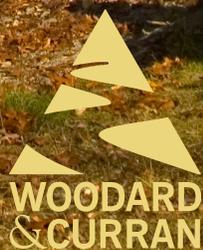




# Watershed Action Plan

Stony Brook &  
Nashoba Brook  
Watersheds



Executive Office  
of Energy &  
Environmental  
Affairs

Town of Westford, MA  
December 31, 2007

## TABLE OF CONTENTS

SECTION	PAGE NO.
<b>Executive Summary.....</b>	<b>ES-1</b>
<b>1. INTRODUCTION .....</b>	<b>1-1</b>
1.1 Watershed Vision .....	1-1
1.2 Social and Economic Setting.....	1-2
1.3 Watershed Overview .....	1-2
1.4 Summary of Planning Process .....	1-4
<b>2. HISTORY OF WATERSHED PROTECTION .....</b>	<b>2-1</b>
<b>3. WATERSHED ANALYSIS .....</b>	<b>3-1</b>
3.1 Open Space Update .....	3-1
3.1.1 Summary of Protected Lands in the 2002 Open Space and Recreation Plan .....	3-1
3.1.2 Additions to Open Space Since 2002.....	3-2
3.2 Impervious Cover .....	3-3
3.3 Inventory of Sensitive Resources .....	3-4
3.3.1 Critical, Sensitive, or Unique Resources .....	3-4
3.3.2 Lands Critical to Sustaining Surface and Groundwater Quality and Quantity.....	3-6
3.4 Summary of Water Quality and Quantity Data.....	3-7
3.4.1 Massachusetts Integrated List of Waters .....	3-7
3.4.2 Total Maximum Daily Loads .....	3-10
3.4.3 Summary of In-Stream Water Quality.....	3-12
3.4.4 Macro Invertebrate Sampling and Biological Assessments.....	3-15
3.4.5 Water Quantity and Stream Flow .....	3-16
3.5 Existing and Potential Sources of Pollution .....	3-17
3.5.1 Point Source Discharges .....	3-17
3.5.2 Nonpoint Sources.....	3-17
3.5.3 Existing and Potential Pollution by Sub-Basin .....	3-18
<b>4. SUB-BASIN PROFILES.....</b>	<b>4-1</b>
<b>5. WATERSHED ACTION PLAN .....</b>	<b>5-2</b>
5.1 Open Space Protection Plan .....	5-2
5.2 Municipal Operations Program .....	5-4
5.3 Regulatory Improvement Plan .....	5-5
5.4 Education and Outreach Program .....	5-8
5.5 Long-Term Water Quality Monitoring Program.....	5-10
<b>6. REFERENCES &amp; ACKNOWLEDGEMENTS .....</b>	<b>6-1</b>

## LIST OF TABLES

TABLE	PAGE NO.
Table 1: Protected and Unprotected Open Space by Sub-basin .....	3-2
Table 2: Percent Protected Land by Sub-basin.....	3-3
Table 3: Impervious Cover by Sub-basin .....	3-4
Table 4: Sources and Expectations for Limiting Bacterial Contamination in the Merrimack River Watershed.....	3-11
Table 5: Massachusetts Surface Water Quality Standards.....	3-13
Table 6: EPA Ambient Water Quality Criteria Recommendations.....	3-13
Table 8: Westford Sampling Sites - 2007.....	5-12
Table 9: Proposed Additional Sampling Sites.....	5-12

## LIST OF FIGURES

FIGURE	PAGE NO.
Figure 1: Stony Brook Watershed .....	1-3
Figure 2: Nashoba & Fort Pond Brook Watershed.....	1-4
Figure 3: Stony Brook Segment MA84B-03 .....	3-8
Figure 4: Stony Brook Segment MA84B-04 .....	3-8
Figure 5: Nashoba Brook Segment MA82B-14 .....	3-9
Figure 6: Massachusetts Stressed Basins .....	3-10
Figure 7: Sub-basin Profile Legend.....	4-1

## APPENDICES

- Appendix A: Maps
- Appendix B: Sub-Basin Statistics
- Appendix C: May 2007 Water Monitoring Manual

## LIST OF ACRONYMS

303(d) list	List of Category 5 Waters on the Massachusetts Integrated List of Waters
ACES	Area of Critical Environmental Concern
CWA	Clean Water Act
CWRA	Charles River Watershed Association
DCR	Massachusetts Department of Conservation and Recreation
DO	Dissolved Oxygen
DWM	MassDEP Division of Watershed Management
EOEEA	Executive Office of Energy and Environmental Affairs, also known as EOEA – Executive Office of Environmental Affairs
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ICM	Impervious Cover Model
IWPA	Interim Wellhead Protection Area
MassDEP	Massachusetts Department of Environmental Protection
MassWildlife	Massachusetts Division of Fisheries and Wildlife
MRWC	Merrimack River Watershed Council
MS4	Municipal Separate Storm Sewer System
NHESP	Natural Heritage & Endangered Species Program
NMCOG	Northern Middlesex Council of Governments
NPDES	National Pollution Discharge Elimination System
NPS	Non-point source
OAR	Organization for the Assabet River
POTW	Publicly Owned Treatment Works
PWS	Public Water Supply
SGAC	Smart Growth Advisory Committee
SuAsCo	Sudbury-Assabet-Concord
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
UST	Underground Storage Tank
WAP	Watershed Action Plan
WENAC	Westford Environmental News and Action Committee
W&C	Woodard & Curran

---

## EXECUTIVE SUMMARY

This Watershed Action Plan (WAP) was prepared by the Town of Westford (the Town), with assistance from their environmental consultants, Woodard & Curran (W&C), in order to better protect the Town's water resources and environmental assesses in the Stony Brook and Nashoba Brook watersheds. The preparation of this report was funded through a grant from the Executive Office of Energy and Environmental Affairs (EOEEA) under the Fiscal Year 2007 Smart Growth Technical Assistance grant program.

The intent of this WAP is to better understand the water and other related important resources within the Town, compile and evaluate the existing data related to these resources, identify areas and topics where additional data collection and research are necessary, and guide future planning and prioritization efforts. This document will assist Westford with focusing on the long-term health and welfare of the environment and of the residents as it guides growth away from sensitive areas within town.

Westford falls within the Merrimack River and Sudbury-Assabet-Concord (SuAsCo) River watersheds. Sub-basins of these two major watersheds are the Stony Brook watershed and the Nashoba Brook watershed, respectively, which cover over 75% of Westford. The Stony Brook watershed covers the northern 16.4 square miles of Westford and can be divided into five sub-basins:

- Main Stem Stony Brook;
- Nabnasset Pond;
- Snake Meadow Brook/Keyes Brook;
- Boutwell Brook; and
- Tadmuck Brook.

The Nashoba Brook watershed covers the south-western 7.5 square miles of Westford and can be divided into four sub-basins:

- Main Stem Nashoba Brook;
- Vine Brook;
- Nonset Brook; and
- Butter Brook.

A variety of groups, including the Town of Westford, the Organization for the Assabet River (OAR), the Westford Watershed Conservation Organization, the Massachusetts Department of Environmental Protection (MassDEP), the Merrimack River Watershed Council, the SuAsCo River Watershed Community Council, the EOEEA, the Westford Conservation Trust, the Westford Environmental News and Action Committee, and the Westford Land Preservation Fund, actively work to protect the Stony Brook and Nashoba Brook watersheds through activities such as public education, water quality sampling and environmental monitoring, open space planning and land preservation/acquisition, water supply assessments, identification of contamination problems, and collaboration plans. These activities and plans will continue to aid in the protection of the watersheds.

The two major components of this WAP are the Watershed Analysis and the Watershed Action Plan, presented in Sections 3 and 5. Section 4 includes Sub-basin Profiles, which summarize information from the Watershed Analysis in tabular form and include an image of each sub-basin.

The Watershed Analysis includes summaries of available information and data, along with Figures A-1 through A-5 in Appendix A, for the Stony Brook and Nashoba Brook watersheds, including:

- Protected and Unprotected Open Space;
- Impervious Cover;
- Critical, Sensitive, or Unique Resources;
- Lands Critical to Sustaining Surface and Groundwater Quality and Quantity;
- Summary of Water Quality and Quantity Data;
- Existing and Potential Sources of Pollution.

This analysis shows that approximately 28% of the Stony Brook watershed is open space, but only 16% of the watershed is protected open space. The Nashoba Brook watershed has a greater percent of open space (42%) than Stony Brook, and a greater percent of protected open space (27%). Protected open space is important in the effort to preserve water quality and quantity and protect environmental and public health. Westford realizes the value of preserving open space for recreation, water supply, wildlife and fisheries habitat, hydrologic and aesthetic/scenic purposes, and the threat of losing existing, unprotected open space land to development. The Town, along with a number of organizations, continues to and plans to acquire additional lands.

While both the Stony Brook and Nashoba Brook watersheds overall have a small percent of impervious cover, 7.8% and 8.4%, respectively, three sub-basins within these watersheds have greater than 10% impervious cover. The Tadmuck Brook, Boutwell Brook, and Vine Brook sub-basins have approximately 10.2% to 10.8% impervious cover, and are considered impacted basins by the Center for Watershed Protection Impervious Cover Model (ICM). As a basin becomes increasingly impervious, thermal pollution occurs, stream erosion is worsened, bank vegetation is limited, and habitat to support aquatic life is substantially diminished.

Sensitive natural resources within the Stony Brook and Nashoba Brook watersheds include lands important to protecting wildlife and plant species as well as areas significant to protecting surface and groundwater quality and quantity. Stony Brook has 51 certified vernal pools and approximately 145 potential vernal pools, while Nashoba Brook has 19 certified vernal pools and approximately 75 potential vernal pools. Vernal pools are temporary bodies of fresh water that provide a critical habitat for many small wildlife species, and protection of these sensitive ecosystems is very important. Both Stony Brook and Nashoba Brook have NHESP estimated habitats of rare wildlife and priority habitats of rare species, which is the known geographical area of habitat for all rare species, both plants and animals, listed under the Massachusetts Endangered Species Act (ESA). Alteration to land within Priority Habitats may result in harm to these species. No Areas of Critical Environmental Concern are located in Westford. Reed Brook, located within the Stony Brook Main Stem Sub-basin, is pending cold water fishery designation by the Massachusetts Division of Fisheries & Wildlife (MassWildlife) Natural Heritage and Endangered Species Program.

Westford's primary drinking water aquifer underlies the Stony Brook watershed. There are 14 public water supply wells in this watershed. There are six public water supply wells scattered through the southern portion of the Nashoba Brook watershed. Protection of lands associated with these drinking water aquifers is critical to sustaining surface and groundwater quality and quantity.

Two river segments on Stony Brook are considered impaired waters. Corrective actions outlined in the Draft Pathogen TMDL for the Merrimack River will assist in improving water quality.

The Nashoba Brook watershed is classified by the Massachusetts Department of Conservation and Recreation (DCR) as a "high stressed basin", which means that current streamflow is typically lower than USGS's estimated median August streamflow. Likewise, the net water budget for both the Stony Brook watershed and the Nashoba Brook watershed is negative, with the exception of the Nabnasset Pond sub-basin in the Stony Brook watershed. A negative water balance occurs when human activities cause streamflow to be lower than it would naturally. A positive water balance occurs when human activities cause streamflow to be greater than it would naturally.

There are a number of potential sources of pollution located within the Stony Brook and Nashoba Brook watersheds. One NPDES authorized point source discharge is located in the Nabnasset Pond sub-basin in the Stony Brook watershed. There is one groundwater discharge within Stony Brook's watershed and four groundwater discharges in the Nashoba Brook watershed. Stony Brook has five hazardous waste sites and eight underground storage tanks, while Nashoba Brook has three hazardous waste sites and one underground storage tank. Westford's capped landfill is located in the Stony Brook Main stem sub-basin. The greatest threat to both sub-basins is stormwater runoff containing oils and grease from developed areas, and fertilizers and pesticides from residential neighborhoods, golf courses, cropland and agricultural land, and large recreational areas.

Information gathered and assessed as part of the Watershed Analysis was used to develop the Watershed Action Plan in Section 5. This plan is divided into five separate elements, each of which take into account specific conditions of each sub-basin as well as general watershed protection measures, and are consistent with recommendations made in various planning studies described in Section 2 and in Section 5. Each element is divided into tasks with a recommended timeline for implementation. The five elements are:

- Open Space Protection Plan – This plan identifies activities to prioritize and permanently protect open space that will benefit water resources in the Stony Brook and Nashoba Brook watersheds.
- Municipal Operations Program – This plan identifies actions to minimize the pollutants entering the municipal separate storm sewer system (MS4), surface waters, and groundwater. The plan includes municipal best management practices, preparation for emergency spills, and awareness of hazardous waste site management and cleanup.
- Regulatory Improvement Plan – This plan aims to address known sources of pollution and potential water quality and habitat losses due to land development based on current zoning and identifies improvements to zoning and non-zoning controls.
- Education and Outreach Program – This plan outlines a multi-media public education and participation program that will promote watershed stewardship throughout Westford with assistance from regional watershed groups.
- Long-term Water Quality Monitoring Program – This plan recommends ongoing efforts to document trends in water quality and stream flow to monitor effectiveness of watershed management efforts.

Together, these five elements will help the Town of Westford maintain natural watershed function, protect sensitive and unique terrestrial and aquatic habitat, proactively manage known sources of pollution, protect the drinking water aquifer, and attain water quality standards in Westford's surface waters. The actions set forth in these plans will enable the Town to protect public health and the environment, while allowing for continued growth that will not compromise the community's character. It is important to recognize that many of the recommended actions in this Plan are already being implemented by various committees, departments, and local organizations. Smart Growth Advisory Committee is hopeful that this Watershed Action Plan will facilitate improved communication and coordination among the various groups to realize watershed goals.

The best results are often achieved when an adaptive management approach is taken, and therefore in five years, the Town should re-evaluate the Watershed Action Plan and make adjustments. The Town should re-assess the goals of the plan and evaluate progress carrying out the Plan based on monitoring results, land protection, and other actions accomplished.

## 1. INTRODUCTION

The Town of Westford (the Town), with assistance from their environmental consultants, Woodard & Curran (W&C), has prepared this Watershed Action Plan (WAP) for the Stony Brook and Nashoba Brook watersheds within Westford to better protect the Town's valuable water resources and other critical environmental assets. The WAP was prepared using the 5-Year Watershed Action Plan Guidance developed by the Executive Office of Energy and Environmental Affairs (EOEEA).

### 1.1 WATERSHED VISION

The goals of this report are to:

- 1) Develop an understanding of the resources within Westford;
- 2) Compile and evaluate existing data related to the watersheds in Westford;
- 3) Identify and protect sensitive resources;
- 4) Identify areas and topics where additional data collection and research is necessary;
- 5) Address new stormwater guidelines and regulations;
- 6) Address water quality requirements such as TMDLs;
- 7) Think on a watershed scale and promote watershed stewardship;
- 8) Consider inter-municipal cooperative efforts to protect our watersheds; and
- 9) Guide future planning and prioritization efforts.

The Watershed Action Plan is intended to be consistent with State planning initiatives, such as the Massachusetts Sustainable Development Principles, Stormwater Management Policy, and the Massachusetts Smart Growth Toolkit, as well as local planning initiatives, such as the Town of Westford's Open Space and Recreation Plan, the Land Use Priorities Committee Report, and the Master Plan.

This WAP includes a Watershed Analysis in Section 3, which characterizes the Stony Brook and Nashoba Brook watersheds in Westford in terms of:

- Amount of protected and unprotected open space
- Amount of developed land and impervious surfaces
- Environmentally critical, sensitive, or unique resources and significant habitats
- Lands critical to sustaining surface and groundwater quality and quantity
- Existing water quality and quantity
- Potential sources of pollution

This information can be used to obtain a general understanding of the watersheds in Westford, and will be used in the WAP to identify critical areas in the sub-basins and to set priorities for future activities. For example, by guiding development away from sensitive areas, Westford can focus on the long-term health and welfare of the environment and of the residents of the Town.

The results of the Watershed Analysis are summarized in a series of Sub-Basin Profiles in Section 4. These are stand-alone fact sheets offering a snap-shot of current watershed health. Given the potential characteristics and risks in each sub-basin, an overall Watershed Action Plan is presented in Section 5 to address the most immediate challenges.

## 1.2 SOCIAL AND ECONOMIC SETTING

The Town of Westford, located in the northeastern area of Middlesex County on 31.3 square miles, is a community with approximately 21,000 residents and 6,941 housing units<sup>1</sup>. Since 1960, the Town population has grown steadily, increasing by approximately 3,500 people every 10 years (or has undergone a 48.21% population increase in the past 20 years).<sup>2</sup> According to the 2000 Northern Middlesex Council of Governments (NMCOG) Build-Out Analysis, Westford has 6,727 acres of additional developable land, which could support an additional 4,637 housing units.

Westford is bordered by Chelmsford to the east, Tyngsboro to the north, Groton to the west, Littleton to the southwest, Acton to the south, and Carlisle to the southeast. Westford is a town with rolling hills, lakes, and apple orchards. Originally Westford was noted for its farms and woolen mills, but today is mostly a bedroom community for commuters.

Westford is home to a number of cultural and recreational resources including the Roudenbush Community Center, the Parish Center for the Arts, the J.V. Fletcher Library, The Butterfly Place, the Westford Museum and Historical Society, the MIT Haystack Observatory and Nashoba Valley Ski Resort. The forests and fields provide a number of trails which are used for hiking, jogging, bird watching, horseback riding, and cross country skiing. Interstate 495 and State Routes 3, 27, 40, and 225 traverse the town.<sup>3</sup>

## 1.3 WATERSHED OVERVIEW

Over 75% of Westford falls within two large watersheds of the Merrimack River and Sudbury-Assabet-Concord (SuAsCo) River; these are the Stony Brook and Nashoba Brook sub-watersheds, respectively.

The Stony Brook watershed is a 45 square mile area located in the south-eastern corner of the Merrimack River watershed. It covers eight towns, including Boxborough, Harvard, Littleton, Ayer, Groton, Westford, Tyngsborough, and Chelmsford. The brook begins in Boxborough and flows 22 miles to its confluence with the Merrimack River. The stream is named Beaver Brook from its headwaters in Boxborough to Forge Pond, and upon exiting the pond in Westford it is named Stony Brook. These bodies are Class B<sup>4</sup> waters and must meet standards for primary (swimming) and secondary (fishing and boating) contact recreation as established under the Clean Water Act (CWA).<sup>5</sup> The Stony Brook watershed covers approximately 16.4 square miles of Westford, including five sub-basins: Main Stem Stony Brook, Nabnasset Pond, Snake Meadow Brook/Keyes Brook, Boutwell Brook, and Tadmuck Brook. These sub-basin boundaries are shown on the maps in Appendix A.

---

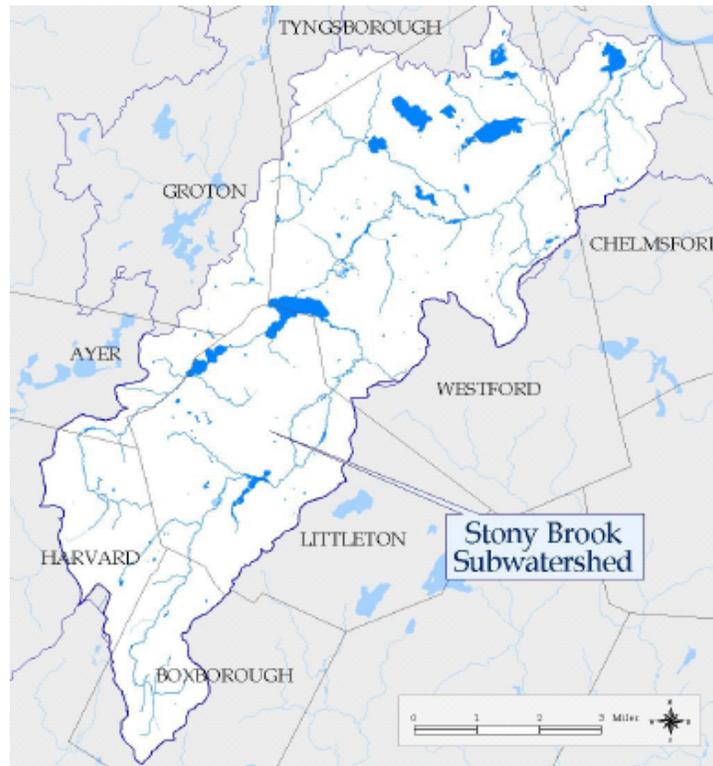
<sup>1</sup> 2000 U.S. Census, U.S. Census Bureau. Accessed on June 4, 2007, online at <http://www.census.gov/>

<sup>2</sup> Stony Brook Watershed Assessment, Merrimack River Watershed Council, July 2001.

<sup>3</sup> Westford Community Profile. Accessed on June 4, 2007, online at <http://www.mass.gov/dhcd/iprofile/330.pdf>

<sup>4</sup> Massachusetts Designated Use – These waters are designated as a habitat for fish, other aquatic life, and wildlife, and for primary and secondary contact recreation, according to 314 CMR 4.05 (b).

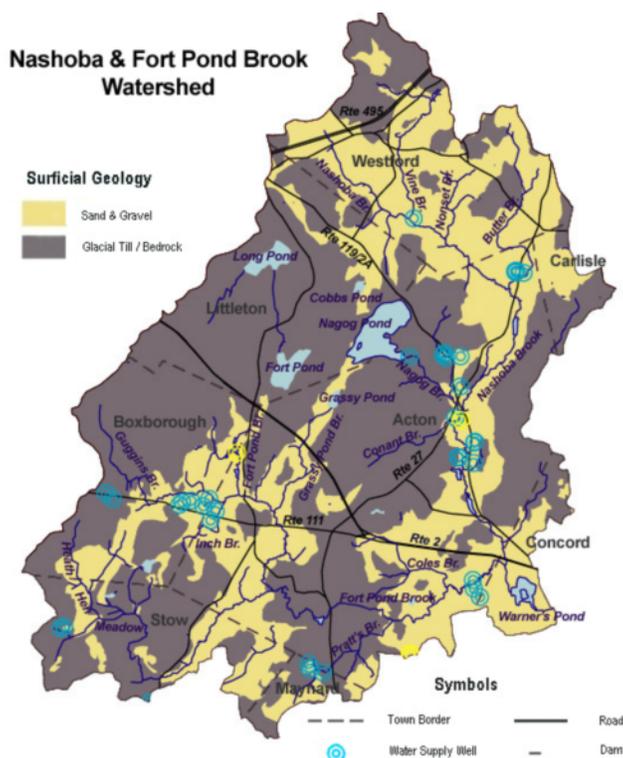
<sup>5</sup> Merrimack River Watershed 5-Year Action Plan 2002-2007, EOE, June 2002.



**Figure 1: Stony Brook Watershed**

Source: Merrimack River 5-Year Watershed Action Plan, 2002-2007

The Nashoba Brook watershed is located in the towns of Westford, Acton, Littleton, Carlisle and Concord. The brook begins in Westford and flows to its confluence with the Assabet River, which then joins the Sudbury River to become the Concord River. Nashoba Brook is a Class B water and therefore must meet primary and secondary contact recreation standards according to the CWA. The Nashoba Brook watershed covers approximately 7.5 square miles of Westford, including four sub-basins: Main Stem Nashoba Brook, Vine Brook, Nonset Brook, and Butter Brook. These sub-basin boundaries are shown on the maps in Appendix A.



**Figure 2: Nashoba & Fort Pond Brook Watershed**

Source: Maps of the Nashoba. Assabet River StreamWatch. Organization of the Assabet River.  
[http://www.assabetriver.org/streamwatch/nashoba\\_a.html](http://www.assabetriver.org/streamwatch/nashoba_a.html)

## 1.4 SUMMARY OF PLANNING PROCESS

The preparation of this report was funded through a grant from the EOEAA under the Fiscal Year 2007 Smart Growth Technical Assistance grant program. A project advisory committee, named the Smart Growth Advisory Committee (SGAC), was created to provide input during the development of the Watershed Analysis and the WAP. The SGAC includes the following seven members:

- Beverly Woods, Resident and NMCOG
- Carol Tucker, Resident and EPA Region 1 Employee
- Darren MacCaughey, Director of Environmental Services, Board of Health
- Jessica Cajigas, Westford Water Department
- John Livsey, Town Engineer, Ex-Officio
- Paul Starratt, Assistant Town Engineer
- Peter Severance, Resident and member of Master Plan Committee

The committee met four times throughout the project (April – December 2007) to provide input and review all work products. This meeting process complied with open meeting laws, and therefore notices were appropriately posted in public locations and on the Town website. Copies of the final WAP document will be located at the Town Clerk's Office.

## 2. HISTORY OF WATERSHED PROTECTION

A number of groups actively work to protect the Stony Brook and Nashoba Brook watersheds in Westford. This section provides a summary of groups working in Westford and recent documents produced and activities conducted as they pertain to the WAP. A detailed list of the works cited in this report is contained under References.

- Executive Office of Energy and Environmental Affairs (EOEEA) – This Agency, previously named the Executive Office of Environmental Affairs (EOEA), developed the Merrimack River 5-Year Watershed Action Plan, which guides actions within the watershed aimed at improving water quality and quantity, protecting and restoring biodiversity and habitats, improving resource use, and promoting shared watershed protection and management. EOEA also produced the SuAsCo Watershed 2001 Water Quality Assessment Report and the Merrimack River Basin 1999 Water Quality Assessment Report, in which water quality conditions were assessed and designated uses were determined. A community water budget for Westford was prepared by the Charles River Watershed Association and ESS Group, Inc., for EOEA, which quantifies the human impacts on sub-basin streamflow, so that critical areas can be identified and prioritized for further attention.
- Massachusetts Department of Environmental Protection (MassDEP) – The MassDEP Source Water Assessment Program developed a Source Water Assessment and Protection Report for the Westford Water Department, which inventories land uses within public water supply recharge areas and assesses susceptibility of the water supply to contamination from these land uses.
- Merrimack River Watershed Council (MRWC) – This regional group has been tasked with protection and promotion of the Merrimack River Watershed through environmental monitoring, watershed education, and recreation activities. The Council developed the Stony Brook Watershed Assessment, which compiles, reviews, and evaluates land use and cover, water quality and quantity, wastewater and stormwater management, natural heritage and endangered species, potential contamination sources, local bylaws and regulations, and population trends within the watershed communities.
- Organization for the Assabet River (OAR) – Since 1992, this organization has conducted water quality sampling in the Assabet River watershed. OAR supports water quality monitoring efforts in Westford by providing technical guidance and safety standards in a StreamWatch Water Quality Monitoring Manual.
- Sudbury-Assabet-Concord (SuAsCo) River Watershed Community Council – This regional group prepared the SuAsCo River Watershed Action Plan for EOEA in 2005, in order to identify critical natural resource problems in the watershed, propose solutions, and plan collaboration efforts to achieve these solutions.
- Town of Westford – The Town has conducted efforts under the NPDES Phase II Stormwater program, including outfall sampling and public education, which have led to a decrease in pollutants entering water bodies and an increased awareness of this problem, and appropriate solutions, on behalf of the general public. Westford has local bylaws intended to protect resources such as their own local wetland bylaw and the Water Resources Protection Overlay District. The Conservation Commission's Open Space Committee developed an Open Space and Recreation Plan in 2002, which reviews natural and cultural resources and open space and outlines future protection goals. This plan and the town's Master Plan are currently being updated. Additionally, the Land Use Priorities Committee in their 2002 Final Report identified lands in Westford that, if acquired, would preserve and protect open space for conservation and recreation and protect natural resources, especially water resources. The Town has also established a pesticide use policy with the long-term goal of protecting public health and maintaining a balanced and healthy ecosystem.

- Westford Conservation Trust – This private, non-profit organization has acquired open space and trails through direct ownership and permanent conservation restrictions in order to preserve open land, water resources, wildlife, trails, and historic land. The Trust owns 17 parcels, independently holds 10 conservation restrictions and 8 trail easements, and, with the Town of Westford, jointly holds 17 conservation restrictions. The Trust is a sponsor of the local water quality sampling conducted by the Westford Watershed Conservation Association.
- Westford Environmental News and Action Committee (WENAC) – Advocates environmental awareness in Westford. Provides local-access television coverage of the Conservation Commission, Planning Board, and Zoning Board of Appeals meetings, as well as other local events.
- Westford Land Preservation Foundation – This non-profit organization works to preserve land in Westford by working with landowners to achieve their goals of both preservation and financial return. In 2004, the Foundation assisted the Town with the purchase of the 286 acre East Boston Campus, along Stony Brook. The Foundation also partnered with a local builder to pay a landowner \$1.2 million to leave 12 of 18 acres as open space in the process of developing a large parcel.
- Westford Watershed Conservation Association – This local environmental group partnered with OAR and conducted water-quality sampling in the summers of 2005, 2006, and 2007 at nine locations in Westford.

### 3. WATERSHED ANALYSIS

Through a literature review and several public meetings with municipal officials, environmental groups, and residents, Woodard & Curran compiled available information for the Stony Brook and Nashoba Brook watersheds. This section provides a summary of this information including an update of protected and unprotected open space, an inventory of sensitive resources and lands critical to protecting surface and groundwater quality and quantity, a summary of water quality and quantity data, and a description of existing and potential sources of pollution. The information included in this section is summarized in nine sub-basin profiles, presented in Section 4, and was considered in development of the 5-Year Watershed Action Plan in Section 5.

#### 3.1 OPEN SPACE UPDATE

In 2002, the Town of Westford developed an Open Space and Recreation Plan, which inventoried the open space throughout the Town, identified the value of this open space, and indicated particular areas of land that could help focus future preservation efforts. Preservation of open space is critical to protect water resources such as Stony Brook and Nashoba Brook and drinking water sources such as the aquifers under Westford.

This section provides a summary of the privately and publicly owned protected and unprotected open space inventoried in the 2002 Plan and additional lands protected since the 2002 Plan. The most up-to-date inventory of protected and unprotected open space within Westford is shown in Figure A-1 in Appendix A and quantified in the Sub-Basin Profiles in Section 4.

##### 3.1.1 Summary of Protected Lands in the 2002 Open Space and Recreation Plan

According to the 2002 Open Space and Recreation Plan, the status of open space in Westford can be designated as privately-held protected land, publicly-owned protected land, or unprotected open space. These three categories of open space are further described below, and town-wide estimates of open space are provided.

- Privately-Held Protected Open Space – Approximately 1,747 acres were considered privately-held protected open space in 2002. There are 49 Conservation Restrictions, totaling 1,188 acres, held by the Town, the Westford Conservation Trust (WCT), New England Forestry Foundation, and the Massachusetts Audubon Society. Of those restrictions, 14 are jointly held by the Town and the WCT. There are 64 acres held by miscellaneous parties. As voted by Town Meeting, 234 acres are considered Conservation Zones. The Westford Conservation Trust owns 117 acres and the Massachusetts Audubon Society owns 144 acres.
- Publicly-Owned Protected Open Space – Approximately 1,497 acres were considered publicly-owned protected open space. The Westford Conservation Commission owned 1,189 acres, the Westford Water Department owned 304 acres, and the Commonwealth of Massachusetts Department of Environmental Management and Division of Fisheries and Wildlife together owned a total of 4 acres.
- Unprotected Open Space – According to the 2000 NMCOG Build-out Analysis, 6,727 acres of developable land were available in Westford, which could support an additional 4,637 housing units. Town-owned unprotected land administered by the Selectmen totaled 698 acres. The Westford Recreation Department owned 49 acres. The Town Forrest Committee owned 84 acres. Chapter 61 lands totaled 1,864 acres; 955 acres were agricultural lands under Chapter 61A, 508 acres were private recreation lands under 61B and thirteen (13) properties (401 acres) were considered private forestland. There were 1,396 acres of unprotected parcels greater than two acres. Together, East Boston Camps, Middlesex County 4-H Fairgrounds, Stony Brook Fish and Game Club, Westford Sportsman's Club, and the M.I.T. Haystack Observatory Site constitute 1,150 acres of open space. The Nashoba Valley Vocational Technical High School is located on 45 acres of land.

