Potential Nutrient Reduction by Treatment Optimization and Treatment Upgrades – An Update

BACWA Board Meeting
San Francisco
14 August 2015

HDR
Brown AND Caldwell

BACWA
BAY AREA CLEAN WATER AGENCIES

Acknowledgements

BACWA Consultant Management Group (CMG)

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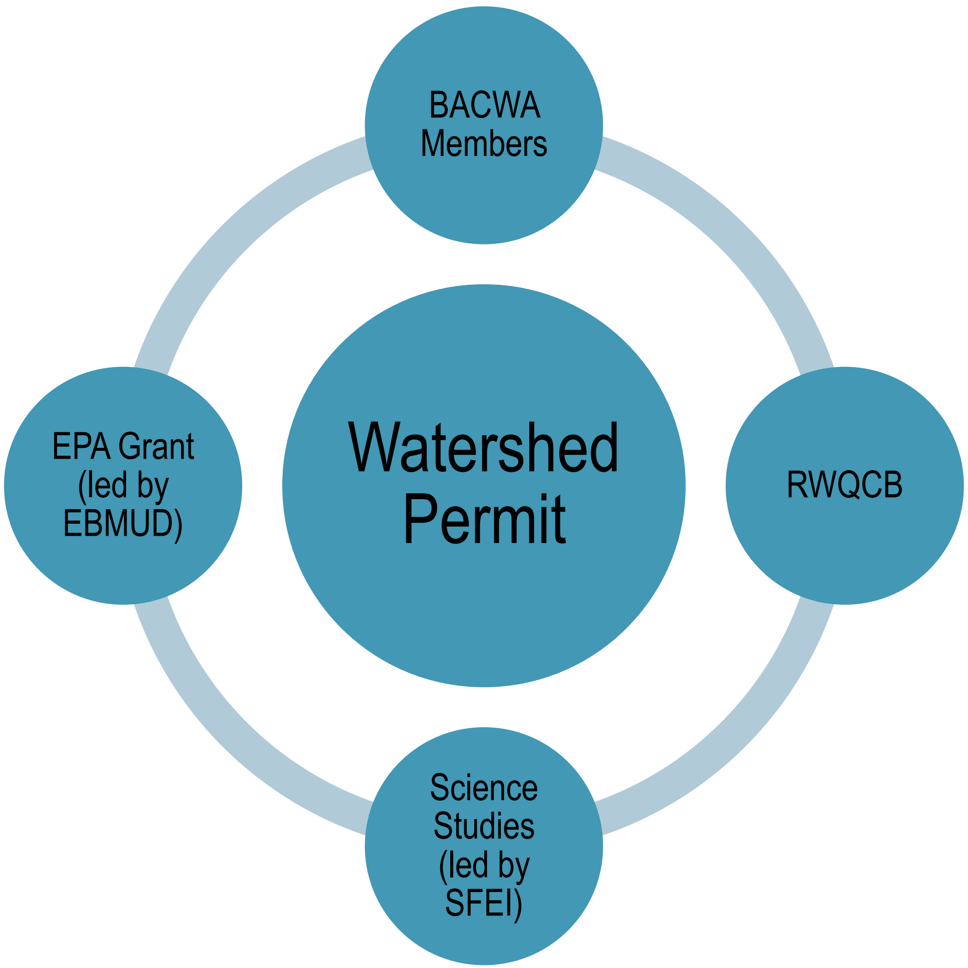

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- Amelia Holmes
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- Dennis Livingston
- Rion Merlo
- JB Neethling
- Mallika Ramanathan
- Linda Sawyer
- Eric Wahlberg

Outline

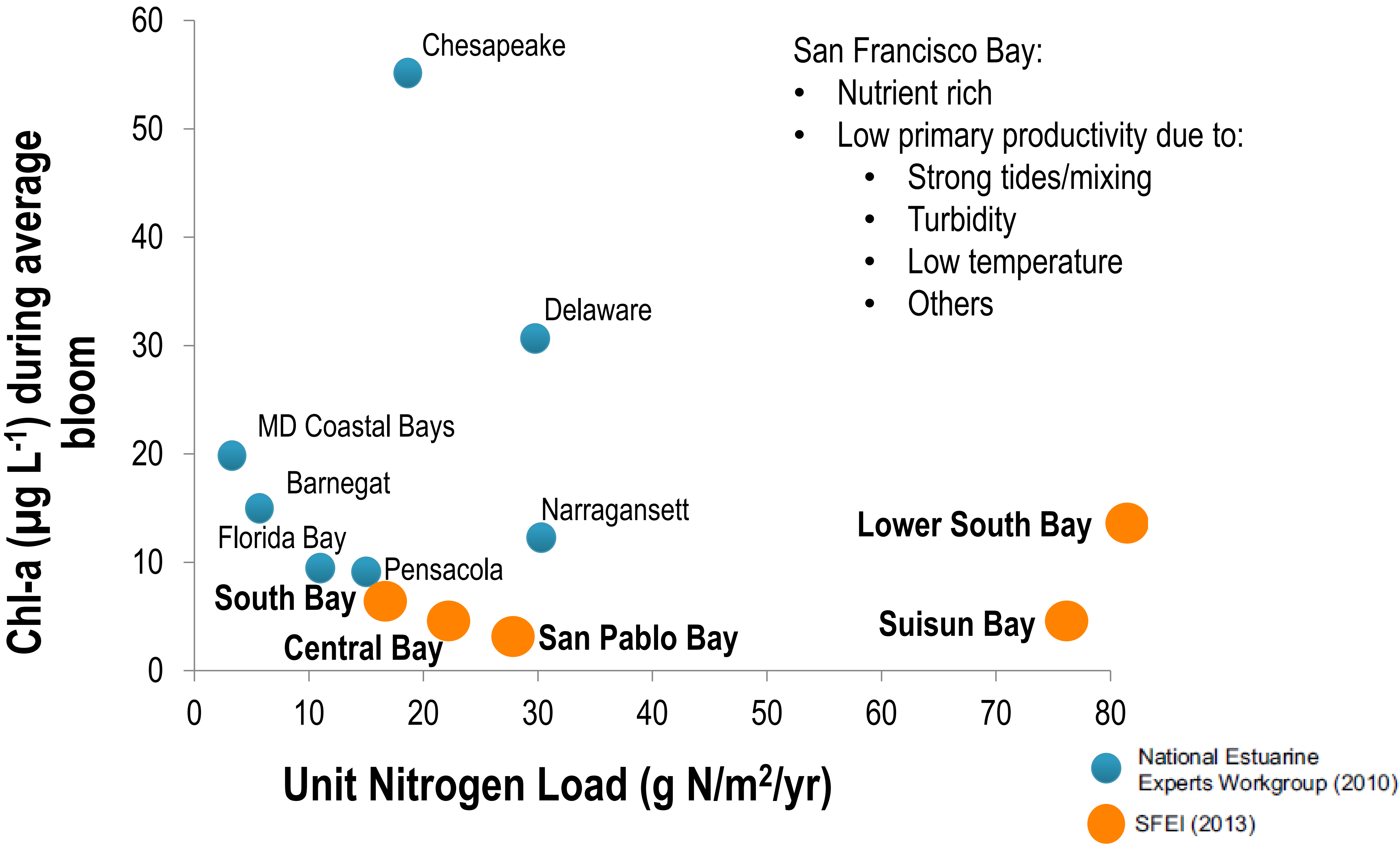
- Upcoming Milestones
- Background
- Group Annual Report Update
- Optimization and Upgrade Update
  - Optimization/Sidestream
  - Upgrades
  - Sample Report Highlights
- Next Steps
- Observations

Upcoming Key Milestones

- Sept 2015: Conclude Site Visits
- October 1, 2015: Group Annual Report Submittal
- Winter 2016: Watershed Permit Draft Report
- July 1, 2018: Watershed Permit Report Submittal

Background

How Do SF Bay Loadings Compare



San Francisco Bay:

- Nutrient rich
- Low primary productivity due to:
    - Strong tides/mixing
    - Turbidity
    - Low temperature
    - Others

Watershed Permit

Edmund G. Brown Jr.
Governor

Matthew Rodriquez
Secretary for
Environmental Protection

California Water Boards

San Francisco Bay Regional Water Quality Control Board

ORDER No. R2-2014-0014
NPDES No. CA0038873

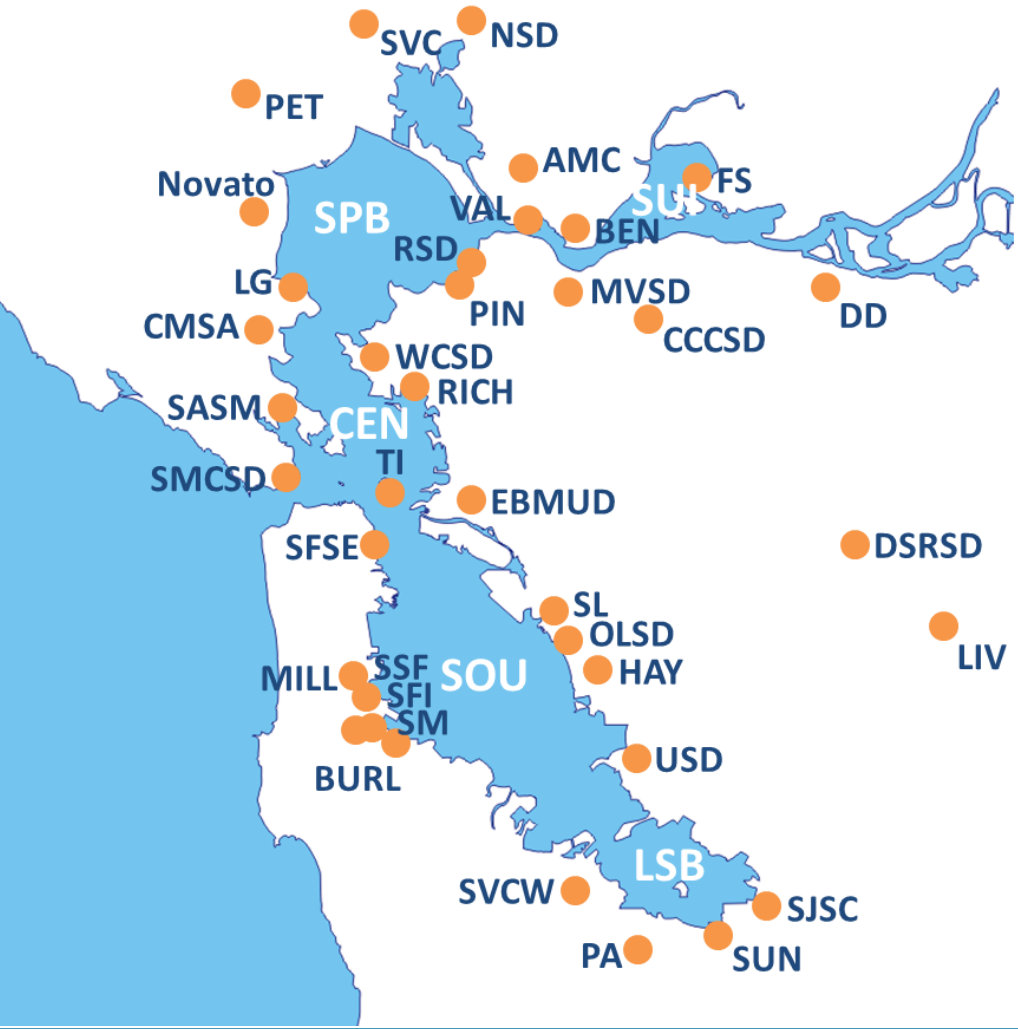
WASTE DISCHARGE REQUIREMENTS FOR NUTRIENTS FROM MUNICIPAL WASTEWATER DISCHARGES TO SAN FRANCISCO BAY

The following dischargers are subject to waste discharge requirements (WDRs) set forth in this Order, for the purpose of regulating nutrient discharges to San Francisco Bay and its contiguous bay segments:

Table 1. Discharger Information

Discharger	Facility Name	Facility Address	Minor/ Major

37 Participating Plants



- **SUI** – Suisun Bay
- **SPB** – San Pablo Bay
- **CEN** – Central Bay
- **SOU** – South Bay
- **LSB** – Lower South Bay

Nutrient Targets

Level	Study	Ammonia	Total Nitrogen (TN)	Total Phosphorus (TP)
Level 1 *	Optimization	--	--	--
Level 2 *	Upgrades	2 mg N/L	15 mg N/L	1.0 mg P/L
Level 3 *	Upgrades	2 mg N/L	6 mg N/L	0.3 mg P/L

* Seasonal impacts will be considered for each level:

- Dry Season – May 1 to September 30
- Wet Season – October 1 to April 30

Group Annual Report Update

Group Annual Report – Due October 1, 2015

- Data Collection/Review
  - 13267 Letter Data (2011-2014)
  - CIWQS (2014-2015)
- Data Analysis and Reporting
  - Data trending by plant type and sub-embayment

HDR

BACWA BAY AREA CLEAN WATER AGENCIES

Table 2-4. Annual Nutrient Loads Discharged from WRRFs – Total Phosphorus

Facility Name	Subembayment	2012/13	2013/14	2014/15	Trend
American Canyon, City of					
Benicia, City of					
Burlingame, City of					
Central Contra Costa Sanitary District					
Central Marin Sanitation Agency					
Delta Diablo					
American Canyon, City of					
Benicia, City of					
Burlingame, City of					
ETC					

Table 2-5. Annual Flows Discharged to Subembayments

Facility Name	2012/13	2013/14	2014/15	Trend
Central Bay				
Lower South Bay				
San Pablo Bay				
South Bay				
Suisun Bay				
Total				

Table 2-6. Annual Nutrient Loads Discharged to Subembayments – Ammonia

Facility Name	2012/13	2013/14	2014/15	Trend
Central Bay				
Lower South Bay				
San Pablo Bay				
South Bay				
Suisun Bay				
Total				

Preliminary Flows Analysis (mgd)

Sub-Embayment	2012/2013	2013/2014	2014/2015 *	Trend
Suisun Bay	59	55	56	→
San Pablo Bay	33	32	33	→
Central Bay	79	76	76	→
South Bay	158	155	143	↓
Lower South Bay	124	115	115	→
Total	453	434	424	↓

* Average from prior years used for missing data in 2014/2015 dataset

Preliminary Ammonia Loading (kg N/day)

