Lake Elsinore and Canyon Lake TMDL Water Quality Monitoring Update

July 27, 2016



Summary of 2015-2016 Watershed Monitoring and Nutrient Loads

Number and Location Description	Total Annual Flow (Mgal)	Number of Storms Monitored	Total Volume of Storms Monitored (Mgal)	Annual Event Mean Storm Concentration (mg/L)		Estimated Annual Load (kg)	
				Total Nitrogen	Total Phosphorus	Total Nitrogen	Total Phosphorus
Site 3 - Salt Creek at Murrieta Road	515	3	301	2.5	0.5	5,647	1,447
Site 4 - San Jacinto River at Goetz Road	872	1	515	2.4	1.4	7,926	4,624
Site 6 - San Jacinto River at Ramona Expressway	0	0	N/A	-	-	-	-
Site 30 - Canyon Lake Spillway	476	0	N/A	Not Measured	Not Measured	Not Measured	Not Measured
Site 1 - San Jacinto River at Cranston Guard Station	263	0	N/A	Not Measured	Not Measured	Not Measured	Not Measured

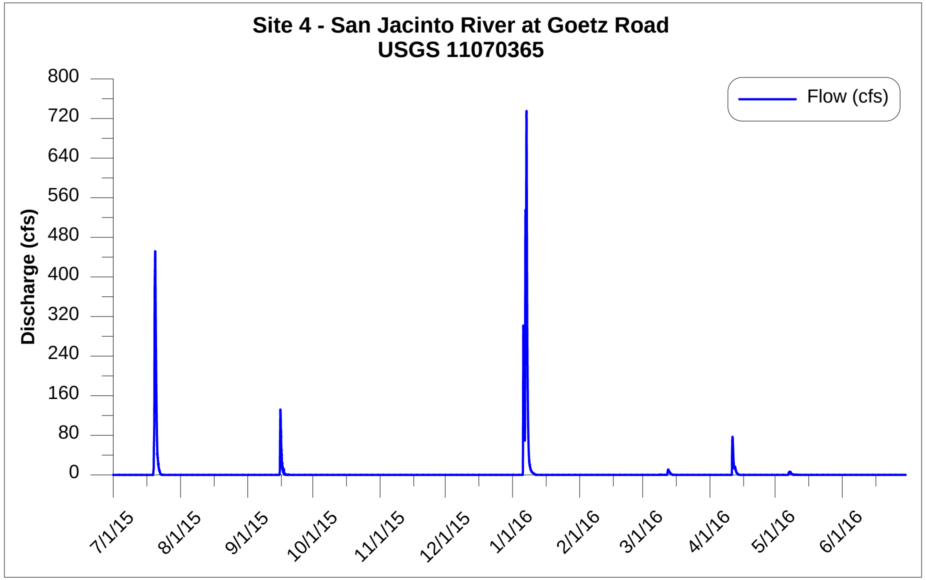
Summary of 2015-2016 Monthly Flow

July 2015-June 2016 Mean Monthly Flow (cfs)	Site 3 - Salt Creek at Murrieta Road (11070465)	Site 4 - San Jacinto River at Goetz Road (11070365)	Site 6 - San Jacinto River at Ramona Expressway (11070210)	Site 30 - Canyon Lake Spillway (11070500)	Site 1 - San Jacinto River at Cranston Guard Station (11069500)
July	5.80	12.8	-	0.17	0.40
August	0.00	0.00	-	0.00	0.00
September	1.59	2.81	-	0.16	0.00
October	0.00	0.00	-	0.30	0.00
November	0.00	0.00	-	1.60	0.03
December	0.00	0.00	-	0.52	2.56
January	17.2	25.4	-	3.49	15.0
February	0.05	0.00	-	3.58	8.08
March	0.12	0.38	-	4.29	1.99
April	0.01	2.08	-	3.47	1.17
May	1.12	0.25	-	3.55	0.49
June	0.00	0.00	-	3.14	0.03
Mean Annual Flow (cfs)	**2.19**	**3.69**	**-**	**2.01**	**1.52**

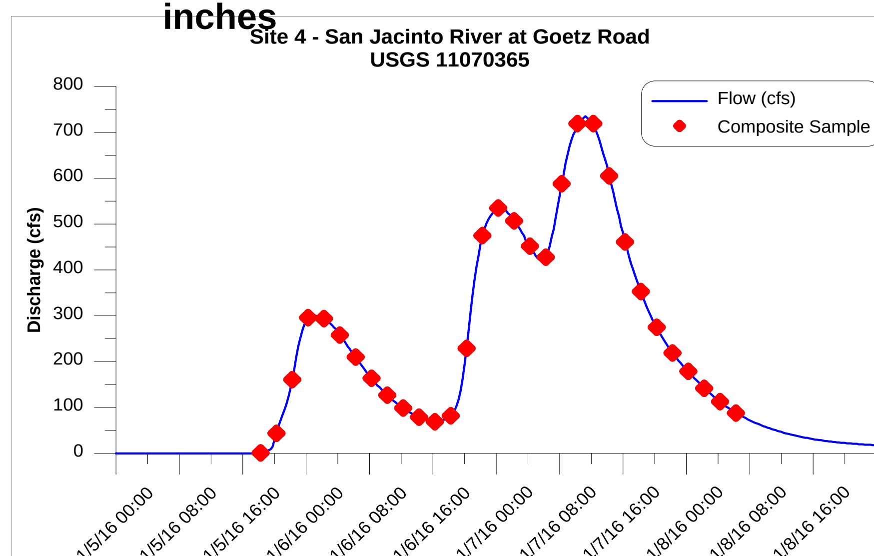
Summary of 2015-2016 Rainfall

ALTA ENVIRONMENTAL

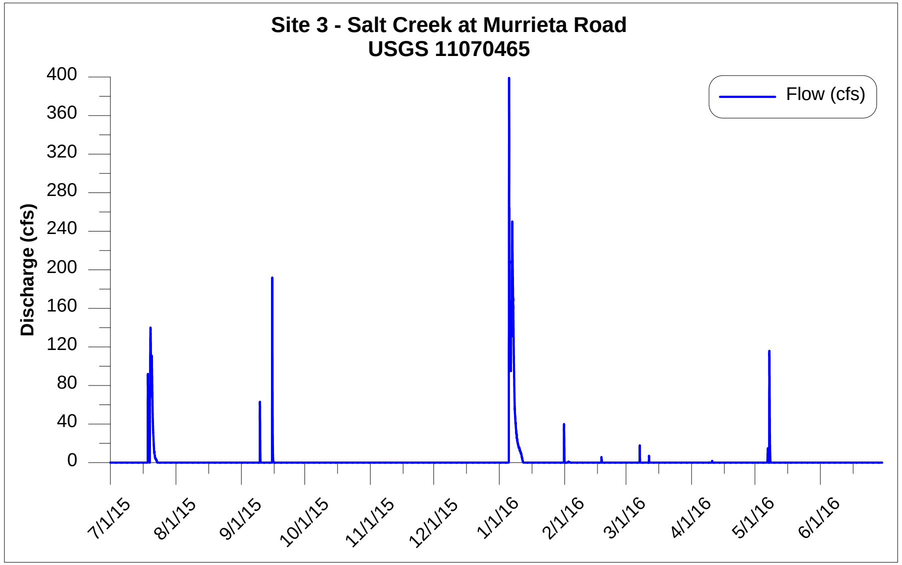
Monthly Rainfall (inches)	Lake Elsinore	Perris CDF	Pigeon Pass	Hemet / San Jacinto	Winchester
Jul	1.20	1.72	2.43	1.75	2.09
Aug	0.00	0.00	0.00	0.06	0.00
Sep	1.06	1.05	1.24	1.37	1.25
Oct	0.07	0.33	0.92	0.37	0.71
Nov	0.04	0.08	0.46	0.24	0.07
Dec	0.40	0.17	1.03	0.54	0.42
Jan	2.17	1.87	3.02	2.27	2.59
Feb	0.76	0.35	0.51	0.44	0.57
Mar	0.61	0.57	1.27	1.02	0.50
Apr	0.21	0.28	1.09	0.24	0.20
May	0.05	0.54	0.10	0.46	0.42
Jun	0.00	0.00	0.00	0.00	0.01
Annual Rainfall (Inches)	**6.57**	**6.96**	**12.07**	**8.76**	**8.83**



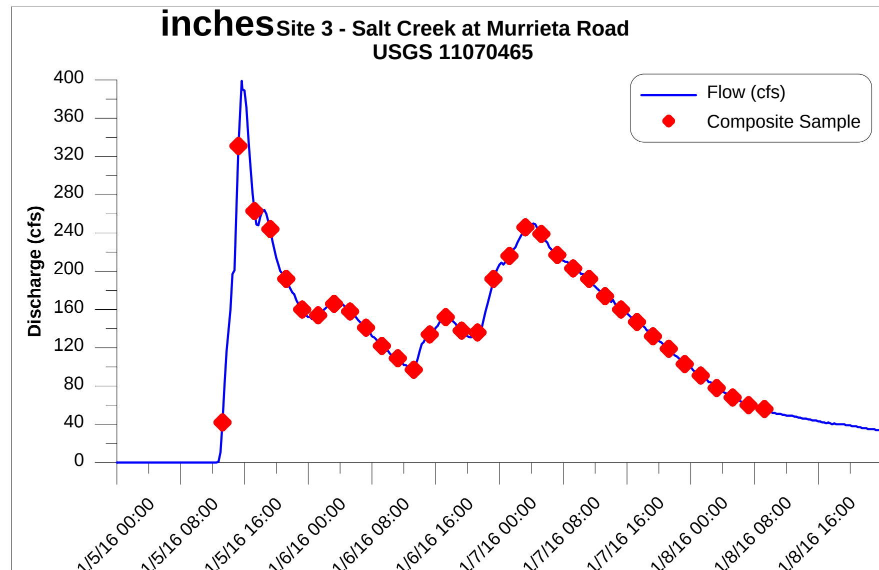
Event Volume: 515 Mgal
Event Rainfall: 1.85-2.95 inches



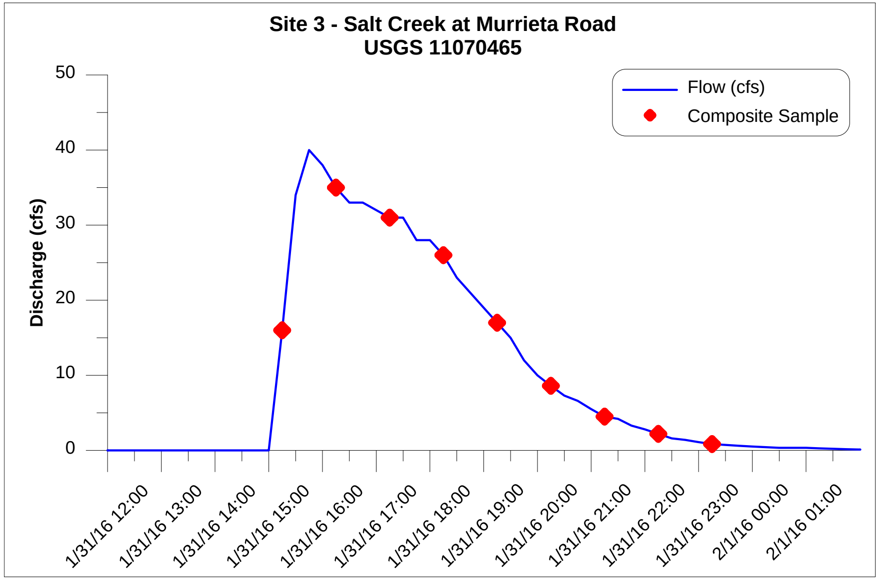
ALTA ENVIRONMENTAL



Event Volume: 294 Mgal
Event Rainfall: 1.85-2.95 inches

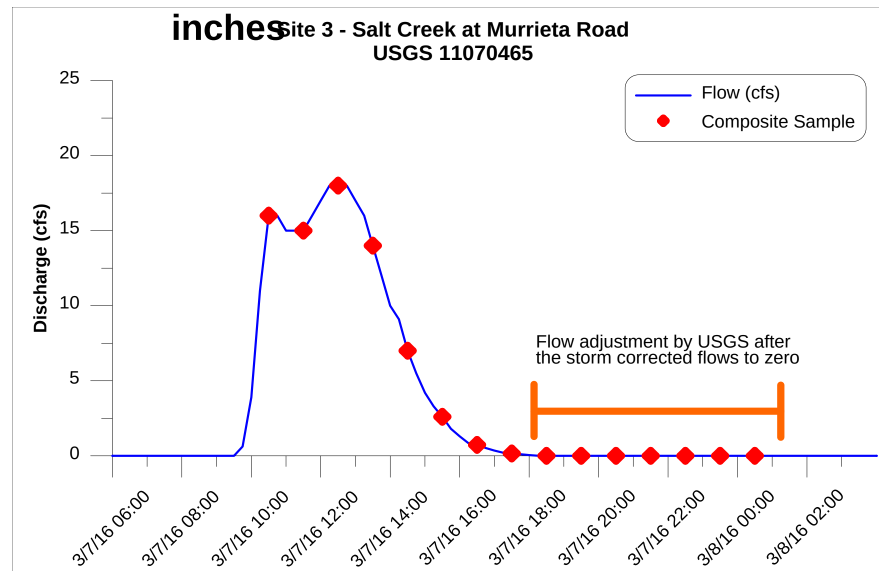


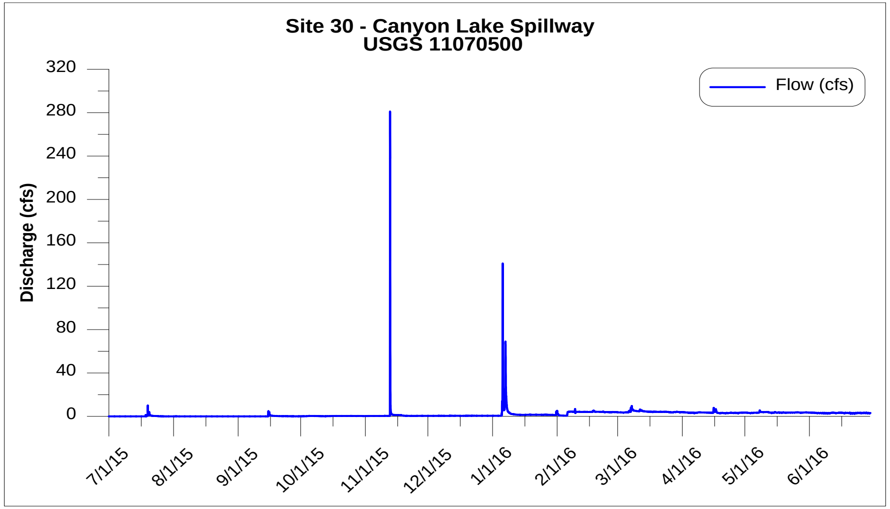
ALTA ENVIRONMENTAL



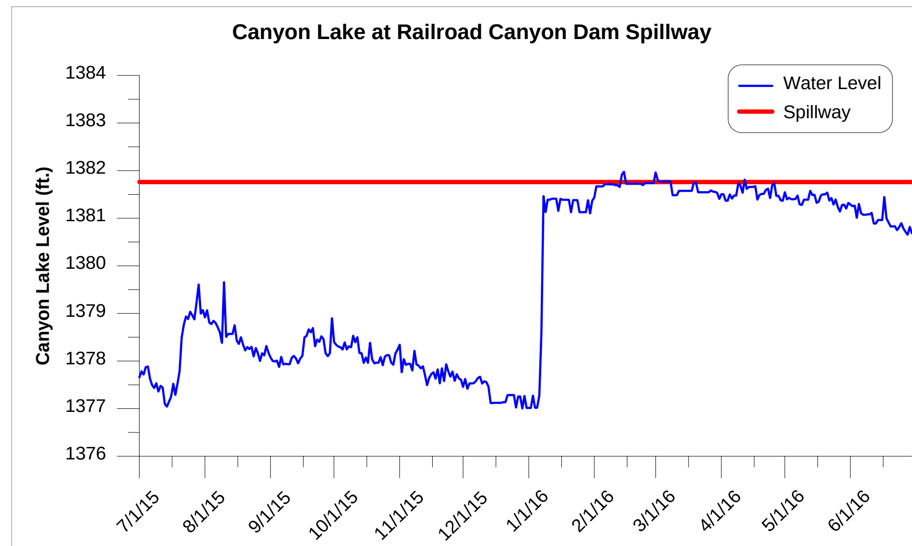
Event Volume: 3.87 Mgal
Event Rainfall: 0.16-0.54 inches

Event Volume: 1.83 Mgal
Event Rainfall: 0.35-0.83 inches





Site 30 - Canyon Lake Spillway
USGS 11070500
Flow (cfs)
Discharge (cfs)
320
280
240
200
160
120
80
40
0
7/1/15
8/1/15
9/1/15
10/1/15
11/1/15
12/1/15
1/1/16
2/1/16
3/1/16
4/1/16
5/1/16
6/1/16



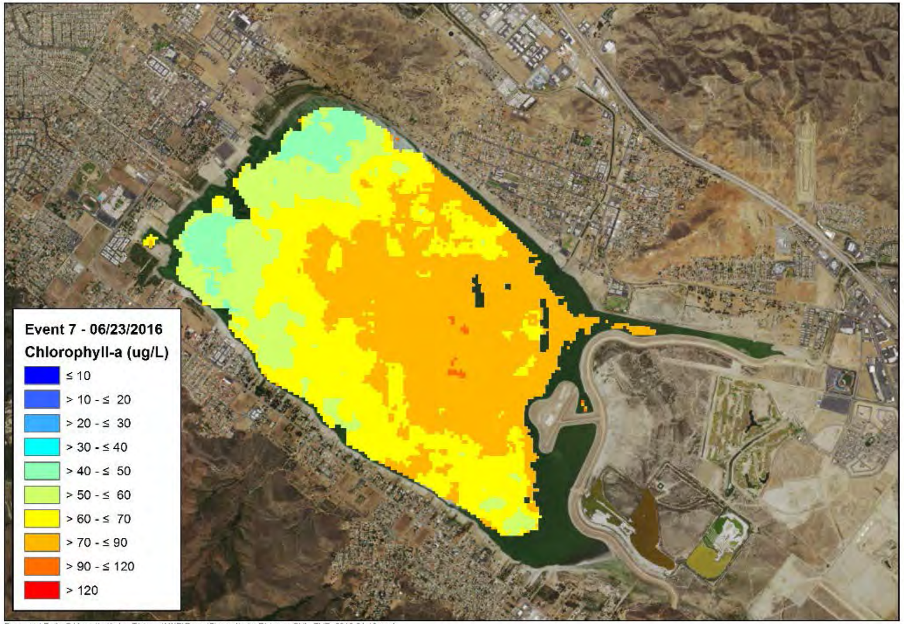
Canyon Lake at Railroad Canyon Dam Spillway
Water Level
Spillway
Canyon Lake Level (ft.)
1384
1383
1382
1381
1380
1379
1378
1377
1376
7/1/15
8/1/15
9/1/15
10/1/15
11/1/15
12/1/15
1/1/16
2/1/16
3/1/16
4/1/16
5/1/16
6/1/16

Station Locations – Lake Elsinore

Station Locations – Canyon Lake

Satellite Imagery – Chlorophyll June 2016

Lake Elsinore



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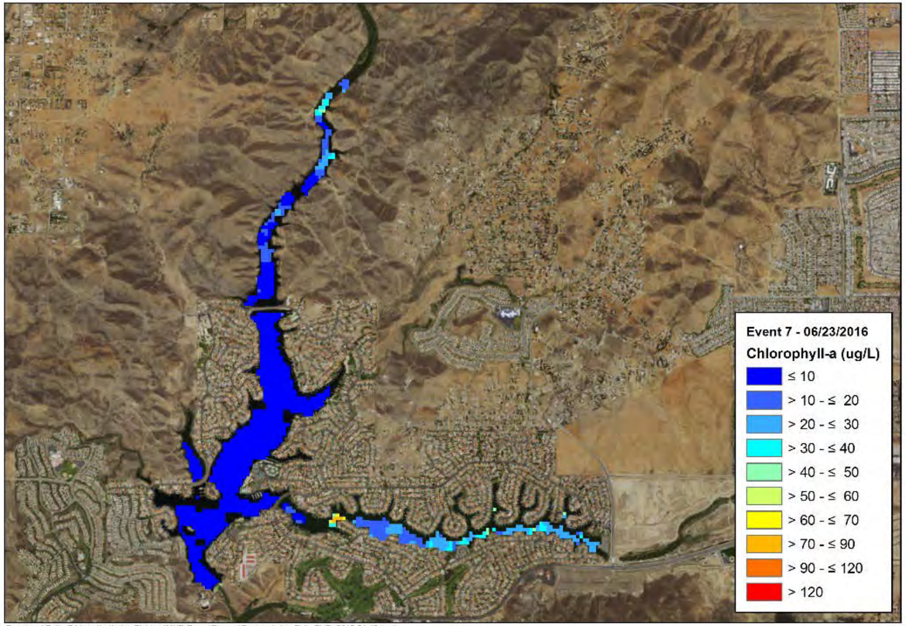
Canyon Lake



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**Not reflective of actual LE concentrations, due to highly elevated levels (>>100 ug/L).
Relative differences accurate (i.e. spatial heterogeneity).

