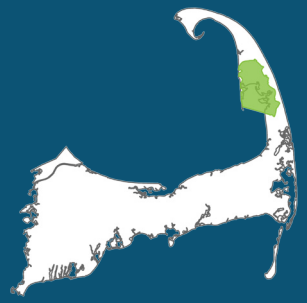
WATERSHED REPORT: OUTER CAPE

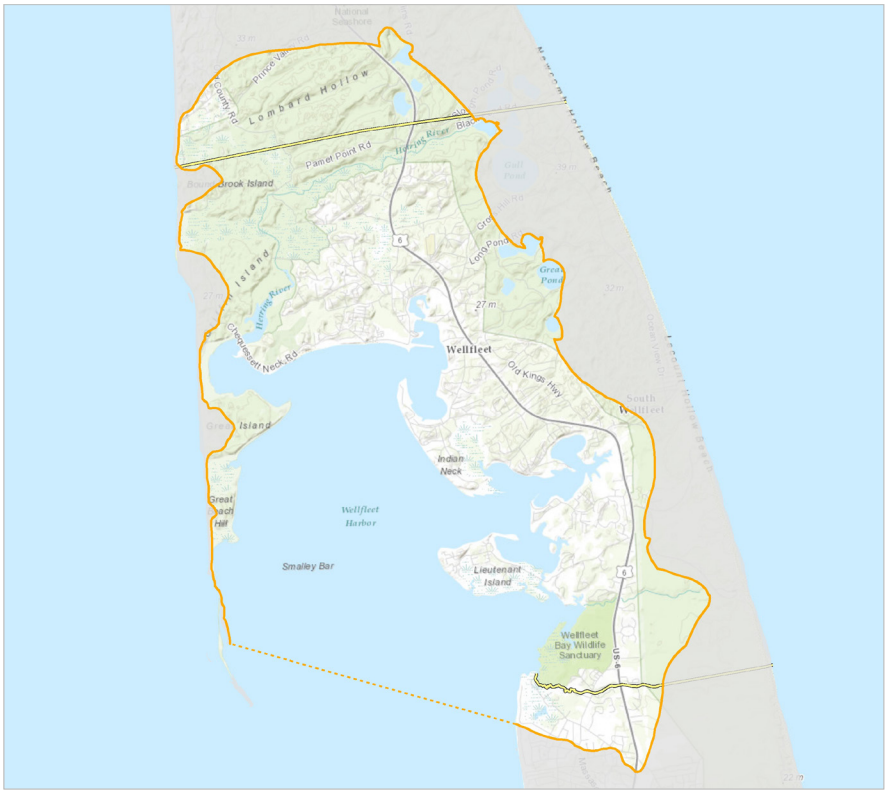
Wellfleet Harbor

WELLFLEET, EASTHAM & TRURO



WATER THREAT LEVEL

MODERATE



Wellfleet Harbor 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.

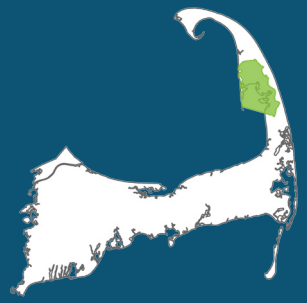
Kilogram responsibility: is calculated by applying the percent contribution to the reduction target and indicates the amount of nitrogen, in kg, that a community is responsible for addressing.

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.

WATERSHED REPORT: OUTER CAPE

Wellfleet Harbor

WELLFLEET, EASTHAM & TRURO



WATER THREAT LEVEL

MODERATE

The Wellfleet Harbor embayment system is one of the Cape's largest. The large Harbor area has several large tributaries, including Duck Creek, Herring River, Blackfish Creek with Drummer Cove and Loagy Bay, and Silver Spring Harbor The estuary supports a variety of recreational uses including boating, swimming, shell fishing and fin fishing.

The Problem

For the purposes of the Section 208 Plan Update, areas of wastewater need are primarily defined by the amount of nitrogen reduction required as defined by the Total Maximum Daily Load (TMDL) and/or Massachusetts Estuaries Project (MEP) technical report. Wellfleet Harbor is presently being assessed by the Massachusetts Estuaries Project (MEP) and a draft technical report has been completed.

