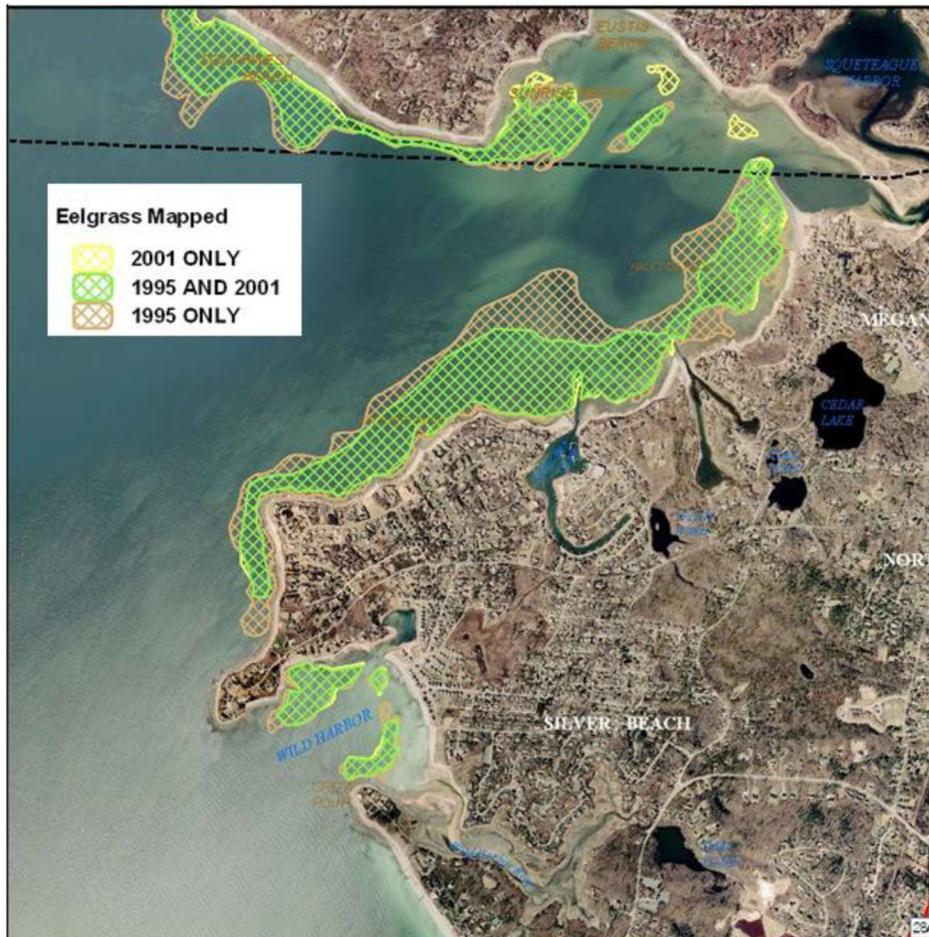


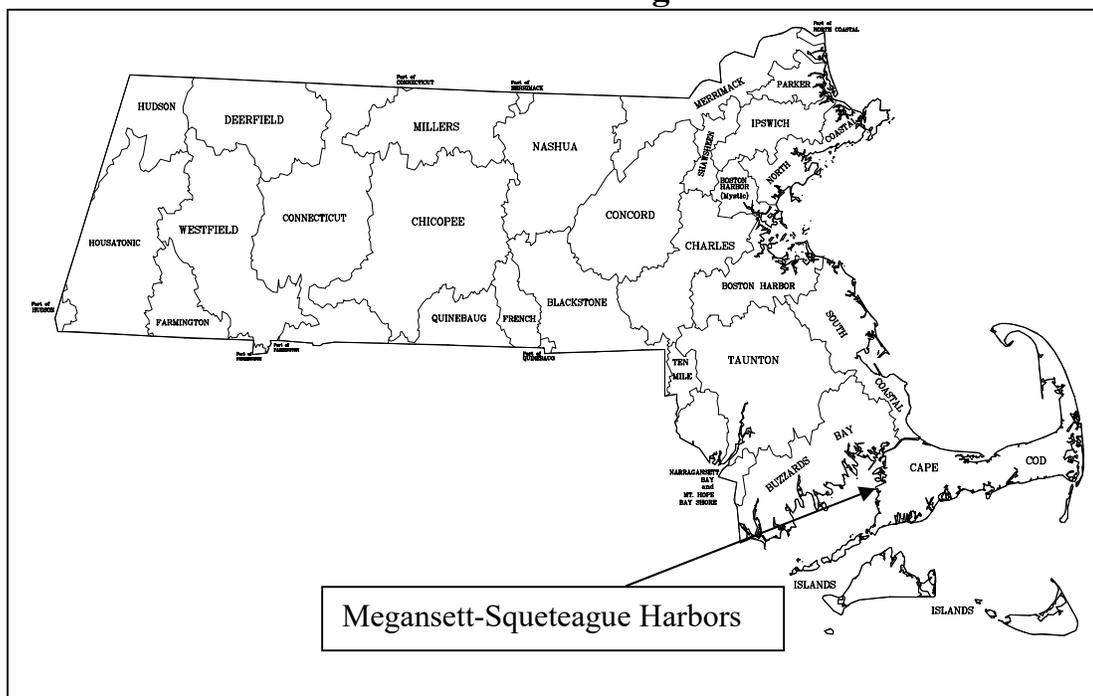
**Final
Megansett - Squeteague Harbor Estuarine System
Total Maximum Daily Load
For Total Nitrogen
(CN #452.1)**



Megansett Eelgrass Coverage Over Time

**COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS
KATHLEEN THEOHARIDES, SECRETARY
MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION
MARTIN SUUBERG, COMMISSIONER
BUREAU OF WATER RESOURCES
KATHLEEN BASKIN, ASSISTANT COMMISSIONER
June 2020**

**Final
Megansett-Squeteague Harbor Estuarine System
Total Maximum Daily Load
For Total Nitrogen**



- Key Feature:** Total Nitrogen TMDL for Megansett-Squeteague Harbor Embayment System
- Location:** EPA Region 1, Towns of Falmouth, and Bourne, MA
- Land Type:** New England Coastal
- 303d Listing:** Megansett Harbor (MA95-19) (Category 5, 2016 Integrated Report), is impaired for Estuarine Bioassessments, Fecal Coliform, Nutrient/Eutrophication and Biological Indicators. Squeteague Harbor (MA95-55) is listed (Category 5) for Nutrient/Eutrophication Biological Indicators.
- Data Sources:** University of Massachusetts – Dartmouth/School for Marine Science and Technology; US Geological Survey; Applied Coastal Research and Engineering, Inc.; Cape Cod Commission; Town of Falmouth; Town of Bourne
- Data Mechanism:** Massachusetts Surface Water Quality Standards, Ambient Data and Linked Watershed Model
- Monitoring Plan:** Cape Cod Commission/Town of Falmouth PondWatch Program, Coalition for Buzzards Bay (CBB) BayWatchers Program with technical assistance by SMAST
- Control Measures:** Sewering, Storm Water Management, Fertilizer Use By-laws, enhance nitrogen attenuation, manage tidal exchange.

Executive Summary

Problem Statement

Excessive nitrogen (N) originating from a variety of sources has added to the impairment of the environmental quality of Megansett-Squeteague Harbor Estuarine System. In general, excessive N in these waters is indicated by:

- Loss of eelgrass beds, which are critical habitats for macroinvertebrates and fish;
- Undesirable increases in macro-algae, which are much less beneficial than eelgrass;
- Periodic decreases in dissolved oxygen concentrations that threaten aquatic life;
- Reductions in the diversity of benthic animal populations;
- Periodic algae blooms.

With proper management of N, inputs these trends can be reversed. Without proper management, more severe problems might develop, including:

- Periodic fish kills;
- Unpleasant odors and scum;
- Benthic communities reduced to the most stress-tolerant species, or in the worst cases, near loss of the benthic animal communities.

Coastal communities, including Falmouth and Bourne, rely on clean, productive, and aesthetically pleasing marine and estuarine waters for tourism, recreational swimming, fishing, and boating, as well as for commercial fin fishing and shellfishing. Failure to reduce and control N loadings could lead to further loss of eelgrass and possible increases in macro-algae, a higher frequency of undesirable decreases in dissolved oxygen concentrations and fish kills, widespread occurrence of unpleasant odors and visible scum, and a further loss of benthic macroinvertebrates throughout most of the system. As a result of these environmental impacts, commercial and recreational uses of the Megansett-Squeteague Harbor estuarine system will be greatly reduced.

Sources of Nitrogen

Nitrogen enters the waters of coastal embayments/ponds from the following sources:

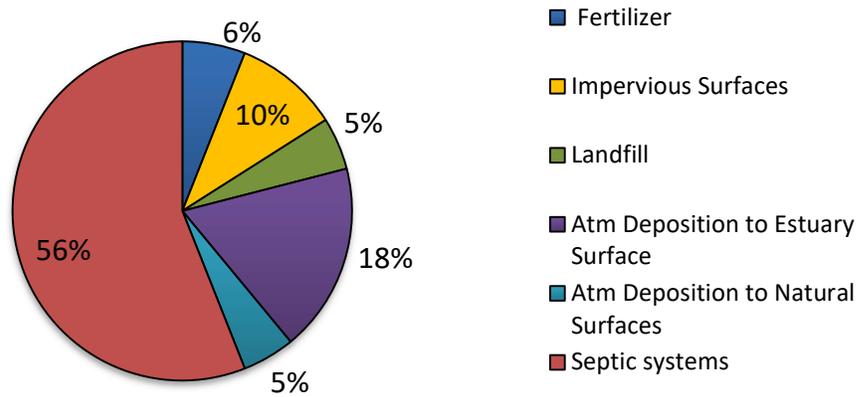
- The watershed
 - on-site subsurface wastewater disposal (septic) systems
 - natural background
 - runoff from impervious surfaces
 - fertilizers
 - landfills
- Atmospheric deposition
- Nutrient-rich bottom sediments in the embayments/ponds

Figure ES-A below indicates the percent contributions of the various sources of N in the watershed to Megansett-Squeteague Harbor Estuarine System. Values are based on Table ES-1 and Table 3 from the Massachusetts Estuaries Project (MEP) Technical Report (Howes *et. al*, 2015). As evident from this figure, most of the controllable N load to Megansett-Squeteague Harbor Estuarine System

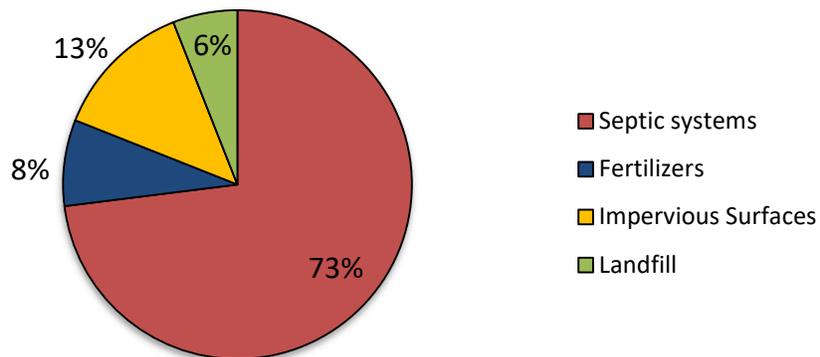
originates from septic systems. The N load contribution from Fiddlers Cove and Rands Harbor to the Megansett-Squeteague estuarine system was included. No changes were made to the EPA approved TMDLs for Fiddlers Cove and Rands Harbor (MassDEP 2017).

Figure ES-A: Percent Contributions of All Watershed Nitrogen Sources and Percent Contributions of Locally Controllable Nitrogen Sources to Megansett Harbor and Squeteague Harbor

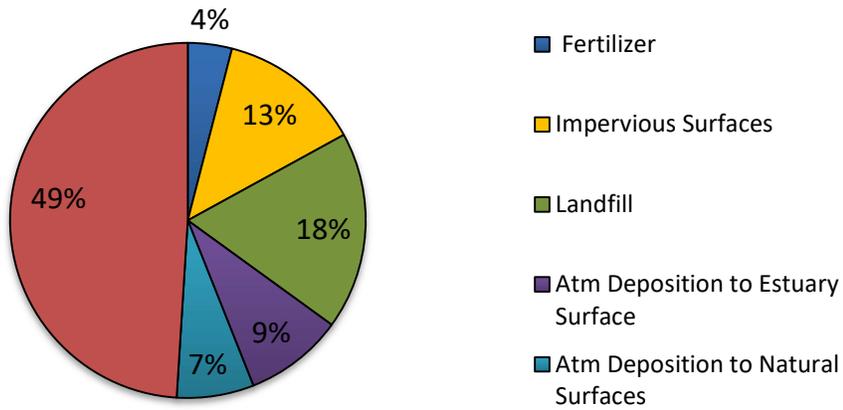
Megansett-Squeteague System Overall Load



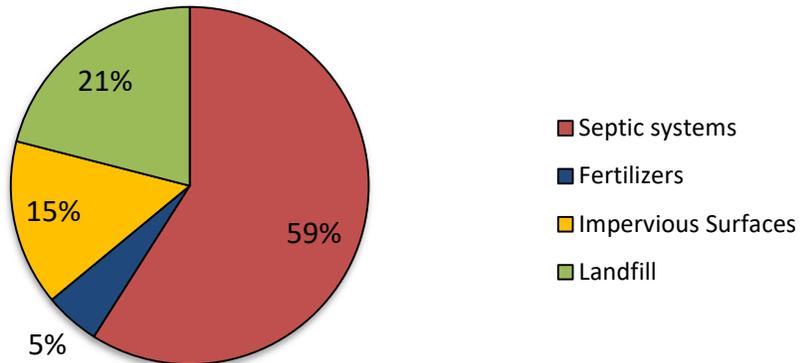
Megansett -Squeteague System Local Control



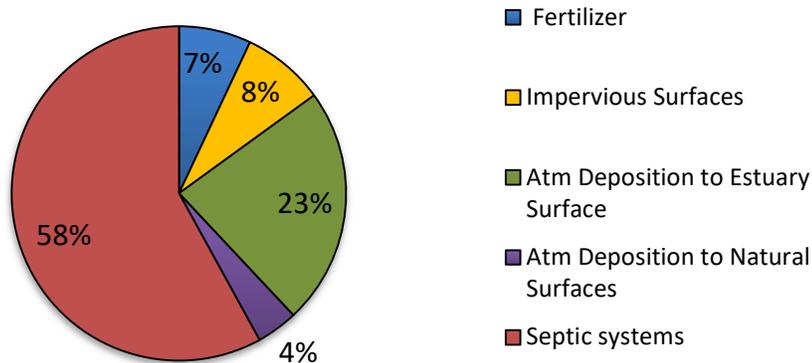
Squeteague Harbor Overall Load



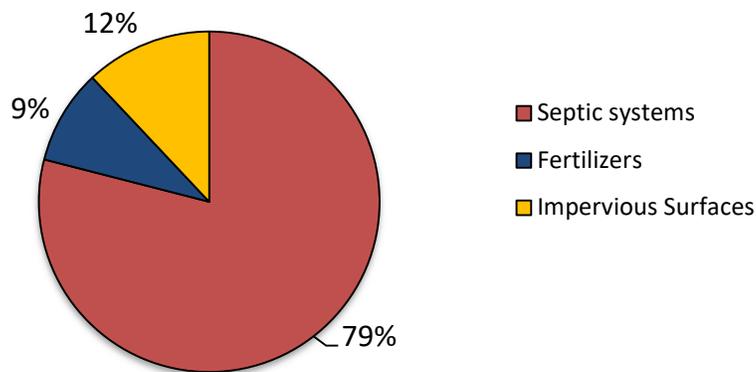
Squeteague Harbor Local Control Load



Megansett Harbor Overall Load



Megansett Harbor Local Control Load



Target Threshold Nitrogen Concentrations and Loadings

The Megansett-Squeteague Harbor estuarine system is located within the Towns of Bourne and Falmouth on Cape Cod, Massachusetts. The watershed of this system is primarily within Falmouth and Bourne, with a small portion in Sandwich. The N that enters the estuary each day (N load) is 31.94 kg/day from the combined three major subwatersheds Megansett Harbor, Megansett Channel, Squeteague Harbor. The present watershed load is the equivalent to land use loading. It does not include other sources such as benthic flux and atmospheric deposition on to the estuary surface.

The resultant average annual concentration of N in Megansett Harbor at MG2, was 0.344 mg/L (milligrams per liter of N) and for Squeteague Harbor was 0.468 mg/L at SQ2 (data collected from 2000 – 2013 as reported in Table VI-1 of the MEP Technical Report and included in Appendix B of this report). The yearly mean of tidally averaged total nitrogen levels ranged between 0.239-0.414 mg/L (Megansett Harbor, MG2, MG3, and MG4), 0.295-0.502 mg/L (Inner Megansett Harbor or the Channel, SQ1 and MG1) and 0.371-0.552 mg/L (Squeteague Harbor, SQ2).

In order to restore and protect this estuarine system, N loadings, and subsequently the concentrations of N in the water, must be reduced to levels below the thresholds that cause the observed environmental impacts. This concentration will be referred to as the *target threshold N concentration*. It is the goal of the TMDL to reach this target threshold N concentration, as it has been determined for each impaired waterbody segment. The MEP has determined that a N concentration of 0.35 mg/L for this estuarine system at the sentinel station (MG-2) will restore eelgrass habitat. In addition, restoration of benthic habitat for infauna animals will occur as management alternatives are implemented for eelgrass.

Based on sampling and modeling analysis and the resulting Technical Report, the MEP has determined that the Total Maximum Daily Load (TMDL) of N to meet the target threshold N concentration of 0.35 mg/L is 35.01 kg N/day for the entire system. The mechanism for achieving these target threshold N concentrations is to reduce the N loadings to the estuarine system. To meet the TMDL this report suggests that a 12.6% reduction of the total watershed nitrogen load to the entire system is required.

This document presents the TMDL for this water body and provides guidance to the communities of Bourne and Falmouth on possible ways to reduce the N loadings to within the recommended TMDL and protect the waters of this estuarine system.

Megansett Harbor (MA95-19) is listed as impaired for estuarine bioassessments and nutrient/eutrophication biological indicators based on MEP sampling which found loss of eelgrass and low dissolved oxygen (MassDEP 2015). Squeteague Harbor (MA95-55) is listed as impaired for nutrient/eutrophication biological indicators based on MEP sampling which found low dissolved oxygen, elevated chlorophyll *a* and degradation of benthic infauna habitat (Table 1).

Implementation

The primary goal of the TMDL implementation will be lowering the concentrations of N in Megansett-Squeteague Harbor Watershed. The MEP linked model has shown that by reducing the loadings from on-site subsurface wastewater disposal systems in the watershed by 20% this target threshold concentration can be met. It is important to note that there is a variety of loading reduction scenarios that could achieve the target threshold N concentration. Implementing best management practices (BMPs) to reduce N loadings from fertilizers and runoff where possible will also help to lower the total N load to this system.

Local officials can explore other load reduction scenarios through additional modeling as part of their Comprehensive Wastewater Management Plan (CWMP). Implementing best management practices (BMPs) to reduce N loadings from fertilizers and runoff where possible will also help to lower the total N load to the system. Methodologies for reducing N loading from septic systems, storm water runoff and fertilizers are provided in detail in the “MEP Embayment Restoration and Guidance for Implementation Strategies”, (MassDEP 2003) available on the MassDEP website: <https://www.mass.gov/doc/embayment-restoration-and-guidance-for-implementation-strategies>.

The appropriateness of any of the alternatives will depend on local conditions and will have to be determined on a case-by-case basis, using an adaptive management approach. This adaptive

management approach will incorporate the priorities and concepts included in the updated area wide management plan established under Clean Water Act Section 208. Finally, growth within the communities of Falmouth and Bourne which would exacerbate the problems associated with N loading should be guided by considerations of water quality-associated impacts.

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Introduction

Section 303(d) of the Federal Clean Water Act requires each state (1) to identify waters that are not meeting water quality standards and (2) to establish Total Maximum Daily Loads (TMDLs) for such waters for the pollutants of concern. The TMDL allocation establishes the maximum loadings of these pollutants of concern, taking into consideration all contributing sources to that water body, while allowing the system to meet and maintain its water quality standards and designated uses, including compliance with numeric and narrative standards. The TMDL development process may be described in four steps, as follows:

1. Determination and documentation of whether or not a water body is presently meeting its water quality standards and designated uses.
2. Assessment of present water quality conditions in the water body, including estimation of present loadings of pollutants of concern from both point sources (discernable, confined, and concrete sources such as pipes) and non-point sources (diffuse sources that carry pollutants to surface waters through runoff or groundwater).
3. Determination of the loading capacity of the water body. EPA regulations define the loading capacity as the greatest amount of loading that a water body can receive without violating water quality standards. If the water body is not presently meeting its designated uses, then the loading capacity will represent a reduction relative to present loadings.
4. Specification of load allocations based on the loading capacity determination for non-point sources and point sources that will ensure that the water body will not violate water quality standards.

After public comment and final approval by the EPA, the TMDL will serve as a guide for future implementation activities. The MassDEP will work with the towns of Falmouth and Bourne to develop specific implementation strategies to reduce N loadings and will assist in developing a monitoring plan for assessing the success of the nutrient reduction strategies.

