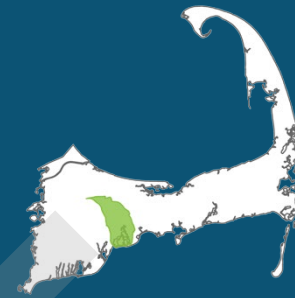


Three Bays

BARNSTABLE & SANDWICH

HIGH



The Three Bays estuary and embayment system is located in the Town of Barnstable. It is comprised of three primary segments that include West Bay, North Bay and Cotuit Bay. Sub-systems include Prince’s Cove that flows into North Bay, the Narrows that flows between North Bay and Cotuit Bay and Eel River that flows into West Bay. The embayment is guarded by Sampson’s Island/Dead Neck which defines the inner Seapuit River waterway between Cotuit Bay and West Bay. Three Bays supports a variety of recreational uses including boating, swimming, shell fishing and fin fishing

The Problem

The Massachusetts Estuaries Project (MEP) technical report (available at www.oceanscience.net/estuaries) indicates that the Three Bays system exceeds its critical threshold for nitrogen, resulting in impaired water quality. A Total Maximum Daily Load (TMDL) for nitrogen has been developed and approved.

- **MEP TECHNICAL REPORT STATUS:** Final
- **TMDL STATUS:** Final TMDL
- **TOTAL WASTEWATER FLOW:** 528 MGY (million gal per year)
 - Treated Wastewater Flow: 8 MGY
 - Septic Flow: 520 MGY
- **UNATTENUATED TOTAL NITROGEN LOAD (MEP):** 74,567 Kg/Y (kilograms per year)
- **ATTENUATED TOTAL NITROGEN LOAD (MEP):** 54,657 Kg/Y
- **SOURCES OF CONTROLLABLE NITROGEN (MEP):**
 - 85% Septic Systems
 - 10% Lawn Fertilizer
 - 5% Stormwater From Impervious Surfaces

CONTRIBUTING TOWNS

Percent contributions listed below are the aggregate sub-embayment contributions identified in Appendix 8C of the Cape Cod Section 208 Plan Update (contributions are based on

attenuated load where available). See Appendix 8C for detailed town allocations by sub-embayment.

- **BARNSTABLE:** 93%
- **SANDWICH:** 7%
- **MASHPEE:** <1%*

*Under existing conditions, the load contributed by Mashpee is so small that reductions are not necessary at this time; however, growth management measures should be taken to ensure that the contribution does not increase. Contributions will be reevaluated at least every five years, based on updated data.

THE MEP RESTORATION SCENARIO

- **WATERSHED TOTAL NITROGEN REDUCTION TARGET:** 46%
- **WATERSHED SEPTIC REDUCTION TARGET:** 60%
(The scenario represents the aggregated sub-embayment percent removal targets from the MEP technical report)

THREE BAYS ESTUARY

- **EMBAYMENT AREA:** 1,251 acres
- **EMBAYMENT VOLUME:** 429 million cubic feet

- **2014 INTEGRATED LIST STATUS:** Category 4a for nitrogen and fecal coliform
 - Category 4a: TMDL is completed
 - www.mass.gov/eea/docs/dep/water/resources/07v5/14list2.pdf

THREE BAYS WATERSHED

- **ACRES:** 12,458
- **PARCELS:** 7,670
- **% DEVELOPED RESIDENTIAL PARCELS:** 85%
- **PARCEL DENSITY:** 1.6 acres per parcel (approx.)
- **WASTEWATER TREATMENT FACILITIES:** 2
 - Cotuit Landing
 - Marstons Mills Elementary School and adjacent Village at Marstons Mills

Freshwater Sources

PONDS

- **IDENTIFIED SURFACE WATERS:** 54
- **NUMBER OF NAMED FRESHWATER PONDS:** 21
- **PONDS WITH PRELIMINARY TROPHIC CHARACTERIZATION:** 19
- **2014 INTEGRATED LIST STATUS:** 6 listed
 - Hamblin Pond
 - Lovells Pond
 - Middle Pond
 - Mystic Lake
 - Lawrence Pond
 - Shubael Pond

Barnstable has participated in the Pond and Lake Stewardship (PALS) program that has helped establish baseline water quality. Trophic characterizations are based on most recent Commission staff assessment.

