Future Opportunities for ROMS Model

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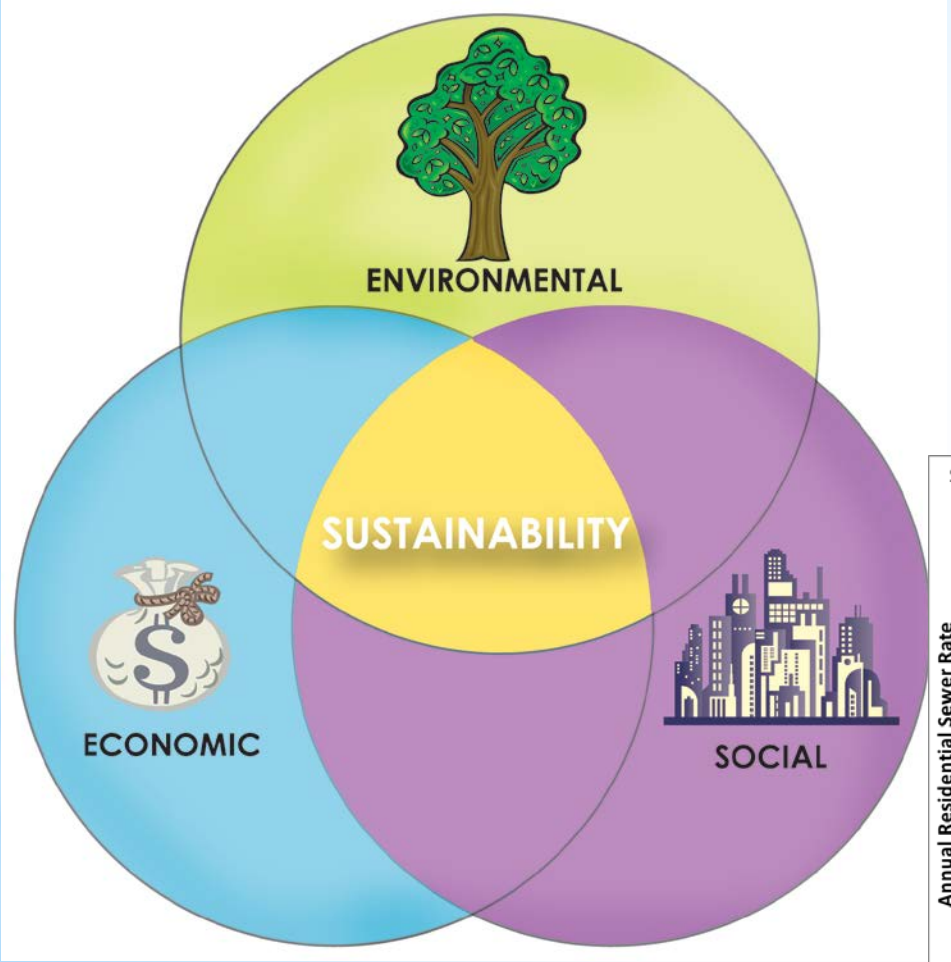
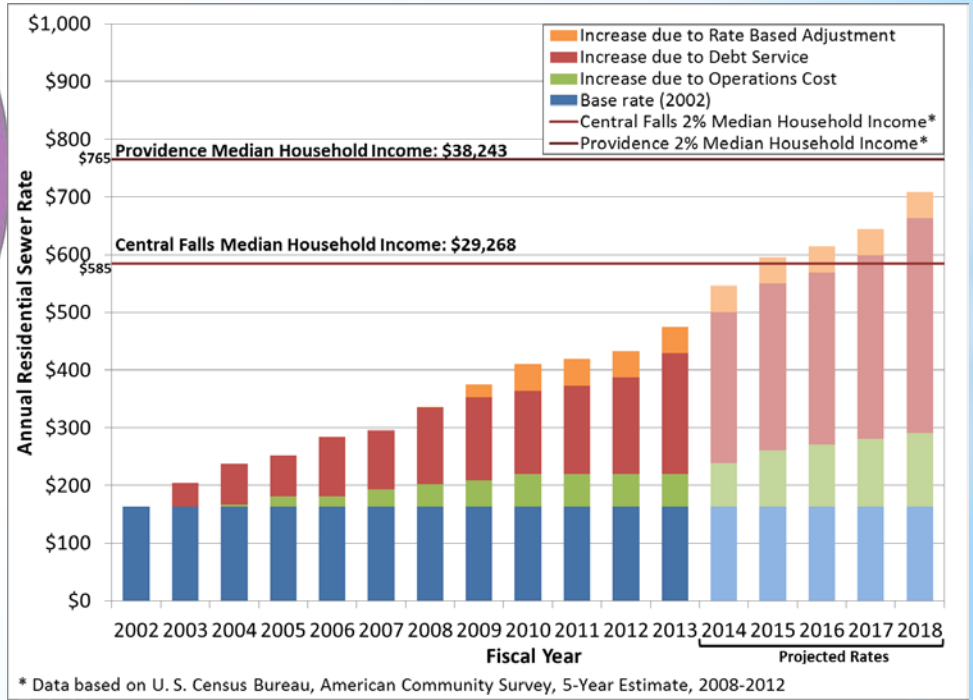
Water Quality Improvements Are Expensive



- Sewage Treatment upgrades causing rates to reach point of unaffordability
- Need to Evaluate Sustainable WQ Improvements
- Environmental, Economic & Social Sustainability – Triple Bottom Line!
- ROMS can be used to evaluate WQ Improvement Alternatives
- Can Help to get the most Bang for the Buck!