In the Megansett-Squeteague Harbor estuarine system the pollutant of concern for this TMDL (based on observations of eutrophication) is the nutrient nitrogen (N). Since nitrogen is generally the limiting nutrient in coastal and marine waters, as its concentration increases, so does plant productivity. This leads to nuisance populations of macro-algae and increased concentrations of phytoplankton and epiphyton that imperil the healthy ecology of the affected water bodies.

The TMDL for total N for the Megansett-Squeteague Harbor estuarine system is based primarily on data collected, compiled and analyzed by University of Massachusetts Dartmouth's School for Marine Science and Technology (SMASST), Cape Cod Commission/Town of Falmouth Pond Watch Program, and the Coalition for Buzzards Bay (CBB) BayWatchers Program. The data were collected over a study period from 2000 to 2013. This study period will be referred to as the "Present Conditions" in the TMDL since it contains the most recent data available. The MEP Technical Report can be found at <https://www.mass.gov/doc/critical-nitrogen-loading-thresholds-for-the-megansett-squeteague-harbor-estuarine-system>. The MEP Technical Report presents the results of

the analyses of this coastal embayment system using the MEP Linked Watershed-Embayment Nitrogen Management Model (Linked Model).

The analyses were performed to assist Falmouth and Bourne with decisions on current and future wastewater planning, wetland restoration, anadromous fish runs, shellfisheries, open-space and harbor maintenance programs. Critical elements of this approach are the assessments of water quality monitoring data, historical changes in eelgrass distribution, time-series water column oxygen measurements and benthic community structure that were conducted on this embayment. These assessments served as the basis for generating a N loading threshold for use as a goal for watershed N management. The TMDL is based on the site-specific target threshold N concentration generated for this embayment. Thus, the MEP offers a science-based management approach to support the wastewater management planning and decision-making process in the towns of Falmouth and Bourne.

Description of Water Bodies and Priority Ranking

The Megansett-Squeteague Harbor estuarine system is located within the towns of Falmouth and Bourne on Cape Cod, Massachusetts. These harbors are hydraulically connected with a well-defined inlet channel that exists between inner Megansett Harbor and Squeteague Harbor which is an enclosed tidal basin. Together these two harbors functionally constitute one ecologically connected embayment system. In addition, the overall embayment system supports two smaller tributary embayments that were previously evaluated by the MEP in 2013, Fiddlers Cove and Rands Harbor (Howes *et. al.*, 2013, MassDEP 2017). Both these tributary embayments discharge to Megansett Harbor from the Town of Falmouth portion of the Megansett Harbor watershed. The nitrogen loads from the previously assessed embayments of Fiddlers Cove and Rands Harbor were included in the Megansett-Squeteague assessment.

Both Megansett Harbor and Squeteague Harbor (in addition to Fiddlers and Rands) exchange tidal waters with Buzzards Bay. The developed regions of the watershed to the Megansett and Squeteague Harbors estuarine system is distributed almost entirely within the towns of Falmouth and Bourne while the largely undeveloped uppermost portion of the watershed falls within the Massachusetts Military Reservation (now Joint Base Cape Cod, JBCC) that exists within the towns of Falmouth, Bourne and Sandwich. This upper watershed within the JBCC (~1/3 of watershed) is mainly undeveloped and developed areas have been sewered. Contribution of nitrogen from a former landfill on the JBCC was included in the total nitrogen load (for landfill location see Figure IV-3, Howes *et. al.*, 2013). The plume emanating from the landfill is located entirely within the Squeteague watershed. In addition to JBCC land, town conservation lands and water supply areas compose the Public Service landuse category which constitutes 73% of the watershed area. The watershed within Sandwich is entirely within JBCC land. The upper portion of the watershed within JBCC is not contributing a significant nitrogen load to the estuary. As a result, the primary stakeholders for the management and restoration of the Megansett Harbor and Squeteague Harbor estuarine system are the towns of Falmouth and Bourne.

The Megansett Harbor and Squeteague Harbor system along with the Fiddlers Cove and Rands Harbor estuaries are intensively utilized estuarine resources. Inner Megansett Harbor supports a small

yacht club and Brewer Fiddlers Cove Marina supports approximately 135 boat slips with additional indoor rack storage. The private marina represents a large part of the boating activity in Fiddlers Cove and operates a full service boat yard with boat fueling and waste pump-out facilities.

The MEP team has delineated a watershed area of 4,560 acres for the Megansett-Squeteague Harbor estuarine system. Overall, 13 sub-watershed areas were delineated within the Megansett and Squeteague Harbor study area with an additional 20 previously delineated subwatersheds to Rands Harbor and Fiddlers Cove (Howes *et. al.*, 2015), which are located along the southern shore of Megansett Harbor. The overall estimated freshwater flow into the Megansett and Squeteague Harbor system from the MEP delineated watershed is 29,886 m³/d. This flow includes balanced corrections for flow removed from the watershed by the Bourne Water Department wells and returned within the watershed by measured public water use on individual parcels (Table III-1, MEP Technical Report Howes *et. al.*, 2015). Ten-year time of travel within the Megansett and Squeteague Harbors subwatersheds has been delineated for ponds, streams and the estuary itself. Review of less than 10-year and greater than 10-year travel time indicates that 96% of the unattenuated nitrogen load from the whole watershed is within less than a 10-year travel time to the estuary (Table IV-1 MEP Tech report Howes *et. al.*, 2015).

In the overall Megansett-Squeteague Harbor watershed, the predominant land use based on area is public service land use, which accounts for 73% of the overall watershed area while residential land use represents the second highest percentage (19%) of watershed area (Howes *et. al.* 2015, pg 35).

A more complete description of this estuarine system is presented in Chapters I and IV of the MEP Technical Report (Howes *et. al.* 2015). A majority of the information presented here on this estuarine system is drawn from the Technical Report. Chapters VI and VII of the MEP Technical Report provide assessment data that show that the Megansett-Squeteague Harbor estuarine system is only slightly beyond its ability to assimilate nitrogen without impairment and is showing a moderate level of nitrogen enrichment, with generally healthy - moderate impairment depending on the component sub-basins being considered (Howes *et. al.* 2015, Table VIII-1).

The nature of enclosed embayments in populous regions brings two opposing elements to bear: 1) as protected marine shoreline they are popular regions for boating, recreation, and land development and 2) as enclosed bodies of water, they may not be readily flushed of the pollutants that they receive due to the proximity and density of development near and along their shores. The Megansett-Squeteague Harbor system is at risk of further eutrophication from nutrient loads in the groundwater and runoff from the watershed.

This estuarine system has been assessed by MassDEP and is listed as a waterbody needing a TMDL for nutrients (Category 5) in the MA 2016 Integrated List of Waters (MassDEP 2019). Megansett Harbor (MA95-19) is listed as impaired for estuarine bioassessments and nutrient/eutrophication biological indicators based on MEP sampling which found loss of eelgrass and low dissolved oxygen. Squeteague Harbor (MA95-55) is listed as impaired for nutrient/eutrophication biological indicators based on MEP sampling which found low dissolved oxygen, elevated chlorophyll *a* and degradation of benthic infauna habitat (Table 1).

While infauna habitat is generally of high quality throughout the main basins of the Megansett-Squeteague Harbor, all of the available information on eelgrass within this estuarine system indicates that although the outer basin of Megansett Harbor continues to support significant eelgrass beds, there is some evidence of a decline in acreage. The decline is in both the southern and northern major eelgrass beds (Section VII.2) and is clearly observed in field verified surveys since 1995. The absence of significant historic eelgrass habitat within the channel and Squeteague Harbor indicates that benthic infauna habitat is the main resource for assessment of impairment by nitrogen enrichment and the focus of management for these basins. Recovery and protection of eelgrass habitat should be the focus within the outer basin of Megansett Harbor.

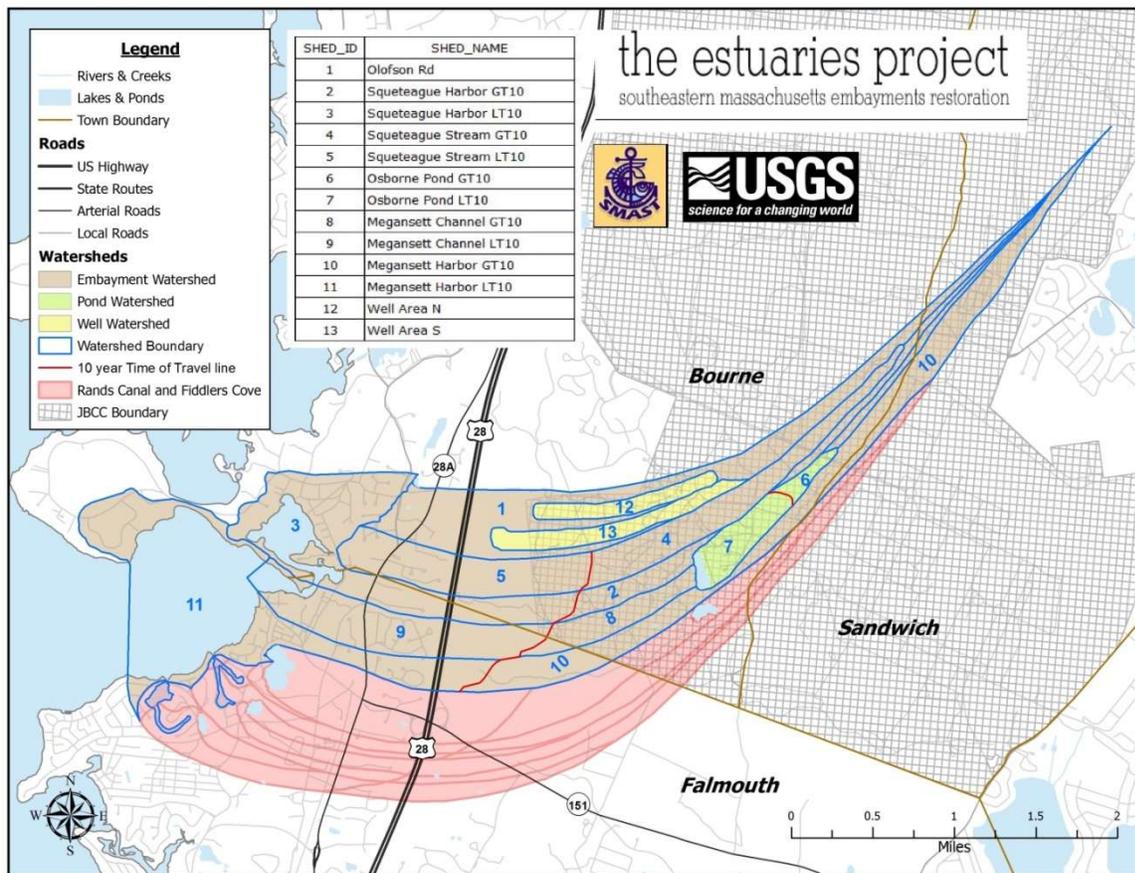


Figure 1: Watershed delineation for the Megansett and Squeteague Harbors Estuarine System, (Howes et. al 2015, pg. 26)

Priority Ranking

The embayment addressed by this TMDL is determined to be a high priority based on three significant factors: (1) the initiative that the towns have taken to assess the conditions of the entire estuarine system; (2) the support of the towns to restore and preserve the embayment; and (3) the extent of impairment in the embayment. In particular, this embayment is at risk of further degradation from increased N loads entering through groundwater and surface water runoff from the increasingly developed watershed. In both marine and freshwater systems an excess of nutrients results in degraded water quality, adverse impacts to ecosystems and limits on the use of water

resources. Observations are summarized in Table 2 and the Problem Assessment section below and detailed in Chapter VII- Assessment of Embayment Nutrient Related Ecological Health of the MEP Technical Report.

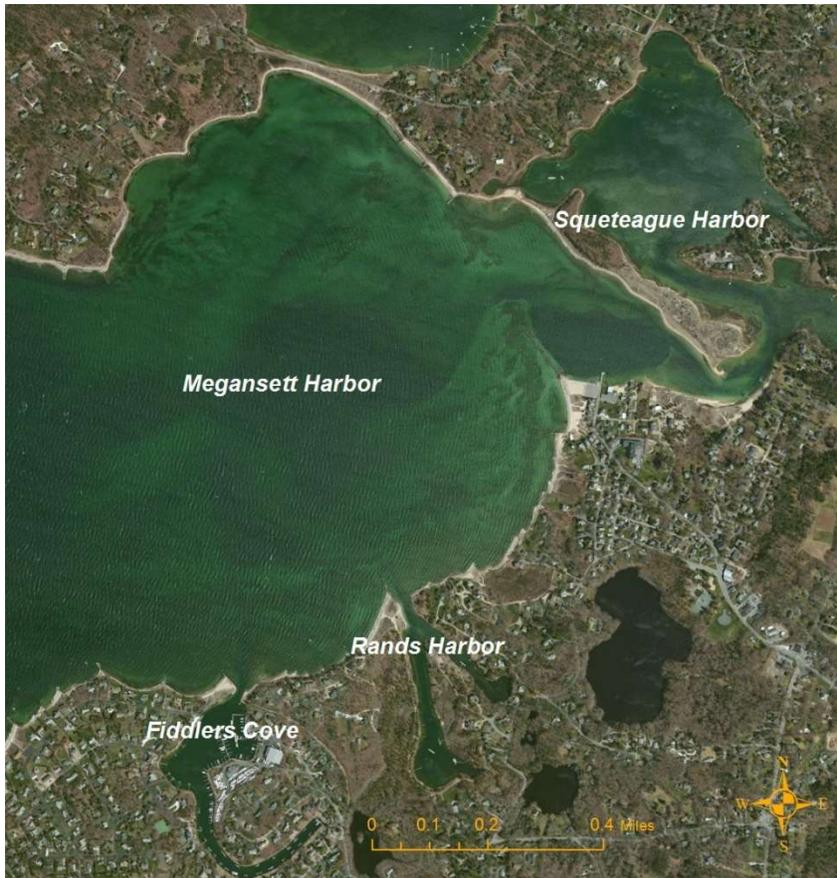


Figure 2: Overview of Megansett Harbor and Squeteague Harbor Embayment System

Table 1: Comparison of DEP and SMAST Impaired Parameters for Megansett-Squeteague Harbor System

System Component	MassDEP Waterbody Segment ID	MassDEP Segment Description	Class	2016 Integrated List Category	SMAST Impaired Parameter ¹	Size (sq. miles)
Megansett Harbor	MA95-19	Falmouth.	SA (Shellfishing)	Bioassessments, Fecal Coliform, Nutrient/Eutrophication Biological Indicators	Eelgrass loss, Nutrients, Dissolved Oxygen,	1.44
Squeteague Harbor	MA95-55	Falmouth.	SA (Shellfishing)	Nutrient/Eutrophication Biological Indicators	Dissolved Oxygen, Chlorophyll- <i>a</i> Benthic infauna	0.15
Channel	Portions in MA95-19, MA95-55					

¹ As determined by the MEP Megansett Squeteague Harbor Study and reported in the Technical Report, Howes *et. al*, 2015.

Description of Hydrodynamics of the Megansett-Squeteague Harbor Estuarine System

The main basin of Megansett Harbor is moderately deep coastal embayment with a wide opening to Buzzards Bay that is bound by Scraggy Neck to the north and the North Falmouth mainland (Nyes Neck) to the south. The main harbor basin narrows to a shallower inner harbor, which is separated from the main basin by a 600-ft-long stone jetty. The inner harbor narrows to a channel that is approximately 150 feet wide before widening again and opening into Squeteague Harbor, the innermost reach of the system. Fiddlers Cove and Rands Harbor, which have approved total nitrogen TMDLs, are located along the southern shore of Megansett Harbor. The average depth of the outer Harbor basin bottom is -7.3 feet mean low water (North American Vertical Datum or NAVD). The mean depth of the inner harbor is -4.5 feet NAVD while the mean depth of the Squeteague Harbor is 3.6 feet NAVD. The total surface coverage of the Megansett Harbor system including Squeteague Harbor is approximately 540 acres.

The MEP project has evaluated the tidal circulation and flushing characteristics of this embayment system using both direct measurements and the RMA-2 model, a well-established model for estuaries. The MEP project deployed three gaging stations throughout the Megansett-Squeteague Harbor system to evaluate tidal characteristics. The computed flushing rates for the harbor system show that as a whole, the system flushes moderately well. A flushing time of 1.6 days for the entire estuary shows that on average, water is resident in the system for less than two days. The inner reaches of the harbor system have local flushing times that are less than one day. The generally low residence times for the system indicate that water quality in Squeteague Harbor will improve when the water quality in Megansett Harbor improves.

Problem Assessment

At present, the Megansett-Squeteague Harbor estuarine system is only slightly beyond its ability to assimilate nitrogen without impairment and is showing a low to moderate level of nitrogen enrichment, with generally low to moderate impairment of eelgrass and infauna habitats. Based upon the ecological assessment from the MEP tech report and the level of eelgrass impairment observed, it appears that the system is presently only slightly beyond its nitrogen threshold for sustainable eelgrass coverage. This assessment is based upon several factors as follows: 1) the distribution of the remaining eelgrass habitat, 2) the observed loss of eelgrass in the northern and southern eelgrass beds bordering the deep basin of Megansett Harbor, 3) that the decline is slow and relatively recent and 4) that the system is only moderately nitrogen and organic matter enriched (Howes *et. al*, 2015).

The infauna surveys indicated that the Megansett-Squeteague Harbor estuary is currently supporting highly productive and diverse benthic communities throughout its component tidal basins. However, there is a modest gradient with highest quality habitat in the Megansett Harbor basin closest to the high quality waters of Buzzards Bay to the moderate to high quality habitat in the northern region of Squeteague Harbor, furthest from Buzzards Bay and with the lowest flushing rate. While infauna habitat is generally of high quality throughout the main basins of the Megansett-Squeteague Harbor estuary, all of the available information on eelgrass within this estuarine system indicates that although the outer basin of Megansett Harbor continues to support significant eelgrass beds, there is

some evidence of a decline in acreage. The absence of significant historical eelgrass habitat within the channel and Squeteague Harbor basin indicates that benthic infauna habitat is the main resource for assessment of impairment by nitrogen enrichment and the focus of management for these basins, while eelgrass habitat should be the focus of restoration and protection within the outer basin of Megansett Harbor.

The primary ecological threat to Megansett-Squeteague Harbor is degradation resulting from nutrient enrichment. Most of the total N load (73%) is from septic systems, with other “controllable” N contributions coming from runoff of impervious surfaces, fertilizers and landfill. Other sources that are not locally controllable include atmospheric deposition to the surface of the estuary and natural surfaces. Nitrogen from these sources enters the groundwater and eventually enters the estuary system.

The towns of Falmouth and Bourne have grown rapidly over the past four decades. In the period from 1970 to 2010 the number of year round residents has grown significantly (Figure 3). Although the majority of the watershed area is public service land uses, the dominant parcel type in all of the subwatershed groupings is residential land uses and single-family residences are the dominant type of residential parcel. Water quality problems associated with residential development result primarily from on-site wastewater treatment systems and to a lesser extent from fertilizers and runoff from these developed areas. The remaining build-out potential within the Megansett-Squeteague Harbor watershed will increase unattenuated system-wide nitrogen loading by about 29%. At the time of the data collection 100% of the residential parcels in the Megansett-Squeteague Harbor watershed relied on privately maintained septic systems for on-site treatment and disposal of wastewater.

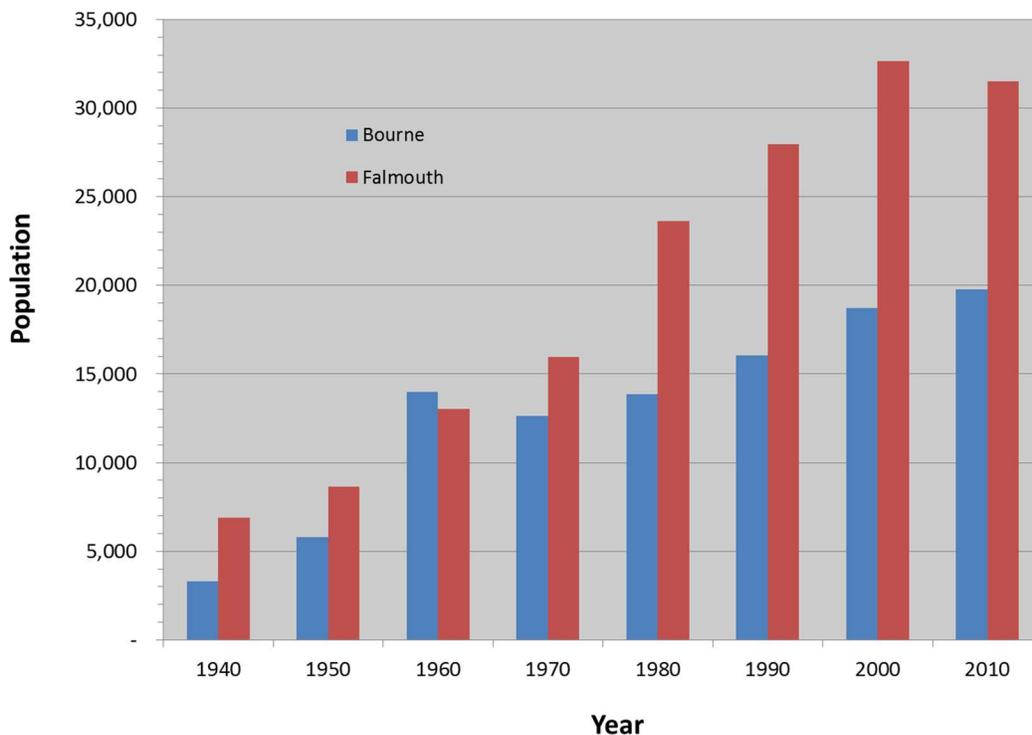


Figure 3: Falmouth and Bourne Historic Residential Population (US Census Bureau)

Prior to the 1970s there were fewer homes and many of those were seasonal. It is generally recognized that declines in water and habitat quality often parallel population growth in the watershed. The problems in Megansett Harbor include a temporal trend in loss of eelgrass from the northern and southern eelgrass beds bordering the deep basin of Megansett Harbor. Both the location and the temporal trend are consistent with nitrogen enrichment (Table 2). If the N concentration continues to increase, future habitat degradation could include periodic fish kills, unpleasant odors and scums and near loss of the benthic community and/or presence of only the most stress-tolerant species of benthic animals. Reducing nitrogen concentrations within the estuary will result in the restoration of dissolved oxygen and chlorophyll *a* to levels supportive of eelgrass and benthic infaunal habitats. Reducing nitrogen concentrations within the estuary will result in the restoration of dissolved oxygen and chlorophyll *a* to levels supportive of eelgrass and benthic infaunal habitats.