- **MEP TECHNICAL REPORT STATUS:** Draft
- **TMDL STATUS:** In Progress

Watershed nitrogen load characteristics were published in the 2016 Draft MEP report for Wellfleet Harbor, reflecting current conditions at the time of writing:

- **TOTAL ATTENUATED NITROGEN LOAD (MEP CHAPTER VIII):** 29,105 Kg/Y
- **SOURCES OF ATTENUATED WATERSHED NITROGEN LOAD:**
  - 82% Wastewater
  - 8% Impervious Surfaces
  - 8% Fertilizers
  - 1% Farm Animals
  - 1% Landfill/Solid Waste

The Commission compiled the following updated water use and nitrogen loads using the regional wMVP database (see page 2), enabling a current estimate of nitrogen loading.

- **TOTAL WASTEWATER FLOW:** 307 million gal per year (MGY)
  - Treated Wastewater Flow: 36 MGY
  - Septic Flow: 271 MGY
- **TOTAL ATTENUATED NITROGEN LOAD (WMVP):** 30,893 kg/Y (kilograms per year)

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.

A portion of the land area in this watershed is within the boundaries of the Cape Cod National Seashore and any nitrogen load that results from Seashore controlled property is not within control of the towns.

- **WELLFLEET:** 87%
- **EASTHAM:** 11%
- **TRURO:** 2%

WELLFLEET HARBOR EMBAYMENT

- **EMBAYMENT AREA:** 11,647 acres
- **EMBAYMENT VOLUME:** 5,848 million cubic feet
- **2014 INTEGRATED LIST STATUS:** Category 2 for fecal coliform
  - Category 2: Attaining some uses; other uses not assessed
  - www.mass.gov/eea/docs/dep/water/resources/07v5/14list2.pdf

WELLFLEET HARBOR WATERSHED

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

- **WATERSHED CHARACTERISTICS:**
  - Acres: 12,322
  - Parcels: 5,009
  - Percent residential parcels: 73%
  - Parcel density: 2.5 acres per parcel (approx.)

Freshwater Sources

PONDS

- **IDENTIFIED SURFACE WATERS:** 26
- **NUMBER OF NAMED FRESHWATER PONDS:** 11
- **NUMBER WITH PRELIMINARY TROPHIC CHARACTERIZATION:** 10
- **2014 INTEGRATED LIST STATUS:** 7 listed
  - Great Pond (Truro); Category 4a: TMDL completed (mercury)
  - Snow Pond; Category 4a: TMDL completed (mercury)
  - Long Pond; Category 4a: TMDL completed (mercury)
  - Great Pond (Wellfleet); Category 4a: TMDL completed (mercury)
  - Dyer Pond; Category 4a: TMDL completed (mercury)
  - Ryder Pond/Higgins Pond; Category 5 (mercury, dissolved oxygen, phosphorus)

Wellfleet, Eastham and Truro have participated in the Pond and Lake Stewardship (PALS) program, that has helped establish baseline water quality, and the Cape Cod National Seashore has an on-going monitoring program that has helped establish baseline water quality. Trophic characterizations are based on most recent Commission staff assessment.

Streams

- **SIGNIFICANT FRESHWATER STREAM OUTLETS:** 3

Herring River:
- Average Flow: 28,323 cubic meters per day (m3/d)
- Average Nitrate Concentrations: 0.076 milligrams per liter (mg/L)

Fresh Brook:
- Average Flow: 2,344 m3/d
- Average Nitrate Concentrations: 0.223 mg/L

Hatches Creek:
- Average Flow: 743 m3/d
- Average Nitrate Concentrations: 1.92 mg/L

Stream data from draft 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.

A number of streams contribute to Wellfleet Harbor through surface water discharge including Herring River, Duck Creek, Pilgrim Spring, Blackfish Creek, Trout Brook, Fresh Brook, Silver Spring Brook and Hatches Creek.

Drinking Water Sources

- **WATER DISTRICTS:** 1
  - Wellfleet Water Supply
- **GRAVEL PACKED WELLS:** 17
  - 5 have nitrate concentrations between 0 and 0.5 mg/L
  - 3 have nitrate concentrations between 0.5 and 1 mg/L
  - 2 have nitrate concentrations between 1 and 2.5 mg/L
  - 3 have nitrate concentrations between 2.5 and 5 mg/L
  - 4 have no nitrate concentration data
- **SMALL VOLUME WELLS:**86

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 MEP technical report also provides a specific targeted amount of nitrogen reduction required by subwatershed (see the figures: Subwatersheds with Total Attenuated Watershed Removal Targets and Subwatersheds with Septic Attenuated Nitrogen Removal Targets).

