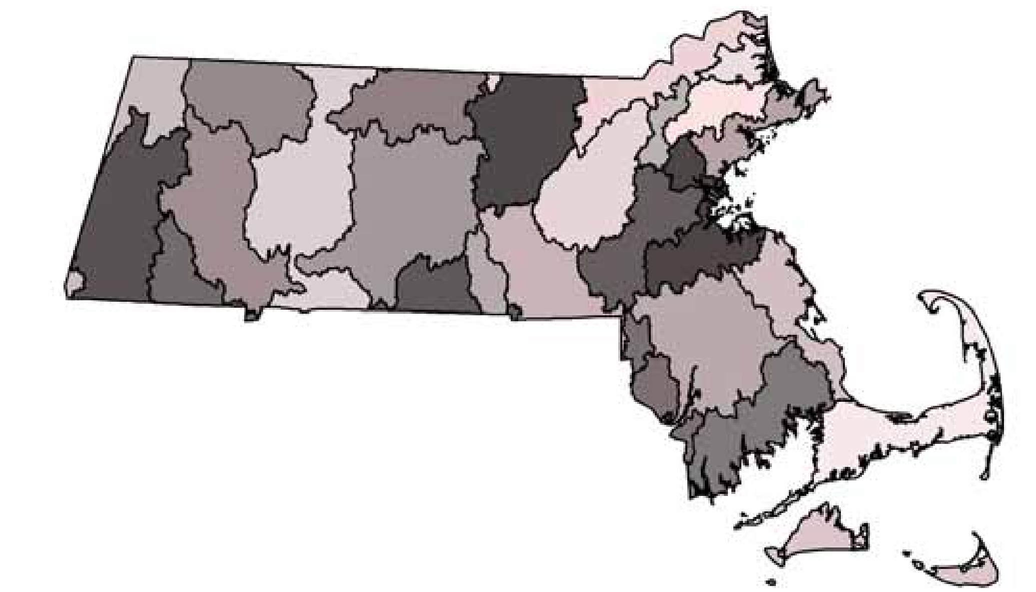
Mitigation Measures to Address Pathogen Pollution in Surface Waters: A TMDL Implementation Guidance Manual for Massachusetts



A Companion Document to the Watershed-Specific Pathogen TMDL Reports

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List of Acronyms

BMP	Best Management Practice
CFU	Colony Forming Unit
CPR	Coastal Pollutant Remediation grant program
CSO	Combined Sewer Overflow
CWA:	Federal Clean Water Act
CZM	Massachusetts Office of Coastal Zone Management
DMF	Massachusetts Division of Marine Fisheries
EPA	United States Environmental Protection Agency
HUC	Hydrological Unit Code
IDDE	Illicit Discharge Detection and Elimination
LIDS	Low Impact Development Strategies
MA DEP	Massachusetts Department of Environmental Protection
MDAR	Massachusetts Department of Agriculture Resources
MEP	Maximum Extent Practicable
MHFA	Massachusetts Housing Finance Authority
MPN	Most Probably Number
MSD	Marine Sanitation Device
MS4	Municipal Separate Storm Sewer System
NDA	No Discharge Area

NPDES	National Pollutant Discharge Elimination System (typically in reference to a state and federal discharge permit to surface water)
NPS	Non Point Source
NRCS	Natural Resources Conservation Service
SWMP	Stormwater Management Plan
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
USDA	United States Department of Agriculture
UV	Ultraviolet
WQM	Water Quality Management
WQS	Water Quality Standards
WWTP	Waste Water Treatment Plant

1.0 INTRODUCTION

This manual provides guidance for mitigating water pollution caused by pathogens. Certain bacteria, such as coliforms, E-coli, and enterococcus are indicators of pathogenic contamination from sewage and/or the feces of warm-blooded animals. As such, the state water quality standards establish minimum bacteria criteria to protect public health from pathogens. Although not all bacteria are pathogenic the words “pathogens” and “bacteria” are used interchangeably in this document.

Total Maximum Daily Loads (TMDLs) for bacteria have been established for each watershed in Massachusetts. This document provides a wide range of implementation techniques that may be applied to reduce bacterial pollution and achieve WQS in surface waters. Stakeholders should use this document to identify bacterial sources and to take appropriate actions to reduce their effects.

The intended audience for this document includes the following stakeholders: municipal personnel, watershed groups, and private citizens responsible for, or interested in, mitigating bacterial pollution to surface waters. Municipal personnel include departments of public works, water and sewer commissions, conservation commissions, boards of health, harbormasters, and others.

In this document, pathogen sources and appropriate mitigation measures are organized based on the land use type they are associated with. Urban, suburban, and agricultural land uses are considered in this document. In addition, mitigation measures are discussed to address bacterial pollution from swimmers, boats, and marinas. Potential bacteria pollution sources include:

- In urban and suburban areas - stormwater runoff, leaking sewer pipes, failing septic systems, combined sewer overflows (CSOs), and pet waste;
- In agricultural areas - field application of manure, grazing livestock, animal feeding operations; and areas where animals are confined (e.g., paddocks); and
- In recreational waters - sewage and gray water from boats and marina facilities, swimmers, wildlife, and pet waste.

For each source, a set of mitigation measures is described. For each mitigation measure, several factors are discussed including appropriate settings and expected effectiveness at reducing pathogen loading.

This introductory section provides an overview of TMDL program requirements, an introduction to pathogens and indicator bacteria, and a discussion of the causes of pathogen impairment. Section 2 provides a description of the recommended approach to implementing bacterial TMDLs. Sections 3, 4, and 5 provide descriptions of mitigation measures designed to reduce pathogen/bacteria loads to achieve WQS. Some information and text in this document was taken directly from The

Massachusetts Nonpoint Source Pollution Management Manual (MA DEP 2004). This manual is scheduled to be available at the Massachusetts Department of Environmental Protection (MA DEP) website (http://www.mass.gov/dep/brp/wm/nonpoint.htm) in the near future – although the exact location where this document will appear on the website is undetermined as of the date of this document.

1.1 TMDL Program Requirements

The Clean Water Act (CWA) (Section 303(d)) requires States to monitor waters, to identify waters not meeting State water quality standards (WQS), and to develop TMDLs to bring those waters back into compliance with WQS. A TMDL is the sum of loads (point and non-point sources) of a pollutant that a waterbody can receive and still meet WQS.

TMDL implementation is the focus of this guidance manual. A TMDL implementation plan is necessary to reduce pollutant loading and ultimately achieve WQS. Once TMDLs are established and approved by EPA, Section 303(e) of the CWA and Water Quality Planning and Management Regulations (40 CFR 130.6 and 130.7) require incorporation of TMDLs into the State's current Water Quality Management (WQM) plan and their application to direct monitoring and implementation activities. This guidance manual is designed to support development of TMDL implementation plans to accompany each Pathogen TMDL.

1.2 Pathogens and Indicator Bacteria

The Massachusetts Pathogen TMDLs are designed to reduce the release of disease-causing organisms, known as pathogens, into surface waters and thus reduce public health risk. Waterborne pathogens enter surface waters from a variety of sources including sewage and the feces of warm-blooded wildlife. Even small numbers of microorganisms from sewage wastes can cause diseases, such as hepatitis, in people who consume or come in contact with the water. Pathogens can also contaminate shellfish and make them unsuitable for human consumption. A secondary benefit to reducing human and animal waste discharges to waterways is a reduction in materials that cause oxygen depletion and associated degradation of water quality.

Waterborne pathogens include a broad range of bacteria and viruses that are difficult to identify and isolate. Thus, certain bacteria are used as indicator organisms. Indicator bacteria are easier to identify in the environment and are associated with other pathogens known to be harmful to human health. Bacteria used as indicator bacteria include fecal coliform, enterococci, and fecal streptococci. High densities of indicator bacteria indicate the likely presence of pathogenic organisms. The Massachusetts Watershed Pathogen TMDLs have been developed based on measurements of indicator bacteria.

1.3 Causes of Pathogen Impairment

Causes of pathogen impairment include a myriad of human activities closely associated with developed land uses (including agricultural, urban, and suburban land use). In this document, sources of pathogens and management measures are organized based on land use. This section summarizes typical causes of pathogen impairment for urban, suburban, agricultural, and recreational water use.

1.3.1 Causes of Pathogen Impairment in Urban and Suburban Areas

Stormwater is an important source of bacteria in urban and suburban areas. Urbanized and suburban land use increases the amount of impervious surface relative to undeveloped areas. The result is increased rates and volumes of runoff. This runoff washes bacteria from a wide range of sources into surface waters through stormwater systems or as overland flow directly into surface waters. Pet waste and wildlife can be significant sources of bacteria in urban and suburban areas. Illicit discharges to stormwater systems may also contribute to high bacteria concentrations in stormwater.

Combined sewers, which collect stormwater and sanitary sewage in one interconnected system, can also be a significant source of pathogens to receiving waters. During wet weather, CSO discharge events and decreased wastewater treatment plant effectiveness can result in significant discharges of pathogens. CSOs occur when high volumes of stormwater overload the system resulting in the discharge of untreated sewage.

Failing private septic systems can be another significant source of pathogen impairment in urban and suburban areas. When properly installed, operated, and maintained, septic systems effectively reduce pathogen concentrations in sewage. However, age, overloading, or poor maintenance can result in failure of septic systems and the release of pathogens and other pollutants (USEPA 2002).

Section 3 describes mitigation measures, including recommended Best Management Practices (BMPs), to reduce pathogen loads to achieve WQS in urban and suburban areas.

1.3.2 Causes of Pathogen Impairment in Agricultural Areas and Other Areas Where Animals are Confined

Agricultural land uses in Massachusetts include: dairy farming, the penning or raising of livestock (including hogs, fowl, horses, llamas**,** alpacas and other animals), crop farming, and use of land for pastures and paddocks. Agricultural land use can contribute to bacterial impairment of surface waters. Land uses with the potential to contribute to pathogen pollution include:

- Field applications of manure and/or manure storage,
- Livestock grazing, and

- Animal feeding operations, barnyards and paddocks.

In agricultural areas, bacteria can reach adjacent streams through a variety of pathways. One typical pathway is via runoff whereby bacteria wash off land surfaces into adjacent streams. Section 4 describes mitigation measures, including recommended BMPs, designed to reduce the contribution of pathogens from agriculture.

1.3.3 Causes of Pathogen Impairment in Recreational Waters

Recreational waters may receive inputs of bacteria from a variety of land-based sources addressed above. In addition, there are a number of sources of bacteria that are specific to recreational environments. These sources include swimmers, wildlife, pets, sewage and gray water from boats, and marina facilities.

Swimmers themselves may contribute to bacterial impairment at swimming areas. When swimmers enter the water, residual fecal matter and urine may be washed from the body and contaminate the water with pathogens. Control of bacterial contamination at recreational beaches is particularly important since large numbers of people are regularly in contact with the water at beaches.

Discharges of sewage and gray water (includes wastewater from sinks, showers, and laundry facilities) from boats are also potential sources of pathogens to marine and freshwaters. Boats are most likely to contribute to pathogen impairment in situations where large numbers congregate in enclosed environments with low tidal flushing. Section 5 describes mitigation measures designed to reduce pathogen loads from these sources.

1.4 Microbial Source Tracking

A key challenge to implementing pathogen TMDLs is identifying the sources of pathogens. Identifying which sources of pathogens are most important in a watershed assists in choosing appropriate mitigation strategies. Sources of pathogens include humans, wildlife, pets, and livestock. One promising technique for identifying which sources are contributing to impairment is microbial source tracking. Each source of pathogens produces unique, identifiable genetic material. Microbial or bacterial source tracking uses this genetic material to identify sources of contamination. More information on microbial or bacterial source tracking is available at:

- EPA New England Regional Laboratory Website. Available at: http://www.epa.gov/ne/lab
- Wastewater Technology Fact Sheet, Bacterial Source Tracking. USEPA 2002. EPA 832-F-02-010. Available at: http://www.epa.gov/owm/mtb/bacsortk.pdf
- Microbial Source Tracking Guide Document. USEPA 2005. EPA 600-R-05-064. Available at: http://www.sfbayjv.org/pdfs/EPAMicrobialSourceTrackingGuideDocument_June2005.pdf

2.0 APPROACH TO TMDL IMPLEMENTATION

The Massachusetts Pathogen TMDLs that have been developed include a compilation of ambient bacteria data and information on potential pathogen sources. The next step in the process is developing a TMDL implementation strategy to reduce pathogen loads to achieve acceptable water quality. This section provides a recommended TMDL implementation strategy. The strategy applies an adaptive management approach to reducing pathogens. The process is iterative. Data are gathered on an ongoing basis; specific sources are identified and eliminated, if possible; and control measures including BMPs, are implemented, assessed, and modified, as needed.

The TMDL implementation strategy should be part of a comprehensive watershed-specific management program. Recommended steps for developing and applying TMDL implementation plans for each watershed are as follows:

1. Review the watershed's Pathogen TMDL report and data;

2. Review, when available, the following information sources:
   - The Massachusetts Department of Environmental Protection (MA DEP) Water Quality Assessment Report for the watershed in question, available on the MA DEP website: http://www.mass.gov/dep/brp/wm/wqassess.htm;
   - The DMF Sanitary Surveys, available on the DMF website: http://www.mass.gov/dfwele/dmf/programsandprojects/shelsani.htm;
   - Local Department of Public Works or Highway files for locations of stormwater discharge pipes;
   - Land-use information to identify potential agricultural sources including vegetable farms, dairy farms, pasturelands, as well as areas where horses and/or other animals are kept;
   - Local Board of Health records to determine septic system failures;
   - Local beach bacteria monitoring data;
   - The Comprehensive Conservation and Management Plan (CCMP) for Buzzards Bay or Massachussetts Bays if appropriate. Available at: http://www.mass.gov/envir/massbays/ccmp.htm and http://www.buzzardsbay.org/ccmptoc.htm
   - Information from local watershed associations;
   - Local reports on high concentrations of waterfowl; and
   - Local reports on pet waste issues.

3. Conduct a detailed source identification and characterization program:
    - Use local knowledge (e.g., from local Departments of Public Works, Boards of Health, and watershed groups) and draw on other ongoing programs (e.g., National Pollution Discharge Elimination System (NPDES) Phase 2 Municipal Separate Storm Sewer System (MS4) stormwater discharge inventories and illicit discharge detection programs);
    - Conduct on-the-ground reconnaissance to identify potential sources;
    - Review infrastructure maps (e.g., storm sewer, sanitary sewer, and CSO maps) to identify potential sources; and
    - Review other available information (e.g., septic tank locations, ages, and reports of failures) to identify potential sources.
4. Prioritize pathogen sources for mitigation. High priority should be assigned to the sources that can be most cost effectively addressed;
5. Use this Implementation Guidance Manual to support identification of specific management techniques to mitigate or remove each source or type of source;
6. Develop detailed site-specific designs and programs for each management practice;
7. Identify funding options to remediate the highest priority pathogen sources;
8. Implement management practices to mitigate pathogen sources;
9. Monitor changes in receiving waters as management practices are implemented (including pre-implementation monitoring) and re-evaluate pathogen sources; and
10. Revisit and/or repeat Steps 3 through 9, as needed until WQS are achieved.

In most watersheds, pathogen sources are many and diffuse. As a result, appropriate management practices must be selected, designed, and implemented at numerous locations to mitigate adverse impacts and control pathogen impairment. The most appropriate suite of management practices will vary depending on land use and pathogen source.

In many cases, the most effective approach to mitigating pathogen pollution is through methods such as outreach and education and the enactment of bylaws and ordinances. These methods can be relatively cost effective and promoting pollution prevention and good housekeeping. Examples of outreach and education methods and ordinances and bylaws are provided in Table 2-1. Specific information on addressing pathogen sources using these approaches is provided in Sections 3.1.5, 3.2.2, and 4.7.

Table 2-1 Enabling Factors for Supporting Pathogen Mitigation

Approach	Examples
Outreach and Education	Brochures and fact sheets Public service announcements Watershed associations Signs Mailings School activities Websites Storm drain stenciling Watershed and beach cleanups Sponsored speaking engagements Trainings Commercials
Bylaws and Ordinances	Create stormwater utilities Require clean up of pet waste Prohibit wildlife feeding or other activities that encourage wildlife congregation Designate no discharge areas (NDAs) for sewage from boats

One potential challenge to addressing pathogen pollution is locating funds. Examples of some funding sources that may be applicable to reducing pathogen pollution are given in Table 2-2. In addition, resources (including websites and documents) are provided with more information about specific funding opportunities.

Table 2-2 Examples of Financing Sources for Mitigating Pathogen Pollution (more information and resources are provided in sections 3.1.5, 3.2.2, 4.4, and 5.6)

Source of Funding	Examples
Federal	Section 319 program Conservation Security Program Conservation Reserve Program Wetlands Reserve Program Environmental Quality Incentives Program Grassland Reserve Program Conservation Corridor Demonstration Program Wildlife habitat reserve program Farm and Ranch Land Protection Program Resource Conservation and Development Program National Natural Resources Conservation Foundation
State	State Revolving Loan Fund Coastal Pollutant Remediation Grant Program Coastal Nonpoint Source Pollution Grant Program Homeowner septic loan program Comprehensive Community Septic Management Program Title 5 Tax Credit Massachusetts Clean Marina Initiative
Local	Stormwater Utilities Property Taxes Private Foundations

Management practices described in the following sections are designed to address a wide range of impacts associated different types of land use. When these practices are implemented, major improvements in watershed health, well beyond reductions in pathogen loading, can be realized. Thus, development and application of the TMDL implementation plan will have far reaching benefits to the watershed. Each of the following sections provides information on mitigation measures, funding opportunities and resources for additional information.

3.0 MANAGEMENT PRACTICES FOR URBAN AND SUBURBAN AREAS

The following sections provide a compilation of management practices for reducing pathogen loads in urban and suburban areas. Urban and suburban land use is used herein to refer to residential (including urban and suburban areas), commercial, and industrial areas. Although they have different characteristics, these land uses are grouped together because they typically have similar sources of pathogens and associated mitigation measures. Mitigation measures are organized by the source of pathogens they address:

- Stormwater-related (Section 3.1)
- Pet waste (Section 3.1.2.3)
- Wildlife (Section 3.1.2.5)
- Septic systems (Section 3.2)
- CSOs (Section 3.3)

For each source type, management practices for mitigating impacts are briefly described and sources for more detailed information (including websites and documents) are provided.

Table 3-1 is a summary of mitigation measures for the pathogen sources discussed in this document, their applicability for various land uses, and their impact on hydrology and water quality. The ratings for applicability and mitigation provided in the table are subjective. This matrix is intended to assist resource managers in evaluating the suitability of each management practice to a given situation.

3.1 Stormwater

The 1998 National Water Quality Inventory Report to Congress identified urban runoff as one of the leading sources of water quality impairment in surface waters. Of the 11 pollution categories listed in the report, urban runoff/storm sewers was ranked as the sixth leading source of impairment in rivers, fourth in lakes, and second in estuaries (USEPA, 2000b). Stormwater is likely to be particularly significant in Massachusetts because the state is almost 40% urbanized, making it the fourth most urbanized state in the country (FHA 1998).

Table 3-1 Management Practices, Mitigation Provided, and Land Use Applicability Matrix

Urbanization and development drastically change the hydrology of our watersheds by increasing the amount of surface runoff. Urbanization begins with the removal of trees, vegetation, and topsoil. These natural features play an important role in allowing rainfall to slowly infiltrate and provide continuous recharge to streams, wetlands and aquifers. Replacing these features with impervious surface (highways, roads, parking areas, sidewalks, roofs, shopping centers, and malls) increases the amount of rainfall that runs off a given area. This runoff is usually collected on roadsides, directed into catch basins, and discharged into the nearest stream, pond, or wetland. Conventional drainage systems prevent water from flowing into the ground and filtering through the soil before ending up in surface or ground waters. This reduces the amount of groundwater recharge and base flow to rivers.

