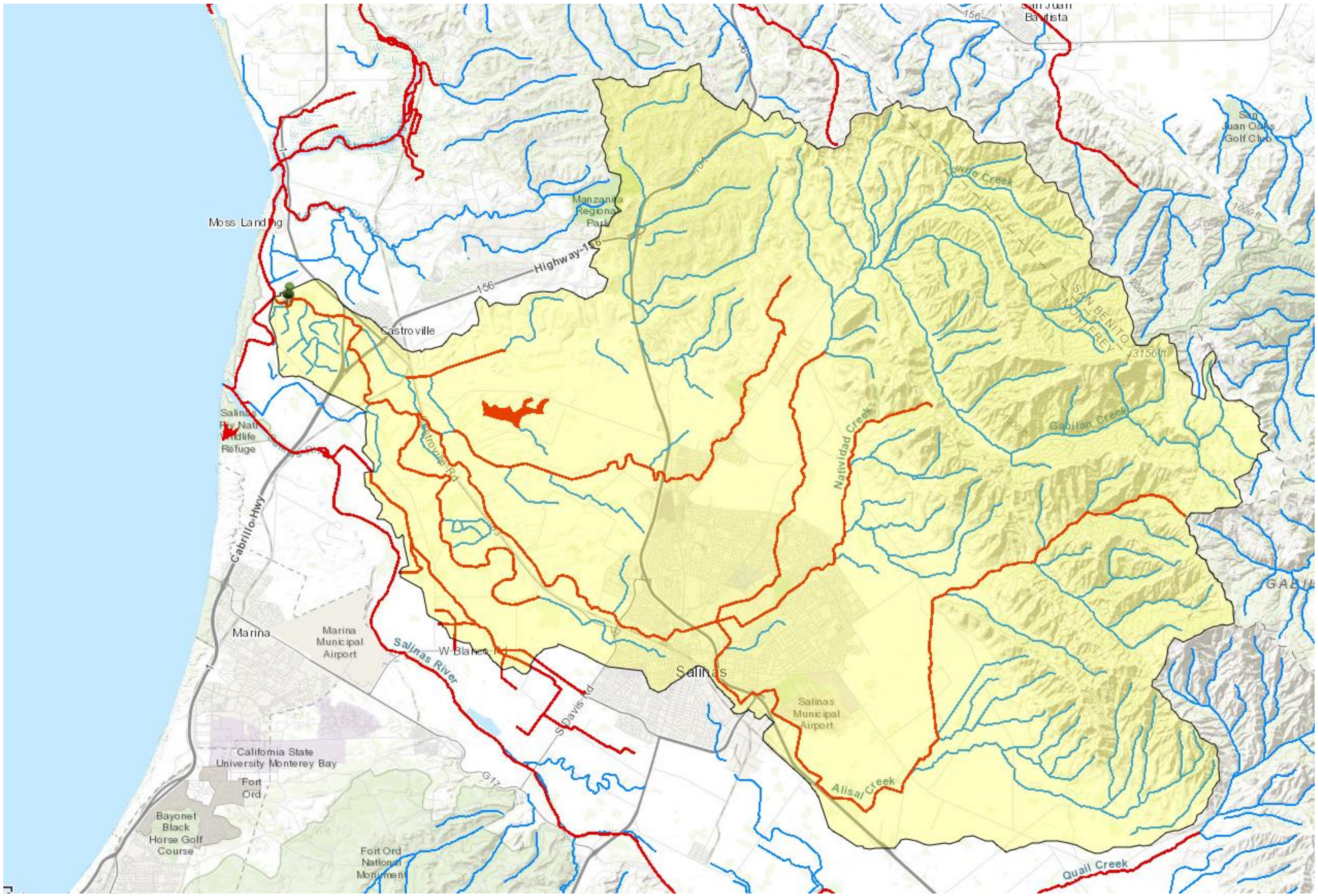
Solving Water Issues in the Lower Salinas Valley

Central Coast Wetlands Group

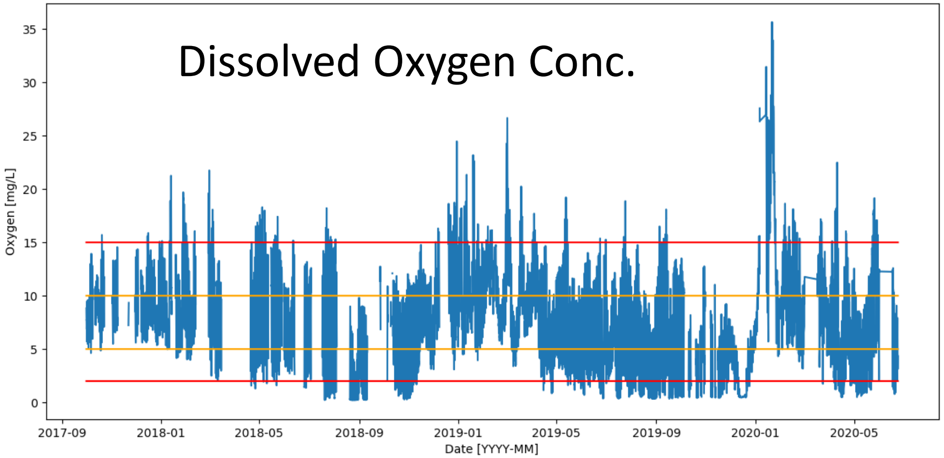
Coordinate the advancement of wetland science and management on the central coast

CENTRAL COAST WETLANDS GROUP

Nitrate Impaired Drainages

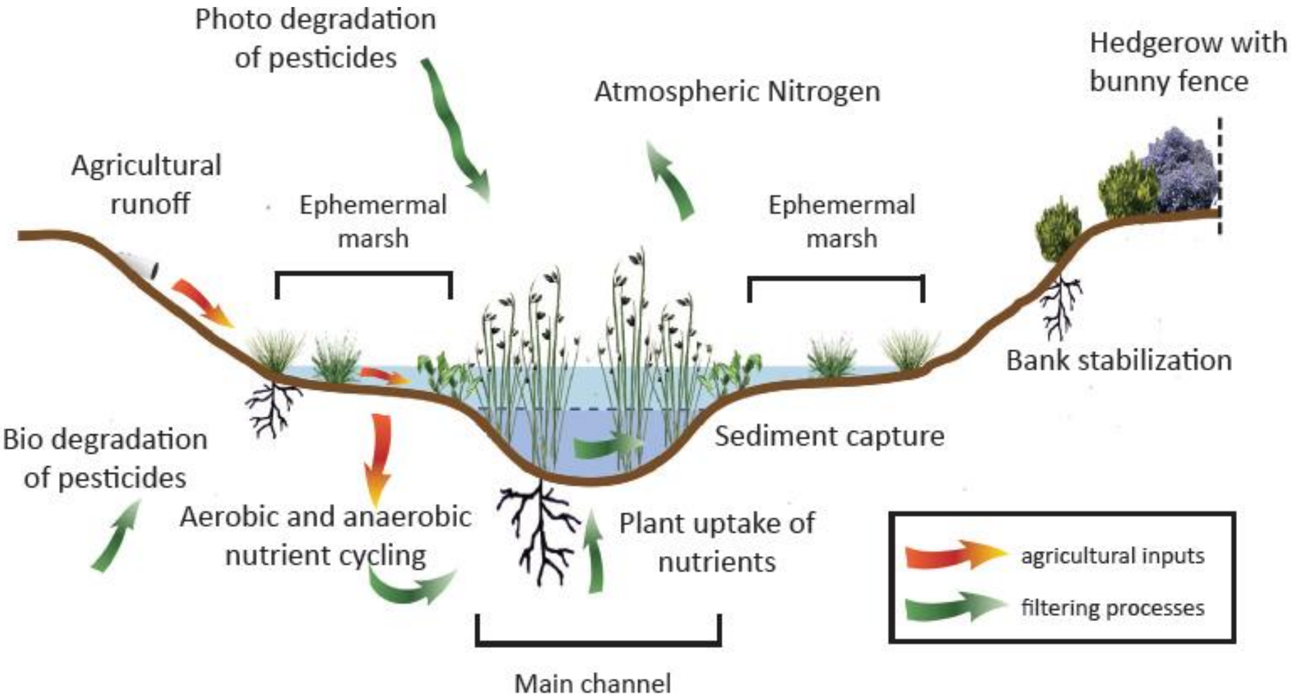


Nutrient Enrichment Impacts



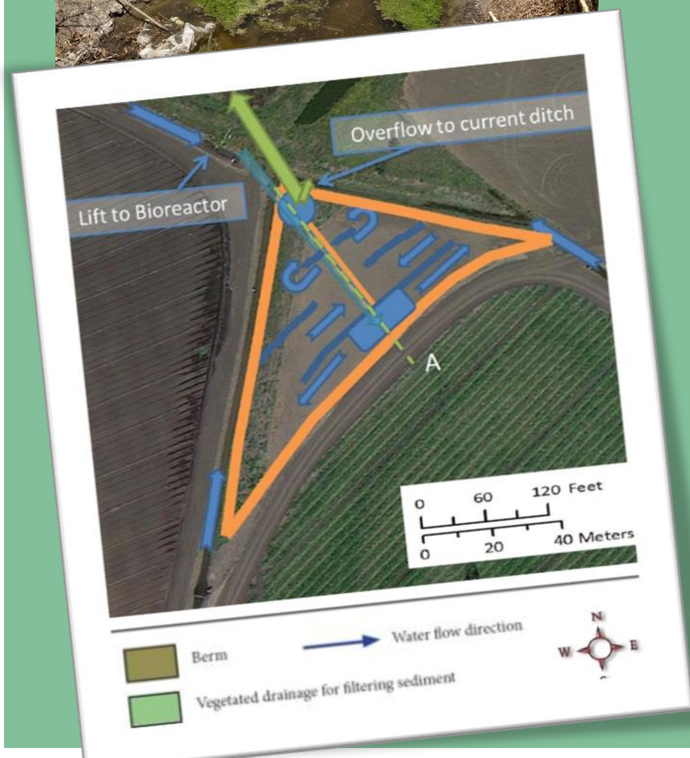
Wetland Restoration in Working Landscapes

