MASSACHUSETTS
watershed·based plans

WATERSHED-BASED PLAN

Mill River (MA34-25) Watershed

April 2021

Prepared By:

Massachusetts Association of Conservation Districts
University of Massachusetts
Geosyntec Consultants, Inc.

Prepared For:

MassDEP
Commonwealth of Massachusetts
Department of Environmental Protection

This project has been financed with Federal Funds from the Environmental Protection Agency (EPA) to the Massachusetts Department of Environmental Protection (the Department) under an s. 319 competitive grant. The contents do not necessarily reflect the views and policies of EPA or of the Department, nor does the mention of trade names or commercial products constitute endorsement or recommendation for use

Contents

Executive Summary

Introduction: The purpose of a Massachusetts Watershed-Based Plan (WBP) is to organize information about Massachusetts' watersheds, and present the information 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 the United States Environmental Protection Agency's (EPA's) recommended format for "nine-element" watershed plans. This WBP was developed by Geosyntec Consultants (Geosyntec) under the direction of the University of Massachusetts, Amherst (UMass) and the Massachusetts Association of Conservation Districts (MACD) with funding, input, and collaboration from the Massachusetts Department of Environmental Protection (MassDEP).

This WBP was developed using funds from the Section 319 Nonpoint Source Pollution Grant Program (Section 319) to assist grantees in developing technically robust WBPs using MassDEP's Watershed-Based Planning Tool (WBP Tool). The University of Massachusetts, Amherst (UMass) was a recipient of Section 319 funding in Fiscal Year 2020 to implement BMPs at an agricultural property in the Mill River watershed (UMass, 2019). MACD was a recipient of Section 319 funding in Fiscal Year 2021 to conduct outreach to farm-owners and implement BMPs at similar agricultural properties in the Mill River watershed (MACD, 2020). Both projects have been identified to reduce bacteria and nutrient loading from agricultural lands, which have been identified as a source of nonpoint source pollution contributing to waterbody impairments within the watershed.

This WBP was prepared for the approximately 30-square mile Mill River watershed, which is a tributary to the Connecticut River. Major streams in the watershed include the Mill River (MA34-25); Cushman Brook (MA34-34); Doolittle Brook; Mountain Brook; Nurse Brook (MA34-59) and Roaring Brook. Major lakes and ponds in the watershed include Lake Warner (MA34098), Puffers Pond, and Leverett Pond (MA34042).

Impairments and Pollution Sources: The Mill River (MA34-25), which flows from Puffers Pond in Amherst to Lake Warner in Hadley, is a category 5 water body on the Massachusetts Year 2016 Integrated List of Waters (303(d) list) (MassDEP, 2019) due to Escherichia coli (*E. coli*) from agriculture, unknown sources, and urban stormwater runoff.

Lake Warner (MA34098) has a completed Phosphorus Total Maximum Daily Load (TMDL) and is a category 4A water body on the 2016 303(d) list due to algae, dissolved oxygen, non-native aquatic plants, total phosphorus (TP), and turbidity from introduction of non-native organisms and unknown sources.

An example of a pollution source that has been identified is Full of Grace Farm. Full of Grace Farm is a 20-acre equine farm located in Hadley, MA, which currently houses 15-17 horses. The Mill River runs through the property, and horses have direct access to the Mill River. In the past, there has been visible leaching and runoff from the on-site manure pile, and there currently are no stormwater management measures being implemented on the property. As discussed later in this WBP, agricultural properties like Full of Grace Farm are being prioritized for implementation of control measures to reduce pollutant discharges from these areas.

MassDEP has collected water quality data to help understand pollutant sources in the Mill River. *E. coli* samples collected between April—November 2003 from the Mill River at Mill River Lane in Hadley (approximately 600 feet downstream of the Full of Grace Farm property) had a geometric mean of 148 colonies/100 ml, which is above the Massachusetts Surface Water Quality Standard of 126 colonies/ 100 ml (MassDEP 2003). *E. coli* samples were also collected from May—September 2008 at the same location and revealed a geometric mean of 171 colonies/ 100 ml (MassDEP, 2008), which is also above the Massachusetts Surface Water Quality Standard. TP samples were also collected at this location from May—September 2008 ranged from 14—77 micrograms per liter (µg/L) with an average of 36 µg/L (MassDEP, 2008), which indicated some exceedances above EPA criteria of 50 µg/L (EPA, 1986) .

The Friends of Lake Warner and the Mill River (FOLWMR) have collected more recent water quality data to help understand pollutant sources in Lake Warner and the Mill River. *E. coli* data obtained from approximately 1/4-mile upstream of where the Mill River enters Lake Warner (at Mill Site Road) was collected in 2016, 2017, 2018, 2019, and 2020 and had a geometric mean of 614, 392, 772, 480, and 680 colonies/ 100 ml, respectively (Johnson, 2019; Johnson, 2021), which is substantially above the Massachusetts Surface Water Quality Standard of 126 colonies/ 100 ml (MassDEP 2003). TP data were also collected at this location in 2003, 2004, 2015, 2016, 2017, 2018, 2019, and 2020 and had numerous exceedances (Johnson, 2019; Johnson, 2021), above the water quality criteria of 50 µg/L (EPA 1986). FOLWMR data also indicated TP and *E. coli* exceedances above the criteria at two locations in Lake Warner and at two small tributaries to the Mill River (Tan Brook and Knightly Brook).

Goals, Management Measures, and Funding: The long-term goal of this WBP is to reduce *E. coli* and TP loading to the Mill River and Lake Warner, eventually leading to delisting of these waterbodies from the 303(d) list by 2035. It is expected that these pollutant load reductions will result in improvements to listed impairments throughout the watershed.

It is expected that goals will be accomplished primarily through installation of agricultural and structural Best Management Practices (BMPs) to capture runoff and reduce *E. coli* and TP loading as well as implementation of non-structural BMPs (e.g., street sweeping, catch basin cleaning), and watershed education and outreach to achieve additional pollutant load reductions. Agricultural and structural BMPs will first be implemented at the Full of Grace Farm in Hadley with Fiscal Year 2020 Section 319 funding (UMass, 2019). Additional planning and implementation will be performed at other farms in the watershed, with funding from the Fiscal Year 2021 Section 319 grant (MACD, 2020).

It is expected that additional funding for management measures will be obtained from a variety of sources including Section 319 funding, Massachusetts Environmental Trust (MET) grants, the Agricultural Environmental Enhancement Program (AEEP), the Agricultural Produce Safety Improvement Program (APSIP), Town capital funds, volunteer efforts, and Natural Resources Conservation Service (NRCS) grants including the Environmental Quality Incentives Program (EQIP) and the Agricultural Management Assistance (AMA) program.

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.

UMass aims to engage the equine industry and community horse owners by hosting an annual field day at the proposed project, including the generation of educational materials and subsequent follow up discussion with interested attendees. It is expected that this program will be evaluated by tracking field day attendance. UMass plans to distribute fact sheets and newsletters to an email list serve of over 800 relevant parties and post news of the project on the “Crops, Dairy, Livestock and Equine” UMass Extension webpage. It is expected that this program will be evaluated by tracking the number of emails and the size of the list serve receiving the emails in addition to visitors to the UMass Extension webpage.

MACD will engage in outreach and dialogue with farmers in the Mill River watershed and share information about the availability of funds from MassDEP, the Massachusetts Department of Agricultural Resources (MDAR) and NRCS to implement BMPs to reduce contaminated runoff from agricultural operations.

A meeting was held on February 24, 2021, which included core stakeholders in the Mill River watershed. The purpose of the meeting was to introduce stakeholders to one another and gain consensus on elements of this WBP.

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 improvements to be directly evaluated over time. Other indirect evaluation metrics are also recommended, included quantification of potential pollutant load reductions from non-structural BMPs. Every three years, progress towards achieving the interim and final water quality goals will be assessed and the WBP will be adjusted as needed.

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 the information 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 the United States Environmental Protection Agency's (EPA'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 WBPs only for selected watersheds. Massachusetts Department of Environmental Protection's (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.

EPA 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 Mill River Watershed includes nine elements (a through i) in accordance with EPA 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 WBP (and to achieve any other watershed goals identified in the WBP), 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 management measures** needed to achieve the load reductions estimated under paragraph (b) above as well as to achieve other watershed goals identified in this WBP, 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, United States Department of Agriculture (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 nonpoint source management measures that will be implemented.

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

g) A description of **interim, measurable milestones** for determining whether nonpoint source 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 WBP needs to be revised or, if a nonpoint source 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 University of Massachusetts, Amherst (UMass) and the Massachusetts Association of Conservation Districts (MACD) with funding, input, and collaboration from MassDEP. This WBP was developed using funds from the Section 319 Nonpoint Source Pollution Grant Program (Section 319) to assist grantees in developing technically robust WBPs using MassDEP's Watershed-Based Planning Tool (WBP Tool). UMass was a recipient of Section 319 funding in Fiscal Year 2020 to implement BMPs at an agricultural property in the watershed (UMass, 2019). MACD was a recipient of Section 319 funding in Fiscal Year 2021 to conduct outreach to farm-owners and implement BMPs at similar agricultural properties in the watershed (MACD, 2020). Both projects have been identified to reduce bacteria and nutrient loading from agricultural lands, which have been identified as a source of nonpoint source pollution contributing to waterbody impairments within the watershed.

The following are core stakeholders in the Mill River watershed:

- Michael Leff—MACD
- Dr. Masoud Hashemi – UMass
- Dr. Timothy Randhir – UMass
- Dr. Christian Guzman—UMass
- Dr. David Reckhow—UMass
- Janice Weldon—UMass
- Dr. Nick Tooker—UMass
- Terri Wolejko—UMass
- Beth Willson—Amherst Department of Public Works
- Bob Duby – Owner of Devine Farm, Hadley
- Diana Laurenitus-Bonacci—Hampden Hampshire Conservation District (HHCD)
- Kathleen Bamford—HHCD
- Bob Skalbite—Hadley Horse Farm
- Jason Johnson—Friends of Lake Warner and the Mill River (FOLWMR)
- Michele Morris-Friedman—Friends of Lake Warner and the Mill River
- Janice Stone—Hadley Conservation Commission
- Peter Maleady—Lake Warner area resident

- Matthew Reardon – MassDEP

This WBP was developed as part of an iterative process:

- The original WBP was developed and approved by MassDEP in December 2019 and included existing data from UMass and FOLWMR.
- Subsequently, stakeholder outreach was expanded and a core stakeholder conference call was held on February 24, 2021 to solicit additional input and gain consensus on elements included in the plan (i.e., identifying problem areas, BMP projects, water quality goals, public outreach activities, etc.). The meeting minutes from the stakeholder conference call are included in **Appendix A**.
- Next, an updated WBP was drafted and reviewed by MassDEP.
- The WBP was finalized based on MassDEP input.

Data Sources

This WBP was developed using the framework and data sources provided by MassDEP's WBP Tool and supplemented by information provided in the Section 319 grant application for "Implementation, Remediation, and Education of Selected Best Management Practices to Minimize the Environmental Impact of Two Equine Operations" (UMass, 2019) and the Section 319 grant application for "Western Massachusetts Agricultural Nonpoint Source Program" (MACD, 2020).

Summary of Past Work

UMass has successfully implemented the following Section 319 grant-funded agricultural BMP improvements in the Mill River watershed (Hashemi and Harper, 2018).

Hadley Horse Farm

The following BMPs were implemented at a horse farm within the Mill River watershed:

- Several sacrifice areas with a total area of 28,800 square feet were installed;
- Vegetated swales were constructed;
- Fencing was installed to exclude horses from wetlands;
- Approximately 32,000 square feet of pasture was reseeded; and
- An aerated composting system was installed.

Mapleline Dairy Farm

Based on soil tests, most of the fields on this farm used for growing corn silage needed additional nitrogen but had excess phosphate being applied. An updated Comprehensive Nutrient Management Plan was developed for this farm, to reduce phosphate application, and implemented in August 2017.

Jonathan Carr Farm

Cover crop was applied to approximately twenty acres of farmland and brush management was implemented on approximately 13 acres of farmland for erosion control. These BMPs were implemented in July 2017—April 2018.

Devine Dairy Farm

Leachate was controlled from silage bunks with a vegetative treatment area, and an existing bunk silo was reconstructed to increase proper storage capacity of corn silage. These BMPs were implemented in June 2018 and September 2017, respectively.

Adriance Farm

An aerated compost pile was constructed and implemented in August 2017 to treat manure from three donkeys and 4 alpacas at the farm.

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 the Mill River watershed, which is in the towns of Hadley, Amherst, Leverett, Sunderland and Shutesbury, Massachusetts, and was delineated to the outlet of Lake Warner in Hadley Massachusetts. Major streams in the watershed include the Mill River (MA34-25); Cushman Brook (MA34-34); Doolittle Brook; Mountain Brook; Nurse Brook and Roaring Brook. Lake Warner (MA34098), Puffers Pond, Leverett Pond (MA34042), and Atkins Reservoir are also included in the watershed. The Mill River is a tributary to the Connecticut River, and has a drainage area of approximately 19,500 acres (approximately 30 square miles).

Table A-1 presents the general watershed information for the Mill River watershed[1] and **Figure A-1** includes a map of the watershed boundary. A bathymetry map of Lake Warner is included in **Appendix B**.

Table A-1: General Watershed Information

Watershed Name (Assessment Unit ID):	Cushman Brook (MA34-34); Doolittle Brook; Mill River (MA34-25); Mountain Brook; Nurse Brook; Roaring Brook; Lake Warner (MA34098); Factory Hollow Pond (MA34021), Leverett Pond (MA34042), Atkins Reservoir (MA34006)
Major Basin:	Connecticut River
Watershed Area (within MA):	19,464 acres

[1] Watersheds are defined by the WBP-tool by utilizing MassGIS drainage sub-basins.

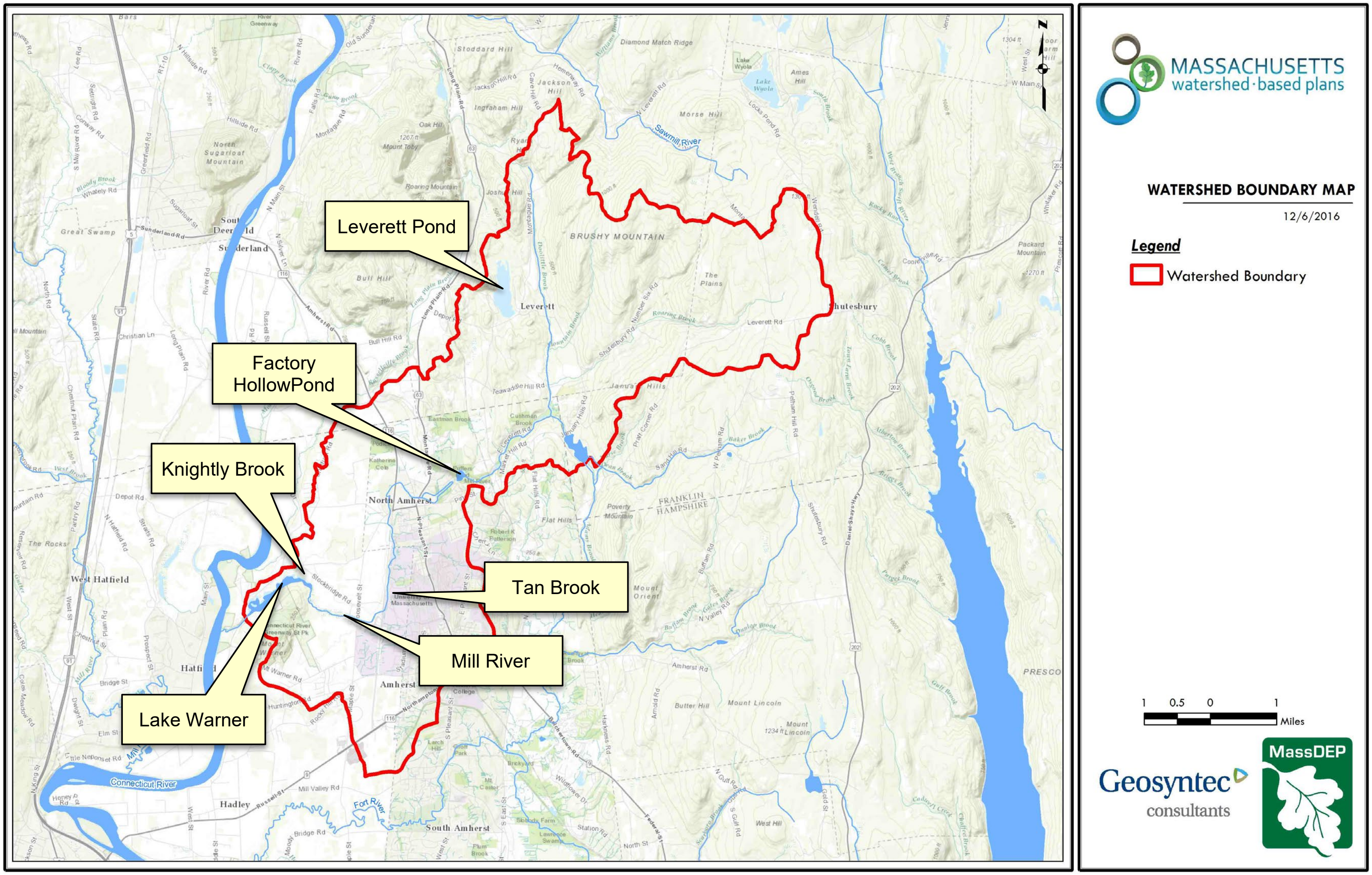


Figure A-1: Watershed Boundary Map

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

MassDEP Water Quality Assessment Report and TMDL Review

Appendix C includes select excerpts from the following reports relating to the water quality in Mill River (MA34-25), Cushman Brook (MA34-34), Lake Warner (MA34098), and Leverett Pond (MA34042):

- Connecticut River Watershed 2003 Water Quality Assessment Report (MassDEP, 2008)
- Total Maximum Daily Loads of Phosphorus for Selected Connecticut Basin Lakes (MassDEP, 2001)
- Connecticut River Watershed 2008 DWM Water Quality Monitoring Data (MassDEP, 2013a)
- Connecticut River Watershed 2008 Benthic Macroinvertebrate Bioassessment (MassDEP, 2013b)

Water Quality Impairments and Pollution Sources

The Mill River (MA34-25) is identified as a category 5 water body on the 2016 Massachusetts Integrated List of Waters (303(d) list) due to Escherichia coli (*E. coli*) from agricultural, unspecified urban stormwater, and unknown sources. Lake Warner (MA34098) is identified as a category 4A water body on the 2016 303(d) list due to algae, dissolved oxygen, non-native aquatic plants, total phosphorus (TP), and turbidity from introduction of non-native organisms and unknown sources. Leverett Pond (MA34042) is listed as a category 4A water body on the 2016 303(d) list due to Eurasian Watermilfoil, non-native aquatic plants, and nutrient/eutrophication biological indicators from introduction of non-native organisms, internal nutrient cycling, on-site treatment systems, and rural residential areas. Leverett Pond (MA34042) is part of the headwaters of Doolittle Brook, a tributary to Cushman Brook, which flows into Factory Hollow Pond in Amherst. The downstream Doolittle Brook, Cushman Brook, and Puffers Pond are not listed as impaired on the 303(d) list.

