Alternative Solutions for Nutrient Management

March 4, 2025
Selectman's Conference Room

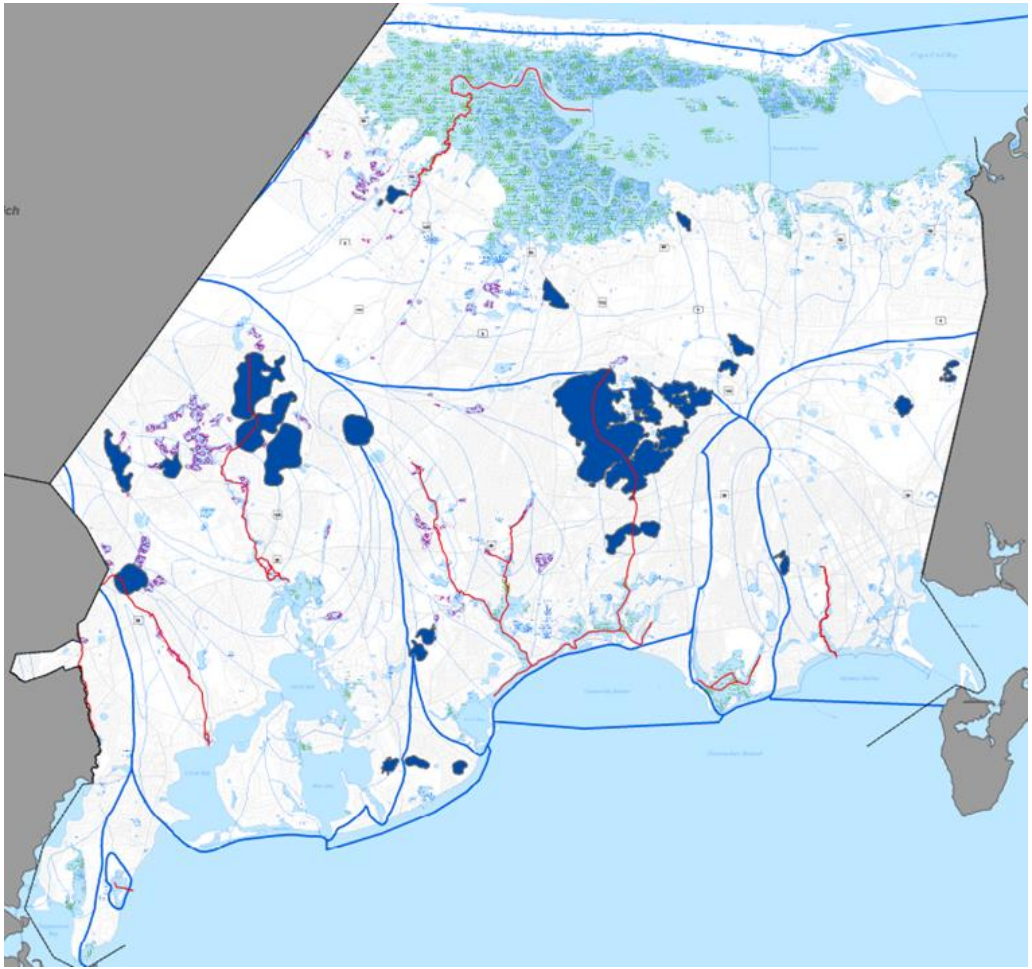
Town of Barnstable
Department of Public Works

Presentation Overview

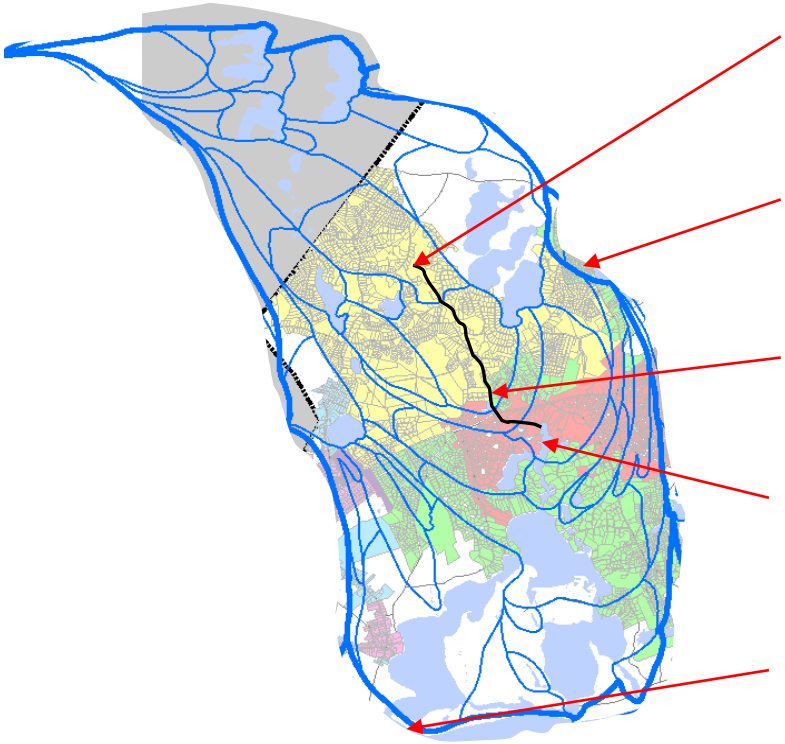
Nitrogen Management:

- Cranberry Bog Restoration
- Dredging
- Aquaculture
- Inlet Widening
- Stormwater Improvements
- Culvert Widening
- Fertilizer & Stormwater Controls
- Permeable Reactive Barriers (PRB)

Phosphorus Management



CWMP Non-Traditional Projects and Three Bays



Cranberry Bog Restoration

Enhanced Innovative Alternative Septics at Shubael Pond

Mill Pond Dredging

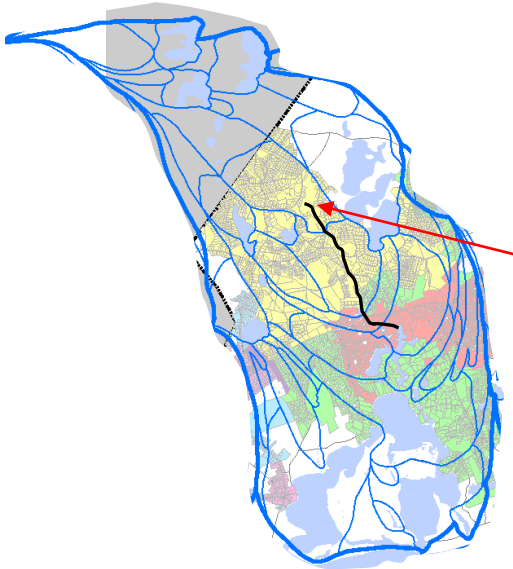
Warrens Cove Dredging and Aquaculture Feasibility Study

Cotuit Bay Inlet Widening

Stormwater Improvements (throughout)

Upper Marstons Mills Cranberry Bog Restoration

- Led by the Barnstable Clean Water Coalition, approximately 60 acres of cranberry bogs at the head waters of the Marstons Mills River are slated for restoration



Upper Marstons Mills Cranberry Bog Restoration

- To restore the bogs, the surface of the bogs will be excavated and a microtopography created increasing dispersion of water across the wetland and overall slowing the flow of the Marstons Mills River