The Town of Barnstable has completed a Pond Action Report as part of its 2012 draft Comprehensive Wastewater Management Plan (CWMP). In addition, the Town has worked with watershed associations to implement alum treatments for Hamblin and Mystic Ponds and Lovells Pond treatment is scheduled. The Town regularly treats several ponds with Sonar, an herbicide to combat invasive weeds.

STREAMS

- **SIGNIFICANT FRESHWATER STREAM OUTLETS:** 2
 - Marstons Mills River:
 - Average Flow: 16,000 cubic meters per day (m³/d)
 - Average Nitrate Concentrations: 0.48 milligrams per liter (mg/L)
 - Little River:
 - Average Flow: 3,500 m³/d
 - Average Nitrate Concentrations: 0.86 mg/L
- **DISCUSSION:** Characterization of freshwater streams like these is a regular part of the MEP technical reports. These concentrations are higher than areas of the aquifer with less than 0.05 mg/L background concentrations that are evident in public supply wells located in pristine areas. This provides further evidence of the impact of non-point source nitrogen pollution from residential areas on the aquifer and receiving coastal waters.

DRINKING WATER SOURCES

- **WATER DISTRICTS:** 3
 - Sandwich Water District
 - Centerville-Osterville-Marstons Mills (COMM) Water District
 - Cotuit Water District

- **GRAVEL PACKED WELLS:** 26
 - 6 have nitrate concentrations between 0 and 0.5 mg/L
 - 7 have nitrate concentrations between 0.5 and 1 mg/L
 - 7 have nitrate concentrations between 1 and 2.5 mg/L
 - 2 have nitrate concentrations between 2.5 and 5 mg/L
 - 4 have no nitrate concentration data
- **SMALL VOLUME WELLS:** 9
- **DISCUSSION:** Each of the water districts and land trusts have acquired significant portions of land in their Zone IIs for water quality protection which, together with adopted land use controls recommended from the 1978 Section 208 Plan, has resulted in excellent water quality.

Degree of Impairment and Areas of Need

For the purposes of the Section 208 Plan Update areas of need are primarily defined by the amount of nitrogen reduction required as defined by the TMDL and/or MEP technical report. The aggregated watershed removal rates are 40% and 60% for total nitrogen and septic nitrogen, respectively. More specifically, the targeted amount of nitrogen reduction required by subwatershed ranges from 20 to 80% removal, as indicated in the figures, Subwatersheds with Total Nitrogen Removal Targets and Subwatersheds with Septic Nitrogen Removal Targets.