Coastal communities rely on clean, productive and aesthetically pleasing marine and estuarine waters for tourism, recreational swimming, fishing, and boating, as well as commercial fin fishing and shellfishing. The continued degradation of this coastal embayment, as described above, could significantly reduce the recreational and commercial value and use of these important environmental resources.

Habitat and water quality assessments were conducted on this estuarine system based upon water quality monitoring data, analysis of historical changes in eelgrass distribution, time-series water column dissolved oxygen and chlorophyll *a* measurements, benthic community structure assessments and sediment characteristics. At present, the Megansett-Squeteague Harbor Estuary is beyond its ability to assimilate nitrogen without impairment and is showing low to moderate levels of nitrogen enrichment, with moderate impairment of eelgrass in Megansett Harbor and low to moderate impairment of benthic infauna habitats in Squeteague Harbor.

(report continued next page)

Table 2: General Summary of Conditions Related to the Major Indicators of Habitat Impairment Observed in Megansett-Squeteague Harbor Estuarine System (excerpted Howes *et. al.* 2015, pg. 139).

Health Indicator	Megansett Harbor	Channel	Squeteague Harbor
Dissolved Oxygen	deep water oxygen appears to be affected by basin structure, but margins of basin >5 mg/L >95% of record consistent with WQMP which was always >4 mg/L, >5 mg/L at MG-1 97%, MG-2 100% of time. [H/MI]	all 3 moorings oxygen always > 4mg/L, >5 mg/L >92% of time, WQMP: >6 mg/L 77% of samples (N=263), 99% of samples >4 mg/L, only 1% of samples <4 mg/L. [H/MI]	all 3 moorings oxygen always > 4mg/L, >5 mg/L >92% of time, WQMP: >6 mg/L 77% of samples (N=263), 99% of samples >4 mg/L, only 1% of samples <4 mg/L. [H/MI]
Chlorophyll <i>a</i>	levels low for a coastal basin, averaging ~5 ug/L (time series) with <10 ug/L >90% of the time and averages 5-6 ug/L at all sites in long-term WQMP monitoring. [H]	low to moderate for a coastal basin, Channel average 8.4 ug/L, Squeteague Basin ~10 ug/L (WQMP 2000-2014, N=54) with time-series (Squeteague) <20 ug/L 90% of record, average 11.6 ug/L. [H]	low to moderate for a coastal basin, Channel average 8.4 ug L-1, Squeteague Basin ~10 ug/L (WQMP 2000-2014, N=54) with time-series (Squeteague) <20 ug/L 90% of record, average 11.6 ug/L. [H/MI]
Macroalgae	drift algae generally absent, patches of attached Codium (filling the eelgrass niche) [H]	drift algae generally absent, patches of attached Codium (filling the eelgrass niche) [H/MI]	sparse to no macroalgae in north basin, patches of Codium in south basin. [H]
Eelgrass Loss	most of the basin margin supports eelgrass habitat, loss of some fringing beds in the region adjacent the inlet to the channel to Squeteague Harbor basin and along the boundary of the shallow and deep water basin along the southern shore. The temporal and spatial pattern of loss from the inner margin of the beds is typical of nitrogen enrichment and indicates moderate impairment. [MI]	no verified evidence that this basin historically supported eelgrass habitat	no verified evidence that this basin historically supported eelgrass habitat
Benthic Fauna	high numbers of individuals (125-219), species (22), diversity (>3) and Evenness (>0.7), community dominated by non-stress indicator species with crustaceans and mollusks and polychaetes dominant. [H]	high numbers of individuals (125-219), species (22), diversity (>3) and Evenness (>0.7), community dominated by non-stress indicator species with crustaceans and mollusks and polychaetes dominant. [H]	north basin and south basin continue the trend in infaunal community of lower metrics with increasing distance from offshore waters; both have moderate to high numbers of species (19 vs 15), individuals (160 vs 260) and diversity (<i>H'</i>) (3.36 vs 2.9), with high Evenness (>0.7). Organic tolerant species are present in patches (mainly tubificids), but the typical community is dominated by polychaetes with crustaceans and mollusks. Amphipods also present at some locations (Ampelisca). [H/MI]

Health Indicator	Megansett Harbor	Channel	Squeteague Harbor
Overall Health	high quality eelgrass habitat from 1995-2012 with only recent loss at the margin to the deep basin area to the south and reductions in patches in the northern cove area, consistent with sandy sediments and low chlorophyll a levels (e.g. high light penetration). Benthic infaunal animal communities are highly diverse and productive relative to others on Cape Cod. Loss of marginal eelgrass coverage is indicative of a nitrogen enrichment and rates a designation of "Moderate Impairment" coupled with a "High Quality" habitat designation based upon the general eelgrass and benthic habitat indicators, low chlorophyll and generally moderate to high D.O. [H/MI]	no eelgrass habitat, but low-moderate levels of phytoplankton biomass, coupled with periodic D.O. depletion to 4 mg/L, with D.O. >5 mg L ⁻¹ 97% of samples (N=349) from WQMP. Infauna community is indicative of a moderate to high quality habitat with high species (19) and number of individuals (~200), diversity (H'=3.28) and Evenness (E=0.79). Indicative of unimpaired habitat. [H]	no eelgrass habitat with moderate to high quality benthic infauna habitat with moderate to high numbers of species (15-19), diversity (H'=2.90-3.36) and high numbers of individuals (160-260) and Evenness (E=0.75-0.80). There is some indication of organic enrichment as amphipods dominate some areas (Ampelisca), suggesting that this basin may be nearing its ability to assimilate additional nitrogen without impairment. This is consistent with the moderate chlorophyll a levels, averaging 11-12 ug/L in the time-series and 9.8 - 10.8 in the long-term grab sample record (BayWatchers 2000-2014). [H/MI]

H - Healthy habitat conditions, **MI** – Moderately Impaired, **SI** – Significantly Impaired - considerably and appreciably changed from normal conditions, **SD** – Severely degraded. These terms are more fully described in MEP report “Site-Specific Nitrogen Thresholds for Southeastern Massachusetts Embayments: Critical Indicators” December 22, 2003.

WQMP=Water Quality Monitoring Program (Coalition for Buzzards Bay's BayWatchers)

Pollutant of Concern, Sources and Controllability

In Megansett-Squeteague Harbor, as in most marine and coastal waters, the limiting nutrient is nitrogen (N). Nitrogen concentrations above those expected naturally contribute to undesirable water quality and habitat conditions (such as described above).

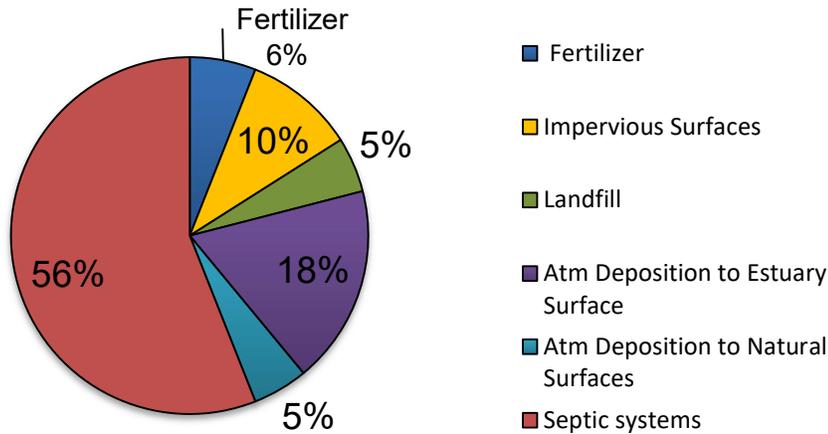
Megansett-Squeteague Harbor has had extensive data collected and analyzed through the MEP, with the cooperation and assistance from the towns of Bourne and Falmouth, BayWatchers Water Quality Monitoring Program and the Cape Cod Commission (CCC). Data collection included both water quality and hydrodynamics as described in Chapters I, IV, V, and VII of the MEP Technical Report. These investigations revealed that loadings of nutrients, especially N, are much larger than they would be under natural conditions and, as a result, the water quality has deteriorated. Figure 4 illustrates the sources and percent contributions of sources of N into the Megansett-Squeteague Harbor Estuary.

The level of “controllability” of each source, however, varies widely as shown in Table 3 below. Cost/benefit analyses will have to be conducted for all possible N loading reduction methodologies in order to select the optimal control strategies, priorities, and schedules.

Table 3: Sources of Nitrogen and their Controllability

Nitrogen Source	Degree of Controllability at Local Level	Reasoning
Atmospheric deposition to the estuary surface	Low	It is only through region- and nation-wide air pollution control initiatives that significant reductions are feasible. Local control although helpful is not adequate.
Atmospheric deposition to natural surfaces (forests, fields, freshwater bodies) in the watershed	Low	Atmospheric deposition (loadings) to these areas cannot adequately be controlled locally. However, the N from these sources might be subjected to enhanced natural attenuation as it moves toward the estuary.
Fertilizer	Moderate	Lawn and golf course fertilizer and related N loadings can be reduced through BMPs, bylaws and public education.
Landfill	High	This nitrogen source can be controlled by appropriate BMPs.
Septic system	High	Sources of N can be controlled by a variety of case-specific methods including: sewerage and treatment at centralized or decentralized locations, transporting and treating septage at treatment facilities with N removal technology either in or out of the watershed, or installing N-reducing on-site wastewater treatment systems.
Sediment	Low	N loadings are not feasibly controlled on a large scale by such measures as dredging. However, the concentrations of N in sediments, and thus the loadings from the sediments, will decline over time if sources in the watershed are removed, or reduced to the target levels discussed later in this document. In addition, increased dissolved oxygen will help keep N from fluxing.
Stormwater runoff from impervious surfaces	Moderate	This nitrogen source can be controlled by BMPs, bylaws and stormwater infrastructure improvements and public education. Stormwater NPDES permit requirements help control stormwater related N loadings in designated communities.

Megansett Squeteague Total Load



Megansett Squeteague Local Control Load

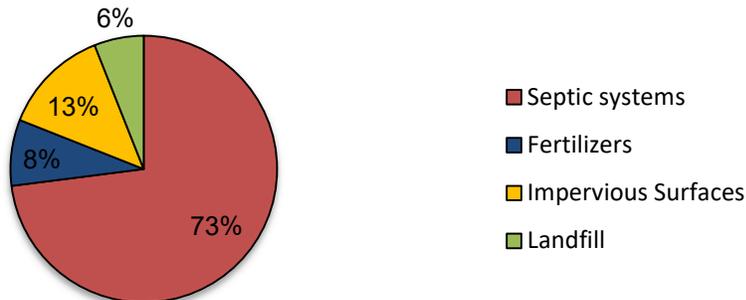


Figure 4: Percent Contribution of Watershed Nitrogen Sources to Megansett-Squeteague Harbor System (Howes *et. al*, 2015)

Description of the Applicable Water Quality Standards

Megansett Harbor and Squeteague Harbor are classified as Class SA waterbodies in the Massachusetts Water Quality Standards (MassDEP 2007). Massachusetts currently has narrative standards for nutrients (nitrogen and phosphorus) for waters of the Commonwealth such that “all surface waters shall be free of nutrients in concentrations that would cause or contribute to impairment of existing or designated uses and shall not exceed site specific criteria developed in a TMDL or otherwise, established by the department” (MassDEP 2007). A more thorough explanation of applicable standards can be found in Appendix A.

Thus, the assessment of eutrophication is based on site-specific information within a general framework that emphasizes impairment of uses and preservation of a balanced indigenous flora and fauna. This approach is recommended by the US Environmental Protection Agency in their Nutrient Criteria Technical Guidance Manual for Estuarine and Coastal Marine Waters (EPA 2001). The guidance manual notes that lakes, reservoirs, streams, and rivers may be subdivided by classes, allowing reference conditions for each class and facilitating cost-effective criteria development for nutrient management. However, individual estuarine and coastal marine waters tend to have unique characteristics, and development of individual water body criteria is typically required.

Methodology - Linking Water Quality and Pollutant Sources

Extensive data collection and analyses have been described in detail in the MEP Technical Report. These data were used by SMAST to assess the loading capacity of each sub-embayment. Physical (Chapter V), chemical, and biological (Chapters IV, VII, and VIII) data were collected and evaluated. The primary water quality objective was represented by conditions that:

- 1) Restore the natural distribution of eelgrass because it provides valuable habitat for shellfish and finfish;
- 2) Prevent algal blooms;
- 3) Restore and protect benthic communities; and
- 4) Maintain dissolved oxygen concentrations that are protective of the estuarine communities.

The details of the data collection, modeling and evaluation are presented and discussed in Chapters IV, V, VI, VII and VIII of the MEP Technical Report. The main aspects of the data evaluation and modeling approach of this study are summarized below.

The core analytical method of the Massachusetts Estuaries Project is the Linked Watershed-Embayment Management Modeling Approach. It fully links watershed inputs with embayment circulation and N characteristics and is characterized as follows:

- Requires site specific measurements within the watershed and each sub-embayment;
- Uses realistic “best-estimates” of N loads from each land-use (as opposed to loads with built-in “safety factors” like Title 5 design loads);
- Spatially distributes the watershed N loading to the embayment;
- Accounts for N attenuation during transport to the embayment;
- Includes a 2D or 3D embayment circulation model depending on embayment structure;
- Accounts for basin structure, tidal variations, and dispersion within the embayment;

- Includes N regenerated within the embayment;
- Is validated by both independent hydrodynamic, N concentration, and ecological data;
- Is calibrated and validated with field data prior to generation of “what if” scenarios.

The Linked Model has previously been applied to watershed N management in numerous embayments throughout southeastern Massachusetts. In these applications it became clear that the model can be calibrated and validated and has use as a management tool for evaluating watershed N management options.

The Linked Model, when properly calibrated and validated for a given embayment, becomes a N management planning tool as described in the model overview below. The model can assess solutions for the protection or restoration of nutrient-related water quality and allows testing of management scenarios to support cost/benefit evaluations. In addition, once a model is fully functional it can be refined for changes in land-use or embayment characteristics at minimal cost. Also, since the Linked Model uses a holistic approach that incorporates the entire watershed, embayment and tidal source waters, it can be used to evaluate all projects as they relate directly or indirectly to water quality conditions within its geographic boundaries. It should be noted that this approach includes high-order, watershed and sub-watershed scale modeling necessary to develop critical nitrogen targets for each major sub-embayment. The models, data and assumptions used in this process are specifically intended for the purposes stated in the MEP Technical Report, upon which this TMDL is based. As such, the Linked Model process does not contain the type of data or level and scale of analysis necessary to predict the fate and transport of nitrogen through groundwater from specific sources. In addition, any determinations related to direct and immediate hydrologic connection to surface waters are beyond the scope of the MEP’s Linked Model process.

The Linked Model provides a quantitative approach for determining an embayment's: (1) N sensitivity; (2) N threshold loading levels (TMDL); and (3) response to changes in loading rate. The approach is fully field validated and unlike many approaches, accounts for nutrient sources, attenuation, and recycling and variations in tidal hydrodynamics (Figure I-3 of the MEP Technical Report). This methodology integrates a variety of field data and models, specifically:

- Monitoring - multi-year embayment nutrient sampling;
- Hydrodynamics;
 - Embayment bathymetry (depth contours throughout the embayment)
 - Site-specific tidal record (timing and height of tides)
 - Water velocity records (in complex systems only)
 - Hydrodynamic model
- Watershed N Loading;
 - Watershed delineation
 - Stream flow (Q) and N load
 - Land-use analysis (GIS)
 - Watershed N model

- Embayment TMDL – Synthesis;
 - Linked Watershed-Embayment N Model
 - Salinity surveys (for linked model validation)
 - Rate of N recycling within embayment
 - Dissolved oxygen record
 - Chlorophyll *a* record
 - Eelgrass and Infaunal surveys

Application of the Linked Watershed-Embayment Model

The approach developed by the MEP for applying the linked model to specific embayments for the purpose of developing target threshold N loading rates includes:

- 1) Selecting one or two stations or sampling locations within the embayment system located close to the inland-most reach or reaches which typically has/have the poorest water quality within the system. These are called “sentinel” stations;
- 2) Using site-specific information and a minimum of three years of sub-embayment-specific data to select target threshold N concentrations for each sub-embayment. This is done by refining the draft target threshold N concentrations that were developed as the initial step of the MEP process. The target threshold N concentrations that were selected generally occur in higher quality waters near the mouth of the embayment system;
- 3) Running the calibrated water quality model using different watershed N loading rates, to determine the loading rate which will achieve the target threshold N concentration at the sentinel station. Differences between the modeled N load required to achieve the target threshold N concentration, and the present watershed N load represent N management goals for restoration and protection of the embayment system as a whole.

Previous sampling and data analyses and the modeling activities described above resulted in four major outputs that were critical to the development of the TMDL.

Two outputs are related to N **concentration**:

- the present N concentrations in the sub-embayments;
- site-specific target threshold N concentrations.

Two outputs are related to N **loadings**:

- the present N loads to the sub-embayments;
- load reductions necessary to meet the site specific target threshold N concentrations.

In summary, if the water quality standards (for dissolved oxygen, nutrients) are met by reducing the N concentration (and thus the N load) at the sentinel station(s), the water quality goals will be met throughout the entire system.

A brief overview of each of the outputs follows.

Nitrogen concentrations in the embayment

1) Observed “present” conditions:

Table 4 presents the average concentrations of N measured in this system from data collected at three stations during the period 2000 through 2013. The yearly mean of tidally averaged total nitrogen levels ranged between 0.239-0.414 mg/L (Megansett Harbor, MG2, MG3, and MG4), 0.295-0.502 mg/L (Inner Megansett Harbor, or the Channel, SQ1 and MG1) and 0.371-0.552 mg/L (Squeteague Harbor, SQ2). The sentinel station is MG-2, located in outer Megansett Harbor. For Megansett Harbor a threshold for tidally averaged TN at the sentinel station (MG-2, Figure 5) of 0.35 mg/L N was selected to restore eelgrass habitat based upon the depth and TN levels within the stable eelgrass bed. The overall means and standard deviations of the averages and modeling results are presented in Appendix B, Table B-1 (reprinted from Table VI-1 of the MEP Technical Report, Howes *et. al*, 2015).

Table 4: Observed Present Nitrogen Concentrations and Sentinel Station Threshold Nitrogen Target Concentration for Megansett-Squeteague Harbor System.

Sub-Embayment	Station	Observed Total Nitrogen Concentration ¹ (mg/L)	Target Threshold Nitrogen Concentration (mg/L) ²
Megansett Harbor	MG2	0.344	0.35
Megansett Channel	SQ1	0.452	
Squeteague Harbor	SQ2	0.468	

¹ Average of 2000 – 2013 data. “data mean” values are calculated as the average of all measurements. MEP Technical Report, Table VI-1, Howes *et. al*, 2015.

² sentinel site is located at the outer Megansett Harbor water quality station MG2.

2) Modeled site-specific target threshold N concentrations:

A major component of TMDL development is the determination of the maximum concentrations of N (based on field data) that can occur without causing unacceptable impacts to the aquatic environment. This is called the *target threshold nitrogen concentration*. Prior to conducting the analytical and modeling activities to determine this target threshold N concentration as described below, SMAST selected appropriate nutrient-related environmental indicators and tested the qualitative and quantitative relationship between those indicators and N concentrations. The Linked Model was then used to determine site-specific threshold N concentrations by using the specific physical, chemical and biological characteristics of each sub-embayment.

