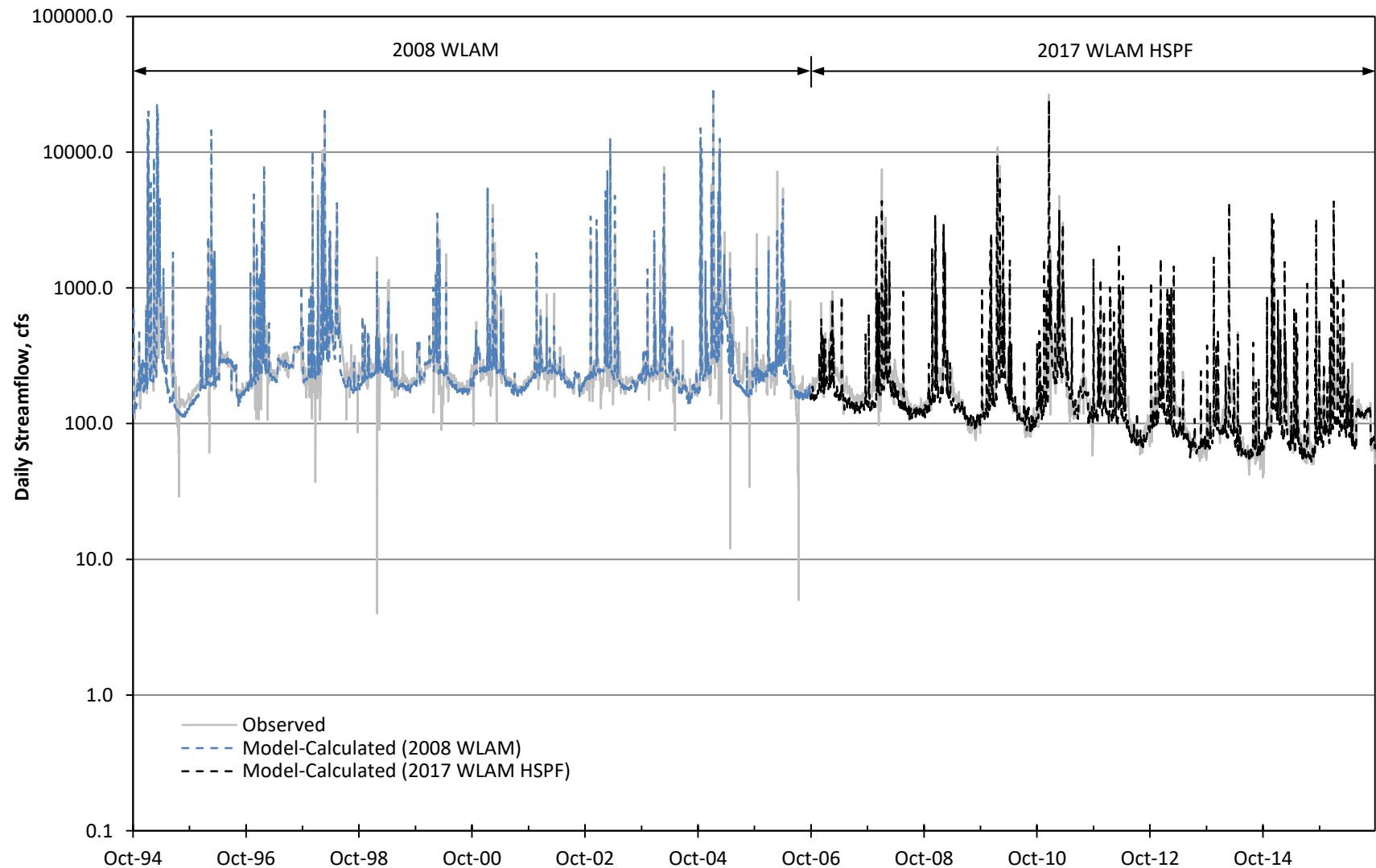


Figure 43

**Hydrographs of Measured and Model-Simulated Daily Streamflow at the Santa Ana River at Santa Ana  
Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (2017 WLAM HSPF)**

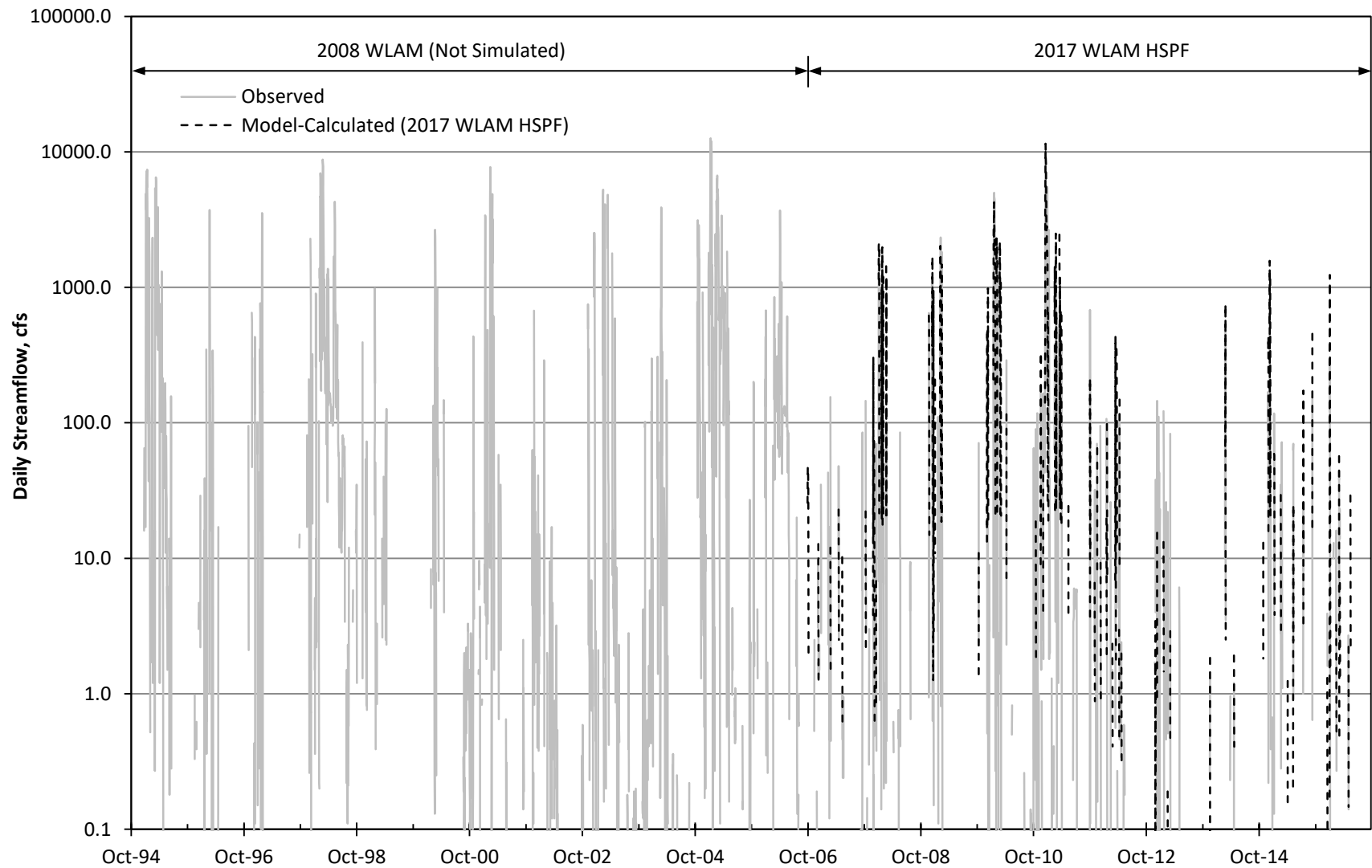


Figure 44

**Hydrographs of Measured and Model-Simulated Monthly Streamflow at the San Temoteo Creek near Loma Linda – Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (2017 WLAM HSPF)**

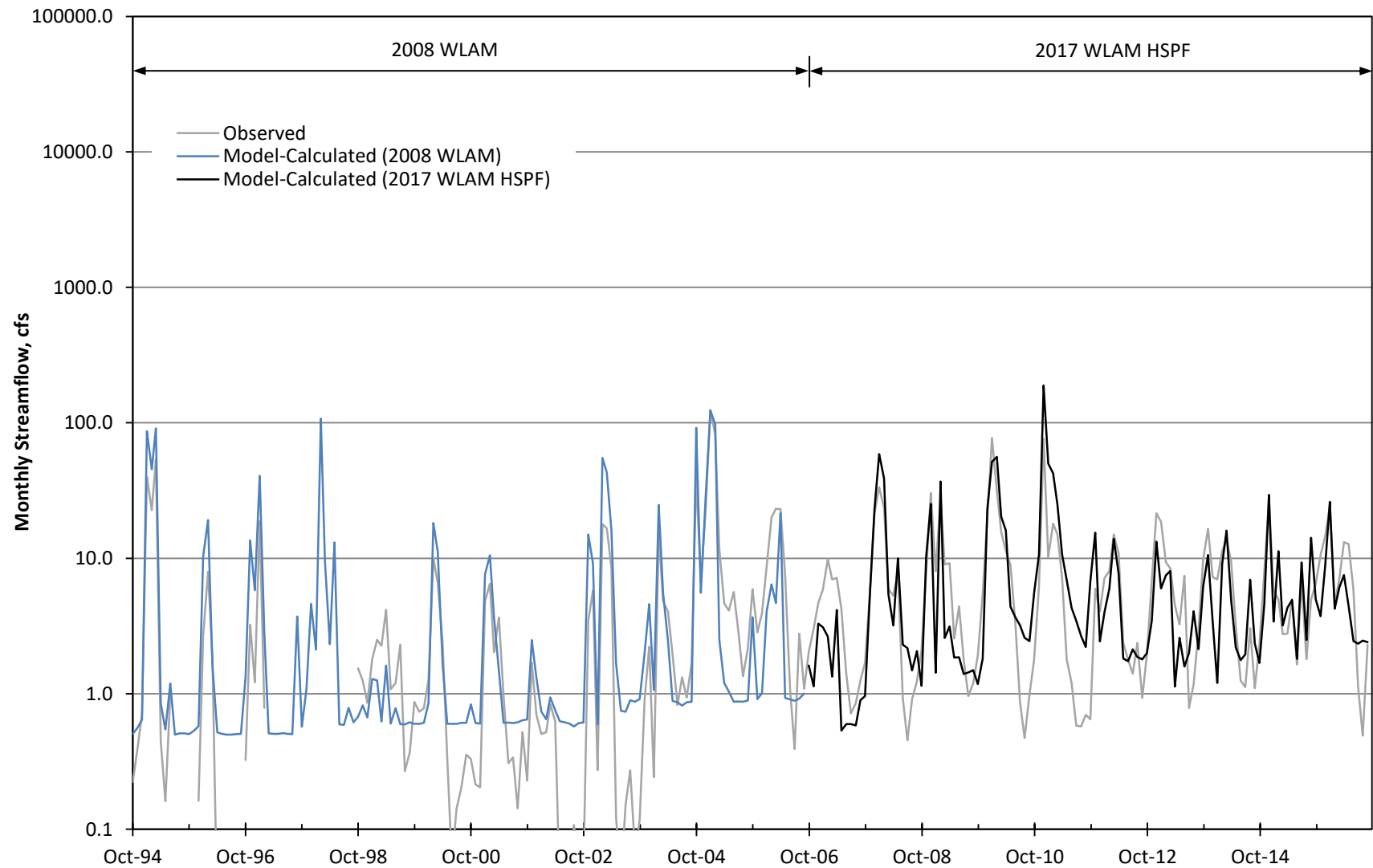


Figure 45

**Hydrographs of Measured and Model-Simulated Monthly Streamflow at the Warm Creek near San Bernardino – Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (2017 WLAM HSPF)**

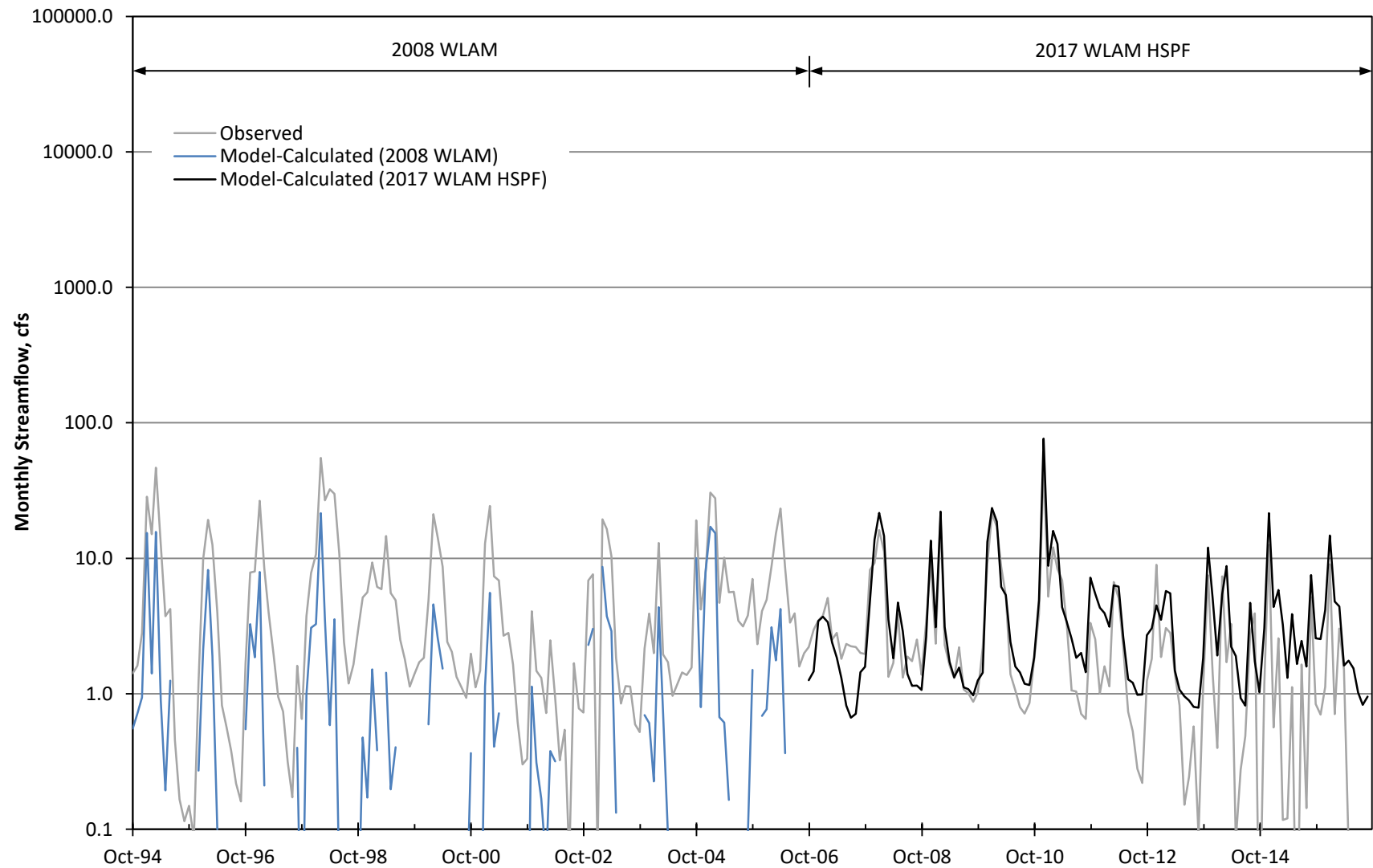


Figure 46

**Hydrographs of Measured and Model-Simulated Monthly Streamflow at the Santa Ana River at E Street  
Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (2017 WLAM HSPF)**

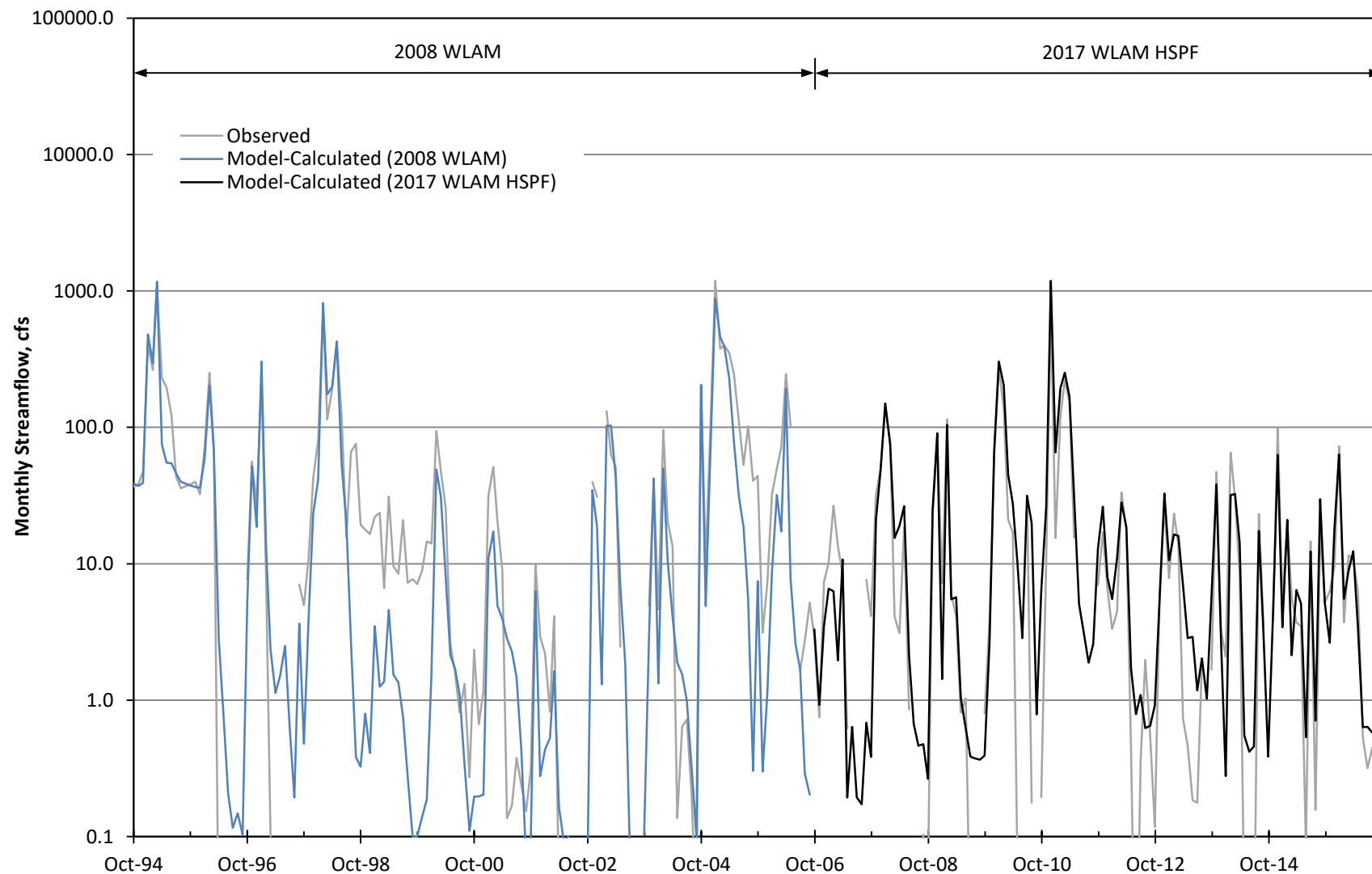


Figure 47

**Hydrographs of Measured and Model-Simulated Monthly Streamflow at the Santa Ana River at MWD  
Crossing – Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (2017 WLAM HSPF)**

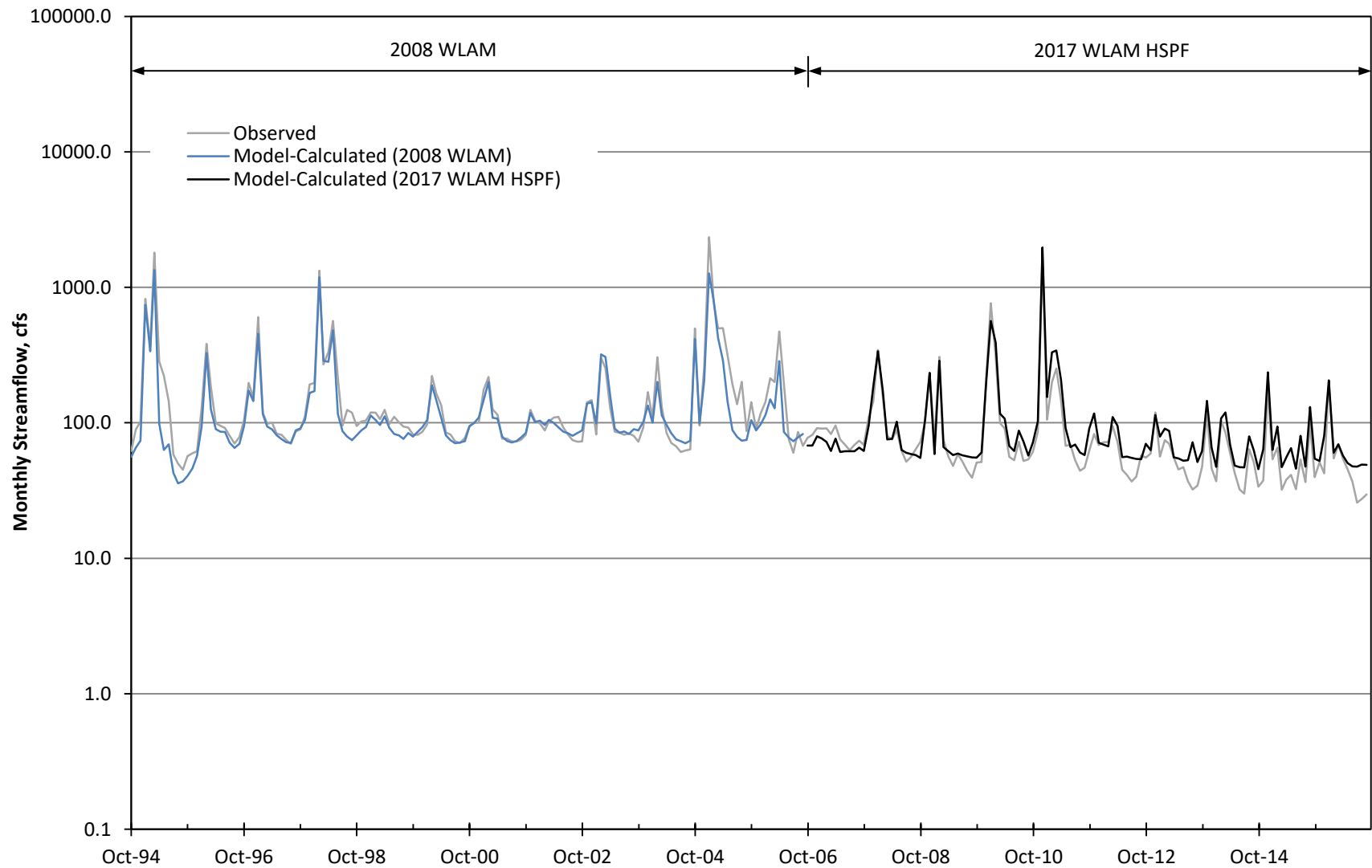


Figure 48

**Hydrographs of Measured and Model-Simulated Monthly Streamflow at the Temescal Creek at Main Street  
Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (2017 WLAM HSPF)**

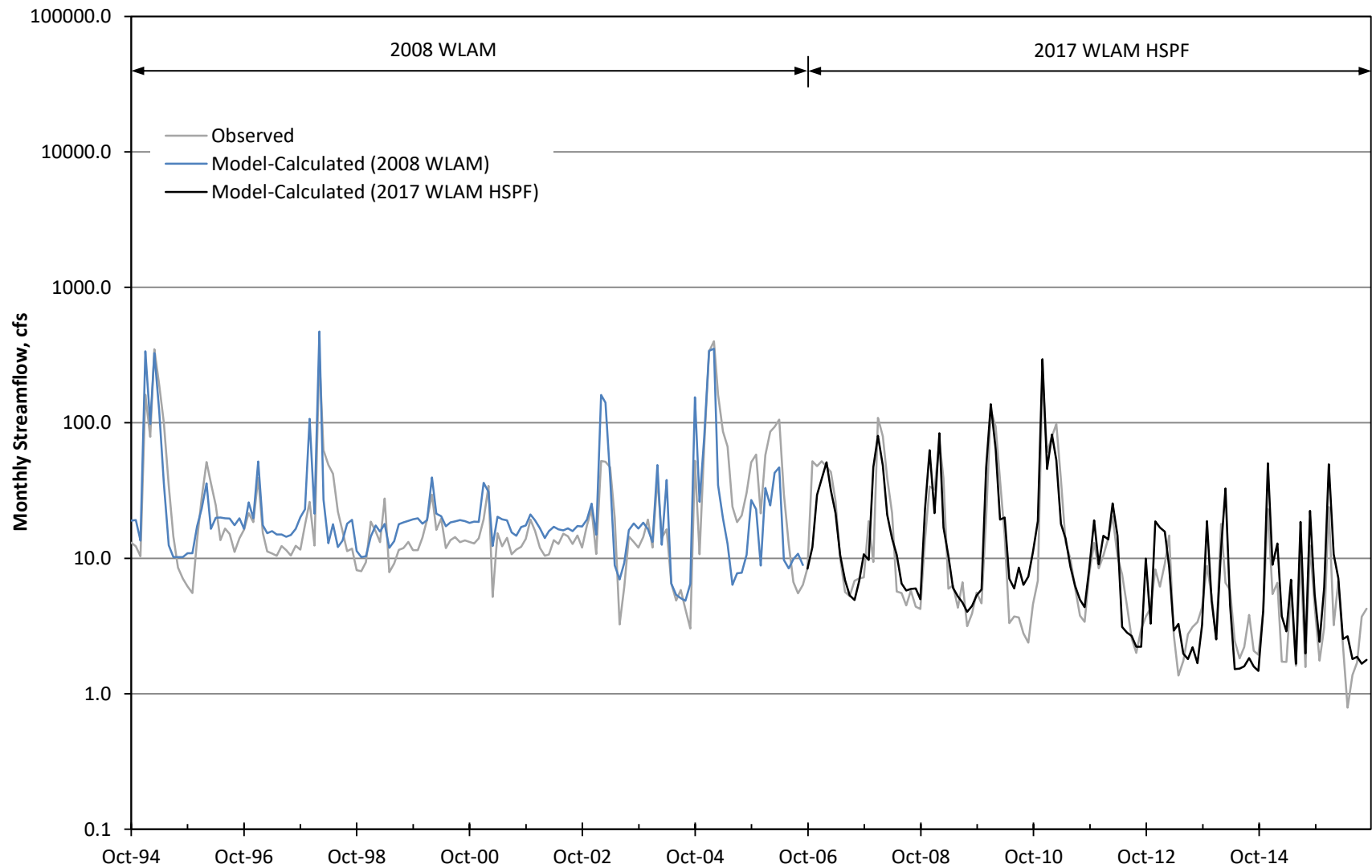


Figure 49

**Hydrographs of Measured and Model-Simulated Monthly Streamflow at the Chino Creek at Schaefer Avenue – Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (2017 WLAM HSPF)**

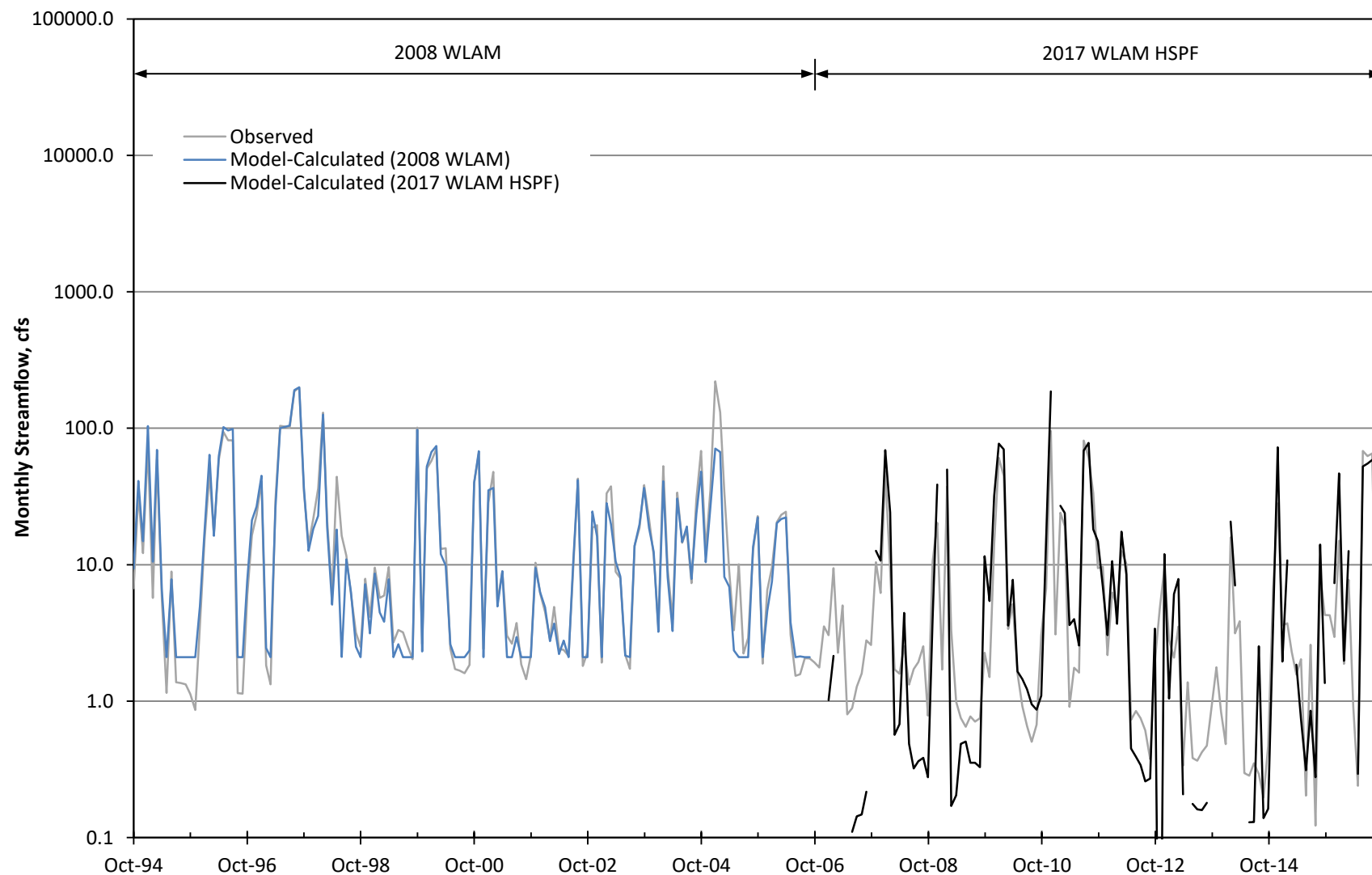


Figure 50

**Hydrographs of Measured and Model-Simulated Monthly Streamflow at the Cucamonga Creek near Mira  
Loma – Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (2017 WLAM HSPF)**

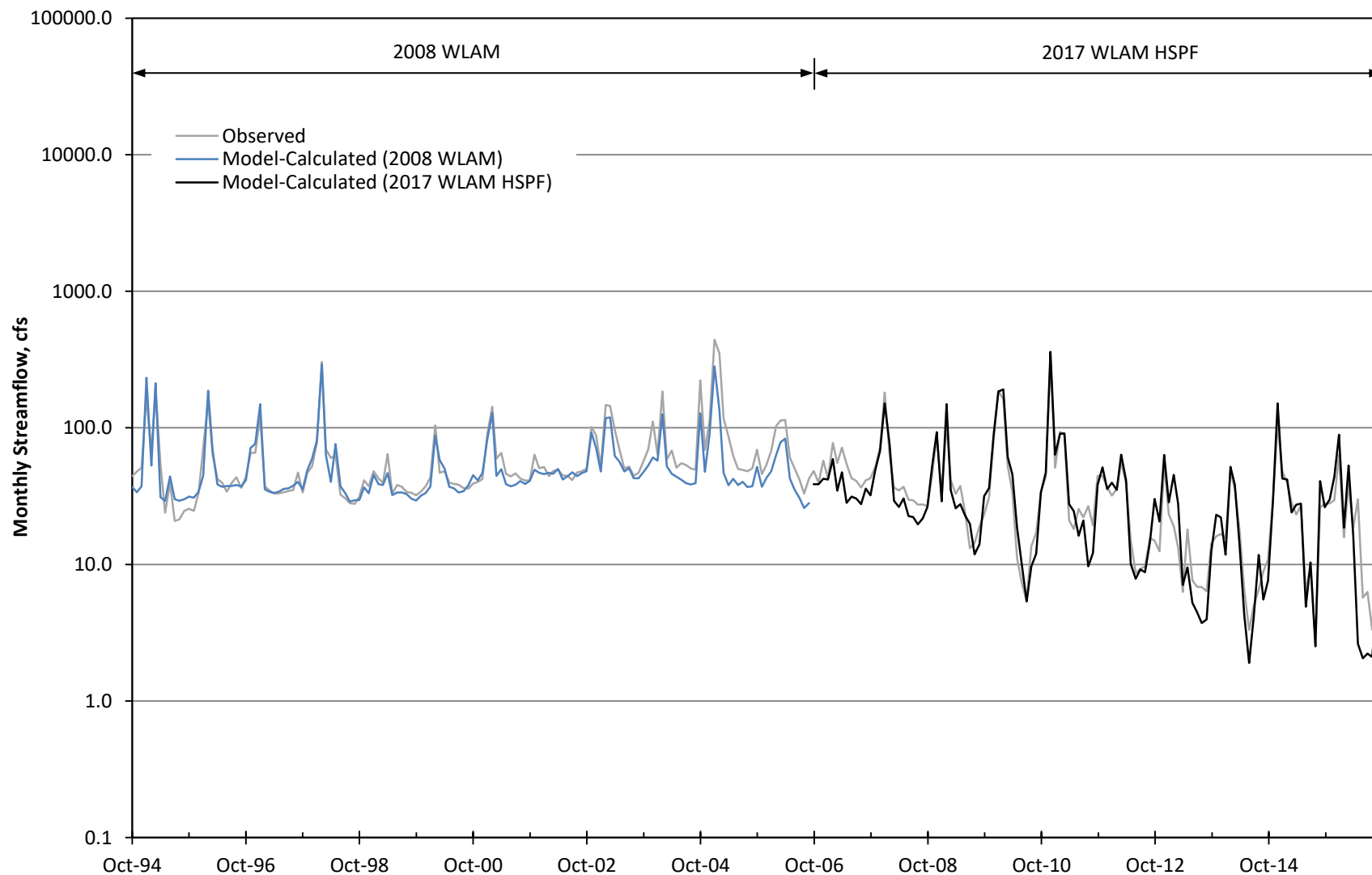


Figure 51

**Hydrographs of Measured and Model-Simulated Monthly Streamflow at the Santa Ana River Inflow to  
Prado – Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (2017 WLAM HSPF)**

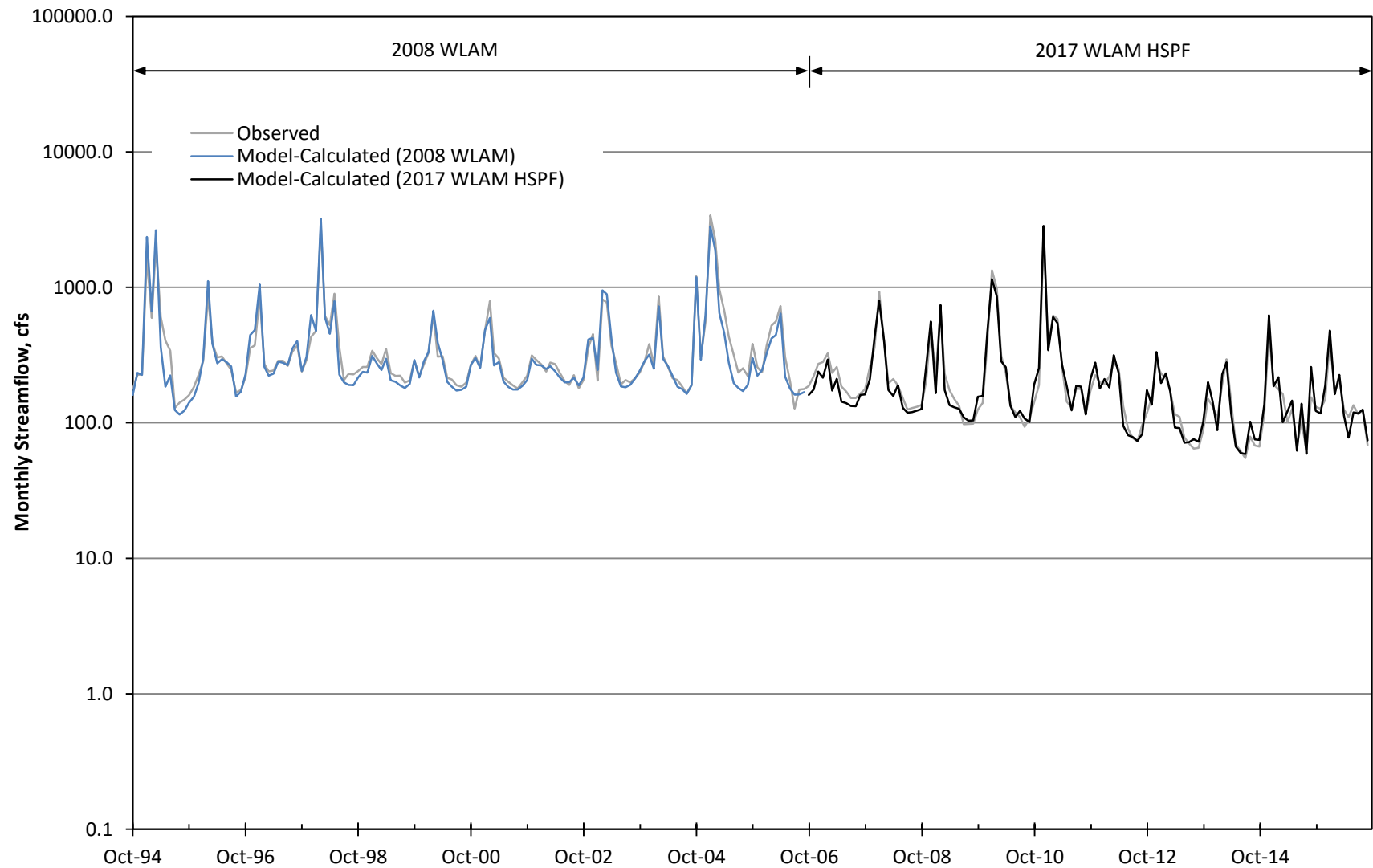


Figure 52

**Hydrographs of Measured and Model-Simulated Monthly Streamflow at the Santa Ana River at Santa Ana  
Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (2017 WLAM HSPF)**