Sub-Embayment	2012/2013	2013/2014	2014/2015 *	Trend
Suisun Bay	3,700	4,300	4,200	↑
San Pablo Bay	880	1,000	1,100	↑
Central Bay	9,200	9,900	9,600	→
South Bay	18,600	21,100	18,500	→
Lower South Bay	600	300	340	↓
Total	33,100	36,500	33,800	→

* Average from prior years used for missing data in 2014/2015 dataset

Preliminary Total N Loading (kg N/day)

Sub-Embayment	2012/2013	2013/2014	2014/2015 *	Trend
Suisun Bay	6,600	7,000	5,200	↓
San Pablo Bay	2,100	2,200	2,300	→
Central Bay	12,200	13,100	12,100	→
South Bay	22,500	24,500	20,200	↓
Lower South Bay	8,600	7,900	7,700	↓
Total	52,000	54,700	47,500	↓

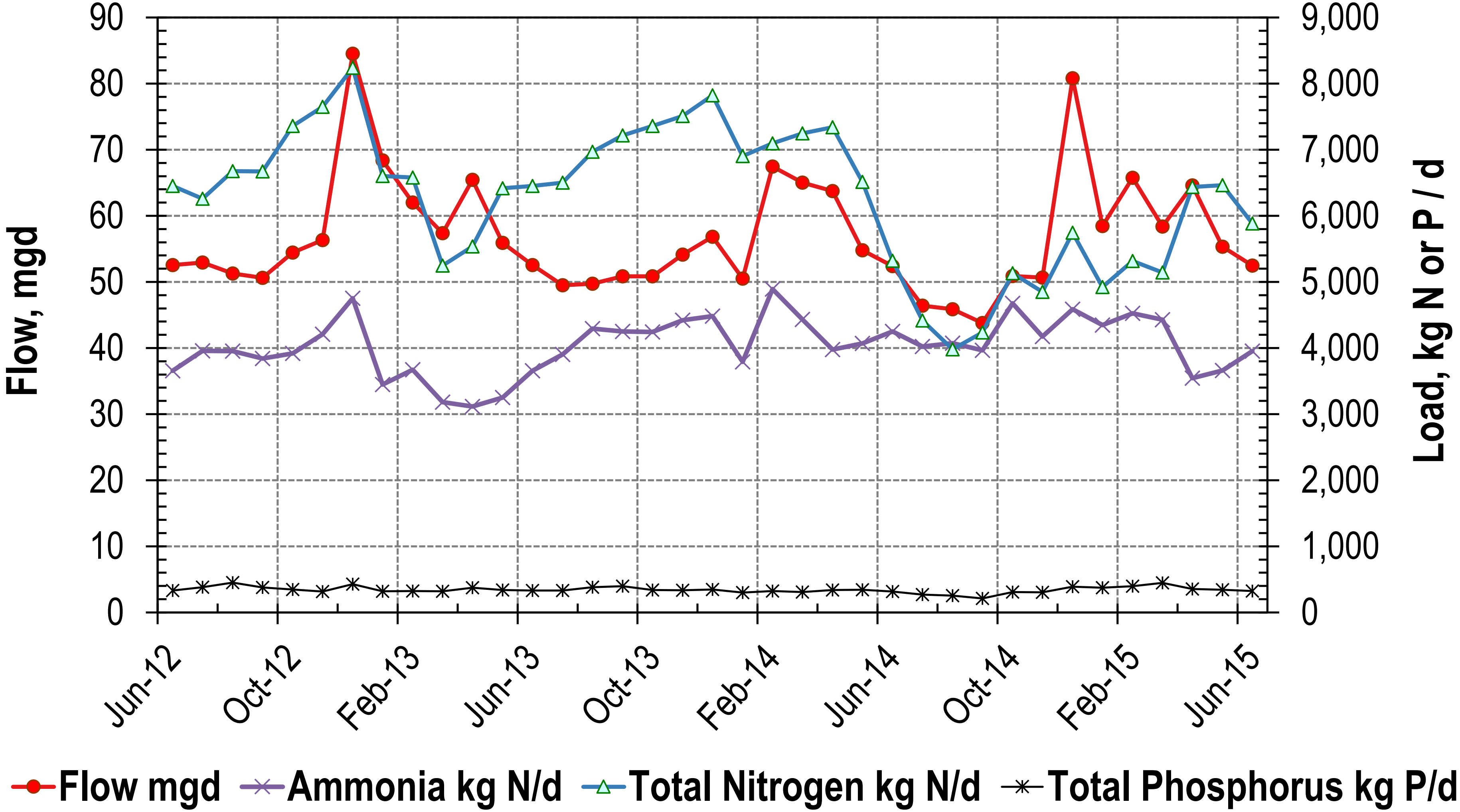
* Average from prior years used for missing data in 2014/2015 dataset

Preliminary Total P Loading (kg P/day)

Sub-Embayment	2012/2013	2013/2014	2014/2015 *	Trend
Suisun Bay	360	340	330	→
San Pablo Bay	320	310	300	→
Central Bay	1,200	1,010	970	↓
South Bay	1,210	1,290	880	↓
Lower South Bay	880	800	740	↓
Total	3,900	3,800	3,200	↓

* Average from prior years used for missing data in 2014/2015 dataset

Preliminary Suisun Bay Results *



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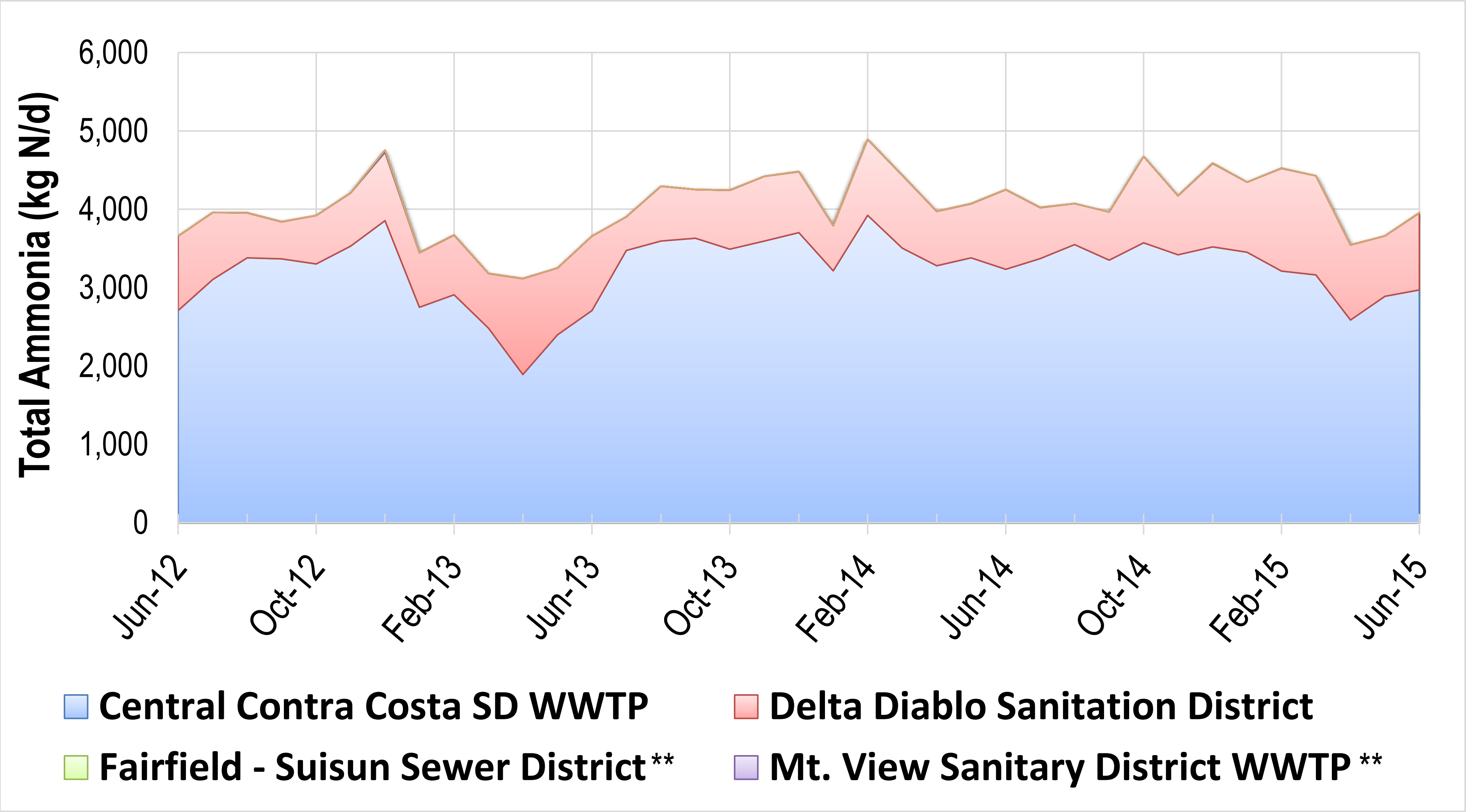
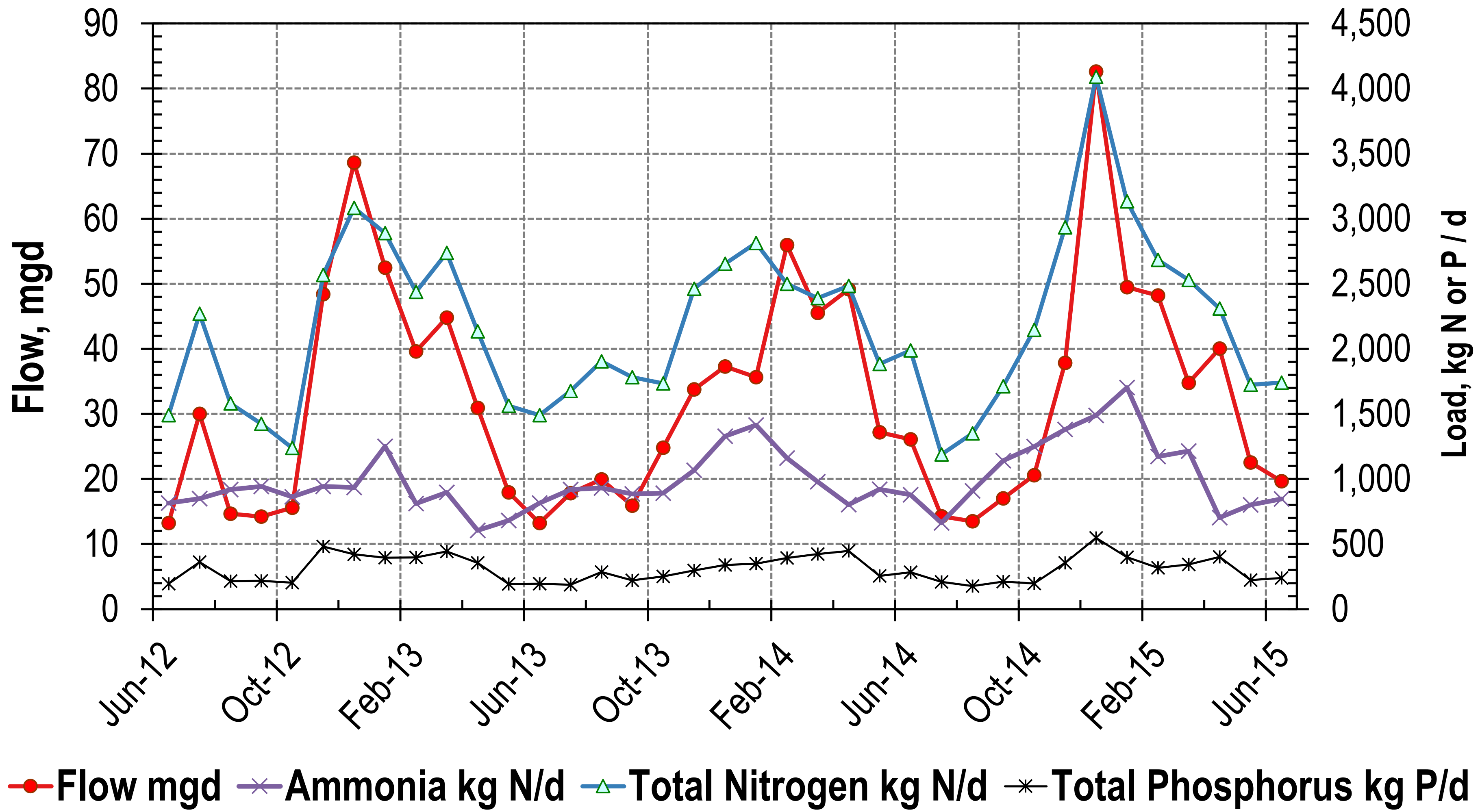
Preliminary Suisun Bay Results *