The approach for determining nitrogen loading rates, which will maintain acceptable habitat quality throughout an embayment system, is to first identify a sentinel location within the embayment and second to determine the nitrogen concentration within the water column which will restore that location to the desired habitat quality. The sentinel location is selected such that the restoration of that one site will necessarily bring the other regions of the system to acceptable

habitat quality levels. Once the sentinel site and its target threshold nitrogen concentration are determined, the MEP study modeled nitrogen loads from the watershed until the targeted nitrogen concentration was achieved.

Determination of the critical nitrogen threshold for maintaining high quality habitat within Megansett-Squeteague Harbor estuarine system is based primarily on the nutrient and oxygen levels, temporal trends in eelgrass distribution and benthic community indicators. The N threshold for Megansett-Squeteague Harbor estuarine system is based upon the goal of restoring eelgrass habitat within the outer basin with the parallel goal of restoring benthic habitat for infaunal animals throughout the system especially inner Squeteague Harbor. As listed in Table 4 above, the site-specific target threshold N concentration is 0.35 mg/L. The findings of the analytical and modeling investigations to determine this target threshold nitrogen concentration for the estuarine system are discussed below.



Figure 5: Nutrient water quality monitoring stations in the Megansett-Squeteague Harbor Estuary System. Sentinel Station is Station MG2.

The MEP Technical Report concluded that the system is presently only slightly beyond its nitrogen threshold for sustainable eelgrass coverage. This assessment is based upon several

factors as follows: 1) the distribution of the remaining eelgrass habitat, 2) the observed loss of eelgrass in the northern and southern eelgrass beds bordering the deep basin of Megansett Harbor, 3) that the decline is slow and relatively recent and 4) that the system is only moderately nitrogen and organic matter enriched.

Determination of the critical nitrogen threshold for maintaining high quality habitat within the Megansett-Squeteague Harbor embayment system is based primarily upon the nutrient and oxygen levels, the distribution of eelgrass and current benthic community indicators. The Megansett-Squeteague Harbor estuarine system presently shows a moderate level of impairment to eelgrass habitat within its Outer Basin (Megansett Harbor).

As eelgrass within the Megansett-Squeteague Harbor embayment system is a critical habitat structuring the productivity and resource quality of the entire system, and given that it is presently showing moderate impairment, restoration of this resource is the primary target for overall restoration of this system. Therefore, to restore eelgrass habitat in Megansett-Squeteague Harbor the nitrogen concentration (tidally averaged TN) at the sentinel location (MG2) needs to be lowered to 0.35 mg/L. In addition, lowering the level of nitrogen enrichment at the sentinel station will lower nitrogen levels throughout the estuary (Section VIII.3 of MEP Tech Report) with the parallel effect of protecting and improving infaunal habitats in the inner reaches of Squeteague Harbor. Therefore, the goal is to achieve the nitrogen target at the sentinel location and restore dissolved oxygen and chlorophyll a to levels supportive of historic eelgrass habitat within Megansett Harbor, which will also result in the protection and improvement of infaunal habitat throughout the system.

This threshold is similar to that for West Falmouth Harbor and Phinneys Harbor and is focused in part on restoring eelgrass where it had persisted until recently. Lowering the level of nitrogen enrichment at the sentinel station will lower nitrogen levels throughout the estuary with the parallel effect of improving infaunal habitats in the inner reaches of Squeteague Harbor. From the eelgrass surveys of 1951 through 2012, it appears that eelgrass coverage could increase by 20% within the outer harbor basin, with parallel restoration of the moderately impaired benthic animal habitat.

Nitrogen loadings to the embayment

1) Present loading rates:

In the Megansett-Squeteague Harbor system overall the highest N loading from controllable sources is from on-site wastewater treatment systems which is almost always the highest N loading source in other coastal embayments in southeast Massachusetts, as well. The MEP Technical Report calculates that septic systems account for 73% of the controllable N load to the overall system. Other controllable sources include runoff from impervious surfaces (13%), fertilizers (8%) and landfill (6%) (Figure 4). The septic system loading is 20.85 kg/day N within the Megansett-Squeteague Harbor watershed. The total N loading from all watershed sources is 31.94 kg N/day. A further breakdown of N loading by source is presented in Table 5. The data on which Table 5 is based can be found in Table ES-1 of the MEP Technical Report.

Table 5: Present Attenuated Nitrogen Loading to the Megansett-Squeteague Harbors Embayment System (from Howes *et. al*, 2015)

System Component	Present Land Use Load N ¹ (kg/day)	Present Septic System Load N (kg/day)	Present Total Watershed Load N ² (kg/day)	Direct Atmospheric Deposition N ³ (kg/day)	Present Net Benthic Flux N (kg/day)	Total N Load from All Sources ⁴ (kg/day)
Megansett Harbor	6.107	12.871	18.978	5.556	-22.515	24.534
Megansett Channel	0.934	2.764	3.699	0.386	-0.682	4.085
Squeteague Harbor	4.047	5.216	9.263	1.00	0.151	10.414
Megansett- Squeteague Estuarine System (total)	11.088	20.852	31.940	6.942	-23.046	38.882

1 Present land use includes fertilizers, landfill, and runoff from impervious surfaces, and atmospheric deposition to lakes and natural surfaces.

2 Watershed load includes present land uses and septic systems.

3 Atmospheric deposition to embayment surface only.

4 Total N load is composed of attenuated loadings from natural background, fertilizer, landfill and runoff from impervious surfaces, septic systems as well as atmospheric deposition and benthic flux loadings. Negative benthic flux set to zero.

As previously indicated, the present N loadings to Megansett-Squeteague Harbor must be reduced in order to restore conditions and to avoid further nutrient-related adverse environmental impacts. The critical final step in the development of the TMDL is modeling and analysis to determine the loadings required to achieve the target threshold N concentrations.

2) Nitrogen loads necessary for meeting the site-specific target threshold N concentrations:

The nitrogen threshold developed by SMAST (Section VIII.2 in the MEP Technical Report) and summarized above was used to determine the amount of total nitrogen mass loading reduction required for restoration of eelgrass and infaunal habitats in the Megansett-Squeteague Harbor system. Tidally averaged total nitrogen concentrations were used to calibrate the water quality model (Section VI in the MEP Technical Report). Modeled watershed nitrogen loads were sequentially lowered until the nitrogen levels reached the threshold level at the sentinel station chosen for Megansett-Squeteague Harbor (MG-2). It is important to note that load reductions can be produced by reduction of any or all sources of N and/or by increasing the natural attenuation of nitrogen within the freshwater systems to the embayment. The load reductions presented here represent only one of a suite of potential reduction approaches that need to be evaluated by the community.

Table 6 includes the present and target threshold watershed N loadings to Megansett-Squeteague Harbor and the percentage reduction necessary to meet the target threshold N concentration at the sentinel station (from Table ES-2 of the MEP Technical Report).

These values represent only one of a suite of potential reduction approaches that need to be evaluated by the towns of Falmouth and Bourne. The presentation is to establish the general degree and spatial pattern of reduction that will be required for restoration of this N impaired embayment. Other alternatives may also achieve the desired target threshold N concentration as well and can be explored using the MEP modeling approach. The towns of Falmouth and Bourne should take any reasonable actions to reduce the controllable N sources.

Table 6: Present Watershed Nitrogen Loading Rates, Calculated Loading Rates that are Necessary to Achieve Target Threshold Nitrogen Concentrations and the Percent Reductions of the Existing Loads Necessary to Achieve the Target Threshold Loadings

System Component	Present Attenuated Watershed Load ¹ (kg/day)	Target Threshold Watershed Load ² (kg/day)	Percent watershed reductions needed to achieve target threshold loads
Megansett Harbor	18.978	15.760	-17.0%
Megansett Channel	3.699	3.422	-7.5%
Squeteague Harbor	9.263	8.741	-5.6%
System Total	31.940	27.924	-12.6%

¹ Composed of wastewater from septic systems, fertilizer, landfill, and runoff from impervious surfaces, atmospheric deposition to freshwater waterbodies and natural surfaces. This load does not include direct atmospheric deposition onto estuarine surfaces or benthic regeneration. From Table VIII-3 MEP Tech Report, Howes *et al.* 2015.

² Target threshold watershed load is the load from the watershed needed to meet the embayment target threshold N concentration of 0.35 mg/L identified in Table 4 above.

Total Maximum Daily Loads

As described in EPA guidance, a total maximum daily load (TMDL) identifies the loading capacity of a water body for a particular pollutant. EPA regulations define loading capacity as the greatest amount of loading that a water body can receive without violating water quality standards. The TMDLs are established to protect and/or restore the estuarine ecosystem, including eelgrass, the leading indicator of ecological health, thus meeting water quality goals for aquatic life support. Because there are no “numerical” water quality standards for N, the TMDL for the Megansett-Squeteague Harbor system is aimed at determining the loads that would correspond to specific N concentrations determined to be protective of the water quality and ecosystems. Bioavailable nutrients - such as nitrogen - in point and non-point discharges can stimulate algal growth, which then die and are eaten by bacteria, depleting oxygen in the water through the process of decomposition. Reducing the bioavailability of nitrogen in the estuarine system through the implementation of this TMDL will result in less algal growth, which will ensure chlorophyll-a levels are reduced and dissolved oxygen levels increase.

The development of a TMDL requires detailed analyses and mathematical modeling of land use, nutrient loads, water quality indicators, and hydrodynamic variables (including residence time) for each waterbody system. The results of the mathematical model are correlated with estimates of impacts on water quality including negative impacts on eelgrass (the primary indicator), as well as dissolved oxygen, chlorophyll and benthic infauna.

The TMDL can be defined by the equation:

$$TMDL = BG + WLAs + LAs + MOS$$

Where:

TMDL = loading capacity of receiving water

BG = natural background

WLAs = portion allotted to point sources

LAs = portion allotted to (cultural) non-point sources

MOS = margin of safety

Background Loading

Natural background N loading is included in the loading estimates but is not quantified or presented separately. Background loading was calculated on the assumption that the entire watershed is forested with no anthropogenic sources of N. It is accounted for in this TMDL but not defined as a separate component. Readers are referred to Table ES-1 of the MEP Technical Report for estimated loading due to natural conditions.

Waste Load Allocations

Waste load allocations (WLA) identify the portion of the loading capacity allocated to existing and future point sources of wastewater. In the Megansett-Squeteague Harbor estuarine system there are no permitted surface water discharges in the watershed with the exception of stormwater. A TMDL may establish a specific WLA for an identified source or, as in the case of stormwater, may establish

an aggregate WLA that applies to numerous sources. EPA interprets 40 CFR 130.2(h) to require that allocations for NPDES regulated discharges of stormwater also be included in the waste load component of the TMDL. In the Megansett-Squeteague Harbor estuarine system this load includes runoff from impervious surfaces.

For purposes of the Megansett-Squeteague Harbor Estuarine System TMDL, MassDEP also considered the nitrogen load reductions from regulated MS4 sources necessary to meet the target nitrogen concentrations. In estimating the nitrogen loadings from regulated stormwater sources, MassDEP considered that most stormwater runoff in the MS4 communities is not discharged directly into surface waters, but, rather, percolates into the ground. The geology on Cape Cod and the Islands consists primarily of glacial outwash sands and gravels, and water moves rapidly through this type of soil profile. A systematic survey of stormwater conveyances on Cape Cod and the Islands was never undertaken prior to the MEP study used in the development of this TMDL. Nevertheless, most catch basins on Cape Cod are known to MassDEP to have been designed as leaching catch basins in light of the permeable overburden. MassDEP, therefore, recognized that most stormwater that enters a catch basin in the regulated area will percolate into the local groundwater table rather than directly discharge to a surface waterbody.

As described in the Methodology Section (above), the Linked Model accounts for storm water loadings and groundwater loading in one aggregate allocation as a non-point source. However, MassDEP also considered that some stormwater may be discharged directly to surface waters through outfalls. In the absence of specific data or other information to accurately quantify stormwater discharged directly to surface waters, MassDEP assumed that all impervious surfaces within 200 feet of the shoreline, as calculated from MassGIS data layers, would discharge directly to surface waters, whether or not it in fact did so. MassDEP selected this approach because it considered it unlikely that any stormwater collected farther than 200 feet from the shoreline would be directly discharged into surface waters. Although the 200 foot approach provided a gross estimate, MassDEP considered it a reasonable and conservative approach given the lack of pertinent data and information about stormwater collection systems on Cape Cod.

MassDEP has calculated the potential waste load allocation for this 200 foot buffer zone previously in a number of nitrogen TMDLs for embayments on Cape Cod. The calculated waste load allocation due to runoff from impervious surfaces within 200 feet of the estuary is 0.09 kg/day, 0.21 % of the total unattenuated watershed load. (Refer to Appendix C for details.) This conservative load is obviously negligible when compared to other sources.

Load Allocations

Load allocations identify the portion of loading capacity allocated to existing and future nonpoint sources. In the case of the Megansett-Squeteague Harbor system, the controllable nonpoint source loadings are primarily from on-site subsurface wastewater disposal systems. Additional N sources include stormwater runoff (except from impervious cover within 200 feet of the waterbody which is defined above as part of the waste load), fertilizers and atmospheric deposition.

Figure 4 (above) and Figure 6 (below) illustrate that septic systems are the most significant portion of watershed sources of controllable attenuated nitrogen (23.04 kg/day N), followed by stormwater

runoff (2.44 kg/day N) and fertilizers from lawns (2.44 kg/day N). Another watershed source of controllable nitrogen is from the former landfill at JBCC, which contributes 1.95 kg/day N (Table IV-3 and Figure IV-3 in the MEP Technical Report). In addition, there are nonpoint sources of N from sediments, natural background and atmospheric deposition that are not feasibly controllable.

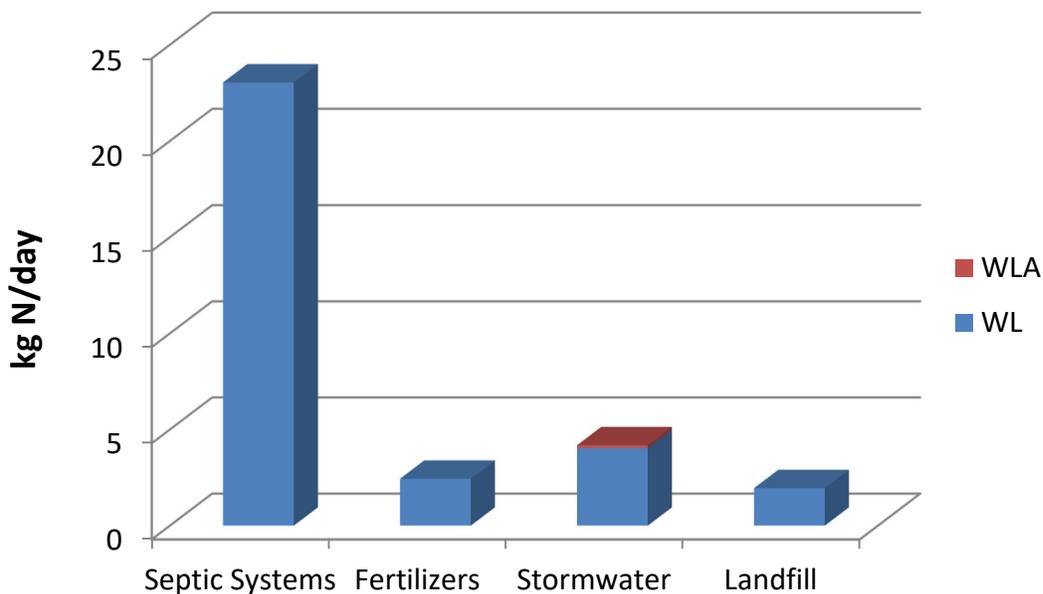


Figure 6: Controllable Watershed Sources of Nitrogen Loading to the Megansett-Squeteague Harbor Estuarine System

Storm water that is subject to the EPA MS4 Phase II Program would be considered a part of the waste load allocation rather than the load allocation. As presented in Chapters IV, V, and VI of the MEP Technical Report, on the Cape, the vast majority of stormwater percolates into the aquifer and enters the embayment system through groundwater. As a result, the TMDL accounts for stormwater loadings and groundwater loadings in one aggregate allocation as a non-point source, thus combining the assessments of wastewater and stormwater for the purpose of developing control strategies. As discussed above, even though there are measurable directly connected impervious areas in these systems, the wasteload allocation for stormwater was determined to be insignificant when compared to the overall controllable N load. Continued Phase II Program implementation in Falmouth and Bourne, new studies and possibly further modeling will identify what portion of the stormwater load may be controllable through Best Management Practices (BMPs).

Sediment loading rates incorporated into the TMDL are different than the existing sediment flux rates because projected reductions of N loadings from the watershed will result in reductions of nutrient concentrations in the sediments, and therefore, over time, reductions in loadings from the sediments will occur. Benthic flux of nitrogen from bottom sediments is a critical (but often overlooked) component of nitrogen loading to the shallow estuarine systems, therefore determination of the site specific magnitude of this component was also performed (see Section VI of the MEP Report).

Benthic N flux is a function of N loading and particulate organic N (PON). Projected benthic fluxes are based upon projected PON concentrations and watershed N loads and are calculated by multiplying the present N flux by the ratio of projected PON to present PON using the following formulae:

$$\text{Projected N flux} = (\text{present N flux}) (\text{PON projected} / \text{PON present})$$

$$\text{When: } PON_{\text{projected}} = (R_{\text{load}}) (D_{\text{PON}}) + PON_{\text{present offshore}}$$

$$\text{When } R_{\text{load}} = (\text{projected N load}) / (\text{Present N load})$$

And D_{PON} is the PON concentration above background determined by:

$$D_{\text{PON}} = (PON_{\text{present embayment}} - PON_{\text{present offshore}})$$

Benthic loading is affected by the change in watershed load. The benthic flux modeled for the Megansett-Squeteague Harbor system is reduced (towards zero) from existing conditions based on the N load reduction from controllable sources. Since there was a negative benthic flux (nutrient uptake) recorded in the Megansett Harbor and Megansett Channel under present conditions, a more conservative approach was used for these segments in the TMDL by assuming zero benthic flux for these segments in the future. This conservative approach was used and is considered part of the margin of safety in the TMDL. Since benthic loading varies throughout the year and the values shown represent “worst case” summertime conditions, loading rates are presented in kilograms per day.

The loadings from atmospheric sources incorporated into the TMDL are the same rates presently occurring because, as discussed above, significant control of atmospheric loadings at the local level is not considered feasible.

Margin of Safety

Statutes and regulations require that a TMDL include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality [CWA para 303 (d)(2)(c), 40C.G.R. para 130.7(c)(1)]. The MOS must be designed to ensure that any uncertainties in the data or calculations used to link pollutant sources to water quality impairment modeling will be accounted for in the TMDL and ensure protection of the beneficial uses. The EPA’s 1991 TMDL Guidance explains that the MOS may be implicit, i.e., incorporated into the TMDL through conservative assumptions in the analysis, or explicit, i.e., expressed in the TMDL as loadings set aside for the MOS. An explicit MOS quantifies an allocation amount separate from other Load and Wasteload Allocations. An explicit MOS can incorporate reserve capacity for future unknowns, such as population growth or effects of climate change on water quality. An implicit MOS is not specifically quantified but consists of statements of the conservative assumptions used in the analysis. The MOS for the Megansett –Squeteague Harbor estuarine system TMDL is implicit. MassDEP used conservative assumptions to develop numeric model applications that account for the MOS. These assumptions are described below, and they account for all sources of uncertainty, including the potential impacts of changes in climate.

While the general vulnerabilities of coastal areas to climate change can be identified, specific impacts and effects of changing estuarine conditions are not well known at this time <https://www.mass.gov/service-details/2011-massachusetts-climate-change-adaptation-report>. Because the science is not yet available, MassDEP is unable to analyze climate change impacts on streamflow, precipitation, and nutrient loading with any degree of certainty for TMDL development. In light of these uncertainties and informational gaps, MassDEP has opted to address all sources of uncertainty through an implicit MOS. MassDEP does not believe that an explicit MOS approach is appropriate under the circumstances or will provide a more protective or accurate MOS than the implicit MOS approach, as the available data simply does not lend itself to characterizing and estimating loadings to derive numeric allocations within confidence limits. Although the implicit MOS approach does not expressly set aside a specific portion of the load to account for potential impacts of climate change, MassDEP has no basis to conclude that the conservative assumptions that were used to develop the numeric model applications are insufficient to account for the lack of knowledge regarding climate change.

Conservative assumptions that support an implicit MOS:

1. Use of conservative data in the linked model

The watershed N model provides conservative estimates of N loads to the embayment. Nitrogen transfer through direct groundwater discharge to estuarine waters is based upon studies indicating negligible aquifer attenuation and dilution, i.e. 100% of load enters embayment. This is a conservative estimate of loading because studies have also shown that in some areas less than 100% of the load enters the estuary. Nitrogen from the upper watershed regions which travel through ponds or wetlands almost always enters the embayment via stream flow and is directly measured (over 12-16 months) to determine attenuation. In these cases, the land-use model has shown a slightly higher predicted N load than the measured discharges in the streams/rivers that have been assessed to date. Therefore, the watershed model as applied to the surface water watershed areas again presents a conservative estimate of N loads because the actual measured N in streams was lower than the modeled concentrations.

