Natural Treatment Opportunities for Nutrient Management in San Francisco Bay

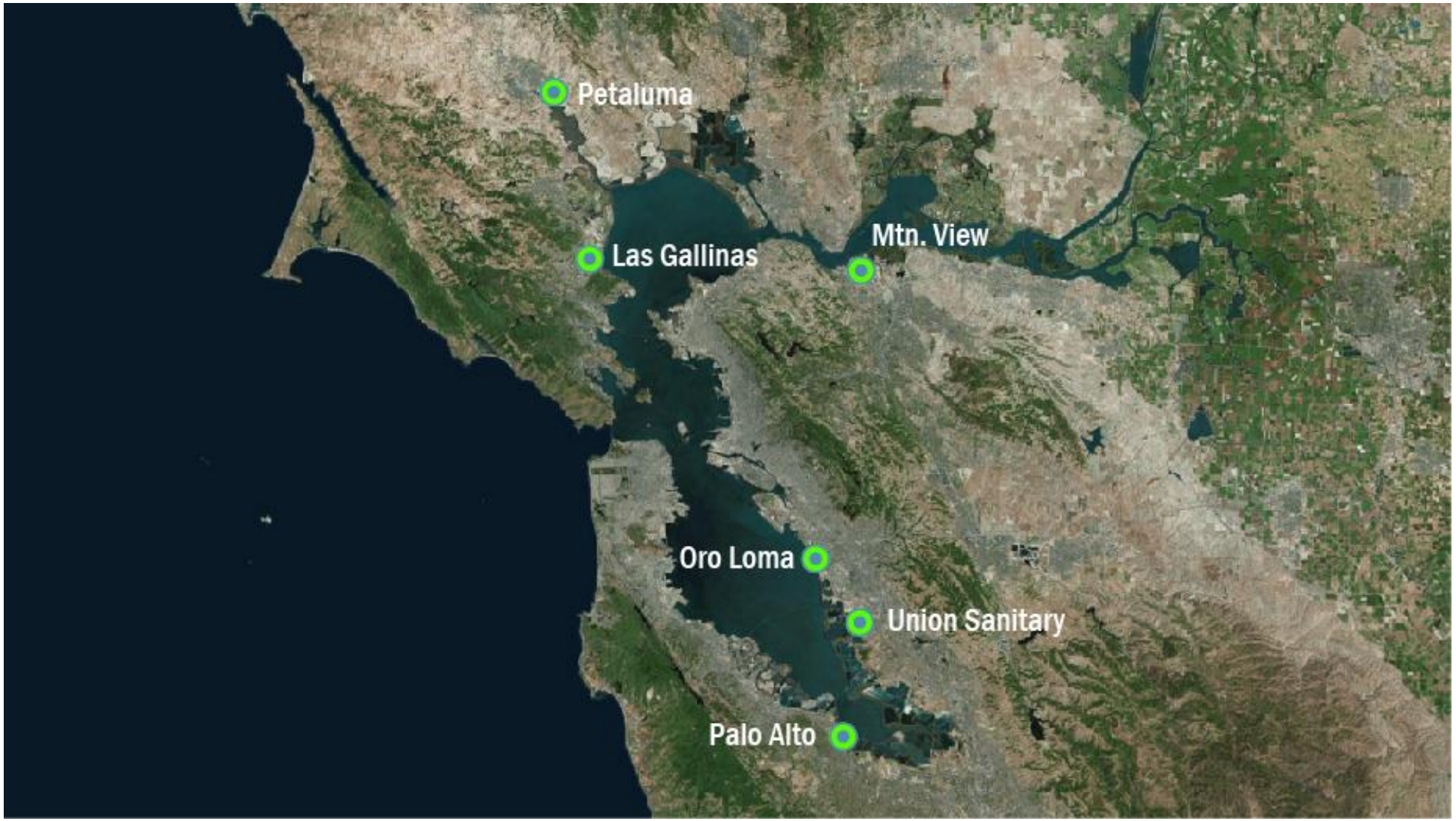
Scoping-Level Opportunities and Constraints Analysis

BACWA Sep 12, 2017 |

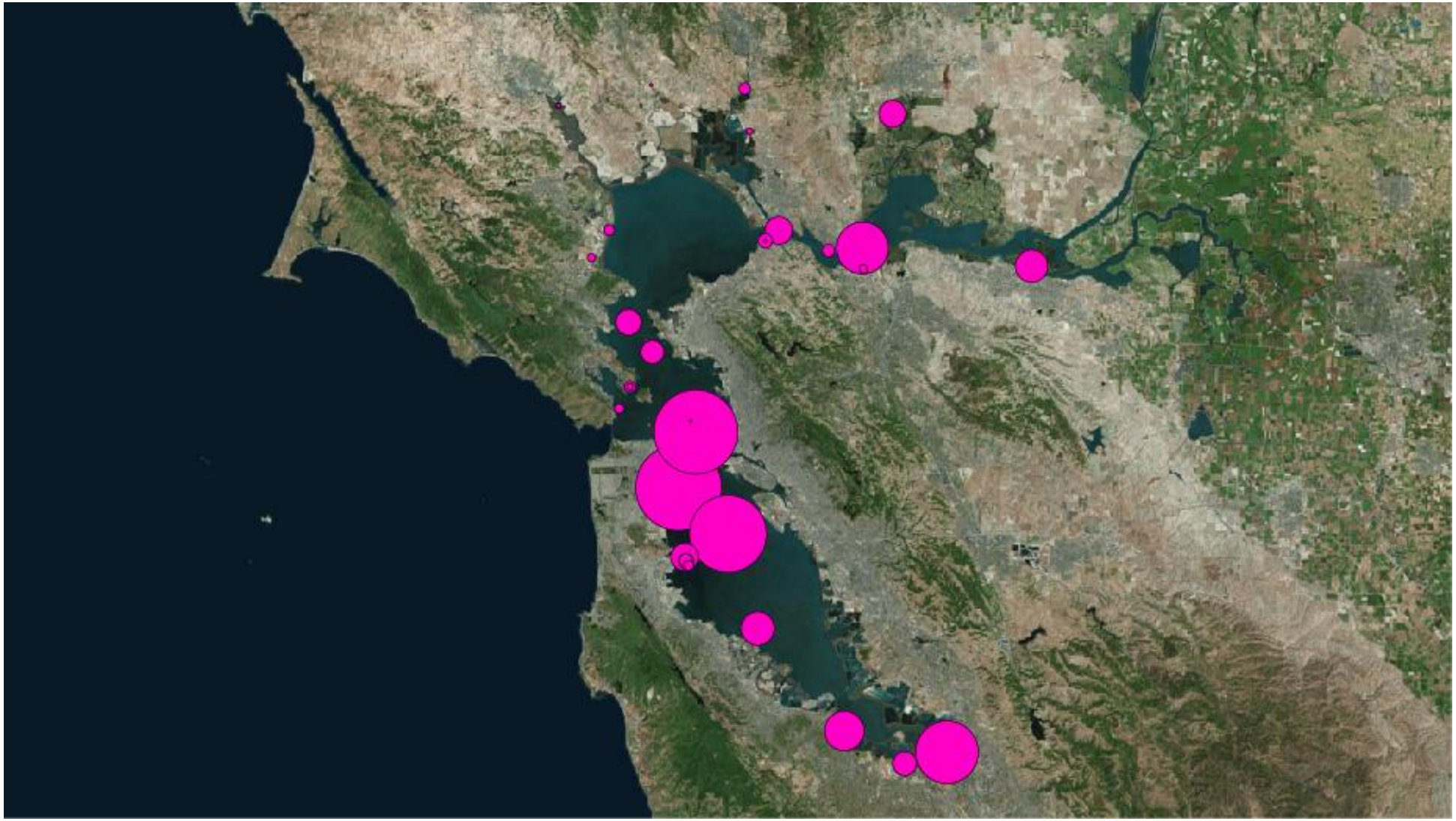
Ian Wren and SFEI

1. Is wetland treatment a viable nutrient management option in SFB?
   - Land: Required vs. available
   - Removal efficiency
   - Cost
2. What are the other major considerations?
   - Synergistic vs. Antagonistic
   - Regulatory
   - Governance

Wetland treatment/discharges are already happening…



Annual Average Total N Loading

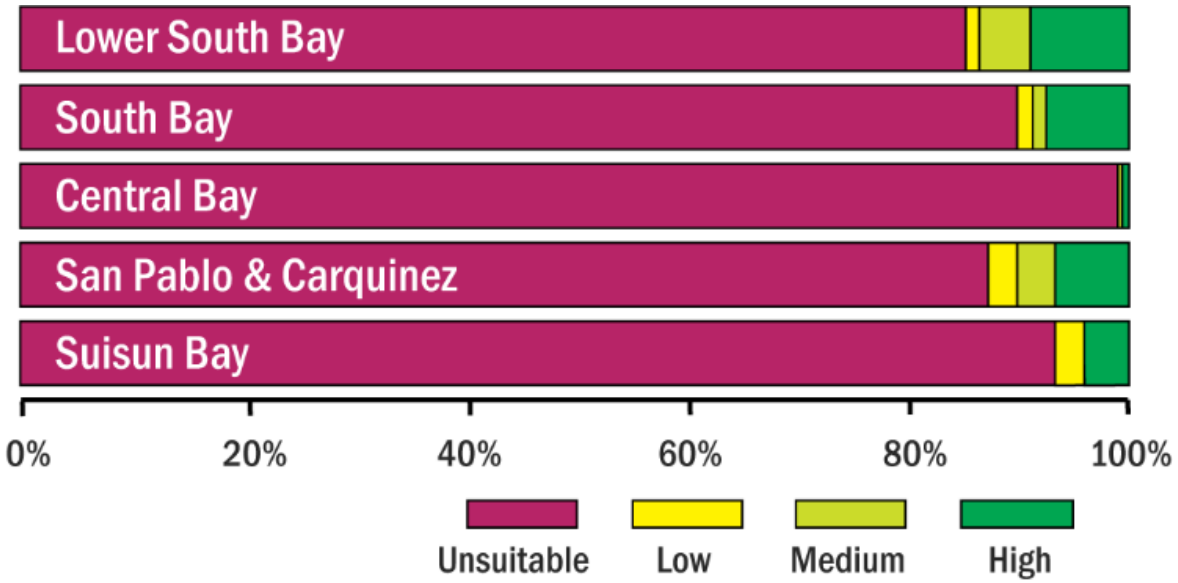


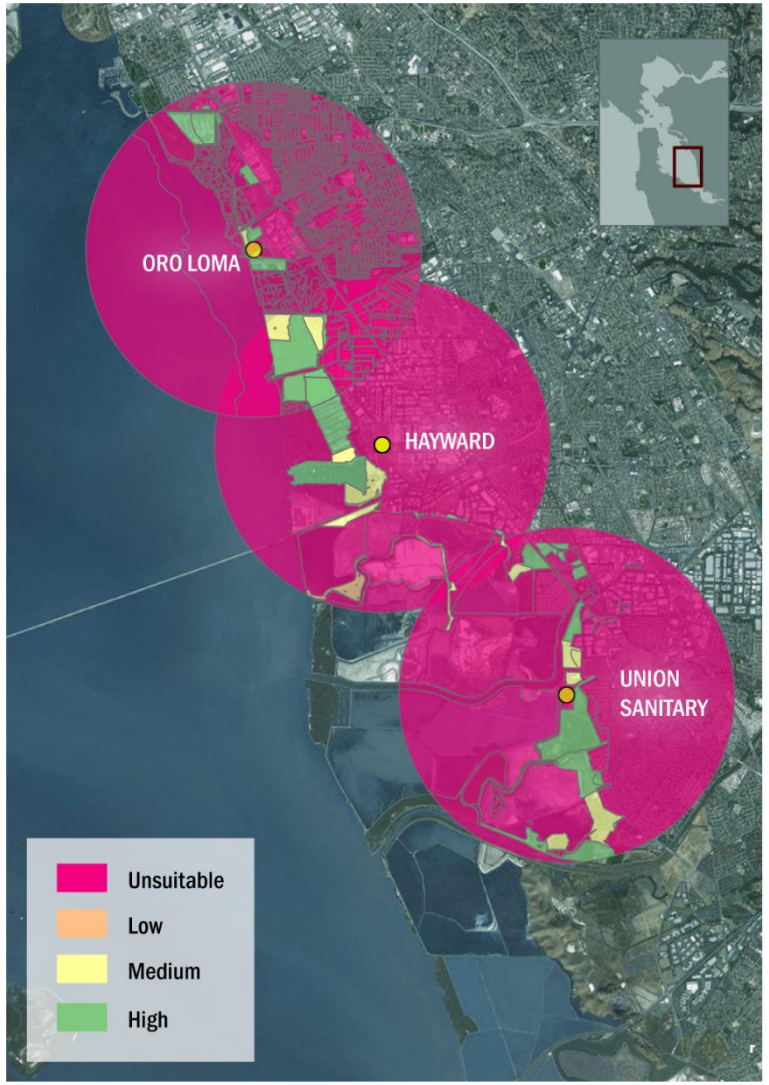
STEP 1: What's Available w/in a 2-mile radius?