* Average from prior years used for missing data in 2014/2015 dataset

** Nitrifying Plant

Preliminary San Pablo Bay Results *



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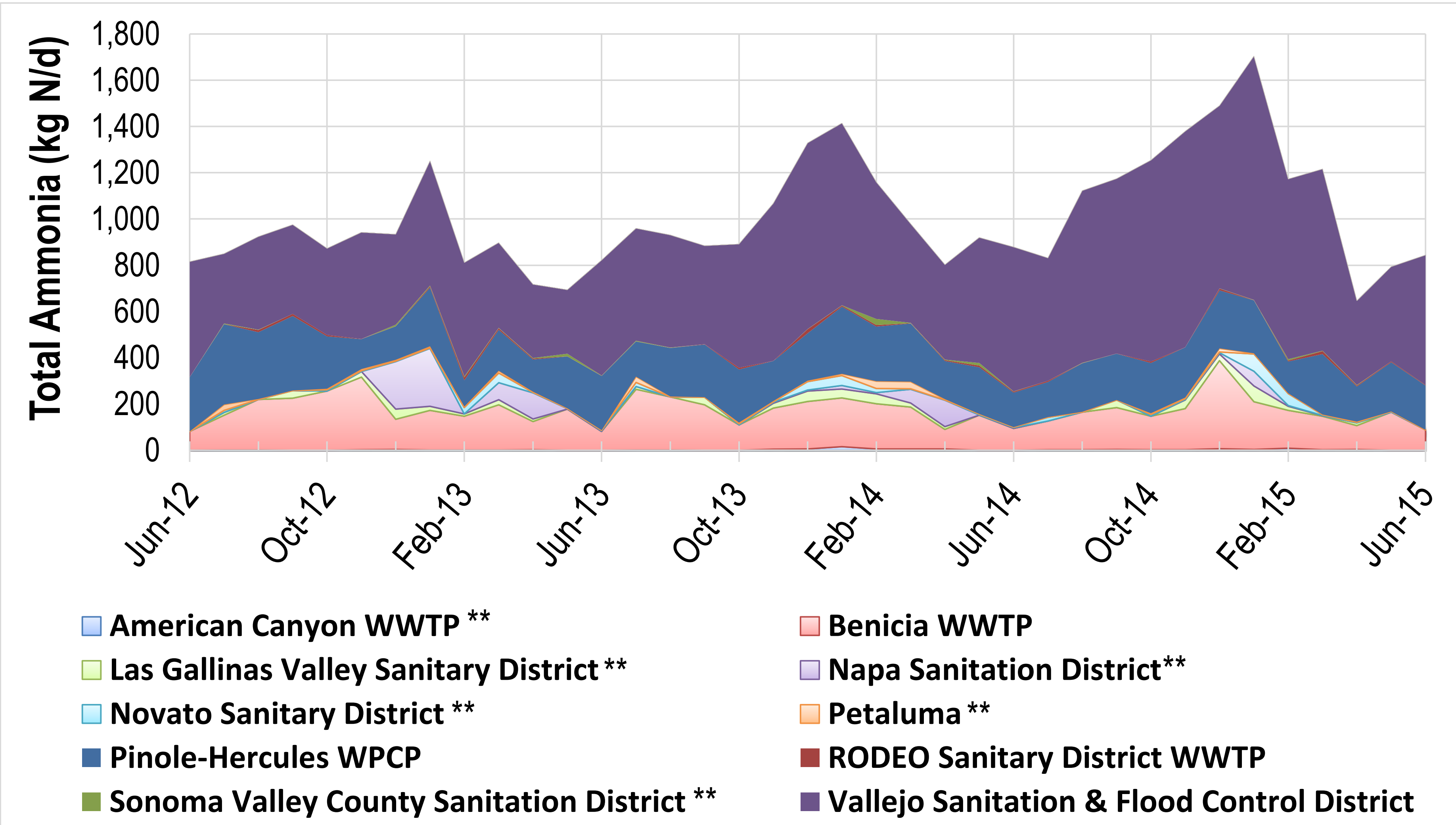
Preliminary San Pablo Bay Results *



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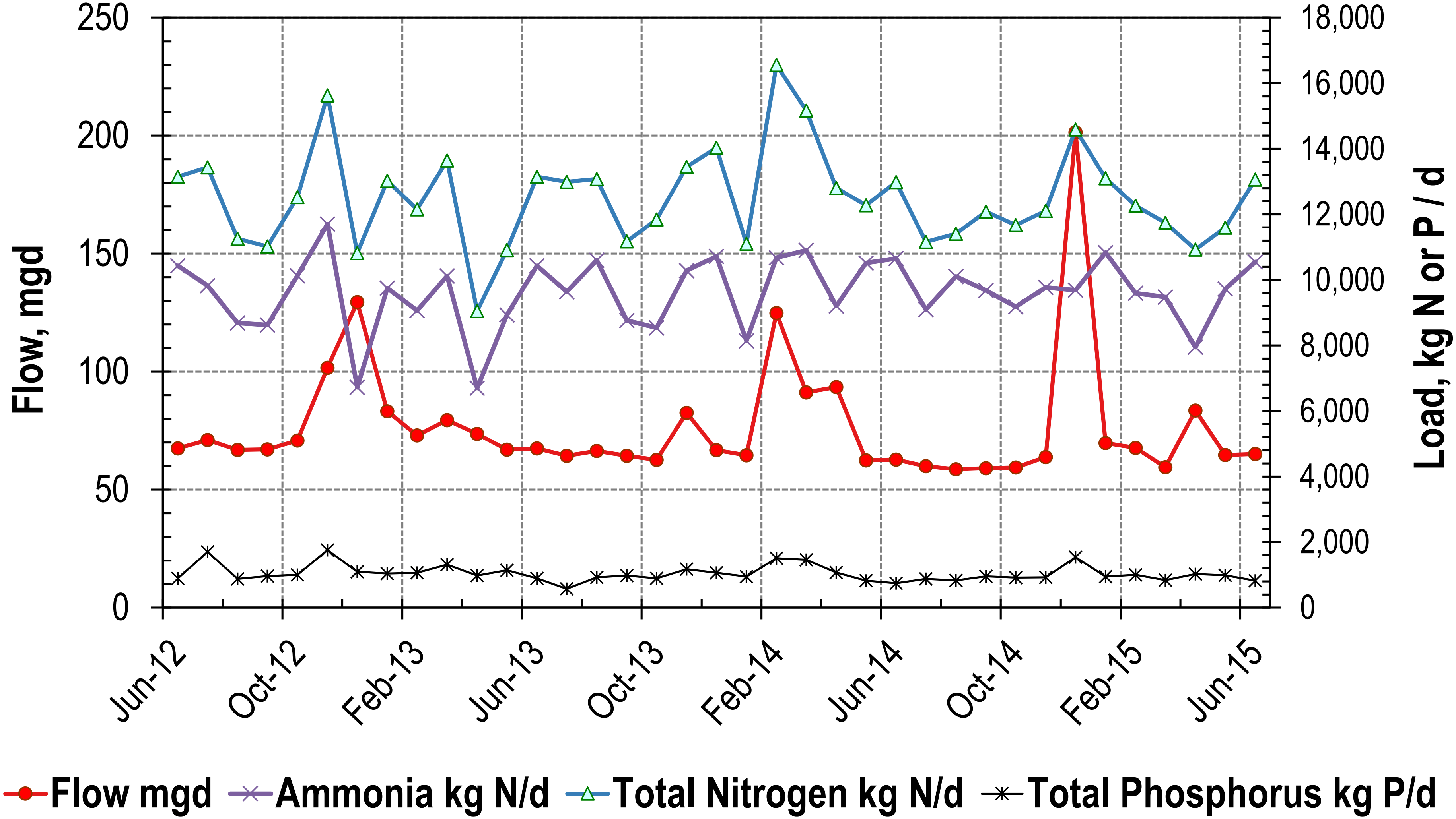
** Nitrifying Plant

Preliminary Central Bay Results *



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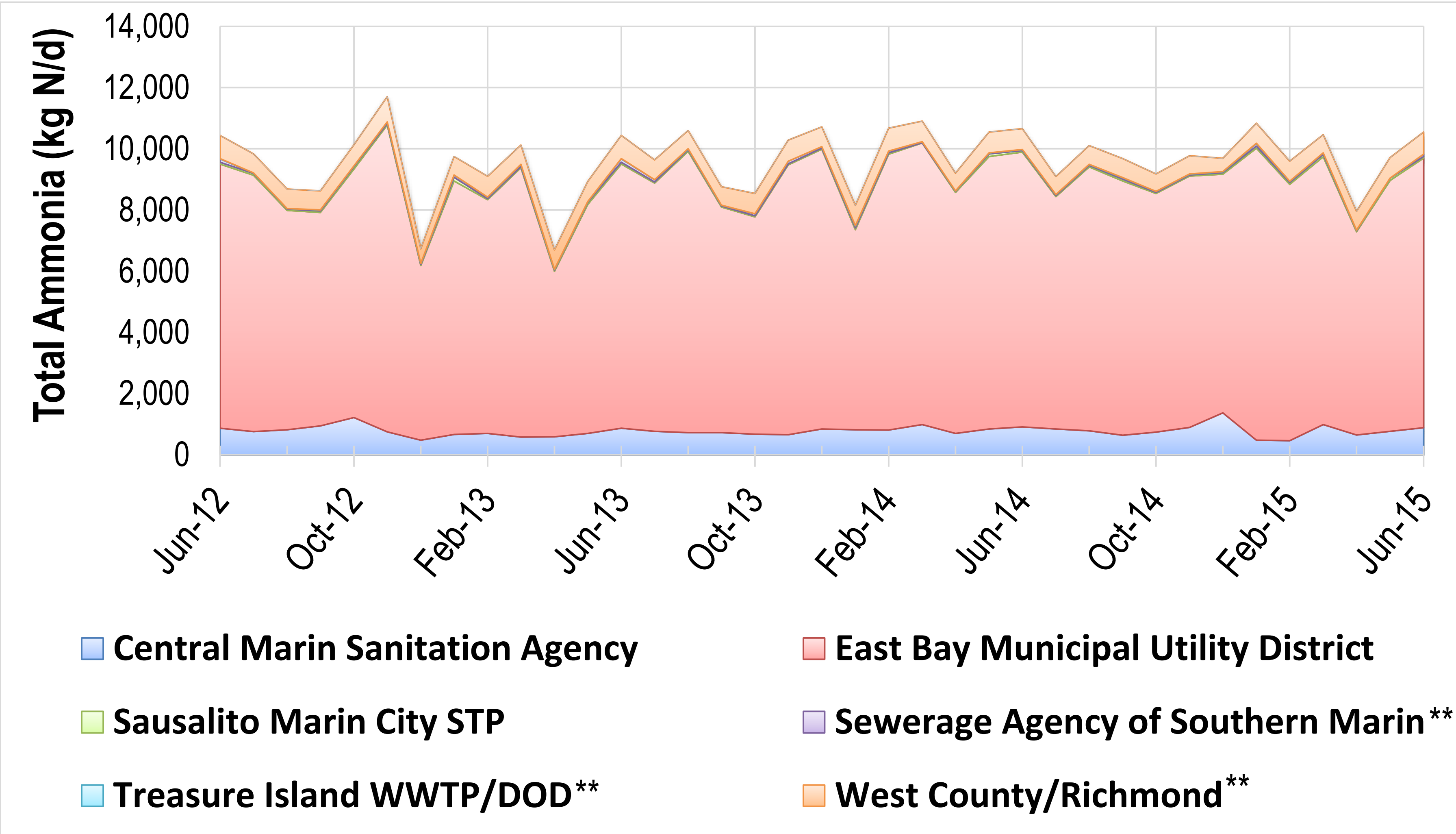
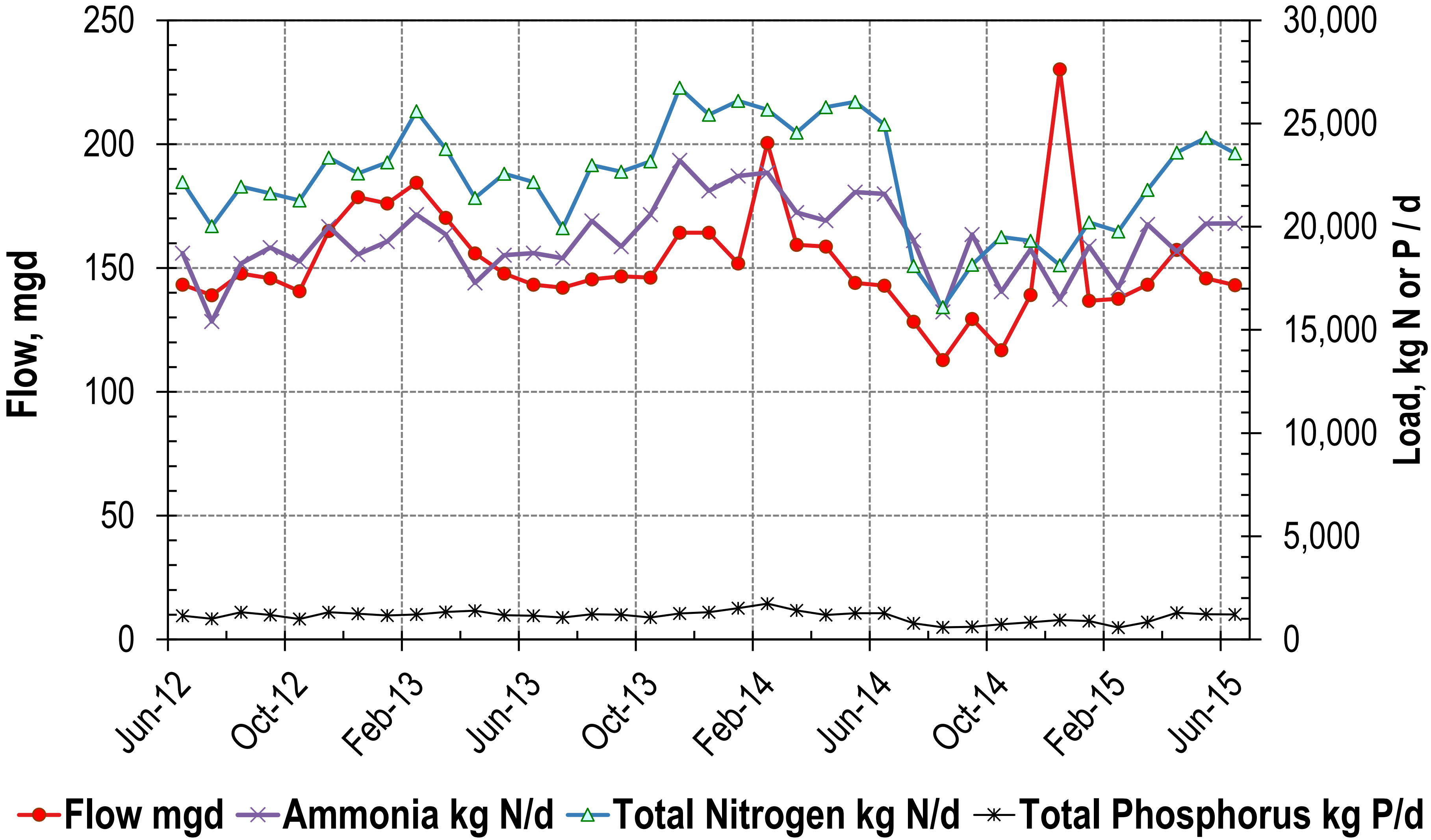
Preliminary Central Bay Results *



