Final Wareham River Estuary System
Total Maximum Daily Load
for Total Nitrogen

Commonwealth of Massachusetts
Executive Office of Energy and Environmental Affairs
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May 2024

CN 549.1

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Prepared by:
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Massachusetts Department of Environmental Protection

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Available Online
https://www.mass.gov/lists/total-maximum-daily-loads-by-watershed

Massachusetts Department of Environmental Protection

The mission of the Massachusetts Department of Environmental Protection (MassDEP) is to protect and enhance the Commonwealth's natural resources – air, water, and land – to provide for the health, safety, and welfare of all people, and to ensure a clean and safe environment for future generations. In carrying out this mission MassDEP commits to address and advance environmental justice and equity for all people of the Commonwealth; provide meaningful, inclusive opportunities for people to participate in agency decisions that affect their lives; and ensure a diverse workforce that reflects the communities we serve.

Watershed Planning Program

The mission of the Watershed Planning Program (WPP) in the Massachusetts Department of Environmental Protection is to protect, enhance, and restore the quality and value of the waters of the Commonwealth. Guided by the federal Clean Water Act, WPP implements this mission statewide through five Sections that each have a different technical focus: (1) Surface Water Quality Standards; (2) Surface Water Quality Monitoring; (3) Data Management and Water Quality Assessment; (4) Total Maximum Daily Load; and (5) Nonpoint Source Management. Together with other state environmental agencies, WPP shares in the duty and responsibility to secure the environmental, recreational, and public health benefits of clean water for all people of the Commonwealth.

Acknowledgements

The Wareham River Estuary System TMDL for Total Nitrogen was developed with data collected, compiled, and analyzed by the University of Massachusetts Dartmouth's School of Marine Science and Technology (SMAST), the Southeast Regional Planning & Economic Development District (SRPEDD), the Buzzards Bay Coalition (BBC) BayWatchers Water Quality Monitoring Program, and the Town of Wareham, as part of the Massachusetts Estuaries Project (MEP).

Disclaimer

References to trade names, commercial products, manufacturers, or distributors in this report constituted neither endorsement nor recommendations by MassDEP.

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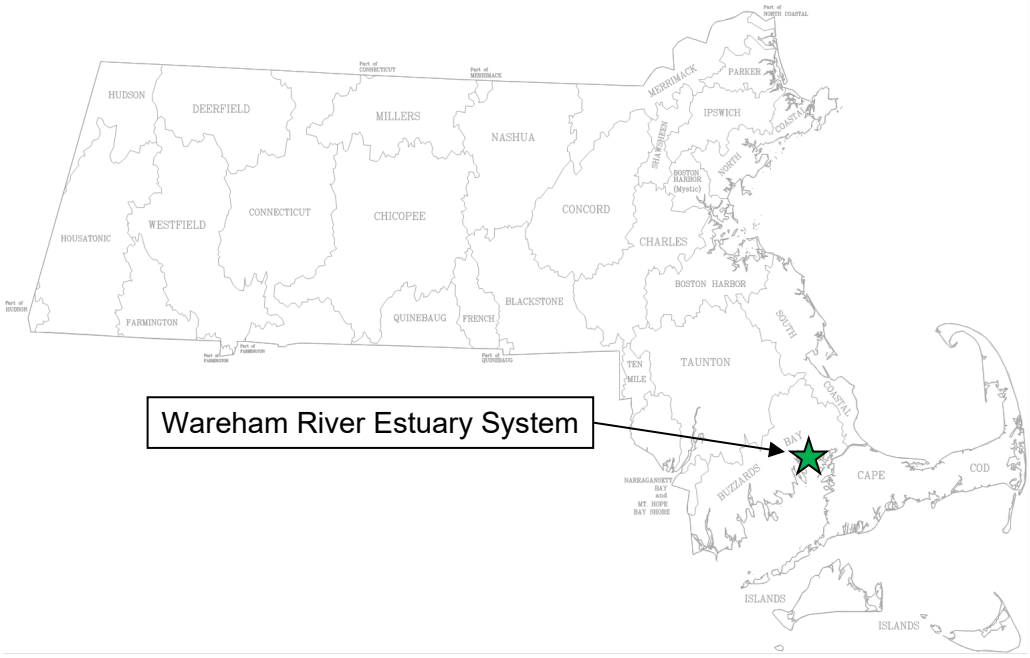

Key Feature:	Total Nitrogen TMDL for the Wareham River Estuary System
Location:	EPA Region 1 – MA Towns of Wareham, Plymouth, & Carver
Land Type:	New England Coastal
2022 Integrated List of Waters Category 5 303d Listings:	Wareham River (MA95-03) - *Total Nitrogen* - *Chlorophyll-a* - *Estuarine Bioassessments* Agawam River (MA95-29) - *Total Nitrogen* - *Algae* - *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.; Southeast Regional Planning & Economic Development District, Cape Cod Commission, Buzzards Bay Coalition (BBC) Baywatchers
Data Mechanism:	Massachusetts Surface Water Quality Standards, Ambient Data, and Linked Watershed-Embayment Nitrogen Model
Monitoring Plan:	Buzzards Bay Coalition (BBC) BayWatchers Water Quality Monitoring Program with assistance from SMAST-UMD
Control Measures:	Sewer Network Expansion, Wastewater Treatment Facility Improvements, Stormwater Management, Attenuation by Impoundments and Wetlands, Fertilizer Use By-laws

Executive Summary

The Massachusetts Department of Environmental Protection (MassDEP) is responsible for monitoring the waters of the Commonwealth, identifying those waters that are impaired, and developing a plan to bring them back into compliance with the Massachusetts Surface Water Quality Standards. The list of impaired waters, also referred to as Category 5 of the State Integrated List of Waters or the "303d list", identifies river, lake, and coastal waters and the cause for impairment. All impaired waters listed in Category 5 require the development of a Total Maximum Daily Load (TMDL).

Once a waterbody is identified as impaired (i.e., not supporting designated uses as established in the Massachusetts Surface Water Quality Standards), MassDEP is required by the federal Clean Water Act (CWA) to essentially develop a "pollution budget" designed to restore the health of the impaired waterbody. The process of developing this pollution budget, generally referred to as a TMDL, includes identifying the source(s) of the pollutant from direct discharges (point sources) and indirect discharges (nonpoint sources), determining the maximum amount of the pollutant that can be discharged to a specific waterbody to meet water quality standards, and developing a plan to meet that goal.

This report develops total nitrogen TMDLs for an interconnected set of six waterbodies within the Wareham River, Broad Marsh, and Marks Cove Embayment System and its upstream waters, hereinafter referred to as the "Wareham River Estuary System".

Problem Statement

Excessive nitrogen (N) originating from a range of sources has impaired the Wareham River Estuary System. In general, excessive N in these waters are indicated by:

- Loss of eelgrass beds, which are critical habitats for macroinvertebrates and fish;
- Undesirable increases in macroalgae, 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; and
- Periodic algae blooms.

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

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

While the estuary is located entirely within the Town of Wareham, its watershed is located within the three towns of Wareham, Carver, and Plymouth. The communities surrounding the Wareham River Estuary System rely on clean, productive, and aesthetically pleasing marine and estuarine waters for recreational boating and swimming, as well as fishing and shellfishing. Failure to reduce and control N loadings will result in complete replacement of eelgrass by macroalgae, a higher frequency of decreases in dissolved oxygen concentrations and fish kills, widespread occurrence of unpleasant odors and visible scum, and a complete loss of benthic macroinvertebrates throughout most of the embayment. As a result of these environmental impacts, commercial and recreational uses of the Wareham River Estuary System coastal waters will be greatly reduced.

Sources of Nitrogen

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

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

Figure ES-A illustrates the percent contribution of all the sources of N and the *controllable* N sources to the estuary system, respectfully. Values are based on Table IV-2 and Figure IV-5 from the Massachusetts Estuaries Project (MEP) Technical Report (Howes *et. al*, 2014). Most of the present *controllable* load to this system comes from agriculture and septic systems.

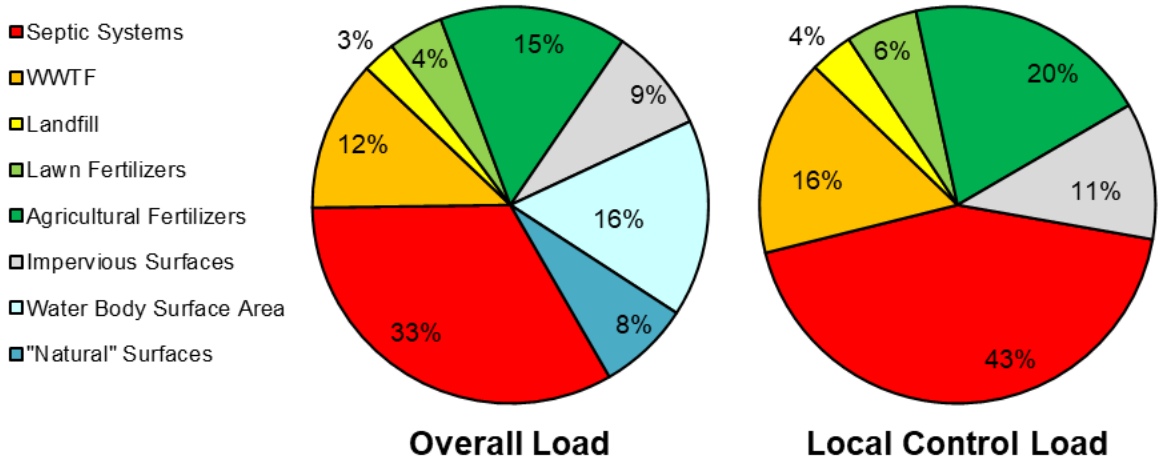

Figure ES-A: Nitrogen loading sources in the Wareham River Estuary System watershed

Target Threshold Nitrogen Concentrations and Loadings

The Wareham River Estuary System and its associated watershed is located primarily within the Town of Wareham, in southeastern Massachusetts. A portion of the watershed to the estuarine system extends into the Towns of Plymouth and Carver. The N that enters the estuary each day (N load) is 232.72 kg/day [1]. The total N load includes the present watershed load in addition to direct atmospheric deposition and benthic flux (Howes *et al.,* 2014, Table ES-1).

The resultant average annual N concentration was 0.50 mg/L (milligrams per liter of N) within the Wareham River Estuary System and ranged from 0.408 to 0.649 mg/L at the 15 monitoring stations where data were collected from 2005 through 2011. The average of the separate yearly means at each station, as reported in Table VI-1 of the MEP Technical Report, are included in Appendix B of this report.

[1] *MassDEP set negative benthic fluxes to zero when developing nitrogen TMDLs from the MEP loading analysis.*

To restore and protect the estuarine system, N loadings, and subsequently N concentrations in the water, must be reduced to levels below the thresholds that cause the observed environmental impacts. These concentrations will be referred to as the *target threshold N concentrations*. It is the goal of the TMDL to reach these target threshold N concentrations, as it has been determined for each impaired waterbody segment. The MEP has determined that total N (TN) concentrations of 0.40 mg/L and 0.42 mg/L at the Lower Wareham River (WR-6) and Upper Wareham River (WR-3) sentinel stations, respectively, are the appropriate threshold values for the restoration of eelgrass at locations within the system where it has historically been present. To ensure restoration of infaunal habitat throughout the embayment and tributaries, secondary target concentrations were established at two locations within the Wareham River Estuary System: a TN level of 0.5 mg/L at the Upper Wareham River (WR-2) and at Lower Broad Marsh River (BR-4) sentinel stations.

Based on sampling and modeling analysis provided in the MEP Technical Report, the N TMDL to meet the target threshold N concentrations is 165.52 kg/day[1] for the entire system (Howes *et al.,* 2014, Table VIII-4). To meet the TMDL and achieve the target concentrations at the sentinel stations, an approximately 38% reduction of the total watershed N load for the system will be required. This document presents the TMDL for this waterbody and provides guidance to the communities of Wareham, Carver, and Plymouth on possible ways to reduce N loadings to within the recommended TMDL and protect the waters of this estuarine system.

Impaired waters within Wareham River Estuary System include the Wareham River (MA95-03) and Agawam River (MA95-29). The 2022 Integrated List of Waters includes the Wareham River as impaired for TN, chlorophyll-a, and estuarine bioassessments (i.e., loss of eelgrass habitat) and the Agawam River as impaired for TN, excess algal growth, and nutrient/eutrophication biological indicators (i.e., benthic habitat impairment) (MassDEP, 2023). Table ES-1 provides a summary of the MassDEP assessment units located within the Wareham River Estuary System and the total nitrogen TMDLs assigned to each waterbody.

Table ES-1: Waterbodies and associated TMDLs within the Wareham River Estuary System

Waterbody	**Assessment Unit ID**	**Waterbody Type**	**TMDL Type**	**TMDL** *kg N/day*
Wareham River	MA95-03	Estuary	Restorative	75.80
Agawam River	MA95-29	Estuary	Restorative	20.92
Agawam River	MA95-28	Freshwater	Protective[2]	22.11
Wankinco River	MA95-50	Estuary	Protective[2]	25.85
Broad Marsh River	MA95-49	Estuary	Protective[2]	17.95
Crooked River	MA95-51	Estuary	Protective[2]	2.88

[1] *MassDEP set negative benthic fluxes to zero when developing nitrogen TMDLs from the MEP loading analysis.*
[2] *Pollution Prevention TMDLs (kg-N/day) for community planning and to prevent further downstream impairment.*

Implementation

The primary goal of the TMDL implementation is to lower N concentrations in the Wareham River Estuary System. The MEP linked model has shown that the load reduction combination necessary to achieve the threshold N concentrations include a **79% removal of septic load** (associated with direct groundwater discharge to the embayment) as well as a reduction of N load from the Wareham Wastewater Control Facility to **4,300 kg/year (11.78 kg N/day).**

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, stormwater runoff and fertilizers are provided in detail in the "*MEP Embayment Restoration and Guidance for Implementation Strategies*" (MassDEP, 2003). 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. Finally, growth within the communities of the Wareham River Estuary System, 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 waterbody, while allowing the system to meet its applicable water quality standards, including compliance with numeric and narrative water quality criteria to support designated uses. The TMDL development process may be described in four steps, as follows:

1) Determination and documentation of whether a waterbody is presently meeting applicable water quality standards and designated uses.

2) Assessment of present water quality conditions in the waterbody, including estimation of present loadings of pollutants of concern from both point sources (discernable, confined, and concrete sources such as pipes) and nonpoint sources (diffuse sources that carry pollutants to surface waters through runoff or groundwater).

3) Determination of the loading capacity of the waterbody. EPA regulations define the loading capacity as the greatest amount of loading that a waterbody can receive without violating water quality standards. If the waterbody is not presently attaining 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 nonpoint sources and point sources that will ensure that the waterbody will not violate water quality standards.

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

In the Wareham River Estuary System, the pollutant of concern for this TMDL (based on observations of eutrophication) is nitrogen (N) because it is the limiting nutrient in coastal and marine waters, which means that plant productivity increases as the N concentration increases. Increased plant productivity leads to nuisance populations of macroalgae, increased phytoplankton and epiphyton abundance, and impairment of the affected waterbodies.

The total N TMDL for the Wareham River Estuary System is based primarily on data collected, compiled, and analyzed by the University of Massachusetts Dartmouth's School of Marine Science and Technology (SMAST), the Southeast Regional Planning & Economic Development District, Buzzards Bay Coalition (BBC) BayWatchers Water Quality Monitoring Program, and the Town of Wareham, as part of the Massachusetts Estuaries Project (MEP). The data were collected over a study period from 1999 through 2011. This study period will be referred to as the "Present Conditions" in the TMDL since it contains the most recent data available. The accompanying MEP Technical Report presents the results of the analyses of the coastal embayment system using the MEP Linked Watershed-Embayment Nitrogen Management Model (Linked Model): https://www.mass.gov/guides/the-massachusetts-estuaries-project-and-reports.

The analyses were performed to assist towns within the Wareham River Estuary System watershed 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 analyses served as the basis for generating an 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 that comprise the system's watershed.

Description of Waterbodies and Priority Ranking

Watershed Characterization

The Wareham River Estuary System is an approximately 797-acre complex estuarine system tributary to Buzzards Bay on its northwestern shore. The estuary is located within the town of Wareham in southeastern Massachusetts (Figure 1) and its watershed is located within the Towns of Carver, Plymouth, and Wareham (Figure 2). The large upper watershed is drained by two large river systems, the Wankinco River and Agawam River, which run in a north-south manner. Both the Agawam River and Wankinco River discharge to the head of the estuary and are among the largest rivers discharging to Buzzards Bay. The central estuary, the Wareham River, is a drowned river valley estuary, with smaller tributary basins: Broad Marsh Cove, Crooked River, and Marks Cove. The Town of Wareham also operates the Wareham Wastewater Control Facility (NPDES Permit No. MA0101893**)** that discharges directly to the headwaters of the Agawam River estuary. The entire system constitutes an important component of the Town's natural, cultural, and marine resources.

Composing 44% of the overall land area in the watershed, public service land is the dominant land use throughout both the upper and lower sections of the overall Wareham River Estuary System watershed. The majority of this public service land within the upper areas of the watershed is the Myles Standish State Forest. Land use within the Wankinco River and Parker Mills Pond sub-watershed, located in the western portion of the overall watershed, is comprised primarily of agricultural land uses. 54% of this western sub-watershed area is classified as agricultural land with cranberry bogs as the dominant form of agricultural land use. In the watershed area that contributes directly to the estuary, the total area of residential land use is slightly lower than the total area of public service land use; 32% of this lower watershed area is residential land use while 34% is classified as public land use. 8% of the overall watershed area is classified as undeveloped, and the majority of this land is located within the lower portion of the watershed that contributes directly to the estuary (Howes *et. al,* 2014). Figure 2 presents the land use in the Wareham River watershed – land use classifications are based on Massachusetts Department of Revenue group classifications, as assigned by individual town assessors.

The accompanying MEP Technical Report builds upon any earlier draft version of MEP Linked Watershed-Embayment Approach, which was first completed in 2007. The groundwater flow directions in the 2007 draft MEP Technical Report varied from groundwater flow directions reported in other studies (e.g. USGS, Scientific Paper 2009-5063, and SMAST, 2012 White Island Pond Water Quality and Management Options Assessment). The MEP Technical Report was updated to include the revised watershed delineations completed by the United States Geological Survey (USGS) during the USGS upgrade of the Plymouth-Carver Aquifer Model. Figure 2 presents the sub-watershed delineations for the Wareham River Estuary System. The lightly shaded sub-watersheds were included in the previous 2007 draft report but are no longer included in the 2014 updated MEP Technical Report and associated modeling.

Horsley Witten was contracted by the MassDEP to evaluate the updated 2014 MEP Technical Report groundwater flow paths and identify the most scientifically defensible sub-watershed delineations in the geographic area. The Horsley Witten analysis focused specifically on whether the water exiting the White Island Pond would predominantly travel southwest to the Wareham River or travel southeast to Buttermilk Bay. The results of their groundwater modeling indicated that water leaving White Island Pond ultimately discharges to Buttermilk Bay and little to no outflow from White Island Pond is likely to contribute to the Wareham River Estuary. Horsley Witten concluded that their analysis is consistent with the SMAST interpretation of contributing area within the 2014 MEP Technical Report and that no new N loading scenarios would need to be evaluated for the purpose of TMDL development (Horsley Witten, 2021).

Description of Waterbodies

The nature of enclosed embayments in populous regions exposes an inherent challenge: as protected marine shoreline they are popular regions for boating, recreation, and land development; as enclosed waterbodies, 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. In particular, the Wareham River Estuary System, like many other embayment systems in the region, is at risk of eutrophication from high N loads in the groundwater and runoff from their watersheds. The estuary system has historically supported high quality habitats associated with high nutrient-related water quality, such as eelgrass beds. But as in many other embayments in southeastern Massachusetts, the Wareham River Estuary System is presently an N-enriched shallow water estuarine system.

The 2022 Integrated List of Waters (the "Integrated List") includes the Wareham River (MA95-03) as impaired for TN, chlorophyll-a, and estuarine bioassessments (i.e., loss of eel grass habitat) and the estuarine portion of the Agawam River (MA95-29) as impaired for TN, excess algal growth, and nutrient/eutrophication biological indicators (i.e., benthic habitat impairment). The dissolved oxygen levels found by MEP in Wareham River and Agawam River were not considered sufficient to impair in the most recent Integrated List.

In addition to the nutrient-related impairments, the majority of the waters within the Wareham River Estuarine system are currently listed as impaired for fecal coliform. Wareham River (MA95-03), Broad Marsh River (MA95-49), Wankinco River (MA95-50), Agawam River (MA95-29), Cedar Island Creek (MA95-52), and Crooked River (MA95-51) have an impairment for fecal coliform addressed by CN 251.1 - Final Pathogen TMDL for the Buzzards Bay (MassDEP, 2009).

Table 1 provides a summary of the MassDEP assessment units located within the Wareham River Estuary System and associated impairments for each waterbody. A more complete description of this embayment system is presented in Chapters I and IV of the MEP Technical Report. Additional information on the nutrient-related health parameters assessed during the MEP study are summarized in Table 2, the Problem Assessment section below, and Chapter VII of the associated MEP Technical Report (Howes *et. al,* 2014).

