

Action Plan 1. Managing Nitrogen-Sensitive Embayments

Problem

Impairments to water quality and living resources caused by excessive nitrogen inputs to Buzzards Bay are one of the most pressing issues identified in this Buzzards Bay CCMP. Most of these impairments occur in the somewhat less well flushed embayments that fringe Buzzards Bay. Loss of eelgrass beds, accumulation of benthic algae smothering shellfish beds, and low oxygen concentrations and resulting fish kills are among the impacts that must be remedied. Elimination of excessive nitrogen loads will ensure that all designated uses for those embayments are met.²⁹ Wastewater discharges are typically the largest source. While state and federal agencies regulate permitted discharges like outfall pipes, non-point sources of pollution like septic system are difficult to regulate. Solutions typically focus on municipal sewer expansion or nitrogen removing onsite systems.

Goals

Goal 1.1. *Ensure that no designated uses will be lost, nor ecosystems adversely affected by excessive contributions of nitrogen to any area of Buzzards Bay.*

Goal 1.2. *Restore lost designated uses and adversely affected ecosystems impaired by the excessive contribution of nitrogen to any area within Buzzards Bay.*

Objectives

Objective 1.1. To develop and adopt scientifically based nitrogen TMDLs for nitrogen impaired areas of Buzzards Bay, where warranted.

Objective 1.2. To reduce the amount of nitrogen currently entering nitrogen-impacted embayments, including all areas identified on 303(d) and Integrated Lists, according to limits specified in approved TMDLs.

Objective 1.3. To limit new additions of nitrogen entering nitrogen-sensitive and impaired embayments.

Objective 1.4. To ensure that state and federal discharge permits meet nitrogen loading limits and waste load allocations specified in approved TMDLs.

Objective 1.5. To promote the development and implementation of local plans to manage nitrogen discharges to coastal waters to meet TMDL limits and waste load allocations.

Objective 1.6. To promote the development and support the use of alternative and advanced nitrogen reducing wastewater treatment technologies at all scales of flow.

Objective 1.7. Monitor water quality and natural resources like eelgrass beds at a sufficient frequency to document management needs, assess the effectiveness of actions taken, and to document ongoing changes and variability in water quality and ecosystems health.

Approaches

Municipalities should take action to reduce nitrogen inputs to impaired waters. Wastewater is the most significant nitrogen source in most watersheds, and sewerage with disposal at centralized or satellite wastewater treatment systems with nitrogen removal will be the most viable solution for reducing wastewater nitrogen inputs from areas with dense development. In less developed areas, where sewerage is cost-prohibitive, advanced nitrogen removal onsite systems and small community scale systems may be part of a solution. To ensure action, it is imperative that DEP develop, and for the U.S. EPA to adopt, total maximum daily load (TMDL) nitrogen limits and waste load allocations for all impaired waters. These limits only directly affect discharges requiring a federal permit, so municipalities must develop comprehensive strategies to manage all nitrogen sources to meet the recommended TMDLs.

In some watersheds, better management of agricultural fertilizer release will be required, and in the case of the cranberry industry, this can be achieved in part through better water management techniques. Though typically a secondary source, stormwater discharges and residential fertilizer use can be locally important contributors, and management solutions to reduce these inputs can compliment other efforts to reduce wastewater nitrogen inputs. All stakeholders should work closely with municipalities to reduce nitrogen to meet TMDLs, and implement comprehensive strategies, including managing or offsetting nitrogen inputs from new development.

Costs and Financing

Preliminary estimates by Buzzards Bay municipalities suggest that sewer expansion in the watershed may exceed \$2 billion. Because of the costs and scale of the effort, meeting TMDLs will remain one of the most formidable political, financial, and management challenges facing municipalities. Implementation will likely take decades and require more state and federal support.

Measuring Success

The issuance of TMDLs, compliance with those TMDLs, and the area of impaired waters will be the management measures tracked. Restoring water quality and recovery of habitat will be the long-term tracking measure, and these will be assessed through the Coalition's Water Quality Monitoring Program and the state's Integrated List of impaired waters.

²⁹ Unless additional impairments are caused by other pollutants. "Designated Uses" are those listed in Massachusetts Water Quality Standards, see entry in Glossary.

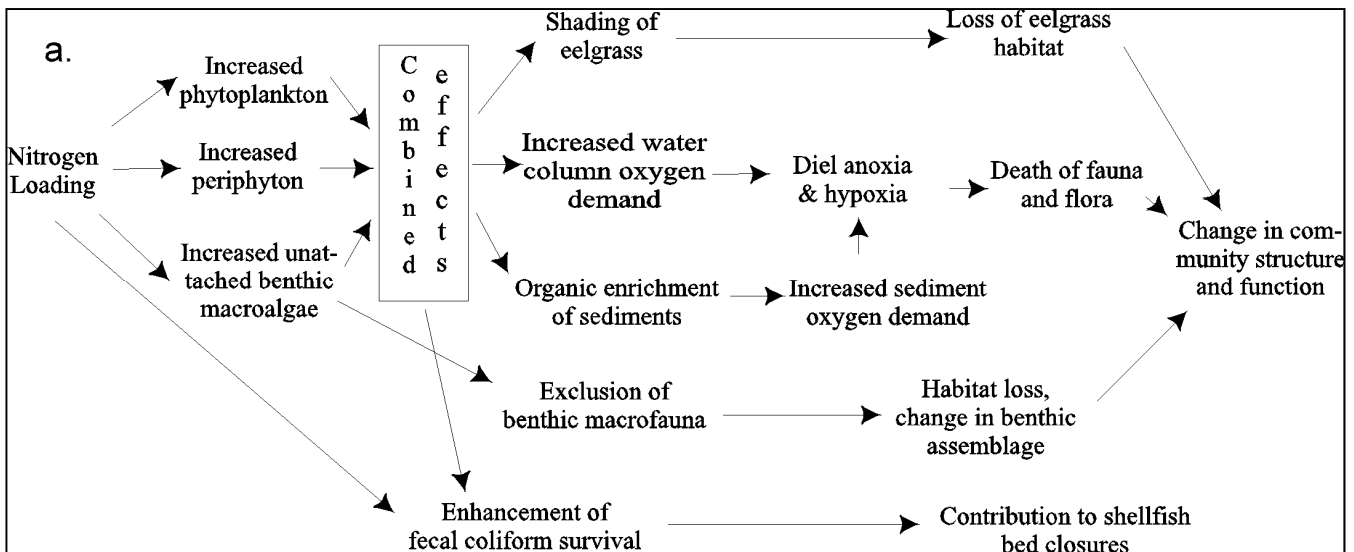


Figure 34. Generalized ecosystem response of a shallow embayment to nitrogen loading.

From Costa et al., 1992.

Background

As summarized in Chapter 3, and as articulated in the Massachusetts DEP's Integrated List of Impaired Waters, many areas of Buzzards Bay are impaired by excessive inputs of nitrogen³⁰. In Buzzards Bay, as in most coastal waters, nitrogen, which is an essential nutrient, typically limits the growth of algae. Algae, which include macroalgae or "seaweeds" and microalgae that live in the water (phytoplankton) or grow on surfaces (periphyton), form the base of many marine food webs. Increased inputs of nitrogen from human activities threaten many embayments in Buzzards Bay by stimulating excessive growth of both microalgae and macroalgae (Figure 34 and Figure 35).