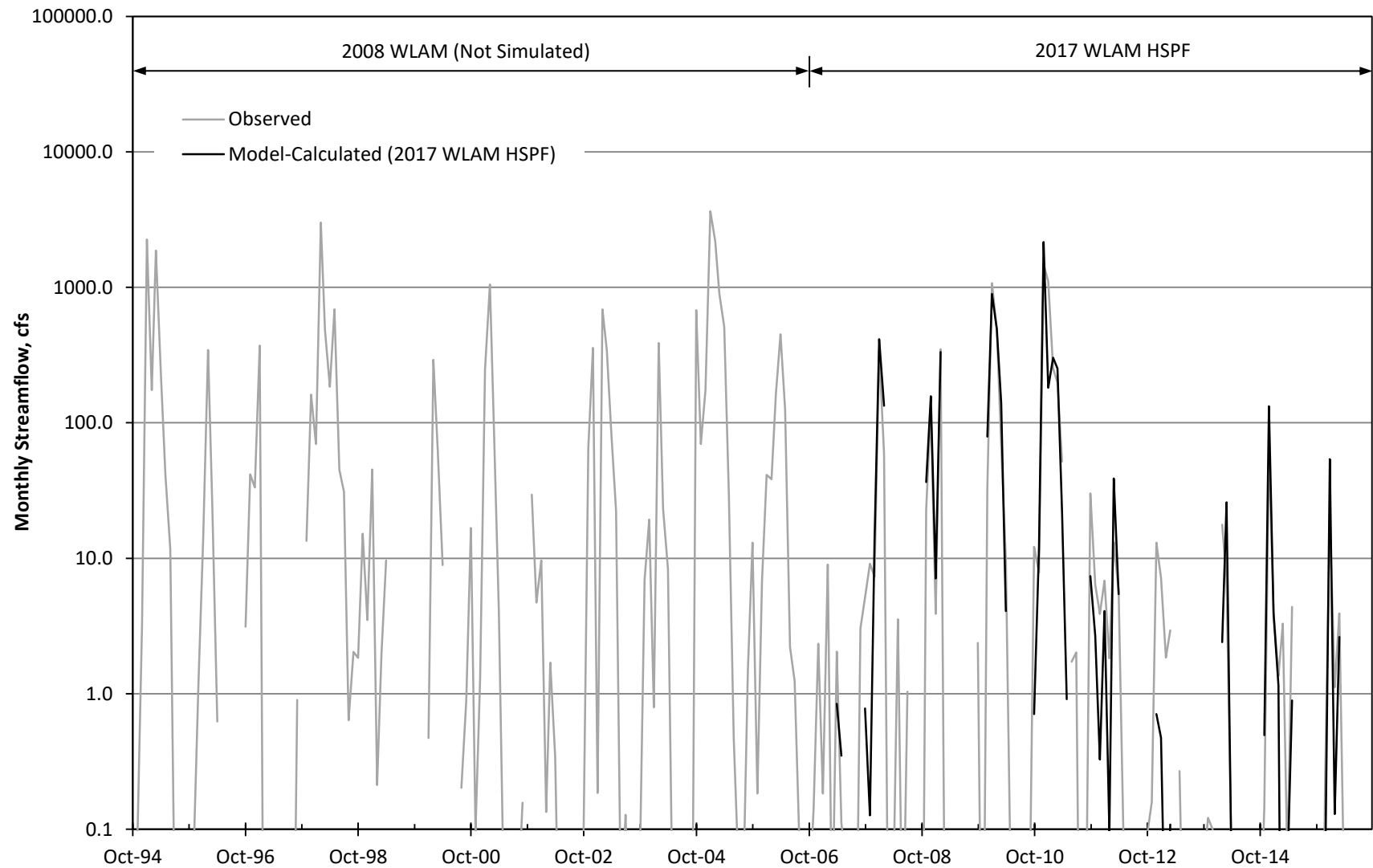
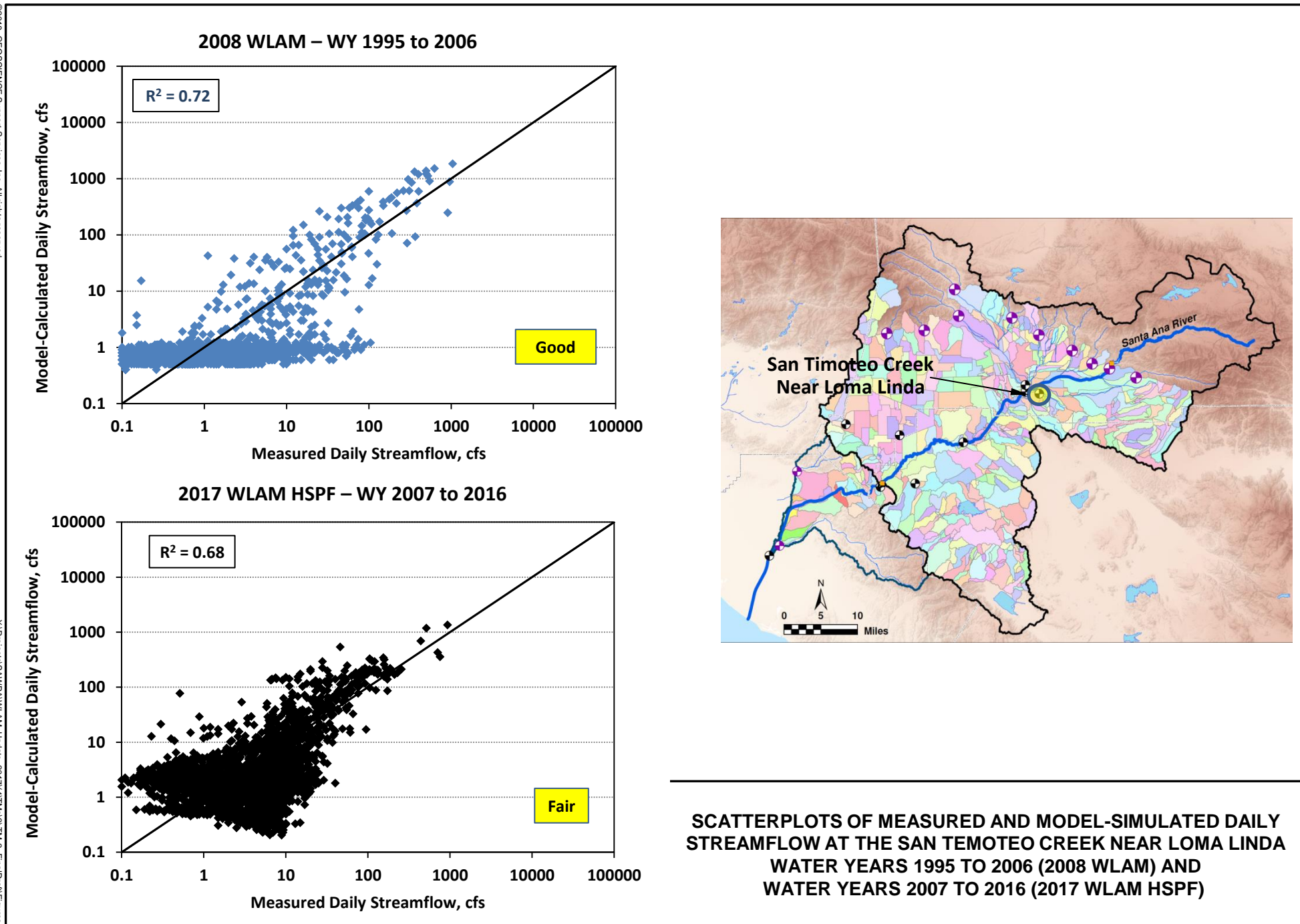
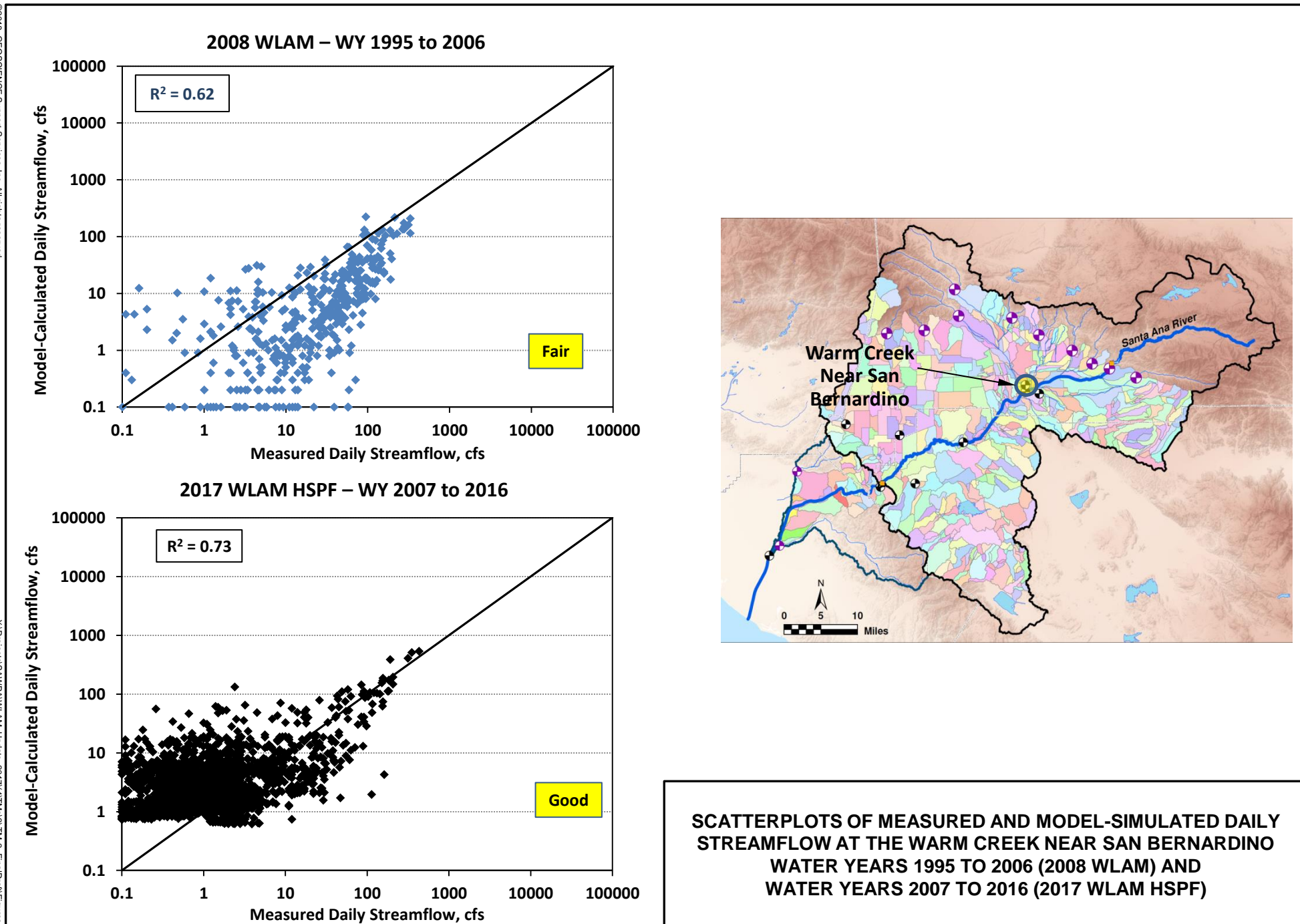


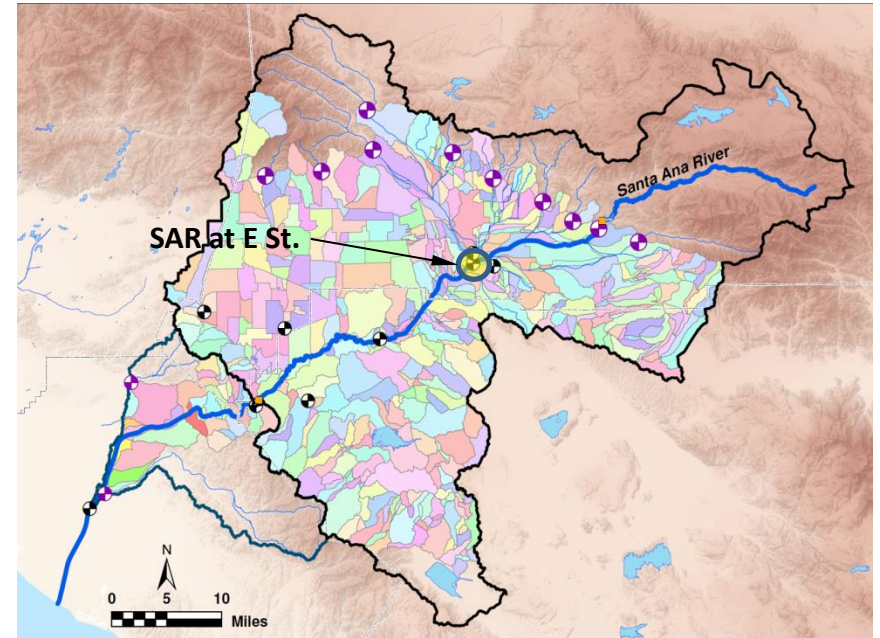
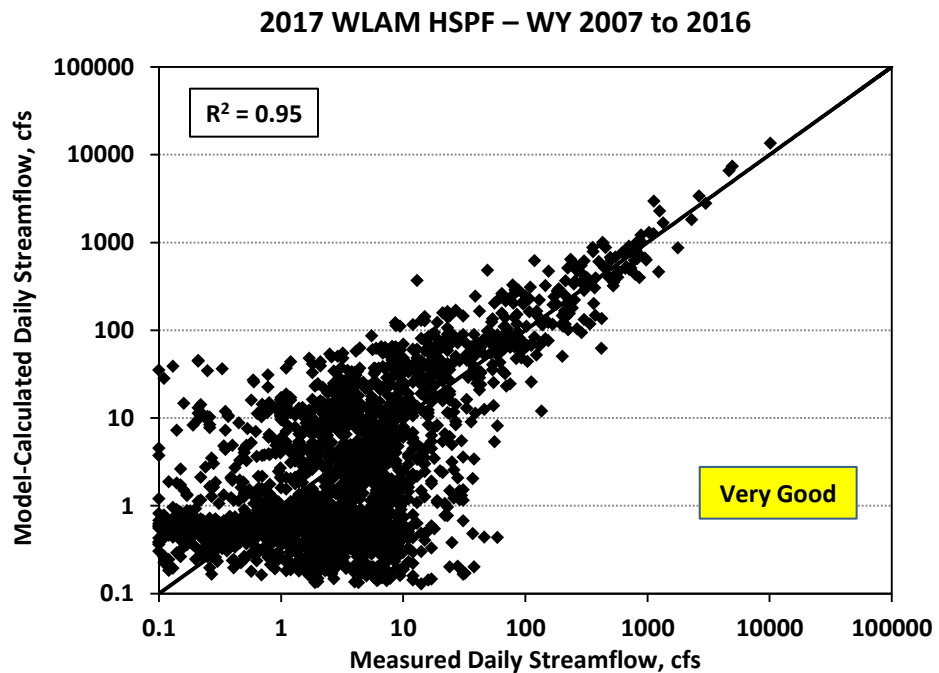
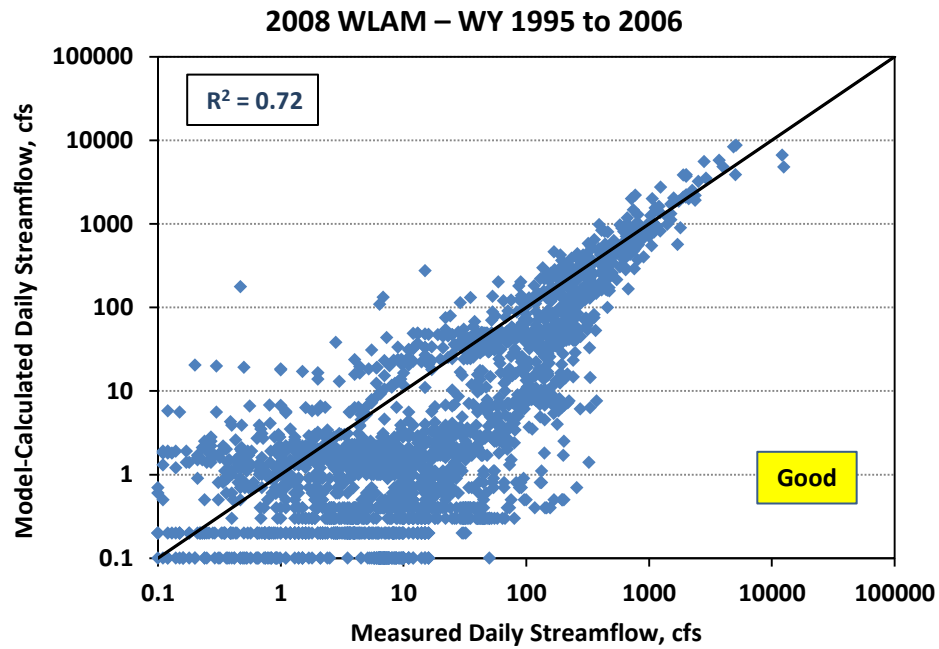
Figure 53



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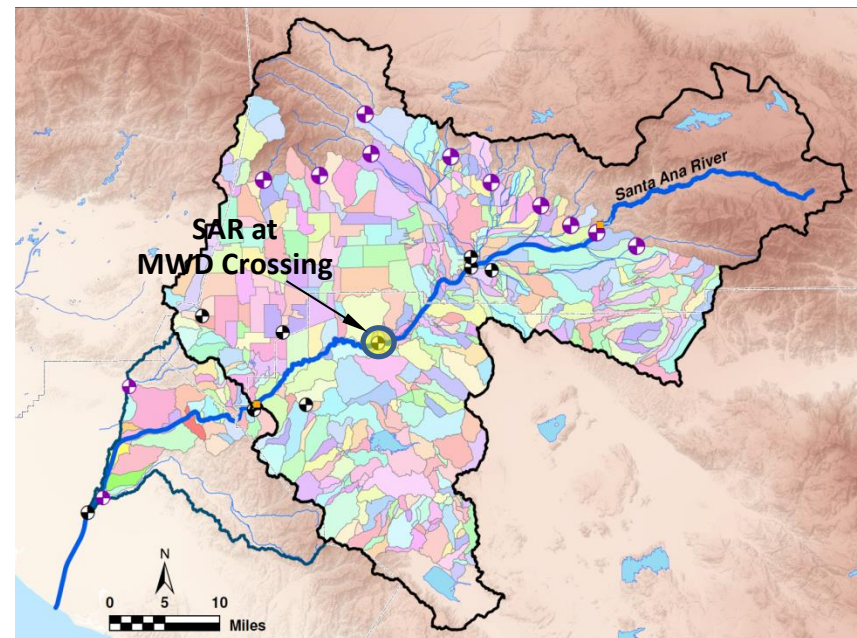
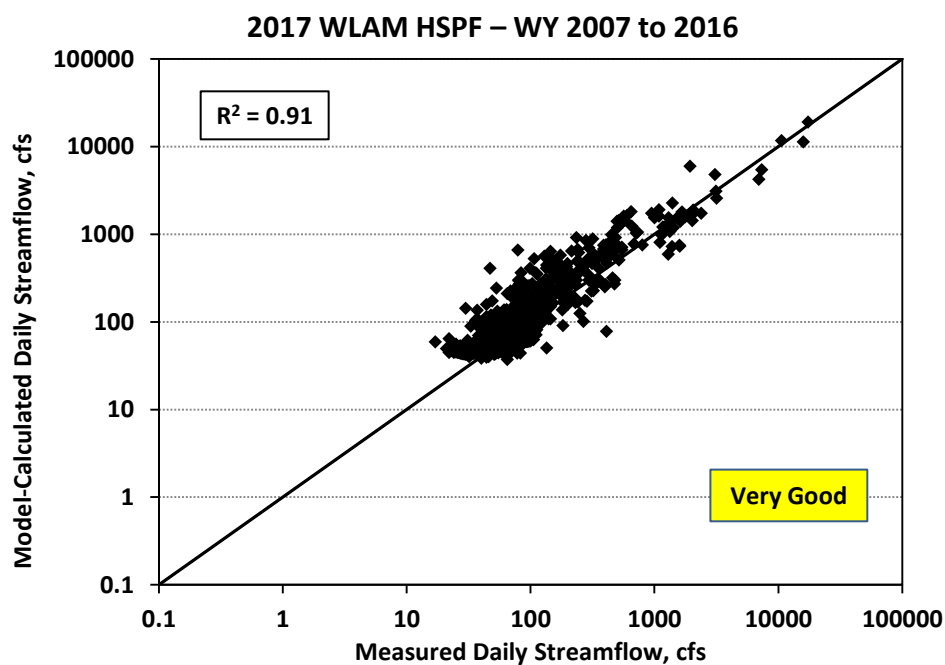
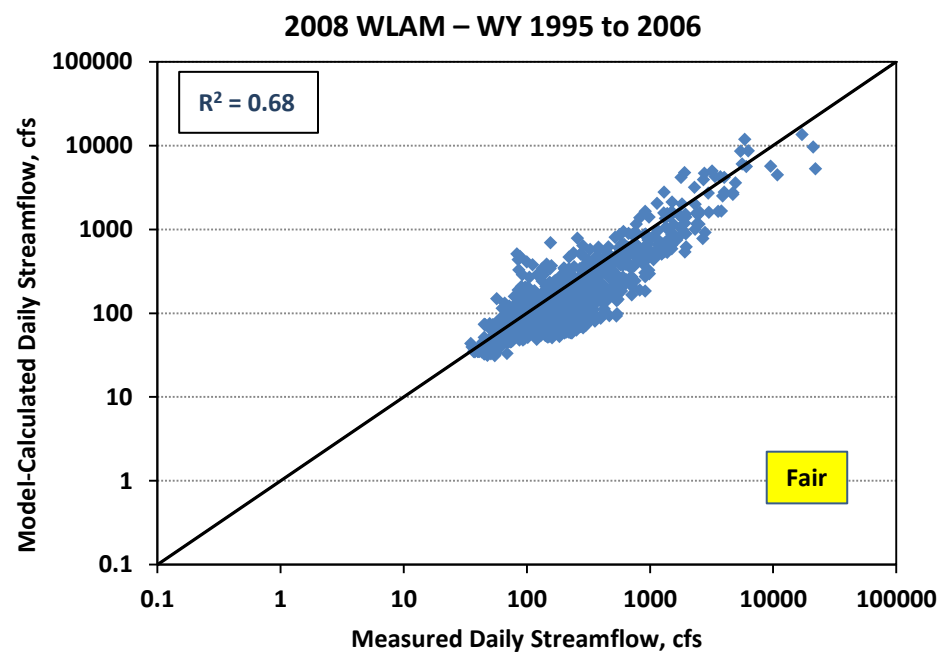


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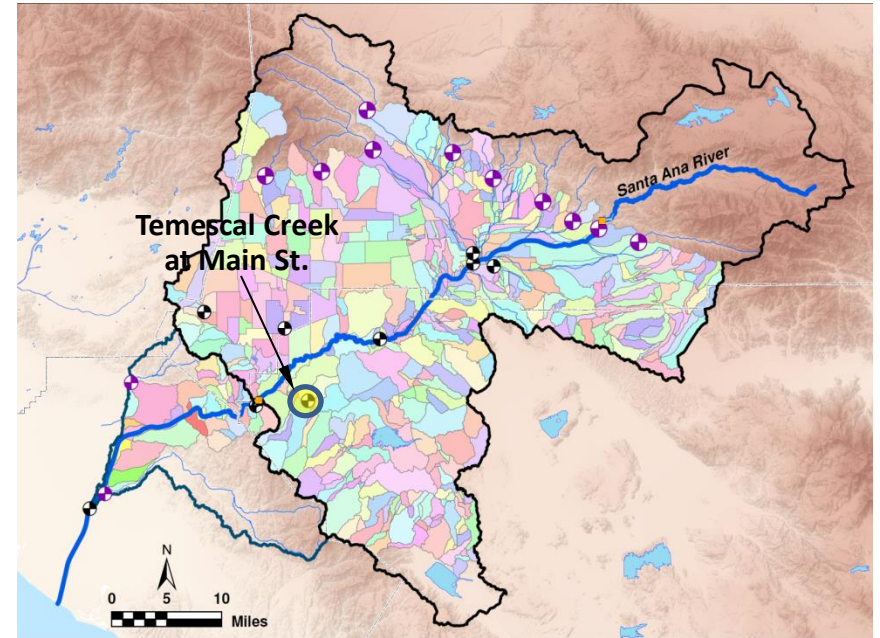
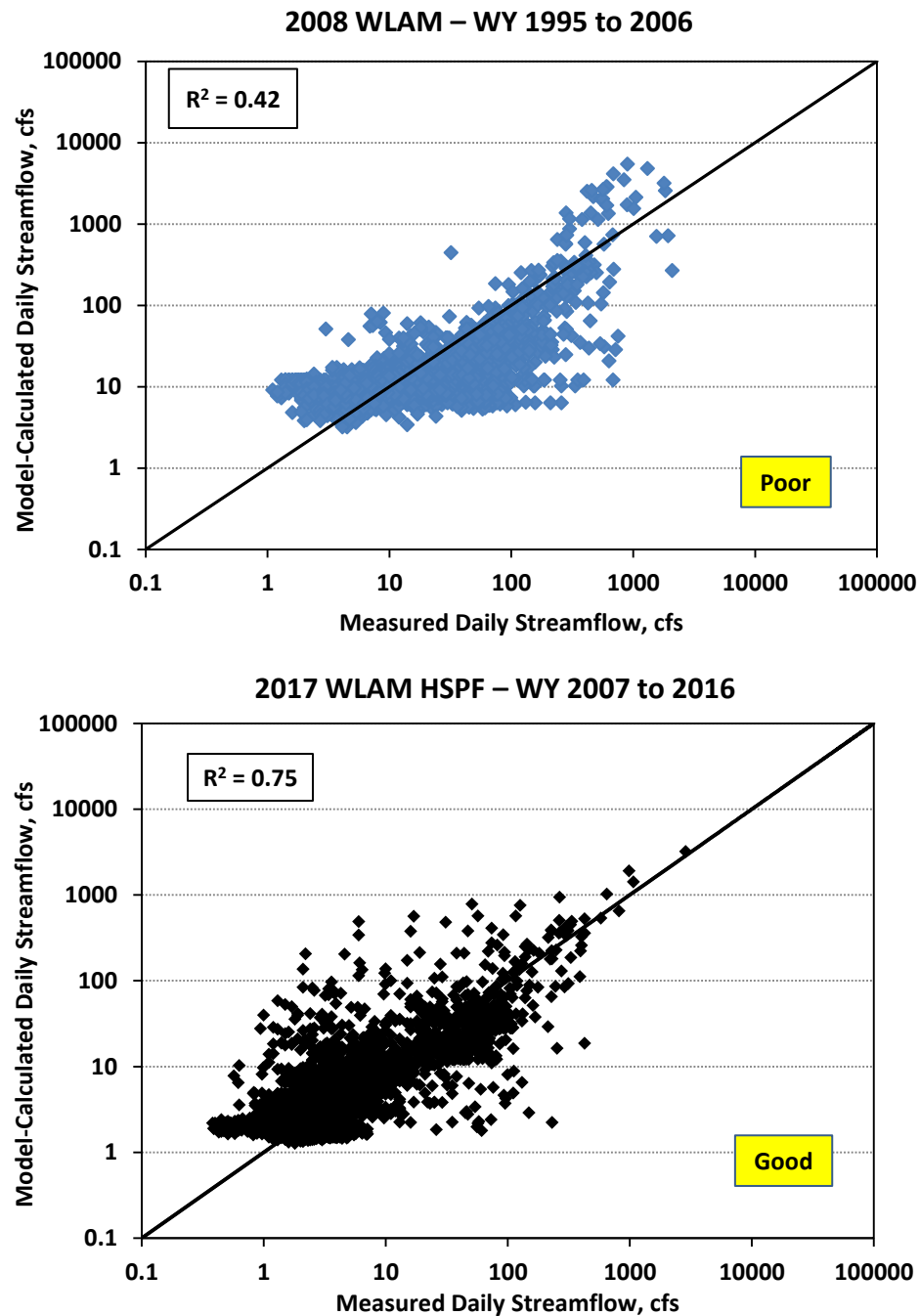
**SCATTERPLOTS OF MEASURED AND MODEL-SIMULATED DAILY STREAMFLOW AT THE SANTA ANA RIVER AT E STREET  
WATER YEARS 1995 TO 2006 (2008 WLAM) AND  
WATER YEARS 2007 TO 2016 (2017 WLAM HSPF)**

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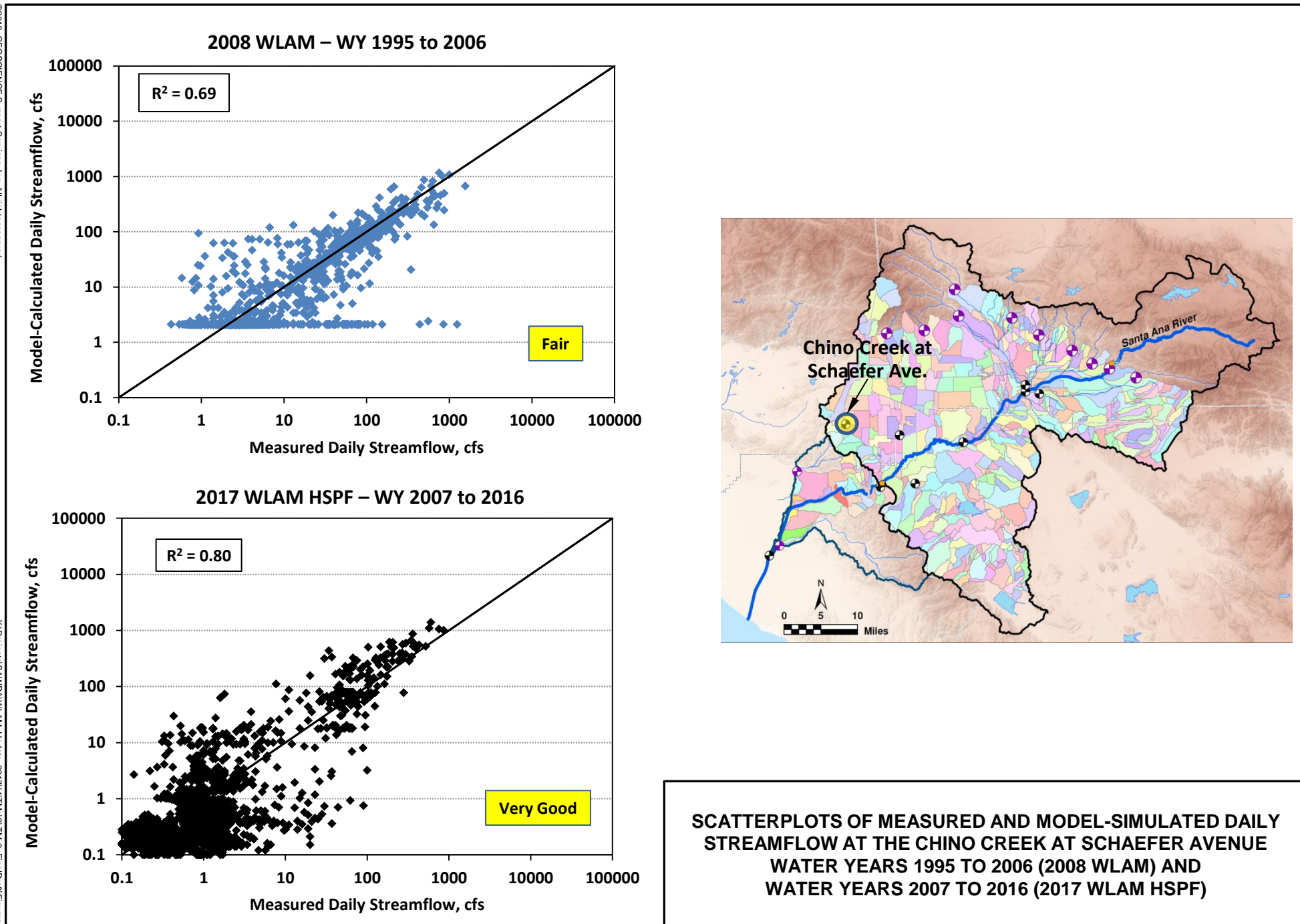
**SCATTERPLOTS OF MEASURED AND MODEL-SIMULATED DAILY STREAMFLOW AT THE SANTA ANA RIVER AT MWD CROSSING WATER YEARS 1995 TO 2006 (2008 WLAM) AND WATER YEARS 2007 TO 2016 (2017 WLAM HSPF)**

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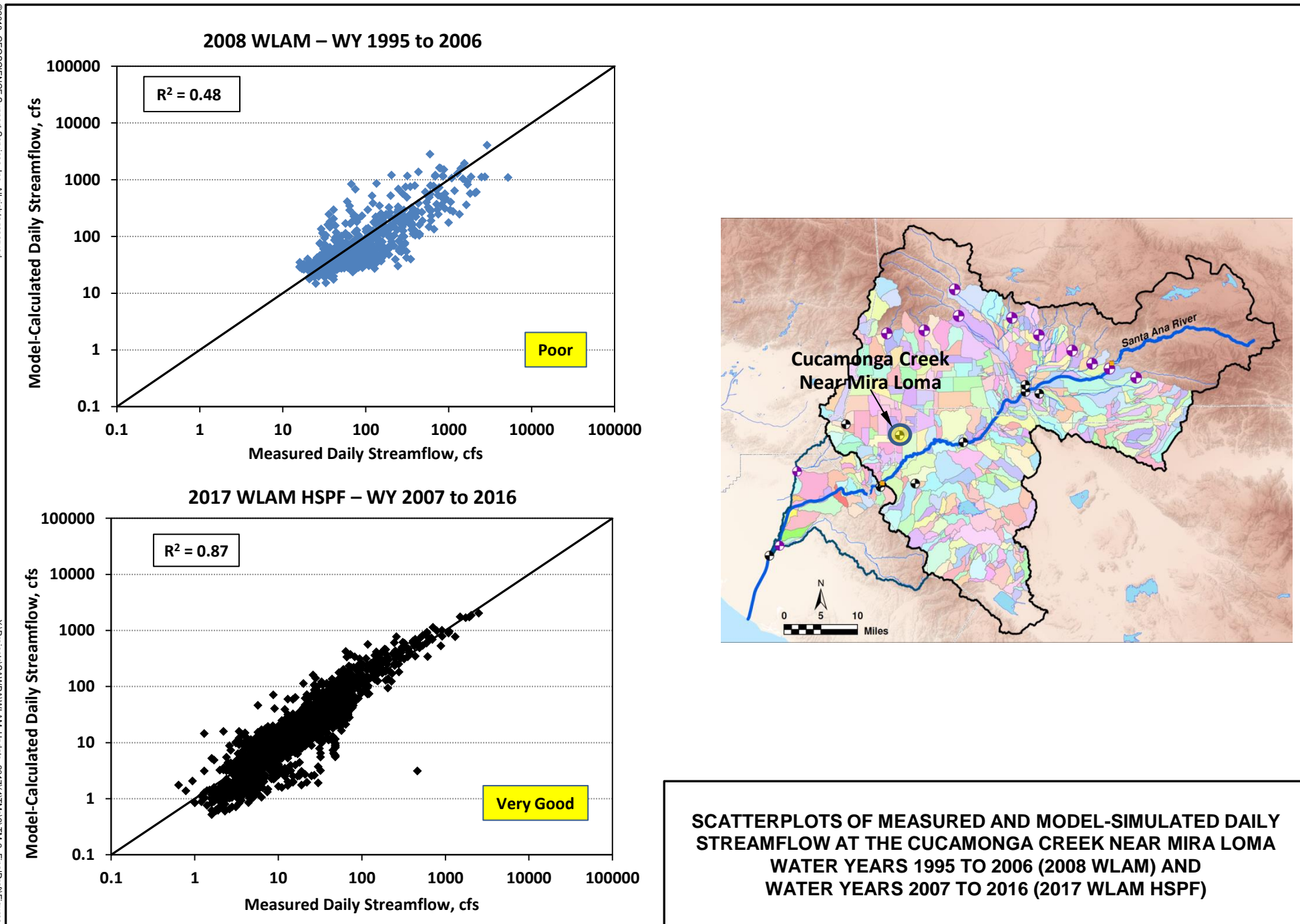


**SCATTERPLOTS OF MEASURED AND MODEL-SIMULATED DAILY STREAMFLOW AT THE TEMESCAL CREEK AT MAIN STREET WATER YEARS 1995 TO 2006 (2008 WLAM) AND WATER YEARS 2007 TO 2016 (2017 WLAM HSPF)**