Runoff washes bacteria from a myriad of sources into stormwater systems and eventually into surface waters. Typical values for fecal coliform concentrations in urban runoff are 15,000 to 20,000 fecal coliform colonies per 100 ml (Center for Watershed Protection 2003). Stormwater runoff from urban areas may also carry a variety of other pollutants, including sediment, organic matter, nutrients, metals, fertilizers, and pesticides. In addition, the increased rate of runoff causes higher flow rates in streams, increased erosion (often leading to stream stabilization issues), and increased flood rates. The large volumes of stormwater and the high concentrations of bacteria in urban runoff often make stormwater the most significant contributor of bacteria to water bodies in urban and suburban watersheds.

Stormwater runoff can be categorized in two forms: point source discharges and non-point source discharges (includes sheet flow or direct runoff). Many point source stormwater discharges to waters of the United States and the Commomwealth are regulated under the NPDES Phase I and Phase II permitting programs. Boston and Worcester are the only communities in Massachusetts subject to Phase I requirements. Communities in Massachusetts subject to Phase II requirements are listed in Appendix B. Municipalities that operate municipal separate storm sewer systems (MS4s) subject to phase II stormwater requirements must develop and implement a stormwater management plan (SWMP) which must employ, and set measurable goals for six minimum control measures. Each of these six minimum control measures is described briefly below and in fact sheets available at: http://cfpub1.epa.gov/npdes/stormwater/swfinal.cfm?program_id=6. Individual municipalities not regulated under the Phase I or II may implement the same six control measures for minimizing stormwater contamination.

1. **Public education and outreach**

   Stormwater educational materials may be provided by states, tribes, EPA, environmental, public interest, or trade organizations. The public education program should inform individuals and households about the steps they can take to reduce stormwater pollution, such as ensuring proper septic system maintenance, pet waste control, and maintaining and/or enhancing riparian vegetation. EPA recommends that the education program inform individuals and groups how to become involved in local stream and beach restoration activities. In addition, the program should promote activities that are coordinated by youth service and conservation corps or other citizen groups.

EPA recommends that the public education program be tailored, using a mix of locally appropriate strategies, to target specific audiences and communities. Examples of strategies include distributing brochures or fact sheets, sponsoring speaking engagements before community groups, providing public service announcements, implementing educational programs targeted at school age children, and conducting community-based projects such as storm drain stenciling and watershed and beach cleanups. In addition, EPA recommends that some of the materials or outreach programs be directed toward targeted groups of commercial, industrial, and institutional entities likely to have significant stormwater impacts.

2. Public participation/involvement

EPA recommends that the public be included in developing, implementing, and reviewing stormwater management programs, and that the public participation process be designed to reach out and engage all economic and ethnic groups. Opportunities for members of the public to participate in program development and implementation include serving as citizen representatives on a local stormwater management panel, attending public hearings, working as citizen volunteers to educate other individuals about the program, assisting in program coordination with other pre-existing programs, or participating in volunteer monitoring efforts.

3. Illicit discharge detection and elimination

Municipalities are required to develop illicit discharge detection and elimination plans. EPA recommends that the plan include procedures for:

- locating priority areas likely to have illicit discharges;
- tracing the source of an illicit discharge;
- removing the source of the discharge; and
- evaluating and assessing the program.

EPA recommends visually screening outfalls during dry weather and conducting field tests of selected pollutants as part of the procedures for locating priority areas. Illicit discharge education actions may include storm drain stenciling; programs to promote, publicize, and facilitate public reporting of illicit connections or discharges; and distribution of outreach materials.

4. Construction site runoff control

Communities are encouraged to provide appropriate educational and training measures for construction site operators. They may choose to require stormwater pollution prevention plans for construction sites within their jurisdiction that discharge into their system.

5. Post construction runoff control

A number of BMPs may be incorporated into site design to minimize water quality impacts associated with development. These post construction runoff controls may include low impact design strategies and infiltration and detention structures (see Section 3.1.3 and Appendix D). EPA recommends that the BMPs chosen be appropriate for the local community, minimize water quality impacts, and attempt to maintain pre-development runoff conditions. When choosing appropriate BMPs, EPA encourages entities engaged in construction activities to participate in locally-based watershed planning efforts which attempt to involve a diverse group of stakeholders including interested citizens.

6. Pollution prevention/good housekeeping

Operation and maintenance should be an integral component of all stormwater management programs. This component is intended to improve the efficiency of stormwater management programs. Properly developed and implemented operation and maintenance programs reduce the risk of water quality problems. EPA recommends that, at a minimum, communities consider the following in developing their programs:

- Maintenance activities, maintenance schedules, and long-term inspection procedures for structural and nonstructural stormwater controls;
- Controls for reducing or eliminating the discharge of pollutants from streets, roads, highways, municipal parking lots, maintenance and storage yards, and fleet or maintenance shops with outdoor storage areas;
- Procedures for properly disposing of waste removed from the separate storm sewers and areas listed above (such as dredge spoil, accumulated sediments, and other debris); and
- Local by-laws and/or ordinances to address pathogen sources such as pet waste.

Stormwater discharges are not subject to numeric NPDES permit limits. Instead, maximum extent practicable (MEP) is the statutory standard that establishes the level of pollutant reductions that regulated municipalities must achieve. The MEP standard is a narrative effluent limitation that is satisfied through implementation of SWMPs and achievement of measurable goals.

Non-point source (NPS) discharges are generally characterized as sheet flow runoff and are not categorically regulated under the NPDES program. NPS discharges can be difficult to manage, but, some of the same principles for mitigating point source impacts may be applicable.

Stormwater management programs are evolving and expanding in order to implement the Stormwater Phase II requirements and address the adverse environmental effects of stormwater. Municipalities can no longer only address flood through the control of post-development stormwater peak discharge rates. Stormwater programs must now include erosion and sediment control measures during the construction phase and minimize the discharge of pollutants after construction is completed by using stormwater treatment practices. Many of these efforts require the development and passage of new regulations and ordinances at the municipal level. Stormwater programs must also include public education efforts and focus more on the long-term maintenance of stormwater systems. This additional effort requires new financial resources or creative use of existing funds.

Reducing stormwater contributions to pathogen impairment is difficult. Most mitigation measures for stormwater are not designed specifically to reduce bacteria concentrations. Instead, BMPs are typically designed to remove sediment and other pollutants. Bacteria in stormwater runoff are, however, often attached to particulate matter. Therefore, treatment systems that remove sediment may also provide reductions in bacteria concentrations.

Stormwater treatment methods may be either offline or online systems. Offline systems are designed to only receive a prescribed volume of runoff (e.g., the first 0.5 inches); the remainder of the flow bypasses the system. These systems have the advantage of treating all runoff from smaller rainfall events and the initial flush of runoff from larger storms, which is generally more polluted, without the capacity requirements for treating all of the runoff. Online systems generally receive all of the flow from a given area. When flow volume exceeds the design capacity of systems their effectiveness at removing pollutants is reduced.

Given the high concentrations of bacteria often found in stormwater and the lack of targeted mitigation measures, perhaps the most effective means of reducing stormwater contributions to pathogen impairment is to reduce the volume of runoff by increasing infiltration to groundwater. This approach results in a reduction in flushing of bacteria from contaminated surfaces. Bacteria are removed from water that infiltrates to groundwater by filtration through the soil matrix.

Minimizing the potential for runoff to come in contact with pathogens is another important means of reducing stormwater's contribution to pathogen impairment. Septic systems, illicit discharges, pets, and wildlife are all potentially important sources of pathogens to stormwater. Information on addressing these sources is in Section 3.1.2.

Once stormwater BMPs have been constructed, operation and maintenance measures become important to ensure that they remain effective. Stormwater can contain large loads of sediments and other debris that can rapidly reduce the effectiveness of many BMPs (USEPA 1999c). Therefore, development of an operation and maintenance program that includes regular inspection, replacement, and repair of stormwater BMPs is vital (see Section 3.1.4).

Brief descriptions of potentially applicable stormwater mitigation measures are provided below (see also Table 3-1). The information provided here is intended only to provide an introduction to commonly used stormwater treatment systems and approaches. The reader should refer to other sources to assess applicability to a given setting, and for design guidelines (see Section 3.1.1.).

3.1.1 General Resources – for Urban and Suburban Stormwater Mitigation

- National Management Measures to Control Nonpoint Source Pollution from Urban Areas – Draft. 2002. EPA842-B-02-003. Available at: http://www.epa.gov/owow/nps/urbanmm/index.html

- Stormwater Management Volume Two: Stormwater Technical Manual. Massachusetts Department of Environmental Management. 1997. Available at: http://www.mass.gov/dep/brp/stormwtr/stormpub.htm

- Fact Sheets for the six minimum control measures for storm sewers regulated under Phase I or Phase II. Available at: http://cfpub1.epa.gov/npdes/stormwater/swfinal.cfm?program_id=6

- A Current Assessment of Urban Best Management Practices. 1992. Metropolitan Washington Council of Governments. Washington, DC

- Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. 1987. Metropolitan Washington Council of Governments. Washington, DC

- 2004 Stormwater Quality Manual. Connecticut Department of Environmental Protection 2004. Available at: http://dep.state.ct.us/wtr/stormwater/strmwtrman.htm

- Stormwater Treatment BMP New Technology Report. California Department of Transportation. 2004. SW-04-069-.04.02 Available at: http://www.dot.ca.gov/hq/env/stormwater/special/newsetup/_pdfs/new_technology/CTSW-RT-04-069.pdf

- Moonlight Beach Urban Runoff Treatment facility: Using Ultraviolet Disinfection to Reduce Bacteria Counts. Rasmus, J. and K. Weldon. 2003. StormWater, May/June 2003. Available at http://www.forester.net/sw_0305_moonlight.html

- Operation, Maintenance, and Management of Stormwater Management Systems. Livingston, Shaver, Skupien, and Horner. August 1997. Watershed Management Institute. Call: (850) 926-5310.

- Model Ordinances to Protect Local Resources – Stormwater Control Operation and Maintenance. USEPA Webpage: http://www.epa.gov/owow/nps/ordinance/stormwater.htm
- Stormwater O & M Fact Sheet Preventive Maintenance. USEPA 1999. 832-F-99-004. Available at: http://www.epa.gov/owm/mtb/prevmain.pdf
- The MassHighway Stormwater Handbook. Massachusetts Highway Department. 2004. Available at: http://166.90.180.162/mhd/downloads/projDev/swbook.pdf
- University of New Hampshire Stormwater Center: Dedicated to the protection of water resources through effective stormwater management. Available at: http://www.unh.edu/erg/cstev/index.htm#
- EPA's Stormwater website: http://www.epa.gov/region1/topics/water/stormwater.html
- The Massachusetts Nonpoint Source Pollution Management Manual. Expected Availability: Fall 2005 on the MA DEP Nonpoint Source Program Website: http://www.mass.gov/dep/brp/wm/nonpoint.htm The exact location of where the manual will appear on the MA DEP website was not available at the time of publication of this document.

3.1.2 Pathogen Source Reductions

There are a number of methods that reduce sources of pathogen to stormwater. These include eliminating illicit discharges to stormwater systems and minimizing incorporation of pet and wildlife waste into runoff. In contrast to many of the other mitigation options, pathogen source reductions are targeted at the source of the problem rather than intercepting and treating contaminated water en route to the water body. Focusing on the pathogen source reduction is often a cost effective way of reducing pathogens in stormwater.

3.1.2.1 Illicit Discharges

Removal of illicit discharges to storm sewer systems, particularly of sanitary wastes, is an effective means of reducing pathogen loading to receiving waters. Illicit discharges include any discharges to stormwater systems that are not entirely composed of stormwater. These include intentional illegal connections from commercial or residential buildings, failing septic systems, and improper disposal of sewage from campers and boats. These sources can contribute significantly to the load of pathogens in stormwater, particularly during periods of dry flow. Identification and elimination of dry and wet weather illicit discharges to MS4s is required as part of the NPDES Phase II stormwater permitting requirements. Industrial facilities requiring NPDES stormwater permits are also subject to these requirements.

Illicit discharges can be addressed through development of a comprehensive illicit discharge detection and prevention program. Such a program may include comprehensive mapping and inspection of stormwater systems, locating priority areas, identifying and removing identified sources, and developing ordinances prohibiting illicit discharges (NEIWPCC 2003). As an example, Appendix C, *Lower Charles River Illicit Discharge Detection & Elimination (IDDE) Protocol Guidance for Consideration - November 2004,* contains recommended program guidance that can be applied throughout the Commonwealth.

Resources – Illicit Discharges

- Lower Charles River Illicit Discharge Detection and Elimination Protocol Guidance for Consideration – November 2004. Appendix C.
- Illicit Discharge Detection and Elimination Manual - A Handbook for Municipalities. 2003. New England Interstate Water Pollution Control Commission. Available at: http://www.neiwpcc.org/PDF_Docs/iddmanual.pdf
- Model Ordinances to Protect Local Resources – Illicit Discharges. USEPA webpage: http://www.epa.gov/owow/nps/ordinance/discharges.htm

3.1.2.2 Pet Waste

In residential areas, pet waste can be a significant contributor of pathogens in stormwater. Each dog is estimated to produce 200 grams of feces per day, and pet feces can contain up to 23,000,000 fecal coliform colonies per gram (Center for Watershed Protection 1999). If the waste is not properly disposed of, these bacteria can wash into storm drains or directly into water bodies and contribute to pathogen impairment.

Encouraging pet owners to properly collect and dispose of pet waste is the primary means for reducing the impact of pet waste. Flushing waste down the toilet is the preferred method of disposal. Alternatively, small amounts of waste may be disposed of by burying or sealing it in a plastic bag and throwing it in the trash (USEPA 2002). It should never be thrown down a storm drain, a common occurrence in urban areas. To increase compliance with these guidelines a number of measures are recommended:

- Developing and enforcing local “pooper scooper” ordinances or bylaws requiring pet owners to correctly dispose of pet waste. These have been enacted in a number of communities in Massachusetts including Worcester, Newton, and Boston
- Conducting public awareness campaigns that can include public service announcements, signs in areas frequented by pet owners, and mailings

- Developing specific “pet waste stations” that include waste receptacles, collection bags, scoops, and shovels
- Ensuring areas, such as public beaches, are either off-limits to pets or subject to certain ordinances to control fecal contamination of swimming areas
- Installing specially designed septic systems for pet waste (doggy loos)
- Maintaining areas with long grass. Dogs prefer defecating in long grass, and areas with long grass allow feces to degrade naturally (MA DEP 2004).

Resources – Pet Waste

- National Management Measure to Control Non Point Source Pollution from Urban Areas – Draft. USEPA 2002. EPA 842-B-02-2003. Available from: http://www.epa.gov/owow/nps/urbanmm/index.html
- Septic Systems for Dogs? Nonpoint Source News-Notes 63. Pet Waste: Dealing with a Real Problem in Suburbia. Kemper, J. 2000. New Jersey Department of Environmental Protection. Available from: http://www.state.nj.us/dep/watershedmgt/pet_waste_fredk.htm
- Stormwater Manager's Resource Center. Schueler, T., Center for Watershed Protection, Inc. http://www.stormwatercenter.net
- Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters. U.S. EPA, Office of Water 1993. Washington, DC.
- National Menu of Best Management Practices for Stormwater Phase II. USEPA. 2002. Available at: http://www.epa.gov/npdes/menuofbmps/menu.htm
- Welcome to NVRC'S Four Mile Run Program. NVRC 2001. Available at: http://www.novaregion.org/fourmilerun.htm
- Boston’s ordinance on dog waste. City of Boston Municipal Codes, Chapter XVI. 16-1.10A Dog Fouling. Available at: http://www.amlegal.com/boston_ma/
- Pet Waste and Water Quality. Hill, J.A., and D. Johnson. 1994. University of Wisconsin Extension Service. http://cecommerce.uwex.edu/pdfs/GWQ006.PDF
- Long Island Sound Study. Pet Waste Poster. EPA. Available at: http://www.longislandsoundstudy.net/pubs/misc/pet.html
- Source Water Protection Practices Bulletin: Managing Pet and Wildlife Waste to Prevent Contamination of Drinking Water. USEPA. 2001. EPA 916-F-01-027. Available at: http://www.epa.gov/safewater/protect/pdfs/petwaste.pdf

- The Massachusetts Nonpoint Source Pollution Management Manual. MA DEP 2004 Expected Availability: Fall 2005 on the MA DEP Nonpoint Source Program Website: http://www.mass.gov/dep/brp/wm/nonpoint.htm although the exact location where this document will appear on the MA DEP website has not yet been determined.

3.1.2.3 Wildlife

Fecal matter from wildlife is a significant source of pathogens in some watersheds. This is particularly true when human activities, including the feeding of wildlife and habitat modification, result in the congregation of wildlife. Concentrations of geese, gulls, and ducks are of particular concern because they often deposit their waste directly into surface waters. Therefore, they can be major sources of pathogens, particularly in lakes and ponds where large resident populations have become established near beaches (Center for Watershed Protection 1999). As a result, many mitigation measures are focused on waterfowl.

Reducing the impact of wildlife on pathogen concentrations in water bodies generally requires either reducing the concentration of wildlife in an area or reducing their proximity to the water body. The primary means for doing this is to eliminate human inducements for congregation. In addition, in some instances population control measures may be appropriate.

Reducing Animal Feeding: Educating the public about the potential impacts to water quality from feeding wildlife can reduce wildlife congregation. Education can take the form of fliers, signs, mailings, or other methods (see Table 2-1). In addition to education, bylaws may be enacted to prohibit the feeding of wildlife. An example of a bylaw prohibiting the feeding of waterfowl can be found at the link provided in the Resources – Wildlife section.

Behavioral Modification: Methods can be used to change the behavior of wildlife to minimize congregation of wildlife in areas where they contribute to water quality problems. These methods include techniques for scaring wildlife out of an area, the introduction of physical barriers, or the modification of the environment to reduce its attractiveness to certain wildlife (Underhill 1999). Scaring wildlife using trained dogs or loud noises has been effective in some instances. Physical barriers may include fencing to either exclude wildlife from areas near water bodies or from areas containing food sources. Finally, changing landscaping may reduce the congregation of wildlife in areas near water.

Population Control: If other measures fail to effectively control the impact of wildlife, population control measures may be appropriate. These include the introduction or expansion of a hunting season, culling, relocation, or the prevention of egg hatching (Underhill 1999). Wildlife agencies should be contacted and consulted to determine legal measures of population control.

Resources – Wildlife

- An example of a bylaw prohibiting the feeding of wildlife: Prohibiting Feeding of Wildlife. Town of Bourne Bylaws Section 3.4.3. Available at: http://www.townofbourne.com/Town%20Offices/Bylaws/chapter 3.htm

- Integrated Management of Urban Canadian Geese. M Underhill. 1999. Conference Proceedings, Waterfowl Information Network.

- Urban Canadian Geese in Missouri. Missouri Conservationist Online. Available at: http://www.conservation.state.mo.us/conmag/2004/02/20.htm

3.1.3 Structural Stormwater Mitigation Measures

In addition to the methods discussed above for addressing pathogen sources, there are various structural approaches to reducing the impact of stormwater from urban and suburban areas. These methods include infiltration and retention structures, detention structures, disinfection and chemical treatment, and low impact design strategies (LIDS). These approaches are discussed in more detail in Appendix D.

3.1.4 Operation and Maintenance

Once stormwater BMPs have been constructed, operation and maintenance measures are important to ensure that they remain effective. Stormwater can contain large loads of sediments and other debris that can rapidly reduce the effectiveness of many BMPs (USEPA 1999c). Therefore, development of an operation and maintenance program that includes regular inspection, replacement, and repair of stormwater BMPs is vital. Appendix D contains a description specific operation and maintenance practices.