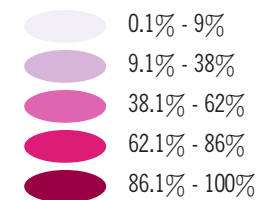
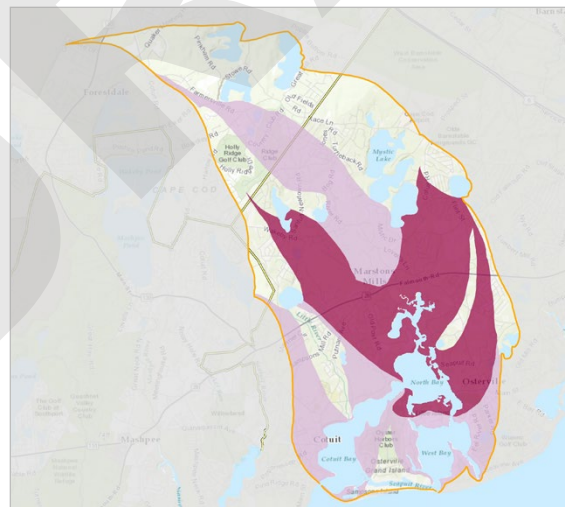
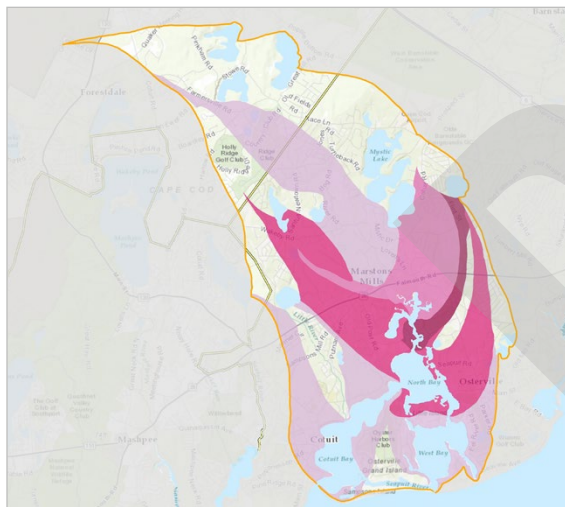
The nitrogen load from the watershed exceeds the TMDL for Three Bays, resulting in impaired waters quality. The ecological health of a water body is determined from water quality, extent of eelgrass, assortment of benthic fauna, and dissolved oxygen and ranges from 1-severe degradation, 2-significantly impaired, 3-moderately impaired, 4- healthy habitat conditions. The upper head waters of Three Bays are

particularly impaired and the upper Prince Cove segment experiences occasional severe eutrophic conditions affecting recreational activities.

ECOLOGICAL CHARACTERISTICS AND WATER QUALITY

- **OVERALL ECOLOGIC CONDITION:** Moderately Impaired to Severely Degraded
- **PRINCES COVE:** Significantly Impaired to Severely Degraded
- **WARRENS COVE:** Severely Degraded
- **UPPER NORTH BAY:** Significantly Impaired to Severely Degraded
- **LOWER NORTH BAY:** Moderately to Significantly Impaired
- **COTUIT BAY:** Moderately Impaired
- **WEST BAY:** Moderately Impaired
- **EEL POND:** Moderately to Significantly Impaired

- **SENTINEL STATION:**
 - Total Nitrogen Concentration Threshold: 0.38 mg/L
 - Total Nitrogen Concentration Existing: 0.5 mg/L
(As reported at the MEP sentinel water-quality monitoring station)



Subwatersheds with Total Watershed Removal Targets

(Left) Benthic and atmospheric loads directly on embayments are not included.

Subwatersheds with Septic Nitrogen Removal Targets

(Right)

Collection & Non-Collection Scenarios

Regional Data

In 2010, the Commission sought to collect regionally consistent data for the purposes of watershed scenario development. Both parcel data and water use data was identified and collected for the entire region. While the scientific basis for planning is the thresholds identified in the MEP technical reports, each report uses data from different years, and in some cases the MEP data used is 10 or more years old. In addition, there are watersheds on Cape Cod without the benefit of an MEP report; therefore, similar data was not available for planning purposes.

The updated regional data set was used to estimate wastewater, stormwater and fertilizer loads, using the same methodologies as the MEP. This approach allows for a reevaluation of existing development, which may have changed in the last 10 years. Parcel data included in the regional database is from 2010-2012 and water use data is from 2008-2011, depending on the water district. This approach allows for regionally consistent watershed scenario development.

Watershed Scenarios

The watershed scenarios that follow outline possibilities for the watershed. A series of non-traditional technologies that might be applicable are included, as well as the amount of flow and approximate number of residential parcels that would

need to be collected if a traditional collection system and treatment facility was implemented. Some assumptions were made in determining the approximate flows and parcels for collection, including a treatment factor of 5 parts per million (ppm), disposal occurring inside the watershed, and no natural attenuation, therefore prioritizing parcels with a direct impact on the water body. Site specific determinations of collection areas may result in the need to collect more or less parcels to meet the nutrient reduction target. The scenarios presented are meant to act as a starting point for discussions regarding effective and cost efficient solutions.

