Coastal Systems Program
School of Marine Science & Technology

Massachusetts Estuaries Project: Status of Application of Approach

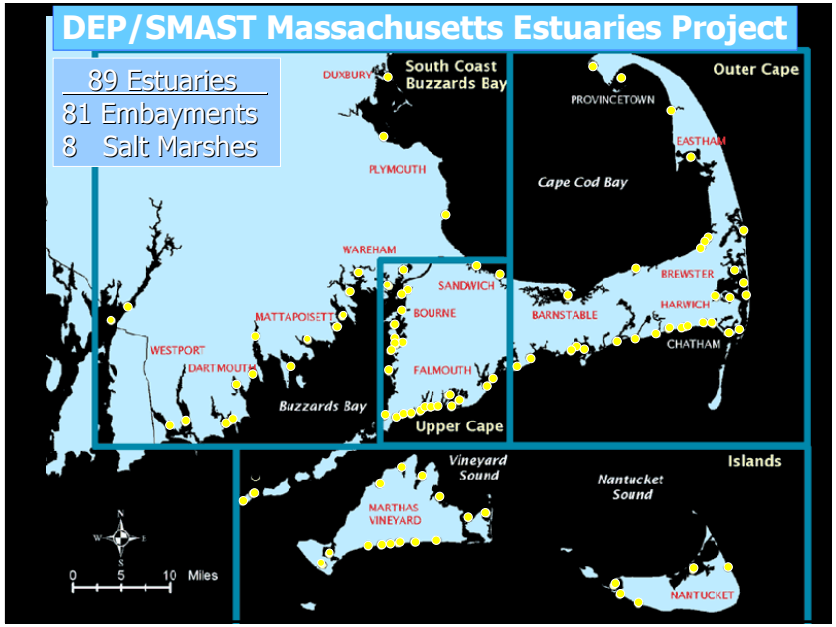
Workshop on Restoring and Protecting Coastal Waters

U.S. EPA & Cape Cod Commission

November 16, 2006

DEP/SMAST Massachusetts Estuaries Project
Natural Resource Restoration/Management

- A partnership between
  - –DEP/EOEA (regulatory, TMDL's)
  - –SMAST/UMassD (science, assessment & modeling)
  - – with S.E. Mass. Municipalities, Barnstable County, Regional Planning Agencies (Cape Cod Commission, MVC, SRPEDD), USGS, EPA, DMF
- Purpose:
  - – to develop nitrogen thresholds and target loads for the 89 coastal embayments of southeastern Massachusetts
  - – to bring new approaches & tools to watershed nitrogen management for estuarine restoration



FOCUS: Major Problems Facing Embayments Throughout SE Mass

- ***The 2 primary issues:***

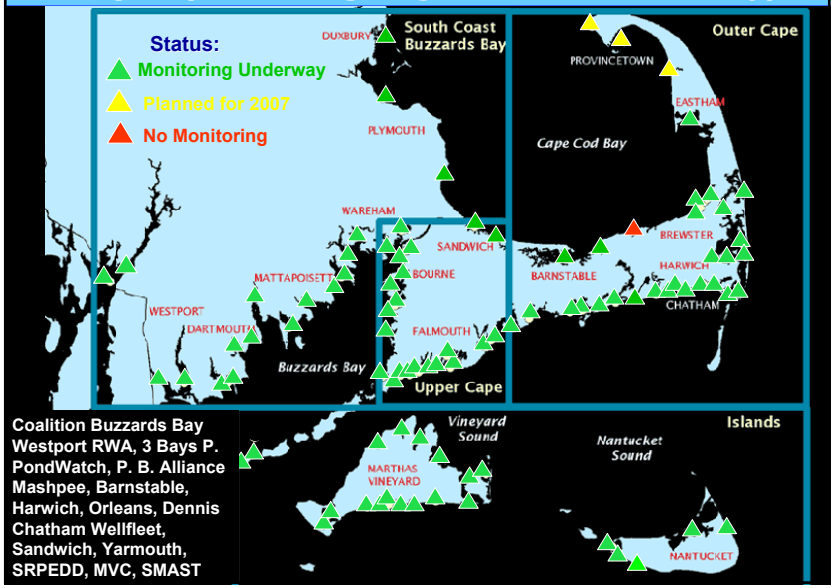
→**increased nutrient loading to the estuary, resulting in wholesale decline in estuarine health from shifting land-use.**

--> bacterial contamination resulting in shellfish bed closures.