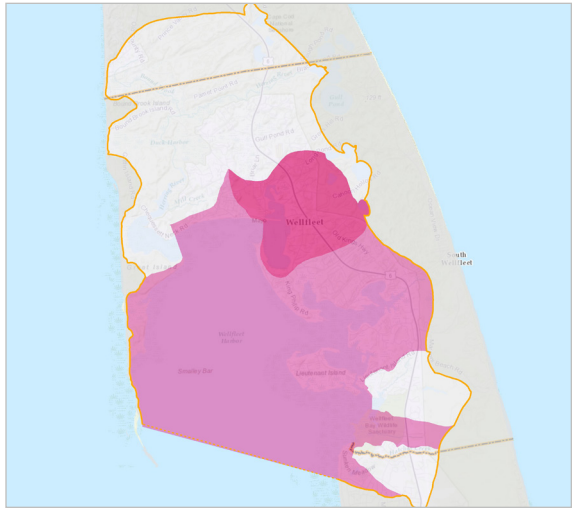
The nitrogen load from the watershed exceeds the threshold for Wellfleet Harbor, resulting in impaired water quality. The ecological health of a water body is determined from water quality, extent of eelgrass, assortment of benthic fauna, and dissolved oxygen and ranges from severe degradation,

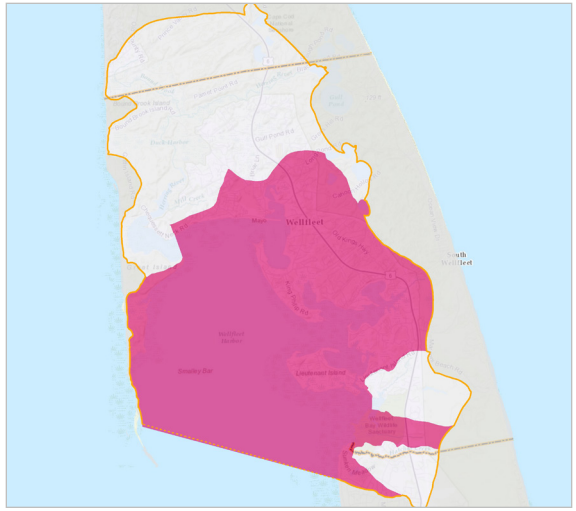
significantly impaired, moderately impaired, or healthy habitat conditions.

ECOLOGICAL CHARACTERISTICS AND WATER QUALITY

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

- **OVERALL ECOLOGIC CONDITION:** Healthy to Significantly Impaired
- **UPPER WELLFLEET HARBOR:** Healthy to Moderately Impaired
- **LOWER WELLFLEET HARBOR:** Healthy
- **DUCK CREEK:** Moderately Impaired to Significantly Impaired
- **THE COVE:** Moderately Impaired
- **HERRING RIVER MOUTH:** Healthy
- **DRUMMER COVE:** Moderately Impaired
- **SOUTH OF LT. ISLAND:** Healthy to Moderately Impaired
- **SENTINEL STATION:**
  - Total Nitrogen Concentration Threshold: 0.53 mg/L
  - Total Nitrogen Concentration Existing: 0.55 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)

Town of Wellfleet Local Progress

The Town of Wellfleet has an established Comprehensive Wastewater Management Planning (CWMP) Committee that is charged with providing a comprehensive strategy for addressing wastewater treatment and disposal issues for the next 40 years and for the foreseeable build out conditions in town. The goal of this effort is to assist the Board of Health, the Board of Water Commissioners, and the Board of Selectmen to ensure protection of the Town's natural resources and economic resources and provide a strategy for addressing wastewater needs, nutrient loading impacts and implementation solutions.

The Committee is in the process of developing a CWMP, having completed the Needs Assessment and Alternatives Analysis and conducted several public meetings to provide information and solicit feedback. The objectives of the CWMP are to protect and enhance the Wellfleet Harbor ecosystem, promote aquaculture based water quality management solutions, identify low-cost and sustainable remedies, develop least-cost alternatives and, only as a final resort, engage in structured solutions.

The CWMP Needs Assessment and Alternatives Analysis, completed in 2012, led Wellfleet to pursue and implement oyster restoration solutions. Wellfleet has more than 100 innovative/alternative septic systems currently installed. In addition, the Town has installed a stormwater system on Commercial Street, which limits nitrogen from stormwater entering Wellfleet Harbor.

