Broad Brook Watershed Report

Prepared by the USDA – Natural Resources Conservation Service

May, 2010

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Executive Summary

The Broad Brook main stem is approximately 11.4 miles long and flows westward through a relatively broad, flat valley located in the north-central portion of the State of Connecticut. Approximately 15.8 square miles (10,102 acres), the Broad Brook drainage basin covers four towns: East Windsor, Ellington, Somers, and Tolland. As early as 2002, water quality monitoring in the basin indicated the presence of elevated levels of bacterium. In 2004, Broad Brook was listed by the Connecticut Department of Environmental Protection (CT DEP) in its *List of Connecticut Waterbodies Not Meeting Water Quality Standards*. Bacterium was cited as the principal water quality concern to be treated with Best Management Practices (BMPs). Subsequent study has shown nitrate inputs from stormwater, ground water, and other sources as a significant water quality concern. In 2005, the Connecticut USDA – Natural Resources Conservation Service (NRCS) began discussing with the CT DEP a cooperative effort to develop a watershed based plan to address the pollutants of concern. Using funding provided in part from Section 319 of the Clean Water Act, NRCS initiated, in May 2007, work on a watershed based planning effort for Broad Brook basin.

Based on a modified NRCS rapid watershed assessment model, NRCS will provide recommendations for Best Management Practices (BMPs) that may be implemented to address water quality concerns. The recommendations presented in the Watershed Based Plan (WBP) are made on two levels: BMPs suitable for implementation throughout the watershed, and BMPs for specific sites within the watershed, identified as “place-based” in the report. The place-based locations are regarded as potentially significant sources of pollutant loading, and the BMPs recommended for these sites are considered the most appropriate and effective measures based on site conditions.

Place-based recommendations focus attention on the impact an individual site may have on water quality. It is important to understand that the place-based locations are not necessarily contributing bacteria to the system, nor may they be contributing more bacteria than other specific sites in the watershed. The categorization of the site as a high potential for pollutant loading is based on the existing site conditions at the time of the investigation.

Land use, land cover, and soils types are some of the factors that were used to evaluate which locations might be more likely contributors of bacteria to Broad Brook and its tributaries. In order to assess the actual contribution of any of these sites more detailed and site specific analysis is required.

Introduction

Broad Brook is considered an impaired waterbody by the Connecticut Department of Environmental Protection (CT DEP), and since 2004 has been included on the *List of Connecticut Waterbodies Not Meeting Water Quality Standards*. Bacterium is cited as the only known pollutant of concern. The other impairment for habitat is of unknown cause. In September 2009, the CT DEP developed a Total Maximum Daily Load (TMDL) for the lower section of the Broad Brook. The Department is currently developing a TMDL for the upper section of the watershed. Until the TMDL for the upper section is completed, the CT DEP has stated that the TMDL for the lower section should be used as a rough guide for load reductions to be achieved in the upper section.

It is important to minimize or eliminate bacterial loading to a waterbody because, according to the US Environmental Protection Agency (US EPA), there is a statistical relationship between the levels of Escherichia Coli (*E. coli*), the indicator bacteria, and human illness rates. *E. Coli,* like some other bacterium, originates from the intestinal tracts of humans as well as other warm blooded animals. The presence of these bacteria in the Broad Brook indicates that human waste or animal waste is present. Though not necessarily harmful themselves, these bacteria are indicators of other disease-causing organisms, and are used as a general indicator of unsanitary water quality conditions.

The Connecticut Water Quality Standard established the following criteria for *E. coli* bacteria in the State's surface waters:

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

These criteria are based on protection of recreation uses such as swimming, kayaking, wading, water skiing, fishing, boating, aesthetic enjoyment, and others. When the bacteria counts exceed the criteria there may be an associated health risk from water contact.

The potential sources of bacterial pollution in the Broad Brook basin include waterfowl, agriculture, crop-related sources, intensive animal feeding operations, natural sources, illicit discharges, and failed or inadequate septic systems. Other potential sources identified through this study include wildlife and domestic pet waste, stormwater runoff, and swimming “accidents”.

Though listed for the elevated levels of bacteria, high levels of the nutrients nitrogen and phosphorous are also water quality concerns for the Broad Brook basin. The United States Geological Survey (USGS) conducted a cooperative groundwater/water quality study from 2002 to 2005 for the Broad Brook (*Nutrient Loads and Ground-Water Residence Times in an Agricultural Basin in North Central Connecticut*, Mullaney, 2006). The study revealed that most concentrations of nitrogen and phosphorous exceeded the US EPA Ecoregion XIV nutrient criteria for streams. Ground water residence times ranged from greater than 2 to more than 50 years. Simulation models showed that about one half of the discharges to the Broad Brook and its tributaries were recharged more than 10 years ago, and that approximately 8% of the discharge was recharged prior to 1960. These findings suggest that the nutrients, nitrogen in particular, remain in the watershed’s groundwater for extended periods of time. The long residence time means that the nutrients move through the system slowly and present a long-term source of pollutant loading to the Broad Brook and its tributaries.

This report will not directly address nutrient loading. Nutrients are not listed as a contaminant source in the CT DEP’s 303(d) Impaired Waterbodies List. The implementation of the BMPs recommended in this report may also reduce some of the nutrient loading in the watershed. None of the suggested BMPs are specifically designed to treat groundwater. Any potential reduction in nutrient loading would likely occur through the practices intended to manage stormwater surface runoff. While the implementation of BMPs may help to reduce nutrient loading, it could likely take several years and possibly decades to see the results of the treatment.

Eventually, the nutrients in the Broad Brook make their way to Long Island Sound. The Broad Brook flows into the Scantic River which outlets into the Connecticut River which drains into Long Island Sound. In an effort to minimize the impact of nutrient loading to the Sound, the State of Connecticut has developed a TMDL for Long Island Sound identifying nitrogen as the pollutant of concern. Even though nutrients, such as nitrogen and phosphorous, are essential elements for aquatic organisms, excessive amounts can cause water quality problems. Eutrophication, excessive plant and algae growth in a waterbody, is the most notable result. An overabundance of plants and algae may deplete a waterbody of dissolved oxygen, affect habitat for aquatic organisms, and alter the process of photosynthesis and nutrient cycling. These changes may affect the ability of a waterbody to support plant and animal life, interfere with water treatment, and decrease aesthetic and recreational values. In addition, some forms of nutrients can be toxic to humans and to animals. (*Understanding the Science Behind Riparian Forest Buffers: Effects on Water Quality*; Authors Julia C. Klapproth, Faculty Assistant-Natural Resources, Maryland Cooperative Extension; James E. Johnson, Extension Forestry Specialist, College of Natural Resources, Virginia Tech, Publication Number 420-151, posted October 2000).

Much of the pollutant loading (bacterial, nutrient, and other types) and poor water quality conditions in the Broad Brook basin can be attributed to nonpoint source (NPS) pollution. Nonpoint source pollution, simply stated, is polluted runoff. Rainfall or snowmelt moves as surface runoff or through the ground carrying natural and human-made pollutants into waterbodies such as lakes, rivers, streams, wetlands, and estuaries. In contrast, point source pollution comes from a specific location, such as discharge pipes or outfalls. Point sources can be easily identified, monitored, and regulated. Nonpoint sources are hard to identify and therefore difficult to monitor and regulate. It should be noted that very few point sources were observed during the trackdown survey conducted along the Broad Brook main stem.

In 2005, the United States Department of Agriculture – Connecticut Natural Resources Conservation Service (NRCS) and the CT DEP entered into discussions on ways that the two agencies might work in cooperation with local watershed stakeholders to develop a watershed based plan describing implementation measures to reduce pollutant loading and remove the

Broad Brook from the 303(d) list of impaired waterbodies. The NRCS and CT DEP signed a formal agreement in April 2007. Work on the project commenced thereafter. This project is funded in part through Section 319 of the Clean Water Act.

Purpose

Because land planning decisions are made at the town level in Connecticut, this plan is intended to help watershed residents and decision makers understand the impact of nonpoint source pollution on the Broad Brook and its tributaries. This planning effort provides local, state, and federal entities with recommendations for the implementation of specific Best Management Practices (BMPs) to address bacterial loading, which is the identified water quality concern in the Broad Brook watershed. In this way, the report serves as a nonpoint source water quality management plan specifically for bacteria. As described above, nutrient loading may be reduced as a concomitant result of BMP implementation.

The plan offers local stakeholders a number of alternatives and variety of options to reduce bacterial loading to the Broad Brook. The recommendations include structural and nonstructural practices on both a watershed-wide basis and place-based basis. Providing watershed-wide and place-based BMPs achieves two objectives. The watershed-wide perspective highlights the relationship between existing land use conditions and water quality. At this broader level the suggested practices represent basic measures that can be used anywhere in the watershed to help decrease the impact of pollutant loading.

Place-based recommendations, on the other hand, focus attention on the impact an individual site may have on water quality. The individual sites identified through this study represent locations where there is a high potential for bacterial loading. It is important to understand that the place-based locations are not necessarily contributing bacteria to the stream system, nor may they be contributing more bacteria than other sites in the watershed. The categorization of the site as a high potential is based on the existing site conditions at the time of the investigation. Land use, land cover, and soils types are some of the factors that were used to evaluate which locations might be more likely contributors of bacteria to the Broad Brook and its tributaries. In order to assess the actual contribution of any of these sites, more detailed and site specific analysis is required.

Implementing the measures outlined in this report, in whole or in part, on a watershed-wide or place-based basis, will help to improve and maintain the health of the Broad Brook and the surrounding landscape. Moreover, the identification of specific BMPs assists the CT DEP with its stated goal of removing the Broad Brook from the 303(d) impaired waterbodies list for bacterial loading. Other water quality concerns that may exist (nutrient loading, heavy metals, sedimentation) would need to be identified before they can be addressed through the implementation of BMPs specific to those concerns. The implementation of the BMPs suggested in this report may have some positive impact on the reduction of any other existing water quality concerns.

The report summarizes the financial and technical scope of the recommended BMPs. The summary itemizes the costs in time and money that may be required for implementation of the suggested practices. Based on the estimates, the involved parties can explore ways to obtain the necessary resources, including allocations in municipal budgets, grant monies, and other sources of funding.

The costs developed by NRCS for the implementation of the recommended BMPs described in this report represent a best estimate based on a variety of sources. It should be understood that the estimates do not consider all of the site specific conditions that may influence the final cost for implementation. Original cost estimates were made based on 2006 costs. These estimates have been adjusted by 8.18 percent to more accurately reflect 2009 dollars. The value for the increase, suggested as a national construction cost index, was taken from Engineering News Record. Costs may change in subsequent years. For a more detailed discussion of cost development, please refer to the Watershed Wide Analysis section of this report.

Scope

As described above, the scope of this project was limited to bacterial loading to the Broad Brook and its tributaries. Bacterium is the only identified contaminant in the CT DEPs impaired waterbodies list. Other water quality concerns, such as nitrogen, which are not specifically identified, may get treated secondarily as a result of the implementation of the suggested BMPs. The watershed assessment and this plan were structured to meet the goals and requirements of Section 319 of the Clean Water Act.

Congress enacted Section 319 of the Clean Water Act in 1987, establishing a national program to control nonpoint sources of water pollution. During the last several years US EPA has been working with the States to strengthen its support for environmental protection at a watershed scale by encouraging local stakeholders to develop and implement watershed-based plans. In particular, US EPA and the States have concentrated efforts on waterbodies listed by States as impaired under Section 303(d) of the Clean Water Act. These plans may also include activities that address waterbodies within the watershed that are not currently impaired and where it is appropriate to prevent future impairments within the watershed.

According to US EPA, attention to these impaired waterbodies is particularly critical because nonpoint source pollution is reported by States and others to be responsible for the majority of remaining water pollution in the United States. As outlined in the Section 319 guidelines, two key steps are needed to solve nonpoint source problems within a watershed context: the development of a watershed-based plan that addresses a waterbody's water quality needs (including the incorporation of any TMDLs that have been developed) and the actual implementation of the plan.

Project Description

This plan provides information for municipal staff and officials, members of local land use commissions, landowners, and individuals interested in watershed management and natural resources within the Broad Brook basin. The plan offers general information about the

Broad Brook watershed and a characterization of current watershed conditions; acts as a management guide for reducing bacterial loading and addressing nonpoint source pollution concerns; serves as a starting point from which stakeholders can prioritize implementation projects; and functions as a funding document. The recommendations made in the report can be used to support requests for future funding of projects designed to improve the health of the Broad Brook watershed.

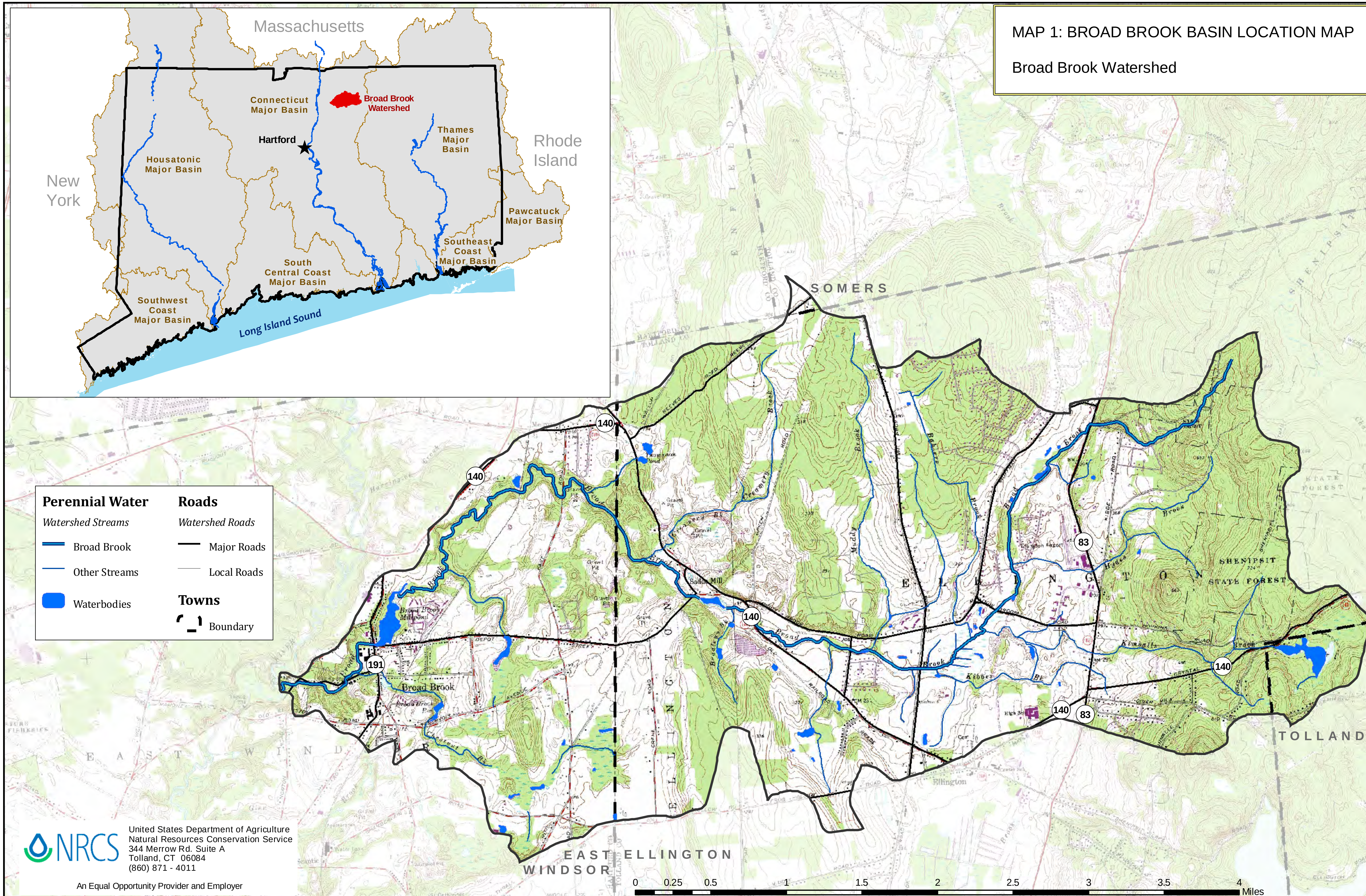
An Advisory Committee was developed as part of this effort. The committee consisted primarily of municipal staff and land use commission members from the towns of Ellington and East Windsor. Formation of the committee created a mechanism for incorporating local input into the plan. Committee members could disseminate information about the effort to the broader public and could bring comments or suggestions from the broader public back to NRCS. This enabled the planning process to be transparent and open. Public outreach and participation for the project was coordinated by the North Central Conservation District.

Watershed Description

Broad Brook watershed is approximately 15.8 square miles in size (10,102) acres. It is oblong in shape. The longest point is roughly seven miles across, running in an east-west direction. The watershed is 3.6 miles at its widest point. Portions of four towns fall within the basin boundaries: 24.1 percent of the watershed is in East Windsor, 73.9 percent in Ellington, 0.2 percent in Somers, and 1.8 percent in Tolland (see Table 1). Major tributaries to the Broad Brook include Chestnut Brook, Muddy Brook, Kibbe Brook, Creamery Brook, Kimballs Brook, Hyde's Brook, and Bahler's Brook. (See Map 1: Broad Brook Location Map).

Table 1: Towns in the Broad Brook Watershed

town	total acres in town	acres of town in watershed	% of town in watershed	% of watershed from town
East Windsor	17,107.00	2,438.0	14.3%	24.1%
Ellington	22,131.60	7,461.4	33.7%	73.9%
Somers	18,323.30	17.7	0.1%	0.2%
Tolland	25,749.10	184.8	0.7%	1.8%
total acres in watershed:		**10,101.8**		100.0%



MAP 1: BROAD BROOK BASIN LOCATION MAP
Broad Brook Watershed
Massachusetts
New York
Rhode Island
Connecticut Major Basin
Broad Brook Watershed
Hartford
Thames Major Basin
Housatonic Major Basin
Pawcatuck Major Basin
Southeast Coast Major Basin
South Central Coast Major Basin
Southwest Coast Major Basin
Long Island Sound
Perennial Water
Watershed Streams
Broad Brook
Other Streams
Waterbodies
Roads
Watershed Roads
Major Roads
Local Roads
Towns
Boundary
SOMERS
ELLINGTON
TOLLAND
EAST WINDSOR
SHENIPSIT STATE FOREST
140
191
83
0 0.25 0.5 1 1.5 2 2.5 3 3.5 4 Miles
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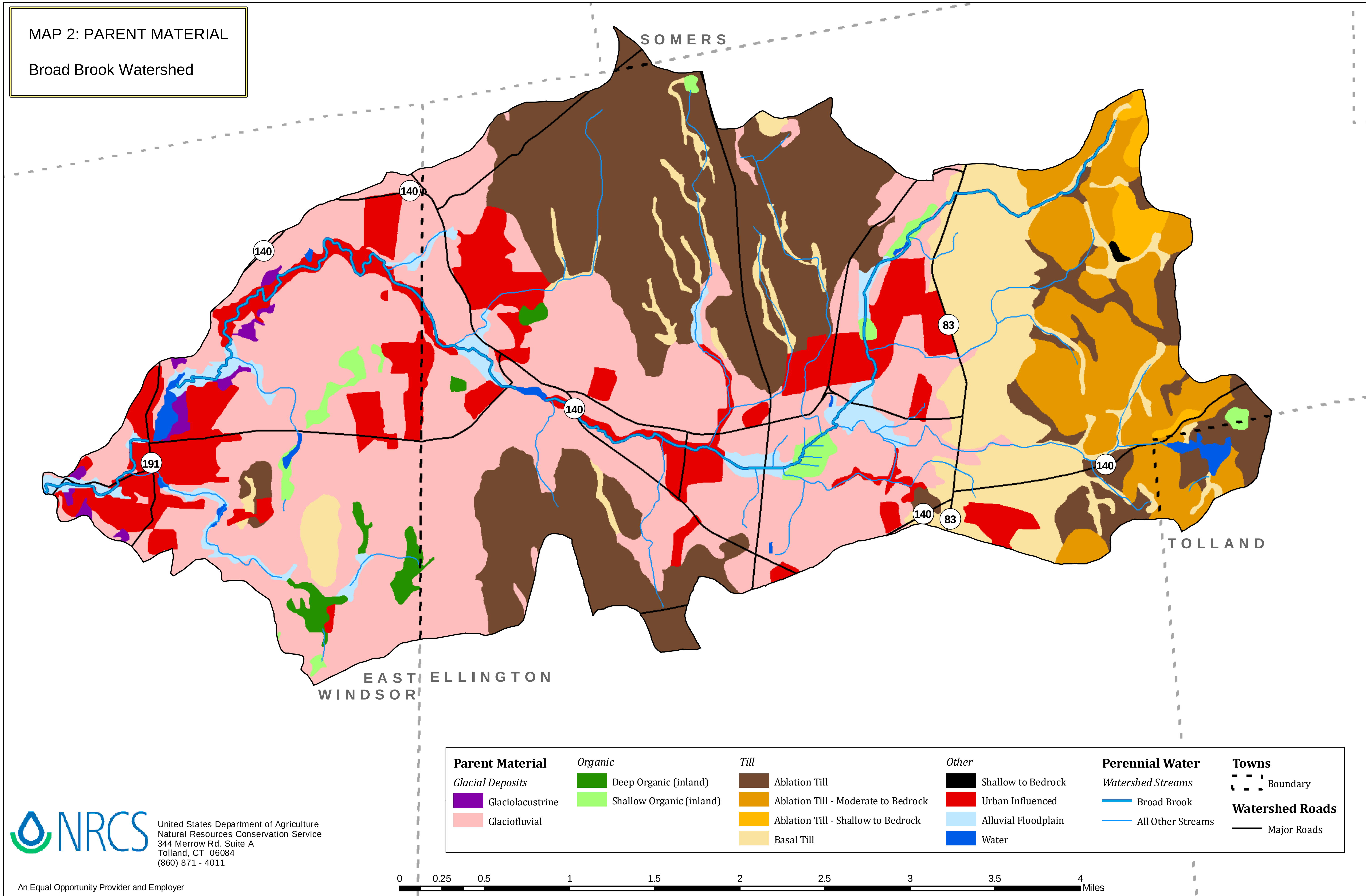
Soil Parent Materials – General Soils Description

Glacial ice receded most recently from Connecticut about 13,000 years ago. As it melted, it left behind the “raw” materials, parent materials, for the soils that cover the State today. Physical, chemical, and biological forces have turned this material into soil over time. Parent material governs what types of minerals are in the soil and it influences many soil properties such as permeability, infiltration, and pH. The resulting soil is also influenced by climate, topography, landscape position, and time. In addition, many types of parent material occupy specific landscape positions and functions in a watershed. Map 2: Parent Material, displays the distribution of parent materials in the watershed.

Glaciolacustrine soils occupy a very small area in the watershed, less than 1 percent, all of it along watercourses on the far west edge. Glaciolacustrine material was deposited from placid waters in large lake systems such as Glacial Lake Hitchcock, which formed in the Connecticut River Valley. These materials have layers (called varves) of well sorted very fine sands, fine silts, and clays which reduce the flow of air and water movement, limiting groundwater recharge. Runoff potential is low to high depending on landscape position. Many areas of these soils occupy depressions.

Organic deposits are rare in the Broad Brook watershed, occupying less than five percent of the total area. Organic soils form in decaying vegetation and occur in bogs, swamps, and other depressions. They have very high water holding capacity, buffering capability, and a year round ponded and/or saturated condition. Because of their landscape position and soil properties, they store and remove nutrients and contaminants from runoff in a watershed and provide food and habitat for wildlife. Soils formed in organic deposits are regulated as Connecticut inland wetlands.

About the same area as organic deposits is occupied by alluvial or floodplain deposits in the watershed. They are found along the Broad Brook and its tributaries. These materials are transported by overflowing streams and occur on level to nearly level flood plains. They are our youngest soils and are still being deposited today with each flood event. Alluvial materials are generally very rich in nutrients and stone free. Their runoff potential is moderate to low. They range from very poorly to excessively drained. Those with good drainage and infrequent flooding make productive soils for agriculture and forestry production. Less well drained alluvial soils provide wildlife food and habitat and buffer streams. They are all important areas for storing floodwaters and are regulated as Connecticut inland wetlands.



MAP 2: PARENT MATERIAL
Broad Brook Watershed
SOMERS
TOLLAND
EAST WINDSOR
ELLINGTON
140
191
83
Parent Material
Glacial Deposits
Glaciolacustrine
Glaciofluvial
Organic
Deep Organic (inland)
Shallow Organic (inland)
Till
Ablation Till
Ablation Till - Moderate to Bedrock
Ablation Till - Shallow to Bedrock
Basal Till
Other
Shallow to Bedrock
Urban Influenced
Alluvial Floodplain
Water
Perennial Water
Watershed Streams
Broad Brook
All Other Streams
Towns
Boundary
Watershed Roads
Major Roads
0 0.25 0.5 1 1.5 2 2.5 3 3.5 4 Miles
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Glaciofluvial materials cover about half of the watershed. These materials were deposited by moving water from melting glacial ice. They occupy terraces, outwash plains, deltas, kames, and eskers whose slopes range from nearly level to very steep. They usually consist of rounded, well sorted sands and gravels. Most are moderately well to excessively drained, although some outwash soils in depressions and other low areas are poorly and very poorly drained wetlands. When these soils are in good condition, runoff infiltrates and percolates readily and they provide groundwater and aquifer recharge in the watershed. Most of the urban influenced areas in the Broad Brook watershed are in Glaciofluvial deposits.

The remaining soils in the watershed were formed in Glacial till, which was transported and deposited directly by glacial ice. It is an unsorted mixture of materials that vary in mineralogy and texture (a mixture of the smallest clay particles to large rock fragments). Soils formed in till are primarily upland soils on hillsides with slopes ranging from gentle to extremely steep. Some tills (ablation or supra-glacial) were deposited from within or atop the ice and are fairly loose throughout. Others (basal or sub-glacial) were deposited directly beneath the glacier. The enormous pressure from the weight of the ice made it compact in the substratum, usually within a few feet of the soil surface. This compact layer ("hardpan") reduces the flow of water and increases the potential for runoff. Many till deposits are shallow (<20" to bedrock) or moderately shallow (20 – 40"). They have less capacity to absorb runoff or hold water for plants.

Urban influenced areas have been altered by human activity and show extreme variability from one location to another. They generally have paved or otherwise impervious areas, increasing their runoff potential. While many urban areas have little capacity to store rainwater unless specific practices are installed, in some cases urban soils have a broader range of perviousness than might be expected. Site specific evaluation should always be conducted to confirm existing conditions.

As it rains in the watershed, water will make its way from the upland till areas towards waterbodies and watercourses. The forest canopy, where present, will slow rainwater down on its way to the soil surface. If the soil condition is good, water will infiltrate and unless taken back up by plants, will percolate downward until it reaches bedrock or hardpan. There it will begin to flow laterally, eventually discharging into wetlands, lakes or streams. Rainwater that falls on compacted or impervious surfaces will run off down slope. Some will flow into level, undisturbed areas of outwash or floodplain materials and be slowed before percolating through the soil or being released into surface water. Some will flow into depressions occupied by organic materials or poorly drained mineral soils and will either seep into the soils, evaporate, or be taken up by plants. The rest will run directly into surface waters. In some cases this direct discharge into surface waters will occur through stormwater runoff being conveyed by catch basin pipe systems.

General Land Use/Land Cover Description

The Broad Brook originates in the northeastern corner of the basin, with its headwaters located in Shenipsit State Forest. The brook flows in a westerly direction for roughly 11 linear miles before draining into the Scantic River on the western edge of the watershed. The upper reaches of the watershed are less densely developed, with the watershed becoming progressively more developed as one moves downstream. As shown in Table 2, agricultural lands and developed lands each comprise just over one quarter of the watershed. The majority of the basin, roughly 41 percent, is classified as forested land. The general land use/ land cover in the basin is shown in Map 3: General Land Use/ Land Cover. Map 4: Detailed Land Use/ Land Cover displays the 28 individual land use/land cover categories and includes Table 3 which describe total acreage of land use/over for each individual category in the watershed.

Table 2: Land Use / Land Cover Classifications

Classification	*Acres*	*Percent of Watershed*
Forest land	4,152.6	41%
Agriculture	2,676.6	26%
Developed	2,593.6	26%
Transitional	336.2	3%
Other	206.3	2%
Water	70.1	1%
Barren	66.4	1%
Total	10,101.8	100%

Water Quality

The State of Connecticut has established water quality standards for both surface and ground water. "The purpose of the Standards is to provide clean and objective statements for existing and projected water quality and the general program to improve Connecticut's water resources." (CT DEP Water Quality Standards) While federal law requires each state to adopt standards for surface waters, water quality standards for ground waters are not subject to federal review. Recognizing that surface and ground waters are interrelated, the State of Connecticut has established standards for both.

Connecticut's Water Quality Standards

Connecticut's Water Quality Standards classify all the waters of the state, specify the designated uses and values that must be supported, and specify criteria that define the water quality necessary to support those uses. Surface waters are designated as either Class AA, A, B, C or D. Uses include:

- AA – Drinking water supply, fish and wildlife habitat, recreational (may be restricted), agricultural and industrial supply
- A – Potential drinking water supply, fish and wildlife habitat, recreational use, agricultural supply, navigation
- B – Recreational, fish and wildlife habitat, agricultural and industrial supply, navigation

Surface waters designated as Class C or D are not attaining designated uses or meeting water quality criteria.

Classifications are often expressed as an existing designation, with a water quality goal, for example as B/A. This means that the goal is "A", but current conditions support a classification of "B".

According to State Surface Water Quality Classifications, roughly the first two linear miles of the Broad Brook are designated as a Class A watercourse. After that point it is categorized as a B/A watercourse. The vast majority of tributaries in the watershed are considered Class A with several stream segments classified as B/A. (See Map 5: Surface and Ground Water Quality Classifications).

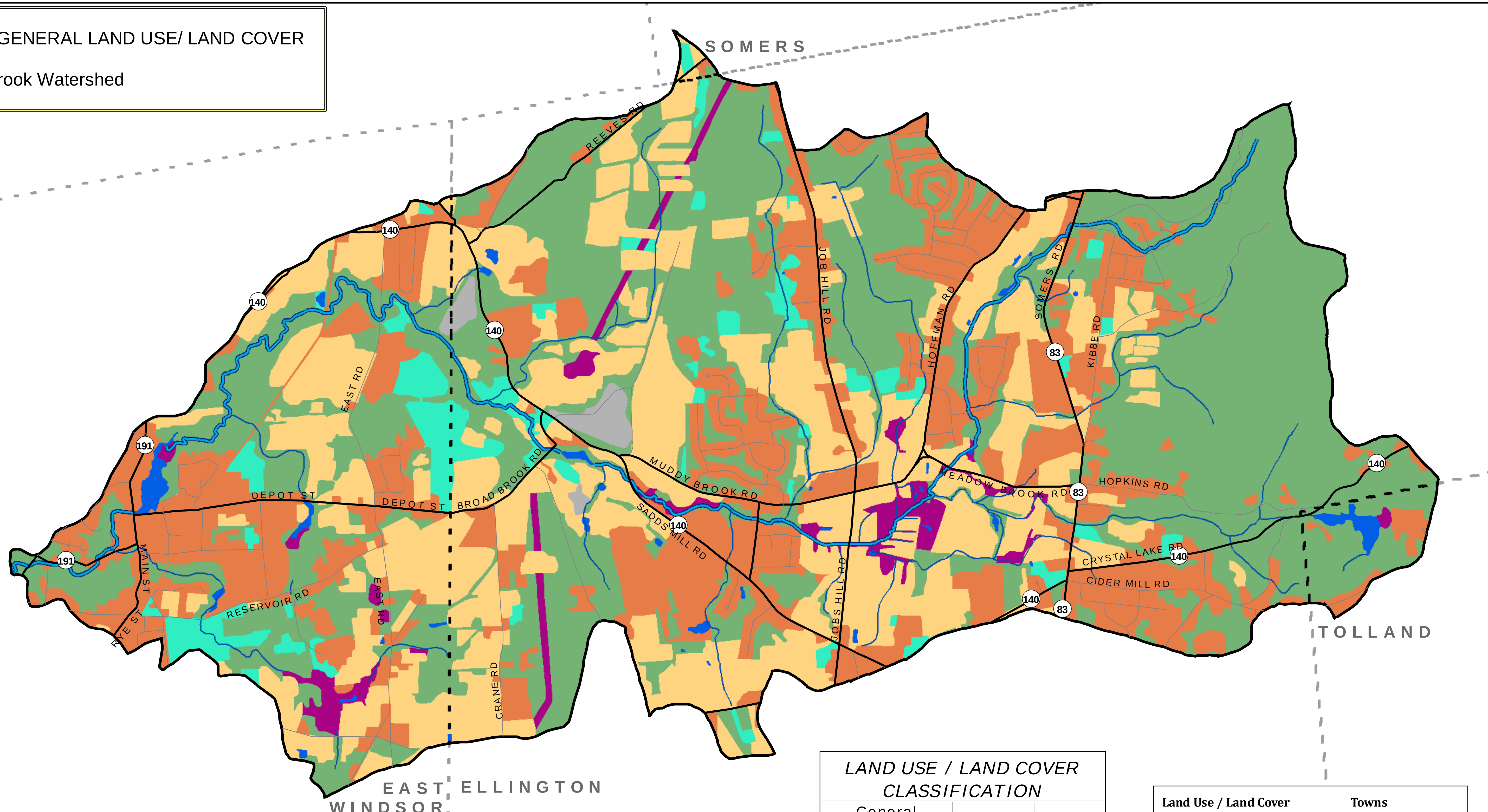
Class	Comment	Use I
GA		existing private and potential public water supply
GAAs	water tributary to public water supply reservoir	existing or potential public drinking water supply
GAA	public water supply, contributing to pws well, future pws	existing or potential public drinking water supply
GA - Impaired	may need treatment before drinking or domestic use	existing or potential public drinking water supply
GAA - Impaired	may need treatment before drinking or domestic use	existing or potential public drinking water supply
GB		presumed needs treatment before human consumption

Most of the mapped ground water, similar to the surface water, is of high quality and has been classified as GA. Some scattered locations are identified as GAAs or GAA. There are some areas of relatively significant size that are categorized as GA impaired or GAA impaired.

There are two USGS monitoring sites along the main stem of the Broad Brook. One station is located at the mouth of the Broad Brook and the other is located approximately 0.80 miles upstream from the mouth of the river at the outlet of Mill Pond. No other monitoring locations are identified in the Impaired Waterbodies report; consequently, the 303(d) listing of the Broad Brook is based solely on these two sites.

