FINAL
Edgartown Great Pond System
Total Maximum Daily Loads
For Total Nitrogen
(Report # 97-TMDL-3 Control #318)

COMMONWEALTH OF MASSACHUSETTS
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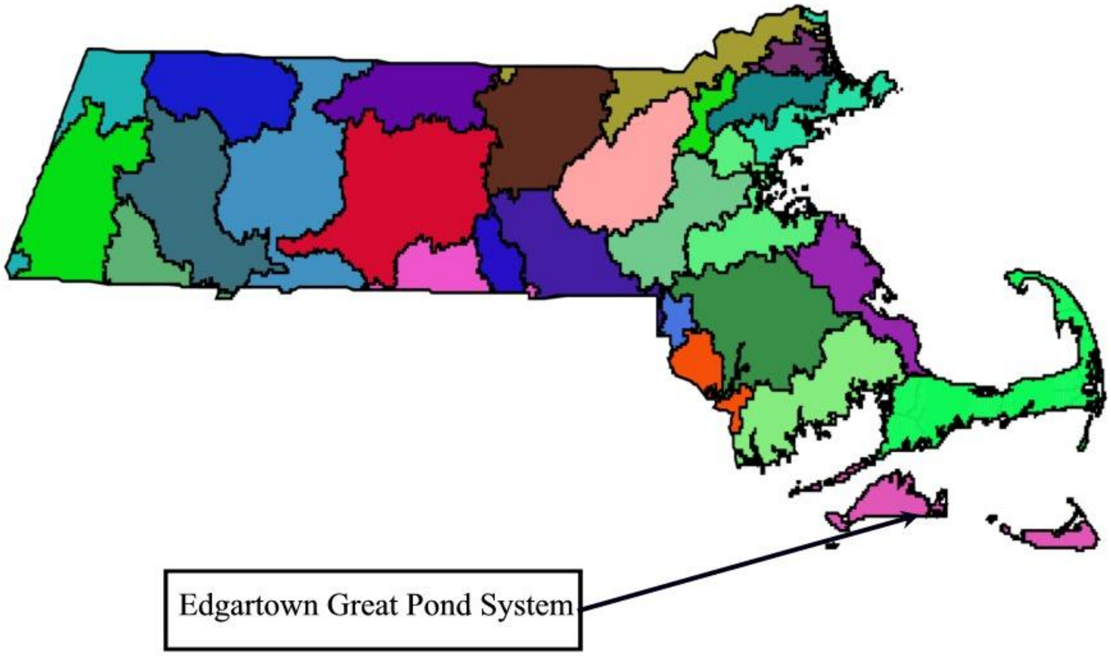

Key Feature: Total Nitrogen TMDL for Edgartown Great Pond System
Location: EPA Region 1
Land Type: New England Coastal
303d Listing: Edgartown Great Pond (Segment MA97-17_2008) is listed as impaired for pathogens and in Category 5 of the current Massachusetts Integrated List of Waters.
Data Sources: University of Massachusetts – Dartmouth/School for Marine Science and Technology; US Geological Survey; Applied Coastal Research and Engineering, Inc.; Cape Cod Commission; Martha's Vineyard Commission; Town of Edgartown
Data Mechanism: Massachusetts Surface Water Quality Standards, Ambient Data, and Linked Watershed Model
Monitoring Plan: Martha's Vineyard Commission/Town of Edgartown - Edgartown Great Pond Water Quality Monitoring Program with technical assistance by SMAST
Control Measures: Sewering, Storm Water Management, Attenuation by Impoundments and Wetlands, Fertilizer Use By-laws, Increased Flushing via Inlet Management

Executive Summary

Problem Statement

Excessive nitrogen (N) originating from a variety of sources, has added to the impairment of the environmental quality of Edgartown Great Pond. In general, excessive N in theses waters are indicated by:

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

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

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

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

Sources of Nitrogen

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

- The watershed
    - On-site subsurface wastewater disposal (septic) systems
    - Natural background
    - Runoff
    - Fertilizers
    - Wastewater treatment facilities
- Atmospheric deposition
- Nutrient-rich bottom sediments in the embayments/ponds

Figure ES-A below indicates the percent contributions of the various sources of N. Values are based on Table ES-1 and Table IV-2 from the MEP Technical Report. The loading contributions were updated from these MEP Report tables to more accurately reflect the post 2007 WWTP loadings. Most (about 74%) of the controllable N load to Edgartown Great Pond originates from wastewater.

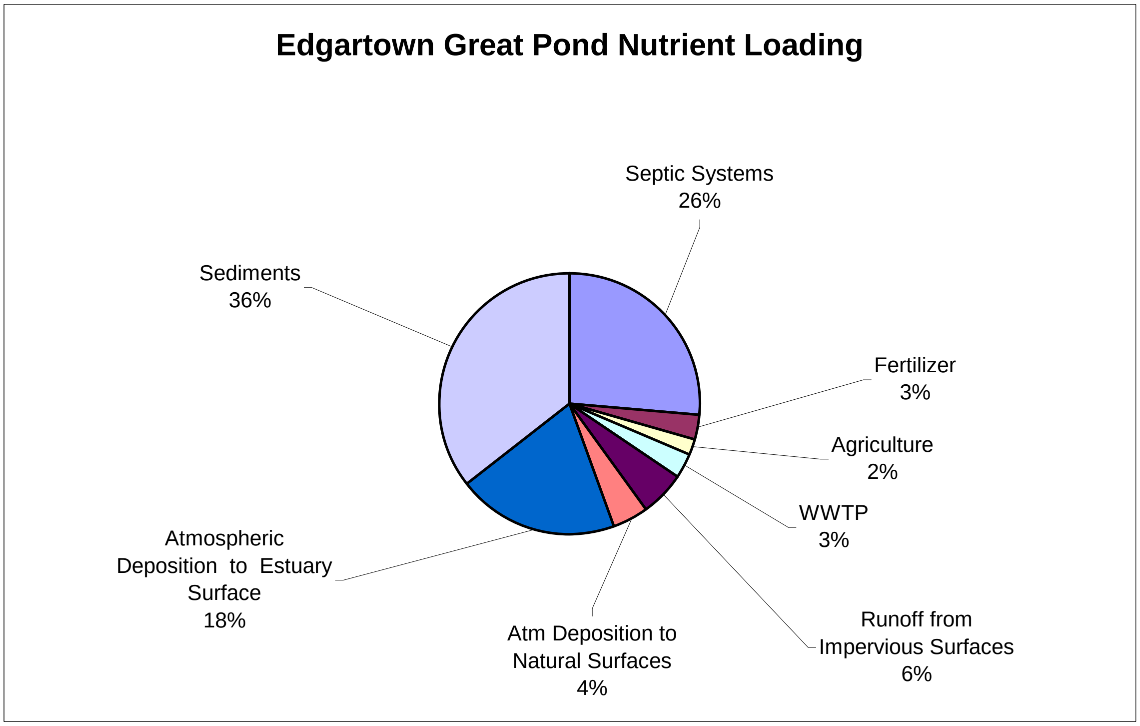

Figure ES-A: Percent contributions of Nitrogen Sources to Edgartown Great Pond

Target Threshold Nitrogen Concentrations and Loadings

The N that enters the estuary each day (N load) is 57.5 kg/day. The resultant concentrations of N in this embayment range from 0.58 mg/L (milligrams per liter of N) to 0.71 mg/L (range of average of yearly means from 10 stations collected from 2003 – 2006 as reported in the MEP Technical report).

In order to restore and protect this embayment system, N loadings, and subsequently the concentrations of N in the water, must be reduced to levels below the thresholds that cause the observed environmental impacts. This concentration will be referred to as the target threshold N concentration. It is the goal of the TMDL to reach this target threshold N concentration, as it has been determined for each impaired waterbody segment. The Massachusetts Estuaries Project (MEP) has determined that, for this embayment system, a N concentration of 0.50 mg/L will improve eelgrass habitat within the lower main basin and will fully restore infaunal habitat quality pond-wide. The mechanism for achieving these target threshold N concentrations is to reduce the N loadings to the embayment. Based on the MEP work and their resulting Technical Report, the MassDEP has determined that the Total Maximum Daily Load (TMDL) of N that will meet the target threshold concentration is 46 kg/day.

This document presents the TMDL for this water body segment and provides guidance to Edgartown on possible ways to reduce the N loadings to within the recommended TMDL, and protect the waters for this embayment.

Implementation

The recommended method of TMDL implementation will be a combination of reducing the loadings from any and all sources of N in the watershed, and altering the schedule of the breaching of the barrier beach to increase the flushing of the estuary.

Methodologies for reducing N loading from septic systems, storm water runoff, and fertilizers, are provided in detail in the "MEP Embayment Restoration Guidance for Implementation Strategies", that is available on the MassDEP website: http://www.mass.gov/eea/agencies/massdep/water/watersheds/coastal-resources-and-estuaries.html. 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 community of Edgartown that would exacerbate the problems associated with N loadings, 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 pollutants of concern), from all contributing sources, that a water body may receive and still meet and maintain its water quality standards and designated uses, including compliance with numeric and narrative standards. The TMDL development process may be described in four steps, as follows:

1. Determination and documentation of whether or not a water body is presently meeting its water quality standards and designated uses.

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

3. Determination of the loading capacity of the water body. EPA regulations define the loading capacity as the greatest amount of loading that a water body can receive without violating water quality standards. If the water body is not presently meeting its designated uses, then the loading capacity will represent a reduction relative to present loadings.

4. Specification of load allocations, based on the loading capacity determination, for non-point sources and point sources that will ensure that the water body will not violate water quality standards.

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

In the Edgartown Great Pond System, the pollutant of concern for this TMDL (based on observations of eutrophication) is the nutrient N. Nitrogen is the limiting nutrient in coastal and marine waters, which means that as its concentration is increased, so is the amount of plant matter. This leads to nuisance populations of macro-algae and increased concentrations of phytoplankton and epiphyton and imperil the healthy ecology of the affected water bodies.

