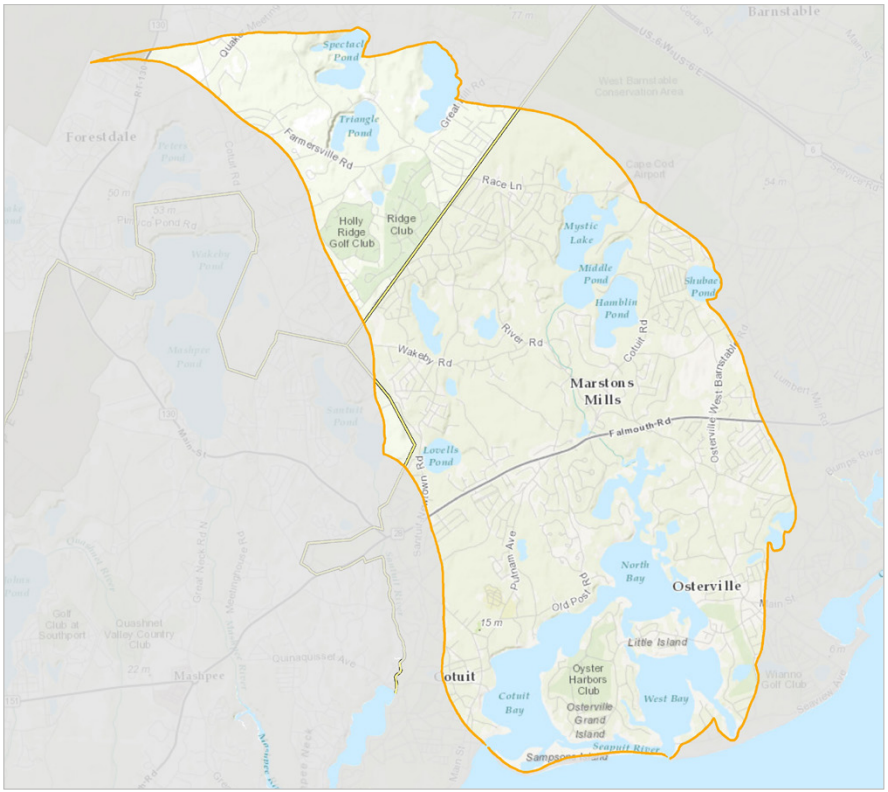
WATERSHED REPORT: MID CAPE

# Three Bays

## BARNSTABLE & SANDWICH

WATER THREAT LEVEL

HIGH




Three Bays Watershed

## Introduction to the Watershed Reports

In 2001, the Massachusetts Estuaries Project (MEP) was established to evaluate the health of 89 coastal embayment ecosystems across southeastern Massachusetts. A collaboration between coastal communities, the Massachusetts Department of Environmental Protection (MassDEP), the School of Marine Science and Technology (SMAST) at the University of Massachusetts-Dartmouth, the US Environmental Protection Agency (US EPA), the United States Geological Survey (USGS), the Massachusetts Executive Office of Energy and Environmental Affairs (EEA), and the Cape Cod Commission, the purpose of the MEP is to identify nitrogen thresholds and necessary nutrient reductions to support healthy ecosystems.

The Cape Cod 208 Plan Update, certified and approved by the Governor of the Commonwealth of Massachusetts and the US EPA in 2015, provides an opportunity and a path forward to implement responsible plans for the restoration of the waters that define Cape Cod.

On Cape Cod there are 53 embayment watersheds with physical characteristics that make them susceptible to nitrogen impacts. In its 2003 report, "The Massachusetts Estuaries Project – Embayment Restoration and Guidance for Implementation Strategies", MassDEP identifies the 46 Cape Cod embayments included in the

MEP. Thirty-three embayments studied to date require nitrogen reduction to achieve healthy ecosystem function. A Total Maximum Daily Load (TMDL) has been established (or a draft load has been identified and is under review) for these watersheds. For those embayments not studied, the 208 Plan Update recommends planning for a 25% reduction in nitrogen, as a placeholder, until information becomes available.