MAP 3: GENERAL LAND USE/ LAND COVER

Broad Brook Watershed



LAND USE / LAND COVER CLASSIFICATION		
General Classification	Acres	Percent
Forest land	4,177.2	41%
Agriculture	2,676.6	26%
Developed	2,520.0	25%
Transitional	385.3	4%
Other	206.3	2%
Water	70.1	1%
Barren	66.4	1%
Grand Total	10,101.8	

Land Use / Land Cover

Label

- Agriculture
- Developed
- Forest
- Transitional
- Barren
- Water
- Other

Towns

- Boundary

Perennial Water

Watershed Streams

- Broad Brook
- Other Streams

Watershed Roads

- Major Roads
- Local Roads

0 0.25 0.5 1 1.5 2 2.5 3 3.5 4 Miles

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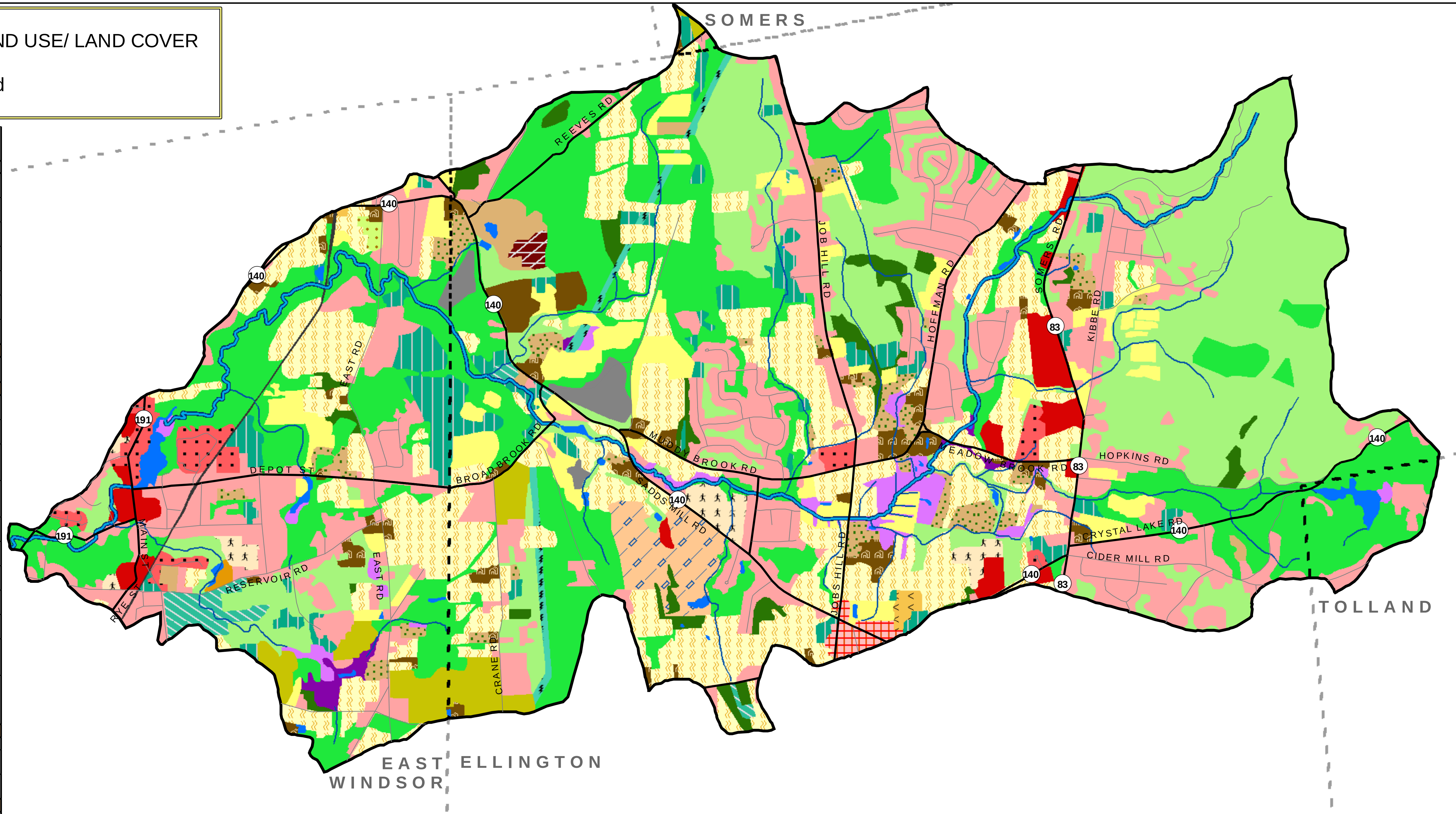
MAP 4: DETAILED LAND USE/ LAND COVER

Broad Brook Watershed

Table 3: Detailed Land Use / Land Cover Classification

General	Detailed	Acres	Percent
Agriculture	agriculture: cultivated	1,615.8	16.0%
	agriculture: farmstead	176.4	1.7%
	agriculture: pasture-grazed	177.4	1.8%
	agriculture: non-cultivated	455.5	4.5%
	agriculture: orchard	9.5	0.1%
	agriculture: pasture-idle	79.2	0.8%
	agriculture: nursery	162.8	1.6%
Agriculture Total		**2,676.6**	**26.5%**
Barren	barren: mines/quarries	66.4	0.7%
Barren Total		**66.4**	**0.7%**
Developed	developed: residential	1,885.9	18.7%
	developed: commercial	154.7	1.5%
	developed: other-golf courses	134.9	1.3%
	developed: high-density residential	128.6	1.3%
	developed: other-ballfields	79.4	0.8%
	developed: other-landfills	47.3	0.5%
	developed: mixed	37.1	0.4%
	developed: transportation	16.1	0.2%
	developed: industrial	15.5	0.2%
	developed: other-cemeteries	14.5	0.1%
	developed: other-compacted grasses	6.0	0.1%
Developed Total		**2,520.0**	**24.9%**
Forest	forest: mixed	2,080.6	20.6%
	forest: deciduous	1,927.3	19.1%
	forest: coniferous	169.2	1.7%
Forest Total		**4,177.2**	**41.4%**
Other	other: herbaceous	120.2	1.2%
	other: right of way	52.2	0.5%
	other: scrub/shrub	33.8	0.3%
Other Total		**206.3**	**2.0%**
Transitional	transitional: mixed	318.3	3.2%
	transitional: partial canopy	66.9	0.7%
Transitional Total		**385.3**	**3.8%**
Water	water: lake/reservoir	70.1	0.7%
Water Total		**70.1**	**0.7%**
Grand Total		**10,101.8**	**100%**



Land Use / Land Cover

Agriculture
- ac: agriculture-cultivated
- an: agriculture-noncultivated
- ag: agriculture-grazed pasture
- ap: agriculture-pasture/idle field
- af: agriculture-farmstead
- au: agriculture-nursery
- ao: agriculture-orchard

Development
- dr: developed-residential
- drh: developed-high density residential
- dc: developed-commercial
- dm: developed-mixed
- di: developed-industrial
- dt: developed-transportation
- dol: developed other-landfill
- dok: developed other-compacted grass
- dog: developed other-golf courses
- doc: developed other-cemeteries
- dob: developed other-ballfields

Forest
- fd: forest-deciduous
- fc: forest-coniferous
- fm: forest-mixed

Transitional
- tm: transitional-mixed
- tl: transitional-partial canopy

Other
- osu:other-utility right of way
- oh: other-herbaceous
- os: other-shrub

Barren
- bm: barren-mine/quarry

Water
- wl/wld: water-lake/reservoir

Towns
- Boundary

Perennial Water

Watershed Streams
- Broad Brook
- Other Streams

Watershed Roads
- Major Roads
- Local Roads

0 0.25 0.5 1 1.5 2 2.5 3 3.5 4 Miles

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Tolland, CT 06084
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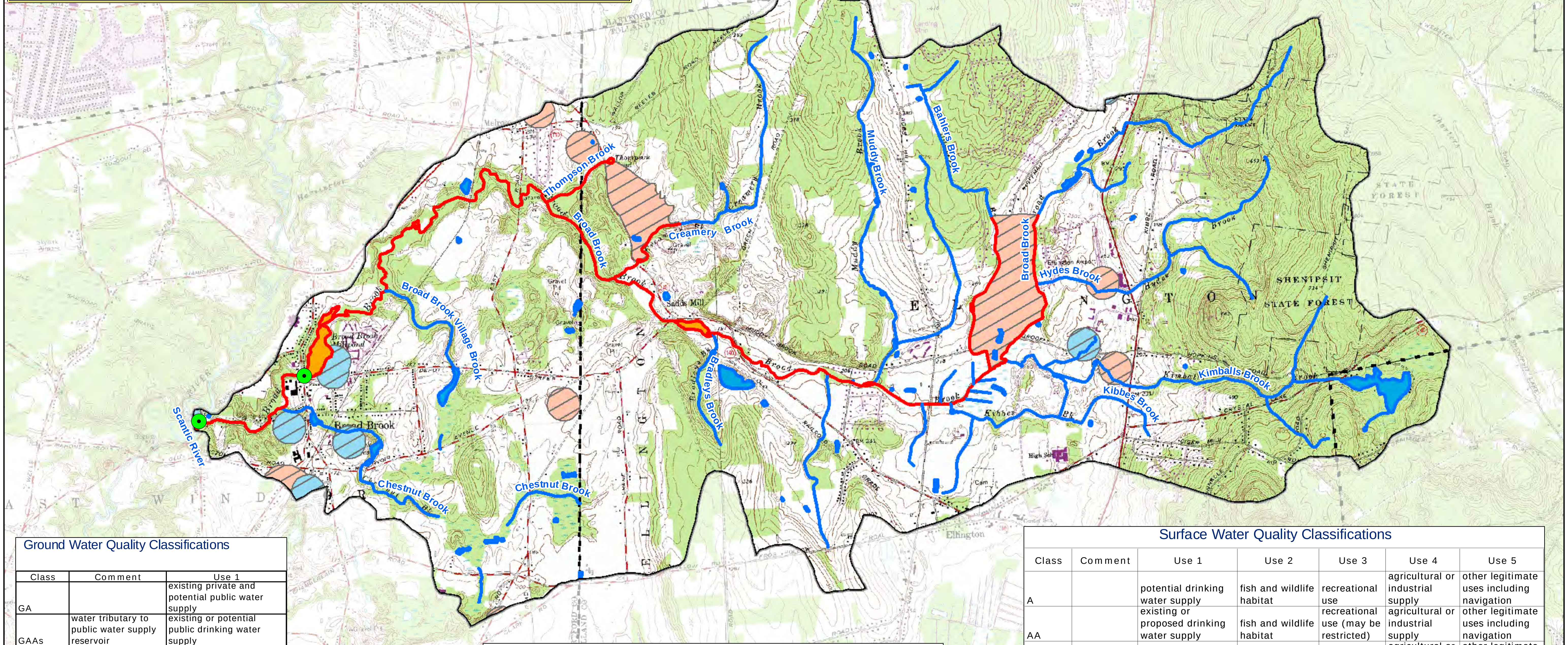
MAP 5: SURFACE AND GROUND WATER QUALITY CLASSIFICATIONS

Broad Brook Watershed



Ground Water Quality Classifications

Class	Comment	Use 1
GA		existing private and potential public water supply
GAAs	water tributary to public water supply reservoir	existing or potential public drinking water supply
GAA	public water supply, contributing to pws well, future pws	existing or potential public drinking water supply
GA - Impaired	may need treatment before drinking or domestic use	existing private and potential public water supply
GAA - Impaired	may need treatment before drinking or public use	existing or potential public drinking water supply
GB		presumed needs treatment before human consumption

Surface Water Quality Class Line

Classification

- A
- B,C,D to A

Surface Water Quality Class Polygon

Classification

- A
- B,C,D to A

Ground Water Quality Class

Classification

- GAA, GAAs
- GA, GAA May be impaired
- GA (all areas that are not GAA or impaired)

USGS Monitoring Sites

- Approximate Location

Surface Water Quality Dataset
Originator:
State of Connecticut, Department of Environmental Protection
(data compiler, editor and publisher)
Publication_Date: 19990101
Title: Surface Water Quality Classifications Line Edition: 20061101

Surface Water Quality Classifications

Class	Comment	Use 1	Use 2	Use 3	Use 4	Use 5
A		potential drinking water supply	fish and wildlife habitat	recreational use	agricultural or industrial supply	other legitimate uses including navigation
AA		existing or proposed drinking water supply	fish and wildlife habitat	recreational use (may be restricted)	agricultural or industrial supply	other legitimate uses including navigation
B			fish and wildlife habitat	recreational use	agricultural or industrial supply	other legitimate uses including navigation
B / A	currently not meeting criteria for target class		fish and wildlife habitat	recreational use	agricultural or industrial supply	other legitimate uses including navigation
B / AA	currently not meeting criteria for target class		fish and wildlife habitat	recreational use	agricultural or industrial supply	other legitimate uses including navigation
C / A	currently not meeting criteria for target class		certain fish and wildlife habitat	certain recreational uses	industrial supply	other legitimate uses including navigation
C / B	currently not meeting criteria for target class		certain fish and wildlife habitat	certain recreational uses	industrial supply	other legitimate uses including navigation
D / B	currently not meeting criteria for target class		certain fish and wildlife habitat	bathing or other recreational use	industrial supply	other legitimate uses including navigation

0 0.25 0.5 1 1.5 2 2.5 3 3.5 Miles

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Report Component Methodology

The watershed analysis was divided into two parts: data collection and data analysis. Both of the collection and analysis components were split into two phases. During phase one of data collection, NRCS gathered existing data and employed various methods to characterize and assess accurately the current physical condition of the Broad Brook watershed. NRCS developed a set of components to evaluate existing watershed characteristics. Each component represents an individual study focusing on a particular aspect of watershed conditions. The studies are designed to provide data that can be used independently, in conjunction with the other watershed studies, and with other outside databases in order to distill the relationship between water quality and watershed conditions. The components included the following:

- a detailed Land Use/Land Cover (LULC) for the watershed,
- a set of maps providing soil based recommendations for storm water management practices,
- a level 1 geomorphic stream assessment,
- an evaluation of pervious/impervious cover,
- an assessment of the soil and parent material in the watershed,
- a municipal regulations review as related to water resources,
- a trackdown survey.

In addition, an advisory committee comprised of local citizens, municipal representatives, and state and federal agency representatives was created. The committee serves as a mechanism for incorporating stakeholder input into planning process, into the plan itself, and as a method for disseminating information about the effort to the public.

Under phase two of the project, NRCS examined the findings from the studies described above by examining the ways in which watershed conditions and characteristics relate to each other and to water quality conditions. Variables under consideration included land use/land cover, soil characteristics, stream types, pervious and impervious area, wetland functionality, existing local municipal regulations, and proximity of potential pollutant sources to waterbodies. The relationships among the different variables were explored through a variety of different analyses.

Watershed conditions are examined on a broad scale, and, based on existing conditions, BMPs that may be appropriate and effective for use throughout the watershed are recommended in this report.

The watershed is evaluated to determine specific locations that might be potential or likely sources of pollutant loading primarily for bacteria and secondarily, nitrogen. Factors included in the analyses include land use and land cover, unbuffered sections of stream, soil suitability for subsurface sewage disposal systems, and impervious and pervious cover, among others. Appropriate "place-based" (site specific BMPs) are recommended for the sites.

This tiered assessment of watershed conditions aids local decision-makers to identify existing and potential impairments to water quality, and to examine more closely the potential sources of those impairments. This information, in turn, informs NRCS's recommendations for the BMPs that would be most suitable and provide the greatest impact for the watershed. Moreover, it enables NRCS and planners to identify specific locations for implementation of priority BMPs to achieve the most benefit. Using this place-based approach gives the local municipalities a focused, strategically developed, and relevant plan. This is significant because municipalities are the key to managing nonpoint source pollution in Connecticut.

Land Use/Land Cover GIS Data Set

<u>Objective</u>

The primary objective of the LULC data set is to provide a picture of the Broad Brook watershed landscape. With this in mind, the NRCS LULC classification scheme is designed to separate out classes of land cover by their potential impacts on the levels of pollutants (specifically bacteria and nitrogen) entering into surface water and/or ground water. Using 2006 aerial photo imagery, a total of 28 classes of land use and land cover were established and used in the Broad Brook Watershed. A minimum mapping unit of one (1) acre was used in order to create a detailed map of the watershed landscape. Small waterbodies, less than 1 acre in size, have been mapped in cases where they may have an influence on water quality conditions. Creating such a detailed, large-scale land use/land cover map sets up a foundation for understanding the relationship between landscape patterns and water quality conditions.

Imagery

The imagery used for remote sensing was of several years and differing resolution. The primary base imagery used was the 1990-1992 leaf-off b/w Orthophotomosaic for Tolland County, Connecticut, 1 m resolution. The true-color, leaf-on, 2006 NAIP FSA-APFO compliance imagery, 1 m resolution was used to detect change in cover or use. Additionally, the 2004 Connecticut Statewide Digital Orthophoto Mosaic, 0.8 ft spatial resolution was used to discern specific use and cover.

Quality Control

Approximately 4% of the polygons were field checked when cover or use could not be discerned through remote sensing. An additional 3% was verified through ground truthing of a random sample. The entire dataset was reviewed by an advisory committee made up of local landowners.

General Approach

The intended use of data controlled the structure of the classification scheme for the NRCS LULC. Data that could be captured in separate data sets, such as ownership of lands, easements, political boundaries, etc., were not classified in this one. Also, the classification of wetlands is not considered here, but the cover over the wetland, (e.g. forest, shrub or herbaceous), is the dominant consideration. The 28 classes in this data set will be used to consider land use/land cover by its potential affect on water quality. The classification scheme is loosely modeled upon the Anderson Classification System, with consideration given to definitions found in the National Resource Inventory glossary, USDA NRCS 2004; and the National Land Cover Dataset, U.S. Geological Survey 1999.

Specific Approach

The NRCS LULC was developed using ESRI ArcGIS 9.2. The base imagery was in UTM NAD 1983 zone 18, so all data layers were projected to match. Vector data sets were imported into a personal geodatabase in order to facilitate the calculation of acres. A topology was used to ensure polygon integrity (there are no gaps between lines or overlapping polygons).

The boundary of the watershed was defined by the dataset "Basins" maintained by the CT DEP on their website (http://dep.state.ct.us/gis/Data/data.asp). For the NRCS LULC, the following basins were merged to form the outer boundary of the Broad Brook Watershed.

Basin Number

- 4206-00-1
- 4206-00-2-R1
- 4206-00-2-R2
- 4206-00-2-R3
- 4206-00-2-R4
- 4206-00-3-L1
- 4206-00-3-L2
- 4206-00-3-R1
- 4206-00-3-R2
- 4206-00-3-R3
- 4206-00-3-R4
- 4206-00-3-R5
- 4206-01-1
- 4206-02-1
- 4206-02-1-L1
- 4206-03-1
- 4206-04-1
- 4206-05-1
- 4206-05-2-R1
- 4206-06-1
- 4206-07-1
- 4206-08-1
- 4206-09-1
- 4206-09-1-L1
- 4206-10-1
- 4206-10-1-L1
- 4206-10-1-L2

This outer boundary was then edited to classify the land use/ land cover. The seven (or nine) digit basin codes were used to label the local basins for individual study.

The Attribute Table (Table 4) for the LULC was designed to contain three levels of classification. The definitions for these classifications can be found in the table below. All polygons were classified at least to Level II, some were further classified to Level III. The label field was calculated to be equal to the highest level of classification of each polygon. By attributing each polygon with levels of classification, it will be simple to display the data set at Level I, Level II or complete classification.

Attribute Table for Land Use / Land Cover Categories

This set of definitions was developed for the watershed planning group with certain criteria in mind. The product that will ultimately be derived from the dataset collected will be addressing water quality issues – specifically NPS pollutants, N, P, sediment and bacteria. As such, the classification was designed to separate out land cover and land use by its potential affect on these issues

Table 4: Attribute Table for Land Use/ Land Cover

Level I	Level II	Level III	Symbol	Definition
DEVELOPED			**D**	**Developed Land** includes areas where much of the land is covered by impervious or artificially compacted surfaces. Included in this category are residential developments, strip developments, shopping centers, industrial and commercial complexes, transportation corridors, active recreational areas and other artificial surfaces. There is a minimum density of 20% cover of constructed materials.
	Residential		**dr**	This unit includes property that has been removed from the rural land base through the erection of residential structures. The unit includes areas ranging from urban centers of multi-unit structures to suburban developments, to less dense, rural residential areas. Constructed materials account for at least 20% of the cover. The delineation includes associated land that is tied to the residential use through fencing, pavement or intensive landscaping. *Note: the 20% threshold was determined through a combination of sources: NLCD uses 30 -80%; NRI calls for 5 structures (each with a min. of .25ac) per 2,640' of road. Using a 100' lot depth, this is a density of 20%. There is no gradation between High and Low density in NRI*
		High density	**drh**	This unit is typically made up of multiple-unit structures of urban cores or residential areas that are between 75% and 100% constructed material cover type.
	Commercial		**dc**	This unit includes urban central business districts, shopping centers, and commercial strip. Institutional land uses, such as educational, religious, health, correctional, and military facilities are also components of this category. Also included are the secondary structures and areas – such as warehouses, driveways, parking lots and landscape areas. Large associated recreation areas (ball fields, etc) will be classified under Other Urban. Pumping stations, electric substations, and areas used for radio, radar, or television antennas are included if they meet the minimum mapping size.
	Industrial		**di**	This unit includes land uses such as light manufacturing complexes, heavy manufacturing plants and their associated, adjacent areas such as parking lots, storage facilities and properties that have been removed from the rural land base through fencing or intensive landscaping.
	Transportation		**dt**	This unit includes areas whose use is dedicated to transportation outside of developed areas. Major highways, including rights-of-way, are included as well as areas used for interchanges, service and terminal facilities. Rail facilities are delineated, including stations and parking lots. Airport facilities include the runways, intervening land, terminals, service buildings, navigation aids, fuel storage, and parking lots.
	Mixed Urban		**dm**	This unit captures areas with a mixture of uses, such as residential, commercial and/or industrial where more than a one-third intermixture of another use or uses occurs in a specific area. Also included are areas where the individual uses cannot be separated at the mapping scale.
	Other Urban		**do**	This unit typically consists of uses such as golf courses, urban parks, cemeteries, waste dumps, grassed water-control structures and spillways, ski areas, and undeveloped land within an urban setting that is greater than 1ac in size. The category does not require that there be structures in place if the land is in very intensive use and resulting compaction can be expected.
	Other Urban	Ball Fields	**dob**	Baseball, soccer, football and other heavily used active recreation areas
		Cemeteries	**doc**	Includes all the area cleared for use as cemetery, even if it is not currently active.
		Golf Courses	**dog**	Includes the developed areas of the course, all buildings and parking lots as well as waterbodies and strips of forestland between greens and fairways.
		Landfills/dumps	**dol**	This category includes both active landfills and landfills that have been capped and do not fall under a new use category.

Level I	Level II	Level III	Symbol	Definition
		Compacted grasses	**dok**	This includes open, unwooded areas of active recreational areas such as ski slopes, grassy areas in parks or other grassed areas without intensive use (such as grassed water control structures)
AGRICULTURE			**A**	Agricultural Land may be defined broadly, as land used primarily for production of food and fiber. When lands produce economic commodities as a function of their wild state such as wild rice or certain forest products they should be included in the appropriate Land Cover category (e.g. Forestland).
	Cultivated		**ac**	Cultivated land includes areas in row crops or close-grown crops under annual tillage.
	Non-cultivated		**an**	Non-cultivated cropland is comprised primarily of hayland. The crop may be grasses, legumes, or a combination of both. Hayland also includes land that is in set-aside or other short-term agricultural programs, and is generally mowed annually.
	Pasture-idle		**ap**	This unit is comprised of land associated with an agricultural use that is primarily in herbaceous cover – usually a grass mixture.
	Pasture-grazed		**ag**	This unit is comprised of land associated with an agricultural use that is primarily in herbaceous cover – usually a grass mixture. In this unit, there is a known use of animal grazing.
	Orchards, Berry Fruit, Vineyards		**ao**	This unit is comprised of fields used for the production of fruit grown on trees, shrubs or vines.
	Nurseries (fields)		**au**	This unit includes fields used for commercial production of shrubs, flowers, trees and other vegetation that is generally sold intact (not for the fruit/seed).
	Farmsteads, Greenhouses, Stables, Barns, Corrals		**af**	This unit includes areas with structures that are associated with an agricultural enterprise. This includes commercial greenhouse complexes as well as the houses, barns, feeding areas and outbuildings that are associated with an active farmstead.
TRANSITIONAL AREAS			**T**	A vegetated area that does not meet the definition of other vegetated cover (forest, agriculture). A clearly defined use cannot be ascribed through remote sensing. There is the potential for the land cover and or land use to change in the future.
	Mixed herbaceous and/or shrub		**tm**	This unit is typically former croplands or pastures that now have grown up in brush in transition back to forest. The land is no longer identifiable as cropland or pasture from imagery
	Recently logged, or partial canopy <25%		**tl**	This unit is typically either former cropland or pasture which have passed through the brush stage and is now sparsely treed (not meeting the 25% canopy cover); or it is forestland that has been recently logged. The land is no longer identifiable as forestland, cropland or pasture from imagery.
FOREST LAND			**F**	Forest Lands have a tree-crown areal density of 25 percent or more, which equates to 10 percent stocked by single-stemmed woody species of any size that will be at least 4 meters (13 feet) tall at maturity. The area must be at least 100 feet to be classified as forestland.
	Deciduous		**fd**	Deciduous Forest Land includes all forested areas having a predominance of trees that lose their leaves at the end of the frost-free season or at the beginning of a dry season.
	Coniferous		**fc**	Evergreen Forest Land includes all forested areas in which the trees are predominantly those which remain green throughout the year.
	Mixed Deciduous/Coni		**fm**	When more than one-third intermixture of either evergreen or deciduous species occurs in a specific area, it is classified as Mixed Forest Land.

Level I	Level II	Level III	Symbol	Definition
	ferous			
WATER			**W**	Water includes all areas that are persistently water covered.
	Lakes, ponds, reservoirs		**wl**	An inland body of water, fresh or salt, occupying a basin or hollow on the earth's surface, which may or may not have a current or single direction of flow. It may be natural or, created in whole or in part by the building of engineering structures.
BARREN			**B**	This unit is comprised of land with limited capacity to support life and having less than 5 percent vegetative cover. Vegetation, if present, is widely spaced.
	Strip mines, Quarries, Pits		**bm**	This unit includes land that is actively used for extraction of ores, minerals, and rock materials.
OTHER			**O**	This category encompasses land that does not have a defined use under earlier classifications. It is not designed as a 'catch-all' and should be used to classify areas that are un-forested and rural (undeveloped) and likely to remain so – for instance: wetlands, areas known to be under conservation wildlife easement, etc.
	Herbaceous cover		**oh**	This unit is comprised of land that has an herbaceous cover, but is not directly associated with an agricultural enterprise. Some ancillary data (e.g. ownership, easements, etc) was used to differentiate this area from agricultural grasslands. This also includes wetland areas that are in herbaceous cover
	Scrub Shrub cover		**os**	This unit is comprised of land that has a mixed herbaceous/shrub cover, but is in a relatively permanent use category. The number of acres of any one use may not be significant so they will be mapped together. Examples include well fields, and scrub-shrub wetlands.
	Scrub-shrub, Right of Way		**osu**	This unit is comprised of land that has a mixed herbaceous/shrub cover, and is artificially maintained in the permanent-use category of utility right of way.

Throughout the data collection, a variety of resource materials were used to support the remote sensing of the imagery. Most of these data layers are available over the internet. The Roads data layer is one provided through agreement between USDA and Tele Atlas North American, Inc. The publication date was 2008, and the Source_Scale_Denominator was 100,000 or better. The Streams data layer is a product of the U.S. Geological Survey, National Mapping Program. The publication date was 2005, and the Data Collection Scale was 1:24,000. It should be noted that as a part of the LULC development, the Streams data layer was modified to better align the stream dataset with the imagery.

Data that is owned by government agencies, (e.g. the Common Land Unit data set, USDA FSA), may not be available to the general public. The information that is contained in this data can be very important. When classifying land uses such as farmsteads and greenhouses in areas where the land use is intertwined with other commercial or residential uses, the CLU data provided ownership information that tied land to an agricultural interest. This distinction helped to determine if land was potentially being used to produce an agricultural commodity. Also, the towns of Ellington and East Windsor provided CT NRCS with their digital zoning layers for use in this project.

Other data layers that provided invaluable information include layers that show municipally owned lands, state-owned lands and natural resource information. By loading the CT Soil Survey data layer, we were frequently able to improve interpretation of unusual sites such as bare rock, beaches, wet soils vs. coniferous forests, etc. Since the wetlands were not delineated in this data set, we did not have to worry about matching or conflicting with existing wetland data layers. However, during the classification, we were able to refer to wetland maps in the GIS. The category 'Other' was the classification used for herbaceous or scrub-shrub wetlands as well as open land (not forested) that was not associated with agriculture.

Topographic layers were useful to find rural residences and to pick out cultural features like cemeteries and public institutions like schools or hospitals. As with all data layers, the user must be careful to remember that the original mapping scale of the data set will control the level of accuracy at which it can be used. Therefore, the topographic maps which were generated at 1:100,000 may appear to be misaligned with the soils information that was mapped at 1:12,000. Likewise, zooming in beyond the scale of 1:12,000 may show soil lines to be out of place on the imagery. The NRCS LULC was mapped on-screen at approximately 1:6,000. A minimum mapping unit of 1 acre was adhered to except in cases of small water bodies which may have an impact on water quality.

Soil Based Recommendations for Storm Water Management Practices

Soil information is used by professionals as one screening tool to assist with a variety of land use planning decisions (e.g. septic suitability, slope stability, etc.). As part of this project, NRCS generated a series of maps based on soil characteristics that influence the functioning of BMPs for stormwater runoff in the watershed. Soils were rated to indicate the extent to which each may be suitable, depending on their properties, for specific stormwater management systems. Four stormwater management maps were generated for the watershed: one for stormwater infiltration systems, one for wet extended detention basins, one for dry detention basins, and one for pervious pavement.

These maps are based on the National Cooperative Soil Survey for the state of Connecticut which was mapped at a 1:12,000 scale. Areas of soils less than about three acres in size cannot be delineated at this scale so map units may contain areas of soils differing from those named. The maps provide an excellent general planning tool to be used in management choices and implementation. They can be used to help guide the successful selection of storm water practices that best fit the soil conditions in comprehensive planning, site planning review or for preliminary site selection and design. Survey based soil interpretations are meant to be used for planning or review and do not replace an on-site soil evaluation for site development.

Geomorphic Assessment

Geography

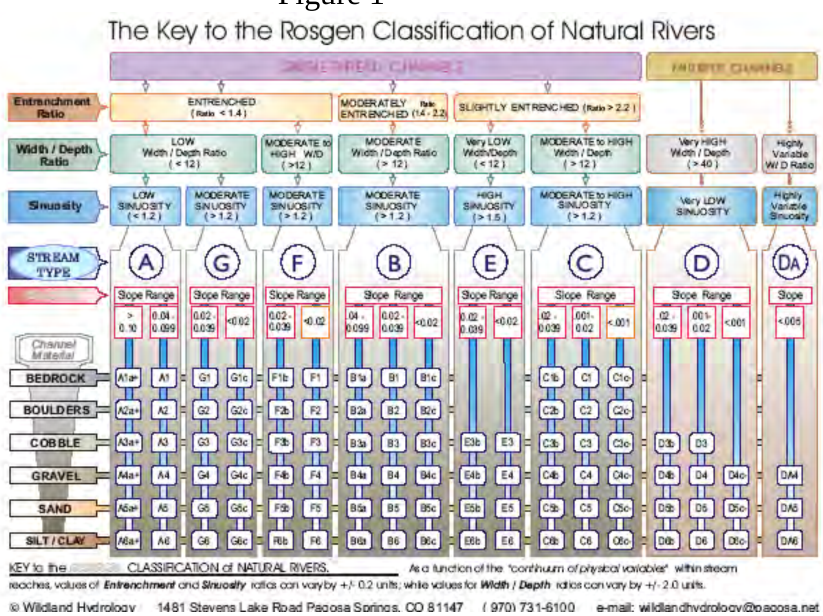
The NRCS *Level I Geomorphic Assessment* for the Broad Brook Watershed includes the entire subregional basin of Broad Brook (4206) which is a subregional basin of the Scantic River (42). The Scantic is within the Connecticut River Major Basin (4). The Broad Brook Watershed includes part of East Windsor within Hartford County as well as the towns of Ellington, Tolland and Somers in Tolland County. However, the fluvial network does not actually extend into the town of Somers.

General Approach

Stream order is a hierarchical ordering of streams based on the degree of branching. A first order stream is a headwater stream without any branching. Two first order streams converge to form a second order stream, and two second order streams converge to form a third order stream. Although stream size may increase in a down-valley progression, stream order only increases when two equal order streams converge. If a lesser order stream converges with a higher order stream the stream order does not change, the resulting stream retains its preexisting higher order.

Level I stream classification (Rosgen methodology) is based on the geomorphic variables of channel slope, channel shape and channel patterns. As such, a level I classification is a geomorphic characterization based on review of topographic maps and aerial photography. The

Figure 1



Rosgen stream classification system for Level I and Level II classification is depicted in Figure 1.

Determining stream order and stream type enhances understanding of how the morphological attributes and position of a stream reach within a watershed affects water quality conditions. Sediment transport, stream hydrology, and the channel-floodplain interactions all influence how nutrients and other materials are transported and/or deposited within a particular stream reach. Both stream type and stream order help to ascertain the response and/or susceptibility of a stream reach to nutrient inputs.

For example, a 1^{st} order B stream type will respond differently to increases and decreases in nutrient loading than a 4^{th} order E stream type. A and B type streams, typically 1^{st} or 2^{nd} order streams, have a steeper slope and less channel-floodplain cycling of materials then C and E stream types. A and B stre Figure 1 herefore, tend to have a short hydraulic residence time and low sediment retention: water flows faster and moves sediment more quickly. As a result, these stream types tend to be insensitive to changes in nutrient loads, and tend to "export" materials out of the reach. Conversely, C and E stream types have a flatter slope, a longer hydraulic residence time, and higher sediment retention. Typically, C and E streams compromise the higher order (3^{rd}, 4^{th}, 5^{th}, etc…) streams within the fluvial network, and tend to be depositional in nature. Subsequently, C and E streams may cycle material between the channel and the floodplain several times before exporting it from the stream reach.

Although there is not a direct relationship between stream size and stream order, as stream order increases, so does stream size (i.e. width). As stream width increases the influence of riparian vegetation on stream shading decreases. As a result, nutrients and other materials flowing through the reach have a greater probability of being used or assimilated by stream biota within the reach, rather than being exported out of the reach.

Water quality, and/or biological conditions may be influenced more by the residual nutrients, or other pollutants within the stream reach, rather than the daily influx of materials in the higher order, C and E stream types.

Quality Control

The accuracy of stream types and stream order is based on the accuracy of the topographic maps, aerial photographs and hydrography layers. Some significant discrepancies between channel location and pattern were noted between the available data layers. Field verifications of various stream reaches throughout the watershed were made to ensure accuracy of stream types.

Specific Approach

Stream order was determined by analysis of the Hydromaster data layer in ArcMap. No distinction was made between intermittent and perennial streams, both were included within the ordering sequence. Stream segments less than 1000 linear feet were not included in the ordering sequence.

Stream type was determined by analysis of both the topography and orthophotography data layers in ArcMap. No distinction was made between intermittent and perennial streams; both were included in the geomorphic characterization of stream type. Verification of stream type was made through field checks and stream measurements.

Pervious / Impervious Surface Analysis (Potential for Runoff)

Using soil type, land use, and land cover information, it is possible to predict areas in the watershed that have the highest potential for runoff as well as those areas with the greatest potential for infiltration and recharge.

Soil runoff classes are generated based on the slope and saturated hydraulic conductivity of a soil map unit. Slope refers to the overall steepness of the soil map unit. The saturated hydraulic conductivity is a measure of the rate of water movement in the soil. The value for saturated hydraulic conductivity assigned to a soil series is an average of its normal range throughout the area. The actual saturated hydraulic conductivity on a specific site may be influenced by land use, cover, and management. A grassy area used for seasonal parking, for example, would have a much lower hydraulic conductivity than undisturbed woodland on the same soil.

Land use / land cover classes are divided into 3 categories of runoff potential: high, moderate, and low. A soil compaction meter was used to evaluate several land uses with grass cover. They included ball fields; high and low traffic recreational areas, abandoned areas, parking, golf courses, and cemeteries (both active and pre-1920).

The highest runoff potential is assigned to highly urbanized, commercial, and industrial areas. In addition, ball fields, picnic areas and grassed parking areas were found to be very compact at the surface. Moderate potential is assigned to most agricultural lands, most recreational areas, and low density development. Woodland is assumed to have the lowest runoff potential. In addition, abandoned areas previously used for agriculture have increased saturated conductivity with time.

Trackdown Survey

In order to identify potential causes and sources of impairment, a trackdown survey of the main stem of the Broad Brook was completed in 2007. The methodology employed for the trackdown is explained in a Quality Assurance Project Plan that was prepared by NCCD and approved by CT DEP and US EPA on 5/24/07 and 5/30/07, respectively.

The trackdown survey used methods based on the Center for Watershed Protection's Urban Stream Assessment (USA). The USA is a focused stream assessment that systematically evaluates conditions of the stream channel and identifies restoration opportunities. The stream is broken down into reaches of approximately one/half mile each to allow for practical data collections over manageable segments.

The USA consists of a reach assessment form that characterizes "average conditions" within a reach (baseflow, substrate, water clarity, wildlife, aquatic plans, algae, shading, channel dynamics and channel dimension); and allows assessment of the following characteristics within each reach: bank stability, instream habitat, riparian vegetation, bank erosion, flood plain connectivity, buffer width, floodplain vegetation, floodplain habitat and floodplain encroachment.

Separate forms are used to assess each impact area within a reach. Impact assessment forms are used for outfall, severe erosion, impacted buffers, utilities, trash and debris, crossings, channel modifications, and miscellaneous impacts. In addition, each affected site is assessed for restoration potential. The location of reaches and impact sites is recorded using a Trimble GPS unit.

Vegetated Buffers

Using the GIS, stream segments were identified as potentially unbuffered by selecting those segments of stream (from the USGS hydrography layer) that intersected land use/land cover areas classified as agricultural or developed and were a minimum of 75 feet wide on either side of the stream. It was decided to use a minimum linear length of 75 feet of stream segment to be considered for a potential planting. Using these criteria enabled prioritization of the unbuffered stream reaches that appear to be most prone to runoff entering into watercourses.

Municipal Regulations Review

The purpose of the review is to examine the existing municipal regulations in order to identify the existing controls, policies, and plans in place to protect and enhance the natural resources in the watershed. The regulations assessed included Zoning, Inland Wetlands, and Subdivision. Because this plan concentrates on water quality, specific information was attained by developing a set of questions about the local regulations that have a direct or indirect relationship to water quality and water quantity concerns.

In Connecticut, each of the 169 municipalities is empowered by the State with the authority to establish local land use planning regulations and policies. Under the current land use planning system, municipalities have responsibility for addressing nonpoint source pollution, while the State has responsibility for addressing point source pollution. Though this authority for municipalities is not explicitly stated, towns can use their regulations to create effective ways to manage the potential adverse affects on water quality that may arise as a result of growth and land planning decisions.

Watershed Conditions Findings

Land Use/Land Cover

Creating a contemporary land use/ land cover layer is critical to understanding the relationship between water quality and the watershed landscape. Generating various levels of classification enable analysis at different watershed scales. Reducing 28 classifications to seven allows general interpretations about broad scale, watershed wide patterns and helps inform recommendations for watershed wide BMPs. Alternatively, mapping the watershed using one acre as a minimum mapping unit allows for site specific analysis and the recommendation of BMPs that may address water quality concerns at specific locations.

Three distinctive landscape features of the Broad Brook watershed surfaced from the LULC analysis. First, a potential relationship exists between the geographical distribution and overall percentage of land use and land cover types in the Broad Brook watershed and the degree of pollutant loading that has and is occurring. In this regard, the distribution and amount of forested and agricultural lands are of particular note. With roughly 41% of the Broad Brook watershed in forested condition it might be presumed there would be a lower potential for pollutant loading than would occur in a more developed watershed. Roots from vegetation take up nutrients, while debris on the forest floor slows the transport of potential pollutants into a watercourse or waterbody. Forested conditions generally have a high potential for infiltration and low potential for runoff. (Refer to the Pervious/Impervious section for more detail regarding runoff potentials). These are areas that may benefit from implementation of low impact development measures/stormwater management techniques to preserve the natural infiltration/runoff relationship.