The TMDL for total N for the Edgartown Great Pond System is based primarily on data collected, compiled, and analyzed by University of Massachusetts Dartmouth's School of Marine Science and Technology (SMAST), the Martha's Vineyard Commission/Town of Edgartown - Edgartown Great Pond Water Quality Monitoring Program, and others, as part of the Massachusetts Estuaries Project (MEP). The data were collected over a study period from 1995 to 2006. This study period will be referred to as the "Present Conditions" in the TMDL since it contains the most recent data available. The MEP Technical Report can be found at http://www.oceanscience.net/estuaries/reports.htm. The MEP Technical Report presents the results of the analyses of this coastal embayment system using the MEP Linked Watershed-Embayment Nitrogen Management Model (Linked Model). The analyses were performed to assist Edgartown with decisions on current and future wastewater planning, wetland restoration, anadromous fish runs, shellfisheries, open-space, and harbor maintenance programs. A critical element of this approach is the assessment of water quality monitoring data, historical changes in eelgrass distribution, time-series water column oxygen measurements, and benthic community structure that was conducted on this embayment. These assessments served as the basis for generating a N loading threshold for use as a goal for watershed N management. The TMDL is based on the site-specific target threshold N concentration generated for this embayment. Thus, the MEP offers a science-based management approach to support the wastewater management planning and decision-making process in the Town of Edgartown.

Description of Water Bodies and Priority Ranking

The Edgartown Great Pond System is an 890-acre coastal salt pond estuary, with a single temporary inlet and multiple sub-embayments (Jobs Neck Cove, Janes Cove, Wintucket Cove, Mashacket Cove, Turkeyland Cove, Slough Cove). Edgartown Great Pond is located completely within the Town of Edgartown, Massachusetts in the southeastern corner of the island of Martha's Vineyard. Most of the pond's watershed lies within the Town of Edgartown; however the headwaters of the drainage extend into the Town of West Tisbury. (See Figure 1) The estuary only occasionally receives tidal waters from the Atlantic Ocean to the south into its large lower main basin based on a breaching schedule set by the town. Outflow from the pond is through a weir with a small herring ladder to Crackatuxet Cove, as recharge through the barrier beach, and during the periodic openings to the Atlantic Ocean.

For the MEP analysis, the Edgartown Great Pond estuarine system was partitioned into two general subembayment groups: the 1) the main basin, which is composed of an upper basin (Lyles Bay to Swan Neck Point) and lower basin (parallel to the barrier beach) and 2) the tributary sub-embayments of Janes Cove, Wintucket Cove, Mashacket Cove and Turkeyland Cove (associated with the upper basin) and Jobs Neck Cove and Slough Cove (associated with the lower basin). (See Figure 2)

The nature of enclosed embayments in populous regions brings two opposing elements to bear: 1) as protected marine shoreline they are popular regions for boating, recreation, and land development and 2) as enclosed bodies of water, they may not be readily flushed of the pollutants that they receive due to the proximity and density of development near and along their shores. In particular, the Edgartown Great Pond System is at risk of further eutrophication from high nutrient loads in the groundwater and runoff from the watershed. This embayment system is already listed as waters requiring a TMDL for pathogens (Category 5) in the MA 2012 Integrated List of Waters, as summarized in Table 1.

Table 1: The Edgartown Great Pond Water Body Segment in Category 5 of the Massachusetts 2012 Integrated List of Waters

Name	Water Body Segment	Description	Size	Pollutant Listed
Edgartown Great Pond	MA97-17_2008	Excluding Jacobs Pond (PALIS# 97038) Edgartown, Martha's Vineyard	1.4 sq mi	Pathogens

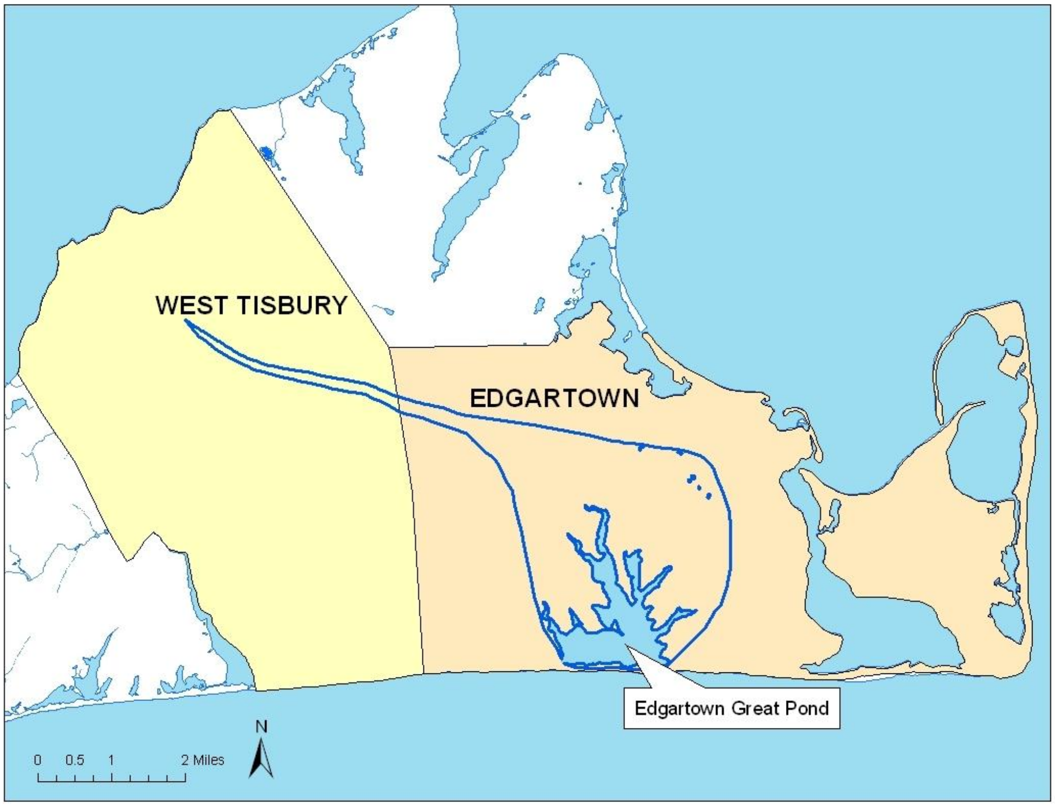

Figure 1: Edgartown Great Pond Watershed Area Delineation with Town Boundaries

A complete description of this embayment system is presented in Chapters I and IV of the MEP Technical Report. A majority of the information on this embayment system is drawn from this report. Chapter VI and VII of the MEP Technical Report provide assessment data that show that the Edgartown Great Pond System is impaired because of nutrients, low dissolved oxygen levels, elevated chlorophyll *a* levels, eelgrass loss, and benthic fauna habitat (Table 2). This assessment will be reflected in future MA Integrated List of Waters. Please note that pathogens are listed in Tables 1 and 2 for completeness. Further discussion of pathogens is beyond the scope of this TMDL.

Table 2: Comparison of Impaired Parameters for the Edgartown Great Pond System

Name	DEP Listed Impaired Parameter	SMAST Listed Impaired Parameter
Edgartown Great Pond	Pathogens	Nutrients DO level Chlorophyll Eelgrass loss Benthic fauna

Figure 2: Overview of Edgartown Great Pond

The embayment addressed by this document is determined to be a high priority based on three significant factors: (1) the initiative that the town has taken to assess the conditions of the entire embayment system, (2) the commitment made by the town to restore and preserve the embayment, and (3) the extent of impairment in the embayment. In particular, this embayment is at risk of further degradation from increased N loads entering through groundwater and surface water from the increasingly developed watershed. In both marine and freshwater systems, an excess of nutrients results in degraded water quality, adverse impacts to ecosystems, and limits on the use of water resources. Observations are summarized in Table 3 and the Problem Assessment section below and detailed in Chapter VII, Assessment of Embayment Nutrient Related Ecological Health, of the MEP Technical Report.

Table 3: General Summary of Conditions Related to the Major Indicators of Habitat Impairment Observed in the Edgartown Great Pond System

Embayment	Dissolved Oxygen Depletion	Chlorophyll *a*[1]	Eelgrass Loss	Benthic Fauna[2]
Edgartown Great Pond System	Oxygen levels generally >6, with depletions rarely 4-3 mg/L H-MI	Moderate to high levels (10 –25 µg/L) MI	Eelgrass present in 1951 in lower main basin only, now very sparse MI	Low to moderate numbers of individuals and species SI- MI

[1] Algal blooms are consistent with chlorophyll *a* levels above 20µg/L
[2] Based on observations of the types of species, number of species, and number of individuals

H - Healthy habitat conditions
MI – Moderately Impaired
SI – Significantly Impaired - considerably and appreciably changed from normal conditions*

* - These terms are more fully described in MEP report "Site-Specific Nitrogen Thresholds for Southeastern Massachusetts Embayments: Critical Indicators", December 22, 2003
http://www.mass.gov/eea/agencies/massdep/water/watersheds/coastal-resources-and-estuaries.html

Problem Assessment

The primary ecological threat to Edgartown Great Pond is degradation resulting from nutrient enrichment. Half of the N load is from sources that are not locally controllable, i.e., atmospheric deposition to the surface of the estuary and from N-rich sediments. The N loading from locally controllable sources, i.e., septic systems, storm water runoff, agriculture, fertilizer, and the Edgartown WWTF's groundwater discharge, make up the other half of the load. Nitrogen from these sources enters the groundwater system, and eventually enters the surface water bodies. In the sandy soils of Martha's Vineyard, effluent that has entered the groundwater travels toward the coastal waters at an average rate of one foot per day.

The towns of Martha's Vineyard have grown rapidly over the past two decades. In the period from 1970 to 2000 the number of year round residents in Edgartown has almost tripled (Figure 3). The watershed of Edgartown Great Pond has had rapid and extensive development of single-family homes and the conversion of seasonal into full time residences. This is reflected in a substantial transformation of land from forest to suburban use between the years 1970 to 2000. Water quality problems associated with this development result primarily from on-site wastewater treatment systems, and to a lesser extent, from runoff - including fertilizers - from these developed areas.

Almost all of the homes in the Edgartown Great Pond watershed rely on privately maintained septic systems for on-site treatment and disposal of wastewater. However, the Town of Edgartown does have a centralized wastewater treatment system which discharges its tertiary treated effluent into the groundwater of the Edgartown Great Pond watershed. The WWTF upgraded to tertiary treatment in 1996. This upgrade has resulted in a decline in N loading. The MEP predicted that the "new" plume from the upgraded treatment plant was expected to reach the pond between 2006 and 2008. More recent (2004-2006) annual N loads from the WWTP were over 70% less than 1996 values.

