WATERSHED-BASED PLAN

Pine Tree Brook (Turners Pond) Watershed within the Towns of Milton and Quincy

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Prepared By:

Town of Milton
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Prepared For:

MassDEP
Commonwealth of Massachusetts
Department of Environmental Protection

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Executive Summary

Introduction: The purpose of a Massachusetts Watershed-Based Plan (WBP) is to organize information about Massachusetts' watersheds, and present it in a format that will enhance the development and implementation of projects that will restore water quality and beneficial uses in the Commonwealth. The Massachusetts WBP follows USEPA's recommended format for “nine-element” watershed plans. This WBP was developed by Geosyntec Consultants (Geosyntec) under the direction of the Town of Milton with funding, input, and collaboration from the Massachusetts Department of Environmental Protection (MassDEP).

Pine Tree Brook (MA73-29) is a tributary to the Neponset River (segment MA73-03) and includes several tributaries and ponds located in the Towns of Milton and Quincy. This WBP was prepared for waterbodies located within the Pine Tree Brook Watershed (MA73-29). These waterbodies include Pine Tree Brook (MA73-29); Balster Brook; Chestnut Run; Trout Brook; and Wendell Brook.

Impairments and Pollution Sources: Pine Tree Brook (MA73-29) is listed on the Massachusetts List of Integrated Waters (303(d) list) as a category 5 waterbody for impairments of dissolved oxygen (DO), physical substrate habitat alterations, aquatic plants, *E. Coli*, fecal coliform, and turbidity. Pine Tree Brook discharges to the Neponset River (segment MA73-03), which is a category 5 water body on the 303(d) list for numerous impairments; and the Neponset River Basin (including Pine Tree Brook) has a TMDL for bacteria (MassDEP, 2002).

The source of the impairments for the Pine Tree Brook Watershed is currently listed as unknown, however, the Neponset River TMDL indicates that suspected sources of bacteria include sanitary sewer overflows, illicit sewer connections, storm water runoff, and failing septic systems.

Goals, Management Measures, and Funding: Water quality goals for this WBP are focused on addressing the Neponset River Watershed Bacteria TMDL, listed DO impairments, and observed elevated concentrations of Total Phosphorus (TP) from ambient monitoring data. The pollutant load reductions needed to achieve water quality goals are focused on TP. It is expected that efforts to reduce TP loading will also result in improvements to *E. Coli* and DO in Pine Tree Brook. This WBP includes an adaptive sequence to establish and track specific water quality goals. First, an interim goal has been established to reduce phosphorus loading by 14 pounds/year in the next five years. From there, the focus will be shifted to the long-term goal of delisting all assessment units within the study area based on adaptively adjusting goals based on ongoing monitoring results.

It is expected that goals will be accomplished primarily through installation of structural best management practices (BMPs) to capture runoff and reduce loading as well as implementation of non-structural BMPs (e.g., street sweeping, catch basin cleaning), and watershed education and outreach. The NepRWA partnered with the Town of Milton to conduct a BMP retrofit feasibility survey within the Milton under funding from the Massachusetts DEP’s 604(b) Program (EPG, 2013). The project identified sites in the Town of Milton that were suitable for retrofitting with structural stormwater BMPs and where conceptual designs could be developed for BMPs at those sites to restore and maintain primary contact recreation and other designated uses. Fifteen sites were initially evaluated and seven were removed from further consideration after a stakeholder meeting at Town Hall. The remaining eight sites were ranked based on water quality benefits, site characteristics, constructability, maintenance access, and potential for public education. The top three ranking sites were further investigated. Conceptual designs for the top three ranking sites were developed. The Town of Milton was awarded funding through the Fiscal Year 2017 Section 319 Nonpoint Source Pollution

Grant Program to implement one of the three sites (to install six tree filter boxes along Wendell Brook) (Town of Milton, 2019). The other two sites are on Lafayette Street and Sumner Street Park and are still strong candidates for future BMP design and implementation in the Pine Tree Brook watershed (EPG, 2013).

It is expected that funding for management measures will be obtained from a variety of sources including Section 319 Grant Funding, Town capital funds, volunteer efforts, and other sources.

Public Education and Outreach: Goals of public education and outreach are to provide information about proposed stormwater improvements and their anticipated benefits and to promote watershed stewardship. The Town of Milton and the NepRWA aim to engage watershed residents and businesses through interpretive signage, education mailing, online resources, and a variety of other means. It is expected that these programs will be evaluated by tracking coverage from local media, number of mailers distributed, activity on online resources, and other tools applicable to the type of outreach performed.

Implementation Schedule and Evaluation Criteria: Project activities will be implemented based on the information outlined in the following elements for monitoring, implementation of structural BMPs, public education and outreach activities, and periodic updates to the WBP. It is expected that a water quality monitoring program will enable direct evaluation of improvements over time. Other indirect evaluation metrics are also recommended, included quantification of potential pollutant load reductions from non-structural BMPs (e.g., street sweeping). The WBP will be re-evaluated and adjusted, as needed, once every three years.

Introduction

What is a Watershed-Based Plan?

Purpose & Need

The purpose of a Massachusetts Watershed-Based Plan (WBP) is to organize information about Massachusetts' watersheds, and present it in a format that will enhance the development and implementation of projects that will restore water quality and beneficial uses in the Commonwealth. The Massachusetts WBP follows USEPA's recommended format for "nine-element" watershed plans, as described below.

All states are required to develop WBPs, but not all states have taken the same approach. Most states develop watershed-based plans only for selected watersheds. MassDEP's approach has been to develop a tool to support statewide development of WBPs, so **that good projects in all areas of the state may be eligible for federal watershed implementation grant funds** under Section 319 of the Clean Water Act.

USEPA guidelines promote the use of Section 319 funding for developing and implementing WBPs. WBPs are required for all projects implemented with Section 319 funds, and are recommended for all watershed projects, whether they are designed to protect unimpaired waters, restore impaired waters, or both.

Watershed-Based Plan Outline

This WBP for the Pine Tree Brook Watershed includes nine elements (a through i) in accordance with USEPA Guidelines:

a. An **identification of the causes and sources** or groups of similar sources that will need to be controlled to achieve the load reductions estimated in this watershed-based plan (and to achieve any other watershed goals identified in the watershed-based plan), as discussed in item (b) immediately below.

b. An **estimate of the load reductions** expected for the management measures described under paragraph (c) below (recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time).

c. A **description of the nonpoint source (NPS) management measures** needed to achieve the load reductions estimated under paragraph (b) above (as well as to achieve other watershed goals identified in this watershed-based plan), and an identification (using a map or a description) of the critical areas in which those measures will be needed to implement this plan.

d. An **estimate of the amounts of technical and financial assistance needed**, associated costs, and/or the sources and authorities that will be relied upon, to implement this plan. As sources of funding, States should consider the use of their Section 319 programs, State Revolving Funds, USDA's Environmental Quality Incentives Program and Conservation Reserve Program, and other relevant Federal, State, local and private funds that may be available to assist in implementing this plan.

e. An **information/education component** that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented.

f. A **schedule for implementing the NPS management measures** identified in this plan that is reasonably expeditious.

g. A description of **interim, measurable milestones** for determining whether NPS management measures or other control actions are being implemented.

h. A set of **criteria to determine if loading reductions are being achieved** over time and substantial progress is being made towards attaining water quality standards and, if not, the criteria for determining whether this watershed-based plan needs to be revised or, if a NPS Total Maximum Daily Load (TMDL) has been established, whether the TMDL needs to be revised.

i. A **monitoring component** to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above.

Project Partners and Stakeholder Input

This WBP was developed by Geosyntec Consultants (Geosyntec) under the direction of the Town of Milton with funding, input, and collaboration from the Massachusetts Department of Environmental Protection (MassDEP). This WBP was developed using funds from the Section 319 program to assist grantees in developing technically robust WBPs using MassDEP's Watershed-Based Planning Tool. The Town of Milton was a recipient of Section 319 funding in Fiscal Year 2020 to implement BMPs in the Pine Tree Brook Watershed.

Core project stakeholders included:

- Anna Meyer – Environmental Coordinator, Town of Milton Department of Public Works
- Patrick Hogan – Neponset River Watershed Association (NepRWA) Water Resources Professional
- Declan Devine – NepRWA Environmental Fellow
- Matthew Reardon – MassDEP

This WBP was developed as part of an iterative process. The Geosyntec project team collected and reviewed existing data from the Town of Milton. This information was then used to develop a preliminary WBP for review by core project stakeholders. A stakeholder conference call was then held to solicit input and gain consensus on elements included in the plan (e.g., water quality goals, public outreach activities, etc.). The WBP was finalized once stakeholder consensus was obtained for all elements.

Data Sources

This WBP was developed using the framework and data sources provided by MassDEP's Watershed-Based Plan Tool and supplemented by information provided in the "Wendell Brook BMPs" Section 319 Nonpoint Source Pollution Grant Program application and final report (Town of Milton, 2016 and Town of Milton, 2019).

Summary of Past and Ongoing Work

Neponset River Watershed Association Citizen Water Monitoring Network (NepRWA, 2020a)

Citizen Water Monitoring Network (CWMN), led by the NepRWA has been collecting water quality data throughout the Neponset River Watershed since 1994. Refer to the website or Element A for more details.

Hot Spot Monitoring (NepRWA, 2020b)

NepRWA conducts a Hot Spot Monitoring Program to assess water quality and locate pollution sources discharging to water bodies in the Neponset River watershed. The program primarily focuses on *E. coli* concentrations, but also monitors for other pollutants. The results of the monitoring are used to identify locations for follow-up investigation.

Town of Milton Year 15 Annual Report (Town of Milton, 2018)

This 2018 report included the results of the Town of Milton's fifteenth year of Stormwater Management Plan (SWMP) implementation. The Town of Milton had multiple achievements including: 727 tons of sand/debris collected by street sweeping, 679 tons of debris removed from storm sewer infrastructure, 9,800 property owners reached by education programs, 100 percent construction sites inspected, and organization of a town-wide cleanup day on April 29, 2017 that engaged watershed residents. The Town of Milton continued to maintain its dedicated Stormwater Management webpages and utilized its Twitter account to post stormwater management messages and educational links. Future plans for the next year of implementation were also outlined in the report, including continuing sponsorship of NepRWA programming at Milton schools, continuing to research BMPs for use in stormwater management design guidance, performing another annual town cleanup day, and working on updating stormwater bylaws[1].

Stormwater BMPs, MA DEP 604(b) Program, Town of Milton, MA (EPG, 2013)

This June 2018 report by Environmental Partners Group (EPG) was the result of MA DEP 604(b) Program funding and summarized work performed by EPG for the Town of Milton and NepRWA. The project identified sites in the Town of Milton that were suitable for retrofitting with structural stormwater BMPs and where conceptual designs could be developed for BMPs at those sites to restore and maintain primary contact recreation and other designated uses. Fifteen sites were initially evaluated and seven were removed from further consideration after a Town Hall meeting. The remaining eight sites were ranked based on water quality benefits, site characteristics, constructability, maintenance access, and public education. The matrix for this ranking of the eight sites is included in Appendix A. Wendell Park, the Lincoln Street Parking Lot/Kelly Field, and Lafayette Street were initially ranked in the "top 3" sites for further design development/field investigation. This included a more detailed site visit and advancement of a test pit (if applicable to the BMP design) at each of the three locations to verify groundwater table elevation and soil type. Following the advancement of test pits at the Lincoln Street Parking lot/Kelly Field, which showed soils with poor percolation rates, it was removed from further consideration and Sumner Street replaced it in the top three. The top three ranking sites were further investigated. Conceptual designs for the top three ranking sites were developed. "Wendell Brook BMPs" was one of the top sites and has been constructed (Town of Milton, 2016 and Town of Milton, 2019). The other two top ranked sites are described below, and the conceptual design packages for these two sites are included in Appendix A. Less detailed construction cost estimates for the remaining five sites are also included in Appendix A.

- **Stormwater BMPs, Town of Milton, MA, Lafayette Street Area (EPG, 2013)**

  This proposed BMP would include a sediment forebay east of Milton's Lafayette Street cul-de-sac and would entail removing the existing 350-foot drainage pipe to allow the drainage to disperse off the end of the street and create an enhanced wetland treatment system abutting Pine Tree Brook. The conceptual design package for this site is included in Appendix A. The Town of Milton has

[1] An updated stormwater bylaw replaced the existing stormwater bylaw after a vote during a virtual Town Meeting, on June 16, 2020.

recently applied for Fiscal Year 2021 Section 319 grant funding to help implement the proposed BMP at Lafayette Street (Town of Milton, 2021). Lafayette Street was chosen as the first priority for future stormwater BMP implementation because of its relatively low cost, its siting on Town land, its discharge area to a distressed waterbody, the relatively large amount of impervious surface treated, and the technical feasibility to retrofit a Low Impact Development stormwater BMP.

- **Stormwater BMPs, Town of Milton, MA, Sumner Street Area (EPG, 2013)**

  This area is area is adjacent to Pope's Pond and includes a park area with a walking/jogging trail that is highly used by the residents. Five stormwater BMPs were designed for the area including a wet swale, sediment forebay, bioretention basin, and 4'x6' Filterra Bioretention System. The conceptual design package for this site is included in Appendix A.

Additional BMPs installed before 2013

Prior to the 604(b) study (in 2004—2005), tree filter boxes were installed along Brook Road and Lincoln Street, and bioretention cells were installed along Pine Tree Brook Path (across from the high school).

Element A: Identify Causes of Impairment & Pollution Sources

Element A: Identify the causes and sources or groups of similar sources that need to be controlled to achieve the necessary pollutant load reductions estimated in the watershed based plan (WBP).

General Watershed Information

This WBP was prepared for waterbodies located within the Pine Tree Brook Watershed located in the Towns of Milton, and Quincy (delineated to the outlet of Turners Pond). These waterbodies include the Pine Tree Brook (MA73-29); Balster Brook; Chestnut Run; Trout Brook; and Wendell Brook. Turners Pond (MA73509) and Pope's Pond (formerly MA73044, now included in MA73-29) are also included in the watershed. Pine Tree Brook is a cold water resource, is a tributary to the Neponset River, and has a drainage area of approximately 4,500 acres (approximately 7 square miles). The headwaters are home to a reproducing population of Eastern Brook Trout, and White Suckers spawn downstream of Pope's Pond Dam.

Table A-1 presents the general watershed information for the applicable Pine Tree Brook watershed and **Figure A-1** includes a map of the watershed boundary.

Table A-1: General Watershed Information

Pine Tree Brook Watershed Information	
Watershed Name (Assessment Unit ID):	Balster Brook; Chestnut Run; Pine Tree Brook (MA73-29); Trout Brook; Wendell Brook; Turners Pond (MA73059)
Major Basin:	Neponset River
Watershed Area (within MA):	4,538 acres

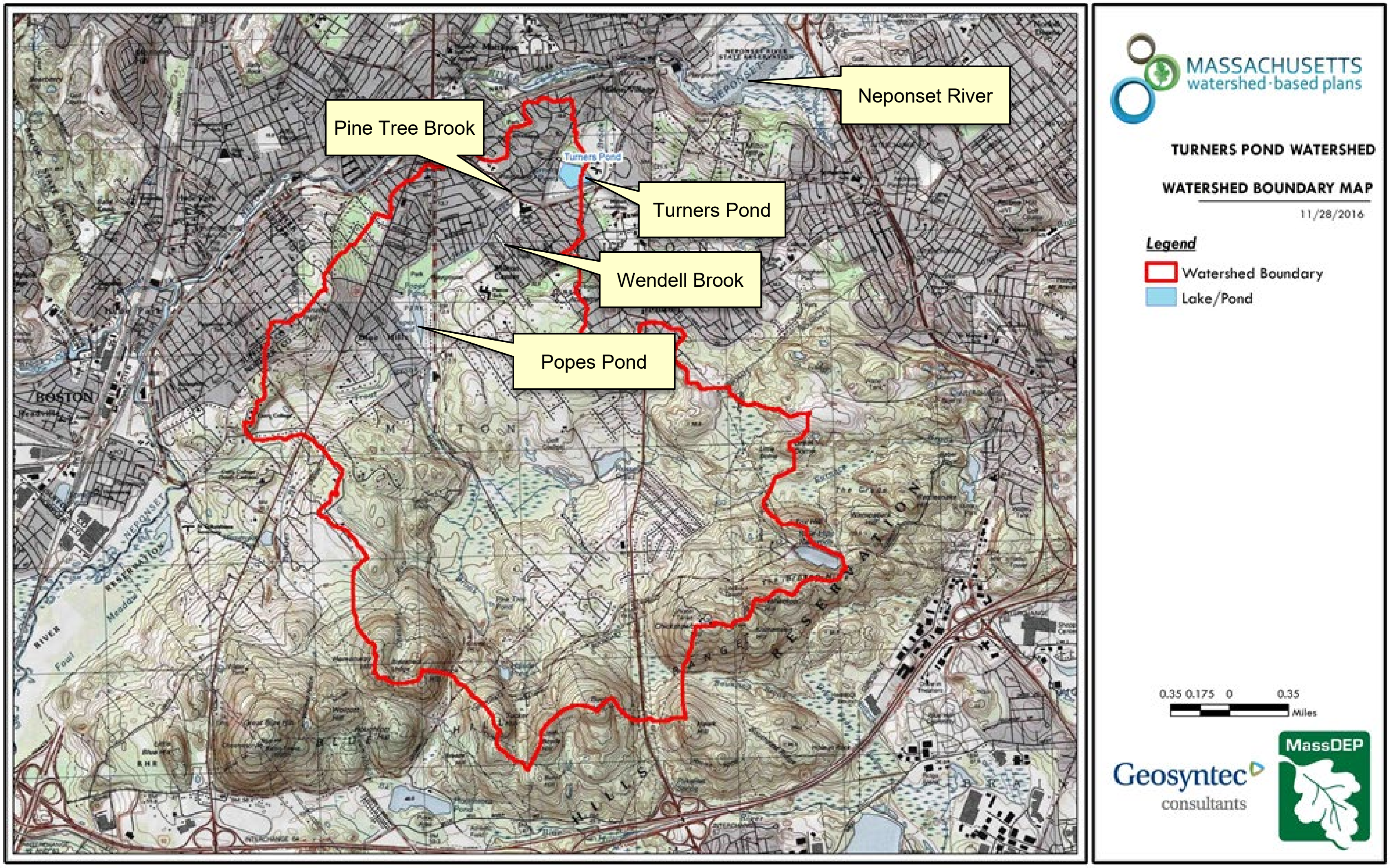


Figure A-1: Pine Tree Brook (Turners Pond) Watershed Boundary Map

(MassGIS, 2007; MassGIS, 1999; MassGIS, 2001; USGS, 2016)

MassDEP Water Quality Assessment Report and TMDL Review

The following reports are available:

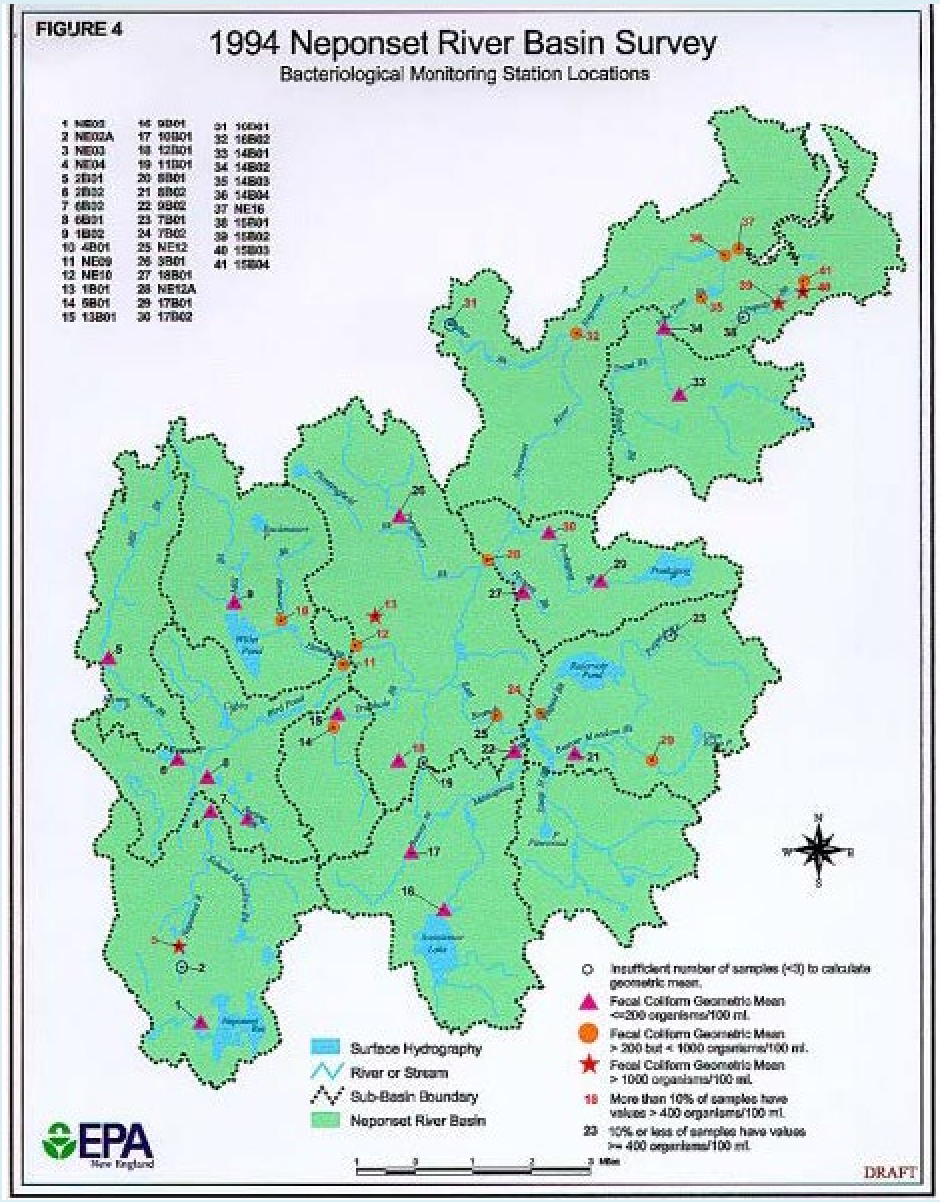
- Neponset River Watershed 2004 Water Quality Assessment Report (MassDEP, 2004)
- Total Maximum Daily Loads of Bacteria for Neponset River Basin (MassDEP, 2002)

Select excerpts from these documents relating to the water quality in the Pine Tree Brook watershed is included below (note: relevant information is included directly from these documents for informational purposes and has not been modified).

Neponset River Watershed 2004 Water Quality Assessment Report (MA73-29 - Pine Tree Brook)
Aquatic Life Use NepRWA measured dissolved oxygen at three sites in 2007 and 2008 (n=27) and found seven violations of the dissolved oxygen criterion (5.0 mg/L). The violations ranged from 2.1 mg/L to 4.9 mg/L. MA DFG collected fish at one site in 2002. The sample was dominated by individuals classified as macrohabitat generalist and pollution tolerant. **Fish Consumption** This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 2). **Primary Contact Recreation** NepRWA collected E. coli samples at one site in 2007 and two sites in 2008. The annual geometric means of the samples collected at each site during the primary contact season ranged from 54 CFU/100ml to 507 CFU/100ml. MassDEP SERO collected E. coli samples at four sites in 2006. The annual geometric means of the samples collected at each site during the primary contact season ranged from 96 CFU/100ml to 345 CFU/100ml. These results violate the geometric mean criterion (126 CFU/100ml) for E. coli. **Secondary Contact Recreation** NepRWA collected E. coli samples at three sites in 2007 and 2008. The annual geometric means of the samples collected at each site ranged from 54 CFU/100ml to 538 CFU/100ml. MassDEP SERO collected E. coli samples at four sites in 2006. The annual geometric means of the samples collected at each site during the primary contact season ranged from 96 CFU/100ml to 345 CFU/100ml. These results do not violate the geometric mean criterion (630 CFU/100ml) for E. coli. An Alert Status is identified for this use due to occasional spikes in E.coli concentrations. **Aesthetics Uses** Insufficient data were available to assess the Aesthetic Use. **Report Recommendations:** The report did not provide recommendations.

Total Maximum Daily Loads of Bacteria for Neponset River Basin (MA73-29 - Pine Tree Brook)
Problem Assessment Extensive water quality data are available for the Neponset River and tributaries. In 1994 the Massachusetts Department of Environmental Protection (MADEP), in cooperation with several other state agencies and citizen monitoring groups, initiated a comprehensive assessment of the Neponset River Basin. The results of this work identified that numerous waterbody segments, including lakes and ponds, in the Neponset River Basin were not attaining the State's water quality standards. The most pervasive water quality problem identified was, and remains, due to excessive levels of fecal coliform indicator bacteria. Since the 1994 study, the Neponset River Watershed Association (NepRWA), a non-profit organization, has collected annual water quality data at numerous locations throughout the basin. Beginning in 1996, all of NepRWA's monitoring activities have been conducted according to EPA approved Quality Assurance Project Plans (QAPP) developed by NepRWA. Establishing a QAPP

represents a significant accomplishment by NepRWA that has resulted in the collection of credible data used to identify waterbody segments that do not attain water quality standards, and identify specific pollutant sources requiring control measures. The following figures (originally Figures 4 and 5 of the "Total Maximum Daily Loads of Bacteria for Neponset River Basin" report, 2002) provide the locations of MADEP (1994) and the NepRWA (1997 through 1999) sampling stations, respectively.



Fecal Contamination of the Neponset River Basin

The NepRWA annual water quality monitoring program and the 1994 MADEP monitoring efforts provide an extensive bacterial monitoring coverage through out the basin. Between 1997 and 1999, NepRWA established and monitored 57 surface water stations, and MADEP monitored 41 stations for bacteria in 1994. The locations of the MADEP and NepRWA (1997-1999) bacteria monitoring stations are provided in the figures above (originally Figures 4 and 5 of "Total Maximum Daily Loads of Bacteria for Neponset River Basin" report, 2002), respectively, illustrating the extensive coverage of the monitoring programs. Individual data may be found in The Neponset River Watershed, 1994 Resource Assessment Report, dated October 1995 and the NepRWA annual monitoring reports. The figures illustrate the extent of non-attainment of the fecal coliform standards in the Neponset River and tributaries. Monitoring stations are depicted where the geometric means exceed 200 organisms per 100 ml and/or where more than 10 % of the samples have values exceeding 400 organisms per 100ml. For the NepRWA stations (1997 –1999), Figure 5 indicates the highest geometric mean of the three years. As indicated, the entire length of the Neponset River, starting near Route 1 in Foxborough downstream to the estuary, and several tributaries do not meet the fecal coliform standards. Also, numerous tributaries were found to be in non-attainment. Exceedences of the fecal coliform criteria were observed at 60% of the NepRWA stations for one or more years, and at 51% of the 1994 MADEP stations. The high percentage of NepRWA stations

Total Maximum Daily Loads of Bacteria for Neponset River Basin
(MA73-29 - Pine Tree Brook)

exceeding fecal coliform criteria is not surprising, considering that, to aid in source identification efforts, NepRWA targeted its monitoring activities in areas with known or suspected problems.

The following tables (originally Tables 4 through 7 of the "Total Maximum Daily Loads of Bacteria for Neponset River Basin" report, 2002) present the calculated geometric means and percent of samples exceeding 400 organisms per 100 ml for each location in 1994, 1997, 1998, and 1999.

