Santa Ana River Wasteload Allocation Model Update

BASIN MONITORING PROGRAM TASK FORCE

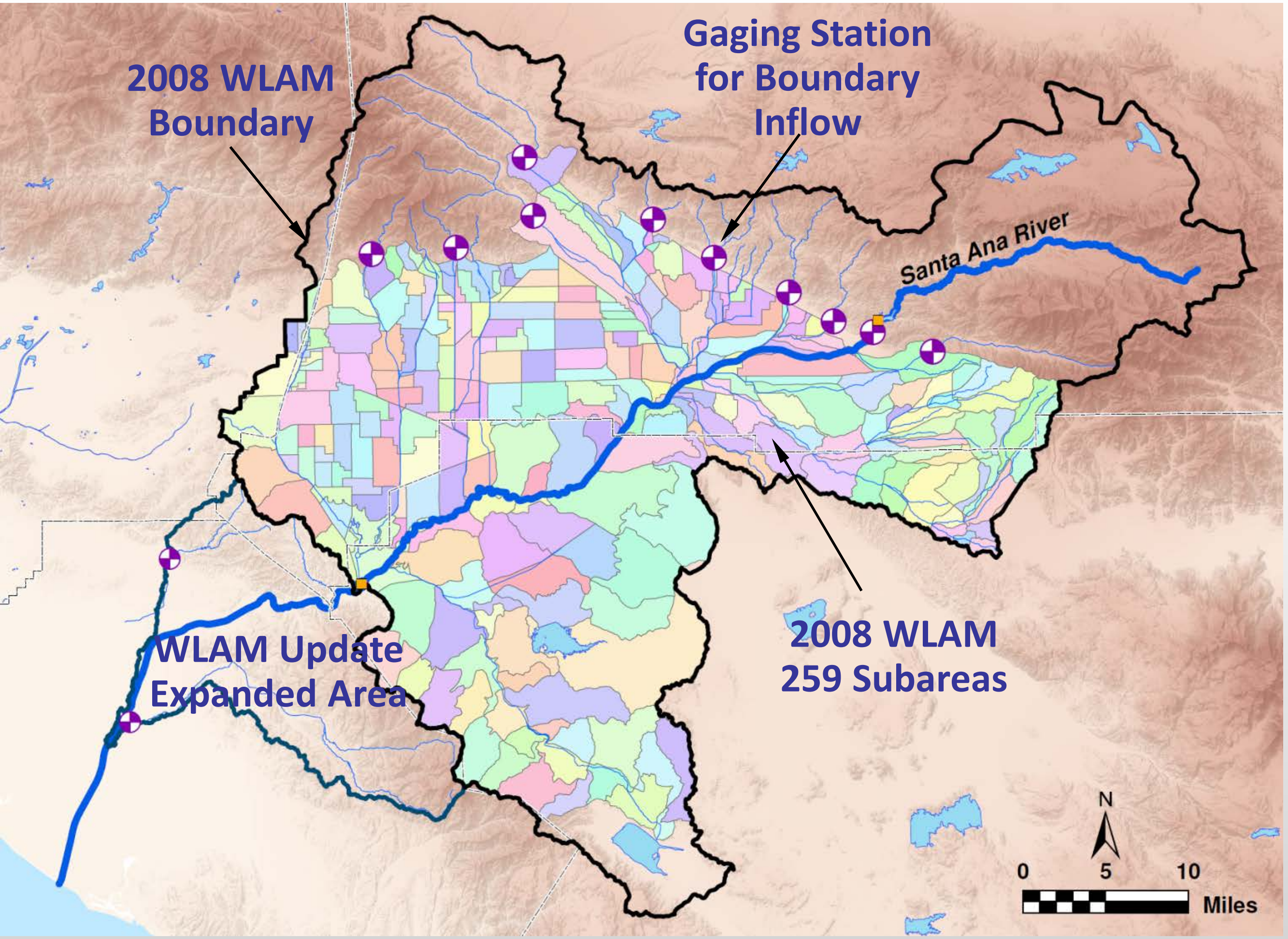
November 16, 2017

SAWPA

GEOSCIENCE

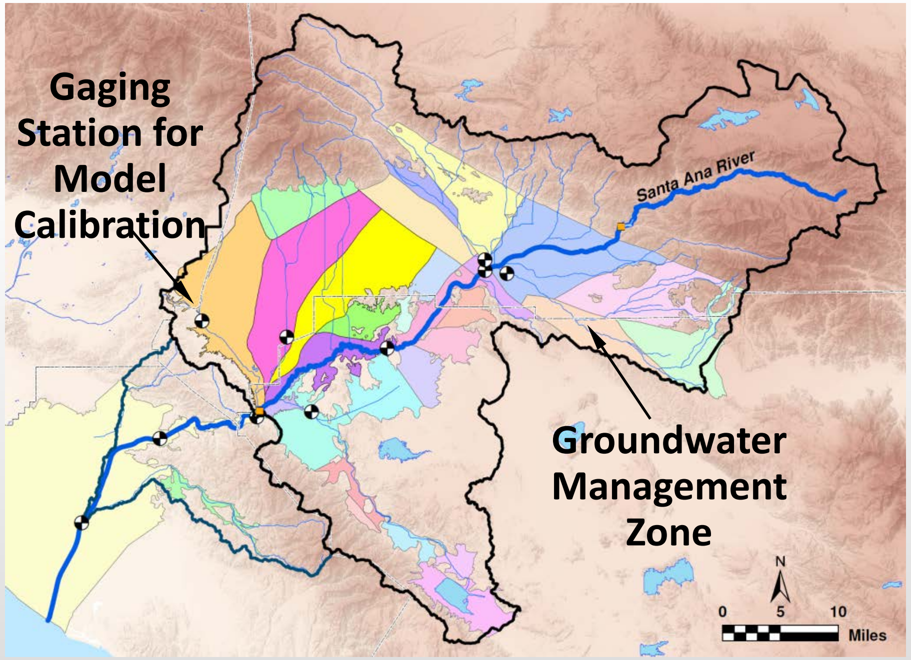
SAR WLAM
Scope of Work Review

Task 1 – Update the Data Used in the Waste Load Allocation Model (WLAM)



- Task 1a: Update relevant land use maps for the region
- Task 1b: Update the stormwater management facility maps
- Task 1c: Update the historical precipitation data for the region
- Task 1d: Review and confirm the operating assumptions for Seven Oaks Dam and Prado Dam
- Task 1e: Update and consolidate the flow data used in the WLAM
- Task 1f: Update and consolidate the water quality data used in the WLAM
- Task 1g: Perform a systematic QA/QC review of all data

Task 2 – Update and Recalibrate the WLAM



- **Task 2a: Update the estimate of surface water runoff to major stream segments**
- **Task 2b: Update the estimate of stream flow in major streams segments**
- **Task 2c: Update the estimated concentration of TDS in major stream segments**
- **Task 2d: Update the estimated concentration of TIN in major stream segments**
- **Task 2e: Estimate the volume of streamflow recharging from each major stream segment to the underlying groundwater management zone**
- **Task 2f: Estimate the average daily concentration and mass of TDS recharging from each major stream segment to the underlying groundwater management zone**
- **Task 2f: Estimate the average daily concentration and mass of TIN recharging from each major stream segment to the underlying groundwater management zone**

2008 WLAM

Algorithm of 2008 WLAM

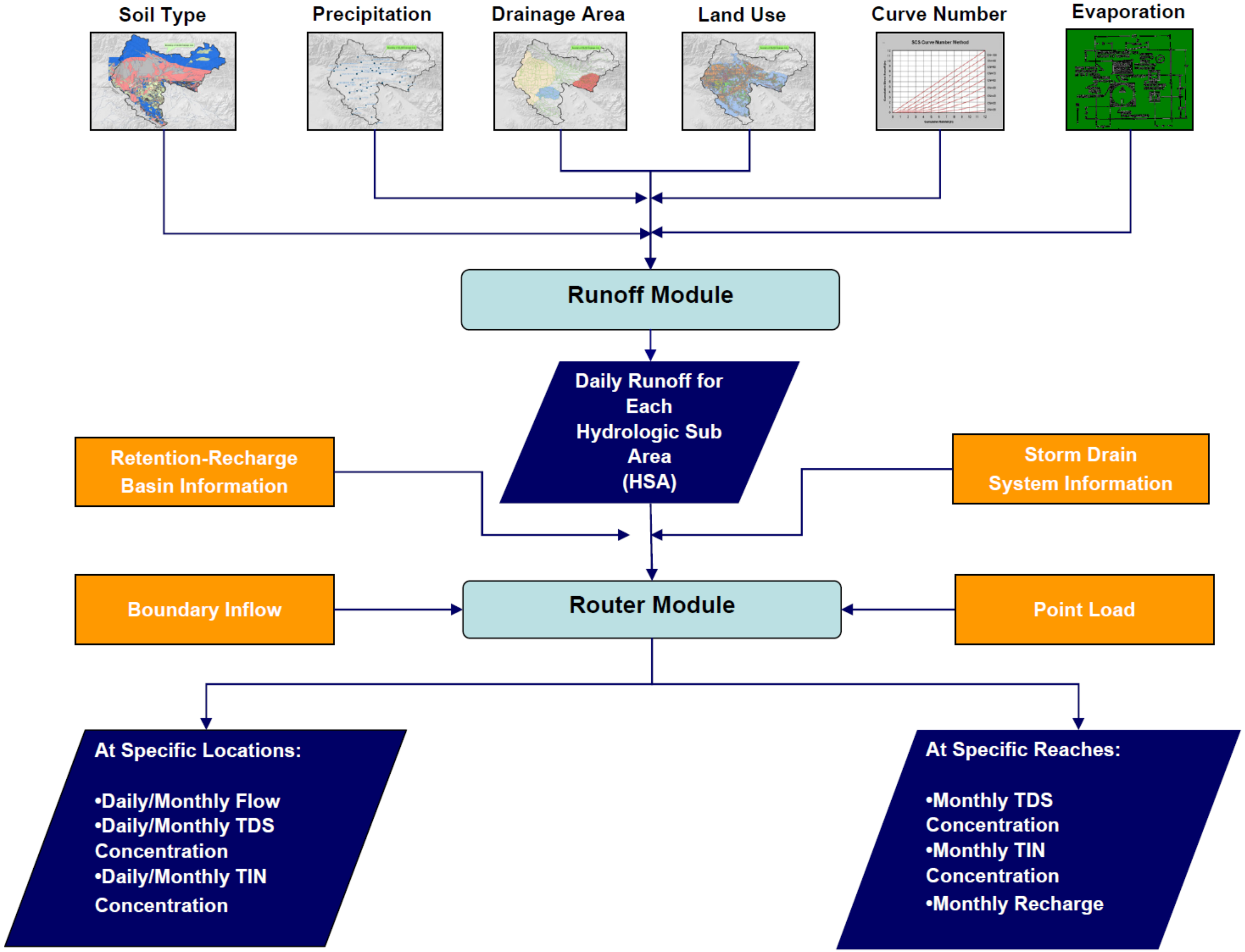


Figure 2-1
Organization of the Wasteload Allocation Model

Source: WEI 2009

Rainfall Runoff Process – 2008 WLAM

$$P = Q + F + Ia \qquad (1)$$

$$I_a = 0.2S \qquad (2)$$

$$Q = \frac{(P-0.2S)^2}{P+0.8\,S} \qquad (3)$$

$$CN = \frac{1000}{10 + S} \qquad (4)$$

$$CN_1 = \frac{CN_2}{2.27-0.0125*CN_2} \qquad (5)$$

$$CN_3 = \frac{CN_2}{0.44+0.0055*CN_2} \qquad (6)$$

$$CN\,(t) = (CN_3 - CN_1) * \frac{\mathrm{SM}(t)}{\mathrm{SM}_{max}} + CN_1 \qquad (7)$$

P = Daily Precipitation

Q = Runoff

F = Retention after runoff begins

I_a = Initial Abstraction

S = Potential retention after runoff begins

CN = Curve Number

CN_1 = Curve Number for AMC I (the lowest runoff potential)

CN_2 = Curve Number for AMC II (the average conditions)

CN_3 = Curve Number for AMC III (the highest runoff potential)

CN(t) = Curve number at a given day

SM(t) = Soil moisture at a given day

SM_{max} = Maximum allowable soil moisture

2008 WLAM Initial Curve Number

Table 2-7
Hydrologic Properties of Each Land Use Type

WEI Land Use Code	Land Use Type	Percent Impervious	AMC	Curve Number Soil Type A	B	C	D
1	Low Density Residential	30	2	32	56	69	75
2	Medium Density Residential	50	2	32	56	69	75
3	High Density Residential	75	2	32	56	69	75
4	Commercial	90	2	32	56	69	75
5	Industrial	90	2	32	56	69	75
6	Orchards and Vineyards	2	2	39	62	75	81
7	Irrigated Cropland and Improved Pasture Land, Golf course	2	2	53	70	80	85
8	Parks, schools	80	2	39	61	74	80
9	Dairy, poultry, horse ranch, etc	0	2	1	1	1	1
10	Impervious	100	2	98	98	98	98
11	Undeveloped	2	2	78	86	91	93
12	Native/mountain	2	2	47	67	78	83

AMC - Antecedent moisture condition

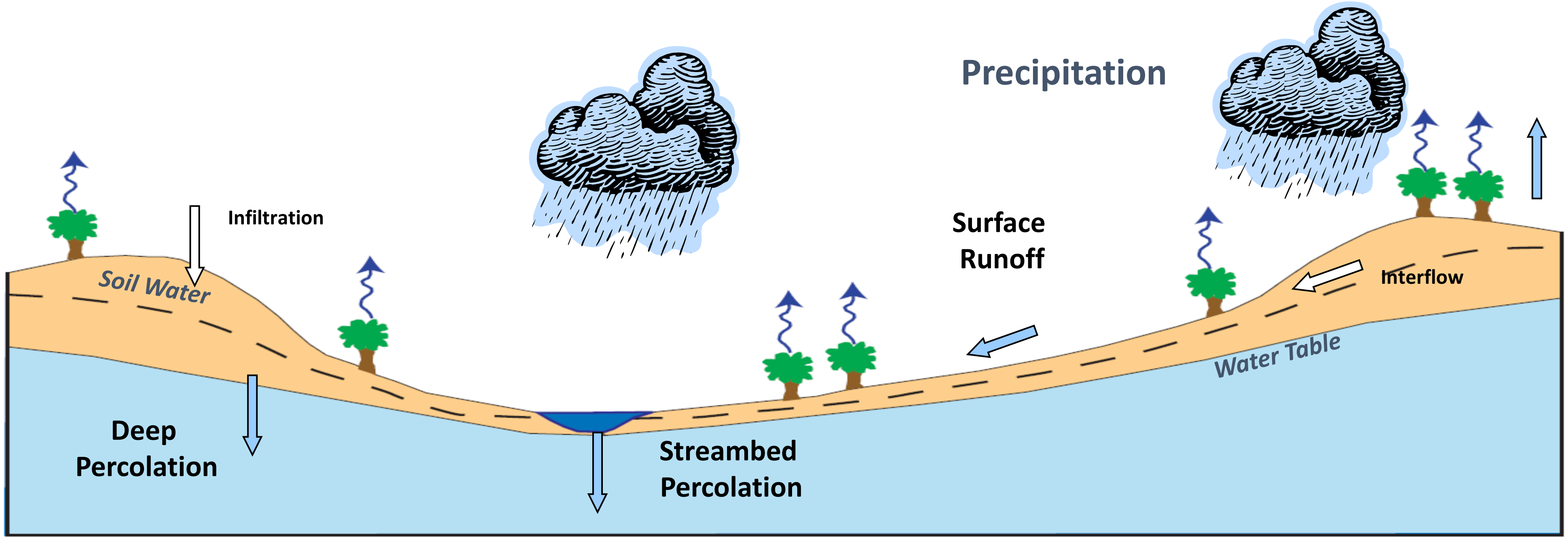
Source: WEI 2009

Table 2-1
SCS Method Curve Numbers[1,2]

Cover Type [3]	Quality of Cover [4]	Soil Group A	B	C	D
Natural Covers					
Barren (Rockland, eroded and graded land)		78	86	91	93
Chaparral, Broadleaf (Manzanita, ceanothus and scrub oak)	Poor	53	70	80	85
	Fair	40	63	75	81
	Good	31	57	71	78
Chaparral, Narrowleaf (Chamise and redshank)	Poor	71	82	88	91
	Fair	55	72	81	86
Grass, Annual or Perennial	Poor	67	78	86	89
	Fair	50	69	79	84
	Good	38	61	74	80
Meadows or Cienegas (Areas with seasonally high water table, principal vegetation is sod forming grass)	Poor	63	77	85	88
	Fair	51	70	80	84
	Good	30	58	72	78
Open Brush (Soft wood shrubs - buckwheat, sage, etc.)	Poor	62	76	84	88
	Fair	46	66	77	83
	Good	41	63	75	81
Woodland (Coniferous or broadleaf trees predominate. Canopy is at least 50 percent)	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	28	55	70	77
Woodland, Grass (Coniferous or broadleaf trees with a canopy density from 20 to 50 percent)	Poor	57	73	82	86
	Fair	44	65	77	82
	Good	33	58	72	79
Urban Covers					
Residential or Commercial Landscaping (Lawn, shrubs, etc.)	Good	32	56	69	75
Turf (Irrigated and mowed grass)	Poor	58	74	83	87
	Fair	44	65	77	82
	Good	33	58	72	79
Agricultural Covers					
Fallow (Land plowed but not tilled or seeded		76	85	90	92
Legumes, Close Seeded (Alfalfa, sweetclover, timothy, etc.)	Poor	66	77	85	89
	Good	58	72	81	85
Orchards, Evergreen (Citrus, avocados, etc.)	Poor	57	73	82	86
	Fair	44	65	77	82
	Good	33	58	72	79
Pasture, Dry land (Annual grasses)	Poor	67	78		89
	Fair	50	69	79	84
	Good	38	61	74	80
Pasture, Irrigated (Legumes and perennial grasses)	Poor	58	74	83	87
	Fair	44	65	77	82
	Good	33	58	72	79
Row Crops (Field crops - tomatoes, sugar beets, etc.)	Poor	72	81	88	91
	Good	67	78	85	89
Small grain (Wheat, oats, barley, etc.)	Poor	65	76	84	88
	Good	63	75	83	87

2017 WLAM HSPF

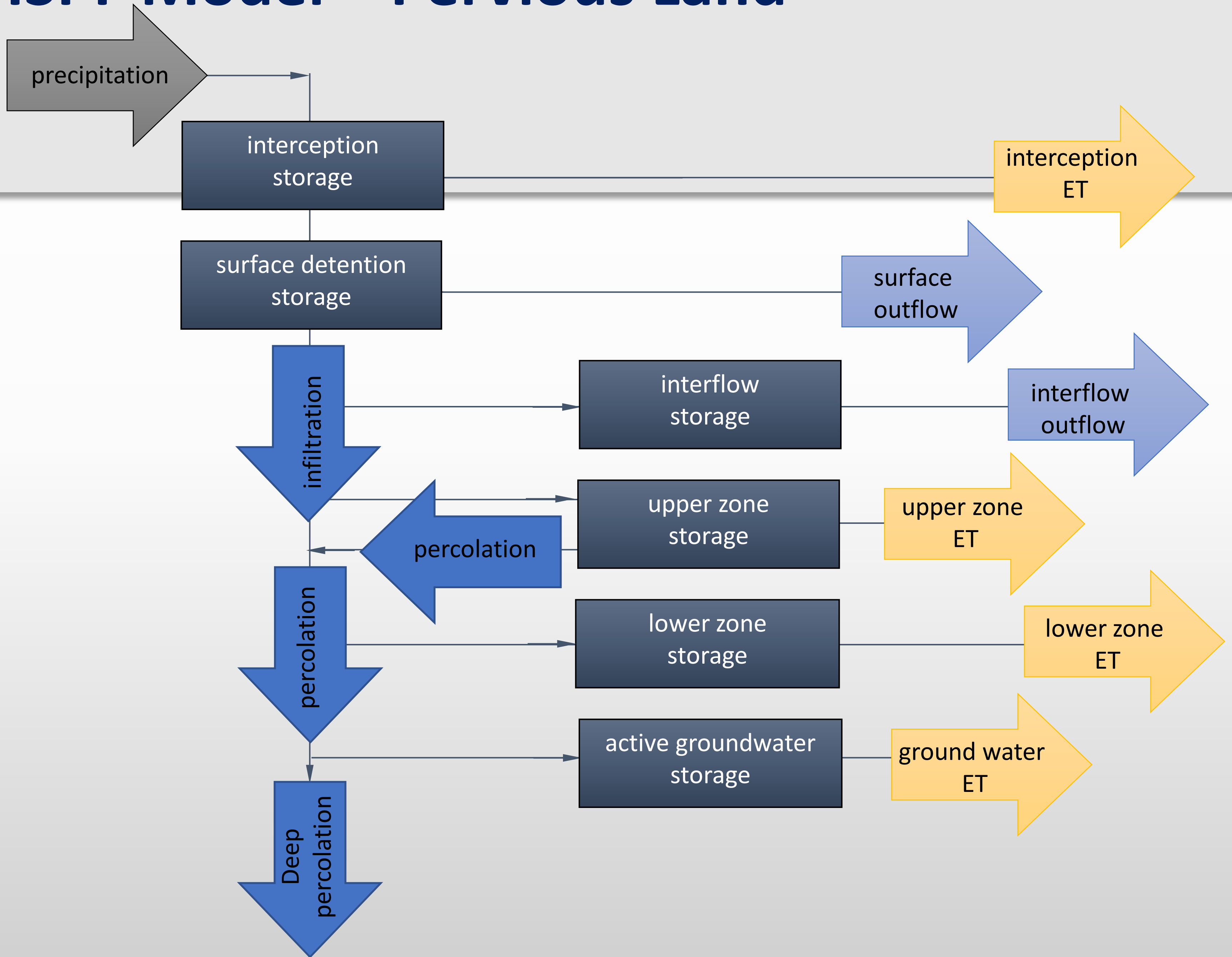
Hydrologic Simulation Program – Fortran (HSPF)



- Evolved from Stanford Watershed Model
- Comprehensive & Physically Based,
- Simulates ALL Water Cycle Components & Water Quality,
- Supported & Maintained by Federal Agencies (EPA & USGS),
- Established Standard Guidelines and Calibration Performance Criteria,
- Windows-Based Interface with Powerful Pre- & Post- Processors, and
- Software is Free.