Aerial view of Blanco Drain Treatment Wetland



The physical, chemical, and biolgical processes that occur in wetlands help filter out pollutants

OceanMist Pre-treatment Bioreactor

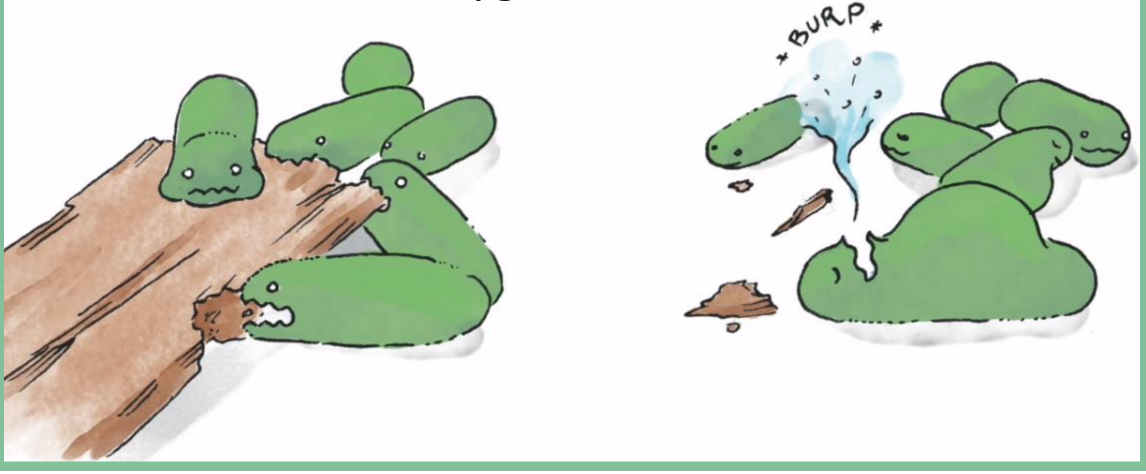


Denitrification Process

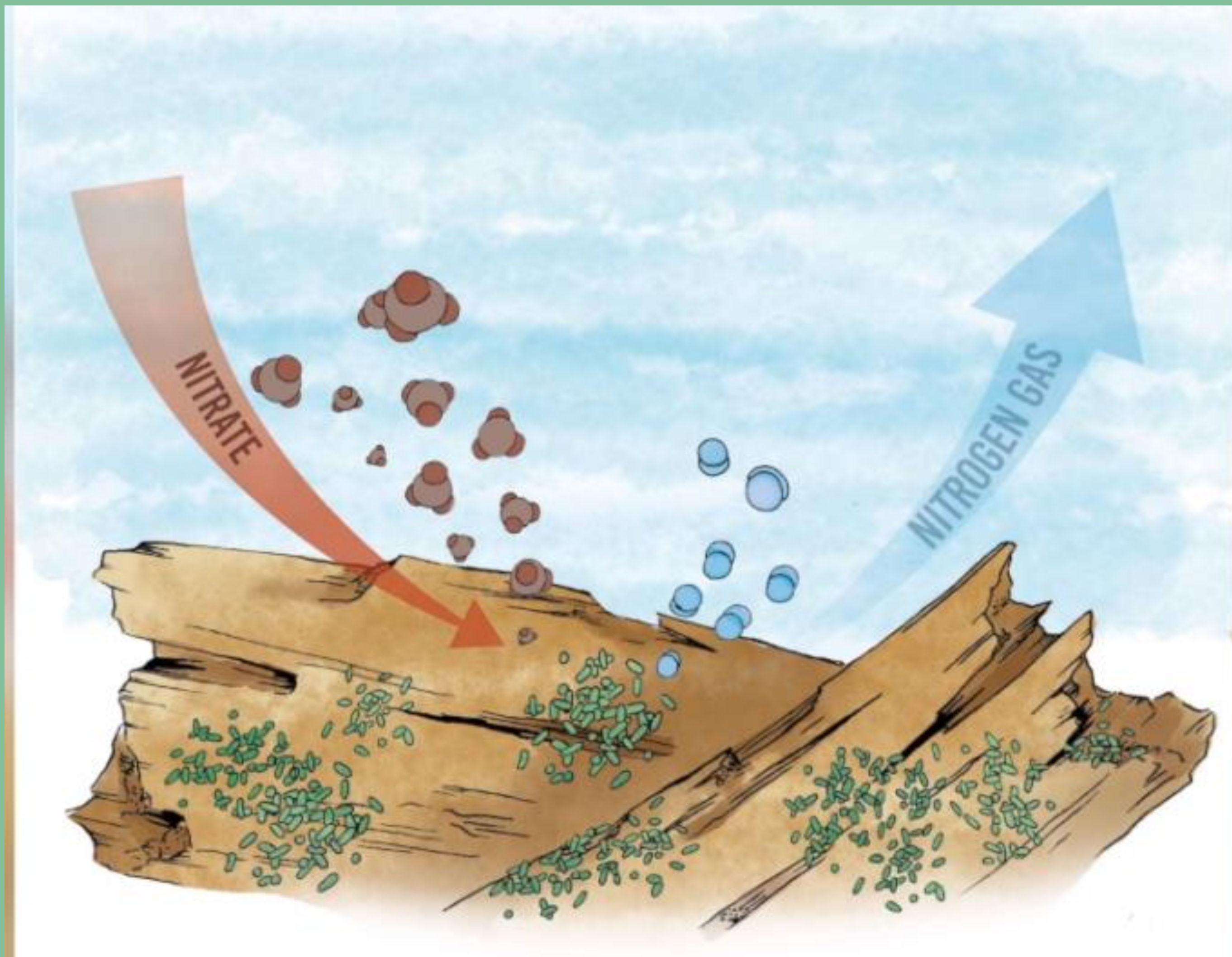
$6NO_3^- + 5CH_3OH = 3N_2 + 5CO_2 + 7H_2O + 6OH'$ A

carbon source (CH_3OH) is required for denitrification to occur.

Low Oxygen Environment



Bioreactors and Wetland Sediments



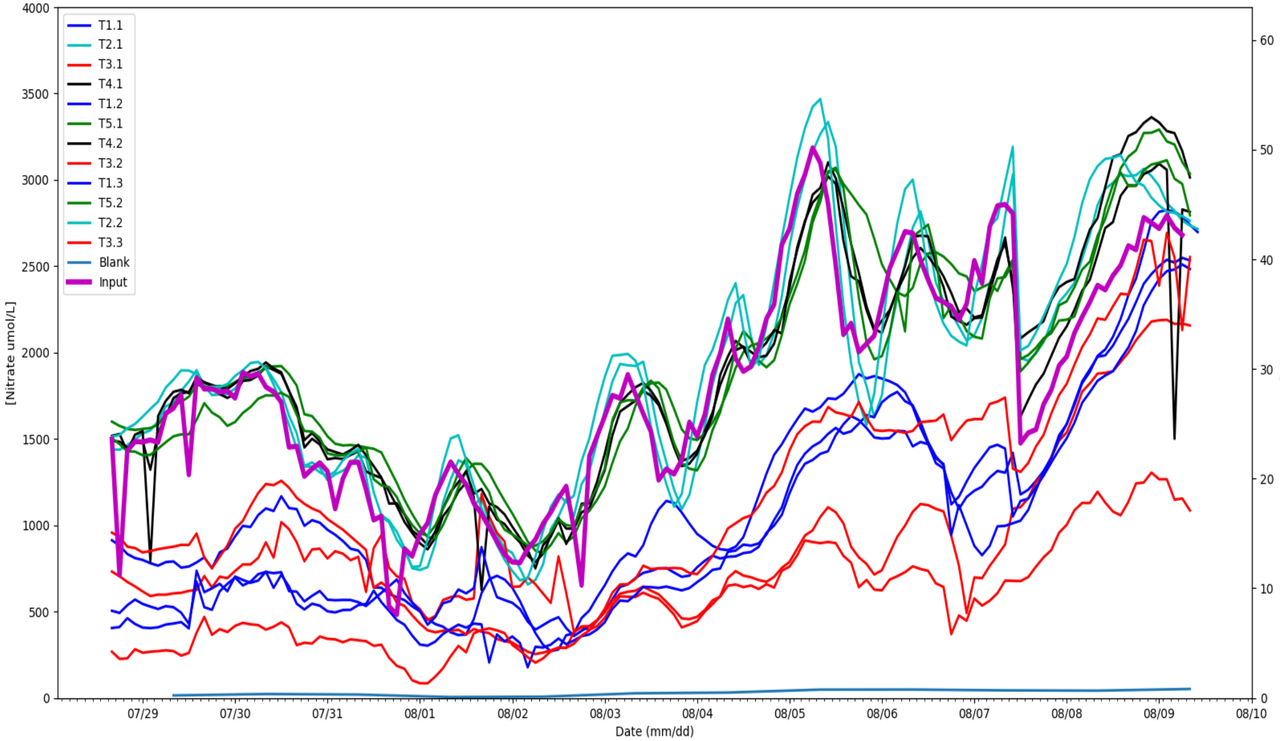
Three dimensional carbon matrix that maximizes water /bacterial interface