Rank	Example Habitat Types
Unsuitable	intact tidal marsh, existing developed lands, open bay
Low	diked marsh, lagoons, managed marsh
Medium	inactive salt ponds, urban open space, former military lands
High	existing storage and treatment ponds, farmed and ruderal baylands

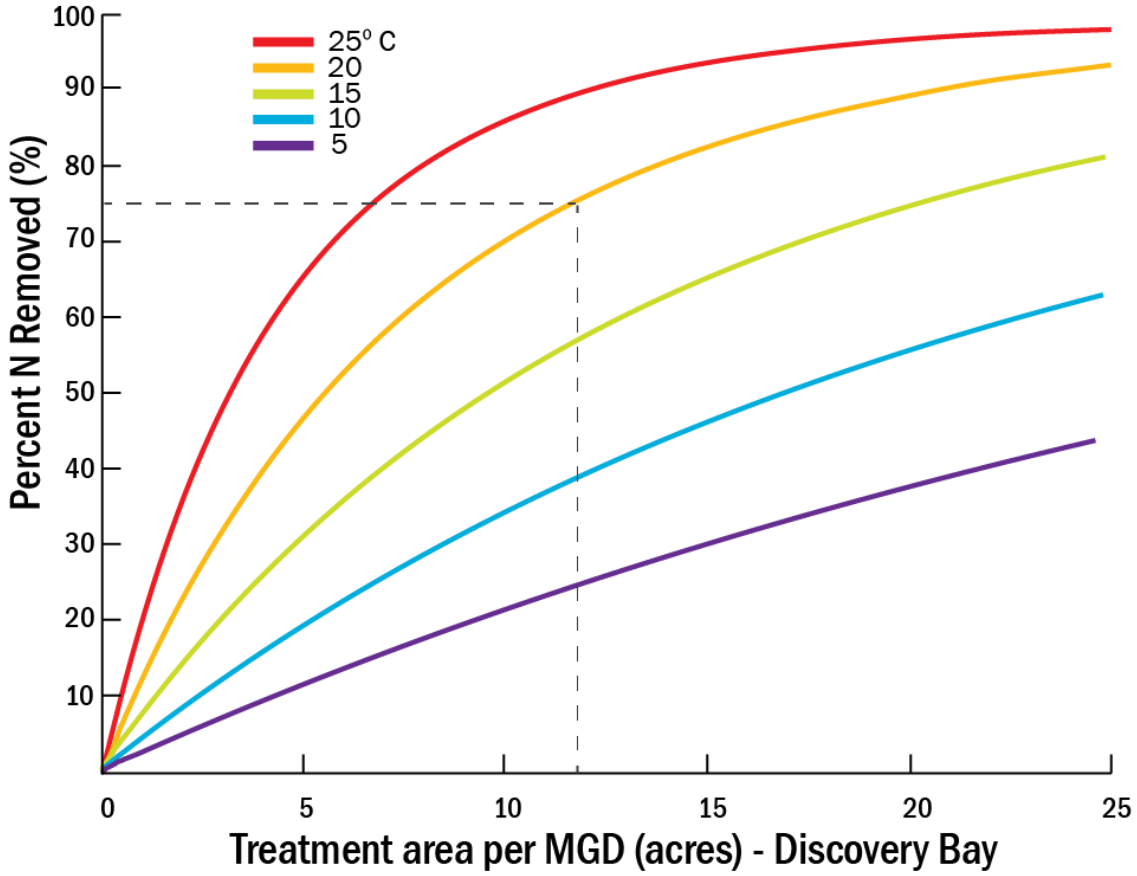
Data Sources: ABAG Land Use, EcoAtlas, BAARI

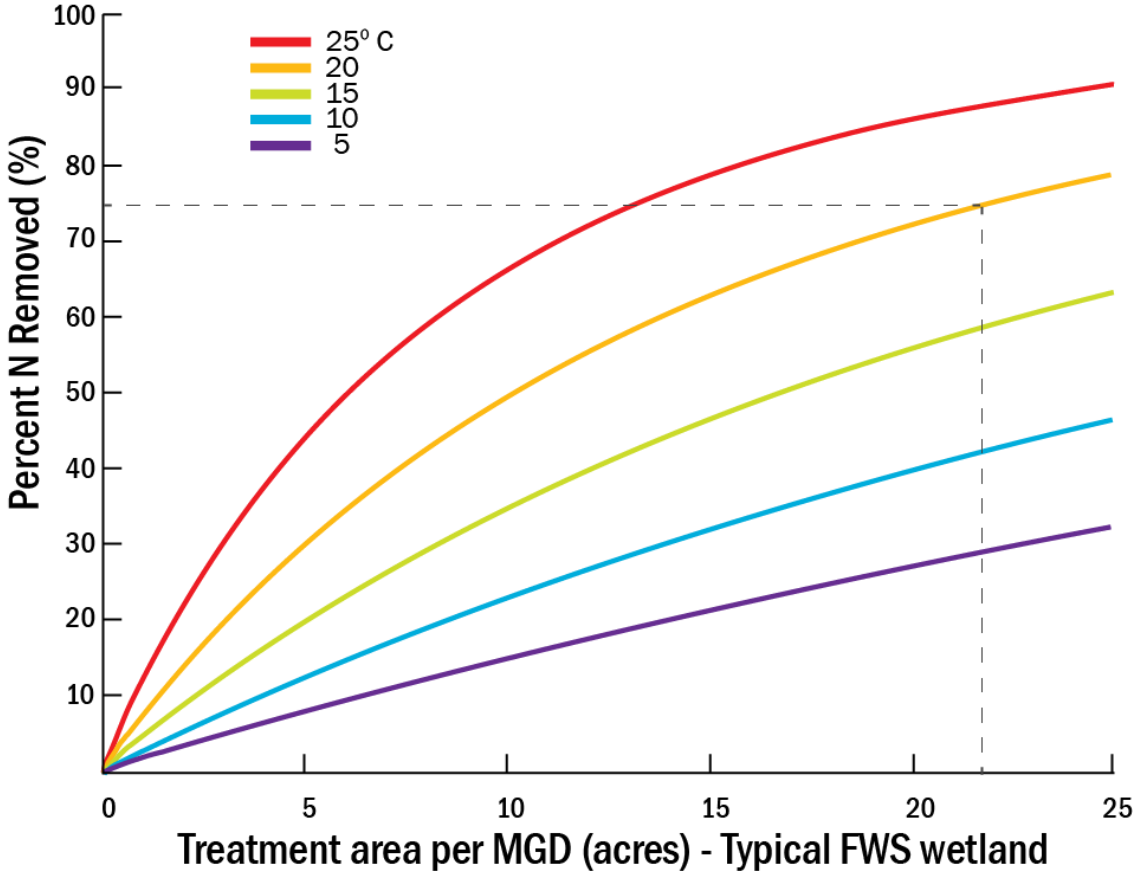
STEP 1: What's Available w/in a 2-mile radius?





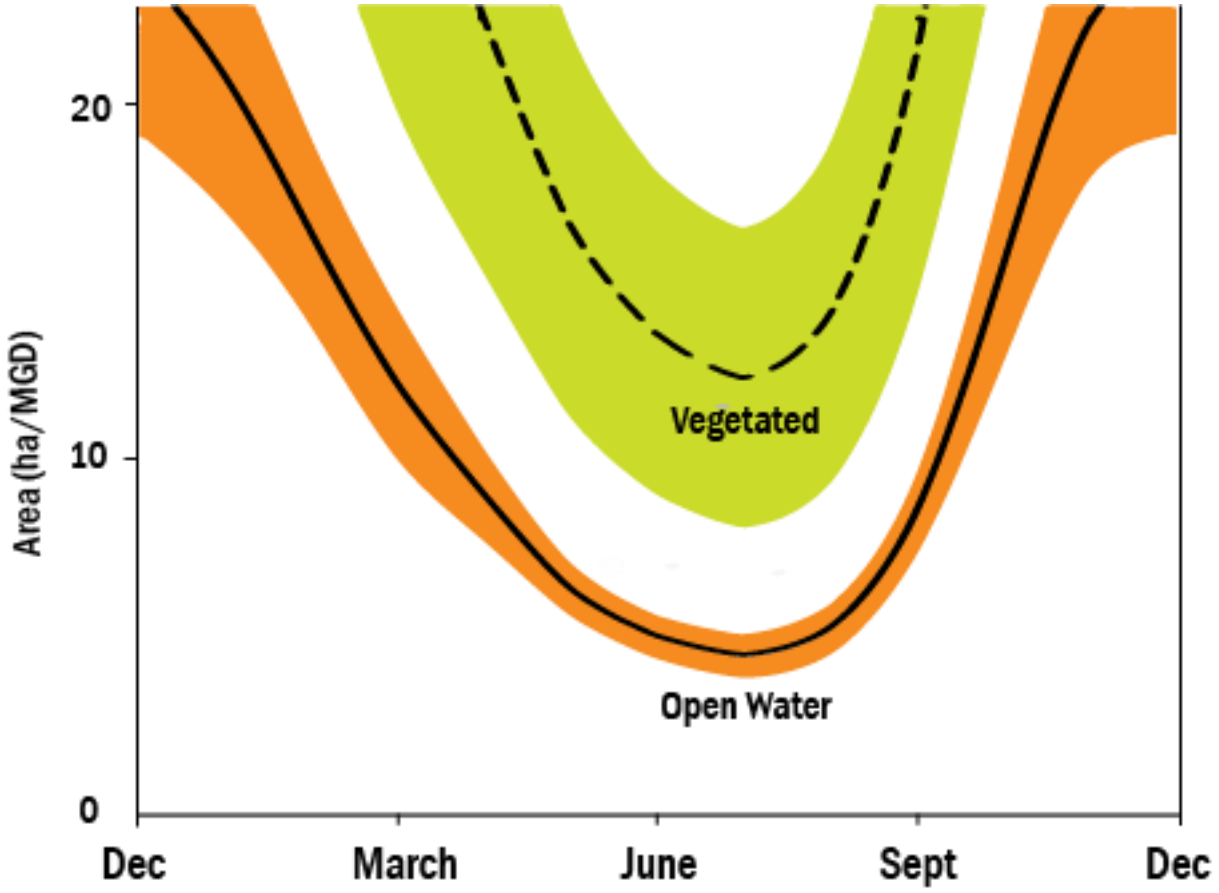
STEP 2: Nitrate Removal Efficiency (It Varies Greatly)





STEP 2: Nitrate Removal Model for Sizing and Effectiveness

- First-order removal – highly temperature sensitive
- Shallow, unvegetated systems more effective than vegetated
- Assuming:
  - Shallow depth (~1 ft)
  - 4-5 day retention under optimized (Discovery Bay) and vegetated (intl. average) conditions
  - Nitrified prior to discharge
  - Constant dry weather temp (21˚C)
  - 40% of potential area not available