ROMS can Evaluate Sustainable Solutions

Achieving Water Quality Standards by Implementing Sustainable Solutions

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The Narragansett Bay Commission, Providence, RI

Field's Point WWTF
Providence, RI

The Narragansett Bay Commission is Rhode Island's largest wastewater authority dedicated to providing reliable, cost-effective wastewater collection and treatment services to over 360,000 residents and 7,700 businesses in ten Rhode Island communities in the metropolitan Providence and Blackstone Valley areas.

Bucklin Point WWTF
East Providence, RI

Narragansett Bay Commission
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Providence, RI 02905
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www.narrabay.com
http://snapshot.narrabay.com

PAST

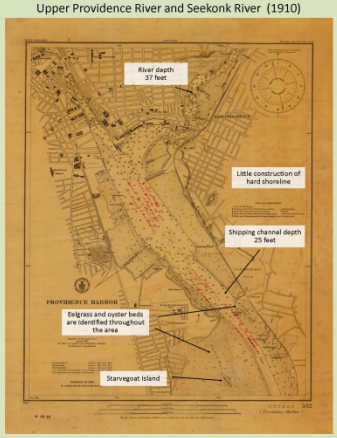
BACK WHEN THINGS WERE "GOOD": Wetlands, eelgrass, and shellfish were abundant, though man had begun to leave its footprint on Narragansett Bay

Providence Wastewater Treatment Facility

Field's Point WWTF was:
- Established in 1901
- The third chemical precipitation plant in the USA
- The largest built of its kind
- "state of the art" in 1901, but no disinfection was provided

This rendition of "The Great Salt Cove" of Providence, circa 1650, shows:
- Wetlands in Rhode Island being filled in and destroyed starting with European colonization
- Conversion of natural landscape to farmland
- Plentiful wetlands acreage remained
- Suitable shellfish & eelgrass habitat

Upper Providence River and Seekonk River (1910)



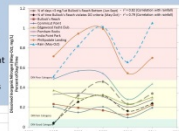
Oyster-shucking houses with piles of oyster shells at Field's Point in 1911.

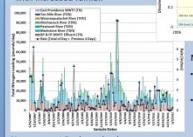
Narragansett Bay's oyster industry:
- Reached its peak in 1910
- Leased oyster beds covering 5,000 acres in the Providence River & upper Bay (Fuller 1905)
- Generated $45,000 in 1903 dollars from lease fees (Fuller 1905)
- Produced nearly 7,000 metric tons of oysters a year (Rice et al 2000)
- Caused people to become sick from contaminated oysters, due to bacterial pollution
- Began to decline in 1911 due to anthropogenic inputs & the Great Hurricane of 1938

PRESENT

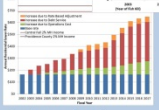
PROBLEM: Upper Narragansett Bay experiences dissolved oxygen impairment thought to be partially caused by elevated nitrogen concentrations

NBC Bay monitoring shows:
- Nitrogen concentration in the upper Bay increases in years with increased rainfall
- Dissolved oxygen (DO) impairment tracks closely with rainfall
- DO impairment is highest in years with increased rainfall

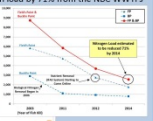




NBC River monitoring shows:
- Nitrogen loading increases with increased rainfall
- WWTF nitrogen loading remains relatively constant even with rainfall



The NBC has invested in its infrastructure, which:
- Reduces both facilities to 5 mg/L TN by 2014
- Decreases the nitrogen load by 71% from the NBC WWTFs
- Caused sewer bills to increase 164% in the past 10 years
- Projects an increase of 296% of the average residential sewer bill by 2017



Narragansett Bay's wetlands:
- Have decreased by roughly 60% since 1600s
- Encompass 3,770 acres, many of which are impounded or impacted with invasive plant species
- Have been drained & hydraulically altered by about 46% to assist in mosquito control (www.edc.uri.edu)

Shellfishing in Rhode Island includes:
- 160 acres of aquaculture farms, producing 245 metric tons of oysters/year (CRMC 2011)
- No shellfishing or aquaculture in the Providence & Seekonk Rivers due to sediment & bacterial contamination
- Prohibitions following rainfall events

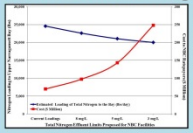
Upper Providence and Seekonk River (2010)

Since 1910, the upper Providence & Seekonk Rivers have undergone significant changes, specifically:
- Construction of hardened shorelines
- Disappearance of wetlands, eelgrass & shellfish beds
- Deeper dredging of the shipping channel
- Silting up of urban rivers
- Backfill of Starvegoat Island
- Creation of a breakwall & hurricane barrier

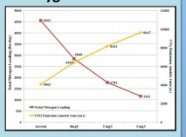
These changes have dramatic ramifications, such as:
- Creation of a gyre, causing reduced flushing & degraded water quality
- Directing nutrient rich Pawtuxet River bottom water north (red arrow) into the gyre

FUTURE

NON-SUSTAINABLE SOLUTION: NPDES regulators typically focus on the water column to improve water quality. An example is NPDES permitting of WWTFs to reduce nitrogen to improve dissolved oxygen

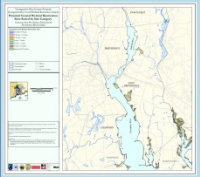


As the level of treatment to remove nitrogen from WWTFs approaches zero:
- The costs increase dramatically
- Requires additional energy
- Creates more greenhouse gases
- Other sources of nitrogen (i.e. atmospheric deposition, stormwater & agriculture) become more influential

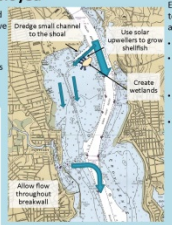


SUSTAINABLE SOLUTION: A holistic ecosystem-based approach utilizing sustainable solutions is employed

Multiple aspects should be considered to achieve sustainability:
- Environmental factors
- Economic components
- Social issues