Stanford Watershed Model
Developed in 1950’ and 1960’

Algorithm of HSPF Model – Pervious Land*



HSPF — Established Calibration Standard & Guidelines

United States Environmental Protection Agency | Office of Water 4305 | EPA-823-R00-012 July 2000

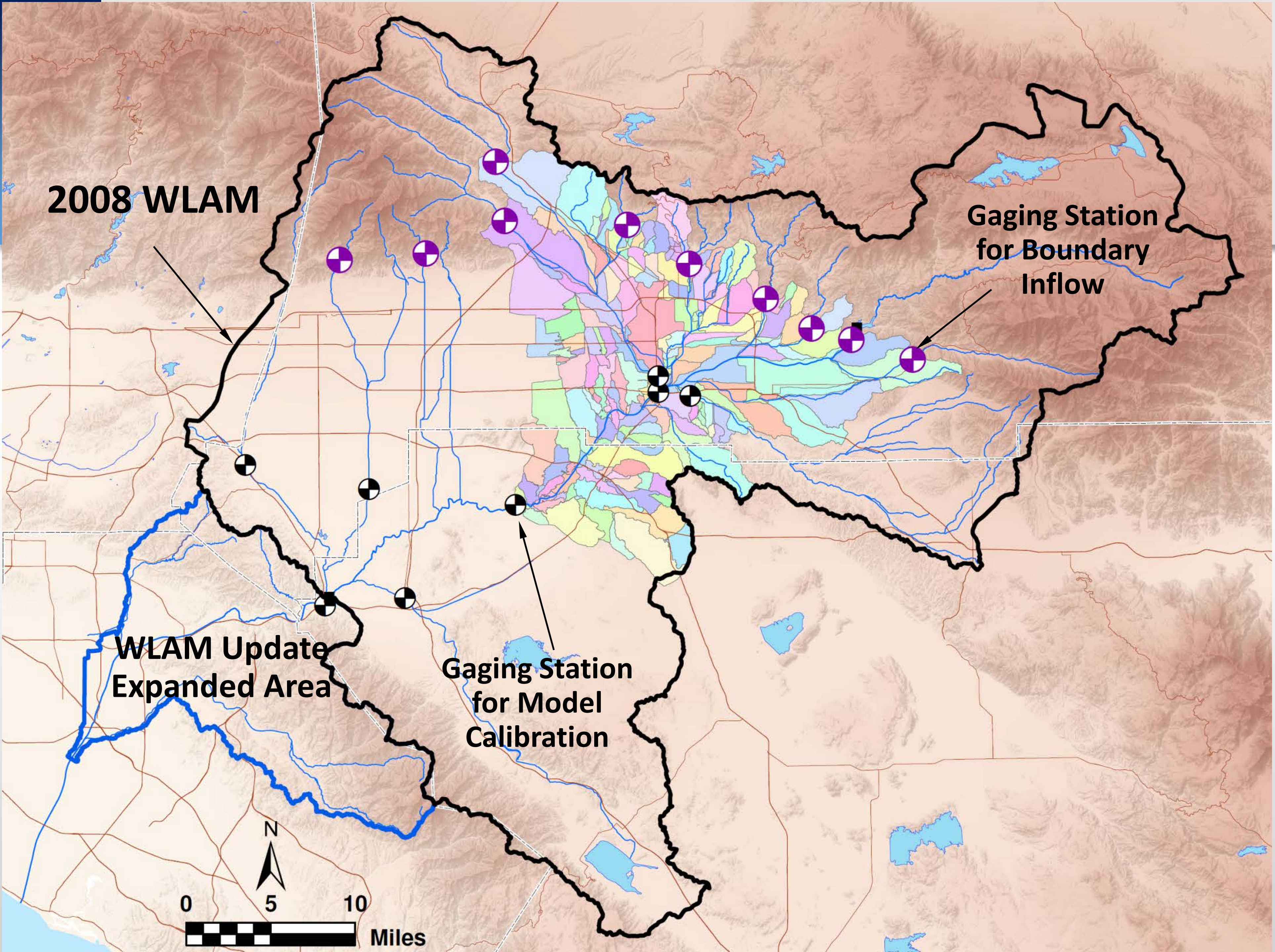
EPA **BASINS Technical Note 6**

Estimating Hydrology and Hydraulic Parameters for HSPF

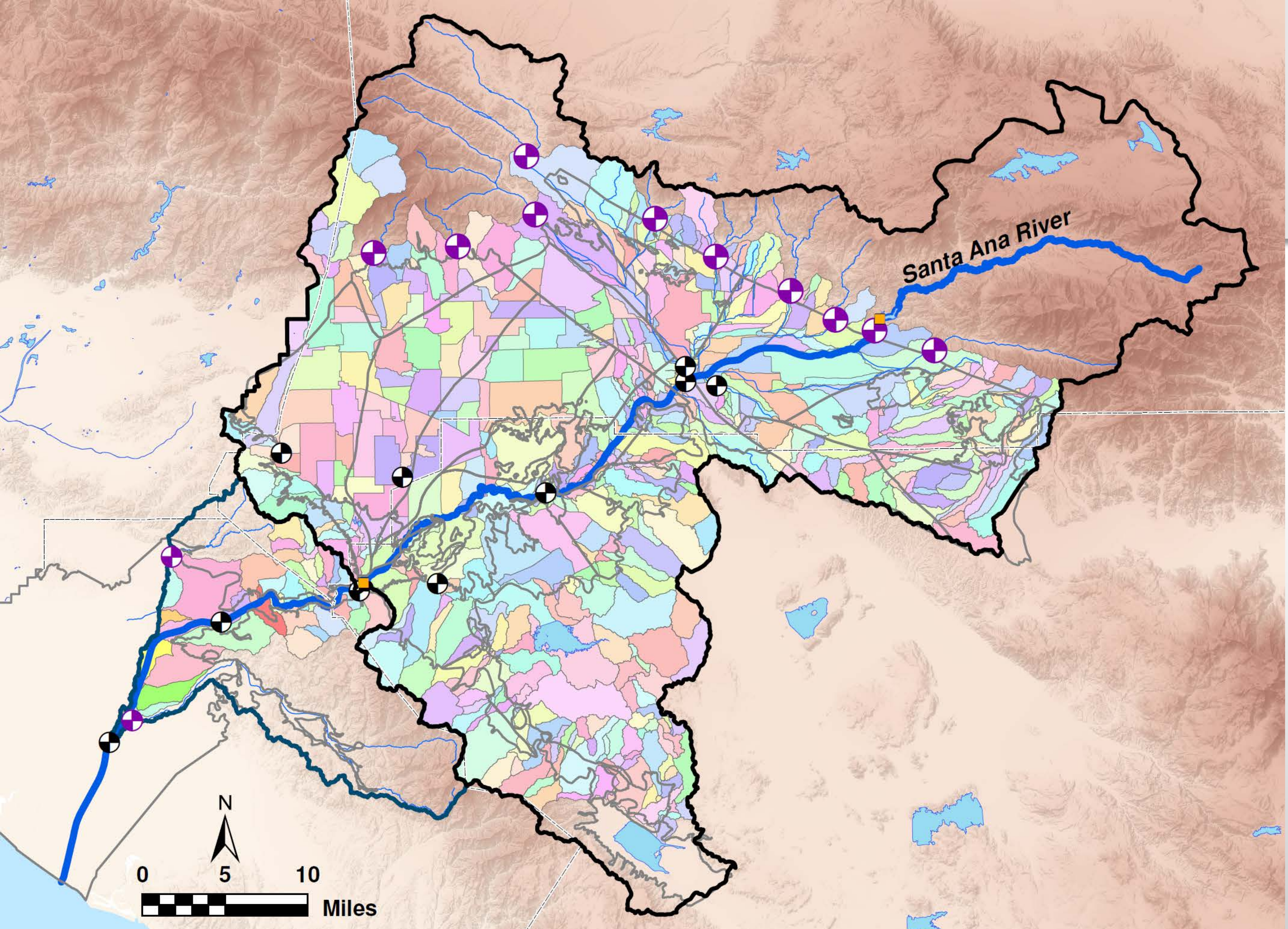
HSPF HYDROLOGY PARAMETERS AND VALUE RANGES

			RANGE OF VALUES					
NAME	DEFINITION	UNITS	TYPICAL		POSSIBLE		FUNCTION OF ...	COMMENT
			MIN	MAX	MIN	MAX		
PWAT - PARM2								
FOREST	Fraction forest cover	none	0.0	0.50	0.0	0.95	Forest cover	Only impact when SNOW is active
LZSN	Lower Zone Nominal Soil Moisture Storage	inches	3.0	8.0	2.0	15.0	Soils, climate	**Calibration**
INFILT	Index to Infiltration Capacity	in/hr	0.01	0.25	0.001	0.50	Soils, land use	**Calibration**, divides surface and subsurface flow
LSUR	Length of overland flow	feet	200	500	100	700	Topography	Estimate from high resolution topo maps or GIS
SLSUR	Slope of overland flow plane	ft/ft	0.01	0.15	0.001	0.30	Topography	Estimate from high resolution topo maps or GIS
KVARY	Variable groundwater recession	1/inches	0.0	3.0	0.0	5.0	Baseflow recession variation	Used when recession rate varies with GW levels
AGWRC	Base groundwater recession	none	0.92	0.99	0.85	0.999	Baseflow recession	**Calibration**

Initial Steps of Model Update



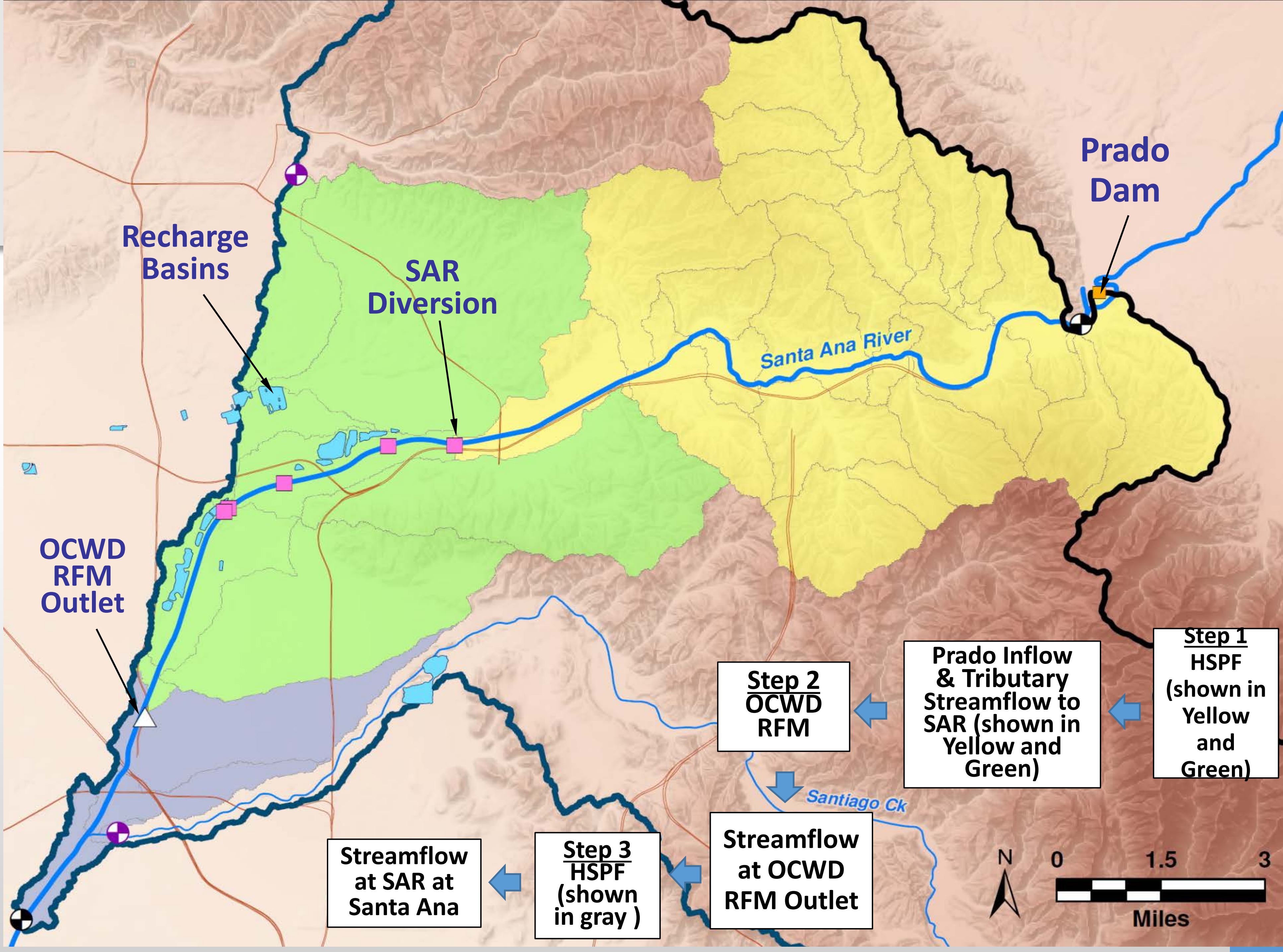
1. Compare results for the period WY 1995 to 2006
2. Update both models and compare the modeling results for the period from WY 2007 to 2016



Model Development

- **564 subareas were delineated**
- **Each subarea consists of**
  - Stream segment,
  - Pervious land area, and
  - Impervious land area.
- **They were delineated based on:**
  - Topography
  - Drainage Patterns
  - Types of stream channels, and
  - Location of gaging stations and recharge basins

Coupling Process of HSPF and OCWD Recharge Facilities Model (RFM)



Status Update at the Basin Monitoring Program Task Force Meetings

- **Provide status update for Task 1 and Task 2 at six Task Force meetings:**
  - March 22, 2017;
  - April 19, 2017;
  - May 15, 2017;
  - June 16, 2017;
  - August 16, 2017; and
  - September 19, 2017.

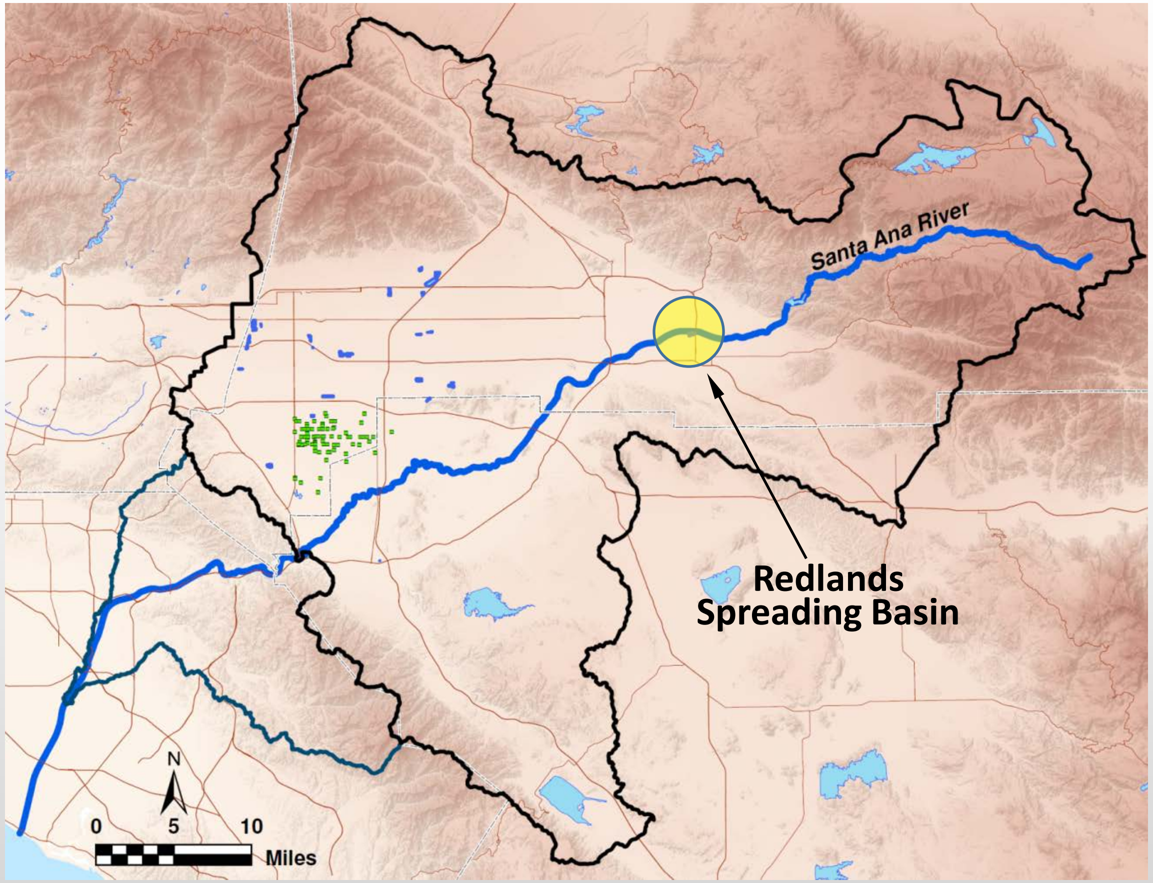
Task 3 – Evaluate Waste Load Allocation Scenarios for Major Stream Segments

- Task 3a: Specify the range of probable conditions
- Task 3b: Use WLAM to analyze six scenarios
- Task 3c: Report the results of the WLAM scenario analysis

Scenario	Hydrology	Land Use	Maximum Discharge (Zero Recycled)	Planned Recycled / Discharge)	50% of Planned Recycled
A	WY 1950-2016	2012	X		
B				X	
C					X
D		General Plan (2040)	X		
E				X	
F					X

Task 4 – Develop WLAM for Managed Recharge in Percolation Basins

- Task 4a: Identify the percolation ponds and recharge basins to be evaluated
- Task 4b: Characterize the volume and quality of water recharged to groundwater
- Task 4c: Summarize the results of Task 4b by groundwater management zone
- Task 4d: Integrate results from Task 4c with the results from Task 3c



Tasks 5 through 11

- 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 & quality of recharge that actually occurred
- Task 7: Compile the WLAM into a run-time software simulation package
- Task 8: Supplemental scenario analyses (Removed)
- Task 9: Draft task reports, draft & final report
- Task 10: Monthly project meetings
- Task 11: Pilot evaluation of the Doppler data compared to precipitation gauge data

Response to Comments on TM No. 1

Response to Comments on TM No. 1 from SAWPA

Comments on Draft TM No. 1 from SAWPA – Comment No. 1

No.	Section	Pg.	Comment	GEOSCIENCE Response
1	2	2	Please change acronym for Riverside County Flood Control and Water Conservation District to (RCFCWCD) as is their normal protocol.	Change will be made.

Comments on Draft TM No. 1 from SAWPA – Comment No. 2

No.	Section	Pg.	Comment	GEOSCIENCE Response
2	General	-	Overall, the report appears to be very brief and summarized citing the sources of data collection that are largely reflected in the original proposal and scope. We recommend additional information be added to this TM about the "process of data collection" particularly for data from the public owned treatment works. The data collection form should be included as an appendix with explanation as to why and how data will be used in the model. Concerns had been raised about some data collection associated with the recharge basins and how this will be incorporated into the new WLAM update.	Additional explanation will be added and raw data will be provided as appendices. In addition, addressing the remaining comments should satisfy this comment as well.

Comments on Draft TM No. 1 from SAWPA – Comment No. 3

No.	Section	Pg.	Comment	GEOSCIENCE Response
3	General	-	Some discussion of how data collected will be entered into the HSPF platform for later would be helpful	Additional explanation will be added.

Response to Comments on TM No. 1 from OCWD

Comments on Draft TM No. 1 from OCWD – Comment No. 1

No.	Section	Pg.	Comment	GEOSCIENCE Response
1	Figures	Figure 6	Figure 6 includes ‘underground pipe’ – some of these features are not part of the channel system but are imported water pipelines – it does not seem relevant to include them in Figure 6	Feature will be removed from Figure.

Response to Comments on TM No. 1 from IEUA and Chino Basin Watermaster

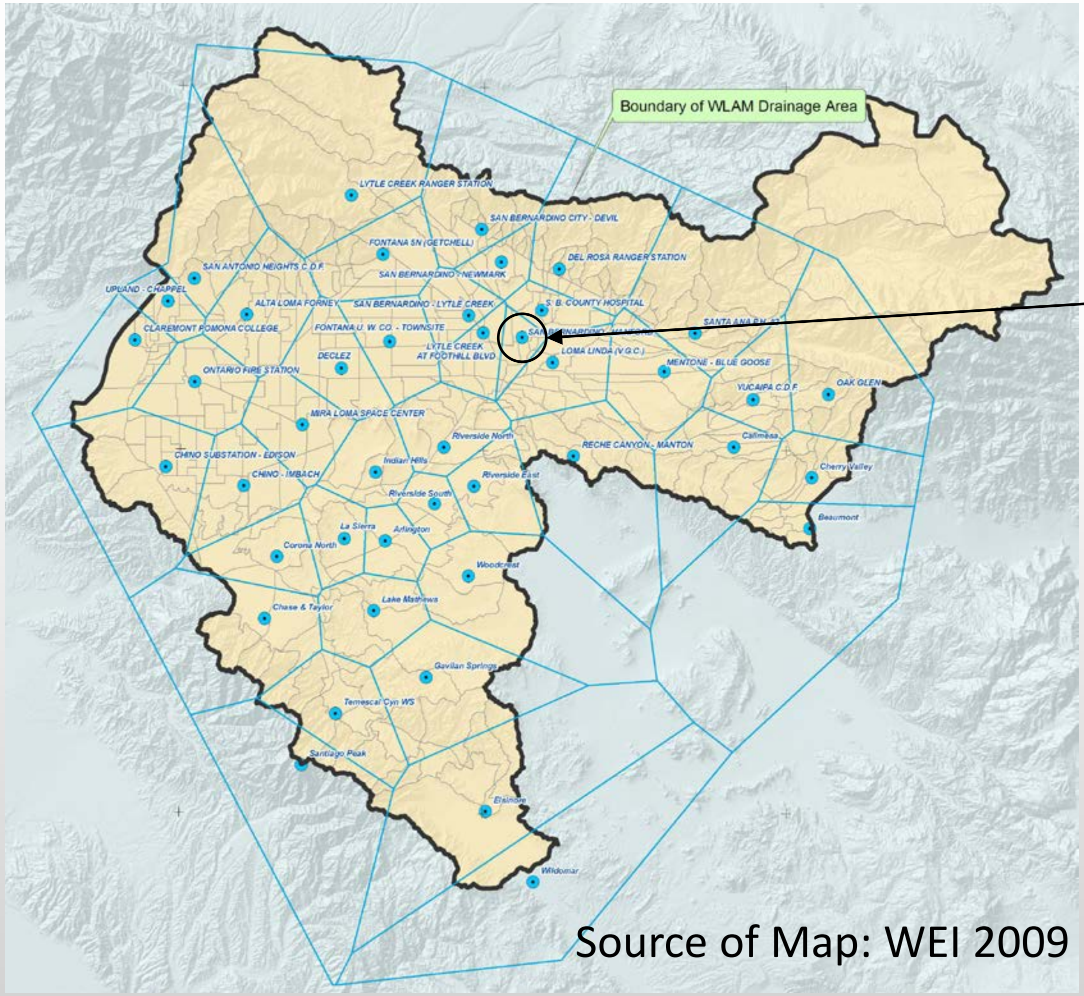
Comments on Draft TM No. 1 from IEUA and Chino Basin Watermaster – General Comment No. 1

No.	Section	Pg.	Comment	GEOSCIENCE Response
G-1	General	-	TM-1 does not provide sufficient information or details to ensure a high-level of reliability in the process (TM-1 specific comments are provided below). TM-1 was not provided to the BMP TF for review and approval prior to the development of TM-2, as prescribed in the RFP. Although this may have initially saved time, data collection and validation is essential to producing accurate modeling results.	Comment noted and is addressed through responses to comments below.

Comments on Draft TM No. 1 from IEUA and Chino Basin Watermaster – Comment No. 1

No.	Section	Pg.	Comment	GEOSCIENCE Response
1	General	-	Please provide summary tables that list the monitoring stations where data was collected, the period of record, and identify the missing and/or questionable data. The report states that the data was collected and QAQC'd. Please provide details and documentation of the process and identification of data eliminated from the analysis.	Tables will be provided as described in the response to individual comments below. In addition, further explanation regarding QA/QC will be included. In general, the QA/QC process involved plotting data, identifying extreme outliers, comparing the data with those from surrounding or nearby stations, and verifying questionable values.

