# NBC Water Quality Improvements and Monitoring Efforts

November 15, 2016 –

Presentation and discussion with members of the Commercial Fisheries Center

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- Bacteria reductions via Combined Sewer Outfall Abatement Program
- Nitrogen reductions at wastewater treatment facilities (WWTFs) and impacts on bay conditions
- Benthic video surveys

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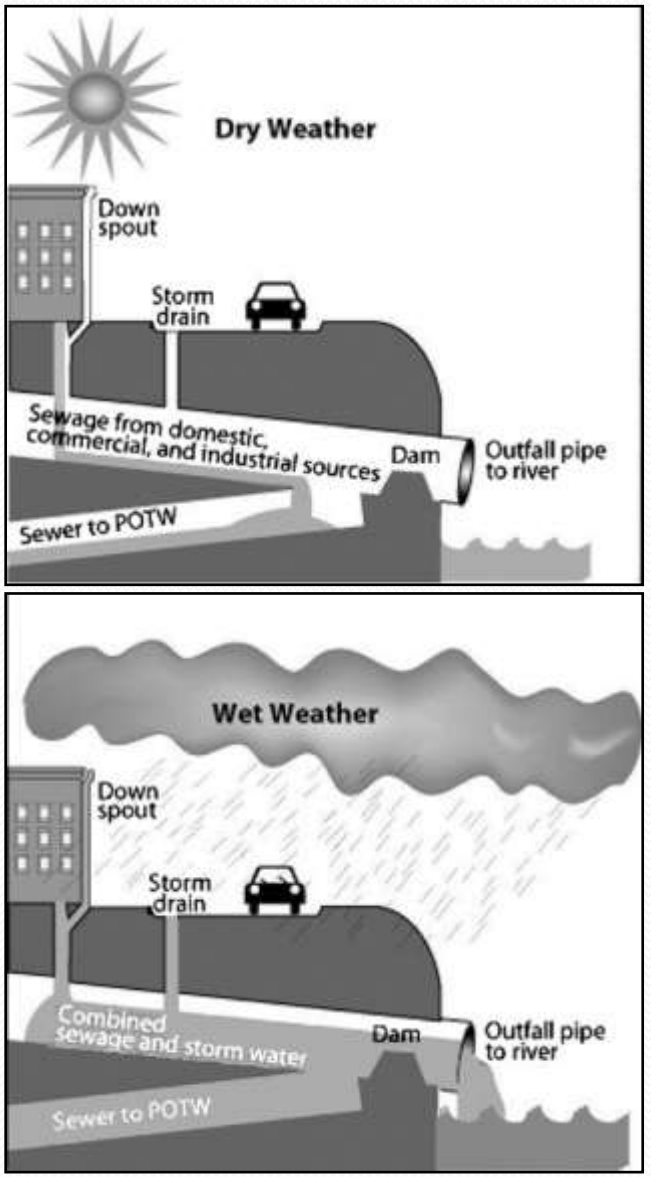
# Combined Sewers

- **Combined Sewer System** - all flow, including domestic sewerage, industrial waste, and rainwater all flow into the same pipe
  - Legacy of historical sewer system
- Overflows occur when stormwater overwhelms capacity of sewer pipes
  - Excess combined sewage discharges into local rivers
- Public health & water quality issues
- CSOs are source of fecal coliform to receiving waters.



# CSO Abatement Project: 3 Phases - ~$1.2 Billion

## PHASE I (2001 – Oct 2008)

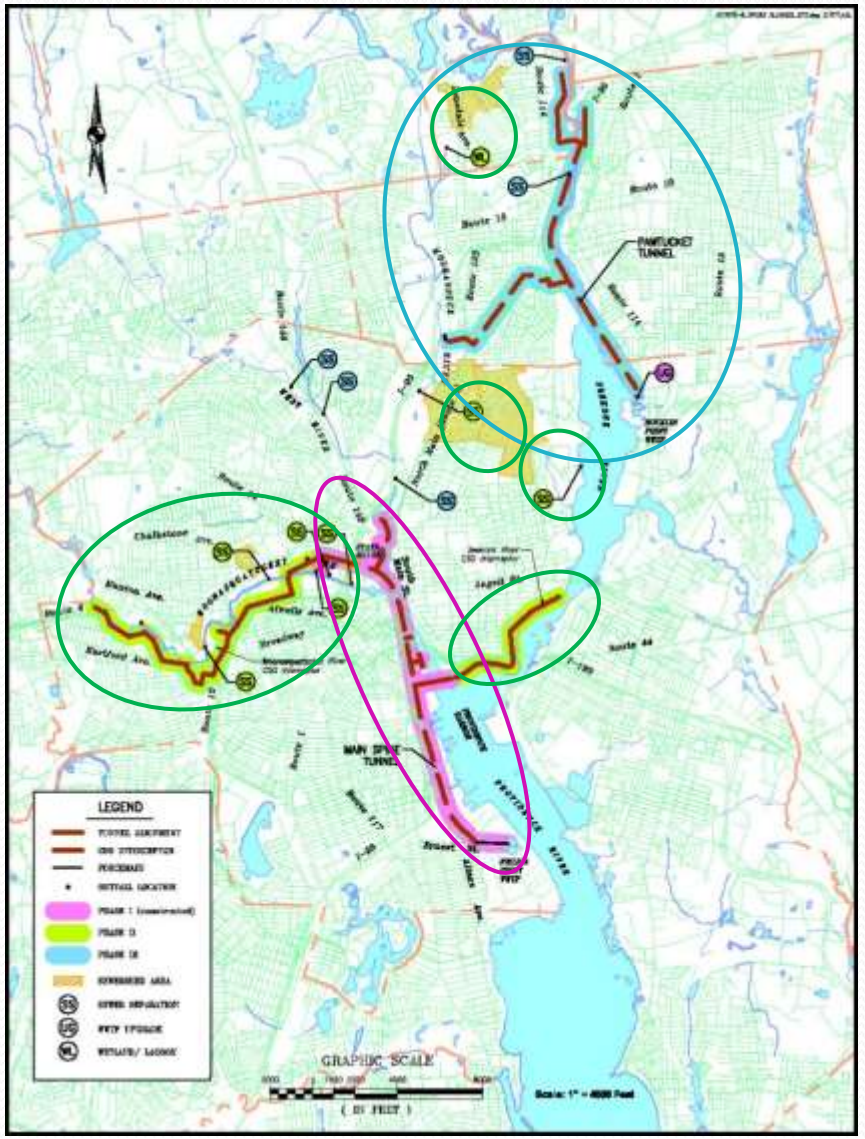
- 26 ft diameter deep rock tunnel
- 3+ mile long, 300 ft. below ground
- 62 MG design capacity

## PHASE II (2012 – 2015)

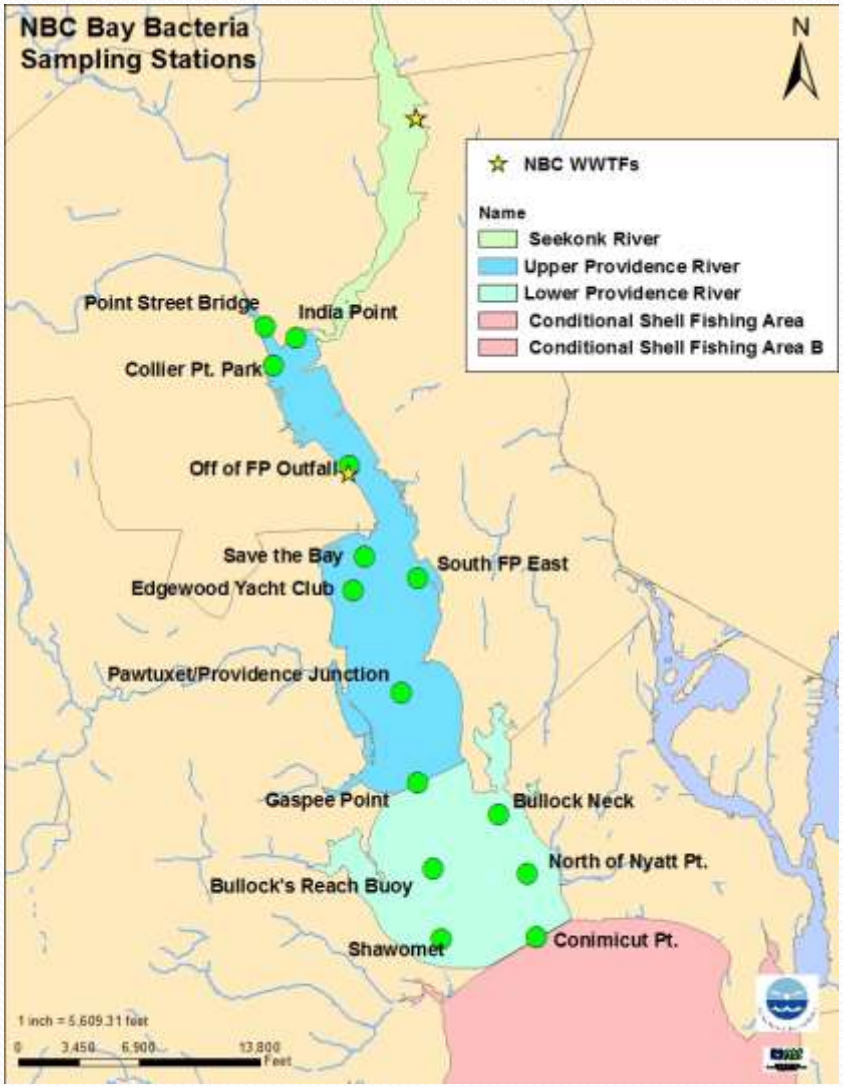
- Woonasquatucket & Seekonk River interceptors constructed to transport flow to the CSO tunnel
- Two sewer separations
- Constructed wetlands facility in Central Falls