3.1.5 Financing Urban Stormwater Management[1]

Local Financing Opportunities: Many rapidly growing areas of the United States are creating stormwater utilities as a mechanism to generate revenue to support a stormwater program and to better regulate, coordinate, and organize stormwater activities under one program. States and local governments including communities in Georgia, Florida, Colorado, Washington State, and Washington D.C. have developed successful stormwater utilities. Resources for more information on stormwater utilities are listed below.

[1] This section relies heavily on the Draft Massachusetts Nonpoint Pollution Management Manual (MA DEP 2004).

- The Pioneer Valley Regional Planning Agency in West Springfield, MA has created a how-to manual on developing stormwater utilities for Massachusetts communities. This work is based on a project with the City of Chicopee, MA that was developed in response to a requirement by the USEPA to resolve a CSO problem. Information is available at: http://www.pvpc.org/docs/landuse/storm_util.pdf

- The Center for Urban Water Policy and the Environment at Indiana University-Purdue University Indianapolis (IUPUI) in cooperation with the Watershed Management Institute, Inc. has created a website that contains numerous documents and provides guidance on stormwater utilities and other mechanisms to finance stormwater controls (http://stormwaterfinance.urbancenter.iupui.edu).

In Massachusetts, most cities and towns share the responsibility for implementing stormwater controls between the elected officials (selectmen, mayor), and many different local boards and departments (planning boards, conservation commissions, Department of Public Works, Boards of Health, etc.). The general revenues raised by local property taxes are the primary sources of funds to support stormwater management at the municipal level in Massachusetts.

Recently, a Massachusetts law was changed to allow local communities to use taxes to raise revenue for developing and maintaining stormwater systems. As of July 1, 2004, Massachusetts General Laws were changed allowing: "The aldermen of any city or the sewer commissioners, selectmen or road commissioners of a town, may from time to time establish just and equitable annual charges for the use of common sewers and main drains and related stormwater facilities, which shall be paid by every person who enters his particular sewer therein. The money so received may be applied to the payment of the cost of maintenance and repairs of such sewers or of any debt contracted for sewer purposes. In establishing quarterly or annual charges for the use of main drains and related stormwater facilities, the city, town, or district may either charge a uniform fee for residential properties and a separate uniform fee for commercial properties or establish an annual charge based upon a uniform unit method; but, the charge shall be assessed in a fair and equitable manner. The annual charge shall be calculated to supplement other available funds as may be necessary to plan, construct, operate and maintain stormwater facilities and to conduct stormwater programs. The city, town or district may grant credits against the amount of the quarterly or annual charge to those property owners who maintain on-site functioning retention/detention basins or other filtration structures as approved by the stormwater utility, conservation commission, or other governmental entity with appropriate authority."

State Revolving Fund and Section 319 Grants: Several communities are using the State Revolving Loan Fund to provide the basic funding to develop stormwater master plans and to implement stormwater controls. Under this program, funds are distributed by EPA to MA DEP. The MA DEP then distributes these funds on an application and priority basis to Massachusetts. Additionally, specific assessment, design and implementation funding is available annually on a competitive basis from the Section 319 Program. These funds can be used to address a wide range of urban nonpoint source pollution problems. However, these funds cannot be used to implement any elements of a community's approved Stormwater Phase II permit program. Resources for more information on the Section 319 Program and the State Revolving Loan Fund are listed below.

- For more information on the Section 319 funding program and other grant programs available in Massachusetts to address nonpoint source pollution see: http://www.mass.gov/dep/brp/mf/othergrt.htm.
- For more information on State Revolving Fund funding for stormwater management see: http://www.mass.gov/dep/brp/mf/mfpubs.htm

The Coastal Pollutant Remediation Grant Program: The Coastal Pollutant Remediation (CPR) grant program, which is administered by the Massachusetts Office of Coastal Zone Management (CZM), allows the Commonwealth to assist communities in their coastal NPS pollution control efforts. The CPR grant program complements the Commonwealth's Stormwater Management Policy, serving as a significant source of funding available to communities. The primary goal of CPR is to improve coastal water quality by reducing or eliminating NPS pollution, specifically transportation-related sources. Within this goal are four main objectives:

- Characterize and treat urban runoff from municipal roadways
- Improve coastal resources such as shellfish beds and fish habitat
- Demonstrate traditional and innovative BMPs
- Educate the public about stormwater runoff problems

Municipalities located in the Greater Massachusetts Coastal Watershed, which encompasses 220 cities and towns in eastern Massachusetts, are eligible for CPR grants. Since 1996, nearly $5 million in CPR grants have been awarded. Grant funds can be used to design and/or construct roadway-related pollution remediation systems and boat pumpout facilities. Example projects include filtering runoff through subsoil leaching galleys, utilizing new technologies for particle separation and filtration, and implementation of alternative and/or innovative stormwater management BMPs (e.g., Low Impact Design, see: http://www.mass.gov/envir/lid/default.htm) that reduce contaminants where they are generated. More information on the CPR is available at the following website: http://www.mass.gov/czm/cprgp.htm.

Coastal Nonpoint Source Pollution Grant Program: The Coastal NPS grant program has been developed to assist public and non-profit entities in implementing NPS pollution control efforts. Coastal NPS grant funding can be used for assessing nonpoint sources of pollution, developing non-structural BMPs, and developing innovative, transferable NPS management tools. The Coastal NPS grant program funds the following types of projects:

- Assessment, identification, and characterization of NPS pollution;

- Targeted assessment of the municipal stormwater drainage system (runoff from municipal roadways, parking lots and bridges);
- Development of transferable tools for NPS control; and
- Implementation of innovative and unique demonstration projects that utilize NPS BMPs (physical/structural control).

More information on the Coastal NPS grant program is available at: http://www.mass.gov/czm/coastalnpsgrants.htm

The Massachusetts Bays and Buzzards Bay Estuary Programs can provide technical assistance with grant writing and assist in obtaining funding. Information on these programs can be found at the following websites:

- Mass Bays Estuary Program. Available at: http://www.mass.gov/envir/massbays/
- The Buzzards Bay Project National Estuary Program Website. Available at: http://www.buzzardsbay.org/

3.2 Septic Systems

Failing private septic systems can be a significant source of pathogens. When properly installed, operated, and maintained, septic systems effectively reduce pathogen concentrations in sewage. However, age, overloading, or poor maintenance can result in failure of septic systems and the release of pathogens and other pollutants (USEPA 2002). To reduce the release of pathogens, practices can be employed to maximize the life of existing systems, identify failed systems, and replace or remove failed systems (table 3-2). Alternatively, the installation of public sewers may be appropriate.

3.2.1 Mitigation Measures – Septic Systems

Boards of Health should review the status of septic systems on a periodic basis to determine if there are any failed systems, especially in areas of pathogen impairment. Boards of Health should also assist in upgrading and/or replacing these systems or pursuing other alternatives to meet state standards.

Replacing Failed Septic Systems: Replacing or upgrading failed septic systems is an option for reducing pathogen contamination from septic systems. In Massachusetts, regulations (310CMR15) require detailed inspection of private septic systems at the time of property transfer. The regulations also require upgrades when any one of the following conditions is met:

- There is a backup of sewage into the facility served by the system or any component of the system as a result of an overloaded and/or clogged soil absorption system or cesspool.
- There is a discharge of effluent directly or indirectly to the surface of the ground through ponding, surface breakout, or damp soils above the disposal area or to a surface water of the Commonwealth.
- The static liquid level in the distribution box is above the level of the outlet invert.
- The liquid depth in a cesspool is less than six inches from the inlet pipe invert or the remaining available volume within a cesspool above the liquid depth is less than ½ of one day's design flow.
- The septic tank or cesspool requires pumping more than four times a year.
- The septic tank is made of metal, unless the owner or operator has provided the System Inspector with a copy of a Certificate of Compliance indicating that the tank was installed within the 20-year period prior to the date of the inspection.
- The septic tank is cracked or is otherwise structurally unsound; indicating that substantial infiltration or exfiltration is occurring or is imminent.
- A cesspool, privy or any portion of the soil absorption system extends below the high groundwater elevation.

As a practical matter, however, only sewage backups or discharges to the surface would be obvious without a detailed system inspection.

<u>Management Practices for Private Septic Systems:</u> Several practices may be employed to maximize the life and efficiency of private septic systems. Typically these practices must be implemented by private homeowners, so aggressive public education and outreach is vital. Table 3-2 lists the Massachusetts DEP's recommended practices for private septic systems.

Table 3-2 Do's and Don'ts of Private Septic System Management

DO...	DON'T...
Do have the on-site system inspected and pumped by a licensed professional approximately every 3 to 5 years. Failure to pump out the septic tank can cause system failure. If the tank fills up with an excess of solids, the wastewater will not have enough time to settle in the tank. These excess solids will then pass on to the leach field, where they will clog the drain lines and soil.	**Do not** use the toilet or sink as a trash can by dumping non-biodegradable material (cigarette butts, diapers, feminine products, etc.) or grease down the sink or toilet. Non-biodegradable material can clog the pipes, while grease can thicken and clog the pipes. Store cooking oils, fats, and grease in a can for disposal in the garbage.
Do know the location of the on-site system and drain field, and keep a record of all inspections, pumping, repairs, contract or engineering work for future references. Keep a sketch of it handy for service visits.	**Do not** put paint thinner, polyurethane, anti-freeze, pesticides, some dyes, disinfectants, water softeners, and other strong chemicals into the system. These can cause major upsets in the septic tank by killing the biological part of the on-site system and polluting the groundwater. Small amounts of standard household cleaners, drain cleansers, detergents, etc. will be diluted in the tank and should cause no damage to the system.
Do grow grass or small plants (not trees or shrubs) above the on-site system to hold the drain field in place. Water conservation through creative landscaping is a great way to control excess runoff.	**Do not** use a garbage grinder or disposal, which feeds into the on-site tank. If there is one, severely limit its use. Adding food wastes or other solids reduces the system's capacity and increases the need to pump the on-site tank. If a grinder is used, the system must be pumped more often.
Do install water-conserving devices in faucets, showerheads and toilets to reduce the volume of water running into the on-site system. Repair dripping faucets and leaking toilets, run washing machines and dishwashers only when full, and avoid long showers.	**Do not** plant trees within 30 feet of the system or park/drive over any part of the system. Tree roots will clog pipes, and heavy vehicles may cause the drain field to collapse.
Do divert roof drains and surface water from driveways and hillsides away from the on-site system. Keep sump pumps and house footing drains away from the on-site system as well.	**Do not** allow anyone to repair or pump the system without first checking that they are licensed system professionals.
Do take leftover hazardous chemicals to an approved hazardous waste collection center for disposal. Use bleach, disinfectants, and drain and toilet bowl cleaners sparingly and in accordance with product labels.	**Do not** perform excessive laundry loads with a washing machine. Doing load after load does not allow the on-site tank time to adequately treat wastes and overwhelms the entire on-site system with excess wastewater. This could flood the drain field without allowing sufficient recovery time. Consult with an on-site tank professional to determine the gallon capacity and number of loads per day that can safely go into the system.
Do use only on-site system additives that have been allowed for usage in Massachusetts by MA DEP. Additives that are allowed for use in Massachusetts have been determined not to produce a harmful effect to the individual system or its components or to the environment at large.	**Do not** use chemical solvents to clean the plumbing or on-site system. "Miracle" chemicals will kill microorganisms that consume harmful wastes. These products can also cause groundwater contamination

Installation of Public Sewers: Installation of public sanitary sewers can be a practical alternative in areas with many failing private septic systems, particularly in older and more densely developed neighborhoods. Capital expenses for these projects are high, particularly if an existing wastewater treatment plant with sufficient capacity for the new flow is not available. Communities must also weigh the environmental benefits of removing failed private septic systems against the potential additional stress on the receiving water by increasing development in areas unsuitable for private septic systems and reducing baseflow due to lost recharge.

Resources – Septic Systems

- National Management Measures to Control Nonpoint Source Pollution from Urban Areas – Draft. Chapter 6. New and Existing Onsite Wastewater Treatment Systems. USEPA 2002. EPA842-B-02-003. Available at: http://www.epa.gov/owow/nps/urbanmm/index.html
- Septic Systems. USEPA Webpage: http://cfpub.epa.gov/owm/septic/home.cfm

3.2.2 Financing of Septic System Upgrades and Replacement

The Commonwealth of Massachusetts has developed three programs to assist homeowners with wastewater management problems.

1. Comprehensive Community Septic Management Program: This program provides funding for long-term community, regional, or watershed-based solutions to onsite disposal failure in highly impacted or sensitive environments. This program will have two options for communities to choose from to receive subsidized loans to make repairs for homeowners. The betterment loans will be available at an interest rate of either 2% or 5%, a decision made by the community.

   A community proposes a Comprehensive Community Septic Management Program on either a community-wide basis, or for a portion of the town. A $10,000 or $15,000 pre-loan assistance payment is awarded to assist communities in identifying priority areas and establishing a comprehensive approach. Areas targeted often include sensitive areas (such as shellfish beds, beaches, or water supplies) or areas with high septic system failure rates. Upon approval of the plan, loans of $200,000 are available. Communities should propose a comprehensive inspection program that meets MA DEP's requirements for the Time of Transfer exclusion contained in Title 5. Communities that join other communities will be eligible for larger loans. A list of current and past towns and cities participating in this program is set out in Appendix E. More information is available at:
   http://www.mass.gov/dep/brp/wwm/localoff/files/cmspimpl.htm

2. Homeowner Septic Loan Program: This program is designed to meet the demand for funds by homeowners whose system will not pass Title 5 inspection. This program provides below market rate loans to homeowners upgrading systems. Loans are administered by banks and are then purchased by the Massachusetts Housing Finance Authority (MHFA). More information is available at http://www.masshousing.com/consumers

3. Title 5 Tax Credit: Through this program, taxpayers who repair or replace a failed septic system may be entitled to a personal income tax credit (the Title 5 credit) (G.L. c. 62, § 6(i)). The Title 5 credit is equal to the lesser of either 40% of the actual cost paid by the taxpayer to repair or replace a failed septic system, or $15,000. More information is available at: http://www.dor.state.ma.us/rul_reg/tir/tir99_5.htm

3.3 Combined Sewer Overflows

Combined sewers collect stormwater and sanitary sewage in one interconnected system. During rainfall events, the capacity of combined sewer systems to treat the combined waste stream may be exceeded due to the volume of stormwater. When this happens, sewage and stormwater may be discharged without being treated. This is known as a CSO. Untreated sewage typically contains fecal coliform concentrations of 10^4 to 10^6 MPN/100ml (Metcalf and Eddy 1991). Therefore, CSOs can be very significant sources of pathogens. In addition, high volumes of waste during rainfall events may decrease the efficiency of the wastewater treatment system and lead to increased bacteria concentrations in the discharge stream. CSO discharges or any direct discharge of sanitary waste is illegal unless it is conducted in accordance with a long-term control plan approved by MA DEP. The following section discusses approaches for mitigating the impact of CSOs (see also Table 3-1).

3.3.1 Mitigation Measures – Combined Sewer Overflows

Combined Sewer Separation: Sewer separation is the practice of separating the combined, single pipe system into separate sewers for sanitary and stormwater flows. Separating part or all of combined systems into distinct storm and sanitary sewer systems may be feasible. In a separate system, stormwater is conveyed to a stormwater outfall for discharge directly into the receiving water. This eliminates overflow events and the discharge of untreated sanitary waste. Communities that elect for partial separation typically use other CSO controls in areas that are not separated.

CSO Prevention Practices: CSO prevention practices are intended to both reduce the volume of pollutants entering a combined sewer system and to reduce the frequency of CSOs. The volume and frequency of CSO events can be reduced by implementing many of the stormwater management measures discussed in this document that reduce the volume and rates of runoff. In addition, management measures that reduce pathogen sources to stormwater will reduce the pathogen concentrations in CSO discharges. The NPDES program requires communities to address CSOs by implementing nine minimum control measures:

1. Proper operation and maintenance of the collection system
2. Maximum use of the collection system for storage
3. Review of pretreatment programs to minimize CSO-related impacts
4. Maximum flow to the treatment plant
5. Prohibit dry-weather overflows
6. Control of solid and floatable materials
7. Pollution prevention
8. Public notification
9. Monitoring to characterize CSO improvements and remaining CSO impacts

Resources – Combined Sewer Overflows

- Combined Sewer Overflows. USEPA Webpage. Available at: http://cfpub.epa.gov/npdes/home.cfm?program_id=5
- Combined Sewer Overflows Guidance for Nine Minimum Control Measures. USEPA 1997. EPA 832-B-95-003. Available at: http://www.epa.gov/npdes/pubs/owm0030.pdf
- Combined Sewer Overflows Guidance for Long-Term Control Plan. USEPA 1995. EPA 832-B-95-002. Available at: http://www.epa.gov/npdes/pubs/owm0272.pdf
- Combined Sewer Overflow Management Fact Sheet, Pollution Prevention. USEPA 1999. EPA 832-F-99-038. Available at: http://www.epa.gov/npdes/pubs/pollutna.pdf

4.0 MANAGEMENT PRACTICES FOR AGRICULTURAL LAND USE

Agricultural land use in Massachusetts includes dairy farming, raising livestock and poultry, growing crops and keeping horses and other animals for pleasure or profit. Activities and facilities associated with agricultural land use can be sources of pathogen impairment to surface waters. Communities, farmers, horse owners and others who confine animals are largely responsible for mitigating pathogen pollution. Activities and facilities with the potential to contribute to pathogen impairment include:

- Manure storage and application,
- Livestock grazing,
- Animal feeding operations and barnyards, and
- Paddock and exercise areas for horses and other animals.

A number of techniques may be applied to reduce the contribution of agricultural activities to pathogen contamination. Many of these methods are intended primarily to reduce sediment loads from agricultural lands. However, since pathogens are often associated with sediments, these techniques are likely to also result in a reduction in pathogen loads in runoff. Brief summaries of each of these techniques are provided below (see also Table 3-1). The techniques are organized into three categories: field application of manure, animal feeding operations and barnyards, and managing grazing areas.

4.1 Mitigation Measures – Field Application of Manure

Pathogen runoff associated with the field application of manure can be minimized by managing the application process and adding vegetated filter strips around fields where manure is applied. Vegetated filter strips and buffers are areas between the disturbed land and aquatic resources that allow some infiltration of runoff. Methods for handling the manure prior to application are discussed in the Section 4.3.

The following management measures can reduce the runoff of bacteria associated with the application of manure to fields (Rosen 2000).

- Apply manure at the beginning of a dry period
- Avoid application of wastes from areas that are flow paths during rainfall events
- Manage the irrigation of fields to minimize the amount of water running off the field following application of manure
- Directly incorporate manure into the soil

To further reduce the runoff of pathogens from areas where manure is applied, vegetated areas of land located between the disturbed land and sensitive resources can be established. These areas include conservation buffers, filter strips, and herbaceous and forest riparian buffers. These BMPs work by slowing runoff from fields, thereby increasing infiltration and trapping sediments and associated contaminants. Their effectiveness at removing pathogens has, however, been questioned. When the initial concentration of bacteria is high, the removal rate of bacteria is often as high as 95%. However, a review by Moore et al. (1988; as reported in Rosen 2000) suggests that filter strips may not be effective at reducing bacteria concentrations below 10^4 to 10^5 fecal coliforms per 100 ml regardless of conditions. Filter strips are best applied in conjunction with other management methods.