TABLE 1994 DEP
NEPONSET RIVER SURVEY
FECAL COLIFORM

STATION ID	STATION LOCATION	NO. OF SAMPLES COLLECTED	GEOMETRIC MEAN	% OF SAMPLES > 400 (cfu/100 ml)
NE02	Neponset River, outlet of Crackrock Pond, Foxborough	3	36	33
NE02A	Neponset River, Route 1, Foxborough	2	-	0
NE03	Neponset River, Summer Street, Walpole	4	1544	100
NE04	Neponset River, South Street, Walpole	3	47	0
2B02	Mine Brook, Mill Pond Road, Walpole	3	<20	0
2B01	Mine Brook, Elm Street, Medfield	3	106	0
6B01	Spring Brook, off Route 27, near playground, Walpole	2	23	0
6B02	Spring Brook, Washington Street, Walpole	3	34	0
NE09	Hawes Brook, Washington Street, Norwood	3	212	33
4B01	Germany Brook, Inlet Ellis Pond, Nichol Street, Norwood	3	410	67
1B02	Mill Brook, inlet Pettee Pond off Clearwater Drive, Brook Street, Westwood	3	92	0
NE10	Neponset River, Pleasant Street Bridge, Norwood	3	855	100
1B01	Meadow Brook, off Meadow Brook Road/Pleasant Street, Norwood	4	85,225	100
5B01	Traphole Brook, Cooney Street, Walpole	3	298	33
12B01	Unnamed Traphole tributary, Union Street and Edge Hill Road, Sharon	3	99	33
13B01	Unnamed Traphole tributary, Union Street, Walpole	3	108	0
11B01	Unnamed Neponset tributary, Edge Hill Road, Sharon	1	-	0
NE12	East Branch Neponset River, Neponset Street, Canton	3	300	0
9B02	Massapoag Brook, Walnut Street off Washington Street, Canton	3	20	0
10B01	Beaver Brook, Upland Road, Sharon	3	78	0
9B01	Massapoag Brook, outlet of Massapoag Lake, Sharon (Cedar, East & Massapoag Street)	3	58	0
7B02	Pequid Brook, Sherman Street, Canton	3	203	33
7B01	Pequid Brook, York Street, Canton	1	-	0
8B02	Beaver Meadow Brook, Pine Street, Canton	3	54	0
8B01	Beaver Meadow Brook, Route 138, Canton	3	288	67
3B01	Purgatory Brook, Route 1 near Everett Street, Norwood	3	154	33
NE12A	Neponset River, Dedham Street Bridge, Canton	3	456	33
18B01	Pecunit Brook, Elm Street, Canton	3	43	0
17B02	Ponkapoag Brook, Elm Street, Canton	3	199	33
17B01	Ponkapoag Brook, Washington Street, Canton	3	56	0
16B02	Mother Brook, Hyde Park Avenue, Hyde Park	4	204	25
16B01	Mother Brook, Washington Street, Dedham	2	-	50
14B04	Pine Tree Brook, Central Avenue, Milton Village	3	420	67
14B03	Pine Tree Brook, Central Avenue, Milton	3	768	67
14B02	Pine Tree Brook, Blue Hills Parkway, Milton	3	113	0
14B01	Pine Tree Brook, Unquity Road and Harland Street, Milton	3	90	0
NE16	Neponset River, downstream of Baker Dam, Adams Street, Milton/Boston line	3	593	67
15B04	Gulliver Creek, Christopher Avenue, Milton	3	512	67
15B03	Unquity Brook, Adams Street, Milton	2	-	0
15B02	Unquity Brook, Brook Road, Milton	2	-	100
15B01	Unquity Brook, Gun Hill Street off Randolph Avenue, Milton	1	-	0

TABLE 1997 NEPONSET RIVER
FECAL COLIFORM DATA

STATION ID	STATION LOCATION	NO. OF SAMPLES COLLECTED	GEOMETRIC MEAN	% OF SAMPLES > 400 (cfu/100 ml)
SMB001	School Meadow Brook at Pine Street, Walpole	6	5	0
SMB013	School Meadow Brook at Washington Street, Walpole	6	123	16.7
SPB008	Spring Brook at Washington Street, Walpole	6	11	0
SPB012	Spring Brook at Stone Street, Walpole	6	7	0
GEB008	Germany Brook at Sycamore Drive, Westwood	6	30	0
GEB020	Germany Brook at inlet of Ellis Pond, Norwood	5	961	80
NER075	Neponset River at Hollingsworth and Vose Dam, Walpole	5	33	0
HAB002	Hawes Brook at Walpole Street, Norwood	6	42	16.7
HAB006	Hawes Brook at Railroad Bridge/Endean Park, Norwood	6	771	83.3
HAB010	Hawes Brook at Washington Street, Norwood	5	651	80
MEB001	Meadow Brook at Sunnyside Road, Norwood	6	9432	100
MEB006	Meadow Brook at Dean Street, Norwood	5	1278	60
THB008	Traphole Brook at High Plain Street, Sharon	2	51	50
THB020	Traphole Brook at Coney Street, Walpole	6	87	16.7
THB026	Traphole Brook at Sumner Street, Norwood	6	141	16.7
NER095	Neponset River at Neponset Street, Canton	4	224	50
MOB001	Mother Brook at Route One Dam, Dedham	6	123	33.3
MOB010	Mother Brook at Bussey Street, Dedham	4	74	0
MOB020	Mother Brook at River Street, Hyde Park/Boston	3	391	33.3
NER130	Neponset River at Green Lodge Street, Canton	4	92	0
NER150	Neponset River at Paul's Bridge, Milton	4	89	0
NER165	Neponset River at Dana Avenue, Hyde Park/Boston	3	655	100
NER175	Neponset River at Truman Parkway, Mattapan/Boston	1	110	0
NER185	Neponset River at Ryan Playground, Mattapan/Boston	6	1168	83.3
PTB012	Pine Tree Brook at Unquity Road, Milton	5	168	0
PTB022	Pine Tree Brook at Canton Avenue, Milton	5	194	20
PTB035	Pine Tree Brook at Brook Road, Milton	6	418	50
PTB047	Pine Tree Brook at Eliot Street, Milton	5	645	80
UNB002	Unquity Brook at Randolph Avenue, Milton	5	668	60
UNB009	Unquity Brook at Brook Road, Milton	5	76	0
UNB016	Unquity Brook at Squantum Street, Milton	6	1533	100
NER200	Neponset river at Adams Street Bridge, Milton/Boston Line	6	523	66.7

TABLE 1998 NEPONSET RIVER SURVEY
FECAL COLIFORM DATA

Station ID	Station Description	Dry Weather Geometric Mean	No. of Dry Samples	Wet Weather Geometric Mean	No. of Wet Samples	Overall Geometric Mean	Overall % > 400 cfu/100ml)
NER021	Neponset River at Sumner Street, Walpole	132	6	247	4	170	10
MIB060	Mine Brook at Mill Pond Road, Walpole	10	6	12	4	11	0
NER075	Neponset River at Hollingsworth and Vose Dam, Walpole	71	6	93	3	78	0
GEB020	Germany Brook at inlet of Ellis Pond, Norwood	169	3	1111	4	495	57
HAB006	Hawes Brook at Railroad Bridge/Endean Park, Norwood	290	5	571	4	392	67
HAB010	Hawes Brook at Washington Street, Norwood	156	5	1212	4	388	44
MEB001	Meadow Brook at Sunnyside Road, Norwood	7573	6	9813	4	8400	100
MEB006	Meadow Brook at Dean Street, Norwood	1574	6	3812	4	2242	90
NER130	Neponset River at Green Lodge Street, Canton	158	6	314	4	208	20
EAB010	East Branch at Neponset Street, Canton	269	5	617	4	389	44
NER150	Neponset River at Paul's Bridge, Milton	119	5	825	4	281	44
NER165	Neponset River at Dana Avenue, Mattapan	265	6	718	4	395	50
NER178	Neponset river at Monponset Street, Mattapan	184	4	1259	2	349	33
NER185	Neponset River at Ryan Playground	607	5	1202	4	822	44
PTB022	Pine Tree Brook at Canton Avenue, Milton	117	6	307	4	172	30
PTB028	Pine Tree Book at Blue Hill Parkway, Milton	128	4	474	4	246	50
PTB035	Pine Tree Brook at Brook Road, Milton	218	5	562	3	311	38
UNB002	Unquity Brook at Randolph Avenue, Milton	309	6	2424	4	704	50
UNB014	Unquity Brook at Adams Street, Milton	109	4	1849	4	449	50
UNB016	Unquity Brook at Squantum Street, Milton	487	6	4491	4	1293	60
NER200	Neponset River at Adams Street Bridge, Milton	179	4	1060	4	436	50
NER215	Neponset river at Granite Avenue, Milton	634	5	648	4	640	33

TABLE 1999 NEPONSET RIVER
FECAL COLIFORM DATA

STATION ID	STATION LOCATION	NO. OF SAMPLES COLLECTED	GEOMETRIC MEAN	% OF SAMPLES > 400 (cfu/100 ml)
PUB022	Purgatory Brook at Rte. 1A, near Everett St., Westwood	4	257	25
NER125	Neponset River at Dedham St. Bridge, Canton	4	164	0
PEB008	Pecunit Brook at Elm St., Canton	4	90	0
POB024	Ponkapoag Brook at Washington St., Canton	4	15	0
NER150	Neponset River at Paul's Bridge, Milton	3	94	0
MOB001	Mother Brook At Route One Dam, Dedham	4	358	50
NER165	Neponset River at Dana Avenue, Hyde Park/Boston	4	197	25
NER185	Neponset River at Ryan Playground, Mattapan/Boston	4	338	50
PTB028	Pine Tree Brook at Blue Hill Parkway, Milton	4	71	0
PTB035	Pine Tree Brook at Brook Road, Milton	5	125	0
PTB047	Pine Tree Brook at Central Ave., Milton	4	259	25
NER200	Neponset River at Adams Street Bridge, Milton	4	469	50
UNB002	Unquity Brook at Randolph Avenue, Milton	7	972	71
UNB014	Unquity Brook at Adams Street	5	309	40
UNB016	Unquity Brook at Squantum Street, Milton	3	452	67
NER002	Neponset River at Outlet of Crackrock Pond, Walpole	3	7	0
NER040	Neponset River at South St., Walpole	3	185	0
MIB037	Mine Brook at Elm St., Medfield	4	125	25
SMB013	School Meadow Brook at Washington Street, Walpole	4	173	0
SPB016	Spring Brook at Rte. 27, Walpole	4	165	0
NER075	Neponset River at Hollingsworth and Vose Dam, Walpole	4	55	0
MLB024	Mill Brook at inlet of Petee's Pond, Westwood	4	84	25
WIP001	Willett Pond, northern site, Walpole	4	53	0
WIP002	Willett Pond, Southern Site, Walpole	4	17	0
WIP003	Willett Pond, Eastern site, Walpole	4	11	0
GEB020	Germany Brook at inlet of Ellis Pond, Norwood	4	93	0
HAB002	Hawes Brook at Walpole Street, Norwood	4	60	0
HAB006	Hawes Brook at Railroad Bridge/Endean Park, Norwood	3	117	0
HAB010	Hawes Brook at Washington Street, Norwood	3	238	0
NER080	Neponset River at Pleasant St. Bridge, Norwood	4	152	0
MEB001	Meadow Brook at Sunnyside Road, Norwood	4	4086	100
THB020	Traphole Brook at Coney Street, Walpole	4	65	0
BEB013	Beaver Brook at Upland Road, Sharon	4	39	0
MPB009	Massapoag Brook at outlet Lake Massapoag, Sharon	4	101	25
MPB088	Massapoag Brook at Walnut St., Canton	2	-	0
SHB021	Steep Hill Brook, at Central St, & West St., Stoughton	4	69	0
BMB026	Beaver Meadow Brook at Pine St., Canton	4	166	0
PQB040	Pequit Brook at Sherman St., Canton	4	184	25
EAB010	East Branch at Neponset St., Canton	4	188	25

Consistent with the Water Quality Standards for fecal coliform, data are summarized and presented in terms of a geometric mean, which is often used as a measure of central tendency for bacteria data. Review of these data reveal that many of the same segments continuously exceed standards indicating the presence of relatively consistent bacteria sources. These data clearly illustrate the impacts of urbanization on ambient bacteria levels since the more developed areas of the watershed typically have the higher bacteria levels. By contrast, low fecal coliform levels are observed in the less developed subwatersheds (i.e., Mine Brook). These data are useful for estimating the natural background contribution for both dry and wet weather conditions.

The majority of the existing data represent dry weather conditions. These data are valuable for identifying dry weather sources of bacteria such as leaking sewers and illicit sewer connections, but are limited for assessing the overall quality of surface waters because there are also impacts associated with wet weather sources. NepRWA was successful in monitoring four wet weather events during the 1998 sampling season. These data are extremely useful to begin documenting the magnitude of wet weather impacts, and give a more complete assessment of the waterbodies during all weather and flow conditions. To illustrate the relative magnitudes of dry and wet weather bacteria levels, the 1998 data table (originally Table 6 of the "Total Maximum Daily Loads of Bacteria for Neponset River Basin" report, 2002) provides separate geometric means for dry and wet weather conditions. As expected, the wet weather geometric means are typically significantly greater than the dry weather geometric means reflecting the inputs of wet weather sources such as storm water runoff and the flushing of materials from piped drainage systems.

Also, the 1997 data are particularly informative because they are representative of drought-like conditions when river flows and the pollutant assimilative capacity were very low. Comparison of the 1997 and 1998 dry weather geometric means reveals that, for most stations, the 1997 dry weather geometric means are notably higher than the 1998 dry weather geometric means.

Stream Base Flow and In-Stream Fecal Coliform Levels

The Neponset River Basin fecal coliform data illustrate the relationship between stream base flow quantity and in-stream bacteria concentrations. As stream base flow (flow in stream channel during dry weather conditions) declines bacteria concentrations typically increase. This relationship is due primarily to the fact that stream base flow is composed mostly of ground water flow entering the stream channel.

The very low concentrations of bacteria in ground water due to the natural filtering action of the soil matrix through which ground water flows effectively dilutes bacterial wastes from other sources that may be entering the stream during dry weather conditions. Individual bacteria data collected from the Meadow Brook system in Norwood clearly illustrate this relationship. Small urbanized watershed systems like Meadow Brook are particularly vulnerable to declining base flows following extended dry weather conditions. In the case of Meadow Brook the highly impervious cover of the watershed and the presence of an antiquated sewer system which carries sanitary sewage and ground water infiltration out of the basin to the MWRA's Deer Island Wastewater Treatment Facility contribute to reduced base flow. The high percentage of impervious cover in the watershed significantly reduces the opportunity for rainwater to percolate into the ground and recharge ground water which in turn recharges stream base flow. Instead much of the rainfall is converted to storm water runoff which quickly passes out of the system.

The importance of maintaining and restoring stream base flow through protecting and enhancing ground water recharge to protect and improve water quality as well as effectively manage municipal storm water will be discussed in the TMDL implementation section of this document.

Identification of Fecal Coliform Bacteria Sources

Largely through the efforts of the NepRWA, the stream teams (citizen monitoring groups active in several subwatersheds of the Neponset River watershed), and MADEP field staff, numerous point and nonpoint sources of fecal contamination have been identified. The following table (originally Table 8 of "Total Maximum Daily Loads of Bacteria for Neponset River Basin" report, 2002) summarizes the river segments impaired due to measured fecal coliform contamination and identifies suspected and known sources. Dry weather sources include leaking sewer pipes, storm water drainage systems (illicit connections of sanitary sewers to storm drains), and failing septic systems. Wet weather sources include storm water runoff and sanitary sewer overflows.

Table : Summary of Fecal Coliform Contamination in the Neponset River Watershed

Location	Known and Suspected Sources
Upper Neponset River	Storm water runoff and failing septic systems and
Hawes and Germany Brooks	Illicit sewer connections, sanitary sewer overflows, and storm water runoff.
East Branch Neponset River, Pequid & Beaver Meadow Brooks	Illicit sewer connections, storm water runoff, and failing septic systems.
Steep Hill Brook	Illicit sewer connections, storm water runoff, and failing septic systems.
Middle Neponset River and Meadow Brook	Leaking sewers, illicit sewer connections, storm water runoff, and failing septic systems.
Traphole Brook	Illicit sewer connections, storm water runoff, and failing septic systems.
Purgatory Brook	Illicit sewer connections, sanitary sewer overflows, storm water runoff, and failing septic systems.
Ponkapoag Brook	Illicit sewer connections, storm water runoff, and failing septic systems.
Lower Neponset River	Illicit sewer connections and storm water runoff.
Mother Brook	Illicit sewer connections and storm water runoff.
Pine Tree Brook	Sanitary sewer overflows, illicit sewer connections, storm water runoff, and failing septic systems.
Neponset River Estuary, Unquity & Gullivers Brooks	Illicit sewer connections, sanitary sewer overflows, storm water runoff, and failing septic systems.

The NepRWA has effectively used its monitoring program to identify bacteria sources and initiate the implementation of necessary controls. For example, the elevated fecal coliform levels in Meadow Brook have been traced to leaking sewers with under-drains that transport sewage to the storm drainage system and to Meadow Brook. Norwood has corrected portions of the faulty sewer system and obtained additional funding to continue repair work.

There are no permitted point source discharges of fecal coliform within the Neponset River Basin. However, a number of nonpoint and non-permitted point pollutant sources do exist. Nonpermitted point sources include piped storm water drainages systems and sanitary sewer overflows. Possible nonpoint sources include, diffuse storm water runoff, leaking sewers, and failing or inadequate septic systems depending on the nature of the discharge to surface waters (discrete or diffuse).

It is difficult to provide accurate quantitative estimates of fecal coliform contributions from the various sources in the Neponset River Basin because many of the sources are diffuse and intermittent, and extremely difficult to monitor or accurately model. Therefore, a general level of quantification according to source category is provided. This approach is suitable for the TMDL analysis because it indicates the magnitude of the sources and illustrates the need for controlling them. Additionally, many of

Total Maximum Daily Loads of Bacteria for Neponset River Basin
(MA73-29 - Pine Tree Brook)

the sources (failing septic systems, leaking sewer pipes, sanitary sewer overflows, and illicit sanitary sewer connections) are prohibited because they indicate a potential health risk and, therefore, must be eliminated. However, estimating the magnitude of overall bacteria loading (the sum of all contributing sources) is achieved for wet and dry conditions using the extensive ambient data available that define baseline conditions.

Leaking sewer pipes, illicit sewer connections, sanitary sewer overflows (SSOs), and failing septic systems represent a direct threat to public health since they result in discharges of partially treated or untreated human wastes to the surrounding environment. Quantifying these sources is extremely speculative without direct monitoring of the source because the magnitude is directly proportional to the volume of the source and its proximity to the surface water. Typical values of fecal coliform in untreated domestic wastewater range from 104 to 106 MPN/100ml.

Illicit sewer connections into storm drains result in direct discharges of sewage via the storm drainage system outfalls. The existence of illicit sewer connections to storm drains is well documented in many urban drainage systems, particularly older systems that may have once been combined. In collecting information to support its Municipal Storm Water NPDES Permit application, the Boston Water and Sewer Commission (BWSC) identified and eliminated fifty-seven illicit connections within the Neponset Basin during 1994 and 1995 (MADEP, 1995).

Since 1997 BWSC has corrected nine illicit connections eliminating an estimated 12,550 gallons per day of sanitary sewage from the storm drainage system and there are two additional illicit connections that have been assigned to a contract for repair (BWSC, 2000). It is probable that numerous other illicit sewer connections exist in storm drainage systems serving the older developed portions of the basin. Monitoring of storm drain outfalls during dry weather is needed to document the presence or absence of sewage in the drainage systems. NepRWA has been active in monitoring storm drain outfalls that has led to the identification of several illicit connections. All communities in the Neponset Basin are subject to the Storm water Phase II Final Rule that will require the development and implementation of an illicit discharge detection and elimination plan.

Storm water runoff is another significant contributor of fecal coliform pollution. During rain events, fecal matter from domestic animals and wildlife are readily transported to surface waters via the storm water drainage systems and/or overland flow. The natural filtering capacity provided by vegetative cover and soils is dramatically reduced as urbanization occurs because of the increase in impervious areas (i.e., streets, parking lots, etc.) in the watershed.

Extensive storm water data have been collected and compiled both locally and nationally in an attempt to characterize the quality of storm water. Bacteria are easily the most variable of storm water pollutants, with concentrations often varying by factors of 10 to 100 during a single storm. The following table (originally Table 9 and 10 of “Total Maximum Daily Loads of Bacteria for Neponset River Basin” report, 2002) summarizes wet weather sampling results of five storm drain outfalls in the Neponset River Basin and provides observed ranges of fecal coliform in storm water from different land uses during two storms monitored in the Wachusett Reservoir.

Table Wet Weather Storm Drain Sampling – Neponset River Basin (1) (MA DEP, 2000)

Land Use Category	Fecal Coliform Organisms / 100 ml	Enterococcus	E. Coli
Residential	< 16 – 25,000	340 – 70,000	<16 – 4,000
Forest/Urban Open	410 – 31,000	2,500 – 45,000	41 – 22,000
Commercial	16 – 5,600	120 – 2,300	<16 – 1,200
Industrial	600 – 3,600	880 – 11,000	130 – 3,000

(1) Grab samples collected for four storms between September 15, 1999 and June 7, 2000.

Table Wachusett Reservoir Storm Water Sampling MDC-CDM Wachusett Storm Water Study (June 1997)

Land Use Category	Fecal Coliform Bacteria (1) Organisms / 100 ml
Agriculture, Storm 1	110 - 21,200
Agriculture, Storm 2	200 - 56,400
"Pristine" (not developed, forest), Storm 1	0 - 51
"Pristine" (not developed, forest), Storm 2	8 - 766
High Density Residential (not sewered, on septic systems), Storm 1	30 - 29,600
High Density Residential (not sewered, on septic systems), Storm 2	430 - 122,000

Considering this variability, storm water bacteria concentrations are difficult to accurately predict. Caution must be exercised when using values from single wet weather grab samples to estimate the magnitude of bacteria loading because it is often unknown whether the sample is representative of the "true" mean. To gain an understanding of the magnitude of bacterial loading from storm water and avoid overestimating or underestimating bacteria loading, event mean concentrations (EMC) are often used. Typical storm water event mean densities for various indicator bacteria are provided in the following tables (originally Table 11 and 12 of "Total Maximum Daily Loads of Bacteria for Neponset River Basin" report, 2002). These EMCs illustrate that storm water bacteria concentrations from certain land uses (i.e., residential) are typically at levels sufficient to cause water quality problems.

NepRWA has begun to quantify the magnitude and extent of fecal contamination in the Neponset Basin during wet weather conditions. With the exception of two sampling stations, Mine Brook (MIB060) and the Neponset River at Hollingsworth and Vose (NER075), excessive levels of fecal coliform were observed at all stations highlighting the need for improved storm water management. The extent of urbanized land cover in the Neponset Basin in conjunction with the fecal coliform EMCs in the following tables (originally Tables 11 and 12 respectively of "Total Maximum Daily Loads of Bacteria for Neponset River Basin" report, 2002), supports the assertions that storm water runoff is a significant cause contributing to the non-attainment of designated uses, and that reductions of wet weather bacteria sources are warranted. However, since wet weather data in the Neponset Basin remains limited, a progressive implementation of the TMDL is proposed to address wet weather bacteria sources. This approach requires estimating the pollutant reductions necessary to meet water quality standards using the best available information and allows controls to be implemented while additional data are collected.

Total Maximum Daily Loads of Bacteria for Neponset River Basin (MA73-29 - Pine Tree Brook)

Table: Storm Water Event Mean Bacteria Concentrations (2) The Lower Basin of the Charles River

Land Use Category	Fecal Coliform Bacteria (Organisms / 100 ml)	Enterococcus Bacteria (Organisms / 100 ml)
Single Family Residential	2,845 – 93,950	5,456 – 86,679
Multifamily Residential	2,185 – 30,624	3,176 – 49,405
Commercial	682 – 27,670	2,134 – 35,489

(2) Event Mean Densities for eight storms sampled during 2000 by USGS.

Table: Storm Water Event Mean Fecal Coliform Concentrations (3)

Land Use Category	Fecal Coliform Bacteria (3) Organisms / 100 ml
Single Family Residential	37,000
Multifamily Residential	17,000
Commercial	16,000
Industrial	14,000

(3) Derived from NURP study event mean concentrations and nationwide pollutant buildup data

Septic systems designed, installed and maintained in accordance with 310 CMR 15.000: Title 5, are not significant sources of fecal coliform bacteria. Studies demonstrate that wastewater located four feet below properly functioning septic systems contain on average less than one fecal coliform bacteria organism per 100 ml (Ayres Associates, 1993). Failed or non-conforming septic systems, however, can be a major contributor of fecal coliform to the Neponset River and tributaries. Wastes from failing septic systems enter surface waters either as direct overland flow or via groundwater. Wet weather events typically increase the rate of transport of pollutant loadings from failing septic systems to surface waters because of the wash-off effect from runoff and the increased rate of groundwater recharge.

Additional Water Quality Data

The NepRWA's Citizen Water Monitoring Network (CWMN) has been collecting water quality data throughout the Neponset River Watershed since 1994. Sampling sites are visited once a month between May and October and are assessed for numerous parameters including TP, DO, and *E. coli*.

The CWMN includes two sampling locations ("PTB028 and PTB035") located along Pine Tree Brook and one sampling location directly downstream of the Pine Tree Brook watershed where it enters the Neponset River (See **Figure A-2**). Most of the results between 2014—2018 indicated that Pine Tree Brook had concerning levels of TP (exceeding 50 µg/L) but there was significant improvement in 2019 with results below 10 ug/L at all three sampling locations. Most of the results at PTB028 between 2014—2019 had levels of *E. Coli* greater than a geometric mean of 126 colonies/100 ml, which is not safe for swimming but less than a geometric mean of 630 colonies/100 ml, which is safe for boating. Some results at PTB035 and PTB047 between 2014--2018 had *E. Coli* levels greater than a geometric mean of 630 colonies/100 ml, which is not deemed safe for swimming or boating. Data collected between 2013 and 2019 indicated that the stream has recently sustained healthy concentrations of DO (greater than 5 mg/L) with only three results below 5 mg/L (PTB028 in 2014 and 2017; and PTB035 in 2014). **Table A-2—A-4** present the NepRWA CWMN data for 2013—2019.

Table A-2: Water Quality Data at Sampling Location PTB028
(Samples were taken once per month from May—October (6 samples per year))
(Source: https://www.neponset.org/your-watershed/cwmn-data/)

Year	E. coli (Geometric Mean - colonies/100 ml)	Average Total Phosphorus (µg/L)	Average Dissolved Oxygen (mg/L)
2013	70	39	7.6
2014	381	68	3.6
2015	172	42	6
2016	182	77	5.3
2017	112	45	4.8
2018	153	52	6.1
2019	318	6	6.5

Table A-3: Water Quality Data at Sampling Location PTB035
(Samples were taken once per month from May—October (6 samples per year))
(Source: https://www.neponset.org/your-watershed/cwmn-data/)

Year	E. coli (Geometric Mean - colonies/100 ml)	Total Phosphorus (µg/L)	Dissolved Oxygen (mg/L)
2013	168	4	7.3
2014	1,330	93	4.8
2015	735	66	6.3
2016	976	248	5
2017	775	55	5.9
2018	356	61	6.4
2019	523	9	6.7

Table A-3: Water Quality Data at Sampling Location PTB047
(Samples were taken once per month from May—October (6 samples per year))
(Source: https://www.neponset.org/your-watershed/cwmn-data/)

Year	E. coli (Geometric Mean - colonies/100 ml)	Total Phosphorus (µg/L)	Dissolved Oxygen (mg/L)
2013	276	41	7.8
2014	892	52	7.7
2015	632	41	8
2016	502	39	8
2017	439	45	7.7
2018	994	62	7.5
2019	515	5	8.4

Figure A-2. CWMN Water Quality Monitoring Locations (PTB028, PTB035, PTB047) within the Pine Tree Brook Watershed

(Source: https://www.neponset.org/your-watershed/cwmn-data/)

Additional sampling was also conducted in 2016—2018 at numerous locations on the downstream section of Pine Tree Brook, which was part of the NepRWA's Hotspot Program. Figure A-3 indicates where the sampling locations were located. The green locations had *E. Coli* results with a geometric mean less than 126 colonies/100 ml; the yellow locations had *E. Coli* results with a geometric mean between 126—630 colonies/100 ml. The red locations had *E. Coli* results greater than 630 colonies/100 ml.

Figure A-3. CWMN Hotspot Monitoring Locations within the Pine Tree Brook Watershed between 2016—2018 (The green locations had E. Coli results with a geometric mean less than 126 colonies/100 ml; the yellow locations had E. Coli results with a geometric mean between 126—630 colonies/100 ml. The red locations had E. Coli results greater than 630 colonies/100 ml).

(Source: https://www.neponset.org/projects/hot-spot-program/)

Additionally, MassDEP sampled at one location in Pine Tree Brook in 2009 (Eliot Street crossing, (Milton Village) Milton). Results of this year's sampling survey can be found in the Technical Memorandum CN 340.1 - Neponset River Watershed 2009 DWM Water Quality Monitoring Data. A summary of MassDEP *E.coli* sampling data in Pine Tree Brook (MA73-29) is provided in **Table A-4**. For more information see https://www.mass.gov/guides/water-quality-monitoring-program-data.

Table A-4: MassDEP Watershed Planning Program Bacteria Data (2005-2011)

UniqueID	Year	Date First Sample	Date Last Sample	Sample Count	Geometric Mean	Bacteria Type
W0573	2006	05/09/06	07/11/06	4	303	*E. coli*
W0573	2009	04/28/09	09/15/09	6	336	*E. coli*
W0574	2006	05/09/06	08/23/06	5	153	*E. coli*
W0575	2006	05/09/06	08/23/06	5	122	*E. coli*
W0576	2006	05/09/06	08/23/06	5	96	*E. coli*
W1624	2006	08/23/06	08/23/06	1	579	*E. coli*

Water Quality Impairments

The Pine Tree Brook is listed under category 5 of the Massachusetts List of Integrated Waters due to multiple impairments including DO, physical substrate habitat alterations, aquatic plants, *E. Coli*, fecal coliform, and turbidity. The water quality impairments are listed in **Table A-6**.

The source of the impairments for Pine Tree Brook are currently listed as unknown; however, the Neponset River TMDL indicates that suspected sources of bacteria include sanitary sewer overflows, illicit sewer connections, storm water runoff, and failing septic systems. In addition, the Town of Milton has identified Wendell Brook, a tributary of Pine Tree Brook, to have high levels of pollutant loading. The Town of Milton has developed strategies to reduce pollutant loading from runoff to Wendell Brook that ultimately discharges to the Pine Tree Brook and the Neponset River.

Table A-5: 2016 MA Integrated List of Waters (303(d) list) Categories

Integrated List Category	Description
1	Unimpaired and not threatened for all designated uses.
2	Unimpaired for some uses and not assessed for others.
3	Insufficient information to make assessments for any uses.
4	Impaired or threatened for one or more uses, but not requiring calculation of a Total Maximum Daily Load (TMDL), including: 4a: TMDL is completed 4b: Impairment controlled by alternative pollution control requirements 4c: Impairment not caused by a pollutant - TMDL not required
5	Impaired or threatened for one or more uses and requiring preparation of a TMDL.

Table A-6: Water Quality Impairments

Assessment Unit ID	Waterbody	Integrated List Category	Designated Use	Impairment Cause	Impairment Source
MA73-29	**Pine Tree Brook**	**5**	Fish, other Aquatic Life and Wildlife	Oxygen, Dissolved	Source Unknown
MA73-29	**Pine Tree Brook**	**5**	Fish, other Aquatic Life and Wildlife	Physical substrate habitat alterations	Source Unknown
MA73-29	**Pine Tree Brook**	**5**	Primary Contact Recreation	Aquatic Plants (Macrophytes)	Source Unknown
MA73-29	**Pine Tree Brook**	**5**	Primary Contact Recreation	Escherichia coli	Source Unknown
MA73-29	**Pine Tree Brook**	**5**	Primary Contact Recreation	Fecal Coliform	Source Unknown
MA73-29	**Pine Tree Brook**	**5**	Primary Contact Recreation	Turbidity	Source Unknown
MA73-29	**Pine Tree Brook**	**5**	Secondary Contact Recreation	Aquatic Plants (Macrophytes)	Source Unknown
MA73-29	**Pine Tree Brook**	**5**	Secondary Contact Recreation	Fecal Coliform	Source Unknown
MA73-29	**Pine Tree Brook**	**5**	Secondary Contact Recreation	Turbidity	Source Unknown

Water Quality Goals

Water quality goals may be established for a variety of purposes, including the following:

a.) For **waterbodies with known impairments**, a Total Maximum Daily Load (TMDL) is established by MassDEP and the United States Environmental Protection Agency (USEPA) as the maximum amount of the target pollutant that the waterbody can receive and still safely meet water quality standards. If the waterbody has a TMDL for total phosphorus (TP) or total nitrogen (TN), or total suspended solids (TSS), that information is provided below and included as a water quality goal.

b.) For **waterbodies without a TMDL for total phosphorus** (TP), a default water quality goal for TP is based on target concentrations established in the Quality Criteria for Water (USEPA, 1986) (also known as the "Gold Book"). The Gold Book states that TP should not exceed 50 ug/L in any stream at the point where it enters any lake or reservoir, nor 25 ug/L within a lake or reservoir. For the purposes of developing WBPs, MassDEP has adopted 50 ug/L as the TP target for all streams at their downstream discharge point, regardless of which type of water body the stream discharges to.

c.) Massachusetts Surface Water Quality Standards (314 CMR 4.00, 2013) prescribe the minimum water quality criteria required to sustain a waterbody's designated uses. **Table A-7** lists the Class for each Assessment Unit ID within the Milton subwatersheds that contribute to the Pine Tree Brook. The water quality goal(s) for bacteria are based on the Massachusetts Surface Water Quality Standards.

Table A-7: Surface Water Quality Classification by Assessment Unit ID

Assessment Unit ID	Waterbody	Class
MA73-29	Pine Tree Brook	B

d.) **Other water quality goals set by the community** (e.g., protection of high-quality waters, in-lake phosphorus concentration goal to reduce recurrence of cyanobacteria blooms, etc.).

Refer to **Table A-8** for a list of water quality goals for TP, bacteria (*E. Coli*) and DO. It is expected that efforts to reduce TP loading will also result in improvements to DO impairment in Pine Tree Brook. Excess TP can cause eutrophication which depletes dissolved oxygen. Effective management of TP can limit eutrophication and allow DO to naturally replenish (USEPA, 2015).