Create and restore wetlands to:
- Provide a value of ~$75,000 as a "water treatment facility" per acre of wetland (Miller 1996)
- Provide critical habitat for biodiversity
- Enhance water quality long-term
- Provide storm protection and flood mitigation
- Contribute aesthetically to the region



Engineering sustainable solutions to improve water quality can be achieved with:
- Responsible WWTF upgrades
- Selective dredging to improve circulation and flushing and remove contaminated sediment
- Creation and restoration of wetland habitats
- Establishment of bio-extraction or aquaculture farms to beneficially use nitrogen

Restoring the Bay's harvestable oyster population to the 1910 status would:
- Increase the harvestable population by over 112.5 million oysters
- Remove an additional 130,000 lbs/year nitrogen when these oysters are harvested (Based on 60 g oyster with 0.52 g TN/oyster; Newell 2004)
- Transplant shellfish to enhance & restore various populations throughout the estuary
- Build the Rhode Island Green economy
- Create local sustainable jobs

- ✓ NBC Poster Presenter at Restore American Estuaries Conference in 2012
- ✓ NBC Proposed Evaluating Eco-System Based Sustainable WQ Improvements
- ✓ Coordination Team Funded NBC/DEM Project to perform evaluations

Expert Stakeholder WQ Evaluation Process

- Goal: ***Complete Feasibility Study to holistically evaluate sustainable solutions to improve upper Bay water quality***

http://www.magazine.noaa.gov/stories/mag161.htm

- NBC/DEM partnership received $150,000 grant from RI BRWCT to begin the process
- This project is evaluating solutions to improve DO water quality, by looking at the health of ecosystem
- Nationally others have employed various “out of the box” solutions in TMDLs

http://www.edc.uri.edu/restoration/html/intro/salt.htm

Sustainable Solutions Feasibility Study

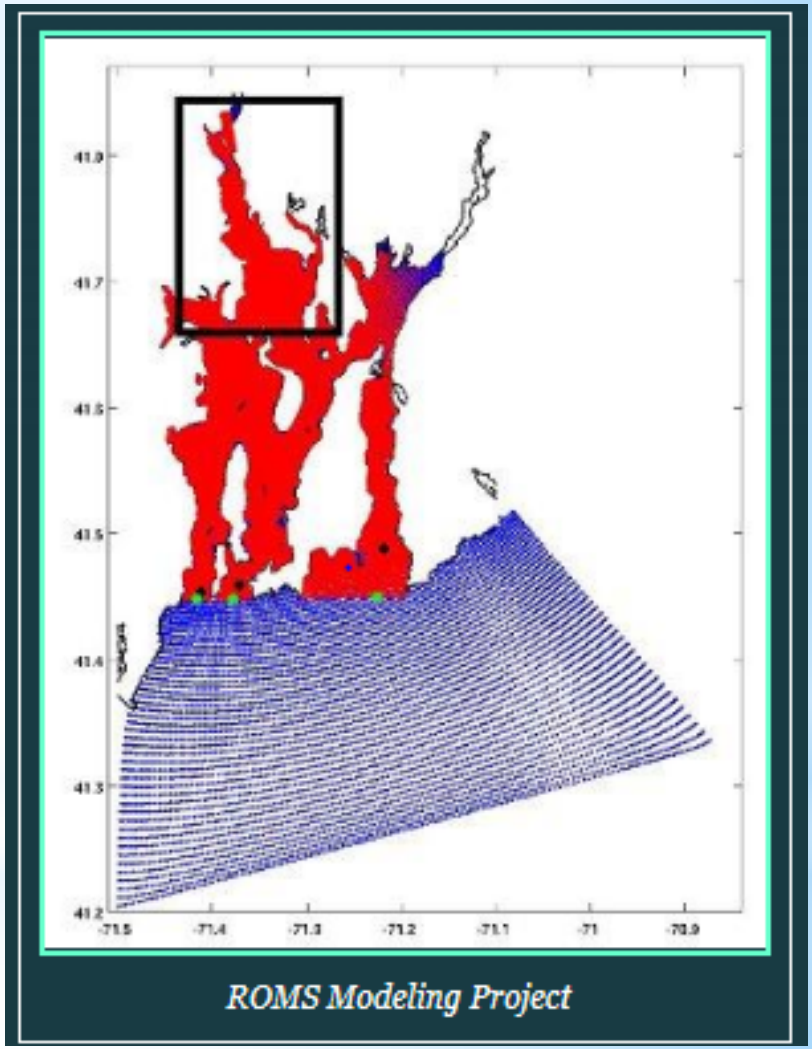
- Year 1: 2014 – 2015
  - ✓ December 2, 2014 – Project Kick-off Meeting
  - ✓ January 15, 2015 – **Salt Marsh/Shoreline Restoration**
  - ✓ February 27, 2015 – **Tidal Restrictions/Circulation Improvements**
  - ✓ March 19, 2015 – **Shellfish Propagation/Bio-Extraction**
  - ✓ May 20, 2015 – **Fresh Water Wetland Buffers**
  - ✓ Draft Report being prepared by Consultant
  - ✓ TBD – Capstone Meeting

- Years 2: 2015 – 2016
  - ✓ Validation of priority topics
  - ✓ Priority topic pilot demonstration projects
  - ✓ Identify “Low Hanging Fruit”
  - ✓ Modification of water quality models

ROMS Can Evaluate Project Options

ROMS Model can be run to evaluate:

- ✓Water quality changes associated with:
  - Point / Non-Point nitrogen reductions
  - Removal of impoundments on the Blackstone
- ✓WQ Impact of changing wastewater treatment plant outfall configurations
- ✓WQ Impact of changing circulation patterns to eliminate zones of impairment or "hot spots"
- ✓Nitrogen draw down expected by:
  - Aquaculture projects
  - Shellfish restoration projects
  - Bio-extraction projects
  - Floating wetlands