### 3.1.2 Additions to Open Space Since 2002

Over the past five years, the Town has continued its open space protection and preservation efforts. The most notable recent acquisition is the 286 acre East Boston Campus, located between Stony Brook and Keyes Brook and surrounding Burge's Pond. The property includes significant wildlife habitat and an extensive trail system. A conservation restriction has been placed on the land.

Information regarding recently acquired and protected open space has been compiled by the Conservation Commission in preparation for the Open Space and Recreation Plan and Master Plan updates that are now underway. This updated information is shown in the Open Space Plan in Figure A-1 in Appendix A.

Using this preliminary information, the amount of protected and unprotected open space was estimated for each watershed. This information is summarized in Table 1 below and in the Sub-basin Comparison in Appendix B.

**Table 1: Protected and Unprotected Open Space by Sub-basin**

	Sub-basin Area (acres)	Protected Open Space (acres)	Unprotected Open Space (acres)	Total Open Space (acres)
<b>Stony Brook Watershed</b>				
Stony Brook (Main Stem)	3,213	455	674	1,129
Boutwell Brook	760	126	120	246
Snake Meadow Brook/Keyes Brook	3,032	521	175	696
Tadmuck Brook	1,284	254	122	376
Nabnasset Pond	2,188	361	175	536
<b>Total</b>	<b>10,477</b>	<b>1,716</b>	<b>1,266</b>	<b>2,982</b>
<b>Nashoba Brook Watershed</b>				
Nashoba Brook (Main Stem)	1,731	402	397	799
Vine Brook	1,312	368	162	530
Nonset Brook	856	327	145	472
Butter Brook	866	188	34	222
<b>Total</b>	<b>4,765</b>	<b>1,286</b>	<b>738</b>	<b>2,024</b>

As shown in Table 2, there is a higher percentage of protected open space in the Nashoba Brook watershed than in the Stony Brook watershed. Approximately 27% of the lands surrounding Nashoba Brook are permanently protected, while 16% of the Stony Brook watershed is permanently protected. Of the Stony Brook sub-basins, the Main Stem is least protected, with 14% permanent open space. This information is used to develop the action plan for future open space protection in Section 5. Note that this Open Space evaluation does not include a complete build-out analysis and does not account for "underdeveloped" lands in each sub-basin. Therefore, the full potential for future development within the Stony Brook and Nashoba Brook watersheds can not be quantified at this time.

**Table 2: Percent Protected Land by Sub-basin**

Sub-basin	% Protected Land
<b>Stony Brook Watershed</b>	
Stony Brook (Main Stem)	14%
Boutwell Brook	17%
Snake Meadow Brook/Keyes Brook	17%
Tadmuck Brook	20%
Nabnasset Pond	16%
<b>Total</b>	<b>16%</b>
<b>Nashoba Brook Watershed</b>	
Nashoba Brook (Main Stem)	23%
Vine Brook	28%
Nonset Brook	38%
Butter Brook	22%
<b>Total</b>	<b>27%</b>

### 3.2 IMPERVIOUS COVER

Research has shown that imperviousness is a “powerful and important indicator of future stream quality and that significant degradation occurs at relatively low levels of development.”<sup>6</sup> The general relationship between impervious cover in a watershed and future stream quality is shown in the Center for Watershed Protection’s Impervious Cover Model (ICM) on Figure A-2 in Appendix A. An increase in impervious surface within a basin can increase stormwater runoff volumes and runoff rates, increase flooding frequency and the size of the floodplain, and diminish baseflow.<sup>7</sup> The ICM predictions are general and may not fully apply to every stream, but the ICM serves as a good rule of thumb. Factors such as stream gradient, stream order, stream type, age of watershed development, prior land use, past management practices can and will make some streams depart from these predictions.<sup>8</sup>

W&C assessed impervious cover in the sub-basins within Stony Brook and Nashoba Brook, as shown on Figure A-2. Table 3 shows the percent impervious surface and associated ICM basin status in each sub-basin. The total impervious cover percentages in the Stony Brook and Nashoba Brook watersheds are 7.8% and 8.4%, respectively. Most of the sub-basins have around 10% impervious cover. Watersheds with about 10% impervious cover are relatively healthy, but sometimes signs of stream erosion and loss of good habitat are apparent.

Boutwell Brook, Tadmuck Brook, and Vine Brook sub-basins are considered impacted basins, which means they have 10% to 25% impervious cover and generally have fair stream quality. Impacted basins are identified by yellow shading in Figure A-2 in Appendix A. While these sub-basins are on the lower end of the “impacted” basin imperviousness range, they are the most densely developed areas within Town. As a basin becomes increasingly impervious, stream erosion is worsened, bank vegetation is limited, and habitat to support aquatic life is substantially diminished.

<sup>6</sup> Schueler, T. 2000. *The Importance of Imperviousness*. The Practice of Watershed Protection. Center for Watershed Protection. Ellicott City, MD. 7-18.

<sup>7</sup> Baseflow is the portion of streamflow that comes from groundwater and not runoff.

<sup>8</sup> The Impervious Cover Model and impervious cover and stream health information are from an EPA Webcast titled “The Eight Tools of Watershed Protection” by Tom Schueler of the Center for Watershed Protection.

Snake Meadow Brook/Keyes Brook and the Nonset Brook sub-basins are approximately 4% to 4.7% impervious, respectively. In basins with less than 5% impervious cover, streams are typically healthy and pristine, provide a variety of habitats, maintain a diverse aquatic ecosystem, and have good tree coverage. The remaining six sub-basins have less than 10% impervious cover and are considered sensitive basins and generally have fair to good stream quality. Sensitive basins are identified by green shading in Figure A-2 in Appendix A.

**Table 3: Impervious Cover by Sub-basin**

Sub-basin	% Impervious Surface	ICM Basin Status
<b>Stony Brook Watershed</b>		
Stony Brook (Main Stem)	8.12%	Sensitive
Boutwell Brook	10.16%	Impacted
Snake Meadow/Keyes Brook	4.01%	Sensitive
Tadmuck Brook	10.74%	Impacted
Nabnasset Pond	9.81%	Sensitive
<b>Nashoba Brook Watershed</b>		
Nashoba Brook (Main Stem)	9.65%	Sensitive
Vine Brook	10.48%	Impacted
Nonset Brook	4.66%	Sensitive
Butter Brook	6.35%	Sensitive

For planning purposes, W&C has set a target maximum impervious cover of 10-15% for each sub-basin. In terms of habitat quality and stream biodiversity, there is a sharp decline beyond 15% imperviousness.<sup>9</sup> To maintain this threshold, a combination of open space reduction and better site design for development projects will need to be employed, as discussed in Section 5. Additionally, through the use of low impact development (LID) techniques that infiltrate and filter runoff from impervious areas, the amount of effective impervious cover can be reduced.

### 3.3 INVENTORY OF SENSITIVE RESOURCES

Woodard & Curran performed an inventory of sensitive natural resources within the Stony Brook and Nashoba Brook watersheds within Westford. These lands include those important to protecting wildlife and plant species as well as areas significant to protecting surface and groundwater quality and quantity.

#### 3.3.1 Critical, Sensitive, or Unique Resources

The following critical, sensitive, or unique resource areas in terms of plant and animal habitat were considered in this analysis. These areas are shown in Figure A-3 and are included in the sub-basin profiles in Section 4:

- NHESP Certified and Potential Vernal Pools – The Natural Heritage & Endangered Species Program (NHESP) certifies the occurrence of vernal pools based on documentation, voluntarily submitted, of the pool's use by one or more groups of species that depend on vernal pools. Vernal pools are temporary bodies of fresh water that provide a critical habitat for many small wildlife species.<sup>10</sup>

<sup>9</sup> Schueler, 2000.

<sup>10</sup> Division of Fisheries & Wildlife Guidelines for the Certification of Vernal Pool Habitat, 2001. Accessed on May 22, 2007, online at <http://www.mass.gov/dfwele/dfw/nhesp/vpcert.pdf>

- Areas of Critical Environmental Concern – ACECs are areas in Massachusetts that obtain special identification because of the quality, uniqueness, and significance of their natural and cultural resources. These areas are identified and nominated at the community level and are reviewed and designated by the state’s Secretary of Environmental Affairs.<sup>11</sup>
- NHESP Priority Habitats of Rare Species – This is the known geographical area of habitat for all rare species, both plants and animals, listed under the Massachusetts Endangered Species Act (ESA). Alteration to land within Priority Habitats may result in harm to these species, and is subject to regulatory review by the NHESP.<sup>12</sup>
- NHESP Estimated Habitats of Rare Wildlife – These areas are a sub-set of the Priority Habitats and show the geographical area of habitat for state-listed rare wildlife, not including plants, under the Wetlands Protection Act.<sup>13</sup>
- Wetlands, Marsh, Swamps, and Bogs – According to the Environmental Protection Agency (EPA), wetlands are “areas that are saturated by surface or ground water at a frequency and duration sufficient to support, and normally do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.” Wetlands provide critical habitat to many plants and animals, area for migrating birds to rest, and also may provide flood storage, mitigate pollutant loading to water bodies, and have recreational value.
- Cold Water Fishery – According to Massachusetts Division of Fisheries and Wildlife (MassWildlife), coldwater fisheries are defined as a water that meets at least one of the following criteria:
  - 1) Brook, brown or rainbow trout has been determined;
  - 2) Slimy sculpin or longnose sucker are present;
  - 3) The water is part of the Atlantic salmon restoration effort or is stocked with Atlantic salmon fry or parr.The pollutant of concern in cold water fisheries is temperature. Ecosystems in these water bodies typically rely on temperatures of 50 to 65 degrees Fahrenheit, and warmer temperatures that can occur due to heated stormwater runoff can substantially impact the fish and plants, as well as water quality.

Figure A-3, Critical, Sensitive, and Unique Resources, is included in Appendix A. NHESP Priority Habitats of Rare Species PH 19, PH 31, and PH 945 and Estimated Habitats of Rare Wildlife EH 311, EH 654, and EH 818 fall within the Stony Brook watershed. NHESP Priority Habitats of Rare Species PH 19 and PH 29, and Estimated Habitats of Rare Wildlife EH 654 and EH 771 fall within the Nashoba Brook watershed. According to MassWildlife, there are a number of endangered species within Westford. These include birds such as the American Bittern and the Least Bittern and plants such as the Toothcup, Wild Senna, and Purple Milkweed. There are also amphibians such as the Blue-spotted Salamander and the Four-toed Salamander, which are species of special concern.<sup>14</sup> There are many beavers and muskrats, as well as Marsh Wrens and Virginia Rails living in the freshwater marshes in Westford. Reed Brook, a potential cold water fishery, is located in the Stony Brook Main Stem Sub-basin. This brook originates on Kissacook Hill, flows parallel to the Norman E. Day School and into Stony Brook. The MassWildlife Natural

<sup>11</sup> Mass.gov ACEC Program Home, Accessed on May 22, 2007, online at <http://www.mass.gov/dcr/stewardship/acec/index.htm>

<sup>12</sup> Natural Heritage & Endangered Species Program. Massachusetts Division of Fisheries & Wildlife. Accessed on May 22, 2007, online at <http://www.mass.gov/dfwele/dfw/nhESP/nhenvprioHab.htm>

<sup>13</sup> Natural Heritage & Endangered Species Program. Massachusetts Division of Fisheries & Wildlife. Accessed on May 22, 2007, online at <http://www.mass.gov/dfwele/dfw/nhESP/nhenvprioHab.htm>

<sup>14</sup> MassWildlife Rare Species by Town. Accessed on June 11, 2007 online at [http://www.mass.gov/dfwele/dfw/nhESP/species\\_info/town\\_lists/town\\_w.htm#westford](http://www.mass.gov/dfwele/dfw/nhESP/species_info/town_lists/town_w.htm#westford)

Heritage & Endangered Species Program plans to evaluate this brook in March 2008 for official cold water fishery certification.

### 3.3.2 Lands Critical to Sustaining Surface and Groundwater Quality and Quantity

The following lands critical to sustaining surface and groundwater quality and quantity were considered in this analysis. These areas are shown in Figure A-4 in Appendix A:

- Public water supply wells – Wells that provide water to the public.
- Zone I - The protective radius required around a public water supply well or well field. For public water system wells with approved yields of 100,000 gpd or greater, the protective radius is 400 feet.<sup>15</sup>
- Zone II (Aquifer Recharge Zone) – The area of an aquifer that contributes water to a well under the most severe pumping and recharge conditions that can be realistically anticipated (180 days of pumping at approved yield, with no recharge from precipitation). It is bounded by the groundwater divides that result from pumping the well and by the contact of the aquifer with less permeable materials such as till or bedrock. In some cases, streams or lakes may act as recharge boundaries. In all cases, Zone II shall extend upgradient to its point of intersection with prevailing hydrogeologic boundaries (a groundwater flow divide, a contact with till or bedrock, or a recharge boundary). The Zone II must include the entire Zone I area. For springs, the Zone II is that area of an aquifer, which contributes water to the spring under naturally flowing conditions.<sup>16</sup>
- Interim Well Protection Area (IWPA) – In the absence of an approved Zone II, MassDEP has adopted the Interim Wellhead Protection Area (IWPA) as the primary, protected recharge area for public water supply (PWS) groundwater sources. The minimum IWPA radius is 400 feet; the maximum (default) radius reached at 100,000 GPD is 2,640 feet (1/2 mile). In instances where MassDEP pumping rate information is unavailable MassDEP approved default radius values are assigned based on PWS well classification. The default radius for community class PWS groundwater sources (GW) is 2,640 feet. The default radius for non-community sources is 750 feet for Non Transient (NTNC) wells and 500 feet for Transient (TNC) wells.<sup>17</sup>
- Aquifer Locations – Aquifer areas are shown in Figure A-4 based on yield.<sup>18</sup>
  - High yield aquifers – pump greater than 300 gallons per minute<sup>19</sup>
  - Medium yield aquifers – pump 100 to 300 gallons per minute<sup>20</sup>
- Water Resource Protection Overlay District II (WRPODII) – According to the Town of Westford Zoning bylaw, this overlay district was developed to ensure adequate drinking water quality and quantity, preserve and protect drinking water supplies, conserve natural resources, and prevent contamination of the environment. This district is bounded by Zone II, IWPA's, and high and medium yield aquifers.<sup>21</sup>

<sup>15</sup> 310 CMR 22.00

<sup>16</sup> 310 CMR 22.00 – Definitions.

<sup>17</sup> MassGIS Wellhead Protection Areas Datalayers. Accessed on May 23, 2007, online at <http://www.mass.gov/mgis/ziis.htm>

<sup>18</sup> MassGIS Aquifer Datalayers. Accessed on May 23, 2007, online at <http://www.mass.gov/mgis/aq.htm>

<sup>19</sup> Pumping rate according to MassGIS aquifer datalayer.

<sup>20</sup> Pumping rate according to MassGIS aquifer datalayer.

<sup>21</sup> Town of Westford Zoning Bylaw, Amended May 6, 2006.

- **Stressed Basins** – A basin or sub-basin in which the quantity of streamflow has been significantly reduced, or the quality of the streamflow is degraded, or the key habitat factors necessary to sustain a biologically diverse habitat are impaired, as shown in Figure 6. It is important to note that Nashoba Brook is considered a highly stressed basin, which means that flow leaving the river is typically less than the median August flow estimated by the United States Geological Survey (USGS).<sup>22,23</sup>

The lands critical to sustaining surface and groundwater quality and quantity in the Nashoba Brook and Stony Brook watersheds are summarized in the sub-basin profiles in Section 4.

### 3.4 SUMMARY OF WATER QUALITY AND QUANTITY DATA

This section provides a summary of water quality and quantity data related to the Nashoba Brook and Stony Brook watersheds. This summary includes relevant information from the Massachusetts Integrated List of Waters, Total Maximum Daily Loads (TMDLs), Massachusetts Surface Water Quality Standards (SWQS), stressed basin status, water quality sampling efforts and results, macro-invertebrate sampling and biological assessments, and water quantity and stream flow.

#### 3.4.1 Massachusetts Integrated List of Waters

The objective of the Federal Clean Water Act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. As a step to reach this goal, MassDEP is tasked with monitoring and assessing the quality of waters of Massachusetts, evaluating if water bodies can support designated uses (aquatic life support, fish and shellfish consumption, drinking water supply, and primary (e.g., swimming) and secondary (e.g., boating) contact-recreation), identifying those that are impaired and developing a plan to bring the impaired waters back into compliance with the Massachusetts SWQS through a TMDL.<sup>24</sup> The Integrated List of Waters identifies specific segments of each water body in five categories:

- (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 the calculation of a Total Maximum Daily Load (TMDL); or
- (5) Impaired or threatened for one or more uses and requiring a TMDL.

Water bodies identified as Category 5 waters on the Integrated List are equivalent to the "303(d) list" of water quality impaired waters under the Clean Water Act. Portions of Stony Brook and Nashoba Brook, as well as ponds within these watersheds, are listed on the Final 2006 Integrated List. Their respective impairments are described below.

---

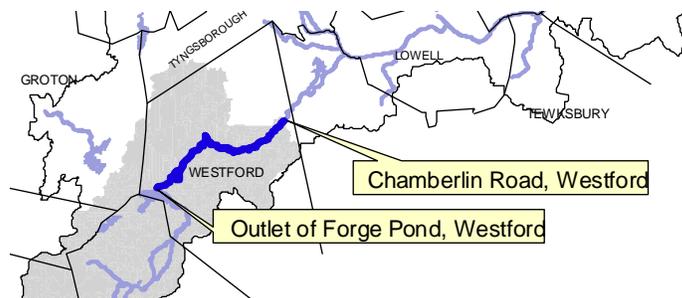
<sup>22</sup> Net outflow equals or exceeds estimated natural August median flow.

<sup>23</sup> The Commonwealth of Massachusetts, Water Resources Commission. Stressed Basins in Massachusetts, Approved December 13, 2001. Accessed on May 23, 2007, online at [http://www.mass.gov/dcr/waterSupply/intbasin/stressed\\_basins.htm](http://www.mass.gov/dcr/waterSupply/intbasin/stressed_basins.htm)

<sup>24</sup> Final Massachusetts 2006 Integrate List of Waters (CWA Sections 303d and 305b), MassDEP, approved by EPA on September 28, 2007.

## Stony Brook

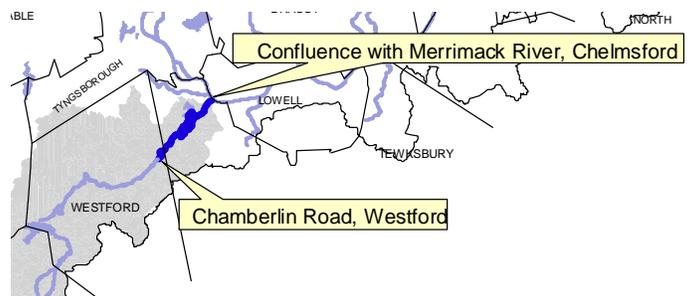
Based on the Final Massachusetts 2006 Integrated List of Waters, there are two sections of Stony Brook that are considered Category 5 waters<sup>25</sup> and require a TMDL. A 7.4 mile section (Segment Number: MA84B-03) from the outlet of Forge Pond to Brookside Road, Westford, is considered impaired due to pH, organic enrichment/low dissolved oxygen (DO), pathogens, and turbidity. This segment is shown in Figure 3.



**Figure 3: Stony Brook Segment MA84B-03**

Source: Merrimack River Basin Water Quality Assessment Report, 1999.

A 3.5 mile section (Segment Number: MA84B-04) from Brookside Road, Westford, to the confluence with the Merrimack River, is considered impaired due to nutrients, pH, organic enrichment/low DO, and pathogens. Only a small portion of this section is located in Westford. This segment is shown in Figure 4.



**Figure 4: Stony Brook Segment MA84B-04**

Source: Merrimack River Basin Water Quality Assessment Report, 1999.

Because Stony Brook has very few point source discharges, stormwater runoff is likely to be the major factor contributing to impairment.<sup>26</sup> The Draft Pathogen TMDL for the Merrimack River has identified leaking sewer pipes, illicit connections to the municipal separate storm sewer system (MS4), combined sewer overflows or sanitary sewer

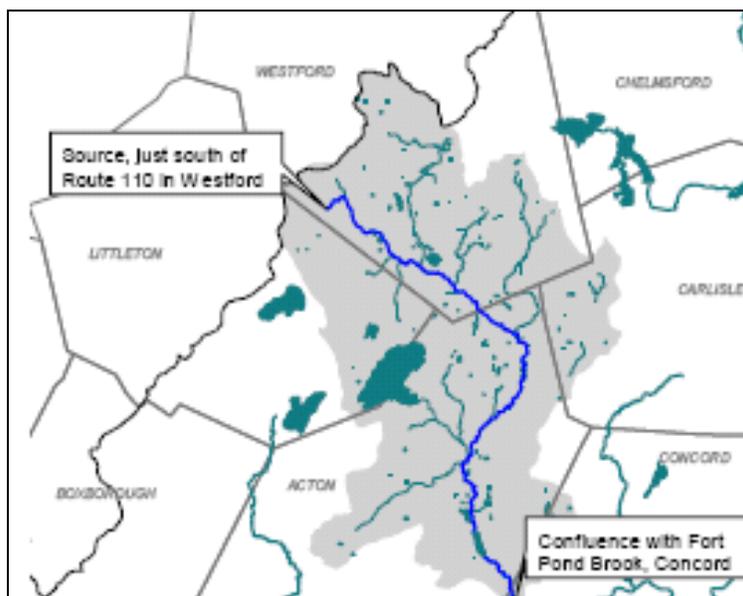
<sup>25</sup> Impaired or threatened for one or more uses (Aquatic Life, Fish Consumption, Drinking Water, Primary Contact Recreation, Secondary Contact Recreation, Shellfish Harvesting, and Aesthetics) and requiring a TMDL, according to MassDEP Division of Watershed Management.

<sup>26</sup> Stony Brook Watershed Assessment, Merrimack River Watershed Council, July 2001.

overflows, failing septic systems, recreational activities, or wildlife as other potential sources of disease-causing pathogens.<sup>27</sup>

### Nashoba Brook

Based on the Final Massachusetts 2004 Integrated List of Waters, there is one section of Nashoba Brook that is listed. A 10.1 mile stretch (Segment Number: MA82B-14), located just south of Route 110 in Westford to the confluence with Fort Pond Brook, Concord, is considered a Category 3 water<sup>28</sup> and no uses are assessed due to insufficient data. This segment is shown in Figure 5.



**Figure 5: Nashoba Brook Segment MA82B-14**

Source: SuAsCo Watershed Year 2001 Water Quality Assessment Report

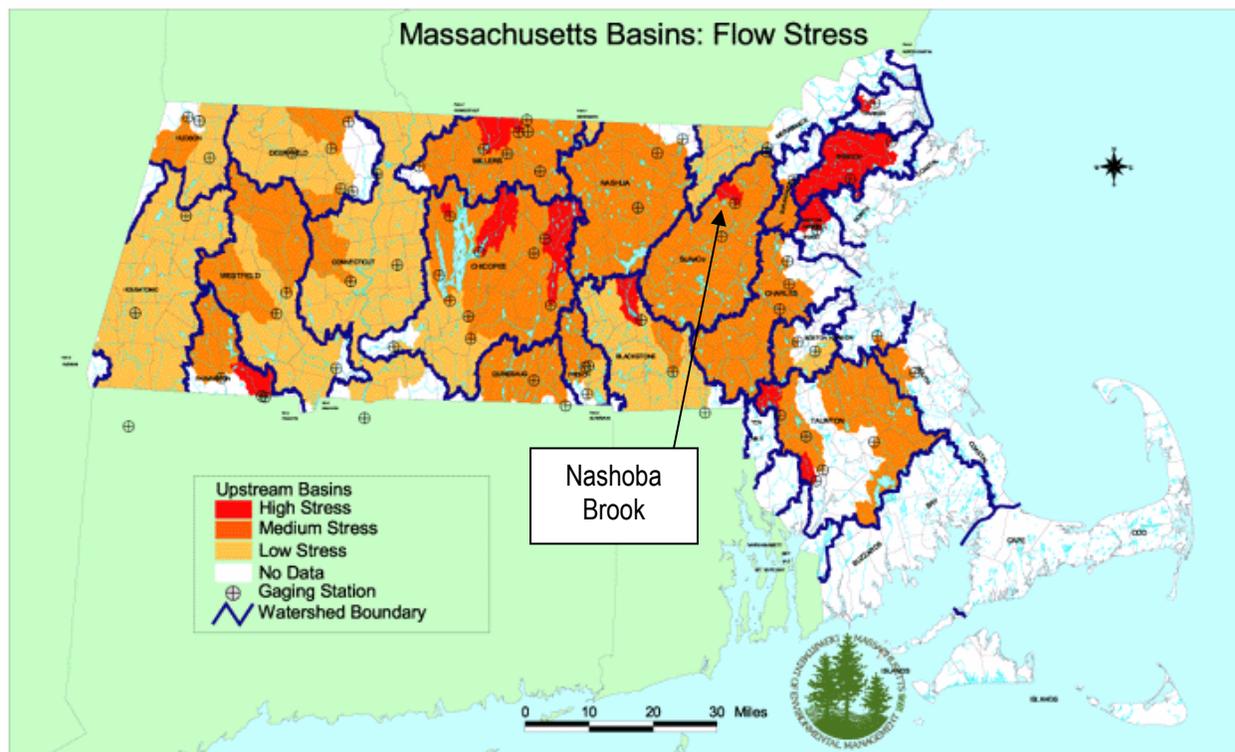
In the Final Massachusetts 2006 Integrated List of Waters, this section length is reduced to 9.4 miles, and is listed as a Category 4c water (impairment not caused by a pollutant). The impairment is due to flow alternation. Nashoba Brook is also suspected to have low DO and high total phosphorus. Septic systems and baseflow depletion from groundwater withdrawals are suspected causes of these impairments.<sup>29</sup> It should also be noted that the Nashoba Brook watershed is classified by the Massachusetts Department of Conservation and Recreation (DCR) as a “high stressed basin” (MWRC 2001). A map of flow stressed basins in Massachusetts is shown in Figure 6.

Nabnasset Pond, part of this sub-basin, is listed on the Final 2006 Integrated List as a Category 4b water, which means that it is expected to attain all designated uses through pollution control measures other than TMDLs. The pollutant of concern in this pond is metals.

<sup>27</sup> Draft Pathogen TMDL for the Merrimack River Watershed

<sup>28</sup> Insufficient information to make assessments for any uses, according to MassDEP Division of Watershed Management.

<sup>29</sup> SuAsCo Watershed Water Quality Assessment Report, 2001.



**Figure 6: Massachusetts Stressed Basins**  
 Source: Massachusetts Water Resources Commission (MWRC)

### 3.4.2 Total Maximum Daily Loads

Once a body of water is identified as a Category 5 water body on the Integrated List of Waters, MassDEP is required by the CWA to develop a “pollution budget” designed to restore the health of the impaired body of water. The process of developing this budget, generally referred to as a TMDL, includes identifying the source(s) of the pollutant from direct discharges (point sources) and indirect discharges (non-point sources), determining the maximum amount of the pollutant that can be discharged to a specific water body to meet water quality standards, and assigning pollutant load allocations to the sources.<sup>30</sup>

#### Stony Brook

A Draft Pathogen TMDL was developed for the Merrimack River Watershed, which applies to the 303(d) listed segments of Stony Brook. Waterborne pathogens, such as disease-causing bacteria, viruses, and protozoa, can be difficult to identify and isolate, so non-pathogenic bacteria are used as easily measurable indicators of contamination from sewage or feces of warm-blooded wildlife (birds and mammals). The TMDL establishes indicator bacteria limits for fecal coliform, *E. coli*, and enterococcus bacteria and outlines corrective actions to achieve these limits.

Stony Brook Segments MA84B-03 and MA84B-04 are considered Class B warm water fisheries. Class B waters are designated as a habitat for fish, other aquatic life, and wildlife, and for primary and secondary contact recreation.<sup>31</sup>

<sup>30</sup> Draft Pathogen TMDL for the Merrimack River Watershed

<sup>31</sup> Massachusetts Surface Water Quality Standards, 314 CMR 4.0.

Based on the classification of these segments, the following waste load allocation and load allocation limits apply for the various pathogen sources.

**Table 4: Sources and Expectations for Limiting Bacterial Contamination in the Merrimack River Watershed<sup>32</sup>**

Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL) <sup>33</sup>	Load Allocation Indicator Bacteria (CFU/100 mL) <sup>34</sup>
Illicit discharges to storm drains	0	N/A
Leaking sanitary sewer lines	0	N/A
Failing septic systems	N/A	0
CSOs	Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms <sup>35</sup>	N/A
NPDES – WWTP	Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms <sup>36</sup>	N/A
Storm water runoff Phase I and II	Not to exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms <sup>37</sup>	N/A
Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms <sup>38</sup>

Source: Draft Pathogen TMDL for the Merrimack River Watershed

<sup>32</sup> This table represents waste load and load reductions based on water quality standards current as of the publication date of these TMDLs, any future changes made to the Massachusetts water quality standards will become the governing water quality standards for these TMDLs.

<sup>33</sup> Waste Load Allocation (WLA) and Load Allocation (LA) refer to fecal coliform densities unless specified in table.

<sup>34</sup> Waste Load Allocation (WLA) and Load Allocation (LA) refer to fecal coliform densities unless specified in table.

<sup>35</sup> Or shall be consistent with an approved Long Term Control Plan (LTCP) for Combined Sewer Overflow (CSO) abatement. If the level of control specified in the LTCP is less than what is necessary to attain Class B water quality standards, then the above criteria apply unless MADEP has proposed and EPA has approved water quality standards revisions for the receiving water.

<sup>36</sup> Or shall be consistent with the Waste Water Treatment Plant (WWTP) National Pollutant Discharge Elimination System (NPDES) permit.

<sup>37</sup> The expectation for WLAs and LAs for storm water discharges is that they will be achieved through the implementation of BMPs and other controls.

<sup>38</sup> The expectation for WLAs and LAs for storm water discharges is that they will be achieved through the implementation of BMPs and other controls.

## Nashoba Brook

Even though the impairment for Nashoba Brook listed on the Integrated List of Waters is not addressed in any draft or final TMDLs, Nashoba Brook does have water quality challenges and it is important to consider downstream impacts. Nashoba Brook flows into the Assabet River, which joins the Sudbury River to become the Concord River. A Final Total Phosphorus TMDL was developed for the Assabet River and a Draft Pathogen TMDL was developed for the Concord River. MassDEP recommends that the information contained in these TMDLs guide management activities for all other waters throughout the watershed to help maintain and protect existing water quality.<sup>39</sup> As development in the Nashoba Brook watershed continues, it is possible that stormwater runoff, septic tanks, and illicit MS4 connections may contain phosphorus and pathogens and lead to degradation of water quality.