## Phase III

- Design and approval
- Deep rock tunnel to Bucklin Point

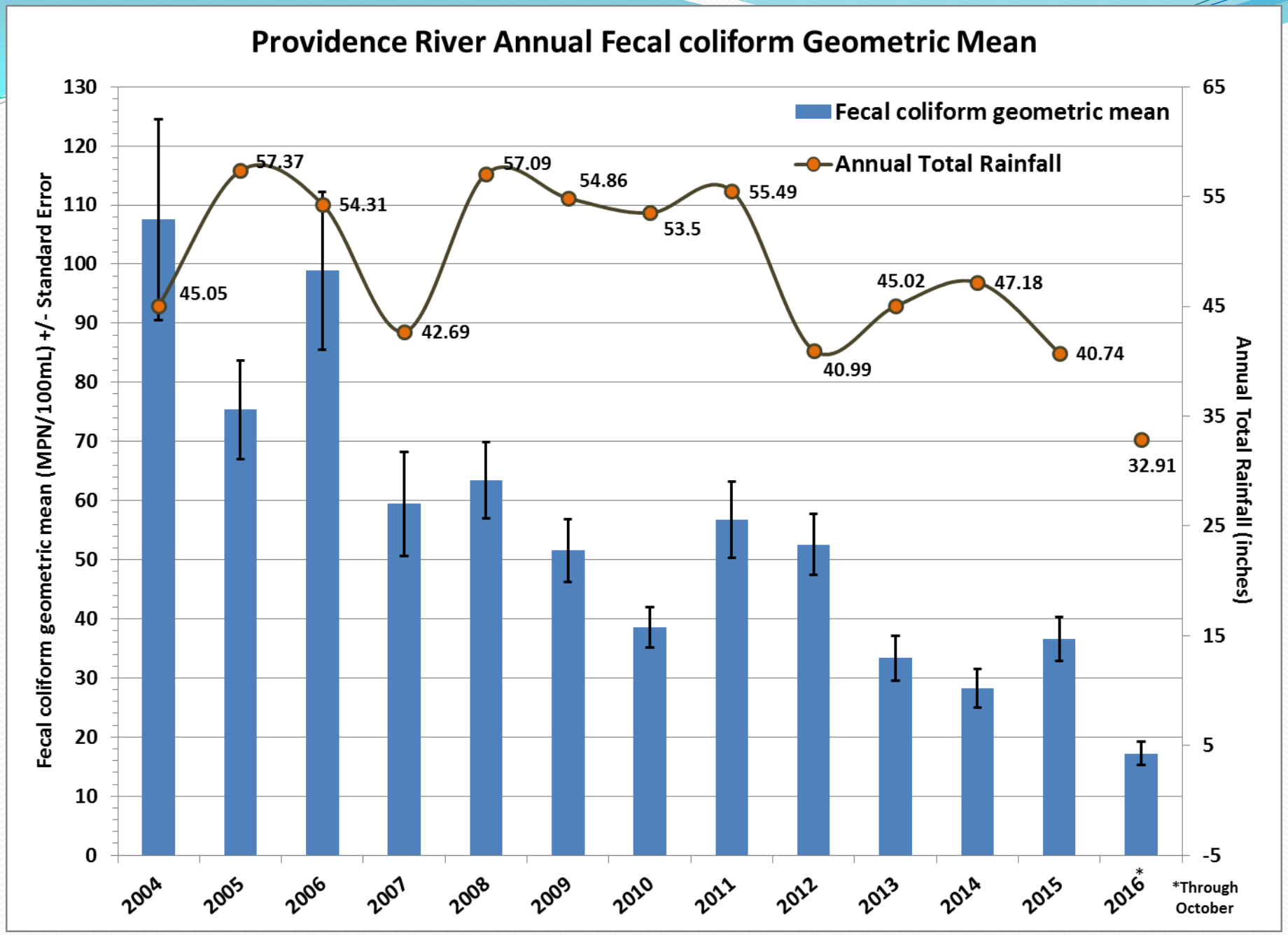


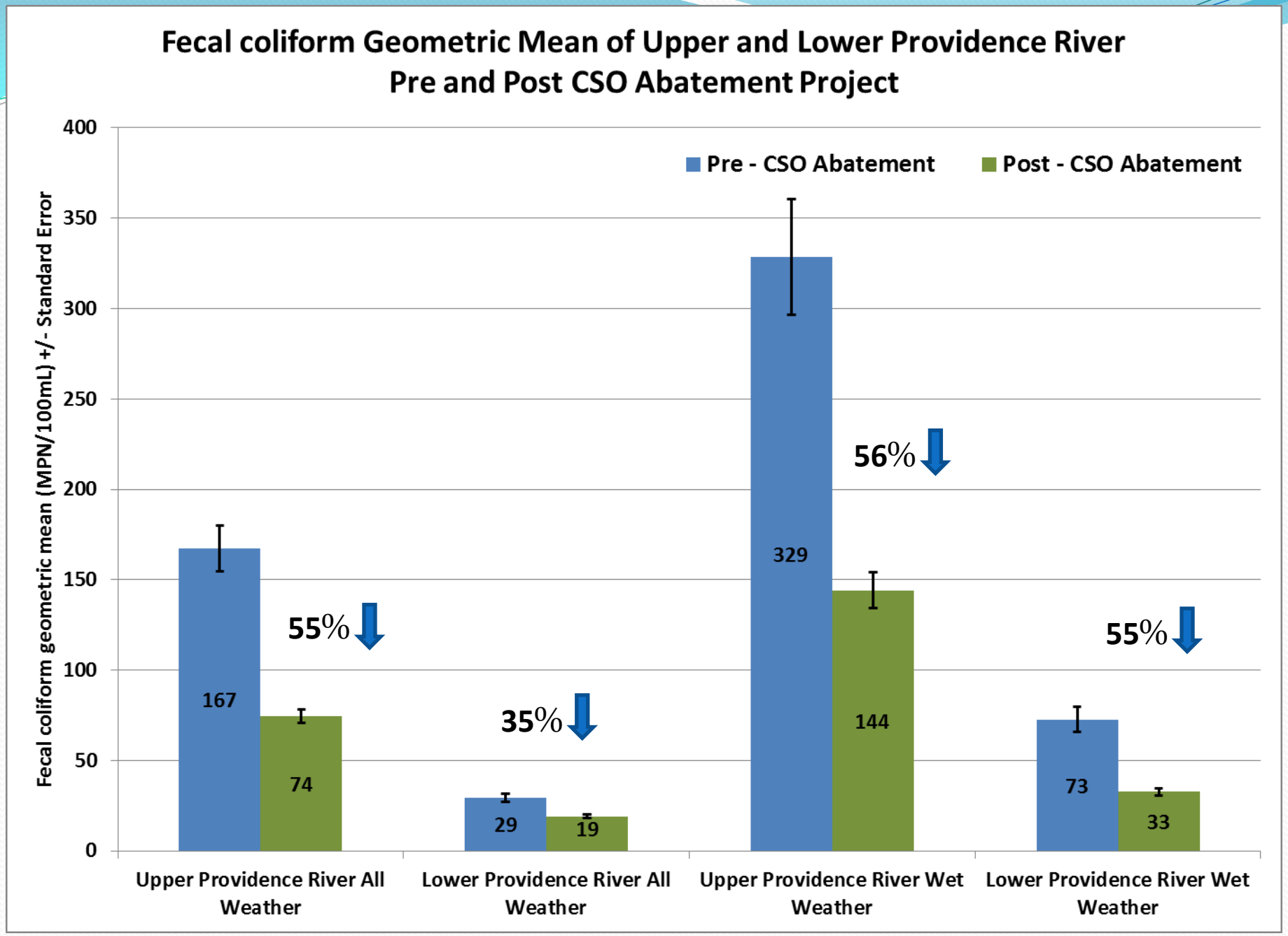
# Upper Bay Bacteria Monitoring

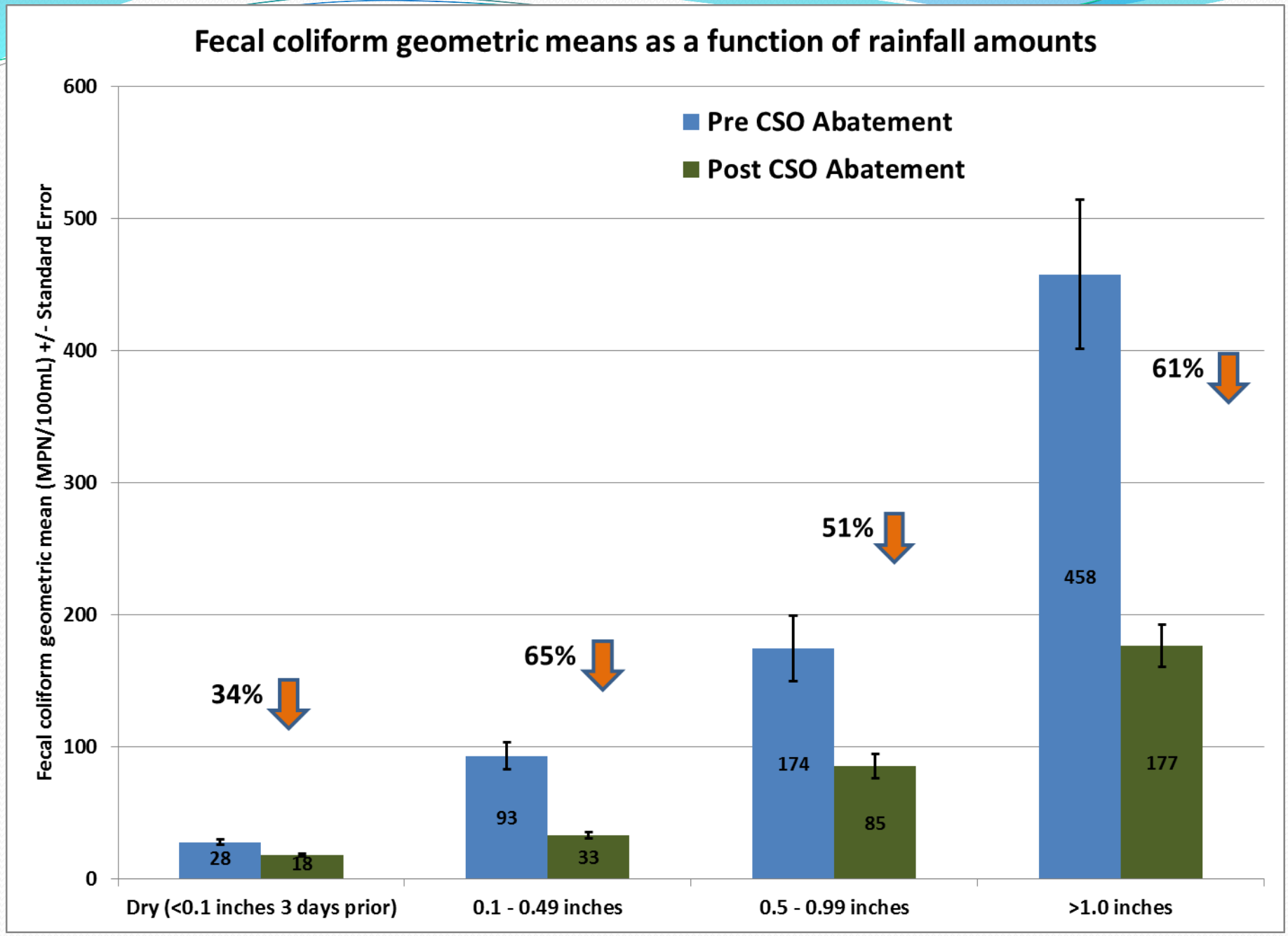


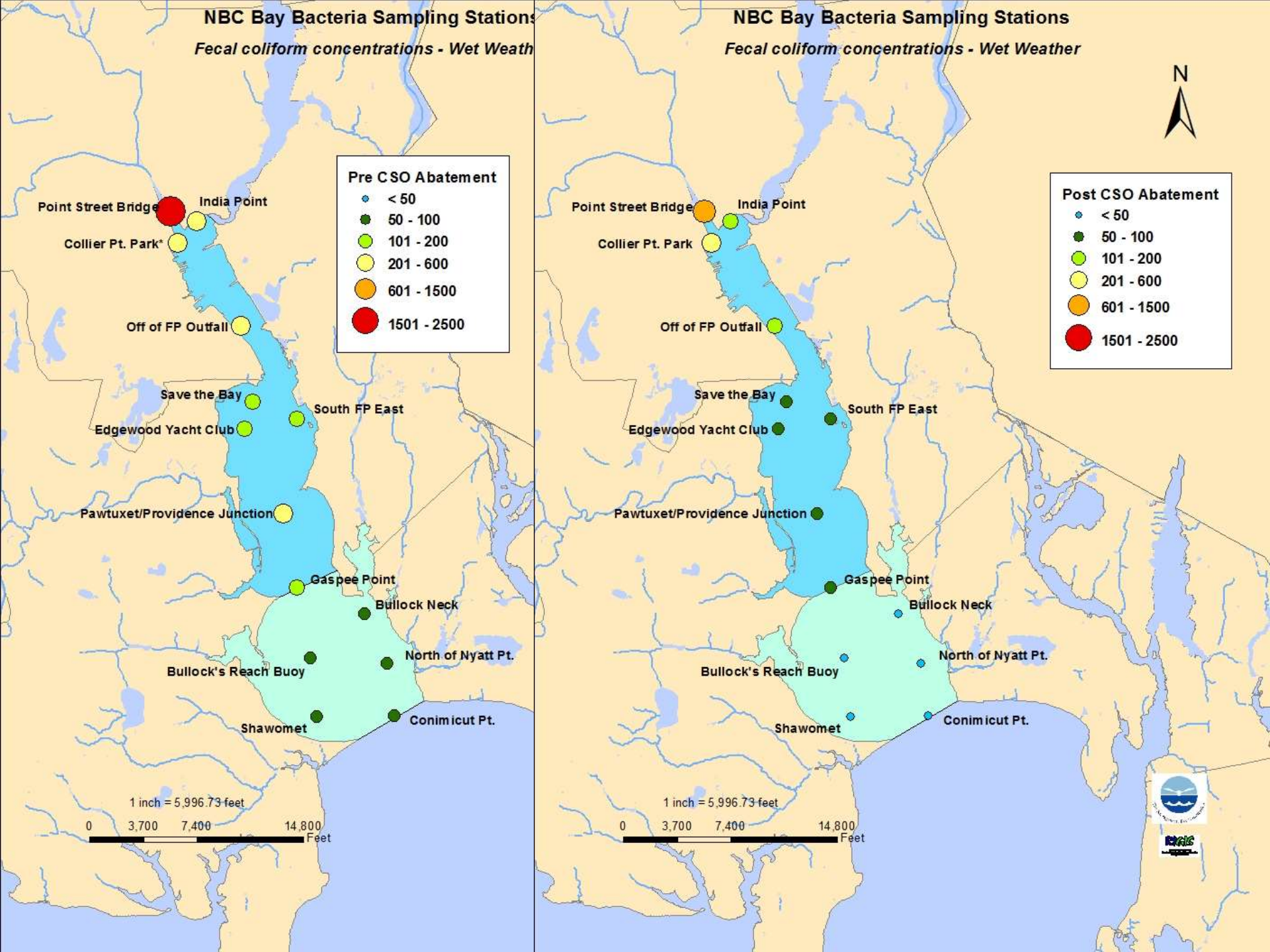

- 20 NBC Bay monitoring stations in Seekonk and Providence "Rivers" – Head of the estuary
  - 6 sites in Seekonk River
  - 14 sites in Providence River
    - 8 sites in Upper Providence River
    - 6 sites in Lower Providence River
- Biweekly throughout year for fecal coliform bacteria
- Pre CSO Abatement (June 2004 – Oct 2008)
- Post CSO Abatement (Nov 2008 – Sept 2016)
- Dry day – <0.1 inches rainfall 3 days prior
- Wet day – >0.1 inches rainfall 3 days prior

- Why monitor? – what impact do large scale infrastructure projects have on water quality in the bay?


Providence River Annual Fecal coliform Geometric Mean
Fecal coliform geometric mean
Annual Total Rainfall
Fecal coliform geometric mean (MPN/100mL) +/- Standard Error
Annual Total Rainfall (inches)
130
120
110
100
90
80
70
60
50
40
30
20
10
0
65
55
45
35
25
15
5
-5
45.05
57.37
54.31
42.69
57.09
54.86
53.5
55.49
40.99
45.02
47.18
40.74
32.91
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016*
*Through October


Fecal coliform Geometric Mean of Upper and Lower Providence River
Pre and Post CSO Abatement Project
Fecal coliform geometric mean (MPN/100mL) +/- Standard Error
400
350
300
250
200
150
100
50
0
Pre - CSO Abatement
Post - CSO Abatement
167
74
55%
29
19
35%
329
144
56%
73
33
55%
Upper Providence River All Weather
Lower Providence River All Weather
Upper Providence River Wet Weather
Lower Providence River Wet Weather


Fecal coliform geometric means as a function of rainfall amounts
Pre CSO Abatement
Post CSO Abatement
Fecal coliform geometric mean (MPN/100mL) +/- Standard Error
600
500
400
300
200
100
0
34%
65%
51%
61%
28
18
93
33
174
85
458
177
Dry (<0.1 inches 3 days prior)
0.1 - 0.49 inches
0.5 - 0.99 inches
>1.0 inches