Example of QA/QC Process



Source of Map: WEI 2009

Date	2287 / 2286AUTO Precipitation
12/27/2014	0.62
12/28/2014	1.85
12/29/2014	0.49
12/30/2014	1.65
12/31/2014	0.02
1/1/2015	2.01
1/2/2015	0.01
1/3/2015	0
1/4/2015	0
1/5/2015	0
1/6/2015	0
1/7/2015	3.01
1/8/2015	24.29
1/9/2015	45.76
1/10/2015	0.39
1/11/2015	0.17
1/12/2015	0.67
1/13/2015	0
1/14/2015	0
1/15/2015	0
1/16/2015	0.08
1/17/2015	0

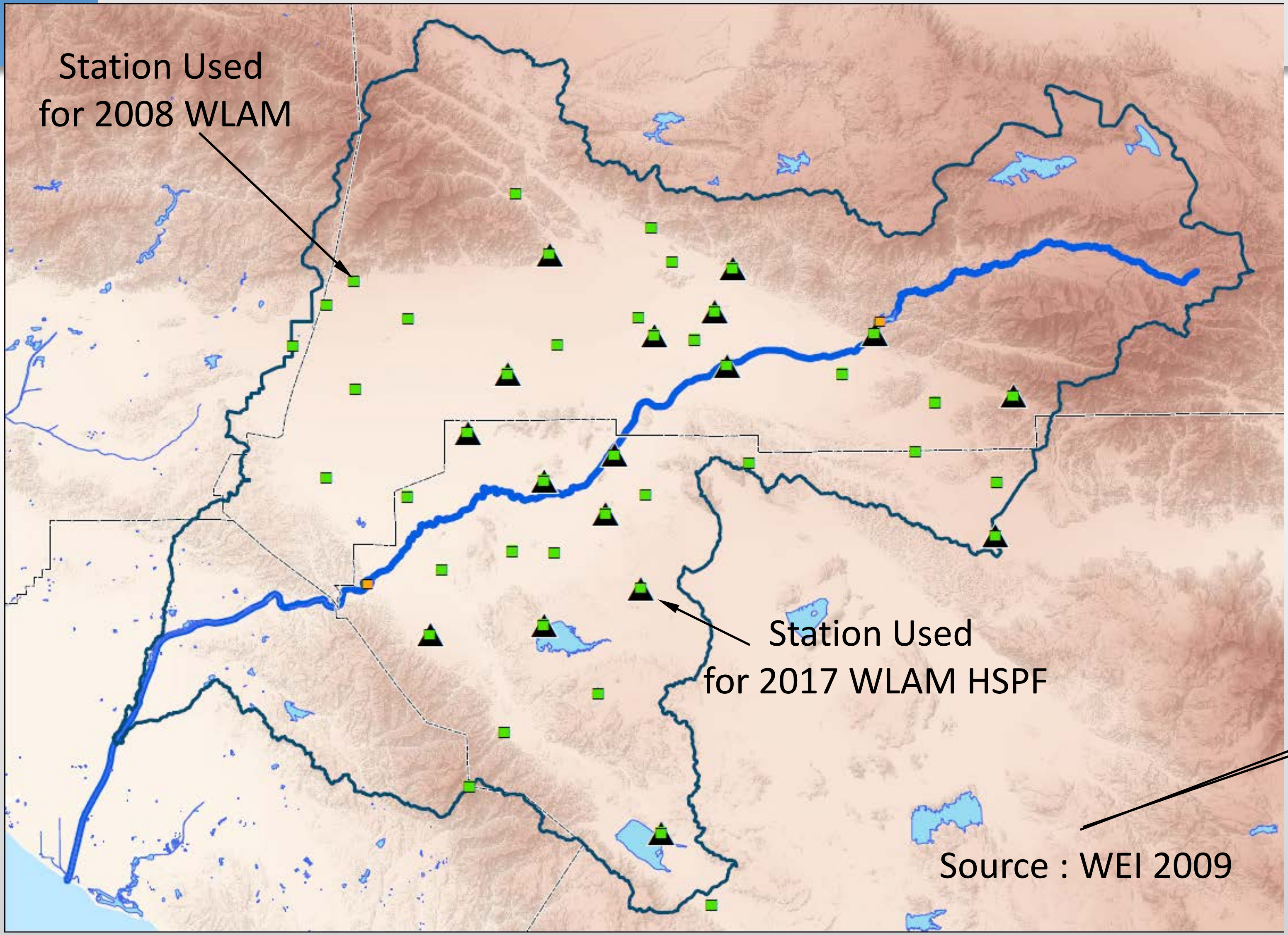
Comments on Draft TM No. 1 from IEUA and Chino Basin Watermaster – Comment No. 2

No.	Section	Pg.	Comment	GEOSCIENCE Response
2	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 wasteload allocation analysis, not updating the old model. Please clarify.	The "update" refers to the update of modeled data (e.g., streamflow, precipitation, land use, etc.) for the recent calibration period using 2012 land use. Text will be clarified.

Comments on Draft TM No. 1 from IEUA and Chino Basin Watermaster – Comment No. 3

No.	Section	Pg.	Comment	GEOSCIENCE Response
3	2.3	3	Page 3, Section 2.3 and Figure 8. Will reducing the precipitation data coverage from 43 stations to 19 have an impact on the model results? Can you provide a table that summarizes the stations considered, including the names, data provider, the period of record available from the station, if the station was eliminated or is new, and if any data gaps exist for the calibration period of record for the final selected 19 stations. Can you show the spatial location of the 24 stations eliminated from the analysis and call out the five new stations on Figure 8? Were NEXRAD gridded precipitation estimates collected and evaluated and if not, why?	While precipitation data was collected from all 43 stations, only the 19 stations with most complete coverage were used for the model calibration. Reducing the precipitation coverage from 43 stations to 19 will not have an impact on the calibration results. A table will be added summarizing precipitation station details. A comparison of NEXRAD precipitation and the recorded precipitation used for model calibration will be performed as part of Task 11.

Precipitation Stations Used for WLAM



Station Number	Station Name	WEI (2009)		County Data	
		Start	End	Start	End
1021AUTO	Mira Loma Space Center	1943	2006	1966	2016
1026	Ontario Fire Station	1934	2006	1933	2002
2071	San Bernardino City - Devil	1928	2006	1927	2007
2159AUTO	Lytle Creek At Foothill Boulevard	1948	2006	1979	2016
2166	San Bernardino City - Newmark	1928	2006	1927	2007
2198	San Bernardino City - Lytle Creek	1927	2006	1926	2007
3014AUTO	Oak Glen	1946	2006	1945	2016
3273	Loma Linda (V.G.C.)	1893	2006	1892	2016
1079	Chino - Imbach	1929	2006	1928	1987
1085	San Antonio Heights C.D.F.	1944	2006	1943	2002
3129	Yucaipa C.D.F.	1951	2006	1950	1980
1034	Claremont Pomona College	1896	2006	1895	1989
1067	Chino Substation - Edison	1927	2006	1927	1982
1175	Alta Loma Forney	1956	2006	1955	1984
2005B	Declez	1943	2006	1977	2016
2009A	Reche Canyon - Manton	1919	2006	1918	1995
2015AUTO	Del Rosa Ranger Station	1943	2006	1957	2016
2017AUTO	Fontana 5N (Getchell)	1958	2006	1957	2016
2037AUTO	Lytle Creek Ranger Station	1958	2006	1957	2003
2146AUTO	San Bernardino County Hospital	1985	2006	1984	2016
2194	Fontana Union Water Company -	1926	2006	1925	2004
2286AUTO	San Bernardino City - Hanford	1930	2006	1974	2016
3162AUTO	Santa Ana P.H. #3	1980	2006	1979	2016
1019AAUTO	Upland - Chapel	1960	2006	1959	1993
3058	Mentone - Blue Goose	1928	2006	1927	1980
13	Beaumont	1929	2006	1940	2016
35	Chase & Taylor	1930	2006	1967	2016
67	Elsinore	1887	2006	1958	2016
75	Temescal Cyn Ws	1905	2006	1905	1999
177	Riverside East	1925	2006	1924	2009
178	Riverside North	1925	2006	1962	2016
179	Riverside South	1881	2006	1975	2016
246	Wildomar	1907	2006	2002	2016
7	Arlington	1963	2006	1962	1996
31	Calimesa	1958	2006	1957	2016
36	Cherry Valley	1956	2006	1955	2012
44	Corona North	1956	2006	1950	2001
100	La Sierra	1905	2006	1955	1996
102	Lake Mathews	1905	2006	1961	2016
202	Santiago Peak	1950	2006	1998	2003
250	Woodcrest	1956	2006	1955	2016
71	Gavilan Springs	1978	2006	1977	1997
265	Indian Hills	1956	2006	1986	2016

Comments on Draft TM No. 1 from IEUA and Chino Basin Watermaster – Comment No. 4

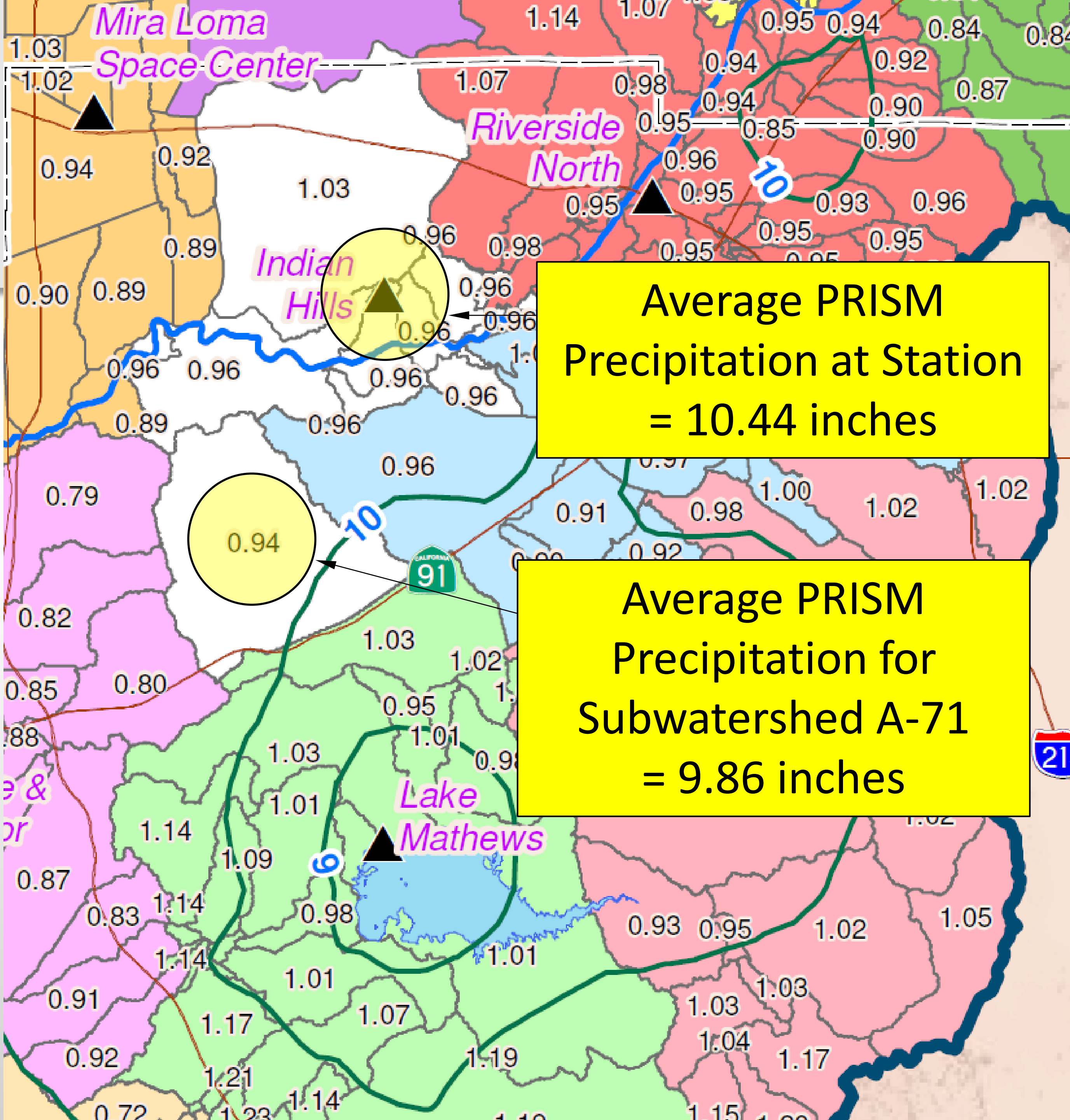
No.	Section	Pg.	Comment	GEOSCIENCE Response
4	2.3	3	Page 3, Section 2.3, Second Paragraph. Why was the PRISM data used for calculating the precipitation adjustment factors only for the period of record through 2010? This excludes the recent drought period. What is the potential impact of not extending this record through at least 2015?	The PRISM data is a 30-year average, which includes dry, wet, and average conditions. The PRISM gridded historical average annual precipitation data from 1981 through 2010 represents the most recently available data set, which was published in 2015. The precipitation adjustment factors are 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, wet and dry periods (including the recent drought) will be reflected.

Precipitation Adjustment Factors

Precipitation Adjustment Factor for A-71
= 9.86 in / 10.44 in = 0.94%

Example of Application of Daily Precipitation at A-71:

[1] Date	[2] Indian Hills (recorded)	[3]=[2]x0.94 A-71 (applied)
3/6/16	0.04 in	0.038 in
3/7/16	0.21 in	0.19 in
3/8/16	0.42 in	0.39 in
3/9/16	0	0
3/10/16	0	0
3/11/16	0.01 in	0.009 in
3/12/16	0.32 in	0.30 in
3/13/16	0.31 in	0.29 in
3/14/16	0	0



Comments on Draft TM No. 1 from IEUA and Chino Basin Watermaster – Comment No. 5

No.	Section	Pg.	Comment	GEOSCIENCE Response
5	2.4	3	Page 3, Section 2.4. Please provide a table that lists and summarizes the characteristics of the stormwater management facilities that reduce discharge to the Santa Ana River.	Information on stormwater management facilities will be provided.

Comments on Draft TM No. 1 from IEUA and Chino Basin Watermaster – Comment No. 6

No.	Section	Pg.	Comment	GEOSCIENCE Response
6	2.5	3	Page 3, Section 2.5. Please provide a table that summarizes the stations, including the names, data provider, the period of record available from the station, and if any data gaps exist for the calibration period of record.	Table will be provided and ET data will be included as an appendix.

Comments on Draft TM No. 1 from IEUA and Chino Basin Watermaster – Comment No. 7

No.	Section	Pg.	Comment	GEOSCIENCE Response
7	2.6	3	Page 3, Section 2.6. How was the streamflow data determined to be reliable? Can you provide a table that summarizes the stations, including the names, data provider/source, the data type (USGS gage vs. wastewater discharge point), the period of record available from the station, and if any data gaps exist for the calibration period of record? For the POTW discharges, can you please provide time-history charts for the agencies to review and QA/QC?	Table will be provided and raw data will be included in appendices.

Comments on Draft TM No. 1 from IEUA and Chino Basin Watermaster – Comment No. 8

No.	Section	Pg.	Comment	GEOSCIENCE Response
8	2.7	4	Page 4, Section 2.7. Please expand this section to clearly describe the information collected. At a minimum, a table of stations for which data was collected, including the names, data provider/source, the data type available (TIN, TDS, or both), the period of record available from the station, and the number of TIN and/or TDS observations available in the calibration period. For the POTW discharges, can you please provide time-history charts for the agencies to review and QA/QC?	Table will be provided and raw data will be included in appendices.

Comments on Draft TM No. 1 from IEUA and Chino Basin Watermaster – Comment No. 9

No.	Section	Pg.	Comment	GEOSCIENCE Response
9	3.0	4	Page 4, Section 3.0. Please expand this section to provide more information about how data was reviewed, and describe if/which data was eliminated from the analysis and why.	Additional information will be added.

Comments on Draft TM No. 1 from IEUA and Chino Basin Watermaster – Comment No. 10

No.	Section	Pg.	Comment	GEOSCIENCE Response
10			In 2010, the 2008 WLAM analysis had to be updated to include revised operating rules for Seven Oaks Dam. This memo does not describe the operating rules for Seven Oaks, San Antonio and the many stormwater recharge projects in the watershed. Please explain if this information was collected, and if, so how it will be used in the model.	Based on conversations with Valley District, the existing control manual is the underlying assumption for now. Explanation of Seven Oaks data will be added.

Comments on Draft TM No. 1 from IEUA and Chino Basin Watermaster – Comment No. 11

No.	Section	Pg.	Comment	GEOSCIENCE Response
11	Figures	Figure 1	Figure 1. It appears the figure depicts an incorrect shapefile of management zone boundaries – the layer does not include the revised Prado Basin and Chino North boundaries incorporated in a 2012 Basin Plan Amendment (R8-2012-0002).	Figure will be revised.

Response to Comments on TM No. 2

Response to Comments on TM No. 2 from SAWPA

Comments on Draft TM No. 2 from SAWPA – Comment No. 1

No.	Section	Pg.	Comment	GEOSCIENCE Response
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 will be added.

Comments on Draft TM No. 2 from SAWPA – Comment No. 2

No.	Section	Pg.	Comment	GEOSCIENCE Response
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 will be clarified. The WEI model will be called the “2008 WLAM” (or “2004 WLAM”, where appropriate) and the GEOSCIENCE model will be referred to as “2017 WLAM HSPF”.

Comments on Draft TM No. 2 from SAWPA – Comment No. 3

No.	Section	Pg.	Comment	GEOSCIENCE Response
3	2.1.1	3	Page 3. Last line. Change "compressive" to "comprehensive".	Text will be corrected.

Comments on Draft TM No. 2 from SAWPA – Comment No. 4

No.	Section	Pg.	Comment	GEOSCIENCE Response
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.	The Puddingstone Dam station was the ET station used in the 2008 WLAM. In the current 2017 WLAM HSPF model, three additional ET stations were incorporated.

Comments on Draft TM No. 2 from SAWPA – Comment No. 5

No.	Section	Pg.	Comment	GEOSCIENCE Response
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 will be clarified in the text.

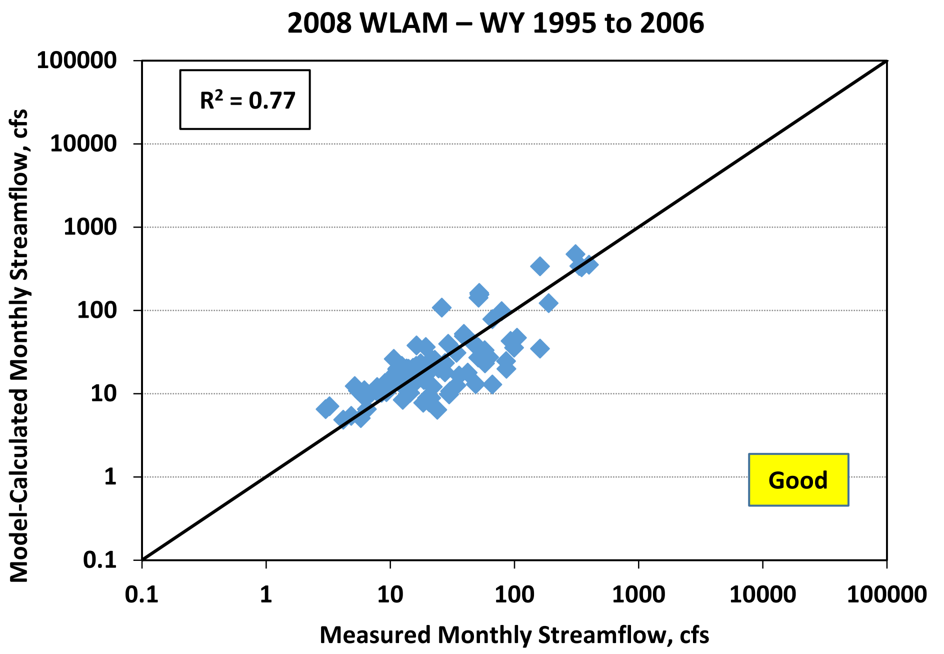
Comments on Draft TM No. 2 from SAWPA – Comment No. 6

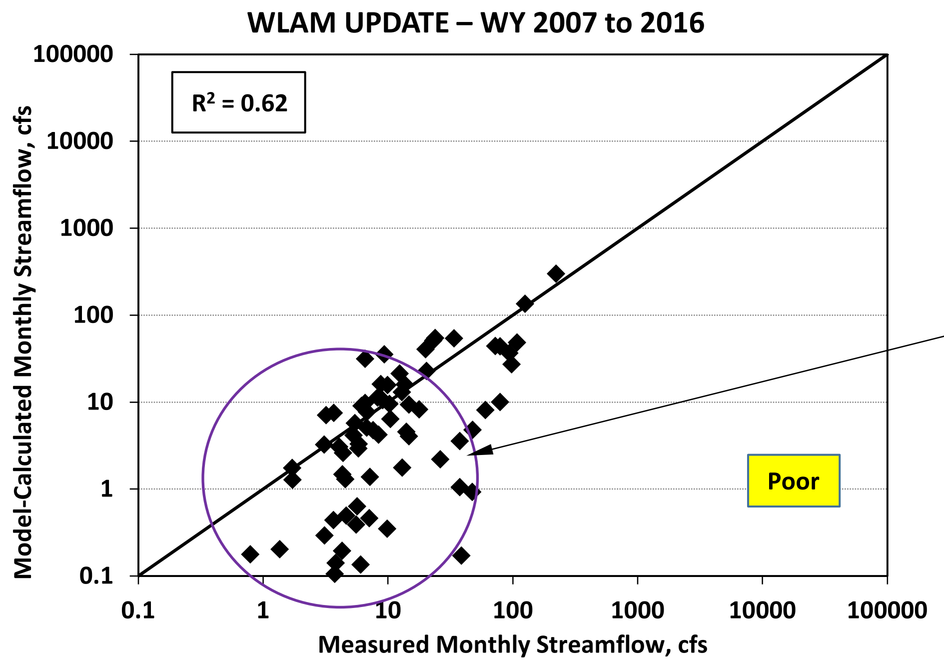
No.	Section	Pg.	Comment	GEOSCIENCE Response
6	2.3.10.2	11	Page 11. The statement that the OCWD wetlands were used to treat all the effluent of WRCWRA plant seems too simplistic and not entirely accurate. Please expound. Devoting just three sentences about the OCWD wetlands and how impacts the WLAM seems 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 will be added.

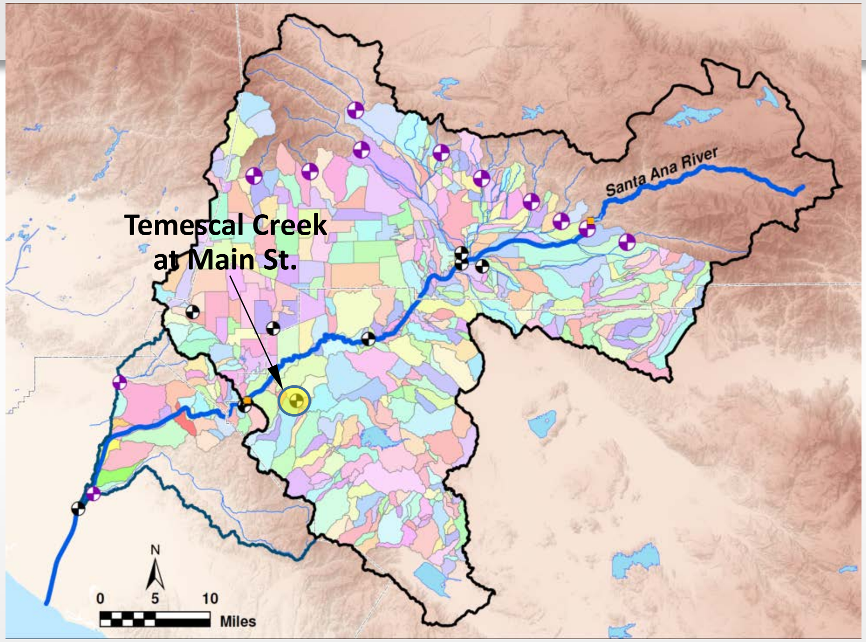
Comments on Draft TM No. 2 from SAWPA – Comment No. 7

No.	Section	Pg.	Comment	GEOSCIENCE Response
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 will be added.

