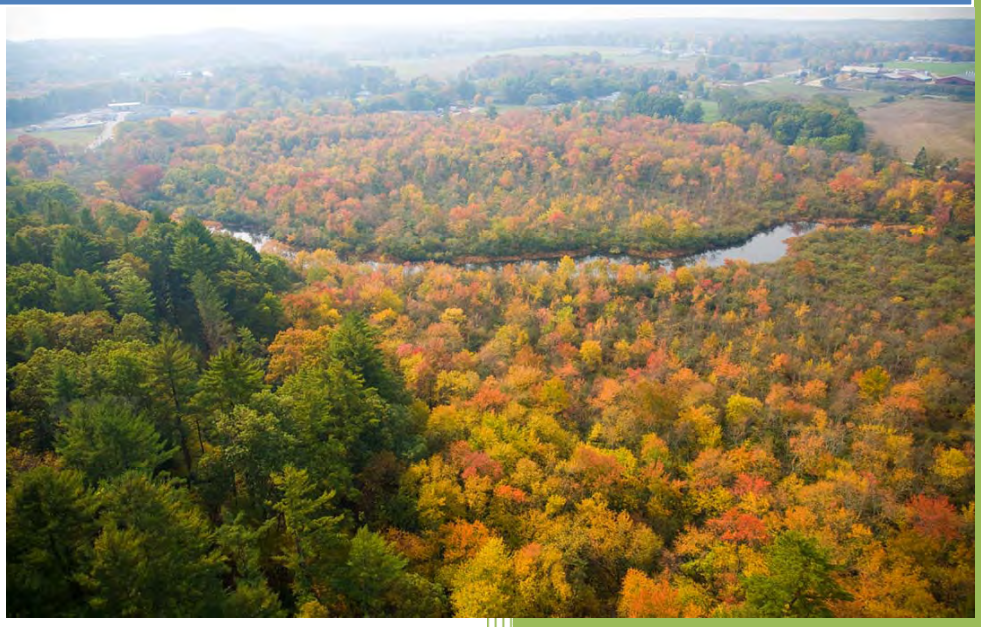
2009

Muddy Brook and Little River Water Quality Improvement Plan



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Prepared by the

Eastern Connecticut

Conservation District, Inc.

www.ConserveCT.org/eastern

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I. Executive Summary

The Eastern Connecticut Conservation District (ECCD) conducted a thorough investigation and evaluation of the Little River watershed in northeastern Connecticut. The other two major waterbodies contained in this watershed are Muddy Brook and Roseland Lake. There are five water segments within this watershed that do not meet the water quality standards for their designated use. Although there has been a considerable investment of funding and energies by several government agencies and other parties over the years, water quality problems have persisted. This situation was the impetus for a close examination of the watershed.

The project included an in-depth review of previous studies, and the gathering of all available existing water quality data and information. Land uses were examined, and detailed field surveys were conducted, including the mapping of storm drain outflows and a survey to determine the current status of BMP installation on the eight dairy operations in the watershed. Water sampling data from several sources was obtained and evaluated with the goal of finding indicators that would help identify or confirm sources of NPS pollution.

This project was pursued with the intent of providing NRCS with a strong foundation for its upcoming Watershed Based Plan development project which will target the Little River watershed. Therefore, it is by design that ECCD's evaluation contains information that addresses or partially addresses all of the 9 elements required by EPA for a Watershed Based Plan. ECCD then went further and created five specific abbreviated Watershed Based Plans, one for each impaired water segment in the watershed. The Watershed Based Plans identify specific management measures that will be necessary for water quality assessment and improvement, enabling the waters to meet the standards for their designated use, and thereby be eligible for delisting.

One of the most valuable products contained in this evaluation is a comprehensive list of recommended implementation actions for improving the water quality throughout the watershed. Some are general in nature, while others are specific. The recommendations are consolidated and organized in one of the latter sections of the report. As is the case with most impaired watersheds in the region, a significant increase in water sampling and testing will be essential to identify the causes and sources of NPS pollution so that effective management measures can be pursued.

II. Introduction

This project is a continuation of a broader concept to conduct a thorough investigation and evaluation of the watersheds north (upstream) of Putnam, Connecticut. The intent is to gain further insight into the reasons some of the water segments continually fail to meet water quality standards set by the State of Connecticut.

The Eastern Connecticut Conservation District (ECCD) is a non-profit organization which focuses on natural resource conservation, and in particular, water resources. ECCD recently celebrated its 60th year, and in that time has built a reputation as a reliable and productive organization. As part of its ongoing commitment to the conservation of natural resources, ECCD seeks grant funds to conduct various projects which are in keeping with the organization's mission. This project is the result of grant funding awarded by the U.S. EPA in accordance with Section 319 of the Clean Water Act. The grant was coordinated and facilitated by the Connecticut Department of Environmental Protection.

ECCD selected this project area for several reasons. First, the water quality of these watersheds has been considered a high priority for many years by both state and federal agencies, in addition to the concerns of local authorities regarding drinking water and public swimming areas. However, effective management measures could not be selected until some of the uncertainty about the sources and causes of the impairments could be eliminated, and that need became the impetus for this project. Second, there existed excellent potential for cooperation and collaboration with the local municipalities, government agencies, concerned organizations, and other watershed stakeholders. Third, the U.S. Geological Survey was conducting related research in the watersheds. Fourth, ECCD had well established relationships with the municipalities, the farming community, and other key stakeholders whose cooperation would be essential to the watershed investigation and resolution of the problems. The fifth and final reason for selecting the Little River watershed was that ECCD's investigation and evaluation would provide the foundation for a future project to be conducted by the USDA Natural Resources Conservation Service (NRCS). The NRCS project will be the production of a full Watershed Based Plan for the little River watershed based on the established U.S. EPA protocol.

The first phase of the overall project was an investigation and evaluation of the upper Quinebaug River, from West Thompson Lake, upstream to the Connecticut State line. That evaluation was completed in 2008. The subject of this current project is the Little River watershed, which includes Muddy Brook and Roseland Lake. In the original proposal, the Quinebaug River evaluation was identified as Phase I, and the Little River watershed evaluation was identified as Phase II. This document includes a full reporting of the investigation and evaluation of the Little River watershed, but moreover it is a management plan for improving the water quality in the watershed.

III. Purpose

There are several purposes for this project. Overall, the purpose was to conduct a complete investigation and evaluation of the Little River Watershed (which includes the Muddy Brook and Roseland Lake watersheds). As anticipated, a primary outcome of this effort was providing decision makers with greater insight into the causes and sources of the impaired water segments in the watershed.

Within the Little River watershed, there are 5 water segments listed as impaired. Improving the water quality of these segments and enabling their delisting is of high importance. One of the purposes of this project was to closely examine these specific segments and develop recommendations for addressing the impairments, with the ultimate goal being delisting.

Following this project conducted by ECCD, the USDA Natural Resources Conservation Service will begin a project to develop a full Watershed Based Plan for the Little River watershed, in accordance with EPA's requirements. An additional purpose for the ECCD project was to provide as much support as possible for that upcoming project.

Lastly, a primary purpose of this project was to formalize recommendations for the implementation of best management practices that will result in improved water quality, as well as practices that will prevent future degradation. Formalizing the recommendations for implementation actions provides a reference which can guide the prioritization, selection, and design of future projects that will provide the greatest benefit to the water quality in the watershed.

IV. Scope

ECCD drew from its own experience gained through past projects, as well as projects that have produced both abbreviated Watershed Based Plans and full Watershed Based Plans, and determined that the following Scope of Work best captures the actions necessary to successfully complete a comprehensive watershed plan that provides useful information and also strives to fulfill EPA's nine elements of a Watershed Based Plan.

1. **Research Impairment**
    - Collect impairment information
    - Verify how impairments were determined

2. **Gather and Review Existing Information**
    - Reports, etc.

3. **Research Existing Available Monitoring Results**
    - Monitoring data from DEP, USGS, Water Pollution Control Authority, Health Department, volunteer Stream Walks, etc.
    - Determine whether additional testing is necessary

4. **Meet with Town and Local Stakeholders to identify concerns and needs**
    - Include Town Planners, zoning officers, wetland officers, health officials, public works, Selectman, Town Manager, Planning and Zoning, Inland Wetlands, Conservation Commission, Water Pollution Control Authority, Parks and Recreation
    - Local groups may include environmental organizations, farmers, business owners
    - Other contacts, including federal and state representatives

5. **GIS maps**
    - Determine what maps are needed and gather information and data layers
    - Create maps

6. **Determine what additional information needs to be obtained via field reviews and testing**

7. **Conduct Field Reviews**
    - Full field investigation of watershed to identify possible sources of impairments, evaluate land use conditions and identify and areas of concern
    - Record GPS coordinates for locations as appropriate

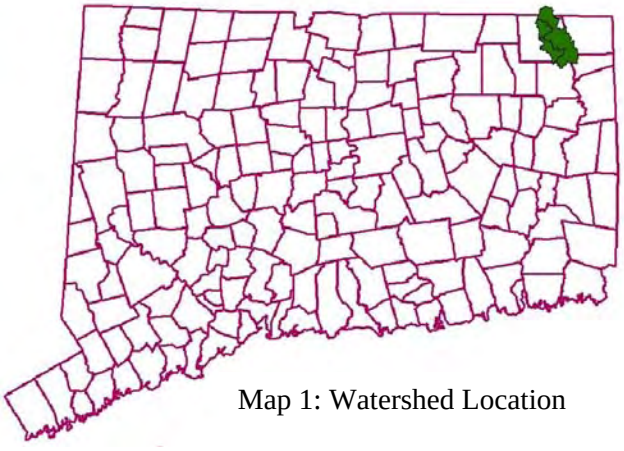
8. **Conduct Field Testing**
    - Conduct field tests, stream walks, etc. to gather additional information

9. **Prepare Complete Report of Findings, and Present Recommendations in the form of a Watershed Plan**

V. Watershed Description

Overview

The Little River watershed is primarily located in northeastern Connecticut, but also extends into Massachusetts. The flow is generally from north to south.



Map 1: Watershed Location

At the headwaters of the watershed, Muddy Pond is located in the north central part of the Town of Woodstock, CT on the Massachusetts border. The outflow of Muddy Pond is the beginning of Muddy Brook, which is the major drainage channel of the upper watershed (above Roseland Lake.) At the terminus of Muddy Brook lies Roseland Lake, a 96 acre natural lake. In addition to Muddy Brook, Mill Brook is another main tributary of Roseland Lake, flowing in from the west. The lake then gives rise to the Little River, which begins at the lake's only outlet. About 5 miles downstream in Putnam, Connecticut, the Little River converges with the Quinebaug River, approximately ¼ mile downstream of the Quinebaug's Cargill Falls.

The majority of the watershed is located in Woodstock, Connecticut, with lesser amounts in Pomfret, Thompson and Putnam, Connecticut, and an additional small portion in Southbridge, Massachusetts. In July 2009, the population of Woodstock was 8600.

In general, the Little River watershed is mostly rural with the exception of the more populated village centers of South Woodstock, Woodstock Hill, and East Woodstock. There is also one portion in the southern (downstream) end which is notably more developed, where part of Putnam lies within the watershed. However, much of Woodstock area is made up of vast areas of land in cultivation for corn and hay. Being located in this mostly rural part of New England known as "The Last Green Valley", and also in the Quinebaug-Shetucket Rivers National Heritage Corridor, the Little River watershed contains a variety of land uses including eight "large" working dairy farms in Woodstock and an assortment of other agricultural operations including orchards, a vineyard and several vegetable farms. Large blocks of mostly un-fragmented forest include western slope of Bull Hill at the Woodstock-Thompson line.

A full reporting of the land uses in the watershed appears later in this report. In summary, the major land uses in the Little River watershed are approximately:

- 62% forested (including forested wetlands)
- 20% agriculture
- 10% developed

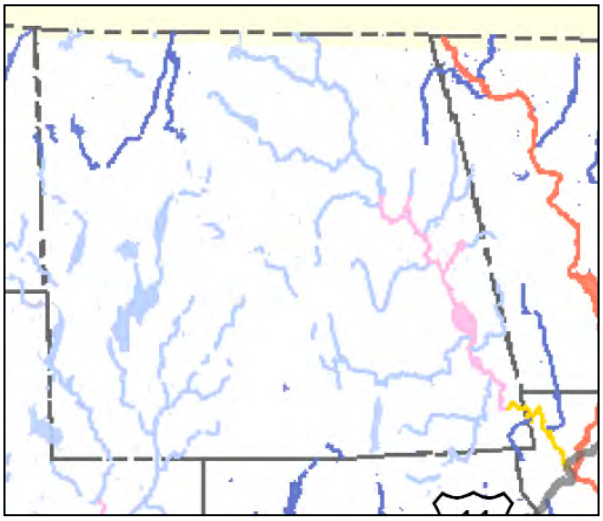
This watershed is part of the Quinebaug River regional watershed, Hydrologic Unit Code 0110001. It is comprised of 3 sub-regional watershed basins: Little River, English Neighborhood Brook, and Mill Brook. The watershed is approximately 11 miles long (north to south) and approximately 5 miles wide (east to west) and covers about 39.0 square miles.

One of the features of this watershed that raises the level of concern is a surface water diversion from the Little River that supplies drinking water to Putnam and Woodstock businesses and residents. The diversion is located at the Shepherd's Pond Dam in South Woodstock. This dam is approximately two and a half miles north of the confluence of Little River and Quinebaug River in Putnam. The area of the watershed located upstream of the diversion is 35.4 square miles.

Recognizing the Little River system for its special features, the Connecticut Greenways Council granted Greenway status in 2006. This status was jointly applied for by the Towns of Woodstock and Putnam as part of a natural resource protection strategy. Protected open space along the greenway includes Roseland Park, the Wyndham Land Trust Little River Preserve, and open space properties owned by the towns of Woodstock and Putnam. The Putnam Fish and Game Club is also owner of a significant portion of the river frontage.

VI. Water Quality Overview

The headwaters regions of Muddy Brook, downstream to Lower Minor Morse Pond in East Woodstock, have been designated Class AA.



Map 2: Little River Water Quality Classifications in Connecticut

Below Lower Minor Morse Pond to the diversion area at Shepherd's Pond Dam in South Woodstock, the surface water is classified as B/AA. B/AA means the water may not be meeting Class AA Criteria or designated uses. The water quality goal is achievement of Class AA criteria and attainment of Class AA designated uses.

CT Inland Surface Water Classifications

Class AA

Designated uses: existing or proposed drinking water supply, fish and wildlife habitat, recreational use (may be restricted,) agricultural and industrial supply.

Discharge restricted to: discharges from public or private drinking water treatment systems, dredging and dewatering, emergency and clean water discharges.

Class A

Designated uses: potential drinking water supply; fish and wildlife habitat; recreational use; agricultural and industrial supply and other legitimate uses including navigation.

Discharge restricted to: same as allowed in AA.

Class B

Designated uses: recreational use: fish and wildlife habitat; agricultural and industrial supply and other legitimate uses including navigation.

Discharge restricted to: same as allowed in A and cooling waters, discharges from industrial and municipal wastewater treatment facilities (providing Best Available Treatment and Best Management Practices are applied), and other discharges subject to the provisions of section 22a-430 CGS.

Class B/AA, B/A, C/A

Water use Intended for Fish and Wildlife, Recreation, or Navigation and is not Meeting Criteria for Target Class.

From the diversion to the Quinebaug River, the Little River is rated Class B. Further information on the CT Inland Surface Water Classifications can be found in the Water Quality Standards issued by the Connecticut Department of Environmental Protection at http://www.ct.gov/dep/lib/dep/water/water_quality_standardsl/wqs.pdf.

Impaired Waters

The Connecticut Department of Environmental Protection (DEP) is required to identify and list waters which do not meet the water quality standards for their designated use. These waters are classified as "impaired". Five waterbody segments within the Little River watershed are listed by the CT DEP on the *2008 State of Connecticut Integrated Water Quality Report* as impaired (i.e. not meeting the standards for a B classification). These segments are listed in Table 1 and shown on Map 3. In addition, Morse Pond north of the state line in Massachusetts is also not meeting water quality goals.

Table 1

Impaired Segments

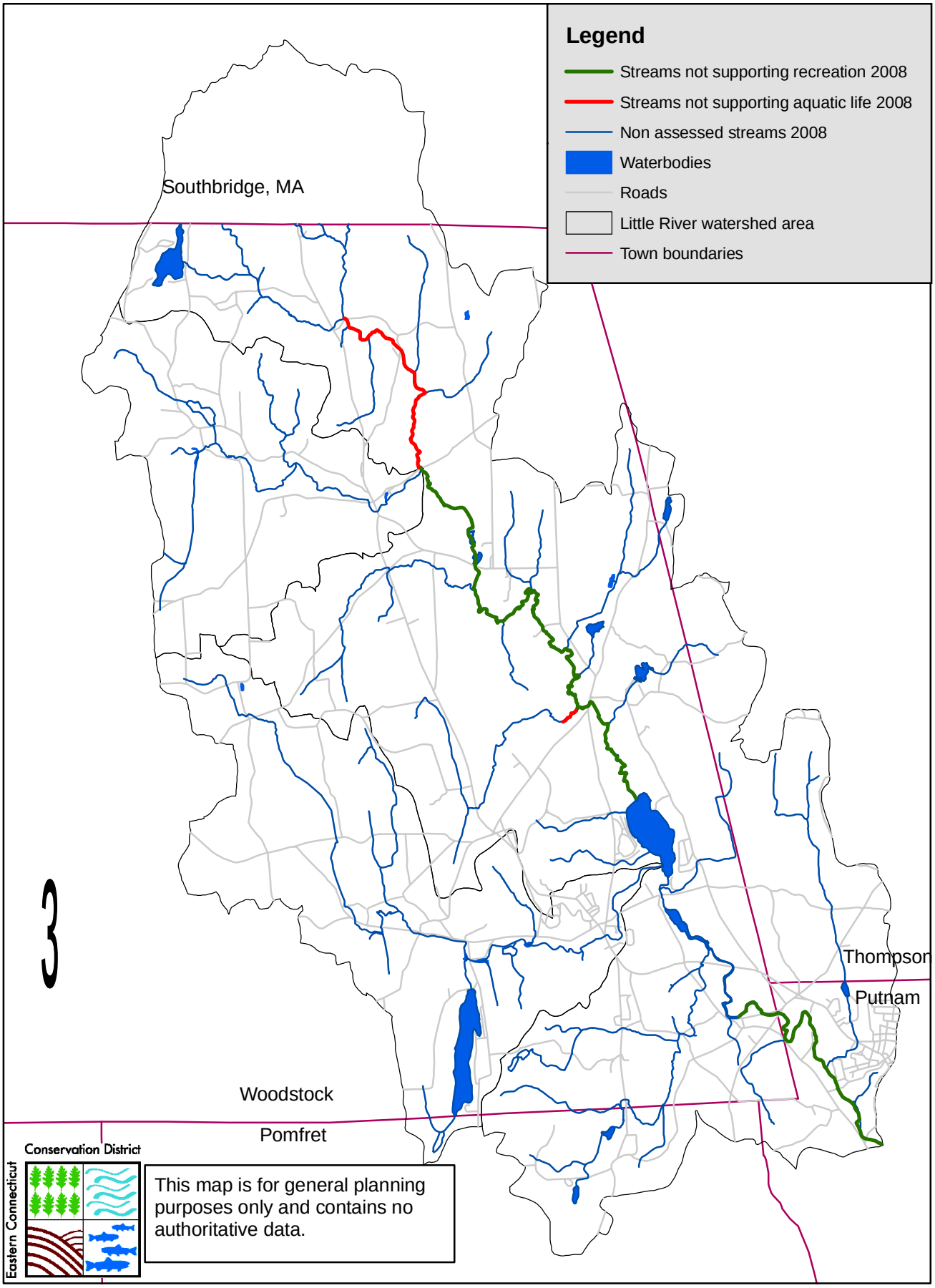
Waterbody Name Segment Code	Location	Impaired Designated Use	Segment length	Cause Potential Source
Muddy Brook (Woodstock)-02 CT3708-01_02	From Route 197 crossing, US to confluence with Moss Brook	Habitat for Fish, Other Aquatic Life and Wildlife	1.98 MILES	**Cause** Unknown **Potential Source** Unknown, Agriculture
Muddy Brook (Woodstock)- 01 CT3708-01_01	From mouth at inlet to Roseland Lake, US to Route 197 crossing, Woodstock.	Recreation	5.44 MILES	**Cause** Escherichia coli **Potential Source** Unknown
North Running Brook-01 CT3708-10_01	From Muddy Brook, US to runoff ditch from farm field (300Ft US of farm road crossing) (farm road crossing is 900Ft US of Muddy Brook confluence, farm road is off of Child Hill Road), Woodstock	Habitat for Fish, Other Aquatic Life and Wildlife	0.19 MILES	**Cause** Unknown **Potential Source** Agriculture, Non-irrigated Crop Production
Roseland Lake (Woodstock) CT3708-00-1-L1_01	Southeast section of Woodstock	Recreation	96.38 ACRES	**Cause** Nutrient/Eutrophication Biological Indicators **Potential Source** Agriculture, Waterfowl, Unknown
Little River (Putnam)-01 CT3708-00_01	From the Quinebaug River, Putnam US to the water treatment plant, Woodstock (southeast corner).	Recreation	2.64 MILES	**Cause** Escherichia coli **Potential Source** Unknown
Morse Pond * (41033) MA41033_2008	Southbridge at MA-CT state line. Outlets to Moss Brook		41.4 ACRES	**Cause** Organic enrichment, Low DO, Noxious aquatic plants **Potential Source** Unknown

* Located in Massachusetts. Not included in this watershed plan.

MAP 3

Little River Watershed

Impaired Stream Segments



Explanation of Impairment Designations

Impaired for Recreational Use based on Bacteria

According to the US Environmental Protection Agency, there is a statistical relationship between the levels of E. coli, the indicator bacteria, and human illness rates. E. coli, like some other bacterium, originates from the intestinal tracts of warm blooded animals, including humans. The presence of these bacteria in the Little River indicates that animal or human waste is present. Though not necessarily harmful themselves, the bacteria are indicators that other disease-causing organisms may also be present, and therefore they are used as a general indicator of sanitary water quality conditions. The Connecticut Water Quality Standards established the following criteria for E. coli bacteria in the State's surface waters to protect persons wishing to use the waters for recreational purposes such as swimming, canoeing, kayaking, wading, fishing, boating, water skiing, aesthetic enjoyment, and similar uses:

- Not to exceed 235 colonies/100ml (for official bathing area) or 576/100ml (all other water contact recreation) for single samples;
- Not to exceed a geometric mean of 126 colonies/100ml for any group of samples

Impaired for Recreational Use based on Excessive Nutrients and/or Biological Indicators

A water segment can also be designated as Impaired for Recreational Use based on excessive nutrients and/or biological indicators. Factors taken into consideration are those such as excessive nutrient levels, chronic algal blooms, extensive coverage by exotic invasive plants, severe sedimentation, and results of surveys by fisheries biologists.

Impaired for Aquatic Life Support

Assessments for aquatic life support are based primarily on benthic invertebrate analysis, augmented by fisheries information and physical/chemical data. Monitoring personnel report potential causes and sources of impairment to aquatic life based on direct observations or knowledge of upstream land use. Often further investigative work is required to make direct linkages to causes and sources. Therefore, "Cause Unknown" or "Source Unknown" is sometimes reported along with any known potential causes and sources.

VII. Investigation and Evaluation of the Watershed

ECCD conducted a thorough investigation and evaluation of the entire 39 square mile watershed. The specific methodologies are described in this section. The activities generated a considerable amount of valuable information, which has been fully evaluated and the results are presented here.

A. Review of Existing Studies, Reports and Other Literature

The water quality in the Little River, Muddy Brook, and Roseland Lake watershed has been a concern for at least several decades. ECCD's research found that the watershed (or portions of it) has been studied and reports written on four previous occasions. Therefore, it was decided that an important part of the current project would be a review of the existing literature. The review was conducted, and useful information was extracted and incorporated into the current project. The four reports that were reviewed are listed below, followed by a brief summary of each.

1978 – Causes of Algae in Roseland Lake
1979 – Connecticut AG 208 Project
1991 – USGS – Suspended-Sediment Characteristics of Muddy Brook
2006 – Little River Sourcewater Protection Plan

The Causes of Algae Growth in Roseland Lake, Woodstock, CT

Connecticut. Department of Environmental Protection. *The Causes of Algae Growth in Roseland Lake, Woodstock, CT*. Hartford, CT: 1978. Print.

In 1978 the Connecticut DEP released a report that discusses eutrophic condition (highly enriched with nutrients) of Roseland Lake. The DEP analysis supported the theory that due to the large upstream watershed area and relatively small lake volume, Roseland Lake would likely support high levels of algae and/or aquatic plants, even without human influences. The lake is described as an eutrophic warm water lake that becomes thermally stratified in the summer months. By June, the bottom layer becomes anaerobic (very low oxygen content) and remains so throughout the summer. In the anaerobic condition, the bottom sediments release phosphorus. It was theorized that poor mixing potential would not make that phosphorus available to support plant growth until fall overturn, and at that time normal flows would flush the excess nutrients out of the basin. Limited tributary sampling indicated that even under low flow conditions, the tributaries contained nutrient loads sufficiently high enough to support nuisance algae growth.

- The importance of control of erosion and sedimentation was emphasized in the recommendations to reduce phosphorus loadings and seasonal algae blooms in Roseland Lake.
- Copper sulfate used as a temporary in-lake algae management practice should be coordinated with the DEP as the treatment, as it may impact non-target species such as trout that are annually stocked in the lake by the DEP.

Connecticut AG 208 Project

Agricultural Portion of the Connecticut Areawide Waste Treatment Management Planning Program – Project Report – October 1979 – by the Connecticut Council on Soil and Water Conservation

As part of the current ECCD project, the AG 208 Project was thoroughly reviewed and a detailed report has been submitted as one of the deliverables. Below is a brief summary.

