

**The Massachusetts Estuaries Project**  
**Embayment Restoration and Guidance for**  
**Implementation Strategies**

**2003**

Massachusetts Department  
of  
**Environmental Protection**

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# Massachusetts Estuaries Project

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Copies can also be obtained from:  
The Department of Environmental Protection  
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# INTRODUCTION

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## Massachusetts Estuaries Project

The **estuaries** and **embayments** of southeastern Massachusetts stretch from the Town of Duxbury south and include Cape Cod, Buzzards Bay, the Islands, and Mt. Hope Bay. They are **ecosystems** that provide not only recreational opportunities but also **habitat** for shellfish and sea grasses and breeding grounds for important marine fisheries.<sup>1</sup> Protection of these coastal water resources has increasingly become a priority for Massachusetts oceanfront communities.

Many estuaries are at risk of, or are already experiencing, degraded **water quality** and habitat due to increases in nitrogen discharges within their watersheds. With local communities dependent on a high quality of water for fishing, shellfishing, and tourism, degradation of these resources has serious economic results: reductions in property values, local commerce, and tax revenues. Given the synergy among these interests, embayment protection and restoration is of paramount importance to the Commonwealth and its coastal communities.

The Massachusetts Estuaries Project (**MEP**) began in order to address the problems caused by excess **nitrogen loading** in 89 estuaries in southeastern Massachusetts (see Appendix C for a complete listing of MEP estuaries). The MEP is a collaborative effort among coastal communities, the Department of Environmental Protection (**DEP**), the School of Marine Science and Technology (**SMAST**) at the University of Massachusetts in Dartmouth,

the US Environmental Protection Agency (**EPA**), the Executive Office of Environmental Affairs (**EOEA**), and the Cape Cod Commission.

The MEP will provide technical data on sources of nitrogen and the maximum amount of nitrogen (**nitrogen threshold**) that each estuary can tolerate without adversely changing its character and use. In other words, the MEP will set the target to be achieved in order to protect and restore the health of estuaries.

There are a variety of pathways that can be taken to reach the final target of a healthy estuary. The challenge for coastal communities will be to determine which pathways are appropriate in their particular watersheds. Specific tasks will include assessing **nutrient** sources, developing an integrated approach to nutrient planning and management, and implementing a plan to avoid continued degradation of estuarine systems.

MEP communities will participate in these tasks in several important ways. They will be asked to contribute approximately 40% of the overall cost of assessment of estuaries. They will need to establish local groups of officials and citizens to interface with SMAST and DEP staff throughout the project, and they may need to assist with filling gaps in data on estuaries. Eventually, communities will take the lead in finalizing and carrying out their implementation plan for nitrogen reduction. Fortunately, many MEP communities are already aware of the impact of nitrogen loading and are taking steps

<sup>1</sup> Estuaries are areas formed when the sea extends inland and meets the mouth of a river or stream. Embayments are the bodies of water beyond the mouth of rivers or streams, partially enclosed by land but with wide openings to larger bays or the ocean. These two terms are used interchangeably in this document.



to address it. Citizen monitoring groups, regional planning and environmental organizations, and local agencies, e.g., Boards of Health (BoH) and Departments of Public Works (DPW), will bring to the table important planning, funding, and regulatory capabilities.

To assist in addressing this challenge, DEP will provide communities with information, tools, and regulatory input. This Guidance is the first of the tools designed to assist communities in the implementation phase of the MEP. It is an introduction for local officials and community members to the issue of excess nitrogen loading and the technical and management approaches available to restore the health of estuaries and embayments. The Guidance presents a menu of traditional and innovative strategies available to communities as they manage nitrogen and coastal water quality issues. Readers should keep in mind that not all the options described here will be necessary, or even appropriate, for every situation.

The Executive Summary on the following pages is a very condensed summary of topics covered in the Guidance. The remaining chapters of the full Guidance are organized as follows:

🌀 **Background:** Nutrient loading, sources of nitrogen loading, establishing nitrogen thresholds, and the state and federal regulatory framework for nitrogen management.

🌀 **Approaches:** Technology and management approaches to address sources of nitrogen loading. Additional resources and relevant state and federal regulations are listed at the end of each topic. Regulatory citations are intended to alert readers to regulations that should be consulted before a particular approach is adopted, rather than as notice that particular permits are required. The additional resources and all state and federal regulations listed throughout the Guidance are compiled

in Appendix B. Most of these publications are available through the Internet. Official copies of DEP regulations are available at the Massachusetts State Bookstore.

🌀 **Appendices:** In order to keep the body of the Guidance to a manageable size, a great deal of information has been put into Appendices. Appendix A is a glossary of terms and acronyms; those included are printed in bold type the first time they appear in the text.

Massachusetts Estuaries Project (MEP) Resources and Regulations	
State	
DEP	Home page for the MEP, including maps and background articles: <a href="http://www.state.ma.us/dep/smerp/smerp.htm">http://www.state.ma.us/dep/smerp/smerp.htm</a>
Bookstore	State Bookstore Room 116, State House Boston, MA 02133 617/727-2834; <a href="http://www.state.ma.us/sec/spr/spridx.htm">http://www.state.ma.us/sec/spr/spridx.htm</a>

## Background

Although nutrients are essential to all organisms, excess nutrients can cause **eutrophication**, which is the uncontrolled growth of aquatic vegetation and algae. Eutrophication can cause the loss of **biodiversity**. Loss of eelgrass is often the first sign that the ecological health of an area is declining. Changes happen incrementally and by the time the losses are apparent, the damage can be quite costly and difficult to **mitigate**.

The focus of this Guidance is on excess nitrogen in marine waters. Nitrogen can enter an estuary from **point and nonpoint** sources. These sources present different challenges to nitrogen reduction efforts. Pollution from point sources has been greatly reduced through federal and state permitting programs. Nonpoint sources are now the primary source of pollution in the nation's watersheds.

State and federal regulations mandate that the Commonwealth and its communities address water quality impairments created by nitrogen loading. The MEP will develop nitrogen thresholds for MEP embayments and provide the information necessary to ensure that nitrogen reduction efforts are consistent with federal and state requirements. The major regulatory programs associated with the MEP are the Massachusetts Water Quality Standards for **surface water** and **ground waters** and the federal **Clean Water Act (CWA)**.

The **Total Maximum Daily Load (TMDL)** is the primary regulatory and technical tool for addressing nitrogen loading. A TMDL is the upper limit of ambient nitrogen concentration that will support a healthy habitat, expressed as a concentration of nitrogen in the water column, in parts per million (ppm) or milligrams per liter

(mg/L). SMAST will use a linked-model approach to calculate the nitrogen threshold for the 89 estuaries in the MEP. The technical report for each estuary will also model the impact on nitrogen concentrations resulting from increased land development, elimination of all human-caused sources of nitrogen, and improvements in tidal flushing. The technical reports will help identify the most promising nitrogen reduction approaches for each estuary.

Technical reports will be incorporated into draft TMDL reports, which are subject to public comment and review by communities, EPA, and DEP. Eventually, communities will use the TMDL report for each estuary in order to develop and implement an appropriate nitrogen reduction strategy for its protection and restoration.

## Approaches to Nitrogen Reduction

This chapter discusses the menu of options for mitigation of excess nitrogen. Not all options will be appropriate for every situation. However, with input from citizens, regulatory bodies, and consultants, communities will be able to identify a mix of options that meets local conditions.

Grants and the **State Revolving Fund (SRF)** loans are available through DEP for **integrated water resources management planning**, which includes implementation of specific nitrogen reduction strategies.

### Tidal Flushing

Improvements in tidal flushing can reduce nitrogen mass in an embayment by up to 20%. Three primary ways to improve tidal flushing are channel dredging, inlet alteration, and culvert design improvements.

### Stormwater Control and Treatment

Most nitrogen loading to Massachusetts embayments is from wastewater. However, stormwater mitigation can be significant in places where stormwater affects local resources such as shellfish beds or public beaches. Most nitrogen in stormwater comes from illicit interconnections between stormwater and sanitary drains, **combined sewer overflows (CSOs)**, failing septic systems, and fertilizer runoff. Source control and pollution prevention, CSO **remediation**, and treatment are all options that need to be considered in addressing nitrogen pollution from stormwater.

CSOs are regulated as point sources and require a **National Pollutant Discharge Elimination System (NPDES)** permit under the federal Clean Water Act and state Surface Water Discharge Permit Program. CSOs in the MEP communities of Fall River, New Bedford, and Taunton are regulated under these programs. Both DEP and EPA regulate stormwater discharges in Massachusetts. DEP's requirements are specified in its Stormwater Management Policy, which requires certain new developments and redevelopments to implement stormwater source controls, provide treatment and **recharge**, and reduce flooding impacts. EPA requirements are specified in the NPDES regulations, which apply to both wastewater and stormwater point source discharges.

### Attenuation via Wetlands and Ponds

Wetlands and ponds improve the quality of water that passes through them by means of natural physical, biological and chemical processes. Although **natural attenuation** can reduce the impact of nitrogen on an estuary, it cannot be used as a wastewater treatment method. It is appropriate only where discharges have already been treated to very high water quality standards and where it will not cause a negative impact on the habitat of the wetlands or pond.

Constructed wetlands may be designed to treat wastewater and to use treated wastewater to restore wetland habitat. The Massachusetts Wetlands Restoration Program (MWRP) is a program within the Massachusetts EOE that supports voluntary efforts to restore the Commonwealth's wetlands and aquatic ecosystems.

### Wastewater

Wastewater can make up to 80% of the annual nitrogen load in some watersheds, and is the most expensive source of nitrogen loading to treat. Wastewater treatment ranges from **on-site treatment and disposal systems** for individual properties to large municipal treatment plants and sewers.

On-site systems serve homes and other small facilities with a **sewage** flow of less than 10,000 **gpd**. Conventional on-site systems do not remove significant amounts of nitrogen. Many **innovative/alternative (I/A)** on-site systems have been designed to remove nitrogen using **biological denitrification**, but require more sophisticated management and maintenance than conventional systems. **Cluster systems** are on-site systems configured to serve more than one residence or facility. They can use either conventional or innovative/alternative technologies, and improve system performance due to more uniform flow.

**Community treatment plants** usually treat 10,000 to 150,000 **gpd**. They are appropriate for areas where a high degree of nitrogen removal is required. DEP is updating its *Guidelines for the Design, Construction, Operation and Maintenance of Small Sewage Treatment Facilities with Land Disposal*, in order to reflect improvements in technology and new DEP policies.

Municipal treatment plants can discharge up to several million gallons of treated **effluent** either to ground or surface water. Large plants with advanced nitrogen treatment are able to meet the most stringent treatment standards, down to as low as 2-3 mg/L nitrogen. Large treatment plants raise complex issues of planning, design, cost, and siting, and require active community participation in their planning and construction.

### Water Conservation and Water Reuse

Water conservation can improve the health of estuaries by ensuring increased ground and surface water flow. The use of reclaimed water for situations that do not require **potable** water quality can reduce the need to develop new water supplies and can provide cost-effective disposal in certain situations. DEP requires a ground water discharge permit for reuse, and has established rigorous reuse standards in order to protect public health.

### Management Districts

Management districts are legal, geographic entities that carry out environmental work such as funding and building infrastructure improvements, managing infrastructure or programs, or providing other environmental protection services. Districts provide benefits from their focus, flexibility, and targeted funding mechanisms. Management districts have only recently been used in Massachusetts to manage non-traditional environmental services, such as management of on-site treatment systems, decentralized sewers, and stormwater control and treatment plans. Massachusetts law provides three mechanisms to establish districts: general state law, special acts of the Legislature, and municipal home rule authority (bylaws and regulations).

### Land Use Planning and Controls

Land development has negative impacts on nutrient loading by increasing human population growth and reducing the ability of the land to naturally remediate nitrogen loading. Through smart growth policies, open space acquisition, and zoning tools, land use planning seeks to influence the amount, rate, location, and character of growth in order to maintain a community's long-term sustainability.

### Nutrient Trading

**Nutrient trading** is a regulatory tool that allows pollutant sources to reallocate responsibilities for pollution reduction among themselves and to fund the most cost-effective reduction methods in order to meet regulatory requirements. EPA encourages watershed-based **effluent trading**, and has published documents to help states and communities use them appropriately. Existing Massachusetts regulations do not expressly authorize **nitrogen trading**, although DEP encourages communities to explore this avenue in developing their implementation plans for nitrogen reduction.



### Nutrient Loading, Eutrophication, and Habitat Loss

Nutrients are essential for the survival of all living organisms. However, excess nutrients in fresh and marine waters can cause uncontrolled growth of aquatic vegetation and algae, a process known as eutrophication. When this happens, water clarity decreases and oxygen levels essential for marine life can drop dramatically, causing fish and other aquatic animals to abandon the habitat or even die.

In marine ecosystems, the nutrient of most concern is nitrogen. In fresh water, the nutrient of most concern is phosphorous, meaning that fresh water can absorb moderate amounts of nitrogen without inducing **algae blooms**, just as marine waters can absorb moderate amounts of phosphorus without altering water or habitat quality. Although phosphorus is a concern in some inland waters of MEP communities and in many other inland areas of Massachusetts, the focus of the MEP and this Guidance is nitrogen.

Eutrophication is a process that occurs naturally and gradually over a period of tens or hundreds of years. However, human-caused or **anthropogenic** sources of nitrogen may be introduced into ecosystems at an accelerated rate that cannot be easily assimilated; the result is a phenomenon known as **cultural eutrophication**. In both marine and freshwater systems, cultural eutrophication results in degraded water quality, adverse impacts to ecosystems, and limits on the use of water resources.



Discussion of the impact of eutrophication on embayments often focuses on measures of water quality, for example, high nitrogen levels and low dissolved oxygen. However, a primary concern is the negative impact on habitat that results from water quality degradation. Habitat quality relates to the amount and variety of species that can inhabit an ecosystem. The greater the biodiversity, the more robust the system and the better able it is to withstand acute upsets in local surroundings.

Ecosystems stressed by high nitrogen loadings often have only a limited variety of plants and animals, and will frequently experience an increase in **invasive species** compared to native species. As a result of excess nitrogen, what would be considered a minor upset in a healthy ecosystem may have a major impact, ranging from nuisance algae blooms to serious fish kills.

Before an ecosystem becomes totally degraded, much of its ecological and economic value has been lost. In many coastal systems, the beginning of this change is the loss of eelgrass. Eelgrass provides habitat for shellfish and finfish spawning, and promotes stability of bottom sediments. As eelgrass is lost due to nitrogen over-enrichment, shellfish and finfish habitat is lost, and sediments are circulated more easily through the **water column**. Resulting increases in **turbidity** limit the distribution and variety of aquatic plants, which in turn allows invasive nuisance species to crowd out native plant species and proliferate. The decomposition of the increased **biomass** depletes the oxygen in the water column and reduces water clarity, which in turn may result in fish kills.

There is not necessarily a specific event that suddenly causes an unhealthy habitat. More likely there is a gradual downward spiral that develops over a period of years. The danger is that incremental changes resulting from degraded water quality may not be immediately noticeable. By the time changes are apparent, they may be very difficult, expensive, and time-consuming to reverse. With an informed understanding of the sensitivity of estuarine waters and the impact of excess nitrogen, as well as knowledge of appropriate methods to mitigate them, effective steps can be taken to protect embayments and estuarine systems. Preventing further degradation of relatively healthy embayments is almost certainly less expensive and disruptive than attempting to restore those already impaired by nitrogen loading.

### Sources of Nitrogen Loading: Point and Nonpoint Sources

Nitrogen enters estuaries from a wide variety of sources, each of them presenting different challenges to a program of nutrient management. Sources are typically categorized as point or nonpoint sources. Although the distinction between point and nonpoint can differ depending on state or federal regulations and the path of a discharge, we have categorized them as follows for purposes of the MEP.

Point sources discharge from a specific geographical point, often as a discharge from a pipe or conveyance. Since passage of the federal Clean Water Act in 1972, pollution from point sources has been greatly reduced through

a combination of federal and state permitting programs. Point sources include the following:

- ⑤ Outflows from a wastewater treatment plant to a river, bay, or ground water.
- ⑤ Indirect discharges from industrial or commercial connections to a sewer.
- ⑤ Discharges from stormwater collection and treatment systems or combined sewers that are piped to a river or embayment.

Nonpoint sources discharge nitrogen across a less defined geographic area and often cannot be traced to a single physical location. They are now the primary source of pollution in the nation's watersheds, and only recently have regulatory programs been developed to address them. Nonpoint sources include the following:

- ⑤ On-site wastewater treatment systems (Title 5 systems).
- ⑤ Stormwater: runoff that washes into estuaries from rain or snow.
- ⑤ Lawns: nitrogen leaching into groundwater or runoff from excessive use of fertilizers on lawns.
- ⑤ Agricultural runoff from improperly managed animal wastes or fertilizers.
- ⑤ Runoff from road and building construction.
- ⑤ Natural **deposition**, either as precipitation (wet) or ash (dry).



## Establishing Nitrogen Thresholds and Reducing Nitrogen Loads

State and federal regulations mandate that the Commonwealth and its communities address water quality impairments created by nitrogen loading. Operating under this broad regulatory umbrella, the MEP will develop nitrogen thresholds for southeastern Massachusetts coastal embayments and provide the information necessary to ensure that nitrogen reduction efforts are consistent with both federal and state requirements. The major regulatory programs associated with the MEP are the Massachusetts Water Quality Standards for surface water and ground waters and the federal Clean Water Act.

### Massachusetts Surface Water Quality Standards

The Massachusetts Surface Water Quality Standards establish quantitative and qualitative standards for the protection of surface waters in inland and coastal areas. The MEP is charged with developing critical nitrogen thresholds that will meet these water quality standards.

The anti-degradation provisions in the standards require that water quality goals be based on the designated uses for water bodies, and that the water quality necessary to sustain these uses be maintained for all surface waters in the Commonwealth. The standards further require that certain high-quality and significant resource waters be protected beyond the minimum national criteria, especially where their character and value cannot be adequately described or protected by traditional water quality criteria. Federal and state statutes also require the protection of all navigable waters, which includes coastal embayments and estuaries.

The standards also address eutrophication. Regulations prohibit new point source discharges of nutrients to lakes and ponds, and require the use of highest and best practical treatment to control nutrients in existing point source discharges. Nutrient control of nonpoint sources is required through **best management practices (BMPs)**. In addition, the standards require that nutrients not exceed a nitrogen threshold developed for a specific estuary.

The standards define three classes - SA, SB, and SC - of coastal and marine waters, based upon the water quality goal for each class ("S" stands for Saltwater or Saline). Standards are both quantitative and qualitative, and at a minimum require that these waters be protected as habitat for fish and other aquatic life, for wildlife, and for swimming and boating. They must also possess "good aesthetic value." Both the quantitative nutrient standards and the qualitative standards for aesthetics, nutrients, water chemistry, bottom pollution, and alteration must be considered in addressing nitrogen loadings. Appendix D provides detailed standards for the parameters that define SA, SB, and SC waters.

Quantitative water quality standards are typically measured in concentration levels of specific **pollutants**, and are supported by scientific research and consensus. For example, public health concerns are the rationale for quantitative water quality measures of bacteria and **nitrates** in drinking water supplies. In the Surface Water Quality Standards, both quantitative and qualitative standards are used



as indicators of ecological health and habitat quality. Quantitative standards include dissolved oxygen, pH, and temperature.

Qualitative standards such as aesthetics, taste, odor, color, turbidity, and floating or suspended solids are also important in measuring ecological health and habitat quality. They can be used to determine if the water body meets its designated uses such as swimming, fishing, and healthy aquatic habitat. Many qualitative measures are more subjective and in some cases have not have been fully developed. One goal of the MEP is to establish appropriate criteria or thresholds for standardized indicators of ecological health in coastal waters.

### Massachusetts Ground Water Quality Standards

Ground water is defined as all water that exists beneath the land surface in soils or geologic formations, specifically that part of the subsurface water in the saturated zone.

Ground water is vitally important to the health of MEP communities for several reasons. First, it is the main, and in some cases the only source of potable water for many communities in southeastern Massachusetts. Second, the ground and ground water is the mechanism used to dispose of pollutants from wastewater treatment works, including on-site wastewater treatment systems. Wastewater disposal facilities need to be located so as not to degrade either the ground water itself or **down gradient** surface waters. Nutrients transported in the ground water from wastewater treatment works could both adversely affect the ground water as a source of drinking water and degrade the quality of surface waters.

The goal of the Massachusetts Ground Water Quality Standards is to control the discharge of pollutants to ground waters to ensure that they are protected to their highest



potential use. The Massachusetts Ground Water Quality Standards follow the same concepts as the Surface Water Quality Standards. They classify the uses for the ground waters of the Commonwealth and specify the water quality criteria necessary to sustain these uses.

All ground waters are assigned to one of three classes (I, II, and III) based upon the most sensitive use for which the ground water is to be maintained. With few exceptions, Massachusetts ground waters are designated as Class I, meaning that they are a source for drinking water or could be used as one in the future. Appendix E outlines the standards for the three ground water classes.

Any subsurface discharge of treated wastewater exceeding 10,000 gpd requires a discharge permit establishing the conditions necessary to comply with ground water standards. Each Ground Water Discharge Permit contains a set of effluent discharge limits that comply with the Standards and are meant to protect all classified waters of the Commonwealth, including surface waters. Ground water permits require a series of ground water monitoring wells and a sampling schedule to determine if the standards are met. A typical permit will contain an effluent total nitrogen limit of 10 mg/L in order to protect the ground water as a potential potable water supply. As our knowledge of the sensitivity of receiving waters increases, it is likely that a more stringent ground water effluent standard will be required on a case-by-case basis to protect the quality of ground waters and surface waters, including estuaries and embayments.

## Federal Clean Water Act and Total Maximum Daily Load (TMDLs)

The Federal Clean Water Act of 1972 provides a framework for the Commonwealth's plan to restore its estuaries to the level required by state water quality standards. Section 303(d) of the Clean Water Act requires that states develop lists of impaired waters, i.e., water bodies (both freshwater and marine) that do not meet the uses designated in each state's water quality standards. Impairment may be caused by many different pollutants, including but not limited to nitrogen, phosphorus, bacteria, or metals. The MEP will address bacterial contamination for selected estuaries where shellfish and recreational resources have been compromised. However, the major thrust of the MEP and the major focus of this Guidance is nitrogen reduction.

A state's list of impaired waters is known as its 303(d) list. The Clean Water Act requires states and communities to take action to restore their impaired waters, a process which begins with assessing the condition of impaired waters, determining the causes of impairment, and specifying the maximum amount of pollution that the waterbody can receive and still meet state standards.

The regulatory and technical tool for this work is the Total Maximum Daily Load (TMDL). A TMDL for an estuary or embayment is its nitrogen threshold (also known as a nitrogen limit), which is the upper limit of ambient nitrogen concentration that will support a healthy habitat. The threshold is expressed as a concentration of

nitrogen in parts per million (**ppm**) or milligrams per liter (**mg/L**) in the water column. SMAST uses a linked-model approach to calculate these numbers, incorporating hydrodynamics, water quality modeling, and land use modeling. See Appendix F for a detailed discussion of the linked-model approach and how nitrogen thresholds are calculated.

The technical evaluation of each estuary done by the MEP team from SMAST will include four linked-modeling scenarios:

- ⑤ The nitrogen threshold that will support a healthy ecosystem and appropriate uses of water resources;
- ⑤ The predicted nitrogen concentrations in the estuary assuming a build-out scenario based on current local zoning regulations;
- ⑤ Potential water quality improvements resulting from the removal of anthropogenic sources of nitrogen from contributing watersheds; and
- ⑤ Potential water quality improvements resulting from physical improvements to increase flushing, such as dredging, inlet alterations, and culvert improvements.

The nitrogen threshold set in the TMDL for each estuary will be incorporated into a draft TMDL Report by DEP. Each draft TMDL Report will include some possible nitrogen reduction strategies for communities to consider in the implementation phase. The draft TMDL Reports will be subject to public comment and input before being finalized and accepted by communities, EPA, and DEP. Because the



MEP is evaluating watersheds, the TMDL Reports will involve both watersheds contained entirely within a single community and those encompassing more than one community. TMDLs will be released for individual estuaries over the next several years as embayment nutrient loads are established. The first ones are scheduled for release in 2003.