Resources – Field Application of Manure

- Conservation Standard Practice-Irrigation Water Management. Number 449. United States Department of Agriculture (USDA) Natural Resources Conservation Service. 2003. Available at: http://www.nrcs.usda.gov/technical/Standards/nhcp.html
- Conservation Standard Practice-Filter Strip. Number 393. USDA Natural Resources Conservation Service (NRCS). 2003. Available at: http://www.nrcs.usda.gov/technical/Standards/nhcp.html
- Buffer Strips: Common Sense Conservation. USDA Natural Resource Conservations Service. No Date. Website. Available at: http://www.nrcs.usda.gov/feature/buffers/
- Conservation Standard Practice-Riparian Forest Buffer. Number 391. USDA Natural Resource Conservation Service. 2003. Available at: http://www.nrcs.usda.gov/technical/Standards/nhcp.html
- Conservation Standard Practice-Riparian Herbaceous Cover. Number 390 USDA Natural Resource Conservation Service. 2003. Available at: http://www.nrcs.usda.gov/technical/Standards/nhcp.html

4.2 Mitigation Measures – Grazing Management

Grazing management methods can reduce the concentration of bacteria in runoff from grazing areas, the direct deposition of fecal matter into water bodies, and erosion. The following grazing management practices may be implemented at agricultural sites as part of the overall implementation strategy to reduce pathogen discharges to receiving waters.

- Exclude livestock from surface water bodies and sensitive shoreline and riparian zones (e.g., using fencing)
- Provide bridges or culverts for stream crossings
- Provide alternative drinking water locations

- Locate salt, feeding areas, and additional shade away from sensitive areas
- Use improved grazing management to reduce erosion and overgrazing
- Provide buffer zones that prevent domesticated animal use of areas alongside streams and other water bodies

Resources – Grazing Management

- Conservation Standard Practice-Stream Crossing. Number 578. USDA Natural Resource Conservation Service. 2003. Available at: http://www.nrcs.usda.gov/technical/Standards/nhcp.html
- Guidance Specifying Management Measures for Nonpoint Source Pollution in Coastal Waters. Chapter 2. Management Measures for Agricultural Sources. Grazing Management. USEPA. Available at: http://www.epa.gov/owow/nps/MMGI/Chapter2/ch2-2e.html

4.3 Mitigation Measures – Animal Feeding Operations (AFOs) and Barnyards

Animal feeding operations, barnyards, paddocks and exercise areas can produce significant volumes of manure with high fecal bacteria concentrations. To reduce the impacts of these areas and operations, EPA recommends addressing the following eight issues (USEPA 2003).

- "*Divert clean water*. Siting or management practices should divert clean water (run-on from uplands, water from roofs) from contact with feedlots and holding pens, animal manure, or manure storage systems.
- *Prevent seepage*. Buildings, collection systems, conveyance systems, and storage facilities should be designed and maintained to prevent seepage to ground and surface water.
- *Provide adequate storage*. Liquid manure storage systems should be (a) designed to safely store the quantity and contents of animal manure and wastewater produced, contaminated runoff from the facility, and rainfall from the 25-year, 24-hour storm and (b) consistent with planned utilization or utilization practices and schedule. Dry manure, such as that produced in certain poultry and beef operations, should be stored in production buildings, storage facilities, or otherwise covered to prevent precipitation from coming into direct contact with the manure.
- *Apply manure in accordance with a nutrient management plan that meets the performance expectations of the nutrient management measure.*
- *Address lands receiving wastes*. Areas receiving manure should be managed in accordance with the erosion and sediment control, irrigation, and grazing management measures as applicable, including practices such as crop and grazing management

practices to minimize movement of nutrient and organic materials applied, and buffers or other practices to trap, store, and "process" materials that might move during precipitation events.

- *Recordkeeping*. AFO operators should keep records that indicate the quantity of manure produced and its utilization or disposal method, including land application.
- *Mortality management*. Dead animals should be managed in a way that does not adversely affect ground or surface waters.
- *Consider the full range of environmental constraints and requirements*. When siting a new or expanding facility, consideration should be given to the proximity of the facility to (a) surface waters; (b) areas of high leaching potential; (c) areas of shallow groundwater; and (d) sink holes or other sensitive areas. Additional factors to consider include siting to minimize off-site odor drift and the land base available for utilization of animal manure in accordance with the nutrient management measure. Manure should be used or disposed of in ways that reduce the risk of environmental degradation, including air quality and wildlife impacts, and comply with Federal, State and local law."

In addition to implementing the recommendations above, the impact of livestock operations can be reduced through the use of constructed wetlands and proper manure storage. Constructed wetlands are used to treat the liquid waste from raising livestock and poultry. Bacteria and viruses are removed from the waste by a number of processes within constructed wetlands. Viruses are adsorbed onto soil and organic particles. Bacteria can be inactivated by ultraviolet light, chemical reactions, or removed by sedimentation and predation by zooplankton (Rosen 2000). Constructed wetlands remove between 82 to 100% fecal coliforms bacteria under various conditions (Hammer 1999; as reported in Rosen 2000).

Proper storage of manure is critical to reducing the introduction of pathogens into the environment. Storage of manure prior to application on fields can reduce the concentration of pathogens in the waste. The reduction of pathogen concentrations in the waste occurs through a number of mechanisms. First, natural die-off of bacteria occurs over time. Therefore, the longer the waste is stored prior to land application, the lower the load of pathogens in the waste. In addition, the heat generated through the decomposition of the waste can generate sufficient temperatures to inactivate pathogens within the waste. In order to ensure uniform heating of the waste, careful management of the composting process is necessary (Rosen 2000). Finally, to ensure effectiveness, manure storage facilities must be properly maintained to ensure that they aren't leaking into either groundwater or surface water.

Resources – Animal Feeding Operations and Barnyards

- National Management Measures to Control Nonpoint Source Pollution from Agriculture. USEPA 2003. Report: EPA 841-B-03-004. Available at: http://www.epa.gov/owow/nps/agmm/index.html
- Livestock Manure Storage. Software designed to asses the threat to ground and surface water from manure storage facilities. USEPA. Available at: http://www.epa.gov/seahome/manure.html
- National Engineering Handbook Part 651. Agricultural Waste Management Field Handbook. NRCS. Available At: http://www.wcc.nrcs.usda.gov/awm/awmfh.html
- Animal Waste Management. NRCS website: http://www.wcc.nrcs.usda.gov/awm/
- Animal Waste Management Software. A tool for estimating waste production and storage requirements. Available at: http://www.wcc.nrcs.usda.gov/awm/awm.html
- Manure Management Planner. Software for creating manure management plans. Available at: http://www.agry.purdue.edu/mmp/
- Animal Feeding Operations Virtual Information Center. USEPA website: http://cfpub.epa.gov/npdes/afo/virtualcenter.cfm

4.4 Massachusetts and Federal Agriculture Resources: Program Overviews, Technical Assistance, and Funding

- The Massachusetts Conservation Districts are a subdivision of state government, established to carry out programs for the conservation and wise management of soil, water, and related resources. Information on the 14 Massachusetts conservation districts and their Conservation Partnerships with Natural Resources Conservation Service (NRCS) is available at: http://www.ma.nrcs.usda.gov/partnerships/conservationpartnership.html
- The Massachusetts Department of Agricultural Resources (MDAR) offers a variety of programs and services "to support, promote and enhance the long-term viability of Massachusetts agriculture." More information is available at: http://www.state.ma.us/dfa/programs.htm
- University of Massachusetts (UMass) – Cranberry Station provides a variety of information related to cranberry production in Massachusetts: http://www.umass.edu/cranberry/. Additional agricultural resources can be found at the UMass (Amherst) Extension website, http://www.umassextension.org/

- The MDAR Groundwater Protection Regulations prevent contamination of public drinking water supplies through regulating application of pesticides on the Groundwater Protection List within primary recharge areas. More information is at: http://www.state.ma.us/dfa/pesticides/water/index.htm

- The Massachusetts Non-Point Source Program annually awards Section 319 Non-Point Source competitive grant funds to projects that are directed at reducing non point-source pollution and restoring water quality. More information is available at http://www.mass.gov/dep/brp/wm/files/319sum04.pdf or by contacting Jane Peirce, State 319 Program Coordinator at (508) 767-2792 or Jane.peirce@state.ma.us

- Additional resources and technical assistance are available from the CZM Office at: http://www.mass.gov/czm, Massachusetts Bays National Estuary Program at: http://www.mass.gov/envir/massbays/, and the Buzzards Bay National Estuary program at: http://www.buzzardsbay.org/.

- USDA-NRCS assists landowners with planning for the conservation of soil, water, and natural resources. Local, state, and federal agencies and policymakers also rely on NRCS expertise. Cost shares and financial incentives are available in some cases. Most work is done with local partners. The NRCS is the largest funding source for agricultural improvements in Massachusetts. To find out about potential funding in Massachusetts, see: http://www.ma.nrcs.usda.gov/programs/. To pursue obtaining funding, contact a local NRCS coordinator. Contact information is available at:: http://www.ma.nrcs.usda.gov/contact/employee_directory.html

- NRCS provides a wealth of information and BMP fact sheets tailored to Massachusetts agricultural and conservation practices through the NRCS Electronic Field Office Technical Guide at: http://efotg.nrcs.usda.gov/efotg_locator.aspx?map=MA

- The 2002 USDA Farm Bill (http://www.nrcs.usda.gov/programs/farmbill/2002/) provides a variety of programs related to conservation. Information can be found at: http://www.nrcs.usda.gov/programs/farmbill/2002/products.html. The following programs can be linked to from the USDA Farm Bill website:

  - Conservation Security Program (CSP): http://www.nrcs.usda.gov/programs/csp/
  - Conservation Reserve Program (CRP): http://www.nrcs.usda.gov/programs/crp/
  - Wetlands Reserve Program (WRP): http://www.nrcs.usda.gov/programs/wrp/
  - Environmental Quality Incentives Program (EQIP): http://www.nrcs.usda.gov/programs/eqip/
  - Grassland Reserve Program (GRP): http://www.nrcs.usda.gov/programs/GRP/

- Conservation of Private Grazing Land Program (CPGL): http://www.nrcs.usda.gov/programs/cpgl/
- Wildlife Habitat Incentives Program (WHIP): http://www.nrcs.usda.gov/programs/whip/
- Farm and Ranch Land Protection Program (FRPP): http://www.nrcs.usda.gov/programs/frpp/
- Resource Conservation and Development Program (RC&D): http://www.nrcs.usda.gov/programs/rcd/

- CORE4 Conservation Practices. The common sense approach to natural resource conservation. USDA-NRCS (1999). This manual is intended to help USDA-NRCS personnel and other conservation and nonpoint source management professionals implement effective programs using four core conservation practices: conservation tillage, nutrient management, pest management, and conservation buffers, available at: http://www.nrcs.usda.gov/technical/ECS/agronomy/core4.pdf
- County soil survey maps are available from NRCS at: http://soils.usda.gov
- Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters. U.S. EPA, Office of Water (1993). Developed for use by State Coastal Nonpoint Pollution Control Programs, Chapter 2 of this document covers erosion control, animal feeding operation management, grazing practices, and management of nutrients, pesticides, and irrigation water, available at:: http://www.epa.gov/owow/nps/MMGI/Chapter2/index.html.
- Farm-A-Syst is a partnership between government agencies and private business that enables landowners to prevent pollution on farms, ranches, and in homes using confidential environmental assessments, available at: http://www.uwex.edu/farmasyst/
- State Environmental Laws Affecting Massachusetts Agriculture: A comprehensive assessment of regulatory issues related to Massachusetts agriculture has been compiled by the National Association of State Departments, available at: http://www.nasda-hq.org/nasda/nasda/Foundation/state/Mass.pdf
- The Massachusetts Nonpoint Source Pollution Management Manual. MA DEP. Expected availability: Fall 2005 on the MA DEP Nonpoint Source Program Website: http://www.mass.gov/dep/brp/wm/nonpoint.htm The exact location of where the manual will appear on the MA DEP website was not available at the time of publication of this document.
- Waterborne Pathogens in Agricultural Wastewater. Rosen, B. H., 2000. USDA, NRCS, Watershed Science Institute. Available at: ftp://ftp-fc.sc.egov.usda.gov/WSI/pdffiles/Pathogens_in_Agricultural_Watersheds.pdf

5.0 MANAGEMENT PRACTICES FOR SWIMMING BEACHES, BOATS, AND MARINAS

Recreational uses of waters can contribute to pathogens loads. Swimming beaches, marinas, and areas frequented by boats may be impacted by any of the pathogen sources discussed in the preceding sections of this document. In addition, there are a number of bacteria sources that are specific to these areas:

- Bacteria from swimmers
- Sewage from boats
- Graywater from boats
- Shore-based marina facilities

This section discusses these pathogen sources and potential mitigation measures and provides resources for more information (see also Table 3-1). Municipal officials, harbor masters, boards of health, departments of public works, marina operators, and citizens are largely responsible for managing these pathogen sources.

Swimming Beaches: Swimmers themselves may contribute to pathogen impairment at swimming areas. Control of pathogen contamination at recreational beaches is particularly important since large numbers of people are regularly in contact with the water at beaches. When swimmers enter the water, residual fecal matter may be washed from the body and contaminate the water with pathogens. In addition, small children in diapers may contribute to contamination of recreational waters. Swimmers are likely to be significant pathogen sources when the number of swimmers is high and the flushing action of waves, tides, or river flow is low. Mitigation measures for pathogens from swimmers can be found in Section 5.1.

Boats: Boats have the potential to discharge pathogens in sewage from installed toilets and gray water (includes drainage from sinks, showers, and laundry). Sewage and gray water discharged from boats can contain pathogens (including bacteria, viruses, and protozoans), nutrients, and chemical products. These constituents can directly harm aquatic life or degrade water quality.

Sewage: Boats with onboard toilets are required to have Marine Sanitation Devices (MSDs) to either store or treat sewage. When MSDs are operated or maintained incorrectly they have the potential to discharge untreated or inadequately treated sewage. For example, some MSDs are simply tanks designed to hold sewage until it can be pumped out at a shore-based pumpout facility or discharged into the water more than 3 miles from shore. Unaware boaters may discharge untreated sewage from these devices into near shore waters. In addition, when MSDs designed to treat sewage are improperly maintained or operated they may malfunction and discharge inadequately treated sewage.

Finally, even properly operating MSDs may discharge sewage in concentrations higher than ambient water quality criteria. Many MSDs discharge "treated" waste with bacteria counts five to 70 times higher than that allowable under state law for shellfishing or swimming waters.

Vessels are most likely to contribute significantly to pathogen impairment in situations where large numbers congregate in enclosed environments with low flushing. Many marinas and popular anchorages are located in such environments. In addition, MSDs do not remove nutrients from sewage and their discharge may contain chemicals that can be toxic to marine and estuary life. Nutrients from sewage can also lead to reduced oxygen levels and cause excessive growth of marine plants/algae and the death of marine animals. Information on mitigating sewage discharge from boats is provided in Section 5.3.

Graywater: Graywater includes wastewater from sinks, showers, and laundry. Graywater can contain low levels of pathogens, detergents, soap, and food wastes. These components can contribute to reduced oxygen levels in small bays and coves by enriching algae growth and bacterial breakdown of wastes, both of which use up oxygen. Information on mitigating the impact of graywater discharge from boats is provided in Section 5.2.4.

Marinas: In addition to the discharges from boats, there are a number of other potential pathogen sources in marinas. Pathogens from shore side restrooms, uncontrolled pet waste, and fecal matter from wildlife attracted to fish cleaning waste can contaminate waters near marinas. Shore side sanitary facilities should be functioning properly to protect public health and the environment. Waste from pets, especially dogs, is a major source of complaints from barefoot boaters and, depending on the frequency that pets are walked in these areas, may substantially affect pathogen levels in nearby beaches. More information on minimizing the pathogen contribution of pets can be found in Section 3.1.2.3. Sport fishing is one of the most popular uses of boats. However, waste from filleting and cleaning fish caught by recreational fisherman can be a major nuisance if not properly handled, attracting gulls, raccoons, and other animals to areas near marinas. Feces from these animals can contribute to pathogen pollution. Information on reducing the contribution of pathogens from shore side restrooms, pets, wildlife, and fish cleaning waste at marinas can be found in Section 5.5.

5.1 Mitigation Measures – Swimming Beaches and Fresh, Estuarine, and Marine Waters

To reduce swimmers' contribution to pathogen impairment, shower facilities should be made available and bathers should be encouraged to shower prior to swimming. In addition, parents, guardians and childcare providers should be encouraged to check and change children's diapers when they are dirty. To encourage adoption of these practices, local health agencies may provide visitor education programs and present information on sanitary practices using notices posted at beach/park entrances, flyers given to individuals, and signs asking visitors to use rest rooms and collect and dispose of pet waste. Furthermore, swimmers should be informed that pathogens remain at elevated levels in waterbodies after rainfall events for up to several days and consequently, swimmers may be at risk if they choose to swim.

Resources – Swimming Beaches and Fresh, Estuarine, and Marine Waters

- EPA New England scientists have conducted (and will continue to conduct) preliminary sanitary surveys at several beaches as part of the Clean New England Beach Initiative -- "It's a Shore Thing." The surveys identify potential sources of indicator bacteria using shoreline and watershed observations, analysis of historical data, mapping of the watershed and drainage system, and collection and measurement of water at the beach, stormwater outfalls, and upstream sources. EPA scientists work directly with the local health or engineering departments or watershed associations and the Massachusetts Department of Public Health to gather information. Based on the surveys, a report is produced with recommendations for mitigating pathogen problems and protecting public health at the particular beach. For copies of the reports, please contact Dr. Matt Liebman at EPA New England at (617) 918-1626 or liebman.matt@epa.gov. To date, surveys have been conducted for:

  - Wollaston Beach, Quincy, MA (2002)
  - Willows Pier, Salem, MA (2002)
  - Provincetown Harbor, Provincetown, MA (2002)
  - West Hill Park Beach, Uxbridge, MA (2003)
  - Kings Beach, Lynn (2003 and 2004))
  - Brackenbury Beach, Beverly, MA (2004)
  - Rices Beach, Beverly, MA (2004)
  - Good Harbor Creek, Gloucester, MA (2004)

- The Massachusetts Division of Marine Fisheries (DMF) has a well established shellfish monitoring program that provides quality assured data for each shellfish growing area. Each growing area (except those classified as prohibited) must have a complete sanitary survey every 12 years, a triennial evaluation every 3 years, and an annual review in order to maintain a shellfish harvesting classification. The National Shellfish Sanitation Program establishes minimum requirements for the sanitary surveys, triennial evaluations, annual reviews, and annual fecal coliform water quality monitoring. The surveys identify specific sources, assess the effectiveness of controls and attainment of standards, and recommend steps to address pollution problems. Sanitary surveys can be very useful at the local level to help identify sources or potential sources of bacteria to a water resource of concern. The principal components of a sanitary survey include: 1) an evaluation of pollution sources that may affect an area, 2) an evaluation of hydrographic and meteorological characteristics that may affect distribution of pollutants, and 3) an assessment of water quality. For more information on the sanitary surveys contact: Mr. Michael Hickey at the following e-mail address and telephone number: michael.hickey@state.ma.us or (508)563-1779 x122.

- Draft Guidance for Saltwater Beaches. California Department of Health Services: http://www.dhs.ca.gov/ps/ddwem/beaches/saltwater.htm
- See sections above on other resources for addressing other pathogen sources

5.2 Mitigation Measures – Pathogens from Boats

A resource manager who suspects that discharges from boats are contributing to pathogen impairment of a particular water body has a number of options for addressing the problem. Options include:

- petitioning the State for the creation of a No Discharge Area (NDA, also referred to as no discharge zones or NDZs);
- supporting development of pumpout facilities for sewage from boats; distributing information on the proper operation and maintenance of MSDs; and
- encouraging marina owners to provide clean and safe onshore restrooms and pumpout facilities.

5.2.1 Establishing No Discharge Areas

Section 312 of the CWA authorizes states to designate areas as NDAs for vessel sewage. A NDA is a designated body of water in which the discharge of ALL boat sewage, even if it is treated, is prohibited. When traveling in NDA waters, boaters with Type I or Type II MSDs must do one of the following: 1) close the seacock and remove the handle 2) fix the seacock in the closed position with a padlock or non-releasable wire-tie 3) lock the door to the space enclosing the toilet with a padlock or door handle key lock.