Watershed Nitrogen Management for Embayment Protection/Restoration

- **Phase I:** Monitoring of Embayment Nutrient Related Health
- **Phase II:** Quantitative Watershed-Embayment Assessment & Modeling
- **Phase III:** Nitrogen Management Planning, use of Validated Watershed-Embayment Model to evaluate management alternatives, (cost/benefit analysis)
- **Phase IV:** Engineering Design & Implementation of Selected N Management Alternatives
- **Phase V:** Embayment Monitoring to support Adaptive Management

Water Quality Monitoring Programs – SMAST Tech Support



Coalition Buzzards Bay
Westport RWA, 3 Bays P.
PondWatch, P. B. Alliance
Mashpee, Barnstable,
Harwich, Orleans, Dennis
Chatham Wellfleet,
Sandwich, Yarmouth,
SRPEDD, MVC, SMAST

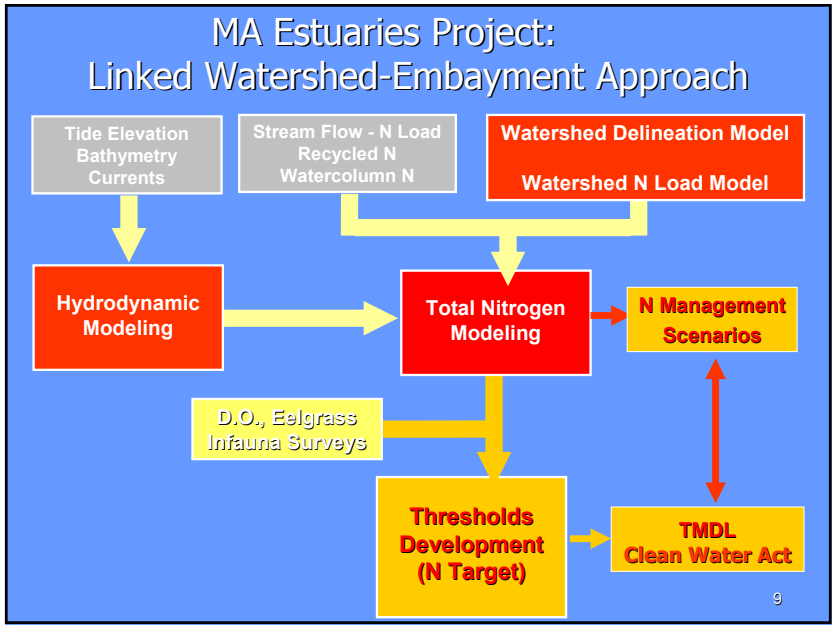
Estuaries Project Approach:

Site-specific Integrated N Model based upon the watershed and embayment conditions REQUIRING:

- Data collection
- Assessment
- Model Construction, Calibration & Validation
- N Management Alternatives Analysis

Linked Watershed-Embayment Management Modeling Approach

- **Watershed Hydrologic Model**
  - Watershed delineation and transport time
- **Watershed Nitrogen Loading Model**
  - Land-use inputs: natural and anthropogenic
  - Natural attenuation of nitrogen
- **Hydrodynamic Model**
  - Flushing characteristics
- **Water Quality Model**
  - Nitrogen species, salinity
  - Recycled nitrogen
- **Site-Specific Critical N Loads (Thresholds)**
  - Benthic animals, eelgrass, macroalgae, D.O., etc.