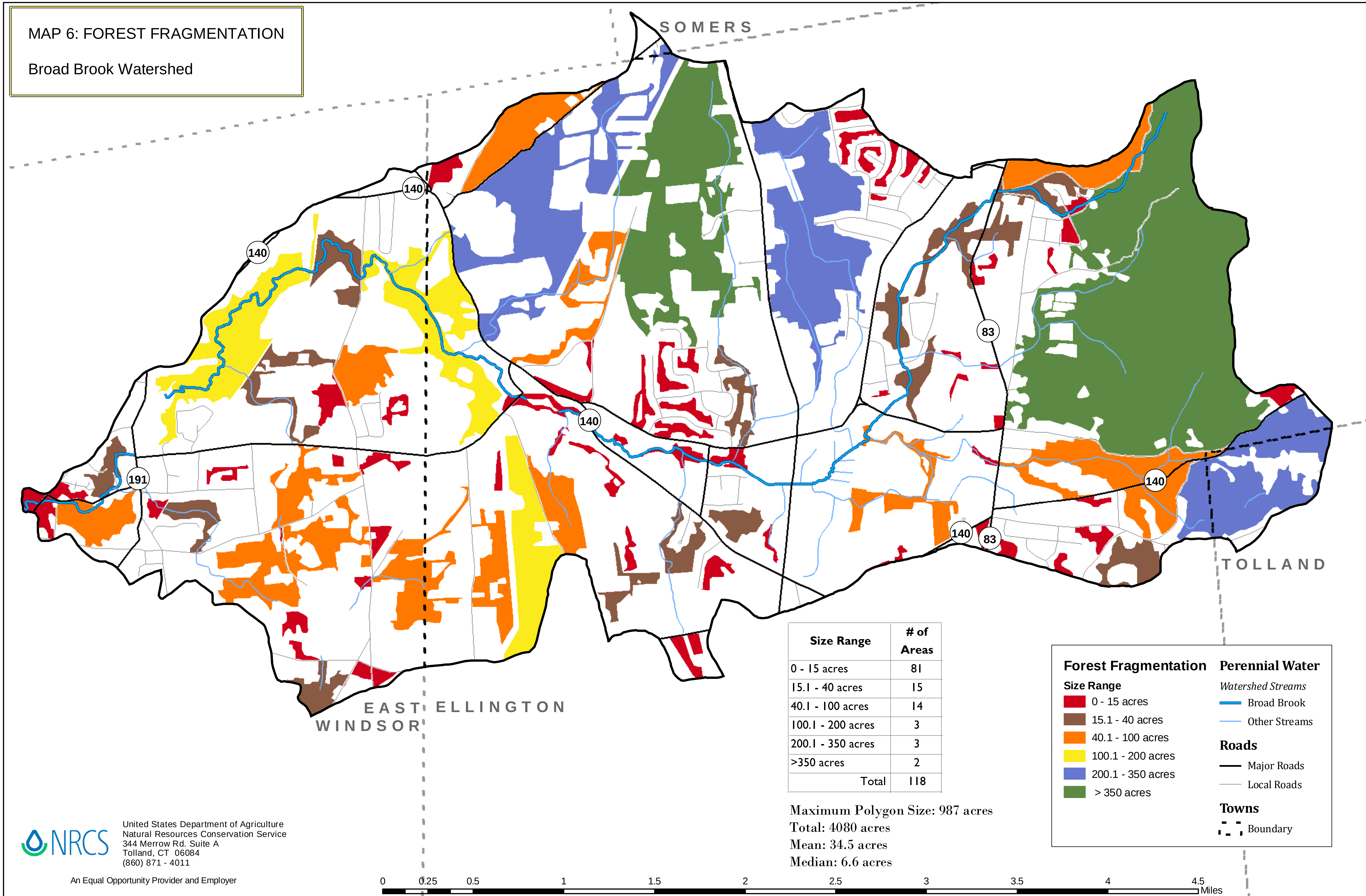
Upon closer examination, however, the LULC shows that roughly 1/3 of the forested land is clustered in the Eastern portion of the watershed. These 1,339 forested acres are situated east of Route 83 and surround the headwaters of the Broad Brook. While such a large, essentially unfragmented block of forest helps to preserve the integrity of the headwaters of the brook, it also means that the remaining two-thirds of forested land (2,723 acres) is spread out over the other 8,761 acres of the watershed. This distribution pattern results in greater forest fragmentation which may affect water quality conditions in two ways. The forested parcels may not be of the size or shape that is adequate for effectively moderating pollutant loading. Because the forested areas may not be located near or along any waterbody or watercourse they may not be ideally situated for mitigating pollutant loading to the watercourses in the basin

Map 6: Forest Fragmentation shows that the majority of remaining larger tracts of forested land (100 acres or more) are located in the Northern half of the basin. In most cases, these forested parcels are separated from each other by agricultural lands. In a few instances developed tracts separate forested parcels from each other. Many of the forested tracts surround the headwaters of the tributaries in the northern half of the watershed. Generally forested tracts present a greater likelihood of buffering than unvegetated or minimally vegetated areas. Consequently, the unforested reaches of stream along the watercourses in the watershed are more susceptible to pollutant loading. It should be noted, however, that the State forest road in the Shenipsit State forest, located in this area, parallels the stream for several hundred feet. The Trackdown Survey revealed erosion and excess sedimentation were present along the unpaved road. Because of the roads proximity to the stream the erosion and sedimentation may affect the stream. Additionally, several of the forested buffers in the watershed appear to be of minimal width and may, therefore, be ineffective in attenuating pollutant loading.

A second landscape feature is the widespread and fairly even distribution of agricultural land throughout the watershed. Waste produced by livestock contains fecal coliform bacteria and fertilizers contain nitrogen and phosphorous. The pattern of even distribution creates abundant points and opportunities for bacteria or nutrients to enter the stream system. Combined with the fragmented nature of forested land this geographical configuration escalates the possibility for pollutant loading.

A third landscape feature of the Broad Brook basin is the limited number of wetland complexes that are present. Wetlands can act as natural filters. The lack of wetlands in the Broad Brook watershed means there are fewer opportunities for pollutants to be filtered naturally. The agricultural character of the watershed together with other elements, such as urban and suburban inputs, may result in the generation of an artificially high amount of bacteria and other pollutants. The few wetlands that are present may be overburdened by the amount of bacteria and nutrients being loaded into the system. The quality of the wetlands is degraded and the potential filtering capacity of the wetlands is reduced.

For example, one of the largest wetland complexes in the basin is located along Muddy Brook Road. (See Map 7: Connecticut Inland Wetland Soils) The wetland, approximately 171 acres in size, is located in close proximity to a dairy farm. It is possible that the system is overwhelmed with inputs from the agricultural operation, and that some or all of the wetland's filtering capacity may be compromised as a result. The stress placed on the

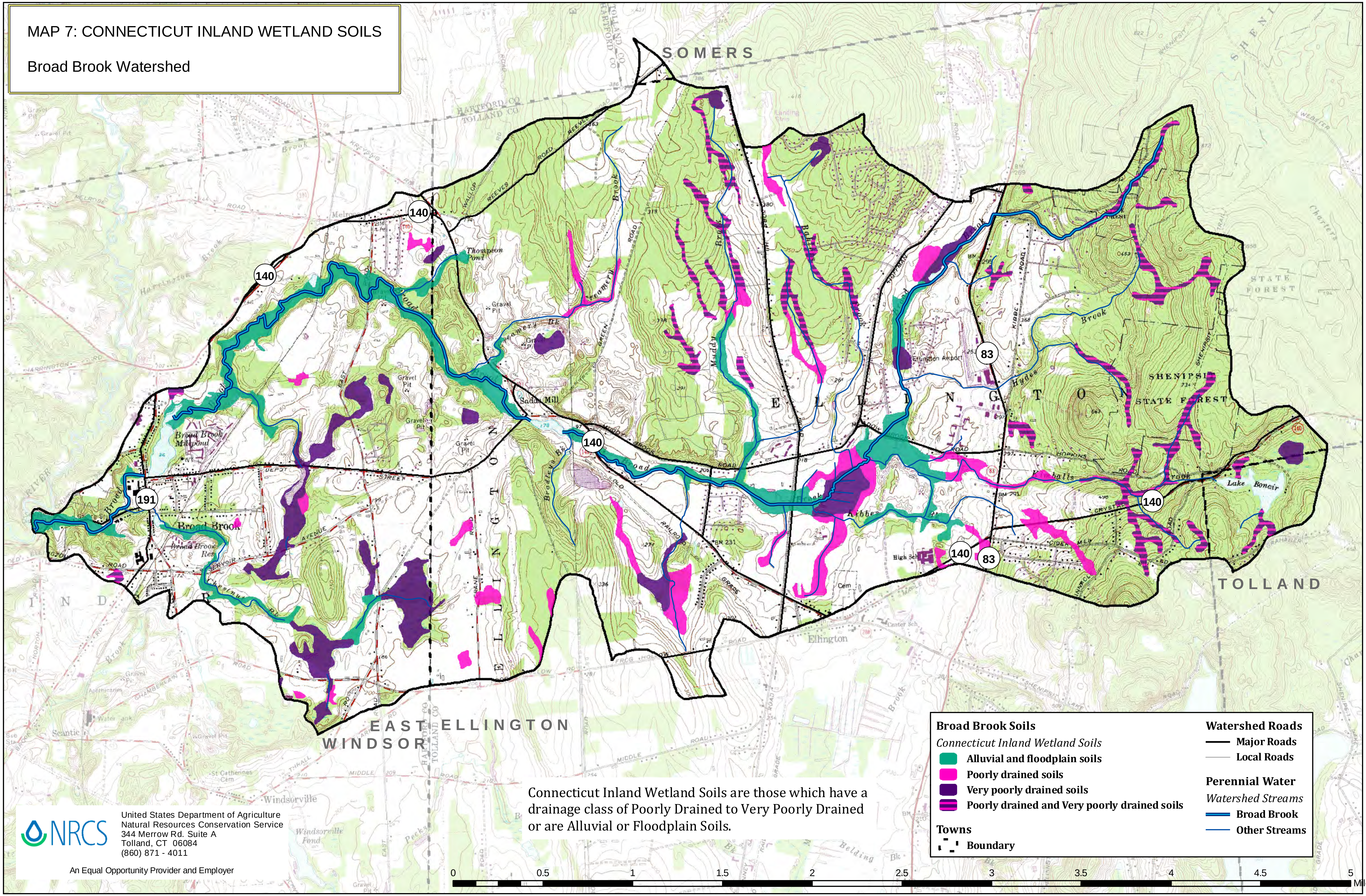


Size Range	# of Areas
0 - 15 acres	81
15.1 - 40 acres	15
40.1 - 100 acres	14
100.1 - 200 acres	3
200.1 - 350 acres	3
>350 acres	2
Total	118

Maximum Polygon Size: 987 acres
Total: 4080 acres
Mean: 34.5 acres
Median: 6.6 acres

MAP 7: CONNECTICUT INLAND WETLAND SOILS

Broad Brook Watershed



Connecticut Inland Wetland Soils are those which have a drainage class of Poorly Drained to Very Poorly Drained or are Alluvial or Floodplain Soils.

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existing wetlands in the basin limits the natural buffering and filtering ability of the system to moderate downstream impacts from pollutants.

Residential property comprises roughly 2,134 acres, or 80% of the 2667.5 acres in the basin classified as developed. Domestic pet waste and failing septic systems are possible sources of bacterial loading that may originate from residential parcels. Fertilizer application on residential lawns can result excess nutrients which may contribute to water quality degradation. Areas in the watershed with smaller lot sizes, denser development, and closer proximity to watercourses or waterbodies have an increased potential for contributing bacteria or nutrients to the stream system in the watershed.

The LULC data, in conjunction with the USGS hydrology layer, was used to determine the location and extent of unbuffered areas. When these data layers were analyzed for the adjacency of polygons of development or agriculture to perennial water, stretches of streambank and shoreline were highlighted that are in need of increased buffering.

The LULC data was analyzed with a variety of soil interpretations. The interpretations relating to stormwater management and subsurface sewage systems (septic) were evaluated, in part, based upon the kinds of land uses that occurred at the site. Being able to visualize the land use on top of the potential limitations of the soil provided a context for discerning potential and likely sources of pollutant loading.

Soils Based Stormwater Recommendations/Findings

Map 8: Stormwater Infiltration Systems

This soil interpretation is meant for large infiltration systems like infiltration trenches and underground galleys. "Suitable" soils are restricted to those that have high hydraulic conductivity and are very deep, non-flooding, well drained or better, and on moderate slopes. Relatively few areas in the watershed fit these criteria. There are more areas that are "somewhat suitable" where design modifications are appropriate. Many of the soils that meet the hydraulic conductivity criteria are limited by seasonal high water tables or steep slopes.

Map 9: Stormwater Basins

In this map,” stormwater basin” refers to a broad range of practices designed to capture and store stormwater runoff. Most areas in the watershed are rated most suitable or somewhat suitable and are likely to accommodate some type of stormwater basin or a low impact development practice such as a single home rain garden. Soils rated least suitable for stormwater basins have seasonal high water very close to the surface, shallow bedrock, or steep slopes.

Map 10: Wet Extended basins

Wet extended detention basins maintain a permanent pond as part of the system. Few soils in Connecticut have fine enough textures to do this without adaptation. Soils rated as “suitable” or ”somewhat suitable” have moderate to very low conductivity and are very deep, non-flooding, and on moderate slopes. The best areas in the watershed for this practice have soils formed in basal till (see parent material section) due to the low permeability of their dense substratum.

Map 11: Dry detention ponds

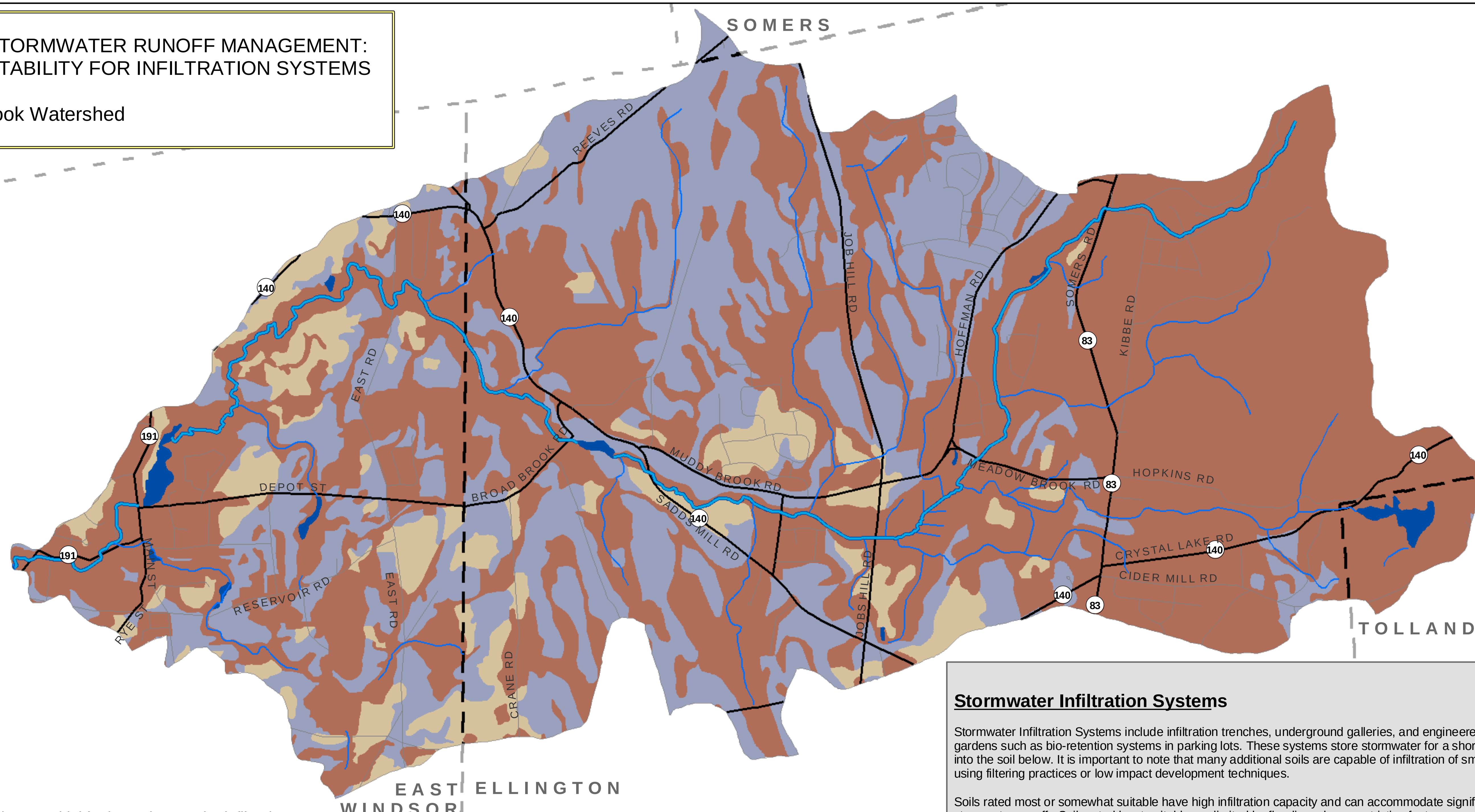
Dry detention ponds, also known as “dry ponds” or “detention basins”, are stormwater basins designed to capture, temporarily hold, and gradually release a volume of stormwater runoff to attenuate and delay stormwater runoff peaks. While very high hydraulic conductivity is not desirable for this practice, maintenance of a permanent pond is not required. Soils rated as “suitable” or ”somewhat suitable” for wet extended detention basins are included along with those with moderately high conductivity. As a result, several more areas are rated as “somewhat suitable”, including many soils in ablation till or loamy outwash.

Map 12: Pervious Pavement

Pervious pavement is designed to allow rainwater and snowmelt to pass through it into a treatment system and the soil below. Soils rated “suitable” or “somewhat suitable” have adequate depth to bedrock and seasonal high water tables, do not flood, and have moderate to high hydraulic conductivity. In addition, slopes must be moderate for installing pervious pavement. Many areas throughout the watershed have potential for this practice.

MAP 8: STORMWATER RUNOFF MANAGEMENT:
SOIL SUITABILITY FOR INFILTRATION SYSTEMS

Broad Brook Watershed



"Infiltration practices are highly dependent on the infiltration capacity of the underlying soils. Low soil infiltration capacity requires structures with larger infiltration surface area and storage capacity to account for slower infiltration rates. Higher soil infiltration rates allow for smaller infiltration structures. Accurate field measurements of infiltration rates are critical for the successful design and implementation of stormwater treatment practices that rely on infiltration of stormwater to underlying soils."

(2004 CT Stormwater Quality Manual)

Broad Brook Soils

Infiltration Systems Interpretation

- Most Suitable
- Somewhat Suitable
- Least Suitable
- Water

Perennial Water

Watershed Streams

- Broad Brook
- Other Streams

Watershed Roads

- Major Roads
- Local Roads

Towns

- Boundary

0 0.25 0.5 1 1.5 2 2.5 3 3.5 4 Miles

Stormwater Infiltration Systems

Stormwater Infiltration Systems include infiltration trenches, underground galleries, and engineered, large scale rain gardens such as bio-retention systems in parking lots. These systems store stormwater for a short time while they seep into the soil below. It is important to note that many additional soils are capable of infiltration of smaller amounts of runoff using filtering practices or low impact development techniques.

Soils rated most or somewhat suitable have high infiltration capacity and can accommodate significant amounts of stormwater runoff. Soils rated least suitable are limited by flooding, slope, restrictive features, or slow permeability.

The following data elements were used to evaluate soil suitability for Infiltration Systems:

* Depth to restrictive layer (bedrock, dense till)
* Depth to seasonal high water table
* Permeability
* Bulk Density
* Flooding
* Slope

Note: To protect ground water resources, the Connecticut DEP requires that field-measured soil infiltration rates be less than 3.0 inches per hour for primary treatment systems. Soils with higher infiltration rates are not suitable for contaminated waste.

This map was generated by the medium intensity National Cooperative Soil Survey of Connecticut . It does not replace an on-site investigation.

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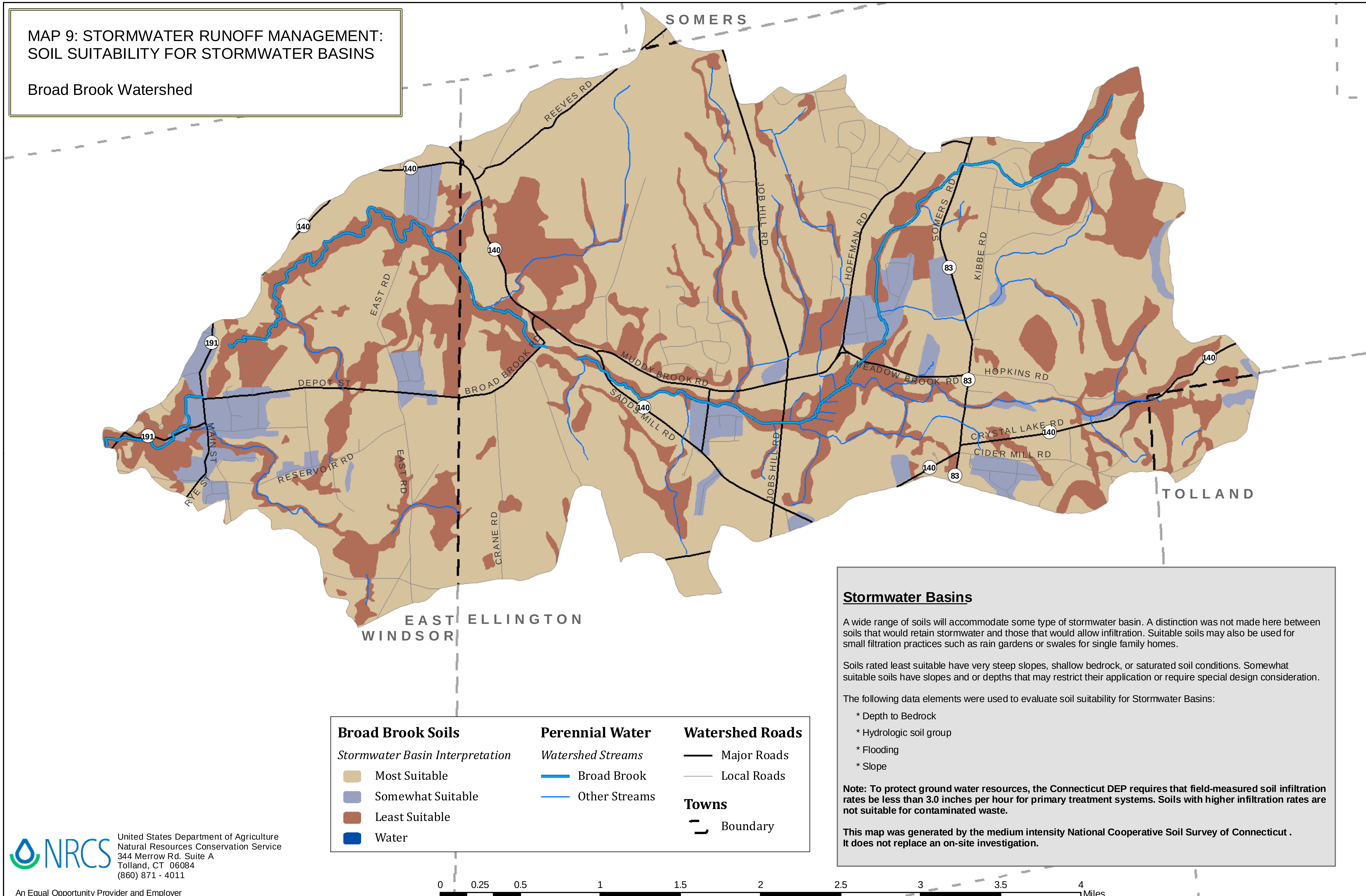
MAP 9: STORMWATER RUNOFF MANAGEMENT:
SOIL SUITABILITY FOR STORMWATER BASINS

Broad Brook Watershed



Stormwater Basins

A wide range of soils will accommodate some type of stormwater basin. A distinction was not made here between soils that would retain stormwater and those that would allow infiltration. Suitable soils may also be used for small filtration practices such as rain gardens or swales for single family homes.

Soils rated least suitable have very steep slopes, shallow bedrock, or saturated soil conditions. Somewhat suitable soils have slopes and or depths that may restrict their application or require special design consideration.

The following data elements were used to evaluate soil suitability for Stormwater Basins:

* Depth to Bedrock
* Hydrologic soil group
* Flooding
* Slope

Note: To protect ground water resources, the Connecticut DEP requires that field-measured soil infiltration rates be less than 3.0 inches per hour for primary treatment systems. Soils with higher infiltration rates are not suitable for contaminated waste.

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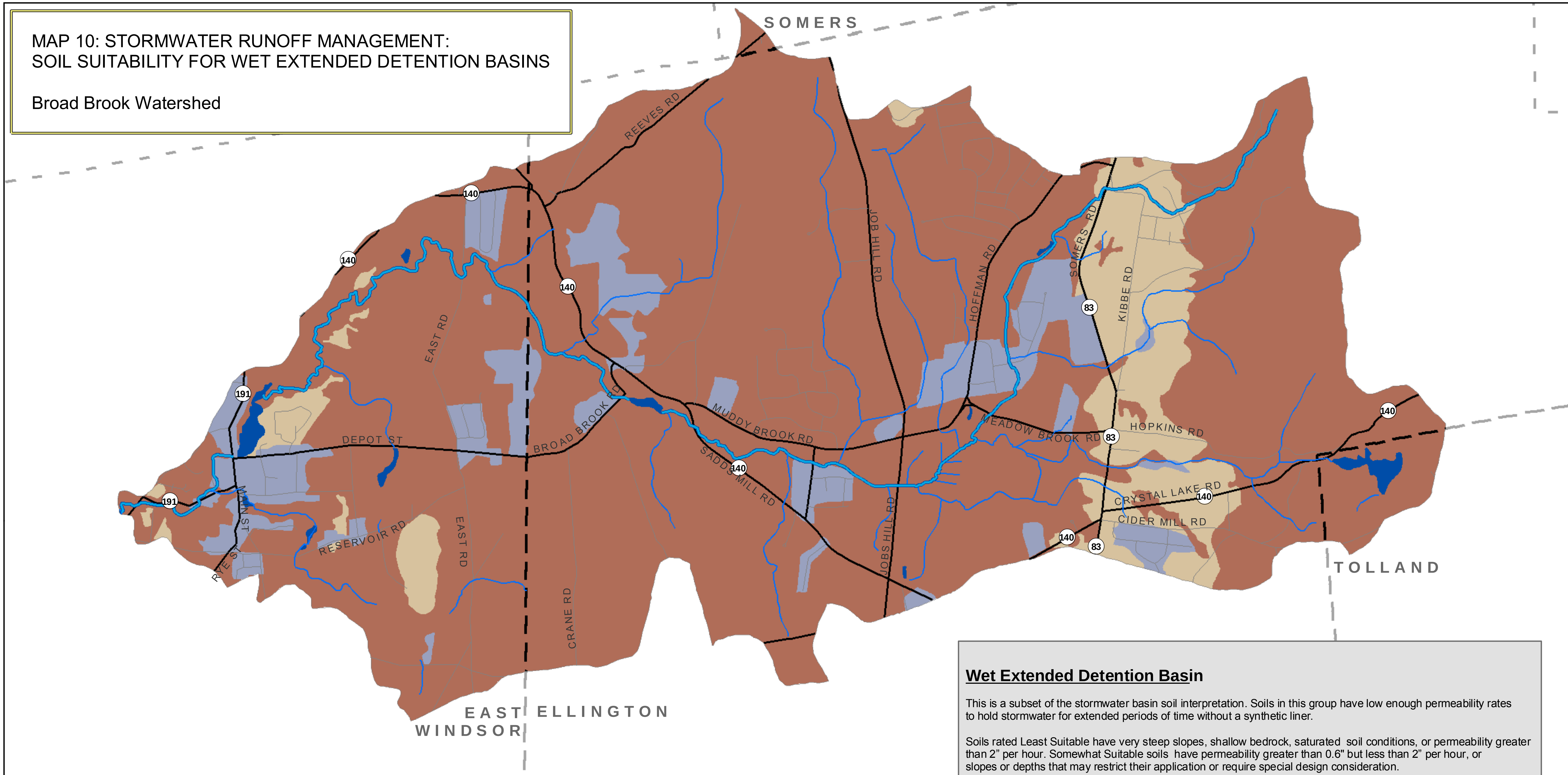
MAP 10: STORMWATER RUNOFF MANAGEMENT:
SOIL SUITABILITY FOR WET EXTENDED DETENTION BASINS

Broad Brook Watershed



Broad Brook Soils

Wet Extended Detention Basin Interpretation

- Most Suitable
- Somewhat Suitable
- Least Suitable
- Water

Perennial Water

Watershed Streams

- Broad Brook
- Other Streams

Watershed Roads

- Major Roads
- Local Roads

Towns

- Boundary

Wet Extended Detention Basin

This is a subset of the stormwater basin soil interpretation. Soils in this group have low enough permeability rates to hold stormwater for extended periods of time without a synthetic liner.

Soils rated Least Suitable have very steep slopes, shallow bedrock, saturated soil conditions, or permeability greater than 2" per hour. Somewhat Suitable soils have permeability greater than 0.6" but less than 2" per hour, or slopes or depths that may restrict their application or require special design consideration.

The following data elements were used to evaluate soil suitability for Stormwater Basins:

* Depth to Bedrock
* Hydrologic soil group
* Flooding
* Slope
* Permeability (ksat)

Note: To protect ground water resources, the Connecticut DEP requires that field-measured soil infiltration rates be less than 3.0 inches per hour for primary treatment systems. Soils with higher infiltration rates are not suitable for contaminated waste.

This map was generated by the medium intensity National Cooperative Soil Survey of Connecticut . It does not replace an on-site investigation.

0 0.25 0.5 1 1.5 2 2.5 3 3.5 4 Miles

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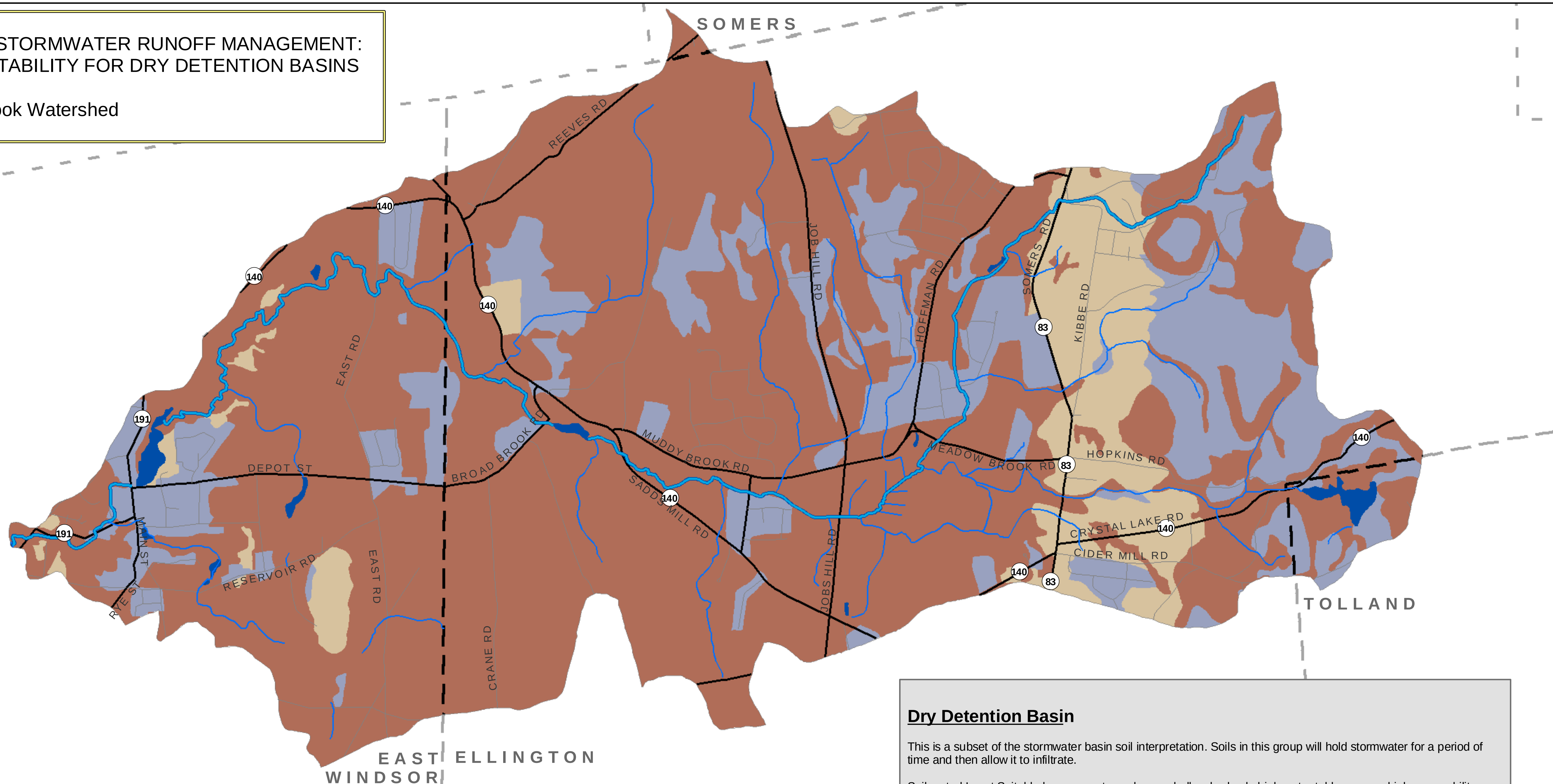
MAP 11: STORMWATER RUNOFF MANAGEMENT: SOIL SUITABILITY FOR DRY DETENTION BASINS

Broad Brook Watershed



Broad Brook Soils

Dry Detention Basin Interpretation

- Most Suitable
- Somewhat Suitable
- Least Suitable
- Water

Perennial Water

Watershed Streams

- Broad Brook
- Other Streams

Watershed Roads

- Major Roads
- Local Roads

Towns

- Boundary

Dry Detention Basin

This is a subset of the stormwater basin soil interpretation. Soils in this group will hold stormwater for a period of time and then allow it to infiltrate.

Soils rated Least Suitable have very steep slopes, shallow bedrock, high water tables or very high permeability. Somewhat Suitable soils have limitations that may restrict their application or require special design considerations..

The following data elements were used to evaluate soil suitability for Stormwater Basins:

* Depth to Bedrock
* Hydrologic soil group
* Flooding
* Slope
* Permeability (ksat)

Note: To protect ground water resources, the Connecticut DEP requires that field-measured soil infiltration rates be less than 3.0 inches per hour for primary treatment systems. Soils with higher infiltration rates are not suitable for contaminated waste.

This map was generated by the medium intensity National Cooperative Soil Survey of Connecticut . It does not replace an on-site investigation.

0 0.25 0.5 1 1.5 2 2.5 3 3.5 4 Miles

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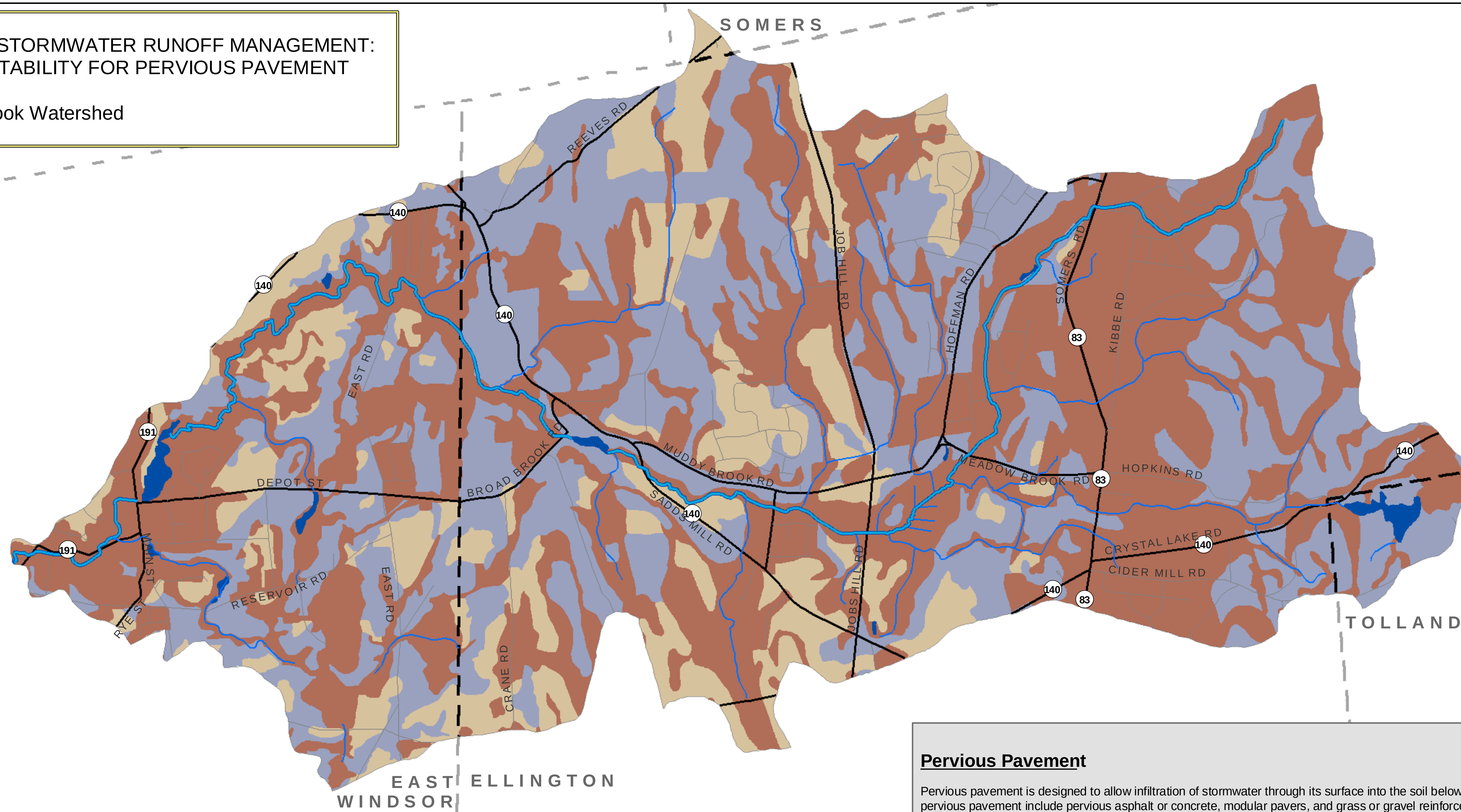
MAP 12: STORMWATER RUNOFF MANAGEMENT:
SOIL SUITABILITY FOR PERVIOUS PAVEMENT

Broad Brook Watershed



Broad Brook Soils

Pervious Pavement Interpretation

- Most Suitable
- Somewhat Suitable
- Least Suitable
- Water

Perennial Water

Watershed Streams

- Broad Brook
- Other Streams

Watershed Roads

- Major Roads
- Local Roads

Towns

- Boundary

Pervious Pavement

Pervious pavement is designed to allow infiltration of stormwater through its surface into the soil below. Types of pervious pavement include pervious asphalt or concrete, modular pavers, and grass or gravel reinforced with grid pavers.

Soils rated least suitable have steep slopes, shallow bedrock, high water tables or low permeability. Somewhat suitable soils have limitations that may restrict their application or require special design consideration

The following data elements were used to evaluate soil suitability for Stormwater Basins:

* Depth to restrictive layer (bedrock, dense till)
* Depth to seasonal high water table
* Permeability
* Flooding
* Slope

Note: To protect ground water resources, the Connecticut DEP requires that field-measured soil infiltration rates be less than 3.0 inches per hour for primary treatment systems. Soils with higher infiltration rates are not suitable for contaminated waste.

**This map was generated by the medium intensity National Cooperative Soil Survey of Connecticut .
It does not replace an on-site investigation.**

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0 0.25 0.5 1 1.5 2 2.5 3 3.5 4 Miles

Geomorphic Assessment

The Broad Brook is a 3rd order tributary to the Scantic River. The 15.8 square mile watershed exhibits a dendritic drainage pattern, with approximately 37.3 miles of stream comprising the fluvial network. Therefore, the drainage basin density or stream density is 2.36 miles/square mile.

The Broad Brook becomes a 3rd order stream after its confluence with Hayden Brook, a 2nd order tributary. Creamery Brook, Kibbes Brook, Kimballs Brook, and Muddy Brook are the other 2nd order tributaries within the basin. All other tributary streams entering the Broad Book are 1st order streams. The majority of Kibbes Brook and Muddy Brook are classified as a first order streams until the confluence of a small first order stream just before their respective confluences with the Broad Brook. The delineation of stream order for the entire watershed is shown on Map 13: Stream Order.

The Broad Brook is primarily a C stream type. The delineation of stream type for the entire watershed is shown on Map 14: Stream Type. Typical of most streams in a glaciated landscape, the headwaters begin as an A stream type, then transitions to a B, before transitioning to a C stream type. However, the Broad Brook transitions to a C stream type while it is still a first order stream, and maintains that stream type for the majority of its length to the confluence with the Scantic River. There are three areas along the main stem where the stream deviates from the predominate type.