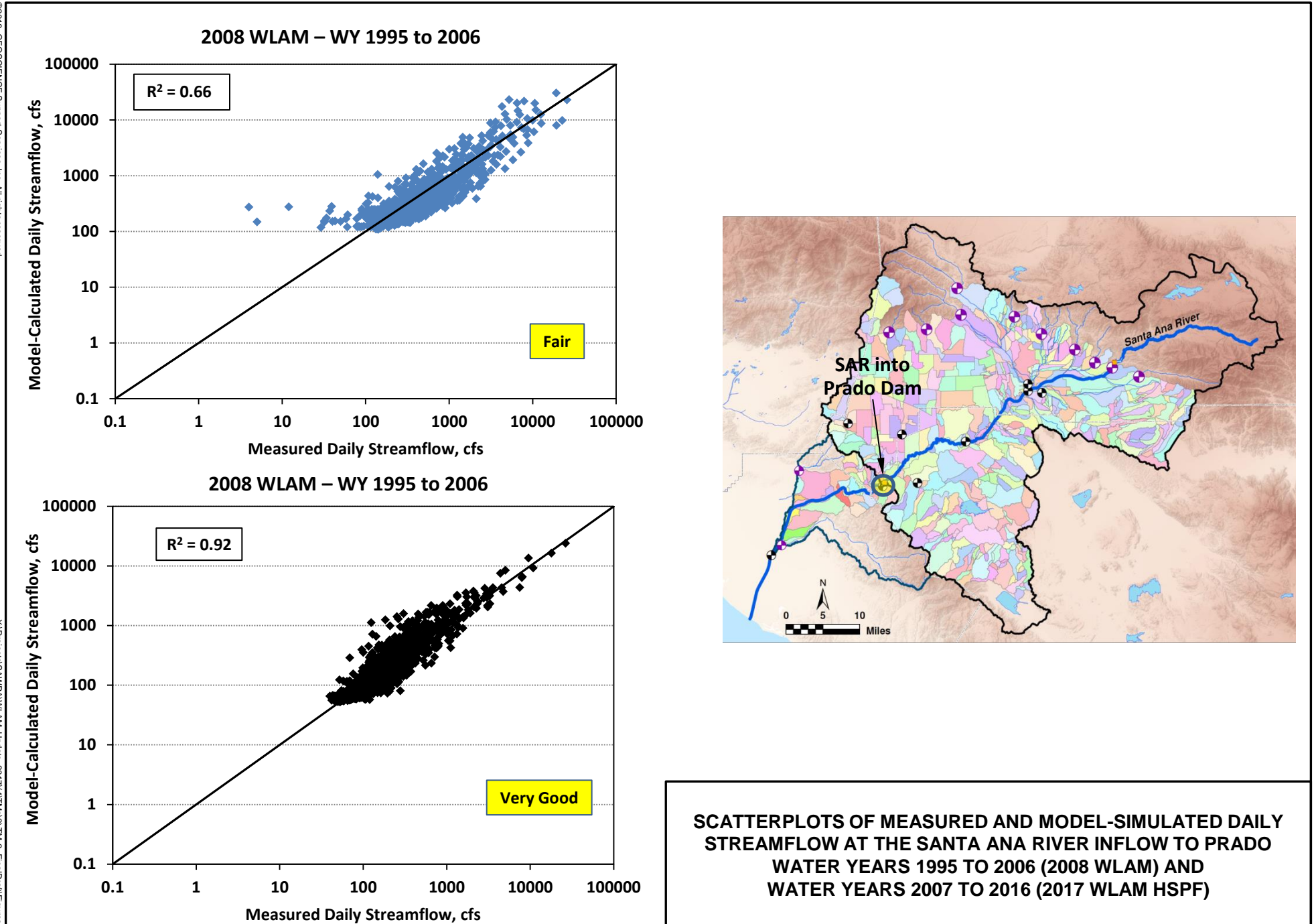
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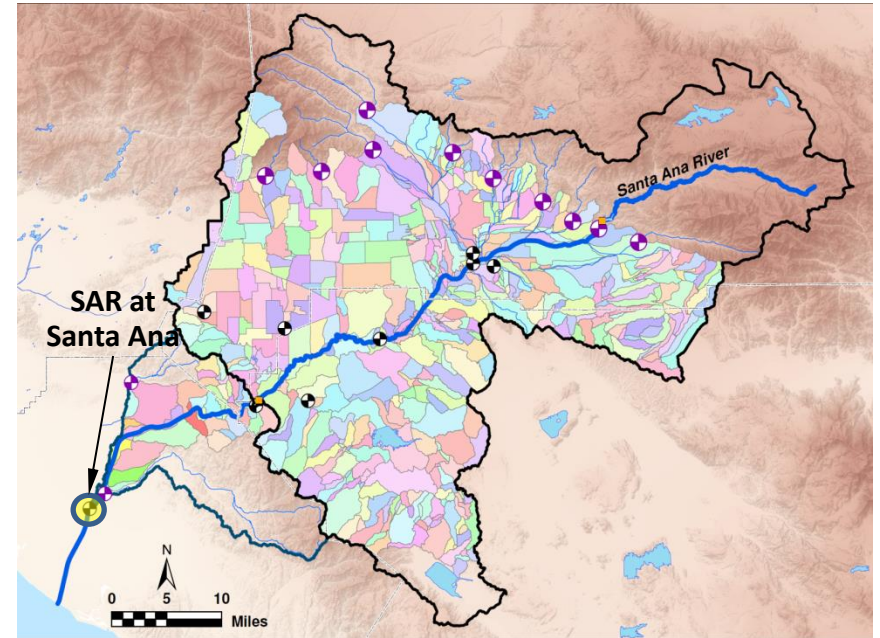
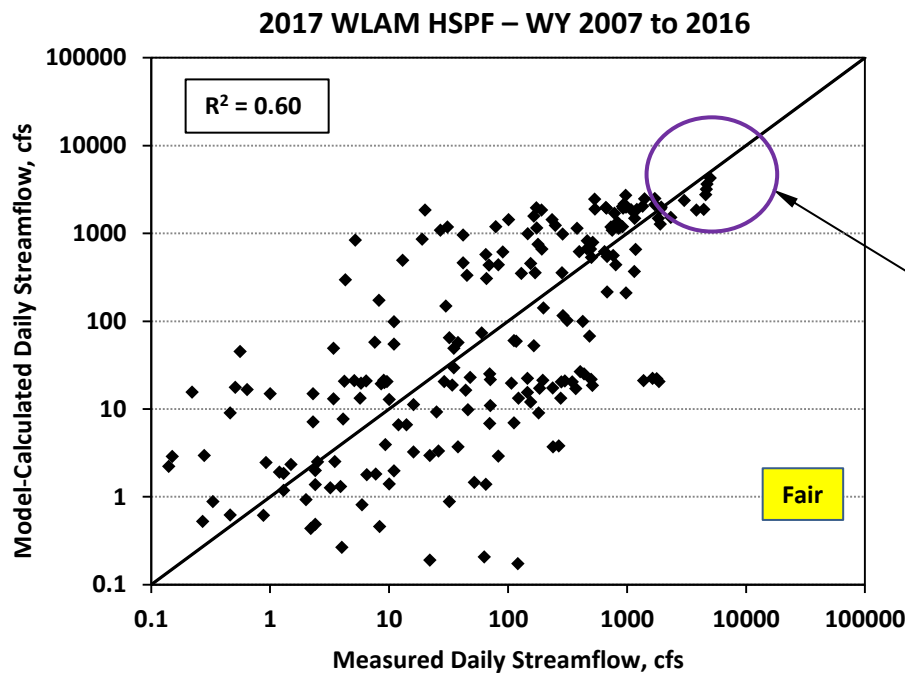
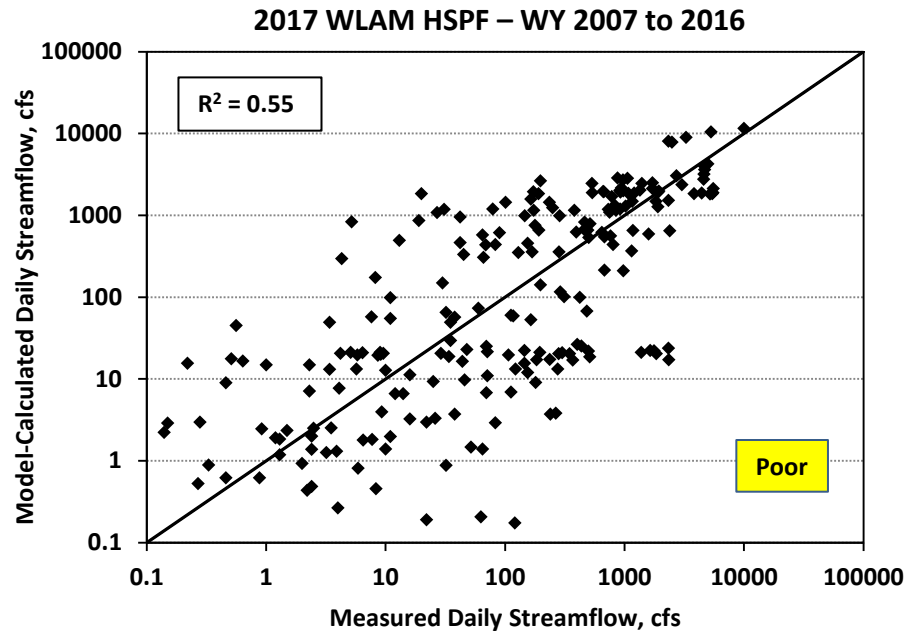
13-Apr-18



13-Apr-18



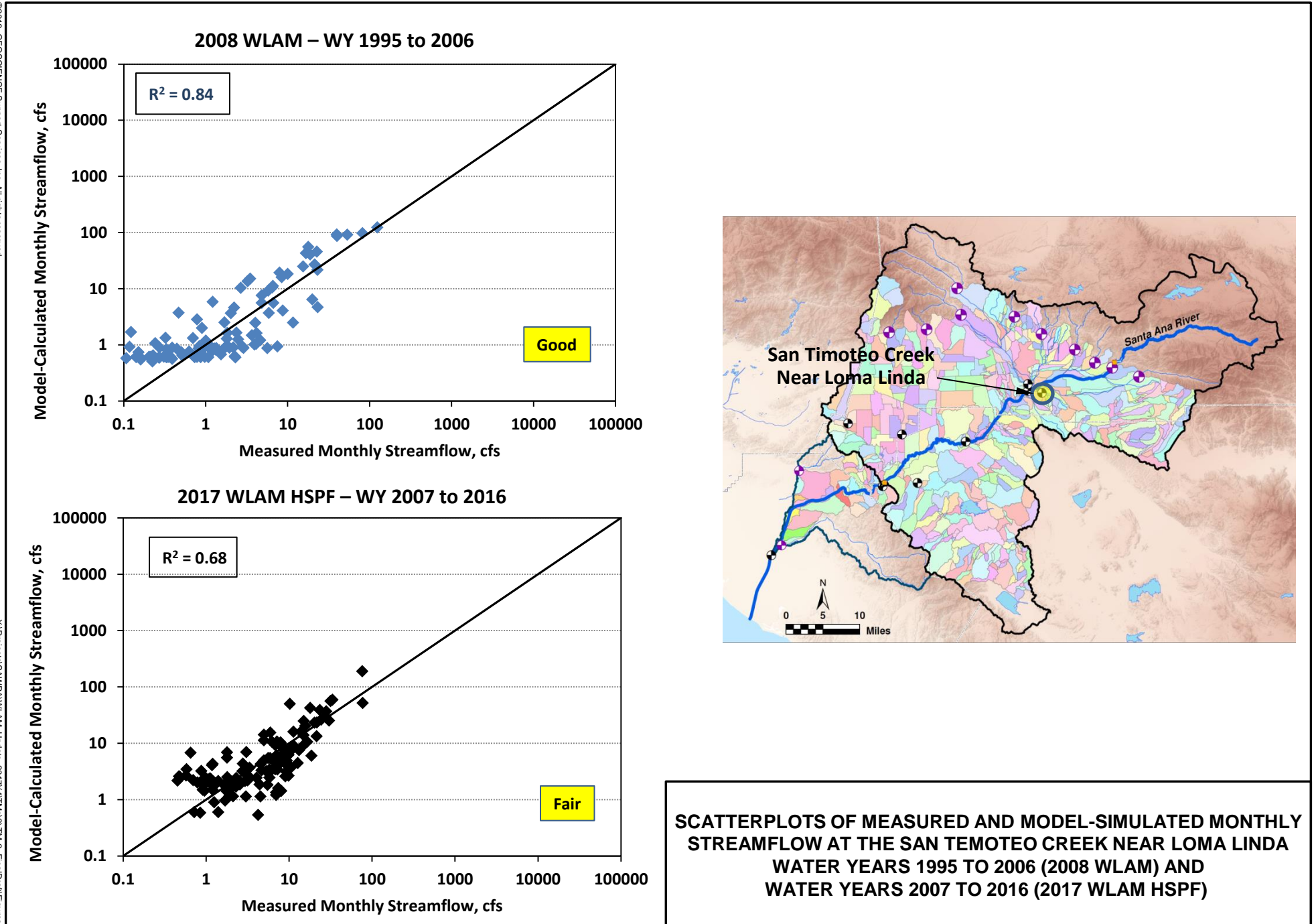
13-Apr-18



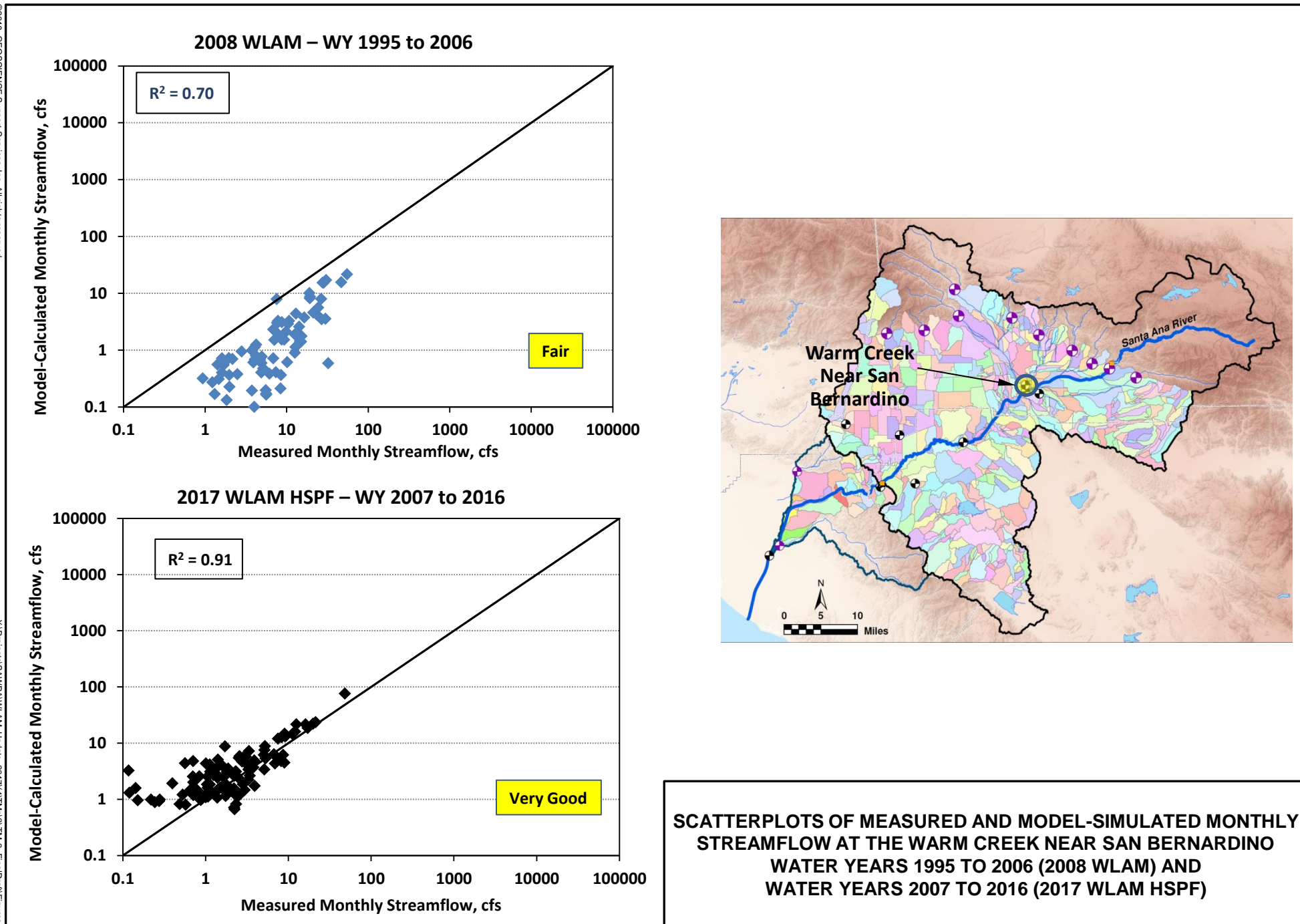
Calibration improved after data between December 19, 2010 and January 12, 2011 were removed (very high flow)

**SCATTERPLOTS OF MEASURED AND MODEL-SIMULATED DAILY STREAMFLOW AT THE SANTA ANA RIVER AT SANTA ANA WATER YEARS 2007 TO 2016 (2017 WLAM HSPF)**

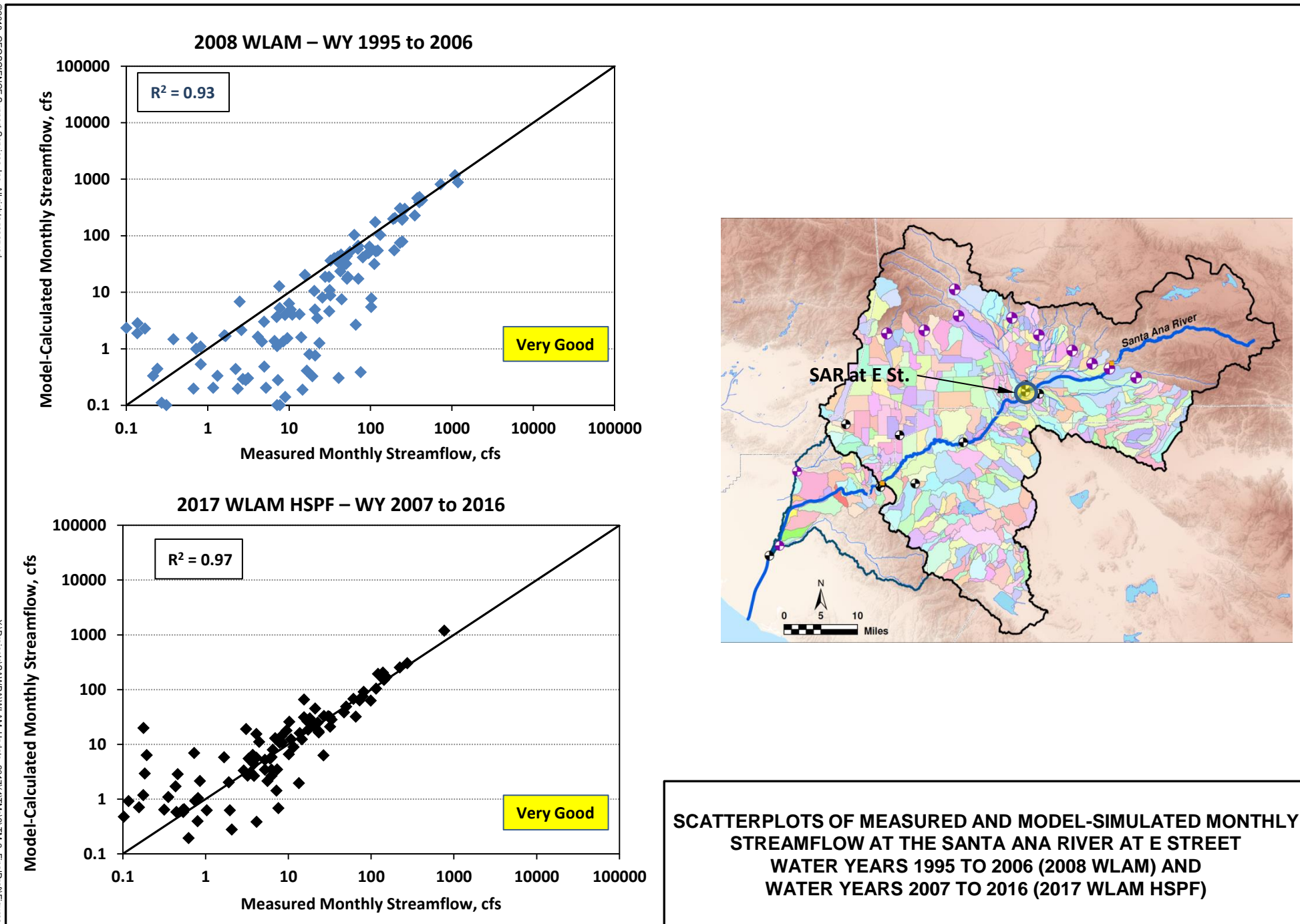
13-Apr-18



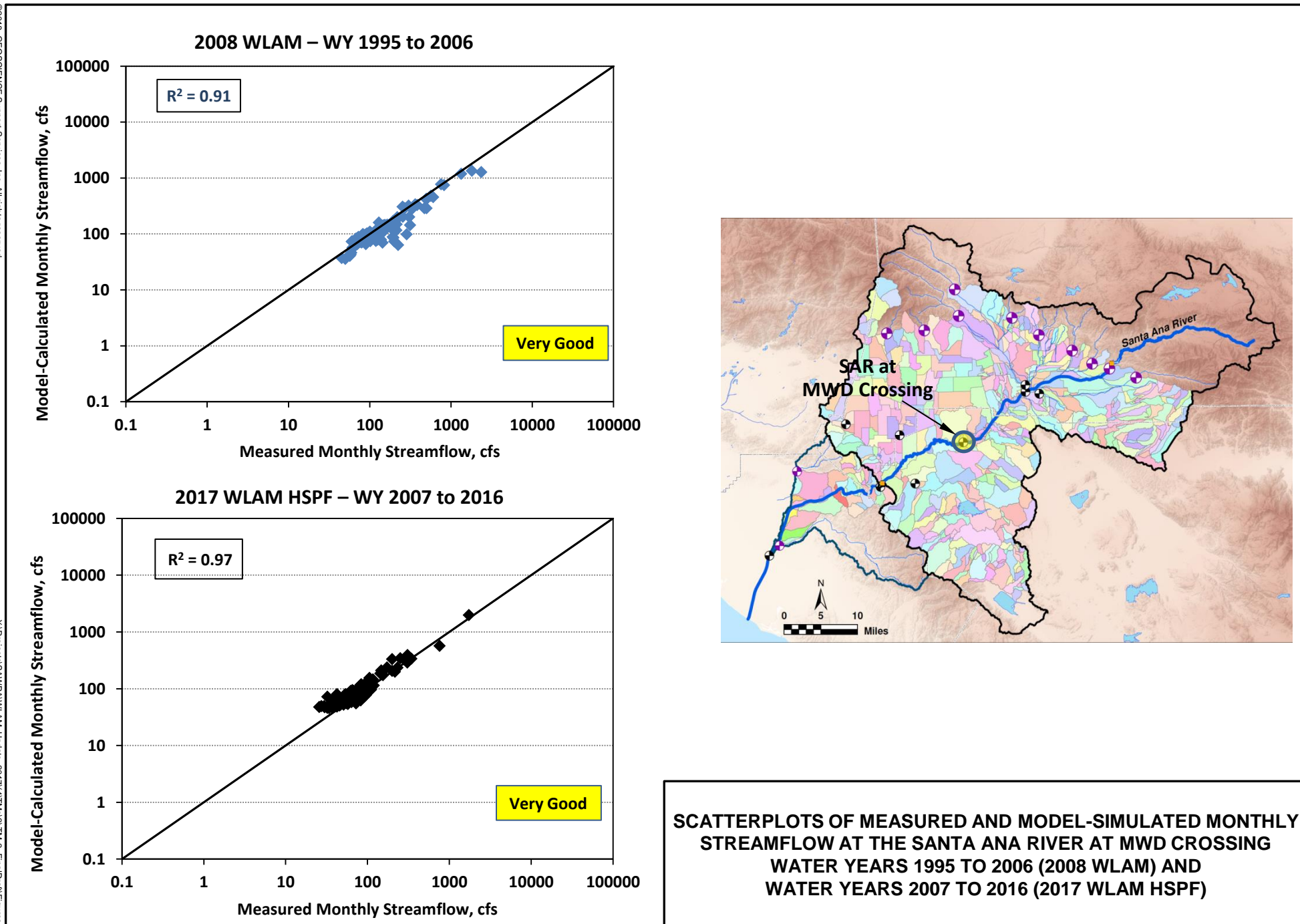
13-Apr-18



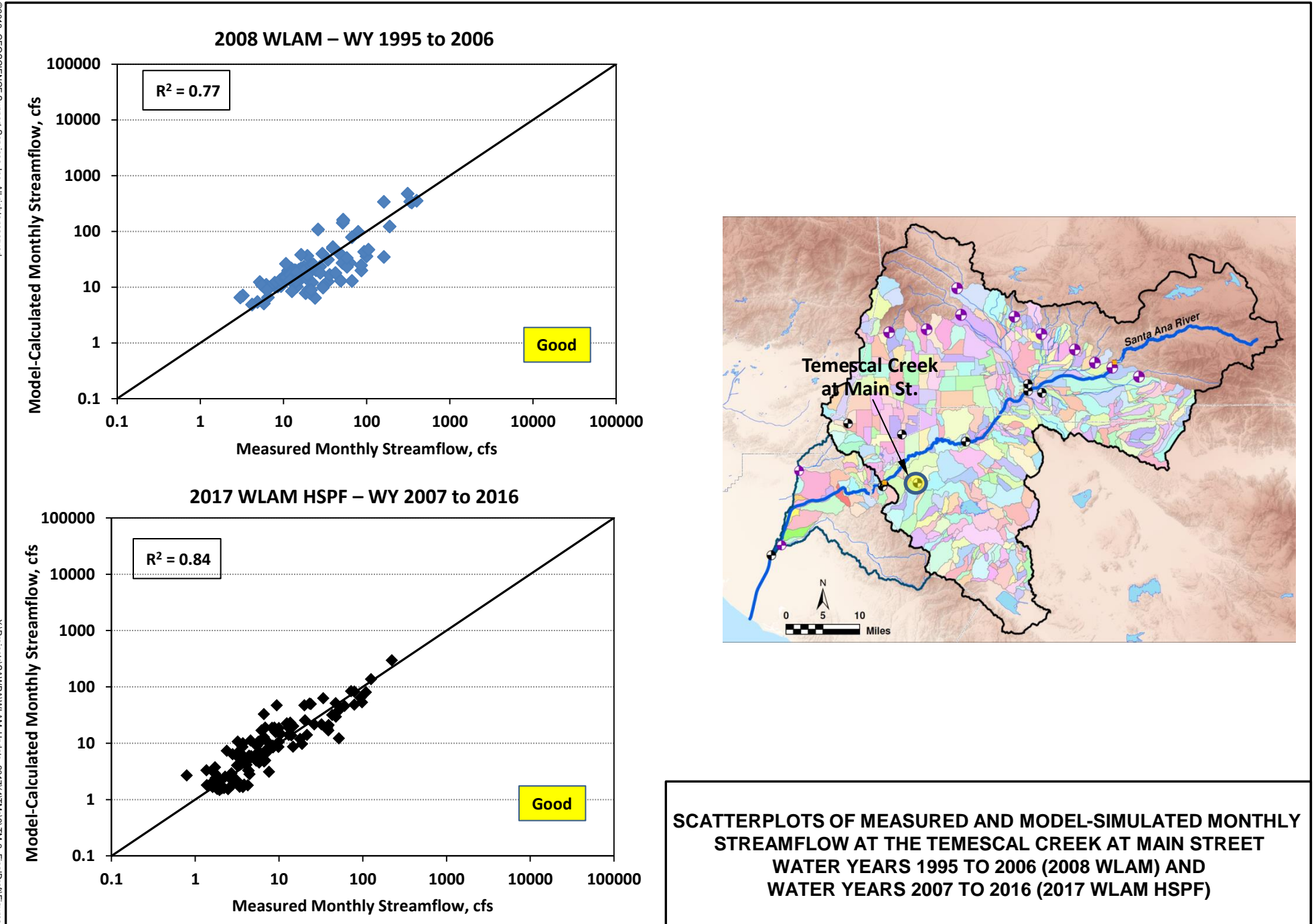
13-Apr-18



13-Apr-18

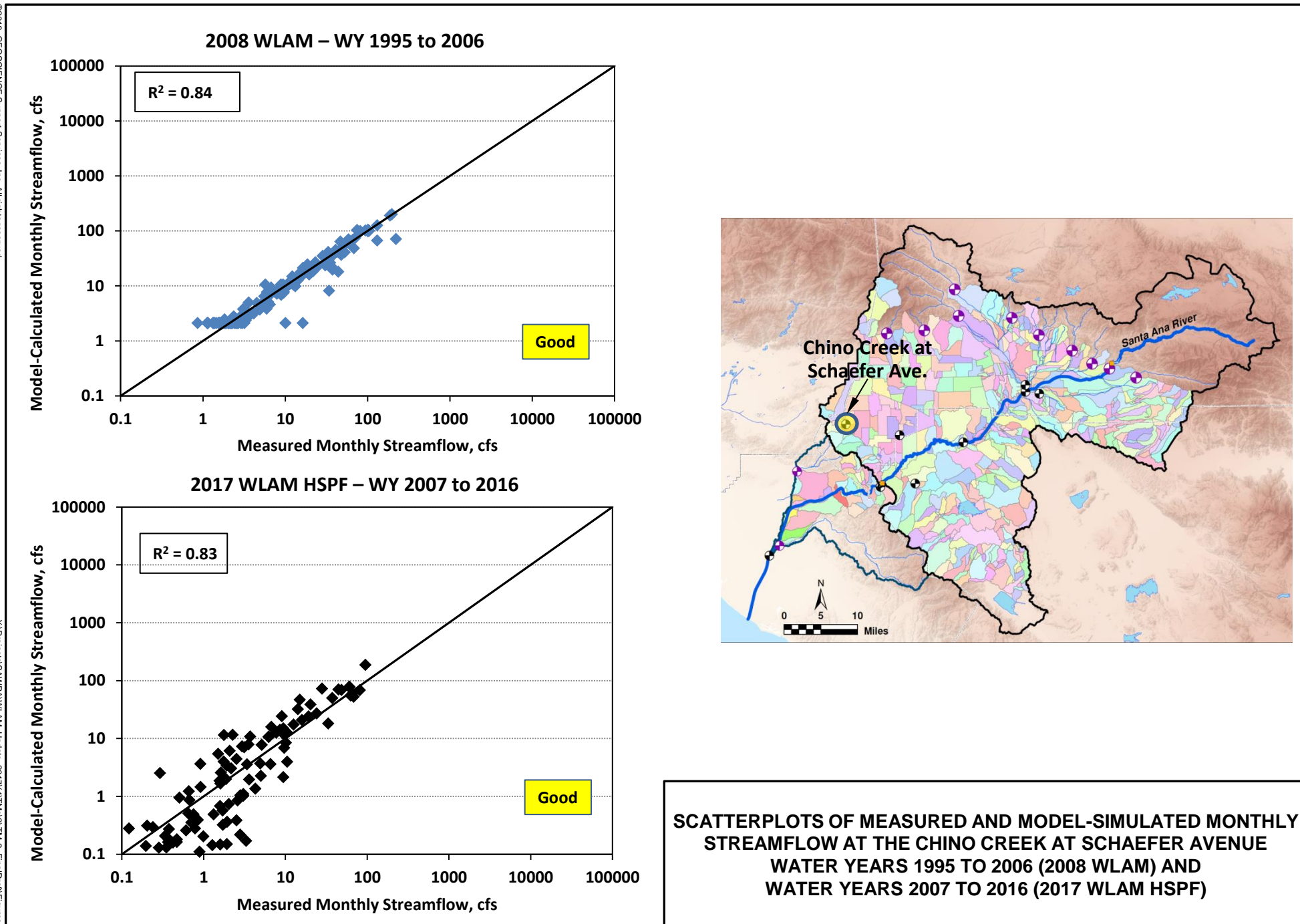


13-Apr-18

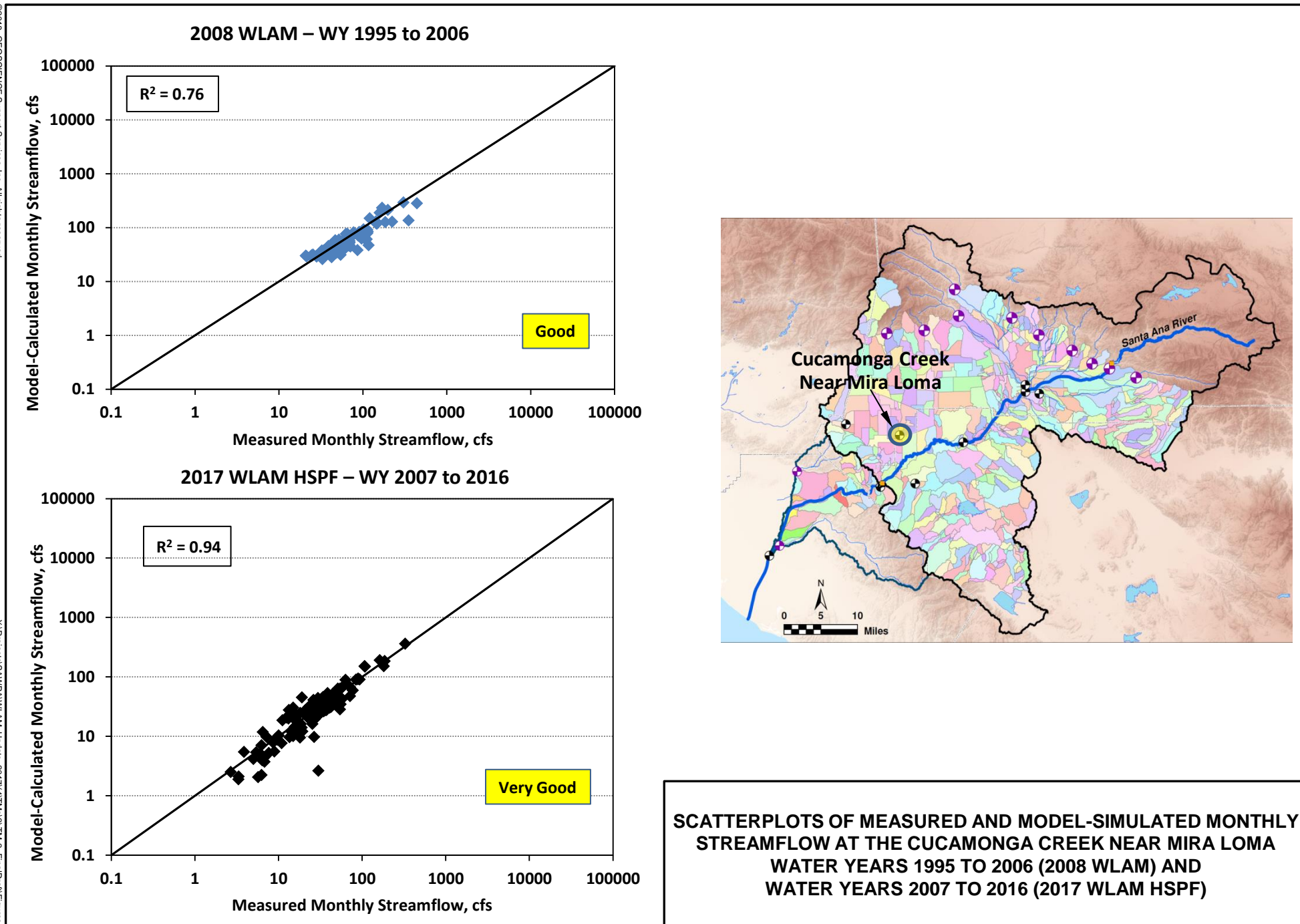


**SCATTERPLOTS OF MEASURED AND MODEL-SIMULATED MONTHLY STREAMFLOW AT THE TEMESCAL CREEK AT MAIN STREET WATER YEARS 1995 TO 2006 (2008 WLAM) AND WATER YEARS 2007 TO 2016 (2017 WLAM HSPF)**

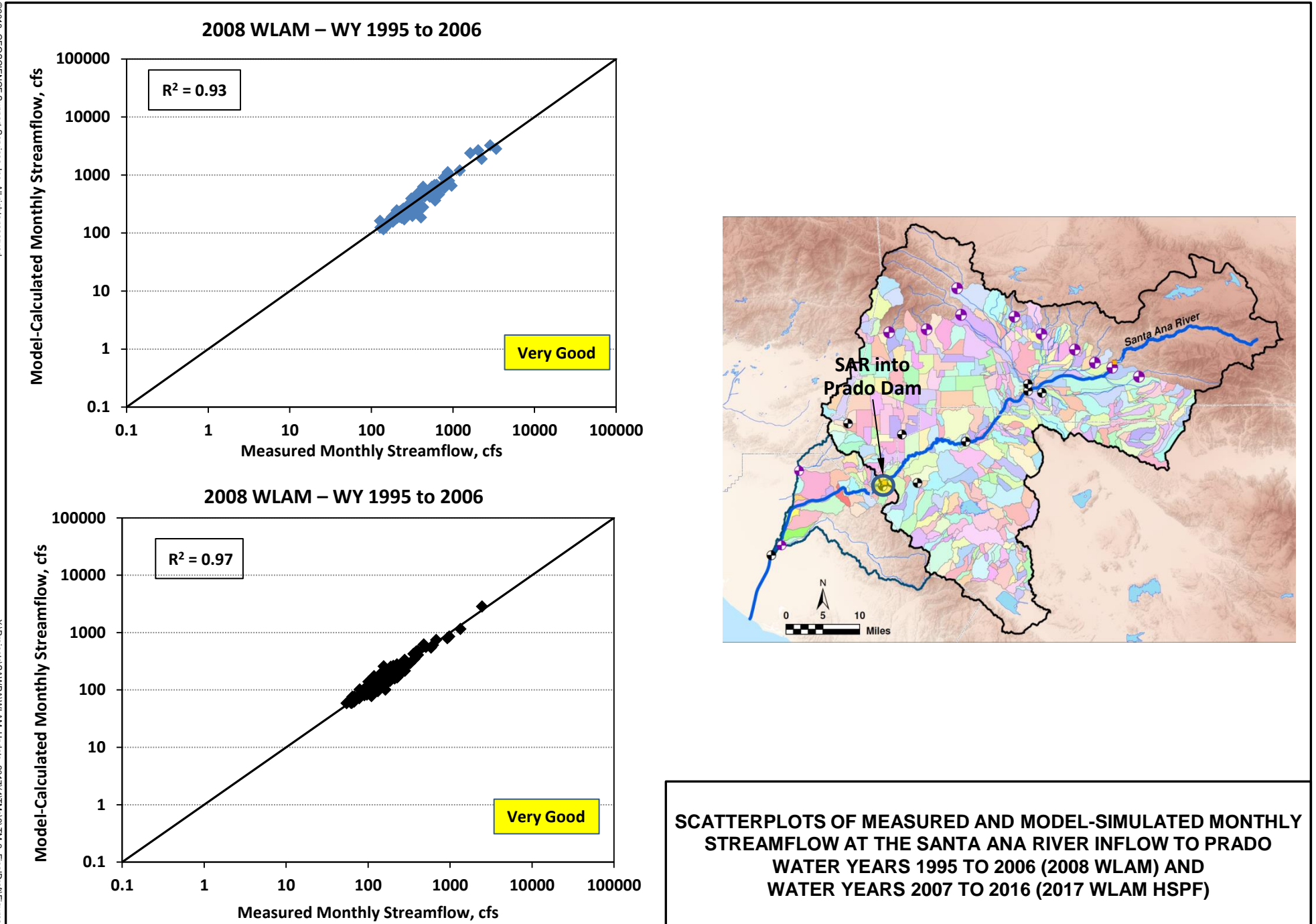
13-Apr-18



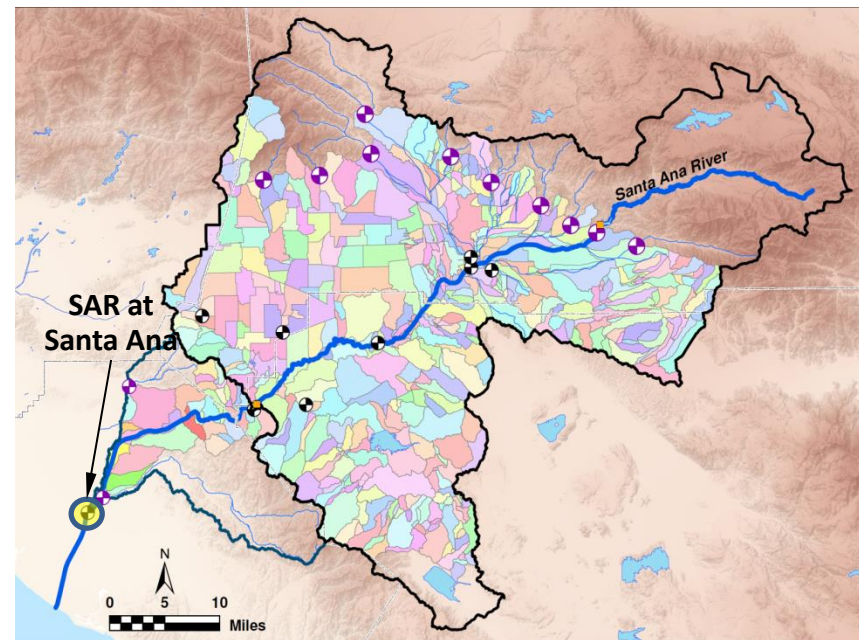
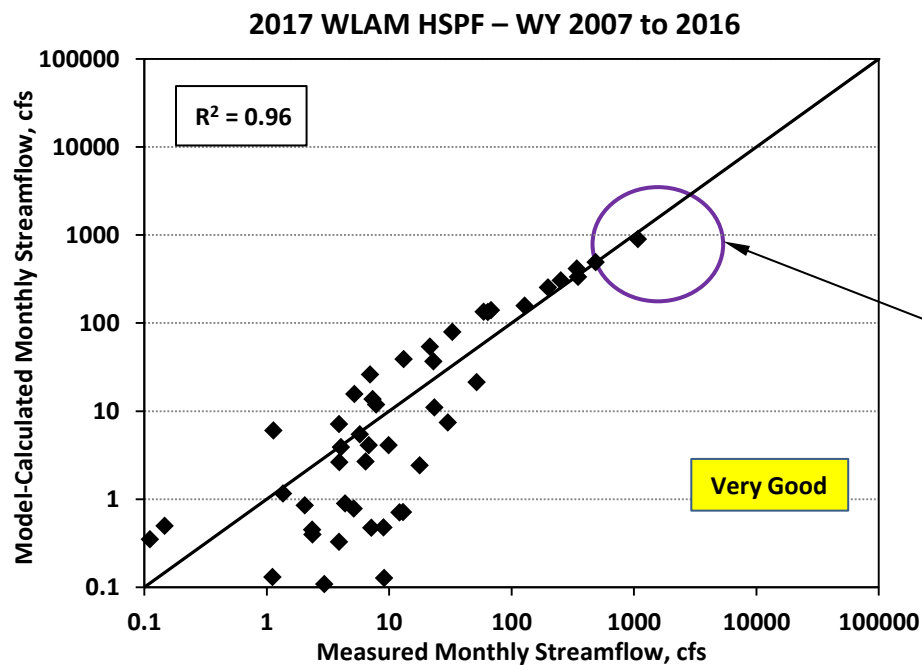
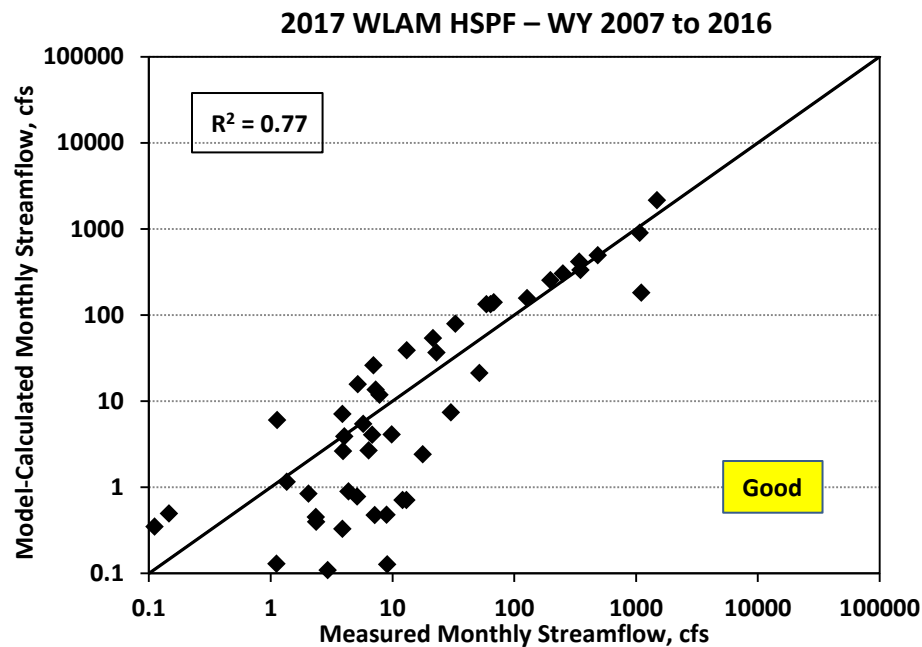
13-Apr-18