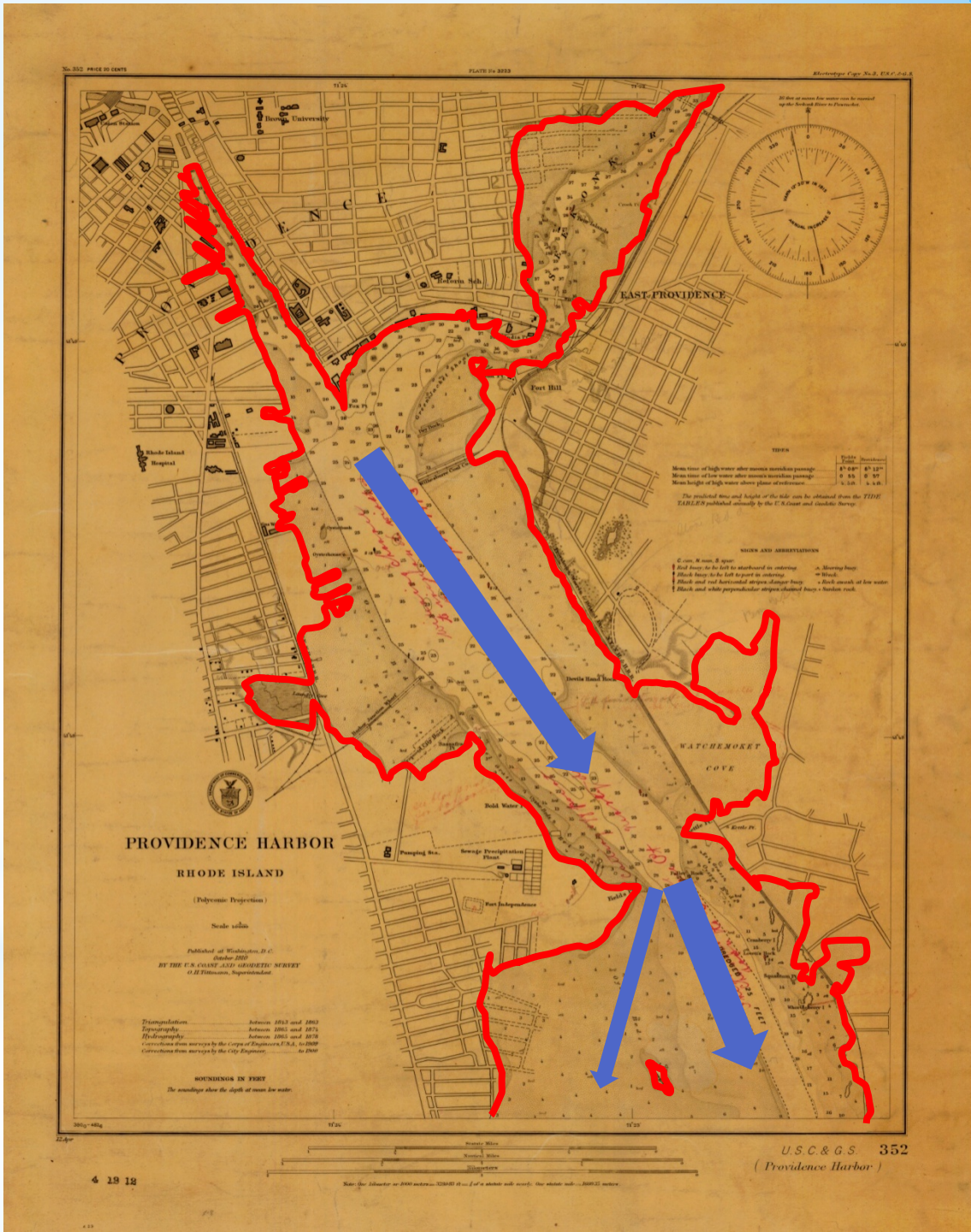


Map of Providence Harbor in 1910

- ROMS can be modified to evaluate effect of changes to bay over the past 100 years
- Map based on 1865 – 1878 “Hydrography”
- Map clearly shows:
  - ✓ Locations of wetlands & eelgrass beds
  - ✓ Oyster beds (5000 leased acres)
  - ✓ Seekonk River - 37’ deep
  - ✓ Providence River channel - 25’ deep