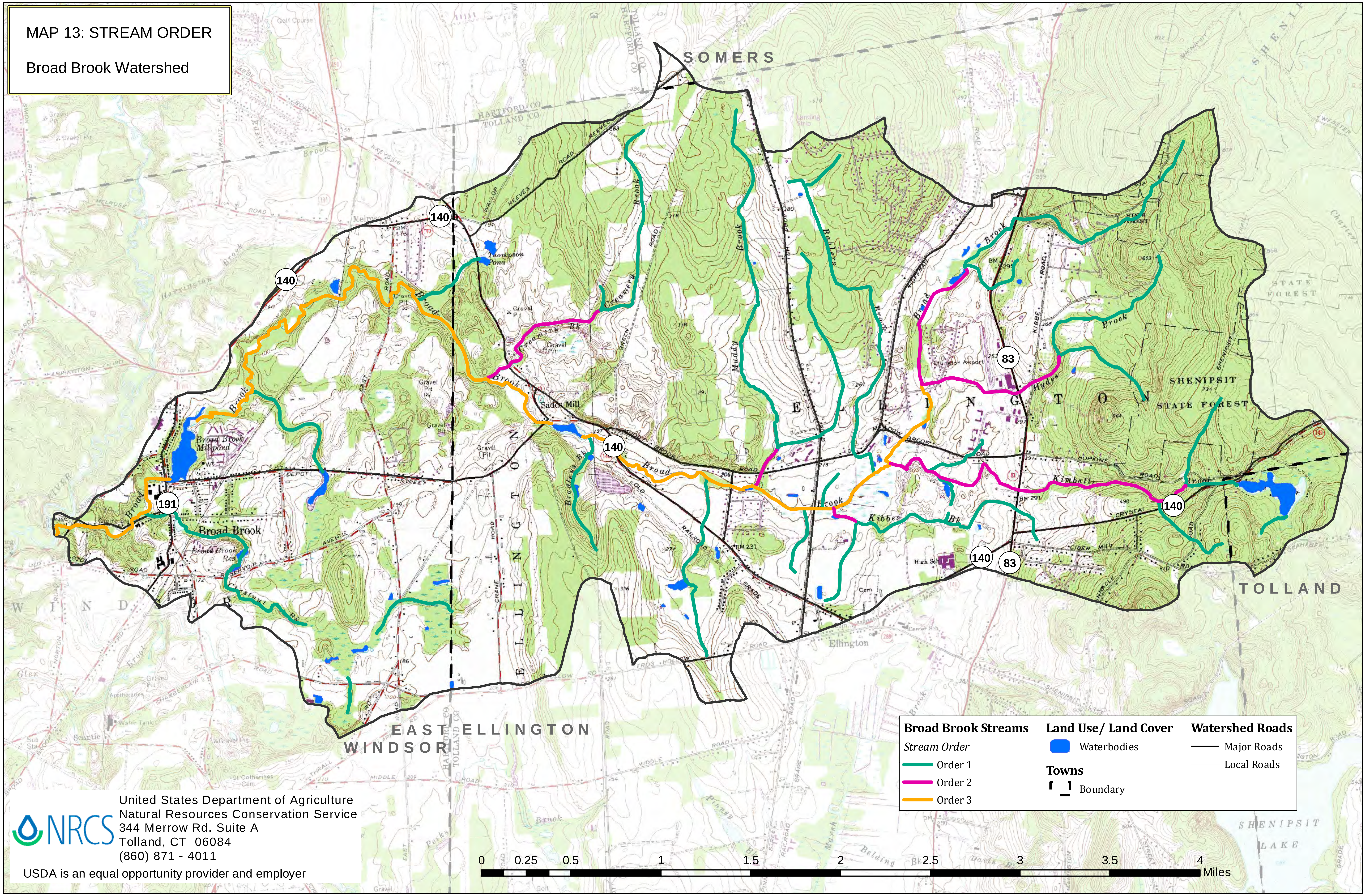
The first is the section between Meadow Brook Road and Jobs Hill Road, where the stream exhibits the characteristics of an E stream type. This is also an area where there have been significant channel modifications in the past to facilitate agricultural production. The stream has been straightened, and several drainage ditches constructed. These modifications to the channel extend at least 1,500 feet downstream of Jobs Hill Road as well. In both reaches, the channel cross-section and channel slope are characteristic of an E stream type; however, the channel sinuosity is low. The reach below Jobs Hill Road has been labeled as a

C stream type due to its lack of sinuosity, however a section of the stream upstream of Jobs Hill Road does exhibit enough channel sinuosity to classify it as an E stream type.

The other two reaches of stream are upstream and downstream of Broad Brook Millpond. A reach approximately 1.4 miles in length above the Millpond is classified as an E stream type. And a reach immediately below the Millpond and under Route 191 is a series of bedrock cascades which can be classified as an A stream type.

The sections of stream identified as C stream type can be described as moderate to low gradient, slightly entrenched streams with well developed floodplains and a meandering, riffle/pool channel morphology of moderate sinuosity. Typical channel gradients for a C stream type range between 0.1% and 2%. The E stream types can be described as a low gradient stream with a well developed floodplain. Although, the E stream type is still a riffle/pool dominated channel, it tends to be much more sinuous and has a lower width/depth ratio than the C stream type. Typical channel gradients for an E stream type are less than 2%.

The majority of tributaries can also be classified as a C stream type. In addition, some sections of the tributaries can be classified as either an A or B stream type. The sections of stream identified as an A stream type can be described as a steep, entrenched stream, with a very low sinuosity, dominated by a cascade or step/pool morphology. These streams are high energy streams with virtually no floodplain. Typical channel gradients for an A stream type range between 4% and 10%. The sections of stream identified as B stream type can be described as a moderate gradient stream, mostly dominated by riffle, with some irregularly spaced pools. These streams are moderately entrenched with access to a limited floodplain. Typical channel gradients for a B stream type are between 2% and 4%.


MAP 13: STREAM ORDER
Broad Brook Watershed
SOMERS
ELLINGTON
EAST WINDSOR
TOLLAND
WINDSOR
SHENIPSIT STATE FOREST
Broad Brook Millpond
Broad Brook
Broad Brook Res
Thompson Pond
Sadds Mill
Creamery Bk
Muddy Brook
Kibbe Bk
Kimball
Ellington
SHENIPSIT LAKE
140
191
83
Broad Brook Streams
Stream Order
Order 1
Order 2
Order 3
Land Use/ Land Cover
Waterbodies
Towns
Boundary
Watershed Roads
Major Roads
Local Roads
0
0.25
0.5
1
1.5
2
2.5
3
3.5
4
Miles
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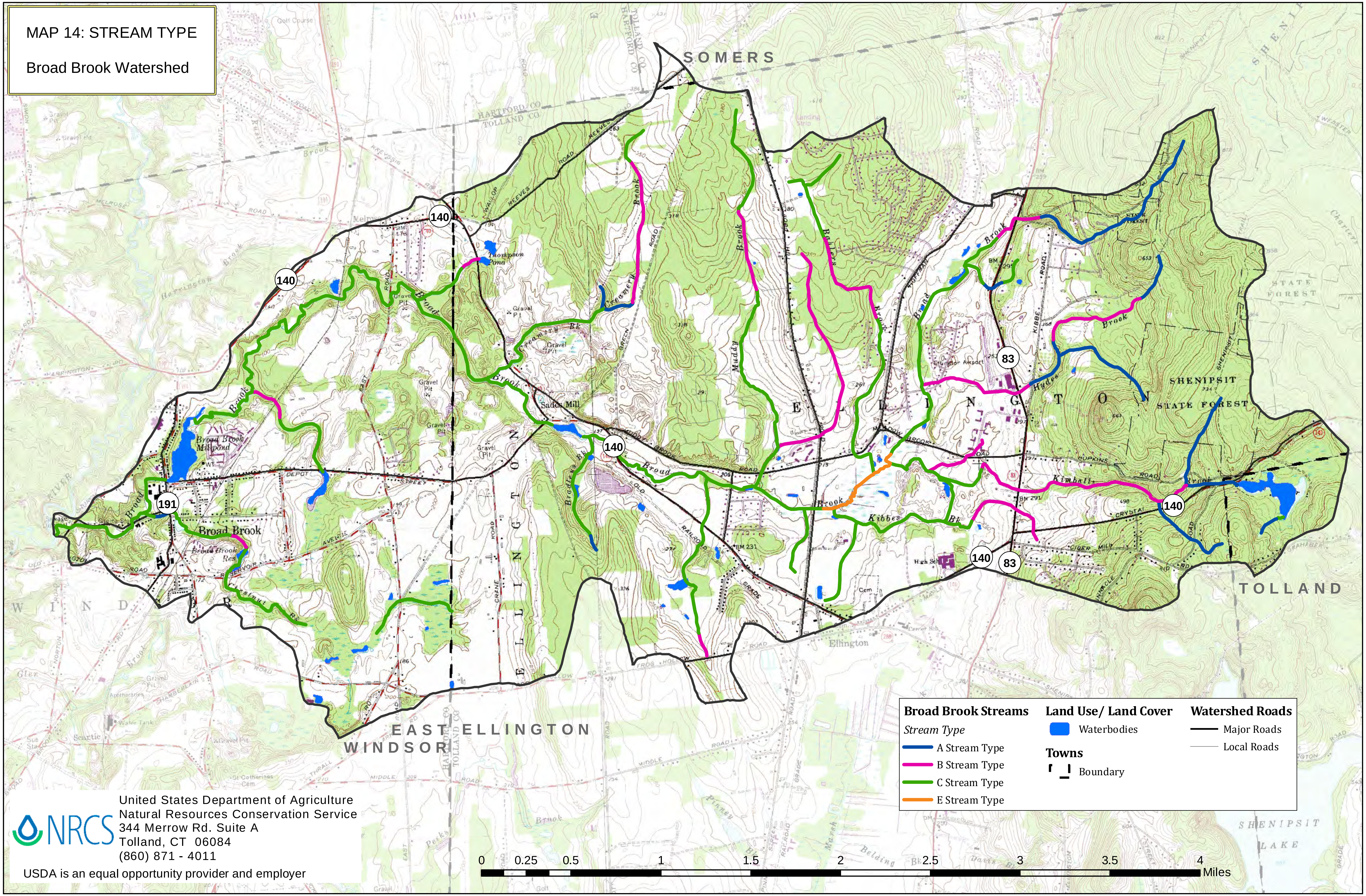
MAP 14: STREAM TYPE
Broad Brook Watershed
SOMERS
ELLINGTON
TOLLAND
EAST WINDSOR
WINDSOR
SHENIPSIT STATE FOREST
SHENIPSIT LAKE
140
191
83
Broad Brook Millpond
Broad Brook
Broad Brook Res
Thompson Pond
Sadds Mill
Creamery Bk
Muddy Brook
Kibbe Brook
Hydes Brook
Kimball Brook
Broad Brook Streams
Stream Type
A Stream Type
B Stream Type
C Stream Type
E Stream Type
Land Use/ Land Cover
Waterbodies
Towns
Boundary
Watershed Roads
Major Roads
Local Roads
0
0.25
0.5
1
1.5
2
2.5
3
3.5
4
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Pervious/Impervious Surface (Potential for Runoff)

An estimate of the area in the watershed remaining in a pervious state can be interpreted by combining soil runoff potential with land use and land cover. This information will be most applicable for planning purposes. The potential for an area to pose a runoff hazard or to allow infiltration will also depend on its position on the landscape and adjacent soils and land uses. Site visits will be necessary to verify conditions. Table 5 characterizes runoff potential based on soils.

Areas with low runoff potential, based on soils and land use, are providing the most protection to the Broad Brook from runoff and the greatest potential for recharge in the watershed. Some of those areas in key positions in the watershed may be considered for protection from development, enhancement for treatment, or as candidates for low impact development techniques. See Map 15: Potential for Runoff Based on a Combination of Soil Properties & Land Use/Land Cover Classification for the areas that have both low potential for land use/land cover and soil. When these areas are developed, the impact on the overall watershed condition may be more significant than in less pervious locations.

In areas where the soil runoff potential is low or moderate but the land use / land cover potential is moderate or high, practices may be employed to increase the on-site infiltration. Depending on location, areas of high runoff potential may be posing a threat to overall water quality in the watershed. On-site investigations and runoff management plans are recommended. See Map 16: Potential for Runoff Based on Soil Properties and Map 17: Potential for Runoff Based on Land Use/ Land Cover.

Table 5: Runoff Potential Based on Soils

Runoff Class	**Acres**	**Percent of Watershed**
Very High	648.6	6%
High	943.5	9%
Sub-total	1,592.1	16%
Medium	1654.4	16%
Sub-total	1,654.4	16%
Low	5,500.3	54%
Very Low	982.3	10%
Negligible	314.4	3%
Sub-total	6797.0	67%
Water	58.3	1%
Total	**10,101.8**	**100%**

Table 6: Runoff Potential Based on LULC Classification			
Runoff Potential	*LULC Class*	*Acres*	*Percent of Watershed*
High	af	176.4	2%
	bm	66.4	1%
	dc	154.7	2%
	di	15.5	0%
	dm	37.1	0%
	dob	79.4	1%
	dok	6.0	0%
	drh	128.6	1%
	dt	16.1	0%
High Total		680.1	7%
Medium	ac	1,628.4	16%
	ag	177.4	2%
	an	442.9	4%
	ao	9.5	0%
	ap	79.2	1%
	au	162.8	2%
	doc	14.5	0%
	dog	134.9	1%
	dol	47.3	0%
	dr	1,959.6	19%
Medium Total		4,656.4	46%
Low	fc	169.2	2%
	fd	1,927.3	19%
	fm	2,056.0	20%
	oh	120.2	1%
	os	33.8	0%
	osu	52.2	1%
	tl	66.9	1%
	tm	269.2	3%
Low Total		4,695.1	46%
Water	wl	51.7	1%
	wla	17.2	0%
	wld	1.2	0%
Water Total		70.1	1%
Grand Total		10,101.8	100%

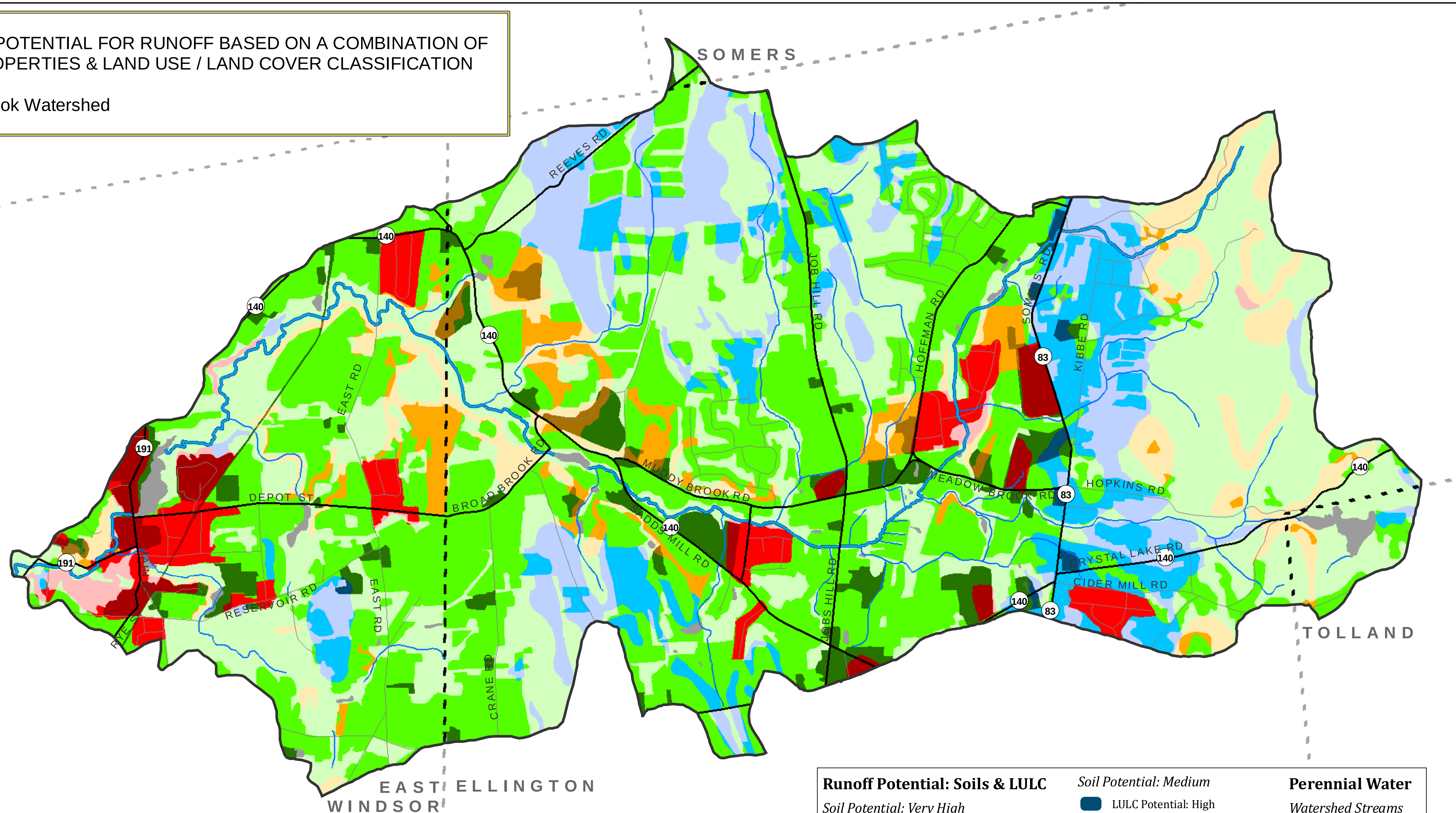
Table 7: Runoff Potential Based on Combination of Soils and LULC Classification			
Runoff Potential Based on Soils	*Runoff Potential Based on LULC*	*Acres*	*Percent of Watershed*
Very High	High	203.6	2%
	Medium	361.2	4%
	Low	83.2	1%
	water	0.6	0%
Very High Total		648.6	6%
High	High	73.9	1%
	Medium	311.4	3%
	Low	557.0	6%
	water	1.1	0%
High Total		943.5	9%
Medium	High	40.5	0%
	Medium	717.6	7%
	Low	895.8	9%
	water	0.5	0%
Medium Total		1,654.4	16%
Low	High	272.9	3%
	Medium	2,724.4	27%
	Low	2,489.9	25%
	water	13.0	0%
Low Total		5,500.2	54%
Very Low	High	68.2	1%
	Medium	429.1	4%
	Low	476.4	5%
	water	8.6	0%
Very Low Total		982.3	10%
Negligible	High	20.0	0%
	Medium	111.1	1%
	Low	179.2	2%
	water	4.1	0%
Negligible Total		314.4	3%
Water	High	1.0	0%
	Medium	1.6	0%
	Low	13.6	0%
	water	42.1	0%
Water Total		58.3	1%
Grand Total		10,101.8	100%

Table 6 shows the runoff potential based on land use and land cover classification.

Table 7 shows the runoff potential based on land use and land cover classification.

MAP 15: POTENTIAL FOR RUNOFF BASED ON A COMBINATION OF SOIL PROPERTIES & LAND USE / LAND COVER CLASSIFICATION

Broad Brook Watershed



Runoff Potential: Soils & LULC

Soil Potential: Very High
- LULC Potential: High
- LULC Potential: Medium
- LULC Potential: Low

Soil Potential: High
- LULC Potential: High
- LULC Potential: Medium
- LULC Potential: Low

Soil Potential: Medium
- LULC Potential: High
- LULC Potential: Medium
- LULC Potential: Low

Soil Potential: Low - Negligible
- LULC Potential: High
- LULC Potential: Medium
- LULC Potential: Low

Not Rated
- Not Rated

Perennial Water

Watershed Streams
- Broad Brook
- Other Streams

Watershed Roads
- Major Roads
- Local Roads

Towns
- Boundary

0 0.25 0.5 1 1.5 2 2.5 3 3.5 4 Miles

Soil Runoff Classes

Soil runoff classes are generated based on the slope and saturated hydraulic conductivity of a soil map unit. Slope refers to the overall steepness of the soil map unit. The saturated hydraulic conductivity is a measure of the rate of water movement in the soil.

Land Use/ Land Cover Groups

High Potential for Runoff:ballfields, compacted grass, high density residential, transportation, commercial areasa, industrial areas, farmsteads, mixed-development, mines/quarries

Medium Potential for Runoff: golf courses, low density residential, cemeteries, landfills, beaches, bare rock, agriculutural areas (except farmsteads)

Low Potential for Runoff: forest lands, transitional areas, other areas

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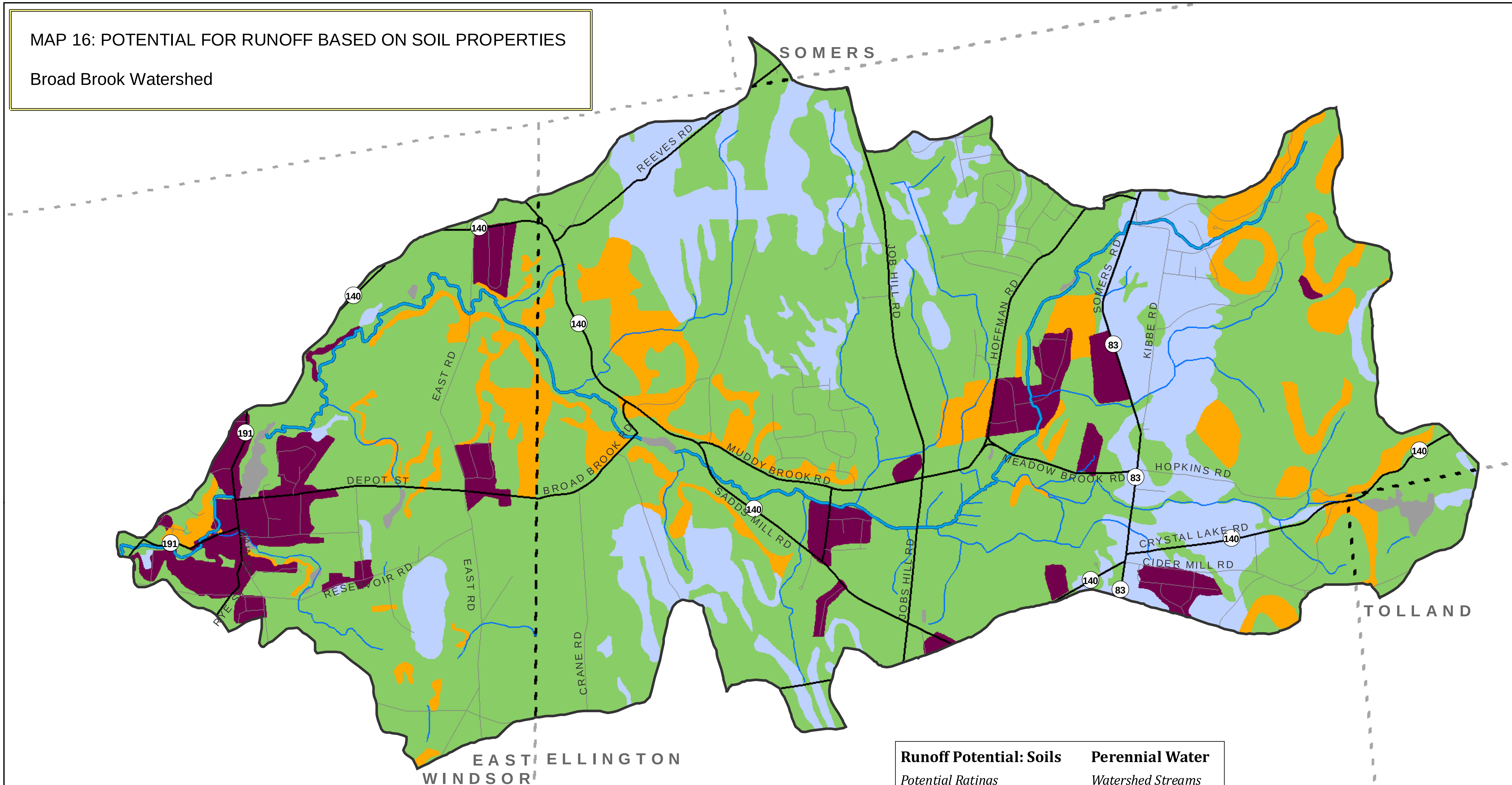
MAP 16: POTENTIAL FOR RUNOFF BASED ON SOIL PROPERTIES

Broad Brook Watershed



Runoff Potential: Soils

Potential Ratings

- Very high
- High
- Medium
- Very low; Low; Negligible
- Not Rated

Perennial Water

Watershed Streams

- Broad Brook
- Other Streams

Watershed Roads

- Major Roads
- Local Roads

Towns

- Boundary

Soil Runoff Classes

Soil runoff classes are generated based on the slope and saturated hydraulic conductivity of a soil map unit. Slope refers to the overall steepness of the soil map unit. The saturated hydraulic conductivity is a measure of the rate of water movement in the soil.

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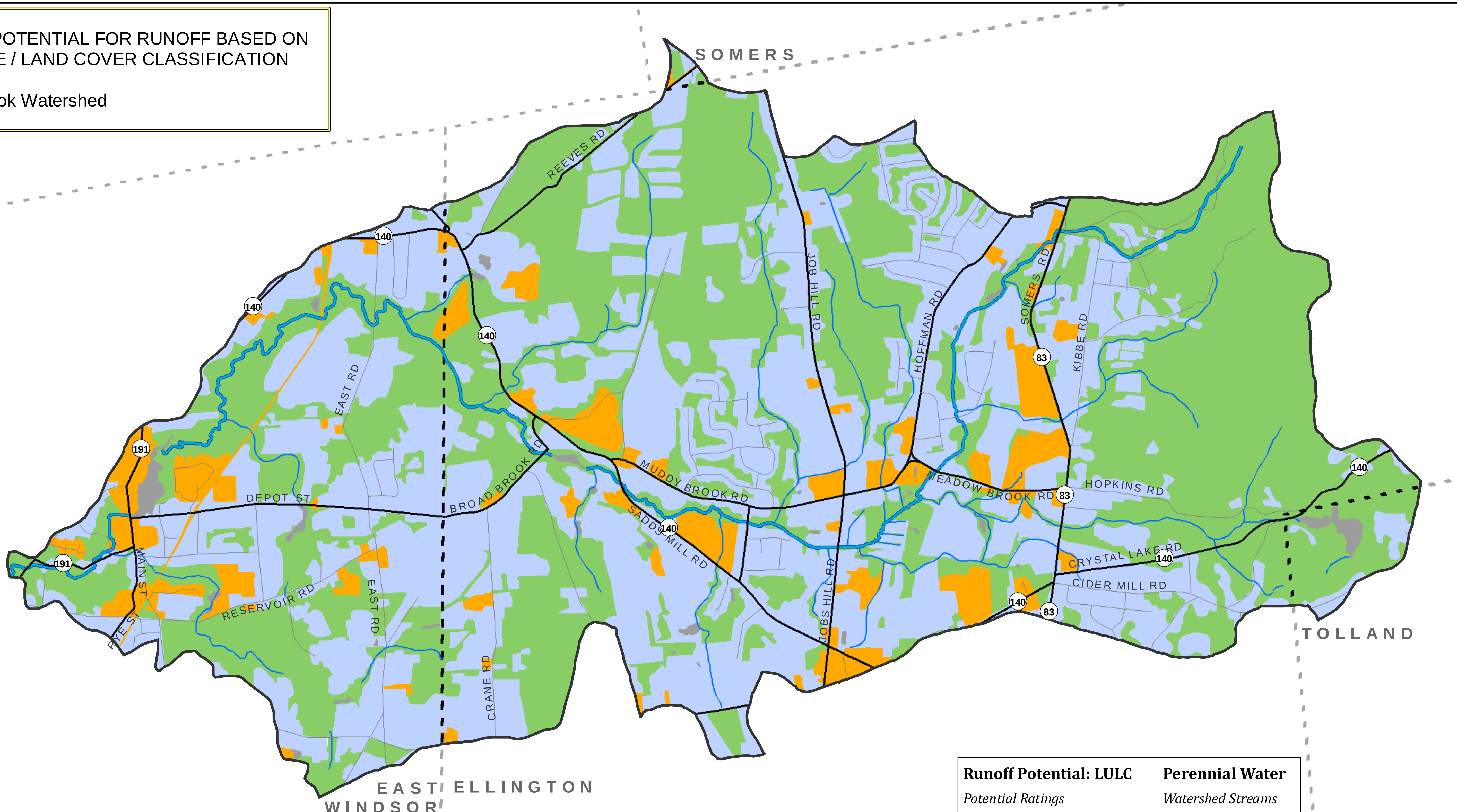
MAP 17: POTENTIAL FOR RUNOFF BASED ON LAND USE / LAND COVER CLASSIFICATION

Broad Brook Watershed



Land Use/ Land Cover Groups

High Potential for Runoff: ballfields, compacted grass, high density residential, transportation, commercial areasa, industrial areas, farmsteads, mixed-development, mines/quarries

Medium Potential for Runoff: golf courses, low density residential, cemeteries, landfills, beaches, bare rock, agriculutural areas (except farmsteads)

Low Potential for Runoff: forest lands, transitional areas, other areas

Runoff Potential: LULC

Potential Ratings

- High
- Medium
- Very low; Low; Negligible
- Not Rated

Perennial Water

Watershed Streams

- Broad Brook
- Other Streams

Watershed Roads

- Major Roads
- Local Roads

Towns

- Boundary

0 0.25 0.5 1 1.5 2 2.5 3 3.5 4 Miles

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Some possible recommendations based on these findings:

- Visit areas rated high for both soils and land use and design BMP if needed.
- High density residential areas, especially those in locations with high and moderate soil-based runoff potential, are good candidates for street sweeping, pet waste management, new or improved stormwater management practices, and possibly low impact development stormwater management practices.
- Evaluate low density residential areas for off-site impacts. Design small practices such as rain gardens to retain more runoff on-site. In areas located on soils with high or moderate runoff potential, be sure to site and size practices so they can handle inflow.
- Evaluate areas with a high rating for land use/land cover and low rating for soils to determine if local site conditions permit use of infiltration BMPs.
- Regulations should address development of wooded areas with high runoff potential. Standards for minimizing off-site impacts should be set and enforced.
- Consider land preservation in areas where both land use/land cover and soils have low runoff potential to maintain their recharge and flood protection services.
- Incorporate low impact development practices into municipal regulations.

Trackdown Survey

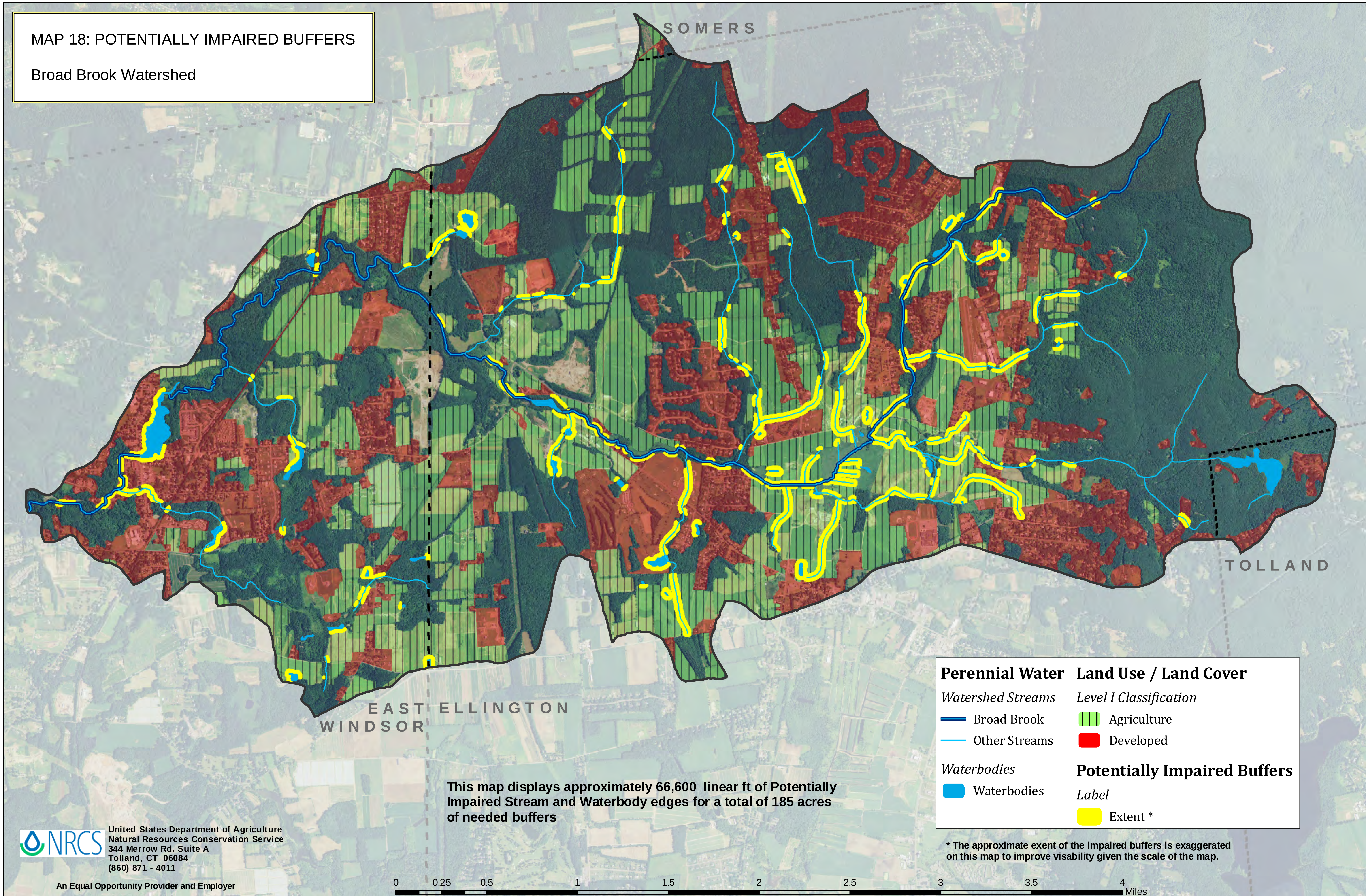
A summary of the findings of each of the reaches evaluated can be found in Appendix A: Trackdown Survey Findings.

Vegetated Buffer

Table 8 shows the number of acres that lacked a riparian buffer at the time of investigation. Map 18: Potentially Impaired Buffers shows the approximate location of these sites.

Table 8: Potentially Impaired Buffers and Adjacent Land Use

Classification Level I	*Label*	*Acres*	*Percent of Buffer Needs*
Agriculture	cultivated	65.4	35%
	non-cultivated (hayland)	30.3	16%
	pasture-grazed	13.7	7%
	farmstead	11.1	6%
	pasture-idle	4.9	3%
	nursery	0.9	0%
Agriculture Total		126.2	68%
Barren	mines/quarry/gravel	0.8	0%
Barren Total		0.8	0%
Developed	residential	32.2	17%
	high density residential	7.6	4%
	commercial	6.2	3%
	other-golf course	5.3	3%
	other-ballfields	4.0	2%
	other-compact grasses	1.5	1%
	transportation	0.5	0%
	mixed development	0.3	0%
	other-landfills	0.2	0%
Developed Total		57.7	31%
Grand Total		**184.8**	100%


MAP 18: POTENTIALLY IMPAIRED BUFFERS
Broad Brook Watershed
SOMERS
TOLLAND
EAST
ELLINGTON
WINDSOR
This map displays approximately 66,600 linear ft of Potentially Impaired Stream and Waterbody edges for a total of 185 acres of needed buffers
Perennial Water
Watershed Streams
Broad Brook
Other Streams
Waterbodies
Waterbodies
Land Use / Land Cover
Level I Classification
Agriculture
Developed
Potentially Impaired Buffers
Label
Extent *
* The approximate extent of the impaired buffers is exaggerated on this map to improve visability given the scale of the map.
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Natural Resources Conservation Service
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Tolland, CT 06084
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An Equal Opportunity Provider and Employer
0
0.25
0.5
1
1.5
2
2.5
3
3.5
4
Miles

Municipal Regulations Review

According to the regulations review conducted by the North Central Conservation District, neither Ellington nor East Windsor address stormwater quality comprehensively through their zoning or subdivisions regulations. A wide range of practices do exist that can be incorporated into municipal regulations to address potential water quality concerns. Preservation of open space or the use of cluster subdivisions are methods designed to protect natural resources by limiting development. Another approach is to use techniques to manage stormwater runoff. These techniques are designed to increase infiltration (e.g. rain gardens, curbless roads, increased use of pervious surfaces, etc.), improve treatment of stormwater before it enters a watercourse, decrease the potential for erosion and sedimentation, and minimize impact from associated land uses (e.g. through buffers, setbacks, impervious/pervious surface, etc.).

As of November 2, 2009, the Town of East Windsor drafted a set of regulations to promote the preservation of agricultural land, and support agriculture as a viable and important business in the community. The regulations include language to ensure that any agricultural operation implements practices to protect water quality and maintain the health of the watershed. This demonstrates a progressive and proactive approach toward balancing agricultural and environmental concerns.

Though each town may have regulations or create regulations that address specific issues, it is difficult to determine the real impact of individual regulations without analyzing the site specific conditions in the context of the watershed as a whole.

Watershed Pollutant Loading Rates

Limited water quality data exists for the Broad Brook watershed. Only two monitoring stations have been established in the watershed. Station one (lower section) is located at the confluence of the Broad Brook with the Scantic River. The second station (upper section) is located at the outlet of the Broad Brook Mill Pond, roughly one mile upstream from the first station. The data gathered at the second station represents the information collected from more than two-thirds of the watershed, which includes nine miles of the main stem stream, and the associated tributaries.

A draft TMDL was written by the CT DEP in the fall 2009 for the lower section of the Broad Brook. According to the draft TMDL, a 71% reduction of pollutant loading is required to meet State standards. At the recommendation of CT DEP, this draft TMDL is being used as the guideline in this report for reduction requirements for the upper section of the Broad Brook.

Because of the limited amount of data and the lack of a completed TMDL for the entire watershed, watershed pollutant loading rates will be based on data from existing literature of watershed studies. Please refer to the References page for a list of the watershed studies and papers that were researched to develop the loading rates used for this study. An extensive literature search and review was conducted and various methodologies explored for determining potential pollutant loading and transport of bacteria to water systems.

Total pollutant loading in the watershed is determined by the concentrations measured at an output (e.g. a monitoring location). One method to determine loading rates is to assign a potential loading rate to land use or land cover. These loading rates are typically given in millions of cfu/100ml. For example, high density residential land contributes x amount of bacteria in a concentration of x million cfu/100ml. In part, the pollutant loading is a function of the amount of flow in the watershed and the distance of the pollutant source from the water and gaging station. Without knowing the total runoff in the watershed it is difficult, if not impossible, to know which land use is actually contributing more to the concentrations of bacteria being measured.