Impairment categories from the 2016 303(d) list are listed in **Table A-2**. Known water quality impairments for the Mill River, Lake Warner, and Leverett Pond, as documented in the 2016 303(d) list, are listed in **Table A-3**.

Table A-2: Massachusetts Year 2016 Integrated List of Waters (303(d) list) Categories (MassDEP, 2019)

303(d) 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-3: Mill River Watershed Water Quality Impairments (MassDEP, 2019)

Assessment Unit ID	Waterbody	303(d) List Category	Designated Use	Impairment Cause	Impairment Source
MA34-25	**Mill River**	**5**	Primary Contact Recreation	Escherichia Coli (*E. coli*)	Unspecified Urban Stormwater
MA34-25	**Mill River**	**5**	Primary Contact Recreation	Escherichia Coli (*E. coli*)	Agriculture
MA34-25	**Mill River**	**5**	Primary Contact Recreation	Escherichia Coli (*E. coli*)	Source Unknown
MA34098	**Lake Warner**	**4A**	Fish, other Aquatic Life and Wildlife	Algae	Source Unknown
MA34098	**Lake Warner**	**4A**	Fish, other Aquatic Life and Wildlife	Dissolved Oxygen	Source Unknown
MA34098	**Lake Warner**	**4A**	Fish, other Aquatic Life and Wildlife	Non-Native Aquatic Plants	Introduction of Non-native Organisms (Accidental or Intentional)
MA34098	**Lake Warner**	**4A**	Fish, other Aquatic Life and Wildlife	Phosphorus, Total	Source Unknown
MA34098	**Lake Warner**	**4A**	Fish, other Aquatic Life and Wildlife	Turbidity	Source Unknown
MA34042	**Leverett Pond**	**4A**	Aesthetic	Eurasian Water Milfoil, Myriophyllum spicatum	Introduction of Non-native Organisms (Accidental or Intentional)
MA34042	**Leverett Pond**	**4A**	Aesthetic	Non-Native Aquatic Plants	Introduction of Non-native Organisms (Accidental or Intentional)
MA34042	**Leverett Pond**	**4A**	Aesthetic	Nutrient/Eutrophication Biological Indicators	Internal Nutrient Recycling
MA34042	**Leverett Pond**	**4A**	Aesthetic	Nutrient/Eutrophication Biological Indicators	On-site Treatment Systems (Septic Systems and Similar Decentralized Systems)
MA34042	**Leverett Pond**	**4A**	Aesthetic	Nutrient/Eutrophication Biological Indicators	Rural (Residential Areas)
MA34042	**Leverett Pond**	**4A**	Fish, other Aquatic Life and Wildlife	Eurasian Water Milfoil, Myriophyllum spicatum	Introduction of Non-native Organisms (Accidental or Intentional)
MA34042	**Leverett Pond**	**4A**	Fish, other Aquatic Life and Wildlife	Non-Native Aquatic Plants	Introduction of Non-native Organisms (Accidental or Intentional)
MA34042	**Leverett Pond**	**4A**	Primary Contact Recreation	Eurasian Water Milfoil, Myriophyllum spicatum	Introduction of Non-native Organisms (Accidental or Intentional)
MA34042	**Leverett Pond**	**4A**	Primary Contact Recreation	Non-Native Aquatic Plants	Introduction of Non-native Organisms (Accidental or Intentional)
MA34042	**Leverett Pond**	**4A**	Primary Contact Recreation	Nutrient/Eutrophication Biological Indicators	Internal Nutrient Recycling
MA34042	**Leverett Pond**	**4A**	Primary Contact Recreation	Nutrient/Eutrophication Biological Indicators	On-site Treatment Systems (Septic Systems and Similar Decentralized Systems)
MA34042	**Leverett Pond**	**4A**	Primary Contact Recreation	Nutrient/Eutrophication Biological Indicators	Rural (Residential Areas)
MA34042	**Leverett Pond**	**4A**	Secondary Contact Recreation	Eurasian Water Milfoil, Myriophyllum spicatum	Introduction of Non-native Organisms (Accidental or Intentional)
MA34042	**Leverett Pond**	**4A**	Secondary Contact Recreation	Non-Native Aquatic Plants	Introduction of Non-native Organisms (Accidental or Intentional)

Assessment Unit ID	Waterbody	303(d) List Category	Designated Use	Impairment Cause	Impairment Source
MA34042	**Leverett Pond**	**4A**	Secondary Contact Recreation	Nutrient/Eutrophication Biological Indicators	Internal Nutrient Recycling
MA34042	**Leverett Pond**	**4A**	Secondary Contact Recreation	Nutrient/Eutrophication Biological Indicators	On-site Treatment Systems (Septic Systems and Similar Decentralized Systems)
MA34042	**Leverett Pond**	**4A**	Secondary Contact Recreation	Nutrient/Eutrophication Biological Indicators	Rural (Residential Areas)

Additional Water Quality Data

TP and *E. coli* data, collected by FOLWMR, is presented in **Table A-4** and **Table A-5**. Bolded values in **Table A-4** and **Table A-5** indicate exceedances above the water quality goals presented in **Table A-7.** All five sampling locations in **Table A-4** exhibited elevated levels of TP in recent years with the highest levels in Knightly Brook and Tan Brook. Knightly Brook and Tan Brook are small streams, which are tributaries to the Mill River (**Figure A-1**). All four sampling locations in **Table A-5** exhibited elevated single sample and geometric mean levels of *E. coli* above the water quality goals presented in **Table A-7.**

Table A-4: TP Data in Mill River Watershed (Johnson, 2019; Johnson 2021)

Date	Total Phosphorus (TP) (µg/L)				
	Mill River Mainstem (at Mill Site Road)	Lake Warner (near Outlet)	Lake Warner (middle of Lake)	Knightly Brook (near confluence with Mill River)	Tan Brook (near confluence with Mill River)
1981	--	**90**	--	--	--
5/5/2003	--	--	27	--	--
6/3/2003	--	--	22	--	--
7/14/03	22	--	**40**	--	--
7/22/03	43	--	--	--	--
8/11/03	--	--	**37**	--	--
9/2/03	21	--	--	--	--
9/16/03	--	--	**43**	--	--
10/10/03	19	--	10	--	--
6/14/04	--	--	--	--	**64**
6/14/04	--	--	--	--	**65**
8/10/2004	--	30	--	--	--
2010	--	**37**	--	--	--
7/2/2015	--	--	15.2	--	--
8/11/2015	**77.8**	--	--	--	--
5/18/2016	17.3	--	19.4	**73.5**	--
6/15/2016	48.4	--		**197.2**	--
7/11/2016	36	--	**41**	**74**	**162**
7/31/2016	**126**	--	--	**190**	**204**
8/11/2016	**99**	--	--	--	**151**
8/15/2016	--	--	**37**	--	--
9/1/2016	--	--	**38**	--	--

Date	Total Phosphorus (TP) (µg/L)				
	Mill River Mainstem (at Mill Site Road)	Lake Warner (near Outlet)	Lake Warner (middle of Lake)	Knightly Brook (near confluence with Mill River)	Tan Brook (near confluence with Mill River)
9/19/2016	--	--	23	--	--
9/29/2016	--	--	--	**85**	--
9/29/2016	--	--	--	**114**	--
10/6/2016	--	--	--	**85**	--
10/6/2016	--	--	--	**90**	--
10/24/2016	27	--	--	**115**	**265**
5/31/2017	--	--	**54**	--	--
6/8/2017	37	--	--	--	--
6/14/2017	--	--	**41**	--	--
6/15/2017	--	--	--	37	--
6/22/2017	--	--	--	**85**	--
6/29/2017	**92**	--	--		--
7/7/2017	--	--	--	**110**	--
7/7/2017	--	--	--	**109**	--
7/8/2017	--	--	**131**	--	--
7/20/2017	31	--	--	--	--
7/31/2017	--	--	**79**	--	--
4/26/2018	27	21	--	**126**	**124**
5/16/2018	32	30	--	**169**	**73**
6/4/2018	**167**	**34**	--	**437**	**223**
6/28/2018	**192**	--	--	--	**188**
6/29/2018	--	**78**	--	--	**95**
7/18/2018	**77**	**38**	--	**297**	**82**
7/27/2018	**54**	**70**	--	**180**	**123**
8/10/2018	**52**	**65**	--	**252**	**200**
9/11/2018	**75**	22	--	**415**	**282**
9/18/2018	**292**	**46**	--	--	**99**
9/26/2018	**51**	**78**	--	**317**	--
5/29/2019	15	27	--	**133**	--
6/26/2019	**67**	**45**	--	**169**	--
7/24/2019	41	**50**	--	**141**	--
8/28/2019	18	**43**	--	**78**	--
6/7/2020	26.6	**34.4**	--	--	--
6/30/2020	42.8	**56.2**	--	--	--
7/24/2020	**59.5**	**47.8**	--	--	--
8/3/2020	49.5	**46.1**	--	--	--
9/17/2020	--	25.5	--	--	--
9/28/2020	20.4	11.2	--	--	--
9/30/2020	22.5	20.4	--	--	--
10/14/2020	46.7	**88.5**	--	--	--

"µg/L' = milligrams per Liter.
" – " indicates no sample was taken.
Bolded values indicate exceedances above the water quality goals (**Table A-7**)

Table A-5: *E. coli* Data and Geometric Mean Concentrations in Mill River Watershed (Johnson, 2019; Johnson 2021)

DATE	*E. coli* bacteria CFU/100mL			
	Mill River Mainstem (at Mill Site Road)	Lake Warner (near Outlet)	Knightly Brook (near confluence with Mill River)	Tan Brook (near confluence with Mill River)
6/2/2016	**435**	79	184	--
6/16/2016	**488**	50	**2420**	**579**
6/30/2016	**260**	**272**	**2420**	**261**
7/14/2016	**1553**	101	**579**	--
7/21/2016	**488**	50	**687**	--
7/28/2016	**365**	50	**2420**	**488**
8/11/2016	**2420**	75	**1733**	--
8/25/2016	**548**	50	**866**	**548**
9/29/2016	--	--	**727**	--
10/6/2016	--	--	**980**	--
6/8/2017	**308**	**579**	**816**	--
6/15/2017	**461**	**1986**	**345**	--
6/22/2017	**326**	55	144	--
6/29/2017	**249**	20	--	--
7/5/2017	**249**	20	--	--
7/13/2017	**921**	53	**2420**	--
7/20/2017	**548**	55	--	--
8/3/2017	**365**	20	--	--
8/17/2017	**411**	23	--	--
5/31/2018	**345**	64	**291**	--
6/7/2018	**980**	116	**548**	--
6/14/2018	**613**	36	--	--
6/21/2018	**816**	127	--	--
6/28/2018	**2420**	79	--	--
7/12/2018	**517**	19	--	--
7/19/2018	**687**	**548**	--	--
7/26/2018	**2420**	58	--	--
8/9/2018	**980**	**1986**	--	--
8/16/2018	**345**	115	--	--
8/23/2018	**326**	**921**	--	--
8/30/2018	**260**	26	--	--
9/6/2018	**1120**	33	--	--
9/13/2018	**1203**	**2420**	--	--
9/20/2018	**488**	**579**	--	--

DATE	*E. coli* bacteria CFU/100mL			
	Mill River Mainstem (at Mill Site Road)	Lake Warner (near Outlet)	Knightly Brook (near confluence with Mill River)	Tan Brook (near confluence with Mill River)
9/27/2018	**2420**	**2420**	--	--
5/30/2019	**21**	96	--	--
6/6/2019	**770**	83	--	--
6/13/2019	**236**	15	--	--
6/20/2019	**411**	26	--	--
6/27/2019	**727**	120	--	--
7/4/2019	**435**	11	--	--
7/11/2019	**435**	35	--	--
7/18/2019	**2420**	60	--	--
7/25/2019	**461**	127	--	--
8/1/2019	**1046**	23	--	--
8/8/2019	**2420**	**488**	--	--
8/15/2019	**345**	15	--	--
9/19/2019	**260**	--	--	--
9/26/2019	**548**	--	--	--
10/3/2019	**411**	51	--	--
10/10/2019	125	205	--	--
10/17/2019	**2420**	**579**	--	--
6/22/2020	**816**	122	--	--
7/6/2020	**488**	38	--	--
7/20/2020	**649**	124	--	--
8/3/2020	**2420**	225	--	--
8/17/2020	**548**	30	--	--
8/31/2020	**416**	13	--	--
9/14/2020	**613**	63	--	--
9/28/2020	**411**	30	--	--
10/13/2020	**866**	57	--	--
***E. coli* Geometric mean (CFU/100mL)**				
2016	**614**	75	**1011**	**449**
2017	**392**	52	**560**	--
2018	**772**	**190**	**399**	--
2019	**480**	61	--	--
2020	**680**	56	--	--

"CFU/100mL" = colony forming units per 100 milliliters

" – " indicates no sample was taken.

Bolded values indicate exceedances above the water quality goals (**Table A-7**)

Water Quality Goals

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

a) For **waterbodies with known impairments**, a TMDL is established by MassDEP and EPA 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** TP, a default water quality goal for TP is based on target concentrations established in the Quality Criteria for Water (EPA, 1986) (also known as the "Gold Book"). The Gold Book states that TP should not exceed 50 micrograms per liter (µg/L) in any stream at the point where it enters any lake or reservoir, nor should TP exceed 25 µg/L within a lake or reservoir. For the purposes of developing WBPs, MassDEP has adopted 50 µg/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-6** lists the classifications for each Assessment Unit ID within the Mill River watershed. The water quality goals for *E. coli* bacteria are based on the Massachusetts Surface Water Quality Standards.

Table A-6: Massachusetts Surface Water Quality Standards Classification by Assessment Unit ID

Assessment Unit ID	Waterbody	Class
MA34-25	Mill River	B
MA34-34	Cushman Brook	B
MA34098	Lake Warner	B
MA34042	Leverett Pond	B

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

Table A-7 lists water quality goals for TP and bacteria (*E. coli*). Element C of this WBP includes proposed BMPs to address these impairments.

Table A-7: Water Quality Goals

Pollutant	Waterbody Name (Assessment Unit ID(s))	Goal	Source
TP	Mill River (MA34-25)	TP should not exceed: --50 µg/L	Quality Criteria for Water (EPA, 1986)
	Lake Warner (MA34098)	TP should not exceed: 30 µg/L	Total Maximum Daily Loads of Phosphorus for Selected Connecticut Basin Lakes
	Leverett Pond (MA34042)	TP should not exceed: 15 µg/L	Total Maximum Daily Loads of Phosphorus for Selected Connecticut Basin Lakes
E. coli	All Assessment Units within the watershed	**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 minimum of 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)

Land Use Information

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

Watershed Land Uses

Land use in the Mill River watershed is mostly forested (approximately 66 percent); approximately 14 percent of the watershed is agricultural; approximately 5 percent of the watershed is open land or water; approximately 5 percent of the watershed is commercial or industrial; approximately 9 percent is residential; and approximately 1 percent is devoted to highways (**Table A-8; Figure A-2**).