- Anticipated construction in 2026

Tidmarsh Restoration. Picture by Interfluve

Upper Marstons Mills Cranberry Bog Restoration

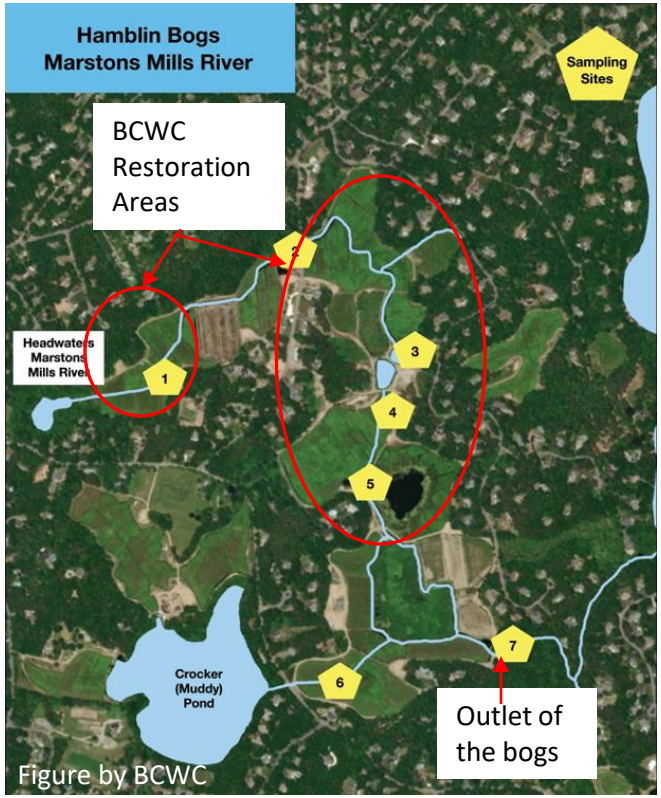
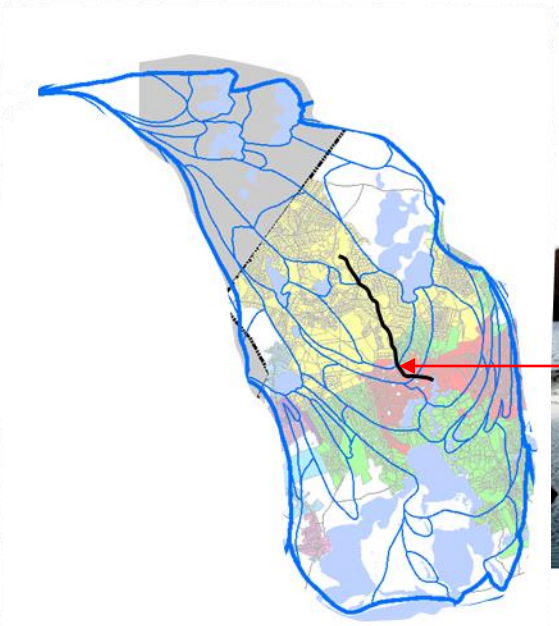


Figure by BCWC

- Pre-construction monitoring by BCWC is underway throughout the bogs
- This monitoring reveals that ~7,500 kg nitrogen exits these bogs annually, of which ~6,300kg is in the form of nitrate, which can be denitrified if the right conditions exist
- At the outlet of the bogs, monitoring will continue post-construction to track extent of nitrogen removal
- Depending on the effectiveness of nitrogen removal, sewer relief may be requested from MA DEP

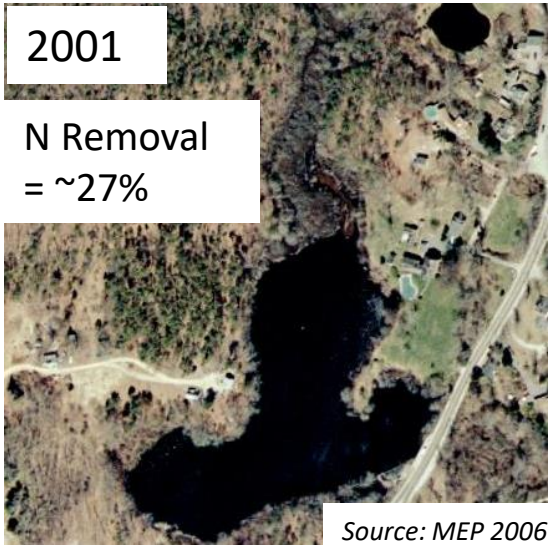
Mill Pond, Marstons Mills

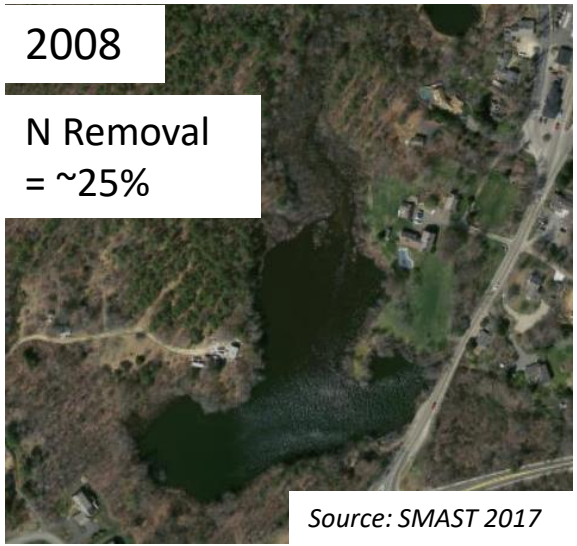


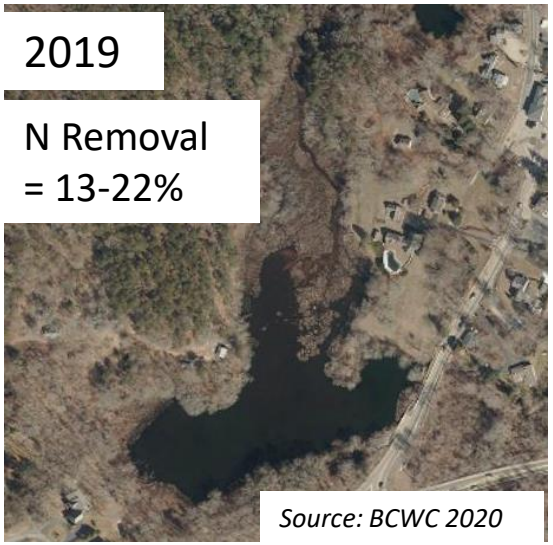
Mill Pond. Picture by Scott Horsley

Mill Pond, Marstons Mills

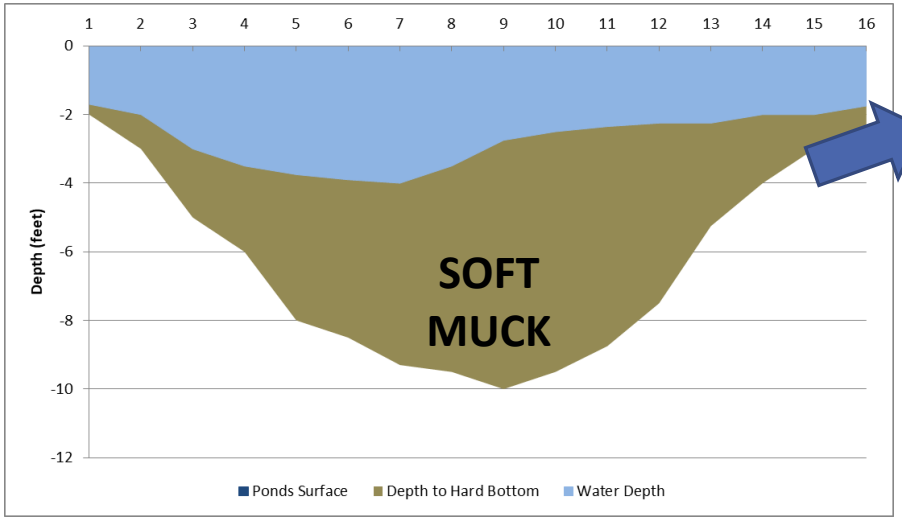
- From 2002 to 2019, there has been a measured decrease in the removal of nitrogen as water passes through Mill Pond
- Most ponds remove 50% of the nitrogen passing through them