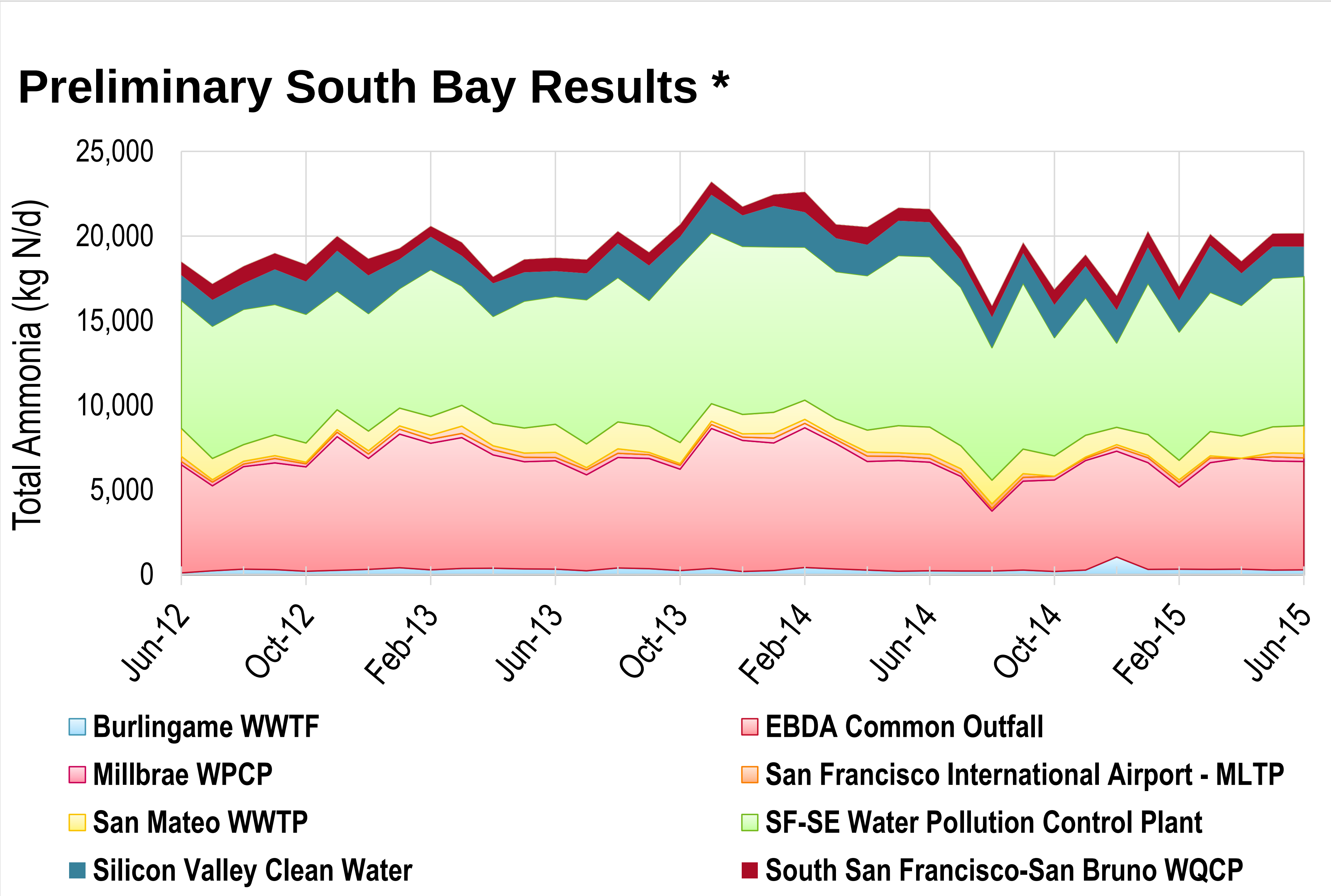
*   Average from prior years used for missing data in 2014/2015 dataset

** Nitrifying Plant

Preliminary South Bay Results *



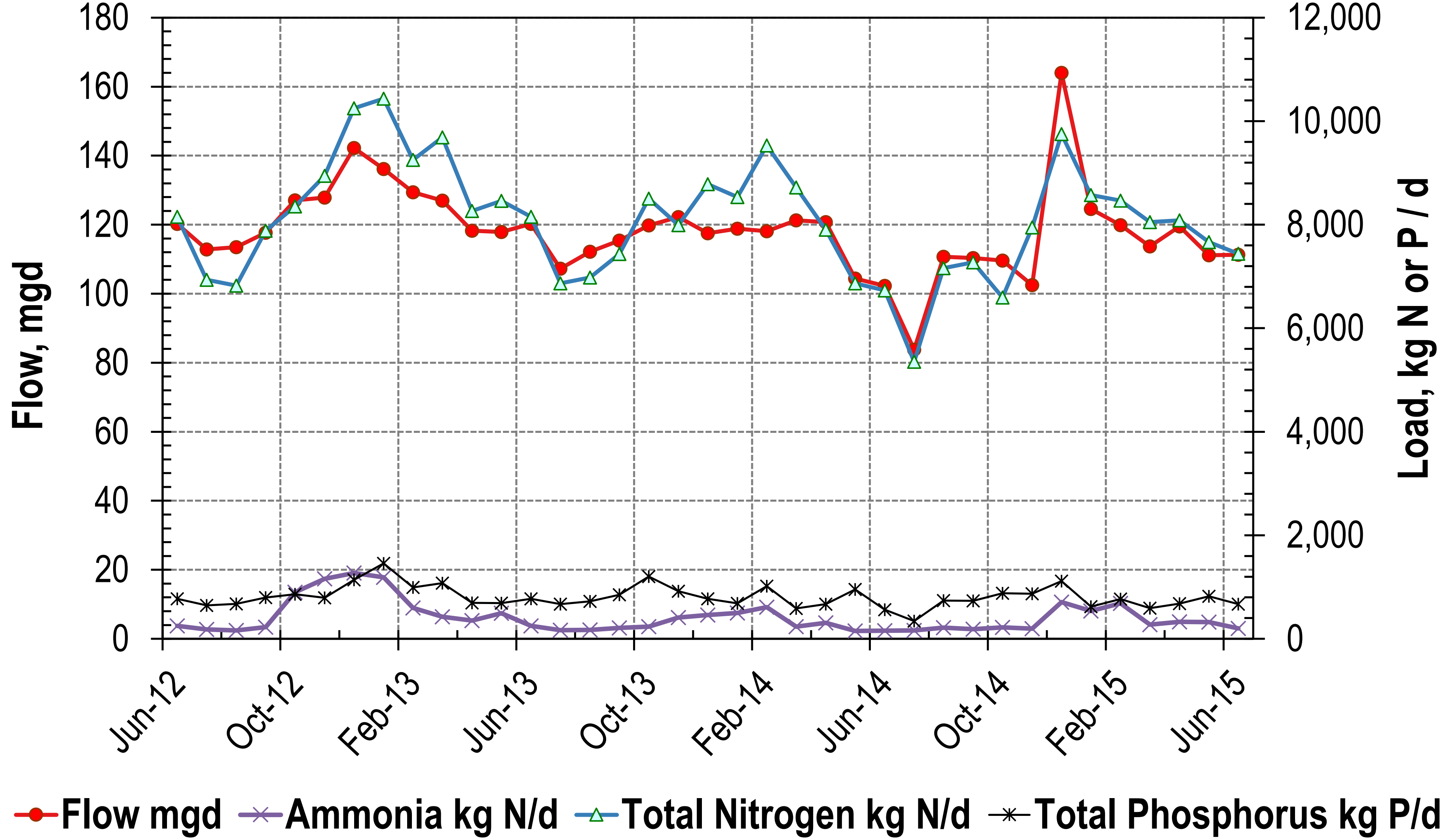
* Average from prior years used for missing data in 2014/2015 dataset