13-Apr-18



13-Apr-18



**SCATTERPLOTS OF MEASURED AND MODEL-SIMULATED MONTHLY STREAMFLOW AT THE SANTA ANA RIVER AT SANTA ANA WATER YEARS 2007 TO 2016 (2017 WLAM HSPF)**

13-Apr-18

**Measured and Model-Simulated Daily TDS Concentrations at the Santa Ana River at MWD Crossing  
Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (2017 WLAM HSPF)**

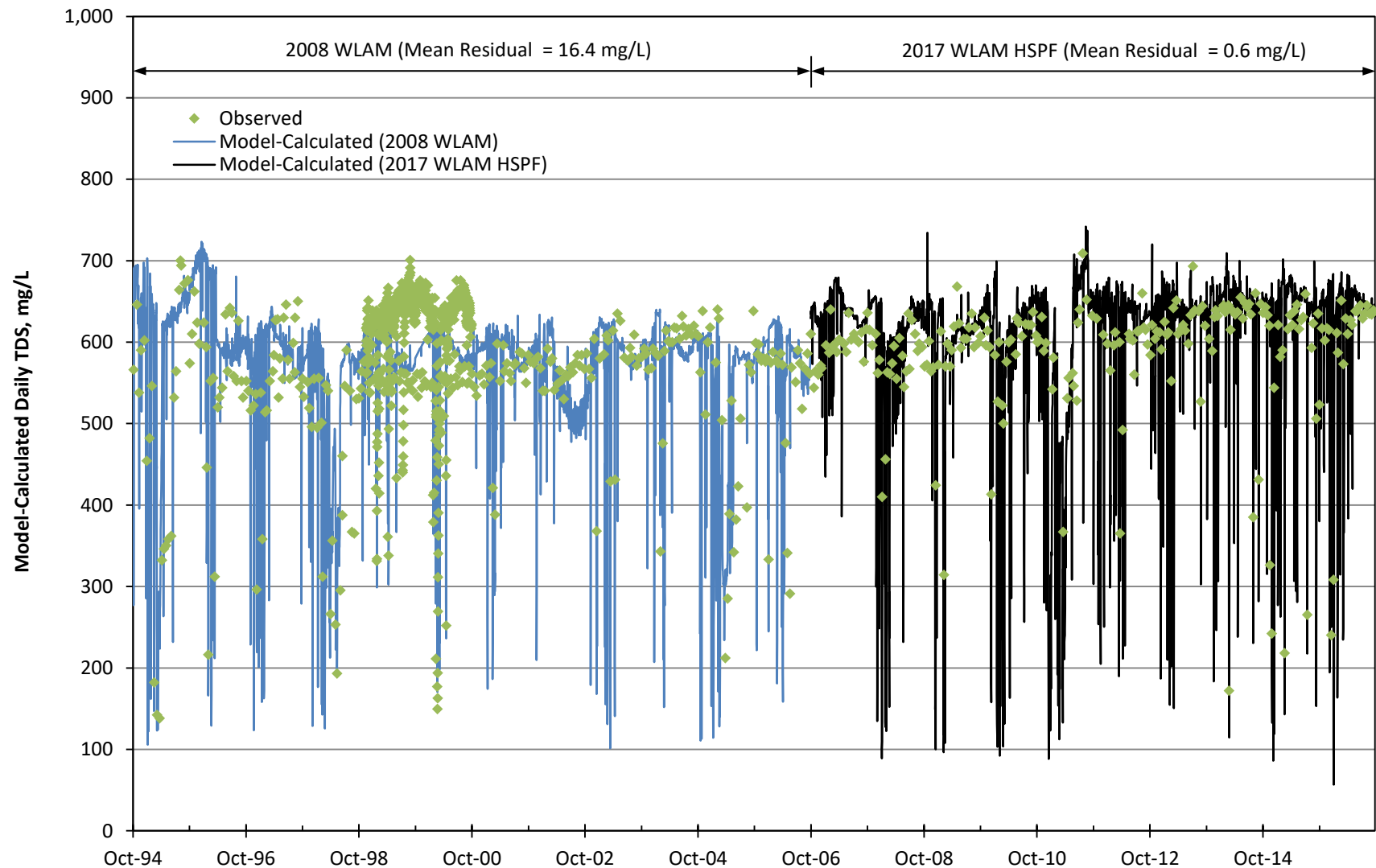


Figure 72

**Measured and Model-Simulated Daily TDS Concentrations at the Santa Ana River below Prado Dam  
Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (2017 WLAM HSPF)**

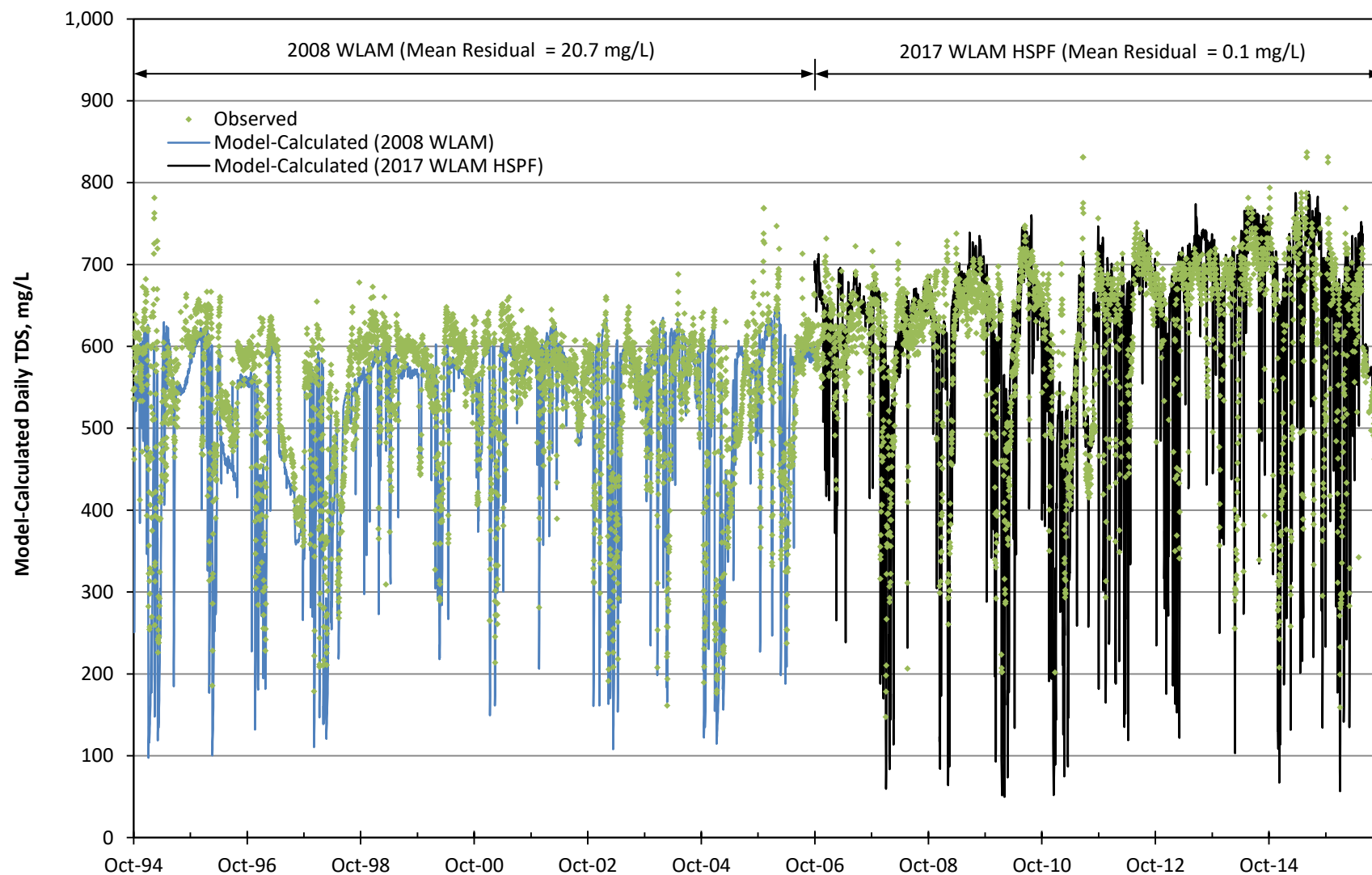


Figure 73

Measured and Model-Simulated Daily TDS Concentrations at the Santa Ana River at Imperial Highway near  
Anaheim – Water Years 2007 to 2016 (2017 WLAM HSPF)

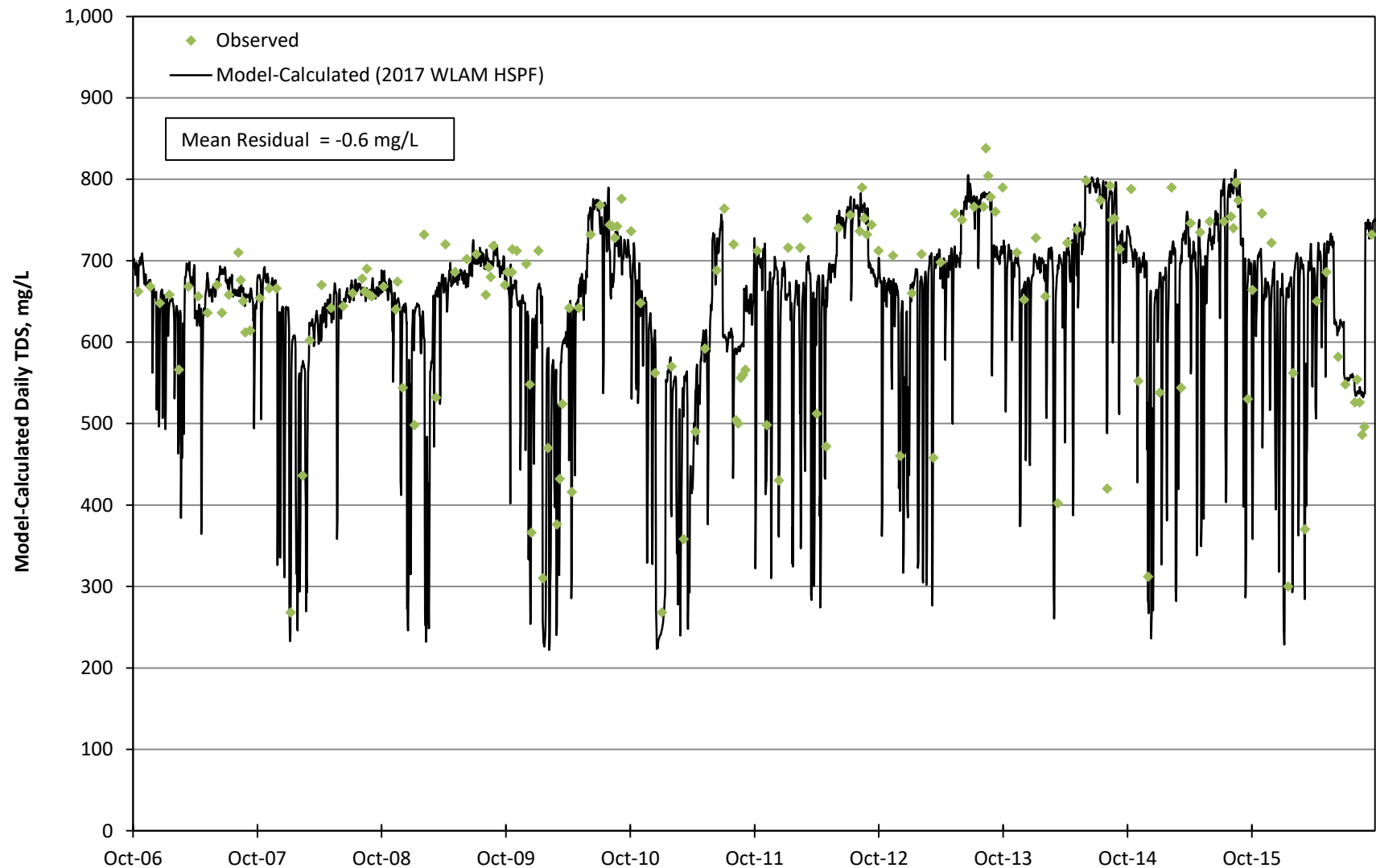


Figure 74

**Measured and Model-Simulated Daily TIN Concentrations at the Santa Ana River at MWD Crossing  
Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (2017 WLAM HSPF)**

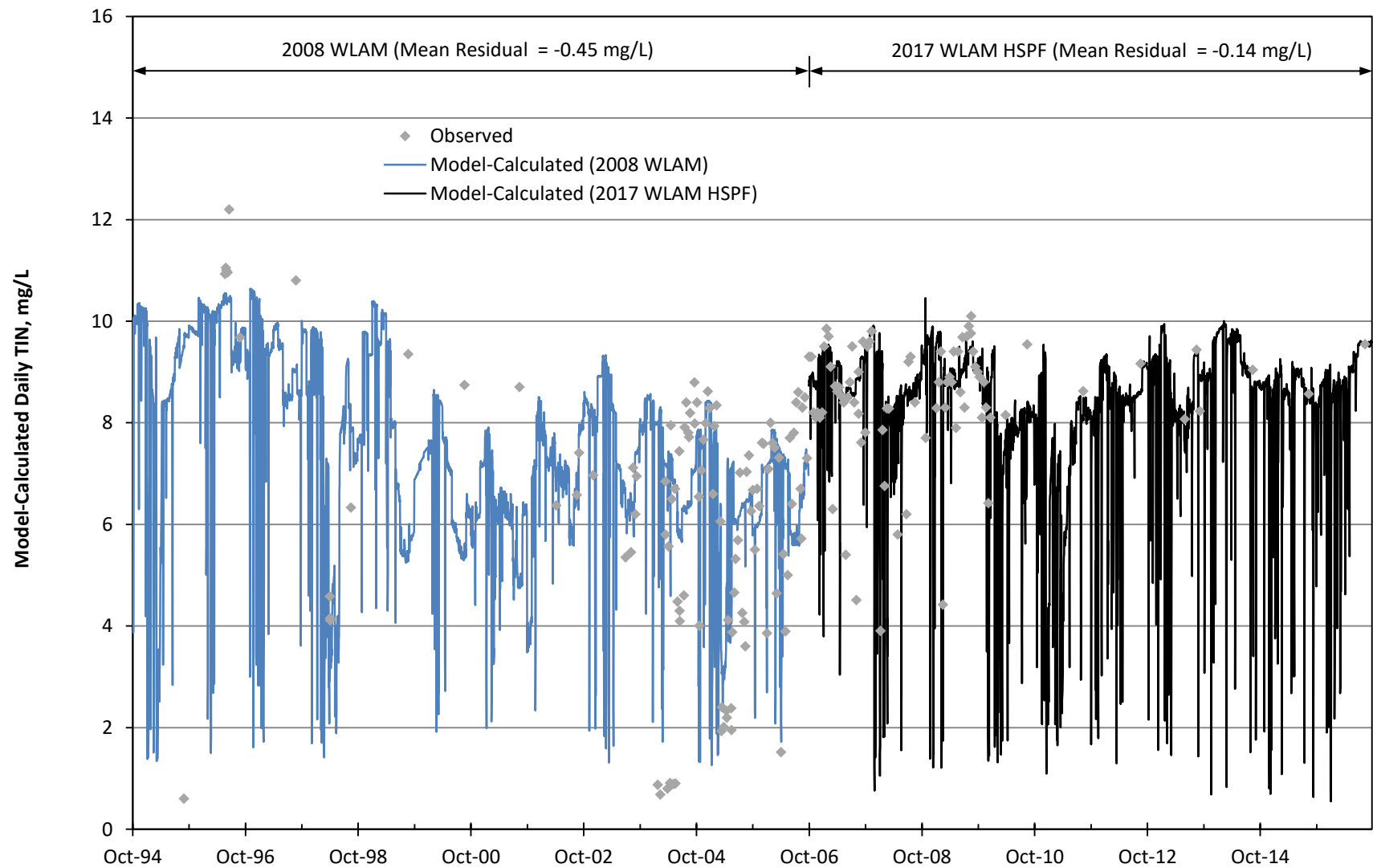


Figure 75

**Measured and Model-Simulated Daily TIN Concentrations at the Santa Ana River below Prado Dam  
Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (2017 WLAM HSPF)**

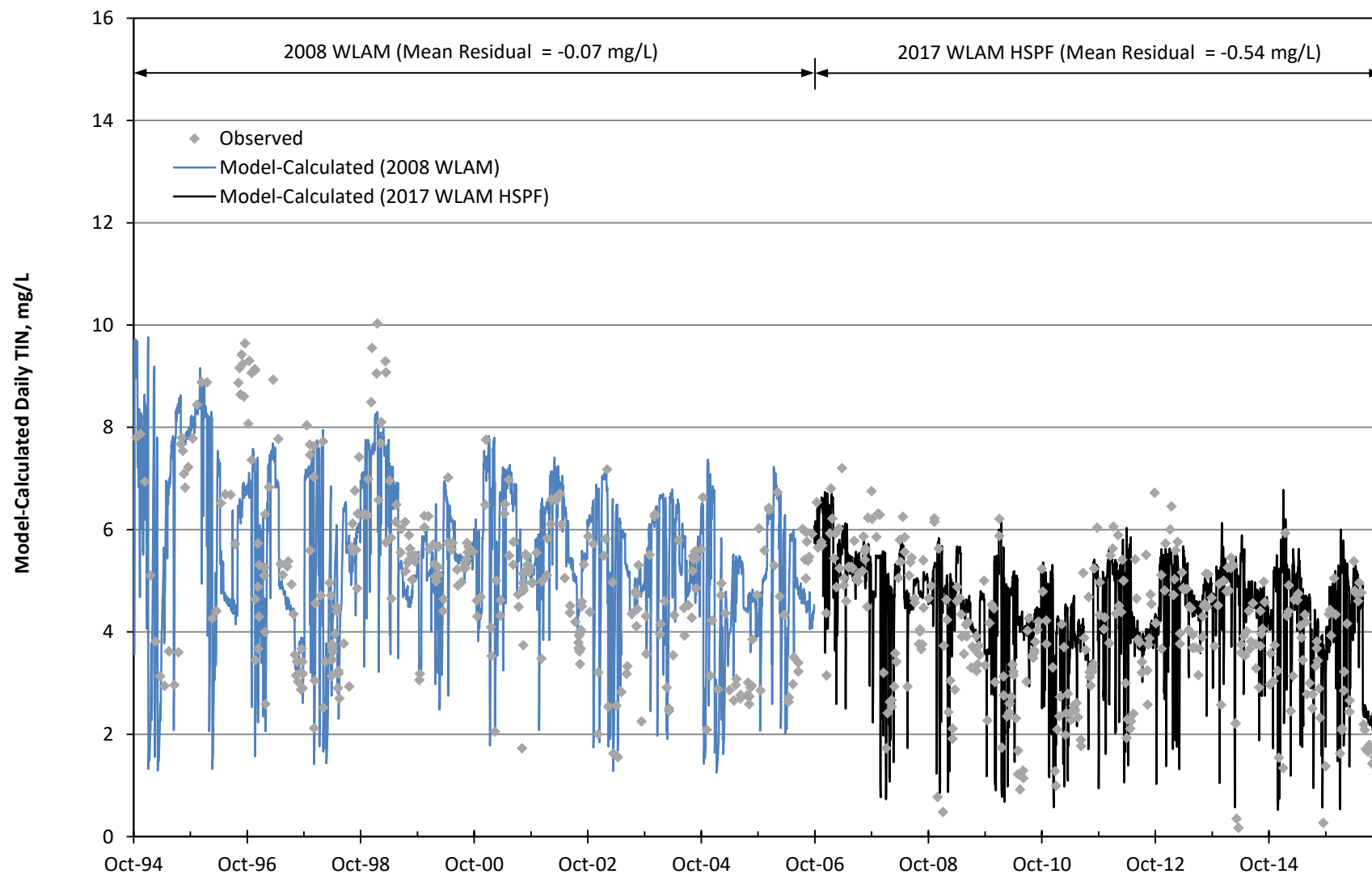


Figure 76

Measured and Model-Simulated Daily TIN Concentrations at the Santa Ana River at Imperial Highway near  
Anaheim – Water Years 2007 to 2016 (2017 WLAM HSPF)

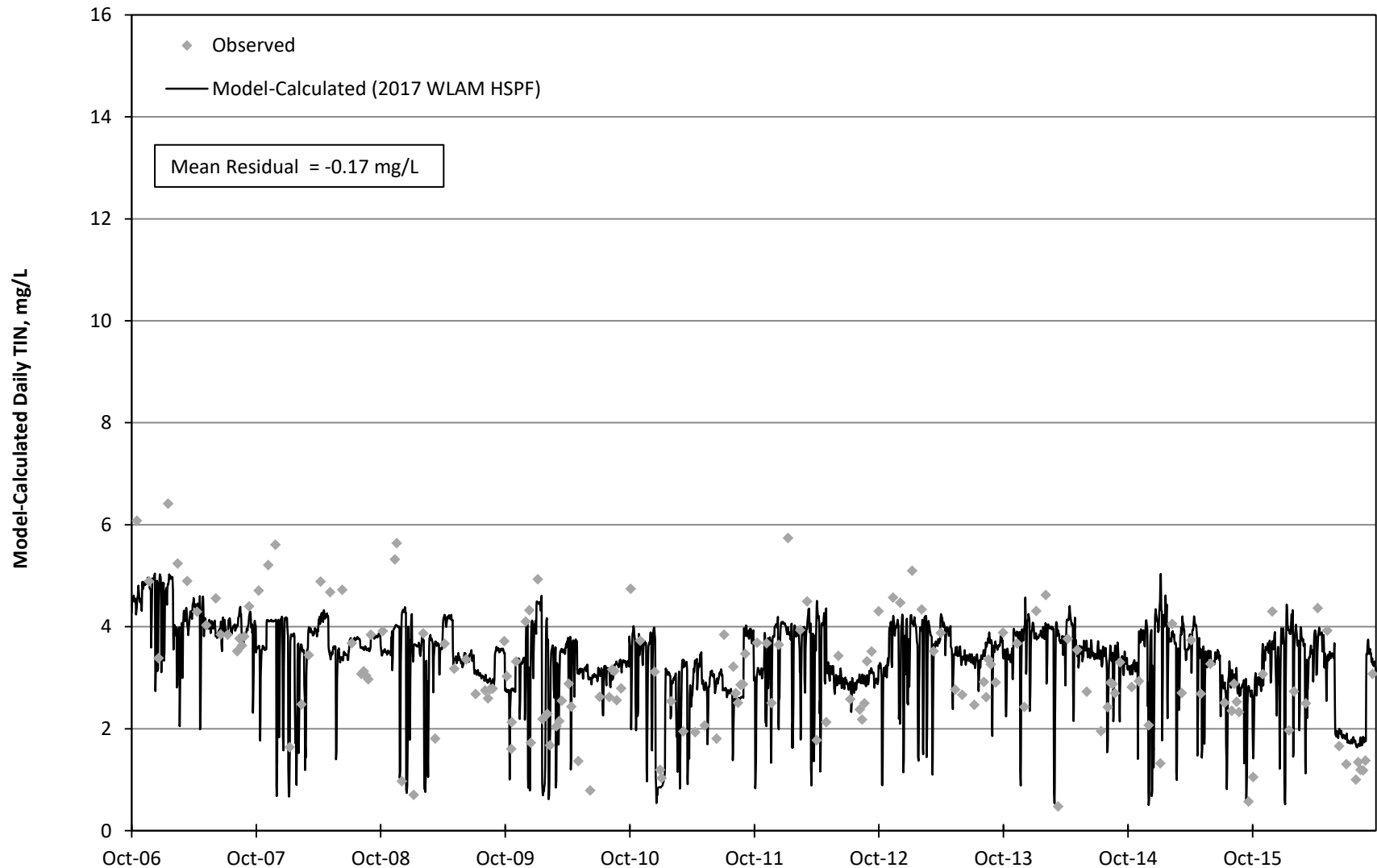


Figure 77

**Measured and Model-Simulated Monthly TDS Concentrations at the Santa Ana River at MWD Crossing  
Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (2017 WLAM HSPF)**

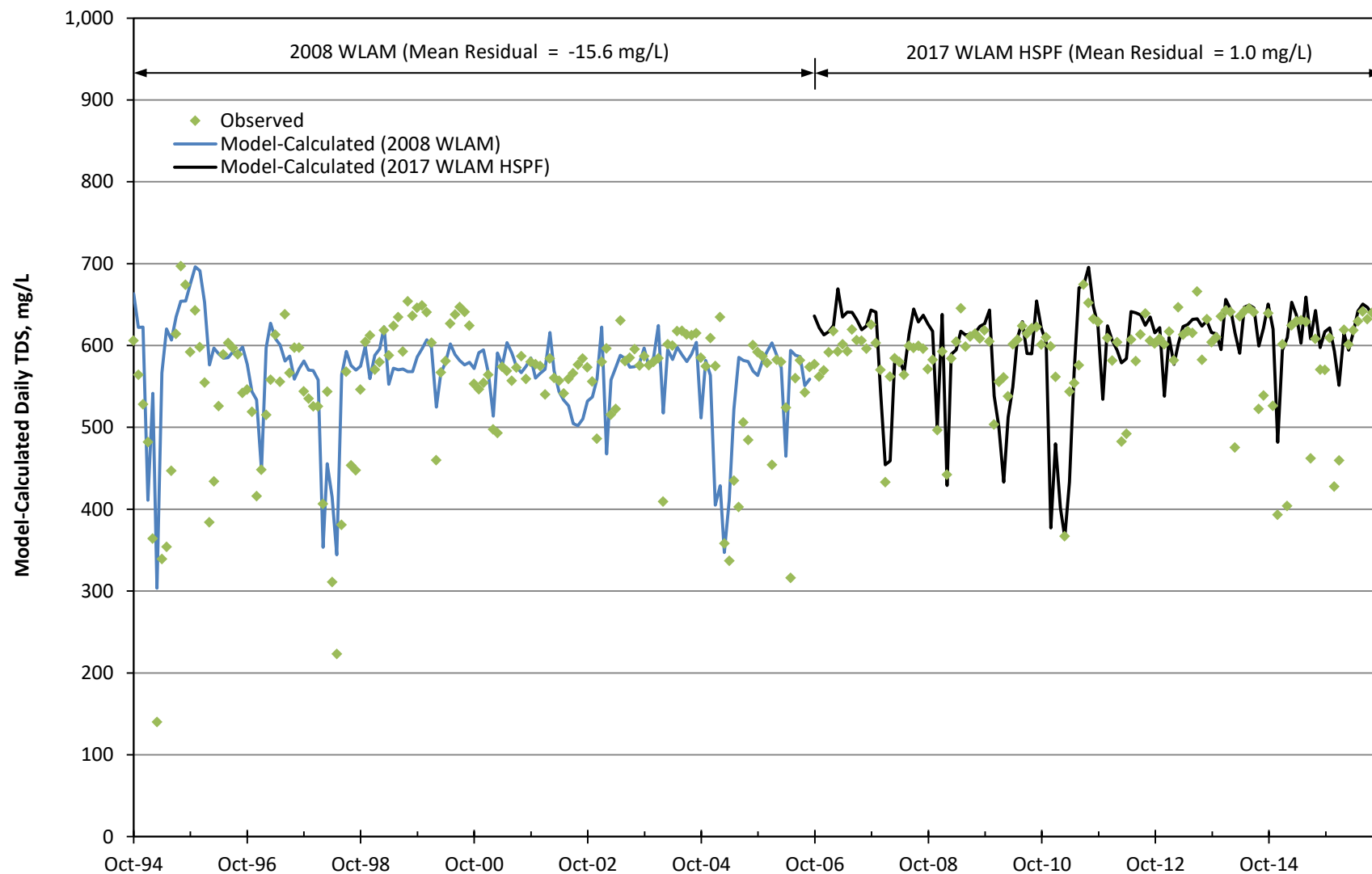


Figure 78

**Measured and Model-Simulated Monthly TDS Concentrations at the Santa Ana River below Prado Dam  
Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (2017 WLAM HSPF)**

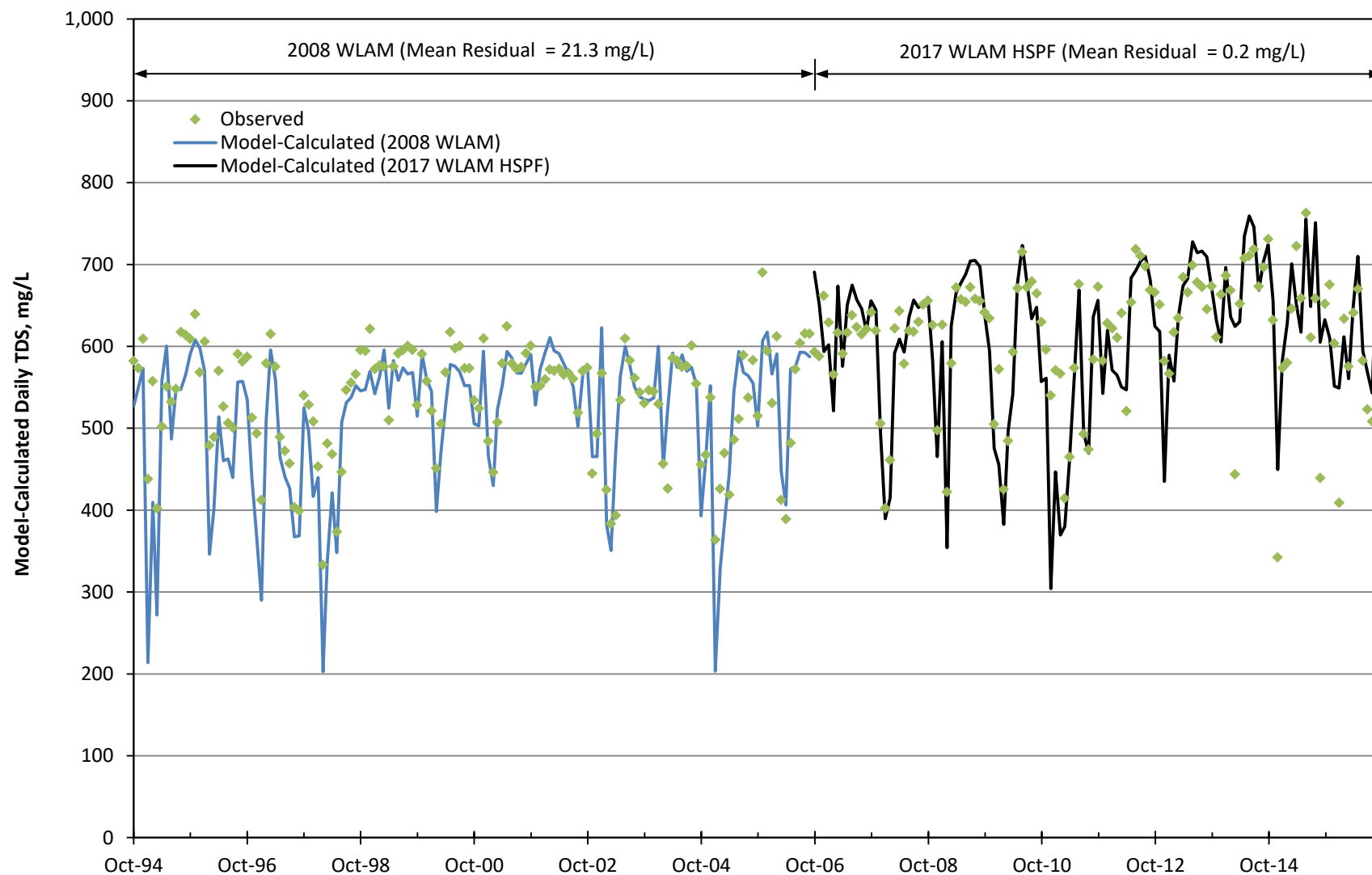


Figure 79

Measured and Model-Simulated Monthly TDS Concentrations at the Santa Ana River at Imperial Highway  
near Anaheim – Water Years 2007 to 2016 (2017 WLAM HSPF)

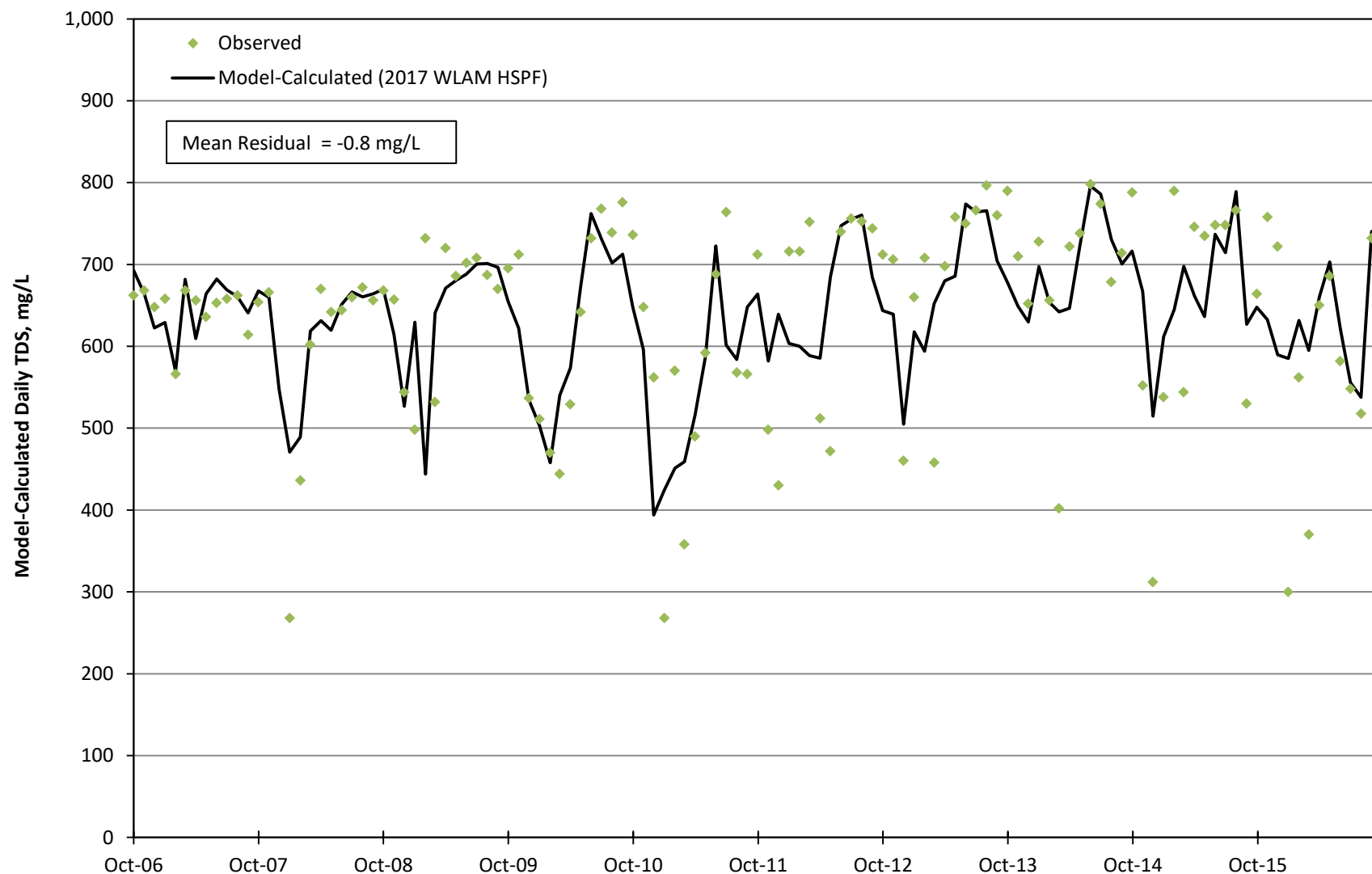


Figure 80

**Measured and Model-Simulated Monthly TIN Concentrations at the Santa Ana River at MWD Crossing  
Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (2017 WLAM HSPF)**