NBC Bay Bacteria Sampling Stations
Fecal coliform concentrations - Wet Weath
Pre CSO Abatement
< 50
50 - 100
101 - 200
201 - 600
601 - 1500
1501 - 2500
Point Street Bridge
India Point
Collier Pt. Park*
Off of FP Outfall
Save the Bay
South FP East
Edgewood Yacht Club
Pawtuxet/Providence Junction
Gaspee Point
Bullock Neck
North of Nyatt Pt.
Bullock's Reach Buoy
Shawomet
Conimicut Pt.
1 inch = 5,996.73 feet
0 3,700 7,400 14,800
Feet
NBC Bay Bacteria Sampling Stations
Fecal coliform concentrations - Wet Weather
N
Post CSO Abatement
< 50
50 - 100
101 - 200
201 - 600
601 - 1500
1501 - 2500
Point Street Bridge
India Point
Collier Pt. Park
Off of FP Outfall
Save the Bay
South FP East
Edgewood Yacht Club
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Bullock Neck
North of Nyatt Pt.
Bullock's Reach Buoy
Shawomet
Conimicut Pt.
1 inch = 5,996.73 feet
0 3,700 7,400 14,800
Feet

| Sampling Location | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Point Street Bridge | 2043 | 2054 | 3981 | 845 | 925 | 945 | 439 | 550 | 531 | ***408*** | 600 | 504 | 559 |
| India Point | 303 | 353 | 255 | 189 | 182 | 117 | 83 | 193 | 95 | 167 | 74 | 52 | ***47*** |
| Collier Point Park | 262 | 349 | 167 | 277 | 387 | 220 | 158 | 208 | 188 | 161 | 149 | 106 | ***38*** |
| Off of FP Outfall | 190 | 245 | 183 | 102 | 159 | 120 | 45 | 134 | 66 | 60 | 36 | 70 | ***33*** |
| Save the Bay | | 54 | 61 | 75 | 46 | 42 | 37 | 46 | 38 | 34 | 21 | 36 | ***11*** |
| South F.P. East | 76 | 84 | 49 | 65 | 78 | 42 | 28 | 44 | 46 | 33 | 34 | 58 | ***14*** |
| Edgewood Yacht Club | 64 | 67 | 98 | 65 | 55 | 35 | 39 | 48 | 40 | 31 | ***16*** | 44 | 22 |
| Pawtuxet/Providence Junction | | 77 | 157 | 116 | 81 | 59 | 42 | 77 | 69 | 43 | 40 | 52 | ***30*** |
| Gaspee Point At Channel | 55 | 67 | 70 | 48 | 61 | 30 | 38 | 37 | 64 | 18 | 15 | 39 | ***11*** |
| Bullock Neck | 35 | 16 | 31 | 27 | 23 | 18 | 25 | 25 | 46 | 19 | 14 | 11 | ***8*** |
| Bullocks Reach Buoy | 40 | 35 | 71 | 21 | 33 | 31 | 23 | 28 | 37 | 19 | ***14*** | 19 | 17 |
| North of Nayatt Point | | 14 | 20 | 20 | 21 | 17 | 21 | 25 | 23 | 11 | 11 | 8 | ***5*** |
| Shawomet | | 22 | 43 | 23 | 49 | 23 | 25 | 31 | 31 | 13 | 13 | 14 | ***8*** |
| Conimicut Point | 32 | 27 | 35 | 11 | 23 | 20 | 16 | 20 | 24 | 11 | 9 | 15 | ***5*** |
| **SEASONAL RAINFALL MAY - OCT** | **22.31** | **29.05** | **32.6** | **14.93** | **24.04** | **29.62** | **19.22** | **30.78** | **24.85** | **24.3** | **14.94** | **20.14** | **18.46** |
| **Storms ≥ 0.5 inches in 24 hours** | **17** | **16** | **19** | **9** | **11** | **21** | **13** | **20** | **21** | **15** | **7** | **13** | **13** |
| *bold italicized numbers = minimum value of all years* | | | | | | | | | | | | | |

- **<u>May 2011:</u>** Conditional Area A, closed after 0.8 inch of rainfall, up from 0.5 inch. Conditional Area B closed after 1.5 inches of rainfall, up from 1.0 inch

- 2 most southern monitoring stations have shown results in compliance with shellfishing standards in 3 of the past 4 years

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- Benthic video surveys

# Nitrogen and Hypoxia

- Phytoplankton & algae blooms
- Blooms decompose, bacteria consume dissolved oxygen
  - 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?

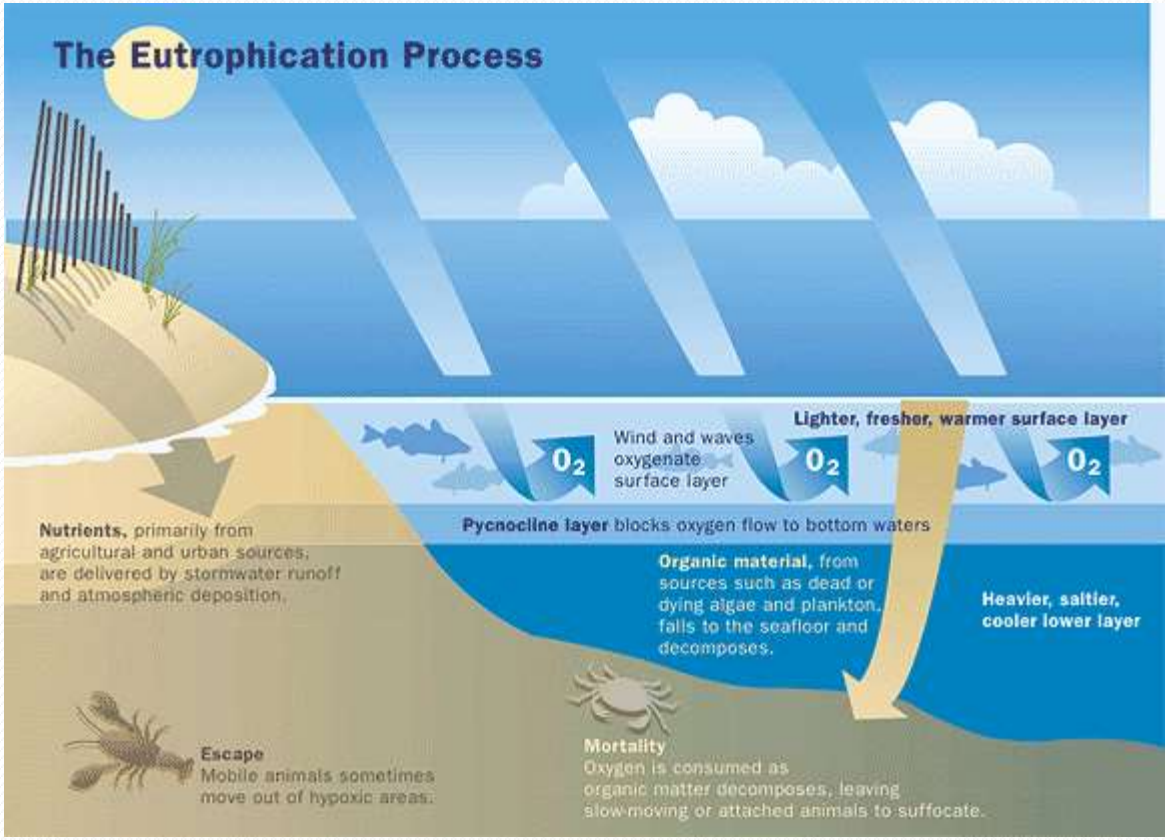



Image credit: Pew Trusts

- Fish kill in Greenwich Bay 2003 accelerated plans by RIDEM to initiate N reductions at WWTFs – GOAL = 50% reduction

# Biological Nutrient Removal (BNR)

- Optimize conditions for nitrification and denitrification
- NBC Permit limit (5 mg/L) in effect May – October