Map of Providence Harbor in 1910

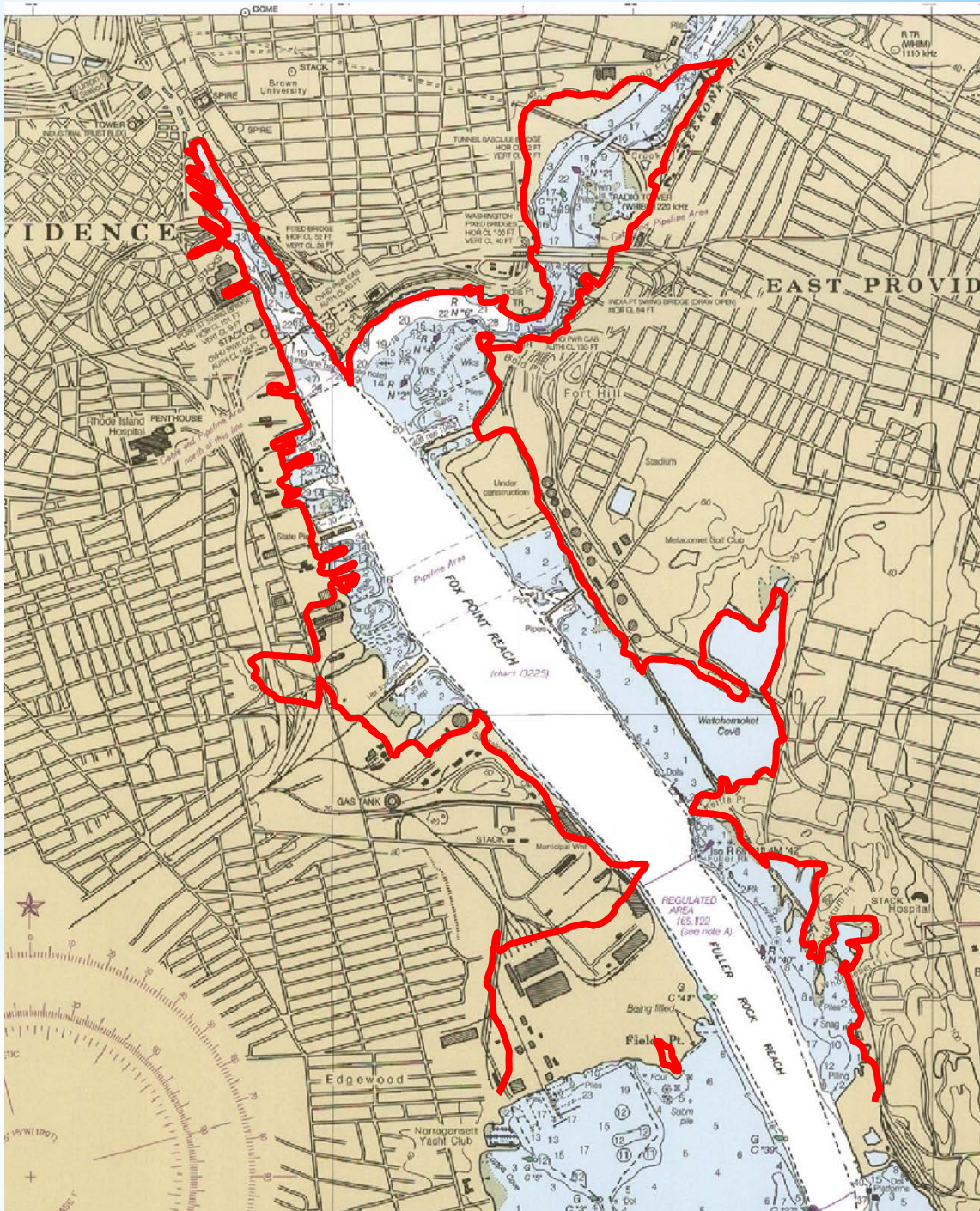
- 1910 Coast Line in Red
- Map indicates City planned to Fill Bay and Build Roads
- Note:
  - ✓ Much Shallower River
  - ✓ Starved Goat Island
- What was flow circulation pattern in 1910? ROMS?



Upper Providence River Today

1910 Coastline in Red

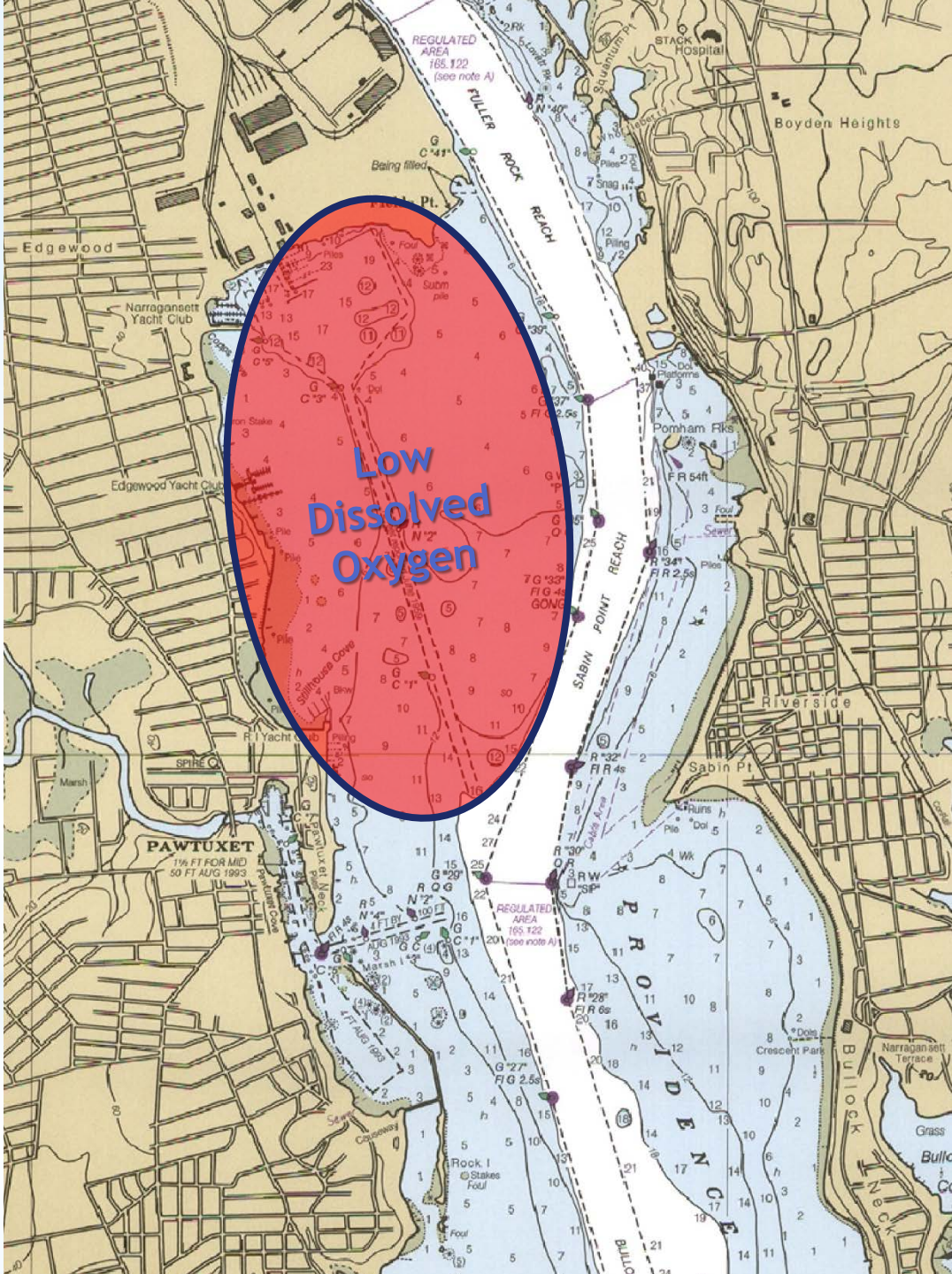
- We filled the bay & wetlands
- Built the hurricane barrier
- Built Pawtuxet River breakwall
- Allowed rivers to silt up
- Dredged channel to 50+’