The detailed planning and implementation phase undertaken by communities will be based on the nitrogen threshold and potential nitrogen reductions provided in the TMDL Report for each estuary. As noted earlier, the primary goal of this Guidance is to introduce communities to the variety of strategies to consider in crafting an implementation plan. During the implementation phase, communities will be able to request additional modeling work in order to determine the nitrogen reductions from scenarios not covered in the original technical evaluations. Following the integrated water resources management planning process described in the chapter “Approaches to Nitrogen Reduction” of this Guidance, communities will plan and implement specific capital improvements and nitrogen management strategies.

### Other State and Federal Regulatory Programs

In addition to the federal Clean Water Act and the state Water Quality Standards for surface water and ground water quality, a number of other regulatory programs will impact nitrogen reduction efforts. In the chapter “Approaches to Nitrogen Reduction,” the relevant state and federal regulations are referenced in

the description of each nitrogen reduction option. Appendix B compiles in one place all the resources and regulatory programs listed throughout the document.

### Regulating Nitrogen Loads, Resources and Regulations

<b>Federal</b> <b>EPA</b>	Total Maximum Daily Load Program: <a href="http://www.epa.gov/OWOW/tmdl/">http://www.epa.gov/OWOW/tmdl/</a>  National Pollutant Discharge Elimination System (NPDES) Regulations, Clean Water Act, § 402: <a href="http://cfpub1.epa.gov/npdes/cwa.cfm?program_id=6">http://cfpub1.epa.gov/npdes/cwa.cfm?program_id=6</a> <a href="http://www.epa.gov/region01/npdes">http://www.epa.gov/region01/npdes</a> <a href="http://cfpub.epa.gov/npdes/">http://cfpub.epa.gov/npdes/</a>
<b>State</b> <b>DEP</b>	Surface Water Quality Standards, 314 CMR 4.00: <a href="http://www.state.ma.us/dep/bwp/iww/files/314004.pdf">http://www.state.ma.us/dep/bwp/iww/files/314004.pdf</a>  Surface Water Discharge Permit Program, 314 CMR 3.00: <a href="http://www.state.ma.us/dep/bwp/iww/files/314cmr3.htm">http://www.state.ma.us/dep/bwp/iww/files/314cmr3.htm</a>  Ground Water Quality Standards 314 CMR 6.00: <a href="http://www.state.ma.us/dep/bwp/iww/files/314006.pdf">http://www.state.ma.us/dep/bwp/iww/files/314006.pdf</a>  Ground Water Discharge Permit Program, 314 CMR 5.00: <a href="http://www.state.ma.us/dep/bwp/iww/files/314005.pdf">http://www.state.ma.us/dep/bwp/iww/files/314005.pdf</a>

## APPROACHES TO NITROGEN REDUCTION

## Massachusetts Estuaries Project

Effective strategies for nitrogen reduction will require a mix of tools ranging from infrastructure changes, which typically involve traditional engineering design and construction, to more recently developed management programs and institutional changes. The following pages are a primer of basic information on the broad menu of options for managing nitrogen loads. Options are presented in the following categories:

- ☉ Tidal flushing
- ☉ Stormwater control and treatment
- ☉ Attenuation via wetlands and ponds
- ☉ Wastewater treatment
- ☉ Water conservation and reuse
- ☉ Management districts
- ☉ Land use planning and controls
- ☉ Nutrient trading

Historically, wastewater treatment has been the primary approach used for nitrogen reduction, and it will continue to be important. At the same time, DEP encourages communities to think beyond the traditional engineering approaches to consider all options and combinations.

Not all of the options presented here will be applicable to the challenges in a particular estuary. The technical evaluations coming out of SMAST will help identify the most promising approaches.

In addition, many MEP communities have developed programs to assist in nitrogen management. Government agencies including Boards of Health and Departments of Public Works, regional commissions, and citizen groups are knowledgeable about planning and funding strategies to implement coastal water quality improvements. By evaluating various options with input from citizens, regulatory bodies, and consultants, communities can craft an implementation strategy to manage nitrogen loads in their watersheds and estuaries.

### Integrated Water Resources Management Planning and Funding Sources

A successful nitrogen management strategy will be based on the concepts of integrated water resources management planning. Integrated water resources management planning includes consideration of the full range of water resources needed to support ecological health as well as meet human needs. It requires extensive outreach and education in order to develop an integrated strategy that has community input and support for the final mix of solutions. Typically, the result of this planning process is definition of the scope and nature of wastewater problems and development of appropriate wastewater solutions. At the same time, DEP recognizes that long-term viable solutions to wastewater problems must consider many factors, including water supplies and demands of the community; streamflow and water quality considerations; ground water as a resource for existing and potential drinking water and a source of base flow to rivers and streams; stormwater management; and the long term land use and economic development goals of a community and the watershed within which it is located.

In the past, communities carried out integrated water resources management planning through a Comprehensive Water Resources Management Plan (CWMP). However, DEP is promoting a more holistic approach and is revising the current guidelines to reflect a watershed-based planning process. The current guidelines are available on the DEP Web site, but communities that will be initiating water resources management planning should consult with the DEP to develop a scope that reflects the more holistic approach.

DEP grant and loan programs provide opportunities to assist communities in integrated water resources management planning, including implementation of specific nitrogen reduction strategies. Programs include the Massachusetts **Clean Water State Revolving Fund Program (CWSRF)** and federal grant programs.

**Massachusetts Clean Water State Revolving Fund Program (CWSRF).** The CWSRF was established to provide a low-cost funding mechanism to assist communities in complying with federal and state water quality requirements. Each year DEP solicits projects from municipalities and wastewater districts to be considered for subsidized loans. The current subsidy is provided via a 2% interest loan. In recent years the program has financed 50-70 projects annually.

CWSRF money is available for planning and construction of facilities for wastewater treatment facilities (new and upgrades), on-site treatment upgrades, stormwater control and treatment, nonpoint source mitigation projects, and CSO remediation. Funds may also be used for planning projects, e.g., identification of nonpoint source pollution. DEP issues an annual solicitation beginning June 1 through August 15, and develops a list of projects eligible for funding from submittals from communities.

**Grant Programs.** DEP awards grants in a number of areas that support the nitrogen reduction efforts of the MEP. The three major grant programs consist of federal funds from EPA.



604(b) Water Quality Management Planning. The RFP is issued each October to cities and towns, regional planning organizations, conservation districts, and interstate agencies. Nonpoint source assessment projects are priorities for this source of funds, including:

- ☉ Stormwater Best Management Practices
- ☉ Local Water Quality Protection
- ☉ Land Use Activities
- ☉ Environmental Awareness, Activities, and Concerns
- ☉ Water Quality Assessment
- ☉ Water Supply/Quality Source Protection Planning
- ☉ Water Supply Development Planning
- ☉ Wetlands Assessment and Restoration Planning

104(b)(3) Wetlands and Water Quality. The RFP is issued in January each year to state agencies in EOEAs. Other organizations can participate with EOEAs in projects. 104(b)(3) goals that are compatible with goals of MEP include the following:

- ☉ Control of point and nonpoint discharges to surface and ground water
- ☉ Resources to ensure no net loss of wetlands
- ☉ Minimizing degradation of wetlands by stormwater runoff
- ☉ Minimizing unpermitted filling or alteration of wetlands
- ☉ Discouraging projects in or next to wetlands

*319 Nonpoint Sources.* Proposals are solicited each February from all Massachusetts public or private organizations. Grants fund implementation projects that address the prevention, control, and abatement of nonpoint source pollution.

DEP's web site provides additional detail on DEP's grant and loan programs. Since priorities, schedules, and requirements may change over time, we encourage readers to investigate DEP's web site for the latest available information. DEP staff are also available to consult with communities on applicability of the programs to local needs.

#### Approaches to Nitrogen Reduction, Resources and Regulations

State	
DEP	<p>Comprehensive Wastewater Management Planning Current guidance (1996):  <a href="http://www.state.ma.us/dep/brp/mf/files/fpintro.htm">http://www.state.ma.us/dep/brp/mf/files/fpintro.htm</a></p> <p>New Guidance for Integrated Water Resources Management Planning is under development. Contact the Department for more information.</p> <p>Grant and Loan Programs: Opportunities for Watershed Protection, Planning and Implementation, updated November 2002:  <a href="http://www.state.ma.us/dep/brp/mf/files/glprgm.pdf">http://www.state.ma.us/dep/brp/mf/files/glprgm.pdf</a></p> <p>Clean Water State Revolving Loan Fund (CWSRF):  <a href="http://www.state.ma.us/dep/brp/mf/cwsrf.htm">http://www.state.ma.us/dep/brp/mf/cwsrf.htm</a></p>

### Tidal Flushing

**Tidal flushing** is the flow of water in and out of an estuary due to rising and falling tides. Determining **flushing rates**, or **residence times**, is an important component of the linked-model approach used in the MEP.

The residence time is the average time required for a particle of water to migrate out of the estuary from a given point in it. **System residence time** refers to the average time for water to migrate through the entire system. **Local residence time** is the average time for water to migrate from a point in a **sub-embayment** to a point outside the sub-embayment.

Residence times provide a rough qualitative estimate of water quality. Lower residence times indicate more efficient flushing and therefore may indicate higher water quality. Conversely, higher residence times indicate less efficient flushing and potentially lower water quality. However, this rule of thumb must be tempered with an understanding of the dynamics of the estuary. For example, efficient flushing will not promote high water quality if a nutrient is loaded into an estuary faster than it can be flushed out.

The dynamics of tidal exchange and flushing are complex and require a model to simulate tidal flows and dynamics. The linked model used in the MEP is able to evaluate the hydrodynamic properties of an estuary or embayment system in order to determine if enhanced flushing can result in higher water quality. If so, relatively low cost measures may yield significant improvements in water quality. For example, improvements in flushing could reduce the nitrogen mass in an embayment by 20%. Communities will need to carry out an

evaluation of these alternatives as part of the implementation phase to determine the most cost-effective approach. The evaluation will also assess the short- and long-term environmental impacts to the wetland systems and tidal flows.

There are three primary ways of improving tidal flushing: channel dredging, inlet alteration, and culvert design or improvements. The same federal and state regulations apply to these three approaches, and are listed in the table below rather than in individual sections.

Tidal Flushing, Resources and Regulations	
<b>Federal</b>	
ACOE	Army Corps of Engineers (ACOE) Permit Authorization under Section 10, Rivers and Harbors Act: <a href="http://www.spk.usace.army.mil/cespk-co/regulatory/regs/start.html">http://www.spk.usace.army.mil/cespk-co/regulatory/regs/start.html</a>
<b>State</b>	
DEP	Waterways License, 310 CMR 9.00, Chapter 91: <a href="http://www.state.ma.us/dep/brp/waterway/ch91regs.htm">http://www.state.ma.us/dep/brp/waterway/ch91regs.htm</a>  Current Dredging Regulations: 401 Water Quality Certification, 314 CMR 9.00 (Contact DEP for updated interim procedures on dredging and management of dredged sediments): <a href="http://www.state.ma.us/dep/bwp/iww/files/314009.pdf">http://www.state.ma.us/dep/bwp/iww/files/314009.pdf</a>
MEPA	Notice of Intent, Wetlands Protection Act, 310 CMR 10.00, Section 10.05, #4: <a href="http://www.state.ma.us/dep/brp/ww/files/310cmr10.pdf">http://www.state.ma.us/dep/brp/ww/files/310cmr10.pdf</a>  Massachusetts Environmental Policy Act: MEPA Certificate, 301 CMR 11.00: <a href="http://www.state.ma.us/envir/mepa/thirdlevelpages/meparegulations/301cmr11.pdf">http://www.state.ma.us/envir/mepa/thirdlevelpages/meparegulations/301cmr11.pdf</a>
CZM	Coastal Zone Management (CZM) Federal Consistency Review, 301 CMR 21.00: Coastal Zone Management Program: Federal Consistency Review Procedures <a href="http://www.state.ma.us/czm/fcr.htm">http://www.state.ma.us/czm/fcr.htm</a>

### Channel Dredging

As navigable channels slowly fill in through natural or induced sedimentation, tidal flushing may be restricted. Where feasible, dredging can improve flushing rates. This option may be limited to areas below the low tide line, since dredging between the **mean low** and **mean high water** shorelines may impact shellfish growing areas. Dredging can also disrupt eelgrass habitat. In addition, sediments need to be sampled to determine if dredging will disturb any contaminated material. Dredging generally must be repeated periodically in order to be effective. A community's evaluation of this approach must examine a range of years in order to compare the environmental and economic costs of repeated dredging and disposal of sediment.

### Inlet Alteration

Embayment systems are not static. Natural coastal processes will alter shoreline profiles over decades or in some instances even from year to year. These changes can alter inlets to embayments and affect flushing. If the present configuration of an inlet restricts flushing, alteration of the inlet may significantly improve water quality in the same way as described in the channel dredging section. Other potential impacts that need to be analyzed for this option are **salinity**, temperature, turbidity, and erosion patterns. **Sediments** need to be sampled to determine if any contaminated material will be disturbed.

### Culvert Design and Improvements

In certain instances culverts or bridge openings can restrict tidal exchange. Increasing culvert or bridge opening size can improve tidal exchange by increasing tidal range. Modeling different culvert sizes can determine optimal configurations. Culvert alteration will result in changes in tidal height, which in turn must be evaluated for potential impacts on surrounding marshlands. If tidal height is too high, greater portions of impacted marshes may be inundated with salt water and the marsh system altered.



### Stormwater Control and Treatment

Stormwater transports nutrients, pathogens and bacteria, metals, suspended solids, and other constituents into embayments via point sources (e.g., stormwater outfall pipes) and nonpoint sources (e.g., runoff from fertilizer). Nitrogen compounds are present in the stormwater and eventually discharge into embayments. Impervious surfaces may accelerate the input of nitrogen into tidal and inland waters.

Nitrogen compounds flushed into estuaries by stormwater come both from natural precipitation (rain and snow) and from anthropogenic sources. Sources flushed from the natural background are part of the **nitrogen cycle**, in which plant matter decays, nutrients are absorbed into the ground, and are then taken up by new plant growth. Anthropogenic sources carried by stormwater include fertilizers (from agricultural, suburban, and urban areas), septic system leachate, farm animal and pet waste, and atmospheric deposition and precipitation of nitrogen compounds from power plants and automobiles. Human activities that attract a concentration of birds can also cause nitrogen loading via stormwater.

Both DEP and EPA regulate stormwater discharges in Massachusetts. DEP's requirements are specified in its Stormwater Management Policy, an umbrella policy adopted under multiple DEP regulations, including the Wetlands Protection regulations. The Stormwater Management Policy requires certain new developments and redevelopments to implement stormwater source controls, provide treatment, recharge, and reduce flooding impacts. EPA's requirements are specified in the NPDES regulations, which apply to both wastewater and stormwater point source discharges. The NPDES stormwater requirements apply to

industry (including all local DPWs), government agencies (e.g., the Massachusetts Highway Department), designated municipalities (72% of Massachusetts towns have been designated), and land disturbances of one acre or more (e.g., construction activities).

Because the vast majority of nitrogen loading to embayments in Massachusetts is from wastewater, reductions in nitrogen from source control of stormwater, remediation of combined sewer overflows (CSOs), control of agricultural land uses, and stormwater treatment may appear to be a relatively small portion of the total nitrogen load in a watershed. However, stormwater mitigation may be necessary in areas where pollution from stormwater affects local resources such as shellfish growing areas or public swimming beaches.

The documents listed in the table below apply generally to stormwater control and treatment strategies. Regulations and resources for specific stormwater issues are listed in each section.

### Source Control and Pollution Prevention

Eliminating sources of nitrogen in stormwater is generally more cost-effective than end-of-pipe treatment. Monitoring both dry and wet weather flow at stormwater outlets is usually necessary to identify point sources of nitrogen. A land use analysis is usually necessary to identify nonpoint sources.

The highest fraction of nitrogen in stormwater is typically from illicit interconnections between stormwater and sanitary drains, CSOs, failing septic systems, and fertilizer runoff. CSO reduction efforts under the NPDES General Permit for Phase II Stormwater will address many of these sources. Communities will be required to locate and eliminate any illicit interconnections between the sanitary and stormwater collection systems. Failing on-site treatment systems that may be impacting stormwater should be identified and brought into compliance with current standards. Cracked or loosely butted stormwater pipes, which allow entry of subsurface sanitary leachate, should also be considered for repair.

Although fertilizer application rates vary with different types of land use, some studies have indicated that runoff and **infiltration** from lawns can comprise more than 10% of the yearly nitrogen load to inland and tidal embayments. Reducing use of fertilizers by homeowners, farmers, or golf-course owners requires an intensive, long-term public outreach/education campaign. Small amounts of nitrogen in stormwater are typically due to pet wastes and other dry deposition on impervious surfaces such as parking lots. Programs to reduce pet waste need to be based on large-scale outreach and education, since private citizens are key to reducing this type of nutrient pollution.

General Stormwater Control and Treatment, Resources and Regulations	
<b>Federal</b>	
EPA	National Pollutant Discharge Elimination System (NPDES) Regulations, Clean Water Act, Section 402: <a href="http://cfpub1.epa.gov/npdes/cwa.cfm?program_id=6">http://cfpub1.epa.gov/npdes/cwa.cfm?program_id=6</a> <a href="http://www.epa.gov/region01/npdes/">http://www.epa.gov/region01/npdes/</a> <a href="http://cfpub1.epa.gov/npdes/stormwater/swphase2.cfm?program_id=6">http://cfpub1.epa.gov/npdes/stormwater/swphase2.cfm?program_id=6</a>
<b>State</b>	
DEP	Stormwater Management: Policy (Vol I) and Technical Handbook (Vol II), 1997. <a href="http://www.state.ma.us/dep/brp/stormwtr/stormpub.htm">http://www.state.ma.us/dep/brp/stormwtr/stormpub.htm</a>

## Combined Sewer Overflow (CSO) Remediation

Combined sewer overflows result from a flow of stormwater to a sanitary sewer, or from an illegal connection of sanitary flow to a storm sewer. Eliminating or reducing CSOs by separating sanitary and stormwater flows, or by other means such as CSO storage and treatment, can play a significant role in reducing bacterial and nutrient loading to specific segments of embayments and other waterways. It has been a long-standing goal of the EPA and DEP to eliminate or reduce CSOs. DEP's *Policy for the Abatement of Pollution from Combined Sewer Overflows* provides detailed information on the regulatory requirements for CSO control.

The CSO planning process provides for an assessment of CSO control alternative, their costs, and water quality benefits. Plans for controlling nitrogen loading should consider the technical information in these CSO plans. Some CSO remediation strategies, such as separating the flows of wastewater and stormwater, may result in increased flow and higher nitrogen loads to the wastewater treatment plant. For this reason, eliminating or reducing CSOs should be evaluated in conjunction with treatment plant upgrades that may be necessary to treat increased nitrogen loading at the plant.

Permitting to eliminate or reduce the number of times a CSO discharges sanitary wastes may include, but is not limited to, CSO permits, Wetlands Protection Act and regulations, and 401 Water Quality Certification. Separating sanitary and storm flows may also result in additional stormwater flows to stormwater outfalls rather than to a wastewater treatment plant. The increase in stormwater outfall discharges will need to be evaluated under a wetlands protection review to determine if peak discharge rates need to be reduced and whether or not additional treatment is necessary under the Massachusetts Stormwater Management Policy.

### CSO Remediation, Resources and Regulations

State	
DEP	<p>Stormwater Management: Policy (Vol I) and Technical Handbook (Vol II), 1997: <a href="http://www.state.ma.us/dep/brp/stormwtr/stormpub.htm">http://www.state.ma.us/dep/brp/stormwtr/stormpub.htm</a></p> <p>401 Water Quality Certification, 314 CMR 9.00: <a href="http://www.state.ma.us/dep/bwp/iww/files/314009.pdf">http://www.state.ma.us/dep/bwp/iww/files/314009.pdf</a></p> <p>Notice of Intent, Wetlands Protection Act, 310 CMR 10.00: <a href="http://www.state.ma.us/dep/brp/ww/files/310cmr10.pdf">http://www.state.ma.us/dep/brp/ww/files/310cmr10.pdf</a></p> <p>Policy for Abatement of Pollution from Combined Sewer Overflows (Under Surface Water Section): <a href="http://www.state.ma.us/dep/brp/brppols.htm">http://www.state.ma.us/dep/brp/brppols.htm</a></p>

### Stormwater Treatment

While end-of-pipe treatment solutions are available to reduce nutrients contained in stormwater, generally these options are more expensive than source controls and pollution prevention measures. However, treatment can be important in specific areas, if a discharge impacts areas such as shellfish growing areas or public swimming beaches.

Portions of many estuaries are designated as **critical resource areas**, in which nitrogen removal is particularly important to maintain water and habitat quality. For this reason, the Massachusetts Stormwater Management Policy requires that stormwater treatment technologies used in critical resource areas be capable of providing a higher level of treatment. See Volume II of the Massachusetts Stormwater Management Technical Handbook and Standard No. 6 of the Stormwater Management Policy for details.

**Off-line** treatment systems are designed to retain a standing volume of stormwater for a designated time period, in order to allow for physical settling of suspended particles and for biological and chemical treatment to occur (e.g., nutrient uptake). Off-line processes that can reduce nitrogen include constructed wetlands and filtration systems.

Many innovative stormwater treatment units operate **on-line**, by treating stormwater at a designated flow rate. Their retention times are very short. While on-line systems do reduce suspended sediments, typically they do not remove nitrogen. Innovative on-line treatment units that have been shown to be capable of removing nitrogen use filtration and biofiltration technology. The Massachusetts Strategic Envirotechnology Partnership (STEP) has evaluated the performance of some innovative stormwater treatment technologies.

Stormwater Treatment, Resources and Regulations	
State	
DEP	Notice of Intent, Wetlands Protection Act, 310 CMR 10.00 (when stormwater treatment impacts areas subject to the Wetlands Protection Act): <a href="http://www.state.ma.us/dep/brp/ww/files/310cmr10.pdf">http://www.state.ma.us/dep/brp/ww/files/310cmr10.pdf</a>
STEP	Strategic Envirotechnology Partnership (STEP) Reports and Fact Sheets on innovative stormwater treatment systems: <a href="http://www.stepsite.org/progress/reports/">http://www.stepsite.org/progress/reports/</a>

### Attenuation via Wetlands and Ponds

In seeking innovative ways of managing nutrients, it is important to consider the ability of natural systems to retain nitrogen in **nutrient sinks** or **attenuate** it through **biologically mediated denitrification**. Natural attenuation can be an effective option for reducing the impact of nitrogen on an estuary. However, over the long term, natural attenuation may present a risk of wetlands degradation and negative impacts on water quality and habitat. DEP has addressed this concern by prohibiting wetlands and ponds from being considered as a primary means of, or substitution for, wastewater treatment. Rather, wetlands and ponds are to be seen as polishing agents for ground water plumes from sources already treated to the highest possible standards, or for attenuating background concentrations in upstream ground water.

Natural attenuation via wetlands or ponds is appropriate only if the discharge has already been treated to Massachusetts Class I Ground Water Quality Standards and has become part of ground water flow. In addition, the concept of natural attenuation does not allow for physical alteration of wetlands or ponds associated with them. Proposals of this type fall into the realm of constructed wetlands and require full compliance with regulations in the **Wetlands Protection Act**.

In considering natural attenuation as a nitrogen reduction tool, it is critical to analyze the discharge location and the wetland's or pond's ability to assimilate nitrogen. Wetlands or ponds that currently intercept effluent plumes from on-site wastewater systems or existing treatment facilities should be priority candidates as natural attenuation tools rather than wetlands or ponds not already impacted by nitrogen in ground water.

