Revision of the Lake Elsinore & Canyon Lake Nutrient TMDL

CDM Smith
Team & Risk Sciences

Load Reductions from Existing Control Programs

April 19, 2017

Lake Elsinore/Canyon Lake Task Force Meeting

RISK SCIENCES

CDM Smith

Presentation Outline

- Allocations for TMDL Revision
  - Watershed sources
  - Internal sources
- Watershed Nutrient Management
- In-Lake Nutrient Management
- Linkage Analysis

Watershed Load Allocations

Allocations by Jurisdiction

- Reference watershed condition
- Hydrology
- Nutrient Concentrations

Responsible Agency Poiunt		Canyon Lake Main Lake		Canyon Lake East Bay		Local Lake Elsinore		Canyon Lake Overflow to Lake Elsinore	
		TP (kg/yr)	TN (kg/yr)	TP (kg/yr)	TN (kg/yr)	TP (kg/yr)	TN (kg/yr)	TP (kg/yr)	TN (kg/yr)
Point Source Reduction to Meet Wasteload Allocations	Banning	-	-	-	-	-	-	1	2
	Beaumont	-	-	-	-	-	-	9	27
	CAFO	5	14	2	6	0	0	7	22
	Caltrans	11	33	4	12	6	17	12	35
	Canyon Lake	12	36	14	44	7	23	14	43
	Federal – Dept. of Defense	26	79	-	-	-	-	14	43
	Hemet	-	-	48	147	-	-	34	104
	Lake Elsinore	15	44	6	19	317	971	11	34
	March Joint Powers Authority	28	87	-	-	-	-	15	47
	Menifee	74	227	279	854	10	30	190	582
	Moreno Valley	278	851	-	-	-	-	151	462
	Murrieta	-	-	5	16	-	-	3	9
	Perris	198	607	1	2	-	-	107	328
	Riverside	6	18	-	-	-	-	3	9
	Riverside County	559	1,712	220	674	139	427	587	1,799
	San Jacinto	1	2	1	2	-	-	24	74
	Wildomar	-	-	0	0	113	345	0	0
Non-Point Source Reduction to Meet Load Allocations	Agriculture (CWAD)	171	523	80	246	0	1	163	500
	Agriculture (Small)	26	79	14	43	1	4	23	71
	CA Dept. of Fish and Wildlife	44	134	-	-	-	-	54	165
	Federal - National Forest	-	-	2	5	121	371	318	976
	Federal – Other	32	97	7	21	-	-	51	157
	Federal – Wilderness	-	-	-	-	-	-	62	190
	State Land	38	115	-	-	-	-	45	139
	Tribal Reservations	-	-	-	-	-	-	17	53
	Western Riv. Co. Reg. Con.	8	24	4	13	-	-	9	29
	Total Allowable Watershed Load	**1,528**	**4,684**	**687**	**2,106**	**715**	**2,190**	**1,925**	**5,900**

Allowable Loads to Allocated Reductions

- Factors for allocating allowable nutrient loads
- Four groups of allocations for three TMDLs (Canyon Lake East Bay, Canyon Lake Main Lake, Lake Elsinore)

Subwatershed Zone	Canyon Lake Main Lake	Canyon Lake East Bay	Lake Elsinore	
			Local Lake Elsinore	Canyon Lake Overflows
1			100%	
2	65%			35%
3		65%		35%
4		65%		35%
5	65%			35%
6	65%			35%
7				100%
8				100%
9				100%

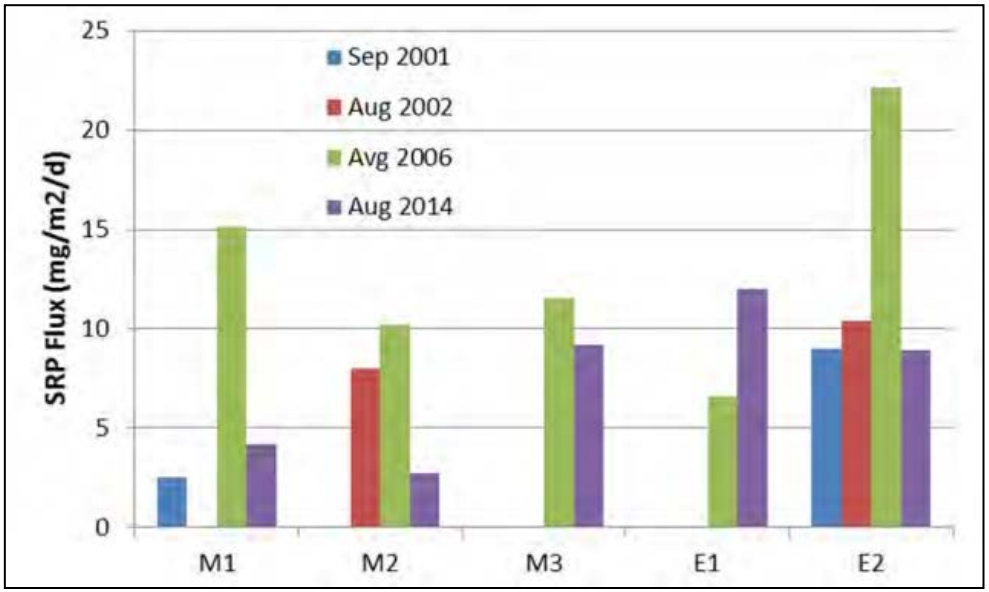
Load Reduction by TMDL Lake Segment

- Required load reduction = estimated current load minus allowable load (i.e. incremental load above reference condition)
- Agriculture EMCs being revised based on soil health study results to update current load

In-Lake Load Allocations

Sediment Nutrient Flux

- Estimates from Anderson chamber studies
- North Ski Area included in Canyon Lake Main Lake acreage



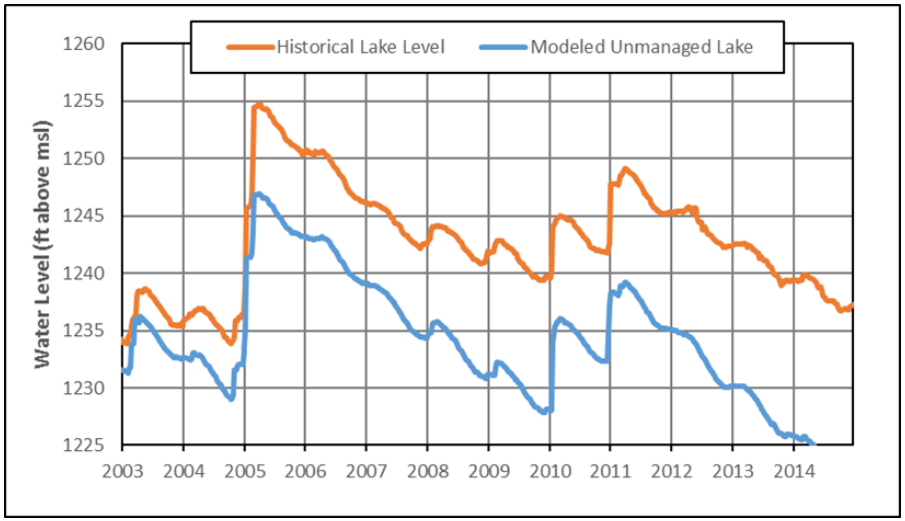
Lake Segment	Acres	Sediment Nutrient Flux (mg/m²/day)		Load Allocation (kg/yr)	
		TP	TN	TP	TN
Canyon Lake (Main Lake)	333.7	8	33	3,943	16,267
Canyon Lake (East Bay)	102.5	11.5	58	1,741	8,782
Lake Elsinore	3,000	10	100	44,315	443,147

Sediment Nutrient Flux

- Substantial weather driven fluctuation in flux rates
- Reductions in watershed load may indirectly reduce long-term averages of sediment nutrient flux after multi-decadal legacy nutrient pool is buried or mineralized
- Lake models for linkage analysis based on static flux rates – dynamic sediment diagenesis feature may be functional in future according to CAEDYM developers

Supplemental Water

- Water quality benefit of lake level stabilization offsets nutrient loading



EVMWD Reclaimed Water Additions	Flow		Concentration		Nutrient Load	
	MGD	AFY	TP (mg/L)	TN (mg/L)	TP (kg/yr)	TN (kg/yr)
Current Permit	8.0	6,037	0.50	1.00	3,721	7,442
TMDL Revision	9.5	10,642	0.31	0.95	4,067	12,463