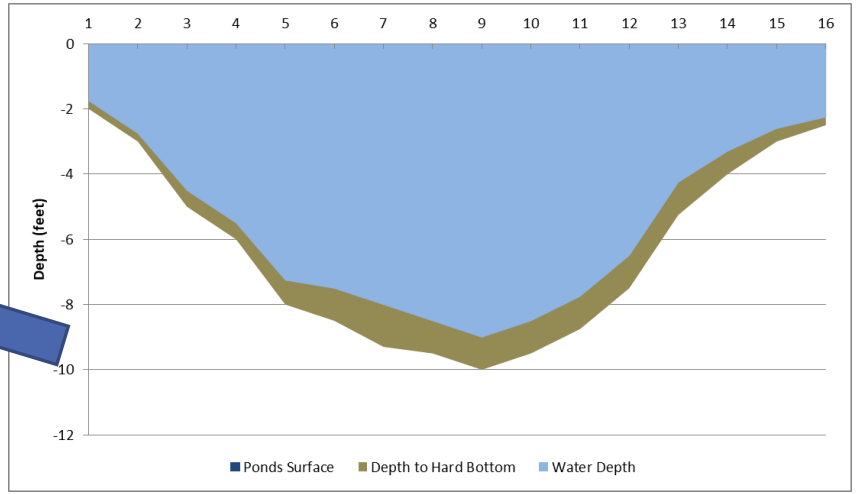




Mill Pond Dredging Project



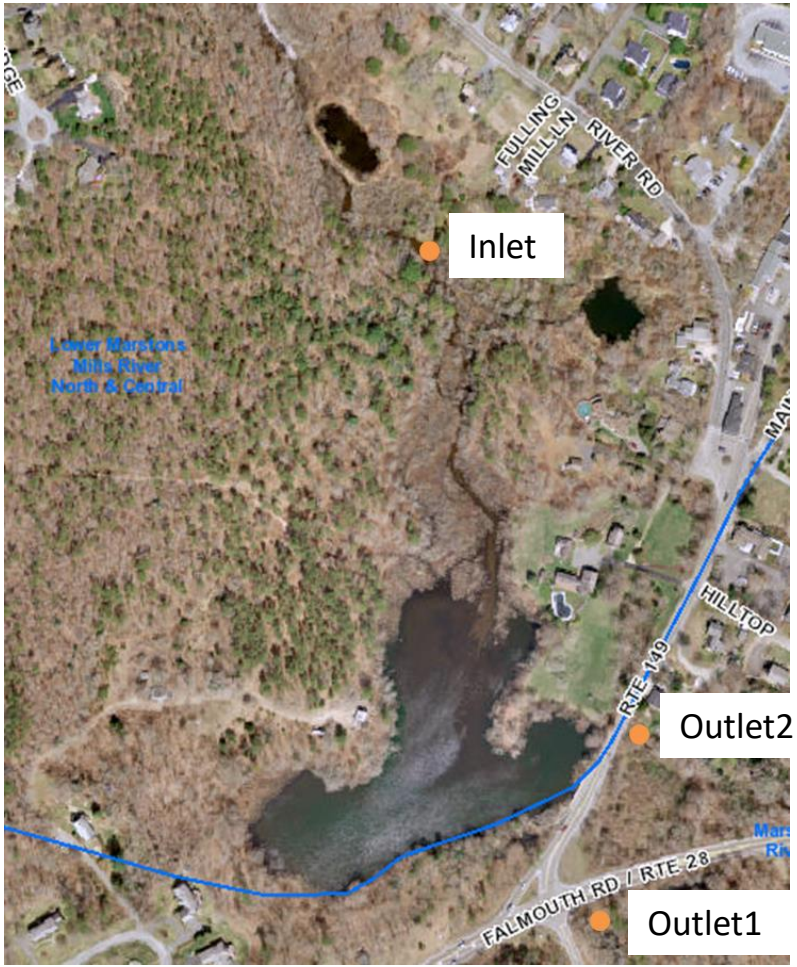
1. Remove 300 years of accumulated sediments from Mill Pond



2. Retain water 2 to 4 times longer than its existing condition, promoting additional nitrogen removal

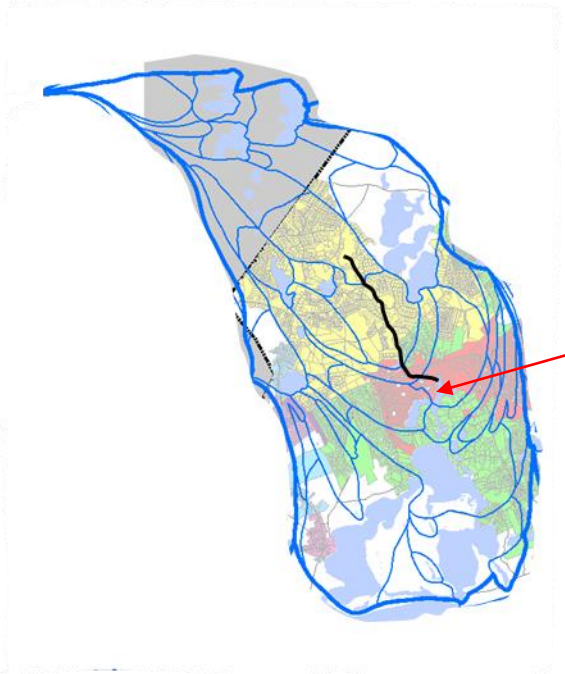
Mill Pond Dredging Project

- Currently in design / permitting phase
- Pre-construction monitoring by BCWC is underway revealing that Mill Pond currently removes ~2,500 kg N / year as the Marstons Mills River passes through Mill Pond
- Post-construction monitoring will be used to track the effectiveness of nitrogen removal and sewer relief may be requested from MA DEP



Warrens Cove Dredging and Aquaculture

- Dredging to remove accumulated sediments and improve water quality for purpose of creating suitable habitat for aquaculture

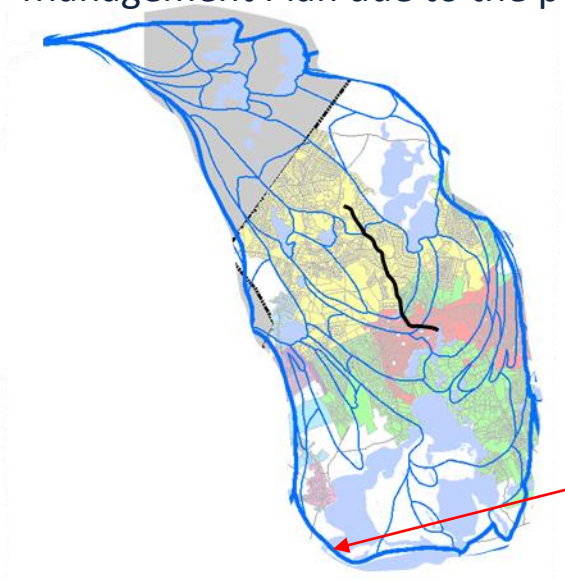


Aquaculture and Nitrogen Removal

- One oyster can filter up to 50 gallons/day
- Oysters remove nitrogen through:
  - Uptake
  - Denitrification
  - Biodeposition
- A demonstration project in Orleans found that ~38,000 lbs of harvested oysters remove ~75kg N

Cotuit Bay Inlet Widening

- After BCWC secured permits, the Town initiated the Cotuit inlet widening
- Increased the inlet's width by 400 feet to improve navigational safety through the inlet, provide nourishment for shorebird habitat, increase coastal resiliency, and tidal flushing
- This project was listed as a potential non-traditional solution in the Comprehensive Wastewater Management Plan due to the potential for increased flushing with Nantucket Sound