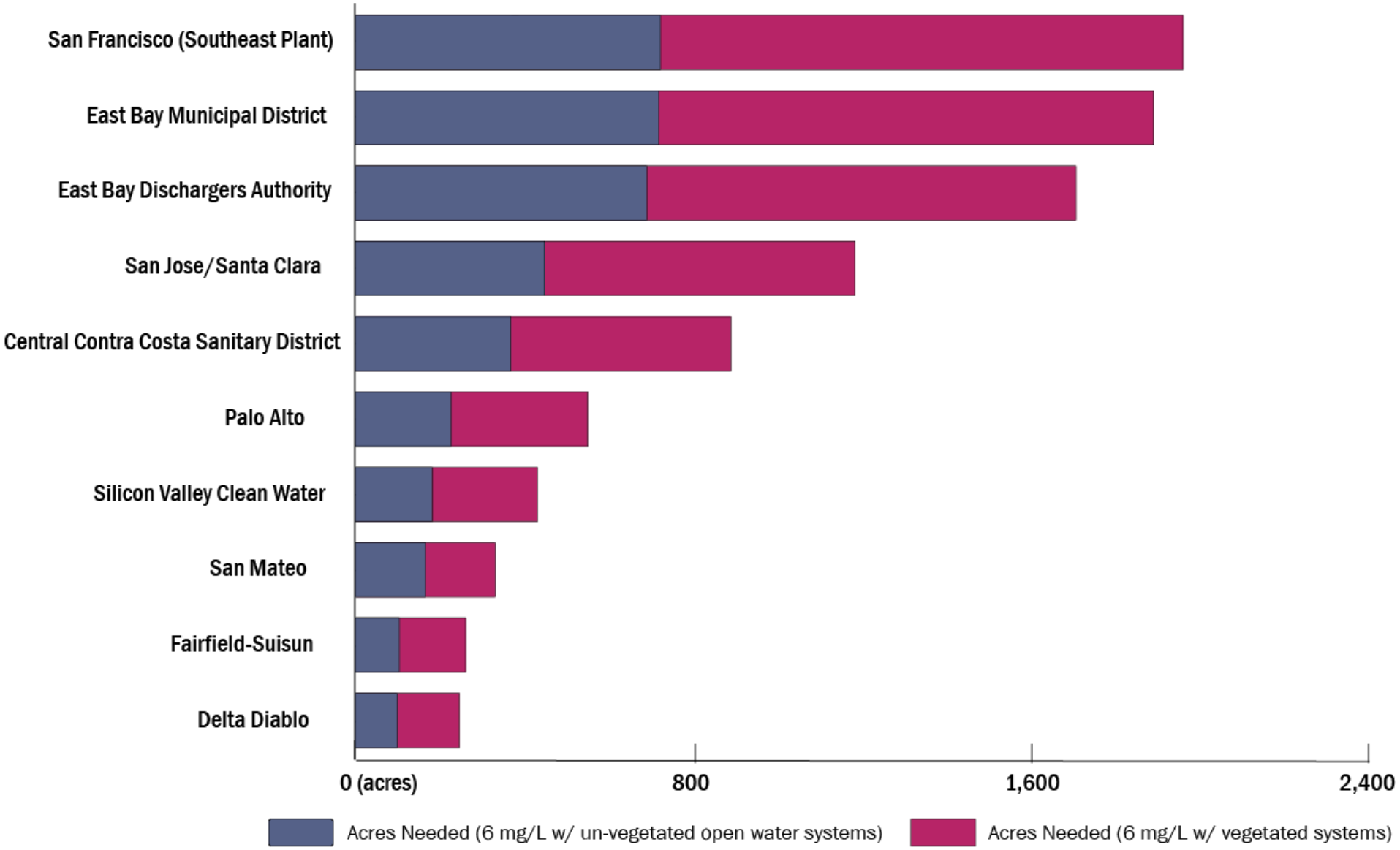
Optimized Un-Vegetated vs. Vegetated

Prado Wetlands, Santa Ana River

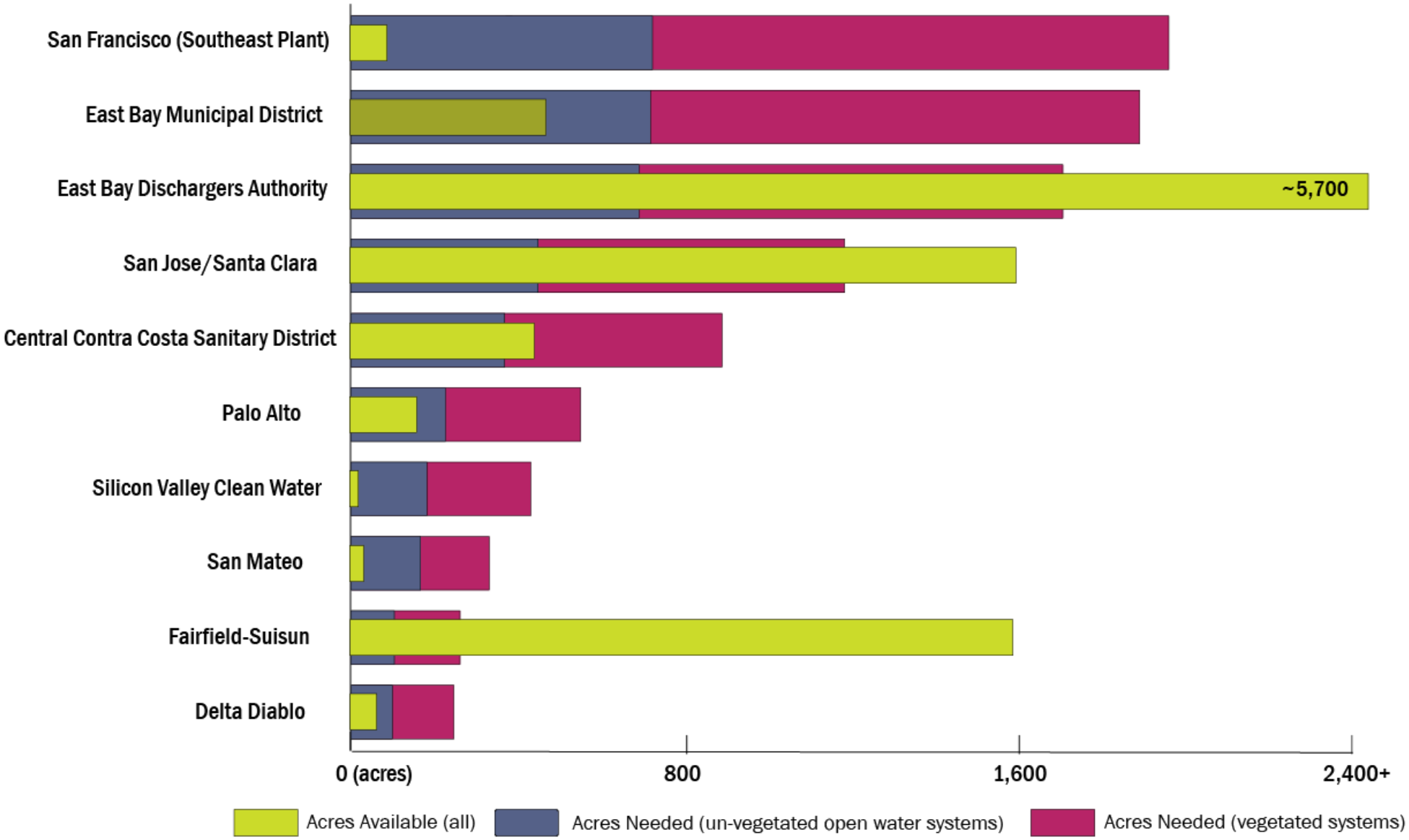
Photo courtesy of David Sedlak, ReNUWIt

Ellis Creek Recycling Facility (Petaluma)

Level 3 Compliance via Wetlands: Shallow Basins vs. Vegetated



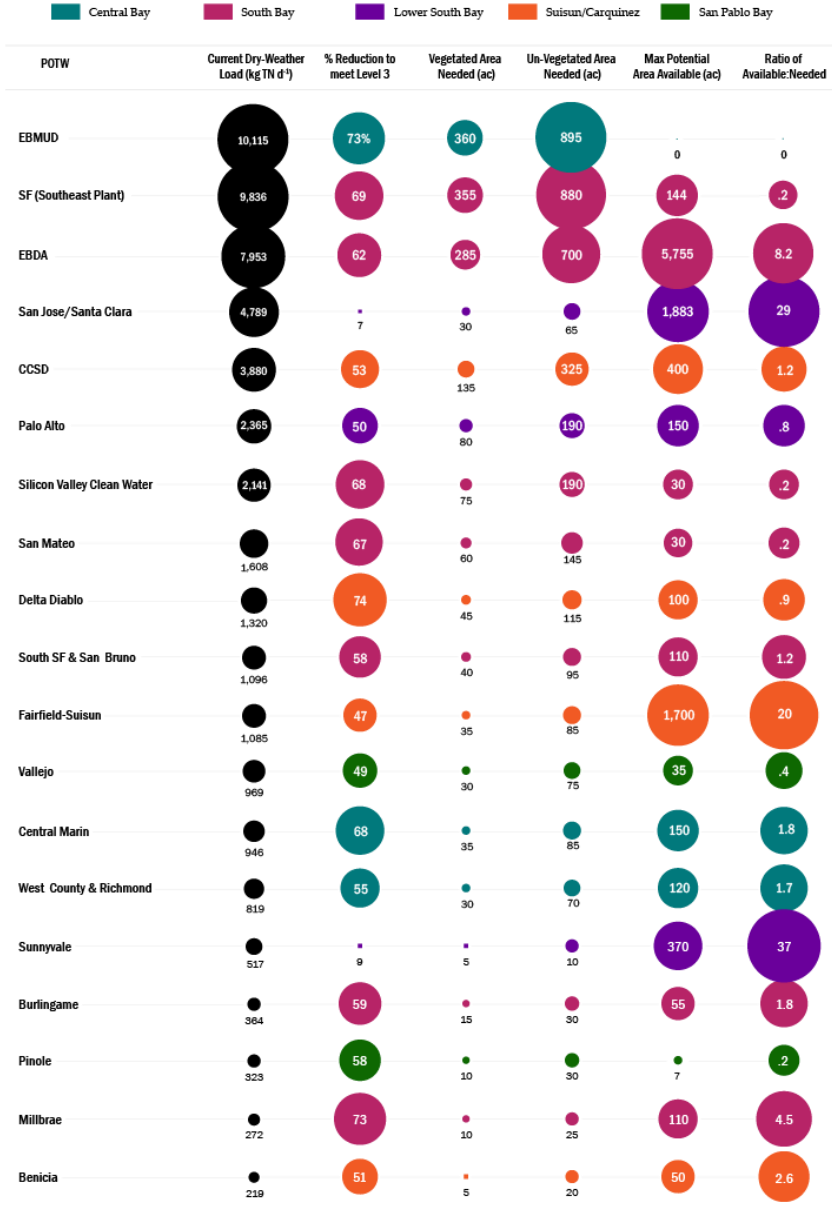
Level 3 Compliance via Wetlands: Shallow Basins vs. Vegetated



DISCHARGER	RATIO OF AREA AVAILABLE TO NEEDED FOR 15 mg/l (VEGETATED)	RATIO OF AREA AVAILABLE TO NEEDED FOR 6 mg/l (VEGETATED)	RATIO OF AREA AVAILABLE TO NEEDED FOR 3 mg/l (VEGETATED)
Mt. View	73.5	29.4	18.4
Sunnyvale	57.2	5.0	2.7
San Jose/Santa Clara	29.0	1.8	1.0
Fairfield-Suisun	20.3	7.5	4.7
East Bay Dischargers Authority	8.2	3.8	2.5
San Francisco International Airport	7.2	3.1	2.2
Millbrae	4.5	2.5	1.7
Benicia	4.2	1.9	1.2
Burlingame	2.9	1.2	0.8
Central Marin Sanitation Agency	1.8	0.9	0.6
West County and City of Richmond	1.7	0.7	0.5
Central Contra Costa Sanitary District	1.2	0.5	0.3
South San Francisco and San Bruno	1.2	0.5	0.3
Delta Diablo	0.9	0.5	0.3

Summary of Wetland Area Needed Versus Available: Level 2 TN Objective

The following 19 POTWs represent the largest dry-weather dischargers ofTotal Nitrogen (TN) to San Francisco Bay. In addition to total TN dry-weather average daily load, this figure shows the percent reduction needed to meet a 6 mg/L TN effluent standard, the estimated acreage needed to acheieve this standard using vegetated and un-vegetated treatment wetlands, as well as the maximum estimated acreage within a 2-mile radius of that could potentially be utilized as treatment wetlands and the ratio of potentially available area to total vegetated treatment wetland area needed.