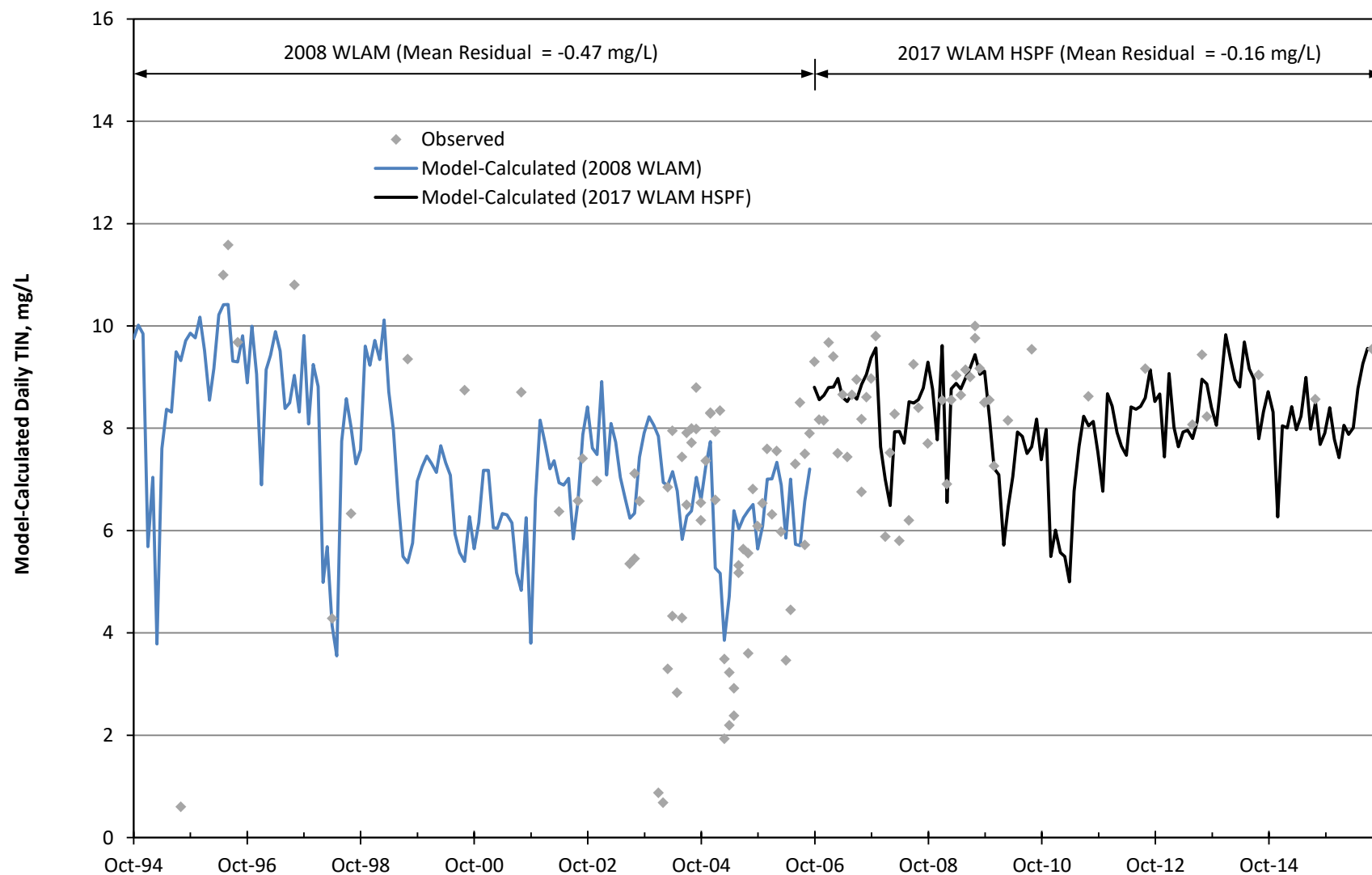


Figure 81

**Measured and Model-Simulated Monthly TIN Concentrations at the Santa Ana River below Prado Dam  
Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (2017 WLAM HSPF)**

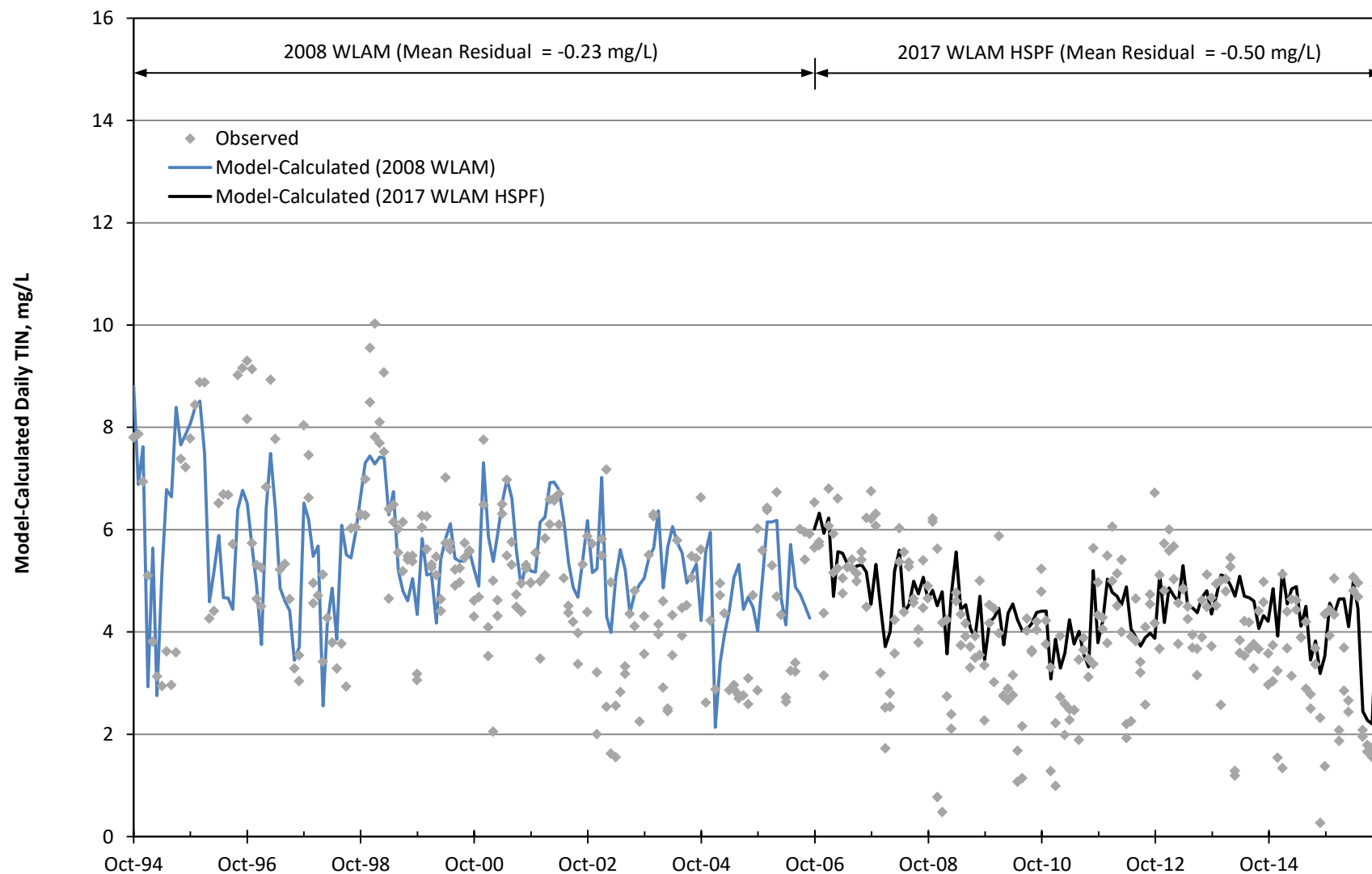


Figure 82

**Measured and Model-Simulated Monthly TIN Concentrations at the Santa Ana River at Imperial Highway  
near Anaheim – Water Years 2007 to 2016 (2017 WLAM HSPF)**

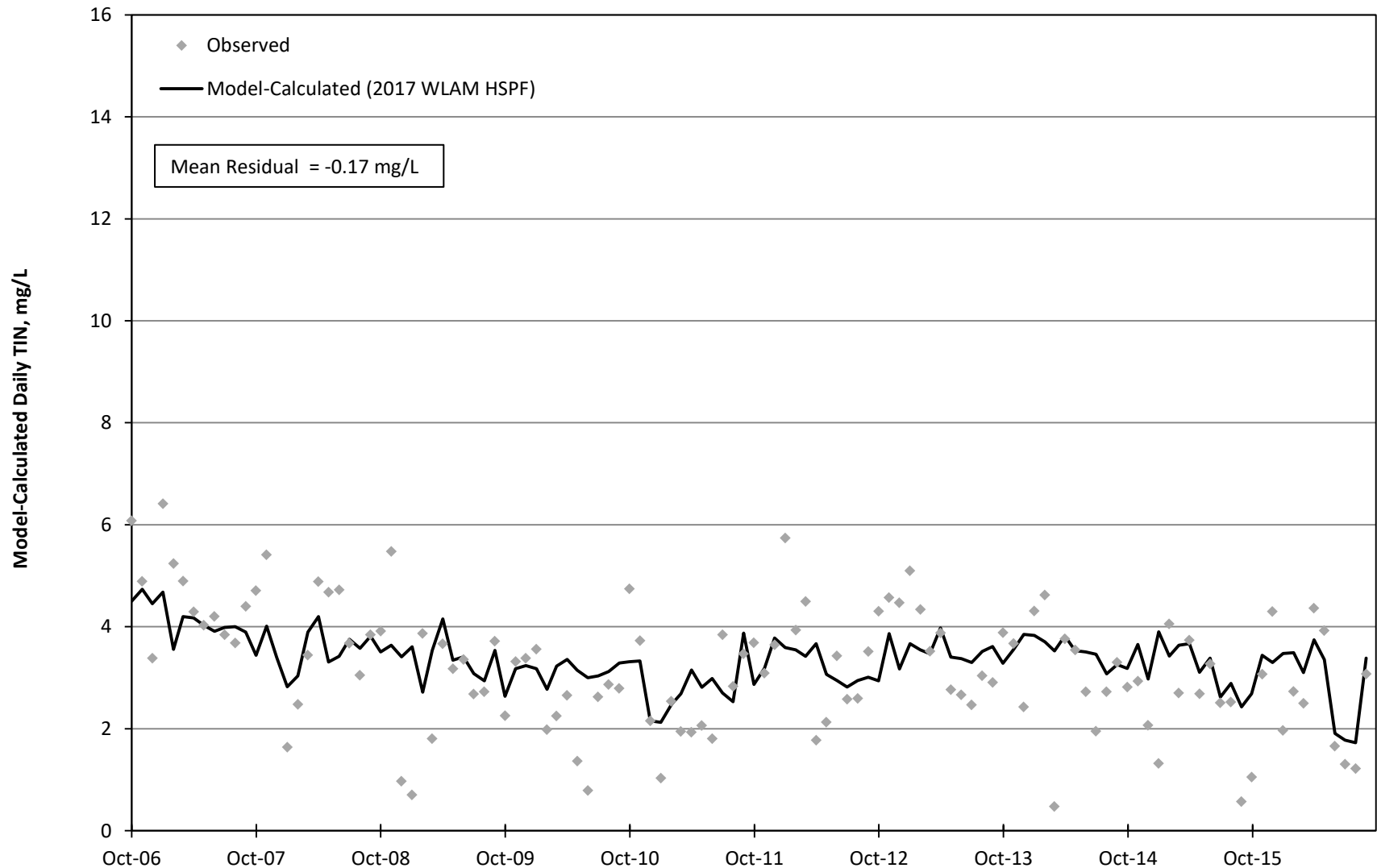


Figure 83

## TABLES

**Sub-Watershed Infiltration Rates**

Basin	Sub-Watershed	Initial Infiltration Index	Initial Infiltration Rates	Calibrated Infiltration Rates
			[in/hr]	[in/hr]
Yucaipa	Y-1	1.5	0.0245	0.0245
Yucaipa	Y-2	1.8	0.0385	0.0385
Yucaipa	Y-3	1.9	0.0436	0.0436
Yucaipa	Y-4	1.8	0.0412	0.0412
Yucaipa	Y-5	1.9	0.0431	0.0431
Yucaipa	Y-6	1.6	0.0303	0.0303
Yucaipa	Y-7	2.1	0.0545	0.0545
Yucaipa	Y-8	2.0	0.0476	0.0476
Yucaipa	Y-9	3.1	0.1372	0.1372
Yucaipa	Y-10	2.4	0.0716	0.0716
Yucaipa	Y-11	1.2	0.0104	0.0104
Yucaipa	Y-12	2.7	0.0841	0.0841
Yucaipa	Y-13	3.2	0.1515	0.1515
Yucaipa	Y-14	3.4	0.2083	0.2083
Yucaipa	Y-15	3.9	0.3739	0.3739
Yucaipa	Y-16	3.3	0.1904	0.1904
Yucaipa	Y-17	3.2	0.1610	0.1610
Yucaipa	Y-18	2.5	0.0751	0.0751
Yucaipa	Y-19	3.0	0.1093	0.1093
Yucaipa	Y-20	3.0	0.1000	0.1000
Yucaipa	Y-21	3.0	0.1103	0.1103
Yucaipa	Y-22	3.1	0.1334	0.1334
Yucaipa	Y-23	3.1	0.1187	0.1187
Yucaipa	Y-24	3.1	0.1403	0.1403
Yucaipa	Y-25	2.8	0.0919	0.0919
Yucaipa	Y-26	2.7	0.0844	0.0844
Yucaipa	Y-27	3.0	0.1000	0.1000
Yucaipa	Y-28	3.0	0.1000	0.1000
Yucaipa	Y-29	3.0	0.1065	0.1065
Yucaipa	Y-30	2.8	0.0876	0.0876
Yucaipa	Y-31	2.9	0.0970	0.0970
Yucaipa	Y-32	2.2	0.0583	0.0583
Yucaipa	Y-33	2.5	0.0773	0.0773
Yucaipa	Y-34	2.8	0.0898	0.0898
Yucaipa	Y-35	3.1	0.1361	0.1361
Yucaipa	Y-36	3.1	0.1280	0.1280
Yucaipa	Y-37	3.0	0.1013	0.1013
Yucaipa	Y-38	3.0	0.1047	0.1047
Yucaipa	Y-39	2.7	0.0832	0.0832
Yucaipa	Y-40	2.5	0.0737	0.0737
Yucaipa	Y-41	2.8	0.0906	0.0906
Yucaipa	Y-42	2.7	0.0857	0.0857
Yucaipa	Y-47	2.2	0.0602	0.0602
Yucaipa	Y-48	1.5	0.0275	0.0275
Yucaipa	Y-49	2.2	0.0614	0.0614
Yucaipa	Y-50	3.0	0.1077	0.1077
Yucaipa	Y-51	2.6	0.0806	0.0806

Basin	Sub-Watershed	Initial Infiltration Index	Initial Infiltration Rates	Calibrated Infiltration Rates
			[in/hr]	[in/hr]
Yucaipa	Y-52	2.1	0.0570	0.0570
Yucaipa	Y-53	2.3	0.0625	0.0625
Yucaipa	Y-54	2.8	0.0898	0.0898
Yucaipa	Y-55	3.0	0.0981	0.0981
Yucaipa	Y-56	2.4	0.0716	0.0716
Yucaipa	Y-57	2.1	0.0543	0.0543
Yucaipa	Y-58	2.7	0.0844	0.0844
Yucaipa	Y-59	2.3	0.0648	0.0648
Yucaipa	Y-60	3.0	0.1000	0.1000
Yucaipa	Y-61	2.2	0.0592	0.0592
Yucaipa	Y-62	2.5	0.0763	0.0763
Yucaipa	Y-63	1.5	0.0276	0.0276
Yucaipa	Y-64	2.2	0.0622	0.0622
Yucaipa	Y-65	1.7	0.0343	0.0343
Yucaipa	Y-66	2.7	0.0825	0.0825
Yucaipa	Y-67	3.2	0.1462	0.1462
Yucaipa	Y-68	2.1	0.0544	0.0544
Yucaipa	Y-69	3.2	0.1549	0.1549
Yucaipa	Y-70	2.8	0.0907	0.0907
Yucaipa	Y-71	3.1	0.1361	0.1361
Yucaipa	Y-72	1.4	0.0221	0.0221
Yucaipa	Y-73	2.9	0.0939	0.0939
Yucaipa	Y-74	2.9	0.0974	0.0974
Yucaipa	Y-75	3.1	0.1364	0.1364
Yucaipa	Y-76	2.7	0.0869	0.0869
Yucaipa	Y-77	3.3	0.1805	0.1805
Yucaipa	Y-78	3.1	0.1387	0.1387
Yucaipa	Y-79	2.9	0.0968	0.0968
Yucaipa	Y-80	2.9	0.0925	0.0925
Yucaipa	Y-81	3.1	0.1222	0.1222
Yucaipa	Y-82	3.0	0.1149	0.1149
Yucaipa	Y-83	2.4	0.0718	0.0718
Yucaipa	Y-84	2.4	0.0716	0.0716
Yucaipa	Y-85	2.0	0.0483	0.0483
SBBA East	SE-1	1.1	0.0058	0.0635
SBBA East	SE-2	2.1	0.0575	0.1090
SBBA East	SE-3	2.3	0.0648	0.0655
SBBA East	SE-4	3.1	0.1242	0.1240
SBBA East	SE-5	3.4	0.2051	0.0930
SBBA East	SE-6	3.8	0.3368	0.3370
SBBA East	SE-7	2.5	0.0773	0.0660
SBBA East	SE-8	3.8	0.3435	0.3340
SBBA East	SE-9	1.5	0.0239	0.0590
SBBA East	SE-10	3.9	0.3667	0.3010
SBBA East	SE-11	2.3	0.0636	0.0815
SBBA East	SE-12	2.7	0.0827	0.1750
SBBA East	SE-13	2.3	0.0666	0.1420
SBBA East	SE-14	2.4	0.0685	0.0910
SBBA East	SE-15	1.1	0.0052	0.0560

Basin	Sub-Watershed	Initial Infiltration Index	Initial Infiltration Rates	Calibrated Infiltration Rates
			[in/hr]	[in/hr]
SBBA East	SE-16	3.0	0.0999	0.2650
SBBA East	SE-17	4.0	0.4000	0.4000
SBBA East	SE-18	1.0	0.0025	0.0480
SBBA East	SE-19	4.0	0.3995	0.2800
SBBA East	SE-20	3.1	0.1363	0.1060
SBBA East	SE-21	4.0	0.4000	0.1450
SBBA East	SE-22	1.1	0.0055	0.0510
SBBA East	SE-23	2.8	0.0886	0.1420
SBBA East	SE-24	1.1	0.0066	0.0520
SBBA East	SE-25	3.3	0.1859	0.0860
SBBA East	SE-26	3.2	0.1591	0.0945
SBBA East	SE-27	4.0	0.4000	0.1120
SBBA East	SE-28	3.6	0.2838	0.1810
SBBA East	SE-29	3.4	0.2246	0.0800
SBBA East	SE-30	3.9	0.3775	0.0975
SBBA East	SE-31	4.0	0.3962	0.1390
SBBA East	SE-32	3.9	0.3643	0.1120
SBBA East	SE-33	3.9	0.3565	0.2170
SBBA East	SE-34	1.0	FALSE	0.0505
SBBA East	SE-35	1.0	FALSE	0.0397
SBBA East	SE-36	1.1	0.0068	0.0495
SBBA East	SE-37	2.2	0.0592	0.1030
SBBA East	SE-38	2.3	0.0655	0.1060
SBBA East	SE-39	3.6	0.2844	0.2200
SBBA East	SE-40	3.4	0.2338	0.1960
SBBA East	SE-41	4.0	0.4000	0.3880
SBBA East	SE-42	1.0	0.0013	0.0500
SBBA East	SE-43	1.0	FALSE	0.0525
SBBA East	SE-44	2.2	0.0597	0.0715
SBBA East	SE-45	2.2	0.0597	0.0720
SBBA East	SE-46	1.0	0.0025	0.0495
SBBA East	SE-47	3.1	0.1363	0.1780
SBBA East	SE-48	3.2	0.1749	0.2080
SBBA East	SE-49	4.0	0.4000	0.3820
SBBA East	SE-50	4.0	0.4000	0.3640
SBBA East	SE-51	4.0	0.4000	0.3700
SBBA East	SE-52	4.0	0.3974	0.3520
SBBA East	SE-53	3.7	0.3067	0.2440
SBBA East	SE-54	4.0	0.4000	0.2890
SBBA East	SE-55	1.6	0.0324	0.0461
SBBA East	SE-56	2.4	0.0675	0.0825
SBBA East	SE-57	4.0	0.4000	0.3580
SBBA East	SE-58	4.0	0.3958	0.3070
SBBA East	SE-59	2.4	0.0702	0.0890
SBBA East	SE-60	2.6	0.0822	0.1450
SBBA East	SE-61	3.9	0.3849	0.2020
SBBA East	SE-62	4.0	0.3858	0.2290
SBBA East	SE-63	3.5	0.2428	0.5000
SBBA East	SE-64	3.6	0.2733	0.5000

Basin	Sub-Watershed	Initial Infiltration Index	Initial Infiltration Rates	Calibrated Infiltration Rates
			[in/hr]	[in/hr]
SBBA East	SE-65	3.0	0.0986	0.5000
SBBA East	SE-66	2.4	0.0711	0.5000
SBBA East	SE-67	3.8	0.3472	0.5000
SBBA East	SE-68	3.7	0.2999	0.5000
SBBA East	SE-69	2.1	0.0528	0.5000
SBBA East	SE-70	2.5	0.0760	0.5000
SBBA East	SE-71	4.0	0.4000	0.5000
SBBA East	SE-72	3.7	0.2975	0.5000
SBBA East	SE-73	3.0	0.1016	0.5000
SBBA East	SE-74	3.9	0.3643	0.5000
SBBA East	SE-75	4.0	0.4000	0.5000
SBBA East	SE-76	4.0	0.4000	0.5000
SBBA East	SE-77	3.4	0.2052	0.5000
SBBA East	SE-78	4.0	0.3992	0.5000
SBBA East	SE-79	3.8	0.3428	0.5000
SBBA West	SW-1	2.1	0.0531	0.0990
SBBA West	SW-2	2.9	0.0939	0.2560
SBBA West	SW-3	4.0	0.3907	0.3910
SBBA West	SW-4	1.1	0.0059	0.0590
SBBA West	SW-5	2.9	0.0936	0.0990
SBBA West	SW-6	2.3	0.0648	0.0875
SBBA West	SW-7	2.1	0.0575	0.0900
SBBA West	SW-8	1.6	0.0284	0.0685
SBBA West	SW-9	3.2	0.1461	0.2440
SBBA West	SW-10	2.5	0.0761	0.0780
SBBA West	SW-11	3.9	0.3641	0.3370
SBBA West	SW-12	2.1	0.0570	0.0935
SBBA West	SW-13	3.4	0.2104	0.2500
SBBA West	SW-14	1.2	0.0113	0.0850
SBBA West	SW-15	2.6	0.0801	0.1660
SBBA West	SW-16	2.8	0.0922	0.1810
SBBA West	SW-17	3.9	0.3587	0.3580
SBBA West	SW-18	2.0	0.0489	0.0840
SBBA West	SW-19	3.6	0.2651	0.2050
SBBA West	SW-20	2.6	0.0822	0.0940
SBBA West	SW-21	4.0	0.4000	0.1810
SBBA West	SW-22	4.0	0.3983	0.1750
SBBA West	SW-23	3.7	0.3190	0.2950
SBBA West	SW-24	4.0	0.3879	0.3850
SBBA West	SW-25	3.8	0.3485	0.2860
SBBA West	SW-26	4.0	0.3994	0.2860
SBBA West	SW-27	4.0	0.4000	0.1750
SBBA West	SW-28	4.0	0.4000	0.1990
SBBA West	SW-29	4.0	0.4000	0.2260
SBBA West	SW-30	3.9	0.3791	0.1270
SBBA West	SW-31	4.0	0.4000	0.1210
SBBA West	SW-32	4.0	0.4000	0.1270
SBBA West	SW-33	4.0	0.4000	0.1480
SBBA West	SW-34	4.0	0.4000	0.2380

Basin	Sub-Watershed	Initial Infiltration Index	Initial Infiltration Rates	Calibrated Infiltration Rates
			[in/hr]	[in/hr]
SBBA West	SW-35	3.9	0.3656	0.1450
Rialto-Colton	RC-1	3.9	0.3786	0.3824
Rialto-Colton	RC-2	4.0	0.4000	0.3217
Rialto-Colton	RC-3	4.0	0.4000	0.3669
Rialto-Colton	RC-4	4.0	0.4000	0.4000
Rialto-Colton	RC-5	4.0	0.4000	0.4000
Rialto-Colton	RC-6	4.0	0.4000	0.3999
Rialto-Colton	RC-7	4.0	0.4000	0.4000
Rialto-Colton	RC-8	4.0	0.4000	0.3975
Rialto-Colton	RC-9	4.0	0.4000	0.3918
Rialto-Colton	RC-10	4.0	0.4000	0.3681
Rialto-Colton	RC-11	4.0	0.4000	0.3759
Rialto-Colton	RC-12	4.0	0.4000	0.3904
Rialto-Colton	RC-13	4.0	0.4000	0.4000
Rialto-Colton	RC-14	4.0	0.4000	0.4000
Rialto-Colton	RC-15	4.0	0.4000	0.4000
Rialto-Colton	RC-16	4.0	0.4000	0.3481
Rialto-Colton	RC-17	4.0	0.3982	0.3873
Rialto-Colton	RC-18	4.0	0.4000	0.2501
Rialto-Colton	RC-19	4.0	0.4000	0.1191
Rialto-Colton	RC-20	4.0	0.4000	0.1711
Rialto-Colton	RC-21	4.0	0.3859	0.3716
Rialto-Colton	RC-22	4.0	0.3963	0.3789
Rialto-Colton	RC-23	4.0	0.4000	0.3083
Rialto-Colton	RC-24	3.9	0.3678	0.3573
Rialto-Colton	RC-25	4.0	0.4000	0.2016
Rialto-Colton	RC-26	4.0	0.4000	0.3815
Rialto-Colton	RC-27	4.0	0.4000	0.3207
Rialto-Colton	RC-28	4.0	0.4000	0.3374
Rialto-Colton	RC-29	4.0	0.4000	0.2898
Rialto-Colton	RC-30	4.0	0.4000	0.3164
Rialto-Colton	RC-31	1.9	0.0466	0.0490
Rialto-Colton	RC-32	2.2	0.0619	0.0740
Rialto-Colton	RC-33	2.9	0.0933	0.0805
Rialto-Colton	RC-34	4.0	0.4000	0.1026
Rialto-Colton	RC-35	3.1	0.1338	0.0820
Rialto-Colton	RC-36	3.0	0.0983	0.0881
Rialto-Colton	RC-37	3.1	0.1274	0.0911
Rialto-Colton	RC-38	3.2	0.1482	0.0888
Rialto-Colton	RC-39	2.8	0.0886	0.0390
Rialto-Colton	RC-40	3.6	0.2706	0.1492
Rialto-Colton	RC-41	3.7	0.3084	0.1018
Rialto-Colton	RC-42	4.0	0.4000	0.2453
Rialto-Colton	RC-43	4.0	0.4000	0.2621
Rialto-Colton	RC-44	3.7	0.3035	0.1070
Rialto-Colton	RC-45	3.3	0.1920	0.0601
Rialto-Colton	RC-46	3.5	0.2404	0.0796
Rialto-Colton	RC-47	3.8	0.3478	0.0945
Rialto-Colton	RC-48	4.0	0.3944	0.3187

Basin	Sub-Watershed	Initial Infiltration Index	Initial Infiltration Rates	Calibrated Infiltration Rates
			[in/hr]	[in/hr]
Rialto-Colton	RC-49	3.6	0.2757	0.0719
Rialto-Colton	RC-50	3.9	0.3775	0.2665
Rialto-Colton	RC-51	3.3	0.1822	0.1014
Riverside	R-1	4.0	0.3943	0.0976
Riverside	R-2	2.6	0.0800	0.0696
Riverside	R-3	2.8	0.0912	0.0801
Riverside	R-4	1.2	0.0112	0.0082
Riverside	R-5	1.6	0.0313	0.0280
Riverside	R-6	2.6	0.0815	0.0664
Riverside	R-7	3.0	0.0979	0.0945
Riverside	R-8	1.0	0.0033	0.0029
Riverside	R-9	2.4	0.0690	0.0519
Riverside	R-10	3.6	0.2930	0.1000
Riverside	R-11	3.4	0.2089	0.1000
Riverside	R-12	3.7	0.3036	0.1000
Riverside	R-13	2.6	0.0790	0.0707
Riverside	R-14	3.4	0.2293	0.0991
Riverside	R-15	3.1	0.1258	0.0934
Riverside	R-16	3.5	0.2510	0.2912
Riverside	R-17	4.0	0.3996	0.0767
Riverside	R-18	3.6	0.2673	0.0747
Riverside	R-19	1.6	0.0311	0.0376
Riverside	R-20	2.6	0.0786	0.0769
Riverside	R-21	1.9	0.0471	0.0488
Riverside	R-22	1.7	0.0366	0.0432
Riverside	R-23	2.0	0.0491	0.0469
Riverside	R-24	2.4	0.0709	0.0496
Riverside	R-25	2.8	0.0918	0.0682
Riverside	R-26	2.2	0.0588	0.0743
Riverside	R-27	3.2	0.1543	0.0982
Riverside	R-28	3.8	0.3254	0.1107
Riverside	R-29	4.0	0.3970	0.0701
Riverside	R-30	2.5	0.0744	0.0714
Riverside	R-31	3.5	0.2408	0.1269
Riverside	R-32	2.8	0.0913	0.0862
Riverside	R-33	3.3	0.1868	0.0700
Riverside	R-34	2.4	0.0701	0.0827
Riverside	R-35	2.9	0.0972	0.0889
Riverside	R-36	3.7	0.3148	0.1131
Riverside	R-37	2.2	0.0586	0.0418
Riverside	R-38	2.4	0.0692	0.0336
Chino East	CE-1	2.6	0.0822	0.0822
Chino East	CE-2	2.3	0.0652	0.0652
Chino East	CE-3	4.0	0.4000	0.4000
Chino East	CE-4	3.5	0.2471	0.2471
Chino East	CE-5	4.0	0.4000	0.4000
Chino East	CE-6	4.0	0.4000	0.4000
Chino East	CE-7	4.0	0.4000	0.4000
Chino East	CE-8	4.0	0.4000	0.4000

Basin	Sub-Watershed	Initial Infiltration Index	Initial Infiltration Rates	Calibrated Infiltration Rates
			[in/hr]	[in/hr]
Chino East	CE-9	4.0	0.4000	0.4000
Chino East	CE-10	4.0	0.4000	0.4000
Chino East	CE-11	4.0	0.4000	0.4000
Chino East	CE-12	4.0	0.3978	0.3978
Chino East	CE-13	4.0	0.3994	0.3994
Chino East	CE-14	3.9	0.3732	0.3732
Chino East	CE-15	3.4	0.2250	0.2250
Chino East	CE-16	3.7	0.3118	0.3118
Chino East	CE-17	2.9	0.0942	0.0942
Chino East	CE-18	2.0	0.0493	0.0493
Chino East	CE-19	2.4	0.0704	0.0704
Chino East	CE-20	2.7	0.0839	0.0839
Chino East	CE-21	1.7	0.0374	0.0374
Chino East	CE-22	2.7	0.0836	0.0836
Chino East	CE-23	3.7	0.3201	0.3201
Chino East	CE-24	3.0	0.0998	0.0998
Chino East	CE-25	4.0	0.4000	0.4000
Chino East	CE-26	4.0	0.4000	0.4000
Chino East	CE-27	4.0	0.4000	0.4000
Chino East	CE-28	4.0	0.4000	0.4000
Chino East	CE-29	4.0	0.4000	0.4000
Chino East	CE-30	4.0	0.4000	0.4000
Chino East	CE-31	3.7	0.3011	0.3011
Chino East	CE-32	2.7	0.0837	0.0837
Chino East	CE-33	2.9	0.0950	0.0950
Chino East	CE-34	3.1	0.1413	0.1413
Chino East	CE-35	3.1	0.1185	0.1185
Chino West	CW-1	2.7	0.0845	0.0845
Chino West	CW-2	3.2	0.1468	0.1468
Chino West	CW-3	4.0	0.4000	0.4000
Chino West	CW-4	1.0	0.0016	0.0016
Chino West	CW-5	3.8	0.3525	0.3525
Chino West	CW-6	4.0	0.4000	0.4000
Chino West	CW-7	4.0	0.4000	0.4000
Chino West	CW-8	4.0	0.4000	0.4000
Chino West	CW-9	1.6	0.0304	0.0304
Chino West	CW-10	4.0	0.4000	0.4000
Chino West	CW-11	1.5	0.0264	0.0264
Chino West	CW-12	3.3	0.1995	0.1995
Chino West	CW-13	3.8	0.3477	0.3477
Chino West	CW-14	3.8	0.3309	0.3309
Chino West	CW-15	3.9	0.3841	0.3841
Chino West	CW-16	4.0	0.4000	0.4000
Chino West	CW-17	4.0	0.4000	0.4000
Chino West	CW-18	4.0	0.4000	0.4000
Chino West	CW-19	3.4	0.2196	0.2196
Chino West	CW-20	4.0	0.3939	0.3939
Chino West	CW-21	3.9	0.3666	0.3666
Chino West	CW-22	4.0	0.4000	0.4000

Basin	Sub-Watershed	Initial Infiltration Index	Initial Infiltration Rates	Calibrated Infiltration Rates
			[in/hr]	[in/hr]
Chino West	CW-23	4.0	0.4000	0.4000
Chino West	CW-24	3.9	0.3562	0.3562
Chino West	CW-25	3.9	0.3709	0.3709
Chino West	CW-26	4.0	0.4000	0.4000
Chino West	CW-27	4.0	0.3983	0.3983
Chino West	CW-28	3.9	0.3744	0.3744
Chino West	CW-29	3.6	0.2858	0.2858
Chino West	CW-30	3.7	0.3093	0.3093
Chino West	CW-31	2.4	0.0699	0.0699
Chino West	CW-32	2.2	0.0607	0.0607
Chino West	CW-33	3.2	0.1564	0.1564
Chino West	CW-34	1.6	0.0321	0.0321
Chino West	CW-35	1.5	0.0240	0.0240
Chino West	CW-36	2.2	0.0612	0.0612
Chino West	CW-37	2.9	0.0950	0.0950
Chino West	CW-38	1.3	0.0160	0.0160
Chino West	CW-39	1.1	0.0050	0.0050
Chino West	CW-40	2.0	0.0495	0.0495
Chino West	CW-41	1.0	0.0023	0.0023
Chino West	CW-42	2.5	0.0773	0.0773
Chino West	CW-43	3.8	0.3339	0.5000
Chino West	CW-44	3.9	0.3737	0.5000
Chino West	CW-45	4.0	0.3929	0.5000
Chino West	CW-46	3.9	0.3732	0.5000
Chino West	CW-47	3.3	0.1962	0.5000
Chino West	CW-48	1.7	0.0359	0.5000
Chino West	CW-49	3.2	0.1742	0.5000
Chino West	CW-50	2.3	0.0647	0.5000
Chino West	CW-51	3.1	0.1183	0.1183
Chino West	CW-52	2.4	0.0717	0.0717
Chino West	CW-53	2.1	0.0539	0.0539
Chino West	CW-54	1.8	0.0406	0.0406
Chino West	CW-55	2.0	0.0505	0.0505
Chino West	CW-56	3.2	0.1553	0.1553
Chino West	CW-57	2.0	0.0486	0.0486
Chino West	CW-58	1.9	0.0456	0.0456
Chino West	CW-59	2.0	0.0500	0.0500
Chino West	CW-60	2.0	0.0500	0.0500
Chino West	CW-61	2.1	0.0553	0.0553
Chino West	CW-62	2.0	0.0497	0.0497
Chino West	CW-63	2.2	0.0616	0.0616
Chino West	CW-64	3.5	0.2631	0.2631
Chino West	CW-65	3.9	0.3713	0.3713
Chino West	CW-66	3.3	0.1809	0.1809
Chino West	CW-67	2.0	0.0500	0.0500
Chino West	CW-68	2.0	0.0512	0.0512
Chino West	CW-69	2.2	0.0622	0.0622
Chino West	CW-70	2.4	0.0677	0.0677
Chino West	CW-71	2.0	0.0481	0.0481

Basin	Sub-Watershed	Initial Infiltration Index	Initial Infiltration Rates	Calibrated Infiltration Rates
			[in/hr]	[in/hr]
Chino West	CW-72	3.1	0.1240	0.1240
Chino West	CW-73	2.1	0.0533	0.0533
Chino West	CW-74	1.7	0.0365	0.0365
Chino West	CW-75	2.7	0.0867	0.0867
Chino West	CW-76	1.9	0.0438	0.0438
Arlington	A-1	1.7	0.0346	0.0346
Arlington	A-2	1.4	0.0215	0.0215
Arlington	A-3	1.7	0.0357	0.0357
Arlington	A-4	1.1	0.0039	0.0039
Arlington	A-5	1.0	0.0012	0.0012
Arlington	A-6	2.7	0.0855	0.0855
Arlington	A-7	1.4	0.0220	0.0220
Arlington	A-8	1.4	0.0202	0.0202
Arlington	A-9	2.2	0.0607	0.0607
Arlington	A-10	1.7	0.0369	0.0369
Arlington	A-11	2.4	0.0713	0.0713
Arlington	A-12	1.6	0.0288	0.0288
Arlington	A-13	2.0	0.0485	0.0485
Arlington	A-14	1.4	0.0217	0.0217
Arlington	A-15	2.7	0.0864	0.0864
Arlington	A-16	1.1	0.0071	0.0071
Arlington	A-17	1.2	0.0087	0.0087
Arlington	A-18	1.9	0.0466	0.0466
Arlington	A-19	1.3	0.0174	0.0174
Arlington	A-20	3.1	0.1209	0.1209
Arlington	A-21	1.9	0.0428	0.0428
Arlington	A-22	1.6	0.0310	0.0310
Arlington	A-23	1.9	0.0460	0.0460
Arlington	A-24	1.8	0.0404	0.0404
Arlington	A-25	1.4	0.0230	0.0230
Arlington	A-26	1.5	0.0235	0.0235
Arlington	A-27	1.7	0.0364	0.0364
Arlington	A-28	1.4	0.0229	0.0229
Arlington	A-29	1.4	0.0214	0.0214
Arlington	A-30	1.1	0.0043	0.0043
Arlington	A-31	2.8	0.0892	0.0892
Arlington	A-32	1.8	0.0425	0.0425
Arlington	A-33	1.1	0.0074	0.0074
Arlington	A-34	1.2	0.0118	0.0118
Arlington	A-35	1.6	0.0316	0.0316
Arlington	A-36	1.6	0.0303	0.0303
Arlington	A-37	1.4	0.0194	0.0194
Arlington	A-38	2.0	0.0504	0.0504
Arlington	A-39	2.2	0.0596	0.0596
Arlington	A-40	1.1	0.0070	0.0070
Arlington	A-41	2.2	0.0603	0.0603
Arlington	A-42	2.4	0.0706	0.0706
Arlington	A-43	2.0	0.0486	0.0486
Arlington	A-44	1.8	0.0419	0.0419

