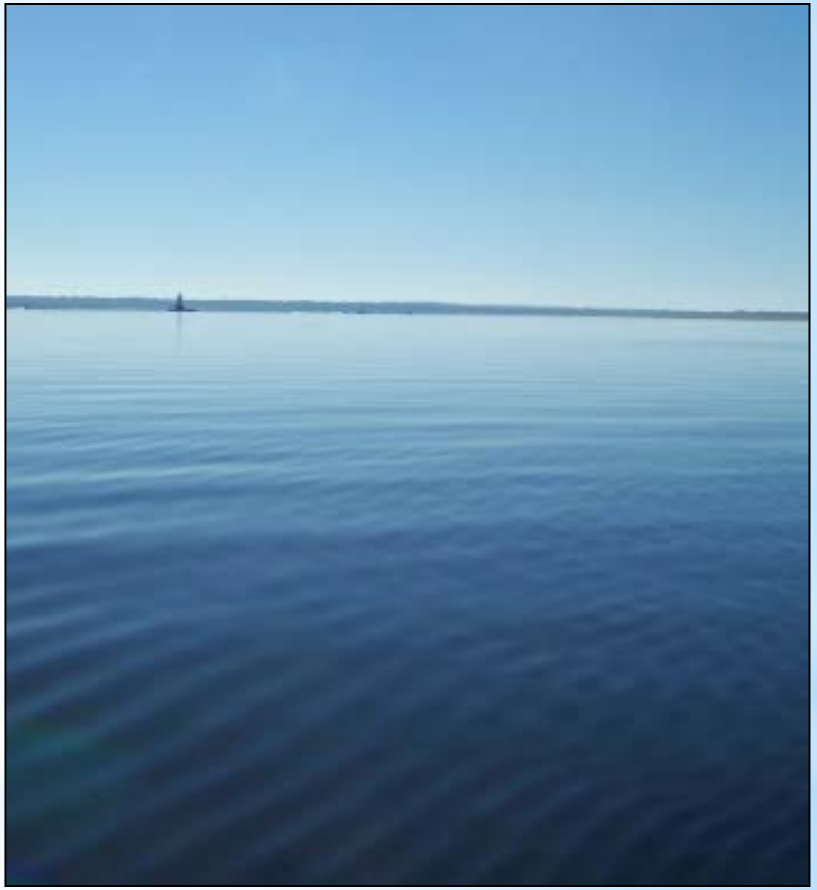
WWTF Nitrogen Reductions and Water Quality Improvements

Eliza Moore
Environmental Scientist
Narragansett Bay Commission

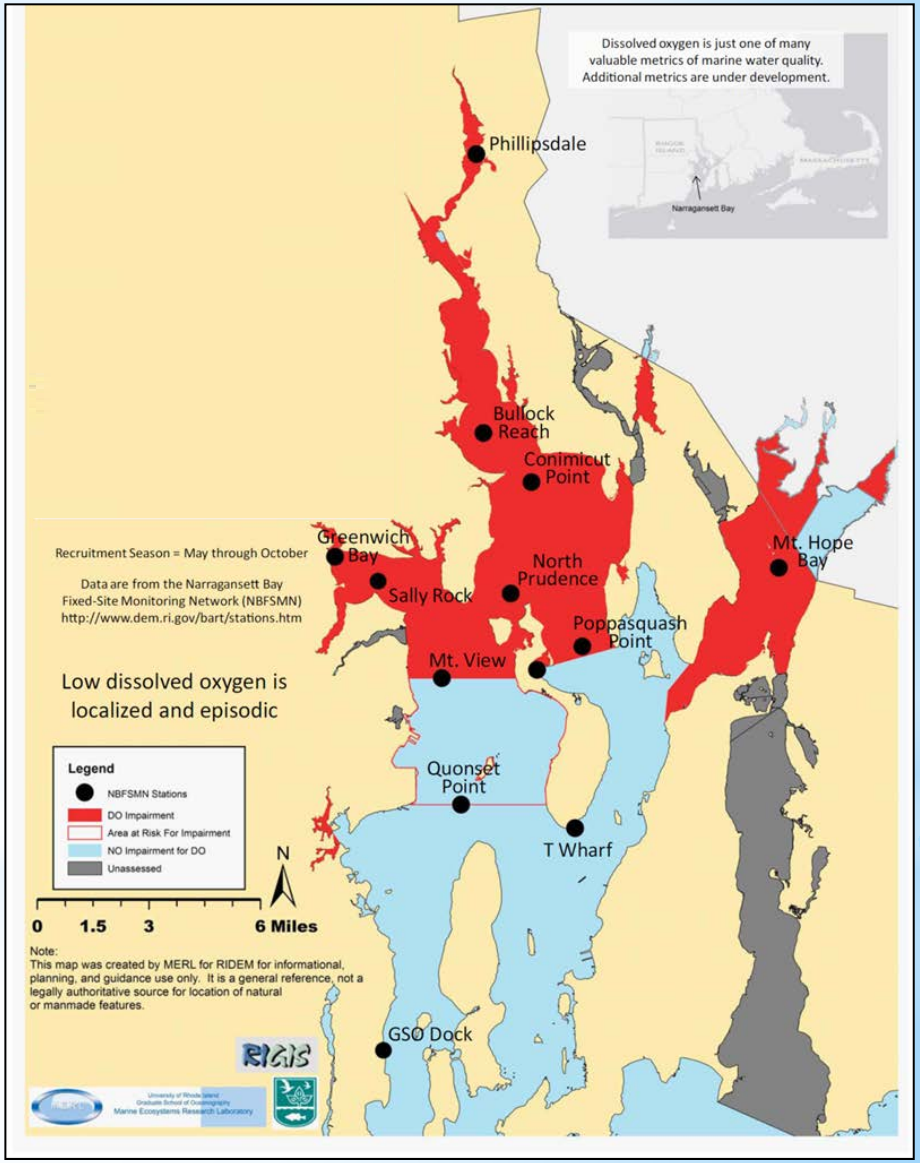
Upper Bay Issues & Impairments

- Bacterial contamination
- Metals in sediments
- Loss of wetlands, habitat, & eelgrass
- Excessive nutrient loads
- Dissolved oxygen impairments – hypoxia and anoxia



Nitrogen and Hypoxia

- Phytoplankton & algae blooms
- Blooms collapse, decomposition consumes dissolved oxygen (DO)
  - Hypoxia (<2.9 mg/L DO)
  - Anoxia (0.0 mg/L DO)
- Other factors contributing to hypoxia:
  - Weather - hot, calm summer periods
  - Stratification
  - Freshwater flows
- Reduce anthropogenic nitrogen to reduce hypoxia?
- Fish kill in Greenwich Bay 2003 accelerated plans by RIDEM to initiate N reductions at WWTFs



NBC Effluent Total Nitrogen Limits

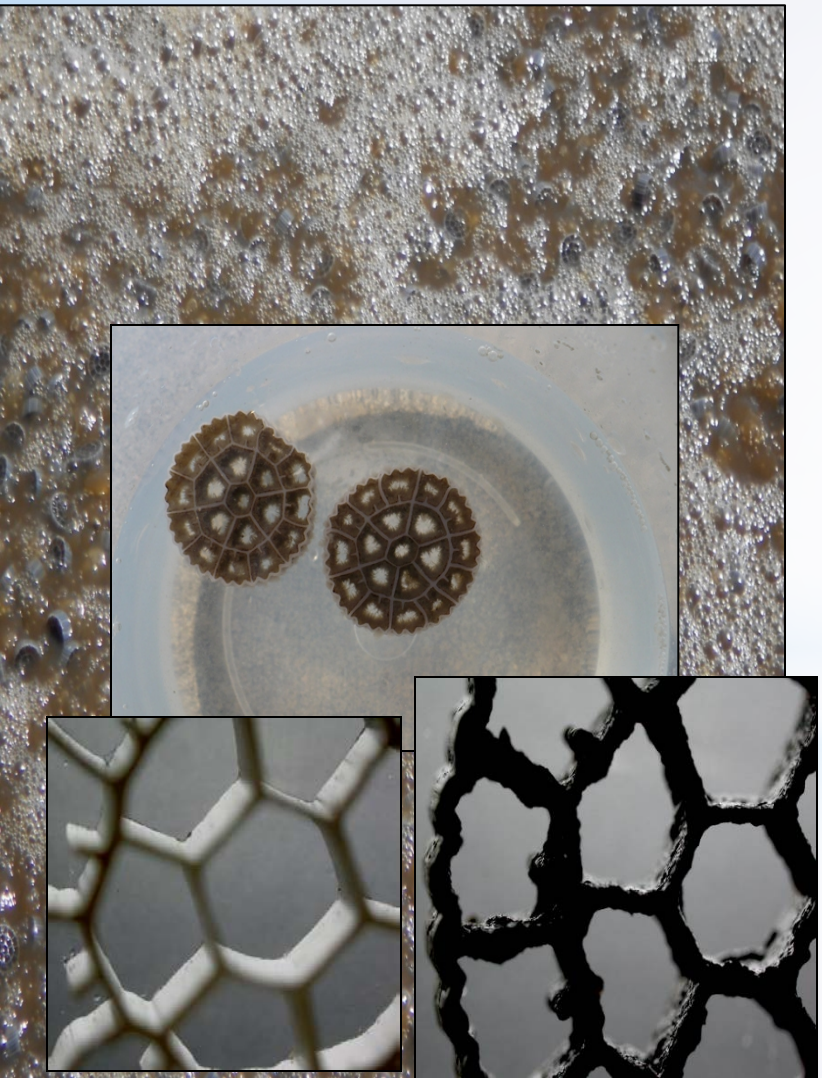
- 2005 – TN limits (May – October):
  - Bucklin Point - 5 mg/L and 1,293 lbs/day
  - Field's Point - 5 mg/L and 2,711 lbs/day
- Require major WWTF modifications to achieve!
- 2006 – Consent Agreement (CA):
  - Bucklin Point - what could be achieved with the current system?
    - 8.5 mg/L, measure and report lbs/day
  - Field's Point - plan and implement new construction
    - 18.2 mg/L, measure and report lbs/day
- **Both plants to meet <u>5 mg/L</u> TN by 2014**

Bucklin Point
Biological Nutrient Removal

- Upgrade to meet seasonal 8.5 mg/L TN in 2005/2006 - **$8.3M** (out of total $59M plant upgrades)
- Upgrade to meet 5 mg/L complete in 2014, permit in effect on July 15th, 2014.
- 2014 seasonal average = 4.0 mg/L
- Reduced 2,319 lbs TN/day vs. 2003