MA Estuaries Project:
Linked Watershed-Embayment Approach
Tide Elevation
Bathymetry
Currents
Stream Flow - N Load
Recycled N
Watercolumn N
Watershed Delineation Model
Watershed N Load Model
Hydrodynamic Modeling
Total Nitrogen Modeling
N Management Scenarios
D.O., Eelgrass Infauna Surveys
Thresholds Development (N Target)
TMDL Clean Water Act
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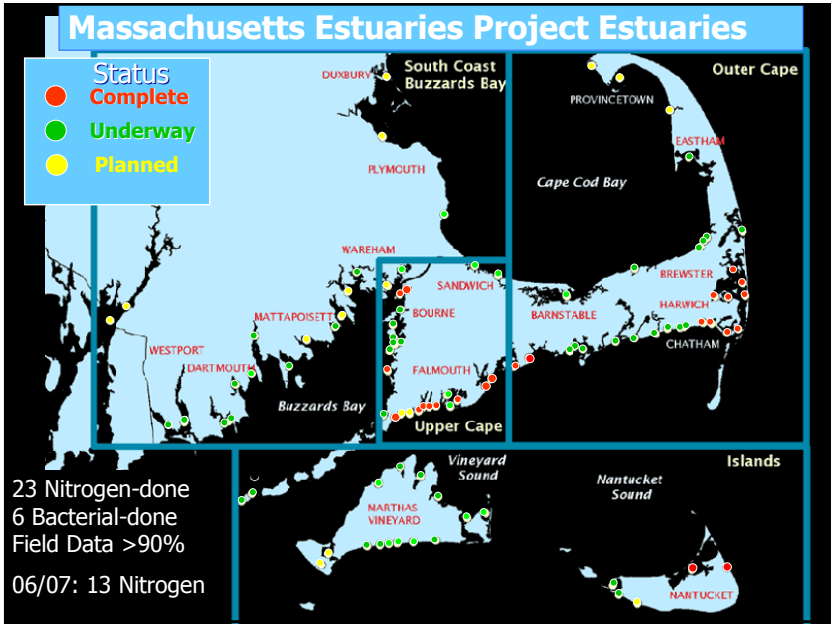

Massachusetts Estuaries Project Estuaries
Status
Complete
Underway
Planned
South Coast
Buzzards Bay
Outer Cape
Cape Cod Bay
Upper Cape
Islands
Buzzards Bay
Vineyard Sound
Nantucket Sound
DUXBURY
PLYMOUTH
PROVINCETOWN
EASTHAM
WAREHAM
SANDWICH
BOURNE
BREWSTER
HARWICH
BARNSTABLE
CHATHAM
MATTAPOISETT
WESTPORT
DARTMOUTH
FALMOUTH
MARTHAS VINEYARD
NANTUCKET
23 Nitrogen-done
6 Bacterial-done
Field Data >90%
06/07: 13 Nitrogen

Why is the Commonwealth using the Estuaries Project Approach for Estuaries?

Uncertainty costs $$

- Provides the most accurate linkage of watershed N loads to estuarine health.
- Determines the site-specific N Threshold level for sustaining a healthy estuarine system
- Creates a tool for quantitative Management Alternatives Analysis

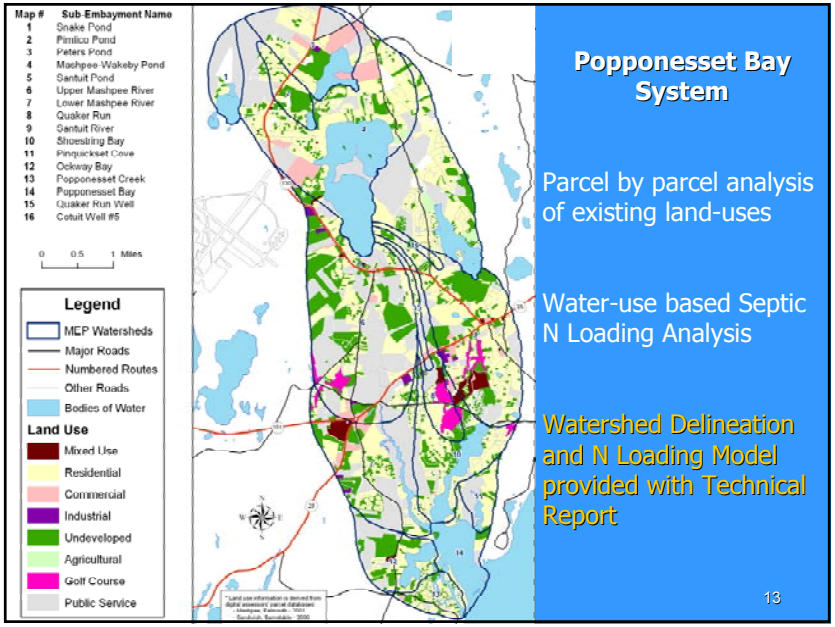
Watershed N Loading to Estuary

- **Watershed N Load to Bay = N Sources - N Sinks + N Storage**

-- **Sources:** wastewater, fertilizers, agriculture, impermeable surfaces, etc.