Cotuit Bay Inlet Widening

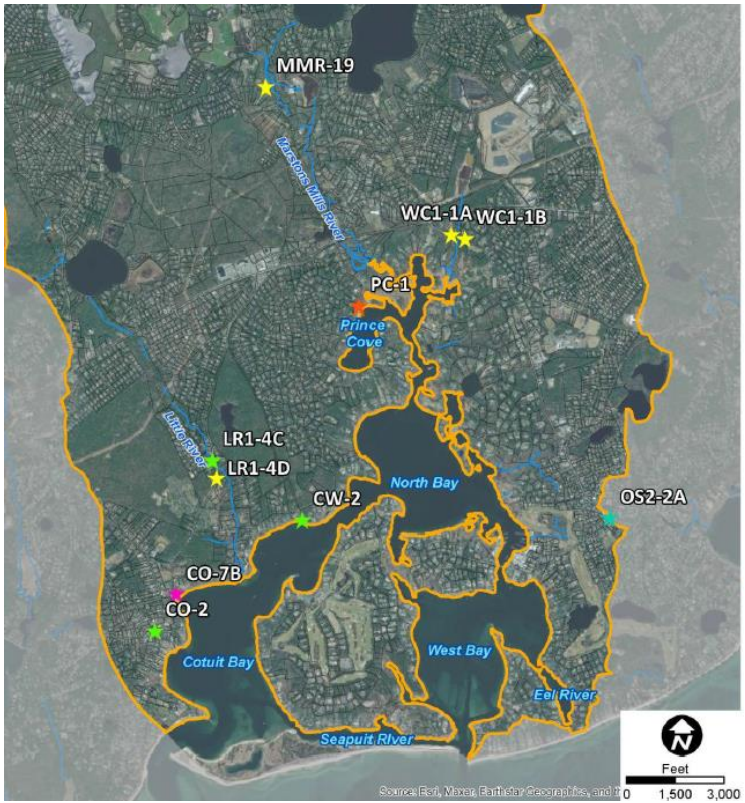
- Monitoring data from 2015-2023 at five stations, including the sentinel station, were evaluated to investigate a possible change in TN as a result of the widening project
- Analysis revealed that observed total nitrogen changes at the five stations were not statistically significant, except for Station 9 in West Bay
- Overall, this project did not affect water quality enough to warrant a request for relief from sewers within the watershed

Stations (and locations)	Pre-Dredge Avg (mg/L)	Post-Dredge Avg (mg/L)	Observed TN Change (mg/L)	Statistical Significance[1]
STA5 (North Bay, north)	0.773	0.626	-0.147	No, p=0.12
STA6 (North Bay, south)	0.560	0.498	-0.062	No, p=0.18
STA9 (West Bay, west)	0.545	0.402	-0.143	Yes, p=0.02
STA13 (Cotuit Bay, south)	0.530	0.523	-0.007	No, p=0.91
STA18 (Sentinel Station)	0.612	0.670	+0.058	No, p=0.29
[1]p value < 0.05 is considered statistically significant.				

Stormwater Improvement Projects

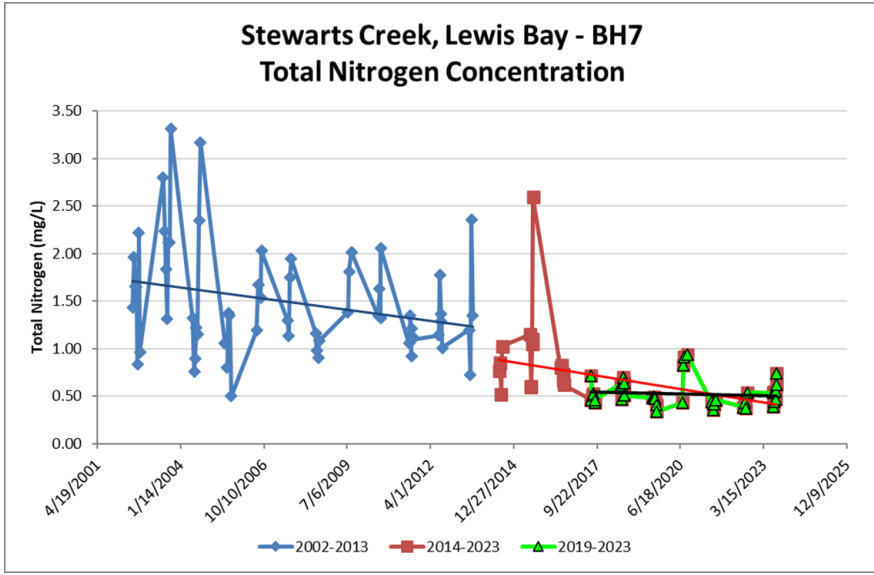
Several stormwater improvement projects were completed in partnership with the Association to Preserve Cape Cod funded with SNEP and CZM grants removing an estimated 35kg N / year

Site Name	Practice Type	Construction Year	Drainage Area	Impervious Surface	Nitrogen Removal		Bacteria Removal		TSS Removal	
			(ac)	*%*	*%*	*lbs*	*%*	*billion colonies*	*%*	*lbs*
Cordwood Landing	Bioretention	2019	1.4*	32	100%	13.1	100%	126.5	100%	398
Prince Cove	Sand Filter	2019	1.8	38	70%	14	86%	164	90%	539
Ropes Beach	Gravel Wetland	2020	0.25*	50	68%	2.2	76%	23.8	90%	88
Putnam Avenue	Bioretention	2020	0.3	56	32%	1.5	55%	25	90%	128
Putnam Avenue	Dry Swale	2020	3.8	18	100%	23	100%	219	100%	685
Cotuit Library	Bioretention	2020	0.17	96	100%	4.4	100%	42.3	100%	133
South County Road	Water Quality Unit	2020	4.7***	27	0%	0	0%	0	80%	687
South County Road	Dry Swales	2021	2.6	24	100%	12	100%	182	100%	513
River Road	Dry Swales	2022	1.1	32	100%	6.3	100%	96.4	100%	302
					Totals:	**76.5**		**879**		**3473**



Stewarts Creek Sewer Expansion and Culvert Widening

- Sewer expansion was completed in 2012, allowing 227 homes to connect to sewer, removing nitrogen from the watershed
- Culvert replacement of a 3-ft diameter culvert to 4-ft x 6-ft box culvert, increasing tidal flushing



Chapter 78 Fertilizer: Nitrogen and Phosphorus Control Regulations

Outlines education, certification, standardization and regulation of practice to provides for a reduction of nitrogen and phosphorus entering the Town's waters and wetlands

Health Division oversees:

- retailer compliance with advertising of phosphorus-containing fertilizer impact on waterways
- responds to complaints regarding improper use of fertilizers
- works with County staff to ensure certifications are provided for certified fertilizer applicators

Conservation Division oversees:

- fertilizer use by noncertified fertilizer applicators within 100 feet to any water body or within the Zone I of a public drinking water well,
- enforcement of proper disposal of grass clippings, leaves, or any other vegetative debris into or within 50 feet of water bodies, retention and detention areas, drainage ditches or stormwater drains, or onto impervious surfaces

Chapter 185: Stormwater Management Ordinance

Regulates stormwater discharges for the protection of water bodies and groundwater resources, safeguard public health, and welfare of natural resources

Department of Public Works oversees:

- Elimination of illicit discharges
- Requirement of erosion and sediment controls during construction
- Requirement of stormwater management for post construction stormwater site controls
  - Use of Low Impact Development design strategies
  - New Development requirement to remove 90% of Total Suspended Solids load and 60% of Phosphorus load from Impervious Area
  - Re-Development requirement to remove 80% of Total Suspended Solids load and 50% of Phosphorus load from Impervious Area
  - Optimize for Nitrogen Removal

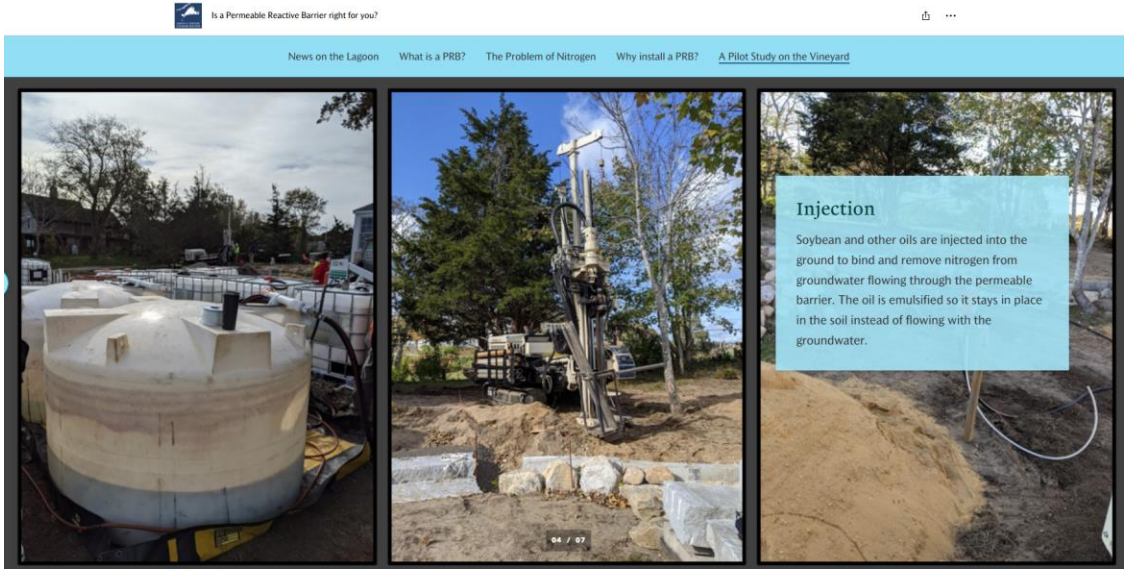
Permeable Reactive Barrier

PRB Micro Siting Case Study on Lagoon Pond, Martha's Vineyard

- Nitrate in the groundwater was reduced from ~5mg/L to 0mg/L after passing through a PRB of soybean oil injected into the ground