Nitrogen Upgrade Cost
~$13 Million

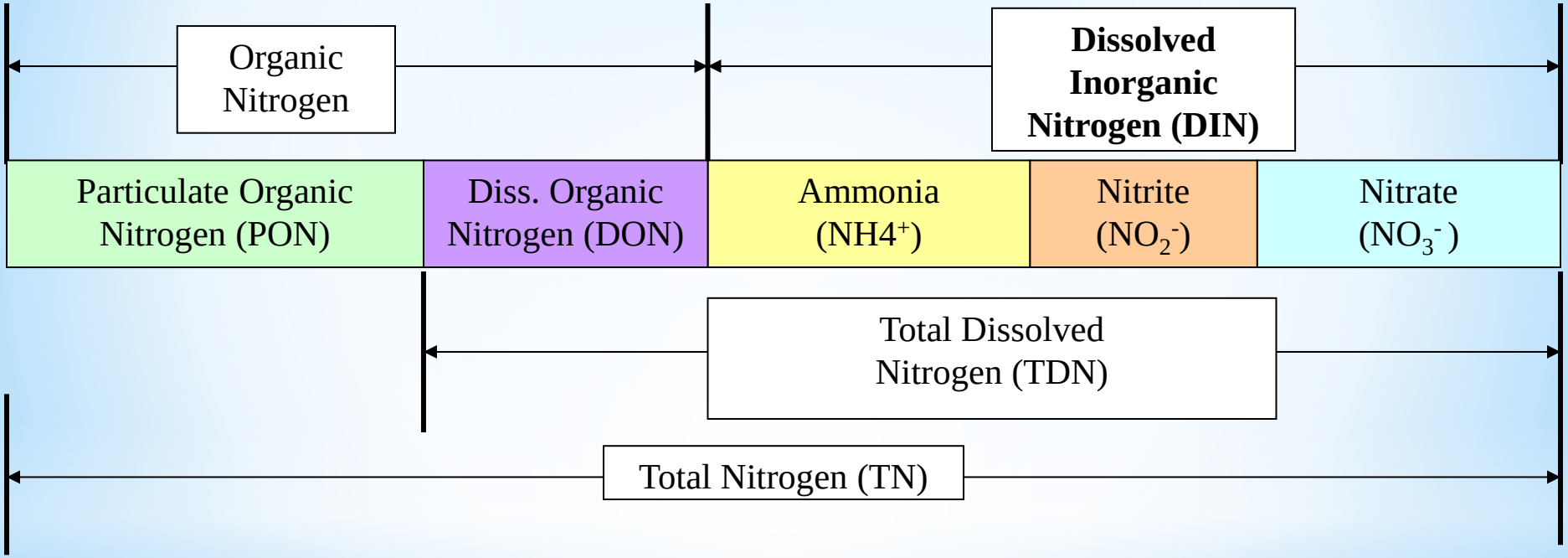
Field's Point
Biological Nutrient Removal



- Integrated Fixed Film Activated Sludge (IFAS) –
  Largest in the world achieving such a low effluent limit!
- Construction completed in 2013 –
  5 mg/L Permit limits in effect on May 1, 2014
- 2014 seasonal average = 3.4 mg/L
- Reduced 4,782 lbs TN/day vs. 2003

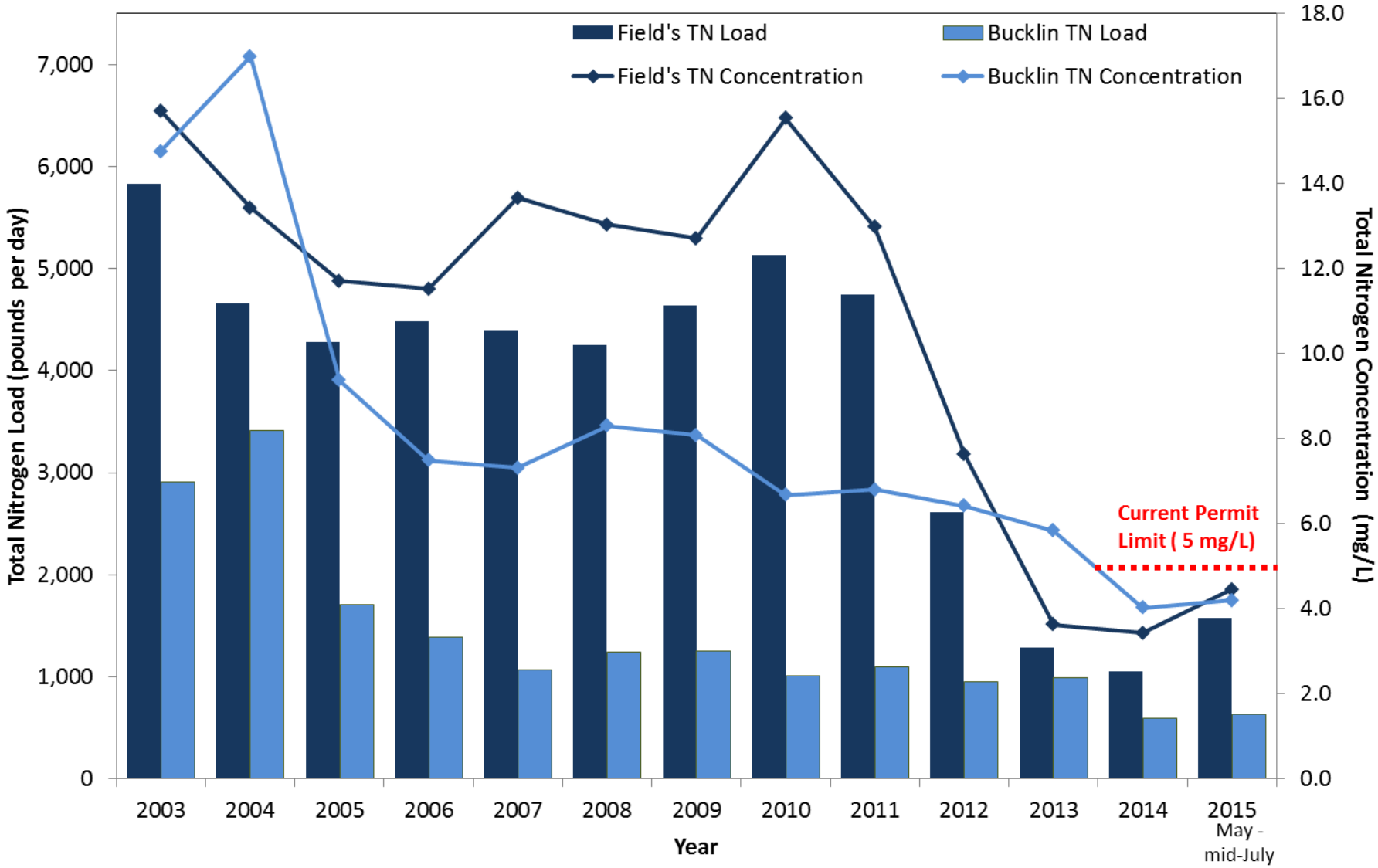
Nitrogen Upgrade Cost
~$31 million

Forms of Nitrogen

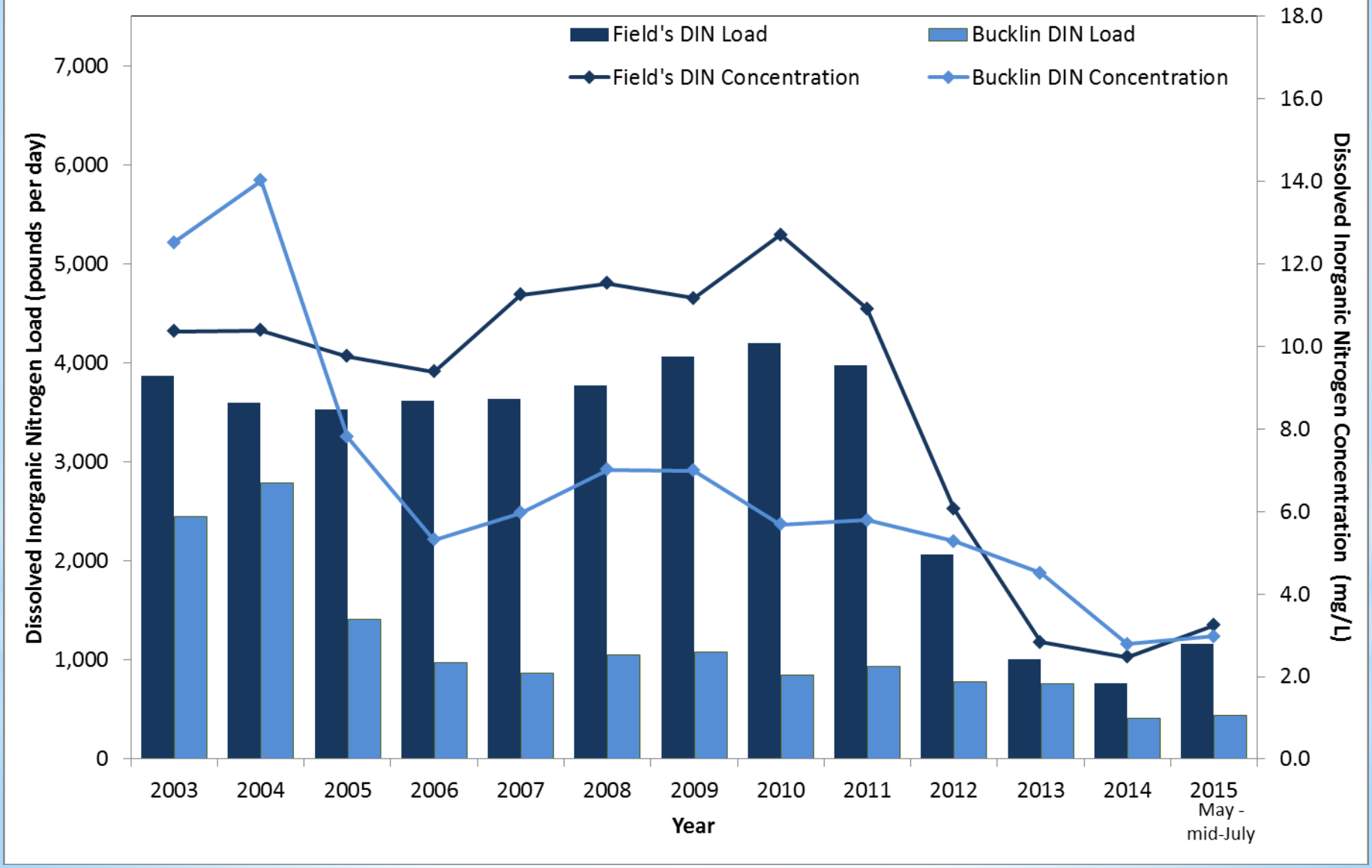


DIN is the most bio-available form of N for use in primary production by plants & algae

Field's Point and Bucklin Point
Seasonal (May - Oct) Average Effluent Total Nitrogen



Field's Point and Bucklin Point
Seasonal (May - Oct) Average Effluent Dissolved Inorganic Nitrogen