Atmospheric Deposition

- Assumes TP in rainwater of 30ug/L (Walker, 1995)
- TN from Newport Bay study (Meixner, 2004)
- North Ski Area included in Canyon Lake Main Lake acreage

Lake Segment	Acres	Atmospheric Deposition Rate (kg/ac/yr)		Load Allocation (kg/yr)	
		TP	TN	TP	TN
Canyon Lake (Main Lake)[1]	334	0.04	3.23	12	1,077
Canyon Lake (East Bay)	103	0.04	3.23	4	331
Lake Elsinore	3,000	0.04	3.23	108	9,682

Allocation Summary

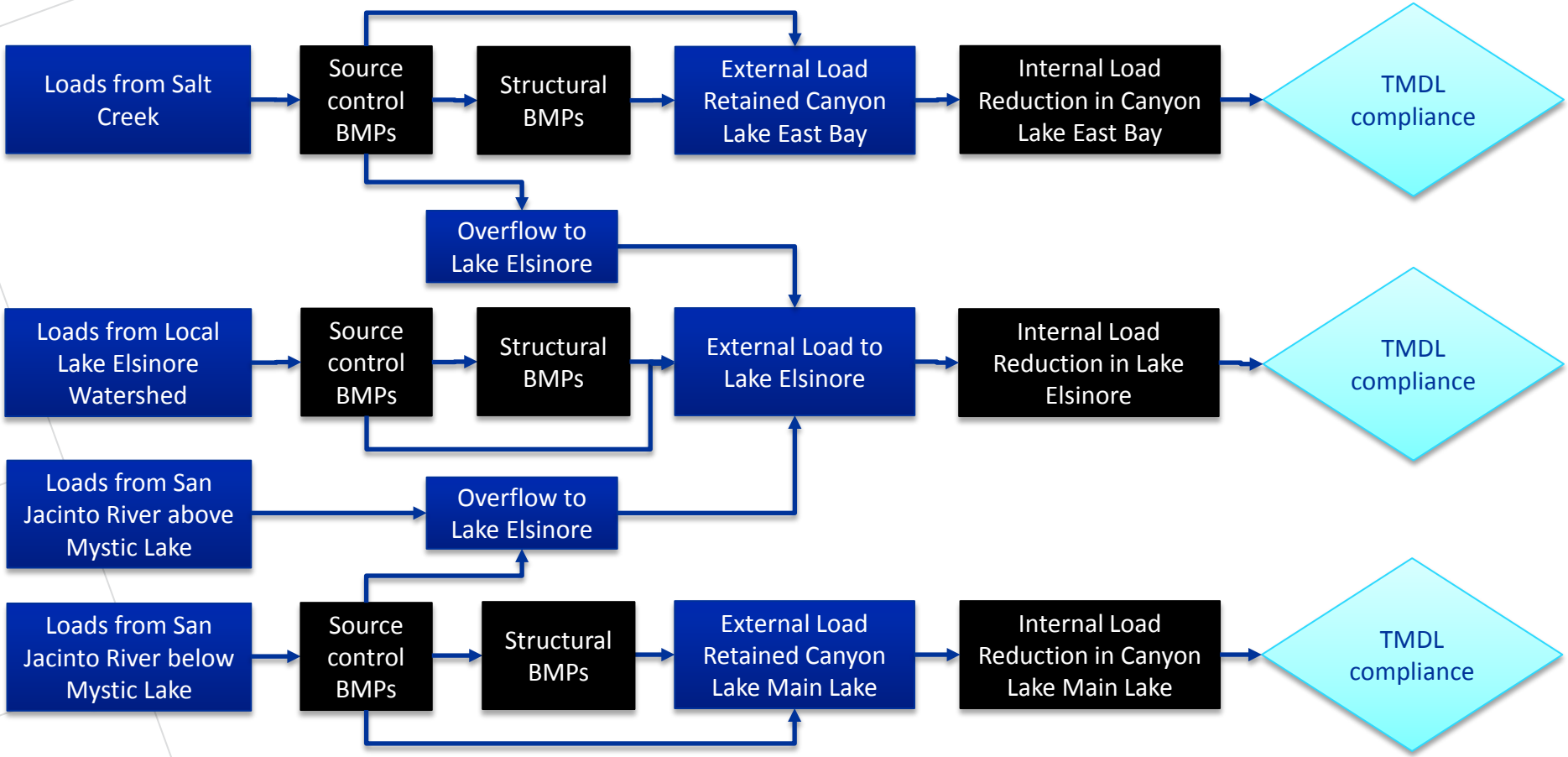
Lake Segment	Wasteload Allocation (kg/yr)		Load Allocation (kg/yr)	
	TP	TN	TP	TN
Canyon Lake (Main Lake)				
Watershed Runoff	1,211	3,711	317	973
Supplemental Water	As needed		n/a	
Atmospheric Deposition	n/a		12	1077
Sediment Nutrient Flux	n/a		3,943	16,267
Canyon Lake (East Bay)				
Watershed Runoff	580	1,778	107	328
Supplemental Water	As needed		n/a	
Atmospheric Deposition	n/a		4	331
Sediment Nutrient Flux	n/a		1,741	8,782
Lake Elsinore				
Watershed Runoff (Canyon Lake overflows)	1,181	3,620	744	2,280
Watershed Runoff (local)	592	1,814	123	376
Supplemental Water	4,067	12,463	n/a	
Atmospheric Deposition	n/a		108	9,682
Sediment Nutrient Flux	n/a		30,000	300,000

Watershed Nutrient Management

Treatment Train

- Source control to reduce washoff from watershed subareas
  - Street sweeping and drainage system debris removal
  - Agricultural field winter crop buffers
  - Septic system management
- Structural BMPs to capture runoff for infiltration or treatment
  - WQMP projects for new development/re-development
  - Diversions to recharge basins
- Retention in upstream lakes, including Canyon Lake

Allowable Watershed Loads to Allocated Reductions

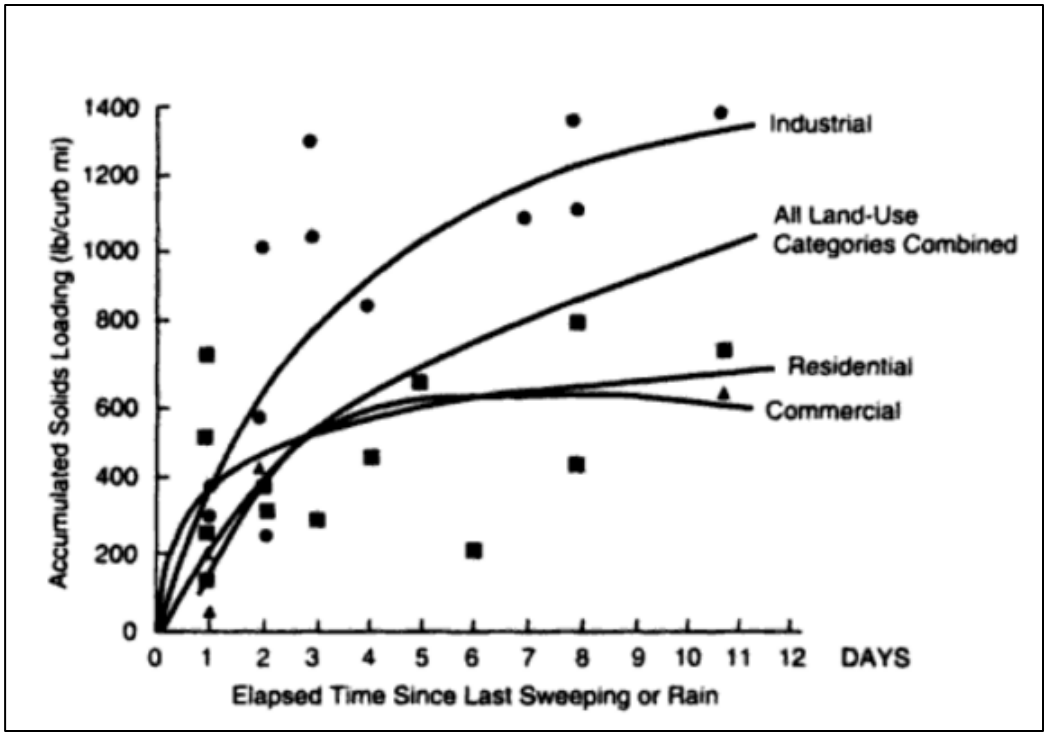


Watershed BMPs

- Watershed BMP deployments reported for urban and ag sources
- Review methodology for nutrient reduction credit estimation
  - CNRP
  - AgNMP
- Present watershed-wide load reductions achieved