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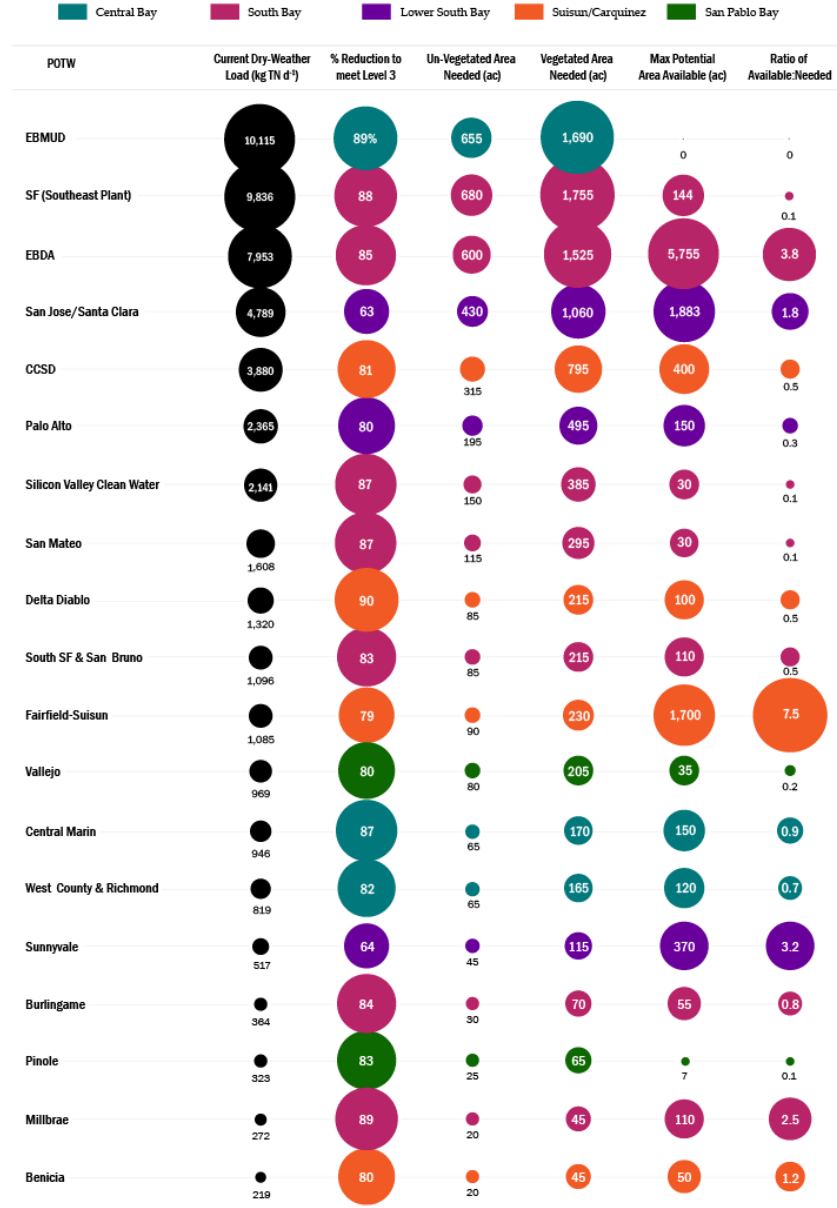

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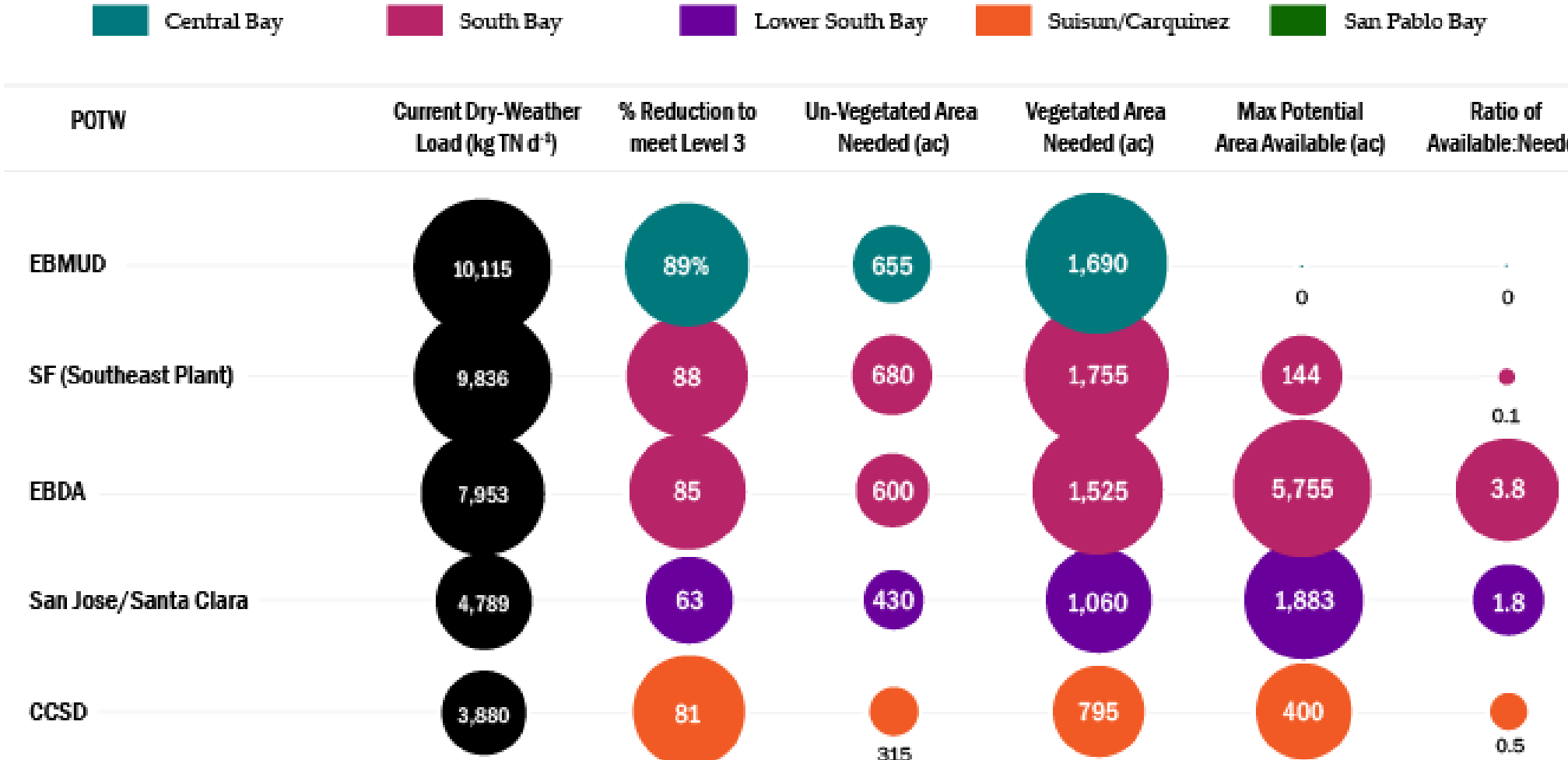

STEP 3: Estimated Cost

Rough estimate provided in Kadlek (2011) for free water surface wetlands on an area basis*:

$$\text{Cost} = 194 * A^{0.690}$$

Where:

Cost = dollars ($1,000)

Area = acres

* Scaled from national 2006 costs to ENR CCI for San Francisco 2017 (12,300)

Estimated cost

TREATMENT OBJECTIVE	TOTAL REGIONAL COST (MILLION)	PER POUND OF NITRATE REMOVED (MIN)	PER POUND OF NITRATE REMOVED (MAX)	PER POUND OF NITRATE REMOVED (MEDIAN)	REGION-WIDE LOAD REDUCTION (%)	AREA UTILIZED (AC)
Level 2 (15 mg/L)	$70	$0.06	$0.90	$0.43	38%	2,075
Level 3 (6 mg/L)	$120	$0.22	$4.23	$0.65	41%	4,500
Advanced (3 mg/L)	$150	$0.22	$4.23	$0.71	45%	6,400

Costs not considered: land acquisition, nitrification (~$1 M/MGD), alkalinity/carbon potential addition, P-removal, contingencies…

Estimated cost

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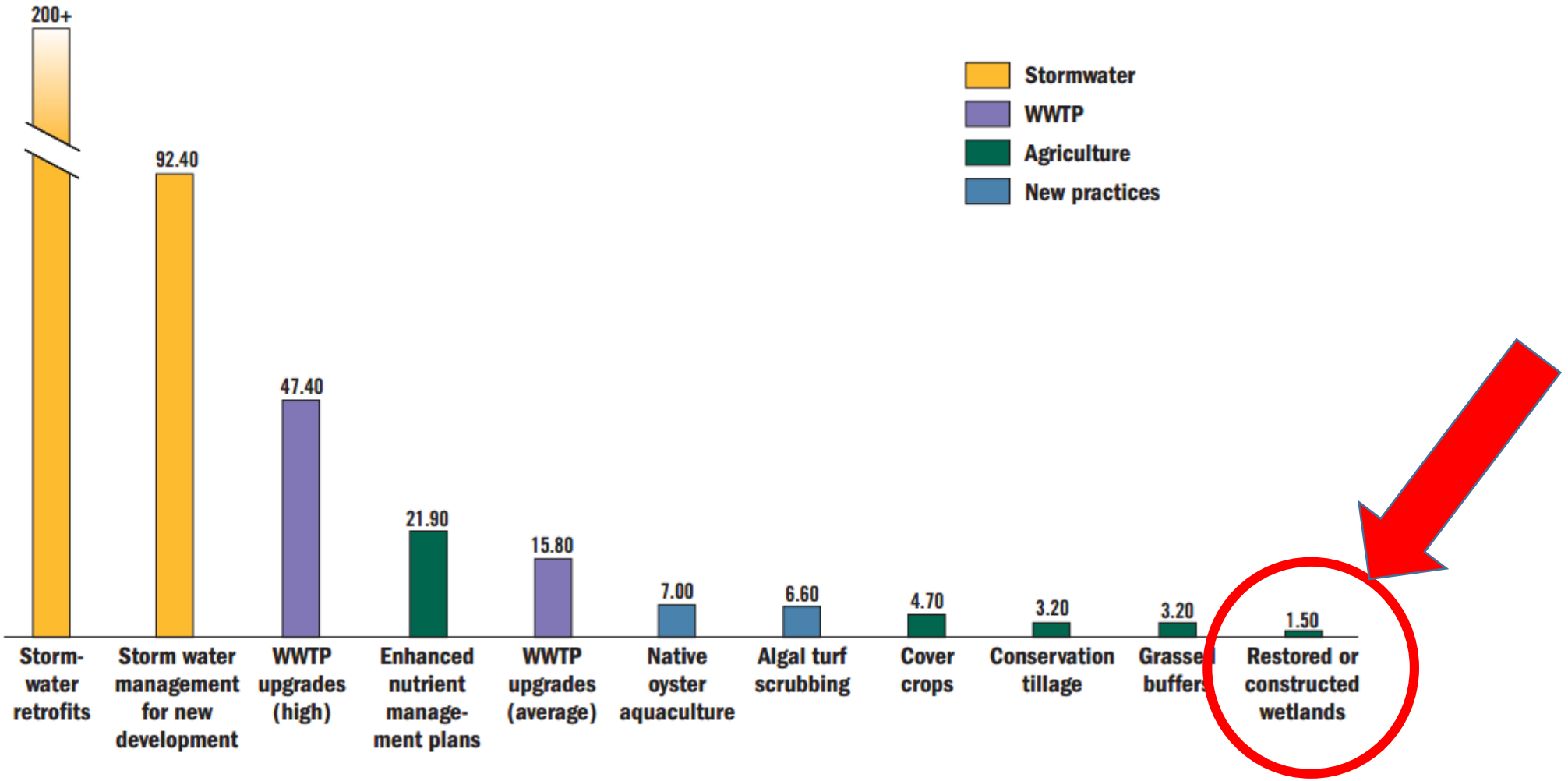
Estimated cost