Draft TM 2 Figure 46







Model underestimation of base flow with poor calibration performance

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 (WLAM UPDATE)

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 (WLAM Update)

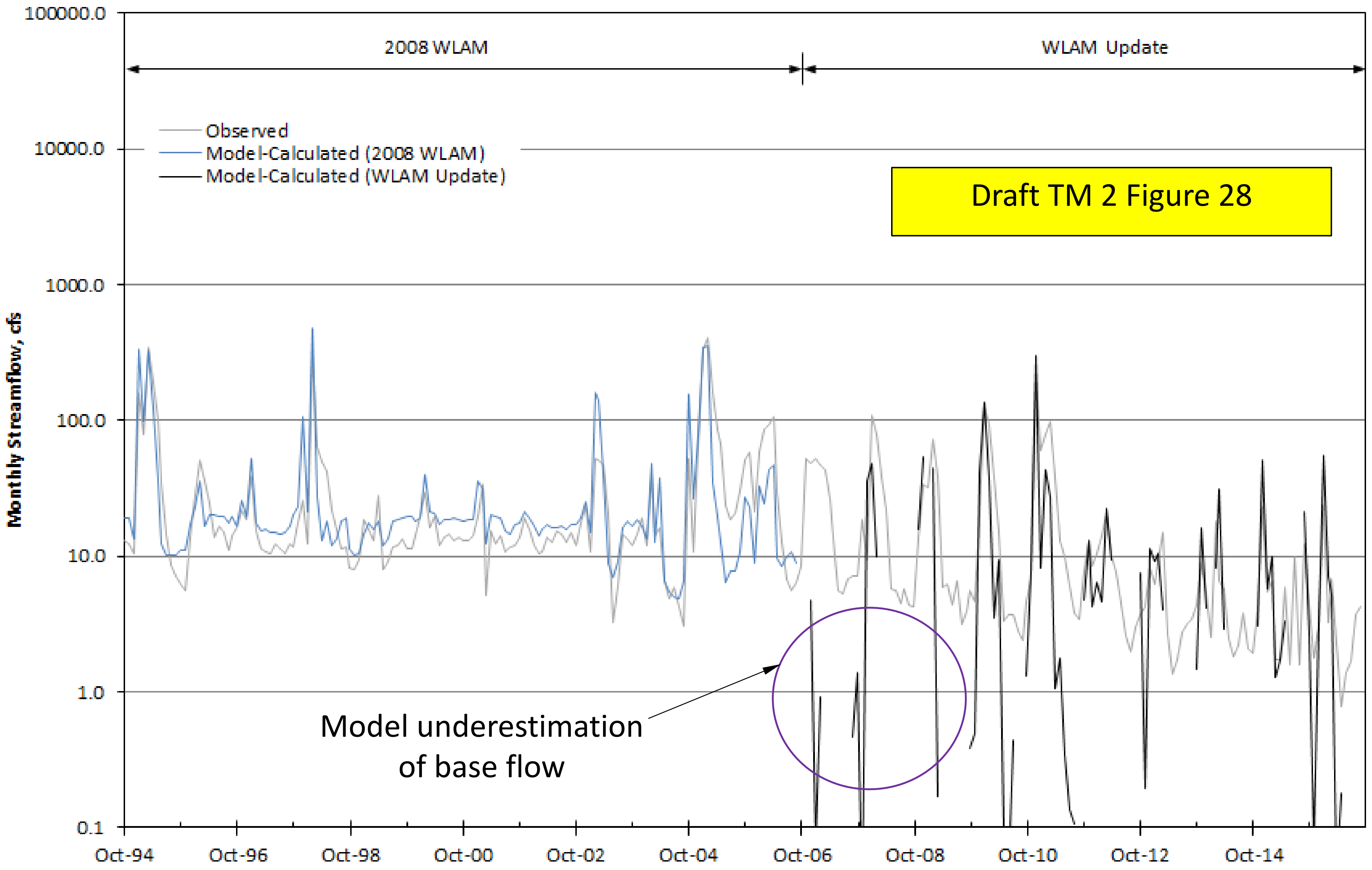
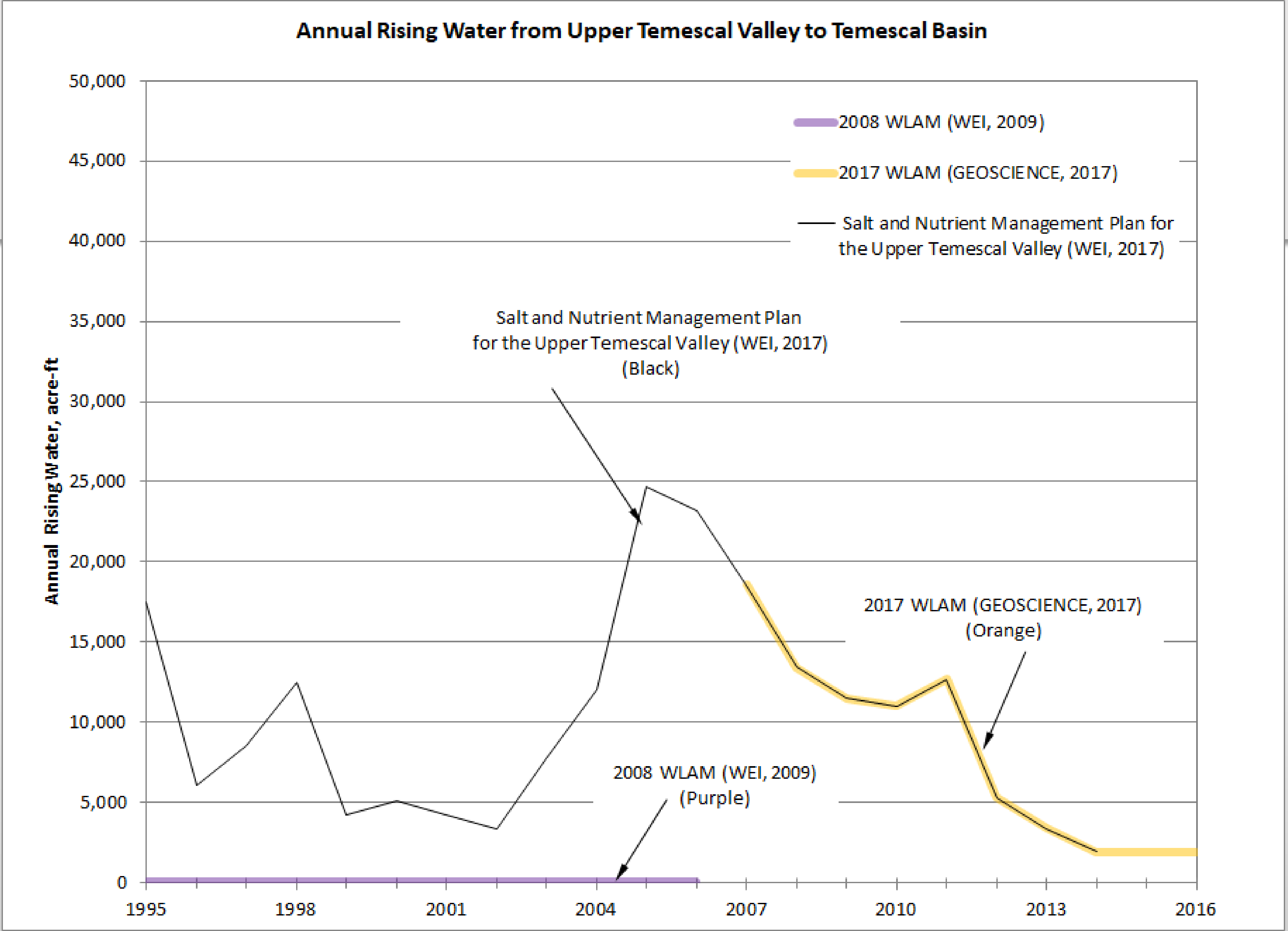


Figure 28


Annual Rising Water from Upper Temescal Valley to Temescal Basin
Annual Rising Water, acre-ft
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
1995
1998
2001
2004
2007
2010
2013
2016
2008 WLAM (WEI, 2009)
2017 WLAM (GEOSCIENCE, 2017)
Salt and Nutrient Management Plan for the Upper Temescal Valley (WEI, 2017)
Salt and Nutrient Management Plan for the Upper Temescal Valley (WEI, 2017) (Black)
2017 WLAM (GEOSCIENCE, 2017) (Orange)
2008 WLAM (WEI, 2009) (Purple)

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 (WLAM Update)

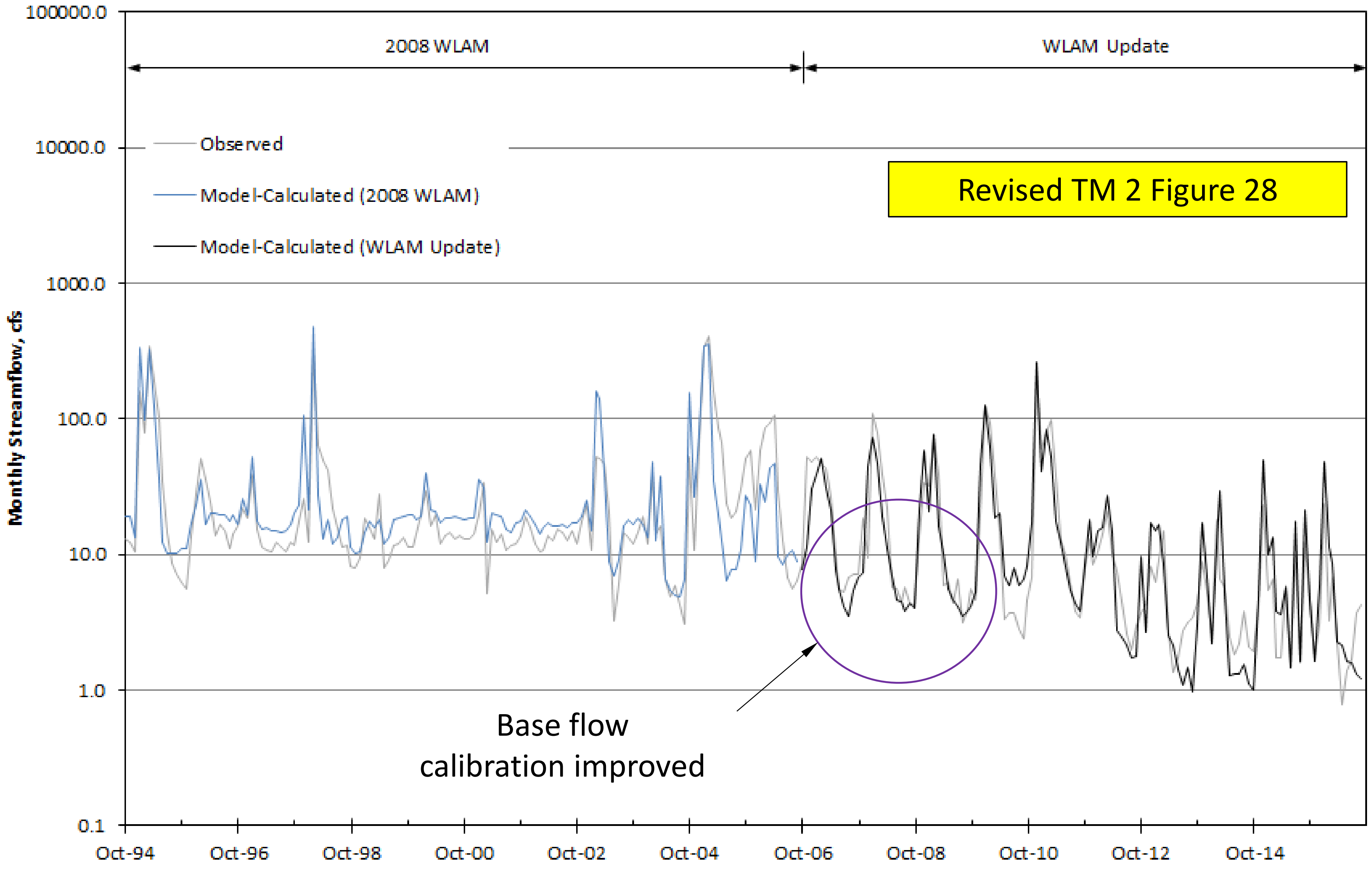
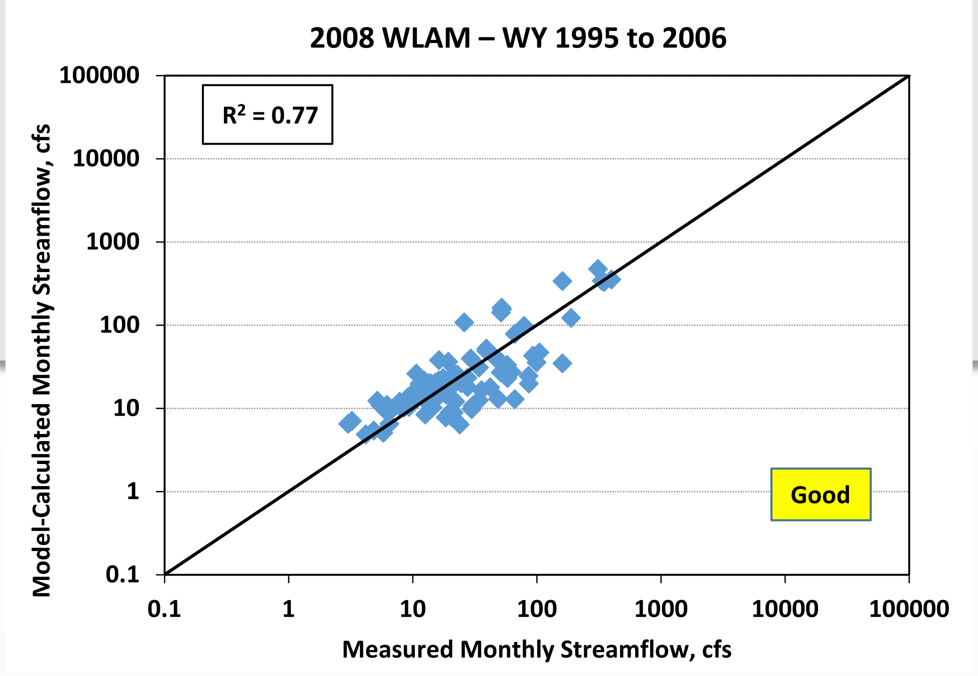
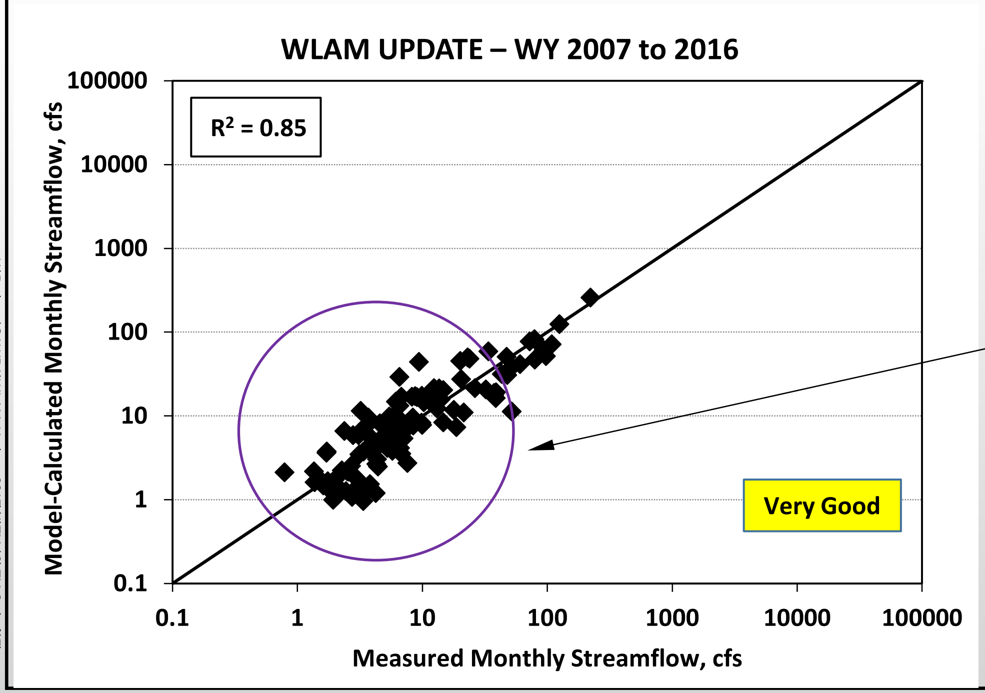
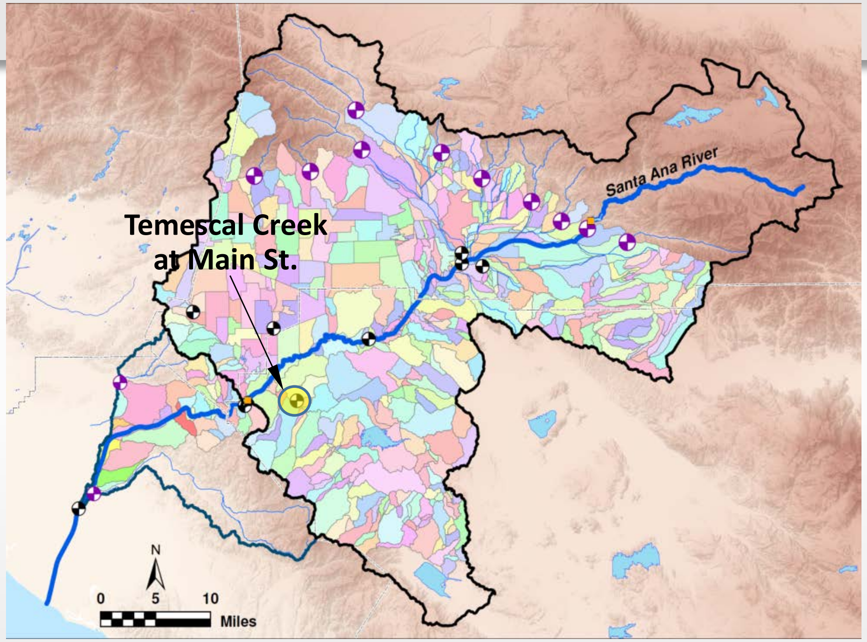


Figure 28

Revised TM 2 Figure 46



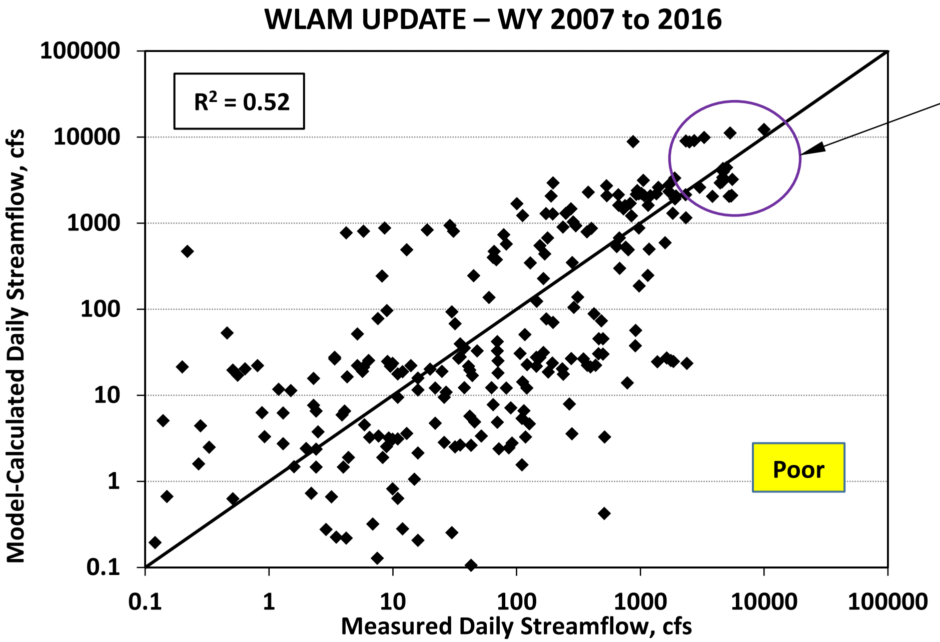




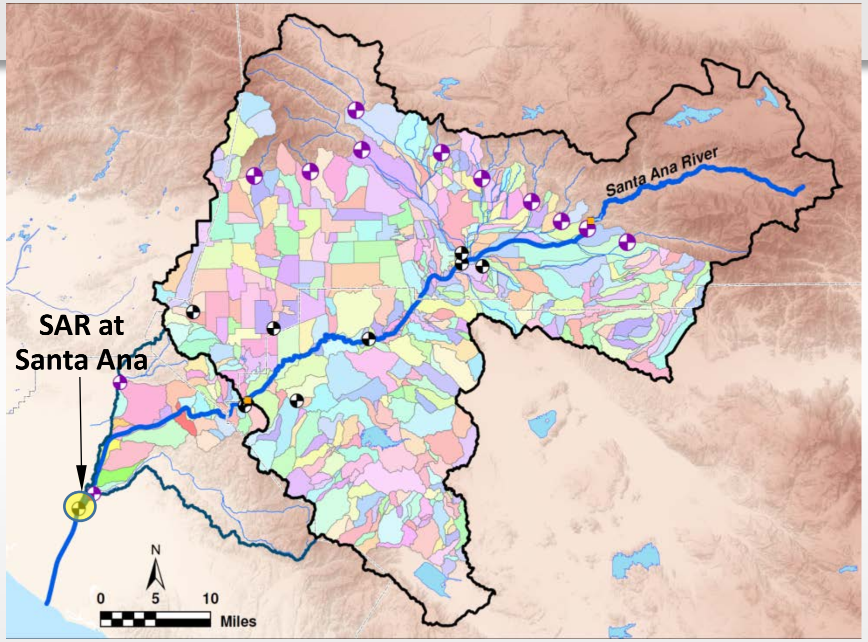
Base flow calibration improved with very good calibration performance