Street Sweeping and Debris Removal

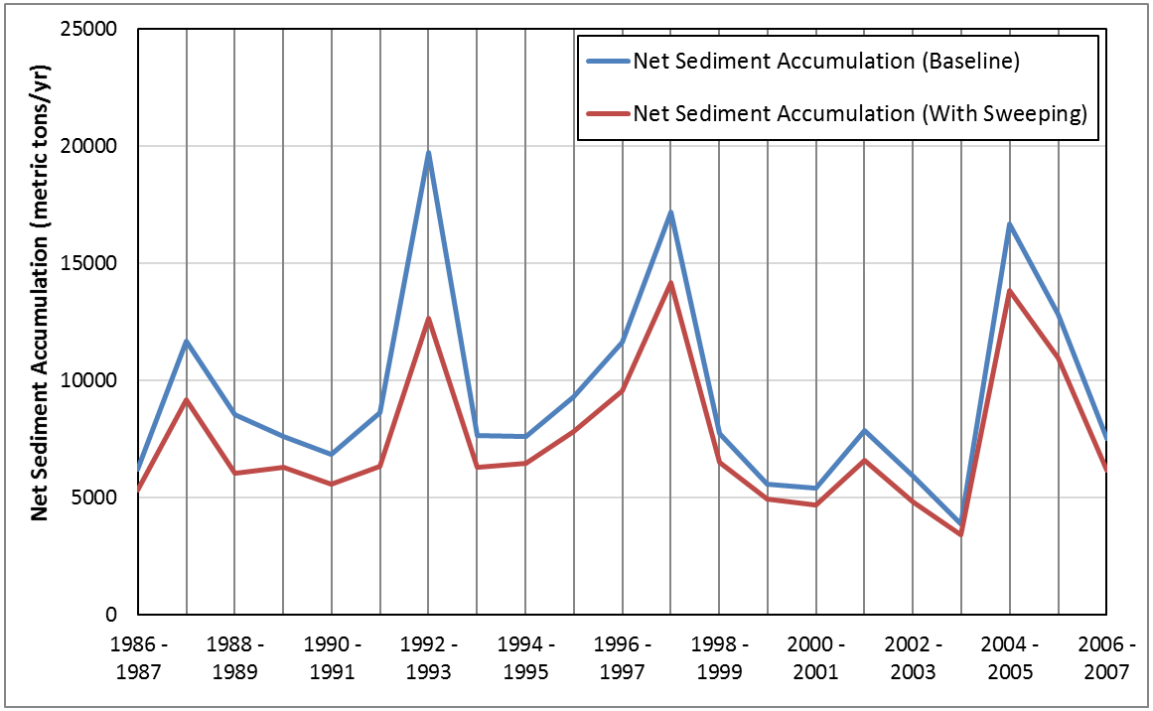
- Exponential buildup/washoff method developed after Sartor and Boyd, 1972
- Historical rainfall data analysis from Lake Elsinore stations for two key inputs:
  - Dry days prior to rains (for buildup model)
  - Depth of runoff (for washoff model)



From Sartor and Boyd, 1972. Water Pollution Aspects of Street Surface Contaminants, EPA R2-72-081.

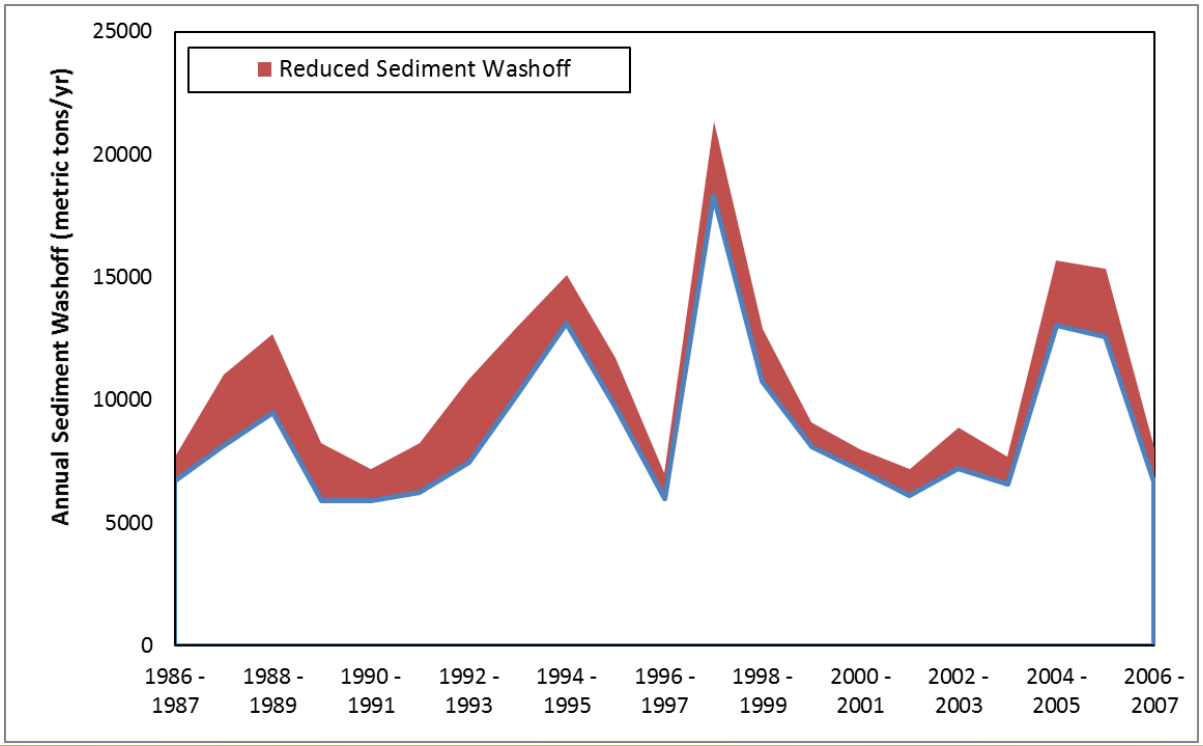
Street Sweeping and Debris Removal

- Buildup model for street sediment
- Exponential buildup as function of dry days - sediment carrying capacity reach after 20 days
- Assumes annual swept material is achieved uniformly over the year for historical hydrology



Street Sweeping and Debris Removal

- Washoff model for street sediment
- Exponential washoff as a function of runoff depth - assume 0.5 inch runoff washes off 90 percent of sediment



Street Sweeping and Debris Removal

- Annual Nutrient Reduction Credits

Sediment Analysis	Baseline	With Sweeping
Street Sweeping (metric tons/yr)	0	5,200
Sediment Washoff (metric tons/yr)	10,789	8,384
Average Annual Reduction in Sediment Washoff (tons/yr)	0	2,406
Average Annual Reduction in Sediment Washoff (%)	0%	46%

Nutrient Reduction Analysis	TP	TN
Concentration in Sediment (kg/metric ton)[1]	0.3	1.1
Reduced Loading (kg/swept ton/yr)	0.15	0.5
Total Reduction (kg/yr)	794	2598

1) Estimated from City of San Diego Targeted Aggressive Street Sweeping Study

Nutrients within Erodible Watershed Soil, Sediment

- Street surface sediment
- Debris in drainage systems
- Agricultural field soils
- Natural hillside soils

Source	Urban		Agriculture		Natural	
	TP (mg/g)	TN (mg/g)	TP (mg/g)	TN (mg/g)	TP (mg/g)	TN (mg/g)
LE/CL TMDL revision [1]	0.3	1.1	0.5 – 1.2	0.9 – 1.6	Under investigation	
Range of reference values [2,3]	0.2 - 1.0	0.5 - 2.0	0.4 – 1.1	1.0		

1) Data for urban street sediment presented in CNRP compliance analysis. Data for agricultural lands presented in Klang, 2017.
2) Reference values for urban street sediment ranges from Sartor and Boyd, 1972; Walch, 2006, Baker et. Al., 2014; San Diego, 2011; Sansalone et. Al., 2011.
3) Agriculture values from F. Fang et. al., 2002; Knisel, 1979.