Dissolved Oxygen – Diurnal Variability Assessment

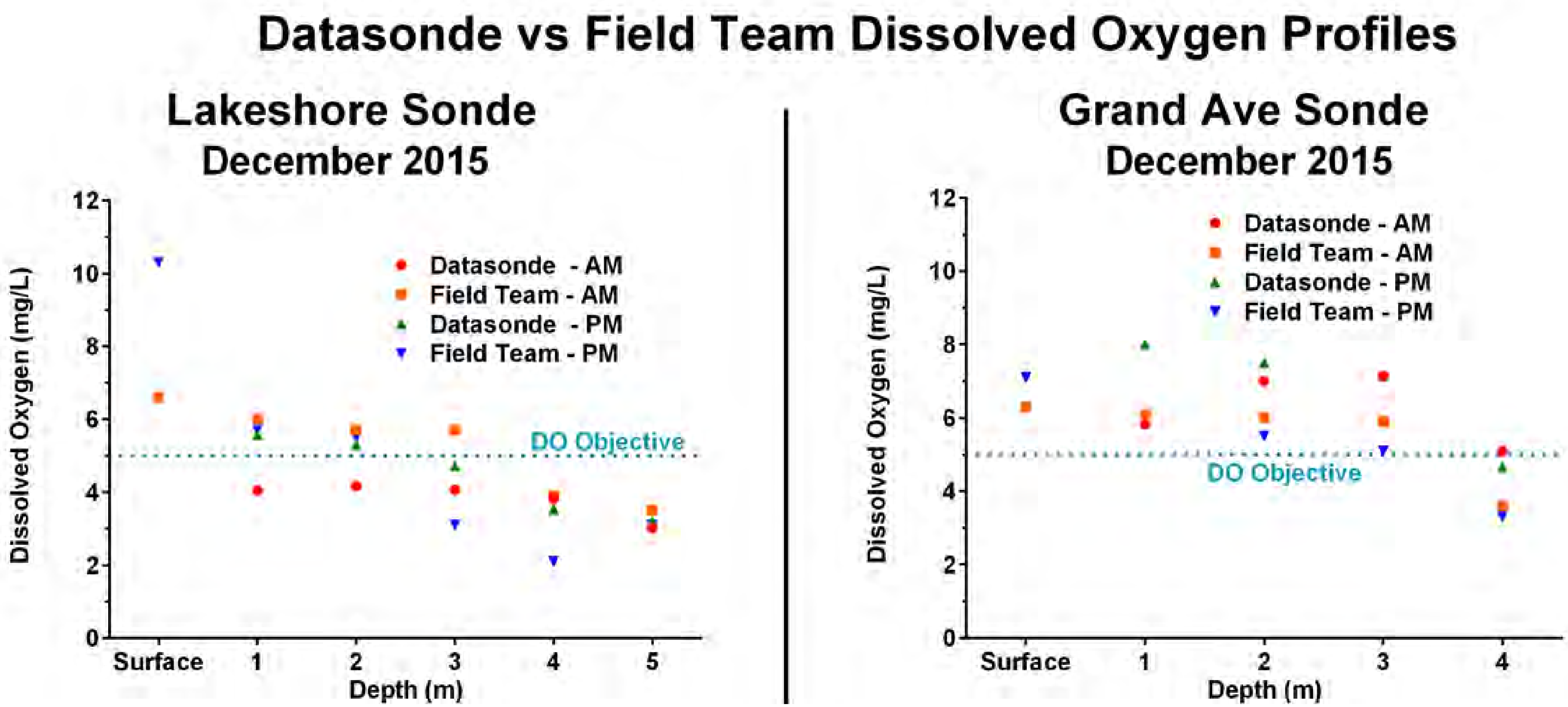
Dissolved Oxygen – Diurnal Variability Assessment

Canyon Lake Dissolved Oxygen Profiles

Dissolved Oxygen – Diurnal Variability Assessment

Canyon Lake Dissolved Oxygen Profiles

Dissolved Oxygen – Diurnal Variability Assessment and Data Sonde Comparison



Lake Elsinore Data Sonde Water Profiles – July 2015

Lakeshore Sonde

Grand Ave. Sonde

Lake Elsinore DO Surface Transects – April 2016

Lake Elsinore DO Surface Transects – June 2016

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Lake Elsinore DO Surface Transects – July 2016

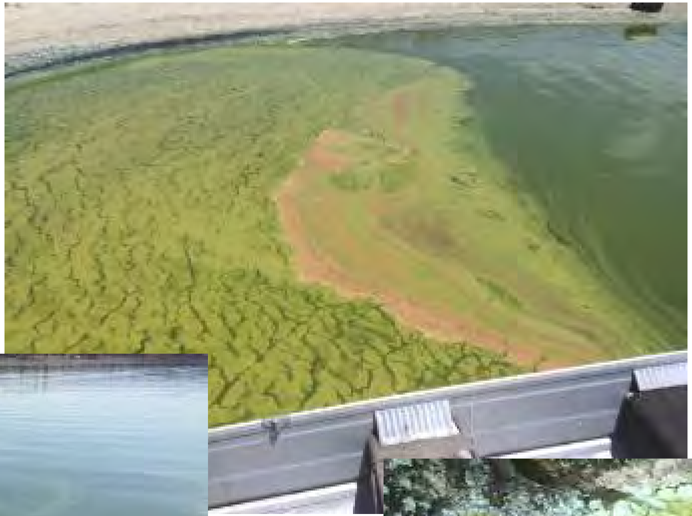
Questions?

Lake Elsinore Data Sonde Water Profiles – July 2015

Lakeshore Sonde

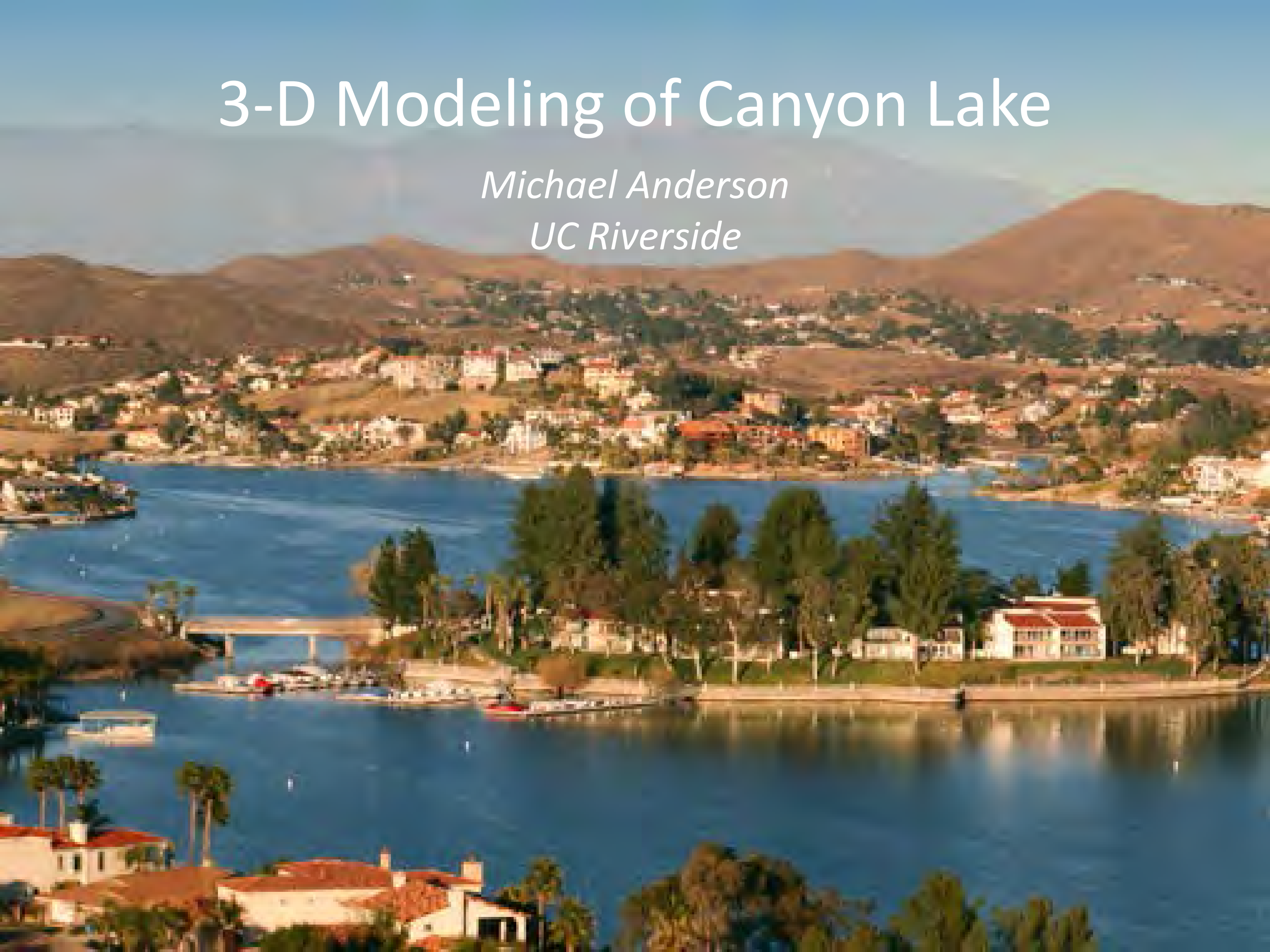
Grand Ave. Sonde

Lake Elsinore – July 25, 2016



3-D Modeling of Canyon Lake

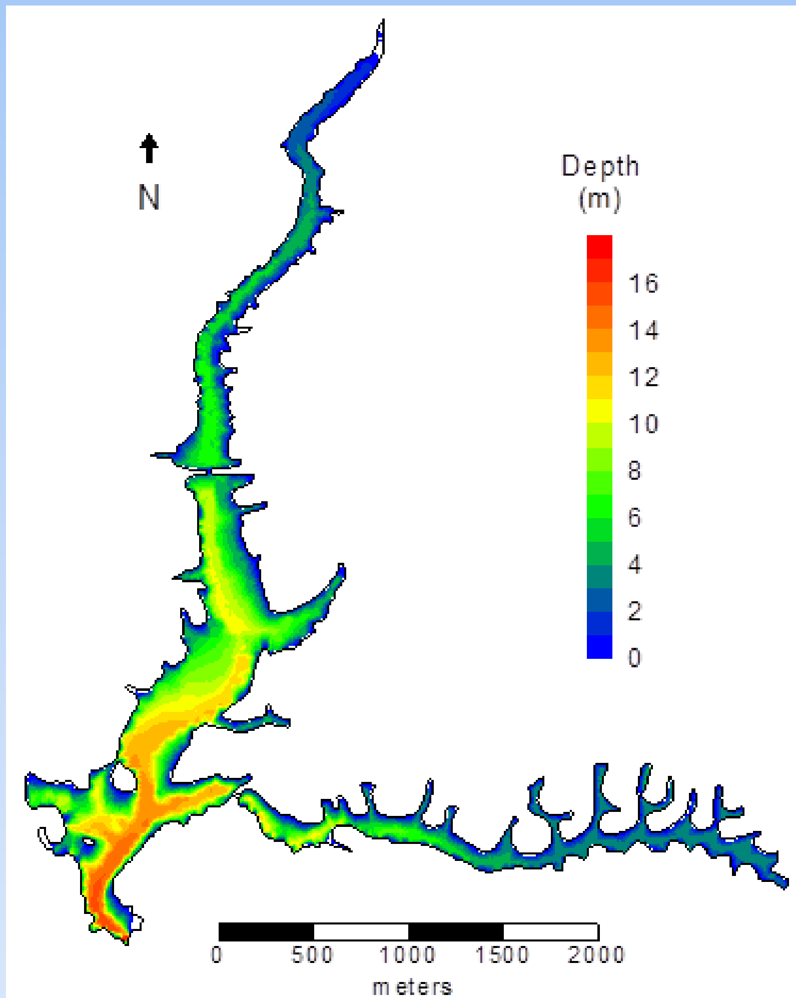
Michael Anderson
UC Riverside



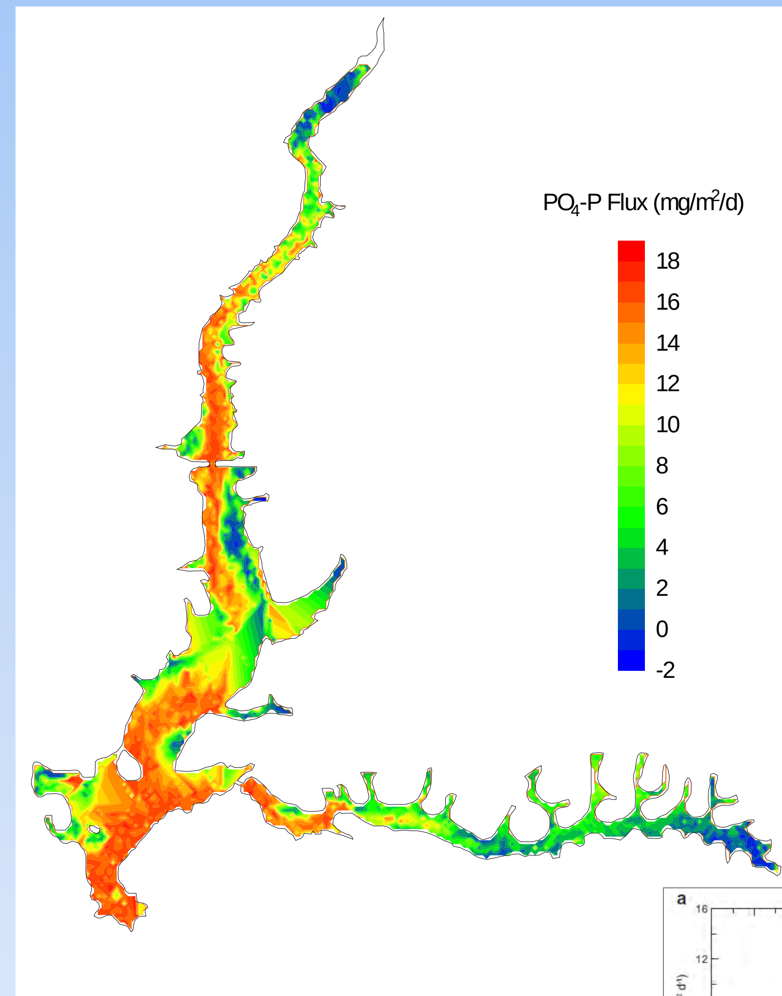
Introduction

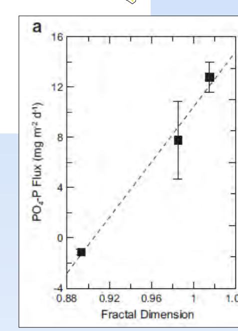
- Modeling of water quality in Canyon Lake has been previously conducted using DYRESM-CAEDYM
- This model has a comprehensive water quality and ecology model (CAEDYM)
- DYRESM uses the 1-D approximation in which the primary gradients are assumed to be in the vertical direction
- The model averages in the horizontal direction
- It is clear that significant gradients often exist *across* the lake
  - East Bay routinely has poorer water quality than the Main Bay
- With detailed bathymetry from the hydroacoustic survey conducted in December 2014, an accurate 3-D representation of the lake basin is available

Bathymetry



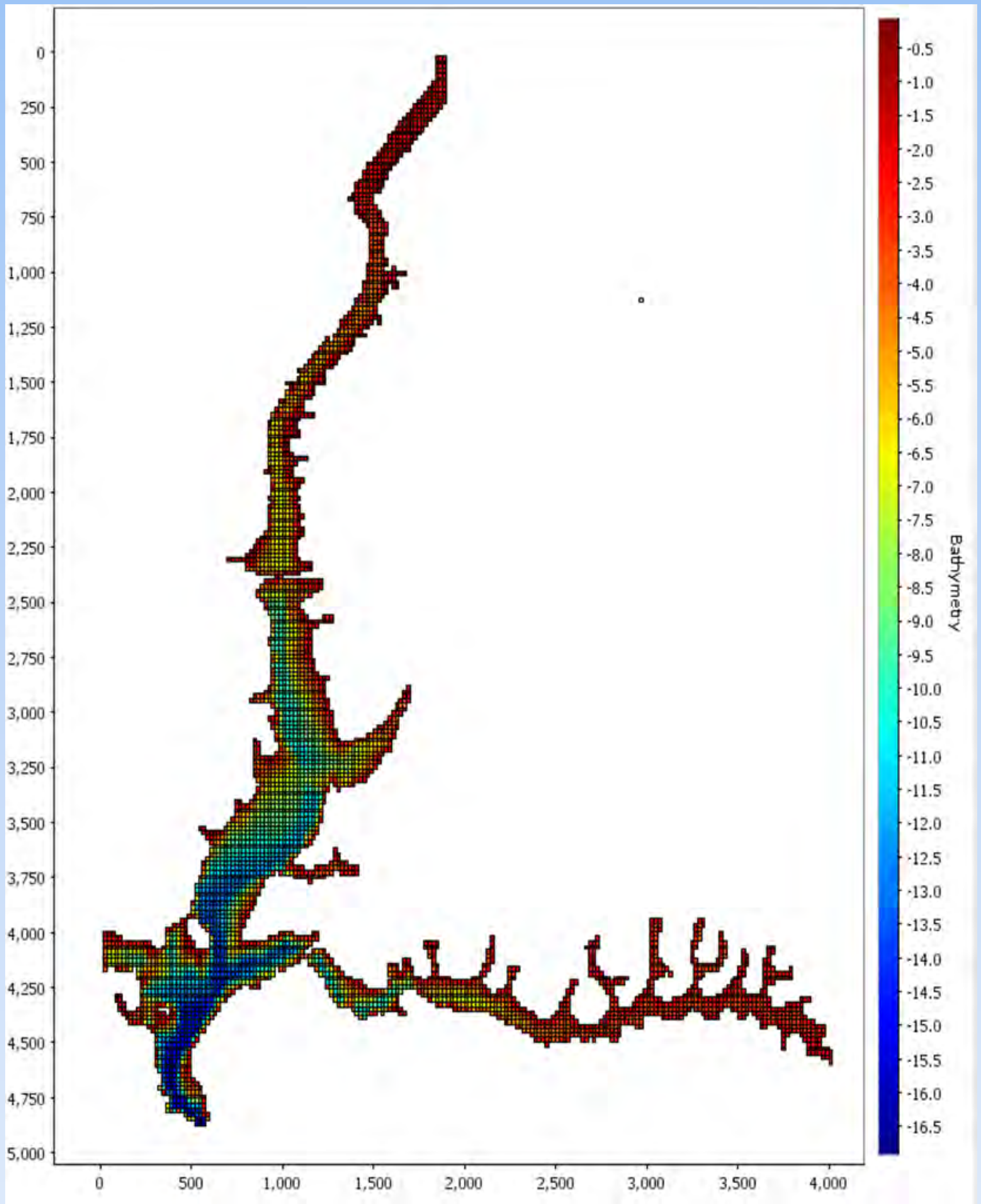
PO_4-P Flux (mg/m²/d)





Approach

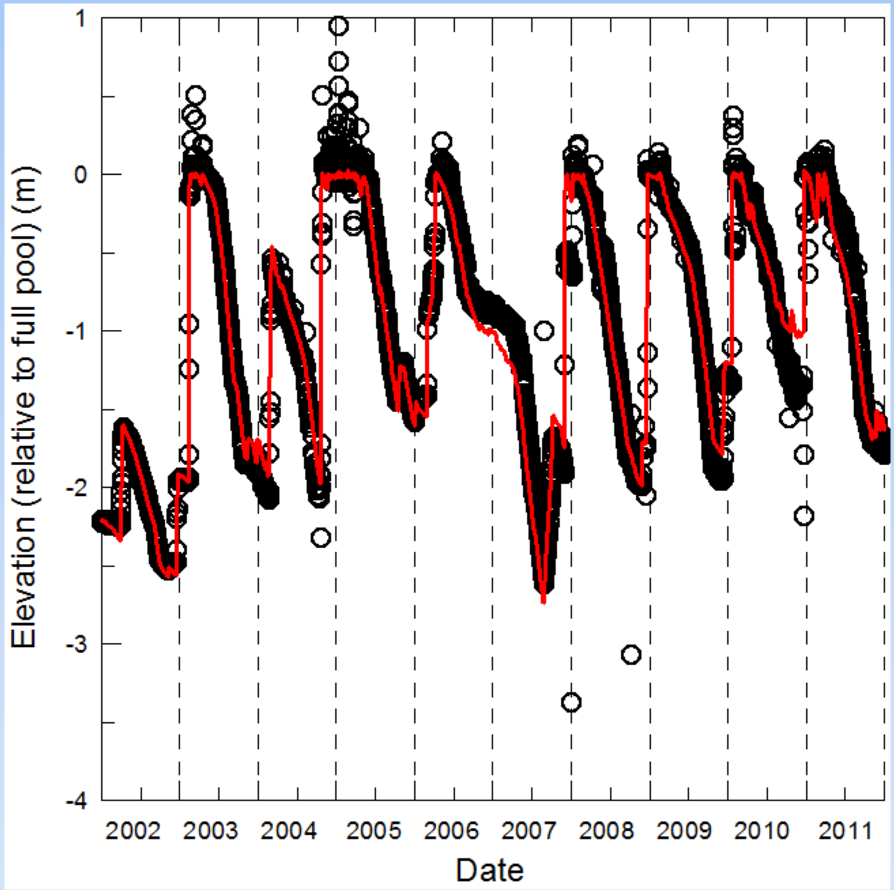
- A 3-D ELCOM-CAEDYM model has been developed for Canyon Lake
- The model uses a 20 m x 20 m lateral grid, with 0.3 m vertical layers
- 247 v x 203 h cells
- 4,712 horizontal "wet" cells
- 92,721 total cells



- The 2002-2011 period of time is being simulated since it spans a wide range of rainfall, runoff and other meteorological conditions
- Daily inflows in San Jacinto River and Salt Creek taken from USGS gages #11070365 and #1107465
- Daily withdrawal flow rates were previously provided by EVMWD
- Meteorological data taken from the CIMIS station at UCR and corrected for elevational differences and wind-sheltering effects (especially East Bay)
- Outflow determined using a dynamic boundary condition from lake elevation and spillway rating curve