The 1979 AG 208 Project identified the Little River watershed as a "Highest Priority" watershed for the reduction of agricultural NPS pollution. The ultimate goal of the project was to have farmers voluntarily implement best management practices that would reduce agricultural NPS pollution.

Although actions could have occurred that time has obscured, ECCD's investigation could find no evidence of BMP implementations that could be attributed to the 208 project. However, over the years several other programs have made progress toward fulfilling the goals of the 208 plan. The NRCS programs have been especially effective, since they have been facilitated by NRCS staff and subsidized through significant financial incentives for the farmers. Progress has also been made through Connecticut DEP programs, University of Connecticut Extension programs, Conservation District projects, and others. At this time, many of the farmers in the watershed have installed numerous effective BMPs, including major improvements such as the five dairy manure storage facilities. However, four surface water segments and Roseland Lake are still listed as impaired for their designated use, and agriculture is listed as a suspected cause for three of those impairments.

Suspended-Sediment Characteristics of Muddy Brook at Woodstock, Connecticut

Suspended-Sediment Characteristics of Muddy Brook at Woodstock, Connecticut, with a section on The Water Quality of Roseland Lake and Its Major Tributaries, Muddy Brook and Mill Brook – by Kenneth P. Culp – US Geological Survey – 1991

From May 1980 through September 1983, daily suspended-sediment and streamflow data were collected for Muddy Brook, as a representative rural, wooded, and agricultural drainage basin in the highlands of northeastern Connecticut. Coinciding with the sediment investigation, a water quality reconnaissance was conducted on Roseland Lake and its major tributaries, Muddy Brook and Mill Brook.

The report provides excellent data and specific results on such characteristics as sediment yield, average daily suspended-sediment concentration, and annual sediment deposition into Roseland Lake. The water quality testing of Muddy Brook and Mill Brook provided streamflow-weighted mean concentrations of nitrogen and phosphorus, and also the total yields for the two drainage basins. The results confirmed that the concentrations of nitrogen and phosphorus were sufficient to support eutrophic conditions in Roseland Lake, with the highest concentrations and loads being transported by Muddy Brook. The report also provides detailed results regarding ph, visibility, conductance, and heavy metals found in the lake sediments.

This study found that Roseland Lake was thermally stratified during the summer, and further stated that, although there are relatively high concentrations of nitrogen and phosphorus in the bottom sediments, it is unlikely the nutrients become available to the phytoplankton in significant quantities during the growing season due to the strong thermal stratification.

Little River Sourcewater Protection Plan

Prepared by the Atlantic States Rural Water and Wastewater Association – February 2006

The Little River Sourcewater Protection Plan was developed in 2006 for the purpose of protecting the Putnam Water Pollution Control Authority drinking water supply and public water system wells in Woodstock. Key stakeholders from both towns included representatives from local land-use boards, town administrations, local businesses, local farmers and other associations. Representatives from the Atlantic States Rural Water & Wastewater Association, Audubon, Connecticut Department of Environmental Protection, Eastern Connecticut Resource Conservation and Development, Eastern Connecticut Conservation District, Green Valley Institute, The Nature Conservancy, Northeast District Department of Health, Quinebaug-Shetucket Heritage Corridor (The Last Green Valley), University of Connecticut Cooperative Extension, and the USDA Natural Resources Conservation Service participated in the planning process.

The original steering committee has met periodically since the creation of the Plan. Unfortunately, a Sourcewater Protection Team (recommended by the Plan) has not been formalized or authorized by the towns. Although there is no formal Team, other watershed stakeholders have conducted activities that fulfill some of the recommendations contained in the Plan. The key recommendations of the Plan and a status update for each recommendation are summarized in Appendix 1.

B. Land Use in the Little River Watershed

The Little River watershed is comprised of three main sub-basins; Muddy Brook/Little River main stem, English Neighborhood Brook and Mill Brook. Acreages are 17,527, 3,087 and 4,436 respectively for a total of 25,050 or just over 39 square miles. Land use within the watershed varies considerably. Large areas of the watershed, particularly in Woodstock, are farms or forests, with smaller commercial and residential centers along state roads. Moving south to Putnam, land-use changes to higher density commercial and residential, creating an urban setting. At the confluence of the Little River and the Quinnebaug, a number of historic mills, in the process of being converted for re-use, line the waterways.

Mapping from the University of Connecticut Center for Land use Education (CLEAR) shows land cover for the three combined sub-watersheds (See Map 4) followed by a brief description of each land cover category. (See Table 3) The following table (Table 2) shows land cover acreage for the combined sub-watersheds, comparing 1985 acreages to 2006 (University of Connecticut, CLEAR website).

Table 2

Land Cover Changes
(Combined sub-watersheds of Muddy Brook/Little River main stem, English Neighborhood Brook and Mill Brook

Land Cover Category	1985 (ac)	2006 (ac)	Change (ac)	% Change in Total Watershed
Developed	2,049	2,372	+323	+1.3%
Turf & Grass	860	1,162	+302	+1.2%
Other Grasses	239	373	+134	+0.5%
Agricultural Fields	5135	4,970	-165	-0.7%
Deciduous Forest	10,407	9,926	-481	-1.9%
Coniferous Forest	4,507	4,365	-142	-0.6%
Water	536	455	-81	-0.3%
Non-forested Wetland	167	175	+8	<0.1%
Forested Wetland	1,144	1,129	-15	-0.1%
Tidal Wetland	0	0	0	0.0
Barren	6	123	+117	+0.5%
Utility (forest)	0	0	0	0.0

MAP 4 Little River 2006 Land Cover

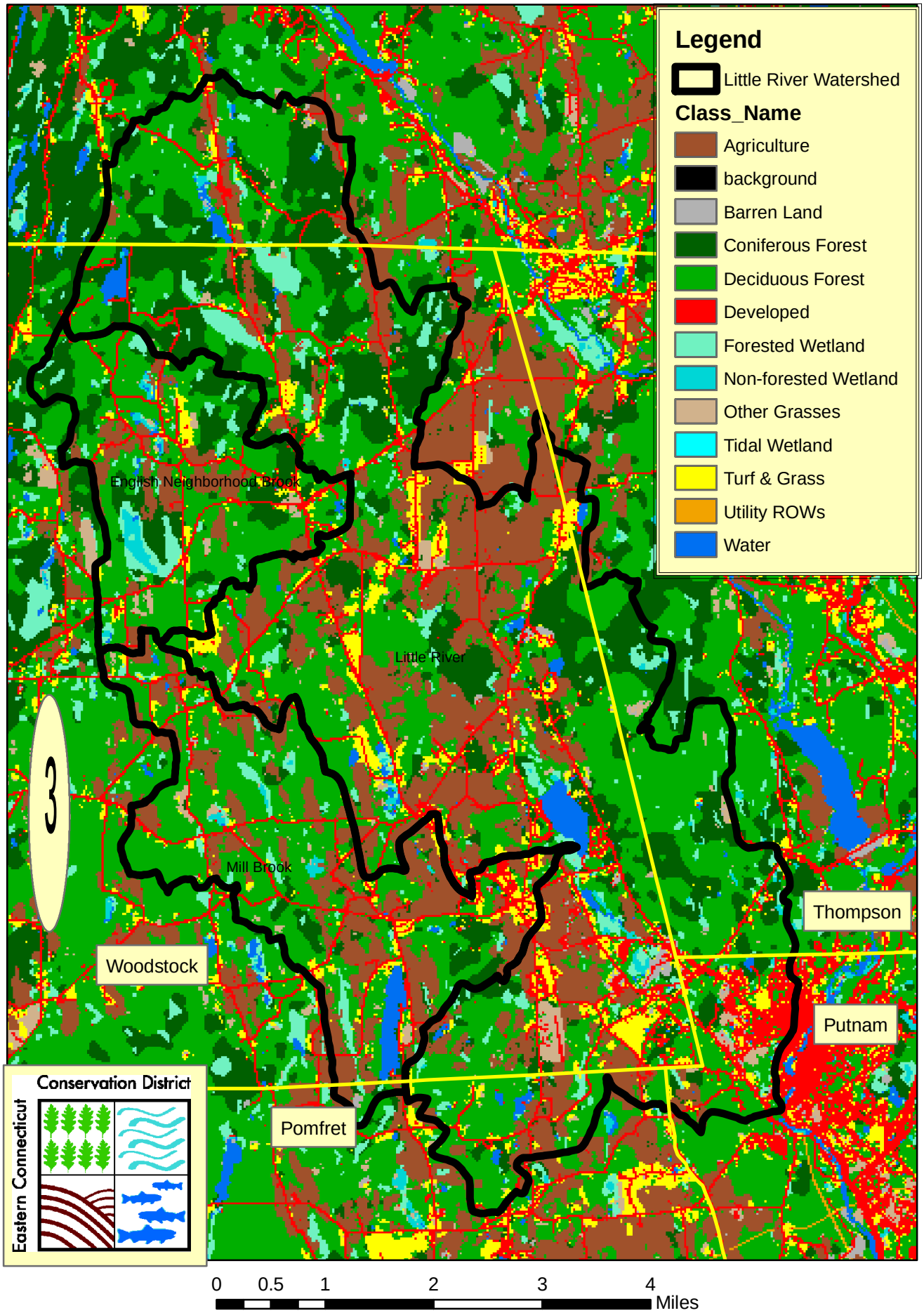


Table 3

Land Use Cover Category Descriptions

	Class	Description
	Developed	High-density built-up areas typically associated with commercial, industrial and residential activities and transportation routes. These areas can be expected to contain a significant amount of impervious surfaces, roofs, roads, and other concrete and asphalt surfaces.
	Turf & Grass	A compound category of undifferentiated maintained grasses associated mostly with developed areas. This class contains cultivated lawns typical of residential neighborhoods, parks, cemeteries, golf courses, turf farms, and other maintained grassy areas. Also includes some agricultural fields due to similar spectral reflectance properties.
	Other Grasses	Includes non-maintained grassy areas commonly found along transportation routes and other developed areas.
	Agriculture	Includes agricultural fields used for both crop production and pasture.
	Deciduous Forest	Includes southern New England mixed hardwood forests. Also includes scrub areas characterized by patches of dense woody vegetation. May include isolated low density residential areas.
	Coniferous Forest	Includes southern New England mixed softwood forests. May include isolated low density residential areas.
	Water	Open water bodies and watercourses with relatively deep water.
	Non-forested Wetland	Includes areas that predominately are wet throughout most of the year and that have a detectable vegetative cover (therefore not open water). Also includes some small water courses due to spectral characteristics of mixed pixels that include both water and vegetation.
	Forested Wetland	Includes areas depicted as wetland, but with forested cover. Also includes some small water courses due to spectral characteristics of mixed pixels that include both water and vegetation.
	Tidal Wetland	Includes wetlands which are influenced by tidal activities
	Barren	Mostly non-agricultural areas free from vegetation, such as sand, sand and gravel operations, bare exposed rock, mines, and quarries. Also includes some urban areas where the composition of construction materials spectrally resembles more natural materials. Also includes some bare soil agricultural fields.
	Utility ROWs	Includes areas established as utility right of ways

Forestry, including deciduous and coniferous combined, make up approximately 57% of the watershed, with agriculture accounting for another 20% and developed land at about 9% of the total watershed. Remaining areas are comprised of forested wetland, turf and grasses, water, non-forested wetlands, other grasses and barren lands (Figure 1). Compared to other watersheds in Connecticut, land cover has remained relatively stable. The most significant changes are noted in the loss of 2.5% forested land cover (deciduous and coniferous combined) and an increase in developed land of 1.3% and turf and grass land of 1.2% (Table 2).

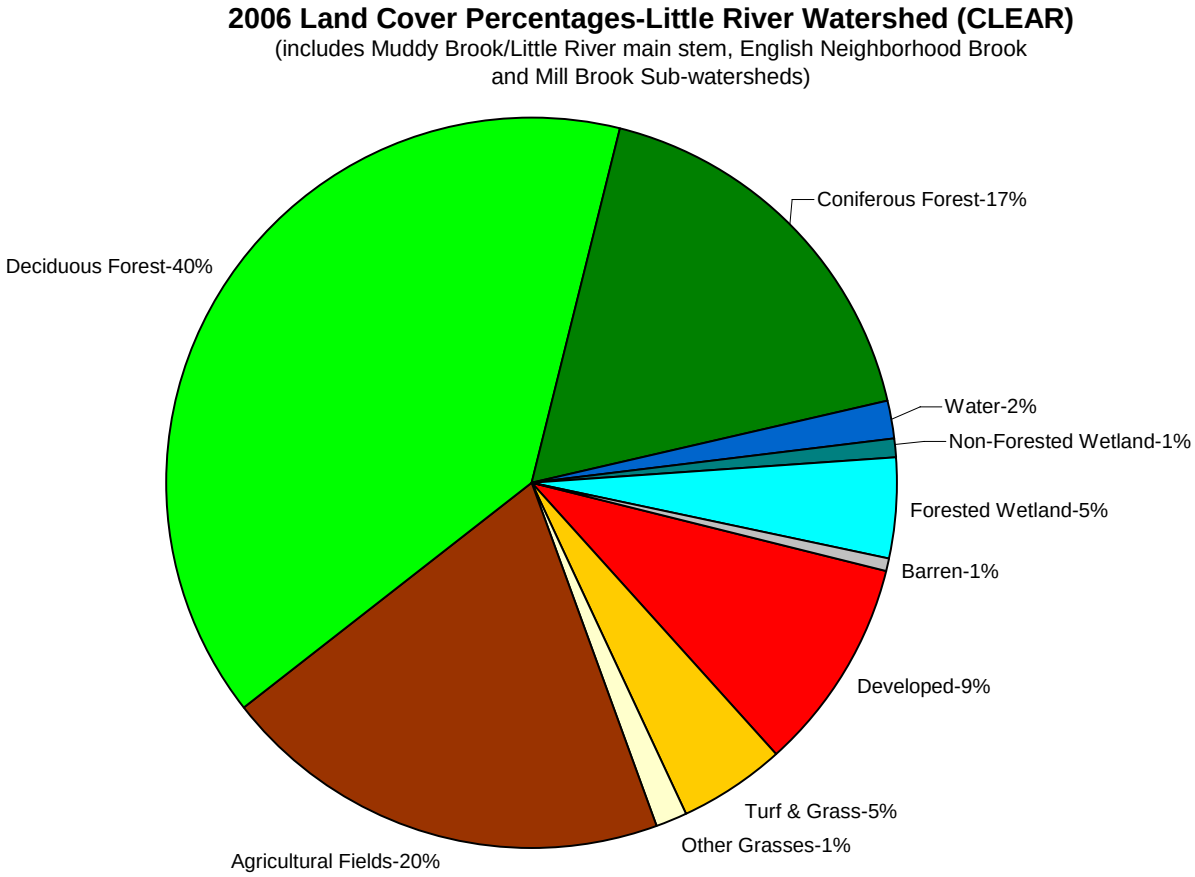


Figure 1

Land Use and Stormwater

Land-use is one of the single most important things contributing to water quality issues. In this watershed, the four key land-use areas of concern include: 1) urban and other densely developed areas, 2) residential development within close proximity to waterbodies, 3) agricultural activities and 4) timber harvesting.

Urban development is often associated with stormwater issues arising from large areas of impervious surfaces. These land covers often contribute large quantities of unregulated flows of stormwater during rain events. These flows can cause significant erosion, undercutting banks, depositing sediments and burying stream bottoms. Further temperature spikes can result as water flows over heated surfaces and is deposited in local waterbodies within minutes, without the benefit of being cooled first. Atmospheric depositions of pollutants on impervious surfaces also find their way to local waterbodies via stormwater. Finally, pollutants associated with snow removal, landscaped areas, pet waste, and illicit discharges to storm drain pipes, often concentrated in urban areas, become part of the stormwater discharged.

Residential development within close proximity to waterways is commonly associated with nutrient loading due to lawn care practices and pet waste, loss of vegetated buffers, and less than optimal functioning septic systems. Roads and driveways to service residential development often drain directly to the waterbody, combined with drainage from roofs and other impervious surfaces taking along any deposited pollutants.

Agriculture, both large and small operations, has the potential to contribute animal waste byproducts from pasture areas or feed lots. Fertilizers and pesticides associated with crop production can find its way into the stormwater stream along with sediment from open fields. Some crops such as corn or newly emerging cover crops attract large populations of migrating geese, which further deposit large amounts of feces. Run-off from storage areas, such as silage crops, can also have detrimental effects on water quality.

Timber harvesting is associated with soil disturbance for haul roads, lay down areas and general machine movement during tree extraction. As timber harvested areas are typically large parcels, steep slopes are commonly part of the landscape. These sensitive areas can be disrupted and exposed causing soil erosion impacting nearby streams. Ruts formed by heavy equipment collect and redirect rainwater, exacerbating erosion issues. Crossings of watercourses can damage banks and change watercourse flow direction eroding adjacent soils.

C. Review of Municipal Planning, Permitting and Management Practices

As part of this watershed planning effort, ECCD also conducted a review of the towns of Woodstock and Putnam municipal planning, permitting and management practices as they relate to stormwater issues. The towns of Thompson and Pomfret were not included due to their limited land area within the watershed. The review has been summarized in table format and can be found in the appendices section of the report. (See Appendix 2)

Along with tabulating municipal planning, permitting and management practices, ECCD has included some general recommendations for consideration by the towns as well as for the development of the full watershed-based plan. These are noted in section: *X. Watershed Plan Recommendations* of this report.

D. Water Quality Monitoring Data Analysis

The Eastern Connecticut Conservation District acquired and reviewed recent water quality data from numerous sources, in addition to their own field investigations. The evaluation of the water quality testing results from the various sources is summarized in this section.

Impairment: Recreation – *Escherichia coli* Bacteria Monitoring

Two of the four listed stream segments in this watershed area are listed as impaired for recreation due to the presence of indicator bacteria, *Escherichia coli* or E. coli. The watershed has been assessed for bacteria at different times in different locations utilizing different methods. ECCD located, gained access to, and evaluated all known data from the past ten years.

DESIGNATED USE CLASS INDICATOR CRITERIA
Freshwater
Drinking Water Supply
Existing / Proposed AA Total coliform
Monthly Moving Average less than 100/100ml
Single Sample Maximum 500/100ml
Potential A
Recreation
Designated Swimming (4) AA, A, B
Escherichia coli Geometric Mean less than 126/100ml
Single Sample Maximum 235/100ml
Non-designated Swimming (5) AA, A, B
Escherichia coli Geometric Mean less than 126/100ml
Single Sample Maximum 410/100ml
All Other Recreational Uses AA, A, B
Escherichia coli Geometric Mean less than 126/100ml
Single Sample Maximum 576/100ml

http://www.ct.gov/dep/lib/dep/water/water_quality_standardsl/wqs.pdf

E. coli Data from Public Swimming Areas

One data source for E. coli levels comes from the monitoring of public swimming locations. The Little River watershed contains only two areas that are or have recently been assessed for recreation as Designated Swimming Areas:

1. Muddy Pond at the headwaters of the Muddy Brook in Woodstock
2. Murphy Park, a former swimming area created by an impoundment of the Little River in Putnam.

Muddy Pond:
The Town of Woodstock maintains a public bathing beach at Muddy Pond. The Northeast District Department of Health monitors the water quality for the Town of Woodstock by collecting water samples on a biweekly basis during the summer months. Samples are transported to the CT Department of Public Health (CT DPH) for assessment following an established protocol. Since 2002, this protocol has been Colilert MMO-MUG fluorescence test. Multiple years of bacteria monitoring at Muddy Pond in Woodstock indicate bacteria levels within the acceptable range for a designated swimming area.

Murphy Park:
Murphy Park, owned and maintained by the Town of Putnam, is located along the Little River in Putnam, CT and formerly included a functioning impoundment of the Little River that was developed into a swimming area with a constructed sandy beach area. In October 2005, a 100 year flood event severely damaged the dam and closed the swimming area. The Town of Putnam is preparing to remove the remaining dam structure. During the time it was an active swimming area, and for an additional year after the breach of the dam, the Northeast District Department of Health collected bi-weekly water samples for bacteria monitoring in this location and transported them to

the CT DPH for analysis as above. The results of the bacteria monitoring, along with additional testing conducted at this site by the CT DPH in 1998/99, indicate multiple exceedances of the upward limit of acceptable E. coli concentrations (235/100 ml) and a geomean of >126/100 ml, which supports the classification of this segment of the Little River as impaired for recreation. (See Appendix 3)

E. coli Data from the Putnam Water Pollution Control Authority (PWPCA)

The PWPCA monitors raw water at the Putnam water treatment facility in South Woodstock. (See Map 5 and Appendix 3)

In September 2008, the Putnam water treatment facility updated their protocol for monitoring bacteria in the raw water sampled at the Putnam water treatment plant intake to be in compliance of new US EPA guidelines. Their current testing protocol is SM 9222 G and they contract with Phoenix Labs in Manchester, CT for this testing.

Prior to September 2008, the drinking water quality monitoring required quarterly raw water sampling for Total Coliform bacteria, and a test for the presence of E. coli, which was reported as only a negative or positive result. The outcomes of the testing for the years of monitoring data provided indicated that the water quality was within acceptable ranges for drinking water standards. The recent results also indicate the water quality in this location meets acceptable limits for recreational contact.

E. coli Data from Other Sources

Multiple short duration bacteria monitoring projects have been conducted in the watershed at various locations and times, by various organizations, including CT Department of Environmental Protection (DEP), CT Department of Public Health (DPH) and the Northeast District Department of Health (NDDH). In order to make a true determination about water quality based on E. coli concentrations, longer duration sampling is recommended. Also, due to differences in rainfall from one season to the next, data collected in one year is not directly comparable to that of another. Therefore, none of these short duration sampling results can be considered conclusive, but they do offer a snapshot of water quality in this watershed at the time the sampling took place. They may also provide guidance if future bracketing of bacteria sources is planned. A Bacteria Monitoring Data Summary Map has been compiled and "tagged" with the monitoring site locations. (See Map 5) The tags indicate:

- Agency involved in the sampling
- Site ID
- Year of the sampling series
- Number of samples taken
- Number of samples that exceed the recommended concentration of E. coli at that location
- Geo-mean of the sample set

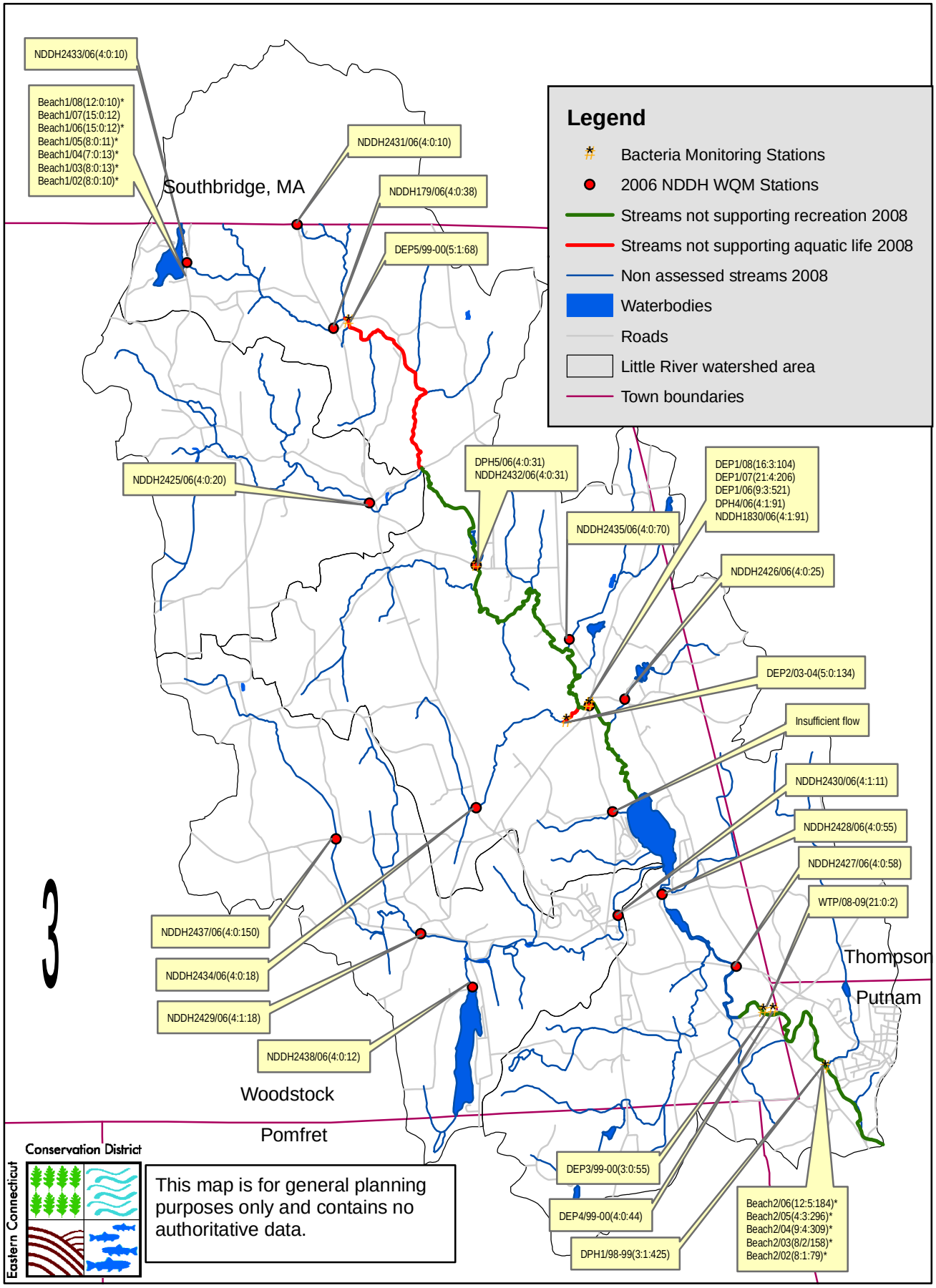
Notes:

- An asterisk after the parenthesis indicates the lower threshold limit of 235/100ml
- "WTP" indicates the data was provided by the Putnam Water Treatment Plant
- Beach1 indicates the swimming beach at Muddy Pond
- Beach2 indicates the swimming beach at Murphy Park
- A complete set of data obtained for this report is available upon request from ECCD

MAP 5

Little River Watershed

Bacteria Monitoring Data Summary



Impairment: Aquatic Life Support – Survey Data

Two of the four stream segments in this watershed are listed as impaired for habitat for fish, other aquatic life and wildlife:

North Running Brook segment CT3707-10_01
Muddy Brook segment CT3708-01_02

The most recent assessment for aquatic life support for the North Running Brook segment was completed in 2004. Information on the aquatic life support function of the Muddy Brook segment was most recently completed around 1999. For both impaired stream segments, the cause of the impairment is listed as unknown, and the potential source of the impairment in both locations is possibly linked to nearby agricultural activity. Both sampling sites are scheduled to be revisited in the fall of 2009.