Considerations to be effective:

- depth to groundwater
- flow direction
- hydraulic conductivity
- nitrogen concentration
- soil type
- any tidal influence on the groundwater



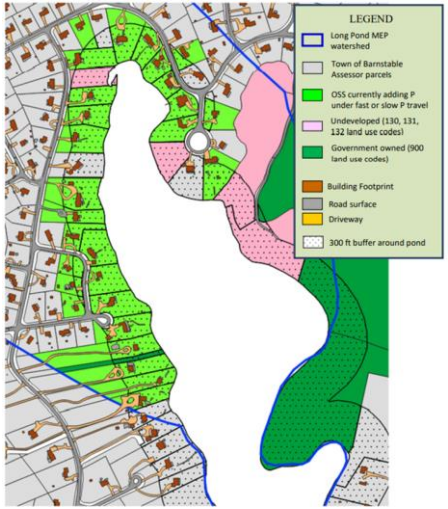
https://storymaps.arcgis.com/stories/9f245ad70aeb479697f45556803d77a7

Freshwater Nutrient Management – Phosphorus

Develop pond specific management plans and implement appropriate solutions

Phosphorus Management of Lakes and Ponds:

- Stormwater improvements through removal of direct discharges
- Phosphorus inactivation through alum treatments of deep sediments
- Deployment of floating wetlands to take up available phosphorus in the water column
- Sewer expansion to homes within the contributing watershed
- Aeration of deep-water column

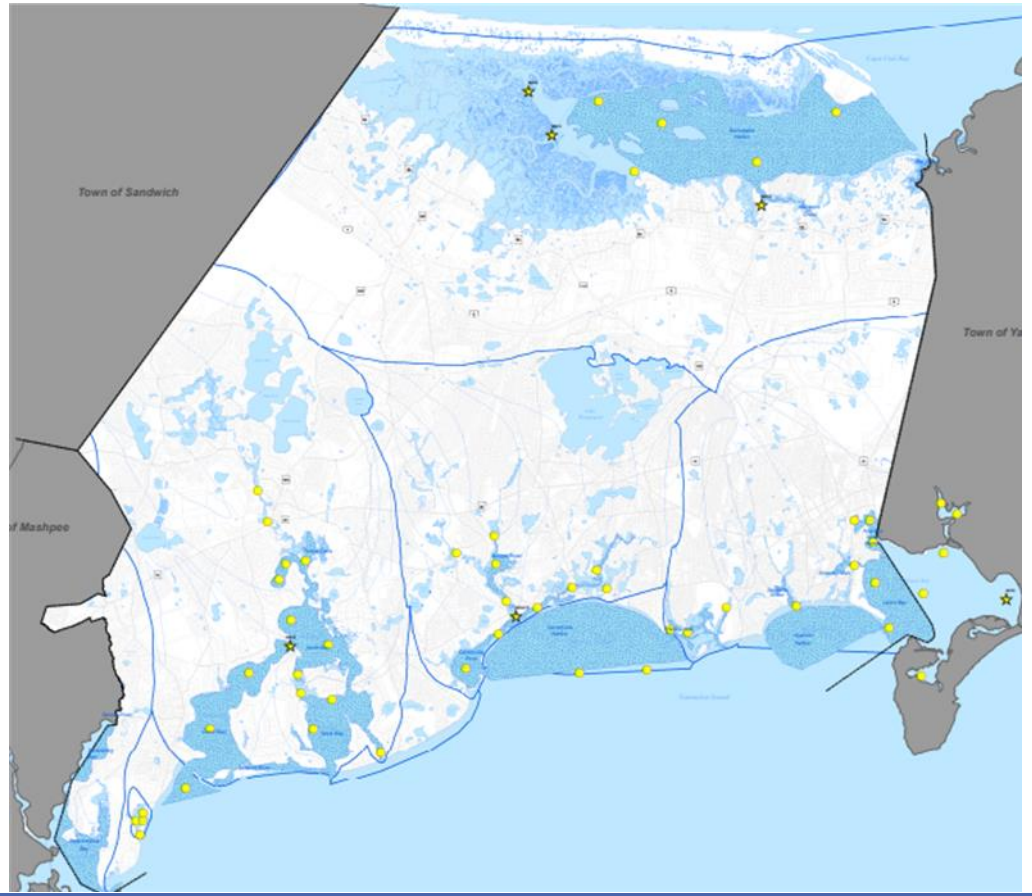


Questions?

Resources

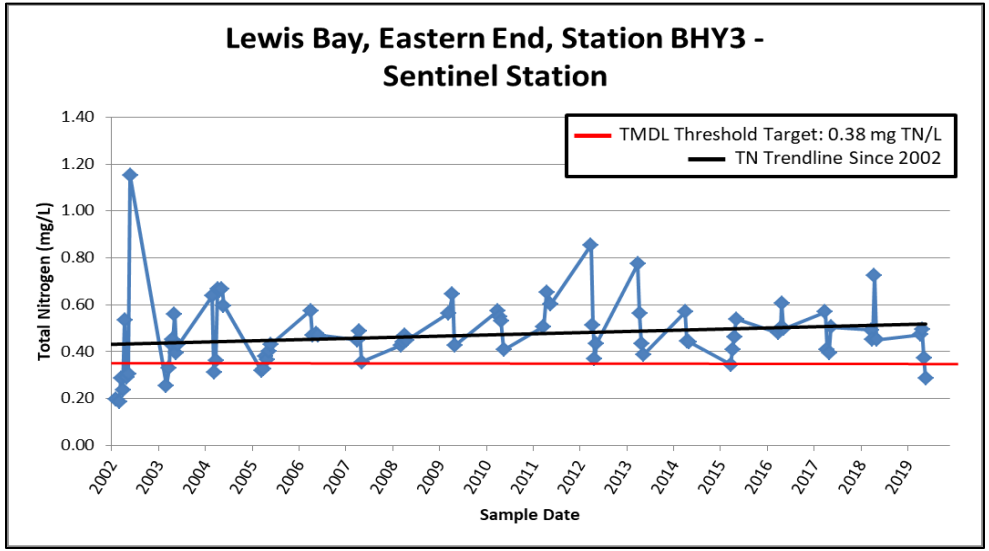
Estuaries – Embayment Monitoring Program