A body of water can become an NDA if a community or state believes that the waters are ecologically and recreationally important enough to require more protection than that provided by current Federal and State laws. Lakes, freshwater reservoirs, or other freshwater impoundments whose entrance points and exit points are too shallow to support traffic by vessels with installed toilets, and rivers that do not support interstate vessel traffic are all, by default, designated NDAs. Other water bodies can be designated NDAs by States and EPA.

<u>NDAs in Massachusetts:</u> There are currently seven NDAs in Massachusetts: all of Buzzards Bay, Waquoit Bay in Falmouth, the Coastal Waters of Harwich, Three Bays/Centerville Harbor in Barnstable, Stage Harbor in Chatham, Wellfleet Harbor, and the Coastal Waters of Nantucket from Muskeget Island to Great Point, including Nantucket Harbor. In addition, the communities in the vicinity of Plymouth, Kingston and Duxbury Harbors are currently working on obtaining an NDA for this area.

Applying for an NDA: The MA Department of Coastal Zone Management (CZM) assists in the writing of the application, provides resources and information to interested communities, coordinates with EPA, and helps to ensure that the proposed NDA has adequate pumpout facilities. In Massachusetts, all NDA applications must be certified by CZM to be consistent with CZM's Program Policies. CZM then officially requests that the Secretary of the Executive Office of Environmental Affairs designate the proposed waters for EPA approval as a NDA. Communities interested in establishing an NDA should view the CZM NDA template that can assist those interested in creating an NDA. This template is available at: http://www.mass.gov/czm/ndatemplate.htm. For additional information, interested parties can contact CZM's NDA Coordinator, Todd Callaghan at 617-626-1233 or todd.callaghan@state.ma.us and Ann Rodney at EPA New England at 617-918-1538 or rodney.ann@epa.gov.

There are seven requirements pursuant to Section 312 (f)(3) of the CWA and Chapter 40 Code of Federal Regulations Section 140.4 that the applicant must provide:

1. A certification that the protection and enhancement of the waters described in the petition requires greater environmental protection than the applicable Federal standards.

2. A map showing the location of commercial and recreational pumpout facilities.

3. A description of the location of pumpout facilities within waters nominated for a NDA.

4. The general schedule of operating hours of the pumpout facilities.

5. The draft requirements on the vessels that may be excluded from a pumpout facility because of insufficient water depth adjacent to the facility.

6. Information indicating that the treatment of waste from such pumpout facilities is in conformance with Federal law.

7. Information on vessel population and vessel usage of the subject waters.

In addition to these seven requirements, EPA New England reviews the type of outreach campaign planned for boaters when evaluating an area for an NDA designation.

Enforcement: It is a violation of Federal Law to discharge treated or untreated boat sewage within the waters of an NDA. The Massachusetts Environmental Police are charged with enforcing the restrictions of NDAs. CZM and Massachusetts Environmental Law Enforcement are actively pursuing an amendment to Massachusetts General Law 90B Sections 11 and 14. The amendment will allow state and local officials to collect fines of up to $2,000 for violations within NDAs. To detect discharges of sewage into NDAs dye tablets may be placed in sewage holding tanks on boats. Any discharge of sewage will then be visible.

5.2.2 Ensuring Clean and Adequate Pumpout Facilities and Shore-Side Restrooms are Available

One potential barrier to compliance with NDA area requirements is the lack of clean and adequate pumpout facilities. Marina owners should ensure that these facilities are clean, easily accessible, and affordable. Clean and adequate sewage pumpout facilities at marinas significantly reduce the number of direct discharges of sewage from boats into the water. If boats in the marina use small portable (removable) toilets, a dump station should also be provided. In addition, maintaining pleasant shore side restrooms can reduce the use of boat toilets and the subsequent discharge of sewage. Dirty, wet, and dark restrooms are often a source of complaints from boaters.

<u>Pumpout Facilities:</u> A sewage pumpout facility is a place where boaters can empty their sewage tanks. A graphic pumpout symbol is often placed at docks and marinas to show boaters where a pumpout facility is located. There are three main types of sewage pumpout facilities:

1. *Fixed-point collection systems* include one or more centrally located sewage pumpout stations generally located at the end of a fueling pier so that fueling and pumpout operations can be combined. Wastewater can be pumped from the boats to an onshore holding tank, a public sewer system, a private treatment facility, or another approved disposal facility

2. *Portable/mobile systems* are similar to fixed-point systems and in some situations may be used in their place at a fueling dock. Portable units include a pump and a small storage tank. The unit is connected to the deck fitting on the vessel, and wastewater is pumped from the vessel's holding tank to the pumping unit's storage tank. When the storage tank is full, its contents are discharged into a municipal sewage system or a holding tank for removal by a septic tank pumpout service

3. *Dedicated slipside systems* provide continuous wastewater collection at a slip. Slipside pumpouts should be provided to live-aboard vessels. The remainder of the marina can still be served by either marina-wide or mobile pumpout systems

To prevent the failure of pumpout stations and improper disposal of sanitary wastes, management measures include:

- Arranging maintenance contracts with contractors competent in the repair and servicing of pumpout facilities;
- Developing regular inspection schedules;

- Maintaining a dedicated fund for the repair and maintenance of marina pumpout stations (Government-owned facilities only); and
- Adding language to slip leasing agreements mandating the use of pumpout facilities and specifying penalties for failure to comply

Marina Restrooms: Providing clean, safe, dry, well-lit, and ventilated restrooms for customers 24 hours a day can minimize the discharge of sewage from boats to the marine environment. Some marinas clean their restrooms four or more times a day on busy summer weekends to maintain pleasant facilities. Other marinas have found that contracting out restroom cleaning is cost effective. In addition it is important to locate restrooms convenient to all boats, especially for guests sleeping overnight on weekends.

5.2.3 Outreach and Education

Two of the most important factors in successfully preventing sewage discharge from boats are providing adequate and reasonably available pumpout facilities and conducting a comprehensive boater education program. Educating boaters about the location of NDAs, the availability of pumpout facilities, and the importance of properly operating and maintaining MSDs, helps reduce the impact of sewage from boats. Marina operators should post signs notifying boaters about the location and requirements of NDAs, and the availability of pumpout facilities and restrooms. Ready-to-use outreach materials for these efforts are available from a number of sources (see Section 5.4). Marina owners and local officials should design education efforts to:

- Educate boaters about the impact of improper vessel discharges on beach closures, shellfish contamination, loss of recreational opportunities and aesthetic losses, and loss of marina industry revenue (Woodley 1999)
- Encourage boaters to install and use a Coast Guard certified MSD that is appropriate for their vessel (see http://www.epa.gov/owow/oceans/regulatory/vessel_sewage/vsdmsd.html)
- Educate boaters on the use and maintenance of their MSDs properly
- Educate boaters on how to use marina pumpout stations for Type III MSDs (Woodley 1999)

5.2.4 Reducing the Impact of Gray Water Discharges

To reduce the amount of untreated wastewater that enters coastal waters, marina owners can provide laundry facilities and an area near the restrooms where boaters can clean their dishes. These changes should be accompanied by an education effort to encourage boaters to implement the following BMPs.

- Refrain from use of dish soap on-board,
- Use low-nitrogen detergents on boats,
- Provide dishwashing and laundry facilities at marinas, and
- Encourage use of marina shower and restroom facilities.

5.3 Resources – Pathogens from Boats

- National Management Measures for Controlling Nonpoint Source Pollution from Marinas and Recreational Boating. US EPA. EPA 841-B-01-005. Available at: http://www.epa.gov/owow/nps/mmsp/
- Environmental Guide for Marinas – Vessel Sewage. Rhode Island Sea Grant http://seagrant.gso.uri.edu/BMP/sewage.html
- No Discharge Zones for Vessel Sewage – EPA Website: http://www.epa.gov/owow/oceans/regulatory/vessel_sewage/vsdnozone.html
- Using your Head to Protect Our Aquatic Resources. US EPA Website: http://www.epa.gov/owow/oceans/regulatory/vessel_sewage/vsdflyer.html
- NDAs. CZM website: http://www.mass.gov/czm/nda.htm
- Massachusetts Pumpout Facilities. CZM. Available at: http://www.mass.gov/czm/potoc.htm
- Clean Vessel Act Symbol. US Fish and Wildlife Service: http://fa.r9.fws.gov/info/falogos.html#CVA_symbol
- Massachusetts Clean Marina Guide. Prepared by Epsilon Associates, Inc. for CZM Available at: http://www.mass.gov/czm/marinas/guide/macleanmarinaguide.htm
- No Discharge Zones: How They Work. Woodley, J. September/October 1999. Available at: http://www.epa.gov/owow/oceans/regulatory/vessel_sewage/vsdarticle.html
- Application for a State Designated, Federally Approved NDA. (Template). CZM. Available at: http://www.state.ma.us/czm/ndatemplate.doc
- Marine Pollution Control Programs. USEPA. Available at: http://www.epa.gov/owow/oceans/regulatory/
- A Guidebook for Marina Owners and Operators on the Installation and Operation of Sewage Pumpout Stations. MDDNR. 1991.
- Vessel Sewage Discharge Program. USEPA 2002. Available at: http://www.epa.gov/owow/oceans/regulatory/vessel_sewage/

- Clean Vessel Act Pumpout Grant Program. U.S. Fish and Wildlife Service, Division of Federal Aid. USFWS. 1999. Available at: http://fa.r9.fws.gov/cva/cvajul97.html
- US Coast Guard Marine Safety Office Boston Website. Available at: http://www.uscg.mil/d1/units/msobos/
- US Coast Guard Marine Safety Office Providence Website. Available at: http://www.uscg.mil/d1/units/msoprov/

5.4 Mitigation Measures – Pathogens from Marinas

In addition to the boats that are present in marinas, there are a number of other potential sources of pathogens. These include; pets, wildlife attracted to fish scraps, and septic systems. These topics are discussed in other sections of the document (pets in Section 3.1.2.2, wildlife in Section 3.1.2.3, and septic systems in Section 3.2). The waters adjacent to marinas often have long residence times (i.e. minimal flushing rates) circulation or inadequate stormwater controls. These conditions and activities make coastal areas particularly sensitive.

This section describes a number of specific measures marina owners and operators can use to address pets in marinas and fish waste disposal (Table 3-1). As with other types of nonpoint source pollution, nonstructural practices such as public education are a crucial component of managing boating, marinas and the beaches alongside marinas. Other important BMPs focus on "clean marina operations" and the management of sewage.

Pets: Proper management is essential for setting ground rules for pets at the marina, avoiding conflicts between marina users over pet issues, and reducing the impacts of pet waste on marina waters. The following BMPs are important components of an effective pet waste management program.

- *Dog Walking Areas:* Provide a specific dog walk area at the marina with signs to direct customers.
- *Pet Waste Disposal:* Require marina customers to immediately clean up all pet feces. Provide free disposable dog scoop or litter bags to boaters and ask them to dispose of the material in the marina dumpster. Also consider installing mini septic systems for pet waste. These systems are buried in the ground and have a lid on top for dropping the waste in. They also come with a digester enzyme. Pet septic systems are available in many pet catalogs for a low cost (<$50). One such product is called the “Doggie Doolie.”
- *Pet Regulations:* Include relevant pet rules and regulations in patron contracts and on signs.
- *Litter Box Use and Disposal:* Encourage cat owners to maintain litter boxes on their boats and to dispose of used litter in appropriate trash receptacles.

Fish waste: If wildlife attracted to fish waste is believed to be contributing to pathogen pollution near a marina, implementation the following BMPs may be appropriate.

- *Offshore Cleaning and Disposal:* Encourage fishermen to clean fish off-shore and discard fish waste at sea.
- *Fish Cleaning Area and Rules:* The best way to prevent a problem is by developing and clearly marking a fish cleaning area and posting rules for disposal of fish waste on the marina property. This will discourage fishermen from cleaning and disposing of fish at improper locations.
- *Fish Cleaning Staff:* Provide a staff person who can clean fish for fishermen for a fee.
- *Covered Containers:* Provide covered containers for fish waste.
- *Fish Cleaning Provisions in Customer Contracts:* Include requirements for cleaning fish in the customer's environmental contract.
- *Fish Composting:* Compost fish waste where appropriate by mixing it with peat moss or wood chips to make garden mulch. This quickly produces excellent compost for use in the marina gardens without any odor problem. For more ideas about composting fish waste, refer to The Leaf and Yard Waste Composting Guide found on the MA DEP's website at www.state.ma.us/dep/recycle/files/leafguid.doc.
- *Fish Cleaning Stations:* Towns should also consider installing fish cleaning stations at public boat launch ramps and fishing piers.
- *Wildlife Feeding Rules:* Prohibit the feeding of wild birds or animals at marinas. Consider posting "No Feeding Wildlife" signs around marina grounds and having staff casually educate children and adults on the negative effects of wildlife feeding.

Resources – Pathogens from Marinas

- Call the DMF at (617) 626-1520 to locate the nearest DMF regional office for assistance.
- Massachusetts Clean Marina Guide: This guide was created for the CZM as part of the Massachusetts Coastal Nonpoint Pollution Control Plan. It provides a comprehensive reference for owners and operators of marinas on strategies to reduce marina and boating impacts on the coastal environment. Available at: http://www.mass.gov/czm/marinas/guide/macleanmarinaguide.htm
- Massachusetts Clean Marine Initiative: This CZM program provides funds for coastal communities to take a number of measures to reduce pollution of marine waters. More information is available via the CZM Information Line at (617) 626-1212 or online at: www.state.ma.us/czm.

- National Management Measures to Control Nonpoint Source Pollution from Marinas and Recreational Boating. USEPA 2001. Available at: http://www.epa.gov/owow/nps/mmsp/index.html
- Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters. USEPA. 1993. Chapter 5. Available at: http://www.epa.gov/owow/nps/MMGI/
- Are Marinas Really Polluting? Natchez, D.S. 1991. International Marina Institute, Wickford.
- The State Sanitary Code regulations (310 CMR 15.00) are available at: www.state.ma.us/dep/brp/wwm/t5pubs.htm#regs.
- National Management Measures for Controlling Nonpoint Source Pollution from Marinas and Recreational Boating. USEPA 2001. EPA 841-B-01-005. Available at: http://www.epa.gov/owow/nps/mmsp/
- Clean Marinas Clear Value; Environmental and Business Success Stories. USEPA. 1996. EPA 841-R-96-003. Available at: http://www.epa.gov/owow/nps/marinas/index.html
- The Virginia Clean Marina Guidebook. Virginia Department of Environmental Quality, Virginia Department of Conservation and Recreation 2001. Richmond, Virginia. Available at: http://www.vims.edu/adv/cleanmarina/guidebook.html
- Coastal Marinas Assessment Handbook. USEPA Region 1985.
- Coastal Nonpoint Pollution Control Program. Available at: http://www.epa.gov/owow/nps/coastnps.html

5.5 Mitigation Measure – Improve Marina Flushing

Water quality within a marina basin depends in part on how well the basin is flushed, which depends on water circulation within the marina. Especially in high-use areas, pathogen concentrations can build-up in areas with minimal flushing. Water exchange is controlled by several factors including tides and bathymetry. It is important to understand how man-made structures such as jetties and piers affect the movement of water during a typical tidal cycle. Constrictions can decrease flushing of the cove, and prevent pollutants from being carried out to sea. Marinas should be designed so that their structures do not significantly restrict the natural circulation and exchange of water. BMPs include:

- *Marina Bottom and Entrance Channel Placement*. Try to avoid having bottoms of the marina and their entrance channels deeper than adjacent navigable harbor channels. If the marina bottom is significantly below that of the main channel, bottom water exchange might be reduced. This could lead to high concentrations of pathogens from boat and land-based sources. This can also restrict the flow of dissolved oxygen to waters around the marina *and lead to fouling and odor problems.*

- *Minimize Dead Water in Marina Designs*. Dead water can form in isolated areas under the marina and where marina structures block water flow. New marina should be designed without structures that will lead to the development of dead water areas, thereby ensuring water movement and exchange throughout the entire marina basin. This reduces the potential for pathogens to reach concentrations in excess of the WQS.

- *Open Marina Designs and Wave Attenuators.* Consider using open designs and wave attenuators where possible to improve flushing. Open designs avoid the use of structures in bottom waters that restrict water flow. Wave attenuators are structures that dampen wave energy, but still allow water to pass through and into the protected area. Wave attenuators may not sufficiently protect the marina in areas subject to significant wave action, and the need for wave protection may make solid breakwaters the only practical alternative for some marinas. Site specific study is required to reach the appropriate solution.

- *Promote Flow-Through Currents.* If feasible without compromising wave protection, provide openings at opposite ends of the marina to promote flow-through currents and increase flushing.

Resources – Improve Marina Flushing

- Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters. Chapter 5. Marina Flushing Management Measure II. Siting and Design. USEPA 1993. Available at: http://www.epa.gov/owow/nps/MMGI/Chapter5/ch5-2a.html

- National Management Measures Guidance to Control Nonpoint Source Pollution from Marinas and Recreational Boating. USEPA 2001. Report: EPA 841-B-01-005 Available at: http://www.epa.gov/owow/nps/mmsp/marinas.pdf

5.6 Financing

CZM offers the CPR and the Coastal NPS grant programs to help address NPS pollution. More information is available in Section 3.1.5, and the following websites:

- Coastal Pollutant Remediation Grant Program at the CZM Website: http://www.mass.gov/czm/cprgp.htm

- Coastal Nonpoint Source Grant Program at CZM Website http://www.mass.gov/czm/coastalnpsgrants.htm

- CZM website available at: http://www.mass.gov/czm

- Massachusetts Bays National Estuary Program at: http://www.mass.gov/envir/massbays/

- Buzzards Bay National Estuary program at: http://www.buzzardsbay.org/

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APPENDIX A

ADDITIONAL WATERSHED FUNDING, OUTREACH TOOLS, AND STRATEGIES

APPENDIX A

ADDITIONAL WATERSHED FUNDING, OUTREACH TOOLS, AND STRATEGIES

Education and Training

Watershed Academy

EPA's Watershed Academy is a focal point in EPA for providing information to watershed practitioners about the watershed approach. See web site at:

http://www.epa.gov/owow/watershed/wacademy/

Key elements of the Academy include:

- ***Watershed Academy Web***
  The Academy has a web-based training program called Watershed Academy Web (see www.epa.gov/watertrain) which has about 50 online training modules addressing all aspects of watershed management. Users can access the modules anywhere, anytime and at no charge. We also offer a Watershed Management Certificate program where users who complete 15 required modules can earn a certificate.

- ***Live training courses***

  The Watershed Academy sponsors a variety of live training courses including for example the ABC's of TMDLs, CWA Tools for Watershed Protection, Watershed Partnership Seminar, etc. We also publicize watershed-related courses sponsored by others.

- ***Documents and other outreach materials***
  The Watershed Academy provides links to a variety of documents/outreach materials on its web site.

Nonpoint Source Web Site

Offers latest tools, funding opportunities and information to help states and communities address polluted runoff, including BMPs, model ordinances, monitoring and assessment tools, and low-impact development. Website is available at: www.epa.gov/owow/nps

Technical Tools

W.A.T.E.R.S.

A powerful mapping tool that allows users to view data from many Office of Water databases and find geography-specific water quality information. Website can be found at: www.epa.gov/waters.

STORET

A repository for water quality, biological, and physical data that is used by state agencies, EPA and other federal agencies, universities, citizens and others. Users can click on the water drop on-line to retrieve monitoring data. Website can be found at: www.epa.gov/storet.