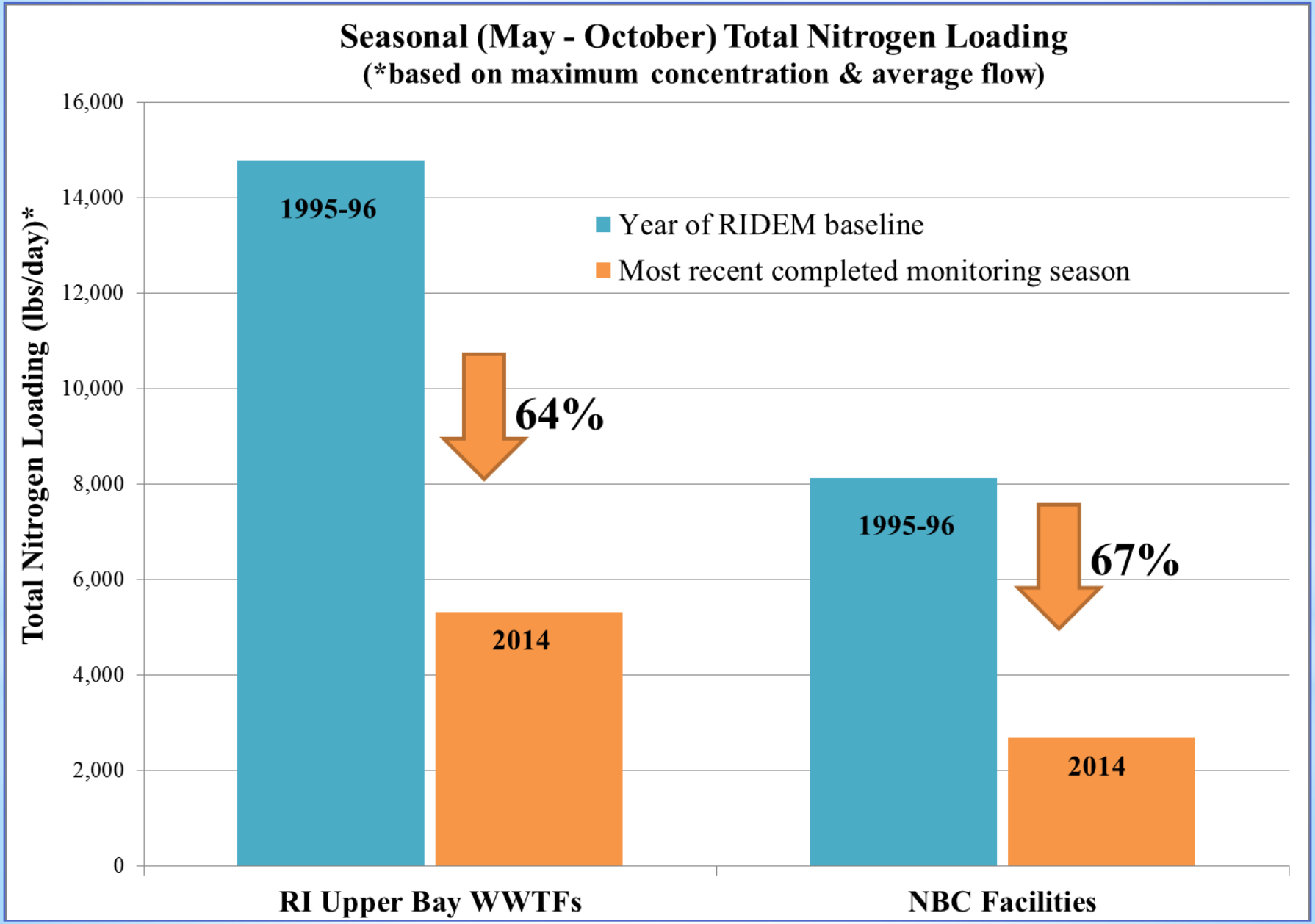


WWTF Nitrogen Limits Throughout the Watershed

5 mg/L	8 mg/L
NBC – Field's Point	Cranston
NBC – Bucklin Point	West Warwick
East Greenwich	Warwick
Warren	Smithfield (10 mg/L)
East Providence (5.9 mg/L)	Northbridge (max. extent)
Woonsocket (3 mg/L)	Burrillville (max. extent)
UBWPAD	North Attleborough
	Attleboro
	Grafton
	Uxbridge

Not all facilities currently meeting these limits - Construction ongoing

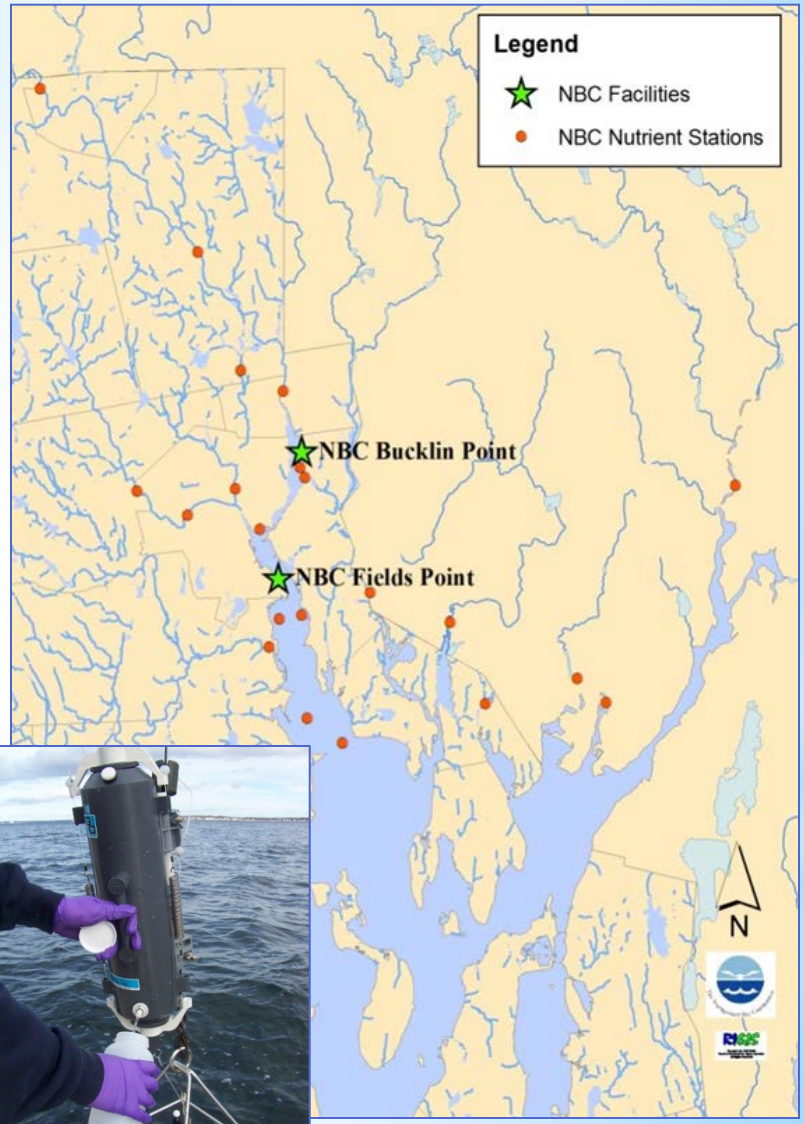
Nitrogen Reductions Realized

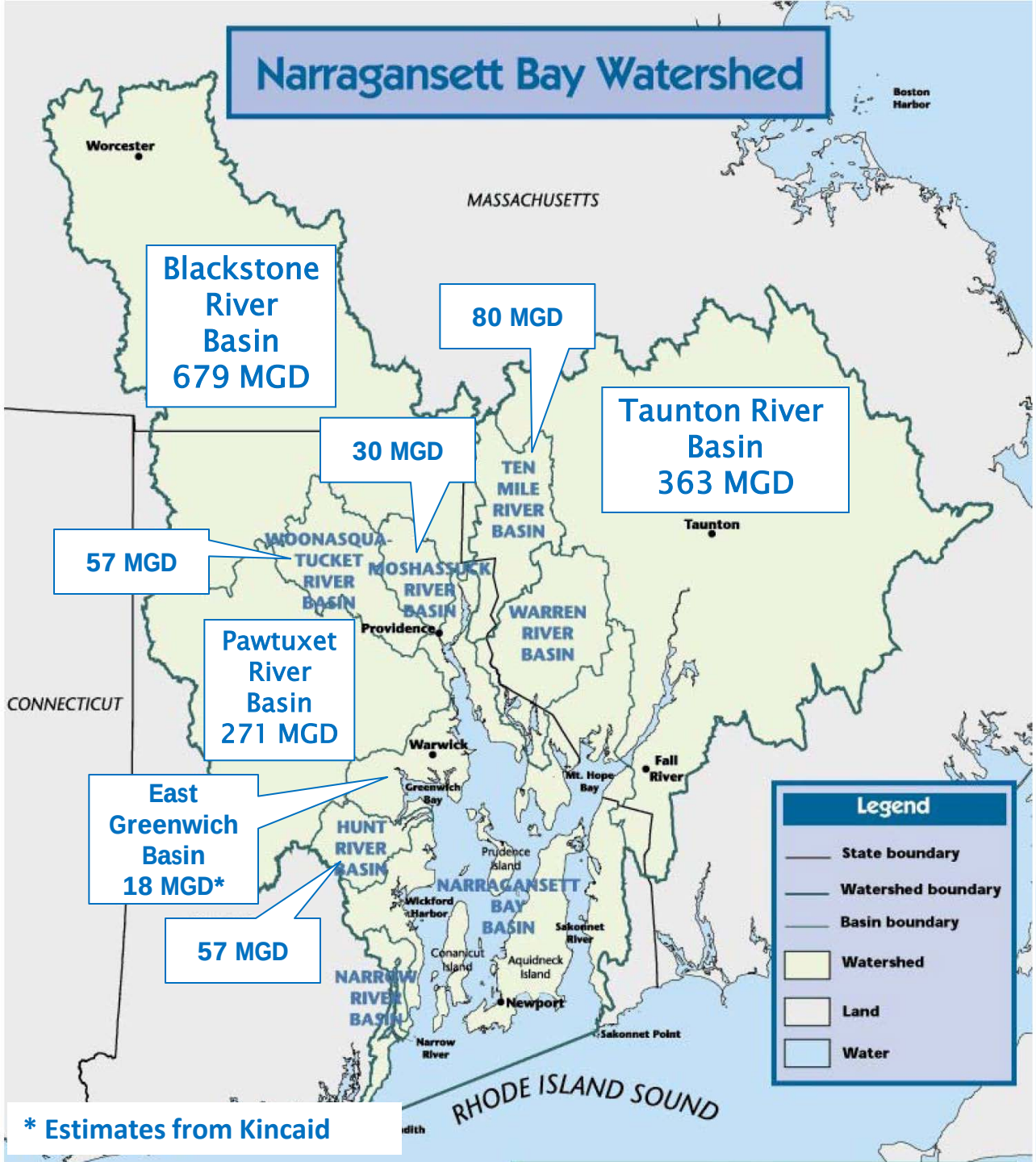


NBC Nutrient Monitoring

NBC Nutrient Monitoring

- NBC monitoring program one of the most extensive in the region
- Provides data & sound science needed to address regulatory mandates, protect ratepayers
- Nutrients are monitored in the upper bay and tributary rivers, including major rivers at the state border