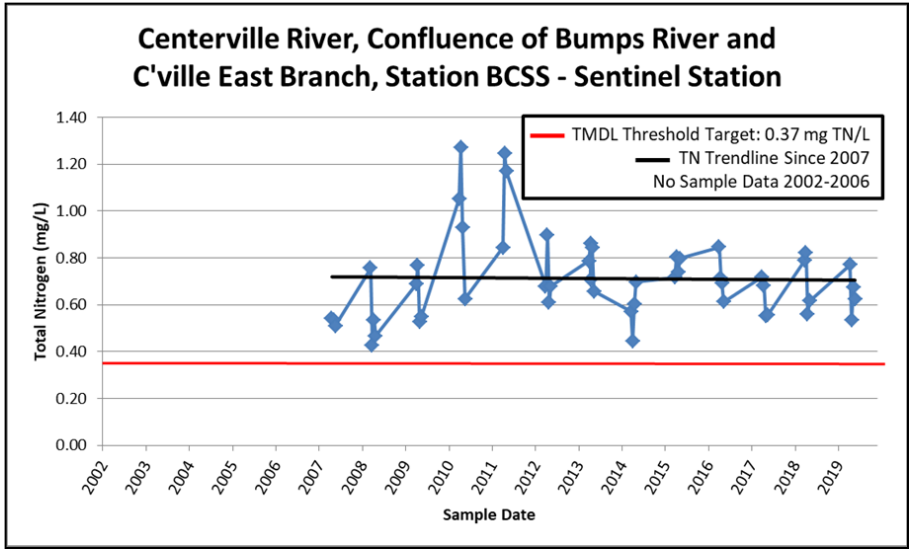
- Initiated in 2002
- 70 stations sampled annually
- Collaborative effort involving:
  - Town staff (DPW, MEA, and Health)
  - Citizen volunteers
  - Barnstable Clean Water Coalition
  - Adjacent Towns, and
  - UMass Dartmouth School for Marine Science and Technology
- 100,000+ data points



Embayment Monitoring Program - Results

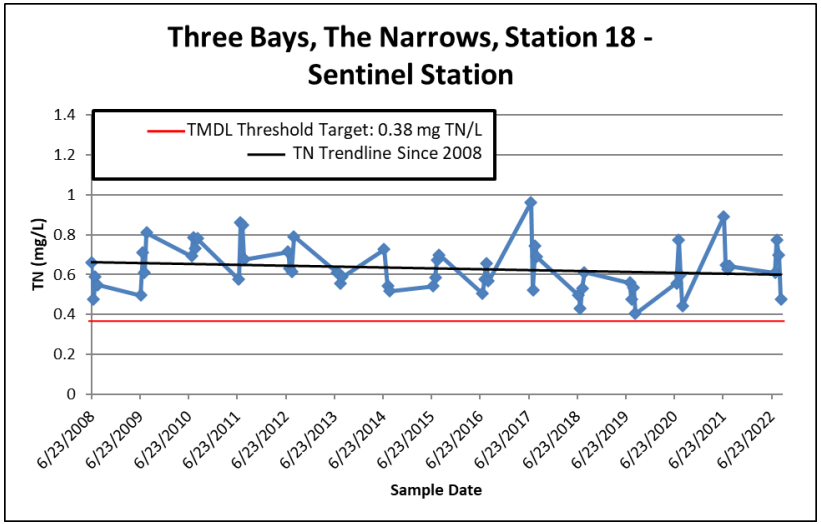
- Lewis Bay and Centerville River water quality is impaired due to excess nitrogen
- Total nitrogen levels at the sentinel stations are above the nitrogen threshold identified as representative of healthy ecosystems

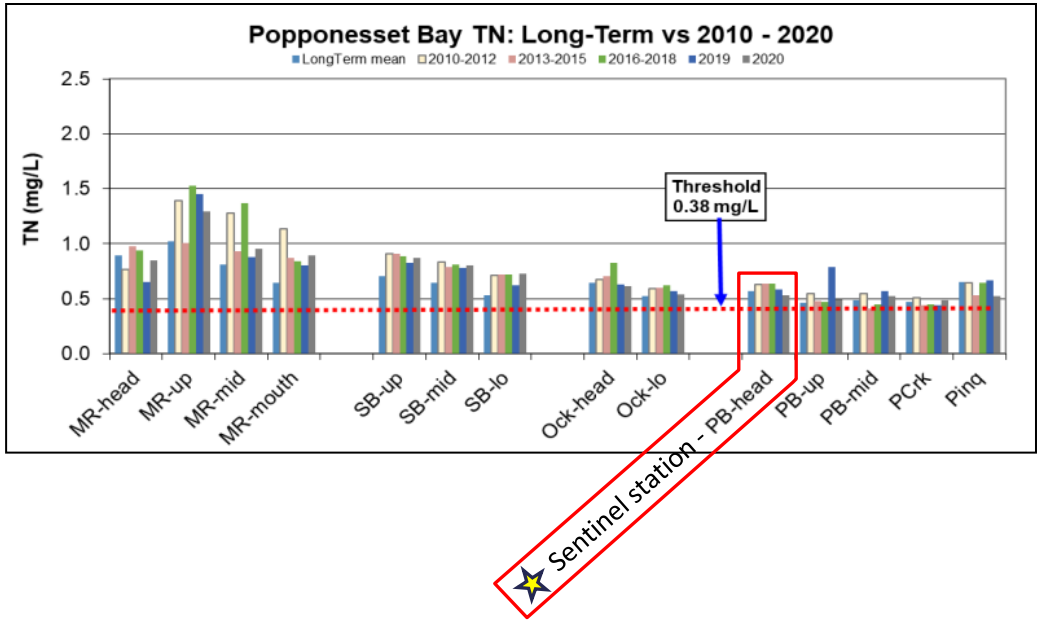




Embayment Monitoring Program - Results

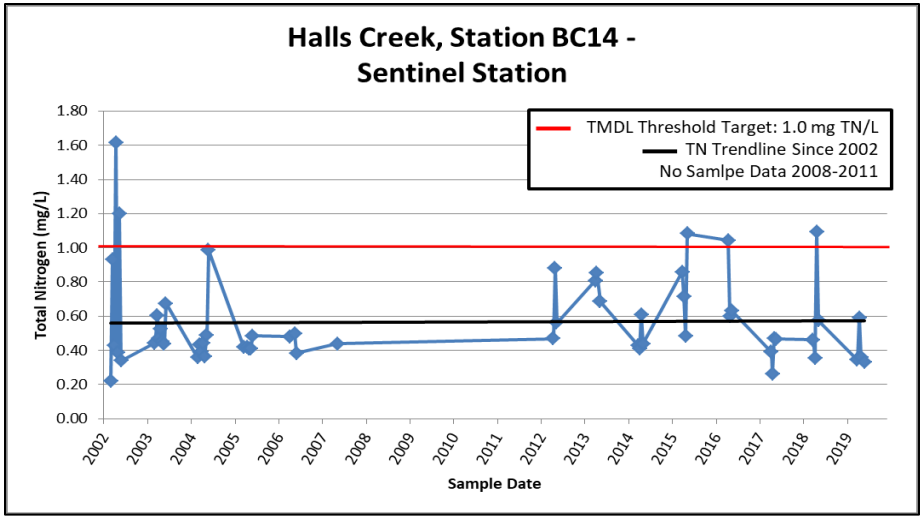
- Three Bays and Popponesset Bay water quality is impaired due to excess nitrogen
- Total nitrogen levels at the sentinel stations are above the nitrogen threshold identified as representative of healthy ecosystems

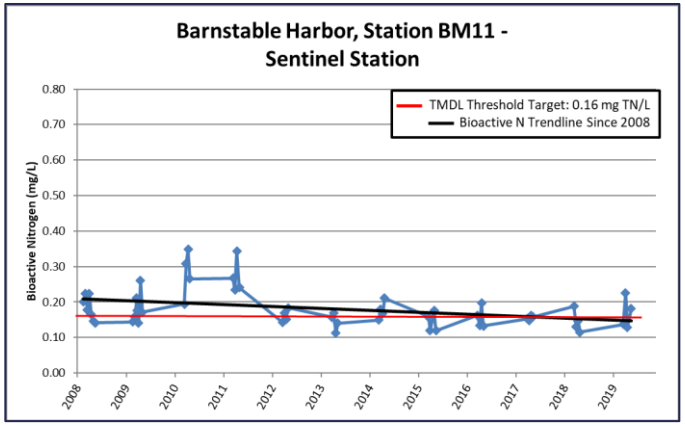


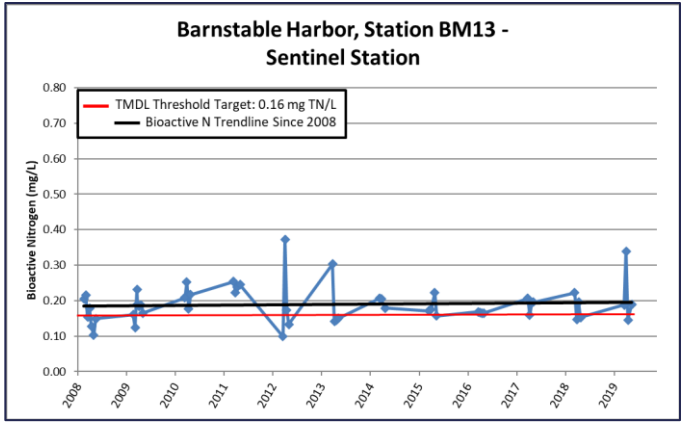


Embayment Monitoring Program - Results

- Halls Creek and Barnstable Harbor water quality is not impaired due to excess nitrogen