The vast majority of studies use fecal coliform as the primary source of their data. The Broad Brook TMDL uses *E. coli* as the potential cause of water quality impairment. In order to develop loading rates it would be necessary to translate fecal coliform into units of *E. coli*. *E. coli*, however, is just one subset of fecal coliform and the translation is not a simple linear conversion. The State of Virginia Department of Environmental Quality used a method to convert fecal coliform loading rates to *E. coli* loading rates. At the gage station in the Broad Brook watershed, *E. coli* counts range from 50 to 26,000 cfu/100ml. The estimates of *E. coli* concentration, found in the literature search, off of a grazed pasture are in the 100,000 cfu/100ml range. Without knowing how much water is flowing through the system it is not possible to know how much the runoff from the pasture is being diluted. Estimating the impact of runoff from a given land use (e.g. pasture) is a guess, at best.

Conducting a total watershed runoff model in conjunction with more specific water quality data at the confluence of the main stem with each of its tributaries would improve the ability to determine actual pollutant sources or watershed areas contributing significant amounts of bacteria. If this data were available the translator model could be used. A caveat in using the translator is that the equation was calibrated for use in Virginia. Upon consultation with CT DEP, it was determined that the translator could theoretically be used to convert fecal coliform rates to *E. coli* rates for the purpose of this report. At the present time neither CT DEP nor US EPA Region 1 has calibrated the model for use in Connecticut, and CT DEP state that the equation should not be used on a statewide basis. Further information regarding this matter can be obtained by contacting the TMDL Division at CT DEP.

An alternative method, and the one used for this report, is to estimate the amount of bacteria being produced by each significant source. For example, the amount of bacteria does a cow, or a failing septic, or a raccoon contribute to the watershed. It is possible to estimate the number of animals or septic systems in the watershed and multiply that number by the estimated cfu being produced by that unit each day. Using this information, a percentage of contribution can be derived and then tied to land use. This method involves some assumptions. The assumption of this model is that all bacteria that lands on the ground in the watershed has an equal chance of reaching the water and affecting the concentration downstream at the gage station. Inherent in this is that elements such as soil, antecedent moisture conditions, slope, distance to water, vegetative cover, and obstacles or diversions to overland flow are presumed to have the same effect on all sources, and are not factors considered when deriving percent contribution of bacteria.

This model involved estimation of some watershed conditions. These estimates included

- The number and type of animal units (livestock) – estimates were based on professional knowledge of NRCS and NCCD employees
- The time of confinement for livestock
- The number and type of wildlife – estimates were based on reports calculating species density and typical habitat requirements (Maryland Department of the Environment, September 2004, "Total Maximum Daily Loads for Island Creek, Town Creek, Trent Hall Creek, St. Thomas Creek, Harper and Pearson Creeks, Goose Creek and Indian Creek and a water quality analysis for Battle Creek of fecal coliform for restricted shellfish harvesting areas in the Lower Patuxent River Basin in Calvert, Charles and St. Mary's Counties, Maryland").
- The number of failing septic systems and potential contribution of each – estimates were based on existing studies (See Maryland Department of the Environment in above bullet point). These studies used different methodologies. This report calculated the potential loading from septic systems using both methods and found the differences between them insignificant.

Tables 9, 10, 11, and 12 below show the values used in this study as the loading rates for the significant sources of bacterial pollution in the Broad Brook watershed. All of the values were based on existing numbers that were derived for other studies.

Table 9: Estimated Efficiencies of Watershed-Wide BMPs		
BMP	**Efficiency**	**Reference**
Street Sweeping/ Catch Basin Cleanout	70%	Watershed Protection Techniques Vol. 3 No. 1 -April 1999, Technical Notes 103 by Center for Watershed Protection
Pet Waste Pickup	50%	Watershed Protection Techniques Feature Article III, "Microbes and Urban Watersheds. Ways to Kill 'Em".
Agricultural Waste Management Plan - Agricultural Operations	75%	Virginia DEQ Guidance Manual for TMDL plans
Small Agriculture Animal Waste Management	60%	Virginia DEQ Guidance Manual for TMDL plans
Elimination of Septic System Failures/Illicit Discharges	90%	
Sources that could be Treated by Buffers	50%	Virginia DEQ Guidance Manual for TMDL plans
Exclusionary Fencing	75%	Virginia DEQ Guidance Manual for TMDL plans
Pasture sources treated by buffers and fencing combination	70%	Virginia DEQ Guidance Manual for TMDL plans; Pomme de Terre River fecal coliform total maximum daily load implementation plan
Wildlife (mammal)	<0.1%	
Wildlife (waterfowl)	70%	

While wildlife contributions to bacterial loading are a known source, estimating the actual amount of loading from wildlife is a difficult task. Table 10, seen below, shows estimates of the wildlife contributions. It is not feasible or recommended to eliminate wildlife from the watershed. Moreover, there are no BMPs specifically designed to address many wildlife sources. An exception to this is contributions from waterfowl. This report outlines BMPs that can be used to reduce bacteria inputs from waterfowl sources. See the watershed wide BMP section for additional detail.

Table 10: Estimate of Wildlife Contribution						
Wildlife type	**Population Density [1]**	**Description of habitat**	**Acres or Miles of Habitat**	**Estimate of Animals in Watershed**	**Fecal Coliform (millions cfu/ animal/day) [1]**	**Total Fecal Coliform/ Source (million cfu/day)**
Deer	0.047	Entire watershed	10,102	475	500	237,397.00
Raccoon	0.07	Within 600 ft of streams and ponds	5,070	355	1,000	354,900
Muskrat	2.75	Within 66 ft of streams and ponds	679	1,867	34	63,487
Beaver	4.8	Mile of stream	34	163	250	40,800
Wild Turkey	0.01	Entire watershed	10,102	101	93	9,395
Total Wildlife Contribution (terrestrial)						**705,979**
Goose	0.087	Entire Watershed	10,102	879	2,430	2,135,664
Duck	0.039	Entire watershed	10,102	394	2,430	957,367
Total Waterfowl Contribution						**3,093,030**

[1] Total Maximum Daily Loads for Island Creek, Town Creek, Trent Hall Creek, St. Thomas Creek, Harper and Pearson Creeks, Goose Creek and Indian Creek and a water quality analysis for Battle Creek of fecal coliform for restricted shellfish harvesting areas in the Lower Patuxent River Basin in Calvert, Charles and St. Mary's Counties, Maryland

Human loading of bacteria to a system results primarily from failed septic systems or direct discharge of subsurface sewage disposal systems into a watercourse or waterbody. The degree of potential loading will be dependent on soil conditions, subsurface system design, and proximity to water among other factors. For this study, the areas in the watershed serviced by public systems were not considered as potential loading sources. Map 21 shows the areas of greatest concern based on soils condition. Table 11 uses total number of homes within 200 feet of a watercourse or waterbody as the basis for the number of septic systems. By using the total number of homes rather than just the homes on soils with subsurface sewage limitations, the report arrives at a more conservative number by arriving at a higher potential loading rate.

Table 11: Estimate of Human Contribution through Failed Septic

Expected Load = P S F_r C Q C_v		
P= average # of people / septic system	2.4	US Census2000 : Ellington, CT =2.48 people/ household; E.Windsor, CT = 2.34 people/ household
S= # of septic systems in area of concern	181	directly measured within 200' of water using GIS/ aerial imagery
F_r= expected failure rate	0.05	5% failure rate assumed (similar to literature)
C= fecal coliform concentration of wastewater (10^6 cfu / 100 ml)	0.01	[1]
Q= daily discharge of wastewater per person (gallons)	75	[1]
C_v=unit conversion factor	37.854	[1]
Calculated Contribution (million cfu/ day):	**616.64**	

[1]Total Maximum Daily Loads for Island Creek, Town Creek, Trent Hall Creek, St. Thomas Creek, Harper and Pearson Creeks, Goose Creek and Indian Creek and a water quality analysis for Battle Creek of fecal coliform for restricted shellfish harvesting areas in the Lower Patuxent River Basin in Calvert, Charles and St. Mary's Counties, Maryland

Table 12: Sources of Bacterial Loading

Source	**Estimated Number in watershed**	**Daily Fecal Coliform Production (millions of cfu/animal/ day)**	**Total Fecal Coliform Production (millions of cfu/day)**	**Contribution by Pasture/ Confinement Rates (millions cfu/day)**	**Efficiency Rate for Removal from Runoff**	**Reduction (millions cfu/day)**		
Beef cows-pasture 100%	450	25,800 [2]	11,610,000	11,610,000	70%	8,127,000		
Milk cows-total	1015	20,000 [1]	20,300,000					
confinement (80%)				16,240,000	75%	12,180,000		
pasture (20%)				4,060,000	70%	2,842,000		
Dry cows-total	338	20,000 [1]	6,760,000					
confinement (25 %)				1,690,000	75%	1,267,500		
pasture (75%)				5,070,000	70%	3,549,000		
Heifers-total	1350	9,200 [1]	12,420,000					
confinement (25%)				3,105,000	75%	2,328,750		
pasture (75%)				9,315,000	70%	6,520,500		
Hogs and pigs	85	8,900 [1]	756,500	756,500	75%	567,375		
Sheep and lambs (pasture)	45	12,000 [2]	540,000	540,000	60%	324,000		
Chickens (layers)	200	136 [2]	27,200	27,200	60%	16,320		
Horses	75	420 [2]	31,500					
confinement (90%)				28,350	75%	21,263		
pasture (10%)				3,150	70%	2,205		
Goats (pasture)	120	12,000 [2]	1,440,000	1,440,000	60%	864,000		
Dogs	950	1,070 [3]	1,016,500	1,016,500	50%	508,250		
Human (failed septic)	see failed septic estimates		617	617	90%	555		
Wildlife	see wildlife table		705,978	705,979	< 0.1%	-		
Waterfowl			3,093,030	3,093,030	70%	2,165,121		
			Estimated Load:	**58,701,325**	**Expected Reduction:**	**41,283,839**	**Expected Percent Reduction:**	**70%**

[1] Bacteria TMDL Development for the Rivanna River Mainstem, North Fork Rivanna River, Preddy Creek and Tributaries, Meadow Creek, Mechums River, and Beaver Creek Watersheds

[2] Fecal Coliform TMDL for Naked Creek in Augusta and Rockingham Counties, Virginia

[3] Development of the Total Maximum Daily Load (TMDL) for Fecal Coliform Bacteria in Moore's Creek, Albemarle County, Virginia

Table 12 summarizes inputs from all sources and describes BMP efficiencies. Should the stakeholders in the watershed implement all of the BMPs at all appropriate locations and should those BMPs function at maximum efficiency it is estimated that a 70% reduction of bacterial loading may be achieved.

Several caveats should be considered when using this report to assess actual load reductions in the Broad Brook basin or when using this report as a comparison for other watersheds:

- The draft TMDL for segment 2, upon which the majority of load reductions are based, has been extrapolated from a draft TMDL for section one. The TMDL for section 1 was written for a small portion of the watershed and is not necessarily representative of the upper portion of the watershed as relates to land use and land cover
- Seasonal weather patterns influence pollutant movement. Accordingly, water quality may vary at different times of the year. Data collected through single events may present very different findings than generalized watershed loading models
- While total pollutant loads are a good indicator of the overall cause of water quality impairments, water quality criteria and standards are based on concentrations not total loads. The reason for this is because the toxicity of a pollutant is more dependent on concentration rather than total load
- If using this report as an example, users should be cognizant of the fact that land use and land cover, soils, hydraulic conductivity, infiltration rates, depth to bedrock or water table, erosion potential, or the spatial relationship between urban, rural and agricultural lands might be dissimilar. These variations in watershed characteristics may translate to significant differences in pollutant loading rates.

Although nutrients are not listed as a primary concern in the Broad Brook TMDL, NRCS performed a rough calculation of the total amount of nutrients being produced by the estimated number of livestock in the Broad Brook basin. Table 13 outlines the amount of land required to assimilate the different nutrients (phosphorous, nitrogen, and potassium). The amount of land varies depending on the type of nutrient and the type of crop. While this does not directly address bacteria, it shows that without the necessary land base to apply nutrient laden manure, excess nutrients will be present and water quality will be threatened. A more detailed discussion of manure management is in the BMP section of this report.

Table 13: Nutrient Loading		
Total Nutrients Produced:		
279,354.12	pounds N per year as N	
217,892.33	pounds P per year as P2O5	
327,144.13	pounds K per year as K2O	
Agronomic Need for Silage Corn - All Sources		
Nitrogen as N	*Phosphorus as P2O5*	*Potassium as K2O*
69.56 lbs./ac/yr.	58.55 lbs./ac/yr.	143.78 lbs./ac/yr.
UConn Recommendations, Crop Removal Rates, per Rich Meinert, Tom Morris, 04/14/2009		
4,016.02 acres	3,721.47 acres	2,275.31 acres
Agronomic Need for Hay - All Sources		
Nitrogen as N	*Phosphorus as P2O5*	*Potassium as K2O*
147.12 lbs./ac/yr.	40.89 lbs./ac/yr.	167.88 lbs./ac/yr.
UConn Recommendations, Crop Removal Rates, per Rich Meinert, Tom Morris, 04/14/2009		
1,898.82 acres	5,328.74 acres	1,948.68 acres

Best Management Practices

Objectives

As explained in the purpose section of this report, the watershed analyses were conducted on two levels – watershed-wide and place-based. The intent of providing recommendations on a watershed-wide basis is to offer basic measures that can be implemented relatively easily anywhere within the Broad Brook basin. Given the complexity of the landscape in the watershed, a variety of watershed-wide BMPs are considered suitable for implementation on a watershed-wide basis. These measures, when put into place, will help to control inputs from stormwater runoff and minimize potential site specific and cumulative impacts within the basin. The watershed-wide measures are not focused on specific locations that may be more direct contributors to water quality concerns. Along with addressing possible bacterial concerns, these practices may help to reduce the non-point source pollution contributions of nitrogen entering the stream system. Reducing nitrogen loads in the Broad Brook will, in turn, decrease the pollutant loading of the Connecticut River and assist in achieving the nitrogen TMDL established for the Long Island Sound.

Place-based BMPs are site specific practices that may include one or more options and may work in conjunction with watershed-wide practices. These sites were selected based on a combination of factors: land use/land cover, proximity to a waterbody or watercourse, and recommendations from the Advisory Committee. Based on available information these sites appeared to have the highest potential for contributing to bacterial loading. Additional investigation should be conducted for each site to determine the most suitable BMP or BMPs for those specific sites. Place based BMPs under consideration include buffer enhancement/creation (tree/shrub establishment), settling basin installation, catch basin filters, structural stormwater management practices (e.g. filtration, infiltration, runoff control, ponds, wetlands, manufactured technical devices, etc…), Low Impact Development techniques (e.g. rain gardens, porous pavement, infiltration swales, etc…), septic system maintenance/repair, goose/water fowl management, dog waste management systems, and education.

Cost Estimates

Cost estimates for BMPs are required in 319 watershed based plans. NRCS developed cost estimates for each place-based BMP recommendation that specifically addresses bacteria. The cost estimates also help local stakeholder evaluate the financial resources necessary to install and maintain recommended BMPs. Below is an explanation of the methods used to develop the cost estimates.

Structural Stormwater BMPs

The cost estimates for structural BMPs are made up of two basic parts: the cost of the BMP itself and the operation and maintenance (O&M) cost for the BMP. In order to compare BMPs, the cost of the BMP was capitalized over its lifespan at an interest rate of 7% (resulting in $/year). The capitalized cost is added to the annual O&M cost to obtain the total annual cost of the BMP. The lifespan of the BMP for this study is what may reasonably be expected with adequate maintenance and is within the range of the “Effective Life” listed by the U.S. Federal Highway Administration (FHWA) (Shoemaker et al., 2002,

Table 5). The cost of the BMP includes the construction cost, design, permitting, and other contingency costs. In the cost tables developed by NRCS, the cost for design, permitting, and other contingency costs are calculated as percentage of the total construction cost. In most cases this amount is 25 percent. The percentage for manufactured devices was lower because some of the design has already been completed. These costs are in 2009 dollars and are exclusive of land costs. General cost estimates for stormwater retrofits are not included since the costs are site specific.

Most construction costs were obtained by comparing several different references (such as *R.S. Means*). Hartford, CT was the locality for each estimate, as this is the city closest to the Broad Brook watershed listed in the RS Means. The construction costs for the structural stormwater BMPs were typically dependent on the water volume or watershed area. The references include several different sources within U.S.EPA documents (U.S.EPA, 2004 & U.S.EPA, 1999) and the on-line Menu of BMPs (U.S.EPA, 2007), the U.S. FHWA (Shoemaker et al., 2002), and the University of New Hampshire Stormwater Center 2005 Data Report. Some construction costs were obtained from manufacturers estimates and/or using RSMeans Building Construction Cost Data 2006. Annual O&M costs were calculated as a percentage of the construction cost. The percentage was taken from within the ranges listed by the U.S.EPA. The costs for BMPs have been adjusted by an increase of 8.18% to reflect 2009 dollars. This adjustment is based on information provided by the Engineering News Record. Tables 14 and 15 illustrate the way cost estimates were developed.

Table 14: Scenario One: 1 acre watershed at 95% imperviousness									
CT Water Quality Volume (WQV)= 0.0754 ac-ft									
		Design & Contingency				Annual Cost Over Lifespan ($/yr) i = 7%	Operation & Maintenance (O&M)		Total Cost /yr over Lifespan
	Const. ($)	% Const.	Cost	Total	Lifespan (years)		% Const.	$ / yr	
Stormwater Ponds	$9,520	25%	$2,380	$11,900	30	$959	4.50%	$428	$1,387
Stormwater Wetland	$12,982	25%	$3,245	$16,227	30	$1,308	4.50%	$584	$1,892
Gravel Wetland	$23,367	25%	$5,842	$29,209	20	$2,757	5%	$1,168	$3,925
Infiltration									
Basin	$6,924	25%	$1,731	$8,654	10	$1,232	7.50%	$519	$1,751
Trench	$24,232	25%	$6,058	$30,290	12	$3,813	7.50%	$1,817	$5,631
Filtration									
Surface Sand Filter	$22,501	25%	$5,625	$28,127	15	$3,088	12%	$2,700	$5,788
Underground Sand Filter	$23,367	25%	$5,842	$29,209	15	$3,207	12%	$2,804	$6,011
Bioretention (Rain Gardens)	$25,963	25%	$6,491	$32,454	15	$3,563	6%	$1,558	$5,121
Manufactured Tech Devices									
Biofilters (e.g. StormTreat)	$25,963	15%	$3,894	$29,858	15	$3,278	5%	$1,298	$4,576

Catch basin (CB) Inserts, Street Sweeping

Cost estimates for CB inserts that target bacteria and street sweeping use the same basic method described above. The general cost estimates are done on a per unit basis (per each and per curb mile, respectively.

Table 15: Scenario Two: 40 acres at 35% impervious									
CT Water Quality Volume (WQV)= 1 ac-ft									
		Design & Contingency				Annual Cost Over Lifespan ($/yr) i=7%	Operation & Maintenance (O&M)		Total Cost /yr over Lifespan
	Const. ($)	% Const.	Cost	Total	Lifespan (years)		% Const.	$ / yr	
Stormwater Pond	$60,581	25%	$15,145	$75,726	30	$6,444	4.50%	$2,726	$9,170
Stormwater Wetland	$82,217	25%	$20,554	$102,771	30	$8,745	4.50%	$3,700	$12,445
Gravel Wetland	$142,798	25%	$35,699	$178,497	20	$16,848	5%	$7,140	$23,988
Infiltration									
Basin	$56,254	25%	$14,063	$70,317	10	$10,012	7.50%	$4,219	$14,231
Filtration									
Surface Sand Filter	$86,544	25%	$21,636	$108,180	15	$11,877	12%	$10,385	$22,262

Buffers, Agricultural Practices, and other source control and management practices

The cost estimates for buffers, agricultural practices and other source control and management practices are on a total cost per unit basis. The cost estimates for buffers, agricultural practices, and wetland restoration came from Connecticut NRCS in-house cost data based on practices done through NRCS programs.

Overall Efficiencies of BMPs

An overall potential efficiency has been determined for each of the recommended BMPs (see Table 9). In all cases, the efficiencies of the BMPs represent best-case scenarios.

In order to accurately and effectively assess load reductions, the percent contribution of potential sources needs to be established. Quantifying the actual percent contribution of each source is extremely difficult. Variability in physical landscape conditions, changing populations of livestock or wildlife, potential overlap of contribution from sources, and seasonal climate patterns are among some of the factors that influence the concentration and overall contribution of different sources. Inherent in each of these estimates is a range of efficiency. As a result, a margin of error should be associated with the potential efficiencies presented in this report. The margin of error may range from plus or minus 10 percent to as much as plus or minus 50 percent. The total percent reduction that may be potentially achieved is also based on a weighted calculation.

The level of difficulty in assessing the percent contribution for the Broad Brook basin is compounded because of the minimal water quality monitoring data that is available. Without more comprehensive data there is no way to localize the potential sources or ascertain if the loading is occurring in a tributary or on the main stem itself.

Additionally, it is difficult to determine the relative contribution from a particular source. For example, the contribution of a pound of cow manure is expected to vary from that of a pound of goose feces or a pound of dog waste. Not only are the bacterial levels of each of those going to vary, the potential impact presented by each will depend on the proximity to a water course, the type of land management practices that are in place, the land cover where the waste is located, and the location within the watershed. Consequently, knowing the percentage of land classified as agricultural, or the number of dogs, or the hot spots for geese does not necessarily allow for an accurate quantification of comparative loading.

The best way to determine the efficiencies of the implemented BMPs and the total percent reduction achieved is to establish a monitoring program. Data would be collected pre- and post- implementation. This would allow people to determine the effectiveness of the individual BMPs and to evaluate the overall impact on bacterial loading to the Broad Brook. Based on the findings, modifications could be made to the BMPs to more aptly address pollutant loading concerns.

Watershed-Wide BMP Recommendations

Listed below are the watershed-wide BMP recommendations. (Refer to Appendix B for a table outlining the costs associated with the watershed-wide practices).

Vacuum-assisted street sweeping

We recommend conducting regular street sweeping. Street sweeping reduces the potential loading of sediment and debris into waterbodies, as well as any associated pollutants that may be adsorbed or absorbed by the sediments. While the efficiency of street sweeping has been debated and differing results have been achieved through various simulation models, any removal of sediment load and potential associated pollutants is better than leaving the sediment in the streets. According to Sartor and Gaboury (1984) (cited from USGS publication, *The Potential Effects of Structural Controls and Street Sweeping on Stormwater Loads to the Lower Charles River,* Massachusetts, Water Resources Investigation Report 02-4220, Zarriello, Breault, Weiskell) on average one kilogram of street dirt contains 3 million colony forming units (CFU) of fecal coliform bacteria. Furthermore, the USGS report indicates that the majority of fecal coliform bacteria load originates from residential streets as opposed to industrial or commercial streets. Vacuum-assisted street sweeping offers an alternative method for stormwater management to areas that may have limitations for the installation of structural practices to control stormwater runoff. Research indicates that weekly street sweeping is most effective, with efficiency decreasing as the time between sweeping events increases.

Because cost and availability of equipment may be limiting factors, particular areas within the watershed could be targeted for more frequent sweeping. Factors to consider may consist of categorizing road based on traffic volumes, number of accidents (increased likelihood of spills), number of catch basins, proximity to wetlands and watercourses, amount of litter and debris, and tree cover (leading to catch basin clogging). Additional guidance for street sweeping may be obtained from the CT DEP's Guideline for municipal Management Practices for Street Sweepings and Catch Basin Cleanings (August 2007). Ideally, all streets in the basin should be swept at least twice each year.

Regular Maintenance of Catch Basins

Catch basins are the entry point for stormwater into a storm sewer system. Typically, catch basins have a sump designed to trap sediment and limit its direct transport and discharge into a watercourse or waterbody. Over time the sump fills with sediment and must be cleaned out. Without regular maintenance, inflows into a catch basin may flush the trapped sediment and any associated pollutants into the receiving waters. Studies have shown that catch basins can reach between 40 – 60% capacity before inflows bypass treatment or sediments are resuspended. Research has shown that increasing the frequency of maintenance and cleanout can improve performance, particularly in industrial or commercial areas. A study conducted in Alameda County, California, showed that increasing the cleaning frequency from once per year to twice per year could increase the total sediment removal from catch basins (Mineart and Singh, 1994) from 54 pounds for annual cleaning, to 70 pounds for semi-annual and quarterly cleaning, and 160 pounds for monthly cleaning. Using the estimate of 3 million CFU of fecal coliform (as described under


Stormwater Runoff Management

the street sweeping section above), 54 pounds of sediment contain roughly 73.6 million CFU. With increased maintenance comes increased cost. The benefit of improved pollutant removal needs to be weighed against the increased cost of maintenance.

Catch Basin Filters

Catch basin inserts are devices installed in an existing catch basin, under the storm grate. The inserts treat stormwater through filtration, settling, or adsorption. A variety of manufacturers have commercially available products that are designed to remove a variety of pollutants, including bacteria, sediment, oil, litter and debris. Units need to be maintained routinely and filters need to be replaced on a regular basis to attain maximum removal efficiency. Replacement rates will depend on the type of pollutants being treated, the amount of sediment loading, and the regularity of street sweeping. Estimates for the cost of inserts range from $650 per filter to $1,300 per filter. Cost for inserts that targeted bacteria in a pilot project in Norwalk, CT ranged from $800 - $1,000.

Installation of filter inserts throughout the watershed would provide a degree of effectiveness without the use of any other measures or BMPs. Improved efficiency would be achieved by instituting a regular schedule of street sweeping. While the initial capital cost may be high, it should be weighed against maintenance of catch basins and the long-term impact and costs associated with water quality renovation.

Domestic Pet Waste Management (including dog walking areas and kennels)

Research indicates that non-human waste comprises a significant source of bacterial contamination in all watersheds. Studies by Alderiso et al. (1996) and Trial et al (1993) suggested that 95 percent of the fecal coliform found in urban stormwater was of non-human origin. Research around the Seattle, Washington area showed that nearly 20 percent of the bacteria that could be matched with its host animal were matched with dogs. According to some studies, one gram of dog feces contains 23 million fecal coliform. Some estimates suggest that two to three days of dog droppings from a population of roughly 100 dogs could contribute enough bacteria and nutrients to temporarily close a bay in a coastal watershed of up to 20 square miles in size to swimming and shellfishing. (EPA, 1993) In comparison, the Broad Brook Watershed is approximately 15 square miles, and has an estimated 934 licensed dogs. (See Table 16).

Table 16: Number of Licensed Dogs

Town	Total Acres in Town	Total Town Acres in Watershed	Percent of town in Watershed	# Licensed Dogs in Town	Proportional # 0f Town Dogs in Watershed
East Windsor	17,107.00	2,438.0	14.3%	1350	193
Ellington	22,131.60	7,461.4	33.7%	2200	741
			Total Number of Dogs:	**In Towns**	**In Watershed**
				3550	**934**

A variety of pet waste management systems could be used to limit the amount of fecal matter left on the ground.

- In-ground pet waste "septic systems" could be installed. There are several commercial marketers of in-ground systems. A bucket is placed in a hole in the ground. The waste is deposited in the bucket and then covered with a lid. A bacteria degrading enzyme is often used to aid in the decomposition of the waste. The enzymes are occasionally sprinkled on the waste. Minimal maintenance is required. Each system can service between 1 and 4 dogs depending on the size of the dog and the size of the system.
- A second option is pet waste stations. Plastic bags are provided for pet owners to pick up waste, and a garbage can is convenient to deposit the waste. Numerous stations can be set up at

known dog walking locations. Periodic collection of the waste is required.

- The “long grass principle” is a third option. Dogs are attracted to areas with long grass to defecate. Keeping a portion of a dog walking area unmowed (approximately 4-5 inches high will provide a localized area for dogs to defecate. The unmowed area should be located such that it minimizes the potential for waste to enter into the water system, e.g. kept away from steep slopes, drainage ditches, streams, etc. Regular pick-up of waste for this alternative would be required.

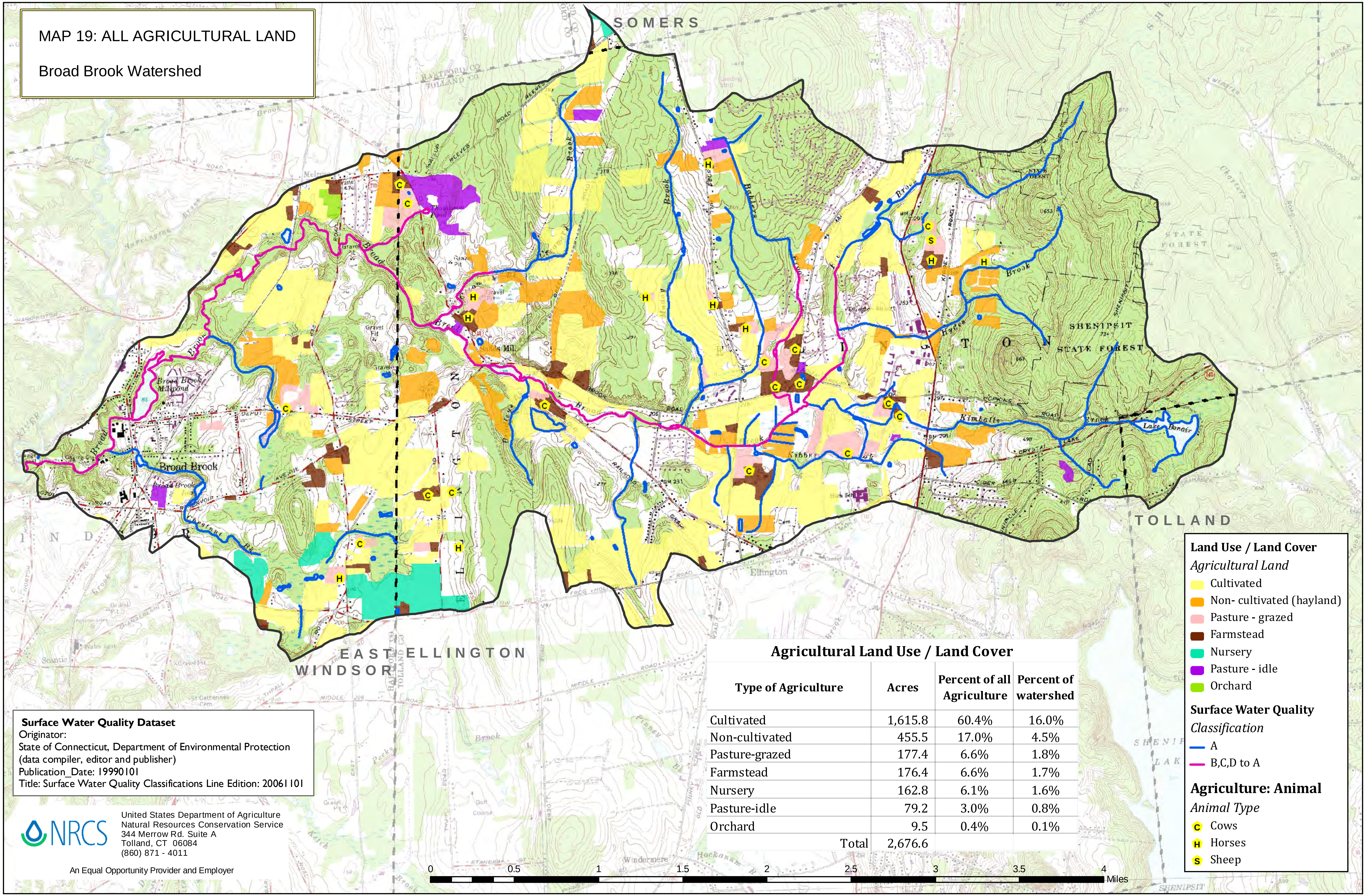
The most suitable waste collection system will depend on the size, location, and land cover of the dog walking area.

Agricultural Waste Management Plans (for all agricultural operations, including horse farms)

Numerous livestock agricultural operations exist in the Broad Brook watershed. (See Map 19: All Agricultural Land). The waste produced by the livestock contains fecal coliform bacteria. Without appropriate management measures in place, stormwater runoff can transport livestock waste into watercourses and waterbodies and result in significant pollutant loading. In some cases, livestock may have direct access to a watercourse which increases the chance for animal feces to be deposited in the stream. Up-to-date nutrient management plans should be developed for agricultural livestock operations of all sizes. Measures may include waste storage facilities, fencing along streams to restrict livestock access, establishment of streamside buffers to trap sediment and waste runoff, installation of stock watering systems which are located away from wetlands and waterbodies, and pasture management. Cost for these practices will vary depending on the size of the operation and number of animals because these factors influence the sizing of structural measures.

MAP 19: ALL AGRICULTURAL LAND

Broad Brook Watershed



Agricultural Land Use / Land Cover

Type of Agriculture	Acres	Percent of all Agriculture	Percent of watershed
Cultivated	1,615.8	60.4%	16.0%
Non-cultivated	455.5	17.0%	4.5%
Pasture-grazed	177.4	6.6%	1.8%
Farmstead	176.4	6.6%	1.7%
Nursery	162.8	6.1%	1.6%
Pasture-idle	79.2	3.0%	0.8%
Orchard	9.5	0.4%	0.1%
Total	2,676.6		

Surface Water Quality Dataset
Originator:
State of Connecticut, Department of Environmental Protection
(data compiler, editor and publisher)
Publication_Date: 19990101
Title: Surface Water Quality Classifications Line Edition: 20061101

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Natural Resources Conservation Service
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Educational Materials for Agricultural Operations

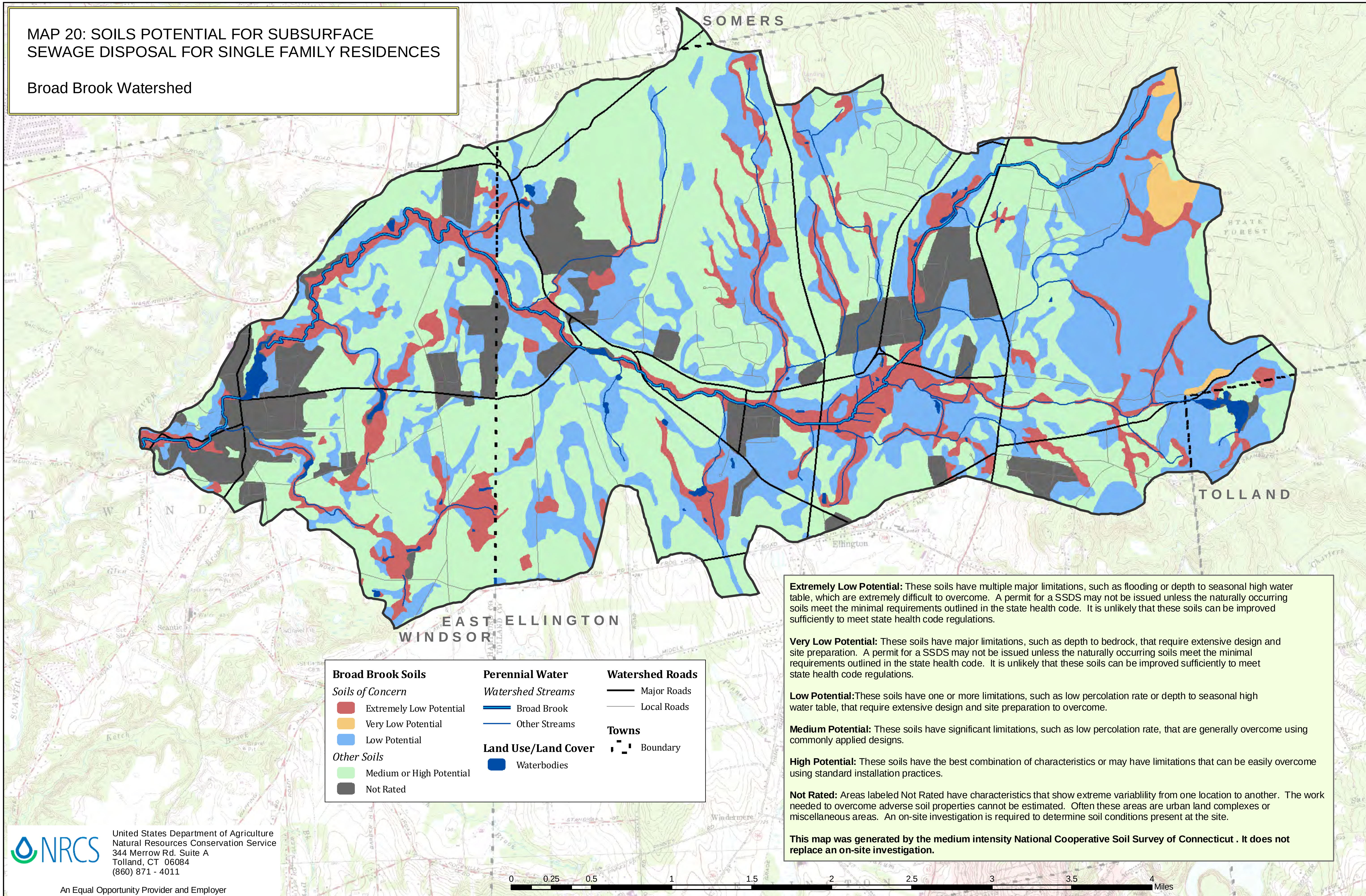
Providing educational materials for agricultural operations enhances the producer's understanding of the relationship between their practices and farm management plan and water quality. Information would describe practices that could be implemented to improve control of stormwater runoff, protection of watercourses, pasture management, and waste management. Technical and financial resources information could also be made available to facilitate efforts on the part of the producer to implement conservation practices on their land. Cost for education and outreach efforts will depend on the exact nature of the materials being produced (e.g. flyers, brochures, booklets, workshops, etc.), and the numbers being produced.

Subsurface Sewage Disposal System Maintenance and Repair (Private Septic)

Failing private septic systems may potentially contribute to pollutant loading. Many factors will directly influence the degree to which a failing system may add to pollutant loading: proximity to a waterbody, type of soils, and the degree to which the system is failing. Watershed residents with private systems should be made aware of the potential problems associated with a failing system and should be encouraged to provide regular maintenance of their system along with timely repair when necessary. Costs for maintenance and repair may vary depending on the size of the system, the type of maintenance being done, or the type of repair necessary. Regular maintenance will minimize the likelihood for future, more expensive repairs. Failing systems located closer to waterbodies are more likely to be problematic, particularly if the soils have a higher hydraulic conductivity, (fluids move through them faster), if the soils are less suitable for effective septic system operation, or if the waste material is already noticeable (visibly or through odor) above ground. (See Map 20: Soils Potential for Subsurface Sewage Disposal for Single Family Residences and Map 21: Residential Areas Located on Soils with Low or Extremely Low Potential for Subsurface Sewage Disposal).