The 208 Plan Update directs Waste Treatment Management Agencies (WMAs) to develop watershed reports within 12 months of certification of the Plan Update. The Watershed Reports outline potential "bookend" scenarios for each watershed that include two scenarios to meet water quality goals in the watershed – a traditional scenario, which relies completely on the typical collection and centralized treatment of wastewater, and a non-traditional scenario, which uses remediation, restoration, and on-site reduction techniques to remove nutrients from raw and treated wastewater, groundwater and affected waterbodies.

The intent of the Watershed Reports is to outline two distinct approaches for addressing the nutrient problem. The reports are not intended to identify preferred and detailed plans for each watershed, but to facilitate discussions regarding effective and efficient solutions, particularly in watersheds shared by more than one town. In some cases, towns have provided information on collection areas and non-traditional technologies that have been specifically considered by that town.

The 208 Update developed a regionally consistent database of the nitrogen load entering each watershed. This data set includes estimates of wastewater, stormwater and fertilizer loads - similar to methodologies used by the MEP. Using this regionally consistent database, the Watershed MVP tool (wMVP) was developed so that different strategies (i.e., bookend scenarios) to reduce excess nitrogen load could be evaluated. The Watershed Reports use the MEP recommendations for the required nitrogen load reductions necessary to meet the threshold loads (that serve as the basis for nitrogen management), and then use the wMVP and the regionally consistent database values to develop bookend scenarios. There are variations of load between the MEP and wMVP, primarily due to differences in comparing older and newer databases.

## Terms Defined

**Total nitrogen load:** the nitrogen load from the watershed contributed by septic, wastewater, fertilizer, stormwater, golf course, landfill, and natural sources.

**Attenuated nitrogen load:** the nitrogen load from the watershed that reaches the embayment after the effect of natural attenuation in wetlands, ponds or streams.

**Threshold:** the amount of nitrogen that a water body can receive from its watershed and still meet water quality goals; this number is based on MEP technical reports or Total Maximum Daily Load (TMDL) reports.

**Reduction target:** an approximation of the amount of nitrogen that needs to be removed from the watershed to achieve the threshold; this number is calculated by subtracting the threshold number from the attenuated total watershed load, and is for planning purposes only.

**Percent contribution:** the percent of attenuated nitrogen load that a town contributes to the watershed.

**Kilogram responsibility:** is calculated by applying the percent contribution to the reduction target and indicates the amount of nitrogen, in kg, that a community is responsible for addressing.

**Total Maximum Daily Load:** a regulatory term in the Clean Water Act, describing a value of the maximum amount of a pollutant that a body of water can receive while still meeting water quality standards. Establishing a TMDL is necessary when a water body has been listed on the 303D list of impaired waters.

# Three Bays

## BARNSTABLE & SANDWICH

WATER THREAT LEVEL
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 http://www.mass.gov/eea/agencies/massdep/water/watersheds/the-massachusetts-estuaries-project-and-reports.html) indicates that the Three Bays system exceeds its critical threshold for nitrogen, resulting in impaired water quality. A MEP technical report has been completed and a Total Maximum Daily Load (TMDL) for nitrogen has been developed and approved.

- **MEP TECHNICAL REPORT STATUS:** Final
- **TMDL STATUS:** Final TMDL

Watershed nitrogen load characteristics were published in the 2006 MEP report, reflecting current conditions at the time of writing:

- **TOTAL ATTENUATED NITROGEN LOAD (MEP CHAPTER VIII):** 47,727 Kg/Y
- **SOURCES OF ATTENUATED WATERSHED NITROGEN LOAD:**
  - 85% Septic Systems
  - 10% Fertilizer
  - 5% Stormwater From Impervious Surfaces

Since the MEP report, the Commission compiled the following updated water use and nitrogen loads using the regional wMVP database, enabling a more current estimate of nitrogen loading (see figure on page 1 for watershed boundary delineation):

- **TOTAL WASTEWATER FLOW:** 528 MGY (million gal per year)
  - Treated Wastewater Flow: 8 MGY
  - Septic Flow: 520 MGY
- **TOTAL ATTENUATED NITROGEN LOAD (WMVP):** 46,221Kg/Y

### 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

General watershed characteristics according to the current wMVP regional database (see figure on page 1 for watershed boundary) follow.