2006 NDDH Water Quality Testing

In 2006, as recommended in the Little River Sourcewater Protection Plan, the Towns of Putnam and Woodstock sponsored a series of quarterly water samples taken at 15 strategically selected locations. All locations were upstream of the PWPCA drinking water diversion. Northeast District Department of Health staff collected the samples which were transported to the CT DPH for analysis. This sampling is referred to as the 2006 NDDH series. The outcome of this data has been compiled into a report entitled "Little River Watershed Water Quality Testing 2006" by Dr. Richard Canavan of CME Engineering. The full report, including the raw data, can be found in Appendices 4 and 7.

Other Raw Water Testing

The Town of Putnam water treatment facility initiated testing which includes tests for specific algae concentrations at the Roseland Lake outflow (sampled at Stone Bridge Road), the Shepherd's Pond outflow (sampled at Route 171) and at the intake in South Woodstock. The algae screening is used to look for concentrations of algae of types known to create odor or flavor issues and to provide guidance on treatment options. Over time, this type of data may be useful as a long range measure of water quality in Roseland Lake.

In addition to the algae monitoring, the Town of Putnam recently implemented an increased battery of water quality evaluations of their raw water sampled at their South Woodstock water treatment plant. Only data related to bioassays for bacteria was included in this report, but information on phosphate concentrations (4 samples required per year) together with the algae concentrations may be useful in future water quality reviews in the watershed upstream of the water treatment plant intake. Additional required testing on raw water includes:

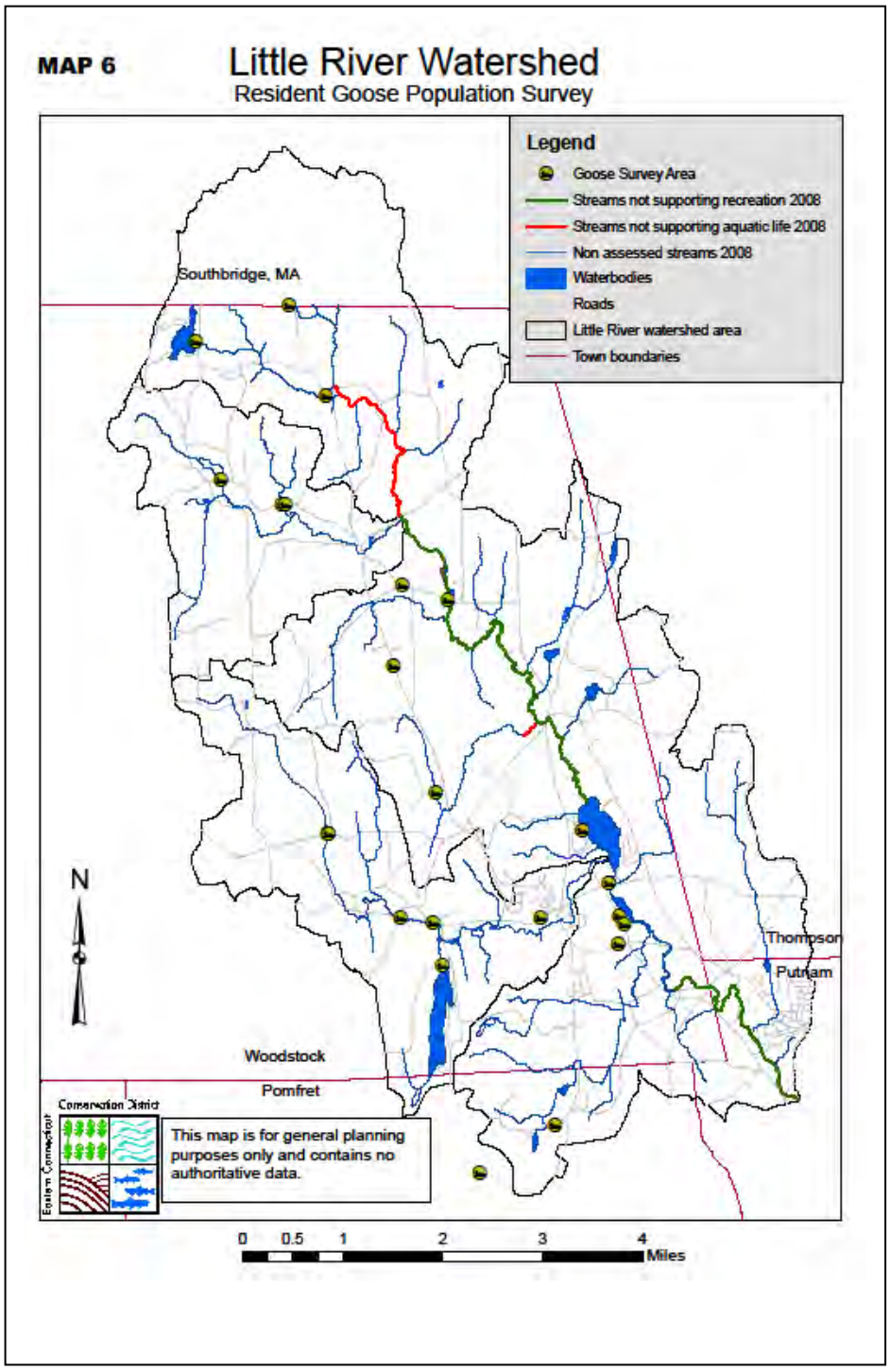
- Nitrate & Nitrite, once per Year
- Inorganic Chemicals once per Year
- Pesticides & Herbicides once per Year
- Total Organic Carbon once per Month (checked daily)
- Total Alkalinity once per Month (checked daily)
- Physical Parameters once per Quarter (checked monthly)

E. Field Investigations

ECCD conducted numerous field investigations and also evaluated the results of field investigations conducted by other entities. The pertinent information is contained in this section.

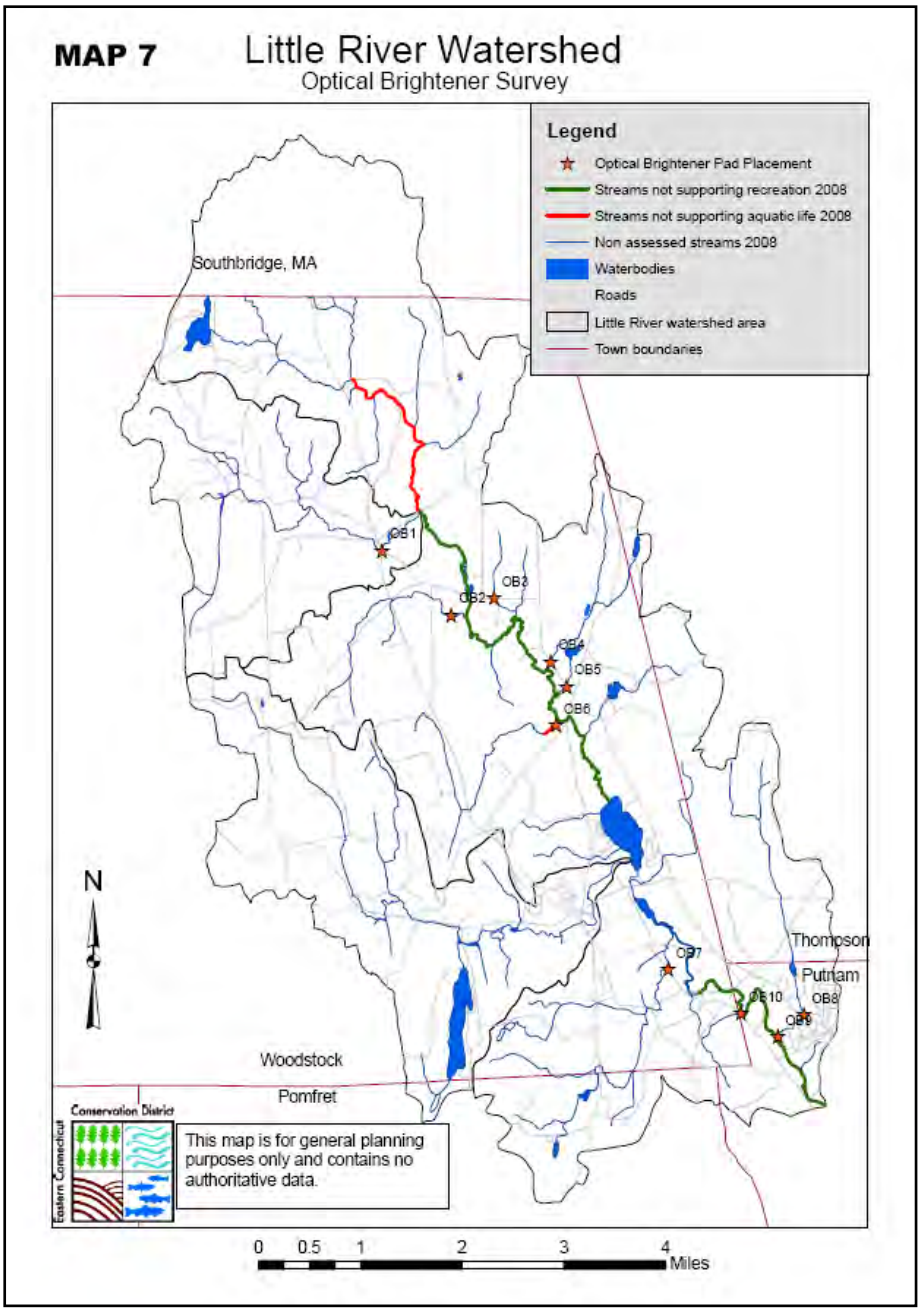
Resident Canada Goose Survey

Canada geese are listed as a potential source of the water quality impairment at Roseland Lake. ECCD staff attended training on how to distinguish resident geese from migratory geese. This training also covered breeding behavior of adults and the permitting process necessary to initiate a volunteer resident Canada goose control effort utilizing the Geese Peace method. Survey sites were selected based on habitat attributes preferred by Canada geese and accessibility from public locations (including public roads) for safe viewing. Ponds on private property not visible from a public road were not included in this survey. A total of twenty-three sites were monitored from March 19, 2009 through April 30, 2009. (See Map 6) Results of this field work along with collaboration of DEP Wildlife specialists have led to the conclusion that although migratory and over-wintering populations are present in this watershed, resident populations are not a primary concern. The full report is available through the Eastern Connecticut Conservation District.



Optical Brightener Test

Optical brighteners are a common laundry detergent additive. Testing for the presence of optical brighter agents in surface water is a method used to determine if household wastewater contamination is present in surface water if there are no waste water treatment plant discharge points upstream. Ten optical brightener pads were obtain from the CT DEP and deployed at various locations in the Muddy Brook/Little River watershed for one week, from June 10 – June 17, 2009. (See map 7). Main stem locations were avoided. Upstream population density and proximity to existing sewer lines were considered when selecting sample sights. Flow rates were measured at the time of placement as well as at the time of retrieval at each sampling sight. Upon collection, the optical brightener pads were individually placed in a new zip type storage bag and transported to the CT DEP office within 24 hours. At the DEP office, they were exposed to a UV lamp to read the outcome. All ten optical brightener pads tested negative after a 7 day exposure. There was a significant rainfall event during the sampling period and the measured flow rate increased at each sampling location. During this exposure period, on June 16, 2009, the CT DEP staff collected a water sample at sampling location CT DEP1 (See Map 5). The result of that test for E. coli was 1,900/100 ml indicating an exceedance of bacterial limits. Six of the 10 optical brightener pads were located upstream of this bacteria monitoring station.



While a positive optical brightener pad result would have supported a conclusion that household wastewater contamination was present, negative results do not necessarily conclusively indicate the lack of wastewater contamination. Late spring/early summer 2009 was a period of higher than normal precipitation in the region and the higher than normal flows at the sampling locations may have impacted the outcome.

Storm Drain Outlet Survey

Once thought to be relatively clean water, it has been well established that stormwater can carry significant loads of pollutants from non-point sources to rivers, streams, waterbodies, and wetland systems. These can include excess fertilizers, pesticides, pathogens, sand, sediment, salt, heavy metals and petroleum products among other things. As such, identifying, mapping and inspecting stormwater systems is an essential part of any overall municipal stormwater management plan. A combined approach of minimizing pollutants that enter the stormwater collection system and providing and maintaining inline treatment offers the best scenario for long term management. Further, identifying specific land-use issues which may be contributing to the pollutant loading is critical for targeting controls.

ECCD staff approached each municipality in the watershed regarding the status of their stormwater outlet inventory and street maintenance policies. This includes the towns of Woodstock, Putnam, Pomfret and Thompson. The Town of Woodstock conducts street sweeping and storm drains are cleaned out on an annual basis. The Town of Putnam conducts street sweeping and storm drain cleaning at least annually. Certain areas are swept more frequently if needed. The Little River area of Putnam is considered a high priority area for street maintenance purposes.

There are currently no mapping of stormwater outflow locations in Putnam, Woodstock or Pomfret. The Town of Thompson recently completed their storm drain outflow mapping and the Town of Pomfret Highway Department is voluntarily creating a storm drain outlet map, but it is not completed at this time. Since both the towns of Pomfret and Thompson are already in the process of mapping their stormwater systems, and there is limited land development in the small areas from either town contributing to the watershed, ECCD focused its efforts on the town of Woodstock and Putnam.

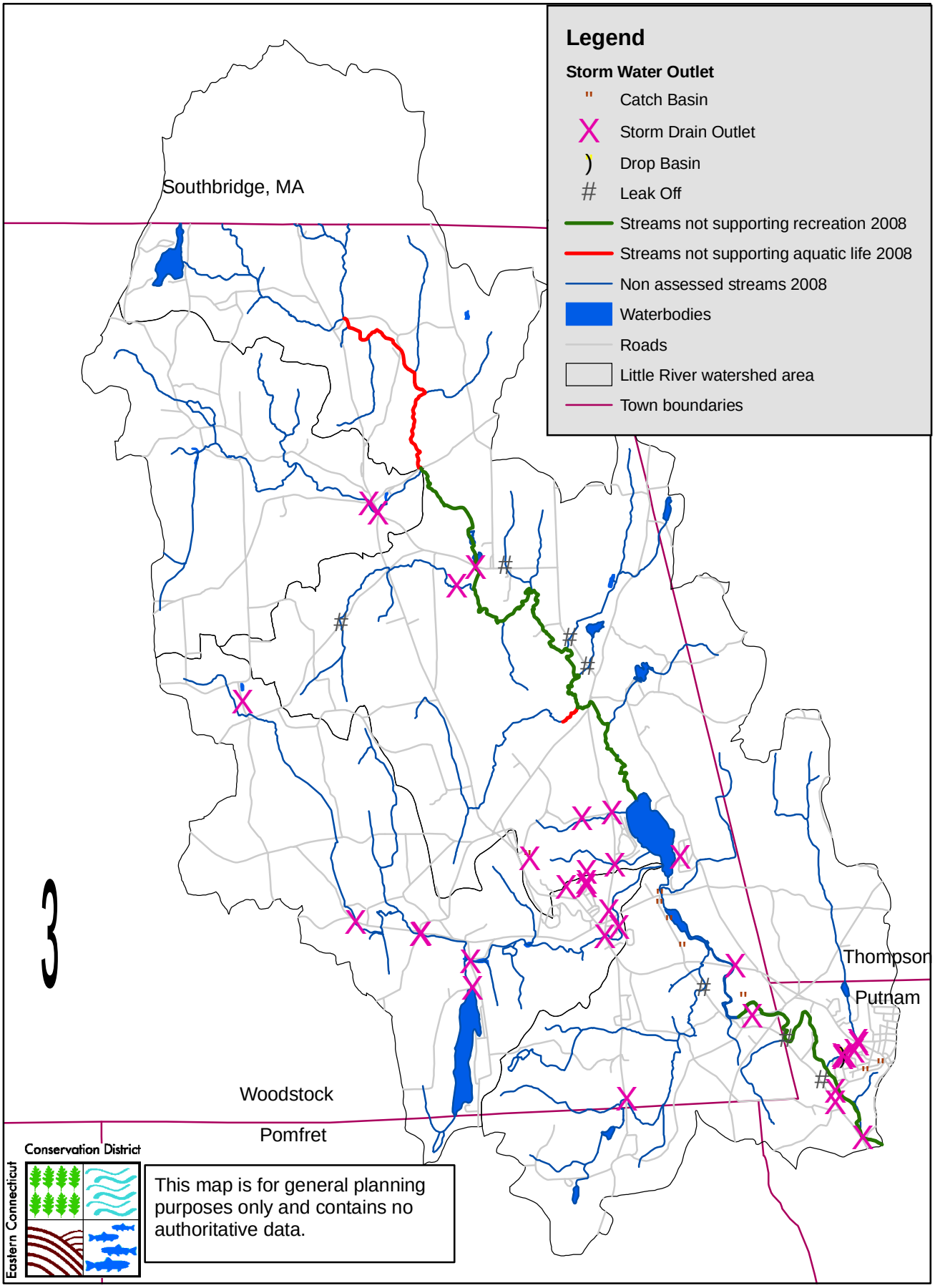
Woodstock and Putnam each provided ECCD with a list of street names along with the number of storm drains located on each street. As part of the field investigation for this report, ECCD staff reviewed the lists and mapped the storm drain outlets that drain directly into streams or their associated riparian areas in the watershed in the areas closest to the impaired stream segments. Storm drain outlets that were included in this review are shown on Map 8. All data associated with this review is available from the ECCD on request. Field observations of nearby land uses were also recorded. When a potential to impact water quality was noted during this field inspection, the data point was tagged as an "area of concern." The most significant areas of concern are listed in a table format, along with follow up recommendations (See Table 4).

No specific storm drain outlet issues were noted above Roseland Lake in the area closest to streams. Curbing to direct stormwater to storm drains was not common. Without the use of curbing or where curbing is limited to culvert crossing areas, leak-offs are common. Almost every stream crossing area is equipped with a leak-off of some type. Even areas with piped outlets commonly had a combined drainage system that included leak-offs. Most of the leak-offs noted provided negligible treatment of stormwater run-off. They are typically paved or excavated shallow channels with limited ability to trap sediments. Also of note was the use of catch inlets without sumps along roads in Woodstock, most notably on Little Pond Road. Catch basins with sumps, if sized appropriately, do provide some ability to trap heavier sands and sediment.

MAP 8

Little River Watershed

Storm Water Outlets in Stream Areas



As part of the storm outlet survey, ECCD staff noted areas of concern (AoC) that related to the condition of the stormwater outlet area and potential pollutant contributions in the immediate vicinity, and other noteworthy issues. These AoCs are shown on Map 9, with further explanation in Table 4.

Table 4:

Storm Drain Survey Areas of Concern

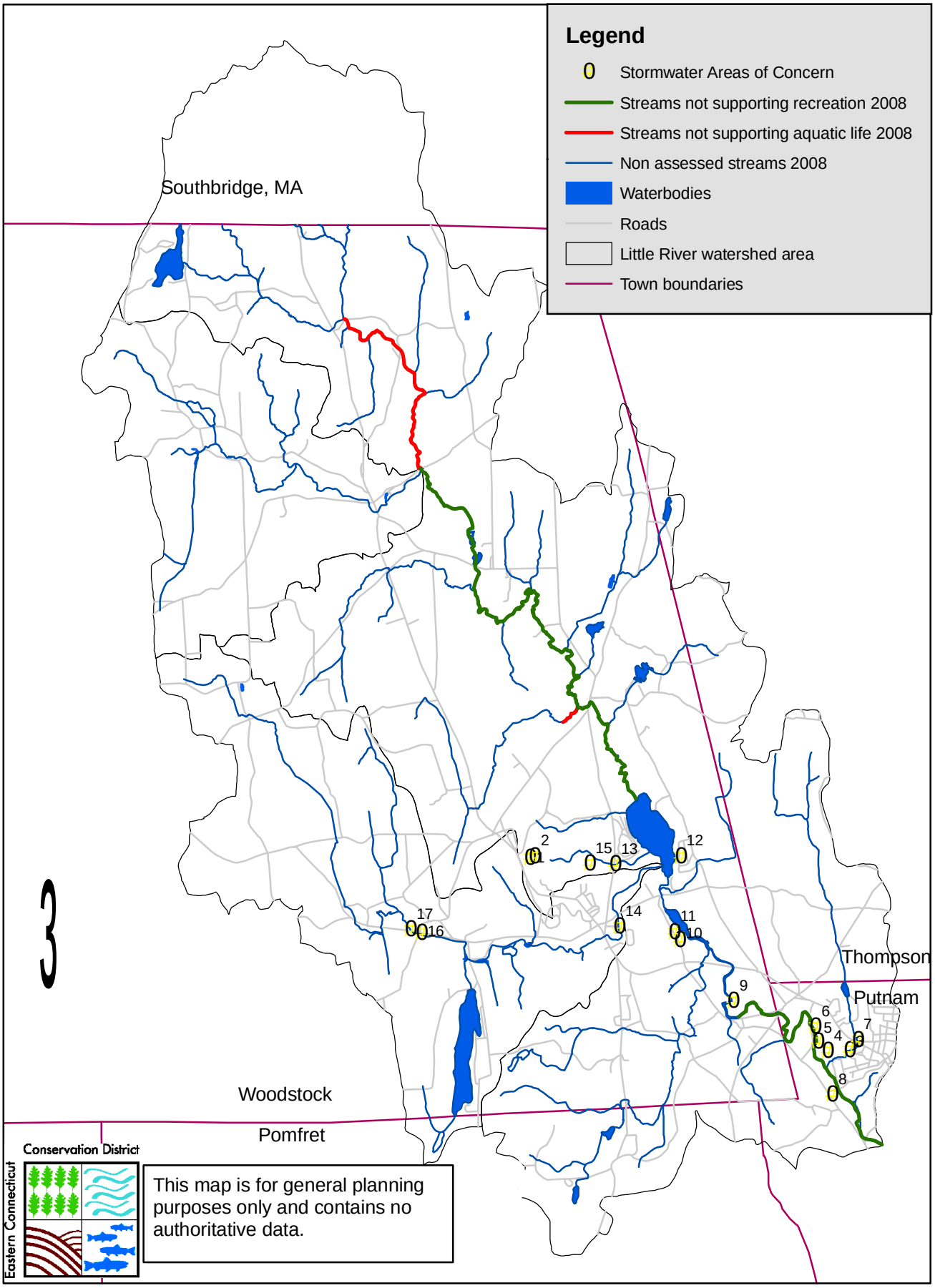
MAP ID	LOCATION	DESCRIPTION	COMMENT
1	Woodstock, Route 169, Arboretum	SDO rock lined erosion channel from uphill runoff through Arboretum	Potential retrofit site
2	See above	End of rock line erosion channel, scouring visible offsite	See above
3	Putnam, Wicker Street	Erosion channel to brook from uphill development	Potential retrofit site
4	Putnam, behind football field	Functioning SW retention pond behind sports complex	Monitor for effectiveness
5	Putnam, school Complex	Athletic field slopes to river, no buffer	Establish no mow area 15-35', or planted buffer
6	Putnam, school Complex	Failed riprap, severe erosion channel from Putnam Middle School	Potential retrofit site
7	Putnam, Providence St	2" plastic pipe from house basement towards brook	Determine source – gray water or sump pump origin
8	Putnam, Sabin Street	Stream piped underground briefly daylights in 24" pipe outfall	Install storm drain sumps in parking area if parking lots drains connect
9	Woodstock, Senexet Village	Boat launch	Post signage re: downstream dam
10	Woodstock, Little Pond Road	Open inlet culvert to open trench, farm field w/ limited buffer	Install wider buffer at edge of farm field
11	Woodstock, Little Pond Road	Open inlet culvert to open trench, erosion on inlet side	Potential retrofit site
12	Woodstock, Laurel Lane	12" outlet to steep slope, outlet at top of partially paved	Potential retrofit site
13	Woodstock, Roseland Park Rd	12" PVC pipe, erosion channel along pipe, outlets to unstable soils	Potential retrofit site
14	Woodstock, North Gate Road	15" pipe in stone headwall drains to river – from fairgrounds, no pretreatment	Potential retrofit site, pre-treatment
15	Woodstock, Frog Pond Rd	Swale parallel to school property, brush lined	No evidence of scouring or erosion, inconclusive if causing offsite impacts
16	Woodstock, New Sweden Rd @ 171	15 & 24" outlets-slopes eroding from overland flow	Potential retrofit site
17	Woodstock, Route 171	Beaver Dam, managed with PVC flow level pipes	Monitor for effectiveness

A 30" outlet pipe was noted but not recorded on the west side of Little Pong Road in Woodstock. While there were not specific issues noted at this outlet, it was later determined that at least some of the catch basins leading into this pipe collect stormwater from the Woodstock Fairgrounds area. No pre-treatment of the stormwater is conducted, therefore this outlet should be added as a potential retrofit site.