TOTAL NITROGEN TREATMENT OBJECTIVE	WETLAND TREATMENT			UPGRADES (HDR)		
	TOTAL REGIONAL COST (MILLION)	$/LB NITRATE REMOVED (MEDIAN)	REGION-WIDE LOAD REDUCTION (%)	TOTAL REGIONAL COST (MILLION)	$/LB NITRATE REMOVED (FLOW WEIGHTED AVERAGE)	REGION-WIDE LOAD REDUCTION (%)
Level 2 (15 mg/L)	$70	$0.43	38%	$5,X00	$5.8	58%
Level 3 (6 mg/L)	$120	$0.65	41%	$7,X00	$8.3	83%

Figure 2 | **Nitrogen Reduction Costs Differ Among Sectors and Practices, Creating Economic Opportunities for Credit Trading**

Dollars per pound of annual nitrogen reduction



Source: U.S. EPA and Abt Associates, 2009; Wieland, et al., 2009; MDNR, 2008; Stewart, E. A., 2006; WRI analysis using WWTP upgrade costs from MDE and VDEQ.

Figure 2 | **Nitrogen Reduction Costs Differ Among Sectors and Practices, Creating Economic Opportunities for Credit Trading**

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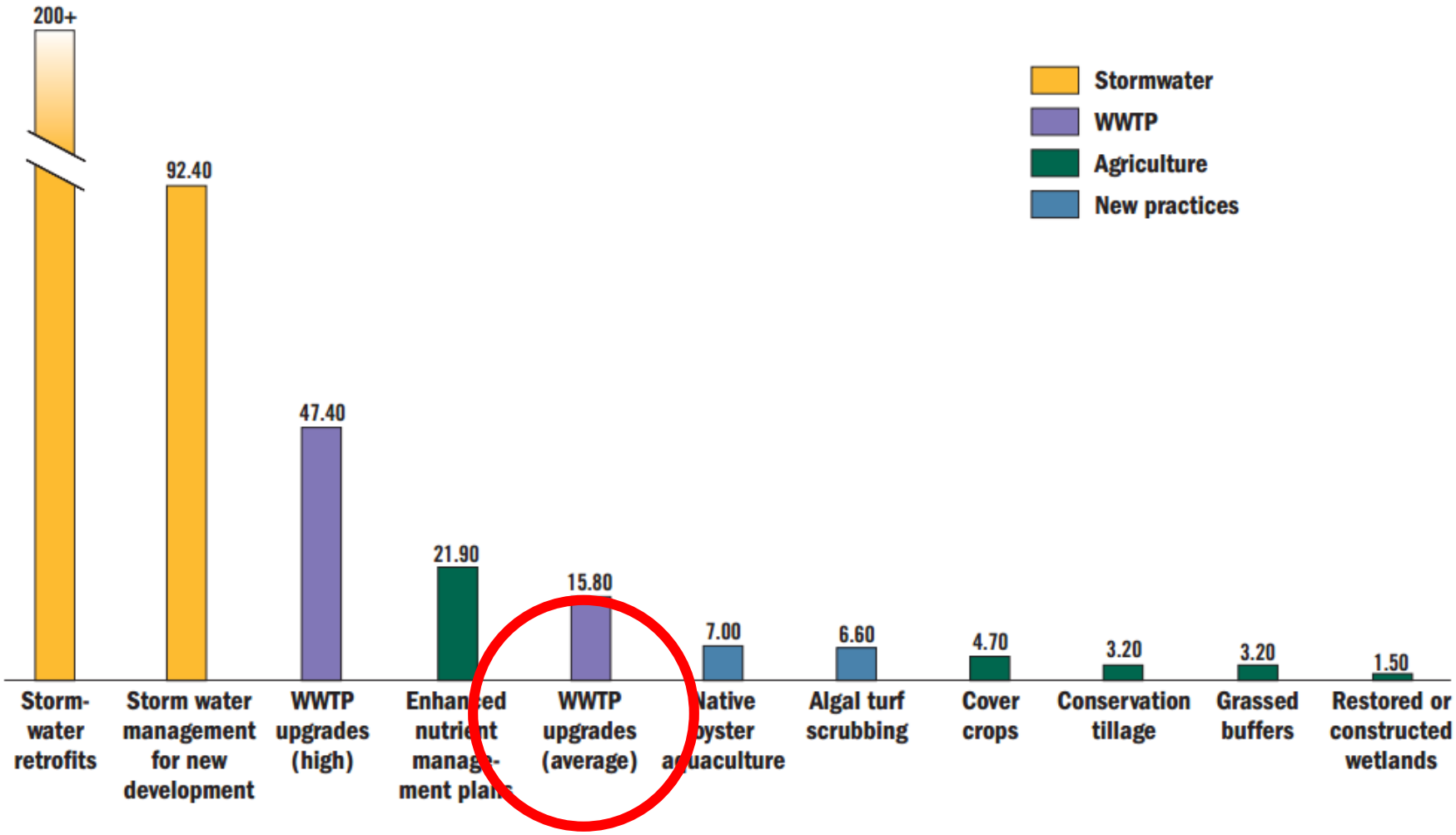
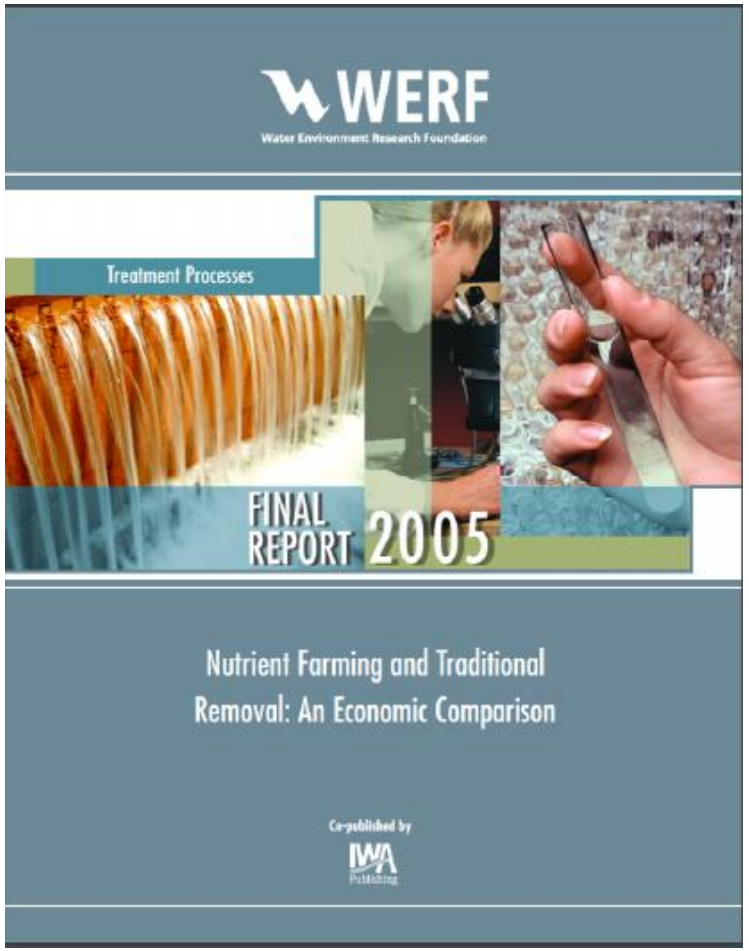


Source: U.S. EPA and Abt Associates, 2009; Wieland, et al., 2009; MDNR, 2008; Stewart, E. A., 2006; WRI analysis using WWTP upgrade costs from MDE and VDEQ.

2005 Chicago Wetland Economic Analysis



- $1,900/ton TN removed via wetlands
- $3,400/ton for treatment (5-stage Bardenpho)
- Assumed year-round compliance & 189,000 acres

- Long Island Sound = $6,870/ton TN (2005)

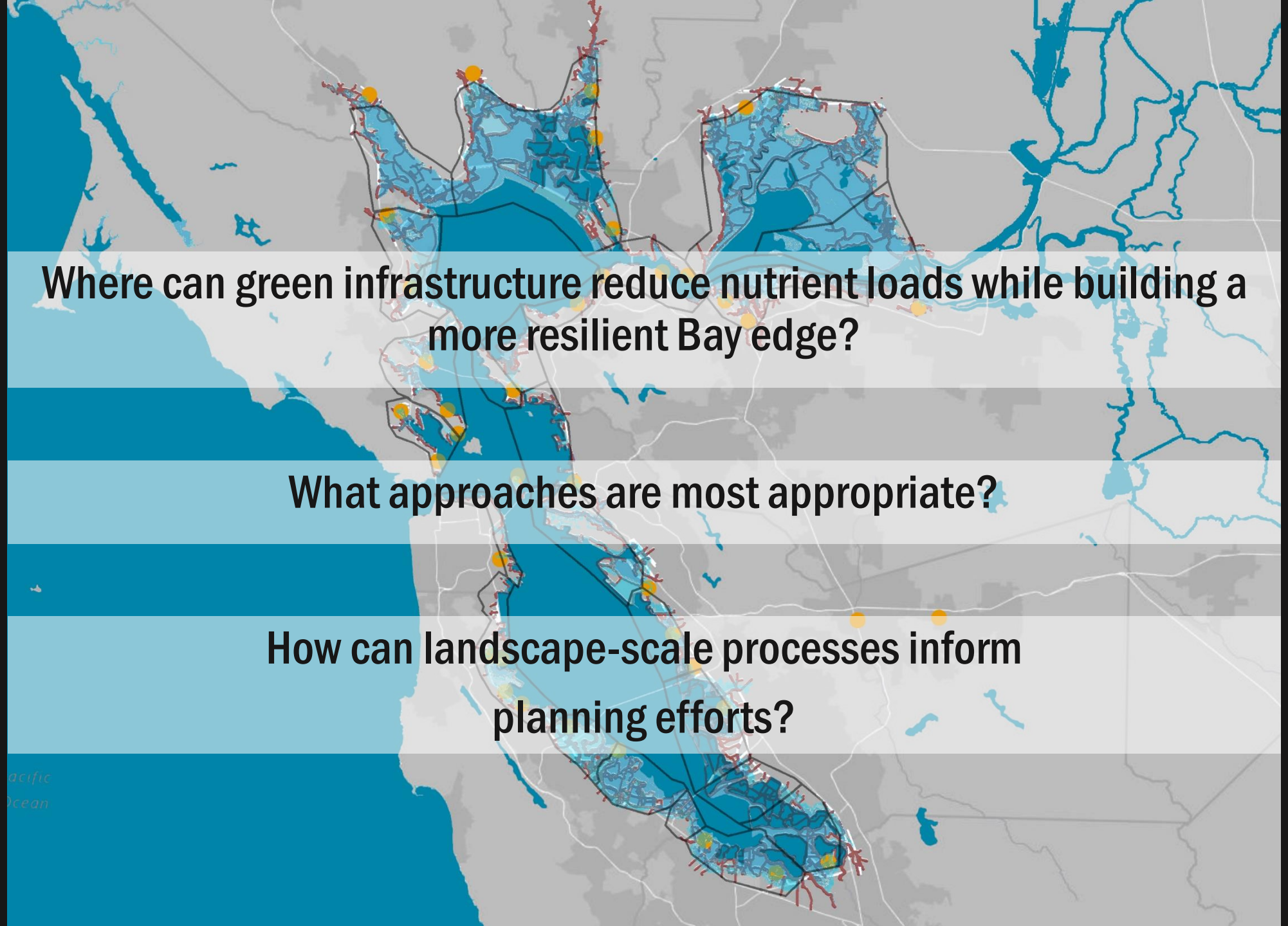
- SF Bay HDR Level 3 estimate ~$15,000/ton TN