The Assabet River is listed on the 303(d) list as impaired primarily due to nutrients and organic enrichment/low DO. These are indicators of a high nutrient, or eutrophied, system. In freshwater systems the primary nutrient known to accelerate eutrophication<sup>40</sup> is phosphorus. In order to prevent further water quality degradation and to ensure that the Assabet River meets state water quality standards, a TMDL for total phosphorus was developed. This TMDL requires decreased loadings from Publicly Owned Treatment Works (POTWs) and from certain non-point sources and outlines corrective actions to achieve specified limits. This TMDL was developed with special emphasis on reducing the extent of nuisance macrophyte growth, meeting minimum DO criteria, reducing extreme diurnal dissolved oxygen fluctuations and excessive dissolved oxygen supersaturation, and reducing ambient total phosphorus concentrations.<sup>41</sup> Nashoba Brook is not known to have high concentrations of phosphorus or other limiting nutrients, but such conditions could occur in the future.

Much like the Draft Pathogen TMDL for the Merrimack River Watershed, the Draft Pathogen TMDL for the Concord River Watershed establishes limits for indicator organisms (fecal coliform, *E. coli*, and enterococcus bacteria) and outlines corrective actions to achieve these limits.<sup>42</sup> Nashoba Brook is not considered impaired by pathogens, but as land uses in its watershed change, the potential for pathogen contamination increases. Septic tanks and illicit connections to MS4s, due to an increase in human presence, can be a major contributor of pathogen contamination.

### 3.4.3 Summary of In-Stream Water Quality

A number of organizations have measured and described water quality in Stony Brook and Nashoba Brook. MassDEP produced water quality assessment reports for the Merrimack River Watershed and the SuAsCo Watershed, which included water quality samples and whole effluent toxicity tests. The Town of Westford, through the efforts of the Westford Conservation Trust and the Westford Watershed Conservation Association, conducted water quality sampling in the summers of 2005, 2006, and 2007. The Merrimack River Watershed Council and the SuAsCo Watershed Council also conducted water quality monitoring. The results of these studies are summarized below. Water quality information is also included for each sub-basin in the Sub-Basin Profiles in Section 4.

---

<sup>39</sup> Draft Pathogen TMDL for the Concord River Watershed

<sup>40</sup> Eutrophication is a process whereby water bodies, such as lakes, estuaries, or slow-moving streams receive excess nutrients that stimulate excessive plant growth (algae, periphyton attached algae, and nuisance plants weeds). This enhanced plant growth, often called an algal bloom, reduces dissolved oxygen in the water when dead plant material decomposes and can cause other organisms to die. Source: USGS Toxic Substances Hydrology Program. Retrieved on May 24, 2007 from <http://toxics.usgs.gov/definitions/eutrophication.html>.

<sup>41</sup> Assabet River TMDL for Total Phosphorus

<sup>42</sup> Draft Pathogen TMDL for the Concord River Watershed

As previously stated, both Stony Brook and Nashoba Brook are Class B Warm Water Fisheries, and must meet the standards set forth in 314 Code of Massachusetts Regulations (CMR) 4.00. Additionally, water quality measurements can be compared with data collected by EPA in rivers in the same "ecoregion" (i.e., "reference conditions"). Nutrient concentrations less than the 25<sup>th</sup> percentile listed below would be considered unimpaired. Water quality should also be consistent with recommendations for maintaining healthy fish habitat. The following tables, compiled by OAR, summarize applicable water quality standards and reference criteria.

**Table 5: Massachusetts Surface Water Quality Standards**

Parameter	Massachusetts Standards
Dissolved oxygen*	>= 5.0 mg/l and 60% saturation for warm water fisheries >= 6.0 mg/l and 75% saturation for cold water fisheries
pH*	6.5-8.3 for inland waters
Nutrients*	"control cultural eutrophication"
Temperature*	<= 28.3 C and less than 2.8 C deviation for warm water fisheries <= 20.0 C and less than 1.7 C deviation for cold water fisheries
Suspended Solids**	Aquatic life: 25 mg/L maximum and less than 10 mg/l increase due to a discharge
Aesthetics Biocommunity**	Primary or secondary contact recreational use: no nuisance organisms that render the water aesthetically objectionable or unusable, "best professional judgment"; cover of macrophytes < 50% within any portion of the lake area at maximum extent of growth.
Fecal coliforms**	Primary contact recreational use -- Dry weather guidance: (<5 samples taken) <= 400 cfu/100ml. Wet weather guidance: dry weather samples meet and wet samples <=2000 cfu/100ml. Secondary contact recreational use -- Dry weather guidance (< 5 samples taken) <=2000 cfu/100ml. Wet weather guidance: dry weather samples meet and wet samples <= 4000 cfu/100ml.
*MassDEP 1997 Massachusetts Surface Water Quality Standards - 314 CMR 4.00 1997.	
** MassDEP 2002 Massachusetts Year 2002 Integrated List of Waters, Part 1.	

**Table 6: EPA Ambient Water Quality Criteria Recommendations**

Reference Conditions for Ecoregion XIV (Eastern Coastal Plain) Subregion 59 (Northeastern Coastal Zone) Streams <sup>43</sup>	
Parameter	Reference Condition (25th percentile of June - September data)
Total Phosphorus (mg/L)	0.025
Total Nitrogen (calculated) (mg/L)	0.44
NO <sub>2</sub> + NO <sub>3</sub> (mg/L)	0.34
TKN (mg/L)	0.30

<sup>43</sup> Adapted from USEPA. 2000. Ambient Water Quality Criteria Recommendations: Rivers and Streams in Nutrient Ecoregion XIV. EPA 822-B-00-022. United States Environmental Protection Agency: Office of Water, Office of Science and Technology, Health and Ecological Criteria Division. Washington, D.C. December 2000.

## Stony Brook

The Stony Brook Stream Team conducted shoreline surveys and sampled at 16 sites throughout the watershed on a monthly basis from July through November 2000. The stream teams conducted a second round of sampling from June through November 2001. Water quality data collected by these stream teams show that the Stony Brook is not meeting state designated water quality standards for basic parameters including dissolved oxygen and fecal coliform bacteria.<sup>44</sup>

In September 2005, the Westford Watershed Conservation Association conducted one round of sampling in the Stony Brook watershed at five locations. These same locations were also sampled monthly from May through September 2006 and May through September 2007. The water quality parameters evaluated included pH, temperature, DO, dissolved solids, conductivity, ammonia, total nitrogen, total phosphorus, and ortho-phosphates. An analysis of this sampling data is included in Section 4, in the Watershed Health Summary of each sub-basin profile.

Westford Anodizing Corporation, located on North Main Street in Westford, was permitted (MA0024414) to discharge an average monthly flow of 0.02 MGD (0.03 MGD maximum daily) treated processed wastewater to Stony Brook. The company performs aluminum anodizing, chromate finishing, and plating operations. In July 1996, the facility was required by EPA, through an Administrative Order, to conduct a Toxicity Identification and Toxicity Reduction Evaluation (TIE/TRE). On six occasions between March 1997 and March 2001, Westford Anodizing collected water samples approximately 50 feet upstream of their discharge (near Broadway Street). They found that instream pH ranged between 6.8 and 7.4, total residual chlorine was below the minimum quantification level of 0.05 mg/L, hardness ranged from 45 to 56 mg/L, and ammonia-nitrogen and suspended solids were below detection limits. Westford Anodizing also conducted whole effluent toxicity tests on samples collected 50 feet upstream of their discharge between March 1997 and March 2001, and found that survival of *C. dubia* and *P. promelas* exposed (48-hour) to Stony Brook was good (> 95%). During the same period, the facility also conducted six acute toxicity tests on their treated effluent. They found that whole effluent LC50's ranged between 19 and >100 % effluent. The facility did not meet its whole effluent toxicity limit in three of the six test events. In 2006, EPA took enforcement action against Westford Anodizing Corporation and this facility no longer discharges to the Stony Brook watershed.

## Nashoba Brook

Past sampling in Nashoba Brook was completed primarily downstream of Westford. The SuAsCo Watershed Year 2001 Water Quality Assessment Report presents water quality information based on sampling in Acton and Concord, MA.

Since 1998, the Acton Board of Health has collected quarterly fecal coliform bacteria samples from six sites along Nashoba Brook. According to the Board of Health, swimming standards were exceeded in Ice House Pond, an impoundment of Nashoba Brook, in approximately 25% of the samples. A likely source of bacteria is septic systems upgradient from Ice House Pond and the brook. The Acton Board of Health also found a small impoundment further upstream where people were feeding the geese and ducks. The presence of many water fowl would lead to fecal coliform contamination, as well.

Between March and November 2000, as part of a SMART monitoring program, water quality sampling was conducted on five occasions at the footbridge in the Nashoba Brook Conservation Area, southeast of Wheeler Lane, Acton. Parameters measured included temperature, pH, specific conductivity, DO, TSS, turbidity, total phosphorus,

---

<sup>44</sup> Stony Brook Watershed Assessment, Merrimack River Watershed Council, 2001.

ammonia-N, alkalinity, and hardness. Between 2001 and 2003, OAR conducted water quality monitoring by Commonwealth Avenue Bridge, Concord. Parameters measured included temperature, DO, pH, conductivity, total suspended solids, total phosphorus, Total Kjeldahl Nitrogen, and nitrate concentrations.

In September 2005, the Westford Watershed Conservation Association conducted one round of sampling in the Nashoba Brook watershed at four locations. These same locations were also sampled monthly from May through September 2006 and May through September 2007. The water quality parameters evaluated included pH, temperature, DO, dissolved solids, conductivity, ammonia, total nitrogen, total phosphorus, and ortho-phosphates. An analysis of this sampling data is included in Section 4, in the Watershed Health Summary of each sub-basin profile.

### 3.4.4 Macro Invertebrate Sampling and Biological Assessments

Benthic macroinvertebrates are the insects, crustaceans, and other small organisms living on and under rocks and sediment in streams. They are relatively immobile, have short life spans, and are sensitive to changes in their environment.<sup>45</sup> As stream conditions such as temperature, DO, and water quantity and velocity change, alterations to the macroinvertebrate community are noticeable. These changes are used to conduct a biological assessment of the water body, or assess the cumulative impacts of stressors leading to habitat degradation, and chemical contamination, which result in a loss of biological diversity. Rapid bioassessment protocols (RBPs) are the methods used to monitor the health of benthic macroinvertebrate communities.<sup>46</sup>

Macroinvertebrate sampling was conducted in both Stony Brook and Nashoba Brook by MassDEP Division of Watershed Management (DWM) in the mid and late 1990s. Recent samples were collected by WENAC, but have not yet been analyzed. Results of these biological assessments show that both Stony Brook and Nashoba Brook are slightly and moderately impaired, respectively, meaning the insect community meets characteristics of one impacted by some pollution.

#### Stony Brook

In July 1999, DWM conducted a Rapid Bioassessment Protocol (RBP) III benthic macroinvertebrate survey of Stony Brook downstream from Brookside Road in Westford. In this survey, DWM used the Fish Brook regional reference station in the Ipswich River watershed as a “least impacted” comparison. The benthic macroinvertebrate data were found to be 53% comparable to this reference site. The community was dominated by filter-feeders (Hydropsychidae and the filter-feeding mussel - *E. complanata*), which is indicative of the effects of moderate enrichment. Based on the RBP III analysis, the benthic community is slightly impacted.<sup>47</sup>

#### Nashoba Brook

In July 1996, DWM conducted a RBP II benthic macroinvertebrate survey of the SuAsCo watershed, including a site on Nashoba Brook in Acton, MA (off Route 2A between Wetherbee St. and Keefe Rd.). DWM selected two sites, Gates Pond Brook, Berlin, and Fort Pond Brook, Acton, that are considered to be “least impacted” within the watershed and are therefore representative of normal conditions in the river. DWM then sampled throughout the

---

<sup>45</sup> Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish. EPA, Second Edition. Accessed May 17, 2007 online at <http://www.epa.gov/owow/monitoring/rbp/>

<sup>46</sup> MassDEP Environmental Monitoring: Biomonitoring. Accessed May 17, 2007, online at <http://www.mass.gov/dep/water/resources/biomon.htm>

<sup>47</sup> Merrimack River Basin Water Quality Assessment Report, 1999.

remainder of the watershed, and calculated impairment based on family-level taxonomy. Based on comparison to the two reference sites, the site sampled on Nashoba Brook was determined to be moderately impacted. DWM suspects this impairment is caused by nonpoint sources.<sup>48</sup>

In 2000, the MassWildlife conducted fish population sampling at two stations in Acton. The number of fish observed was low and the fish population was dominated by macrohabitat generalists. Due to low flow alterations and the results of the fish bioassessment, the Aquatic Life Use was assessed as impaired.

### 3.4.5 Water Quantity and Stream Flow

In April of 2007, the Charles River Watershed Association (CWRA) and ESS Group, Inc., released a Community Water Budget Report for the Town of Westford. This report provides water budgets for small sub-basins<sup>49</sup> within Westford, with the goal of quantifying human impacts on sub-basin streamflow so that critical sub-basins can be identified and prioritized for further attention. The water budget allows better understanding of withdrawals from and discharges to streams and rivers, and can help guide mitigation measures or bylaws to reduce impacts on the water bodies from human activities.

The water budget is developed by accounting for all human inputs and outputs of water for each sub-basin. The inflows (gains) considered are:

- Wastewater discharges into groundwater or surface water; and
- Water supply imported through a distribution system.

The outflows (losses) considered are:

- Large water withdrawals from wells, diversions, and pumps;
- Wastewater exported via a sewer distribution system;
- Water lost from all irrigated areas via Evaporation;
- Recharge loss from impervious areas; and
- Loss from surface water reservoirs.

This is then compared to the estimated natural streamflow, in order to determine the relative human impact. A negative water balance occurs when human activities cause streamflow to be lower than it would be naturally. A positive water balance occurs when human activities cause streamflow to be higher than it would be naturally.

CWRA and ESS found that, during the low-flow month of September, the Stony Brook sub-basins, except for the Nabnasset Pond sub-basin, had heavily impacted streamflow volumes and therefore have a negative water balance, mainly due to water withdrawals. The results of this report are captured in the sub-basin profiles included in Section 4.

---

<sup>48</sup> Appendix H, SuAsCo Watershed Water Quality Assessment Report, 2001.

<sup>49</sup> In this study, the sub-basins used were delineated by the US Geological Survey (USGS) and are defined as small surface water basins that are generally less than twenty square miles and average about four square miles in extent.

### 3.5 EXISTING AND POTENTIAL SOURCES OF POLLUTION

There are a number of potential sources of pollution located within the Stony Brook and Nashoba Brook watersheds. These sources include: point sources (NPDES authorized discharges), ground water discharges<sup>50</sup>, hazardous waste sites such as MassDEP 21E sites<sup>51</sup> and Underground Storage Tanks (UST)<sup>52</sup>, solid waste sites such as landfills, and non-point sources including runoff from agricultural sites, golf courses, roads and developed land. There is also potential for impacts to the watersheds due to future land development or changes in land use.

Figure A-5, Potential Sources of Pollution, in Appendix A, depicts both land use types and specific water quality hazards in each watershed that may impact Westford's water resources. These sources do not necessarily cause contamination, but potentially could depending on management practices. To protect watersheds from these possible harms, it is critical to first understand the location and nature of potential threats. This section describes the existing and potential sources of pollution in the Stony Brook and Nashoba Brook watersheds and their sub-basins, discusses the potential impacts of each pollutant source, and describes the susceptibility of each watershed to the particular pollutant source.

#### 3.5.1 Point Source Discharges

Point source discharges refer to a distinct origin of contamination and are associated with a pipe discharge. These discharges typically include domestic and industrial wastewater treatment plant effluent. All point source discharges must be issued permits in compliance with the regulations of the National Pollution Discharge Elimination System (NPDES) of the CWA. There is one NPDES authorized discharge within Westford. Fletcher Granite Company, located on Groton Road,<sup>53</sup> was issued a permit (MA0020231) to discharge overflow water from the quarry supply pond and processes water into Gilson Brook, in the Nabnasset Pond Sub-basin.<sup>54</sup> Westford Anodizing Corporation on North Main Street., was permitted (MA0024414) to discharge an average monthly flow of 0.02 MGD (0.03 MGD maximum daily) treated process wastewater to Stony Brook from aluminum anodizing, chromate finishing, and plating operations. In 2006, EPA cited an enforcement action against the company, citing them for violations of the Clean Water Act due to exceeding effluent limits in their permit.<sup>55</sup> This discharge permit is no longer active.

#### 3.5.2 Nonpoint Sources

Nonpoint source (NPS) pollution comes from many diffuse sources. NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made

---

<sup>50</sup> Ground water discharges include: Sanitary sewage in excess of 10,000 gpd; discharges of non-contact cooling water; discharges from coin-operated Laundromats; discharges from car washes; and discharges from treatment systems designed to remediate contaminated groundwater.

<sup>51</sup> These are oil and/or hazardous material disposal sites that have been reported and Tier Classified under M.G.L. Chapter 21E and the Massachusetts Contingency Plan (MCP).

<sup>52</sup> Updated based on MA Department of Fire Services UST Query Tool. Accessed June 13, 2007, online at <http://db.state.ma.us/dfs/ust/ustQueryPage.asp>

<sup>53</sup> PCS Water Discharge Permits, EPA Envirofacts

<sup>54</sup> Merrimack River Basin 1999 Water Quality Assessment Report, MassDEP.

<sup>55</sup> EPA Cites Westford Metal Plater for Environmental Problems, July 8, 2006. Accessed on June 13, 2007, online at <http://www.epa.gov/Region1/pr/1996/pr0708a.html>

pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and even our underground sources of drinking water. These pollutants include:<sup>56</sup>

- Excess fertilizers, herbicides, and insecticides from agricultural lands and residential areas;
- Oil, grease, and toxic chemicals from urban runoff and energy production;
- Sediment from improperly managed construction sites, crop and forest lands, and eroding stream banks;
- Salt from irrigation practices and acid drainage from abandoned mines; and
- Bacteria and nutrients from wildlife, livestock, pet wastes, and faulty septic systems.

NPS pollution also comes from ground water discharges, including septic tanks and permitted discharges. Permitted ground water discharges are regulated by MassDEP Division of Watershed Management (DWM) Water Permitting Program (WPP) and include: sanitary sewage in excess of 10,000 gpd; discharges of non-contact cooling water; discharges from coin-operated laundromats; discharges from car washes; and discharges from treatment systems designed to remediate contaminated groundwater.<sup>57</sup> Septic tanks and permitted ground water discharges have the potential to contribute a number of pollutants, including phosphorus, nitrogen, and trace amounts of soaps, oils and grease, heavy metals, organic compounds, hydrocarbons, PCBs, pesticides and herbicides.

### 3.5.3 Existing and Potential Pollution by Sub-Basin

The following section describes potential sources of point and non-point pollution in each sub-basin of Stony Brook and Nashoba Brook. The potential impacts to the basin and the susceptibility of each basin to the pollutant is described.

#### Stony Brook Watershed

- Boutwell Brook – The potential sources of pollution in this sub-basin include cropland in the north-east, and a small area of commercial and industrial zones located near the convergence of Boutwell Brook with the Main Stem Stony Brook. Next to the commercial and industrial zones is an area of residential lots smaller than ¼ acre. There is also potential for future development on unprotected lands in this sub-basin. The sub-basin is at most risk from the commercial and industrial zones and the small residential lots. These areas are located alongside Boutwell Brook, and due to the high density and likeliness of substantial impervious surface area, pollutants such as nutrients and oils/grease could quickly enter the water body during precipitation events.
- Nabnasset Pond – The potential sources of pollution in this sub-basin include three MassDEP Tier 1C 21E sites in the middle of the sub-basin, one waste disposal facility, and one golf course. Fletcher Granite Company discharges industrial process wastewater to the brook. There is also a large portion of land used for mining and a small area of cropland and pasture tributary to the pond. A large portion of this sub-basin is ¼ to ½ acre lots, which is high density housing that may lead to pollutant loading from stormwater runoff. The most likely cause of pollution in this sub-basin is stormwater runoff from developed areas and from the golf course. There is also a potential for contamination from the waste disposal facility, the NPDES surface water discharge, and the agricultural activities.
- Snake Meadow Brook/Keyes Brook - Within this sub-basin, there are two USTs, a small commercial area approximately 100 feet from the brook, and an area of cropland, which is located approximately 150 feet

<sup>56</sup> Nonpoint source pollution description from US EPA *Polluted Runoff (Nonpoint Source Pollution)* website. Retrieved on 2/2/07 from <http://www.epa.gov/nps/>.

<sup>57</sup> MassGIS Groundwater Discharge data layer.

from the brook. The USTs contain gasoline, which could potentially leak and contaminate the groundwater, eventually migrating into the brook. These USTs are about 3,500 feet from the brook. Throughout the sub-basin, there are residential lots bordering the brook. Stormwater runoff from these areas could contribute pollutants to the brook. There is also a large area of forested land in the upper basin, which has potential for development. Pollution in this sub-basin is most likely from stormwater runoff from agricultural activities, the residential developed areas, and potentially the USTs, if they are not properly maintained. In addition, future development could lead to a greater impervious surface in this sub-basin, contributing more pollutants via stormwater runoff.

- **Tadmuck Brook** – In this sub-basin, there is a large orchard in the east and a small portion of orchard in the south and to the west. The orchards are not considered a major threat at this time due to limited size and distance to the brook, but they likely contribute nutrients and pesticides to the sub-basin. A large portion of this sub-basin has already been developed, so there is limited area available for additional development. There is also a MassDEP Tier II 21 E site in the west, and four USTs. Three of these USTs are very close to the brook, and given they contain gasoline, leaks could potentially quickly impact water quality.
- **Stony Brook Main Stem** – There are a number of potential sources of pollution within this sub-basin. There are two mining areas to the north-east, a Tier 1B 21E site on the main stem near Boutwell Brook, and two USTs where Gilson Brook meets Main Stem. One solid waste facility, the Town of Westford's landfill, which operated for 50 years, is located in the south-west of the sub-basin, and is adjacent to two town wells, the Russell Bird and Wildlife Sanctuary, town forest land, and is in the flood plain of Stony Brook.<sup>58</sup> The landfill was closed in 1985 and capped in 1988.<sup>59</sup> Leachate from the landfill could potentially enter the water body, due to its proximity to wetlands connected to the brook. A post-closure monitoring program is in place. The Westford Anodizing Corporation no longer discharges to the brook. There is one ground water discharge permit, near Reed Brook, a cold water fishery. Depending on the hydrogeology of this area, the ground water discharge could impact Reed Brook. Cropland in the lower basin is in close proximity to the brook, and a small area of multifamily housing borders the brook. Stormwater runoff from these areas could impact the water quality of the brook.

### **Nashoba Brook Watershed**

- **Vine Brook** – The potential sources of pollution within this sub-basin include one UST, runoff from a major transportation corridor (I-495) and from commercial and industrial areas, including one MassDEP Bureau of Waste Management (BWP) major facility. There are three groundwater discharges in this sub-basin, all three of which are close to the brook. Depending on the hydrogeology of the site, these discharges could impact the brook. There is also a great potential for development north of I-495, but this area is not close to the brook, so impacts from such development on water quality are likely to be low. The brook could be contaminated by runoff from the commercial and industrial areas, which could potentially contain hazardous material such as motor oil and metals and nutrients like phosphorus and nitrogen.
- **Nonset Brook** – There are large areas of cropland and pasture within this sub-basin, which, in some cases, are within 100 feet of the brook. About ½ of the sub-basin is developed, which could lead to contaminated stormwater runoff and harmful changes in hydrology.

---

<sup>58</sup> 2002 Town of Westford Open Space and Recreation Plan

<sup>59</sup> Inactive or Closed Solid Waste Landfills, June 2006. Access on May 23, 2007, online at <http://www.mass.gov/dep/recycle/inactlf.pdf>

- 
- Butter Brook – There is an area of  $\frac{1}{4}$  to  $\frac{1}{2}$  acre lots in the northern tip of this sub-basin approximately 1,500 feet from the brook, which could potentially contribute pollutants via stormwater runoff. There is also an area of mining located in the lower west of the sub-basin, which is within 100 feet of the brook and the main stem of Nashoba Brook. The brook travels through a golf course, as well. Fertilizers and pesticides applied to the course could easily be captured in stormwater and runoff into the brook.
  - Nashoba Brook Main Stem – A number of commercial and industrial sites are located in the upper basin, along with a major transportation corridor. Stormwater runoff from these areas could contain hazardous materials such as motor oils, and potentially contain high salt concentrations from roadway deicing practices. A large area dedicated to mining is located in the lower basin, which could contribute high concentrations of sediments and nutrients. There are also two Tier II 21 E sites on the border of the main stem and Vine Brook and one groundwater discharge north of the highway. One golf course is located next to the brook, along with a number of small cropland and pasture areas, which due to maintenance practices, may lead to phosphorus and nitrogen entering Nashoba Brook in high and concentrated quantities. Nashoba Valley Ski Area is in this sub-basin, and while it is primarily used in the winter, snowmelt in the spring from the site could easily and quickly carry contaminants into the brook. One groundwater discharge is located in the upper area of the sub-basin, but will not likely impact the brook.

## 4. SUB-BASIN PROFILES

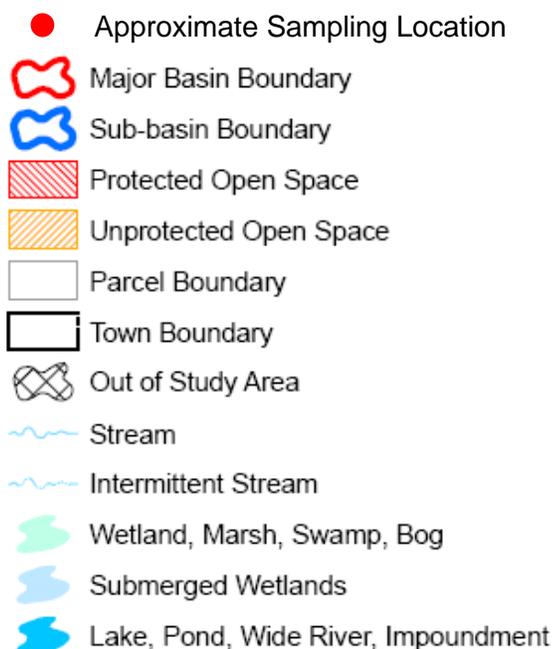
The information included in the Watershed Analysis in Section 3 was distilled into nine sub-basin profiles. These profiles are a compilation of the reports, studies, and data related to the sub-basins within the Stony Brook and Nashoba Brook watersheds. The profile metrics are used to gage overall sub-basin health and will guide future protection with the goal to preserve the natural and water resources and maintain the character of the Town.

Each Sub-Basin Profile includes a map of the sub-basin drainage area and presents vital statistics in the following categories:

- Physical Characteristics;
- Stream Statistics;
- Land Use – Open Space and Impervious Surface;
- Habitat Characteristics;
- Lands Critical to Sustaining Surface and Groundwater Quality and Quantity; and
- Summary of Potential Sources of Pollution.

In addition, a Watershed Health Summary is included. W&C compared data collected by the Westford Watershed Conservation Association to applicable surface water quality standards and assessed if the measured parameters are on average higher or lower than the standards. Impervious surface cover, basin stress status, and the net water budget are also used as indicators of overall watershed health in each sub-basin. The legend provided below applies to the nine sub-basin profiles.