### General Wetlands and Ponds, Resources and Regulations

Federal	
EPA	Wetlands Program, Office of Water <a href="http://www.epa.gov/owow/wetlands/">http://www.epa.gov/owow/wetlands/</a>
State	
DEP	Wetlands Program: . <a href="http://www.state.ma.us/dep/brp/ww/rpwwhome.htm">http://www.state.ma.us/dep/brp/ww/rpwwhome.htm</a>  Wetlands Protection Act Regulations, 310 CMR 10.00: <a href="http://www.state.ma.us/dep/brp/ww/files/310cmr10.pdf">http://www.state.ma.us/dep/brp/ww/files/310cmr10.pdf</a>

### Wetlands

Wetlands improve the quality of water that passes through them by means of physical, biological, and chemical processes. As the water enters the wetland, it spreads out and slows down, allowing for physical settling. Soil particles, organic matter and some nutrients are filtered out, absorbed, or settled. Communities of microorganisms are able to grow on the stems and roots of plants by using the nutrients and organic material carried in the water entering the wetland, offering an ideal environment for bacteria and algae to degrade organic material and remove chemicals that originate from upstream.

The actual conversion of nitrogen in this environment is known as biologically mediated denitrification. Nitrogen enters the ground water predominantly as nitrate, which does not change to any other form of nitrogen unless the proper conditions exist for some type of conversion. Salt marsh wetlands fringing an embayment will generally be good candidates for this type of conversion: marsh peat and mud contain the right combination of organic carbon, naturally occurring denitrifying bacteria, and anoxic conditions that allow the conversion of nitrate to nitrogen gas. Nitrogen gas is an inert form of nitrogen that vents without harm to the atmosphere, where it makes up approximately 80% of the air we breathe.

If a wastewater treatment facility discharges to the ground, the treated effluent will leach to the ground water and move down gradient with it in a relatively well-defined plume. If the discharge area can be sited so that the ground water flow containing the plume is intercepted by a wetland, additional nitrogen removal may occur naturally.

Although wetland systems (and ponds) should not be used in lieu of wastewater treatment, it is possible to take advantage of their ability to attenuate nitrogen, thereby providing a buffer of protection for water quality. This may result in an overall reduction of nitrogen loading to an embayment. A hydrogeologic study must be done to evaluate hydrogeologic conditions and ground water flow, in order to ensure that the effluent plume is intercepted by the wetland system. The evaluation is also necessary to confirm that the proper conditions exist for nitrogen removal, and that other pollutants in the plume (e.g., phosphorus or BOD) will not have an adverse impact on the wetlands.

As an example, assume an existing treatment facility that discharges to the ground and a nitrogen-rich ground water plume that ultimately empties into an embayment about a mile away. A salt marsh wetlands surrounds a portion of the embayment, and it has been demonstrated that natural attenuation in the marsh removes about 20% of the nitrogen in the ground water plume before the plume enters the embayment. The treatment plant currently discharges 800,000 gallons per day (gpd) at 10 milligrams per liter (mg/L) total nitrogen. However, the MEP linked model indicates that nitrogen loading in the embayment is over the allowable threshold. The critical nitrogen limit can only be achieved by improving the discharge to 3 mg/L total nitrogen at a flow of 750,000 gpd, not accounting for the marsh attenuation. If natural attenuation in the marsh can remove an additional 20% of nitrogen, the flow from the treatment plant can be increased from 750,000 gpd to 937,500 gpd at a concentration of 3 mg/L.

#### Wetlands, Resources and Regulations

State	
DEP	Ground Water Quality Standards, 314 CMR 6.00: <a href="http://www.state.ma.us/dep/bwp/iww/files/314006.pdf">http://www.state.ma.us/dep/bwp/iww/files/314006.pdf</a>
	Groundwater Discharge Permit Program, 314 CMR 5.00: <a href="http://www.state.ma.us/dep/bwp/iww/files/314005.pdf">http://www.state.ma.us/dep/bwp/iww/files/314005.pdf</a>
MEPA	Massachusetts Environmental Policy Act: MEPA Certificate, 301 CMR 11.00: <a href="http://www.state.ma.us/envir/mepa/thirdlevelpages/meparegulations/301cmr11.pdf">http://www.state.ma.us/envir/mepa/thirdlevelpages/meparegulations/301cmr11.pdf</a>

#### Ponds

Ponds can act as nitrogen sinks by retaining nitrogen in the water column or in sediments. However, for the same reasons described above under wetlands systems, any consideration of a pond for nitrogen attenuation requires a thorough analysis of its assimilative capacity with regard to both nitrogen and phosphorus. The analysis should also evaluate the potential for other contaminants such as pathogens to be transported into pond water or ground water.

#### Ponds, Resources and Regulations

State	
DEP	Ground Water Quality Standards, 314 CMR 6.00: <a href="http://www.state.ma.us/dep/bwp/iww/files/314006.pdf">http://www.state.ma.us/dep/bwp/iww/files/314006.pdf</a> Ground Water Discharge Permit Program, 314 CMR 5.00: <a href="http://www.state.ma.us/dep/bwp/iww/files/314005.pdf">http://www.state.ma.us/dep/bwp/iww/files/314005.pdf</a>
MEPA	Massachusetts Environmental Policy Act: MEPA Certificate, 301 CMR 11.00: <a href="http://www.state.ma.us/envir/mepa/thirdlevelpages/meparegulations/301cmr11.pdf">http://www.state.ma.us/envir/mepa/thirdlevelpages/meparegulations/301cmr11.pdf</a>

#### Constructed Wetlands and Wetlands Restoration

The ability of vegetation, soils, and microbial activity in natural wetlands to treat wastewater has led to the idea of constructing wetlands for environmental purposes. Unlike natural wetlands, constructed wetlands may be designed both to treat wastewater and to use treated wastewater to restore wetland habitat. As of October 2000, the EPA reported that there were more than 600 active constructed wetlands in the United States.

Volume Two of DEP's Stormwater Management Handbook (referenced in the introduction to Stormwater) has detailed information on the advantages and disadvantages of constructed wetlands and guidance on their siting. Although this information is written for stormwater treatment systems, it can be adapted to wastewater treatment.

The Massachusetts Wetlands Restoration Program (MWRP) is a program within the Massachusetts EOEA that supports voluntary efforts to restore the Commonwealth's wetlands and aquatic ecosystems. MWRP inventories wetlands restoration sites and facilitates the implementation of priority restoration projects through its GROWetlands (Groups Restoring Our Wetlands) Initiative. In collaboration with its many federal, corporate, and non-profit partners, MWRP works with project sponsors to provide or obtain whatever assistance –financial, technical, monitoring or other support– is required to complete the project.

#### Constructed Wetlands and Wetlands Restoration, Resources and Regulations

Federal	
EPA	Guidance on Constructed Wetlands <a href="http://www.epa.gov/owow/wetlands/watersheds/cwetlands.html">http://www.epa.gov/owow/wetlands/watersheds/cwetlands.html</a>
State	
EOEA	Executive Office of Environmental Affairs, Massachusetts Wetlands Restoration Program: <a href="http://www.state.ma.us/envir/mwrp/index.htm">http://www.state.ma.us/envir/mwrp/index.htm</a>

## Wastewater Treatment

In a majority of watersheds in Massachusetts, wastewater is the major source of nitrogen loading; in some watersheds, it makes up approximately 80% of the annual nitrogen load. Wastewater is also the most expensive source of nitrogen loading to control. Initial community reaction to wastewater treatment options may be based on inaccurate perceptions of their effectiveness and their impact on local land use patterns.

The most common misperception about wastewater treatment is that construction of community or municipal treatment plants will lead to an increase in development. Local planning and zoning tools are available to ensure that the technological options selected to address nitrogen loading are used in accordance with local land use goals. In addition, the integrated water resources management planning process provides an objective evaluation of each technical option and public input, thereby ensuring a plan that has a much greater chance of being accepted by the community.

## On-Site Treatment and Disposal Systems

Conventional on-site treatment and disposal systems are generally the least expensive and most passive means of treating sanitary sewage. They typically serve individual homes and other facilities with sewage flow of less than 10,000 gallons per day (gpd) and consist of a **septic tank**, a distribution system, and a **soil absorption system (SAS)**.

The septic tank is a pretreatment unit designed to accept raw sewage and separate solids and scum from the liquid portion of the sewage. The septic tank is designed to have a **holding time** of at least 48 hours. In addition to promoting settling of solids and separation of grease and oils, this holding time allows for some

decomposition of solid and sludge. Because of the solid and scum accumulation in the tank, septic tanks need to be periodically pumped.

Septic tanks also provide a degree of **anaerobic** treatment that makes the clarified effluent more amenable to further treatment in the soil absorption system. This clarified effluent is eventually discharged from the septic tank to a distribution system. Distribution systems consist of a distribution box for gravity feed or a pump system where gravity distribution is not possible or a pressurized system is required. Whatever the configuration, the purpose of distribution systems is to deliver septic tank effluent equally across the soil absorption system.

The soil absorption system (SAS) is where the majority of treatment takes place in an on-site system. As the clarified septic tank effluent enters the SAS, it percolates through the stone of the SAS and the surrounding soil. A biological mat forms, consisting of naturally occurring bacteria that break down the impurities in the effluent. With a proper depth of unsaturated soil between the bottom of the SAS and the ground water, removal of nutrients, pathogenic organisms, and other pollutants occurs.

In Massachusetts, Title 5 of the State Environmental Code governs on-site subsurface sewage treatment and disposal systems up to 10,000 gpd. Title 5 is a state regulation; in most instances, the local Board of Health has permitting and enforcement authority. Operation and maintenance of the systems is the responsibility of the property owner.

Properly designed and sited, conventional systems do an excellent job of removing **organic pollutants**, solids, and **pathogens**. However, they do not provide significant nitrogen reduction. Based on performance data from the Massachusetts Septic System Test Center, overall nitrogen removal rates in conventional on-site systems average between 15 and 20%. The average nitrogen concentration in flows exiting a conventional system is 35 mg/L.



In addition to prescribing design standards for conventional systems, Title 5 provides for the use of **innovative/alternative (I/A)** systems that can provide enhanced treatment. Typically, these systems use **biological denitrification** to improve nitrogen removal. Removal of nitrogen is accomplished by converting the organic nitrogen and ammonia found in raw sewage to inert nitrogen gas that harmlessly escapes to the atmosphere. While the details of unit operations may differ among the various systems, the basic principles of a biologically mediated nitrogen cycle remain the same. Most I/A systems still require septic tanks and all rely on an SAS for ultimate disposal.

Systems qualifying for a nitrogen credit under Title 5 must demonstrate an ability to reduce nitrogen to 19-25 mg/L total nitrogen, depending on acreage and flow. When operating at maximum efficiency, I/A systems can improve nitrogen reduction by even more, down to a 70% overall reduction in total nitrogen.

It must be stressed, however, that consistently high nitrogen removal rates approaching or exceeding 70% require an increased level of oversight that may be more economically and technically feasible within the context of a watershed or wastewater management district. Although Title 5 requires

that I/A systems be monitored by a certified operator under a maintenance contract, the monitoring and testing frequency mandated may not be sufficient to ensure that the system is performing with optimal efficiency. National experience has shown that management districts improve the reliability of I/A systems and their nitrogen reduction capability by removing the burden of oversight from home and facility owners.

Title 5 has special loading limitations in areas considered particularly sensitive to nitrogen pollution. Nitrogen Sensitive Areas are defined as **Zone IIs** and **Interim Wellhead Protection Areas (IWPAs)** of public drinking water supply wells, as well as nitrogen sensitive embayments. Residential lots with new construction served by both a private drinking water well and an on-site wastewater system are also areas where nitrogen discharges to ground water are regulated. In these areas, the design flow for on-site wastewater systems is 440 gpd per acre in order to limit nitrogen levels in public and private drinking water supplies.

The planning goal for nitrogen in public drinking water supplies is 5 mg/L, and the Maximum Contamination Level (MCL) is 10 mg/L. The 440 gpd per acre loading limit from on-site systems was developed to meet a standard of 10 mg/L (total nitrogen). However, the wastewater loadings considered to be adequate for drinking water and ground water protection are not appropriate for protection of marine systems, which are typically sensitive to nitrogen contamination at one to two orders of magnitude lower than 10 mg/L.

### On-Site Treatment and Disposal Systems, Resources and Regulations

Federal	
NSFC	National Small Flows Clearinghouse: <a href="http://www.nesc.wvu.edu/nsfc/">http://www.nesc.wvu.edu/nsfc/</a>
State	
DEP	Title 5 Program: <a href="http://www.state.ma.us/dep/brp/wwm/t5pubs.htm#it">http://www.state.ma.us/dep/brp/wwm/t5pubs.htm#it</a>
	Title 5: Standard Requirements for ... On-Site Sewage Treatment and Disposal Systems and for the Transport and Disposal of Septage, 310 CMR 15.00: <a href="http://www.state.ma.us/dep/brp/files/310cmr15.pdf">http://www.state.ma.us/dep/brp/files/310cmr15.pdf</a>
	Certification of Operators of Wastewater Treatment Facilities, 257 CMR 2.00: <a href="http://www.state.ma.us/dep/bwp/iww/files/257cmr2.htm">http://www.state.ma.us/dep/bwp/iww/files/257cmr2.htm</a>

## Cluster Systems

Title 5 allows shared on-site systems to serve more than one residence or facility; these are known as shared or cluster systems, and are limited to total flows of less than 10,000 gpd. Treatment technologies used in cluster systems are similar to those used for single on-site systems. By combining flows from several facilities, design strategies for shared systems can attenuate daily flow variations, resulting in improved and more reliable performance. As with all I/A technologies, the performance of a nitrogen-reducing cluster system is highly dependent on proper operation and maintenance, which must be carried out by a certified operator. Well-managed cluster systems using I/A technology in residential settings have been known to reduce total nitrogen below 10 mg/L.

If permitted individually under Title 5, cluster systems can only be credited for nitrogen removal down to 19-25 mg/L total nitrogen. However, it is possible to incorporate cluster systems into an overall watershed management plan regulated under a Ground Water Discharge Permit, even if the flow from the system is less than 10,000 gpd. In these cases, the discharge can be credited for nitrogen removal down to 10 mg/L total nitrogen or less, depending on the performance capability of the system.

Depending on the density of the area served, several cluster systems may be required in order to stay under the 10,000 gpd limit on flow. In these instances, a cost analysis should be performed to determine if it may be more cost-effective to install a community treatment plant or connect to a larger municipal treatment facility. Costs of cluster systems to consider are the capital cost of the required number of cluster systems, installation of collection systems from individual properties to the cluster treatment unit, and operation and maintenance of the

cluster systems, including the treatment unit, SAS, and any pretreatment units at the treatment site or on individual properties.

### Cluster Systems with Enhanced Treatment, Resources and Regulations

Cluster Systems with Enhanced Treatment, Resources and Regulations	
<b>Federal</b>	
NSFC	National Small Flows Clearinghouse: <a href="http://www.nesc.wvu.edu/nsfc/">http://www.nesc.wvu.edu/nsfc/</a>
<b>State</b>	
DEP	Title 5 Program: <a href="http://www.state.ma.us/dep/brp/wwm/t5pubs.htm#it">http://www.state.ma.us/dep/brp/wwm/t5pubs.htm#it</a>  Title 5: Standard Requirements for ... On-Site Sewage Treatment and Disposal Systems and for the Transport and Disposal of Septage, 310 CMR 15.00: <a href="http://www.state.ma.us/dep/brp/files/310cmr15.pdf">http://www.state.ma.us/dep/brp/files/310cmr15.pdf</a>  Certification of Operators of Wastewater Treatment Facilities, 257 CMR 2.00: <a href="http://www.state.ma.us/dep/bwp/iww/files/257cmr2.htm">http://www.state.ma.us/dep/bwp/iww/files/257cmr2.htm</a>

## Community Treatment Plants

Community treatment plants generally are considered for flows in the 10,000 - 150,000 gpd range, and are appropriate in areas where a higher degree of nitrogen removal is required (down to 7 to 10 mg/L total nitrogen) and/or where cluster systems may not be cost-effective. In special circumstances, community treatment plants may be necessary for flows below 10,000 gpd in order to achieve the Class I Ground Water Quality Standards.

Community treatment plants are larger and more complex than cluster systems, and their requirements for management oversight, operation, and maintenance are much more stringent than for cluster or on-site systems. They require at a minimum a chief operator (Grade 3 or higher) and an assistant operator with coverage of at least two hours a day, five days per week.

There is a greater variety in treatment processes available for community treatment plants than for on-site or cluster systems. In many cases, community treatment plants will employ the same treatment systems found in larger municipal treatment plants, such as **activated sludge**, **rotating biological contactors (RBC)**, and **sequencing batch reactors (SBR)**. In addition to the plant itself, collection systems will be required to deliver sewage from individual homes or businesses to the community treatment plant. Consideration must also be given to the design and location of disposal systems for these facilities. Options include open sand infiltration beds or subsurface disposal systems.

Community treatment systems provide greater flexibility in treatment options and better performance than cluster systems or on-site systems, but they involve a more complex permitting, siting, and design process. An economic analysis should be performed to see if specific circumstances render them more cost-effective than other options. Performance bonds or some other acceptable arrangement may be required to protect against failure of the process or equipment.

DEP is now updating its *Guidelines for the Design, Construction, Operation and Maintenance of Small Sewage Treatment Facilities with Land Disposal*, last published in 1988. The new Guidelines will be a technical guide for the design, construction, and operation of small wastewater treatment facilities. They also will outline DEP's current regulations, policies, and



standards for facilities that discharge to the ground. Publication is expected during 2003.

The new Guidelines will reflect the following changes:

- ☺ Improvements in existing technology as well as technologies not available before.
- ☺ Advances in understanding of ground water flow dynamics and the potential for impacts on downstream resources.
- ☺ New DEP policies and initiatives, such as the reclaimed water guidelines and the watershed approach, which directly impact the ground water discharge permit program.
- ☺ Experience since 1988 in reviewing the design and operation of wastewater treatment facilities, and new insights into what is necessary to construct, operate, and maintain a modern community treatment facility.

The intent of the new Guidelines is to supplement the standards and design criteria found in the New England Interstate Water Pollution Control Commission document, *TR-16: Guides for the Design of Wastewater Treatment Works – 1998 Edition*. TR-16 will continue to be the primary design reference for DEP use. The Guidelines will provide further information and standards, where necessary, given the particular design and construction problems faced in Massachusetts.

DEP’s policy is to encourage the use of new and innovative processes and equipment that have been demonstrated to operate satisfactorily and achieve the primary objective of protecting the waters of the Commonwealth. It will not be possible to cover all recently developed collection, treatment, and disposal processes in the new Guidelines. Processes not specifically referenced in the new Guidelines will be reviewed on a case-by-case basis if they meet the following conditions:

- ☉ Thoroughly tested as a pilot plant operated for a sufficient time under representative conditions to demonstrate successful performance and
- ☉ Demonstrated performance in full-scale comparable installations under competent supervision

### Municipal Treatment Plants and Sewers

The traditional concept of a municipal or **publicly-owned treatment works (POTW)** is one that serves an entire municipality or significant portions of it, with a treatment facility often located remotely from the areas served. These facilities will discharge up to several million gallons per day of treated effluent either to ground water or surface water. In order to transport sewage over greater distances, an extensive collection system employing gravity sewers, vacuum sewers, force mains, or a combination of these options is required.

Large treatment plants are able to meet very stringent nitrogen treatment standards. They can reliably meet a standard of 3 mg/L nitrogen, and can reach 2 mg/L in some cases. Larger plants can better assimilate variations in flow and wastewater characteristics. If run properly by a trained professional staff, they provide consistent and reliable results.

Large plants entail significant capital costs. Other cost considerations are operation and maintenance by a full time staff, with a chief operator and assistant rated at Grade 5 or above. Additionally, these facilities require significant land area, which may limit site options or increase costs if land must be purchased. On the other hand, large plants benefit from economies of scale, and depending on specific circumstances, they may be more cost-effective than several cluster systems or community treatment plants.

#### Community Treatment Plants, Resources and Regulations

State	
DEP	<p><i>Guidelines for the Design, Construction, Operation and Maintenance of Small Sewage Treatment Facilities with Land Disposal.</i> Contact DEP for a copy of the 1988 Guidelines.</p> <p>Ground Water Quality Standards, 314 CMR 6.0: <a href="http://www.state.ma.us/dep/bwp/iww/files/314006.pdf">http://www.state.ma.us/dep/bwp/iww/files/314006.pdf</a></p> <p>Ground Water Discharge Permit Program, 314 CMR 5.00: <a href="http://www.state.ma.us/dep/bwp/iww/files/314005.pdf">http://www.state.ma.us/dep/bwp/iww/files/314005.pdf</a></p> <p>Certification of Operators of Wastewater Treatment Facilities, 257 CMR 2.00: <a href="http://www.state.ma.us/dep/bwp/iww/files/257cmr2.htm">http://www.state.ma.us/dep/bwp/iww/files/257cmr2.htm</a></p>
Other	
NEIWPCC	<p>New England Interstate Water Pollution Control Commission: Document <i>TR-16: Guides for the Design of Wastewater Treatment Works</i>, 1998 Edition. <a href="http://www.neiwpcc.org/publication.html#16">http://www.neiwpcc.org/publication.html#16</a></p>

Large municipal treatment plants present complex planning, design, cost, and siting challenges. More than any of the other wastewater treatment options discussed in this Guidance, they require active community involvement in planning and implementation.

**Municipal Treatment Plants and Sewers, Resources and Regulations**

Federal	
EPA	NPDES Regulation: Clean Water Act, Section 402: National Pollutant Discharge Elimination System. <a href="http://cfpub1.epa.gov/npdes/cwa.cfm?program_id=6">http://cfpub1.epa.gov/npdes/cwa.cfm?program_id=6</a>
State	
DEP	Surface Water Quality Standards, 314 CMR 4.00: <a href="http://www.state.ma.us/dep/bwp/iww/files/314cmr4.htm">http://www.state.ma.us/dep/bwp/iww/files/314cmr4.htm</a>
	Surface Water Discharge Permit Program, 314 CMR 3.00: <a href="http://www.state.ma.us/dep/bwp/iww/files/314cmr3.htm">http://www.state.ma.us/dep/bwp/iww/files/314cmr3.htm</a>
	Ground Water Quality Standards, 314 CMR 6.00: <a href="http://www.state.ma.us/dep/bwp/iww/files/314006.pdf">http://www.state.ma.us/dep/bwp/iww/files/314006.pdf</a>
	Ground Water Discharge Permit Program, 314 CMR 5.00: <a href="http://www.state.ma.us/dep/bwp/iww/files/314005.pdf">http://www.state.ma.us/dep/bwp/iww/files/314005.pdf</a>
	Certification of Operators of Wastewater Treatment Facilities, 257 CMR 2.00: <a href="http://www.state.ma.us/dep/bwp/iww/files/257cmr2.htm">http://www.state.ma.us/dep/bwp/iww/files/257cmr2.htm</a>

**Water Conservation and Reuse**

While Massachusetts may be water-rich in comparison to some sections of the United States, there are several parts of the Commonwealth where a combination of rapid population growth and commercial development has significantly lowered water tables and diminished available water resources in **aquifers**, rivers, ponds, and wetlands. Drought conditions over the past few years have exacerbated these conditions. As a result, a number of communities have been forced to implement severe water use restrictions, and in some instances have curtailed the development of new public drinking water supply wells or individual private wells. The rising cost of water and wastewater treatment, coupled with the difficulty of identifying and permitting viable ground water discharge sites, has also created difficult treatment and disposal issues for communities. Water conservation and wastewater reuse are tools that can help communities deal with these problems.

**Water Conservation**

Water conservation has an indirect, but potentially important, impact on nitrogen loading to estuaries. With the exception of loadings from lawns, golf courses, and agriculture, nutrient loading does not drop with most water conservation efforts, since the amount of pollution discharged does not change.

However, water conservation can significantly improve the health of estuaries and reduce the costs of restoring them. Lower water withdrawals result in increased ground water and surface water flow, particularly in upstream rivers and ponds. The result is less overall stress on ecosystems and more ability to respond

to other system upsets. Water conservation also means lower costs for communities, both for drinking water source development and treatment and wastewater treatment and disposal. In some cases, water conservation programs have allowed communities to forego costly construction or expansion projects.