-- **Sinks:** denitrification within wetlands, aquifer transport, surface water ecosystems, well withdrawals

-- **Storage:** sorption, aquifer transport, biomass accumulation, etc.



Popponesset Bay System

Parcel by parcel analysis of existing land-uses

Water-use based Septic N Loading Analysis

Watershed Delineation and N Loading Model provided with Technical Report

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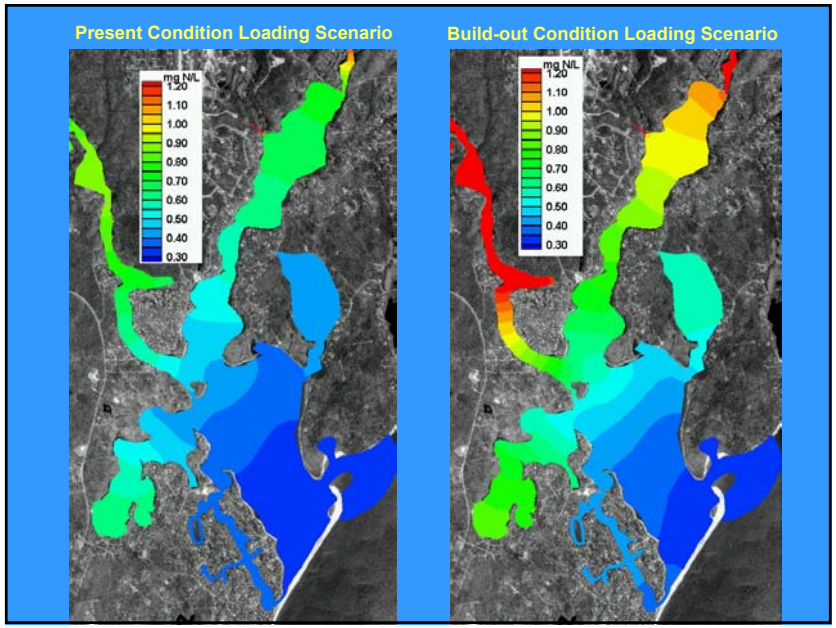
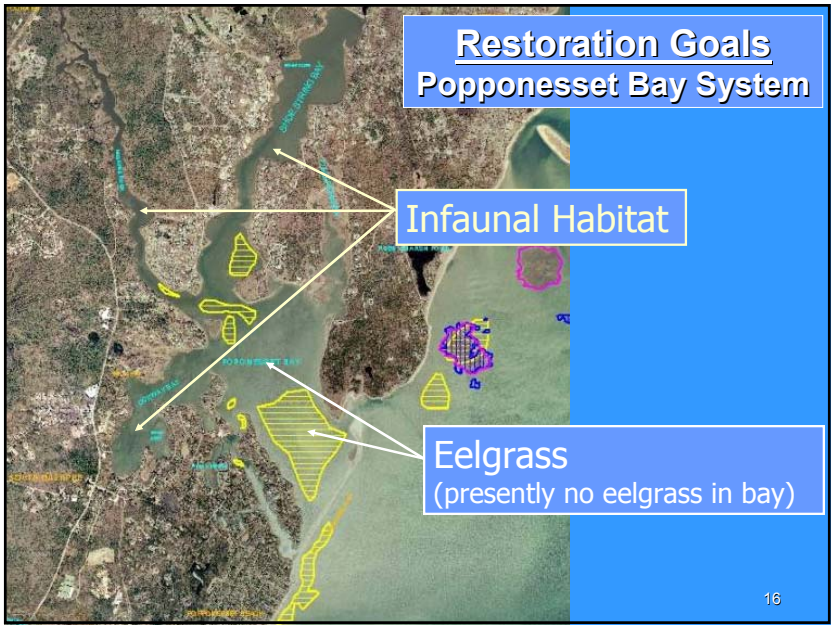
MEP Measured Natural N Attenuation