In Three Bays, the Towns of Barnstable and Sandwich have done additional and more detailed planning. Included in the last section of this report is a description of their efforts, along with details of plans developed to date.

THREE BAYS NITROGEN SOURCES	TOTAL NITROGEN LOAD (kg-N/yr)
Wastewater	34,387
Fertilizer	5,076
Stormwater	4,364
Other	2,139
TOTAL	45,966
Total Watershed Load (including atmospheric)	45,966
Total Watershed Threshold	25,643
TOTAL LOAD TO BE REMOVED	20,323


Collection & Non-Collection Scenarios

Non-Collection

-  25 % Nitrogen Reduction - Fertilizer Management
-  25 % Nitrogen Reduction - Stormwater Mitigation
-  3,000 Linear Feet - Permeable Reactive Barrier (PRB)
-  225 Acres - Fertigation - Turf
-  66,000 Cubic Yards - Dredging/Inlet Widening
-  41 Acres - Aquaculture/Oyster Beds
-  4,700 Square Feet - Floating Constructed Wetlands
-  114 Units - Ecotoilets (UD & Compost)
-  110 People Per Year - UD School or Public Facility

Collection



 = 50 Residential Parcels	6,066	873,476
	Residential Equivalents Necessary to Meet Nitrogen Reduction Target	Flow Collected (gpd)

SCENARIO ASSUMPTIONS: Assumes treatment to 5 parts per million (ppm) nitrogen. Assumes disposal occurs inside the watershed. Assumes no natural attenuation; therefore, prioritizing parcels with a direct impact on the water body.

Town of Barnstable Local Progress

The Cape Cod Commission and the Town of Barnstable met and discussed the use of WatershedMVP to evaluate targeted watershed approaches for each of the watersheds in which they have jurisdiction. In 2015, the town reformulated its Citizen's Advisory Committee (CAC) for wastewater planning to better address local needs. In addition to local participation, the newly formed committee (the Water Resources Advisory Committee or WRAC) includes state and regional representatives. Town staff provided modifications to Commission-developed watershed scenarios and presented those scenarios to their WRAC for review and discussion. Those scenarios are included in this report.

Barnstable is also working closely with Mashpee and Sandwich on a watershed permit for the Popponesset Bay watershed.

The Town of Barnstable operates the Hyannis Water Pollution Control Facility (WPCF), located off Bearses Way in Hyannis, which is the primary wastewater treatment facility serving approximately 2,900 properties in Hyannis and Barnstable village. The treatment facility has been upgraded and permitted to treat additional flows up to a total of 4.2 million gallons per day (MGD), upon meeting requirements of an adaptive management plan approved by the Commission in 2007. Property along Route 132 was acquired by the town in 2002 to potentially accommodate future disposal needs. The site is approved under a 2006 Massachusetts Environmental Policy Act (MEPA) certificate to discharge up to 0.5 MGD. The site is not presently in use. However, a force main and sewer has been extended to the site from the WPCF.

The WPCF treats an average daily flow of 1.46 MGD and a maximum monthly average flow of 1.94 MGD. Treatment performance has averaged 5 milligrams per liter (mg/L) total nitrogen in the treated effluent and the facility has a discharge limit of 5 mg/L under the 2007 Development of Regional Impact (DRI) decision and a limit of 10 mg/L under a Groundwater Discharge Permit (GWDP). The facility is also equipped with sludge thickening, storage and dewatering facilities sized for the current process conditions.

The Town of Barnstable also operates two smaller facilities – the Marstons Mills Wastewater Treatment Facility (WWTF) and the Red Lily Pond Cluster System. The Marstons Mills WWTF is limited to a discharge flow of 42,900 gallons per day (GPD) and is intended to service the Barnstable United Elementary School and the Village at Marstons Mills affordable housing development. The Red Lily Pond Cluster System currently serves 17 homes. According to the comprehensive wastewater management plan (CWMP) approved in 2007, no performance sampling of the system occurs and the system is assumed to produce comparable effluent to any conventional single family septic system.