The hydrodynamic and water quality models have been assessed directly. In the many instances where the hydrodynamic model predictions of volumetric exchange (flushing) have also been directly measured by field measurements of instantaneous discharge, the agreement between modeled and observed values has been $\geq 92\%$. For the water quality model, it was possible to conduct a quantitative assessment of the model results as fitted to a baseline dataset - computed root mean squared (RMS) error is less than 0.021 mg/l, which demonstrates a good fit between modeled and measured data for this system (Howes *et. al* 2015, pg. 95). Since the water quality model incorporates all of the outputs from the other models, this excellent fit indicates a high degree of certainty in the final result. The high level of accuracy of the model provides a high degree of confidence in the output so less of a margin of safety is required.

Within the Megansett and Squeteague Harbors study area, there are two freshwater ponds with delineated watersheds: Osborne Pond and Cedar Lake. Neither pond has available pond-wide bathymetric data or sufficient water quality data collection outside of the MEP to provide a basis for

an alternative nitrogen attenuation rate. Osborne Pond has been evaluated for Superfund-related contamination, but that evaluation did not include monitoring for nitrogen or bathymetry (Howes *et al.*, 2015). Cedar Lake has been sampled six times during the nine years of Cape Cod Pond and Lakes Stewardship (PALS) Snapshots and Osborne Pond has not been sampled through the PALS Program. MEP staff did have a stream gauge at the Cedar Lake surface water outlet to help to evaluate its water and nitrogen flow. This monitoring was documented in the Fiddlers Cove and Rands Harbor MEP report (Howes *et al.*, 2013). Using the information collected at this gauge, MEP staff assigned a 20% nitrogen attenuation rate to Cedar Lake. This attenuation rate balanced the measured flow and load leaving the pond through the stream gauge and indicated discharge of a portion of the watershed flow and load from the pond through its downgradient shoreline. The portion of the flow leaving through the Cedar Lake downgradient shoreline discharges into the Megansett Harbor subwatershed. Osborne Pond, on the other hand, did not have any detailed information and was assigned the 50% nitrogen attenuation rate for freshwater ponds, similar to other MEP studies and considered conservative.

MEP conducted long-term measurements of natural attenuation relating to surface water discharges to the perimeter of the embayment system at the single major surface water flow system in the Squeteague Harbor watershed, Squeteague Stream discharging from Cuffs Pond. Cuffs Pond, unlike many of the freshwater ponds on Cape Cod, has a surface water discharge rather than draining solely to the aquifer along its down-gradient shore. This outflow through Squeteague Stream may serve to decrease the pond attenuation of nitrogen, but it also provides for a direct measurement of nitrogen load from the sub-watershed and the extent of nitrogen attenuation. Based upon lower total nitrogen load (843 kg/yr) discharged from the freshwater stream compared to that added by the various land-uses to the associated watershed (1,421 kg/yr), the integrated attenuation in passage through ponds, streams and freshwater wetlands prior to discharge to the estuary is ~40% (Table IV-4, Howes *et al.*, 2015).

Similarly, the water column N validation dataset was also conservative. The model is calibrated to measured water column N and validated to salinity. However, the model predicts average summer N concentrations. The very high or low measurements are marked as outliers. The effect is to make the N threshold more accurate and scientifically defensible. If a single measurement two times higher than the next highest data point in the series raises the average 0.05 mg/L N, this would allow for a higher “acceptable” load to the embayment. Marking the very high outlier is a way of preventing a single and rare bloom event from changing the N threshold for a system. This effectively strengthens the data set so that a higher margin of safety is not required.

Finally, the predicted reductions of the amount of N released from the sediments are most likely underestimates, i.e. conservative. The reduction is based solely on a reduced deposition of particulate organic nitrogen (PON) due to lower primary production rates under the reduced N loading in these systems. As the N loading decreases and organic inputs are reduced it is likely that rates of coupled remineralization-nitrification, denitrification and sediment oxidation will increase. It was also conservatively assumed that the negative benthic flux in Megansett Harbor and Megansett Channel (-23.545 and -0.669 kg/day N, respectively) does not exist under future loading conditions and as such was designated as “0” for purposes of the TMDL.

Benthic regeneration of N is dependent upon the amount of PON deposited to the sediments and the percentage that is regenerated to the water column versus being denitrified or buried. The

regeneration rate projected under reduced N loading conditions was based upon two assumptions:(1) PON in the embayment in excess of that of inflowing tidal water (boundary condition) results from production supported by watershed N inputs; and (2) Presently enhanced production will decrease in proportion to the reduction in the sum of watershed N inputs and direct atmospheric N input. The latter condition would result in equal embayment versus boundary condition production and PON levels if watershed N loading and direct atmospheric deposition could be reduced to zero (an impossibility of course). This proportional reduction assumes that the proportion of remineralized N will be the same as under present conditions, which is almost certainly an underestimate. As a result, future N regeneration rates are overestimated which adds to the margin of safety.

Finally, decreases in air deposition through continuing air pollution control efforts are unaccounted for this TMDL and provide another component of the margin of safety.

2. Conservative sentinel station/target threshold nitrogen concentration

Conservatism was used in the selection of the sentinel station and target threshold N concentration. The sites were chosen that had stable eelgrass or benthic animal (infaunal) communities, and not those just starting to show impairment, which would have slightly higher N concentration. Meeting the target threshold N concentration of 0.35 mg/L at the sentinel station, MG2, will result in reestablishment of eelgrass in Megansett Harbor and benthic habitat throughout the rest of the system.

3. Conservative approach

The target loads were based on tidally averaged N concentrations on the outgoing tide which is the worst case condition because that is when the N concentrations are the highest. The N concentrations will be lower on the flood tides; therefore, this approach is conservative.

Finally, the linked model accounted for all stormwater loadings and groundwater loadings in one aggregate allocation as a nonpoint source and this aggregate load is accounted for in the load allocation. The method of calculating the WLA in the TMDL for regulated stormwater was conservative as it did not disaggregate this negligible load from the modeled stormwater LA, hence this approach further enhances the margin of safety.

In addition to the margin of safety within the context of setting the N threshold levels described above, a programmatic margin of safety also derives from continued monitoring of this embayment to support adaptive management. This continuous monitoring effort provides the ongoing data to evaluate the improvements that occur over the multi-year implementation of the N management plan. This will allow refinements to the plan to ensure that the desired level of restoration is achieved.

Seasonal Variation

Since the TMDLs for the waterbody segments are based on the most critical time period, i.e. the summer growing season, the TMDLs are protective for all seasons. The daily loads can be converted to annual loads by multiplying by 365 (the number of days in a year). Nutrient loads to the embayment are based on annual loads for two reasons. The first is that primary production in coastal waters can peak in both the late winter-early spring and in the late summer-early fall periods.

Second, as a practical matter, the types of management necessary to control the N load do not lend themselves to intra-annual manipulation since a considerable portion of the N is from non-point sources. Thus, calculating annual loads is most appropriate, since it is difficult to control non-point sources of N on a seasonal basis and N sources can take considerable time to migrate to impacted waters.

TMDL Values for the Megansett-Squeteague Harbors System

As outlined above, the total maximum daily loadings of N that would provide for the restoration and protection of the embayment were calculated by considering all sources of N grouped by natural background, point sources and non-point sources. A more meaningful way of presenting the loadings data from an implementation perspective is shown in Table 6 and Appendix D.

Table 7: The Nitrogen Total Maximum Daily Load for the Megansett-Squeteague Harbors System

System Component	Target Threshold Watershed Load ¹ (kg N/day)	Atmospheric Deposition (kg N/day)	Load from Sediments ² (kg N/day)	TMDL ³ (kg N/day)
Megansett Harbor	15.760	5.556	0	21.316
Megansett Channel	3.422	0.386	0	3.808
Squeteague Harbor	8.741	1.00	0.146	9.888
System Total	27.924	6.942	0.146	35.012

1. Target threshold watershed load is the load from the watershed needed to meet the embayment target threshold nitrogen concentration identified in Table 4.
2. Projected future flux (present rates reduced approximately proportional to watershed load reductions). (Negative fluxes set to zero.)
3. Sum of target threshold watershed load, atmospheric deposition load and sediment load.

In this table N loadings from the atmosphere and from nutrient rich sediments are listed separately from the target watershed threshold loads. The watershed load is composed of atmospheric deposition to freshwater and natural surfaces along with locally controllable N from on-site subsurface wastewater disposal systems, storm water runoff, landfill, and fertilizer sources. The TMDL was calculated by projecting reductions in locally controllable watershed sources of N. The target load identified in this table represents one alternative loading scenario to achieve that goal but other scenarios may be possible and approvable as well. It must be demonstrated however, that any alternative implementation strategies will be protective of the entire embayment system. Once again, the goal of this TMDL is to achieve the identified target threshold N concentration at the identified sentinel station.

Implementation Plans

The critical element of this TMDL process is achieving the sentinel station specific target threshold N concentration presented in Table 4. This is necessary for the restoration and protection of water

quality, benthic invertebrate habitat, and eelgrass within the Megansett-Squeteague Harbor estuarine system. In order to achieve these target threshold N concentrations, N loading rates must be reduced throughout the Megansett-Squeteague Harbor system. Table 7 above lists the target threshold watershed N load for this system.

Septic Systems:

Because the majority of controllable N load is from individual septic systems for private residences, the Comprehensive Water Resources Management Plan (CWRMP) should assess the most cost-effective options for achieving the target threshold N watershed loads, including but not limited to, sewerage and treatment for N control of sewage and septage at either centralized or de-centralized locations, and denitrifying systems for all private residences. The CWMP should include a schedule of the selected strategies and estimated timelines for achieving those targets. However, the MassDEP realizes that an adaptive management approach may be used to observe implementation results over time and allow for adjustments based on those results. The appropriateness of any of the alternatives will depend on local conditions and will have to be determined on a case-by-case basis, using an adaptive management approach. This adaptive management approach will incorporate the priorities and concepts included in the updated area wide management plan established under the Clean Water Act Section 208.

Table 8 (from Table VIII-2 of the MEP Technical Report) summarizes the present loadings from septic systems and the reduced loads that would be necessary to achieve the target threshold N concentration in the Megansett-Squeteague Harbor system under the scenario modeled here. A 19.3% reduction in present septic loading achieved the target threshold N concentration of 0.35 mg/L at the sentinel station (Station MG-2), time averaged over the summer period. This septic load change will result in a 12.6% decrease in the total watershed load to the Megansett-Squeteague Harbor system.

Table 8: Summary of the Present Septic System Loads and the Loading Reductions that Would be Necessary to Achieve the TMDL by Reducing Septic System Loads Alone.

System Component	Present Septic N Load (kg N/day)	Threshold Septic load (kg N/day)	Threshold Septic Load % Change
Megansett Harbor	12.871	9.653	-25%
Megansett Channel	2.764	2.488	-10%
Squeteague Harbor	5.216	4.695	-10%
System Total	20.852	16.836	-19.3%

The above modeling results provide one scenario of achieving the threshold level for the sentinel site within the estuarine system. This example does not represent the only method for achieving this goal. The Towns of Falmouth and Bourne are encouraged to evaluate other load reduction scenarios and take any reasonable steps to reduce the controllable N sources.

Stormwater:

EPA and MassDEP authorized most of the watershed communities of Falmouth and Bourne for coverage under the NPDES Phase II General Permit for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems (MS4s) in 2003. EPA and MassDEP reissued the MS4 permit in April 2016 and it took effect July 1, 2018. The NPDES permits issued in Massachusetts do not establish numeric effluent limitations for stormwater discharges, rather, they establish narrative requirements, including best management practices, to meet the following six minimum control measures and to meet State Water Quality Standards.

1. Public education and outreach particularly on the proper disposal of pet waste,
2. Public participation/involvement,
3. Illicit discharge detection and elimination,
4. Construction site runoff control,
5. Post construction runoff control, and
6. Pollution prevention/good housekeeping.

As part of their applications for Phase II permit coverage, communities must identify the best management practices they will use to comply with each of these six minimum control measures and the measurable goals they have set for each measure. Therefore, compliance with the requirements of the Phase II stormwater permit in the towns of Falmouth and Bourne will contribute to the goal of reducing the nitrogen load as prescribed in this TMDL for the Megansett-Squeteague Harbor estuarine system watershed.

Climate Change:

MassDEP recognizes that long-term (25+ years) climate change impacts to southeastern Massachusetts, including the area of this TMDL, are possible based on known science. Massachusetts Executive Office of Energy and Environmental Affairs 2011 Climate Change Adaptation Report: : <https://www.mass.gov/service-details/2011-massachusetts-climate-change-adaptation-report> predicts that by 2100 the sea level could be from 1 to 6 feet higher than the current position and precipitation rates in the Northeast could increase by as much as 20 percent. However, the details of how climate change will affect sea level rise, precipitation, streamflow, sediment and nutrient loading in specific locations are generally unknown. The ongoing debate is not about whether climate change will occur, but the rate at and the extent to which it will occur and the adjustments needed to address its impacts. EPA's 2012 Climate Change Strategy (https://www.epa.gov/sites/production/files/2015-09/documents/sspp2012_adaptationplan_508.pdf) states: "Despite increasing understanding of climate change, there still remain questions about the scope and timing of climate change impacts, especially at the local scale where most water-related decisions are made." For estuarine TMDLs in southeastern Massachusetts, MassDEP recognizes that this is particularly true, where water quality management decisions and implementation actions are generally made and conducted at the municipal level on a sub-watershed scale.

EPA's Climate Change Strategy identifies the types of research needed to support the goals and strategic actions to respond to climate change. EPA acknowledges that data are missing or not available for making water resource management decisions under changing climate conditions. In addition, EPA recognizes the limitation of current modeling in predicting the pace and magnitude of localized climate change impacts and recommends further exploration of the use of tools, such as

atmospheric, precipitation and climate change models, to help states evaluate pollutant load impacts under a range of projected climatic shifts.

In 2013, EPA released a study entitled, “Watershed modeling to assess the sensitivity of streamflow, nutrient, and sediment loads to potential climate change and urban development in 20 U.S. watersheds.” (National Center for Environmental Assessment, Washington D.C.; EPA/600/R-12/058F). The closest watershed to southeastern Massachusetts that was examined in this study is a New England coastal basin located between Southern Maine and Central Coastal Massachusetts. These watersheds do not encompass any of the watersheds in the Massachusetts Estuary Project (MEP) region, and it has vastly different watershed characteristics, including soils, geography, hydrology and land use – key components used in a modeling analysis. The initial “first order” conclusion of this study is that, in many locations, future conditions, including water quality, are likely to be different from past experience. However, most significantly, this study did not demonstrate that changes to TMDLs (the water quality restoration targets) would be necessary for the region. EPA’s 2012 Climate Change Strategy also acknowledges that the Northeast, including New England, needs to develop standardized regional assumptions regarding future climate change impacts. EPA’s 2013 modeling study does not provide the scientific methods and robust datasets needed to predict specific long-term climate change impacts in the MEP region to inform TMDL development.

MassDEP believes that impacts of climate change should be addressed through TMDL implementation with an adaptive management approach in mind. Adjustments can be made as environmental conditions, pollutant sources, or other factors change over time. Massachusetts Coastal Zone Management (CZM) has developed a StormSmart Coasts Program (2008) to help coastal communities address impacts and effects of erosion, storm surge and flooding which are increasing due to climate change. The program, www.mass.gov/czm/stormsmart offers technical information, planning strategies, legal and regulatory tools to communities to adapt to climate change impacts.

As more information and tools become available, there may be opportunities to make adjustments in the TMDL in the future to address predictable climate change impacts. When the science can support assumptions about the effects of climate change on the nitrogen loadings to the TMDL can be reopened, if warranted.

Implementation Guidance

The watershed communities of Bourne and Falmouth are urged to meet the target threshold N concentrations by reducing N loadings from any and all sources, through whatever means are available and practical, including reductions in on-site subsurface wastewater disposal system loadings as well as reductions in stormwater runoff and/or fertilizer use within the watershed through the establishment of local by-laws and/or the implementation of stormwater Best Management Practices (BMPs).

MassDEP’s MEP Implementation Guidance report (MassDEP 2003) provides N loading reduction strategies that are available to Falmouth that could be incorporated into the implementation plans. The following topics related to N reduction are discussed in the Guidance:

- Wastewater Treatment;
 - On-Site Treatment and Disposal Systems
 - Cluster Systems with Enhanced Treatment
 - Community Treatment Plants
 - Municipal Treatment Plants and Sewers
- Tidal Flushing;
 - Channel Dredging
 - Inlet Alteration
 - Culvert Design and Improvements
- Stormwater Control and Treatment*;
 - Source Control and Pollution Prevention
 - Stormwater Treatment
- Attenuation via Wetlands and Ponds;
- Water Conservation and Water Reuse;
- Management Districts;
- Land Use Planning and Controls;
 - Smart Growth
 - Open Space Acquisition
 - Zoning and Related Tools
- Nutrient Trading.

*The towns of Falmouth and Bourne are members of the 237 communities in Massachusetts currently covered by the Phase II storm water program requirements.

Monitoring Plan

MassDEP is of the opinion that there are two forms of monitoring that are useful to determine progress towards achieving compliance with the TMDL. MassDEP's position is that implementation will be conducted through an iterative process where adjustments may be needed in the future. The two forms of monitoring include: 1) tracking implementation progress as approved in the town CWMP plan (as appropriate); and 2) monitoring ambient water quality conditions, including but not limited to, the sentinel station identified in the MEP Technical Report.

If necessary, to achieve the TMDL, the CWMP will evaluate various options to achieve the goals set out in the TMDL and Technical Report. It will also make a final recommendation based on existing or additional modeling runs, set out required activities and identify a schedule to achieve the most cost effective solution that will result in compliance with the TMDL. Once approved by MassDEP, tracking progress on the agreed-upon plan will, in effect, also be tracking progress towards water quality improvements in conformance with the TMDL.

Relative to water quality, MassDEP believes that an ambient monitoring program, much reduced from the data collection activities needed to properly assess conditions and to populate the model, will be important to determine actual compliance with water quality standards. Although the TMDL load values are not fixed, the target threshold N concentrations at the sentinel stations are. Through discussions amongst the MEP it is generally agreed that existing monitoring programs which were designed to thoroughly assess conditions and populate water quality models can be substantially

reduced for compliance monitoring purposes. Although more specific details need to be developed on a case by case basis, MassDEP's current thinking is that about half the current effort (using the same data collection procedures) would be sufficient to monitor compliance over time and to observe trends in water quality changes. In addition, the benthic habitat and communities would require periodic monitoring on a frequency of about every 3-5 years. Finally, in addition to the above, existing monitoring conducted by MassDEP for eelgrass should continue into the future to observe any changes that may occur to eelgrass populations as a result of restoration efforts.

The MEP will continue working with the watershed communities to develop and refine monitoring plans that remain consistent with the goals of the TMDL. Through the adaptive management approach ongoing monitoring will be conducted and will indicate if water quality standards are being met. If this does not occur other management activities would have to be identified and considered to reach to goals outlined in this TMDL. It must be recognized however that development and implementation of a monitoring plan will take some time, but it is more important at this point to focus efforts on reducing existing watershed loads to achieve water quality goals.

Reasonable Assurances

MassDEP possesses the statutory and regulatory authority, under the water quality standards and/or the State Clean Water Act (CWA), to implement and enforce the provisions of the TMDL through its many permitting programs, including requirements for N loading reductions from on-site subsurface wastewater disposal systems. However, because most non-point source controls are voluntary, reasonable assurance is based on the commitment of the locality involved. Bourne and Falmouth have demonstrated this commitment through comprehensive wastewater planning that they initiated before the generation of the TMDL. The town expects to use the information in this TMDL to generate support from their citizens to take the necessary steps to remedy existing problems related to N loading from on-site subsurface wastewater disposal systems, stormwater, and runoff (including fertilizers) and to prevent any future degradation of these valuable resources.

Moreover, reasonable assurances that the TMDL will be implemented include enforcement of regulations, availability of financial incentives and local, state and federal programs for pollution control. Stormwater NPDES permit coverage will address discharges from municipally owned stormwater drainage systems. Enforcement of regulations controlling non-point discharges include local implementation of the Commonwealth's Wetlands Protection Act and Rivers Protection Act; Title 5 regulations for on-site subsurface wastewater disposal systems and other local regulations such as the Town of Rehoboth's stable regulations.

Financial incentives include federal funds available under Sections 319, 604 and 104(b) programs of the CWA, which are provided as part of the Performance Partnership Agreement between MassDEP and EPA. Other potential funds and assistance are available through Massachusetts' Department of Agriculture's Enhancement Program and the United States Department of Agriculture's Natural Resources Conservation Services. Additional financial incentives include income tax credits for Title 5 upgrades and low interest loans for Title 5 on-site subsurface wastewater disposal system upgrades available through municipalities participating in this portion of the state revolving fund program.

As the town implements this TMDL, the TMDL values (kg/day of N) will be used by MassDEP as guidelines for permitting activities and should be used by local communities as a management tool.

Public Participation

The public meeting to present the results of and answer questions on this TMDL was held on December 19, 2019 in the Selectman's meeting room in Falmouth Town Hall. Notice of the public meeting was issued through a press release, a notice was placed in the Massachusetts Environmental Policy Act (MEPA) Monitor, and an email was sent to town officials and volunteer groups. A copy of the draft TMDL was placed on the MassDEP website.