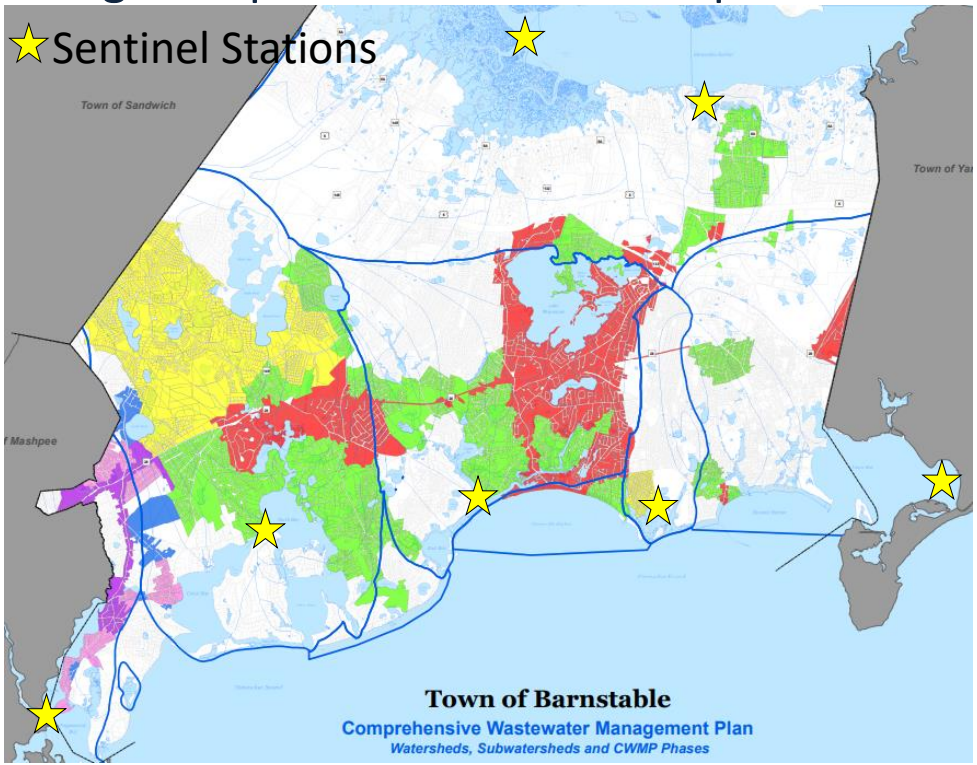






Embayment Monitoring Program – Looking Forward

- This monitoring program provides the baseline data for our estuaries and the ability to track nitrogen improvements as we implement the CWMP

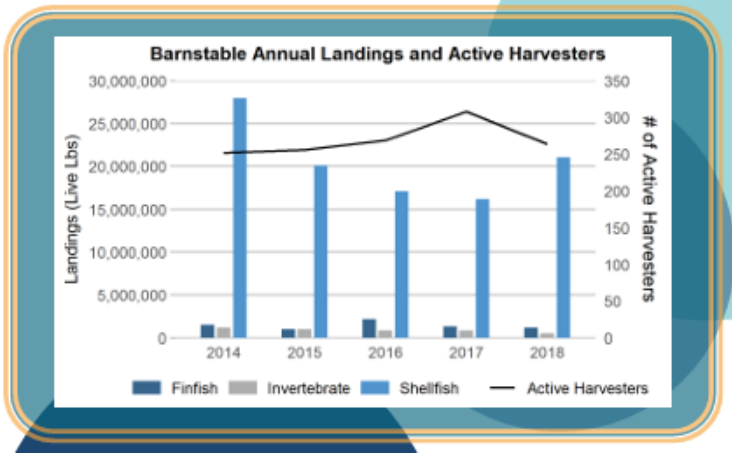


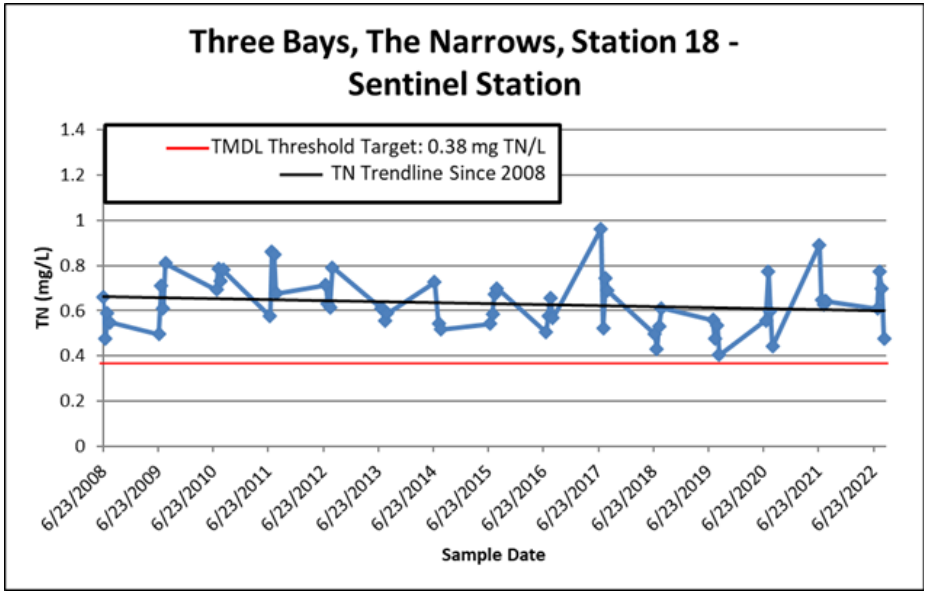
Aquaculture and Nitrogen Removal

- Total shellfishing landings vary year to year
- Water quality at embayment sentinel stations relatively unchanged in 20 years

5 Year Trends in Commercial Landings and Value

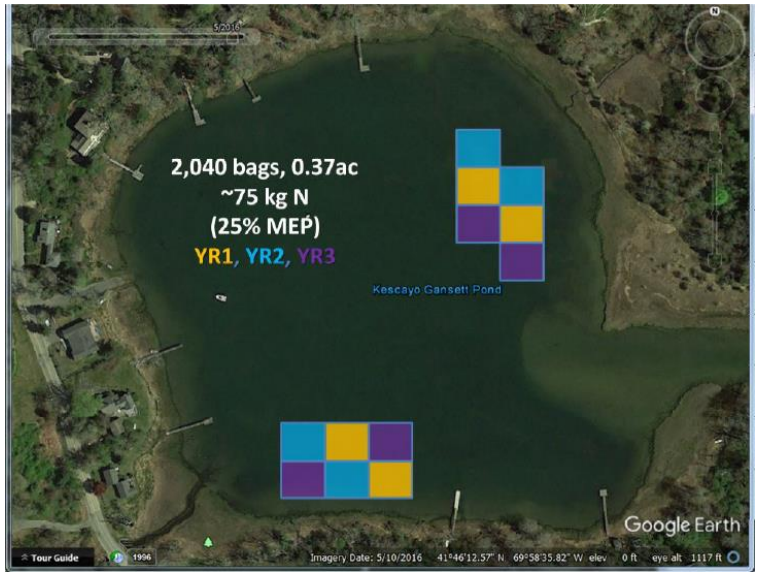
Source: DMF Permitting and Statistics Data; ACCSP Data Warehouse