**Total NBC Upgrade Cost: $44 Million**

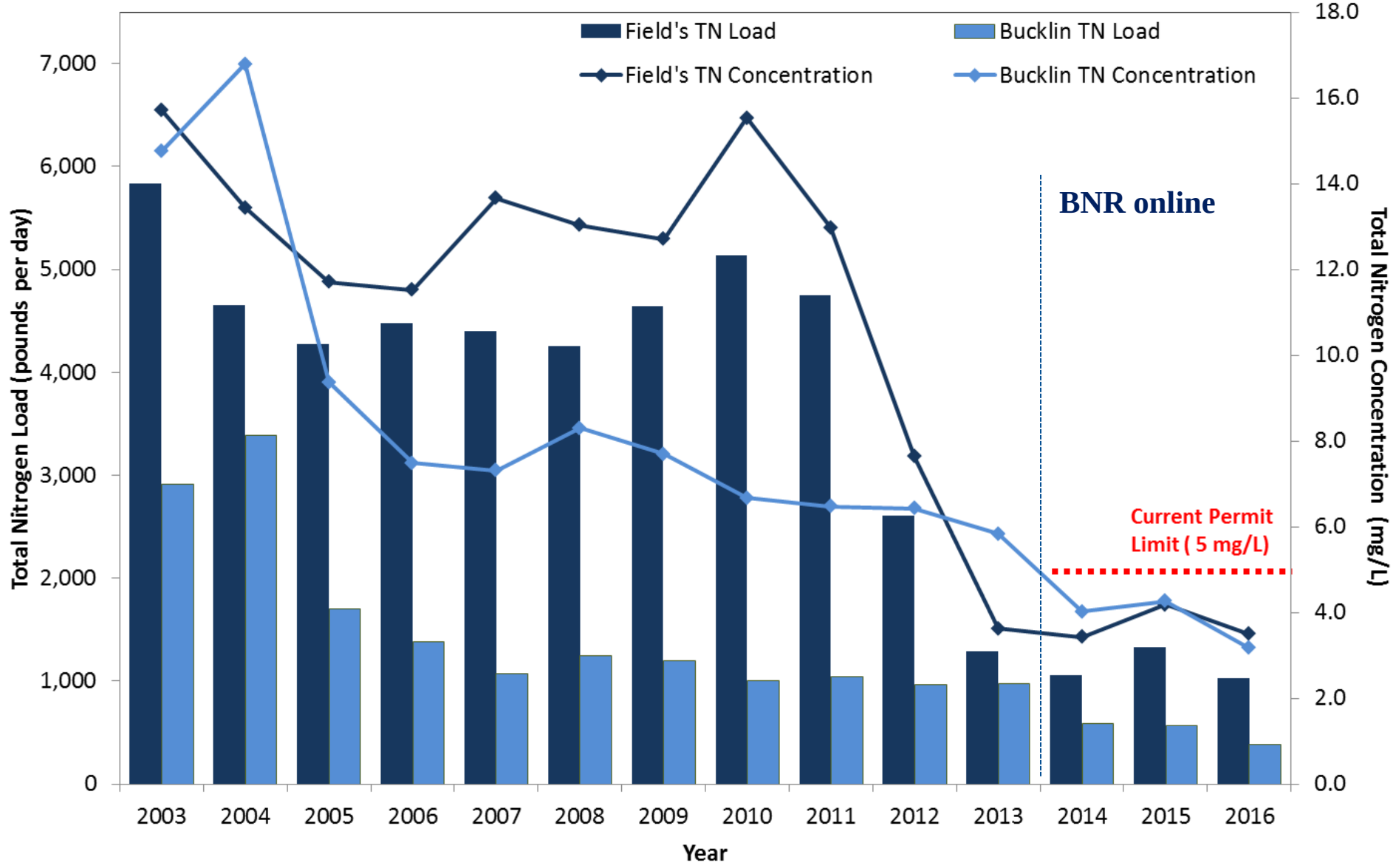
## Field's Point

- Integrated Fixed Film Activated Sludge (IFAS) – Largest in the world!
- 5 mg/L Permit limits in effect May 2014

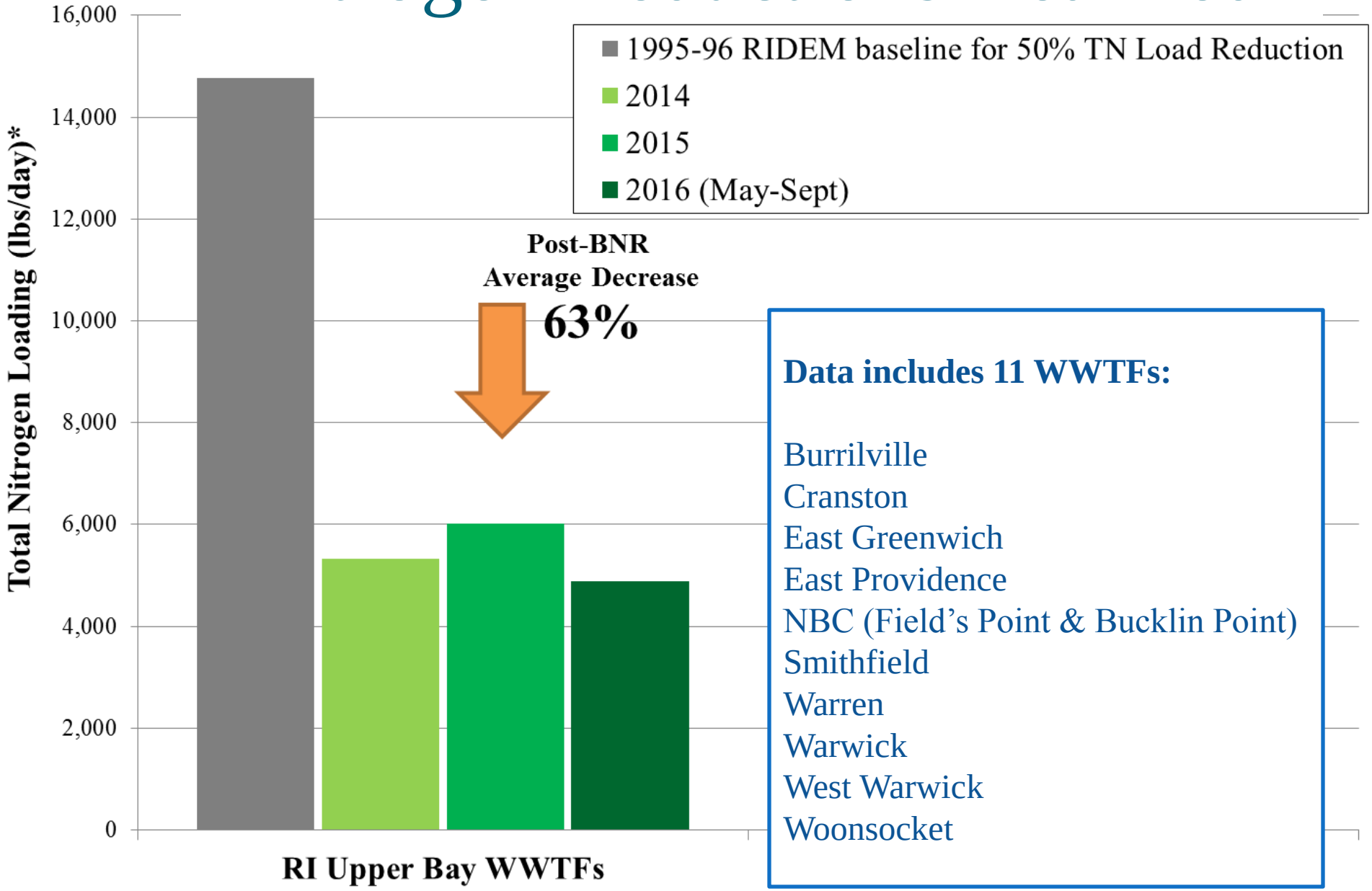
## Bucklin Point

- Initial upgrades completed in 2006
- 5 mg/L limit in effect July 2014

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



# Nitrogen Reductions Realized

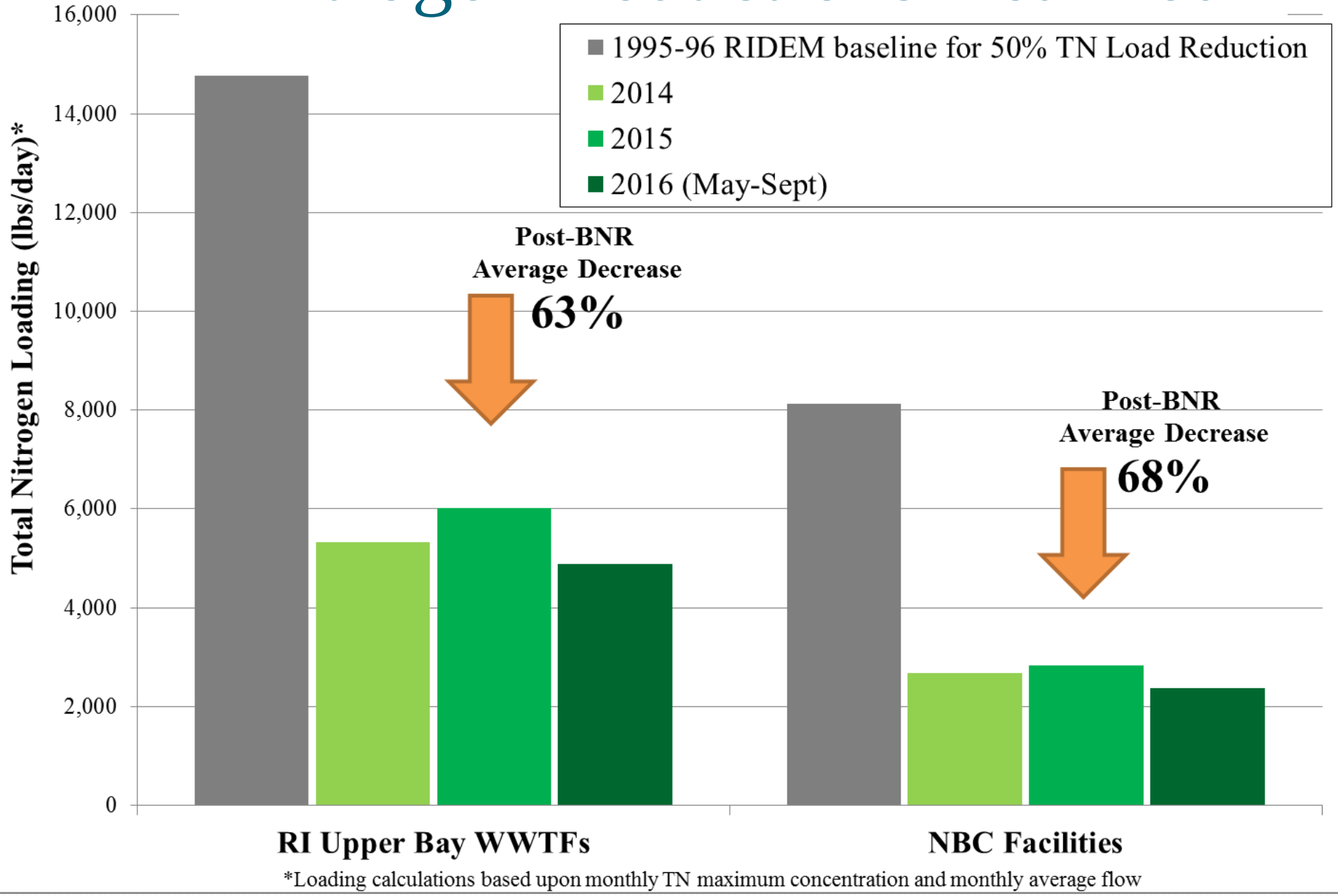



**Data includes 11 WWTFs:**

Burrilville
Cranston
East Greenwich
East Providence
NBC (Field's Point & Bucklin Point)
Smithfield
Warren
Warwick
West Warwick
Woonsocket