**Figure 7: Sub-basin Profile Legend**



### Sub-basin Statistics

#### Physical Characteristics

Drainage area (sq. mi)	5.02
Drainage area (acres)	3213
Contribution of sub-basin to entire watershed in Westford (%)	30.67

#### Stream Statistics

Miles of perennial streams	3.92
Total acres of perennial streams with 200 foot buffers	228
Acres of buffer area around perennial streams lost to impervious surface	12
Miles of intermittent streams	3
Acres of intermittent streams with 200-foot buffers	178
Acres of buffer area around intermittent streams lost to impervious surface	8

#### Land Use

Acres of open space	902
Acres of protected open space	455
% protected open space	14
Acres of unprotected open space	447
% unprotected open space	13.92
Acres of impervious surface	261
% impervious surface	8.12

#### Habitat Characteristics

Number of certified vernal pools	15
Number of potential vernal pools	33
Acres of vernal pools with 200-foot buffers	43
Acres of buffer area around vernal pools already lost to impervious surface	2
Acres of Area of Critical Environmental Concern (ACEC)	n/a
Acres of NHESP Priority Habitats of Rare Species	409
Acres of NHESP Estimated Habitats of Rare Wildlife	409
Acres of Wetlands, Marsh, Swamp, and Bogs	172
Acres of Pond/Lakes	74

#### Lands Critical to Sustaining Surface and GW Quality and Quantity

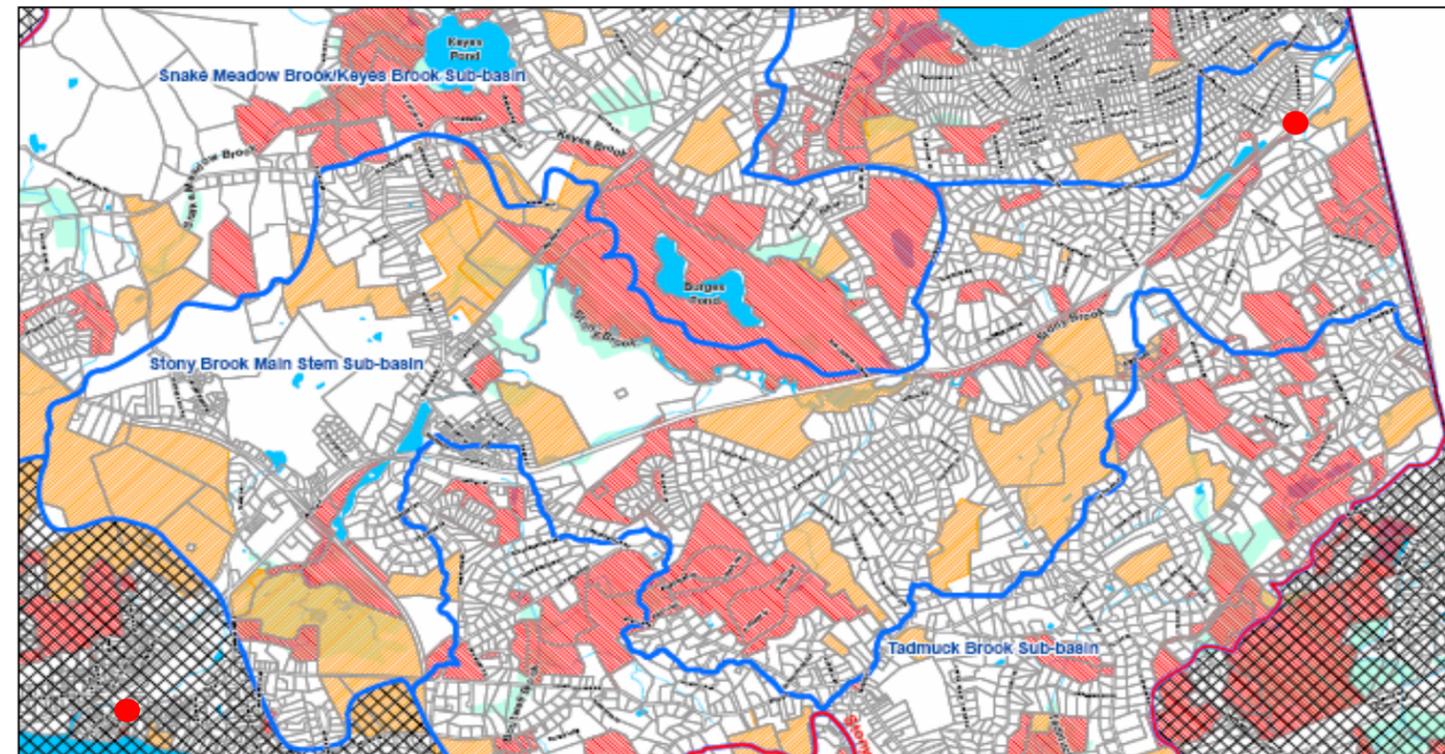
Number Public Water Supply Wells	8
Acres Zone I	46
Acres Zone II	1023
Acres Interim Well Protection Areas	0
Acres low-yield aquifer	0
Acres medium-yield aquifer	416
Acres high-yield aquifer	393
Stressed Basin (Y/N)	N
Net Water Budget	Negative

#### Summary of Potential Sources of Pollution

NPDES surface water discharge	0
Groundwater discharges	1
BWP Major Facility	0
MassDEP 21 E Sites	1
Underground Storage Tank	2

### Sub-basin Health Summary

Parameter	Minimum	Maximum	Average	Standard	Concern
<b>Massachusetts Water Quality Standards (314 CMR 4.00)</b>					
Temperature (°C):	10.40	24.10	18.69	<= 28.3	none
pH:	6.29	7.32	6.93	6.5 – 8.3	none
Dissolved Oxygen:	6.50	10.00	7.64	>= 5.0	none
<b>MassDEP 2002 Integrated List of Waters, Part 1</b>					
DO Saturation (%):	61.06	93.00	80.07	>= 60	none
TSS (mg/L):	0.50	17.00	3.45	< 25	none
<b>EPA Ambient Water Quality Criteria Recommendations</b>					
Total Phosphorus (mg/L):	0.01	0.06	0.02	< 0.025	none
Total Nitrogen (mg/L):	0.16	0.98	0.55	< 0.44	slightly high
TKN (mg/L):	0.01	0.84	0.29	< 0.3	none
NO2 (mg/L):	0.10	0.24	0.17	NE	n/a
Ammonia (mg/L):	0.03	0.36	0.07	NE	n/a
Impervious Cover:	8.12%, Sensitive Sub-basin (Good Stream Quality)				
Stressed Basin:	No				
Net Water Budget:	Negative				



### Sub-basin Statistics

#### Physical Characteristics

Drainage area (sq. mi)	1.19
Drainage area (acres)	760
Contribution of sub-basin to entire watershed in Westford (%)	59364.84

#### Stream Statistics

Miles of perennial streams	1.28
Total acres of perennial streams with 200 foot buffers	71
Acres of buffer area around perennial streams lost to impervious surface	5
Miles of intermittent streams	2.47
Acres of intermittent streams with 200-foot buffers	131
Acres of buffer area around intermittent streams lost to impervious surface	4

#### Land Use

Acres of open space	246
Acres of protected open space	126
% protected open space	16.55
Acres of unprotected open space	120
% unprotected open space	15.76
Acres of impervious surface	77
% impervious surface	10.16

#### Habitat Characteristics

Number of certified vernal pools	8
Number of potential vernal pools	9
Acres of vernal pools with 200-foot buffers	23
Acres of buffer area around vernal pools already lost to impervious surface	2
Acres of Area of Critical Environmental Concern (ACEC)	n/a
Acres of NHESP Priority Habitats of Rare Species	118
Acres of NHESP Estimated Habitats of Rare Wildlife	118
Acres of Wetlands, Marsh, Swamp, and Bogs	28
Acres of Pond/Lakes	2

#### Lands Critical to Sustaining Surface and GW Quality and Quantity

Number Public Water Supply Wells	0
Acres Zone I	0.00
Acres Zone II	300
Acres Interim Well Protection Areas	0.00
Acres low-yield aquifer	0
Acres medium-yield aquifer	125
Acres high-yield aquifer	31
Stressed Basin (Y/N)	N
Net Water Budget	Negative

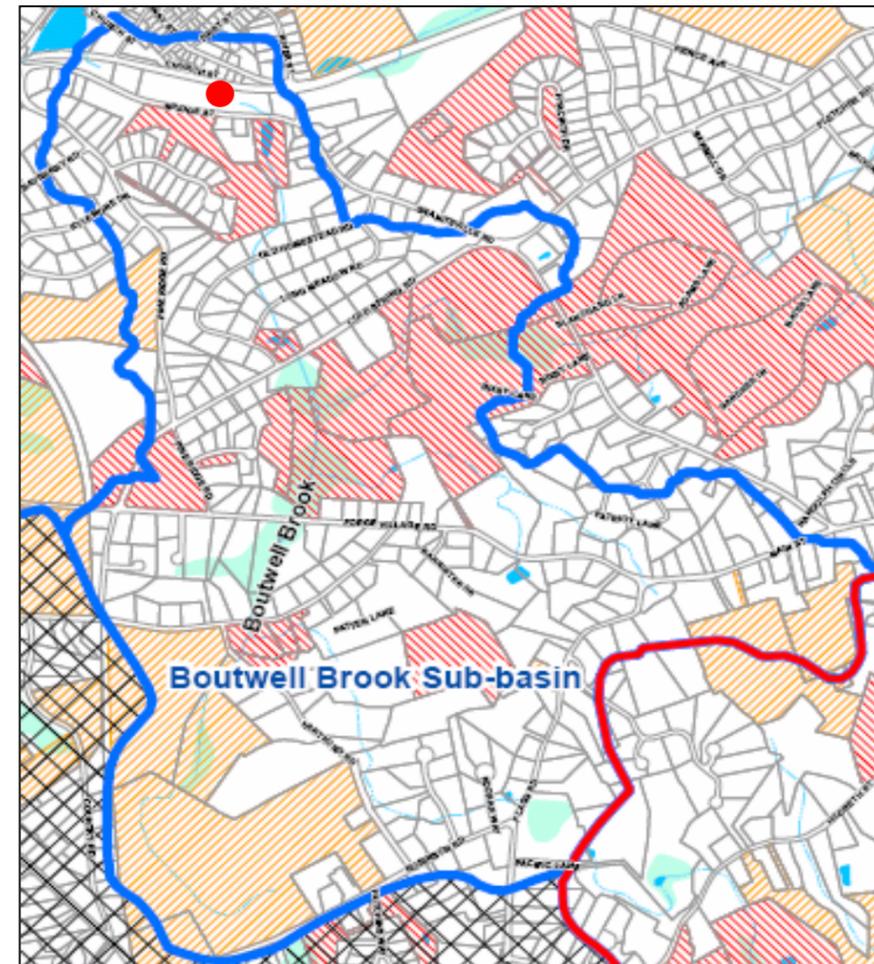
#### Summary of Potential Sources of Pollution

NPDES surface water discharge	0
Groundwater discharges	0
BWP Major Facility	0
MassDEP 21 E Sites	0
Underground Storage Tank	0

### Sub-basin Health Summary

Parameter	Minimum	Maximum	Average	Standard	Concern
<b>Massachusetts Water Quality Standards (314 CMR 4.00)</b>					
Temperature (°C):	10.10	23.10	16.94	<= 28.3	none
pH:	5.60	6.26	6.11	6.5 – 8.3	low
Dissolved Oxygen:	2.60	5.00	4.03	>= 5.0	low
<b>MassDEP 2002 Integrated List of Waters, Part 1</b>					
DO Saturation (%):	24.10	50.50	40.08	>= 60	low
TSS (mg/L):	2.00	23.00	6.75	< 25	none
<b>EPA Ambient Water Quality Criteria Recommendations</b>					
Total Phosphorus (mg/L):	0.01	0.05	0.03	< 0.025	slightly high
Total Nitrogen (mg/L):	0.10	3.70	1.10	< 0.44	high
TKN (mg/L):	0.01	2.50	0.50	< 0.3	high
NO2 (mg/L):	0.70	1.20	0.34	NE	n/a
Ammonia (mg/L):	0.02	0.49	0.15	NE	n/a

Impervious Cover: 10.16%, Impacted Sub-Basin (Fair Stream Quality)  
 Stressed Basin: No  
 Net Water Budget: Negative



## Sub-basin Statistics

### Physical Characteristics

Drainage area (sq. mi)	4.74
Drainage area (acres)	3032
Contribution of sub-basin to entire watershed in Westford (%)	29

### Stream Statistics

Miles of perennial streams	7
Total acres of perennial streams with 200 foot buffers	353
Acres of buffer area around perennial streams lost to impervious surface	7
Miles of intermittent streams	1
Acres of intermittent streams with 200-foot buffers	51
Acres of buffer area around intermittent streams lost to impervious surface	2

### Land Use

Acres of open space	792
Acres of protected open space	521
% protected open space	17
Acres of unprotected open space	271
% unprotected open space	9
Acres of impervious surface	122
% impervious surface	4

### Habitat Characteristics

Number of certified vernal pools	9
Number of potential vernal pools	46
Acres of vernal pools with 200-foot buffers	26
Acres of buffer area around vernal pools already lost to impervious surface	3
Acres of Area of Critical Environmental Concern (ACEC)	n/a
Acres of NHESP Priority Habitats of Rare Species	1369
Acres of NHESP Estimated Habitats of Rare Wildlife	1369
Acres of Wetlands, Marsh, Swamp, and Bogs	191
Acres of Pond/Lakes	183

### Lands Critical to Sustaining Surface and GW Quality and Quantity

Number Public Water Supply Wells	3
Acres Zone I	23
Acres Zone II	486
Acres Interim Well Protection Areas	43
Acres low-yield aquifer	0
Acres medium-yield aquifer	251
Acres high-yield aquifer	191
Stressed Basin (Y/N)	N
Net Water Budget	Negative

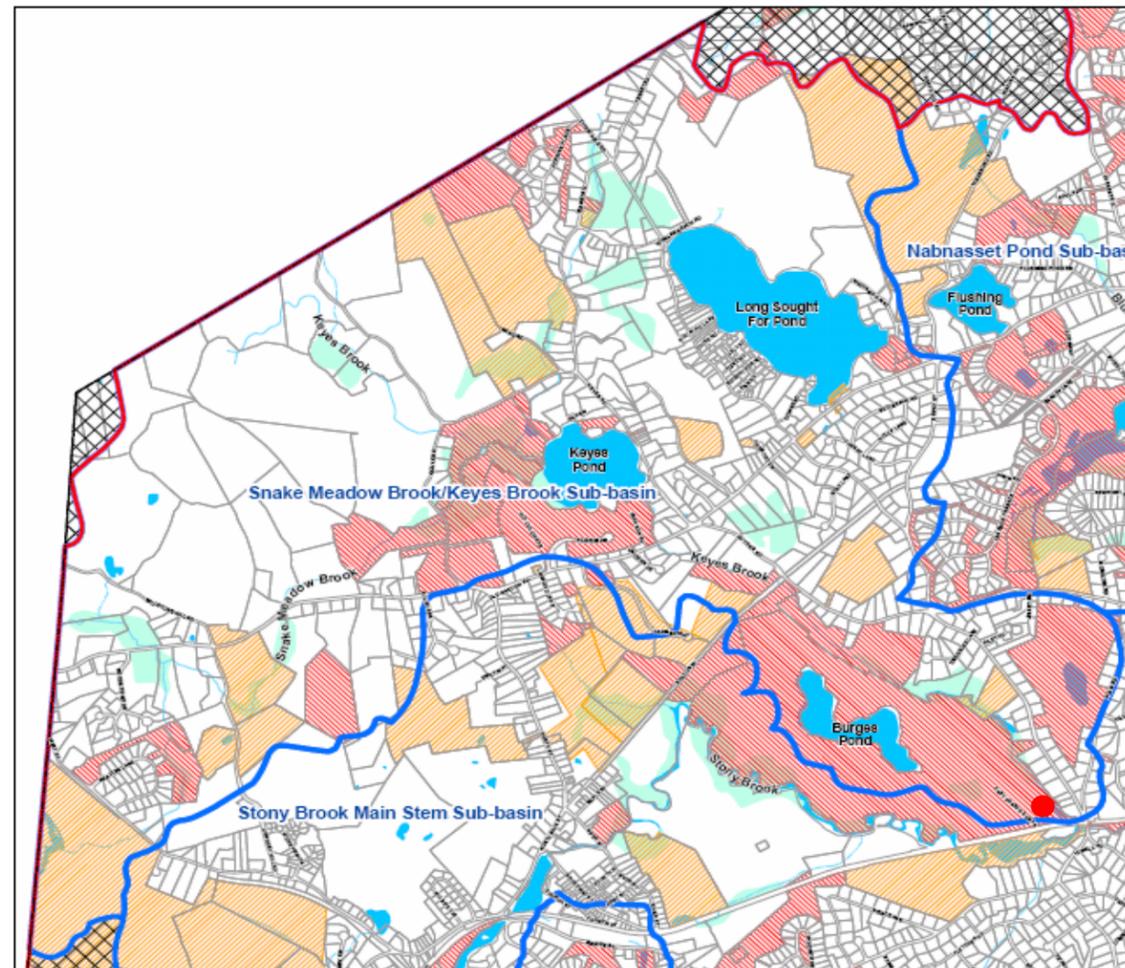
### Summary of Potential Sources of Pollution

NPDES surface water discharge	0
Groundwater discharges	0
BWP Major Facility	0
MassDEP 21 E Sites	0
Underground Storage Tank	2

## Sub-basin Health Summary

Parameter	Minimum	Maximum	Average	Standard	Concern
<b>Massachusetts Water Quality Standards (314 CMR 4.00)</b>					
Temperature (°C):	10.20	24.50	17.95	<= 28.3	none
pH:	5.86	7.02	6.28	6.5 – 8.3	slightly low
Dissolved Oxygen:	3.80	8.15	5.30	>= 5.0	none
<b>MassDEP 2002 Integrated List of Waters, Part 1</b>					
DO Saturation (%):	40.54	74.70	54.18	>= 60	slightly low
TSS (mg/L):	1.00	5.00	2.20	< 25	none
<b>EPA Ambient Water Quality Criteria Recommendations</b>					
Total Phosphorus (mg/L):	0.00	0.05	0.02	< 0.025	none
Total Nitrogen (mg/L):	0.10	1.89	0.55	< 0.44	slightly high
TKN (mg/L):	0.01	1.80	0.33	< 0.3	none
NO2 (mg/L):	0.05	0.10	0.08	NE	n/a
Ammonia (mg/L):	0.03	0.09	0.05	NE	n/a

Impervious Cover: 4.01%, Sensitive Sub-basin (Good Stream Quality)  
 Stressed Basin: No  
 Net Water Budget: Negative



### Sub-basin Statistics

#### Physical Characteristics

Drainage area (sq. mi)	2.01
Drainage area (acres)	1284
Contribution of sub-basin to entire watershed in Westford (%)	12

#### Stream Statistics

Miles of perennial streams	3
Total acres of perennial streams with 200 foot buffers	151
Acres of buffer area around perennial streams lost to impervious surface	9
Miles of intermittent streams	2
Acres of intermittent streams with 200-foot buffers	109
Acres of buffer area around intermittent streams lost to impervious surface	5

#### Land Use

Acres of open space	315
Acres of protected open space	254
% protected open space	20
Acres of unprotected open space	62
% unprotected open space	5
Acres of impervious surface	138
% impervious surface	11

#### Habitat Characteristics

Number of certified vernal pools	1
Number of potential vernal pools	16
Acres of vernal pools with 200-foot buffers	3
Acres of buffer area around vernal pools already lost to impervious surface	0
Acres of Area of Critical Environmental Concern (ACEC)	n/a
Acres of NHESP Priority Habitats of Rare Species	102
Acres of NHESP Estimated Habitats of Rare Wildlife	102
Acres of Wetlands, Marsh, Swamp, and Bogs	102
Acres of Pond/Lakes	8

#### Lands Critical to Sustaining Surface and GW Quality and Quantity

Number Public Water Supply Wells	0
Acres Zone I	0
Acres Zone II	33
Acres Interim Well Protection Areas	0
Acres low-yield aquifer	0
Acres medium-yield aquifer	0
Acres high-yield aquifer	0
Stressed Basin (Y/N)	N
Net Water Budget	Negative

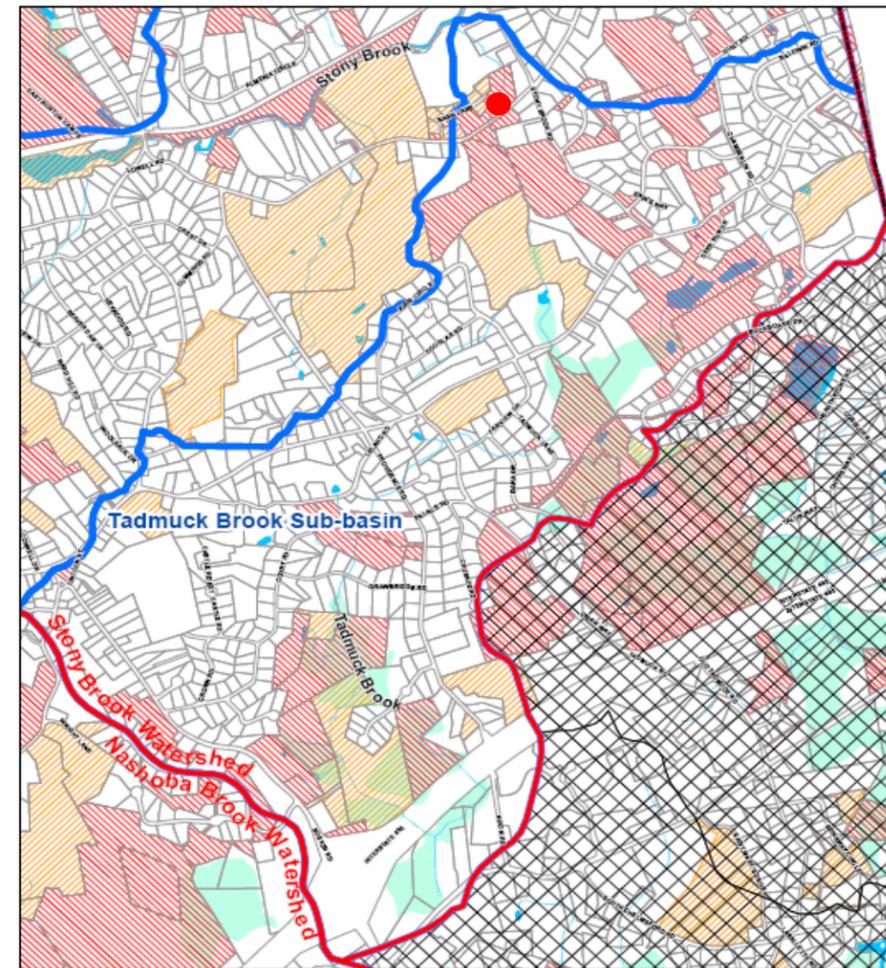
#### Summary of Potential Sources of Pollution

NPDES surface water discharge	0
Groundwater discharges	0
BWP Major Facility	0
MassDEP 21 E Sites	1
Underground Storage Tank	4

### Sub-basin Health Summary

Parameter	Minimum	Maximum	Average	Standard	Concern
<b>Massachusetts Water Quality Standards (314 CMR 4.00)</b>					
Temperature (°C):	10.10	21.60	16.45	<= 28.3	none
pH:	6.17	7.55	6.87	6.5 – 8.3	none
Dissolved Oxygen:	4.40	10.79	8.27	>= 5.0	none
<b>MassDEP 2002 Integrated List of Waters, Part 1</b>					
DO Saturation (%):	41.51	95.30	83.05	>= 60	none
TSS (mg/L):	1.00	6.00	2.80	< 25	none
<b>EPA Ambient Water Quality Criteria Recommendations</b>					
Total Phosphorus (mg/L):	0.01	0.13	0.04	< 0.025	high
Total Nitrogen (mg/L):	0.56	1.74	1.06	< 0.44	high
TKN (mg/L):	0.05	1.20	0.42	< 0.3	slightly high
NO2 (mg/L):	0.12	0.94	0.35	NE	n/a
Ammonia (mg/L):	0.02	0.31	0.08	NE	n/a

Impervious Cover: 10.74%, Impacted Sub-basin (Fair Stream Quality)  
 Stressed Basin: No  
 Net Water Budget: Negative



### Sub-basin Statistics

#### Physical Characteristics

Drainage area (sq. mi)	3.42
Drainage area (acres)	2188
Contribution of sub-basin to entire watershed in Westford (%)	21

#### Stream Statistics

Miles of perennial streams	3
Total acres of perennial streams with 200 foot buffers	164
Acres of buffer area around perennial streams lost to impervious surface	7
Miles of intermittent streams	1
Acres of intermittent streams with 200-foot buffers	52
Acres of buffer area around intermittent streams lost to impervious surface	3

#### Land Use

Acres of open space	448
Acres of protected open space	361
% protected open space	16
Acres of unprotected open space	87
% unprotected open space	4
Acres of impervious surface	215
% impervious surface	10

#### Habitat Characteristics

Number of certified vernal pools	18
Number of potential vernal pools	41
Acres of vernal pools with 200-foot buffers	49
Acres of buffer area around vernal pools already lost to impervious surface	2
Acres of Area of Critical Environmental Concern (ACEC)	n/a
Acres of NHESP Priority Habitats of Rare Species	625
Acres of NHESP Estimated Habitats of Rare Wildlife	625
Acres of Wetlands, Marsh, Swamp, and Bogs	108
Acres of Pond/Lakes	220

#### Lands Critical to Sustaining Surface and GW Quality and Quantity

Number Public Water Supply Wells	3
Acres Zone I	18
Acres Zone II	940
Acres Interim Well Protection Areas	0
Acres low-yield aquifer	0
Acres medium-yield aquifer	443
Acres high-yield aquifer	92
Stressed Basin (Y/N)	N
Net Water Budget	Positive

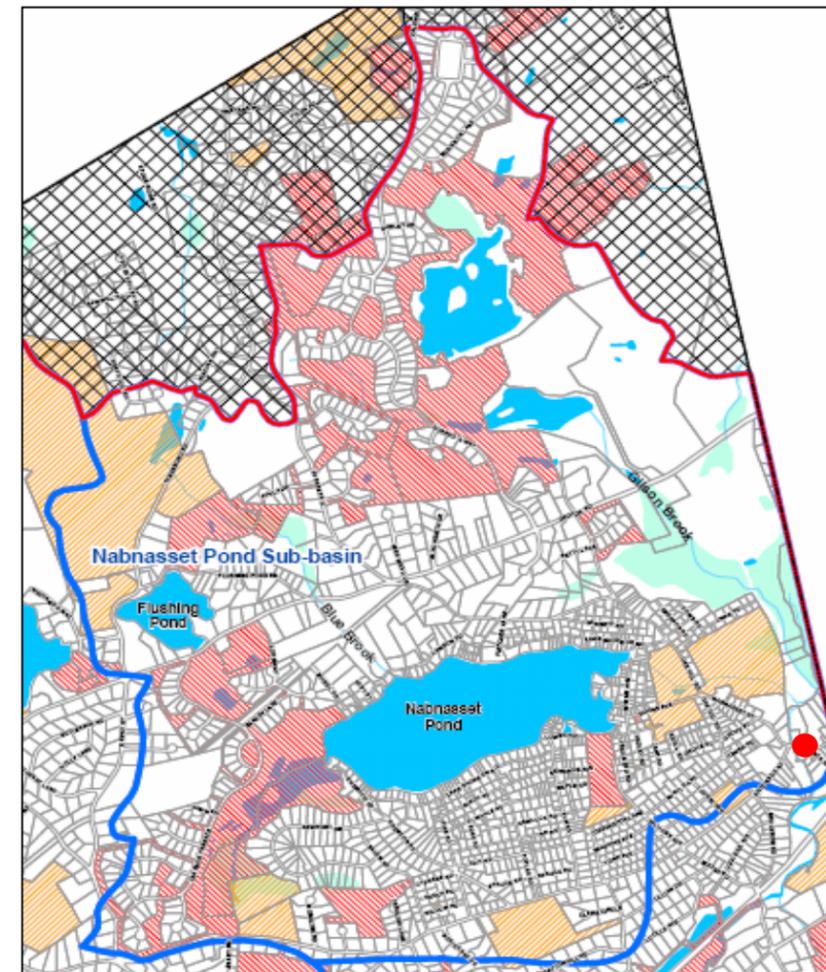
#### Summary of Potential Sources of Pollution

NPDES surface water discharge	1
Groundwater discharges	0
BWP Major Facility	0
MassDEP 21 E Sites	3
Underground Storage Tank	0

### Sub-basin Health Summary

Parameter	Minimum	Maximum	Average	Standard	Concern
<b>Massachusetts Water Quality Standards (314 CMR 4.00)</b>					
Temperature (°C):	11.80	25.20	19.33	<= 28.3	none
pH:	6.30	7.06	6.73	6.5 – 8.3	none
Dissolved Oxygen:	6.10	8.67	7.16	>= 5.0	none
<b>MassDEP 2002 Integrated List of Waters, Part 1</b>					
DO Saturation (%):	54.95	87.90	75.70	>= 60	none
TSS (mg/L):	0.50	7.00	2.65	< 25	none
<b>EPA Ambient Water Quality Criteria Recommendations</b>					
Total Phosphorus (mg/L):	0.00	0.05	0.02	< 0.025	none
Total Nitrogen (mg/L):	0.74	1.39	0.95	< 0.44	high
TKN (mg/L):	0.09	0.86	0.31	< 0.3	none
NO2 (mg/L):	0.28	0.94	0.57	NE	n/a
Ammonia (mg/L):	0.02	0.11	0.06	NE	n/a

Impervious Cover: 9.81%, Sensitive Sub-basin (Good Stream Quality)  
 Stressed Basin: No  
 Net Water Budget: Positive



### Sub-basin Statistics

#### Physical Characteristics

Drainage area (sq. mi)	2.70
Drainage area (acres)	1730
Contribution of sub-basin to entire watershed in Westford (%)	36.32

#### Stream Statistics

Miles of perennial streams	4.45
Total acres of perennial streams with 200 foot buffers	212
Acres of buffer area around perennial streams lost to impervious surface	4
Miles of intermittent streams	2.11
Acres of intermittent streams with 200-foot buffers	116
Acres of buffer area around intermittent streams lost to impervious surface	5

#### Land Use

Acres of open space	587
Acres of protected open space	402
% protected open space	23.24
Acres of unprotected open space	186
% unprotected open space	10.72
Acres of impervious surface	167
% impervious surface	9.66

#### Habitat Characteristics

Number of certified vernal pools	3
Number of potential vernal pools	23
Acres of vernal pools with 200-foot buffers	8
Acres of buffer area around vernal pools already lost to impervious surface	0
Acres of Area of Critical Environmental Concern (ACEC)	n/a
Acres of NHESP Priority Habitats of Rare Species	867
Acres of NHESP Estimated Habitats of Rare Wildlife	859
Acres of Wetlands, Marsh, Swamp, and Bogs	146
Acres of Pond/Lakes	10

#### Lands Critical to Sustaining Surface and GW Quality and Quantity

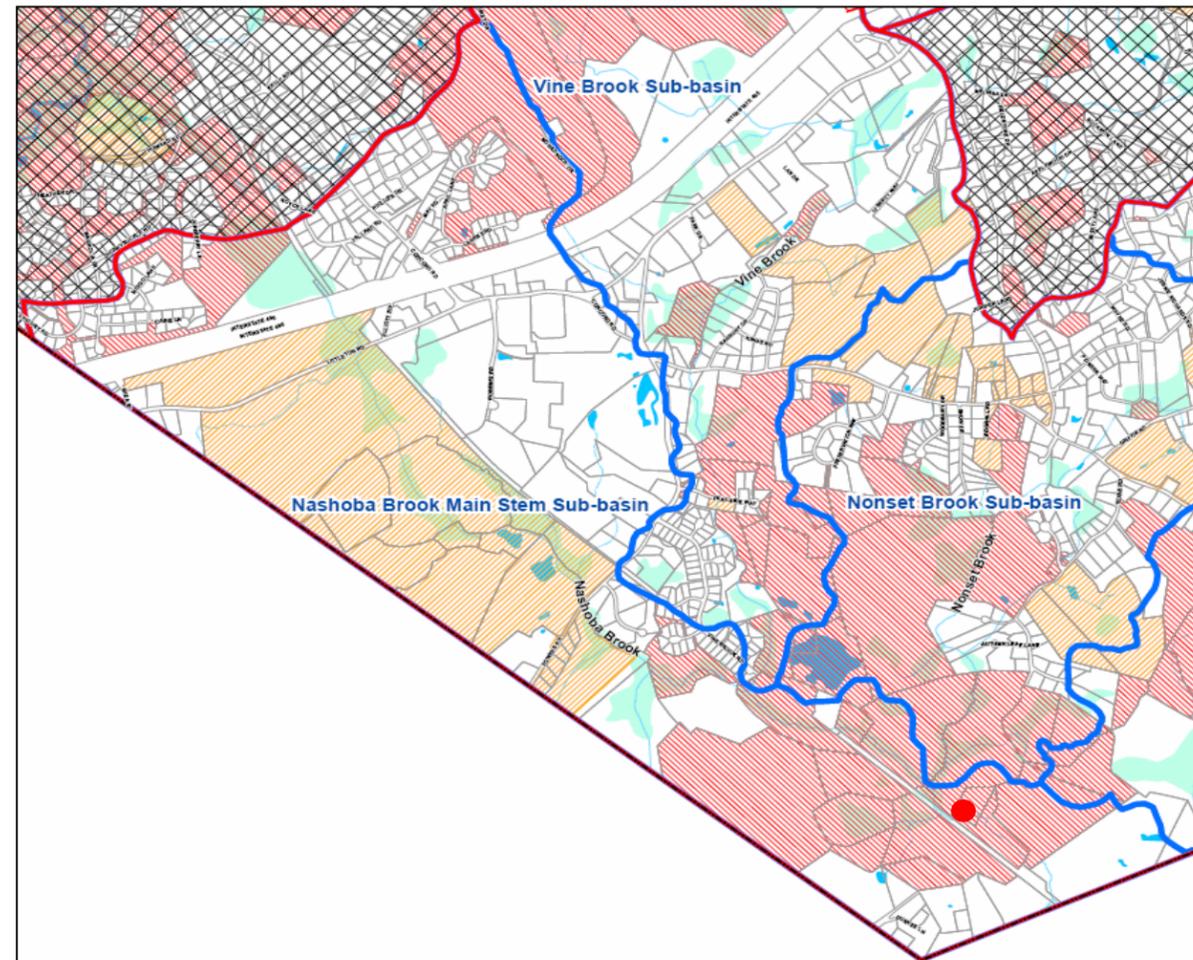
Number Public Water Supply Wells	5
Acres Zone I	37
Acres Zone II	214
Acres Interim Well Protection Areas	326
Acres low-yield aquifer	0
Acres medium-yield aquifer	258
Acres high-yield aquifer	0
Stressed Basin (Y/N)	Y, highly
Net Water Budget	Negative

#### Summary of Potential Sources of Pollution

NPDES surface water discharge	0
Groundwater discharges	1
BWP Major Facility	0
MassDEP 21 E Sites	2
Underground Storage Tank	0

### Sub-basin Health Summary

Parameter	Minimum	Maximum	Average	Standard	Concern
<b>Massachusetts Water Quality Standards (314 CMR 4.00)</b>					
Temperature (°C):	9.40	20.90	15.95	<= 28.3	none
pH:	5.80	7.30	6.59	6.5 – 8.3	none
Dissolved Oxygen:	4.20	8.51	5.75	>= 5.0	none
<b>MassDEP 2002 Integrated List of Waters, Part 1</b>					
DO Saturation (%):	39.66	80.39	56.93	>= 60	slightly low
TSS (mg/L):	2.00	118.00	15.45	< 25	none
<b>EPA Ambient Water Quality Criteria Recommendations</b>					
Total Phosphorus (mg/L):	0.04	0.23	0.11	< 0.025	high
Total Nitrogen (mg/L):	0.18	1.39	0.69	< 0.44	high
TKN (mg/L):	0.01	0.95	0.33	< 0.3	none
NO2 (mg/L):	0.16	0.55	0.32	NE	n/a
Ammonia (mg/L):	0.03	0.10	0.07	NE	n/a
Impervious Cover:	9.65%, Sensitive Sub-basin (Good Stream Quality)				
Stressed Basin:	Yes, highly				
Net Water Budget:	Negative				