Table A-8: Pine Tree Brook Water Quality Goals (MA73-29)

Pollutant	Goal	Source
Total Phosphorus (TP)	Total phosphorus should not exceed: --50 ug/L in any stream	Quality Criteria for Water (USEPA, 1986)
Bacteria	**Class B Standards** • Public Bathing Beaches: For E. coli, geometric mean of 5 most recent samples shall not exceed 126 colonies/ 100 ml and no single sample during the bathing season shall exceed 235 colonies/100 ml. For enterococci, geometric mean of 5 most recent samples shall not exceed 33 colonies/100 ml and no single sample during bathing season shall exceed 61 colonies/100 ml; • Other Waters and Non-bathing Season at Bathing Beaches: For E. coli, geometric mean of samples from most recent 6 months shall not exceed 126 colonies/100 ml (typically based on min. 5 samples) and no single sample shall exceed 235 colonies/100 ml. For enterococci, geometric mean of samples from most recent 6 months shall not exceed 33 colonies/100 ml, and no single sample shall exceed 61 colonies/100 ml.	Massachusetts Surface Water Quality Standards (314 CMR 4.00, 2013)
Dissolved Oxygen (DO)	Dissolved oxygen saturation should not be less than 5 mg/L in warm water fisheries or less than 6 mg/L in cold water fisheries.	Massachusetts Surface Water Quality Standards (314 CMR 4.00, 2013)

Land Use Information

Land use information and impervious cover is presented by the tables and figures below. Land use source data is from 2005 and was obtained from MassGIS (2009b).

Watershed Land Uses

As summarized by **Table A-9**, land use in the Pine Tree Brook watershed is mostly forested (approximately 57.6 percent); approximately 33.0 percent of the watershed is residential; approximately 3.5 percent of the watershed is open land or water; approximately 3.2 percent is agricultural; approximately 2.4 percent of the watershed is commercial; approximately 0.2 percent is devoted to highways; and approximately 0.1 percent of the watershed is industrial.

Table A-9: Watershed Land Uses

Land Use	Area (acres)	% of Watershed
Forest	2,612.05	57.6
Low Density Residential	765.76	16.9
High Density Residential	552.71	12.2
Medium Density Residential	178.47	3.9
Agriculture	146.52	3.2
Commercial	107.07	2.4
Open Land	102.09	2.2
Water	59.82	1.3
Highway	7.64	0.2
Industrial	5.44	0.1
TOTAL:	4,537.57	100

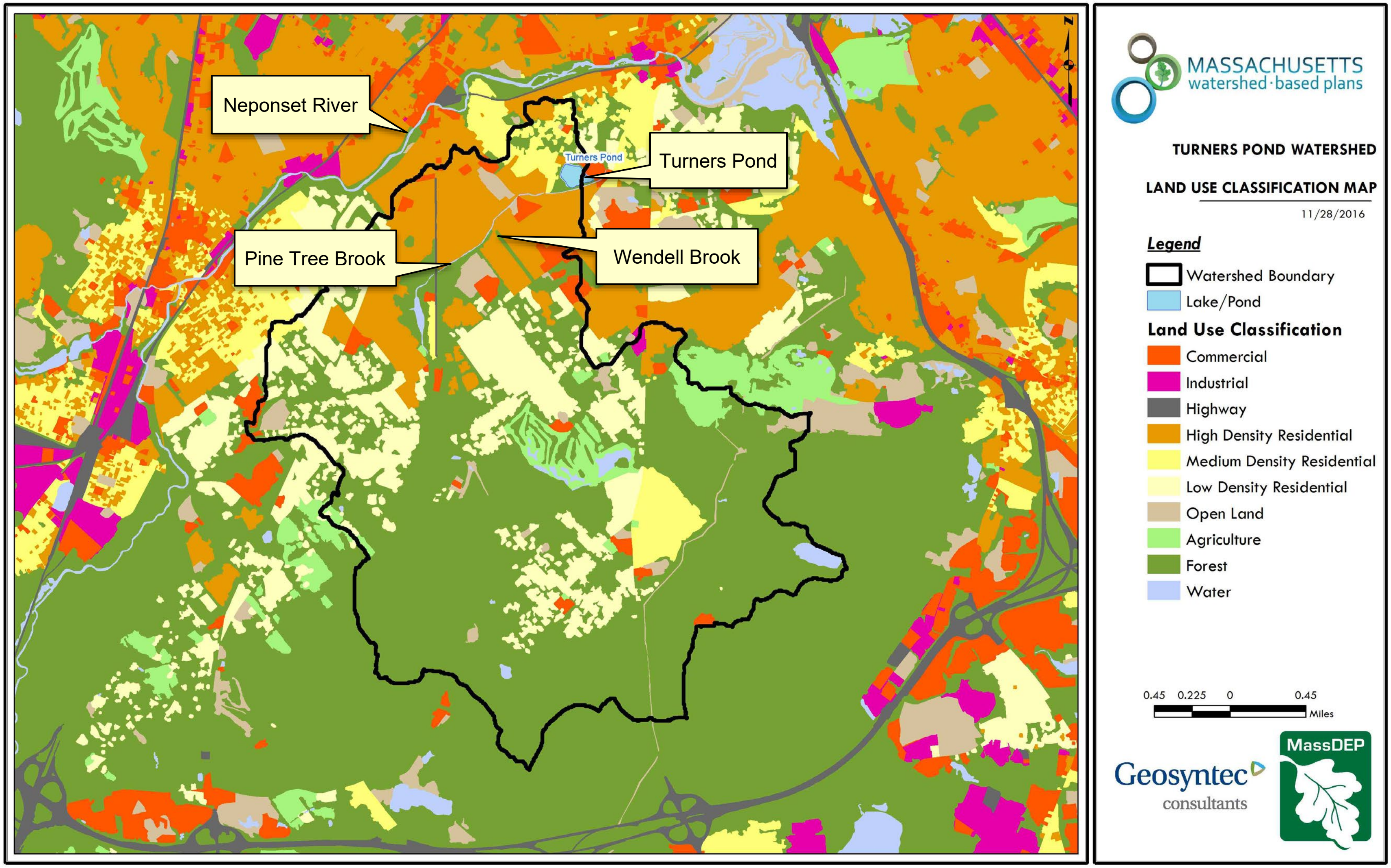


Figure A-4: Pine Tree Brook (Turners Pond) Watershed Land Use Map
(MassGIS, 2007; MassGIS, 2009b; MassGIS, 1999; MassGIS, 2001; USGS, 2016)

Watershed Impervious Cover

There is a strong link between impervious land cover and stream water quality. Impervious cover includes land surfaces that prevent the infiltration of water into the ground, such as paved roads and parking lots, roofs, basketball courts, etc. Impervious area within the watershed of the Pine Tree Brook is concentrated in northern portion of the watershed as illustrated in **Figure A-5** below.

Impervious areas that are directly connected (DCIA) to receiving waters (via storm sewers, gutters, or other impervious drainage pathways) produce higher runoff volumes and transport stormwater pollutants with greater efficiency than disconnected impervious cover areas which are surrounded by vegetated, pervious land. Runoff volumes from disconnected impervious cover areas are reduced as stormwater infiltrates when it flows across adjacent pervious surfaces.

An estimate of DCIA for the subwatershed area was calculated based on the Sutherland equations. USEPA provides guidance (USEPA, 2010) on the use of the Sutherland equations to predict relative levels of connection and disconnection based on the type of stormwater infrastructure within the total impervious area (TIA) of a watershed. Within the subwatershed, the total area of each land use was summed and used to calculate the percent TIA (**Table A-10**).

Table A-10: TIA and DCIA values for the Watershed

Watershed	Estimated TIA (%)	Estimated DCIA (%)
Pine Tree Brook	14.2	9.9

The relationship between TIA and water quality can generally be categorized as listed by **Table A-11** (Schueler et al. 2009). The TIA value for the watershed range is 14.2%; therefore, the river and surrounding tributaries can be expected to show clear signs of degradation.

Table A-11: Relationship between Total Impervious Area (TIA) and water quality (Schueler et al. 2009)

% Watershed Impervious Cover	Stream Water Quality
0-10%	Typically high quality, and typified by stable channels, excellent habitat structure, good to excellent water quality, and diverse communities of both fish and aquatic insects.
11-25%	These streams show clear signs of degradation. Elevated storm flows begin to alter stream geometry, with evident erosion and channel widening. Streams banks become unstable, and physical stream habitat is degraded. Stream water quality shifts into the fair/good category during both storms and dry weather periods. Stream biodiversity declines to fair levels, with most sensitive fish and aquatic insects disappearing from the stream.
26-60%	These streams typically no longer support a diverse stream community. The stream channel becomes highly unstable, and many stream reaches experience severe widening, downcutting, and streambank erosion. Pool and riffle structure needed to sustain fish is diminished or eliminated and the substrate can no longer provide habitat for aquatic insects, or spawning areas for fish. Biological quality is typically poor, dominated by pollution tolerant insects and fish. Water quality is consistently rated as fair to poor, and water recreation is often no longer possible due to the presence of high bacteria levels.
>60%	These streams are typical of "urban drainage", with most ecological functions greatly impaired or absent, and the stream channel primarily functioning as a conveyance for stormwater flows.

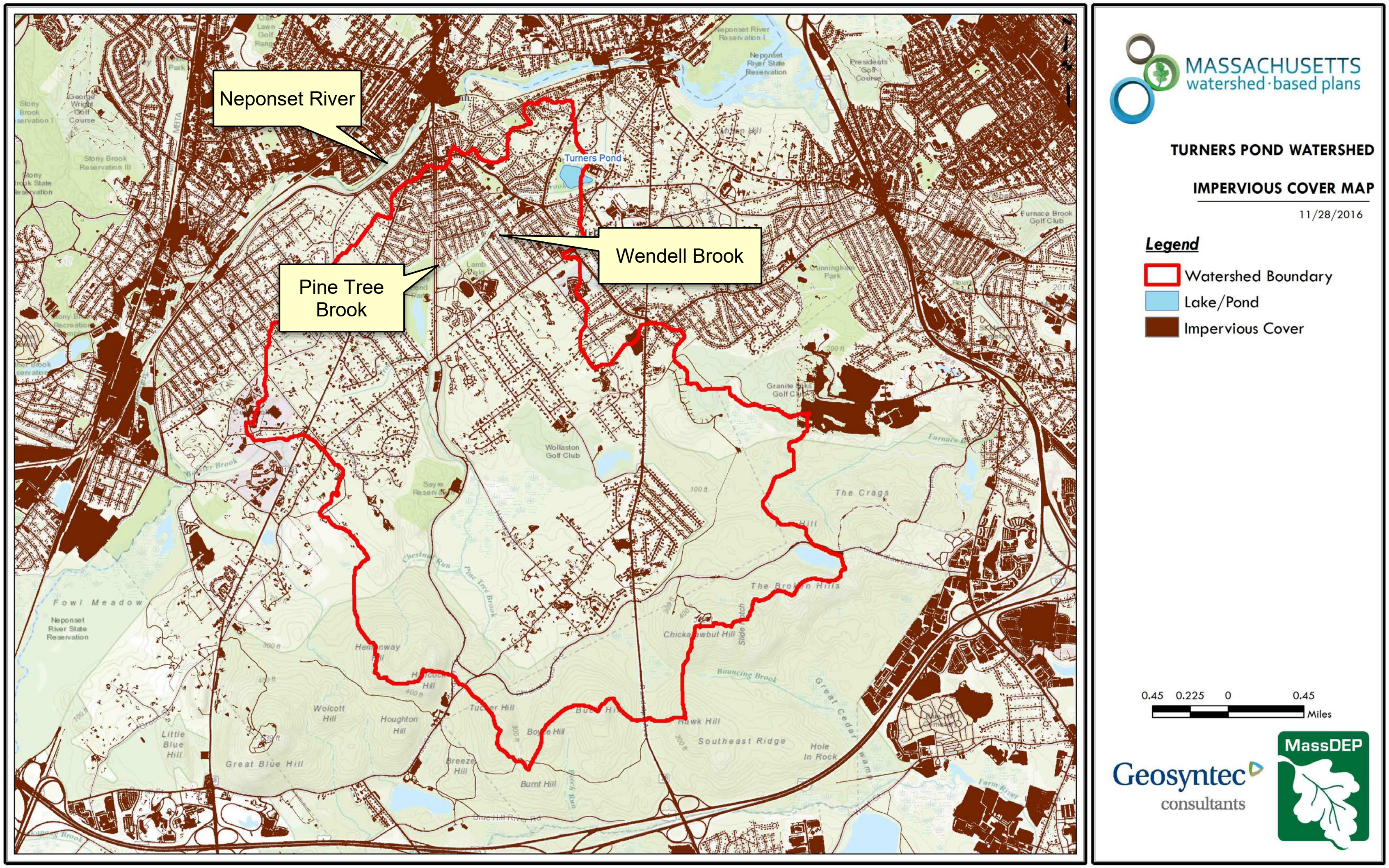


Figure A-5: Pine Tree Brook (Turners Pond) Watershed Impervious Surface Map

(MassGIS, 2007; MassGIS 2009a; MassGIS, 1999; MassGIS, 2001; USGS, 2016)

Pollutant Loading

The land use data (MassGIS, 2009b) was intersected with impervious cover data (MassGIS, 2009a) and United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) soils data (USDA NRCS and MassGIS, 2012) to create a combined land use/land cover grid. The grid was used to sum the total area of each unique land use/land cover type.

The amount of DCIA was estimated using the Sutherland equations as described above and any reduction in impervious area due to disconnection (i.e., the area difference between TIA and DCIA) was assigned to the pervious D soil category for that land use to simulate that some infiltration will likely occur after runoff from disconnected impervious surfaces passes over pervious surfaces.

Pollutant loading for key nonpoint source pollutants in the subwatershed area was estimated by multiplying each land use/cover type area by its pollutant load export rate (PLER). The PLERs are an estimate of the annual total pollutant load exported via stormwater from a given unit area of a particular land cover type. The PLER values for TN, TP and TSS were obtained from USEPA (Voorhees, 2016b) (see documentation provided in Appendix C) as follows:

$$L_n = A_n * P_n$$

Where L_n = Loading of land use/cover type n (lb/yr); A_n = area of land use/cover type n (acres); P_n = pollutant load export rate of land use/cover type n (lb/acre/yr)

The estimated land use-based phosphorus to receiving waters within the watershed areas is 1,490 pounds per year, as presented by **Table A-12**. The largest contributor of the land use-based phosphorus and nitrogen load originates from areas designated as residential (56% of the total phosphorus load and 61% of the total nitrogen load). Residential areas provide excellent opportunities for nutrient load reductions through urban BMPs and green infrastructure. The second largest contributors of the land use-based phosphorus and nitrogen load in the watershed are forested areas. Phosphorus generated from forested areas is a result of natural process such as decomposition of leaf litter and other organic material; these portions of the watershed are unlikely to provide opportunities for nutrient load reductions through BMPs.

Table A-12: Estimated Pollutant Loading for Key Nonpoint Source Pollutants within Pine Tree Brook

Land Use Type	Pollutant Loading[1]		
	Total Phosphorus (TP) (lbs/yr)	Total Nitrogen (TN) (lbs/yr)	Total Suspended Solids (TSS) (tons/yr)
High Density Residential	474	3,155	47.08
Forest	411	2,228	101.25
Low Density Residential	260	2,620	35.7
Commercial	109	944	11.81
Medium Density Residential	97	821	11.44
Agriculture	73	438	6.16
Open Land	53	533	12
Industrial	8	68	0.85
Highway	6	46	2.94
TOTAL	1,490	10,852	229.25

[1]These estimates do not consider loads from point sources or septic systems.

Element B: Determine Pollutant Load Reductions Needed to Achieve Water Quality Goals

Element B of your WBP should:

Determine the pollutant load reductions needed to achieve the water quality goals established in Element A. The water quality goals should incorporate Total Maximum Daily Load (TMDL) goals, when applicable. For impaired water bodies, a TMDL establishes pollutant loading limits as needed to attain water quality standards.

Estimated Pollutant Loads

Estimated pollutant loads for total phosphorus (TP) (1,490 lbs/yr), total nitrogen (TN) (10,852 lb/yr), and total suspended solids (TSS) (229 tons/yr) were previously presented in Table A-9 of this WBP. *E. Coli* and DO loading have not been estimated for this WBP, because there are no known PLERs for *E. Coli* or DO; however, data collected between 2013—2019 along Pine Tree Brook, as part of the NepRWA's CWMN and Hotspot Program, included *E. Coli* values that ranged from 1—1,330 cfu/100 ml and DO concentrations that were mostly above 5 mg/L (with the exception of one data point in 2014) (see Element A).

Water Quality Goals

There are many methodologies that can be used to set pollutant load reduction goals for a WBP. Goals can be based on water quality criteria, surface water standards, existing monitoring data, existing TMDL criteria, or other data. As discussed by Element A, water quality goals for this WBP are focused on addressing the Neponset River Watershed Bacteria TMDL, the listed DO impairment, and observed elevated concentrations of TP from ambient monitoring data. A description of criteria for each water quality goal is described by **Table B-1**. Since it is not practical to estimate *E. coli* and DO in terms of loading, the pollutant load reductions needed to achieve water quality goals are focused on TP. It is expected that efforts to reduce TP loading will also result in improvements to *E. Coli* and DO in Pine Tree Brook. Excess TP can cause eutrophication which depletes dissolved oxygen. Effective management of TP can limit eutrophication and allow DO to naturally replenish (USEPA, 2015).

The following adaptive sequence is recommended to establish and track water quality goals.

1. Establish an **interim goal** to reduce land use-based TP to Pine Tree Brook by 14 pounds/year over the next 5 years (by 2025) within the watershed.
2. Establish an **interim goal** to reduce *E. Coli* concentrations to be equal to or less than a geometric mean of 126 colonies/100 ml (by 2025) within the watershed.
3. Continue to maintain and expand, as feasible, the Citizen Water Monitoring Network (CWMN) in accordance with recommendations from Elements H&I. Use monitoring results to perform trend analysis to identify if proposed Element C management measures are resulting in improvements and to identify site candidates to be sampled as indicator sites.

4. Establish a **long-term goal** to reduce land use-based phosphorus by 151 pounds per year and to meet all applicable water quality standards over the next 20 years, leading to the delisting of Pine Tree Brook from the 303(d) list.

Table B-1: Pollutant Load Reductions Needed

Pollutant	Existing Estimated Total Load	Water Quality Goal	Planned Load Reduction
Total Phosphorus[1]	1,490 lbs/yr	1,339 lbs/yr	151 lbs/yr
Bacteria (*E. Coli*)[2]	*MSWQS for bacteria are concentration standards (e.g., colonies of fecal coliform bacteria per 100 ml), which are difficult to predict based on estimated annual loading. Data collected between 2013—2019 indicated that Beaver Meadow Brook had levels of E. coli ranging from a geometric mean of 1—1,330 colonies/100 ml.*	**Class B Standards** • Public Bathing Beaches: For E. coli, geometric mean of 5 most recent samples shall not exceed 126 colonies/ 100 ml and no single sample during the bathing season shall exceed 235 colonies/100 ml. For enterococci, geometric mean of 5 most recent samples shall not exceed 33 colonies/100 ml and no single sample during bathing season shall exceed 61 colonies/100 ml; • Other Waters and Non-bathing Season at Bathing Beaches: For E. coli, geometric mean of samples from most recent 6 months shall not exceed 126 colonies/100 ml (typically based on min. 5 samples) and no single sample shall exceed 235 colonies/100 ml. For enterococci, geometric mean of samples from most recent 6 months shall not exceed 33 colonies/100 ml, and no single sample shall exceed 61 colonies/100 ml.	*90% – Concentration Based (goal is to reduce geometric mean to 126 colonies/100 ml or less)*
Dissolved Oxygen (DO)[3]	*MSWQS for DO are concentration standards (e.g., mg/L), which are difficult to predict based on estimated annual loading. However, data collected between 2015—2019 indicated that Pine Tree Brook has recently sustained healthy concentrations of DO (greater than 5 mg/L).*	Dissolved oxygen saturation should not be less than 5 mg/L in warm water fisheries or less than 6 mg/L in cold water fisheries.	*Concentration Based (2015—2019 data indicates achievement of water quality goal)*

Notes:

1. *According to the USEPA Gold Book, total phosphorus should not exceed 50 ug/L in any stream at the point where it enters any lake or reservoir. The water quality loading goal was estimated by multiplying this target maximum phosphorus concentration (50 ug/L) by the estimated annual watershed discharge for Beaver Meadow Brook. To estimate the annual watershed discharge, the mean flow was used, which was estimated based on United States Geological Survey (USGS) "Runoff Depth" estimates for Massachusetts (Cohen and Randall, 1998). Cohen and Randall (1998) provide statewide estimates of annual Precipitation (P), Evapotranspiration (ET), and Runoff (R) depths for the northeastern U.S. According to their method, Runoff Depth (R) is defined as all water reaching a discharge point (including surface and groundwater), and is calculated by: P - ET = R. A mean Runoff Depth R was determined for the watershed by calculating the average value of R within the watershed boundary. This method includes the following assumptions/limitations: The estimated existing loading value only accounts for phosphorus due to stormwater runoff. Other sources of phosphorus may be relevant, particularly phosphorus from on-site wastewater treatment (septic systems) within proximity to receiving waters. Phosphorus does not typically travel far within an aquifer, but in watersheds that are primarily unsewered, septic systems and other similar groundwater-related sources may contribute a significant load of phosphorus that is not captured in this analysis. As such, it is important to consider the estimated TP loading as "the expected TP loading from stormwater sources*
2. *For all waterbodies, including impaired waters that have a pathogen TMDL, the water quality goal for bacteria is based on the Massachusetts Surface Water Quality Standards (MSWQS) (314 CMR 4.00, 2013) that apply to the Water Class of the selected water body. See Appendix A for additional information from the Neponset River Watershed Bacteria TMDL.*
3. *Dissolved oxygen criteria are based on the Massachusetts Surface Water Quality Standards (MSWQS) (314 CMR 4.00, 2013).*

Element C: Describe management measures that will be implemented to achieve water quality goals

> **Element C:** A description of the nonpoint source management measures needed to achieve the pollutant load reductions presented in Element B, and a description of the critical areas where those measures will be needed to implement this plan.

Existing and Ongoing Management Measures

The Town was awarded funding through the Fiscal Year 2017 Section 319 Nonpoint Source Pollution Grant Program to install six tree filter boxes along Wendell Brook. Each tree filter box was designed to capture approximately 0.30 acres of drainage area within the roadway, effectively treating the entirety of the impervious surfaces within the Town of Milton's right of way on Wendell Park. Each tree filter box is accompanied by a catch basin, installed directly down stream of each tree filter box to serve as a bypass during large storm events when the tree filter boxes may be over capacity. The tree filter boxes and catch basins were tied into the existing drainage bypass pipes. Granite curbing was also installed for 10 ft on either side of the structures to help channelize storm water into them. Loaming and seeding was performed along the length of the roadway to help fortify the shoulders and establish the gutter in order to direct as much stormwater as possible into the new structures while still allowing the stormwater to flow overland into the brook in the event of larger storms. Following the installation of new structures, the remaining fifteen bypass pipes were capped and filled with a concrete slurry for abandonment. The project also included the removal of dead vegetation and felled trees along the brook in order to restore proper uninhibited flow. It is anticipated that these BMPs will result in a combined load reduction of approximately 2,163 lbs/yr of TSS, 4.3 lbs/yr of TP, 8.5 lbs/yr of TN, and 147,400 billion colonies/year of fecal coliform (Town of Milton, 2019).

Future Management Measures

Priority BMPs

The NepRWA partnered with the Town of Milton to conduct a BMP retrofit feasibility survey within the Town under funding from the Massachusetts DEP's 604(b) Program. The project identified sites in the Town of Milton that were suitable for retrofitting with structural stormwater BMPs and where conceptual designs could be developed for BMPs at those sites to restore and maintain primary contact recreation and other designated uses. Fifteen sites were initially evaluated and seven were removed from further consideration after a stakeholder meeting. The remaining eight sites were ranked based on water quality benefits, site characteristics, constructability, maintenance access, and public education. The matrix for this ranking of the eight sites is included in Appendix A. Wendell Park, the Lincoln Street Parking Lot/Kelly Field, and Lafayette Street were initially ranked in the "top 3" sites for further design development/field investigation. This included a more detailed site visit and advancement of a test pit (if applicable to the BMP design) at each of the three locations to verify groundwater table elevation and soil type. Following the advancement of test pits at the Lincoln Street Parking lot/Kelly Field, which showed soils with poor percolation rates, it was removed from further consideration and Sumner Street replaced it in the top three. These top three ranking sites were further investigated and conceptual designs for the top three ranking sites were developed.

Wendell Park has been constructed and is described in the section above. The other two sites, on Lafayette Street and Sumner Street Park, are still strong candidates for future BMP design and implementation in the Pine Tree Brook watershed (EPG, 2013). These two sites are described below, and design concepts for these two sites are included in Appendix A.

- **Lafayette Street BMP (1st Priority)**

The proposed BMP at Lafayette Street includes installing a sediment forebay east of Milton's Lafayette Street cul-de-sac and removing the existing 350-foot drainage pipe to allow the drainage to disperse off the end of the street and create an enhanced wetland treatment system abutting Pine Tree Brook.. It was estimated that this BMP would result in a combined load reduction of approximately 2,905 lbs/yr of TSS, 3.6 lbs/yr of TP, 8.2 lbs/yr of TN, and 226,638 billion colonies/year of fecal coliform (EPG, 2013). The Town of Milton has applied for Fiscal Year 2021 Section 319 grant funding to help implement the proposed BMP at Lafayette Street (Town of Milton, 2021). Lafayette Street was chosen as the first priority for future stormwater BMP implementation because of its relatively low cost, its siting on Town land, its discharge area to a distressed waterbody, the relatively large amount of impervious surface treated, and the technical feasibility to retrofit a Low Impact Development stormwater BMP.

- **Sumner Street Park BMP (2nd Priority)**

The proposed BMPs at Sumner Street Park include a wet swale, bioretention basin with sediment forebay and bioretention filtration systems. It was estimated that these BMPs would result in a combined load reduction of approximately 3,510 lbs/yr of TSS, 5.9 lbs/yr of TP, 10.3 lbs/yr of TN, and 250,675 billion colonies/year of fecal coliform (EPG, 2013).

- **Five additional priority sites**

The remaining five priority sites are located at Milton Street, Gulliver Street, Lincoln Street Parking Lot/Kelly Field, Meetinghouse Lane, and Elm Street. Less detailed construction cost estimates for the remaining five sites are also included in Appendix A.

Additional Investigation – Structural BMPs

Once these proposed BMPs have been implemented and/or deemed infeasible for implementation upon further analysis, the NepRWA and/or the Town of Milton may consider additional investigation with the following recommended general sequence to identify and implement future structural BMPs within the Pine Tree Brook watershed. The following general sequence is recommended to identify and implement structural BMPs. The sequence has significant overlap with the Town of Milton's SWMP (Town of Milton, 2019) and should be coordinated accordingly during implementation.

1. **Identify Potential Implementation Locations**: Perform a desktop analysis using aerial imagery and GIS data to develop a preliminary list of potentially feasible implementation locations based on soil type (i.e., hydrologic soil groups A and B); available public open space (e.g., lawn area in front of a police station); potential redevelopment sites where additional public-private partnerships may be leveraged; and other factors such as proximity to receiving waters, known problem areas, or publicly owned right of ways or easements. Additional analysis can also be performed to fine-tune locations to maximize pollutant removals such as performing loading analysis on specifically delineated subwatersheds draining to single outfalls and selecting those subwatersheds with the highest loading rates per acre. The BMP retrofit feasibility survey also identified five additional potential implementation locations (Milton Street, Gulliver Street, Kelly Field, Meetinghouse Lane, and Elm Street) that should be included in the potential implementation locations (EPG, 2013).

2. **Visit Potential Implementation Locations**: Perform field reconnaissance, preferably during a period of active runoff-producing rainfall, to evaluate potential implementation locations, gauge feasibility, and identify potential BMP ideas. During field reconnaissance, assess identified locations for space constraints, potential accessibility issues, presence of mature vegetation that may cause conflicts (e.g., roots), potential utility conflicts, site-specific drainage patterns, and other factors that may cause issues during design, construction, or long-term maintenance.
3. **Develop BMP Concepts**: Once potential BMP locations are conceptualized, use the BMP-selector tool on the watershed-based planning tool to help develop concepts. Concepts can vary widely. One method is to develop 1-page fact sheets for each concept that includes a site description, including definition of the problem, a description of the proposed BMPs, annotated site photographs with conceptual BMP design details, and a discussion of potential conflicts such as property ownership, O&M requirements, and permitting constraints. The fact sheet can also include information obtained from the BMP-selector tool including cost estimates, load reduction estimates, and sizing information (i.e., BMP footprint, drainage area, etc.).
4. **Rank BMP Concepts**: Once BMP concepts are developed, perform a priority ranking based on site-specific factors to identify the implementation order. Ranking can include many factors including cost, expected pollutant load reductions, implementation complexity, potential outreach opportunities and visibility to public, accessibility, expected operation and maintenance effort, and others.

Prioritized BMP concepts should focus on reducing TP and *E. coli* loading to Pine Tree Brook as summarized in Element B.

Non-Structural BMPs

Note that planned BMPs can also be non-structural (e.g., street sweeping, catch basin cleaning). It is recommended that these municipal programs be evaluated and potentially optimized. First, it is recommended that potential pollutant load removals from ongoing activities be calculated in accordance with Elements H and I. Next, it is recommended that ongoing activities be evaluated to see if potential improvements can be implemented to achieve higher pollutant load reductions such as increased frequency or improved technology.

Element D: Identify Technical and Financial Assistance Needed to Implement Plan

Element D: Estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan.

Current and Ongoing Management Measures

The funding needed to implement the existing and ongoing management measures as well as future management measures, which are presented in Element C of this WBP, are included in Table D-1. Additionally, The Town of Milton currently maintains tree filter boxes on other streets. The operation and maintenance plans for those BMPs were adapted for the Wendell Brook BMP and implemented to ensure the long-term performance of the BMPs as designed (Town of Milton, 2019). The estimated annual operation and maintenance costs for the Wendell Brook BMPs were estimated, based on input from the Milton Town Engineer, to be approximately $5,000/year. The Milton Town Engineer also estimated that the annual Operation and Maintenance costs for all of the existing BMPs and the proposed BMP on Lafayette Street is approximately $30,000/year

Table D-1: Summary of Proposed BMPs Costs

Existing and Ongoing Management Measures			
BMP	**Total Cost**	**Portion of Total Cost that is grant-funded**	**Grant**
Wendell Brook BMPs	$200,641	$87,030	Section 319
Future Management Measures			
BMP	**Total Cost**	**Portion of Total Cost that is grant-funded**	**Grant (see Note 1)**
Lafayette Street BMPs (EPG, 2013)	$118,059	70,598	Section 319
Sumner Street Area BMPs (EPG, 2013)	$227,922	TBD	TBD

1: Funding for future BMP installations to further reduce loads within the watershed may be provided by a variety of sources, such as the Section 319 Nonpoint Source Pollution Grant Program, town capital funds, state grants such as Coastal Pollution Remediation grants, Municipal Vulnerability Preparedness or other grant programs such as hazard mitigation funding. Guidance is available to provide additional information on potential funding sources for nonpoint source pollution reduction efforts at: http://prj.geosyntec.com/prjMADEPWBP_Files/Guide/Element%20D%20-%20Funds%20and%20Resources%20Guide.pdf

Element E: Public Information and Education

Element E: Information and Education (I/E) component of the watershed plan used to:

1. Enhance public understanding of the project; and
2. Encourage early and continued public participation in selecting, designing, and implementing the NPS management measures that will be implemented.