Research Question: How do various nutrient reduction techniques work under comparable conditions?

NITRATE REDUCTIONS FROM VARIOUS TREATMENTS

Nitrate Removal Calculation = $f(\tau)\text{: } C_{out,p} = C_{in,p} - k_{v0}\tau$

(For Standard Residence Time)



Residence Time Within Flow Through Treatments

Parameters (HRT)

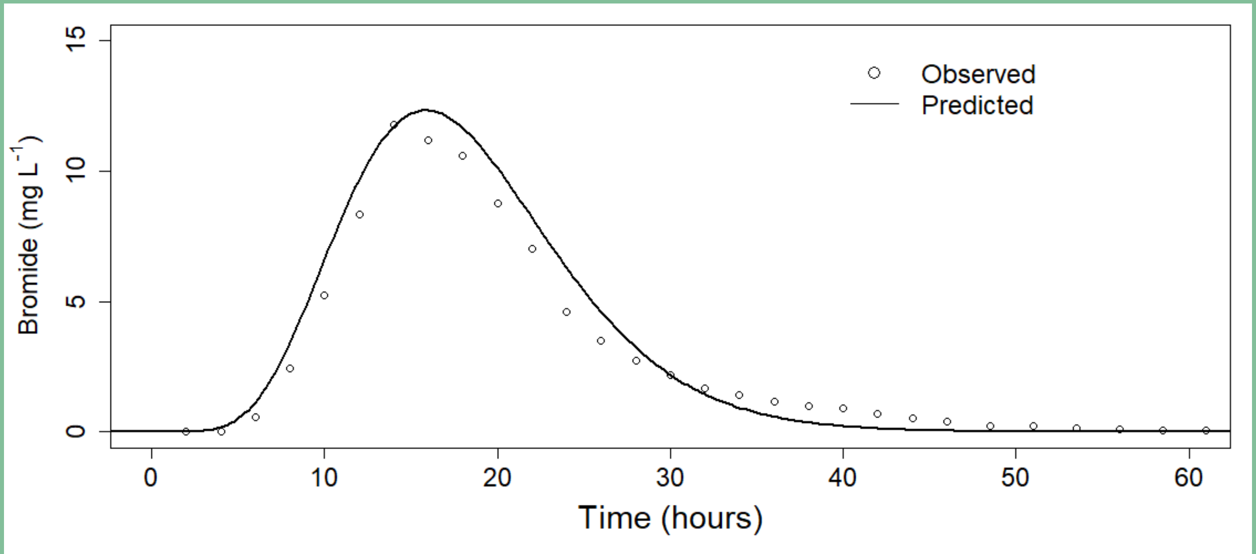
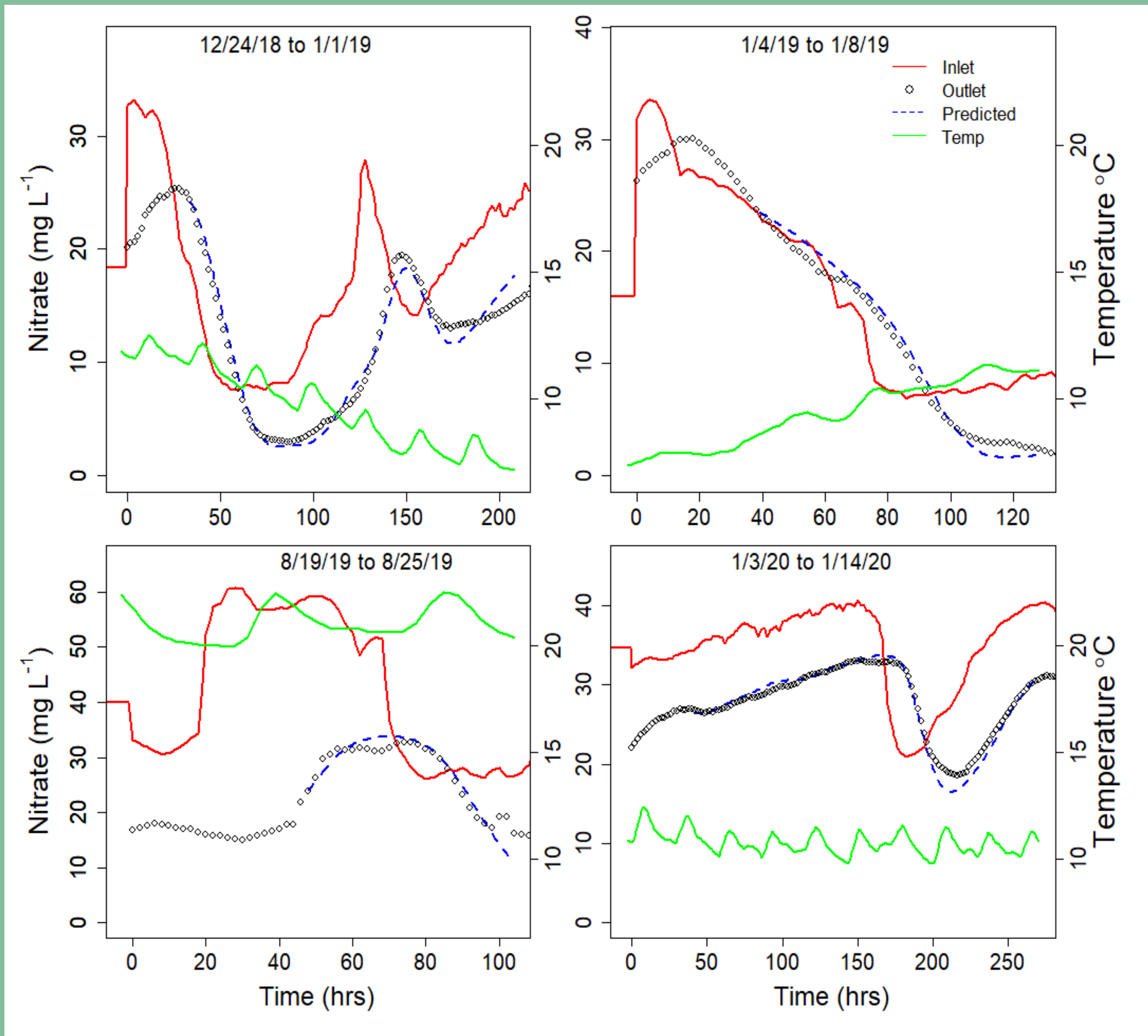
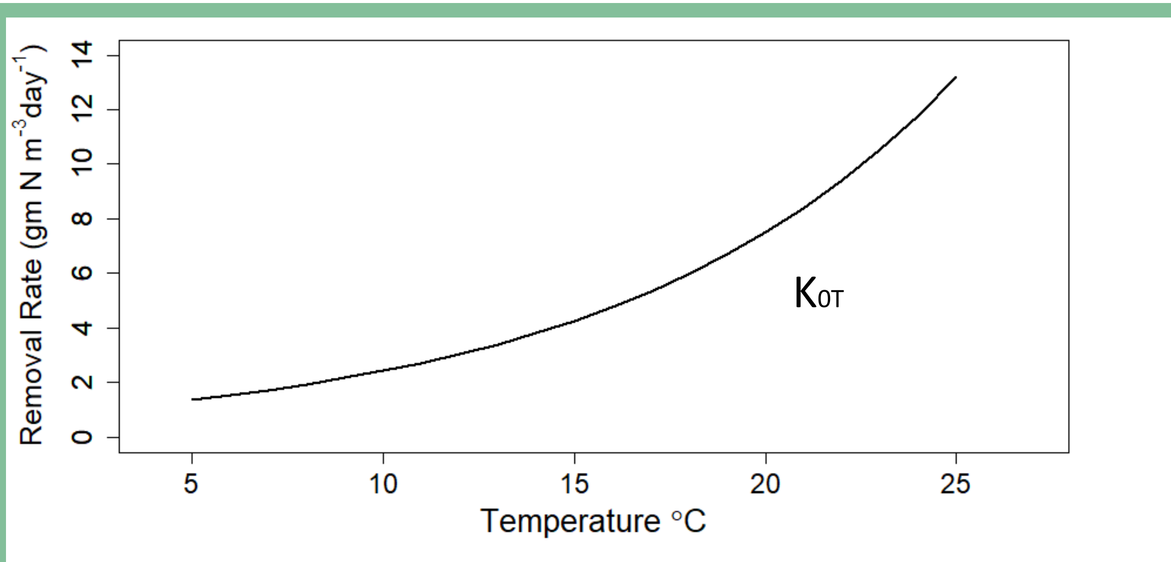


Figure 1: Bromide was added to the bioreactor Channel 1 at the inlet at Time = 0 . Using a Tanks-in-Series model depicted by a gamma function, we calculated the hydraulic residence time distribution based on model parameters of residence time (τ) and number of tanks in series (N).