Table A-8: Subwatershed Land Uses

Land Use	Area (acres)	% of Watershed
Forest	12,835.70	65.9
Agriculture	2,698.37	13.9
Low Density Residential	967.28	5
Commercial	852.03	4.4
Open Land	796.63	4.1
Medium Density Residential	448.81	2.3
High Density Residential	353.85	1.8
Water	277.51	1.4
Industrial	131.71	0.7
Highway	101.88	0.5

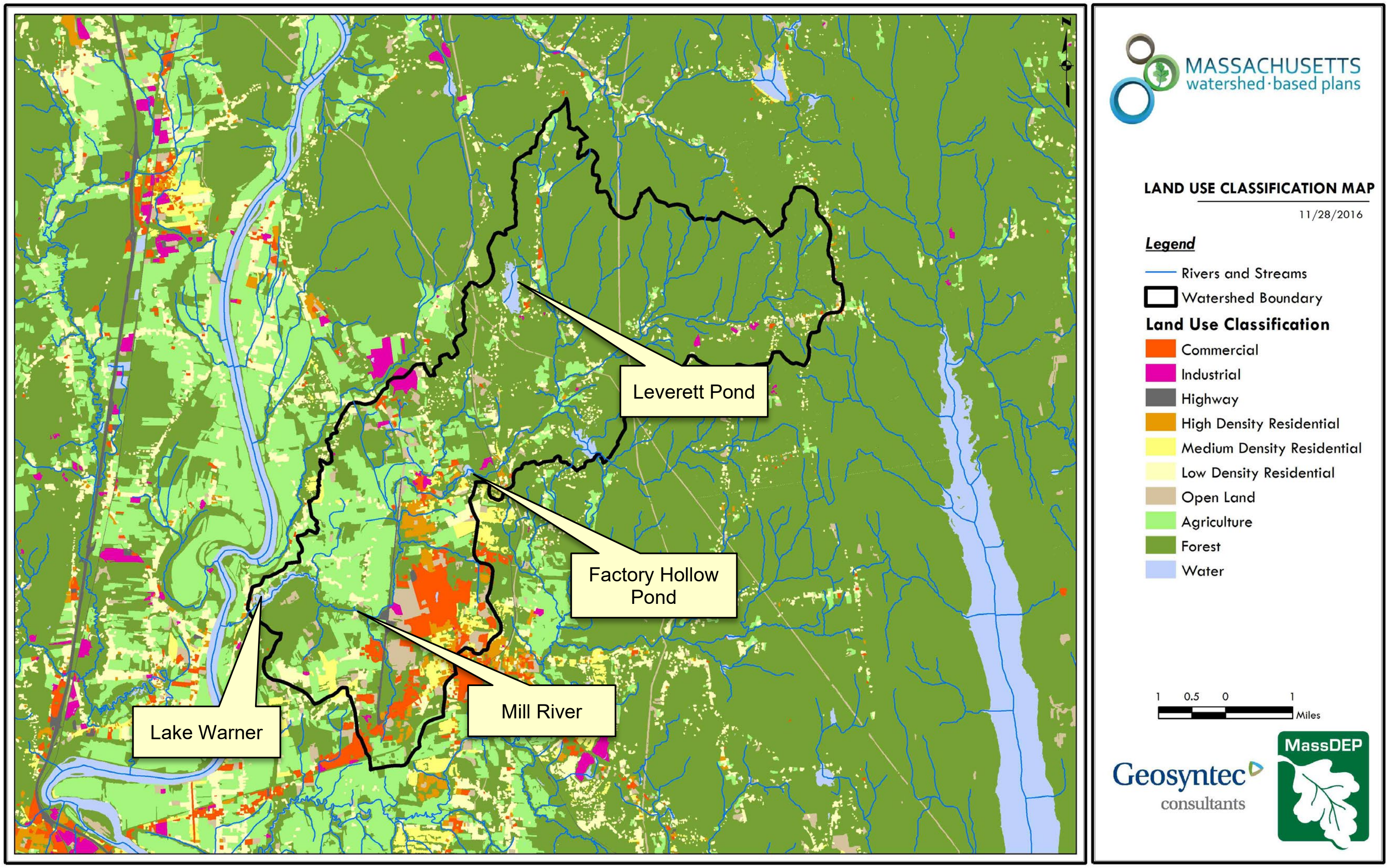


Figure A-2: Subwatershed Land Use Map

(MassGIS, 2007; MassGIS, 2009a; 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 Mill River is mostly concentrated in the Amherst town center and UMass (**Figure A-3)**.

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. EPA provides guidance (EPA, 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. The estimated TIA and DCIA for the Mill River watershed is 7.9 percent and 6.4 percent, respectively.

The relationship between TIA and water quality can generally be categorized as listed by **Table A-9** (Schueler et al. 2009). The TIA value for the watershed range is 7.9%; therefore, the river and surrounding tributaries can be expected to show good to excellent water quality; nevertheless, it is likely there is better water quality in the upstream forested parts of the watershed while more downstream developed areas have poorer water quality.

Table A-9: Relationship between Total Impervious Area (TIA) and Water Quality (Schueler et al. 2009)

% Watershed Impervious Cover	Stream Water Quality
0% to 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% to 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% to 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.

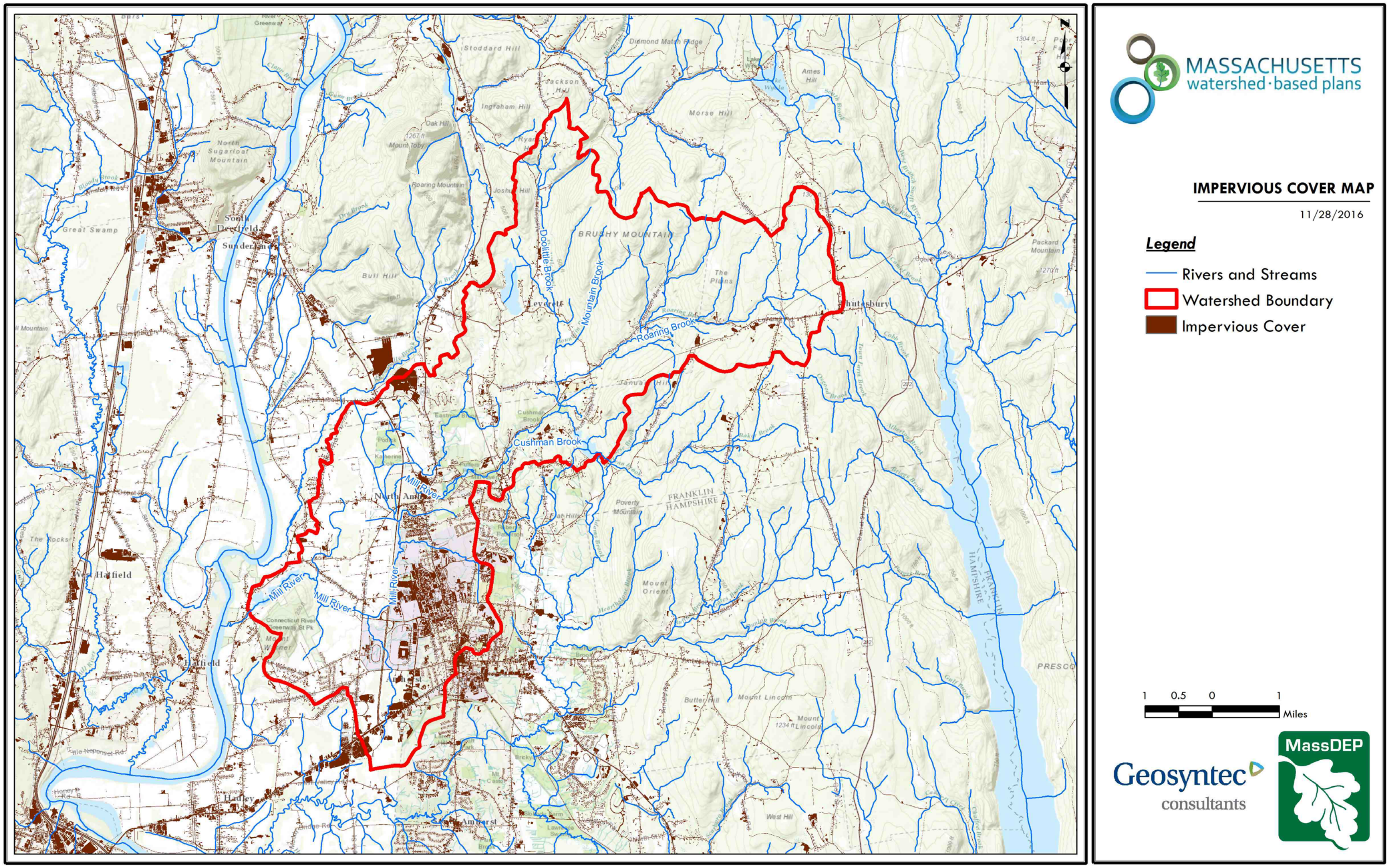


Figure A-3: Subwatershed Impervious Surface Map

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

Pollutant Loading

The land use data (MassGIS, 2009a) was intersected with impervious cover data (MassGIS, 2009b) 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 EPA (Voorhees, 2016) (see documentation provided in **Appendix D**) as follows:

$$L_n = A_n * P_n$$

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

The estimated land use-based TP loading to receiving waters within the subwatershed areas is 5,120 lbs/yr, as presented by **Table A-10**. The largest contributor of the land use-based TP, TN, and TSS load originates from areas designated as forested. TP and TN generated from forested areas is generally a result of natural processes such as decomposition of leaf litter and other organic material; therefore, the forested portions of the watershed are unlikely to provide opportunities for nutrient load reductions through BMPs. Agricultural areas are the second largest contributors of the land use-based TP and TN load in the watershed. Agricultural areas provide excellent opportunities for nutrient load reductions through agricultural BMPs as described in the sections below.

Table A-10: Estimated Pollutant Loading for Key Nonpoint Source Pollutants

Land Use Type	Pollutant Loading[1]		
	TP (pounds/year)	TNN (pounds/year)	Total Suspended Solids (TSS) (tons/year)
Forest	1,752	8,903	319
Agriculture	1,336	8,063	89
Commercial	872	7,513	94
High Density Residential	299	1,964	30
Open Land	250	2,381	50
Low Density Residential	237	2,317	32
Industrial	166	1,425	18
Medium Density Residential	138	1,175	17
Highway	69	569	32
TOTAL	5,120	34,309	680

[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 TP (5,120 lbs/yr), TN (34,309 lbs/yr), and TSS (680 tons/yr) were previously presented in Element A of this WBP. *E. coli* loading has not been estimated for this WBP, because there are no known PLERs for *E. coli*. The TMDL for Lake Warner used the NPSLAKE model to estimate existing TP loads to Lake Warner. The TMDL estimated an existing TP load to Lake Warner of 7,150 kg/year (15,763 lbs/year) (MassDEP, 2001); the difference between the TMDL value for TP loading and the value presented in Element A of this WBP is mostly attributed to differences in model assumptions (i.e., the NPSLAKE model also considers internal P sources and point sources to the lake whereas the methodology presented in Element A does not).

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 in Element A, water quality goals for this WBP are focused on reducing *E. coli* and TP loading to the Mill River. TP water quality goals from this WBP are based on criteria from the TMDL of Phosphorus for Selected Connecticut Basin Lakes (MassDEP, 2001). The TMDL established an overall 75 percent load reduction goal of approximately 11,817 lbs/year (5360 kg/year) for the Lake Warner watershed and provided waste load allocations (WLA) for TP based on specific land use areas (See **Table B-1**). The TMDL required the largest TP load reduction from internal P Sources while it required an approximately 41% reduction of TP from non-natural land use types. *E. coli* water quality goals of this WBP are based on MSWQS concentration standards and are difficult to predict based on estimated annual loading (see **Table B-2**).

Table B-1: TP Load Reduction Goals for the Mill River Watershed (Table adapted from "*Total Maximum Daily Loads of Phosphorus for Selected Connecticut Basin Lakes* " (MassDEP, 2001)

Source	Current TP Loading (lb/yr)	Target TP Load Allocation (lb/yr)	% Reduction Required
Forest	1,279	1,279	0%
Agriculture	1,014	595	41%
Open Land	419	243	42%
Residential (Low den.)	265	154	42%
Residential (High den.)	551	331	40%
Comm. Indust.	198	110	44%
Septic System	22	22	0%
Internal P Sources	12,015	1,213	90%
Total Inputs	15,763	3,946	75%

Table B-2: Bacteria (*E. coli*) Goals for Mill River Watershed

Pollutant	Existing Estimated Total Load	Water Quality Goal	Required Load Reduction
Bacteria	*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. E. coli samples collected between April—November 2003 from the Mill River at Mill River Lane in Hadley (Station 25C) had a geometric mean of 148 colonies/100 ml. E. coli samples were collected from May—September 2008 at the same location and revealed a geometric mean of 171 colonies/ 100 ml (MassDEP 2008). E. coli data obtained from approximately 1/4-mile upstream of where the Mill River enters Lake Warner (collected by the Friends of Lake Warner and the Mill River) was collected in 2016, 2017, 2018, 2019 and 2020 and had a geometric mean of 614, 392, 772, 480 and 680 colonies/ 100 ml, respectively (Johnson, 2019; Johnson, 2021),*	Class B. **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.	Concentration Based

The proposed projects described in this plan are expected to reduce both *E. coli* and TP loads to the Mill River, however, additional load reductions will be required to meet the water quality goals.

The following adaptive sequence is recommended to sequentially track and meet these load reduction goals:

1. Given current water quality conditions and previous TMDL work, establish an **interim goal** to reduce land use-based TP (except from forested land uses) by 10% over the next 5 years (by 2026). Considering known pollutant loads for existing and proposed BMPs (please refer to the Introduction or Element C for more details on existing and proposed BMPs), it is anticipated that projects implemented in the past four years may reduce land use-based TP loading by 9,344 lb/year (Hashemi and Harper, 2018) and the proposed BMPs may reduce the land use-based TP loading by an additional 665 lb/year (UMass, 2019), depending on influent loads to each BMP. It is noted that the anticipated load reduction numbers from the existing and proposed BMPs are greater than the existing agricultural estimated loads presented in Table B-1, which are from the TMDL (MassDEP, 2001). It is recommended that the estimated load reduction of the implemented agricultural BMPs be re-evaluated after a baseline water quality monitoring program is established and implemented (see step 3 below) to validate the accuracy of these estimates and confirm how much load is actually discharging to each BMP. In addition, the agricultural land use-based TP loading estimate may be underestimating actual loading and therefore should be revised as more data are collected.

2. Given current water quality conditions, establish an **interim goal** to reduce the geometric mean concentration of *E. coli* by 50% over the next 10 years (by 2031). Considering known pollutant loads for existing and proposed BMPs (please refer to the Introduction or Element C for more details on existing and proposed BMPs), it is anticipated that projects implemented in the past four years will reduce land use-based *E. coli* loading by 1.38 $\times 10^{14}$ organisms/year and the proposed BMPs will reduced the land use-based *E. coli* loading by 2.48×10^{12} organisms/year.

3. Establish a baseline water quality monitoring program in accordance with Element I. Results from the monitoring program should advise if Element C management measures have been effective at addressing listed water quality impairments or water quality goals for other indicator parameters established by Element A.5 of this WBP (e.g., TN, dissolved oxygen, chlorophyll-a). Results can further be used to periodically inform or adjust load reduction goals.

4. Establish a **long-term reduction goal** to reduce land use-based TP (except for loading from forested land uses) by 41% based on the TMDL (MassDEP, 2001) over the next 15 years. Based on monitoring data, establish additional **long-term reduction goal(s)** for *E. coli* and other parameters, if needed, to lead to delisting of all assessment units within the study watershed from the 303(d) list.

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 Management Measures

As indicated in the introduction of this WBP, UMass has implemented BMPs at five different agricultural sites over the past four years in the Mill River watershed. Resulting from the implementation of these BMPs, a combined TP reduction of 9,344 lb/year, TN reduction of 20,881 lb/year, TSS reduction of 3,060 tons/year and an average *E. coli* reduction of 1.38 x 10^{14} organisms per year was estimated (Hashemi and Harper, 2018).

Ongoing Management Measures

UMass was awarded Fiscal Year 2020 Section 319 grant funding to install structural BMPs at Full of Grace Farm in Hadley, MA, which is within the Mill River Watershed. The proposed BMPs include:

a) Installation of a solar powered static aerated composting system;
b) Installation of three sacrifice lots with a total area of approximately 2,400 square feet;
c) Installation of fencing to inhibit horses from directly accessing the Mill River and wetlands;
d) Installation of gutters, french drain and underground pipes to direct clean water to the vegetated swale;
e) Reparation of the existing eroded horse path; and
f) Maintenance of the existing drainage swale to regain its intended purposed as a conveyance stormwater treatment BMP.

The planning level cost estimates and pollutant load reduction estimates were based off information obtained from the “Implementation, Remediation, and Education of Selected Best Management Practices to Minimize the Environmental Impact of Two Equine Operations” Section 319 Nonpoint Source Pollution Grant Program application (UMass, 2019). It is anticipated that the BMPs at this location will result in a combined load reduction to the Mill River of 2,104 lbs N/year, 665 lbs P/year, and an average fecal coliform count of 2.48×10^{12} organisms/year (UMass, 2019). A schematic of the proposed BMPs at Full of Grace Farm are presented in **Figure C-1**.