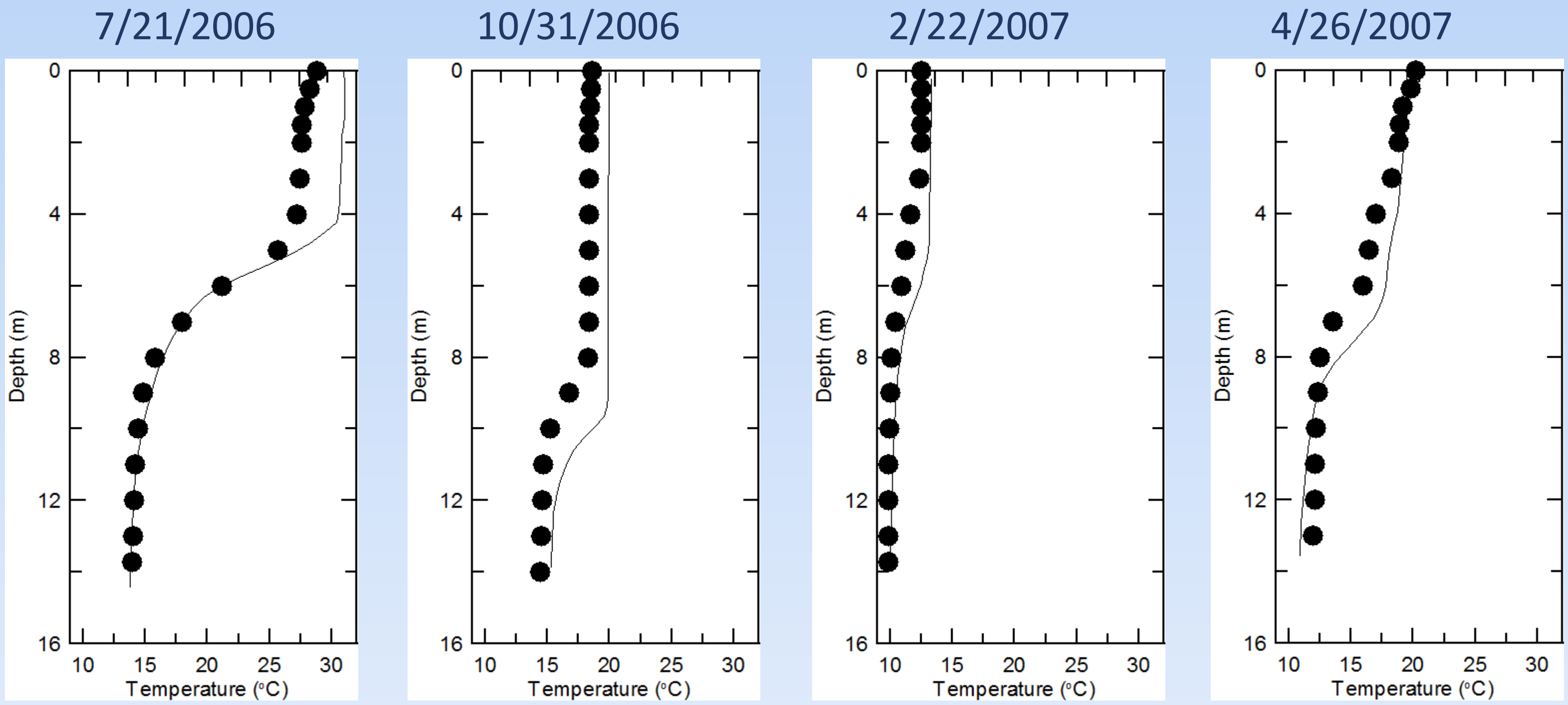
Water Budget (2002-11)

- One of the first tasks was to evaluate the 3-D model's ability to reproduce lake surface elevation
- This requires accurate inflow, withdrawal, meteorological and bathymetric data
- The model (red line) did a good job reproducing the strongly varying lake level recorded by EVMWD staff over the 2002-11 period (open circles)



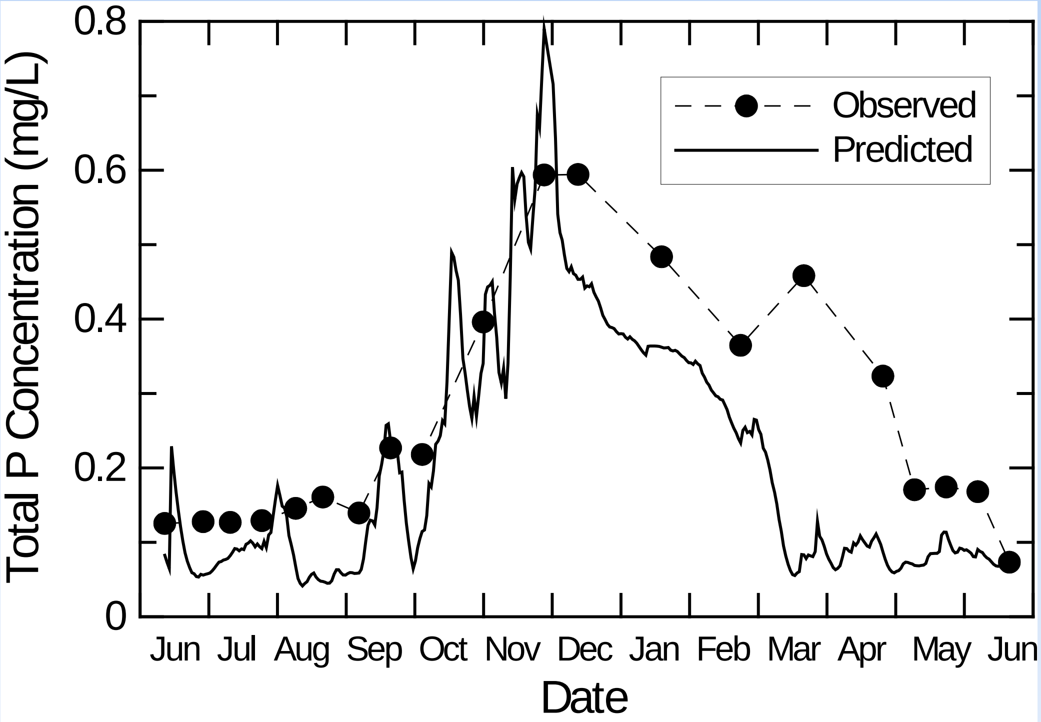
Water Column Temperatures (2006-07)

- It is also important that the model reasonably reproduce water column temperatures and thermal stratification that may be present in the lake
- This requires accurate meteorological data and model representation for heat flux
- The model (solid line) did an adequate job reproducing temperature profiles e.g.,at site M1 in the main body (solid circles)

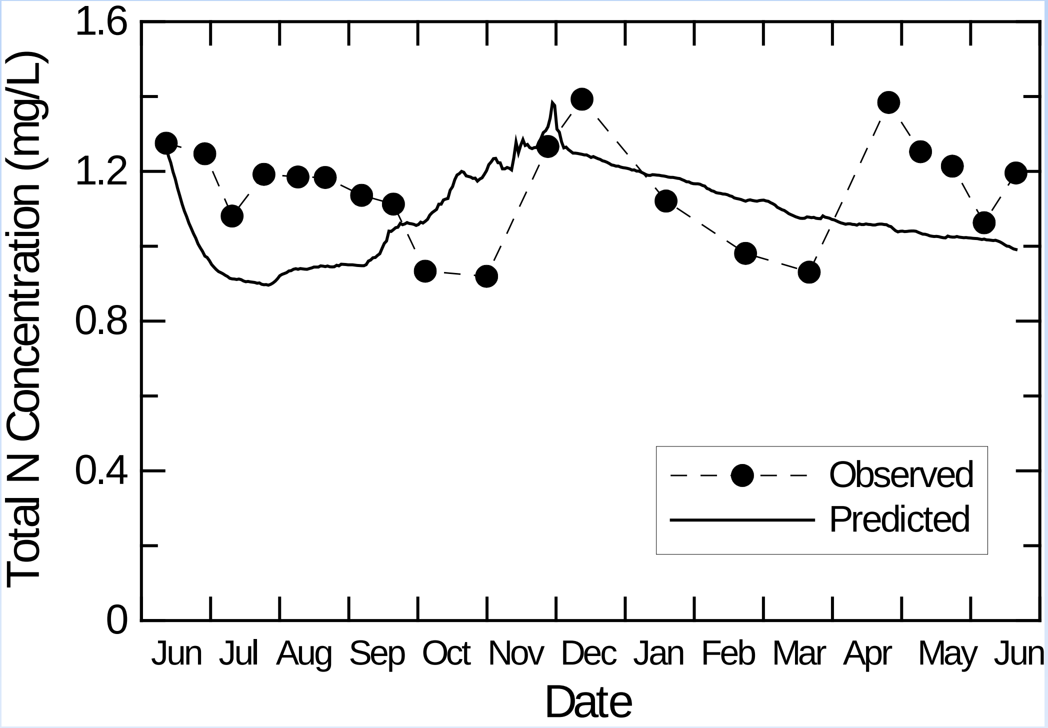


Nutrient Concentrations (2006-07)

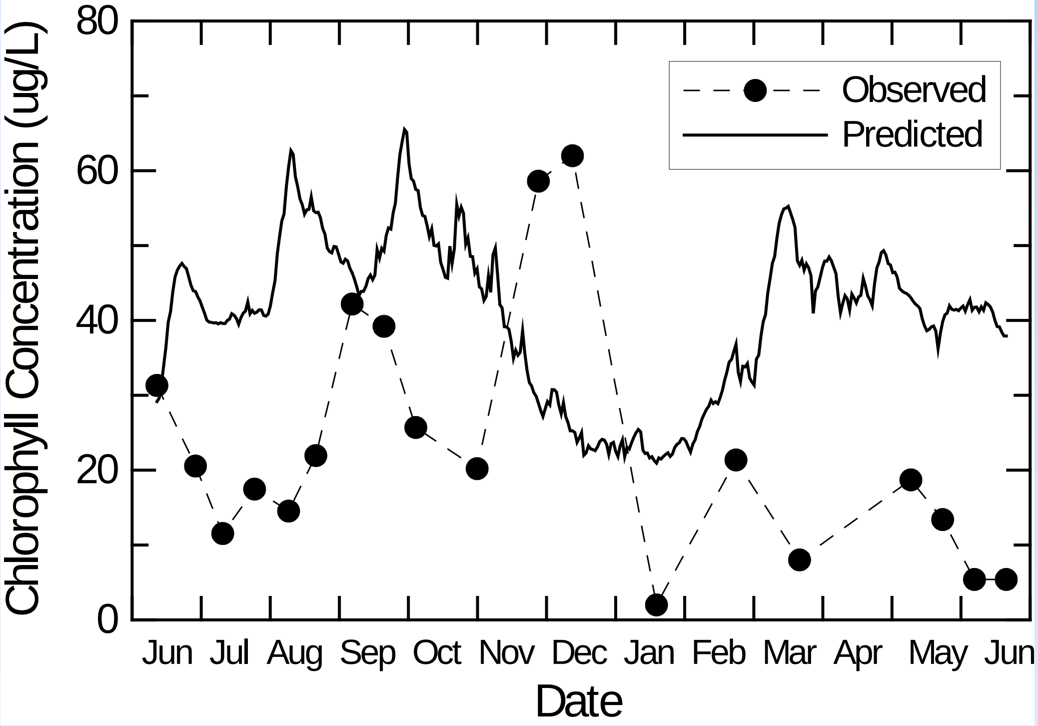
- The model also needs to adequately reproduce measured concentrations within the lake over time
- This requires accurate runoff volumes, nutrient concentrations & representation of internal nutrient recycling, uptake and loss
- It has proven to be challenging reproducing measured water column total P and PO_4-P concentrations over longer periods of time



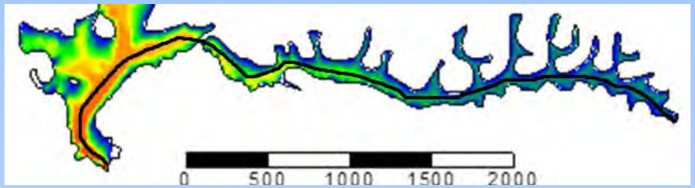
- Measured total N concentrations exhibited less variability than total P (solid circles) and varied between 0.9 and 1.4 mg/L
- The model (solid line) adequately reproduced average concentration e.g., for 2006-07 and some trends but missed others (analytical variability in measured values not shown)



- Model (line) tended to over-predict total chlorophyll a concentrations (solid circles)
- A little work thus remains to improve the agreement between predicted and observed concentrations
- Comparisons for East Bay being developed

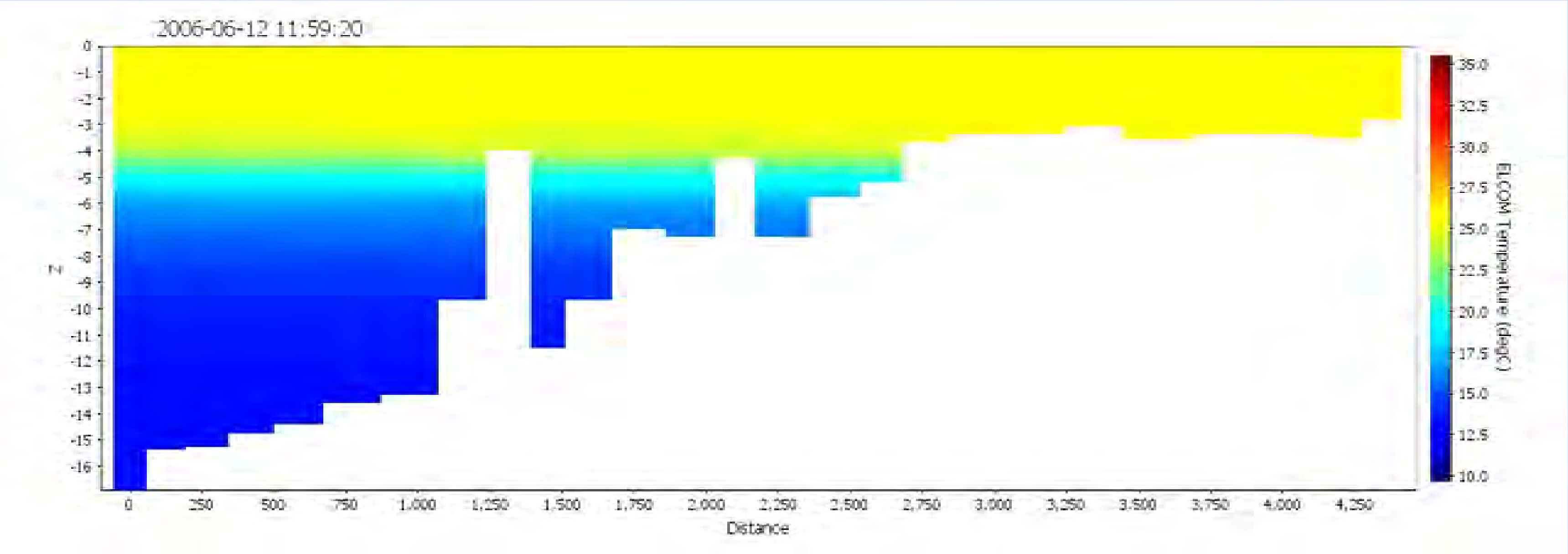


Temperature (June 12, 2006 – June 20, 2007)



Main Lake **East Bay**

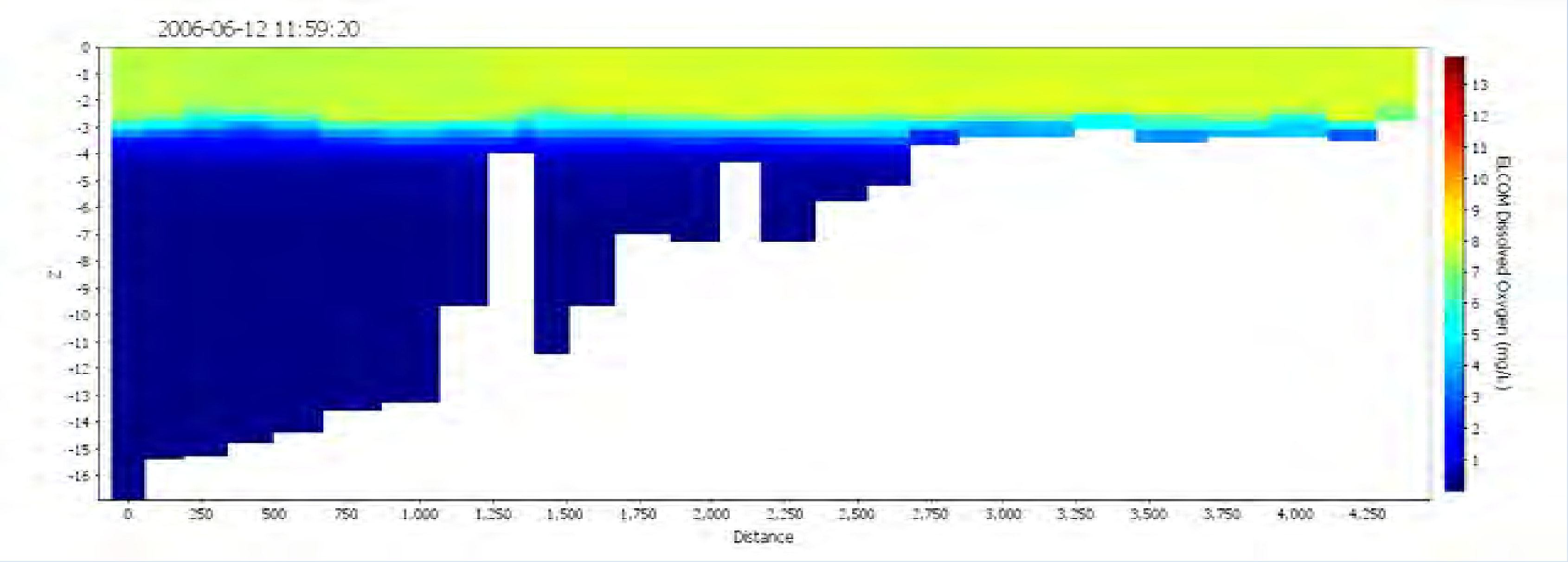
Dam *Causeway* *Salt Creek*



Dissolved Oxygen (June 12, 2006 – June 20, 2007)

Main Lake **East Bay**

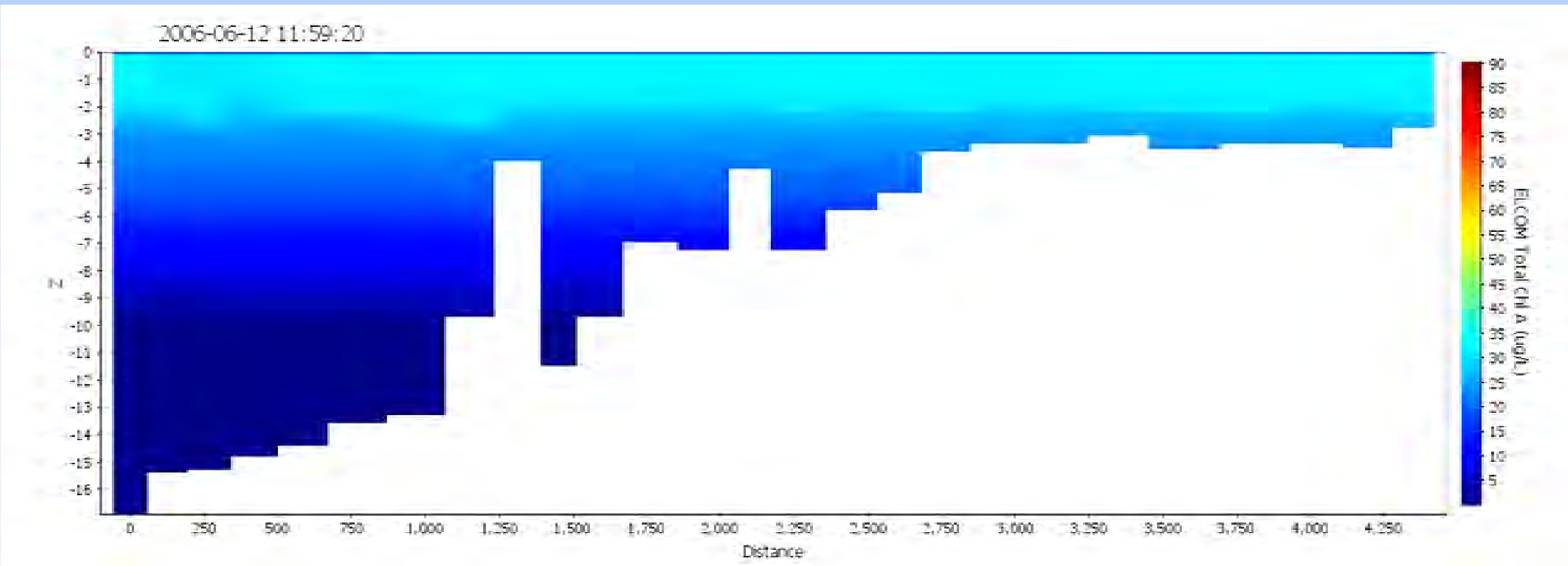
Dam *Causeway* *Salt Creek*



Chlorophyll a (June 12, 2006 – June 20, 2007)

Main Lake **East Bay**

Dam *Causeway* *Salt Creek*



Conclusions

- 3-D model much better suited for lake compared with 1-D
- Tremendously rich simulation datasets with very high horizontal and vertical resolution (have generated and discarded >1 TB data)
- 3-D model does introduce additional complexity and time involved in developing, calibrating and simulating Canyon Lake
- Primary challenges to satisfactorily simulating Canyon Lake have now been resolved
- Remaining steps involve final simulations of 2002-2011 time period under actual conditions and under pre-development conditions
- This will be completed within the next 4 weeks