In addition to municipally-owned facilities, there are two privately-owned treatment facilities treating wastewater from the Cotuit Landing shopping plaza and the Cape Regency nursing and rehabilitation facility. These facilities provide high levels of wastewater treatment. The treatment facility at Cotuit Landing was designed with additional treatment capacity beyond the expected needs of the shopping plaza for potential treatment of flows from neighboring properties.

Barnstable is working on a town-wide nutrient management plan that will provide the basis of its Comprehensive Wastewater Management Plan (CWMP). The plan will address nitrogen and other needs in watersheds draining to Three Bays, Centerville River, and Lewis Bay. A nitrogen total maximum daily load (TMDL) for Barnstable Harbor has not been approved by US EPA. The MEPA certificate scope for the Final Environmental Impact Report (FEIR) includes engagement in a targeted watershed approach, consistent with the 208 Plan Update.

In the fall of 2014, Barnstable adopted local nitrogen-oriented fertilizer management regulations consistent with the Cape-wide Fertilizer Management District of Critical Planning Concern (DCPC).

In 2015, the Town submitted a Statement of Interest to the US EPA for a hydrogeologic site characterization as an initial step toward piloting a permeable reactive barrier in the town. One of three sites proposed by the Town was selected for characterization. The work was completed in 2016. The draft report is presently being reviewed by the Town.

Throughout 2015 and 2016, Three Bays Preservation, Inc, worked with the Commission and town staff to develop conceptual plans for priority non-traditional projects within the Three Bays watershed. Detailed assessments of five priority projects were completed and designs were developed. The project sought to identify pilot projects where technologies could be implemented on a small scale and monitored to determine their effectiveness.

Town of Barnstable Watershed Scenario Details

Three Bays		CREDITS		REDUCTION TECHNOLOGIES			REMEDATION AND RESTORATION TECHNOLOGIES			REMOVAL
NAME OF TECHNOLOGY		% Nitrogen Reduction	Load Reduction (kg-N/yr)	# Properties / Units	Flow Collected (gpd)	Load Reduction (kg-N/yr)	# Units Proposed	Unit Metric	Load Reduction (kg-N/yr)	Total Scenario Load Reduction (kg-N/yr)
Traditional Scenario										19,700
Centralized Sewer - Outside Disposal				3,930	710,000	19,700				
Non-Traditional Scenario										19,043
Fertilizer Management		25%	498							
Stormwater Mitigation		25%	1,008							
Permeable Reactive Barrier (PRB)							3,000	Linear Feet	2,833	
Fertigation - Golf Course							188	Acres	600	
Aquaculture/Oyster Beds							43	Acres	10,200	
Coastal Habitat Restoration							66,000	Cubic Yards	1,590	
Floating Constructed Wetlands							4,700	Square Feet	1,472	
Ecotoilets (UD & Compost)				113	Units	684				
UD School or Public Facility				69	People Per Year	157				

In June 2016, Barnstable received \$28,850 from the Commission to fund upgrades to three stormwater treatment BMPs. Funding was part of \$142,149 in local grants made available to communities by the Commission in support of 208 Plan implementation.

Town of Sandwich Local Progress

The Town of Sandwich has an established water quality committee to oversee water quality and wastewater planning efforts. In October 2015 town staff and their consultant (Wright-Pierce) met with Cape Cod Commission staff to discuss watershed planning, decision support tools, and scenario development for Sandwich watersheds. In the same month the town was approached by Mashpee regarding approaches for Popponesset Bay, and a potential watershed permit, and has agreed to participate with Mashpee and Barnstable in this shared effort. It is expected that Barnstable, Mashpee, and Sandwich will collaborate on the first watershed permit in the region in close coordination with the Cape Cod Commission and the Massachusetts Department of Environmental Protection.