In 2013, Wellfleet entered into cooperative Memoranda of Understanding with Truro and Eastham, acknowledging the shared resources of Herring River and the Chequessett groundwater lens and agreed to mutually cooperate by carrying out joint meetings and discussions if issues of mutual concern are identified in these water bodies.

As of 2017, Wellfleet has a total of 259 acres of aquaculture, 350 acres of wild, commercially harvestable shellfish, and 38,035 acres of total shellfish habitat. In addition, the Town anticipates 950 acres of coastal habitat restoration resulting from eventual implementation of the Herring River restoration project and the Mayo Creek restoration project. The Committee calculates the potential for a 58,148 kg/yr reduction from the restoration efforts. Water quality monitoring has been ongoing since 2012 and has provided necessary data for the town to make informed decisions moving forward. In addition, it has informed the 208 Plan Update Technologies Matrix and other oyster restoration projects across the region, including those in Falmouth and Mashpee.

Town of Eastham Local Progress

The town of Eastham completed a town-wide needs assessment in March 2009. The needs assessment concluded that a new public water supply system to protect public health was an overriding concern.

The spring 2014 Town Meeting approved $45.8 million to fund a scaled back version of the full town-wide water system. The Cape Cod Commission approved this project as a Development of Regional Impact (DRI) in February 2015.

In May 2015 Eastham staff, along with their consultant (GHD), met with Commission staff to discuss the 208 planning process, decision support tools, and scenario development for their watersheds, the beginnings of a shift toward wastewater planning after a necessary focus on securing a clean drinking water supply for residents.

Eastham shares the watershed to the Nauset estuary with the town of Orleans and is willing to have further discussions about potential opportunities to share the wastewater treatment facility proposed in the approved Orleans Comprehensive Wastewater Management Plan (CWMP). The town has sent a representative to each of the Orleans Water Quality Advisory Panel meetings, as they discussed potential scenarios in 2014 and early 2015. The town of Eastham is actively pursuing the protection and restoration of its freshwater ponds. The town completed a town-wide assessment and is pursuing in-pond restoration efforts. Alum treatments for Herring Pond and Great Pond are complete and others are under consideration.

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

Eastham is a member of the Orleans, Brewster and Eastham Ground Water Protection District which, until June 1, 2016, operated the Tri-Town Septage Treatment Facility in Orleans. The member towns voted to decommission and remove the facility, which is expected to take place in 2017.

In addition, Eastham staff are working with the Commission and the Cape Cod National Seashore on a number of other projects to address nitrogen in their watersheds. The Commission is assisting the town to modify a design for stormwater management along Route 6 and to conduct hydrogeologic modeling at a previously identified site for a permeable reactive barrier.

Eastham submitted conceptual watershed scenarios based on discussions with the Commission, use of available decision support tools, and ongoing local water quality planning efforts. Those scenarios are included in this report.

At the Spring 2017 Town Meeting, Eastham voted to fund wastewater planning and pilot projects in the amount of $150,000, as part of their Capital Plan.

Town of Truro Local Progress

The town of Truro approved funds for an Integrated Water Resources Management Plan (IWRMP), acknowledging that protection of private-well drinking water is of paramount importance, and established a water resources oversight committee. The IRWMP kicked off in 2012 with a focus on septic systems and stormwater runoff and their impact on drinking water and embayment water quality. The planning process seeks to assemble existing data, and develop a GIS program to evaluate land and water data, historic septic-system management information and key areas for further analysis and characterization.

The Water Resource Oversight Committee (WROC) and their consultant completed Phase I of the IWRMP in October 2014. Phase I of the report concluded that water samples from local wells show nitrogen levels are within safe levels. But some neighborhoods show concentrations have risen above the typical amount found in Truro. Phase II of the IWRMP began in March 2015. The focus of Phase II is to define potential threats to groundwater quality and solutions to protect against these threats. The WROC is also developing a presentation on Truro's water quality and groundwater protection as part of the Public Education and Outreach aspect of the IWMRP. The consultant presented the findings of the Collected Water Flow Data from Beach Point to the Board of Selectmen at their February 28, 2017 meeting. Based on the data collected and modeling, groundwater is mostly moving towards East Harbor, not Cape Cod Bay as previously studied. In June 2016, Truro received $9,400 from the Commission to design stormwater rain gardens adjacent to the Truro Library. Funding was part of $142,149 in local grants made by the Commission in support of 208 Plan implementation.