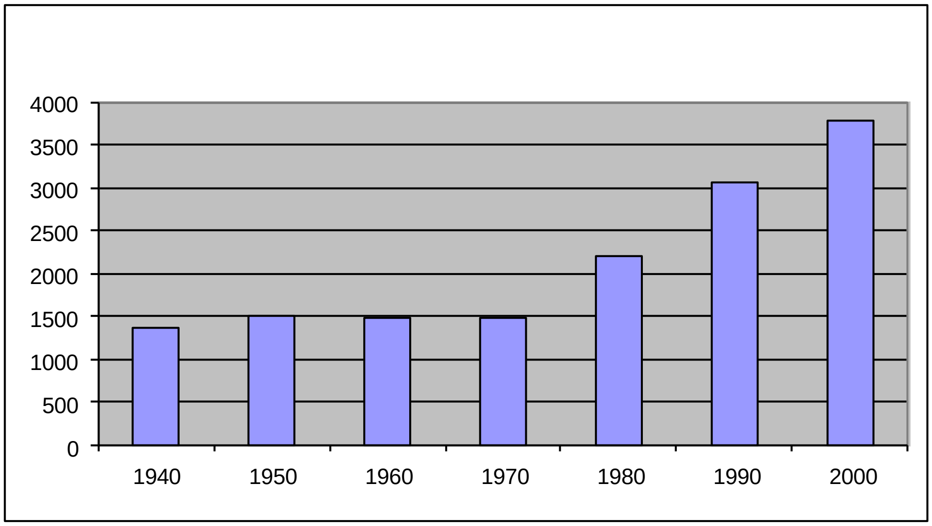

Figure 3: Edgartown Resident Population

Prior to the 1970s there were few homes and many of those were seasonal. It is generally recognized that declines in water and habitat quality often parallel population growth in the watershed. The problems in Edgartown Great Pond include periodic decreases of dissolved oxygen, decreased diversity and quantity of benthic animals, reduced density of eelgrass, and periodic algal blooms. If the N concentration continues to increase, future habitat degradation could include periodic fish kills, unpleasant odors and scums, and near loss of the benthic community and/or presence of only the most stress-tolerant species of benthic animals.

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

Habitat and water quality assessments were conducted on this embayment system based upon water quality monitoring data, historical changes in eelgrass distribution, time-series water column oxygen measurements, and benthic community structure. Since tidal exchange is only periodic in this system, horizontal gradients in water quality parameters and eelgrass habitat within the upper and lower basins are not strong. Generally, the habitat quality is highest in the lower large lagoon-like basin (below Swan Neck) and poorest in the upper basin and major tributary coves. This is indicated by slight gradients of the various indicators. Nitrogen concentrations are moderately enriched in the lower basin and increase slightly in the upper basin and major tributary coves. Although the MEP study could not confirm the historic density of eelgrass in Edgartown Great Pond, anecdotal evidence supports the conclusion that eelgrass coverage has declined to only sparse colonization in the lower basin. Besides water depth, which tends to limit eelgrass coverage in the main basins of the Pond to areas <1.5m deep, elevated N (mean summertime concentration 0.59 mg/L), and chlorophyll *a* concentrations (10 – 25 µg/L) are major factors causing shifts in eelgrass habitat within this system. Additionally, the benthic infauna study showed a lack of diversity throughout the system. Gradients in benthic habitat quality were similar to gradients observed for chlorophyll, nutrients and organic matter enrichment. Tributary sub-basins support moderately to significantly impaired benthic habitat and the lower main basin shows moderate benthic habitat quality.

Pollutant of Concern, Sources, and Controllability

In Edgartown Great Pond, as in most marine and coastal waters, the limiting nutrient is nitrogen (N). Nitrogen concentrations beyond those expected naturally contribute to undesirable conditions, including the impacts described above, through the promotion of excessive growth of algae, including nuisance vegetation.

Edgartown Great Pond has had extensive data collected and analyzed through the Massachusetts Estuaries Program (MEP) and with the cooperation and assistance from the Town of Edgartown, and the Martha's Vineyard Commission. Data collection included both water quality and hydrodynamics as described in Chapters I, IV, V, and VII of the MEP Technical Report. These investigations revealed that loadings of nutrients, especially N, are much larger than they would be under natural conditions, and as a result the water quality has deteriorated.

Figure 4 illustrates the sources and percent contribution of N into Edgartown Great Pond.

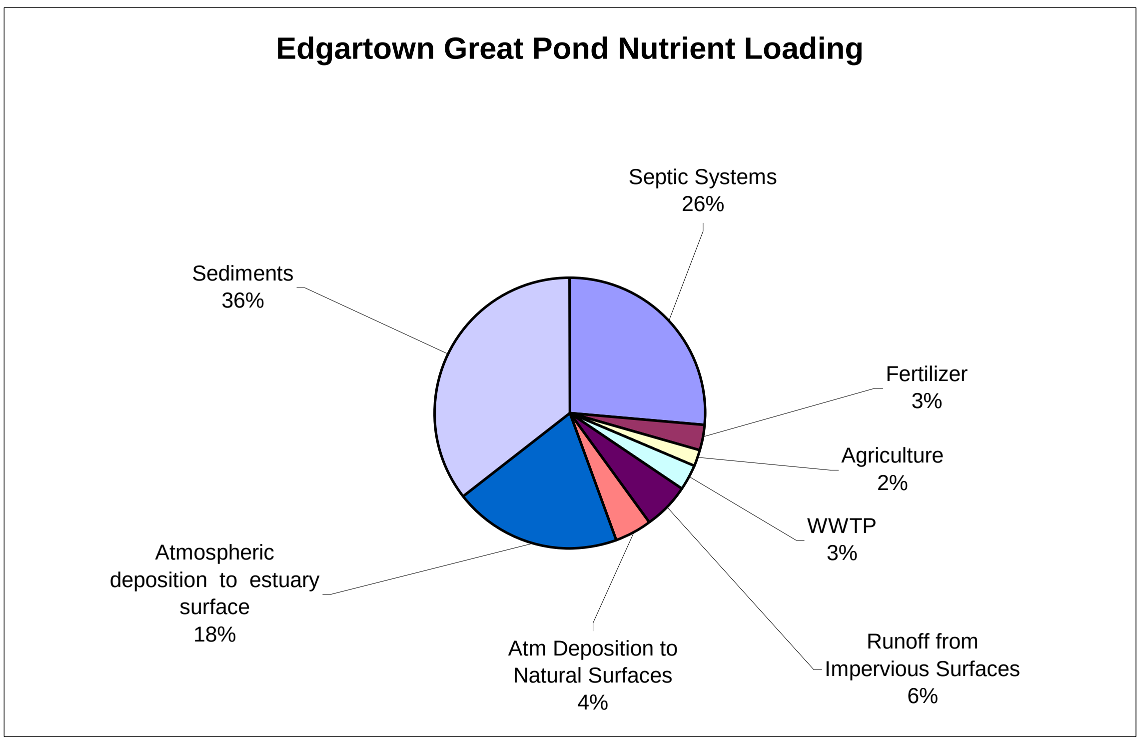

Figure 4: Percent Contribution of Nitrogen Sources to Edgartown Great Pond

The level of "controllability" of each source, however, varies widely:

Atmospheric nitrogen - cannot be adequately controlled locally – it is only through regional and national air pollution control initiatives that significant reductions are feasible;

Fertilizer – related N loadings can be reduced through bylaws and public education;

Runoff – related N loadings can be reduced through best management practices (BMPs), bylaws, storm water infrastructure improvements and public education;

Agricultural – related N loadings can be controlled through agricultural BMPs;

WWTF – related N loadings have been reduced by upgrading the treatment process to include N removal. The Edgartown WWTF was upgraded in 1996. The MEP report predicted that the discharge plume with reduced N concentrations resulting from the upgrade will have reached the pond between 2006 and 2008.

Septic system - sources of N are the largest controllable sources. These 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;

Atmospheric deposition to natural surfaces (forests, fields, etc.) in the watershed – 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 towards the estuary;

Nitrogen from sediments - control by such measures as dredging is not feasible on a large scale. 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. Increased dissolved oxygen will help keep N from fluxing;

Cost/benefit analyses will have to be conducted for all possible N loading reduction methodologies in order to select the optimal control strategies, priorities, and schedules.

Description of the Applicable Water Quality Standards

The Water Quality Classification of Edgartown Great Pond is SA. Water quality standards of particular interest to the issues of cultural eutrophication are dissolved oxygen, nutrients, aesthetics, excess plant biomass, and nuisance vegetation. The Massachusetts Water Quality Standards (314 CMR 4.00) contain numeric criteria for dissolved oxygen, but have only narrative standards that relate to the other variables, as described below:

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

314 CMR 4.05(5)(b) states: "Bottom Pollutants or Alterations. All surface waters shall be free from pollutants in concentrations or combinations or from alterations that adversely affect the physical or

chemical nature of the bottom, interfere with the propagation of fish or shellfish, or adversely affect populations of non-mobile or sessile benthic organisms."

314 CMR 4.05(5)(c) states, "Nutrients. Unless naturally occurring, all surface waters shall be free from nutrients in concentrations that would cause or contribute to impairment of existing or designated uses and shall not exceed the site specific criteria developed in a TMDL or as otherwise established…"

314 CMR 4.05(b) 1:
Class SA

Dissolved Oxygen -

a. Shall not be less than 6.0 mg/L unless background conditions are lower;
b. Natural seasonal and daily variations above this level shall be maintained.

Thus, the assessment of eutrophication is based on site-specific information within a general framework that emphasizes impairment of uses and preservation of a balanced indigenous flora and fauna. This approach is recommended by the US Environmental Protection Agency in their draft Nutrient Criteria Technical Guidance Manual for Estuarine and Coastal Marine Waters (EPA-822-B-01-003, Oct 2001). The Guidance Manual notes that lakes, reservoirs, streams, and rivers may be subdivided by classes, allowing reference conditions for each class and facilitating cost-effective criteria development for nutrient management. However, individual estuarine and coastal marine waters tend to have unique characteristics, and development of individual water body criteria is typically required.

Methodology - Linking Water Quality and Pollutant Sources

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

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

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

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

• Requires site specific measurements within the watershed and each sub-embayment;

• Uses realistic “best-estimates” of N loads from each land-use (as opposed to loads with built-in “safety factors” like Title 5 design loads);

• Spatially distributes the watershed N loading to the embayment;

• Accounts for N attenuation during transport to the embayment;

• Includes a 2D or 3D embayment circulation model depending on embayment structure;

• Accounts for basin structure, tidal variations, and dispersion within the embayment;

• Includes N regenerated within the embayment;

• Is validated by both independent hydrodynamic, N concentration, and ecological data;

• Is calibrated and validated with field data prior to generation of “what if” scenarios.