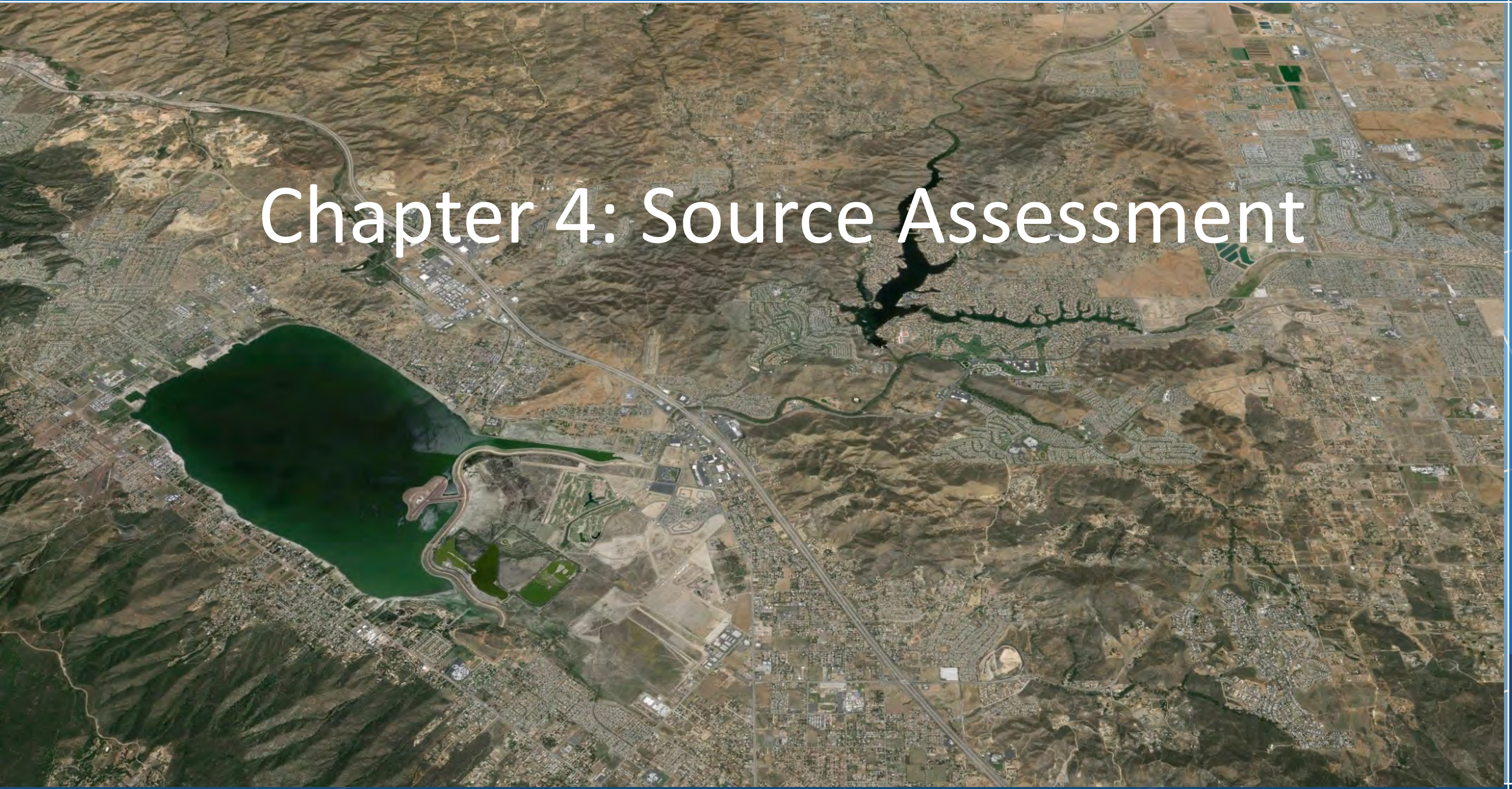
Revision of the Lake Elsinore & Canyon Lake Nutrient TMDL

CDM Smith Team
& Risk Sciences

June 14, 2016

Lake Elsinore/Canyon Lake Task Force Meeting

Chapter 4: Source Assessment



CDM Smith

RISK SCIENCES

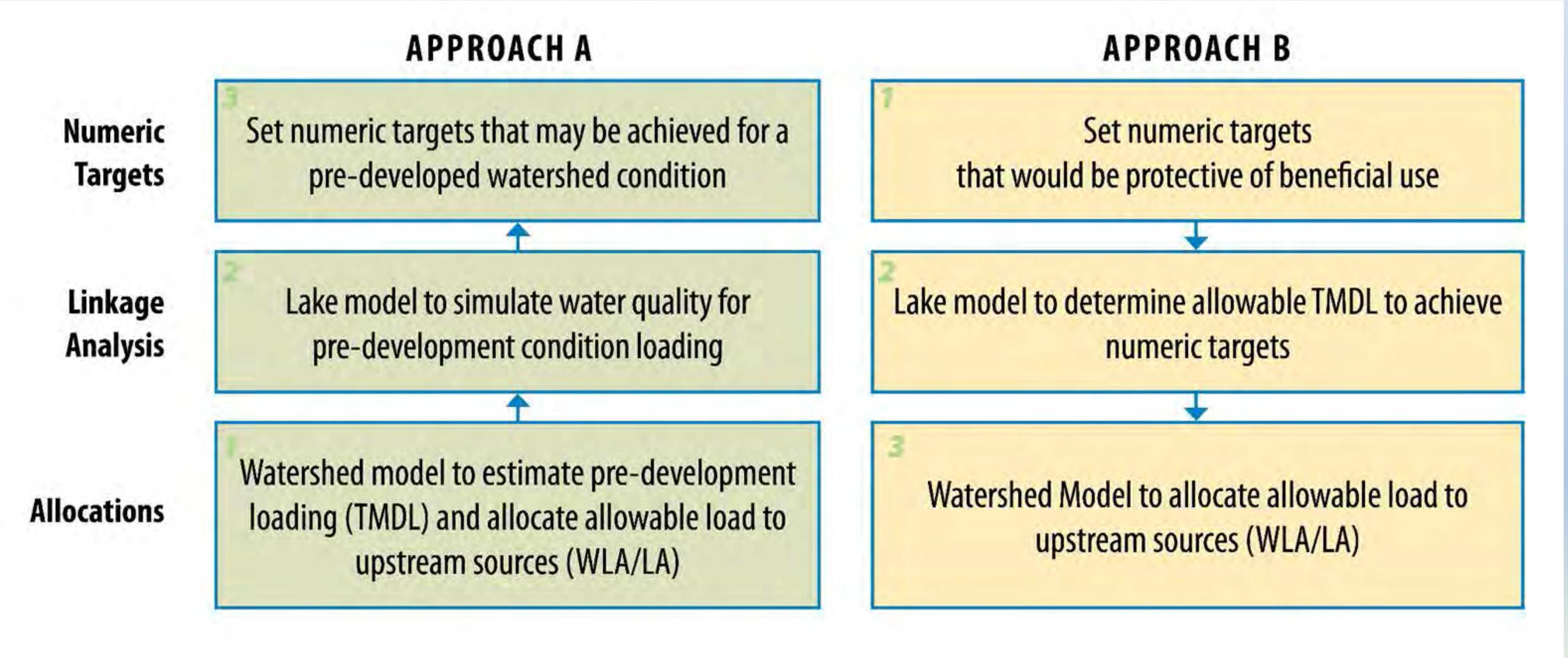
Presentation Outline

- Baseline Natural Loading
- External Watershed Runoff Source Assessment

BASELINE AND CURRENT LOADING

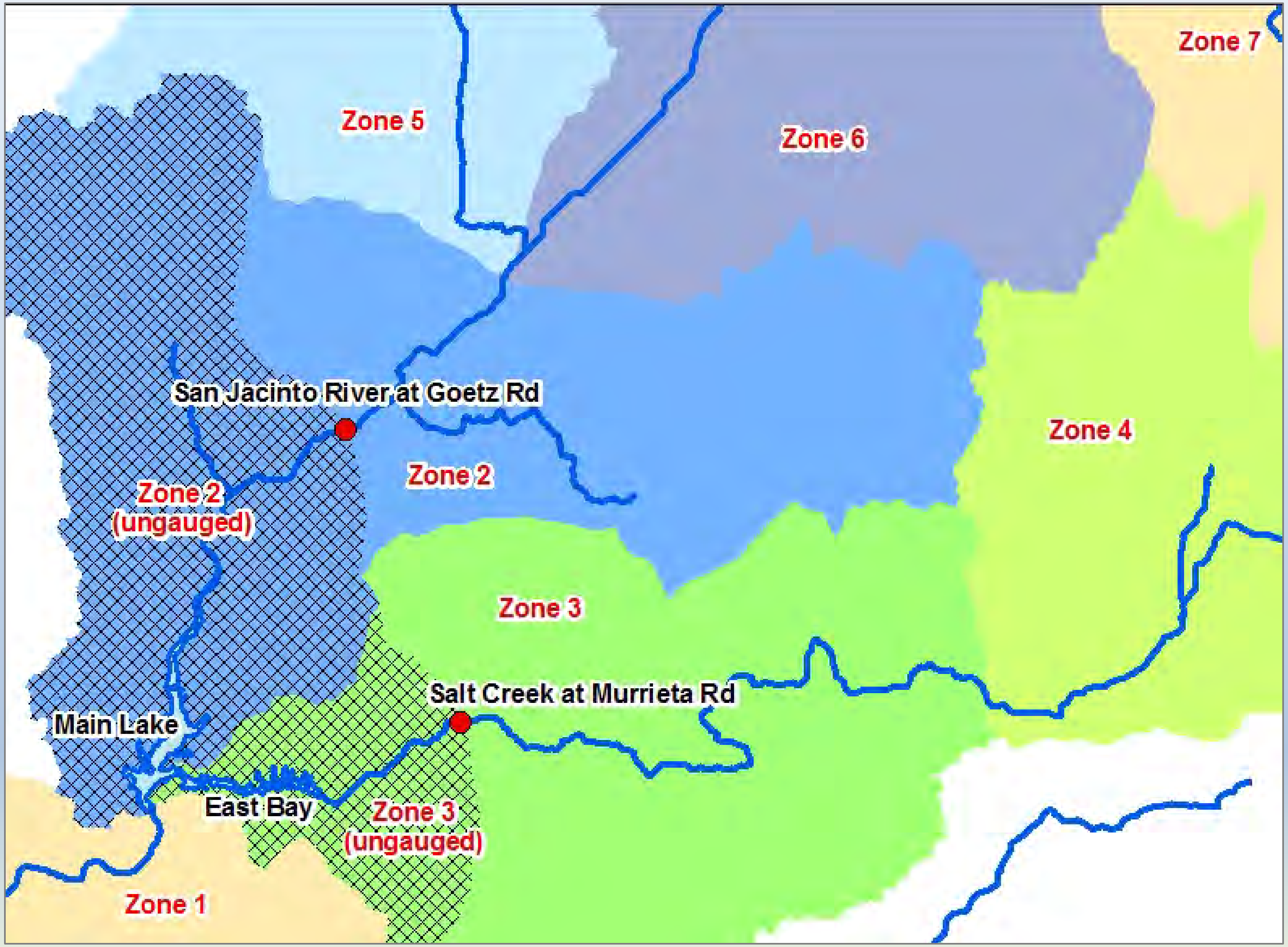
Two Approaches for TMDL Development

- Reference watershed approach (A) different than traditional TMDL development (B)



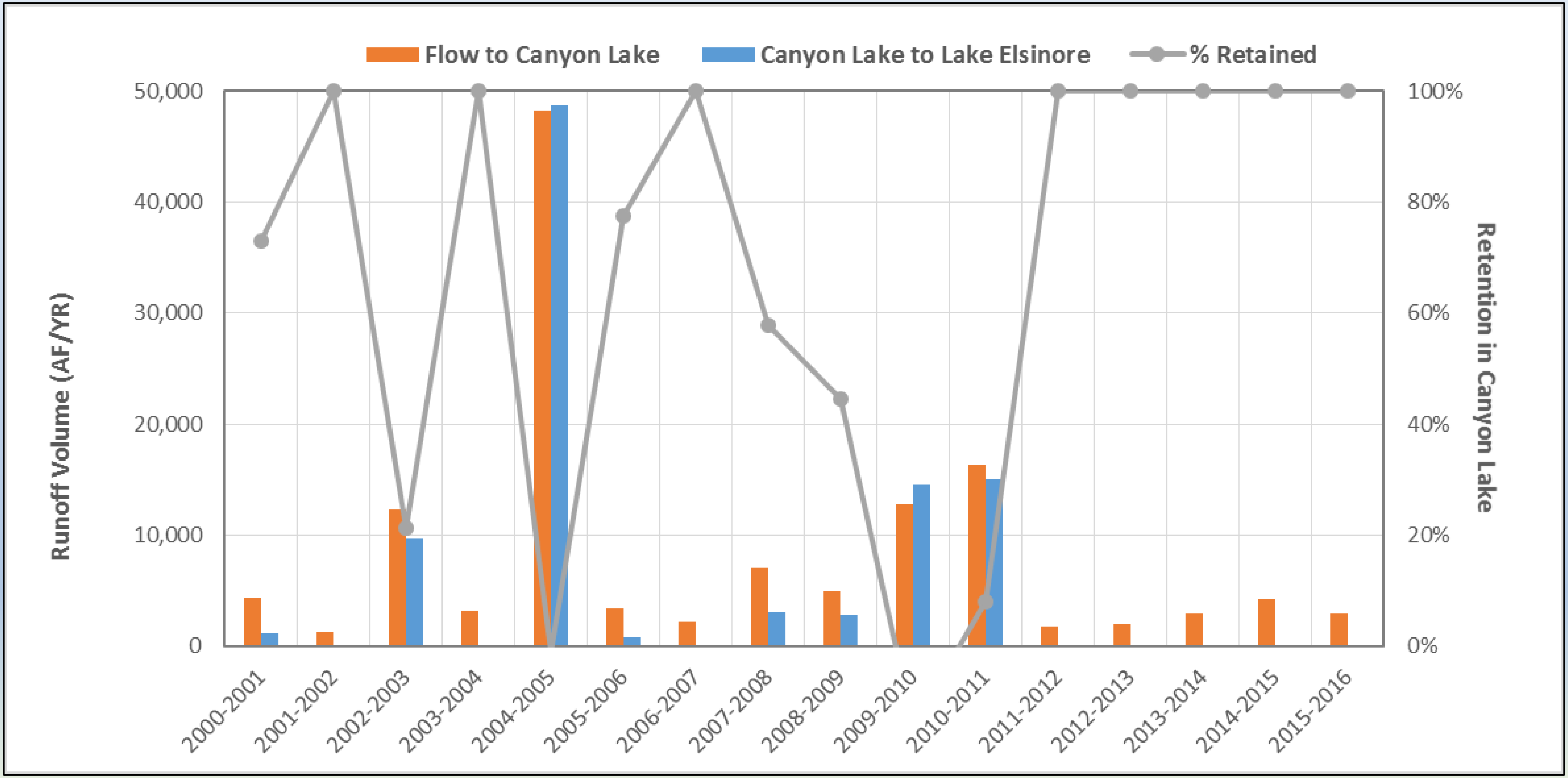
Watershed Monitoring

- Measured data at lake inflows to compute load to Canyon Lake
- ~20 percent of flow and nutrient load to Canyon Lake from ungauged areas



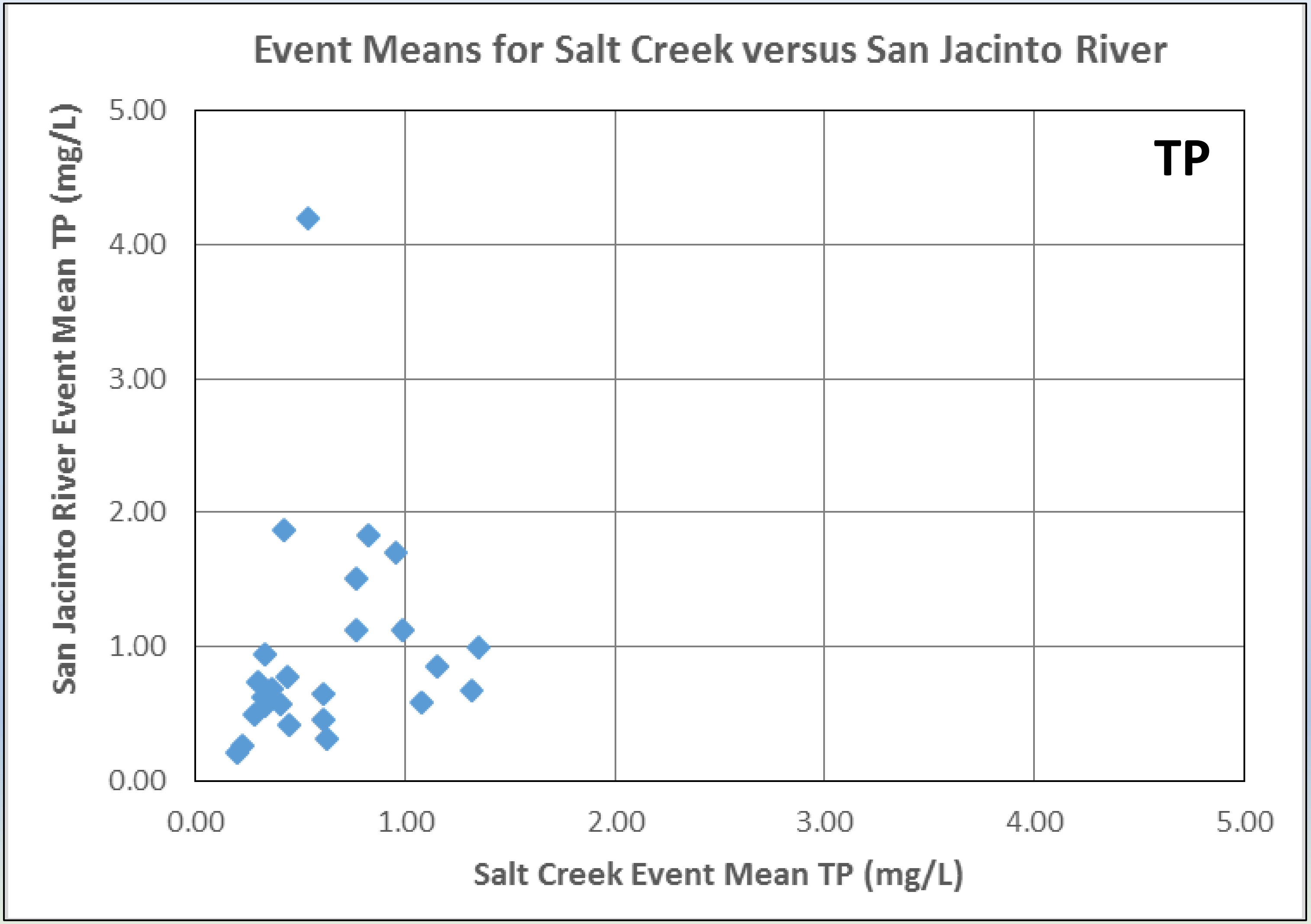
Measured Runoff Inflows to Canyon Lake

- Current runoff volume from 2000 – 2016 USGS gauged flow



Measured Nutrient Concentrations to Canyon Lake

- Median of 25 event mean concentrations
  - Salt Creek: 0.54 mg/L TP, 2.49 mg/L TN
  - San Jacinto River: 0.71 mg/L TP, 2.57 mg/L TN
- Correlation between tributaries would indicate a controlling hydrologic variable