Water Conservation, Resources and Regulations	
<b>Federal</b> EPA	Water efficiency programs: <a href="http://www.epa.gov/owm/water-efficiency/index.htm">http://www.epa.gov/owm/water-efficiency/index.htm</a>
<b>State</b> DEP	Water conservation information: <a href="http://www.state.ma.us/dep/brp/dws/conserv.htm">http://www.state.ma.us/dep/brp/dws/conserv.htm</a>

### Water Reuse

The use of reclaimed water for situations that do not require the advanced quality of potable water can significantly reduce the pressure to develop new potable water sources or to overuse existing sources, as well as provide cost-effective and environmentally sound options for wastewater disposal. Applications such as spray irrigation can also have beneficial impacts on water quality, by allowing vegetation and soils to treat contaminants as the water passes through them.

DEP requires a ground water discharge permit for water reuse. To help communities and property owners use this option, DEP has developed *Interim Guidelines on Reclaimed Water*. The Guidelines include the following requirements in order to protect public health:

- Ⓞ Rigorous water quality criteria: The reclaimed water must be virtually pathogen and contaminant free. The greater the risk of human exposure, the more stringent the standard.

- Ⓞ Demonstrated ability of the wastewater treatment plant to consistently meet effluent standards, and an alternate disposal option that can be employed immediately if reclaimed water criteria are not met.

- Ⓞ Duplicative systems and alternate sources of power for the treatment plant, so that treatment capabilities will not be jeopardized during power outages and repairs.

- Ⓞ Best management practices (BMPs) are aimed at minimizing direct human exposure.

- Ⓞ Advanced monitoring program to determine the effluent quality at the treatment plant and measure impacts on both surface water and ground water.

- Ⓞ Public acceptability: Regardless of the technical and environmental soundness of the reuse program, the public must believe that wastewater reclamation and reuse is a viable approach.



DEP allows the following uses of reclaimed water:

☉ *Golf Course and Nursery Irrigation.* These are reuse options for the summer months, and require a number of BMPs to minimize direct human exposure.

☉ *Toilet Flushing.* A dual plumbing system is required in order to prevent public access to the plumbing. Appropriate signage is critical, to inform the public that reclaimed rather than potable water is being used.

☉ *Artificial Aquifer Recharge.* Reclaimed water discharges into Zone IIs (hydrogeologic zones of contribution to a public water supply well), are allowed if they result in a net environmental improvement within the watershed and do not adversely impact ground water uses in the Zone II. Due to pathogen transport concerns, discharges that would take less than two years to travel to any public water supply are not normally allowed. A discharge may be permitted within the two-year time of travel under exceptional circumstances deemed by DEP to be extraordinary and critical with no other feasible siting alternatives, and provided an advanced level of treatment and monitoring is included.

As knowledge and experience in the use of reclaimed water increases in Massachusetts, DEP may allow other uses. DEP has already received inquiries on using reclaimed water to irrigate ball fields and outdoor areas at office parks and public facilities, as cooling water, and for use in car wash facilities. Several of these uses, e.g., drip irrigation of landscape planting, have already been approved on a pilot basis to determine their feasibility, necessary treatment standards, and operational restrictions. DEP is presently conducting a review of the interim reclaimed

water guidance, including the potential addition of new uses and revised treatment standards consistent with national practice. The review will be complete and new guidelines available in the near future.

### Water Reuse, Resources and Regulations

State	
DEP	Interim Guidelines on Reclaimed Water: <a href="http://www.state.ma.us/dep/brp/wwm/files/reuse.pdf">http://www.state.ma.us/dep/brp/wwm/files/reuse.pdf</a>
	Ground Water Quality Standards, 314 CMR 6.0: <a href="http://www.state.ma.us/dep/bwp/iww/files/314006.pdf">http://www.state.ma.us/dep/bwp/iww/files/314006.pdf</a>
	Ground Water Discharge Permit Program, 314 CMR 5.00: <a href="http://www.state.ma.us/dep/bwp/iww/files/314005.pdf">http://www.state.ma.us/dep/bwp/iww/files/314005.pdf</a>

### Management Districts

Management districts are legal, geographic entities established in order to carry out environmental work such as funding and building infrastructure improvements, managing infrastructure or programs, or providing other environmental protection services. This section of the Guidance introduces the concept of management districts, summarizes the legal mechanisms available to establish them, and notes advantages and disadvantages of different district approaches. Appendix G provides more detail on legal mechanisms for establishment of management districts. DEP also plans to develop more comprehensive guidance on management districts for use by municipalities.

Districts are used throughout the United States to protect many different types of environmental resources, but they are less common in Massachusetts given our tradition of strong local government. However, districts have been used here to provide traditional environmental protection and utility services, most commonly for water delivery and wastewater or septage treatment in geographic areas that cross municipal boundaries.

More recently, a few Massachusetts local governments have established districts and management programs to provide non-traditional environmental services or to manage activities that have historically been the responsibility of individual property owners, for example, management of on-site treatment systems, construction and management of decentralized sewers, and operation of stormwater treatment systems. Appendix H lists some of the newer management districts and programs in use in Massachusetts.

### Benefits of the District Approach

Districts are an important approach for dealing with nutrient pollution, particularly when a problem is difficult or expensive to address with conventional municipal services or management mechanisms, or where the environmental impact of individual activity requires a higher degree of management. The benefits of management districts are their *focus*, *flexibility*, and *appropriate funding*:

**Focus:** Districts provide a targeted approach to environmental, resource, or public health issues specific to a certain geographic area. They allow the management clarity and specificity sometimes lacking in the wide spectrum of activities carried out by local governments.

**Flexibility:** Management districts can be structured and funded differently depending upon the services being provided, the geographic area included, and the available funding. Examples of flexibility include:

- ⑤ Services for watersheds, lakes, and estuaries whose boundaries cross municipal boundaries.
- ⑤ Services that differ from those traditionally offered by a municipality, such as management of on-site wastewater systems.
- ⑤ Services based on regulations and programs of multiple authorities, each with its own set of requirements, performance criteria, and involved parties.
- ⑤ A comprehensive range of services, or a single service. Districts also have flexibility in providing the services themselves, contracting with other providers, or establishing performance standards that district members must meet.

### Funding:

- ⑤ Districts can be designed to generate fees or levy taxes solely on the individuals benefiting from the services, without increasing costs to other taxpayers.
- ⑤ Districts can issue bonds and notes and raise revenues to carry out their stated purposes.
- ⑤ For services traditionally provided by individual property owners, such as on-site wastewater system maintenance, the pooling of services offered by a district can save money for individual homeowners.

### Legal Mechanisms to Establish Districts

Many legal factors go into a municipality's decision to form a district and its choice of the legal mechanism to establish the district. Discussions with local officials, legal counsel, and the DEP and EPA are crucial, and it is also important that local bylaws do not substantively conflict or interfere with DEP's regulatory and permitting authority over wastewater facilities and discharges. Input from municipal legal counsel is needed to assess the issues associated with charging a fee for any municipal permitting activities.

Massachusetts law provides three mechanisms to establish districts:

- ④ **General State Law**
- ④ **Special Act of the Legislature**
- ④ **Municipal Home Rule Authority, Bylaws, and Regulations.**

### General State Law

**Massachusetts General Laws (MGL)** have three legal options for the establishment of management districts.

*Water Pollution Abatement Districts.* Under the Massachusetts Clean Waters Act, DEP is authorized to propose, and in some cases mandate, the establishment of water pollution abatement districts consisting of one or more cities or towns, or designated parts thereof.

A regional water pollution abatement district is an independent entity administered by a district commission, with authority to

- ④ Adopt bylaws and regulations;
- ④ Acquire, dispose of and encumber real and personal property, including acquiring real property by eminent domain;
- ④ Construct, operate, and maintain water pollution abatement facilities; and
- ④ Issue bonds and notes, and raise revenues to carry out the purposes of the district by means of apportioned assessments on

the member municipalities.

This mechanism allows communities to work together and with DEP to form a management district without a special act of the Legislature. DEP has the authority to mandate formation of a water pollution abatement district, but has not exercised it to date. DEP can also require such a district to implement a water pollution abatement plan subject to DEP approval.

*Independent Water and Sewer Commissions and Intermunicipal Agreements.* Massachusetts General Law authorizes municipalities to establish an independent water and sewer commission within the boundaries of a municipality, and to enter into intermunicipal agreements for the purpose of jointly performing a service that a municipality is authorized to do individually or to allow one municipality to perform a service for another.

*Regional Health Districts.* Massachusetts General Law authorizes two or more municipalities to form a regional health district, which has powers and duties equivalent to those exercised by the **Boards of Health (BoH)** and health departments of the constituent municipalities. The primary purpose of a regional health district does not appear to be pollution abatement, but the language is broad enough to encompass the wastewater regulatory powers of a BoH and, therefore, may be another general law option worth exploring.



### Special Act of the Legislature

The Massachusetts Constitution authorizes municipalities to file home rule petitions with the Legislature requesting enactment of a special law. In practice, this is the legal mechanism most often used to establish a region-wide district. A special act may also be necessary or appropriate when a municipality is seeking to manage a service within its boundaries in a manner that goes beyond or is inconsistent with applicable general or special laws.

The municipal legislative body must approve a home rule petition before it can be acted on by the Legislature, although a local vote does not preclude legislative amendments. In addition to involving the municipality's executive, municipal counsel, and state legislator(s) in discussions about home rule petitions, it is also important to consult with EOE and DEP. Both agencies will typically comment on the merits of the proposed legislation, and their support can be an important factor in securing passage of the bill.

Because of the Legislature's broad authority to enact laws consistent with the state constitution, including the power to exempt municipalities from otherwise applicable general laws, the enactment of special legislation can be the most effective vehicle for establishing a district encompassing more than one municipality, an environmentally important geographic area, or for innovative organization of district activities.

### Municipal Home Rule Authority, Bylaws, and Regulations.

The Massachusetts Constitution grants authority to a municipality to exercise any power or function which the Legislature has the power to confer on it and which is not inconsistent with the Constitution or a state law or prohibited by the municipality's charter. Municipalities may adopt zoning or general bylaws to regulate a wide range of uses and activities within all or a portion of their boundaries, although the bylaws must be reviewed and approved by the Commonwealth's Attorney General.

*Zoning Bylaws.* A zoning bylaw typically imposes restrictions on categories of land uses located in a defined geographical area. For example, it may establish an aquifer protection district that encompasses the boundaries of the Zone II of contribution to a public water supply well and prohibit certain new land uses within that area. However, zoning bylaws must allow the continuation of nonconforming land uses within a zoning district, provided the uses were in place prior to passage of the bylaw. A zoning bylaw requires a planning board hearing and a two-thirds vote of town meeting.

*General Bylaws.* In contrast, a general bylaw typically applies uniformly to all existing and new uses or activities subject to the bylaw, and requires only a majority vote of town meeting. A common example is a wetlands protection bylaw that implements a local permit program with more stringent requirements than the state Wetlands Protection Act. A general bylaw is not required by state law to grandfather prior nonconforming uses.

*Local Boards of Health.* It is worth noting that a Board of Health has broad authority to regulate wastewater independently of general municipal bylaws. Boards of Health are authorized to promulgate “reasonable” regulations, including regulations that exceed the minimum requirements of Title 5, provided the BoH makes explicit the local conditions that exist and/or reasons that support more stringent regulation. For this particular type of authority, a BoH regulation can be effective, given its existing jurisdiction in this area, experience, and its significant penalty authority.

### Choosing the Appropriate Legal Mechanism

Each of these legal approaches has advantages and disadvantages. Under general state law, the provisions for establishing a water and sewer commission and regional health districts are mechanisms available to establish districts that can have a regional focus and/or independent financing and operating authority. On the other hand, sewer commissions and regional health districts have not yet been used to address the wide range of issues related to nutrient loadings. Water Pollution Abatement Districts can be structured to meet particular local needs, but they have not been used to date.

A special act of the Legislature allows one or more communities to craft a district that meets their particular needs. However, this approach requires close work with a large group of stakeholders. Municipal home rule authority can be used relatively quickly to establish districts, and the local departments administering them are well-known mechanisms. However, districts formed through local bylaws cannot cover more than single municipality and they are dependent on the municipality for their authority and

funding mechanisms.

Communities may opt to provide management services through their Board of Health authority because it may be more expedient and because of confusion about what constitutes a management district and its benefits. However, the complexity of watershed-based nutrient management plans and the challenges in managing nutrients from sources such as on-site systems or stormwater are strong arguments in favor of a more formal district structure.

Management Districts, Resources and Regulations	
<b>Federal</b> EPA	Draft EPA Guidelines for Management of On-site/Decentralized Wastewater Systems, September 2000: <a href="http://www.epa.gov/owmitnet/mtb/decent/downloads/guidelines.pdf">http://www.epa.gov/owmitnet/mtb/decent/downloads/guidelines.pdf</a>
<b>State</b> Marine Studies Consortium	M.T. Hoover: A Framework for Site Evaluation, Design, and Engineering of On-Site Technologies Within a Management Context, 1997. Executive Summary: <a href="http://www.brandeis.edu/marinestudies/risk.html">http://www.brandeis.edu/marinestudies/risk.html</a> Entire Report: <a href="http://www.state.ma.us/dep/brp/wwm/files/hoovered.doc">http://www.state.ma.us/dep/brp/wwm/files/hoovered.doc</a>
Pioneer Valley Planning Commission	<i>How to Create a Stormwater Utility</i> , 1999. <a href="http://www.pvpc.org/docs/landuse/pubs/storm_util.pdf">http://www.pvpc.org/docs/landuse/pubs/storm_util.pdf</a>

## Land Use Planning and Controls

Land development leads to increased nitrogen loading for several reasons. It increases human population growth and activity, and also reduces the ability of the land to naturally remediate nutrients, by increasing impermeable surface areas, removing vegetation that naturally recycles nitrogen, and destabilizing soils, thereby allowing the release of soil-bound nutrients.

Land use planning does not attempt to stop growth, but does seek to influence its amount, rate, location, and character, in order to maintain the community's long-term viability. Awareness of the issues raised by growth is increasing, and tools have been developed to help communities plan and control the use of land. For example, the Community Preservation Initiative within EOEA focuses on preserving and enhancing the quality of life in Massachusetts communities, including land and watershed protection, affordable housing, historic preservation, economic development, and transportation. It seeks both to balance these interests and also to encourage communities to maintain their unique characteristics and quality of life as they develop.



## Smart Growth

Typically, planning for land developments requiring state permits for drinking water sources, wastewater disposal, and stormwater management does not begin with an evaluation of the capacity of the natural resources on the site to accommodate the development. Most often, DEP is involved only in a final and separate stage, to consider the impact of the development on public health and natural resources. A smarter approach to developing sites requiring multiple state permits would minimize the competition between permits and use an integrated approach to evaluate combined resource needs and the impact of the development on issues of watershed quality.

As part of the MEP, DEP is evaluating ways to integrate issues raised by land development with the issuance of environmental permits. The Community Preservation Initiative within EOEA also provides communities with tools and programs to support planning. The **Metropolitan District Commission (MDC)** has published *Growth Management Tools: A Summary for Planning Boards in Massachusetts*, which summarizes a number of options available to local boards.

## Open Space Acquisition

Although of limited utility in remediating waterbodies suffering the effects of high nitrogen loads, open space acquisition remains an important option in preventing further degradation by new discharges. Consideration should be given to acquiring or protecting additional open space in places that will support the ecological health of water bodies. For example, communities may maintain areas of open space to prevent further nitrogen loading or to offset more densely developed areas. Purchasing nitrogen loading land use restrictions

instead of a fee acquisition may also provide a more cost-effective approach to limiting discharges and nitrogen inputs to the watershed.

### Zoning and Related Tools

In addition to state-level permitting, local zoning bylaws remain an important mechanism to promote the type and amount of development compatible with the capacity of local resources. Frequently there is a disconnect between the maximum build-out allowable under zoning bylaws and the capacity of a site to generate and protect sufficient water supplies and also to adequately dispose of wastewater discharges and stormwater runoff.

The Commonwealth’s Rivers Protection Act establishes riverfront areas and buffer zones along streams and rivers for which local Conservation Commissions must review activities that may impact on wetland resource areas and water quality. These regulations are helpful to communities seeking to limit nutrient loading from riverfront development, for example, nitrogen and phosphorus loadings from lawn fertilizing.

### Nutrient Trading

Nutrient trading is a regulatory tool that allows pollution sources to reallocate responsibilities for pollution reduction among themselves and fund the most cost-effective reduction measures in order to meet regulatory requirements. Following is a brief introduction to watershed-based nitrogen trading, including issues to consider when evaluating this tool. The concepts and issues identified here apply to nitrogen, phosphorus, and other water quality pollutants; however, nitrogen is the pollutant of interest for this Guidance.

**Pollution trading** has been used extensively in air quality programs in the United States, and watershed-based trading is an emerging tool for communities to consider in meeting nitrogen threshold limits set in TMDLs. EPA promotes the use of effluent trading in watersheds, and has issued a Draft Framework for Watershed-Based Trading to guide communities in its use. EPA proposed a National Water Quality Trading Policy in January 2003.



#### Land Use Planning and Controls, Resources and Regulations

<b>State</b>	
EOEA	Community Preservation Initiative web site: <a href="http://commpres.env.state.ma.us">http://commpres.env.state.ma.us</a>
MDC	<i>Growth Management Tools: A Summary for Planning Boards in Massachusetts</i> , August 2002. <a href="http://www.state.ma.us/mdc/MDC%20Growth%20Management%20Tools.pdf">http://www.state.ma.us/mdc/MDC%20Growth%20Management%20Tools.pdf</a>
DEP	Wetlands Protection Act (WPA): <a href="http://www.state.ma.us/dep/brp/ww/files/310cmr10.pdf">http://www.state.ma.us/dep/brp/ww/files/310cmr10.pdf</a> Rivers Protection Act, 1996 amendment to the WPA: <a href="http://www.state.ma.us/dep/brp/ww/files/riveract.htm">http://www.state.ma.us/dep/brp/ww/files/riveract.htm</a>

Trading offers the following benefits to communities as a tool for nitrogen management:

- ④ Cost-effective pollution reduction and flexibility on choice of nitrogen reduction methods, which can provide significant savings to communities. Nitrogen reduction from nonpoint sources is usually much less expensive than from point sources, which makes this type of trading particularly cost-effective.

- ④ Increased incentives to reduce pollution below regulatory limits. If a source voluntarily reduces its pollution load, it can sell these credits to dischargers facing more expensive pollution reduction costs.

- ④ Incentives to develop new and more cost-effective technologies to prevent or reduce pollution and monitor results.

- ④ In some cases, independent watershed groups are allowed to purchase pollutant discharge credits, essentially retiring them. This also leads to an overall improvement in water quality, since it reduces the amount of overall effluent that can be discharged.

Current Massachusetts wastewater regulations do not expressly authorize nutrient trading as a wastewater management tool. However, a small number of treatment plant permits (NPDES and ground water discharge) in the state have included nutrient offsets, which is one form of trading. *(See Appendix I for more information and case studies of nutrient trading in Massachusetts and other states.)*

DEP encourages communities to explore all approaches to nutrient trading in combination with other management tools, using EPA's publications as guidelines. DEP will work with communities to evaluate nutrient trading approaches that meet their needs, and plans to evaluate the role of nitrogen trading tools within Massachusetts wastewater regulations.

### Nutrient Trading, Resources and Regulations

Federal	
EPA	<p>Draft framework and other background documents: <a href="http://www.epa.gov/owow/watershed/framwork.html">http://www.epa.gov/owow/watershed/framwork.html</a></p> <p>Office of Water: Final Water Quality Trading Policy, January 13, 2003: <a href="http://www.epa.gov/owow/watershed/trading/finalpolicy2003.html">http://www.epa.gov/owow/watershed/trading/finalpolicy2003.html</a></p> <p>Environomics: <i>A Summary of U.S. Effluent Trading and Offset Projects</i>, November 1999: <a href="http://www.environomics.com/Effluent-Trading-Summaries_Environomics.pdf">http://www.environomics.com/Effluent-Trading-Summaries_Environomics.pdf</a></p>
Other	
National Wildlife Federation	<p>Northbridge Environmental: <i>Overview of Water Pollution Trading in Massachusetts</i>, June 2001. Printed copies are available from DEP.</p> <p><i>A New Tool for Water Quality. Making Watershed-Based Trading Work for You</i>, June 1999: <a href="http://www.nwf.org/watersheds/newtool.html">http://www.nwf.org/watersheds/newtool.html</a></p>
World Resources Institute (WRI)	<p><i>Fertile Ground. Nutrient Trading's Potential to Cost-Effectively Improve Water Quality, 2000</i> <a href="http://www.wri.org/wri/water/nutrient.html">http://www.wri.org/wri/water/nutrient.html</a></p> <p>WRI web site that tracks trades and provides historical information on past trades: <a href="http://www.nutrientnet.org/">http://www.nutrientnet.org/</a></p>

*a. glossary*



*b. resources and regulations*



*c. embayments in the massachusetts  
estuaries project*



*d. massachusetts surface water quality standards*



*e. massachusetts groundwater quality standards*



*f. linked model approach to calculating  
nitrogen thresholds*



*g. legal framework for management districts*



*h. examples of management districts in  
massachusetts*



*i. nutrient trading: information and case studies*



**Activated Sludge** - An aerobic, biological wastewater treatment process which uses the metabolic reactions of microorganisms to treat effluent.

**Aerobic** – Condition where free oxygen is present.

**Algae Blooms** - A growth of algae resulting from excessive nutrient (nitrogen or phosphorus) levels or other physical and chemical conditions that enable algae to reproduce rapidly. The overgrowth of algae can form scums and mats, and reduce the amount of oxygen as they decay.

**Anaerobic** – Condition where free oxygen is not present or is unavailable.

**Anthropogenic** – Of, relating to, or resulting from the influence of human beings on nature.

**Aquifers** – Geologic formations (rock, sand, or gravel) that are saturated and sufficiently permeable to yield significant quantities of water.

**Attenuate** – Reduce the force or amount or magnitude.

**Benthic** – Occurring at the bottom of the sea or lake (e.g., benthic organisms).

**Benthic Regeneration** – The regrowth of organisms on lake or sea floors.

**Best Management Practices (BMPs)**– Conservation practices to reduce nonpoint and point pollution from sources such as construction, agriculture, timber harvesting, marinas, and stormwater.

**Biodiversity** – Biological diversity in an environment as indicated by the numbers of different species of plants and animals.

**Biological Assimilation** – The process in which nourishment is absorbed into living tissue.

**Biological Mediated Denitrification or Biologically Mediated Denitrification** - The removal of nitrogen (nitrates, **nitrites**) via natural (microbial) processes resulting in the release of nitrogen gas into the air.

**Biomass** – A measure of the amount of living matter per unit area or volume of habitat.

**Biota** - A community of plant and animal organisms.

**BoH** - Board of Health.

**Cluster System** – A wastewater collection and treatment system where two or more facilities, but less than an entire community, is served.

**CMR** – Code of Massachusetts Regulations.

**Combined Sewer Overflow (CSO)** – A sewer pipe or system through which both sanitary wastewater and stormwater flows. During significant precipitation events, stormwater is mixed with sanitary flow, may bypass wastewater treatment, and can be released to a receiving waterbody without treatment.

**Critical Resource Area** – Localities that have been judged to be essential to the ecological well-being of the environment. They are subject to protection under MGL c. 131.

**Cultural eutrophication** – The accelerated aging process of waterbodies resulting from human sources of nutrients that stimulate the growth of aquatic plants and lead to the depletion of dissolved oxygen.

**CWA** - Federal Clean Water Act.

**CZM** – Massachusetts Office of Coastal Zone Management.

**Deposition** – The process by which pollutants absorbed by the atmosphere are released to land or water through precipitation or wind.

**Depuration** - Process of flushing toxins from shellfish before they are sold by holding them in tanks of clean water for a fixed amount of time.