*Loading calculations based upon monthly TN maximum concentration and monthly average flow

# Nitrogen Reductions Realized



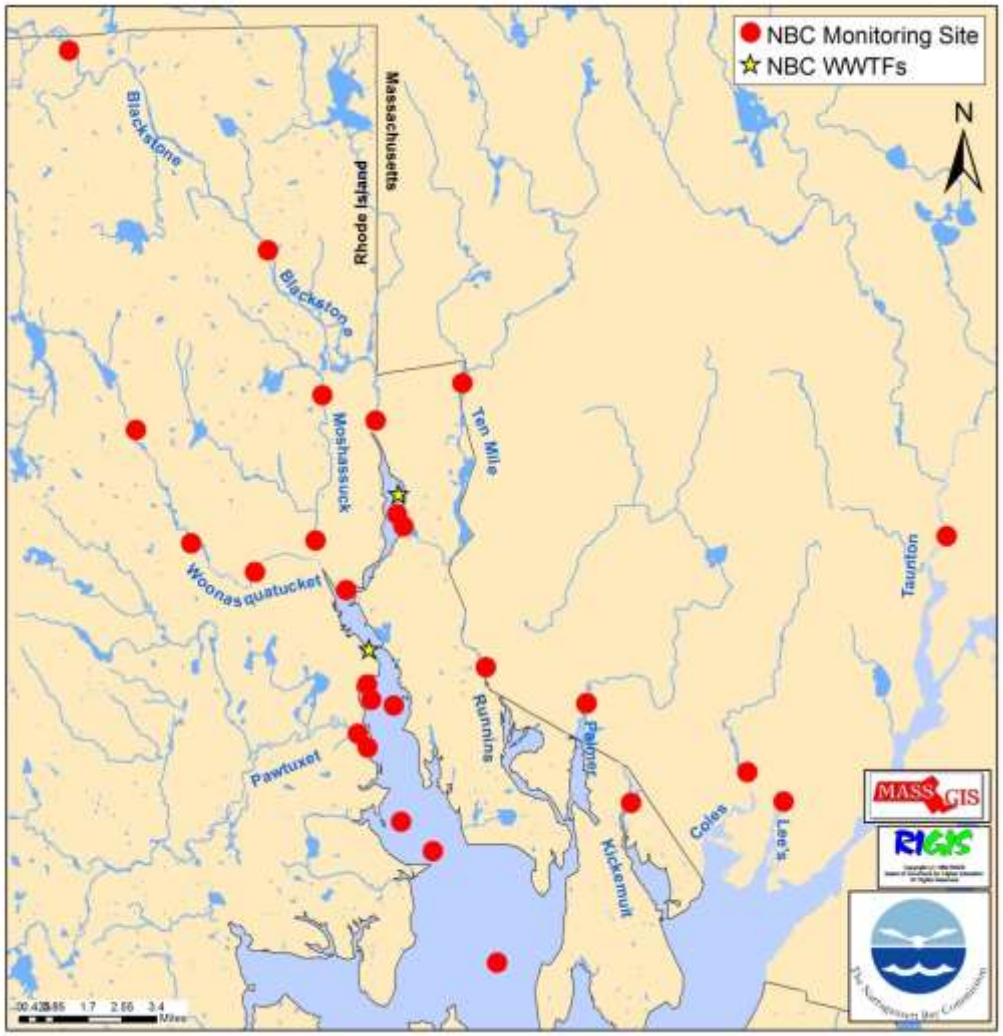

*Loading calculations based upon monthly TN maximum concentration and monthly average flow

# NBC Nutrient Monitoring

- **Why:**
  - To support decision making for future infrastructure investments.
  - To support partner organizations studying the bay.
- **When:**
  - Every two weeks (weather permitting)
- **What:**
  - Total dissolved nitrogen, total nitrogen, and orthophosphate
  - Dissolved inorganic nitrogen (DIN) = nitrite, nitrate, ammonia

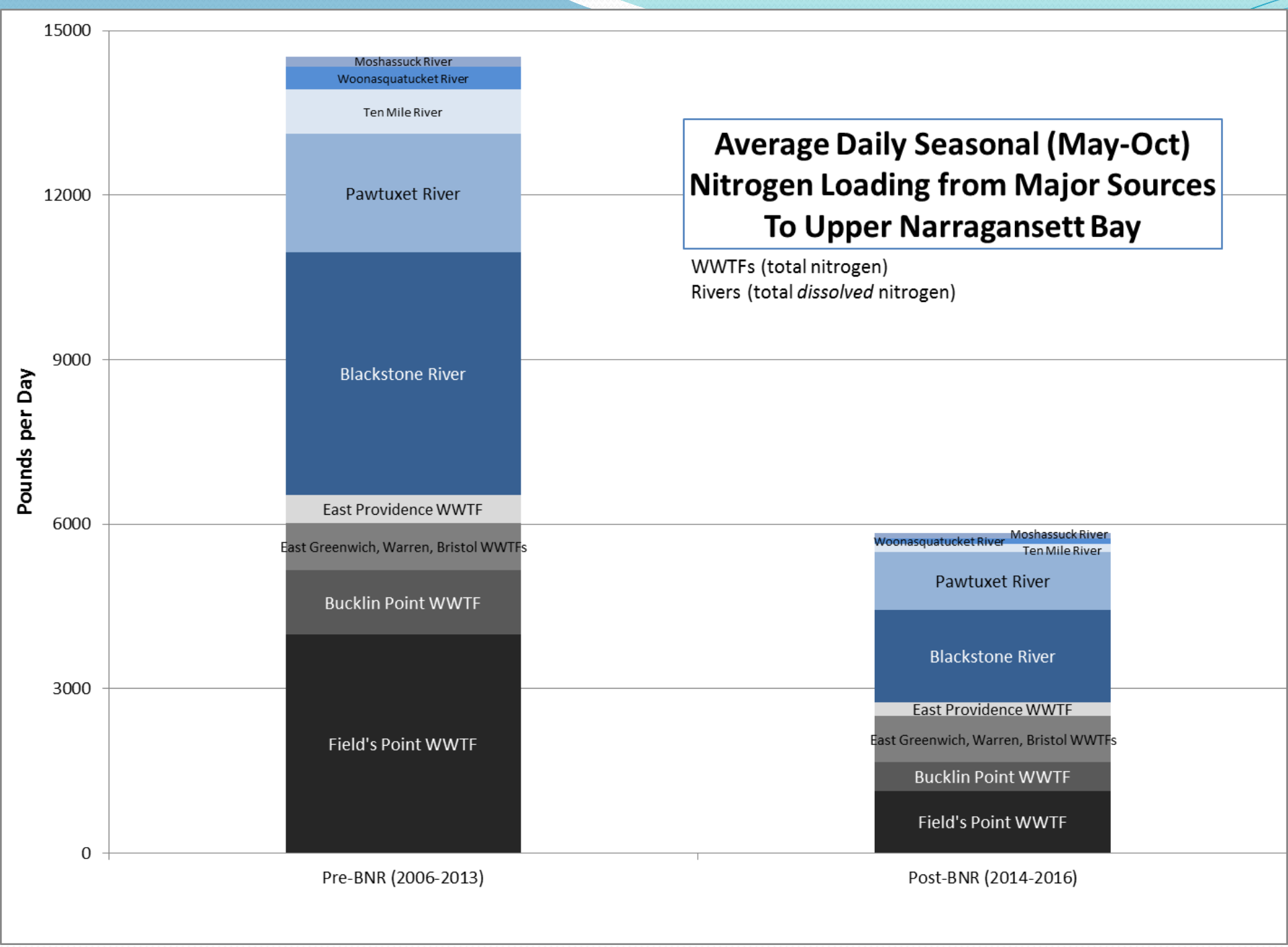
Data available online: http://snapshot.narrabay.com

# NBC Nutrient Monitoring




- **Where:**
  - River monitoring:
    - 15 active sites in RI and MA;
    - 11 Rivers
    - Loading calculated using USGS flow data
  - Bay Monitoring:
    - 7 active sites in the Seekonk and Providence River estuaries