"Not all Nitrogen discharged to watershed gets to bay"

Cape Cod Estuaries	Nitrogen Loads (kg N yr -1)			
	Watershed Loading	Discharge to Estuary	Natural Attenuation	% Attenuation
Falmouth Salt Ponds				
Coonamesset River (Great Pond)	20601	8260	12341	60%
Backus Brook (Green Pond)	3719	1391	2328	63%
Bournes Brook (Bournes Pond)	3201	1201	2000	62%
Waquoit Bay System				
Quashnet River	12290	7541	4749	39%
Popponesset Bay System				
Mashpee River	19671	7989	11682	59%
Santuit River	11693	5687	6006	51%
Phinney's Harbor System				
Back River	1018	498	520	51%
Three Bays System				
Marstons Mills Pond/River	14,539	5,299	9,238	64%
Little River	2,932	1,446	1,486	51%


Present Condition Loading Scenario
Build-out Condition Loading Scenario
mg N/L
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30


Restoration Goals
Popponesset Bay System
Infaunal Habitat
Eelgrass
(presently no eelgrass in bay)
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Watershed Nitrogen Management for Embayment Protection/Restoration

- ✓ **Phase I:** Monitoring of Embayment Nutrient Related Health
- ✓ **Phase II:** Quantitative Watershed-Embayment Assessment & Modeling
- ➢ Phase III: Implementation-Design, use of Validated Watershed-Embayment Model to Prioritize Management Options, cost/benefit
- • **Phase IV:** Engineering Design & Implementation of Selected N Management Alternatives
- • **Phase V:** Embayment Monitoring to support Adaptive Management

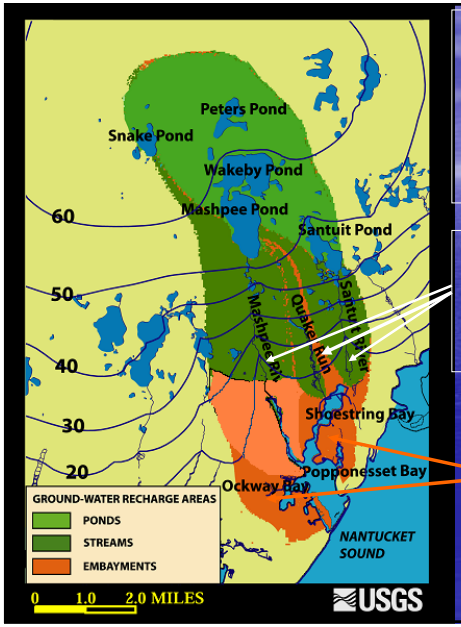
Nitrogen Management Options for Estuaries:

- ➢ Hydrodynamic options
  - Tidal flushing/circulation enhancement & management
- ➢ Natural attenuation options
  - Nitrogen source location to maximize natural attenuation
  - Wetland/riparian zone restoration to increase attenuation
  - Pond restoration to create zones of natural attenuation
- ➢ Nitrogen source reductions
  - Fertilizer education
- ➢ Wastewater options (what, where, how much)
  - Centralized and decentralized systems

MEP Restoration Approach

for Development of Nitrogen Management Alternatives:

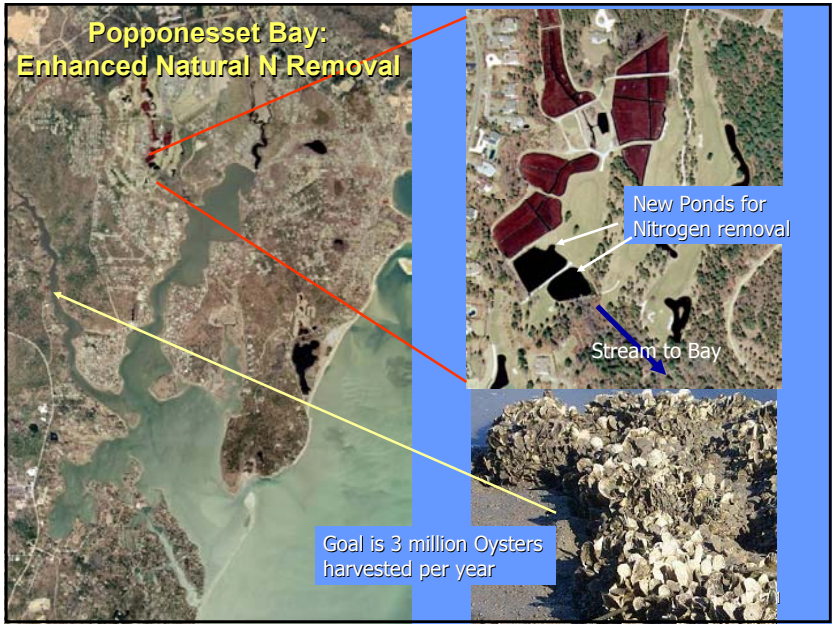
- **First - maximize the hydrodynamics (Flushing)**
- **Second - maximize natural nitrogen removal processes within watershed and estuary**
- **Third - source reduction through education**
- **Last - targeted nitrogen removal through wastewater treatment systems**

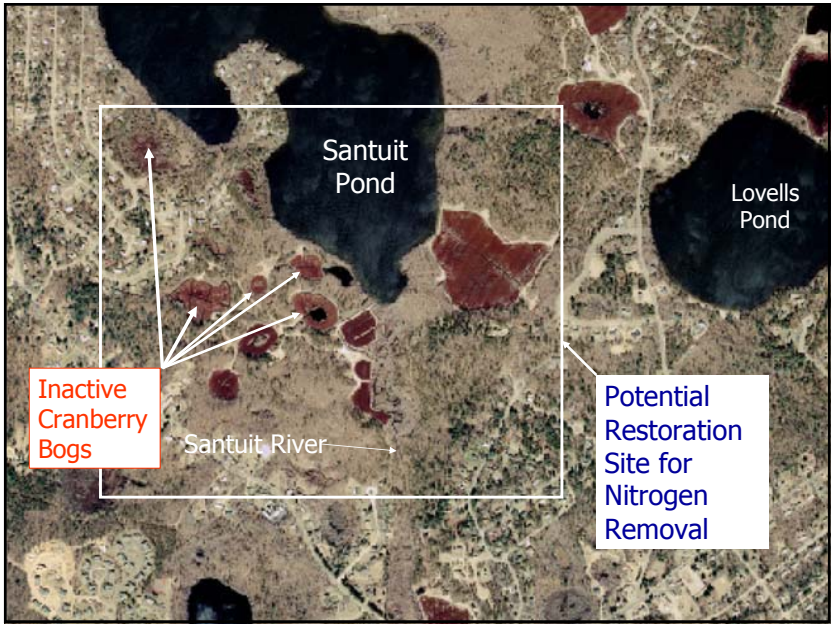


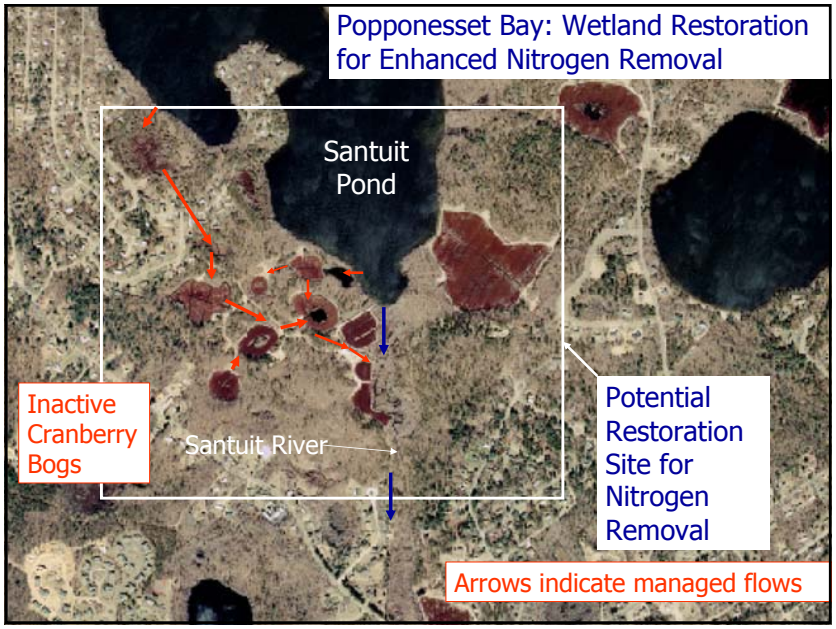
Popponesset Bay Nitrogen Management Alternative