Step 1: Goals and Objectives

The goals and objectives for the watershed information and education program.

1. Provide information about proposed stormwater improvements and their anticipated water quality benefits.
2. Provide information to promote watershed stewardship.

Step 2: Target Audience

Target audiences that need to be reached to meet the goals and objectives identified above.

1. All watershed residents.
2. Businesses within the watershed.
3. Schools within the watershed.
4. Watershed organizations and other user groups, including Neponset River Watershed Association.

Step 3: Outreach Products and Distribution

The outreach product(s) and distribution form(s) that will be used for each.

1. For the Wendell Brook BMP project, the outreach campaign included:
    a. A press release for distribution by local media.
    b. Sent a town-wide educational mailing to all residents and businesses.
    c. A targeted post card
    d. Several online blog and newsletter articles
    e. Social medial posts
    f. Interpretative signage at the Wendell Brook BMP locations
2. A similar outreach effort to that of the Wendell Brook BMP project will be completed for future BMP projects in the Pine Tree Brook watershed such as the proposed Lafayette Street BMPs.
3. The Stormwater Management Program (SWMP) for the town of Milton includes additional outreach efforts being conducted within the Town of Milton (Town of Milton, 2019).

Step 4: Evaluate Information/Education Program

Information and education efforts and how they will be evaluated.

1. Track the number of media outlets that publish the press release and their estimated readership.
2. Track the number and residents and businesses that receive the educational mailer.
3. Track the number of emails and size of list serve receiving the emails related to the Wendell Brook BMPs project summary.
4. Track attendance at the meeting of the Neponset Stormwater Partnership where the Wendell Brook BMPs are discussed.
5. Track the number of posts and associated activity (likes/shares) related to posts of the Wendell Brook BMPs on the Town of Milton’s social media pages.

Elements F & G: Implementation Schedule and Measurable Milestones

Element F: Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.

Element G: A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.

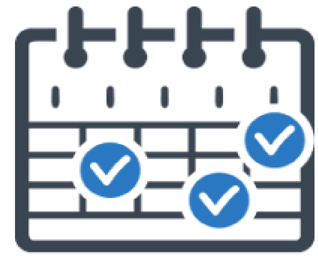


Table FG-1 provides a preliminary schedule for implementation of recommendations provided by this WBP. It is expected that the WBP will be re-evaluated and updated in 2023, or as needed, based on ongoing monitoring results and other ongoing efforts. New projects for further implementation of the watershed based plan will be identified through future data analysis and stakeholder engagement and will be included in updates to the implementation schedule.

Table FG-1: Implementation Schedule and Interim Measurable Milestones[2]

Category	Action	Estimated Cost	Year(s)
Monitoring	Continue to perform annual water quality sampling per Element H&I monitoring guidance and the EPA-approved Quality Assurance Project Plan (QAPP) developed by NepRWA		Annual
Structural BMPs	Obtain funding and implement proposed BMPs at Lafayette Street	$118,059	2021--2023
	Obtain funding and implement proposed BMPs at Sumner Street Area	$227,922	2023
	Obtain funding and implement 2-3 additional BMPs within the Pine Tree Brook watershed	$300,000	2027
Nonstructural BMPs	Document potential pollutant removals from ongoing non-structural BMP practices (i.e., street sweeping, catch basin cleaning)		2021
	Evaluate ongoing non-structural BMP practices and determine if modifications can be made to optimize pollutant removals (e.g., increase frequency).		2022
	Routinely implement optimized non-structural BMP practices		Annual
Public Education and Outreach *(See Element E)*	Periodically post project updates to websites, social media, and blog profiles	$5,000	Annual
	Develop and post informational signs at proposed BMP locations	$5,000	
	Develop and distribute educational mailings	$5,000	Annual
Adaptive Management and Plan Updates	Establish working group comprised of stakeholders and other interested parties to implement recommendations and track progress. Meet at least twice per year.	--	2021
	Re-evaluate Watershed Based Plan at least once every three (3) years and adjust, as needed, based on ongoing efforts (e.g., based on monitoring results, 319 funding, etc.). – Next update, June 2023	--	2023
	Reach interim goal to reduce land-based phosphorus by 14 lbs/yr)	**--**	**2025**
	Reach interim goal to reduce E. Coli concentrations to be equal to or less than a geometric mean of 126 colonies/100 ml		**2025**
	Reach long-term goal to de-list Pine Tree Brook from the 303(d) list		**2040**

[2] Note that goals and milestones of this WBP are intended to be adaptable and flexible. Goals and milestones are not intended to be tied to Municipal Separate Storm Sewer (MS4) permit requirements. Stakeholders will perform tasks contingent on available resources and funding.

Elements H & I: Progress Evaluation Criteria and Monitoring

Element H: A set of criteria used to determine (1) if loading reductions are being achieved over time and (2) if progress is being made toward attaining water quality goals. Element H asks "**how will you know if you are making progress towards water quality goals?**" The criteria established to track progress can be direct measurements (e.g., E. coli bacteria concentrations) or indirect indicators of load reduction (e.g., number of beach closings related to bacteria).

Element I: A monitoring component to evaluate the effectiveness of implementation efforts over time, as measured against the Element H criteria. Element I asks "**how, when, and where will you conduct monitoring?**"

The water quality target concentration(s) is presented under **Element A** of this plan. To achieve this target concentration, the annual loading must be reduced to the amount described in **Element B**. **Element C** of this plan describes the various management measures that will be implemented to achieve this targeted load reduction. The evaluation criteria and monitoring program described will be used to measure the effectiveness of the proposed management measures (described in **Element C**) in improving the water quality of the Pine Tree Brook.

Indirect Indicators of Load Reduction

Non-Structural BMPs

Potential load reductions from non-structural BMPs (i.e., street sweeping and catch basin cleaning) can be estimated from indirect indicators, such as the number of miles of streets swept or the number of catch basins cleaned. Appendix F of the 2016 Massachusetts Small MS4 General Permit provides specific guidance for calculating phosphorus removal from these practices. As indicated by **Element C**, it is recommended that potential phosphorus removal from these ongoing actives be estimated. Next, it is recommended that ongoing activities be evaluated to see if potential improvements can be implemented to achieve higher pollutant load reductions such as increased frequency or improved technology.

The Town of Milton currently performs street sweeping and catch basin cleaning, in addition to other non-structural BMPs. The Town partners with the NepRWA to assist with river cleanups, which engage watershed residents. The Town is in the process of identifying sources of phosphorus in the watershed. The Town of Milton has multiple programs to address water quality, including erosion and sediment control standards for construction projects, and post-construction water quality requirements.

Phosphorus load reductions can be estimated in accordance with Appendix F of the 2016 Massachusetts Small MS4 General Permit as summarized by **Figure HI-1 and HI-2**.

$$\text{Credit}_{sweeping} = IA_{swept} \times PLE_{IC\text{-land use}} \times PRF_{sweeping} \times AF \quad \textbf{(Equation 2-1)}$$

Where:

$\text{Credit}_{sweeping}$	=	Amount of phosphorus load removed by enhanced sweeping program (lb/year)
IA_{swept}	=	Area of impervious surface that is swept under the enhanced sweeping program (acres)
$PLE_{IC\text{-land use}}$	=	Phosphorus Load Export Rate for impervious cover and specified land use (lb/acre/yr) (see Table 2-1)
$PRF_{sweeping}$	=	Phosphorus Reduction Factor for sweeping based on sweeper type and frequency (see Table 2-3).
AF	=	Annual Frequency of sweeping. For example, if sweeping does not occur in Dec/Jan/Feb, the AF would be 9 mo./12 mo. = 0.75. For year-round sweeping, AF=1.0[1]

As an alternative, the permittee may apply a credible sweeping model of the Watershed and perform continuous simulations reflecting build-up and wash-off of phosphorus using long-term local rainfall data.

Table 2-3: Phosphorus reduction efficiency factors ($PRF_{sweeping}$) for sweeping impervious areas

Frequency[1]	Sweeper Technology	$PRF_{sweeping}$
2/year (spring and fall)[2]	Mechanical Broom	0.01
2/year (spring and fall)[2]	Vacuum Assisted	0.02
2/year (spring and fall)[2]	High-Efficiency Regenerative Air-Vacuum	0.02
Monthly	Mechanical Broom	0.03
Monthly	Vacuum Assisted	0.04
Monthly	High Efficiency Regenerative Air-Vacuum	0.08
Weekly	Mechanical Broom	0.05
Weekly	Vacuum Assisted	0.08
Weekly	High Efficiency Regenerative Air-Vacuum	0.10

Figure HI-1. Street Sweeping Calculation Methodology

$$\text{Credit}_{CB} = IA_{CB} \times PLE_{IC\text{-land use}} \times PRF_{CB} \quad \textbf{(Equation 2-2)}$$

Where:

Credit_{CB}	=	Amount of phosphorus load removed by catch basin cleaning (lb/year)
IA_{CB}	=	Impervious drainage area to catch basins (acres)
$PLE_{IC\text{-and use}}$	=	Phosphorus Load Export Rate for impervious cover and specified land use (lb/acre/yr) (see Table 2-1)
PRF_{CB}	=	Phosphorus Reduction Factor for catch basin cleaning (see Table 2-4)

Table 2-4: Phosphorus reduction efficiency factor (PRF_{CB}) for semi-annual catch basin cleaning

Frequency	Practice	PRF_{CB}
Semi-annual	Catch Basin Cleaning	0.02

Figure HI-2. Catch Basin Cleaning Calculation Methodology

Project-Specific Indicators

Number of BMPs Installed and Pollutant Reduction Estimates:

Anticipated pollutant load reductions from existing, ongoing (i.e., under construction), and future BMPs will be tracked as BMPs are installed. For example, the estimated TP load reduction for the Wendell Brook BMPs is 4.3 lbs/yr. These BMPs will also be evaluated through measured changes in water quality documented by NepRWA's on-going volunteer-based water quality monitoring program which collects samples six times per year at locations both upstream (monitoring location PTB028) and downstream (PTB035) of the project.

TMDL Criteria

TMDL requirements include the continuation of the NepRWA's CWMN monitoring program during both wet and dry weather. In addition, the TMDL requires development of a detailed monitoring plan and sampling associated with illicit discharge detection.

Direct Measurements

Direct measurements are generally expected to be performed in accordance with existing monitoring activities by the NepRWA's CWMN, as summarized below, along with additional recommendations to supplement sampling[3] . The CWMN includes three core sampling sites, "PTB028" "PTB035", and "PTB047", along Pine Tree Brook. These locations are sampled regularly. The CWMN also has seventeen additional "hot spot" sites, along Pine Tree Brook, which are sampled based on anticipated needs.

River Sampling

Regular sampling of sampling site PTB028, PTB035 and PTB047 in accordance with the CWMN will continue. Since there were two "hot spot" sampling sites that recently exhibited heightened levels of *E. Coli* (see summary in Element A) and these locations are located downstream of the Wendell Brook BMPs, more frequent sampling (in accordance with the CWMN program) is recommended at this location. It is also recommended to continue monitoring "hot spot" sampling site during and following the implementation of BMPs to help assess effectiveness of the BMPs.

Adaptive Management

Long-term goals will be re-evaluated at least **once every three years** and adaptively adjusted based on additional monitoring results and other indirect indicators. If monitoring results and indirect indicators do not show improvement to the nutrient and bacteria concentrations, as well as other indicators (e.g., dissolved oxygen) measured within the watershed, the management measures and loading reduction analysis (Elements A through D) will be revisited and modified accordingly.

[3] A full explanation of the CWMN, including sampling frequencies, parameters, and locations is provided at this link: https://www.neponset.org/your-watershed/cwmn-data/.

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Appendices

Appendix A – BMP Conceptual Designs- Lafayette Street and Sumner Street Park (Town of Milton, 2013)

Town of Milton
Stormwater BMP's
Ranking
June, 2013

Location	1.0 WATER QUALITY BENEFITS (40 Points)				2.0 SITE CHARACTERISTICS (30 Points)			3.0 Constructability (20 Points)				4.0 MAINTENANCE (5 Points)	5.0 PUBLIC EDUCATION (5 Points)		
Location Description	Impervious Area Treated	Total Area Treated	Water Quality Volume Treated	Type of Pollutant Treated	Location	Current Treatment	High Traffic Area	Cost of Construction	Area Required	Available Land	Groundwater & Soil Constraints	Maintenance Access	Public Visibility & Awareness	Total Score	RANK
1. Milton Street	10	7	3	3	3	3	8	3	5	5	5	5	1	61	8
2. Wendell Park	10	6	10	10	10	10	6	3	5	3	1	5	5	84	3
3. Gulliver Street	10	6	6	6	6	10	6	3	3	1	1	5	1	64	T6
4. Kelly Field	10	7	10	10	10	10	8	5	5	1	1	5	5	87	1
5. Meetinghouse Lane	10	9	6	6	6	10	6	1	5	1	3	5	1	69	5
6. Lafayette Street	10	7	6	6	10	6	6	5	5	5	3	5	5	79	4
7. Sumner Street	10	7	10	10	10	6	8	3	3	5	3	5	5	85	2
8. Elm Street	10	6	6	6	6	10	6	3	3	1	1	5	1	64	T6

SCORING CATEGORY	1.0 WATER QUALITY BENEFITS (40 Points)				2.0 SITE CHARACTERISTICS (30 points)			3.0 CONSTRUCTABILITY (20 Points)				4.0 MAINTENANCE (5 Points)	5.0 PUBLIC ED (5 Points)
SCORING DESCRIPTION	Impervious Area Treated	Total Area Treated	Water Quality Volume Treated	Type of Pollutant Treated	Location	Current Treatment	High Traffic Area	Cost of Construction	Area Required	Available Land	Groundwater and Soil Constraints	Maintenance Access	Public Visibility and Awareness
High Scoring Description	Greater than 1 Acre Treated	Greater than 5 Acres Treated	1" or More Treated (Entire WQV or More)	Nutrients, Bacteria, Turbidity and Others	Adjacent or Direct Discharge to River	No Current Treatment	High Traffic Area (e.g. Downtown or Main Roadway)	Highly Cost Effective	Minimal Area Required (<0.25 acres)	Plentiful Land, not Actively Utilized	Deep Groundwater Anticipated	Easy to Access (Public Land)	High Visibility (e.g. Highly Visible or Downtown)
High Point Value	10 points	10 points	10 points	10 points	10 points	10 points	10 points	5 points	5 points	5 points	5 points	5 points	5 points
Moderate Scoring Description	0.25 to 1 Acre Treated	1 to 5 Acres Treated	0.5" to 1" Treated (First Flush to WQV)	Bacteria, Turbidity and Other Pollutants	Adjacent or Direct Discharge to Tributary	unused	Moderate Traffic Area (e.g. secondary road, seldom used	Moderately Cost Effective	Medium Area Required (0.25 - 0.5 acre)	Somewhat Available Land	Moderate Depth to Groundwater Anticipated	Moderately Accessible (Public and Private Land)	Medium Visibility (e.g. Somewhat Visible)
Mid Point Value	6 points	6 points	6 points	6 points	6 points	6 points	6 points	3 points	3 points	3 points	3 points	3 points	3 points
Low Scoring Description	Less than 0.25 Acres Treated	Less than 1 Acre Treated	Less than 0.5" Treated (Less than First Flush)	Turbidity and Other Pollutants Only	Upland from River and Tributaries	Some Current Treatment	Low Traffic Area (e.g. Wooded or Low Use Road)	Minimally Cost Effective	Large Area Required (>0.5 acre)	Currently Utilized Land	Shallow Depth to Groundwater Anticipated	Difficult to Access (Private Land)	Low Visibility (e.g. Underground or Low Traffic Area)
Low Point Value	3 points	3 points	3 points	3 points	3 points	3 points	3 points	1 point	1 point	1 point	1 point	1 point	1 point
Total Score	10	10	10	10	10	10	10	5	5	5	5	5	5
	<- - - - - - - - - - - - - - - - - 100 Possible Points - - - - - - - - - - - - - - - - ->												

APPENDIX E
CONSTRUCTION COSTS FOR REMAINING SITES NOT SELECTED FOR DESIGN

Basis for Construction Cost Estimates: Cost estimates for the construction of BMP's at the remaining sites not selected for design were based on the detailed cost estimates for Wendell Park and Sumner Street, (Appendices B and D, respectively). For each of these two location, the average cost per acre of EPG's designs is $90,100 (i.e., both are almost exactly the same cost/acre). The cost estimate for Lafayette was not used as it was a unique design (i.e., using an existing wetland as a filtering mechanism). For both Wendell Park and especially at Sumner St, the designs have the type of BMP's likely to be used for the remaining sites not selected for design: Tree filter boxes, forebays, bioretention basins, swale work, etc. The figure of $90,100/acre was therefore used, without actually designing each system for each non-selected area.

1. **Milton Street**: Impervious Area = 89,210 SF = 2.05 AC.
   Potential BMP: Leaching Catch Basins
   1" WQV = 7,434 CF.
   Estimated Cost = $184,705.

2. **Gulliver Street**: Impervious Area = 71,339 SF = 1.64 AC.
   Potential BMP: Bioretention Area/Infiltration Swale
   1" WQV = 5,945 CF.
   Estimated Cost = $147,764.

3. **Lincoln Street Parking Lot/Kelly Field**: Impervious Area = 95,768 SF = 2.2 AC.
   Potential BMP: Bioretention Area
   1" WQV = 7,981 CF.
   Estimated Cost = $198,220.

4. **Meetinghouse Lane**: Impervious Area = 186,421 SF = 4.28 AC.
   Potential BMP: Leaching Catch Basins.
   1" WQV = 15,535 CF.
   Estimated Cost = $385,628.

5. **Elm Street**: Impervious Area = 78,916 SF = 1.81 AC.
   Potential BMP: Bioretention Area/Infiltration Swale
   1" WQV = 6,576 CF.
   Estimated Cost = $163,081.

Environmental Partners GROUP
A partnership for engineering solutions.

May 24, 2013

Mr. William Guenther
Neponset River Watershed Association
2173 Washington Street
Canton, MA 02021

RE: Stormwater BMP's
Town of Milton, MA
Lafayette Street Area

Dear Mr. Guenther:

Environmental Partners Group, Inc. (EPG) is submitting this design package for the selected Stormwater Best Management Practices (BMP's) for the Lafayette Street area in Milton, MA. This project involves retrofitting stormwater BMP's considering various site constraints and preferences.

Following an evaluation of over a dozen sites in Milton, this area was selected as a "top 3" candidate for stormwater BMP design because of its potential relatively low cost, available space, its discharge area to a distressed waterbody, the amount of impervious surface treated, and technical ability to retrofit a Low Impact Development (LID) Stormwater BMP.

The Lafayette Street area is located between Blue Hill Avenue (Route 138) and Popes Pond/Pine Tree Brook. It is a dense residential area that receives stormwater runoff from impervious surfaces. There are currently stormwater systems in the area (catch basins, manholes, piping) that interconnect and eventually discharge directly into Pine Tree Brook, via drainage piping from Lafayette Street. A 350-foot long exposed drain pipe carries the collected stormwater east from the eastern paved limits of Lafayette Street to Pine Tree Brook. Pine Tree Brook is considered an EPA Category 5 TMDL-impaired waterbody due to pathogens, low dissolved oxygen and organic enrichment.

The goal of the Stormwater BMP is to eliminate this direct discharge from impervious areas to Pine Tree Brook. By removal of the pipeline, installation of pretreatment, the existing wetlands can serve as a BMP in filtering the stormwater runoff prior to its reaching Pine Tree Brook. The wetlands will function as a bioretention basin.

The Stormwater BMP was designed based on the location of the site, the size of the impervious area, existing utilities, and abutting wetlands. The physical size of the BMP is limited by the edge of pavement and drainage structures at the east end of Lafayette Street, privately owned land on the north and south sides of the cul de sac, and an existing walking path south of the 350-foot drain pipe. In addition the area is assumed to have high groundwater based on the water observed within the wetlands to the east.

These site features triggered the selection of a sediment forebay just east of the Lafayette Street cul de sac, and the removal of the existing 350-foot drainage piping in order to allow the drainage to disperse freely from the drainage system into the wetlands.

In addition, the installation of a berm is proposed within the manhole at the corner of Lafayette Street and Truro Lane, in order to promote all stormwater that is captured within the interconnected systems in the area to primarily flow to the east end of Lafayette Street and through the proposed BMP's. As a result, the outlet leading north from the manhole at the corner of Lafayette Street and Truro Lane will only be used as a secondary relief/overflow during large rain events, if the system at the east end of Lafayette Street reaches capacity.

The total amount of impervious area within this watershed is 2.16 Acres, and the 1-inch Water Quality Volume (WQV) is 7,843 cubic feet. Because of the large size of the existing vegetated wetlands east of the cul de sac and north of the foot path, it is assumed that the area has the capacity to treat the WQV. According to the Massachusetts Stormwater Handbook, the recommended volume for the proposed forebay to pretreat water quality volume is 0.1-inch per impervious acre, or 784 cubic feet. Due to the area constraints detailed above, and the desire to have minimal impacts on the existing wetlands east of the cul de sac (i.e., no build-out of the forebay into the wetlands), the pretreatment volume of the proposed forebay is proposed to be 516 cubic feet.

The annual runoff has been calculated to be 41.55 inches (based on average annual precipitation). It has been calculated that the annual removal totals for the proposed sediment forebay and existing wetland area (bioretention basin) is approximately 2,905 lbs of TSS, 3.58 lbs of TP, 8.21 lbs of TN, and 226,638 billion colonies of Fecal Coliform. It is assumed that this system will treat 37.4 inches of rain annually, which is 90% of the annual runoff (assume that 10% of the annual runoff will divert to the overflow/secondary outlet in the manhole at the corner of Lafayette Street and Truro Lane). The total estimated construction cost for this proposed design is $79,170 with an annual O&M cost of $1,200. Other opportunities to reduce the costs include use of Town-owned forces to self-perform much of the work (e.g., pipe removal) and Construction Administration/Resident Engineering.

Should you have any questions or concerns regarding the enclosed documents or the project in general, please do not hesitate to contact me. You can reach me via e-mail (ccf@envpartners.com) or telephone 617-657-0254.

Very Truly Yours,
Environmental Partners Group, Inc.

C. Carter Fahy, P.E., LSP
Principal

Attachments:

1. Selected BMP Information
2. Retrofit Design Summary Table
3. Runoff and Pollutant Load Calculations Table
4. Pollutant Removal Calculations Table
5. Cost Estimate
6. Drainage Area Plan
7. Conceptual Design Plan

cc: John Thompson, Town Engineer, Town of Milton DPW
Dale Horsman, Town of Milton DPW
Steven Belanger, EPG
File

ATTACHMENT 1
Selected BMP Information

ATTACHMENT 2
Retrofit Design Summary Table

ATTACHMENT 3
Runoff and Pollutant Load Calculations Table

ATTACHMENT 4
Pollutant Removal Calculations Table

ATTACHMENT 5
Construction Cost Estimate

ATTACHMENT 6
Drainage Area Plan

ATTACHMENT 7
Conceptual Design Plan

ATTACHMENT 1

SELECTED BMP INFORMATION

Sediment Forebays

Description: A sediment forebay is a post-construction practice consisting of an excavated pit, bermed area, or cast structure combined with a weir, designed to slow incoming stormwater runoff and facilitating the gravity separation of suspended solids. This practice is different from a sediment trap used as a construction period BMP.

Ability to meet specific standards

Standard	Description
2 - Peak Flow	Provides no peak flow attenuation
3 - Recharge	Provides no groundwater recharge
4 - TSS Removal	MassDEP requires a sediment forebay as pretreatment before stormwater is discharged to an extended dry detention basin, wet basin, constructed stormwater wetland or infiltration basin. No separate credit is given for the sediment forebay. For example, extended dry detention basins with sediment forebays receive a credit for 50% TSS removal. Wet basins and constructed stormwater wetlands with sediment forebays receive a credit for 80% TSS removal. When they provide pretreatment for other BMPs, sediment forebays receive a 25% TSS removal credit.
5 - Higher Pollutant Loading	Recommended as a pretreatment BMP
6 - Discharges near or to Critical Areas	Recommended as a pretreatment BMP
7 - Redevelopment	Usually not suitable due to land use constraints

Advantages/Benefits:

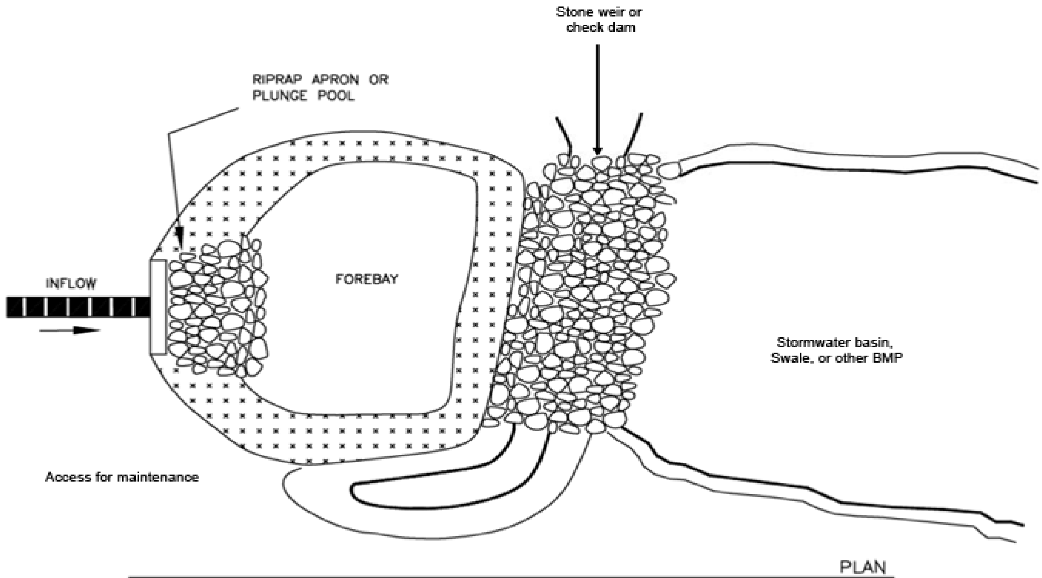
- Provides pretreatment of runoff before delivery to other BMPs.
- Slows velocities of incoming stormwater
- Easily accessed for sediment removal
- Longevity is high with proper maintenance
- Relatively inexpensive compared to other BMPs
- Greater detention time than proprietary separators

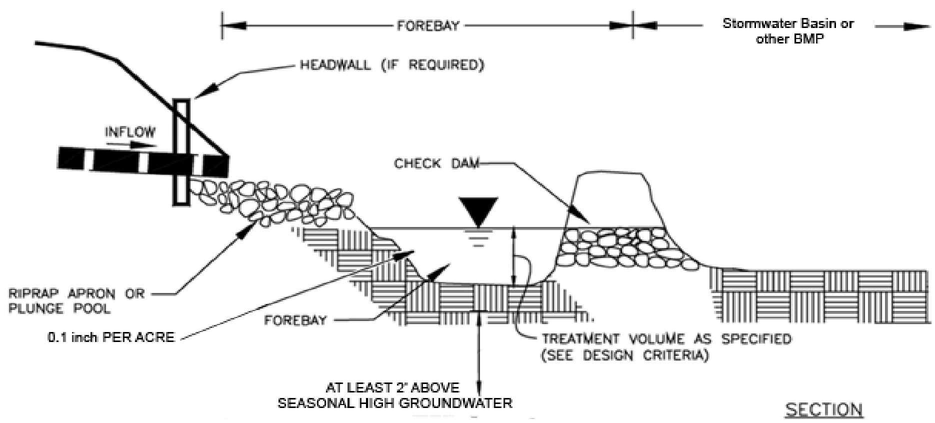
Disadvantages/Limitations:

- Removes only coarse sediment fractions
- No removal of soluble pollutants
- Provides no recharge to groundwater
- No control of the volume of runoff
- Frequent maintenance is essential

Pollutant Removal Efficiencies

- Total Suspended Solids (TSS) - 25%
- Nutrients (Nitrogen, phosphorus) - Insufficient data
- Metals (copper, lead, zinc, cadmium) - Insufficient data
- Pathogens (coliform, e coli) - Insufficient data





adapted from the Vermont Stormwater Handbook

Maintenance

Activity	Frequency
Inspect sediment forebays	Monthly
Clean sediment forebays	Four times per year and when sediment depth is between 3 to 6 feet.

Special Features

MassDEP requires a sediment forebay as pretreatment before discharging to a dry extended detention basin, wet basin, constructed stormwater wetland, or infiltration basin.

MassDEP uses the term sediment forebay for BMPs used to pretreat stormwater after construction is complete and the site is stabilized. MassDEP uses the term sediment trap to refer to BMPs used for erosion and sedimentation control during construction. For information on the design and construction of sediment traps used during construction, consult the Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas: A Guide for Planners, Designers and Municipal Officials.

Sediment Forebays

Design

Sediment forebays are typically on-line units, designed to slow stormwater runoff and settle out sediment.

At a minimum, size the volume of the sediment forebay to hold 0.1-inch/impervious acre to pretreat the water quality volume.

When routing the 2-year and 10-year storms through the sediment forebay, design the forebay to withstand anticipated velocities without scouring.

A typical forebay is excavated below grade with earthen sides and a stone check dam.

Design elevated embankments to meet applicable safety standards.

Stabilize earth slopes and bottoms using grass seed mixes recommended by the NRCS and capable of resisting the anticipated shearing forces associated with velocities to be routed through the forebay. Use only grasses. Using other vegetation will reduce the storage volume in the forebay. Make sure that the selected grasses are able to withstand periodic inundation under water, and drought- tolerant during the summer. MassDEP recommends using a mix of grasses rather than relying upon a single grass species.

Alternatively, the bottom floor may be stabilized with concrete or stone to aid maintenance. Concrete floors or pads, or any hard bottom floor, greatly facilitate the removal of accumulated sediment.

When the bottom floor is vegetated, it may be necessary to remove accumulated sediment by hand, along with re-seeding or re-sodding grasses removed during maintenance.