Previously the committee developed a scope of work for a Comprehensive Wastewater Management Plan (CWMP) and submitted the scope under the Sagamore Lens Natural Resource Damages Assessment, related to past groundwater contamination at the Textron facility at Joint Base Cape Cod (JBCC). The town received an award of \$400,000 to conduct its water/wastewater plan and completed a comprehensive needs assessment, as well as an interim wastewater solutions plan to accommodate economic development in the South Sandwich Village Center.

The town spent several years working with a private developer on a development project that included a public-private wastewater component for the construction of a facility that

would accommodate the private project, in addition to some public wastewater needs. That project will not be completed, but the town is again seeking a private partner to create new economic growth and to potentially participate in infrastructure development.

The town has participated in discussions at JBCC about the potential use of its existing wastewater infrastructure as a regional option for the Upper Cape towns.

In February 2016 the Town of Sandwich requested a meeting with Commission staff to discuss watershed scenarios and potential modifications to watersheds in which Sandwich has jurisdiction. The town provided collection footprints and assumptions for a single treatment facility to serve all three watersheds (Popponesset Bay, Three Bays, and Waquoit Bay), consistent with the Sandwich CWMP, and identified locations for non-traditional approaches, in addition to credits for stormwater and fertilizer reduction. The Town proposes a 25% fertilizer management credit and a 6.25% stormwater management credit. While the proposed interventions, alone, do not meet the nitrogen allocations identified in Appendix 8C of the 208 Plan Update, the town has expressed a preference to rely on nutrient trading or cost sharing to reduce the load allocated to the downgradient towns in the shared watersheds of Popponesset Bay, Three Bays and Waquoit Bay, where nitrogen reductions can be more cost effectively attained.

Town of Sandwich Watershed Scenario Details

Three Bays	CREDITS		REDUCTION TECHNOLOGIES			REMEDATION AND RESTORATION TECHNOLOGIES			REMOVAL	
	NAME OF TECHNOLOGY	% Nitrogen Reduction	Load Reduction (kg-N/yr)	# Properties / Units	Flow Collected (gpd)	Load Reduction (kg-N/yr)	# Units Proposed	Unit Metric	Load Reduction (kg-N/yr)	Total Scenario Load Reduction (kg-N/yr)
Traditional Scenario										1,222
Centralized Sewer - Outside Disposal			780	162,623	1,222					
Non-Traditional Scenario										410
Fertilizer Management	25%	35								
Stormwater Mitigation	6.25%	16								
Fertigation - Turf						75 Acres			118	
Golf Course Fertilizer Reduction						5,991 Pounds*			241	





















*Golf course fertilizer use was reduced by a total of 5,991 lbs/year, the corresponding nitrogen reduction is 241 kg/year.