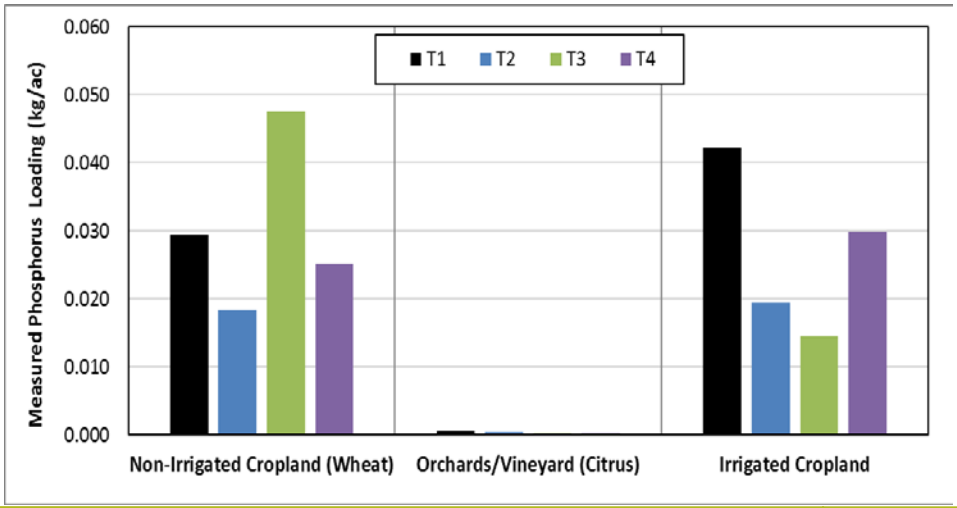
Cropping Practices to Reduce Erosion

- AgNMP based reductions on experiments by UC Riverside

Treatment Matrix	Non-irrigated Cropland	Orchards / Vineyards	Irrigated Cropland
T1	Control	Control	Control
T2	Incorporated manure	Cover Crop	Incorporated manure
T3	Spread manure	PAM	PAM
T4	Vegetated buffers	Mulch	Vegetated buffers

- Compliance analysis

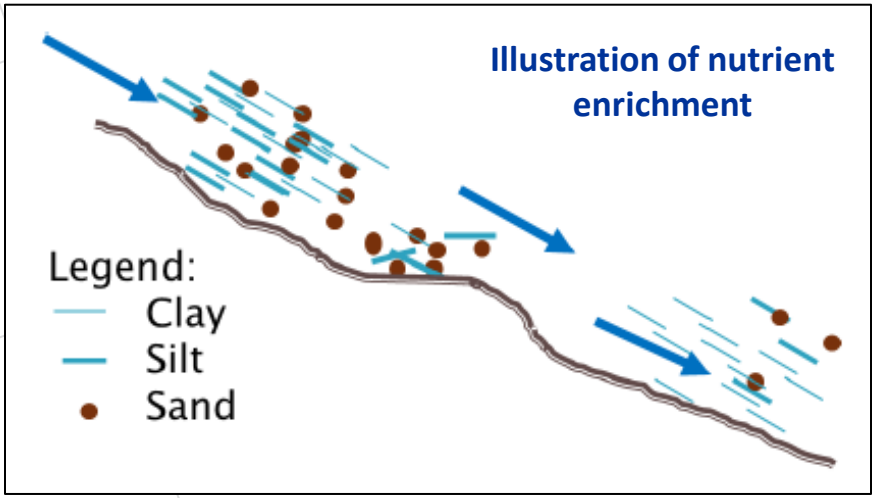
Land Use	Reduced TP (kg/yr)	Reduced TN (kg/yr)
Irrigated Cropland	174	55
Non-irrigated Cropland	89	202
Orchards / Vineyards	3	3



Cropping Practices to Reduce Erosion

- New soil health study by WRCAC
  - Will improve load reduction estimates from agricultural land BMPs
- Samples analyzed for N and P

From Rolfes, T. 2017. NRCS Work on Soil Health Presented at the NRCS and CDFA Summit: Building Partnerships on Healthy Soil. January 11, 2017

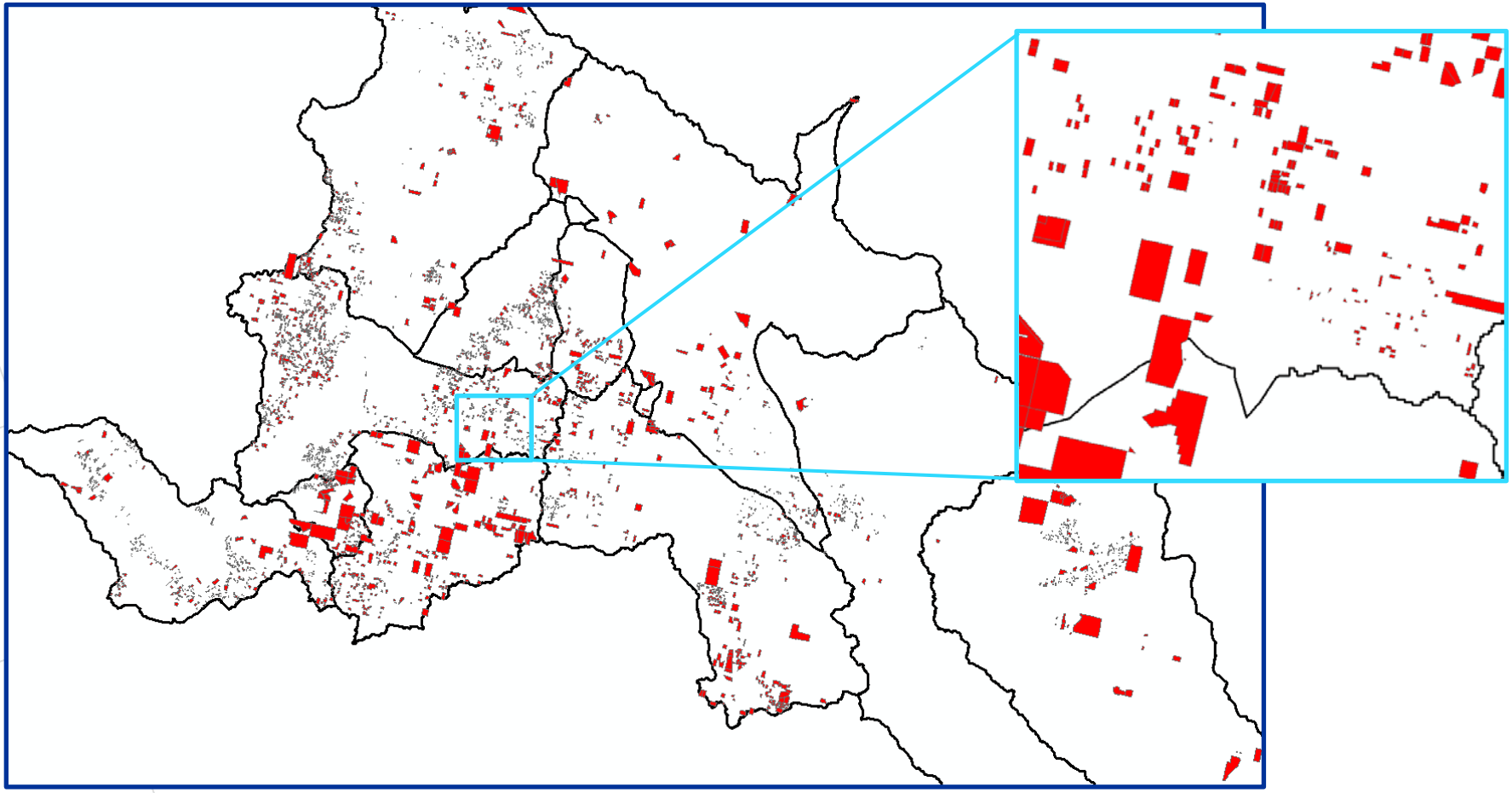


- Scope expanded to develop expert estimates of edge of field erosion

from Klang, 2017. Agricultural Phosphorus and Nitrogen Non-point Source Loading Estimates, Technical Memorandum, Feb 22, 2017.