Basin	Sub-Watershed	Initial Infiltration Index	Initial Infiltration Rates	Calibrated Infiltration Rates
			[in/hr]	[in/hr]
Arlington	A-45	1.4	0.0211	0.0211
Arlington	A-46	1.8	0.0416	0.0416
Arlington	A-47	1.9	0.0471	0.0471
Arlington	A-48	1.5	0.0232	0.0232
Arlington	A-49	2.0	0.0490	0.0490
Arlington	A-50	1.8	0.0421	0.0421
Arlington	A-51	1.9	0.0440	0.0440
Arlington	A-52	1.7	0.0377	0.0377
Arlington	A-53	2.0	0.0507	0.0507
Arlington	A-54	2.0	0.0503	0.0503
Arlington	A-55	2.3	0.0674	0.0674
Arlington	A-56	1.6	0.0300	0.0300
Arlington	A-57	1.8	0.0399	0.0399
Arlington	A-58	2.0	0.0517	0.0517
Arlington	A-59	1.5	0.0265	0.0265
Arlington	A-60	1.9	0.0472	0.0472
Arlington	A-61	1.6	0.0313	0.0313
Arlington	A-62	2.0	0.0512	0.0512
Arlington	A-63	2.8	0.0907	0.0907
Arlington	A-64	3.0	0.1009	0.1009
Arlington	A-65	1.9	0.0471	0.0471
Arlington	A-66	1.8	0.0398	0.0398
Arlington	A-67	2.7	0.0863	0.0863
Arlington	A-68	1.2	0.0125	0.0125
Arlington	A-69	2.9	0.0968	0.0968
Arlington	A-70	3.2	0.1556	0.1556
Arlington	A-71	2.6	0.0818	0.5000
Arlington	A-72	3.1	0.1422	0.5000
Arlington	A-73	2.5	0.0737	0.5000
Arlington	A-74	2.4	0.0686	0.0686
Arlington	A-75	1.7	0.0363	0.0363
Arlington	A-76	1.1	0.0076	0.0076
Arlington	A-77	2.1	0.0559	0.0559
Arlington	A-78	1.7	0.0342	0.0342
Arlington	A-79	2.6	0.0780	0.0780
Arlington	A-80	3.0	0.1125	0.1125
Arlington	A-81	1.9	0.0461	0.0461
Arlington	A-82	2.8	0.0898	0.0898
Warm Springs	WS-1	1.7	0.0333	0.0666
Warm Springs	WS-2	1.3	0.0181	0.0361
Warm Springs	WS-3	1.3	0.0169	0.0339
Warm Springs	WS-4	1.9	0.0443	0.0885
Warm Springs	WS-5	1.7	0.0333	0.0667
Warm Springs	WS-6	1.2	0.0132	0.0264
Warm Springs	WS-7	1.0	0.0033	0.0066
Warm Springs	WS-8	1.3	0.0178	0.0356
Warm Springs	WS-9	1.0	0.0029	0.0058
Warm Springs	WS-10	1.4	0.0201	0.0403
Warm Springs	WS-11	1.6	0.0321	0.0641

Basin	Sub-Watershed	Initial Infiltration Index	Initial Infiltration Rates	Calibrated Infiltration Rates
			[in/hr]	[in/hr]
Warm Springs	WS-12	1.9	0.0452	0.0904
Warm Springs	WS-13	1.2	0.0125	0.0250
Warm Springs	WS-14	1.1	0.0080	0.0159
Warm Springs	WS-15	1.0	0.0010	0.0020
Warm Springs	WS-16	1.5	0.0242	0.0484
Warm Springs	WS-17	2.7	0.0875	0.1750
Warm Springs	WS-18	2.2	0.0582	0.1165
Warm Springs	WS-19	1.4	0.0193	0.0385
Warm Springs	WS-20	1.1	0.0078	0.0155
Warm Springs	WS-21	2.4	0.0697	0.1393
Warm Springs	WS-22	1.5	0.0276	0.0552
Warm Springs	WS-23	1.1	0.0074	0.0148
Warm Springs	WS-24	1.6	0.0309	0.0619
Warm Springs	WS-25	1.3	0.0144	0.0288
Warm Springs	WS-26	1.1	0.0036	0.0071
Warm Springs	WS-27	1.1	0.0078	0.0155
Warm Springs	WS-28	1.3	0.0135	0.0269
Warm Springs	WS-29	1.7	0.0341	0.0681
Warm Springs	WS-30	1.0	0.0010	0.0020
Warm Springs	WS-31	1.0	0.0010	0.0020
Warm Springs	WS-32	1.4	0.0203	0.0406
Warm Springs	WS-33	1.9	0.0430	0.0859
Warm Springs	WS-34	1.0	0.0018	0.0035
Warm Springs	WS-35	1.3	0.0160	0.0321
Warm Springs	WS-36	1.0	0.0010	0.0020
Warm Springs	WS-37	2.1	0.0573	0.1145
Warm Springs	WS-38	1.2	0.0108	0.0215
Warm Springs	WS-39	4.0	0.4000	0.4000
Warm Springs	WS-40	1.1	0.0055	0.0111
Warm Springs	WS-41	1.5	0.0279	0.0558
Warm Springs	WS-42	1.1	0.0065	0.0131
Warm Springs	WS-43	1.6	0.0300	0.0601
Warm Springs	WS-44	3.1	0.1282	0.2565
Warm Springs	WS-45	2.5	0.0730	0.1460
Orange County	O-1	1.6	0.0294	0.0294
Orange County	O-2	1.4	0.0187	0.0187
Orange County	O-3	2.7	0.0865	0.0865
Orange County	O-4	1.8	0.0407	0.0407
Orange County	O-5	1.7	0.0345	0.0345
Orange County	O-6	1.6	0.0318	0.0318
Orange County	O-7	1.9	0.0437	0.0437
Orange County	O-8	1.9	0.0449	0.0449
Orange County	O-9	1.8	0.0421	0.0421
Orange County	O-10	1.7	0.0358	0.0358
Orange County	O-11	1.8	0.0394	0.0394
Orange County	O-12	1.2	0.0132	0.0132
Orange County	O-13	1.7	0.0368	0.0368
Orange County	O-14	1.6	0.0301	0.0301
Orange County	O-15	1.8	0.0419	0.0419

Basin	Sub-Watershed	Initial Infiltration Index	Initial Infiltration Rates	Calibrated Infiltration Rates
			[in/hr]	[in/hr]
Orange County	O-16	1.3	0.0160	0.0160
Orange County	O-17	2.5	0.0758	0.0758
Orange County	O-18	1.9	0.0457	0.0457
Orange County	O-19	1.3	0.0160	0.0160
Orange County	O-20	2.1	0.0567	0.0567
Orange County	O-21	1.8	0.0387	0.0387
Orange County	O-22	2.1	0.0540	0.0540
Orange County	O-23	1.3	0.0133	0.0133
Orange County	O-24	1.4	0.0183	0.0183
Orange County	O-25	2.2	0.0596	0.0596
Orange County	O-26	2.6	0.0809	0.0809
Orange County	O-27	1.7	0.0375	0.0375
Orange County	O-28	2.0	0.0509	0.0509
Orange County	O-29	1.5	0.0274	0.0274
Orange County	O-30	2.6	0.0794	0.0794
Orange County	O-31	3.3	0.2032	0.2032
Orange County	O-32	3.0	0.0998	0.0998
Orange County	O-33	1.6	0.0286	0.0286
Orange County	O-34	2.1	0.0550	0.0550
Orange County	O-35	3.3	0.1783	0.1783
Orange County	O-36	3.8	0.3318	0.3318
Orange County	O-37	3.8	0.3529	0.3529
Orange County	O-38	3.6	0.2716	0.2716
Orange County	O-39	2.0	0.0488	0.0488
Orange County	O-40	2.0	0.0522	0.0522
Orange County	O-41	2.8	0.0908	0.0908
Orange County	O-42	3.8	0.4	0.3525

**Sub-Watershed Land Use Summary (2012)**

Basin	Sub-Watershed	Agriculture/ Parks/ Golf Course	Commercial/ Industrial/ Public Facilities	Open Space/ Dry Agriculture/ Water Body	High Density Residential Housing	Low Density Residential Housing	Medium Density Residential Housing	Total Area
		[acres]						
Yucaipa	Y-1	15	28	879	0	31	0	953
Yucaipa	Y-2	165	13	953	0	26	0	1,157
Yucaipa	Y-3	0	2	520	0	20	3	544
Yucaipa	Y-4	45	27	409	0	69	0	551
Yucaipa	Y-5	16	22	403	1	25	0	467
Yucaipa	Y-6	6	16	406	3	59	0	489
Yucaipa	Y-7	29	6	1,215	0	65	0	1,314
Yucaipa	Y-8	0	1	1,310	77	160	42	1,591
Yucaipa	Y-9	2	26	112	0	53	33	225
Yucaipa	Y-10	0	0	875	0	0	0	875
Yucaipa	Y-11	0	0	575	0	0	0	575
Yucaipa	Y-12	2	21	1,303	0	42	0	1,368
Yucaipa	Y-13	0	28	9	0	47	0	84
Yucaipa	Y-14	0	2	12	11	1	0	27
Yucaipa	Y-15	0	12	53	0	5	0	69
Yucaipa	Y-16	0	2	41	1	5	16	65
Yucaipa	Y-17	14	23	25	0	2	130	195
Yucaipa	Y-18	25	12	522	31	86	28	704
Yucaipa	Y-19	27	11	711	39	347	23	1,158
Yucaipa	Y-20	0	0	6	2	0	9	17
Yucaipa	Y-21	17	15	522	19	106	35	715
Yucaipa	Y-22	46	21	586	33	70	83	838
Yucaipa	Y-23	0	3	12	0	8	0	23
Yucaipa	Y-24	116	152	1,012	19	93	355	1,747
Yucaipa	Y-25	27	168	249	117	227	570	1,360
Yucaipa	Y-26	0	12	74	0	32	30	149
Yucaipa	Y-27	0	0	210	0	0	0	210
Yucaipa	Y-28	0	5	165	0	0	0	170
Yucaipa	Y-29	43	126	295	15	210	154	842
Yucaipa	Y-30	0	17	11	0	1	1	30
Yucaipa	Y-31	11	144	366	22	192	60	795
Yucaipa	Y-32	2	0	1,966	39	59	1	2,067
Yucaipa	Y-33	8	2	403	5	313	0	731
Yucaipa	Y-34	58	2	1,263	1	53	0	1,376
Yucaipa	Y-35	4	0	359	8	41	0	413
Yucaipa	Y-36	1	0	10	0	20	0	31
Yucaipa	Y-37	43	88	594	89	538	267	1,620
Yucaipa	Y-38	39	117	600	238	542	406	1,943
Yucaipa	Y-39	43	16	235	0	0	0	294
Yucaipa	Y-40	3	51	985	16	60	22	1,137
Yucaipa	Y-41	7	100	178	85	225	266	862
Yucaipa	Y-42	81	34	2,220	30	289	0	2,654
Yucaipa	Y-47	0	28	698	0	19	0	745
Yucaipa	Y-48	2	12	1,047	0	10	0	1,072
Yucaipa	Y-49	57	24	671	5	52	0	808
Yucaipa	Y-50	64	5	359	0	29	5	461
Yucaipa	Y-51	394	118	1,579	128	459	388	3,066
Yucaipa	Y-52	22	2	989	1	29	0	1,043
Yucaipa	Y-53	20	352	877	7	11	0	1,267
Yucaipa	Y-54	155	52	940	19	245	7	1,419
Yucaipa	Y-55	246	20	468	164	281	7	1,186

Basin	Sub-Watershed	Agriculture/ Parks/ Golf Course	Commercial/ Industrial/ Public Facilities	Open Space/ Dry Agriculture/ Water Body	High Density Residential Housing	Low Density Residential Housing	Medium Density Residential Housing	Total Area
		[acres]						
Yucaipa	Y-56	0	0	249	0	7	0	256
Yucaipa	Y-57	57	7	680	11	6	0	760
Yucaipa	Y-58	9	6	10	0	0	0	25
Yucaipa	Y-59	36	27	1,361	7	24	0	1,455
Yucaipa	Y-60	263	187	1,437	16	50	2	1,955
Yucaipa	Y-61	3	0	1,015	0	7	0	1,024
Yucaipa	Y-62	0	13	182	14	32	0	241
Yucaipa	Y-63	0	0	843	0	0	2	845
Yucaipa	Y-64	0	90	1,471	0	11	0	1,572
Yucaipa	Y-65	0	0	495	0	2	0	497
Yucaipa	Y-66	0	21	738	0	14	0	773
Yucaipa	Y-67	0	0	22	0	1	0	23
Yucaipa	Y-68	31	0	1,614	0	0	0	1,645
Yucaipa	Y-69	61	126	1,105	21	294	89	1,696
Yucaipa	Y-70	55	372	1,376	57	453	657	2,970
Yucaipa	Y-71	0	2	15	0	0	0	17
Yucaipa	Y-72	97	0	1,225	0	6	0	1,328
Yucaipa	Y-73	24	78	1,636	102	375	7	2,222
Yucaipa	Y-74	0	1	316	0	0	0	316
Yucaipa	Y-75	8	61	378	9	169	13	637
Yucaipa	Y-76	9	16	470	1	264	25	786
Yucaipa	Y-77	136	126	203	0	89	181	735
Yucaipa	Y-78	12	27	442	0	57	0	538
Yucaipa	Y-79	178	41	505	0	275	25	1,024
Yucaipa	Y-80	48	59	1,248	1	206	8	1,570
Yucaipa	Y-81	0	3	863	11	65	0	943
Yucaipa	Y-82	46	40	171	0	100	7	364
Yucaipa	Y-83	115	279	2,093	65	60	21	2,635
Yucaipa	Y-84	246	118	1,829	0	35	3	2,231
Yucaipa	Y-85	31	194	428	0	0	0	653
SBBA East	SE-1	0	16	882	3	1	0	903
SBBA East	SE-2	0	67	225	0	0	0	292
SBBA East	SE-3	0	30	5	0	0	0	35
SBBA East	SE-4	0	4	97	0	27	0	129
SBBA East	SE-5	10	53	121	56	8	234	482
SBBA East	SE-6	4	382	46	39	5	54	530
SBBA East	SE-7	0	82	348	31	26	104	591
SBBA East	SE-8	1	180	22	11	90	292	595
SBBA East	SE-9	15	13	195	0	3	51	277
SBBA East	SE-10	68	179	51	76	76	768	1,218
SBBA East	SE-11	0	26	2,771	19	144	12	2,972
SBBA East	SE-12	0	38	321	0	14	0	372
SBBA East	SE-13	0	17	40	0	1	18	77
SBBA East	SE-14	23	169	325	1	18	41	577
SBBA East	SE-15	0	9	375	0	10	1	395
SBBA East	SE-16	8	33	24	6	23	30	125
SBBA East	SE-17	0	121	0	0	2	0	122
SBBA East	SE-18	0	9	2,002	0	0	2	2,013
SBBA East	SE-19	94	115	1	19	50	463	742
SBBA East	SE-20	83	628	806	148	84	744	2,494
SBBA East	SE-21	0	112	1	8	0	265	387
SBBA East	SE-22	1	2	885	0	6	4	899
SBBA East	SE-23	0	9	6	0	9	4	28

Basin	Sub-Watershed	Agriculture/ Parks/ Golf Course	Commercial/ Industrial/ Public Facilities	Open Space/ Dry Agriculture/ Water Body	High Density Residential Housing	Low Density Residential Housing	Medium Density Residential Housing	Total Area
		[acres]						
SBBA East	SE-24	0	5	667	0	0	0	672
SBBA East	SE-25	0	3	24	0	13	15	56
SBBA East	SE-26	6	59	385	70	97	718	1,336
SBBA East	SE-27	6	29	6	29	0	31	100
SBBA East	SE-28	9	219	74	72	17	320	710
SBBA East	SE-29	0	10	11	16	3	25	66
SBBA East	SE-30	0	19	27	13	31	106	196
SBBA East	SE-31	9	484	208	240	56	1,253	2,250
SBBA East	SE-32	92	386	148	125	62	563	1,375
SBBA East	SE-33	0	46	13	0	0	13	73
SBBA East	SE-34	0	0	446	0	0	0	446
SBBA East	SE-35	0	25	72	6	0	1	104
SBBA East	SE-36	0	0	380	0	2	0	382
SBBA East	SE-37	0	17	86	0	0	0	103
SBBA East	SE-38	0	1	305	0	88	11	404
SBBA East	SE-39	1	54	203	53	1	38	350
SBBA East	SE-40	4	90	389	0	292	640	1,415
SBBA East	SE-41	1	42	136	2	1	29	212
SBBA East	SE-42	0	0	1,479	0	0	0	1,479
SBBA East	SE-43	2	0	44	0	0	0	46
SBBA East	SE-44	9	1	58	0	24	0	92
SBBA East	SE-45	0	19	64	0	3	7	94
SBBA East	SE-46	0	0	773	0	0	15	788
SBBA East	SE-47	82	37	577	5	75	583	1,359
SBBA East	SE-48	71	217	1,911	0	116	95	2,410
SBBA East	SE-49	7	431	507	3	0	14	962
SBBA East	SE-50	23	117	81	43	17	212	491
SBBA East	SE-51	0	72	62	3	9	1	146
SBBA East	SE-52	0	186	209	18	44	200	658
SBBA East	SE-53	23	161	204	58	119	303	869
SBBA East	SE-54	10	969	204	17	9	90	1,301
SBBA East	SE-55	140	138	2,971	0	27	0	3,276
SBBA East	SE-56	208	174	5,073	4	272	10	5,741
SBBA East	SE-57	0	448	604	0	0	0	1,052
SBBA East	SE-58	999	1,206	2,814	274	240	1,473	7,007
SBBA East	SE-59	1,052	282	2,462	106	388	408	4,697
SBBA East	SE-60	367	869	781	249	1,272	1,653	5,191
SBBA East	SE-61	5	164	32	4	1	21	227
SBBA East	SE-62	4	315	64	19	1	17	420
SBBA East	SE-63	142	73	348	3	45	88	700
SBBA East	SE-64	39	95	462	32	24	288	940
SBBA East	SE-65	0	40	371	0	0	0	411
SBBA East	SE-66	0	6	163	0	0	0	169
SBBA East	SE-67	7	12	15	12	1	14	61
SBBA East	SE-68	26	145	82	70	27	200	551
SBBA East	SE-69	0	3	195	0	5	0	203
SBBA East	SE-70	0	5	48	0	30	70	153
SBBA East	SE-71	0	14	12	37	1	50	113
SBBA East	SE-72	19	67	13	15	5	13	133
SBBA East	SE-73	396	1,092	421	310	487	1,557	4,263
SBBA East	SE-74	624	2,418	1,029	3	65	50	4,189
SBBA East	SE-75	0	11	0	0	0	5	15
SBBA East	SE-76	4	8	1	13	0	8	35

Basin	Sub-Watershed	Agriculture/ Parks/ Golf Course	Commercial/ Industrial/ Public Facilities	Open Space/ Dry Agriculture/ Water Body	High Density Residential Housing	Low Density Residential Housing	Medium Density Residential Housing	Total Area
		[acres]						
SBBA East	SE-77	19	135	17	0	65	68	304
SBBA East	SE-78	77	305	246	0	105	134	866
SBBA East	SE-79	347	472	265	95	85	251	1,515
SBBA West	SW-1	0	4	46	0	0	0	50
SBBA West	SW-2	0	31	33	0	0	0	63
SBBA West	SW-3	0	104	66	0	0	0	170
SBBA West	SW-4	0	6	507	0	0	0	513
SBBA West	SW-5	0	6	61	0	0	0	67
SBBA West	SW-6	0	50	237	0	0	0	286
SBBA West	SW-7	0	5	153	0	0	0	158
SBBA West	SW-8	0	29	303	0	9	0	341
SBBA West	SW-9	0	297	333	0	6	273	910
SBBA West	SW-10	0	0	3	0	0	0	3
SBBA West	SW-11	16	50	44	12	19	155	295
SBBA West	SW-12	37	333	4,858	57	336	17	5,638
SBBA West	SW-13	26	63	230	10	48	3	380
SBBA West	SW-14	0	1	309	0	0	0	310
SBBA West	SW-15	1	4	139	1	20	11	177
SBBA West	SW-16	0	152	705	1	86	143	1,087
SBBA West	SW-17	0	360	495	0	32	1	888
SBBA West	SW-18	7	426	7,155	1	609	4	8,203
SBBA West	SW-19	7	583	1,980	0	42	1	2,612
SBBA West	SW-20	2	941	7,367	0	72	0	8,382
SBBA West	SW-21	0	95	345	0	0	0	440
SBBA West	SW-22	70	198	361	0	20	35	685
SBBA West	SW-23	0	358	153	71	2	179	763
SBBA West	SW-24	0	39	108	6	545	166	863
SBBA West	SW-25	140	449	330	46	323	391	1,679
SBBA West	SW-26	188	397	979	10	397	484	2,457
SBBA West	SW-27	0	174	101	88	17	611	990
SBBA West	SW-28	0	1	93	0	1	14	109
SBBA West	SW-29	13	411	214	129	38	403	1,208
SBBA West	SW-30	59	219	142	42	14	74	549
SBBA West	SW-31	0	289	11	21	1	17	339
SBBA West	SW-32	6	154	43	23	4	42	272
SBBA West	SW-33	0	178	27	0	0	11	216
SBBA West	SW-34	0	79	16	0	0	0	95
SBBA West	SW-35	157	2,280	608	306	96	3,078	6,524
Rialto-Colton	RC-1	218	1,947	2,777	33	213	1,300	6,487
Rialto-Colton	RC-2	22	352	484	38	85	1,028	2,009
Rialto-Colton	RC-3	2	112	90	40	34	421	699
Rialto-Colton	RC-4	0	1	19	0	3	17	41
Rialto-Colton	RC-5	0	41	35	21	15	24	136
Rialto-Colton	RC-6	9	345	254	126	149	857	1,739
Rialto-Colton	RC-7	0	0	0	9	0	0	9
Rialto-Colton	RC-8	0	157	50	47	6	75	337
Rialto-Colton	RC-9	13	115	35	0	2	11	176
Rialto-Colton	RC-10	30	448	203	72	88	1,046	1,888
Rialto-Colton	RC-11	19	234	116	149	21	257	796
Rialto-Colton	RC-12	0	30	0	0	0	0	30
Rialto-Colton	RC-13	0	55	2	0	3	3	63
Rialto-Colton	RC-14	0	14	0	0	0	0	14
Rialto-Colton	RC-15	0	114	5	0	0	1	120

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		[acres]						
Rialto-Colton	RC-16	0	331	80	0	0	0	411
Rialto-Colton	RC-17	65	445	128	0	0	29	666
Rialto-Colton	RC-18	0	125	2	77	6	507	717
Rialto-Colton	RC-19	0	53	13	47	22	170	305
Rialto-Colton	RC-20	28	110	56	101	20	364	680
Rialto-Colton	RC-21	0	59	22	0	9	176	267
Rialto-Colton	RC-22	3	447	79	29	19	348	925
Rialto-Colton	RC-23	29	438	52	22	69	361	973
Rialto-Colton	RC-24	6	376	50	0	2	0	433
Rialto-Colton	RC-25	6	549	21	285	45	874	1,780
Rialto-Colton	RC-26	0	54	7	0	0	0	60
Rialto-Colton	RC-27	0	13	11	2	0	31	58
Rialto-Colton	RC-28	0	17	11	12	0	31	71
Rialto-Colton	RC-29	0	244	15	0	0	0	260
Rialto-Colton	RC-30	0	123	38	46	2	26	235
Rialto-Colton	RC-31	90	48	3,829	2	365	0	4,333
Rialto-Colton	RC-32	5	5	1,043	27	711	110	1,901
Rialto-Colton	RC-33	38	32	466	37	268	70	911
Rialto-Colton	RC-34	0	7	0	0	0	2	8
Rialto-Colton	RC-35	0	150	158	241	281	112	943
Rialto-Colton	RC-36	5	114	173	58	63	295	708
Rialto-Colton	RC-37	10	142	304	11	108	392	967
Rialto-Colton	RC-38	145	115	274	8	81	228	850
Rialto-Colton	RC-39	0	33	6	48	67	7	162
Rialto-Colton	RC-40	0	195	23	0	4	0	222
Rialto-Colton	RC-41	184	495	262	145	67	430	1,582
Rialto-Colton	RC-42	0	34	47	0	0	0	82
Rialto-Colton	RC-43	1	56	53	24	6	5	144
Rialto-Colton	RC-44	0	245	339	205	243	145	1,177
Rialto-Colton	RC-45	0	80	23	0	14	0	118
Rialto-Colton	RC-46	0	198	117	0	134	0	449
Rialto-Colton	RC-47	0	10	41	0	6	0	58
Rialto-Colton	RC-48	99	971	531	16	257	236	2,110
Rialto-Colton	RC-49	0	292	266	0	310	0	869
Rialto-Colton	RC-50	0	46	220	0	0	0	266
Rialto-Colton	RC-51	18	266	156	0	21	3	464
Riverside	R-1	11	126	97	0	12	5	251
Riverside	R-2	748	651	1,703	60	194	454	3,810
Riverside	R-3	40	469	468	0	0	0	978
Riverside	R-4	0	0	697	0	17	6	719
Riverside	R-5	0	11	264	0	64	137	477
Riverside	R-6	25	176	108	170	17	177	674
Riverside	R-7	0	208	30	0	0	6	244
Riverside	R-8	0	0	376	0	0	0	377
Riverside	R-9	2	510	477	87	44	185	1,304
Riverside	R-10	0	14	10	0	0	0	24
Riverside	R-11	0	10	2	0	0	0	12
Riverside	R-12	0	23	6	0	0	0	29
Riverside	R-13	1	44	59	5	26	68	203
Riverside	R-14	3	134	39	13	53	153	397
Riverside	R-15	168	316	92	49	15	266	906
Riverside	R-16	278	1,381	1,828	98	483	829	4,899
Riverside	R-17	6	2	146	0	17	16	187

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		[acres]						
Riverside	R-18	163	15	386	12	27	71	675
Riverside	R-19	54	569	1,242	167	217	536	2,787
Riverside	R-20	62	1,302	78	129	67	671	2,309
Riverside	R-21	22	497	485	81	71	462	1,618
Riverside	R-22	1,744	939	1,232	129	356	715	5,114
Riverside	R-23	48	44	24	20	36	581	753
Riverside	R-24	211	187	65	63	282	628	1,435
Riverside	R-25	12	28	0	2	2	12	56
Riverside	R-26	104	31	18	40	22	48	264
Riverside	R-27	16	0	106	0	9	10	140
Riverside	R-28	97	58	239	19	2	78	493
Riverside	R-29	19	2	274	0	0	0	295
Riverside	R-30	97	764	162	149	447	1,844	3,463
Riverside	R-31	0	1	345	1	28	86	462
Riverside	R-32	17	111	49	8	41	352	578
Riverside	R-33	0	0	42	0	1	9	51
Riverside	R-34	190	382	1,712	21	338	730	3,373
Riverside	R-35	39	288	509	34	52	319	1,241
Riverside	R-36	1	2	76	0	30	1	110
Riverside	R-37	44	43	294	5	217	136	738
Riverside	R-38	82	127	224	6	16	100	556
Chino East	CE-1	15	171	3,652	0	53	465	4,355
Chino East	CE-2	121	282	1,940	12	151	168	2,674
Chino East	CE-3	84	532	1,005	5	161	270	2,056
Chino East	CE-4	0	254	3,376	0	93	13	3,736
Chino East	CE-5	28	215	219	0	39	40	541
Chino East	CE-6	49	298	1,015	3	217	932	2,512
Chino East	CE-7	37	852	441	87	178	1,191	2,786
Chino East	CE-8	22	509	469	189	175	1,103	2,467
Chino East	CE-9	2	341	396	36	143	249	1,167
Chino East	CE-10	5	111	126	17	59	129	446
Chino East	CE-11	76	954	284	225	469	2,334	4,342
Chino East	CE-12	0	1,809	593	67	10	32	2,512
Chino East	CE-13	24	1,654	276	5	153	520	2,631
Chino East	CE-14	8	951	119	0	0	80	1,159
Chino East	CE-15	252	2,034	2,438	46	699	1,367	6,836
Chino East	CE-16	41	276	187	1	131	27	663
Chino East	CE-17	27	112	231	1	632	17	1,020
Chino East	CE-18	385	1,281	3,243	72	2,734	888	8,602
Chino East	CE-19	15	303	323	1	11	155	808
Chino East	CE-20	776	1,816	253	508	540	2,552	6,445
Chino East	CE-21	42	213	128	11	0	69	463
Chino East	CE-22	670	163	1,811	0	313	407	3,364
Chino East	CE-23	2	0	229	0	2	0	233
Chino East	CE-24	0	408	1,886	0	1	16	2,311
Chino East	CE-25	28	207	315	0	426	650	1,626
Chino East	CE-26	75	917	409	81	54	1,180	2,715
Chino East	CE-27	0	1,358	230	10	0	0	1,598
Chino East	CE-28	12	2,442	151	0	0	0	2,605
Chino East	CE-29	0	665	48	0	0	0	713
Chino East	CE-30	0	1,094	75	0	0	0	1,168
Chino East	CE-31	322	1,864	1,200	0	12	27	3,425
Chino East	CE-32	72	159	159	4	1,476	13	1,883

Basin	Sub-Watershed	Agriculture/ Parks/ Golf Course	Commercial/ Industrial/ Public Facilities	Open Space/ Dry Agriculture/ Water Body	High Density Residential Housing	Low Density Residential Housing	Medium Density Residential Housing	Total Area
		[acres]						
Chino East	CE-33	178	6	285	0	212	1	682
Chino East	CE-34	434	242	679	194	501	302	2,353
Chino East	CE-35	939	244	1,763	1	1,089	1,553	5,589
Chino West	CW-1	0	0	2,327	0	0	0	2,327
Chino West	CW-2	0	495	1,093	0	275	214	2,077
Chino West	CW-3	60	262	115	301	61	934	1,732
Chino West	CW-4	0	45	168	0	28	0	240
Chino West	CW-5	4	155	155	0	413	428	1,155
Chino West	CW-6	31	219	40	201	49	913	1,452
Chino West	CW-7	30	12	108	0	0	0	150
Chino West	CW-8	98	1,830	429	311	21	479	3,167
Chino West	CW-9	0	128	1,101	0	18	8	1,255
Chino West	CW-10	0	100	49	0	5	53	206
Chino West	CW-11	0	64	1,332	0	28	41	1,466
Chino West	CW-12	63	119	488	0	191	963	1,824
Chino West	CW-13	0	92	59	10	13	447	622
Chino West	CW-14	84	289	37	99	170	1,547	2,227
Chino West	CW-15	25	796	412	290	122	1,356	3,001
Chino West	CW-16	0	533	343	83	10	225	1,196
Chino West	CW-17	4	897	50	0	0	0	952
Chino West	CW-18	6	171	20	0	0	0	196
Chino West	CW-19	46	506	885	2	505	1,184	3,128
Chino West	CW-20	110	177	12	124	8	936	1,367
Chino West	CW-21	143	758	139	318	17	1,288	2,663
Chino West	CW-22	71	799	123	219	99	1,735	3,045
Chino West	CW-23	37	1,035	232	27	64	159	1,554
Chino West	CW-24	44	239	79	0	0	0	363
Chino West	CW-25	403	336	57	38	61	285	1,181
Chino West	CW-26	0	28	22	13	3	0	67
Chino West	CW-27	80	2,033	722	97	5	1	2,937
Chino West	CW-28	88	1,127	204	63	26	745	2,254
Chino West	CW-29	679	49	75	0	3	19	825
Chino West	CW-30	4,294	348	676	0	45	61	5,423
Chino West	CW-31	829	192	1,077	260	774	1	3,133
Chino West	CW-32	820	180	1,112	226	362	21	2,721
Chino West	CW-33	58	211	343	0	0	0	612
Chino West	CW-34	0	0	3,536	0	4	0	3,540
Chino West	CW-35	0	1	2,899	0	2	0	2,902
Chino West	CW-36	0	13	5,108	63	29	0	5,212
Chino West	CW-37	0	0	703	0	0	0	703
Chino West	CW-38	0	3	1,904	0	0	0	1,906
Chino West	CW-39	0	0	1,247	0	0	0	1,247
Chino West	CW-40	3	28	587	0	5	2	625
Chino West	CW-41	0	0	1,069	0	0	0	1,069
Chino West	CW-42	0	6	28	0	0	0	34
Chino West	CW-43	69	1,504	1,338	378	235	1,100	4,623
Chino West	CW-44	20	962	78	102	41	444	1,647
Chino West	CW-45	143	1,750	135	442	45	1,928	4,444
Chino West	CW-46	188	1,180	394	347	1,016	1,247	4,373
Chino West	CW-47	80	707	167	296	140	1,248	2,639
Chino West	CW-48	222	186	505	57	15	449	1,435
Chino West	CW-49	105	1,108	532	407	137	1,670	3,958
Chino West	CW-50	4	140	55	21	27	97	345

Basin	Sub-Watershed	Agriculture/ Parks/ Golf Course	Commercial/ Industrial/ Public Facilities	Open Space/ Dry Agriculture/ Water Body	High Density Residential Housing	Low Density Residential Housing	Medium Density Residential Housing	Total Area
		[acres]						
Chino West	CW-51	58	426	220	61	306	1,026	2,097
Chino West	CW-52	0	772	17	0	24	16	829
Chino West	CW-53	81	66	734	12	239	388	1,521
Chino West	CW-54	69	88	1,035	54	106	687	2,040
Chino West	CW-55	4	111	22	27	24	235	423
Chino West	CW-56	116	2,049	317	229	54	1,209	3,974
Chino West	CW-57	115	226	79	182	60	736	1,399
Chino West	CW-58	457	134	1,511	3	140	448	2,693
Chino West	CW-59	2	5	3	0	0	8	18
Chino West	CW-60	65	1,185	145	0	0	3	1,398
Chino West	CW-61	234	243	1,059	57	10	407	2,011
Chino West	CW-62	8	6	400	4	1	21	439
Chino West	CW-63	18	15	199	29	0	41	302
Chino West	CW-64	1,796	463	353	31	108	765	3,516
Chino West	CW-65	63	658	108	225	312	1,383	2,749
Chino West	CW-66	102	164	133	72	36	773	1,281
Chino West	CW-67	51	700	2	1	30	1	783
Chino West	CW-68	102	1,748	69	51	3	0	1,973
Chino West	CW-69	253	42	183	30	4	0	512
Chino West	CW-70	73	1	246	46	11	9	385
Chino West	CW-71	40	42	569	18	5	122	795
Chino West	CW-72	25	0	201	0	0	0	226
Chino West	CW-73	6	67	1,192	3	11	71	1,351
Chino West	CW-74	0	123	652	0	0	0	775
Chino West	CW-75	381	1,297	2,461	119	18	554	4,830
Chino West	CW-76	0	55	103	0	0	0	158
Arlington	A-1	0	18	591	0	20	0	629
Arlington	A-2	10	106	2,281	4	40	0	2,440
Arlington	A-3	27	50	2,174	0	63	72	2,385
Arlington	A-4	0	0	1,694	0	0	0	1,694
Arlington	A-5	0	0	387	0	0	0	387
Arlington	A-6	37	408	558	36	20	7	1,066
Arlington	A-7	3	164	1,281	8	57	48	1,560
Arlington	A-8	170	66	6,781	0	395	0	7,412
Arlington	A-9	0	38	68	0	0	0	106
Arlington	A-10	0	212	194	0	0	0	406
Arlington	A-11	0	5	23	0	0	0	29
Arlington	A-12	195	487	5,462	8	167	206	6,526
Arlington	A-13	15	76	554	0	27	116	789
Arlington	A-14	0	207	1,735	0	0	0	1,942
Arlington	A-15	1	86	90	0	0	123	300
Arlington	A-16	95	0	767	0	3	1	867
Arlington	A-17	0	1	468	0	0	15	484
Arlington	A-18	0	0	17	0	0	3	20
Arlington	A-19	15	1	1,130	0	0	84	1,231
Arlington	A-20	4	57	21	0	0	36	119
Arlington	A-21	66	254	1,417	30	166	33	1,965
Arlington	A-22	94	94	1,181	6	1,025	0	2,401
Arlington	A-23	29	66	1,104	31	1,503	19	2,752
Arlington	A-24	412	47	3,254	11	687	35	4,444
Arlington	A-25	30	7	508	0	188	0	734
Arlington	A-26	48	37	368	16	348	0	818
Arlington	A-27	30	14	1,329	15	224	0	1,612

Basin	Sub-Watershed	Agriculture/ Parks/ Golf Course	Commercial/ Industrial/ Public Facilities	Open Space/ Dry Agriculture/ Water Body	High Density Residential Housing	Low Density Residential Housing	Medium Density Residential Housing	Total Area
		[acres]						
Arlington	A-28	0	0	35	29	6	0	70
Arlington	A-29	51	0	1,039	20	41	0	1,152
Arlington	A-30	0	0	233	0	15	0	248
Arlington	A-31	2	17	112	0	28	0	159
Arlington	A-32	11	79	1,929	12	259	0	2,290
Arlington	A-33	79	72	7,437	5	915	0	8,507
Arlington	A-34	0	9	776	0	2	0	787
Arlington	A-35	550	0	1,206	0	29	3	1,788
Arlington	A-36	0	1	85	0	4	0	91
Arlington	A-37	0	3	2,150	0	22	0	2,176
Arlington	A-38	0	3	50	0	8	0	61
Arlington	A-39	1	16	75	0	0	0	91
Arlington	A-40	0	0	3,158	0	0	0	3,158
Arlington	A-41	523	47	762	0	32	48	1,412
Arlington	A-42	0	30	34	0	0	0	64
Arlington	A-43	123	180	808	0	246	538	1,896
Arlington	A-44	0	4	76	0	1	0	81
Arlington	A-45	0	153	763	0	18	0	934
Arlington	A-46	0	35	85	0	1	0	121
Arlington	A-47	24	106	292	4	501	346	1,272
Arlington	A-48	3	835	1,058	0	6	0	1,902
Arlington	A-49	440	23	1,038	0	75	63	1,640
Arlington	A-50	39	4	38	0	123	0	204
Arlington	A-51	134	1	258	0	1	14	408
Arlington	A-52	488	246	2,230	17	2,876	37	5,893
Arlington	A-53	282	119	1,026	12	954	129	2,523
Arlington	A-54	89	1	33	0	10	6	137
Arlington	A-55	536	0	88	0	7	0	631
Arlington	A-56	211	211	554	1	578	395	1,949
Arlington	A-57	24	65	477	0	531	3	1,100
Arlington	A-58	342	14	251	0	414	42	1,064
Arlington	A-59	41	263	1,235	72	1,087	687	3,385
Arlington	A-60	75	1	73	2	333	136	619
Arlington	A-61	44	39	608	3	690	288	1,671
Arlington	A-62	165	0	38	0	28	0	230
Arlington	A-63	288	95	25	9	17	7	442
Arlington	A-64	369	383	124	38	86	449	1,449
Arlington	A-65	242	59	395	1	342	203	1,242
Arlington	A-66	206	445	2,035	43	466	827	4,022
Arlington	A-67	65	1,153	496	163	577	1,129	3,583
Arlington	A-68	11	1	2,500	0	127	20	2,659
Arlington	A-69	41	140	63	27	132	522	925
Arlington	A-70	19	117	19	17	10	186	368
Arlington	A-71	85	1,318	1,294	394	1,365	2,001	6,457
Arlington	A-72	1,040	596	288	109	195	845	3,073
Arlington	A-73	110	893	357	301	232	1,011	2,904
Arlington	A-74	80	235	94	5	27	205	645
Arlington	A-75	233	672	763	111	758	349	2,886
Arlington	A-76	297	0	2,974	0	8	0	3,279
Arlington	A-77	24	27	586	16	101	411	1,164
Arlington	A-78	28	15	1,021	66	13	211	1,354
Arlington	A-79	66	976	857	235	247	1,747	4,128
Arlington	A-80	4	244	238	11	6	105	607