MAP 20: SOILS POTENTIAL FOR SUBSURFACE SEWAGE DISPOSAL FOR SINGLE FAMILY RESIDENCES

Broad Brook Watershed



Extremely Low Potential: These soils have multiple major limitations, such as flooding or depth to seasonal high water table, which are extremely difficult to overcome. A permit for a SSDS may not be issued unless the naturally occurring soils meet the minimal requirements outlined in the state health code. It is unlikely that these soils can be improved sufficiently to meet state health code regulations.

Very Low Potential: These soils have major limitations, such as depth to bedrock, that require extensive design and site preparation. A permit for a SSDS may not be issued unless the naturally occurring soils meet the minimal requirements outlined in the state health code. It is unlikely that these soils can be improved sufficiently to meet state health code regulations.

Low Potential: These soils have one or more limitations, such as low percolation rate or depth to seasonal high water table, that require extensive design and site preparation to overcome.

Medium Potential: These soils have significant limitations, such as low percolation rate, that are generally overcome using commonly applied designs.

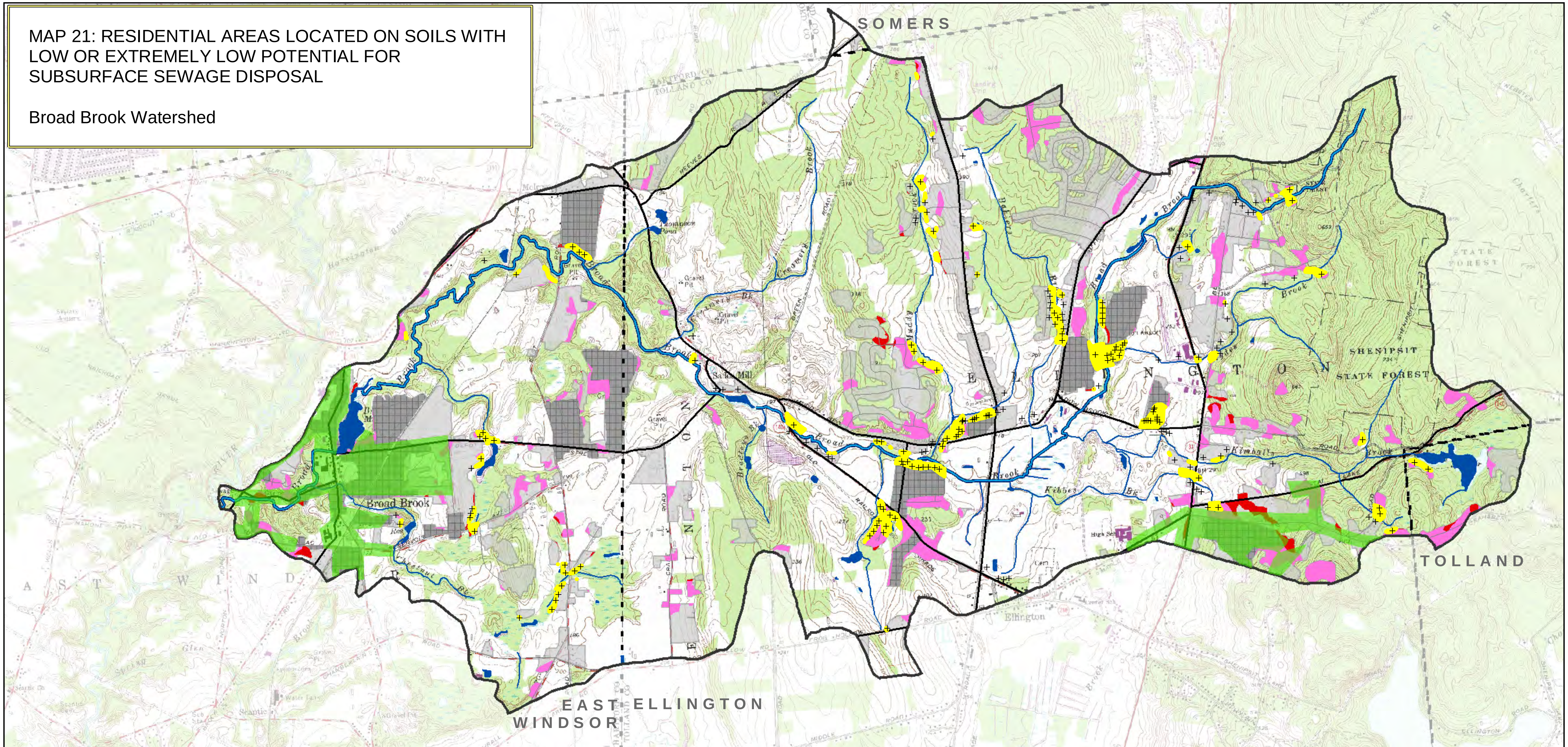
High Potential: These soils have the best combination of characteristics or may have limitations that can be easily overcome using standard installation practices.

Not Rated: Areas labeled Not Rated have characteristics that show extreme variablility from one location to another. The work needed to overcome adverse soil properties cannot be estimated. Often these areas are urban land complexes or miscellaneous areas. An on-site investigation is required to determine soil conditions present at the site.

This map was generated by the medium intensity National Cooperative Soil Survey of Connecticut . It does not replace an on-site investigation.

MAP 21: RESIDENTIAL AREAS LOCATED ON SOILS WITH LOW OR EXTREMELY LOW POTENTIAL FOR SUBSURFACE SEWAGE DISPOSAL

Broad Brook Watershed



Residential Land Use on Soils of Concern

- Within 200' of a stream or waterbody *

Residences within 200' of water

- + Approximate location

Public Sewered Areas

- Approximate location

Residential Land Use

Soils Septic Potential Rating

- Low Potential
- Extremely Low Potential
- Not Rated

Residential

- All Other Ratings

Perennial Water

Watershed Streams

- Broad Brook
- Other Streams

Land Use/Land Cover

- Waterbodies

Watershed Roads

- Major Roads
- Local Roads

Towns

- Boundary

* These are residential areas within 200' of a stream or waterbody that are on soils with Poor to Extremely Poor Potential for Septic Systems or are on soils which are Not Rated for Septic Potential. The extent has been exaggerated in order to display these areas on the map.

Low Potential: These soils have one or more limitations, such as low percolation rate or depth to seasonal high water table, that require extensive design and site preparation to overcome.

Extremely Low Potential: These soils have multiple major limitations, such as flooding or depth to seasonal high water table, which are extremely difficult to overcome. A permit for a SSDS may not be issued unless the naturally occurring soils meet the minimal requirements outlined in the state health code. It is unlikely that these soils can be improved sufficiently to meet state health code regulations.

Not Rated: Areas labeled Not Rated have characteristics that show extreme variablility from one location to another. The work needed to overcome adverse soil properties cannot be estimated. Often these areas are urban land complexes or miscellaneous areas. An on-site investigation is required to determine soil conditions present at the site.

This map was generated by the medium intensity National Cooperative Soil Survey of Connecticut . It does not replace an on-site investigation.

0 0.25 0.5 1 1.5 2 2.5 3 3.5 4 Miles

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Vegetated Buffers

The presence of vegetation along a watercourse or waterbody provides numerous services. Vegetated buffers help decrease pollutant loading by slowing sediment transport, and through nutrient uptake and storage. Though the overall effectiveness of vegetated buffers is debated, the presence of a buffer, like street sweeping, is generally accepted to be better than no buffer. In addition, vegetated buffers create a visual barrier for geese, and have been found to be effective in discouraging the birds from using a waterbody. Given that a typical goose dropping has approximately 130,000 fecal coliform, keeping geese from the water through the use of buffers may offer a significant improvement in fecal coliform loading.

Municipal Regulations

Neither the Ellington nor East Windsor zoning or subdivision regulations address stormwater quality comprehensively. Zoning regulations from both towns have limits on impervious surface coverage. These limits are relatively high (15-25%) in terms of water quality protection. However, it is difficult to determine the real impact of such limits without analyzing the location of zones relative to water resources, existing site specific stormwater management, and other land use impacts in the context of the whole watershed. Ellington zoning regulations, which were updated recently to add provisions for age restricted developments, include provisions for alternative stormwater management systems to be used in these types of development.

The foregoing review and recommendations address specific issues in the regulations at the time of review, but do not address stormwater management in a comprehensive manner. If municipalities wish to address water quality comprehensively, there are several models that can be used. However, the authors believe the easiest way to address the issue is set water quality goals and standard in the regulations and then provide guidance documents or technical standards that may be used to achieve those goals. For instance, if the goal of the municipality is to require that all post construction stormwater discharges remove 80% of total solids (which is consistent with Phase II stormwater requirements), than a standard can be incorporated into the zoning and subdivision regulations with a requirement that the methods to achieve those results be taken from the 2004 Connecticut Stormwater Quality Manual or other set of technical standards, as discussed below.

Low Impact Development (LID) can be adopted by municipalities to deal with water quality concerns. LID offers municipalities alternative subdivision designs to manage stormwater runoff. The goals of LID are to replicate, as closely as possible, natural hydrologic conditions by maintaining infiltration rates and runoff conditions as they were in a pre-development state. The methods described above, infiltration swales and basins, curbless roads, rain gardens, and porous pavement are some of the measures that make up the suite of practices that can be used in LID.

Another model is the development of a stand-alone document of *Public Improvement Standards*. Such a document avoids the need to significantly revise existing regulations. The document includes technical standards for streets and storm drainage and can be modified to reflect improved engineering standards without the need to alter regulations. A Public Improvement Standard would allow for the incorporation of LID techniques as well as new measures to be integrated based on technology improvements.

The other method is to adopt a stand-alone stormwater ordinance. A model ordinance can be found in the 2004 Connecticut Stormwater Quality Manual. The disadvantage of a stand-alone ordinance is that it does not incorporate existing regulations and may be more difficult to implement in the context of existing town procedures. (For a more detailed account, see Appendix C).

Site specific investigation should be conducted in order to ensure that appropriate land planning techniques are implemented. The cost for a regulations review is associated with the time required to review and modify the regulations. (For a more detailed account of findings, see Appendix C).

Place-Based BMP Recommendations

Agricultural Operations

Along with the historic, economic, and cultural place that farming occupies in the Broad Brook watershed, agricultural land also maintains a strong physical presence. According to this study, 25% of the land in the watershed is agricultural. The fact that several of the agricultural parcels are large, relatively unbroken tracts accentuates the place of farming in the community (See map 18: Agricultural Land).

Many of these larger tracts, as well as numerous smaller fields, are located within 500 feet of a watercourse or waterbody (see Map 22: Agricultural Land Use and Proximity to Water). Together these parcels comprise a total of 1158.5 acres, or 44 percent of the agricultural land in the watershed. Of the land within the 500 foot distance, 75 percent is categorized as either cultivated, pasture, or farmstead. Though pollutant loading may occur from any of the agricultural lands, the cultivated, pastured, and farmstead fields present the highest risk.

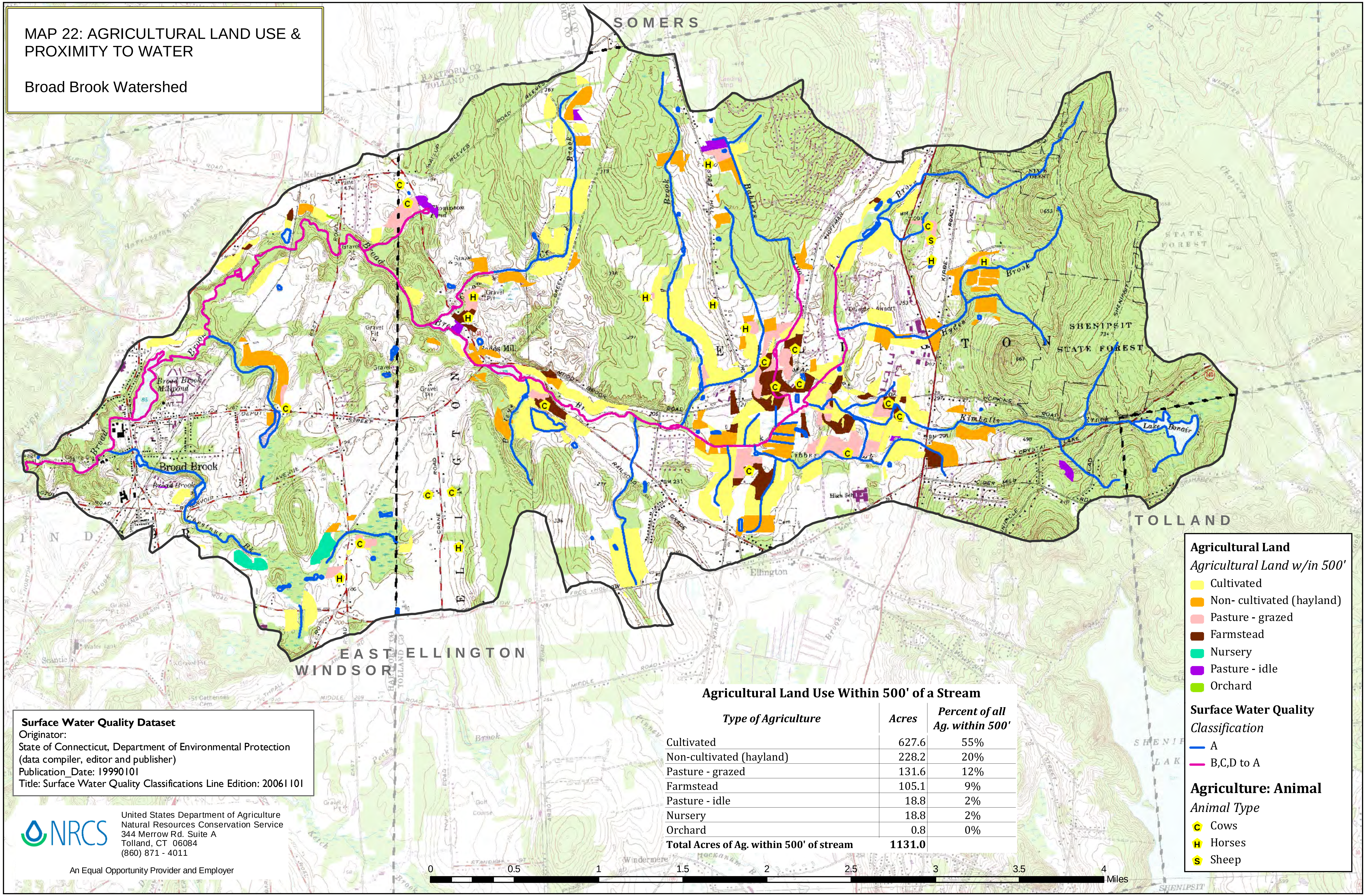
The cultivated and pastured fields within the 500 foot distance are high risk because of the relative proximity to a watercourse or waterbody and because of the activities taking place on the land. Manure spread on these cultivated fields has less distance to travel as part of stormwater runoff before entering directly into water. Livestock on pastured lands may have direct access to the water. As a result of direct access, contaminants on the animals themselves or animal feces can be directly deposited into the water. Additionally, manure deposited on these pastured fields has a greater likelihood of being transported by runoff to water. These conditions increase the chance that water quality degradation may occur.

Land classified as farmsteads includes barns, barnyards, corrals, feeding areas, manure and silage storage areas and all other structures associated with agriculture. There is a high potential for bacterial contamination of stormwater runoff in these areas as many are either paved or highly compacted soils. Because of the compacted soils and/or impervious surfaces the pollutants from these areas can be transported more easily as part of stormwater runoff into nearby watercourses and waterbodies.

Though the remaining 400 +/- acres is classified as non-cultivated and idle pasture it should be remembered these fields were classified using 2006 imagery. These fields, as well as the other agricultural land, may have multiple uses within a year and use may change from year to year.

MAP 22: AGRICULTURAL LAND USE & PROXIMITY TO WATER

Broad Brook Watershed



Agricultural Land Use Within 500' of a Stream

Type of Agriculture	*Acres*	*Percent of all Ag. within 500'*
Cultivated	627.6	55%
Non-cultivated (hayland)	228.2	20%
Pasture - grazed	131.6	12%
Farmstead	105.1	9%
Pasture - idle	18.8	2%
Nursery	18.8	2%
Orchard	0.8	0%
Total Acres of Ag. within 500' of stream	**1131.0**	

Surface Water Quality Dataset
Originator:
State of Connecticut, Department of Environmental Protection
(data compiler, editor and publisher)
Publication_Date: 19990101
Title: Surface Water Quality Classifications Line Edition: 20061101

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Many of the watershed's producers recognize the potential impact on the watershed from their farming activities. These producers are working with, or have worked with, NRCS and other agencies to implement conservation practices on their farms in order to minimize the potential impact from their operations. These practices include, but may not be limited to

- Comprehensive Farm Plan
    - Nutrient Management
    - Waste Storage Facility
    - Pasture and Hayland Planting
    - Prescribed Grazing
    - Cover crop
- Roof Runoff System
- Fence
- Access Road
- Animal Trails and Walkways
- Silage Leachate Collection
- Heavy Use Area
- Underground outlet
- Riparian Buffers

Some operators have installed heavy use areas, roof runoff systems, animal trails and walkways as a means of reducing the impact from stormwater runoff on the Broad Brook as well as its tributaries. Several operators have implemented nutrient testing practices as well. A feasibility study was recently conducted in the watershed by Eastern Connecticut

Resource Conservation and Development for construction of a methane digester. The primary intent of the digester would be to capture and use methane for energy, or the reduction of methane emissions. A secondary benefit from the use of a digester is the reduction of pathogens in the digester slurry. Research has shown that at a temperature of 95 degrees Fahrenheit up to 90% of pathogens will be killed in three days. Producers in the watershed are continuing to investigate the potential for construction of such a facility. Issues concerning nutrient management still remain. In many cases, the implementation of additional practices by many of the farmers will help to abate further pollutant loading.

Despite the concerted efforts to implement conservation measures, the proximity of farm operations to watercourses and waterbodies presents a significant challenge. Map 22 shows agricultural land that abuts or intersects the Broad Brook and or its tributaries. As areas used by livestock, pastured lands are areas where animal waste has a greater likelihood of entering directly into a watercourse or being transported by stormwater runoff into a stream. In addition to the practices already initiated and completed, there are several practices which could be implemented as a means to protect the stream and reduce the potential for pollutant loading to the watercourse. The goal(s) would be to prevent direct access by animals to water and/or reduce the transport of animal waste to the water. These practices include:

- Development of a comprehensive conservation plan, including pasture management, nutrient management and waste management.
- Establishment of exclusionary fencing along reaches of the Broad Brook and its tributaries on the property where fencing does not currently exist. This would prevent livestock from having direct access to the stream. A watering facility for the livestock should be installed away from the river.
- Plant a streamside vegetated buffer. Ideally the buffer would be a minimum of 35 feet and would include trees and shrubs. The buffer should extend for the full length of the portion of the river which abuts the agricultural land. Vegetation should consist of at least 50% tree and shrubs with the remaining 50% in grasses and herbaceous cover. The planting of a buffer would complement the exclusionary fencing previously described.

Implementation of manure management strategies is another key element in reducing pathogen concentrations in animal waste. Management strategies include storage and pre-treatment, timing and rate of application, and application method.

According to research, pathogens do not compete well outside of their host organism (Elliot and Ellis 1977). By reducing pathogen concentrations prior to land application the risk of fecal coliform contamination of water systems is reduced. Long-term storage of waste (Elliot and Ellis 1977; Crane et al. 1983; Patni et al. 1985) and composting (Edwards and Daniel 1992; Deluca 1997; Pell 1997) are two basic methods that can decrease fecal bacteria densities before applying manure to the land. Construction of larger storage facilities would permit farmers increased flexibility in deciding when to spread manure on their fields (Warnemuende and Kanwar 2000).

Timing and rate of manure application also play a role in potential fecal coliform contamination. The highest risk for fecal coliform transport and contamination happen with rainfall occurring either just before or just after manure has been applied. The potential drainage discharge under these circumstances is higher than under dry conditions (Joy, et al, 1998; McLellan et al. 1993). Existing tile drains would already be flowing and overland runoff would transport freshly applied animal waste. Research conducted by Warnemuende and Kanwar (2000) suggests that animal waste should not be applied 72 hours prior to a runoff event or on frozen or snow covered ground. Bacteria tend to survive longer in cold temperatures. Additionally, their research found that fields with spring applications of manure had higher bacterial densities than fall applications. The downside of a fall application is potential nutrient loss.

Manure application method also influence potential bacterial contamination. Methods such as subsurface injection and tilling each have their advantages and disadvantages. Subsurface injection may decrease surface bacteria losses, but also decreases contact between surface soils and the bacteria. Direct injection into the ground potentially increases transport to groundwater or any existing tile drainage systems (Warnemuende and Kanwar

2000). Injection may also affect a soil's macropore structure and create more soil to bacteria contact.

Several studies have demonstrated that tillage provides modest reductions of bacterial loading (Geohring et al 1999; Abu-Ashour et al. 1998; McMurry et al. 1998; and Culley and Philips 1982). It should be noted that results varied in the level of transport that was occurring and that the timing of the application would influence rates of transport. For example, Culley and Philips research recommended that manure be applied and plowed under in the fall, prior to freezing. While this method would minimize bacteria numbers in spring runoff, it might increase survival rates of bacteria and transport of bacteria to subsurface drainage.

In short, field investigations have shown that bacteria transport occurs through tile drainage systems under all manure application protocols and across environmental conditions. However, environmental variables make it difficult to ascertain the exact source of the bacteria or allow for a precise assessment of efficiency of manure management practices. There are some basic points about environmental variables that should be highlighted

- Soil moisture content at the time of application exerts a strong influence on bacterial transport to subsurface drainage systems. It is recommended that animal wastes should not be applied to tile drained fields when the tiles are flowing.
- Precipitation in the 2 to 3 weeks following the application significantly affects bacterial transport.
- The mortality of enteric microorganisms is greatest during hot dry conditions. These conditions prevail for only a limited period of time in humid climates. It has also been shown that enteric microorganisms can survive for long periods of time, and even grow, under commonly found soil conditions.

- Studies indicate that the transport of fecal bacteria under conditions of ideal matrix flow is inversely related to particle size. Soils consisting of small particles (e.g. primarily silt and clay) may be highly effective in physically filtering bacterial cells under conditions of ideal matrix flow. However, column and field experiments have indicated that macropore, or non-matrix flow, is the dominant transport pathway for fecal bacteria. As a result, soils which are more susceptible to shrinking or cracking, such as clays, could be less effective than sandy soils in terms of limiting bacterial transport.
- Research suggests that bacterial survival is greater in finer grained soils, which have an enhanced ability to retain moisture and nutrients.
- Management strategies to reduce bacterial transport may conflict with management strategies designed to moderate other environmental impacts. Tillage has been shown to reduce bacterial transport to subsurface drains by disrupting preferential flow paths. Yet, no-till and conservation tillage are currently being promoted to improve soil quality and reduce other environmental impacts. It is also recommended that manure should be applied during hot, dry conditions to facilitate greater bacterial mortality, but ammonia volatilization is significantly enhanced under these conditions. Hot, dry conditions may exacerbate odor problems, thus making producers hesitant to spread under those conditions for fear of nuisance complaints.

The environmental variables and potential impact from a site will vary; consequently, agricultural operations should be assessed on a site by site basis to evaluate potential impact and determine most appropriate conservation measures. Regardless of the findings, not all producers will have the financial resources available to implement long-term waste storage and/or pretreatment methods which have been shown to be the most effective in reducing bacterial transport.

There are several farms in the watershed that have not worked with NRCS. The operators at each of these operations should be contacted to determine the conservation measures that are currently in place. I

Unbuffered Stream Locations

As outlined in the watershed-wide recommendations, the establishment of vegetated buffers may help to reduce pollutant loading. An analysis of the entire watershed was conducted to determine specific locations along Broad Brook and its tributaries that would be most suitable for riparian plantings. These areas have been identified in Map 18: Potentially Impaired Buffers. The preliminary selection of these sites was based on two basic factors: land use/land cover, and length of segment.

Table 8: Potentially Impaired Buffers and Adjacent Land Use Streams shows the total number of acres of potentially impaired buffers with the corresponding land use and the percentage of buffer needs associated with that land use. There is a total of 66,599 unbuffered linear feet, this includes streams and lakes. With the 75 foot width that was used, this translates to a total of 184.8 acres of unbuffered area in the basin. It should be understood that this analysis illustrates where buffers are inadequate and how much buffer needs to be established to create a 75 foot wide buffer. See Appendix D for additional information.

Each of the individual sites should be investigated further to determine how significant a problem the site represents, the feasibility for establishment of a buffer, the potential effectiveness of the buffer based on local inflows, the appropriate type of vegetation, and the associated cost. The added detail will help local stakeholders to prioritize the sites and target funding and efforts on the segments of highest concern first. Additional data that could help to prioritize the unbuffered sites include the following:

- Soil characteristics – hydraulic conductivity (how rapidly water moves through the soil), and suitability for different types of planting (trees, shrubs, herbaceous cover),
- Detailed land use/land cover classification (e.g. industrial, commercial, residential, pasture, orchard, cultivated cropland), may yield greater insight about the potential for runoff and buffer establishment,
- Land use/land cover polygon size – the larger the area, potentially the greater amount of runoff that could be flowing into the associated watercourse.

Typical cost for a grass/herbaceous buffer will range from $450 to $850 per acre. A tree and shrub establishment costs approximately $2400 per acre. These costs will vary depending on the specific plants selected, the degree of site preparation that is required, and the recommended density for planting.

Soil Suitability for Subsurface Sewage Disposal Systems

Watershed soils were reviewed for their potential use for private septic systems. The range of ratings included high, low, very low, and extremely low potential and not rated. The soils mapped with a high potential rating have the best characteristics for standard installation of septic systems and any limitations that exist are easily overcome. At the other end of the spectrum, soils with extremely low potential have multiple major limitations and it is unlikely that the soils can be sufficiently improved to meet State health code regulations. Areas identified as Not Rated have extreme variability from one location to another. Typically these areas are urban land complexes or miscellaneous lands that have been manipulated, such as an excavation operation. For more information refer to Map 20: Soils Potential Rating: Subsurface Sewage Disposal Systems for Single Family Residences. The NRCS used soils data and GIS to evaluate areas of residential development containing soils with extremely low to low potential for septic systems, as well as map units classified as Not Rated. The least suitable locations were further narrowed by selecting sites within the residential areas that are 75 feet or less from a watercourse or waterbody. These areas should be considered as priorities to investigate and confirm that no septic failures or illicit discharges are taking place.

Approximately 898 acres of all residential lands in the watershed have a rating of either extremely low, low, or Not Rated septic potential. This constitutes 43 percent of all residential land. The septic systems located on sites with these types of soils present a higher risk of failure.

Horse farms

With assistance from appropriate agencies, a comprehensive conservation plan, including pasture management, nutrient management and waste management could be developed. For detailed information about specific BMPs that may be implemented please refer to *Agricultural Management Practices for Commercial Equine Operations*, produced by Rutgers University Cooperative Extension. The document may be found on line at www.esc.rutgers.edu. Also, the Horse Environmental Awareness Program (HEAP) may be a source of information and technical support for horse owners. HEAP is a coalition of federal and states agencies, organizations and individuals interested in protecting the environment by educating horse owners on good horse management practices. It has no regulatory authority and its only interest is to help horse owners improve their management practices. Information can be found online at:
http://www.ct.nrcs.usda.gov/programs/rc&d/km_heap-program.html

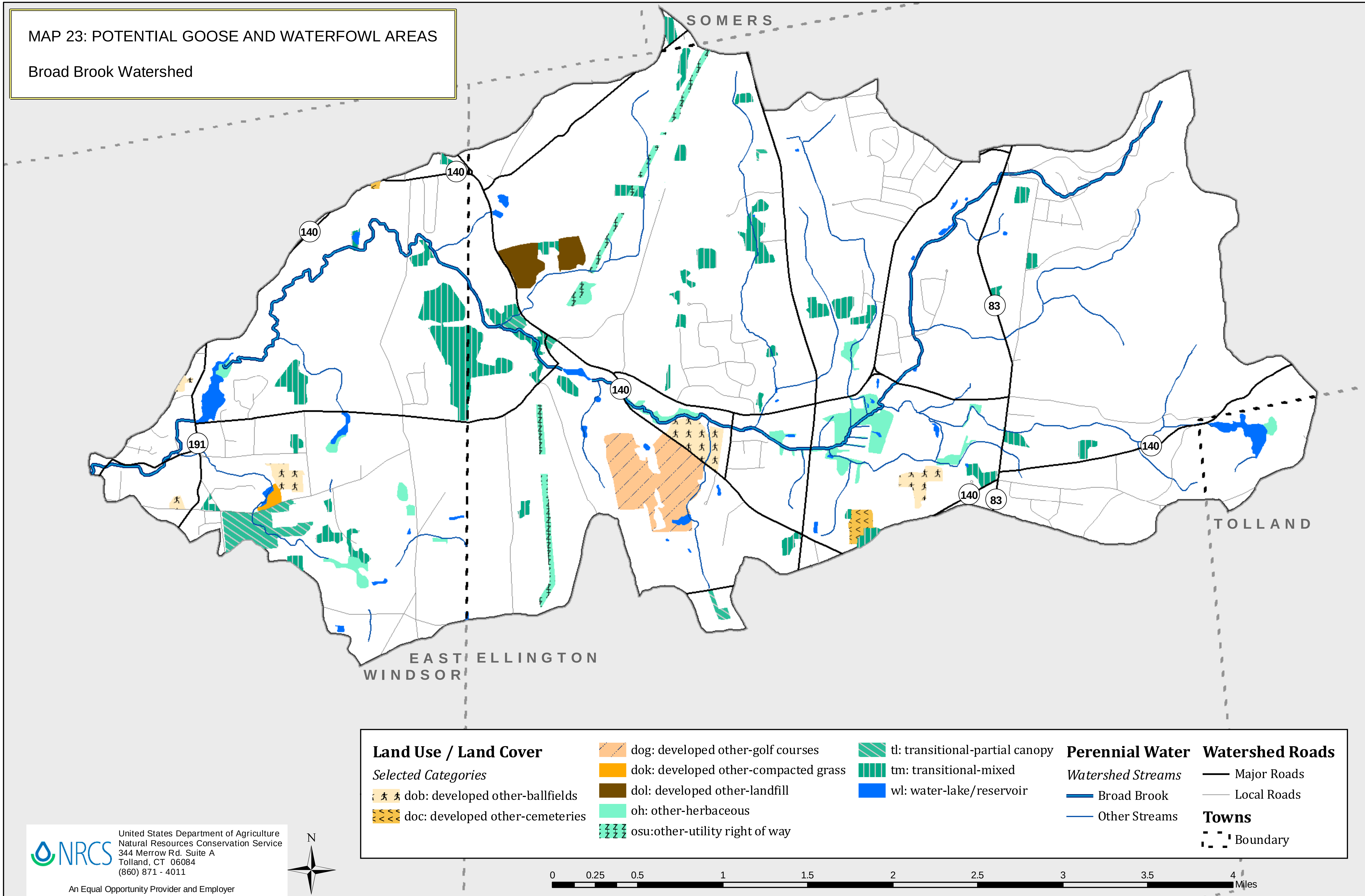
Waterfowl


Broad Brook Mill Pond – Parking Area

As noted above, waterfowl have been observed at the Broad Brook Mill Pond. Goose droppings were present at the East Windsor Park at the time a site visit was conducted. Geese

MAP 23: POTENTIAL GOOSE AND WATERFOWL AREAS

Broad Brook Watershed



will also utilize agricultural fields, ball fields and other large grassy areas. Map 23: Potential Goose and Waterfowl Areas shows large open parcels that may be attractive sites for geese and other birds. Agricultural fields are not included in this map. Options to address this concern include

- Goose control through a variety of possible techniques
- egg addling,
- harassment – dogs,
- fencing,
- vegetated buffer.

The recommended method for control is the establishment of a vegetated buffer. With relatively low maintenance needs and long-term effectiveness, buffers are the most attractive alternative for the site. While studies have shown that grass and herbaceous buffers are effective on their own, the inclusion of some trees and shrubs may further deter geese from landing in a pond. A minimum buffer width of 15 foot is recommended, although a buffer 30-50' would be preferred because of the surrounding slopes and the amount of pollutant loading. While maintaining vegetation at a height of at least six to eight inches will reduce a goose's interest and ability to find food, taller vegetation decreases the likelihood that geese will use a waterbody at all. A minimum height of 18 to 24 inches would improve buffer effectiveness.

Wildlife contributions

Like domestic pets or farm livestock, warm blooded wildlife (raccoons, deer, coyote, among others) are sources of bacteria. Different species will be found throughout the watershed. Raccoons, rodents, and gulls might be more prevalent in developed parts of the basin, while fox, deer, and coyotes may reside in the less densely developed areas. Fecal matter from all of these animals contributes to bacterial loading in stormwater. An average gull dropping, for example, has approximately 184 million coliform colonies. Feces from any of the wildlife can enter directly into a watercourse or waterbody or be transported through stormwater runoff.

Often the wildlife found on more suburban and urban lands is scavenging for food discarded by people. Efforts should be made to work with business owners to ensure that food waste properly discarded and secured in dumpsters or trash bins. Instituting a combination of food waste control practices with site cleanup could greatly reduce any wildlife waste contributions that might be occurring. A similar effort could be made with residential property owners. By increasing awareness and offering suggestions, property owners can make sure that they dispose of their food waste properly and securely to discourage wildlife visitors. Less wildlife in developed areas reduces the potential for the waste matter to be transported over the impervious surfaces or through the catch basin system and discharged into a watercourse.

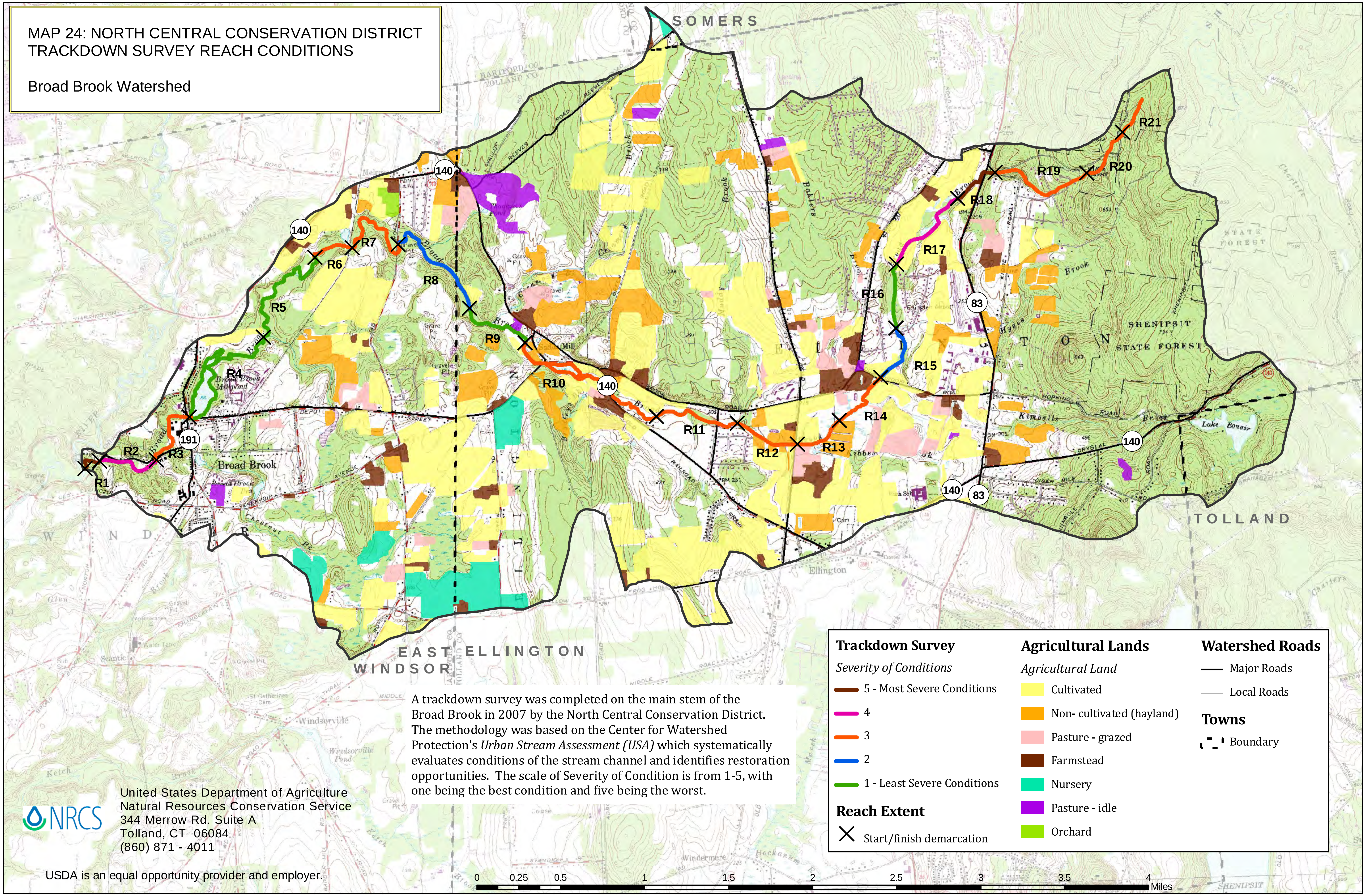
Controlling the contribution from wildlife less developed and more rural areas is very difficult, if not impossible. For example, eliminating pollutant loading in Shenipsit State Forest from wildlife sources is not a realistically achievable goal. However, it is important to understand that wildlife waste is a potential source of pollution. This information can be factored into the development of a realistic goal for reduction.

Nursery Operations

A large nursery operation is located along the headwaters of Chestnut Brook. Appropriate erosion and sedimentation controls should be installed on site to ensure that exposed soils are not transported into the basin’s watercourses and waterbodies. Eliminating the transport of sediment into the watercourses and waterbodies will serve to prevent minimize pollutant loading (bacteria, nutrients, or other toxic materials).

MAP 24: NORTH CENTRAL CONSERVATION DISTRICT TRACKDOWN SURVEY REACH CONDITIONS

Broad Brook Watershed



A trackdown survey was completed on the main stem of the Broad Brook in 2007 by the North Central Conservation District. The methodology was based on the Center for Watershed Protection's *Urban Stream Assessment (USA)* which systematically evaluates conditions of the stream channel and identifies restoration opportunities. The scale of Severity of Condition is from 1-5, with one being the best condition and five being the worst.