The proposed project comprises site survey and final design of a stormwater treatment and infiltration project. The project will rely on enhanced soils and plantings to reduce nitrate transported by stormwater runoff before it percolates to the local aquifer.

Following construction, the WROC will sample water quality at or near the Library facility on an annual basis to monitor any changes in nitrate levels in groundwater. From these or other potential sources, the WROC would obtain annual samples from at least one (1) nearby well on an annual basis for analysis for nitrate.

In June 2016, the Town signed an Agreement for a Project Management Plan (Scope of Work) with the US Army Corps of Engineers (USACE) that will build upon a study conducted in 1998 that evaluated restoring tidal flow within the Pamet River. The updated study will supplement the prior investigation by providing numerical model predictions to further define potential impacts with reintroducing tidal flow to the upper portion of the Pamet River. The goal of this study is to recommend an alternative that will restore flushing while avoiding impacts to residential septic systems, drinking water well and generalized flooding. Data Collection and groundwater sampling began in late Fall 2016 and is expected to continue through late Spring 2017.

At the Spring 2017 Town Meeting, Truro appropriated $3,700,000 for the repair and replacement of the culvert which connects Cape Cod Bay with East Harbor ('Pilgrim Lake') in North Truro, including design, permitting and construction. The project has environmental benefits such as increasing tidal flushing to improve water quality, wetland restoration, as well as minimizing potential threats to road utilities and infrastructure.

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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.

TOTAL ATTENUATED NITROGEN LOAD VALUES (FROM WMVP)

Wellfleet Harbor Nitrogen Sources	Total Attenuated Watershed Nitrogen Load (kg-N/yr)
Wastewater[1]	22,591
Fertilizer[2]	2,138
Stormwater	4,577
Other[3]	1,587
TOTAL WATERSHED LOAD	30,893
Total Watershed Threshold	20,020
TOTAL ATTENUATED LOAD TO BE REMOVED	10,873

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

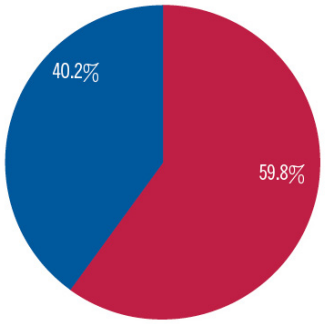
Non-Traditional

UNIT OF APPLIED TECHNOLOGY	ATTENUATED NITROGEN REMOVED IN KG/Y
25 % Nitrogen Reduction - Fertilizer Management	535
25 % Nitrogen Reduction - Stormwater Mitigation	1,144
40 Acres - Fertigation - Turf [1]	160
21 Acres - Aquaculture/Oyster Beds [2]	5,250
29 Acres - Coastal Habitat Restoration [3]	3,393
10 Units - Ecotoilets (UD & Compost)	25
126 Units - I & A Systems	209
50 Units - Enhanced I & A Systems	150
TOTAL	**10,866**

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

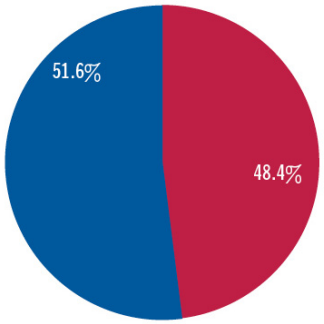
Traditional

CENTRALIZED TREATMENT WITH DISPOSAL INSIDE THE WATERSHED

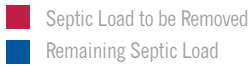


Assumes load to be collected and treated is disposed in the watershed, requiring additional collection to offset the load.

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.



NOTES: This non-traditional scenario reflects interventions the Town has implemented since 2011, as impacts from any interventions implemented prior to 2011 would have been captured in the MEP baseline data and analysis.

1. Reflects available area at Chequessett Yacht and Country Club golf course.
2. Reflects the minimum acres needed to meet scenario reduction target; however, Wellfleet has thousands of acres of aquaculture, commercially harvestable shellfish and shellfish habitat.
3. Reflects the minimum acres needed to meet scenario reduction target; however, Wellfleet anticipates 950 acres of coastal habitat restoration resulting from implementation of the Herring River and Mayo Creek restoration projects.

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).

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 are noted below, based on the Technologies Matrix or newer data. The nitrogen thresholds for each embayment were determined from the Massachusetts Estuaries Project (MEP).

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.

Methodology for Selecting Non-Traditional Technology Scenarios

- **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.