- **WATERSHED CHARACTERISTICS**
  - Acres: 12,458
  - Parcels: 7,670
  - % Developed Residential Parcels: 85%
  - Parcel Density: 1.6 acres per parcel (approx.)

# 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.

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

Stream data from MEP technical report. Nitrate concentrations higher than 0.05 mg/L background concentrations, evident in public supply wells located in pristine areas, provide evidence of the impact of non-point source pollution on the aquifer and receiving coastal water bodies.

## 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

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.

Drinking water data from Cape Cod Commission and MassDEP data sources – nitrate values obtained from drinking water wells are from 2009-2012. The state and federal drinking water limit for nitrate is 10 mg/L. The Cape Cod Commission nitrate loading standard is 5 mg/l.

# Degree of Impairment and Areas of Need

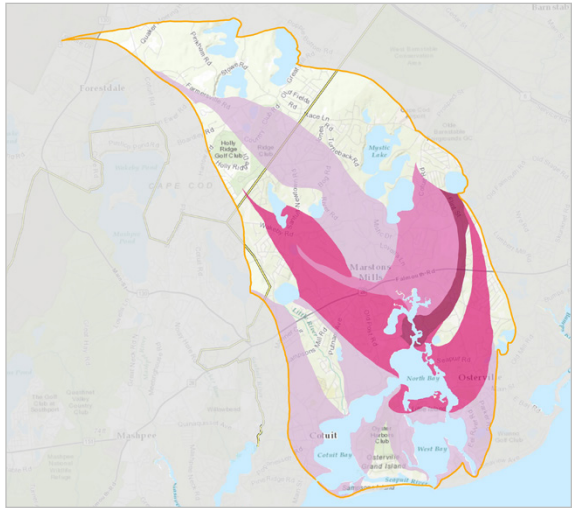
For the purposes of the Section 208 Plan Update areas of need are primarily defined by the amount of nitrogen reduction required as defined by the TMDL and/or MEP technical report. The aggregated watershed removal rates are 46% and 60% for total attenuated nitrogen and septic nitrogen, respectively. 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 Attenuated Watershed Removal Targets and Subwatersheds with Septic Attenuated Nitrogen Removal Targets.

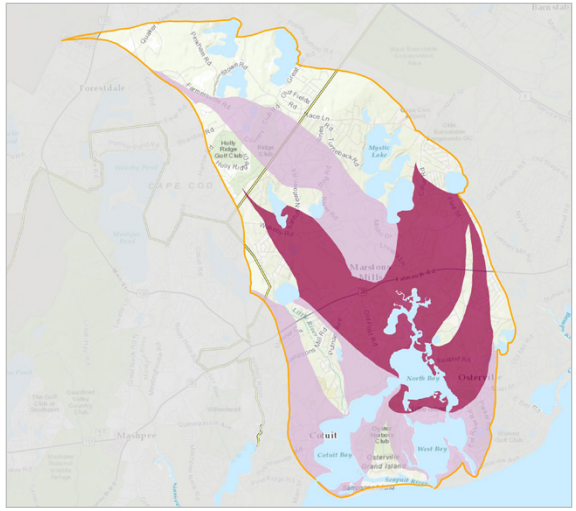
The nitrogen load from the watershed exceeds the TMDL for Three Bays, resulting in impaired water quality. The ecological health of a water body is determined from water quality, extent of eelgrass, assortment of benthic fauna, and dissolved oxygen and ranges from severe degradation, significantly impaired, moderately impaired, or 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