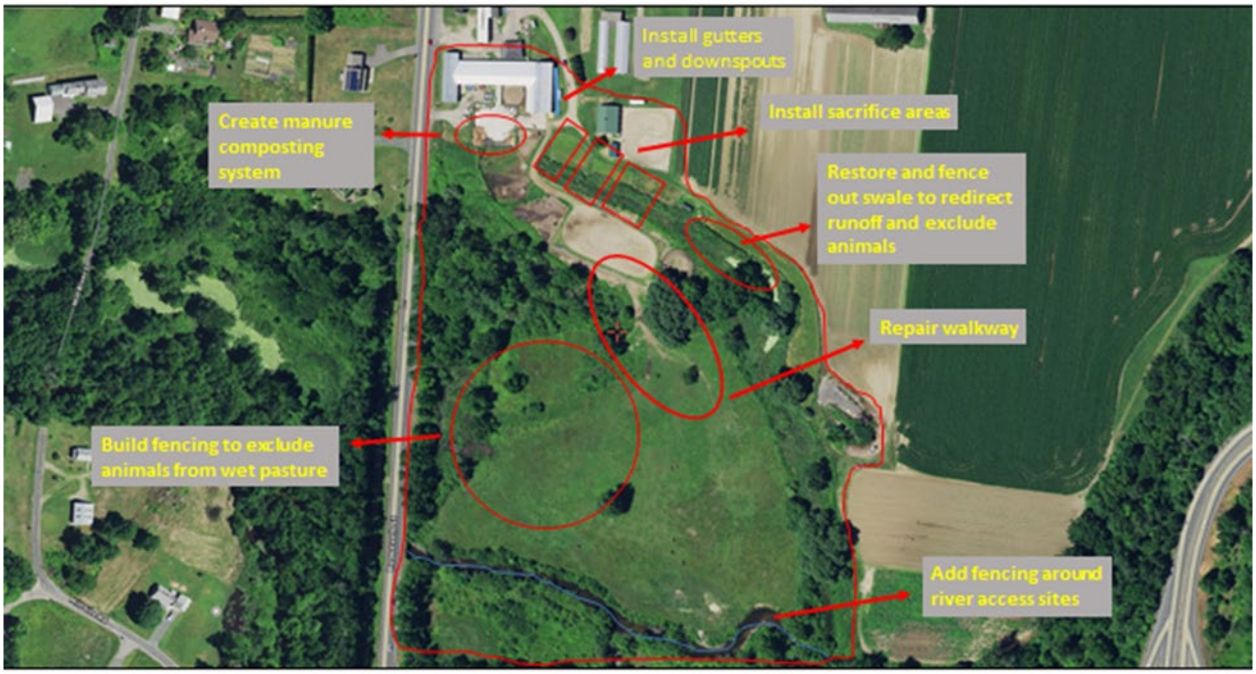


Figure C-1: Proposed BMPs at Full of Grace Farm (UMass, 2019)

MACD was awarded Fiscal Year 2021 Section 319 grant funding to conduct outreach to farmers in the Mill River watershed, develop conservation plans for selected farms outlining BMPs to reduce pollutant loading from nonpoint source runoff, assist farm-owners in accessing funding resources, select farms for agricultural BMP implementation, and assist and oversee operation and maintenance practices. During the stakeholder meeting that was held on February 24, 2021, numerous farms int the Mill River watershed were identified for outreach and possible implementation of agricultural BMPs. These farms are identified in **Figure C-2**.

Future Management Measures

A team at UMass has identified a location at the confluence of Tan Brook and the Mill River for implementation of a constructed wetland. This location is also identified in **Figure C-2**.

As discussed by Element B, it is recommended that future planning initially focus on water quality goals related to *E. coli* and TP in the Mill River Watershed. It is recommended that management measures be recommended for future BMPs that emphasize reducing *E. coli* and TP loading to meet target water quality goals, as feasible. The following general sequence is recommended to identify and implement structural BMPs.

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.

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 *E. coli* and TP loading to the Mill River as summarized by Element B.

Additional Non-structural BMPs

It is recommended that nonstructural BMPs that the Towns of Hadley and Amherst currently implement, including street sweeping and catch basin cleaning, 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 of this document. 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.

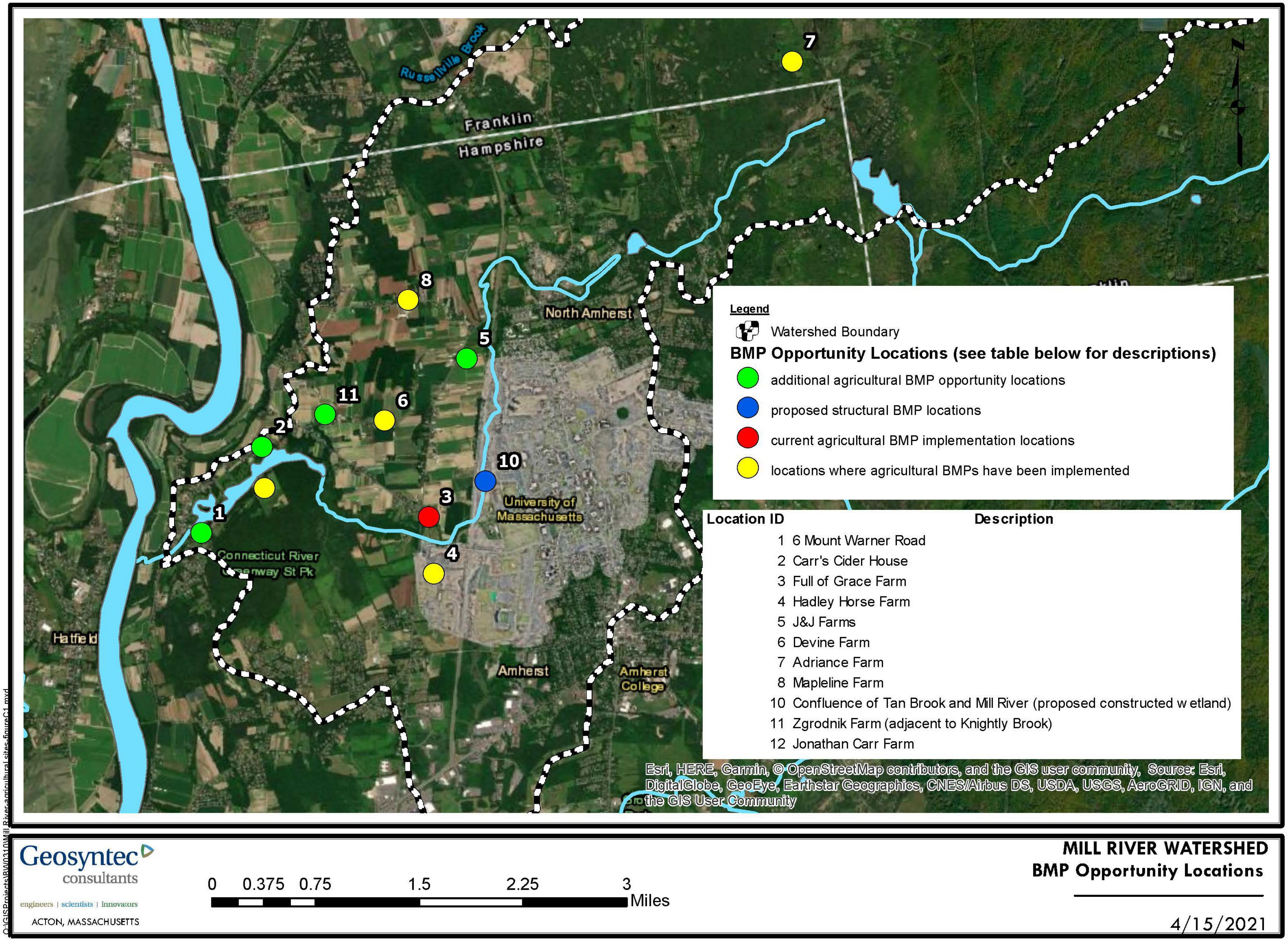


Figure C-2: Mill River Watershed BMP Opportunity Locations

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 proposed management measures presented in this WBP (proposed structural BMPs at Full of Grace Farm in Hadley) is identified in **Table D-1** (UMass, 2019). The total costs for structural and non-structural BMPs, information/education measures, and monitoring/evaluation activities is estimated at $239,033. Additionally, annual operation and maintenance costs were estimated, based on best professional judgment, to be two percent of the BMP supplies and contracts cost (i.e., approximately $1,400/year).

The funding needed to implement the MACD Western Massachusetts Agricultural Nonpoint Source Program is presented in Table D-2 (MACD, 2020). These costs will be divided between the Mill River watershed and three other watersheds in Western Massachusetts. The total cost for the program was estimated at $434,000.

Table D-1: Summary of Proposed BMPs Costs (Full of Grace Farm, Hadley)

Expense Item	s.319 Amount	Non-Federal Match and Source	Total Amount
Salary and Wages			
University staff	$0	$43,190	$43,190
Technical Extension staff	$38,858	$0	$38,858
Students Assistance	$3,882	$0	$3,882
Supplies			
Publications (posters, signage, worksheets)	$250	$0	$250
BMP supplies and contracts	$68,200	$0	$68,200
Travel	$750	$0	$750
Indirect Costs			
26% indirect	$20,807	$0	$20,807
59.5% vs 26% waived indirect on Fed share	$0	$52,508	$52,508
Totals	**$143,335**	**$95,698**	**$239,033**

Table D-2: Summary of Proposed BMPs Costs (Western Massachusetts Agricultural Nonpoint Source Program)

Expense Item	s.319 Amount	Non-Federal Match and Source	Total Amount
Salary and Wages			
Project Coordinator	$9,000	$2,000	$11,000
Sub-contractors	$81,000	$5,000	$86,000
Students Assistance	$3,882	$0	$3,882
Supplies			
BMP Materials and Supplies	$160,000	$0	$160,000
DMBE/DWBE		$168,000	$168,000
Travel	$750	$0	$750
Indirect Costs			
Overhead	$9,000	$0	$9,000
Totals	**$259,000**	**$175,000**	**$434,000**

Future Management Measures

Funding for future BMP installations to further reduce loads within the watershed may be provided by a variety of sources including Section 319 funding, Massachusetts Environmental Trust (MET) grants, the Agricultural Environmental Enhancement Program (AEEP), the Agricultural Produce Safety Improvement Program (APSIP), Town capital funds, volunteer efforts, and Natural Resources Conservation Service (NRCS) grants including the Environmental Quality Incentives Program (EQIP) and the Agricultural Management Assistance (AMA) program. UMass and MACD have previously been successful with and will continue to pursue securing grant funding through various sources. Guidance is available to provide additional information on potential funding sources for nonpoint source pollution reduction efforts[2].

[2] Guidance on funding sources to address nonpoint source pollution: 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.

Public information and education was one of the topics discussed during the stakeholder meeting of February 24, 2021 (**Appendix A**). A large component of MACD's current Section 319-funded project involves outreach to farm-owners. The HHCD has done similar outreach work with farmers in the Mill River watershed. The components of the watershed public information and education program are described below. Additional outreach products will be determined when future management measures and activities are planned for implementation in the watershed. This section of the WBP will be updated when the plan is reevaluated in 2024 in accordance with Elements F&G of this document.

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.
3. Provide information and incentives to farmers on funding resources for BMP implementation

Step 2: Target Audience

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

1. Farm-owners in the watershed (targeted through MACD and UMass Extension).
2. All watershed residents.
3. Businesses within the watershed.
4. Schools within the watershed, including UMass.
5. Watershed organizations and other user groups, including the FOLWMR and the Connecticut River Conservancy.
6. Horse owners and related groups (such as riding clubs).

Step 3: Outreach Products and Distribution

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

1. Develop and post informational signs at proposed BMP locations (Full of Grace Farm BMP improvements).

2. One annual field day at Full of Grace Farm, which will include an educational workshop for equine farm owners and its users on the BMPs.
3. A minimum of five new and/or revised factsheets related to the various aspects of manure management, composting, protecting wetlands, sacrifice lots, pasture management, mud management, and controlling runoff will be generated and posted online ("Crops, Dairy, Livestock and Equine" UMass Extension website) and emailed to an equine list serve (800 members and counting).
4. Host additional farm tours highlighting agricultural BMPs
5. Host workshops (examples include equine workshop, soil health workshop)
6. One-on-one meetings between MACD representative and farm-owners and development of farm conservation plans
7. Installation of dog waste signage

Step 4: Evaluate Information/Education Program

Information and education efforts and how they will be evaluated.

1. Track farm tour and workshop attendance (such as at Full of Grace Farm).
2. Tracking the number of fact sheet emails and the size of the list serve receiving the emails in addition to visitors to the UMass Extension webpage.
3. Tracking the number of farmers participating in outreach and education efforts, conservation plans, and implementation of BMPs.

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.

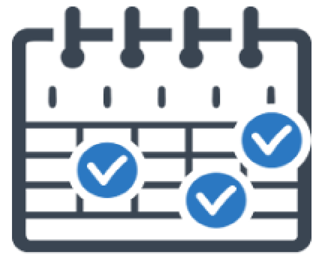


Table FG-1 provides a preliminary schedule for implementing recommendations provided by this WBP. It is expected that the WBP will be re-evaluated and updated in 2024, or as needed, based on ongoing monitoring results and other ongoing efforts. New projects will be identified through future data analysis and stakeholder engagement and will be included in updates to the implementation schedule.

Table FG-1: Implementation Schedule and Interim Measurable Milestones[3]

Category	Action	Cost Estimate	Year(s)
Task 1: Establish Expert Guidance Team	Create an expert team consisting of a nutrient management specialist and a watershed specialist from UMass, representatives from NRCS and Hampden Hampshire Conservation Districts, along with manager and owner of Full of Grace Farm.	$5,000	2020
Task 2: Assessment, Installation, and Implementation of BMPs at Full of Grace Farm	**BMPs at FULL OF GRACE FARM:** • Installation of a solar powered static aerated composting system; • Installation of three sacrifice lots with a total area of approximately 2,400 square feet; • Installation of fencing to inhibit horses from directly accessing the Mill River and wetlands; • Installation of gutters, french drain and underground pipes to direct clean water to the vegetated swale; • Reparation of the existing eroded horse path; and • Maintenance of the existing drainage swale to regain its intended purposed as conveyance stormwater treatment BMP.	$184,033	2020 -- 2021
Task 3: Western Massachusetts Agricultural Nonpoint Source Program	**MACD will provide a conservation planner and** • Focus on farmers who have had previous contact with NRCS and MACD to engage as many as possible in the implementation of BMPs • Identify a second conservation planner to further scale outreach and BMP implementation practices in the Mill River watershed.	$108,500	2021—2022
Task 4: Educational Workshops, Meetings, Tours for Equine Industry and Community Horse Owners	Annual educational workshops on agricultural stormwater BMPs will be held at various locations in Western Massachusetts. One annual field day will be held at the equine facility to discuss the rational and demonstrate the implemented BMPs.	$15,000	Annually

[3] Note that goals and milestones of this WBP are intended to be adaptable and flexible. Stakeholders will perform tasks contingent on available resources and funding.

Category	Action	Cost Estimate	Year(s)
Task 5: Development of Factsheets and Educational Materials	A minimum of five new and/or revised factsheets related to the various aspects of manure management, composting, protecting wetlands, sacrifice lots, pasture management, mud management, and controlling runoff will be generated and posted online. Copies of and revised factsheets and the calendar developed for this task will be submitted in a suitable format for reproduction and web posting.	$15,000	2020 -- 2021
Task 6: Reporting	Quarterly progress reports will be submitted electronically to the Section 319 Program Coordinator	$20,000	Quarterly
Task 7: Future BMP locations	Investigate other farms for agricultural BMP implementation projects and S. 319 grant applications. Possibilities in the Mill River watershed include J&J Dairy Farm in Amherst and Devine Farm in Hadley.	-	2022

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 WBP. 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 Fort River.

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 TP removal from these practices. As indicated by Element C, it is recommended that potential TP 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.

TP 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**.

$$\text{Credit}_{\text{sweeping}} = \text{IA}_{\text{swept}} \times \text{PLE}_{\text{IC-land use}} \times \text{PRF}_{\text{sweeping}} \times \text{AF} \qquad \textbf{(Equation 2-1)}$$

Where:

$\text{Credit}_{\text{sweeping}}$	=	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)
$\text{PLE}_{\text{IC-land use}}$	=	Phosphorus Load Export Rate for impervious cover and specified land use (lb/acre/yr) (see Table 2-1)
$\text{PRF}_{\text{sweeping}}$	=	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 ($\text{PRF}_{\text{sweeping}}$) for sweeping impervious areas

Frequency[1]	Sweeper Technology	$\text{PRF}_{\text{sweeping}}$
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

$$\text{Credit}_{\text{CB}} = \text{IA}_{\text{CB}} \times \text{PLE}_{\text{IC-land use}} \times \text{PRF}_{\text{CB}} \qquad \textbf{(Equation 2-2)}$$

Where:

$\text{Credit}_{\text{CB}}$	=	Amount of phosphorus load removed by catch basin cleaning (lb/year)
IA_{CB}	=	Impervious drainage area to catch basins (acres)
$\text{PLE}_{\text{IC-and use}}$	=	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, once ongoing BMPs are installed, the anticipated TP load reduction for the Full of Grace Farm installation is estimated to be 665 pounds per year.