Figure 1: Overview of Wareham River Estuary System, Wareham, MA

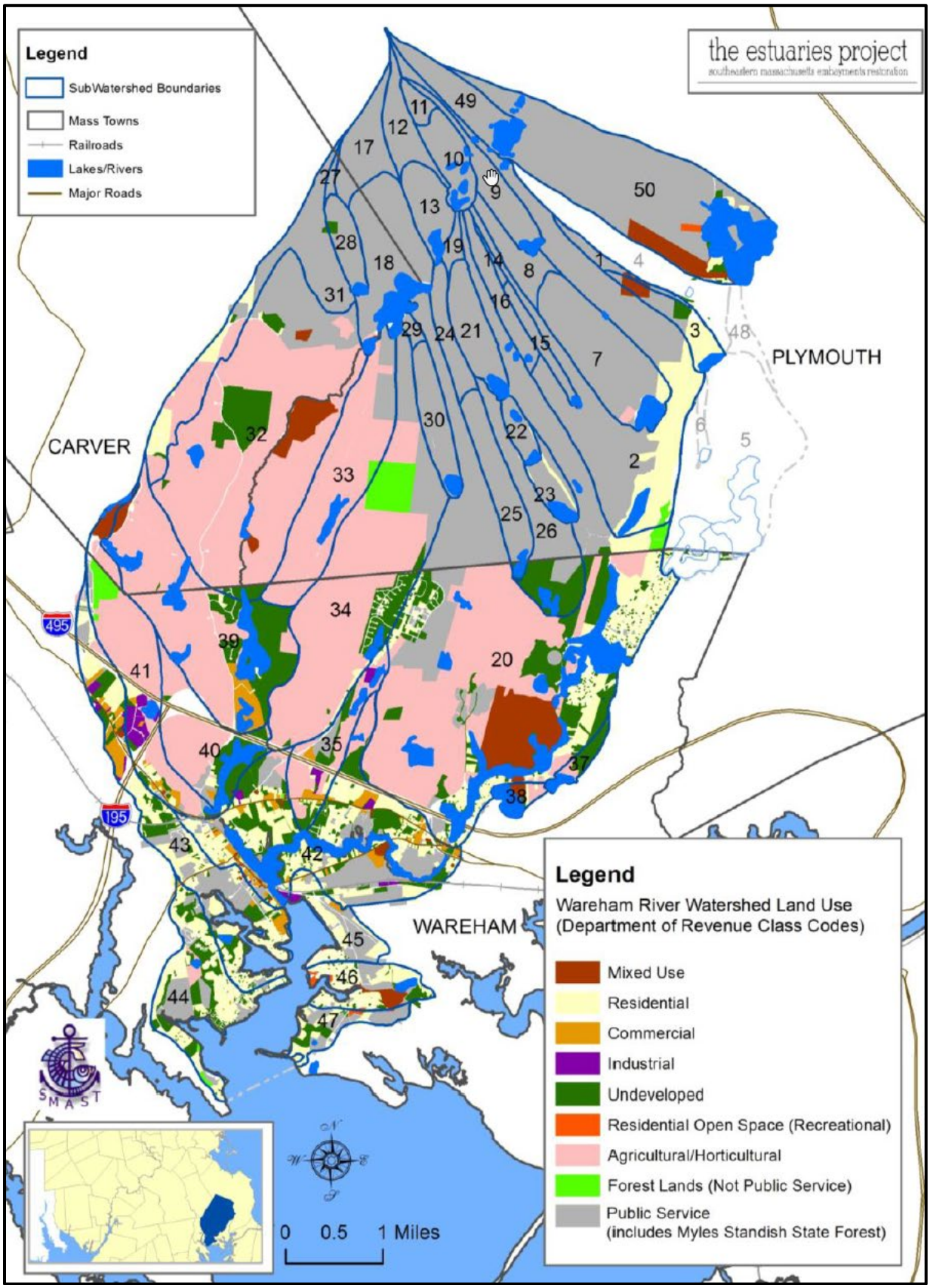

Figure 2: Wareham River Estuary System Watershed and Sub-watershed Delineations
Figure reprinted from MEP Technical Report (Howes et. al, 2014, Figure IV-1)

Table 1: MassDEP Assessment Units (AUs) within the Wareham River Estuary System

MassDEP AU Name & AU ID	MassDEP AU Description	MassDEP AU Type, Class, & Size	MassDEP 2022 Integrated List Impairment Parameters & (Category)	MEP Nutrient Related Habitat Health Indicators
Wareham River *MA95-03*	From confluence of Wankinco and Agawam Rivers at Route 6 bridge, Wareham to Buzzards Bay (at an imaginary line from Cromeset Point to curved point east/southeast of Long Beach Point), Wareham. Including Marks Cove, Wareham.	Estuary *Class SA* 1.18 sq.mi.	- Total Nitrogen (5) - Estuarine Bioassessments (5) - Chlorophyll-a (5) - Fecal Coliform (4A)*	- Benthic Fauna - Chlorophyll *a* - Eelgrass Loss
Agawam River *MA95-29*	Wareham WWTP outfall, Wareham to confluence with Wankinco River (forming headwaters of the Wareham River) just north of the Route 6 bridge, Wareham.	Estuary *Class SB* 0.16 sq.mi	- Total Nitrogen (5) - Algae (5) - Nutrient/Eutrophication Biological Indicators (5) - Fecal Coliform (4A)*	- Benthic Fauna - Chlorophyll *a* - Macroalgae
Agawam River *MA95-28*	Outlet Mill Pond, Wareham to Wareham WWTP outfall, Wareham.	Freshwater *Class B\WWF* 0.61 mi.	- Fish Passage Barrier (4c)	- *Not assessed*
Broad Marsh River *MA95-49*	Headwaters in salt marsh south of Marion Road and Bourne Terrace, Wareham to confluence with the Wareham River, Wareham.	Estuary *Class SA* 0.17 sq.mi.	- Fecal Coliform (4A)*	- *Not impaired*
Wankinco River *MA95-50*	From outlet of Parker Mills Pond, south of Elm Street, Wareham to the confluence with the Agawam River (at a line between a point south of Mayflower Ridge Drive and a point north of the railroad tracks near Sandwich Road (forming headwaters of the Wareham River)) just north of Route 6 bridge, Wareham.	Estuary *Class SA* 0.05 sq.mi.	- Fecal Coliform (4A)*	- *Not impaired*
Cedar Island Creek *MA95-52*	Estuarine portion southwest of the intersection of Parker Drive and Camardo Drive, Wareham to the mouth at Marks Cove, Wareham.	Estuary *Class SA* 0.01 sq.mi.	- Fecal Coliform (4A)*	- *Not assessed*
Crooked River *MA95-51*	Estuarine portion east of Indian Neck Road, Wareham to the confluence with the Wareham River, Wareham.	Estuary *Class SA* 0.04 sq.mi.	- Fecal Coliform (4A)* - Enterococcus (4A)*	- Assessed for Benthic Fauna: *Not impaired*

* Addressed by *CN 251.1 - Final Pathogen TMDL for the Buzzards Bay* (MassDEP, 2009).

Description of Hydrodynamics of the Wareham River Estuary System

Wareham River Estuary System is a sinuous estuary open to the northern extent of Buzzards Bay, made up of several smaller tidal sub-embayments, including Broad Marsh River, Crooked River, and the estuarine waters of Wankinco River and Agawam River. Located within the estuary system is nearly 300 acres of salt

marsh that borders the Wankincco River, Agawam River, and the Broad Marsh River. These sub-estuaries function as shallow tidal salt marsh systems that generally have a higher tolerance for nutrient loading. The mainstem of the Wareham River is deep, well-flushed embayment that serves as a mixing zone for the freshwater inflows from contributing watershed and the saline tidal flow from Buzzards Bay. From the farthest estuarine reach of the system, it is approximately 5.5 miles to the mouth on Buzzards Bay.

The MEP project 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 (Norton et al., 1973). Tide data records were collected concurrently at a station in Buzzards Bay, at five locations in the Wareham River, and at a single station in the Weweantic River. The Temperature Depth Recorders (TDR) used to record the tide data were deployed for a 50-day period to measure tidal variations through an entire neap-spring cycle.

The computed flushing rates for the estuary system show that the system flushes moderately well. The MEP project calculated local residence times of 0.66 days for the Wareham River, 0.45 days for the Broad Marsh River, and 0.39 days for the estuarine portions of the Agawam River. These local flushing times of under 0.7 days for each sub-embayment show that on average, water is resident in each subsystem less than one day. However, the system residence times for the Broad Marsh River and Agawam River were calculated to be 4.17 days and 5.65 days, respectively. These longer system residence times indicate that these estuarine tributaries are more sensitive to the water quality as they do not experience the same efficient rate of tidal exchange with Buzzards Bay when compared to the mainstem of the Wareham River (Howes *et. al,* 2014).

Priority Ranking

The embayment addressed by this TMDL was 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 estuarine system;
2) the commitment made by the towns to restore and preserve the embayment; and
3) the extent of impairment in the embayment.

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

Problem Assessment

The populations of three towns in the Wareham River Estuary System watershed (Wareham, Plymouth, and Carver) have been steadily growing over the past several decades (Figure 3). Declines in water and habitat quality often parallel population growth in the watershed. Water quality problems associated with this development result primarily from on-site wastewater treatment systems and to a lesser extent from wastewater treatment facility (WWTF) discharge, fertilizers, and runoff from these developed areas.

The primary ecological threat to Wareham Harbor is degradation resulting from nutrient enrichment. Most of the total N load (43%) is from septic systems, with other "controllable" N contributions coming from fertilizers (20%), WWTF discharge (16%), and impervious surface runoff (11%). Other sources that are not locally controllable include atmospheric deposition to the surface of the estuary and natural surfaces. N from these sources migrates downward to groundwater and eventually enters the estuary system.

The Wareham River Estuary System is a complex estuary composed of three functional types of component basins: an embayment (Wareham River-Marks Cove), a salt marsh pond/embayment (Broad Marsh River), and a tidal river with significant marginal wetlands (Agawam-Wankinco estuarine reaches). Each of these three functional components has different natural sensitivities to N enrichment and organic matter loading. The MEP project reported the Wareham River Estuary System is showing variations in N enrichment and habitat quality among its various component basins.

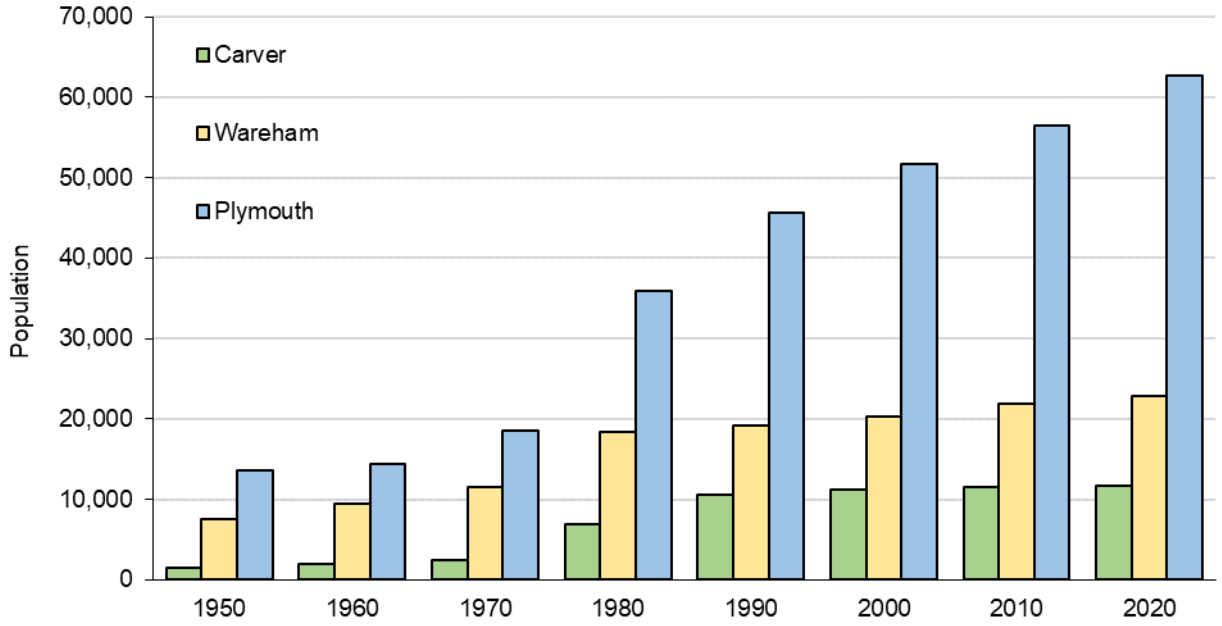

Figure 3: Towns of Carver, Wareham, and Plymouth Historic Residential Population
Source: United States Census records and Population Estimates Program data

Table 2: General Summary of Conditions Related to the Major Indicators of Habitat Impact

MassDEP Waterbody	Overall Health	MEP Identifier	Eelgrass [1]	Dissolved Oxygen	Chlorophyll *a*[2]	Macroalgae	Benthic Fauna [3]
Wareham River *MA95-03*	Impacted due to significant loss of eelgrass habitat, occasional moderate D.O. depletions, moderate/high chlorophyll *a* concentrations, and poor infaunal habitat quality. **[SI]**	Upper Wareham River	Moderate eelgrass habitat loss between 1985-2001 **[MI]**	Concentrations rarely below 5 mg/L **[HH]**	Moderate/high concentration average of 15 µg/L **[MI]**	Very sparse presence or absence of drift algae **[HH]**	Low number of individuals, high diversity and evenness **[SI]**
		Lower Wareham River	Significant eelgrass habitat loss between 1985-2001 **[SI]**	Concentrations rarely below 6 mg/L **[HH]**	Moderate/high concentration average of 10 µg/L **[MI]**	Very sparse presence or absence of drift algae **[HH]**	High number of individuals, low diversity and evenness **[MI]**
		Mark's Cove	Significant eelgrass habitat loss between 1985-2001 **[SI]**	*Not assessed*	*Not assessed*	Very sparse presence or absence of drift algae **[HH]**	High number of individuals, low diversity and evenness **[MI]**
Agawam River *MA95-29*	Impacted due to regularly elevated chlorophyll *a* concentrations, moderate D.O. depletions, and poor infaunal habitat with moderate number of species and low diversity. **[SI]**	Upper Agawam River	No historic evidence of eelgrass habitat **[NS]**	*Not assessed*	*Not assessed*	Very sparse presence or absence of drift algae **[HH]**	Moderate/low numbers of species and individuals low diversity and evenness **[SI]**
		Lower Agawam River	No historic evidence of eelgrass habitat **[NS]**	Salt marsh basin habitat; concentrations rarely below 4 mg/L and often climbed above 10 mg/L **[HH]**	High levels of chlorophyll *a*: Concentrations greater than 25 µg/L for 48% of time **[SI]**	Drift algae present; filamentous red and Ulva **[MI]**	Moderate/ high numbers of species and individuals, moderate diversity and evenness. **[MI]**
Wankinco River *MA95-50*	Benthic fauna indicative of healthy tidal river fringing a salt marsh. **[HH]**	Agawam-Wankinco	No historic evidence of eelgrass habitat **[NS]**	*Not assessed*	*Not assessed*	*Insufficient data*	High number of species and individuals, high diversity and evenness **[HH]**
Broad Marsh River *MA95-49*	Water quality and infauna are indicative of a healthy salt marsh habitat. **[HH]**	Broad Marsh River	No historic evidence of eelgrass habitat **[NS]**	Salt marsh basin habitat; concentrations only rarely below 5 mg/L **[HH]**	Concentrations below 12 µg/L, generally daily averages of 7 µg/L or less **[HH]**	Absence of drift algae; small patches of Codium **[HH]**	Salt marsh basin habitat; high numbers of species and individuals **[HH]**

[1] Based on comparison of present conditions to 1951 survey data
[2] Algal blooms are consistent with chlorophyll *a* levels above 20 µg/L
[3] Based on observations of the type of species, number of species, and number of individuals

[HH] Healthy Habitat Conditions*
[MI] Moderately Impacted*
[SI] Significantly Impacted * – considerably and appreciably changed from normal conditions
[SD] Severe Degraded* – critically or harshly changed from normal conditions
[NS] Non-supportive habitat*

** These terms are more fully described in the MEP report "Site-Specific Nitrogen Thresholds for Southeastern Massachusetts Embayments: Critical Indicators" December 22, 2003*

Table adapted and excerpted from MEP Report (Howes et. al, 2014, Table VIII-1)

Broad Marsh River (MA95-49)

The Broad Marsh River (MA95-04) was determined to be non-supportive of eelgrass habitat due to the naturally nutrient enriched shallow waters and salt marsh environment. The system generally supported oxygens levels greater than 5 mg/L and average chlorophyll a levels less than 12 µg/L. The infaunal communities consisted of a moderate number of individuals, and species indicative of an organic rich environment. The MEP determined the water quality and benthic results to be consistent with a high quality, healthy salt marsh basin habitat.

Wankinco River (MA95-50)

Similar to the Broad Marsh River, there is no evidence that eelgrass has colonized the estuarine reach of the Wankinco River (MA95-50), and the benthic invertebrate analysis demonstrated communities consistent with a nutrient-rich, estuarine sediment. The high number of infaunal species and diversity in this area indicates that the Wankinco River supports the high quality benthic habitat of a wetland-influenced tidal river.

Agawam River (MA95-29)

The MEP classified the estuarine portions of Agawam River (MA95-29) to be a tidal river with significant bordering wetlands, similar to the estuarine portions of the Wankinco River. Unlike the neighboring Wankinco, the Agawam River was determined to be significantly impaired in terms of both water quality and benthic habitat.

Chlorophyll *a* concentrations were recorded to be greater than 25 µg/L for 48% of the observed time period. Dissolved oxygen rarely went below 4 mg/L, but concentrations often climbed above 10 mg/L and occasionally above 12 mg/L, consistent with the high phytoplankton biomass. The MEP determined that the observed periodic oxygen depletion during summer is consistent in part with the river system's role as a tidal river bordered by extensive wetlands. MEP reported that the benthic fauna analysis clearly indicated a stressful environment with poor benthic habitat quality, as it featured low species numbers and a moderate density of individuals with low diversity and evenness. Due to the observed elevated chlorophyll *a* concentrations and poor benthic habitat, the MEP determined the Agawam River to be significantly impaired.

Wareham River (MA95-03)

The largest waterbody in the Wareham River Estuary System, the Wareham River (MA95-03) embayment featured the greatest area of historic eelgrass habitat. For the MEP technical report, the results of eelgrass mapping efforts were available for the years 1988, 1995, and 2001. The 1988 mapping estimated that eelgrass colonized most of the shoals of the lower basin of the Wareham River (those waters located south of Broad Marsh River). These eelgrass beds located within the Lower Wareham River were limited to the shallow margins of the basin and were not present within the deeper channel that runs along the centerline of the estuary.

The 1995 and 2001 results of the MassDEP Eelgrass Mapping Program indicated a complete loss of those marginal beds in the Lower Wareham River. The 1995 & 2001 mapping captured the emergence of fringe eelgrass beds in upper basin of the Wareham River (those waters located north of Broad Marsh River). Like those beds located in the Lower Wareham River, the eelgrass beds within the Upper Wareham River were limited to the shallow margins of the upper basin.

Although unavailable to the MEP during their assessment of eelgrass habitat quality, MassDEP's more recent 2013 and 2017 eelgrass mapping products captured the expansion of the fringe eelgrass beds located in the Upper Wareham River. The expanded eelgrass habitat appears to be constrained to the shallow depths of the northern edges of the estuary basin. Despite the expansion of beds in the upper basin, the more recent eelgrass mapping did not capture the return of the historic eelgrass beds within the lower basin of the Wareham River. Figure 5 presents the historic extent of eelgrass within the Wareham River (MA95-03).

Dissolved oxygen observations were generally high (greater than 5 mg/L) with rare moderate depletions. Chlorophyll *a* concentration averaged 15 µg/L in the upper region of the river and 10 µg/L in the central/lower region of the river. Specifically, concentrations were recorded to be greater than 10 µg/L for 42% of observed time period in the Wareham Narrows, which is upstream region of the Wareham River mainstem. In the Hamilton Beach area, located approximately in center of the Wareham River, concentrations were recorded to be greater than 10 µg/L for 45% of observed time period. The high chlorophyll *a* concentration coincided with observed phytoplankton blooms and oxygen depletions.

The MEP reported that the lower basin of the Wareham River showed high numbers of benthic species and individuals, with high diversity. However, the upper basin of the Wareham River was determined to have a poor benthic habitat likely due to transport of low-quality waters from the Agawam River on receding tides. The MEP determined the Wareham River to be impaired due to significant loss of eelgrass habitat, moderate elevated chlorophyll *a* concentration, and poor infaunal habitat quality.

MEP concluded that the benthic habitat in the Wareham River and Agawam River ranges from moderately to significantly impaired. Both waterbodies are also considered impaired due to elevated chlorophyll *a* concentration. Additionally, the Wareham River is significantly to moderately impaired based on the loss of historic eelgrass beds. The distribution of these habitat impairments throughout the Wareham River Estuary system is consistent with the observed N and the chlorophyll levels and the functional basin types comprising this estuary. As a result, both eelgrass and infaunal animal habitats are impaired in this estuary system, and N management is required for their restoration (Howes *et. al,* 2014).