Funding and Grants

Catalog of Federal Funding for Watershed Protection

EPA has an easy to use searchable database that provides information on more than 85 Federal programs that provide funding (cost sharing, loans, etc.) for various watershed protection activities. This searchable database has been updated to include FY 2005 funding information and is posted on EPA's website at: www.epa.gov/watershedfunding

National Environmental Finance Centers' Enhanced Database of Funding Sources

This enhanced and updated on-line directory allows users to search for federal, state, local, and private watershed funding sources available for the development and implementation of watershed projects. Information on nationwide funding opportunities, as well as state and local funding opportunities for fund seekers in EPA's Regions 1 (CT, MA, ME, NH, RI, VT) and Region 10 (AK, ID, OR, WA), is available at: http://ssrc.boisestate.edu. Information regarding New England's Environmental Finance Center can be found at: http://efc.muskie.usm.maine.edu/

Watershed Academy Web Sustainable Finance On-line Training Module

A finance on-line training module will be created to transfer strategic financial planning tools and case studies to watershed organizations and local governments.

The training module will be available at http://www.epa.gov/watertrain

Plan2Fund

A watershed planning tool that helps organizations track financial information as it relates to their goals, objectives, and tasks. Available at: http://sspa.boisestate.edu/efc/services.htm

Office of Wetlands Oceans and Watersheds (OWOW) Funding Website

This website will serve as a central portal to federal grant information, case studies, the Watershed Academy Web, and other relevant funding and links. The website will be available at http://www.epa.gov/owow/funding.html

Targeted Watersheds Grant Program

The Targeted Watershed Grant Program provides monetary assistance directly to watershed organizations to implement restoration/protection activities within their watershed. Grants are also available to support watershed service providers in their effort to train and educate watershed organizations to become more effective and autonomous. The Targeted Watershed Grant Program website is available at: http://www.epa.gov/owow/watershed/initiative/

Information and Outreach

Adopt Your Watershed

EPA maintains a searchable, on-line database of local watershed protection efforts, which allows users to find information easily about watershed protection efforts in their communities. Users can click on a map or type in a zip code to find their 8-digit Hydrologic Unit Code (HUC) or watershed address and then link to information about groups active in their communities. The database includes over 3,500 groups, including broad-based watershed partnerships involved in developing and implementing watershed protection plans as well as school and community groups doing stream cleanups, restoration, and monitoring projects. We now offer an on-line editing feature that allows groups to up-date their own information). Website can be found at: www.epa.gov/adopt/

Water Drop Patch Project

This project, developed by OWOW in partnership with the Girl Scouts of the USA, is part of a broader interagency Linking Girls to the Land Initiative designed to engage Girl Scouts in hands-on conservation and environmental stewardship programs. The Girl Scout Water Drop booklet includes twenty community-based watershed protection activities, including water quality monitoring, stream cleanups, stream assessments, water festivals, and storm drain stenciling to help build stewardship for local waters. More information can be found at: http://www.epa.gov/adopt/ and http://www.epa.gov/linkinggirls/

APPENDIX B

MUNICIPALITIES IN MASSACHUSETTS REGULATED BY THE PHASE II NPDES STORMWATER PERMIT PROGRAM

APPENDIX B

MUNICIPALITIES IN MASSACHUSETTS REGULATED BY THE PHASE II NPDES STORMWATER PERMIT PROGRAM

Municipalities Fully-Regulated by the Phase II NPDES Stormwater Permit Program

(Permit requirements apply throughout the entire geographic boundary of the municipality)

Abington	Arlington	Attleboro	Belmont	Beverly
Braintree	Brockton	Brookline	Burlington	Cambridge
Chelmsford	Chelsea	Chicopee	Danvers	Dedham
Everett	Fairhaven	Fitchburg	Framingham	Gloucester
Haverhill	Holbrook	Holyoke	Hull	Lawrence
Leominster	Lexington	Longmeadow	Lowell	Lynn
Lynnfield	Malden	Marlborough	Maynard	Medford
Melrose	Milton	Nahant	Needham	New Bedford
Newton	Northampton	Norwood	Peabody	Pittsfield
Quincy	Randolph	Reading	Revere	Salem
Saugus	Somerset	Somerville	Springfield	Stoneham
Swampscott	Taunton	Wakefield	Waltham	Watertown
Wellesley	West Springfield	Westfield	Weymouth	Wilmington
Winchester	Winthrop	Woburn		

Municipalities Partially-Regulated By the Phase II NPDES Stormwater Permit Program

(Permit requirements apply throughout a limited geographic area within the municipality)

Acton	Acushnet	Agawam	Amesbury	Andover	Ashland
Auburn	Avon	Barnstable	Bedford	Bellingham	Billerica
Blackstone	Boxborough	Boylston	Bridgewater	Canton	Charlton
Cohasset	Concord	Dalton	Dartmouth	Dennis	Dighton
Dover	Dracut	Dudley	East Bridgewater	East Longmeadow	Easthampton
Easton	Essex	Fall River	Foxborough	Franklin	Freetown
Georgetown	Grafton	Granby	Groton	Groveland	Hadley
Hamilton	Hampden	Hanover	Hanson	Hingham	Holden
Holliston	Hudson	Lanesborough	Leicester	Lincoln	Littleton
Ludlow	Lunenburg	Manchester	Mansfield	Marblehead	Mashpee
Medfield	Medway	Merrimac	Methuen	Middleton	Millbury

Municipalities Partially-Regulated By the Phase II NPDES Stormwater Permit Program

(Permit requirements apply throughout a limited geographic area within the municipality)

Millis	Millville	Natick	Norfolk	North Andover	North Attleboro
North Reading	Northborough	Northbridge	Norton	Norwell	Oxford
Paxton	Pembroke	Plainville	Raynham	Rehoboth	Rockland
Rockport	Sandwich	Scituate	Seekonk	Sharon	Shrewsbury
South Hadley	Southampton	Southborough	Southwick	Stoughton	Stow
Sudbury	Sutton	Swansea	Tewksbury	Tyngsborough	Uxbridge
Walpole	Wayland	Webster	Wenham	West Boylston	West Bridgewater
Westborough	Westford	Westminster	Weston	Westport	Westwood
Whitman	Wilbraham	Williamsburg	Wrentham	Yarmouth	

APPENDIX C

LOWER CHARLES RIVER ILLICIT DISCHARGE DETECTION & ELIMINATION (IDDE) PROTOCOL GUIDANCE FOR CONSIDERATION-NOVEMBER 2004

APPENDIX D

STRUCTURAL STORMWATER MITIGATION PRACTICES

APPENDIX D

STRUCTURAL STORMWATER MITIGATION PRACTICES

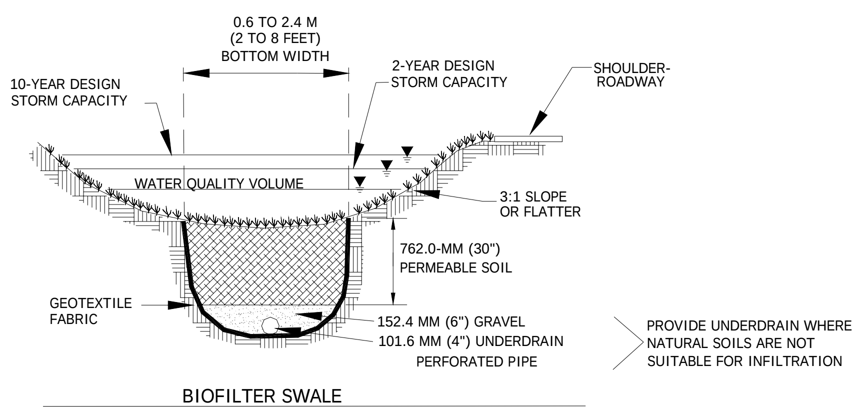
D.1 Stormwater Infiltration/Retention Practices

Stormwater infiltration and retention BMPs store runoff and allow it to gradually infiltrate to groundwater. Retention BMPs, also known as exfiltration systems, include infiltration basins, trenches, swales, and vegetated filter strips. These systems must be designed with sufficient storage capacity to hold runoff long enough to permit gradual infiltration. Infiltration systems remove pathogens by filtration through the soil matrix and reduce stormwater volume. Pre-treatment of runoff is often required to prevent failure of infiltration systems due to sediment accumulation. Infiltration systems have historically had significant failure rates and site constraints often limit their effectiveness (Schueler et al 1992). Off-line infiltration systems are generally preferable. Offline systems only treat a proscribed volume of runoff (e.g. the first 0.5 inches of a rainfall event). Resources for more information on vegetated filter strips are provided in Section 3.1.1.

D.1.1 Infiltration/Biofilter Swales

Infiltration swales (also referred to as biofilter swales) are channels designed to retain stormwater runoff until it infiltrates to the groundwater. Figure D-1 is a schematic diagram of an infiltration swale. They are generally designed with sufficient volume to retain a 10-year storm event. To ensure adequate infiltration they must either be built in areas with soils capable of supporting significant infiltration or must have an underdrain system (MassHighway 2004). Infiltration swales can significantly reduce pathogen loading to a water body by eliminating the direct discharge of stormwater runoff to surface waters. Pathogens in the water that infiltrates to groundwater are removed through filtering in the soil matrix. Due to their linear nature, infiltration swales are well suited for treating road runoff.

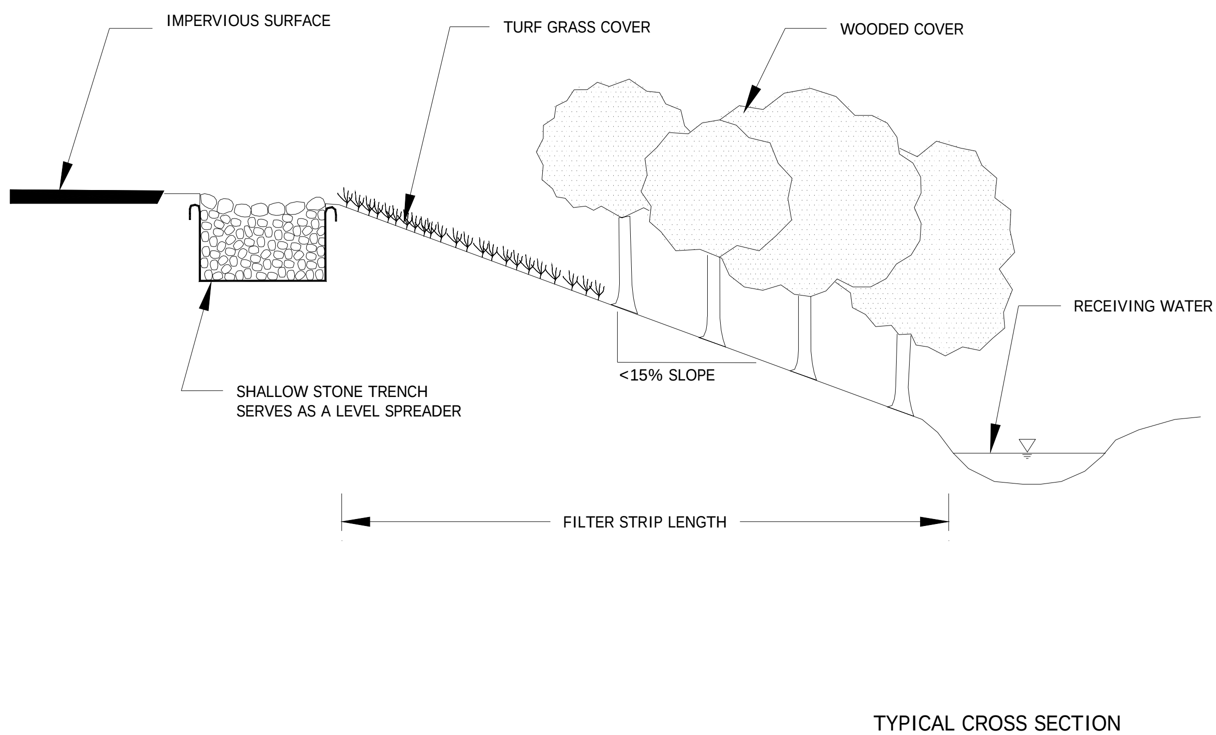
Figure D-1 Infiltration Swale (MassHIghway 2004)



D.1.2 Vegetated Filter Strips

Vegetated filter strips are vegetated areas that are intended to treat sheet flow from adjacent impervious areas. However, no data is available on the effectiveness of filter strips at removing bacteria. One problem associated with filter strips is that maintaining sheet flow is difficult. Consequently, urban filter strips are often "short circuited" by concentrated flows, which results in little or no treatment of stormwater runoff. Figure D-2 is a schematic diagram of a vegetated filter strip. Filter strips function by slowing runoff velocities, filtering out sediment and other pollutants, and providing some infiltration into underlying soils. The reduction of flow and removal of sediments can also reduce the pathogen load to adjacent water bodies. Filter strips were originally used as an agricultural treatment practice, and have more recently evolved into an urban practice. With proper design and maintenance, filter strips may provide relatively high pollutant removal in some circumstances. Filter strips are best suited to treating runoff from roads and highways, roof downspouts, and small parking lots. They are also ideal components of the "outer zone" of a stream buffer or as pretreatment for other stormwater treatment practices (Stormwater Manager's Resource Center, no date).

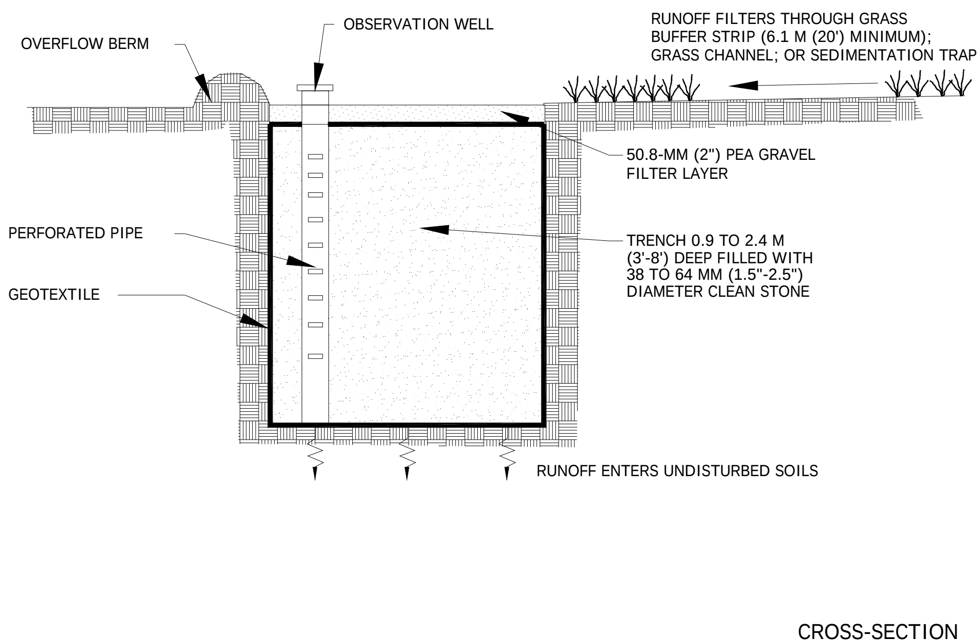
Figure D-2 Vegetated Filter Strip (MassHighway 2004)



D.1.3 Infiltration Trenches

Infiltration trenches are trenches backfilled with stones to create a reservoir to store runoff and allow it to infiltrate to the groundwater. Infiltration trenches have a high failure rate; slightly more than half totally or partially fail within five years of construction (Schueler et al. 1992). Figure D-3 is a schematic diagram of an infiltration trench. It is important that soils at the site have sufficient permeability to allow infiltration and pretreatment is necessary for removing sediments to reduce clogging. Grass clippings, sediments, and leaves can accumulate on the surface of the trench. They should be removed regularly. Bacteria removal by infiltration trenches is estimated to be 90% (Schueler et al 1992).

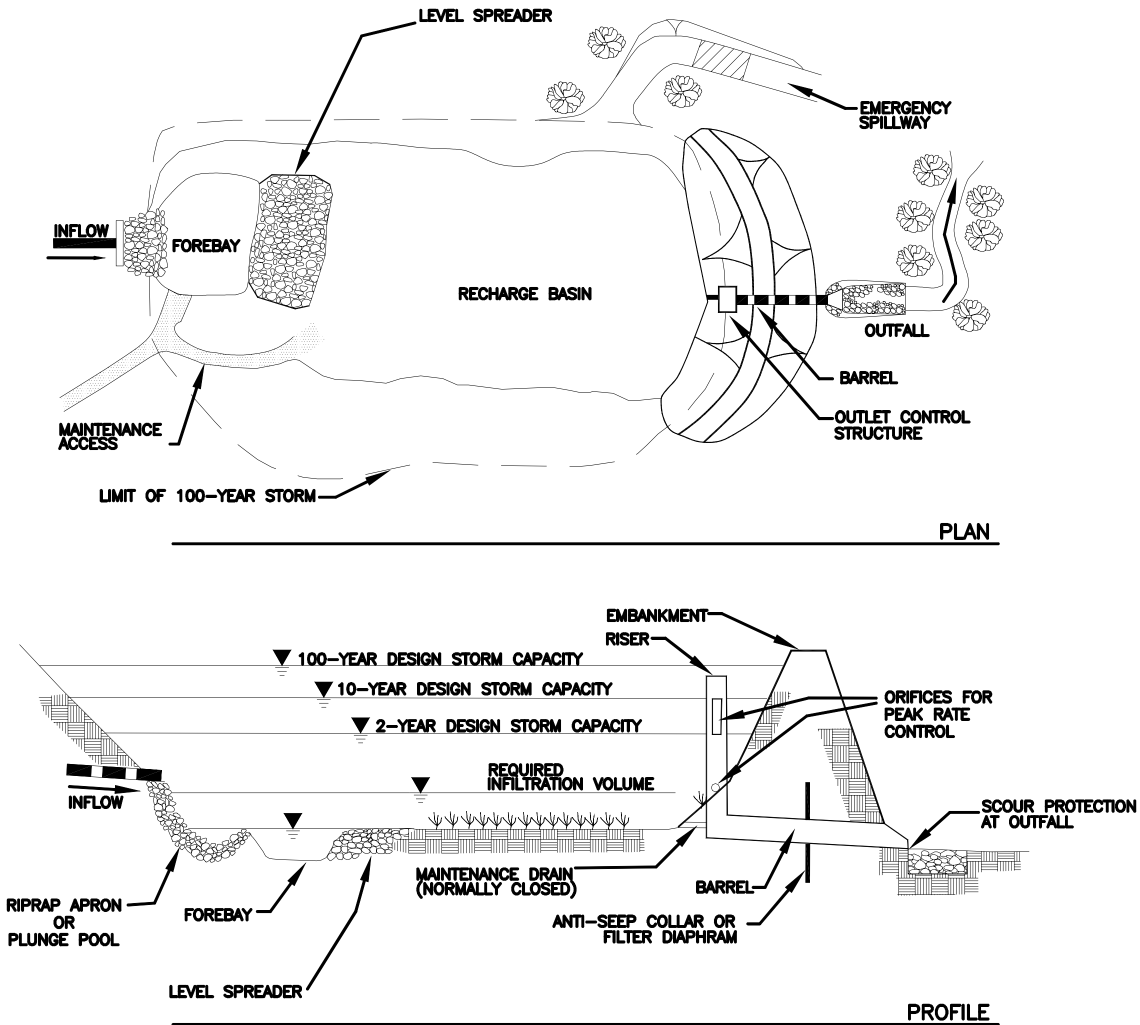
Figure D-3 Infiltration Trench (MassHighway 2004)



D.1.4 Infiltration Basin

Infiltration basins are stormwater impoundment structures designed to store runoff until it infiltrates to the groundwater through the floor of the basin. However, failure rates for infiltration basins are high. Within five years, 60-100% of infiltration basins fail due to reduced permeability of the underlying soils due to clogging with sediments (Schueler et al 1992). Figure D-4 is a schematic diagram of an infiltration basin showing side and top views. Infiltration basins may be designed to allow a portion of the stormwater to run out during large storm events. Their use is limited to areas with permeable soils, and pre-treatment of runoff to remove sediments is vital. Pollutant removal is achieved by filtration through the soil matrix. Estimated removal rates for bacteria range from 75-98% depending on how much runoff passes through the structure without infiltrating (Schueler 1987).