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

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

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

• Monitoring - multi-year embayment nutrient sampling

• Hydrodynamics
  - Embayment bathymetry (depth contours throughout the embayment)
  - Site-specific tidal record (timing and height of tides)
  - Water velocity records (in complex systems only)
  - Hydrodynamic model

• Watershed N Loading
  - Watershed delineation
  - Stream flow (Q) and N load
  - Land-use analysis (GIS)
  - Watershed N model

• Embayment TMDL - Synthesis
  - Linked Watershed-Embayment N Model
  - Salinity surveys (for linked model validation)
  - Rate of N recycling within embayment
  - Dissolved oxygen record
  - 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 sub-embayments within the embayment system, located close to the inland-most reach or reaches, which typically has the poorest water quality within the system. These are called "sentinel" stations;

2) Using site-specific information and a minimum of three years of sub-embayment-specific data to select target threshold N concentrations for each sub-embayment. This is done by refining the draft target threshold N concentrations that were developed as the initial step of the MEP process. The target threshold N concentrations that were selected generally occur in higher quality waters near the mouth of the embayment system;

3) Running the calibrated water quality model using different watershed N loading rates, to determine the loading rate which will achieve the target threshold N concentration at the sentinel station. Differences between the modeled N load required to achieve the target threshold N concentration, and the present watershed N load, represent N management goals for restoration and protection of the embayment system as a whole.

Previous sampling and data analyses, and the modeling activities described above, resulted in four major outputs that were critical to the development of the TMDL. Two outputs are related to N **concentration**:

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

And, two outputs are related to N **loadings:**

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

In summary, meeting the water quality standards by reducing the N concentration (and thus the N load) at the sentinel station(s), the water quality goals will be met throughout the entire system.A brief overview of each of the outputs follows:

<u>Nitrogen concentrations in the embayment</u>

- Observed "present" conditions:

Table 4 presents the average concentrations of N measured in this system from data collected during the period 2003 through 2006. Concentrations of N are similar throughout the Edgartown Great Pond system (0.58-0.71 mg/L). The overall means and standard deviations of the averages are presented in Appendix A (reprinted from Table VI-1 of the MEP Technical Report).

- Modeled site-specific target threshold N concentrations:

A major component of TMDL development is the determination of the maximum concentrations of N (based on field data) that can occur without causing unacceptable impacts to the aquatic environment. Prior to conducting the analytical and modeling activities described above, 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. As listed in Table 4, the site-specific target threshold N concentration is 0.50 mg/L.

Table 4: Observed Present Nitrogen Concentrations and Sentinel Station Threshold Nitrogen Target Concentration for Edgartown Great Pond

Embayment (Sentinel Stations)	Observed Nitrogen Concentration [1] (mg/L)	Sentinel Station[3] Target Threshold Nitrogen Concentration (mg/L)
Edgartown Great Pond Range of 5 Stations (EGP1,2,3,5,6,9)	0.58 - 0.71 [2]	0.50
Atlantic Ocean (Boundary Condition)	0.23	

[1] Calculated as the average of the separate yearly means of 2003-2006 data.
Overall means and standard deviations of the average are presented in Appendix A
[2] Listed as a range since it was sampled at five stations (Appendix A)
[3] Sentinel Stations are EGP 1,2,3,5,6,9 to represent pond-wide conditions.

The findings of the analytical and modeling investigations for this embayment system are discussed below.

The target threshold N level for an embayment represents the average water column concentration of N that will support the habitat quality or dissolved oxygen conditions being sought. The water column N level is ultimately controlled by the integration of the watershed N load, the N concentration in the inflowing tidal waters (boundary condition) and dilution due to ground or surface water flows and (in the case of Edgartown Great Pond) limited flushing via tidal flows during periodic breaching of the barrier beach. The water column N concentration is also modified by the extent of sediment regeneration and by direct atmospheric deposition.

The N threshold for Edgartown Great Pond is based upon the goal of improving eelgrass habitat within the lower main basin and on pond-wide restoration of benthic habitat for infaunal animals. (The MEP study concluded that there was no evidence (past or present) of eelgrass within the upper main basin or within the major tributary coves and historic eelgrass habitat within the lower main basin was not likely of high quality due to limited tidal exchange. Routine breaching of the barrier beach to allow tidal flushing was required to maintain eelgrass habitat in the lower main basin in the past and this practice continues presently.)

Comparative analyses with similar organically enriched estuarine systems in Southeastern Massachusetts performed by MEP suggests that a healthy infaunal habitat would be achieved at an average N level of <0.5 mg/L N. The MEP study demonstrated that Edgartown Great Pond is currently supporting a moderately impaired infaunal community at levels of about 0.6 mg/L N. The study predicts that the lowering of average N levels to <0.5 mg/L will restore healthy infaunal habitat within the pond as well as improve eelgrass habitat.

The MEP study used a dispersion-mass balance model of Edgartown Great Pond to accurately simulate the N conditions that exist under present N loadings and periodic openings to tidal exchange and examined the effectiveness of various management alternatives to restore the observed N related habitat impairments (Section VIII.1of the MEP Technical Report).

The MEP approach for determining nitrogen loading rates that will maintain acceptable habitat quality throughout an embayment system, is to first identify the critical spatial distribution and secondly, to determine the nitrogen concentration within the water column which will restore specific locations to a desired habitat quality. These sentinel location(s) are selected such that their restoration will necessarily bring the other regions of the system to acceptable habitat quality levels.

Since the Edgartown Great Pond System does not support strong horizontal gradients the effect of alterations to N loads and/or pond-opening practices on habitat quality was gauged from predicted changes in water quality conditions pond-wide rather than at one or two sentinel stations. The study identified the long term water quality monitoring stations EGP1, 2,3,5,6,9 (shown in Figure 5 below) as representative of pond-wide conditions. That is, the average concentrations at these stations approximate concentrations throughout the pond waters.

The main goal is to prevent time averaged pond-wide TN concentrations in the pond from rising above the target threshold N concentration of 0.50 mg/L during the summer months, when benthic regeneration and algae production is greatest. The time-averaged total nitrogen level of 0.5 mg/L, means that the average total nitrogen level from just after the tidal inlet closes until the next inlet is opened equals 0.5 mg N/L across stations EGP1, 2,3,5,6,9 (Figure 5). One effective alternative to achieving this goal was to reduce the watershed N loading to the pond, together with an additional mid-summer breach.

Using the linked models, watershed loadings were sequentially reduced from present (2006) conditions until time averaged pond-wide N concentrations would remain below 0.50 mg/L during a 45-day period. The threshold modeling assumptions include 1) a successful early summer breach, which lowers the average pond N concentration to 0.35 mg/L; 2) a successful mid-summer breach that remains open for 11-days, and which again lowers pond-averaged N concentrations to 0.35 mg/L; and 3) a combined freshwater input rate (groundwater + precipitation) of 11.0 ft^3/sec, which is the lower range of summertime groundwater flow rates to the pond. Note that in the alternative, a 45 day period was used to calculate the time-averaged N concentration.

This alternative can be further modified by continuing to decrease the controllable N load while also lengthening the period between pond openings, or, by managing N loads less with shorter intervals between pond openings. This scenario was based upon the history of successful pond openings and a moderate level of watershed N management. The resulting threshold septic loading is taken from Table VIII-2 and VIII- 3 in the MEP Technical report. A 30% reduction in the present (2003-06) septic load to the pond, in combination with the plume of treated effluent from the “new” WWTF replacing the historical N load from the “old” WWTF discharge (pre-1996) was sufficient to achieve the threshold requirements. This septic load change results in a 17.8% change in the total watershed load to the pond. The 30% reduction in present septic loading coupled with a midsummer pond opening, 45 days after the late spring opening, achieved the target threshold N concentration of a time averaged pond-wide N concentrations below 0.50 mg/L over the summer period.

<u>Nitrogen loadings to the embayment</u>

- Present loading rates:

In the Edgartown Great Pond System overall, the highest N loading from controllable sources is from on-site wastewater treatment systems, which is almost always the highest N loading source in other coastal embayments as well. The septic system loading is 15.17 kg/day in Edgartown Great Pond. The total N loading from all sources is 57.50 kg/day across Edgartown Great Pond embayment. A further breakdown of N loading, by source, is presented in Table 5. The data on which Table 5 is based can be found in Table ES-1 of the MEP Technical Report. The loadings are updated from the MEP table and are based on the upgraded WWTP load that was predicted to reach the pond between 2006 and 2008 as described on page 30 of the MEP Technical Report.

As previously indicated, the present N loadings to Edgartown Great Pond 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.