Data available online: http://snapshot.narrabay.com


Average Daily Seasonal (May-Oct) Nitrogen Loading from Major Sources To Upper Narragansett Bay
WWTFs (total nitrogen)
Rivers (total *dissolved* nitrogen)
Pounds per Day
15000
12000
9000
6000
3000
0
Moshassuck River
Woonasquatucket River
Ten Mile River
Pawtuxet River
Blackstone River
East Providence WWTF
East Greenwich, Warren, Bristol WWTFs
Bucklin Point WWTF
Field's Point WWTF
Pre-BNR (2006-2013)
Post-BNR (2014-2016)

# DIN Concentrations in the Bay

- Compared to National Coastal Condition Assessment Guidelines

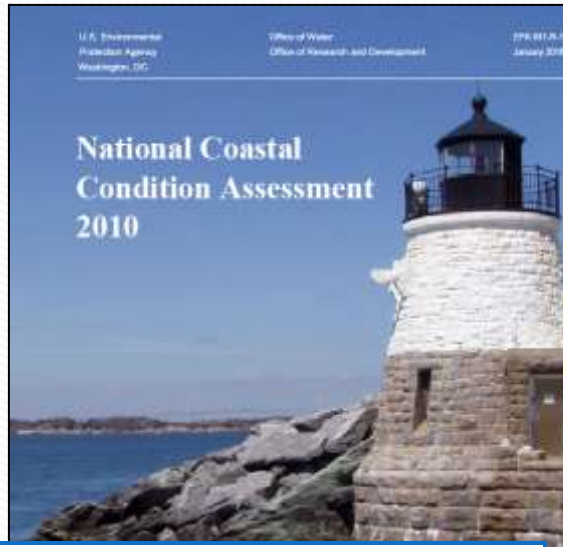
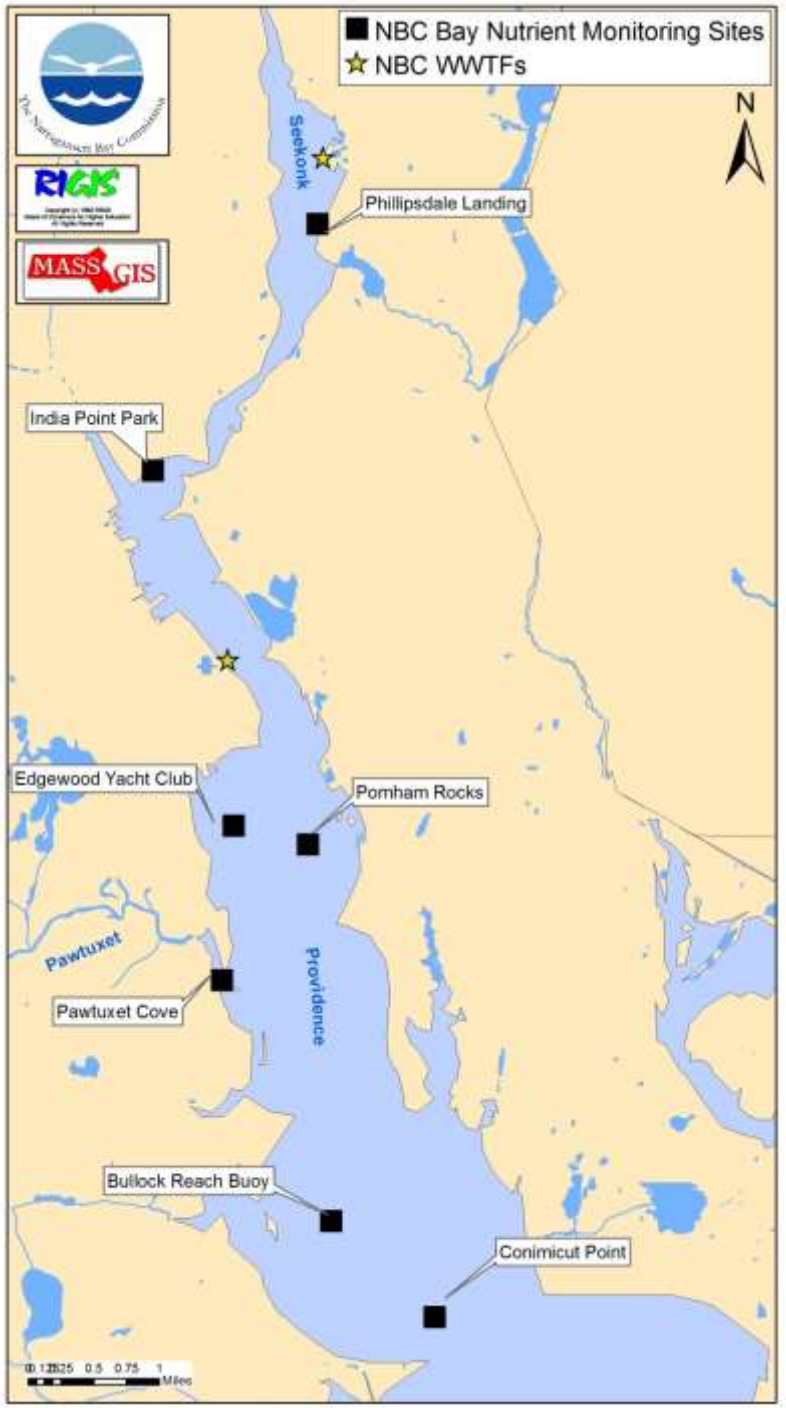



Table 2-5. NCCA guidelines for evaluating the five component indicators used in the water quality index to assess estuarine coastal condition.

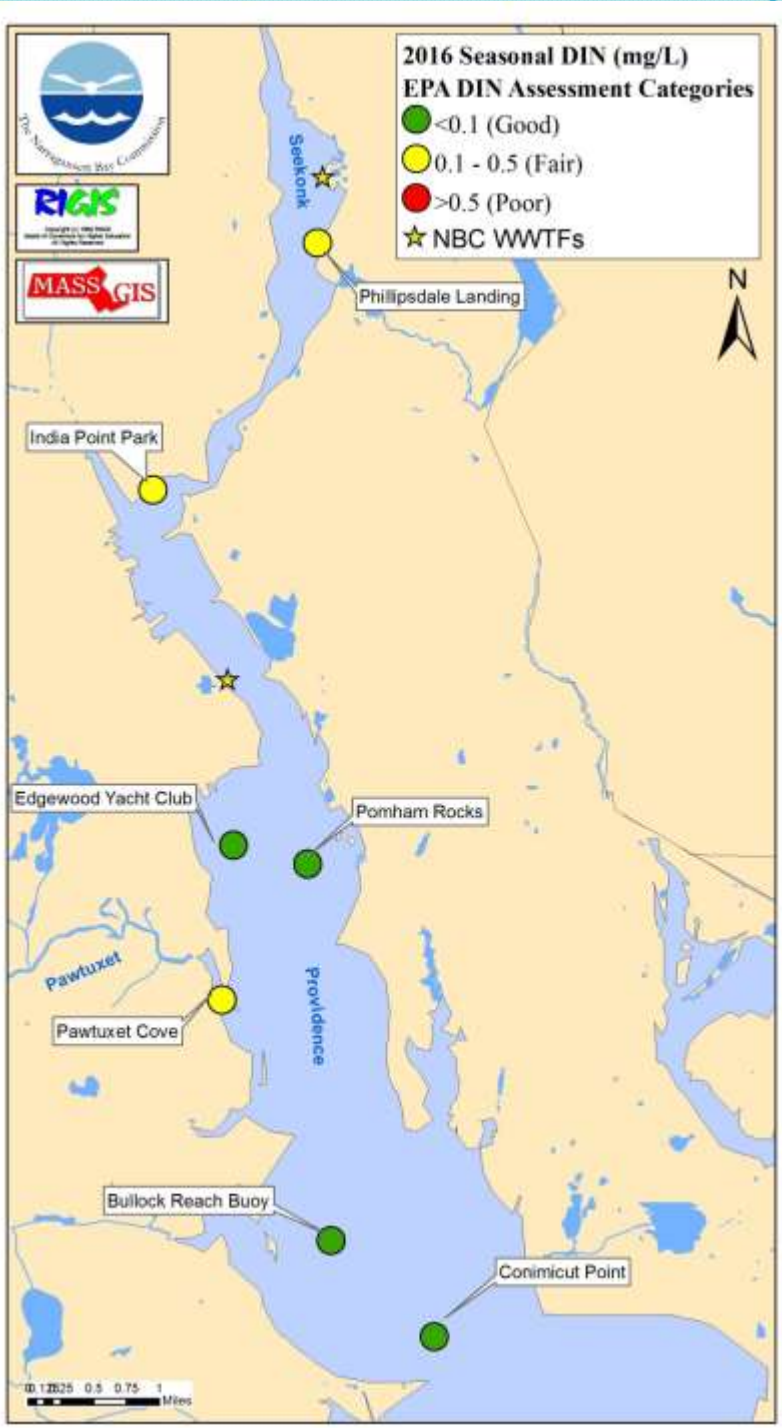
| | Estuarine Water Quality Thresholds | | | |
|---|---|---|---|---|
| | Region | Good | Fair | Poor |
| Surface Concentrations of Dissolved Inorganic Nitrogen (DIN): Estuaries | Northeast Southeast Gulf | < 0.1 mg/L | 0.1 – 0.5 mg/L | > 0.5 mg/L |
| | West | < 0.35 mg/L | 0.35 – 0.5 mg/L | > 0.5 mg/L |
| | Tropical [a] | < 0.05 mg/L | 0.05 – 0.1 mg/L | > 0.1 mg/L |