This increased production and accumulation of micro- and macroalgae can result in many adverse changes to coastal ecosystems, in a process called "coastal eutrophication" or "nutrient enrichment". For example, increased abundance of algae can limit the transmission of light reaching eelgrass leaves, resulting in the loss of eelgrass beds that provide habitat for shellfish and other animals. The loss of eelgrass as a result of eutrophication has occurred in many parts of Buzzards Bay, as has happened at the north end of Buzzards Bay in the Wareham River estuary (Figure 36), one of the more eutrophic areas of Buzzards Bay.

Dense layers of macroalgae can also accumulate on the bottom of some shallow bays, which destroys valuable habitat for shellfish and other invertebrates. In addition, decay of macroalgae depletes oxygen in the water

and causes unpleasant odors. Severe oxygen depletion can kill fish and shellfish. There is also evidence that excess nitrogen promotes, directly and indirectly, the survival of coliform bacteria, which contributes to closures of shellfish areas. Algae blooms and accumulation of macroalgae may also cause aesthetic problems and inhibit typical recreational uses of the water such as swimming and boating. Overall, the addition of excess nitrogen is one of the most serious long-term problems threatening many embayments around Buzzards Bay.

The response of coastal ecosystems to excessive anthropogenic (human generated) contributions of nitrogen is complex and varied but most pronounced in embayments with restricted water exchange or where the amount of nitrogen added is large as compared to the volume of the receiving water (Figure 37). Perhaps the most overriding feature that defines the response of coastal ecosystems to nitrogen loading is the bathymetry of the receiving waters, particularly the area of bottom within the photic zone; that is where there is enough light for either seagrasses or algae to grow on the bottom.



Photo by Joe Costa.

Figure 35. Excessive algal growth shading out eelgrass is one of the many adverse impacts of nitrogen pollution.

³⁰ This action plan principally targets management of point and nonpoint sources of nitrogen at an embayment level, rather than bay-wide. This Buzzards Bay CCMP addresses nitrogen loading from sewer outfalls in more detail in the Sewage Treatment Facilities action plan.

Table 15. Summary of subwatershed loading and total loadings to Buzzards Bay from various sources

EMBAYMENT	Existing N Load (kg/y)	Note
Allens Pond	5,707	(1)
Apponagansett Bay	24,213	(1)
Aucoot Cove	10,574	(1)
Brant Island Cove	1,225	(1)
Buttermilk Bay	33,175	(1)
Clarks Cove	30,813	(1)
Hen Cove	5,244	(1)
Little Bay Fairhaven	31,192	(1)
Little River	4,225	(2)
Mattapoisett Harbor	51,071	(1)
Megansett / Squeteague Harbor	31,168	(1)
Little Bay / Nasketucket Bay	31,192	(1)
New Bedford Harbor (Acushnet River)	89,633	(3)
Onset Bay	20,169	(1)
Phinneys Harbor Back River	19,704	(1)
Pocasset Harbor	5,555	(1)
Pocasset River	9,417	(1)
Quisset Harbor	1,722	(1)
Red Brook Harbor	9,474	(1)
Sippican Harbor	17,175	(1)
Slocums River	32,087	(3)
Wareham River	95,142	(1,4)
Weweantic River	160,509	(1,4)
West Falmouth Harbor	15,234	(2)
Widows Cove	2,016	(1)
Wild Harbor	9,772	(1)
Wings Cove	4,199	(1)
Westport Rivers	175,200	(2)
Non-embayment watersheds	108,832	(1)
Buzzards Bay, atmos.	785,258	(5)
New Bedford Wastewater Outfall	368,214	(6)
Dartmouth Wastewater Outfall	97,892	(6)
Grand Total	2,287,004	

(1) BB NEP approximation from MassGIS landuse and MEP loading assumptions
(2) MEP draft or final report, includes precipitation to estuary areas
(3) BB NEP estimate from parcel data and other sources
(4) Calculation using MEP 2000-2010 cranberry bog loading rates
(5) Atmospheric loading to entire bay surface in the NEP study (MA waters to RI border), but does not include estuary surface waters in embayment watersheds (total= 162,429 acres), times the MEP loading rate of 4.41 kg per acre.
(6) Outfall loadings as reported to EPA, July 2010 to June 2011, at <http://www.epa-echo.gov/echo/>

Table 16. Relative contribution of septic system, atmospheric, and wastewater facility loading in various published MEP studies.

Studies of Buzzards Bay embayments are mostly incomplete as of 2012

Estuary System	septic system load	wastewater facility load	atmospheric to estuary surface
Rock Harbor	84%	1%	1%
Centerville River System	80%	0%	2%
Green Pond	78%	6%	7%
Taylor's Pond	77%	0%	3%
Bournes Pond	74%	0%	11%
Great Pond (Falmouth)	72%	3%	6%
Oyster Pond (Falmouth)	68%	0%	15%
Three Bays System	68%	0%	11%
Popponesset Bay	66%	0%	11%
Farm Pond	63%	6%	8%
Lagoon Pond	63%	0%	15%
Stage Harbor System	62%	0%	21%
Phinneys Harbor System	62%	0%	18%
Sulphur Spring System	59%	13%	2%
Sengekontacket Pond	58%	0%	23%
Lewis Bay System	55%	20%	11%
Little Pond	53%	0%	3%
Great Pond (Edgartown)	36%	16%	27%
West Falmouth Harbor	23%	82%	6%
Slocums River	21%	0%	4%
Average	59%	7%	13%

Sources of anthropogenic nitrogen reaching coastal waters (also defined here as "nitrogen loading") include sewage treatment facilities, septic systems, atmospheric deposition, and fertilizer used on lawns, golf courses, and agricultural land. Atmospheric loading to Buzzards Bay as a whole is quite large; about 1/3 of total loadings (Table 15). However, atmospheric loadings to individual embayments only averages 13% of total loadings among publicly available MEP studies, with wastewater disposal averaging 63% of estuary loading (Table 16).

The nitrogen from watershed sources enters the bay via streams, groundwater, direct rain deposition, storm-water runoff, and by effluent discharge. Cumulatively, the single largest source of nitrogen entering Buzzards Bay are discharges from sewage facilities; with the next largest amount derived from home septic systems (see Chapter 4, Action Plan 1, Table 12).