MAP 9

Little River Watershed

Stormwater Areas of Concern



Survey of BMP Implementation on Large Farms

The impairments in the Little River watershed have been a concern for decades, and it has long been suspected that the nutrient-rich runoff from the large diary farms is a leading source of the causes, be they nutrients, E. coli, biological indicators, or unknown. As a result, numerous programs and projects have focused on reducing agricultural runoff for at least the last 30 years. Therefore, a logical step for this current project was to assess the progress, and determine the current state of the control of runoff from the large farms in the watershed.

The first step in the process was to define and identify the "large farms". It is a known fact that all the larger farms in the Little River watershed are dairy operations. Dairy operations need to be large enough to be economically viable, so there exists a clear distinction between larger dairy farms and smaller farms. The numerical distinction of 150 or more milking cows was used for this evaluation. Farms meeting this criteria were categorized as large farms. All other farms in the watershed have far fewer animals, and were therefore categorized as small farms. Over the past 30 years the number of dairy farms has decreased. ECCD found that currently there are eight farms in the watershed that fit into the large farm category.

There is a very long list of best management practices that are recommended to reduce agricultural nonpoint source pollution. What sets the large farms apart from the small farms is that fact that many animals are confined to a limited space, which results in the manure and feed being concentrated, in addition to being much greater quantities. The official term for these operations is Animal Feeding Operations (AFO). ECCD's evaluation focused on those BMPs that are specific to confined Animal Feeding Operations.

In the spring of 2009, ECCD personally interviewed the primary operator of each of the eight large farms in the Little River watershed to determine the current state of runoff control from their AFOs. The following BMPs where evaluated.

Table 5

BMPs Related to Dairy Confined Animal Operations	
Practice	**Description**
1. Manure Storage Facility	Typically a lagoon or tank capable of holding 6 months of manure or more. A manure storage facility is a BMP that enables implementation of two other important BMPs: 1) Capture manure from AFO area as opposed to uncontrolled runoff 2) Farmer is able to spread the manure at optimal times of the year (spring and fall) for soil incorporation and plant utilization, as opposed to spreading year-round
2. Manure Application BMPs	There are two BMPs in addition to the one dependent on a Manure Storage Facility (above): 1) Transport manure to distant fields as opposed to spreading it all close to the AFO area 2) Conduct soil tests to determine best fields for spreading manure
3. Milk House Waste Management System	Typically a system that captures the milk house waste and directs it to the manure storage facility or some other containment
4. Silage Leachate collection system	Typically a system that captures the silage leachate and directs it to the manure storage facility or some other containment
5. Stormwater Management for AFO area	Uncontrolled stormwater runoff from confined animal areas can contribute greatly to nutrient and bacteria contamination of surface water. Various practices exist to manage stormwater, primarily: 1) Swales, berms, pipes, etc. to direct clean stormwater away from AFO area 2) Roof over AFO area 3) Rain gutters to capture and direct runoff, in concert with #1 or #4, below 4) Swales, berms, pipes, etc. to capture runoff from AFO area directed to manure storage facility or other containment
6. Animals have no direct access to surface water	This BMP is an obvious requirement to prevent surface water contamination. It is included in this evaluation so as to not discount an important measure implemented over the years, as the efforts to reduce agricultural NPS pollution have progressed.

In the results chart below (Table 6), implementation of the BMPs listed above was ranked as Full, Partial, or Not Implemented. Also, one farm has BMPs scheduled for construction.

Three of the eight farms do not have Manure Storage Facilities that meet NRCS requirements (6 months of storage capacity). Even though these three farms do not have 6 months of storage capacity, they each do have a method for collecting and holding their manure. Unfortunately, their storage capacity is limited, which sometimes results in either untimely spreading, or manure escaping the containment area and entering the environment. Therefore, any farm which does not have a Manure Storage Facility with 6 months storage capacity could only achieve a Partial ranking for Manure Application BMPs, since one of the BMPs is spreading manure at optimal times of the year. Otherwise, the overwhelming majority of the BMPs have been widely implemented. (See Table 6)

Table 6

Survey of the Eight Large Dairy Farms in the Little River Watershed								
Practice	**Farm**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1. Manure Storage Facility	Partial	Full	Full	Partial	Full	Full	Full	Partial
2. Manure Application BMPs	Partial	Full	Full	Partial	Full	Full	Full	Partial
3. Milk House Waste Management System	Full	Full	Construction Scheduled	Full	Full	Full	Full	Partial
4. Silage Leachate collection system	Full	Full	Construction Scheduled	Partial	Partial	Not Implemented	Full	Partial
5. Stormwater Management for AFO area	Full	Full	Full	Full	Partial	Full	Full	Partial
6. Animals have no direct access to surface water	Full	Full	Full	Full	Full	Full	Full	Full

The results of this survey demonstrate that major progress has been made, but that there is still more to be done. The most obvious need is manure storage facilities at 3 of the eight farms. The installation of manure storage typically resolves other runoff issues, because the errant runoff (from milk house, silage, and/or AFO area) can often be directed into the manure storage facility.

The first purpose of this survey was to determine the current status of key AFO BMPs. The second purpose was to determine what recommendations should be made for future implementations. Those recommendations have been compiled in the section of this report entitled "X. Watershed Plan Recommendations".

All of the large farmers in the watershed are aware of agricultural NPS pollution, and they are very willing to install the necessary BMPs for prevention. However, funding is the primary barrier to any further progress. The majority of BMPs are expenses that do not generate income. Although there is some financial assistance available, the fact that the farmers must pay for a very large portion of the BMP means they must be profitable enough to afford their share of the cost.

Three situations are having a major impact at this time. First, the current state of the economy has impacted every aspect of the dairy business, resulting in higher costs and lower profits (or even losses). Second, the price the farmers are being paid for their milk is less than the cost of producing it. Restructuring of milk pricing would be a major help to the farmers. Third, new funding rules set by NRCS have resulted in restrictions on funding assistance for some of the farmers. NRCS is the major funding source for high priced BMPs such as manure storage facilities, which means the new funding restrictions have eliminated the ability of several farms to install needed BMPs.

With adequate funding, installation of the key BMPs needed to reduce the majority of agricultural NPS runoff from the eight large farms in the watershed is achievable.

Evaluation of Small Farms

Farming has changed dramatically over the last century. While larger farms in Connecticut are on the decline, smaller specialty farms are on the rise according to the Farmland Trust and the Connecticut Conference of Municipalities. Unique operations specializing in organic produce, herbs, cheeses, and other products are now fairly common.

Backyard farms also include the keeping of agricultural animals, such as chickens, goats, cows, pigs, llamas and particularly horses. The estimated horse population in Connecticut was 43,059 in 2006 (Nadeau, 2006). As part of the field work ECCD conducted for this watershed plan, windshield tours verified the presence of at least twenty small operations with domestic farm animals. This represents only what is visible from the road and it is anticipated that actual numbers are higher.

Several of the small operations with domestic farm animals are located in areas which have increased potential to impact water resources. This is due primarily to size of the property compared to the animals' needs or lack of best management practices. Of the operations observed, several would benefit from additional best management practices aimed at reducing animal waste run-off from entering nearby watercourses, including establishing vegetative buffers and fencing to prevent animal access to water resources.

Further outreach is needed to help make connections between farming practices and water quality. The Horse Initiative is a group with representatives from the Resource Conservation and Development Program (RC&D), Natural Resource Conservation Service (NRCS), the Connecticut Horse Council, and ECCD. Its goal is to provide a BMP handbook directed at horse owners offering information regarding various practices, along with site considerations and possible needs for additional resources. As part of this effort, ECCD participated in editing a selected sample of the handbook to improve the readability and consistency of the individual practices. It is anticipated that this handbook will be available soon to horse owners in all towns, including the Little River watershed towns (Woodstock, Putnam, Pomfret and Thompson.) Much of the horse BMP handbook information is also relative to other domestic farm animals.

References:

http://www.joe.org/joe/2006december/tt3.php

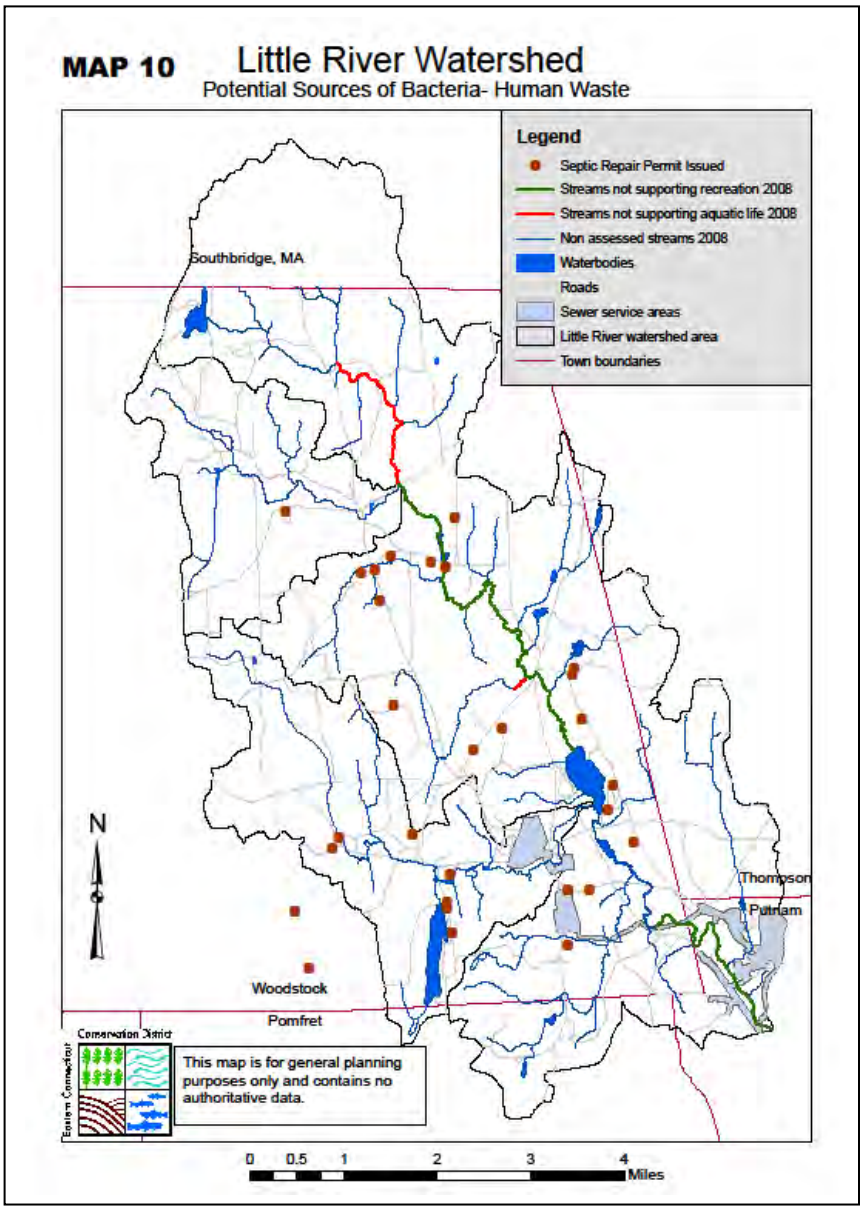
Planning for Agriculture: A Guide for Connecticut Municipalities, A Publication of American Farmland Trust and Connecticut Conference of Municipalities

Stream Walk Surveys

A Stream Walk is a visual assessment of a watershed utilizing a protocol developed by the USDA Natural Resources Conservation Service. Stream Walks offer a means of gathering easily observable information on the current watershed condition. Three Stream Walk assessments were conducted in the Muddy Brook/Little River watershed from 2006 through 2009, including the Little River from Roseland Lake downstream to the Route 44 crossing in Putnam, a portion of Peake Brook in Woodstock, and an unnamed tributary that flows into Roseland Lake. The most relevant Areas of Concern were noted and field investigations have been planned to attempt to track down the sources of the issues. Data and additional information related to these Stream Walks is available from ECCD upon request.

Septic Tank Repair Permit Plotting

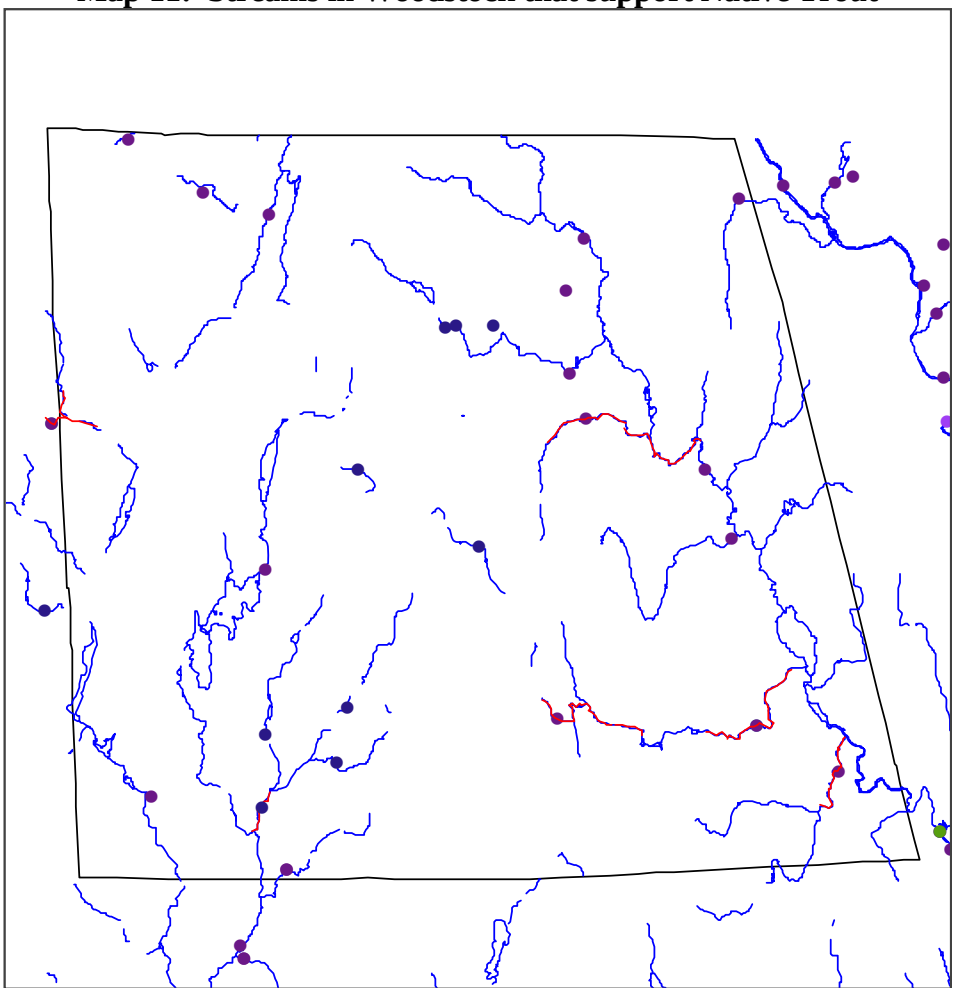
Failed septic systems cannot only be a source of bacteria and other disease causing organisms, but a significant source of nutrients as well. Using information provided by the Northeast District Department of Health, addresses in Woodstock where septic tank repair permits were issued between July 2004 and June 2009 were utilized to create a map overlay to look for clusters of septic tank failures in the Muddy Brook and Roseland Lake areas. This type of analysis was not conducted in Putnam, where most of the homes and businesses in the watershed are hooked up to the sewer system. (See Map 10)



Trout Assessment

Data was received from the DEP Inland Fisheries Division regarding known native brook trout locations in the watershed. Brook trout are cold water species and require relatively clean water for survival. Where they are present, native brook trout are a part of the overall picture of stream conditions. However, the converse is not necessarily an indicator, because their absence may not be related to water quality.

Map 11: Streams in Woodstock that support Native Trout



The red stream sections contain trout.

The Dots represent actual sample locations.

Wild trout streams in Woodstock include:

1. Mill Brook
2. Peake Brook
3. Gravelly Brook
4. Muddy Brook below Lower Minor Morse Pond to Spring Brook

The Little River was not assessed above the water treatment plant diversion.

Roseland Lake is stocked with trout annually but not likely to support overwintering populations. Dams across Muddy Brook at Lower and/or Upper Minor Morse Ponds in East Woodstock may act as a fish passage barrier for upstream migration of fish populations present below the impoundments. Other possible fish passage barriers have not been documented and were not a part of this study.

VIII. Outreach

During the grant contract period, the Eastern Connecticut Conservation District was directly involved in over 22 education and outreach activities specifically related to the goals of this project. Additional outreach occurred as a part of day to day business, through conversations with members of the general public, meetings with stakeholders throughout the watershed, website postings, email communications, and similar means. ECCD's outreach took various forms and covered numerous NPS pollution topics. ECCD was either a part of, or solely produced, several workshops, festivals, meetings, and other events that communicated NPS issues in a face to face setting. Written communications were also used extensively. Newspaper articles, newsletters, brochures, fact sheets, signs, etc. were all part of ECCD's outreach efforts. Electronic media is becoming one of the primary forms of communication, and ECCD made full use of this format. ECCD maintains its own website where NPS prevention information and advertisements for various NPS outreach events are posted. ECCD is also responsible for the Thames River Basin Partnership website which provides NPS information, and ECCD has access to several email listserves that help advertise upcoming outreach events. A full report was submitted to the Connecticut DEP as part of this project. Copies are available upon request.

IX. Watershed Based Plans

In the near future, a project will be conducted by the USDA Natural Resources Conservation Service (with 319 funding provided by EPA and CT DEP) that will develop a full Watershed Based Plan for the Little River, Muddy Brook, Roseland Lake watershed. Throughout this now completed watershed investigation and evaluation document, there is information which addresses the 9 elements required by EPA to create a Watershed Based Plan. Thus, it is intended that this watershed evaluation document will serve as an abbreviated Watershed Based Plan, which NRCS can expand to address any elements not addressed to the extent needed for EPA approval.

One of the challenges of this effort is that the watershed contains five different impaired segments, and each needs to be looked at separately. Although this document fulfills many of the requirements of a watershed-wide Watershed Based Plan, ECCD has also prepared five separate abbreviated Watershed Based Plans, one for each impaired segment. The impaired segments are shown on Map 3, and listed below:

1. Muddy Brook – CT3708-01_02
2. Muddy Brook – CT3708-01_01
3. North Running Brook – CT3708-10_01
4. Roseland Lake – CT3708-00-1-L1_01
5. Little River – CT3708-00_01

However, an evaluation of only the impaired segments would not present a complete understanding of the impairments and the potential sources. Therefore, as part of ECCD's watershed approach to this evaluation, ECCD compiled extensive information in relation to several contributing non-impaired segments in the watershed. This information has been summarized in Appendix 6.

The abbreviated Watershed Based Plans for the five impaired segments appear below, in the order listed above.

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1. Watershed Based Plan for Muddy Brook – CT3708-01_02

a) Impairment:

Muddy Brook segment CT3708-01_02 is located between Route 197 (at the downstream end) and the convergence with Moss Brook in North Woodstock. This segment of the stream is not meeting water quality standard for aquatic life support. The most recent water quality sample to support this stream condition was collected around 1999. It is suspected that the impairment was the result of runoff from one or two specific dairy farms. One of the farms discontinued their dairy operation a few years ago, and at this time, this section of the Muddy Brook watershed includes only one operating dairy farm.

The DEP and NRCS worked with the remaining farm, and updated BMPs were installed. Without further information on the current state of this stream segment, it is difficult to make more than general recommendations on measures to make water quality improvements.

b) Load Reduction

The load reduction to be attained is not quantified, but will be evidenced by the meeting of the standards for aquatic life support.

c) Management Measures – Description

1. Monitor Muddy Brook for aquatic life support suitability as part of the DEP monitoring program.

d) Technical & Financial Assistance Needed

1. Measure 1: DEP staff to conduct monitoring as scheduled. Since corrective actions to address the farm run-off have been completed, there is an expectation that no additional technical or financial assistance will be needed.

e) Public Information & Education

With the expectation that the problem was confined to one or two specific farms, and has since been resolved, no public information or outreach should be necessary.

f) Management Measures – Schedule

Monitoring is scheduled to be completed in 2010.

g) Milestones, h) Performance, and i) Monitoring

The milestone will be completion of the monitoring. It is anticipated that, with the installment of BMPs, the pollutant loading has been reduced and the segment will meet the standards for aquatic life support. The performance criteria by which to measure success will be confirming that the standards are being met, and the delisting of the segment. Future monitoring will be conducted by DEP as part of their program for monitoring the waters of the State.

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2. Watershed Based Plan for Muddy Brook – CT3708-01_01

a) Impairment:

Muddy Brook segment CT3708-01_01 extends 5.44 miles from the mouth of Roseland Lake, upstream to the Route 197 crossing in Woodstock. The Connecticut DEP began regularly monitoring Muddy Brook at Child Hill/Paine District/Roseland Park Road intersection as part of their probabilistic monitoring program in 2005. (Site is identified as DEP 1 on Map 5.) Based on the monitoring results, the Connecticut DEP added this segment of Muddy Brook to the 303d list of impaired waterbodies in their 2008 Water Quality Assessment Report. This was due to the exceedances for bacteria of a single sample, as well as exceeding the statistically significant geometric mean of the sample set.

The source of the bacterial contamination is listed as unknown. However, the sampling location is downstream of five dairy farms, located either along Muddy Brook or one its tributaries. All of the farms have confined Animal Feeding Operations. Four of the five farms have manure storage facilities, leaving one that does not. The sampling location is also located a short distance downstream of a horse property that is in need of improved manure management. These factors have lead to the suspicion that agriculture is the source of the impairment.

A review of available bacterial monitoring data does not offer conclusive information, but the snapshot of information presented by short term monitoring efforts indicates that additional monitoring is needed to bracket the source of contamination. There is an example of "bracketing" between a site at Woodstock Road (shared by sampling sites DPH 5 and NDDH 2432; (See Map 5), and the DEP 1 site discussed above. Both DPH 5 and NDDH 2432 were analyzed for E. coli in 2006. The DPH 5 set of 4 samples showed 0 exceedances and a geo-mean of 31. The NDDH 2432 set of 4 samples also showed 0 exceedances and also a geo-mean of 31. Neither sample set is large enough to represent a statistically significant data set, but combined, the information may have higher relevance. The results suggest that the source of the E. coli bacteria is between Woodstock Road where DPH 5 and NDDH 2432 are located, and DEP 1 at Child Hill Road.

b) Load Reduction

The load reduction goal is lowering bacterial contamination to the meet Connecticut's standards.

c) Management Measures – Description

1. Increase the number of locations and the frequency of sampling to:
    a) Obtain statistically significant test results
    b) Bracket the source(s) of bacterial contamination

2. Provide assistance to the single dairy farm (Elm Farm) that does not have a manure storage facility, to install a facility that meets NRCS standards, and provide additional assistance to implement other NPS BMPs.

3. Identify and educate owners of small livestock operations in the watershed regarding agricultural NPS pollution, and implement manure management BMP's on their farms.

d) Technical & Financial Assistance Needed

1. The technical and financial assistance for Measure 1 will be CT DEP conducting the monitoring, or providing the necessary financial assistance for a reputable partner to handle the monitoring.

2. Measure 2 will be costly (in excess of $200,000), and thus will require considerable technical and financial assistance. NRCS is typically the lead agency involved in assisting farmers with manure storage facilities.

3. Measure 3 will require technical assistance to provide education and outreach, and financial assistance for BMP implementation, as well as for the expenses associated with education and outreach. Cost will be moderately high. A program could be run by NRCS, DEP, or an agriculture-related non-profit organization such as ECCD or RC&D.

e) Public Information & Education

A complete outreach and education program should be developed and implemented that focuses specifically on small farms and owners of agricultural livestock. This program should contain the following steps:

- Identification of locations of small farms and agricultural livestock owners
- Development of effective outreach materials aimed at problem identification and practical solutions
- Development of programs that provide technical and financial support for instituting Best Management Practices
- Follow-up measures to ensure effectiveness of practices

This program should include cooperation of several organizations such as NRCS, CT-DEP, CT Horse Council, ECCD, and local small farm owners. Town involvement would also facilitate the program.

f) Management Measures – Schedule

1. Measure 1 can be completed in one year, although a longer period would insure more accurate results. After a definitive determination has been made, monitoring should be ongoing in future years as part of DEP's program for monitoring the waters of the State.

2. Given funding and technical support, Measure 2 can be completed within five years.

3. Given funding and technical support, the majority of farms and BMPs contemplated by Measure 3 can be completed within five years, but it is recommended that activities be ongoing for an additional five years.

g) Milestones, h) Performance, and i) Monitoring

The milestones will be 1) Identifying the source(s) of bacteria, and 2) Implementing BMPs which prevent the bacteria from entering surface waters. The performance criteria by which to measure success will be confirming that the standards are being met, and the delisting of the segment. Future monitoring will be conducted by DEP as part of their program for monitoring the waters of the State.

3. Watershed Based Plan for North Running Brook – CT3708-10_01

a) Impairment

North Running Brook segment CT3708_10-01 enters Muddy Brook approximately 1 mile north of Roseland Lake. A 0.19 mile segment of North Running Brook upstream of the convergence with Muddy Brook is not meeting water quality standards for aquatic life support. This segment is described as beginning at a runoff ditch from a farm field 300 feet upstream of a farm road crossing that is 900 feet upstream of the Muddy Brook confluence. The farm road is located off of Child Hill Road in Woodstock. The cause of the impairment is said to have been caused by cows being confined in an area where a natural spring created a continuous flow of water from the confinement area directly to North Running Brook via the runoff ditch described above. Silage leachate may have contributed to the problem. Silage leachate contains high concentrations of sugars and nutrients. Small amounts can deplete oxygen, killing fish and other aquatic organisms.