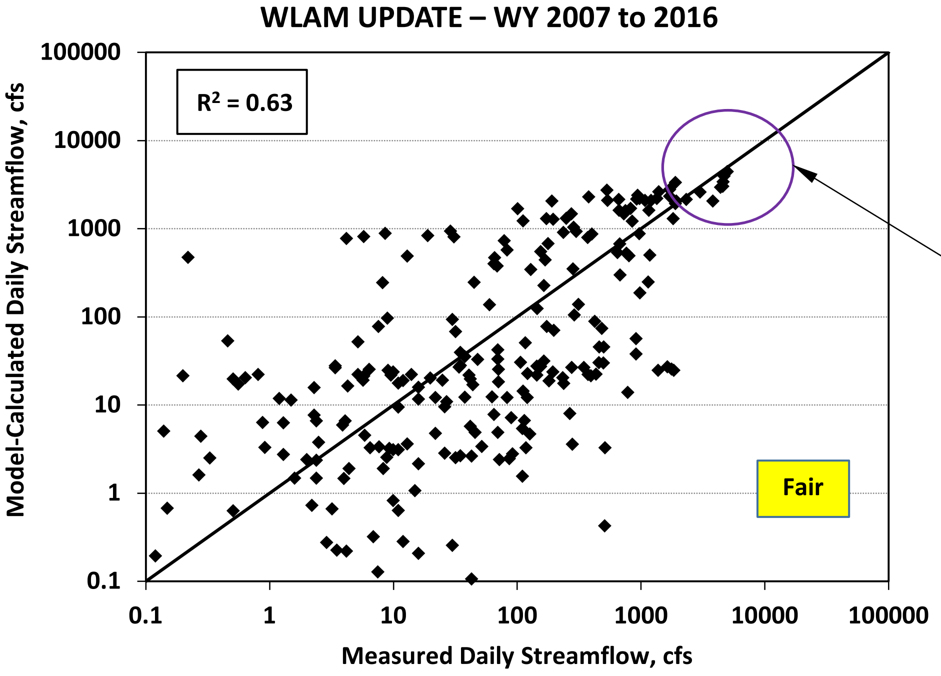
SCATTERPLOTS OF MEASURED AND MODEL-SIMULATED MONTHLY STREAMFLOW AT THE TEMESCAL CREEK AT MAIN STREET WATER YEARS 1995 TO 2006 (2008 WLAM) AND WATER YEARS 2007 TO 2016 (WLAM UPDATE)

2-Nov-17



Model overestimates flow in December 2010 and underestimates flow in January 2011



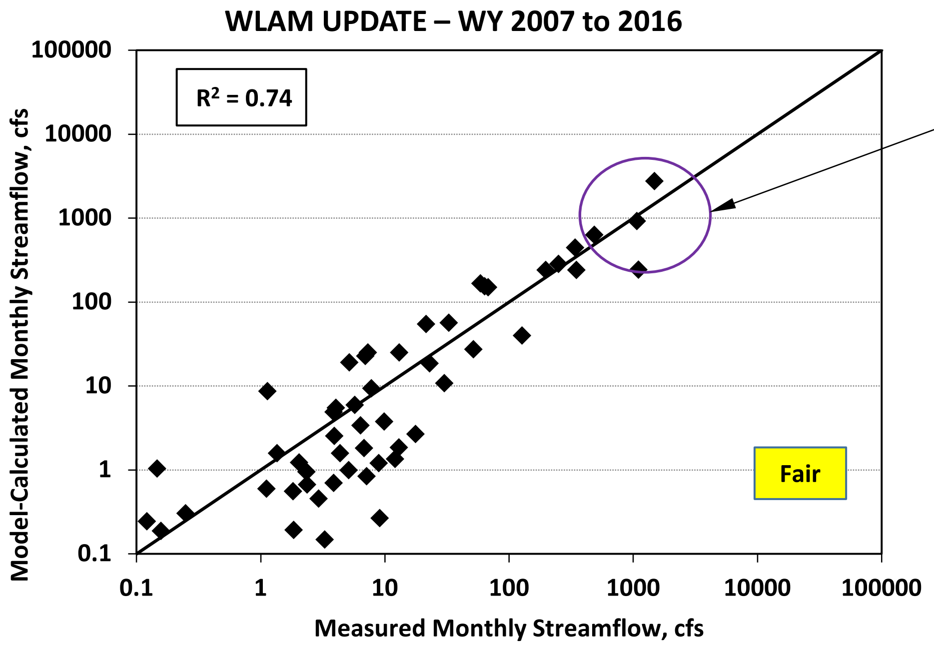


Calibration improved after data between December 19, 2010 and January 11, 2011 were removed

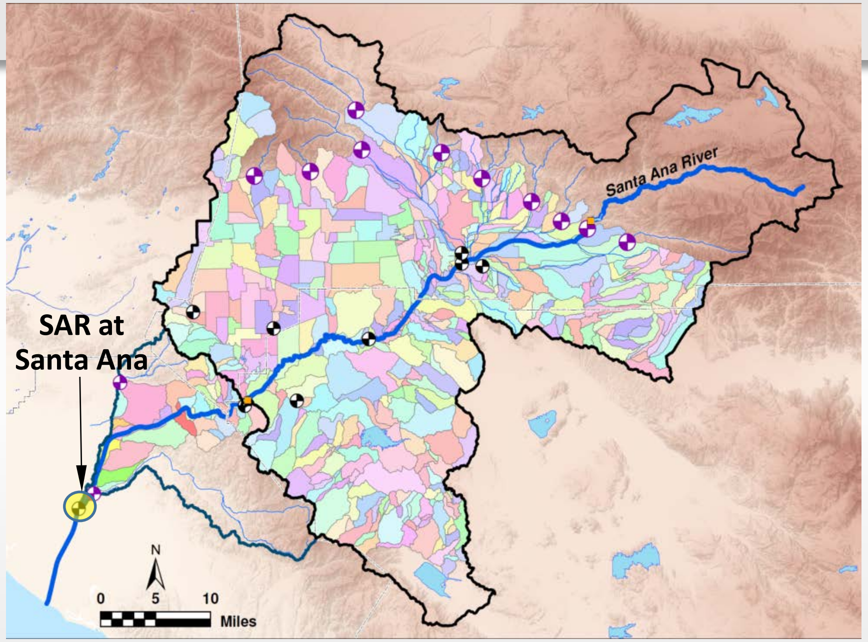
SCATTERPLOTS OF MEASURED AND MODEL-SIMULATED DAILY STREAMFLOW AT THE SANTA ANA RIVER AT SANTA ANA WATER YEARS 2007 TO 2016 (WLAM UPDATE)

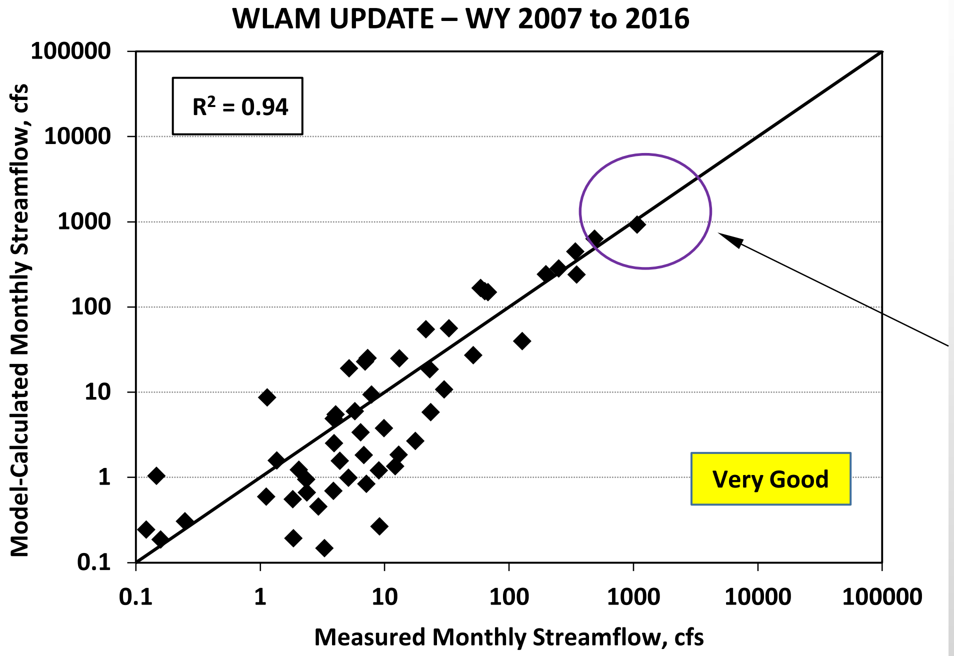
X:\Projects\SAWPA\WLAM_Update_2017\(4)TMs\(2) TM-2_draft\Figures

2-Nov-17



Model overestimates flow in December 2010 and underestimates flow in January 2011





Calibration improved after data between December 19, 2010 and January 12, 2011 were removed

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

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2-Nov-17

Response to Comments on TM No. 2 from RWQCB

Comments on Draft TM No. 2 from RWQCB – Comment No. 1

No.	Section	Pg.	Comment	GEOSCIENCE Response
1	2.3.10.2	11	Add reference for TIN in effluent from OCWD wetlands.	Reference will be added.

Comments on Draft TM No. 2 from RWQCB – Comment No. 2

No.	Section	Pg.	Comment	GEOSCIENCE Response
2	3.1	12	Add the degree of accuracy for streamflow data for each gaging station used for model calibration.	Additional information will be added.

Degree of Accuracy for Streamflow Data

Station Name	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
San Timoteo Creek near Loma Linda	Poor	Poor	Fair	Poor	Poor	Poor	Poor	Fair	Fair	Fair
Santa Ana River at E Street	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor
Santa Ana River at MWD Crossing	Good - Fair	Fair - Poor	Fair - Poor	Fair - Poor	Poor	Poor	Poor	Poor	Poor	Poor
Temescal Creek at Main Street	Fair - Poor	Fair - Poor	Fair - Poor	Fair - Poor	Fair - Poor	Fair - Poor	Fair - Poor	Fair - Poor	Fair - Poor	Fair - Poor
Chino Creek at Schaefer Avenue	Fair - Poor	Fair - Poor	Fair	Fair	Good	Good	Good	Good - Fair	Good - Fair	Good - Fair
Cucamonga Creek near Mira Loma	Fair	Poor	Poor	Fair - Poor	Fair - Poor	Fair - Poor	Fair - Poor	Fair - Poor	Fair - Poor	Fair - Poor
Santa Ana River Below Prado Dam	Fair - Poor	Fair - Poor	Good - Poor	Good	Fair	Fair	Fair	Good	Good	Good
Warm Creek near San Bernardino	Fair - Poor	Good - Poor	Good	Good - Poor	Good - Poor	Good	Fair - Poor	Good - Poor	Good - Poor	Good - Poor
Santa Ana River at Santa Ana	Fair	Fair	Poor	Fair	Poor	Poor	Poor	Poor	Poor	Poor

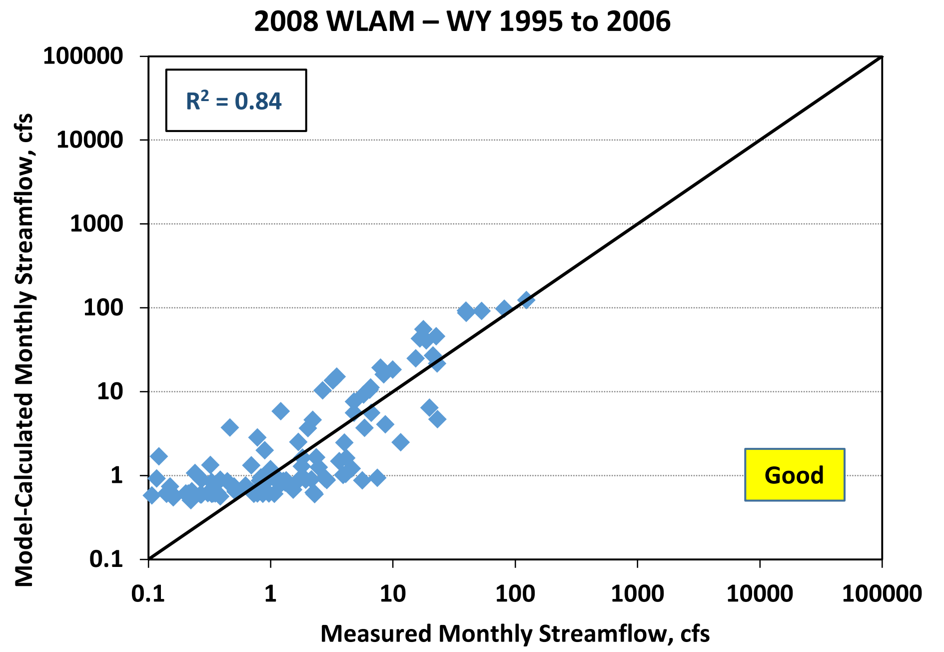
"Good" indicates that about 95 percent of the daily discharges are within 10 percent of the true value;
"Fair" indicates that about 95 percent of the daily discharges are within 15 percent of the true value;
"Poor" indicates that daily discharges have less than "fair" accuracy.

Comments on Draft TM No. 2 from RWQCB – Comment No. 3

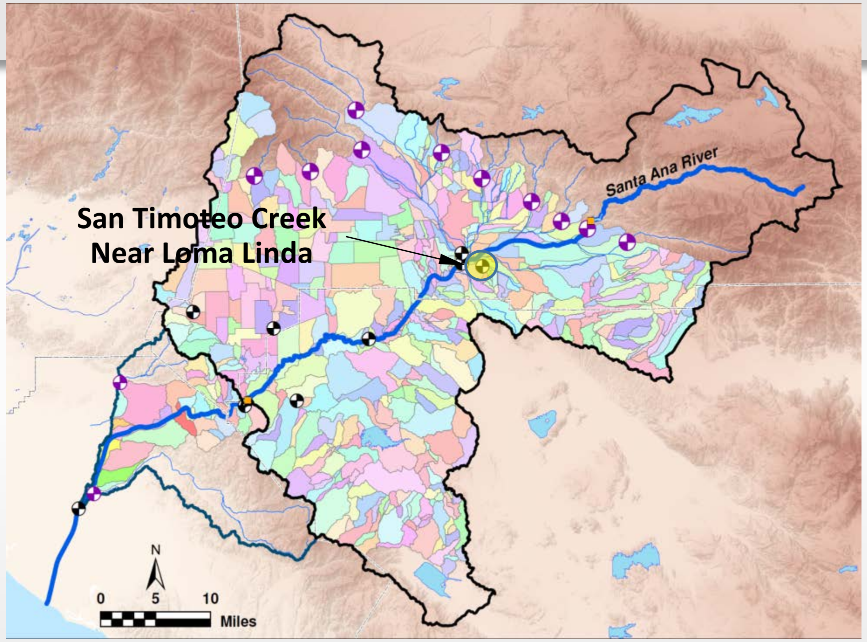
No.	Section	Pg.	Comment	GEOSCIENCE Response
3	3.1	12	Provide explanation on why only three gaging stations were used for the TDS/TIN calibration.	The 2008 WLAM used the gaging stations at Santa Ana River at MWD Crossing and Santa Ana River below Prado Dam for the TDS/TIN calibration, due to data availability. 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.

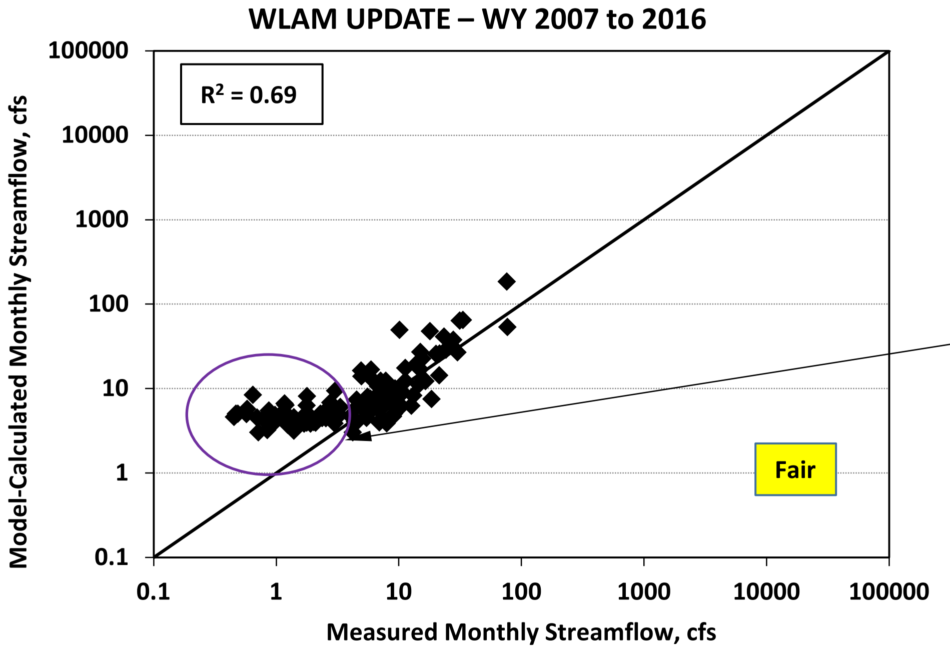
Comments on Draft TM No. 2 from RWQCB – Comment No. 4

No.	Section	Pg.	Comment	GEOSCIENCE Response
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 will be refined to improve model calibration.



Draft TM 2 Figure 42





Model overestimates streamflow

SCATTERPLOTS 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 (WLAM UPDATE)

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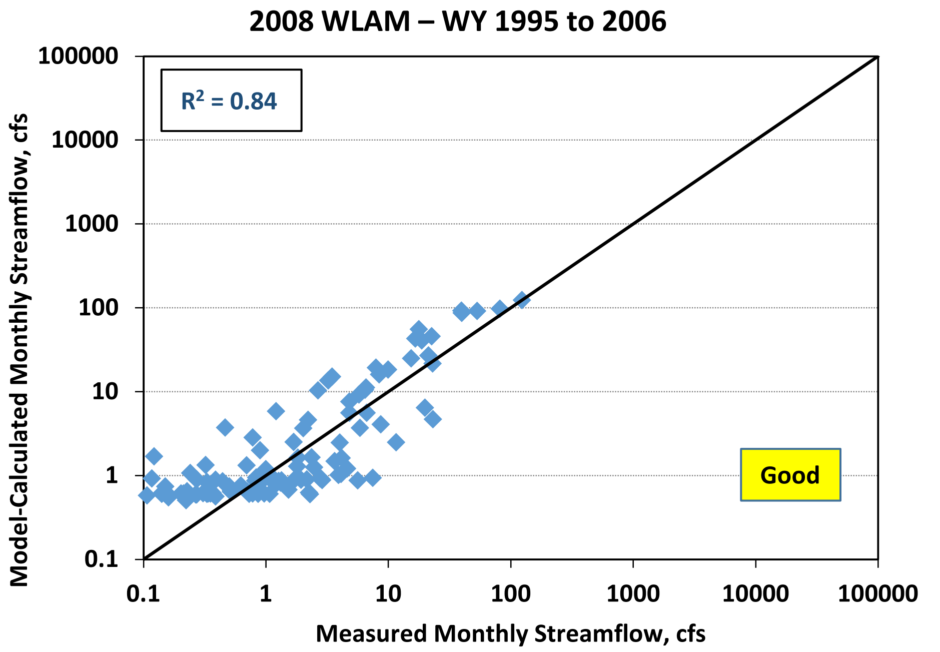
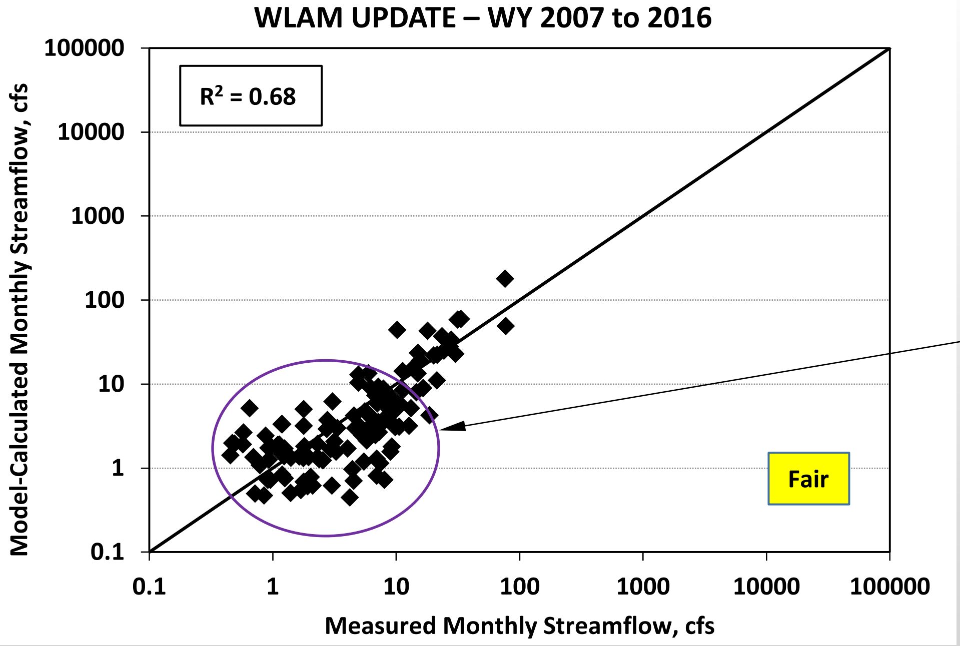
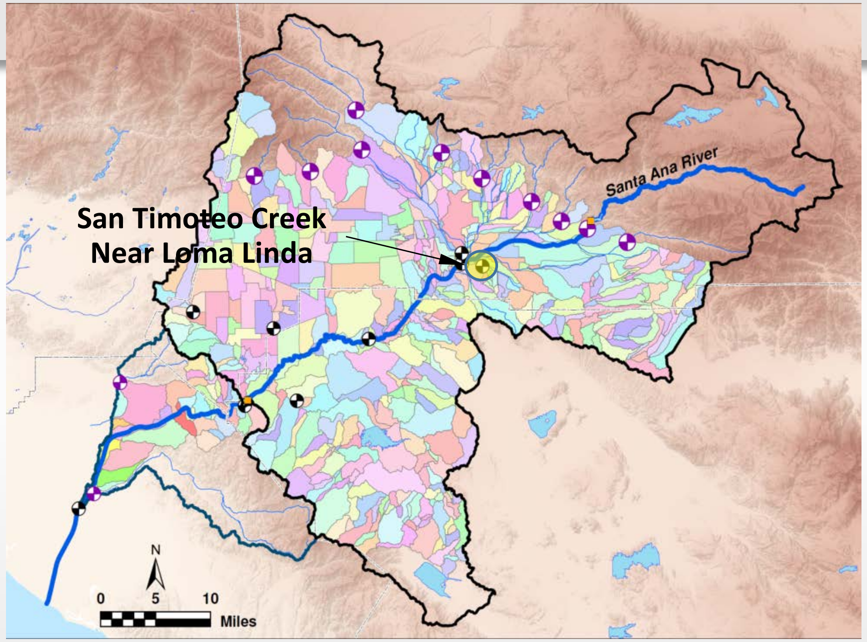
19-Sep-17





Revised TM 2 Figure 42



Baseflow calibration improved slightly. However, R^2 was not improved

SCATTERPLOTS 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 (WLAM UPDATE)