Water Quality Problems

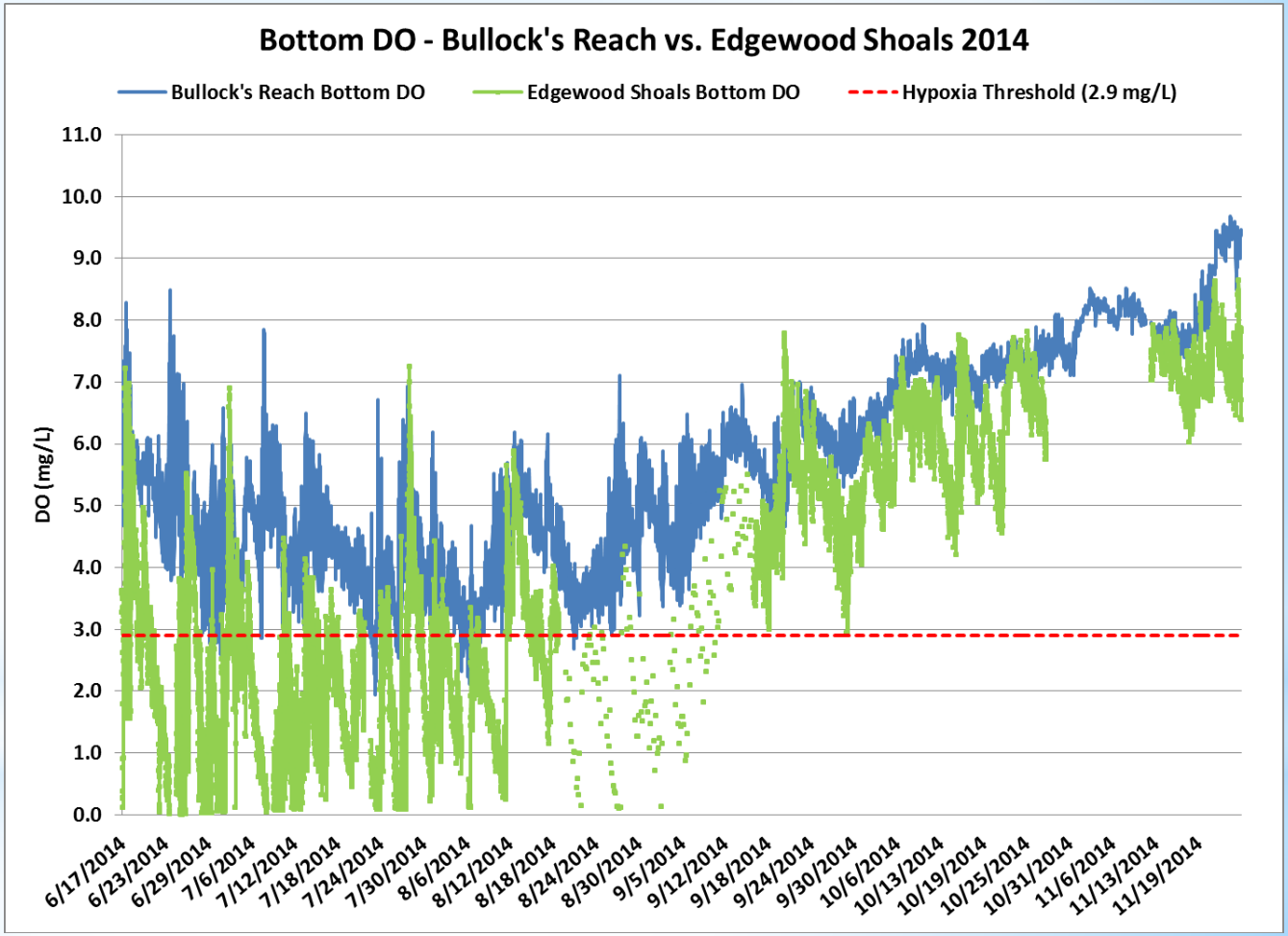
- Edgewood Shoals area is DO impaired!!! WHY???