### Sub-basin Statistics

#### Physical Characteristics

Drainage area (sq. mi)	2.05
Drainage area (acres)	1312
Contribution of sub-basin to entire watershed in Westford (%)	27.54

#### Stream Statistics

Miles of perennial streams	3.78
Total acres of perennial streams with 200 foot buffers	177
Acres of buffer area around perennial streams lost to impervious surface	9
Miles of intermittent streams	2.91
Acres of intermittent streams with 200-foot buffers	158
Acres of buffer area around intermittent streams lost to impervious surface	7

#### Land Use

Acres of open space	400
Acres of protected open space	368
% protected open space	28.02
Acres of unprotected open space	33
% unprotected open space	2.49
Acres of impervious surface	138
% impervious surface	10.48

#### Habitat Characteristics

Number of certified vernal pools	4
Number of potential vernal pools	32
Acres of vernal pools with 200-foot buffers	12
Acres of buffer area around vernal pools already lost to impervious surface	1
Acres of Area of Critical Environmental Concern (ACEC)	n/a
Acres of NHESP Priority Habitats of Rare Species	239
Acres of NHESP Estimated Habitats of Rare Wildlife	239
Acres of Wetlands, Marsh, Swamp, and Bogs	123
Acres of Pond/Lakes	5

#### Lands Critical to Sustaining Surface and GW Quality and Quantity

Number Public Water Supply Wells	0
Acres Zone I	6
Acres Zone II	0
Acres Interim Well Protection Areas	96
Acres low-yield aquifer	0
Acres medium-yield aquifer	101
Acres high-yield aquifer	0
Stressed Basin (Y/N)	Y, highly
Net Water Budget	Negative

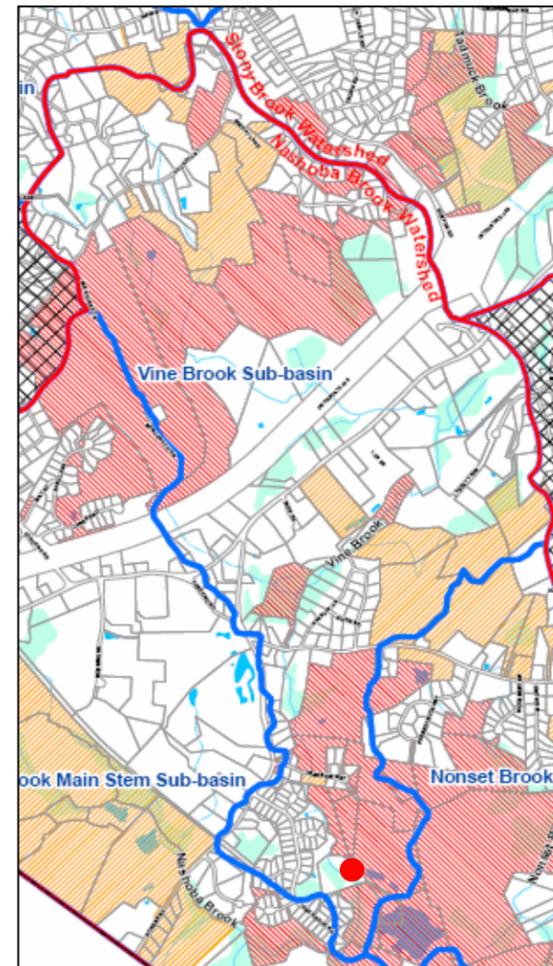
#### Summary of Potential Sources of Pollution

NPDES surface water discharge	0
Groundwater discharges	3
BWP Major Facility	1
MassDEP 21 E Sites	0
Underground Storage Tank	1

### Sub-basin Health Summary

Parameter	Minimum	Maximum	Average	Standard	Concern
<b>Massachusetts Water Quality Standards (314 CMR 4.00)</b>					
Temperature (°C):	9.80	21.10	16.09	<= 28.3	none
pH:	6.05	7.13	6.61	6.5 – 8.3	none
Dissolved Oxygen:	2.80	8.40	6.54	>= 5.0	none
<b>MassDEP 2002 Integrated List of Waters, Part 1</b>					
DO Saturation (%):	28.00	79.00	65.32	>= 60	slightly low
TSS (mg/L):	1.00	51.00	16.20	< 25	none
<b>EPA Ambient Water Quality Criteria Recommendations</b>					
Total Phosphorus (mg/L):	0.03	0.19	0.10	< 0.025	high
Total Nitrogen (mg/L):	0.18	1.39	0.69	< 0.44	slightly high
TKN (mg/L):	0.13	1.58	0.66	< 0.3	slightly high
NO2 (mg/L):	0.09	0.65	0.27	NE	n/a
Ammonia (mg/L):	0.03	0.23	0.09	NE	n/a

Impervious Cover: 10.48%, Impacted Sub-basin (Fair Stream Quality)  
 Stressed Basin: Yes, highly  
 Net Water Budget: Negative



### Sub-basin Statistics

#### Physical Characteristics

Drainage area (sq. mi)	1.34
Drainage area (acres)	856
Contribution of sub-basin to entire watershed in Westford (%)	17.97

#### Stream Statistics

Miles of perennial streams	1.87
Total acres of perennial streams with 200 foot buffers	93
Acres of buffer area around perennial streams lost to impervious surface	2
Miles of intermittent streams	2.74
Acres of intermittent streams with 200-foot buffers	152
Acres of buffer area around intermittent streams lost to impervious surface	5

#### Land Use

Acres of open space	356
Acres of protected open space	327
% protected open space	38.22
Acres of unprotected open space	28
% unprotected open space	3.31
Acres of impervious surface	40
% impervious surface	4.66

#### Habitat Characteristics

Number of certified vernal pools	7
Number of potential vernal pools	14
Acres of vernal pools with 200-foot buffers	20
Acres of buffer area around vernal pools already lost to impervious surface	0
Acres of Area of Critical Environmental Concern (ACEC)	n/a
Acres of NHESP Priority Habitats of Rare Species	561
Acres of NHESP Estimated Habitats of Rare Wildlife	561
Acres of Wetlands, Marsh, Swamp, and Bogs	80
Acres of Pond/Lakes	15

#### Lands Critical to Sustaining Surface and GW Quality and Quantity

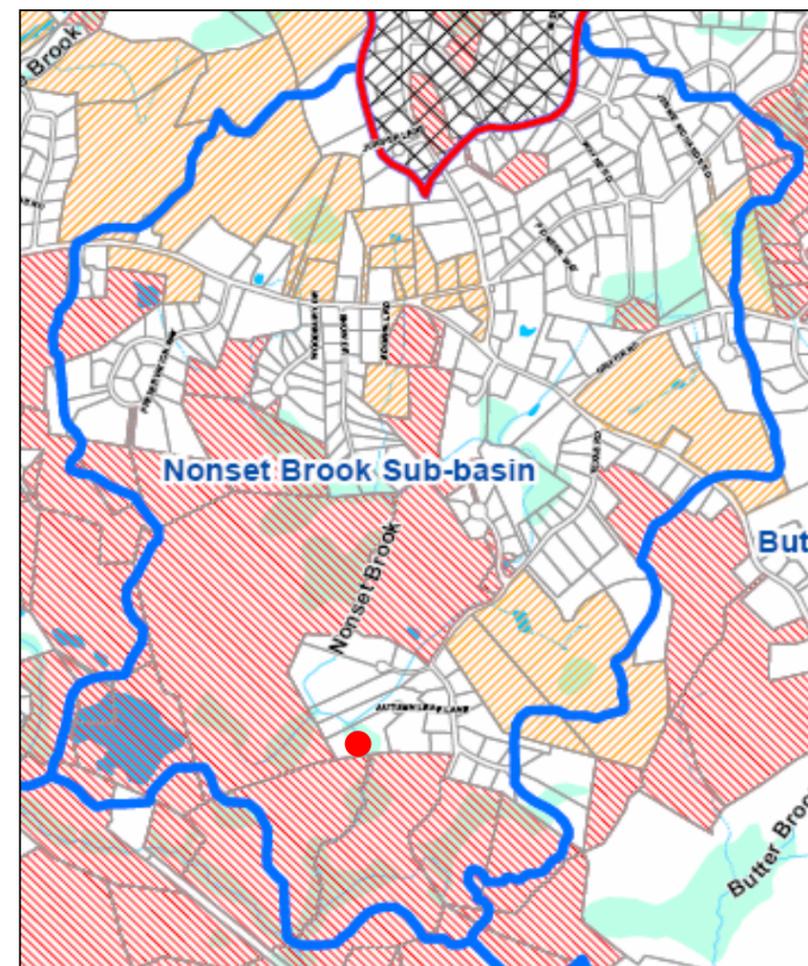
Number Public Water Supply Wells	0
Acres Zone I	3
Acres Zone II	46
Acres Interim Well Protection Areas	101
Acres low-yield aquifer	0
Acres medium-yield aquifer	88
Acres high-yield aquifer	0
Stressed Basin (Y/N)	Y, highly
Net Water Budget	Negative

#### Summary of Potential Sources of Pollution

NPDES surface water discharge	0
Groundwater discharges	0
BWP Major Facility	0
MassDEP 21 E Sites	0
Underground Storage Tank	0

### Sub-basin Health Summary

Parameter	Minimum	Maximum	Average	Standard	Concern
<b>Massachusetts Water Quality Standards (314 CMR 4.00)</b>					
Temperature (°C):	9.40	22.60	16.82	<= 28.3	none
pH:	5.58	6.52	6.06	6.5 – 8.3	low
Dissolved Oxygen:	1.80	5.83	3.08	>= 5.0	low
<b>MassDEP 2002 Integrated List of Waters, Part 1</b>					
DO Saturation (%):	19.59	52.00	30.89	>= 60	low
TSS (mg/L):	1.00	140.00	35.60	< 25	high
<b>EPA Ambient Water Quality Criteria Recommendations</b>					
Total Phosphorus (mg/L):	0.01	0.11	0.05	< 0.025	slightly high
Total Nitrogen (mg/L):	0.21	1.27	0.44	< 0.44	none
TKN (mg/L):	0.11	1.26	0.46	< 0.3	slightly high
NO2 (mg/L):	0.01	0.20	0.07	NE	n/a
Ammonia (mg/L):	0.03	0.39	0.14	NE	n/a
Impervious Cover:	4.66%, Sensitive Sub-basin (Good Stream Quality)				
Stressed Basin:	Yes, highly				
Net Water Budget:	Negative				



### Sub-basin Statistics

#### Physical Characteristics

Drainage area (sq. mi)	1.35
Drainage area (acres)	866
Contribution of sub-basin to entire watershed in Westford (%)	18.17

#### Stream Statistics

Miles of perennial streams	2.74
Total acres of perennial streams with 200 foot buffers	134
Acres of buffer area around perennial streams lost to impervious surface	4
Miles of intermittent streams	1.56
Acres of intermittent streams with 200-foot buffers	88
Acres of buffer area around intermittent streams lost to impervious surface	4

#### Land Use

Acres of open space	193
Acres of protected open space	189
% protected open space	21.77
Acres of unprotected open space	5
% unprotected open space	0.53
Acres of impervious surface	55
% impervious surface	6.35

#### Habitat Characteristics

Number of certified vernal pools	5
Number of potential vernal pools	6
Acres of vernal pools with 200-foot buffers	14
Acres of buffer area around vernal pools already lost to impervious surface	1
Acres of Area of Critical Environmental Concern (ACEC)	n/a
Acres of NHESP Priority Habitats of Rare Species	324
Acres of NHESP Estimated Habitats of Rare Wildlife	324
Acres of Wetlands, Marsh, Swamp, and Bogs	79
Acres of Pond/Lakes	2

#### Lands Critical to Sustaining Surface and GW Quality and Quantity

Number Public Water Supply Wells	1
Acres Zone I	12
Acres Zone II	357
Acres Interim Well Protection Areas	15
Acres low-yield aquifer	0
Acres medium-yield aquifer	19
Acres high-yield aquifer	0
Stressed Basin (Y/N)	Y, highly
Net Water Budget	Negative

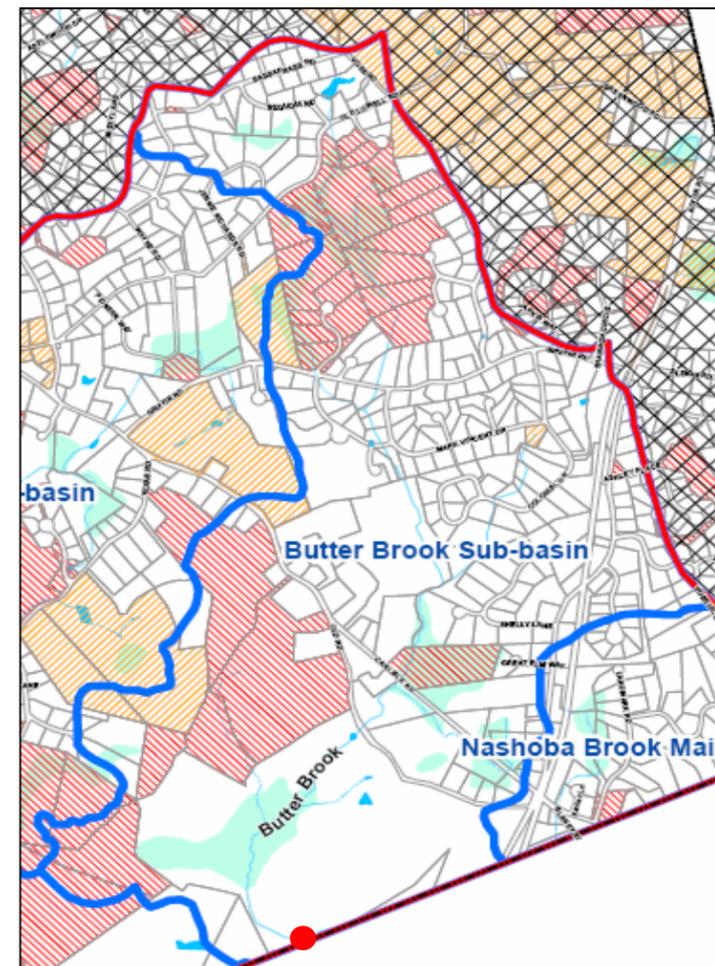
#### Summary of Potential Sources of Pollution

NPDES surface water discharge	0
Groundwater discharges	0
BWP Major Facility	0
MassDEP 21 E Sites	0
Underground Storage Tank	0

### Sub-basin Health Summary

Parameter	Minimum	Maximum	Average	Standard	Concern
<b>Massachusetts Water Quality Standards (314 CMR 4.00)</b>					
Temperature (°C):	8.90	19.00	15.06	<= 28.3	none
pH:	5.54	6.97	6.29	6.5 – 8.3	low
Dissolved Oxygen:	5.37	9.04	6.66	>= 5.0	none
<b>MassDEP 2002 Integrated List of Waters, Part 1</b>					
DO Saturation (%):	45.38	87.00	64.82	>= 60	none
TSS (mg/L):	0.50	36.00	4.85	< 25	none
<b>EPA Ambient Water Quality Criteria Recommendations</b>					
Total Phosphorus (mg/L):	0.01	0.08	0.05	< 0.025	high
Total Nitrogen (mg/L):	0.06	1.41	0.65	< 0.44	high
TKN (mg/L):	0.01	0.73	0.24	< 0.3	none
NO2 (mg/L):	0.01	1.20	0.41	NE	n/a
Ammonia (mg/L):	0.02	0.09	0.05	NE	n/a

Impervious Cover: 6.35%, Sensitive Sub-basin (Good Stream Quality)  
 Stressed Basin: Yes, highly  
 Net Water Budget: Negative



## 5. WATERSHED ACTION PLAN

The Watershed Action Plan for Stony Brook and Nashoba Brook was developed with the following watershed priorities in mind:

1. Maintain or restore natural watershed function;
2. Protect sensitive and unique terrestrial and aquatic habitat;
3. Proactively manage known sources of pollution;
4. Protect the drinking water aquifer; and
5. Attain water quality standards in Westford's surface waters.

The Watershed Action Plan is divided into five separate elements as follows:

- Open Space Protection Plan,
- Municipal Operations Program,
- Regulatory Improvement Plan,
- Education and Outreach Program, and
- Long-term Water Quality Monitoring Program.

These five elements take into account specific conditions in each subwatershed as well as general watershed protection measures. Likewise, the Watershed Action Plan is consistent with recommendations made in various planning studies, many of which are described in Section 2. Each plan is divided into tasks with a recommended timeline for implementation. Sufficient data has been collected to date by local and regional groups to adequately characterize challenges and evaluate long-term trends in each sub-basin; no additional large-scale watershed assessments are recommended at this time.

The action plans use a 5-year timeline. W&C recommends that the Watershed Action Plan be reevaluated after five years to realign goals and actions based on new data, progress on plan implementation, changing local priorities, and policy changes.

It should be noted that the Town, through the efforts of various boards, committees, and local organizations, has historically devoted significant resources to watershed protection, meeting many of the recommendations of each of the five elements of this plan. However, we suggest that the ongoing activities recommended in this plan be better coordinated among the different groups. At a minimum, information sharing and more frequent communication will make watershed protection efforts in Town more efficient, and ultimately may yield better results.

### 5.1 OPEN SPACE PROTECTION PLAN

As discussed in Section 3, there are many organizations interested in preserving and protecting open space in Westford, and various potential means of providing protection for open space land have been identified. Multiple plans and studies addressing the subject have been conducted and the value of preserving open space for recreation, water supply, wildlife and fisheries habitat, hydrologic and aesthetic/scenic purposes, and the threat of losing existing, unprotected open space land to development, is keenly recognized.

Parcels identified as having particular open space and water resources protection value are listed and prioritized in Westford's 2002 Open Space and Recreation Plan (Open Space Plan), Technical Paper #4 – Open Space and

Recreation of Westford’s June 2007 Draft Master Plan Update (TP#4), and the 2002 Final Report of the Westford Land Use Priorities Committee (LUPC Final Report). Both the Open Space and Recreation Plan and the Master Plan are currently being updated. These reports should be relied upon to prioritize future land acquisition and land protection efforts in the Stony Brook and Nashoba Brook watersheds.

Westford should continue the activities to protect and preserve Open Space land identified and started in the Open Space Plan. In particular, the following actions should be taken, or continued:

- Seek creative financing techniques and grants to fund open space purchases or conservation restrictions,
- Work with the Westford Conservation Trust to be prepared when Chapter 61 properties become available for purchase to take advantage of the first right of refusal,
- Investigate potential purchase or other means of protecting the parcels identified in the LUPC Final Report as High Priority Parcels for Conservation Use, especially those identified for Water Resource protection,
- Investigate potential purchase, or other means of protecting the critical unprotected parcels listed in Appendix I of the Open Space Plan, discuss with landowners,
- Promote, and purchase or otherwise protect, greenways and trails along all major waterways
- Transfer land under Selectmen’s control to Conservation Commission for permanent protection
- Enforce and enhance Water Resources Protection Bylaw
- Use local Wetlands By-law and Rivers Protection Act to protect perennial streams and brooks from development impacts,
- Encourage use of Flexible Development standards to gain open space, particularly when it is adjacent to existing Open Space and water bodies, and
- Encourage trails in conservation restriction land as part of subdivision development, link new trails to those already in place. Complete and keep mapped inventory of trails current.

In summary, the Town of Westford must continue to investigate creative ways of protecting and preserving open space for water resource protection. As stated in the 2007 Draft Master Plan, that the community supports expenditure of resources to acquire and maintain open space lands for the future. This not only protects Westford’s natural resources, but it preserves the character of the community for future generations. The following table summarizes the action plan for land protection.

<b>ACTION PLAN: Open Space Protection Plan (2008-2012)</b>		
<b>1</b>	<b>Continue to Implement the Recommendations of the Land Use Priorities Committee <i>Final Report (2002)</i>, the <i>Master Plan</i> and the <i>Open Space and Recreation Plan (2002)</i>, as they may be updated</b>	The Land Acquisition Oversight Committee, as well as the Open Space Committee, will oversee the execution of these plans, including determination of priority lands, methods of permanent protection, funding mechanisms, and cooperation with property owners.  These groups should work with the Westford Conservation Trust to the extent possible to secure conservation lands.
<b>2</b>	<b>Planning Board and Zoning Board of Appeals Will Encourage Smart Growth Techniques to Permanently Preserve Open Space in Sensitive Areas</b>	See Section 5.3 for recommended Regulatory Improvements.

## 5.2 MUNICIPAL OPERATIONS PROGRAM

The Town of Westford is covered under the EPA Phase II National Pollutant Discharge Elimination System (NPDES) program and is thereby required to implement Best Management Practices (BMPs) to minimize the pollutants entering the municipal separate storm sewer system (MS4). Under this program, the Town is required to employ maintenance and housekeeping procedures at their facilities. Below is a list of appropriate maintenance and housekeeping BMPs that the Town should use at their facilities to minimize pollution.

- Fully embrace and implement guidelines in Storm Water Pollution Prevention Plans (SWPPPs) that have been prepared for the Highway Garage. Items include:
  - Carefully handle and recycle waste oil
  - Store hazardous materials inside
  - Provide employee training
  - Keep salt and salt/sand piles covered
- Fully embrace and implement guidelines in SWPPPs for other municipal facilities where storm water discharges are covered by the Multi-Sector General Permit for the Discharge of Stormwater from Industrial Activities (MSGP), or where there is potential for pollution to be carried from the site by stormwater.
- Develop storm water management and pollution prevention plans for the municipal facilities that aren't covered by the MSGP.
- Develop and abide by Storm Water Pollution Prevention Plans prepared for construction activities conducted on behalf of the Town such as roadway improvements and construction of new public buildings.
- Provide Town employee and contractor training so they understand the importance of preventing and reducing the flow of pollutants to water resources.
- Sweep streets at least annually. Preferably as soon as possible after snowmelt.
- Clean catch basins at least once a year and develop a program to evaluate need to clean them more frequently.
- Check for areas of erosion in ditches and at outfalls; repair when necessary.
- Develop program for evaluation, and repair if necessary, of storm drain infrastructure to minimize groundwater infiltration and sediment entry through conveyances and structures.
- Post appropriate informational signs and encourage litter and pet waste control in Town public areas.
- Develop, implement, and enforce local stormwater by-laws that prohibit illicit discharges and require stormwater management at new construction and redevelopment sites.
- Develop and implement a plan to respond to spills, particularly when there is danger that the spill could result in contamination of the storm drain system or receiving surface or ground waters. Ensure adequate funding and staffing is available to provide necessary equipment, supplies, training, and personnel to respond to spills in a timely manner when needed.
- Proactively manage proper procedures and on-going maintenance are conducted at operations in Westford that potentially contribute pollutants to water resources in the Town. In addition to Town facilities this would include any mining operations, solid waste facilities, hazardous waste sites, and facilities covered by the EPA MSGP.

This action plan will help minimize the introduction of pollutants into water resources from operations under the control of the Town of Westford.

<b>ACTION PLAN: Municipal Best Management Practices to Protect Water Resources (2008-2012)</b>		
<b>1</b>	<b>Locally implement and enforce EPA's NPDES program</b>	BMPs, as stipulated in the program's MS4 General Permit to be developed, implemented and enforced.
<b>2</b>	<b>Be prepared for emergency spills to the MS4 and downstream receiving waters</b>	<p>The Massachusetts Emergency Management Agency (MEMA) and the Town of Westford have prepared a Comprehensive Emergency Management Plan (CEMP) that is periodically updated. The most recent version is dated October 2007. Copies of this plan, which is confidential, are kept by the Town Manager, Emergency Management Directors, Police and Fire Chiefs and the Highway Dept.</p> <p>We recommend that the Town continue to use the CEMP for any emergency spills that threaten Westford's water resources. Staff training and up-to-date drainage mapping are critical components of this program</p>
<b>3</b>	<b>Be aware of management practices and their employment at Hazardous Waste Sites</b>	<ul style="list-style-type: none"> <li>• Maintain up-to-date maps of Hazardous Waste Site locations</li> <li>• Get periodic tracking updates from MassDEP</li> <li>• Ensure site management is following correct clean-up and site management practices</li> <li>• Enforce local Hazardous Material Bylaw</li> </ul>

### 5.3 REGULATORY IMPROVEMENT PLAN

As discussed in previous sections, there is a considerable amount of unprotected open space in Westford that is susceptible to future development. Town-wide, there are about 80 properties with a total of 1,900 acres in Westford that are subject to temporary restrictions under M.G.L. c.61, c.61A or c.61B. Additionally, Westford has several large, residentially zoned parcels with no protection in place to prohibit or limit future development. Considering both land owned by private individuals and non-profit organizations, these parcels include a combined total of about 1,500 acres, though not all of this and is currently considered developable. Westford also has many small, vacant parcels that may seem less important when viewed individually, but together, they include a considerable amount of land. Throughout Westford, there are hundreds of "underdeveloped" parcels – these parcels are 3 acres or more in size that are considered developed, but could be subdivided or redeveloped to their full potential under current zoning. These smaller parcels provide open space in areas that have largely been developed, and this makes them important from a neighborhood perspective. Collectively, unprotected residential land parcels in Westford today contain about 1,030 acres.<sup>60</sup>

<sup>60</sup> All undeveloped land and open space estimates are from *Technical Paper #4 – Open Space and Recreation*, prepared by the Westford Comprehensive Master Plan Committee. Draft Westford Comprehensive Plan. August 2007.

With significant potential for future development, impervious cover in the Stony Brook and Nashoba Brook watersheds could easily exceed the 15% target for healthy streams based on the Impervious Cover Model. Increased and contaminated stormwater runoff associated with developed land uses and the impacts of soil erosion and sedimentation are known to cause:

- Impairment of water quality and flow in lakes, ponds, streams, rivers, wetlands, and groundwater;
- Contamination of drinking water supplies;
- Erosion of stream channels;
- Alteration and destruction of aquatic and wildlife habitat;
- Flooding; and
- Overloading or clogging of municipal storm drain systems.

It is not economically feasible to acquire or otherwise permanently protect all of the open space in town. Most of the town's land acquisition and land protection efforts target large unprotected parcels, and the smaller undeveloped lands are left vulnerable to land development projects. Therefore, it is critical to establish sound local regulations that will guide development and redevelopment projects in terms of where in town certain types of development should occur and what techniques and design standards should be implemented to best protect Westford's natural resources.

To that end, Westford has been forward thinking and ahead of many communities in Massachusetts in their efforts to adopt and enforce these types of Zoning and non-zoning bylaws. Local codes promoting watershed protection and growth management are listed below. Not to be overlooked, the Town has also adopted bylaws and regulations that prohibit the discharge of hazardous materials and other types of pollution into the environment. The following local bylaws have been adopted to help meet the aforementioned watershed protection goals:

- Westford Zoning Bylaw
  - Growth Management (Section 6 – Special Regulations)
  - Open Space Residential Development (Section 7 – Special Residential Regulations)
  - Flexible Development (Section 7 – Special Residential Regulations)
  - Water Resource Protection Overlay District (WRPOD) (Section 8 – Special Districts)
  - Floodplain Overlay District (FOD) (Section 8 – Special Districts)
  - Conservation Overlay District (COD) (Section 8 – Special Districts)
  - General site design and construction standards
- Westford General Bylaws
  - Chapter 61 - Hazardous Materials Storage
  - Chapter 90 – Earth Removal
  - Chapter 160 – Trees and Plants
  - Chapter 171 - Wetlands
- Subdivision Rules and Regulations – General site design and construction standards

Additionally Master Planning efforts further shape the local land use patterns. For example, Westford has designated a development corridor, which has been very successful in attracting business growth. Directing growth can have the effect of saving “greenfields” — undeveloped rural lands — from development.<sup>61</sup> The updated Master Plan will also highlight areas where development should be discouraged or closely regulated, such as stream buffers, aquifer protection areas, and sensitive habitat. This approach to town-wide planning for natural resource protection is an important concept in “Smart Growth”, which is more broadly defined as “well-planned development that protects open space and farmland, revitalizes communities, keeps housing affordable and provides more transportation choices.” The Commonwealth of Massachusetts encourages communities to adopt and implement smart growth measures in order to realize the many environmental, fiscal, and social benefits of smarter land use.<sup>62</sup>

Suggested improvements to local regulations and other actions with the purpose of watershed protection in Westford are summarized in the Action Plan below.

<b>ACTION PLAN: Regulatory Improvement Plan (2008-2012)</b>		
<b>1</b>	<b>Stormwater and LID By-law</b>	<p>Under the NPDES Phase II Stormwater Program, communities are required to adopt and enforce a bylaw that controls construction site and post-construction stormwater runoff. This bylaw will expand the Town’s authority to control stormwater to all land-disturbing activities that disturb one acre or more, regardless of Wetlands jurisdiction or applicability of Subdivision or Zoning regulations. The Town has begun to create this bylaw and plans to present it for adoption at the 2008 Town Meeting.</p> <p>This bylaw presents an opportunity to incorporate low impact development (LID) techniques into local stormwater management and drainage design. These techniques are smaller, distributed throughout the site, and typically recharge stormwater, mimicking the natural hydrology of the watershed.</p> <p>As part of the process to develop this new bylaw, the Town should also consider modifications to the Subdivision Rules and Regulations that will allow the use of LID techniques in lieu of traditional pipe and pond stormwater management practices.</p>
<b>2</b>	<b>By-law Prohibiting Illicit Discharges to the Municipal Drainage System</b>	<p>Another requirement of the NPDES Phase II Stormwater Program, which has not yet been incorporated into Westford’s local regulations, is a bylaw that prohibits the discharge of pollution into the storm drain system. This bylaw should also prohibit illegal dumping of pollutants anywhere in Westford.</p>
<b>3</b>	<b>Dog Fouling or “Pooper Scooper” Law</b>	<p>Westford has established a leash law in the General Bylaws, Chapter 84 – Dogs. In addition to requiring that dogs be kept on their leash, this bylaw should be modified to require dog owners to</p>

<sup>61</sup> Northern Middlesex Council of Governments (NMCOG). 2020 Vision: Planning for Growth in the Northern Middlesex Region. June 1999.