* Average from prior years used for missing data in 2014/2015 dataset

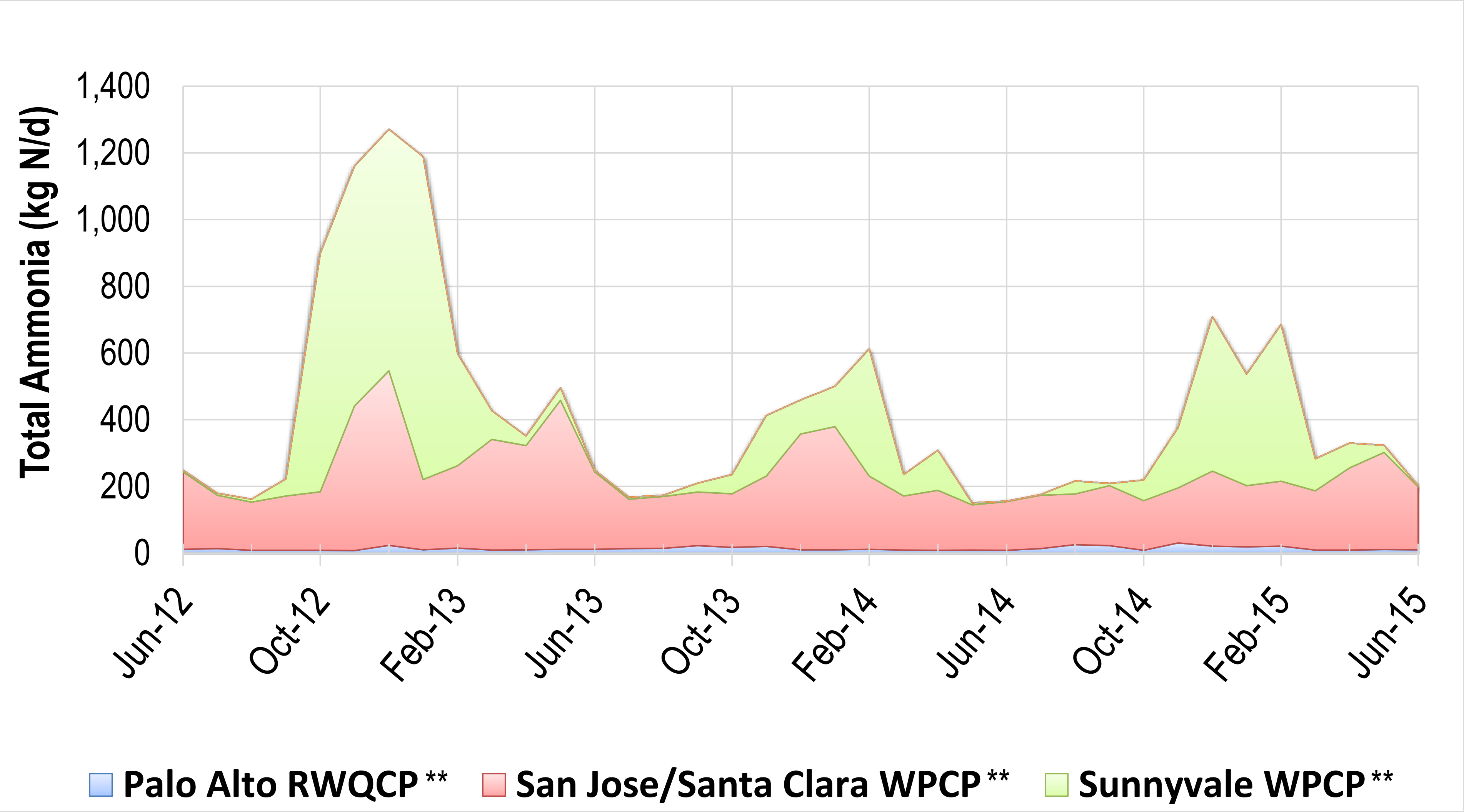
** Nitrifying Plant

Preliminary Lower South Bay Results *



* Average from prior years used for missing data in 2014/2015 dataset

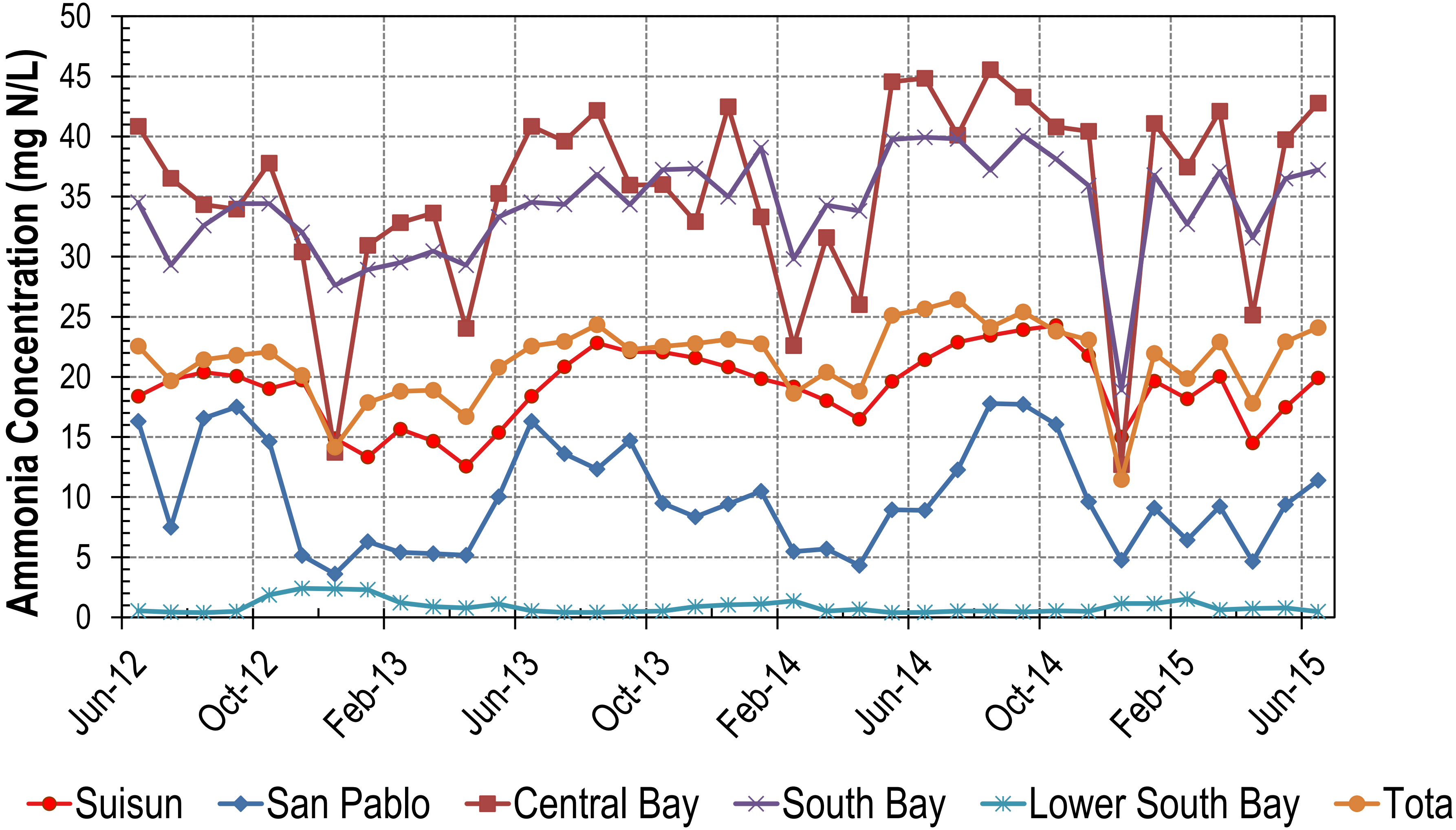
Preliminary Lower South Bay Results *



* Average from prior years used for missing data in 2014/2015 dataset

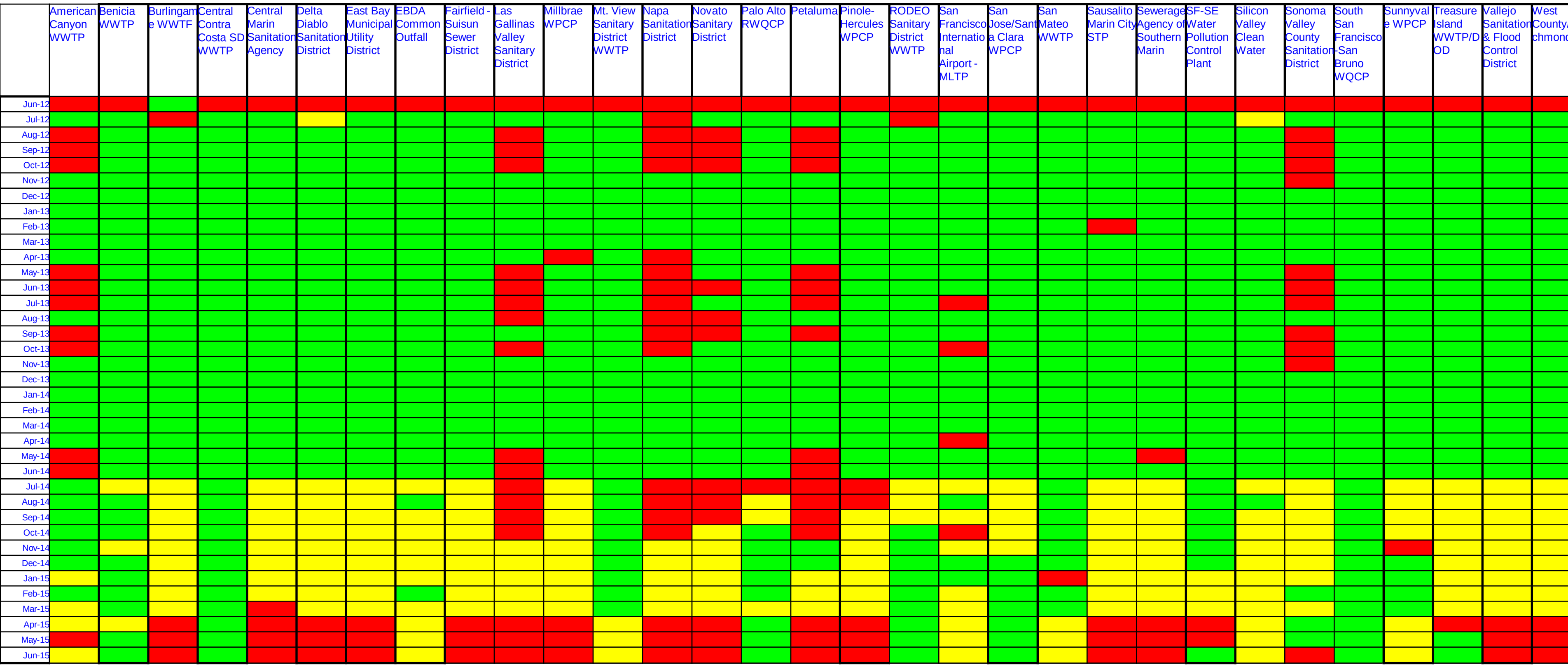
** Nitrifying Plant

Preliminary Bay Wide Plant Discharge Ammonia Concentrations*



* Average from prior years used for missing data in 2014/2015 dataset

Incomplete Dataset



Green = Complete Dataset

Red = Missing Data

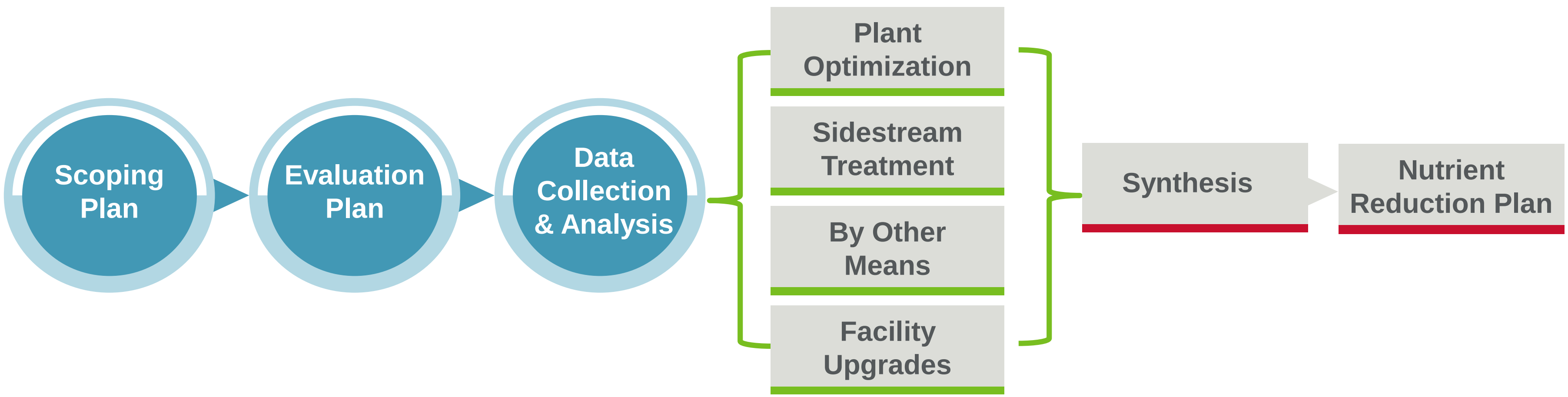
Yellow Data = Incomplete Dataset

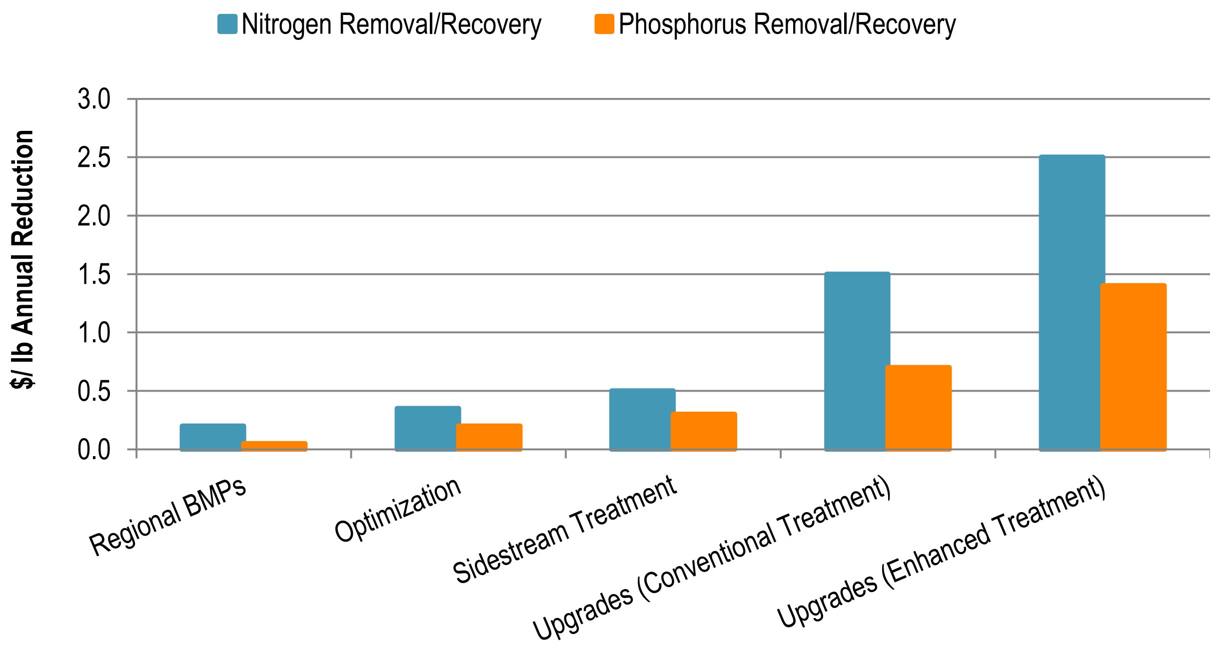
Summary

- Incomplete dataset for the most recent year
  - Limited data in April, May, and June 2015
  - Relied on values from prior years
- Some data gaps / concerns
  - Ortho Phosphate data in 2014/15 seems too low compared to earlier years
  - In general, the 2014/15 data has errors and outliers that still need to be addressed
- Trends in existing data need further analysis due to data issues
- Additional data analysis is required before conclusions can be drawn

Optimization and Upgrades Update

Watershed Permit Approach





Site Visits

Potential Nutrient Reduction by Treatment Optimization and Treatment Upgrades

Facility Information	
Facility Name	
Address	
Facility Contact	
Date of Visit	
Facility Attendees	
Consultant Mgmt Group Attendees	
Consultant Process Engineer	
Consultant Operations Expert	
Describe Existing Nutrient Limits *(if any)*	Ammonia = 170 mg N/L AMEL and 220 mg N/L MDEL
Permitted Capacity	19.5 mgd ADWF; 31.1 mgd PWWF

Current Conditions		
Flow	**Summer**	**Winter**
Annual Average Flow, mgd	13.0	13.1
Peak Month, mgd	13.3	13.7
Max Day, mgd	14.3	17.0
Peak Hour Flow, mgd	19	31.5
TSS Loads (Marginal seasonal impacts)		
Annual Average, lb/d	38,500	38,900
Peak Month, lb/d	42,500	43,400
Max Day, lb/d	58,500	60,500
BOD Loads (Marginal seasonal impacts)		
Annual Average, lb/d	35,700	37,400
Peak Month, lb/d	38,700	41,700
Max Day, lb/d	42,300	54,300
Ammonia Loads (Marginal seasonal impacts)	**Summer**	**Winter**
Annual Average, lb/d	3,500	3,800
Peak Month, lb/d	3,800	4,100
Max Day, lb/d	3,800	4,400
TKN Loads (Marginal seasonal impacts)		
Annual Average, lb/d	5,400	5,700
Peak Month, lb/d	6,000	6,200
Max Day, lb/d	6,500	6,300
Ortho-P Loads (Marginal seasonal impacts)		
Annual Average, lb/d	360	370
Peak Month, lb/d	420	490
Max Day, lb/d	430	610
Total P Loads (Marginal seasonal impacts except for Max Day)		
Annual Average, lb/d	690	700
Peak Month, lb/d	760	780
Max Day, lb/d	2,100 High due to solids from water recycling return streams	900

- The current flows and loads are in-line with the Master Plan historical and projected flows and loads. The current flows and loads show marginal seasonal impacts on flows and loads.
- The max day summer total P loads are high due to phosphorus in the solids return stream from the Recycled Water Facility (RWF). Delta Diablo adds ferrous chloride (FeCl2) to their sewer at the Pittsburg and Antioch pump stations (PS) and alum at the ActiFlo® process located at the RWF.

Documentation (check all available documents)	
☒	Current Master Plan
☒	PFD
☐	Facility Plan
☐	Sea Level Rise Report

Optimization




Optimization Concepts

- Use offline tankage
- Operate in split treatment mode
- Modify operational mode (e.g., raise SRT)
- Modify blower set points
- Add chemicals
  - P removal
  - To unlock downstream capacity
- Shut down aeration to create anoxic zones
- Process control instrumentation
- Add internal recycle for denitrification

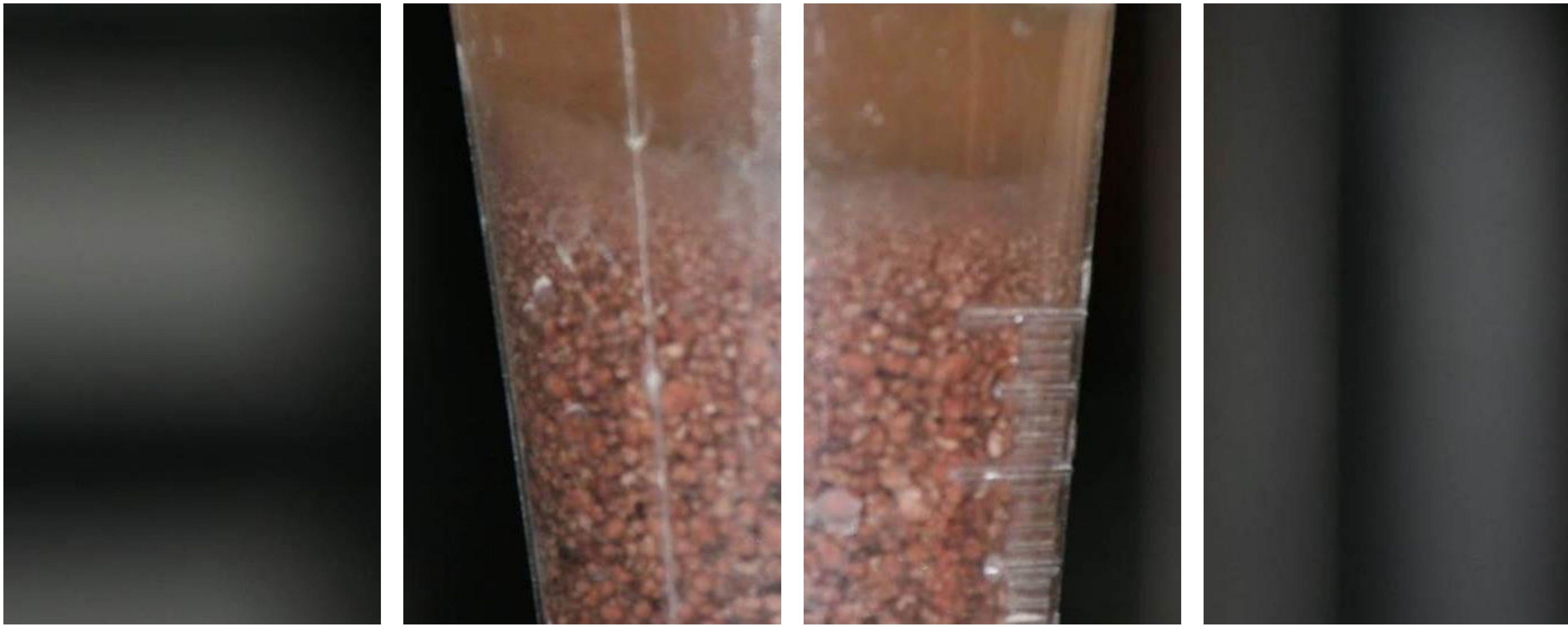
Optimization Findings

- Site visits have tracked fairly well with original list of options
- Large portion of facilities can do CEPT
- Several facilities can remove ammonia in trickling filters
- Examples from site visits:
  - Unused tankage
  - CEPT
  - Nitrification in trickling filters