Figure D-4 Infiltration Basin (MassHighway 2004)



D.2 Stormwater Detention Practices

Stormwater detention BMPs are structures that temporarily store runoff and slow its release to the watershed. These methods are primarily designed to reduce stormwater surges and the concentrations of sediments and nutrients in stormwater. Stormwater detention may also reduce pathogen concentrations in stormwater to a limited extent. See Table 3-1 for an overview of various stormwater detention practices and the mitigation they provide. Detaining runoff may reduce bacteria through a number of mechanisms including:

- Natural dye-off of bacteria occurs during detention;
- Sediments and associated bacteria settle out; and
- Stormwater may infiltrate to the groundwater and pathogens removed by filtration through the soil matrix.

Although detention systems may reduce bacteria concentrations, there is also the potential that they can add to the problem if they attract waterfowl or other wildlife. Therefore, consideration should be given to factors that reduce use of the detention structure by waterfowls. Resources for more information on stormwater detention practices are provided in Section 3.1.1.

D.2.1 Created Wetlands

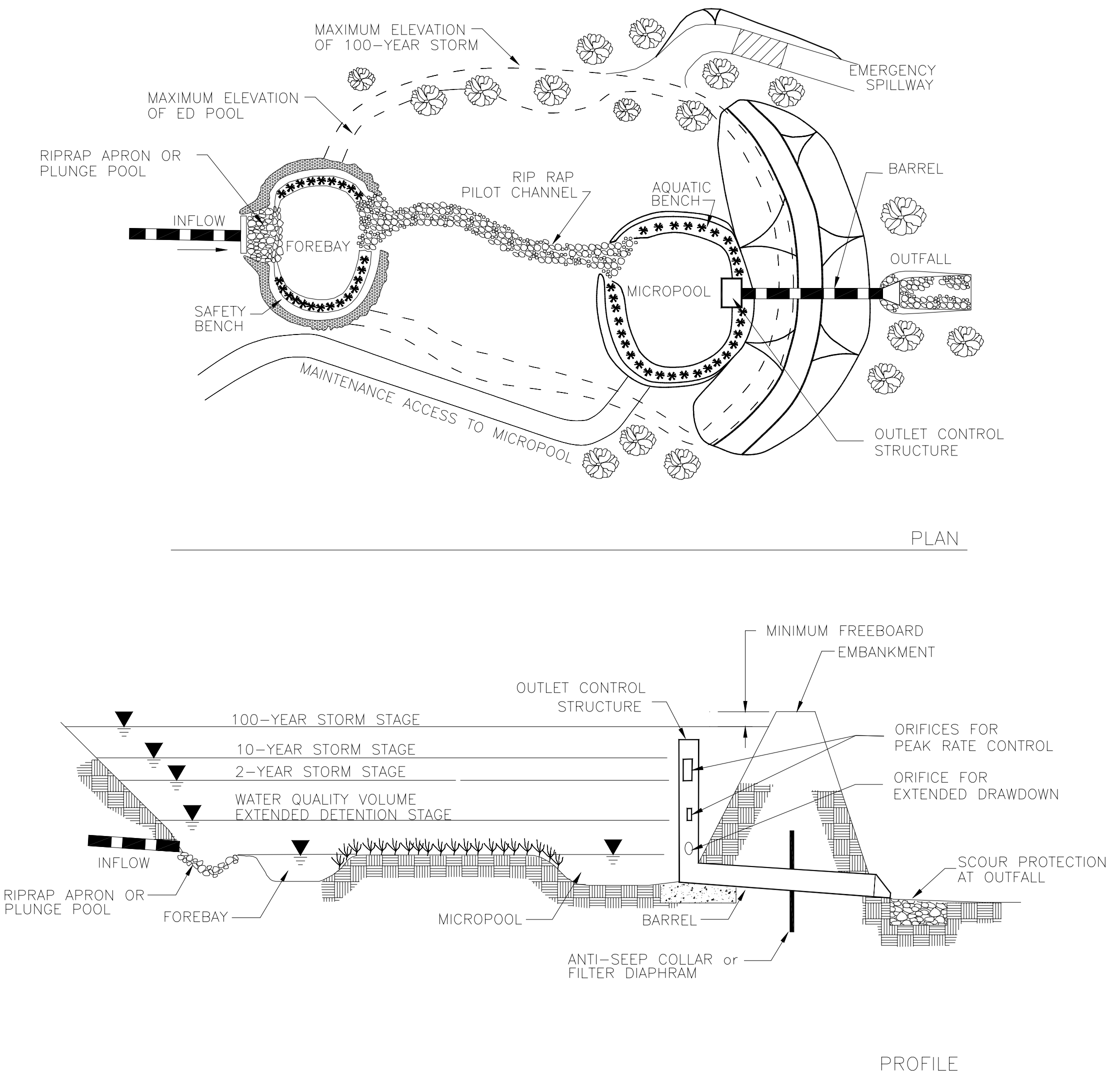
Created wetlands are shallow pools that create conditions suitable for the growth of marsh or wetland plants. These systems achieve pathogen reduction through sedimentation, exposure to ultraviolet radiation, chemical reactions, natural die-off, and predation by zooplankton (Rosen 2000). These mechanisms result in an estimated 78% reduction of bacteria in stormwater (Winer 2000; as cited in Center for Watershed Protection 2003). In addition to reducing pathogen concentrations, wetlands have the benefit of significantly reducing the concentrations of nutrients, metals, and suspended solids while creating habitat for wildlife. Created wetlands may be combined with wet ponds or extended detention. These structures are suitable for on-line or off-line treatment (assuming adequate hydrology can be maintained with off-line systems).

D.2.2 Extended Detention Ponds

Extended detention ponds are designed, as the name suggests, to hold stormwater in the pond and slow its release to the watershed. Figure D-5 is a schematic diagram showing an aerial and a cross sectional view of an extended detention pond. Extended detention ponds generally feature a low-flow orifice attached to the outlet of the pond. During detention, sedimentation and natural die-off reduce pathogen concentrations in the runoff. A detention time of 32 hours may result in an order of magnitude reduction in bacteria concentration in stormwater (Whipple and Hunter 1981; as cited in Schueler 1987). As an added benefit, detention can reduce downstream erosion and remove up to 90% of particulate pollutants (Schueler 1987).

There are two types of extended detention ponds for mitigating stormwater impacts, wet and dry detention ponds. Wet extended detention ponds include a storage volume above a permanent pool. Dry ponds drain completely between precipitation events. Wet ponds may be enhanced with wetland features or combined with extended detention. In comparison to wet ponds, sediment re-suspension is more likely in dry detention ponds and they generally do not provide adequate soluble pollutant removal. Extended detention ponds are suitable for on-line or off-line treatment.

Figure D-5 Extended Detention Pond (MassHighway 2004)



D.2.3 Vegetative Riparian Buffer Zones

Vegetative riparian buffers are vegetated corridors along aquatic channels. These areas may preserve existing vegetation or be designed and constructed to protect water quality. However, data on their effectiveness at removing pathogens are not available. Vegetated riparian buffers act primarily by reducing runoff velocity resulting in increased sedimentation and infiltration. However, forested buffers have only a limited ability to remove pollutants because stormwater is often concentrated and travels through the buffer area in a channel or ditch (Center for Watershed Protection 2003).

D.2.4 Swales

Swales are vegetated earthen channels that convey runoff. They are often used in residential areas as an alternative to curb and gutter systems. Despite there effectiveness at removing some pollutants, Winer (2000; as referenced in Center for Watershed Protection 2003) found that swales can increase bacteria concentrations in the water that flows through them. Therefore, unless they provide significant infiltration, swales should not be relied on to reduce bacteria concentrations. Instead, they may be implemented as part of a comprehensive stormwater management strategy. Pollutant removal primarily occurs via settling, filtration through the vegetation, and plant uptake. Depending on site conditions infiltration may also occur. Use of check dams in the swale slows flow and may enhance pollutant removal.

D.3 Disinfection, Chemical Treatment, and Other Treatment Practices

In addition to treatment methods that rely on infiltration and detention, there are a number of other methods for treating stormwater. These include chemical disinfection, alum treatment, sand filters, oil and grit chambers, and catch basins with sumps and hoods. A brief description of these methods is provided below (see also Table 3-1). With the exception chemical disinfection, these technologies are not designed primarily to remove pathogens from stormwater. Therefore, the efficacy of these methods at removing pathogens is often limited.

D.3.1 Chemical Disinfection

A number of chemical disinfection technologies for reducing pathogen concentrations in wastewater and drinking water may be applicable for treating stormwater. However, to date none of these technologies have been widely used to treat runoff. This is likely due to their high costs and a number of technical challenges. These technologies may be applicable, however, to situations where other means to reduce pathogen concentrations in stormwater are ineffective, impractical, or insufficient. Application of these technologies will generally require pretreatment to reduce turbidity and sediment content prior to disinfection. A brief description of a few disinfectant methods and the potential advantages and disadvantages of their use for treating stormwater is provided below.

<u>Chlorination:</u> Chlorination is the most commonly used disinfectant for wastewater and drinking water treatment. Chlorination relies on the oxidation of organic molecules to inactivate pathogens.

Advantages

- Effective at treating a wide range of pathogens
- Economical relative to other disinfectant technologies
- Relies on proven and effective technology (USEPA 1999a)

Disadvantages

- Toxic to aquatic life and has the potential to negatively impact the receiving water body
- Discharge would likely require a NPDES permit (Caltrans 2004)
- Since chlorine effectiveness can be reduced by suspended solids, in most cases stormwater would require treatment to remove suspended solids prior to chlorination
- Produces disinfectant byproducts that are potential carcinogens (USEPA 1999a)

Ozone Treatment: Ozone treatment is used for treating drinking water and wastewater, but is not widely used for treating stormwater. Ozone works by directly oxidizing organic molecules and producing hydroxyls radicals that also oxidize organic molecules (USEPA 1999a).

Advantages

- Effluent does not contain residuals that are toxic to aquatic life (Caltrans 2004)
- Reduces the concentration of organic contaminants
- Can reduce BOD and total suspended solids (TSS) (Caltrans 2004)
- Produces fewer disinfectant byproducts than chlorine (Caltrans 2004)

Disadvantages

- High cost
- High energy requirements
- Most suitable for continuous flows (Caltrans 2004)

Ultraviolet Irradiation: Disinfection of water can be achieved through exposure to ultraviolet radiation of sufficient intensity. Ultraviolet radiation inactivates bacteria by penetrating the cell wall and disrupting nucleic acids and other cell components (USEPA 1999a). A system to treat dry-weather runoff using ultraviolet irradiation in California is reported to achieve mean fecal coliform concentrations of 2 CFU/100ml (Rasmus and Weldon 2003).

Advantages

- Minimal residual in the effluent
- Relatively low maintenance requirements
- Can achieve low pathogen concentrations

Disadvantages

- Effectiveness can be greatly reduced by turbidity
- May require substantial pre-treatment (Caltrans 2004)
- Requires extremely high ultraviolet (UV) dosages to inactivate cryptosporidium and giardia (USEPA 1999a)

Resources for Disinfection and Chemical Treatment

- Stormwater Treatment BMP New Technology Report. California Department of Transportation. 2004. SW-04-069-.04.02 Available at: http://www.dot.ca.gov/hq/env/stormwater/special/newsetup/_pdfs/new_technology/CTSW-RT-04-069.pdf
- Moonlight Beach Urban Runoff Treatment facility: Using Ultraviolet Disinfection to Reduce Bacteria Counts. Rasmus, J. and K. Weldon. 2003. StormWater, May/June 2003. Available for download at http://www.forester.net/sw_0305_moonlight.html

D.3.2 Alum Treatment

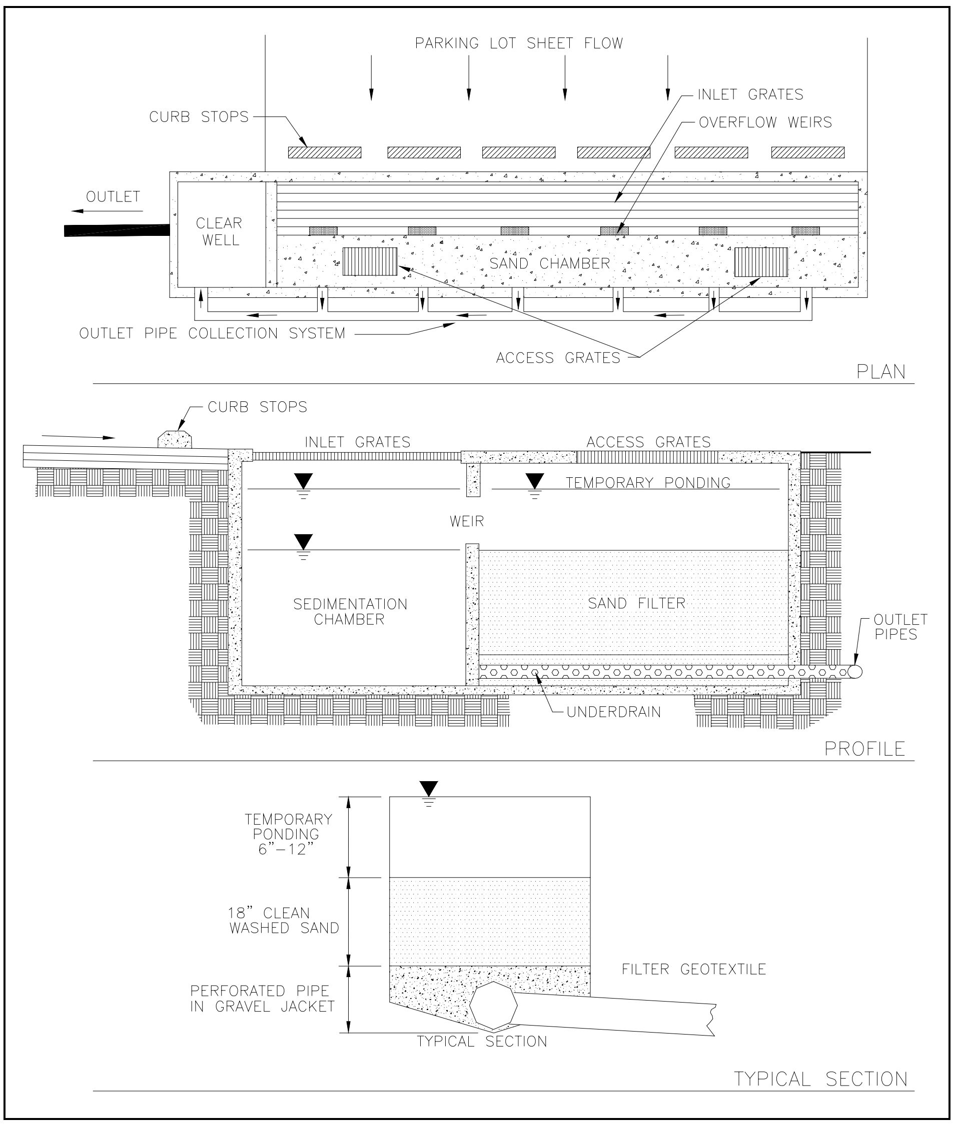
Treatment with alum or other aluminum coagulants involves the dosing of stream flows with coagulant to bind phosphorus and coagulate sediments to promote settling. Alum treatment is primarily applied for phosphorus removal where other BMPs are not viable. However, removal rates ranging from 50 - 99% have been documented for bacteria and other pollutants. This treatment technology has been applied successfully for treating stormwater. Buffering is typically required due to the low alkalinity of most New England waters. An alum treatment system design must consider the following elements:

- A secure facility to house the system elements,
- One or more 3,000 – 6,000 gallon tanks to hold a slurry of alum and buffering solutions,
- Pumps and/or diversion structures (for off-line systems),
- Flow metering devices and triggers to activate the discharge of chemical at a pre-determined flow,
- Mechanical mixing or aeration to maximize contact and promote floc formation, and
- Fluctuations in stormwater quality during the course of a storm or from storm to storm may result in variable treatment effectiveness.

D.3.3 Sand Filters/Filter Beds

Filter beds are designed to strain runoff through a sand filter to an underdrain system for discharge. Figure D-6 is a schematic diagram showing top and side views of a sand filter. To date, extensive application of this technology has been limited to the mid-Atlantic and southwestern US. Sand filters have achieved fecal coliform removal rates of 40% in stormwater (Schueler et al 1992). In addition, sand filters reduce sediment, nutrient, and trace metal concentrations. Frequent maintenance of the filter is required to remove accumulated sediments, trash, debris, and leaf litter (Schueler et al 1992). Sand filters should not generally be used as on-line systems.

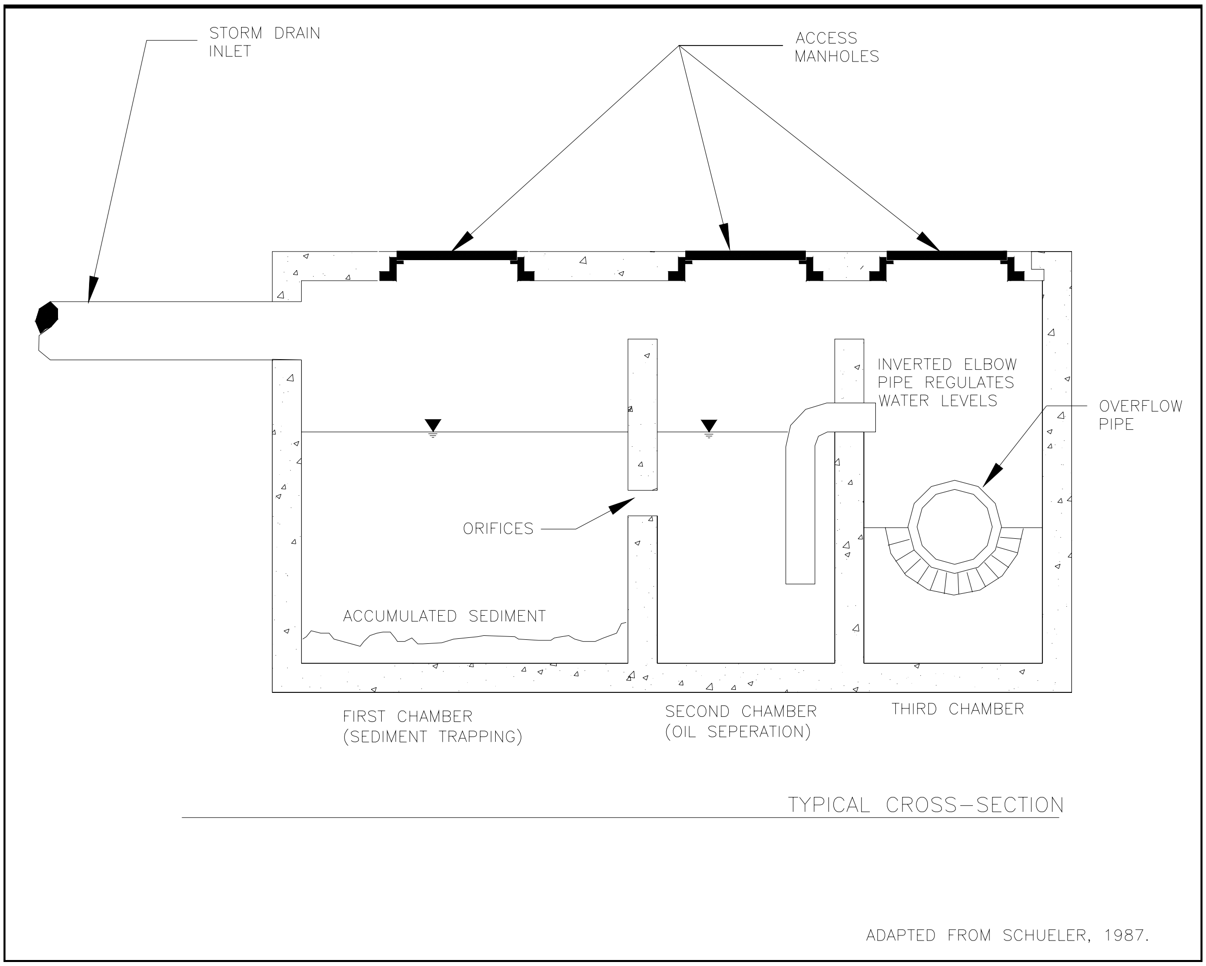
Figure D-6 Sand Filter (MassHighway 2004)



D.3.4 Oil/Grit Chambers

Oil and grit chambers are underground systems consisting of multiple chambers for the separation of coarse sediments and floating contaminants from stormwater. Oil and grit chambers are unlikely to achieve significant reductions in pathogen concentrations. Figure D-7 is a schematic diagram of an oil and grit chamber. There a number of oil/grit chamber designs currently on the market. These self-contained units include a small permanent pool below the inlet to permit the settling of coarse sediments and typically have hooded outlet structures to remove oil and floating contaminants (Figure D-7). In addition, several proprietary designs rely on a vortex to enhance sediment removal. Their primary utility is the removal of coarse sediments as a pre-treatment for other BMPs. Since actual pollutant removal does not occur until the chambers are cleaned out, the effectiveness of these systems relies on regular maintenance (Schueler 1992). In addition, re-suspension of sediments in the chambers may limit their effectiveness (Schueler 1992). Pollutant removal may be enhanced for off-line systems.