<sup>62</sup> Executive Office of Energy and Environmental Affairs (EOEA). Smart Growth / Smart Energy Toolkit. [http://www.mass.gov/envir/smart\\_growth\\_toolkit/](http://www.mass.gov/envir/smart_growth_toolkit/)

		<p>remove and properly dispose of any feces left by their dogs. This bylaw should cover waste left by dogs on sidewalks, streets, parks and neighbors' yards.</p> <p>Fecal coliform bacteria, an indicator organism for potentially harmful microorganisms in water, is found in pet waste and easily travels in stormwater runoff to local waterways. Controlling pet waste is especially important in the Stony Brook watershed as pathogens are a pollutant of concern and the subject of a draft TMDL for the Merrimack River Watershed.</p>
4	<p><b>Continue to Implement Zoning that Encourages Smart Growth – Transfer of Development Rights (TDR) Density Bonus Approach</b></p>	<p>The Zoning Bylaw Special Residential Regulations for Open Space Residential Development and Flexible Development are excellent methods to preserve open space within a subdivision or contiguous set of parcels held in common ownership.</p> <p>Westford should consider implementing the Density Bonus Approach of TDR that creates a Preservation (or “Sending”) District and a Receiving District that allows transfer of development rights by Special Permit to a parcel that is not necessarily contiguous. This bylaw may help to curb the existing sprawl pattern of development while fostering growth levels and densities that are higher than what existing zoning allows in specific areas. The Comprehensive Master Plan Committee would need to play a large part in determining the boundaries of these districts.</p> <p>A model TDR Bylaw from the EEA Smart Growth /Smart Energy Toolkit is included in Appendix D.</p>
5	<p><b>Rely on State Law to Protect Sensitive and Threatened Resources</b></p>	<p>Westford should continue their efforts to obtain state certification of sensitive areas, such as Outstanding Resource Waters (e.g., Certified Vernal Pools), NHESP Priority Habitats of Rare Species, Cold Water Fisheries, and others. These designations provide additional protection under State law that should be locally enforced to the maximum extent practicable.</p>

#### 5.4 EDUCATION AND OUTREACH PROGRAM

Westford is a community with a very involved public as evidenced by the past activities of the Land Use Priorities Commission, and current levels of participation in the Master Plan update process. Survey information reported in the Draft Master Plan indicates that the public is concerned with and puts a high value on the natural and cultural environments that exist in Westford, and have expressed an interest in having the Town expend funds to preserve those environments to the greatest extent possible. Non-profit organizations actively work with the Town to protect and preserve lands, and on a regional basis Westford has the Merrimack River Watershed Team and the SuAsCo Watershed Community Council and SuAsCo Stormwater Community Assistance Program, organizations who show interest in and care for the waters that flow through Westford.

As part of its Stormwater Management Program, developed in compliance with the EPA NPDES General Permit for Storm Water Discharges from Municipal Separate Storm Sewer Systems (MS4 General Permit), the Town has identified activities to educate the public about stormwater and illicit discharges. Education about these topics directly ties to education about watershed protection. Similar education and outreach efforts are ongoing through the Water Department, with topics such as water conservation and pesticide and fertilizer awareness, and additional information is available through the Conservation Commission and the Board of Health.

Westford also has initiatives that involve the public and their participation in the promotion of activities to improve water quality and minimize stormwater pollution in the community. Some of those activities that are on-going and likely to be continued include:

- Use traveling stormwater display to involve 5<sup>th</sup> graders in stormwater management priorities
- Volunteer water quality sampling at sites in the Stony Brook and Nashoba Brook watersheds coordinated by Westford's Watershed Conservation Association.
- The Water Department teaches 4<sup>th</sup> graders about the water cycle, the Town's drinking water system, ways to conserve water at home, and preventing water pollution.
- Outreach to 5<sup>th</sup> grade campers at the East Boston Camp to find indicator organisms in ponds and learn about water quality indicators and sampling.

Using classroom materials developed through Westford's partnership with the SuAsCo Watershed Community Council, the Engineering Department and the Water Department just completed a week long Living Lab education program for all fifth grade students in Westford. The award winning Living Lab program introduces fifth grade students to the responsible stewardship of natural resources. Students were also given an outdoor demonstration of how storm drains function along the Reed Brook. Students brainstorm ways to prevent water pollution from sources such as farms, construction sites, factories, and more.

In addition, the Town website currently has a Stormwater Management section, which describes some of the activities conducted that affect the Town's watersheds and includes links to the MassDEP Stormwater website, the Center for Watershed Protection website, the SuAsCo Watershed Community Council website, and the Organization for the Assabet River website. The Water Department web page also has educational material posted, such as the InFLOWmation Newsletter and a Kid's Area.

In order to further educate the community about watershed protection, the following plan should be implemented in the next five years.

<b>ACTION PLAN: Public Education and Involvement (2008-2012)</b>		
<b>1</b>	<b>Promote Watershed Stewardship through Multi-Media Public Education</b>	<p>Westford will continue to educate the public through various methods, including:</p> <ul style="list-style-type: none"> <li>– Town Website</li> <li>– Cable TV</li> <li>– Distribution of Brochures, fliers, and newsletters</li> <li>– Signage</li> <li>– Press Releases</li> </ul> <p>Future topics to consider are illicit discharges and illegal dumping, pet waste, and invasive species identification. At trailheads and water body access points, informational materials should include a</p>

		phone number for reporting suspicious activity. Links to relevant reports, flyers, and state websites for additional information should also be included on the Town's website whenever possible.
2	<b>Encourage Public Participation</b>	The Town should continue outreach and participation through various programs at Westford's schools. In addition, WENAC and OAR should continue to recruit volunteers in Westford in their water quality monitoring efforts.
3	<b>Coordination with Regional Watershed Groups</b>	<p>The Town should continue to coordinate with OAR in their water quality sampling efforts, and begin to coordinate with the Merrimack River Watershed Council and SuAsCo, particularly in their efforts to promote water conservation and non-point source education (flyers, brochures, posters, workshops, and other outreach methods). These regional watershed groups are a valuable resource for obtaining low-cost informational materials.</p> <p>Additionally, partnering with these groups in watershed protection efforts can leverage state and federal grant funding and add a regional perspective to projects in Westford.</p>

## 5.5 LONG-TERM WATER QUALITY MONITORING PROGRAM

A long-term water quality monitoring program is essential to any watershed management plan to document trends in water quality and stream flow and monitor effectiveness of watershed management efforts. The Westford Watershed Conservation Association started monitoring in the Nashoba Brook and Stony Brook watersheds in 2006 using the Organization for the Assabet River's (OAR) StreamWatch sampling methods. The monitoring program is also supported by the Westford Water Department, who have provided additional funding and equipment. The objectives of this program are to:

- Assess whether the rivers meet the state's Water Quality Standards (Class-B).
- Assess the effect of changes in the management of point and non-point pollution sources as the state's TMDL recommendations, NPDES permits, and this Watershed Action Plan are implemented.
- Provide sound scientific information to support OAR's advocacy for the rivers.
- Identify problem spots for further investigation.
- Understand the connections between water quality, streamflow, and habitat for native fish and to identify habitat-stressed sub-basins.
- Raise awareness of the tributaries, influence short-term water conservation decisions, and to build long-term capacity across the watershed for making water management decisions that will protect the ecological integrity of the watershed.

Appendix C contains the "StreamWatch – Westford Section, Water Monitoring Manual" dated May 2007, which describes the sampling program in detail. **We recommend that this program continue each summer with minimal changes.**

---

Monitoring is done in two parts:

- Weekly staff gage readings (for gaged tributary sites); and
- Monthly water quality sampling.

Water quality indicators are:

- Observations: Include an estimate of channel flow status (score from 1 to 20), weather, etc.
- In Situ Testing: dissolved oxygen (DO), pH, and temperature
- Laboratory Analysis: ammonia, nitrate, ortho-phosphorus, total kjeldahl nitrogen (TKN), total nitrogen (TN), total phosphorus, and total suspended solids

During routine monitoring events, volunteers record observations that include an estimate of channel flow status (score from 1 to 20), weather conditions, and more. We recommend that field observations also include:

- Any infractions of wetlands and river regulations and local bylaws. If such conditions exist, notify the Conservation Commission and/or property owners; and
- The occurrence of invasive species. If non-native species are observed, consult the regional watershed association (Merrimack River or SuAsCo) for guidance to control the impact of these species on the local ecosystem.

The sampling locations were strategically chosen by OAR and the Westford Watershed Conservation Association to characterize stream health and pollutant contribution from discrete sections of the Stony Brook and Nashoba Brook watersheds. If funding is available, we suggest including two additional sampling locations in the program. We recommend one additional sampling location on Nashoba Brook off Powers Road to quantify potential upstream sources, such as Kimball Farm and the Nashoba Valley Ski Area, before the confluence of Vine Brook and Nonset Brook. We also recommend collecting data from Reed Brook, as this is a delicate ecosystem designated as a Cold Water Fishery. Information collected by K-5 students through the Living Lab program at Reed Brook can also be incorporated into the annual Water Quality Monitoring summary reports. The sampling locations, including the recommended changes, are summarized in the tables below. Potential sources of pollution and impervious cover percentages within each sub-basin to consider in interpretation of the water quality and quantity data are described in Section 3.

**Table 8: Westford Sampling Sites - 2007**

Watershed	Site #	Site Name	Lat/Long
Stony Brook	BOU(S)-006	Boutwell Brook	42° 35.26'N, 71° 27.68'W
	KEY(S)-001	Keyes Brook	42° 35.84'N, 71° 26.21'W
	GIL(S)-001	Gilson Brook	42° 36.96'N, 71° 24.55'W
	TAD(S)-003	Tadmuck Brook	42° 35.86'N, 71° 25.15'W
	STN(S)-031	Stony Brook at Brookside	42° 36.58'N, 71° 24.64'W
	STN(S)- 070	Stony Brook at Pleasant	42° 34.71'N, 71° 29.39'W
Nashoba Brook	VIN(N)-006	Vine Brook	42° 32.77'N, 71° 26.08'W
	NON(N)-002	Nonset Brook	42° 32.18'N, 71° 25.32'W
	BUT(N)-007	Butter Brook	42° 31.88'N, 71° 24.05'W
	NSH(N)-066	Nashoba Brook	42° 31.94'N, 71° 25.25'W

**Table 9: Proposed Additional Sampling Sites**

Watershed	Site #	Site Name	Lat/Long
Stony Brook	REE(S)- TBD	Reed Brook	Actual location to be determined in the field
Nashoba Brook	NSH(N)- TBD	Nashoba Brook @ Powers	Actual location to be determined in the field

The following table describes the Town's five-year plan for water quality monitoring.

<b>ACTION PLAN: Long-Term Water Quality Monitoring (2008-2012)</b>		
<b>1</b>	<b>Continue Water Quality Monitoring</b>	<p>Westford Watershed Conservation Association will continue to lead water quality monitoring efforts each summer with assistance from OAR and the Town as necessary.</p> <p>We recommend adding the two additional sampling sites in Table 9. If budget allows in the future, extend the annual sampling period into the spring and fall.</p> <p>When evaluating the results of the sampling program, consider</p>

		e.coli sampling at public beaches conducted by the Board of Health and coordinate the timing of sampling as necessary. Also consider data collected by the Engineering Department as part of the Town's Illicit Discharge Detection and Elimination Program.
2	<b>Training Program for Volunteers and Staff</b>	Before each sampling season begins, the field team will be trained by experienced members of the Westford Watershed Conservation Association and/or OAR on the proper sampling and measurement protocol, safety precautions, and other topics to assist with field observations.
3	<b>Coordination with Other Local Water Quality Monitoring Efforts</b>	Through various state and federal mandated programs, Town boards are often required to collect water quality data. For example, the Engineering Department recently performed dry weather sampling at drainage outfalls. Westford Watershed Conservation Association, the Engineering Department, and the Conservation Commission will communicate as necessary to keep each other informed of monitoring efforts and to share data with the goal of quickly identifying sources of pollution and areas of concern.

## 6. REFERENCES & ACKNOWLEDGEMENTS

Woodard & Curran would like to acknowledge the active participation of following members of Westford's Smart Growth Advisory Committee throughout development and review of this Watershed Action Plan: Jessica Cajigas, John Livsey, Darren Maccaughey, Peter Severance, Paul Starratt, Carol Tucker, and Beverly Woods. Woodard & Curran also acknowledges William Turner of the Westford Conservation Commission and Judi Barrett of the Community Opportunities Group, Inc., for their assistance updating open space information.

The preparation of this report was funded through a grant from the Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA) under the Smart Growth Technical Assistance grant program.

The following is a list of references used in the development of this document:

Horsley Witten Group (for EOEA). Massachusetts Smart Growth Toolkit.

Town of Westford Land Use Priorities Committee Final Report, January 2002.

Dunn, William J. and Michelle Carley. Merrimack River 5-Year Watershed Action Plan (2002-2007). Executive Office of Energy and Environmental Affairs – Wildlife Management Initiative. June, 2002.

Ambient Engineering and SuAsCo Watershed Community Council. Sudbury-Assabet-Concord River Watershed Action Plan. Executive Office of Energy and Environmental Affairs. 2005.

Open Space and Recreation Plan Committee – Conservation Commission. Open Space and Recreation Plan, Westford, MA 2002.

Inactive or Closed Solid Waste Landfills, June 2006. Access on May 23, 2007, online at <http://www.mass.gov/dep/recycle/inactf.pdf>

Turner, William. Westford Conservation Commission – Communications via email to Janet Moonan.

Division of Watershed Management. Massachusetts 2006 Integrated List of Waters: Final list of the condition of Massachusetts' waters pursuant to Sections 303(d) and 305(b) of the Clean Water Act. September 28, 2007.

Division of Watershed Management. Massachusetts 2004 Integrated List of Waters: Final list of the condition of Massachusetts' waters pursuant to Sections 303(d) and 305(b) of the Clean Water Act. April 2005.

U.S. EPA – Office of Water. Ambient Water Quality Criteria Recommendations – Information Supporting the Development of State and Tribal Nutrient Criteria for Rivers and Streams in Nutrient Ecoregion XIV. December 2000.

Monnelly, Anne and Jessica Strauss. Stony Brook Watershed Assessment. Merrimack River Watershed Council, July 2001.

Massachusetts Department of Environmental Protection. Reportable Releases

Charles River Watershed Association and ESS Group, Inc. Water Budget Report – Stony Brook Watershed (Prepared for EOEA and Hanscom AFB), June 11, 2007.

Charles River Watershed Association and ESS Group, Inc. Community Water Budget Report – Town of Westford (Prepared for EOE and Hanscom AFB), June 11, 2007.

Flint, Suzanne and Peter Severance. StreamWatch – Westford Section Water Monitoring Manual. Organization for the Assabet River and Westford Watershed Conservation Associated, May 2007.

Communications with Peter Severance – Westford Water Quality Monitoring Data from summer 2005, 2006, and 2007 and Stream Watch – Westford Section Water Monitoring Manual.

Assabet River Total Maximum Daily Load for Total Phosphorus. Executive Office of Energy and Environmental Affairs, MassDEP – Bureau of Resource Protection and Division of Watershed Management

MassDEP, U.S. EPA – Region 1, and ENSR International. Draft Pathogen TMDL for the Merrimack River Watershed.

MassDEP, U.S. EPA – Region 1, and ENSR International. Draft Pathogen TMDL for the Concord River Watershed.

SuAsCo Watershed – 2001 Water Quality Assessment Report. Executive Office of Energy and Environmental Affairs, MassDEP – Bureau of Resource Protection and Division of Watershed Management.

Merrimack River Basin – 1999 Water Quality Assessment Report. Executive Office of Energy and Environmental Affairs, MassDEP – Bureau of Resource Protection and Division of Watershed Management.

MassDEP. Source Water Assessment and Protection (SWAP) Report for Westford Water Department. April 2003. Available online at <http://www.mass.gov/dep/water/drinking/2330000.pdf>

EPA Office of Water. EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters. October 2005.

The Executive Office of Energy and Environmental Affairs 5-Year Watershed Action Plan Guidance.

Westford Comprehensive Master Plan – Technical Paper #2 – Natural and Cultural Resources, Draft, June 2007.

Westford Comprehensive Master Plan – Technical Paper #4 – Open Space and Recreation, Draft, August 2007.

Northern Middlesex Council of Governments (NMCOG). 2020 Vision: Planning for Growth in the Northern Middlesex Region. June 1999.

U.S. EPA. Polluted Runoff (Nonpoint Source Pollution). Retrieved on 2/2/07 from <http://www.epa.gov/nps/>.

Massachusetts Department of Fire Services. UST Query Tool. Retrieved on June 13, 2007, online at <http://db.state.ma.us/dfs/ust/ustQueryPage.asp>

U.S. EPA. EPA Cites Westford Metal Plater for Environmental Problems, July 8, 2006. Retrieved on June 13, 2007, online at <http://www.epa.gov/Region1/pr/1996/pr0708a.html>

U.S. EPA. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish. EPA, Second Edition. Retrieved on May 17, 2007 online at <http://www.epa.gov/owow/monitoring/rbp/>

---

United States Census Bureau. 2000 US Census Available online at <http://www.census.gov/>.

MassDEP Environmental Monitoring: Biomonitoring. Retrieved on May 17, 2007, online at <http://www.mass.gov/dep/water/resources/biomon.htm>

MassGIS Wellhead Protection Areas Datalayers. Retrieved on May 23, 2007, online at <http://www.mass.gov/mgis/ziis.htm>

MassGIS Aquifer Datalayers. Retrieved on May 23, 2007, online at <http://www.mass.gov/mgis/aq.htm>

Massachusetts Division of Fisheries & Wildlife. Natural Heritage & Endangered Species Program. Retrieved on May 22, 2007, online at <http://www.mass.gov/dfwele/dfw/nhosp/nhenvprioHab.htm>

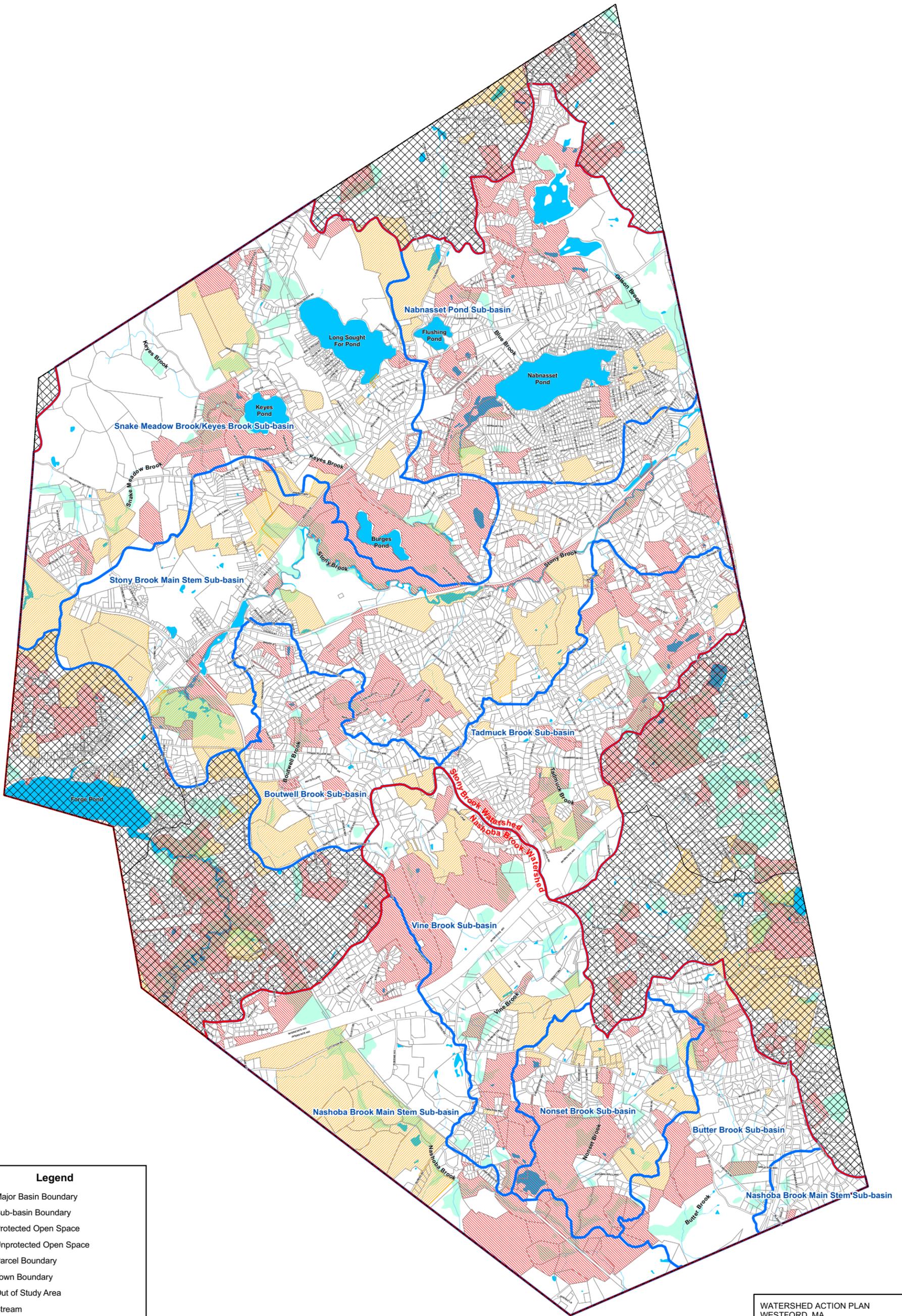
Massachusetts Division of Fisheries & Wildlife. Guidelines for the Certification of Vernal Pool Habitat, 2001. Retrieved on May 22, 2007, online at <http://www.mass.gov/dfwele/dfw/nhosp/vpcert.pdf>

MassWildlife Rare Species by Town. Retrieved on June 11, 2007 online at [http://www.mass.gov/dfwele/dfw/nhosp/species\\_info/town\\_lists/town\\_w.htm#westford](http://www.mass.gov/dfwele/dfw/nhosp/species_info/town_lists/town_w.htm#westford)

Westford Community Profile. Retrieved on June 4, 2007, online at <http://www.mass.gov/dhcd/iprofile/330.pdf>

The Commonwealth of Massachusetts, Water Resources Commission. Stressed Basins in Massachusetts, Approved December 13, 2001. Retrieved on May 23, 2007, online at [http://www.mass.gov/dcr/waterSupply/intbasin/stressed\\_basins.htm](http://www.mass.gov/dcr/waterSupply/intbasin/stressed_basins.htm)

## APPENDIX A: MAPS



**Legend**

-  Major Basin Boundary
-  Sub-basin Boundary
-  Protected Open Space
-  Unprotected Open Space
-  Parcel Boundary
-  Town Boundary
-  Out of Study Area
-  Stream
-  Intermittent Stream
-  Wetland, Marsh, Swamp, Bog
-  Submerged Wetlands
-  Lake, Pond, Wide River, Impoundment

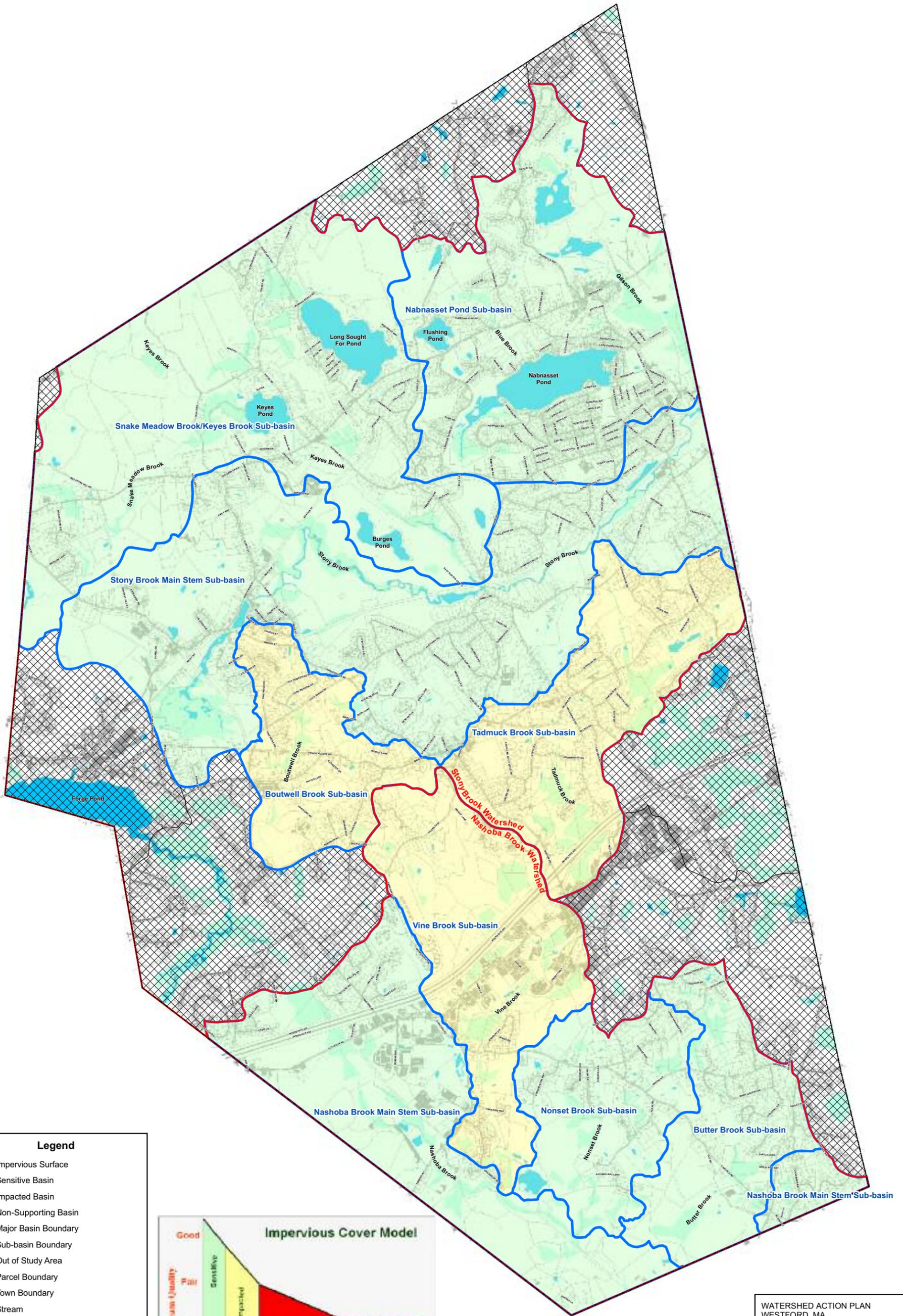
WATERSHED ACTION PLAN  
WESTFORD, MA

**OPEN SPACE**

**FIGURE A-1**

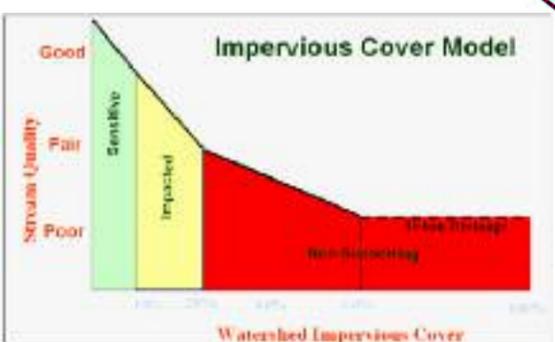
SCALE: 1" = 1500'	DOC: FIGURE_A_1.MXD
DATE: DECEMBER 2007	JOB NO.: 210760.02
DRAWN BY: DWP	SOURCE: MassGIS & Westford





**Legend**

- Impervious Surface
- Sensitive Basin
- Impacted Basin
- Non-Supporting Basin
- Major Basin Boundary
- Sub-basin Boundary
- Out of Study Area
- Parcel Boundary
- Town Boundary
- Stream
- Intermittent Stream
- Wetland, Marsh, Swamp, Bog
- Submerged Wetlands
- Lake, Pond, Wide River, Impoundment

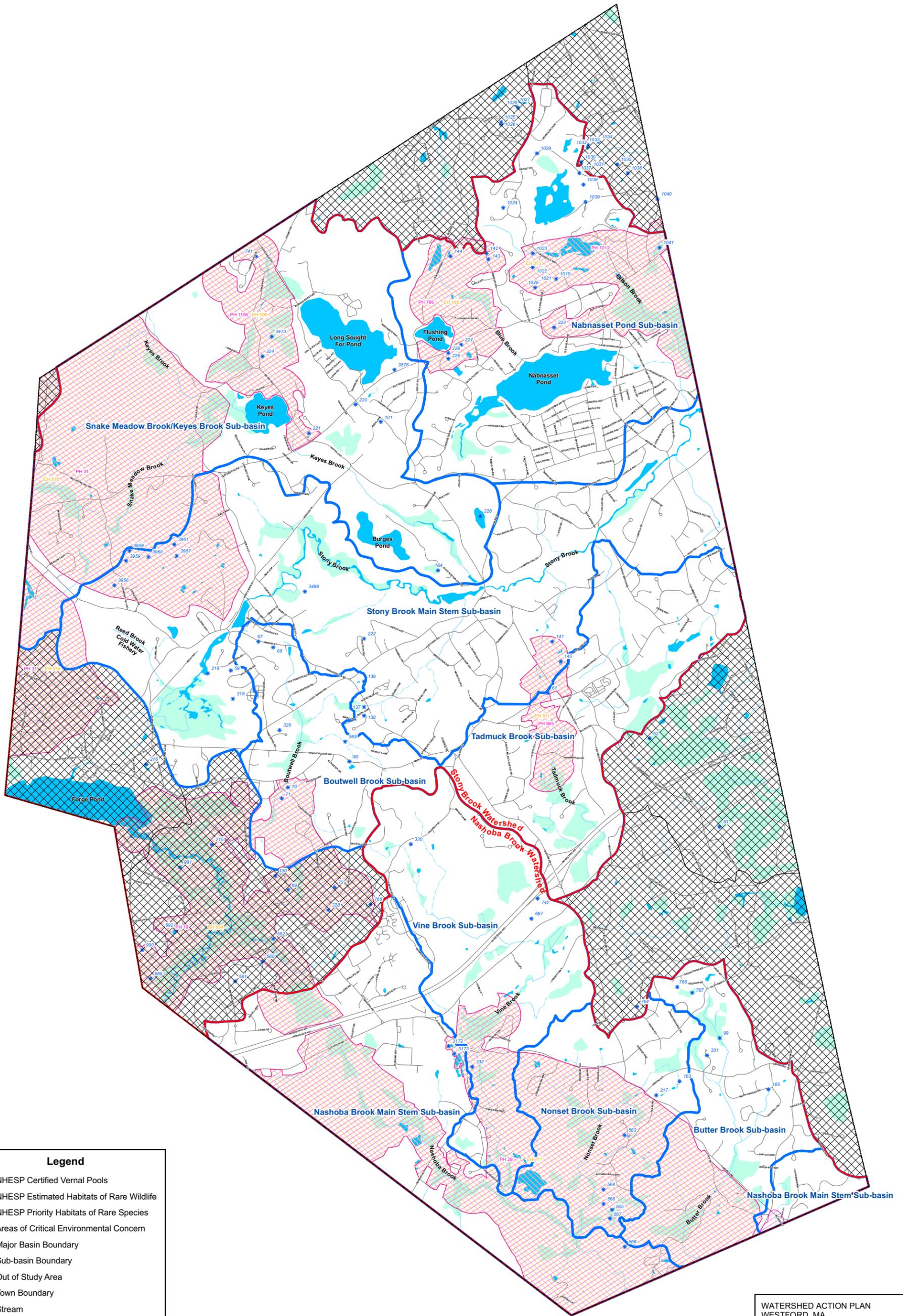


WATERSHED ACTION PLAN  
WESTFORD, MA

**IMPERVIOUS SURFACE**

**FIGURE A-2**

SCALE: 1" = 1500'	DOC: FIGURE_2.MXD
DATE: DECEMBER 2007	JOB NO.: 210760.02
DRAWN BY: DWP	SOURCE: MassGIS & Westford



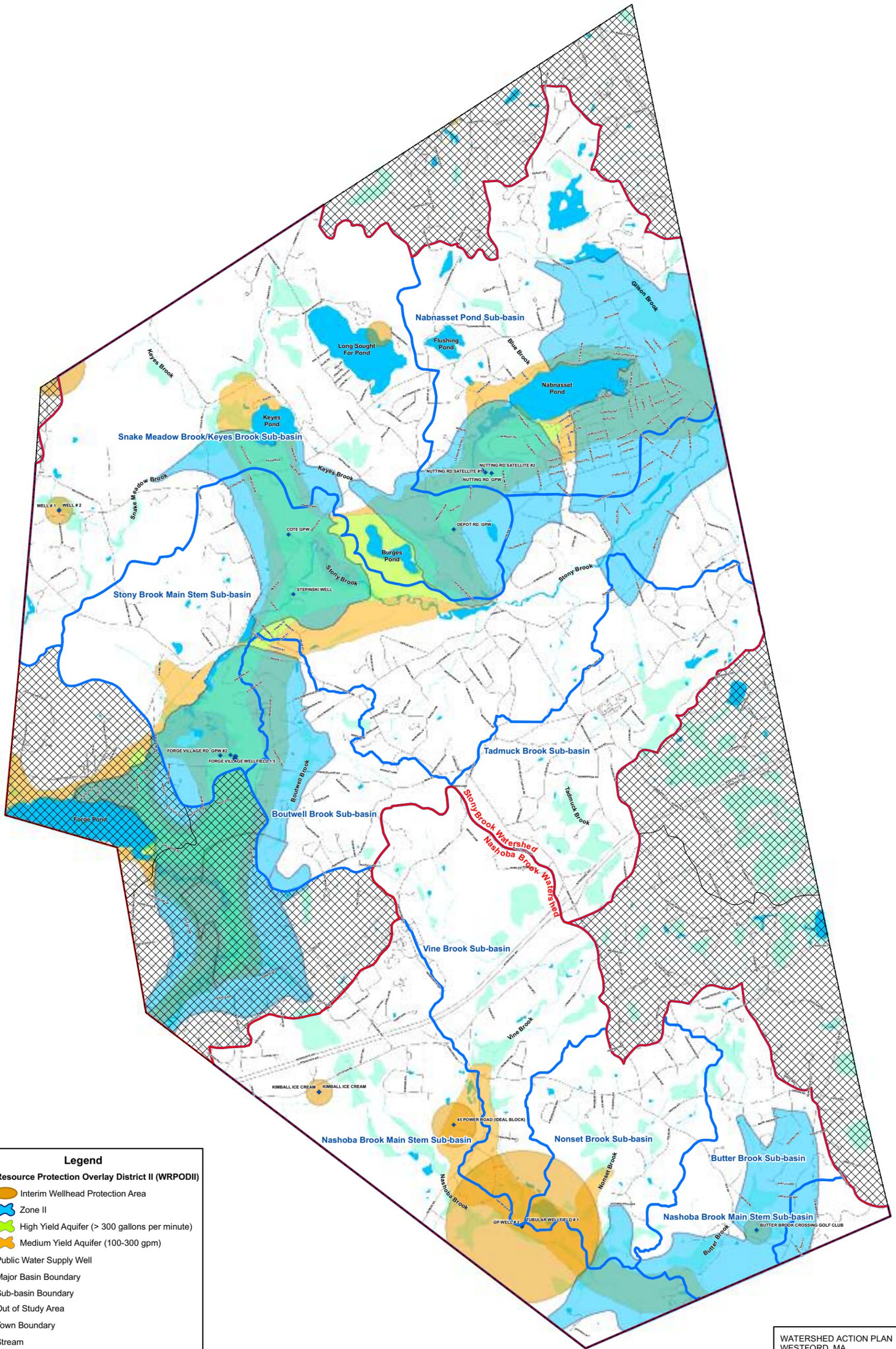
**Legend**

-  NHESP Certified Vernal Pools
-  NHESP Estimated Habitats of Rare Wildlife
-  NHESP Priority Habitats of Rare Species
-  Areas of Critical Environmental Concern
-  Major Basin Boundary
-  Sub-basin Boundary
-  Out of Study Area
-  Town Boundary
-  Stream
-  Intermittent Stream
-  Wetland, Marsh, Swamp, Bog
-  Submerged Wetlands
-  Lake, Pond, Wide River, Impoundment