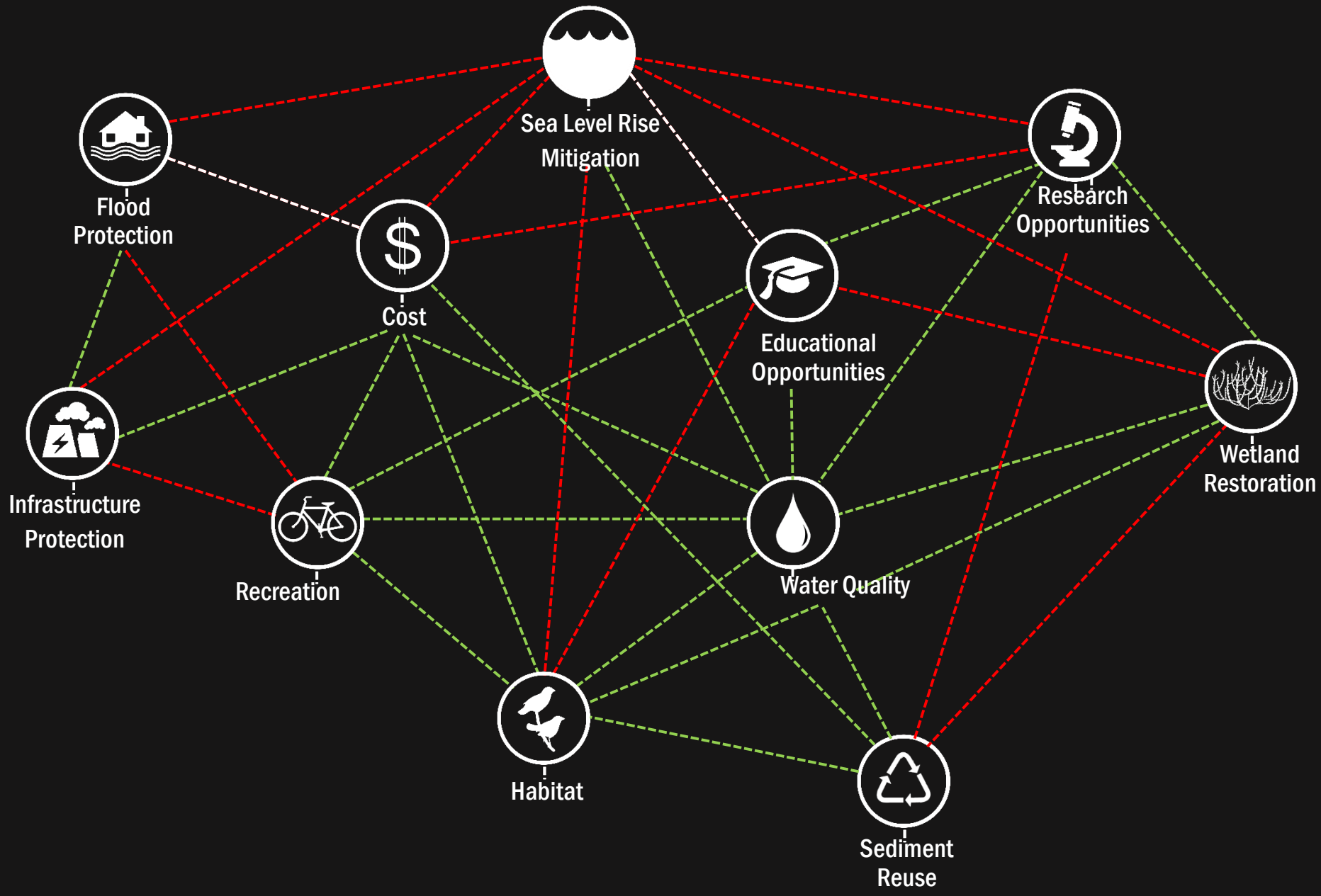
Challenges

- Land use, infrastructure and environmental conflicts
- Ownership & acquisition
- Mosquito abatement and vegetation management
- Public perception
- Regulatory (i.e. ESA, CWA)
- SLR vulnerability
- GHG release (N_2O) associated with denitrification

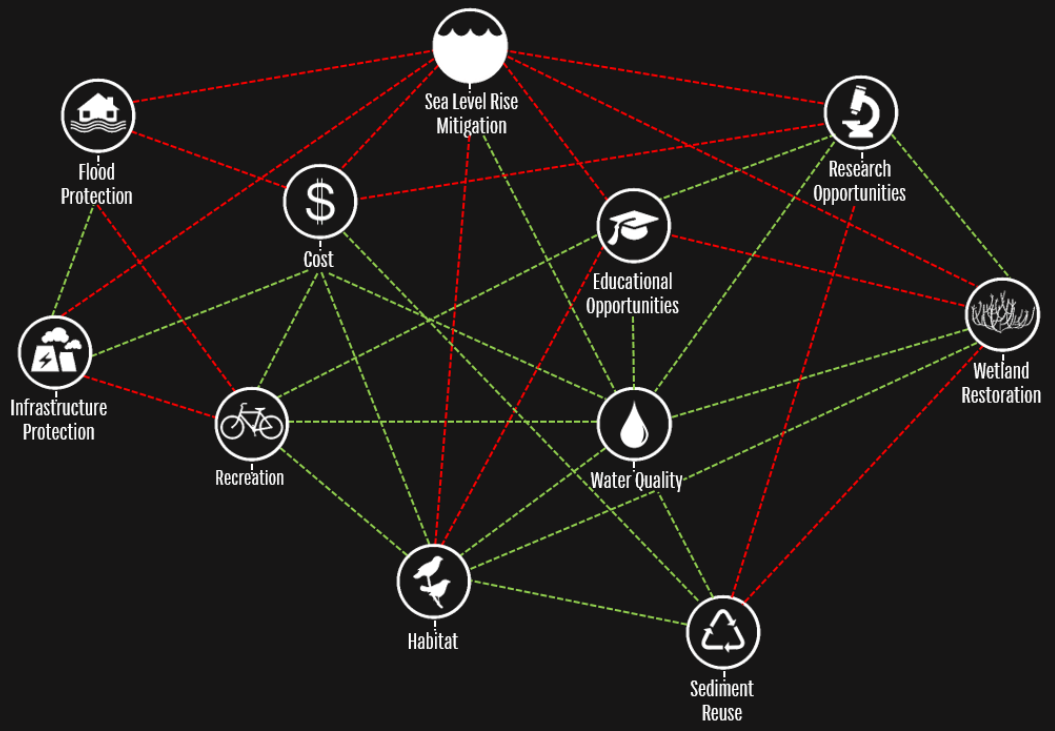
Benefits

- Freshwater inputs are needed to achieve restoration goals
- Freshwater marshes accrete peat/biofilms faster than tidal wetlands
- Potentially huge cost savings could change the value proposition & present funding partnerships
- Lower nutrient loads… but also greater habitat variability, SLR adaptation potential, CEC removal, habitat gains
- Cost-effective element of a potential trading program


Where can green infrastructure reduce nutrient loads while building a more resilient Bay edge?
What approaches are most appropriate?
How can landscape-scale processes inform planning efforts?


Sea Level Rise Mitigation
Flood Protection
Cost
Research Opportunities
Educational Opportunities
Wetland Restoration
Infrastructure Protection
Recreation
Water Quality
Habitat
Sediment Reuse

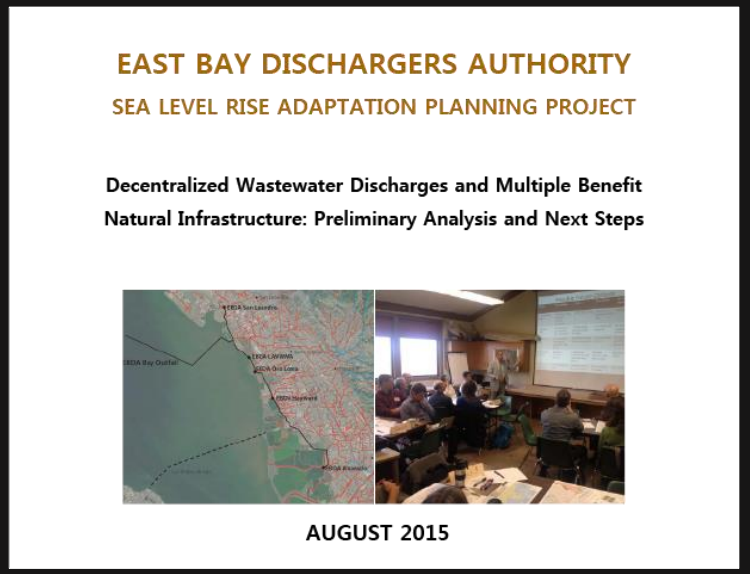
COMPLEMENTARY PLANNING EFFORTS CONSIDERING MULTIPLE BENEFITS



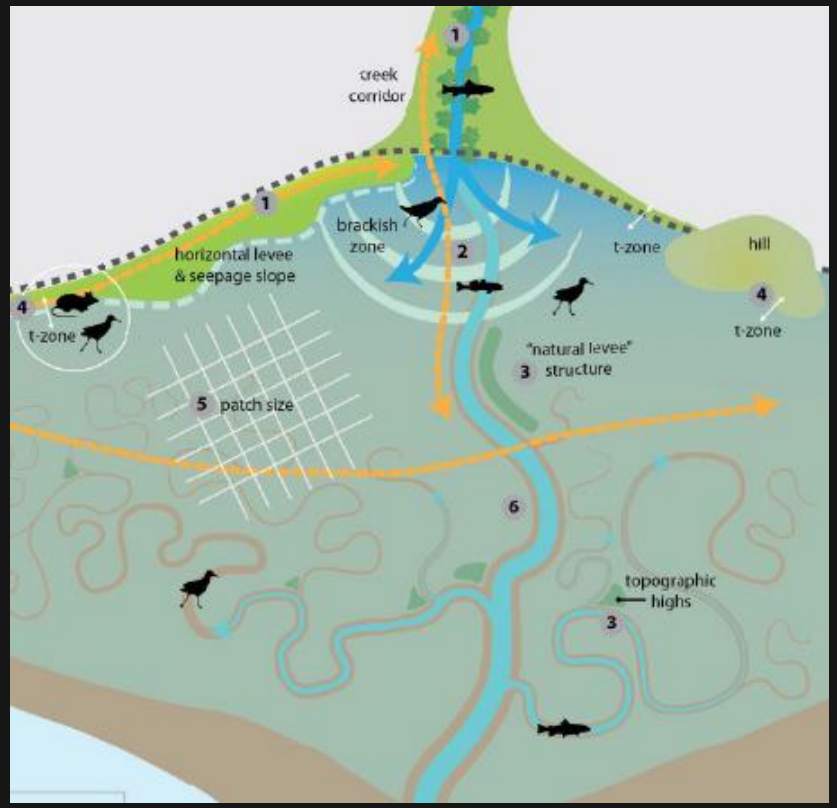
- South Bay Salt Ponds Restoration Project
- Flood Control 2.0
- Adapting to Rising Tides
- Bay Area Resilient by Design
- Etc.