Temperature and initial concentration



Reaction Rate K_0



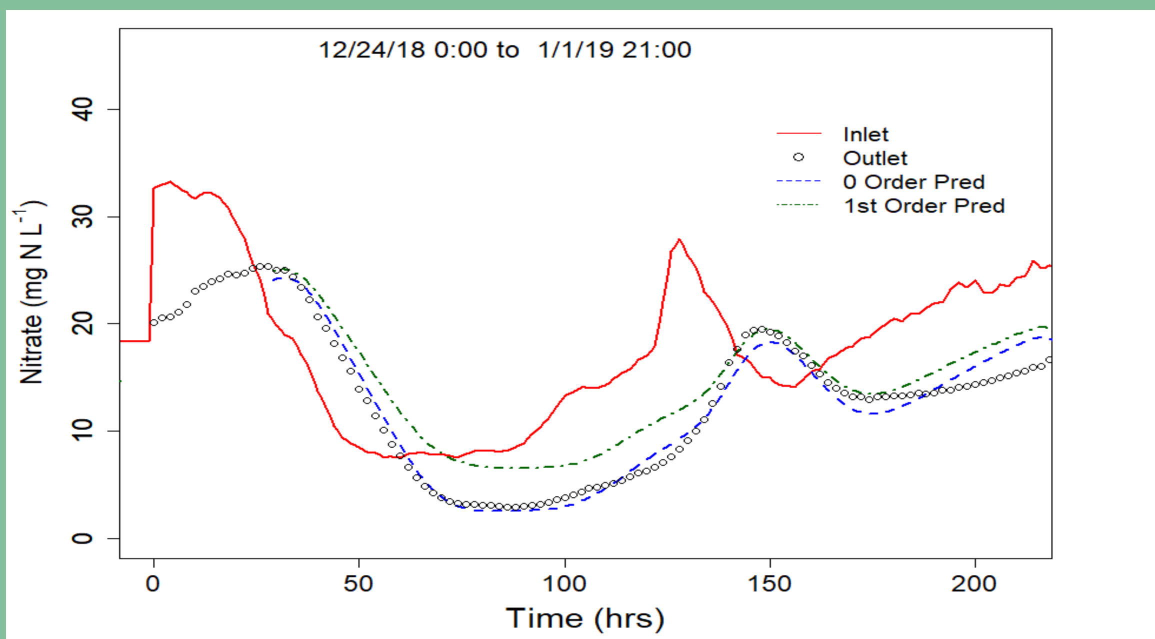
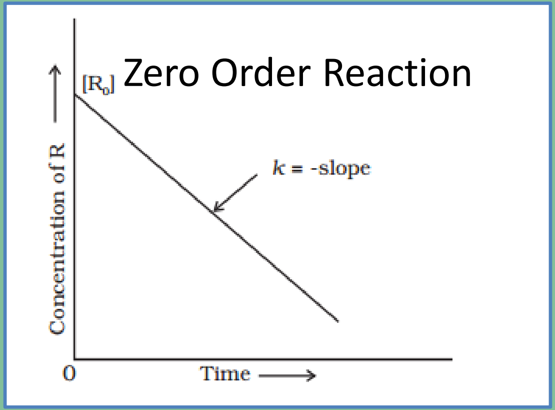


Figure 4. The zero-order prediction fit the observed data better than did the first-order model even in the sampling period with the lowest nitrate inputs.

Decay rate

Our comparison of first-order and zero-order model responses found that zero-order decay best describes nitrate removal in the WBR over the range of concentrations and temperatures evaluated.

(k_0=7.5 mg N m^3 day^{-1}) @ 20°C



Krone et al 2020 (in prep)

Sizing new Systems?

How big does our wetland or bioreactor need to be?

SIZING NEW SYSTEMS

Central Coast Wetlands Group

In Affiliation with Moss Landing Marine Labs

Bioreactor Sizing

that can be used to help farmers implement water quality treatment systems to specifically fit
able to sufficiently reduce environmental contamination from agricultural runoff and improve

To Estimate % Reduction Enter the Following:

Enter temperature in Fahrenheit (°F): 65

Enter input concentration (mg/L): 25

Enter Retention Time (hours): 24

Calculate

Predicted % Reduction is: 63.22%

Output Concentration is 9.20

SIZING NEW SYSTEMS

Central Coast Wetlands Group

In Affiliation with Moss Landing Marine Labs

e Bioreactor Sizing

hat can be used to help farmers implement water quality treatment systems to specifically fit their lar
able to sufficiently reduce environmental contamination from agricultural runoff and improve wildlife

Bioreactor Sizing Calculator

Enter Desired Hydraulic Residence Time (hours): 24

Enter Pump Discharge Rate (gpm): 50

Enter Pump Runtime (hours per day): 18

Enter Channel Width (feet): 8

Enter Channel Depth (feet): 3

Calculate

Estimated Bioreactor Length: 599 feet

Use of Treatment Wetlands

Castroville Treatment Wetland

Figure 5. Map of Castroville treatment wetland in relation to watershed flows and adjacent habitat restoration areas. Blue arrows depict flow pathway and yellow dots represent location of a portion of water quality sample sites. The multi-chamber bioreactor research area is located directly upstream of sample location 1.

Restored Wetland nutrient reductions

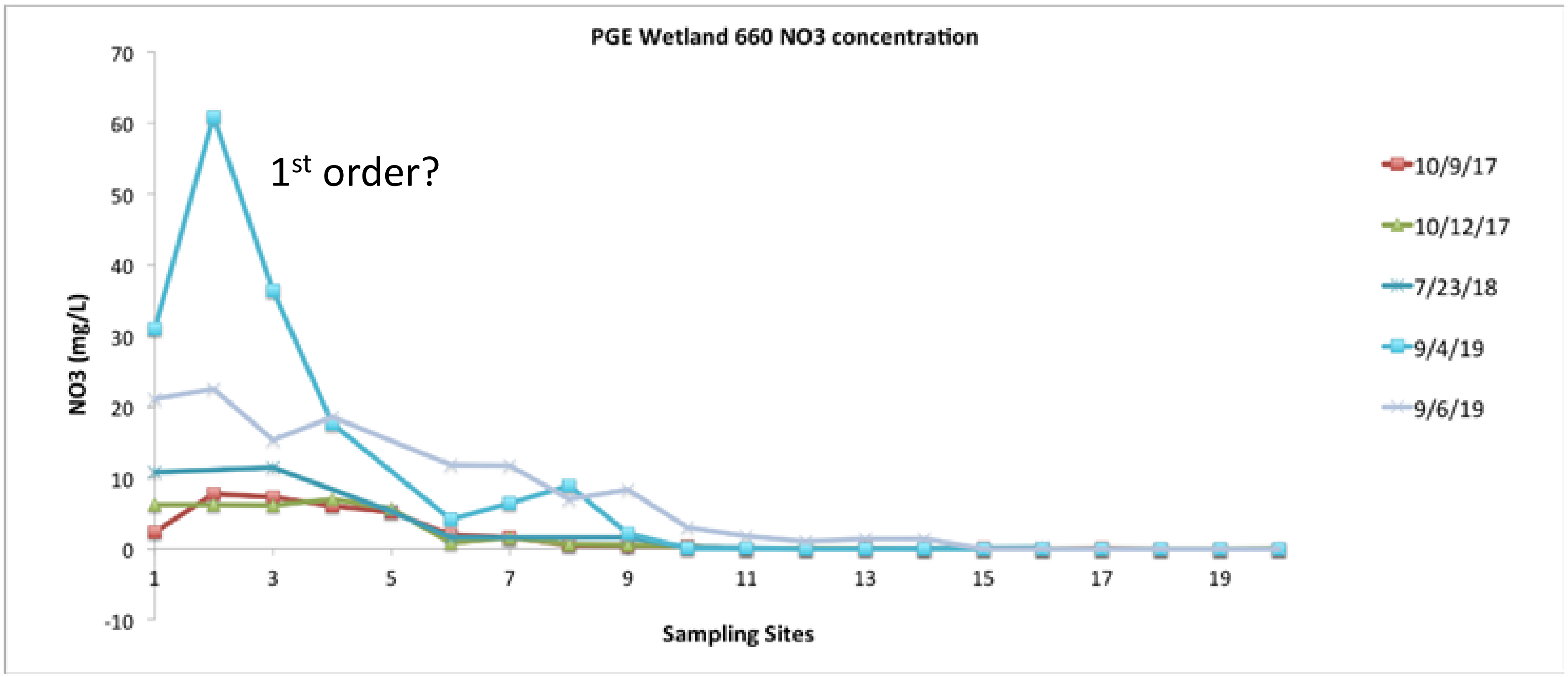


Figure 7. Nitrate concentration (NO3-N) reduction along the length of the 1250m channel of the Castroville Slough treatment wetland. A representative portion of the sample locations are shown in Figure 5

Castroville Treatment Wetland

Yellow area notes wetland area necessary to reduce nitrate concentrations to 1mg/l.