The MEP report provides the following characterization of the estuary's health:

- **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)





0.1% - 9%
9.1% - 38%
38.1% - 62%
62.1% - 86%
86.1% - 100%

Subwatersheds with
Total Attenuated Watershed Removal Targets

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

Subwatersheds with
Septic Attenuated Nitrogen Removal Targets

(Right)

# Traditional & Non-Traditional Scenarios

## SCENARIO DEVELOPMENT

Through the 208 Stakeholder process, the Commission developed "bookend" scenarios – one looking at a possible solution using traditional collection and treatment, the other examining a possible suite of non-traditional technologies – to address the nitrogen management needs in each watershed. These bookend scenarios provide guidance for communities as they continue to discuss alternatives, priorities, and opportunities for identifying well-considered solutions that will address communities' needs and interests.

## REGIONAL DATA

In preparation for this effort, the Commission collected 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 are 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 supplier and based on best available data. 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 residential load that would need to be collected if a traditional collection system and treatment facility was implemented. The pie charts show the load to be collected for treated effluent disposal both inside and outside the watershed.

Site specific analyses of collection areas may result in the need to collect wastewater from more or fewer parcels to meet the nitrogen reduction target. The scenarios presented are conceptual and are meant to inform discussions regarding effective and efficient solutions; they are not specific recommendations and should be viewed as resource information for additional and more detailed wastewater management planning.

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.

**TOTAL ATTENUATED WATERSHED NITROGEN LOAD VALUES (FROM WMVP)**

| Three Bays Nitrogen Sources | Total Attenuated Watershed Nitrogen Load (kg-N/yr) |
|---|---|
| Wastewater[1] | 34,376 |
| Fertilizer[2] | 5,070 |
| Stormwater | 4,361 |
| Other[3] | 2,414 |
| **TOTAL WATERSHED LOAD** | 46,221 |
| Total Watershed Threshold | 25,643 |
| **TOTAL ATTENUATED LOAD TO BE REMOVED** | 20,578 |

1. Includes nitrogen loads from septic systems and wastewater treatment facilities.
2. Includes nitrogen loads from lawns, cranberry bogs, and golf courses.
3. Includes nitrogen loads from landfills and atmospheric deposition to vacant land.

# Traditional & Non-Traditional Scenarios

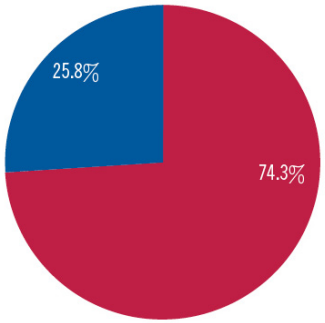
## Non-Traditional

| UNIT OF APPLIED TECHNOLOGY | ATTENUATED NITROGEN REMOVED IN KG/Y |
|---|---|
| 25 % Nitrogen Reduction - Fertilizer Management | 1,268 |
| 25 % Nitrogen Reduction - Stormwater Mitigation | 1,090 |
| 3,000 Linear Feet - Permeable Reactive Barrier (PRB) (Capture load calculated by wMVP: 3,907.6 kg/Y) | 2,833 |
| 225 Acres - Fertigation - Turf | 660 |
| 66,000 Cubic Yards - Dredging/Inlet Widening | 1,590 |
| 41 Acres - Aquaculture/Oyster Beds | 10,200 |
| 4,700 Square Feet - Floating Constructed Wetlands | 1,472 |
| 269 Units - Ecotoilets (UD & Compost) | 684 |
| 336 People Per Year - UD School or Public Facility | 157 |
| **TOTAL** | **19,954** |

A summary of the approach and methodology that was applied using non-traditional technologies follows at the end of this report.