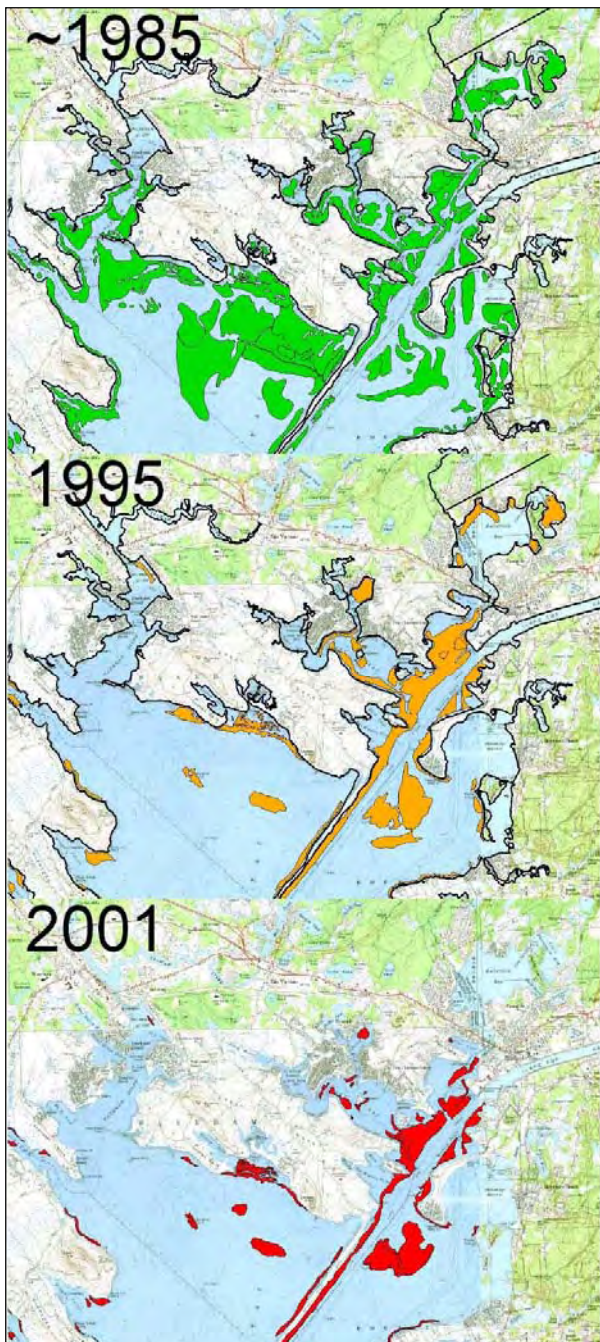


Figure 36. Recent losses of eelgrass in northern Buzzards Bay.

Top panel from data in Costa 1988a,b (posted at buzzards-bay.org/eelgrass.htm), middle and bottom panel from DEP eelgrass surveys, data posted at MassGIS.

This overview of nitrogen sources in approved MEP reports does not adequately reflect loadings in many Buzzards Bay watersheds. Draft reports for Westport and Wareham show agricultural sources as large as (Wareham) or exceeding septic system discharges (Westport). In New Bedford Harbor, the watershed is mostly sewered, the Fairhaven wastewater facility discharge is one of the largest sources, and stormwater and

CSO discharges are also significant. As noted in the original 1991 CCMP, even a large sewage treatment facility discharge such as New Bedford's, primarily affect waters close to the outfall. The MEP findings continue to affirm both the localized nature of coastal eutrophication, variability among watersheds sources, and the need for watershed-specific strategies to manage nitrogen inputs.

Although such discharges are important and managers may limit their nitrogen discharge, Buzzards Bay as a whole has a large well-flushed volume of water relative to nitrogen inputs so that human activity does not appreciably affect the central portion of the bay to the same degree that small embayments along the periphery of the bay are affected. In Buzzards Bay, shallow, less well-flushed embayments are most sensitive to nitrogen additions and are most likely to exhibit the symptoms and impacts described above. The Buzzards Bay NEP coined the terms "Nitrogen-Sensitive Embayments" and "Nitrogen-Impacted Embayments" to describe these systems in the 1991 Buzzards Bay CCMP.

Evolving Management Approach

Since the 1980s, the U.S. EPA required that impaired waters listed by states on either their so-called "303 (d)" or "Integrated Lists" have a Total Maximum Daily Load developed to mitigate those impairments (see Figure 38 for current listed embayments in Buzzards Bay). However, the Commonwealth had not yet adopted a methodology to define nitrogen TMDLs for coastal waters. The 1991 CCMP sought to address this problem by suggesting the use of parcel level data³¹ to calculate watershed nitrogen loading and to set watershed nitrogen loading limits by considering the relationship between watershed loading and total nitrogen concentrations and eelgrass loss relationship to define embayment specific TMDLs³². The strategy attempted to integrate surface water quality classifications so that degraded systems (SB waters) had higher acceptable thresholds than SA waters or Outstanding Resource waters (ORWs). To set the appropriate watershed mass-loading standard for each of these coastal systems, the Buzzards Bay NEP examined the empirical relationship between theoretical nitrogen loading (based on land use loading models) and ecosystem response, based on available eelgrass distribution information, and limited water quality data. The

³¹ "To calculate anthropogenic nitrogen loads, a parcel level land-use analysis is required using a well defined set of nitrogen loading assumptions. [pg 45]"

³² In the 1991 CCMP the TMDLs were defined as Total Maximum Annual Loads because it was felt that it was impractical to determine the actual loading to an estuary from groundwater and river water on a daily basis, however a subsequent legal ruling (U.S. Court of Appeals for the D.C. Circuit in *Friends of the Earth, Inc. v. EPA et al.*, No. 05-5015, April 25, 2006) determined that TMDLs must be expressed as daily loads, because that is the precise term used in the Clean Water Act.

estimated nitrogen loading was scaled to the degree of tidal flushing of each embayment, based on the established principle that well flushed embayments have less eutrophication impacts than otherwise similar, but less well flushed systems. (see also Costa et al., 1992).

At the time the 1991 CCMP was developed, embayment water quality data to evaluate water quality modeling was completely lacking and existing embayment modeling was quite challenging. Consequently, the BBNEP in 1991, adopted a simple tiered system of recommended loadings based on the empirical response between nitrogen loading and various ecosystem measures like eelgrass cover, and assigning loading standards that corresponded to state water quality classifications. Our approach was used for setting or initiating watershed loading targets in several estuaries during the 1990s, including the upgrade of the Wareham wastewater treatment facility, planned originally in the late 1990s.

In the 1991 CCMP the Buzzards Bay NEP recognized the limitations of its approach and noted,

"Future nitrogen management strategies may be based on embayment-specific nitrogen limits determined from computer models based on a large number of variables. This approach has not yet been developed and the proposed tiered approach is the most practical strategy based upon existing scientific understanding of coastal ecosystem response to nitrogen loading. Nonetheless, the proposed loading rates in table 5.1 should not be used if it can be well documented that a more appropriate limit be selected. For example, if it has been documented that an embayment showed catastrophic decline of eelgrass habitat or shellfish abundance at a certain time in its recent history - and that it has been demonstrated that this loss was due to nitrogen loading, then an appropriate loading limit goal for remediation activities should be set for nitrogen impact rates before the catastrophic degradation."

The BBNEP also recognized that for nitrogen management actions to be justified, it was important to collect water quality data in all of Buzzards Bay's more than 30 embayments. This data was essential to justify the costs of remediating impacts to coastal embayments already degraded. Because of this need, and because volunteer based water monitoring programs had proved effective on Cape Cod, in 1992, the BBNEP set up a water quality monitoring program with the Buzzards Bay Coalition called Baywatchers. By 1996, the Coalition assumed all management aspects of this program, and provided most of the funding for the effort. The effort led to important insights into water quality conditions in Buzzards Bay embayments (Figure 37) and began raising public awareness of the problem. This water quality data also demonstrated that the 1991 approach for setting limits for coastal embayments was simplistic and often too lenient. In the late 1990s, the BBNEP attempted to re-

verse downward the recommended limits based on the findings of the monitoring program, and in 2000, the program also proposed nitrogen water quality standards for classified surface waters based on this data (see footnote 35).