WATERSHED ACTION PLAN  
WESTFORD, MA  
**CRITICAL, SENSITIVE, OR UNIQUE  
RESOURCES**



<b>FIGURE A-3</b>	
SCALE: 1" = 1500'	DOC: FIGURE_3.MXD
DATE: DECEMBER 2007	JOB NO.: 210760.02
DRAWN BY: DWP	SOURCE: MassGIS & Westford



**Legend**

**Water Resource Protection Overlay District II (WRPODII)**

- Interim Wellhead Protection Area
- Zone II
- High Yield Aquifer (> 300 gallons per minute)
- Medium Yield Aquifer (100-300 gpm)
- Public Water Supply Well
- Major Basin Boundary
- Sub-basin Boundary
- Out of Study Area
- Town Boundary
- Stream
- Intermittent Stream
- Wetland, Marsh, Swamp, Bog
- Submerged Wetlands
- Lake, Pond, Wide River, Impoundment

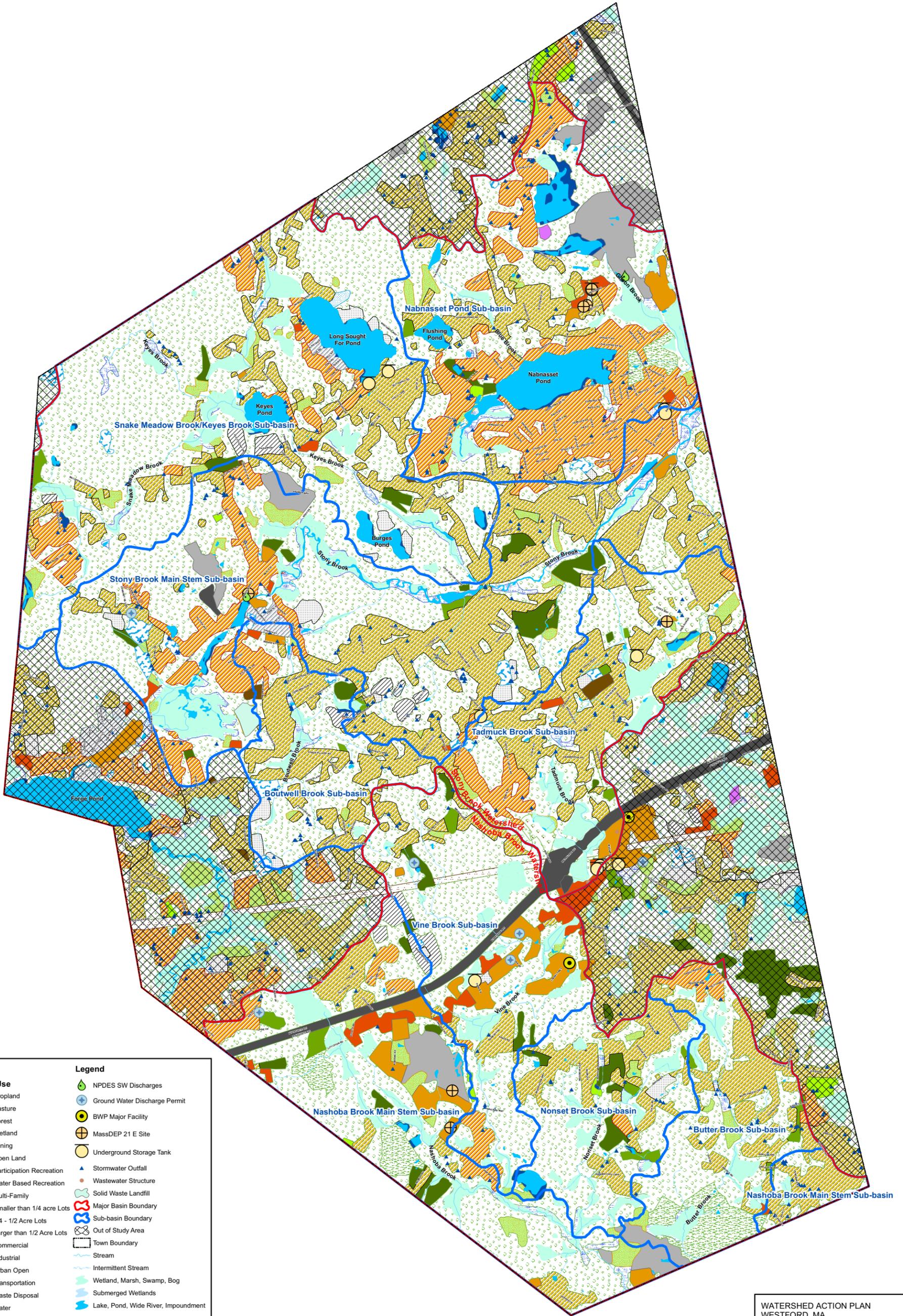
WATERSHED ACTION PLAN  
WESTFORD, MA

**LANDS CRITICAL TO SUSTAINING  
SURFACE AND GROUNDWATER  
QUALITY AND QUANTITY**

**FIGURE A-4**

SCALE: 1" = 1500'	DOC: FIGURE_4.MXD
DATE: DECEMBER 2007	JOB NO.: 210760.02
DRAWN BY: DWP	SOURCE: MassGIS & Westford





Legend	
<b>Land Use</b>	NPDES SW Discharges
Cropland	Ground Water Discharge Permit
Pasture	BWP Major Facility
Forest	MassDEP 21 E Site
Wetland	Underground Storage Tank
Mining	Stormwater Outfall
Open Land	Wastewater Structure
Participation Recreation	Solid Waste Landfill
Water Based Recreation	Major Basin Boundary
Multi-Family	Sub-basin Boundary
Smaller than 1/4 acre Lots	Out of Study Area
1/4 - 1/2 Acre Lots	Town Boundary
Larger than 1/2 Acre Lots	Stream
Commercial	Intermittent Stream
Industrial	Wetland, Marsh, Swamp, Bog
Urban Open	Submerged Wetlands
Transportation	Lake, Pond, Wide River, Impoundment
Waste Disposal	
Water	
Powerlines	
Golf or Ski	
Urban Public	
Cemeteries	
Orchard or Nursery	

WATERSHED ACTION PLAN  
WESTFORD, MA

POTENTIAL SOURCES OF  
POLLUTION

FIGURE A-5



SCALE: 1" = 1500'	DOC: FIGURE_A_5.MXD
DATE: DECEMBER 2007	JOB NO.: 210760.02
DRAWN BY: DWP	SOURCE: MassGIS & Westford

## APPENDIX B: SUB-BASIN STATISTICS

## Sub-basin Comparison

	Stony Brook Watershed						Nashoba Brook Watershed					Source
	Stony Brook (Main Stem) Sub-basin	Boutwell Brook Sub-basin	Snake Meadow/Keyes Brook Sub-basin	Tadmuck Brook Sub-basin	Nabnasset Pond Sub-basin	Total Stony Brook Watershed	Nashoba Brook (Main Stem) Sub-basin	Vine Brook Sub-basin	Nonset Brook Sub-basin	Butter Brook Sub-basin	Total Nashoba Brook Watershed	
<b>Physical Characteristics</b>												
Drainage area (sq. mi)	5.02	1.19	4.74	2.01	3.42	16.38	2.70	2.05	1.34	1.35	7.44	1
Drainage area (acres)	3213.34	759.87	3031.83	1284.19	2187.88	10477.11	1730.51	1312.23	856.46	865.85	4765.05	1
Contribution of sub-basin to entire watershed in Westford (%)	30.67	7.25	28.94	12.26	20.88	100.00	36.32	27.54	17.97	18.17	100.00	n/a
<b>Stream Statistics</b>												
Miles of perennial streams	3.92	1.28	7.10	2.85	3.04	18.19	4.45	3.78	1.87	2.74	12.84	2
Total acres of perennial streams with 200 foot buffers	227.82	71.17	352.57	150.76	163.84	966.16	212.32	176.60	93.40	133.65	615.97	2
Acres of buffer area around perennial streams lost to impervious surface	11.80	4.75	6.96	8.52	6.76	38.79	3.78	9.35	2.25	3.57	18.95	2
Miles of intermittent streams	3.09	2.47	0.71	2.05	0.91	9.23	2.11	2.91	2.74	1.56	9.32	2
Acres of intermittent streams with 200-foot buffers	177.61	130.59	51.31	108.80	52.00	520.31	115.50	157.53	152.16	88.40	513.59	2
Acres of buffer area around intermittent streams lost to impervious surface	7.77	4.10	1.60	4.82	2.92	21.21	4.57	7.38	5.40	4.40	21.75	2
<b>Land Use</b>												
Acres of open space	902.43	245.52	791.61	315.33	447.55	2702.44	587.48	400.36	355.72	193.06	1536.62	3
Acres of protected open space	455.11	125.77	520.95	253.53	360.93	1716.29	401.97	367.71	327.38	188.50	1285.56	3
% protected open space	14.16	16.55	17.18	19.74	16.50	16.38	23.23	28.02	38.22	21.77	26.98	
Acres of unprotected open space	447.32	119.75	270.66	61.80	86.62	986.15	185.51	32.65	28.34	4.56	251.06	3
% unprotected open space	13.92	15.76	8.93	4.81	3.96	9.41	10.72	2.49	3.31	0.53	5.27	
Acres of impervious surface	261.00	77.19	121.70	137.91	214.53	812.33	167.06	137.53	39.90	54.98	399.47	4
% impervious surface	8.12	10.16	4.01	10.74	9.81	7.75	9.65	10.48	4.66	6.35	8.38	n/a
<b>Habitat Characteristics</b>												
Number of certified vernal pools	15	8	9	1	18	51	3	4	7	5	19	4
Number of potential vernal pools	33	9	46	16	41	145	23	32	14	6	75	4
Acres of vernal pools with 200-foot buffers	42.78	23.03	25.91	2.88	48.71	143.31	8.41	11.51	19.71	14.39	54.02	4
Acres of buffer area around vernal pools already lost to impervious surface	1.62	1.81	2.63	0.22	2.07	8.35	0	0.98	0.42	1.16	2.56	2
Acres of Area of Critical Environmental Concern (ACEC)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	4
Acres of NHESP Priority Habitats of Rare Species	409.22	118.16	1368.78	101.85	625.04	2623.05	867.00	239.20	560.82	324.28	1991.3	4
Acres of NHESP Estimated Habitats of Rare Wildlife	409.22	118.16	1368.78	101.85	625.04	2623.05	859.00	239.20	560.82	324.28	1983.3	4
Acres of Wetlands, Marsh, Swamp, and Bogs	171.84	28.12	190.64	102.05	107.54	600.19	145.82	123.01	79.56	79.32	427.71	4
Acres of Pond/Lakes	73.79	1.83	183.08	8.26	220.25	487.21	9.87	4.78	15.14	1.60	31.39	4
<b>Lands Critical to Sustaining Surface and GW Quality and Quantity</b>												
Number Public Water Supply Wells	8	0	3	0	3	14	5	0	0	1	6	4
Acres Zone I	45.87	0.00	23.46	0	17.80	87.13	36.91	6.32	3.12	11.53	57.88	4
Acres Zone II	1022.61	300.05	486.45	32.57	939.56	2781.24	214.45	0	46.23	356.69	617.37	4
Acres Interim Well Protection Areas	0	0	42.89	0	0	42.89	326.31	95.64	101.02	15.24	538.21	4
Acres low-yield aquifer	0	0	0	0	0	0	0	0	0	0	0	4
Acres medium-yield aquifer	416.00	125.21	250.54	0	443.09	1234.84	258.32	100.83	87.79	18.86	465.8	4
Acres high-yield aquifer	393.40	30.74	190.54	0	92.10	706.78	0	0	0	0	0	4
Stressed Basin (Y/N)	N	N	N	N	N	N	Y, highly	Y, highly	Y, highly	Y, highly	Y, highly	5
Net Water Budget	Negative	Negative	Negative	Negative	Positive	Negative	Negative	Negative	Negative	Negative	Negative	6
<b>Summary of Potential Sources of Pollution</b>												
NPDES surface water discharge	0	0	0	0	1	1	0	0	0	0	0	7
Groundwater discharges	1	0	0	0	0	1	1	3	0	0	4	4
BWP Major Facility	0	0	0	0	0	0	0	1	0	0	1	4
MassDEP 21 E Sites	1	0	0	1	3	5	2	0	0	0	2	4
Underground Storage Tank	2	0	2	4	0	8	0	1	0	0	1	8

### Source

- 1 Westford GIS
- 2 Woodard & Curran
- 3 Town of Westford
- 4 MassGIS
- 5 DCR Water Resources Commission
- 6 Charles River Watershed Association and ESS Group
- 7 EPA
- 8 MA Department of Fire Services

## APPENDIX C: MAY 2007 WATER MONITORING MANUAL

***Stream Watch – Westford Section  
Water Monitoring Manual***  

---

***Organization for the Assabet River  
2007 Edition***

**Prepared by**  
**Suzanne Flint, Staff Scientist**  
***Organization for the Assabet River***  
9 Damonmill Square, Suite 1E  
Concord, MA 01742  
978-369-3956  
978-318-0094 (fax)  
sflint@assabriver.org

**Peter Severance**  
**Westford Watershed Conservation Association**  
3 Snow Drive  
Westford, MA 01886  
978-392-8885  
[pseverance@verizon.net](mailto:pseverance@verizon.net)

May 2007

Background .....	4
OAR’s StreamWatch: water quality and quantity monitoring program .....	4
Water Quality Indicators .....	5
Sampling Site Directions .....	8
Stony Brook Watershed .....	8
Nashoba Brook Watershed.....	8
Other Places: .....	9
Safety .....	10
Automobiles and Roadways.....	10
Bridges .....	10
Wading.....	10
Weather Conditions .....	10
Emergency Numbers.....	10
Non-emergency Numbers .....	10
General Bottle Sampling Notes.....	11
Water Quality Sampling Kit .....	11
Keeping Records .....	11
Photographs.....	11
Duplicate samples .....	11
Blank samples .....	11
Night before sampling.....	12
Observations .....	13
Immediately Upon Arrival at a Site .....	13
Take samples and readings .....	13
Air Temperature Measurement .....	14
Staff Gage Readings (not all sites have staff gages) .....	15
Estimating Channel Flow Status .....	16
General Bottle Sampling Procedure:.....	17
Nutrient Samples.....	18
Bucket Sampling Procedures .....	19
In-situ Sampling Procedures .....	20
Data Collection General Notes .....	20
Using the 650 MDS Data Logger Keyboard:.....	20
Taking in-situ field measurements.....	21
Note: 650 MDS Data Logger Instrument Lockup.....	21
After Collecting All Samples.....	22
Sample Check-In.....	22
YSI Set Up and Calibration: .....	23

Entering the Site List: ..... 27  
Post-field calibration check..... 27  
File Transfer ..... 28

## Background

In the summer, parts of the Assabet and Concord Rivers are as green as a well-watered lawn. The green is a blanket of floating duckweed and algae, and, beneath that, hides a forest of aquatic plants rooted in the shallow sediments. This condition, termed "eutrophication," is caused by an overabundance of nutrients (mainly nitrogen and phosphorus) in the river acting as fertilizer for the aquatic plants. During the growing season the overgrowth of plants creates problems for fish and other aquatic creatures by affecting dissolved oxygen concentrations and pH in the water column. After the growing season, the plants and algae decay, lowering dissolved oxygen levels and producing that distinctive bad odor you probably associate with late summer along the Assabet if you've walked by the Powdermill dam on Rte 62 in Acton or lived along the Ben Smith impoundment in Maynard.



“Quantity” or “flow” simply refers to the amount of water in the river. The rivers need not only good-quality water but also enough water to provide habitat for a healthy population of fish, to support recreational uses (canoeing, kayaking, fishing) and to dilute pollutants in wastewater discharges and storm water. The rivers’ problems are exacerbated by low flows. During the natural low flow periods in the summer and early fall, upper sections of the Assabet River can consist largely of treated wastewater. Summertime flow in the river depends on “baseflow,” the cool, clean water coming from aquifers and tributaries in the watershed. When an aquifer is tapped for water supply and the water taken is not returned to that aquifer, the water is not available to feed the tributary streams or river. If the aquifers are depleted, the river suffers and water supply in the region is threatened.

### OAR’s StreamWatch: water quality and quantity monitoring program

OAR has collected water quality data on the Assabet River since 1992. In 2002, we extended our baseline program to include water quality and streamflow measurements on the major tributaries of the basin and, in 2004, we added monitoring at sites on the Concord River and River Meadow Brook, the largest tributary of the Concord. The Westford Watershed Conservation Association started monitoring in the Nashoba Brook and Stony Brook watersheds in 2006 using OAR’s sampling methods.

The main goals of the program are (1) to document summertime water quality and streamflow conditions and long-term trends in the rivers and their larger tributaries and (2) to provide timely accurate information to the public and decision makers on the local, state, and federal levels. Toward these goals we will work to:

- Assess whether the rivers meet the state’s Water Quality Standards (Class-B).
- Assess the effect of changes in the management of point and non-point pollution sources as the state’s TMDL recommendations and NPDES permits are implemented.

- Provide sound scientific information to support OAR's advocacy for the rivers.
- Identify problem spots for further investigation.
- Understand the connections between water quality, streamflow, and habitat for native fish and to identify habitat-stressed sub-basins.
- Raise awareness of the tributaries, influence short-term water conservation decisions, and to build long-term capacity across the watershed for making water management decisions that will protect the ecological integrity of the watershed.

Monitoring is done in two parts:

- Weekly staff gage readings (for gaged tributary sites)
- Monthly sampling (dissolved oxygen, pH, water temperature, phosphorus, nitrogen, and total suspended solids).

#### Water Quality Indicators

**Ammonia:** Collected samples will be analyzed for a series of nutrients, one of which is ammonia. Ammonia (NH<sub>3</sub>) is a form of nitrogen. Sources are the breakdown of organic nitrogen in sediments; ammonia is always present in untreated sewage. Other sources of ammonia include: fertilizer, home cleaning products and food processing. Analysis for this parameter is provided by Thorstensen Laboratory Inc.

**Depth/Flow:** Depth and flow measure the amount of water in a river. Sufficient flow is vital to the overall health of the river ecosystem, affecting water quality and survival of aquatic flora and fauna. When the water quantity decreases, the concentration of pollutants increases ultimately degrading water quality. This parameter will be measured by reading the fixed staff gages along the streams and recording flow readings from the USGS gages at Maynard and Lowell.

**Dissolved Oxygen:** DO is the amount or percentage of oxygen dissolved in the water. Oxygen must be available for fish and other aquatic species. Low morning DO concentrations and large diurnal changes in DO are indicative of eutrophication: the growth of excessive vegetation often brought on by the input of excess nutrients. During the daylight hours photosynthesis by the aquatic plants pumps oxygen into the water column; at night plant respiration extracts oxygen from the water column. Bacterial decomposition of dead plant matter incorporated in sediments also uses up oxygen. Dissolved oxygen is measured as milligrams of oxygen per liter of water (mg/l) or percentage oxygen saturation. This parameter will be measured with a DO meter.

**Nitrate:** Nitrate is the form of nitrogen essential for plants and animals. Most of the nitrogen in the environment is in gaseous form (N<sub>2</sub>) and makes up 80% of our air. Nitrogen is also found in aquatic systems as nitrates (NO<sub>3</sub>), nitrites (NO<sub>2</sub>) and ammonia (NH<sub>3</sub>). Nitrates enter rivers and streams from soil, animal wastes, decomposing plants, and organic sediments. The major human sources are sewage, fertilizers, wastewater treatment plant effluent, and animal waste. Analysis for nitrate will be provided by Thorstensen Laboratory Inc.

**Ortho-phosphorus:** Phosphorus, another nutrient, exists in freshwater systems in either particulate or dissolved phases. Orthophosphate (ortho-P) is a soluble inorganic phosphate, the form required by

plants. Plants absorb it from the water and convert it into organic phosphorus, which is then bound to the plant and no longer available. Analysis for this parameter will be provided by Thorstensen Laboratory Inc.

**pH:** pH is a measure of the acidity of water and is measured on a scale from 1 to 14, with 1 being very acidic, 7 being neutral, and 14 being very basic. Water that is too acidic or, at the opposite extreme, too basic, can be toxic to fish and other aquatic life. pH also plays an important role the behavior of other pollutants, such as heavy metals, in the environment. High or low pH levels can be the result of acid rain/snow, chemicals entering the waterways, or certain natural conditions. This parameter will be measured in the field with a multifunction meter.

**Temperature:** Elevated water temperature might not seem like “pollution”, but it is critical for rivers and streams to remain relatively cool for fish and other aquatic life to survive. Water temperatures can get too warm from a lack of shade along river banks, from discharges of cooling water, from storm water running off hot pavement, or when cool water from underground aquifers is diverted from the stream by nearby wells. This parameter will be measured using YSI meters in the field.

**Total Kjeldahl Nitrogen:** Total Kjeldahl nitrogen (TKN) is a measure of both organic and inorganic nitrogen except nitrates. Analysis for this parameter will be provided by Thorstensen Laboratory Inc.

**Total Nitrogen:** Total nitrogen (TN) is calculated as the sum of the nitrogen measured as total Kjeldahl nitrogen and nitrate.

**Total Phosphorus:** Phosphorus enters rivers and streams from many sources: animal wastes, human wastes, fertilizer, detergents, erosion and storm runoff. The organic and inorganic, particulate and soluble forms of phosphorous undergo continuous transformations in the water column. Phosphorus is generally the limiting factor for plant growth in freshwater systems; total phosphorus concentrations greater than about 0.024 mg/L stimulate excess aquatic plant growth, often algal and duckweed blooms. When the plants or algae die and are decomposed by bacteria, the bacteria take up oxygen, ultimately decreasing the amount of oxygen available to other organisms. Total phosphorus, reported in mg/l, is a measure of all forms of phosphorus in the system. Analysis for this parameter will be provided by Thorstensen Laboratory Inc.

**Total Suspended Solids:** TSS is a measure of the amount of dust, dirt, sand and other particles stirred up in the water. Excessive amounts of suspended solids can bury fish and aquatic plants, and can make rivers and streams unpleasant for recreation. In addition, other pollutants such as oil, heavy metals and nutrients are frequently attached to suspended solids. Thus, TSS can sometimes give a rough indication of where there might be problems with these other pollutants. TSS is measured in mg/l. Analysis for this parameter will be provided by Thorstensen Laborator

Table 1: Westford Sampling Sites - 2007

Watershed	Site #*	Site Name	Lat/Long
Stony Brook	BOU(S)-006	Boutwell Brook	42° 35.26'N, 71° 27.68'W
	KEY(S)-001	Keyes Brook	42° 35.84'N, 71° 26.21'W
	GIL(S)-001	Gilson Brook	42° 36.96'N, 71° 24.55'W
	TAD(S)-003	Tadmuck Brook	42° 35.86'N, 71° 25.15'W
	STN(S)-031	Stony Brook at Brookside	42° 36.58'N, 71° 24.64'W
	STN(S)- 070	Stony Brook at Pleasant	42° 34.71'N, 71° 29.39'W
Nashoba Brook	VIN(N)-006	Vine Brook	42° 32.77'N, 71° 26.08'W
	NON(N)-002	Nonset Brook	42° 32.18'N, 71° 25.32'W
	BUT(N)-007	Butter Brook	42° 31.88'N, 71° 24.05'W
	NSH(N)-066	Nashoba Brook	42° 31.94'N, 71° 25.25'W

\* Sites are designated with a three-letter code indicating the stream name, plus “(S)” for the Stony Brook watershed or “(N)” for the Nashoba Brook watershed, and a three digit number indicating rivermiles to the tenth upstream from the confluence that tributary with its next larger stream. E.g. NON-002 is the Nonset Brook site 0.02 miles upstream of Nonset’s confluence with Nashoba Brook; NSH-066 is the Nashoba Brook site 6.6 miles upstream of Nashoba’s confluence with the Assabet River.

## **Sampling Site Directions**

Note: "Left" and "Right" banks are left and right as you stand looking *downstream*.

### **Stony Brook Watershed**

#### **Keyes Brook KEY(S)-001**

From the corner of Plain Road and Depot Street, turn into the entrance of East Boston Camps and park 200 feet from the entrance. The sample location is in the woods on your right.

#### **Tadmuck Brook TAD(S)-003**

From the intersection of Burbeck way and Lowell Road, travel east about one mile and park at the entrance to the Cider Mill Conservation Area on the right. Walk less than .1 mile downhill on Lowell Road to reach Tadmuck Brook. The sampling site is immediately downstream of the culvert under the road.

#### **Stony Brook at Brookside STN(S)-031**

From the intersection of Lowell Road and Brookside Road travel north about .15 miles. Cross the Bridge over Stony Brook and park between the bridge and the railroad tracks, on the right. The sampling location is through the woods downstream.

#### **Gilson Brook GIL(S)-001**

From the corner of Brookside Road and Nabnasset Street, travel east less than .1 mile, crossing the stream and park on the right between the stream and the package store.

#### **Boutwell Brook, BOU(S)-006**

From the corner of Graniteville Road and Cold Spring Road, drive north about .3 mile and turn left on Old Homestead. The stream crosses under the road about .3 miles hence, in front of # 13. The sample site is on the upstream side of the culvert under the road.

#### **Stony Brook at Pleasant Street, STN(S)-070**

Park in the driveway just south of the railroad tracks which cross Pleasant Street at the intersection with East/West Prescott Street. The sample site is the middle of the stream to the south.

### **Nashoba Brook Watershed**

#### **Vine Brook VIN(N)-006**

From the corner of Powers Road and Trailside, travel 0.1 miles east to where Vine Brook crosses under the road. The sampling site is immediately upstream from the culvert.

#### **Butter Brook BUT(N)-007**

From the intersection of Rtes. 27 and 225, drive south less than 4/10 mile to the Organic Farm on the right. Park in the entrance, out of the way of the gate. Walk back north on the same side of the road less than 200 feet. The sample site is just before the stream flows into the culvert (the northeast side is easier to approach the stream from).

#### **Nonset Brook NON(N)-002 and Nashoba Brook NSH(N)-066**

From the corner of Texas Road and Sherlock Lane: walk down the trail to the south approximately 0.2 miles until side-trail on right which leads to Nonset Brook. Walk less than ¼ mile to boardwalk/stream crossing just below a beaver dam. The sample site is downstream from the beaver dam.

Go back the way you came to the first trail you were on, and go right. In less than 0.10 mile you will be walking around the edge of a marsh pond on your left. Continue around this marsh for another 0.10 mile until you see a distinct trail branch to the left, going uphill. (If instead of finding this trail you come to a very open area of flat sand/gravel, you've gone to far...just turn around and look for a trail a hundred yards back on your left.) Follow this trail ¼ mile until you come to the foot bridge crossing Nashoba Brook. We sample downstream from the bridge.

Other Places:

**OAR Office, West Concord:**

9 Damonmill Square, Suite 1E, Concord, MA

978-369-3956 [www.assabriver.org](http://www.assabriver.org)

The office is in Damonmill Square on Rt. 62 (Main Street). From Rte. 2, take Rte. 62 West (toward West Concord), bearing left to follow Rte. 62 at the "99 Restaurant". Damonmill is on the right about 1.6 miles west of Rte. 2. Park in the lot in back of the mill and walk back up the driveway towards the street, go in the door just past the first speed bump. The sign at the curb reads "Blaney, Millwright, OAR". Our office is downstairs.

**ABT-033 West Concord Pump Station, West Concord (1992) FOR INSTRUMENT QC:**

From the OAR office parking lot, turn left out of the parking lot to head east on Rte 62. About 1.1 miles along you'll pass a Dunkin Donuts on your right. Just past that, turn right into the parking lot for a dry cleaner's and pet supplies shop before you go over the Assabet. *In-situ* sampling is done from the bridge.

**Thorstensen Laboratories, Westford:**

66 Littleton Road, Westford, MA

978-692-8395

From Westford center, take Boston Road southeast, passing under Rte 495. Take a left on Rte 110 (Littleton Road) and go about 1.1 miles. Thorstensen Laboratories is on the right, just past Tadmuck Road, in a small shopping plaza.