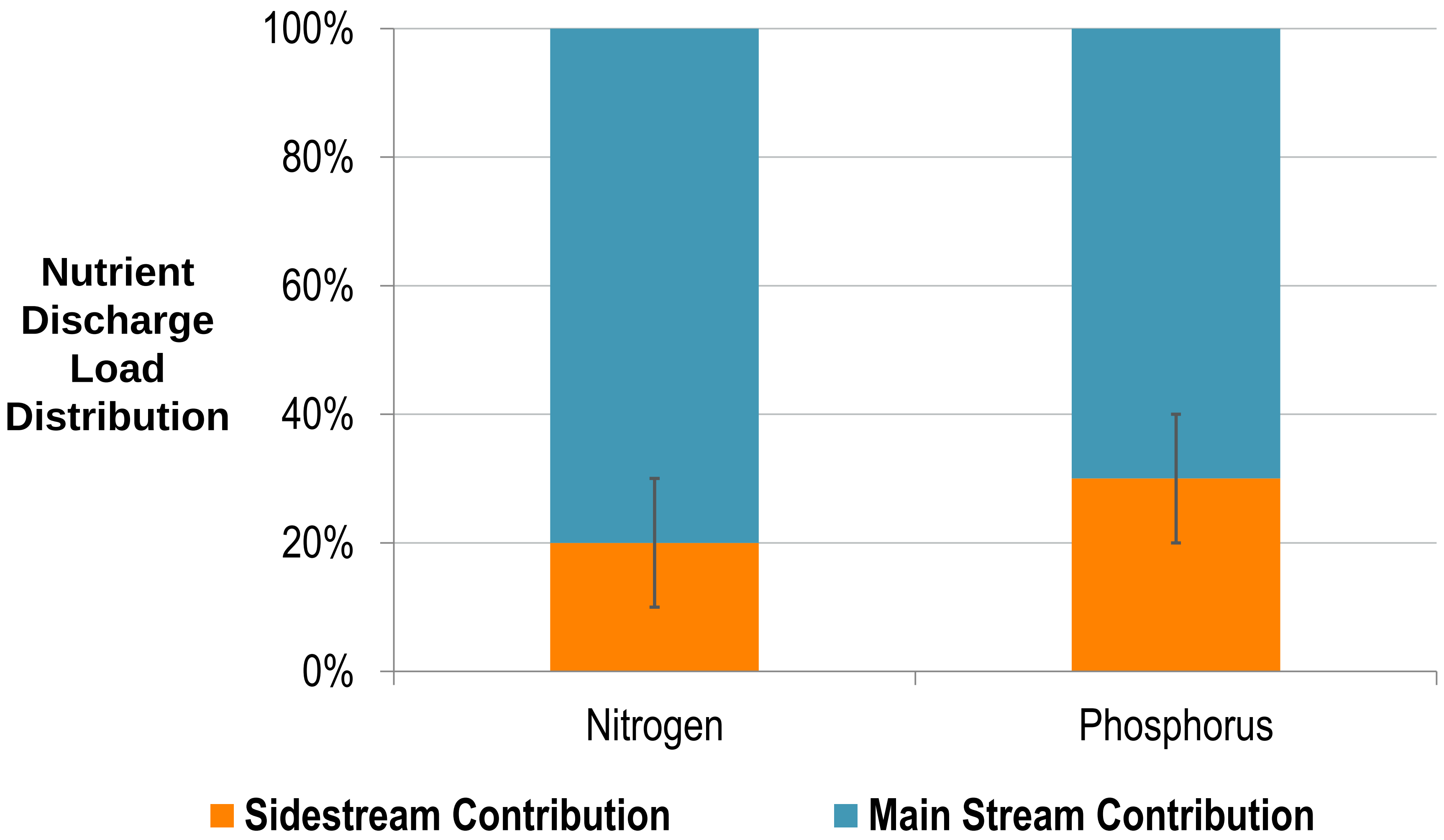
Optimization Potential

Concept	Nutrient	Removal Percentage, %	Comment
CEPT	Total P	65 to 85	• Limited to ortho-P Removal • Removal a function of chemical dose
Bio-P	Total P	65 to 85	• Limited to ortho-P Removal • Struvite concerns
Nitrify in Trickling Filters	Ammonia	5 to 50	• Needs >1 TF • Limited by loading (10 versus 150 lb/c/cf) • Ability to control loading between TFs
Seasonal Nitrification	Ammonia	25 to 85	• Difficulty going in/out nit • Depends on whether split or all basins treated (85 if all) • Reduced biosolids/biogas • Foam concerns
Seasonal Nit/Denite	Total N	25 to 50	• Requires anoxic selector (basin mods) • Limited to RAS recycle • Difficulty going in/out nit • Reduced biosolids/biogas • Foam concerns

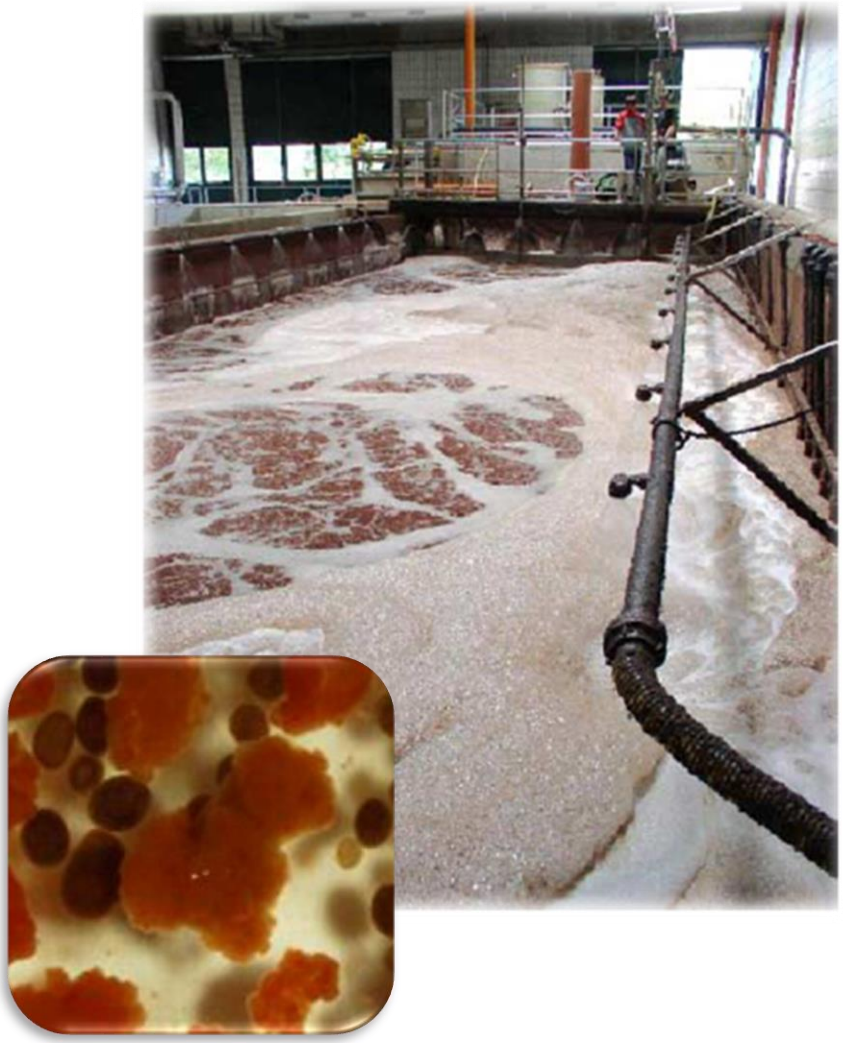
Sidestream Treatment



Typical Sidestream Load Contributions



Sidestream Treatment - Deammonification Technologies



- Benefits
  - Anaerobic Environ. (low energy)
  - Oxygen savings (60%)
  - Alkalinity savings (60%)
  - No external carbon source
  - Compact footprint

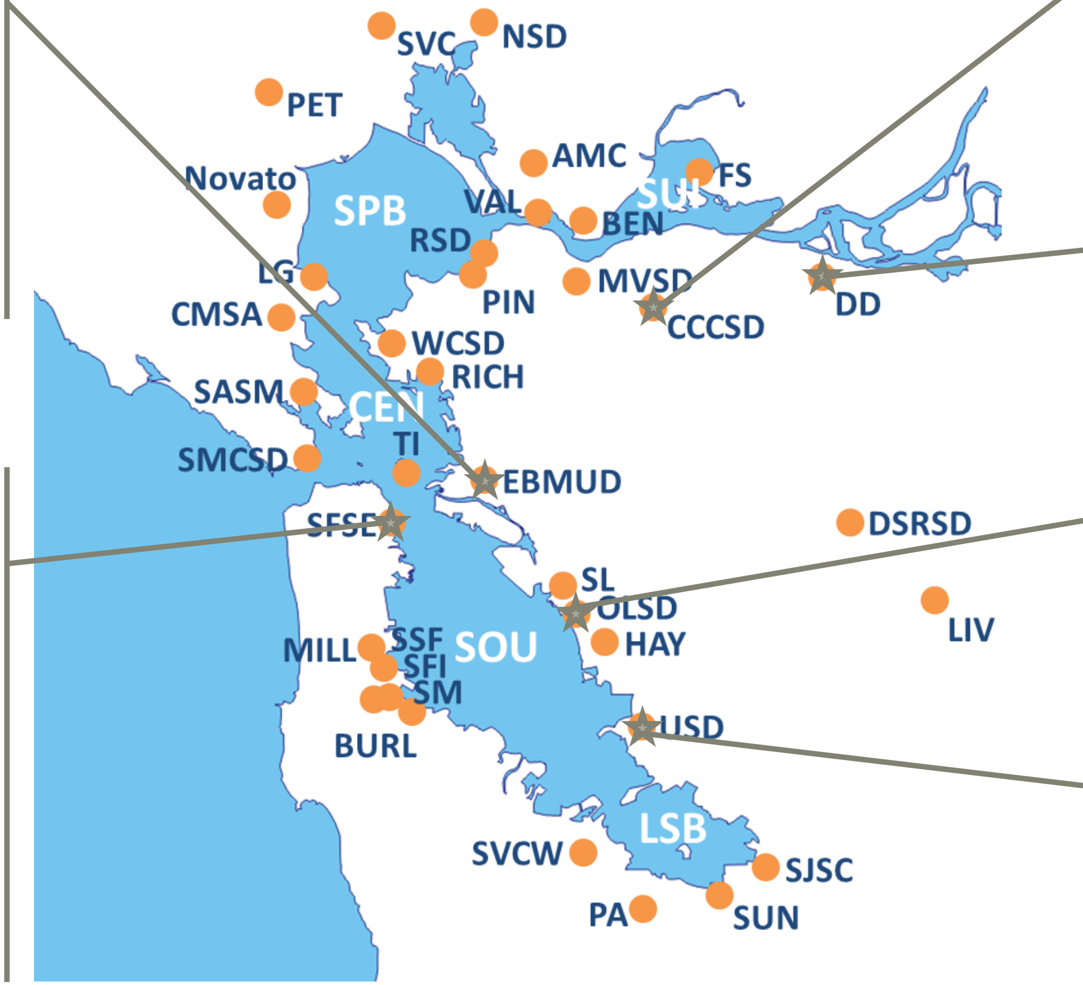
EPA Grant – Piloting Efforts

EBMUD:
Deammonification
- Suspended growth
- Attached growth

Completed

SFPUC:
Deammonification
- Suspended growth
- Attached growth
- Biozeolite

On-going



CCCSD:
Zeolite/
Anammox
On-going

DD:
CANDO
Completed

OLSD:
Zeolite/
Anammox
On-going

USD:
Krüger
AnitaMox™
Completed

CANDO = Coupled Aerobic-anoxic Nitrous Decomposition Operation process, DD = Delta Diablo, OLSD = Oro Loma Sanitary District
USD = Union Sanitary District; SFPUC = San Francisco Public Utilities Commission

Sidestream Treatment

Anaerobic Digestion & Dewatering?