While the original recommendations to manage nitrogen in Buzzards Bay met with some successes (changes in zoning in some municipalities, adoption of the most stringent nitrogen loading limits in the state for the Wareham Sewage Treatment facility³³, DEP action to require TMDL studies and an upgrade of the Falmouth Wastewater facility, see also Table 17), in the end the methodology did not meet the site-specific rigor needed by DEP when the agency planned a state-wide program to establish watershed nitrogen TMDLs for Massachusetts coastal estuaries in the late 1990s. By 2000, DEP developed an initiative to meet their needs called the Massachusetts Estuaries Project (MEP) that would incorporate embayment-specific water quality hydrodynamic models that would be linked and build upon existing nitrogen loading models.

The MEP effort represents fulfillment of one of the goals of the original Buzzards Bay CCMP to identify embayment specific nitrogen loading limits based on sound science. The key elements of the MEP effort are defined by several documents. Howes et al (2000) evaluated nitrogen management approaches, including the one defined by the Buzzards Bay NEP in the 1991 Buzzards Bay CCMP and subsequent documents, and settled upon an approach they had developed to evaluate loading in other Cape Cod embayments (e.g. Howes et al, 1997).

Specifically, the MEP would employ what they called a "Linked Watershed-Embayment Model" for their 89 embayment evaluations. This approach linked a water quality circulation model³⁴ to a parcel based watershed loading model, a conventional nitrogen loading spreadsheet uses loading coefficients quite similar to those used by the Buzzards Bay NEP and Cape Cod Commission. This linked approach enabled the investigators to predict for each embayment concentrations of compounds that act conservatively with mixing (e.g. salinity), or near conservatively (total nitrogen, with adjustments made for benthic flux of nitrogen from sediments) at any location within an embayment. It is the linkage between the water quality and circulation models and the watershed nitrogen loading model (including groundwater and surface flow pathways and attenuation

³³ A 4 ppm total nitrogen discharge limit 7 months of the year.

³⁴ The water quality and loading software used by the MEP were proprietary customizations of the SMS, WMS, RMS software packages produced by BOSS International. These software packages allow the user to import GIS shapefiles, bathymetric data, and site-specific tidal elevation data to model the embayment's circulation patterns.

Buzzards Bay Water Quality, 1992-2005

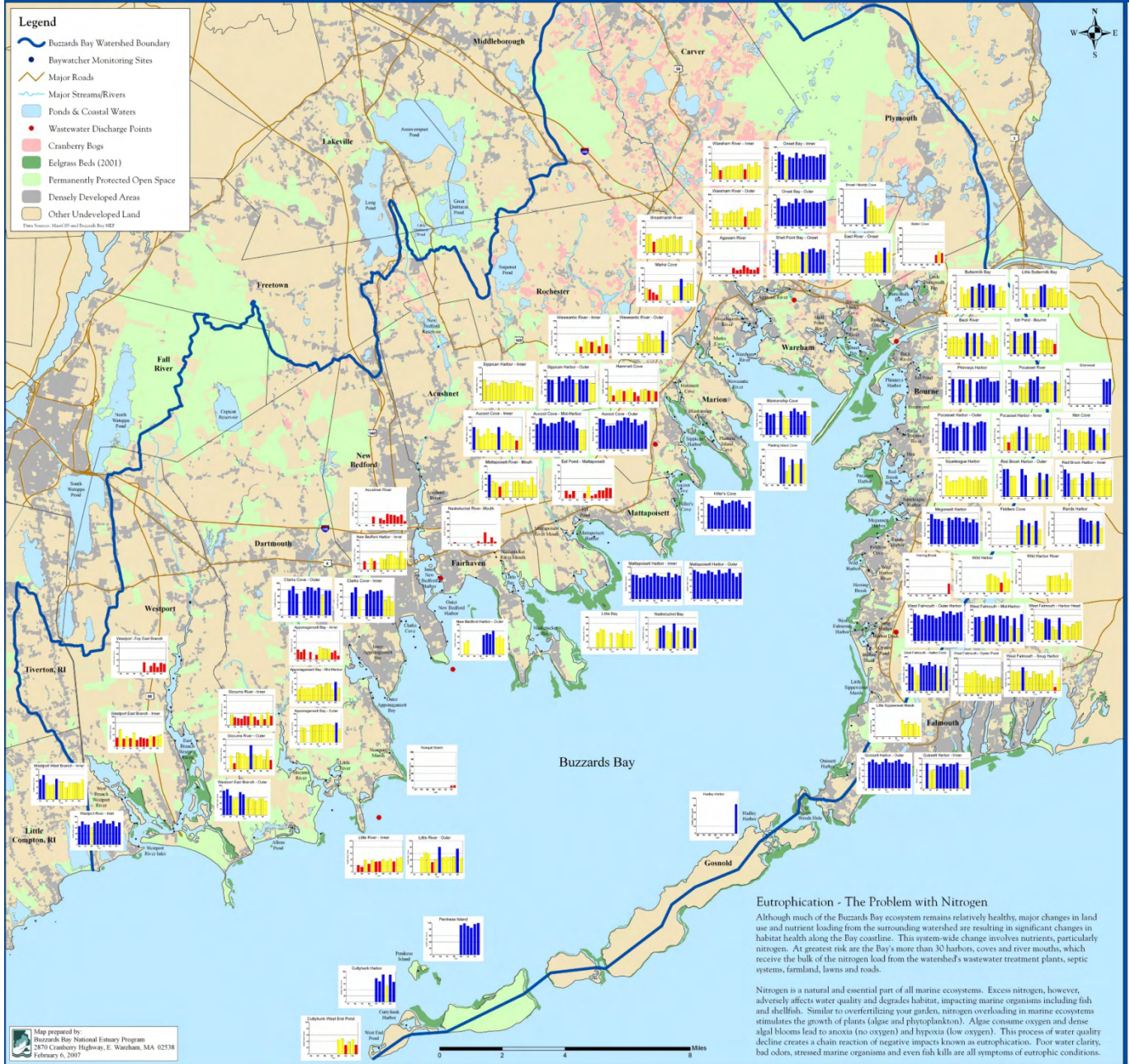


Figure 37. Summary of 13 years of coastal monitoring data collected by the Buzzards Bay Coalition.

Graphic of eutrophication index trends was from a poster prepared by the Buzzards Bay NEP for the Buzzards Bay Coalition water quality monitoring outreach program

estimates) that represent the core predictive modeling approach used by the MEP for setting TMDLs.

Among other elements included in the MEP model was the use of municipal water use records to estimate septic system loadings in seasonal and intermittently occupied vacation communities common on Cape Cod. The adoption of upper subwatershed attenuation coefficients based on differences between stream loadings and the watershed loading model added additional watershed specificity to each analysis.