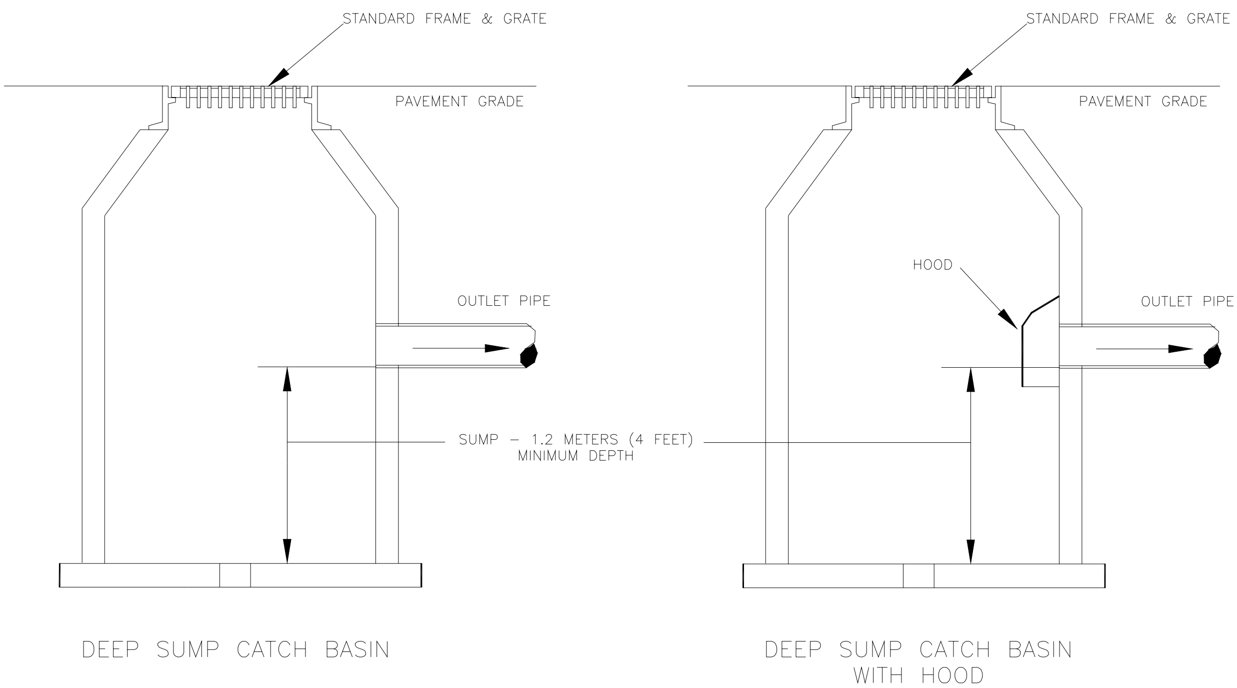
Figure D-7 Oil and Grit Chamber (MassHighway 2004)



D.3.5 Catch Basin w/ Sumps & Hood

Deep sump catch basins are inlet structures that provide for some removal of sediments and floating contaminants. The effectiveness of catch basins with sumps and hoods at removing pathogens has not been tested. However, it is likely to be negligible. Therefore, catch basins may provide adequate pre-treatment for other BMPs but they should not be relied on to reduce pathogen concentrations. Figure D-8 is a schematic diagram of a deep sump catch basin. Deep sump catch basins function similarly to oil and grit chambers. Stormwater flows into the sump where coarse sediment is removed by settling. The outlet of the sump is below the waterline so oil and grease and other floating materials are retained in the catch basin. When regularly maintained they may remove limited amounts of coarse sediments and oil and grease.

Figure D-8 Deep Sump Catch Basin (MassHighway 2004)



CATCHBASIN MATERIALS AND FABRICATION VARIES. SEE DRAWINGS IN MASSHIGHWAY "CONSTRUCTION AND TRAFFIC STANDARD DETAILS" (METRIC EDITION 1996).

D.4 Low Impact Development Strategies

Low impact development strategies (LIDS) are a set of tools intended to restore or maintain the hydrology of the watershed by reducing runoff rates and volume and increasing groundwater recharge. LIDS are defined as follows (from USEPA 2000a):

> LID is a site design strategy with a goal of maintaining or replicating the pre-development hydrologic regime through the use of design techniques to create a functionally equivalent hydrologic landscape. Hydrologic functions of storage, infiltration, and ground water recharge, as well as the volume and frequency of discharges are maintained through the use of integrated and distributed micro-scale stormwater retention and detention areas, reduction of impervious surfaces, and the lengthening of flow paths and runoff time (Coffman, 2000). Other strategies include the preservation/protection of environmentally sensitive site features such as riparian buffers, wetlands, steep slopes, valuable (mature) trees, flood plains, woodlands and highly permeable soils.
>
> LID principles are based on controlling stormwater at the source by the use of micro-scale controls that are distributed throughout the site. This is unlike conventional approaches that typically convey and manage runoff in large facilities located at the base of drainage areas. These multifunctional site designs incorporate alternative stormwater management practices such as functional landscape that act as stormwater facilities, flatter grades, depression storage and open drainage swales. This system of controls can reduce or eliminate the need of a centralized best management practice (BMP) facility for the control of stormwater runoff. Although traditional stormwater control measures have been documented to effectively remove pollutants, the natural hydrology is still negatively affected (inadequate base flow, thermal fluxes or flashy hydrology), which can have detrimental effects on ecosystems, even when water quality is not compromised (Coffman, 2000). LID practices offer an additional benefit in that they can be integrated into the infrastructure and are more cost effective and aesthetically pleasing than traditional, structural stormwater conveyance systems.

Although LIDS are not primarily designed to reduce pathogen pollution, their mitigation of hydrologic impacts is likely to reduce pathogen loading from stormwater in many situations. One of the primary impacts of increased urbanization is the increase in impervious surface area within the watershed. As a result, runoff volume and velocity increase leading to more flushing of contaminants, including pathogens, into adjacent surface waters. Therefore, one of the most significant ways to reduce stormwater's contribution to pathogen contamination is to reduce the volume and rate of runoff from a given area. LIDS aim to reduce runoff by increasing infiltration to groundwater and plant uptake. These approaches may be particularly effective if they are targeted at areas known to contribute significantly to pathogen contamination, such as areas with high use by domestic animals or wildlife.

Although LIDS are often intended primarily for new development, many of these practices can be applied as retrofits to existing sites with similar benefits. The following section focuses on the LIDS that are most likely to be applicable to existing developments (see also Table 3-1). For more information on LIDS for future development see the information referenced in Resources – Low Impact Development Strategies (Section D.4.8).

D.4.1 Disconnecting Impervious Areas

One of the most effective LIDS is “disconnecting” impervious areas. Impervious areas that drain directly to closed drainage systems produce runoff in all but the smallest rain events. If runoff from paved surfaces is allowed to flow over pervious or vegetated surfaces before entering a drainage collection system, some or all of the runoff from small rain events will be intercepted and percolated into the ground. This can eliminate stormwater’s contribution to pathogen impairment during small storm events. The following steps can be taken to disconnect impervious areas:

- Remove curbs on roads and parking lots
- Locate catch basins in pervious areas adjacent to parking lots, as opposed to in the paved portion of the lot
- Disconnect roof drains and direct flows to vegetated areas
- Direct flows from paved areas such as driveways to stabilized vegetated areas
- Break up flow directions from large paved surfaces
- Encourage sheet flow through vegetated areas
- Carefully locate impervious areas so that they drain to natural systems, vegetated buffers, natural resource areas, or infiltratable zones/soils

D.4.2 Bioretention

Bioretention uses a conditioned planting soil bed and planting materials to filter runoff stored within a shallow depression. The method combines physical filtering and adsorption with biological processes. These processes are likely to remove sediments and associated pathogens from the water. A bioretention system can include the following components: a pretreatment filter consisting of a grass channel inlet area, a shallow surface water ponding area, a bioretention planting area, a soil zone, an underdrain system, and an overflow outlet structure (MD DNR, 1999).

D.4.3 Soil Amendment

The aeration and addition of compost amendments to disturbed soils is extremely effective at restoring the hydrologic functions of soils and reducing runoff. Soil amendments increase the spacing between soil particles so that the soil can absorb and hold more moisture. Compared to compacted, un-amended soils, amended soils provide greater infiltration and subsurface storage which reduces a site's overall runoff volume, and helps maintain or restore the predevelopment peak discharge rate and timing. The reduction in runoff, along with the filtering effect of the soil matrix can reduce pathogen loading.

D.4.4 Porous Pavement

Porous pavement allows rain and snowmelt to pass through it and infiltrate into the ground, thereby reducing the runoff from a site. This reduction in runoff may also reduce the area's contribution to pathogen loading. However, porous pavement is reported to have a failure rate of 75% due to clogging with sediments (Schueler et al 1992). The two primary types of porous pavement include porous asphalt and pervious concrete. Porous asphalt consists of an open-graded coarse aggregate, bonded together by asphalt cement, with sufficient interconnected voids to make it highly permeable. Pervious concrete consists of specially formulated mixtures of Portland cement, uniform, open-graded coarse aggregate, and water. Pervious concrete has enough void space to allow rapid percolation of liquids through the pavement. The porous pavement surface is typically placed over a highly permeable layer of open-graded gravel and crushed stone. The void spaces in the aggregate layers act store runoff. Porous pavement may substitute for conventional pavement on parking areas, areas with light traffic, and the shoulders of airport taxiways and runways, provided that the grades, subsoil, drainage characteristics, and groundwater conditions are suitable (USEPA 1999b).

D.4.5 Green Roofs

Green roofs, also known as vegetated roof covers, eco-roofs, or nature roofs, help to mitigate the effects of urbanization on water quality by filtering, absorbing and detaining rainfall. They are constructed of a lightweight soil media, underlain by a drainage layer, and a high quality impermeable membrane that protects the building structure. The soil is planted with a specialized mix of plants that can thrive in the harsh, dry, high temperature conditions of the roof and tolerate short periods of inundation from storm events. Green roofs may reduce pathogen loads when roof runoff flows over potentially contaminated surfaces by reducing the volume and frequency of the runoff.

D.4.6 Rain Barrels and Cisterns

Rain barrels are low-cost, effective, and easily maintained retention devices applicable to residential, commercial, and industrial sites. Rain barrels operate by retaining a predetermined volume of rooftop runoff. Rain barrels are typically used to store runoff for later reuse in lawn and garden watering.

Stormwater cisterns are roof runoff management devices that provide retention storage volume in underground storage tanks for re-use for irrigation or other uses. Reduction in pathogen loading may occur when the stored runoff would have otherwise washed contaminants into stormwater systems. On-lot storage with later reuse of stormwater also provides an opportunity for water conservation and the possibility of reducing water utility costs (MD DER, 1999). Rain barrels are a bad idea unless there is a way of preventing mosquitoes from laying their eggs.

D.4.7 Rain Gardens

A simple, yet effective method to control stormwater is through the use of rain gardens. Also known as bioretention areas, rain gardens are small vegetated depressions that collect, store, and infiltrate stormwater runoff. They contain various soil types from clays to sands and size varies depending on area drained and available space. Their primary utility in reducing pathogen in stormwater relies on the reduction in runoff volume and in the increase infiltration.

D.4.8 Resources – Low Impact Development Strategies

- Low Impact Development Page. USEPA Website: http://www.epa.gov/owow/nps/lid/
- Low Impact Development Center. Website: http://www.lowimpactdevelopment.org/
- Low Impact Development Design Strategies. Prince George's County Maryland, Department of Environmental Resources 1999. Available at: http://www.epa.gov/owow/nps/lid/lidnatl.pdf
- Low Impact Development, a Literature Review. USEPA 2000a. EPA-841-B-00-005. Available at: http://www.epa.gov/owow/nps/lid/lid.pdf
- Bioretention Applications. USEPA 2000 [do these need to be in the references?]. EPA-841-B-00-005A. Available at: http://www.epa.gov/owow/nps/bioretention.pdf
- Field Evaluations of Permeable Pavements for Stormwater Management. USEPA 2000. EPA-841-B-00-005B. Available at: http://www.epa.gov/owow/nps/pavements.pdf
- Vegetated Roof Cover. USEPA 2000. EPA-841-B-00-005D Available at: http://www.epa.gov/owow/nps/roofcover.pdf

D.5 Operation and Maintenance Measures

Operation and maintenance programs should be comprehensive and include annual inspection and maintenance of mitigation measures that have been enacted. Requirements of an operation and maintenance program will depend on the specific BMPs employed. However, some general guidelines and specific examples are provided below. The effectiveness of operation and maintenance activities at reducing pathogen concentrations will be dependent on the specific BMP in question.

Recommended general operation and maintenance measures include:

- Conduct inspections and prompt repair or replacement of runoff management practices;
- Maintain transportation and storm drain infrastructure to reduce loads at the source;
- Inspect, maintain, and repair controls to maintain design treatment capacity; and
- Inspect, maintain, and repair aquatic buffers.

The Massachusetts Highway Department suggests the following for operation and maintenance of stormwater systems associated with highways and bridges (MassHighway 2004):

> "1. Maintain records that document catch basin inspection and cleaning (as well as any maintenance activities for other drainage structures), including: executed contracts, certificates of completion, contractor invoices, or other types of maintenance logs.
>
> a. Develop a centralized database for keeping records on inspection and maintenance of catch basins. This will include developing a map of its drainage systems, on a project by project basis as individual roadway projects are proposed and issued environmental permits. MassHighway will collect data on the accumulation of debris (including the frequency of cleaning catch basins, and any drainage problems) for representative areas, and determine if the current inspection and cleaning schedule should be altered for particular areas.
>
> b. The schedule will target areas that are in most need of cleaning, with an emphasis on locations adjacent to sensitive receiving waters (e.g., public drinking water reservoirs), while corresponding to MassHighway's limited maintenance budgets.
>
> c. Upon completion of the review, the Standard Operating Procedure for catch basin cleaning will be updated, as necessary;
>
> 2. Sweep roadways on an annual basis after winter deicing applications as warranted, with an emphasis on high sand accumulation areas and locations adjacent to sensitive receiving waters;
>
> 3. Note problems and take appropriate corrective actions to maintain outlets and BMPs in good working condition;
>
> 4. Take appropriate control measures to avoid discharge of materials to receiving wetland and water resources during cleaning and maintenance activities (e.g., avoid side-casting sediments from ditch cleaning into adjacent wetlands);

5. Install, inspect and maintain construction BMPs to ensure appropriate sediment control is provided throughout construction and until the site is stabilized."

D.5.1 Resources – Operation and Maintenance

- National Management Measure to Control Non Point Source Pollution from Urban Areas – Draft. USEPA 2002. EPA 842-B-02-2003. Available at: http://www.epa.gov/owow/nps/urbanmm/index.html
- Operation, Maintenance, and Management of Stormwater Management Systems. Livingston, Shaver, Skupien, and Horner August 1997. Watershed Management Institute. Call: (850) 926-5310.
- Model Ordinances to Protect Local Resources – Stormwater Control Operation and Maintenance. USEPA Webpage: http://www.epa.gov/owow/nps/ordinance/stormwater.htm
- Stormwater O & M Fact Sheet Preventive Maintenance. USEPA 1999. 832-F-99-004. Available at: http://www.epa.gov/owm/mtb/prevmain.pdf
- The MassHighway Stormwater Handbook. Massachusetts Highway Department. 2004. Available at: http://166.90.180.162/mhd/downloads/projDev/swbook.pdf

D.6 References

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APPENDIX E

TOWNS AND CITIES PARTICIPATING IN THE COMPREHENSIVE COMMUNITY SEPTIC MANAGEMENT PROGRAM

APPENDIX E

TOWNS AND CITIES PARTICIPATING IN THE COMPREHENSIVE COMMUNITY SEPTIC MANAGEMENT PROGRAM

Current Towns and Cities Participating in the Program

Barnstable	Bellingham	Bourne
Bridgewater	Chatham	Dartmouth
Dennis	East Bridgewater	Eastham
Essex	Falmouth	Halifax
Hanson	Holden	Hopkinton
Kingston	Leicester	Mashpee
Middleborough	Middleton	Norton
Orleans	Pembroke	Provincetown
Shirley	Shrewsbury	Southborough
Southhampton	Taunton	Townsend
Wellfleet	West Boylston	West Bridgewater
West Newbury	Whitman	Wrentham

Towns and Cities that Participated in the Program in the Past

Acushnet	Agawam	Amesbury	Amherst	Ashburnham	Ashland
Athol	Attleboro	Avon	Ayer	Barnstable	Barre
Belchertown	Bellingham	Belmont	Berlin	Bernardston	Blackstone
Bourne	Boxford	Boylston	Brewster	Bridgewater	Brookfield
Carver	Chatham	Chesterfield	Colrain	Concord	Conway
Dartmouth	Dedham	Dennis	Dighton	Dover	Dracut
Dudley	Duxbury	East Bridgewater	Eastham	Easton	Essex
Fairhaven	Falmouth	Foxborough	Franklin	Georgetown	Gill
Gloucester	Grafton	Greenfield	Groton	Halifax	Hanover
Hardwick	Harwich	Hatfield	Haverhill	Hingham	Holbrook
Holden	Hopkinton	Hubbardston	Hudson	Kingston	Lakeville
Lancaster	Leicester	Lexington	Littleton	Longmeadow	Lunenburg
Lynnfield	Mashpee	Maynard	Medfield	Medway	Medway
Mendon	Merrimac	Middleborough	Middleton	Millville	Milton

Towns and Cities that Participated in the Program in the Past

Monterey	Nantucket	Natick	Needham	North Reading	Northampton
Northborough	Northbridge	Norton	Norwell	Orange	Paxton
Pembroke	Phillipston	Plymouth	Plympton	Provincetown	Raynham
Reading	Rowley	Royalston	Rutland	Sandwich	Saugus
Scituate	Seekonk	Sharon	Shrewsbury	Shutesbury	Southampton
Southborough	Southbridge	Southwick	Spencer	Stoughton	Sunderland
Sutton	Taunton	Templeton	Tisbury	Townsend	Truro
Wakefield	Walpole	Wareham	Wayland	Webster	West Boylston
West Newbury	Westford	Weymouth	Whitman	Wilmington	Winchendon
Winchester	Wrentham	Yarmouth			