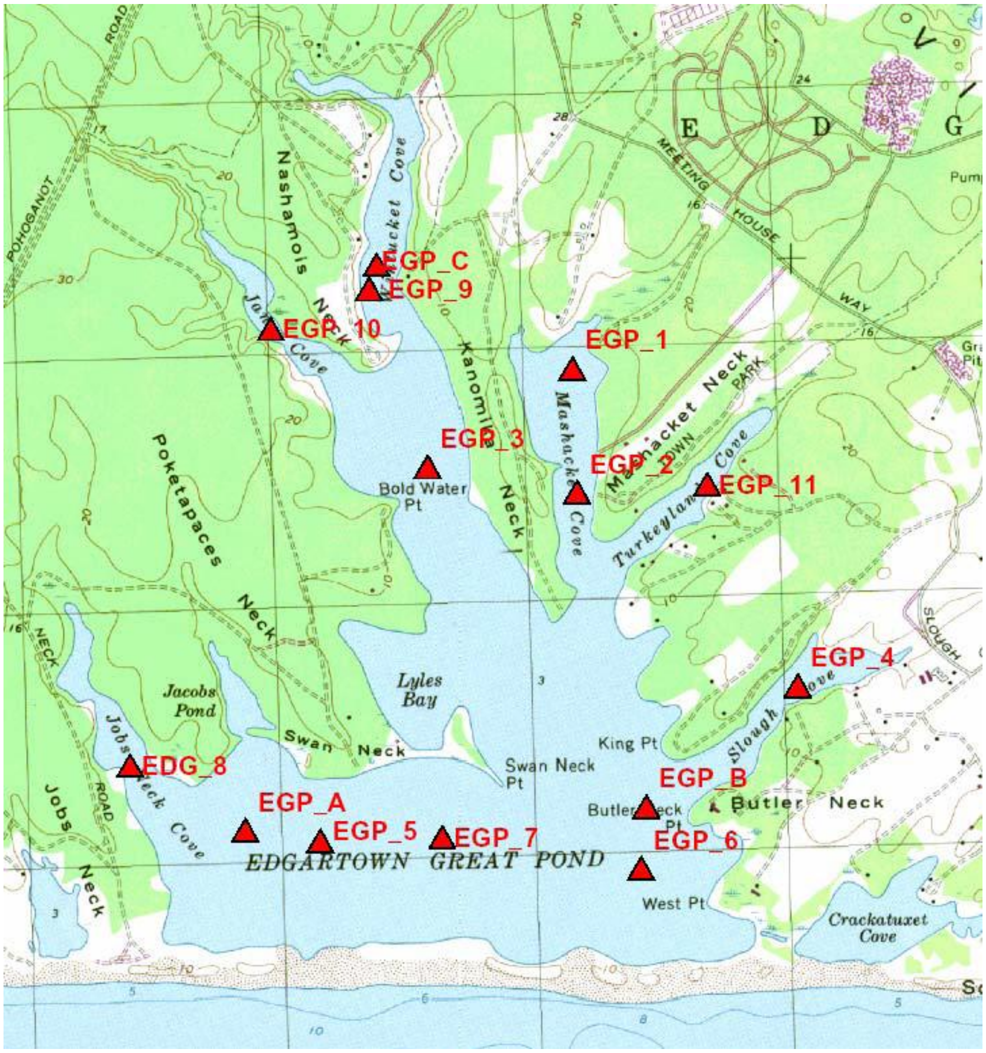

Figure 5: Edgartown Great Pond Long Term Monitoring Stations.
(EGP1, 2, 3, 5, 6 and 9 are identified as the locations for calculating time-averaged pond-wide N concentrations rather than using one or two sentinel stations.)

Table 5: Nitrogen Loadings to Edgartown Great Pond Embayment from Within the Watershed

Embayment	Present Non-Wastewater Watershed Load[1] (kg/day)	Present Load from WWTP (kg/day)[2]	Present Septic System Load (kg/day)	Present Atmospheric Deposition[3] (kg/day)	Present Load from Nutrient Rich Sediments (kg/day)	Total nitrogen load from all sources (kg/day)
Edgartown Great Pond	8.53	1.90	15.17	11.45	20.44	57.50

[1] Includes fertilizers, runoff, and atmospheric deposition to lakes and natural surfaces
[2] Based on upgraded tertiary WWTP load (2004 – 2006 average annual loads)
[3] Includes atmospheric deposition to the estuarine surface only

- Nitrogen loads necessary for meeting the site-specific target threshold N concentrations: Table 6 presents the present and target threshold watershed N loadings to Edgartown Great Pond, and the percentage reduction necessary to meet the target threshold N concentration at the sentinel station (see following section). It is very important to note that load reductions can be produced through reduction of any or all sources of N. Loads to the system could potentially be reduced by increasing the natural attenuation of N within the freshwater systems. Modifying the tidal flushing through inlet reconfiguration (where appropriate) is a means of increasing the dilution of the N in the embayment, and thus reducing the impact.

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

Embayment	Present Total Watershed Load [1] (kg N/day)	Target Threshold Watershed Load[2] (kg N/day)	Watershed Load Reductions Needed to Achieve Threshold Loads	
			Kg N/day	percent
Edgartown Great Pond	25.61	21.06	4.55	17.8 %

[1] Composed of fertilizer, runoff from impervious surfaces, septic systems, atmospheric deposition to natural surfaces and upgraded WWTP load

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

Table VIII-2 of the MEP Technical Report (and included as Appendix B of this document) summarizes the present loadings from on-site subsurface wastewater disposal systems and the reduced loads that would be necessary to achieve the target threshold N concentration in the Edgartown Great Pond System, under the scenario modeled here. Edgartown should take any reasonable steps to reduce the controllable N sources.

Total Maximum Daily Loads

As described in EPA guidance, a total maximum daily load (TMDL) identifies the loading capacity of a water body for a particular pollutant. EPA regulations define loading capacity as the greatest amount of loading that a water body can receive without violating water quality standards. The TMDLs are established to protect and/or restore the estuarine ecosystem, including eelgrass, the leading indicator of ecological health, thus meeting water quality goals for aquatic life support. Because there are no "numerical" water quality standards for N, the TMDL for the Edgartown Great Pond System is aimed at determining the loads that would correspond to specific N concentrations determined to be protective of the water quality and ecosystems.

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

The TMDL can be defined by the equation:

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

Where:

TMDL = loading capacity of receiving water
BG = natural background
WLAs = portion allotted to point sources
LAs = portion allotted to (cultural) non-point sources
MOS = margin of safety

Background Loading

Natural background N loading is included in the loading estimates presented here, but is not quantified and presented separately. It is a component of the target watershed threshold. Readers are referred to Table ES-1 of the MEP Technical Report for estimated loading due to natural conditions.

Waste Load Allocations

Waste load allocations identify the portion of the loading capacity allocated to existing and future point sources of wastewater. EPA interprets 40 CFR 130.2(h) to require that allocations for NPDES regulated discharges of storm water be included in the waste load component of the TMDL. For purposes of the Edgartown Great Pond TMDL, there are no NPDES regulated areas for the discharges of stormwater in the watershed. However, MassDEP also considered the nitrogen load reductions from impervious areas adjacent to the waterbody necessary to meet the target nitrogen concentrations in the WLA. Since the majority of the N loading from the watershed comes from septic systems, the Edgartown WWTF, fertilizer, and storm water that infiltrates into the groundwater, the allocation of N for any stormwater pipes that discharge directly to this embayment is insignificant but is estimated here for completeness.

In estimating the nitrogen loadings from impervious sources, MassDEP considered that most stormwater runoff from impervious surfaces in the watershed is not discharged directly into surface waters, but, rather, percolates into the ground. The geology on Cape Cod and the Islands consists primarily of glacial outwash sands and gravels, and water moves rapidly through this type of soil profile. A systematic survey of stormwater conveyances on Cape Cod and the Islands has never been undertaken. Nevertheless, most catch basins on Cape Cod and the Islands are known to MassDEP to have been designed as leaching catch basins in light of the permeable overburden. MassDEP, therefore, recognized that most stormwater that enters a catch basin in these areas will percolate into the local groundwater table rather than directly discharge to a surface waterbody.

As described in the Methodology Section (above), the Linked Model accounts for storm water loadings and groundwater loading in one aggregate allocation as a non-point source. However, MassDEP also considered that some stormwater may be discharged directly to surface waters through outfalls. In the absence of specific data or other information to accurately quantify stormwater discharged directly to surface waters, MassDEP assumed that all impervious surfaces within 200 feet of the shoreline, as calculated from MassGIS data layers, would discharge directly to surface waters, whether or not it in fact did so. MassDEP selected this approach because it considered it unlikely that any stormwater collected farther than 200 feet from the shoreline would be directly discharged into surface waters. Although the 200 foot approach provided a gross estimate, MassDEP considered it a reasonable and conservative approach given the lack of pertinent data and information about stormwater collection systems on Martha's Vineyard. For Edgartown Great Pond this calculated stormwater WLA based on the 200 foot buffer is 0.26% of the total N load or 0.08 kg N/day as compared to the overall N load of 30.29 kg N/day to the embayment (see Appendix C for details). This conservative load is a negligible amount of the total nitrogen load to the embayment when compared to other sources.

Load Allocations

Load allocations identify the portion of loading capacity allocated to existing and future nonpoint sources. In the case of the Edgartown Great Pond System, the nonpoint source loadings are primarily from on-site subsurface wastewater disposal systems. Additional N sources include: Edgartown WWTF effluent groundwater plume (post-upgrade effluent N concentration), agriculture, storm water runoff (including N from fertilizers), atmospheric deposition, and nutrient-rich sediments.

Storm water that is subject to the EPA Phase II Program would be considered a part of the wasteload allocation, rather than the load allocation. As presented in Chapters IV, V, and VI, of the MEP Technical Report, on the Islands, the vast majority of storm water percolates into the aquifer and enters the embayment system through groundwater. Given this, the TMDL accounts for storm water loadings and groundwater loadings in one aggregate allocation as a non-point source. Ultimately, when the MS4 Phase II Program is implemented in Edgartown, new studies, and possibly further modeling, will identify what portion of the storm water load may be controllable through the application of Best Management Practices (BMPs).

The sediment loading rates incorporated into the TMDL are lower than the existing sediment flux rates listed in Table 5 above 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 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)

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

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

And 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 Edgartown Great Pond system is reduced from existing conditions based on the load reduction from controllable sources.

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

Locally controllable sources of N within the watersheds are categorized as on-site subsurface wastewater disposal system wastes, the effluent plume from the Edgartown WWTF, and land use (which includes agriculture, storm water runoff and fertilizers). Figure 6 emphasizes the fact that the overwhelming majority (74%) of locally controllable N comes from on-site subsurface wastewater disposal systems.

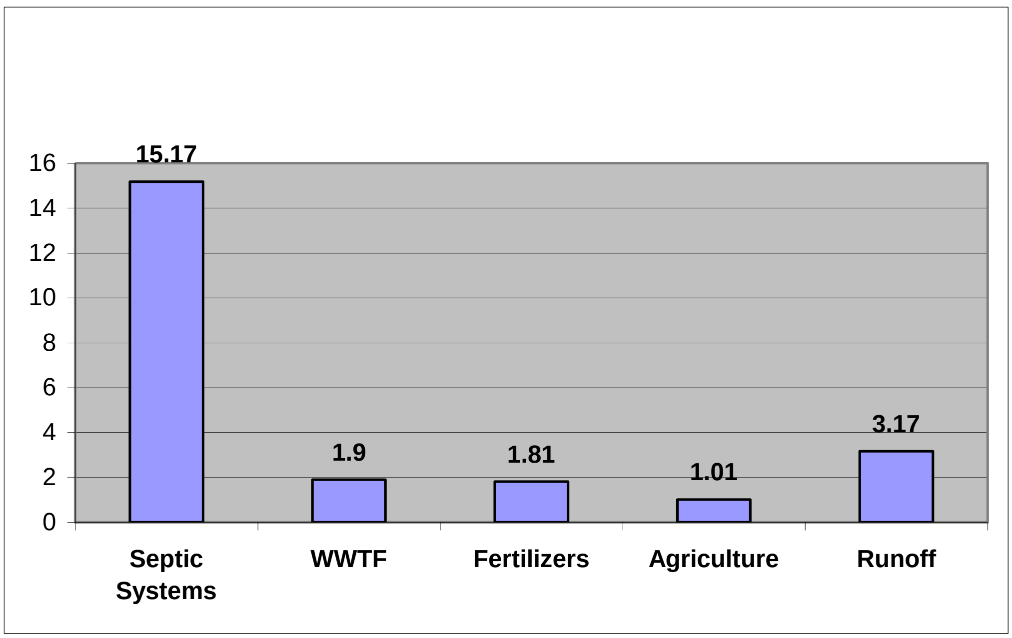

Figure 6: Controllable Nitrogen Load (kg N/day) to Edgartown Great Pond

Margin of Safety

Statutes and regulations require that a TMDL include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality [CWA para 303 (d)(20C, 40C.G.R. para 130.7C(1)]. 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. The MOS for the Edgartown Great Pond System TMDL is implicit, and the conservative assumptions in the analyses that account for the MOS are described below.