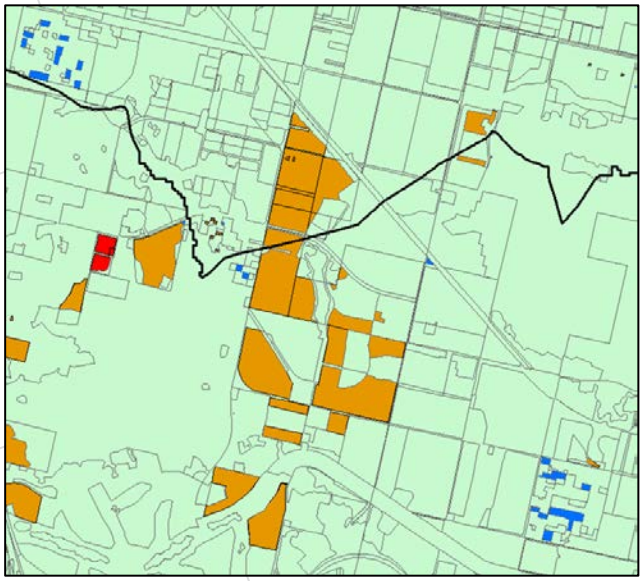
Septic System Management

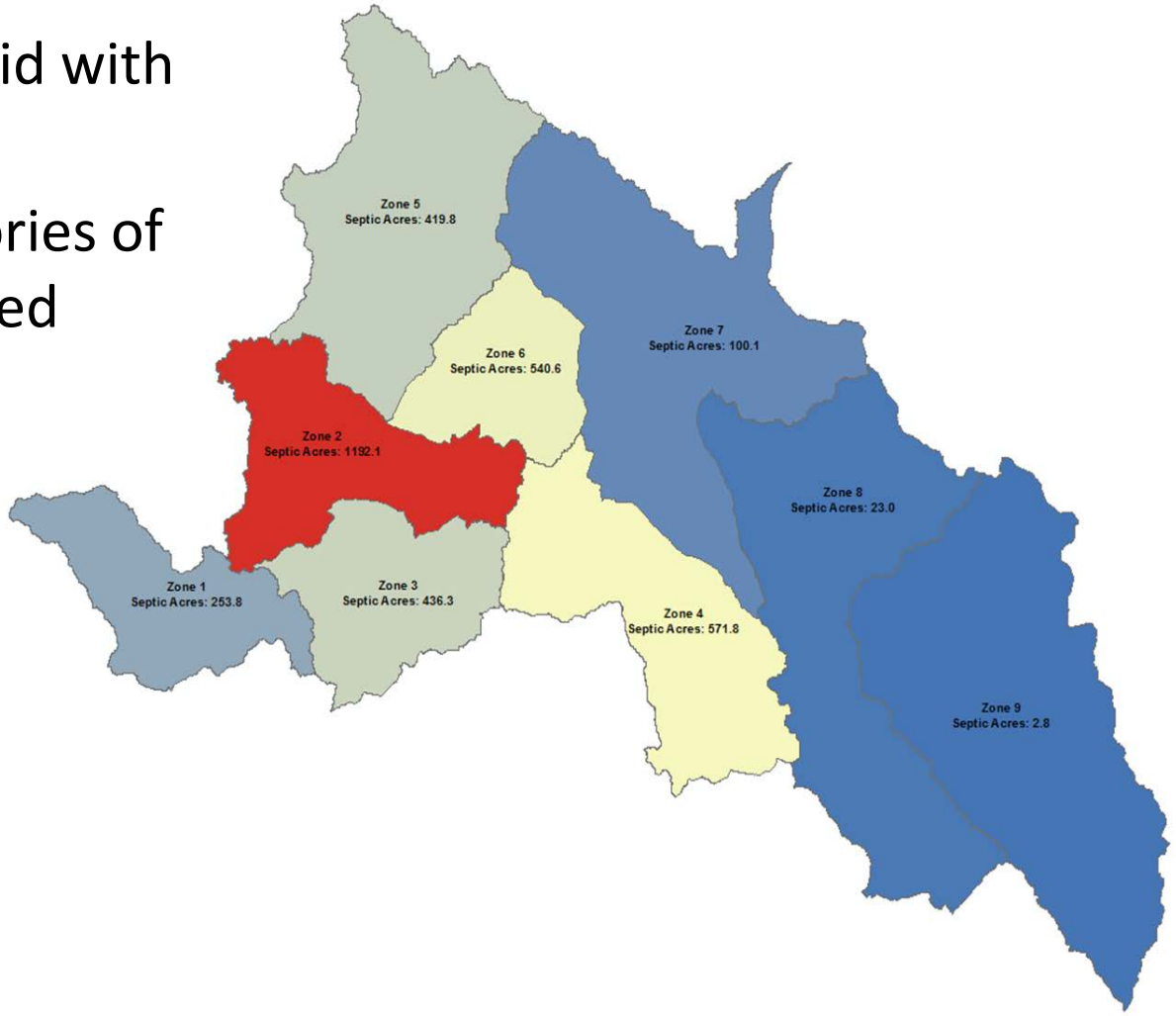
- Septic parcel areas from Riverside County



Septic System Management

- Septic parcels overlaid with residential land use
- New land use categories of sewered or unsewered residential





Septic System Management

- Incremental difference in sewered and unswered EMCs is attributed to septic source

Septic system elimination	TP	TN
EMCs for Unsewered Residential	0.59	5.30
EMCs for Sewered Residential	0.48	2.93
DeltaEMC (Sewered - unsewered)	0.11	2.37

Runoff (in/yr)	1.00	1.00
Load Reduction (kg/ac/yr)	0.01	0.24

Watershed loading model

Septic System Management

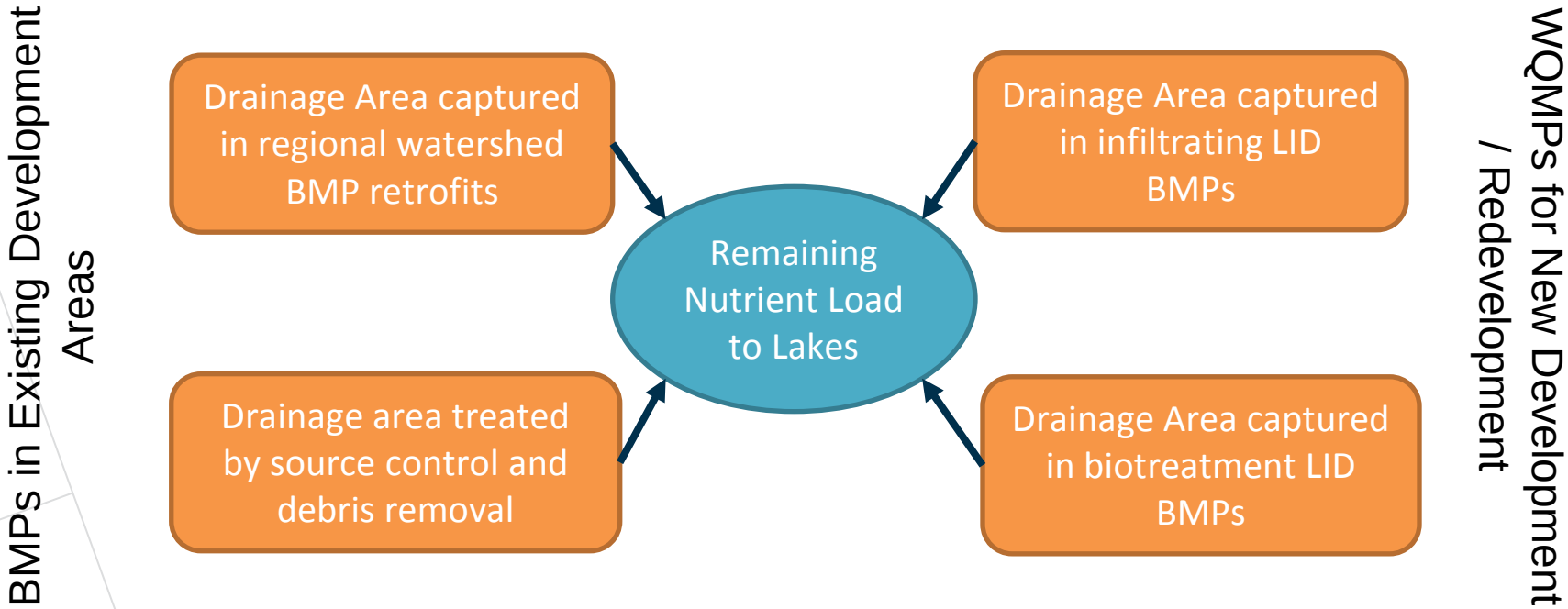
- Septic parcels overlaid with residential land use to develop land use categories of sewered or unsewered