Pollutant of Concern, Sources, and Controllability

In the Wareham River Estuary System, as in most marine and coastal waters, the limiting nutrient is nitrogen (N). N concentrations above those expected naturally contribute to undesirable water quality and habitat conditions (such as those described previously). Wareham River Estuary System has had extensive data collected and analyzed through the MEP, with the cooperation and assistance from the BBC Baywatchers Water Quality Monitoring Program. 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 nutrient loading, especially for N, are much larger than they would be under natural conditions and, as a result, the water quality has deteriorated.

Most of the watershed N loading to the estuary is from on-site subsurface wastewater disposal systems (septic systems, 33%), atmospheric deposition (16%), agricultural fertilizers (15%) and the wastewater treatment facilities (WWTFs, 12%). Less N originates from impervious surfaces, natural surfaces, lawn fertilizers, and landfills. The N loading that is considered controllable affecting this system originates predominately from on-site subsurface wastewater disposal systems (43%), agricultural fertilizers (20%), and the Wareham WWTF (8%). Figure 4 illustrates the percent contributions of N sources to the Wareham River Estuary System. Values are based on Table IV-2 and Figure IV-5 from the MEP Technical Report (Howes *et. al,* 2014). The level of "controllability" of each source, however, varies widely as shown in Table 3. 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 schedule.

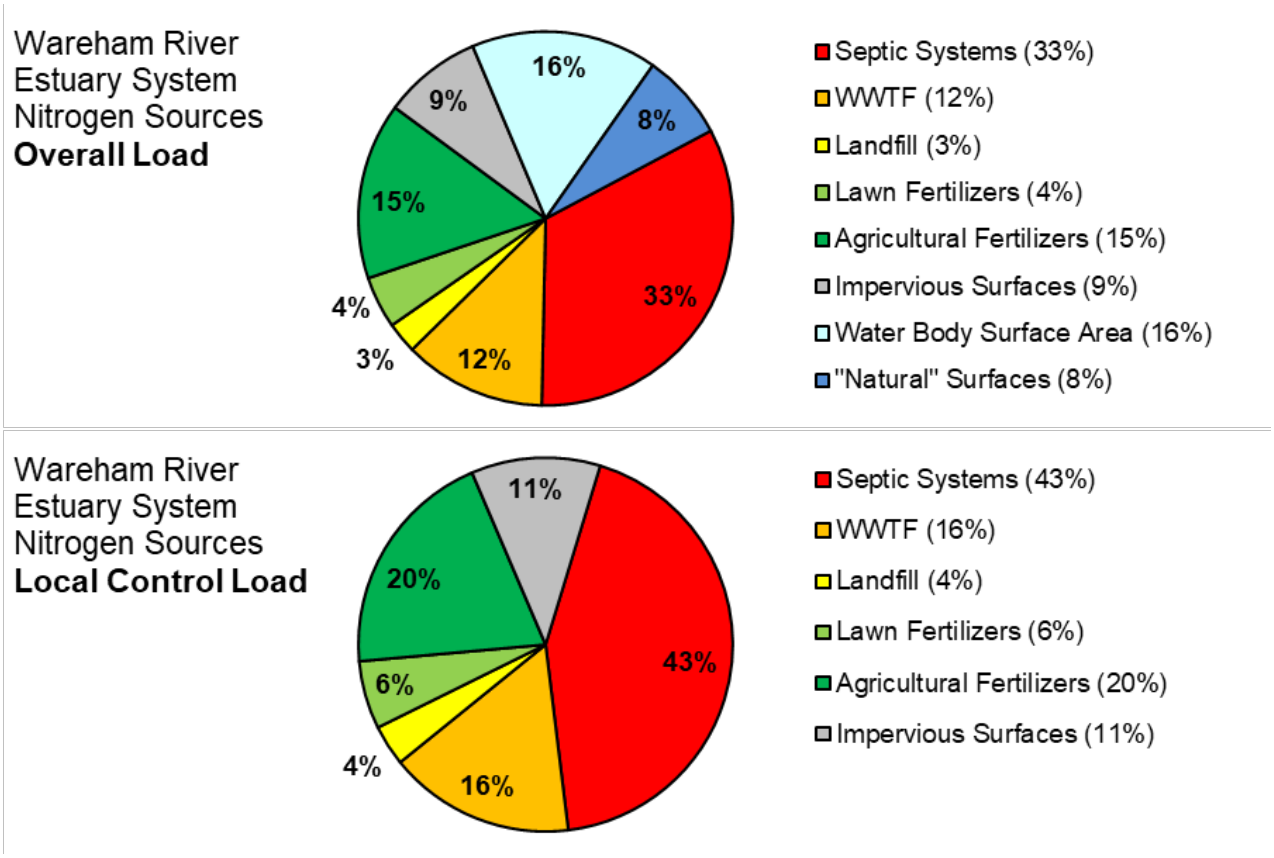

Figure 4: Contribution of Watershed Nitrogen Sources to Wareham River Estuary System

Table 3: Sources of Nitrogen and their Controllability

Nitrogen Source	Degree of Controllability at Local Level	Reasoning
Agricultural fertilizer and animal wastes	Moderate	These N loadings can be controlled through appropriate agricultural Best Management Practices (BMPs).
Atmospheric deposition to the estuary surface	Low	It is only through region- and nationwide air pollution control initiatives that significant reductions are feasible. Local control although helpful is not adequate.
Atmospheric deposition to natural surfaces (forests, fields, fresh waterbodies) 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.
Landfills	Low	Related N loadings can be controlled through appropriate BMPs and management techniques.
Septic system	High	Sources of N can be controlled by a variety of case-specific methods including: sewering 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 N 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.
Wastewater treatment facility (WWTF)	High	WWTFs as point sources of pollution to surface water are permitted under the National Pollution Discharge Elimination System. Treated wastewater effluent discharged to groundwater disposal systems are permitted by MassDEP. There is a high degree of regulatory certainty that within the limits of technology, nutrient sources at these facilities can be controlled.

Description of Applicable Water Quality and Pollutant Standards

Wareham River, Crooked River, Broad Marsh River, and Wankinco River are classified as Class SA waterbodies based on the Massachusetts Surface Water Quality Standards (MassDEP, 2021). The estuarine portion of the Agawam River is classified as Class SB and the freshwater portion of the Agawam River is classified as a Class B\WWF waterbody.

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, 2021). A more thorough explanation of the applicable water quality standards can be found in Appendix A.

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 U.S. 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 waterbody 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 to provide habitat for shellfish and finfish;
2) Prevent algal blooms;
3) Protect benthic communities from impairment or loss; and
4) Maintain dissolved oxygen concentrations that protect 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 MEP 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; and
- 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 over 65 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 an 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. This approach includes high-order, watershed and sub-watershed scale modeling necessary to develop critical N 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 N 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)
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-2 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 Nitrogen Loading
  - Watershed delineation
  - Stream flow (Q) and N load
  - Land-use analysis (GIS)
  - Watershed N model
- Embayment TMDL
  - Synthesis
  - Linked Watershed-Embayment Nitrogen Model
  - Salinity surveys (for linked model validation)
  - Rate of N recycling within embayment
  - Dissolved oxygen record
  - Macrophyte survey
  - Infaunal survey (in complex systems)

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 that 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 that 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.

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 N concentrations

In summary, by reducing the N concentration (and thus the N load) at the sentinel station(s) to meet the applicable water quality standards, the water quality goals will be met throughout the entire system. A brief overview of each output is listed below.

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 15 MEP monitoring stations from 2005 through 2011. Average yearly N concentrations at the 15 stations ranged from 0.408 – 0.649 mg/L with the lowest average concentration found in the Lower Wareham River (Station WR-7) and the highest average within the Upper Broad Marsh River (Station BR-1). The standard deviation of the averages and number of samples are presented in Appendix B (reprinted from Table VI-1 of the MEP Technical Report).

The primary sentinel stations are WR-3 and WR-6, located in the mainstem of the Wareham River. Threshold concentrations for tidally averaged TN of 0.40 mg/L at the Lower Wareham River (WR-6) and 0.42 mg/L at Upper Wareham River (WR-3) were selected to restore eelgrass habitat based upon the depth and TN levels surrounding the eelgrass bed located in the upstream region of the Wareham River. Target concentrations were also established at secondary sentinel stations within the Wareham River Estuary System.

The secondary sentinel stations are WR-2 in the Wareham River and BR-4 in the Broad Marsh River. Threshold concentrations for tidally averaged TN of 0.5 mg/L at the Upper Wareham River (WR-2) and at Lower Broad Marsh River (BR-4) were selected to ensure restoration of infaunal habitat throughout the embayment. Figure 5 presents the location of each monitoring station within the Wareham River Estuary System. Monitoring stations that serve as primary sentinel threshold stations are highlighted in red and stations that serve as secondary sentinel threshold stations are highlighted in yellow.

Table 4: Observed Sentinel Station N Concentrations and Threshold N Target Concentration

MEP Sub-Embayment	**Monitoring Station**	**Mean Concentration**[1] (mg/L N)	**Target Threshold Nitrogen Concentration** (mg/L N)
Marks Cove	MC-3	0.420	-
Marks Cove	MC-2	0.440	-
Marks Cove	MC-1	0.464	-
Lower Wareham River	WR-7	0.408	-
Lower Wareham River[2]	WR-6	0.453	0.40
Upper Wareham River	WR-5	0.459	-
Upper Wareham River	WR-4	0.469	-
Upper Wareham River[2]	WR-3	0.477	0.42
Upper Wareham River[2]	WR-2	0.490	0.50
Lower Broad Marsh	BR-6	0.541	-
Lower Broad Marsh[2]	BR-4	0.560	0.50
Upper Broad Marsh	BR-3	0.586	-
Upper Broad Marsh	BR-1	0.649	-
Lower Agawam River	AG-2	0.533	-
Middle Agawam River	AG-1	0.554	-

[1] *Mean concentration values are calculated as the average of the separate yearly means*
[2] *This monitoring station serves as a sentinel station.*

Table adapted and excerpted from MEP Report (Howes et. al, 2014, Table VII-1)

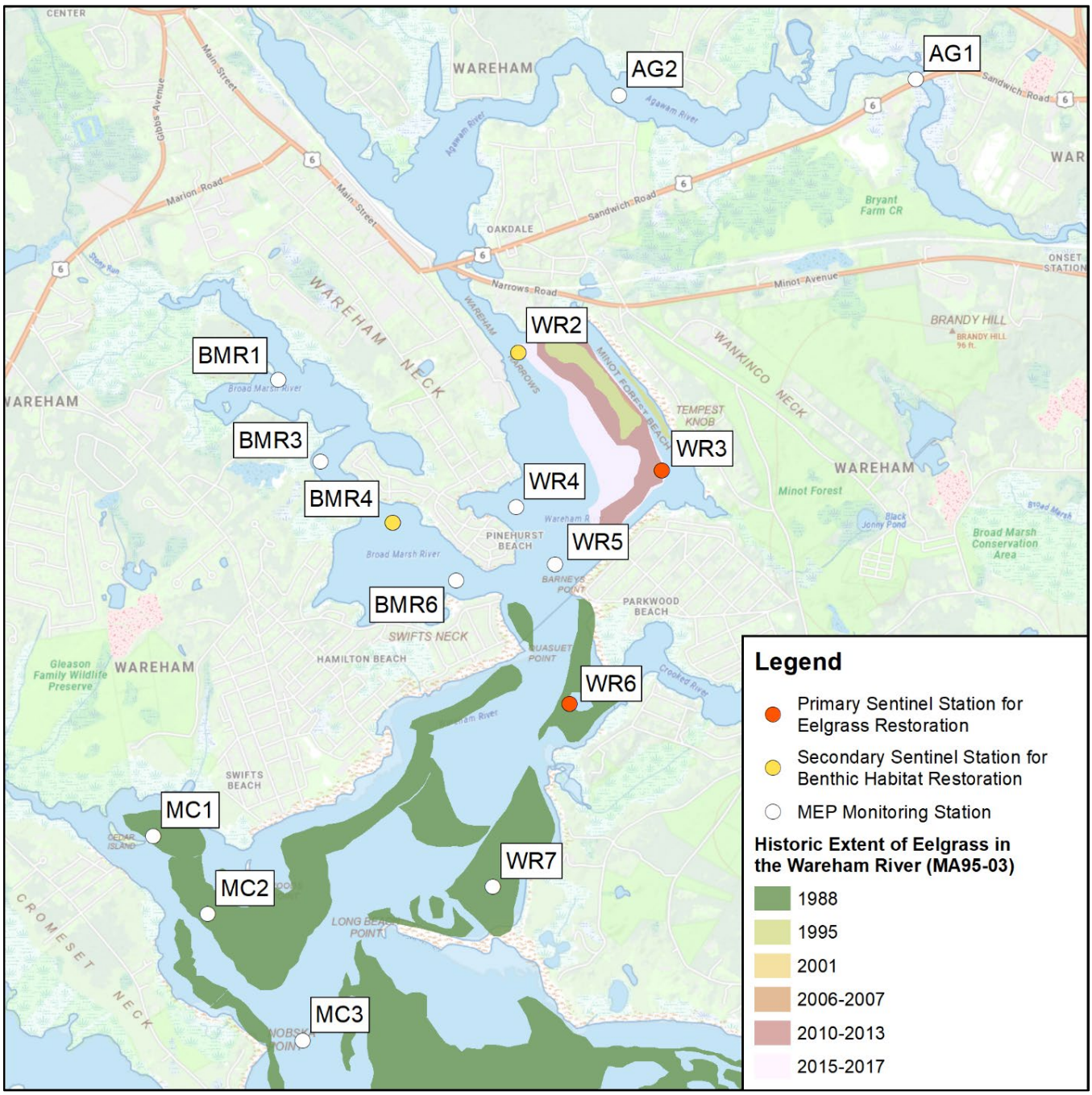

Figure 5: *Location of Monitoring Stations, Sentinel Threshold Stations, & The Historic Extent of Eelgrass Habitat in the Wareham River (MA95-03)*

2) Modeled site-specific target threshold N concentrations:

A major component of TMDL development is the determination of the maximum N concentrations (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 N 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 N concentration within the water column that will restore the sentinel 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 N concentration are determined, the MEP study modeled N loads from the watershed until the targeted N concentration was achieved.

Determination of the critical N threshold for maintaining high quality habitat within the Wareham River Estuary System is based primarily on the nutrient levels, oxygen levels, water column depth, temporal trends in eelgrass distribution, and benthic community indicators. The N threshold for Wareham River Estuary System is based upon the primary goal of restoring eelgrass habitat within the central estuary with the parallel goal of restoring and protecting benthic habitat for infaunal animals throughout the system.

The principal habitat degradation within the Wareham River Estuary System relates to loss of eelgrass beds in the central Wareham River – specifically from the mouth of the Broad Marsh River to Buzzards Bay. The eelgrass habitat presence and loss are consistent with the observed oxygen depletions and elevated chlorophyll *a* concentrations, as well as the three functional basin types recognized within the system. Therefore, the primary objective of the site-specific target threshold N concentration is the restoration of eelgrass habitat within the Wareham River.

As listed in Table 4, the primary site-specific target threshold N concentrations for eelgrass habitat restoration are 0.40 mg/L at WR-6 and 0.42 mg/L at WR-3 sentinel stations. Lowering the level of N enrichment at the sentinel station will lower N levels throughout the estuary with the parallel effect of protecting and improving infaunal habitats in the inner reaches of the system (Howes *et. al* 2014, Section VIII-3). The secondary threshold N concentrations are 0.5 mg/L at the WR-2 and BR-4 sentinel stations. These secondary values were designed to provide a check on the acceptability of conditions within the tributary basins. The analytical and modeling MEP investigations were used to develop target threshold N concentrations specific to the Wareham River Estuary System.

To meet the primary objective of eelgrass restoration, WR-6 was selected as a sentinel threshold station based upon its position within the upper most region of the documented 1988 historical extent that ranged from Broad Marsh River to Buzzards Bay. The WR-6 sentinel station is a long-term BayWatcher Water Quality Monitoring station located within the Lower Wareham River, near the mouth of Broad Marsh River and Crooked River. Positioned north of WR-6 in the Upper Wareham River, WR-3 was also selected as a sentinel threshold station based upon its proximity to the emerging 1995 fringe eelgrass beds within the shallow upper reaches of the estuary system.

Prior MEP analyses, including the Bournes Pond Estuary in Falmouth (Howes *et. al,* 2005), Lewis Bay in Barnstable & Yarmouth (Howes *et. al,* 2008), Swan Pond River Estuarine System in Dennis (Howes *et. al*, 2017), and the Westport River Embayment System in Westport (Howes *et. al*, 2013), were taken into

consideration when developing N threshold concentrations for eelgrass restoration. For regions within these estuary systems, the MEP identified stable beds of eelgrass at tidally averaged N concentrations ranging from 0.40 to 0.50 mg/L.

Based upon data that the MEP collected within the Wareham River Embayment System and from other systems in the Buzzards Bay region, threshold concentrations for tidally averaged total N (TN) of 0.40 mg/L at the Lower Wareham River (WR-6) and 0.42 mg/L at Upper Wareham River (WR-3) were selected to restore eelgrass habitat in these areas. Lowering the level of N enrichment at the sentinel station will lower N levels throughout the estuary with the parallel effect of improving infaunal habitats in the inner reaches of the system.

While the primary N management target is the restoration of eelgrass habitat, the restoration and protection of benthic infaunal habitat quality is a secondary target. In addition to the primary threshold concentrations for tidally averaged TN at WR-3 and WR-6, the MEP established secondary sentinel stations as a check to ensure that all impaired regions within the Wareham River Estuary System are restored. Secondary target concentrations were established at two locations within the Wareham River Estuary System: a tidally averaged TN concentration of 0.5 mg/L at the Upper Wareham River (WR-2) and at Lower Broad Marsh River (BR-4) stations.

Regions within the system that were determined to be impaired for benthic habitat quality include the northern area of the Wareham River and the estuarine portion of the Agawam River. Based on the water quality observations, the present average TN concentration in these areas is 0.524 mg/L and 0.573 mg/L, respectively. While not determined to be impaired, the lower area of the Broad Marsh River displayed a present average TN concentration of 0.529 mg/L. Due to its classification a tidal salt marsh basin, the Broad Marsh River was determined to be naturally nutrient enriched due to its shallow waters and salt marsh environment. The Lower Broad Marsh River (BR-4) station and Upper Wareham River (WR-2) were selected as secondary sentinel stations based upon their proximity to major tributary basins of the Wareham River Estuary System with elevated TN levels and benthic habitat impairments.

Based upon data that the MEP collected from similar estuary systems in the Buzzards Bay region, an upper concentration limit of 0.50 mg/L tidally averaged TN would support healthy infaunal habitat in this system and was therefore set at the secondary sentinel stations of WR-2 and BR-4.

Nitrogen loadings to the embayment

1) Present loading rates

In the Wareham River Estuary System, the highest N loading from controllable sources is from on-site wastewater treatment systems (septic systems). The MEP Technical Report calculates that septic systems account for 43% of the controllable N load to the overall system. Other controllable N sources include agricultural fertilizers (20%), WWTF discharge (16%), and runoff from impervious surfaces (11%). Table 5 presents a further breakdown of present N loading by source for each sub-watershed of the estuary system.

As previously indicated, the present N loadings to Wareham River Estuary System 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.

Table 5: Present Nitrogen Loadings within the Wareham River Estuary System Watershed

MEP Watershed	**Land Use Load**[1] (kg/day)	**Present Attenuated Septic System Load** (kg/day)	**Present WWTF Load**[2] (kg/day)	**Present Total Attenuated Watershed Load**[3] (kg/day)	**Direct Atmospheric Deposition**[4] (kg/day)	**Benthic Flux** (kg/day)	**Total N Load from All Sources**[5] (kg/day)
Broad Marsh River	3.674	4.271	-	7.945	1.681	15.656	25.282
Marks Cove	3.271	1.603	-	4.874	0.959	2.987	8.820
Crab Cove	1.049	2.499	-	3.548	1.614	0[6]	5.162
Crooked River	1.351	4.000	-	5.351	0.333	0[6]	5.684
Wareham River (Lower)	0.219	0.499	-	0.718	5.18	73.028	78.926
Wareham River (Upper)	5.526	18.140	18.523	42.189	1.803	0[6]	43.992
Agawam River	22.112	12.156	-	34.268	-	-	34.268
Wankinco River	25.909	4.677	-	30.586	-	-	30.586
System Total	**63.111**	**47.845**	**18.523**	**129.479**	**11.57**	**91.671**	**232.72**

[1] Composed of fertilizer, runoff, and atmospheric deposition to freshwater and natural surfaces
[2] Existing wastewater treatment facility discharges
[3] Composed of the sum of land use, septic, and WWTF loading
[4] Atmospheric deposition to embayment surface only.
[5] Composed of background, fertilizer, runoff, septic system, WWTF, atmospheric deposition and benthic flux loadings
[6] Negative benthic flux set to zero.