1. <u>Use of conservative data in the linked model</u>

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

The hydrodynamic and water quality models have been assessed directly. In the many instances where the hydrodynamic model predictions of volumetric exchange (flushing) have also been directly measured by field measurements of instantaneous discharge, the agreement between modeled and observed values has been $\geq$95%. Field measurement of instantaneous discharge was performed using acoustic doppler current profilers (ADCP) at key locations within the embayment (with regards to the water quality model, it was possible to conduct a quantitative assessment of the model results as fitted to a baseline dataset - a least squares fit of the modeled versus observed data showed an R^2>0.95, indicating that the model accounted for 95% of the variation in the field data). Since the water quality model incorporates all of the outputs from the other models, this excellent fit indicates a high degree of certainty in the final result. The high level of accuracy of the model provides a high degree of confidence in the output, therefore, less of a margin of safety is required.

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

Finally, the predicted reductions of the amount of N released from the sediments are most likely underestimates, i.e. conservative. The reduction is based solely on a reduced deposition of 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.

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

2. Conservative sentinel station/target threshold nitrogen concentration

Conservatism was used in the selection of the sentinel station and target threshold N concentration. The site was chosen that had stable eelgrass or benthic animal (infaunal) communities, and not those just starting to show impairment, which would have slightly higher N concentration. Meeting the target threshold N concentration at the sentinel station will result in reductions of N concentrations in the rest of the system.

3. Conservative approach

The linked model accounted for all stormwater loadings and groundwater loadings in one aggregate allocation as a non point source and this aggregate load is accounted for in the load allocation. The method of calculating the WLA in the TMDL for impervious cover within the 200 foot buffer area of the waterbody was conservative as it did not disaggregate this negligible load from the modeled stormwater LA, hence this approach further enhances the MOS.

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

Since the TMDLs for the waterbody segments are based on the most critical time period, i.e. the summer growing season, the TMDLs are protective for all seasons. The daily loads can be converted to annual loads by multiplying by 365 (the number of days in a year). Nutrient loads to the embayment are based on annual loads for two reasons. The first is that primary production in coastal waters can peak in both the late winter-early spring and in the late summer-early fall periods. Second, as a practical matter, the types of management necessary to control the N load do not lend themselves to intra-annual manipulation since a considerable portion of the N is from non-point sources. Thus, calculating annual loads is most appropriate, since it is difficult to control non-point sources of N on a seasonal basis and N sources can take considerable time to migrate to impacted waters.

TMDL Values for the Edgartown Great Pond System

As outlined above, the total maximum daily loadings of N that would provide for the restoration and protection of the embayment were calculated by considering all sources of N grouped by natural background, point sources, and non-point sources. A more meaningful way of presenting the loadings data, from an implementation perspective, is presented in Table 7.

Table 7: The Total Maximum Daily Load for the Edgartown Great Pond System, Represented as the Sum of the Calculated Target Threshold Load, Atmospheric Deposition and Benthic Load

Sub-embayment	Target Threshold Watershed Load [1] (kg N/day)	Atmospheric Deposition (kg N/day)	Load from Nutrient Rich Sediments (kg N/day)	TMDL [2] (kg N/day)
Edgartown Great Pond	21.06	11.45	13.56	46

[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] Sum of target threshold watershed load and atmospheric deposition load and benthic load

In this table, N loadings from the atmosphere and from nutrient rich sediments are listed separately from the target watershed threshold loads. The watershed load is composed of atmospheric deposition to freshwater and natural surfaces along with locally controllable N from the WWTP (post upgrade), on-site subsurface wastewater disposal systems, storm water runoff, agriculture and fertilizer sources. In the case of the Edgartown Great Pond System the TMDL was calculated by projecting reductions in locally controllable septic systems, the Edgartown WWTP, storm water runoff, and fertilizer sources. Once again the goal of this TMDL is to achieve the identified target threshold N concentration at the identified sentinel station.

Implementation Plans

The critical element of this TMDL process is achieving the sentinel station specific target threshold N concentration presented in Table 4 above. This is necessary for the restoration and protection of water quality, benthic invertebrate habitat, and eelgrass within the Edgartown Great Pond System. In order to achieve this target threshold N concentration, MEP is recommending a combination of approaches that includes reducing N loading rates throughout this embayment, and altering the schedule of the breaching of the barrier beach to increase the flushing of the estuary. Table 7 above, lists the target threshold watershed N load for this system. The MEP Technical Report provides a variety of breach opening alternatives that will have to be considered during the development of the CWMP.

Edgartown is encouraged to explore loading reduction scenarios combined with various barrier beach opening schedules, through additional modeling as part of the Comprehensive Wastewater Management Plan (CWMP). To this end, additional linked model runs can be performed by the MEP at a nominal cost to assist the planning efforts of the town in achieving target N loads that will result in the desired target threshold N concentration.

The CWMP should include a schedule of the selected strategies and estimated timelines for achieving those targets. However, the MassDEP realizes that an adaptive management approach may be used to observe implementation results over time and allow for adjustments based on those results.

Because the vast majority of controllable N load is from individual septic systems for private residences, the CWMP should 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.

Edgartown is 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 storm water runoff and/or fertilizer use within the watershed through the establishment of local by-laws and/or the implementation of storm water BMPs, in addition to reductions in on-site subsurface wastewater disposal system loadings.

MassDEP's MEP Implementation Guidance report (http://www.mass.gov/eea/agencies/massdep/water/watersheds/coastal-resources-and-estuaries.html) provides N loading reduction strategies that are available to Edgartown and 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
- Storm water Control and Treatment *
    - Source Control and Pollution Prevention
    - Storm water 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 Town of Edgartown is not one of the 237 communities in Massachusetts covered by the Phase II storm water program requirements.

Monitoring Plan

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

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 the Department, tracking progress on the agreed-upon plan will, in effect, also be tracking progress towards water quality improvements in conformance with the TMDL.

Relative to water quality, MassDEP believes that an ambient monitoring program, much reduced from the data collection activities needed to properly assess conditions and to populate the model, will be important to determine actual compliance with water quality standards. Although the TMDL load values are not fixed, the target threshold N concentrations at the sentinel stations are. Through discussions amongst the MEP it is generally agreed that existing monitoring programs, which were designed to thoroughly assess conditions and populate water quality models, can be substantially reduced for compliance monitoring purposes. Although more specific details need to be developed on a case by case basis MassDEP's current thinking is that about half the current effort (using the same data collection procedures) would be sufficient to monitor compliance over time and to observe trends in water quality changes. In addition, the benthic habitat and communities would require periodic monitoring on a frequency of about every 3-5 years. Finally, in addition to the above, existing monitoring conducted by MassDEP for eelgrass should continue into the future to observe any changes that may occur to eelgrass populations as a result of restoration efforts.

The MEP will continue working with the Town of Edgartown to develop and refine monitoring plans that remain consistent with the goals of the TMDL. It must be recognized however that development and implementation of a monitoring plan will take some time, but it is more important at this point to focus efforts on reducing existing watershed loads to achieve water quality goals.

Reasonable Assurances

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

N loading from on-site subsurface wastewater disposal systems, storm water, 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. Future storm water NPDES permit coverage will address discharges from municipally owned storm water drainage systems. Enforcement of regulations controlling non-point discharges include local implementation of the Commonwealth's Wetlands Protection Act and Rivers Protection Act; Title 5 regulations for on-site subsurface wastewater disposal systems, and other local regulations such as the Town of Rehoboth's stable regulations. Financial incentives include federal funds available under Sections 319, 604 and 104(b) programs of the CWA, which are provided as part of the Performance Partnership Agreement between MassDEP and EPA. Other potential funds and assistance are available through Massachusetts' Department of Agriculture's Enhancement Program and the United States Department of Agriculture's Natural Resources Conservation Services. Additional financial incentives include income tax credits for Title 5 upgrades and low interest loans for Title 5 on-site subsurface wastewater disposal system upgrades available through municipalities participating in this portion of the state revolving fund program.

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

Public Participation

The Department publically announced the draft TMDL in early March of 2010 and copies were made available to all key stakeholders. The draft TMDL was posted on the Department's web site for public review on March 2, 2010. In addition, a public meeting was held at the Town of Edgartown Town Hall on March 31, 2010 for all interested parties and the public comment period extended until close of business April 30, 2010. Christine Duerring (MassDEP) summarized the Mass Estuaries Project and described the Draft Nitrogen TMDL Report findings. This final version of the TMDL report includes both a summary of the public comments together with the Department's response to the comments and scanned image of the attendance sheets from the meetings (Appendix E). MEP representatives at the public meeting included MassDEP (Christine Duerring, Brian Dudley, Cathy Vakalopoulos) and SMAST (Brian Howes).

Appendix A

Table A-1: Summary of the Nitrogen Concentrations for Edgartown Great Pond System
(from Chapter VI of the MEP Technical Report)

Table VI-1. Measured nitrogen concentrations and salinities for Edgartown Great Pond. "Data mean" values are calculated as the average of the separate yearly means. TN data represented in this table were collected in 2003 through 2006 in Great Pond and 2002 through 2004 for salinity. The offshore Atlantic Ocean data (offshore Pleasant Bay Inlet) are from the summer of 2005.