Zone	Septic Acres	Sewer Acres	% Septic	TP (kg/yr)	TN (kg/yr)
1	254	6,652	3.7%	2.9	61.8
2	1,192	9,009	11.7%	13.5	290.1
3	436	9,536	4.4%	4.9	106.1
4	572	7,914	6.7%	6.5	139.2
5	420	16,407	2.5%	4.7	102.2
6	541	2,456	18.0%	6.1	131.6
7	100	7,757	1.3%	1.1	24.3
8	23	2,370	1.0%	0.3	5.6
9	3	15	16.1%	0.0	0.7
10	322	3,609	8.2%	3.6	78.4
Total	3,863	65,726	5.6%	43.7	940.0

- 2004 TMDL Septic Load Estimate
  - 518 kg/yr TP
  - 7,071 kg/yr TN
- Based on concentrations in sewage and assumed failure rates

Structural BMPs

- 2010 MS4 Permit requires project-specific WQMP
- Prioritize BMPs that maximize onsite retention
- Other stormwater retrofits can reduce nutrient loads



Structural BMPs

Jurisdiction	Infiltration / Bioretention	Extended Detention / Bioretention with Underdrains	Separators	Vegetated Swale	Media Filter
	Effectiveness (% TP Removal for TP, TN) approximated from International BMP Database				
	100, 100	75, 24	33, 13	47, 0	69, 0
	Drainage Area to BMP Treatment (acres)				
Caltrans		46		47	
Hemet	73	44		17	
Lake Elsinore	24	1,142	35	40	100
March ARB	496		1,001	1	
March JPA	45	34		6	
Menifee	39	730	65	290	30
Moreno Valley	264	1,248	208	109	389
Murrieta	14	236			
Perris	614	773	819	114	18
Riverside		511			
Riverside County		25			
Subtotal (below Mystic Lake)	1,569	4,789	2,128	624	537

Structural BMPs

- Estimated nutrient reduction achieved in structural BMPs implemented since 2005

BMP Type	To Canyon Lake	To Lake Elsinore
Infiltration/Bioretention w/o Underdrain	1,545	24
Extended Detention	3,647	1142
Hydrodynamic Separator	2,093	35
Vegetated Swale	584	40
Media/Sand Filter	437	100
TP Reduction (kg/yr)	222	39
TN Reduction (kg/yr)	948	107

Structural BMPs

- Baseline estimated nutrient loads averaged for urbanized land use types
  - TP: 0.05 kg/ac/yr; TN: 0.44 kg/ac/yr
- Estimate of deployment levels that would meet WLA without other source control or in-lake controls

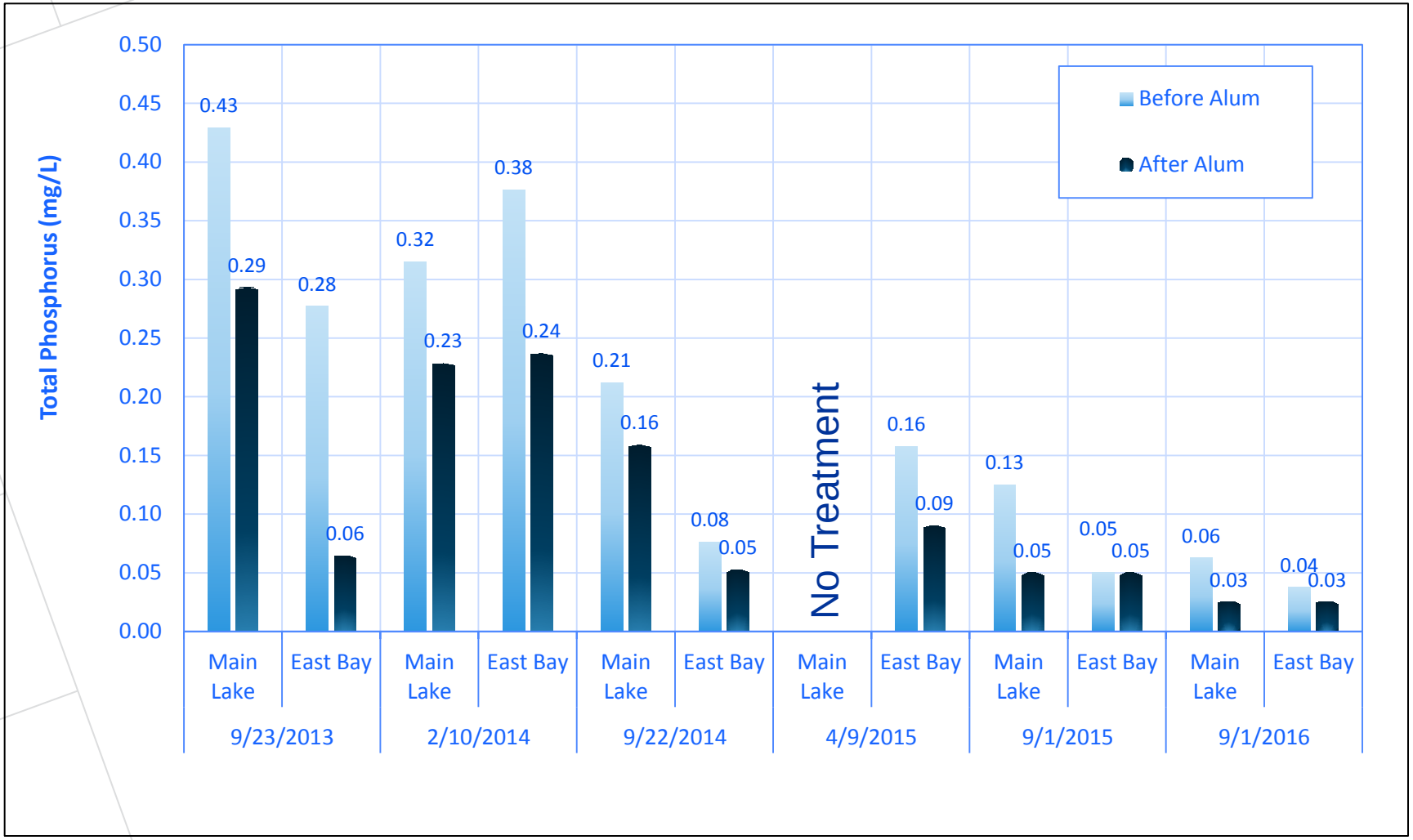
BMP Type	TP Load Reduction (kg/ac/yr)	TN Load Reduction (kg/ac/yr)	Drainage Area Treated to achieve LE/CL WLAs for MS4s	
			TP	TN
Infiltration / Bioretention	0.04	0.35	71,744	8,083
Extended Detention / Bioretention with drains	0.03	0.09	95,659	33,678
Hydrodynamic Separator	0.01	0.05	217,407	62,175
Vegetated Swale	0.02	0.00	152,648	n/a
Media Filter	0.03	0.00	103,977	n/a