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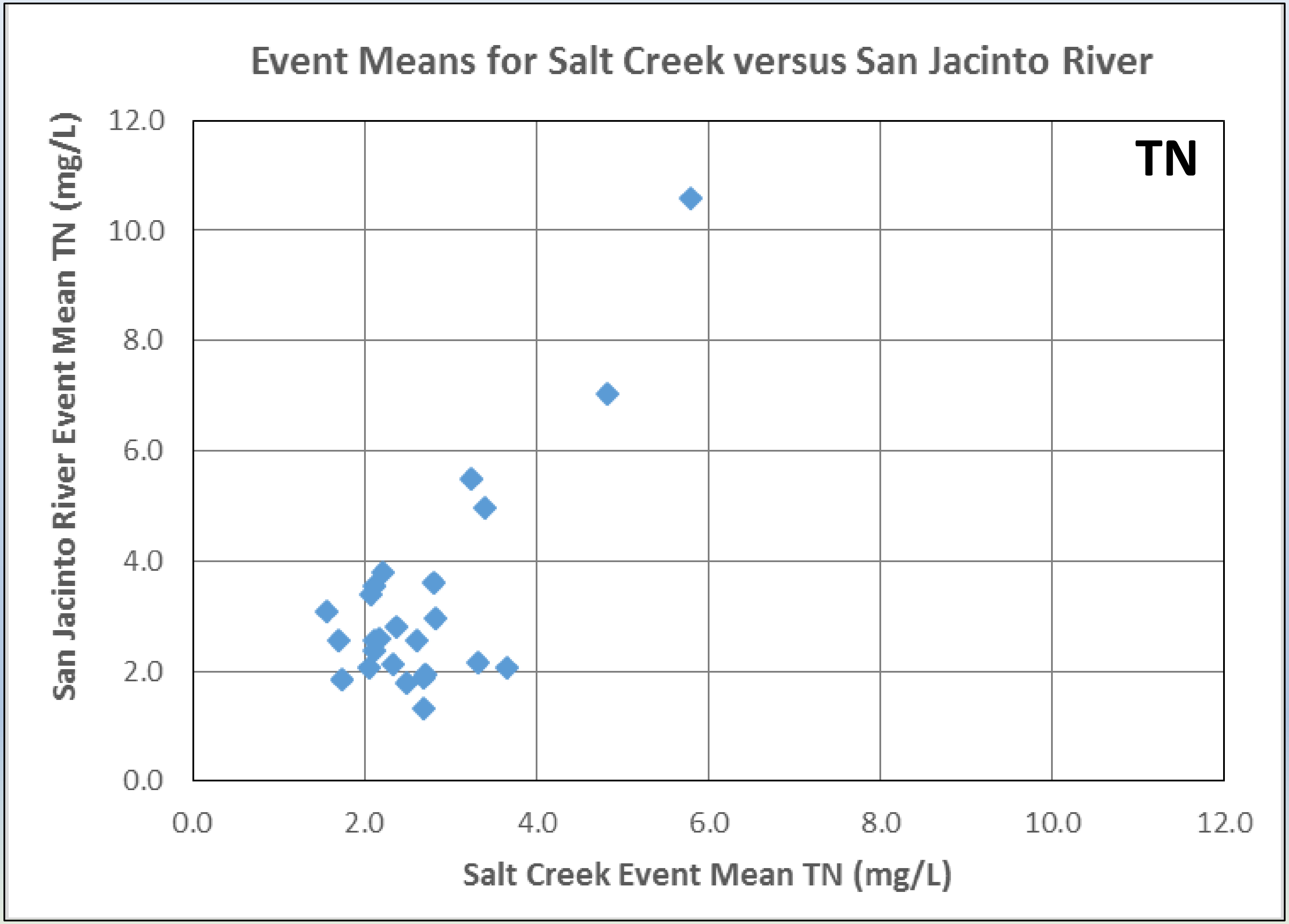
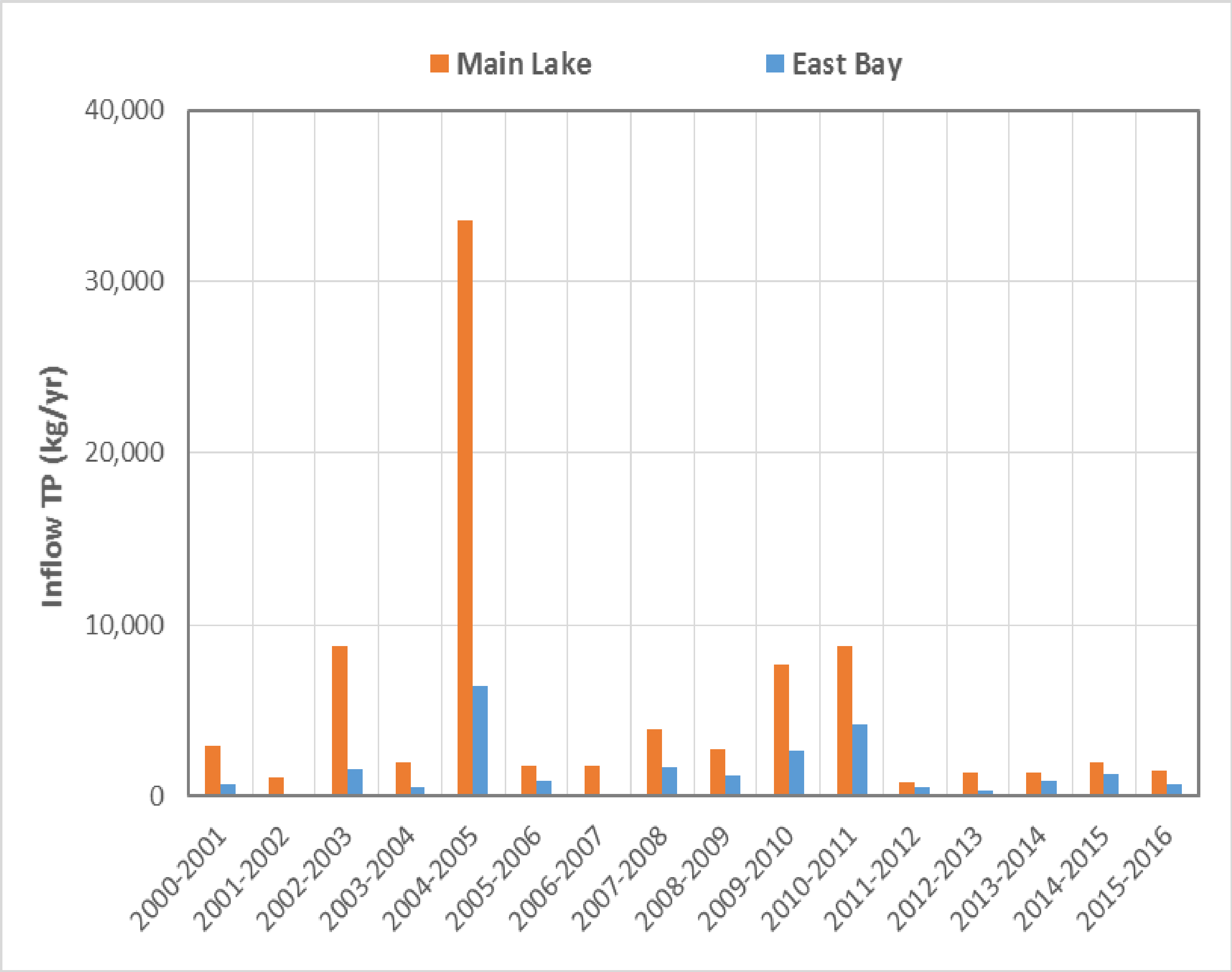
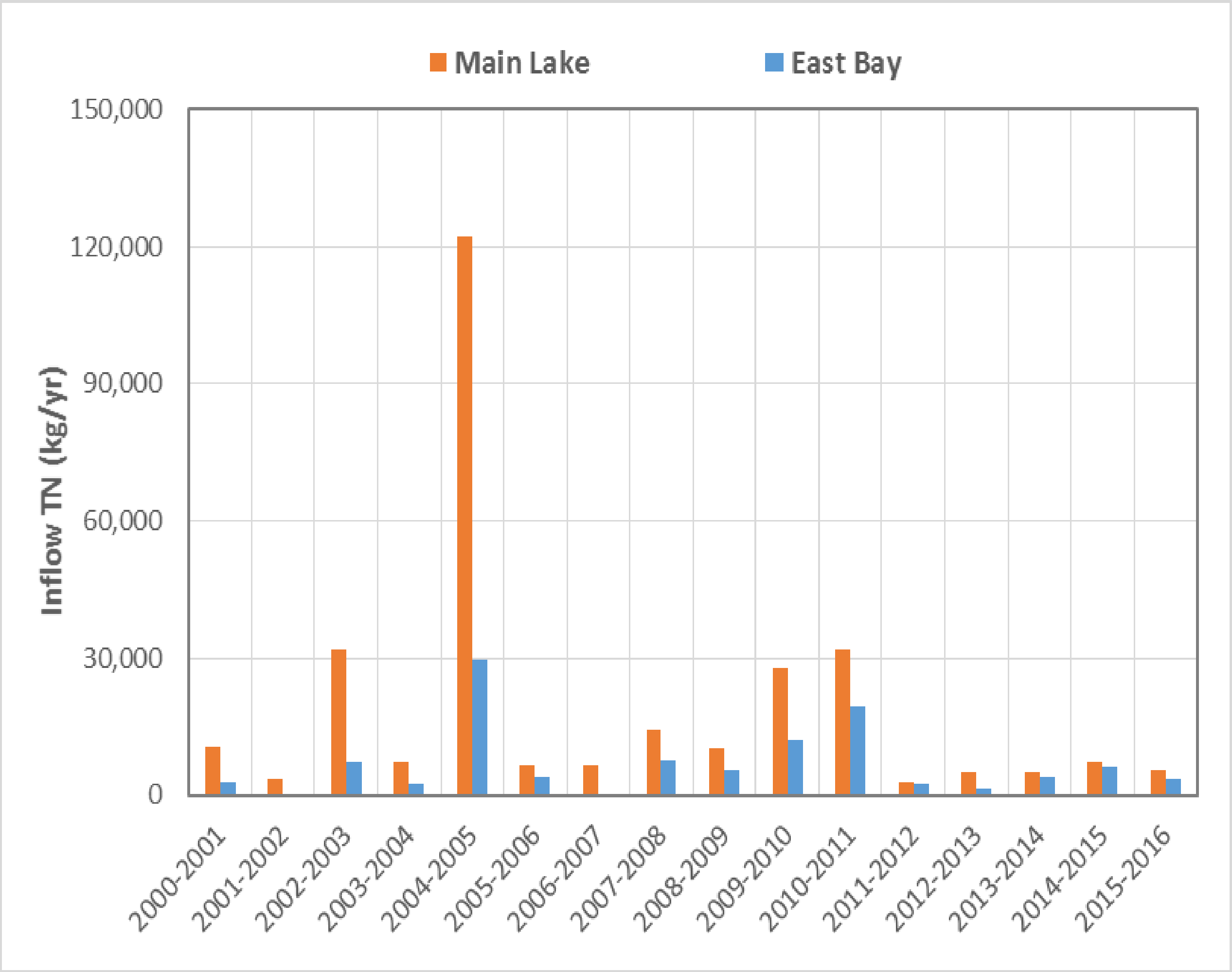


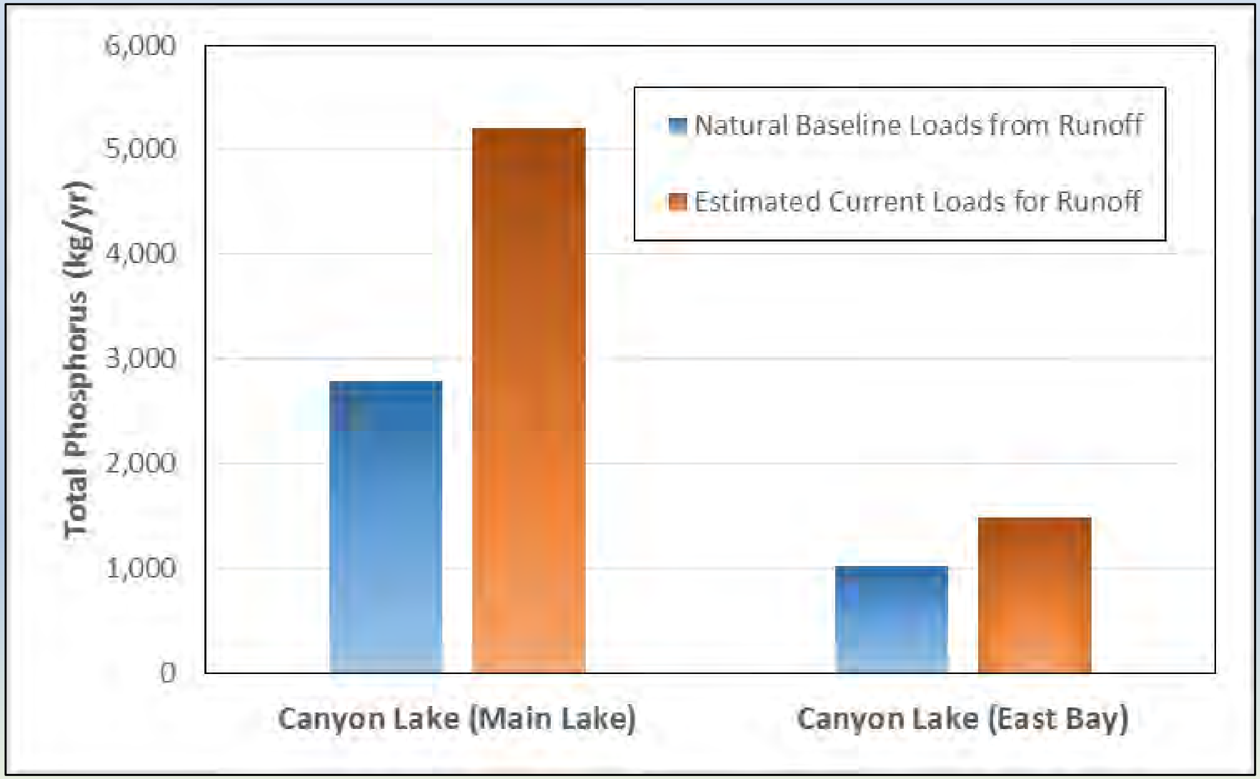
Measured Loading to Canyon Lake

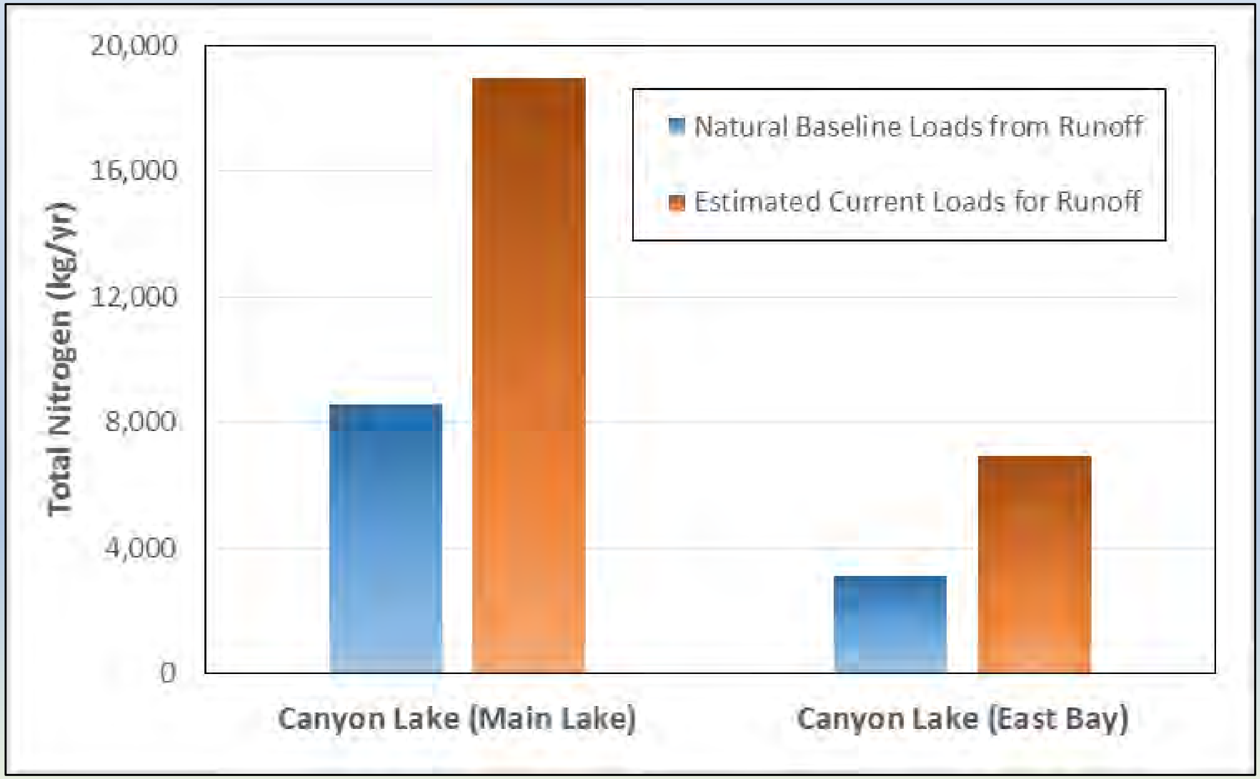




Natural Baseline Runoff Nutrient Loads

- Natural runoff loads = $C_{reference} * V_{average}$
- Cranston Guard Station median serves as reference concentration
  - TP = 0.31 mg/L; TN = 0.95 mg/L

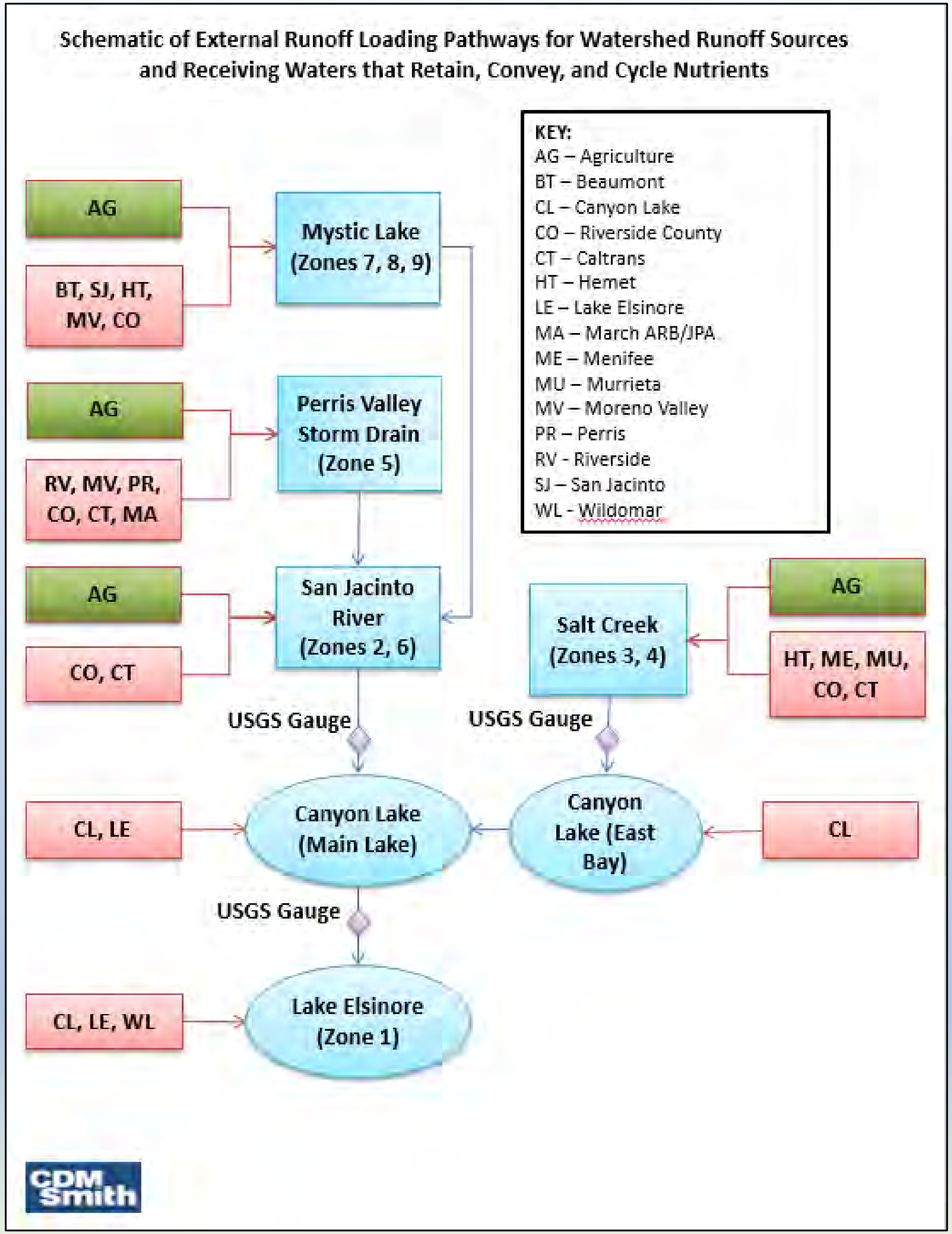




SOURCE ASSESSMENT (EXTERNAL SOURCES)

Watershed Runoff Model

- Develop a tool to estimate portion of downstream loads to Canyon Lake from upstream sources
  - Jurisdictions
  - Land use types
- Simple method for average annual pollutant loads (as in peer reviewed public domain PLOAD tool)



Watershed Runoff Model

- TMDL revision
  - EMCs for common land uses in different jurisdictions for equitable per acre allocation of loads
  - Technically sound, leverage data, modifiable with newer data
- LSPC model
  - TMDL adjusted land use based buildup/washoff parameters to calibrate downstream water quality in uniform land use tributaries

Simple Method

- Annual runoff estimation using simple method
- Additional term to account for runoff retained downstream of watershed lands within channel bottoms or on-site (e.g. CAFOs)

$$Q_{annual} = (Precip_{annual} * \text{RC}) - \text{Retention}$$

- Loads computed for aggregated watershed lands with common land use (*LU*), jurisdiction (*J*), and subwatershed zone (*Z*)

$$L_{LU,J,Z} = Q_{annual} * EMC_{LU}$$

Key Parameters

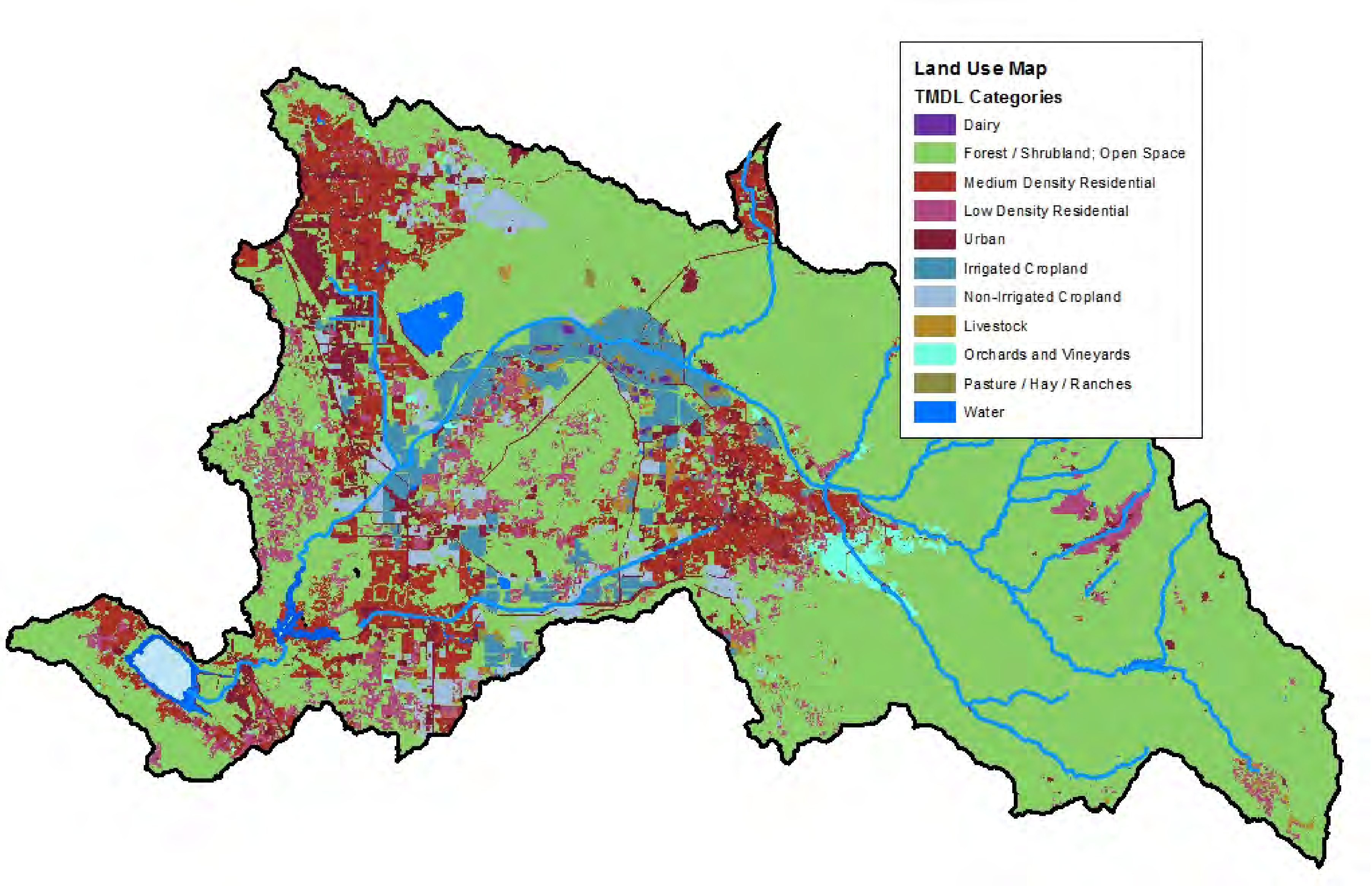
- Input data
  - Rainfall
  - Land use
  - Subwatersheds
- Variables
  - Imperviousness
  - Land use based EMCs
  - Downstream retention
  - Septic systems