3 acres for 1000 acres of farmland

QUESTION: CAN TREATMENT SYSTEMS ACHIEVE WATERSHED SCALE NUTRIENT REDUCTIONS

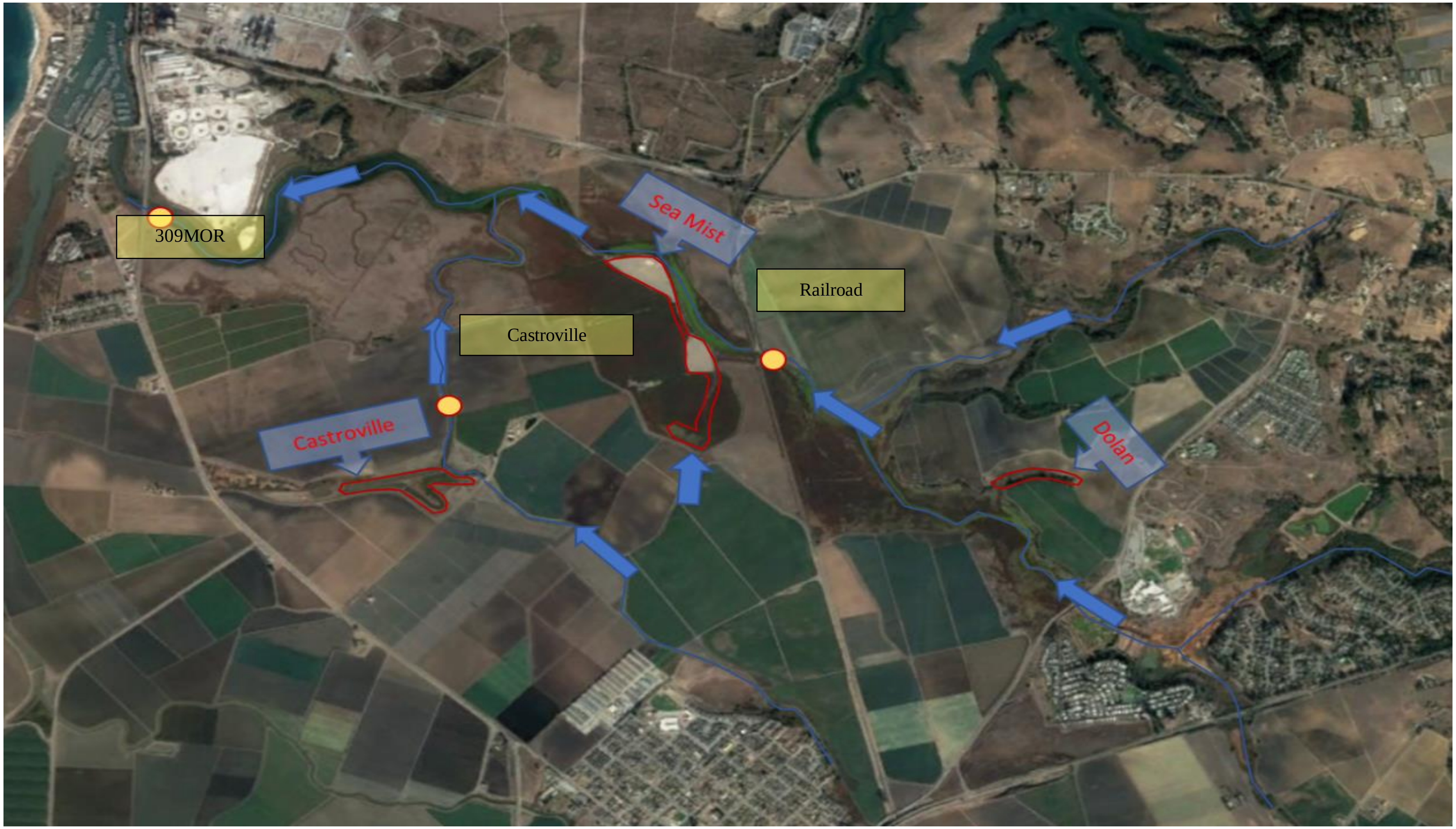


Figure 1. Locations of installed wetland treatment systems and habitat restoration areas (red) within the Moro Cojo watershed. Yellow dots and labels identify ambient water quality collection sites referenced within this document. Blue arrows depict flow direction through watershed to receiving water.

DOLAN TREATMENT WETLAND

Figure 2. Dolan project infrastructure and sample locations.

Table 1. Average water quality concentrations as water flows through a sediment basin and treatment wetland (2005 through 2015).

Site	O2 (mg/L)	pH	Salinity (ppt)	Turbidity (NTU)	NO3-N (mg/L)	NO2-N (mg/L)	NH3-N (mg/L)	DIN mg/L	PO4-P (mg/L)
1	12.37	8.46	0.5	822	9.335	0.276	0.297	9.908	0.442
2	5.88	7.84	0.49	152	1.364	0.1	0.518	1.982	0.672
3	9.99	7.97	0.59	167	0.825	0.104	0.211	1.14	0.58

Sea Mist wetland
(22 acres)

Figure 4. Sea Mist treatment wetland design and sample locations.

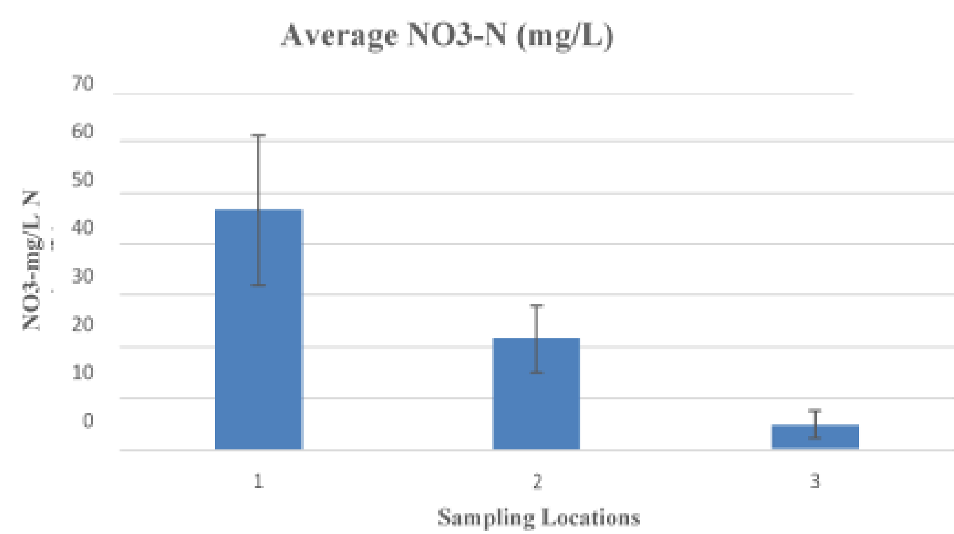


Figure 3. Average nitrate concentration as water flows from site 1 through 3, documenting nitrate reduction effects of treatment wetland (2006-2008). From CCWG 2007.

Castroville Treatment System

Figure 6a. Multi-chamber bioreactor (left) and 6b Castroville slough treatment wetland (right).