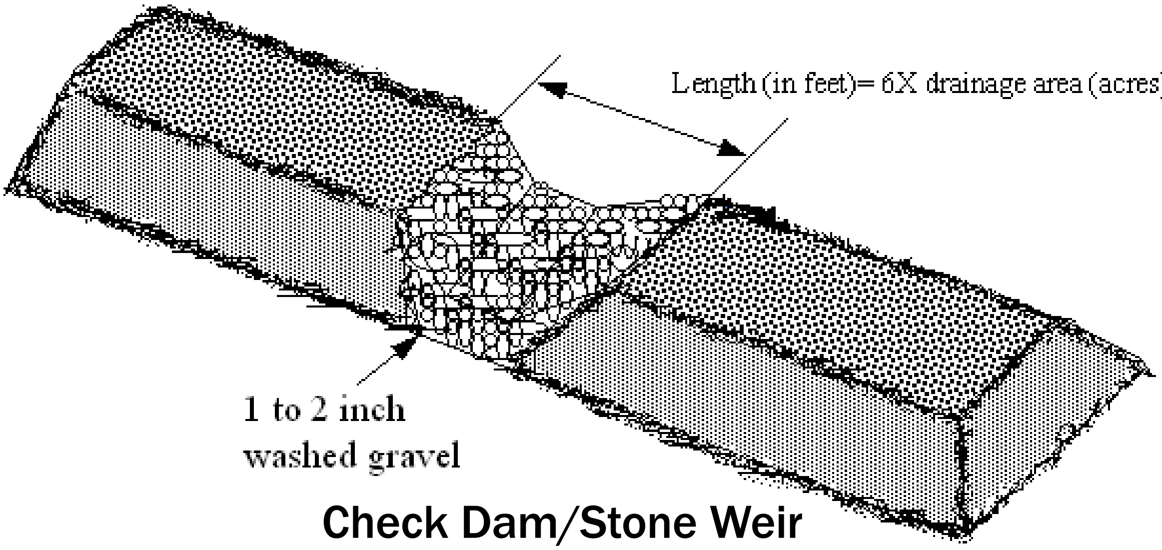
Design sediment forebays to make maintenance accessible and easy. If machinery is required to remove the sediment, carefully incorporate equipment access in the design. Sediment forebays may require excavation so concrete flooring may not always be appropriate.

Include sediment depth markers to simplify inspections. Sediment markers make it easy to determine when the sediment depth is between 3 and 6 feet and needs to be removed. Make the side slopes of sediment forebays no steeper than 3:1. Design the sediment forebay so that the discharge or outflow velocity can control the 2-year peak discharge without scour. Design the channel geometry to prevent erosion from the 2-year peak discharge.

Do not confuse post-construction sediment forebays with the sediment traps used as a construction-period control. Construction-period sediment control traps are sized larger than forebays, because there is a greater amount of suspended solids in construction period runoff. Construction-period sediment traps are sized based on drainage area and not impervious acre. Never use a construction-period sediment trap for post-construction drainage purposes unless it is first brought off-line, thoroughly cleaned (including check dam), and stabilized before being made re-operational.

Refer to the section of this chapter for information on the design of the check dam component of the sediment forebay. Set the minimum elevation of the check dam to hold a volume of 0.1-inch of runoff/ impervious acre. Check dam elevations may be uniform or they may contain a weir (e.g., when the top of the check dam is set to the 2-year or 10-year storm, and the bottom of the weir is set to the top of the 0.1-inch/impervious acre volume). When a weir is included in a stone berm, make sure that the weir is able to hold its shape. Fabric or wire may be required.

Unless part of a wet basin, post construction sediment forebays must be designed to dewater between storms. Set the bottom of the forebay at a minimum of 2 feet above seasonal high groundwater, and place pervious material on the bottom floor to facilitate dewatering between storms. For design purposes, use 72 hours to evaluate dewatering, using the storm that produces either the ½ inch or 1-inch of runoff (water quality volume) in a 24-hour period. A stone check dam can act as a filter berm, allowing water to percolate through the check dam. Depending on the head differential, a stone check dam may allow greater dewatering than an earthen berm.



Check Dam/Stone Weir

MassDEP Stormwater Handbook, 1996

Maintenance

Sediments and associated pollutants are removed only when sediment forebays are actually cleaned out, so regular maintenance is essential. Frequently removing accumulated sediments will make it less likely that sediments will be resuspended. At a minimum, inspect sediment forebays monthly and clean them out at least four times per year. Stabilize the floor and sidewalls of the sediment forebay before making it operational, otherwise the practice will discharge excess amounts of suspended sediments. When mowing grasses, keep the grass height no greater than 6 inches. Set mower blades no lower than 3 to 4 inches. Check for signs of rilling and gullying and repair as needed. After removing the sediment, replace any vegetation damaged during the clean-out by either reseeding or re-sodding. When reseeding, incorporate practices such as hydroseeding with a tackifier, blanket, or similar practice to ensure that no scour occurs in the forebay, while the seeds germinate and develop roots.

Bioretention Areas & Rain Gardens

Description: Bioretention is a technique that uses soils, plants, and microbes to treat stormwater before it is infiltrated and/or discharged. Bioretention cells (also called rain gardens in residential applications) are shallow depressions filled with sandy soil topped with a thick layer of mulch and planted with dense native vegetation. Stormwater runoff is directed into the cell via piped or sheet flow. The runoff percolates through the soil media that acts as a filter.

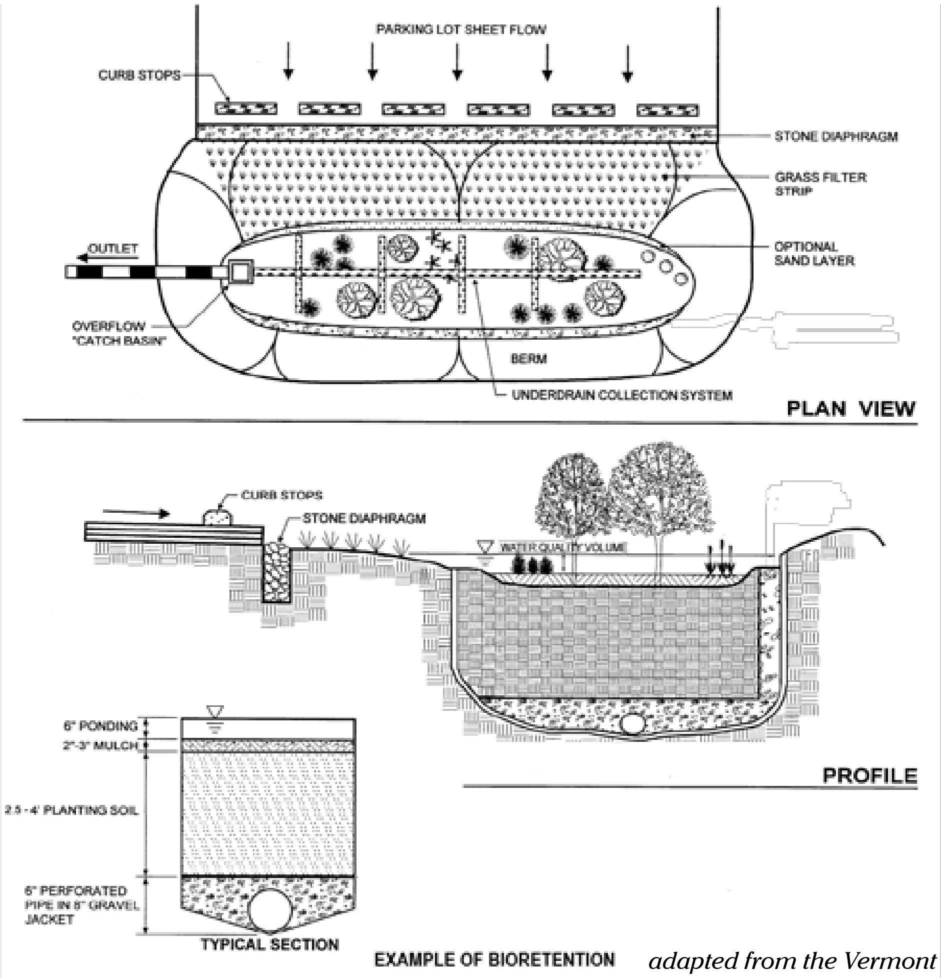
There are two types of bioretention cells: those that are designed solely as an organic filter filtering bioretention areas and those configured to recharge groundwater in addition to acting as a filter exfiltrating bioretention areas. A filtering bioretention area includes an impermeable liner and underdrain that intercepts the runoff before it reaches the water table so that it may be conveyed to a discharge outlet, other best management practices, or the municipal storm drain system. An exfiltrating bioretention area has an underdrain that is designed to enhance exfiltration of runoff into the groundwater.

Ability to meet specific standards

Standard	Description
2 - Peak Flow	N/A
3 - Recharge	An exfiltrating bioretention area provides groundwater recharge.
4 - TSS Removal	90% TSS removal credit with adequate pretreatment
5 - Higher Pollutant Loading	Can be used for certain land uses with higher potential pollutant loads if lined and sealed until adequate pretreatment is provided. Adequate pretreatment must include 44% TSS removal prior to infiltration. For land uses that have the potential to generate runoff with high concentrations of oil and grease such as high intensity use parking lots and gas stations, adequate pretreatment may also include an oil grit separator, sand filter or equivalent. In lieu of an oil grit separator or sand filter, a filtering bioretention area also may be used as a pretreatment device for infiltration practices exfiltrating runoff from land uses with a potential to generate runoff with high concentrations of oil and grease.
6 - Discharges near or to Critical Areas	Good option for discharges near cold-water fisheries. Should not be used near bathing beaches and shellfish growing areas.
7 - Redevelopment	Suitable with appropriate pretreatment

Pollutant Removal Efficiencies

• Total Suspended Solids (TSS)	90% with vegetated filter strip or equivalent
• Total Nitrogen	30% to 50% if soil media at least 30 inches
• Total Phosphorus	30% to 90%
• Metals (copper, lead, zinc, cadmium)	40% to 90%
• Pathogens (coliform, e coli)	Insufficient data



adapted from the Vermont Stormwater Manual

Special Features:
- Can be lined and sealed to prevent recharge where appropriate
- Adequate pretreatment is essential
- Not recommended in areas with steep slope
- Depth of soil media depends on type of vegetation that is proposed
- Soil media must be 30 inches deep to achieve removal of nitrogen

Advantages/Benefits:
- Can be designed to provide groundwater recharge and preserves the natural water balance of the site
- Can be designed to prevent recharge where appropriate
- Supplies shade, absorbs noise, and provides windbreaks
- Can remove other pollutants besides TSS including phosphorus, nitrogen and metals
- Can be used as a stormwater retrofit by modifying existing landscape or if a parking lot is being resurfaced
- Can be used on small lots with space constraints
- Small rain gardens are mosquito death traps
- Little or no hazard for amphibians or other small animals

Disadvantages/Limitations:
- Requires careful landscaping and maintenance
- Not suitable for large drainage areas

Maintenance

Activity	Frequency
Inspect and remove trash	Monthly
Mow	2 to 12 times per year
Mulch	Annually
Fertilize	Annually
Remove dead vegetation	Annually
Prune	Annually

Bioretention Areas & Rain Gardens

Not all bioretention cells are designed to exfiltrate. Only the infiltration requirements are applicable to bioretention cells intended to exfiltrate.

Applicability

Bioretention areas can provide excellent pollutant removal for the "first flush" of stormwater runoff. Properly designed and maintained cells remove suspended solids, metals, and nutrients, and can infiltrate an inch or more of rainfall. Distributed around a property, vegetated bioretention areas can enhance site aesthetics. In residential developments they are often described as "rain gardens" and marketed as property amenities. Routine maintenance is simple and can be handled by homeowners or conventional landscaping companies, with proper direction.

Bioretention systems can be applied to a wide range of commercial, residential, and industrial developments in many geologic conditions; they work well on small sites and on large sites divided into multiple small drainage areas. Bioretention systems are often well suited for ultra-urban settings where little pervious area exists. Although they require significant space (approximately 5% to 7% of the area that drains to them), they can be integrated into parking lots, parking lot islands, median strips, and traffic islands. Sites can be retrofitted with bioretention areas by replacing existing parking lot islands or by re-configuring a parking lot during resurfacing. On residential sites, they are commonly used for rooftop and driveway runoff.

Effectiveness

Bioretention areas remove pollutants through filtration, microbe activity, and uptake by plants; contact with soil and roots provides water quality treatment better than conventional infiltration structures. Studies indicate that bioretention areas can remove from 80% to 90% of TSS. If properly designed and installed, bioretention areas remove phosphorus, nitrogen, metals, organics, and bacteria to varying degrees.

Bioretention areas help reduce stress in watersheds that experience severe low flows due to excessive impervious cover. Low-tech, decentralized bioretention areas are also less costly to design, install, and maintain than conventional stormwater technologies that treat runoff at the end of the pipe.

Decentralized bioretention cells can also reduce the size of storm drain pipes, a major component of stormwater treatment costs. Bioretention areas enhance the landscape in a variety of ways: they improve the appearance of developed sites, provide windbreaks, absorb noise, provide wildlife habitat, and reduce the urban heat island effect.

Planning Considerations

Filtering bioretention areas are designed with an impermeable liner and underdrain so that the stormwater may be transported to additional BMPs for treatment and/or discharge. Exfiltrating bioretention areas are designed so that following treatment by the bioretention area the stormwater may recharge the groundwater.

Both types of bioretention areas may be used to treat runoff from land uses with higher potential pollutant loads. However, exfiltrating bioretention areas may be used to treat runoff from land uses with higher potential pollutant loads, only if pretreatment has been provided to achieve TSS removal of at least 44%. If the land use has the potential to generate runoff with high concentrations of oil and grease, other types of pretreatment, i.e., a deep sump catch basin and oil grit separator or a sand filter, is required prior to discharge of runoff to an exfiltrating bioretention area. A filtering bioretention area may also be used as a pretreatment device for an exfiltrating bioretention area or other infiltration practice that exfiltrates runoff from land uses with a potential to generate runoff with high concentrations of oil and grease.

To receive 90% TSS removal credit, adequate pretreatment must be provided. If the flow is piped to the bioretention area a deep sump catch catch basin and sediment forebay should be used to provide pretreatment. For sheet flow, there are a number or pretreatment options. These options include:

- A vegetated filter strip, grass channel or water quality swale designed in accordance with the specifications set forth in Chapter 2.
- A grass and gravel combination. This should consist of at least 8 inches of gravel followed by 3 to 5 feet of sod. (source: North Carolina Stormwater Manual, 2007, http://h2o.enr.state.nc.us/su/documents/Ch12-Bioretention_001.pdf)
- Pea diaphragm combined with a vegetated filter strip specially designed to provide pretreatment for a bioretention area as set forth in the following table. (source: Georgia Stormwater Manual and Claytor and Schuler 1996)

Dimensions for Filter Strip Designed Specially to Provide Pretreatment for Bioretention Area

Parameter	Impervious Area				Pervious Areas (lawns, etc.)			
Maximum inflow approach length (feet)	35		75		75		100	
Filter strip slope (max=6%)	<2%	>2%	<2%	>2%	<2%	>2%	<2%	>2%
Filter strip minimum length (feet)	10	15	20	25	10	12	15	18

Bioretention areas must not be located on slopes greater than 20%. When the bioretention area is designed to exfiltrate, the design must ensure vertical separation of at least 2 feet from the seasonal high groundwater table to the bottom of the bioretention cell.

For residential rain gardens, pick a low spot on the property, and route water from a downspout or sump pump into it. It is best to choose a location with full sun, but if that is not possible, make sure it gets at least a half-day of sunlight.

Do not excavate an extensive rain garden under large trees. Digging up shallow feeder roots can weaken or kill a tree. If the tree is not a species that prefers moisture, the additional groundwater could damage it. Size the bioretention area using the methodology set forth in Volume 3.

Design

Size the bioretention area to be 5% to 7% of the area draining to it. Determine the infiltrative capacity of the underlying native soil by performing a soil evaluation in accordance with Volume 3. Do not use a standard septic system (i.e., Title 5) percolation test to determine soil permeability.

The depth of the soil media must be between 2 and 4 feet. This range reflects the fact that most of the pollutant removal occurs within the first 2 feet of soil and that excavations deeper than 4 feet become expensive. The depth selected should accommodate the vegetation. If the minimum depth is used, only shallow rooted plants and grasses my be used. If there is a Total Maximum Daily Load that requires nitrogen to be removed from the stormwater dischrges, the bioretention area should have a soil media with a depth of at least 30 inches, because nitrogen removal takes place 30 inches below the ground surface. If trees and shrubs are to be planted, the soil media should be at least 3 feet.

Size the cells (based on void space and ponding area) at a minimum to capture and treat the required water quality volume (the first 0.5 inch or 1 inch of runoff) if intended to be used for water quality treatment (Stormwater Standard No. 4), the required recharge volume if used for recharge (Stormwater Standard No. 3), or the larger of the two volumes if used to achieve compliance with both Stormwater Standards 3 and 4.

Cover the bottom of the excavation with coarse gravel, over pea gravel, over sand. Earlier designs used filter fabric as a bottom blanket, but more recent experiences show that filter fabric is prone to clogging. Consequently, do not use fabric filters or sand curtains. Use the Engineered Soil Mix below.

Engineered Soil Mix for Bioretention Systems Designed to Exfiltrate

- The soil mix for bioretention areas should be a mixture of sand compost and soil.
  - o 40 % sand,
  - o 20-30% topsoil, and
  - o 30-40% compost.

- The soil mix must be uniform, free of stones, stumps, roots or similar objects larger than 2 inches. Clay content should not exceed 5%.
- Soil pH should generally be between 5.5-6.5, a range that is optimal for microbial activity and adsorption of nitrogen, phosphorus, and other pollutants.
- Use soils with 1.5% to 3% organic content and maximum 500-ppm soluble salts.
- The sand component should be gravelly sand that meets ASTM D 422.

Sieve Size	**Percent Passing**
2-inch	100
¾-inch	70-100
¼-inch	50-80
U.S. No. 40	15-40
U.S. No. 200	0-3

- The topsoil component shall be a sandy loam, loamy sand or loam texture.
- The compost component must be processed from yard waste in accordance with MassDEP Guidelines (see http://www.mass.gov/dep/recycle/reduce/leafguid.doc). The compost shall not contain biosolids.

On-site soil mixing or placement is not allowed if soil is saturated or subject to water within 48 hours. Cover and store soil to prevent wetting or saturation.

Test soil for fertility and micro-nutrients and, only if necessary, amend mixture to create optimum conditions for plant establishment and early growth.

Grade the area to allow a ponding depth of 6 to 8 inches; depending on site conditions, more or less ponding may be appropriate.

Cover the soil with 2 to 3 inches of fine-shredded hardwood mulch.

The planting plan shall include a mix of herbaceous perennials, shrubs, and (if conditions permit) understory trees that can tolerate intermittent ponding, occasional saline conditions due to road salt, and extended dry periods. A list of plants that are suitable for bioretention areas can be found at the end of this section. To avoid a monoculture, it is a good practice to include one tree or shrub per 50 square feet of bioretention area, and at least 3 species each of herbaceous perennials and shrubs. Invasive and exotic species are prohibited. The planting plan should also meet any applicable local landscaping requirements.

All exfiltrating bioretention areas must be designed to drain within 72 hours. However, rain gardens are typically designed to drain water within a day and are thus unlikely to breed mosquitoes.

Bioretention cells, including rain gardens, require pretreatment, such as a vegetated filter strip. A stone or pea gravel diaphragm or, even better, a concrete level spreader upstream of a filter strip will enhance sheet flow and sediment removal.
Bioretention cells can be dosed with sheet flow, a surface inlet, or pipe flow. When using a surface inlet, first direct the flow to a sediment forebay. Alternatively, piped flow may be introduced to the bioretention system via an underdrain.

For bioretention cells dosed via sheet flow or surface inlets, include a ponding area to allow water to pond and be stored temporarily while stormwater is exfiltrating through the cell. Where bioretention areas are adjacent to parking areas, allow three inches of freeboard above the ponding depth to prevent flooding.

Most bioretention cells have an overflow drain that allows ponded water above the selected ponding depth to be dosed to an underdrain. If the bioretention system is designed to exfiltrate, the underdrain is not connected to an outlet, but instead terminates in the bioretention cell. If the bioretention area is not designed to exfiltrate, the underdrain is connected to an outlet for discharge or conveyance to additional best management practices.

Construction

During construction, avoid excessively compacting soils around the bioretention areas and accumulating silt around the drain field. To minimize sediment loading in the treatment area, direct runoff to the bioretention area only from areas that are stabilized; always divert construction runoff elsewhere.

To avoid compaction of the parent material, work from the edge of the area proposed as the location of an exfiltrationg bioretention cell. Never direct runoff to the cell until the cell and the contributing drainage areas are fully stabilized.

Place planting soils in 1-foot to 2-foot lifts and compact them with minimal pressure until the desired elevation is reached. Some engineers suggest flooding the cell between each lift placement in lieu of compaction.

Maintenance

Premature failure of bioretention areas is a significant issue caused by lack of regular maintenance. Ensuring long-term maintenance involves sustained public education and deed restrictions or covenants for privately owned cells. Bioretention areas require careful attention while plants are being established

Bioretention Maintenance Schedule

Activity	*Time of Year*	*Frequency*
Inspect & remove trash	Year round	Monthly
Mulch	Spring	Annually
Remove dead vegetation	Fall or Spring	Annually
Replace dead vegetation	Spring	Annually
Prune	Spring or Fall	Annually
Replace entire media & all vegetation	Late Spring/early Summer	As needed*

** Paying careful attention to pretreatment and operation & maintenance can extend the life of the soil media* and seasonal landscaping maintenance thereafter.

In many cases, a landscaping contractor working elsewhere on the site can complete maintenance tasks. Inspect pretreatment devices and bioretention cells regularly for sediment build-up, structural damage, and standing water.

Inspect soil and repair eroded areas monthly. Re-mulch void areas as needed. Remove litter and debris monthly. Treat diseased vegetation as needed. Remove and replace dead vegetation twice per year (spring and fall).

Proper selection of plant species and support during establishment of vegetation should minimize—if not eliminate—the need for fertilizers and pesticides. Remove invasive species as needed to prevent these species from spreading into the bioretention area. Replace mulch every two years, in the early spring. Upon failure, excavate bioretention area, scarify bottom and sides, replace filter fabric and soil, replant, and mulch. A summary of maintenance activities can be found on the previous page.

Because the soil medium filters contaminants from runoff, the cation exchange capacity of the soil media will eventually be exhausted. When the cation exchange capacity of the soil media decreases, change the soil media to prevent contaminants from migrating to the groundwater, or from being discharged via an underdrain outlet. Using small shrubs and plants instead of larger trees will make it easier to replace the media with clean material when needed.

Plant maintenance is critical. Concentrated salts in roadway runoff may kill plants, necessitating removal of dead vegetation each spring and replanting. The operation and maintenance plan must include measures to make sure the plants are maintained. This is particularly true in residential subdivisions, where the operation and maintenance plan may assign each homeowner the legal responsibility to maintain a bioretention cell or rain garden on his or her property. Including the requirement in the property deed for new subdivisions may alert residential property owners to their legal responsibilities regarding the bioretention cells constructed on their lot.

Cold Climate Considerations

Never store snow in bioretention areas. The Operation and Maintenance plan must specify where on-site snow will be stored. All snow dumps must comply with MassDEP's guidance. When bioretention areas are located along roads, care must be taken during plowing operations to prevent snow from being plowed into the bioretention areas. If snow is plowed into the cells, runoff may bypass the cell and drain into downgradient wetlands without first receiving the required water quality treatment, and without recharging the groundwater.

References

Center for Watershed Protection, 2000, Bioretention as a Water Quality Best Management Practice, Article 110 from Watershed Protection Techniques; http://www.cwp.org/Downloads/ELC_PWP110.pdf
Federal Highway Administration , YEAR, Bioretention Fact Sheet, http://www.fhwa.dot.gov/environment/

Low Impact Development Center, 2003, Drainage – Bioretention Specification, http://www.lowimpactdevelopment.org/epa03/biospec.htm

Prince Georges County, 2002, Bioretention Manual, http://www.goprincegeorgescounty.com/der/bioretention.asp

Puget Sound Action Team, 2005, Low Impact Development, Pp. 174 - 184 http://www.psat.wa.gov/Publications/LID_tech_manual05/LID_manual2005.pdf

U.S. Environmental Protection Agency, 1999, Stormwater Technology Fact Sheet, Bioretention, EPA 832-F-99-012, http://www.epa.gov/owm/mtb/biortn.pdf

U.S. Environmental Protection Agency, 2005, National Management Measures to Control Nonpoint Source Pollution from Urban Areas, Publication Number EPA 841-B-05-004, Pp. 5-29 http://www.epa.gov/nps/urbanmm/

University of North Carolina,
www.bae.ncsu.edu/topic/bioretention
www.bae.ncsu.edu/stormwater/PublicationFiles/DesigningRainGardens2001.pdf

ATTACHMENT 2

RETROFIT DESIGN SUMMARY TABLE

Neponset River Watershed Association
Milton, MA Stormwater Retrofit Project
Retrofit Design Summary Table
Lafayette Street Area

Environmental Partners GROUP
A partnership for engineering solutions.

May 2013

BMP Designation Number	Catchment Area Description	Stormwater Best Management Practice	Drainage Area (sf)	Minimum Recommended Volume to Pretreat Water Quality Volume (0.1-inch/impervious acre)	Actual PreTreatment Volume (cf)	1-inch Water Quality Volume (cf)	Water Quality Volume Treated (cf)	% Water Quality Volume Treated
1	Lafayette-1	Sediment Forebay	94,115.00	784.29	516.00	7,842.92	516.00	6.58%
2	Lafayette-1	Existing Vegetated Area as Bioretention Basin	94,115.00	See Sediment Forebay	See Sediment Forebay	7,842.92	7,842.92	100.00%

Notes:

1. Assume all runoff is from impervious area
2. Intent of design is to use the existing vegetated area as a bioretention basin for treatment.
   The proposed design includes a sediment forebay for pretreatment and the removal of the existing piping.
3. Assume the volume of the existing vegetated area is more than adequate to treat the 1-inch water quality volume.
4. Due to lmited information, the actual size of the existing vegetated area was not calculated.

ATTACHMENT 3

RUNOFF AND POLLUTANT LOAD CALCULATIONS TABLE

Neponset River Watershed Association
Milton, MA Stormwater Retrofit Project
Runoff and Pollutant Load Calculations
Lafayette Street Area

Environmental Partners Group — A partnership for engineering solutions.

May 2013

BMP Designation Number	Catchment Area Description	Stormwater Best Management Practice	(A) Drainage Area (ac)	(R) Runoff (in)	(L) Annual TSS (lbs)	(L) Annual TP (lbs)	(L) Annual TN (lbs)	(L) Annual FC (billion colonies)
1 & 2	Lafayette 1	Sediment Forebay & Existing Vegetated Area as Bioretention Basin	2.16	41.55	3,489.88	11.16	28.41	342,146.66

Coefficients for Use in Polluted Load Calculations[1]:

Landuse	% Impervious	(C) TSS (mg/l)	(C) TP (mg/l)	(C) TN (mg/l)	Fecal Coliform (1,000 colonies/ml)
Residential Street	100%	172	0.55	1.40	37

Pollutant Loading Formulas - The Simple Method[1, 3]:

For TSS, TP, & TN:
L = 0.226 * R * C * A
Where: L = Annual load (lbs)
R = Annual runoff (inches)
C = Pollutant Concentration (mg/l)
A = Area (acres)
0.226 = Unit Conversion Factor

For Fecal Coliform (FC):
L = 103 * R * C * A
Where: L = Annual load (billion colonies)
R = Annual runoff (inches)
C = Bacteria concentration (1,000 colonies/ml)
A = Area (acres)
103 = Unit Conversion Factor

For Annual Runoff (R):
$R = P * P_j * Rv$
Where: R = Annual runoff (inches)
P = Annual rainfall (inches) = 48.6[2]
P_j = Fraction of rainfall events that produce runoff (assume 0.9)
Rv = Runoff coefficient = 0.05 + 0.9 Ia
Ia = Impervious fraction (%)

References:
1. New York State Stormwater Management Design Manual, Appendix A-The Simple Method to Calculate Urban Stormwater Loads
http://www.dec.ny.gov/docs/water_pdf/simple.pdf
2. Weatherbase - Average Annual Precipitation
http://www.weatherbase.com/weather/weather.php3?s=744920&cityname=Dedham-Massachusetts-United-States-of-America
3. The Simple Method: http://stormwatercenter.net/

ATTACHMENT 4

POLLUTANT REMOVAL CALCULATIONS TABLE

Neponset River Watershed Association
Milton, MA Stormwater Retrofit Project
Runoff and Pollutant Removal Calculations
Lafayette Street Area

Environmental Partners GROUP
A partnership for engineering solutions.

May 2013

			BMP Removal Efficiency					Quantity of Pollutant Removed			
BMP Designation Number	**Catchment Area Description**	**Stormwater Best Management Practice**	**(A) Drainage Area (ac)**	**TSS Removal (%)**	**TP Removal (%)**	**TN Removal (%)**	**Fecal Coliform Removal (%)**	**Annual TSS Removed (lbs)**	**Annual TP Removed (lbs)**	**Annual TN Removed (lbs)**	**Annual FC Removed (billion colonies)**
1	Lafayette 1	Sediment Forebay	2.16	25.0%	8.0%	3.0%	12.0%	872.47	0.89	0.85	41,057.60
2	Lafayette 1	Existing Vegetated Area as Bioretention Basin	2.16	90.0%	30.0%	30.0%	70.0%	2,355.67	3.08	8.27	210,762.34
							Lafayette Total Removal if 100% Annual Runoff is Treated =	**3,228.14**	**3.97**	**9.12**	**251,819.94**
							Assume BMP's Treat 90% of the Annual Runoff* =	**2,905.33**	**3.58**	**8.21**	**226,637.95**

Annual Calculated Pollutant Load (from Runoff and Pollutant Load Calculations)

BMP Designation Number	**Catchment Area Description**	**Annual TSS (lbs)**	**Annual TP (lbs)**	**Annual TN (lbs)**	**Annual FC (billion colonies)**
1 & 2	Lafayette 1	3,489.88	11.16	28.41	342,146.66

BMP Removal Efficiencies for Sediment Forebay[1,3]

Source	**TSS Removal (%)**	**TP Removal (%)**	**TN Removal (%)**	**Fecal Coliform or Bacteria (%)**
MA SW Handbook (sand & organic filters)	**25%**	N/A	N/A	N/A
Rhode Island Stormwater Manual	25%	**8%**	**3%**	**12%**

BMP Removal Efficiencies for Bioretention Basin[1,3]

Source	**TSS Removal (%)**	**TP Removal (%)**	**TN Removal (%)**	**Fecal Coliform or Bacteria (%)**
MA SW Handbook (sand & organic filters)	**90%**	**30%** - 50%	**30%** - 90%	N/A
Rhode Island Stormwater Manual	90%	30%	55%	**70%**

Note: Bold-faced values are the selected removal efficiencies

References:

1. Rhode Island Storm Water Manual 2010, Appendix H
http://www.dem.ri.gov/pubs/regs/regs/water/swmanual.pdf
2. New York State Stormwater Management Design Manual, Appendix A-The Simple Method to Calculate Urban Stormwater Loads
http://www.dec.ny.gov/docs/water_pdf/simple.pdf
3. Massachusetts Stormwater Handbook, Volume 2, Chapter 2: Structural BMP Specifications for the Massachusetts Stormwater Handbook
http://www.mass.gov/dep/water/laws/v2c2.pdf

* Remaining 10% would flow down Truro Lane during heavy stormwater events

ATTACHMENT 5

CONSTRUCTION COST ESTIMATE

Neponset River Watershed Association
Milton, MA Stormwater Retrofit Project
Preliminary Construction Cost Estimate
Lafayette Street Area

References:
A. MAPC South Shore Consortium Bid Prices 2013.
B. MA DOT Weighted Bid Prices 2013.