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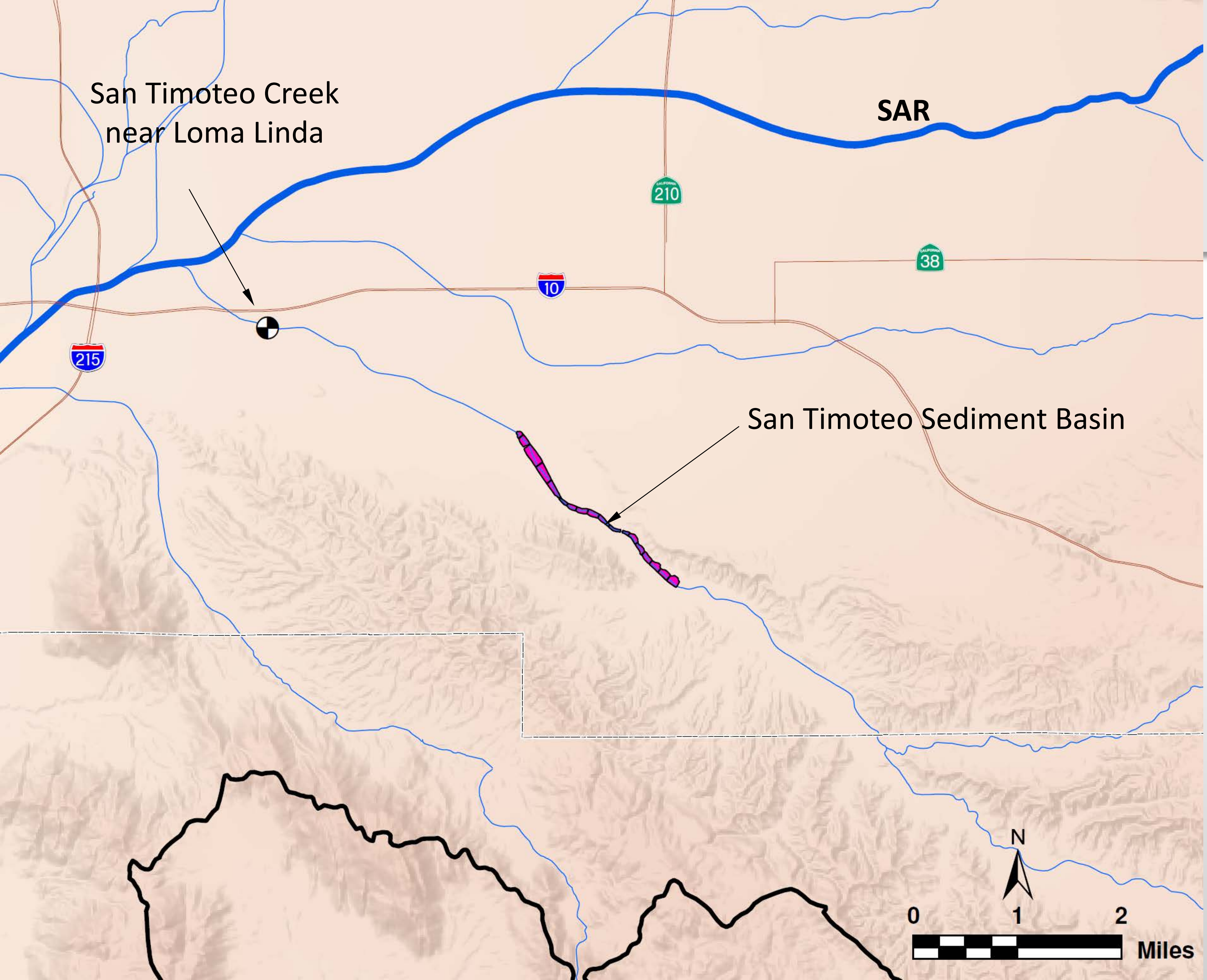
19-Sep-17

San Timoteo Sediment Basin

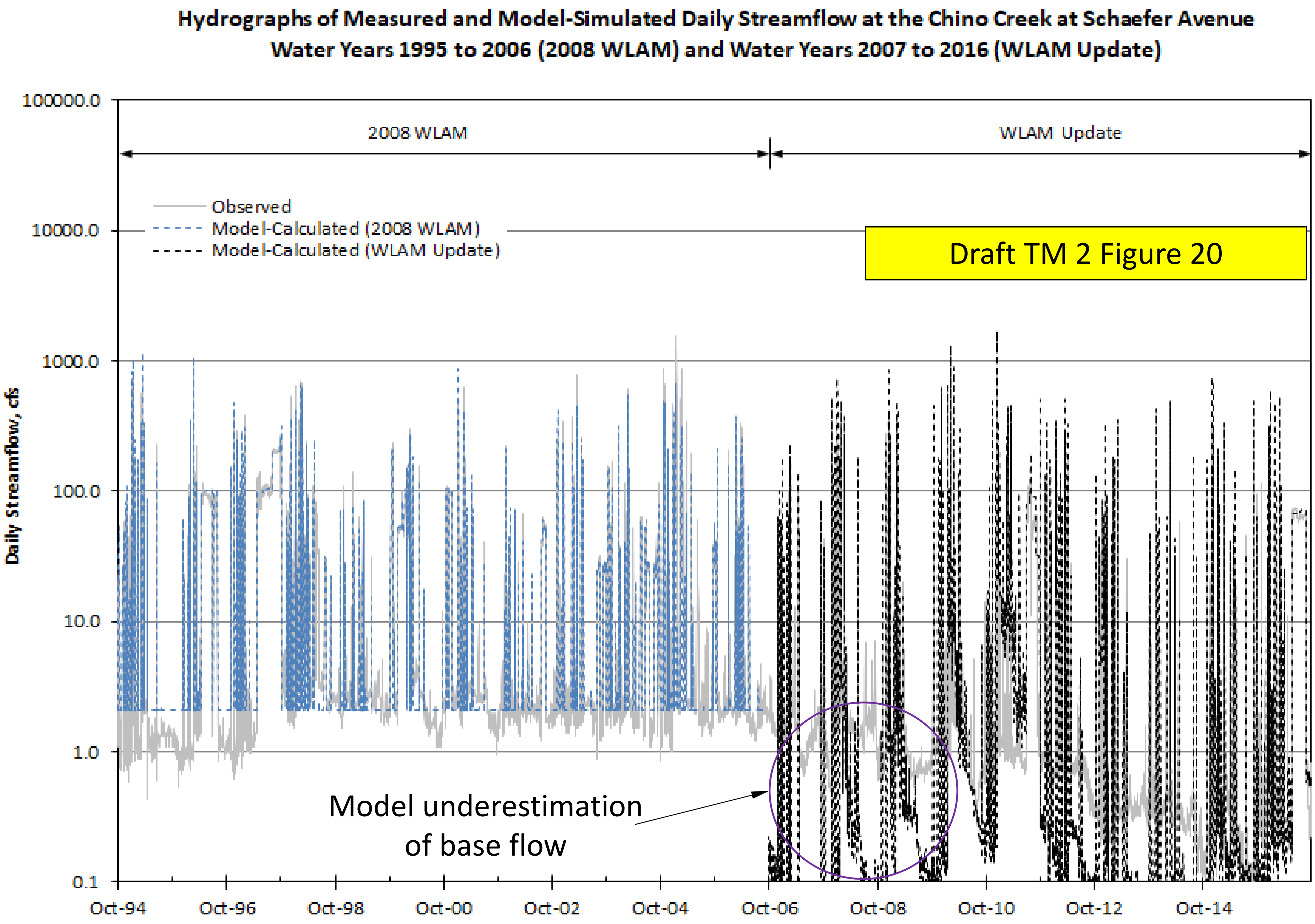


Comments on Draft TM No. 2 from RWQCB – Comment No. 5

No.	Section	Pg.	Comment	GEOSCIENCE Response
5	3.3	15	Provide an explanation for the poor model performance at the Santa Ana River at Santa Ana gaging station.	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.

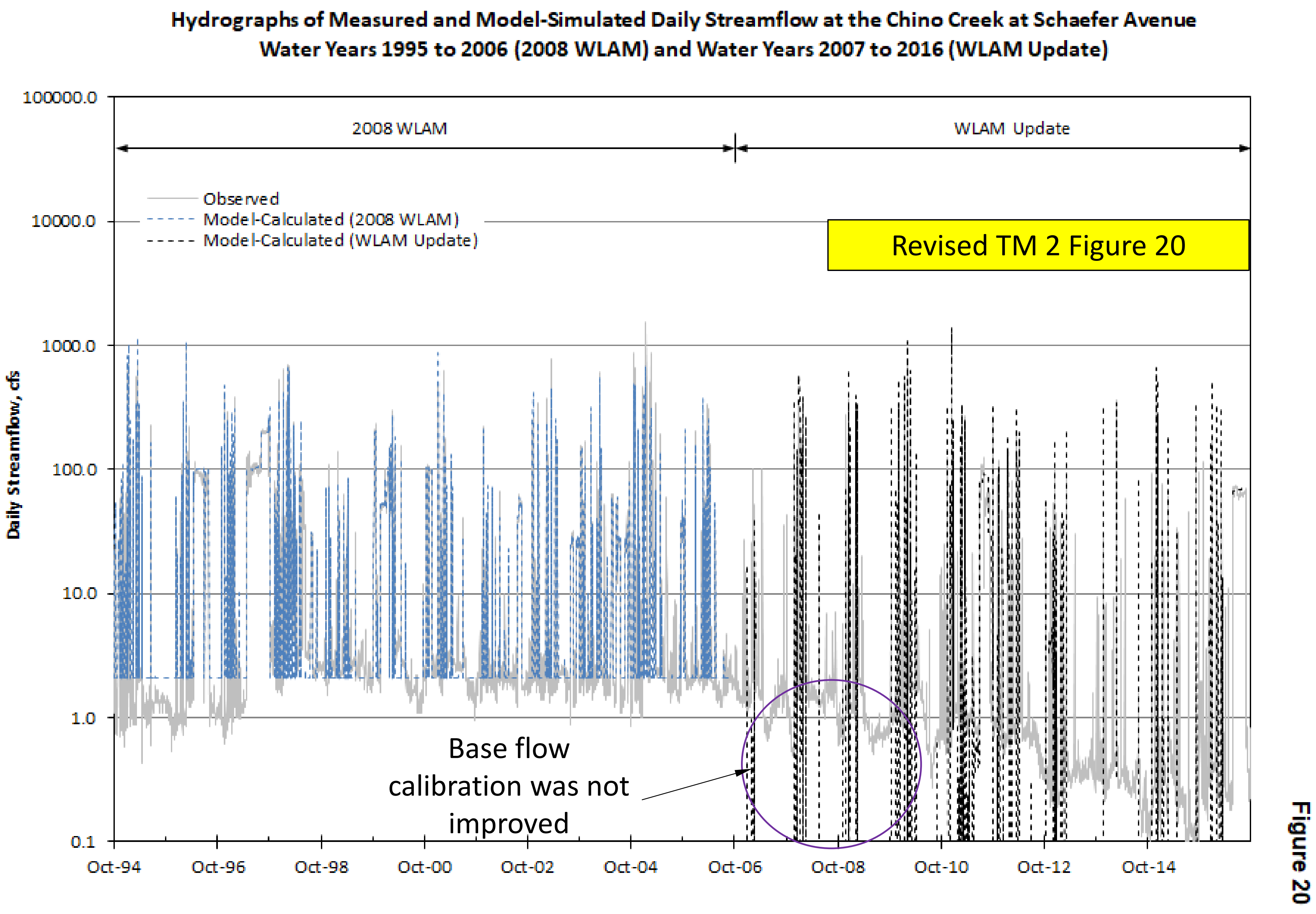
Comments on Draft TM No. 2 from RWQCB – Comment No. 6

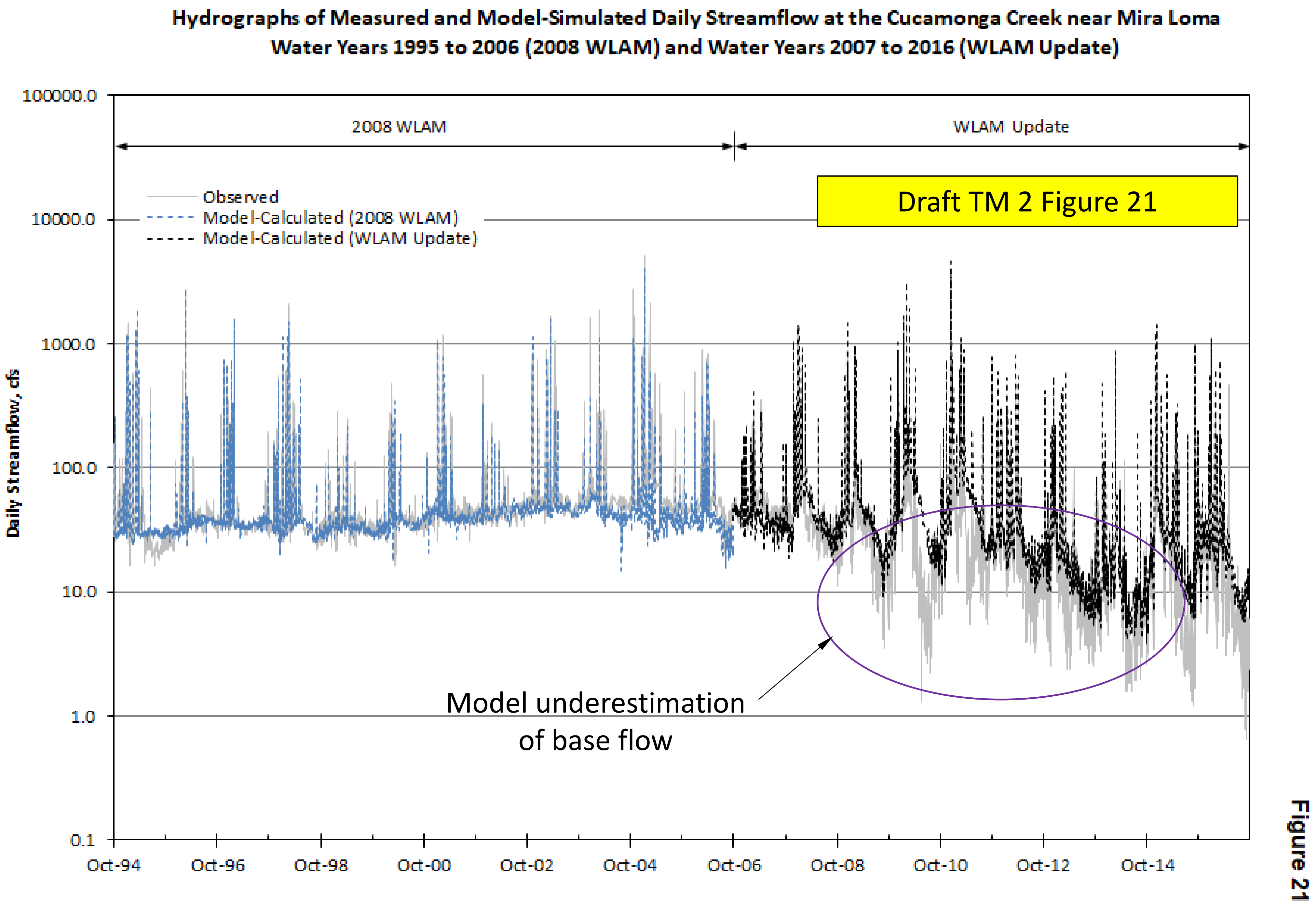
No.	Section	Pg.	Comment	GEOSCIENCE Response
6	General	-	Revisit areas where the model is over/underestimating streamflow and may need improvement (e.g., Figures 20, 21, 24, and 28).	Underperforming areas will be revisited.

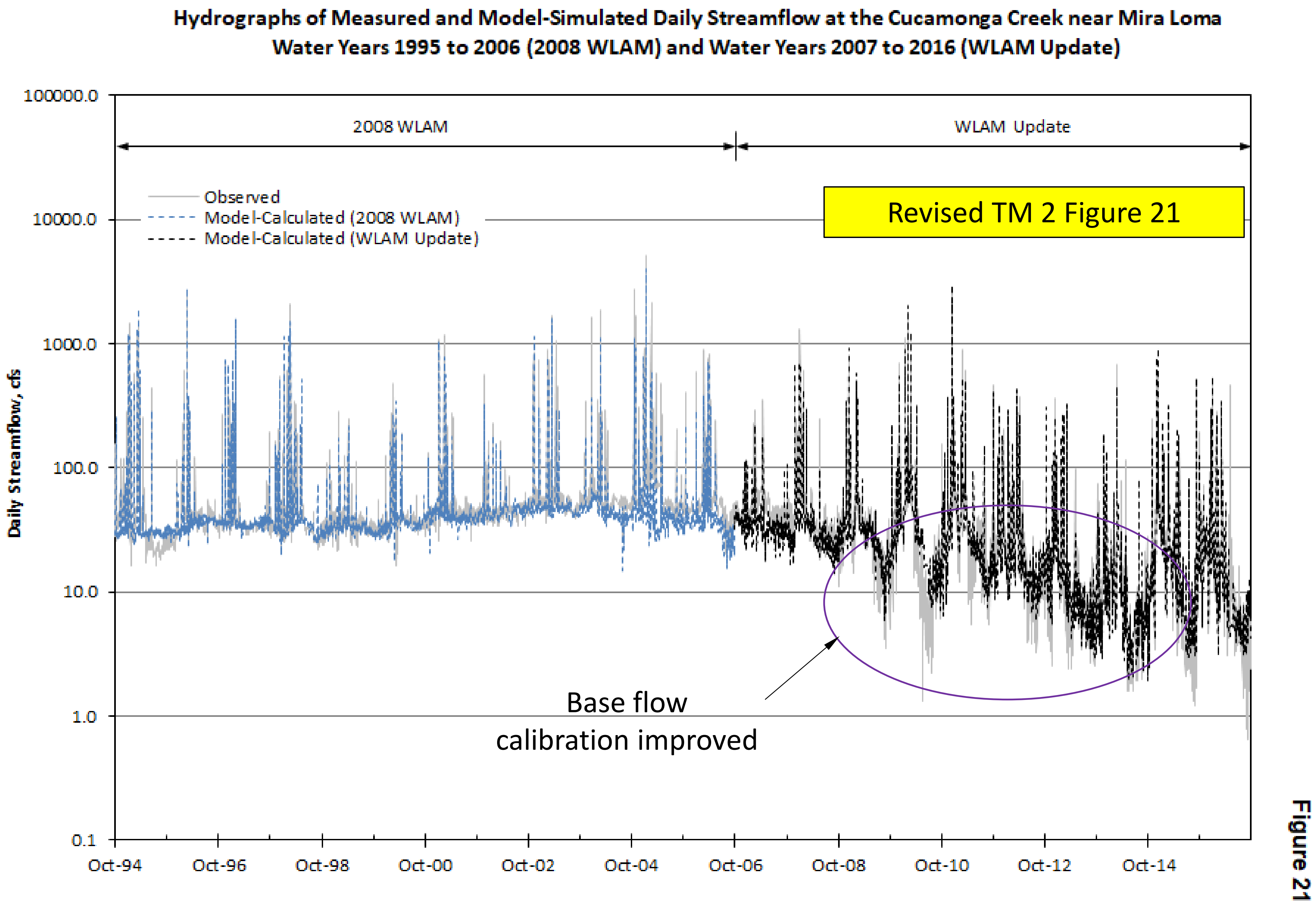


Hydrographs of Measured and Model-Simulated Daily Streamflow at the Chino Creek at Schaefer Avenue
Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (WLAM Update)
2008 WLAM
WLAM Update
Observed
Model-Calculated (2008 WLAM)
Model-Calculated (WLAM Update)
Draft TM 2 Figure 20
Daily Streamflow, cfs
100000.0
10000.0
1000.0
100.0
10.0
1.0
0.1
Oct-94
Oct-96
Oct-98
Oct-00
Oct-02
Oct-04
Oct-06
Oct-08
Oct-10
Oct-12
Oct-14
Model underestimation of base flow

Figure 20


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 (WLAM Update)
2008 WLAM
WLAM Update
Observed
Model-Calculated (2008 WLAM)
Model-Calculated (WLAM Update)
Revised TM 2 Figure 20
Daily Streamflow, cfs
100000.0
10000.0
1000.0
100.0
10.0
1.0
0.1
Base flow calibration was not improved
Oct-94
Oct-96
Oct-98
Oct-00
Oct-02
Oct-04
Oct-06
Oct-08
Oct-10
Oct-12
Oct-14
Figure 20

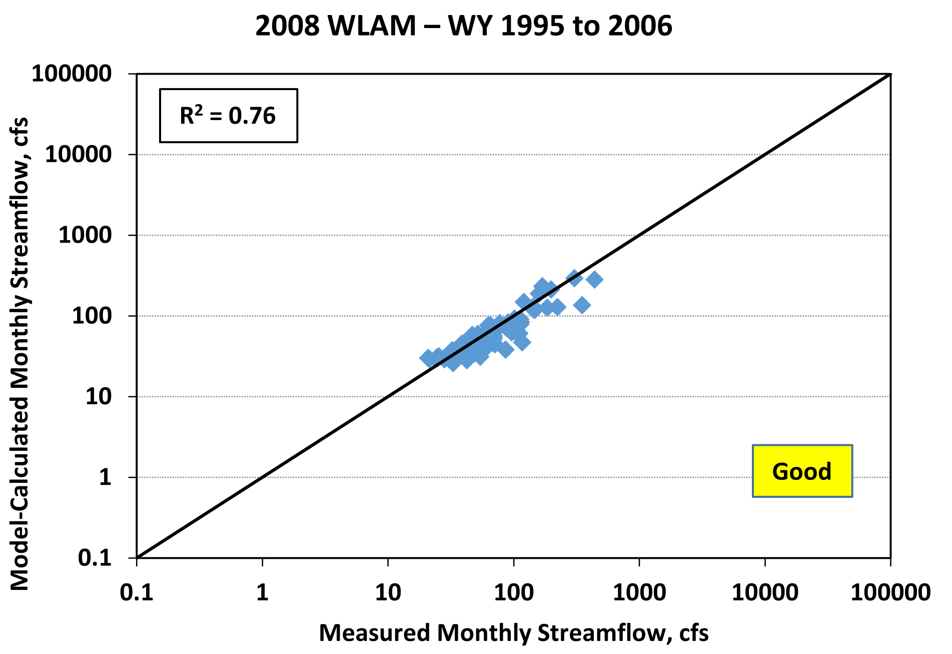

Hydrographs of Measured and Model-Simulated Daily Streamflow at the Cucamonga Creek near Mira Loma
Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (WLAM Update)
2008 WLAM
WLAM Update
Draft TM 2 Figure 21
Observed
Model-Calculated (2008 WLAM)
Model-Calculated (WLAM Update)
Daily Streamflow, cfs
100000.0
10000.0
1000.0
100.0
10.0
1.0
0.1
Oct-94
Oct-96
Oct-98
Oct-00
Oct-02
Oct-04
Oct-06
Oct-08
Oct-10
Oct-12
Oct-14
Model underestimation
of base flow
Figure 21

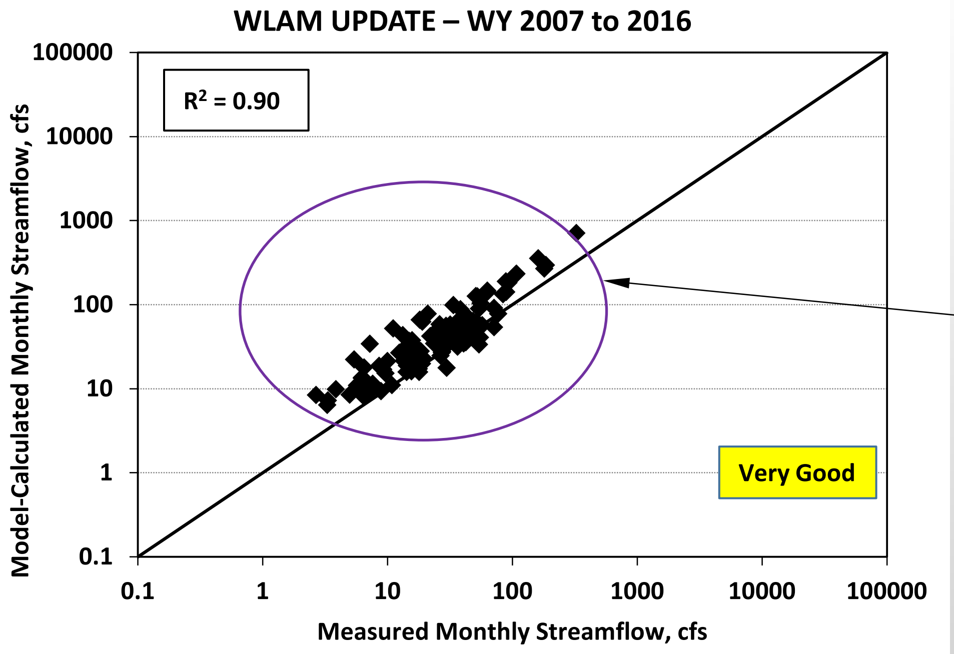


Hydrographs of Measured and Model-Simulated Daily Streamflow at the Cucamonga Creek near Mira Loma
Water Years 1995 to 2006 (2008 WLAM) and Water Years 2007 to 2016 (WLAM Update)
2008 WLAM
WLAM Update
Observed
Model-Calculated (2008 WLAM)
Model-Calculated (WLAM Update)
Revised TM 2 Figure 21
Daily Streamflow, cfs
100000.0
10000.0
1000.0
100.0
10.0
1.0
0.1
Base flow
calibration improved
Oct-94
Oct-96
Oct-98
Oct-00
Oct-02
Oct-04
Oct-06
Oct-08
Oct-10
Oct-12
Oct-14
Figure 21

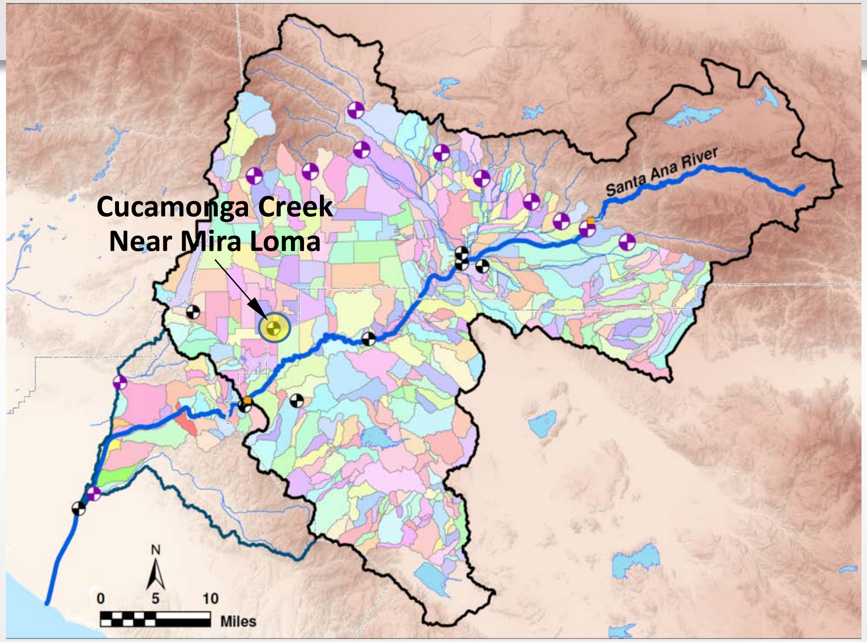
Comments on Draft TM No. 2 from RWQCB – Comment No. 7

No.	Section	Pg.	Comment	GEOSCIENCE Response
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.