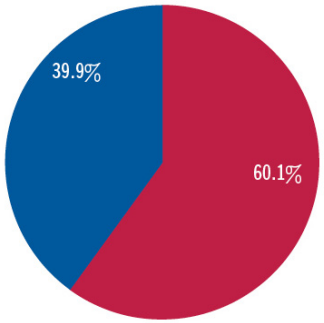
## Traditional

CENTRALIZED TREATMENT WITH DISPOSAL INSIDE THE WATERSHED

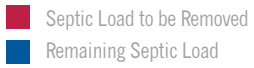



Assumes load to be collected and treated is disposed in the watershed, requiring additional collection to offset the load.

CENTRALIZED TREATMENT WITH DISPOSAL OUTSIDE THE WATERSHED




Assumes that the load to be collected and treated is removed from the watershed so no offset is required.



# 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 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 sough 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 | | | REMEDIATION 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 t0 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 | | | REMEDIATION 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** | | | | | | | | | 1,170 |
| Centralized Sewer - Outside Disposal | | | 780 | 162,623 | 1,170 | | | | |
| **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 | |

NOTES:

* The Town of Sandwich will rely on nutrient trading as an additional measure to meet the TMDL, if necessary.

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

# Scenario Maps

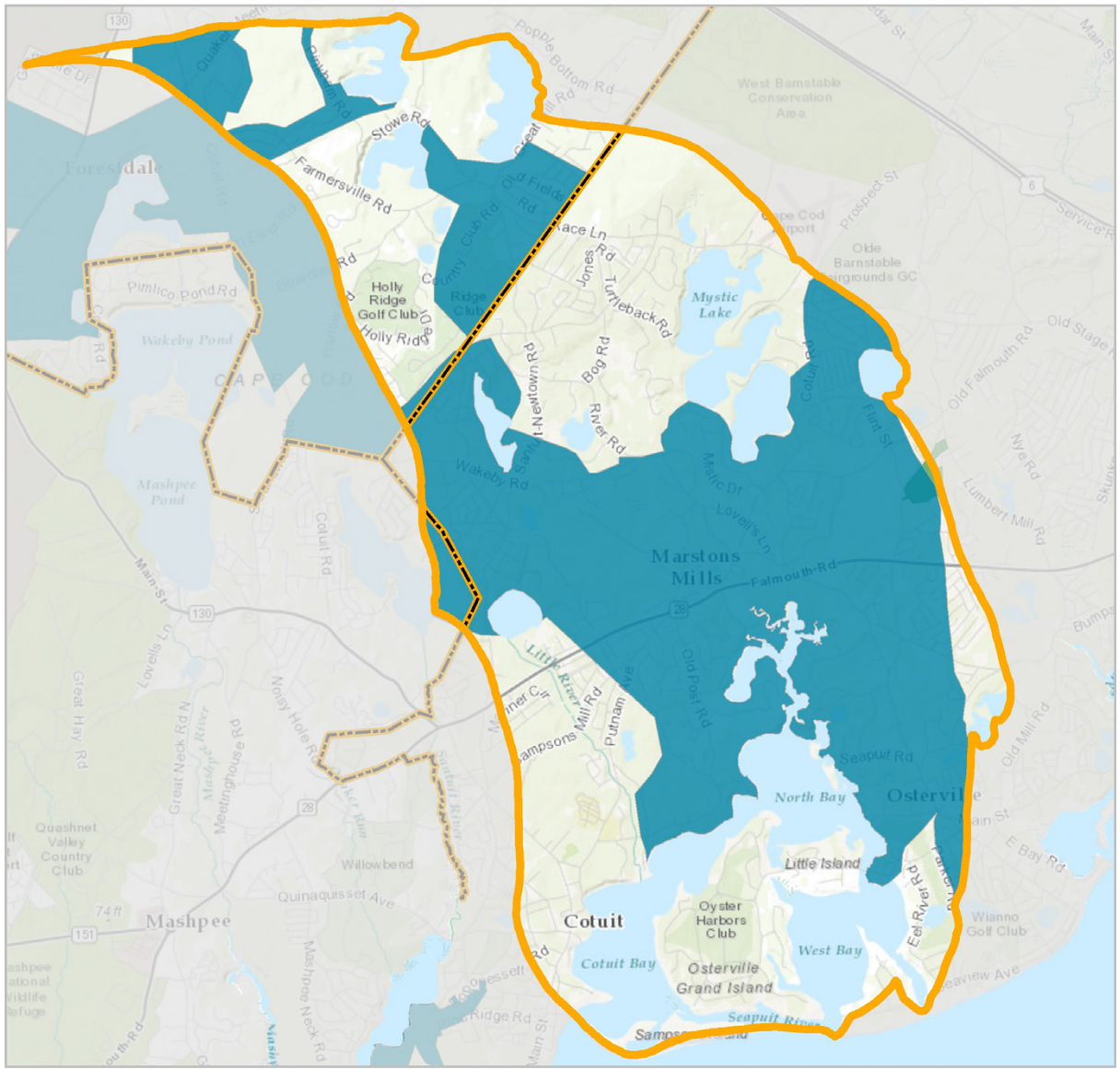
Three Bays Watershed
Traditional Scenario