Patti Kellogg and Barbara Kickham with the MassDEP summarized the Mass Estuaries Project and described the Draft Total Nitrogen TMDL Report findings. Brian Dudley and Laura Blake, also with MassDEP, assisted with responding to questions. Public comments received at the public meetings and comments received in writing within a 30-day comment period following the public meeting were considered by the Department. This final version of the TMDL report includes both a summary of the public comments together with the Department's response to the comments and scanned images of the attendance sheets from the meetings (Appendix E). SMAST representatives at the public meeting included Brian Howes and Ed Eichner.

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Appendix A: Overview of Applicable Water Quality Standards

Water quality standards of particular interest to the issues of cultural eutrophication are dissolved oxygen, nutrients, bottom pollutants or alterations, aesthetics, excess plant biomass, and nuisance vegetation. The Massachusetts water quality standards (314 CMR 4.0) contain numeric criteria for dissolved oxygen, but have only narrative standards that relate to the other variables. This brief summary does not supersede or replace 314 CMR 4.0 Massachusetts Water Quality Standards, the official and legal standards. A complete version of 314 CMR 4.0 Massachusetts Water Quality Standards is available online at <https://www.mass.gov/regulations/314-CMR-4-the-massachusetts-surface-water-quality-standards>.

Applicable Narrative Standards

314 CMR 4.05(5)(a) states “Aesthetics – All surface waters shall be free from pollutants in concentrations that settle to form objectionable deposits; float as debris, scum, or other matter to form nuisances, produce objectionable odor, color, taste, or turbidity, or produce undesirable or nuisance species of aquatic life.”

314 CMR 4.05(5)(b) states “Bottom Pollutants or Alterations. All surface waters shall be free from pollutants in concentrations or combinations or from alterations that adversely affect the physical or chemical nature of the bottom, interfere with the propagation of fish or shellfish, or adversely affect populations of non-mobile or sessile benthic organisms.”

314 CMR 4.05(5)(c) states, “Nutrients – Unless naturally occurring, all surface waters shall be free from nutrients in concentrations that would cause or contribute to impairment of existing or designated uses and shall not exceed the site specific criteria developed in a TMDL or as otherwise established by the Department pursuant to 314 CMR 4.00. Any existing point source discharge containing nutrients in concentrations that would cause or contribute to cultural eutrophication, including the excessive growth of aquatic plants or algae, in any surface water shall be provided with the most appropriate treatment as determined by the Department, including, where necessary, highest and best practical treatment (HBPT) for POTWs and BAT for non POTWs, to remove such nutrients to ensure protection of existing and designated uses. Human activities that result in the nonpoint source discharge of nutrients to any surface water may be required to be provided with cost effective and reasonable best management practices for nonpoint source control.”

Description of Coastal and Marine Classes and Numeric Dissolved Oxygen Standards

Excerpt from 314 CMR 4.05(4) (a):

(a) Class SA. These waters are designated as an excellent habitat for fish, other aquatic life and wildlife, including for their reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation. In certain waters, excellent habitat for fish, other aquatic life and wildlife may include, but is not limited to, seagrass. Where designated in the tables to 314 CMR 4.00 for shellfishing, these waters shall be suitable for shellfish harvesting without depuration (Approved and Conditionally Approved Shellfish Areas). These waters shall have excellent aesthetic value.

1. Dissolved Oxygen. Shall not be less than 6.0 mg/l. Where natural background conditions are lower, DO shall not be less than natural background. Natural seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained.

Excerpt from 314 CMR 4.05(4) (b):

(b) Class SB. These waters are designated as a habitat for fish, other aquatic life and wildlife, including for their reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation. In certain waters, habitat for fish, other aquatic life and wildlife may include, but is not limited to, seagrass. Where designated in the tables to 314 CMR 4.00 for shellfishing, these waters shall be suitable for shellfish harvesting with depuration (Restricted and Conditionally Restricted Shellfish Areas). These waters shall have consistently good aesthetic value.

1. Dissolved Oxygen. Shall not be less than 5.0 mg/l. Seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained. Where natural background conditions are lower, DO shall not be less than natural background.

Waterbodies Not Specifically Designated in 314 CMR 4.06 or the tables to 314 CMR 4.00

Note many waterbodies do not have a specific water quality designation in 314 CMR 4.06 or the tables to 314 CMR 4.00. Coastal and Marine Classes of water are designated as Class SA and presumed High Quality Waters as described in 314 CMR 4.06 (4).

314 CMR 4.06(4):

(4) Other Waters. Unless otherwise designated in 314 CMR 4.06 or unless otherwise listed in the tables to 314 CMR 4.00, other waters are Class B, and presumed High Quality Waters for inland waters and Class SA, and presumed High Quality Waters for coastal and marine waters. Inland fisheries designations and coastal and marine shellfishing designations for unlisted waters shall be made on a case-by-case basis as necessary.

Applicable Antidegradation Provisions

Applicable antidegradation provisions are detailed in 314 CMR 4.04 from which an excerpt is provided:

Excerpt from 314 CMR 4.04:

4.04:Antidegradation Provisions

(1) Protection of Existing Uses. In all cases existing uses and the level of water quality necessary to protect the existing uses shall be maintained and protected.

(2) Protection of High Quality Waters. High Quality waters are waters whose quality exceeds minimum levels necessary to support the national goal uses, low flow waters, and other waters whose character cannot be adequately described or protected by traditional criteria. These waters shall be protected and maintained for their existing level of quality unless limited degradation by a new or increased discharge is authorized by the Department pursuant to 314 CMR 4.04(5). Limited degradation also may be allowed by the Department where it determines that a new or increased discharge is insignificant because it does not have the potential to impair any existing or designated water use and does not have the potential to cause any significant lowering of water quality.

(3) Protection of Outstanding Resource Waters. Certain waters are designated for protection under this provision in 314 CMR 4.06. These waters include Class A Public Water Supplies (314 CMR 4.06(1)(d)1.) and their tributaries, certain wetlands as specified in 314 CMR 4.06(2) and other waters as determined by the Department based on their outstanding socio-economic, recreational, ecological and/or aesthetic values. The quality of these waters shall be protected and maintained.

(a) Any person having an existing discharge to these waters shall cease said discharge and connect to a Publicly Owned Treatment Works (POTW) unless it is shown by said person that such a connection is not reasonably available or feasible. Existing discharges not connected to a POTW

shall be provided with the highest and best practical method of waste treatment determined by the Department as necessary to protect and maintain the outstanding resource water.

(b) A new or increased discharge to an Outstanding Resource Water is prohibited unless:

1. the discharge is determined by the Department to be for the express purpose and intent of maintaining or enhancing the resource for its designated use and an authorization is granted as provided in 314 CMR 4.04(5). The Department's determination to allow a new or increased discharge shall be made in agreement with the federal, state, local or private entity recognized by the Department as having direct control of the water resource or governing water use; or
2. the discharge is dredged or fill material for qualifying activities in limited circumstances, after an alternatives analysis which considers the Outstanding Resource Water designation and further minimization of any adverse impacts. Specifically, a discharge of dredged or fill material is allowed only to the limited extent specified in 314 CMR 9.00 and 314 CMR 4.06(1)(d). The Department retains the authority to deny discharges which meet the criteria of 314 CMR 9.00 but will result in substantial adverse impacts to the physical, chemical, or biological integrity of surface waters of the Commonwealth

(4) Protection of Special Resource Waters. Certain waters of exceptional significance, such as waters in national or state parks and wildlife refuges, may be designated by the Department in 314 CMR 4.06 as Special Resource Waters (SRWs). The quality of these waters shall be maintained and protected so that no new or increased discharge and no new or increased discharge to a tributary to a SRW that would result in lower water quality in the SRW may be allowed, except where:

- (a) the discharge results in temporary and short term changes in the quality of the SRW, provided that the discharge does not permanently lower water quality or result in water quality lower than necessary to protect uses; and
- (b) an authorization is granted pursuant to 314 CMR 4.04(5).

(5) Authorizations.

(a) An authorization to discharge to waters designated for protection under 314 CMR 4.04(2) may be issued by the Department where the applicant demonstrates that:

1. The discharge is necessary to accommodate important economic or social development in the area in which the waters are located;
2. No less environmentally damaging alternative site for the activity, receptor for the disposal, or method of elimination of the discharge is reasonably available or feasible;
3. To the maximum extent feasible, the discharge and activity are designed and conducted to minimize adverse impacts on water quality, including implementation of source reduction practices; and
4. The discharge will not impair existing water uses and will not result in a level of water quality less than that specified for the Class.

(b) An authorization to discharge to the narrow extent allowed in 314 CMR 4.04(3) or 314 CMR 4.04(4) may be granted by the Department where the applicant demonstrates compliance with 314 CMR 4.04(5)(a)2. through 314 CMR 4.04(5)(a)4.

(c) Where an authorization is at issue, the Department shall circulate a public notice in accordance with 314 CMR 2.06. Said notice shall state an authorization is under consideration by the Department, and indicate the Department's tentative determination. The applicant shall have the burden of justifying the authorization. Any authorization granted pursuant to 314 CMR 4.04 shall not extend beyond the expiration date of the permit.

(d) A discharge exempted from the permit requirement by 314 CMR 3.05(4) (discharge necessary to abate an imminent hazard) may be exempted from 314 CMR 4.04(5) by decision of the Department.

(e) A new or increased discharge specifically required as part of an enforcement order issued by the Department in order to improve existing water quality or prevent existing water quality from deteriorating may be exempted from 314 CMR 4.04(5) by decision of the Department.

(6) The Department applies its Antidegradation Implementation Procedures to point source discharges subject to 314 CMR 4.00.

(7) Discharge Criteria. In addition to the other provisions of 314 CMR 4.00, any authorized Discharge shall be provided with a level of treatment equal to or exceeding the requirements of the Massachusetts Surface Water Discharge Permit Program (314 CMR 3.00). Before authorizing a discharge, all appropriate public participation and intergovernmental coordination shall be conducted in accordance with Permit Procedures (314 CMR 2.00).

Appendix B: Summary of the Nitrogen Concentrations in Megansett-Squeteague Harbor Estuarine System

Table B-1: Summary of the Nitrogen Concentrations for the Megansett-Squeteague Harbor Estuarine System (Excerpted from Table VI-1 of the MEP Technical Report, Howes *et. al*, 2015 pg. 91)

Measured data and modeled nitrogen concentrations for the Megansett-Squeteague Harbor Estuarine System (at stations indicated in Figure VI-1). All concentrations are given in mg/L N. "Data mean" values are calculated as the average of all measurements. Data represented in this table were collected in the summers of 2000 through 2013.							
Sub-Embayment	Station	Mean (all data)	Standard Deviation (all data)	N	model min	model max	model average
Megansett Channel	MG1	0.407	0.081	46	0.365	0.438	0.394
Megansett Harbor	MG2	0.344	0.066	48	0.352	0.379	0.363
Megansett Harbor	MG3	0.358	0.072	93	0.334	0.366	0.350
Megansett Harbor	MG4	0.332	0.071	47	0.328	0.342	0.331
Squeteague Harbor	SQ1	0.452	0.070	92	0.377	0.445	0.415
Squeteague Harbor	SQ2	0.468	0.105	42	0.416	0.449	0.432

Appendix C: Stormwater Loading Information

Table C-1: The Megansett-Squeteague Harbor Estuarine System estimated waste load allocation (WLA) from runoff of all impervious areas within 200 feet of its waterbodies.

System Name	Impervious Area in 200 ft. buffer (acres) ¹	Total Impervious Area in Watershed (acres)	Total Watershed Area (acres)	% Impervious of Total Watershed Area	Impervious Area in 200 ft. buffer as Percentage of Total Watershed Impervious Area	MEP Total Unattenuated Subwatershed Impervious Load (kg/day) ²	MEP Total Unattenuated Watershed Load (kg/day) ³	Impervious buffer (200ft) WLA (kg/d) ⁴	Buffer area WLA as percentage of MEP Total Unattenuated Subwatershed Load ⁵
Squeteague Harbor	5.3	178.9	1,658.4	10.8%	3.0%	1.47	11.84	0.04	0.37%
Megansett Channel	2.1	63.3	477.5	13.2%	3.4%	0.47	4.14	0.02	0.39%
Megansett Harbor ⁶	5.6	185.9	1,744.2	10.7%	3.0%	0.93	25.75	0.03	0.11%
Total	13.1	428.1	3,880	11.0%	3.0%	2.88	41.74	0.09	0.21%

1. The entire impervious area within a 200 foot buffer zone around all waterbodies as calculated by MassGIS. Due to the soils and geology of Cape Cod it is unlikely that runoff would be channeled as a point source directly to a waterbody from areas more than 200 feet away. Some impervious areas within approximately 200 feet of the shoreline may discharge stormwater via pipes directly to the waterbody. For the purposes of the waste load allocation (WLA) it was assumed that all impervious surfaces within 200 feet of the shoreline discharge directly to the waterbody.

2. From Table IV-3 of the MEP Technical Report

3. This includes the unattenuated nitrogen loads from wastewater from septic systems, landfill, fertilizer, and runoff from both natural and impervious surfaces, and atmospheric deposition to freshwater waterbodies. This does not include direct atmospheric deposition to the estuary surface.

4. The impervious subwatershed 200 ft. buffer area (acres) divided by total watershed impervious area (acres) then multiplied by total impervious subwatershed load (kg/day).

5. The impervious subwatershed buffer area WLA (kg/day) divided by the total subwatershed load (kg/day) then multiplied by 100.

6. Does not include Rands Harbor and Fiddlers Cove (see Final Fiddlers Cove and Rands Harbor Embayment Systems Total Maximum Daily Loads for Total Nitrogen)

Appendix D: Megansett-Squeteague Harbor Estuarine System Total Nitrogen TMDLs

Table D-1: TMDLs for Megansett-Squeteague Harbor Estuarine System – Two Total Nitrogen TMDLs

Waterbody Name	Segment ID	Impairment ¹	TMDL Type	TMDL (kg N/day)
Megansett Harbor	MA95-19	Bioassessments, Fecal Coliform, Nutrient/Eutrophication Biological Indicators	Restoration	21.32
Megansett Channel (portion in Megansett Harbor)	MA95-19		Restoration	3.00
<i>Megansett Harbor Total</i>	MA95-19		Restoration	24.32
Squeteague Harbor	MA95-55	Nutrient/Eutrophication Biological Indicators	Restoration	9.89
Megansett Channel (portion in Squeteague Harbor)	MA95-55		Restoration	0.81
<i>Squeteague Harbor Total</i>				10.70
<i>Megansett-Squeteague Harbor Estuarine System</i>				35.01

1. MassDEP 2016 Integrated Report

Appendix E: Massachusetts Estuaries Project (MEP) Response to Comments

DRAFT TOTAL MAXIMUM DAILY LOAD (TMDL) REPORT FOR
WAQUOIT BAY (378.0)
MEGANSETT-SQUETEAGUE HARBORS (CN 374.0)
FALMOUTH INNER HARBOR (CN 396.0)
REPORTS DATED AUGUST 2019

PUBLIC MEETING ON DECEMBER 19, 2019
FALMOUTH TOWN HALL SELECTMEN'S MEETING ROOM,
FALMOUTH, MA

1) What is Enhanced Nitrogen Removal?

MassDEP Response: Enhanced nitrogen removal refers to techniques that can be implemented to increase or optimize nitrogen removal or containment. An example is maximizing nitrogen uptake by plants in wetlands areas that could be restored or expanded. Increased nitrogen removal can be achieved through Permeable Reactive Barriers (PRBs) where the nitrogen in the groundwater adsorbs to the material in the PRB. Shellfish aquaculture is in use in estuaries with the intent of decreasing nitrogen concentrations in the water column. These techniques do not address source reduction but are intended to reduce the amount of nitrogen reaching the estuaries.

2) The scenario provided in the Technical Report directed 100% reduction of septic load in certain subwatersheds in Waquoit Bay? Is that correct and how did they come up with exactly 100%?

MassDEP Response: The scenario provided in the Technical Report which was to reduce the septic nitrogen load by 100% in some select sub-watersheds (through sewerage) is just one scenario to meet the nitrogen target at the sentinel station. S Mast's decision to select certain subwatersheds within Waquoit Bay is in part based on the density of development and feasibility to pursue sewerage. Sewerage in those areas was maximized. In some areas, the modeling may have indicated that even more than 100% nitrogen reduction through sewerage would be needed to meet the threshold concentrations. The scenario presented in the Technical Report should be considered an illustration, not an engineering study, of what could be done to remove the needed nitrogen from the watershed.

3) What happens if 100% removal through sewerage is required to meet the target concentration in the estuary, but the town can only reduce (or sewer) a smaller amount?

MassDEP Response: MassDEP strongly encourages the towns in the watershed(s) to work together on comprehensive planning so that the burden of nitrogen removal and sewerage is distributed equitably. An overall, cooperative agreement provides greater flexibility, increased assurance, and a better chance of success. Note that there is flexibility in how towns meet the needed reductions through your Comprehensive Water Resources Management Plan (CWRMP).

The Technical Report provided just one scenario for each estuarine system that meets the target concentrations. Completing additional modeling and analyses may reveal other scenarios that may be pursued to meet the necessary reductions and recover the benthic and eelgrass habitats of the estuaries and harbors.

4) Is there a possibility for trading credits?

MassDEP Response: MassDEP is considering the possibility of trading nitrogen credits. There can be some mixing and matching to meet the target concentrations so that the burden is shared proportionally and equitably.

SMASST Response: As part of developing the nitrogen reduction strategy, we looked for areas that were potentially “sewerable” and were densely developed to maximize reductions in total nitrogen in the watershed. If Hamblin and Jehu Ponds and the associated rivers on the east side of Waquoit Bay in Mashpee, were sewerred, these areas could see habitat recovery without waiting for work to be completed in other parts of the estuary system, such as Eel River and Childs River to the west. You can mix and match nitrogen removal between subwatersheds, however, not all nitrogen removal has the same benefit. Nitrogen reduction further up in the watershed provides long-term improvement compared to nitrogen removal close to where it discharges to the estuary. Mixing and matching of nitrogen reduction scenarios between subwatersheds such as Waquoit Bay, must be done through estuary specific modeling.

5) How long does it take to see effects on eelgrass after the target threshold is met?

MassDEP Response: The time it takes to observe regrowth of eelgrass is very estuary specific. It depends on where the nitrogen removal or the sewerred occurred which will inform you on the time of travel to the estuary. Each Technical Report broke out the travel time within subwatersheds to less than, and greater than, a ten-year travel time to the estuary. When and if the source of all the nitrogen is removed, it will still take years for the nitrogen in the groundwater to discharge to the estuary. If the town sewers homes close to the bay, it may be 1 or 2 years to see some improvement, particularly if there was still some eelgrass remaining in the embayment. But it will take several years to see the full recovery. More generally it could take several years to see eelgrass return to the estuary after source reduction begins.

6) What happens if we hit the target threshold at the sentinel station, let’s say for several consecutive years, but eelgrass does not return?

MassDEP Response: The goal of the TMDL is to restore the estuary habitats for eelgrass and benthic infauna and that the target concentrations are the guide to getting there. If we reach the target concentration at the sentinel stations then the TMDL allows, through the process of Adaptive Management, a re-evaluation of the nitrogen reduction strategy and lowering of the target concentration. This may require additional modeling to determine if additional nitrogen reductions are needed. The threshold concentration is a target, but the final goal is habitat restoration.

7) There was a lot of negative benthic flux in the sediments as reported in the Waquoit Bay Technical Report. The negative sediment benthic flux was then set to zero for the TMDL. Why didn’t that change the percent reduction needed?

MassDEP Response: The TMDLs for the MEP are the sum of the watershed nitrogen loads, the background or atmospheric deposition of nitrogen, and the benthic sediment flux. The atmospheric deposition and the benthic sediment flux are not locally controllable therefore we focus on the reduction of nitrogen sources in the watershed (septic systems, fertilizers, stormwater, landfills, etc). The percent reduction of the nitrogen load in the watershed to meet the threshold concentration at the sentinel stations (controllable load), is independent of the benthic flux and atmospheric deposition (not controllable). In the case of Waquoit Bay, the model predicted a large negative benthic sediment flux with reductions in watershed nitrogen loading. In establishing the MEP TMDLs, MassDEP sets negative benthic sediment flux to zero, which is conservative and adds to our margin of safety. (A negative flux assumes that the sediment is a nitrogen sink.) By setting the benthic sediment flux to zero, the value of the TMDL is larger than if we included a negative flux, but it does not change the reductions needed within the watershed to meet the target concentrations in the estuaries.

- 8) The Town of Falmouth and the Buzzards Bay Coalition are looking for Innovative Alternatives (IA) for nitrogen reducing septic systems with effluent concentrations under 10 ppm. The IA systems that have been approved by MassDEP have an average effluent of 19 ppm, however, the high cost of IA systems does not justify construction of a system with effluent concentrations of 19 ppm. Falmouth would like assistance from the State in getting approved IA technology that will reliably get below 10 ppm and is reasonably priced. Other states are way ahead of us.**

MassDEP Response: Other states lack the rigorous review that Massachusetts requires but also, the technologies approved by other states are not necessarily intended for nitrogen reduction. We are looking at very high levels of nitrogen treatment and the appropriate technologies do not yet exist. Although in the past three to four years, we have started to see promising new technologies with effluent concentrations less than 19 ppm, not down to 10 ppm. Approval of IA systems through the State's rigorous Title 5 process takes a minimum of 4.5 years. New I/A technologies require piloting up to 15 systems for 18 months. If provisional approval is granted, three years of data must be collected from 50 systems. The target effluent concentration must be met for 90% of the data collected under provisional approval before the system will be approved for general use.