**Down Gradient** - The direction that ground water flows; similar to “downstream” for surface water.

**Ecosystem** – The system of living organisms that interact with one another and their physical environment, functioning as an ecological unit.

**Effluent** – Treated or untreated wastewater from a treatment facility or unit that is discharged into the environment.

**Effluent Trading** – Strategies/tools to reduce problem pollutants in rivers and streams, lakes, estuaries, and coastlines. Trading allows a wastewater treatment plant, factory, or other facilities that discharge waste into a waterbody to purchase controls of a particular pollutant elsewhere in the watershed, instead of installing tighter controls for that pollutant at the plant or factory.

**Embayment** – A bay or a conformation resembling a bay. The terms embayment and estuary are used interchangeably in this Guidance.

**EOEA** – The Executive Office of Environmental Affairs.

**EPA** – The United States Environmental Protection Agency.

**Estuary** – Partially enclosed body of water that consists of fresh and saltwater where the tide meets the river’s current. (*see embayment*)

**Eutrophication** – A waterbody’s natural aging process due to enrichment in dissolved nutrients that stimulate the growth of aquatic plant life, usually resulting in the depletion of dissolved oxygen.

**Flushing Rates** – The time it takes for an entire volume of water to be exchanged, usually expressed in days or years.

**GPD** – Gallons Per Day.

**Ground Water** – Water below the land surface in a saturated zone.

**Ground Water Discharge Permit Program**– 314 CMR 5.00 establishes that discharges of pollutants to the ground waters of the Commonwealth will be regulated by DEP pursuant to MGL c.21, § 43, and that the outlets for these types of discharges and the treatment works associated with these discharges also be regulated by DEP.

**Habitat** – An environment in which plants and animals live, feed, find shelter, and reproduce.

**Holding Time** - Amount of time needed in a septic tank to allow for some decomposition of solids.

**Infiltration** - Downward movement of water through soil.

**Innovative/Alternative (I/A) Systems** - Advanced on-site wastewater treatment and disposal systems that provide additions or alternatives to one or more of the components of a conventional system while providing at least an equivalent degree of environmental and public health protection. I/A systems are becoming more widely used, particularly for cost-effective upgrades of failing systems on difficult sites that cannot accommodate a conventional system. I/A technologies also are used for enhanced treatment to reduce nitrogen in nitrogen sensitive areas.

**Integrated Water Resources Management Planning**– Process to evaluate all technical and management aspects of water and wastewater resources needed for ecological and human health and develop a strategy to meet these needs.

**Interim Wellhead Protection Areas (IWPA)**– Applicable to public water systems using wells or wellfields that lack DEP-approved Zone IIs. The IWPA is a half-mile radius measured from the well or wellfield for sources whose approved pumping rate is 100,000 gallons per day or greater.

**Invasive Species** – Aggressive and spreading plants or animals that do not naturally occur in a specific area and whose introduction may cause economic or environmental harm.

**Local Residence Time** - Average time for water to migrate from a point in a sub-embayment to a point outside the sub-embayment.

**Mass Balance** – Standard engineering and scientific calculations based on the law of conservation of mass.

**Massachusetts Clean Waters Act** – MGL c.21, § 26-53, which prohibits the discharge of pollutants to waters of the Commonwealth without a permit, unless exempted by regulation.

**MDC** - Massachusetts Metropolitan District Commission.

**Mean High Water** – A tidal datum. The mean of all the high water heights observed over the National Tidal Datum Epoch (*see National Tidal Datum Epoch*).

**Mean Low Water** - A tidal datum. The mean of all the low water heights observed over the National Tidal Datum Epoch. (*see National Tidal Datum Epoch*).

**MEP** – Massachusetts Estuaries Project.

**MEPA** – Massachusetts Environmental Policy Act.

**Mg/L** – Milligrams Per Liter.

**MGD** – Million Gallons Per Day.

**MGL** – Massachusetts General Laws.

**Mitigate** – To take corrective action to eliminate pollution or reduce its impact.

**MPN** - Most probable number.

**National Pollutant Discharge Elimination System (NPDES)** - A federal permit program established in 1972 by the Federal Water Pollution Control Act, known as the Clean Water Act. NPDES regulates the discharge of pollutants into waterbodies. Massachusetts is not authorized to administer the NPDES program.

**National Tidal Datum Epoch** - The 19-year period adopted by the National Ocean Service as the official time segment over which tide observations are taken and reduced to obtain mean values for mean low water and mean high water.

**Natural Attenuation** – Using a naturally occurring system (wetland or pond) to reduce the amount of nitrogen impact on an estuary.

**NEIWPCC** – The New England Interstate Water Pollution Control Commission.

**Nitrate** – Component of fertilizer. Considered a broad indicator of the contamination of groundwater. The nitrogen species in marine systems that is most responsible for eutrophication.

**Nitrite** – A salt or ester of nitrous acid. An intermediate oxidation state of nitrogen, between nitrate and ammonia.

**Nitrogen Cycle** – Continuous cyclic progression of chemical reactions in which atmospheric nitrogen is compounded, dissolved in rain, deposited in the soil, assimilated and metabolized by bacteria and plants, and returned to the atmosphere by organic decomposition.

**Nitrogen Loading** - The input of nitrogen to estuaries and embayments from natural and anthropogenic sources.

**Nitrogen Threshold** - Maximum amount of nitrogen that an estuary or embayment can assimilate without adversely changing its character and use. Also known as the critical nitrogen limit.

**Nonpoint Source** – Pollution from many diffuse sources that is carried to surface waters by runoff or ground water. Nonpoint source pollution is typically caused by sediment, nutrients, and organic and toxic substances originating from land-use activities and/or the atmosphere.

**NSFC** – National Small Flows Clearing House.

**Nutrient Sink** – Waterbodies/wetlands that hold nutrients in the water column or in the sediments, making them either temporarily or permanently unavailable for biological processes.

**Nutrient Trading** - Strategies/tools to reduce problem pollutants in rivers and streams, lakes, estuaries, and coastlines. Trading allows a wastewater treatment plant, factory, or other facilities that discharge waste into a waterbody to purchase controls of a particular pollutant elsewhere in the watershed, instead of installing tighter controls for that pollutant at the plant or factory.

**Nutrients** – Any substance required by plants and animals for normal growth and maintenance e.g., nitrogen and phosphorus.

**Off-Line** - Stormwater treatment systems designed to retain a standing volume of stormwater to allow for a physical settling of suspended particles and for other biological and chemical treatment processes to occur.

**On-Line** - Stormwater treatment systems designed to treat stormwater at a designated flow rate. The retention time in these systems is very short.

**On-Site Treatment and Disposal System** – A natural system or mechanical device used to collect, treat, and discharge or reclaim wastewater from an individual dwelling without the use of community-wide sewers or a centralized treatment facility. It includes a septic tank and a leach field.

**Organic pollutants** – Carbon-based pollutants such as proteins, carbohydrates, and fats and oils, present in wastewater.

**Pathogen** – An agent such as a virus, bacterium, or fungus capable of causing disease.

**Point Source** – Pollution from discernable, confined, and concrete conveyances, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling rock, concentrated animal feeding operation, vessel or other floating craft from which pollutants are or may be discharged. This term does not include return flows from irrigation agriculture.

**Pollutants** – Any element or property of sewage, agricultural, industrial, or commercial waste, runoff, leachate, heated effluent, or other matter in whatever form, and whether originating at a point or nonpoint source, that is or may be discharged, drained, or otherwise introduced into any sewage system, treatment works, or waters of the Commonwealth.

**Pollution Trading** – A regulatory tool that allows pollution sources to reallocate responsibilities for pollution reduction among themselves and find the most cost-effective reduction measures in order to meet regulatory requirements.

**POTW** – Publicly Owned Treatment Works.

**PPM** – Parts Per Million.

**Recharge** – The return of water to an underground aquifer by natural or artificial means.

**Remediation** – Corrective action taken to eliminate pollution or reduce its impact.

**Residence Times** – The average time required for a particle of water or pollutant to migrate through an estuary.

**Rotating Biological Contactor (RBC)** - Wastewater treatment technology that uses bacteria grown on partially submerged plates to treat effluent.

**Salinity** – The measure of the salt content of water.

**Sediment** – Mineral and organic material that settles from suspension in the water column.

**Septic tank** – A buried tank designed to receive and pretreat wastewater from individual homes by separating settleable and floatable solids from wastewater. A component of an on-site wastewater treatment and disposal system.

**Sequencing Batch Reactor (SBR)** - Wastewater treatment technology in which aeration and clarification are carried out sequentially in the same tank.

**Sessile** - Describing a marine or freshwater organism that is permanently attached to another surface.

**Sewage** – The water-carried human or animal wastes from residences, buildings, industrial establishments, or other places, together with such ground water infiltration and surface water as may be present.

**SMAST** – The University of Massachusetts School of Marine Science and Technology.

**Soil Absorption System (SAS)** – System of trenches, chambers, pits, fields, or beds, and distribution lines that receives effluent from a septic tank and transmits it to the soil for treatment in a biological mat and subsequent disposal to the underlying soils.

**State Revolving Fund (SRF)** – This program assists towns, cities, and wastewater districts in the financing of water pollution abatement projects. There are two types of funding through this program: the **Clean Water** and **Drinking Water** State Revolving Fund grants (**CWSRF** and **DWSRF**). The clean water fund supports low interest loans to help communities build/upgrade wastewater facilities. The drinking water fund supports low interest loans to help communities build/upgrade water treatment systems.

**Sub-embayment** - Cove within an embayment.

**Surface Water** - All waters other than ground waters within the jurisdiction of the Commonwealth, including, without limitation, rivers, streams, lakes, ponds, springs, impoundments, estuaries, wetlands, coastal waters and vernal pools.

**System Residence Time** - Average time for water to migrate through an entire estuarine system.

**Tidal Flushing** – The exchange of water from an estuarine system to the waterbody into which it empties.

**Total Maximum Daily Load (TMDLs)** – The greatest amount of a pollutant that a waterbody can accept and still meet water quality standards for protecting public health and maintaining the designated beneficial uses of those waters for drinking, swimming, recreation, and fishing.

**Turbidity** – A measure of soil or organic particles that cloud the water and do not allow light rays to pass through.

**Water Column** – The open-water environment, as distinct from the bed or shore, that may be inhabited by marine or fresh water organisms.

**Water Quality** – Pertaining to the presence and amount of pollutants in water.

**Wetlands Protection Act (WPA)** – MGL c. 131, § 40. Under the provisions of the Act, no person may remove, fill, dredge, or alter certain resource areas without first filing a Notice of Intent and obtaining an Order of Conditions. The Act requires that the Order contain conditions to contribute to the following interests: protection of public and private surface and ground water supply, flood control, storm damage prevention, prevention of pollution, protection of fisheries, land containing shellfish, and protection of wildlife habitat.

**WWTP** – Wastewater Treatment Plant.

**Zone II** – That area of an aquifer that contributes water to a well under the most severe pumping and recharge conditions that can be anticipated. See 310 CMR 22.00 for a more detailed regulatory definition: <http://www.state.ma.us/dep/brp/dws/files/310cmr22.pdf>

Documents in this Appendix are categorized by source: state, federal, and other. Documents are listed in the order in which they appear in the body of the Guidance.

*Copies of regulations on DEP's web site are not the "Official Version" of Commonwealth regulations. In particular, they lack page numbers and the effective dates at the bottom of each page. Other unexpected differences may also be present. HTML versions are offered as a convenience to our users and DEP believes that the body of the text is a faithful copy of the regulations. If readers must know that the version being used is absolutely correct and up-to-date, they must purchase the document through the State Bookstore (at <http://www.state.ma.us/sec/spr/spridx.htm>). The official versions of all state statutes and regulations are only available through the State Bookstore.*

### State Regulatory Programs and Resources

Home page for the MEP, including maps and background articles: <http://www.state.ma.us/dep/smerp/smerp.htm>.

State Bookstore: Room 116, State House, Boston, MA 02133 617/727-2834; <http://www.state.ma.us/sec/spr/spridx.htm>

Surface Water Quality Standards, 314 CMR 4.0: <http://www.state.ma.us/dep/bwp/iww/files/314004.pdf>

Surface Water Discharge Permit Program, 314 CMR 3.00: <http://www.state.ma.us/dep/bwp/iww/files/314cmr3.htm>

Ground Water Quality Standards, 314 CMR 6.00: <http://www.state.ma.us/dep/bwp/iww/files/314006.pdf>

Ground Water Discharge Permit Program, 314 CMR 5.00: <http://www.state.ma.us/dep/bwp/iww/files/314005.pdf>

Comprehensive Wastewater Management Planning. Current guidance (1996): <http://www.state.ma.us/dep/brp/mf/files/fpintro.htm>.

Grant and Loan Programs: Opportunities for Watershed Protection, Planning and Implementation, updated November 2002: <http://www.state.ma.us/dep/brp/mf/files/glprgm.pdf>

Clean Water State Revolving Loan Fund: <http://www.state.ma.us/dep/brp/mf/cwsrf.htm>

Waterways Program, Chapter 91 License, 310 CMR 9.00, Chapter 91: <http://www.state.ma.us/dep/brp/waterway/ch91regs.htm>

401 Water Quality Certification, 314 CMR 9.00: <http://www.state.ma.us/dep/bwp/iww/files/314009.pdf>

Notice of Intent, Wetlands Protection Act, 310 CMR 10.00: <http://www.state.ma.us/dep/brp/ww/files/310cmr10.pdf>

Current Dredging Regulations: 401 Water Quality Certification, 314 CMR 9.00: <http://www.state.ma.us/dep/bwp/iww/files/314009.pdf>. Contact DEP for updated interim procedures on dredging and management of dredged sediments.

Massachusetts Environmental Policy Act: MEPA Certificate, 301 CMR 11.00: <http://www.state.ma.us/envir/mepa/thirdlevelpages/meparegulations/301cmr11.pdf>

Coastal Zone Management (CZM) Federal Consistency Review Procedures, 301 CMR 21.00: <http://www.state.ma.us/czm/fcr.htm>

Stormwater Management: Policy (Vol I) and Technical Handbook (Vol II), 1997. <http://www.state.ma.us/dep/brp/stormwtr/stormpub.htm>

Policy for Abatement of Pollution from Combined Sewer Overflows: <http://www.state.ma.us/dep/brp/brppols.htm> (Surface Water Section)

EOEA, Strategic Envirotechnology Partnership (STEP) Reports and Fact Sheets on innovative stormwater treatment systems: <http://www.stepsite.org/progress/reports/>

Wetland Program: <http://www.state.ma.us/dep/brp/ww/rpwwhome.htm>

Wetlands Protection Act Regulations, 310 CMR 10.00: <http://www.state.ma.us/dep/brp/ww/files/310cmr10.pdf>

EOEA, Massachusetts Wetlands Restoration Program: <http://www.state.ma.us/envir/mwrp/index.htm>

Title 5 Program: <http://www.state.ma.us/dep/brp/wwm/t5pubs.htm#it>

Title 5: Standard Requirements for ... On-Site Sewage Treatment and Disposal Systems and for the Transport and Disposal of Septage, 310 CMR 15.00: <http://www.state.ma.us/dep/brp/files/310cmr15.pdf>

Certification of Operators of Wastewater Treatment Facilities, 257 CMR 2.00: <http://www.state.ma.us/dep/bwp/iww/files/257cmr2.htm>

*Guidelines for the Design, Construction, Operation and Maintenance of Small Sewage Treatment Facilities with Land Disposal*, 1988. Contact DEP for a copy.

Water conservation information: <http://www.state.ma.us/dep/brp/dws/conserv.htm>

Interim Guidelines on Reclaimed Water: <http://www.state.ma.us/dep/brp/wwm/files/reuse.pdf>

EOEA, Community Preservation Initiative: <http://commpres.env.state.ma.us/>

MDC: *Growth Management Tools: A Summary for Planning Boards in Massachusetts*, August 2002. <http://www.state.ma.us/mdc/MDC%20Growth%20Management%20Tools.pdf>

Rivers Protection Act, 1996 amendment to the Wetlands Protection Act: <http://www.state.ma.us/dep/brp/ww/files/riveract.htm>.

## Federal Regulatory Programs and Resources

Total Maximum Daily Load Program: <http://www.epa.gov/OWOW/tmdl/>

National Pollutant Discharge Elimination System (NPDES): [http://cfpub1.epa.gov/npdes/stormwater/swphase2.cfm?program\\_id=6](http://cfpub1.epa.gov/npdes/stormwater/swphase2.cfm?program_id=6); <http://cfpub.epa.gov/npdes/>; <http://www.epa.gov/region01/npdes/>

Army Corps of Engineers (ACOE), Permit Authorization under Section 10, Rivers and Harbors Act: <http://www.spk.usace.army.mil/cespk-co/regulatory/regs/start.html>

Wetlands Program, Office of Water: <http://www.epa.gov/owow/wetlands/>

Guidance on Constructed Wetlands: <http://www.epa.gov/owow/wetlands/watersheds/cwetlands.html>

Water efficiency programs: <http://www.epa.gov/owm/water-efficiency/index.htm>

Draft framework for watershed-based permitting and other background documents: <http://www.epa.gov/owow/watershed/framwork.html>

Office of Water: Final Water Quality Trading Policy, January 13, 2003: <http://www.epa.gov/owow/watershed/trading/finalpolicy2003.html>

National Small Flows Clearinghouse: <http://www.nesc.wvu.edu/nsfc/>

## Other Resources

New England Interstate Water Pollution Control Commission: *Document TR-16: Guides for the Design of Wastewater Treatment Works*, 1988 Edition: <http://www.neiwpcc.org/publication.html#16>

Marine Studies Consortium, M.T. Hoover: *A Framework for Site Evaluation, Design, and Engineering of On-Site Technologies Within a Management Context*, 1997. Executive Summary: <http://www.brandeis.edu/marinestudies/risk.html>

Entire Report: <http://www.state.ma.us/dep/brp/wwm/files/hovered.doc>

Pioneer Valley Planning Commission: *How to Create a Stormwater Utility*, 1999: [http://www.pvpc.org/docs/landuse/pubs/storm\\_util.pdf](http://www.pvpc.org/docs/landuse/pubs/storm_util.pdf)

Northbridge Environmental: *Overview of Water Pollution Trading in Massachusetts*, June 2001. Printed copies are available from DEP.

Environomics: *A Summary of U.S. Effluent Trading and Offset Projects*, November 1999:

[http://www.environomics.com/Effluent-Trading-Summaries\\_Environomics.pdf](http://www.environomics.com/Effluent-Trading-Summaries_Environomics.pdf)

National Wildlife Federation: *A New Tool for Water Quality. Making Watershed-Based Trading Work for You*, June 1999: <http://www.nwf.org/watersheds/newtool.html>

World Resources Institute (WRI): *Fertile Ground. Nutrient Trading's Potential to Cost-Effectively Improve Water Quality, 2000.* [www.wri.org/wri/water/nutrient.html](http://www.wri.org/wri/water/nutrient.html)

WRI Web site: <http://www.nutrientnet.org/>

# Appendix C

# 2003

Embayments in the  
Massachusetts Estuaries Project

Massachusetts  
Estuaries Project

## Community

Duxbury

Plymouth

Fall River, Somerset, Swansea, Dighton, Rehoboth,  
Seekonk

24 communities: Taunton, Avon, Berkley,  
Bridgewater, Brockton, Dighton, East Bridgewater,  
Easton, Franklin, Foxborough, Freetown, Halifax,  
Hanson, Lakeville, Mansfield, Middleborough, Norton,  
Plympton, Raynham, Sharon, Somerset, Stoughton,  
West Bridgewater, Whitman

Westport  
Dartmouth

Dartmouth/New Bedford  
New Bedford/Dartmouth/Fairhaven  
New Bedford/Fairhaven/Acushnet  
Fairhaven  
Mattapoissett  
Marion/Mattapoissett  
Marion  
Wareham

Wareham/Plymouth

Wareham/Plymouth/Bourne

## Watershed and Embayment

### South Coastal Watershed

Duxbury Harbor  
Ellisville Harbor  
Plymouth Harbor/Eel River

### Mt Hope Bay & Taunton River Watersheds

Mt Hope Bay

Taunton River System

### Buzzards Bay Watershed

Westport River - East & West Branch  
Slocums River  
Little River  
Apponagansett Bay  
New Bedford Harbor (Outer)/Clarks Cove  
Acushnet River/New Bedford Inner Harbor  
Nasketucket Bay/Little Bay  
Mattapoissett Harbor/Eel Pond  
Aucoot Cove  
Sippican Hbr/Hammett Cv/Blankenship/Planting Island  
Weweantic River  
Onset Bay/Shell Pt. Bay/Broad Cove  
Wareham River System (+Marks Cove)  
Agawam River/Wankinco River/Broad Marsh

Buttermilk & Little Buttermilk Bays

Community

Watershed and Embayment

Cape Cod & Islands Watershed -- Cape Cod

Bourne

Phinney's Harbor  
Back River/Eel Pond  
Pocasset River

Falmouth/Bourne  
Falmouth

Pocasset Harbor/Hen Cove/Red Brook Hbr  
Megansett Harbor/Squeteague  
Wild Harbor  
Rands Canal  
Fiddlers Cove  
West Falmouth Harbor  
Quissett Harbor  
Oyster Pond  
Salt Pond  
Falmouth Harbor  
Little Pond  
Great/Perch Pond  
Green Pond  
Bournes Pond  
Eel River, Falmouth  
Waquoit Bay-Proper  
Childs River

Mashpee  
Mashpee/Barnstable  
Barnstable

Hamblin Pond/Jehu Pond/Quashnet River  
Popponesset Bay  
Rushy Marsh  
Three Bays  
East Bay/Centerville River/Halls Creek

Barnstable/Yarmouth

Lewis Bay System  
– Hyannis Harbor  
– Snows Creek  
– Lewis Bay

Yarmouth/Dennis  
Harwich

Bass River  
Saquatucket Harbor  
Allen Harbor  
Herring River  
Wychmere Harbor  
Swan Pond/River  
Taylors Pond  
Muddy Creek

Dennis  
Chatham/Harwich

Community

Chatham

Chatham

Orleans/Harwich/Brewster  
Orleans/Eastham

Sandwich

Barnstable  
Dennis  
OrleansWellfleet  
Truro  
Provincetown

Gosnold

Chilmark  
Chilmark/West Tisbury  
Chilmark/AquinaTisbury  
Tisbury/Oak Bluffs  
West Tisbury

Edgartown

Watershed and EmbaymentSulfur Spring/Bucks Creek  
Stage Harbor System

Bassing Harbor/Ryders Cove/Frost Fish Creek

Chatham Harbor  
Upper Pleasant Bay  
Nauset Marsh  
Sandwich Harbor  
Scorton Creek  
Barnstable Harbor/Great Marshes  
Sesuit Harbor  
Namskaket Creek  
Little Namskaket Creek  
Rock HarborWellfleet Harbor  
Pamet Harbor  
Provincetown Harbor  
Hatches Harbor  
Cuttyhunk Harbor  
West End Pond, Cuttyhunk  
Penikese Island HarborCape Cod & Islands Watershed -- Martha's VineyardBlack Point Pond  
Tisbury Great Pond  
Chilmark Great Pond  
Squibnocket Pond  
Menemsha Pond  
Tashmoo  
Lagoon Pond  
James PondLong Cove Pond  
Katama Bay/Edgartown Harbor  
Cape Pogue Pond/Pochet Pond/Calebs Pond  
Edgartown Great Pond

Community

Edgartown/Oak Bluffs

Nantucket

Watershed and Embayment

Oyster Pond  
Sengekontacket Pond/Trapps Pond/Majors Cove

Cape Cod & Islands Watershed --  
Nantucket

Nantucket Harbor  
Sesechacha Pond  
Madaket Harbor  
Long Pond  
Hummock Pond

# Appendix D

2003

Massachusetts Surface Water  
Quality Standards

Massachusetts  
Estuaries Project

The Massachusetts Surface Water Quality Standards in 314 CMR 4.00 (<http://www.state.ma.us/dep/bwp/iww/files/314004.pdf>) set forth classifications for coastal and marine waters. These classifications apply standards that are both quantitative and descriptive and, at a minimum, require “good aesthetic value.” The three classes are SA, SB and SC. A description of each follows.