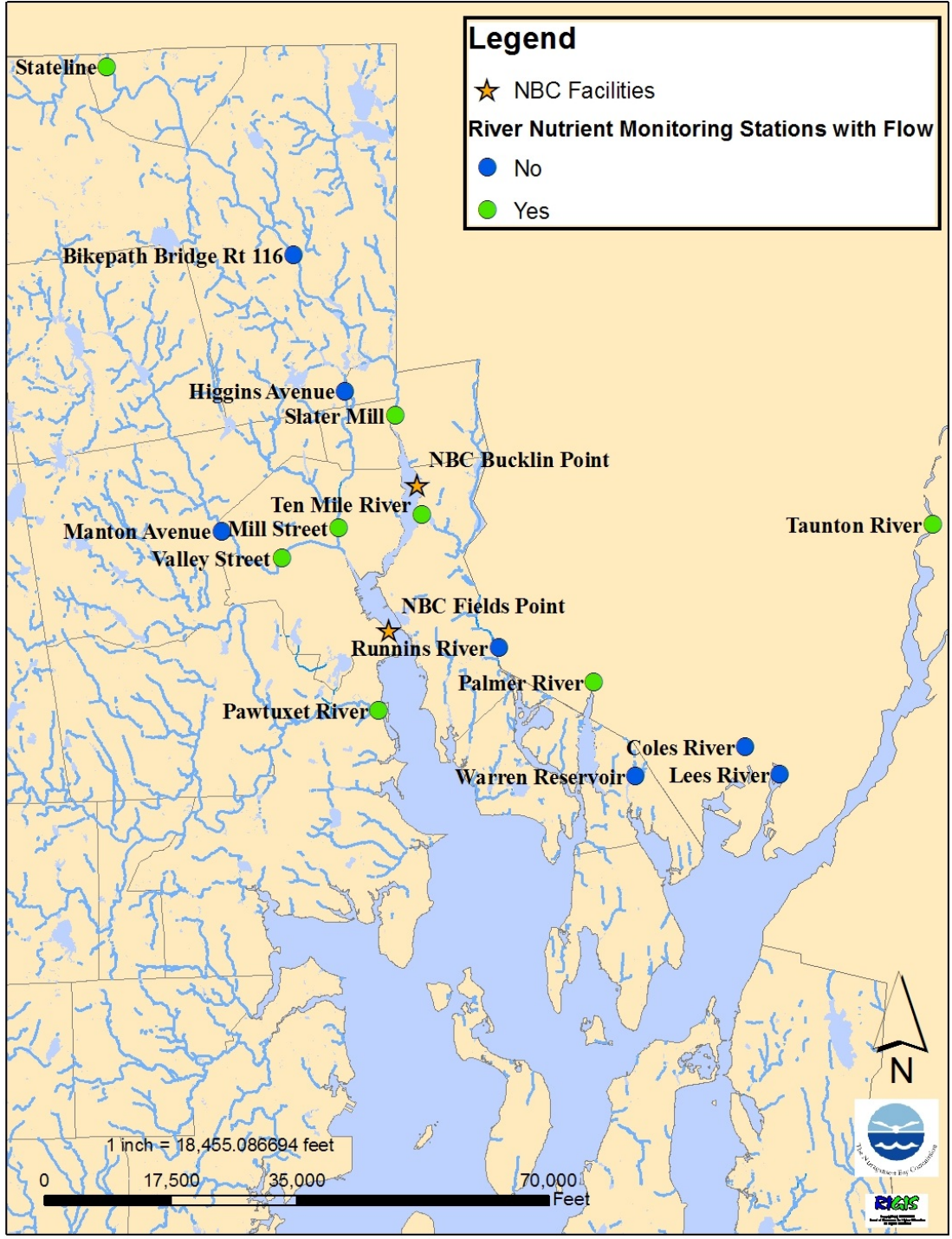


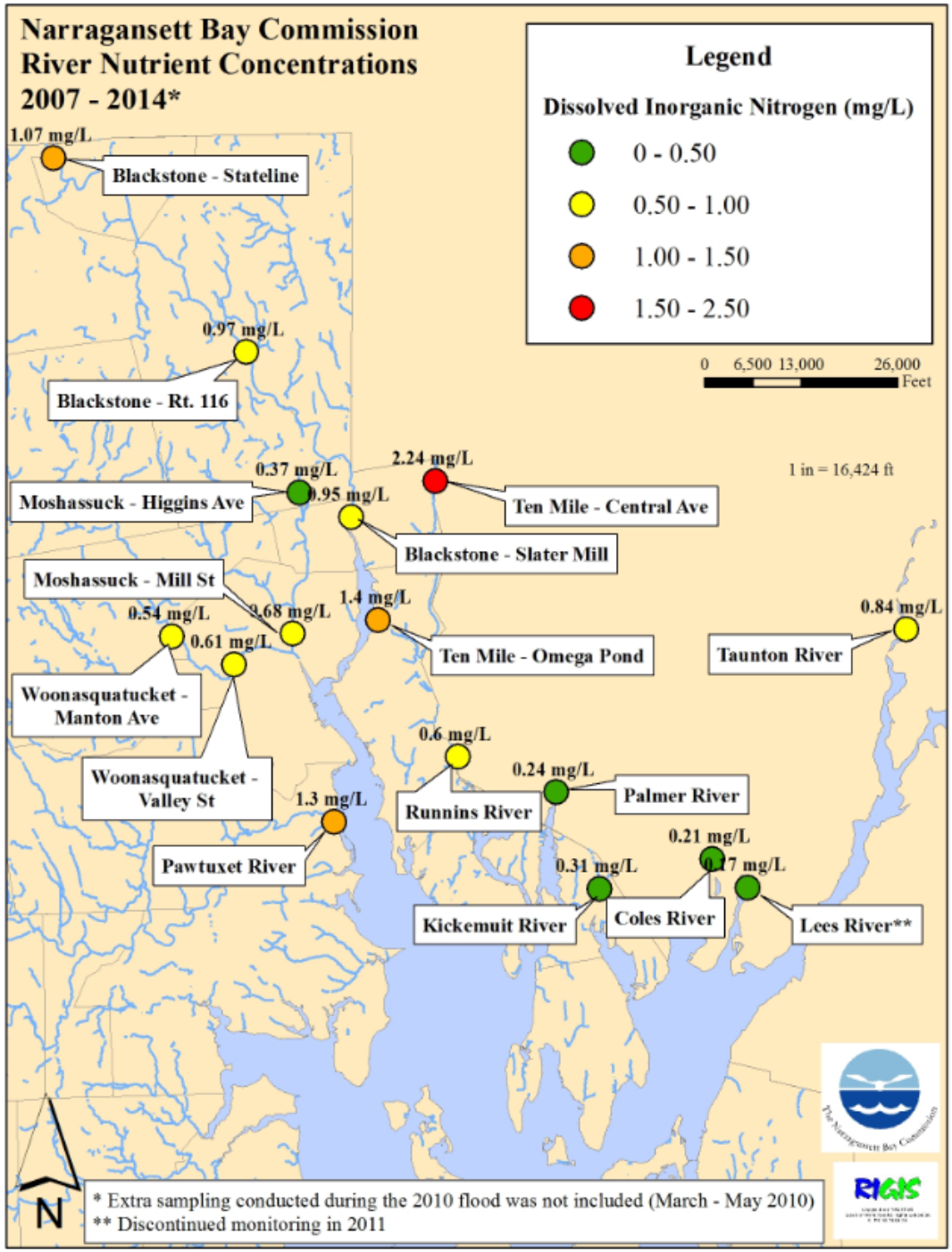
River Inputs

- Major sub-watersheds
- WWTFs
- Urban
- Agricultural
- Industrial
- Rural/Residential

River Nutrient Stations

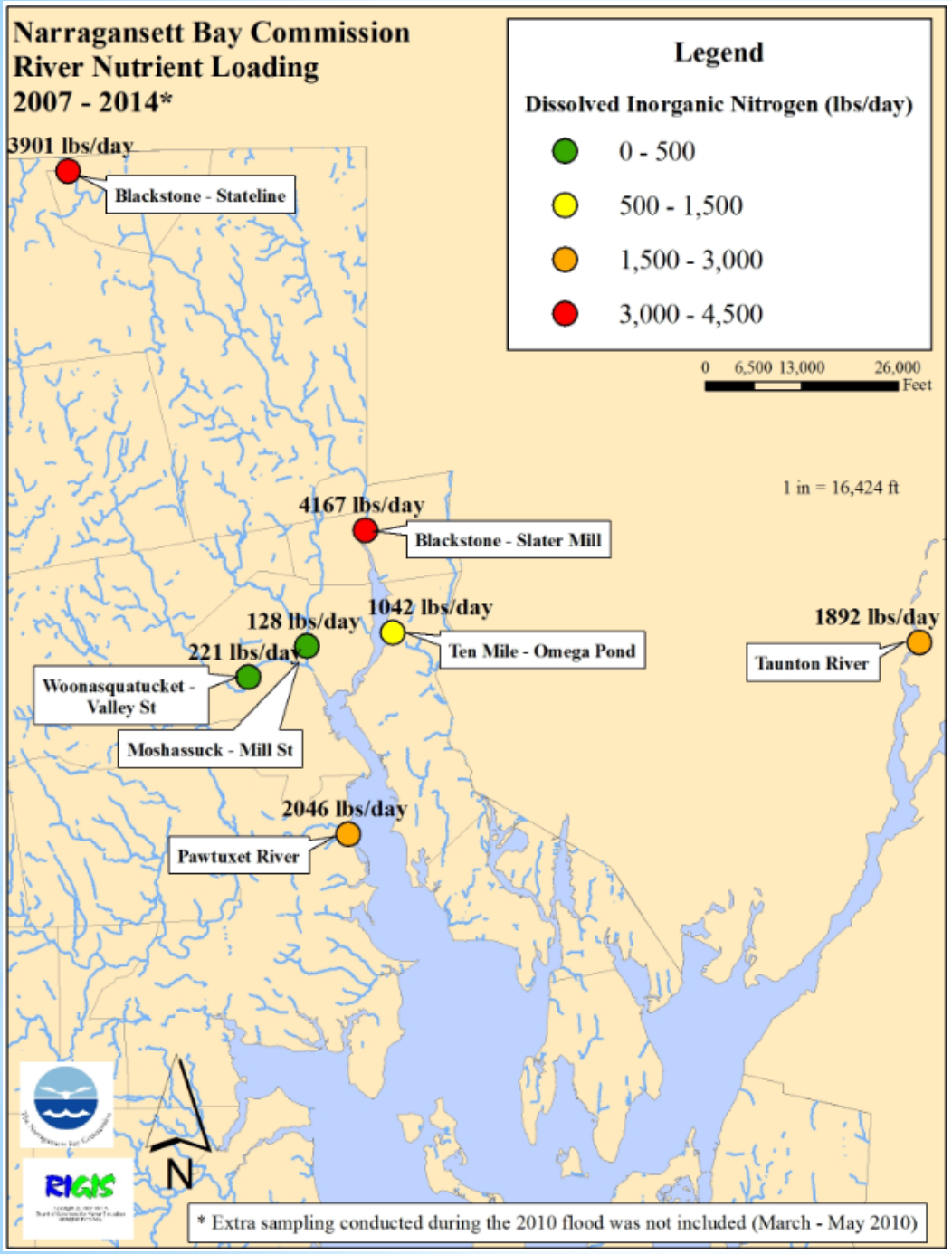
- Measured bi-monthly at 15 sites in RI & MA
- Total N loading – USGS river flow data
- Rivers with flow data:
  - Blackstone River
  - Moshassuck River
    Woonasquatucket River
  - Pawtuxet River
  - Taunton River
  - Ten Mile River
  - Palmer River*