No → Not Applicable

Yes ↓

<u>Water Quality</u>
Temperature > 30 C
NH4 > 500 mg/L
Alk ~ 50% needed

No →

Ammonia Recovery Process (ARP)
Conventional Nitrification to NO3*
Conventional Nit/Denit*

*** May require alkalinity and/or carbon addition**

Yes ↓

Deammonification
Nitrite Shunt
CANDO
Ammonia Recovery Process (ARP)
Conventional Nitrification to NO3*
Conventional Nit/Denit*

Sidestream Findings

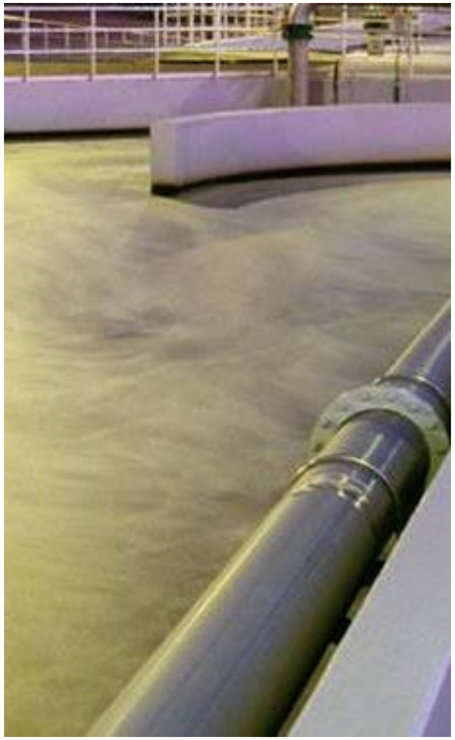
- 32 out of 37 plants are potential candidates for sidestream treatment
- Additional sampling:
  3 samples collected/analyzed in July 2015
- Most smaller plants were not aware of nutrient load contributions from sidestream treatment
- Most plants are candidates for deammonification technologies
- Examples from site visits:
  - Flow management
  - Conventional nitrification
  - Deammonification
  - Steam stripping

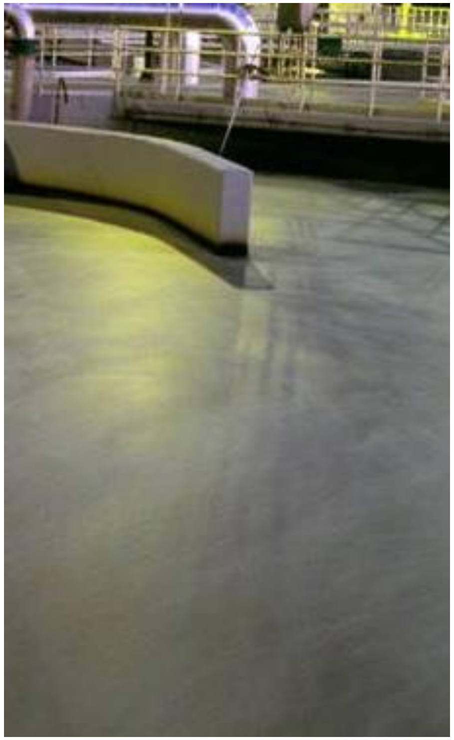
Sidestream Treatment Costs

Source	Unit	Cost (Capital)	Annualized O&M Cost[1]	Cost (Capital + O&M)[1]	Configuration
Regional San	$/lb N	0.6	0.8	1.4	Conventional Nit (SBR)
HRSD	$/lb N	0.5 - 0.7	0.4	0.9 - 1.1	DEMON[1,2]
HRSD	$/lb N	0.5 - 0.6	1.0	1.5 - 1.6	Nitritation/Denitritation[1]
HRSD	$/lb N	0.3 - 0.8	1.3	1.6 - 2.1	Bioaugmentation(e.g., BABE)[1]
DC Water	$/lb N	0.4	Not available	--	DEMON®[3]

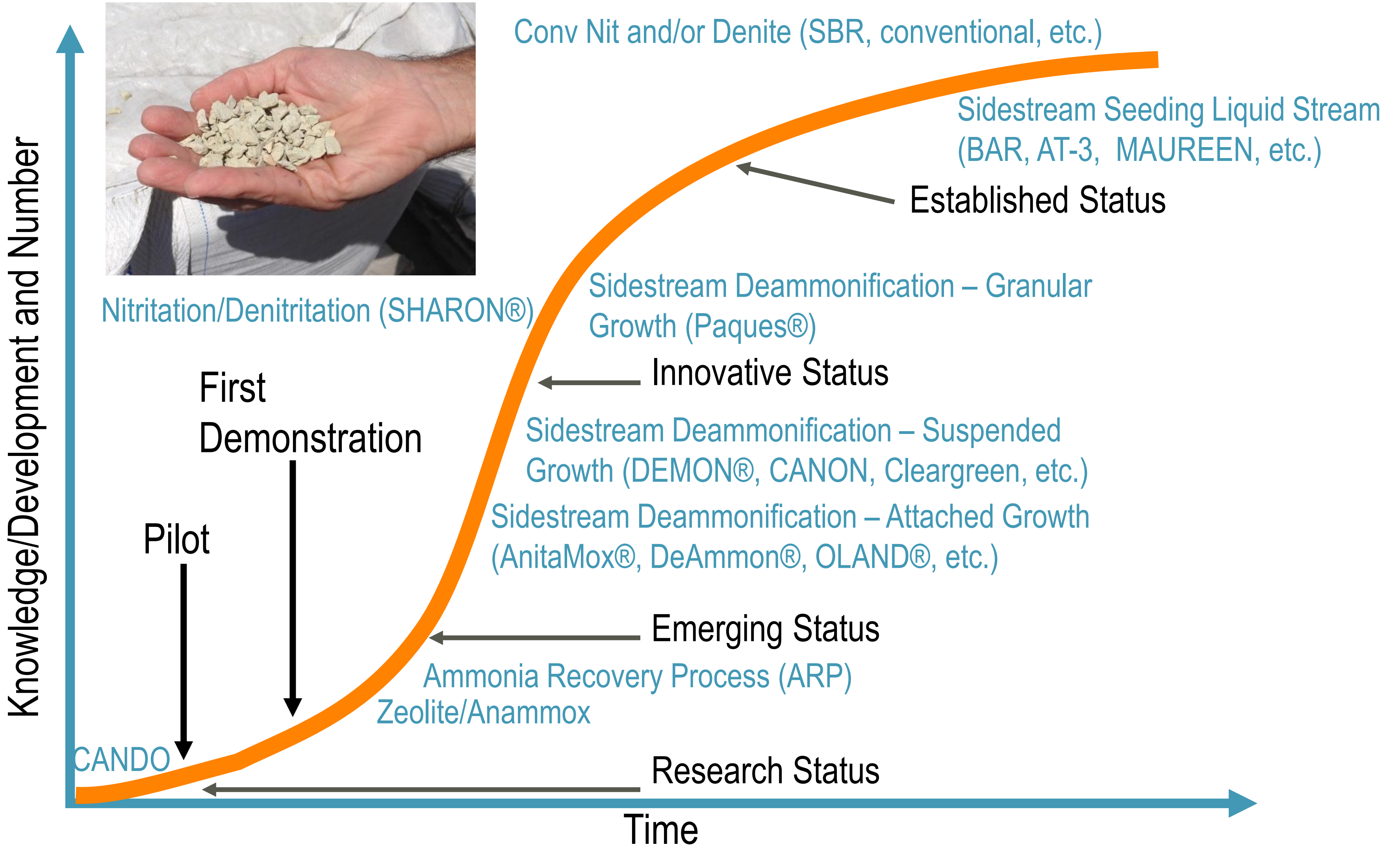
1 Economics based on 20 years, 5% cost of financing, and 3% cost of inflation
2 Installations/Studies at Hampton Roads Sanitation District (HRSD), Norfolk, VA
3 Dilution water required to dilute high strength loads from CAMBI® process

WRRF Upgrades



Utilize Established Technologies to Determine Cost and Footprint Sizing

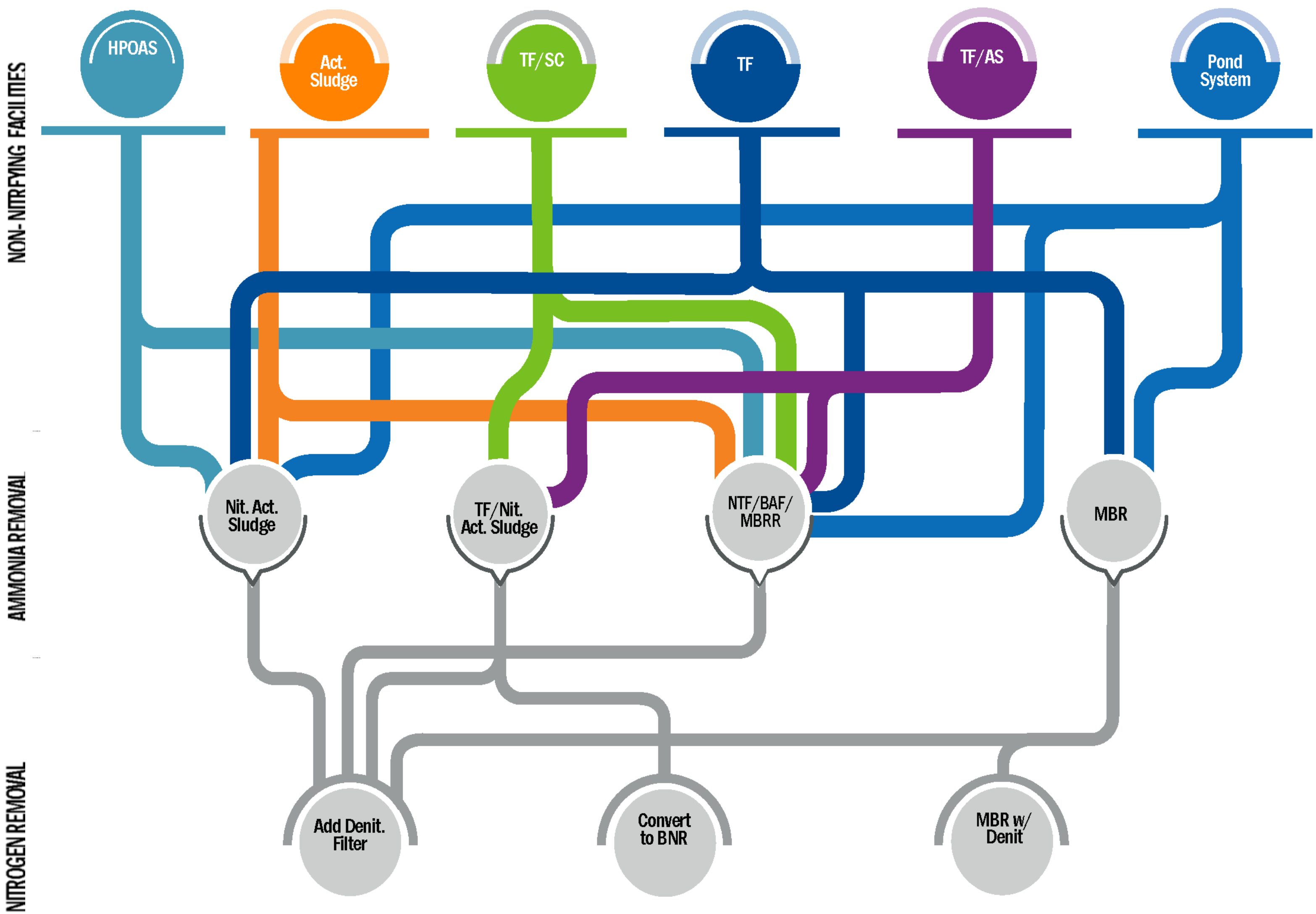


Adapted from Tetra Tech (2013) and Parker et al. (2011)

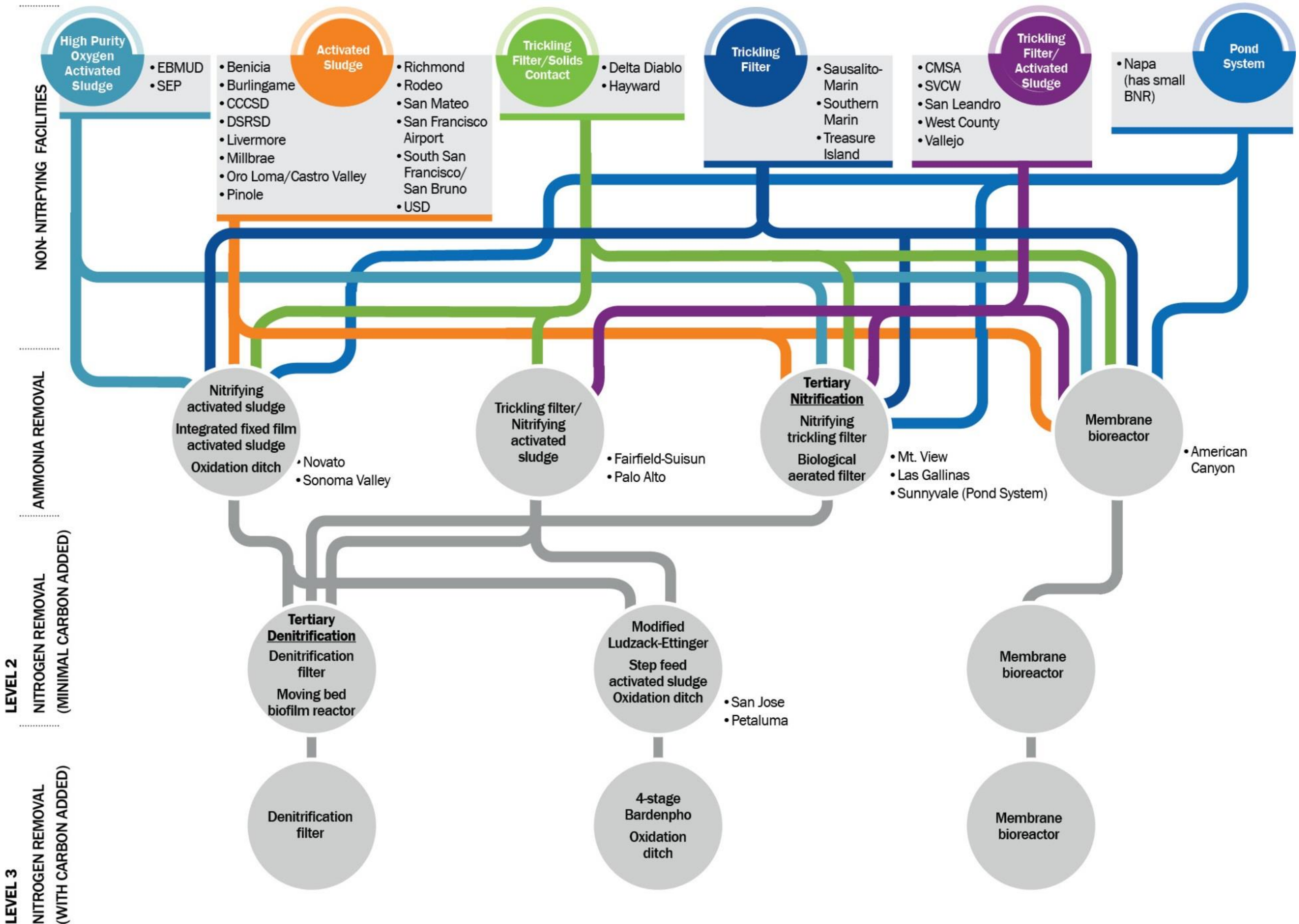
Approach to Plant Upgrades

Approach to Plant Upgrades

Approach to Plant Upgrades



Approach to Plant Upgrades



Upgrades Findings

- In general, the upgrade recommendations followed the proposed approach
- Site constraints are a major issue
- Plant Staff Feedback:
  - Interest in selecting a technology for future recycled water, in particular IPR
  - Concern over selecting a technology that would be obsolete once implemented
  - Concern about nutrient targets during peak storm flows.
  - Concern regarding role of water conservation on reaching the nutrient targets.
  - Delaying upgrades until the nutrient picture is clearer.