TMDL Criteria

TMDL requirements encourage ongoing monitoring to assess progress towards the TMDL's water quality goals. The TMDL indicates that pilot projects should include monitoring to assess their effectiveness at removing TP. Mill River (MA34-25) will be included in the upcoming "Massachusetts Statewide TMDL for Pathogen-Impaired Inland Freshwater Rivers" which is currently being drafted.

Direct Measurements

Direct measurements are generally expected to be performed in accordance with the existing quality assurance project plan (QAPP) for the Mill River watershed (Johnson and O'Donnell, 2019) and as described below. Additional water quality monitoring may be performed through a volunteer training program to save on costs in accordance with established practices for MassDEP's environmental monitoring for volunteers.

River Sampling

Establish regular sampling to understand the water quality in Mill River Watershed, including determining sources for pollution and tracking achievements toward water quality goals, including analysis of *E. coli*, TP, TN, and turbidity. Additional parameters such as chlorophyll-a, dissolved oxygen, temperature, conductivity, pH, and flow rate could provide additional data for consideration. If possible, obtain sampling of the Mill River directly downstream of Full of Grace Farm and other implemented BMPs to determine the impact of proposed BMPs within the watershed. Monitoring locations will be selected based on accessibility and representativeness and shall be appropriate to quantify water quality improvements in the watershed[4].

In-Lake Phosphorus and Water Quality Monitoring

Sampling programs specific for the ponds (e.g., Lake Warner, Leverett Pond, Factory HollowPond) within the watershed could be established to track the progress of water quality improvements more closely towards water quality goals. Monitoring locations should at minimum include the outlet of the pond, tributaries, and the deepest "in-lake" location[5]. It is recommended that sampling programs include analysis of *E. coli*, secchi disk transparency, TP, chlorophyll-a, turbidity, temperature/oxygen profiles, and aquatic vegetation. These parameters will also enable tracking relative to Carlson's state trophic index to evaluate improvements over time.

Adaptive Management

As discussed by Element B, the baseline monitoring program will be used to establish a long-term (15 year) *E. coli* and TP load reduction goal (or other parameter(s) depending on results). 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 *E. coli* and TP concentrations and other indicators (e.g., chlorophyll-a) measured within the watershed, the management measures and loading reduction analysis (Elements A through D) will be revisited and modified accordingly.

---

[4] Additional guidance is provided at: https://www.epa.gov/sites/production/files/2015-06/documents/stream.pdf and https://www.mass.gov/guides/water-quality-monitoring-for-volunteers#2

[5] Additional guidance is provided at: https://www.epa.gov/sites/production/files/2015-06/documents/lakevolman.pdf

References

314 CMR 4.00 (2013). "*Division of Water Pollution Control, Massachusetts Surface Water Quality Standards*"

Cohen, A. J.; Randall, A.D. (1998). "*Mean annual runoff, precipitation, and evapotranspiration in the glaciated northeastern United States, 1951-80.*" Prepared for United States Geological Survey, Reston VA.

EPA (1986). "*Quality Criteria for Water (Gold Book)*" EPA 440/5-86-001. Office of Water, Regulations and Standards. Washington, D.C.

EPA. (2010). "*EPA's Methodology to Calculate Baseline Estimates of Impervious Area (IA) and Directly Connected Impervious Area (DCIA) for Massachusetts Communities.*"

Hashemi, M and Harper, M. (2018). "Reducing Nonpoint Source Pollution from Two Livestock Facilities through Implementation, Remediation, and Education of Selected BMPs". Project Number: 16-09/319. Dates: 2016-2018.

Johnson, Jason. Friends of Lake Warner and the Mill River. (2019) "*Mill River Monitoring Data*" Message to Julia Keay, Geosyntec Consultants. 20 December 2019. E-mail.

Johnson, Jason. Friends of Lake Warner and the Mill River. (2021) "*Mill River Watershed-based Plan Update*" Message to Julia Keay, Geosyntec Consultants. 14 January 2021. E-mail.

Johnson, Jason and O'Donnell, Ryan (2019). "Mill River & Lake Warner Watershed Nutrient Study – Amherst, MA, Quality Assurance Project Plan. April 2019

MACD (2020). "*Western Massachusetts Agricultural Nonpoint Source Program (NPS)*.

MassDEP (2001). "*Total Maximum Daily Loads of Phosphorus for Selected Connecticut Basin Lakes* "

MassDEP (2008). "*Connecticut River Watershed, 2003 Water Quality Assessment Report*"

MassDEP (2013a). "*Connecticut River Watershed 2008 DVM Water Quality Monitoring Data*".

MassDEP (2013b). "*Connecticut River Watershed 2008 Benthic Macroinvertebrate Bioassessment*". December 2013.

MassDEP (2019). "Massachusetts Year 2016 Integrated List of Waters, Final Listing of Massachusetts' Waters Pursuant to Sections 305(b), 314 and 303(d) of the Clean Water Act". December 2019.

MassGIS (1999). "*Networked Hydro Centerlines*" Shapefile

MassGIS (2001). "*USGS Topographic Quadrangle Images*" Image

MassGIS (2007). "*Drainage Sub-basins*" Shapefile

MassGIS (2009a). "*Land Use (2005)*" Shapefile

MassGIS (2009b). "*Impervious Surface*" Image

Schueler, T.R., Fraley-McNeal, L, and K. Cappiella (2009). "*Is impervious cover still important? Review of recent research*" Journal of Hydrologic Engineering 14 (4): 309-315.

United States Geological Survey (2016). "*National Hydrography Dataset, High Resolution Shapefile*"

UMass (2019). "*Implementation, Remediation, and Education of Selected Best Management Practices to Minimize the Environmental Impact of Two Equine Operations*".

USDA NRCS and MassGIS (2012). "*NRCS SSURGO-Certified Soils*" Shapefile

Voorhees, Mark, EPA. (2015). "*FW: Description of additional modelling work for Opti-Tool Project*" Message to Chad Yaindl, Geosyntec Consultants. 23 April 2015. E-mail.

Voorhees, Mark, EPA. (2016). "*FW: Description of additional modelling work for Opti-Tool Project*" Message to Chad Yaindl, Geosyntec Consultants. 23 April 2015. E-mail.

Appendices

Appendix A – Mill River Stakeholder Meeting Minutes, February 24, 2021

Meeting Minutes

SORENSEN

Project Name:	Mill River Watershed-Based Plan
Project #:	SP #1078
Location:	Mill River Watershed (Hadley, Amherst, Sunderland, Leverett, and Shutesbury, MA)

Meeting Date, #:	2021-2-24	Meeting Time:	2:00 PM - 3:30 PM
Prepared By:	Marie Sorensen, RA	Meeting Location:	Zoom videoconference per Sorensen Partners invitation
Distribution:	All listed below		

Attendees:

Discussion Group	Name	Organization
1	Beth Willson	Amherst DPW, Environmental Scientist
1	Bob Duby	Devine Farm, Hadley
1	Dr. Christian Guzman	UMass, Civil and Environmental Engineering, Assistant Professor
1	Diana Laurenitis-Bonacci	Hampden Hampshire Conservation District (HHCD), Outreach/Conservation Planner in-training, Hadley MA
1	Janice Stone	Hadley Conservation Commission, Conservation Agent
1	Jason Johnson	Friends of Lake Warner and Mill River, ED
1	Julia Keay	Geosyntec
1	Kathleen Bamford	Hampden Hampshire Conservation District, Administrator
1	Michael Leff	MACD, Massachusetts Association of Conservation Districts, ED
2	Adam Questad	Geosyntec
2	Bob Skalbite	UMass Hadley Horse Farm, Farm Manager
2	Dr. David Reckhow	UMass, Civil & Environmental Engineering, Professor
2	Janice Weldon	UMass, Civil & Environmental Engineering, Graduate Student
2	Marie Sorensen	Sorensen Partners | Architects + Planners, Inc.
2	Matt Reardon	MassDEP
2	Michele Morris-Friedman	Friends of Lake Warner and Mill River, Board Member
2	Dr. Nick Tooker	UMass, Civil & Environmental Engineering, Professor of Practice
2	Peter Maleady	Lake Warner Area Resident
2	Terri Wolejko	UMass, Environmental Health and Safety, Assistant Director for Environmental and Hazardous Materials Management Services

"*This project has been financed with Federal Funds from the Environmental Protection Agency (EPA) to the Massachusetts Department of Environmental Protection (the Department) under an s. 319 competitive grant. The contents do not necessarily reflect the views and policies of EPA or of the Department, nor does the mention of trade names or commercial products constitute endorsement or recommendation for use.*"

Minutes to be considered final unless comments are received within five (5) business days.

AGENDA

- Greeting – Matt Reardon, MassDEP & Marie Sorensen, Sorensen Partners
- Watershed & Goals Overview (15 min) – Julia Keay & Adam Questad, Geosyntec
- Brief Introductions from All Participants (15 min) – All
- Breakout Discussion (20 min) – All
- Reporting Out (10 min) – Julia Keay & Adam Questad, Geosyntec
- Strategy (30 min) – All

WATERSHED & GOALS OVERVIEW
• Adam Questad of Geosyntec discussed the goals of the meeting, including forming new relationships and partnerships to undertake s. 319 grants. • Julia Keay of Geosyntec briefly presented the Mill River Watershed-based Plan and showed pages from the plan. • Julia Keay of Geosyntec briefly presented the MassDEP Clean Water Toolkit, specifically focusing on how to see examples of agricultural Best Management Practices (BMPs). MassDEP Clean Water Toolkit Link: https://megamanual.geosyntec.com/npsmanual/default.aspx • Julia Keay of Geosyntec briefly presented the MassDEP Watershed-based Plans Tool. MassDEP Watershed-based Plans Tool Link: http://prj.geosyntec.com/prjMADEPWBP/Home

BRIEF INTRODUCTIONS FROM ALL PARTICIPANTS

Participants were asked to briefly address the following prompts:

⇒ Name?
⇒ Affiliation?
⇒ Current or potential project locations?
⇒ Grant funding you're pursuing or have received?
⇒ What are you doing for monitoring?
⇒ What BMPs are you implementing?

Michael Leff, ED of MACD. This kind of watershed-based plan is a requisite for the contract they're putting in place for Western MA, which will involve outreach to farmers to help them implement BMPs. MACD has just wrapped up a similar project in the Palmer River Watershed and Westport River Watershed, which included development and implementation of farm conservation plans with numerous farms in the watersheds.

Jason Johnson, ED of Friends of Lake Warner and Mill River, a 501c3 nonprofit looking at stewardship issues of the lake and watershed. They have been working on strategic planning projects throughout the watershed, monitoring tributaries, monitoring e-coli and doing stormwater planning and coordination throughout the watershed.

Bob Skalbite, Farm Manager for UMass Hadley Horse Farm. Mostly here for informational purpose, also interested in collaborations. BMPs he uses are pasture management and soil conservation.

Bob Duby, Devine Farm, Hadley. Primarily here for informational purposes to figure out what's going on and who's involved. Devine Farm is a dairy farm milking about 150 cows and associated livestock, approximately 150 acres.

Dr. Christian Guzman, Professor at UMass, interested in watershed monitoring and nutrient transport. Recently connected to Jason Johnson's work.

Janice Weldon, graduate student at UMass, working with David Reckhow and Nick Tooker. Looking at building a constructed wetland, potentially with 319 grant funding, at the confluence of the Tan Brook and Mill River. Monitoring for phosphorus and E.coli. Looking at doing some PFAS monitoring.

Dr. David Reckhow, faculty in Civil & Environmental Engineering at UMass. Working with Nick Tooker and Janice Weldon. Also oversees and manages the UMass Water & Energy Testing (WET) Facility along the Mill River. Monitoring water quality, mostly dissolved organic matter and some nutrient monitoring, mostly on a constant basis.

Michelle Morris-Friedman, Board of Friends of Lake Warner and Mill River, here to listen and learn.

Dr. Nick Tooker, faculty in Civil & Environmental Engineering at UMass. Working with David Reckhow and Janice Weldon.

Beth Willson, Amherst DPW Environmental Scientist. Part of the watershed is in Amherst. DPW's stormwater system is part of the watershed. They are monitoring outfalls as part of their MS4 permit requirements.

Peter Maleady, Mill River Neighbor. About 1 mile of Mill River is “in his backyard” and he visits daily.

Janice Stone, Hadley Conservation Agent, knows some people involved with the watershed based plan through wetland permitting. Inquires about status of work at Full of Grace Farm. Heard there was some permitting required. Looks like it’s finished without permitting. [Adam Questad, Geosyntec: work not initiated yet.]

Kathleen Bamford, Adminstrator for Hamden Hampshire Conservation District, now in 3rd year receiving grants from National Association of Conservation Districts (NACD) to fund a conservation planner to work with farmers in the watershed to see what they can do together. Did some geo-mapping in 2018.

Diana Laurenitis-Bonacci, Conservation Planner at Hampden Hampshire Conservation District, doing work in both counties, doing training through NACD’s Natural Resources Conservation Service (NRCS), takes 2-4 years. Doing outreach to farmers to get them in the system. Trying to get appointments and get people talking to offer assistance.

Terri Wolejko, Assistant Director for Environmental Health & Safety, UMass, new to her position at UMass, getting a handle on managing pollutants.

BREAKOUT DISCUSSION – REPORTING OUT

A breakout discussion was held for 20 minutes with two groups (Group 1 and Group 2, see attendees list for participants). Following the discussion, Julia Keay and Adam Questad of Geosyntec reported out on the topics discussed.

Group 1 Report-out (Julia Keay, facilitator)

1. *What are the problem areas in the watershed? What are the known sources of nonpoint source pollution?*
    - High phosphorous and E.coli loading identified in Knightly Brook and main stem of Mill River.
    - Hadley Farm area as well,.
    - Basically everything downstream of Puffers Pond.
    - Jason Johnson identified potential sources:
        - Tan Brook is mainly urban.
        - UMass is mainly urban.
        - Horse Farm Brook is a combination of sources.
        - East Farm Brook is agricultural but also runs through Cherry Hill Golf Course.
2. *Are you conducting any water quality/quantity monitoring?*
    - Jason Johnson has a lot of lot of water quality data from Puffers Pond and Cushman and at Lake Warner and Tributaries.
3. *Where are potential project locations that you can support?*
    - Structural BMPs. Beth Wilson mentioned nothing planned this year but planning MS4 future BMPs.
    - Diana Laurenitis-Bonacci stated that lots of farms in Mill River Watershed are in the NRCS database. Diana mentioned this but had to honor privacy of those farms and couldn’t share project details of any farms.
4. *At what stage of development are the projects?*
5. *What stakeholders could help answer some of these questions?*
    - DPW of Hadley
    - Agricultural Cultural Commission of Amherst
    - Hadley Agricultural Commission
6. *What are you doing/ planning for public education and outreach?*
    - Friends of Lake Warner has done a lot of outreach in Hadley, wants to do more in Amherst.
    - Beth stated that Amherst has recently put up dog waste signs at Puffers Pond and are doing other outreach as required by their MS4 permit requirements.
    - Diana Laurenitis-Bonacci mentioned brainstorming ways to reach out to the community, possibly doing educational workshops in the watershed.
    - Jason Johnson mentioned the Hadley Farm has done a lot of agriculture education and outreach.
    - Michael Leff mentioned that this call is useful, and watershed-based plan is useful as they will target farms captured in the watershed-based plans, and this is helping them identify outreach.

7. *What grant funding are you pursuing?*
    - Friends of Lake Warner has received an MET grant and is interested in supporting others. MET Grant Link: https://www.mass.gov/met-projects-and-grant-awards
    - Diana stated a lot of the farms are already in NRCS system.

Group 2 Report-out (Adam Questad, facilitator)

1. *What are the problem areas in the watershed? What are known sources of nonpoint source pollution?*
    - UMass was discussed as a potential source of impervious area, specifically as impacting Tan Brook.
    - Parking lots at UMass came up.
    - Also development in North Amherst, increased hardscape, changing land use, could be impacting water table in brook near Route 9.
    - UMass farms some of pastures are staying wetter longer, more frequently, impacts management.
2. *Are you conducting any water quality/quantity monitoring?*
    - UMass is actively monitoring six sampling locations, doing phosphorous, E. coli, plans to do PFAS, found Phosphorus spike at campus pond.
3. *What are potential project locations that you can support?*
    - UMass project for constructed wetlands at confluence of Tan Brook and Mill River.
    - Also Peter Maleady shared discussion of Hadley Great Swamp, area he visits regularly, natural detention area, settles sediment/nutrients; could study how in-stream concentrations are changing through swamp.
4. *At what stage of development are the projects?*
5. *What stakeholders could help answer some of these questions?*
6. *What are you doing/planning for public education and outreach?*
    - MS4 outreach, UMass is working with Pioneer Valley Planning Commission.
    - More public involvement planned in the future for UMass public participation program.
7. *What grant funding are you pursuing?*
    - UMass wants to pursue a section 319 grant.