Developing these new technologies is resource intensive, however, the State supported early research on IA systems conducted at the Massachusetts Alternative Septic System Test Center through Section 319 Grants. MassDEP will accept data from other states if the data collection is as rigorous as we would require. Non-governmental Organizations (NGOs) such as the Barnstable Clean Water Coalition and Buzzards Bay Coalition have been tremendously helpful in getting more of these systems in the ground in sufficient numbers within a watershed to monitor operations and collect data. MassDEP needs to be confident that the technology works so that we do not approve and install expensive treatment systems, only to realize in the future that the technology was inadequate and must be replaced.

- 9) There used to be an early spring algal bloom, but now there is only a summer bloom. Why is that?**

Response by Member of the Water Quality Management Committee: In the past, we used to observe algal bloom in the spring and again in the late summer, however, now we only observe

the late summer algal bloom. We attribute the lack of an early bloom due to increasing ocean temperatures rather than to the excess nitrogen. There are more jellyfish and other marine organisms that move in and eat the algae that created the early bloom. The late blooms still occur because of the amount/extent of the algae is greater than the number and types of organisms that consume it.

10) Megansett Harbor is located in Falmouth and Squeteague Harbor is located in Falmouth, and the majority of the watersheds for both are within Bourne. Is a municipal agreement between the towns required?

MassDEP Response: There are three ways the towns could approach this. First you could do a cooperative agreement with Bourne and develop a combined plan, a Comprehensive or Targeted Watershed Management Permit. This would require an Inter-Municipal Agreement (IMA). A second approach, Falmouth could address nitrogen reduction strategies within their municipal boundaries alone and Bourne could do the same. The third option, each town can address nitrogen reductions according to the percentage of the watershed that is within their respective municipal boundaries. The problem with the second and third approaches is that if only one town pursues nitrogen reduction, the estuaries will not likely see habitat recovery within an acceptable time frame.

11) Presentation by Ron Zweig: I would like to provide the example of Great Pond in Falmouth that is under evaluation with a draft water quality improvement scenario and consider Adaptive Management. For Great Pond, the current approach is to remove excess nitrogen loading on an annual mass balance basis required to achieve the nitrogen TMDL, using development of sewers in two sub-areas, a pilot permeable reactive barrier, stormwater management, nitrogen, credit from fertilizer reduction per the Town's bylaw to limit its use and shellfish aquaculture.

I would like you to consider one scenario for Great Pond shows that the nitrogen TMDL could be achievable during only the warmer months (May - September) by implementing all of the non-traditional interventions, only including sewers in sub-area 1. However, during the cold months when there would be no benefit from shellfish aquaculture, the nitrogen concentration would exceed the TN TMDL; but likely with little adverse effect during that period. Also, from the Great Pond MEP report, freshwater inflows from the Coonamessett River and groundwater seepage plus precipitation, there are just over 11 volume turnovers, with flows to Vineyard Sound, without considering additional freshening from tidal exchanges. For a preliminary draft comparison of the two approaches, please see the slide below:

**Draft Concept to Achieve Nitrogen TMDL and Nitrogen TMDL Alternative
for Great Pond estuary in Falmouth, MA (All figures in kg-N per year)**

	TMDL - MEP 12 months	TMDL Alternative May - Sept: 5 months (42%)
Annual N Removal Target	12,154	5,064
N Reduction Intervention Options		
Town Fertilizer Control By-law (25% N load credit)	425	425
Permeable Reactive Barrier (300 ft)	1,325	552
Stormwater (25% N runoff per NDPEP)	580	242
Shellfish Aquaculture (10 acres)	1,700	1,700
Existing Sewer Area (253 units) 1/	1,207	503
New Sewer -- Sub-area 1 (825 units) 2/	3,985	1,660
New Sewer -- Sub-area 2 (687 units) 2/	3,280	
Total Removal	12,502	5,082

1. Existing Little Pond Sewer Service Area partially within Great Pond watershed
2. At 4.772 kg-N/unit/year per MEP

Prepared by Ron Zweig, Falmouth Resident

MassDEP Response: TMDLS are required under the Clean Water Act to be representative of a daily load. The plan presented is the same daily load reduction but only over the summer months, which represents only a 42% reduction of the TMDL that is in place for the Great Pond estuary. The MEP model results provided load estimates to meet the target concentrations at the sentinel stations that will bring habitat recovery to the estuaries.

This plan does not meet the necessary load reductions. Even a seasonal reduction of 100% of the required annual load reduction in place over the summer months would not provide adequate protection. This plan does not consider the travel time delay – the time it takes for nitrogen entering the groundwater to eventually reach the estuaries. Reductions in the summer would not be immediately observed in the estuaries and would allow excess TN into the system for the remainder of the year. The plan you present does not take into consideration that the tidal flushing is far greater than the freshwater exchange. The plan does not consider that the sediment could be acting as a sink and that the nitrogen isn't flushed, but rather is entrained in the system.

Each TMDL that is developed out of the MEP has language that allows each town to meet the load reductions of the TMDL in any way they wish as long as they demonstrate that they can meet the target concentrations and recover the habitat. If the plan is different than the scenario proposed in the Final Tech Report, this would require additional modeling of the system to verify that the new scenario will be effective. This proposed plan seems to be a partial implementation of the MEP scenario. Keep in mind the town can address the TMDL load reductions in a phased manner with monitoring to record progress to meeting the targets.

Adaptive management allows for mid-course corrections to acknowledge changing conditions, advances in technology, etc. For example, if the target concentration is met at the sentinel station, but we do not observe estuarine recovery, then we may have to remodel the system, decrease the target concentration and require additional load reductions. Alternately if we record sustainable improvement in habitat before reaching the target threshold, we could reduce the TN reduction needed.

For clarification, an Alternative TMDL is not an option when there is a TMDL in place. The Alternative TMDL option is pursued to begin the implementation process prior to completion of a formal TMDL and must have the goal of meeting Massachusetts Surface Water Quality Standards and recovering habitat for eelgrass and or benthic habitat.

12) We have good information on nitrogen removal using shellfish. What does MassDEP think about the use of aquaculture?

MassDEP Response: Aquaculture or shellfish beds complement nitrogen removal and have shown some promise in water quality improvements. Though aquaculture does not address source control or reduction, it may help or supplement larger scale nitrogen reduction strategies. Closure of shellfishing beds is generally due to bacterial contamination and not necessarily nutrient enrichment. The most direct way to address excess nitrogen is through source control and reduction, however MassDEP understands that alternative methods may be used to assist in reducing the impacts of excess nitrogen. Several towns have explored oyster cultivation projects for water quality improvement including Wellfleet, Mashpee, Orleans and Falmouth. A lot of research is currently being conducted on the complicated and poorly understood shellfish nitrogen cycle, (ie. the uptake and release of nitrogen by shellfish).

13) The Buzzards Bay Coalition BBC encourages MassDEP to send these TMDLs to EPA for final approval as soon as possible.

MassDEP Response: Thank you for your support of the TMDL. We will do our best to finalize the TMDL in a timely manner.

14) BBC requests DEP expedite alternative technologies.

MassDEP Response: Please refer to the response to question 8 above.

15) Why are the TMDLs all different?

MassDEP Response: Every waterbody is different in the size and type of contributing land-uses, hydrology, bathymetry, and water quality and degree of impairment. The MEP was designed to provide estuary specific implementation guidance to meet the target concentrations, instead of a "one size fits all" approach. Although the target concentrations for eelgrass and benthic infauna habitat restoration are similar between estuaries, the restoration strategies (including targeted sewerage) differ between watersheds.

Email from Ron Zweig; rdzweig@gmail.com dated 12/20/2019

Dear Brian and Barbara,

Firstly, thanks for attending and presenting at the Falmouth Water Quality Management Committee meeting yesterday.

Regarding the point I made at the meeting about the comparison of the two tables from on the percent watershed reduction required when Benthic Flux figures were zeroed versus from negative values (used previously via the MEP), having no impact on the watershed reductions to meet the nitrogen TMDLs, I attach below the respective tables from the SMAST-MassDEP March 2013 and the EOEEA, DEP, BWR August 2019 reports for the Waquoit Bay system as an example. As can be seen when the Benthic Flux figure is changed from -56.779 to 0 kg-N/day,

the required watershed nitrogen reduction percentage remains the same. It is unclear to me why the percentage N reduction would not increase. Also, Footnote 3 in the 2013 report's table indicates that the Benthic Flux was estimated based on the future flux when the watershed loads have been reduced.

Sub-embayments	Present Watershed Load ¹ (kg/day)	Target Threshold Watershed Load ² (kg/day)	Direct Atmospheric Deposition (kg/day)	Benthic Flux Net ³ (kg/day)	TMDL ⁴ (kg/day)	Percent watershed reductions needed to achieve threshold load levels
WAQUOIT BAY SYSTEM						
<i>groundwater sources</i>						
Waquoit Bay	2.066	2.066	11.956	-58.779	-42.735	0.0%
Childs River - upper	12.019	4.076	0.455	-4.291	0.240	-65.1%
Eel Pond - east branch	2.170	0.820	1.011	19.480	21.310	-82.2%
Eel Pond - south basin	0.523	0.523	0.663	-4.032	-3.440	0.0%
Eel Pond - west branch	18.337	8.808	0.890	-2.900	8.798	-48.1%
Quashnet River	2.775	1.497	0.252	9.498	11.245	-48.0%
Hamblin Pond	4.381	0.953	1.529	5.712	8.184	-78.2%
Little River	1.006	0.211	0.158	2.554	2.022	-80.7%
Jehu Pond	3.812	1.025	0.674	6.897	8.598	-73.8%
Great River	3.671	0.997	1.307	14.222	16.526	-72.8%
Sage Lot Pond	2.753	1.622	0.471	-2.726	-0.833	-41.1%
<i>surface water sources</i>						
Childs River	10.822	4.115	-	-	4.115	-61.3%
Quashnet River	20.507	13.409	-	-	13.409	-34.3%
Red Brook	8.014	2.008	-	-	2.008	-73.8%
Waquoit Bay System Total	90.856	42.300	19.364	-12.957	48.657	-53.4%
(1) Composed of combined natural background, fertilizer, runoff, and septic system loadings.						
(2) Target threshold watershed load is the load from the watershed needed to meet the embayment threshold concentrations identified in Table ES-1.						
(3) Projected future flux (present rates reduced approximately proportional to watershed load reductions).						
(4) Sum of target threshold watershed load, atmospheric deposition load, and benthic flux load.						

Table 7: The Total Maximum Daily Loads (TMDL) for the Waquoit Bay System sub-embayments.

Subembayment	Present Watershed Load (kg/day)	Target Watershed Load ¹ (kg/day)	Atmospheric Deposition (kg/day)	Benthic Flux ² (kg/day)	TMDL ³ (kg/day)	Percent Reductions
<i>Groundwater</i>						
Waquoit Bay	2.09	2.09	11.96	0.00	14.04	0.0
Childs River - upper	12.02	4.08	0.46	0.00	4.53	-66.1
Eel Pond - east	2.17	0.82	1.01	19.48	21.31	-62.2
Eel Pond - south	0.52	0.52	0.66	0.00	1.19	0.0
Eel Pond - west	16.34	8.81	0.89	0.00	9.70	-46.1
Quashnet River	2.77	1.50	0.25	9.50	11.25	-46.0
Hamblin Pond	4.38	0.95	1.53	5.71	8.19	-78.2
Little River	1.10	0.21	0.16	2.55	2.92	-80.7
Jehu Pond	3.91	1.03	0.67	6.90	8.60	-73.8
Great River	3.67	1.00	1.31	14.22	16.53	-72.8
Sage Lot Pond	2.75	1.62	0.47	0.00	2.09	-41.1
<i>Freshwater</i>						
Childs River ⁴	10.62	4.12			4.12	-61.3
Quashnet River ⁴	20.51	13.47			13.47	-34.3
Red Brook ⁴	8.01	2.10			2.10	-73.8
Waquoit Bay System Total	90.87	42.30	19.36	58.36	120.02	-53.4

1- Target threshold watershed load is the load from the watershed needed to meet the embayment threshold concentrations identified in Table 4.

2- Projected sediment N loadings obtained by reducing the present loading rates (Table 5) proportional to proposed watershed load reductions and factoring in the existing and projected future concentrations of PON. (Negative fluxes set to zero.)

Also, on the question about timing that Brian Dudley had raised in the scenario I presented some clarification is needed. In so far as the existing and future sewer operation, PRB function and watershed reduction etc., except for the shellfish component, they would function on a year around basis. The benefits of shellfish would only be realized during the growing season, just prior to which it would be implemented each year. The second column in the table I showed (below attached) shows what the amount of nitrogen that would need to be removed to reduce the nitrogen load to achieve the Sentinel Threshold/N TMDL, during the growing season (about five months) from all interventions -- year around and seasonal.

**Draft Approach to Achieve Estuary Restoration via Phased, Adaptive Management
Approach for Great Pond Estuary in Falmouth, MA (All figures in kg-N per year)**

	N TMDL - MEP 12 months	Phase 1 per Falmouth Plan May - Sept: 5 months (42%)
N Removal Target	12,154	5,064
N Reduction Intervention Options		
Town Fertilizer Control By-law (25% N load credit)	425	425
Permeable Reactive Barrier (300 ft)	1,325	552
Stormwater (25% N runoff per NDPEP)	580	242
Shellfish Aquaculture (10 acres) 1/	1,950	1,950
Existing Sewer Area (253 units) 2/	1,207	503
New Sewer -- Sub-area 1 (811 units) 3/	3,870	1,613
New Sewer -- Sub-area 2 (687 units) 3/	3,280	
Total Removal	12,637	5,284

1. Nitrogen removal lowest estimate -- 62% of maximum estimate.
2. Existing Little Pond Sewer Sevice Area partially within Great Pond watershed
3. At 4.772 kg-N/unit/year per MEP

The Great Pond estuary could be an excellent opportunity to pilot the concept under the first phase of Falmouth's plan to remediate the water quality in that estuary per the current plan. Whether this strategy would be as effective as envisioned would need to be verified via a monitoring program of N concentrations in the water column during the growing season as well as the potential resultant impact on the recovery of biota in the estuary. If unsuccessful, a second phase of sewer expansion or other interventions in the watershed would then be initiated. I hope this makes some of what I presented yesterday clear enough. Your views, any questions or need for further clarification would be welcome.

Thanks again.

With best wishes to you and your families for the holiday season.

Respectfully yours,

Ron Zweig

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*MassDEP Response: See responses to comments 7 and 11 above.*



January 21, 2020

Barbara J. Kickham, TMDL Section Chief  
MA Department of Environmental Protection  
Watershed Planning Program  
8 New Bond Street  
Worcester, MA 01616

**Re: Buzzards Bay Coalition Requests the Immediate Approval as Final of the Megansett-Squeteague Harbor Estuarine System Total Maximum Daily Loads for Total Nitrogen (CN-452.0)**

Dear Ms. Kickham,

The Buzzards Bay Coalition (Coalition) has reviewed the Draft Megansett-Squeteague Harbor Estuarine System Total Maximum Daily Loads for Total Nitrogen (CN-452.0) dated August 2019 (draft Megansett-Squeteague TMDL). The Coalition urges the Massachusetts Department of Environmental Protection (MassDEP) to send the draft Megansett-Squeteague TMDL to the US Environmental Protection Agency (EPA) to approve as final. This letter follows our comments at the public meeting in Falmouth on December 19, 2019.

The draft Megansett-Squeteague TMDL confirms the need for nitrogen reductions. The TMDL forms the basis for the towns of Falmouth and Bourne to create plans for how they will reduce nitrogen pollution in the Megansett-Squeteague watershed to meet the TMDL. Delay in TMDL approval will postpone and hinder local action on nitrogen reductions and lead to further degradation of Megansett and Squeteague Harbors.

The Coalition is a membership-supported non profit organization dedicated to the restoration, protection and sustainable use and enjoyment of Buzzards Bay and its watershed including the watersheds of all three estuary systems. The Coalition is supported by more than 10,000 individuals, families, and businesses throughout the region including over 1,400 members affected by water quality in Falmouth and 647 members affected by water quality in Bourne.

The Coalition requests that the MassDEP and EPA consider the following comments in assessing whether these TMDLs successfully achieve water quality standards in Megansett and Squeteague Harbors.

**Background:**

The Towns of Falmouth and Bourne thrive on clean, productive and beautiful marine waters. Swimming, fishing, boating, fin-fishing, and shellfishing all support the local economy. However, as recognized by the draft TMDLs, the continued degradation of water quality due to nitrogen pollution in these estuaries reduces their recreational and commercial values.

The Federal Clean Water Act requires the Commonwealth of Massachusetts to identify waters that fail to meet water quality standards. The state is required to draft TMDLs establishing the maximum load (amount) of pollution from all sources that the identified water may receive and still meet water quality standards. The nitrogen capacity of Megansett and Squeteague Harbors were evaluated through the Massachusetts Estuaries Project (MEP) and the Megansett-Squeteague MEP report was finalized in 2015. The MEP report documented impairment of the water bodies and the need for nitrogen reductions.

The water quality in Megansett and Squeteague Harbors is degraded by nitrogen pollution. High nitrogen loads from septic systems, stormwater, and fertilizers cause low dissolved oxygen levels, elevated algae levels, loss of eelgrass, and decreased diversity and quantity of marine animals living on the seafloor. During the past 28 years, the Coalition has collected water quality data from three sites in Squeteague Harbor, and five sites in Megansett Harbor that clearly documents this impairment, including common incidences of dissolved oxygen levels less than 6 mg/L. Without reduction, these nitrogen loads could lead to further water quality and habitat degradation including fish kills, unpleasant odors and scums, and loss of critical marine animal communities.

**Major Findings of the TMDL:**

Both Megansett and Squeteague Harbors are listed as waterbodies needing a TMDL for nutrients. There has been significant decline in eelgrass coverage since 1995 in Megansett Harbor and the benthic infauna habitat has been degraded in Squeteague Harbor and the Megansett Channel. The draft Megansett-Squeteague TMDL establishes a target threshold concentration for total nitrogen in outer Megansett Harbor of 0.35 mg/L at the sentinel station MG2. The draft Megansett-Squeteague TMDL asserts that water quality standards for the entire system will be met when this target concentration is met, which will lead to improved water clarity, restoration of eelgrass habitat, and high quality habitat for seafloor species.

To meet the target thresholds and obtain water quality standards requires reductions in the watershed nitrogen loads of all three areas (17% in Megansett Harbor, 7.5% in Megansett Channel, and 5.6% in Squeteague Harbor), which equates to a 12% reduction to the whole system. The draft Megansett-Squeteague TMDL presents a scenario of meeting the target threshold via reductions from septic systems. A 19.3% reduction of the existing load from septic systems would achieve the target threshold nitrogen concentration of 0.35 mg/L at the sentinel station.

**TMDL Implementation:**

The draft Megansett-Squeteague TMDL presents a single scenario for nitrogen load reduction focused on septic system load removal. Targeting septic systems is prudent since the majority of the total controllable nitrogen load is from septic systems. It is now the responsibility of the Towns to develop and implement a Comprehensive Wastewater Management Plans (CWMP) that will assess the most cost-effective options for achieving the target nitrogen watershed loads, including possible sewerage at either centralized or de-centralized (i.e., neighborhood scale) locations and the use of nitrogen-reducing septic systems.

The Coalition looks forward to working with the Town of Falmouth, Town of Bourne, MassDEP, EPA, and local stakeholders in the development and implementation of CWMPs for Megansett and Squeteague Harbors. The Coalition has partnered with homeowners around the watershed to upgrade to nitrogen-reducing septic systems, including 30 homeowners around West Falmouth Harbor in collaboration with the Town of Falmouth. This effort has shown the capability of the systems to provide significant nitrogen reductions and the Coalition is ready to provide information on the learnings of these efforts for application in places such as the Megansett-Squeteague watershed.

**Comments:**

In order to expeditiously proceed with nitrogen reduction planning and implementation, the Coalition urges the MassDEP to send the draft Megansett-Squeteague TMDL to the EPA to approve as final as soon as possible. However, we request that EPA and MassDEP consider the following comments in the implementation of these TMDLs and in their future updates. We do not suggest that any of the issues discussed below justify re-evaluation or further delays in issuance of the draft Megansett-Squeteague TMDL.

**1. The TMDLs' categorization of all septic systems into the Load Allocation is inaccurate.**

The MEP technical report acknowledges that the geology of Cape Cod and the Islands allows water to move rapidly through the ground, and the draft TMDL includes stormwater from impervious surfaces within 200 feet of the shoreline as point sources and includes it in the Waste Load Allocation. Septic systems within the watershed of Megansett-Squeteague Harbor should also be included in the Waste Load Allocation. The rapid movement of wastewater from septic systems to coastal waters, without significant attenuation of nitrogen, makes it appropriate to consider septic systems as part of the Waste Load Allocation. Nevertheless, we encourage EPA to finalize the draft Megansett-Squeteague TMDL, but suggest that MassDEP and EPA develop a methodology for allocating septic systems into the Waste Load Allocation portion of TMDLs in order to more effectively regulate septic systems as the primary point source of nitrogen in southeastern Massachusetts estuaries.