EXAMPLE VISIONS

EBDA: CLIMATE READY



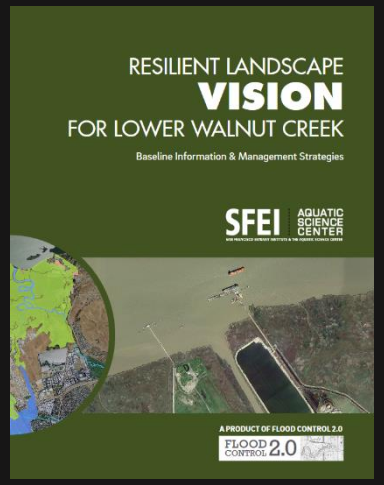
- Workshops and planning for nutrients SLR and other factors
- Treated wastewater was identified as a key input to sustain resilient marshes & SLR adaptation



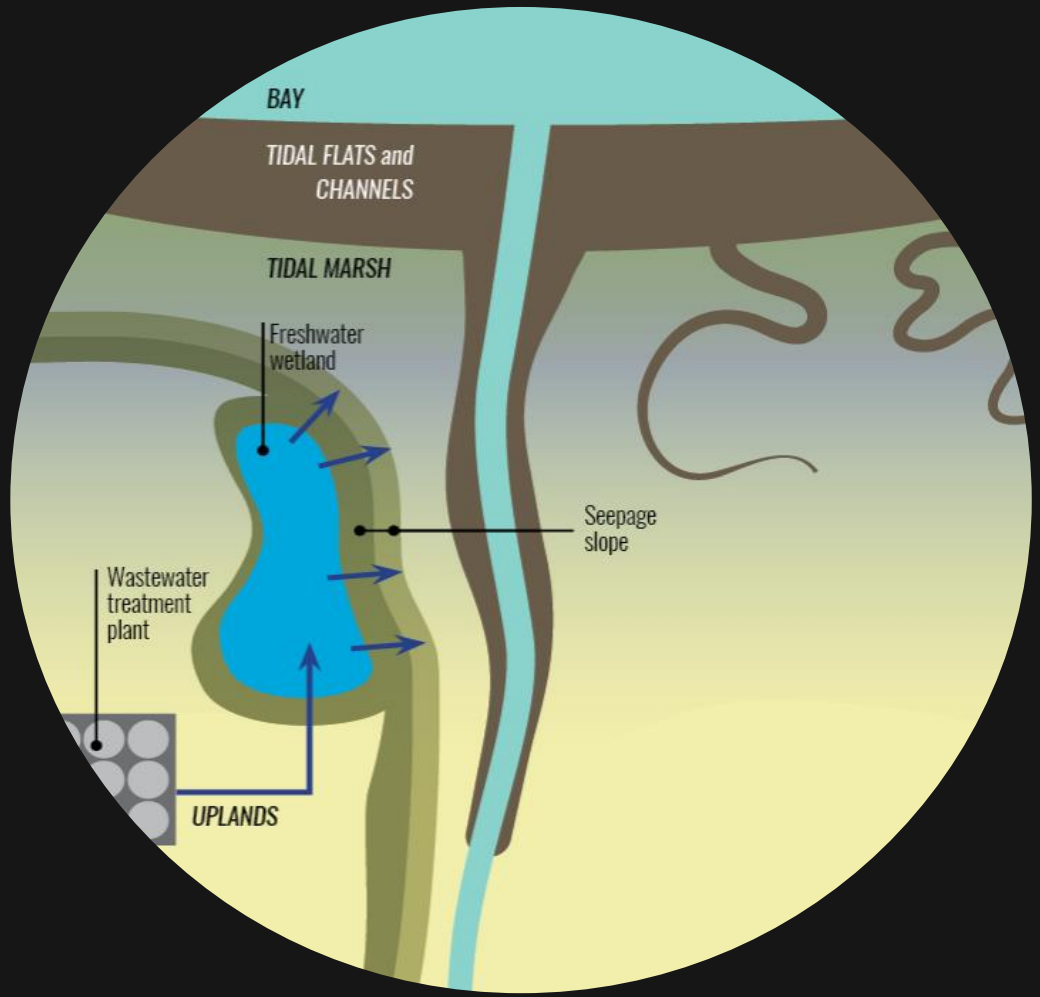
- Informed Oro Loma horizontal levee – monitoring in progress

LOWER WALNUT CREEK

SFEI: Nov 2016

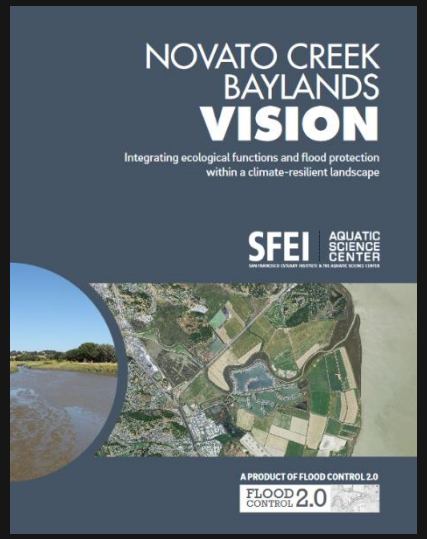


- Workshop findings informed multi-benefit management concepts of a long-term vision
- Treated wastewater was identified as a key input to sustain resilient marshes, including:
  - Supporting freshwater wetlands with wastewater discharges
  - Supporting seepage slopes with diffuse wastewater discharges



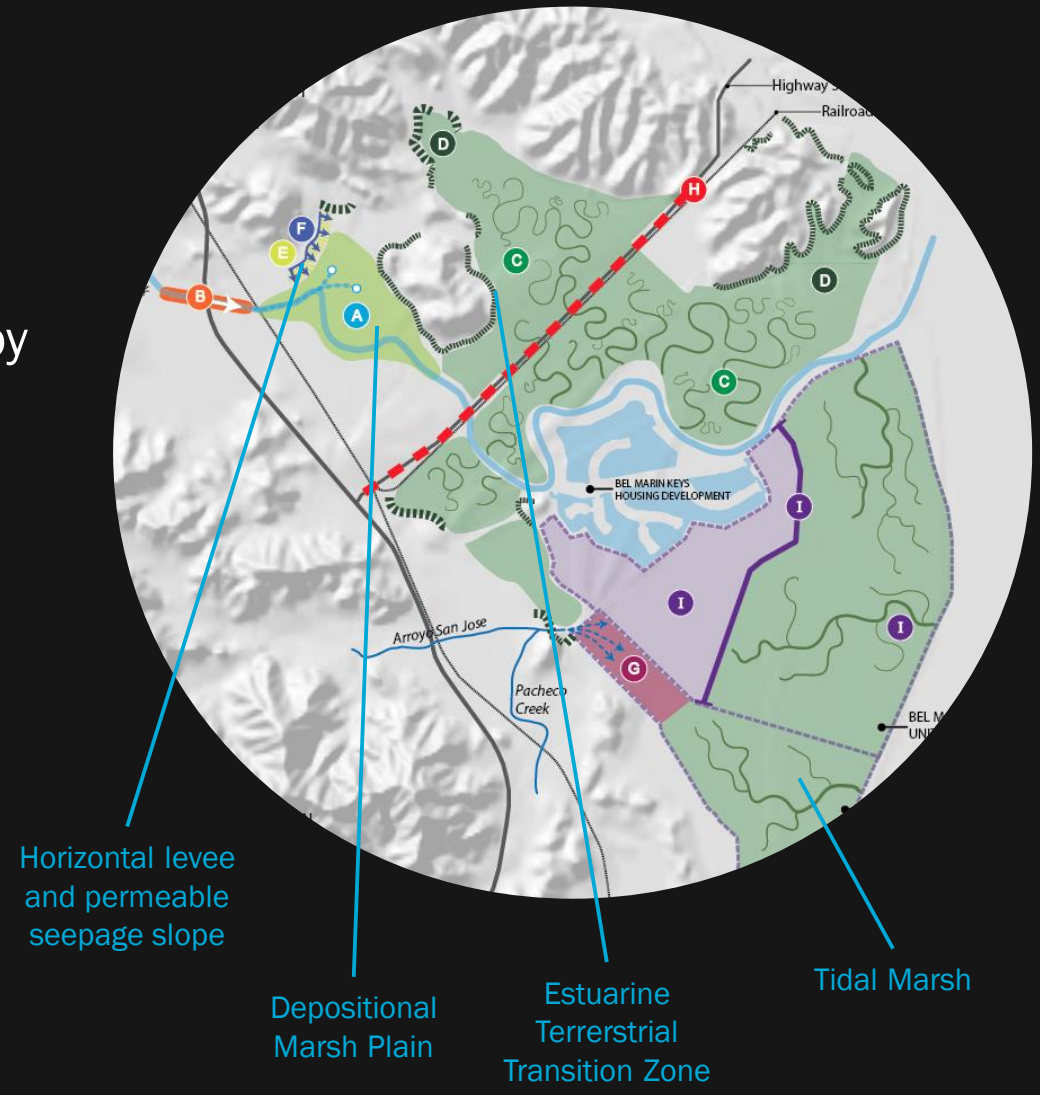
NOVATO CREEK BAYLANDS

SFEI: Nov 2015



- Intended to help address some of the current and future challenges faced by Marin County DPW by:
  - Reducing long-term costs of sediment dredging
  - Alleviating coastal flooding and erosion of levees
  - Elevating subsided baylands through sediment nourishment

- Implementation would increase resilience to climate change and improve ecosystem functioning
- Horizontal levee and permeable seepage slope



Planning for Multi-Benefit Management: Where to go next?

Lessons from Sasha Harris-Lovett outreach (UCB/ReNUWIt):

- Nutrient reduction regulations are inevitable but should be based on sound science
- General support for no-regrets actions but should incorporate multiple benefits
- DPR is of interest management strategy though regulations and permitting pathway needed
- Wetlands are interesting but the path forward is very murky

‘NUTRIENTS ARE THE TICKET TO THE PARTY’

Multi-Benefit Water Project

It's ~~Party~~ Time!