### Class SA

314 CMR 4.04(4)(a): “These waters are designated as an excellent habitat for fish, other aquatic life and wildlife and for primary and secondary contact recreation. In approved areas, they shall be suitable for shellfish harvesting without **depuration** (Open Shellfish Areas). These waters shall have excellent aesthetic value.” Class SA standards for specific parameters are in the table below:

Parameter	Standard
Dissolved Oxygen	a. Not less than 6.0 mg/L unless background conditions are lower. b. Natural seasonal and daily variations above this level shall be maintained; levels shall not be lowered below 75% of saturation due to a discharge. c. Site-specific criteria may apply where background conditions are lower than specified levels, or to the bottom stratified layer where the Director determines that the designated uses are not impaired.
Temperature	Shall not exceed 85°F or a maximum daily mean of 80°F. A rise in temperature due to a discharge shall not exceed 1.5° F.
pH	Shall be in the range of 6.5 through 8.5 standard units and not more than 0.2 units outside the normally occurring range.
Fecal Coliform	a. Waters approved for shellfishing shall not exceed a geometric mean <b>MPN</b> of 14 colonies/100 mL, nor shall more than 10% of the samples exceed an MPN of 43 colonies/100 mL. b. Waters not designated for shellfishing shall not exceed a geometric mean MPN of 200 colonies/100 mL, nor shall more than 10% of the samples exceed an MPN of 400 colonies/100 mL.
Solids	Shall be free from floating, suspended and settleable solids in concentrations or combinations that would impair any use assigned to this class, that would cause any objectionable conditions or that would impair the <b>benthic biota</b> or degrade the chemical composition of the bottom.
Color and Turbidity	Shall be free from color and turbidity in concentrations or combinations that are aesthetically objectionable or would impair any use assigned to this class.
Oil and Grease	Shall be free from oil and grease and petrochemicals.
Taste and Odor	None other than of natural origin.

**Class SB**

314 CMR 4.05(4)(b): “These waters are designated as a habitat for fish, other aquatic life and wildlife and for primary and secondary contact recreation. In approved areas they shall be suitable for shellfish harvesting with depuration (Restricted Shellfish Areas). These waters shall have consistently good aesthetic value.” Class SB standards for specific parameters are in the table below:

Parameter	Standard
Dissolved Oxygen	a. Not less than 5.0 mg/L unless background conditions are lower. b. Natural seasonal and daily variations above this level shall be maintained; levels shall not be lowered below 60% of saturation due to a discharge. c. Site-specific criteria may apply where background conditions are lower than specified levels, or to the bottom stratified layer where the Director determines that the designated uses are not impaired.
Temperature	Shall not exceed 85°F or a maximum daily mean of 80°F. The rise in temperature due to a discharge shall not exceed 1.5°F during the summer months (July through September) or 4°F during the winter months (October through June).
pH	Shall be in the range of 6.5 through 8.5 standard units and not more than 0.2 units outside the normally occurring range.
Fecal Coliform	a. Waters approved for shellfishing shall not exceed a geometric mean MPN of 88 colonies/100 mL, nor shall more than 10% of the samples exceed an MPN of 260 colonies/100 mL. b. Waters not designated for shellfishing shall not exceed a geometric mean MPN of 200 colonies/100 mL, nor shall more than 10% of the samples exceed an MPN of 400 colonies/100 mL.
Solids	Shall be free from floating, suspended and settleable solids in concentrations or combinations that would impair any use assigned to this class, that would cause any objectionable conditions, or that would impair the benthic biota or degrade the chemical composition of the bottom.
Color and Turbidity	Shall be free from color and turbidity in concentrations or combinations that are aesthetically objectionable or would impair any use assigned to this class.
Oil and Grease	Shall be free from oil and grease and petrochemicals that produce a visible film on the surface of the water, impart an oily taste to the water or an oily or other undesirable taste to the edible portions of aquatic life, coat the banks or bottoms of the water course, or are deleterious or become toxic to aquatic life.
Taste and Odor	None in such concentrations or combinations that are aesthetically objectionable, that would impair any use assigned to this class, or that would cause tainting or undesirable flavors in the edible portions of aquatic life.

**Class SC**

314 CMR 4.05(4)(c): “These waters are designated as a habitat for fish, other aquatic life and wildlife and for secondary contact recreation. They shall also be suitable for certain industrial cooling and process uses. These waters shall have good aesthetic value.” Class SC standards for specific parameters are in the table below:

Parameter	Standard
Dissolved Oxygen	a. Not less than 5.0 mg/L at least 16 hours of any 24-hour period and not less than 4.0 mg/L at any time unless background conditions are lower. b. Natural seasonal and daily variations above this level shall be maintained; levels shall not be lowered below 50% of saturation due to a discharge. c. Site-specific criteria may apply where background conditions are lower than specified levels, or to the bottom stratified layer where the Director determines that the designated uses are not impaired.
Temperature	Shall not exceed 85°F. The increase due to a discharge shall not exceed 5°F.
pH	Shall be in the range of 6.5 through 9.0 standard units and not more than 0.5 units outside the normally occurring range.
Fecal Coliform	Shall not exceed a geometric mean of 1000 colonies/100 mL nor shall 10% of the samples exceed 2000 colonies/100 mL.
Solids	Shall be free from floating, suspended and settleable solids in concentrations or combinations that would impair any use assigned to this class, that would cause any objectionable conditions or that would impair the benthic biota or degrade the chemical composition of the bottom.
Color and Turbidity	Shall be free from color and turbidity in concentrations or combinations that are aesthetically objectionable or would impair any use assigned to this class.
Oil and Grease	Shall be free from oil and grease and petrochemicals that produce a visible film on the surface of the water, impart an oily taste to the water or an oily or other undesirable taste to the edible portions of aquatic life, coat the banks or bottoms of the water course, or are deleterious or become toxic to aquatic life.
Taste and Odor	None in such concentrations or combinations that are aesthetically objectionable, that would impair any use assigned to this class, or that would cause tainting or undesirable flavors in the edible portions of aquatic life.

The Surface Water Quality Standards apply additional minimum criteria to all surface waters:

Parameter	Standard
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.
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 <b>sessile</b> benthic organisms.
Nutrients	Shall not exceed the site-specific limits necessary to control accelerated or cultural eutrophication.
Radioactivity	All surface waters shall be free from radioactive substances in concentrations or combinations that would be harmful to human, animal or aquatic life or the most sensitive designated use.
Toxic Pollutants	All surface waters shall be free from toxic substances in concentrations or combinations that would be harmful to human, animal or aquatic life or wildlife. This includes consideration of site-specific limits, human health risk levels and accumulation of pollutants.

314 CMR 6.00 establishes the Massachusetts Ground Water Quality Standards <http://www.state.ma.us/dep/bwp/iww/files/314006.pdf>. These standards consist of ground water classifications which designate and assign the uses for which the various ground waters of the Commonwealth shall be maintained and protected. These Standards also include water quality standards necessary to sustain the designated uses and regulations necessary to achieve the designated uses or maintain the existing ground water quality.

All ground waters of the Commonwealth are assigned to Class I, II, or III based upon the most sensitive uses for which the ground water is to be maintained and protected:

Ⓢ Class I - Ground waters assigned to this class are fresh ground waters found in the saturated zone of unconsolidated deposits or consolidated rock and bed rock and are designated as a source of potable water supply.

Ⓢ Class II - Ground waters assigned to this class are saline waters found in the saturated zone of the unconsolidated deposits or consolidated rock and bed rock and are designated as a source of potable mineral waters, for conversion to fresh potable waters, as raw material for the manufacture of sodium chloride or its derivatives, or similar products.

Ⓢ Class III - Ground waters assigned to this class are fresh or saline waters found in the saturated zone of unconsolidated deposits or consolidated rock and bed rock and are designated for uses other than as a source of potable water supply. At a minimum the most sensitive use of these waters shall be as a source of non-potable water that may come in contact with, but is not ingested by, humans.

**Class I and Class II Ground Waters.** The following minimum criteria are applicable to all Class I and Class II ground waters:

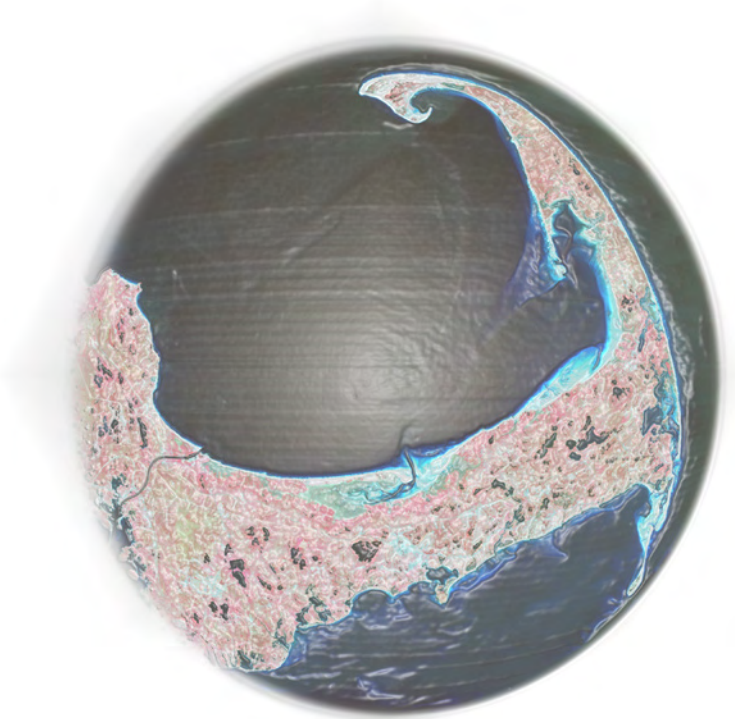
Parameter	Standard
Pathogenic Organisms	Shall not be in amounts sufficient to render the ground waters detrimental to public health and welfare or impair the ground water for use as source of potable water.
Coliform Bacteria	Shall not exceed the maximum contaminant level as stated in the National Interim Primary Drinking Water Standards.
Arsenic	Shall not exceed 0.05 mg/L
Barium	Shall not exceed 1.0 mg/L
Cadmium	Shall not exceed 0.01 mg/L
Chromium	Shall not exceed 0.05 mg/L
Copper	Shall not exceed 1.0 mg/L
Fluoride	Shall not exceed 2.4 mg/L
Foaming Agents	Shall not exceed 0.5 mg/L
Iron	Shall not exceed 0.3 mg/L
Lead	Shall not exceed 0.05 mg/L
Manganese	Shall not exceed 0.05 mg/L

**Class I and Class II Ground Waters.** The following minimum criteria are applicable to all Class I and Class II ground waters:

Parameter	Standard
Mercury	Shall not exceed 0.002 mg/L
Nitrate Nitrogen (as Nitrogen)	Shall not exceed 10.0 mg/L
Total Trihalomethanes	Shall not exceed 0.1 mg/L
Selenium	Shall not exceed 0.01 mg/L
Silver	Shall not exceed 0.05 mg/L
Sulfate	Shall not exceed 250 mg/L
Zinc	Shall not exceed 5.0 mg/L
Endrin (1,2,3,4,10, 10-hexachloro-1,7-epoxy-1,4,4a,5,6,7,8,9a-octahydro-1,4-endo,endo-5,8-dimethanonaphthalene)	Shall not exceed 0.0002 mg/L
Lindane (1,2,3,4,5,6 hexachlorocyclohexane, gamma isomer)	Shall not exceed 0.004 mg/L
Methoxychlor (1,1,1- Trichloro-2, 2-bis(p-methoxyphenyl) ethane)	Shall not exceed 0.1 mg/L
Toxaphene (C <sub>10</sub> H <sub>10</sub> C <sub>18</sub> , Technical Chlorinated Camphene, 67-69 percent chlorine)	Shall not exceed 0.005 mg/L
Chlorophenoxy:2,4-D,(2,4-Dichloro-phenoxyacetic acid)	Shall not exceed 0.1 mg/L
2,4,5-TP Silvex (2,4, 5-Trichlorophenoxy-propionic acid)	Shall not exceed 0.01 mg/L
Radioactivity	Shall not exceed the maximum radionuclide contaminant levels as stated in the National Interim Primary Drinking Water Standards.
pH	Shall be in the range of 6.5-8.5 standard units or not more than 0.2 units outside of the naturally occurring range.
All Other Pollutants	None in such concentrations which in the opinion of the Department would impair the waters for use as a source of potable water or to cause or contribute to a condition in contravention of standards for other classified waters of the Commonwealth.

**Class III Ground Waters.** The following minimum criteria are applicable to all Class III ground waters:

Parameter	Standard
Pathogenic Organisms	Shall not be in amounts sufficient to render the ground waters detrimental to public health, safety or welfare.
Radioactivity	Shall not exceed the maximum radionuclide contaminant levels as stated in the National Interim Primary Drinking Water Standards.
All Other Pollutants	None in concentrations or combinations which upon exposure to humans will cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions or physical deformations or cause any significant adverse effects to the environment, or which would exceed the recommended limits on the most sensitive ground water use.



# Appendix F

Linked Model Approach  
to Calculating Nitrogen  
Thresholds

2003

Massachusetts  
Estuaries Project

The Department of Environmental Protection has adopted a model developed at the University of Massachusetts Dartmouth School of Marine Science and Technology to calculate the capacity of estuaries to assimilate nitrogen and to run predictive scenarios to aid in planning nitrogen reductions. The model uses a linked approach to incorporate hydrodynamics (for flushing characteristics), water quality modeling (for calibration, validation and predictive scenarios), and land use modeling (to determine nitrogen inputs to the embayment or estuary from the contributing watershed). The model also accounts for regeneration of nitrogen from benthic sediments that can impart a significant seasonal impact on the nitrogen flux in a system. Once the model is calibrated and validated to show that it accurately predicts existing conditions, it is used to establish critical nitrogen thresholds that are attainable water quality targets, and to predict the impact of nitrogen reduction measures.

In establishing nitrogen thresholds, it would be ideal if we could input parameters such as dissolved oxygen, chlorophyll, light attenuation, and nitrogen (among others) and receive as an output a complete listing of the flora and fauna that could thrive in such an environment. However, this kind of ecological response model does not exist, so we have to rely on more indirect methods to determine loading limits. The two ways employed in the linked model are to use historical records or to run a “no-load” scenario.

The historical approach is the less common of the two because it relies on the rare confluence of a good historical record on both eelgrass coverage and water quality data. Eelgrass is a sentinel species indicator of pristine water quality. By correlating eelgrass coverage to nitrogen data in the same time period, we can identify the point at which the nitrogen concentration is high enough to initiate eelgrass loss and use that information to determine the nitrogen-loading limit.

The no-load scenario is the more common method of determining nitrogen-loading limits. Here, all anthropogenic sources of nitrogen are removed as model inputs under the assumption that this will yield the naturally occurring background nitrogen concentration in the water body. The specific characteristics of the watershed will dictate whether this scenario represents attainable water quality or whether there need to be allowances for nitrogen inputs in addition to those from natural sources.

It is important to realize that the model evaluates segments of an embayment and not the embayment as a whole. Therefore, there may be different nitrogen thresholds at different points in the embayment. Generally, the upper reaches of the watershed (i.e., farther from the mouth of the estuary) will exhibit poorer water quality than the lower reaches. Accordingly, attainable water quality goals may be lower for upper reaches than for lower reaches.

## Mass Balance Calculations

The principle of **mass balance** forms the basis of the SMAST model. Mass balance calculations are standard engineering and scientific equations based on the law of conservation of mass. The SMAST model calculates a mass balance for a single component, in this case nitrogen. The control volume is the total volume of water in the embayment or estuary.

The principle of mass balance may be stated as:

**Rate of accumulation within a control volume = Rate of mass input across a control volume - Rate of mass output across a control volume + Rate of reaction of mass within control volume (can be a positive or negative value)**

Or, more simply as in Equation 1 below:

**Accumulation = Input - Output + [Generation - (Consumption + Storage)]**

In the context of estuary modeling, these terms consist of the following:

☉ **Input:** nitrogen coming into the estuary from such sources as wastewater, fertilizers, stormwater and atmospheric nitrogen. The model also considers nitrogen contributions

from background boundary conditions (i.e. the ocean).

☉ **Output:** dictated by the flushing characteristics of the system and how nitrogen is physically circulated through the outlet of the system, or is retained due to circulation patterns.

☉ **Generation: benthic regeneration.**

☉ **Consumption:** natural attenuation, **biological assimilation**, and sedimentation.

☉ **Storage:** ambient nitrogen in the water column.

The Accumulation term quantifies how a constituent increases (positive accumulation), decreases (negative accumulation), or maintains a steady state (zero accumulation). In the linked model, we assume steady state conditions over the time period of the model run, because within a given year the inputs will not change significantly. The Accumulation term is set to zero to reflect the steady state assumption. With this assumption, the model will produce accurate results only if all the terms on the right side of the equation cancel each other out.

The following examples from a hypothetical embayment are a simplified illustration of mass balance calculations, analysis of the annual nitrogen load, and the impact of nitrogen-reducing measures.



## Example 1: Modeling the Nitrogen Load

We assume the embayment's watershed has an overall land area of 1000 acres (43,560,000 square feet). The waterbody itself is 500 acres (21,780,000 sq. ft.) with an average depth of 10 feet. Therefore, the total volume of the waterbody is 217,800,000 cubic feet. Precipitation averages 40 inches per year and results in an annual recharge of 20 inches. Three years of monitoring data show that the average summer concentration of total nitrogen in the embayment is 0.47 milligrams per liter (mg/L). The embayment opens out to Nantucket Sound, which has an ambient nitrogen concentration of 0.30 mg/L.

We assume nitrogen inputs from wastewater, atmospheric nitrogen, stormwater, and fertilizers based on 1000 homes in the watershed served by on-site wastewater treatment and disposal systems, a 1.0 million gallon per day wastewater treatment plant discharging 10 mg/L total nitrogen, and 6,000,000 square feet of impervious surfaces (roads, parking lots, etc.). The hydrodynamic model indicates that the input from Nantucket Sound is 750,000 pounds per year (lbs/yr) of nitrogen and the output to the Sound is 775,500 lbs/yr.

Benthic regeneration accounts for 120,000 lbs/yr, biological assimilation and sedimentation for 130,000 lbs/yr, and the rate of natural attenuation in the marsh fringes of the embayment is 20%. Because of the location of the marsh fringe, only the plume from the wastewater treatment plant is intercepted.

Calculations are based on annual loadings, as follows:

### Inputs:

#### 1. Treatment Plant Wastewater:

$$1.0 \text{ MGD} \times 10 \text{ mg/L} \times 8.34 \text{ lbs} \cdot \text{L/MG} \cdot \text{mg} \times 365 \text{ days/yr} = 30,441 \text{ lbs/yr}$$

(MGD = million gallons per day, MG = million gallons, and 8.34.L/MG.mg is a conversion factor to calculate nitrogen loadings)

#### 2. On-site Systems:

$$1000 \text{ homes} \times 2.5 \text{ persons/home} \times 5.9 \text{ lbs/person/yr} = 14,750 \text{ lbs/yr}$$

#### 3. Runoff:

There is no infiltration from impervious surfaces so we assume 40 in/yr of rainfall at 1.5 mg/L of nitrogen.

$$6,000,000 \text{ sq. ft. of impervious surface} \times 40/12 \text{ ft/yr} \times 7.48 \text{ gal/cu. ft.} \times 1.5 \text{ mg/L} \times 1 \text{ MG/1} \times 106 \text{ gal} \times 8.34 \text{ lbs} \cdot \text{L/MG} \cdot \text{mg} = 1871 \text{ lbs/yr}$$

#### 4. Fertilizer:

Each home has 2,000 sq. ft. of lawn with an application rate of 3.5 lbs/1,000 sq. ft./yr.

We assume that 10% of the nitrogen in the fertilizer leaches into the embayment.

$$0.10(1,000 \text{ homes} \times 2,000 \text{ sq. ft./home} \times 3.5 \text{ lbs/1,000 sq. ft./yr}) = 700 \text{ lbs/yr}$$

#### 5. Atmospheric Deposition:

40 in/yr of rain falls directly on the embayment. The land contribution is negligible.

$$21,780,000 \text{ sq. ft.} \times 40/12 \text{ ft/yr} \times 7.48 \text{ gal/cu. ft.} \times 0.05 \text{ mg/L} \times 1 \text{ MG/1} \times 106 \text{ gal} \times 8.34 \text{ lbs} \cdot \text{L/MG} \cdot \text{mg} = 226 \text{ lbs/yr.}$$

#### 6. Boundary Waterbody (Nantucket Sound):

We know from our hydrodynamic model that the nitrogen coming into the embayment from Nantucket Sound is 750,000 lbs/yr.

$$\text{Total input: } 30,441 + 14,750 + 1871 + 226 + 700 + 750,000 = 797,988 \text{ lbs/yr.}$$

### Output:

We know from our hydrodynamic model that the output from tidal flushing into Nantucket Sound is 775,500 lbs/yr.

**Generation:**

Direct measurement of the sediments shows that benthic regeneration is 120,000 lbs/yr.

**Consumption through Natural attenuation and Sedimentation:**

Natural attenuation will intercept the land-based nitrogen inputs at a rate of 20%.

$$0.20(30,441) = 6,088 \text{ lbs/yr}$$

Sedimentation includes biomass settling to the bottom.

Direct measurement shows this term to be 130,000 lbs/yr.

**Storage:**

Storage is the ambient load of nitrogen in the water column, which we can determine based on the ambient nitrogen concentration of 0.47 mg/L.

$$(0.47 \text{ mg/L} \times 217,800,000 \text{ cu ft} \times 7.48 \text{ gal/cu ft} \times 1 \text{ MG/1} \times 106 \text{ gal} \times 8.34 \text{ lbs} \cdot \text{L/MG} \cdot \text{mg})/\text{yr} = 6,386 \text{ lbs/yr}$$

To calculate the mass balance of nitrogen in the embayment system, we insert the above numbers into our mass balance equation (Equation 1):

$$\text{Accumulation} = \text{Input} - \text{Output} + [\text{Generation} - (\text{Consumption} + \text{Storage})]$$

Because the model assumes a steady state system, the Accumulation term is zero. Therefore, we can rearrange the equation to place the storage term on the left side in order to check that storage equals all the other terms on the right side.

$$\text{Storage} = \text{Input} - \text{Output} + \text{Generation} - \text{Consumption}$$

$$6,386 = 797,988 - 775,500 + 120,000 - (130,000 + 6,088)$$

$$6,386 \sim 6,400$$

The two terms agree within 1% of each other, so we are satisfied that the mass balance calculations accurately represent conditions in the watershed.

## Conclusions from Mass Balance Calculations

We can derive several insights from Example 1. The most obvious is that, even in this simplified example, the linked model is a complex procedure that relies heavily on site-specific measurements within individual embayments. Components such as benthic regeneration, sedimentation, and biological assimilation cannot be accurately modeled and require data collected from the embayment system. Hydrodynamic behavior within an embayment system requires a sophisticated computer program to model the circulation patterns, which allow us to predict certain loading terms. Hydrodynamic modeling is also key in the calibration and validation steps of the final model output.

Second, the quality of the waterbody into which the embayment empties sets the lowest limit of ambient nitrogen that can be obtained; hence its designation as the boundary condition. In Example 1, this limit is 0.30 mg/L in Nantucket Sound, which is the “feeder” water for the embayment. We cannot expect to reduce nitrogen levels below 0.30 mg/L.

Third, we can see which sources of nitrogen we can control and those that we cannot. If we need to limit nitrogen inputs, our choices are obviously limited to those we can control. We can also analyze the proportional contribution from each source. Example 1 shows that the greatest input of nitrogen is in the tidal exchange

coming in from Nantucket Sound, an input we cannot control. The next largest input is wastewater from the treatment plant and on-site systems, which are sources that we can control. In the majority of cases, source reduction efforts will focus on wastewater, because this is the most significant source of nitrogen that we can realistically expect to reduce.