Draft TM 2 Figure 48



Model overestimates streamflow consistently

SCATTERPLOTS 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 (WLAM UPDATE)

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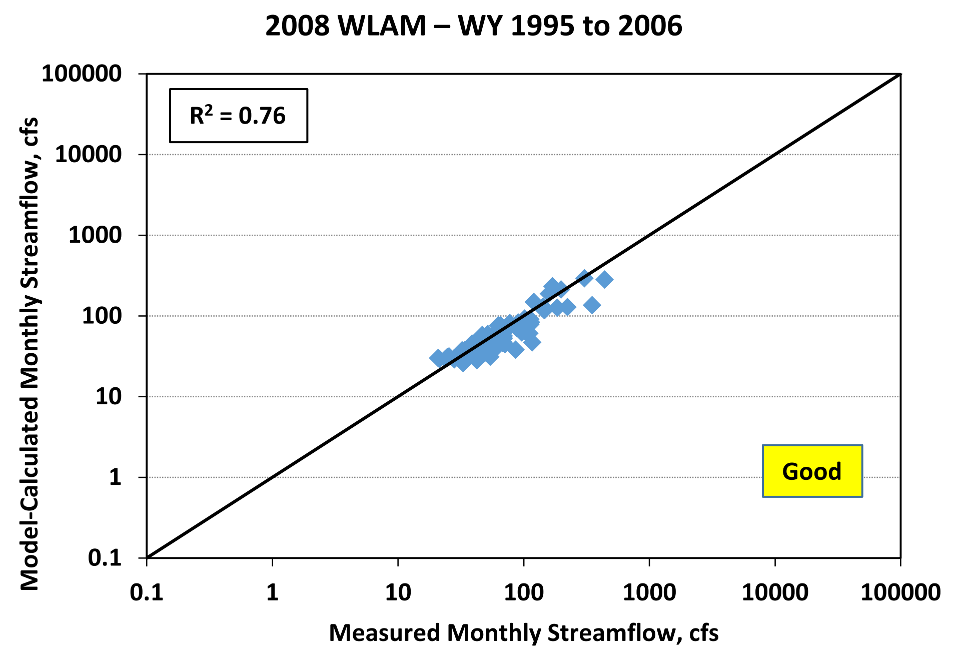
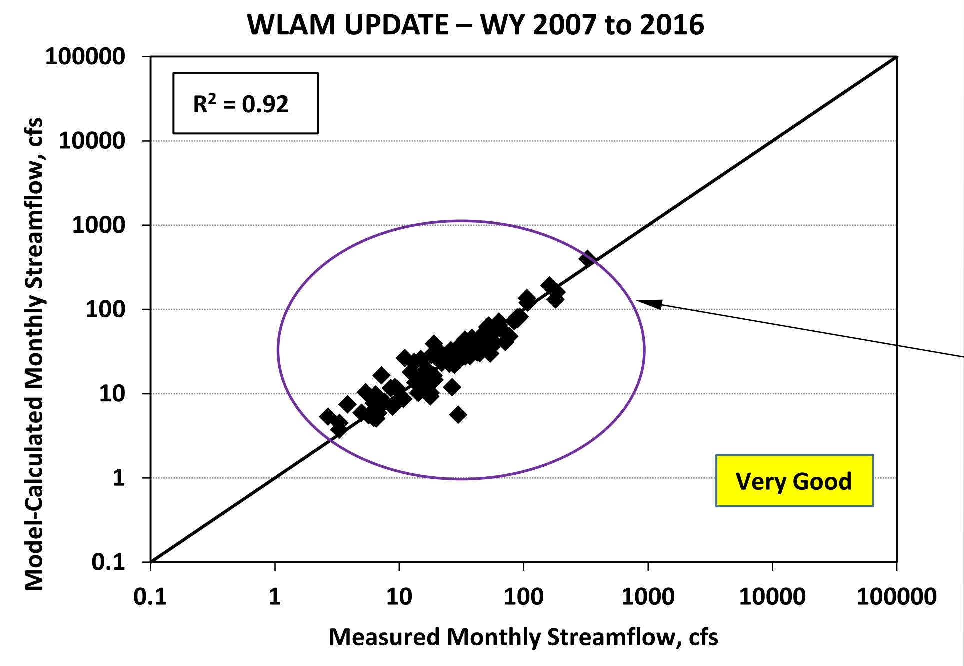
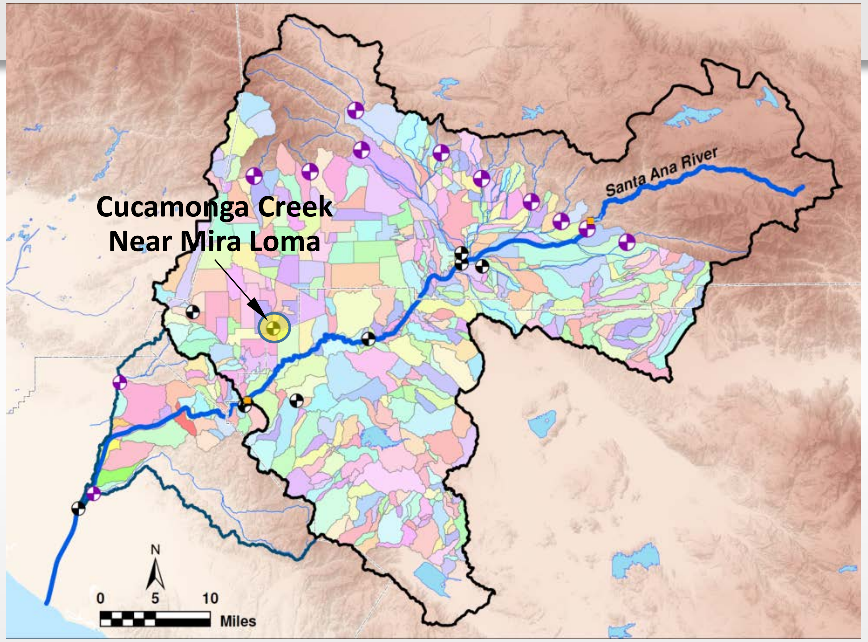
19-Sep-17

Revised TM 2 Figure 48







Overestimation of streamflow improved

SCATTERPLOTS 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 (WLAM UPDATE)

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Response to Comments on TM No. 2 from OCWD

Comments on Draft TM No. 2 from OCWD – Comment No. 1

No.	Section	Pg.	Comment	GEOSCIENCE Response
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 will be added.

Comments on Draft TM No. 2 from OCWD – Comment No. 2

No.	Section	Pg.	Comment	GEOSCIENCE Response
2	Figures	Figure 2	For Figure 5, please add a legend for the symbols	Legend will be added.

Comments on Draft TM No. 2 from OCWD – Comment No. 3

No.	Section	Pg.	Comment	GEOSCIENCE Response
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 will be provided as an appendix.

Comments on Draft TM No. 2 from OCWD – Comment No. 4

No.	Section	Pg.	Comment	GEOSCIENCE Response
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 will be added to the text.

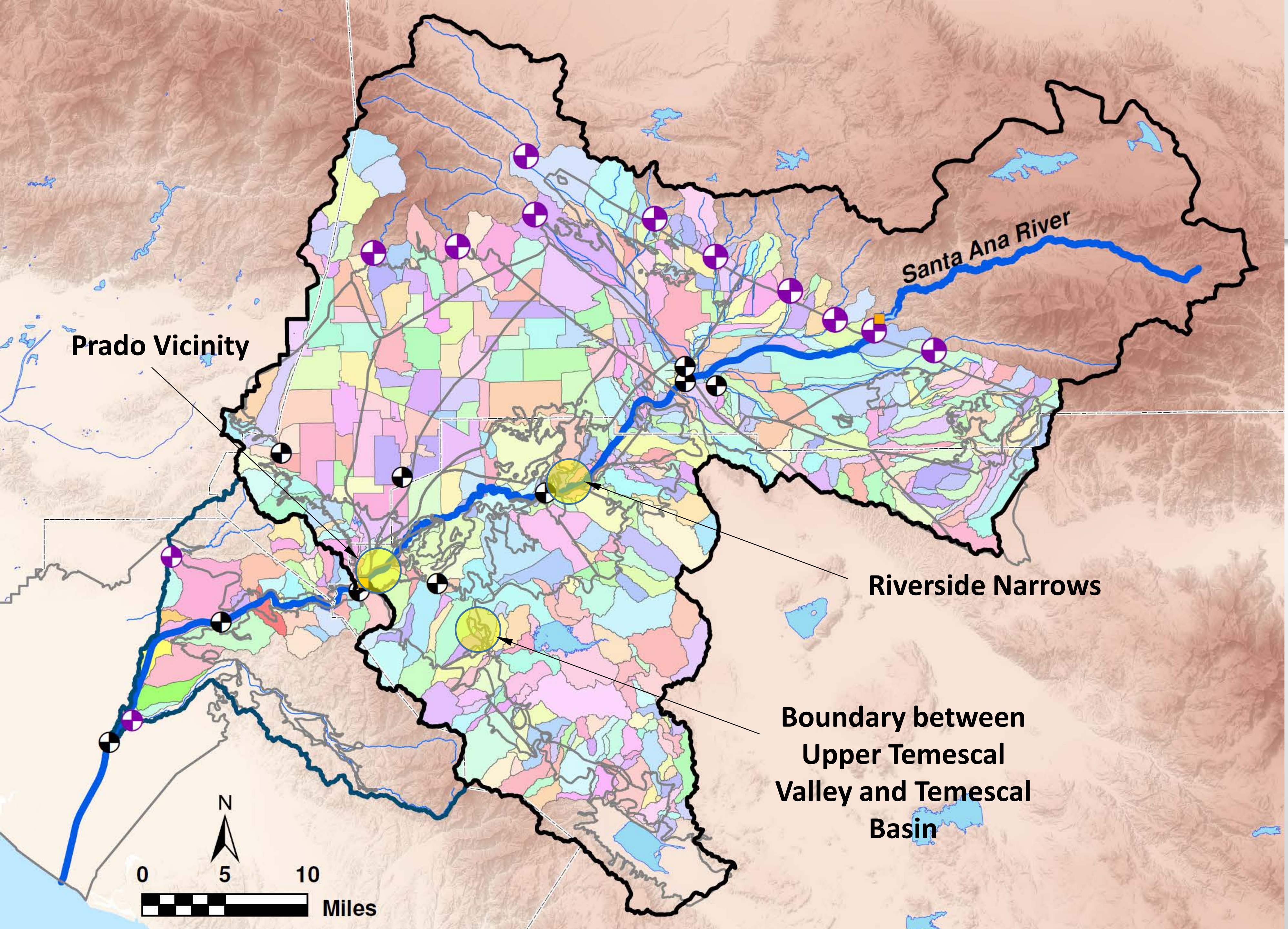
Comments on Draft TM No. 2 from OCWD – Comment No. 5

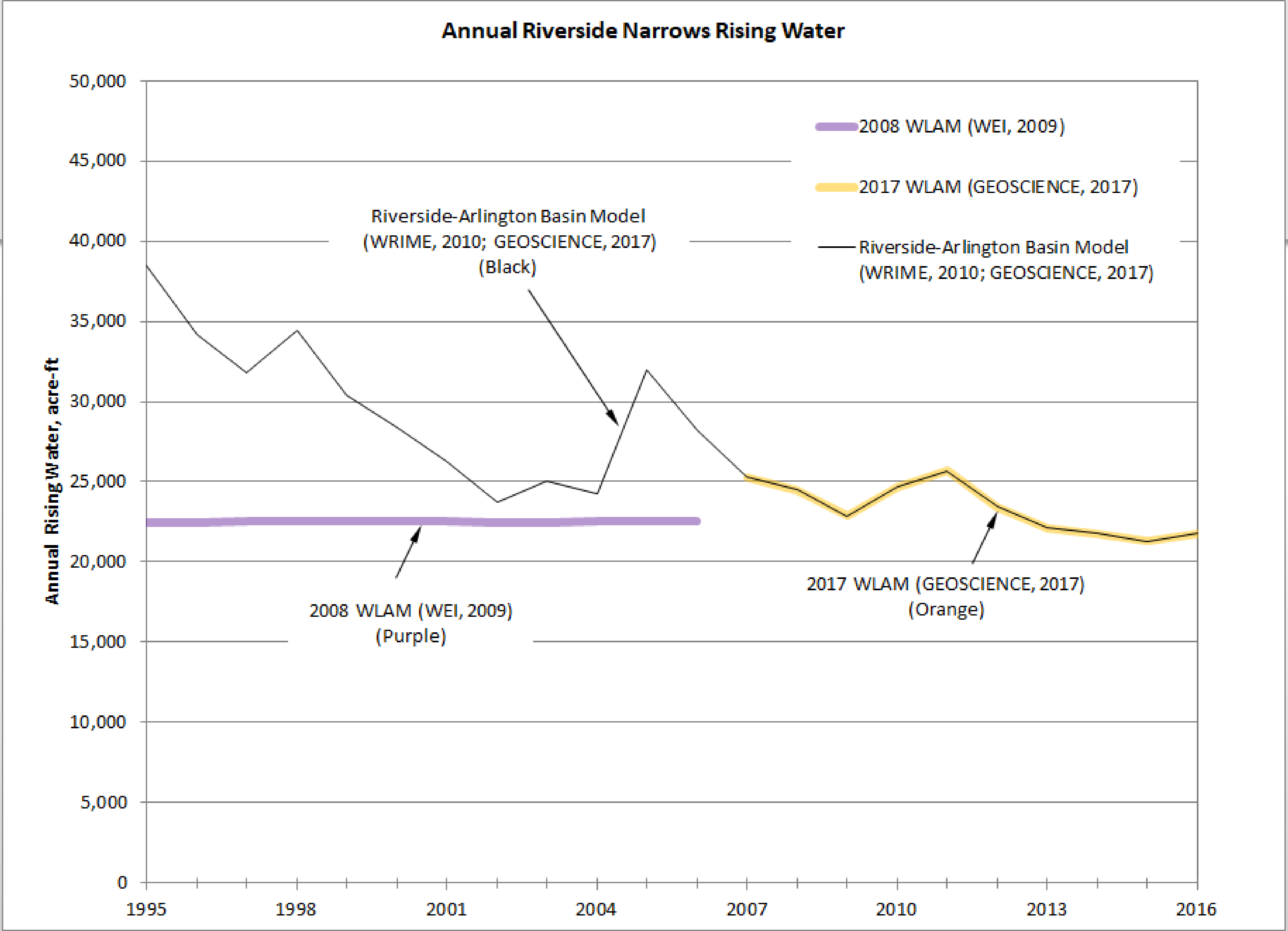
No.	Section	Pg.	Comment	GEOSCIENCE Response
5	General	-	A water budget summary table should be included – among other items, the table should list total runoff, total wastewater discharge, total unmanaged streambed infiltration, total managed infiltration (such as OCWD managed infiltration, and other 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.	A water budget table will be added.

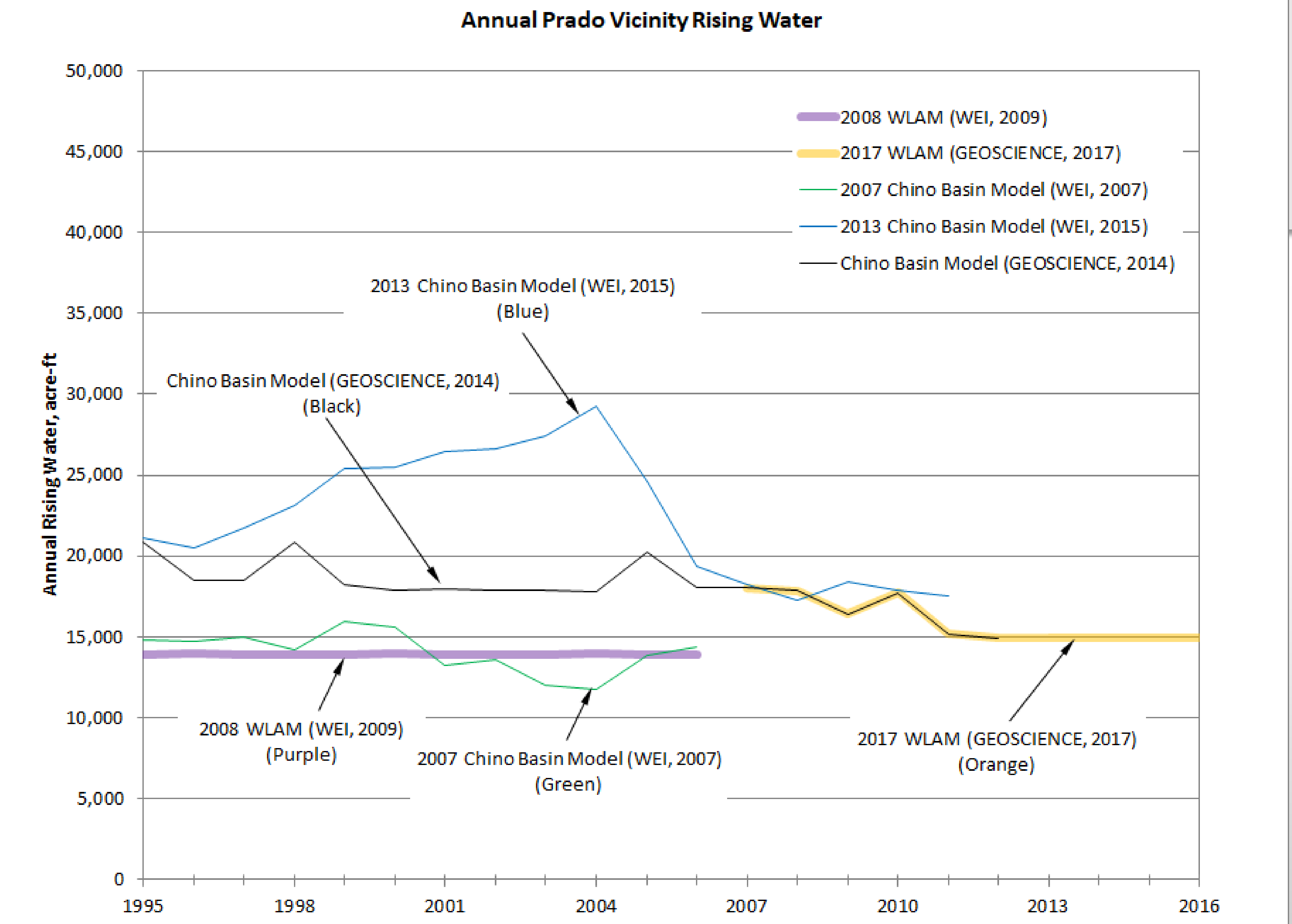
Comments on Draft TM No. 2 from OCWD – Comment No. 6

No.	Section	Pg.	Comment	GEOSCIENCE Response
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 will be added.