Basin	Sub-Watershed	Agriculture/ Parks/ Golf Course	Commercial/ Industrial/ Public Facilities	Open Space/ Dry Agriculture/ Water Body	High Density Residential Housing	Low Density Residential Housing	Medium Density Residential Housing	Total Area
		[acres]						
Arlington	A-81	209	1,148	973	1	1,988	818	5,137
Arlington	A-82	2	5	289	0	104	119	519
Warm Springs	WS-1	23	175	544	41	103	195	1,082
Warm Springs	WS-2	0	0	238	0	0	0	239
Warm Springs	WS-3	14	0	127	0	0	0	141
Warm Springs	WS-4	15	14	9	0	0	0	38
Warm Springs	WS-5	148	18	275	0	35	0	476
Warm Springs	WS-6	6	0	506	0	0	0	513
Warm Springs	WS-7	23	0	602	0	0	0	626
Warm Springs	WS-8	12	28	1,441	6	716	0	2,203
Warm Springs	WS-9	0	0	552	0	0	0	552
Warm Springs	WS-10	0	0	182	0	21	0	203
Warm Springs	WS-11	3	25	283	1	2	0	314
Warm Springs	WS-12	20	241	945	0	225	50	1,481
Warm Springs	WS-13	0	15	1,905	4	107	0	2,031
Warm Springs	WS-14	0	0	435	0	0	0	435
Warm Springs	WS-15	0	0	305	0	0	0	305
Warm Springs	WS-16	2	27	575	0	105	0	709
Warm Springs	WS-17	0	7	30	0	25	2	64
Warm Springs	WS-18	62	46	126	8	208	34	483
Warm Springs	WS-19	8	201	2,985	7	222	125	3,548
Warm Springs	WS-20	0	1	327	0	15	0	343
Warm Springs	WS-21	0	5	32	0	0	0	37
Warm Springs	WS-22	0	8	333	0	215	0	556
Warm Springs	WS-23	0	1	516	0	148	0	666
Warm Springs	WS-24	0	0	312	0	2	0	314
Warm Springs	WS-25	0	0	177	0	0	0	177
Warm Springs	WS-26	0	0	1,061	0	11	0	1,072
Warm Springs	WS-27	0	0	174	0	8	0	182
Warm Springs	WS-28	0	1	291	0	17	0	309
Warm Springs	WS-29	0	73	295	0	5	0	373
Warm Springs	WS-30	0	0	223	0	0	0	223
Warm Springs	WS-31	0	0	1,091	0	36	0	1,127
Warm Springs	WS-32	0	5	124	0	0	0	129
Warm Springs	WS-33	13	570	1,100	0	38	11	1,731
Warm Springs	WS-34	0	0	545	0	0	0	545
Warm Springs	WS-35	12	4	644	0	59	0	719
Warm Springs	WS-36	0	0	314	0	0	0	314
Warm Springs	WS-37	190	446	3,252	13	59	538	4,497
Warm Springs	WS-38	0	0	259	0	0	0	259
Warm Springs	WS-39	0	0	12	0	0	0	12
Warm Springs	WS-40	0	0	210	0	0	0	210
Warm Springs	WS-41	0	6	509	0	3	9	527
Warm Springs	WS-42	3	0	674	0	0	0	677
Warm Springs	WS-43	11	0	1,407	0	0	0	1,419
Warm Springs	WS-44	118	9	354	0	13	5	498
Warm Springs	WS-45	0	4	45	0	0	0	49
Orange County	O-1	26	217	1,498	81	121	480	2,424
Orange County	O-2	0	8	1,059	0	8	43	1,118
Orange County	O-3	0	12	10	0	0	1	22
Orange County	O-4	295	39	875	0	2	110	1,322
Orange County	O-5	0	0	1,534	0	0	0	1,534
Orange County	O-6	0	0	701	0	0	0	701

Basin	Sub-Watershed	Agriculture/ Parks/ Golf Course	Commercial/ Industrial/ Public Facilities	Open Space/ Dry Agriculture/ Water Body	High Density Residential Housing	Low Density Residential Housing	Medium Density Residential Housing	Total Area
		[acres]						
Orange County	O-7	0	0	106	0	0	0	106
Orange County	O-8	0	0	783	0	0	0	783
Orange County	O-9	0	0	238	0	0	0	238
Orange County	O-10	0	0	823	0	0	0	823
Orange County	O-11	0	0	582	0	0	0	582
Orange County	O-12	0	0	401	0	0	0	401
Orange County	O-13	0	0	199	0	0	0	199
Orange County	O-14	0	0	866	0	0	0	866
Orange County	O-15	0	0	49	0	0	0	49
Orange County	O-16	0	0	523	0	0	0	523
Orange County	O-17	21	1	74	0	0	0	95
Orange County	O-18	337	82	1,172	44	3	16	1,654
Orange County	O-19	0	6	1,365	0	0	0	1,371
Orange County	O-20	0	29	304	0	5	26	364
Orange County	O-21	2	3	939	6	16	57	1,023
Orange County	O-22	33	110	929	65	97	474	1,707
Orange County	O-23	0	33	1,739	0	0	0	1,772
Orange County	O-24	0	0	480	0	0	0	480
Orange County	O-25	70	146	1,241	0	1	86	1,544
Orange County	O-26	3	142	244	47	17	105	558
Orange County	O-27	66	82	390	51	173	148	910
Orange County	O-28	67	431	553	156	74	402	1,683
Orange County	O-29	46	68	1,837	13	191	710	2,864
Orange County	O-30	152	248	255	126	51	700	1,532
Orange County	O-31	36	539	560	39	4	369	1,547
Orange County	O-32	47	909	214	57	45	502	1,774
Orange County	O-33	361	371	945	488	834	2,191	5,191
Orange County	O-34	147	1,516	247	243	245	2,506	4,904
Orange County	O-35	0	154	1	0	0	0	154
Orange County	O-36	31	1,125	72	232	54	1,266	2,781
Orange County	O-37	28	482	30	134	32	243	949
Orange County	O-38	84	140	44	93	16	302	678
Orange County	O-39	156	191	177	73	47	868	1,513
Orange County	O-40	529	1,649	965	359	1,159	3,504	8,167
Orange County	O-41	5	522	186	17	1	11	741
Orange County	O-42	3	8	5	1	0	62	78
<b>Total</b>		<b>44,552</b>	<b>129,465</b>	<b>356,838</b>	<b>20,075</b>	<b>66,918</b>	<b>123,258</b>	<b>741,105</b>

POTW and Non-Tributary Discharges

Water Year	Beaumont WWTP	YVWD H.N. Wochholz Water Recycling Facility	San Bernardino WRP	SB Geo 1, 3, 3a, and 4c	SB Geo 2, and 2a	Colton WWTP	RIX facility	Riverside RWQCP	Western Riverside County RWAP	OC-59	IEUA RP-1 001	IEUA RP-1 002 and RP-4	IEUA RP-2	IEUA RP-5	Carbon Canyon WRF	EMWD Regional WRFs	EVMWD Regional WWRF	Lee Lake WRF	Corona WWTP No. 1	Corona WWTP No. 3	Arlington Desalter
	[MGD]																				
2007	2.3	3.6	0.0	0.9	0.2	0.0	46.6	32.5	4.0	0.0	7.0	21.4	0.0	11.2	6.2	11.5	4.3	0.6	5.2	0.2	0.4
2008	2.5	3.6	0.5	1.4	0.1	0.0	44.5	31.8	5.3	0.0	5.3	17.8	0.0	10.9	7.2	9.6	0.7	0.4	3.1	0.2	1.3
2009	2.5	3.6	0.2	1.3	0.2	0.0	42.1	30.8	5.7	0.0	5.3	16.6	0.0	9.8	6.9	5.9	0.5	0.8	3.0	0.2	0.2
2010	2.6	3.7	0.5	1.0	0.2	0.0	41.7	30.2	5.7	0.0	4.0	15.2	0.0	7.2	6.4	4.4	0.8	0.8	1.5	0.2	0.1
2011	2.3	3.7	2.6	0.9	0.1	0.0	41.2	29.9	5.9	11.1	2.8	13.4	0.0	6.5	5.3	5.1	4.0	0.6	3.2	0.3	0.1
2012	2.6	3.7	0.1	0.7	0.1	0.0	39.8	28.8	5.7	0.0	2.3	10.7	0.0	6.4	4.6	1.1	0.7	0.7	2.8	0.2	0.1
2013	2.7	3.7	0.0	1.0	0.2	0.0	37.5	29.5	6.2	0.2	2.3	7.2	0.0	4.8	4.5	2.4	0.6	0.5	2.1	0.2	0.0
2014	3.0	3.7	0.2	0.8	0.2	0.0	35.5	27.0	6.4	0.0	2.6	6.2	0.0	2.8	3.2	0.0	0.6	0.5	1.6	0.0	0.0
2015	3.1	3.6	0.0	0.8	0.2	0.0	33.9	26.6	6.2	0.0	2.4	10.4	0.0	3.6	3.7	0.0	0.6	0.5	1.5	0.0	0.1
2016	3.1	3.7	0.0	0.8	0.1	0.0	34.6	25.9	6.8	11.5	2.4	8.3	0.0	2.6	2.9	0.0	0.6	0.5	5.8	0.0	0.1

**TDS Mass Balance in Reach 5 of the Santa Ana River overlying the Bunker Hill-B GMZ<sup>1</sup>**  
**(Water Year 2007 to 2016)**

Water Year	Inflow									Outflow								
	Direct Precipitation and Atmospheric Deposition			Surface Runoff			San Bernardino WRP			Streambed Percolation			Evapotranspiration			Downstream Outflow		
	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass
	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons
2007	5	57	0	9,220	161	2,019	14	498	10	7,119	145	1,400	19	0	0	2,085	219	620
2008	21	24	1	35,981	134	6,566	562	509	390	14,820	151	3,046	30	0	0	21,149	122	3,521
2009	20	19	1	23,432	136	4,344	263	488	174	9,925	145	1,956	19	0	0	13,509	130	2,387
2010	53	12	1	60,621	148	12,201	545	506	375	18,479	162	4,068	39	0	0	42,149	142	8,133
2011	100	10	1	147,477	159	31,847	2,906	526	2,078	32,526	161	7,142	53	0	0	114,972	158	24,704
2012	11	40	1	18,088	152	3,738	76	515	54	11,209	150	2,279	25	0	0	6,866	156	1,460
2013	11	37	1	16,025	143	3,126	13	517	9	10,039	146	1,999	23	0	0	5,976	139	1,127
2014	17	16	0	15,371	145	3,031	175	501	119	6,795	143	1,321	18	0	0	8,575	147	1,710
2015	17	19	0	16,990	132	3,047	0	504	0	8,043	136	1,485	18	0	0	8,949	128	1,562
2016	14	21	0	14,960	113	2,299	17	477	11	7,546	131	1,346	18	0	0	7,407	95	953
Annual Average	27	26	1	35,817	142	7,222	457	504	322	12,650	147	2,604	26	0	0	23,164	144	4,618

1. GMZ = Groundwater Management Zone

TIN Mass Balance in Reach 5 of the Santa Ana River overlying the Bunker Hill-B GMZ<sup>1</sup>  
(Water Year 2007 to 2016)

Water Year	Inflow									Outflow											
	Direct Precipitation and Atmospheric Deposition			Surface Runoff			San Bernardino WRP			Streambed Percolation			Evapotranspiration			Downstream Outflow			Denitrification		
	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass
	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons
2007	5	0.0	0	9,220	1.4	17	14	12.2	0	7,119	1.3	12	19	0.0	0	2,085	1.6	5	NA	NA	0
2008	21	0.0	0	35,981	1.7	81	562	13.0	10	14,820	2.0	41	30	0.0	0	21,149	1.4	40	NA	NA	0
2009	20	0.0	0	23,432	1.6	51	263	11.7	4	9,925	1.9	25	19	0.0	0	13,509	1.4	26	NA	NA	0
2010	53	0.0	0	60,621	2.0	168	545	14.5	11	18,479	2.0	51	39	0.0	0	42,149	2.0	117	NA	NA	0
2011	100	0.0	0	147,477	2.2	448	2,906	12.7	50	32,526	1.9	83	53	0.0	0	114,972	2.3	364	NA	NA	1
2012	11	0.0	0	18,088	1.2	30	76	15.2	2	11,209	1.4	21	25	0.0	0	6,866	1.0	9	NA	NA	0
2013	11	0.0	0	16,025	1.2	26	13	11.5	0	10,039	1.3	18	23	0.0	0	5,976	0.9	8	NA	NA	0
2014	17	0.0	0	15,371	0.8	16	175	13.6	3	6,795	1.0	9	18	0.0	0	8,575	0.6	7	NA	NA	0
2015	17	0.0	0	16,990	0.8	19	0	12.8	0	8,043	1.1	12	18	0.0	0	8,949	0.6	7	NA	NA	0
2016	14	0.0	0	14,960	1.2	24	17	10.8	0	7,546	1.5	15	18	0.0	0	7,407	0.9	9	NA	NA	0
Annual Average	27	0.0	0	35,817	1.4	88	457	12.8	8	12,650	1.5	29	26	0.0	0	23,164	1.3	59	NA	NA	0

1. GMZ = Groundwater Management Zone

TDS Mass Balance in Reach 4 of the Santa Ana River overlying the Colton GMZ<sup>1</sup>  
(Water Year 2007 to 2016)

Water Year	Inflow						Outflow								
	Direct Precipitation and Atmospheric Deposition			Surface Runoff			Streambed Percolation			Evapotranspiration			Downstream Outflow		
	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass
	[acre-ft]	[mg/L]	[tons]	[acre-ft]	[mg/L]	[tons]	[acre-ft]	[mg/L]	[tons]	[acre-ft]	[mg/L]	[tons]	[acre-ft]	[mg/L]	[tons]
2007	58	179	14	4,267	187	1,088	843	162	186	267	0	0	3,225	210	919
2008	131	84	15	29,484	111	4,464	1,557	129	273	451	0	0	28,155	120	4,596
2009	118	90	14	19,024	112	2,908	1,171	103	165	333	0	0	17,891	121	2,932
2010	243	47	16	53,365	125	9,078	1,805	129	316	585	0	0	51,739	130	9,153
2011	265	44	16	142,386	140	27,078	2,630	154	552	629	0	0	142,241	148	28,622
2012	91	120	15	11,182	134	2,038	1,249	128	217	409	0	0	9,685	143	1,889
2013	90	118	15	9,118	132	1,630	1,104	145	217	368	0	0	7,743	136	1,435
2014	127	81	14	13,585	135	2,499	1,041	130	184	285	0	0	12,553	143	2,448
2015	133	79	14	14,969	110	2,237	1,200	112	184	308	0	0	13,584	112	2,068
2016	125	83	14	11,754	84	1,337	1,102	106	159	326	0	0	10,459	85	1,203
Annual Average	138	93	15	30,913	127	5,436	1,370	130	245	396	0	0	29,727	135	5,526

1. GMZ = Groundwater Management Zone

**TIN Mass Balance in Reach 4 of the Santa Ana River overlying the Colton GMZ<sup>1</sup>**  
**(Water Year 2007 to 2016)**

Water Year	Inflow						Outflow											
	Direct Precipitation and Atmospheric Deposition			Surface Runoff			Streambed Percolation			Evapotranspiration			Downstream Outflow			Denitrification		
	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass
	[acre-ft]	[mg/L]	[tons]	[acre-ft]	[mg/L]	[tons]	[acre-ft]	[mg/L]	[tons]	[acre-ft]	[mg/L]	[tons]	[acre-ft]	[mg/L]	[tons]	[acre-ft]	[mg/L]	[tons]
2007	58	0.0	0	4,267	0.9	5	843	0.7	1	267	0.0	0	3,225	1.0	5	NA	NA	0
2008	131	0.0	0	29,484	1.1	43	1,557	1.6	3	451	0.0	0	28,155	1.3	49	NA	NA	0
2009	118	0.0	0	19,024	1.1	27	1,171	0.9	1	333	0.0	0	17,891	1.2	30	NA	NA	0
2010	243	0.0	0	53,365	1.7	121	1,805	1.4	3	585	0.0	0	51,739	1.8	128	NA	NA	0
2011	265	0.0	0	142,386	2.0	383	2,630	2.0	7	629	0.0	0	142,241	2.2	426	NA	NA	0
2012	91	0.0	0	11,182	0.7	10	1,249	0.8	1	409	0.0	0	9,685	0.8	11	NA	NA	0
2013	90	0.0	0	9,118	0.7	9	1,104	0.8	1	368	0.0	0	7,743	0.7	8	NA	NA	0
2014	127	0.0	0	13,585	0.4	8	1,041	0.5	1	285	0.0	0	12,553	0.6	11	NA	NA	0
2015	133	0.0	0	14,969	0.4	8	1,200	0.5	1	308	0.0	0	13,584	0.4	8	NA	NA	0
2016	125	0.0	0	11,754	0.6	10	1,102	0.7	1	326	0.0	0	10,459	0.7	9	NA	NA	0
Annual Average	138	0.0	0	30,913	1.0	62	1,370	1.0	2	396	0.0	0	29,727	1.1	68	NA	NA	0

1. GMZ = Groundwater Management Zone

TDS Mass Balance in Reach 3 & 4 of the Santa Ana River overlying the Riverside-A GMZ<sup>1</sup>  
(Water Year 2007 to 2016)

Water Year	Inflow																		Outflow								
	Direct Precipitation and Atmospheric Deposition			Surface Runoff			Colton WWTP			Rialto WWTP			RIX Facility			Rising Water			Streambed Percolation			Evapotranspiration			Downstream Outflow		
	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass
	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons
2007	18	218	5	10,519	153	2,191	0	0	0	7,654	478	4,976	44,537	489	29,627	25,718	804	28,115	40,515	671	36,941	255	0	0	47,625	432	27,964
2008	92	49	6	46,144	106	6,679	0	0	0	7,257	503	4,962	42,737	500	29,079	24,728	804	27,032	42,123	625	35,825	265	0	0	78,494	299	31,926
2009	82	51	6	34,245	95	4,437	0	0	0	6,958	487	4,604	40,214	474	25,925	23,247	804	25,427	38,933	633	33,524	241	0	0	65,504	302	26,870
2010	171	27	6	77,167	106	11,080	0	0	0	6,651	383	3,468	40,107	487	26,538	23,818	858	27,799	42,049	630	36,030	265	0	0	105,512	229	32,854
2011	397	14	7	183,168	122	30,505	0	0	0	6,829	222	2,057	39,333	491	26,261	26,164	893	31,763	48,237	614	40,277	298	0	0	207,176	179	50,311
2012	49	84	6	22,623	111	3,429	0	0	0	6,766	352	3,242	37,966	498	25,714	23,616	824	26,464	39,026	650	34,469	264	0	0	51,680	347	24,378
2013	55	73	5	20,962	118	3,367	0	0	0	6,649	361	3,261	35,391	506	24,337	22,375	805	24,504	37,009	644	32,429	250	0	0	48,130	352	23,041
2014	61	65	5	26,465	121	4,365	0	0	0	6,527	355	3,151	33,270	496	22,429	21,844	807	23,967	36,116	642	31,543	264	0	0	51,744	318	22,371
2015	99	41	5	32,097	93	4,072	0	0	0	6,285	386	3,300	31,641	505	21,730	21,368	808	23,489	35,971	633	30,969	251	0	0	55,216	288	21,620
2016	58	69	5	23,229	65	2,064	0	0	0	6,437	469	4,108	32,431	479	21,143	21,687	807	23,808	35,963	639	31,222	245	0	0	47,583	308	19,898
Annual Average	108	69	6	47,662	109	7,219	0	0	0	6,801	400	3,713	37,763	493	25,278	23,456	822	26,237	39,594	638	34,323	260	0	0	75,866	305	28,123

1. GMZ = Groundwater Management Zone

TIN Mass Balance in Reach 3 & 4 of the Santa Ana River overlying the Riverside-A GMZ<sup>1</sup>  
(Water Year 2007 to 2016)

Water Year	Inflow																		Outflow											
	Direct Precipitation and Atmospheric Deposition			Surface Runoff			Colton WWTP			Rialto WWTP			RIX Facility			Rising Water			Streambed Percolation			Evapotranspiration			Downstream Outflow			Denitrification		
	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass
	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons
2007	18	0.0	0	10,519	0.5	7	0	0.0	0	7,654	8.1	84	44,537	7.0	424	25,718	11.1	388	40,515	9.3	511	255	0.0	0	47,625	6.0	388	NA	NA	2
2008	92	0.0	0	46,144	0.9	54	0	0.0	0	7,257	8.2	81	42,737	7.2	421	24,728	11.2	376	42,123	8.8	502	265	0.0	0	78,494	4.0	427	NA	NA	2
2009	82	0.0	0	34,245	0.7	33	0	0.0	0	6,958	8.8	83	40,214	8.3	451	23,247	11.2	354	38,933	9.3	491	241	0.0	0	65,504	4.8	428	NA	NA	2
2010	171	0.0	0	77,167	1.3	133	0	0.0	0	6,651	8.8	79	40,107	7.3	397	23,818	10.4	338	42,049	8.1	462	265	0.0	0	105,512	3.4	482	NA	NA	2
2011	397	0.0	0	183,168	1.7	432	0	0.0	0	6,829	8.7	81	39,333	7.1	378	26,164	10.3	365	48,237	7.5	494	298	0.0	0	207,176	2.7	758	NA	NA	2
2012	49	0.0	0	22,623	0.5	15	0	0.0	0	6,766	9.5	87	37,966	7.2	370	23,616	10.4	334	39,026	8.5	453	264	0.0	0	51,680	5.0	350	NA	NA	1
2013	55	0.0	0	20,962	0.4	12	0	0.0	0	6,649	9.0	81	35,391	7.5	363	22,375	10.4	316	37,009	8.7	436	250	0.0	0	48,130	5.1	335	NA	NA	1
2014	61	0.0	0	26,465	0.4	14	0	0.0	0	6,527	9.1	81	33,270	9.2	414	21,844	10.4	309	36,116	9.1	447	264	0.0	0	51,744	5.2	369	NA	NA	2
2015	99	0.0	0	32,097	0.3	13	0	0.0	0	6,285	9.5	81	31,641	6.9	296	21,368	10.4	302	35,971	8.4	409	251	0.0	0	55,216	3.7	281	NA	NA	1
2016	58	0.0	0	23,229	0.4	13	0	0.0	0	6,437	9.3	81	32,431	7.9	347	21,687	10.4	307	35,963	8.8	429	245	0.0	0	47,583	4.9	317	NA	NA	1
Annual Average	108	0.0	0	47,662	0.7	72	0	0	0	6,801	8.9	82	37,763	7.5	386	23,456	10.6	339	39,594	8.6	463	260	0.0	0	75,866	4.5	414	NA	NA	2

1. GMZ = Groundwater Management Zone

TDS Mass Balance in Reach 3 of the Santa Ana River overlying the Chino-South GMZ<sup>1</sup>  
(Water Year 2007 to 2016)

Water Year	Inflow									Outflow								
	Direct Precipitation and Atmospheric Deposition			Surface Runoff			Riverside RWQCP			Streambed Percolation			Evapotranspiration			Downstream Outflow		
	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass
	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons
2007	30	147	6	54,517	573	42,464	36,375	599	29,638	21,967	603	18,023	520	0	0	68,389	581	54,071
2008	78	56	6	105,415	333	47,712	35,703	635	30,836	41,771	385	21,890	516	0	0	98,837	422	56,656
2009	81	54	6	88,857	347	41,908	34,541	644	30,223	37,722	406	20,821	500	0	0	85,192	443	51,307
2010	143	31	6	150,233	253	51,584	33,780	594	27,285	53,034	311	22,451	477	0	0	130,530	318	56,406
2011	180	24	6	268,084	202	73,777	33,487	605	27,530	92,713	244	30,700	504	0	0	208,455	249	70,585
2012	63	69	6	68,557	431	40,208	32,323	618	27,161	28,800	499	19,547	547	0	0	71,544	492	47,824
2013	60	73	6	62,953	438	37,465	33,094	626	28,180	28,928	500	19,661	530	0	0	66,596	508	45,989
2014	45	97	6	63,028	429	36,744	30,302	622	25,644	29,632	491	19,779	560	0	0	63,133	496	42,619
2015	119	37	6	78,489	342	36,517	29,766	622	25,192	35,688	419	20,330	536	0	0	72,092	422	41,380
2016	65	68	6	63,315	391	33,637	29,074	625	24,718	28,410	481	18,584	522	0	0	63,482	461	39,777
Annual Average	86	66	6	100,345	374	44,202	32,844	NA	27,641	39,867	434	21,179	521	0	0	92,825	439	50,661

1. GMZ = Groundwater Management Zone

TIN Mass Balance in Reach 3 of the Santa Ana River overlying the Chino-South GMZ<sup>1</sup>  
(Water Year 2007 to 2016)

Water Year	Inflow									Outflow											
	Direct Precipitation and Atmospheric Deposition			Surface Runoff			Riverside RWQCP			Streambed Percolation			Evapotranspiration			Downstream Outflow			Denitrification		
	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass
	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons
2007	30	0.0	0	54,517	7.7	570	36,375	9.8	486	21,967	8.7	260	520	0.0	0	68,389	8.3	775	NA	NA	19
2008	78	0.0	0	105,415	4.4	625	35,703	8.4	408	41,771	4.9	279	516	0.0	0	98,837	5.5	736	NA	NA	18
2009	81	0.0	0	88,857	4.9	586	34,541	9.8	462	37,722	5.7	293	500	0.0	0	85,192	6.4	736	NA	NA	19
2010	143	0.0	0	150,233	3.2	664	33,780	7.9	362	53,034	4.0	286	477	0.0	0	130,530	4.1	723	NA	NA	16
2011	180	0.0	0	268,084	2.7	980	33,487	7.9	359	92,713	3.2	405	504	0.0	0	208,455	3.2	916	NA	NA	17
2012	63	0.0	0	68,557	5.5	510	32,323	6.9	304	28,800	5.9	231	547	0.0	0	71,544	5.8	567	NA	NA	15
2013	60	0.0	0	62,953	5.6	479	33,094	7.3	326	28,928	6.0	236	530	0.0	0	66,596	6.1	554	NA	NA	15
2014	45	0.0	0	63,028	5.5	474	30,302	6.7	275	29,632	5.8	234	560	0.0	0	63,133	5.8	500	NA	NA	14
2015	119	0.0	0	78,489	4.1	438	29,766	6.8	276	35,688	4.7	230	536	0.0	0	72,092	4.8	470	NA	NA	13
2016	65	0.0	0	63,315	5.2	451	29,074	4.6	184	28,410	5.2	202	522	0.0	0	63,482	4.9	420	NA	NA	12
Annual Average	86	0.0	0	100,345	4.9	578	32,844	NA	344	39,867	5.4	266	521	0.0	0	92,825	5.5	640	NA	NA	16

1. GMZ = Groundwater Management Zone

**TDS Mass Balance in Reach 3 of the Santa Ana River overlying the Prado Basin GMZ<sup>1</sup>**  
**(Water Year 2007 to 2016)**

Water Year	Inflow															Outflow											
	Direct Precipitation and Atmospheric Deposition			Surface Runoff			Western Riverside County RWAP			Corona WWTP-1			Rising Water			Streambed Percolation			Evapotranspiration			OCWD Prado Wetland Diversion			Downstream Outflow		
	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass
	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons
2007	46	131	8	142,847	513	99,598	4,437	579	3,494	5,837	820	6,510	18,006	1,175	28,755	7,845	604	6,441	770	0	0	31,868	585	25,335	130,671	600	106,593
2008	135	45	8	199,019	378	102,421	6,002	560	4,566	3,512	715	3,412	17,664	909	21,834	7,878	572	6,125	763	0	0	35,082	522	24,878	182,558	408	101,243
2009	137	44	8	176,557	387	92,867	6,373	549	4,753	3,308	712	3,203	16,125	1,064	23,318	7,846	586	6,248	740	0	0	31,239	542	23,021	162,637	429	94,893
2010	246	25	8	253,777	278	95,895	6,404	532	4,630	1,708	699	1,624	17,668	1,079	25,929	7,864	520	5,558	706	0	0	37,358	469	23,813	233,805	311	98,715
2011	316	19	8	381,255	217	112,713	6,563	517	4,611	3,632	651	3,216	15,134	1,255	25,818	7,885	484	5,194	747	0	0	43,887	430	25,671	354,291	240	115,492
2012	114	53	8	137,173	416	77,623	6,435	518	4,536	3,139	658	2,808	14,881	1,040	21,033	7,865	573	6,129	810	0	0	31,034	520	21,949	122,010	470	77,938
2013	95	64	8	117,560	447	71,452	6,906	522	4,901	2,299	718	2,244	14,749	903	18,105	7,840	583	6,215	785	0	0	29,562	532	21,401	103,391	492	69,098
2014	69	88	8	101,939	456	63,268	7,114	532	5,143	1,822	693	1,717	14,749	908	18,202	7,837	600	6,389	828	0	0	25,836	556	19,537	91,169	504	62,418
2015	173	35	8	140,472	354	67,537	6,931	532	5,010	1,722	710	1,663	14,749	938	18,812	7,842	572	6,097	793	0	0	27,243	498	18,455	128,141	393	68,481
2016	105	58	8	122,754	386	64,485	7,601	524	5,410	6,530	682	6,056	14,802	903	18,170	7,859	580	6,201	772	0	0	26,287	524	18,716	116,836	436	69,210
Annual Average	144	56	8	177,335	383	84,786	6,477	536	4,705	3,351	706	3,245	15,853	1,017	21,998	7,856	567	6,060	771	0	0	31,940	518	22,278	162,551	428	86,408

1. GMZ = Groundwater Management Zone

TIN Mass Balance in Reach 3 of the Santa Ana River overlying the Prado Basin GMZ<sup>1</sup>  
(Water Year 2007 to 2016)

Water Year	Inflow															Outflow														
	Direct Precipitation and Atmospheric Deposition			Surface Runoff			Western Riverside County RWAP			Corona WWTP-1			Rising Water			Streambed Percolation			Evapotranspiration			OCWD Prado Wetland Diversion			Downstream Outflow			Denitrification		
	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass
	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons	acre-ft	mg/L	tons
2007	46	0.0	0	142,847	6	1,159	4,437	6.7	40	5,837	4.6	37	18,006	7.8	190	7,845	8.2	87	770	0.0	0	31,868	8	342	130,671	5.4	952	NA	NA	47
2008	135	0.0	0	199,019	4.1	1,116	6,002	2.4	20	3,512	5.0	24	17,664	4.3	103	7,878	6.9	74	763	0.0	0	35,082	6	299	182,558	3.4	850	NA	NA	42
2009	137	0.0	0	176,557	4.5	1,080	6,373	1.5	13	3,308	5.9	27	16,125	1.7	37	7,846	7.5	81	740	0.0	0	31,239	7	298	162,637	3.3	739	NA	NA	43
2010	246	0.0	0	253,777	3.1	1,063	6,404	0.0	0	1,708	5.1	12	17,668	4.1	99	7,864	5.8	62	706	0.0	0	37,358	5	266	233,805	2.6	811	NA	NA	37
2011	316	0.0	0	381,255	2.5	1,286	6,563	0.0	0	3,632	5.5	27	15,134	6.9	142	7,885	5.3	57	747	0.0	0	43,887	5	283	354,291	2.2	1,079	NA	NA	39
2012	114	0.0	0	137,173	4.3	797	6,435	1.3	12	3,139	6.6	28	14,881	3.7	75	7,865	6.1	65	810	0.0	0	31,034	6	233	122,010	3.5	583	NA	NA	34
2013	95	0.0	0	117,560	4.5	722	6,906	5.0	47	2,299	4.9	15	14,749	4.6	93	7,840	6.6	71	785	0.0	0	29,562	6	242	103,391	3.8	532	NA	NA	35
2014	69	0.0	0	101,939	4.4	610	7,114	3.7	36	1,822	7.7	19	14,749	4.6	93	7,837	6.9	74	828	0.0	0	25,836	6	212	91,169	3.6	442	NA	NA	32
2015	173	0.0	0	140,472	3.4	644	6,931	3.0	28	1,722	6.4	15	14,749	4.2	84	7,842	6.1	65	793	0.0	0	27,243	5	192	128,141	2.8	486	NA	NA	29
2016	105	0.0	0	122,754	3.4	573	7,601	2.3	24	6,530	6.0	54	14,802	4.1	82	7,859	5.5	59	772	0.0	0	26,287	5	175	116,836	3.0	473	NA	NA	27
Annual Average	144	0.0	0	177,335	4.0	905	6,477	2.6	22	3,351	5.8	26	15,853	4.6	100	7,856	6.5	69	771	0.0	0	31,940	6	254	162,551	3.4	695	NA	NA	36

1. GMZ = Groundwater Management Zone

TDS Mass Balance in Reach 2 of the Santa Ana River overlying the Orange County GMZ<sup>1</sup>  
(Water Year 2007 to 2016)

Water Year	Inflow						Outflow											
	Direct Precipitation and Atmospheric Deposition			Surface Runoff			Streambed Percolation			Evapotranspiration			OCWD Recharge Facilities Diversion			Downstream Outflow		
	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass	Flow	TDS Conc.	TDS Mass
	[acre-ft]	[mg/L]	[tons]	[acre-ft]	[mg/L]	[tons]	[acre-ft]	[mg/L]	[tons]	[acre-ft]	[mg/L]	[tons]	[acre-ft]	[mg/L]	[tons]	[acre-ft]	[mg/L]	[tons]
2007	129	216	38	140,184	566	107,975	1,496	238	483	1,454	0	0	136,603	575	106,867	618	622	523
2008	386	73	38	205,274	369	102,939	11,618	238	3,764	1,496	0	0	158,240	404	86,968	34,096	262	12,124
2009	433	65	38	188,197	379	96,936	10,508	243	3,467	1,474	0	0	145,699	414	82,080	30,743	271	11,326
2010	746	38	39	281,052	266	101,590	30,461	251	10,412	1,481	0	0	153,482	272	56,867	96,038	262	34,263
2011	897	32	39	418,018	209	119,007	55,950	219	16,676	1,575	0	0	182,681	189	47,027	178,130	227	55,079
2012	359	79	38	141,702	414	79,680	3,019	142	583	1,589	0	0	133,720	427	77,632	3,598	269	1,316
2013	211	133	38	116,235	446	70,531	1,553	35	75	1,485	0	0	113,217	457	70,295	80	175	19
2014	185	150	38	102,752	459	64,083	1,461	117	233	1,550	0	0	98,085	474	63,183	1,735	241	568
2015	480	59	38	152,213	343	70,970	4,388	185	1,104	1,550	0	0	136,741	358	66,601	9,855	242	3,239
2016	292	96	38	134,896	383	70,204	2,642	122	438	1,514	0	0	127,350	397	68,718	3,549	204	984
Annual Average	412	94	38	188,052	383	88,392	12,310	179	3,724	1,517	0	0	138,582	397	72,624	35,844	278	11,944

1. GMZ = Groundwater Management Zone

TIN Mass Balance in Reach 2 of the Santa Ana River overlying the Orange County GMZ<sup>1</sup>  
(Water Year 2007 to 2016)

Water Year	Inflow						Outflow														
	Direct Precipitation and Atmospheric Deposition			Surface Runoff			Streambed Percolation			Evapotranspiration			OCWD Recharge Facilities Diversion			Downstream Outflow			Denitrification		
	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass	Flow	TIN Conc.	TIN Mass
	[acre-ft]	[mg/L]	[tons]	[acre-ft]	[mg/L]	[tons]	[acre-ft]	[mg/L]	[tons]	[acre-ft]	[mg/L]	[tons]	[acre-ft]	[mg/L]	[tons]	[acre-ft]	[mg/L]	[tons]	[acre-ft]	[mg/L]	[tons]
2007	129	0.0	0	140,184	5.0	955	1,496	1.4	3	1,454	0.0	0	136,603	5.1	943	618	3.8	3	NA	NA	5
2008	386	0.0	0	205,274	3.1	857	11,618	1.0	16	1,496	0.0	0	158,240	3.6	782	34,096	1.1	52	NA	NA	4
2009	433	0.0	0	188,197	2.9	748	10,508	1.1	15	1,474	0.0	0	145,699	3.4	678	30,743	1.2	49	NA	NA	4
2010	746	0.0	0	281,052	2.2	828	30,461	1.1	47	1,481	0.0	0	153,482	3.0	619	96,038	1.2	154	NA	NA	7
2011	897	0.0	0	418,018	1.9	1,104	55,950	0.8	64	1,575	0.0	0	182,681	3.1	778	178,130	0.9	211	NA	NA	47
2012	359	0.0	0	141,702	3.1	590	3,019	0.7	3	1,589	0.0	0	133,720	3.2	576	3,598	1.2	6	NA	NA	3
2013	211	0.0	0	116,235	3.4	536	1,553	0.1	0	1,485	0.0	0	113,217	3.5	531	80	0.8	0	NA	NA	3
2014	185	0.0	0	102,752	3.2	445	1,461	0.3	1	1,550	0.0	0	98,085	3.3	440	1,735	0.5	1	NA	NA	3
2015	480	0.0	0	152,213	2.4	493	4,388	0.6	4	1,550	0.0	0	136,741	2.6	475	9,855	0.8	11	NA	NA	3
2016	292	0.0	0	134,896	2.6	478	2,642	0.5	2	1,514	0.0	0	127,350	2.7	469	3,549	0.6	3	NA	NA	3
Annual Average	412	0.0	0	188,052	3.0	703	12,310	0.8	15	1,517	0.0	0	138,582	3.3	629	35,844	1.2	49	NA	NA	8

1. GMZ = Groundwater Management Zone

**Streambed Percolation and TDS/TIN Mass  
(Water Year 2007 to 2016)**

Water Year	Reach 5 of the Santa Ana River overlying the Bunker Hill-B GMZ <sup>1</sup>			Reach 4 of the Santa Ana River overlying the Colton GMZ			Reach 3 & 4 of the Santa Ana River overlying the Riverside-A GMZ			Reach 3 of the Santa Ana River overlying the Chino-South GMZ			Reach 3 of the Santa Ana River overlying the Prado Basin GMZ			Reach 2 of the Santa Ana River overlying the Orange County GMZ		
	Flow	TDS Mass	TIN Mass	Flow	TDS Mass	TIN Mass	Flow	TDS Mass	TIN Mass	Flow	TDS Mass	TIN Mass	Flow	TDS Mass	TIN Mass	Flow	TDS Mass	TIN Mass
	acre-ft	tons	tons	acre-ft	tons	tons	acre-ft	tons	tons	acre-ft	tons	tons	acre-ft	tons	tons	acre-ft	tons	tons
2007	7,119	1,400	12	843	186	1	40,515	36,941	511	21,967	18,023	260	7,845	6,441	87	1,496	483	3
2008	14,820	3,046	41	1,557	273	3	42,123	35,825	502	41,771	21,890	279	7,878	6,125	74	11,618	3,764	16
2009	9,925	1,956	25	1,171	165	1	38,933	33,524	491	37,722	20,821	293	7,846	6,248	81	10,508	3,467	15
2010	18,479	4,068	51	1,805	316	3	42,049	36,030	462	53,034	22,451	286	7,864	5,558	62	30,461	10,412	47
2011	32,526	7,142	83	2,630	552	7	48,237	40,277	494	92,713	30,700	405	7,885	5,194	57	55,950	16,676	64
2012	11,209	2,279	21	1,249	217	1	39,026	34,469	453	28,800	19,547	231	7,865	6,129	65	3,019	583	3
2013	10,039	1,999	18	1,104	217	1	37,009	32,429	436	28,928	19,661	236	7,840	6,215	71	1,553	75	0
2014	6,795	1,321	9	1,041	184	1	36,116	31,543	447	29,632	19,779	234	7,837	6,389	74	1,461	233	1
2015	8,043	1,485	12	1,200	184	1	35,971	30,969	409	35,688	20,330	230	7,842	6,097	65	4,388	1,104	4
2016	7,546	1,346	15	1,102	159	1	35,963	31,222	429	28,410	18,584	202	7,859	6,201	59	2,642	438	2
<b>Annual Average</b>	<b>12,650</b>	<b>2,604</b>	<b>29</b>	<b>1,370</b>	<b>245</b>	<b>2</b>	<b>39,594</b>	<b>34,323</b>	<b>463</b>	<b>39,867</b>	<b>21,179</b>	<b>266</b>	<b>7,856</b>	<b>6,060</b>	<b>69</b>	<b>12,310</b>	<b>3,724</b>	<b>15</b>