Item	Item Description	Qty	Unit	Unit Cost	Ext Cost	Reference	Notes
1	Site Preparation	1	LS	$5,000	$5,000	EPG Judgement	Installation of Erosion Control Matting, Temporary access ramps, filter sock, minor site grading repairs
2	12" Diameter Filter Sock for Erosion Control	200	LF	$2	$400	MAPC	Allowance. Assume erosion controls needed for forebay work and connecting to existing grades (approx 200 lf). Assume no erosion controls needed for existing pipe removal and disposal
3	Existing Drainage Piping, Removal and Disposal	350	LF	$40	$14,000	EPG Judgement	Assume no hazardous material. Assume removing and hauling to Town DPW yard, and Town will dispose of piping. Assume Town provides haul truck. 3-day removal
4	Sediment Forebay	1,300	SF	$18	$23,400	EPG Judgement	Includes new piping from existing drainage structure to forebay if needed, flared end, rip rap, stone weir/check dam, loam, seed, and connecting to existing grades. Assume maintenance is $1,200/year total for both sediment forebay and bioretention basin.
5	Installation of Berm in Existing Manhole at corner of Lafayette and Truro	1	Crew/Day	$2,500	$2,500	EPG Judgement	Assume 1 crew, 1 day, to install berm.
6	Loam Borrow	100	CY	$30	$3,000	EPG Judgement	Allowance.
7	Wetland Restoration	1	LS	$3,000	$3,000	EPG Judgement	Allowance for restoration of temporary impacted wetland areas
7	Seeding	250	SY	$1	$250	EPG Judgement	Allowance.
	Construction Subtotal				**$51,550**		
	Permitting				$7,000		Conservation Commission Notice of Intent/Hearing, likely minor wetland restoration
	General Conditions (10%)				$5,155		Bonds, Insurance, Mobilization
	Const. Admin/Resident Engineering (15%)				$7,733		
	Contingency (15%)				$7,733		
	Total Construction Cost				**$79,170**		

ATTACHMENT 6

DRAINAGE AREA PLAN

0 50 100 150
SCALE IN FEET
SCALE: 1"=50'

TOWN OF MILTON SETTLED 1640 INCORPORATED 1662

Environmental Partners GROUP
A partnership for engineering solutions.

MARK	DATE	DESCRIPTION

Scale	1"=50'-0"
Date	5/23/13
Job No.	299-1301
Designed by	SDB
Drawn by	SDB
Checked by	CCF
Approved by	CCF

THIS LINE IS ONE INCH LONG WHEN PLOTTED AT FULL SCALE ON A 22" X 34" DRAWING

MILTON STORMWATER RETROFIT PROJECT
NEPONSET RIVER WATERSHED ASSOCIATION &
TOWN OF MILTON, MASSACHUSETTS

LAFAYETTE STREET

DRAINAGE AREAS

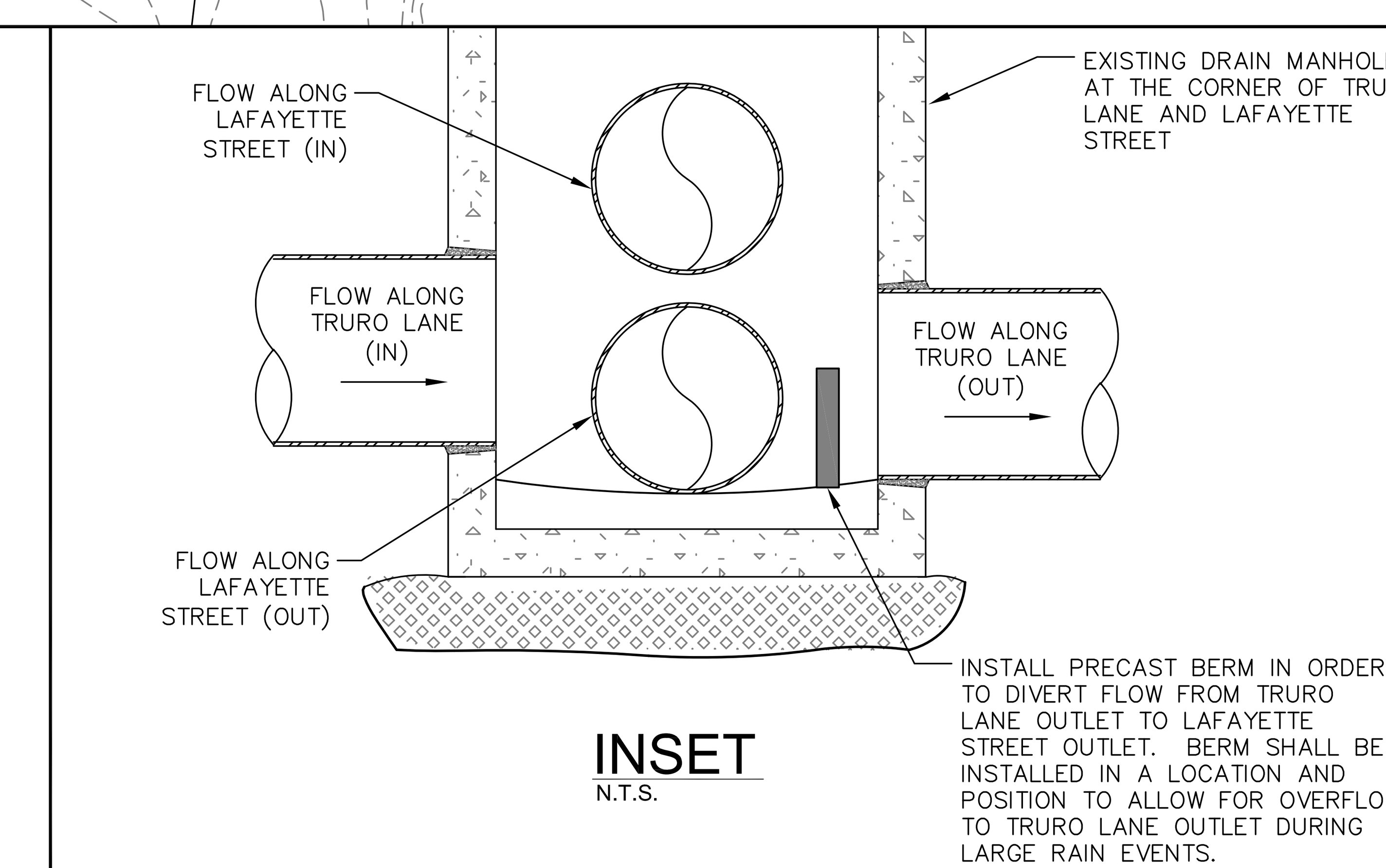
NOT FOR CONSTRUCTION

Sheet No.

C-2A

ATTACHMENT 7

CONCEPTUAL DESIGN PLAN



INSET
N.T.S.

Drawing file: I:\Milton\2. Stormwater BMP's\4. Design\Drawings\Lafayette\Lafayette Design Crop.dwg Plot Date: May 23,2013-12:35pm

TOWN OF MILTON — SETTLED 1640 · INCORPORATED 1662

Environmental Partners GROUP
A partnership for engineering solutions.

MARK	DATE	DESCRIPTION

Scale	AS SHOWN
Date	5/23/13
Job No.	299-1301
Designed by	SDB
Drawn by	SDB
Checked by	CCF
Approved by	CCF

THIS LINE IS ONE INCH LONG WHEN PLOTTED AT FULL SCALE ON A 22" X 34" DRAWING

MILTON STORMWATER RETROFIT PROJECT
NEPONSET RIVER WATERSHED ASSOCIATION &
TOWN OF MILTON, MASSACHUSETTS

LAFAYETTE STREET

CONCEPTUAL BMP DESIGN

NOT FOR CONSTRUCTION

Sheet No.

C-2

Environmental Partners GROUP
A partnership for engineering solutions.

June 7, 2013

Mr. William Guenther
Neponset River Watershed Association
2173 Washington Street
Canton, MA 02021

RE: Stormwater BMP's
Town of Milton, MA
Sumner Street Area

Dear Mr. Guenther:

Environmental Partners Group, Inc. (EPG) is submitting this design package for the selected Stormwater Best Management Practices (BMP's) for the Sumner Street area in Milton, MA. This project involves retrofitting stormwater BMP's considering various site constraints and preferences.

Following an evaluation of over a dozen sites in Milton, this area was selected as a "top 3" candidate for stormwater BMP design because of its potential relatively low cost, available space, its discharge area to a distressed waterbody, the amount of impervious surface treated, and technical ability to retrofit a Low Impact Development (LID) Stormwater BMP.

The Sumner Street area is located between Canton Avenue and Gould Lane. It is a dense residential area that receives stormwater runoff from impervious surfaces. It also includes an open space/park area with a walking/jogging trail that is highly used by the residents. The area abuts Pope's Pond. There are currently stormwater systems in the area (catch basins, manholes, and piping) that interconnect and eventually discharge directly into a tributary to Pope's Pond/Pope's Pond, via 3 different outlets. Pope's Pond is a tributary to Pine Tree Brook. Pine Tree Brook is considered an EPA Category 5 TMDL-impaired waterbody due to pathogens, low dissolved oxygen and organic enrichment.

This area has been split into 3 different watershed areas. For each of these watershed areas, Stormwater BMP Practices have been selected based on the existing features and uses. The goal of the Stormwater BMP's is to provide additional treatment to the stormwater runoff from this area, prior to discharge into a Pope's Pond.

A total of 5 Stormwater BMP's were designed based on each watershed, the location of the site, the size of the impervious area, existing utilities, and abutting wetlands. The proposed Stormwater BMP's include a wet swale, sediment forebay, bioretention basin, and 4'x6' Filterra Bioretention Systems. One test was performed in the approximate location of the proposed bioretention basin. Due to the nature of the soil (silt/topsoil), groundwater elevation observed (~4' bgs), and nature of the proposed BMP (Bioretention Basin) a sample was not sent to a laboratory for evaluation.

The first watershed area discharges to an existing unvegetated swale that empties directly into Pope's Pond. The intent in this area is to use the existing swale as a proposed wet swale and perform maintenance/upgrades such as grading to fix the washouts, low points, and high points, install rip rap check dams, and expose and clean the existing pipe culvert that carries the stormwater from the swale, below the walking/jogging path, to Pope's Pond. The total amount of impervious area within this watershed is 1.70 Acres, and the recommended pretreatment water quality volume is 0.1-inch per impervious acre, or 615 cubic feet. The estimated proposed pretreatment volume of the wet swale is 1,000 cubic feet. The annual runoff has been calculated to be 41.55 inches (based on average annual precipitation). Therefore, the swale can treat approximately 256,405/ cubic feet/1.92 million gallons) over the 1.7 acres of impervious surface.

The second watershed area (0.61 impervious acres) includes an existing drainage pipe that discharges directly from a stormwater system on Sumner Street (catch basins and manhole) to a tributary to Pope's Pond. The intent in this area is to use the existing stormwater pipe and outlet, and retrofit a combined sediment forebay/bioretention basin within the pipe run. The existing pipe would be cut and capped, and new piping would be installed in order to carry the stormwater from the existing pipe into the proposed forebay, then from the proposed bioretention basin back into the existing pipe.

The total amount of impervious area within this watershed is 0.61 Acres, and the 1-inch Water Quality Volume (WQV) is 2,217 cubic feet. The total estimated proposed volume of the bioretention basin (below outlet invert) is 2,337 cubic feet. According to the Massachusetts Stormwater Handbook, the recommended volume for the proposed forebay to pretreat water quality volume is 0.1-inch per impervious acre, or 221 cubic feet. The estimated proposed pretreatment volume of the forebay is 322 cubic feet. The annual runoff has been calculated to be 41.55 inches (based on average annual precipitation). Therefore, the forebay/bioretention basin can treat approximately 92,004 cubic feet/717,632 gallons) over the 0.61 acres of impervious surface.

The third watershed area is relatively small (0.2 impervious acres), and due to the location and nature of the existing stormwater system, and the existing grades, two 4'x6' Filterra Bioretention Systems are proposed (one on either side of the Trout Brook Avenue intersection). The 4'x6' Filterra Bioretention System can treat up to 0.32 acres of impervious area (based on Filterra's Northeast Region Engineering Design Assistance Kit, and Recommended Commercial Contributing Drainage Area, where C=0.85). This system is designed to treat the first flush of a rain event (1" of rain over the impervious area). The expected maximum flow rate for this system is 0.056 cf/s.

Based on Filterra's Northeast Region Engineering Design Assistance Kit, the system can treat 90% of the annual runoff. The total amount of impervious area within this watershed is 0.20 acres; however, the road is crowned, so each of the proposed systems would treat 0.10 Acres. The annual runoff has been calculated to be 41.55 inches (based on average annual precipitation). Therefore, the two systems can treat 37.4 inches of rain annually (27,181 cubic feet/203,331 gallons) over the 0.20 acres of impervious surface. Due to the expected flow rate capacity of the system, the system is recommended to be designed with an overflow. The intent is to use the existing catch basins as overflows for each of the systems.

The annual runoff has been calculated to be 41.55 inches (based on average annual precipitation). It has been calculated that the annual removal totals for all of the proposed Stormwater BMP's (5 total: wet swale, sediment forebay, bioretention basin, and two 4'x6' Filterra Bioretention Systems) is approximately 3,510 lbs of TSS, 5.85 lbs of TP, 10.32 lbs of TN, and 250,675 billion colonies of Fecal Coliform. The total amount of water treated would be approximately 2.84 million gallons.

The total estimated construction cost for this proposed design is $227,922 with an annual O&M cost of $3,000 ($1,000 for the two Filterra Bioretention Systems, $800 for the wet swale, and $1,200 for the sediment forebay and bioretention basin). However, the option of installing some of the proposed systems now (and possibly installing the remainder at a later date) to lower the cost in order to potentially install BMP's elsewhere on another site is a possibility. Other opportunities to reduce the costs include use of Town-owned forces to self-perform much of the work (e.g., pipe removal) and Construction Administration/Resident Engineering.

Should you have any questions or concerns regarding the enclosed documents or the project in general, please do not hesitate to contact me. You can reach me via e-mail (ccf@envpartners.com) or telephone 617-657-0254.

Very Truly Yours,
Environmental Partners Group, Inc.

C. Carter Fahy, P.E., LSP
Principal

Attachments:

1. Selected BMP Information
2. Retrofit Design Summary Table
3. Runoff and Pollutant Load Calculations Table
4. Pollutant Removal Calculations Table
5. Cost Estimate
6. Drainage Area Plan
7. Conceptual Design Plan
8. Test Pit Log

cc: John Thompson/Dale Horsman, Town of Milton DPW
Steven Belanger, EPG
File

ATTACHMENT 1

SELECTED BMP INFORMATION

5.7 Open Channel Systems

Source: HW Group File Photo

Description: Open channel systems are vegetated open channels that are explicitly designed to capture and treat the full WQ_v within dry or wet cells formed by check dams or other means. Design variants include Dry Swales and Wet Swales.

KEY CONSIDERATIONS

FEASIBILITY

- Maximum longitudinal slope of 4%, without checkdams.

CONVEYANCE

- Non-erosive (3.5 to 5.0 fps) peak velocity for the 1-year storm.
- Safe conveyance of the 10-year storm.
- Side slopes gentler than 2:1 (3:1 preferred).
- The maximum allowable temporary ponding time of 48 hours.

PRETREATMENT

- 10% of the WQ_v in pretreatment, usually provided using check dams at culverts or driveway crossings.

TREATMENT

- Storage of WQ_v in facility (wet swale) or through properly sized filter media/bioretention soil (dry swale).
- Bottom width no greater than 8 feet, but no less than 2 feet.
- Dry Swale utilizes bioretention soil media as detailed in Appendix F.

STORMWATER MANAGEMENT SUITABILITY

- [x] Water Quality
- [x] Recharge
- [x] Channel Protection*
- [ ] Overbank Flood Control

* Generally applies only to wet swale

Accepts LUHPPL Runoff: *Yes (requires impermeable liner for water quality treatment)*

IMPLEMENTATION CONSIDERATIONS

L	Capital Cost
L	Maintenance Burden

Residential/Subdivision Use: *Yes*

High Density/Ultra-Urban: *No*

Drainage Area: *5 acres max. to one inlet*

Soils: *No restrictions*

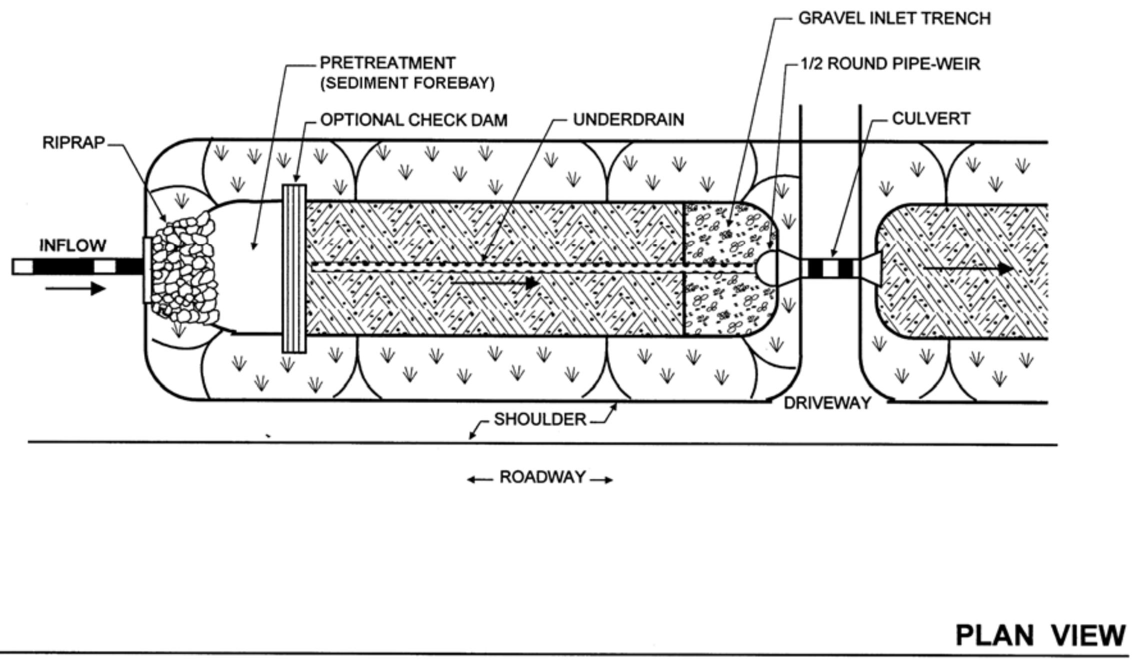
Other Considerations:

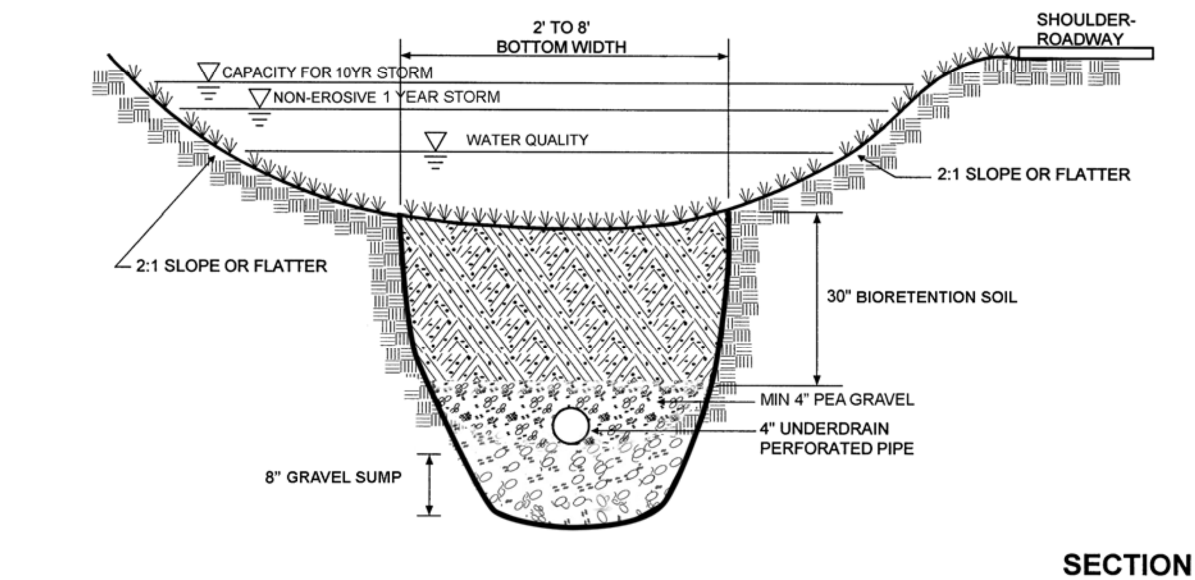
- Bioretention soil layer (Dry Swale)
- Emergent plants (Wet Swale)

Key: L=Low M=Moderate H=High

MAINTENANCE REQUIREMENTS:	POLLUTANT REMOVAL	
• Legally binding maintenance agreement. • Removal of sediment build-up within the bottom of the channel when 25% of the original WQ_v volume has been exceeded. • Maintain an average grass height of 6" in dry swales. • Correct erosion gullies and maintain healthy stand of vegetation.	G	Phosphorus
	G	Nitrogen
	G	Metals - Cadmium, Copper, Lead, and Zinc removal
	F	Pathogens - Coliform, Streptococci, E. coli removal
	Key: G=Good F=Fair P=Poor	

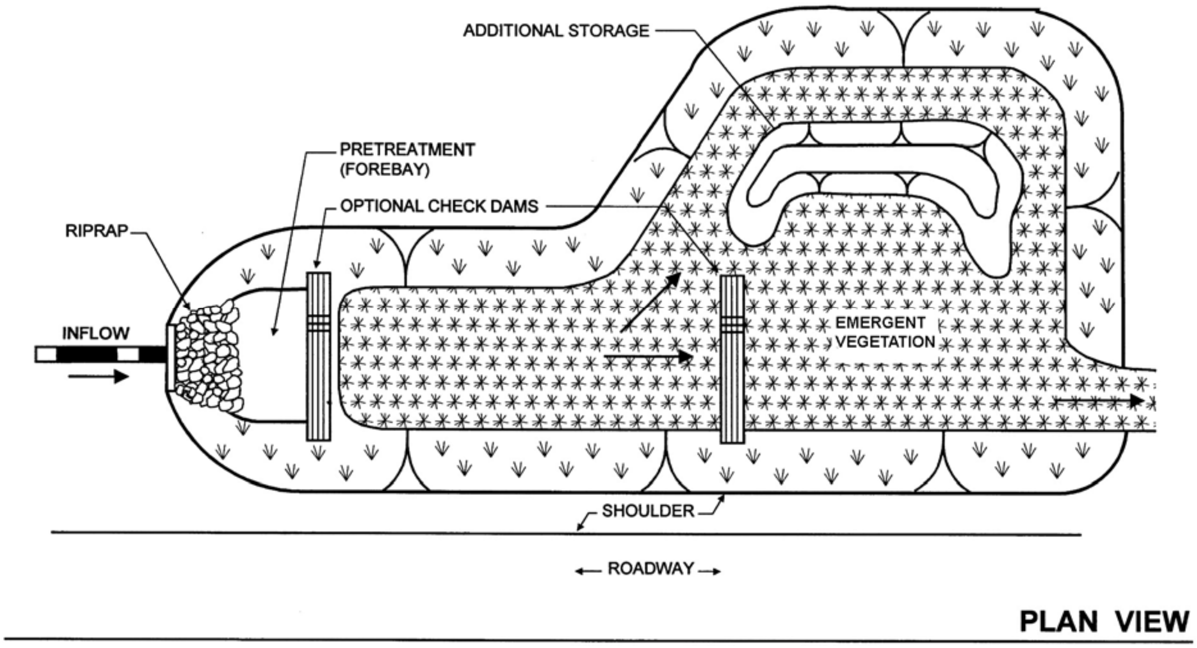
Figure 5-17 Dry Swale

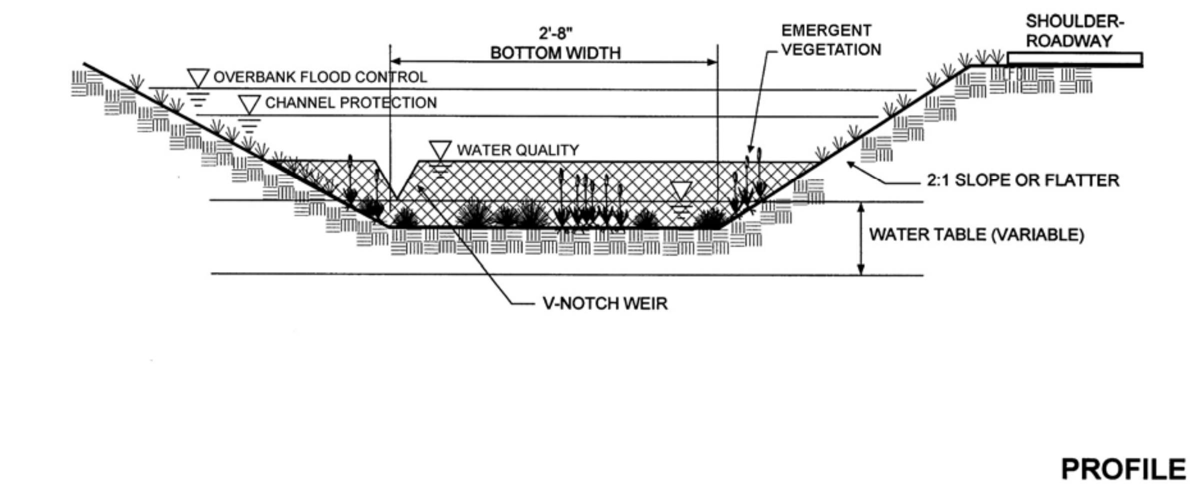




Adapted from MDE, 2000

Figure 5-18 Wet Swale





Adapted from MDE, 2000

5.7.1 Feasibility

Required Elements

- Open channels shall have a maximum drainage area of 5 acres draining to any one inlet. No maximum drainage area if flow enters via sheet flow along a linear feature, such as a road.

- Open channels shall have a maximum longitudinal slope of 4%, without check dams.
- Wet Swales are constructed in groundwater. The bottom of a Dry Swale shall be located at or above the seasonal high groundwater table; the top of a Dry Swale shall be located at least 3 feet above the seasonal high groundwater table.
- Wet swales shall be placed a minimum 50 feet downgradient of any OWTS drainfield.

Design Guidance

- Dry Swales are primarily applicable for land uses such as roads, highways, residential development, and pervious areas.
- Wet Swales should be restricted in residential areas because of the potential for stagnant water and other nuisance ponding.
- Wet Swales excavated into groundwater may trigger a water budget analysis at the discretion of the permitting agency.
- In order to maintain the required permanent pool volume, Wet Swales typically need a longitudinal slope of <1%.

5.7.2 Conveyance

Required Elements

- The maximum allowable temporary ponding time within a channel shall be less than 48 hours. An underdrain system shall be used in the dry swale to ensure this ponding time, unless designed as an exfilter in which case an underdrain might not be necessary. (An exfilter is a conventional stormwater filter without an underdrain system; the filtered volume ultimately infiltrates into the underlying soils).
- The peak velocity for the 1-year storm must be non-erosive (i.e., 3.5-5.0 fps).
- Open channels shall be designed to safely convey the 10-year storm.
- Channels shall be designed with moderate side slopes (flatter than 3:1) for most conditions. Designers may utilize a 2:1 maximum side slope, where 3:1 slopes are not feasible.
- If the site slope is greater than 4%, additional measures such as check dams shall be utilized to retain the water quality volume within the swale system.

Design Guidance

- Open channel systems may be designed as off-line systems to reduce erosion during large storm events.
- Open channel systems which directly receive runoff from non-roadway impervious surfaces may have a 6” drop onto a protected shelf (pea gravel diaphragm) to minimize the clogging potential of the inlet. Runoff from roads should drain over a vegetative slope, check dam, or forebay prior to flowing into a swale.
- The underdrain system should be composed of a minimum 4” pea gravel bed, underlain a minimum 8” gravel sump.

5.7.3 Pretreatment

Required Elements

- Provide 10% of the WQ_v in pretreatment.

Design Guidance

- The pretreatment storage is usually obtained by providing forebays/checkdams at pipe inlets and/or driveway crossings.
- Road drainage entering a swale along the length of the road may pre-treat runoff using a vegetative filter strip, see Chapter Six for design guidance.
- A washed, pea gravel diaphragm and gentle side slopes may be utilized along the top of channels to provide pretreatment for lateral sheet flows.

5.7.4 Treatment

Required Elements

- Wet swale length, width, depth, and slope shall be designed to temporarily accommodate the WQ_v through surface ponding.
- Dry swales shall consist of the following treatment components: A 30" deep bioretention soil bed, a surface mulch layer, and no more than a 12" deep average surface ponding depth. Soil media shall meet the specifications outlined for bioretention areas.
- The minimum filter area for dry swales shall be sized based on the principles of Darcy's Law. A coefficient of permeability (k) shall be used as follows:

  Dry Swale (same as for bioretention): 1.0 ft/day for sandy-loam soils

The minimum required filter area is computed using the following equation:

$$A_f = (WQ_v)\,(d_f) \,/\, [(k)\,(h_f + d_f)\,(t_f)]$$

Where:

A_f = Surface area of filter bed (ft^2)
d_f = Filter bed depth (ft)
k = Coefficient of permeability of filter media (ft/day)
h_f = Average height of water above dry swale surface (ft)
t_f = Design filter bed drain time (days)
(2 days is maximum t_f for dry swales, per first bullet in Section 5.7.2)

- Swales shall be designed with a bottom width no greater than 8 ft to avoid potential gullying and channel braiding, but no less than 2 ft.

Design Guidance

- Open channels should maintain a maximum ponding depth of one foot at the

longitudinal mid-point of the channel, and a maximum depth of 18” at the end point of the channel (for head/storage of the WQ_v).
- For the wet swale, the permanent pool may be included in water quality volume calculations.
- The bioretention soil depth of dry swales may be reduced to 12” on a case-by-case basis as demonstrated by the designer that 30” is not feasible, such as sites with high groundwater or shallow depth to bedrock or clay soils, or in retrofit situations where pre-existing site constraints exist. In these cases, the designer should add 20% (by volume) of well-aged (6-12 months), well-aerated, leaf compost (or approved equivalent) to the bioretention soil mixture and will need to provide a calculation to demonstrate that an equal WQ_v is provided as with a 30” deep soil bed.

5.7.5 Vegetation

Design Guidance

- The planting plan should specify proper grass species and emergent plants based on specific site, soils, and hydric conditions present along the proposed swale (see Appendix B for guidance on species selection).