STRATEGY

A general strategy discussion was held with the following discussion prompts:

⇒ Discuss potential collaborative Projects
⇒ New possible Projects
⇒ Understand eligibility requirements
⇒ Identifying other stakeholders
⇒ Identifying hot-spots in the watershed for future BMP implementation

Michele Morris. Would be interested in finding out more about testing along the river from North Amherst to Route 16. Have worked with HHCD. Does know some farmers interested in BMPs (no-till buffers) but they are generally overworked and underpaid. Need something to make it easier for them to invest and link them to BMPs.

Michael Leff. Their grant can be used towards BMP implementation at priority sites that they identify, for a willing farmer.

Adam Questad. Is the biggest challenge for farmers the time to work through this? Or knowing where to go for funding and support?

Diana Laurentitis-Bonacci. Yes farmers are overworked and underpaid. Not easy to think about other things. So expensive to farm in the area. They need to take care of their priorities first, including harvesting crops. Need to give them financial incentives (e.g., money they could save by using less fertilizer or less time required on the tractor). Has been trying to do that in her position, so people can come to her and she can share. Doing some research for a farmer right now on irrigation grants, other things; happy to do that work for them because they don't have the time to do it. That kind of position is helpful, someone who knows all the programs.

Adam Questad. One alternative could be that some other group is responsible for planning, design, implementation of BMPs such as a vegetated buffers. Farmer would just need to give consent or financial incentive to have it installed.

Diana Laurentitis-Bonacci. Farmers can be very independent. Could be wary of having someone do something on their land. Can take a while for them to get to know you and trust you. NRCS does help with that, they do give technical assistance with their BMPs.

Janice Stone. Wondering how much of an impact Route 116 makes on the water quality, always concerned about the salt use on the roadways.

Jason Johnson. Channelization effect has had effect of moving material, no room for storage; did not see a whole lot of differentiation between 116 and Amherst and Meadow Street, Roosevelt Street in Hadley. Amherst will be looking at chloride levels for their MS4. So we might be looking at salting of roads. That area is not very naturally conducive to storing sediments or phosphorous. Could lay back the banks and provide plantings to do more storage for flood flows.

Jason Johnson. Good project locations: Knightly Brook, up from Zgrodnik Farm. Full of Grace Farm. Banks are over-steepened, not a lot of set-back.

Bob Duby, Devin Farm. Jason, what do you mean for a “project” in Knightly Brook?

Jason Johnson. Bob, you were involved in some no-till and silage BMPs. Could be a detention basin as water is exiting the farm.

Bob Duby. What is the scale of funding for these projects?

Matt Reardon. Palmer total project funding was about $300K (individual farm projects were less as noted below). NRCS was able to fund bigger projects like manure storage. In Palmer had some people do work themselves and match with grant. If you come up with a good idea, go for it, and we’ll try to make it work.

Michael Leff. Highest he was aware of was $50K for one farmer. A few others were $20K, $10K.

Bob Duby. Playing devil’s advocate, after listening to the discussion: A lot of things I’ve heard are already being discussed and there have been a lot of projects funded by NRCS and MDAR. It’s like you’re trying to compete with these other entities. Not understanding how it all fits in. We’ve worked with NRCS in terms of no-till, cover crops, mitigating some of the issues with surface water. I’m hearing you’re trying to compete with what NRCS is already doing.

Michael Leff. Wouldn’t call it competing. It intersects with NRCS specs. It’s complementing, supplementing. The agencies are not in a vacuum.

Matt Reardon. Definitely not competing. There was lots of good collaboration in the Palmer watershed with the two agencies.

Diana Laurentitis-Bonacci. Who can get the funds? Farmers? UMass? Someone who has a lot of frontage in their backyard by a stream with no buffer zone. Any stipulations? Thinking in terms of pollutions and pesticides in lawns.

Michael Leff. This grant program is very focused on agricultural land. Work in Franklin County Conservation District around Sawmill River watershed, those are not strictly focused on agriculture. Focused on farmers, forest, other landowners.

Matt Reardon. Yes. Town of Amherst deals with a lot of runoff from people’s yards, has a lot of impact.

Michael Leff. Don’t hold back in terms of involving other types of sites.

Michele Morris-Friedman. Some towns are having pollinator-friendly events for people with yards, also involves using non-pesticides for lawns.

Diana Laurentitis-Bonacci. Could make a big difference. People need funds to implement it.

Bob Duby. Are there any projects planned for Lake Warner itself in terms of dredging the contaminants that are in there that have occurred over the years? The pond is likely the “sump” from sediment over the years. Do these contaminants continue to leach out and how much do they contribute to the annual cycles of blooms in Lake Warner?

Jason Johnson. Looked at Lake Warner sediment samples in 2016; didn’t find anything too nasty. It’s rich with phosphorous. Also rich with materials absorbing those nutrients. It’s a matter of the redox of that phosphorous back into the system. The State likely won’t be supportive of any in-lake work until nutrient load is reduced from the inflow; at least that is what the directive is from the TMDL. Last year definitely had some anomalies at outlet compared to main stem inlet. But after averaged out was all pretty equal at about 30—35 PPB. The emphasis of section 319 grants is to cut down on runoff and nutrient loading from watershed before anything as expensive as phosphorus inoculation or sediment dredging would be considered for the lake. But creating some small detention areas or treatment wetlands, or some wetland restoration, off-channel, is probably a successful way to remove sediment and nutrient from the system if we can identify those high-priority areas.

Bob Duby. Currently it sounds like most of the work being done is monitoring to discover where nutrient loading is coming from.

Jason Johnson. Yes.

Bob Duby. At what point will the implementation phase begin to mitigate loading?

Jason Johnson. Some of those projects are going on now. NRCS or the conservation district just isn’t able to talk about them yet. Design process happened at Full of Grace.

Matt Reardon. Permit issues are being worked on for Full of Grace. Dr. Masoud Hashemi at UMass has a project there. We’re looking to identify areas for future work, and locations for MACD to implement projects. Monitoring could help focus projects. We talked about UMass parking lots. There are a lot of project ideas.

Marie Sorensen. Are there any major landowners who are not involved right now, with potential project locations?

Janice Stone. Food Bank of Western Mass has a new farm near the intersection of Shattuck Rd and Comins Rd. Thinks they’re working with NRCS now on some ditching and other management items.

Jason Johnson. They are also looking at demonstration practices.

Diana Laurentitis-Bonacci. Yes they talked about holding a no-till demonstration plot.

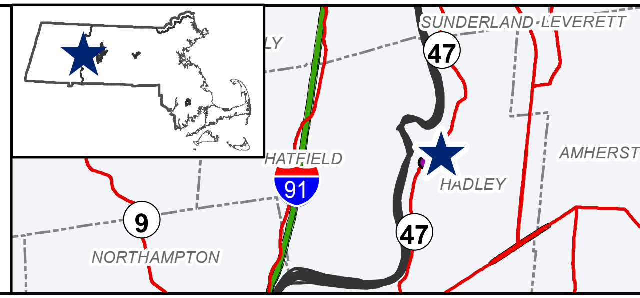
Matt Reardon. MassDEP has an open 604b grant which could be used for North Amherst area design. New solicitation will go out in April of this year for project ideas.

Contact: Julia Keay, JKeay@geosyntec.com
Adam Questad, AQuestad@geosyntec.com
Matt Reardon, Matthew.Reardon@state.ma.us

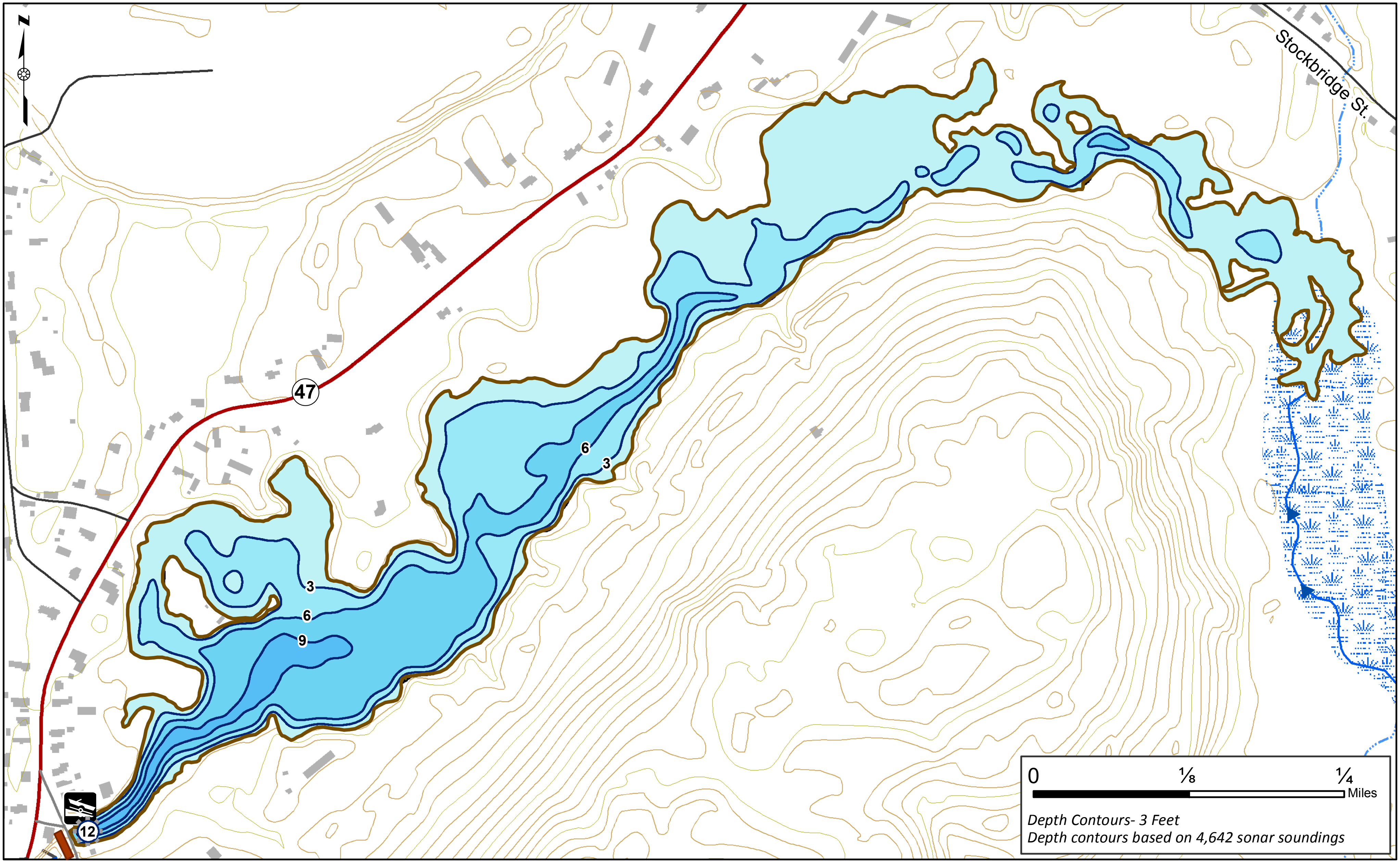
Appendix B—Lake Warner Bathymetry Map

Lake Warner

70 Acres
Hadley
Connecticut River Watershed
Coordinates: 72°34'52"W 42°23'10"N
USGS Quad: MT TOBY
Map updated November, 2018



Boat Ramp-Concrete
Stream-Flow Direction
Wetland
Deepest Point
Interstate
Major Road
Road
Buildings
Dam
Island/Sand Bar



Appendix C– Select Excerpts from Connecticut River Watershed 2003 Water Quality Assessment Report (MassDEP, 2008); Total Maximum Daily Loads of Phosphorus for Selected Connecticut Basin Lakes (MassDEP, 2001); and Connecticut River Watershed 2008 DWM Water Quality Monitoring Data (MassDEP, 2013)

Connecticut River Watershed 2003 Water Quality Assessment Report (MA34-34 - Cushman Brook)
AQUATIC LIFE Habitat/Flow On 17 September 2003 DWM biologists conducted a habitat assessment of Cushman Brook at the south side of State Street in Amherst. Most of the habitat measures were found to be within the "optimal" range. The total habitat score arrived at for this fish population survey was 167/200 (Appendix D). DWM biologists also conducted a habitat assessment on Cushman Brook in conjunction with benthic macroinvertebrate sampling upstream from Factory Hollow Pond in Amherst in 2003. The total habitat score for Cushman Brook at that location was 154 / 200 (Appendix C). Biology DWM conducted benthic macroinvertebrate sampling in Cushman Brook at Station B0508, upstream from Factory Hollow Pond in Amherst on 22 July 2003. The total metric score for Cushman Brook is 86% comparable to the reference station (Amethyst Brook) in terms of community structure, resulting in an assessment of "non-impacted" (Appendix C). DWM conducted fish population sampling in Cushman Brook, south side of State Street in Amherst on 17 September 2003 (Appendix D). Five fish species were collected from this station, including: 26 brown trout (multiple age classes), 13 blacknose dace, 1 brook trout, 1 white sucker, and 1 longnose dace. Pollution intolerant fluvial specialist/dependant species dominated the fish community. This segment of Cushman Brook is assessed as support for the Aquatic Life Use based on the non-impacted benthic macroinvertebrate community and the fish community data. PRIMARY AND SECONDARY CONTACT RECREATION AND AESTHETICS USES No objectionable conditions were noted by the DWM biologists during the fish population or benthic macroinvertebrate surveys (Appendix C and Mitchell 2007). **Report Recommendations:** Conduct bacteria sampling to evaluate the Primary and Secondary Contact Recreation uses.

Connecticut River Watershed 2003 Water Quality Assessment Report (MA34-25 - Mill River-Hadley)

USE ASSESSMENT
AQUATIC LIFE
Habitat/Flow
The total habitat score recorded by DWM fisheries biologists for the Mill River – Hadley site in 2003 was 112 out of a possible 200. This is the poorest score of all stations examined in the Connecticut watershed in 2003 (Appendix D). Habitat was most limited by the poor epifaunal substrate score (no riffles were present). Scores were also suboptimal for embeddedness, sediment deposition, and velocity-depth combinations. These conditions were considered to be naturally occurring; the reach is within the Connecticut River Valley floor, is of relatively low gradient, and has a sandy bottom.

Biology
DWM conducted fish population sampling in the Mill River - Hadley, East of Route 116 in Amherst on 17 September 2003. Only 15 fish were captured during the survey, representing eight species. However, electro-fishing efficiency was rated as "poor," and due to the depth and width of the stream some fish were not captured (Appendix D). The fish community was dominated by moderately pollution tolerant fluvial specialist/dependant species.

Chemistry - water
DWM conducted water quality sampling at Mill River Lane in Hadley, Station 25C, on this segment of the Mill River - Hadley between April and October 2003 (Appendix B and E). All measurements were indicative of good water quality conditions.

This segment of Mill River - Hadley is assessed as support for the Aquatic Life Use based on the good water quality data. The poor collection efficiency noted with the fish community data makes it difficult to determine if the low numbers of fish collected are truly representative of the fish community present at that location. The low habitat score is a concern but is naturally occurring and does not overrule the good water quality data.

PRIMARY AND SECONDARY CONTACT RECREATION AND AESTHETICS USES
DWM collected *E. coli* samples from the Mill River – Hadley at Mill River Lane in Hadley (Station 25C) between April and November 2003 (Appendix B). The geometric mean of these samples was 148 cfu/100ml.

DWM personnel made field observations at Station 25C during surveys conducted between April and October 2003. A methane odor was reported at this station on one occasion. No objectionable deposits were noted, and the water clarity was recorded as highly turbid on two occasions (MassDEP 2003).

The Primary Contact Recreational Use is assessed as impaired because of elevated *E. coli* bacteria counts, noted particularly during wet weather. The Secondary Contact Recreation and Aesthetics uses are assessed as support based upon bacteria counts that are acceptable for secondary contact and the general lack of objectionable conditions.

Report Recommendations:
Fish population surveys should be revisited during lower flows, at a more suitable location, or with different methods in order to sample the fish community more accurately than in 2003.

Connecticut River Watershed 2003 Water Quality Assessment Report (MA34098 - Lake Warner)

AQUATIC LIFE
Biology
A non-native species (Trapa natans) was observed in Lake Warner during the 1998 synoptic surveys (MassDEP 1998). The Silvio O. Conte National Fish and Wildlife Refuge has led an effort to control Trapa natans populations in the Connecticut River Watershed. They have reported the presence of a substantial population of this non-native aquatic macrophyte in Lake Warner (Boettner 2007). Volunteers conducting a plant survey on Lake Warner identified Cabomba caroliniana in the lake in 2003 and had the finding confirmed by Dr. Paul Joseph Godfrey (Schoen 2004).