Fourth, discharge locations are very important. In Example 1, the discharge from the wastewater treatment plant is eligible for the 20% credit for natural attenuation, because the salt marsh fringe intercepts the plume. If the marsh fringed the entire embayment, the 20% credit for natural attenuation could apply to more sources of nitrogen. In virtually all watersheds, there are marsh areas that can attenuate nitrogen loadings, but typically they do not extend along the entire shoreline of the embayment. Thus, it is important to locate discharges where natural attenuation can be maximized.

Fifth, tidal flushing significantly affects nitrogen-loading dynamics. The mass balance equation in Example 1 is dominated by the tidal flushing of the embayment system. Tidal input accounts for 750,000 lbs/yr of nitrogen, and 775,500 lbs/yr are flushed out on the tide. Given that the nitrogen concentration is higher in the embayment than in Nantucket Sound and there is a 25,500 lbs/yr difference between the input and output, it would appear that there is significant system residence time in the embayment. The figures further suggest that the outlet to the Sound may be restricted. Appropriate steps for outlet management, which may include dredging, inlet alteration, or culvert improvements, could possibly improve the flushing of the system and increase the amount of nitrogen transported out of the embayment. This may be a lower cost option than improved wastewater treatment or other source reduction measures.

The preceding exercise shows how each element in the linked model contributes to the condition of an embayment and which nitrogen sources are appropriate candidates for reduction efforts. However, before those decisions can be made, we have to know the ambient nitrogen level that will support a healthy ecosystem and how much nitrogen needs to be removed from the watershed.

The ultimate aim of a nitrogen management plan is to restore a eutrophic embayment or estuary to ecological health or to prevent eutrophication in the first place. The ambient water quality in our example, 0.47 mg/L total nitrogen, is not generally indicative of a healthy system. We also know that the theoretical lower limit of 0.30 mg/L in the boundary water is not an attainable goal. To determine the attainable nitrogen loadings, we can use the historical approach or the no-load scenario. Since we do not have enough historical data on eelgrass coverage and water quality to use the historical approach, we use the no-load scenario to run the model with no anthropogenic inputs from wastewater, runoff from impervious surfaces, or fertilizer. The output provides an ambient nitrogen concentration in the embayment that mimics natural conditions. These target limits can then be used to back-calculate the annual load of nitrogen from the watershed that can be safely assimilated within the embayment.

In this simplified example, we assume that the linked model shows that an ambient nitrogen concentration of 0.35 mg/L is necessary to restore shellfish beds and allow eelgrass to flourish, and that the 0.35 mg/L level is attainable. We are now ready to evaluate nitrogen-reducing approaches, as shown in Example 2.

## Example 2: Modeling Nitrogen Reduction Approaches

We know that the ambient nitrogen concentration in the embayment is 0.47 mg/L.

$$0.47 \text{ mg/L} \times 217.8 \text{ million cu.ft.} \times 7.48 \text{ gal/cu. ft.} \times 8.34 = 6,386 \text{ lbs}$$

The target concentration is 0.35 mg/L, or 4,755 lbs, which will require eliminating 1,631 lbs/yr of nitrogen.

### Nitrogen Reduction Options:

#### 1. Improved Flushing:

The model shows that improvements to the outlet channel of the embayment can increase flushing from 775,000 lbs/yr to 776,000 lbs/yr. This will reduce nitrogen loading in the embayment by 500 lbs/year.

#### 2. Wastewater Treatment:

Because the wastewater treatment plant plume travels through a marsh system that can attenuate 20% of the nitrogen load, removing some of the on-site systems and connecting those homes to the sewer system may be the easiest way to attenuate that nitrogen load. The wastewater treatment plant discharges 10 mg/L total nitrogen and an on-site system discharges 35 mg/L. The difference of 25 mg/L translates to an annual reduction in mass loadings of 10.5 lbs/yr for each home that is connected to the treatment plant.

$$25 \text{ mg/L} \times 55 \text{ gpd/person} \times 2.5 \text{ persons/home} \times 1 \text{ MGD/106 gal} \times 8.34 \times 365 \text{ days/yr} = 10.5 \text{ lb/yr/home}$$

In order to remove 1,131 lbs/yr of nitrogen, we estimate that 108 homes would need to be sewerred. The additional flow from these homes to the treatment plant is 108 homes  $\times$  2.5 persons/home  $\times$  55 gpd/person = 14,850 gpd. We now need to adjust our mass balance terms to see if we meet our target of 0.35 mg/L in the embayment.

### On-site systems:

$$(1,000 - 108) \text{ homes} \times 2.5 \text{ persons/home} \times 5.9 \text{ lbs nitrogen/person/yr} = 13,157 \text{ lbs/yr}$$

### Wastewater treatment plant:

$$1.01485 \text{ MGD} \times 10 \text{ mg/L} \times 8.34 \times 365 \text{ days/yr} = 30,893 \text{ lbs/yr}$$

### Natural attenuation:

$$0.20 \times 30,893 \text{ lbs/yr} = 6,178 \text{ lbs/yr}$$

### Our adjusted input term is:

$$30,893 + 13,157 + 1871 + 226 + 700 + 750,000 = 796,847 \text{ lbs/yr}$$

Using our total mass balance equation (Equation 1):

$$\text{Storage} = \text{Input} - \text{Output} + \text{Generation} - \text{Consumption}$$

$$4,669 = 796,847 - 776,000 + 120,000 - (130,000 + 6,178)$$

Since the calculated storage term is less than the target storage term of 4,755 lbs/yr, this combination of sewerred and improved flushing will achieve our water quality goal.

The full model runs and technical reports for each estuary or estuary segment will include evaluation of other appropriate nitrogen-management approaches such as improved treatment at the wastewater treatment plant, use of nitrogen-reducing on-site systems, reduced fertilizer use, and stormwater controls. In order to keep this example simple, they are not included here.

A district can be an effective means of managing wastewater in one or more municipalities. In simple terms, districts can be established (1) pursuant to a general state law; (2) a special act of the Legislature; or (3) through the exercise of a municipality's home rule authority (e.g., by enactment of a bylaw). Set forth below is a summary of how districts are established by means of these three pathways.

### Establishing a water pollution abatement district pursuant to general state law

#### DEP-Mandated Districts

Under the Massachusetts Clean Waters Act, DEP is authorized to propose, and in some cases mandate, the establishment of water pollution abatement districts consisting of one or more cities or towns, or designated parts thereof. *[M.G.L. c. 21, §28 – 30, 32, 35 and 36.]* When proposing the formation of a district, DEP must first obtain the approval of the Massachusetts Water Resources Commission (WRC). Within 90 days of a municipality's receipt of DEP's proposal to establish a district, the municipality must take a vote, of its city council or at town meeting as applicable, whether to accept DEP's proposal. If the municipality votes no, DEP is directed to hold a hearing pursuant to M.G.L. c. 30A to further consider the matter. Upon completion of the hearing, DEP may, upon finding that the creation of the district "is necessary for the prompt and efficient abatement of water pollution" and with the approval of the WRC, declare the mandatory formation of the district.

An established district may only be dissolved by an act of the Legislature. DEP, with the approval of the WRC, may also propose the enlargement of a district or the consolidation of one or more districts, subject to the approval of the Legislature or pursuant to the process outlined above for establishing a district by agreement of the affected municipalities or mandatorily by DEP.

Each water pollution abatement district established under the Massachusetts Clean Waters Act is an independent entity administered by a "district commission." When the district is established with the agreement of the affected municipalities, representatives of the municipalities comprise the members of the district commission. When the district is established mandatorily by DEP, each member of the district commission is appointed by DEP, with the approval of the WRC. The district commission is required to employ a registered professional engineer to serve as the executive director of the district, and a person with accounting and financial experience to serve as the treasurer of the district.

A district commission's powers include authority to:

- adopt bylaws and regulations;
- acquire, dispose of and encumber real and personal property, including acquiring real property by eminent domain;
- construct, operate and maintain water pollution abatement facilities; and
- issue bonds and notes; and raise revenues to carry out the purposes of the district by means of apportioned assessments on the member municipalities.

Regarding the latter assessment authority of the district, the member municipalities may, in turn, impose assessments on those residents, corporations, and other users served by the district. If a municipality fails to pay the district commission their apportioned assessment, the state may pay the amount owed the district commissions from other appropriations designated by the state for the municipality.

A district is required to present a plan for the abatement of water pollution within the district to DEP within one year after its establishment or such greater or lesser time period established by DEP. The plan must include detail as to the:

- ④ sources of pollution within the district;
- ④ means by which and the extent to which such pollution is to be abated;
- ④ project(s) for the construction, acquisition, extension or improvement of facilities required by the plan, and the estimates of the capital costs associated with such projects;
- ④ amount of federal financial assistance applicable to such project costs for which the district proposes to apply; and
- ④ method of apportioning among the member municipalities the capital and operation and maintenance costs associated with such projects.

After approval, the district's plan may be altered only with the approval of DEP.

In summary, DEP has broad statutory authority to propose and mandate the establishment of a district under the MA Clean Waters Act, and to require the district to implement a water pollution abatement plan subject to DEP's approval. To date, DEP has not exercised this authority. However, municipalities and other interested parties should be aware of the availability of this authority when evaluating the district option as a means of more effectively managing wastewater on a regional basis.

### Independent Water and Sewer Commissions and Intermunicipal Agreements

Massachusetts general laws also authorize municipalities to establish an independent water and sewer commission within the boundaries of a municipality pursuant to M.G.L. c. 40N, and to enter into intermunicipal agreements pursuant to M.G.L. c. 40, §4A for the purpose of jointly performing a service that the municipality is authorized to do individually or to allow one municipality to perform a service for another. Unlike districts established under the Clean Waters Act, these statutory options do not require prior approval of DEP (although a municipality must vote to accept the provisions of M.G.L. c. 40N before availing itself of the authority thereunder), and they can be alternative means of accomplishing some of the benefits of a district on a more modest scale.

### Regional Health Districts

Finally, M.G.L. c. 111, §27B authorizes two or more municipalities to form a "regional health district," which consists of a regional board of health, a director of health, and his or her staff. A regional health district established thereunder has "all the powers and shall perform all the duties conferred upon, or exercised by, the boards of health and health departments of the constituent municipalities under any law or ordinance pertaining thereto." Unlike a district established pursuant to the MA Clean Waters Act, the primary purpose of a regional health district does not appear to be pollution abatement, but the language of M.G.L. c. 111, §27B is broad enough to encompass the wastewater regulatory powers of a Board of Health and, therefore, may be another general law option worth exploring.

## Establishing a district through the enactment of a special act of the Legislature

In practice, districts of regional scope in Massachusetts have been established by special acts of the Legislature. As examples, in 1968 the Legislature enacted separate acts of special legislation establishing two regional water pollution abatement districts - the Greater Lawrence Sanitary District (GLSD), and the Upper Blackstone Water Pollution Abatement District (UBWPAD). [*Chapter 750 of the Acts of 1968, establishing the GLSD, and Chapter 752 of the Acts of 1968, establishing the UBWPAD.*] GLSD's enabling legislation established a district consisting of the Cities of Lawrence and Methuen and the Towns of Andover and North Andover. GLSD, pursuant to statute and contract, also serves the Town of Salem, New Hampshire. In comparison, UBWPAD's special legislation authorized the City of Worcester and several adjoining towns to create a district, the boundaries of which are based on an affirmative vote of each of the member municipalities. In particular, the GLSD enabling legislation, as amended by subsequent special legislation (*Chapter 320, Acts of 1970*), is similar to the framework established for a water pollution abatement district under the MA Clean Waters Act. Both the GLSD and UBWPAD special acts comprehensively address the scope of authority and responsibilities essential to a regional district, such as authority to take land by eminent domain, to issue bonds and notes, and to impose assessments on member municipalities, who in turn may assess user charges.

Special legislation may also be necessary or appropriate when a municipality is seeking to manage wastewater within its boundaries in

a manner that goes beyond or is inconsistent with applicable general or special laws. For example, Chapter 157 of the Acts of 2000 provides that notwithstanding the provisions of two sections in a state general law (*M.G.L. c. 83*) that govern a municipality's authority to establish and administer a sewer system, the Town of Provincetown may limit those properties that may connect to the sewer to ones where an on-site septic system cannot be constructed on the property in compliance with 310 CMR 15.000 (*Title 5*). The above referenced provision of state law from which the Legislature exempted Provincetown gives property owners the right to connect to an abutting municipal sewer line with available capacity. This special legislative authority to restrict the scope of properties initially served by the sewer system significantly reduced the cost of the municipal wastewater treatment facility and gives the Town more flexibility to control growth. The Provincetown special legislation also varied the requirements of *M.G.L. c. 80*, the state general law on betterments, by allowing the Town to defer imposing a betterment assessment on the properties adjoining the sewer system unless and until the property is actually connected to the sewer, rather than upon the completion of the sewer.

The Massachusetts Constitution authorizes municipalities to file home rule petitions with the Legislature, which request enactment of a special law. [*Section 8 of the Home Rule Amendment (Mass Const. Amend., Article 2, as appearing in Amend. Article 89.)*] The municipal legislative body must first approve a home rule petition before it can be acted on by the Legislature. The municipal vote approving a home rule petition may be general in that it requests legislation to accomplish a general purpose, and may or may not include draft legislation. A general vote does not preclude legislative amendments. If the municipality does not approve a draft bill,

the legislation may be drafted by the municipal executive (the mayor, manager, or selectmen) or by the state legislator who files it. A municipal vote may also specifically restrict or preclude the Legislature from making substantive amendments to the draft bill approved by the municipality. The downside to this approach is that the municipality may need to vote again on legislative amendments to its proposed bill in order to secure passage of the special legislation, which could delay action for months, particularly if a town meeting vote is required. Another option is to include language in the municipal vote that authorizes the municipal executive (e.g., selectmen) to approve amendments to the bill that are within the scope of the general public objectives of the petition. *[Memorandum to City Solicitors and Town Counsels from the Counsel to the House of Representatives and the Counsel to the Senate, dated March 24, 1998, on the Form of Home Rule Petitions.]*

Because of the Legislature's broad authority to enact laws consistent with the state constitution, including the power to exempt municipalities from otherwise applicable general laws, the enactment of special legislation can be the most effective vehicle for establishing a district encompassing one or more municipalities or an environmentally relevant geographic area and/or to manage wastewater and its related impacts in creative ways. Parties that need to be involved in the special legislation route to establishing a district include the municipality's executive, municipal counsel, and state legislator(s). It is also important to consult with EOE and DEP in the development and legislative review of special legislation of this nature. Both agencies will typically weigh in the merits of the proposed legislation, and their support can be an important factor in securing passage of the bill.

## Establishing a district through the enactment of a municipal bylaw

A municipality's home rule powers under the Massachusetts Constitution grant authority to any city or town to exercise any power or function which the Legislature has the power to confer on it, which is not inconsistent with the Constitution or a state law or prohibited by the charter of a city or town. *[Section 6 of the Home Rule Amendment to the Massachusetts Constitution, and M.G.L. c. 43B ("Home Rule Procedures").]* As a result, municipalities may adopt zoning or general bylaws to regulate a wide range of uses and activities within all or a portion of a municipality.

Zoning and general bylaws differ in their approach and procedure for adoption. Both a zoning and general bylaw must be approved by the Attorney General (AG). If the AG fails to act within ninety days, the bylaw is deemed constructively approved by the AG. The AG's narrow standard of review is whether the bylaw is, on its face, consistent with the state constitution and state laws.

### Zoning Bylaws

A zoning bylaw typically imposes restrictions on categories of land uses located in a defined geographical area. For example, a zoning bylaw may establish an aquifer protection district that encompasses the boundaries of the Zone II of contribution to a public water supply well. This type of zoning bylaw imposes additional wellhead protection zoning controls that prohibit the siting of certain new land uses within that zone because of their potential adverse impact on the well. *[310 CMR 22.21 of DEP's Drinking Water Program Regulations, which sets forth the scope of wellhead protection zoning and nonzoning controls that must be adopted to*

*protect a new public water supply well approved by DEP.] A building inspector has the authority to withhold a building or occupancy permit if the structure would violate a zoning bylaw. However, a zoning bylaw “grandfathers” (i.e., allows the continuation of) prior nonconforming uses within a zoning district. Procedurally, a zoning bylaw is adopted in accordance with the provisions of M.G.L. c. 40A, §5, and requires a planning board hearing and a two-thirds vote of town meeting.*

### General Bylaws

In comparison, a general bylaw is adopted pursuant to a municipality’s home rule authority and in accordance with the procedures in M.G.L. c. 40, §32, which require only a majority vote of town meeting. Moreover, a general bylaw is not required by state law to grandfather prior nonconforming uses, and typically applies uniformly to all existing and new uses or activities subject to the bylaw. A common example of a general bylaw is a wetlands protection bylaw that implements a local permit program with more stringent requirements than the state Wetlands Protection Act. A number of municipalities have also enacted bylaws that require residents to comply with water conservation measures, such as restrictions on outdoor watering. Violations of a general bylaw are subject to penalties of up to \$300 per violation and may be enforced pursuant to the non-criminal disposition provisions of M.G.L. c. 40, §21D, which allow the municipality to issue a “ticket” for the violation.

Accordingly, a municipality has broad home rule authority to enact a general bylaw

applicable to existing and new uses in a defined environmentally sensitive or other geographical “district” within the boundaries of the municipality. Such a bylaw may impose more stringent requirements related to wastewater management within the district, including limitations on the use of fertilizers or setbacks on wastewater discharges that have the potential to impact nearby surface water bodies. The bylaw could also establish a related permit program that further regulates nutrient generating activities. Municipalities must be careful, however, that their bylaw permitting scheme does not substantively conflict or interfere with DEP’s plenary regulatory and permitting authority over wastewater facilities and discharges under the Massachusetts Clean Waters Act, M.G.L. c. 111, §17 and M.G.L. c. 83. It is also important to consult with municipal legal counsel to assess the issues associated with charging a fee for any such municipal permitting activities. These issues include ensuring that the assessment constitutes a valid fee rather than a tax that has not been authorized by the Legislature, and evaluating whether and under what circumstances fee revenues can be deposited into a dedicated revolving fund rather than the municipality’s general fund. [*e.g., M.G.L. c. 44, §53 and §53E½.*]

The cost of a municipality’s construction of wastewater treatment facilities or extension of its municipal sewer system to serve uses within the district is typically recovered through the assessment of betterments on the benefited properties pursuant to M.G.L. c. 80.

### Board of Health Authority

Finally, it is worth noting that a Board of Health (BoH) has broad authority to regulate wastewater independent of a general bylaw adopted by a municipality. A Board of Health is authorized to promulgate “reasonable” regulations under M.G.L. c. 111, §31, including regulations that exceed the minimum requirements of Title 5, provided the BoH states at the public hearing on the proposed regulation the local conditions that exist and/or reasons that support the more stringent regulation. A BoH may assess a fine of up to \$1000 for a violation of its regulations, as compared to a maximum \$300 fine that can be assessed for a violation of a general bylaw. Boards of Health also have the authority to enter into betterments associated with the upgrade of failed Title 5 systems pursuant to M.G.L.c. 111, §127B½.

Compared to a general bylaw, a BoH regulation can be an effective vehicle for managing wastewater within all or a portion of a municipality in view of a board of health’s existing jurisdiction in this area (under Title 5) and attendant experience, and its greater penalty authority. As discussed above, two or more municipalities have the authority under M.G.L. c. 111, §27B to form a regional health district that would allow the uniform application and enforcement of more comprehensive local wastewater management regulations across a broader geographic area.

### Legal Framework for Management Districts Legal and Regulatory Citations

#### **Massachusetts General Laws and Constitutional Amendments**

Massachusetts Clean Waters Act: M.G.L. c. 21, § 26-53.  
Water Pollution Abatement Districts: M.G.L. c. 21, § 28-30, 32, 35 and 36.

DEP Authority to Establish and Approve Wastewater Facilities: M.G.L. c. 83, § 6 and M.G.L. c. 111, § 17.

Independent Water and Sewer Commissions: M.G.L. c. 40N.

Intermunicipal Agreements: M.G.L. c. 40, § 4A.

Regional Health Districts: M.G.L. c. 111, § 27B.

Home Rule Petitions for Special Acts of the Legislature: Section 8 of the Home Rule Amendment to the Massachusetts Constitution, Article 2, as appearing in Amendment Article 89.

General State Law on Betterments: M.G.L. c. 80.

Municipal Authority for General and Zoning Bylaws: Section 6 of the Home Rule Amendment to the Massachusetts Constitution, and M.G.L. c. 43B.

Authority and Procedures for Adopting and Enforcing Municipal General Bylaws: M.G.L. c. 40, § 21, 32, and 21D respectively.

Authority and Procedures for Adopting Zoning Bylaws: M.G.L. c. 40A.

Board of Health Authority: M.G.L. c. 111, § 31 and 127B ½.

Municipal Finance: M.G.L. c. 44, § 53 and 53E½ .

### **Massachusetts Special Legislation**

Greater Lawrence Sanitary District Enabling Legislation: Statutes of 1986, c. 750, and Statutes of 1970, c. 320.

Upper Blackstone Water Pollution Abatement District Enabling Legislation: Statutes of 1968, c. 752.

Town of Provincetown Special Legislation: Statutes of 2000, c. 157.

### **DEP Regulations and Other Citations**

DEP On-Site Sewage Treatment and Disposal (Title 5): 310 CMR 15.000: <http://www.state.ma.us/dep/brp/files/310cmr15.pdf>.

DEP Drinking Water Program Regulations: 310 CMR 22.21: <http://www.state.ma.us/dep/brp/dws/files/310cmr22.pdf>

Memorandum to City Solicitors and Town Counsels on the Form of Home Rule Petitions, from the Counsel to the House of Representatives and the Counsel to the Senate, dated March 24, 1998.

### **Document Availability**

Massachusetts General Laws and Constitutional Amendments are available through the internet: Massachusetts General Laws (MGL): <http://www.state.ma.us/legis/laws/mgl/mgllink.htm>

Massachusetts Constitution and Amendments: <http://www.state.ma.us/legis/const.htm>

For copies of special legislation or legislative memoranda, readers can contact the districts, municipalities, or the State Library of Massachusetts: <http://www.state.ma.us/lib/homepage.htm>

## Appendix H

Examples of Management  
Districts and Programs in  
Massachusetts

## 2003

Massachusetts Estuaries  
Project

This table summarizes districts and programs established by some Massachusetts municipalities to provide wastewater management for sources other than traditional sewers and treatment works. This is not a complete listing for Massachusetts. Information is correct as of January 2003.