# 2016 Surface DIN

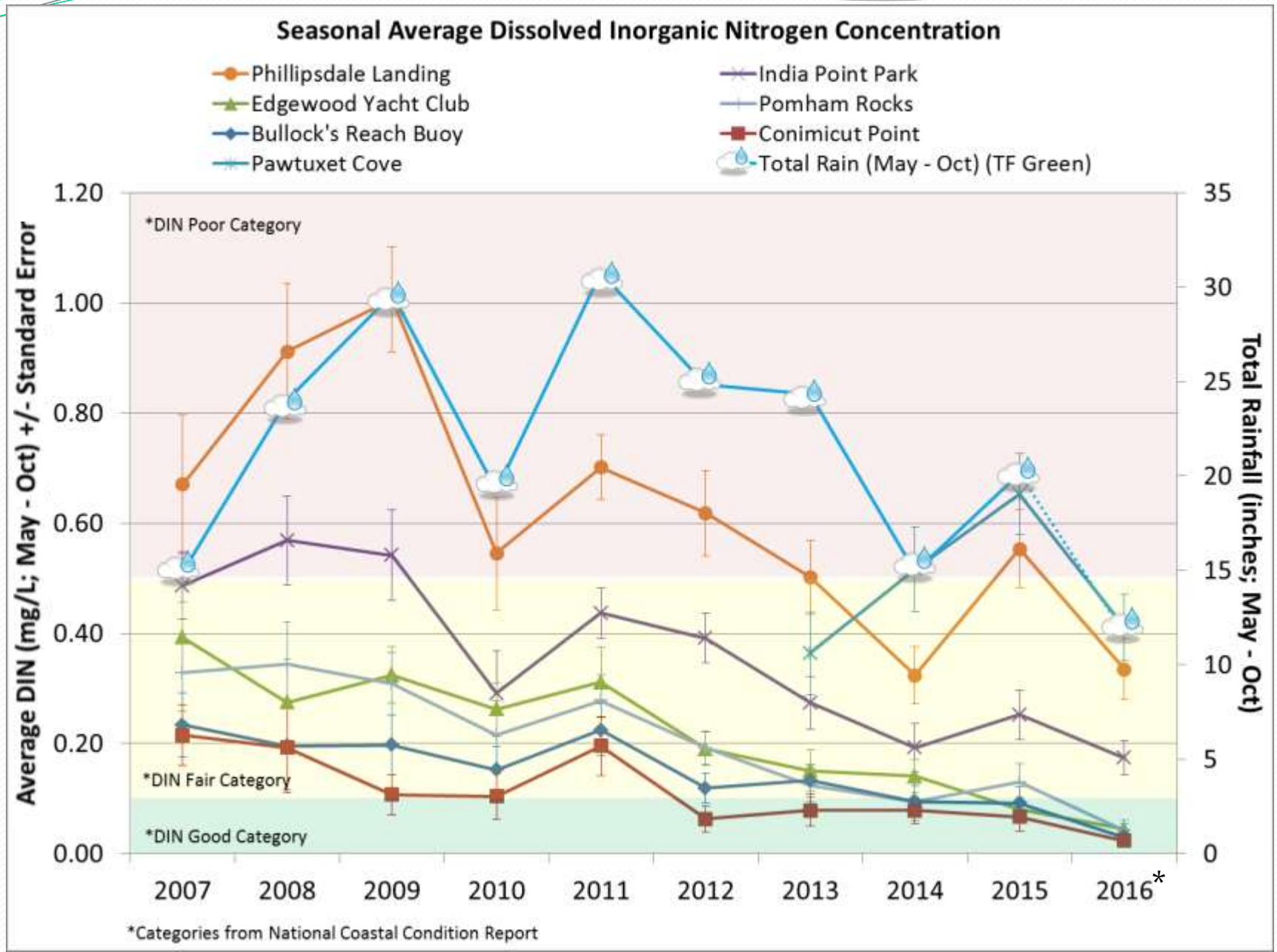
## May – September 14, 2016
## Rainfall Total: 11.64 inches

| Station | DIN (mg/L) | EPA CCR Category |
|---|---|---|
| DIN (mg/L)<br>Good <0.1<br>Fair 0.1-0.5<br>Poor >0.5 | | |
| Phillipsdale Landing | 0.33 | |
| India Point Park | 0.17 | |
| Edgewood Yacht Club | 0.04 | |
| Pomham Rocks | 0.04 | |
| Pawtuxet Cove | 0.41 | |
| Bullock's Reach | 0.03 | |
| Conimicut Point | 0.02 | |

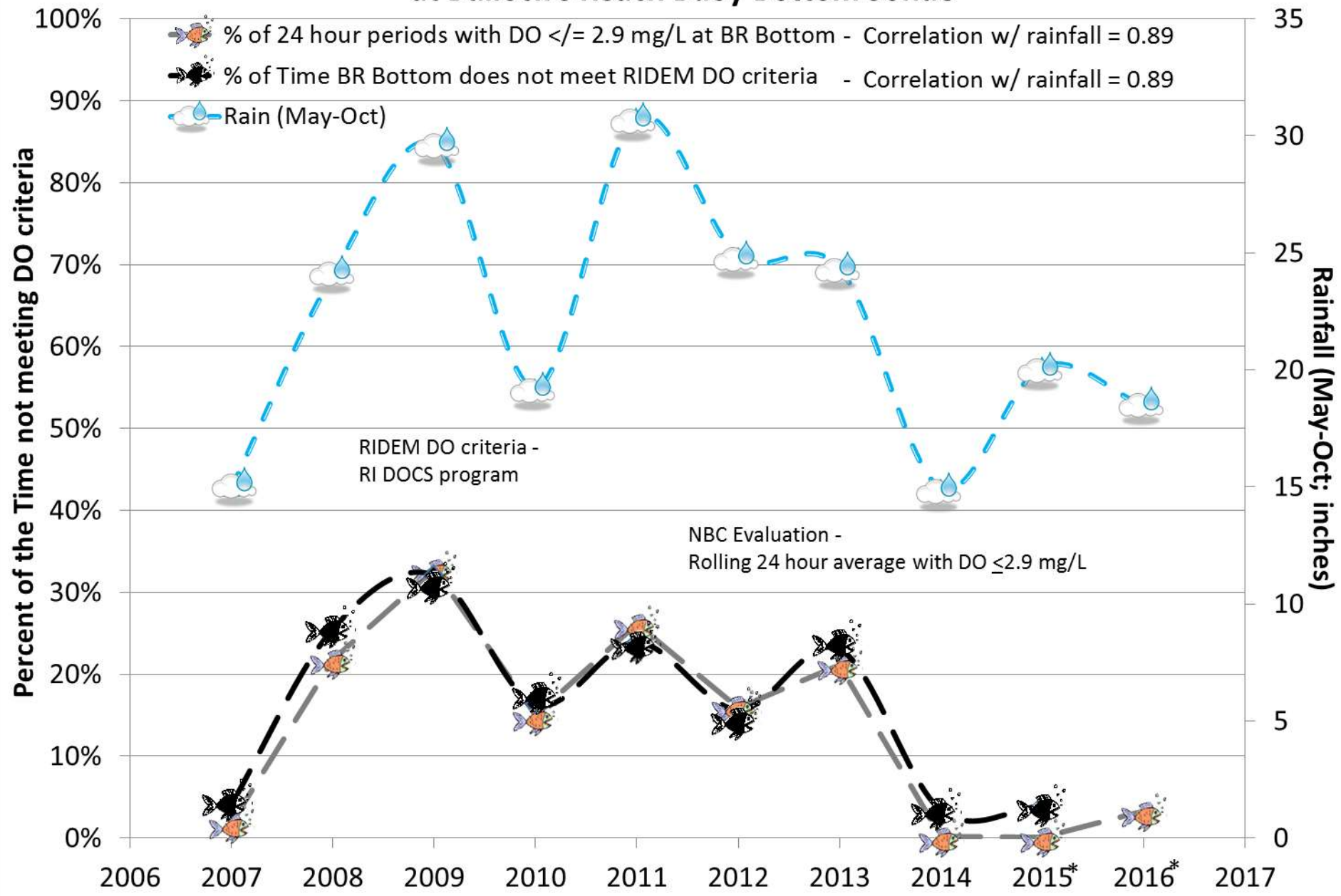


# Surface DIN

*2016 DIN May-Sept 14
*2016 Rain total May –Sept 14



# Correlation between Hypoxia and Rainfall at Bullock's Reach Buoy Bottom Sonde




BR bottom sonde missing data for 2 weeks from late Aug - early Sept in 2015

* RIDEM data unavailable for 2016

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# Benthic Video

- Began in 2011; in earnest in 2014
- Goal – note observable changes to benthos
- Underwater camera towed on custom sled
- Three "permanent" transects, ~1 km length each, ~1 hr footage each
- Attempt to survey monthly