Volunteers from the Mill River/ Lake Warner study group conducted a monitoring program on Lake Warner in 2003 and 2004 (Schoen 2004, 2005). A QAPP for this project was submitted and approved by MassDEP prior to the start of monitoring. Parameters measured included DO, Secchi disk depths, and total phosphorus. Each parameter was measured at least five times each year. Total phosphorus data were analyzed at the Umass Environmental Analytical Laboratory. Total phosphorus results generated by the Umass Environmental Analytical Laboratory in 2003 and 2004 are thought to be subject to significant uncertainty due to a settling step contained in the analytical procedure at that time. Because of this uncertainty, EAL Lake Warner TP data from 2003 and 2004 have not been used for assessment. DO concentrations and Secchi depth are considered valid and are considered here for assessment.

Secchi disk depths ranged from 0.69 to 2.13 m (n = 11), with only one measurement less than 1.2 meters. Dissolved oxygen concentrations measured at depth ranged from 4.6 to 9.9 mg/L (n =9), with only one measurement less than 5.0 mg/L. It should be noted that the report states that DO measurements were generally made between 10AM and 2PM, and thus they likely do not represent the worst-case scenario.

The Aquatic Life Use for this segment is assessed as impaired based on the presence of a non-native species.

PRIMARY AND SECONDARY CONTACT RECREATION AND AESTHETICS USES
Due to the good water clarity, as measured by Secchi disk depth, the Secondary Contact Use is supported. Due to a general lack of objectionable deposits or conditions, the Aesthetics Use is also supported. The Primary Contact Recreation is not assessed due to too limited data.

CONNECTICUT RIVER WATERSHED – LAKE SEGMENTS ASSESSED

Currently there is uncertainty associated with the accurate reporting of freshwater beach closure information to MA DPH, which is required as part of the Beaches Bill. Therefore, no Primary Contact Recreational Use assessments (either support or impairment) decisions are being made using Beaches Bill data for these waterbodies. Bathing beaches located in this watershed are listed in their respective lake segments.

The City of Springfield received a grant to monitor the water quality of the lakes and ponds within the city limits, and monitoring was conducted during 2001 and 2002 (Godfrey 2007). A QAPP was submitted and approved in 2003 to document data collection methods. However, no additional data collection took place after 2002 under the direction of that QAPP (Connors 2007), thus these data are not used to make assessment decisions. Clear violations of criteria noted in these data have been described in the appropriate segment and may result in an Alert Status for the appropriate use.

Report Recommendations:
Continue to monitor for the presence of invasive non-native aquatic vegetation and determine the extent of the infestation. Prevent spreading of invasive aquatic plants. Once the extent of the problem is determined and control practices are exercised, vigilant monitoring needs to be practiced to guard against infestations in unaffected areas, including downstream from the site, and to ensure that managed areas stay in check. A key portion of the prevention program should be posting of boat access points with signs to educate and alert lake-users to the problem and their responsibility to prevent spreading these species.

Conduct water quality monitoring to evaluate designated uses.

Total Maximum Daily Loads of Phosphorus for Selected Connecticut Basin Lakes (MA34098 - Lake Warner)

Lake Warner in Hadley is a large reservoir of approximately 68 acres. The watershed is 58 percent forested and the remainder consists of 20 percent agricultural, 14 percent rural and 8 percent urban land use with areas of high density residential and commercial-industrial land use. Populations in Hadley ranged between 4,125 and 4,231 from 1980 to the 1990 census. Miser predictions on growth are 4,591 for the year 2000 and 4,707 for the year 2010 with an estimated 20 year growth rate of about 11 percent. Masshighways Route 47 is within the watershed of the reservoir. Secchi disk transparency was recorded at 1.0 m in 1978. Lake Warner was assessed by DEP in the summer of 1994 and the assessment comments reported: "High phosphorus levels and potential nuisance macrophyte species threaten future conditions." A report by Snow and DiGiano (1976) indicated that the sediments are likely the source of high total phosphorus in the lake and that an alum treatment of approximately 12 gm/m2 would reduce TP to 45 ppb.

The pollutant stressors reported on the 1998 303d list which are related to this phosphorus TMDL are listed in the table below.

Table . Pollutant Stressors listed on 1998 303d list.

WBID	Lake Name	Town	Area	303d list pollutant/stressor
MA34002	Aldrich Lake East	Granby	18.5	Noxious plants
MA34106	Aldrich Lake West	Granby	10.7	Noxious plants
MA34042	Leverett Pond	Leverett	65	Noxious plants;Turbidity
MA34045	Loon Pond	Springfield	25.4	Nutrients;Noxious plants
MA34098	Lake Warner	Hadley	68	Nutrients; Low DO;Noxious plants;Turbidity
MA34103	Lake Wyola	Shutesbury	129	Nutrients; Low DO;Noxious plants

Unfortunately, no detailed study of the nutrient sources within the watersheds has been conducted to date. Thus, nutrient sources were estimated based on land use modeling within the DEP's NPSLAKE model. The NPSLAKE model of Mattson and Isaac (1999) was designed to estimate watershed loading rates of phosphorus to lakes. The phosphorus loading estimates from the model are used with estimates of water runoff and these are used as inputs into a water quality model of Reckhow (1979). A brief description of the NPSLAKE model and data inputs is given here. MassGIS digital maps of land use within the watershed were used to calculate areas of landuse within three major types: Forest, rural and urban landuse. This model takes the area in hectares of land use within each of three categories and applies an export coefficient to each to predict the annual external loading of phosphorus to the lake from the watershed. Because much of the landuse data is based on old (1985) aerial photographs, the current landuses within the watershed may be different today. This can be important in the development of the TMDL because different landuses can result in different phosphorus loadings to the waterbody in question. For many rural areas, landuse changes often result in conversion of open or agricultural lands to low density housing, in which case, the export coefficients of the NPSLAKE model are the same and no change in loading is predicted to occur. However, in cases where development changes forests to residential areas or rural landuses to urban landuses, phosphorus loadings are predicted to increase. In some cases, loadings are predicted to decrease if additional agricultural land is abandoned and forest regrowth occurs. To account for this uncertainty in landuse changes, a conservative target is chosen. In addition, the MassGIS landuse maps are scheduled to be updated with current aerial photos and the TMDL can be modified as additional information is obtained.

Other phosphorus sources, such as septic system inputs of phosphorus, are estimated from an export coefficient multiplied by the number of homes within 100 meters of the lake. Point sources are estimated manually based on discharge information and site-specific information for uptake and storage. Other sources such as atmospheric deposition to lakes was determined to be small and not significant in the NPSLAKE model, perhaps because lakes tend to be sinks rather than sources of phosphorus (Mattson and Isaac, 1999). For similar reasons wetlands were also not considered to be significant sources of phosphorus following (Mattson and Isaac, 1999). Other, non-landuse sources of phosphorus such as inputs from waterfowl were not included, but can be added as additional information becomes available. If large numbers of waterfowl are using the lake the total phosphorus budget may be an underestimate, and control measures should be considered.

Internal sources (recycling) of phosphorus is not included because it is not considered as a net external load to the lake, but rather a seasonal recycling of phosphorus already present in the lake. In cases where this internal source is large it may result in surface concentrations higher than predicted from landuse loading models and may contribute to water quality violations during the critical summer period. As additional monitoring data become available, these lakes will be assessed for internal contributions and possibly control of these sources by alum or other means. The major sources according to the land use analysis are shown for the lake in the following table (from "Total Maximum Daily Loads of Phosphorus for Selected Connecticut Basin Lakes", 2001).

Table . Lake Warner MA34098

Total Estimated Nonpoint Source Pollution loads based on GIS Landuse

Watershed Area=	7733.6 Ha (29.9 mi2)
Average Annual Water Load =	47143848.3 m3/yr (53.4 cfs)
Average Runoff=	61.0 cm/yr (24.0 in/yr)
Lake area=	26.0 Ha. (64.2ac)
Areal water loading to lake: q=	181.3 m/yr.
Homes with septic systems within 100m of lake.=	24.0
Other P inputs =	5448.0 kg/yr

Estimate of annual Nonpoint Source Pollution Loads by land use

Land use	Area Ha (%)	P Load kg/yr (%)	N Load kg/yr	TSS Load kg/yr
Forest category				
Forest:	4464.7 (57.7)	580.4 (8.1)	11161.8	107152.9
Rural category				
Agriculture:	1515.2 (19.6)	454.6 (6.4)	16084.2	566814.5
Open land:	632.0 (8.2)	189.6 (2.7)	3286.4	121039.7
Residential Low:	411.2 (5.3)	123.3 (1.7)	2261.4	159531.5
Urban category				
Residential High:	437.8 (5.7)	250.5 (3.5)	2898.8	231671.5
Comm - Ind:	160.6 (2.1)	91.9 (1.3)	1600.8	89958.7
Other Landuses				
Water:	66.8 (0.9)	0.0 (0.0)	0.0	0.0
Wetlands:	45.3 (0.6)	0.0 (0.0)	0.0	2401.6
Subtotal	7733.6	1690.4	37491.8	1281208.6
Internal P inputs*:	NA	5448.0 (76.2)		
24.0 Septics:	NA	12.0 (0.2)		
Total	7733.6 (100.0)	7150.4(100)	37491.8	1281208.6

Summary of Lake Total Phosphorus Modeling Results

*Predicted by difference to agree with observed TP concentrations.
Areal P loading L= 27.5 g/m2/yr.
Reckhow (1979) model predicts lake TP = L/(11.6+1.2q)*1000 = 120.0 ppb.
Predicted transparency = 0.4 meters.

If all land were primeval forest P export would be 990.8 kg/yr
And the forested condition lake TP would be 16.6 ppb.

The NPSLAKE model assumes land uses are accurately represented by the MassGIS digital maps and that land use has not changed appreciably since the maps were compiled in 1985. The predicted loading is based on the equation:

P Loading (kg/yr)= 0.5* septics + 0.13* forest ha + 0.3* rural ha + 14* (urban ha)0.5

The coefficients of the model are based on a combination of values estimated with the aid of multiple regression on a Massachusetts data set and of typical values reported in previous diagnostic/feasibility studies in Massachusetts.

All coefficients fall within the range of values reported in other studies. Further details on the methods, assumptions, calibration and validation of the NPSLAKE model can be found in Mattson and Isaac (1999). The overall standard error of the model is approximately 172 kg/yr. If not data is available for internal loading a rough estimate of the magnitude of this sources can be estimated from the Reckhow model by substitution of the in-lake concentration for TP. The difference in predicted loadings from this approach and the landuse approach is the best estimate of internal loading.

The NPSLAKE model also generates predictions of estimated yearly average water runoff to the lake based on total watershed area and runoff maps of Massachusetts (Mattson and Isaac, 1999). Other estimates of nitrogen and total suspended solid (TSS) loading rates are estimates based on Reckhow et al.(1980), and are provided here for informational and comparison purposes only.

Because of the general nature of the landuse loading approach, natural background is included in land use based export coefficients. Natural background can be estimated based on the forest export coefficient of 0.13 kg/ha/yr multiplied by the hectares of the watershed assuming the watershed to be entirely forested. Without site specific information regarding soil phosphorus and natural erosion rates the accuracy of this estimate would be uncertain and would add little value to the analysis.

Mattson, M.D. and R.A. Isaac. 1999. Calibration of Phosphorus Export coefficients for Total Maximum Daily Loads of Massachusetts Lakes. Lake and Reservoir Man. 15(3):209-219.
Reckhow, K.H. 1979. Uncertainty Analysis Applied to Vollenweider's Phosphorus Loading Criteria. J. Water Poll. Control Fed. 51(8):2123-2128.
Reckhow, K.H., M.N. Beaulac, J.T. Simpson. 1980. Modeling Phosphorus Loading and Lake Response Under Uncertainty: A Manual and Compilation of Export Coefficients. U.S.E.P.A. Washington DC. EPA 440/5-80-011.
Snow, P.D., and F.A. DiGiano. 1976. Mathematical Modeling of Phosphorus Exchange Between Sediments and Overlying Water in Shallow Eutrophic Lakes. Sept. 1976 Report No. Env. E. 54-76-3, Envir. Eng. Dept. Civil Eng. Umass, Amherst, MA.

Connecticut River Watershed 2003 Water Quality Assessment Report (MA34042 - Leverett Pond)

AQUATIC LIFE
Biology
Two non-native species (Myriophyllum spicatum and Najas minor) were documented in Leverett Pond in 1998 (MassDEP 1998).

The Aquatic Life Use for this segment is assessed as impaired based on the presence of non-native species.

CONNECTICUT RIVER WATERSHED – LAKE SEGMENTS ASSESSED

Currently there is uncertainty associated with the accurate reporting of freshwater beach closure information to MA DPH, which is required as part of the Beaches Bill. Therefore, no Primary Contact Recreational Use assessments (either support or impairment) decisions are being made using Beaches Bill data for these waterbodies. Bathing beaches located in this watershed are listed in their respective lake segments.

The City of Springfield received a grant to monitor the water quality of the lakes and ponds within the city limits, and monitoring was conducted during 2001 and 2002 (Godfrey 2007). A QAPP was submitted and approved in 2003 to document data collection methods. However, no additional data collection took place after 2002 under the direction of that QAPP (Connors 2007), thus these data are not used to make assessment decisions. Clear violations of criteria noted in these data have been described in the appropriate segment and may result in an Alert Status for the appropriate use.

Report Recommendations:
Continue to monitor for the presence of invasive non-native aquatic vegetation and determine the extent of the infestation. Prevent spreading of invasive aquatic plants. Once the extent of the problem is determined and control

practices are exercised, vigilant monitoring needs to be practiced to guard against infestations in unaffected areas, including downstream from the site, and to ensure that managed areas stay in check. A key portion of the prevention program should be posting of boat access points with signs to educate and alert lake-users to the problem and their responsibility to prevent spreading these species.

Conduct water quality monitoring to evaluate designated uses.

Total Maximum Daily Loads of Phosphorus for Selected Connecticut Basin Lakes (MA34042 - Leverett Pond)

Leverett Pond in Leverett is a large pond of approximately 65 acres. The watershed is 60 percent forested, 23 percent water and wetlands, 15 percent rural and the remaining 2 percent consists of high-density residential land use. Populations in Leverett ranged between 1,471 and 1,785 from 1980 to the 1990 census. Miser predictions on growth are 2,083 for the year 2000 and 2,289 for the year 2010 with an estimated 20-year growth rate of about 28 percent. Secchi depth was recorded at 3.8 m in 1978, however, Leverett Pond was assessed by DEP in the summer of 1994 and the assessment comments reported: "Very dense growths of aquatic macrophytes cover the entire littoral zone. The non-native macrophyte Myriophyllum spicatum has been detected, via citizen monitoring and confirmed by DWPC limnologists, in the northwest portion of the lake and along the eastern shore. Populations have been expanding and threaten the entire lake. Citizen monitoring data during summer 1993 indicated three months of Secchi disk transparency values below the safety criteria (<1.2 m). "

The pollutant stressors reported on the 1998 303d list which are related to this phosphorus TMDL are listed in the table below.

Table . Pollutant Stressors listed on 1998 303d list.

WBID	Lake Name	Town	Area	303d list pollutant/stressor
MA34002	Aldrich Lake East	Granby	18.5	Noxious plants
MA34106	Aldrich Lake West	Granby	10.7	Noxious plants
MA34042	Leverett Pond	Leverett	65	Noxious plants;Turbidity
MA34045	Loon Pond	Springfield	25.4	Nutrients;Noxious plants
MA34098	Lake Warner	Hadley	68	Nutrients; Low DO;Noxious plants;Turbidity
MA34103	Lake Wyola	Shutesbury	129	Nutrients; Low DO;Noxious plants

Unfortunately, no detailed study of the nutrient sources within the watersheds has been conducted to date. Thus, nutrient sources were estimated based on land use modeling within the DEP's NPSLAKE model. The NPSLAKE model of Mattson and Isaac (1999) was designed to estimate watershed loading rates of phosphorus to lakes. The phosphorus loading estimates from the model are used with estimates of water runoff and these are used as inputs into a water quality model of Reckhow (1979). A brief description of the NPSLAKE model and data inputs is given here. MassGIS digital maps of land use within the watershed were used to calculate areas of landuse within three major types: Forest, rural and urban landuse. This model takes the area in hectares of land use within each of three categories and applies an export coefficient to each to predict the annual external loading of phosphorus to the lake from the watershed. Because much of the landuse data is based on old (1985) aerial photographs, the current landuses within the watershed may be different today. This can be important in the development of the TMDL because different landuses can result in different phosphorus loadings to the waterbody in question. For many rural areas, landuse changes often result in conversion of open or agricultural lands to low density housing, in which case, the export coefficients of the NPSLAKE model are the same and no change in loading is predicted to occur. However, in cases where development changes forests to residential areas or rural landuses to urban landuses, phosphorus loadings are predicted to increase. In some cases, loadings are predicted to decrease if additional agricultural land is abandoned and forest regrowth occurs. To account for this uncertainty in landuse changes, a conservative target is chosen. In addition, the MassGIS landuse maps are scheduled to be updated with current aerial photos and the TMDL can be modified as additional information is obtained.