Input Data - Rainfall

Station	Period of Record	Long -Term Average Annual Rainfall (in/yr)	Last 15 Year Average Annual Rainfall (in/yr)	Watershed Zone
San Jacinto	1903/04 - Present	12.7	10.0	7, 8, 9 (below 3000')
Elsinore	1896/97 - Present	12.1	10.0	1
Perris	1910/11 - Present	10.5	8.9	2, 6
Winchester	1940/41 - Present	10.9	9.4	3, 4
Pigeon	1956/57 - Present	12.2	11.4	5
Idyllwild	1928/29 - Present	26.6	22.8	7, 8, 9 (above 3000')

Input Data - Landuse

- Land use data current as of 2014

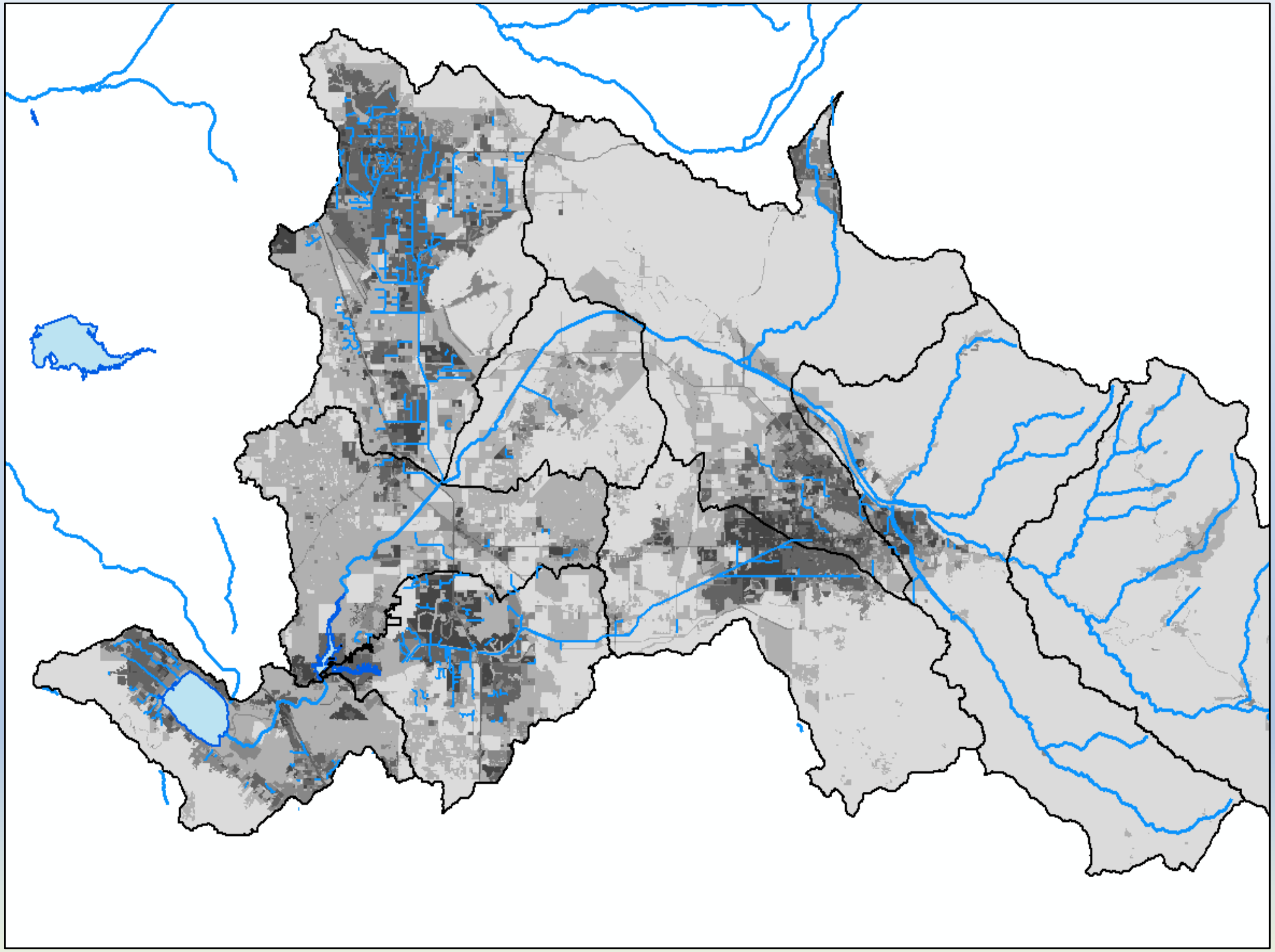


Input Data - Subwatersheds

- Revisions to Mystic Lake boundary
- Revisions in areas around Canyon Lake including estimation of drainage area below USGS gauge stations

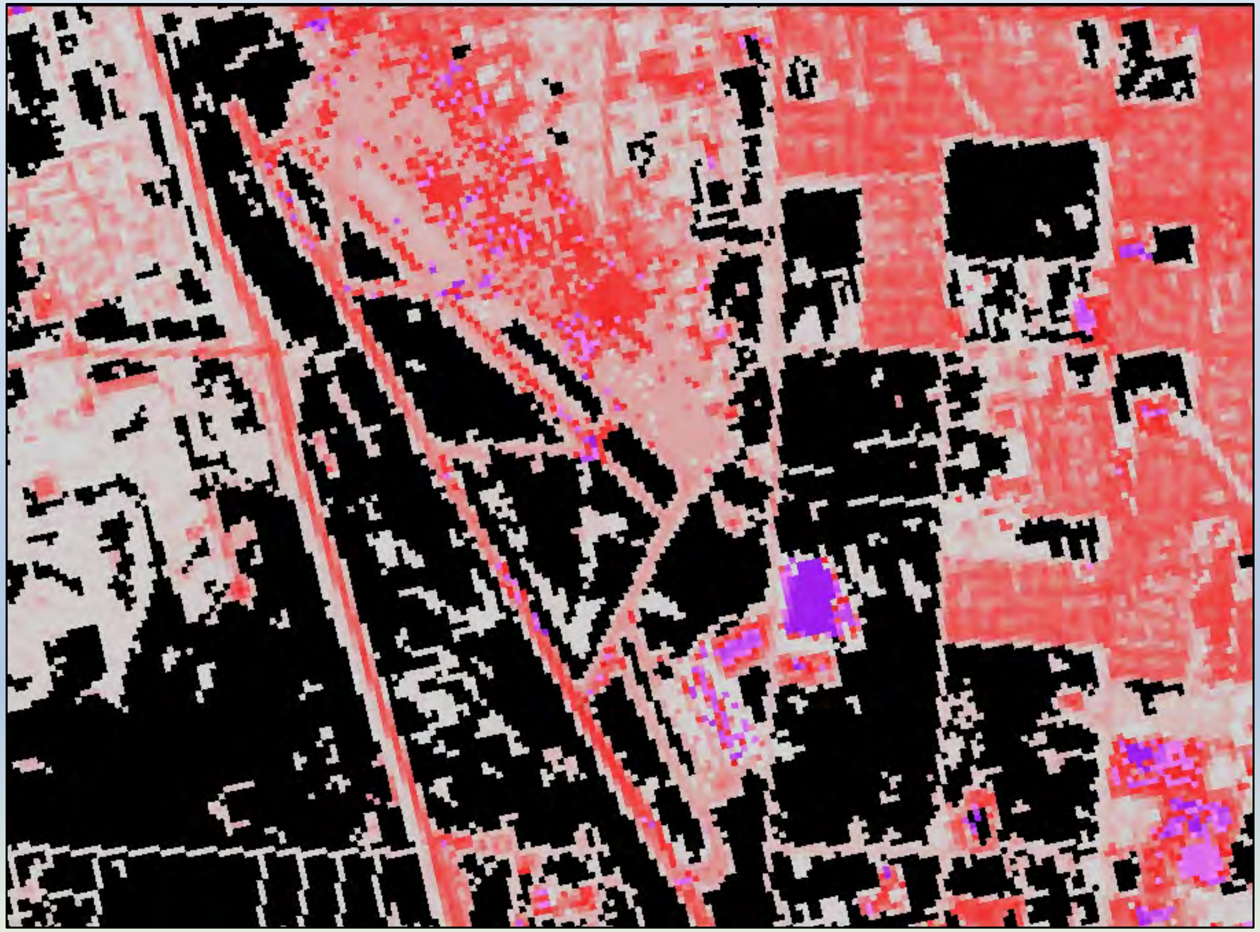
Variables - Imperviousness

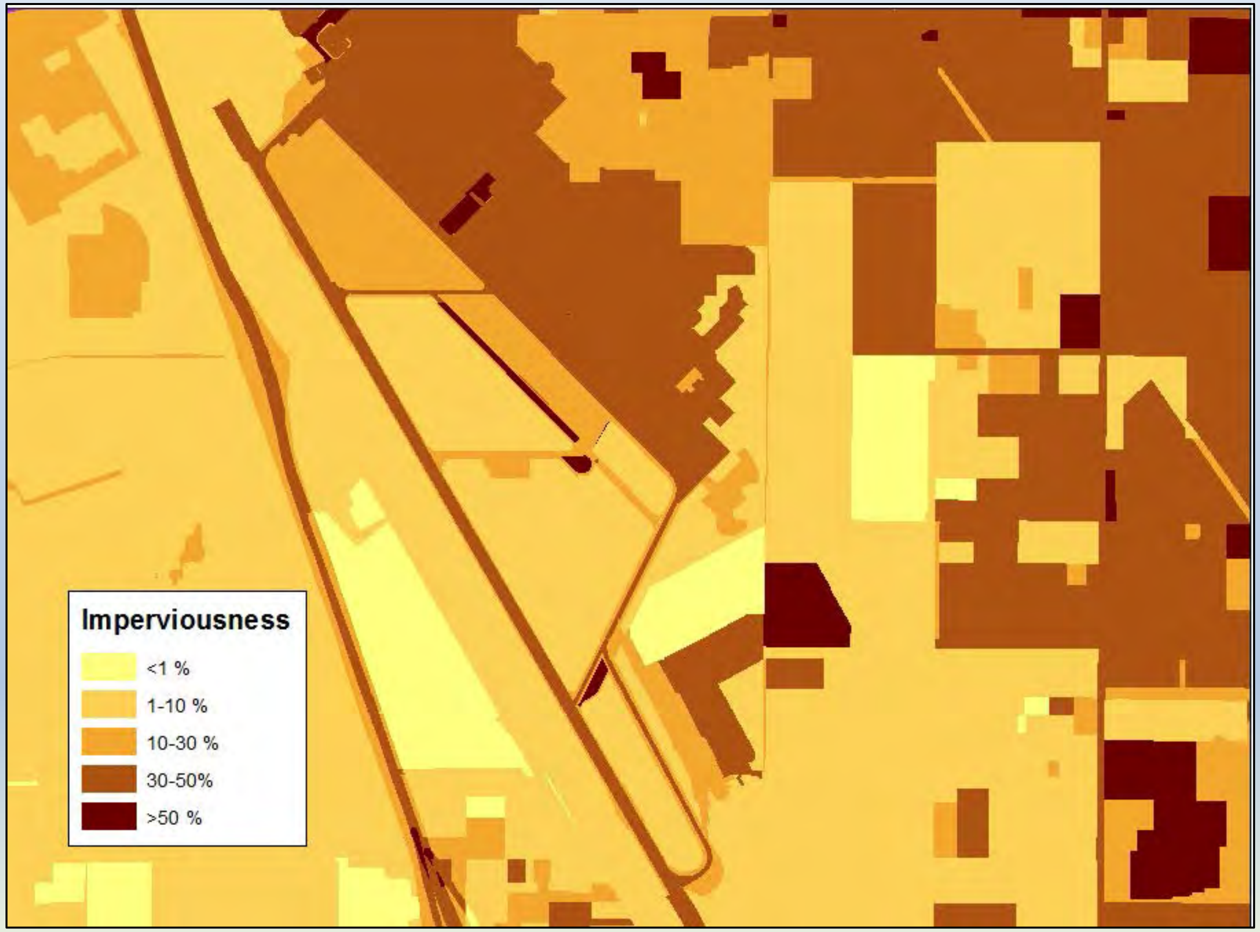
- Calibration of a runoff coefficient (RC)
- Exponential function of subarea imperviousness (new mapping data)
- $RC = a * e^{(b*imp)}$



Variables - Imperviousness

- More precise that assumptions for aggregated land use categories



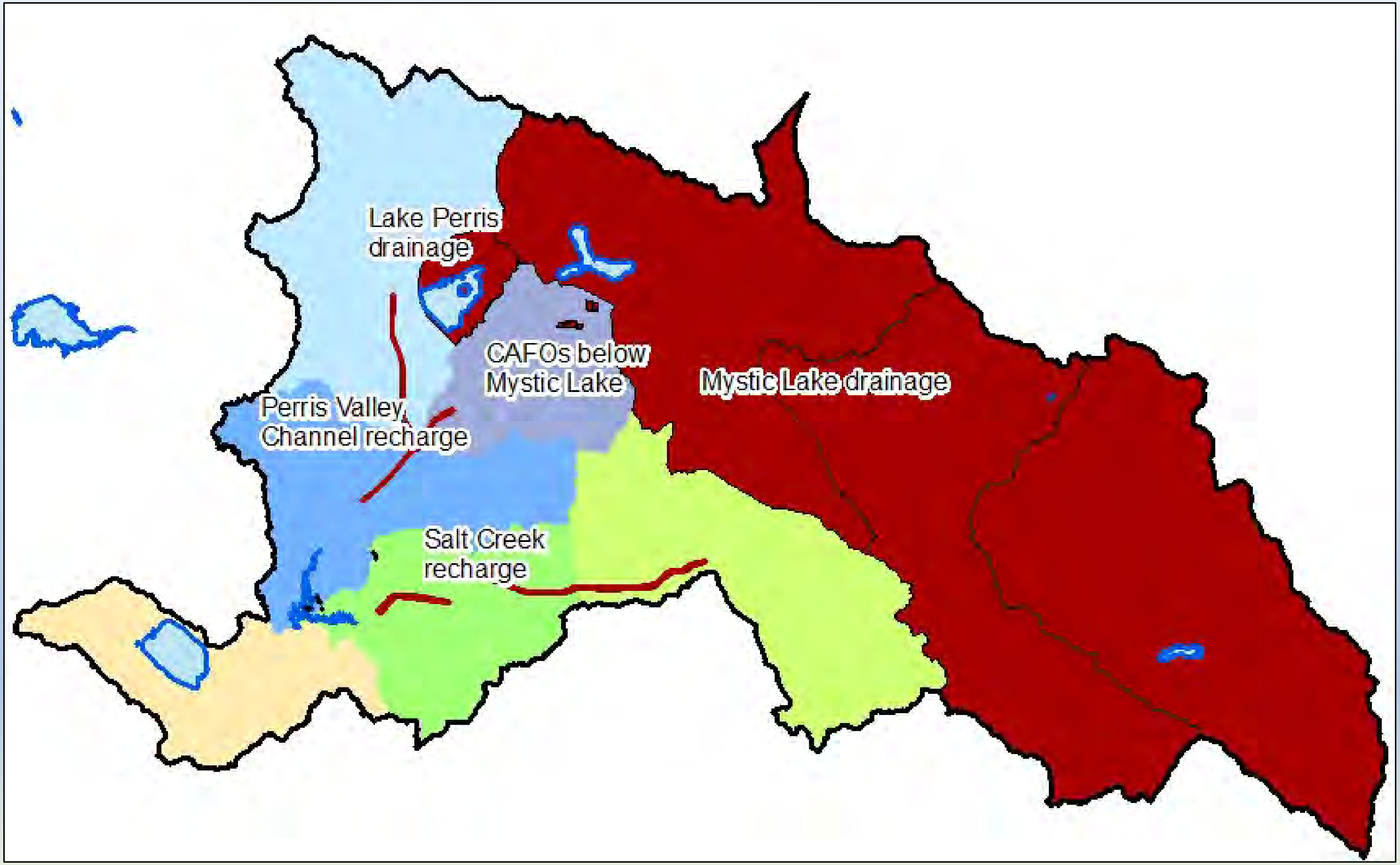


Variables - Event Mean Concentration (EMC)

- Preliminary values, extracted from local and literature sources

Land Use	Event Mean Concentration		Source
	TP (mg/L)	TN (mg/L)	
Dairy	0.0	0.0	Presume compliance with CAFO Permit
Forested	0.3	1.0	Cranston Guard Station
High-Density Residential	1.0	4.0	Central Arizona Project Urban LTER (n=146)
Irrigated Cropland	1.0	4.1	UCR Ag Study
Low-Density Residential	0.8	2.5	Central Arizona Project Urban LTER (n=146)
Non-Irrigated Cropland	0.5	3.0	UCR Ag Study
Open Space	0.3	1.0	Cranston Guard Station
Orchards/Vineyards	1.1	1.8	UCR Ag Study
Other Livestock	1.5	6.0	Assumed value to be refined
Pasture / Hay	0.6	2.0	Assumed value to be refined
Roadway	0.5	3.5	National Stormwater Quality Database - Rainfall region 6 Freeway landuse (n=92)
Commercial / Industrial	0.9	3.3	NSQD Rainfall region 6 CO,ID landuses (n=95)

Variables - Downstream Retention



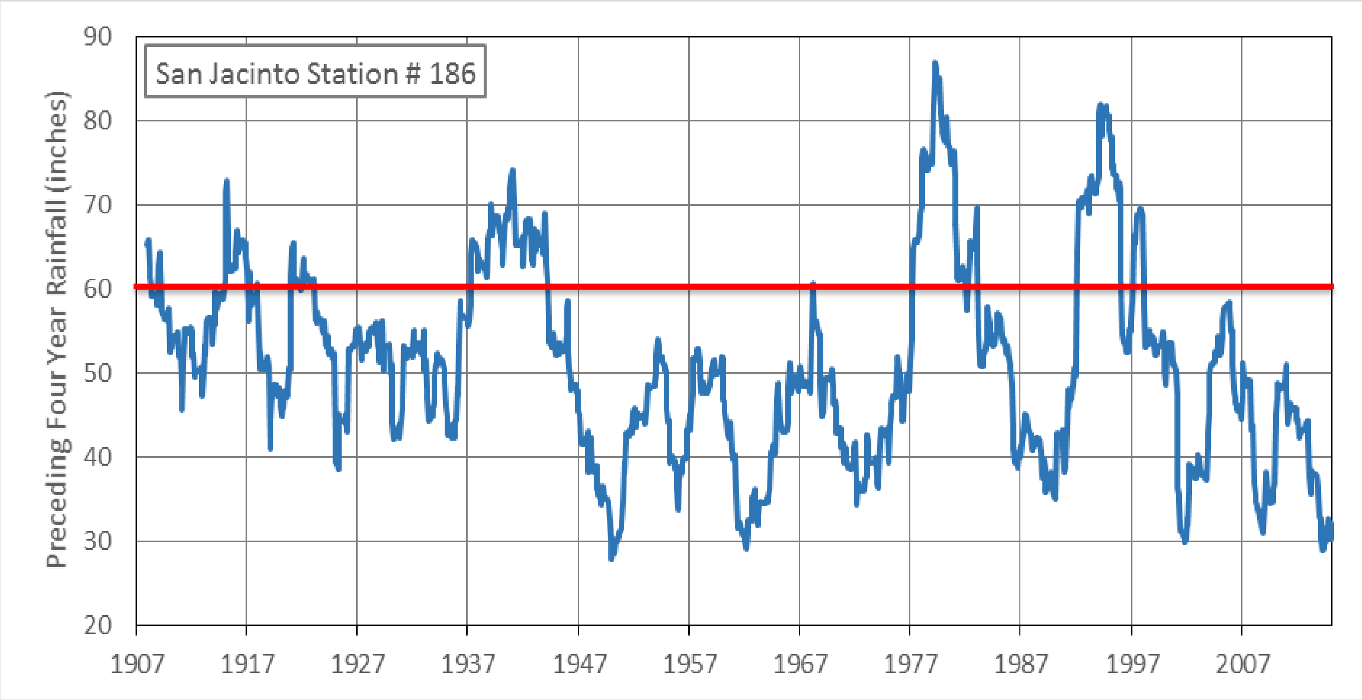
Variables - Downstream Retention - In-Stream Attenuation

- Estimate of annual recharge within unlined channel bottoms
- Credit for recharge on days when downstream discharge is above a threshold (i.e. presence of runoff for recharge)
- Upstream zones receive credited volume retained

Segment	Bottom Area (acres)	Recharge Rate (ft/day)	Downstream Flow Threshold (cfs)	Estimated Annual Recharge (AFY)
Salt Creek	600	0.2	10	1,710
Perris Valley Channel	222	0.2	20	720
San Jacinto River	111	0.2	20	360