Table adapted and excerpted from MEP Report (Howes et. al, 2014, Table ES-1)

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

The N threshold developed by SMAST summarized above was used to determine the amount of total N mass loading reduction required for restoration and protection of eelgrass and benthic invertebrate habitats in the Wareham River Estuary System. Tidally averaged total N concentrations were used to calibrate the water quality model (Section VI in the MEP Technical Report). Modeled watershed N loads were sequentially lowered until the N levels reached the threshold levels at the primary sentinel stations (WR-3 & WR-6) and secondary sentinel stations (WR-2, BR-4) chosen for the Wareham River Estuary System. Load reductions can be produced by reduction of any or all sources of N and/or by increasing the natural attenuation of N within the freshwater systems to the embayment. Table 6 includes the present and target threshold watershed N loadings to Wareham River Estuary System and the percentage reduction necessary to meet the target threshold N concentration at the sentinel station.

The approach described above is only one scenario that will meet the target N concentration enough to restore habitat throughout the system, which is the goal of the TMDL. There can be variations depending on the chosen sub-watershed and which controllable source is selected for reduction. Alternate scenarios will result in different amounts of N being reduced in different sub-watersheds. For example, removing N upstream will impact how much N must be removed downstream. The towns of Wareham, Plymouth, and Carver should take any reasonable effort 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

MEP Watershed	**Present Total Watershed Load** [1] (kg/day)	**Target Threshold Watershed Load**[2] (kg/day)	**Percent Watershed Load Reductions Needed to Achieve Target**
Broad Marsh River	7.945	4.101	-48.4%
Marks Cove	4.875	4.073	-16.4%
Crab Cove	3.548	2.299	-35.2%
Crooked River	5.351	2.551	-52.3%
Wareham River (Lower)	0.718	0.468	-34.7%
Wareham River (Upper)	42.189	19.121	-54.7%
Agawam River	34.268	22.112	-35.4%
Wankinco River	30.586	25.851	-15.5%
System Total	**129.479**	**80.634**	**-37.7%**

[1] *Composed of fertilizer, runoff, atmospheric deposition to lakes and natural surfaces and septic system loadings.*

[2] *Target threshold watershed load is the load from the watershed needed to meet the target threshold N concentrations as identified above in Table 4.*

Table adapted and excerpted from MEP Report (Howes et. al, 2014, Tables ES-2 & VII-3)

Total Maximum Daily Loads

A total maximum daily load (TMDL) identifies the loading capacity of a waterbody for a pollutant. EPA regulations define loading capacity as the greatest amount of loading that a waterbody 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 generally applicable or site-specific numeric N criteria for the Wareham River Estuary System in the Massachusetts Surface Water Quality Standards, the TMDL calculates 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 nonpoint discharges can stimulate algal growth, which then die and decompose though the action of bacteria, depleting oxygen in the water. Reducing the bioavailability of N in the estuarine system through the implementation of this TMDL will result in less algal growth, which will ensure chlorophyll *a* concentrations are reduced and dissolved oxygen levels are increased.

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:

$$\boldsymbol{TMDL = WLAs + LAs + MOS}$$

where:

TMDL = loading capacity of receiving water
WLAs = portion allotted to point sources
LAs = portion allotted to (cultural) nonpoint 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. The MEP Technical Report includes 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 wastewater point sources. There is a permitted surface water discharge in the watershed. The Wareham Wastewater Control Facility (MA0101893) discharges into the Agawam River (MA95-28). The MEP estimated waste load from this facility is 18.52 kg N/day (Figure 6). 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 National Pollutant Discharge Elimination System (NPDES) regulated discharges of stormwater also be included in the waste load component of the TMDL.

Areas of the Wareham River Estuary System watershed that contain EPA designated "urbanized areas" and are required to obtain coverage under the NPDES Phase II General Permit for stormwater discharges from Small Municipal Separate Storm Sewer Systems (MS4s). In addition, there are directly connected impervious areas (DCIAs) that discharge stormwater directly to waterbodies via a conveyance system such as a swale, pipe, or ditch throughout the entire watershed as identified by the EPA in: https://www.epa.gov/npdes-permits/regulated-ms4-massachusetts-communities. This TMDL treats stormwater discharge from all DCIA (even those outside of regulated urbanized areas) as part of a waste load allocation.

The Linked Model accounts for stormwater and groundwater loadings in one aggregate allocation as a nonpoint source – combining the assessments of wastewater and stormwater (including stormwater that infiltrates into the soil and direct discharge pipes into waterbodies) for the purpose of developing control strategies. Based on land use, the Linked Model accounts for loading from stormwater, but does not differentiate stormwater into a load and waste load allocation. In order to distinguish the point source or waste load allocation of stormwater originating from DCIAs from the nonpoint source stormwater contribution (LA or load allocation), the percent of the impervious area (IA) that was identified as DCIA was determined and multiplied by the impervious surface N load (kg N/day) as reported in Table IV-5 of the MEP Technical Report.

DCIA was calculated in accordance with EPA methodology (EPA, 2010) using the "Sutherland Equations" (Sutherland, 2000). As outlined in the methodology: the IA of each sub-watershed was determined using the MassGIS 2005 Impervious Surface data layer, the land use categories in the MassGIS Land Use 2005 datalayer were reclassified into commonly used land use categories that correspond with the Sutherland watershed selection criteria, and the "Sutherland Equations" were applied to the IA to calculate DCIA as a percentage of IA in each sub-watershed.

The WLAs for stormwater nitrogen contribution (kg N/day) was determined using the DCIA for each sub-embayment divided by total IA in the sub-embayment, then multiplying the total impervious surfaces runoff N load for the sub-watershed (Table IV-2 of the MEP Technical Report) per EPA methodology. The remaining impervious surfaces loads were assigned as the LA. Table 7 shows the existing WLA and LA from stormwater runoff from impervious surfaces in the Wareham River Estuary System watershed.

Load Allocations

Load allocations identify the portion of loading capacity allocated to existing and future nonpoint sources. In the case of the Wareham River Estuary 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 classified as "directly connected" to the waterbody, which is defined above as part of the waste load), fertilizers, and landfill runoff.

Table 7: Existing Stormwater WLA and LA as determined by Percentage of Directly Connected Impervious Area (DCIA) in the Wareham River Estuary System watershed

MEP Watershed	DCIA as % of Impervious Area (%) [1]	Watershed Impervious Load (kg N/day) [2]	Stormwater WLA (kg N/day) [3]	Stormwater LA (kg N/day)
Broad Marsh	75.0%	1.773	1.331	0.44
Marks Cove	68.8%	1.559	1.073	0.49
Crab Cove	57.3%	0.568	0.325	0.24
Crooked River	50.3%	0.657	0.331	0.33
Wareham River (Lower)	15.6%	0.065	0.010	0.06
Wareham River (Upper)	64.3%	2.562	1.647	0.92
Agawam River	24.2%	3.562	0.862	2.70
Wankinco River	24.0%	2.084	0.500	1.58
System Total	**39.0%**	**12.830**	**6.079**	**6.75**

[1] *DCIA calculated using GIS and EPA methodology (EPA, 2010) divided by Total Impervious Area*
[2] *From MEP Technical Report, Table IV-2*
[3] *The DCIA as % of Total Impervious Area multiplied by the MEP Total Unattenuated Watershed Impervious Load*

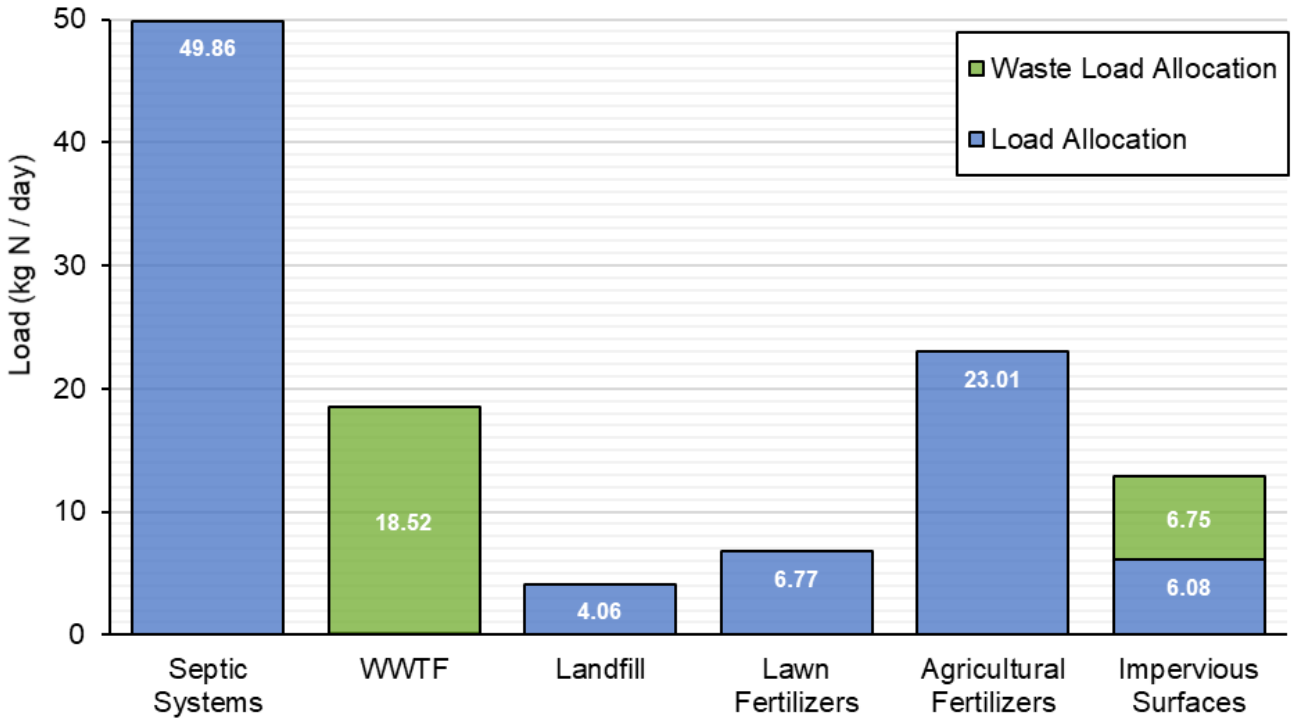

Figure 6: Wareham River Estuary System - *Present* Locally Controllable N Sources

Benthic Flux and Atmospheric Deposition

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 N from bottom sediments is a critical (but often overlooked) component of N 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:

Projected N flux = (present N flux) (PON projected / PON present)

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

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

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

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

Benthic loading is affected by the change in watershed load. The benthic flux modeled for the Wareham River Estuary 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 Upper Wareham River, Crab Cove, and Crooked River sub-embayments 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 to be 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 waste load allocations and water quality [CWA para 303 (d) (20C, 40C.G.R. para 130.7C(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 designated 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 waste load 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 Wareham River Estuary 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 climate change.

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/adapting-to-climate-change). 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. Considering 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. N 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. N 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.

MEP conducted long-term measurements of natural attenuation relating to surface water discharges at the two major surface water sources of the Wareham River Estuary System: the Agawam and Wankinco Rivers. Based upon the total N loads discharged from the Agawam River (12,461 kg/yr) and Wankinco River (11,139 kg/year) compared to that added by the various land-uses to the watershed (13,537 kg/yr), the integrated attenuation in passage through ponds, streams and freshwater wetlands prior to discharge to the estuary is approximately 8% for the Agawam River and 18% for the Wankinco River (Howes *et. al*, 2014)

Within the Wareham River Estuary System study area, there are 20 freshwater ponds with delineated watersheds. None of these ponds has available pond-wide bathymetric data or sufficient water quality data collection outside of the MEP to provide a basis for an alternative N attenuation rate. Assignment of the standard MEP 50% attenuation in all the ponds with delineated sub-watersheds resulted in attenuated N loads at the gages that were significantly less than the measured N loads. In order to be conservative and match the measured data, MEP staff assigned no attenuation to any of the pond N loads. Instead, all attenuation is determined based on measured N loads at the gages for the Agawam and Wankinco Rivers.

The hydrodynamic and water quality models have been assessed directly. For the water quality model, it was possible to conduct a quantitative assessment of the model total N results as fitted to a baseline dataset - computed root mean squared (RMS) error is less than 0.03 mg/l, which demonstrates a good fit between modeled and measured data for this system (Howes *et. al,* 2014). Since the water quality model incorporates

all the outputs from the other models, this excellent fit indicates a high degree of certainty in the result. The high level of model accuracy provides a high degree of confidence in the output and reduces the margin of safety required.

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. 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 by 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 dataset so that a higher margin of safety is not required.

Additionally, 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 the sub-embayments of Crab Cove, Crooked River, and Upper Wareham River (-35.4, -216.8, and -413.6 kg N/year, 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 as opposed to being denitrified or buried. The regeneration rate projected under reduced N loading conditions was based upon two assumptions:(1) PON in the embayment exceeding 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 concentrations if watershed N loading and direct atmospheric deposition could be reduced to zero, which is impossible. This proportional reduction assumes that the proportion of remineralized N will be the same as under present conditions, which is almost certainly an underestimate. Future N regeneration rates are therefore overestimated, which adds to the margin of safety.
Finally, decreases in air deposition through continuing air pollution control efforts are unaccounted for in this TMDL and provides 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 infaunal communities, and not those just starting to show impairment, which would have slightly higher N concentration. Meeting the target threshold N concentration at the sentinel station will result in reestablishment of eelgrass 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.

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

The TMDLs for the waterbody segments are protective for all seasons because they are based on the most critical time period, i.e., the summer growing season. 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 nonpoint sources. Thus, calculating annual loads is most appropriate, since it is difficult to control nonpoint N sources on a seasonal basis, and N sources can take considerable time to migrate to impacted waters.

TMDL Values for the Wareham River Estuary System

As outlined above, the total maximum daily N loads that would provide for the restoration and protection of the embayment were calculated by considering all N sources grouped by natural background, point sources, and nonpoint sources. A more meaningful way of presenting the loads from an implementation perspective is shown in Table 8 and Appendix D.

Table 8: Nitrogen Total Maximum Daily Loads for the Wareham River Estuary System

MEP Watershed	**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)
Broad Marsh River	4.101	1.681	12.168	17.95
Marks Cove	4.073	0.959	2.407	7.44
Crab Cove	2.299	1.614	0[4]	3.91
Crooked River	2.551	0.333	0[4]	2.88
Wareham River (Lower)	0.468	5.18	58.8	64.45
Wareham River (Upper)	19.121	1.803	0[4]	20.92
Agawam River	22.112	-	-	22.11
Wankinco River	25.851	-	-	25.85
System Total	**80.634**	**11.57**	**73.375**	**165.52**

[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).
[3] Sum of target threshold watershed load, atmospheric deposition load, and sediment load.
[4] Negative benthic flux is set to zero.

In this table, N loadings from the atmosphere and from nutrient rich sediments are listed separately from the target watershed threshold loads. The target watershed load is composed of locally controllable N from landfills, on-site subsurface wastewater disposal systems (septic systems), WWTF discharges, stormwater runoff, and fertilizer sources. In the case of the Wareham River Estuary System, 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 Plan

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 Wareham River Estuary System. To achieve these target threshold N concentrations, N loading rates must be reduced throughout the Wareham River Estuary System and its upstream waters. Table 8 lists the target threshold watershed N load for this system.

Septic Systems

The vast majority of controllable N load is from individual septic systems for private residences. The Comprehensive Wastewater Management Plan (CWMP) should therefore assess the most cost-effective options for achieving the target threshold N watershed loads, including, but not limited to, sewering 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, 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.

Table 9 summarizes the present loadings from septic systems and the reduced loads that would be necessary to achieve the target threshold N concentration in the Wareham River Estuary System under the scenario modeled here, which includes both reductions to the Wareham Wastewater Control Facility load and septic loads. A 79% reduction in present septic loading combined with the Wastewater Control Facility load described below achieved the target threshold N concentrations at the primary and secondary sentinel stations This septic load change will result in an 30% decrease in the total watershed load to the Wareham River Estuary System.

Table 9: Reductions Necessary to Achieve the TMDL by Reducing Septic System Loads

MEP Watershed	**Present Septic Load** (kg N/day)	**Threshold Septic Load** (kg N/day)	**Threshold Septic Load % Change**
Broad Marsh	4.27	0.43	-90%
Wareham River (Marks Cove)	1.60	0.80	-50%
Crab Cove	2.50	1.25	-50%
Crooked River	4.00	1.20	-70%
Wareham River (Lower)	0.50	0.25	-50%
Wareham River (Upper)	18.14	1.81	-90%
Agawam River (from Mill Pond)	12.16	0.00	-100%
Wankinco River (from Parker Mills Pond)	4.68	3.27	-30%
Wareham River Estuary System (total)	**47.85**	**9.01**	**-79%**

WWTF and Outfall

As shown in Table 9, the N load reductions within the system necessary to achieve the threshold N concentrations required a combined 79% removal of septic load (associated with direct groundwater discharge to the embayment) for the river watershed. In addition, the Wareham Wastewater Control Facility load will require reduction to 4,300 kg N/year (11.78 kg N/day), from the MEP estimated present discharge of 6,761 kg N/year (18.52 kg N/day). The CWMP should assess the most cost-effective options to meet this reduction in WWTF loading.

The 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 communities located within the Wareham River Estuary System watershed 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 within the Wareham River Estuary System watershed 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 effective July 1, 2018 (with modification effective January 6, 2021). 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 the Massachusetts Surface 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 Wareham River Estuary System watershed towns will contribute to the goal of reducing the N load as prescribed in this TMDL for the 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 occurring based on known science. Massachusetts Executive Office of Energy and Environmental Affairs 2011 Climate Change Adaptation Report (EOEEA, 2011), 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 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" (EPA, 2012). 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." (EPA, 2013). 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 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 to help coastal communities address impacts and effects of erosion, storm surge and flooding which are increasing due to climate change. The program, 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 TMDLs in the future to address predictable climate change impacts. When the science can support assumptions about the effects of climate change on the N loadings to the Wareham River Estuary System, the TMDL can be reopened, if warranted.

Implementation Guidance

The watershed communities of Wareham, Plymouth, and Carver 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 Wareham, Plymouth, and Carver 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 Wareham, Plymouth, and Carver are members of the 237 communities in Massachusetts with urbanized areas regulated by the MS4 General Stormwater Permit requirements*

Monitoring Plan

MassDEP is of the opinion that there are three 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 three forms of monitoring include:

1) tracking implementation progress as approved in the town CWMP plan (as appropriate);
2) monitoring ambient water quality conditions, including, but not limited to, the sentinel station identified in the MEP Technical Report; and
3) monitoring and tracking the extent of eelgrass habitat.

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 considered fixed. Through discussions amongst the MEP project partners, 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 5+ years. Finally, in addition to the above, existing monitoring conducted by MassDEP for eelgrass should continue to observe any changes that may occur to eelgrass populations as a result of restoration efforts.

MassDEP 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 the goals outlined in this TMDL. However, 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. Finally, additional monitoring efforts within the adaptive management framework that indicate water quality standards are not being met may inform revised threshold concentrations and loadings to the Wareham River Estuary System, such that the TMDL can be reopened, if warranted.

Reasonable Assurances

MassDEP possesses the statutory and regulatory authority, under the Massachusetts Clean Waters Act and Massachusetts Surface Water Quality Standards, 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 nonpoint source controls are voluntary, reasonable assurance is based on the commitment of the locality involved.

The Towns of Wareham, Plymouth, and Carver have demonstrated this commitment through the comprehensive wastewater planning initiated well before the generation of the TMDL. The towns expect 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 wastewater treatment facility discharge, 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 nonpoint 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(b), and 104(b) programs of the CWA, which are provided as part of the Performance Partnership Agreement between MassDEP and EPA. Wareham River Estuary System watershed towns are encouraged to investigate the use of Coastal Zone Management Coastal Pollutant Remediation grants and the EPA Southeast New England Program grants and technical assistance to improve water quality impaired by nonpoint sources, including stormwater. Other potential funds and assistance are available through the Massachusetts Department of Agriculture's Enhancement Program and the US 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 document, 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

An information session to present the results of this TMDL report was held on November 28, 2028. The session was a virtual meeting that offered the ability to participate via Zoom. The Town of Wareham hosted a physical meeting room in the Wareham Town Hall where attendees were able to access the virtual meeting. Notice of the 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 interested parties. A copy of the draft TMDL was published on the MassDEP website.

Mason Saleeba, TMDL Analyst in the Watershed Planning Program (WPP) at MassDEP, summarized the Massachusetts Estuaries Project and described the Draft Total Nitrogen TMDL Report findings. Andrew Osei, Environmental Engineer in the MassDEP Southeastern Regional Office (SERO), summarized the implementation and Comprehensive Wastewater Management Planning (CWMP) process. Additional MassDEP staff were present to respond to questions including Matthew Reardon (TMDL Section Chief, WPP), Holly Brown (TMDL Analyst, WPP), Tim Fox (TMDL Analyst, WPP), Gerard Martin (Deputy Regional Director, SERO), Jon Hobill (Environmental Engineer, SERO), and Lealdon Langley (Director, Division of Watershed Management).

Public comments received during the meeting and comments received in writing within a 30-day comment period following the meeting were considered by the Department. This final version of the TMDL report includes a summary of the public comments, the Department's response to the comments, and attendance records from the virtual meeting and physical meeting room (Appendix E).