## **Safety**

***OAR volunteer and staff safety is the top priority. Please read the following safety precautions carefully. Do not put yourself in harm's way to complete the sampling.***

### Automobiles and Roadways

Many sites are located on bridges and busy roadways, which are not commonly used by pedestrians. Your presence may be a surprise to motorists. Please observe the following precautions:

- wear high-visibility clothing (reflective jogging vests are good);
- warn approaching traffic of your presence by parking your car down the street on the same side if possible, or follow site description parking recommendation; and
- use extreme caution when crossing the street.

### Bridges

Always use extreme caution at the edge of a bridge. Test railings before leaning against them. Do not climb or sit on railings.

### Wading

Wading is necessary at most sites. Wading should only be done when the water is less than waist deep and not fast moving. Waders are advised. Do not wade alone.

### Weather Conditions

We do sample in cold and/or rainy conditions. Volunteers should expect to be out for up to two hours and should dress appropriately. If there is lightning in the area, stay out of contact with the water and avoid contact with metal on bridges.

### Emergency Numbers

In case of emergency while monitoring, **call 911 first.**

After notifying the police, please notify the OAR office at 978-369-3956.

### Non-emergency Numbers

For non-emergency sampling day problems call the OAR office 978-369-3956 or Sue's cell phone (**only** for sampling day problems) 781-367-6795.

## **General Bottle Sampling Notes**

### Water Quality Sampling Kit

1 thermometer	1 set of spare sample bottles
1 float with rope and lid	1 Water Quality Monitoring Manual
2 black Sharpie permanent markers	1 cooler with temperature blank bottle
1 clipboard with plastic cover sheet	1 WQ Volunteer list and monitoring schedule
data sheets	distilled water (Poland Springs)
Chain of Custody record sheets	YSI meter with data logger, sampling and
latex gloves	travel caps, and cable
1 procedure checklist	extra C-cell batteries and screwdriver
4 - 5 sets of sample bottles in ziplock bags	

### Optional:

1 sampling bucket with rope

### Keeping Records

Record all observations on the data sheets provided with a permanent marker. Never erase a mistake. Instead cross it out, neatly with a single line, and write the correct entry next to or above it.

### Photographs

If you have a digital camera available, please take photographs of anything unusual at a site and email them to the OAR office ([oar@assabriver.org](mailto:oar@assabriver.org) or [sflint@assabriver.org](mailto:sflint@assabriver.org)).

### Duplicate samples

A duplicate sample is simply a second sample for the same parameter, collected in the same way. Duplicate samples from each of the sites will be done periodically to ensure that all samples are of a consistent high quality. Volunteers must collect duplicate samples according to the schedule listed with the sampling dates; a second set of sample bottles will be provided for those dates/sites. The duplicate sample bottles will be labeled with the site number, as usual, plus "FD" (for Site ABT-033 the sample bottles would be labeled "ABT-033" and "ABT-033-FD"). Be sure to collect duplicate samples one right after another, using exactly the same technique each time.

### Blank samples

Field blanks from each of the sites will be collected periodically to check for contamination from the bottles and from collection techniques. Volunteers will collect blank samples according to the schedule listed with the sampling dates; a second set of sample bottles will be provided for those dates/sites. The blank sample bottles will be labeled with the site number, as usual, plus "BL" (e.g. for Site ABT-033 the blank bottles would be labeled "ABT-033-BL.") The bottle tops will also be labeled "BL." For sites sampled directly from the river, pour distilled water from the bottle of distilled water (supplied with each kit) directly into the sample bottle. For sites that are bucket sampled, follow the bucket sampling procedure exactly using distilled water instead of river water (see bucket sampling procedure).

Night before sampling

- 1) Contact your team and agree on meeting place and time; exchange cell phone numbers if you'll be carrying phones. The team member picking up the meter will come directly to the OAR office at 5:30 am to get the meter and take the first two readings (duplicates with the other meters for quality control purposes). Other team members will join the meter operator at the first of their sections' sampling sites (times may vary a little with travel time, but the Upper Assabet and Concord River sections will likely meet at 6:30am). Designate a courier who will deliver samples, instrument, and documentation to the OAR office.
- 2) Assemble and check all equipment.
- 3) Review which tests you will be collecting and where. Review sampling procedures in the Water Quality Monitoring Manual.
- 4) Buy (or freeze) a bag of ice for the cooler. It should be enough to cover the bottom of the cooler and partially bury the samples.
- 5) Make sure that someone in your family knows you are going sampling the next morning.

## **Observations**

### **Immediately Upon Arrival at a Site**

- 1) While your partners are getting supplies ready, take the air temperature reading. Make sure the thermometer is dry. Let reading stabilize 3 – 4 minutes. When required, take a second reading by having a second person read the thermometer. Record results on the River Observation form.
- 2) At the first site, put the temperature blank (bottle with distilled water) into the cooler on top of the ice.
- 3) Fill out the general section “River Observation Form.” Record the site # and site name.
- 4) Complete the “Weather” section. Note any precipitation in the last 48 hours. (This only needs to be filled in for one site per sampling day unless there is a change in the conditions while you are sampling.)
- 5) Complete the “Physical” description section. If you see any recreational use or other activity on the river, note it; it can help answer the question “who cares?” when you present data to an audience.
- 6) Complete the “Stage” section. Stage is the level of water. If there is a staff gage, take a reading to the nearest 1/100<sup>th</sup> of a foot (directions below). There are gages at all the tributary stream sites (except RVM-005) and at the USGS gage in Maynard, Cox Street in Hudson, and Maynard Street in Westboro.
- 7) Estimate the channel flow status (directions below) and circle the score that best describes the current condition of the stream.
- 8) Write the time (to the nearest 5 minutes of sampling) and your initials on the bottle labels.

### **Take samples and readings**

- 1) Take the required bottle samples, duplicates, and blanks (directions below) and record times on the Chain of Custody sheets.
- 2) Record in-situ readings from the YSI meters on the in-situ data sheet and log the readings with the data logger (directions below).

Air Temperature Measurement

**Supplies:** Alcohol Thermometer

***Taking Air Temperature***

- 1) Take thermometer out of kit and allow the reading to stabilize at least 3 - 5 minutes.
- 2) Holding the thermometer at the upper end, read temperature to the nearest degree.

***Duplicate Measurements***

On each sampling day, choose one site at which to take a second set of temperature readings for quality control purposes. (This should *not* be the same site each month.) Have a second person on your sampling team repeat the steps above and record both sets of readings on the River Observation sheet.

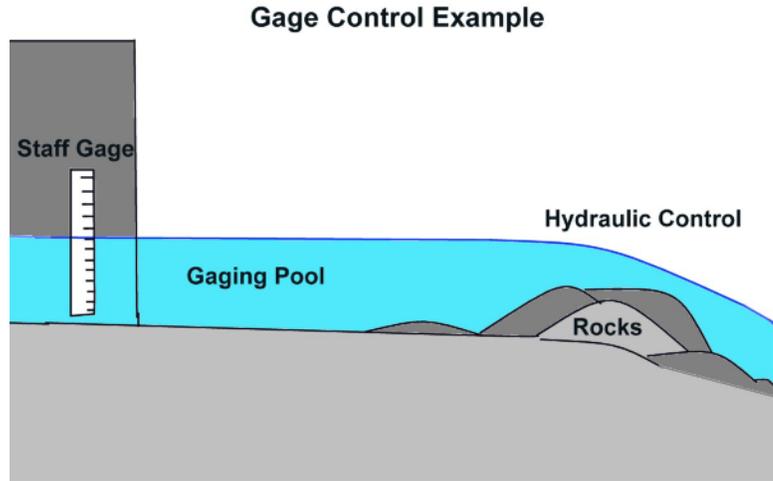
***Documentation:***

Record the air temperature on the River Observation Form under “Weather.” Record the thermometer ID # from its tag.

Staff Gage Readings (not all sites have staff gages)

**Observations**

Site descriptions include descriptions of the staff gage location and hydraulic control for that gage. When you first get to the site, look at the rocks or channel that control the height of the water at the gage (a.k.a. the gage's "hydraulic control"). Note whether there are any changes. Have rocks been moved? Are there leaves, branches, or other debris on the control or gage? Is there increased siltation around the site? Have more weeds grown in the channel? If

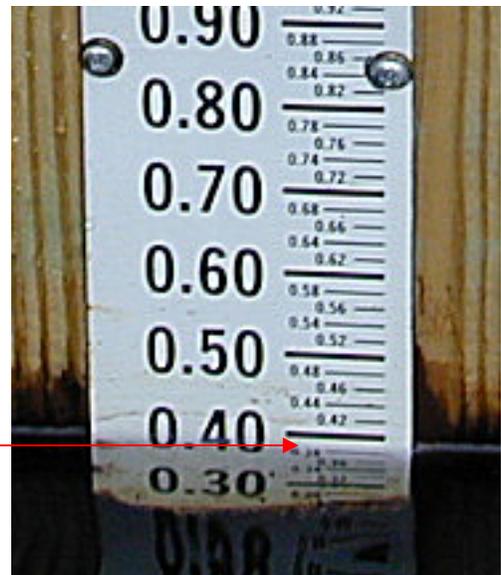


necessary remove any debris from the control and wait 10 – 15 minutes for the gage pool to drop to its normal height. Note any changes in the field record and, if possible, take a picture to document the conditions.

**Reading the Staff Gage**

The staff gages installed by USGS are graduated in feet. Read the water level to the nearest 1/100<sup>th</sup> of a foot. The graduations between the smallest markings are 0.02 ft. If there are waves or surface disturbances, estimate the level as closely as you can and note the problem in the comments section of the field record. The gages are best read standing at the level of the gage, either close enough to read the graduations or with binoculars - please note in the comments where you've read the gage from.

For example, on this staff gage the water level is at about 0.39 ft, half way between 0.38 ft and 0.40 ft.



**Documentation**

Take the clipboard and field sheet with you when you go out to read the gage and record your observations on the spot.

Estimating Channel Flow Status

“Channel flow status” is an estimation of the amount of the streambed covered with water at a given cross-section. At each tributary site there is a cross-section marked with orange-painted stakes on either bank. Read the descriptions on the field sheet carefully and circle the number below the description what best describes the current condition of the channel. If there is no marked cross-section (mainstem sites), estimate the channel flow status at the cross-section where you sampled.

		Channel Flow Status																		
		Optimal					Suboptimal					Marginal					Poor			
SCORE	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >76% of the available channel; or <25% of channel substrate is exposed.					Water fills 25 – 75% of the available channel, and/or riffle substrates are mostly exposed.					Very little water in channel and mostly present as standing pools.								
		20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2



Danforth Brook cross-section at flow status = 20.



Danforth Brook cross-section at flow status = 2.

**General Bottle Sampling Procedure:**

- 1) *Never wade alone!*
- 2) Wade in carefully to where you are in the main the flow. Sample from midstream if the stream is small. If not, get only as far out from shore as is safe. Establish a solid footing before filling a sample.
- 3) Stand facing upstream. Stand still for a few seconds to allow any stirred up sediment to be carried away by the current.
- 4) Always collect from your upstream side and empty rinse water (if needed) on your downstream side.
- 5) Representative samples are best collected 6 - 12” below the surface or at 1/2 depth, if the river is shallower than 6”. Sediments or surface debris in the sample can interfere with the accuracy of the laboratory analyses. Therefore, to take a sample, position the collection bottle, lid on, 6 - 12” below the surface (or 1/2 depth for shallower flows). Uncap underwater, allow the bottle to fill, recap underwater and finally bring to the surface.

## Nutrient Samples

### **Supplies**

\_\_\_\_\_ Thorstensen bottle with preservative (sulfuric acid; H<sub>2</sub>SO<sub>4</sub>)

**Caution:** sulfuric acid is corrosive, if you get it on your hands or clothes, rinse immediately with lots of water. The bottles with preservative will have bottle tops labeled “+”.

Sample for lab tests: total phosphorous (TP), ammonia (NH<sub>3</sub>), and total Kjeldahl nitrogen (TKN).

\_\_\_\_\_ Thorstensen bottle without preservative. These bottles will have bottle tops labeled “-”.

Sample for lab tests: nitrate (NO<sub>3</sub>), and total suspended solids (TSS), and ortho-phosphorus.

\_\_\_\_\_ Chain of Custody form

### **Sampling with the bottle “+” preservative**

a) Leave the bottle with preservative on shore or in the float.

b) Take the bottle without preservative and position the closed bottle 6 – 12” below the surface of the water, upstream from where you are standing. Uncap the bottle underwater and allow to fill, recap underwater.

c) Transfer the sample into the bottle with preservative. Do not overfill; leave some airspace in the bottle. Cap bottle and check that it is properly labeled (with the time and your initials) and place in cooler.

### **Sampling with the bottle “-” preservative**

a) Get sample as in step 1b.

b) Check that bottle is properly labeled (time and initials) and place in cooler.

### **Duplicates and field blanks**

a) To collect a duplicate sample, repeat the steps above exactly for each bottle. Collect the duplicate right after the first sample. Duplicates will be indicated with the site # and “FD” (e.g. the bottle for a duplicate at ABT-033 will be “ABT-033FD”).

b) To collect a field blank, pour distilled water (supplied with kit) directly into the sample bottle for the blank. Bottles will be indicated with the site number and “BL” (e.g. the bottle for a field blank for ABT-033 will be “ABT-033BL”). Bottle tops for field blanks will also be labeled with “BL.”

### **Documentation**

Complete the Chain of Custody form (time, initials, comments). Make sure that the lab tests requested are the same on the label, the Chain of Custody form and the Observation Sheet.

## **Bucket Sampling Procedures**

**Bucket sampling from a bridge: use when conditions will not permit safe wading for bottle sampling.**

- 1) Ensure rope is securely tied onto the bucket and stand on loose end of rope (or tie to wrist) before casting bucket.
- 2) Cast bucket into water on upstream side of bridge. Let water fill the bucket. NOTE: a full bucket is heavy! One half to two thirds full is adequate for rinsing and sampling. Begin raising bucket before it reaches upstream edge of bridge.
- 3) Raise bucket carefully, gently swinging side to side. Make sure it does not bump the bridge abutments or other structures. Do not let loose rope fall into bucket.
- 4) Slosh water around to rinse the rim. Make sure that hands and rope do not touch inside or rim of bucket. Empty bucket into gutter, or into the river on the downstream side of bridge.
- 5) Repeat steps 1 - 6 for a total of three rinses.
- 6) Fill bucket with sample water by repeating steps 1- 4. Remember not to touch the inside or the rim. If there is floating debris in the bucket, try to pour it off before filling bottles.
- 7) To fill the two nutrient sample bottles (Thorstensen's bottles with and without preservative), start pouring water from the bucket onto the ground and then move the sample container into the stream of water a few seconds later. Remember not to touch the rim or lid. Store samples in cooler.
- 8) Fill out all Chain of Custody forms as usual.
- 9) To take a field blank sample: Rinse the bucket three times with distilled water (supplied with the kit): pour a small amount of distilled water into the bucket, slosh around the bucket to clean all sides and rim, pour out and repeat. Take the blank sample by pouring an appropriate amount of distilled water into the rinsed bucket, start pouring the water from the bucket onto the ground and then move the sample container into the stream of water a few seconds later. Store the sample in the cooler.

## In-situ Sampling Procedures

### Data Collection General Notes

The YSI 6000-series units are capable of collecting data in two distinct modes: discrete sampling or unattended sampling. For OAR's water quality sampling, the unit is used in discrete sampling mode: short term, spot sampling applications when the user is present on site and the unit is attached to a data logger. The list of sampling sites, using an abbreviated site name, is entered on the data logger before field sampling and the field readings will be logged to this file. To back up the information logged, all readings are also recorded on field sheets in permanent marker.

### *Equipment*

- YSI multi-parameter instrument with 25 or 50 ft field cable
- 650 MDS data logger
- US Environmental Rental yellow trunk - to carry instrument
  - YSI Operations Manual
  - DO membrane repair kit
  - Cigarette lighter/charger cord
  - Extra C-cell batteries for the 650 MDS
- field sheet

### *Quality control measurements*

The in-situ sampling teams start together, taking side-by-side measurements at two sites. These are the quality control field duplicate measurements. Compare results on the spot and if there is a significant problem with an instrument contact the OAR office.

### Using the 650 MDS Data Logger Keyboard:

Turn the logger on by pressing the green On/Off key  on the upper left of the keypad. The Main Menu screen will be displayed. The top part of the screen shows menu options, the bottom shows the status bar with date, time, and battery charge. To access the Run mode (live readings from the sonde), use the **▲▼** keys to highlight **Sonde Run** and press **Enter** (the **↵** key) to display the real-time sonde readings. To illuminate the display screen, press the **⚙** key at the top right of the keypad. Pushing the backlight key again will turn backlight key off. The backlight will turn off automatically after two minutes of non-use.



Taking in-situ field measurements

- 1) Put the sampling cap on the sonde and make sure that cable connections are tight.
- 2) Turn the data logger on by pressing and releasing the on/off button on the top left of the instrument keypad. The “650 Main Menu” will be displayed. Use the ▲ ▼ keys to highlight “Sonde Run” and press Enter (the ↵ key) to display the real-time sonde readings.
- 3) Aim to take your measurements near the center of the channel, at mid-depth. Readings can be taken either at the bottle sampling site if the river is shallow or from a bridge near the bottle sampling site if the water is too deep to safely get into the main flow of the river.
- 4) Estimate the total water depth by lowering the sonde to the bottom of the river and counting the number of taped one-foot marks on the cable. Raise the sonde to mid-depth to take the readings.
- 5) Make sure that the sonde is not in the soft sediments of the bottom! (DO readings will be near zero if the probe is in the soft sediments. If conductivity readings are zero, check that the probes are covered with water.)
- 6) Wait for the readings to stabilize (sometimes as much as 2-3 minutes) and record the readings, measurement depth, approximate total depth, and time of measurement on the field sheet. Record the data on the data logger (as described below).
- 7) Logging data
  - a. In Run mode there is a box displaying the logging options at the top of the data logger screen. Use the ◀ ▶ keys to highlight “Log one sample” under the 650 section of the box (left side). Press Enter (↵) to log a sample.
  - b. The site list will be displayed automatically. Use the up and down arrow (▲ ▼) keys to highlight the appropriate site and press enter.
  - c. The logger will automatically return to Run mode and will flash Data logged near the top of the screen.
- 8) Keep the DO probe moist when not in use. For transport between sites during sampling, the instrument can be carried with its sampling cap on. When the instrument will be left longer between readings, replace the sampling cap with the transport cap (the solid one with a damp sponge in the bottom).

Note: 650 MDS Data Logger Instrument Lockup

If the data logger display locks up, unscrew the battery compartment on the back of the data logger, remove one of the C-cell batteries, wait 30 seconds, and then replace the battery and replace the logger compartment lid. This should restore function and does not seem to interfere with calibration or logger memory.

The only sort of maintenance you might have to do in the field would be replacing the batteries in the data logger. Extra batteries and a small screwdriver are supplied with the kits for this purpose. For other problems with the instrument, call the OAR office for help.

## **After Collecting All Samples**

- 1) Make sure all samples are properly labeled, all observations are recorded on the River Observation sheets, and samples are checked off on the Chain of Custody forms. Make sure that readings for all sites have been recorded on the in-situ readings sheet.
- 2) When you bring the samples and meter to the office, the designated check-in person will check all samples against the Chain of Custody forms. Sign your Chain of Custody forms.

## **Sample Check-In**

- 1) Sample check-in person should set up refreshments for volunteers (five sample couriers). Customarily these are coffee and donut holes (or anything your heart desires). Get cooler(s) for transferring samples to Thorstensen's out of the back room.
- 2) Check sample bottles against Chain of Custody and River Observation forms as you transfer each bottle from sampler's cooler to lab cooler(s):
  - a. Bottles: Are the bottle labels consistent with C of C forms? All samples taken?
  - b. Cooler temperature: using one of the alcohol thermometers, measure the temperature of the temperature blank in cooler and record the result on Chain of Custody forms.
  - c. Chain of Custody Forms: First courier and then Check-in person each sign the form.
  - d. River Observation Forms: One for every site? Complete? Gage readings recorded for all tributary sites? Good comments?
  - e. Check the in-situ readings on the sheet. Are all the sites recorded? Do the readings seem reasonable?
- 3) Samples for Thorstensen Laboratories: When all samples are in, put a temperature blank bottle into the lab cooler, sign the C of C forms over to the lab courier. Directions to Thorstensen's are taped to the cover of the cooler. At the lab sign the C of C forms transferring the samples to the lab, measure the cooler temperature from the temperature blank bottle and bring back completed forms (the lab will keep a copy for their records) and empty cooler.

## YSI Set Up and Calibration:

The YSI shall be calibrated in accordance with the manufacturer's instruction manual prior to field use. The required calibration procedures are summarized below, for a complete description see the manufacturer's manual.

### ***Calibration Equipment:***

Calibration Standards*:	small plastic beakers
pH 7.00 standard buffer solution	Kim-wipes or paper towels
pH 4.00 standard buffer solution	Ring stand and clamps
pH 10.00 standard buffer solution	Squirt bottles with distilled water
1 mS/cm (1000 $\mu$ S/cm) conductivity standard	Large bucket of river water
YSI 6000-series transportation cup	NIST - certified thermometer

\* Calitech™ calibration solutions purchased from US Environmental Rental. All calibration standards are stored at 25 ° C in the dark and should be not used after their expiration date. Do not reuse standards.

### ***General Calibration Notes:***

- 1) Use the small plastic cups (washed and rinsed with distilled water) to hold calibration solutions during calibration.
- 2) Use calibration solutions at room temperature.
- 3) Ensure that the sensor being calibrated and the temperature probe are immersed in the calibrating solution during calibration.
- 4) Between calibration steps, rinse the sensors with ambient temperature distilled water, then gently blot with Kim-wipes or paper towel. (Never touch the membrane of the dissolved oxygen sensor.)
- 5) For each parameter, record the initial reading in the standard solution (before calibration) and the reading after calibration.

### ***Using the Data logger:***

- 1) On the 650-MDS Data Logger, from the **650 Main Menu** access the Calibration menu by selecting (highlight and press **enter**) **Sonde Menu**, then **Calibrate**. Or using the 610-DM: From the **Run** mode press the **Esc** key to return to the **Main menu**. For calibration mode, select **Calibrate** from the Main menu.
- 2) From the calibrate menu (either logger) select the parameter to be calibrated and follow cues.
- 3) Note: To move down through the menu tree of the data logger, use the arrow keys to highlight the menu you want, and press the **Enter** key. To return to the previous menu, press the **Esc** key. This moves you back up towards the Main menu.

**Set up:**

- 1) Collect river water in a large bucket and let it stand at room temperature for several hours to let the temperature stabilize.
- 2) Set the instruments up. Attach data logger to the sonde with field cable and MS-8 Pigtail (hand tighten - do NOT use any tools), attach the strain relief connector to the sonde bail, put the sampling caps onto the sondes. Put 1-foot marks on the sonde and field cable using waterproof tape (used to approximate water depths in the field).

**Dissolved Oxygen Calibration:**

- 1) Secure the sondes on their stands with clamp provided.
- 2) Rinse the DO probe with distilled water and blot the sensors gently dry with the Kim-wipe WITHOUT touching the DO sensor membrane. Make sure there are no large drops of water on the membrane surface.
- 3) Place approximately 1/8" (3mm) of water into the YSI transport cup (the solid cup) and put it onto the sonde, engaging only 1 or 2 threads. Make certain that the DO and temperature probes are not immersed in the water. Do not tighten the cap, a loose connection which allows the transport cup to freely vent to the atmosphere is required for this calibration.
- 4) Wait approximately 10 minutes for the air in the calibration cup to become water saturated and for the temperatures of the thermistor and the oxygen probe to equilibrate.
- 5) Check the sea-level-corrected pressure reading from NWS Bedford station (<http://www.erh.noaa.gov/box/rws.shtml> and click "Southern New England"), and calculate the true pressure using the formula at the top of the instrument calibration sheet. (True pressure = [(Corrected BP in inches Hg) x 25.40] - [2.5 x local altitude (127ft) /100].)
- 6) Select **2-Dissolved Oxy** from the **Calibrate** Menu, then select **1-DO%** to access the DO % calibration procedure. Enter the true barometric pressure when prompted and press **Enter**. When the DO % reading is stable and the message "Press enter to calibrate" appears, record the reading on the calibration sheet and then press **Enter** to calibrate.
- 7) The logger will now display the new data from the sonde to allow you to see the improvement in the data. Press **Esc** to return to calibrate mode and continue calibration. (Calibration of the DO sensor to 100% DO simultaneously calibrates the DO mg/L mode.)

**Conductivity Calibration:**

- 1) Remove the transport cap for the rest of the calibration procedure.
- 2) Rinse the sensors with distilled water and blot dry (do not touch the DO sensor membrane).
- 3) Place the appropriate volume of 1000 $\mu$ S/cm standard conductivity solution in the clean plastic beaker marked "Cond" and immerse the conductivity and temperature probes. Ensure that the standard solution completely covers the conductivity cell. Allow 1 minute for temperature equilibration before proceeding.
- 4) From the Calibrate menu select **1-Conductivity** to access the conductivity calibration mode and select **1-SpCond**. Enter the calibration value of the standard (1 mS/cm) at the prompt

and **Enter**. The current sensor values will be displayed. When the unit has stabilized and there are no significant changes for approximately 30 seconds, record the reading in the lab notebook and press **Enter** to calibrate. At the “Successful” prompt press any key to continue.

***pH - Three Point Calibration:***

- 1) To cover the range of pH's in the Assabet (pH's from ~6.5 to 9.0) the 3-point pH calibration needs to be performed. Calibrate pH in this order: 4.0, 10.0, and 7.0.
- 2) Rinse the sensors with distilled water and blot dry.
- 3) Place the appropriate volume of pH 4.00 standard buffer solution in the clean plastic beaker marked “pH 4.0” and immerse the pH and temperature probes. Allow 1 minute for temperature equilibration before proceeding.
- 4) From the Calibrate menu select **4-ISE1 pH** to access the pH calibration procedure and select **3-3 point**. Enter the value of the buffer (4.00) at the prompt, **Enter**. The current sensor values will be displayed. When the unit has stabilized and there are no significant changes for approximately 30 seconds, record the reading in the lab notebook and press Enter to calibrate. Record new reading in lab notebook.
- 5) Rinse the sensors with distilled water, blot dry, and repeat the calibration process for pHs 10.00 and 7.00.

***MWWP pH QC check:***

- 1) After calibrating all three pH's, measure the pH of the Mass Water Watch Partnership pH quality control sample.
- 2) Leave the pH QC sample capped at room temperature until ready for use. Pour some of the QC sample into a clean plastic beaker, careful not to introduce bubbles into the sample, and measure the pH immediately using each YSI. Record the readings and report an average of the two readings to Mass Water Watch (the reading must be within  $\pm 0.2$  pH standard units to pass).

***Temperature Calibration Check and “lab duplicate” readings:***

- 1) Put the sampling cap back on the instrument(s), and immerse the instrument(s) in the bucket of river water. Record the side-by-side temperature measurements of each YSI and the NIST-certified thermometer (kept in the gray cabinet in the back room). Measurements should agree within 0.5 ° C. (Thermistors, the temperature sensors, cannot be calibrated by the user.)
- 2) In Run mode (on the 610-DM data logger), record the side-by-side readings for all parameters for each of the instruments on the calibration sheet. This comparison gives an estimate of the relative precision between the instruments.

Entering the Site List:

***Using the 650 MDS Data Logger***

- 1) To enter the site list (multiple sites under one file name), from the Main menu, select **Logging setup** and press the **Enter** key.
- 2) On the **Logging setup** menu, make sure that you have activated **Use site list** and **Store Site Number** (highlight and press **Enter**) and that **Store barometer** and **Store Lat and Long** are deactivated. Then highlight **Edit Site List** and press **Enter**.
- 3) Enter a file name (such as Upper, Middle, Lower, Concord) using the alpha/numeric keys. To enter a character, press the appropriate key repeatedly until the desired letter or number appears on the screen. The site name under file name can be any combination of up to 8 letters and numbers. Enter unique site for each site/reading (only the site numbers will appear in the file transferred to the computer). ◀ key will backspace to correct an entry. There are further prompts at the bottom of the screen.

In this “Marked” mode the logger stores a site number in the data file, not a site name so you must write down the name/number association that you’ve entered. Also, making an entry on the site list does NOT create a file, it only stores a file name for future use.

Post-field calibration check

*Instrument calibration should be checked as soon as possible after completing field sampling following the same basic procedures used for calibration EXCEPT for entering the calibration.*

***Temperature Check:***

Leaving the YSI’s in the large bucket of river water, record the side-by-side temperature measurements of each YSI and the NIST-certified thermometer. Measurements should agree within 0.5 ° C.

***Dissolved Oxygen Check:***

- 1) Secure the sondes on their stands with clamp provided.
- 2) Rinse the DO probe with distilled water and blot the sensors gently dry with the Kim-wipe WITHOUT touching the DO sensor membrane. Make sure there are no large drops of water on the membrane surface.
- 3) Place approximately 1/8” (3mm) of water into the YSI transport cup (the solid cup) and put it onto the sonde, engaging only 1 or 2 threads. Make certain that the DO and temperature probes are not immersed in the water. Do not tighten, a loose connection which allows the transport cup to freely vent to the atmosphere is required for this step.
- 4) Wait ~ 10 minutes for the air in the calibration cup to become water saturated and for the temperature to equilibrate.
- 5) In Run mode, record the DO % readings from each instrument on the calibration sheet.

**Conductivity Check:**

- 1) Remove the transport cap for the rest of the calibration procedure.
- 2) Rinse the sensors with distilled water and blot dry (do not touch the DO sensor membrane).
- 3) Place the appropriate volume of 1000 $\mu$ S/cm standard conductivity solution in the clean plastic beaker marked “Cond” and immerse the conductivity and temperature probes. Ensure that the standard solution completely covers the conductivity cell. Allow 1 minute for temperature equilibration before proceeding.
- 4) In Run mode record the SpCon readings from each instrument on the calibration sheet.

**pH - Three Point Check:**

- 1) Check pH in this order: 7.0, 10.0, and 4.0.
- 2) Rinse the sensors with distilled water and blot dry.
- 3) Place the appropriate volume of pH 7.00 standard buffer solution in the clean plastic beaker marked “pH 7.0” and immerse the pH and temperature probes. Allow 1 minute for temperature equilibration before proceeding.
- 4) Rinse the sensors with distilled water, blot dry, and repeat the calibration process for pHs 10.00 and 4.00.

File Transfer

**File Transfer from the 650 to the OAR PC:**

- 1) At the end of the sampling session, download the marked file from the 650 to the OAR Staff Scientist’s computer.
- 2) Start EcoWatch from the desktop icon.
- 3) Select settings from the **Comm** menu. Verify the settings: Baud Rate 9600, data 8 bits, parity none, protocol Kermit, Handshaking XoffXon (Sonde), Comm Port 1. Select **Sonde** from the Comm menu, Comm Port 1, **enter**. A blank screen will appear.
- 4) Connect the 655174 PC Interface cable to the appropriate PC serial port. Connect the other end of the cable to the 650 data logger.
- 5) From the 650 Main menu, select **File**, then select **Upload to PC**. Select the file you wish to send, and press **Enter**.

**To view files logged on the 650:**

The View file selection in the 650 File menu allows the user to examine the data logged. From the 650 **Main** menu, select **File**, **Enter**, then **View file** and press **Enter**. Then highlight the file of interest and press **Enter** to view the data on the 650 display. Use the arrow keys to scroll vertically to view more data points or scroll horizontally to view more sensor data within a particular data entry. To return to the main menu, press **Esc** repeatedly to move back up the menu tree.