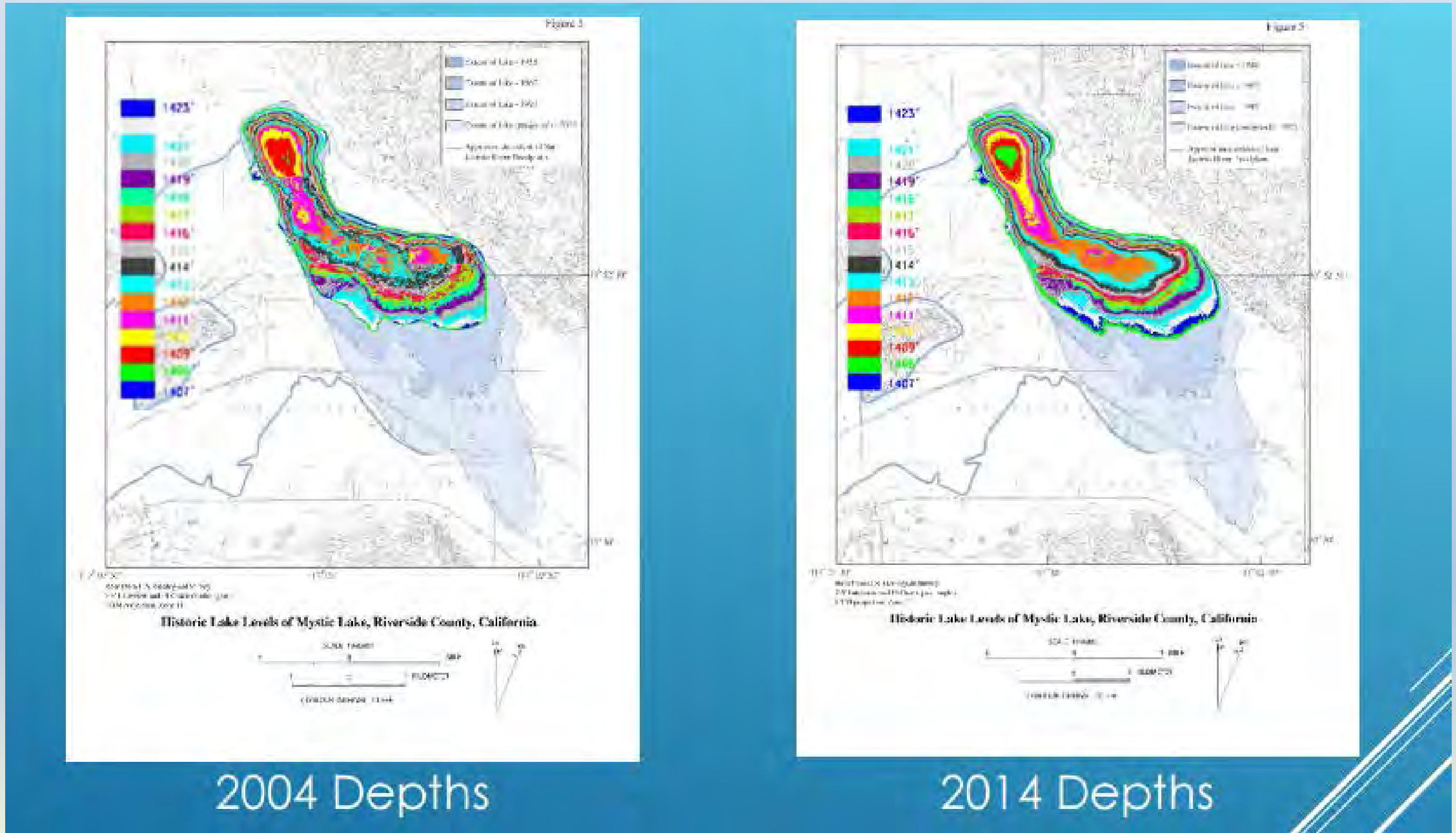
Variables - Downstream Retention - Mystic Lake Overflow

- Review historical rainfall record at San Jacinto station
- Overflows approximated to occur when preceding 4-yr rain exceeds 60 inches, plus above average current year rainfall
  - 16 of 112 years meet these conditions (most recent in 1993, 1995, 1998; NOT in 2005)



Variables - Downstream Retention - Mystic Lake Overflow

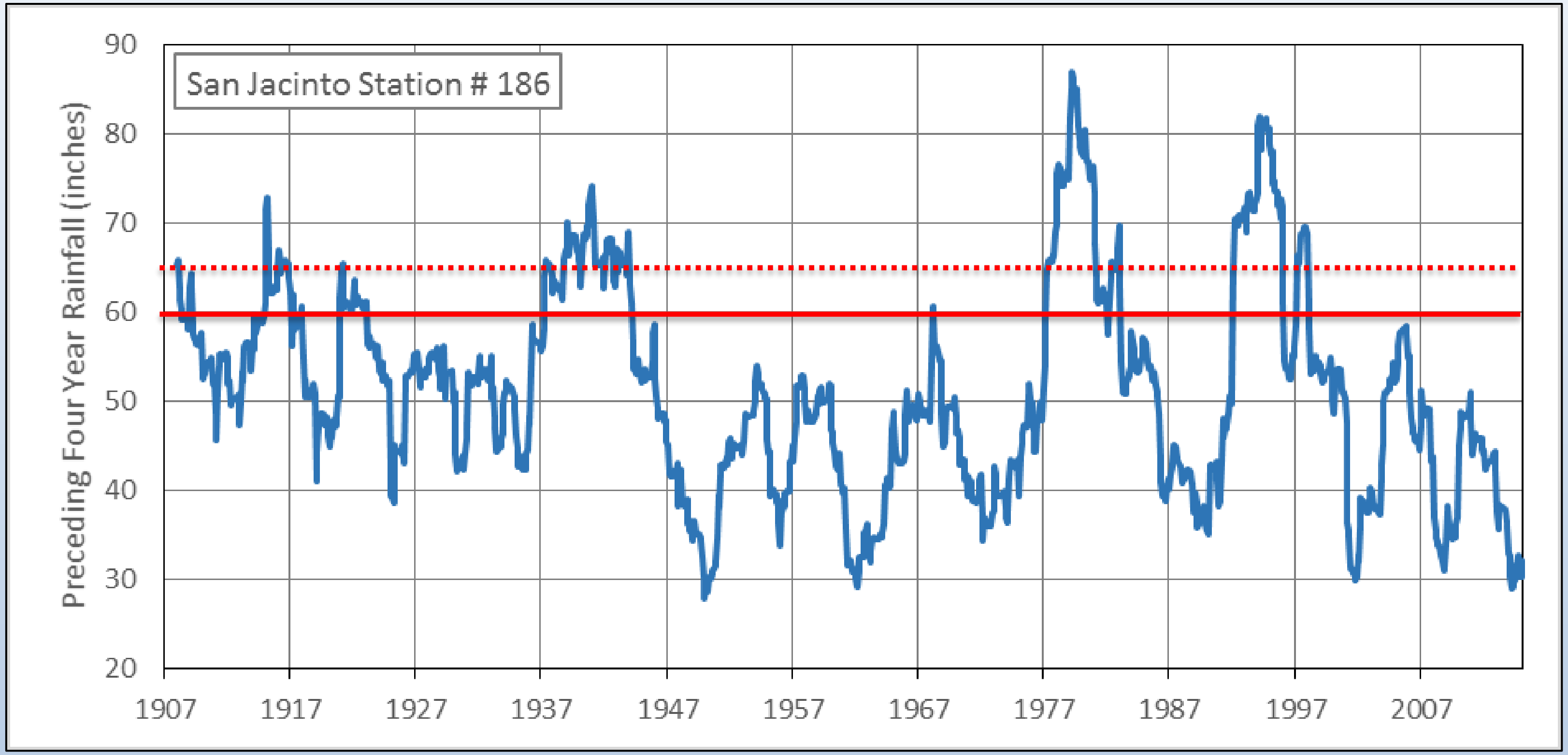
- Continued subsidence adds ~200 AF of new storage each year (potentially 5,000 AF in next 25 years)



Graphic created by Doug Morton and presented to Task Force by Mike Venable, RCFC&WCD

Variables - Downstream Retention - Mystic Lake Overflow

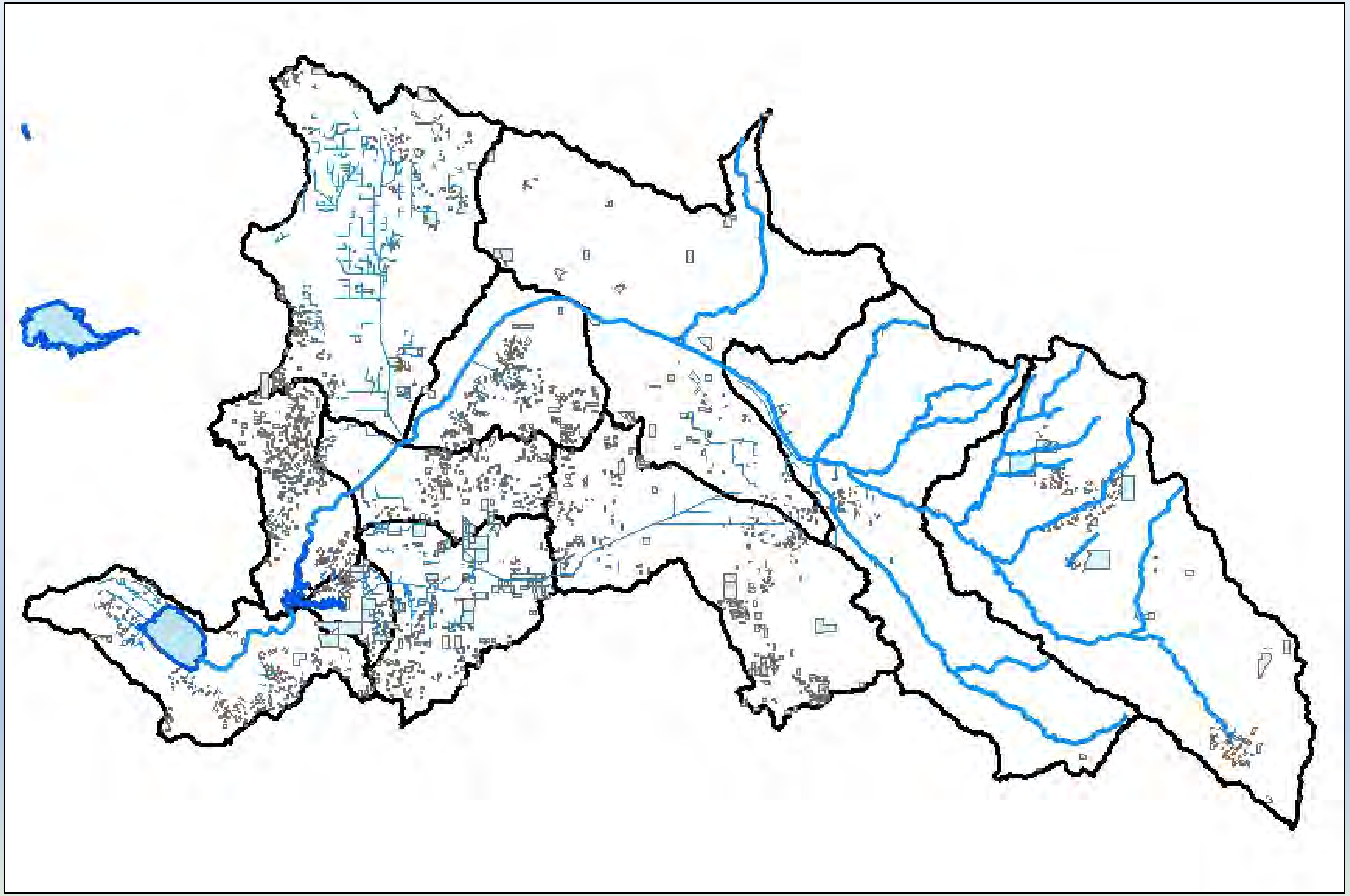
- Zones 7-9 runoff loading factor of 0.11 for projected overflow frequency



Condition	Runoff Retention (AF)	Approximate 4-yr Rainfall (in)	Estimated Overflow Years
Current Basin	65,000	60	16 / 112
Projected (2040)	70,000	65	12 / 112

Variables – Septic Systems

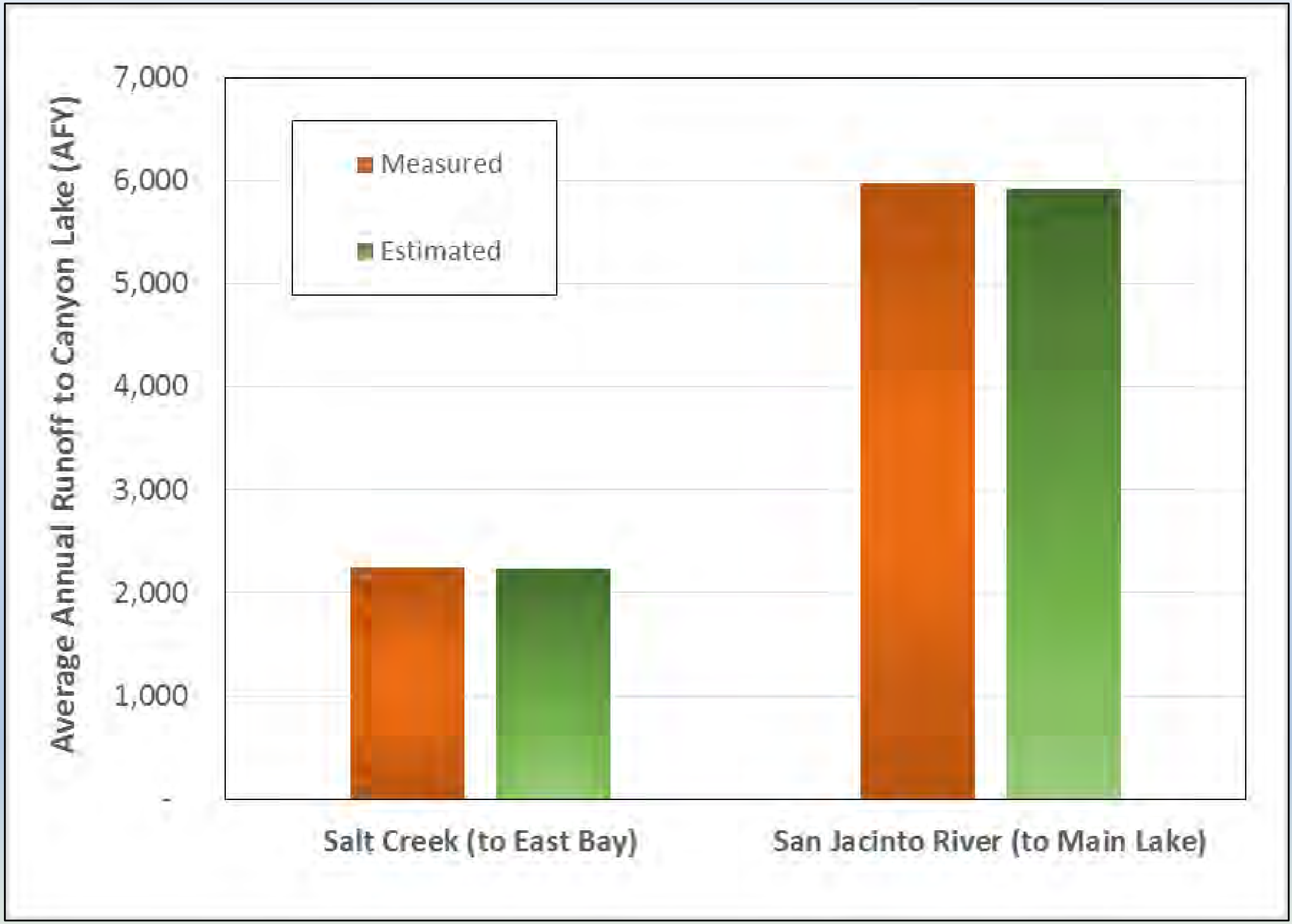
- High nutrient loads to receiving waters IF system is failing



SOURCE ASSESSMENT RESULTS
EXTERNAL SOURCES

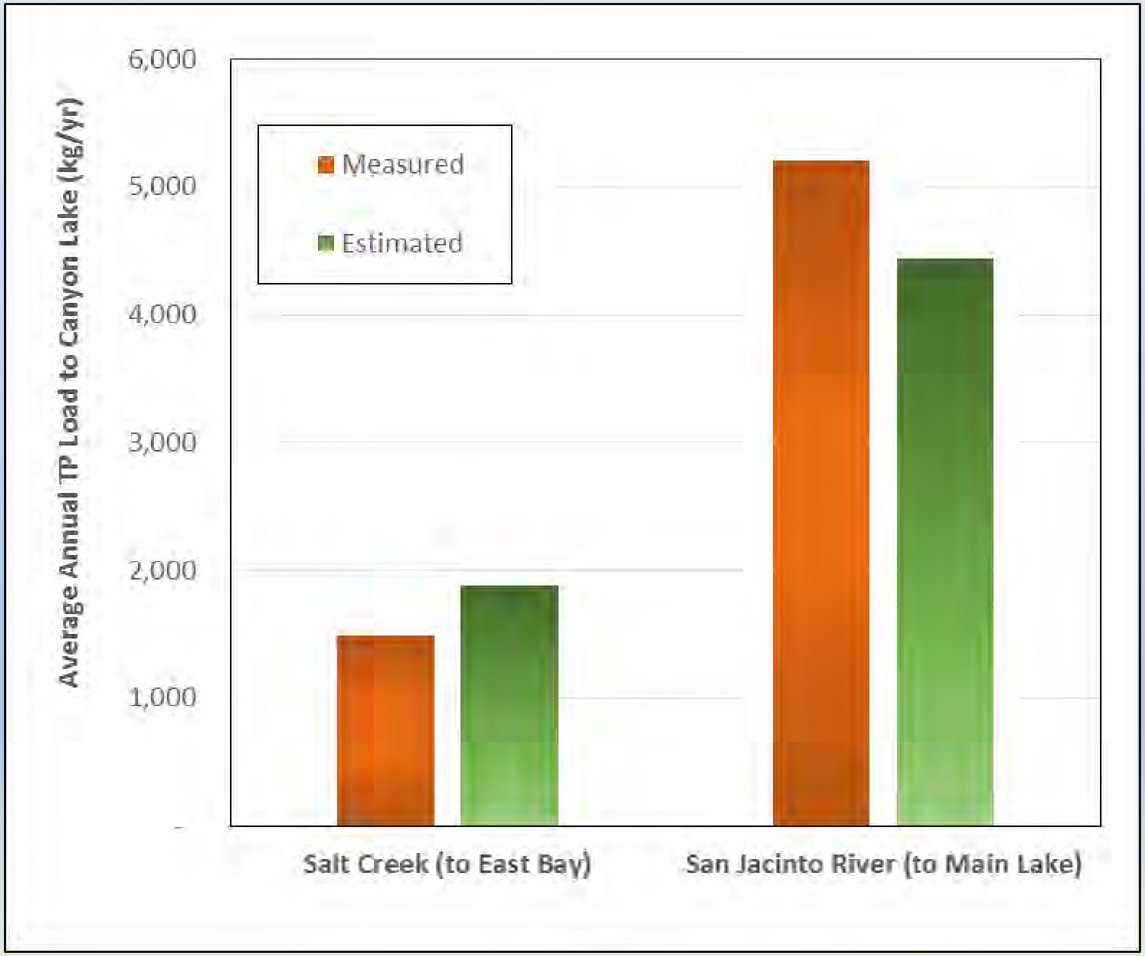
Results – Runoff Volume

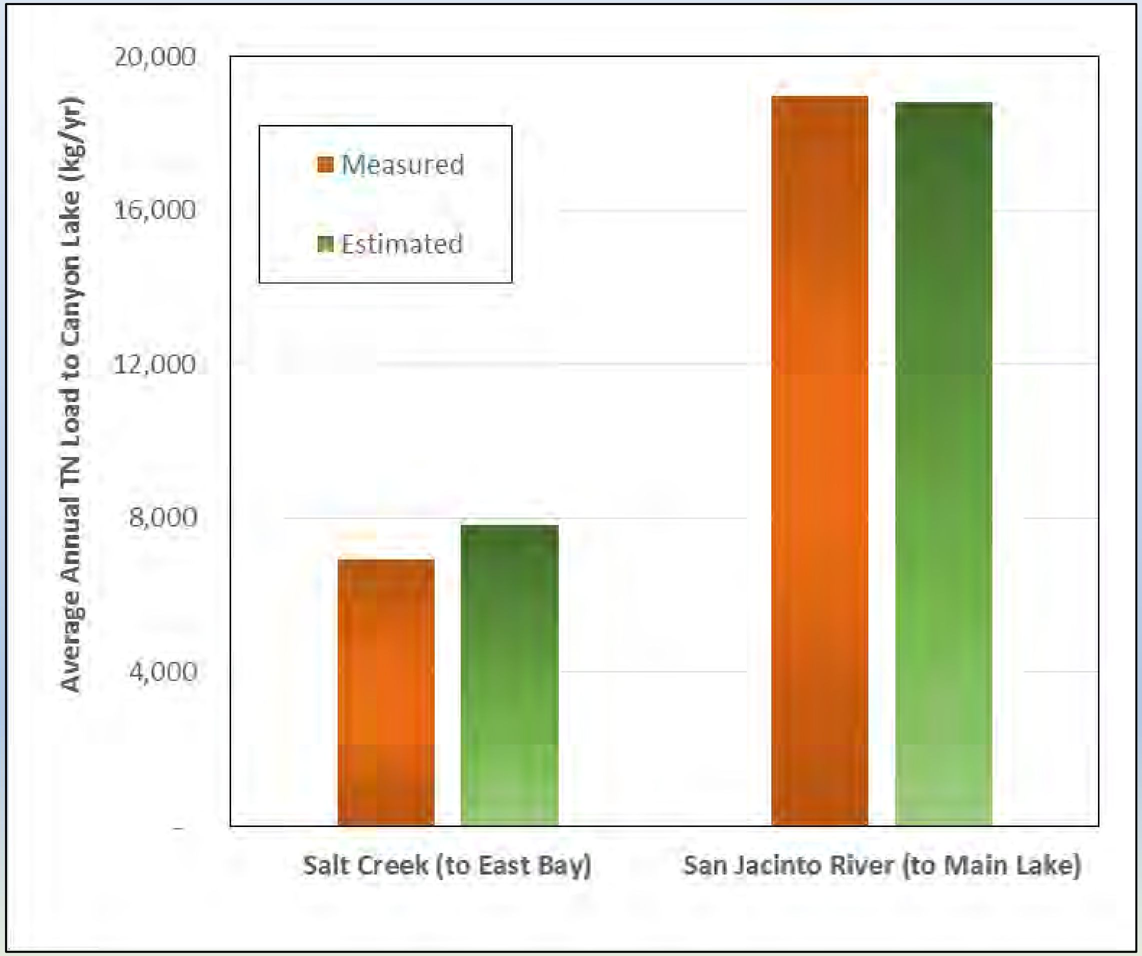
- Parameters fit long term average runoff volume and load
  - Runoff coefficient parameters
  - Channel bottom recharge rate