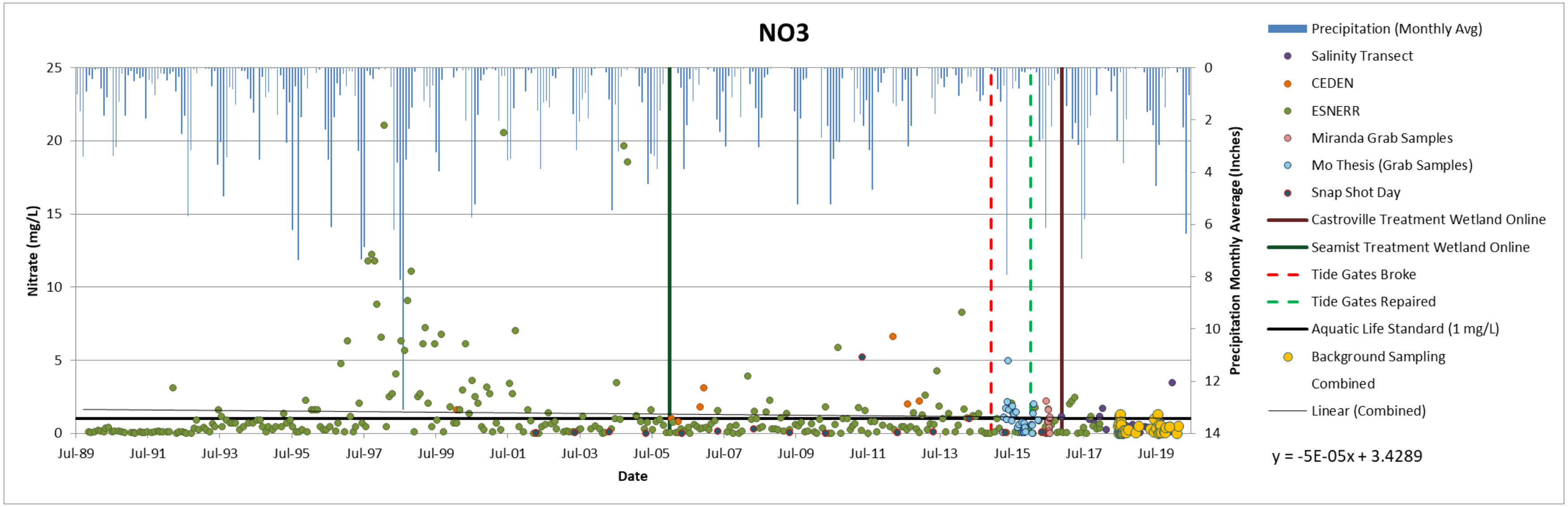
Watershed Scale Results

Table 1. Load reductions of various treatment systems within the Moro Cojo Watershed. Dolan treatment wetland lacks fl measurements needed to calculate loads.

System	System area (m2)	Daily flow (Q) (m3/d)	Input concentration mg/L (g/m3)	Output concentration mg/L (g/m3)	HRT (d)	Load removal (kg/y)	Load removed /treatment area (kg/y/m2)	Watershed area (acres)	Farm area (acres)
Sea Mist bioreactor	700	500	52	18	1	6,205	8.9	200	180
Sea Mist wetland (before bioreactor)	8,900	500	52	6	3.5	8,395	0.9	200	180
Sea Mist wetland (after bioreactor)	8,900	500	18	2	3.5	2,920	0.3	200	180
Castroville bioreactor	216	400	3.9	0.9	1	15	0.1	1400	1000
Castroville bioreactor high input	216	400	38.5	18.2	1	105	0.5	1400	1000
Castroville wetland (stations 1-11)	1,100	800	11	1.7	1	2,916	2.7	1400	1000

Watershed load reduction approximately 11,000 kg/year

Moro Cojo Receiving Water Trend Analysis



Moro Cojo Receiving Water Hypothesis Testing

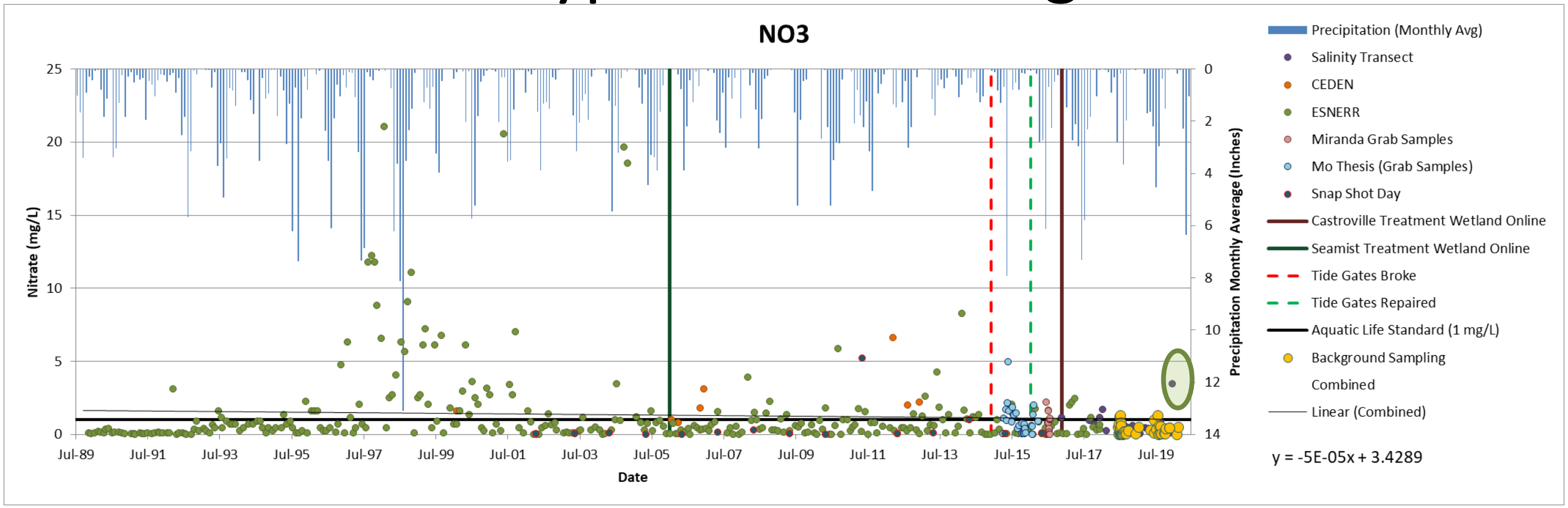
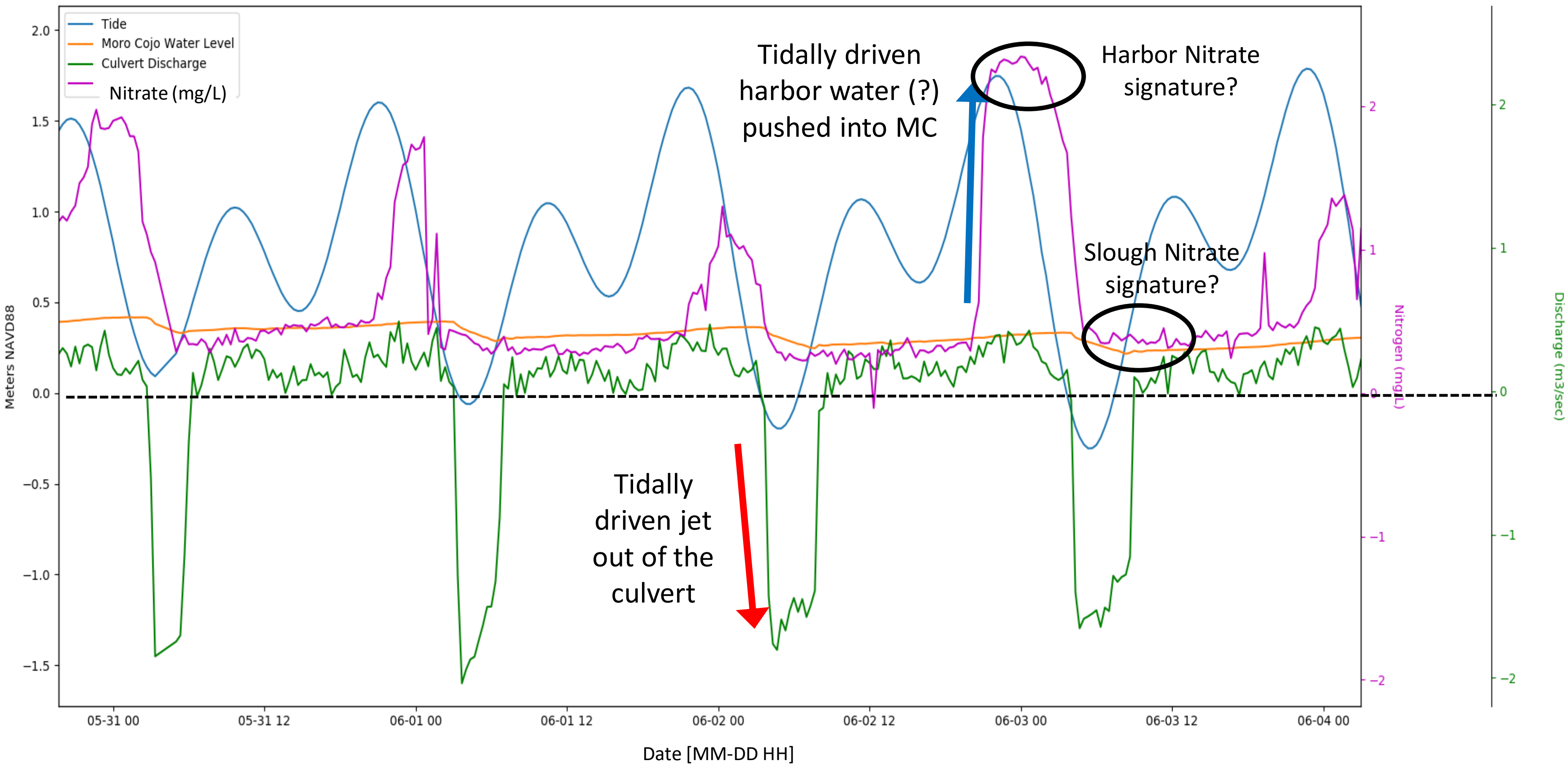