NRCS

United States Department of Agriculture
Natural Resources Conservation Service
344 Merrow Rd. Suite A
Tolland, CT 06084
(860) 871 - 4011

Trackdown Survey Sites

- Reach 2 – one broken stormwater pipe in need of repair or retrofit (R2OT1), as well as an area of severe stream bank erosion in need of stabilization.
- Reach 7 – two instances of moderate stream bank erosion in need of stabilization (R7ER1), a stream crossing that inhibits fish passage, and a pipe discharging road runoff directly into the stream.
- Reach 8 – two areas of severe bank erosion.
- Reach 9 – collapsed bank and down-cutting, sediment island and sediment delta (R9SC2).
- Reach 10 – two outfalls in need of outlet protection (R10OT1 and R10OT2), an area of slope failure and erosion of a stream bank.
- Reach 11 – an area of heavy sediment deposition and an area of excess debris, both in need of removal, a pond contributing sediment to the stream is in need of riparian management.
- Reach 12 – a culvert contributing sediment is a candidate for daylighting, eroding stream segment contributing sediment is in need of stabilization.
- Reach 15 – excess sedimentation at the mouth of an outfall would improve with outfall protection, stream flow has been altered and is in need of repair to reduce sedimentation.
- Reach 16 – farmland water pump causing sedimentation, livestock have access to buffer zone and stream.
- Reach 17 – outfall configuration allows livestock to enter the stream, a portion of the stream containing an old farm pond is in need of restoration.
- Reach 18 – severe stream bed and bank erosion contributing to sediment load is in need of stabilization; elevated culvert is eroding, inhibiting fish passage, and causing embankment failure.
- Reach 19 – severe bank erosion in two areas in need of restoration, outfall stabilization needed for one pipe (R19OT1), retrofit needed to control bacteria at another outfall (R19OT2), two culverts inhibiting fish passage.
- Reach 20 – excess sedimentation from bank erosion in two areas (R20ER1 and R20ER2) in need of stabilization, two culverts contributing to sediment deposition need alterations, sediment basin is in need of riparian management to keep sediment out of the stream.


Broad Brook Mill Pond – Parking Area

The locations of these sites can be seen on Map 24: North Central Conservation District Trackdown Survey Reach Conditions.

Broad Brook Mill Pond (ducks, water fowl)

Broad Brook Mill Pond is located between Depot Street and Route 191. The southern end of the pond, located at the junction of Route 191 and Depot Street, is dammed. Surrounding land use/land cover consists of high density residential property along the western and south-eastern portion of the pond. The east/northeastern edge of the pond is bordered by mixed forest cover. The large size of the pond and the sparsely vegetated western perimeter of the waterbody make it an ideal location for waterfowl.


Broad Brook Mill Pond


East Windsor Town Park

Stormwater runoff represents another potential source of pollutant loading to the pond. Although no specific investigation was conducted to determine how many outfalls exist around the pond, it is likely that there are several which discharge either directly or indirectly into the pond. At least two catch basins were observed along Route 191 and are believed to be discharging into the Reservoir.

Options for addressing the sources of pollution include the following:

- Install catch basin filters in each catch basin that is part of the network discharging to the pond. The filters should be properly maintained to ensure maximum efficiency.
- Construct either a detention basin or stormwater wetland to capture the runoff prior to entry into the pond. Both systems would require regular maintenance to ensure maximum efficiency.
- Establish a controlled street sweeping program for the roads that have catch basins which discharge to the pond. Conducting such a program could serve as a way to evaluate the effectiveness of street sweeping and to assist in determining the best

timing for sweeping to be conducted. Street sweeping could be performed as a stand alone measure or in conjunction with any of the other measures suggested for the pond. As a complementary practice, sweeping would reduce the level of maintenance required for filters, detention basin, or constructed wetland because it would decrease the amount of solids being transported.

- Buffer the western edge of the pond with woody vegetation. This may reduce the number of waterfowl that use the pond. Based on the size of the pond and the amount of visible surface area, this may have a limited effect in deterring waterfowl from using the pond. The establishment of a buffer will, however, help to mitigate any pollutant loading that is currently occurring from land bordering the pond.

East Windsor Park (Reservoir Road) – Ball fields

The East Windsor Park is a municipally owned parcel located on Reservoir Road in East Windsor. The property is 21.5 acres in size and is home to a swimming pond, basketball court, tennis courts, picnic areas and several ball fields.

The swimming pond, approximately ½ acre in size, is an in-stream pond. This means that the pond was excavated (constructed) within the Chestnut Brook stream channel. An in-stream settling pond was constructed just upstream from the swimming pond. An earthen impoundment divides the two ponds. A 36" culvert was installed in the earthen impoundment to allow flow between the ponds.

The potential sources of pollution at the park include waterfowl waste and stormwater runoff.

Option 1:

No riparian vegetation exists along the eastern side of the settling pond or the swimming pond. It is recommended that a vegetated buffer be planted along the eastern side of the ponds. The buffer should be a minimum of 25 feet wide. Along the settling pond the buffer should extend the length from Reservoir Road, where Chestnut Brook feeds the pond, to just beyond the earthen impoundment dividing the settling pond and the swimming pond. (See Figure 2, red line designates buffer section)

Figure 2

The vegetated buffer along the swimming pond should start at the impoundment separating the two ponds and stop just before the beach area. This is shown in Figure 2 by the yellow line.

Additional vegetated buffers could be planted along the eastern side of Chestnut Brook downstream from the ponds (blue line in Figure 2). The installation of this buffer would minimize pollutant loading from stormwater runoff originating elsewhere in the park.


East Windsor Town Park

The buffers may also serve as a deterrent for any geese or other waterfowl that are using the ponds. Goose waste was observed on the grounds around the ponds.

The length of buffer along the settling pond is approximately 440 feet, while the reach of Chestnut brook downstream from the swimming pond is 425 feet, and 135 at the southern end of the swimming pond could be buffered. Together the three segments total 1000 feet. If all three segments are replanted with a tree and shrub establishment at the minimum width of 25 feet, just over ½ acre would be planted. Using $2,400/acre cost, the buffer planting would cost approximately $1,380.00. If all three sections were to be planted in herbaceous or grass buffer the cost would range between $260 and $495, depending on the mix selected.

Option 2:

As seen in the foreground of the adjacent image, an outlet labeled as a sewer line runs through the park. Similarly, the raised structure in the background of the picture is a catch basin junction box. It should be determined if stormwater runoff is being discharged from either of these lines directly into the brook. If the lines are directly discharging into Chestnut Brook, catch basin filters can be installed. Furthermore, if the sewage line is active the material should be treated prior to discharge in order to minimize or eliminate pollutant loading. A leaching area could be constructed on site to treat the effluent prior to discharge into the Brook.

East Windsor Town Park

Conclusion

Next Steps

It should be understood that local stakeholders can use this plan as a guiding document for improving water quality and the overall health of the Broad Brook watershed. In order to implement the most effective BMPs and achieve the greatest likelihood for success, it is incumbent upon the stakeholders and the CT DEP to work in collaboration and cooperation. Through a collaborative and cooperative effort the watershed community and the State can prioritize both short and long term needs and goals, and find appropriate partners to help meet those goals.

When developing projects for implementation it should be kept in mind that the findings in this report are preliminary in nature. The level of success and effectiveness is a function of the accuracy and precision of the data used and assumptions governing the proposed models. First, water quality data for the basin is limited. Only two water quality monitoring stations are established in the basin, both within a mile of the mouth of the Broad Brook main stem. Second, this plan used existing data and literature to determine potential sources and rates of bacterial loading in the watershed were derived from existing data and literature. Similarly, BMP effectiveness was based on existing studies. As a consequence of these factors the estimates and assumptions upon which this report are predicated may not accurately reflect all of the existing and changing conditions in the watershed. While not a prerequisite for implementation, additional monitoring of existing water quality and BMP effectiveness would improve the likelihood for the success and effectiveness of efforts to improve water quality.

Additional monitoring would help to ‘localize’ sources of pollutant loading and BMP monitoring would allow stakeholders and the State to develop a realistic sense of the effectiveness of implemented conservation measures. Employing this method of implementation would allow for adaptive management principles to be applied to water quality work in the watershed: the community could effectively modify its approach to reducing pollutant loading by having accurate data upon which to base its decisions.

The need for additional information should not deter stakeholders from beginning efforts to improve water quality. Education and backyard conservation can serve as the starting points for a campaign to change the way in which people think and act about and toward the natural resources in their community.

Milestones, Scheduling, and Goals

Outlined below is a working (dynamic) plan of operation or actions that can be used as a basic framework for initiating implementation of projects within the Broad Brook Basin. The goals and objectives are not listed in any particular order or order of importance or priority. Rather, they represent a general list of desired outcomes with possible actions that will help them to be realized. The table should be considered as a dynamic or working document; one that can be modified as work is completed, as priorities change, as financial and technical resources are available. Implementation of best management practices is a fluid process that benefits as much from pre-planning as it does from an ability of stakeholders to adapt to changing situations and respond to the energy and direction of the local community.

Implementation efforts are a key priority and the next step to the WBP. Some of the BMPs identified in this report can be implemented on a small scale with relative ease and in a short timeframe. Some examples of these BMPs are dog waste cleanup, septic system maintenance and pump out, and installation of residential rain gardens or rain barrels. Other BMPS will require a longer timeframe to implement due to design and permitting needs. If additional scheduling and planning is needed, local stakeholders should do so before applying for implementation funds. Local stakeholders should determine and clearly define the implementation priorities and best management practices for which they want to use the proposed funding. Once goals and objectives are clearly prioritized, local stakeholders can outline and schedule the milestones needed to meet the desired objective.

Table 17: Milestones, Scheduling and Goals

Goal	Improved water quality of the Broad Brook watershed by reducing bacterial contamination and degradation from other non-point source pollutants, including nitrogen.
Objective 1	Identify potential sources of funding (1 year)
Actions/Milestones	Research funding organizations
	Incorporate funding source information into the WBP
	Grant application submitted for specific project
BMPs	N/A
Responsible Parties	CT DEP, NRCS, NCCD, Municipalities, Private Land owners, NGO's…
Timeline	1 - 3 years
Anticipated Products	Section of WBP with funding potential sources identified.
Estimated Cost	N/A
Evaluation	N/A
Objective 2	Work with the agricultural community to enhance understanding of land stewardship and use of BMPs to protect water quality.
Actions/Milestones	Gather existing educational information for agricultural management, and develop new agricultural management educational materials as needed.
	Create new materials (includes both general information as well as information specific to particular types of agriculture [horse farming, greenhouse operations, etc…])
	Distribute written materials to agricultural operators in the watershed
	Provide materials explaining State (CT DOA, CT DEP) and Federal (USDA) programs
	Advertise the Horse Educations and Awareness Program (HEAP and work to involve horse farm operation in HEAP
	Conduct workshops dependent upon interest and need.
	Obtain funding to produce and distribute materials and to conduct workshops.
BMPs	Educational materials and workshops.
Responsible Parties	NCCD, NRCS, RC&D, CT DOA, CT DEP, FSA, AFT, Farm Bureau
Timeline	1 - 10 years
Anticipated Products	Educational materials
Estimated Cost	N/A
Evaluation	Surveys regarding product effectiveness, participant feedback, surveys.
Timeline	1 - 10 years
Objective 3	Build awareness of nonpoint source management practices and reduce nonpoint source contributions from residential areas through development and distribution of educational materials.
Actions/Milestones	Collect existing educational materials
	Develop new and/or revise existing materials as needed.

	Distribute materials to residential and urban watershed residents Conduct workshops focusing on non-point source issues Obtain funding to produce and distribute materials and to conduct workshops.
BMPs	
Responsible Parties	NCCD, NRCS, CT DEP, CT Forest and Parks Assoc., Jonah Center, Middlesex Land Trust, Municipalities
Timeline	1 - 10 years
Anticipated Products	Educational materials and workshops.
Estimated Cost	N/A
Evaluation	Surveys regarding product effectiveness, participant feedback, surveys.
Timeline	1 - 10 years

Objective 4	Establish riparian buffers in priority areas
Actions/Milestones	Identify priority sites for establishment of buffers Contact landowners to obtain determine level of interest, cooperation, and obtain permission Obtain funding for implementation of five (5) buffer sites Design the riparian plantings (develop a painting plan) Plant the buffers Water quality monitoring
BMPs	Established buffers
Responsible Parties	NCCD, NRCS, CT DEP, land owners, Municipalities
Timeline	2 - 4 years
Anticipated Products	Planting/Buffer design plans, before-after photo documentation of sites
Estimated Cost	$450/ac - $2,400/ac (dependent on materials selected)
Evaluation	Photo documentation. Pre-post water quality monitoring of sites, documentation of number of sites and the linear feet buffered
Timeline	3 - 6 years

Objective 5	Assess septic systems to determine if areas of failure and investigate for illicit discharges in priority areas. Develop plan to address failing systems or illicit discharges.

Actions/Milestones	Work with Town sanitarians to evaluate the residential septic systems in the priority areas as defined by the WBP
	Provide educational materials regarding septic system maintenance and municipal ordinances
	Prioritize areas for assessment
	Asses the sites
	Report findings
	Select sites for repair or enforcement
	Work with landowners to implement repairs
	Select and hire contractors
	Repair systems
BMPs	Repaired septic systems and eliminated illicit discharges
Responsible Parties	Municipalities (Town Sanitarians), landowners
Timeline	5 - 10 years
Anticipated Products	Fixed septic systems, elimination of illicit discharges
Estimated Cost	N/A
Evaluation	Photo-documentation, sanitarian confirmation, municipal testing and monitoring
Timeline	1 - 3 years

Objective 6	Implement ongoing water quality monitoring program in the watershed to develop baseline conditions and measure changes pre and post BMP implementation.
Actions/Milestones	Identify specific locations for monitoring (10 - 15 sites). Sites should include at least one location (e.g. confluence) for each of the tributaries to the main stem and some sites along the minister
	Obtain funding for monitoring program
	Develop monitoring parameters and program details
	Train volunteers (if necessary)
	Monitor sites
	Report results
BMPs	Report that improves knowledge of originating locations of bacteria and other nps pollutants
Responsible Parties	CT DEP, USGS, NCCD, Local stakeholders, Municipalities
Timeline	1 - 5 years
Anticipated Products	Monitoring data, report describing data, recommendations for focus areas
Estimated Cost	
Evaluation	Review data with appropriate agencies
Timeline	1 year

Objective 7	Implement Place Based BMPs - structural and non-structural measures, to reduce bacteria loading along with nitrogen and other nps pollutants.
Actions/Milestones	Prioritize place-based sites
	Select sites and contact landowners to determine level of interest and cooperation
	Apply for grants and funding; obtain funding
	Develop design for structural BMP implementation
	Develop implementation plan for non-structural measures
	Obtain proper permits
	Construct structural measures; implement non-structural measures
	Monitoring program to assess practice effectiveness
BMPs	Construction of structural practices (e.g. stormwater wetlands, stormwater treatment units...) implementation of non structural practices (e.g. street sweeping, dog waste management, etc…)
Responsible Parties	Municipalities, NCCD, NRCS, local stakeholders
Timeline	3 - 6 years
Anticipated Products	Monitoring report, Photo documentation, site design plans
Estimated Cost	See cost estimates in report.
Evaluation	Document number of sites, monitoring data to show effectiveness, quantify level of pollutants (e.g. sediment, animal feces, etc…) removed
Timeline	2 - 10 years

Objective 8	Strengthen municipal land use regulations and Plans of Conservation and Development to protect water quality and minimize future water quality degradation issues.
Actions/Milestones	Review the findings of the Regulations review (conducted as part of the WBP effort) with municipal officials and commissions (Examine regulations including but not limited to zoning, subdivision, wetlands, erosion and sedimentation, …)
	Gather existing model regulations to present to local officials and commission members
	Work with local staff and commissions to develop regulations and language that reflect the interests of the local communities
	Adoption of the new language, amendments, and regulations
BMPs	Provide information regarding water quality, implementation municipal control measures
Responsible Parties	Municipalities, NCCD, NRCS, CT DEP, NEMO
Timeline	1.5 - 10 years
Anticipated Products	Municipal regulations and language incorporated into municipal regulations
Estimated Cost	N/A
Evaluation	Work with municipal staff, commission members, and developers to ascertain effectiveness, challenges and opportunities.
Timeline	3 - 5 years

Monitoring

Monitoring is an important step in determining the effectiveness and efficiency of implemented practices. According to the EPA monitoring both water quality and land treatment helps to

> ensure smooth implementation and to measure progress toward meeting goals. The adaptive management approach is not linear but circular, to allow you to integrate results back into your program. You need to create decision points at which you'll review information and then decide whether to make changes in your program or stay the course. Figure 13-2 illustrates how the adaptive management approach feeds back into your program based on information gathered from monitoring and management tracking. As part of your evaluation efforts, you'll periodically review the activities included in your work plan and the monitoring results to determine whether you're making progress toward achieving your goals.

Funding Sources

A table of potential funding sources was developed by DEP, with assistance of NRCS. (See Table 17). The funding entities and grant programs listed in the table is not necessarily a complete list. Watershed stakeholders can use the table as a starting point to seek funding opportunities for implementation of the BMP recommendations in this report. The DEP maintains a funding sources list on its website. Please refer to http://www.ct.gov/dep/cwp/view.asp?a=2719&q=335494&depNav_GID=1654&pp=12&n=1 for the most current funding list.

The recommendations in this report will support future grant proposals by demonstrating a comprehensive analysis of watershed conditions and presenting options for addressing identified concerns. Moreover, the table can be considered a dynamic document. Modifications can be made to reflect changes to the availability of funding or changes to the funding cycle, and to include other funding entities or grant programs. It should be understood that different funding sources prioritize different aspects and elements of watershed projects. One funding source may be more appropriate for planning activities while another may be more focused on implementation. Links and emails included in the table below are current as of March 2010.

Table 18: Potential Funding Sources

Funding Source	Maximum Dollar amount	Minimum Dollar amount	Required match	Applications Open	Deadline
DEP Watershed Funding Website					
http://www.ct.gov/dep/cwp/view.asp?a=2719&q=335494&depNav_GID=1654&pp=12&n=1 Index of many potential funding sources for funding watershed-based planning projects.					
DEP CT Landowner Incentive Program	up to $25,000	at least 25%			
http://www.ct.gov/dep/cwp/view.asp?a=2723&q=325734&depNav_GID=1655					
DEP Long Island Sound License Plate Program	$25,000			January	March
http://www.ct.gov/dep/cwp/view.asp?a=2705&q=323782&depNav_GID=1635					
DEP Open Space and Watershed Land Acquisition				March	June
860-424-3016 david.stygar@ct.gov http://www.ct.gov/dep/cwp/view.asp?a=2706&q=323834&depNav_GID=1641					
DEP Recreation and Natural Heritage Trust Program					
http://www.ct.gov/dep/cwp/view.asp?a=2706&q=323840&depNav_GID=1641					
Eastman Kodak / Nat'l Geographic American Greenways Awards optional Program	$2500	$500	Optional	April	June
jwhite@conservationfund.org, Jen White					
EPA Healthy Communities Grant Program	35,000	5,000	optional, up to 5%	March	May
617-918-1698 Padula.Jennifer@epa.gov					
Northeast Utilities Environmental Community Grant Program	250	1,000			15-Apr
http://www.nu.com/environmental/grant.asp Cash incentives for non-profit organizations					
EPA Targeted Watershed Grants Program			25% of total project costs (non-federal)		
http://www.epa.gov/twg/ Requires Governor nomination.					
DEP CWA Section 319 NPS			40% of total project costs (non-federal)		October 15
Nonpoint Source Management http://www.ct.gov/dep/nps 20-25 projects targeting both priority watersheds and statewide issues.					
DEP Section 6217 Coastal NPS			N/A		

http://www.ct.gov/dep/cwp/view.asp?a=2705&q=323554&depNav_GID=1709 Section 6217 of the CZARA of 1990 requires the State of Connecticut to implement specific management measures to control NPS pollution in coastal waters. Management measures are economically achievable measures that reflect the best available technology for reducing nonpoint source pollution.					
DEP Hazard Mitigation Grant Program			75% Federal/25% Local		
http://www.ct.gov/dep/cwp/view.asp?a=2720&q=325654&depNav_GID=1654 Provides financial assistance to state and local governments for projects that reduce or eliminate the long-term risk to human life and property from the effects from natural hazards.					
NRCS Conservation Reserve Program					
Joyce Purcell, (860) 871-4028					
American Rivers-NOAA Community-Based Restoration Program Partnership					
http://www.amrivers.org/feature/restorationgrants.htm These grants are designed to provide support for local communities that are utilizing dam removal or fish passage to restore and protect the ecological integrity of their rivers and improve freshwater habitats important to migratory fish.					
FishAmerica Foundation Conservation Grants	average 7,500				
703-519-9691 x247 fishamerica@asafishing.org					
Municipal Flood & Erosion Control Board	1/3 project cost	2/3 project costs			
NFWF Long Island Sound Futures Fund Small Grants	6,000	1,000	optional (non-federal)	Fall	February
631-289-0150 Lynn Dwyer LISFFAnfwf.org					
NFWF Long Island Sound Futures Fund Large Grants	150,000	10,000	optional(non-federal)	Fall	February
631-289-0150 Lynn Dwyer LISFFAnfwf.org					
NRCS Wildlife Habitat Incentives Program (WHIP)	50,000/year	1,000	25%		
Joyce Purcell, (860) 871-4028 For creation, enhancement, maintenance of wildlife habitat; for privately owned lands.					
NRCS Environmental Quality Incentives Program (EQIP)	50,000/year		25 - 50%		
Joyce Purcell, (860) 871-4028 For implementation of conservation measures on agricultural lands.					
NRCS Healthy Forests Reserve Program					
NRCS Wetlands Reserve Program					
Nels Barrett, (860) 871-4015					

USFS Watershed and Clean Water Action and Forestry Innovation Grants					
http://www.na.fs.fed.us/watershed/gp_innovation.shtm This effort between USDA FS-Northeastern Area and State Foresters to implement a challenge grant program to promote watershed health through support of state and local restoration and protection efforts.					
Corporate Wetlands Restoration Partnership (CWRP)	typically 20,000	typically 5,000	3 to 1	April and August	
http://www.ctcwrp.org/9/ Can also apply for in-kind services, e.g. surveying, etc.					
DEP 319 NPS Watershed Assistance Small Grant			40% of total project costs (non-federal)		
860-361-9349 rivers@riversalliance.org					
Trout Unlimited EmbraceAStream	5,000				
USFWS National Coastal Wetlands Conservation Grant Program	1 million		50%		
Ken Burton 703-358-2229 Only states can apply.1					
YSI Foundation	60,000		optional	March	April
937-767-7241 x406 Susan Miller Susan Miller smiller@ysi.com					
Grants Program	$2,500	$500			November
(860) 347-0340					
Other Financial Opportunities					
Private Foundation Grants and Awards					
http://www.rivernetwork.org Private foundations are potential sources of funding to support watershed management activities. Many private foundations post grant guidelines on websites. Two online resources for researching sources of potential funding are provided in the contact information.					
Congressional Appropriation - Direct Federal Funding					
Congressman Larson, Courtney, DeLauro, Shays, Murphy					
State Appropriations - Direct State Funding					
http://www.cga.ct.gov/					
Membership Drives					
Membership drives can provide a stable source of income to support watershed management programs.					
Donations					
Donations can be a major source of revenue for supporting watershed activities, and can be received in a variety of					

ways.					
User Fees, Taxes, and Assessments					
Taxes are used to fund activities that do not provide a specific benefit, but provide a more general benefit to the community.					
Rates and Charges					
Alabama law authorizes some public utilities to collect rates and charges for the services they provide.					
Stormwater Utility Districts					
A stormwater utility district is a legal construction that allows municipalities to designated management districts where storm sewers are maintained in order to the quality of local waters. Once the district is established, the municipality may assess a fee to all property owners.					
Impact Fees					
Impact fees are also known as capital contribution, facilities fees, or system development charges, among other names.					
Special Assessments					
Special assessments are created for the specific purpose of financing capital improvements, such as provisions, to serve a specific area.					
Sales Tax/Local Option Sales Tax					
Local governments, both cities and counties, have the authority to add additional taxes. Local governments can use tax revenues to provide funding for a variety of projects and activities.					
Property Tax					
These taxes generally support a significant portion of a county's or municipality's non-public enterprise activities.					
Excise Taxes					
These taxes require special legislation, and the funds generated through the tax are limited to specific uses: lodging, food, etc.					
Bonds and Loans					
Bonds and loans can be used to finance capital improvements. These programs are appropriate for local governments and utilities to support capital projects.					
Investment Income					
Some organizations have elected to establish their own foundations or endowment funds to provide long-term funding stability. Endowment funds can be established and managed by a single organization-specific foundation or an organization may elect to have a community foundation to hold and administer its endowment. With an endowment fund, the principal or actual cash raised is invested. The organization may elect to tap into the principal under certain established circumstances.					
Emerging Opportunities For Program Support					
Water Quality Trading					
Trading allows regulated entities to purchase credits for pollutant reductions in the watershed or a specified part of the watershed to meet or exceed regulatory or voluntary goals. There are a number of variations for water quality credit trading frameworks. Credits can be traded, or bought and sold, between point sources only, between NPSs only, or between point sources and NPSs.					

Mitigation and Conservation Banking					
Mitigation and Conservation banks are created by property owners who restore and/or preserve their land in its natural condition. Such banks have been developed by public, nonprofit, and private entities. In exchange for preserving the land, the "bankers" get permission from appropriate state and federal agencies to sell mitigation banking credits to developers wanting to mitigate the impacts of proposed development. By purchasing the mitigation bank credits, the developer avoids having to mitigate the impacts of their development on site. Public and nonprofit mitigation banks may use the funds generated from the sale of the credits to fund the purchase of additional land for preservation and/or for the restoration of the lands to a natural state.					

Appendices

Appendix A: Trackdown Survey Findings

Reach 1: Confluence with Scantic River to junction with Church Street
Impact Forms:

- Stream Crossing

Reach 1 contains clear water flowing over a gravel substrate. No water quality issues were observed. There are no signs of algae or aquatic plants in the reach, but there was evidence of raccoon along the banks. A fallen log crosses the channel about a quarter of a mile from the start. The land surrounding the area is forested, and is accessible for heavy equipment and stockpiling materials.

Stream Crossing R1SC1, located at the downstream limit of the reach, is a cement box culvert with an overlying road (Church Street). Consisting of three barrels, the culvert is 8 feet tall, 8 feet wide and 30 feet long. The structure is not flow-aligned; the flow of the river trends toward the left bank. There is a sediment deposit in one of the barrels. There are no problems associated with the structure.

Reach 2: Junction with Church Street to ½ mile upstream
Impact Forms:

- Outfalls (2)
- Impacted Buffer
- Stream Crossing
- Severe Bank Erosion

Water in this reach is opaque and milky. The stream bed is gravel. There are no aquatic plants, but some algae were observed attached to the substrate. Fish were observed. The reach is uniformly incised with slight meanders nearest the start and end of the segment. Forest habitat borders the reach, and access is somewhat limited.

There are two outfalls emptying into the stream. The first, R2OT1, is an 18 inch circular concrete pipe. It is suspended above the stream and discharges directly into it, but no pooling or scour was observed. The pipe was not flowing, and no odor, deposits, stains, or vegetation were documented. The pipe is broken. It was identified as a possible candidate for a storm water retrofit. Access with machinery is possible.

The second, R2OT2, is a circular concrete pipe 18 inches in diameter with a flared end and no headwall. The pipe emerges from the slope near the bottom of the bank and is surrounded by riprap. It has no flow, odor, deposits or stains associated with it. The overall condition of the pipe is excellent and does not require any restoration.

The area surrounding R2OT2 is an impacted buffer. The site (R2IB1) is on the right bank and is covered with riprap to stabilize the slope around the outfall pipe. At the top of the bank is a guardrail immediately bordered by a road. The rip-rapped slope is 200 feet long and 15 feet wide. The site is a potential candidate for replanting and re-vegetation. However, the site currently stable and should be evaluated in the context of other restoration priorities. A small wooden bridge spans the brook.

A section of severe erosion was identified near the bottom of the reach. The section is located at a large meander segment in the stream. The affected area is about 50 feet long and three feet wide and situated on the left bank. There is also evidence of deposition of sediment on the adjacent right bank, behind the meander bend. The segment has been identified as actively widening and eroding at a moderate rate, though posing no threat to property or infrastructure. It has been suggested the area be considered for possible restoration in the form of bank stabilization. The site has good access for heavy machinery and material stockpiles.

Reach 3: New box culvert (R3SC1) to Mill Pond Dam

Impact Forms:

- Outfalls (2)
- Stream Crossing (3)
- Misc.: USGS Monitoring Station, Tributary

Reach 3 is composed mostly of a cobble bed. Water flow is opaque or milky. The majority of the reach is channelized, with a wide elbow bend at the top and meandering bends at the lower limit. Although there are no aquatic plants, algae is attached to the substrate in certain sections. The stream is mostly shaded and a mature Tiger Trout was observed.

Chestnut Brook enters the stream about halfway down the reach. There were no significant changes in main-stem stream characteristics or water quality downstream from the confluence. A section of the stream, just above Chestnut Brook is abutted by a brownfield. An active USGS stream gauge is present near the upper limit of the reach. The area surrounding the reach is suburban, and access to the stream is somewhat limited and would require tree removal or impact to landscaped areas.

A number of stream crossings are present. The first, located at the top of the reach, is a single-barreled box culvert with an overlying road. The structure is concrete and is flow aligned. There are no problems associated with the crossing. A second stream crossing exists just downstream from the Mill Pond Dam. This structure, R3SC2, is a single-barreled concrete bridge that spans the stream. Although the bridge is flow-aligned, there is evidence of a downstream scour hole possibly associated with the structure. The bridge also acts as grade control. The third structure, R3SC3, is Mill Pond Dam. It is made of poured concrete, and achieves total physical blockage of the stream. The structure does not include any fish passage device. It has been identified as a possible candidate for restoration, the focus of which would be modification for fish passage.

There are two outfalls that discharge into the stream. The first, R3OT1, is located at the top of the reach. The structure is an 18- inch concrete pipe on the bottom of the left bank. There was a trickle of flow discharging from the pipe despite the area receiving no rain 24 hours before the site visit. There was also green benthic growth associated with the discharge. The pipe has no headwall and is surrounded by a riprap-stabilized slope. The pipe discharges into a poorly-protected pool. It has been identified as needing outfall stabilization.

The second outfall is located in between the two stream crossings at the reach's lower limit. The structure is an 18 inch concrete pipe at the top of the right bank. The pipe is stained black in the area of centralized flow, but no odors were observed. There is a pool at the discharge of the pipe caused by inadequate outlet protection. The pipe has been identified as a candidate for a storm water retrofit.

Reach 4: Mill Pond Dam to just upstream of unnamed tributary
Impact Forms:

- Misc.: (Phragmites)

The stream bed of Reach 4 is dominated by silt and clay, and most of the water flowing through it is turbid and full of suspended matter. A section of the stream is channelized, but the stream also has several meandering bends. The start of the reach is Mill Pond, created from the concrete dam observed in Reach 3. There is a large stand of Phragmites australis located in the northwest corner of the pond. Access to the Phragmites for restoration would be difficult. Further upstream is a wetland area adjacent to a large meander bend. Near the end of the reach is an unnamed tributary that discharges into the stream. The overall condition of the stream is considered suboptimal due to the altered in-stream habitat (the pond), bank erosion, and floodplain modification. There are no structures or outfalls in this reach of the stream, and the entire area is forested.

Reach 5: Reach 4 end to Reach 6 start
Access to this reach was denied by the landowner. Conditions are unknown, no data was collected.

Reach 6: Reach 5 end to upstream of stream crossing (R6SC4)
Impact Forms:

- Stream Crossing (4)

Reach 6 consists of turbid water flowing over a mostly gravel bed. The stream is channelized, with a slight meander toward both the start and the end of the reach. It is mostly shaded, with a large amount of algae attached to the stream bed. In-stream habitat and vegetative protection are optimal. There is some bank erosion through the reach. The banks of the stream are actively widening, though the action poses no threat to property or infrastructure.

There are a number of stream crossings on the reach. The first (R6SC1) is a footbridge that spans the width of the stream. The bridge is made of wood and is in stable condition. No restoration efforts are needed.

R6SC2 is a stream crossing for farm equipment. There is no infrastructure present, only a gravel bed crossing the channel. Stabilizing the crossing would reduce the impact to the stream.
The third crossing, R6SC3, is a railroad bridge that spans the width of the stream. The structure is concrete and does not intrude into the stream. There is evidence of chipping, cracking, or corrosion associated with the bridge. The bridge is acting as a form of grade control. The severity of the degradation of the structure is not critical, and the crossing is not a candidate for potential restoration.
R6SC4 is a triple box culvert made of concrete with an overlying road. The condition of the structure is good, and no restoration is required.

Reach 7: End of Reach 6 to upstream of stream crossing (R7SC2)
Impact Forms:

- Outfall
- Severe Bank Erosion (2)
- Stream Crossing (2)
- Trash and Debris

Reach 7 consists mostly of turbid water flowing over a cobble bed layer. Some channelization is present, but for the most part the stream flows through large meander bends. Although no in-stream aquatic plants are present, the stream does harbor a large amount of attached algae and some floating colonies. Overall, the condition of the stream is nearly optimal, with good in-stream habitat, vegetative protection. Bank erosion limited to a few small areas. The only concern with the reach is moderate floodplain encroachment due to filling or manmade structures in a few locations.

Two areas of bank erosion were noted. The first, R7ER1, is approximately ¼ mile upstream from the start of the reach. It is located on the left bank of a meander bend, and consists of slope failure. The stream is actively widening at this point, and the banks are eroding at a moderate rate. Although the erosion is not a threat to property or infrastructure, bank stabilization is recommended. Access to the area, however, is difficult due to steep slopes woods.

The second bank area is further upstream on a straight section of stream after a meander bend. The erosion site is on the left bank. There is active bank erosion that could be stabilized with hard armoring.

A pile of rocks creates a stream ford about 1/8 mile from the top of the reach. Apparently manmade, the rocks create rapids downstream and prevent fish passage. Another stream crossing is present near the end of the reach. R7SC2 is an elliptical metal bridge. The structure is in fair condition and is flow-aligned. Under the bridge is a stormwater outfall. Located on the left bank, it emerges six feet from the channel. The 18 inch pipe is corrugated metal there is no headwall. It is a potential candidate for a storm water retrofit, as it discharges road runoff directly into the stream.

Reach 8: End of Reach 7 to ½ mile upstream

Impact Forms:

- Severe Bank Erosion (2)

Reach 8 has a mostly cobble bed and water is clear. The stream meanders over the course of the reach, though some areas are channelized. Aquatic vegetation is minimal, and there are colonies of algae attached to the stream bed. Two tributaries enter the reach; discharge from Thompson Pond enters the brook about halfway through the reach, and an unnamed tributary enters just upstream from a manmade log stream crossing. Both streams introduce sediment-laden water into the system. Evidence of beaver activity was present along the stream. Overall, the condition of the stream is suboptimal and two sites of severe bank erosion. The riparian zone and floodplains are in good condition, with a wide buffer zone and forested floodplain. Access to the reach is limited.

There are two sites of severe bank erosion located on the same meander bend. Although the erosion poses no threat to infrastructure or property, the bank is actively eroding. Both sites are restoration candidates. Access to the area is difficult.

Reach 9: Upstream of R9SC1 to R9ER1

Impact Forms:

- Stream Crossing

- Severe Bank Erosion
- Impacted Buffer

Reach 9 has clear water flowing over a mostly cobble bed-layer. The brook meanders extensively toward the end of the reach. While there is no aquatic vegetation present in the stream, there are colonies of algae attached to the bed. A tributary, Creamery Brook, enters the reach about ¼ mile from the start. In two separate locations, there are fences that cross the stream which are collecting debris. The overall condition of the stream is suboptimal due to lack of vegetative protection and poor in-stream habitat. The majority of the floodplain vegetation is shrub or old field growth.

Toward the end of the reach, a large section of the bank has collapsed. It is located on the outside edge of a meander bend. The height of the bank is estimated to be approximately 40 feet high and is nearly vertical. Much of the reach is actively down-cutting. The erosion is currently not a threat to infrastructure or property, and there adequate access to the affected area through a privately owned field. The bank is a candidate for restoration.

There are also two sites where sedimentation was observed. An approximately 20 feet long channel, island has formed within the channel. Restoration potential is limited because of poor access. Further down the reach, sedimentation has occurred in the form of a sediment delta on the left bank of the stream. Restoration here may be possible with access from an earthen stream crossing (R9SC2).

Invasive vegetation in the reach is widespread. Colonies of Multiflora rose and Autumn Olive are present on both banks. The level of invasive presence is extensive.

Reach 10: End of Reach 9 to start of Reach 11

Impact Forms:

- Outfalls (4)
- Severe Bank Erosion
- Stream Crossing (4)

Reach 10 consists of clear water flowing over a mostly cobble-lined bed layer. Aquatic plants are common and there is a large amount of algae attached to the bed. The stream bed is covered in a layer of silt and/or organic material. There is evidence of fish, deer and raccoon. The overall stream condition is sub-optimal, with the most significant problems associated with the floodplain system. The area is surrounded by pasture and some sections have no buffer. The reach also contains a number of manmade structures that may effect on floodplain's function.

A number of outfalls discharge into Broad Brook at this reach, two of which are creating bank erosion and contributing to stream sedimentation. R10OT1 is a corrugated metal pipe that discharges midway up the left bank. The outfall is lined with an inadequate rip-rap splash pad. Additional stabilization is warranted. R10OT2 is also causing erosion and sedimentation within the channel. Outfall stabilization is the recommended. The last outfall of interest is a channel structure entering the stream from a lawn bordering the stream. The outfall pipe is made of vitrified tile that has become chipped and cracked. The bed layer of the outfall channel is bare earth, and it has been recommended that riprap be installed in order to halt stream sedimentation.

A section of bank erosion exists on the right bank of one of the channelized sections of the reach. The slope of the bank has failed due to runoff from an adjacent road, and is causing sedimentation. The severity of the erosion has been classified as minimal, affecting only isolated areas and not eroding at a critical rate. Although not an imminent threat to infrastructure, the affected area is in close proximity to a roadway. Installation of a rigid or hard bank stabilization structure is recommended.

A number of stream crossings are present in the reach, the majority of which are not impacting the stream. There is a small concrete dam which is a partial fish barrier..

Reach 11: End of Reach 10 to upstream of small pond (R11MI1)

Impact Forms:

- Stream Crossing
- Trash / Debris
- Miscellaneous: turbid discharge from pond

Reach 11 has opaque or milky water flowing over areas of silt, clay, and gravel substrates. In addition to algal colonies covering the bed layer in many areas, there is an abundance of attached aquatic plants in the stream channel. In-stream habitat is marginal due to moderately unstable banks and in-stream erosion.

A concrete box culvert with an overlying road is present near the top of the reach. Consisting of three barrels, the culvert is not flow-aligned and directs flow toward the right bank, causing some bank erosion and downstream sediment deposition. There is an area of heavy sediment deposition directly after the culvert. The deposit is vegetated and has begun collecting debris. The area has been identified as a possible candidate for sediment removal.

There are two areas of trash and debris. A rusted lawn tractor, nearly submerged in the middle of the brook, is located in the upper sections of the reach. Further upstream, the remains of a wooden footbridge are present on the bank and in the adjacent channel.