DEP, NRCS, and the farmer have been working together to address the problems. Cows are no longer confined in the spring-fed area, and the spring water is piped such that it does not get contaminated by manure. In addition, a system has been designed that will reduce or eliminate the incidence of leachate draining from the silage storage area. The proposal is to capture and direct the leachate to the new manure storage facility. The BMP should be functional in 2011.

The impaired North Running Brook stream segment has not been sampled since 2004. However, during a spot inspection in 2009, approximately 50 fingerling fish were observed in a 10 foot segment of the brook where the runoff ditch (described in the first paragraph above) meets North Running Brook, indicating that the brook now supports aquatic life. CT DEP will be monitoring this location in fall 2009 as part of the 5 year watershed rotational program.

b) Load Reduction

The load reduction goal is for the segment to meet the standards for aquatic life support, and reduce the incidence and amount of silage leachate to levels acceptable to DEP.

c) Management Measures – Description

1. Monitor North Running Brook for aquatic life support suitability as part of the DEP monitoring program.

2. Implement a BMP system that will prevent silage leachate from entering surface waters. The proposal is to capture and direct the leachate to the new manure storage facility.

d) Technical & Financial Assistance Needed

1. Measure 1: DEP staff to conduct monitoring as scheduled, funded by the Connecticut State budget.

2. Measure 2: Implementing the proposed BMP will require significant technical and financial assistance, some of which is currently being provided by NRCS.

e) Public Information & Education

With the expectation that the problem is confined to one specific farm, no public information or outreach should be necessary.

f) Management Measures – Schedule

1. Monitoring is scheduled to be completed in 2010.

2. Measure 1 can be completed in approximately 1 year.

g) Milestones, h) Performance, and i) Monitoring

The milestone will be implementing the BMP system. The performance criteria by which to measure success will be confirming that the standards are being met, and the delisting of the segment. Future monitoring will be conducted by DEP as part of their program for monitoring the waters of the State.

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4. Watershed Based Plan for Roseland Lake – CT3708-00-1-L1_01

a) Impairment

Roseland Lake is located in the southeastern part of Woodstock. It is a 96 acre natural lake that averages 8 deep. The deepest part is around 18 feet deep. The main tributaries to Roseland Lake are Muddy Brook at the northern end, and Mill Brook near the southern end. Two additional unnamed tributaries flow into Roseland Lake, but field observations show these streams only flow intermittently. Roseland Lake has one outlet at the southern end, and that outlet is the starting point of the Litter River.

Roseland Lake is included on the 2008 Water Quality Assessment Report impaired waters list due to excess nutrients and biological indicators. Recreation is listed as the impaired designated use. Roseland Lake has not been a Designated Swimming Area for decades, therefore the impairment is for other recreational uses.

The term for excess nutrients is "eutrophic". The Connecticut water quality definitions for eutrophic lake conditions are:

> Eutrophic: May be Class AA, Class A, or Class B water. Highly enriched with plant nutrients. High biological productivity characterized by frequent blooms of algae and/or extensive areas of dense macrophyte beds. Water contact recreation opportunities may be limited.
>
> Highly Eutrophic: May be Class AA, Class A, or Class B water. Excessive enrichment with plant nutrients. High biological productivity, characterized by severe blooms of algae and/or extensive areas of dense macrophyte beds. Water contact recreation may be extremely limited.

Waterfowl (primarily Canada geese) are listed as a potential source of nutrient enrichment at Roseland Lake. There is both anecdotal and photographic evidence that Roseland Lake is utilized as a roosting location for thousands of migratory Canada geese in the fall and spring. In the fall, the farming practice of planting rye grass as a cover crop appears to be an attractant to geese, as the tender rye seedlings are just emerging at the time the migrant geese are arriving. However, based on the information gathered during ECCD's investigation, migratory geese do not stay in the watershed long enough to be of concern.

When waterfowl was listed as a potential source, the belief was that large numbers of Canada geese had taken up residence in the watershed. Based on extensive field work, in conjunction with interviews with various land and business owners, and also consultations with DEP Wildlife personnel, ECCD has confirmed that resident geese are not present in numbers that would be needed to be a significant source of nutrient enrichment in the watershed. Lack of resident Canada geese in the watershed today however does not guarantee against future populations becoming established.

Agriculture is also listed as a potential source. There are several agricultural fields in the vicinity of the lakeshore that ultimately drain into Roseland Lake. However, there are significant buffers of woodlands between these fields and the lake. Agricultural nutrient contributions are more likely being transported into the lake by Muddy Brook and Mill Brook.

Other sources are unknown. Of those, internal loading originating from the sediments could be a significant contributor. (See Appendix 4)

A nearby golf course could also be a potential source. The golf course is located on the west side of Roseland Park Road, across from Roseland Park. One of the fairways drains into an intermittent stream channel with a limited vegetative buffer. The stream channel empties into Roseland Lake.

b) Load Reduction

The load reduction goal is to reduce the nutrient load entering Roseland Lake. The level of reduction to set as a goal will need to be established based on thresholds set by DEP, data, and realistic expectations.

c) Management Measures – Description

1. DEP identifies the designated recreational use(s) which are impaired and establishes thresholds of nutrients, eutrophication, and biological indicators, so goals can be set for de-listing.

2. Confirm that nutrient loading from bottom sediments is a significant factor and evaluate corrective actions.

3. For all applicable land uses in the watershed, implement BMPs that target nutrient NPS pollution. Because the BMPs necessary to reduce nutrient NPS pollution need to be promoted through public education and outreach, the management measures have been listed under the *Public Information and Education* section, below, in Table 7.

d) Technical & Financial Assistance Needed

1. Measure 1 can be accomplished by DEP without additional technical or financial assistance

2. Measure 2 might best be accomplished by the USGS, as they recently conducted a similar study at nearby West Thompson Lake. USGS has the technical expertise, but would require financial assistance. The cost would be moderately high. If sediments are a significant source, the corrective actions would likely be very costly.

3. Measure 3 will require considerable technical and financial assistance. The extent to which BMPs can be implemented is immeasurable. A realistic level of BMP implementation and estimated costs can be set upon the completion of Measure 1.

e) Public Information & Education

Public education and outreach is a critical part of several of the management practices outlined, especially those that rely solely on changing habits and practices, and those that cannot effectively be controlled though regulations alone. Following is a table summarizing educational and outreach opportunities for each of the management measures.

Table 7

Public Information and Education for Roseland Lake Management Measures

BMP Measures	Possible Responsible Party	Specific Activities
Stormwater Retrofits	Public Works, ECCD, DEP, NRCS, local landowners, Land-Use Boards and Staff	Provide general information to town boards, and landowners on importance of stormwater treatment maintenance and upgrades. Work with local Land-Use boards to provide for technical support on redevelopment sites for potential to upgrade stormwater facilities
Establish/Increase Vegetated Buffers	Land-Use Boards and Staff, Conservation Commission, Friends of Roseland Park, Neighborhood Associations	Provide information sessions to general public on importance of vegetated buffer. Work with local nurseries to include native stock and additional information. Work with local citizens to "adapt" a section of the Lake Shore.
Pooper Scooper Ordinance	Town legislative Body,Park & Rec. Department, Friends of Roseland Park, Neighborhood Associations	Provide signage and printed information on importance of removal of pet waste from public areas and private areas within close proximity to the lake.
Manage Crop Land Cover and Fertilizer Application	NRCS and Farmers	Encourage local agricultural enterprises to work with NRCS to develop/continue sound management practices
BMP Practices forSmall Farms	NRCS, CT Horse Council, ECCD and owners	Develop an BMP education program combined with technical and financial assistance for small farms and owners of agricultural animals
Adapt Green Lawn-Care Practices	Land-Use Dept., Park and Rec. Dept., Neighborhood Associations & local businesses	Develop green lawn-care practices for town/public maintained areas and offer demonstrations, coordinated with local groups and businesses to promote green practices, provide printed material & sources for further info.on various practices. Offer a local "green" certification.
Monitor/Repair Septic Systems	Health District and home owners	Develop program to remind landowners to perform maintenance, run occasional newspaper notices, publish information on website and provide other printed materials
Good Housekeeping Practices including Stormwater Maintenance and Erosion Controls	Zoning and Wetlands, ECCD	Education landowners/developers on a case by case basis or in workshops on the importance and appropriate control measures and maintenance. Develop checklists for existing and newly approved sites.
Incorporate Stormwater BMPs with New Development	Land-Use Commissions and Staff, Public Works Dept. and Design Consultants, NEMO	Provide information and training sessions to Land-Use Boards and Staff and local developers on various methods of LID and Stormwater BMPs
Conserve Open Space	Land Trusts, Land-Use Boards and Town Financial and Legislative Bodies	Conduct surveys to determine level of awareness and support for open space. Provide public information on the value of open space. Encourage public access to natural areas where feasible to increase public support.

f) Management Measures – Schedule

1. Measure 1 can be accomplished in one year or less.

2. Measure 2 can be accomplished in approximately 3 years.

3. Measure 3 can be a standing program which continues indefinitely.

g) Milestones, h) Performance, and i) Monitoring

The milestones will be 1) Completion of Measure 1, and 2) Establishment of a sustainable program that will educate the public and facilitate BMP implementation. Milestones for addressing possible nutrient loading from bottom sediments will need to be determined after the completion of measure 2. The performance criteria by which to measure success will be confirming that there is continuing progress toward nutrient reduction, and the ultimate criteria will be the delisting of Roseland Lake. Future monitoring could probably be best conducted by Putnam WPCA as part of their program for monitoring surface water upstream of their drinking water diversion.

5. Watershed Based Plan for Little River – CT3708-00_01

a) Impairment

Little River segment CT3708-00_01 begins at the Quinebaug River and extends upstream 2.64 miles to a Putnam Water Pollution Control Authority (WPCA) water treatment plant. This segment of the Little River is not meeting water quality standards for recreational contact due to high levels of E. coli bacteria. The samples showing the E. coli exceedances were collected at Murphy Park, which is approximately at the mid-point of the segment. The source of this contamination is unknown.

This segment flows from the treatment plant through a portion of Woodstock, which is an area of low to medium density residential land. This area also includes a golf course and a condominium complex. Once in Putnam, the river meanders through a significant open space parcel owned by the town. Beyond that, the Town of Putnam Middle School/Elementary School/sports field complex borders the left bank of the river with varying widths of wooded riparian cover. A trail parallels the river behind this complex. Since the majority of residences and businesses in this part of the watershed are connected to the sewer system, the land uses do not point to a likely source of bacteria

This segment of the Little River includes a former Designated Swimming Area, Murphy Park. During the time Murphy Park was a swimming area, biweekly water quality tests for indicator bacteria were conducted. Each year since 2002, there were exceedances of the limit of 235/100 ml. In the years 2003 – 2006 (the last year sampling took place) the geo-mean of the samples sets exceeded the limit of 126/100ml. Test outcomes are summarized on Map 5 (Station ID "Beach 2").

The ECCD watershed evaluation included extensive field inspections and other research to look for potential sources of bacterial contamination upstream of the Murphy Park (Beach 2) monitoring location. Locations in need of NPS BMPs were observed, however, the only apparent source of bacteria observed was pet waste. ECCD also placed optical brighter pads in this part of the watershed, and they did not show evidence of contamination with household wastewater. ECCD consulted with the Putnam WPCA, and was informed that they have not needed to perform any sewer line repairs in the Little River watershed area within the last few years.

ECCD's investigation identified one possible septic system issue. A now vacant National Guard Armory reported problems with their septic system some years ago. Indications are that the problem was not fixed, however the building is no longer in use.

b) Load Reduction

The load reduction goal is lowering bacterial contamination to the meet Connecticut's standards.

c) Management Measures – Description

1. Conduct water quality monitoring in the Little River and Wheaton Brook to:
    a) Obtain statistically significant test results
    b) Bracket the source(s) of bacterial contamination

2. If water quality tests indicate a possible leak in a sewer line, inspect lines for leaks.

3. Inspect and dye test the septic system at the National Guard Armory.

4. Implement BMPs to resolve any problems identified via measures 1 through 3.

5. Conduct an education campaign to educate residents about pet waste impacts on water quality.

d) Technical & Financial Assistance Needed

1. Measures 1 through 3 can be accomplished by DEP, NDDH, and the Town of Putnam and/or Putnam WPCA without additional technical assistance. Putnam/Putnam WPCA would likely need financial assistance to fulfill its part of the Measures.

2. See #1

3. See #1.

4. Measure 4 will likely require technical and financial assistance to resolve the problems identified via measures 1 through 3. The costs cannot be estimated until the source or sources are identified and the cost of corrective measures estimated.

5. Measure 5 will require technical assistance to provide education and outreach, and financial assistance for expenses associated with education and outreach. Cost will be low. A program could be run by the town or an interested organization.

e) Public Information & Education

Develop an educational marketing campaign aimed at reducing pet waste:

- Install and maintain pet waste stations in public parks and trail systems. Accompany with "attention getting" signage.
- Research and implement effective social marketing strategies aimed at making connections between pet waste and water quality and "doing the right thing".
- Develop local schools programs by promoting proper pet waste disposal both at home and in public areas.

This campaign could be conducted by a number of different parties, such as a local commission, Parks and Recreation Department, neighborhood association, local scout troop, etc.

f) Management Measures – Schedule

1. Measure 1 can be completed in one year, although a longer period would insure more accurate results. After a definitive determination has been made, monitoring should be ongoing in future years as part of DEP's program for monitoring the waters of the State.

2. Measure 2 can be completed within one year of the identification of a possible leak (via Measure 1).

3. Measure 3 can be completed in one year or less.

4. Measure 4 is an unknown until problems are identified. After a problem has been identified, and implementation schedule can be set.

5. Measure 5 can be completed in 1 to 2 years.

g) Milestones, h) Performance, and i) Monitoring

The milestones will be 1) Identifying the source(s) of bacteria, and 2) Implementing BMPs which prevent the bacteria from entering surface waters. The performance criteria by which to measure success will be confirming that the standards are being met, and the delisting of the segment. Future monitoring will be conducted by DEP as part of their program for monitoring the waters of the State.

X. Watershed Plan Recommendations

For Implementation of NPS Management Measures

The recommendations section includes three sub-sections. The first is an overall watershed recommendation section which addresses issues pertinent to the entire watershed. The second is a compilation of the recommendations made in the preceding five abbreviated Watershed Based Plans, for the five impaired segments. Those recommendations have been consolidated here for easy reference. In addition, this section includes "secondary" recommendations for each impaired segment that are not included in the five Watershed Based Plans. The third section addresses specific recommendations for other watercourse segments in the watershed.

A. Overall Watershed Recommendations

This section is a compilation of watershed management recommendations based on the various field studies, and also the review of existing municipal regulations and management actions currently used. Previous recommendations from the *Sourcewater Protection Plan* that are relevant to this plan have also been included. The recommendations have been organized into categories based land-use or management entities.

Administration:

1. Form a local Watershed/Sourcewater Protection Team
2. Organize and support additional household hazardous waste collection days to prevent illegally disposal of substances.
3. Support preservation of key watershed parcels
4. Adopt and enforce "pooper scooper" ordinances for parks, walking areas and residential areas of higher density within close proximity to waterbodies.

Land-Use Management and Regulation:

1. Training on the use of soil-based planning to match stormwater treatment with underlying soil characteristics is recommended. Utilize NRCS Soil Web information when conducting planning and application reviews. Recommend workshops with NRCS personnel on the use of the NRCS Soil-Web as a tool in the planning and permitting process. Mapping and planning with restrictions regarding highly erodible soils is recommended as part of the full Watershed Based Plan.
2. To the extend feasible, town zoning maps should show overlay zones for aquifer protection areas, surface drinking water protection zones and the Little River greenway overlay zone. General wetland soil mapping should be available in a format that is aligned with parcel boundaries. Open space designations for natural resource protection and water supply protection, should be included on resource mapping and in POCDs.
3. Open space intended for active recreation should be located where potential impacts to sensitive resources such as streams or rivers, is minimal.
4. Adoption of net buildable areas can minimize the potential development impacts to wetlands, watercourses, steep slopes, flood prone areas, etc.

5. Maintaining natural vegetative wetland and watercourse buffers should be a priority. The land-use permitting process should take into consideration areas where restoration of riparian buffer vegetation or where potential wetland mitigation areas adjacent to watercourses would be beneficial.
6. Continue to encourage the use of LID practices for new developments to promote treatment and infiltration of stormwater. Minimizing street widths and installing sidewalks on only one side of the road, where public safety would not be compromised, would reduce the area of impervious surfaces. Where appropriate, stormwater BMPs such as vegetated swales should be encouraged as a means to encourage infiltration of stormwater. Shared parking lots should be encouraged when appropriate as a means to reduce impacts and costs.
7. Impervious surfaces should be defined as part of lot coverage. Proposals to use pervious surfaces or retrofit impervious to pervious surfaces should be encouraged as an effort to reduce stormwater impacts.
8. Regarding any relatively large blocks of land in Putnam in the Little River watershed that can be subdivided, consideration should be given to cluster or open space subdivisions which are designed to maximize resource protection while maintaining underlying densities and reducing development costs.
9. Redevelopment of existing sites should be encouraged to incorporate strategies to install and/or retrofit existing stormwater facilities using current stormwater BMPs.
10. All developments with proposed stormwater quality controls should have a long-term maintenance plan to ensure proper functioning. Filing the plan with the property deed or homeowners association should be considered so new property owners are aware of the requirements. Public verses private responsibilities should be well defined. Discussions with Public Works Departments for their maintenance concerns should be held early on during the design process of new developments.
11. Periodic watershed hydrology reviews should be conducted to determine where water detention is necessary and to what degree. Sites not requiring retention will generally have more flexibility with stormwater quality BMPs.
12. Groundwater protection should continue to be a priority. Uses which pose a possible threat to groundwater contamination should not be permitted, or only permitted with appropriate controls to ensure groundwater protection. For new commercial developments that may carry fertilizers, pesticides, or other hazardous/regulated substances, it is recommended that storage, management, spill containment and emergency procedures be addressed.
13. If erosion issues on pre-existing lots are prevalent, consideration should be given to revising the zoning regulations to require erosion control for these lots. Permit conditions requiring third party erosion control inspections may offer an alternative to limited staff field inspection time.
14. Linkage of forested parcels should a consideration in open space planning. Town-owned parcels should be evaluated by a qualified forester to develop a forest management plan aimed toward long-term productivity and soil preservation.

Public Health/Source Water Protection Initiatives:

1. Install an interpretive sign explaining the importance of the watershed as a public water supply on publicly accessible parcels.
2. Use the provisions of CT statutes and regulations governing activities in public water supply watersheds to protect the Little River system.
3. Verify and update Potential Contaminant Sources (PCSs) inventory done by the Connecticut Department of Health.
4. Assess threats to the drinking water source and develop strategies to address those threats. Develop a contingency plan in the event the supply is lost.
5. Continue outreach to owners with on-site septic systems. Periodically reviewing "hotspots" of septic system failures may allow for targeted outreach. Establish a tracking system or ordinance for septic system tank pumping.

Outreach and Education:

1. Periodic outreach should be directed toward to property owners along lake and pond shorefronts to discourage the presence of Canada geese. Targeting homeowner associations with shared water resources is recommended.
2. Install interpretive signage at lake/pond public access areas explaining the issue of invasive species and how to avoid introducing them.
3. Develop a media campaign to reach the public with educational information about local drinking water and water quality, and about the current watershed/sourcewater protection effort.
4. Work with local schools to develop watershed curricula focusing on connections between land activities and water quality concerns.
5. Encourage homeowners to adopt residential best management practices regarding lawn care, vegetative buffers, hazardous materials use, septic system maintenance and fuel storage tanks.

Monitoring:

1. Create a map-database where all monitoring data can be displayed via map points.
2. Develop a database for data input which allows tracking of water quality conditions.
3. Visually inspect the mainstems and tributaries in the watershed via paddle craft or on foot on a schedule of at least once every five years.
4. Continue support of citizen-based stream monitoring programs

Farming:

1. Support programs for small farms that address the following BMPs;
    - Manure stockpiling
    - Fencing to prevent stream access
    - Vegetative buffers
    - Prevention of open steep slopes
    - Pesticide usage

2. If agricultural operations continue to be overrun with populations of migrating Canada geese, further meetings should be encouraged between the farmers and the DEP Migratory Gamebird Program and NRCS, to ensure that all programs are used to their fullest.
3. Support installation of manure storage facilities at three farms in the watershed.
4. Ensure that runoff from milk house, silage and AFO areas are captured on all farms to prevent discharge to waterbodies.

Stormwater Management:

1. Storm drain outlet mapping in accordance with MS4 general permit requirements should be completed.
2. Stormwater outlet retrofits should be prioritized and a schedule for completion should be established.
3. Periodic monitoring of the stormwater systems, to note where heavier loading is taking place, should be conducted. In key areas, consideration should be given to increasing the frequency of sweeping and catchbasin maintenance.
4. Modify practices such as hydrant flushing and use of roadside herbicides to minimize erosion.
5. Address Areas of Concern as outlined in Table 4 of this report.

Park Management

1. Request an Aquatic Assessment of Roseland Lake and Muddy Pond by the CT Agriculture Experiment Station.
2. Public areas, such as Muddy Pond Swimming Area, Roseland Park and Murphy Park should be posted with information discouraging the feeding of waterfowl and explaining why it is bad for environment and bad for the birds.
3. Encourage the use of organic lawn care practices at golf courses and other public parks and playgrounds. Consider a demo putting green for "green" practices at one of the golf courses. Periodic soil testing of sites to ensure proper applications should be required. Training of new staff members is essential.
4. Institute and enforce a pet-waste removal program.
5. Encourage vegetative buffers in park areas wherever feasible to prevent bank erosion, filter run-off and provide habitat resources.
6. Institute or continue efforts for invasive species removal and control.

B. Impaired Segments: Primary Recommendations (from the Watershed-Based Plans) and Secondary Recommendations

This section includes both the primary recommendations aimed at addressing the specific water quality impairments for the five impaired watercourse segments as well as secondary considerations. Secondary considerations are critical to addressing water quality, but are generally longer term strategies. Further discussion of these five segments is found in the Watershed Management Plans section of this report.

1. Watershed Based Plan for Muddy Brook – CT3708-01_02

Primary:

1. Monitor Muddy Brook for aquatic life support suitability as part of the DEP monitoring program.

Secondary:

1. Inventory small farms and conduct BMP education
2. Use LID concepts in new development as an anti-degradation strategy.

2. Watershed Based Plan for Muddy Brook – CT3708-01_01

Primary:

1. Increase the number of locations and the frequency of sampling to:
    a) Obtain statistically significant test results
    b) Bracket the source(s) of bacterial contamination
2. Provide assistance to the single dairy farm (Elm Farm) that does not have a manure storage facility, to install a facility that meets NRCS standards, and provide additional assistance to implement other NPS BMPs.
3. Educate owners of small livestock operations in the watershed regarding agricultural NPS pollution, and implement manure management BMP's on their farms.

Secondary:

1. A more complete inventory of small hobby farms should be completed in conjunction with BMP outreach and education, especially in riparian areas.
2. Consider adopting guidelines or regulations concerning addressing the keeping of livestock in specific areas of concern.
3. Partner with the 4-H Club to provide another avenue for education on matters related to manure management of horses and farm pets.
4. Sampling location of the DEP 1 monitoring station at North Running Brook and Muddy Brook may need to be modified due location of hobby farms in the immediate vicinity.

3. Watershed Based Plan for North Running Brook – CT3708-10_01

Primary:

1. Monitor North Running Brook for aquatic life support suitability as part of the DEP monitoring program.
2. Implement a BMP system that will prevent silage leachate from entering surface waters. The proposal is to capture and direct the leachate to the new manure storage facility.

Secondary: None

4. Watershed Based Plan for Roseland Lake – CT3708-00-1-L1_01

Primary:

1. DEP identifies the designated recreational use(s) which are impaired and establishes thresholds of nutrients, eutrophication, and biological indicators, so goals can be set for de-listing.
2. Determine if nutrient loading from bottom sediments is a significant factor and evaluate corrective actions.
3. For all applicable land uses in the watershed, implement BMPs that target nutrient NPS pollution. (See Table 7)

Secondary:

1. The Connecticut DEP should re-evaluate the classification of Roseland Lake as impaired for recreation during their 2009/10 monitoring season. The Connecticut Department of Public Health has determined the lake should not be utilized as a State Designated Swimming Area due to the proximity to a surface drinking water supply intake. There does not seem to be data to support impairment for recreation as a non-swimming area. The bulk of the Phragmites along the shoreline has been eliminated and extensive areas of macrophyte beds are absent.
2. Algae data collected by the Putnam Water Treatment Plant operators should be used as part of a long range monitoring of watershed conditions. Additional monitoring of Roseland Lake should be encouraged using volunteers trained to use a secchi disk as part of the monitoring process.
3. Compare watershed/ water quality relationships of Roseland Lake in Woodstock and Morse Pond in Southbridge to see if there is a relationship to soil type/land use and other factors in the Little River watershed.
4. The Connecticut Ag Experiment Station should be invited to evaluate Roseland Lake for aquatic invasive plant populations and map the findings.
5. At Roseland Park, dredge or otherwise excavate out the dead or dislodged Phragmites rhizomes remaining and tubers that have become piled along the shoreline wall at the site. The area of most significant disturbance is situated between the concrete abutments of a former pier and a wall which juts out slightly, creating a concave "trap" for floatables that are carried by wind and waves from the northeast. (See Appendix 6)
6. The DEP should update their geographic information system data to accurately depict where Shepherd's Pond Dam is located
7. Continued field observations for Canada geese should be conducted as an effort to document establishment of resident Canada geese populations. Establishment or expansion of resident populations should be reported to the DEP Migratory Gamebird Program. This could be part of a volunteer effort. Roseland Park should be posted with information discouraging the feeding of waterfowl and explaining why it is bad for environment and bad for the birds. Periodic outreach should be directed toward property owners along lake and pond shorefronts to discourage the presence of Canada geese. Targeting homeowner associations with shared water resources is recommended.