Other phosphorus sources, such as septic system inputs of phosphorus, are estimated from an export coefficient multiplied by the number of homes within 100 meters of the lake. Point sources are estimated manually based on discharge information and site-specific information for uptake and storage. Other sources such as atmospheric deposition to lakes was determined to be small and not significant in the NPSLAKE model, perhaps because lakes tend to be sinks rather than sources of phosphorus (Mattson and Isaac, 1999). For similar reasons wetlands were also not considered to be significant sources of phosphorus following (Mattson and Isaac, 1999). Other, non-landuse sources of phosphorus such as inputs from waterfowl were not included but can be added as additional information becomes available. If large numbers of waterfowl are using the lake the total phosphorus budget may be an underestimate, and control measures should be considered.

Internal sources (recycling) of phosphorus is not included because it is not considered as a net external load to the lake, but rather a seasonal recycling of phosphorus already present in the lake. In cases where this internal source is large it may result in surface concentrations higher than predicted from landuse loading models and may contribute to water quality violations during the critical summer period. As additional monitoring data become available, these lakes will be assessed for internal contributions and possibly control of these sources by alum or other means. The major sources according to the land use analysis are shown for the lake in the following table (from "Total Maximum Daily Loads of Phosphorus for Selected Connecticut Basin Lakes", 2001).

Table . Leverett Pond MA34042

Total Estimated Nonpoint Source Pollution loads based on GIS Landuse

Watershed Area=	166.8 Ha (0.6 mi2)
Average Annual Water Load =	1016846.3 m3/yr (1.2 cfs)
Average Runoff=	61.0 cm/yr (24.0 in/yr)
Lake area=	35.8 Ha. (88.4ac)
Areal water loading to lake: q=	2.8 m/yr.
Homes with septic systems within 100m of lake.=	40.0
Other P inputs =	37.0 kg/yr

Estimate of annual Nonpoint Source Pollution Loads by land use

Land use	Area Ha (%)	P Load kg/yr (%)	N Load kg/yr	TSS Load kg/yr
Forest category				
Forest:	100.1 (60.0)	13.0 (12.2)	250.2	2402.3
Rural category				
Agriculture:	5.5 (3.3)	1.7 (1.6)	43.2	1327.8
Open land:	3.0 (1.8)	0.9 (0.8)	15.6	228.5
Residential Low:	16.1 (9.6)	4.8 (4.5)	88.5	6241.3
Urban category				
Residential High:	4.3 (2.6)	29.2 (27.4)	23.9	2021.1
Comm - Ind:	0.0 (0.0)	0.0 (0.0)	0.0	0.0
Other Landuses				
Water:	35.8 (21.4)	0.0 (0.0)	0.0	0.0
Wetlands:	2.0 (1.2)	0.0 (0.0)	0.0	105.4
Subtotal	166.8	49.5	421.3	12326.3
Internal P inputs*:	NA	37.0 (34.7)		
40.0 Septics:	NA	20.0 (18.8)		
Total	166.8 (100.0)	106.5(100)	421.3	12326.3

Summary of Lake Total Phosphorus Modeling Results

*Predicted by difference to agree with observed TP concentrations.
Areal P loading L= 0.3 g/m2/yr.
Reckhow (1979) model predicts lake TP = L/(11.6+1.2q)*1000 = 19.8 ppb.
Predicted transparency = 2.4 meters.

If all land were primeval forest P export would be 16.8 kg/yr
And the forested condition lake TP would be 3.1 ppb.

The NPSLAKE model assumes land uses are accurately represented by the MassGIS digital maps and that land use has not changed appreciably since the maps were compiled in 1985. The predicted loading is based on the equation:

P Loading (kg/yr)= 0.5* septics + 0.13* forest ha + 0.3* rural ha + 14* (urban ha)0.5

The coefficients of the model are based on a combination of values estimated with the aid of multiple regression on a Massachusetts data set and of typical values reported in previous diagnostic/feasibility studies in Massachusetts.

Total Maximum Daily Loads of Phosphorus for Selected Connecticut Basin Lakes (MA34042 - Leverett Pond)

All coefficients fall within the range of values reported in other studies. Further details on the methods, assumptions, calibration and validation of the NPSLAKE model can be found in Mattson and Isaac (1999). The overall standard error of the model is approximately 172 kg/yr. If not data is available for internal loading a rough estimate of the magnitude of this sources can be estimated from the Reckhow model by substitution of the in-lake concentration for TP. The difference in predicted loadings from this approach and the landuse approach is the best estimate of internal loading.

The NPSLAKE model also generates predictions of estimated yearly average water runoff to the lake based on total watershed area and runoff maps of Massachusetts (Mattson and Isaac, 1999). Other estimates of nitrogen and total suspended solid (TSS) loading rates are estimates based on Reckhow et al.(1980), and are provided here for informational and comparison purposes only.

Because of the general nature of the landuse loading approach, natural background is included in land use based export coefficients. Natural background can be estimated based on the forest export coefficient of 0.13 kg/ha/yr multiplied by the hectares of the watershed assuming the watershed to be entirely forested. Without site specific information regarding soil phosphorus and natural erosion rates the accuracy of this estimate would be uncertain and would add little value to the analysis.

In the case of Leverett Pond, the NPSLAKE model predictions of in-lake total phosphorus based on landuse do not agree well with in-lake total phosphorus concentrations observed in 1993 (although they do agree with conditions in 1978). As noted above, volunteer measurements of Secchi disk depths were less than 1.2 meters in 1993 and total phosphorus concentrations were 20 ppb, but the model predicts transparency to be 3.7 meters based on predicted total phosphorus concentrations of 12.9 ppb. Thus, there is probably an additional source of phosphorus to the pond and the most likely source is internal phosphorus from the sediments. This source was estimated by difference so that the new model predictions agree with the observed concentration. Further study on phosphorus sources to this pond is suggested.

Mattson, M.D. and R.A. Isaac. 1999. Calibration of Phosphorus Export coefficients for Total Maximum Daily Loads of Massachusetts Lakes. Lake and Reservoir Man. 15(3):209-219.

Reckhow, K.H. 1979. Uncertainty Analysis Applied to Vollenweider's Phosphorus Loading Criteria. J. Water Poll. Control Fed. 51(8):2123-2128.

Reckhow, K.H., M.N. Beaulac, J.T. Simpson. 1980. Modeling Phosphorus Loading and Lake Response Under Uncertainty: A Manual and Compilation of Export Coefficients. U.S.E.P.A. Washington DC. EPA 440/5-80-011.

Connecticut River Watershed 2008 DWM Water Quality Monitoring Data (MA34-25 - Mill River-Hadley)

Water Quality Monitoring Data

Table 1. MassDEP, DWM 2008 Connecticut River Watershed sampling station descriptions, sampling parameters and frequency.

Station ID	Unique ID	Waterbody	Description	Latitude	Longitude	Nutrients/ Solids/Color	*E.Coli*	Attended Multiprobe	Deployed MultiProbe	Temperature Logger
MRHAD1	W1050	Mill River	Mill River Lane, Hadley	42.38640	-72.55039	5	6	8	4	

Table 5. 2008 Field observations from MassDEP DWM Connecticut River Watershed river surveys

S=sparse (0-25%, M=moderate (25-50%), D=dense (50-75%), VD=very dense (75-100%), N=none, U=unobservable, NA=not recorded, NP=not applicable – probe deploy field sheet)

Station ID	Unique ID	Date	Odor	Water Clarity	Color	Aquatic Plants	Filamentous Algae	Film Algae	Loose Floc	Moss	Floating Scum	Floating Scum Comments	Objectionable Deposits	Objectionable Deposit Comments
MRHAD1	W1050	05/06/08	N	Clear	Clear	S	N	N	N	N	No		No	
MRHAD1	W1050	05/30/08	N	Slightly Turbid	Clear	N/A	N/A	N/A	N/A	N/A	N/A		N/A	
MRHAD1	W1050	06/03/08	N	Clear	Clear	S	N	N	N	N	No		No	
MRHAD1	W1050	06/27/08	N	Slightly Turbid	Brown	N/A	N/A	N/A	N/A	N/A	N/A		N/A	
MRHAD1	W1050	07/01/08	N	Highly	Yellow/	S	N	N	N	N	No		No	
MRHAD1	W1050	07/25/08	N	Highly Turbid	U	N/A	N/A	N/A	N/A	N/A	N/A		N/A	
MRHAD1	W1050	07/29/08	N	Clear	Clear	S	U	U	U	U	No		No	
MRHAD1	W1050	09/03/08	Musty	Clear	Clear	S	N	N	N	N	No		No	
MRHAD1	W1050	09/05/08	N	Slightly Turbid	Yellow/ Tan	N/A	N/A	N/A	N/A	N/A	N/A		N/A	
MRHAD1	W1050	09/09/08	Musty	Clear	Yellow/ Tan	S	NR	NR	NR	NR	No		No	

Table 6. 2008 MassDEP, DWM Connecticut River Watershed water quality data

NOTE: Result Qualifier definitions appear in Appendix 1.

Station ID	Unique ID	OWMID	Date	Time	Analyte	Units	Result	Result Qualifiers
MRHAD1	W1050	34-0585	05/06/08	10:37	Ammonia-N	mg/L	0.02	
MRHAD1	W1050	34-0687	06/03/08	10:58	Ammonia-N	mg/L	0.04	
MRHAD1	W1050	34-0789	07/01/08	10:29	Ammonia-N	mg/L	0.05	
MRHAD1	W1050	34-0921	07/29/08	10:41	Ammonia-N	mg/L	0.03	
MRHAD1	W1050	34-1032	09/09/08	10:22	Ammonia-N	mg/L	0.04	
MRHAD1	W1050	34-0585	05/06/08	10:37	*E. coli*	CFU/100mL	26	
MRHAD1	W1050	34-0687	06/03/08	10:58	*E. coli*	CFU/100mL	232	
MRHAD1	W1050	34-0789	07/01/08	10:29	*E. coli*	CFU/100mL	200	
MRHAD1	W1050	34-0921	07/29/08	10:41	*E. coli*	CFU/100mL	140	
MRHAD1	W1050	34-0978	09/03/08	10:20	*E. coli*	CFU/100mL	340	
MRHAD1	W1050	34-1032	09/09/08	10:22	*E. coli*	CFU/100mL	440	
MRHAD1	W1050	34-0585	05/06/08	10:37	Suspended Solids	mg/L	2.0	
MRHAD1	W1050	34-0687	06/03/08	10:58	Suspended Solids	mg/L	3.1	
MRHAD1	W1050	34-0789	07/01/08	10:29	Suspended Solids	mg/L	3.3	
MRHAD1	W1050	34-0921	07/29/08	10:41	Suspended Solids	mg/L	5.5	
MRHAD1	W1050	34-1032	09/09/08	10:22	Suspended Solids	mg/L	3.6	
MRHAD1	W1050	34-0585	05/06/08	10:37	Total Nitrogen	mg/L	0.69	
MRHAD1	W1050	34-0687	06/03/08	10:58	Total Nitrogen	mg/L	1.1	
MRHAD1	W1050	34-0789	07/01/08	10:29	Total Nitrogen	mg/L	1.0	
MRHAD1	W1050	34-0921	07/29/08	10:41	Total Nitrogen	mg/L	0.79	h
MRHAD1	W1050	34-1032	09/09/08	10:22	Total Nitrogen	mg/L	0.89	
MRHAD1	W1050	34-0585	05/06/08	10:37	Total Phosphorus	mg/L	0.014	
MRHAD1	W1050	34-0687	06/03/08	10:58	Total Phosphorus	mg/L	0.022	
MRHAD1	W1050	34-0789	07/01/08	10:29	Total Phosphorus	mg/L	0.028	
MRHAD1	W1050	34-0921	07/29/08	10:41	Total Phosphorus	mg/L	0.077	h
MRHAD1	W1050	34-1032	09/09/08	10:22	Total Phosphorus	mg/L	0.037	
MRHAD1	W1050	34-0585	05/06/08	10:37	True Color	PCU	<15	
MRHAD1	W1050	34-0687	06/03/08	10:58	True Color	PCU	<15	
MRHAD1	W1050	34-0789	07/01/08	10:29	True Color	PCU	23	
MRHAD1	W1050	34-0921	07/29/08	10:41	True Color	PCU	39	
MRHAD1	W1050	34-1032	09/09/08	10:22	True Color	PCU	41	
MRHAD1	W1050	34-0585	05/06/08	10:37	Turbidity	NTU	2.2	b
MRHAD1	W1050	34-0687	06/03/08	10:58	Turbidity	NTU	2.8	b
MRHAD1	W1050	34-0789	07/01/08	10:29	Turbidity	NTU	4.4	
MRHAD1	W1050	34-0921	07/29/08	10:41	Turbidity	NTU	4.3	
MRHAD1	W1050	34-1032	09/09/08	10:22	Turbidity	NTU	3.7	

Connecticut River Watershed 2008 DWM Water Quality Monitoring Data (MA34-25 - Mill River-Hadley)

Table 7. Geometric mean* of the 2008 *E. coli* results for each DWM Connecticut River sampling station

*The detection limit or the upper quantification limit was used in the geometric mean calculation if the result was either below the detection limit or above the upper quantification limit. Results from duplicate samples were removed before completing the geometric mean calculation. Stations that had *E. coli* results that were below the detection limit are marked with [1]. Stations that had *E. Coli* results above the upper quantification are marked with a [2]. Please see Table 6 for a complete listing of *E. coli* results.

Station ID	Unique ID	Sample Count	Geometric Mean (CFU/100 ml)
MRHAD1	W1050	6	171.3

Table 8. 2008 MassDEP, DWM Connecticut River Watershed Attended Multiprobe Data

Note: Descriptions of data qualifiers may be found in Appendix 1.

Station ID	Unique ID	OWMID	Date	Time	Sample Depth (m)	Depth Qualifiers	Temperature °C	Temperature Qualifiers	pH (SU)	pH Qualifiers	Specific Conductivity (µS/cm)	Specific Conductivity Qualifiers	Total Dissolved Solids (mg/l)	Total Dissolved Solids Qualifiers	Dissolved Oxygen (mg/l)	Dissolved Oxygen Qualifiers	Dissolved Oxygen Saturation (%)	Dissolved Oxygen Saturation Qualifiers
MRHAD1	W1050	34-0635	05/30/08	11:52	0.5		14.5		6.8		210	i	135	i	9.6		95	
MRHAD1	W1050	34-0636	06/04/08	11:41	0.1		16.1		6.7	i	188	i	120	i	8.2		85	
MRHAD1	W1050	34-0737	06/27/08	12:14	0.1		16.9		6.6		182		116		8.5		89	
MRHAD1	W1050	34-0738	07/02/08	11:53	0.4		19.7		6.7		222		142		8		89	
MRHAD1	W1050	34-0869	07/25/08	11:54	--		19.4		6.4		106		68		6.8		75	
MRHAD1	W1050	34-0870	07/30/08	12:02	0.5		19.1		6.5		169		108		7.5		82	
MRHAD1	W1050	34-1007	09/05/08	11:29	--		20		6.8		231		148		7.5		83	
MRHAD1	W1050	34-1008	09/10/08	10:09	--		16.1		--		--		--		7.7		79	

Connecticut River Watershed 2008 DWM Water Quality Monitoring Data (MA34-25 - Mill River-Hadley)

Table 9. 2008 MassDEP, DWM Connecticut River Watershed Deployed Multiprobe Data

Note: Descriptions of data qualifiers may be found in Appendix 1.

Station ID	Unique ID	OWMID	Start Date	Deployment Duration (Hours)	Minimum Dissolved Oxygen (mg/l)	Average Dissolved Oxygen (mg/L)	Amount of Time < 5.0 mg/L (Hours)	Percentage of Time < 5.0 mg/L (%)	Amount of Time < 6.0 mg/L (Hours)	Percentage of Time < 6.0 mg/L (%)	Minimum Saturation (%)	Average Saturation (%)	Maximum Saturation (%)
MRHAD1	W1050	34-0634	05/30/08	119.5	6.9	8.2	0	0	0	0	72.4	84.7	98
MRHAD1	W1050	34-0736	06/27/08	82.5	5.7	6.8	0	0	4.0	4.8	63	75.1	84.5
MRHAD1	W1050	34-0868	07/25/08	59.5	5.1	6.0	0	0	26.1	43.9	56.6	66.8	75.1
MRHAD1	W1050	34-1006	09/05/08	9.0	7.7	8.0	0	0	0	0	86.3	91.3	93.9

Table 10. 2008 MassDEP, DWM Connecticut River Watershed Temperature Data

Note: Data qualifier descriptions appear in Appendix1. Temperature data sourced from both deployed multiprobes and deployed temperature loggers.

Station ID	Unique ID	OWMID	Start Date	Deployment Duration (hours)	Mean Temperature °C	Maximum Temperature °C	Mean of the Daily Maximum Temperature °C	Amount of time temperature greater than 20 °C (Hours)	Percent of time temperature greater than 20 °C (%)	Amount of time temperature greater than 28.3 °C (Hours)
MRHAD1	W1050	34-0634	05/30/08	119.5	16.5	18.3	18.0	0.0	0.0	0
MRHAD1	W1050	34-0736	06/27/08	119	19.3	20.9	20.3	29.6	24.9	0
MRHAD1	W1050	34-0868	07/25/08	120	19.7	20.7	20.4	37.2	31.0	0
MRHAD1	W1050	34-1006	09/05/08	12.5	20.9	21.4	--	12.4	99.6	0

Appendix D—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			