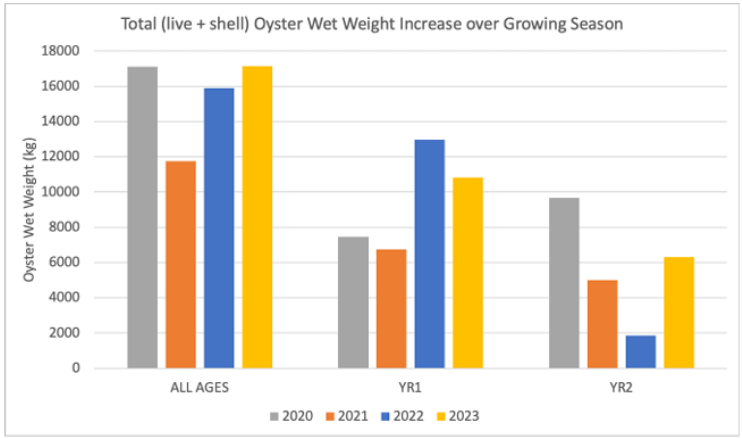


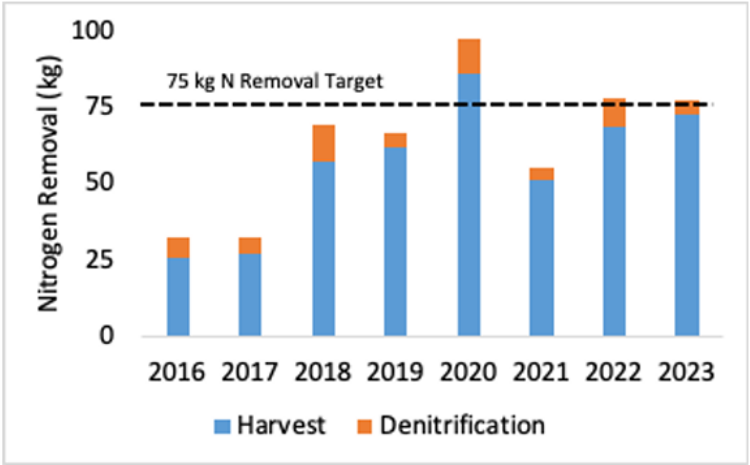


Aquaculture and Nitrogen Removal

- Example: Lonnies Pond, Orleans
- Town authorized new shellfishing areas in 2019
- ~38,000 lbs of oysters remove ~75kg N

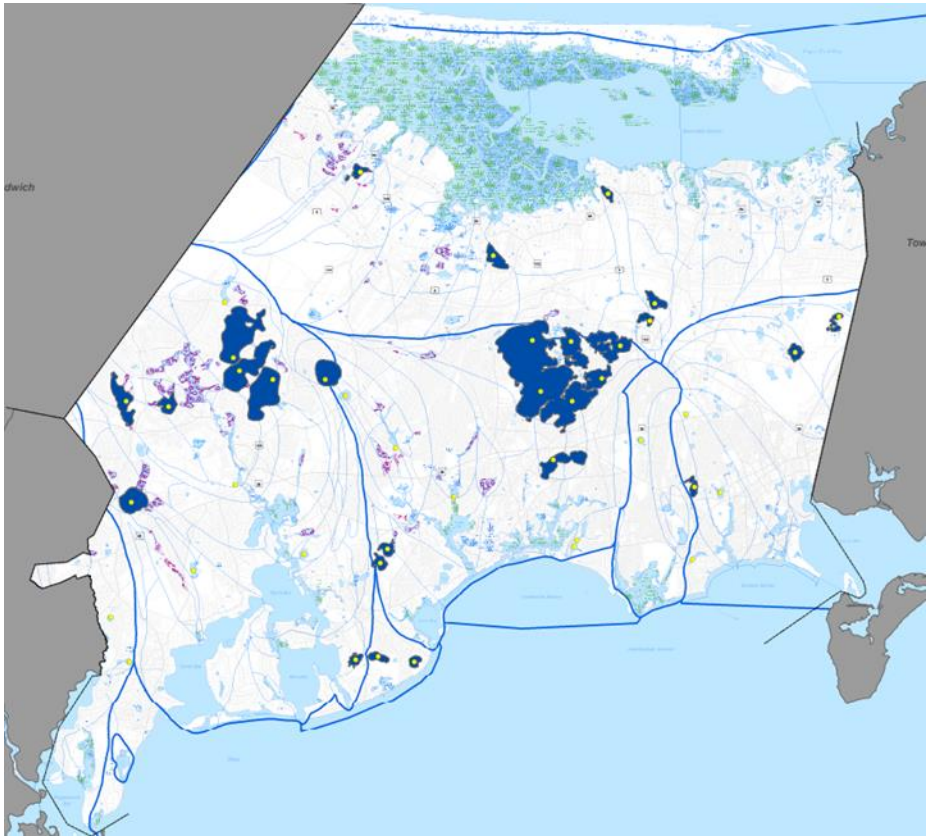






Ponds and Lakes – Monitoring Program Results

- 32 ponds have at least five years of data and were evaluated for impairment based on MassDEP regulations and Cape Cod pond thresholds
- Of the 32 ponds:
  - 23 are impaired,
  - 7 are borderline impaired, and
  - 2 are unimpaired
- Ponds can be impaired due to excess nutrients (particularly phosphorus), algal blooms, poor water clarity, and low dissolved oxygen

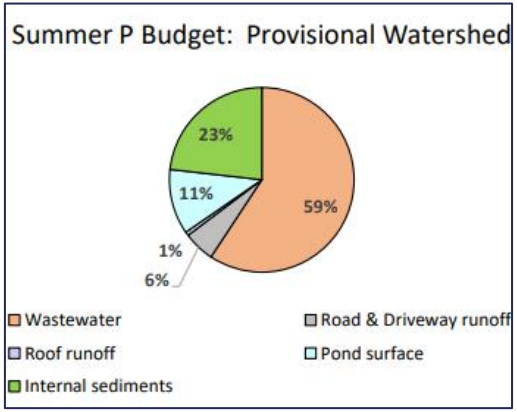


Ponds and Lakes – Management Plan Program

- In 2020, Ponds and Lakes Monitoring and Management Plan Program established by Town Council, providing for management plan development:
  - 2020 – Shubael Pond
  - 2021 – Long Pond Marstons Mills
  - 2022 – Lovells Pond
  - 2023 – Wequaquet Lake, Bearses Pond, and Gooseberry Cove
  - 2024 – Long Pond Centerville
- Management plans developed over two phases:
  - Year 1 – Monitoring Phase
    - Water quality sampling
    - Stormwater sampling
    - Stream sampling
    - Sediment nutrient regeneration analysis
    - Bathymetry, mussel, and macrophyte mapping
    - Phytoplankton enumeration and composition
  - Year 2 – Management Plan Report
    - Combines field and water quality data with land use analysis to develop recommended management strategies to improve water quality

Ponds and Lakes – Management Plan Program

- 2022 – Shubael Pond Management Plan recommends phosphorus management of:
  - Septic Systems with sewers
  - Internal Sediments with Alum
  - Road runoff with stormwater improvements

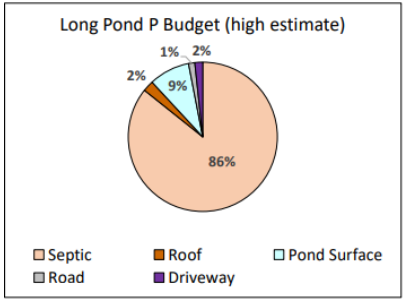


Alum Treatment by Boat

Alum Delivery Truck

Ponds and Lakes – Management Plan Program

- 2022 – Long Pond MM Management Plan recommends:
  - Sewers to address phosphorus loading from septic systems
  - Floating Treatment Wetlands to remove phosphorus through plant growth



- 2023 – Lovells Pond Management Plan *draft* findings:
  - Primary source of phosphorus load is from the sediments
  - Septic systems contribute 35% of the phosphorous load