In-Lake Nutrient Management

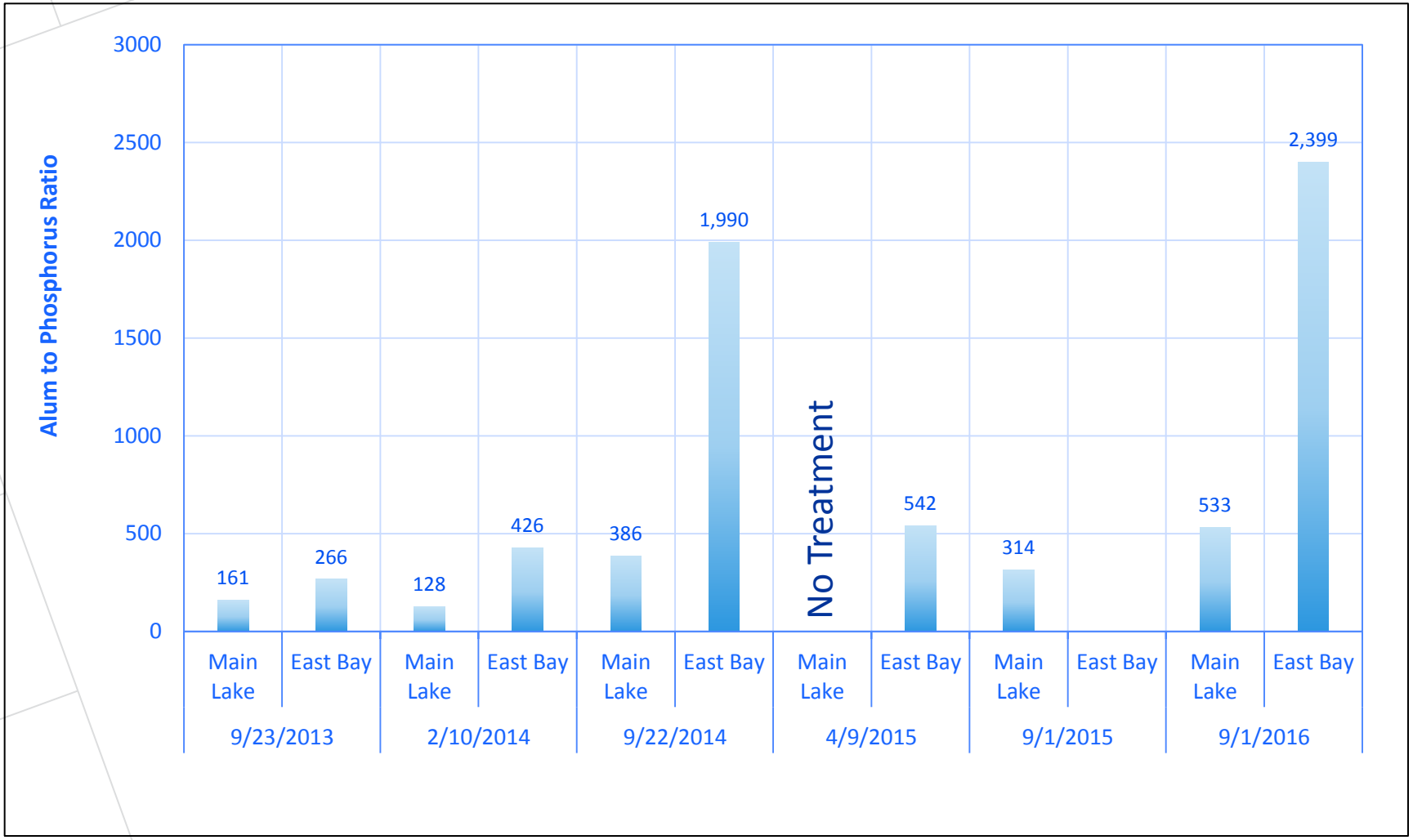
Alum Effectiveness Monitoring

- Monitor water column phosphorus before/after additions
- Efficiency estimated from ratio of alum applied to water column P removed
- Lower Alum:P ratio means treatment more effective for water column stripping
- Six alum treatments evaluated:
  - 9/23/2013
  - 2/10/2014
  - 9/22/2014
  - 4/9/2015
  - 9/2015
  - 9/2016

Phosphorus Reduction

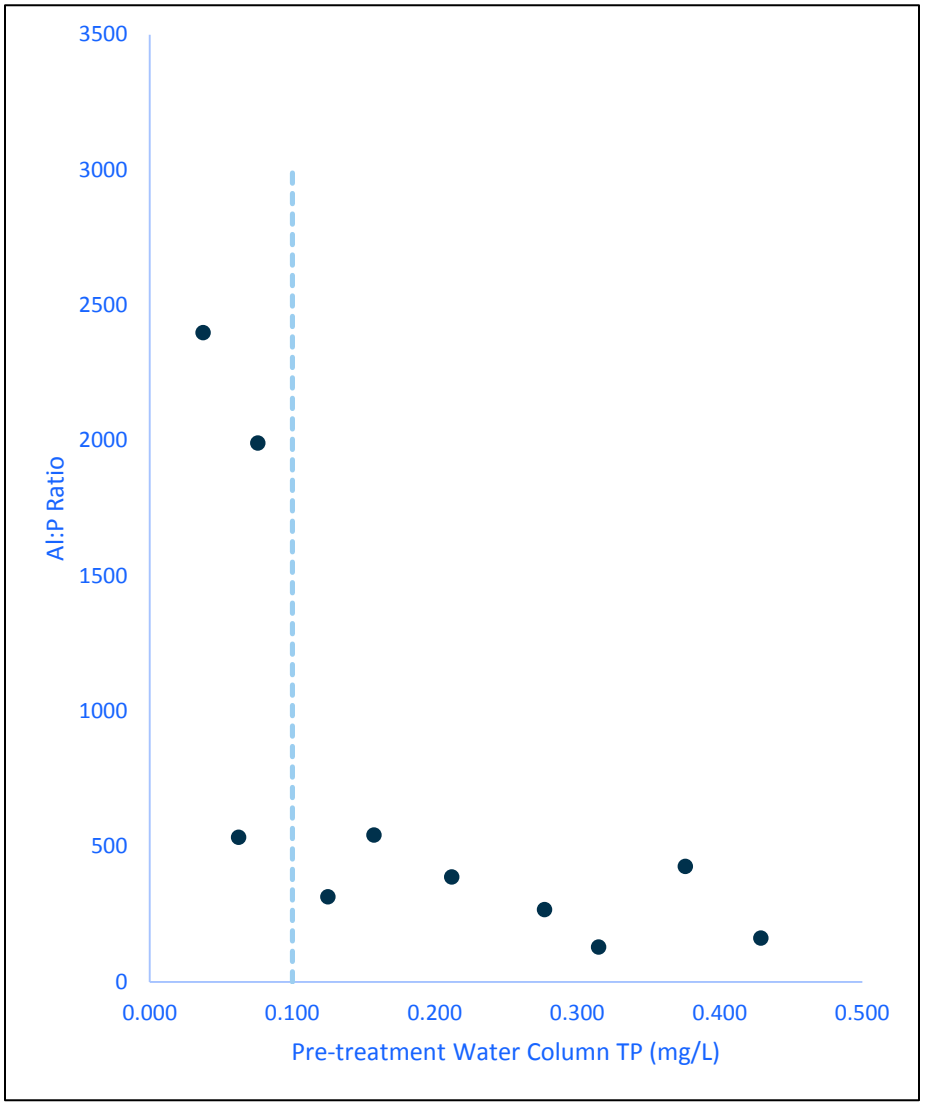


Alum to Phosphorus Ratio



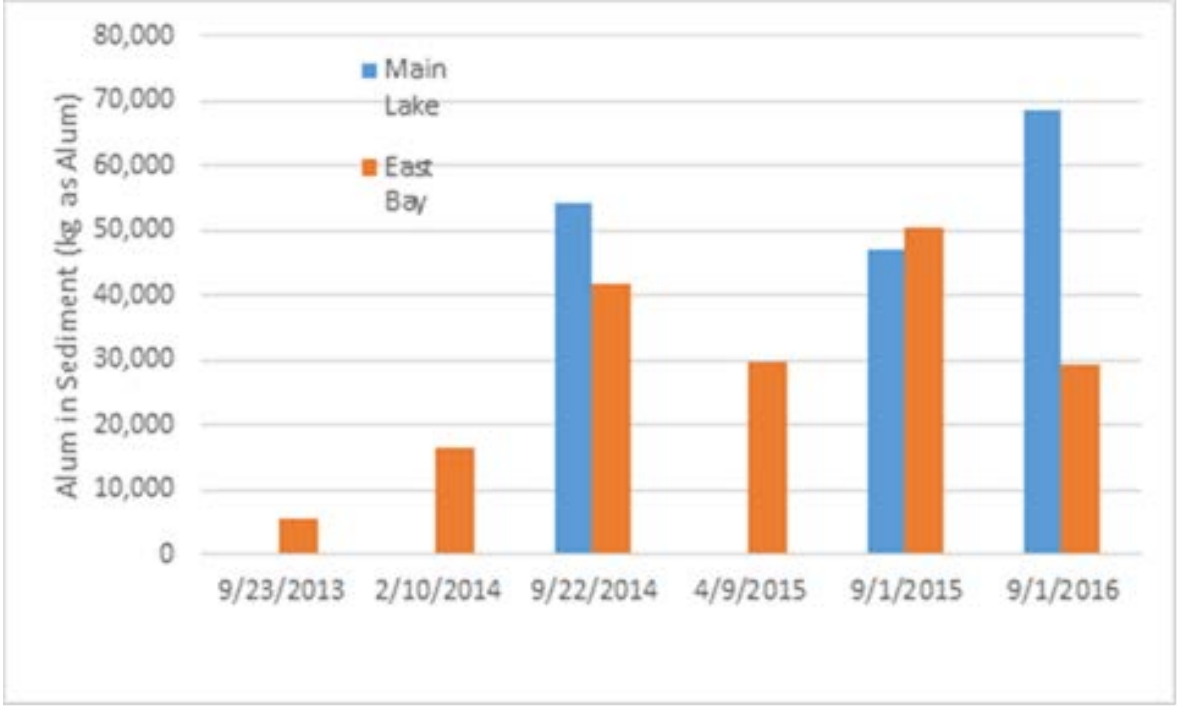
Alum to Phosphorus Ratio

- Al:P ratio from water column measurements is variable
- Al:P ratio typically high for pre-treatment TP < 0.1 mg/L
- Increasing water column stripping efficacy at high pre-alum TP concentrations