8. If agricultural operations continue to be overrun with populations of migrating Canada geese, further meetings should be encouraged between the farmers and the DEP Migratory Gamebird Program and NRCS, to ensure that all programs are used to their fullest extent.
9. As part of an anti-degradation strategy, install a demonstration rain garden on public land to educate homeowners on backyard water conservation strategies.
10. Plant buffers where appropriate along the Roseland Lake shoreline to reduce erosion from stormwater runoff from further degrading water quality.
11. Widen the stream channel vegetated buffer along the first fairway of the Woodstock Golf Course. On a trial basin, introduce organic land care practices to the first fairway, which is adjacent to a stream channel which flows toward Roseland Lake. Compare it to "conventional" golf course management and monitor the site for nutrient runoff differences.
12. Encourage developers and permitting authorities to incorporate LID practices into all new development.
13. Use soil maps as a planning tool to avoid disturbance of highly erodible soils.

5. Watershed Based Plan for Little River – CT3708-00_01

Primary:

1. Conduct water quality monitoring in the Little River and Wheaton Brook to:
    a) Obtain statistically significant test results
    b) Bracket the source(s) of bacterial contamination
2. If water quality tests indicate a possible leak in a sewer line, inspect lines for leaks.
3. Inspect and dye test the septic system at the National Guard Armory.
4. Implement BMPs to resolve any problems identified via measures 1 through 3.
5. Conduct an outreach campaign to educate residents about pet waste impacts on water quality.

Secondary:

1. Complete the mapping of storm drain outlets in the watershed.
2. Require larger vegetative buffer setbacks for multi-family and other development along primary watercourses.

C. Recommendations for Other Notable Non-Impaired Segments

This last section provides specific and general recommendations for other individual watercourse segments in the watershed. While these segments have not been listed as impaired, land-use activities conducted within these areas may be contributing to impairments. Proper watershed management in these areas is critical to maintaining water quality. Further information regarding each of the segments as well as additional non-impaired segments can be found in Appendix 5.

1. Gravelly Brook

Recommendations:

- Identify and implement BMPs for small agricultural operations.

2. Muddy Brook above segment 02 and Muddy Pond

Recommendations:

- Anti-degradation strategies should be employed in this part of the watershed, including LID strategies in new development.
- Land use officials should use available tools to protect the existing riparian vegetation from disturbance.
- Septic tank maintenance literature should be distributed in the area.
- Owners of rental properties should inspect septic systems on an annual basis.

3. English Neighborhood Brook Sub-regional Basin 3708

Recommendations:

- Plant a stream buffer on both sides of English Neighborhood Brook (approximately 500 feet) west of the 197 and 169 intersection.
- Anti-degradation strategies should be employed in this part of the watershed, including LID strategies in new development.
- Land use officials should use available tools to protect the existing riparian vegetation from disturbance.
- An inventory of small hobby farms should be completed in conjunction with BMP outreach and education, especially in riparian areas.
- Support volunteer water quality monitoring such as rapid bioassessments.

4. Mill Brook Sub-regional Basin 3707

Recommendations:

- Anti-degradation strategies should be employed in this part of the watershed, including LID strategies in new development.
- Land use officials should use available tools to protect the existing riparian vegetation from disturbance.
- An inventory of small hobby farms should be completed in conjunction with BMP outreach and education, especially in riparian areas.
- Support volunteer water quality monitoring such as rapid bioassessments
- Property owners along Quasset Lake should be encouraged to replant shore buffers for slope and shore stabilization.
- The lake association should inspect all storm drain outlet pipes for signs of erosion below the outlet.
- Seek retrofit options for stormwater catch basins on North Gate Road to treat stormwater runoff potentially contaminated with animal waste.
- Use soil maps for septic system site suitability in new development.
- Additional monitoring for bacteria should be conducted in Mill Brook.

5. Little River CT3708-00_02

Recommendations:

- Review engineering plans for the 30" stormwater outlet pipe from North Gate Road, and seek retrofit options.
- Monitor the sediment plume in Shepherd's Pond.
- Inspect drainage channels on the east side of Little Pond Road and evaluate their condition.
- Increase the buffer width along the farm field on the west side of Little Pond Road.

6. Wheaten Brook

Recommendations:

- Complete the mapping of storm drain outlets in the watershed.
- Require larger vegetative buffer setbacks for multi-family and other development along primary watercourses.
- Install signage and a pet waste station at the entrance to the walking trail along the Little River.
- Conduct an outreach campaign to educate residents about pet waste impacts on water quality.

XI. Conclusion

Eastern Connecticut Conservation District staff completed a very thorough investigation of water quality issues in the Muddy Brook and Little River watersheds, acquiring and compiling water quality data from many sources for the first time, in order to comprehend the condition of the connected yet separate watershed issues discussed in this report. From this data, reasonable recommendations were made that will improve water quality conditions where possible, and prevent further degradation from occurring.

Muddy Brook segment "02" is listed as impaired for Aquatic Life Support functions, and the cause has was linked to specific local farmland runoff issues. Consultations with CT DEP officials and the local farmers in question lead to the conclusion that the issues in Muddy Brook 02 have been resolved and water quality analysis scheduled in the near future should confirm this to be the case.

Muddy Brook segment "01" is impaired for recreation due to E. coli bacteria from an unknown source or sources. Further water quality monitoring will be required to isolate the cause of this contamination. During field investigations, ECCD staff noted that, in addition to the five dairy farms in this part of the watershed, there are many small farms which are in need of better management practices for horses and/or other livestock waste.

North Running Brook "01" is listed as impaired for Aquatic Life Support functions and the cause was linked to specific local farmland runoff issues. The dairy farm suspected for the impairment has worked with DEP and NRCS and has eliminated the primary source of contaminated runoff. There is still a concern about the possibility of silage leachate runoff, and a BMP to address that source has been designed. However, even when fully implemented, the source may not be controlled to the level necessary to enable delisting. This is due to the high cost of resolving the problem and limited funding. In order to delist this segment, additional assistance for the farm in question should be seriously considered.

Roseland Lake is eutrophic and research suggests this would be the natural condition regardless of human activity in the watershed, due to the size of the lake in proportion to the watershed. A USGS study established that many of the soils in the watershed are highly erodible. Seasonal algae blooms are being monitored by Putnam Water Treatment Plant staff and chemical control is utilized when appropriate. *Phragmites australis* was a problem approximately five years ago, but a multiyear herbicide program has effectively reduced the population along most of the shore areas. No dense weed beds were apparent during multiple field visits by ECCD staff. A more definitive explanation of the recreation impairment will be necessary in order to develop a plan to remedy the impairment. In addition, analysis of the lake sediments as a source of internal phosphorus loading will be necessary to determine if internal loading needs to be addressed in order to delist this lake as impaired.

Little River segment "01" was the most surprising outcome of this effort. Although the data does not conclusively prove it, it supports the conclusion that the water quality issues (bacteria) measured in Putnam are isolated from upstream issues, and are local in origin. One septic system at a vacant military facility in close proximity to a sampling location needs to be investigated as a potential source. A secondary source of contamination may be pet waste washing into storm drains in urban runoff.

For the watershed overall, assistance for agricultural operations should focus on the three out of eight dairy farms which do not have manure storage facilities that meet NRCS standards. Also important, will be a focus on small farms with horses and other livestock, especially those near streams.

Finally, it must be reported that the large size and multiple issues in this watershed made the development of this watershed based plan a challenge. For future watershed investigation and evaluation projects, a watershed of this size (39 square miles) should be divided into smaller sub-watersheds.

APPENDICES

Appendix 1

Status of Little River Sourcewater Protection Plan Recommendations

Plan Recommendation	Status
Sourcewater Protection Team	
1. Form a Local Sourcewater Protection Team	The original Sourcewater Protection Plan Steering Committee has met periodically, but has not been formalized or authorized by the towns, and as a result there is not a functioning team.
General Tasks of Steering Committee	
2. Meet at least once a year to review and update plan and assess its progress	Committee has met periodically since the plan was finalized. No updates or assessments of the Plan, with the exception of this report, have been made to date.
3. Verify and update Potential Contaminant Sources (PCSs) inventory done by the Connecticut Department of Public Health (DPH)	Not completed
4. Assess threats to the drinking water source	Several activities are underway including: • Streamwalk assessments by CT Audubon • Completion of Muddy Brook/Little River Abbreviated Watershed Based Plan by ECCD • Full Watershed Based Plan to be completed by NRCS
5. Develop management strategies for these threats	Recommendations and management strategies will be included in the Watershed Plans
6. Develop a contingency plan in the event the supply is lost	Town of Putnam is currently undergoing permitting for surface water diversion-development of contingency plans will be a part of that process
Sourcewater Protection Assessment Report Recommendations	
7. Determine trophic status of Roseland Lake and Shepherd's Pond	Review of studies to date are included in ECCD's Watershed Plan with additional recommendations to address issues with each waterbody.
8. Encourage homeowners to adopt residential best management practices regarding hazardous materials use, septic system maintenance and fuel storage tanks	NDDH has begun this effort by providing information to the Muddy Pond homeowners on septic system maintenance. Septic maintenance information is also available on its website. Household Hazardous Waste Days (HHWD) are scheduled regionally every other year. Putnam is considering changes to increase number of HHWDs

9. Increase the amount of preserved land within the watershed	New subdivisions in Woodstock require a 50% open space of gross buildable area. Woodstock's POCD designates key areas and resources to be protected. Putnam's POCD targets opens space on a town-wide basis. Opacum Land Trust purchased 116 acres surrounding Morse Pond in Southbridge. Wyndham Land Trust acquired ~60 acres associated with Taylor Brook.
10. Establish local watershed protection regulations	Woodstock has adopted regulations for LID incorporation, stormwater and erosion controls. Overlay zones for watershed protection areas are anticipated on the new zoning map. Putnam is currently updating its zoning regulations which will strengthen its stormwater management and erosion control practices. Aquifer protection regulations are also proposed.
11. Support environmental awareness and education in the community	Although not directly associated with the Sourcewater Protection Plan, ECCD has conducted extensive outreach in the watershed including topics on residential best management practices, invasive aquatic species, small farm best management practices, environmentally friendly boating practices and nuisance waterfowl.
Education and Outreach Campaign	
12. Send a tax bill stuffer with educational information to all residences and small businesses within the SWPA.	Neither Woodstock nor Putnam has sent tax bill informational stuffers
13. Develop a media campaign to reach the public with educational information about local drinking water, and about the current sourcewater protection effort	A media campaign has not been developed. See 8 and 11.
14. Incorporate groundwater education activities into school curricula	Only what is conducted as part of science curriculum to date
15. Hold an informational meeting with local residents about the sourcewater protection effort to increase local awareness of the link between land use and drinking water quality	Sourcewater Protection Committee meetings are open to the public. Although not a Sourcewater Committee effort, the Woodstock Conservation Commission and ECCD, along with several other sponsors held a fair for local residents with a primary focus on water quality.
16. Involve the public in sourcewater protection activities.	The Last Green Valley and the CT Audubon Society sponsors a volunteer water quality monitoring program. The Woodstock CC will refund any training expenses to Woodstock residents if they complete WQM in town

Include Drinking Water Protection in Town Planning and Ordinances	
17. Submit joint applications (Woodstock and Putnam) to DEP to declare the land along the Little River and its major tributaries an official greenway.	Completed
18. Develop ordinances requiring homeowners to inspect and maintain septic systems at regular intervals	Woodstock has focused on voluntary and outreach efforts for septic system maintenance. Putnam is mostly sewered in this watershed.
19. Inspect underground fuel storage tanks and remove if failing	Only activities to date based on jurisdiction of State regulations and Fire Marshall
20. Engage and educate developers regarding proper stormwater management during and after construction	Both Woodstock and Putnam use the preliminary development review process
21. Aggressively enforce existing regulations	Woodstock has proposed a permit tracking program to ensure compliance. Limited staff is a primary concern
22. Organize and support ongoing household hazardous waste collection days to prevent material from being illegally dumped or disposed	See 8.
23. Use the provisions of CT statutes and regulations governing activities in public water supply watershed to protect the Little River System	Towns need further information on this
Support Efforts to De-list Roseland Lake and Signage at Muddy Pond	
24. Encourage Roseland Park Trustees to maintain and improve the lake as a resource for the area and as a buffer along the lake	Discussions between Woodstock Conservation Commission and Friends of Roseland (Park) are underway regarding vegetative buffers. Friends of Roseland have met with ACOE to discuss several activities to improve water quality.
25. Continue to control invasive phragmites reeds	Friends of Roseland Park are pursuing this and have met with ACOE to discuss phragmites control options.
26. Work with DEP to find ways to remove lake from Impaired Waterbodies list	Recommendations regarding Roseland Lake are included in ECCD's Watershed Plan.
27. Work with Dept. of Public Health to again allow swimming at the lake as it is over 2 miles from diversion at Peake Brook Road	A formal request was submitted and denied by the State Department of Public Health.
28. Install an interpretive sign explaining the importance of the watershed as a public water supply and dangers of invasive species and how to avoid introducing them	ECCD has installed signage at Roseland Lake and Muddy Pond regarding aquatic hitchhikers and invasive species.

Appendix 2

Review of Municipal Planning, Permitting and Management Practices

Category	Town	
Town Planning	**Putnam**	**Woodstock**
Does the town have an updated Plan of Conservation and Development?	Yes-updated in 2004	Update underway
Has the town mapped sensitive resources such as wetlands and flood prone areas?	Will be getting updated Resource Mapping from NECCOG	Yes, but wetlands map should be updated to line up better with property lines
Do watershed lines, surface drinking water protection setbacks and aquifer protection areas show on zoning maps?	Will be getting updated Resource Mapping from NECCOG-Currently aquifer mapping is on a separate map but will be put on new zoning map	There is no official zoning map-proposed zoning map would have some overlay/setback areas mapped
Does the town use the NRCS Soil Web and associated soil types, characteristics and limitations in the planning process when establishing resource protection areas and zoning?	Not used-Town is interested in learning more about this as a tool for planning and review	Not used-Town is interested in learning more about this as a tool for planning and review
Does the town actively promote agriculture or have a "right to farm" ordinance?	Town has an established agricultural district. Specific agricultural activities are allowed as of right or by special permit in most zones, subject to zoning requirements. New zoning regulations will most likely continue to support agricultural uses.	Yes and prime agricultural soils are required to be mapped for subdivision applications, however there are sometimes concerns between rights to develop land and town' s desire to preserve farmland when there is no interest in continuing farming practices
Does the town have any regulations governing farming activities	Yes, see above	No
Open Space and Lot Development	**Putnam**	**Woodstock**
Does the town encourage a preliminary review of a development?	Yes	Yes
Does the town allow "open space" or "cluster developments"?	No, Town does allow multi-family housing in specific zones	Yes
Can the town require "open space" or "cluster developments'?	No	Yes
Are there defined open space set-aside percentages for proposed developments? If so, what is the range?	In subdivisions, a minimum of 1000s.f. per dwelling unit is required, but town is not limited to just 1000s.f.	Yes, on subdivisions-50% of gross buildable area

Does the town accept fee in lieu of open space?	Not a common practice	Rarely, but does have the ability
What is the main purpose of open space set-asides? Active recreation, passive recreation, resource protection	Resource protection and active recreation	Resource protection, passive recreation and preservation of farmland
Does the town make recommendations on land to be set aside for open space?	Yes	Yes
Are Net Buildable Area regulations in place?	No	Yes, wetlands, watercourses, steep slopes and open space are not allowed in net buildable area
Wetland and Watercourse Protection	**Putnam**	**Woodstock**
Does the town have a "regulated setback" from wetlands? And if so what is the distance?	Yes, typically 100', however the Little River Greenway is 200'	Yes 75' from wetlands 125' from watercourses
Are wetlands required to be defined by a certified soil scientist as part of a wetland application?	Depends on application	Yes
Are stormwater discharges to wetlands or watercourses reviewed as part of Wetlands review, Planning and Zoning review, or both?	Both	Both, but sometimes review is done more by one commission, depending on the application
Are erosion control plans within wetland regulated setbacks, reviewed as part of Wetlands review, Planning and Zoning review, or both?	Both	Both, but sometimes review is done more by one commission, depending on the application
Does the town recommend wetlands and/or vegetative riparian buffer restoration as potential mitigation?	Yes as applicable	Yes as applicable
Are soil characteristics and limitations used during application review process?	Yes	Submitted as part of Conservation Commission reports to Inland Wetlands and Planning and Zoning
Stormwater Water Quality and Lot Development Review	**Putnam**	**Woodstock**
Does the town recommend the use of the State Stormwater Design Manual for development of stormwater management plans?	Yes, it is used as part of review process	Yes, more reference will be included in updating of regulations

Does the town require a stormwater management plan for long term maintenance?	Yes, permit conditions and homeowner or condominium documents are used to record requirements	Yes, Bonding is required during construction and for a period after until final acceptance for erosion controls and corrective action. Long term stormwater management sometimes part of legal documents-easements
Does the town recommend the use of the E&S Guidelines for development proposals?	Yes, 1985 reference in existing zoning regulations, will be updated in new regulations.	Yes
Are all projects which disturb soils required to submit an E&S plan?	No, areas under ½ acre and lots that pre-exit subdivisions are not required	No, areas under ½ acre and lots that pre-exist subdivision are not required
Are road widths defined? If yes, what are they?	Yes Primary-32' Secondary-28' (not likely to change in new regulations)	Yes Arterial-24' Collector-24' Local-20' Private-20'
Is curbing required?	Yes-however in rural areas it may be omitted by waiver of the Planning Board. New regulations will most likely require Cape Cod curbing	LID practices encouraged first, if not suitable then Cape Cod curbing is generally required
Are sidewalks required?	Yes, 4', both sides of street on new roads-however in rural areas it may be omitted by waiver of the Planning Board.	Not typically required
What are parking lot requirements for commercial developments?	Varies depending on use	All commercial parking done by special permit-"adequate" parking required
What are parking lot requirements for multi-family developments?	2.25 spaces per unit	All multi-family parking done by special permit-"adequate" parking required
Is shared parking allowed	Will be considered if uses will allow adequate spaces	Yes, would be encouraged if conditions are right
Are rear or flag lots allowed?	Yes	Yes, but subject to overall regulation of only one curb cut every 1000' off town road
Are shared driveways allowed? If yes, then how many dwellings per shared driveway are allowed?	NO	Yes, they are encouraged and up to five dwellings per shared driveway is allowed
Does the town define and promote "Low Impact Development"	Not defined in regulations yet, but will most likely be included with update, promoted in practice though	Yes, encourages LID practices during preliminary design

Does the town allow or recommend grass swales along roadways?	Has used when conditions allow	Yes
Does the town promote vegetative treatment of stormwater when possible?	Yes	Yes
Does the town encourage the use of rain gardens and rain barrels?	Primarily a lot owner decision	Yes for rain gardens on P&Z applications. Rain gardens and rain barrels are both encouraged by the Conservation Commission
Does the town have requirements on amount of impervious surface per parcel?	Town uses lot coverage, which primarily covers structures	The town defines impervious surfaces and requires the amount of impervious surface to be included as part of some applications for review
Does the town encourage the use of pervious surfaces to replace impervious surfaces?	Anticipated that this may be encouraged in the future	Haven't used much but would encourage if suitable application was submitted
On redevelopment or expanded development sites, does the town look to upgrade pre-existing stormwater treatment?	Yes, if warranted, has used in-line treatment and infiltrators	Yes, but only if additional construction that increases building or parking lot area is proposed, which will then require a zoning approval.
Watershed Hydrology	**Putnam**	**Woodstock**
Has the town established a limit on the net increase that can result in stormwater flow as a result of development? If yes, what is the net outflow permitted?	Looks for no net increase outflow for two year storm. Other requirements depend on development and position in watershed	Dependant on development and position in the watershed. Projects are reviewed on a case specific basis.
Does the town use a certain sized storm for the design of its stormwater management practices? If yes, what sized storm?	Uses 2 year storm for water quality purposes.	First one inch (first flush) is used for stormwater quality design. Other requirements depend on development and position in watershed
Are retention or detention systems recommended in the regulations? Are they commonly used as a method of controlling stormwater flows?	Fairly commonly used on new developments	Drainage swales are a preferred method of slowing down flows wherever applicable. If larger amounts need to be detained, then detention basins are typically used to control peak flows as opposed to underground storage.
Who is responsible for the maintenance of stormwater management structures?	Typically private, town may have drainage rights	If private, then owner, if public then town

Floodplain Management	**Putnam**	**Woodstock**
Are regulations in place preventing development in identified floodplains?	Development is reviewed to ensure minimal damage or flooding impacts	Yes
Highly Erodible Soils	**Putnam**	**Woodstock**
Have highly erodible soils been mapped for the town?	May be included in updated Resource Mapping from NECCOG	No, but would like a map of highly erodible soils
Does the town protect highly erodible soils or limit development in those areas?	Reviews erodible soils as part of erosion control review	Some, if it is aware, then additional controls or modifications may be required
Municipal Sites	**Putnam**	**Woodstock**
What does the town use to de-ice municipal roads and sites?	Sand/salt mixture, may try some solid salt only areas	Sand/salt mixture
How frequently are roads swept and catch basins pumped?	Once per year-Little River is considered a high priority area	Once per year
Does the town use organic or environmentally friendly lawn care practices on its municipal sites, including building and recreation areas?	Many areas, no fertilizers or pesticides are used. In a few areas, small amounts are used as needed	Town uses organic or environmentally friendly products on town recreation or building sites when needed.
Does the town have a "pooper scooper" ordinance for municipal sites?	Yes	No
Groundwater Protection	**Putnam**	**Woodstock**
Does the town have aquifer protection regulations?	Yes	No
Has the town identified areas of significant groundwater resources?	Yes as part of development of public water supplies	Part of Natural Resource mapping
Is groundwater hydrology a consideration in resource extraction regulations?	Yes, a minimum of 5' finished grade above the groundwater table is required	It would be generally considered for a new commercial gravel extraction. Many smaller private gravel pits are connected with farm use or "grandfathered in" so there are few controls
Septic Systems	**Putnam**	**Woodstock**
Are there specified distances between a septic system and wetlands or watercourses?	Typically per the State Health Code unless there are additional concerns relative to wetlands	Typically per the State Health Code unless there are additional concerns relative to wetlands
Are engineered septic systems allowed?	Yes	Yes
Are soil limitations cited as a limiting factor for septic system placement and installation?	Yes, Per on-site testing of soils by Health Department	Yes, Per on-site testing of soils by Health Department

Forestry Resources	Putnam	Woodstock
Are forested parcels included on the POCD plan?	Shown as undeveloped	Yes
Is forestry a consideration when determining open space designations?	Yes	Yes
Do local regulations or guidance exist regarding timber cutting or clear cuts?	Most operations receive some review. Forestry BMP handbook used for guidance. Wetland issues are reviewed by wetlands agency	Not in zoning regulations, certain activities associated with timbering may require wetlands approval, such as a wetland crossing
Does the town conduct timber operations on any of its open space parcels? If yes, does it perform timber management or timber harvesting?	Yes, it has conducted timber harvesting activities	Yes, it has conducted timber management activities

Appendix 3

Summary of Bacteria Samples

Site ID	Waterbody	Location	Year	test1	test2	test3	test4	test5	test6	test7	test8	test9	test10	test11	test12	test13	test14	test15	test16	test17	test18	test19	test20	test21	geo mean
DEP1	Muddy Brook	Roseland Park Road	2008	130	10	10	170	20	10	20	10	98	230	390	820	5000	560	590	190						104
DEP1	Muddy Brook	Roseland Park Road	2007	20	74	74	2100	63	2300	3900	240	150	120	150	270	130	84	110	120	230	270	200	640	150	206
DEP1	Muddy Brook	Roseland Park Road	2006	340	300	530	600	1000	260	680	260	1900													521
DEP2	North Running Brook	farm road behind Child Hill Rd farm	2003-04	110	20	560	130	270																	134
DEP3	Little River	Peake Brook Road US dam	1999-2000	74	20	110																			55
DEP4	Little River	Peake Brook Road DS dam	1999-2000	74	52	96	10																		44
DEP5	Muddy Brook	confluence with Moss Brook	1999-2000	1300	210	10	10	52																	68
DPH1	Little River	Murphy Park	1998-99	3400	150	150																			425
DPH4	Muddy Brook	Roseland Park Road	2006	110	20	600	52																		91
DPH5	Muddy Brook	Woodstock Road	2006	10	74	41	31																		31
Beach1	Muddy Pond	Pond Factory Road	2008	10	10	10	10	10	10	10	10	10	10	10	10										10
Beach1	Muddy Pond	Pond Factory Road	2007	10	10	10	10	31	42	10	10	10	10	10	10	10	10	10							12
Beach1	Muddy Pond	Pond Factory Road	2006	10	10	20	31	10	10	10	10	10	10	10	10	10	20	10							12
Beach1	Muddy Pond	Pond Factory Road	2005	10	10	10	10	20	10	10	10														11
Beach1	Muddy Pond	Pond Factory Road	2004	10	10	10	10	31	10	20															13
Beach1	Muddy Pond	Pond Factory Road	2003	10	20	31	10	10	10	10	10														13
Beach1	Muddy Pond	Pond Factory Road	2002	10	10	10	10	10	10	10	10														10
Beach2	Murphy Park	Recreation Park Road	2006	64	75	270	87	2000	830	53	87	140	360	320	110										184
Beach2	Murphy Park	Recreation Park Road	2005	64	360	450	740																		296
Beach2	Murphy Park	Recreation Park Road	2004	310	210	890	890	160	150	2000	120	87													309
Beach2	Murphy Park	Recreation Park Road	2003	64	320	1200	64	160	110	160	87														158
Beach2	Murphy Park	Recreation Park Road	2002	20	10	99	210	87	31	210	620														79
WTP	Putnam WTP raw water	Peake Brook Road	2008-09	0.1	70	30	20	200	80	0.1	0.1	24	10	0.1	27	50	0.1	8	0.1	0.1	7	0.1	0.1	12	2
nddh2434	North Running Brook	Route 169	2006	51	10	20	10																		18
nddh2429	Mill Brook	New Sweden Road	2006	1300	52	97	41																		128
nddh2438	Quasset Pond outflow	West Quasset Road	2006	10	20	10	10																		12
nddh2427	Little River	Route 171	2006	110	10	96	110																		58
nddh2428	Little River	Stone Bridge Road	2006	350	10	31	86																		55
nddh2430	Mill Brook	Stone Bridge Road	2006	780	120	52	31																		111
nddh1830	Muddy Brook	Roseland Park Road	2006	110	20	600	52																		91
nddh2426	Johnstone Pond outflow	Senexet Road	2006	10	31	41	31																		25
nddh2435	Peckham Brook	Dugg Hill Road	2006	360	31	110	20																		70
nddh2432	Muddy Brook	Woodstock Road	2006	10	74	41	31																		31
nddh2425	English Neighborhood Brook	Route 197	2006	31	10	52	10																		20
nddh2437	Taylor Brook (rev 11/22/05)	Pulpit Rock Road	2006	31	440	310	120																		150
nddh179	Muddy Brook	Route 169	2006	10	130	52	30																		38
nddh2431	Morse Pond outfall (Moss Br)	Route 169	2006	10	10	10	10																		10
nddh2433	Muddy Pond outfall	Pond Factory Road	2006	10	10	10	10																		10

exceeds standards for bathing beach plus recreation contact >576/100ml
exceeds standards for bathing beach 235/100 ml
exceeds standards for recreational contact >576/100ml
exceeds geomean standard 126/100ml

Complete sample data information is available on request from the Eastern Connecticut Conservation District.