The MEP approach is used to calculate load reductions to achieve embayment-specific target total nitrogen concentrations at sentinel stations within each estuary. Because the Commonwealth of Massachusetts had not adopted numeric criteria in its water quality standards, which were narratives of water quality goals, the MEP presented the basis for site-specific nitrogen thresholds in Howes et al (2003). This approach allowed for embayment-specific water quality standards at sentinel stations in order to establish the watershed TMDL, which

would become the basis for identifying corrective actions needed to achieve the water quality narrative. As noted in the document, "as a nutrient specific watershed management tool, the nitrogen thresholds and the process by which they are developed help communities focus implementation strategies on manageable (anthropogenic and subject to TMDL allocation process) sources of nutrients versus those that are naturally occurring." As noted in this document, the approach proposed by the MEP helps "bridge the gap in the existing water quality standards by providing a translator between the current narrative standard and nitrogen thresholds (as they relate to the ecological health of each embayment)." In 2003, DEP released a guidance document as to how municipalities may comply with TMDLs (DEP, 2003).

A fundamental first step in setting a TMDL for an estuary in the MEP approach is to select a location for a sentinel monitoring station and to establish a threshold target total nitrogen concentration for that station. Typically the MEP selects a sentinel station of around 0.4 ppm or less total nitrogen, if the water quality goal is to restore or protect eelgrass, and 0.5 ppm or higher, if the goal is only to protect or restore benthic habitat like shellfish beds³⁵.

The placement of the sentinel station, and the selection of a target total nitrogen concentration, affect the estimated total maximum daily load (TMDL) of nitrogen goal for that estuary, and how much watershed nitrogen loading must be reduced. The actual selection of the specific TN concentration at a sentinel station in an estuary, and the location of that station, are subjective decisions based on best professional judgment. These decisions also define the watershed nitrogen loading target and the resulting management reduction strategies. Typically the MEP considers the past maximum extent of eelgrass in an estuary, and the concentration of total nitrogen in nearby estuaries where eelgrass continues to survive, or the modeled concentrations of total nitrogen in those portions of the estuary (or nearby estuaries) that represent the maximum extent of eelgrass. This methodology can best be defined as the "reference site" approach to setting TMDLs as defined by the U.S. EPA (1999, 2000). The MEP then extrapolates the results of their water quality models to determine what amount of watershed nitrogen loading reduction would result in the proposed target concentration at the sentinel station. Small changes in the nitrogen concentration targets can appreciably affect loading reduction targets.

The Massachusetts Estuaries Project was originally estimated to cost \$15 million in state federal and local funds to evaluate 89 Massachusetts embayments over 8

³⁵ The BBNEP proposed similar water quality standards in 2000 correspondence to DEP, Managing anthropogenic nitrogen inputs to coastal embayments: BBNEP (2000), [Technical basis and evaluation of a management strategy adopted for Buzzards Bay. Supplementary information on water quality and habitat goals.](#)

Table 17. Some successes and timeline related to the 1991 Buzzards Bay CCMP Nitrogen Management Action Plan

- In 1991 Wareham, Plymouth and Bourne adopt zoning changes to manage future nitrogen inputs to Buttermilk Bay.
- In 1992, in partnership with the Buzzards Bay Coalition, the Buzzards Bay NEP creates a citizen-based water quality monitoring program to collect eutrophication related water quality data in order to justify management action.
- In 1993, the Buzzards Bay NEP creates the eutrophication index in an effort to simplify and communicate the results of the water quality monitoring program to residents and town officials.
- In 1995-1997, reports and analysis from the Buzzards Bay NEP of nitrogen loading impacts of the Falmouth wastewater facility to West Falmouth Harbor initiated further studies that lead to the construction, in 2002, of an upgraded facility to achieve high levels of nitrogen removal and a groundwater discharge limit of 5 ppm.
- In 1996, DEP adopts "nitrogen-sensitive area" standards in the 1996 Title 5 onsite system regulations.
- In 1998, the Buzzards Bay NEP revises downward its recommended nitrogen loading limits based on the results of the monitoring program.
- In 1999, EPA uses Buzzards Bay NEP loading analyses and recommended limits, and the Buzzards Bay Coalition water quality data to justify Best Available Technology upgrades at the Wareham Wastewater Treatment Facility and an NPDES discharge limit of 4 ppm nitrogen during 7 critical months of the year.
- In 2000, DEP recognizes the need to limit nitrogen to coastal embayments but realizes the Buzzards Bay NEP's 1991 tiered nitrogen loading strategy is too simplistic to meet the development of TMDLs. Instead they establish an ambitious 10-year effort to evaluate 89 Massachusetts embayments using a linked watershed loading-water quality model approach as the basis of the program. Work in West Falmouth Harbor becomes a model for the program. The Buzzards Bay Citizen Water Quality Monitoring Program data becomes the basis for evaluating the ecosystem response and nitrogen loading models.
- In 2006, the Massachusetts MEP completes the first TMDL for a Buzzards Bay embayment.

years. The costs, time, and level of effort required to complete this effort was underestimated, and by 2010 only three Buzzards Bay embayments had been issued final TMDL reports. However, DEP remains committed to completing the effort for most of the remaining systems originally planned for evaluation within Buzzards Bay.

With delays in the MEP program, some municipalities have sought to pass interim measures to limit nitrogen. The most notable of these efforts were the repeated attempts and failures of town officials in Wareham to pass bylaws in 2006, 2007, 2008, and 2012 to require nitrogen reducing septic systems. These efforts were prompted by a desire to address the poor water quality in the community, and a recognition that with the completion of the current \$50 million facility upgrade and sewer expansion initiative still underway, the likelihood of the town adopting a new sewer expansion program seemed unlikely in the near future.

From TMDLs to Management Action

All conventional septic systems release nitrogen as ammonia that converts rapidly to nitrate in soils above the water table. Whether a system is properly operating, or fails to meet Title 5 standards, it is presumed to contribute the same amount of nitrogen to the environment³⁶. Nitrate in groundwater flows great distances without attenuation and with little chance of uptake by plants, except in upper watershed areas, where groundwater may be intercepted by wetlands and fresh surface waters. Still, in the MEP loading models, in many river and upper watershed areas, net nitrogen transmission to coastal waters may still equal 50 to 70% of the presumed loading to groundwater. Given the large number of septic systems in most watersheds, it is not surprising that septic systems account for 50-75% of the nitrogen entering coastal waters in most of the MEP studies to date.

Not all parts of Buzzards Bay have these suburban residential patterns of development. In some rural agricultural areas like Westport, Carver and Middleborough, fertilizer on agricultural lands or wastes from livestock may be significant contributors of anthropogenic nitrogen and exceed septic system discharges. In an urban area like New Bedford, the Fairhaven wastewater facility and New Bedford CSOs and stormwater are the principal sources of nitrogen to the harbor. Because each embayments has its own specific sources of nitrogen, management strategies will be specific to those watersheds.

Whether or not septic systems are the largest single source, they are viewed as one of the easiest sources to control. Even in the 1991 CCMP, septic systems were viewed as one of the primary problems and sewerage was identified as a solution, as was the allowance and use of nitrogen removing onsite systems, which at the time were a novel idea³⁷. Twenty-one years later, and after a

decade of work most MEP TMDL reports identify sewer expansion as the modeled scenario to reduce nitrogen.

Restoration strategies in the original CCMP relied upon voluntary action by municipalities to expand sewer systems or take other measures. With the ongoing TMDL effort by the MEP, a far more scientifically defensible basis for watershed nitrogen TMDLs is now available. However, while existing permitted discharges must comply to the maximum extent feasible, actions by municipalities to expand sewer systems and eliminate septic systems is still largely remain a voluntary action, at least under federal regulations. State and municipal government have more authority, but these powers have not yet been exerted to address watershed TMDLs. For example, DEP has broad authority to enforce the federal Clean Water Act under Massachusetts law³⁸, but these authorities have not been utilized.