River DIN Concentrations

- Relatively high DIN concentrations at Ten Mile River and Pawtuxet River.
- Moderately high DIN at Blackstone River and Taunton River



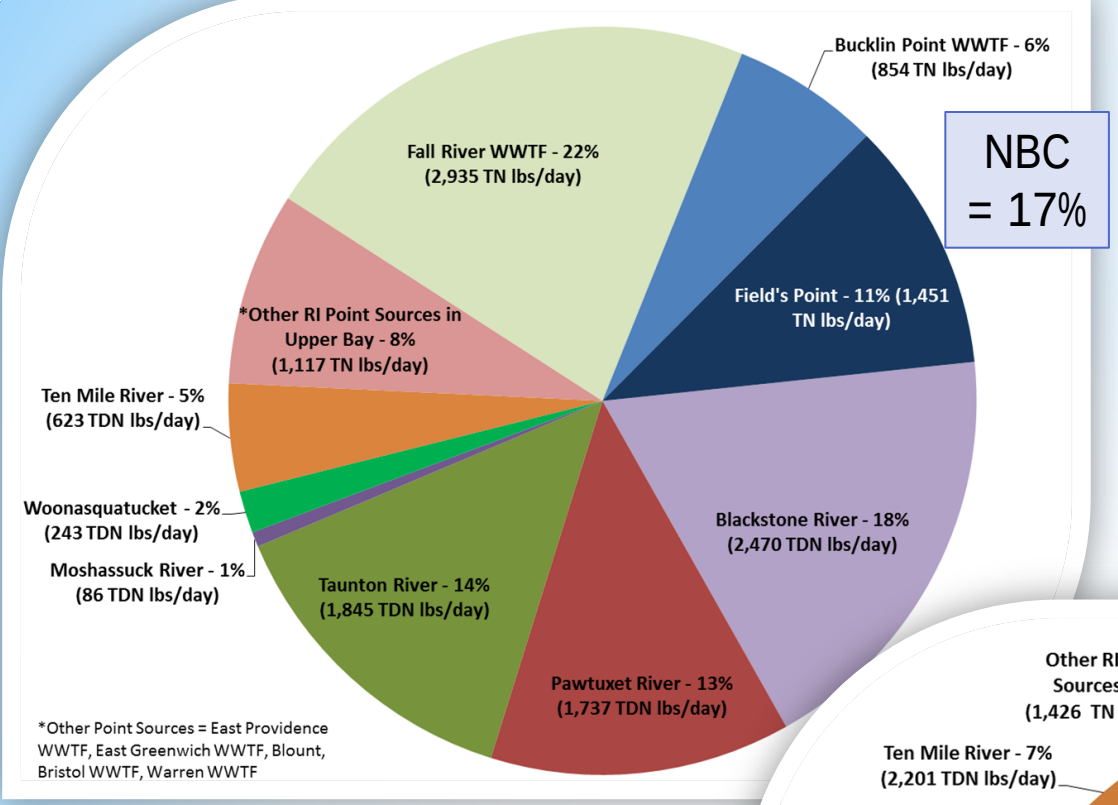
DIN Loading

- Highest loads – Blackstone River
- Taunton River and Pawtuxet Rivers also substantial
- Ten Mile River - high concentration, but low flow
- Moshassuck and Woonasquatucket – low flow & concentration

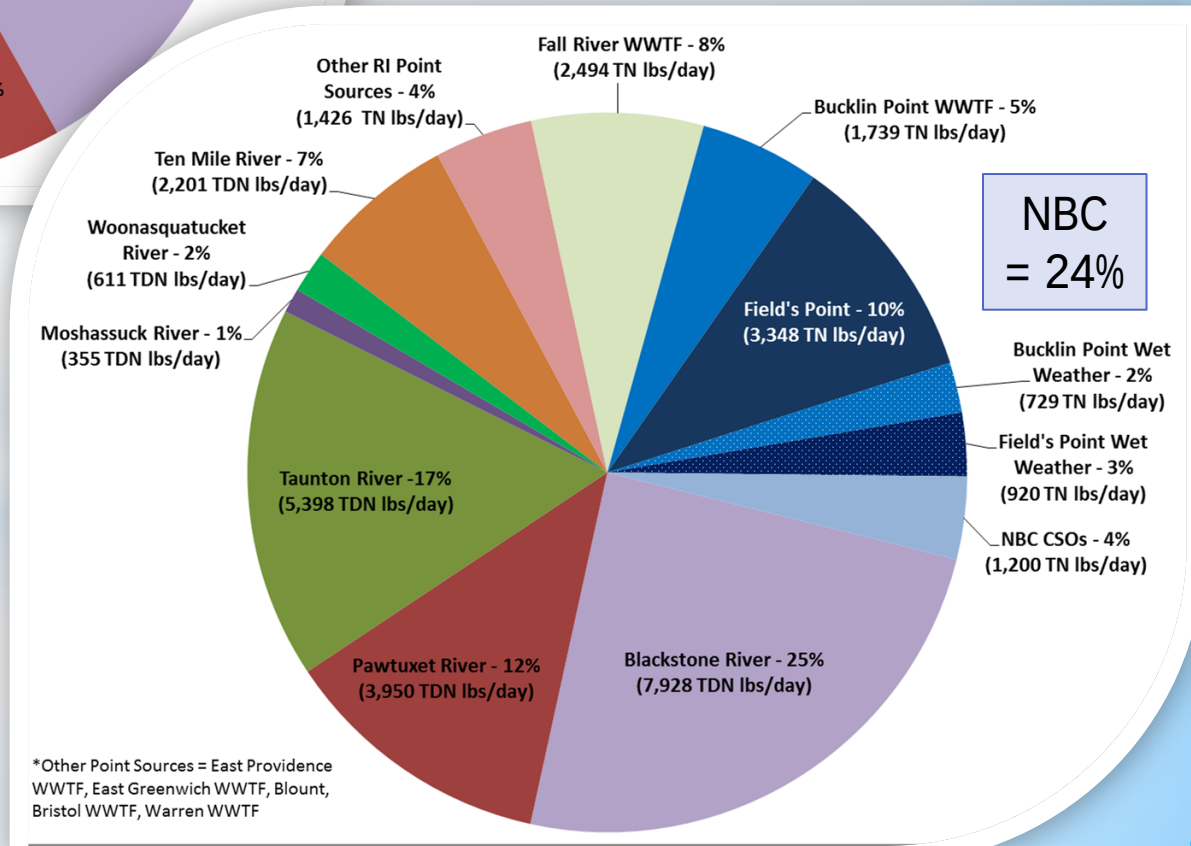
2013 – 2014 Average Loads

DRY Weather Days

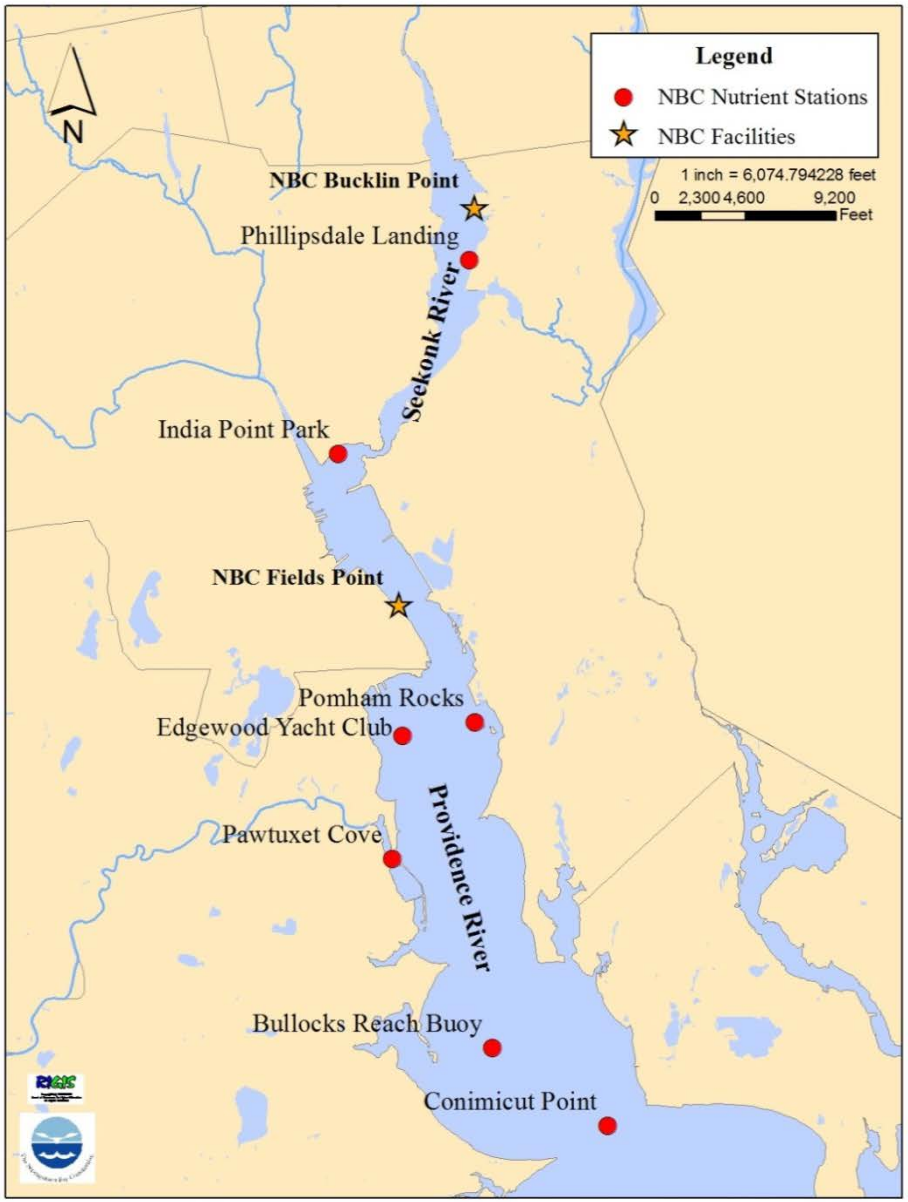
<0.1 inch of rain over prev. 3d



WET Weather Days



NBC Bay Sampling Locations



- Since 2007
- Nutrients measured bi-monthly
- Surface & bottom
- Collect at various stages of the tidal cycle throughout the year
- Nutrient suite includes:
  - Nitrite/nitrate
  - Nitrite
  - Total Dissolved Nitrogen
  - Ammonia
  - Orthophosphate
  - Silicate
  - Chlorophyll a
  - Total Suspended Solids
- Determine impact of NBC's BNR systems & inform stakeholders