**BARNSTABLE & SANDWICH**

Representative locations of conceptually proposed infrastructure

**Legend**

- Town Lines
- Sewered Areas
- Embayment Watersheds
- Proposed Sewershed



# Scenario Maps

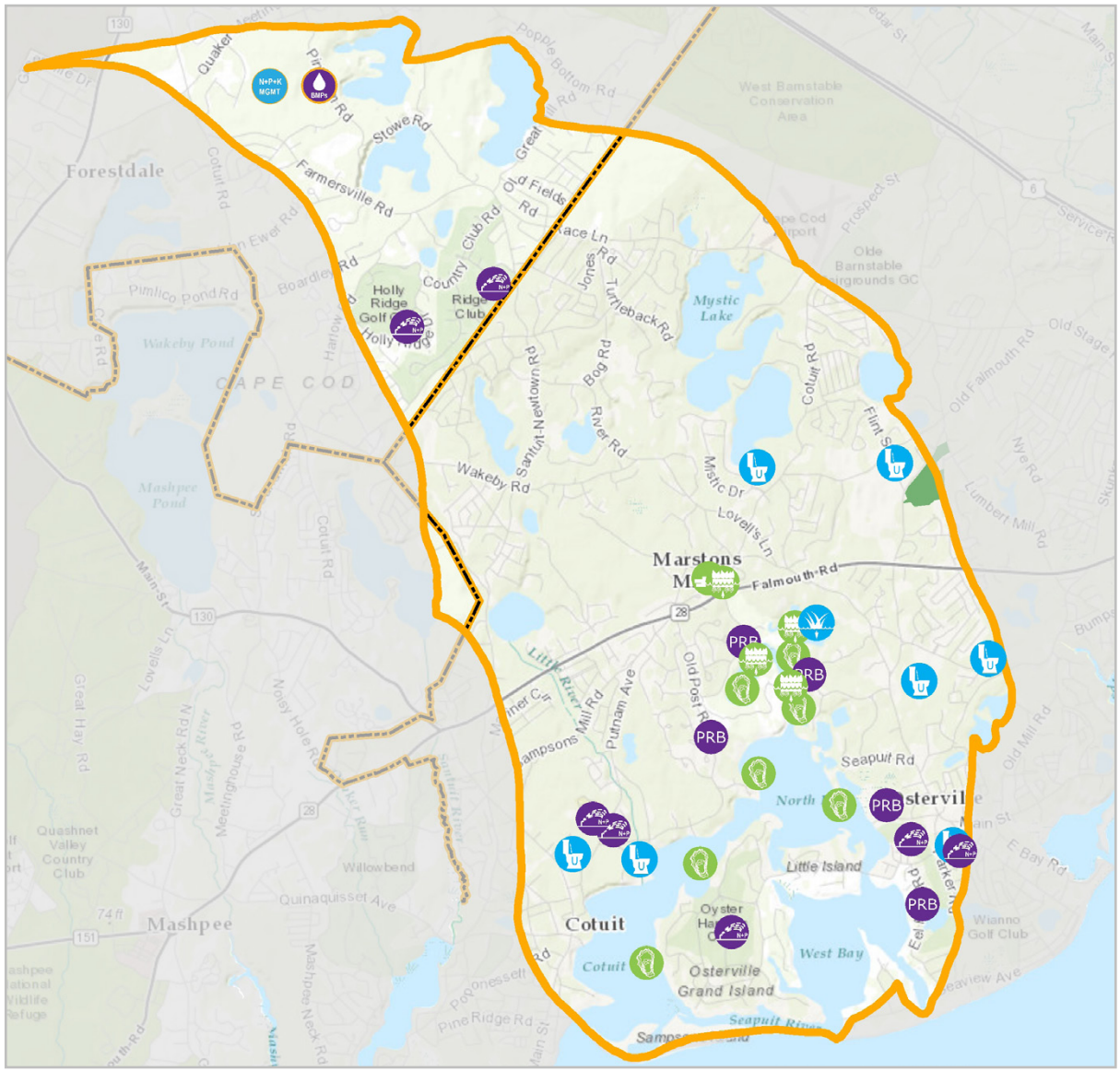
Three Bays Watershed
Non-Traditional Scenario