DEP and EPA's approval of the TMDLs developed by the MEP are actions within the framework of Section 303(d) of the Clean Water Act. Although these new limits are also just mass loading limits based on best available science, once adopted as TMDLs, they are enforceable by state and federal agencies for regulated (permissible) discharges. However, efforts to solve the problem have been delayed and become more intractable because of the immense cost of sewerage. Many state and local regulators do not view the widespread use of nitrogen removing onsite systems as a panacea because of costs and implications of possibly managing hundreds or thousands of nitrogen removal onsite systems. While our scientific understanding and capacity to model nitrogen impacts have vastly improved since 1991, regulatory tools to deal with the problem, either within local bylaws or state regulations, have changed little during the same period, often resulting in continued inaction.

The failure of federal, state or local government to meet these TMDLs can also be the subject of lawsuits under the Clean Water Act by citizens and citizen groups. This fact led to the Buzzards Bay Coalition and the Conservation Law Foundation filing a citizen lawsuit, that among other things, challenged the EPA's policies and rules that groundwater discharges were not part of a TMDL's "waste load allocation"; that is, not a regulated discharge under the Clean Water Act. As of early 2012, this suit remains unsettled.

³⁶ The exception may be those cesspools located in saturated soils close to water bodies. Properly designed leach fields help remove some nitrogen, and these processes do not occur when an anaerobic effluent plume is discharged directly to the water table close to a water body. See Costa et al, 2002.

³⁷ A specific recommendation in the 1991 action plan was that "DEP will actively promote the development and acceptance of

cost-effective alternative technologies for wastewater denitrification by assigning additional personnel to overview pilot projects."

³⁸ M.G.L. c. 21, §§ 26 through 53 directs DEP to " It directs the Department to take all action necessary or appropriate to secure to the Commonwealth the benefits of the Clean Water Act, 33 U.S.C. §1251 et seq."

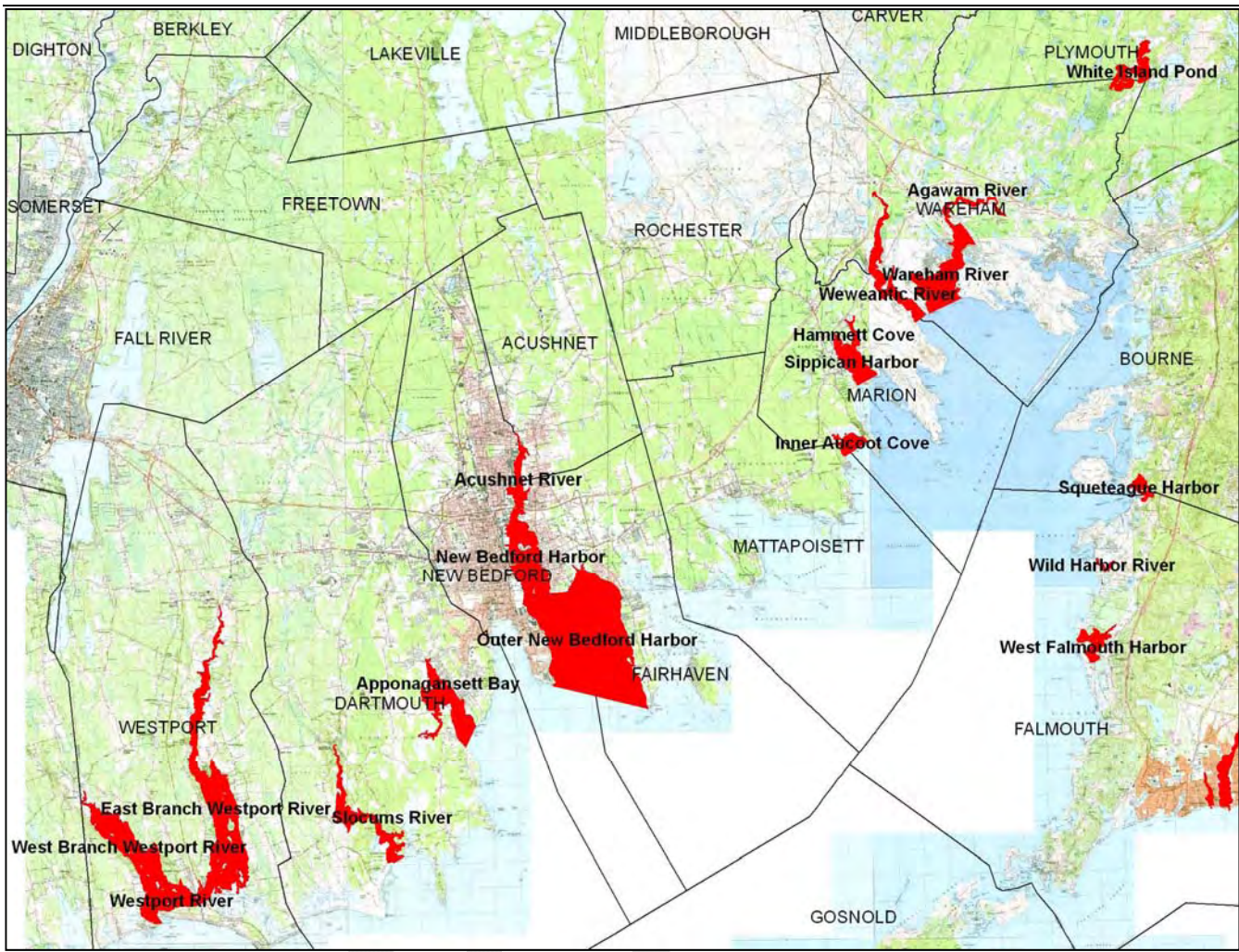


Figure 38. Coastal embayments listed as impaired for nitrogen in the Buzzards Bay watershed

From DEP's 303(d) Integrated List, last updated in December 2008. Note that on Cape Cod, TMDLs have been set based on MEP reports even though they are not listed as Category 5 waters in the state's Integrated List, therefore the number of TMDLs in Buzzards Bay will be greater than the number shown on this map.

Major Issues

As described in the preceding section, there are several major issues that have hindered progress on this issue since the adoption of the 1991 CCMP. About 2002, the MA DEP and the Massachusetts Estuaries Project encouraged municipalities not to adopt nitrogen management controls until DEP had adopted nitrogen TMDLs for each nitrogen impaired coastal embayment. Due to delays, cost overruns, and insufficient funding, as of March, 2012 only 2 TMDLs have been approved for Buzzards Bay, so most communities continue to defer taking management action, all the while development continues, and sites for treatment solutions diminish.

Second, as illustrated on Cape Cod, even when TMDLs are established, in most cases the proposed solution for reducing nitrogen is the construction of new sewage treatment facilities and creation or expansion of

sewer networks. Based on town estimates and press reports, these costs will likely total billions of dollars for Buzzards Bay watershed communities. In some towns, betterments just for sewer tie-ins have in some cases exceeded \$40,000 per home. This does not include the cost of new or expanded treatment facilities, annual sewer fees, or connection costs. These cost concerns have prompted financial studies of alternative approaches (e.g., Barnstable County Wastewater Cost Task Force, 2010). Such high costs, and the absence of federal grants and limited availability of SRF funds have made these management solutions politically unsellable to large sectors of the population if all the costs are borne locally.