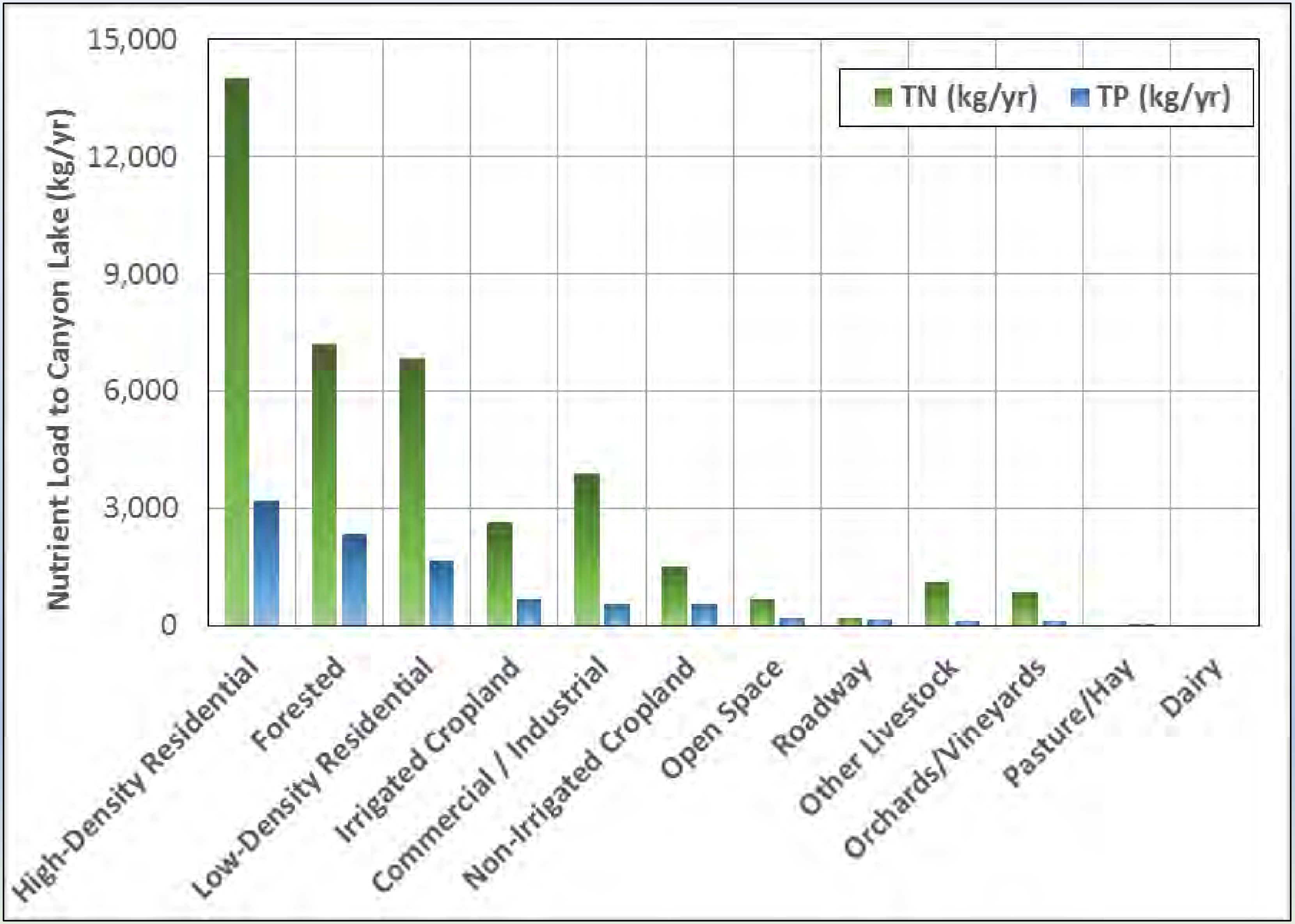
Results – Nutrient Loads

- Adjustment of EMCs to fit long term average annual loading to lake



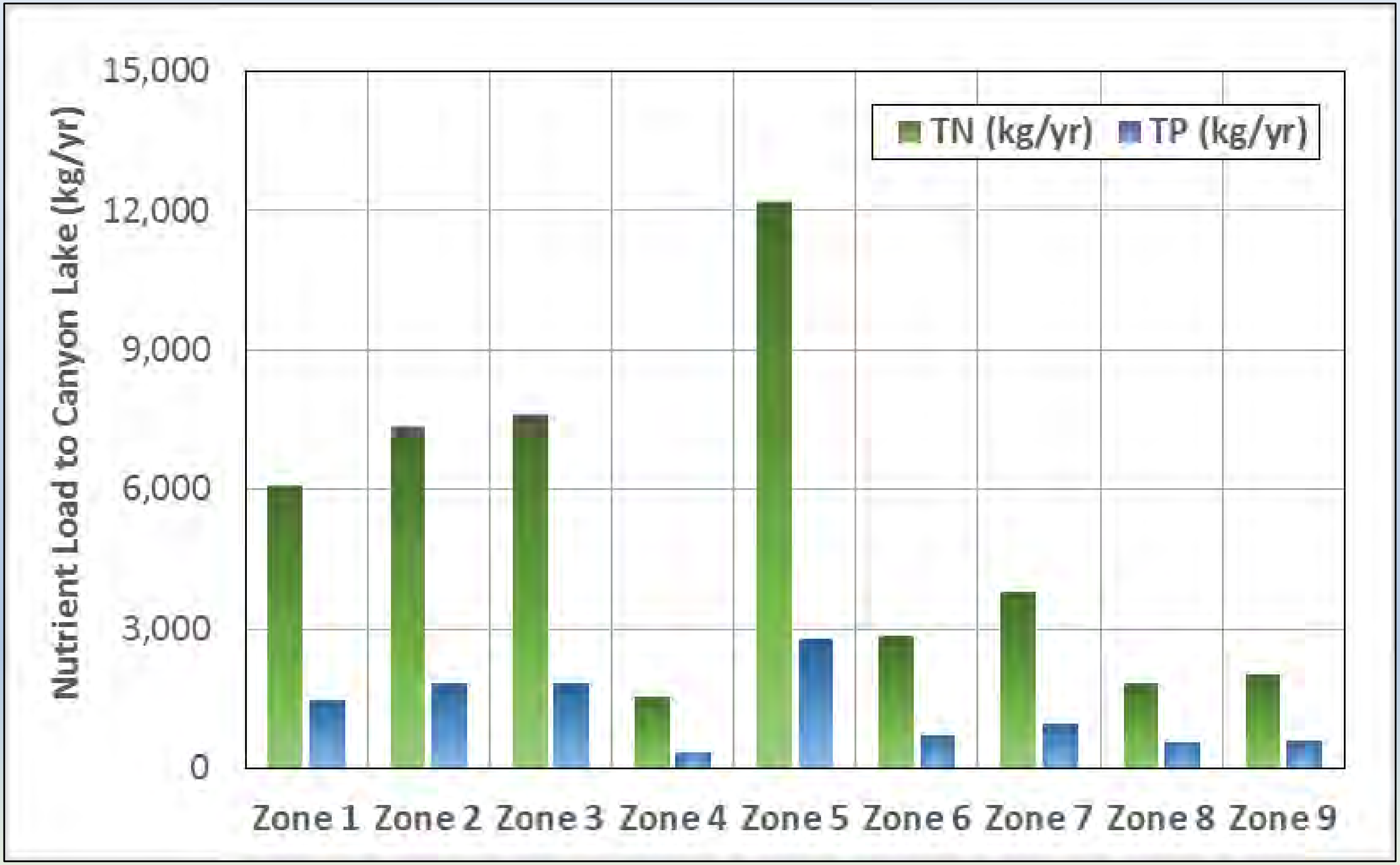


Results – Nutrient Loads by Runoff Source



Results – Nutrient Loads by Subwatershed

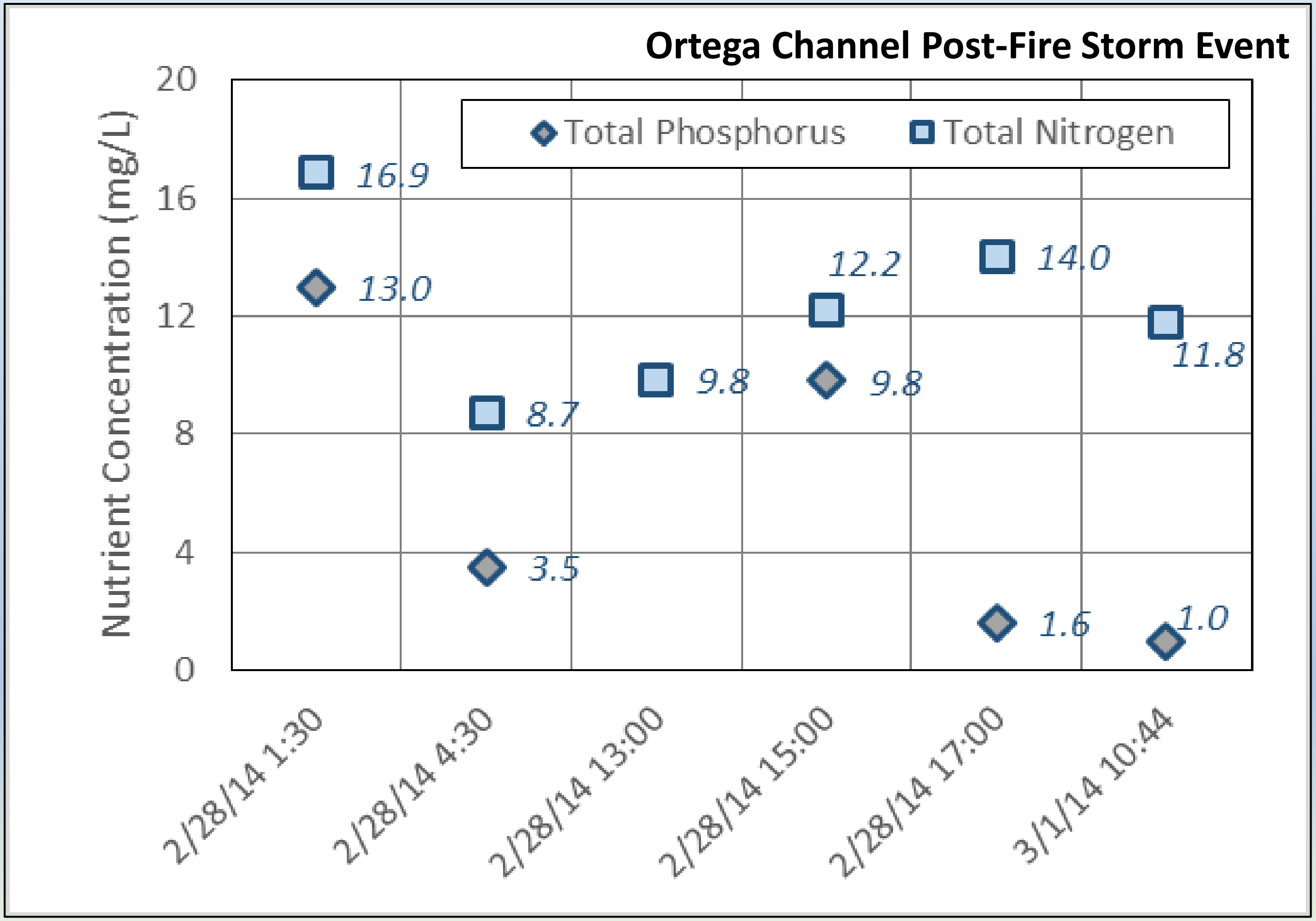
- Increase load to Canyon Lake (Main Lake) from Mystic Lake overflows
- Assumes no retention in spill years



SOURCE ASSESSMENT (OTHER CONSIDERATIONS)

Influence of Forest Fire

- Significant increase in nutrient loading in burned areas



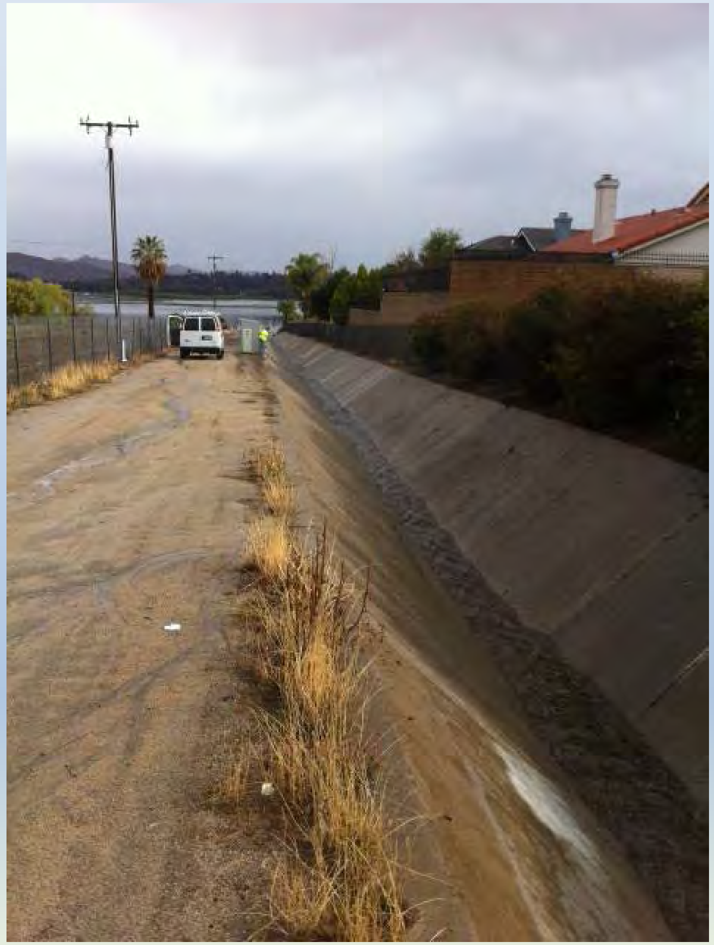
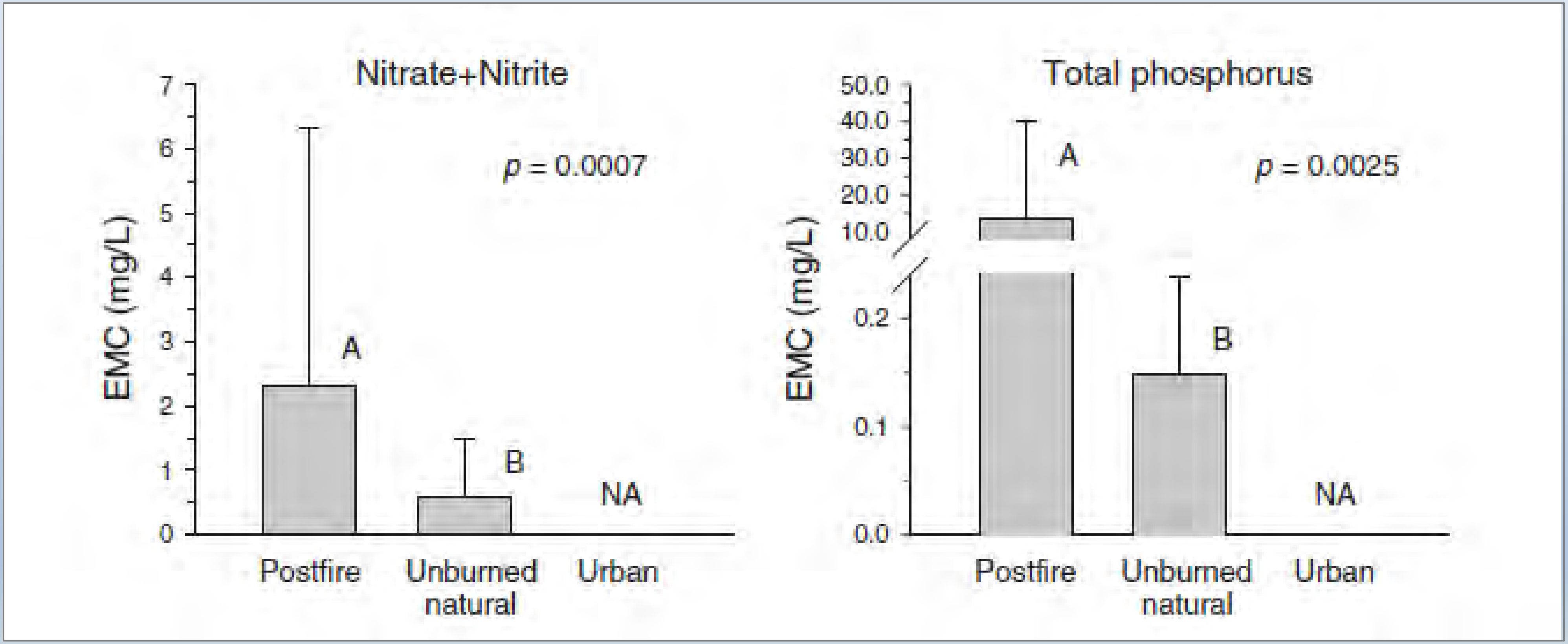


Photo provided by Kyle Gallup, RCFC&WCD

Influence of Forest Fire

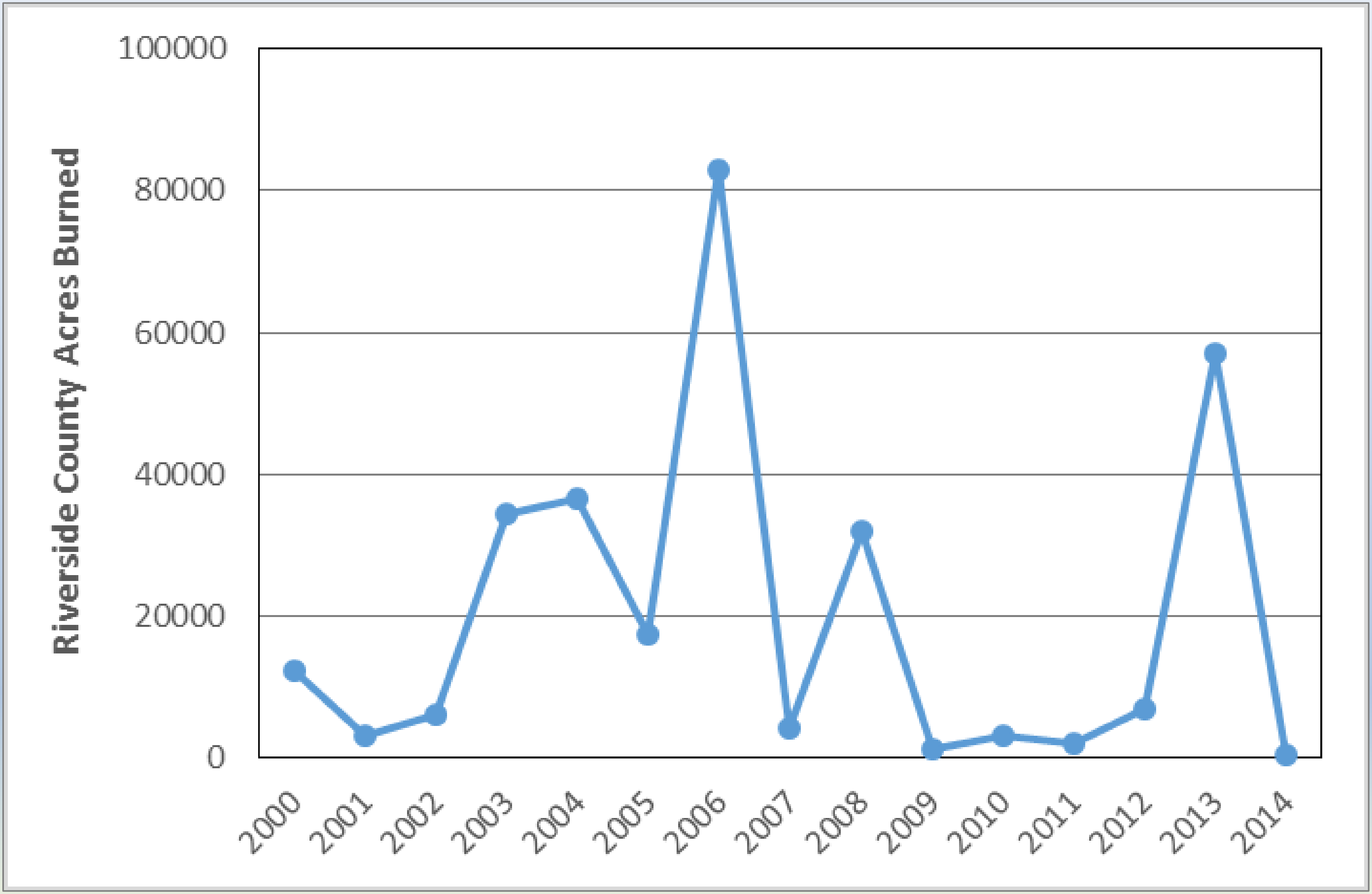
- SCCWRP study comparing burned and unburned areas



Reference: Eric D. Stein, Jeffrey S. Brown, Terri S. Hogue, Megan P. Burke and Alicia Kinoshita (2012). Stormwater contaminant loading following southern California wildfires. *Environmental Toxicology and Chemistry,* v31(2625-2638).

Influence of Forest Fire

- Riverside countywide inventory of fires



Influence of Forest Fire

- Area-weighted average of burned and unburned areas

Condition	% of Watershed	TN	TP	Source
Unburned	97%	0.6	0.11	Experimental Forest
Burned	3%	12.2	5.8	Ortega Channel Post-Fire Samples
Combined (Assumed forest land EMCs)		1.0	0.3	Calculated area-weighted Average

- Total forest/open space 335K acres, thus 10K acres with some upstream burned area could increase natural land nutrients by 2-3 times

SOURCE ASSESSMENT (INTERNAL SOURCES)

Key Elements of Internal Source Assessment

- Internal sediment nutrient flux
- Resuspension
- Atmospheric deposition
- Nitrogen fixation
- Evapo-concentration