- ✓ We changed flow circulation patterns
- ✓ Poor flushing
- ✓ Nitrogen enrichment
- ✓ Stratification
- ✓ 2014 buoy data shows DO impairments within the gyre



Edgewood Shoal Gyre vs Bullocks Reach

- ✓ Edgewood Shoal estimated volume ~8 million cubic meters of low DO water
- ✓ Estimated 15 cubic meters/sec flow to Bay when gyre breaks up
- ✓ Can the “Hot Spot” be eliminated?
- ✓ ROMS can be used to model scenarios to break up the gyre

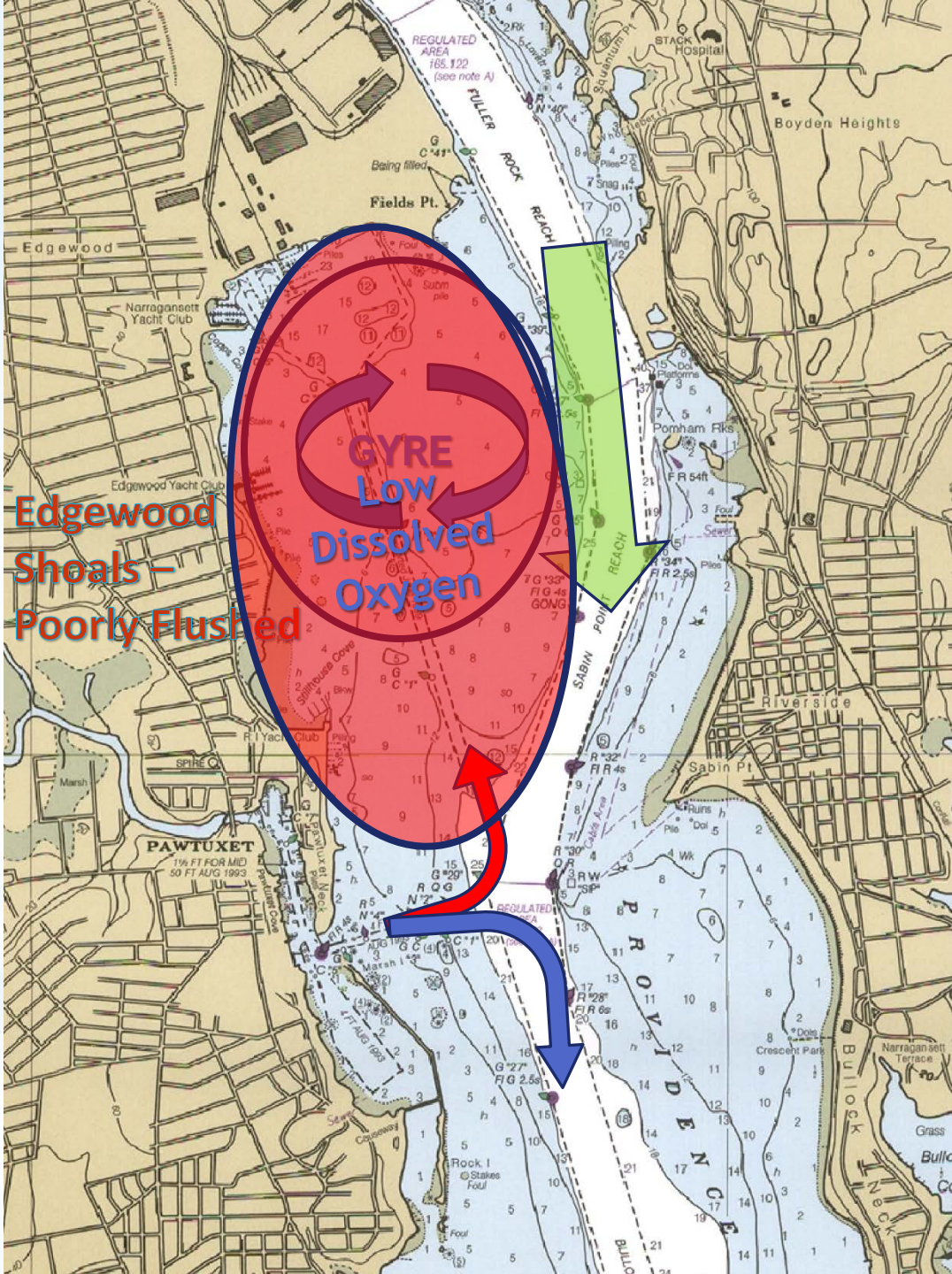


Water Quality Problems

ROMS Model Indicates:

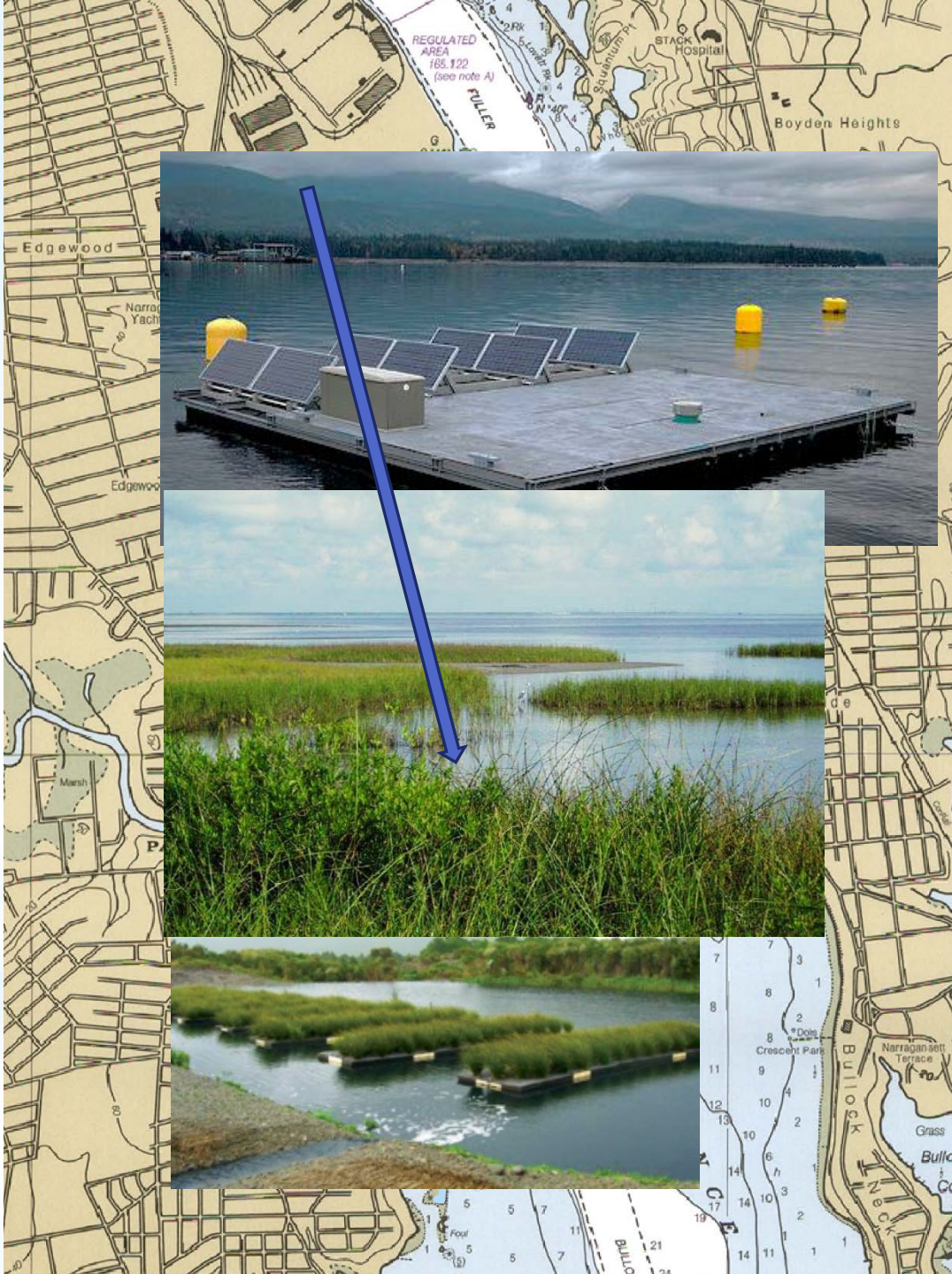
- ✓ Jet of water down the shipping channel
- ✓ Sets up a clockwise gyre on Shoal
- ✓ Bottom waters from Pawtuxet River transport nitrogen onto the shoal

✓ROMS can model options to break up the gyre



Possible Sustainable Solutions

- ***Can we improve Bay WQ By "Smart Engineering" or other sustainable projects?***
  - ✓ Outfall relocation
  - ✓ Selective dredging?
  - ✓ Maybe create a channel to redirect flow over shoal - improve circulation?
  - ✓ Remove or open breakwalls to improve circulation?
  - ✓ Create islands, wetland habitats, natural buffers to redirect flow, protect shoreline, coastal resilience?
  - ✓ Establish bio-extraction or aquaculture projects to utilize excess nutrients?
  - ✓ ROMS can model these various options to evaluate WQ impacts



ROMS Can Evaluate These Options

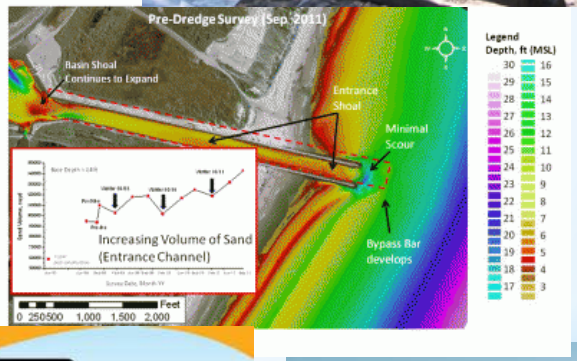
ROMS can Model WQ Impacts of Nitrogen Uptake Projects

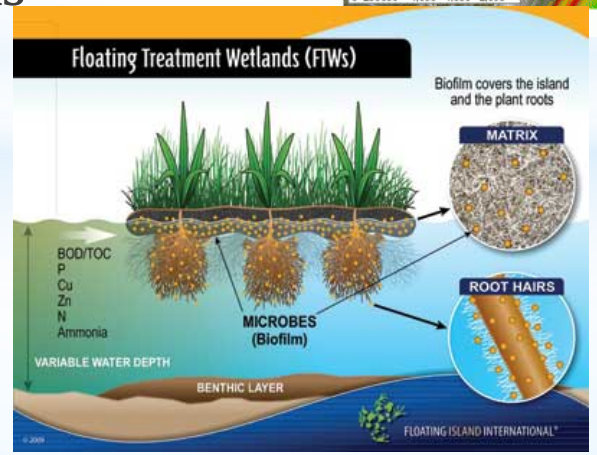
- ✓ Bio-extraction
- ✓ Relay Aquaculture
- ✓ Oyster Bed & Shellfish Restoration Projects
- ✓ **Goals & Benefits:**
  - ✓ Improved fisheries - shellfish & benthic species restoration & enhancement
  - ✓ Once established, enhanced water filtration by shellfish
  - ✓ Habitat creation & restoration - protects shoreline & provides habitat
  - ✓ Create Green Jobs for the future
  - ✓ Great WQ improvement for the buck

Photos courtesy of: http://www.jaxshells.org/gdim.htm, http://viudeepbay.com/2012/02/12/design-and-construction-report-solar-flupsy-project/, algaebiodiesel.com, Cape Cod Cooperative Extension

ROMS Can Evaluate These Options

- **Hydro-modifications**
  - ✓Breakwall alteration &Channel creation
- **Dam Flow Management**
  - ✓Maintain river flows necessary to maintain water quality
- **WQ improvements by creating and restoring wetlands in Upper Bay**
- **Evaluate floating wetlands**





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Questions ???