**2. The effects of climate change on water quality have not been adequately addressed in this TMDL; a larger Margin of Safety should be considered in future TMDLs.**

The TMDL states that “MassDEP believes that impacts of climate change should be addressed through TMDL implementation with an adaptive management approach in mind.” Research into the Coalition’s long-term water quality database, attached here, indicates Buzzards Bay waters are warming. At the same time, the relationship between nitrogen concentrations and algae growth (as measured by algal pigment concentrations) has shifted, with higher levels of algae growth occurring in more recent years than 25 years ago at the same nitrogen concentration. This shift in the relationship suggests that with a warming climate, greater algae growth and ecological impairment may occur than expected based on historic nitrogen concentrations.

The draft TMDL anticipates that an adaptive management approach will be utilized to assess the effectiveness of the TMDL and CWMP implementation. The adaptive management approach provides an opportunity to incorporate new understandings such as the effect of temperature on algae growth. To restore water quality, it is critical that adaptive management is effectively implemented and additional steps are taken if necessary.

**3. Eelgrass recovery targets may require lower nitrogen thresholds.**

Extensive eelgrass loss has occurred over the last century in Megansett Harbor with a very dramatic decline between 1951 and 1995. Since 1995, additional significant losses have occurred, with almost 40% of the remaining eelgrass disappearing between 1995 and 2012. The draft TMDL’s primary restoration focus for the outer basin of Megansett Harbor is the recovery and protection of eelgrass habitat. A nitrogen threshold of 0.35 mg/L at sentinel station MG2 was selected as a target for restoring eelgrass.

The total nitrogen concentration at station MG2, as measured by the Baywatchers Monitoring Program fluctuated around the threshold level of 0.35 mg/L between 2000 and 2013. During this time period, eelgrass loss occurred. This suggests that the total nitrogen threshold of 0.35 mg/L may need to be maintained consistently for a number of years for eelgrass restoration to occur or that a lower total nitrogen concentration is required. Monitoring of both the nitrogen concentrations and eelgrass recovery will be required to assess whether nutrient reductions result in consistently lower nitrogen concentrations at the sentinel station and whether this allows for eelgrass recovery. Adaptive management plans need to anticipate and react to this monitoring information.

**4. An implementation schedule and monitoring plan should be promptly developed.**

The establishment of this TMDL anticipates that actions will be taken to meet the TMDL so that Megansett and Squeteague Harbors will be restored and meet water quality standards. We encourage MassDEP to work with the towns to develop a timeframe for TMDL implementation

and a plan for monitoring. The timeframe should lay out a set of milestone goals that the towns can work towards achieving.

The TMDL states that "existing monitoring programs which were designed to thoroughly assess conditions and populate water quality models can be substantially reduced for compliance monitoring purposes." The TMDL indicates that about half the current effort would be sufficient to observe water quality changes. The MassDEP should clearly define what exactly it means by this.

Since 1992, through its Baywatchers Monitoring Program, the Coalition has performed summertime water quality monitoring in Megansett and Squeteague Harbors. This data forms the long-term water quality monitoring records used in the development of the MEP report that the TMDL is based upon. The Coalition intends to continue our water quality monitoring program and provides our data free of charge to any interested parties.

Funding for the Baywatchers Monitoring Program comes from a variety of sources including grants from federal and state sources, private foundations, and member contributions. For much of its history, the Coalition has received significant annual funding (~\$125,000) from the MA State Legislature. There is \$75,000 to support the Baywatchers Monitoring Program in the FY20 State Budget. As we consider how to modify our program with limited resources, MassDEP needs to clarify what it will require for monitoring of TMDL compliance.

**Summary:**

The issuance of this TMDL is a critical step in restoring the water quality of Megansett and Squeteague Harbors. The draft TMDL confirms the need for nitrogen reductions and requires the towns of Falmouth and Bourne to create plans for how they will reduce nitrogen to meet the TMDL. The Coalition urges the MassDEP to send the draft Megansett-Squeteague TMDL to the EPA to approve as final so that the towns of Falmouth and Bourne can begin planning for how to meet the required nitrogen reductions.

Sincerely,



Mark Rasmussen, President  
Buzzards Bay Coalition

Attachment

cc: Kathleen Theoharides, MA Secretary of Energy & Environmental Affairs

Martin Suuberg, MassDEP Commissioner  
Patti Kellogg, Bureau of Water Resources, MassDEP – SERO  
Kenneth Moraff, US EPA

Town of Falmouth  
Board of Selectmen  
Water Quality Management Committee  
Conservation Commission  
Board of Health  
Planning Board  
Wastewater Department

Town of Bourne  
Board of Selectmen  
Sewer Commissioners  
Conservation Commission  
Board of Health  
Planning Board  
Department of Public Works

US Congressman William Keating  
Representative David Vieira  
Representative Dylan Fernandes

Cape Cod Commission

Attachment:

Rheuban JE, Williamson S, Costa JE, Glover DM, Jakuba RW, McCorkle DC, Neill C, Williams T, and Doney SC. 2016. Spatial and temporal trends in summertime climate and water quality indicators in the coastal embayments of Buzzards Bay, Massachusetts. *Biogeosciences*, 13, 253-265.

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MassDEP Response: Thank you for your support of the TMDL for the Megansett-Squeteague Harbors system. In addition, thank you for your long-term commitment (>25 years) to data collection efforts in this estuary and throughout Buzzards Bay. The importance of these data cannot be overstated. Your major comments are addressed below.

The TMDL’s categorization of all septic systems into the Load Allocation portion of the draft Megansett-Squeteague Harbors TMDL is inaccurate.

MassDEP Response: The scientific analysis underlying TMDLs is designed to address pollutant loading based on watershed scale modeling. The Linked Model that was used to develop the TMDL is not a fate and transport model that predicts the movement of individual pollutants (e.g., nitrate) in groundwater from a particular source or sources. Instead, it is designed to assess the sensitivity to nitrogen loading within the embayment; the assimilative capacity for nitrogen within that surface water; and water quality responses within the embayment to changes in nitrogen loading rates (i.e., as opposed to measuring nitrogen loads from particular sources). Accordingly, the Linked Model does not contain the type of data or level and scale of analysis necessary to predict the fate and transport of pollutants through groundwater from any specific

source or to support a specific determination that a discharge to the ground or groundwater has a direct and immediate hydrological connection to surface water. Although the model links watershed inputs with embayment circulation and nitrogen characteristics, it conservatively assumes that nitrogen moves through groundwater and that nitrogen directly transported via groundwater enters the embayments. In short, the data and analysis provided, which supports the regional framework required for a TMDL, simply does not contain the type of data or level and scale of analysis that can support the site- and source-specific ecological determinations necessary to find that a discharge via groundwater has a direct and immediate hydrological connection to surface waters for any given source on Cape Cod. Therefore, MassDEP considered the pollutant loads discharged from septic systems and WWTFs discharging to soils to be nonpoint sources for purposes of the TMDL, and it allocated these sources to the LA.

The effects of climate change on water quality have not been adequately addressed in this TMDL; a larger Margin of Safety should be considered in future TMDLs.

MassDEP Response: MassDEP recognizes that long-term climate change impacts to southeastern Massachusetts are occurring based on known science. However, the details of how climate change will affect future precipitation, streamflow, sediment and nutrient loading in specific locations are generally unknown. In light of the uncertainties, MassDEP has chosen to address the uncertainty of climate change through an implicit MOS (i.e., incorporated into the TMDL through conservative assumptions). Furthermore, TMDLs are developed and implemented with an adaptive management approach. MassDEP will address climate change issues more specifically through TMDL implementation, as warranted.

Eelgrass recovery targets may require lower nitrogen thresholds.

MassDEP Response: MassDEP agrees that a lower nitrogen concentration at the sentinel station may be required to observe habitat recovery. The goal of the TMDL for Megansett-Squeteague Harbors is to restore the estuary habitats first for eelgrass with a consequent improvement in the benthic infauna habitat and the target concentration of 0.35 mg/L at station MG-2 is the guide to getting there. If we reach the target concentration at the sentinel station but do not observe eelgrass habitat improvement, then the TMDL allows, through the process of Adaptive Management, a re-evaluation of the nitrogen reduction strategy and lowering of the target concentration. The threshold concentration is a target, but the final goal is habitat restoration. Proposed nitrogen reductions within the watershed should be fully implemented, prior to reevaluating sentinel station concentrations, particularly if habitat recovery is not observed. Establishing a revised target concentration and nitrogen reduction strategy will likely require additional modeling.

An implementation schedule and monitoring plan should be promptly developed.

MassDEP Response: MassDEP is working with the watershed towns for these TMDLs in developing or implementing Comprehensive Water Resources or Wastewater Management Plans (CWRMP or CWMP). Each of the towns is progressing and is at different stages in the process. Implementation plans and schedules are not required as part of the TMDL but are required in watershed permits and CWRMP/CWMPs. The Town of Bourne issued a request for proposal

(RFP) to develop a CWMP on December 30, 2019. Through the CWMP the town will incorporate the TMDL and develop an implementation schedule.

The Town of Falmouth was issued a certificate from the Massachusetts Policy Act office (MEPA) for a third Notice of Project Change (NPC) for the CWMP on February 7, 2020 (EEA #14154). The NPC “summarized data collected through water quality monitoring and reviewed the status and effectiveness of pilot projects, including shellfish aquaculture, permeable reactive barriers (PRBs), eco-toilets, I/A septic systems, adoption of a Nitrogen Control Bylaw for fertilizer, stormwater management and the Bourne Pond inlet widening project.” The third NPC provided updates on the Target Watershed Management Plans (TWMP) for Falmouth’s southern estuaries and West Falmouth Harbor. The goal of CWMP is to meet Surface Water Quality Standards through the achievement of the TMDLs.

General and Frequently Asked Questions:

- 1. Can a Comprehensive Water Resources Management Plan (CWRMP) include the acquisition of open space, and if so, can State Revolving Funds (SRF) be used for this?**

MassDEP Response: State Revolving funds can be used for open space preservation if a specific watershed property has been identified as a critical implementation measure for meeting the TMDL. The SRF solicitation should identify the land acquisition as a high priority project for this purpose which would then make it eligible for the SRF funding list. However, it should be noted that preservation of open space will only address potential future nitrogen sources (as predicted in the build-out scenario in the MEP Technical report) and not the current situation. The town will still have to reduce existing nitrogen sources to meet the TMDL.

- 2. Do we expect eelgrass to return if the nitrogen goal is higher than the concentration that can support eelgrass?**

MassDEP Response: There are a number of factors that can control the ability of eelgrass to re-establish in any area. Some are of a physical nature (such as boat traffic, water depth, or even sunlight penetration) and others are of a chemical nature like nitrogen. Eelgrass decline in general has been directly related to the impacts of eutrophication caused by elevated nitrogen concentrations. Therefore, if the nitrogen concentration is elevated enough to cause symptoms of eutrophication to occur, eelgrass growth will not be possible even if all other factors are controlled. The eelgrass will not return until the water quality conditions improve. Where there is no historical evidence of eelgrass, the target concentration has been set at a higher concentration than generally tolerated by eelgrass, with the goal of restoring the benthic habitat.

- 3. Who is required to develop the CWRMP? Can it be written in-house if there is enough expertise?**

MassDEP Response: The CWRMP can be prepared by the town. There are no requirements that it must be written by an outside consultant; however, the community should be very confident that its in-house expertise is sufficient to address the myriad issues involved in the CWRMP process. MassDEP would strongly recommend that any community wishing to undertake this endeavor on its own should meet with MassDEP to develop an appropriate scope of work that will result in a robust and acceptable plan.

4. Have others written regional CWRMPs (i.e. included several neighboring towns)?

MassDEP Response: The Cape Cod Commission prepared a Regional Wastewater Management Plan or RWMP which formed a framework and set of tools for identifying several solutions for restoring water quality for each watershed on the Cape. The Section 208 Plan Update (or 208 Plan) is an area-wide water quality management plan and in general each town then prepared or is preparing its own CWRMP. An example of neighboring towns working on a regional plan is the Pleasant Bay Alliance which consists of Orleans, Brewster, Harwich, and Chatham. Harwich, Dennis and Yarmouth are in discussions regarding a shared wastewater treatment plant.

Joint Comprehensive Wastewater Management Plans (CWMPs) have been developed by multiple Towns particularly where Districts are formed for purposes of wastewater treatment. Some examples include the Upper Blackstone Water Pollution Abatement District that serve all or portions of the towns Holden, Millbury, Rutland West Boylston and the City of Worcester and the Greater Lawrence Sanitary District that serves the greater Lawrence area including portions of Andover, N. Andover, Methuen and Salem NH. There have also been recent cases where Towns have teamed up to develop a joint CWMP where districts have not been formed. The most recent example is the Towns which discharge to the Assabet River. They include the Towns of Westboro and Shrewsbury, Marlboro and Northborough, Hudson, and Maynard. The reason these towns joined forces was because as a group, they received more priority points in the State Revolving Fund application process than they otherwise would have as individual towns.

5. Does nitrogen entering the system close to shore impair water quality more? If we have to sewer, wouldn't it make sense to sewer homes closer to the shore?

MassDEP Response: Homes closer to the waterbody allow nitrogen to get to that waterbody faster (shorter travel times). Those further away may take longer but still get there over time and are dependent upon the underlying geology. However, what is more important is the density of homes. Larger home density means more nitrogen being discharged thus the density typically determines where to sewer to maximize reductions. Also, there are many factors that influence water quality such as flushing and morphology of the water body.

6. Do you take into account how long it takes nitrogen in groundwater to travel to the estuaries?

MassDEP Response: Yes, the MEP Technical report has identified long term (greater than 10 years) and short-term time of travel boundaries in the ground-watershed.

7. What if a town can't meet its TMDL?

MassDEP Response: A TMDL is simply a nutrient budget that determines how much nitrogen reduction is necessary to meet water quality goals as defined by state Water Quality Standards. It is unlikely that the TMDL cannot be achieved however in rare occasions it can happen. In those rare cases the Federal Clean Water Act provides an alternative mechanism which is called a Use Attainability Analysis (UAA). The requirements of that analysis are specified in the Clean Water Act but to generalize the process, it requires demonstration that the designated use cannot be achieved. In other words, demonstrate that the body of water cannot support its designated uses such as fishing, swimming or protection of aquatic biota. Demonstrating this is very difficult and must be approved by the U.S. Environmental Protection Agency. As long as a plan is developed and actions are being taken at a reasonable pace to achieve the goals of the TMDL, MassDEP will use discretion in taking enforcement steps. However, in the event that reasonable progress is not being made, MassDEP can take additional regulatory action through the broad authority granted by the Massachusetts Clean Waters Act, the Massachusetts Water Quality Standards, and through point source discharge permits and MS4 stormwater permits.

8. What is the relationship between the linked model and the CWRMP?

MassDEP Response: The model is a tool that was developed to assist the Town to evaluate potential nitrogen reduction options and determine if they meet the goals of the TMDL at the established sentinel station in each estuary. The CWRMP is the process used by the Town to evaluate your short and long-term needs, define options, and ultimately choose a recommended option and schedule for implementation that meets the goals of the TMDL. The models can be used to assist the Towns during the CWRMP process.

9. Is there a federal mandate to reduce fertilizer use?

MassDEP Response: No, it is up to the states and/or towns to address this issue. However, the Massachusetts Department of Agricultural Resources (MassDAR) passed plant nutrient regulations (330 CMR 31.00) in June 2015, which requires specific restrictions for agricultural and residential fertilizer use, including seasonal restrictions, on nutrient applications and setbacks from sensitive areas (public water supplies and surface water) and Nutrient Management Plans. Compliance with the MassDAR regulations will result in reductions in future N loading from agricultural sources.

10. Will monitoring continue at all stations or just the sentinel stations?

MassDEP Response: At a minimum, MassDEP would like to see monitoring continued at the sentinel stations bi-monthly, May-September in order to determine compliance with the TMDL. However, ideally, it would be good to continue monitoring all of the stations, if possible. The benthic stations can be sampled every ~5 years since changes are not rapid. The towns may want to sample additional locations if warranted. MassDEP intends to continue its program of eelgrass monitoring in cooperation with the Massachusetts Maritime Academy.

11. What is the state’s expectation with CWRMPs?

MassDEP Response: The CWRMP is intended to provide the Towns with potential short and long-term options to achieve water quality goals and therefore provides a recommended plan and schedule for sewerage/infrastructure improvements and other nitrogen reduction options necessary to achieve the TMDL. The state also provides a low interest loan program called the state revolving fund or SRF to help develop these plans. Towns can combine forces to save money when they develop their CWRMPs.

12. Can we submit parts of the plan as they are completed?

MassDEP Response: Submitting part of a plan is not recommended because absent a comprehensive plan, a demonstration cannot be made that the actions will meet the requirements of the TMDL. With that said however the plan can contain phases using an adaptive approach if determined to be reasonable and consistent with the TMDL.

13. How do we know the source of the bacteria (septic vs. cormorants, etc.)?

MassDEP Response: This was not addressed because this is a nitrogen TMDL and not a bacteria TMDL.

14. Is there a push to look at alternative new technologies?

MassDEP Response: MassDEP recommends communities consider all feasible alternatives to develop the most effective and efficient plans to meet water quality goals. The 208 Plan Update includes an analysis of a wide range of traditional and alternative approaches to nutrient reduction, remediation, and restoration. If a CWRMP relies on such alternative technologies and approaches, the plan must include demonstration protocols, including monitoring, that will confirm that the proposed reduction credits and, when appropriate, removal efficiencies are met. The implementation schedule is in the demonstration protocol for each alternative technology or approach, at which time a determination must be made as to whether the alternative technology/approach meets the intended efficacy goal. MassDEP is also developing Watershed Permits (or Targeted Watershed Management Plans), which includes but is not limited to Under Ground Injection Control (UIC) and groundwater discharge permits and provides a permitting mechanism to approve nontraditional methods of wastewater management and/or impact

mitigation that could not otherwise be approved by MassDEP under a typical wastewater management and discharge permit. Watershed permits include implementation timetables, standards to be achieved, and long-term monitoring to evaluate water quality improvements.

The Massachusetts Alternative Septic System Test Center, located on Cape Cod and operated by the Barnstable County Department of Health and Environment, tests and tracks advanced innovative and alternative septic system treatment technologies. In addition, MassDEP evaluates pilot studies for other alternative technologies; however, absent a CWRMP and Watershed Permit, MassDEP will not approve a system for general use unless it has been thoroughly studied and documented to be successful.

15. How about using shellfish to remediate and reduce nitrogen concentrations?

MassDEP Response: The use of shellfish to remediate and reduce nitrogen concentrations is an alternative approach that has been utilized and is being evaluated in some areas of Long Island Sound (LIS), Wellfleet, and Chesapeake Bays. More recently, some Cape communities have been evaluating this method, including Falmouth, Mashpee and Orleans. While this approach has demonstrated promise for reducing nitrogen concentrations, there remain questions regarding the effectiveness and circumstances where it can be successfully utilized. MassDEP recommends communities considering this option discuss such plans with the Department and evaluate the results from ongoing efforts on the Cape and on other states.

16. The TMDL is a maximum number, but we can still go lower.

MassDEP Response: The state's goal is to achieve designated uses and water quality criteria. There is nothing however that prevents a Town from implementing measures that go beyond that goal. It should also be noted that the TMDL is developed conservatively with a factor of safety included.

17. Isn't it going to take several years to reach the TMDL?

MassDEP Response: It is likely that several years will be necessary to achieve reductions and to see a corresponding response in the estuary. However, the longer it takes to implement solutions, the longer it is going to take to achieve the goals.

18. The TMDL is based on current land use but what about future development?

MassDEP Response: The TMDL is based on a habitat restoration target(s) for conditions during the period of data collection. Buildout was considered in the MEP model as part of scenario runs to evaluate implementation strategies. Evaluation of buildout conditions must be considered as part of the CWMP.

SIGN IN SHEET 12/19/2019
 Waquoit Bay, Falmouth Inner Harbor, Megansett and Squeteague Harbors Estuarine Systems
 Nitrogen TMDL Public Meeting

Print Name	Affiliation
1. Tom Duncan	FALMOUTH WASTEWATER MGMT. COMM
2. Krisen Rathjen	Science Waves
3. Eric Turley	Falmouth WSDC
4. Jeff Greys	GHD INC.
5. Virginia Valiela	Falmouth WDMC
6. Stephen Leighton	" "
7. PETER FANK	Falmouth Water Stewards
8. Rachel Jakuba	Buzzards Bay Coalition
9. Korrin Petersen	" "
10. LAURA BLAKE	MASS DEP
11. Barbara Kichham	Mass DEP
12. Drew Osei	Mass DEP

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	Print Name	Affiliation
13.	BRIAN DUDLEY	MASS DEP
14.	Ed Schuer	TMDL Solutions
15.	Brian Howes	SMAS - UMD
16.	Amy Lowell	Town - Wastewater Dir
17.	FROLDREYER	PLANNING BOARD
18.	Patti Kellogg	Mass DEP
19.		
20.		
21.		
22.		
23.		