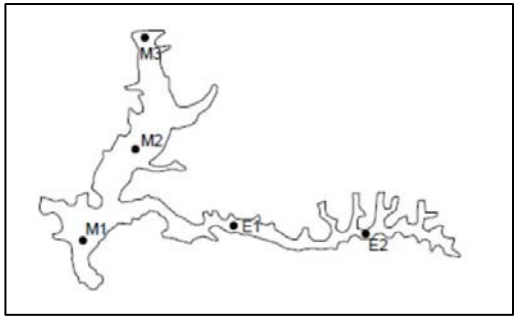
Unused Alum: Where does it go?

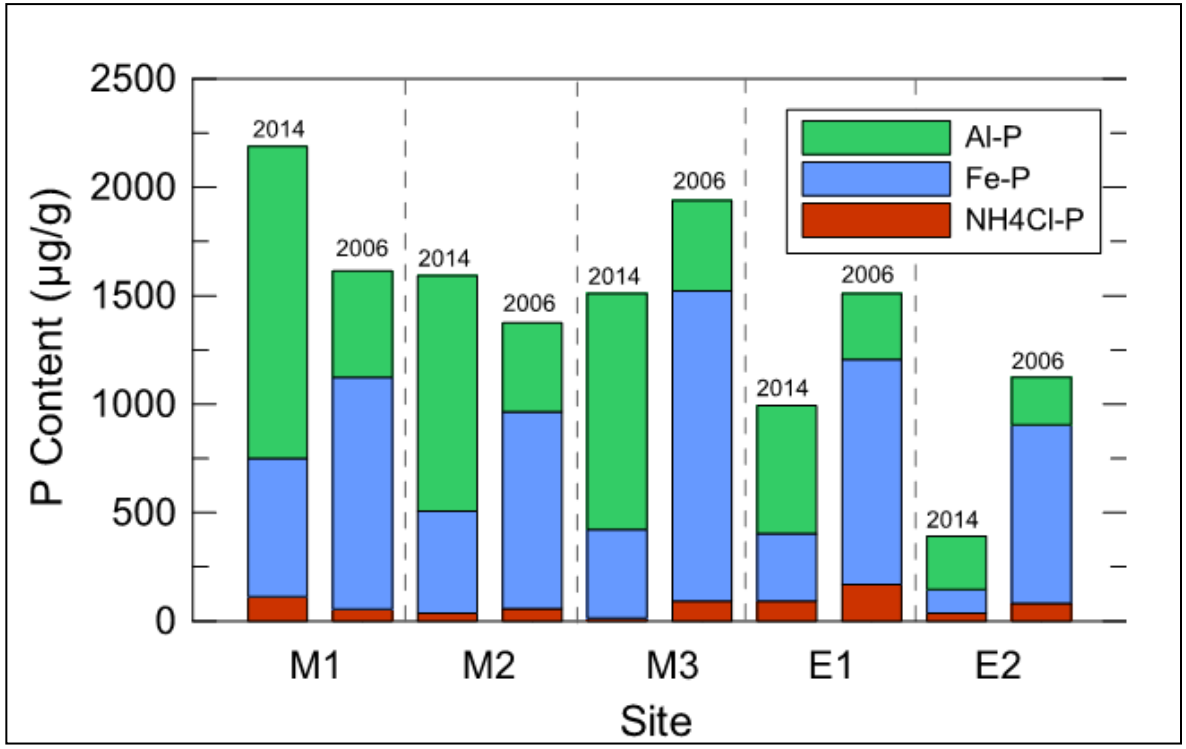
- Reduce pH forming aluminate precipitate (gibbsite)
- Settles to bottom as aluminum hydroxide and serves to permanently bind mobile P in sediments



Evidence of Aluminum in Sediments

- Iron-bound P levels reduced since 2006
- Aluminum-bound P levels increased since 2006
- Suggests alum applications are having an effect on sediment P

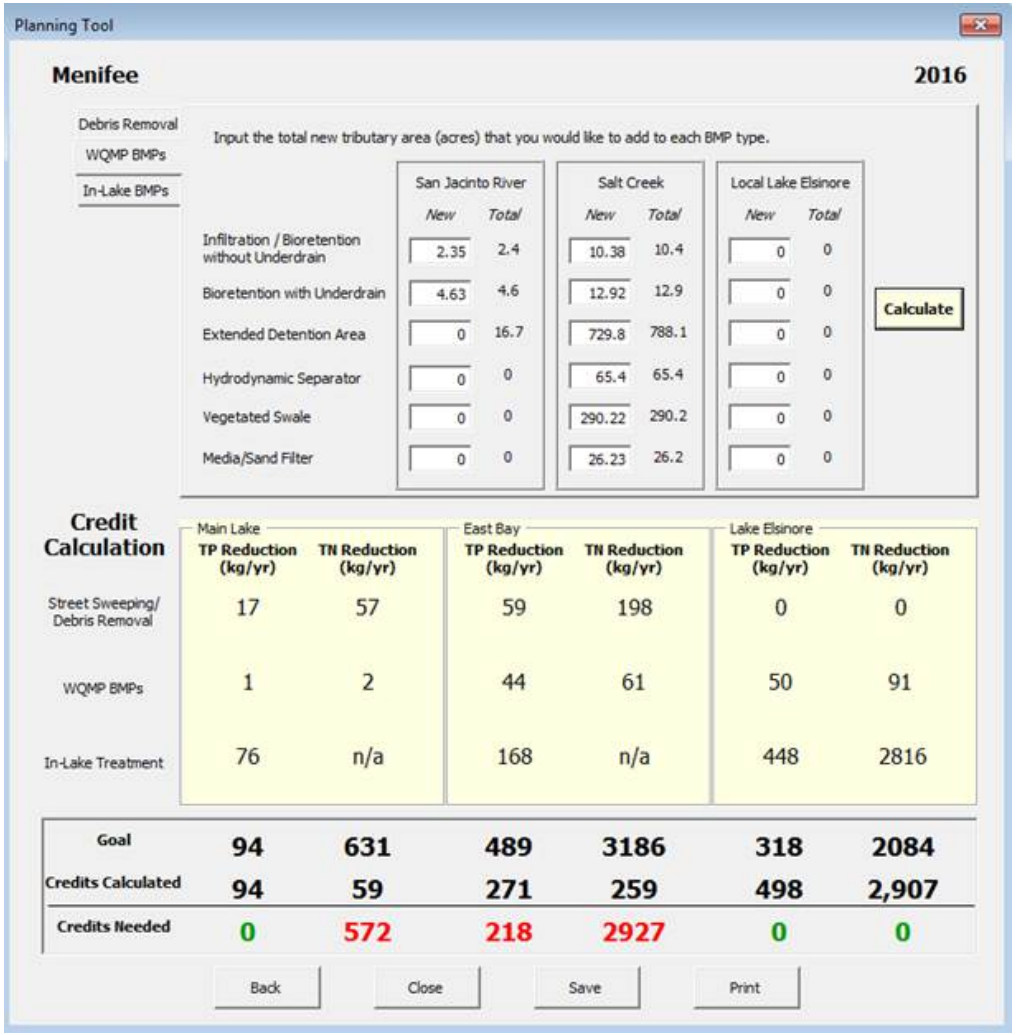




Source: Anderson (2016), Technical Memorandum, Task 2.4: Mobile-P and Internal Phosphorus Recycling Rates in Canyon Lake

Development of Load Reduction Credit Tracking Tool

- Data input by agencies through straightforward GUI
- Developed for MS4 program
- Could be expanded for other stakeholders
- SAWPA to manage



Overview of Linkage Analysis

Linkage Analysis Nexus

- Allocations → Linkage Analysis → Numeric Targets
- Chapter is drafted, awaiting final calibration outputs for Canyon Lake