Location of Rising Water




Annual Riverside Narrows Rising Water
Annual Rising Water, acre-ft
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
1995
1998
2001
2004
2007
2010
2013
2016
2008 WLAM (WEI, 2009)
2017 WLAM (GEOSCIENCE, 2017)
Riverside-Arlington Basin Model (WRIME, 2010; GEOSCIENCE, 2017)
Riverside-Arlington Basin Model (WRIME, 2010; GEOSCIENCE, 2017) (Black)
2008 WLAM (WEI, 2009) (Purple)
2017 WLAM (GEOSCIENCE, 2017) (Orange)


Annual Prado Vicinity Rising Water
Annual Rising Water, acre-ft
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
1995
1998
2001
2004
2007
2010
2013
2016
2008 WLAM (WEI, 2009)
2017 WLAM (GEOSCIENCE, 2017)
2007 Chino Basin Model (WEI, 2007)
2013 Chino Basin Model (WEI, 2015)
Chino Basin Model (GEOSCIENCE, 2014)
2013 Chino Basin Model (WEI, 2015) (Blue)
Chino Basin Model (GEOSCIENCE, 2014) (Black)
2008 WLAM (WEI, 2009) (Purple)
2007 Chino Basin Model (WEI, 2007) (Green)
2017 WLAM (GEOSCIENCE, 2017) (Orange)

TDS and TIN Concentrations for Rising Water

Rising Water Area	2008 WLAM WY 1995-2006		2017 WLAM HSPF WY 2007-2016	
	TDS Concentration	TIN Concentration	TDS Concentration	TIN Concentration
	mg/L	mg/L	mg/L	mg/L
Riverside Narrows	900	11	790	10
Prado Vicinity	1,100	11	1,160	7
Upper Temescal Valley to Temescal Basin	NA	NA	770	6

Comments on Draft TM No. 2 from OCWD – Comment No. 7

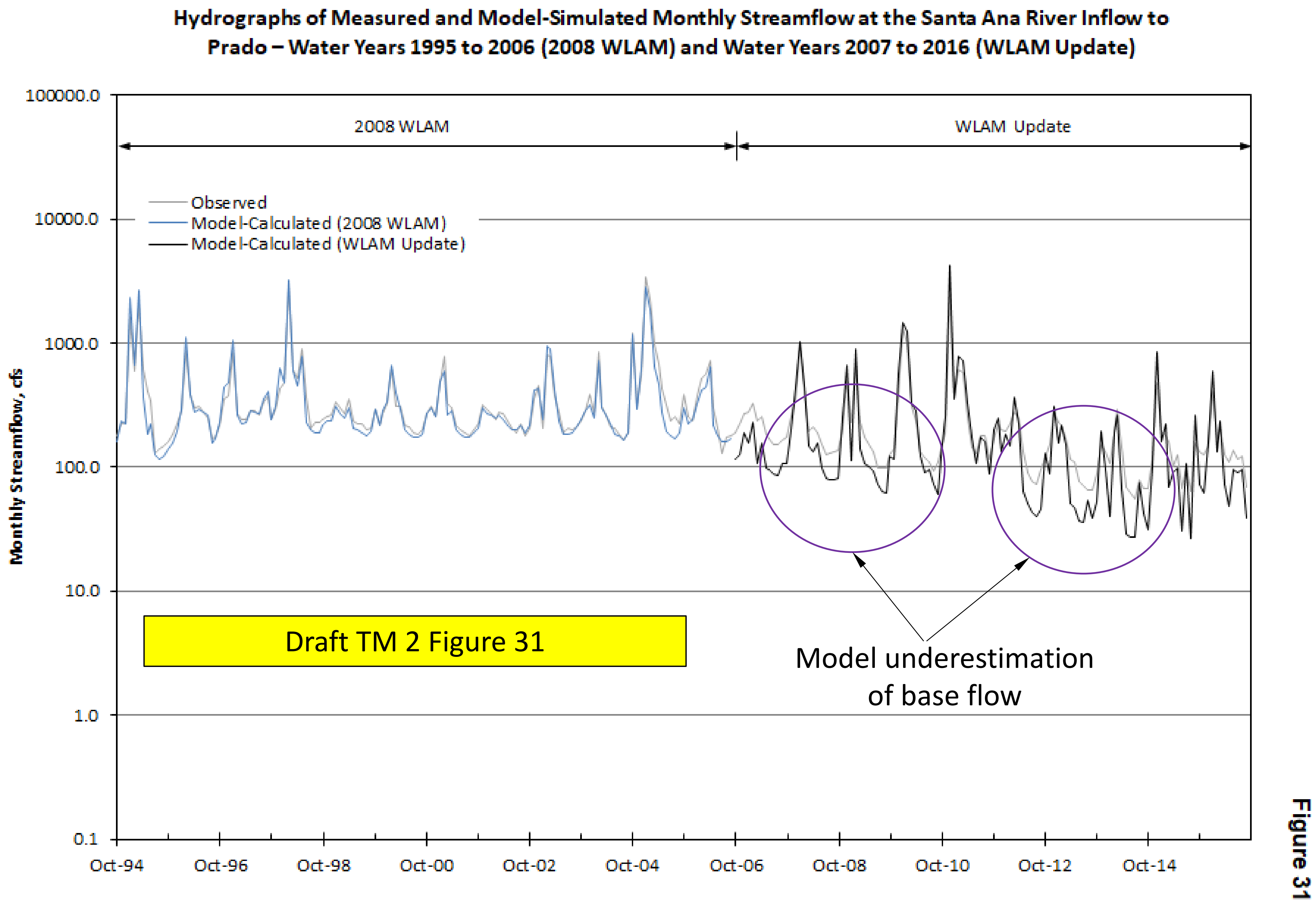
No.	Section	Pg.	Comment	GEOSCIENCE Response
7	2.3.10.2	10	Section 2.3.10.2, OCWD Wetlands – the TIN of effluent from the OCWD Prado Wetlands should be varied seasonally – the winter time nitrate removal rate is lower than the summer time removal rate. For May-October, a TIN effluent of 1 mg/L is appropriate; for November-April, 4 mg/L is appropriate.	Model will be revised to incorporate this comment.

Comments on Draft TM No. 2 from OCWD – Comment No. 8

No.	Section	Pg.	Comment	GEOSCIENCE Response
8	3.3	15	Section 3.3, Streamflow Calibration Results – the R2 values should be included in the table on page 15.	R^2 values will be added

Comments on Draft TM No. 2 from OCWD – Comment No. 9

No.	Section	Pg.	Comment	GEOSCIENCE Response
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.



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 (WLAM Update)
2008 WLAM
WLAM Update
Observed
Model-Calculated (2008 WLAM)
Model-Calculated (WLAM Update)
Monthly Streamflow, cfs
100000.0
10000.0
1000.0
100.0
10.0
1.0
0.1
Oct-94
Oct-96
Oct-98
Oct-00
Oct-02
Oct-04
Oct-06
Oct-08
Oct-10
Oct-12
Oct-14
Draft TM 2 Figure 31
Model underestimation of base flow
Figure 31

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 (WLAM Update)

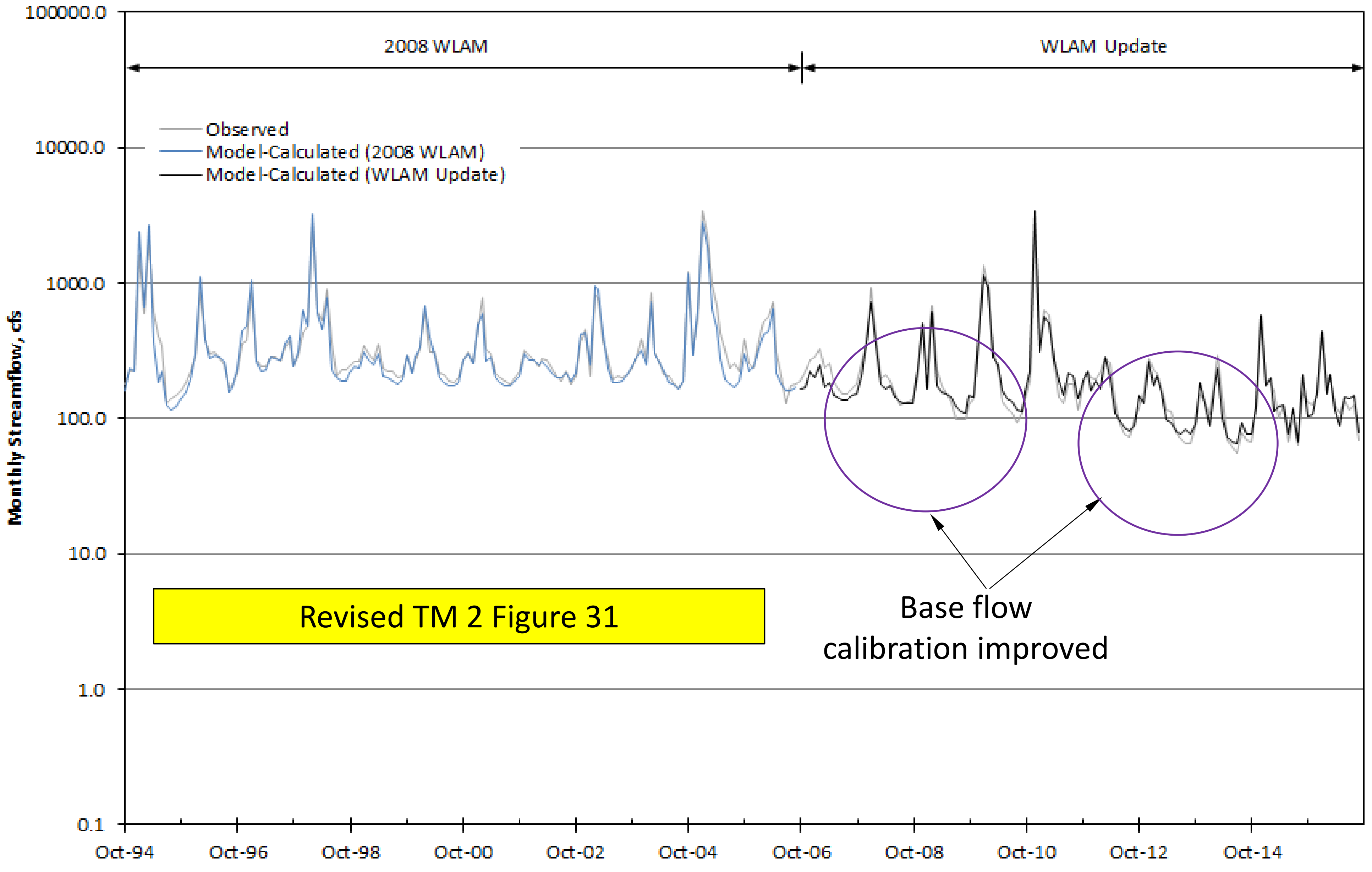


Figure 31

Comments on Draft TM No. 2 from OCWD – Comment No. 10

No.	Section	Pg.	Comment	GEOSCIENCE Response
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 will be added.

Comments on Draft TM No. 2 from OCWD – Comment No. 11

No.	Section	Pg.	Comment	GEOSCIENCE Response
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 will be added.

Comments on Draft TM No. 2 from OCWD – Comment No. 12

No.	Section	Pg.	Comment	GEOSCIENCE Response
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 will be added.

TDS Calibration Statistics - Mean Residuals

Gaging Station	2008 WLAM WY 1995-2006			2017 WLAM HSPF WY 2007-2016		
	Mean Residuals	Average of Observed TDS	Mean Residual as % of Average of Observed TDS	Mean Residuals	Average of Observed TDS	Mean Residual as % of Average of Observed TDS
	mg/L	mg/L	%	mg/L	mg/L	%
Santa Ana River at MWD Crossing	16.4	591	2.8%	5.5	587	0.9%
Santa Ana River below Prado Dam	20.7	535	3.9%	6.0	615	1.0%
Santa Ana River at Imperial Highway near Anaheim	NA	NA	NA	0.1	640	0.0%

TIN Calibration Statistics - Mean Residuals

Gaging Station	2008 WLAM WY 1995-2006			2017 WLAM HSPF WY 2007-2016		
	Mean Residuals	Average of Observed TIN	Mean Residual as % of Average of Observed TIN	Mean Residuals	Average of Observed TIN	Mean Residual as % of Average of Observed TIN
	mg/L	mg/L	%	mg/L	mg/L	%
Santa Ana River at MWD Crossing	-0.45	6.14	-7.4%	-0.31	8.45	-3.6%
Santa Ana River below Prado Dam	-0.07	5.13	-1.4%	-0.54	3.92	-13.8%
Santa Ana River at Imperial Highway near Anaheim	NA	NA	NA	-0.21	3.09	-6.9%

Comments on Draft TM No. 2 from OCWD – Comment No. 13

No.	Section	Pg.	Comment	GEOSCIENCE Response
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) will be added to the tables.

TDS Calibration Statistics - RMSE Normalized to Range of Observed TDS

Gaging Station	2008 WLAM WY 1995-2006			2017 WLAM HSPF WY 2007-2016		
	RMSE	Range of Observed TDS	RMSE as % of Range of Observed TDS	RMSE	Range of Observed TDS	RMSE as % of Range of Observed TDS
	mg/L	mg/L	%	mg/L	mg/L	%
Santa Ana River at MWD Crossing	77	563	13.7%	82	537	15.4%
Santa Ana River below Prado Dam	77	620	12.5%	104	690	15.0%
Santa Ana River at Imperial Highway near Anaheim	NA	NA	NA	86	570	15.2%

TIN Calibration Statistics - RMSE Normalized to Range of Observed TIN

Gaging Station	2008 WLAM WY 1995-2006			2017 WLAM HSPF WY 2007-2016		
	RMSE	Range of Observed TIN	RMSE as % of Range of Observed TIN	RMSE	Range of Observed TIN	RMSE as % of Range of Observed TIN
	mg/L	mg/L	%	mg/L	mg/L	%
Santa Ana River at MWD Crossing	2.42	11.60	20.8%	1.20	6.20	19.4%
Santa Ana River below Prado Dam	1.61	8.48	19.0%	1.38	7.03	19.7%
Santa Ana River at Imperial Highway near Anaheim	NA	NA	NA	1.04	5.94	17.5%

Streamflow Calibration Statistics – Mean Residuals (Monthly)

Gaging Station	2008 WLAM WY 1995-2006			2017 WLAM HSPF WY 2007-2016		
	Mean Residuals	Average of Observed Flow	Mean Residual as % of Average of Observed Flow	Mean Residuals	Average of Observed Flow	Mean Residual as % of Average of Observed Flow
	cfs	cfs	%	cfs	cfs	%
San Timoteo Creek near Loma Linda	-2.2	5.5	-41%	-0.4	8.2	-5%
Warm Creek near San Bernardino	4.9	6.4	77%	-0.6	3.5	-16%
Santa Ana River at E Street	12.8	69.8	18%	-4.3	26.3	-16%
Santa Ana River at MWD Crossing	32.9	183.3	18%	-5.5	97.2	-6%
Temescal Creek at Main Street	-1.3	34.1	-4%	0.5	17.3	3%
Chino Creek at Schaefer Avenue	1.8	24.5	7%	-2.5	9.0	-28%
Cucamonga Creek near Mira Loma	9.6	64.9	15%	1.6	37.4	4%
Santa Ana River Inflow to Prado	11.5	399.0	3%	2.9	223.6	1%
Santa Ana River at Santa Ana	NA	NA	NA	-5.0	49.7	-10%

Streamflow Calibration Statistics - RMSE Normalized by Range of Observed Flow (Monthly)

Gaging Station	2008 WLAM WY 1995-2006			2017 WLAM HSPF WY 2007-2016		
	RMSE	Range of Observed Flow	RMSE as % of Range of Observed Flow	RMSE	Range of Observed Flow	RMSE as % of Range of Observed Flow
	cfs	cfs	%	cfs	cfs	%
San Timoteo Creek near Loma Linda	9.2	124	7%	11.7	77	15%
Warm Creek near San Bernardino	8.0	55	15%	2.8	48	6%
Santa Ana River at E Street	45.0	1,185	4%	39.0	764	5%
Santa Ana River at MWD Crossing	110.1	2,305	5%	33.7	1,704	2%
Temescal Creek at Main Street	32.4	397	8%	12.0	221	5%
Chino Creek at Schaefer Avenue	14.9	220	7%	11.8	95	12%
Cucamonga Creek near Mira Loma	28.6	421	7%	12.5	325	4%
Santa Ana River Inflow to Prado	123.5	3,268	4%	98.7	2,407	4%
Santa Ana River at Santa Ana	NA	NA	NA	142.8	1,484	10%

Comments on Draft TM No. 2 from OCWD – Comment No. 14

No.	Section	Pg.	Comment	GEOSCIENCE Response
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 will be added.

Comments on Draft TM No. 2 from OCWD – Comment No. 15

No.	Section	Pg.	Comment	GEOSCIENCE Response
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 will be numbered and listed in the Table of Contents.

Response to Comments on TM No. 2 from IEUA and Chino Basin Watermaster

Comments on Draft TM No. 2 from IEUA and Chino Basin Watermaster – General Comment No. 2

No.	Section	Pg.	Comment	Response
G-2	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.

Comments on Draft TM No. 2 from IEUA and Chino Basin Watermaster – Comment No. 1

No.	Section	Pg.	Comment	Response
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 will be reported in TM-2.

Comments on Draft TM No. 2 from IEUA and Chino Basin Watermaster – Comment No. 2

No.	Section	Pg.	Comment	Response
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.	A comparison of NEXRAD precipitation and the recorded precipitation used for model calibration will be performed as part of Task 11. 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 will be clarified.

Comments on Draft TM No. 2 from IEUA and Chino Basin Watermaster – Comment No. 3

No.	Section	Pg.	Comment	Response
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 will be revisited to address this comment.

Comments on Draft TM No. 2 from IEUA and Chino Basin Watermaster – Comment No. 4

No.	Section	Pg.	Comment	Response
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.	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 will be provided in the revised TM No. 2. Rising water will also be added between Upper Temescal Valley and Temescal Basin, based on the September 2017 report from Eastern Municipal Water District (WEI, 2107).

Comments on Draft TM No. 2 from IEUA and Chino Basin Watermaster – Comment No. 5

No.	Section	Pg.	Comment	Response
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 will be called the "2008 WLAM" (or "2004 WLAM", where appropriate) and the GEOSCIENCE model will be referred to as "2017 WLAM HSPF".

Comments on Draft TM No. 2 from IEUA and Chino Basin Watermaster – Comment No. 6

No.	Section	Pg.	Comment	Response
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.	The "update" refers to the update of modeled data (e.g., streamflow, precipitation, etc.) for the longer calibration period. Text will be clarified

Comments on Draft TM No. 2 from IEUA and Chino Basin Watermaster – Comment No. 7

No.	Section	Pg.	Comment	Response
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 will be corrected. However, mention of the R4 in connection to the WLAM is made in the 2008 model report on page 2-1.

Computer Code Used for 2008 WLAM

Section 2 – Model Description and Calibration

2.1 Model Origin and Uses

The origin of the WLAM traces to the CBWCD and the Chino Basin Watermaster. These agencies wanted to estimate the storm water recharge in the Chino Basin that occurred in recharge basins, flood retention basins, and in unlined streams. WEI developed daily simulation models (RUNOFF and ROUTER) to estimate runoff, route the runoff through the Chino Basin drainage system, calculate recharge on a daily basis, and produce reports that summarized recharge performance. These models were initially developed for the western Chino Basin in 1994 (Mark J. Wildermuth, 1995) and were expanded to the entire Chino Basin in 1996 (WEI, 1998). Subsequently, the model was used in the Chino Basin to estimate the recharge performance of new basins and the recharge benefits of improved basin maintenance. The *Phase 2 Chino Basin Recharge Master Plan* (Black & Veatch, 2001) used the RUNOFF and ROUTER model results as a basis of recharge facility design and cost estimates.

In 2001, WEI updated the model to include water quality simulations and expanded the modeling area to the Santa Ana River Basin for the wasteload allocation investigation (WEI, 2002).

The WLAM was applied, along with the Storm Water Management Model (SWMM), to evaluate various water resources management alternatives and facilities for the Beaumont area (WEI, 2006).

WEI added a root zone (or top soil zone) soil moisture accounting module, ROOTZONE module, to the WLAM, and the WLAM became known as the R4 model (RAINFALL, RUNOFF, ROUTER, and ROOTZONE). The R4 model can be used to simulate rainfall infiltration to the soil zone, irrigation demand, evapotranspiration consumption, and deep percolation below root zone. WEI has successfully applied the R4 model to estimate 40 years of historical surface recharge in the Beaumont (report in preparation) and Arlington (WEI, 2008) Basins and 70 years of historical surface recharge in the Chino Basin (WEI, 2007).

Comment No. 8 stated that the R4 model was never applied by WEI for the wasteload allocation work. However, mention of the R4 in connection to the WLAM is made in the 2008 model report on page 2-1

Source: WEI 2009

Comments on Draft TM No. 2 from IEUA and Chino Basin Watermaster – Comment No. 8

No.	Section	Pg.	Comment	Response
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 will be clarified.

Comments on Draft TM No. 2 from IEUA and Chino Basin Watermaster – Comment No. 9

No.	Section	Pg.	Comment	Response
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.	Text will be corrected.

Comments on Draft TM No. 2 from IEUA and Chino Basin Watermaster – Comment No. 10

No.	Section	Pg.	Comment	Response
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 will be added.

Comments on Draft TM No. 2 from IEUA and Chino Basin Watermaster – Comment No. 11

No.	Section	Pg.	Comment	Response
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.	Addressing comments on TM-1 will satisfy this comment as well.

Comments on Draft TM No. 2 from IEUA and Chino Basin Watermaster – Comment No. 12

No.	Section	Pg.	Comment	Response
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 will be added regarding the procedure to estimate initial infiltration rates. 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.

Infiltration Rates

United States Environmental Protection Agency | Office of Water 4305 | EPA-823-R00-012 July 2000

EPA BASINS Technical Note 6

Estimating Hydrology and Hydraulic Parameters for HSPF

SCS Hydrologic Soil Group	INFILT Estimate (in/hr)	INFILT Estimate (mm/hr)	Runoff Potential
A	0.4 - 1.0	10.0 - 25.0	Low
B	0.1 - 0.4	2.5 - 10.0	Moderate
C	0.05 - 0.1	1.25 - 2.5	Moderate to High
D	0.01 - 0.05	0.25 - 1.25	High

HSPF HYDROLOGY PARAMETERS AND VALUE RANGES

			RANGE OF VALUES					
NAME	DEFINITION	UNITS	TYPICAL		POSSIBLE		FUNCTION OF ...	COMMENT
			MIN	MAX	MIN	MAX		
INFILT	Index to Infiltration Capacity	in/hr	0.01	0.25	0.001	0.50	Soils, land use	Calibration, divides surface and subsurface flow

Comments on Draft TM No. 2 from IEUA and Chino Basin Watermaster – Comment No. 13

No.	Section	Pg.	Comment	Response
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.

Impervious Land Percentages

Land Use Type	GSSI 2017	WEI 2004	WEI 2008	RCFC&WCD	SBC
Ag/Golf/Parks	0	2-5	0-2, 80[1]	0-10	0-25
Open/Dry Ag/Water	0	0-2	2	0-10	0
Commercial/Industrial	80	0-100	90	80-100	80-100
Residential Low	10	40	30	10-25	5-25
Residential Med	50	60	50	30-45	20-50
Residential High	60	80	75	45-90	35-90

Notes:

[1] WEI used 80% for parks

Comments on Draft TM No. 2 from IEUA and Chino Basin Watermaster – Comment No. 14

No.	Section	Pg.	Comment	Response
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 will be clarified.

Comments on Draft TM No. 2 from IEUA and Chino Basin Watermaster – Comment No. 15

No.	Section	Pg.	Comment	Response
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.

Comments on Draft TM No. 2 from IEUA and Chino Basin Watermaster – Comment No. 16

No.	Section	Pg.	Comment	Response
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 will be clarified in the text.

Comments on Draft TM No. 2 from IEUA and Chino Basin Watermaster – Comment No. 17

No.	Section	Pg.	Comment	Response
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 will be added to the text.

Comments on Draft TM No. 2 from IEUA and Chino Basin Watermaster – Comment No. 18

No.	Section	Pg.	Comment	Response
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 will be clarified. Mass was added at locations of rising groundwater according to the rising water concentrations.

Comments on Draft TM No. 2 from IEUA and Chino Basin Watermaster – Comment No. 19

No.	Section	Pg.	Comment	Response
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 will be added.

Comments on Draft TM No. 2 from IEUA and Chino Basin Watermaster – Comment No. 20

No.	Section	Pg.	Comment	Response
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.

Comments on Draft TM No. 2 from IEUA and Chino Basin Watermaster – Comment No. 21

No.	Section	Pg.	Comment	Response
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 columns will be added showing residuals as a percentage of observed TDS and TIN concentrations, in response to comments during the meeting, along with standard deviation.

Comments on Draft TM No. 2 from IEUA and Chino Basin Watermaster – Comment No. 22

No.	Section	Pg.	Comment	Response
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 will be added and standard deviations will be included.

Comments on Draft TM No. 2 from IEUA and Chino Basin Watermaster – Comment No. 23

No.	Section	Pg.	Comment	Response
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 will be held to review the detailed technical work, and GEOSCIENCE will continue to work with the technical group.