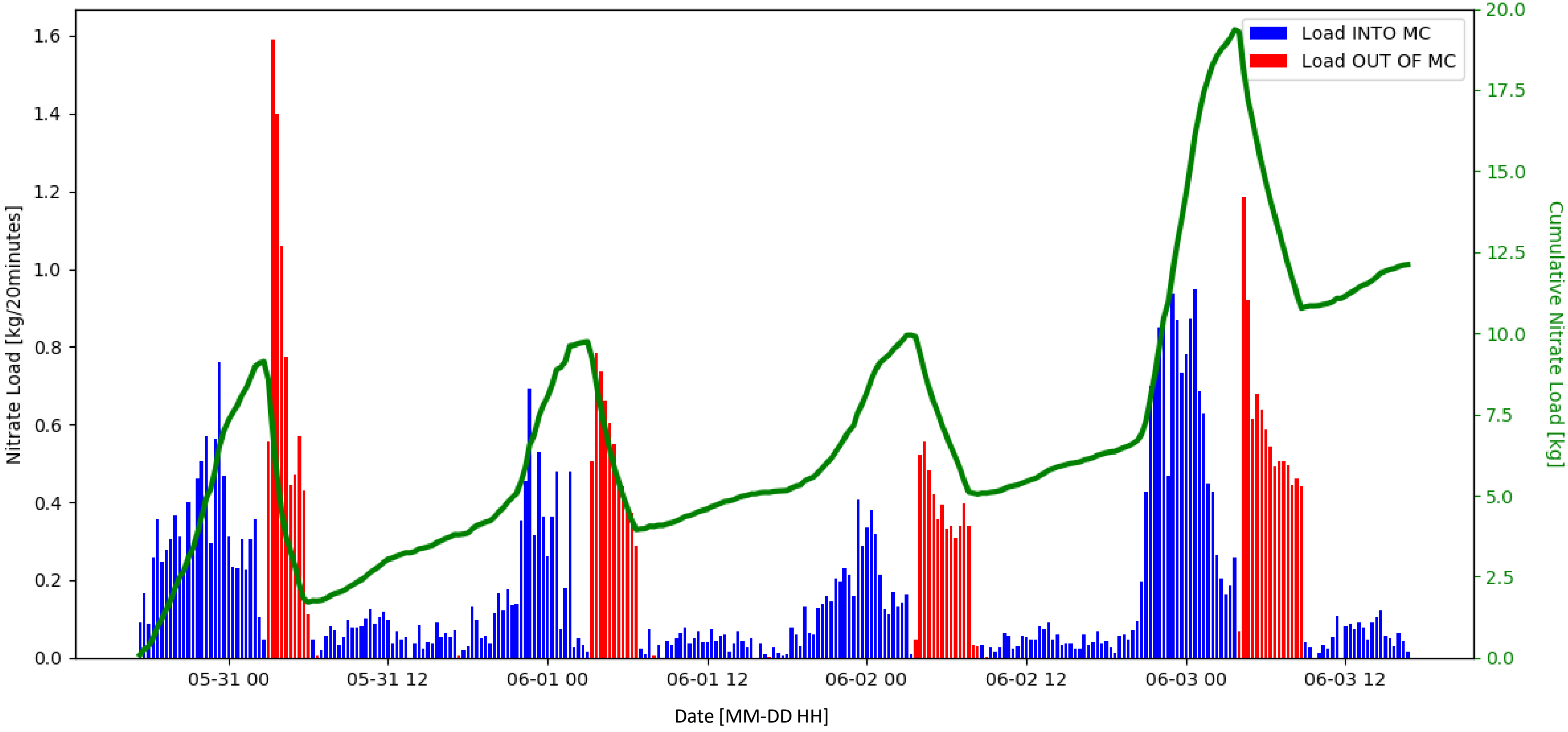
Table 5. Number and percent of water quality samples at the 309MOR with total inorganic nitrogen values that exceeded seasonal water quality thresholds (8mg/L wet season and 1.7 mg/L dry season total nitrogen as N) before and after each treatment wetland were constructed. No seasonal nitrogen exceedances occurred since construction of the wetland in 2016.

Year Range	Samples Collected		Number or Exceedances			Percent of Exceedances	
	Wet Season	Dry Season	10mg/l	8mg/l Wet Season	1.7mg/l Dry Season	8mg/l Wet Season	1.7mg/l Dry Season
1989-2006	96	95	8	10	24	5.2%	12.6%
2006-2016	147	171	0	1	14	0.3%	4.4%
2016-2019	31	54	0	0	0	0%	0%

Other Sources of Nitrate



Nitrate Loading from Adjacent Watersheds and Upwelling



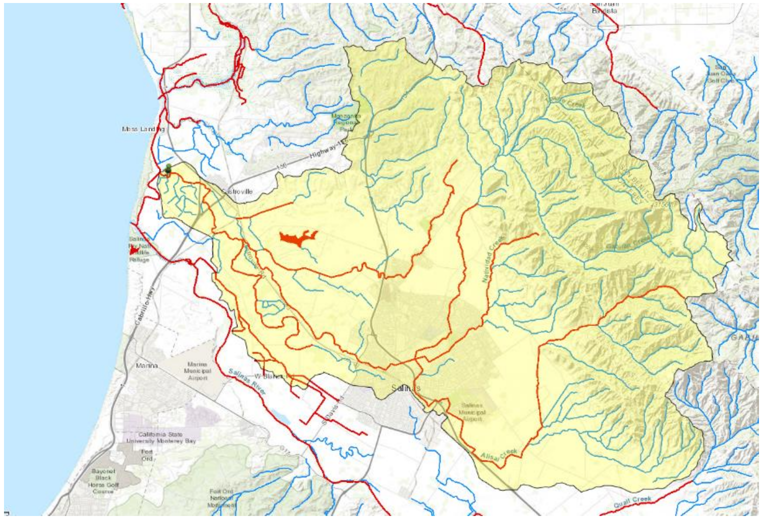
RESULTS

- Q1: Bioreactors and Treatment Wetlands effectively remove nitrates from surface water.
- Q2: Construction of treatment systems within key portions of a watershed can reduce nitrate loading enough to meet water quality objectives.

Comparison	OceanMist	PGE Wetland
Acres	0.4	12
Construction	$ 85,000	$ 490,000
Maintenance (10yr)	$ 7,500	$ 10,000
water treated / day	102,000	140,000
load reduction /day	10.2 kg/day	6.4 kg/day
WQ cost/benefit	**$ 2.67**	**$ 4.21**

Expansion to Salinas Valley

- Salinas Valley Stormwater Plan
  - Load estimates from various sub-watersheds
  - Map opportunity areas within sub-watersheds
  - Estimate Load reduction potential of example projects