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Appendix A: Overview of Applicable Water Quality Standards

Water quality standards that govern surface water conditions that may result from cultural eutrophication are dissolved oxygen, nutrients, bottom pollutants or alterations, aesthetics, excess plant biomass, and nuisance vegetation. The Massachusetts Surface Water Quality Standards (SWQS, 314 CMR 4.00) contain numeric criteria for dissolved oxygen, site-specific numeric and narrative standards for nutrients, and solely narrative standards for the other variables. This summary does not supersede or replace 314 CMR 4.00. A complete version of the SWQS is available online (MassDEP 2021).

Applicable Narrative Standards

The following narrative standards are excerpted from the SWQS:

> 314 CMR 4.05(5)(a): *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): *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): *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 including, but not limited to, those established in 314 CMR 4.06(6)(c): *Table 28: Site-specific Criteria*. 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

The following class descriptions and numeric standards are excerpted from the SWQS:

> 314 CMR 4.05(4)(a): *Class SA*. Those Coastal and Marine Waters so designated pursuant to 314 CMR 4.06; including, without limitation, 314 CMR 4.06(2) and (5), and certain qualified waters designated in 314 CMR 4.06(6)(b). 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 for shellfishing in 314 CMR 4.06(6)(b), these waters shall be suitable for shellfish harvesting without depuration (Approved and Conditionally Approved Shellfish Areas). These waters shall have excellent aesthetic value.

314 CMR 4.05(4)(a)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.

314 CMR 4.05(4)(b): *Class SB*. Those Coastal and Marine Waters so designated pursuant to 314 CMR 4.06; including, without limitation, 314 CMR 4.06(2) and certain surface waters designated in 314 CMR 4.06(6)(b). 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 for shellfishing in 314 CMR 4.06(6)(b), these waters shall be suitable for shellfish harvesting with depuration (Restricted and Conditionally Restricted Shellfish Areas). These waters shall have consistently good aesthetic value.

314 CMR 4.05(4)(b)1.: *Dissolved Oxygen*. Shall not be less than 5.0 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.

Surface Waters Not Specifically Designated in 314 CMR 4.06

Note many waterbodies do not have a specific water quality designation in 314 CMR 4.06: *Classification, Figures, and Tables***.** Those that do not have a specific designation are classified by category. Coastal and Marine Classes of water are designated as Class SA and presumed High Quality Waters as described in 314 CMR 4.06 (5).

314 CMR 4.06(5): *Other Waters*. Unless otherwise designated in 314 CMR 4.06: *Classification, Figures, and Tables*, 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: *Antidegradation Provisions*, from which an excerpt is provided:

314 CMR 4.04(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.

314 CMR 4.04(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.

314 CMR 4.04(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: *401 Water Quality Certification for Discharge of Dredged or Fill Material, Dredging, and Dredged Material Disposal in Waters of the United States within the Commonwealth* 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

314 CMR 4.04(4) *Protection of Special Resource Waters*. The quality of Special Resource Waters shall be protected and maintained. No new or increased discharge to an SRW, and no new or increased discharge to a tributary to an 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).

314 CMR 4.04(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: *Public Notice and Comment*. 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.

314 CMR 4.04(6): The Department applies its Antidegradation Implementation Procedures to point source discharges subject to 314 CMR 4.00.

314 CMR 4.04(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 314 CMR 3.00: *Surface Water Discharge Permit Program*. Before authorizing a discharge, all appropriate public participation and intergovernmental coordination shall be conducted in accordance with 314 CMR 2.00: *Permit Procedures*.

Appendix B: Nitrogen Monitoring Summary

Table B-1: Summary of the Nitrogen Concentrations* for the Wareham River Estuary System
(Reprinted from Table VI-1 of the MEP Technical Report, Howes et al., 2014)

MEP Sub-embayment	Monitoring Station	Data Mean	Standard Deviation (all data)	N	Model Min	Model Max	Model Average
Marks Cove	MC-3	0.420	0.082	22	0.344	0.445	0.37
Marks Cove	MC-2	0.440	0.090	24	0.347	0.451	0.396
Marks Cove	MC-1	0.464	0.093	24	0.432	0.502	0.468
Lower Wareham River	WR-7	0.408	0.065	21	0.348	0.497	0.407
Lower Wareham River	WR-6	0.453	0.072	23	0.358	0.536	0.442
Upper Wareham River	WR-5	0.459	0.084	22	0.372	0.549	0.464
Upper Wareham River	WR-4	0.469	0.091	25	0.392	0.551	0.477
Upper Wareham River	WR-3	0.477	0.098	23	0.428	0.56	0.494
Upper Wareham River	WR-2	0.490	0.078	68	0.448	0.588	0.524
Lower Broad Marsh	BR-6	0.541	0.094	47	0.371	0.63	0.479
Lower Broad Marsh	BR-4	0.560	0.121	25	0.403	0.703	0.529
Upper Broad Marsh	BR-3	0.586	0.118	48	0.448	0.812	0.603
Upper Broad Marsh	BR-1	0.649	0.117	24	0.487	0.907	0.666
Lower Agawam River	AG-2	0.533	0.137	22	0.554	0.597	0.573
Middle Agawam River	AG-1	0.554	0.178	26	0.558	0.595	0.573
Buzzards Bay - Boundary	*MC-3*	*0.345*	-	-	-	-	-

**Measured data and modeled nitrogen concentrations for the Wareham River Estuary System. All concentrations are given in mg/L N. "Data mean" values are calculated as the average of the separate yearly means. Data represented in this table were collected in the summers of 2005 through 2011. The Buzzards Bay boundary condition was developed using data from station MC-3, and represents the lowest quartile of measurements.*

Appendix C: Stormwater Loading Information

Impervious surfaces such as roadways, parking lots, rooftops, sidewalks, driveways, and other pavements impede stormwater infiltration and generate surface runoff. The amount of impervious area (IA) in a watershed is correlated with a decrease in water and habitat quality, including increased flood peaks and frequency; increased sediment, nutrient, and other pollutant levels; channel erosion; aquatic biota impairments; and reduced groundwater recharge. Directly connected impervious area (DCIA) is the portion of IA with a direct hydraulic connection to the waterbody via continuous paved surfaces, gutters, drain pipes, or other conventional conveyance and detention structures that do not reduce runoff volume.

DCIA does not include:

- Impervious area draining to stormwater practices designed to meet recharge and other volume reduction criteria.
- Isolated impervious area with an indirect hydraulic connection to the Small Municipal Separate Storm Sewer Systems (MS4s), or that otherwise drain to a pervious area.
- Swimming pools or man-made impoundments, unless drained to an MS4.
- The surface area of natural waterbodies (e.g., wetlands, ponds, lakes, streams, rivers).

When determining the TMDL for a pollutant, MassDEP has decided that stormwater from all areas defined as DCIAs should be considered part of the stormwater waste load allocation (WLA) regardless of whether the area is part of an EPA designated "urbanized area" and as such subject to the NPDES Phase II General Permit for stormwater discharges from MS4s. The WLA consists of the stormwater DCIA contribution and the Wareham Wastewater Control Facility Outfall point source.

DCIA was calculated in accordance with EPA methodology (EPA, 2010) using the "Sutherland Equations" (Sutherland, 2000). As outlined in the methodology: the IA of each sub-watershed was determined using the MassGIS 2005 Impervious Surface data layer (MassGIS, 2007), the land use categories in the MassGIS Land Use 2005 datalayer (MassGIS, 2009) were reclassified into commonly used land use categories that correspond with the Sutherland watershed selection criteria, and the "Sutherland Equations" were applied to the IA to calculate DCIA as a percentage of IA in each sub-watershed.

The WLAs for stormwater nitrogen contribution (kg N/day) was determined using the DCIA for each sub-embayment divided by total IA in the sub-embayment, then multiplying the total impervious surfaces runoff N load for the sub-watershed (Table IV-2 of the MEP Technical Report) per EPA methodology. The remaining impervious surfaces loads were assigned as the LA. Table 7 shows the existing WLA and LA from stormwater runoff from impervious surfaces in the Wareham River Estuary System watershed.

To complete the WLA calculation, the total stormwater load from impervious surfaces as determined by the MEP study (12.8 kg N/day from Table IV-2 in the MEP Technical Report) was multiplied by 0.39 (the percentage of IA that was determined to be DCIA in the watershed - see Table C-1). The resulting value of 6.1 kg N/day is the WLA and the remaining 6.7 kg N/day is assigned to the nonpoint source contribution to the load allocation (LA).

Table C-1: Directly Connected Impervious Area (DCIA) and Stormwater WLA for the Wareham River Estuary System

MEP Watershed	**Total Watershed Land Area** (acres)	**Total Impervious Area in Watershed**[1] (acres)	**Impervious Area as % of Total Watershed Area** (%)	**DCIA Area**[2] (acres)	**DCIA as % of Total Impervious Area** (%)	**MEP Total Unattenuated Watershed Impervious Load**[3] (kg N/day)	**MEP Total Unattenuated Watershed Load** [3,4] (kg N/day)	**WLA** (kg N/day)[5]	**WLA as % of MEP Total Unattenuated Watershed Load**[6] (%)
Broad Marsh	982.4	232.7	23.7%	174.7	75.0%	1.773	11.942	1.331	11.1%
Wareham River (Marks Cove)	638.1	109.1	17.1%	75.1	68.8%	1.559	7.471	1.073	14.4%
Crab Cove	263.4	47.3	18.0%	27.1	57.3%	0.568	4.620	0.325	7.0%
Crooked River	309.2	52.1	16.8%	26.2	50.3%	0.657	6.609	0.331	5.0%
Wareham River (Lower)	204.9	8.4	4.1%	1.3	15.6%	0.065	1.552	0.010	0.6%
Wareham River (Upper)	2,089.2	362.3	17.3%	232.9	64.3%	2.562	43.983	1.647	3.7%
Agawam River	14,193.3	667.3	4.7%	161.6	24.2%	3.562	37.089	0.862	2.3%
Wankinco River	10,197.4	814.3	8.0%	195.5	24.0%	2.084	37.294	0.500	1.3%
System Total	**28,878**	**2,293**	**7.9%**	**894.2**	**39.0%**	**12.830**	**150.559**	**6.079**	**4.0%**

[1] Total Impervious Area calculated using MassGIS 2005 Impervious cover datalayer (MassGIS, 2007).
[2] DCIA calculated per MEP sub-embayment using GIS and EPA methodology (EPA, 2010).
[3] From MEP Technical Report, Table IV-2.
[4] This includes the unattenuated nitrogen loads from wastewater from septic systems, landfills, fertilizer, agriculture, runoff from both natural and impervious surfaces, atmospheric deposition to freshwater waterbodies.
[5] The DCIA Area as % of Total Impervious Area multiplied by the MEP Total Unattenuated Watershed Impervious Load (kg N/day).
[6] The WLA (kg N/day) divided by the total watershed load (kg N/day) then multiplied by 100.

Appendix D: Wareham River Estuary System Total Nitrogen TMDLs

Table D-1: TMDLs for Wareham River Estuary System – Two Total Nitrogen TMDLs and Four Protective TMDLs

MassDEP Assessment Unit Name & ID	**MassDEP AU Type & Class**	**MEP Watershed**	**MassDEP Impairment Parameters Associated with the TMDL**	**Action Type**	**TMDL** *kg N/day*
Wareham River MA95-03	Estuary *Class SA*	Wareham River (Lower)	- Total Nitrogen - Chlorophyll-a - Estuarine Bioassessments	Restorative TMDL	75.80
		Crab Cove			
		Marks Cove			
Agawam River MA95-29	Estuary *Class SB*	Wareham River (Upper)	- Total Nitrogen - Algae - Nutrient/Eutrophication Biological Indicators	Restorative TMDL	20.92
Agawam River MA95-28	Freshwater *Class B\WWF*	Agawam River	-	Protective TMDL [1]	22.11
Wankinco River MA95-50	Estuary *Class SA*	Wankinco River	-	Protective TMDL [1]	25.85
Broad Marsh River MA95-49	Estuary *Class SA*	Broad Marsh River	-	Protective TMDL [1]	17.95
Crooked River MA95-51	Estuary *Class SA*	Crooked River	-	Protective TMDL [1]	2.88
				System Total:	**165.52**

[1] *Pollution Protection TMDLs (kg-N/day) for community planning and to prevent further downstream impairment.*

Appendix E: Response to Comments

DRAFT WAREHAM RIVER ESTUARY SYSTEM
TOTAL MAXIMUM DAILY LOAD (TMDL)
FOR TOTAL NITROGEN (CN 549.1)

REPORT DATED AUGUST 2023
PUBLIC MEETING ON NOVEMBER 28, 2023

This was a virtual meeting hosted via Zoom. The Town of Wareham hosted a physical meeting room in the Wareham Town Hall where attendees were able to access the virtual meeting. Attendance records for the virtual (Zoom) meeting and in-person meeting are included at the end of the appendix. The meeting was recorded by MassDEP. The recording was used internally to review the comments and suggestions provided during the meeting.

Questions & comments received on November 28th from meeting attendees:

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1) The quantity of information and detail of it is somewhat overwhelming. I think as far as the sewer plant is concerned with Wareham, it is a functional facility and certainly can be appropriately used for the quantities we are currently dealing with. However, to go beyond what is anticipated, we really need the ability to expand. Our objective is to try to get an outfall which will accommodate the increased processing that we need to accommodate our community and perhaps some of the portions of the abutting communities. It is not that we don't want to do it, it's just the cost of doing it and we really need help in that area. MassDEP indicated that the projects and reports are part of the application process for funds. What you're doing is very necessary as it accurately documents what the needs and solutions are.

- ***Bernard Pigeon, Wareham Sewer Commission Chairmen***

MassDEP Response:
Thank you for your support of the Total Nitrogen TMDL for the Wareham River Estuary System. The Comprehensive Wastewater Management Plan (CWMP) is intended to provide the Towns with potential short and long-term options to achieve water quality goals and therefore provide a recommended plan and schedule for wastewater, and 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 (SRF) to help develop these plans. Towns with estuaries that have EPA-approved TMDLs qualify for zero percent SRF loans for infrastructure construction projects for nutrient reduction.

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2) The Community Land & Water Coalition is a regional network of groups and individuals working to protect and preserve land and water in southeastern Massachusetts. One of the main campaigns and research projects that we've been working on is the extensive sand & gravel mining, and deforestation by the cranberry industry. We recently issued a report showing that there are over 2,500 acres of forest and lands that have been mined, 75% of it by the cranberry industry in the last 20 to 30 years. We've got expert testimony showing that this contributes to nitrogen pollution. And we have some testimony by Scott Horsley. How is MassDEP taking this into account and what is the state doing to stop the cranberry industry from conducting sand and gravel mining under the ruse of agriculture, and to take

into account the impacts of nitrate and nitrogen pollution? As I'm sure you know, this isn't just normal land development. It's stripping the forest down to bare sand, leaving them as open pit mines, and, in some cases, covering it over with industrial scale solar. Obviously, this removes, I think it's 90% of the nitrogen filtration that's provided by forests and sand and gravel. It's also changing the base flow of the rivers, according to our experts. Can you explain how that's being taken into account in terms of the land use changes? What MassDEP will be doing to encourage the cranberry industry in particular to stop this practice and to provide support to groups like ours and communities that are trying to regulate this deforestation? Is there a way for nonprofit groups like ours to participate in the process to obtain funding and to have our research incorporated into the land use model that you run or any other relevant place? Our report is on our website (sandwarssoutheasternma.org) and identifies 110 sand & gravel mining sites and the volumes removed and describes the nitrogen loading impacts, etc.

- ***Meg Sheehan, Community Land & Water Coalition***

MassDEP Response:

Please refer to the response to Comment 35, which addresses the formal written comments submitted by the Community Land & Water Coalition regarding cranberry bogs and sand mining. Regarding funding, there are several funding sources for pollution abatement. The Southeast New England Program (SNEP) Watershed Implementation Grants Program targets water pollution, habitat degradation, and other high-priority environmental issues to foster sustainable coastal and watershed communities. The state provides low interest loans on a competitive basis through the State Revolving Fund (SRF) for water pollution abatement planning and construction of projects to assist municipalities in complying with federal and state water quality requirements. SRF loans 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. The Massachusetts 319 grant program provides up to $2 million per year in grants and TMDL implementation has historically been a high priority in the 319 grant program.

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3) I'm sure everybody here has different personal interests or agendas as far as water pollution. We've been waiting 10 years or more for final results from this TMDL. You're putting the communities, not just Wareham, but everybody that's on the west side Buzzards Bay, under extreme pressure and expecting really unrealistic results. If you look at a map, water runs from north to south, underground, etc. Wareham obviously suffers from all the communities north of us, with all the stuff that goes through those communities. Whether they have a sewer, septic, cesspool, etc. People that have extremely green lawns and throw nitrogen-based materials for their lawns to be that green. Those materials all come down and end up coming out through Wareham. So, the numbers for Wareham are grossly distorted, as far as what is Wareham's responsibility.

As a select board member, I really am not going to be willing to sit there and just smile and say: “Sure, we'll take care of everybody else's problems”. It's financially impossible. This is one of these things where basically, everybody needs to be involved and everybody needs to contribute financially. It's the same thing in Wareham. If we have a part of the area sewered and we have to expand to a larger area, then we're probably going to have to take a very difficult political stance and say that everybody in town has to pay for a newer sewer plant. This is just the same idea what has to happen at the State level, as far as what goes into the Buzzards Bay. Either we all pay or none of us pay and there's no other way around it. And if you’re going to leave it the way it is right now then it's not going to happen. We'll have a bunch of lawsuits and that's all we're going to have. Thank you.

- ***Alan Slavin, Wareham Select Board***

MassDEP Response:

MassDEP encourages neighboring towns to work together to restore water quality in their watershed. Towns have three options to implement this approach. First, a cooperative agreement with neighboring towns could be used to develop a combined plan, a Comprehensive or Targeted Watershed Management Plan. This would require an Inter-Municipal Agreement (IMA). As a second approach, Wareham could address nitrogen reduction strategies within their municipal boundaries alone and Carver and Plymouth could do the same. For the third option, each town could 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 timeframe.

An example of neighboring towns working on a regional plan is the Pleasant Bay Alliance, which consists of Orleans, Brewster, Harwich, and Chatham. If the watershed contribution from a given town is a small percentage of the total load, the high cost of sewering may not justify construction of a separate sewering project. Instead, the town might consider contributing to the sewering project of a neighboring town for the rights to connect some portion of the town to municipal sewers. MassDEP encourages resource sharing between municipalities, particularly where it results in increased efficiency and cost savings.

The Cape Cod Commission prepared a Regional Wastewater Management Plan or RWMP that 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. 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. Also, the Greater Lawrence Sanitary District 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. Another regional collaboration example is the Towns discharging to the Assabet River. They include the Towns of Westborough and Shrewsbury, Marlboro and Northborough, Hudson, and Maynard. A significant reason why these towns joined forces was that they received higher priority points in the State Revolving Fund (SRF) as a group than they otherwise would have individually.

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4) Assuming that over time we hit the target nitrogen concentration, how long do we think it would take to reestablish eelgrass levels back to 1988 at least? Eelgrass is a real good barometer for the health of the body of water. I'm more familiar with Long Island Sound, but when we talk about eel grass restoration, we're talking about a 50-year program. I think it's important that people in the community understand what the TMDL is really looking for in terms of its scales. I'm really concerned when we talk about any of these things that people understand that it's not something that they're going to see an immediate turnaround on. I think it's imperative to be candid about it, so people do not have an expectation that eelgrass suddenly shows up when we hit the target - that's not how it works.

Have nitrogen reducing innovative/alternative (I/A) septic systems been used in all the new development (apartment, town homes, and clustered housing)? I also heard that the TMDL would not include zoning requirement regarding the use of septic systems. Instead, it includes only a

recommendation. Isn't one way that we can help the water is by getting these I/A systems used by the more recent developments as they'd get permitted so that we're not adding to the problem?

I'd like to go back to what Alan was saying, in terms of the fact that it's more of a regional issue than a local issue. Maybe there needs to be a little bit of countywide or even statewide modifications of permitting on this in order to make it go from a recommendation to something mandatory. If there's a better technology out there to reduce nitrogen flow should be used in in in the current time at least, as opposed to, you know, putting in a less effective system.

- ***John Bahouth, Resident***

MassDEP Response:

The time it takes to observe regrowth of eelgrass is very estuary specific. There are multiple factors that can control the ability of eelgrass to re-establish in any area. Some are due to physical factors (such as boat traffic, water depth, or even sunlight penetration) and others are due to chemicals such as 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 and the eelgrass will not return until the water quality conditions improve. 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. More generally it could take several years to see eelgrass return to the estuary after source reduction begins.

Regarding new development, the TMDL does not include detailed septic information in any new development since the completion of the MEP Technical Report. The TMDL was developed using the baseline data from 2005-2011 and the modeling scenario analysis predicted that the restoration targets could be achieved. The MEP Technical Report also modeled the build out scenario and estimated additional nitrogen loading. Any additional nitrogen loading that has occurred since the baseline data collection may require additional overall nitrogen load removal. However, the target threshold concentrations remain the same.