Appendix 4

Little River Watershed Water Quality Testing - 2006

In 2006, the Northeast District Department of Health (NDDH) performed a series of water quality tests in support of the Little River Sourcewater Protection Team. Fifteen sampling locations were selected. (See attached map.) The locations were spread throughout the watershed and were chosen strategically to possibly identify specific portions of the watershed where water quality problems may originate.

The fifteen locations were sampled four times each, one sample each season, on the same day. The samples were collected in February, May, August, and October, of 2006. The samples were processed by the Connecticut Department of Public Health. Results for the following parameters were provided:

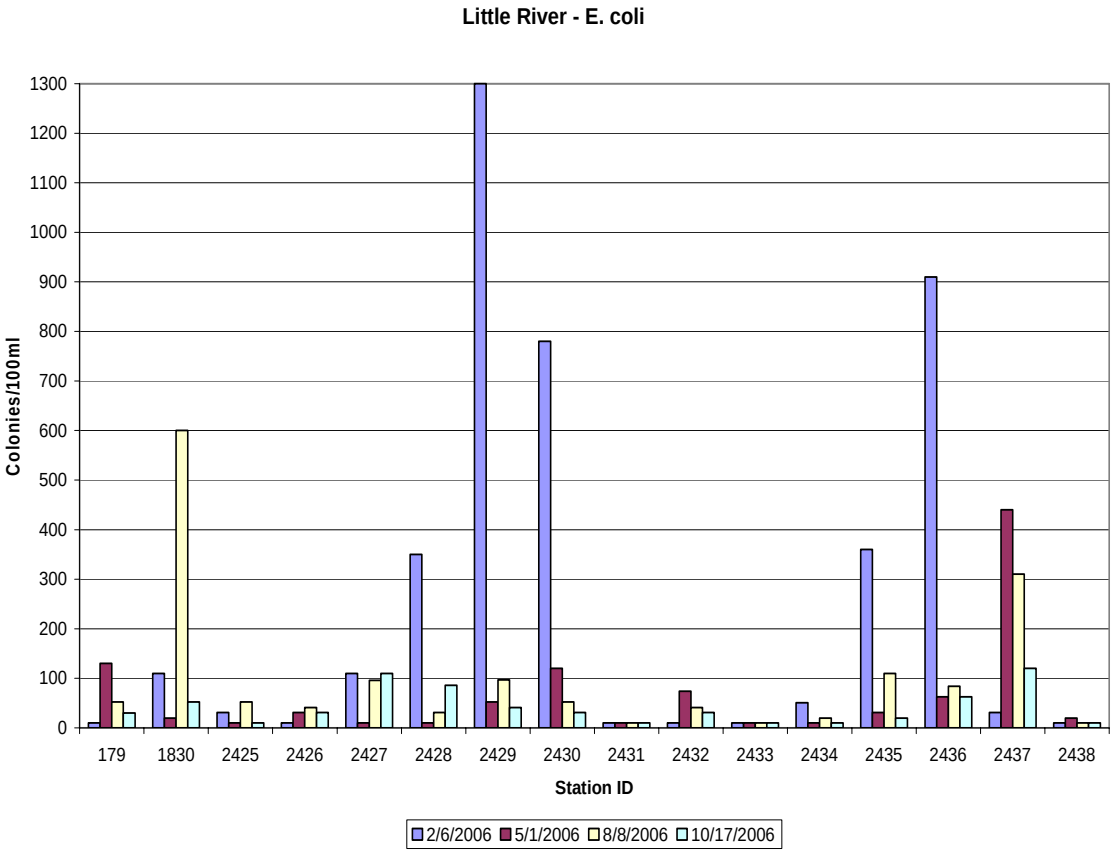
E. coli
Turbidity
Total Suspended Solids (TSS)
pH
Alkalinity
Hardness
Chloride
Color
Organic nitrogen
Ammonia nitrogen
Total Kjeldahl nitrogen
Nitrate (detection level = 0.1 mg/l)
Nitrite (detection level = 0.05 mg/l)
Total phosphorus
Orthophosphorus

See Appendix 7 for a complete set of the raw data.

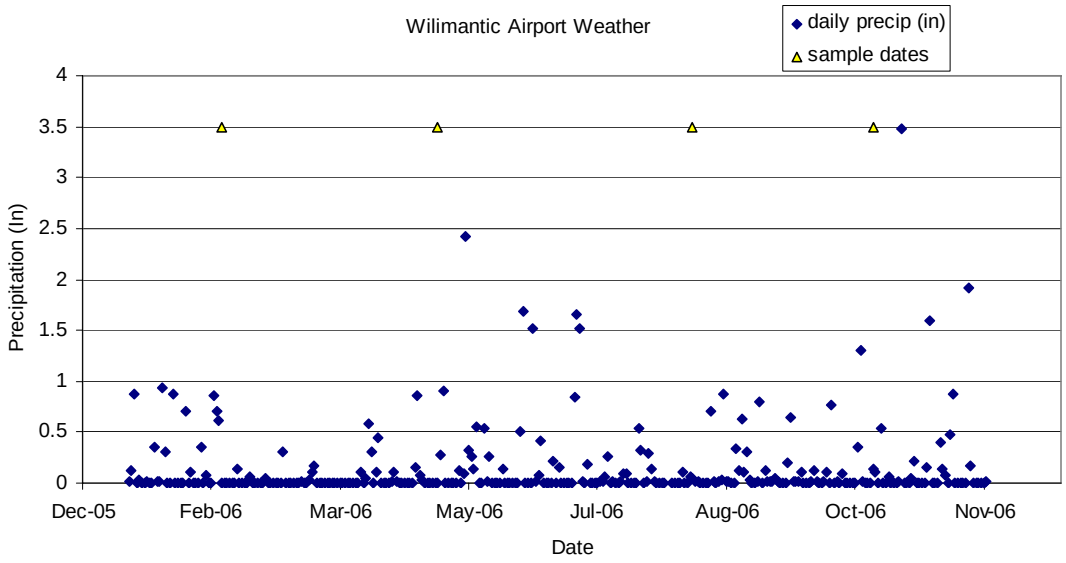
The Connecticut DEP Bureau of Water Protection and Land Reuse was consulted, and based on their advice, the data was consolidated using bar graphs, one graph for each of the items listed above. (Graphs available upon request.) With few exceptions, results were within acceptable ranges. To better understand the results of this testing, Dr. Richard Canavan of CME Associates, Inc. evaluated the results and has graciously provided the following analysis of several key factors.

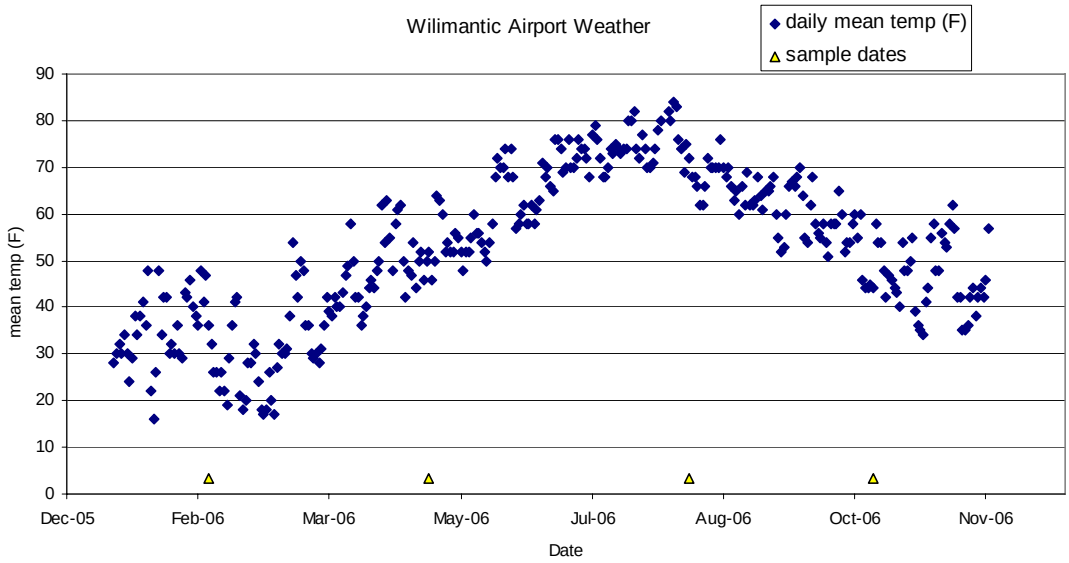
E. coli, Turbidity and TSS

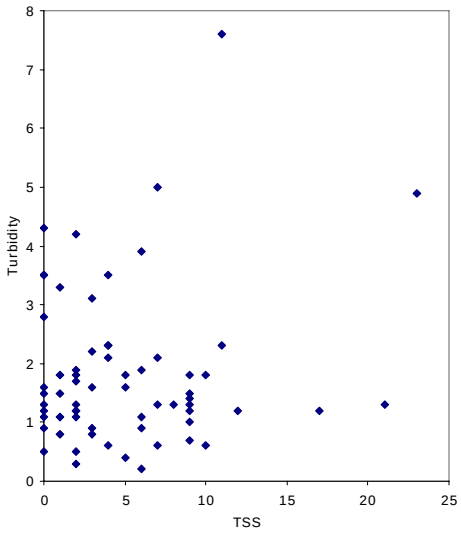
E.coli bacteria counts were high in February at several sites (see bar graph).



Based on a review of regional weather (plots of 2006 precipitation and mean temperature for Willimantic Airport in Windham CT are provided for reference) three days of rain and unseasonably warm weather (highs above 50 °F) preceded that sample event. These conditions may have led to the elevated bacteria measurements in February. The period preceding the other three sampling events were drier (but warmer). The bacterial counts display a lot of variability which was expected. Generally sites in the southern portion of the watershed had greater numbers, and pond outlets had lower bacteria values. One might attribute some of the higher levels at locations near but upstream of Roseland Lake to land use differences. Taylor Brook is relatively high (for E. coli, TSS and turbidity) despite flowing through a wetland area for some distance upgradient of the sample point.





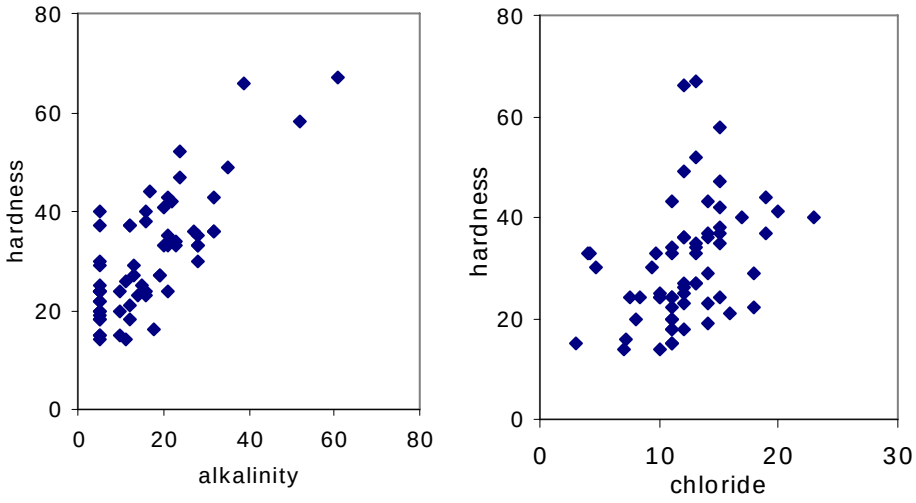


The E. coli, TSS and turbidity results suggest these parameters are largely independent, plotting TSS versus turbidity shows a high degree of scatter, this is even greater when comparing to E. coli results (not shown). Higher TSS values at pond outfalls were found and may be due to algae as heavier solids should settle in the pond (sediment resuspension near the outlet is another possibility). Generally the TSS levels were low, which is good since that can be an

important transport mechanism for other pollutants and nutrients. The USGS report (Kulp, 1991) found that 51% of the TSS load in the period from 1980-1983 was transported by the seven largest storm events in that period. Additional testing would be required to determine how conditions in the watershed may have changed since that study in the early 1980s.

Hardness, Alkalinity, Chloride

These measures are all related to the major ion chemistry of water. Hardness and Alkalinity are somewhat dependant where Hardness ≈ Calcium + Magnesium, and alkalinity ≈ HCO3. The cations frequently associated with carbonate are calcium and magnesium. These parameters are not found at levels suggesting water quality problems.



Phosphorus

Phosphorus concentrations were generally low, only two samples of total phosphorus exceeded 0.01 mg/L, spring samples at Muddy Brook (at Rt. 169) and Muddy Pond outfall. Ortho-P not detected in these samples therefore the phosphorus was likely present as organic-P possibly in algae flushing from the pond. The highest concentrations of ortho-P were observed at Mill Brook (8/8/06; 0.07 mg/l) and Peckham Brook (2/6/06; 0.06 mg/l). These concentrations are good and excellent (per the EPA criteria). Phosphorus transport may occur primarily during storm events associated with suspended solids.

Nitrogen

No detections of nitrite and few detections of ammonium were made which is not uncommon in flowing (oxygenated) water. The one notable detection of ammonium was at Muddy Brook (August; 0.5 mg/l). Dissolved Inorganic Nitrogen or available nitrogen was dominated by nitrate and was generally low (maximum value was 3.3 mg/L at Peckham Brook in February). Organic nitrogen concentrations were also at acceptable levels with the maximum observed concentrations of 3.4 mg/l at North Running Brook in February.

The 2006 water quality monitoring provides four "snapshots" of the watershed to screen for potential water quality problems. The results did not indicate trends of poor water quality either by location, season, or individual parameter. Future testing may wish to focus on specific areas within the watershed such as Taylor Brook and Mill Brook (Taylor Brook is a tributary of Mill Brook) where results were poor relative to other locations. Future testing programs should have an objective and allow for comparison to previous results when feasible. Obtaining more information about the response of water quality to storm events and seasonal changes may require a much larger monitoring effort. It is widely accepted by the watershed stakeholders that this testing is not enough to provide a complete understanding of the water quality issues within the watershed. These results do provide a useful set of recent data upon which more monitoring efforts can be built.

Roseland Lake

There have been several evaluations of Roseland Lake dating back to the Deevey study of Connecticut Lakes in the 1930s. However, little information is available about current conditions in the lake. In the publication "Connecticut Lakes" (Canavan and Siver, 1995) includes water quality information from several previous sources. In summary, the lake was found to be "a hypereutrophic lake with nutrient and chlorophyll-a levels greatly exceeding all other sites in the eastern uplands, and with severely low transparency". Internal loading of nutrients was also identified as an issue.

The USGS conducted an extensive study of the Roseland Lake watershed in the period between 1980 and 1983 (Kulp, 1991). This study estimated that 427 tons of sediment were deposited in the lake annually during that time period. This study also notes internal nutrient loading as a potential problem in the Lake. Although nutrient loads in the contributing streams may have declined in the last 30-years, nutrients stored in the sediment of the Lake may provide a continuing source to maintain hypereutrophic conditions.

The initial findings of a recent USGS study of nearby West Thompson Lake reveal that phosphorus trapped in sediments at the bottom of the lake becomes available as the lake water stratifies in the summer and the lower hypoliminon becomes anoxic. The result is excessive nutrient availability in the lake and in downstream waters during the warmer months, resulting in extensive algae growth.

At Roseland Lake, it is highly probable that there is a significant quantity of phosphorus-rich sediments at the bottom of the lake, and internal loading may be a major source of nutrients for algae growth. The fact that the NDDH water quality monitoring results display relatively low nutrient concentrations, gives further support to this hypothesis.

Based on the evaluation of the NDDH testing, two recommendations are being suggested:

1. Monitor the water quality at several key sites in the watershed to develop a better understanding of how water quality responds to seasonal changes and storm events. Include Taylor Brook and Mill Brook in the evaluation and sites from the earlier USGS study to allow for a comparison of how conditions have changed since 1980.
2. Conduct a study of Roseland Lake to determine extent to which internal loading of nutrients from the sediment to the overlying water may be responsible for hypereutrophic conditions and poor water quality in lower portions of the Little River. This study should focus on the development of anoxic bottom waters, sediment phosphorus concentrations and sediment depth. Additional feasibility studies of how best to limit the impact of sediment nutrients should follow.

Appendix 5

Information Regarding Notable Non-Impaired Segments

Within the Connecticut portion of the Little River sub-regional watershed, five waterbodies are listed in the 2008 Connecticut Water Quality Assessment Report as not meeting water quality standards. These segments and recommendations to improve water quality in the segments are discussed elsewhere in this report. It is important to note that during the ECCD evaluation of impaired segments, a total watershed approach was utilized, and non-impaired segments were also examined for their potential to contribute to water quality issues in the listed impaired segments. Influences from water entering from outside the State of Connecticut jurisdiction were also examined.

A watershed is defined as an area of land that drains to a common waterway. The Little River sub-regional watershed is part of the Quinebaug regional watershed, which in turn is part of the Thames River watershed which is a significant part of the Long Island Sound watershed. English Neighborhood Brook and Mill Brook sub-regional watersheds drain into impaired segments of the Little River watershed, and their potential contributions to water quality issues were examined. In addition, where information was available, potential NPS contributions from tributary streams of the impaired segments were also reviewed.

Little River Sub-regional Basin

Little River CT3708-00-02

This segment of the Little River lies between Roseland Lake and Shepherd's Pond Dam. Shepherd's Pond Dam is located approximately across from the intersection of Peake Brook Road and Lane Street. This segment of the river includes Shepherd's Pond, a naturally wide and deeper part of the stream channel. For clarification, it should be noted that Shepherd's Pond is more than a mile upstream of Shepherd's Pond Dam. Wyndham Land Trust Little River Preserve and the Putnam Fish and Game Club own significant river frontage in this stream segment. The Town of Woodstock recently acquired significant river frontage opposite the water treatment plant, which is preserved as open space. Significant areas of the wooded floodplain are protected open space.

There are no known water quality issues in this stream segment. Water quality was tested at the Route 171 crossing of Little River as part of the 2006 NDDH series and bacteria concentrations was found to be within the acceptable range. Bi-weekly raw water samples tested at Shepherd's Pond Dam at the most downstream portion of this segment beginning in 2008 also support the classification of this segment of the river as non-impaired for recreation. There is no known biological data from this river segment.

The Storm Drain Survey conducted by ECCD revealed several Areas of Concern in the Shepherd's Pond area of the river. Little Pond Road in Woodstock is parallel to the west side Shepherd's Pond. On the west side of the road, there are a series of box culvert openings directed to road culverts that drain into unlined channels on the opposite side of the road. These

channels lead towards Shepherd's Pond. Dense vegetation surrounding the drainage channels obscured further review of these areas. During a 2006 Stream Walk of Little River, it was noted that a fine sediment deposit extended into the west shore of Shepherd's Pond. In October 2005, there was a significant flood event northeastern CT. It is unknown if the sediment deposit existed prior to October 2005. The sediment deposit should be monitored. ECCD staff was unable to determine if any of the drainage channels from Little Pond Road led to this sediment deposit.

2006 Sediment plume in Shepherd's Pond

Photo by ECCD

A 30" stormwater outlet pipe that leads to a culvert under Little Pond Road was traced to North Gate Road and the Woodstock Fairgrounds. There is no treatment of the stormwater before it enters the stormwater conveyance system.

Other streams in the Little River sub-regional watershed include Gravelly Brook, Moss Brook, Peake Brook, Wheaton Brook, plus several smaller tributaries that do not have any reported water quality issues.

Gravelly Brook

Gravelly Brook is a small stream that flows into Muddy Brook upstream of North Running Brook and downstream of the Lower Minor Morse Pond dam in East Woodstock. There are no known water quality issues in Gravelly Brook. This brook was not sampled as part of the 2006 NDDH series.

Data provided by DEP Inland Fisheries indicate that there are native brook trout populations in Gravelly Brook, which indicates good water quality where the fish samples were taken.

A windshield survey in this watershed noted small farm operations that were in need of improvements. Observed were places where a mix of farm animals overgrazed land on a hillside, leaving exposed soil, and in another location, cows were seen standing in Gravelly Brook.

Muddy Brook above segment 02 and Muddy Pond

Muddy Pond Beach

Photo by ECCD

Muddy Pond and the headwater region of Muddy Brook upstream of the Moss Brook convergence are not demonstrating water any quality issues. Muddy Pond is a State Designated Swimming Area. The Town of Woodstock owns and operates a public bathing beach at Muddy Pond, and the water is tested on a biweekly basis for E. coli in the summer season. The past seven years of E. coli monitoring

have demonstrated the water quality for recreation as a State Designated Swimming Area is meeting required standards.

Muddy Pond is experiencing problems with Variable Milfoil. A permit was secured to introduce sterile carp to the lake as a biologic control measure.

Upper Muddy Brook was monitored at the Route 169 road crossing as part of the NDDH series. No abnormal water quality results were noted.

Summer cottages as well as year round homes surround portions of Muddy Pond. Many of the cottages are clustered together and are not owner occupied. This may become a future source of water quality degradation if the septic tanks are not maintained regularly. There is no formal lake association for Muddy Pond.

Moss Brook

Moss Brook begins as the outflow of Morse Pond at the CT/MA border on the west side of Route 169, and ends at its convergence with Muddy Brook. This brook was included as a sampling location in the NDDH series. The results of that sampling did not indicate any water quality issues at the outflow of Morse Pond. It should be noted that Morse Pond (MA41033_2008) in Southbridge, MA is listed as impaired on the MA 2008 Water Quality Assessment Report and has been on the list of impaired waters in Massachusetts since 1996 due to noxious weeds, nutrient enrichment and low dissolved oxygen. There is no apparent relationship between water quality issues in Morse Pond and Muddy Brook segment 02.

Morse Pond, Southbridge MA

Photo by ECCD

Peckham Brook

Peckham Brook flows into Muddy Brook below Woodstock Road. The four samples taken as part of the 2006 NDDH series (NDDH 2435) do not indicate a concern for E. coli contamination.

Johnston Pond outflow brook

The Johnston Pond outflow brook (NDDH 2426) did not demonstrate elevated E. coli levels in the 4 samples analyzed in 2006.

Wheaton Brook

Wheaton Brook begins in a relatively undeveloped part of Thompson and converges with Little River just upstream of the former impoundment used for swimming at Murphy Park in Putnam. A significant portion of the Putnam Special Services District is located in the Little River watershed, specifically in the watershed of Wheaton Brook. The area includes a few commercial

areas and high density residential housing where curbing and sidewalks are prevalent. The Town of Putnam has a formal pet waste disposal policy for public areas, including sidewalks. Without a formal study, it was obvious during the ECCD storm drain survey that the pet waste policy is not enforced. Also, pets are allowed on a leash at the Little River Trail in Murphy Park. No signage about the pet waste policy was posted nor are pet waste disposal materials available.

Optical Brightener Pad Placement in Wheaton Brook

Photo by ECCD

Studies have indicated that pet waste in urban stormwater runoff can be a significant source of bacteria.

Most homes and business are required to be connected to the public sewer system in this part of Putnam, with the notable exception of the Putnam Armory located on Wicker Street as previously noted. ECCD staff deployed two optical brightener pads in Wheaton Brook and results were negative.

The 2006 Land Cover Map 4 demonstrates a high amount of impervious cover in the watershed of Wheaton Brook. Many studies have demonstrated a link between high amounts of impervious cover with water quality degradation in nearby streams. There is a high potential for non-point sources of contamination in Wheaton Brook from polluted stormwater. Pet waste is a realistic concern. Also, as previously noted is the concern of the proximity of Wheaton Brook to the Putnam Armory, which is not connected to the sewer system. Putnam Water Pollution Control Authority officials were contacted by Armory officials regarding the process of connecting to the sewer line at some time since 2000 because of potential issues with their on-site waste disposal system, but no further action was taken. The Northeast District Department of Health has no record of a septic tank repair permit issued for the Putnam Armory address. Further evaluation of water quality in Wheaton Brook is warranted.