**BARNSTABLE & SANDWICH**

Representative locations of conceptually proposed infrastructure

**Legend**

- Dredging
- Fertilizer Management
- Stormwater Management
- Eco-Toilets
- Fertigation
- Floating Constructed Wetlands
- Constructed Wetland
- Permeable Reactive Barrier
- Aquaculture
- Town Lines
- Embayment Watersheds
- Sewered Areas



# Methodology for Selecting Non-Traditional Technology Scenarios

This section summarizes the approach and methodology that was applied during the 208 Update to develop plans for reducing nitrogen loading to estuaries using non-traditional (NT) technologies. It includes descriptions of regional credits for stormwater and fertilizer reductions, regional screening for potential sites for several technologies, and site-specific analyses for others. Nitrogen attenuation rates for each technology were derived from the Technologies Matrix. The nitrogen thresholds for each embayment were determined from the Massachusetts Estuaries Project (MEP).

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Regional credits were developed for potential stormwater retrofits and fertilizer reductions. They were calculated as a percent reduction of existing nitrogen loads as identified in the MEP reports and updated GIS data developed by the Cape Cod Commission.

- **STORMWATER MANAGEMENT:** Most Cape communities have already begun the process of identifying significant untreated stormwater discharges and developing appropriate mitigation projects. With the prospect of the MS4 regulatory requirements it was assumed that additional mitigation efforts would be implemented. Based upon the evidence developed by the University of New Hampshire Stormwater Center that several vegetated stormwater management practices (including bioretention and constructed wetlands) are able to achieve nitrogen reductions of 50% or more and the assumption that only a portion (estimated at 50%) of identified sites would be retrofitted a 25% nitrogen reduction credit was assumed for each watershed. Specific locations and number of locations were not identified; this was deferred to individual towns to consider as part of the suite of nitrogen management strategies.
- **FERTILIZER REDUCTIONS:** Based upon the success of most Cape Cod towns to implement either regulatory or non-regulatory fertilizer management programs and the efforts of the Cape Cod Extension Service in educating homeowners a 25% reduction in fertilizer applications was assumed for each watershed.

Regional GIS screening methods were developed to identify locations for some non-traditional technologies. A GIS viewer was developed as an on-line tool for staff and consultants to utilize during the watershed planning process.