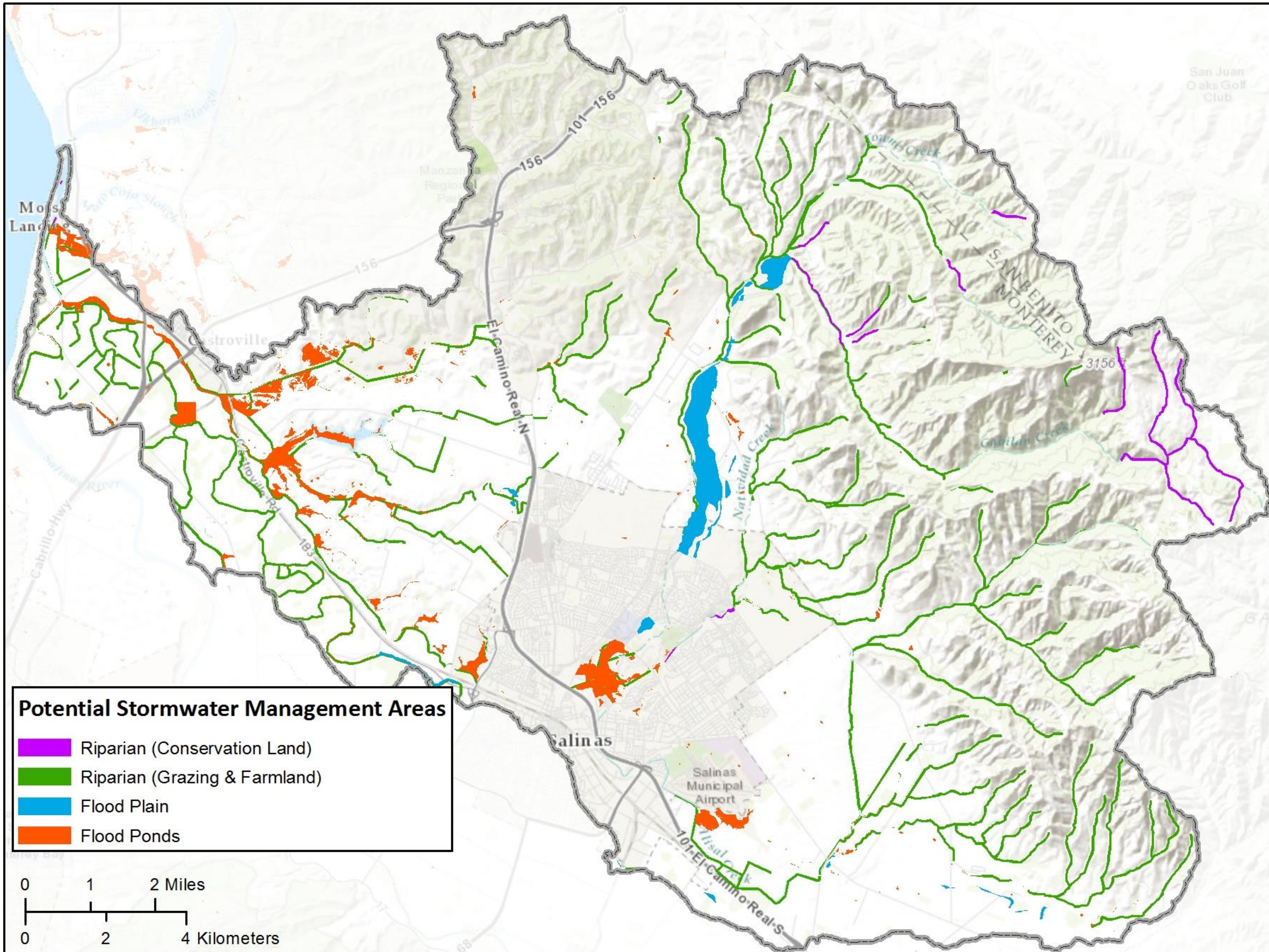


Expansion to Salinas Valley

- Load estimates from various sub-watersheds

Subwatershed	N yield kg/yr	flow wet ft3/s	flow dry ft3/s	Load Dry	Load Wet	Allowable loads kg/yr Wet	Allowable loads kg/yr Dry	Load exceeded Wet	Load exceeded Dry
Wetland	21,124	2.46	0.44	8	6.4	15,819	2,829	(5,257)	7,733
Espinosa	15,104	0.48	0.09	8	6.4	3,087	579	4,465	6,973
SanJon Detention	33,163	1.12	0.2	8	6.4	7,202	1,286	9,380	15,295
Boronda	5,321	1.67	0.12	8	6.4	10,739	772	(8,078)	1,889
Old Stage	545	0.25	0.02	8	2	1,116	89	(844)	183
Old Stage South	2,715	0.32	0.06	8	2	1,429	268	(71)	1,090
Old Stage Lower	3,012	0.13	0.02	8	2	581	89	925	1,417
Castro Pond	39,734	3.02	0.54	8	6.4	19,420	3,472	447	16,395
Carr Lake	158,876	8.05	0.65	8	2	35,947	2,903	43,491	76,535
Airport	75,709	2.67	0.52	8	2	11,923	2,322	25,932	35,532

DRAFT Storm Water Management Areas

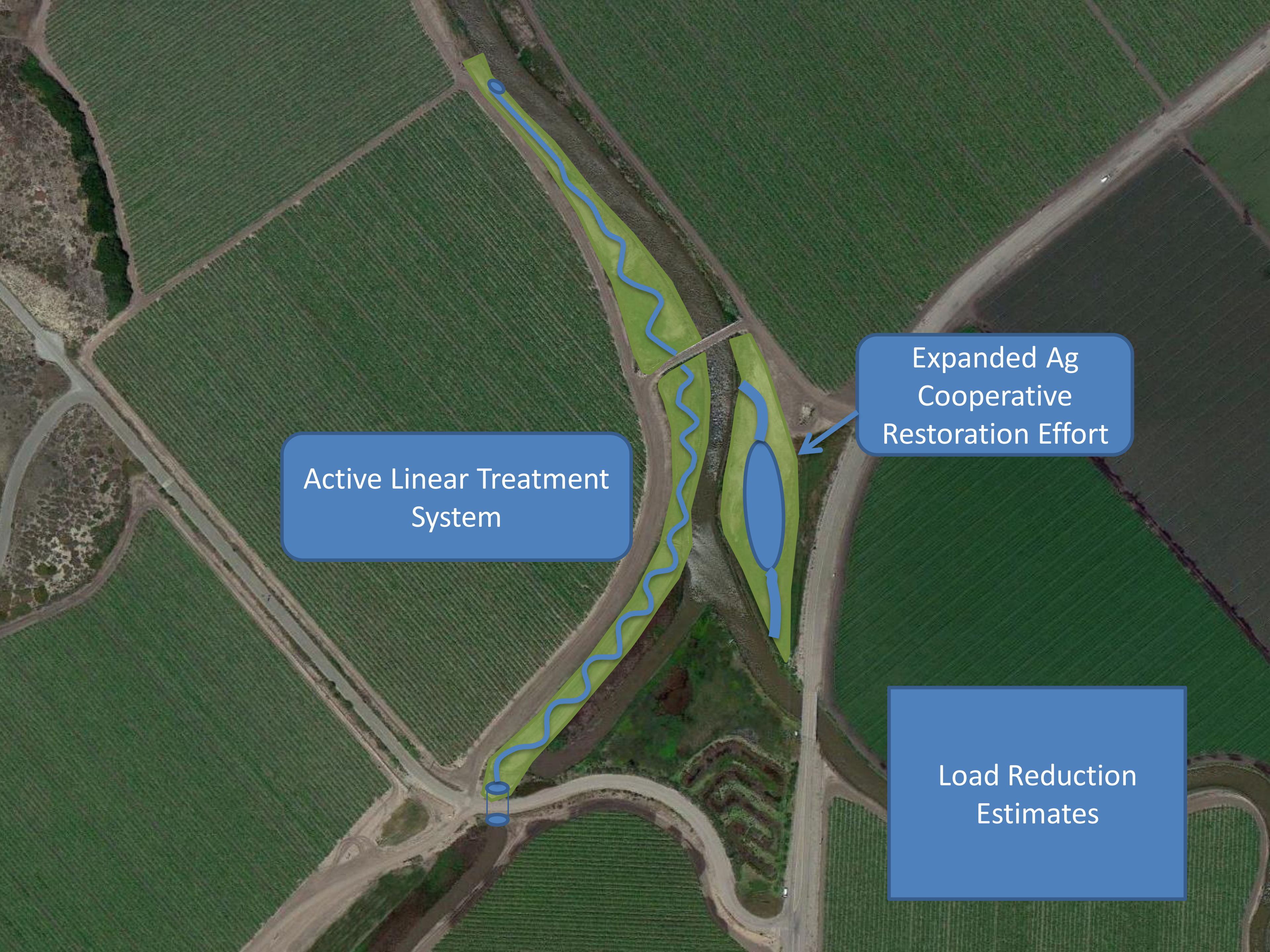


Sources: CCWG

Expansion to Salinas Valley

- Acres of wetlands needed and opportunity site identification

Sub Watershed Basin	Nitrate WQO	TMDL category	Load Exceeded	Size of treatent (acres) to meet WQO	Size of treatent (acres) to get to 0mg/l	Conceptual Treatment acres	% need
1	Wetland	Tembladero	11,216.0	3.1	5.8	3.61	117%
2	Espinosa	Espinosa	13,159.0	3.6	4.1	10.00	277%
3	SanJon Detention	rec canal	28,653.0	7.9	9.1	9.08	115%
4	Boronda	rec canal	-901.4	-0.2	1.5	35.47	NA
5	Natividad	Gabilan	30,787.0	8.5	8.5	40.00	473%
6	Old Stage	Natividad creek	-353.5	-0.1	0.1	1.15	NA
7	Old Stage South	Alisal	1,534.6	0.4	0.7	7.08	1681%
8	Old Stage Lower	Alisal	2,536.3	0.7	0.8	18.07	2595%
9	Castro Pond	Tembladero	27,571.0	7.6	10.9	4.58	61%
10	Carr Lake	G/N/A	129,939.6	35.7	43.6	33.40	94%
11	Airport	Alisal	65,843.3	18.1	20.8	32.69	181%
			Total	**85.1**	**106.0**	**195.1**	**229%**



Expanded Ag Cooperative Restoration Effort
Active Linear Treatment System
Load Reduction Estimates

Next Steps

- Validate watershed models with subwatershed loading data
- Install nutrient and flow meters in Old Salinas River
- Construct next projects with predicted reduction and test results