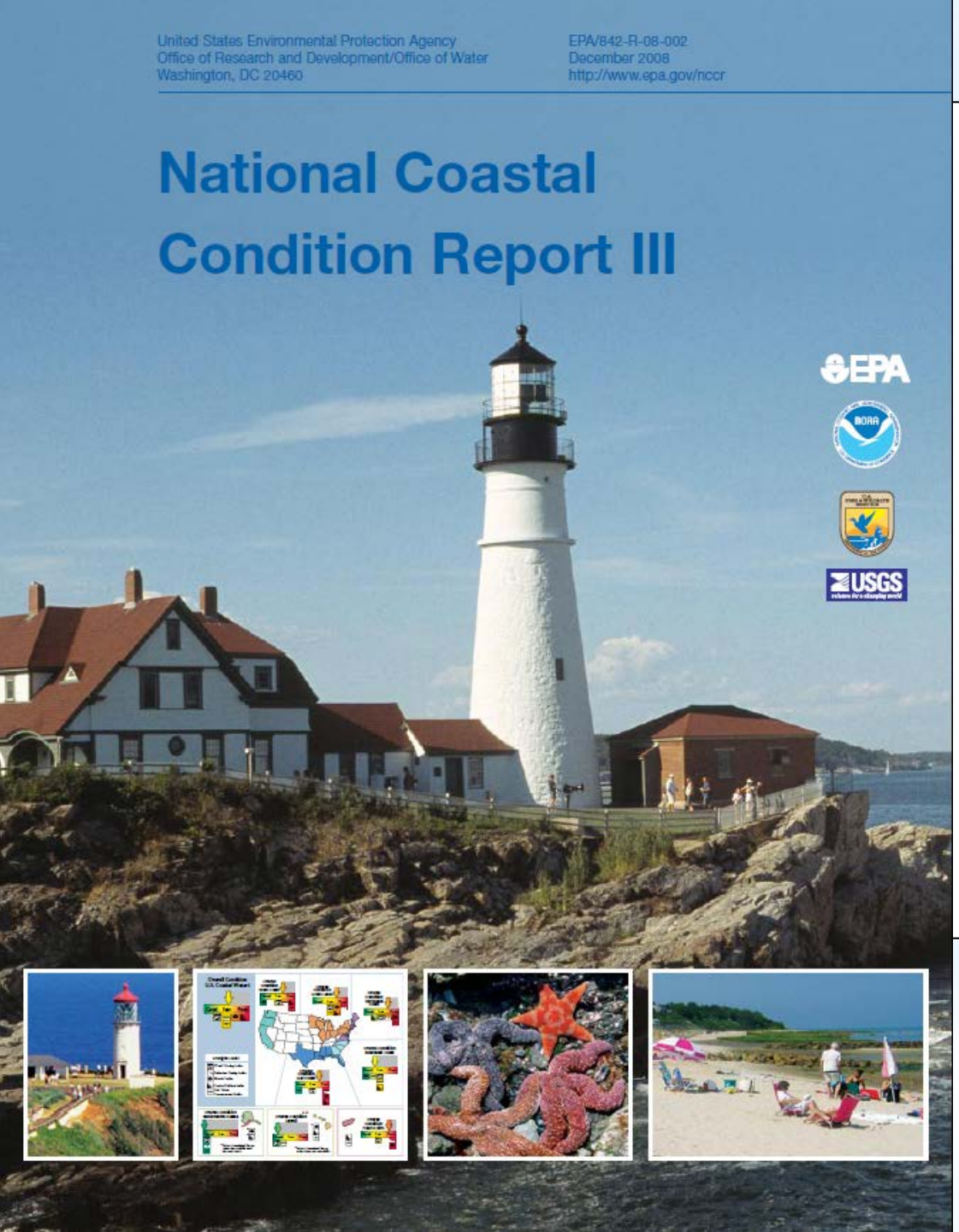


Table 1-2. Criteria for Assessing Dissolved Inorganic Nitrogen (DIN)

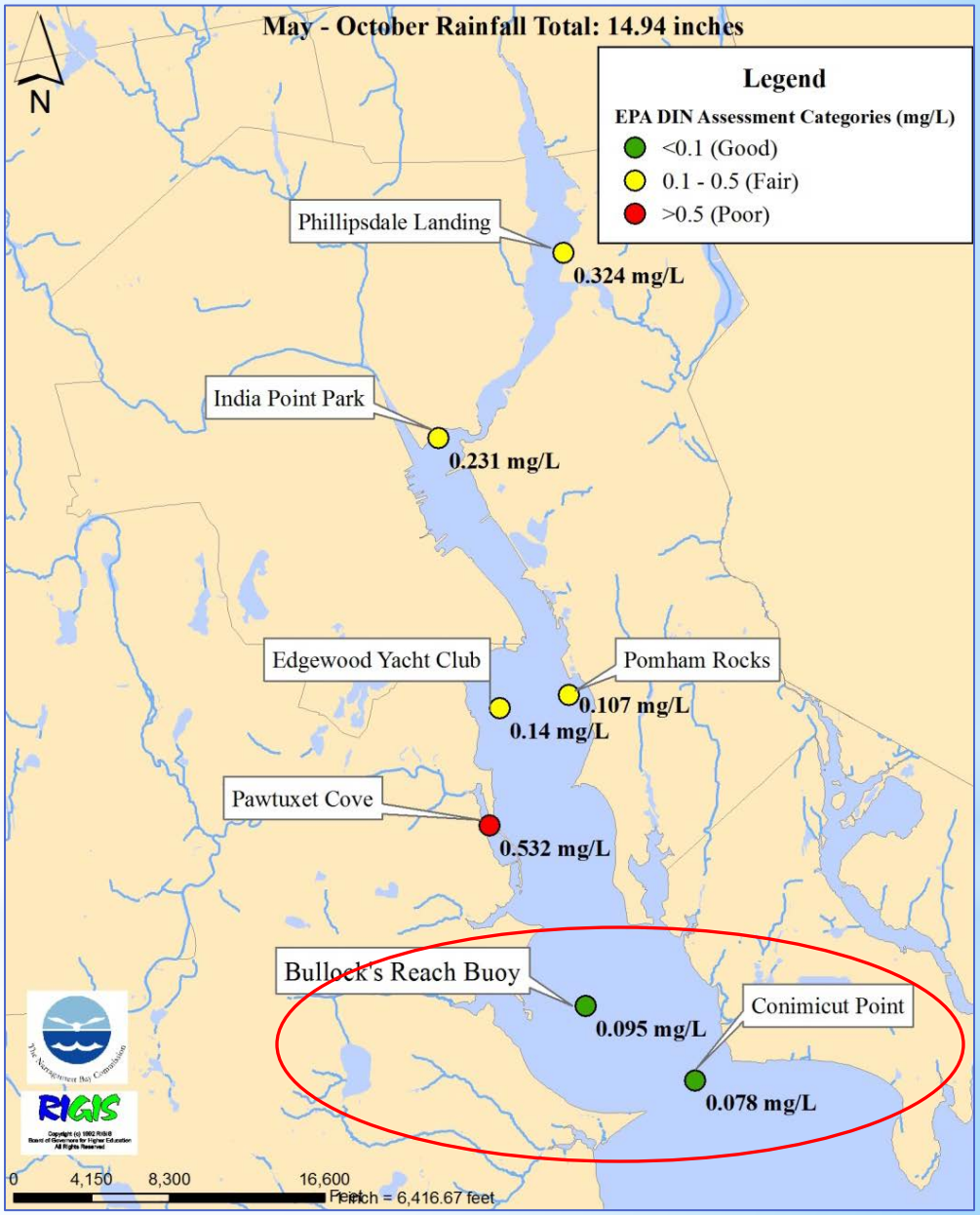
Area	Good	Fair	Poor
Northeast, Southeast, and Gulf Coast sites	< 0.1 mg/L	0.1–0.5 mg/L	> 0.5 mg/L
West Coast and Alaska sites	< 0.5 mg/L	0.5–1.0 mg/L	> 1 mg/L
Hawaii, Puerto Rico, and Florida Bay sites	< 0.05 mg/L	0.05–0.1 mg/L	> 0.1 mg/L
Regions	Less than 10% of the coastal area is in poor condition, and more than 50% of the coastal area is in good condition.	10% to 25% of the coastal area is in poor condition, or more than 50% of the coastal area is in combined poor and fair condition.	More than 25% of the coastal area is in poor condition.