1. GMZ = Groundwater Management Zone

## **APPENDIX A**

### **Comments and GEOSCIENCE Responses for Draft WLAM TM-2 (19-Sep-2017)**



**Comments and GEOSCIENCE Responses for Draft WLAM TM-2**

Commenter	No.	Section	Pg.	Comment	Response
IEUA/CBWM	G-1	General	-	Model appears to rely on a national database for several of its parameters. It is recommended that local data use be maximized and supplemented with national database parameters. More details are provided in TM-2 comments below.	Comment noted and is addressed through responses to comments below.
IEUA/CBWM	1	General	-	The work described in the RFP as Tasks 2e (stream flow volume from major stream segments), 2f (concentration and mass of TDS recharging from major streams), and 2g (concentration and mass of TIN recharging from major streams) was not reported in TM-2.	Stream flow volume and concentration and mass of TDS and TIN recharging from major streams was reported in TM-2 in Section 3.5.
IEUA/CBWM	2	2.3.4	7	Precipitation: The TM should compare the spatial/temporal estimates of precipitation to the gridded NEXRAD estimates on an annual basis to demonstrate that the recommended method of assigning precipitation estimate to the sub watershed is reliable and the best alternative. There is significant variability across the watershed year to year, and using a thirty-year average isohyetal map may not be the appropriate representation. There are gridded radar-based precipitation estimates that can be used to estimate precipitation on the watershed on daily and sub-daily time steps. These datasets may be more accurate than estimating based on a 30-year average annual isohyetal map. The comparison and recommendation of estimating precipitation should be provided in the TM for the task force’s review and concurrence.	<p>A comparison of NEXRAD precipitation and the recorded precipitation used for model calibration will be performed as part of Task 10.</p> <p>The PRISM 30-year average data were only used to develop precipitation adjustment factors for each subwatershed, following an industry standard approach. Since actual precipitation is used as model input, variations in local precipitation are represented. This methodology was clarified in Section 2.2.4.</p>
IEUA/CBWM	3	2.3.5	8	Evapotranspiration (ET): A regression is developed based on the statement that ET is a function of elevation. Solar radiation, wind, temperature, and humidity may vary with elevation at any point in time but elevation cannot be used to predict their individual values. The TM developed regression equations without discussing alternative approaches. The text uses “ET” and “evaporation” interchangeably– this should be corrected. There are two CIMIS stations in the upper watershed and one in the lower watershed with potential ET estimates based on solar radiation, temperature, humidity and wind – and not elevation. The TM does not provide a clear relationship between ET and elevation. The TM does not address why the CIMIS stations were not used and the scientific basis for the regression equations. It would be instructive for the TM to present elevation vs ET estimates from the various CIMIS stations in the southern California area and see how closely it matches the ET estimates used in the work documented in the TM. The TM reports the use of evaporation pans for four stations that were used to develop the regression equations. It is our understanding that only two of those stations have pan evaporation data during the entire calibration period. One station has no data during the calibration period, please clarify.	CIMIS stations were revisited and hourly reference evapotranspiration data were collected from the Pomona #78 and UC Riverside #44 CIMIS stations (see Section 2.2.5).
IEUA/CBWM	4	2.3.9	9	Rising Groundwater: There was no demonstrated attempt to develop rising groundwater estimates upstream of the Riverside Narrows or at Prado Dam. Attempting to mimic rising water by reducing streambed infiltration may not be the best or most accurate alternative. The impact of rising water on TDS concentration is very significant at the Riverside Narrows and at Prado Dam. The rising water contributions and their associated TDS and nitrogen concentrations can be estimated from available data. Please describe the alternatives of how to accurately address rising groundwater.	<p>Rising groundwater was based on groundwater model results, rather than an assumed (constant) value. This will reflect the local hydrology. Clarification of the rising water approach was provided in the revised TM No. 2 in Sections 2.2.8 (flow) and 2.2.9.3 (TDS/TIN).</p> <p>Rising water was also added between Upper Temescal Valley and Temescal Basin, based on the September 2017 report from Eastern Municipal Water District (WEI, 2017).</p>

**Comments and GEOSCIENCE Responses for Draft WLAM TM-2**

Commenter	No.	Section	Pg.	Comment	Response
IEUA/CBWM	5	General	-	General Comment. Both the Wildermuth Environmental, Inc. (WEI) and Geoscience modeling work are referenced throughout the report – in text and exhibits. Both are referred to as the WLAM. A timeframe is generally used to distinguish between the two models, but not consistently. The WEI model is interchangeably referred to as WLAM, 2008 WLAM, existing 2008 WLAM, R4 model, and R4 computer code. The Geoscience work is referred to as WLAM, “this WLAM”, “updated WLAM”, “WLAM update”. For clarity, we recommend using a single unique name for each and using those consistently throughout to improve clarity for the reader.	The WEI model is called the “2008 WLAM” (or “2004 WLAM”, where appropriate) and the GEOSCIENCE model is referred to as “2017 WLAM HSPF”.
IEUA/CBWM	6	1.1	1	Page 1, Paragraph 1. The text states that Geoscience was retained to “update, calibrate and apply the Wasteload Allocation Model (WLAM)...”. It is our understanding that Geoscience was going to be developing and implementing a whole new model platform (HSPF) for the Waste Load Allocation analysis, not updating the old model. Please clarify.	Text was clarified in Section 1 pg 1 to reflect that the Waste Load Allocation Model (WLAM) was updated by developing and calibrating a watershed model using the Hydrological Simulation Program - Fortran (HSPF) computer code (i.e., 2017 WLAM HSPF).
IEUA/CBWM	7	1.2	2	Page 2, Paragraph 3. The R4 model was never applied by WEI for the wasteload allocation work; and R4 was developed prior to 2008.	Text was corrected.
IEUA/CBWM	8	1.2	2	Page 2, Paragraph 4. Please clarify if the WEI version of the WLAM was updated and recalibrated, or if a new model was constructed and calibrated for this study.	The 2008 WLAM was originally updated with 2012 land use for comparison/validation, but it was not recalibrated. Text was added to summarize this initial comparison, per Risk Science's comment #13, in Section 2.3.1.
IEUA/CBWM	9	2.1.1	3	Page 3, Section 2.1.1, Paragraph 1. The comparison to R4 is incorrect. It should be compared to the 2008 WLAM.	Reference to the R4 code was removed.
IEUA/CBWM	10	2.2	4	Page 4, Section 2.2, Paragraph 3. Beyond this brief paragraph, there is no other discussion of the RFM or presentation of modeling showing interaction or its result of OCWD recharge basins.	Additional explanation was added in Section 2.2.6.5.
IEUA/CBWM	11	2.3	4	Page 4, Section 2.3, Last sentence. This may be misleading. TM-1 very generally describes the data collection process, but does not provide or present the data for anything other than land use and soil types.	Comments addressed on TM-1 satisfies this comment as well. Revised TM-1 was submitted on March 9, 2018 and now provides raw data collected for the 2017 WLAM HSPF.
IEUA/CBWM	12	2.3.2	5	Page 5 and Table 1. Soil group and infiltration rate. Infiltration rate values are significantly lower compared to the values recommended in the HSPF user guide. The procedure to estimate initial infiltration rate should be discussed in detail. Table 1 should include an infiltration index, as well as initial and final calibrated infiltration rates for each sub-watershed.	Additional detail was added regarding the procedure to estimate initial infiltration rates in Section 2.2.3. All values are within the possible range listed in EPA Basins Technical Note 6 (Estimating Hydrology and Hydraulic Parameters for HSPF, July 2000) of 0.001-0.50 in/hr (provided in Table 1).
IEUA/CBWM	13	2.3.3	7	Page 7 – Inset Table on Land Use % Pervious. The pervious area percentages presented in this table may not be representative of the development in the Santa Ana River watershed. Most of the development that has occurred between the 1980s and 2010 were at higher densities than prior 1980. This means a simple national average reported by Aqua Terra may not be representative in the Santa Ana River watershed. Please provide additional clarification to demonstrate the applicability of information in the table.	The Aqua Terra report is from modeling done in Ventura County, southern California. In addition, the pervious percentages compare similarly to those listed in the Riverside County Flood Control and Water Conservation District and San Bernardino County Hydrology Manuals, as well as those used in the 2004 WLAM and 2008 WLAM. Table 2-1 was added to Section 2.2.3, which compares the pervious percentages used in the studies listed above.
IEUA/CBWM	14	2.3.4	7	Page 7, Section 2.3.4. The method used to estimate daily precipitation may not be appropriate. Given that there is significant variability across the watershed from year to year, it may be more appropriate to use an annual isohyetal map for each year in the calibration period instead of using a 30-year average isohyetal map. There are gridded radar-based precipitation estimates that can be used to estimate precipitation on the watershed on daily and sub-daily time steps. Please provide a comparison of a subset of your sub-watershed estimates to the gridded NEXRAD estimates to demonstrate this method is reliable and the best alternative.	The PRISM 30-year average data were only used to develop precipitation correction factors for each subwatershed. The precipitation adjustment factors were then used to assign daily precipitation data from precipitation stations across the watershed area to the individual subwatersheds delineated in the HSPF model. This is an industry standard approach. Since actual precipitation is used as model input, variations in local precipitation are represented. This methodology was clarified in Section 2.2.4.

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Commenter	No.	Section	Pg.	Comment	Response
IEUA/CBWM	15	2.3.6	9	Page 9. Section 2.3.6. Seven Oaks Dam outflow was used as boundary inflow. Please explain how will the future Seven Oaks Dam operation will be handled.	Based on conversations with Valley District, the existing control manual is the underlying assumption for now. The assumptions for future scenarios will be provided in the predictive scenarios TM (TM-3). Seven Oaks Dam outflow was discussed in Section 2.2.6.1.
IEUA/CBWM	16	2.3.7	9	Page 9, Section 2.3.7. There is no mention of the stormwater diversions to spreading basins or how they were used. Please explain if/how these diversions were included in the model. If they were not included, please explain. Also, there is no information in TM-1 or TM-2 describing the stream system characteristics, just that they were considered and their associated properties were developed from a national database. Please describe how urban storm drainage system data were used.	Spreading basins were handled outside of the HSPF model because actual percolation data was obtained. This was clarified in the text in Section 2.2.6.3.
IEUA/CBWM	17	2.3.8	9	Page 9, Section 2.3.8. This section describes the non-tributary discharge from POTWs. Please explain if this is comprehensive in including other non-tributary discharges, and how they are accounted for in the model.	Non-tributary discharge from Eastern Municipal Water District and OC-59 was added to the text (Section 2.2.6.2). In addition, flows from the San Bernardino geothermal plant and Arlington Desalter were also included in the model.
IEUA/CBWM	18	2.3.9	9-10	Page 9/10, Section 2.3.9. Please clarify the approach to modeling rising groundwater. Our understanding is that the model parameters are adjusted to mimic rising water by reducing streambed infiltration. If this is the case, what will be the resulting impact to the estimation of TDS and TIN in streambed infiltration and surface flow downstream of the rising water areas? The impact of rising water on TDS concentration is significant at Prado Dam and for this reason, this method may not be appropriate.	Modeling approach to rising groundwater was clarified in Sections 2.2.8 (flow) and 2.2.9.3 (TDS/TIN). Mass was added at locations of rising groundwater according to the groundwater flow model-calculated rising water.
IEUA/CBWM	19	3.1	12	Page 12, Section 3.1, Paragraph 2. Please explain why the calibration period of WY 2007 through WY 2016 was selected. Why not a longer calibration period?	This calibration period represents an appropriate time period for calibration to 2012 land use. Explanation was added in Section 3.0.
IEUA/CBWM	20	3.3, 3.4	13	Page 13, Section 3.3/3.4 (Figures 15 through 32). Please provide clarity on the purpose of comparing the old (2008 WLAM) and new model (2017 WLAM-HSPF) calibration results in these figures if each calibration effort is based on completely different calibration time periods/data sets?	The purpose of comparing the 2008 WLAM results with the HSPF model results is to ensure model calibration performance is consistent with previous work. This was stated in Section 3.3.
IEUA/CBWM	21	3.4	16	Page 16, Inset Table. The residual values for TDS seem misleading given the large range in positive and negative residuals seen in Figures 51 through 53. Please provide a table that compares the measured versus modeled data and the residual calculations more explicitly.	New rows and columns were added in Table 3-5 showing residuals as a percentage of observed TDS and TIN concentrations, standard deviation, and RMSE in response to comments during the Task Force meeting. Monthly statistics were provided as well in Table 3-6.
IEUA/CBWM	22	3.4		The mean residual error approach used to evaluate the calibration for TIN and TDS is unclear. Please provide further explanation of how the quality of the calibration was assessed. Review of TM-2 Figures 51 and 52 show that there are large positive and negative values and the resulting near zero residuals is caused by compensatory errors that cancel each other out. The residual error does explain systematic error.	Clarification was added and standard deviations were included in Tables 3-5 and 3-6.
IEUA/CBWM	23	General	-	We recommend that a peer review be conducted prior to using the model for planning or wasteload allocation scenarios evaluation. Due to the comments above, and the fact that the WLAM is 1) Being updated with substantially different information and methods, and 2) Being moved to a new model platform, it is recommended that the model undergo a peer review. A peer review at this critical juncture will provide the modeler and the BMP TF with a defensible foundation, and build confidence in this significant modeling effort. It is critical that the new WLAM replicate the functionality and accuracy of the most recent WLAM.	Comment noted. A peer review meeting was held on November 16, 2017 to review the detailed technical work. GEOSCIENCE will continue to work with the technical group for any further peer review deemed necessary.

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Commenter	No.	Section	Pg.	Comment	Response
OCWD	1	2.2	4	Section 2.2, Watershed Model Development – it is not clear if the stormwater runoff in the green shaded area in Figure 5 is accounted for in the model. The green shaded area includes flow that would be conveyed to the SAR through the Carbon Diversion Channel, Fletcher Channel, and some other small tributaries to the SAR that are located between OCWD’s Imperial Highway inflatable dam and Santiago Creek. OCWD’s Recharge Facilities Model does not simulate runoff in the green shaded area. Please provide more discussion of the modeling of stormwater runoff in the green shaded area in Figure 5.	The area shaded in green is accounted for in the model. Explanation was added in Section 2.2.6.5 and Figure 13 (formerly Figure 5) was clarified as well.
OCWD	2	Figures	Figure 2	For Figure 5, please add a legend for the symbols	Legend was added (now Figure 13).
OCWD	3	2.3.8	9	Section 2.3.8, Wastewater Discharge – add a table showing the wastewater discharge for each facility per year	Discharge data was provided in the revised TM-1 (dated March 9, 2018) as Appendix B.
OCWD	4	2.3.8	9	Section 2.3.8, Wastewater Discharge – is there no discharge by Eastern MWD at their discharge point to Temescal Creek?	Non-tributary discharge from Eastern Municipal Water District and OC-59 was added to the text in Section 2.2.6.2. In addition, flows from the San Bernardino geothermal plant and Arlington Desalter were included in the model.
OCWD	5	General	-	A water budget summary table should be included – among other items, the table should list total runoff, total wastewater discharge, total unmanaged streambed infiltration, total managed infiltration (such as OCWD managed infiltration, and other agencies if it can be accounted for), total evapotranspiration, rising groundwater at Riverside Narrows, rising groundwater in Prado Basin, and total outflow at the downstream model boundary; the table should list the above terms by year; the table should be used to demonstrate that all the water in the system is accounted for from a mass balance perspective on an annual basis.	Water budgets were provided in Tables 4 through 15
OCWD	6	2.3.9	10	Section 2.3.9, Rising Groundwater – text should be added to describing how the rising groundwater rate was estimated at the two locations; reference is made in the text to Figure 10, but it is not clear from Figure 10 where the rising groundwater is specified; please include additional features on Figure 10 to specify where rising groundwater is defined in the model;	Explanation was added in Sections 2.2.8 (flow) and 2.2.9.3 (TDS/TIN). An additional figure (Figure 14) was also added showing the location of rising water.
OCWD	7	2.3.10.2	10	Section 2.3.10.2, OCWD Wetlands – the TIN of effluent from the OCWD Prado Wetlands should be varied seasonally – the winter time nitrate removal rate is lower than the summer time removal rate. For May-October, a TIN effluent of 1 mg/L is appropriate; for November-April, 4 mg/L is appropriate.	The effluent concentrations were varied seasonally as suggested. This is mentioned in Section 2.2.9.4
OCWD	8	3.3	15	Section 3.3, Streamflow Calibration Results – the R2 values should be included in the table on page 15.	R2 values were added were added to Tables 3-1 and 3-2 for flow calibration.
OCWD	9	3.3	15	Section 3.3, Streamflow Calibration Results – in the table on page 15, the monthly streamflow calibration is listed as ‘very good’ for both the 2008 WLAM and the WLAM Update for the Prado Inflow – in looking at Figure 31, the 2008 WLAM calibration result is noticeably better than the WLAM Update – since (1) Prado Dam is where runoff in the upper Santa Ana Watershed collects before flowing to the lower Santa Ana Watershed, (2) Water Quality Objectives are identified for Reach 2 and 3 in the Regional Board’s Basin Plan, and (3) Reaches 2 and 3 are demarcated at Prado Dam, additional attention should be given to the WLAM Update calibration results at Prado Dam. OCWD is not yet ready to use the WLAM Update for assessing future conditions until more evaluation is given to the calibration shown in Figure 31.	Model calibration at Prado Dam was revisited. Updated model calibration results are presented in the revised TM-2 in Tables 3-1 and 3-2.

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Commenter	No.	Section	Pg.	Comment	Response
OCWD	10	3.3	13	Section 3.3, Streamflow Calibration Results – it would be helpful to have more discussion of the parameters that were changed for calibration – for example, discussion could be added to explain the degree to which each parameter was changed, and whether it was changed throughout the model or in certain areas; this should be added to Section 3.3, or an earlier section.	Additional discussion was added in Section 3.1.
OCWD	11	3.3	15	Section 3.3, Streamflow Calibration Results – the daily streamflow calibration for the WLAM Update is listed as ‘poor’ for the SAR at Santa Ana – the reason for the poor calibration should be described in greater detail.	The poor calibration for daily streamflow at Santa Ana River at Santa Ana is a product of the modeling process. Flow at this location is largely from the OCWD recharge facilities model, which simulated Prado Dam operations. Actual releases from Prado may be different, which causes a discrepancy between the modeled and observed streamflow at this location. Explanation was added in Section 3.3 and Section 4.0.
OCWD	12	3.4	16	Section 3.4, TDS and TIN Calibration – the table showing the residuals on page 16 should also include the residuals calculated on a percentage basis.	The percentage was added to Tables 3-5 and 3-6.
OCWD	13	3.4	16	Section 3.4, TDS and TIN Calibration – the evaluation of the flow calibration uses the methodology of Donigian (2002) to categorize the calibration performance; is there a similar methodology for the calibration of TDS and TIN that can be used to categorize the residuals?	There is no similar way to categorize calibration performance for TDS/TIN. However, per other comments, additional statistics (e.g., RMSE) were added to the tables in Section 3.4 (Tables 3-5 and 3-6).
OCWD	14	3.4	16	Section 3.4, TDS and TIN Calibration – it would be helpful to have more discussion of the parameters that were changed for calibration – for example, discussion could be added to explain the degree to which each parameter was changed, and whether it was changed throughout the model or in certain areas; a brief amount of text is already included for the nitrogen reaction rate coefficients, but discussion should be added for the other parameters that were changed.	Additional discussion was added in Section 3.1.
OCWD	15	General	-	General document formatting comment – the tables that are imbedded in the text are not numbered (for example, there is no table number for the table on page 16); these tables are some of the most important tables in the document and will be referred to frequently; these tables should be numbered for ease of reference.	Tables were numbered and listed in the Table of Contents.
Risk Sciences	1			Please describe how dam operations (7 Oaks & Prado) are handled when calibrating the flow model. Need to note that ACOE does not always follow their own formal operating rules for the dams and that there is no way to predict these deviations in the WLAM. This is especially important for the 2010-11 wet season.	Additional explanation on Seven Oaks and Prado dam outflows was added to the text in Sections 2.2.6.1 and 2.2.6.5, respectively.
Risk Sciences	2			Please describe in greater detail the flow and water quality data provided by the POTWs. Was this data assumed to be QA/QC'd by the provider or did Geosciences do additional QA/QC on the data? Did POTWs provide daily data for TIN & TDS or were the monthly averages assigned to all days in each month?	This comment was partly addressed in the revised TM-1 (Section 3.0). Additional description on how data was applied in the model was provided in the revised TM-2.
Risk Sciences	3			There are significant discharges from the San Bernardino's geothermal plant to Warm Creek. These do not appear to be accounted for in the model calibration and may explain some of the discrepancy at this station.	Discharges from the geothermal plant were incorporated in the 2017 WLAM HSPF.
Risk Sciences	4			Discharges from Eastern Municipal Water District are not depicted on several figures including: Fig. 12, Fig. 35 & Fig. 43 (and there may be others). EMWD is also not listed among the POTW discharges described in Section 2.3.8 on pg. 9 of the report.	Discharges from EMWD were included in the 2017 WLAM HSPF.
Risk Sciences	5			On occasion, under certain extreme wet weather conditions, the Cities of San Bernardino and Colton may discharge directly to the river rather than sending secondary effluent to RIX for filtration. Although rare, these discharges may be confounding the calibration. Please check with POTWs for more details regarding these events.	Direct discharges from RIX were included in the 2017 WLAM HSPF.

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Commenter	No.	Section	Pg.	Comment	Response
Risk Sciences	6			Historically, SBVMWD has operated a dewatering discharge of approximately 6.3 cfs. This does not appear to be accounted for in the calibration. Please check with Valley District to determine if the discharge is still occurring.	No dewatering discharge occurred during the model calibration period. This has been added to the discussion in Section 2.2.6.2.
Risk Sciences	7			Historically, there was up to 7.9 cfs of discharge from the Arlington Desalter. This does not appear to be accounted for in the calibration and may explain some of the discrepancy at Temescal Creek. Please check with SAWPA to better characterize these flows.	Discharges from the Arlington Desalter were included in the 2017 WLAM HSPF.
Risk Sciences	8			Please indicate whether salinity data was originally provided as TDS (mg/L) or Electrical Conductivity (uS/cm) and what conversion factor was used to translate between these different measurement units.	TDS was provided in mg/L. This was added in Section 2.2.9.
Risk Sciences	9			Please prepare a table summarizing key similarities and differences between the 2002 WLAM, the 2015 WLAM (Scenario 8) and the 2017 WLAM including, but not limited to, the following categories: land use data, precipitation data, gauge data, number of sub-areas, POTW data, soil data, evaporation stations, nitrogen reaction coefficients, calibration period, calibration endpoints (R2, RMSE, other), etc.	Table 2-3 was created summarizing differences between the 2004, 2008, and 2017 WLAMs.
Risk Sciences	10			Please describe why Geosciences elected to estimate local rainfall using the Prism contours rather than the Thiessen Polygon approach used in the previous WLAM.	Additional explanation was added in Section 2.2.4.
Risk Sciences	11			The new and prior WLAM presume that TIN concentration in water leaving the Prado Wetlands (operated by OCWD) is 1 mg/L (see pg. 13). Do we have data to defend that conclusion? If so, it should be cited in a reference. Perhaps OCWD has better data with higher resolution under a wider variety of input conditions. This may improve the TIN calibration at Prado Dam.	Per the recommendation of OCWD (comment #7), TIN effluent concentrations are 1 mg/L from May through October and 4 mg/L from November through April. Explanation was added to the text in Section 2.2.9.4.
Risk Sciences	12			The WLAM should probably be revised to treat the Prado Wetlands as a discrete impoundment so that the model can better account for the minor evapotranspiration losses that occur for river flows diverted through those ponds. This will probably improve the TDS and flow calibration at Prado Dam.	A separate impoundment was created to account for additional evapotranspiration from the wetlands and removal of TIN. An additional section was added to the text to describe this addition in Sections 2.2.6.4 (flow) and 2.2.9.4 (TDS/TIN).
Risk Sciences	13			Please provide a new subsection describing the side-by-side analyses of the 2015 (Scenario 8) WLAM vs. the HSPF model for the upper Santa Ana Watershed that Geosciences performed at the outset of this effort.	A new section (Section 2.3.1) was added to describe the initial comparison made by applying HSPF to the existing 2008 WLAM.
Risk Sciences	14			For all tables showing the relative percent error between modeled and observed scores, please add a footnote indicating how the percent error was calculated and whether a negative valence indicates that the model is over- or under-estimating in relation to the measured value.	A footnote was added to all tables in Section 3.0.
Risk Sciences	15			Please add text explaining that the HSPF model is used to calculate precipitation runoff in Reach 2 of the Santa Ana River (see green area in Fig. 5). OCWD's RFM model is only used as an accounting tool to track diversions and recharges not to estimate runoff from adjacent land areas.	Explanation was added in Section 2.2.6.5.
Risk Sciences	16			Please add text explaining that variance at very low flows may be partially explained by sensitivity and precision of the gages at their detection limits (e.g. 0.1 cfs - 1.0 cfs). See Fig. 26 for example.	Explanation was added in Section 4.0.
Risk Sciences	17			IUEA's RP-2 treatment plant was decommissioned in about 2002. The loss of perennial flows probably altered the subsequent streambed percolation rates in Chino Creek. This may explain some of the calibration problems at this station.	Explanation was added in Sections 3.3 and 4.0.
Risk Sciences	18			Figure 22 and Figure 33 are entitled: "Inflow to Prado." This is somewhat confusing. Since the USGS gage is located below Prado Dam (in Reach 2 of the SAR), is this really referring to "Outflow from Prado?"	Inflow to Prado Dam was used to avoid discrepancies caused by dam operations. Text was clarified in Section 3.1.

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Commenter	No.	Section	Pg.	Comment	Response
Risk Sciences	19			Neither the old nor the new WLAM explicitly account for dry weather urban runoff caused by return flows from landscape or crop irrigation. At some times and places such flows can be quite large. In addition, there is a long-term declining trend in such flows in response to conservation efforts. If there is no way to account for these flows, then the text should acknowledge their existence and indicate that this may explain some of the discrepancy between measured and observed values particularly in dry weather, low flow conditions.	A discussion about dry weather urban runoff was added in Sections 3.3 and 4.0.
Risk Sciences	20			Figures 51 thru 56 present daily water quality data. Similar graphs should be prepared showing the relationships based on monthly averages.	Monthly water quality figures were generated and statistics are summarized in Table 3-6.
Risk Sciences	21			Please describe how the new WLAM accounts for diversion of dry weather flows and stormwater flows to off-channel recharge basins (esp. in San Bernardino County).	Additional explanation was added in Section 2.2.6.3.
Risk Sciences	22			Please provide a more detailed explanation of the decision criteria used to include or exclude data from rainfall gaging stations. Why did Geosciences use far fewer precipitation stations than were used in the previous WLAM (see Section 2.3.4 on pg. 7 of the report)?	Additional explanation was added in Section 2.2.4.
Risk Sciences	23			It appears that there are very little TIN data available at most gaging stations. It may be possible to augment this dataset by computing a synthetic TIN value by summing the value of Ammonia + Nitrate + Nitrite. Nitrite is not critical to this computation as the concentration is usually very small.	TIN data was augmented by including measurements of Ammonia + Nitrate + Nitrite (also acknowledged in revised TM-1, Section 2.6). This was stated in Section 2.2.9.
Risk Sciences	24			Please describe what TIN and TDS concentrations were assumed for mountain runoff and wet weather urban runoff and dry weather urban runoff? What was the scientific basis for these assumed values? Please provide relevant reference citations.	Additional explanation was added in Section 2.2.9.1. Calibrated average annual concentrations are also shown on Figures 84-89.
Risk Sciences	25			Please add text explaining the unavoidable discrepancies associated with delays between the rainfall event and when the runoff reaches a gage. For example, rainfall that begins late at night one day and flow gage data that spikes the following day. This is why the monthly data generally calibrates better than the daily data. Add text noting that, given the primary use of the WLAM (e.g. to protect groundwater quality), calibration to a monthly time step is more than adequate to implement Basin Plan objectives (note: groundwater objectives are calculated as a 20-year average and recharge compliance is computed using a 10-year average). It should also be noted that we rarely have accurate daily data for some non-tributary discharges (e.g. OC-59 deliveries of SPW)	Additional explanation was added to Section 4.0.
Risk Sciences	26			Please add text describing the significant channel improvements that have been made to San Timoteo Creek over the last 10 years and note the impact this has on the model calibration. See Fig. 33. Note: San Timoteo is misspelled as "San Temoteo" in numerous places throughout the document.	Channel improvements were discussed in Sections 3.3 and 4.0. San Timoteo spelling was corrected.
Risk Sciences	27			Please provide a more detailed description of the precise methods used to account for the amount of flow, and related water quality of those flows, for rising groundwater at the Riverside Narrows and at Prado Dam. Compare and contrast the method(s) used by Geosciences to that used in the previous WLAM. Discuss Pros and Cons of both methods and, in particular, how the different methods may affect subsequent calculations required by the RFP-SOW for this project (e.g. Task 3b: volume and quality of water recharging to each individual aquifer through streambed percolation from each surface segment of the river).	Additional discussion was added in Section 2.2.8.

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Commenter	No.	Section	Pg.	Comment	Response
Risk Sciences	28			It may be appropriate to do some formal outlier analysis for those data points where the model estimates and the observed values differ by more than two orders of magnitude (see, for example, Figures 32, 35, 36 & 41). Such discrepancies seem quite large even if the overall average relative percent difference is small. Large differences in both directions tend to cancel each other out and give the illusion that the overall error is small when it is not. This analysis should focus on only the most extreme deviations which would have the greatest adverse effect on R2 values. For example, in Figure 37, there seem to be several instances where the model predicts flows in the 0.1 to 1.0 cfs range but the measured flows range from 10 to 100 cfs. This may be an example of where the model cannot account for excess irrigation runoff in the Arlington orchard area that ultimately drains to Temescal Creek.	A formal outlier analysis was performed and additonal discussion was added as Section 3.3.1.
Risk Sciences	29			Please provide a detailed forensic analysis of how the prior WLAM was able to achieve an acceptable R2 value at San Timoteo when the new WLAM did not.	Additional discussion was added in Section 3.3.
Risk Sciences	30			Please provide a detailed forensic analysis of how the prior WLAM was able to achieve an acceptable R2 value at Chino Creek (Schaefer Ave.) when the new WLAM did not. Figure 20 appears to indicate that the old WLAM established a minimum flow and truncated all model estimates below that threshold.	Additional discussion was added in Section 3.3.
Risk Sciences	31			Please provide a detailed forensic analysis of how the prior WLAM was able to achieve an acceptable R2 value at Temescal Creek when the new WLAM did not. Figure 15 appears to indicate that the old WLAM established a minimum flow value and truncated all model estimates below that threshold.	Additional discussion was added in Section 3.3.
Risk Sciences	32			Please provide a reference citation for the "Standards and Guidelines" for calibrating HSPF models that is described on page 3 of the report.	Reference for EPA (2000) was added.
Risk Sciences	33			Please provide a more detailed explanation of the steps used to perform a QA/QC review of the flow data, TIN data and TDS data used to populate the new WLAM. Please add text indicating that Geosciences did not re-evaluate prior data that had already been QA/QC'd as part of the 2015-Scenario #8 WLAM prepared by WEI. Only new data collected after 2012 was QA/QC'd by Geosciences.	Additional explanation was added in revised TM-1 (Section 3.0; submitted March 9, 2018).
Risk Sciences	34			Please provide a reference citation for the source of data used to describe characteristics of the storm channels in Figure 11. All three counties were required to submit GIS layers and an Access Database describing the flood control channels to the Regional Board as part of the 2012 Basin Plan amendment for bacteria standards.	Sources were discussed in Section 2.2.7.
Risk Sciences	35			Please add USGS Gage number, Lat/Long coordinates, and period of record to the list of stations shown on page 12 of the report.	USGS gage number and lat/long coordinates were added to the list of stations in Section 3.1. The period of record (including specific days with missing data) is presented in TM-1.
Risk Sciences	36			Please add actual R2 values to each cell in the table shown on page 15 of the report.	R2 values were added
Risk Sciences	37			Please add text emphasizing the new WLAM used a different calibration period (WY2006-2016) then the 2002 WLAM (WY1999-2006) or the 2015-Scenario #8 WLAM (WY1995-2006). The computed R2 values for the two older WLAM should not be compared directly to the R2 values for the new WLAM. Rather, the older R2 values were computed solely to determine what has been previously considered acceptable level of model performance.	Text was added in Section 3.2.
Risk Sciences	38			Please provide a footnote to the last sentence on page 3 of the report describing the website address where the HSPF software and user manual can be downloaded.	Footnote was added.

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Commenter	No.	Section	Pg.	Comment	Response
Risk Sciences	39			Please provide additional description and explanation of "GoldSim" where that model is first discussed on page 4 of the report.	Additional description was added in Section 2.2.6.5.
Risk Sciences	40			The report should add text explaining that the prior WLAM also did not attempt to optimize the water quality predictions by maximizing R2 or minimizing RMSE because there wasn't enough data to do so.	Text was added in Section 3.4.
Risk Sciences	41			Please add a section at the beginning of the report describing the chronology of WLAM development. It is important to distinguish the WLAM that was developed in 2002 (approved by the Regional Board in 2004) from the updates that were developed in 2008-9 and finalized (as Scenario #8) in 2015. Only the 2002 version was actually approved by the Regional Board. While the 2008-2015 versions were submitted to Regional Board staff for review, they were never agendized for formal Regional Board approval. In addition, the nomenclature for referring to all of the various WLAM versions needs to be standardized throughout the report.	A chronology was added in Section 1.2.
RWQCB	1	2.3.10.2	11	Add reference for TIN in effluent from OCWD wetlands.	Reference was added (communication from OCWD staff) in Section 2.2.9.4.
RWQCB	2	3.1	12	Add the degree of accuracy for streamflow data for each gaging station used for model calibration.	Degree of accuracy was added in the revised TM-1 (Section 2.5)
RWQCB	3	3.1	12	Provide explanation on why only three gaging stations were used for the TDS/TIN calibration.	The 2008 WLAM used the gaging stations at Santa Ana River at MWD Crossing and Santa Ana River below Prado Dam for the TDS/TIN calibration, due to data availability. These same stations were utilized in the 2017 WLAM HSPF version, but an additional gage was added (Santa Ana River at Imperial Highway near Anaheim) due to the extension of the model into Orange County. Additional explanation was added in Section 3.1.
RWQCB	4	3.3	15	Provide an explanation for the reduction in model performance between the 2008 WLAM (R4) and the WLAM Update (HSPF) seen at the San Timoteo Creek near Loma Linda and Temescal Creek at Main Street gaging stations.	Model was refined to improve model calibration. Additional discussion of model performance at this location was added in Section 3.3.
RWQCB	5	3.3	15	Provide an explanation for the poor model performance at the Santa Ana River at Santa Ana gaging station.	Model performance at this gage was revisited. Updated calibration results are provided in the revised TM-2. Additional discussion of model performance at this location was added in Section 3.3.
RWQCB	6	General	-	Revisit areas where the model is over/underestimating streamflow and may need improvement (e.g., Figures 20, 21, 24, and 28).	Underperforming areas were revisited and the updated calibration results were presented.
RWQCB	7	Figures	Figure 48	According to the scatter plot shown on Figure 48, the model appears to consistently overestimate streamflow. Please address.	Overestimation was addressed and the updated calibration results were presented in Section 3.3.
SAWPA	1	1.1	1	Page 1. This TM has a significant number of acronyms associated with model components, see page 10, so it is recommended to have a list of acronyms and abbreviations. I may have missed them but many do not appear to be defined at all.	List of acronyms/abbreviations were added.
SAWPA	2	1.2	2	Page 2. The last paragraph on this page needs further explanation. It is unclear from these sentences whether reference to "the model update" is referring to just the 2008 WLAM model or/and the new model using HSPF.	Reference to the various models was clarified. The WEI model is called the "2008 WLAM" (or "2004 WLAM", where appropriate) and the GEOSCIENCE model is referred to as "2017 WLAM HSPF".
SAWPA	3	2.1.1	3	Page 3. Last line. Change "compressive" to "comprehensive".	Text was corrected.

Comments and GEOSCIENCE Responses for Draft WLAM TM-2

Commenter	No.	Section	Pg.	Comment	Response
SAWPA	4	2.3.5	8	Page 8. 1st paragraph. It seems very odd to be using an ET station labeled "Los Angeles County Public Works (LACPW) station at Puddingstone Dam" which is outside the Santa Ana River Watershed should be used. There are multiple ET sites in the Santa Ana River Watershed that have been established by water agencies to support the development of water budgets. Please confirm accuracy of ET and whether use of more local ET stations is warranted.	CIMIS stations were revisited and hourly reference evapotranspiration data were collected from the Pomona #78 and UC Riverside #44 CIMIS stations (see Section 2.2.5).
SAWPA	5	2.3.10.1	10	Page 10. Please explain what "nitrogen reaction rate coefficients" are. Are these the same thing as nitrogen loss coefficients?	The nitrogen reaction rate coefficient is the same as the nitrogen loss coefficient. This was clarified in the text in Section 2.2.9.5.
SAWPA	6	2.3.10.2	11	Page 11. The statement that the OCWD wetlands were used to treat all the effluent of WRCWRA plant seems too simplistic and not entirely accurate. Please expound. Devoting just three sentences about the OCWD wetlands and how impacts the WLAM seems overly brief and summarized. More detail is warranted. For example, though the wetlands is effective in nitrogen removal, evaporation through the wetlands would increase the TDS concentrations. Is this negligible? Please discuss why this particular nitrogen loss mechanism is addressed by the model why other nitrogen loss uptakes such as vegetation are not.	Additional explanation was added in Section 2.2.9.4.
SAWPA	7	3	12, 15	Page 12 & 15. The first sentence states that the calibration is a trial and error process until a "reasonable" match is met between model simulation and actual flows. However, some calibration results indicate a rating of Poor with the new WLAM model. Please explain why a "Poor" R2 level is considered a "reasonable" or "satisfactory" match. Please explain.	The poor calibration for monthly streamflow at Temescal Ck at Main Street has been addressed. The poor calibration for daily streamflow at Santa Ana River at Santa Ana is a product of the modeling process. Flow at this location is largely from the OCWD recharge facilities model, which simulated Prado Dam operations. Actual releases from Prado may be different, which causes a discrepancy between the modeled and observed streamflow at this location. Additional explanation to this effect was added in Section 3.3.



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