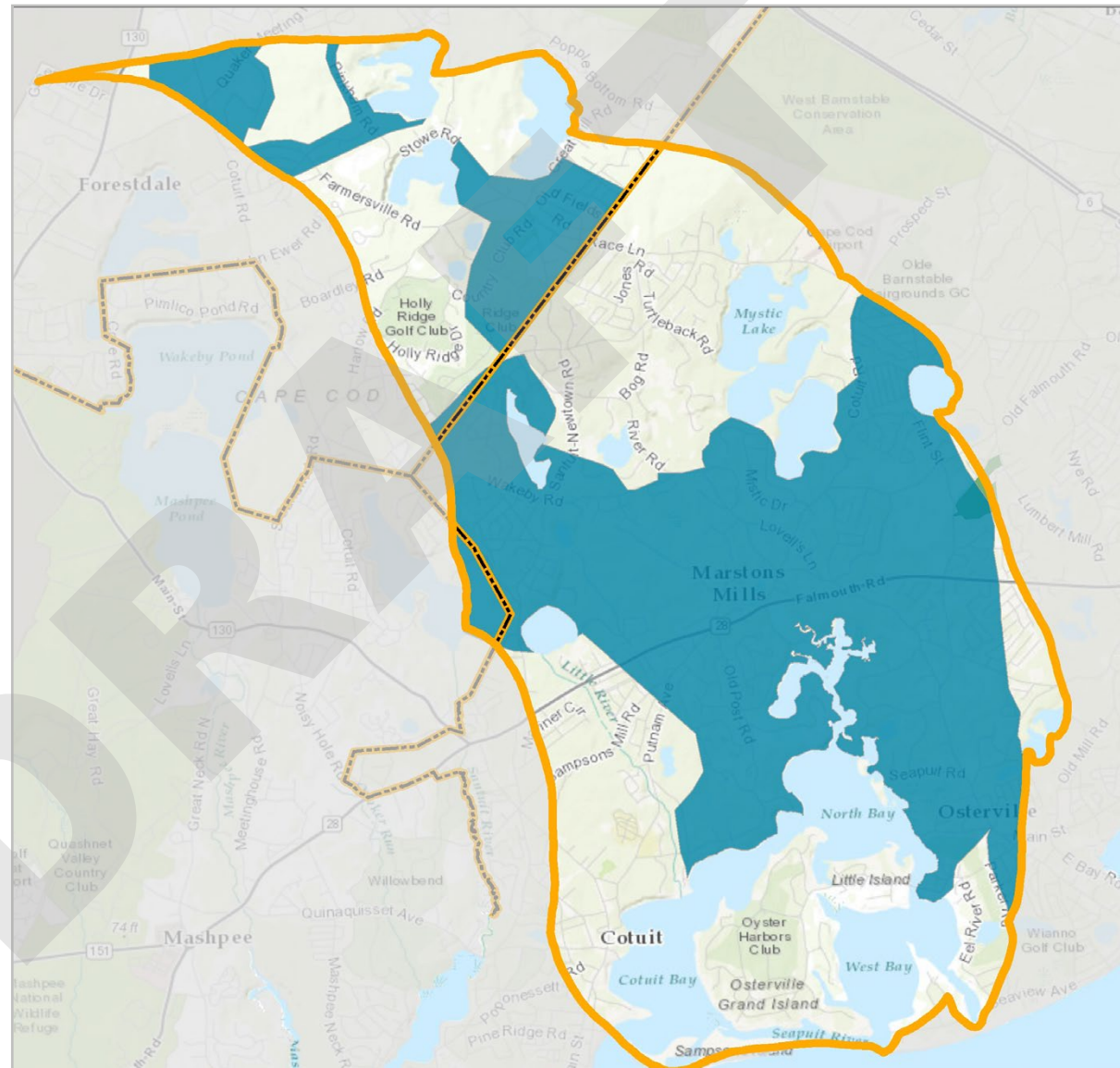
Scenario Maps

Three Bays Watershed Traditional Scenario BARNSTABLE & SANDWICH

Representative locations of conceptually proposed infrastructure

Legend

-  Aquaculture
-  Constructed Wetland
-  Eco-Toilets
-  Fertigation
-  Fertilizer Management
-  Floating Constructed Wetlands
-  IA Toilet
-  Inlet Widening
-  Permeable Reactive Barrier
-  PhytoRemediation
-  PhytoBuffer
-  Coastal Restoration
-  Stormwater
-  Stormwater - Bio Retention
-  Stormwater Management
-  Widening
-  Town Lines
-  Embayment Watersheds
-  Proposed Sewershed
-  Sewered Areas























Scenario Maps

Three Bays Watershed Non-Traditional Scenario BARNSTABLE & SANDWICH

Representative locations of conceptually proposed infrastructure

Legend

-  Aquaculture
-  Constructed Wetland
-  Eco-Toilets
-  Fertigation
-  Fertilizer Management
-  Floating Constructed Wetlands
-  IA Toilet
-  Inlet Widening
-  Permeable Reactive Barrier
-  PhytoRemediation
-  PhytoBuffer
-  Coastal Restoration
-  Stormwater
-  Stormwater - Bio Retention
-  Stormwater Management
-  Widening
-  Town Lines
-  Embayment Watersheds
-  Proposed Sewershed
-  Sewered Areas