Nitrogen TMDL not yet developed for Narragansett Bay

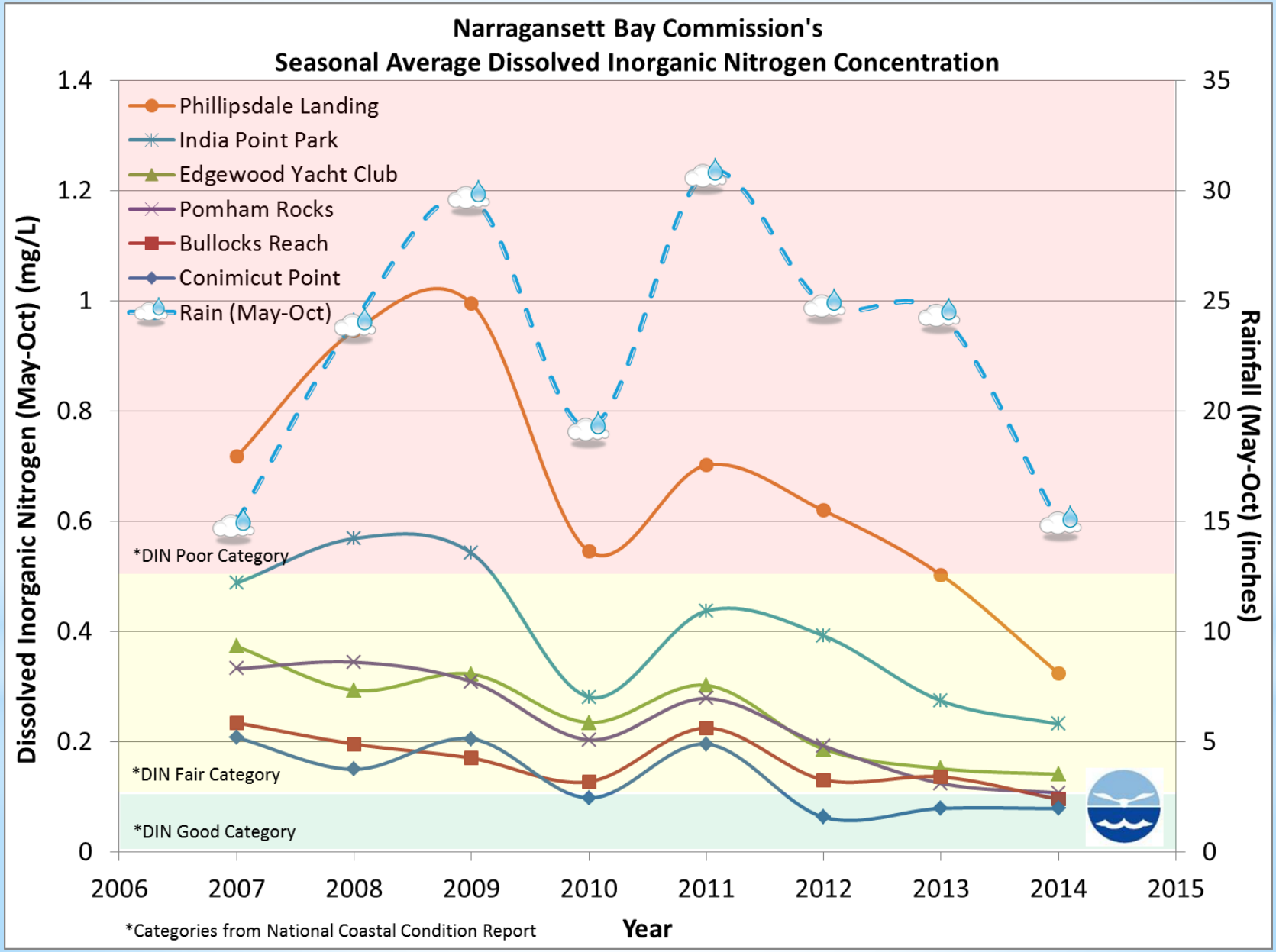
2014 Surface DIN

May – October 2014
Rainfall Total: 14.94 inches

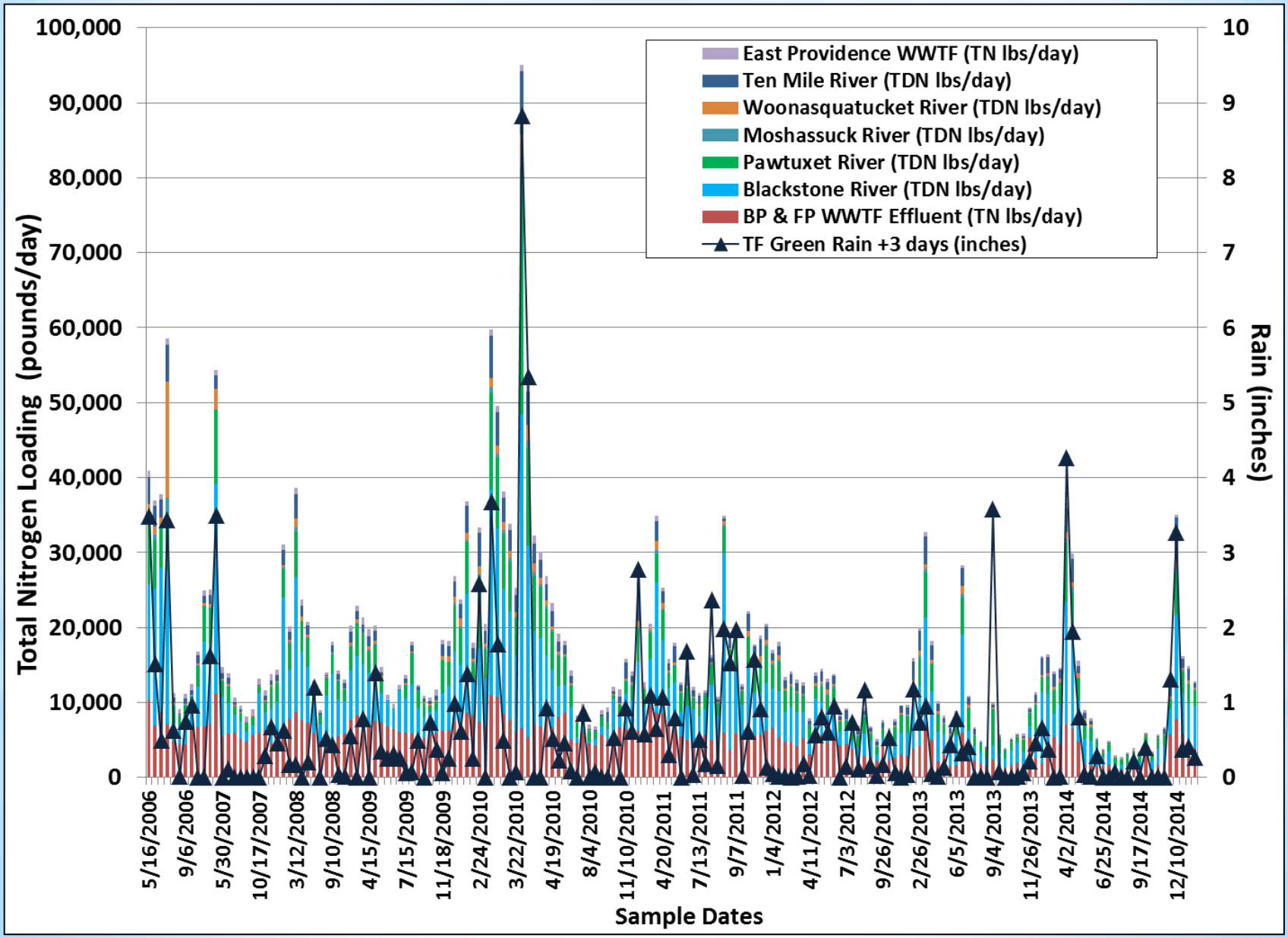
DIN (mg/L) Good <0.1 Fair 0.1-0.5 Poor >0.5 Station	DIN (mg/L)	EPA CCR Category
Phillipsdale Landing	0.324	
India Point Park	0.231	
Edgewood Yacht Club	0.140	
Pomham Rocks	0.107	
Pawtuxet Cove	0.532	
Bullock's Reach	0.095	
Conimicut Point	0.078	



Surface DIN

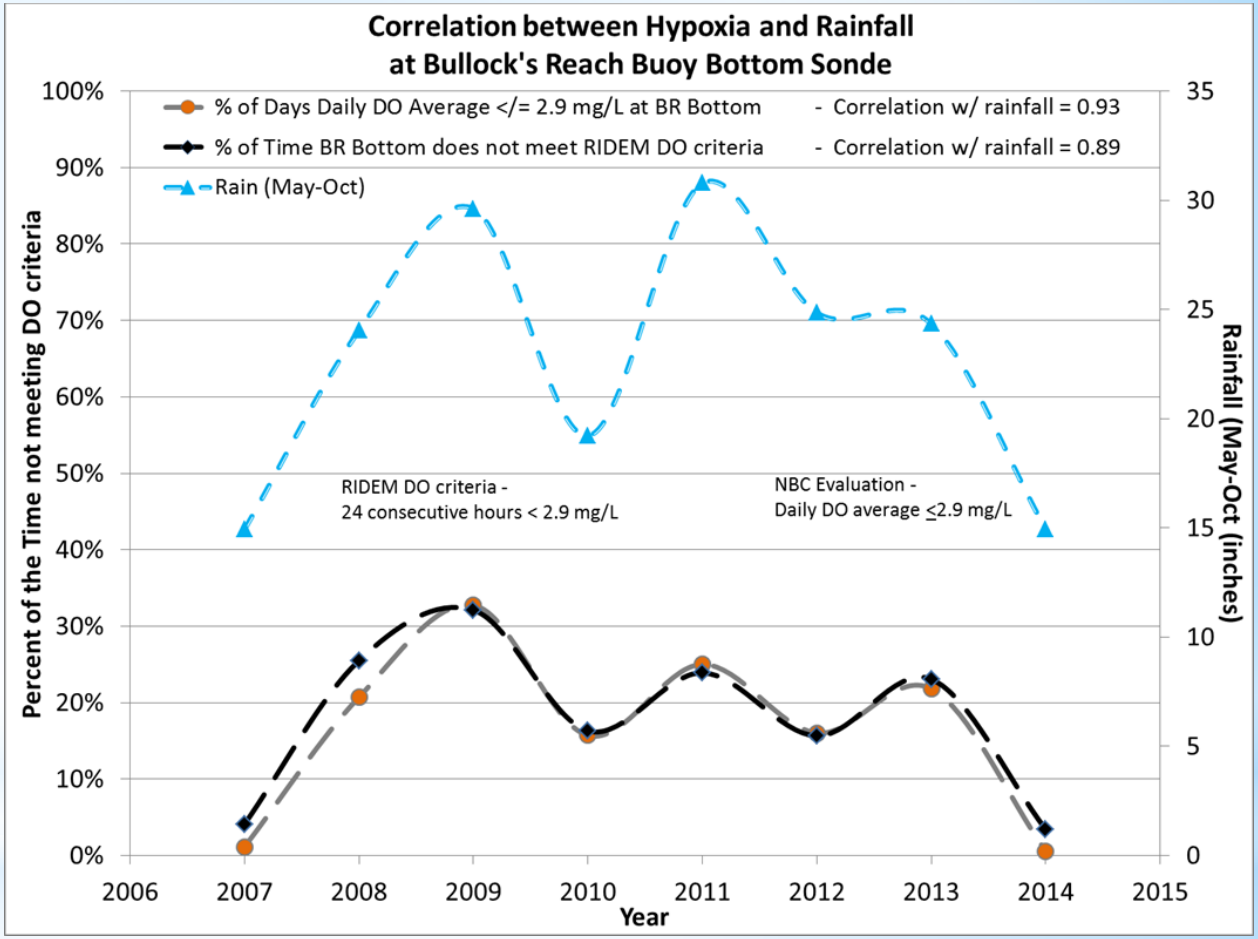

Narragansett Bay Commission's
Seasonal Average Dissolved Inorganic Nitrogen Concentration
Phillipsdale Landing
India Point Park
Edgewood Yacht Club
Pomham Rocks
Bullocks Reach
Conimicut Point
Rain (May-Oct)
*DIN Poor Category
*DIN Fair Category
*DIN Good Category
Dissolved Inorganic Nitrogen (May-Oct) (mg/L)
Rainfall (May-Oct) (inches)
Year
1.4
1.2
1
0.8
0.6
0.4
0.2
0
35
30
25
20
15
10
5
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
*Categories from National Coastal Condition Report

Total Nitrogen Loading and Rain



Hypoxia and Rainfall

- Hypoxia and rainfall correlated
- Hypoxia and DIN not correlated
- Rainfall increases point source and non-point source loads
- Rainfall contributes to stratification



Where Do We Go From Here?