Wheaton Brook watershed

Photo courtesy of www.glsweetnam.com

English Neighborhood Brook Sub-regional Basin

The area of the English Neighborhood Brook sub-regional watershed basin is 3,087 acres. This watershed is classified as AA. English Neighborhood Brook converges with Muddy Brook downstream of the village area of North Woodstock. Below this convergence, is the beginning of Muddy Brook segment 3708-01_01 which is listed as impaired for recreation. Limited information on the quality the water in English Neighborhood Brook is available beyond quarterly samples as part of the 2006 NDDH series. Of those 4 samples, none exceeded the limit for recreation impairment. Other parameters tested within normal ranges. It seems unlikely that drainage from the English Neighborhood watershed is contributing significantly

Former mill site, North Woodstock

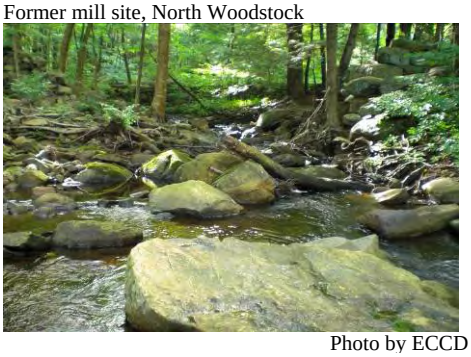


Photo by ECCD

to the recreation impairment of Muddy Brook Segment 3708-01_01.

The absence of native brook trout in the watershed is not necessarily an indication of poor water quality. Evidence of prior land use include rows of rock walls in wooded areas, indicating the area was at one time more intensively farmed. Downstream impoundments left over from former mill sites in East Woodstock may be preventing trout from returning to the naturally restored habitat. Ruins of stone mill dams are evidence of prior industries that once used the river as a source of power. Agricultural fields currently comprise only about 11% of the area while forested areas represent about 70% of the existing land cover. Developed land represents only about 8% and that includes scattered residential areas.

A windshield survey of the area exposed one notable area of concern. West of the village of North Woodstock, along Route 197, there is a segment of the brook with no riparian cover. Managed lawn grows to both sides of a rock line channel through which the stream flows.

Mill Brook Sub-regional Basin 3707

This watershed area is classified as AA. Mill Brook (aka Saw Mill Brook) has an area of 4,456 acres. More that 25% of the land cover is comprised of agricultural fields and 55% is in various forms of forest cover. The developed landscape on this watershed is just under 10%, with a cluster of development in the village area of South Woodstock. Mill Brook flows through the village and under Route 169. Afterward, it flows north adjacent to the Woodstock Fair Grounds before it turns east and drains into the southeast end of Roseland Lake.

South Woodstock village area

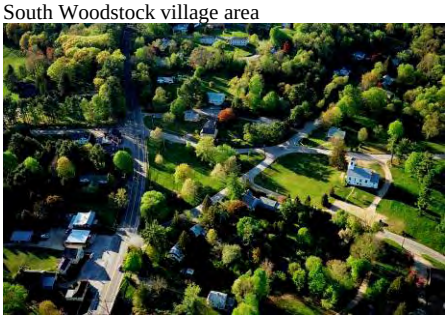


Photo courtesy of www. glsweetnam.com

In 2006 four different water quality monitoring stations were selected in this watershed in response a Little River Source Water Protection Plan recommendation These places were sampled on a quarterly basis to obtain a snapshot of water quality upstream Roseland Lake. From the Canavan review of the 2006 NDDH series, "The results did not indicate trends of poor water quality either by location, season, or individual parameter. Future testing may wish to focus on specific areas within the watershed such as Taylor Brook and Mill Brook (Taylor Brook is a tributary of Mill Brook) where results were poor relative to other locations." Taylor Brook is a first order headwater stream that flows through an area that contains a dairy farm and, at the time the sampling took place, a wetland complex up gradient to the sampling location on Pulpit Rock Road. By 2009, the wetland complex had been converted to a shallow pond with emergent vegetation through the industriousness of local beaver. Also up gradient of this location is the Town of Woodstock Highway Garage, where an issue with the salt storage facility was found to have contaminated the groundwater beneath that site and

New beaver pond in Taylor Brook

Photo by ECCD

above normal levels of sodium have been detected in at least one neighboring well.
Two Mill Brook test sites demonstrated indications of E. coli concentrations in exceedance of the single sample standard for recreation standards in the February 06 sample. The numbers were highest at New Sweden Road, and then a decreased concentration was detected at the Stone Bridge Road crossing. The source of this bacterium is unknown. The sampling station at Taylor Brook, downstream of the dairy farm and wetland complex, did not exceed the standard on that date; however, the geomean of the four samples from the Taylor Brook station exceeds the accepted threshold of 126/100 ml. Four samples are not a large enough sample size to make a determination of water quality, but follow up monitoring, as recommended by Canavan may provide a better indication of water quality trends.

Above the 2006 NDDH series test location at the New Sweden Road, beaver have recently impounded a marsh complex just above the Route 171 stream crossing. Current conditions of the watershed do not match the local conditions in 2006.

DEP fisheries biologists have reported two segments of Mill Brook where populations of native brook trout have been located (Refer to Map 11). Native brook trout are a cold water species and are sensitive to environmental degradation, including thermal pollution. Their populations in Connecticut are in decline due to loss of suitable habitat.

During the ECCD storm drain survey, it was noted that a series of stormwater catch basins located along North Gate Road outletted directly into Mill Brook through a pipe built into the stone bridge headwall. The Woodstock Highway Department confirmed the storm water catch basins have no stormwater treatment system included in their design. During the Woodstock Fair, the pavement area adjacent to these storm drain catch basins is used as an animal wash area.

Quasset Lake (also known as Wappaquasset Pond) is located in the Mill Brook watershed. Quasset Lake is a long, narrow 88 acre dam controlled pond with private lake front managed by a private lake association. It is used for swimming and boating by members with lake privileges. The Pomfret School maintains a boat house there and the lake is used for crew races. The lake association applied for a DEP permit in December 08 to control nuisance aquatic weeds.

During the ECCD watershed-wide goose survey in the spring of 2009, Quasset Lake was observed on multiple occasions. While there we no signs of resident Canada geese at the lake, staff noted several opportunities for improvements along the lake shore front. Multiple homes maintained grassy lawns to the lake on steep slopes with no trees or shrubs along the shoreline. A construction project upslope of the lake had a failed silt fence near the lake shoreline.

Many storm drain catch basins were observed along East Quasset Road. The discharge area of these storm drains was not determined because they outletted on private land in dense brush. The outlet pipes were directed towards the Quasset Lake shoreline, but not inspected by ECCD staff.

A review of the failed septic repair permits issued by the Northeast District Department of Health revealed a small cluster of repair permits issued in the last few years near the northeast end of Quasset Lake. The 2006 NDDH series of water quality monitoring did not reveal any indications of excessive bacteria exiting the lake outflow during that sampling period.

Appendix 6

US ACE Recommendations for Roseland Lake

March 25, 2009
Revision June 24, 2009

Regulatory Division
CENAE-R-PEB
File No. NAE-2008-3702

MEMORANDUM FOR FILE

SUBJECT: Roseland Park Pond - Invasive Species Management Coordination

1. Meeting Date/Location: March 25, 2009 at Roseland Lake, Woodstock, Connecticut

2. Participants: Rita Choiniere, Roseland Park Lake; Also in attendance members of Friends of Roseland Park and Barbara Newman/Cori Rose, Corps.

3. Background: We reviewed photographs for the subject proposal in the winter of 2008. At the time of the coordination the photographs did not show a significant presence of live *Phragmites* in the nearshore vegetated zone identified as the target location by Ms. Choiniere. Consequently, there was some confusion as to whether the proposed removal of Phragmites was warranted. The pictures depicted a moderately healthy emergent wetland at the border of a somewhat eutrophic lake that had some level of diversity. Vegetation that appears present based on just a review of the photos include *Iris* spp., *Carex* spp., *Pontederia cordata*, and *Scirpus* spp. The upland margin of the seasonally inundated area appears to have taller bushier vegetation that looks to be *Solidago* spp., *Impatiens* spp., and maybe *Asclepias incarnate*. I recommended that Ms. Choiniere obtain the services of a local biologist/botanist, maybe through the UCONN extension center or the Regional Conservation Office and have the wetland vegetation along the shoreline surveyed and documented this spring. Once that is underway I would be willing to come out and take a look at the site characteristics and make some more specific recommendations as to what areas could be selectively targeted for invasive species management without creating a project that is unlikely to receive acceptance at either the state or federal level.

4. Discussion: Ms. Choiniere requested the site visit so that we could provide direction as to what might be necessary to remove invasive vegetation and restore the beach and shallow subtidal condition at the site and to determine what federal or state permits might be required. When we visited the site it was too early in the growing season to obtain a better estimation as to what species of plants are present. What became clear at the time of the site visit, though, was that *Phragmites* control by the state agency had been relatively successful. What the applicant is looking to do is to dredge or otherwise excavate out the dead or dislodged rhizomes and tubers that have become piled along the shoreline wall at the site. The area of most significant disturbance is situated between the concrete abutments of a former pier and a wall which juts out slightly, creating a concave “trap” for floatables that are carried by wind and waves from the northeast.

Of particular interest given the scenario is whether the proposed removal of the dislocated remnant vegetation and/or the accumulated organic materials from the nearshore environment would require a permit from the Corps pursuant to Section 404 of the Clean Water Act. To answer this question definitively requires a specific analysis of the proposed activity and the methodology for removal of

the material from the lake bed. Unfortunately, a conceptual plan for removal of the material had not been sufficiently developed. Based on the 2007 D.C. District Court decision regarding regulation of the discharge of dredged material, the Corps is required to make a case-specific determination as to whether a given activity results in a discharge of dredged material, other than incidental fallback.

At the meeting we discussed options for potential removal of the vegetative matter and organic sediments at the site. There are three realistic scenarios: 1) to use a backhoe or a dragline from the upland behind the wall to reach into the lake and "scoop out" the material, 2) to use a barge-mounted excavator to "scoop out" the material, or 3) during a draw down or seasonal low water, to use a bulldozer or front end loader to enter the lake bed and either "pick up" or "push" the material onto the upland, or to a point where it can be picked up for removal from the lake.

Given the scenarios that we discussed, either the use of a backhoe or a dragline (Scenario 1) or a barge mounted bucket dredge (Scenario 2) is not likely to result in a regulated discharge that would require a permit from the Corps. Under the third scenario, a case-by-case determination is required. The use of the front-end loader, if it is technically feasible without temporary fill for stability, might not require a permit, if the excavated material is scooped up and moved directly to an upland site and no more than incidental fallback returns to the water. However, our understanding of the situation is that up to three feet of accumulated organic muck can be anticipated in the proposed work area and it is unlikely that this material could support the weight of a front loader. If phasing of the work could be undertaken in such a manner that the initial removal of organics occurred at the upland access point for the front loader with removal to the original sand layer, and work commenced waterward from that point, picking up the excavated material and returning it to the upland access point (assuming an appropriately sloped access area exists), a regulated discharge might not occur and a permit may not be required. However use of a bulldozer to push excavated material to a location at some distance from the point of initial excavation or raise the bottom elevation and fill in low areas, is likely to result in a regulated discharge.

Based upon my review of the Roseland Lake site and the information provided by the project proponent, Scenarios 1 and 2, or the use of a front-loader starting from an upland access point, as described above, are not likely to result in a regulated discharge of dredged material, provided all material excavated from wetlands is properly disposed of in uplands and no excavated material is placed in any waters of the United States located on the subject tract or elsewhere. If the work is completed in this way, I recommend the Corps not assert jurisdiction in this particular case pursuant to Section 404 of the Clean Water Act. Without the use of the "staged" methodology identified above, the use of either a front-loader or a bulldozer will require specific review for determination as to whether a permit under Section 404 of the Clean Water Act is required.

6. Follow-up Action Required: None until more concrete plan for removal of pond bed material is developed, then review to determine if the proposed activity will result in a regulated discharge of dredged or fill material.

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Cori M. Rose
Senior Project Manager
Regulatory Division

Appendix 7

Water Quality Testing By NDDH - 2006

stationid	Name	Waterbody	Street	collection date	collectors number	accession number	turbidity	suspsolids	ph	orgnitro	ammonia	tkn	alkalinity	hardnes	chloride	nitrate	nitrite	total phos	orthophos
2434	WPT063	North Running Brook	Route 169	2/6/06	mm26	22352658	1.8	5	6.4	3.4	0.1	3.5	12	18	11	<0.1	<0.05	<0.01	<0.01
2434	WPT063	North Running Brook	Route 169	5/1/06	mm24	22355597	1.4	9	6.4	0.5	<0.1	0.5	12	37	19	<0.1	<0.05	0.02	<0.01
2434	WPT063	North Running Brook	Route 169	8/8/06	mm24	22358995	2.3	4	6	0.2	<0.2	0.2	15	25	12	<0.1	<0.05	<0.02	<0.02
2434	WPT063	North Running Brook	Route 169	10/17/06	mm23	22361343	1.6	5	6.3	0.6	<0.5	0.6	14	23	14	<0.1	<0.05	<0.02	<0.02
2429	WPT064	Mill Brook	New Sweden Rd	2/6/06	mm29	22352660	1.5	0	6.5	0.1	0.1	0.2	<10	15	11	<0.1	<0.05	See note	0.03
2429	WPT064	Mill Brook	New Sweden Rd	5/1/06	mm28	22355599	1.2	17	6.6	0.3	<0.1	0.3	13	29	18	0.2	<0.05	0.02	0.01
2429	WPT064	Mill Brook	New Sweden Rd	8/8/06	mm28	22358997	3.5	0	6.1	0.6	<0.2	0.6	23	33	11	<0.1	<0.05	0.07	0.07
2429	WPT064	Mill Brook	New Sweden Rd	10/17/06	mm27	22361345	1.5	9	6.3	0.6	<0.5	0.6	19	27	13	<0.1	<0.05	<0.02	<0.02
2438	WPT065	Wappaquasset Pond Outfall	West Quasset Rd	2/6/06	mm34	22352662	1.2	2	6.7	0.2	<0.1	0.2	<10	20	11	<0.1	<0.05	<0.01	<0.01
2438	WPT065	Wappaquasset Pond Outfall	West Quasset Rd	5/1/06	mm32	22355601	1.3	7	6.6	0.9	<0.1	0.9	16	38	15	0.2	<0.05	<0.01	<0.01
2438	WPT065	Wappaquasset Pond Outfall	West Quasset Rd	8/8/06	mm32	22358999	2.1	7	6.4	0.31	<0.2	0.31	21	24	8.3	<0.1	<0.05	0.05	<0.02
2438	WPT065	Wappaquasset Pond Outfall	West Quasset Rd	10/17/06	mm31	22361347	1.2	0	6.4	0.6	<0.5	0.6	18	16	7.2	<0.1	<0.05	<0.02	<0.02
2427	WPT066	Little River	Route 169	2/6/06	mm1	22352646	1.9	6	6.6	0.1	<0.1	0.1	<10	25	10	<0.1	<0.05	0.04	<0.01
2427	WPT066	Little River	Route 169	5/1/06	mm2	22355586	2.3	11	6.9	0.8	<0.1	0.8	24	47	15	0.5	<0.05	0.02	0.01
2427	WPT066	Little River	Route 169	8/8/06	mm2	22358984	3.5	4	7	0.85	<0.2	0.85	32	36	14	0.4	<0.05	0.05	<0.02
2427	WPT066	Little River	Route 169	10/17/06	mm1	22361332	4.3	0	7.6	0.7	<0.5	0.7	27	36	12	<0.1	<0.05	0.05	<0.02
2428	WPT067	Little River	Stone Bridge Rd	2/6/06	mm4	22352647	1.6	0	6.7	<0.1	<0.1	<0.1	10	24	10	<0.1	<0.05	0.03	0.01
2428	WPT067	Little River	Stone Bridge Rd	5/1/06	mm4	22355587	1.8	9	7	0.7	<0.1	0.7	21	43	14	0.2	<0.05	0.04	0.01
2428	WPT067	Little River	Stone Bridge Rd	8/8/06	mm4	22358985	3.1	3	8.4	0.87	<0.2	0.87	32	36	12	<0.1	<0.05	0.05	0.03
2428	WPT067	Little River	Stone Bridge Rd	10/17/06	mm3	22361333	3.9	6	7.3	<0.5	<0.5	<0.5	28	33	13	<0.1	<0.05	0.05	<0.02
2430	WPT068	Mill Brook	Stone Bridge Rd	2/6/06	mms	22352648	1.3	9	6.7	0.4	<0.1	0.4	<10	24	11	<0.1	<0.05	0.03	0.01
2430	WPT068	Mill Brook	Stone Bridge Rd	5/1/06	mm6	22355588	0.8	3	7.3	0.6	<0.1	0.6	20	41	20	0.1	<0.05	0.03	<0.01
2430	WPT068	Mill Brook	Stone Bridge Rd	8/8/06	mm6	22358986	2.8	0	7.2	<0.2	<0.2	<0.2	28	35	15	0.2	<0.05	0.06	<0.02

2430	WPT068	Mill Brook	Stone Bridge Rd	10/17/06	mm5	22361334	0.9	0	7	<0.5	<0.5	<0.5	16	24	11	<0.1	<0.05	<0.02	<0.02
2424	WPT069	"Golf Course" Brook	Roseland Park Rd	2/6/06	mm8	22352649	1	0	7	0.3	<0.1	0.3	16	31	19	0.2	<0.05	0.01	<0.01
1830	WPT070	Muddy Brook	Roseland Park Rd	2/6/06	mm10	22352650	1.6	3	6.6	0.2	<0.1	0.2	<10	24	10	<0.1	<0.05	0.01	0.01
1830	WPT070	Muddy Brook	Roseland Park Rd	5/1/06	mm8	22355589	1.2	12	6.8	0.4	<0.1	0.4	22	42	15	0.6	<0.05	0.03	0.01
1830	WPT070	Muddy Brook	Roseland Park Rd	8/8/06	mm8	22358987	2.1	4	6.8	See note	0.5	See note	35	49	12	1.1	<0.05	0.05	0.02
1830	WPT070	Muddy Brook	Roseland Park Rd	10/17/06	mm7	22361335	0.5	2	6.8	<0.5	<0.5	<0.5	22	34	13	0.3	<0.05	<0.02	<0.02
2426	WPT071	Johnstone Pond Outfall	Senexet Rd	2/6/06	mm12	22352651	0.5	0	6.3	0.2	<0.1	0.2	<10	15	3.1	<0.1	<0.05	<0.01	<0.01
2426	WPT071	Johnstone Pond Outfall	Senexet Rd	5/1/06	mm10	22355590	1.1	6	6.9	0.3	<0.1	0.3	21	33	4.2	<0.1	<0.05	0.07	0.01
2426	WPT071	Johnstone Pond Outfall	Senexet Rd	8/8/06	mm10	22358988	3.3	1	6.8	<0.2	<0.2	<0.2	28	33	4	0.1	<0.05	0.06	0.03
2426	WPT071	Johnstone Pond Outfall	Senexet Rd	10/17/06	mm9	22361336	4.2	2	6.7	0.5	<0.5	0.5	28	30	4.7	<0.1	<0.05	<0.02	<0.02
2435	WPT072	Peckham Brook	Dugg Hill Rd	2/6/06	mm13	22352652	1.3	2	7.2	0.4	<0.1	0.4	24	52	13	3.3	<0.05	0.06	0.06
2435	WPT072	Peckham Brook	Dugg Hill Rd	5/1/06	mm12	22355591	0.6	10	7.3	0.5	<0.1	0.5	39	66	12	2.5	<0.05	0.02	0.01
2435	WPT072	Peckham Brook	Dugg Hill Rd	8/8/06	mm12	22358989	2.3	4	7	<0.2	<0.2	<0.2	61	67	13	1.1	<0.05	0.04	0.02
2435	WPT072	Peckham Brook	Dugg Hill Rd	10/17/06	mm11	22361337	1.5	1	6.8	<0.5	<0.5	<0.5	52	58	15	1	<0.05	<0.02	<0.02
2432	WPT073	Muddy Brook	Woodstock Rd	2/6/06	mm15	22352653	1.1	2	6.6	0.1	<0.1	0.1	10	20	11	<0.1	<0.05	0.01	<0.01
2432	WPT073	Muddy Brook	Woodstock Rd	5/1/06	mm14	22355592	1.8	10	7.2	0.5	<0.1	0.5	12	37	14	<0.1	<0.05	0.03	0.01
2432	WPT073	Muddy Brook	Woodstock Rd	8/8/06	mm14	22358990	2.2	3	6.9	<0.2	<0.2	<0.2	20	33	9.8	<0.1	<0.05	0.05	<0.02
2432	WPT073	Muddy Brook	Woodstock Rd	10/17/06	mm13	22361338	1.9	2	6.8	0.7	<0.5	0.7	11	26	12	<0.1	<0.05	<0.02	<0.02
2425	WPT074	English Neighborhood Brook	Route 197	2/6/06	mm18	22352654	1.1	1	6.4	0.2	<0.1	0.2	10	15	11	<0.1	<0.05	<0.01	<0.01
2425	WPT074	English Neighborhood Brook	Route 197	5/1/06	mm16	22355593	0.9	3	6.7	0.3	<0.1	0.3	<10	37	15	0.1	<0.05	0.01	<0.01
2425	WPT074	English Neighborhood Brook	Route 197	8/8/06	mm16	22358991	1.1	0	6.7	<0.2	<0.2	<0.2	16	23	12	0.1	<0.05	0.04	0.04
2425	WPT074	English Neighborhood Brook	Route 197	10/17/06	mm15	22361339	0.8	1	6.6	<0.5	<0.5	<0.5	<10	22	11	<0.1	<0.05	<0.02	<0.02

2437	WPT075	Taylor Brook (rev 11/22/05)	Pulpit Rock Rd	2/6/06	mm27	22352659	1.3	0	6.5	0.4	<0.1	0.4	<10	19	14	0.2	<0.05	<0.01	<0.01
2437	WPT075	Taylor Brook (rev 11/22/05)	Pulpit Rock Rd	5/1/06	mm26	22355598	1.3	8	6.6	0.4	<0.1	0.4	17	44	19	1	<0.05	<0.01	<0.01
2437	WPT075	Taylor Brook (rev 11/22/05)	Pulpit Rock Rd	8/8/06	mm26	22358996	7.6	11	6	<0.2	<0.2	<0.2	32	43	11	0.9	<0.05	0.03	<0.02
2437	WPT075	Taylor Brook (rev 11/22/05)	Pulpit Rock Rd	10/17/06	mm25	22361344	1.8	1	6.4	<0.5	<0.5	<0.5	21	35	13	0.4	<0.05	<0.02	<0.02
179	WPT076	Muddy Brook	Route 169	2/6/06	mm20	22352655	0.2	6	6.1	0.2	<0.1	0.2	11	14	7	<0.1	<0.05	<0.01	<0.01
179	WPT076	Muddy Brook	Route 169	5/1/06	mm18	22355594	0.6	4	6.3	0.5	<0.1	0.5	<10	30	9.4	<0.1	<0.05	0.4	<0.01
179	WPT076	Muddy Brook	Route 169	8/8/06	mm18	22358992	1.2	2	6.3	0.95	<0.2	0.95	<10	24	7.6	<0.1	<0.05	0.03	0.03
179	WPT076	Muddy Brook	Route 169	10/17/06	mm17	22361340	0.9	6	6	0.7	<0.5	0.7	<10	20	8	<0.1	<0.05	<0.02	<0.02
2431	WPT077	Morse Pond Outfall	Route 169	2/6/06	mm2	22352656	0.3	2	6.1	0.2	<0.1	0.2	12	21	16	<0.1	<0.05	<0.01	<0.01
2431	WPT077	Morse Pond Outfall	Route 169	5/1/06	mm20	22355595	1	9	6.6	0.6	<0.1	0.6	<10	40	23	<0.1	<0.05	0.01	<0.01
2431	WPT077	Morse Pond Outfall	Route 169	8/8/06	mm20	22358993	1.3	21	6	<0.2	<0.2	<0.2	<10	24	15	<0.1	<0.05	<0.02	<0.02
2431	WPT077	Morse Pond Outfall	Route 169	10/17/06	mm19	22361341	0.6	7	6.3	0.7	<0.5	0.7	<10	22	18	<0.1	<0.05	<0.02	<0.02
2433	WPT078	Muddy Pond Outfall	Pond Factory Rd	2/6/06	mm24	22352657	0.4	5	6.2	0.3	<0.1	0.3	13	27	12	<0.1	<0.05	<0.01	<0.01
2433	WPT078	Muddy Pond Outfall	Pond Factory Rd	5/1/06	mm22	22355596	0.7	9	6.5	0.4	<0.1	0.4	<10	29	14	<0.1	<0.05	0.33	<0.01
2433	WPT078	Muddy Pond Outfall	Pond Factory Rd	8/8/06	mm22	22358994	5	7	6.1	0.3	<0.2	0.3	<10	18	11	<0.1	<0.05	0.03	0.03
2433	WPT078	Muddy Pond Outfall	Pond Factory Rd	10/17/06	mm21	22361342	4.9	23	6.4	0.6	<0.5	0.6	<10	14	10	<0.1	<0.05	<0.02	<0.02
2436		Sampson Pond	New Sweden Rd	2/6/06	mm31	22352661	1.7	2	6.4	0.9	0.1	0.1	<10	18	12	<0.1	<0.05	See note	0.03
2436		Sampson Pond	New Sweden Rd	5/1/06	mm30	22355600	1.2	9	6.5	0.4	<0.1	0.4	16	40	17	0.2	<0.05	0.02	0.01
2436		Sampson Pond	New Sweden Rd	8/8/06	mm30	22358998	3.5	0	6.2	<0.2	<0.2	<0.2	23	34	11	<0.1	<0.05	0.07	0.06
2436		Sampson Pond	New Sweden Rd	10/17/06	mm29	22361346	1.8	2	6.4	0.6	<0.5	0.6	19	27	13	<0.1	<0.05	<0.02	<0.02

Note: Interference