Sampling Station Location	total nitrogen			salinity		
	data mean (mg/L)	s.d. all data (mg/L)	N	data mean (ppt)	s.d. all data (ppt)	N
Jobs Neck Cove – EGP8	0.583	0.174	9	17.9	5.1	11
Jane's Cove – EGP10	0.582	0.153	7	16.5	3.4	10
Wintucket Cove – EGP9	0.597	0.123	10	18.0	3.8	11
Upper Mash Cove – EGP1	0.650	0.170	9	18.9	4.6	14
Lower Mash Cove – EGP2	0.613	0.159	9	18.2	5.6	14
Turkeyland Cove – EGP11	0.639	0.107	5	19.8	3.4	11
Upper Slough Cove – EGP4	0.711	0.193	10	16.2	4.6	32
Upper EGP Basin – EGP3	0.587	0.175	10	18.4	5.1	14
Lower EGP West – EGP5	0.595	0.187	11	20.9	4.6	14
Lower EGP East – EGP6	0.591	0.205	9	22.1	5.4	14
Atlantic Ocean	0.232	0.044	17	32.3	0.6	5

Appendix B

Table B-1: Summary of the Present On-Site Subsurface Wastewater Disposal System Loads, and the Loading Reductions that would be Necessary to Achieve the TMDL by Reducing On-Site Subsurface Wastewater Disposal System Loads, Ignoring All Other Sources
(from Chapter VIII of the MEP Technical Report
http://www.oceanscience.net/estuaries/reports.htm)

Table VIII-2 Comparison of septic loads used for modeling of present 2003-2006 and modeled target threshold loading scenarios of Edgartown Great Pond. Septic loads are from existing residential and commercial properties. These loads do not include direct atmospheric deposition (onto the surface) or benthic flux loading terms.

	Present N Load (kg N/day)	Threshold (kg N/day)	Threshold Change
Edgartown Great Pond	15.167	10.617	-30%

Appendix C

Table C-1: The Edgartown Great Pond System Estimated Waste Load Allocation (WLA) from Runoff of all Impervious Areas within 200 Feet of Water Bodies

Watershed Name	Watershed Impervious Area in 200 ft Buffer of Embayment Waterbody (acres)[1]	Total Watershed Impervious Area (acres)[2]	Watershed Impervious Area in 200 ft buffer as % of Total Watershed Impervious Area	MEP Total Unattenuated Impervious Watershed Load (Kg N/day)[3]	MEP Total Unattenuated Watershed Load (Kg N/day)[4]	Watershed Impervious buffer (200 ft) WLA (Kg N/day)[5]	Watershed Buffer Area WLA as Percentage of MEP Total Unattenuated Watershed Load[6]
Edgartown Great Pond	20.09	781.00	2.5%	3.17	30.29	0.08	0.26%

[1]The entire impervious area within a 200 foot buffer zone around all waterbodies as calculated from GIS. Due to the soils and geology of Martha's Vineyard it is unlikely that runoff would be channeled as a point source directly to a waterbody from areas more than 200 feet away. Some impervious areas within approximately 200 feet of the shoreline may discharge storm water via pipes directly to the waterbody. For the purposes of the wasteload allocation (WLA) it was assumed that all impervious surfaces within 200 feet of the shoreline discharge directly to the waterbody.
[2]Total impervious surface for the watershed was obtained from SMAST N load data files.
[3]From Table IV-3 of the MEP Technical Report.
[4]From Table IV-3 of the MEP Technical Report.This includes the unattenuated nitrogen loads from wastewater from septic systems,WWTP, fertilizer, runoff from both natural and impervious surfaces, and atmospheric deposition to freshwater waterbodies. This does not include direct atmospheric deposition to the estuary surface.
[5]The impervious subwatershed 200 ft buffer area (acres) divided by total watershed impervious area (acres) then multiplied by total impervious subwatershed load (kg N/year).
[6]The impervious subwatershed buffer area WLA (kg N/day) divided by the total subwatershed load (kg N/day) then multiplied by

Appendix D

Table D-1: 1 Total Nitrogen TMDL

Embayment System	Segment ID	Impairment/TMDL Status	TMDL
Edgartown Great Pond	MA97-17_2008	Determined to be impaired for nutrients during the development of this TMDL	46 kg N /day

Appendix E

Massachusetts Estuaries Project
Response to Comments
DRAFT TMDL REPORT FOR EDGARTOWN GREAT POND
(Draft Report Dated February 23, 2010)

Questions and responses from Public Hearing for Draft Nitrogen TMDL held March 31, 2010
Edgartown Town Hall, Edgartown MA

Chris Duerring (MassDEP) summarized the Mass Estuaries Project and described the Draft Nitrogen TMDL Report findings. The public was able to ask questions and provide comments during and after the presentation. The following is a summary of the public comments either received verbally at the meeting or in written format within the 30 day comment period. A scanned image of the attendance sheet from the public meeting is also attached.

1) Is the percent contribution of nitrogen from the sediments based on an annual average or a snapshot sampling event?

The simple answer to this question is that the sediment nitrogen contribution is based on a net annual load from the sediments that considered the relative balance of nitrogen inputs and outputs (fluxes). MEP used sediment and water column data collected during worst-case summer conditions in their calculations and models to determine this annual sediment nitrogen contribution. However, the approach used by MEP is complex and a more detailed explanation is provided below as excerpted from Chapter IV of the MEP Technical Report.

MEP used two independent methods to determine the sediment N loading rate to Edgartown Great Pond. The first method was based on sediment core samples taken from 19 sites throughout the pond during summertime worst-case conditions (July and August of 2002). Cores were incubated over time and nitrogen release rates were determined. The results for each site were combined to calculate the net nitrogen regeneration rates for the pond. The overall objective of the benthic nutrient flux surveys was to quantify the summertime exchange of nitrogen between the sediments and overlying waters throughout the pond. MEP also used a mass-balance modeling approach to determine an integrated pond-wide nitrogen flux. This model was based on time series water-column total nitrogen data (average summer-time data during a period the pond was not open to the ocean) and the rate of external nitrogen loading (watershed plus atmosphere). The water column data were used to calculate the total change of nitrogen within the pond over the sampling period and then integrated with the watershed and nitrogen loading data. Since the modeled results compared well with the sediment incubation method results, MEP used the modeled system-wide nitrogen release rate in the nitrogen water quality modeling for Edgartown Great Pond.

2) Does DEP consider increasing shellfish farming as a way to also increase attenuation? What is the impact of a healthy oyster population on its ability to clean the pond?

DEP has no experience or data regarding the effectiveness of using shellfish farming as an implementation method for nitrogen attenuation in an embayment or salt pond in order to meet a nitrogen TMDL. We are aware that the states of Connecticut and New York have recently been investigating this possibility in Long Island Sound but no conclusions have been drawn as yet. In theory the concept makes sense and could have very positive outcomes for the town by way of increased shellfish revenue and improved water quality, however DEP cannot recommend or discourage shellfish farming as a viable TMDL implementation option without additional information. In general DEP promotes activities that reduce the nitrogen loads at their sources and encourages the town to explore all feasible alternatives to reduce sources of nitrogen.

3) Do you only measure dissolved nitrogen or also take into account what is in the phytoplankton? What is the speciation of nitrogen?

Nitrogen is measured as total nitrogen in the MEP study and thus includes both the organic and inorganic forms of nitrogen.

4) Is there a way to enhance denitrification in the sediments? Does sediment nitrogen help contribute to denitrification?

The rate of denitrification is controlled by the organic levels within the sediment and the concentration of nitrate in the overlying water. Organic rich sediment systems with high overlying nitrate frequently show large net nitrogen uptake throughout the summer months. In reality both sediment uptake and release occur in most embayments at different times of the year and under specific conditions. To enhance this process these conditions would have to be created or present such as found in freshwater streams and ponds as well as salt marshes where overlying waters support high nitrate levels. DEP believes the best way to control both sediment release as well as denitrification is to reduce watershed inputs. Doing this reduces the load in the embayment and thus the amount that gets deposited in the sediment. The natural system will then strive to achieve equilibrium between the sediment and water column over time.

5) Edgartown has been sewering more homes over the past few years and 149 more will be sewered this summer. Does this count towards the reduction recommended here?

If the additional properties are located in the Edgartown Great Pond watershed, then they should count towards the recommended reductions.

6) The TMDL is used to assist with the CWMP development. If we are meeting the TMDL, do we have to develop a CWMP?

A CWMP is only required if the community intends to apply for state funding to assist in meeting its wastewater management goals. However, DEP recommends that towns develop a CWMP to provide a well planned strategy to address specific local and perhaps regional wastewater management goals regardless of funding sources. What DEP is seeking is a local commitment including a detailed plan and schedule for watershed nutrient reductions *necessary to achieve the TMDL threshold targets. This can be achieved by developing a CWMP or if state funding is not being sought, the development of a nutrient management plan. That plan can include actions taken to date as well as actions needed to meet the TMDL goals. However, any such plan should be developed in coordination with MassDEP in order to insure that it addresses the necessary level of nitrogen reduction and is sustainable over the long term.*

7) Can a CWMP include the acquisition of open space, and if so, can state funds (SRF) be used for this?

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

8) Do we expect eelgrass to return if the nitrogen goal is higher than the concentration that can support eelgrass?

There are a number of factors that can control the ability of eelgrass to re-establish in any area. Some are of a physical nature (such as boat traffic, water depth, or even sunlight penetration) and others are of a chemical nature like nitrogen. Eelgrass decline in general has been directly related to the impacts of eutrophication caused by elevated nitrogen concentrations. Therefore, if the nitrogen concentration is elevated enough to cause symptoms of eutrophication to occur, eelgrass growth will not be possible even if all other factors are controlled and the eelgrass will not return until the water quality conditions improve.

Since there was uncertainly about the historical eelgrass density in the pond, as reported in the MEP technical report, the nitrogen threshold limit (goal) for Edgartown Great Pond was established by SMAST based on both improving eelgrass habitat in the lower main basin ***and*** *full restoration of infaunal habitat quality pond-wide.*

9) Is the recent reduction in nitrogen from the WWTP reflected in the TMDL report?

Yes, the TMDL was calculated assuming the "new" wastewater plume has now reached the pond.

10) Who is required to develop the CWMP? Can it be written in-house if there is enough expertise?