Enhanced Attenuation (26% removal or ½ Nitrate Load in Rivers)

91% Septic Removal (sewers)


Popponesset Bay:
Enhanced Natural N Removal
New Ponds for
Nitrogen removal
Stream to Bay
Goal is 3 million Oysters
harvested per year


Santuit
Pond
Lovells
Pond
Inactive
Cranberry
Bogs
Santuit River
Potential
Restoration
Site for
Nitrogen
Removal



Other Examples MEP Alternatives Analysis

- **Hydrodynamic alteration**
  - Tidal Inlet Management
    - Bournes Pnd, Rushy M, Little Pnd, Oyster Pnd, Sesachacha Pnd
  - Internal Flow/Circulation Management
    - Popponesset Bay, Muddy Creek, Perch Pond, Back River/Eel Pnd
- **Natural Attenuation**
  - Source Relocation
    - West Falmouth Harbor
  - Wetland Restoration – Cranberry Bogs
    - Popponesset Bay, Lewis Bay
  - Pond Restoration
    - 3 Bays, Centerville River
- **Wastewater Management**
  - Targeted Sewering of sub-watersheds
    - Great Pond, Bournes Pond, Green Pond, Popponesset Bay,
  - WWTF discharges
    - West Falmouth Harbor

Steps to Conducting Alternative Analysis:

- First
  - Site-specific guidance from MEP Rept & Technical Team
  - Town groups develop conceptual management scenarios
- Second
  - for N attenuation and N source relocation: determine specific sites and areas involved
  - for inlet alteration, indicate inlet locations (usually historic)
  - for sewering, determine the % of septic systems within each MEP sub-watershed that will be "removed" and the site of WWTF discharge.
- Third
  - Linked Watershed-Embayment Model runs to gauge "result"
  - of the scenarios, those which look "good", develop rough cost estimate.

MEP Unintended Consequences

Use of wetlands/pond/river restoration to enhance natural nitrogen removal processes for restoring nitrogen impaired estuaries.

Result:

- Lower costs for watershed nitrogen management
- Impetus for environmental restoration

"Knowledge and Need are the Basis of Innovation"

Questions & Discussion

Primary Technical Contributors:

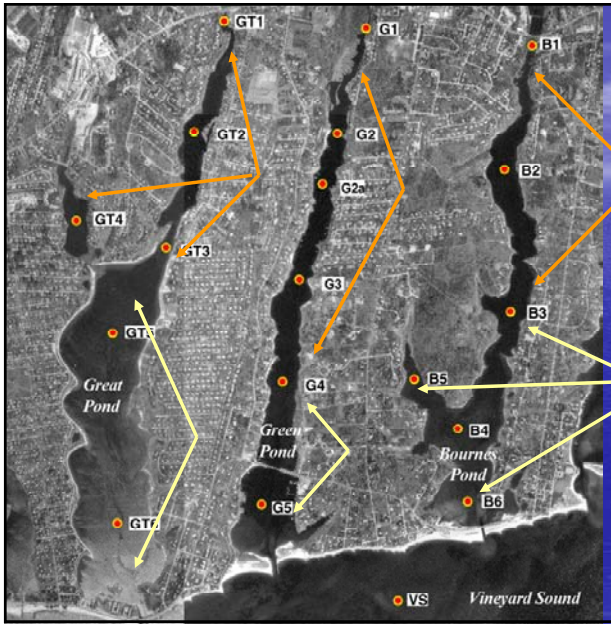
Ed Eichner	Brian Howes	Sara Sampieri	John Ramsey
Xiatong Wu	Roland Samimy	Jen Benson	Sean Kelley
Tom Cambareri	David Schlezinger	Mike Bartlett	Trey Ruthven
Maisy McDarby	David White	George Hampson	Liz Hunt
Don Walter	Dale Toner	Interns TNC	
Jon Masterson	Betsy White		

What is information is needed to develop scenarios?