- **CONSTRUCTED WETLANDS/ PHYTOREMEDIATION:** A GIS-based screening method was developed by the Cape Cod Commission to identify and rank parcels of land that have potential for the location of constructed wetlands and phytoremediation. The ranking utilized parcel size and ownership, depth to groundwater, suitable soils, distance from wetlands, and undeveloped parcels. A nitrogen removal rate of 500 kg/Y/acre and 532 kg/Y/acre was used for Constructed Wetlands and Phytoremediation, respectively.
- **PERMEABLE REACTIVE BARRIERS (PRBS):** A GIS-based screening method was developed to identify existing roads that are proximate to receiving waters, downgradient of high density development, run perpendicular to groundwater flow (to have the highest potential to intercept nutrients in groundwater), and where the depth to groundwater is relatively shallow to maximize the area of saturated thickness treated in the aquifer.

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- **FERTIGATION WELLS:** Golf courses were mapped to identify areas where fertigation wells could be utilized to recapture nitrogen-enriched groundwater and re-apply it to the managed turf areas to serve both irrigation and fertilization needs. Most golf courses were assumed to be eighteen holes with a fertilized area of 75 acres. Fertigation water was assumed to have an average concentration of 5 mg/liter. An uptake/attenuation rate of 80% was applied resulting in an assumed nitrogen reduction of 300 kg/year for each golf course with effectively located fertigation wells. In some cases other irrigated areas (such as athletic fields and cemeteries) were identified as potential fertigation locations. A nitrogen removal rate of 4 kg/Y/acre was used.

The MVP tool and other site-specific tools were utilized to quantify nitrogen load reductions for several potential NT interventions.

- **PERMEABLE REACTIVE BARRIERS:** for each PRB that was identified during the prior GIS-screening process an approximate capture area was identified using available water table maps and the wMVP tool. Upgradient contributing areas were digitized within wMVP and the nitrogen load was calculated. A nitrogen reduction of 72.5% was applied (calculated as an average of the reported attenuation range from the Technologies Matrix).
- **CONSTRUCTED WETLANDS (WITH COLLECTION):** Constructed wetlands were considered as a tertiary, polishing treatment for existing wastewater treatment plants. This included small-scale wastewater treatment systems. A nitrogen removal rate of 500 kg/Y/acre was used.
- **AQUACULTURE/OYSTER REEFS:** Potential areas for aquaculture and/or oyster reef restoration were considered based upon discussions with town representatives and review of maps to identify potential areas for these operations without significant conflicts to navigation. In some cases actual recent aquaculture expansions were included where they were developed after the MEP reports were prepared. An assumption of 1 million oysters per acre was used with a nitrogen removal rate of 250 kg/Y/acres.
- **FLOATING CONSTRUCTED WETLANDS:** Potential areas for floating wetlands were considered in areas where no conflicts with navigation or swimming areas were identified. A nitrogen removal rate of 0.4 kg/Y/sq foot was used.
- **INLET WIDENING AND COASTAL HABITAT RESTORATION:** Only considered in areas where these projects were identified by towns or state agencies and where detailed hydrologic investigations and modeling had been performed due to wide variations in nitrate load reduction, flushing impacts, impacts on flooding, and costs (dredging only, replacing infrastructure, removing and replacing roadways or bridges, etc.). Nitrogen removal rates were based on MEP or other studies.
- **INNOVATIVE & ALTERNATIVE SEPTIC SYSTEMS AND ECOTOILETS:** In most cases specific locations for these technologies were not identified. Rather general estimates for the percent adoption were provided based upon discussions with the stakeholder groups and their views on potential adoption rates. In some watersheds a 5% adoption rate was included based upon this stakeholder input. In a limited number of instances specific locations for these technologies were included based upon town input and suggestions. A nitrogen removal rate of 1.658 kg/Y for each system was used for I&A Septic Systems, and 2.984 kg/Y for enhanced I&A systems. A removal rate of 2.542 kg/Y was used for each home installation of an Ecotoilet, and 0.467 kg/Y for installation of urine diversion toilets in public settings.

Finally, the locations of specific technologies were discussed during the 208 stakeholder engagement process. Stakeholders across the Cape 'groundtruthed' potential NT locations and NT scenarios were adjusted accordingly.