The CWMP can be prepared by the town. There are no requirements that it must be written by an outside consultant; however, the community should be very confident that its in-house expertise is sufficient to address the myriad issues involved in the CWMP process. MassDEP *would strongly recommend that any community wishing to undertake this endeavor on its own should meet with MassDEP to develop an appropriate scope of work that will result in a robust and acceptable plan. Also please refer to response #6 above.*

11) Have others written regional CWMPs (i.e. included several neighboring towns)?

Joint CWMPs have been developed by multiple Towns particularly where Districts are formed for purposes of wastewater treatment. Some examples include the Upper Blackstone Water Pollution Abatement District that serve all or portions of the towns Holden, Millbury, Rutland West Boylston and the City of Worcester and the Greater Lawrence Sanitary District that serves the greater Lawrence area including portions of Andover, N. Andover, Methuen and Salem NH. There have also been recent cases where Towns have teamed up to develop a joint CWMP where districts have not been formed. The most recent example are the Towns discharging to the Assabet River. They include the Towns of Westboro and Shrewsbury, Marlboro and Northboro, Hudson, and Maynard. The reason these towns joined forces was they received higher priority points in the SRF coming in as a group than they otherwise would have individually.

12) Would we have to do an island-wide CWMP?

An island-wide CWMP is not required but the town may want to consider the economic, environmental and engineering benefits of some form of regional CWMP to address watershed-wide wastewater management issues that cross municipal boundaries.

13) Can the recent work done by the town be added to the model?

The town can request MEP to run additional linked-model scenarios that take into consideration recent nitrogen management activities in the watershed. These additional scenarios would be at the expense of the town.

14) Should we use the WWTP to treat wastewater from other watersheds? Another thing to consider, should we discharge to another watershed?

From a water quality management perspective groundwater discharges of treated wastewater should ideally be located within the watershed of the collection system, however this may not always be feasible due to economic, engineering and/or other reasons. Discharging to another watershed would have to be completely evaluated because it may have adverse affects on local wells or the receiving water quality in a different embayment system.

15) When the project started 30% of waste water nitrogen was proposed to be reduced, but the TMDL calls for a 17.8% reduction in nitrogen. Why are these values different?

The total amount of nitrogen loading reduction required to meet the TMDL is 17.8% from ***all*** *sources. The recommended scenario in the MEP Technical report to reach this goal was to reduce the septic load by 30% and include an additional summer-time breach to the pond.*

Without the improved flushing that an additional breach would provide more sewering (>30%) would be required to meet the TMDL.

16) Suggestion that the Town use a dredge to maintain an opening in the pond for at least a 12 day period. Beyond that length of time it is counterproductive.

Your suggestion is duly noted and should be directed to the Town of further discussion and evaluation.

17) A copy of the management plan to organize the pond openings on a formal schedule was adopted by the relevant town committee in 2008. Last year, 2009, was the first year that the schedule was applied. This plan was written to address additional concerns other than just the openings and it follows below: (submitted via email 4/25/2010 by Dudley Levick)

June 20, 2007

The objective of this management plan is the restoration of an eelgrass ecosystem in Edgartown Great Pond. Besides being a primary producer, eelgrass is the keystone species in providing habitat for a stable and diverse ecosystem.

The decline in eelgrass has been caused by an increase in the standing crop of phytoplankton which deprives the eelgrass of sufficient sunlight to survive. The increase in phytoplankton is attributed to an increase in nitrogen compounds entering the pond.

The first step in reestablishing eelgrass is to improve water clarity by targeting the problem of nitrogen loading. This plan proposes a three pronged response; 1. Interdiction, 2. Purging, and 3. Bioremediation.

Improvements in the sewer system and in Board of Health regulations have been aimed at interdicting nitrogen at its source. It is expected that future studies will provide an accurate assessment of the total allowable nitrogen load, which will give guidance to future efforts at interdiction. It must be noted that interdiction alone cannot solve the nitrogen problem because there are sources, such as acid rain and blue-green algae, which are beyond our control.

Nitrogen can be purged from the system by opening the pond to the ocean. The seawater which replaces the pond water is lower in nitrogen. Pond openings also provide access to and from the ocean for all the estuarine species that make up the ecosystem. Pond openings are necessary to raise the salinity, making possible the survival of oysters and clams. It is the filter feeding shellfish that provide the means to bio-remediate the adverse effects of nitrogen loading.

The nitrogen that remains in the pond can be bio-remediated by using oysters to metabolize it. Oysters filter the water, improving the clarity. Their feces and pseudo-feces degrade nitrogen compounds and deliver them to the sediment surface where de-nitrifying bacteria convert the nitrogen compounds to nitrogen gas, which leaves the system. It is possible to improve the pond's production of oysters by coordinating the pond openings with the oysters' life cycle.

Pond openings are the most significant management tools we have. Experience has shown that four openings a year are possible, and that salinity can be maintained in the 12-24 ppt range that oysters require. Since openings are accomplished by the head of water that develops inside the pond, a brief description of the pond's annual water budget is in order.

Great Pond covers 900 acres, or about 39 million square feet. Three and three quarter feet of rain deliver 146 million cubic feet of water, which weigh 4.5 million tons. In addition, Great

Pond has a 5000 acre watershed. These 218 million square feet also receive 3.75' of rain per year, half of which enters the groundwater, delivering 12.6 million tons of water to the pond. Great Pond then has about 17 million tons of fresh water in its annual budget.

Pond openings drop the water level 2.5 feet. Multiplied by 900 acres gives a loss of 3.35 million tons of water per opening. Four openings a year will spend 13.5 million tons of water, leaving a balance of 3.5 million tons. A loss of 8 inches per year to evaporation accounts for .75 million tons, leaving 2.5 million tons that are lost as seepage through the barrier beach.

Scheduling a plan of pond openings requires that the time necessary to recharge the pond be established. This is inexact because the time the breach remains open is variable, as is the timing of rain events which cause short term variations in the rate of recharge. That said, it is reasonable to expect an average opening to last 10 days and the recharge by groundwater to take 40 days. It should be expected that openings can be scheduled 60 days apart.

To return to the question of scheduling openings to the oysters' advantage, there are some times when the pond should be kept closed. High water during the months of December, January, and February would protect the beds from freezing. In addition, the pond should be kept closed when the immature larval oysters are adrift in the water column, between June 15 and July 20.

Since oyster spawning is triggered by a rise in water temperature, a spawning could be stimulated by scheduling an opening for May 15. The pond should then close before June 1, with the water low, salty, and cool. The June sun should warm the pond steadily and induce spawning between June 20 and July 1. Three weeks of maturation should prepare the larvae to be capable of setting by July 21. An opening scheduled for July 25 would introduce salt water which would precipitate setting. These two openings are the year's most important in terms of their timing. A third opening should be effected before the end of November to allow the pond to close and rise before mid-December. The timing of this opening is not critical. A fourth opening is desirable to keep salinity above 12 ppt. The timing is not critical, but should be done before March 15 to prepare for a May 15 opening, initiating a new cycle.

This schedule is built around oysters. The dates given are accurate to within a week and represent a reasonable framework for the time of the spawning. Obviously, there will be variation from year to year, but the principle is valid and it is possible to optimize oyster recruitment by paying attention to the spawning cycle and planning pond openings accordingly. Remember that oysters are not problem free. Although they seem to be acquiring resistance to the strain of dermo that entered the pond in 1992, they are vulnerable to other diseases. The long term record is that they recover from setbacks. They are targeted for propagation instead of clams because clams require a higher salinity, which has proven difficult to maintain.

The sluiceway is to be used to limit the height of the pond to 3.5 feet above mean sea level as established by the 1929 National Geodetic Survey. The sluice boards are to be set so that flow out of Great Pond will begin at 3.3 feet above mean sea level. The discharge is to be limited to the months of January and February. The intent is to reduce shoreline erosion caused by high water. It is recognized that alewives cause an increase in algal density, and are contrary to the purpose of encouraging eelgrass. The sluiceway is not to be used to provide passage for alewives.

Cracktuxet Pond is to be managed separately from Great Pond. Cracktuxet is to be the terminus of the Herring Creek alewife run. The salinity is to be kept below 10 ppt. Discharge from Great Pond through the sluiceway is to be restricted if it will raise the salinity in Cracktuxet above 10 ppt.

In accord with the principle of using oysters to enable the return of eelgrass, oyster aquaculture is to be encouraged. It is recommended that a fishing sanctuary comprising 5% of the pond's area be established where no shellfishing be permitted for a period of 20 years. At the end of that time the policy should be evaluated. It is recommended that dragging for shellfish be prohibited in half the pond for 5 years. At the end of that time the policy should be evaluated.

It is recognized that eelgrass and oysters do not constitute the whole of the ecosystem. Other players in the system include, but are not limited to, bass, flounder, white perch, yellow perch, white mullet, herring, alewives, eels, crabs, and clams. In addition to the animals that live in the water, there are the birds, both resident and migratory, that use the shore and waters. It is posited that establishing an eelgrass habitat is the most effective way to assure balance in these systems. Until that point is reached, it may be necessary to intervene in cases of gross imbalance. The cormorant population may fit this category. In recent years they have increased far beyond historical numbers. Without the protection provided by eelgrass cover, the cormorants can destroy populations of juvenile fish. It is recommended that a way be found to limit cormorants that is consistent with state and federal regulations.

Dredging has been done twice in Great Pond since 2000. Removing the flat in front of the opening site greatly increased the effectiveness and duration of the opening that followed. However, the rate of sedimentation was also greatly increased. There needs to be further investigation to find a balance of how much dredging at how much cost to what benefit in order to establish a dredging policy. The dredging policy should include protection of the barrier beach and ways of building dunes.

DEP acknowledges the effort made by the town to develop this pond management plan and encourages the town to follow all applicable State Wetlands Protection Act regulations when implementing the pond breaching schedule.

SIGN IN SHEET 3/31/2010
Edgartown Great Pond
Draft TMDL Public Meeting

Signature	Print Name	Affiliation
[signature]	R. Cliff Harris	Edgartown Wastewater Comm.
[signature]	Joe Alosso	Edgartown Wastewater
[signature]	Dudley Levick	
[signature]	Bill Wilcox	MV Commission
[signature]	Paul Bagnall	Edg. Shellfish Dept
[signature]	Tom Wallace	Edg. Ponds Advisory Committee
[signature]	Jane M Varkonda	Conservation Agent
[signature]	Bob Woodruff	Great Pond Foundation
[signature]	Mike Giggey	Wright - Pierce
[signature]	Gary Smith	Wright - Pierce