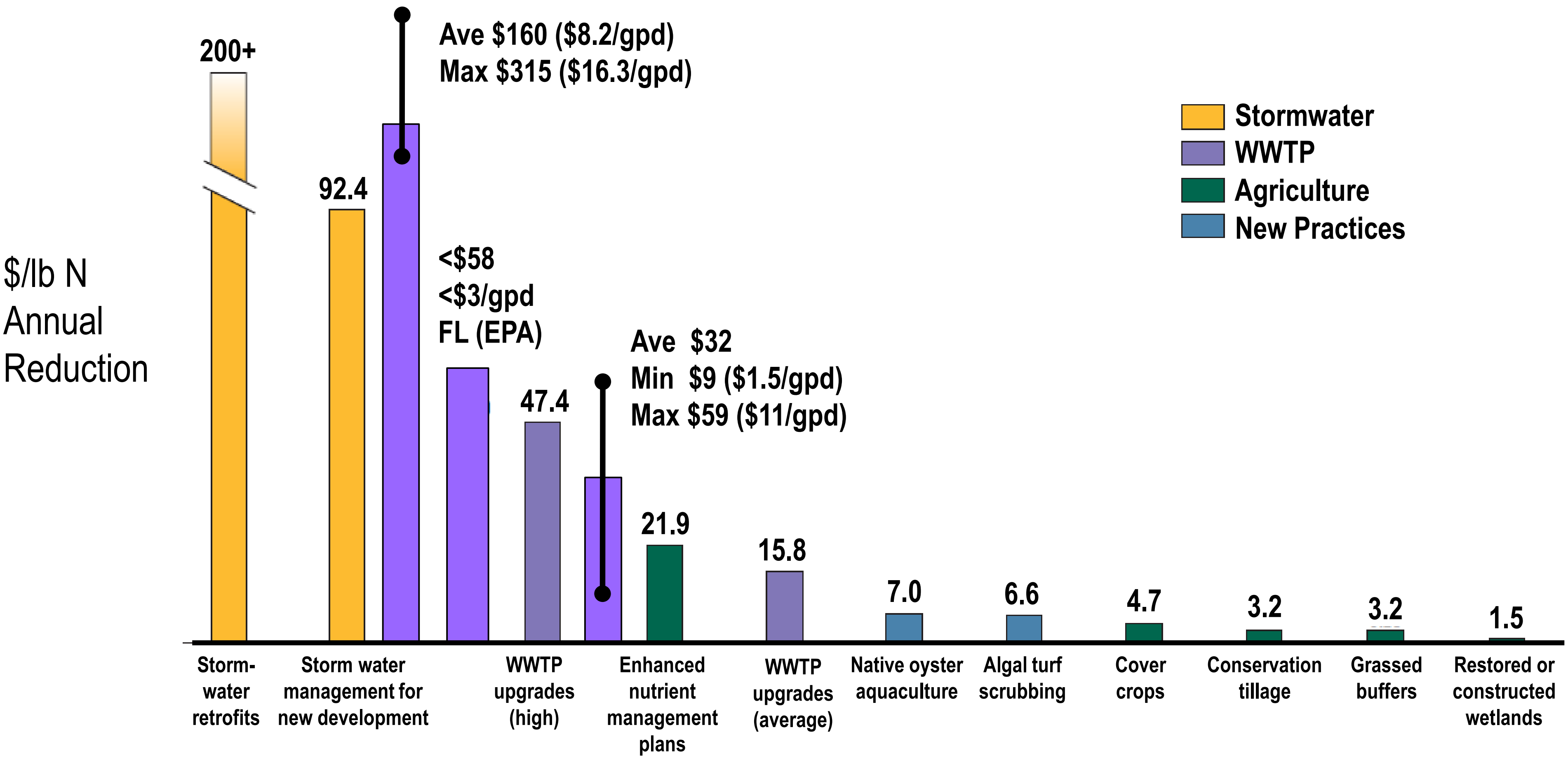
Upgrade Costs

Location	Unit	Cost (Capital)	Annualized O&M Cost[1]	Cost (Capital + O&M)[1]	Configuration
Regional San	$/lb N	0.8			Conventional MLE (Limited to Aeration Basin)
Bay Area Master Plan	$/lb N	2.5			Conventional MLE
Bay Area Master Plan	$/lb N	3.1			Membrane Bioreactor
Central Valley Planning	$/lb N	0.8			Denite Filters
HRSD (Retrofit)	$/lb N	0.9 - 1.6	1.7 - 1.8	2.7 - 3.3	5-stage Bardenpho + Denite Filters

No Net Loading – Awaiting Completion of First Group Annual Report

Nutrient Removal By Other Means

Nutrient Removal By Other Means Example



Sources: USEPA and Abt Associates, 2009; Wieland et al., 2009; MDNR, 2008; Stewart, E.A., 2006; WRI analysis using WWTP upgrade costs from MDE and VDEQ; Carollo (2010); HDR (2011)

Regional Board Submittal

- Optimization and Sidestream: No Nutrient Targets
  - Optimization Strategies
  - Capital and O&M Costs
  - Adverse and Ancillary Benefits
  - Nutrient Reduction and Unit Costs
    (e.g., $/lb nutrient; lb GHG/lb nutrient)
- Upgrades: Select Technology for Levels 2 and 3
  - Same as Optimization plus Footprint Requirements
  - ID Emerging Technologies for the Future Consideration
- Nutrient Removal By Other Means:
  - Compile previous reports

Sample Report - Optimization

Strategy	Capital Elements	Operating Elements	Cost
1: Optimize CEPT for P removal	None	Increase ferric and alum dose (bench test results)	Low
2: Seasonal nitrification by increasing SRT	None	Decrease WAS pumping to achieve a long enough SRT	Low*
3: Split treatment with trickling filters (1 pair nitrifying; 1 pair BOD removal)	Modifications to the piping at the biotower pumping station	Decrease pumping to biotowers 1 and 2	Medium
4: Increase recycled water	None	Facilities and users are in place	Medium

* Increasing the SRT will require using existing excess capacity and may not be feasible in the long term without significant investment.

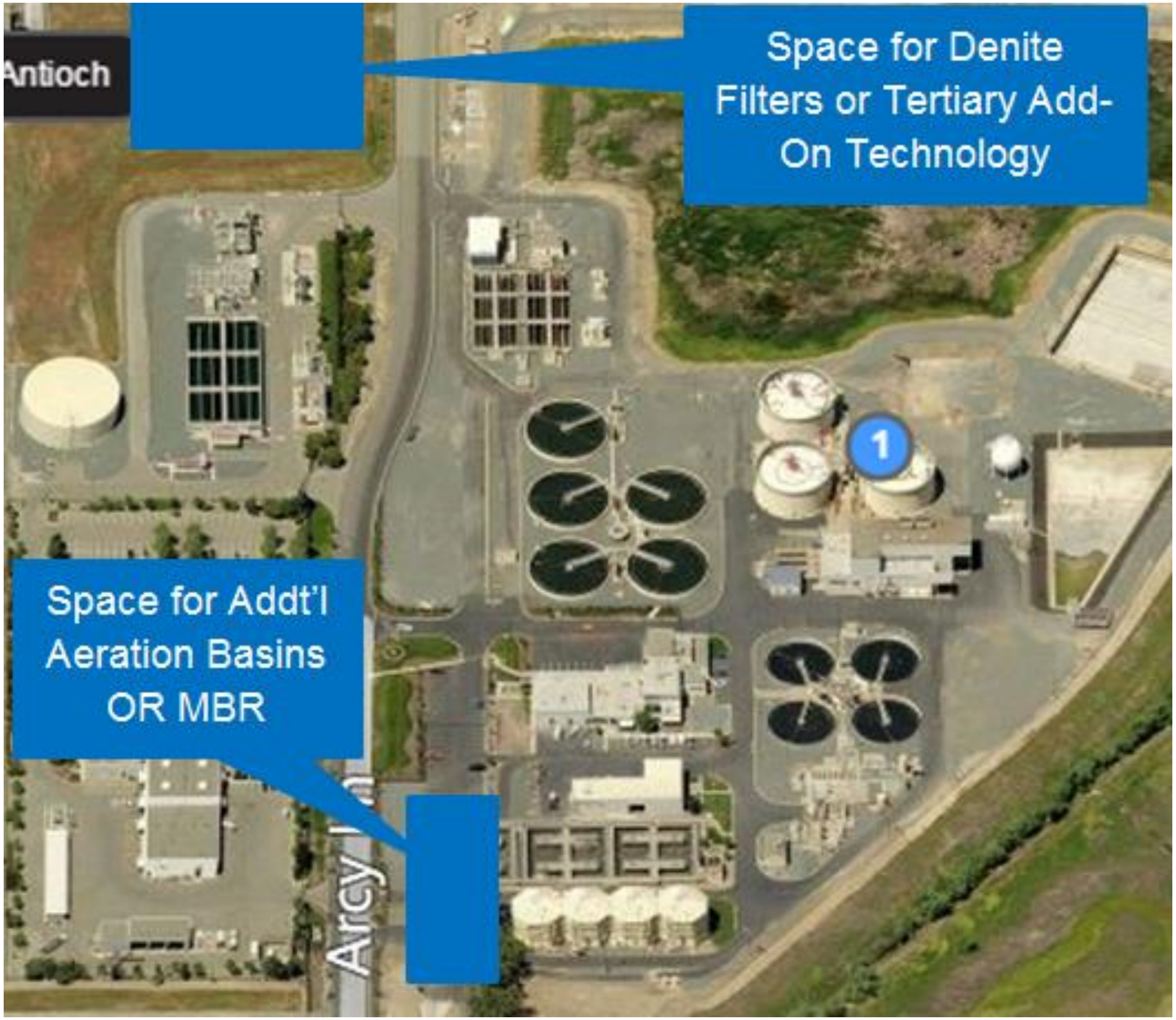
Sample Report – Sidestream Treatment

Construction Elements	Units	Current Conditions	Permitted Capacity
Flows and Loads:			
Flow	mgd	0.10	0.20
BOD	lb/d	210	420
TSS	lb/d	290	580
Ammonia	lb N/d	630	1,260
Flow Equalization	MG	0.03	0.06
Influent Pumping	mgd	0.10	0.20
Deammonification Reactor			
Volume	MG	0.20	0.40
Oxygen Demand	lb O_2/hr	50	100
Blower Power	hp	30	60
Alkalinity	lb/hr as $CaCO_3$	--	--

Plant Upgrades

- Level 2:
  - Parallel Membrane Bioreactor (MBR)
  - Use Biotowers/Act Sludge for nitrogen removal

- Level 3:
  - Same as Level 2
  - Add denite filters to polish N and P removal



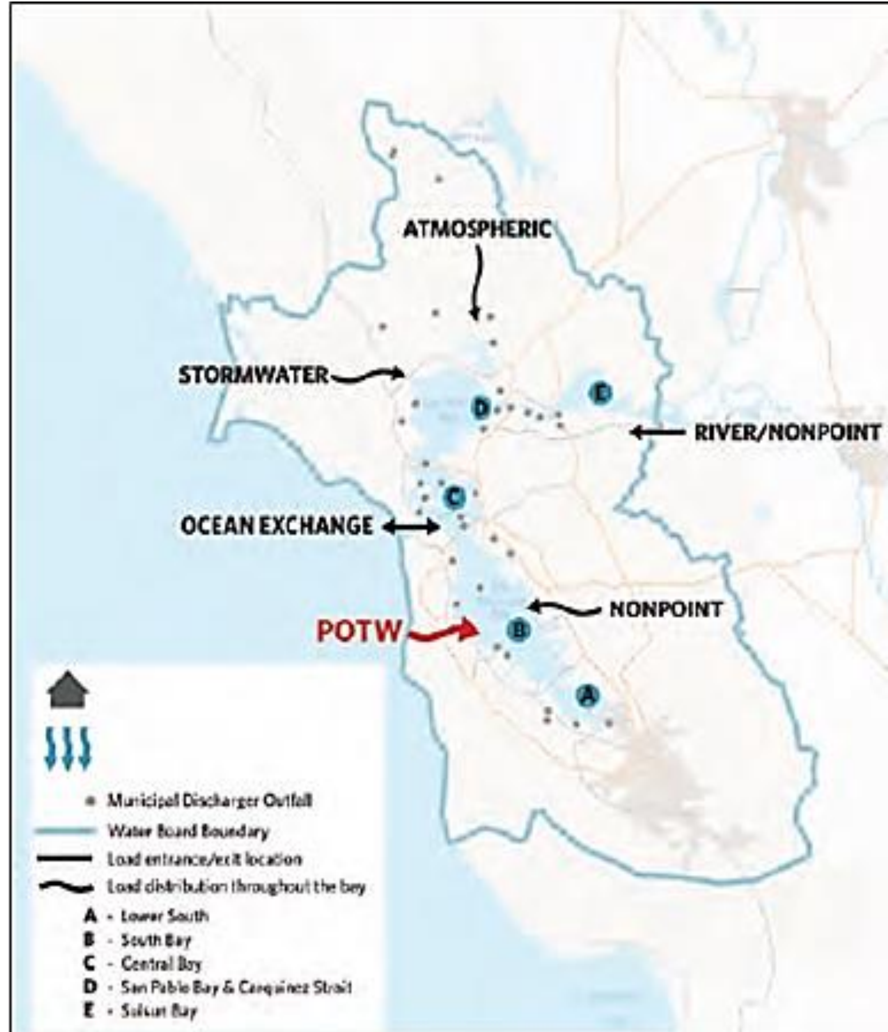
Reduction Through Recycled Water

- Purple Pipe
- IPR/DPR

Summary

Observations

- Each plant has done an exceptional job of working with our team
- Major surprises:
  - Every plant is unique
    (workbook filtered approach does not work)
  - Benefits of having process/ops experts on-site
- Unanticipated issues:
  - Amount of coordination
  - Level of outreach
- Plants are delaying upgrades and rehab work → may increase costs (similar to Chesapeake Bay)
- Plants concerned about PWWF and interested in relaxed discharge requirements
  - Need to explore averaging periods



Next Steps

- Complete the Group Annual Report
  - Draft Submittal: August 31, 2015
  - Final Draft: September 17, 2015
  - Water Board Submittal: October 1, 2015
- Complete the Site Visits
  - September 2015
  - Finalize Site Visit Forms
- Continue analysis of optimization, sidestream, upgrades, and NNL recommendations
  - Rolling Through 2015
- Input Needed...
  - Sidestream Candidates need to submit data
  - As we're wrapping up the reports, will need feedback from the POCs
  - Will need buy-off from each agency on findings

HDR