In 2013, the Wareham Board of Health passed Water Quality Protection regulations to reduce new sources of nitrogen pollution to its coastal waters. The municipal regulations target septic systems – specifically those proximal to surface waterbodies. MassDEP has not proposed any state regulations to require Title 5 system upgrades or other measures to reduce the nitrogen load in the Wareham River Estuary watershed. Any such effort in the future will require public notice and involvement of the affected municipalities.

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5) In general, the output for the plant is more focused on nitrate. Is there a better breakdown of the total nitrogen, specifically Kjeldahl nitrogen and nitrate, that was measured in these different estuaries? As far as the breakdown goes, was there a focus on the portion of the load that was nitrate? Regarding the I/A systems, they tend to be fantastic at nitrifying and not as great with denitrifying. In the end, they can produce a total nitrogen higher than you otherwise might have without them.

- ***Scott Kraihanzel, Director of Wareham Water Pollution Control***

MassDEP Response:

The Buzzards Bay Coalition has been monitoring water quality in the Wareham River since 1992. The data collected by the BBC includes nitrate, nitrite, total kjeldahl nitrogen, and total nitrogen.

The Coalition publishes the Baywatchers Water Quality Monitoring Program data on their website (www.savebuzzardsbay.org/bay-health).

The predominant nitrogen load in the Wareham River Estuary System is from septic loading. Innovative/alternative (I/A) septic systems designed for nitrogen removal are approved for the nitrogen reduction level stated in the approval issued by MassDEP for each technology. MassDEP is currently reviewing I/A system performance and will be working with technology proponents to improve system performance. In addition, some new technologies are showing promising results. 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.

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6) I want to make 3 quick points. The first one is recognizing the work that the Town of Wareham has done to reduce nitrogen in their coastal estuaries. In 2013, Wareham was the first town to pass a Board of Health regulation requiring new construction in the town to install nitrogen-reducing septic systems. Anything new, that's not on a sewer line, should be installing a nitrogen-reducing septic system in the Town of Wareham. They were one of the first towns, and I think the first town in the Buzzards Bay watershed, to move in that direction. We have had more towns since then, but kudos to Wareham. In 2005, Wareham upgraded their wastewater treatment facility from secondary treatment to tertiary treatment and it has been one of the better performing plants in all of Buzzards Bay over the last two decades. You can see the change or the reduction in total nitrogen in the river after that upgrade in our data. Is it enough reduction in the river? No, but you definitely can see a good, positive response in the river from going from secondary to tertiary treatment. The Wareham plant reduces nitrogen by 95% and they just passed, at the town meeting, 36 million dollars to keep that plant going. I wanted to start there and recognize everything that the Town of Wareham has been doing. Through the discussions at the Sewer Commission meetings, I think the town knows that they need to move forward with expanded collection system and more wastewater treatment. Municipal wastewater treatment is the best way to reduce nitrogen pollution and so to the extent the Coalition can continue to support the town in moving that direction, we will.

The second thing I want to talk about is that there's a lot more work to be done. The Coalition's been monitoring water quality at the sentinel stations that MassDEP talked about since 1992 and we are still above what the threshold will allow. We still don't have our eelgrass back, so we know we need to expand more sewers and get the nitrogen out of the septic systems and into the sewer treatment plant. The Coalition supports the science behind the TMDL and establishing the threshold limits. Those are good targets for the town to aim for.

The final thing that I want to say is just to underscore the utility of the TMDL for the town to restore and protect water quality. It gives the town a target. We all know how expensive wastewater projects are. This TMDL helps the town prioritize actions to take in order to reduce nitrogen to meet water quality standards. As the Chairmen of the Wareham Sewer Commission said, it also makes Wareham more attractive for funding. When you have a TMDL, you have that total maximum daily load established by the state and approved by the federal government. We need as much federal and state money as possible to fix this nitrogen problem. So with that, the Coalition supports the TMDL. We thank MassDEP and the Town of Wareham. We look forward to working with the town on planning and implementation so we can protect and restore water quality for future generations.

- ***Korrin Petersen, Buzzards Bay Coalition***

MassDEP Response:

Thank you for your support of the Total Nitrogen TMDL for the Wareham River Estuary System. In addition, thank you for your long-term commitment (>30 years) to data collection efforts in this estuary and throughout Buzzards Bay. The importance of these data cannot be overstated.

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7) I live at the lower end of the Agawam River. It appears the Agawam River contributes about 15% of the nitrogen load the Wareham River. It's not a large percentage and the data also seems from 2014. So, it's quite a long time ago that we're basing our decisions on where we should put our priorities. Another thing I note is that the data collection points for the Agawam River are below the waste treatment plant. So, you don't really have a data to differentiate where the nitrogen load comes from upstream - be it the runoff from the bogs or the septic systems or whatever. So, where do we spend our money?

I think that data being so old, it isn't reflective. For example, I'm a member of organization called CAMP, Clean Agawam Mill Pond. For the last 5 years or so, we've gone a long way to cleaning up a lot of the invasive weeds and restore the whole lower third of the Agawam River to a more balanced ecosystem. Which is going to play a very positive role in terms of the mediation of nitrogen coming from upstream, which it wasn't capable of doing before. I guess my concern is with data that is so old, how relevant is it to the current situation? Among other things, it is not going to reflect whatever additional septic load is from the development up Agawam River. So, you just don't have a data to spend a lot of money one direction or the other with any kind of confidence. That that was one thing that really surprised me, is how old the data is and how much we're looking to bank on that. Also, for example, whatever mediation that the cranberry bog may have been doing through the years, they seem to be attuned to such things. How can we best update the data so we can have current situations rather than trying to solve problems from 10 years ago?

Another trivial thing, one of the suggestions is essentially eliminating all septic systems along the Agawam River and therefore going to zero nitrogen load. No, that's not true because we're still going to have sewage. Yes, it's going to be transferred to the treatment plant and it'll probably do much better job than septic systems that exist. But it's not going to get to zero so it's just an unreasonable goal. It just makes me question all the numbers which are printed out with such incredible precision. How in the world would you get anywhere near that precision? You're incapable of measuring those numbers that precisely, therefore you cannot possibly measure change that precisely so you can never know that you've met your goal. So, it's an unreasonable goal and it's unattainable.

That's really what you need, you need these so-called smart goals: something that is specific, that is attainable, that's achievable, relevant, and has a timeline. And you don't have a timeline here. You don't have how you're going to measure your difference? Doesn't mean that you're claiming you can. And it is not really attainable. I just don't think we have current data and measurements that we can actually use to get to detail that you're suggesting. I don't really see that we have a realistic plan to get there. Again, it's a big concern to me that it's reliant on such old data. It's a double-edged sword. In some cases, you're not going to be seeing some of the changes that have been made to improve the situation. In other cases, you're not going to pick up areas that are now more of a hotspot than ever. So, it just comes off as chasing our tails.

- ***Michael Bower, Resident***

MassDEP Response:

The Buzzards Bay Coalition Baywatchers program has been monitoring water quality in the Wareham River since 1992. The aquatic health of the Wareham River Estuary System was assessed by MassDEP based upon the extensive record of water quality data collected by the BBC, benthic infauna species analysis performed as part of the Massachusetts Estuaries Project (MEP), and historical mapping and change analysis of eelgrass distribution collected under the MassDEP Eelgrass Mapping and Monitoring Program.

The TMDL was developed using the baseline data from 2005-2011 and the modeling scenario analysis predicted that the restoration targets could be achieved. The MEP Technical Report also modeled the build out scenario and estimated additional nitrogen loading. Any additional nitrogen loading that has occurred since the baseline data collection may require additional overall nitrogen load removal, however, the target threshold concentrations remain the same.

To restore and protect this estuarine system, nitrogen loadings, and subsequently the concentrations of nitrogen in the water, must be reduced to levels below those that cause the observed environmental impacts. This nitrogen concentration is referred to as the target threshold nitrogen concentration. The MEP determined that by achieving the specified nitrogen concentration at sentinel stations, water and habitat quality will be restored in these systems.

In the case of the Wareham River, the target threshold nitrogen concentrations of 0.40 mg/L and 0.42 mg/L at the Lower Wareham River (WR-6) and Upper Wareham River (WR-3) sentinel stations, respectively, are the appropriate threshold values for the restoration of eelgrass at locations within the system where it has historically been present. The sentinel station locations were chosen such that the restoration of the target threshold nitrogen concentration at these sites would bring the other regions of the system to acceptable concentrations and support eelgrass habitat quality and the aquatic life use goals. The development of the target threshold N concentrations and the required N loadings are fully described in the MEP Technical Report and are based on sound science. The process utilized several different types of data including baseline water quality data, estuary bathymetry data, land use data, tidal and streamflow data, eelgrass mapping, and macroinvertebrate data.

At a minimum, MassDEP would like to see monitoring continued at the sentinel stations monthly from May-September to determine compliance with the TMDL. Ideally, it would be good to continue monitoring all of the stations, if possible. The benthic stations can be sampled every 3-5 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.

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8) In Wareham, we've been reasonably proactive in trying to go beyond our limitations. As an example, you mentioned the package treatment plants. My vice chair is working in little Harvard to see the application because we have a small group in that particular location. Scott, the director is working with the wood chip issue and doing very well down the plant for that area, and we're constantly trying to improve the resources that we have to expand. We've reached our limits in terms of our state permits. And to go further, we have to begin expansion, and that's difficult to do in this timeframe because there's not a lot of infrastructure money available. And we've sewered about 60% of our community. It now more costly to reach those areas in the rest of the community but very obviously they must be done. It’s become more and more difficult, because, of course, all the surrounding communities are trying to adapt

attempt the same issues. But we're very proactive and I'm very proud of that and the people we work with. We'll keep going on need all the help we can get.

- ***Bernard Pigeon, Wareham Sewer Commission Chairmen***

MassDEP Response:

Thank you for this additional information. MassDEP appreciates the work of the Wareham Sewer Department and their efforts towards the protection and enhancement of the Wareham River Estuary.

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9) Could anyone just speak to the potential impacts this could have on private septic systems? Is there going to come a time when we will be required to replace septic systems, even properly functioning ones? And what kind of a time frame would that be?

- ***Jill Risgin, Resident***

MassDEP Response:

The TMDL does not require owners of septic systems to upgrade their systems within a certain number of years. The TMDL is a planning document that provides a framework for water quality restoration and nutrient management. The TMDL is separate from a Title 5 Natural Resource Area - Nitrogen Sensitive Area Designation. Any future proposal involving the implementation of nitrogen reducing strategies would occur only after undertaking a planning effort with the affected municipalities, and after significant public process.

MassDEP's promulgation of revisions to Title 5 (310 CMR 15.000) and new regulations for Watershed Permits (310 CMR 21.00) are geographically limited to the municipalities covered by the Cape 208 Plan, meaning only those towns on Cape Cod. Although MassDEP's draft regulations were originally proposed to apply to Buzzards Bay, and the Islands municipalities, MassDEP reduced the geographic scope of the regulations in response to public comments. The TMDL is a study that identifies the maximum amount of a pollutant that can enter a water body and still meet water quality standards. Adoption of a TMDL does not impose any regulatory requirements to eliminate the sources of pollution. MassDEP has not proposed any state regulations to require Title 5 system upgrades or other measures to reduce the nitrogen load in the Wareham River Estuary watershed. Any such effort in the future will require public notice and involvement of the affected municipalities.

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10) There were 15 data collection points that was set up and form the basis of the information that was collected a decade ago. Have they continued in operation. If more recent information exists, is it currently available?

- ***Michael Bower, Resident***

MassDEP Response:

The Buzzards Bay Coalition Baywatchers program has been monitoring water quality in the Wareham River since 1992. The BBC publishes the water quality monitoring program data on their website (www.savebuzzardsbay.org/bay-health).

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11) Is the MassDEP conducting performance evaluations for Innovative/Alternative (I/A) Title 5 on-site septic systems? Is that data or the performance evaluations available? Will they become part of some sort of approved system? What is the end goal for that?

- ***Margaret Ishihara, Resident***

MassDEP Response:

Under the Title 5 Regulations (310 CMR 15.000), MassDEP must approve an innovative/alternative septic-system technology before it can be used in Massachusetts. As part of this process, MassDEP receives data on the performance of Title 5 I/A systems. MassDEP is currently reviewing those data to see how well those systems have been performing. It is our intention to provide a list of the Best Available Nitrogen Reducing Technology (BANRT) to the public. We are currently conducting outreach to the technology proponents who own those technologies. If their systems are not performing to the levels proposed, then they would have an opportunity to make corrections. MassDEP expects that results should be available to the public in the coming weeks. Additional information about approved innovative/alternative technologies is located on the MassDEP website (https://www.mass.gov/septic-systems-title-5). I/A system performance analysis readily available through Barnstable County Department of Health & Environment (www.capecod.gov/departments/health-environment/programs-services/water-and wastewater/alternative-septic-system-tracking/).

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12) I know that we can't make specific correlations at this time between land use and the Wareham River watershed and the nitrogen data in the specific river. Can the MassDEP talk in general about the role of forests, vegetation, and soil in the natural attenuation of nitrogen within the watershed?

- ***Katherine Harrelson, Community Land & Water Coalition***

MassDEP Response:

The Massachusetts Estuaries Project determined that the ultimate cause of water quality degradation in estuarine systems is the increase in nitrogen inputs from changing land-use over the past century; the shift from pasture-land or forest to residential development with on-site disposal of wastewater resulted in a substantial increase in nitrogen loading on a per area basis.

In terms of the Wareham River Estuary System TMDL, the MEP Linked Watershed-Embayment Model calculates nitrogen loading based upon the different types of land use within the watershed. Within the MEP modeling framework, natural areas, like forested land, generally have higher attenuation rates and lower nitrogen loading rates than the developed areas of the watershed. The accompanying MEP Technical Report presents the results of the nitrogen loading analysis of the embayment system using the MEP Linked Watershed-Embayment Nitrogen Management Model (https://www.mass.gov/doc/linked-watershed-embayment-model-for-wareham-2014/download).

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13) I do have some serious issues with the data. I think even doing a literature review on data that's over 10 years old is not considered best practice in any research field or in any kind of professional domain. I say that as a researcher. My biggest thing here, after listening to all of this, is that meetings are intended to be public and should be accessible to everybody. I think that having a Zoom Meeting about something as important as this in the middle of the day is extremely short sighted. There are lots of people who have been saying I can't access the raise my hand. It could very well be that they can, but they are not used to using Zoom as frequently as some of us might be. I think that it's really important to really consider the

community, the needs of the community, and making public meetings public. To me, it seems like this was snuck in. It is 2:00 PM on a workday. I luckily have the flexibility to be able to attend, as do some of my neighbors. But I'm very surprised that there's only 58 people on this meeting right now and I know for a fact that more than 20 of my neighbors are not on because they're working, they can't log on, and they can't attend. I would like for all of the people here to just really make sure that you pay attention. A public meeting should not be on Zoom midday. It also shouldn't require preregistration. I think you're really omitting a lot of people who might even just want to listen. A lot of this information actually made me feel a little bit better about the chitter chatter and what's been in the newspaper. But this was a very short-sighted way to present this information and to inform our town.

- ***Jennifer Kearns Fox, Resident***

I put it in those sentiments (See Comment 13) as a comment prior to this meeting. As it turned out, it was undeliverable to the address that I was given. I don't know what happened there. I certainly agree and I'm very surprised to discover today that the Town Hall meeting was open apparently. So, people could have gone there. It was definitely my impression that there would be no public meeting, especially based on some of the comments in the Wareham Week. They decided specifically not to do that because there might be some angry people involved. So yeah, I'm very disappointed. This is not truly an open community meeting, and it certainly should be.

- ***Michael Bower, Resident***

MassDEP Response:

Thank you for your attendance and feedback. This meeting was not a formal public meeting hosted by the Town of Wareham. This was an information session about the TMDL report that was hosted by MassDEP. The information session was designed to provide context for the TMDL and kickoff the 30-day formal public comment period. MassDEP appreciates the comments and will take them into account when planning future meetings.

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14) I'd like to follow up on one of the comments about agriculture and agricultural practices over the last 10 years. We have seen a lot of "so called" tailwater recovery ponds being constructed by the cranberry industry. There is a 20 acre one in Plymouth on Federal Furnace Bogs and we've got a couple of big ones on the Wankinkco. These are 20 acre or more "supposedly agricultural ponds", where they level hills and then they excavate and dredge in the in the aquifer for sand and gravel. We have asked the Cranberry Extension service for scientific data to show that that actually improves the nitrogen issues with the cranberry bogs. They do not have any scientific data to show that tailwater recovery pond - the one in Plymouth that was done under an MOU with MassDEP and the cranberry industry - is reducing nitrogen in White Island Pond and that was the purpose of this mining operation to create this bog. There was a lot of work around the TMDL for White Island Pond and getting that done. Do you have data about how those cranberry tailwater recovery pond improve nitrogen loading and water quality in the Wareham River?

- ***Meg Sheehan, Community Land & Water Coalition***

The Coalition just released a report (www.savebuzzardsbay.org/news/cranberry-report-findings/). It's a compilation of 10 years of water quality research on various types of cranberry bogs. The big takeaway is that the flowthroughs are the worst, and to the extent you can do restoration on cranberry bogs, you can reduce nitrogen not just from the bog, but also from other areas. We looked at all different types of bogs, including tail water recovery and different aspects. Every bog is a little bit different. They're all located in different locations.

- ***Korrin Petersen, Buzzards Bay Coalition***

I did read that, but I didn't see any evidence to establish that the tailwater recovery ponds that have been built in the last 10 years have had any positive impact, and I also noticed that that report did not take into account all the sand & gravel mining that's going on around the bogs under the ruse of agriculture. I think that's really a gaping hole in all of this analysis in that report as well. I really encourage you to look at our investigation and our study that we're going to be continuing to update to try to get a handle on these land use changes and what they're doing to nitrogen and water quality in these rivers.
- ***Meg Sheehan, Community Land & Water Coalition***

MassDEP Response:
Please refer to the response to Comment 35 which addresses the formal written comments submitted by the Community Land & Water Coalition.

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15) Since 2015, Wareham Fire District has either through CR or through purchase, has taken quite a bit of cranberry agricultural property offline. Most of it a lot of it's up in the Maple Springs wildlife management area. Tomorrow night there's another is a meeting to purchase another 127 acres, of which majority of it is productive cranberry bog - at least that's what it appears by the map. I think that's important to take into consideration and to include these reductions and removal of the cranberry industry and active cranberry bogs into the Total Maximum Daily Load.
- ***Jim Munise, Resident***

MassDEP Response:
Thank you for this additional information. We encourage interested parties to reduce the agricultural contribution through the implementation of feasible agricultural best management practices (BMPs) or through land conservation with a goal of reducing N contribution from agricultural sources. The Massachusetts Division of Conservation Services offers a Massachusetts Land and Water Conservation Fund Grant Program that can be used to acquire land for conservation or recreational purposes. State Revolving Funds can also 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 undeveloped 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.

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16) I would like to add another resource of data for the innovative alternative septic systems. The Barnstable County Department of Health and Environment operates the Massachusetts Alternative Septic System Test Center. They do test on site at Joint Base Cape Cod and they collect data from other locations and some from out of state. It's another resource for data on alternative septic systems beyond what MassDEP will have. I'm sure that they will come complement each other with available data for the forms of those systems.
- ***Jon Hobill, MassDEP***

MassDEP Response:
Thank you for this additional information.

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17) I appreciate the answer to my last questions about natural processes that can affect the nitrogen loading in a river. What role do natural forests, existing forests, and natural vegetation play in the nitrogen cycle? How can deforestation and removal of a natural vegetated cover affect the nitrogen loading in a watershed or river?

- ***Katherine Harrelson, Community Land & Water Coalition***

MassDEP Response:
Please refer to the response to Comment 12.

Questions & comments received on November 28th in the virtual meeting chat:

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18) Please include the data from this report (http://www.sandwarssoutheasternma.org) in the Land Use Data. The report shows at least 1,000 acres of sand and gravel mining in the Wareham-Carver-Plymouth that is contributing to nutrient loading.

- ***Meg Shehan, Community Land & Water Coalition***

MassDEP Response:
Thank you for this additional information. It will be included in the TMDL Response to Comments. Please refer to the response to Comment 35, which addresses the formal written comments submitted by the Community Land & Water Coalition.

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19) Where find this slide show?

- ***Meg Shehan, Community Land & Water Coalition*:**

MassDEP Response:
*The presentation slides are available online on the MassDEP TMDLs by Watershed webpage: (*https://www.mass.gov/lists/total-maximum-daily-loads-by-watershed)

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20) Since agriculture is a controllable source and 2nd largest contributor, what specifically is proposed to reduce N loading from agriculture in this watershed?

- **Anita Smith**

MassDEP Response:
MassDEP recommends that the watershed communities implement agricultural best management practices (BMPs) with a goal of reducing nitrogen contribution from agricultural sources. The Center for Agriculture, Food, and the Environment (CAFE) at the University of Massachusetts Amherst maintains a catalog of agricultural and horticultural BMPs (ag.umass.edu/resources/agriculture-resources/best-management-practices-bmps). The CAFE also publishes information on plant nutrient regulations in Massachusetts and resources for nutrient management planning and practices

(ag.umass.edu/resources/agriculture-resources/umass-extension-nutrient-management). Additionally, the UMass Cranberry Station maintains a catalog of research-based BMPs for the cranberry industry (ag.umass.edu/cranberry/publications-resources/best-management-practices) and publishes resources, templates, and tools specifically targeting nutrient management for cranberries (ag.umass.edu/cranberry/publications-resources/nutrient-management-for-cranberries).