Water Quality

Water Supply

Flood Protection

Recreation

Aesthetics

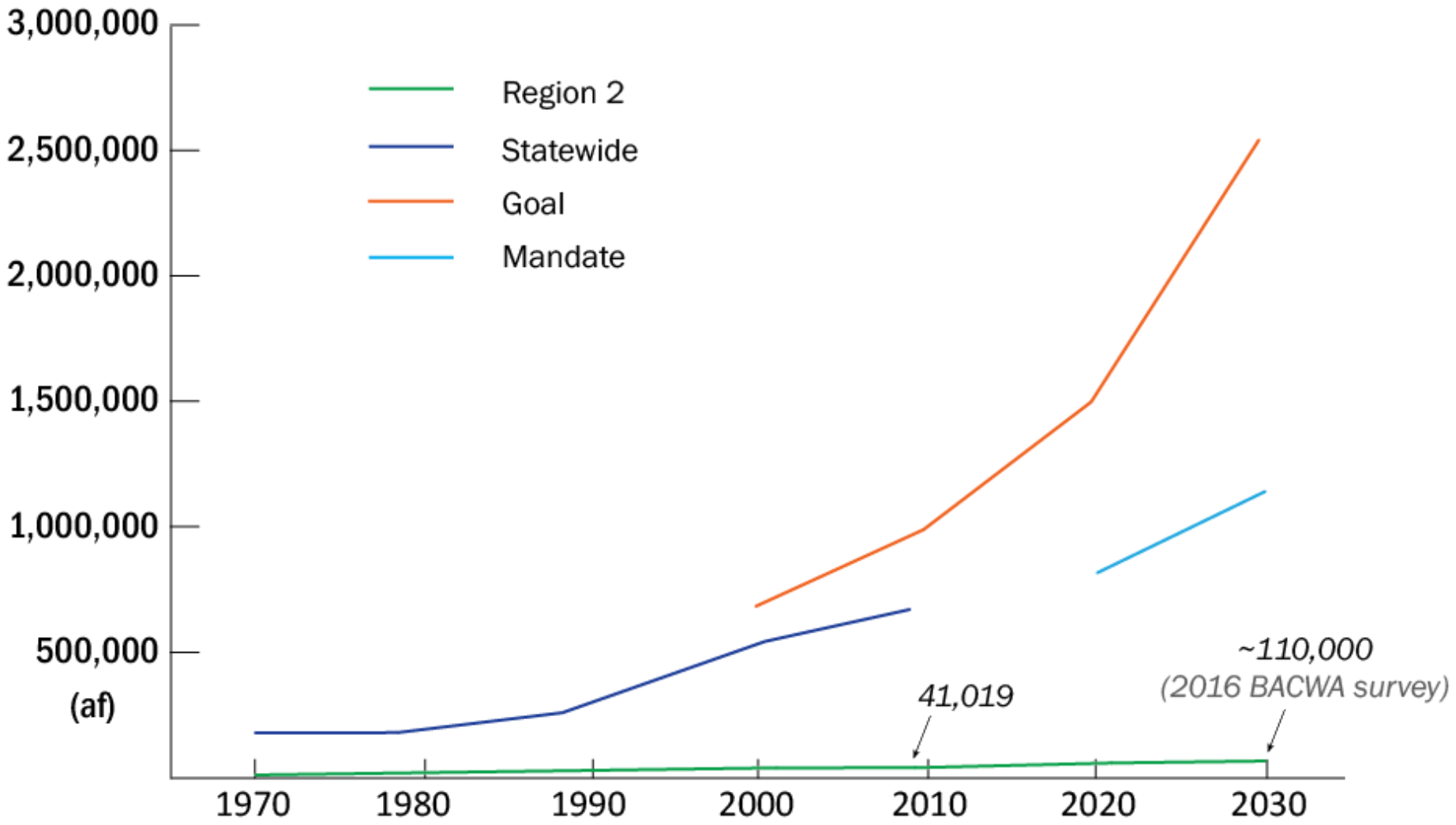
Wastewater Treatment

Habitat Enhancement

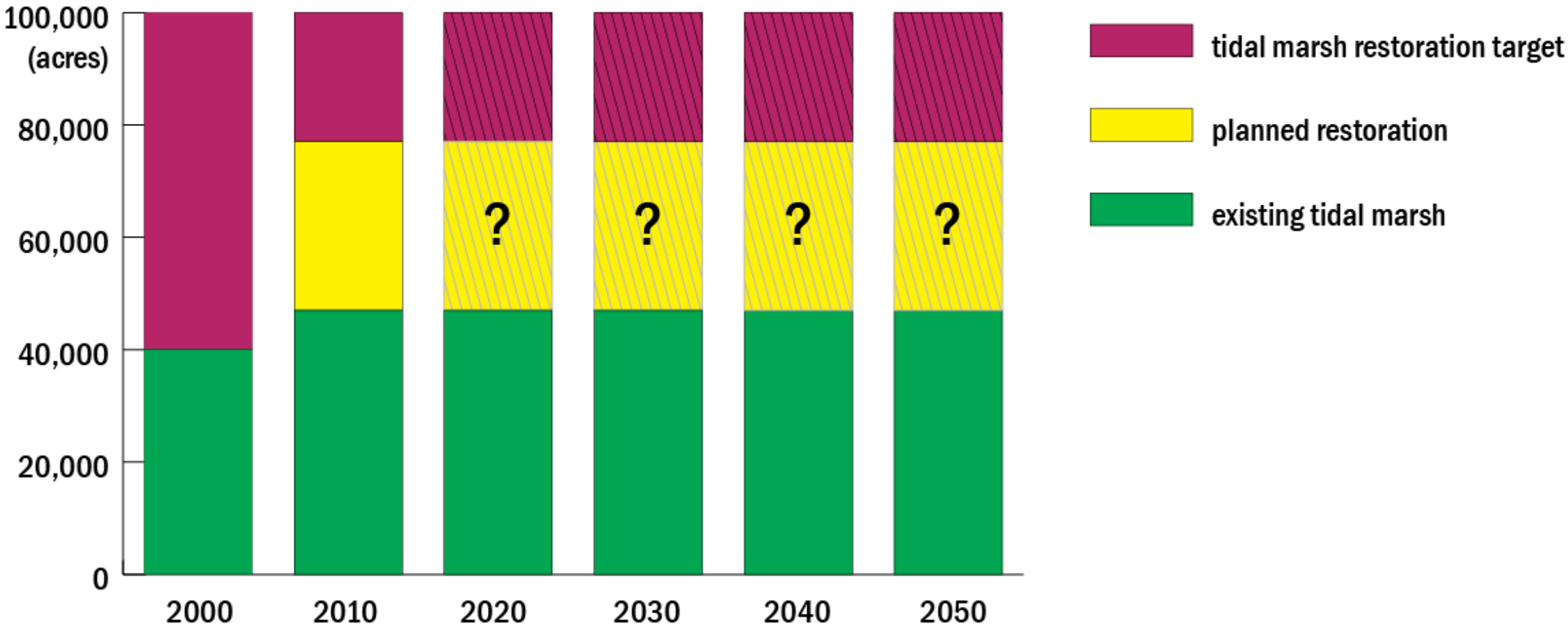
What are the primary options?

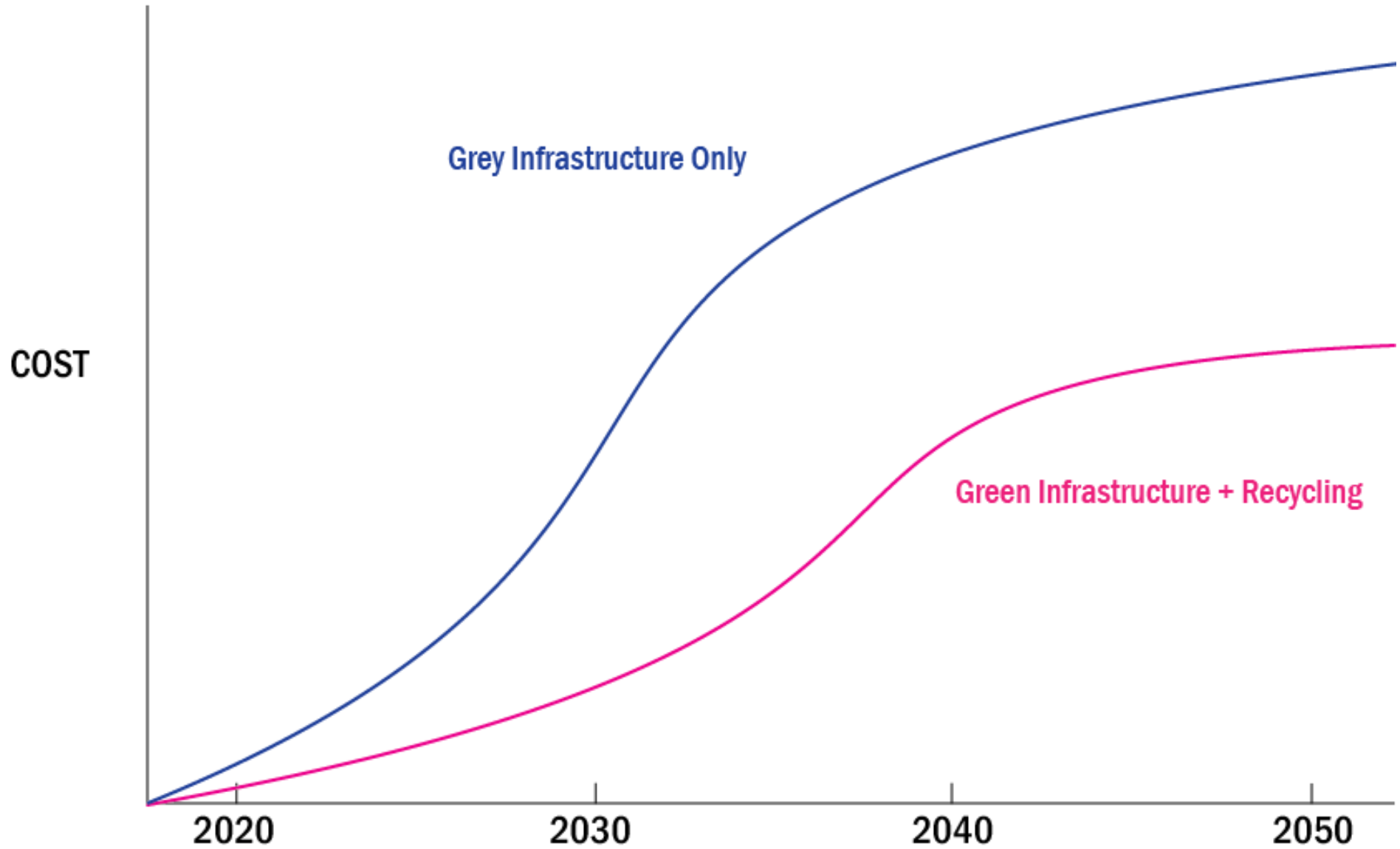
MANAGEMENT OPTIONS	CHALLENGES	WORTH CONSIDERING?
Wetlands and Green Infrastructure	Permitting, land ownership, public perception, who takes the lead?	**YES**: informal regulatory consultation, site specific analysis, economic analysis, alternatives analysis, fundraising, cooperation
Title 22 Recycling	Proximity to customers, infrastructure, opportunities known & limited in some locales	**YES**: coordination with existing networks & IRWM, regionalization & cooperation with existing networks
Direct Potable Reuse	Regulations non-existent, concentrate disposal/management	**MAYBE**: advance regulations & analyze concentrate management options

Help Meet Recycled Water Targets



Help Meet Marsh Restoration Targets




COST
Grey Infrastructure Only
Green Infrastructure + Recycling
2020
2030
2040
2050

Needs for Advancing Wetlands and Recycling

- **Will** among regulators and the regulated community
- **Coordinating entity** for partnerships and fundraising
- **Regulatory outreach** (RWQCB/SWRCB, USEPA, NOAA, USFWS, CDFW, BCDC, ACOE)
- **Consistent regulations and permitting guidance** for design and siting
- **Stakeholder outreach** (community groups and NGOs)
- **Data collection** (land ownership, partners, design criteria)
- **Quantification of integrated benefits/impacts** (water quality, water resources, flood risk, habitat, air quality, greenhouse gases, beneficial reuse)
- **Economic analysis** (i.e. cost benefit of single- versus multi-benefit projects, DPR as a management strategy, accurate wetland treatment estimates)

Potential Objectives (2-3 year)

TECHNICAL	OUTREACH	FINANCIAL
Develop wetland project guidelines	Stakeholder visioning	Fundraising
Integrated modeling for nutrient reduction performance & tradeoffs	Integration of IRWM / SF Bay Restoration Authority / water recycling working groups	Cost-benefit analyses of single- vs. multi-benefit benefit scenarios
Permitting issues & streamlining options	Informal regulatory consultation	Develop credit trading or other cost sharing mechanism
Priorities and Options for DPR & concentrate management	Community group/NGO partnerships	Site-specific cost estimates for wetlands & DPR
Formation of Technical Work Group	via NMS Program Coordination efforts	Formation of Financial Work Group

Potential Near-Term Activities

Regulatory guidance/wetland treatment criteria based on Regional Boards '*Staff Report: Wetland Policy Climate Change Update Project NPDES Permit Case Studies: Findings and Recommendations*' (April 2017) – updates to Water Board Resolution No. 94-086 "Policy on the Use of Wastewater to Create, Restore, and/or Enhance Wetlands."

Prop 1 Implementation funds to implement pilot/full scale projects

Other multi-benefit scoping analyses:

- nutrient recovery potential: survey of existing technology and market analysis of fertilizer applications
- water recycling & concentrate management (AB574: 5-year timeline to adopt uniform water recycling criteria for direct potable reuse): coordinate with SCVWD/ReNUWIt on wetland treatment pilot project

Questions?

- Questions and comments on wetlands report
- Recommendations for near-term analyses regarding wetlands or other multi-benefit options
- Ideas for addressing governance challenges
- Interest in seeking Prop 1 Implementation funds for pilot projects and regional coordination