- **Tidal Flushing:**
  - MEP conducts an analysis of inlet "restriction" as part of the Tech Report
  - Historic changes in inlet numbers & placement
    - Requires: only inlet location
- **Natural Attenuation:**
  - Evaluate the location of potential aquatic restoration sites relative to ability to intercept watershed N sources
  - Evaluate potential source relocation to take advantage
    - (step 1) need location and area, (step 2) limited field data
- **Targeted Sewering:**
  - Remove N load from groundwater sub-watersheds
    - need %sewering/MEP watershed & effluent discharge site

Massachusetts Estuaries Project
Embayment Restoration

Case Study:
Targeted Sewering
Great, Green, Bournes Ponds
Town of Falmouth



Restoration Goals

Infaunal Habitat

Eelgrass Habitat

Sewering Scenarios:

Developed by Town of Falmouth

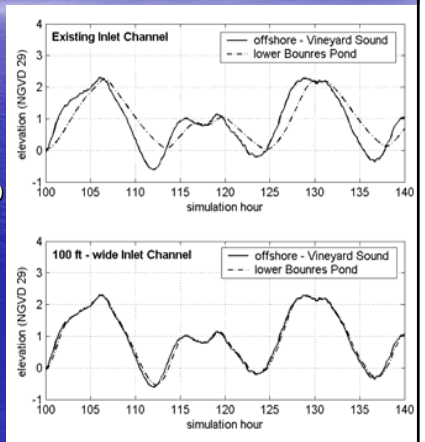
#1: Sewer A
Discharge A: Outside

#2: Sewer A+B
Discharge A: Outside
Discharge B: 3 Golf Courses

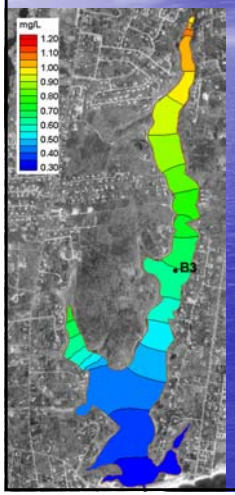
#3 Sewer A+B+C
Discharge A: Outside
Discharge B: 3 Golf Courses
Discharge C: 3 Golf Courses

Improvements to Tidal Flushing Bournes Pond, Falmouth MA

- Present inlet is undersized, producing less than ideal flushing conditions.
- Increasing inlet from 50' to 100' improves tidal exchange means **better water quality** for the same N load



Massachusetts Estuaries Project
Bournes Pond, Falmouth

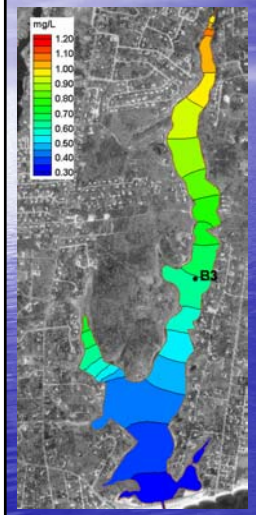


Widening Inlet (50' to 100') Reduces Sewering to Meet Threshold TN Concentrations.

Inlet Modification is equivalent to sewering 100% of upper + 15% of lower watershed

Note: Threshold can only be attained with additional targeted sewering

Present Loading Existing Inlet



Threshold Loading

- To meet threshold target set for ***Bournes Pond***, required load removals are:
  - 100% lower watershed
  - (10.08 kg/day)
  - 55% upper watershed
  - (1.33 kg/day)
  - (Bournes Brook)
- Threshold met by Town's sewering ***Scenario 2***, and also an ***improved inlet*** (100 ft wide, similar to Green Pond)
- ***B3 TN=0.45mg/l***