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21) Can MassDEP clarify whether agriculture in the watershed includes sand and gravel mining by the cranberry industry?

- ***Meg Shehan, Community Land & Water Coalition***

MassDEP Response:

Please refer to the response to Comment 35, which addresses the formal written comments submitted by the Community Land & Water Coalition.

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22) Based on the results of the wood chip pilot study, there may be an opportunity to apply it to the agriculture outfall.

- ***Scott Kraihanzel, Director of Water Pollution Control, Wareham Sewer Department***

MassDEP Response:

Thank you for this additional information. MassDEP appreciates the work of the Wareham Sewer Department and their efforts toward the protection and enhancement of the Wareham River Estuary.

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23) Can the MassDEP talk more in general about the roles of forests and vegetation and soil in natural attenuation of nitrogen in the watershed?

- Katherine Harrelson, Community Land & Water Coalition

MassDEP Response:

Please refer to the response to Comment 12.

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24) Are there regulations in place for limiting the use of lawn and cranberry fertilizations that add nitrogen?

- ***Mary Dooley, Resident***

MassDEP Response:

The Massachusetts Department of Agricultural Resources (MassDAR) promulgated plant nutrient regulations (330 CMR 31.00) in 2015, which require specific restrictions, including seasonal restrictions, on nutrient applications and set-backs 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. These regulations apply to both agricultural and non-agricultural land, including lawn and turf, and individual homeowners.

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25) How does MassDEP coordinate its land use recommendations for reducing nitrogen with the state's energy policies that are resulting in deforestation by industrial solar. Wareham, Carver, and Plymouth

have lost at least 1,000 acres of forest to industrial solar. Should the TMDL Program be talking to DOER about the importance of forests vs. solar?

- ***Meg Shehan, Community Land & Water Coalition***

MassDEP Response:

Please refer to the response to Comment 35, which addresses the formal written comments submitted by the Community Land & Water Coalition.

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26) Please note the Cape Cod Commission has control over all the communities on Cape Cod. This is unique!

- ***Alan Slavin, Wareham Select Board***

MassDEP Response:

The Cape Cod Commission (CCC) is the regional land use planning, economic development, and regulatory agency of Barnstable County regional government. MassDEP cannot comment on the legal mandate or degree of control that the Commission has on the communities of Cape Cod. The Commission is responsible for reviewing regional projects for consistency with the Cape Cod Regional Policy Plan. More information on the CCC is available on their website (www.capecodcommission.org).

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27) Is the information on the performance evaluations for I/A system available from DEP?

- ***Margaret Ishihara, Resident***

MassDEP Response:

Please refer to the response to Comment 11.

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28) It is important to recognize that this meeting is not accessible to all who may want to attend. Several people do not have the necessary technology OR know how to utilize it to listen and participate in what is supposed to be a public meeting. This needed pre-registration and is occurring mid-day in many peoples work week.

- ***Jennifer Kearns Fox, Resident***

MassDEP Response:

Please refer to the response to Comment 13.

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29) We would have preferred the town hall meeting in person and a very disappointed at the last-minute switch...

- ***Anita Smith, Resident***

MassDEP Response:

Please refer to the response to Comment 13.

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30) Are comments from today included?

- ***Jennifer Kearns Fox, Resident***

MassDEP Response:
Yes - comments from the virtual meeting will be included in the TMDL Response to Comments.

Questions & comments received via e-mail:

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31) Email from Carla Troupe <ccltroupe@gmail.com> November 27, 2023

Subject: Question on Wareham River Estuary System public meeting

To whom it may concern;

I live on [redacted] in West Wareham off of [redacted] on the Rochester town line. I did not see my neighborhood on any of the maps involved in this study/project. Does that mean that if this passes and residents are forced to upgrade their septic systems, we will be exempt, or will it be inclusive of the whole town of Wareham, regardless of that fact? Thank you.

Carla Troupe

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MassDEP Response:

First, a TMDL applies to a waterbody and associated upstream watershed or drainage area. A TMDL allocates loading only to those sections of a Municipality located within the designated watershed or drainage area. Therefore, the Wareham River Estuary System TMDL does not include the entire town of Wareham.

Second, the TMDL does not require owners of septic systems to upgrade their systems within a certain number of years. The TMDL is a planning document that provides a framework for water quality restoration and nutrient management. The TMDL is separate from a Title 5 Natural Resource Area - Nitrogen Sensitive Area Designation.

Once the TMDL is finalized, communities decide through Comprehensive Wastewater Management Planning (CWMP) or Targeted Watershed Management Planning (TWMP) how best to implement the TMDL in order to achieve the desired water quality goals. MassDEP reviews and approves a community's CWMP or TWMP, and makes subsequent permitting decisions based on its approved Plan.

Under current Title 5 regulations, new construction and existing septic systems in the Wareham River Estuary System watershed would not be required to upgrade as the result of local government not adopting a CWMP, TWMP, or Watershed Management Plan.

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32) Email from Patrick Tropeano <patrickgtropeano@yahoo.com> November 27, 2023
Subject: Questions

How do you propose to reduce the 56% by other. And since the Wareham treatment plant is at capacity. The only solution being an outfall pipe to the canal. That has meet with a great deal of issues and the fact that denitrifying systems do not work near as well as they are designed to. (This according to Barnstable county numbers) how much real benefit will this lead to and at what cost!!

Sent from my iPhone

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MassDEP Response:
A TMDL is a nutrient budget that determines how much nitrogen reduction is necessary to meet water quality goals as defined in the Massachusetts Surface Water Quality Standards. There are no deadlines that the town is expected to meet specifically related to the TMDL. However, the town must develop a plan to restore and protect the estuary and take actions at a reasonable pace to achieve the goals of the TMDL. MassDEP will work with communities to develop a plan to protect and restore impaired waters. There are some funding programs that consider whether there is an approved TMDL when considering the competitiveness of a grant application, including SRF loans and the Southeast New England Program (SNEP) grants. It is to the advantage of the community to apply for federal grants and low interest loans wherever possible.

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33) Email from Carl Persson <carl.persson2@gmail.com> November 28, 2023
Subject: Public Meeting-Wareham River Estuary System Total Maximum Daily Load For Total Nitrogen

Good morning, Mason

Given the MEP Technical Report quantifies bottom sediment regeneration of nitrogen (benthic flux) at 35 to 50 percent of total nitrogen supplied to the system, is the MassDEP open to new and in situ nature-based solutions that can address this specific load? Such solutions supply dissolved oxygen to the top layer of the sediment.

A problem in restoring eelgrass meadows is the condition of the sediment. It will likely reflect a past low oxygen environment and will be sulfidic and hold a lot of ammonium. Both are toxic and stressors to either eelgrass seeds or plantings. How will you re-condition the sediment?

We are organizing a project to field test our process to solve these problems.

Thanks for your time,
Carl Persson
Ocean Solutions Inc

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MassDEP Response:
The goal of the TMDL is to restore the estuary habitats for eelgrass and benthic infauna through targeted nitrogen load reductions. If the target concentration at the sentinel stations is achieved but

eelgrass does not return, 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.

There are several factors that can control the ability of eelgrass to re-establish in any area. Some are of a physical nature and others are of a chemical nature, such as 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 and the eelgrass will not return until the water quality conditions improve.

The most direct way to address excess nitrogen is through source control and reduction. However MassDEP understands that alternative methods, including in situ nature-based solutions, may be used to assist in reducing the impacts of excess nitrogen. If a CWMP relies on such alternative approaches, the plan must include demonstration protocols, including monitoring, that will confirm that the proposed reductions and 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 or approach meets the intended efficacy goal.

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34) Email from Michael Bower < mikiemmb@hotmail.com> November 28, 2023

Subject: Summited 11/21, failed to connect

The planned virtual public meeting of Nov. 28 on Watershed Planning Program does not meet the basic requirement for a "public" meeting. A large percentage of the population does not have access to the internet. Of those that do, a very large percentage of them do not have the internet skills to attend a virtual meeting.

While it is a good thing that those who have access and necessary skills to attend are provided with this opportunity, it leaves out a very large percentage of the population. I would suggest that in Wareham, a low-income community, this is especially true.

The likely costs to individual homeowners of upgrading sceptic systems will be especially hard felt. The current WWTF is maxed out and therefore not an option. Such requirements need to be very precise for maximum benefit. Since the government of the people, by the people, and for the people is effectively retroactively imposing these upgrades than they should be willing to bear the costs to provide equity.

While I applaud virtual access, I feel an actual local physical public meeting is mandatory in keeping with historical traditions. I would also suggest that WCTV be involved in presenting the virtual meeting as has been the case for all local government meetings.

Regards,

Michael Bower
Wareham Resident

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MassDEP Response:

Thank you for your comment. Please refer to the response to Comment 13.

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35) Email from <environmentwatchsoutheasternma@gmail.com> December 26, 2023
Subject: Wareham River TMDL CN 549.1 comments

To the MassDEP Watershed Program,

Please see the attached comments on the Wareham River Draft TMDL.

The focus of these comments is that the Draft TMDL is insufficient because it fails to address the sand and gravel mining activities of the cranberry industry and other commercial operations. These activities are controllable and largely illegal. The expert testimony we provide shows that this mining creates conditions that increase nitrogen pollution in the watershed.

We request that the Draft TMDL be revised accordingly.

Thank you.
Meg Sheehan
Coordinator
Attorney
--
Community Land & Water Coalition
environmentwatchsoutheasternma@gmail.com
P.O. Box 1699
Plymouth MA 02362
www.communitylandandwater.org

Community Land & Water Coalition
P.O. Box 1699
Plymouth MA 02360
www.communitylandandwater.org
www.sandwarssouthasternma.org

December 26, 2023

Massachusetts Department of Environmental Protection
Watershed Planning Program
8 New Bond Street
Worcester MA 01606
dep.wpp@mass.gov

Re: Wareham River TMDL - CN 549.0 Comments

Dear Mass DEP Watershed Planning Program,

Thank you for the opportunity to submit comments on the TMDL for the Wareham River Estuary.

These comments are submitted by Community Land & Water Coalition (a project of Save the Pine Barrens, Inc.) (CLWC) a non-profit public interest network of groups and individuals whose mission is to protect, preserve and steward the lands and waters of Southeastern Massachusetts, including the Wareham River estuary. CLCW submits these comments on behalf of itself and its members who live, work and recreate in the Wareham River estuary area impacted by the degraded water quality that the TMDL seeks to address.

For decades, members of the CLWC network have been working on issues relating to the degradation of water quality and the state's regulatory responsibility to address this degradation under the federal Clean Water Act section 303(d). The state's efforts to address this have lagged behind as rapid industrial, commercial and residential development, sand and gravel mining and ground mounted industrial scale solar in the region have caused and continue to cause deforestation that contributes to nitrogen loading in the groundwater and surface water. The region has one of the highest rates of loss of open space and forests in the state. The TMDL report and the May 2014 Estuaries report upon which it is based do not address the rapid deforestation in the

watershed area attributable to sand and gravel mining and ground mounted industrial solar. The TMDL overlooks and fails to include these sources of nitrogen loading resulting in a serious, material deficiency in the TMDL report. Instead, the report focuses on residential septic systems as if these commercial and industrial uses that strip the land down to bare soil do not exist.

This letter contains comments and incorporates by reference the reports and documentation in the Exhibit List which are being sent in with these comments. MassDEP is requested to download and include in the record the aerial images and drone footage of the industrial scale sand and gravel mining operations and industrial in the region that are having impact on nitrogen pollution according to the expert testimony we are providing with these comments.

CLWC and its members participated in the MassDEP public hearing on the TMDL on November 28, 2023. These comments are in addition to the comments provided during that meeting.

CLWC requests that MassDEP withdraw the TMDL report and conduct an update to the 2014 estuaries report that addresses the rapid deforestation due to thousands of acres of sand and gravel mining and deforestation from industrial solar, which is often combined with sand and gravel mining.

1. **The Report should address sand and gravel mining and agricultural practices associated with it and industrial solar impacts**

The list of sources of nitrogen pollution in the Report, such as on Page iii do not include sand and gravel mining and the "agricultural" practices linked to sand and gravel mining. Nor do they address the impacts of the state's renewable energy subsidy program that is directly linked to deforestation in the watershed area for large ground mounted solar. See, Exhibit 7, Report from Partnership for Policy Integrity. This is a major data gap in the TMDL that warrants withdrawing the report and collecting up to date reliable information about the contribution of these activities to nitrogen pollution.

According to the Wareham River Estuary System TMDL Report, 54% of the land in the watershed is classified as agricultural land and the majority of this land is used for cranberry bogs. The Report states that 54% of the land in the western portion of the watershed is classified as agricultural land, with cranberry bogs as the dominant form of agricultural land use. The state's largest landowner, A.D. Makepeace Co. owns 10,000 acres much of it in the western portion of the watershed. Much of this land is being used for industrial scale sand and gravel mining. A.D. Makepeace owns and operates Read Custom Soils on the Wankinko River on the border of Carver and Plymouth. This is reported to be the largest aggregate mining operation east of the Mississippi. The company sources aggregate materials for this aggregate business from mines in Plymouth, Carver and Wareham in the Wareham River watershed and directly adjacent to water bodies. The company also mines in the groundwater to extract aggregate.

As shown by many objective sources including satellite images, much of the "cranberry" land identified in the Report is used for commercial sand and gravel mining which increases nitrogen pollution according to experts. Therefore, Figure 2 in the Report is inaccurate and must be redone to reflect the current and proposed locations of sand and gravel mines on agricultural lands. This is at least 1,000 acres or more.

The Wareham River Estuary System TMDL Report identifies agriculture as a significant source of nitrogen pollution in the estuary. According to the report, agricultural sources contribute 15% of the total nitrogen load to the estuary, with the majority of that coming from fertilizer use. The report also notes that the Wareham River Estuary is located in an area with a high density of cranberry bogs, which are a major agricultural crop in the region. However, a major flaw in the Report is that it does not address the mining operations associated with so-called "agriculture" in the area. Examples of the so-called agricultural activities that are contributing to the nitrogen pollution and that are not addressed in the Report are described below. The TMDL 2014 report also ignores the impacts of sand and gravel mining operations being conducted by the cranberry industry under the claim of "cranberry agriculture."

The sand and gravel mining activities of the agricultural industry in the watershed area are addressed in CLWC report entitled, ***Sand Wars in Southeastern Massachusetts: An investigation into the money, politics and corruption in the sand and gravel industry,*** October, 2023. Please visit the website, www.sandwarssoutheasternma.org which contains an interactive map. Look up the sand and gravel mining sites in the Wareham River estuary area. The Sand Wars Report documents thousands of acres of deforestation, about 74% of it for the alleged purpose of "cranberry agriculture", with 50% of that conducted by A.D. Makepeace Cranberry Co.

Expert testimony submitted with these comments explains that removing trees, vegetation and sand and gravel removes the natural filtration for the groundwater and surface water and increases nitrogen pollution dramatically. See for example:

- Affidavit of Scott W. Horsley in the case of *Troy Currence et al. v. A.D. Makepeace Cranberry Co. et al*., Superior Court, 2022 (Carver MA earth removal sites)
- Affidavit of Jimmy Powell, *Troy Currence et al. v. A.D. Makepeace Cranberry Co.* et al., Superior Court, 2022, (Carver MA earth removal sites)
- Affidavit of Gary James, P.E. et al., *Josephine Beadling et al. v. Carver Earth Removal Committee*, Superior Court, 2022

The impacts of deforestation for large ground mounted solar in the Wareham River watershed are addressed in the new MassAudubon Report, *Growing Solar-Protecting Nature*. We request that you incorporate that report into these comments. Available at: https://www.massaudubon.org/our-work/publications-resources/growing-solar-protecting-nature

Why does the Report ignore this information that is readily available to MassDEP?

2. **The Report does not address the nitrogen pollution impacts of so-calld "agricultural" practices such as commercial mining for the alleged purpose of creating "tailwater recovery ponds" and "new style cranberry bogs.**

The Sand Wars report documents dozens of commercial sand and gravel mining operations removing tens of millions of cubic yards of sand and gravel and stripping bare thousands of acres of forest in the estuary area for the alleged purpose of cranberry agriculture, including new bogs, ponds and "tailwater recovery" ponds. The TMDL Report does not address this at all. Often, the cranberry bogs are never built yet mining continues as "cranberry agriculture" for a decade or more. For example, A.D. Makepeace has been mining at 46 Federal Road on the Wankinko River for over a decade. The bogs are "in progress" according to the CEO. https://www.youtube.com/watch?v=YPM_wHbM5s4

Here is October 2023 drone video of this 46 Federal Road, Carver MA "bog construction" project that has been strip mining sand and gravel for over a decade. https://www.youtube.com/watch?v=4W0cYzXIZ-w

The TMDL Report makes vague unsubstantiated statements such as, agricultural sources contribute a small amount of nitrogen pollution to the watershed, accounting for approximately 3% of the total nitrogen load. While the TMDL report notes that cranberry bogs are a significant land use in the Wareham River watershed and that the nitrogen loading from cranberry bogs has been revised since the original MEP report, it ignores the cumulative decades long impact of commercial mining by the cranberry industry allegedly to create bogs and ponds.

The TMDL 2023 Report found that non-flow through bogs lose less nitrogen to downgradient systems than flow through bogs. Practices such as building new "non-flow through" bogs such as AD Makepeace is planning by mining about 135 acres on the Wankinko River or the "tail water ponds" are most likely contributing significantly to nitrogen pollution, not reducing it.

Why does the TMDL report and MassDEP not investigate how these "new style" bogs and ponds are being created by leveling hills, stripping vegetation and removing large amounts of sand and gravel in order to install these "new style" bogs or tailwater ponds? According to CLWC's research, including inquiries to Hilary Sandler at the UMass Cranberry Extension Service and Casey Kennedy at the US Agricultural Research Service, there is **NO EVIDENCE** that these ongoing practices and their attendant commercial mining components are in fact helping to reduce nitrogen or other pollutants.

An obvious example of the lack of documentation that these "agricultural" practices involving sand and gravel mining are not delivering clean water is the "MOU" entered into between A.D. Makepeace, MassDEP and Federal Furnace Cranberry in order to clean up White Island Pond. The water from White Island Pond is downstream from the Agawam River where AD Makepeace has been conducting massive deforestation for its Red Brook commercial and residential development.

AD Makepeace's rapid deforestation along the Agawam River in Plymouth can be viewed here on You Tube. https://www.youtube.com/watch?v=JaRjuOEbvZk&t=9s

What is the impact of this on nitrogen loading?

Exhibit 8, hereto, the Memorandum of Agreement (MOA) between the Commonwealth of Massachusetts, Department of Agricultural Resources ("DAR"), the Commonwealth of Massachusetts, Department of Environmental Protection ("MassDEP"), the Cape Cod Cranberry Growers' Association (CCCGA), and UMASS Cranberry Station claimed that it would create a pilot program to develop and implement practices to reduce the discharge of nutrients associated with cranberry cultivation in order to meet applicable water quality standards.

MassDEP stated the goals of MOU were to:
* Develop and implement practices to mitigate the impact of cranberry cultivation on the waters of the Commonwealth.
* Provide a menu of options that may be able to be utilized in other locations as BMP's where irrigation return flows are discharged to surface water bodies from cranberry farming practices.
* Meet the TMDL for White Island Pond.

The "improved agricultural practices" by AD Makepeace and Federal Furnace Cranberry (later EJ Pontiff Cranberry) pursuant to the MOU mentioned above has involved and continues to involve massive sand and gravel mining in Plymouth on White Island Pond and the Agawam River. Where are the results of this MassDEP "pilot program" entered into with MDAR and the cranberry industry? Where is the evidence that the so-called "practices" – including strip mining – conducted by Makepeace and the cranberry industry under this cover of this MOU actually improved water quality?

The EJ Pontiff/Federal Furnace Cranberry "tailwater pond" is causing nitrogen pollution because it leveled a 10 acre hill and mined 50 feet into the aquifer to extract sand and gravel for commercial sale. This can be viewed here.

https://www.youtube.com/watch?v=9IuIRfSsW3s

At the Nov. 28, 2023 public meeting MassDEP remarked to the effect that it cannot force municipalities to control this type of commercial and industrial activity in order to ensure water quality, and this is a "local land use matter." The TMDL Report states that

nitrogen pollution is difficult to control locally. The report recommends that nitrogen loading from atmospheric deposition be reduced through regional and national air pollution control initiatives. This is an unacceptable response.

MassDEP must take leadership on the issue of addressing uncontrolled sand and gravel mining at the local level in the region and fully assess the impacts on the TMDL for the Wareham River before going any further with this TMDL. The cranberry industry operations include mining in the groundwater aquifer to dredge for sand and gravel. This is documented by drone, aerial photography and eyewitness reports. These operations are a direct cause of nitrogen pollution according to both of the expert reports provided with these comments. Yet, this totally ignored in the TMDL. MassDEP can use the authority of the Clean Water Act, enforce the sand and gravel Clean Water Act regulations to prohibit mining within 4 feet of groundwater, and prohibit it in the zones of protection of drinking water wells and on the shores of rivers, ponds and streams. The Sand Report documents the sediment pollution and wetlands impacts of these operations that contribute to water pollution.