- Will point-source reductions in nitrogen load lead to reduced hypoxia?
- 5-10 year delay in environmental response to N reductions & some area plants still coming online
- Hypoxia impacted by many environmental factors in addition to anthropogenic eutrophication
- What are the next steps?

NBC Seasonal Load to Upper Bay

*Projected loadings based on '09-'14 average flow

	Concentration (mg/L)	Loading (lbs/day)	Percent Reduction from 2003 Loading
Field's Point			
2003	15.7	5,834	
(projected) **5 mg/L**	5.0	1,756	70%
(projected) **3 mg/L**	3.0	1,054	82%

NBC Seasonal Load to Upper Bay

*Projected loadings based on '09-'14 average flow

	Concentration (mg/L)	Loading (lbs/day)	Percent Reduction from 2003 Loading
Field's Point			
2003	15.7	5,834	
(projected) **5 mg/L**	5.0	1,756	70%
(projected) **3 mg/L**	3.0	1,054	82%
Bucklin Point			
2003	14.8	2,908	
(projected) **5 mg/L**	5.0	772	73%
(projected) **3 mg/L**	3.0	463	84%

NBC Seasonal Load to Upper Bay

*Projected loadings based on '09-'14 average flow

	Concentration (mg/L)	Loading (lbs/day)	Percent Reduction from 2003 Loading
Field's Point			
2003	15.7	5,834	
(projected) **5 mg/L**	5.0	1,756	70%
(projected) **3 mg/L**	3.0	1,054	82%
Bucklin Point			
2003	14.8	2,908	
(projected) **5 mg/L**	5.0	772	73%
(projected) **3 mg/L**	3.0	463	84%
Combined NBC			
2003	FP: 15.7 BP: 14.8	8,741	
(projected) **5 mg/L**	5.0	2,528	71%
(projected) **3 mg/L**	3.0	1,517	83%

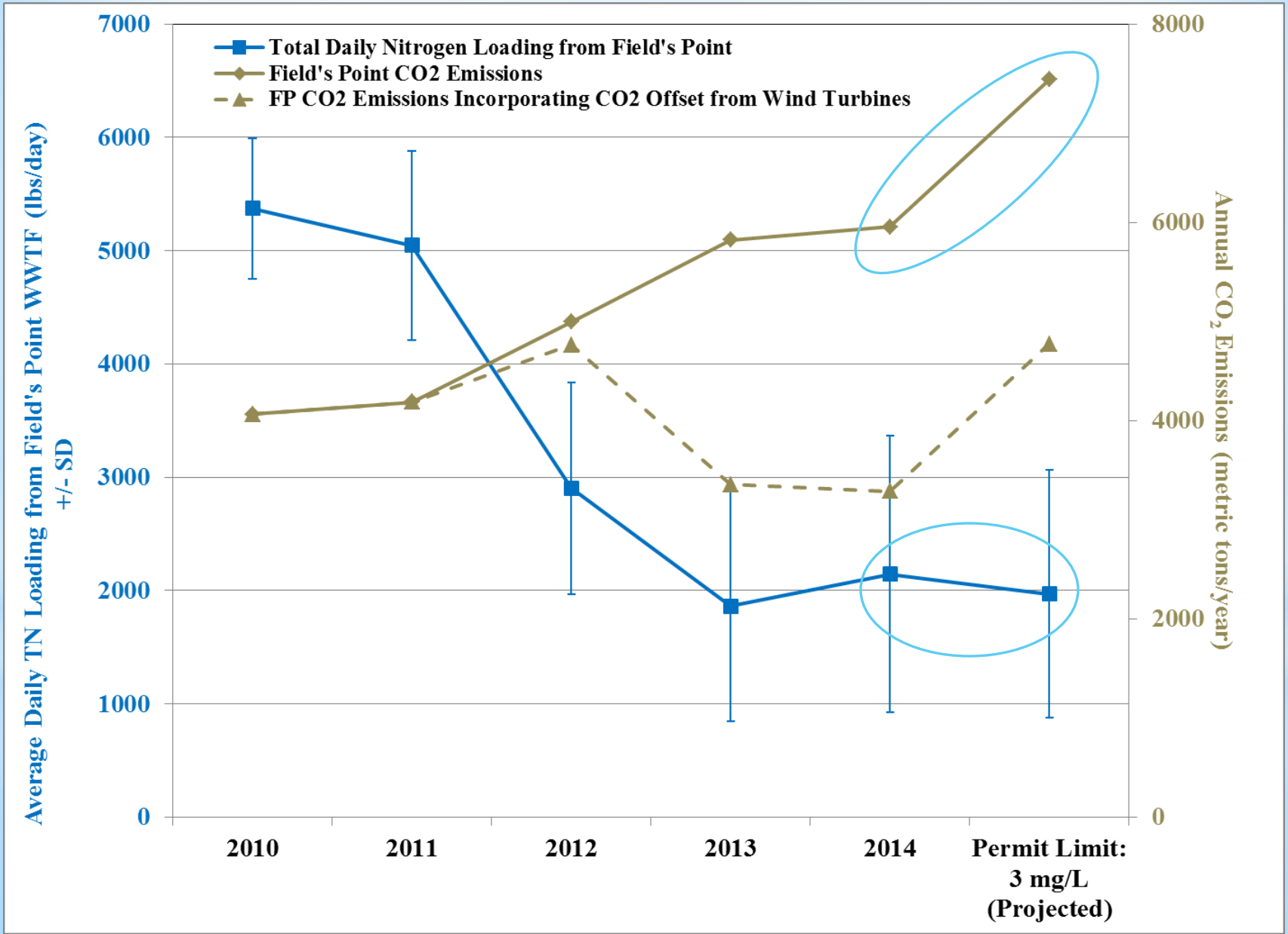
NBC Seasonal Load to Upper Bay

*Projected loadings based on '09-'14 average flow

	Concentration (mg/L)	Loading (lbs/day)	Percent Reduction from 2003 Loading
Field's Point			
2003	15.7	5,834	
(projected) **5 mg/L**	5.0	1,756	70%
(projected) **3 mg/L**	3.0	1,054	82%
Bucklin Point			
2003	14.8	2,908	
(projected) **5 mg/L**	5.0	772	73%
(projected) **3 mg/L**	3.0	463	84%
Combined NBC			
2003	FP: 15.7 BP: 14.8	8,741	
(projected) **5 mg/L**	5.0	2,528	71%
(projected) **2014 Conc.**	FP: 3.4 BP: 4.0	1,812	79%
(projected) **3 mg/L**	3.0	1,517	83%

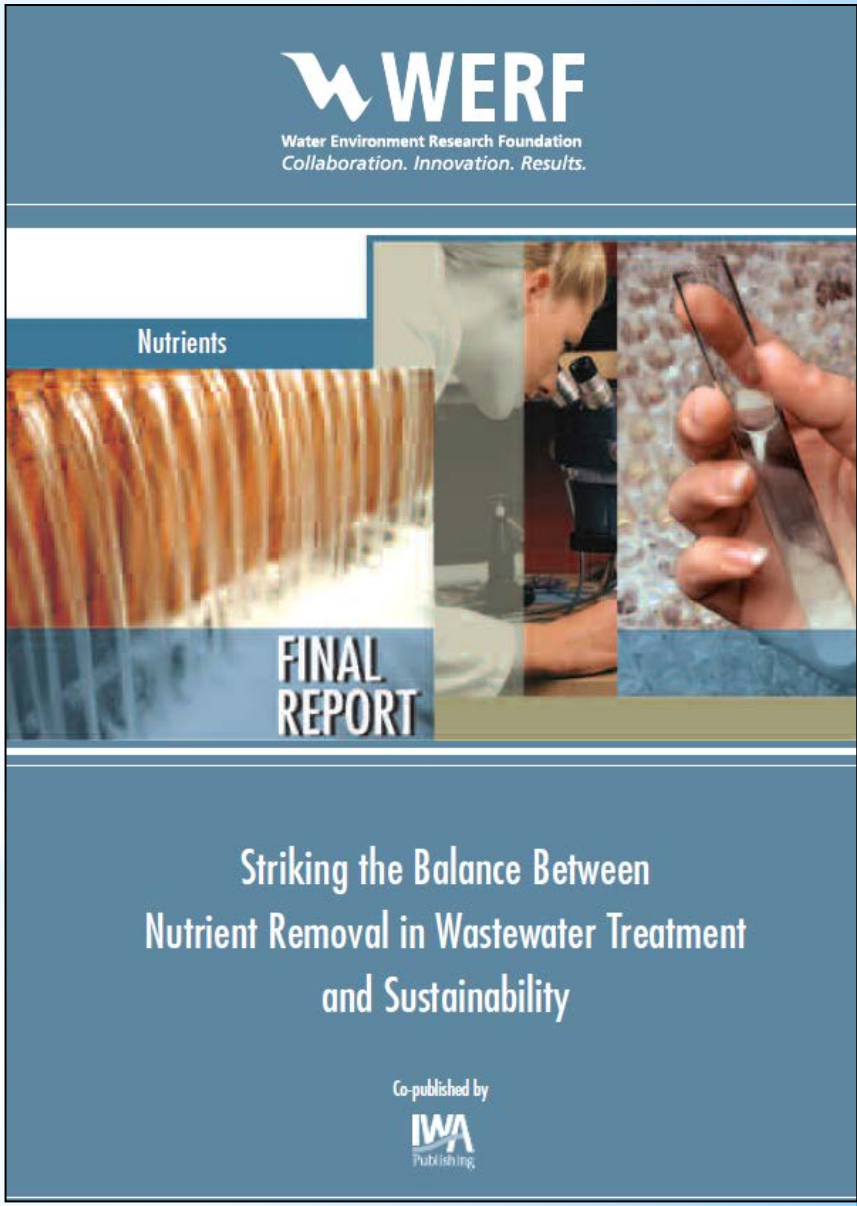
Upgrade to 3 mg/L TN may reduce ~295 Pounds of Nitrogen per Day

Average Nitrogen Loading at Field's Point vs. Estimated Greenhouse Gas Emissions (Electricity Use)



Nitrogen Reduction & Sustainability

- Water Environment Research Foundation Report – 2011
- Nitrogen removal to 3 mg/L = negative sustainability impacts for small water quality improvements
- CO2 emissions and costs (capital and operational) prohibitive
- Dissolved Organic Nitrogen impairs WWTF's ability to reliably achieve low TN.



Looking Ahead…

- WWTF upgrades have substantially reduced point-source nitrogen loadings –
  - DIN in the upper Bay “fair-good” in 2014
  - Impacts on hypoxia to-be-determined with more time
- Further reductions by WWTFs may have diminishing returns
  - Increasing financial and environmental cost
- Non-point sources of nitrogen become more significant
- Alternate approaches to reducing nitrogen impacts
  - Address non-point sources through fertilizer/stormwater controls
  - Restoration of shellfish (oyster reefs) to increase resilience

Acknowledgements

- NBC Environmental Monitoring and Data Analysis crew
- NBC Laboratory
- Policy, Planning, & Regulation staff