Town/Coverage	Purpose	Legal Authority	Contact
Tri-Town Septage District  Townwide program in Orleans, Brewster, Eastham	Initially there was an on-site inspection and testing program, as well as operation of a septage treatment plant. This was paid by discharge fees to property owners. On-site program was terminated once all systems were inspected. BoH sends out reminder letters to pump every 3 years.	Special legislation	James Burgess, Chief Operator 508/255-4190
Tisbury  Townwide program	Operation of a conventional sewer system in downtown area, and inspection and monitoring of on-site systems throughout rest of town.	Town Meeting	Tom Pachico, Health Agent 508/696-4290 Tpachico@ci.tisbury.ma.us
Wayland  Town-wide district; services currently provided only to central business district	Treatment plant operation and connection of on-site systems near the plant.	Special legislation	Jeff Ritter, Executive Secretary 508/358-3620
Chicopee  Townwide program	Comprehensive stormwater management utility: capital improvements, inspection, and operation and maintenance of stormwater BMPs. Stormwater management fee.	State law governing water/sewer utilities. City ordinance used to establish fees	Stan Kulig, Public Works Supt 413/594-3557 Skulig@chicopee.ma.us
Cohasset  Townwide program	Voluntary inspection, monitoring, maintenance and repair of on-site systems; approximately 1500 on-site systems are located in the Town, or 60% of properties.	Board of Health	Joe Godzik, Health Agent 781/383-4116 Cohassetboardofhealth@hotmail.com
Concord  Townwide program	Wastewater mgmt services to all facilities, either by sewer or on-sites. On-site services include tech assistance / education / revolving fund. Environmentally sensitive areas will have inspections, loading criteria, and potentially failure criteria.	Board of Health	Mike Moore, Health Agent 978/318-3275 mmoore@concordnet.org

Town/Coverage	Purpose	Legal Authority	Contact
Tritown Health District Townwide program in Lenox, Lee, Stockbridge	Outreach/education to on-site owners: I/A information, technical assistance, tax credit information, and information on proper maintenance.	Board of Health	Peter Kolodziej, 413/243-5540 TriTownHealth@aol.com
Gloucester	Tracking and inspection of on-site systems. Private inspectors do inspections and any repairs, under Health Dept oversight; property owners pay all costs. 155 I/A systems are tracked, as well as any upgrades or new construction. More rigorous testing is done in 7 priority areas, including deep pits to check on ground water. Depending on results, full inspections can be required more frequently than every 3.5 years.	Department of Health	Dave Sargent, Health Department 978/291-9771 dsargent@ci.gloucester.ma.us
Hingham	Tracking of on-site systems through local permits: Town fee for installation of any on-site system, and annual permit fee for I/A systems.	Board of Health	Bruce Capman, BOH Director, 781/741-1466 capmanb@hth.ssec.org
Buttermilk Bay Watershed within the Towns of Plymouth, Wareham, Bourne  Townwide, tri-town nitrogen management strategy (Plymouth, Wareham, Bourne)	Three towns adopted nitrogen loading goals and limits on growth recommended by the Buzzards Bay Project, in order to limit future nitrogen inputs to Buttermilk Bay.  Bourne and Plymouth adopted zoning bylaw changes to increase minimum lot size to reduce future growth potential, and also adopted water protection overlay districts that included nitrogen loading goals. Wareham zoning was deemed adequate. Wareham and Bourne also extended sewerage around the bay. (Dr. Joseph Costa. Personal communication 1/23/03).	Intermunicipal agreement.  Local zoning and other bylaws	Dr. Joseph Costa, Executive Director, Buzzards Bay Project National Estuary Program 508/291-3625 x.19 jcosta@buzzardsbay.org

## How Nutrient Trading Works

Nutrient trading allows pollution sources (e.g., wastewater treatment facilities) to fund nitrogen reductions elsewhere in a watershed or trading area, thus reducing the overall release of nitrogen while not being required to meet more stringent permit requirements themselves. Sources that can implement low-cost pollution reduction efforts also have an incentive to reduce their nutrient loadings below the required level, if there is a system in place allowing them to sell credits for their reductions to facilities with higher control costs. A fundamental principle of nutrient trading is that total discharges in the watershed or trading area will be reduced. As noted in the body of the Guidance, the concepts and issues identified here apply to nitrogen, phosphorus, and other water quality pollutants. In the following discussion, the terms “nutrient” and “nitrogen” are used interchangeably; however, nitrogen is the pollutant of concern in this document.

Nutrient trading has evolved nationally to include a variety of mechanisms depending on geographic area, source of pollutant, and type of discharger. The most common are as follows:

④ **Cap and trade:** includes a mandatory cap on a discharge and is more common in situations where regulatory limits are not being met. The cap is established (for example, in a TMDL) on the amount of total nutrients that can enter waters in the trading area, and the total quantity of allowable discharges is divided among sources taking part in the trading program. Sources responsible for the nitrogen loading then trade with each other or use a bank of credits to make the most cost-effective pollution reductions to meet the TMDL requirements.

A cap may be increased without resulting in an increase in nutrients to the watershed if pollution sources not already subject to the cap reduce their loadings by the same amount or more than the cap is increased.

④ **Open systems:** typically a voluntary system and used where effluent standards are already being met. The total amount of discharge may be a percentage reduction goal. Reductions below a baseline are made to generate credits that in the future can be used to meet future nutrient reduction requirements or sold to other dischargers.

④ **Offsets:** a facility applying for a new or increased discharge reduces discharges from other sources. This tool has been used in a few Massachusetts communities, where permits for wastewater treatment facilities included the connection of on-site systems to their facility, thereby reducing the total nutrient discharge to the watershed. (*See Case Studies at the end of this Appendix.*)

Trading can take place among a variety of point and nonpoint sources of nitrogen:

④ **Point-to-Point Trading:** between point sources such as wastewater treatment plants.

④ **Intra-facility Trading:** between different discharges in the same facility (usually an industrial plant).

④ **Pretreatment Trading:** between a wastewater treatment plant and one of its industrial or commercial customers. Typically, the POTW pays for pretreatment upgrades for its customers rather than for upgrades to its own plant.

④ **Point Source to Nonpoint Source Trading:** between a point source and a nonpoint source. For nitrogen control, this type of trade can have a significant impact, since there are many opportunities for nonpoint source controls that are less costly than those from point sources. Examples would be an increase in the discharge from a POTW, in return for reductions in loadings from on-site treatment systems.

⌚ Nonpoint Source to Nonpoint Source: between nonpoint sources, depending on where controls will be more effective and less costly. For communities without large point sources of nitrogen, this type of trading is an important implementation tool.

### Implementation Issues

Because it is a new and complex tool, nitrogen trading presents challenges to communities seeking to use it appropriately. A comprehensive trading program must involve the public and regulatory agencies, consider the size of the watershed and location of trading partners, and be able to enforce controls and quantify results. Notable challenges for trading programs include the following:

- ⌚ Credibility of nonpoint pollutant reductions, given the cost and difficulty of monitoring and enforcing nonpoint source controls.
- ⌚ Trading may allow wealthy communities to put more of the pollution burden on poorer communities. One way to avert this situation is to ensure that the public is informed and involved in any trade decisions.
- ⌚ The formation of “hot spots,” or locally degraded areas in the watershed due to an increased discharge. Although the discharger may have provided nitrogen management elsewhere in the watershed that will improve overall water quality, the area just downstream of the discharge may be degraded.
- ⌚ Transaction costs. If the cost of making and tracking trades is too high, there will be no incentive to pursue it as a means of pollution abatement. It is therefore necessary to create an easy way for potential traders to find each other and to determine the needs of individual participants.

⌚ Public knowledge and acceptance of proposed or actual trades. A simple trail of transactions needs to be recorded so that government and the general public can review any part of a trading agreement.

To address these issues, EPA has developed a framework of eight principles for stakeholders to consider in determining the applicability of this approach:

- ⌚ Participating facilities should meet applicable technology-based requirements.
- ⌚ Trades should be consistent with the water quality standards set in local, state, and federal laws.
- ⌚ Trades should be based on a TMDL or an equivalent regulatory framework such as a NPDES permit.
- ⌚ Trades should take place within existing regulations and enforcement systems.
- ⌚ Trading should take place within manageable trading areas, usually a watershed or sub-watershed.
- ⌚ Participating facilities and communities should expect to do increased monitoring to verify results of trading.
- ⌚ The localized impact of trading should be considered, so that water quality is not degraded in any one part of the trading area.
- ⌚ Trading systems should involve all stakeholders and the public.

## Nutrient Trading Case Studies

*Edgartown, Massachusetts*

*Falmouth, Massachusetts*

*Wayland, Massachusetts*

*Neuse River, North Carolina*

*Tar-Pamlico Basin, North Carolina*

The format for the following Case Studies is adapted from the following report prepared for the EPA: *A Summary of U.S. Effluent Trading and Offset Projects*, November 1999. [http://www.environomics.com/Effluent-Trading-Summaries\\_Environomics.pdf](http://www.environomics.com/Effluent-Trading-Summaries_Environomics.pdf).

Information for the Wayland, Neuse River, and Tar-Pamlico Basin is taken from the above document, with updates as of January 2003. Information is reprinted with permission.

### Town of Edgartown Wastewater Treatment Facility Upgrade/Edgartown Great Pond Nutrient Management

**Nature of Activity:** Upgrade of a wastewater treatment facility, additional sewerage and nutrient management in the Edgartown Great Pond watershed.

**Environmental Problem:** Cultural eutrophication due to increased nitrogen inputs to Edgartown Great Pond.

**Pollutant(s)/Pollution Type(s):** Nitrogen

**Trade Types:** Point/nonpoint offset between advanced tertiary treatment, additional sewerage, use of on-site denitrifying systems, use of agricultural fertilizers, and purchase of conservation easements.

**Stage of Implementation:** As part of a comprehensive wastewater management plan, the current Edgartown wastewater treatment facility was upgraded in 1996 to meet Class I Ground Water Discharge Standards, with a goal of limiting the annual nitrogen loading to 2200 kilograms. Although the facility is designed for

750,000 gpd, the ground water discharge permit limits the flow initially to 500,000 gpd until actual performance data is available. To date, the facility has exceeded expectations with an average total nitrogen discharge below 5 mg/L. Approximately 300 additional residences in the recharge area will be connected to the facility, but there is no current timetable for this phase of the project. Denitrifying on-site treatment systems will be encouraged elsewhere within the watershed.

**Relation to TMDL:** On the initial list of 20 estuaries for detailed analysis by the Massachusetts Estuaries Project.

**Number of Potential Participants:** 300 homes are to be sewerage and a number of facilities (as yet to be determined) are to install denitrifying on-site treatment systems.

**Trading Ratios:** The target ambient nitrogen concentration in Edgartown Great Pond was used to back calculate the reductions in mass loading and allocations throughout the watershed necessary to achieve the target range, particularly the treatment facility annual limit of 2200 kilograms of total nitrogen. The provision of sewer service to 300 homes and denitrifying on-site systems for approximately 900 new homes will produce a yearly saving of 1130 and 1135 kilograms of total nitrogen, respectively.

**Estimated Cost Savings:** Undetermined at this time.

**Available Written Information:** *Edgartown Great Pond: Nutrient Loading and Recommended Management Program* – November 1998 prepared by the Martha's Vineyard Commission.

**Innovative Aspects:** Conservation easements

**Obstacles:** Funding for sewer extensions and conservation easements.

**Contact:** Bill Wilcox, Martha's Vineyard Commission 508/693-3453.

### Town of Falmouth Wastewater Treatment Facility Upgrade/West Falmouth Harbor Nutrient Management

**Nature of Activity:** Upgrade of a wastewater treatment facility, additional sewerage and nutrient management in the West Falmouth Harbor watershed.

**Environmental Problem:** Cultural eutrophication due to increased nitrogen inputs to West Falmouth Harbor.

**Pollutant(s)/Pollution Type(s):** Nitrogen.

**Trade Types:** Point/nonpoint offset between advanced tertiary treatment, additional sewerage, and use of on-site denitrifying systems.

**Stage of Implementation:** As part of a comprehensive wastewater management plan initiated in 1998, the current Falmouth wastewater treatment facility is being upgraded from a Class III to a Class I ground water discharge. Construction of the new facility is expected to begin in the Spring of 2003. More than 400 additional connections will be made to the treatment plant from homes and businesses in the watershed west of Route 28; there is no current timetable for this phase of the project. Denitrifying on-site treatment systems will be installed at sites east of Route 28, and will be centrally managed. A management plan still needs to be implemented to oversee this work. The treatment plant will be designed at 1.2 mgd and to meet a 3 mg/L total nitrogen discharge at a maximum rate of 1 mgd within the watershed. Any additional discharge will have to occur outside the watershed.

**Relation to TMDL:** On the 1998 list for pathogens and mentioned in Appendix C of the 2002 list for the Massachusetts Estuaries Project.

**Number of Potential Participants:** 400+ homes are to be sewerage and a number of facilities (as yet to be determined) are to install denitrifying on-site treatment systems.

**Trading Ratios:** The target ambient nitrogen concentration was used to back calculate the reductions in mass loading and allocations throughout the watershed necessary to achieve the target range. An allowance was factored in for a 20% attenuation of nitrogen through the Masapaquit Creek salt marsh and 45% attenuation of nitrogen through spray irrigation in woodlands at the wastewater treatment facility.

**Estimated Cost Savings:** Undetermined at this time, but without the 20% attenuation credit, the discharge within the watershed would have been decreased from the current 800,000 gpd to 700,000 gpd rather than be able to increase to 1 mgd.

**Available Written Information:** Falmouth's Comprehensive Wastewater Management Plan.

**Innovative Aspects:** Providing credit for natural attenuation.

**Obstacles:** Funding for sewer extensions.

**Contacts:** Dr. Brian Howes, SMAST, 508/910-6310; bhowes@capecod.net. Brian Dudley, DEP, 508/946-2753, brian.dudley@state.ma.us

## Wayland, Massachusetts Business Center Treatment Plant Permit

**Nature of Activity:** The Wayland Business Center, an office building complex under new ownership, sought to discharge effluents from its wastewater treatment plant into the Sudbury River. The facility had been operated by the Raytheon Corporation, and the new owners originally sought to renew and transfer the existing permit. DEP and the U.S. EPA ruled that the Raytheon permit could not be transferred to the new owners of the Wayland Business Center, and hence the facility's discharge was to be construed as a new discharge. As a condition for allowing the discharge, the NPDES permit specified that the facility needed to obtain an offset of phosphorus. The facility is obtaining offsets by connecting to the plant septic systems on neighboring properties which are in a high water table area and/or are failing.

**Environmental Problem:** General water quality and eutrophication of Sudbury River.

**Pollutant(s)/Pollution Type(s):** Phosphorus.

**Trade Types:** Point/nonpoint.

**Stage of Implementation:** The process began in early 1998; the permit was issued in September 1998. The municipality decided to take ownership of the facility and conducted a negotiated eminent domain taking of the facility. The small scale, pressure sewer was designed and installed. Each property owner connecting to the sewer will pay for the cost of its hookup to the stub provided in the street in front of each property. As of January 2003, 25 properties had been connected. The additional properties are being charged as though they were hooked up.

**Relation to TMDL:** Parts of the Sudbury River are on the state's list of waters not meeting water quality standards and for which TMDLs must be developed (the 303(d) list) for metals,

and parts of neighboring rivers are 303(d)-listed for nutrients. The offset does not have a direct relation to a TMDL, but the actions will result in an 80% decrease in phosphorus loadings to the Sudbury from the participating point source and nonpoint sources. The wastewater from the septic systems would have flowed, via the high water table, into the Sudbury River without any appreciable removal of phosphorus if it had not been routed through the treatment plant.

**Number of Potential Participants:** The Wayland Business Center, two municipal buildings of the Town of Wayland, and 32-34 property owners with septic tanks.

**Trading Ratios:** The facility is permitted to discharge 0.125 pounds per day (ppd) of phosphorus, and must reduce loadings via septic tank connections by at least 0.375 ppd, thus the trading ratio is 3:1. The plant's flow is permitted at 45,000 gpd.

**Estimated Cost Savings:** The users paid the entire cost of the plant, approximately \$500,000. The plant may have been less expensive for individual users than installing very costly on-site systems. Some property owners also felt that sewerage was a more aesthetically pleasing option than the raised leach fields that would have been necessary in some cases.

**Available Information:** The NPDES permit, including the trading clauses.

**Innovative Aspects:** A clause in the NPDES permit specifying the offset provision and the septic tank sewerage is believed to be the first of its kind. The municipality has assumed responsibility for the business center's WWTP, effectively making it a POTW. A contingency plan was specified if the sewer connection option could not be implemented, including the possibility of harvesting excess algal growth in the river.

**Obstacles:** The corporate owners of the Wayland Business Center did not have legal authority to perform sewerage work. From a public health standpoint, it was preferable to have the town own the plant so that users would not be dependent on a private entity.

**Contact:** Jeff Ritter, Executive Secretary, 508/358-6360.

### Neuse River, North Carolina Nutrient Sensitive Water Management Strategy

**Nature of Activity:** North Carolina established a nutrient management strategy for the Neuse River Basin to reduce the total nitrogen load to the Neuse estuary from all sources. The strategy sets annual nitrogen allocations for existing point source dischargers over 0.5 mgd, and also provides the option of joining a basin-wide association of point sources. The association's allocation will equal the sum of its members' allocations. If the association or any non-association discharger exceeds its allocation in any year, it must make an offset payment to the state's Wetlands Restoration Fund. The association's members have also made trades among themselves. Any new or expanding discharger must either purchase its allocation from an existing discharger at a negotiated price, or make a payment to the Wetlands Restoration Fund. The Fund restores wetlands and riparian areas.

The program also addresses nonpoint sources of nitrogen from urban stormwater. New residential and commercial developments are required to meet nitrogen discharge limits of 3.6 pounds/acre/year. If projects cannot reduce their loadings below certain levels (6 pounds for residential, 9 pounds for commercial), they can purchase discharge credits by paying funds

to the Wetlands Restoration Fund. As of 2003, about \$1.5 million has been collected, but no restoration projects have been carried out. To be eligible for funding, restoration projects must be able to remove 5,000 pounds of nitrogen for 30 years.

**Environmental Problem:** Nutrient enrichment-driven eutrophication, fish kills in the Neuse estuary.

**Pollutant(s) / Pollution Type(s):** Nitrogen and phosphorus (though only nitrogen will be traded).

**Trade Types:** Point/point, point/nonpoint, nonpoint/nonpoint.

**Stage of Implementation:** The state classified the upper portion of the basin as Nutrient Sensitive Waters in 1983 and declared the entire basin Nutrient Sensitive in 1988. The state began developing basin-wide nutrient rules in 1995, and most rules were effective in August 1998. Dischargers will have to meet their allocations by 2003 or pay for offsets.

**Relation to TMDL:** Several waters in the basin are on the 303(d) list. A TMDL for total nitrogen in the Neuse estuary was approved by EPA in July 1999. The basis for the TMDL was the study used to implement the trading program.

**Number of Potential Participants:** Forty point sources submitted letters of interest in joining the association before a March 1998 deadline, when enrollment was closed for 5 years. This number includes about 90% of point source flows and 70-80% of the point source dischargers in the watershed.

**Trading Ratios:** There is no ratio established by the rule for trading among the point sources, nor is the offset rate (the amount per pound to be paid to the Wetland's Restoration Fund by a discharger exceeding its allocation) formally

a trading ratio. However, the amount of the payment (\$11/lb/year) is based on calculations done by the state for the Tar-Pamlico Basin trading program and represents roughly twice the cost of the least cost-effective nutrient BMPs that the state has been supporting farmers in implementing throughout the state. The state's charge of \$11/lb per year when a point source exceeds its allocation is two or more times higher than the cost at which the state has been obtaining reductions from nonpoint sources. Thus, if we were to assume that a payment into the Wetlands Fund has the effect of increasing the state's spending on nonpoint source BMPs by a similar amount, the offset rate would have a 2:1 trading ratio embedded in it. Moreover, new or expanding point sources that do not purchase allocations from the association must buy offsets from the Wetlands Fund at price 200% of the base offset rate.

**Estimated Cost Savings:** The offset rate is \$11/lb nitrogen for each pound over the association's allocation. For comparison, costs for at-the-plant controls elsewhere in North Carolina (in the Tar-Pamlico Basin) were estimated at roughly \$25-30/lb.

**Available Information:** Two 1997 reports from the North Carolina Department of Environment, Health and Natural Resources (now DENR), several fact sheets. Web site: [http://h2o.enr.state.nc.us/nps/Neuse\\_NSW\\_Rules.htm](http://h2o.enr.state.nc.us/nps/Neuse_NSW_Rules.htm)

**Innovative Aspects:** By instigating nonpoint source controls and collecting payments from point sources that do not meet their allocations, the state assumes much of the burden of trading transactions. Under the strategy's rules for agriculture, farmers can participate in their county plans or implement BMPs individually; however, they will not trade directly with point sources.

**Obstacles:** Trading between point sources and agriculture was not authorized, in part over concern that farmers would be challenged to meet their own 30% loading reduction goals and thus might have difficulty generating tradable "excess" reductions. Farmers were also concerned about having full responsibility for reducing nitrogen loadings. Because the state provides significant funding for wetlands restoration in addition to federal funds, farmers may have less incentive to sell credits to other dischargers.

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### Tar – Pamlico Basin, North Carolina Nutrient Reduction Trading Program

**Nature of Activity:** North Carolina established a basin-wide nutrient trading program to reduce nitrogen and phosphorus loads to the Pamlico estuary. There are two main components: The Tar-Pamlico Basin Association (point sources) and a trading mechanism. The Association works cooperatively to meet nutrient caps set by the state. If the Association does not meet its goals it must purchase offsets by paying a pre-set price per pound to the state's Agriculture Cost-Share Program for Nonpoint Source Pollution Control. This is a statewide program that pays farmers up to 75 % of the average cost of implementing approved BMPs. Monies paid by the Association to the cost-share program are earmarked to finance nutrient offsets from agricultural nonpoint sources in the Tar-Pamlico basin. Association members pay annual dues, but no exceedance taxes have been paid yet. Since the state cost-share program contracts with the

farmers, the state rather than the point sources is responsible for finding trading partners and ensuring the validity of the offsets.

**Environmental Problem:** Eutrophication of Pamlico River Estuary.

**Pollutant(s) / Pollution Type(s):** Nitrogen and phosphorus.

**Trade Types:** Point/point cooperation and point/nonpoint trading in the form of a cap exceedence offset fee.

**Stage of Implementation:** The Basin was designated a Nutrient Sensitive Water in 1989, and program development began in 1990. In 1991, the Association hired an engineering firm to investigate measures and costs for nutrient reduction at the Association's facilities. Trading rules were fully developed in 1992. The point sources have met their collective cap each year since 1990 via the operational measures and minor capital improvements recommended by the engineering analysis, and through the addition of nutrient removal processes at a total of seven member facilities. The Association purchased and banked credits for future use, but has not yet needed to use them. The current membership in the Association and price for offsets will continue through 2004. Phase I: 1990-1994. Phase II: 1995-2004, to be followed by Phase III.

**Relation to TMDL:** A TMDL is in place, having been developed during Phase I. An estuarine response model that was developed under Phase I was used to develop the TMDL.

**Number of Potential Participants:** The Association began with 14 members and opened enrollment to additional facilities after 1999. It has since added one member and another is in process. Fourteen of the current members are municipal treatment works, and one is in

industry. The Agricultural Cost Share Program works with farmers throughout the basin.

**Trading Ratios:** The current cost of offsets includes a 2:1 ratio. The offset rate of \$29/kg/yr is based on the estimated cost of the least cost-effective agricultural BMP typically implemented in the Tar-Pamlico Basin: \$13/kg/yr, plus an additional \$13 (a 2:1 ratio) and a 10% fee for administrative costs.

**Estimated Cost Savings:** The offset rate is currently set at \$29/kg for each kg over the Association's allocation. For comparison, the sum of all individual members meeting technology limits of 6 mg/L N and 2 mg/L P was projected to cost \$50-100 million in 1998, or a cost of \$250 to \$500 per kg. Additionally, a Great Lakes Trading Network report cites Malcolm Green (President of the Association) to the effect that the reductions achievable for \$1 million from nonpoint sources would have cost \$7 million from point sources.

**Available Information:** Two North Carolina Department of Environment, Health and Natural Resources (now DENR) reports from 1995, and one each from 1997 and 1998. Web site: <http://h2o.enr.state.nc.us/nps/tarpam.htm>

**Innovative Aspects:** The state takes on the burden of arranging for and vouching for the nonpoint source load reductions via the Agriculture Cost-Share Program. From the point of view of point sources, this sharply reduces the transaction costs and uncertainties of trading. Members of the Association jointly paid for the engineering study. New dischargers or non-members wishing to expand must pay offsets for agricultural BMPs as well as meet technology limits from 1995 of 6 mg/L N and 1 mg/L P.

**Obstacles:** It was very complex to quantify the impacts of runoff from animal feeding operations. Imprecise language in the Phase II agreement resulted in a disagreement over the duration of the offset rate and credits that have been purchased. This will be resolved in Phase III discussions. Other issues for Phase III will be to revisit the caps, establish an offset rate for phosphorus (the \$29 is for Nitrogen), and replace the gross assumptions on in-stream losses from end-of-pipe to estuary which were used in the Phase II cap-setting process with actual fate and transport modeling for all dischargers.

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