Finally, because septic systems discharge to groundwater, they are not regulated by the federal government under the Clean Water Act and are designated part of the watershed waste load non-point source pollution. Therefore, ultimately there is no legal requirement

under federal law for municipalities to connect septic systems to wastewater facilities to meet a TMDL. Thus for the foreseeable future, unless DEP exerts its authorities under state law, municipalities will make progress toward reducing nitrogen discharges to coastal waters in a time frame that is politically and financially feasible for the residents.

Management Approaches

The Buzzards Bay Coalition's water quality monitoring and DEP's eelgrass mapping program has clearly documented which embayments in Buzzards Bay are impaired. The MEP studies on Cape Cod has resulted in the adoption of TMDLs in nearly every system where eelgrass loss or habitat degradation has occurred, so it is likely that most Buzzards Bay embayments, and many more than those shown in Figure 38, will have a TMDL.

The primary state-local planning tool to implement these TMDLs will be the Comprehensive Wastewater Management Plan (CWMP). The goal of the CWMP process is to make environmentally sound and cost effective decisions on the planning, design, construction and maintenance of wastewater facilities, and that reflect the collective input of citizens, local officials and other interested stakeholders. The adoption of CWMPs that address watershed nitrogen TMDLs also makes communities eligible for 0% interest SRF loans.

The outcome of the CWMP process will vary from Town to Town. Even before a TMDL was approved for the Wareham River estuary, strict nitrogen limits were required for the Wareham wastewater facility based on recommended limits by the Buzzards Bay NEP and water quality data from Buzzards Bay Coalition's Baywatchers Program. This translated to 4 ppm for 7 months (April through October) of the year which was incorporated into a past CWMP. An updated CWMP for Wareham will need to incorporate any newly adopted TMDLs.

In most watersheds, further reductions in watershed loading must focus principally on onsite septic systems, although agricultural fertilizer use is also a major source in some watersheds. In the case of agricultural fertilizer use or manure management, normal farm practices are exempt from local control and are little regulated or exempt from state and federal environmental laws as well. This situation means the focus on fertilizer management will either be directed toward voluntary and collaborative work with farmers, or on the use and management of fertilizer on residential and active recreational lands.

For the relatively few embayments that are nitrogen sensitive, but not yet nitrogen impacted, managers can implement a combined strategy of managing nitrogen from new growth through sewerage, nitrogen removing community scale package plants, or advanced onsite systems. However, given that nearly all embayments studied on Cape Cod require nitrogen reductions, so too it is

likely that all embayments in Buzzards Bay will require TMDLs and loading reductions, not just the impaired systems identified in Figure 38. Local legislative bodies and regulators can initiate some supporting measures to reduce fertilizer impacts by changing fertilizer use on public lands, or by adopting fertilizer ordinances that control the type and period of use of fertilizer, requiring vegetative buffers between turf and wetlands during the permitting process for new development and redevelopment, or by treating stormwater discharges³⁹. In most estuary watersheds, however, these sources account for 20% or far less of the controllable load entering the estuary.

Other tools municipalities could adopt include requirements of "nitrogen neutrality" or no net nitrogen for new development, minimum town-wide nitrogen standards for new development (which also become a negotiating point for new Chapter 40B projects), and Transfer of Development rights with elements to allow nitrogen trading. Zoning changes can also support these efforts (nitrogen overlay districts, minimum lot size), although these tools will be used primarily to manage new sources of nitrogen.

The localized nature of coastal eutrophication and watershed loading limits were novel to local officials with Buzzards Bay CCMP was adopted in 1991. Today, the public is far more conversant with the seriousness of the problem, and the science defining coastal eutrophication is now widely accepted. Nonetheless, because of the high cost of solving the problem, the restoration of impaired estuaries seem far off. The loading analyses of the MEP, and earlier assessments by the Buzzards Bay NEP point to common outcomes and needs. Even where TMDLs have not yet been developed, it is clear that wastewater management must be the primary focus in every community, and it is imperative that municipalities begin the wastewater planning process..

Financial Approaches

The main financial support offered by the federal and state government is the federally funded State Revolving Fund (SRF) program, which is jointly administered by the DEP Division of Municipal Services and the Massachusetts Water Pollution Abatement Trust.. For municipalities with an approved CWMP, SRF offers loans with as low as 0% interest loan, for 20 to 30 year loan periods. In today's financial climate, these loan represent a cost saving on projects of 18-28% (Barnstable County Wastewater Cost Task Force, 2010). However,

³⁹ The state Wetlands Protection Act regulates activities in a buffer zone with the goal of protecting adjoining wetlands, not to protect or maintain a buffer zone. Through some municipal bylaws, the buffer zone may itself be a resource area to protect, or a no-build buffer is enforced. See Action Plan 7. Protecting Wetlands for recommendations on this topic.

there is far more demand for the loan program than there are funds available. This means most of the costs of meeting TMDLs will be borne through local property taxes, betterment fees, and sewer fees.

On Cape Cod, the estimated costs to comply with watershed nitrogen TMDL is high. Falmouth has estimated sewerage costs at \$650 million⁴⁰, Chatham \$350 million, and Bourne \$300 million. These are the costs to sewer only the densest developed portions of their communities, and may not cover the costs of sewage treatment upgrades. These costs translate into \$40,000 to \$100,000 per home connected. Some managers have criticized these projections as over-estimates, but a consensus is developing among municipal and state officials that Cape Cod sewerage will in fact total four to eight billion dollars⁴¹.

For the Town of Falmouth, most of the estimated \$650 million price tag to comply with nitrogen TMDLs will be associated with projects outside of the Buzzards Bay watershed. However, some areas of West Falmouth Harbor and Quisset Harbor will need to be sewerage, and the town's wastewater facility, which is in the Buzzards Bay watershed, will need to be expanded, with new leaching fields installed outside of the West Falmouth Harbor watershed. These costs will likely exceed many tens of millions of dollars to \$100 million.

Actual costs will be defined by the specific solutions or strategies a municipality adopts, and reports by the Barnstable County Wastewater Cost Task Force (2010) and Wright-Pierce et al (2005) provide excellent summaries relevant to southeastern Massachusetts and Cape Cod. For most Buzzards Bay watershed communities, sewerage costs may be ameliorated by the fact that many densely developed areas are already sewerage, so most towns are merely facing sewer expansion, not the construction costs of new wastewater facilities. However, major expansions of sewer systems typically also require expensive upgrades or expansions of existing systems, so savings are not always realized. Still, upgrading existing facilities to meet more stringent discharge limits is sometimes also required, and as less densely developed areas are sewerage, sewer tie-in costs per home increase dramatically.

On top of these costs are connection fees and septic removal costs (\$4,000 to \$8,000 per home), sewer fees, and hundreds of millions of dollars to upgrade the capacity and performance of existing wastewater facilities. Currently, in the Buzzards Bay watershed there are roughly 250,000 people living in 100,000 dwelling units.