5.7.6 Maintenance

Required Elements

- A legally binding and enforceable maintenance agreement shall be executed between the facility owner and the responsible authority.
- Open channel practices shall be inspected annually and after storms of greater than or equal to the 1-year, 24-hour Type III precipitation event.
- Sediment build-up within the bottom of the channel or filter strip shall be removed when 25% of the original WQ_v volume has been exceeded.
- Eroded side slopes and channel bottoms shall be stabilized as necessary.
- In the absence of evidence of contamination, removed debris may be taken to a landfill or other permitted facility.
- Sediment testing may be required prior to sediment disposal when a LUHPPL is present.
- Vegetation in dry swales shall be mowed as required to maintain grass heights in the 4-6 inch range, with mandatory mowing once grass heights exceed 10 inches.
- Woody vegetation in wet swales shall be pruned where dead or dying branches are observed, and reinforcement plantings shall be planted if less than 50% of the original vegetation establishes after two years.
- If the surface of the dry swale becomes clogged to the point that standing water is observed on the surface 48 hours after precipitation events, the bottom shall be roto-tilled or cultivated to break up any hard-packed sediment, and then reseeded.

Design Guidance

- Every five years, the channel bottom of dry swales should be scraped to remove sediment and to restore original cross section and infiltration rate, and should be seeded to restore ground cover.
- During inspection, any structural components of the system, including trash racks, valves, pipes and spillway structures, should be checked for proper function. Any clogged openings should be cleaned out and repairs should be made where necessary.

Table H-3 Pollutant Removal Efficiency Rating Values for Water Quality BMPs

Water Quality BMPs (those meeting Min. Std 3)		Median Pollutant Removal Efficiency (%)			
		TSS	TP	TN	Bacteria
WVTS	Shallow WVTS	85%[2]	48%[3]	30%[2]	60%[2]
	Gravel WVTS	86%[3]	53%[1]	55%[3]	85%[2]
Infiltration Practices	Infiltration Basin	90%[2]	65%[3]	65%[2]	95%[2]
	Infiltration Trench	90%[2]	65%[3]	65%[2]	95%[2]
	Subsurface Chambers	90%[2]	55%[2]	40%[2]	90%[2]
	Dry Well	90%[2]	55%[2]	40%[2]	90%[2]
	Permeable Paving	90%[1]	40%[1]	40%[2]	95%[2]
Filters	Sand Filter	86%[3]	59%[3]	32%[3]	70%[2]
	Organic Filter	90%[2]	65%[2]	50%[2]	70%[2]
	Bioretention	90%[1]	30%[2]	55%[2]	70%[2]
	Tree Filter	90%[1]	30%[2]	55%[2]	70%[2]
Green Roofs	Extensive	90%[4]	30%[4]	55%[4]	70%[4]
	Intensive	90%[4]	30%[4]	55%[4]	70%[4]
Open Channels	Dry Swale	90%[1]	30%[2]	55%[2]	70%[2,6]
	Wet Swale	85%[3]	48%[3]	30%[2]	60%[2]

Sediment Forebays

Description: A sediment forebay is a post-construction practice consisting of an excavated pit, bermed area, or cast structure combined with a weir, designed to slow incoming stormwater runoff and facilitating the gravity separation of suspended solids. This practice is different from a sediment trap used as a construction period BMP.

Ability to meet specific standards

Standard	Description
2 - Peak Flow	Provides no peak flow attenuation
3 - Recharge	Provides no groundwater recharge
4 - TSS Removal	MassDEP requires a sediment forebay as pretreatment before stormwater is discharged to an extended dry detention basin, wet basin, constructed stormwater wetland or infiltration basin. No separate credit is given for the sediment forebay. For example, extended dry detention basins with sediment forebays receive a credit for 50% TSS removal. Wet basins and constructed stormwater wetlands with sediment forebays receive a credit for 80% TSS removal. When they provide pretreatment for other BMPs, sediment forebays receive a 25% TSS removal credit.
5 - Higher Pollutant Loading	Recommended as a pretreatment BMP
6 - Discharges near or to Critical Areas	Recommended as a pretreatment BMP
7 - Redevelopment	Usually not suitable due to land use constraints

Advantages/Benefits:

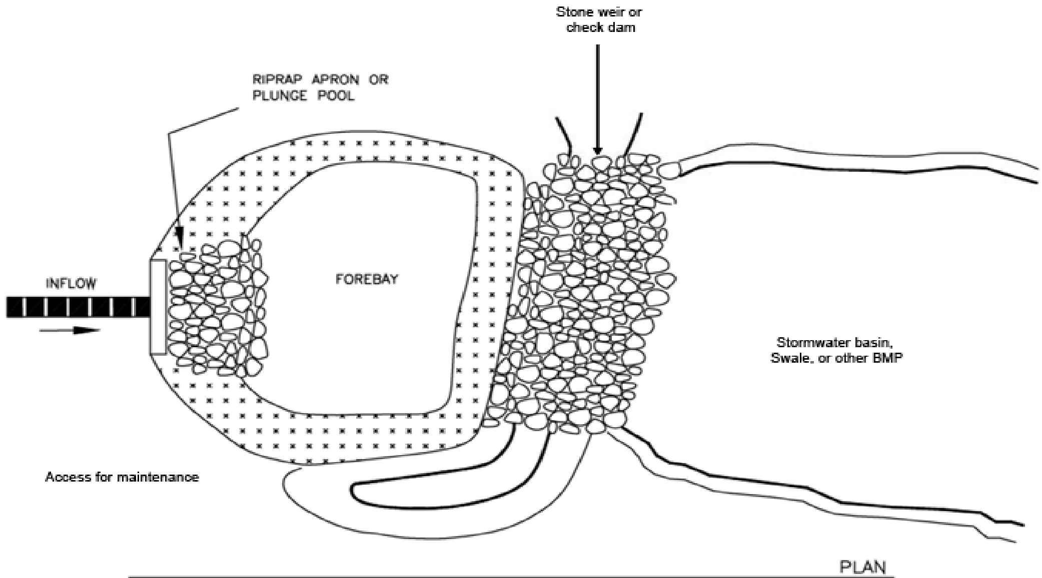
- Provides pretreatment of runoff before delivery to other BMPs.
- Slows velocities of incoming stormwater
- Easily accessed for sediment removal
- Longevity is high with proper maintenance
- Relatively inexpensive compared to other BMPs
- Greater detention time than proprietary separators

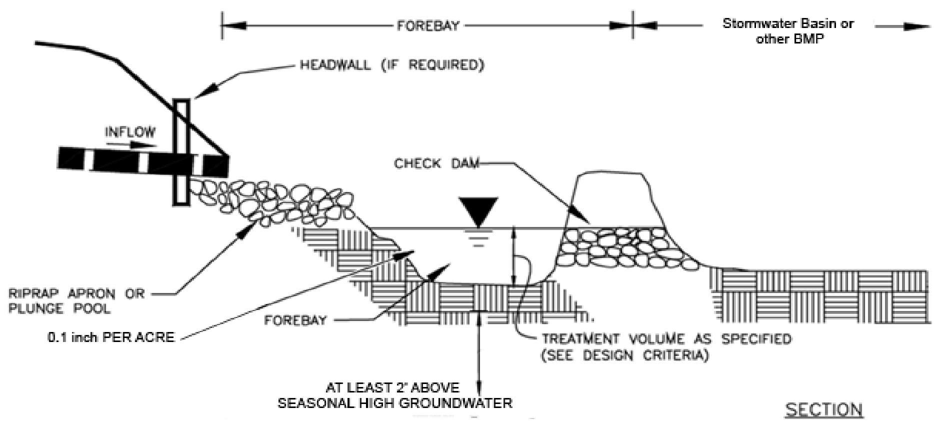
Disadvantages/Limitations:

- Removes only coarse sediment fractions
- No removal of soluble pollutants
- Provides no recharge to groundwater
- No control of the volume of runoff
- Frequent maintenance is essential

Pollutant Removal Efficiencies

- Total Suspended Solids (TSS) - 25%
- Nutrients (Nitrogen, phosphorus) - Insufficient data
- Metals (copper, lead, zinc, cadmium) - Insufficient data
- Pathogens (coliform, e coli) - Insufficient data





adapted from the Vermont Stormwater Handbook

Maintenance

Activity	Frequency
Inspect sediment forebays	Monthly
Clean sediment forebays	Four times per year and when sediment depth is between 3 to 6 feet.

Special Features

MassDEP requires a sediment forebay as pretreatment before discharging to a dry extended detention basin, wet basin, constructed stormwater wetland, or infiltration basin.

MassDEP uses the term sediment forebay for BMPs used to pretreat stormwater after construction is complete and the site is stabilized. MassDEP uses the term sediment trap to refer to BMPs used for erosion and sedimentation control during construction. For information on the design and construction of sediment traps used during construction, consult the Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas: A Guide for Planners, Designers and Municipal Officials.

Sediment Forebays

Design

Sediment forebays are typically on-line units, designed to slow stormwater runoff and settle out sediment.

At a minimum, size the volume of the sediment forebay to hold 0.1-inch/impervious acre to pretreat the water quality volume.

When routing the 2-year and 10-year storms through the sediment forebay, design the forebay to withstand anticipated velocities without scouring.

A typical forebay is excavated below grade with earthen sides and a stone check dam.

Design elevated embankments to meet applicable safety standards.

Stabilize earth slopes and bottoms using grass seed mixes recommended by the NRCS and capable of resisting the anticipated shearing forces associated with velocities to be routed through the forebay. Use only grasses. Using other vegetation will reduce the storage volume in the forebay. Make sure that the selected grasses are able to withstand periodic inundation under water, and drought- tolerant during the summer. MassDEP recommends using a mix of grasses rather than relying upon a single grass species.

Alternatively, the bottom floor may be stabilized with concrete or stone to aid maintenance. Concrete floors or pads, or any hard bottom floor, greatly facilitate the removal of accumulated sediment.

When the bottom floor is vegetated, it may be necessary to remove accumulated sediment by hand, along with re-seeding or re-sodding grasses removed during maintenance.

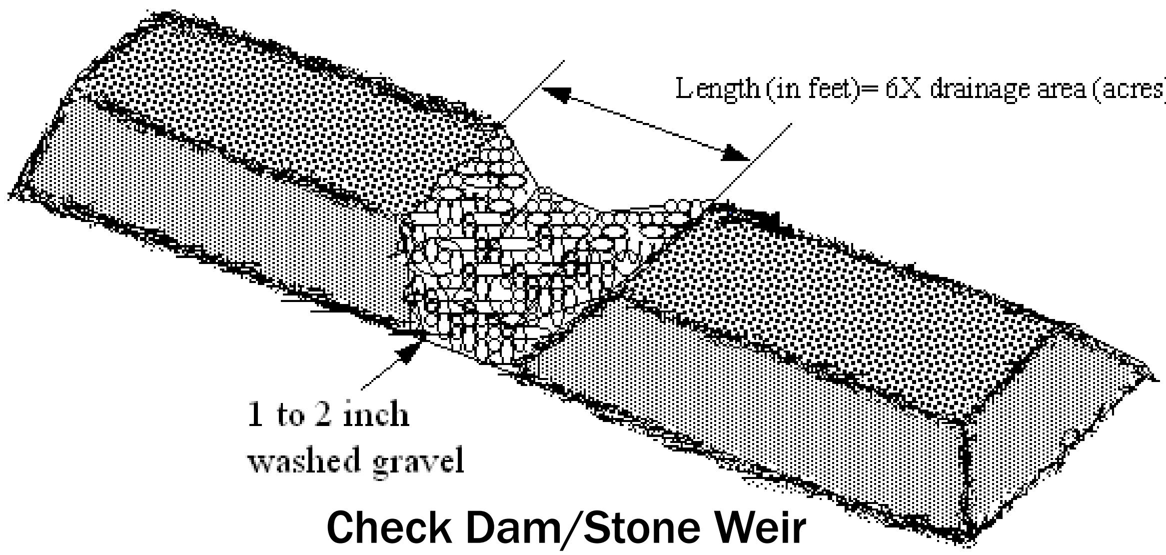
Design sediment forebays to make maintenance accessible and easy. If machinery is required to remove the sediment, carefully incorporate equipment access in the design. Sediment forebays may require excavation so concrete flooring may not always be appropriate.

Include sediment depth markers to simplify inspections. Sediment markers make it easy to determine when the sediment depth is between 3 and 6 feet and needs to be removed. Make the side slopes of sediment forebays no steeper than 3:1. Design the sediment forebay so that the discharge or outflow velocity can control the 2-year peak discharge without scour. Design the channel geometry to prevent erosion from the 2-year peak discharge.

Do not confuse post-construction sediment forebays with the sediment traps used as a construction-period control. Construction-period sediment control traps are sized larger than forebays, because there is a greater amount of suspended solids in construction period runoff. Construction-period sediment traps are sized based on drainage area and not impervious acre. Never use a construction-period sediment trap for post-construction drainage purposes unless it is first brought off-line, thoroughly cleaned (including check dam), and stabilized before being made re-operational.

Refer to the section of this chapter for information on the design of the check dam component of the sediment forebay. Set the minimum elevation of the check dam to hold a volume of 0.1-inch of runoff/impervious acre. Check dam elevations may be uniform or they may contain a weir (e.g., when the top of the check dam is set to the 2-year or 10-year storm, and the bottom of the weir is set to the top of the 0.1-inch/impervious acre volume). When a weir is included in a stone berm, make sure that the weir is able to hold its shape. Fabric or wire may be required.

Unless part of a wet basin, post construction sediment forebays must be designed to dewater between storms. Set the bottom of the forebay at a minimum of 2 feet above seasonal high groundwater, and place pervious material on the bottom floor to facilitate dewatering between storms. For design purposes, use 72 hours to evaluate dewatering, using the storm that produces either the ½ inch or 1-inch of runoff (water quality volume) in a 24-hour period. A stone check dam can act as a filter berm, allowing water to percolate through the check dam. Depending on the head differential, a stone check dam may allow greater dewatering than an earthen berm.



Check Dam/Stone Weir

MassDEP Stormwater Handbook, 1996

Maintenance

Sediments and associated pollutants are removed only when sediment forebays are actually cleaned out, so regular maintenance is essential. Frequently removing accumulated sediments will make it less likely that sediments will be resuspended. At a minimum, inspect sediment forebays monthly and clean them out at least four times per year. Stabilize the floor and sidewalls of the sediment forebay before making it operational, otherwise the practice will discharge excess amounts of suspended sediments. When mowing grasses, keep the grass height no greater than 6 inches. Set mower blades no lower than 3 to 4 inches. Check for signs of rilling and gullying and repair as needed. After removing the sediment, replace any vegetation damaged during the clean-out by either reseeding or re-sodding. When reseeding, incorporate practices such as hydroseeding with a tackifier, blanket, or similar practice to ensure that no scour occurs in the forebay, while the seeds germinate and develop roots.

Bioretention Areas & Rain Gardens

Description: Bioretention is a technique that uses soils, plants, and microbes to treat stormwater before it is infiltrated and/or discharged. Bioretention cells (also called rain gardens in residential applications) are shallow depressions filled with sandy soil topped with a thick layer of mulch and planted with dense native vegetation. Stormwater runoff is directed into the cell via piped or sheet flow. The runoff percolates through the soil media that acts as a filter.

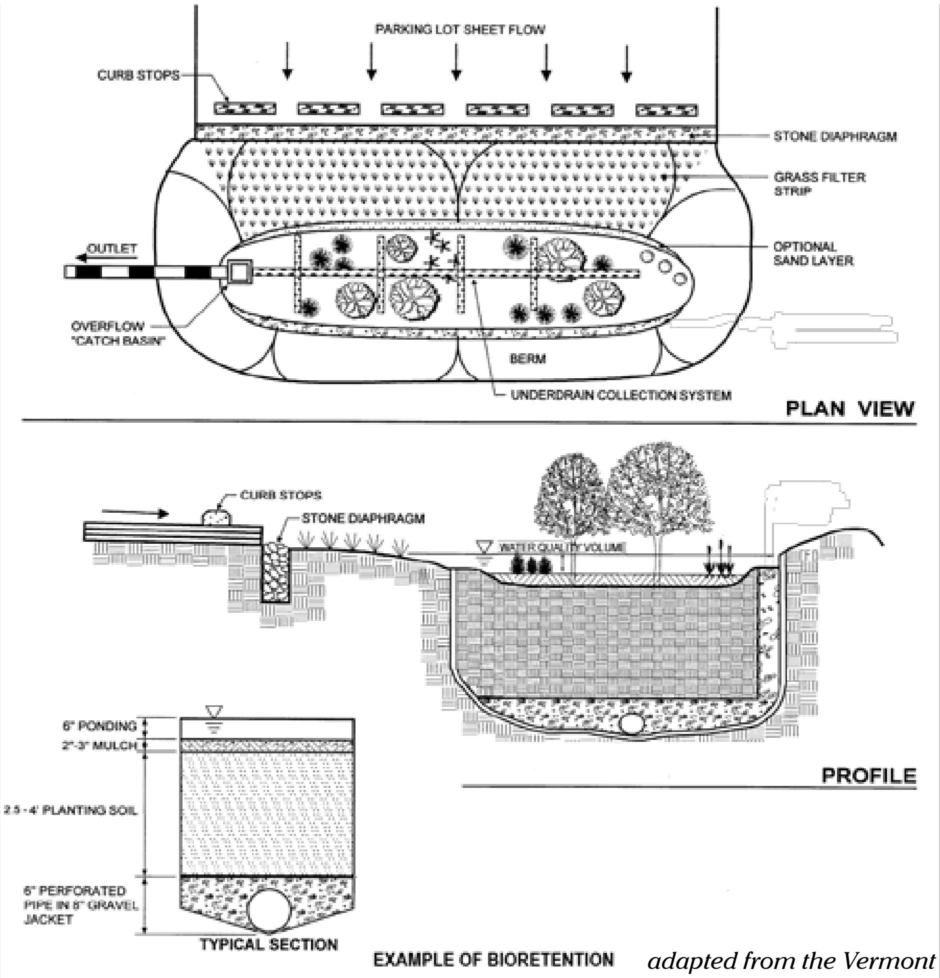
There are two types of bioretention cells: those that are designed solely as an organic filter filtering bioretention areas and those configured to recharge groundwater in addition to acting as a filter exfiltrating bioretention areas. A filtering bioretention area includes an impermeable liner and underdrain that intercepts the runoff before it reaches the water table so that it may be conveyed to a discharge outlet, other best management practices, or the municipal storm drain system. An exfiltrating bioretention area has an underdrain that is designed to enhance exfiltration of runoff into the groundwater.

Ability to meet specific standards

Standard	Description
2 - Peak Flow	N/A
3 - Recharge	An exfiltrating bioretention area provides groundwater recharge.
4 - TSS Removal	90% TSS removal credit with adequate pretreatment
5 - Higher Pollutant Loading	Can be used for certain land uses with higher potential pollutant loads if lined and sealed until adequate pretreatment is provided. Adequate pretreatment must include 44% TSS removal prior to infiltration. For land uses that have the potential to generate runoff with high concentrations of oil and grease such as high intensity use parking lots and gas stations, adequate pretreatment may also include an oil grit separator, sand filter or equivalent. In lieu of an oil grit separator or sand filter, a filtering bioretention area also may be used as a pretreatment device for infiltration practices exfiltrating runoff from land uses with a potential to generate runoff with high concentrations of oil and grease.
6 - Discharges near or to Critical Areas	Good option for discharges near cold-water fisheries. Should not be used near bathing beaches and shellfish growing areas.
7 - Redevelopment	Suitable with appropriate pretreatment

Pollutant Removal Efficiencies

• Total Suspended Solids (TSS)	90% with vegetated filter strip or equivalent
• Total Nitrogen	30% to 50% if soil media at least 30 inches
• Total Phosphorus	30% to 90%
• Metals (copper, lead, zinc, cadmium)	40% to 90%
• Pathogens (coliform, e coli)	Insufficient data



adapted from the Vermont Stormwater Manual

Special Features:

- Can be lined and sealed to prevent recharge where appropriate
- Adequate pretreatment is essential
- Not recommended in areas with steep slope
- Depth of soil media depends on type of vegetation that is proposed
- Soil media must be 30 inches deep to achieve removal of nitrogen

Advantages/Benefits:

- Can be designed to provide groundwater recharge and preserves the natural water balance of the site
- Can be designed to prevent recharge where appropriate
- Supplies shade, absorbs noise, and provides windbreaks
- Can remove other pollutants besides TSS including phosphorus, nitrogen and metals
- Can be used as a stormwater retrofit by modifying existing landscape or if a parking lot is being resurfaced
- Can be used on small lots with space constraints
- Small rain gardens are mosquito death traps
- Little or no hazard for amphibians or other small animals

Disadvantages/Limitations:

- Requires careful landscaping and maintenance
- Not suitable for large drainage areas

Maintenance

Activity	Frequency
Inspect and remove trash	Monthly
Mow	2 to 12 times per year
Mulch	Annually
Fertilize	Annually
Remove dead vegetation	Annually
Prune	Annually

Bioretention Areas & Rain Gardens

Not all bioretention cells are designed to exfiltrate. Only the infiltration requirements are applicable to bioretention cells intended to exfiltrate.

Applicability

Bioretention areas can provide excellent pollutant removal for the "first flush" of stormwater runoff. Properly designed and maintained cells remove suspended solids, metals, and nutrients, and can infiltrate an inch or more of rainfall. Distributed around a property, vegetated bioretention areas can enhance site aesthetics. In residential developments they are often described as "rain gardens" and marketed as property amenities. Routine maintenance is simple and can be handled by homeowners or conventional landscaping companies, with proper direction.

Bioretention systems can be applied to a wide range of commercial, residential, and industrial developments in many geologic conditions; they work well on small sites and on large sites divided into multiple small drainage areas. Bioretention systems are often well suited for ultra-urban settings where little pervious area exists. Although they require significant space (approximately 5% to 7% of the area that drains to them), they can be integrated into parking lots, parking lot islands, median strips, and traffic islands. Sites can be retrofitted with bioretention areas by replacing existing parking lot islands or by re-configuring a parking lot during resurfacing. On residential sites, they are commonly used for rooftop and driveway runoff.

Effectiveness

Bioretention areas remove pollutants through filtration, microbe activity, and uptake by plants; contact with soil and roots provides water quality treatment better than conventional infiltration structures. Studies indicate that bioretention areas can remove from 80% to 90% of TSS. If properly designed and installed, bioretention areas remove phosphorus, nitrogen, metals, organics, and bacteria to varying degrees.

Bioretention areas help reduce stress in watersheds that experience severe low flows due to excessive impervious cover. Low-tech, decentralized bioretention areas are also less costly to design, install, and maintain than conventional stormwater technologies that treat runoff at the end of the pipe.

Decentralized bioretention cells can also reduce the size of storm drain pipes, a major component of stormwater treatment costs. Bioretention areas enhance the landscape in a variety of ways: they improve the appearance of developed sites, provide windbreaks, absorb noise, provide wildlife habitat, and reduce the urban heat island effect.

Planning Considerations

Filtering bioretention areas are designed with an impermeable liner and underdrain so that the stormwater may be transported to additional BMPs for treatment and/or discharge. Exfiltrating bioretention areas are designed so that following treatment by the bioretention area the stormwater may recharge the groundwater.

Both types of bioretention areas may be used to treat runoff from land uses with higher potential pollutant loads. However, exfiltrating bioretention areas may be used to treat runoff from land uses with higher potential pollutant loads, only if pretreatment has been provided to achieve TSS removal of at least 44%. If the land use has the potential to generate runoff with high concentrations of oil and grease, other types of pretreatment, i.e., a deep sump catch basin and oil grit separator or a sand filter, is required prior to discharge of runoff to an exfiltrating bioretention area. A filtering bioretention area may also be used as a pretreatment device for an exfiltrating bioretention area or other infiltration practice that exfiltrates runoff from land uses with a potential to generate runoff with high concentrations of oil and grease.

To receive 90% TSS removal credit, adequate pretreatment must be provided. If the flow is piped to the bioretention area a deep sump catch catch basin and sediment forebay should be used to provide pretreatment. For sheet flow, there are a number or pretreatment options. These options include:

- A vegetated filter strip, grass channel or water quality swale designed in accordance with the specifications set forth in Chapter 2.
- A grass and gravel combination. This should consist of at least 8 inches of gravel followed by 3 to 5 feet of sod. (source: North Carolina Stormwater Manual, 2007, http://h2o.enr.state.nc.us/su/documents/Ch12-Bioretention_001.pdf)
- Pea diaphragm combined with a vegetated filter strip specially designed to provide pretreatment for a bioretention area as set forth in the following table. (source: Georgia Stormwater Manual and Claytor and Schuler 1996)

Dimensions for Filter Strip Designed Specially to Provide Pretreatment for Bioretention Area

Parameter	Impervious Area				Pervious Areas (lawns, etc.)			
Maximum inflow approach length (feet)	35		75		75		100	
Filter strip slope (max=6%)	<2%	>2%	<2%	>2%	<2%	>2%	<2%	>2%
Filter strip minimum length (feet)	10	15	20	25	10	12	15	18

Bioretention areas must not be located on slopes greater than 20%. When the bioretention area is designed to exfiltrate, the design must ensure vertical separation of at least 2 feet from the seasonal high groundwater table to the bottom of the bioretention cell.

For residential rain gardens, pick a low spot on the property, and route water from a downspout or sump pump into it. It is best to choose a location with full sun, but if that is not possible, make sure it gets at least a half-day of sunlight.

Do not excavate an extensive rain garden under large trees. Digging up shallow feeder roots can weaken or kill a tree. If the tree is not a species that prefers moisture, the additional groundwater could damage it. Size the bioretention area using the methodology set forth in Volume 3.

Design

Size the bioretention area to be 5% to 7% of the area draining to it. Determine the infiltrative capacity of the underlying native soil by performing a soil evaluation in accordance with Volume 3. Do not use a standard septic system (i.e., Title 5) percolation test to determine soil permeability.

The depth of the soil media must be between 2 and 4 feet. This range reflects the fact that most of the pollutant removal occurs within the first 2 feet of soil and that excavations deeper than 4 feet become expensive. The depth selected should accommodate the vegetation. If the minimum depth is used, only shallow rooted plants and grasses my be used. If there is a Total Maximum Daily Load that requires nitrogen to be removed from the stormwater dischrges, the bioretention area should have a soil media with a depth of at least 30 inches, because nitrogen removal takes place 30 inches below the ground surface. If trees and shrubs are to be planted, the soil media should be at least 3 feet.

Size the cells (based on void space and ponding area) at a minimum to capture and treat the required water quality volume (the first 0.5 inch or 1 inch of runoff) if intended to be used for water quality treatment (Stormwater Standard No. 4), the required recharge volume if used for recharge (Stormwater Standard No. 3), or the larger of the two volumes if used to achieve compliance with both Stormwater Standards 3 and 4.

Cover the bottom of the excavation with coarse gravel, over pea gravel, over sand. Earlier designs used filter fabric as a bottom blanket, but more recent experiences show that filter fabric is prone to clogging. Consequently, do not use fabric filters or sand curtains. Use the Engineered Soil Mix below.

Engineered Soil Mix for Bioretention Systems Designed to Exfiltrate

- The soil mix for bioretention areas should be a mixture of sand compost and soil.
  - o 40 % sand,
  - o 20-30% topsoil, and
  - o 30-40% compost.

- The soil mix must be uniform, free of stones, stumps, roots or similar objects larger than 2 inches. Clay content should not exceed 5%.
- Soil pH should generally be between 5.5-6.5, a range that is optimal for microbial activity and adsorption of nitrogen, phosphorus, and other pollutants.
- Use soils with 1.5% to 3% organic content and maximum 500-ppm soluble salts.
- The sand component should be gravelly sand that meets ASTM D 422.

Sieve Size	Percent Passing
2-inch	100
¾-inch	70-100
¼-inch	50-80
U.S. No. 40	15-40
U.S. No. 200	0-3

- The topsoil component shall be a sandy loam, loamy sand or loam texture.
- The compost component must be processed from yard waste in accordance with MassDEP Guidelines (see http://www.mass.gov/dep/recycle/reduce/leafguid.doc). The compost shall not contain biosolids.

On-site soil mixing or placement is not allowed if soil is saturated or subject to water within 48 hours. Cover and store soil to prevent wetting or saturation.

Test soil for fertility and micro-nutrients and, only if necessary, amend mixture to create optimum conditions for plant establishment and early growth.

Grade the area to allow a ponding depth of 6 to 8 inches; depending on site conditions, more or less ponding may be appropriate.

Cover the soil with 2 to 3 inches of fine-shredded hardwood mulch.

The planting plan shall include a mix of herbaceous perennials, shrubs, and (if conditions permit) understory trees that can tolerate intermittent ponding, occasional saline conditions due to road salt, and extended dry periods. A list of plants that are suitable for bioretention areas can be found at the end of this section. To avoid a monoculture, it is a good practice to include one tree or shrub per 50 square feet of bioretention area, and at least 3 species each of herbaceous perennials and shrubs. Invasive and exotic species are prohibited. The planting plan should also meet any applicable local landscaping requirements.

All exfiltrating bioretention areas must be designed to drain within 72 hours. However, rain gardens are typically designed to drain water within a day and are thus unlikely to breed mosquitoes.

Bioretention cells, including rain gardens, require pretreatment, such as a vegetated filter strip. A stone or pea gravel diaphragm or, even better, a concrete level spreader upstream of a filter strip will enhance sheet flow and sediment removal.
Bioretention cells can be dosed with sheet flow, a surface inlet, or pipe flow. When using a surface inlet, first direct the flow to a sediment forebay. Alternatively, piped flow may be introduced to the bioretention system via an underdrain.

For bioretention cells dosed via sheet flow or surface inlets, include a ponding area to allow water to pond and be stored temporarily while stormwater is exfiltrating through the cell. Where bioretention areas are adjacent to parking areas, allow three inches of freeboard above the ponding depth to prevent flooding.

Most bioretention cells have an overflow drain that allows ponded water above the selected ponding depth to be dosed to an underdrain. If the bioretention system is designed to exfiltrate, the underdrain is not connected to an outlet, but instead terminates in the bioretention cell. If the bioretention area is not designed to exfiltrate, the underdrain is connected to an outlet for discharge or conveyance to additional best management practices.

Construction

During construction, avoid excessively compacting soils around the bioretention areas and accumulating silt around the drain field. To minimize sediment loading in the treatment area, direct runoff to the bioretention area only from areas that are stabilized; always divert construction runoff elsewhere.

To avoid compaction of the parent material, work from the edge of the area proposed as the location of an exfiltrationg bioretention cell. Never direct runoff to the cell until the cell and the contributing drainage areas are fully stabilized.

Place planting soils in 1-foot to 2-foot lifts and compact them with minimal pressure until the desired elevation is reached. Some engineers suggest flooding the cell between each lift placement in lieu of compaction.