The TMDL Report does not even list sand and gravel mining and the associated cranberry "agricultural" practices such as creating "tailwater ponds" as one of the four sources of excessive nitrogen. It glosses over the agricultural sources by addressing the use of agricultural fertilizers as the third-largest source of N loading, accounting for 20% of the total N load. What is the cumulative impact of the agricultural sand and gravel mining, deforestation and mining in the groundwater documented in the Sand Wars Report? As noted, much of the land that the TMDL Report claims is in "agricultural use" is in fact being used for commercial mining. The TMDL Report recommends that the Wareham River Estuary adopt a TMDL that will reduce nitrogen pollution from all sources, including agriculture. The TMDL will establish a limit on the amount of nitrogen that can be discharged into the estuary from all sources. This limit is supposed to help to protect the water quality of the estuary and ensure the health of the ecosystem. How is MassDEP going to reduce the nitrogen pollution from cranberry agriculture and it sand and gravel mining and the other sand and gravel mines operation in the region?

3. Environmental Justice outreach was insufficient

About Fifty percent of Carver and Wareham are designated as Environmental Justice populations by the state. Was there outreach and compliance with the state's EJ policy in this TMDL process? These communities rely on clean water for many purposes identified by the Clean Water Act. Has MassDEP conducted outreach to the Wampanoag people whose ancestral land is the Wareham estuary to obtain input on how nitrogen pollution is impacting their ancestral rights to fish, hunt and trap the lands?

MassDEP conducted the one public hearing in the middle of a work day, Nov. 28, 2023 at 2 p.m. via Zoom only. The timing and method of the public hearing excluded large segments of the public including the EJ communities, preventing them from being able to participate.

In conclusion, the TMDL report has a gaping data gap and is based on outdated information. The industrial scale mining operations in the watershed, deforestation from ground mounted solar, and reckless residential development that is often preceded by sand mining that strips the land down to bare soil must be addressed. MassDEP must exercises its full legal authority to address these issues. It cannot shunt this off to municipalities that are ill-equipped to address the powerful cranberry lobby and its sand and gravel enterprises. The municipalities are no match for the industrial solar energy industry or the state's renewable energy policy that is causing deforestation.

Thank you for the opportunity to comment.

Very truly yours,

Meg Sheehan, Coordinator, Community Land & Water Coalition,
meg@communitylandandwater.org
PO Box 1699
Plymouth MA 02362
Tel. 774-260-7864

LIST OF EXHIBITS
CLCW Comments on Wareham River TMDL
December 27, 2023

1. *Sand Wars in Southeastern Massachusetts: An investigation into the money, politics and corruption in the sand and gravel industry,* October, 2023. Please visit the website to download the PDF. www.sandwarssoutheasternma.org which contains an interactive map. Look up the sand and gravel mining sites in the Wareham River estuary.

2. Affidavit of Scott W. Horsley in the case of Troy Currence et al. v. A.D. Makepeace Cranberry Co. et al., Superior Court, 2022 (Carver MA earth removal sites)

3. Affidavits of Jimmy Powell, Rebecca Lipton and Patrick Garner, Troy Currence et al. v. A.D. Makepeace Cranberry Co. et al., Superior Court, 2022, (Carver MA earth removal sites)

4. Affidavit of Gary James, P.E. et al., Josephine Beadling et al. v. Carver Earth Removal Committee, Superior Court, 2022

5. Drone videos showing commercial sand and gravel mining operations by the cranberry industry in the Wareham River estuary area – examples only, many

more available on You Tube, Save the Pine Barrens Southeastern Massachusetts

https://www.youtube.com/playlist?list=PLDPhmu8GbbLIggLsX9oaSWdlagPldfKo6

AD Makepeace Cranberry Co. sand and gravel mining sites including:
Frogfoot Reservoir, Plymouth
46 Federal Road, 59 Federal Road, 24 Federal Road, Carver
Six sites along Federal Road and Tihonet Road in Carver, request for enforcement, 2021 https://www.youtube.com/watch?v=pE3iSAZ6_4Y

6. Sand and gravel mining sites in Wareham, MA are documented in this demand letter to the Town of Wareham. No action has been taken to address the unlawful and unpermitted mining operations.

See drone video:
https://www.youtube.com/watch?v=BRrTkSU5j3s&list=PLDPhmu8GbbLIdW3IQ2QRDbOsJArNKtDgv

7. Report from Partnership for Policy Integrity, 2021.

8. MassDEP-Department of Agriculture-Cranberry Growers Association MOU

MassDEP Response:

Thank you for your comments on the Total Nitrogen TMDL for the Wareham River Estuary System. In addition, thank you for your commitment towards the protection and enhancement of the land and water resources of Southeastern Massachusetts. Your major comments are addressed below.

(1) Impacts of sand & gravel mining, agricultural practices, and industrial solar

The Massachusetts Estuaries Project determined that the ultimate cause of the eutrophication to estuarine systems is the increase in nitrogen inputs from changing land-use over the past century; the shift from pasture-land or forest to residential development with on-site disposal of wastewater resulted in a substantial increase in nitrogen loading on a per area basis. While MassDEP cannot speak to the specifics of the sand & gravel mining, agricultural, and industrial solar practices, the Community Land and Water Coalition (CLWC) is correct in highlighting that deforestation generally contributes to increased nitrogen pollution.

A TMDL is simply a nutrient budget that determines how much nitrogen reduction is necessary to meet water quality goals as defined in the Massachusetts Surface Water Quality Standards. The TMDL is a planning document that provides a framework for water quality restoration and nutrient management. The associated TMDL modeling was used to develop this nutrient budget.

MassDEP encourages you to discuss your concerns regarding the local requirements for agricultural and sand mining with your local community leaders. If the cranberry facilities are violating Massachusetts Department of Agricultural Resources (MDAR) Land Use or Agricultural Preservation Restriction Regulations, MDAR has the authority to revoke their registration and thereafter MassDEP will take appropriate actions to bring the site into compliance to protect public health, safety, or the environment.

(2) Nitrogen pollution impacts of cranberry bogs and tailwater recovery ponds

Please see the response to Comment 20 for additional information regarding agricultural best management practices for the cranberry industry.

(3) Environmental Justice Outreach

MassDEP maintains a policy of environmental justice to better serve the environmental needs of the Commonwealth's most vulnerable residents. The report and associated information session for the Total Nitrogen TMDL for the Wareham River Estuary System underwent the regular public notice process in accordance with current administrative procedures:

- *the Draft TMDL was posted on the MassDEP website*
- *Public Notice was submit to the Environmental Monitor (MEPA Notice)*
- *Public Notice was published in an official MassDEP Press Release*
- *Public Notice was sent directly (via email) to Interested Parties*

In addition to municipalities and local watershed groups, MassDEP included both regional and statewide environmental justice contacts as Interested Parties throughout the public notice process. Thank you for indicating that the Wampanoag Tribes were not included within the list of environmental justice contacts. MassDEP will update our internal procedures to ensure that the Wampanoag Tribes are included in all future lists of Interested Parties throughout the TMDL process. MassDEP is

committed to environmental justice and the principle that all people have a right to be protected from environmental hazards and to live in and enjoy a clean and healthy environment.

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36) Email from Korrin Petersen <petersen@savebuzzardsbay.org> December 27, 2023

Subject: Support for the Wareham River Estuary System Total Maximum Daily Loads for Total Nitrogen (CN-549.0)

Dear Ms. Brown –

Please find attached the Buzzards Bay Coalition's comments on the Wareham River Estuary System Total Maximum Daily Loads for Total Nitrogen (CN-549.0). We appreciate the opportunity to support this TMDL. Kindly reply to this email to ensure that the comments have been received by your office. Thank you and I wish you a Happy New Year.

Best,
Korrin N. Petersen, Esq., Vice President for Clean Water Advocacy
BUZZARDS BAY COALITION
Main - 114 Front Street, New Bedford, MA 02740
Tel – 508-999-6363 x206
www.savebuzzardsbay.org

By email

December 27, 2023

Holly Brown
TMDL Analysis, Watershed Planning Program
MA Department of Environmental Protection
8 New Bond Street
Worcester, MA 01616

Re: Support for the Wareham River Estuary System Total Maximum Daily Loads for Total Nitrogen (CN-549.0)

Dear Ms. Brown,

The Buzzards Bay Coalition (Coalition) has reviewed the Draft Wareham River Estuarine System Total Maximum Daily Loads for Total Nitrogen (CN-549.0) dated August 2023 (draft Wareham River TMDL). **The Coalition urges the Massachusetts Department of Environmental Protection (MassDEP) to send the draft Wareham River TMDL to the US Environmental Protection Agency (EPA) to approve as final.** This letter follows our comments at the public hearing held by Zoom on November 28, 2023.

The draft Wareham River TMDL confirms the need for nitrogen reductions. The TMDL forms the basis for the towns of Wareham, Carver and Plymouth to create plans for how they will reduce nitrogen pollution within the Wareham River watershed to meet the TMDL. Delay in TMDL approval will postpone and hinder local action on nitrogen reductions, delay funding opportunities, and lead to further degradation of the Wareham River.

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 11,000 individuals, families, and businesses throughout the region.

Background:

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 the Wareham River was evaluated through the Massachusetts Estuaries Project (MEP) and the Wareham River MEP report was

finalized in 2014. The MEP report documented impairment of the Harbor and the need for nitrogen reductions.

The water quality in the River is degraded by nitrogen pollution. High nitrogen loads, primarily from residential wastewater cause low dissolved oxygen levels, elevated algae levels, and decreased diversity and quantity of marine animals living on the seafloor. During the past 31 years, the Coalition has collected water quality data from seven sites in the Wareham River 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.

TMDL Findings:

The Wareham River is listed as a waterbody requiring a TMDL for nutrients. The draft Wareham River TMDL establishes a target threshold concentration for total nitrogen of 0.4 mg/L at the Lower Wareham River and .42mg/L at the Upper Wareham River. The draft Wareham River TMDL asserts that water quality standards for the entire system will be met when this target concentration is met.

The draft TMDL identifies septic systems as the largest nitrogen load to the Inner Harbor at 43% of the locally controllable load, followed by agricultural fertilizers at 20%, the Wareham Water Pollution Control Facility at 16%, impervious surfaces at 11%, and the land fill and law fertilizers making up the remainder. **Nitrogen from wastewater sources makes up 59% of the locally controllable sources of nitrogen.**

The draft TMDL states that one way to achieve the necessary nitrogen reductions to meet the target threshold concentration is to remove 79% of the septic load and a nitrogen load reduction from the Wareham Wastewater Control Facility to 4,300 kg/year of nitrogen.

Town of Wareham Action:

While significant work lies ahead to restore water quality to the Wareham River, the Coalition recognizes actions taken by the town of Wareham to address nitrogen from wastewater sources. In 2013, the town of Wareham was the first Bay-town to pass a Board of Health regulation requiring new construction within 500 feet of a water resource to install a nitrogen reducing septic system. Recognizing, ten years ago, that the Wareham River was already overloaded with nitrogen, it made little sense for the town to continue to permit new sources of nitrogen.

Wareham invested in important actions to assess alternatives to nitrogen pollution reductions to the Wareham River. Wareham's participation in the "Upper Bay Project" evaluated the feasibility of solving the nitrogen pollution problem on a regional scale by expanding and optimizing the use of the Wareham WPCF to expand sewering, eliminating nitrogen from septic

systems, and relocating the Wareham WPCF discharge from the Agawam River to a more appropriate location.

Finally, the town is taking steps to update the 2002 Comprehensive Wastewater Management Plan to reduce nitrogen pollution. A final. EPA-approved, TMDL will increase the town's likelihood of federal funding for CWMP implementation. Adoption of this TMDL will aid community action by improving the borrowing eligibility of the communities when seeking 0% SRF funds.

Comments:

In order to expedite nitrogen reduction planning and implementation, the Coalition urges the MassDEP to send the draft Wareham River Estuary TMDL to the EPA to approve as final as soon as possible. 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 Wareham River Estuary TMDL.

1. **Cranberry Bogs**

In November 2023, the Coalition released the results of a decade of scientific investigation regarding how cranberry bogs impact watershed nutrients. As part of that investigation, the study looked at how fertilizers from cranberry bogs affected water quality. The study updated the nutrient loading model and found that cranberry bogs accounted for about 20% of the nitrogen flowing into the Wareham River. This validates the estimates presented in the draft TMDL.

The study also found that not all bogs contribute equal amounts of nitrogen. Flow-through bogs, bogs that line river channels, release more nitrogen than bogs that are connected to water bodies through streams or ditches. As water travels from bogs to small streams that connect with larger streams and eventually to the Wareham River, some of the nitrogen from the bogs is used by aquatic plants and bacteria – reducing the impact of nitrogen from certain types of cranberry bogs.

2. **Addressing the effects of climate change on water quality through adaptive management.**

The TMDL states that "MassDEP believes that impacts of climate change should be addressed through TMDL implementation with an adaptive management approach in mind." The Coalition's long-term water quality data 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 30 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. **An implementation schedule should be developed.**

The establishment of this TMDL anticipates that actions will be taken to meet the TMDL so that the Wareham River will be restored and meet water quality standards. We encourage MassDEP to work with the towns to develop a timeframe for TMDL implementation. The timeframe should lay out a set of milestone goals that the towns can work towards achieving.

Summary:

The issuance of this TMDL is a critical step in restoring the water quality of the Wareham River. The draft TMDL confirms the need for nitrogen reductions and requires Wareham and the surrounding towns to create plans for how they will reduce nitrogen to meet the TMDL. The **Coalition urges the MassDEP to send the draft Wareham River TMDL to the EPA to approve as final so that the communities can continue to move forward to meet the required nitrogen reductions.**

Sincerely,

Korrin N. Petersen, Esq.
Vice President of Clean Water Advocacy
petersen@savebuzzardsbay.org

CC:

US Environmental Protection Agency

Senator Pacheco
Senator Moran
Representative Gifford
Representative Muratore

Town of Wareham
Select Board
Sewer Commissioners

Board of Health
Planning Board
Sewer Department

Town of Carver
Select Board
Board of Health
Planning Board

Town of Plymouth
Select Board
Board of Health
Planning Board
Department of Public Works - Sewer

MassDEP Response:

Thank you for your support of the Total Nitrogen TMDL for the Wareham River Estuary System. In addition, thank you for your long-term commitment (>30 years) to data collection efforts in this estuary and throughout Buzzards Bay. Your major comments are addressed below.

(1) Cranberry Bogs

Thank you for contributing this additional information. The results published in the BBC "Cranberry Agriculture and Water Quality in Buzzards Bay" report will be helpful in the development and implementation of nutrient management practices across the Massachusetts.

(2) Addressing the effects of climate change on water quality through adaptive management.

MassDEP agrees that adaptive management is an appropriate strategy to address the impact and uncertainty associated with the effect of climate change on the Wareham River Estuarine System. This approach also recognizes that restoring polluted waters is a long-term process, particularly when groundwater is polluted by nonpoint sources. For this reason, MassDEP supports an adaptive management approach to implementing a TMDL: taking the most cost-effective measures first, measuring their impact, and adjusting where necessary. Prioritizing projects with more immediate impacts on water quality will help communities adjust implementation steps if needed. Furthermore, the data collected by the Buzzards Bay Coalition will be invaluable in identifying potential ecological changes due to climate change.

(3) An implementation schedule should be developed.

MassDEP is working with the watershed towns named within the TMDL. The goal is to provide guidance at any phase of the project, whether it is the planning, implementation, or adaptive management phase. The implementation schedule is documented within respective Comprehensive Water Resources or Wastewater Management Plans (CWRMP or CWMP). Implementation plans and schedules are not required as part of the TMDL but are required in watershed permits and CWRMP/CWMPs. MassDEP will continue to provide technical assistance and guidance as they plan, implement, and apply adaptive management.

Zoom Registration Information:

Name	Organization	Registration Date
Mason Saleeba	MassDEP	10/17/2023
Patrick Macdonald	Town of Wareham	11/1/2023
Ken Buckland	Town of Wareham	11/2/2023
Charlene Nagel	NA	11/2/2023
Linda S.	Resident	11/2/2023
Elaine Renzi	NA	11/2/2023
Nancy Mchale	Town of Wareham, Land Trust	11/4/2023
Anita Smith	Resident	11/9/2023
Jackie Boyer	Beals And Thomas, Inc.	11/10/2023
Kristin Lyons	Segura Consulting LLC	11/10/2023
Linda Hannon	NA	11/13/2023
Rosemary Comrie	Comrie Real Estate	11/13/2023
Margaret Ishihara	Law Office of Margaret A. Ishihara	11/13/2023
Liam Mayo	Wareham Week	11/13/2023
Sandy Slavin	Sewer Commissioner, Conservation Chair	11/15/2023
Alan Slavin	Town of Wareham	11/15/2023
Marie Garrity	Resident	11/15/2023
Carla Troupe	Resident	11/15/2023
Kathleen Pappalardo	NA	11/15/2023
Tricia Wurts	Town of Wareham Select Board Member	11/15/2023
Paula Papineau	Resident	11/16/2023
Bryan Dohmen	Homeowner	11/17/2023
Emma Wick	Cape Cod Cranberry Growers' Association	11/17/2023
Jim Munise	Resident	11/18/2023
Maryanne Pepe	Resident	11/18/2023
Robert Guthro	NA	11/19/2023
Peter Lorenz	A.D. Makepeace	11/20/2023
Meg Sheehan	Community Land and Water Coalition	11/20/2023
Martha Sullivan	MassDEP	11/20/2023
Mark Truran	Homeowner	11/20/2023
Michael Curran	Atlantic Solutions	11/21/2023
Mary Dooley	Wareham	11/21/2023

Name	Organization	Registration Date
Michael Bower	Homeowner	11/21/2023
Mary Davis	Swifts Beach Citizens Group	11/21/2023
Matthew Reardon	MassDEP	11/21/2023
Donna Gully	NA	11/21/2023
Lisen Cameron	NA	11/21/2023
Kislaine Brito	NA	11/21/2023
John Bahouth	UConn	11/24/2023
Megan Savage	Resident	11/25/2023
Antonio Botta, Jill Risgin	Homeowner	11/25/2023
Christine Bird	NA	11/25/2023
Jennifer Kearns Fox	Homeowner	11/25/2023
Eric Nicotra	NA	11/25/2023
Carl Persson	Ocean Solutions Inc	11/26/2023
Barry Cosgrove	NA	11/26/2023
Rhonda Atchison	Town Resident	11/26/2023
Jennifer Kearns Fox	Resident	11/26/2023
Katherine Harrelson	Community Land and Water Coalition	11/27/2023
Patrick Tropeano	Town of Wareham, Board of Health	11/27/2023
Norma Scogin	Town of Wareham, Finance Committee Chair	11/27/2023
James Giberti	Sewer Commissioner	11/27/2023
Peter Dunlop	Town of Wareham, WPCF Commissioner	11/27/2023
Nathaniel Munafo	Marion WPCF	11/27/2023
Timothy Fox	MassDEP	11/27/2023
Richard Carey	MassDEP	11/27/2023
Gerard Martin	MassDEP	11/27/2023
Sherry Quirk	Town of Wareham, Planning Board	11/27/2023
Diane Barbour	Homeowner	11/27/2023
Holly Brown	MassDEP	11/27/2023
Lawrence Perry	Town of Wareham, Board Of Health	11/27/2023
Brett Rowe	MassDEP	11/27/2023
Anne Eisenmenger	Homeowner	11/27/2023
Susanne Pirolli	Homeowner	11/27/2023

Name	Organization	Registration Date
Ian Jarvis	MassDEP	11/27/2023
Bernard Pigeon	Town of Wareham, Sewer Commission Chairman	11/27/2023
Tricia Wurts	Town of Wareham	11/27/2023
Korrin Petersen	Buzzards Bay Coalition	11/27/2023
Andrew Osei	MassDEP	11/28/2023
Jim Healy	Orenco Water	11/28/2023
Jon Hobill	MassDEP	11/28/2023
Hui Liang	MassDEP	11/28/2023
Richard Rondeau	MassDEP	11/28/2023
Brendon Beech	Town of Wareham	11/28/2023
Anastasia Rudenko	GHD, Inc	11/28/2023
Marc Drainville	GHD, Inc	11/28/2023
Robert Scanlan	Town of Wareham, Sewer Commission	11/28/2023
DJ Wilson	NA	11/28/2023
Aaron Raposo	MassDEP	11/28/2023
Kevin Condon	Resident	11/28/2023
Dennis Huston	NA	11/28/2023
Kathy Baskin	MassDEP	11/28/2023
Scott Kraihanzel	Town of Wareham, Water Pollution Control Facility	11/28/2023
Sherbie Worthen	BBC, Committee Volunteer, CPC Board Member	11/28/2023
Al Yellick	Homeowner	11/28/2023
Sean Carney	MassDEP	11/28/2023
Michael Clements	Homeowner	11/28/2023
Macleod Fox	Resident	11/28/2023

Town of Wareham Meeting Room Sign-In Sheet:

Total Nitrogen TMDL for Wareham River Estuary System

Sign in Sheet

Name	Phone	Email
Sherry Burke		
Diane Beebower		
J. Tabaczky		
Ken Buckland		