Roughly, half, or 50,000 of these units are sewerage. If half of these estimated septic systems in Buzzards Bay needed to be sewerage, the cost of wastewater facility upgrades and betterments, system removals and house tie will likely exceed \$1.25 billion (25,000 systems x \$50,000 average total cost per unit). Thus the total costs to comply with nitrogen TMDL in the Buzzards Bay watershed will likely exceed \$1 billion and may approach \$2 billion dollars.

For some embayments, simpler and less costly solution may be available. Dredging harbor entrances to increase flushing rates may be a viable option in only a few small systems. However, even when dredging is a potential solution, it may be controversial because enlarging channels may increase tidal ranges, change salinities, limit light reaching bottom habitat, or result in significant changes in sediments deposition; these changes could have significant impacts on the distribution and abundance of many species. At this time, dredging appears to be an option for only one small embayment (Eel Pond, Mattapoisett).

Some communities, like Wareham, have been considering requiring individual onsite or community nitrogen removal septic systems as an alternative to wide scale sewer expansion. The motivation for adopting this strategy is partly the result of the high costs of their wastewater facility upgrade (\$30 million), and the cost of sewer expansion and septic system removal. For example, in the early 2000s, sewer expansion resulted in betterments of \$12,000 to \$15,000 per home. Because of distance from the wastewater facility and the lesser density of some planned sewerage areas, future betterments are expected to range from \$20,000 to \$40,000 per residence, and possibly higher. In 2011, Wareham residents were challenging a sewer expansion that would have required a \$32,000 betterment per home⁴². These costs do not include \$640 annual sewer fees, the cost of tying into the sewer system, or costs of removing abandoned septic tanks which may cumulatively exceed \$4,000 to \$8,000 per home, and are directly paid by the homeowner.

Similarly, betterments for sewer expansion in neighboring Marion in 2008 cost \$30,000 per home. In 2010, a Mattapoisett sewer expansion that would cost \$32,000 per home in betterments passed town meeting⁴³. In all these communities, most of the expansion of sewerage served parcels less than a quarter acre, and in some villages, parcels to a tenth of an acre. Small densely clustered parcels create an economy of scale and service costs in sewerage, and efforts to expand sewerage

⁴⁰ See <http://www.capenews.net/communities/falmouth/news/442>, last downloaded 22 November 2011

⁴¹ Cape Cod Times, February 27, 2011, Wastewater: Cape Faces Costly Cleanup, last download November 22, 2011 at: <http://www.capecodonline.com/apps/pbcs.dll/article?AID=/2011/02/27/NEWS/102270320/-1/SPECIAL25>.

⁴² New Bedford Standard Times June 30, 2011 article available at <http://www.southcoasttoday.com/apps/pbcs.dll/article?AID=/2011/06/30/NEWS/106300345>.

⁴³ On the third attempt, see the May 12, 2010 Mattapoisett Sentinel article available at: <http://www.wickedlocal.com/mattapoisett/news/x968913213>.

into less densely developed areas will result in dramatically higher costs.

In Wareham, the prospect of having to sewer 70% of the remaining existing homes⁴⁴ (to achieve a 50% septic reduction as proposed in their TMDL report), not to mention the costs of sewerage for another 4,000 potential units in the Wareham portion of the Wareham River watershed has worried local officials about the capacity of municipal government to assimilate these costs. Consequently, the alternate strategy of adopting local regulations and standards requiring individual and community-scale wastewater systems⁴⁵ is attractive to some.

Such a strategy would entail requiring new construction and the retrofit of old construction with nitrogen removal septic systems. Local regulations could also require community scale plants for large new subdivisions. Such a strategy faces several obstacles. First, even for new construction the cost of adding a minimum-performing (19 ppm) nitrogen removal septic system will add an average of \$10,000 over the costs of a conventional septic system already averaging close to \$15,000, plus annual operation, maintenance, and monitoring costs. Second, a municipality would require a program to oversee these systems to ensure they are properly operated and maintained. Finally, the state minimum standard of 19 ppm total nitrogen discharge concentration is far greater than what is possible with a large scale nitrogen removal facility (4 ppm 7 months a year). It is possible for the town to require better performing nitrogen removing septic systems, but more advanced residential nitrogen removal systems (10 ppm) might add \$15,000 to 20,000 over the cost of a conventional system for new construction. Such solutions have been proposed in Articles at Wareham Town meeting, but all have been rejected.

A municipal oversight program to oversee advanced alternative onsite systems is achievable, and on Cape Cod, Barnstable County has implemented a program to require operation and maintenance contracts for onsite nitrogen removal systems. This program oversees 3,000 units on Cape Cod through a web based reporting system. At a cost of \$15,000, Barnstable County created a website where vendors and operators of nitrogen removal septic systems can report on the existence of an

⁴⁴ If 3,000 homes were sewerage, tie-in costs, plus betterments and sewer fees spread over 20-years to pay for capital costs, the 20 year cost per homeowner could range from \$40,000 to \$60,000 per unit, and possibly more. The cost of sewerage for 3,000 existing homes to meet a TMDL might cost \$120-180 million. Estimates for towns with no existing sewage infrastructure, like Westport, will be considerably higher.

⁴⁵ Community scale systems are generally defined as having more than 10,000 gpd (roughly 23 homes) discharge and requiring a state groundwater discharge permit. Shared systems are generally described as systems servicing two or more homes, but under 10,000 gpd, and are permitted by municipal boards of health under the Title 5 regulations.

operation and maintenance contract, and to submit data on discharge testing. One staff person oversees this reporting, and prepares correspondence based on reports from the software when systems are not in compliance with county regulations.

Regulators do not favor the widespread use of denitrifying onsite wastewater systems because they do not achieve the same high level of nitrogen removal as centralized advanced treatment municipal wastewater systems, and because it is difficult for government to track and ensure that they are properly maintained and performing well. If these issues were ever overcome, and these alternative systems were more cost effective than the cost of sewerage, they offer the prospect of the private sector and property owners financing the costs of constructing and maintaining this decentralized wastewater treatment process.

Financial obstacles are not the only impediments, and establishing waste load allocations for meeting TMDLs is another problem that must be worked out. Some Buzzards Bay embayments will require management of sources from outside their watershed. This is because in a few instances a neighboring more eutrophic embayment system is dominating water quality in what would be a system with good water quality. This situation exists for Marks Cove in Wareham (nestled between the Wareham and Weweantic Rivers), and Little River in Dartmouth, with its small watershed at the confluence of the mouth of the larger eutrophic Slocums River.

Monitoring Progress

The issuance of and the compliance with TMDLs will be the principal management measures tracked to evaluate the success of this management plan. This will be accomplished by tracking embayments the state's Integrated List of impaired waters.

At the local level, the adoption and implementation of specific milestones in CWMPs, together with adoption of companion regulations such as zoning and health regulations will be the principal tracking measures.

Restoring water quality and recovery of habitat is the goal of this action plan and these will also be the long-term environmental tracking measures. Water quality and total nitrogen concentrations will be tracked by the ongoing Buzzards Bay Coalition Citizen Water Quality Monitoring program. In some instances, the Coalition will need to add an estuary monitoring station to match the TMDL sentinel station defined by the MEP.

Eelgrass will be the principal habitat tracked for evaluating the success of nitrogen control measures. DEP must continue to monitor eelgrass cover at a frequency of no less than 5 years.

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