Maintenance

Premature failure of bioretention areas is a significant issue caused by lack of regular maintenance. Ensuring long-term maintenance involves sustained public education and deed restrictions or covenants for privately owned cells. Bioretention areas require careful attention while plants are being established

Bioretention Maintenance Schedule

Activity	*Time of Year*	*Frequency*
Inspect & remove trash	Year round	Monthly
Mulch	Spring	Annually
Remove dead vegetation	Fall or Spring	Annually
Replace dead vegetation	Spring	Annually
Prune	Spring or Fall	Annually
Replace entire media & all vegetation	Late Spring/early Summer	As needed*

** Paying careful attention to pretreatment and operation & maintenance can extend the life of the soil media* and seasonal landscaping maintenance thereafter.

In many cases, a landscaping contractor working elsewhere on the site can complete maintenance tasks. Inspect pretreatment devices and bioretention cells regularly for sediment build-up, structural damage, and standing water.

Inspect soil and repair eroded areas monthly. Re-mulch void areas as needed. Remove litter and debris monthly. Treat diseased vegetation as needed. Remove and replace dead vegetation twice per year (spring and fall).

Proper selection of plant species and support during establishment of vegetation should minimize—if not eliminate—the need for fertilizers and pesticides. Remove invasive species as needed to prevent these species from spreading into the bioretention area. Replace mulch every two years, in the early spring. Upon failure, excavate bioretention area, scarify bottom and sides, replace filter fabric and soil, replant, and mulch. A summary of maintenance activities can be found on the previous page.

Because the soil medium filters contaminants from runoff, the cation exchange capacity of the soil media will eventually be exhausted. When the cation exchange capacity of the soil media decreases, change the soil media to prevent contaminants from migrating to the groundwater, or from being discharged via an underdrain outlet. Using small shrubs and plants instead of larger trees will make it easier to replace the media with clean material when needed.

Plant maintenance is critical. Concentrated salts in roadway runoff may kill plants, necessitating removal of dead vegetation each spring and replanting. The operation and maintenance plan must include measures to make sure the plants are maintained. This is particularly true in residential subdivisions, where the operation and maintenance plan may assign each homeowner the legal responsibility to maintain a bioretention cell or rain garden on his or her property. Including the requirement in the property deed for new subdivisions may alert residential property owners to their legal responsibilities regarding the bioretention cells constructed on their lot.

Cold Climate Considerations

Never store snow in bioretention areas. The Operation and Maintenance plan must specify where on-site snow will be stored. All snow dumps must comply with MassDEP's guidance. When bioretention areas are located along roads, care must be taken during plowing operations to prevent snow from being plowed into the bioretention areas. If snow is plowed into the cells, runoff may bypass the cell and drain into downgradient wetlands without first receiving the required water quality treatment, and without recharging the groundwater.

References

Center for Watershed Protection, 2000, Bioretention as a Water Quality Best Management Practice, Article 110 from Watershed Protection Techniques; http://www.cwp.org/Downloads/ELC_PWP110.pdf

Federal Highway Administration , YEAR, Bioretention Fact Sheet, http://www.fhwa.dot.gov/environment/

Low Impact Development Center, 2003, Drainage – Bioretention Specification, http://www.lowimpactdevelopment.org/epa03/biospec.htm

Prince Georges County, 2002, Bioretention Manual, http://www.goprincegeorgescounty.com/der/bioretention.asp

Puget Sound Action Team, 2005, Low Impact Development, Pp. 174 - 184 http://www.psat.wa.gov/Publications/LID_tech_manual05/LID_manual2005.pdf

U.S. Environmental Protection Agency, 1999, Stormwater Technology Fact Sheet, Bioretention, EPA 832-F-99-012, http://www.epa.gov/owm/mtb/biortn.pdf

U.S. Environmental Protection Agency, 2005, National Management Measures to Control Nonpoint Source Pollution from Urban Areas, Publication Number EPA 841-B-05-004, Pp. 5-29 http://www.epa.gov/nps/urbanmm/

University of North Carolina,
www.bae.ncsu.edu/topic/bioretention
www.bae.ncsu.edu/stormwater/PublicationFiles/DesigningRainGardens2001.pdf

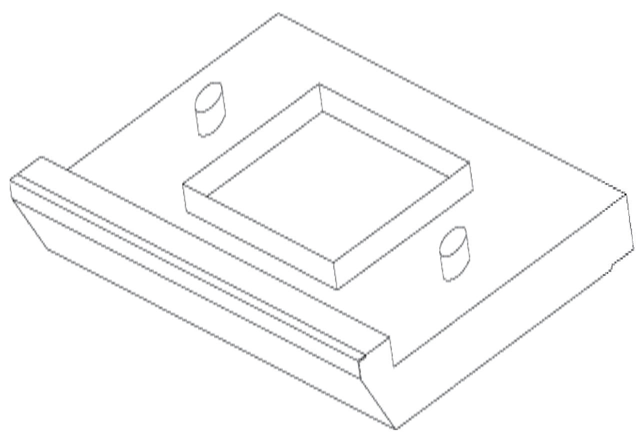
Filterra® Modified Options: Recessed Tops

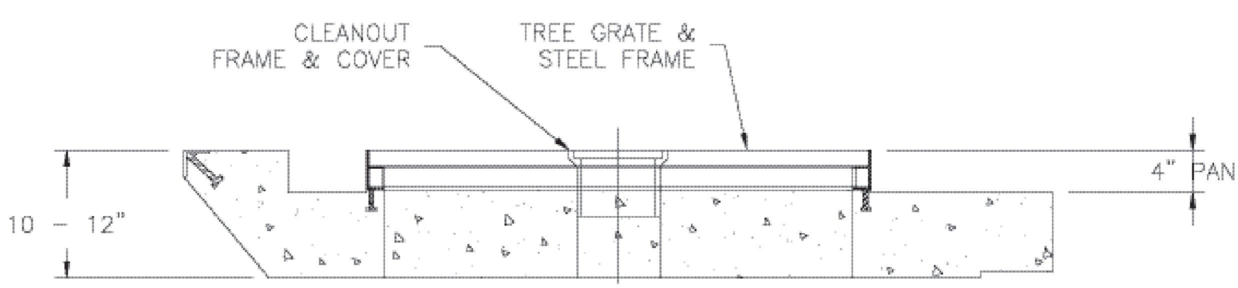
Modified recessed top with sod

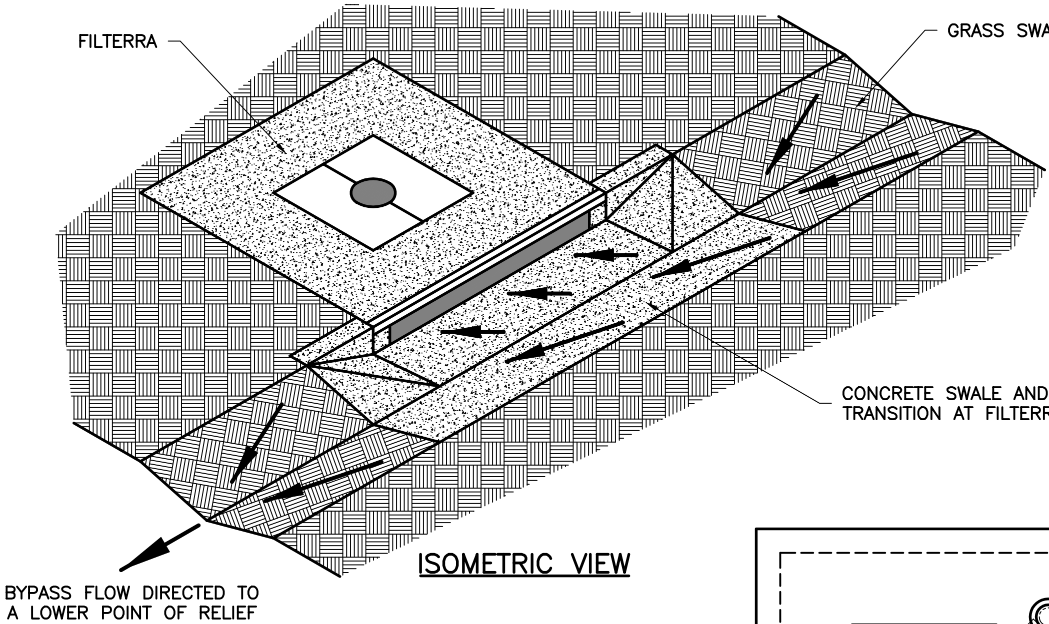
Filterra® modified recessed tops allow a seamless integration using pavers, mulch or sod.

NOTE: Modified recessed tops increase the depth of the Filterra® invert out.

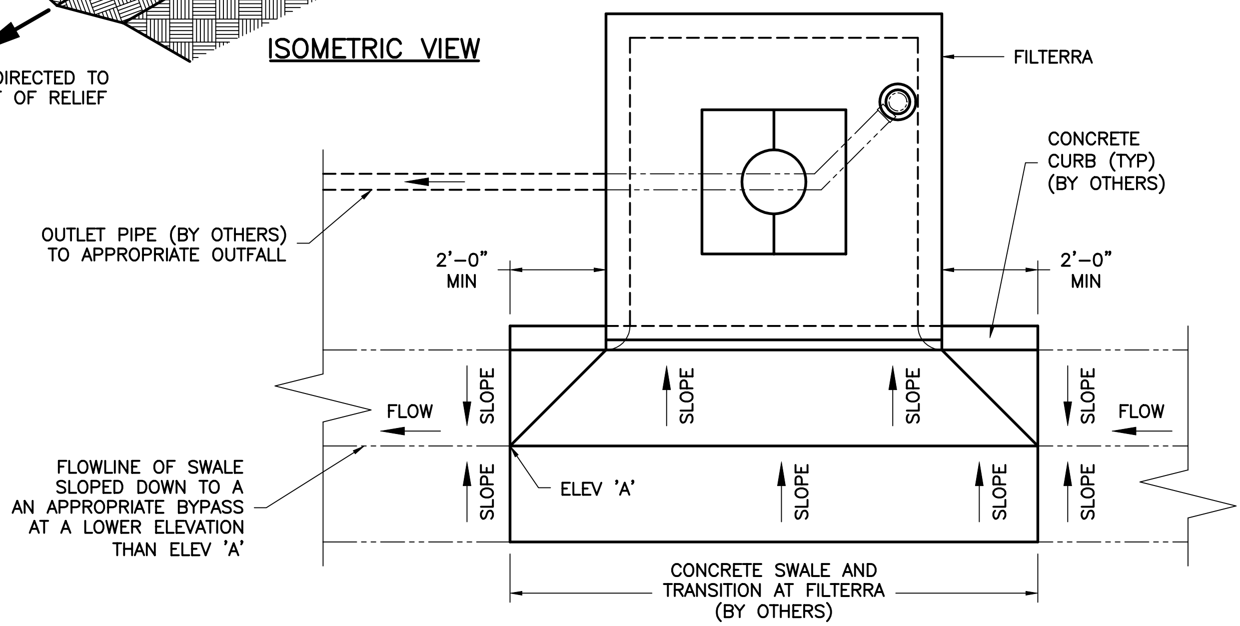
Modified recessed top prior to shipping



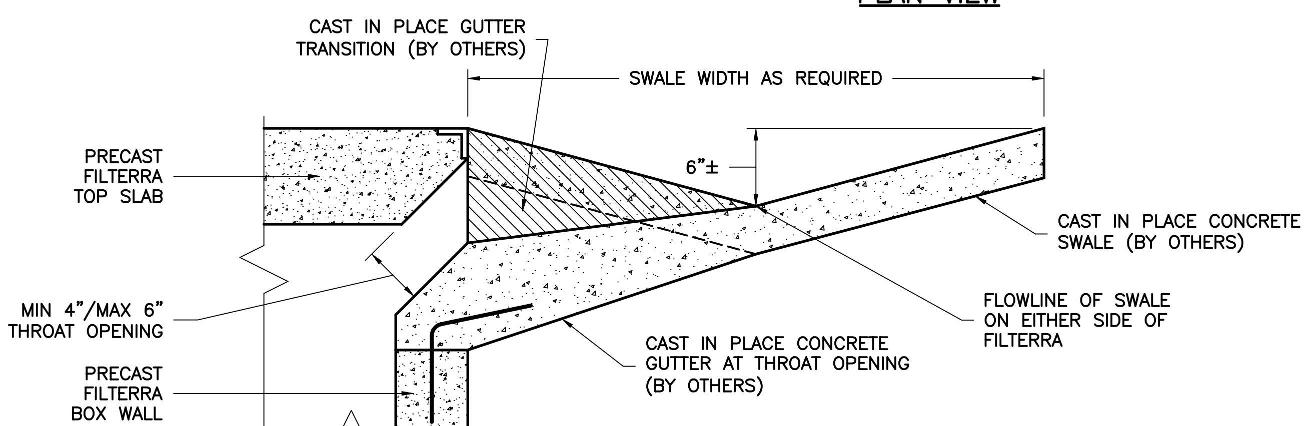




ISOMETRIC VIEW



PLAN VIEW



SECTION VIEW AT FILTERRA

DRAWING AVAILABLE IN TIF FILE FORMAT.

AMERICAST®

DATE: 03–10–05

DWG: FTSWL–1

PRECAST FILTERRA® UNIT
TYPICAL SWALE
CONFIGURATION

filterra®

US PAT 6,277,274
AND 6,569,321

ATTACHMENT 2

RETROFIT DESIGN SUMMARY TABLE

Neponset River Watershed Association
Milton, MA Stormwater Retrofit Project
Retrofit Design Summary Table
Sumner Street Area

Environmental Partners Group — A partnership for engineering solutions.

Jun 2013

BMP Designation Number	Catchment Area Description	Stormwater Best Management Practice	Drainage Area (sf)	Recommended Volume to Pretreat Water Quality Volume (0.1-inch/impervious acre) (cf)	Actual PreTreatment Volume (cf)	% PreTreatment Volume Treated	1-inch Water Quality Volume (cf)	Water Quality Volume Treated (cf)	% Water Quality Volume Treated
1	Sumner-1	Wet Swale	73,845.00	615.38	1,000.00	162.50%	N/A	N/A	N/A
2	Sumner-2	Sediment Forebay	26,609.00	221.74	322.00	145.21%	N/A	N/A	N/A
3	Sumner-2	Bioretention Basin	26,609.00	N/A	N/A	N/A	2,217.42	2,337.00	105.39%
4	Sumner-3	Bioretention Filtration System	4,229.50	N/A	N/A	N/A	352.46	352.46	100.00%
5	Sumner-3	Bioretention Filtration System	4,229.50	N/A	N/A	N/A	352.46	352.46	100.00%

Notes:
1. Assume all runoff is from impervious area.
2. Each Bioretention Filtration system can treat 90% of annual runoff.
3. Maximum flow rate for Bioretention Filtration System is 0.056 cf/s for the system, and anything above will divert to bypass.

ATTACHMENT 3

RUNOFF AND POLLUTANT LOAD CALCULATIONS TABLE

Neponset River Watershed Association
Milton, MA Stormwater Retrofit Project
Runoff and Pollutant Load Calculations
Sumner Street Area

Environmental Partners GROUP
A partnership for engineering solutions.

Jun 2013

BMP Designation Number	Catchment Area Description	Stormwater Best Management Practice	(A) Drainage Area (ac)	(R) Runoff (in)	(L) Annual TSS (lbs)	(L) Annual TP (lbs)	(L) Annual TN (lbs)	(L) Annual FC (billion colonies)
1	Sumner 1	Wet Swale	1.70	41.55	2,745.92	8.78	22.35	269,209.42
2 & 3	Sumner 2	Sediment Forebay and Bioretention Basin	0.61	41.55	985.30	3.15	8.02	96,598.67
4 & 5	Sumner 3	Bioretention Filtration System	0.20	41.55	323.05	1.03	2.63	31,671.70

Coefficients for Use in Polluted Load Calculations[1]:

Landuse	% Impervious	(C) TSS (mg/l)	(C) TP (mg/l)	(C) TN (mg/l)	Fecal Coliform (1,000 colonies/ml)
Residential Street	100%	172	0.55	1.40	37

Pollutant Loading Formulas - The Simple Method[1, 3]:

For TSS, TP, & TN:
$L = 0.226 * R * C * A$
Where: L = Annual load (lbs)
R = Annual runoff (inches)
C = Pollutant Concentration (mg/l)
A = Area (acres)
0.226 = Unit Conversion Factor

For Fecal Coliform (FC):
$L = 103 * R * C * A$
Where: L = Annual load (billion colonies)
R = Annual runoff (inches)
C = Bacteria concentration (1,000 colonies/ml)
A = Area (acres)
103 = Unit Conversion Factor

For Annual Runoff (R):
$R = P * P_j * Rv$
Where: R = Annual runoff (inches)
P = Annual rainfall (inches) = 48.6[2]
P_j = Fraction of rainfall events that produce runoff (assume 0.9)
Rv = Runoff coefficient = 0.05 + 0.9 Ia
Ia = Impervious fraction (%)

References:

1. New York State Stormwater Management Design Manual, Appendix A-The Simple Method to Calculate Urban Stormwater Loads
http://www.dec.ny.gov/docs/water_pdf/simple.pdf
2. Weatherbase - Average Annual Precipitation
http://www.weatherbase.com/weather/weather.php3?s=744920&cityname=Dedham-Massachusetts-United-States-of-America
3. The Simple Method: http://stormwatercenter.net/

ATTACHMENT 4

POLLUTANT REMOVAL CALCULATIONS TABLE

Neponset River Watershed Association
Milton, MA Stormwater Retrofit Project
Runoff and Pollutant Removal Calculations
Sumner Street Area

Environmental Partners GROUP
A partnership for engineering solutions.

Jun 2013

			BMP Removal Efficiency					Quantity of Pollutant Removed			
BMP Designation Number	**Catchment Area Description**	**Stormwater Best Management Practice**	**(A) Drainage Area (ac)**	**TSS Removal (%)**	**TP Removal (%)**	**TN Removal (%)**	**Fecal Coliform Removal (%)**	**Annual TSS Removed (lbs)**	**Annual TP Removed (lbs)**	**Annual TN Removed (lbs)**	**Annual FC Removed (billion colonies)**
1	Sumner 1	Wet Swale	1.70	85.0%	48.0%	30.0%	60.0%	2,334.03	4.21	6.71	161,525.65
2	Sumner 2	Sediment Forebay	0.61	25.0%	8.0%	3.0%	12.0%	246.33	0.25	0.24	11,591.84
3	Sumner 2	Bioretention Basin	0.61	90.0%	30.0%	30.0%	70.0%	665.08	0.87	2.33	59,504.78
4	Sumner 3	Bioretention Filtration System	0.10	82.0%	50.4%	39.5%	57.0%	132.45	0.26	0.52	9,026.43
5	Sumner 3	Bioretention Filtration System	0.10	82.0%	50.4%	39.5%	57.0%	132.45	0.26	0.52	9,026.43
							Sumner Total Removal =	**3,510.34**	**5.85**	**10.32**	**250,675.14**

Annual Calculated Pollutant Load (from Runoff and Pollutant Load Calculations)

BMP Designation Number	**Catchment Area Description**	**Annual TSS (lbs)**	**Annual TP (lbs)**	**Annual TN (lbs)**	**Annual FC (billion colonies)**
1	Sumner 1	2,745.92	8.78	22.35	269,209.42
2 & 3	Sumner 2	985.30	3.15	8.02	96,598.67
4 & 5	Sumner 3	323.05	1.03	2.63	31,671.70

BMP Removal Efficiencies for Wet Swale[1]

Source	**TSS Removal (%)**	**TP Removal (%)**	**TN Removal (%)**	**Fecal Coliform or Bacteria (%)**
Rhode Island Stormwater Manual	**85%**	**48%**	**30%**	**60%**

BMP Removal Efficiencies for Sediment Forebay[1,3]

Source	**TSS Removal (%)**	**TP Removal (%)**	**TN Removal (%)**	**Fecal Coliform or Bacteria (%)**
MA SW Handbook (sand & organic filters)	**25%**	N/A	N/A	N/A
Rhode Island Stormwater Manual	25%	**8%**	**3%**	**12%**

BMP Removal Efficiencies for Bioretention Basin[1,3]

Source	**TSS Removal (%)**	**TP Removal (%)**	**TN Removal (%)**	**Fecal Coliform or Bacteria (%)**
MA SW Handbook (sand & organic filters)	**90%**	**30%** - 50%	**30%** - 90%	N/A
Rhode Island Stormwater Manual	90%	30%	55%	**70%**

BMP Removal Efficiencies for Filterra Bioretention System[4, 5]

Source	**TSS Removal (%)**	**TP Removal (%)**	**TN Removal (%)**	**Fecal Coliform or Bacteria (%)**
Filterra (manufacturer)	85%	60% - 70%	0.43%	**57%** - 76%*
MASTEP Review	**82%**	**50.4%** - 68.3%	**39.5%** (TKN)	N/A

*Standard Blend

Note: Bold-faced values are the selected removal efficiencies

References:

1. Rhode Island Storm Water Manual 2010, Section 5 and Appendix H
http://www.dem.ri.gov/pubs/regs/regs/water/swmanual.pdf
2. New York State Stormwater Management Design Manual, Appendix A-The Simple Method to Calculate Urban Stormwater Loads
http://www.dec.ny.gov/docs/water_pdf/simple.pdf
3. Massachusetts Stormwater Handbook, Volume 2, Chapter 2: Structural BMP Specifications for the Massachusetts Stormwater Handbook
http://www.mass.gov/dep/water/laws/v2c2.pdf
4. The Massachusetts Stormwater Technology Evaluation Project (MASTEP)
http://www.mastep.net/
5. Filterra: http://filterra.com/

ATTACHMENT 5

CONSTRUCTION COST ESTIMATE

Neponset River Watershed Association
Milton, MA Stormwater Retrofit Project
Preliminary Construction Cost Estimate
Sumner Street Area

References:
A. MAPC South Shore Consortium Bid Prices 2013.
B. MA DOT Weighted Bid Prices 2013.

Item	Item Description	Qty	Unit	Unit Cost	Ext Cost	Reference	Notes
1	Site Preparation	1	LS	$5,000	$5,000	EPG Judgement	Minor clearing for access, Temporary access ramps, filter sock, minor site grading.
2	12" Diameter Filter Sock for Erosion Control	600	LF	$2	$1,200	MAPC	Allowance. Assume erosion controls needed for swale and forebay/basin. Assume no erosion controls needed for Filterra bioretention units.
3	Existing Swale Maintenance and Rehab (Wet Swale)	2	Crew/Day	$2,500	$5,000	EPG Judgement	Assume 1 crew, 2 days, to perform work. Including grading, rip rap check dams, etc. Assume O&M = $500/year/unit = $800/year.
4	4'X6' Filterra Bioretention System	2	EA	$13,000	$26,000	Filterra	Assume O&M = $500/year/unit = $1,000/year.
5	4" SDR-35 PVC Piping	40	LF	$30	$1,200	EPG Judgement	For connecting proposed Filterra units to existing drainage structures.
6	Sediment Forebay	840	SF	$20	$16,800	EPG Judgement	Includes connecting to and installing new piping from existing drainage pipe to forebay, rip rap, stone weir/check dam, loam, seed, and connecting to/restoring existing grades.
7	Bioretention Basin	3,181	SF	$30	$95,430	EPG Judgement	Includes connecting to and installing new piping from existing drainage pipe to forebay, rip rap, loam, seed, and connecting to/restoring existing grades. Assume maintenance is $1,200/year total for both sediment forebay and bioretention basin combined.
8	Loam Borrow	250	CY	$30	$7,500	EPG Judgement	Allowance. Assume loam needed for swale and any outside disturbed areas.
9	Seeding	1,100	SY	$1	$1,100	EPG Judgement	Allowance. Assume seed needed for swale and any outside disturbed areas.
	Construction Subtotal				**$159,230**		
	Permitting				$5,000		Conservation Commission Notice of Intent/Hearing
	General Conditions (10%)				$15,923		Bonds, Insurance, Mobilization
	Const. Admin/Resident Engineering (15%)				$23,885		
	Contingency (15%)				$23,885		
	Total Construction Cost				**$227,922**		

ATTACHMENT 6

DRAINAGE AREA PLAN

Drawing file: I:\Milton\2. Stormwater BMP's\4. Design\Drawings\Sumner\Sumner Design 06-06-13.dwg Plot Date: Jun 06,2013-1:17pm

TOWN OF MILTON SETTLED 1640 INCORPORATED 1662

Environmental Partners GROUP
A partnership for engineering solutions.

MARK	DATE	DESCRIPTION

Scale	1"=70'-0"
Date	6/7/13
Job No.	299-1301
Designed by	SDB
Drawn by	SDB
Checked by	CCF
Approved by	CCF

THIS LINE IS ONE INCH LONG WHEN PLOTTED AT FULL SCALE ON A 22" X 34" DRAWING

MILTON STORMWATER RETROFIT PROJECT
NEPONSET RIVER WATERSHED ASSOCIATION &
TOWN OF MILTON, MASSACHUSETTS

SUMNER STREET

DRAINAGE AREAS

NOT FOR CONSTRUCTION

Sheet No.

C-3A

ATTACHMENT 7

CONCEPTUAL DESIGN PLAN

Drawing file: I:\Milton\2. Stormwater BMPs\4. Design\Drawings\Sumner\Sumner Design 06-06-13.dwg Plot Date: Jun 06,2013-4:05pm

TOWN OF MILTON SETTLED 1640 INCORPORATED 1662

Environmental Partners GROUP

A partnership for engineering solutions.

MARK	DATE	DESCRIPTION

Scale	1"=50'-0"
Date	6/7/13
Job No.	299-1301
Designed by	SDB
Drawn by	SDB
Checked by	CCF
Approved by	CCF

THIS LINE IS ONE INCH LONG WHEN PLOTTED AT FULL SCALE ON A 22" X 34" DRAWING

MILTON STORMWATER RETROFIT PROJECT
NEPONSET RIVER WATERSHED ASSOCIATION &
TOWN OF MILTON, MASSACHUSETTS

SUMNER STREET

CONCEPTUAL BMP DESIGN

NOT FOR CONSTRUCTION

Sheet No.

C-3

ATTACHMENT 8

TEST PIT LOG

1900 Crown Colony
Drive, Suite 402
Quincy, MA 02169
(617) 657-0200

EXPLORATORY TEST PIT LOG

Environmental Partners GROUP
A partnership for engineering solutions.

Project:	NepRWA - MILTON BMP'S		Test Pit No: **TP- 1**
Location:	MILTON, MA	Location:	Sumner Street Park/Green Area
Client:	TOWN OF MILTON	Approx. Ground Elevation:	36
Contractor/Operator:	TOWN OF MILTON	Datum:	NAVD 88
Equipment:	John Deere 410 E	Project No.	299-1301
Weather:	Sunny, 60's	Time Started:	8:00 AM
Performed By: SDB	Date: 5/28/2013	Time completed:	9:00 AM
Checked By: CCF	Date: 6/3/2013		

Strata Depth (feet)	***Sample No.***	***Soil Description***	***Excavation Effort***	***Boulder Count***	***Remark No.***
0" - 12"		Topsoil/Silty Loam	E	A	
18" - 46"		Brown silty gravel with stones and rocks	E	A	
46" - 54"		Rusty brown gravelly sand with stones and rocks; wet soil at approximately 48"	E	A	1

REMARKS:

Total depth of test pit =4.5 feet

Depth to ground water= 4'-4" B.G.S.

1 Due to the nature of the soil and the depth of groundwater observed, a soil sample was not taken to a lab for analysis.

2 Existing RCP drain pipe found approximately 2'-2.5' B.G.S.

LEGEND

Boulder Count Size Range	Letter	***Excavation Effort***
6"-18"	A	E = Easy
18"-36"	B	M = Moderate
36" Plus	C	D = Difficult

Pit Dimensions

W = 4'

4'x5'x4.5'

L = 5'

NORTH

Volume (cy) 3.33

Appendix B – Pollutant Load Export Rates (PLERs)

Land Use & Cover[1]	PLERs (lb/acre/year)		
	(TP)	(TSS)	(TN)
AGRICULTURE, HSG A	0.45	7.14	2.59
AGRICULTURE, HSG B	0.45	29.4	2.59
AGRICULTURE, HSG C	0.45	59.8	2.59
AGRICULTURE, HSG D	0.45	91.0	2.59
AGRICULTURE, IMPERVIOUS	1.52	650	11.3
COMMERCIAL, HSG A	0.03	7.14	0.27
COMMERCIAL, HSG B	0.12	29.4	1.16
COMMERCIAL, HSG C	0.21	59.8	2.41
COMMERCIAL, HSG D	0.37	91.0	3.66
COMMERCIAL, IMPERVIOUS	1.78	377	15.1
FOREST, HSG A	0.12	7.14	0.54
FOREST, HSG B	0.12	29.4	0.54
FOREST, HSG C	0.12	59.8	0.54
FOREST, HSG D	0.12	91.0	0.54
FOREST, HSG IMPERVIOUS	1.52	650	11.3
HIGH DENSITY RESIDENTIAL, HSG A	0.03	7.14	0.27
HIGH DENSITY RESIDENTIAL, HSG B	0.12	29.4	1.16
HIGH DENSITY RESIDENTIAL, HSG C	0.21	59.8	2.41
HIGH DENSITY RESIDENTIAL, HSG D	0.37	91.0	3.66
HIGH DENSITY RESIDENTIAL, IMPERVIOUS	2.32	439	14.1
HIGHWAY, HSG A	0.03	7.14	0.27
HIGHWAY, HSG B	0.12	29.4	1.16
HIGHWAY, HSG C	0.21	59.8	2.41
HIGHWAY, HSG D	0.37	91.0	3.66
HIGHWAY, IMPERVIOUS	1.34	1,480	10.2
INDUSTRIAL, HSG A	0.03	7.14	0.27
INDUSTRIAL, HSG B	0.12	29.4	1.16
INDUSTRIAL, HSG C	0.21	59.8	2.41
INDUSTRIAL, HSG D	0.37	91.0	3.66

Land Use & Cover[1]	PLERs (lb/acre/year)		
	(TP)	(TSS)	(TN)
INDUSTRIAL, IMPERVIOUS	1.78	377	15.1
LOW DENSITY RESIDENTIAL, HSG A	0.03	7.14	0.27
LOW DENSITY RESIDENTIAL, HSG B	0.12	29.4	1.16
LOW DENSITY RESIDENTIAL, HSG C	0.21	59.8	2.41
LOW DENSITY RESIDENTIAL, HSG D	0.37	91.0	3.66
LOW DENSITY RESIDENTIAL, IMPERVIOUS	1.52	439	14.1
MEDIUM DENSITY RESIDENTIAL, HSG A	0.03	7.14	0.27
MEDIUM DENSITY RESIDENTIAL, HSG B	0.12	29.4	1.16
MEDIUM DENSITY RESIDENTIAL, HSG C	0.21	59.8	2.41
MEDIUM DENSITY RESIDENTIAL, HSG D	0.37	91.0	3.66
MEDIUM DENSITY RESIDENTIAL, IMPERVIOUS	1.96	439	14.1
OPEN LAND, HSG A	0.12	7.14	0.27
OPEN LAND, HSG B	0.12	29.4	1.16
OPEN LAND, HSG C	0.12	59.8	2.41
OPEN LAND, HSG D	0.12	91.0	3.66
OPEN LAND, IMPERVIOUS	1.52	650	11.3

[1]HSG = Hydrologic Soil Group