Removal is recommended. In both cases, removal of the debris would restore the channel to its original flow characteristics and prevent the collection of debris.

Near the end of the reach, a small pond, heavily laden with algae and sediment, discharges into the stream. Turbid water from the pond discolors stream flow in the main stem. The pond is a potential candidate for riparian management. Further downstream, a sediment bar has become established mid-channel. The island is changing the flow dynamics of the reach

Reach 12: End of Reach 11 to upstream of road culvert (R12SC1)
Impact Forms:

- Outfall
- Severe Bank Erosion
- Stream Crossing
- Trash / Debris

Reach 12 contains opaque or milky water flowing over a bed layer of mostly silt and clay. The area supports a both attached and floating aquatic plants, as well as numerous algal colonies. The reach is surrounded by suburban areas and cropland. The reach is actively eroding and downcutting. A large amount of sediment is entering the channel from bank erosion. The vegetated buffer is also marginal, especially in the cropland areas, where the buffer zone has been reduced to as little as 10 feet.

An outfall discharges into the stream upstream from the start of the reach. Constructed of concrete and in good condition, the pipe was discharging clear, odorless water upon inspection. The outfall appears to be a source of sediment in the stream and has been identified as a possible candidate for stream daylighting.

The overall condition of the reach is marginal to poor. High banks prevent the stream from accessing the floodplain, and the stream is actively eroding. In addition, the erosion is contributing sediment to the stream, resulting in sections which are extremely turbid. One sections of the stream has experienced bank failure due to undercutting, and the area has been identified as a candidate for bank stabilization.

A triple-barrel box culvert crosses the stream just downstream from the end of Reach 12. The structure is concrete and flow-aligned. Although there is some evidence of sediment deposition, the culvert is not in need of restoration.

The remnants of a small, wooden footbridge can be found just upstream from the start of the reach. The debris is located in-stream, and should be removed as part of a stream cleanup.

Reach 13: End of Reach 12 to start of Reach 14

Impact Forms:

- Miscellaneous

Reach 13 contains turbid water flowing over a sandy stream bed. The reach supports a large amount of algae and plant growth, both floating and attached to the bed. Surrounded by cropland, the quality of the buffer and floodplain is marginal due to a narrow buffer zone and the absence of wetland soils. A farm drainage ditch enters the reach from the surrounding cropland. The stream is also deeply entrenched, keeping flood flow from reaching the floodplain during times of high volume. Evidence of past downcutting is visible, and there is evidence of sediment deposition. A turbidity tube was utilized in three places in the reach: the start, middle, and end. All three measurements were 60 cm, indicating an NTU (Nephelometric Turbidity Unit) of less than 10. The Connecticut Water Quality Standards establish a criterion of 5 NTU, indicating that this reach of Broad Brook is over the accepted value, though only slightly.

There are several areas of extensive sedimentation present in the reach. Five areas of concern were identified, all of which contained large deposits of sediment. In some areas, the depositions are as high as two to three feet above the stream bed. Suspended solids were observed flowing downstream. An additional turbidity tube measurement of 51.5 was taken at R13MI1, indicating an NTU of around 10, slightly higher than the previous measurements. There are also areas of significant organic buildup in the stream.

Reach 14: End of Reach 13 to stream crossing (R14SC4)

Impact Forms:

- Stream Crossing (4)
- Miscellaneous

Reach 14 contains clear water flowing over gravel substrate. A moderate amount of attached aquatic plants exist alongside floating and attached algae colonies. Bahler and Kimball's brooks discharge into the reach from the bordering crop and pastureland. Both of the streams accept drainage from adjacent farmland. Two additional drainage ditches also enter the reach. The ditches contain approximately two feet of organic matter and sediment and a large concentration of algae.

The floodplain and buffer zones are identified as marginal based on the minimal buffer width, lack of wetland habitat, and manmade activities such as filling and infrastructure. In addition, the banks are not vegetated in some spots, with banks as steep as 90 degrees.

The reach contains four stream crossings, all of which impact the flow of the stream. Two of the crossings, R14SC3 and R14SC4, are concrete pipe culverts, both consisting of two barrels with diameters of 36" and 60", respectively. SC3 is not flow-aligned, and is causing a scour hole downstream. Of the four crossings, only one was identified as being a possible candidate for restoration. R14SC1, another concrete pipe culvert, has debris blocking its mouth, causing a potential fish barrier. It is recommended that the debris be removed to allow the upstream passage of fish.

Reach 15: End of Reach 14 to upstream of stream crossing (R15SC1)
Impact Forms:

- Outfall
- Stream Crossing
- Trash / Debris

Reach 15 contains opaque, milky water flowing over a sandy and gravel bed. Surrounded by forest and pastureland, the stream supports a moderate amount of floating and attached plant life, as well as some attached algal colonies. The reach is in good condition, with the overall stream and floodplain/buffer conditions rated as suboptimal. The bank is stable with only isolated areas of erosion, and high flows are able to enter the floodplain. The buffer zone is between 25 and 50 feet with only minor human encroachment, and there is evidence of standing or ponded water.

An outfall enters the stream close to the end of the reach midway up the left bank. The structure is a 24” flared concrete pipe that discharges about three feet above the level of the stream. Excessive sedimentation was observed at the mouth. Although the severity has been identified as low, the outfall is a possible candidate for outfall stabilization.

Just downstream of the end of the reach is a triple-barrel concrete box culvert. Significant sedimentation is associated with the structure despite being flow-aligned. It is recommended that the area undergo stream repair in order to restore the stream’s original flow dynamics.

Two trash deposits are present in the middle of the reach. The first is a large fuel oil tank resting against the bank. Due to the possibility of the tank containing hazardous materials, it is recommended it be removed. Access, however, is extremely limited and it is unlikely that the necessary heavy equipment would be able to reach the area. Another trash deposit is located directly upstream. The object is large and made of fiberglass, and should be removed. However, to this site is also restricted.

Reach 16: Stream crossing (R15SC1) to start of Reach 17
Impact Forms:

- Impacted Buffer
- Miscellaneous

Reach 16 contains opaque water flowing over a mixture of silt, clay, and cobble substrates. Although there are no aquatic plants present in the reach, there are large areas of algal colonies attached to the bed layer. There are a few bacterial colonies in the middle of the reach which may require further investigation. The suspected bacterial formations appear to be iron bacteria. The bacteria are present in areas adjacent to the town landfill.

Further upstream, several stands of Multiflora rose have colonized the buffer zone. Coverage is widespread, the affected area being approximately 100 feet long and 20 feet wide. The surrounding area is agricultural field, allowing the invasive plant more room to spread. Removal has been recommended to regain the buffer zones functionality.

Impacts from the surrounding farmland are evident throughout the reach. Across from the Multiflora rose stand is a water pump for one of the adjacent farms' irrigation system. The pump has an area of sedimentation associated with it. There are also areas of cattle tracks, indicating that livestock are allowed to enter the buffer zones and stream.

Reach 17: End of Reach 16 to upstream of pond diversion

Impact Forms:

- Outfall (2)
- Stream Crossing (2)
- Channel Modification
- Trash / Debris

Reach 17 contains clear water flowing over a mixture of silt, clay, and sand substrates. The reach is surrounded by pasture, and supports a moderate amount of floating aquatic plants. The buffer zones, however, are sparsely vegetated. The overall condition of the stream is marginal to poor due to extensive disruption of the stream bank and a lack of desirable habitat. The buffer zone is marginal in quality, with a width of 10-25 feet and moderate filling of the floodplain. The reach contains flowing water for a quarter of a mile, where it becomes supplied from the discharge from two ponds. Upstream of the ponds the stream bed is completely dry.

A large, rusted automobile has been left adjacent to the pond. Removal is recommended and would require heavy equipment.

Two outfalls discharge into stream about halfway up the reach. One, hidden amongst vegetation, is functioning properly and needs no restoration. The other, however, is a 24" pipe that is discharging from the adjacent farmland. The configuration of fencing and the pipe allow livestock to enter into the stream channel. It is recommended that the outfall be modified to exclude livestock from the stream.

The reach also has two earthen paths crossing over the stream channel. Used for farm-related crossings, neither of the structures are possible restoration projects.
Reach 17 ends at an old farm pond. The pond was constructed by diverting the stream into both the pond and a diversion channel around the edge of the pond. Remnants of the primary diversion channel exist behind the earthen berm on the banks of the pond, and when the pond fills, water overflows into an auxiliary channel, which merges with the primary diversion channel. The pond has been identified as a restoration candidate to restore original flow conditions. Several restoration techniques could be employed, from removing the dam and restoring the stream channel, to removing fill and turning the area into wetland habitat. Further analysis is needed to determine the additional restoration opportunities.

Reach 18: Upstream of pond to beginning of Reach 19
Impact Forms:
- Severe Bank Erosion
- Stream Crossing (5)

All reaches upstream of Reach 17 were dry or partially dry during the track down survey. Immediately upstream from the pond discussed in the reach 17 assessment, the stream is braided and flows through a thickly wooded area. Further upstream, the stream bed is composed of a cobble substrate. The condition of the stream bed is identified as poor, due to active erosion and inability of overflowing waters to enter the floodplain. A major source of erosion is Kibbe Road, which crosses the stream and contributes sediment. Down-cutting is evident in this location, and bank stabilization measures must be taken in order to reduce the downstream sediment load. The stabilization of this section of the brook is important due to the flow it harbors during and immediately after storm events.

Another source of concern is the culvert under Route 83, which also crosses the stream. Currently, the culvert is a 240 foot long concrete pipe that discharges significantly higher than the stream’s baseflow, causing a fish barrier. In addition, the embankment is failing and the pipe is degrading. Recommended management includes replacing the entire structure with a spanning bridge, restoring fish passage and removing derelict infrastructure.

Reach 19: End of Reach 18 to upstream of stream crossing (R19SC2)
Impact Forms:
- Outfall
- Stream Crossing (2)
- Severe Bank Erosion (2)
- Miscellaneous

Reach 19 was dry during the track down survey. The substrate is a mixture of cobble and boulder. An unnamed tributary enters the stream approximately halfway up the reach, and the surrounding landscape is primarily forested. The overall condition of the stream and buffer / floodplain is suboptimal. Aside from moderate floodplain filling and a deeply entrenched stream, no other problems were observed.

Erosion, however, is extensive in the reach. There are two instances of severe bank erosion just upstream of the start of the reach, both requiring significant restoration measures. Both areas are caused by bank failure and exceed 100 feet in length. Installation of a hard/rigid bank is necessary both for slope stability and to halt the transmission of sediment downstream. Downcutting is also of major concern in other areas of the reach.

Two outfalls discharge into the reach. R19OT1 is a corrugated metal pipe which empties 4 feet above stream level and has been identified as a possible outfall stabilization site. R19OT2, a concrete pipe, had a small flow during the track down survey. Green benthic growth was present around the outfall. Due to this, the pipe has been identified as a possible site for a stormwater retrofit.

There are two different stream crossings in the reach that are identical in structure. The pipes are made of corrugated metal, elliptical in shape, flared, and 50 feet in length. They are, additionally, both fish barriers. Restoration has been recommended in order to allow fish passage upstream.

Reach 20: End of Reach 19 to start of Reach 21

Impact Forms:

- Severe Bank Erosion (2)
- Stream Crossing (2)
- Miscellaneous

Reach 20 was dry during the track down survey. The substrate is a mixture of cobble and boulder. Although the stream was dry, algal colonies were observed attached to the stream bed. The overall stream condition is optimal; there are no problems associated with either the health of the in-stream habitat, buffer zones, vegetation, or the floodplain. Aquatic vegetation is nonexistent, but there are patches of algal colonies attached to the dry stream bed. The surrounding area is forested.

There are two areas of bank erosion in need of restoration. The first, R20ER1, is contributing a large amount of sediment to the channel and requires rigid or hard bank stabilization. The second, R20ER2, is an area of significant channelization and sediment deposition. While not a threat to property or infrastructure, it has been recommended that this area too be restored with bank stabilization structures. Access to the areas is fair, with some impact to the surrounding forest being necessary.

There are two culverts in the reach where roads run over the stream channel. Both of the structures appear to be in need of repair due to chipping and cracking of their corrugated metal pipes. In addition, they both appear to be causing sediment deposition downstream. In light of this, it has been suggested that the culverts undergo repair or replacement measures.

Another road running close to the stream has developed into a sediment basin within the borders of the Broad Brook riparian area. The basin is collecting sediment which eventually enters the stream channel, adding to the stream's sedimentation issues. It has been recommended the basin undergo riparian management measures to ensure the sediment does not affect the stream.

Reach 21: Upstream of stream crossing (R20SC2) to end of Broad Brook
Impact Forms:

- None

Reach 21 signals the end of the track down survey. Broad Brook begins at this point and flows downstream to Reach 1. The reach was dry during the track down survey. The substrate is once again a mixture of cobble and boulder. The stream becomes braided toward the start of the reach, then forms a single channel soon after. Surrounded by forest, the stream is in excellent condition. There are no issues with the reach.

Appendix B: Best Management Cost Data

BEST MGT PRACTISES (BMPs)				
	Amount	**Units**	**Comments**	**Reference**
Pet Waste Station sign with bags & receptacle on post	$540.00	ea.		On-line products Paw Pal &J J B Solutions Inc. plus installation
Pet waste flyer mailing				
Pet waste ad-TV				
-newspaper				
Riparian Buffer-Herbaceous	$558.50	ac.		In-house DraftCost Sheet for EQIP & WHIP
-Shrub/Tree	$2,712.00	ac.		In-house DraftCost Sheet for EQIP & WHIP
-Warm Season grasses for goose manage	$960.50	ac.		In-house DraftCost Sheet for EQIP & WHIP
Fencing-Woven Wire	$11.30	lf		In-house DraftCost Sheet for EQIP & WHIP
-4/5 strand barbed wire	$6.44	lf		In-house DraftCost Sheet for EQIP & WHIP
-4/5 strand electric	$10.17	lf		In-house DraftCost Sheet for EQIP & WHIP
solar charger for elec.	$339.00	ea.		In-house DraftCost Sheet for EQIP & WHIP
Wetland Restoration-broadcast seed	$2,938.00	ac.		In-house DraftCost Sheet for EQIP & WHIP
Livestock Watering Facility	$593.25	ea.		In-house DraftCost Sheet for EQIP & WHIP
Well for watering facility	$7,119.00	ea. (average)	can vary widely	In-house DraftCost Sheet for EQIP & WHIP
Pumping Plant for water facility	$2,825.00	ea.		In-house DraftCost Sheet for EQIP & WHIP
2 " underground supply pipe	$7.91	lf		In-house DraftCost Sheet for EQIP & WHIP

	Initial cost ($)	Lifespan (yrs)	Capitalized cost over Lifespan^		Operation & Maintenance		Total	
			($/yr)	units	($/yr)	units	($/yr)	units
Street Sweeping-regen. air/vac sweeper serving 8160 curb miles/yr*	$185,000	8	$4.10	curb mi.	$20.00	curb mi.	$24.10	curb mi.
Catch basin insert for bacteria (e.g. AbTech Ultra Urban Filter with Smart Sponge)#	$1,100	1 to 3	$454 to $1,188	ea.	$194.00	ea.	$648 to $1,294	ea.

*Ref. from EPA 1999 EPA determination Sweeper can service 8160 curb miles per year
#lifespan depends on maintenance & loading
^Capitalized cost over the Lifespan takes the total cost of the initial cost and capitalizes it over the its lifespan at an interest rate of 7%.

NOTE: Just increased the $/yr and O&M $/yr cost for street sweeping and catch basin insert. No increase for initial capital cost.

Used 8% increase for structural practices on bottom. Used 13% increase for AG/wildlife BMPs

Appendix C: Regulations Review

A REVIEW OF LAND USE REGULATIONS FOR THE TOWNS OF EAST WINDSOR AND ELLINGTON

1.0 Background

Municipal planning, zoning, and wetland regulations are the principal controls guiding patterns of development within a town. By controlling building density, the location and ratio of residential, commercial, and industrial development, and by setting technical standards for public infrastructure, municipal regulations can have an effect on water quality, particularly stormwater. However, while the location of roads and structures has had an effect on impervious coverage (see discussion below) and therefore water quality, municipal planning and zoning regulations have only recently been written to specifically address water quality. The statutory authority to address water quality through planning and zoning regulations has never been explicit.

The Connecticut Inland Wetlands and Watercourses Act was enacted in 1978. The Act authorizes municipal regulation of activities that alter wetlands and watercourses, but jurisdiction is typically limited to a defined upland review area. Therefore "watershed level" impacts to water quality are difficult to address through the inland wetland review process.

Linking land use regulation with water quality has progressed slowly since the late 1970's. State statutes governing planning and zoning in the 1980's began to incorporate provisions for erosion control on construction sites, thereby improving water quality during the construction phase of projects. In the last several years, a few municipalities have begun to address issues such as impervious surface coverage and to adopt provisions for Low Impact Development (LID).

1.1 Phase II Stormwater Regulations

In 1995, the State of Connecticut adopted Phase II Stormwater Regulations that require towns in "urbanized areas" to adopt provisions to protect receiving waters from stormwater pollution. The state has adopted a phased approach to the program allowing municipalities adequate time to adopt Phase II standards. Both Ellington and East Windsor are regulated under Phase II

In order to comply with the standards, towns must adopt a number of practices and procedures to improve the quality of stormwater being discharged from the municipal stormwater system. Some of these practices involve improvements to erosion control during construction. Phase II standards also require an 80% reduction of total suspended solids in post construction stormwater discharges

Under the Phase II Program, regulated municipalities must comply with the DEP General Permit for the Discharge of Stormwater from Small Municipal Separate Storm Sewer Systems (MS4 General Permit). Under the general permit, municipalities must adopt a Stormwater Management Plan that addresses six "minimum control measures". Those measures are:

1. Public education and outreach addressing storm water impacts;

2. Public involvement/participation;

3. Illicit discharge detection and elimination (includes mandatory mapping of the stormwater systems, including points of discharge);

4. Construction site stormwater runoff control;

5. Post-construction stormwater management in new development and re-development of existing facilities;

6. Pollution prevision and good housekeeping for municipal operations.

The following section addresses existing land use regulations and their implications for general watershed protection strategies, particularly focusing on impervious coverage. While the recommendations are consistent with Phase II standards, relatively minor changes in the regulations, addressing items 4 and 5 above, may be all that is necessary to meet the requirements of Phase II standards. The following review covers a broader scope than simple compliance with the Phase II standards

1.2 Impervious Coverage and Low Impact Development (LID): The most direct link between development and watershed protection involves impervious cover and its relationship to water quality degradation. A number of studies have concluded that there is a direct relationship between impervious coverage (soil covered with buildings, blacktop and other surfaces that prevent rainfall from infiltrating into soil) and water quality degradation. Most studies show that degradation of surface water quality and biological integrity can be detected once 10% of a watershed is covered with impervious surfaces. More pronounced degradation occurs at twenty-five impervious cover.

Low Impact Development (LID) offers alternative designs to reduce impervious coverage. LID refers to any stormwater management method or structure that preserves natural hydrologic conditions. The goals of LID are to maintain existing infiltration rates and existing run-off conditions. These methods include measures such as:

- Infiltration swales and basins
- Curbless roads
- Rain Gardens
- Pavers

- Bioretention
- Porous Pavement

There are several manuals for LID. Probably the most comprehensive is Low-Impact Development Design Strategies An Integrated Design Approach, prepared by the Prince George's County, Maryland Department of Environmental Resources. The 2004 Connecticut Stormwater Quality Manual includes both LID concepts and more traditional stormwater management measures. Simply referencing the manual in the town regulations may exclude new and evolving technologies for LID development. Given the existing structure of most land use regulations, the easiest method for incorporating technical standards for LID concepts is through the development of "Public Improvement Standards". This concept is discussed in the Summary and Recommendations on page sixteen. The following discussion does not attempt to incorporate comprehensive LID concepts into the existing regulatory structure. Doing so is beyond the scope of this review and would require a comprehensive restructuring of the existing regulations.

1.3 Statutory Authority

Land use regulations are administered by various commissions and boards, each possessing specific responsibilities authorized by the Connecticut General Statutes.

Table 1: Land Use Commissions and Boards

East Windsor	• Planning and Zoning Commission • Inland Wetlands and Watercourses Commission • Economic Development Commission • Zoning Board of Appeals
Ellington	• Planning and Zoning Commission • Inland Wetlands and Watercourses Commission • Conservation Commission • Economic Development Commission • Zoning Board of Appeals

The Connecticut General Statutes provide the authority for municipalities to establish planning, zoning, and wetlands commissions and provide much of the procedural structure under which local boards must act. Every ten years, municipalities must also prepare a plan of conservation and development. The plan outlines the Planning Commission's recommendations for the most desirable use of land for residential, recreational, commercial, industrial purposes and directs development patterns in the town. The plans are comprehensive in scope and cover all aspects of land use and development within a town. The plans are typically "goal based" and it often takes several years for concepts in the plan to be implemented under land use regulation.

Other health and safety regulations may also affect water quality. Aquifer protection, floodplain protection, water and sewer regulations all have specific areas of focus.

Table 3: Municipal Land Use Regulations Matrix (Date Adopted/Most Recent Amendment Date)

	Zoning	Subdivision	Inland Wetland Watercourse s	Aquifer Protection s	Floodplain Protection s	Septic Regulations
East Windsor	1978/2007	1953/2006	1973/2007	Not yet adopted	Incorporate d in Zoning Regs.	1982 (ordinance)
Ellington	1952/2008	1954/2008	1974/2007	Not yet adopted	Incorporate d in Zoning Regs.	1966 (ordinance)

2.0 Zoning Regulations

Zoning regulations, and the zoning map establish the overall development pattern for land use within a municipality. The plan of conservation and development is a major contributor in the development of zoning regulations and must be considered, as required by state statute, during the zoning process.

The following summarizes sections of Ellington's and East Windsor's zoning regulations that are relevant to water quality or watershed protection.

2.1 East Windsor Zoning Regulations

The Town of East Windsor's zoning regulations have incorporated several amendments to address recommendations from the 2004 Plan of Conservation and Development. Currently, the zoning regulations address sediment and erosion control plans and water quantity. There are few specific provisions relating to water quality, other than impervious coverage limits.

Section 401 – Bulk and Area Requirements – Residential Districts: Lot size, lot coverage, setbacks, and density factors for residentially zoned lots are listed in this section. The regulations control the dispersion of residential development within the community and determine how impervious surfaces associated with residential development are distributed.

Comments: Density Factor: East Windsor uses a calculation to determine the quantity or "yield" of lots that a subdivided parcel of land will produce. The density factor for each of the five residential zoning districts is used to determine the lot yield. Sensitive areas of the parcel such as steep slopes, wetlands & watercourses, special flood hazard areas, etc. are subtracted from the total land area prior to conducting the calculation. For example, a Planned Residential Development (PRD) in an A-1 zone must use a density factor of a 0.50 to determine lot yield. As such, a fourteen acre parcel of land with one acre of steep slopes (> 15%), two acres of wetlands, and one acre of flood hazard area will net ten acres of developable land. The lots yield is calculated as follows: 10 acres of developable land x 0.50 (density factor for a PRD in an A-1 residential zone) = 5 lots.

Associated with the bulk and area requirement is the amount of impervious surface coverage permitted on each lot. In East Windsor's residential zoning districts, this amount varies from a maximum of fifteen percent permitted for building coverage to a maximum of twenty-five percent allowed for all impervious surfaces combined.

Comment: The goals of this section are generally consistent with LID concepts in that impervious surfaces are limited. However, impervious coverage over 10% is associated with water quality degradation, so additional stormwater management is warranted.

Section 408 - Rear Lots: This section provides the minimum standards for the creation and development of rear lots. Currently, there is no discussion of shared driveways in the regulations.

Recommendations:

1. Consider encouraging the use of shared driveways in all new residential development projects, and requiring the use of shared drives on rear lots unless the applicant shows there are no feasible alternatives.

2. Consider encouraging the use of alternative driveway construction standards that use permeable materials or other porous construction methods such as two track systems or bricks and pavers.

Section 504.9 – General Development Plan (GDP): This section provides the minimum mapping standards required for submittal of a general development plan. Plans must show existing and proposed development site features, including, topography, water features, all existing and proposed infrastructure, and nearby land uses. A GDP is required as part of the special permit process for uses within the Highway Interchange Floating Zone (HIFZ).

Recommendations**:**

1. Consider requiring that General Development Plans (GDP) show the location of the proposed site within the context of its local watershed.

2. Consider requiring that General Development Plans (GDP) identify receiving lands or waters for run-off created from the development.

Section 601 Off-Street Parking Regulations

Comments**:** Paved parking areas constitute a substantial portion of impervious surfaces in the developed environment. Most parking regulations set a minimum number of parking spaces for each use that reflects a worse-case scenario. That is, parking lots are built for peak use.

There are several alternatives available to municipalities to address the issue of off-street parking. One method is to conduct a parking utilization survey to ascertain actual parking need.

Another method to reduce the impacts of over-built parking areas is to establish parking caps or maximums rather than the conventional 'minimum' standards. Maximum standards can help prevent the construction of excess paved surfaces and require applicants to analyze nearby parking areas for the possibility of shared usage for overflow. The regulation could allow for spaces beyond the maximum if the applicant demonstrates a need. If conditions require spaces beyond the maximum, the Commission may require the use of alternative paving materials for the additional parking area.

East Windsor's regulations permit a reduction in the minimum standards when uses share differing peak usage times. A twenty-five percent (25%) reduction of a use's required spaces may be permitted. The regulations also permit the temporary reduction of up to thirty-five (35%) of a site's required parking if an applicant can satisfactorily demonstrate several conditions. The regulation allows some flexibility to reduce impervious surfaces, however it is only temporary, up to six (6) months, and not a permanent reduction.

Another option to reduce parking space is to permit developers to pay a fee in lieu of providing the required parking spaces. Section 8-2c of the Connecticut General Statutes authorizes municipal zoning commissions to adopt regulations that allow developers of certain types of projects to pay a fee to the municipality instead of providing the required amount of parking spaces. The circumstances that must be present for the Commission to waive the parking requirement and accept a fee in its place are: 1. there is an excess of parking in the area for that use, or 2. parking could not be accommodated on the parcel of land to be developed due to some physical constraint. The Statute also allows the Commission to restrict this provision to specific areas of the municipality. The fees collected under this regulation must be set aside in a fund exclusively for the "acquisition, development, expansion or capital repair of municipal parking facilities" or other transportation-related facilities or projects.

Recommendations:

1. Consider conducting a parking utilization survey to determine whether the current parking standards are realistic in meeting actual use dependent need.
2. Consider setting a maximum parking standard rather than a minimum. Alternative paving surfaces could be required for additional parking areas.
3. Encourage the use of porous materials for all parking areas. Consider establishing an incentive based system for applicants that employ such methods.
4. Consider regulation allowing fee in lieu of parking requirement.

<u>Section 606 – Sidewalks and Trails</u>: This section sets forth the provisions for sidewalks and/or trail within new developments.

Comments: While sidewalks contribute to passive recreation and provide for safe pedestrian use, they also contribute to the amount of impervious surface. Like parking areas, there are opportunities to minimize the amount of impervious surface while meeting the needs of its users.

East Windsor's sidewalk regulations require sidewalks in all developments that contain new buildings in excess of 1,000 square feet. The requirements allow for off-site sidewalks in areas approved by the Commission and provisions for fees in lieu of sidewalks that direct payment equal to forty percent (40%) of the estimated cost of sidewalks into the Town Sidewalk and Trail Fund.

The regulations also set forth standards for sidewalks by requiring concrete construction. No alternative materials are currently permitted. The regulations do allow for the installation of trails as an alternative to sidewalks.

***Recommendations*:**

1. Consider creating sidewalk priority areas that require new developments to take into account the imperviousness of a watershed when determining where sidewalks should be required.

2. Consider providing standards for alternative methods that allow the installation of sidewalks using permeable materials.

<u>Section 801 – Planned Residential Development (PRD)</u>: This section outlines the standards and requirements for single-family detached conservation and open space subdivisions. The regulations allow for flexibility in lot design (i.e., reductions of lot frontage, lot area, setbacks and yard dimensions, and increases in building coverage and impervious cover), in return for an increased percentage of dedicated open space exceeding thirty percent (30%).

Comments: In terms of water resource protection, the Planned Residential Development (PRD) regulation provides many advantages compared to a conventional subdivision design. In return for an increased percent of open space, an applicant gains design.

<u>Section 802.8 subsection (g) – Special Permits – Natural Resource Conservation</u>: This section requires plans to provide for the conservation of natural features, drainage basins, and the protection of the environment.

Comments*:* Plans must address potential impacts to environmentally sensitive areas and mitigate any negative affects as effectively as possible. This section of the regulations provides an opportunity for the commission to request specific information regarding water quality impacts from a proposed development. Information may include: the volume of water expected to leave the site (in relation to pre-development levels; the location and nature of receiving waters; anticipated pollutant loads; and an analysis of what specific impact a proposed use may have on surface or groundwater within the watershed.

***Recommendations*:**

1. Consider requiring applicants to provide supplemental data to report on a developments potential impact on receiving waters.

<u>Section 810 – Flood Hazard Regulations</u>: This section provides the standards for development within flood hazard areas identified by FEMA on its Flood Insurance Rate Maps (FIRM).

Comments: Effective flood plain regulations seek to minimize development within a floodplain and discourage construction of excess impervious coverage. The town requires a development permit prior to the commencement of any construction or development activities within the special flood hazard area. The flood plain regulations provide sufficient protection against the placement of inconsistent land uses with the floodplain.

<u>Section 813 – Livestock</u>: This section provides standards for the keeping of livestock within residential and agricultural zones within East Windsor.

Comments: Livestock practices that may cause impacts to water quality include inappropriate waste management and disposal practices. Regulation should be aimed at controlling livestock density; and siting of livestock grazing areas and similar facilities. Water quality concerns related to the keeping of livestock include impacts on wetlands and watercourses, and downstream recreational and drinking water uses.

The East Windsor zoning regulations allow the keeping of livestock in residential R-1, R-2, and R-3 zones with a minimum of four (4) acres and in the A agricultural zone with a minimum of three (3) acres. The zoning regulations require all livestock operations to adhere to all state and federal regulations pertaining to the keeping of livestock. The regulations also establish a buffer area for livestock shelters and manure piles. (Revisions pertaining to agricultural land use are currently being drafted, but were not completed for inclusion in this report).

<u>Section 814 – Earth Removal & Filling</u>: This section provides the standards for the excavation and filling of land within the municipality.
Comments: Activities associated with the excavation and filling of land have the potential to create significant erosion problems.

Earth excavation and filling operations are allowed by Special Use Permit in any zone in East Windsor. This gives the planning and zoning commission discretion over the appropriateness of any specific proposed site. The regulation restricts the area of land to be excavated at any one time to seven (7) acres, and requires a detailed erosion and sediment control plan be submitted with each application.

Recommendations:

1. Consider requiring Special Use Permit applicants for earth removal and filling operations to submit a map delineating the site's local watershed. Additional information could also include the receiving waterbodies or wetlands.

2. Consider including a requirement that all erosion and sedimentation control plans comply with the standards set forth in the 2002 Connecticut Guidelines for Soil Erosion and Sediment Control.

Section 900.3 – Site Plan Application: This section provides the standards for the submittal of a site development plan application.

Comments: A site plan application must comply with the standards established in the zoning regulations, relevant statutes, and any other development criteria such as public health codes and measures for fire protection.

Recommendations:

1. Consider amending Section 900.3 by requiring all stormwater drainage systems comply with the 2004 CT. Stormwater Quality Manual and referencing the document in the regulation.
2. Consider amending Section 900.3 by requiring erosion and sedimentation control plans comply with the 2003 CT. Erosion and Sedimentation Control Guidelines and referencing such document in the regulation.
3. Consider requiring applicants to provide supplemental data on a site's potential impact to water quality. The additional data may include:
   - delineation of the site within the watershed,
   - a summary of the potential water quality impacts resulting from site development.

2.2 Ellington Zoning Regulations

Section 3.1 – Permitted Uses – Residential Zones: This section lists the uses permitted in all of the town's residential zones and the type of town approval, permitted by right or special permit, required.

Comments: A broad mix of zoning districts are located within the Broad Brook watershed including: RA-Rural Agricultural Residence, A-Residence, AA-Residence, MF-Multi-Family Residence, C-Commercial, PC-Planned Commercial, I-Industrial, and OS-Open Space. Residentially zoned land constitutes the largest segment of the watershed with RA-Rural Agricultural Residential and A-Residence zones accounting for the majority of the area.

Section 3.1 and 4.1– Lot Area and Bulk Requirements – This section defines the minimum lot size, lot coverage, and setbacks for all of the various zoning districts in the town. (Revisions affecting density in residential zones were being drafted during preparation of this report, but were not completed in time for inclusion).

Comments: Ellington's residential lot and bulk requirements are consistent with low impact design techniques. Lot area requirements are contingent on soil conditions.

<u>Section 3.4 – Age Restricted Cluster Housing Zone (ARCHZ)</u>: Applicants may receive a density bonus for choosing this development option in return for dedicated "green space" of at least twenty percent. Density may be increased even more in return for cash payments equal to $5,000 per each housing unit.

***Comments*:** The ARCHZ is a creative regulation that meets the demand for age restricted housing while protecting the environment. The ARCHZ regulation requires developers to consider many factors associated with protecting water resources including:

- Preservation of existing natural landscapes and topography,
- Maximum width of twenty-four feet (24') for all interior roads (main collector road that serve more than 30 units may be increased to twenty-eight feet (28'),
- Stormwater systems must comply with NPDES Phase II Stormwater requirements and
- The project's design must provide sufficient protection for natural resources including any mitigation activities.

The stormwater section of the regulation provides a strong opportunity for developers to incorporate LID elements into each project.

Recommendations:

1. Reference the <u>2004 CT Stormwater Quality Manual</u> in Section 3.4.7(G).

<u>Section 5 – Flood Plain District</u>: This section outlines the development requirements for land located within the special flood hazard.

Comments: The Town of Ellington's flood plain regulations provide sufficient protection against the placement of inconsistent land uses with the floodplain. Key elements include: restrictions on all construction related activities in areas of special flood hazard, professional engineers certification for all new construction, and prohibition on any encroachments that would result in an increase in flood levels.

<u>Section 6.2 – Parking and Loading Requirements</u>: This section outlines the standards for the design of parking areas and the number of spaces required for specific uses.

***Comments**:* The Town of Ellington employs several techniques that allow developers to reduce the amount of parking. Parking facilities where users share spaces but have divergent peak hours are allowed to reduce the amount of required parking by up to twenty-five percent (25%). The regulation also has a provision for large parking lots where 25% of the total spaces may be constructed using size standards for compact vehicles (8' x 16' compared to 9' x 18').

The regulation also allows the use of alternative materials for parking lots. An applicant must show that the alternative surface provides for groundwater recharge and reduction of stormwater runoff.

Recommendations:

1. Consider conducting a parking utilization survey to determine whether current parking standards meet actual uses.
2. Consider setting a maximum parking standard rather than a minimum requirement. Alternative materials could be required for parking areas with a demonstrated need beyond the maximum.
3. Consider creation of a regulation allowing fees in lieu of parking requirement. Fees can be applied to a transportation or parking fund.

Section 6.4 – Soil Erosion and Sediment Control: This section outlines the requirements for the submittal of soil and erosion control plans for developments that disturb more than a half acre of land.

Comments: The regulation is consistent with and references the 2002 Connecticut Guidelines for Soil Erosion and Sedimentation Control.

Section 7.5 – Earth Excavation: This section provides the conditions for obtaining a special use permit for the operation of an earth materials excavation and processing facility.

Comments: Earth excavation operations are allowed by special permit in any zone in Ellington granted the use meets the standards in the regulation. This gives the planning and zoning commission discretion over the appropriateness of any proposed site. The regulation contains guidelines that protect against the affects of erosion and adverse water quality impacts.

The regulation provides considerable regulatory oversight of excavation operations with built-in controls such as annual plan reviews to determine plan compliance, strict requirements for working slopes, and measures that address erosion, sedimentation, and dust control.

Recommendation

Although the regulation refers to a "detailed erosion control plan", a reference should also be made to the 2002 Connecticut Guidelines for Soil Erosion and Sedimentation Control. Also, delineation of the site in context with its local watershed should be included with the drainage data.

Section 7.8 – Open Space Residential Development: This regulation provides for up to a 25% reduction in lot size in return for open space. (Revisions to the open space requirements were being drafted during preparation of this report but were not completed in time for inclusion).

Comments:. In return for reduced lot size, the developer must deed at least ten (10) acres of the project to the town for the purpose of open space preservation. Compliance with all other bulk and area requirements and subdivision standards is required, including the density of the underlying zoning district.

<u>Section 7.9 – Rear Lots</u>: This section provides the standards for the development of rear lots.

Comments: The regulation provides the circumstances that must exist to allow the creation of rear lots. Creation of such lots as part of a subdivision is only permitted after the Commission finds that the topography and shape of the land is best suited to rear lot development.

Recommendations:

1. Consider the use of shared driveways in all new residential development projects, and requiring the use of shared drives in all rear lots unless the applicant shows there are no feasible alternatives.
2. Consider allowing the use of permeable driveway materials that maintain infiltration.

<u>Section 8.2 – Site Development Plan Standards and Procedures</u>: This section lists the standards for site plans submitted for special permit uses, commercial uses, industrial uses, and other uses listed in the regulations.

***Comments*:** The standards include submittal of an erosion control plan consistent with the <u>2002 Connecticut Guidelines for Soil Erosion and Sediment Control</u>.

***Recommendations*:**

1. Consider amending Section 8.2.2(J) by requiring that all stormwater drainage systems comply with the <u>2004 Connecticut Stormwater Quality Manual</u> and referencing such document in the regulation.
2. Consider requiring applicants to provide supplemental data to report on a site's potential impact to water resources.

<u>Section 8.3 – Special Permit Standards and Procedures</u>: This section lists the standards governing special permit applications.

Comments: The standards include a requirement that a proposed use "provides for the conservation of natural features, drainage basins and the protection of the environment of the area". This provision provides the Commission with an opportunity to analyze a proposed use for compatibility with the surrounding natural environment.

3.0 <u>Subdivision Regulations</u>

Subdivision regulations provide the design standards for the creation of new lots and the construction of new streets. The subdivision regulations also contain requirements for open space, sidewalks, installation of stormwater management systems, and guidelines for erosion and sedimentation control. The regulations establish consistent standards for all public improvements as well as ensuring that land is capable of supporting proposed uses.

The following summarizes pertinent sections of Ellington's and East Windsor's subdivision regulations that contain watershed related implications.

3.1 East Windsor's Subdivision Regulations

Section 2.11 – Improvements Required: This section lists the required public improvements that are necessary within a subdivision.
Comments: The regulation requires the installation of curbs on all streets in conformance with town standards. The requirement for curbs should be reviewed in the context of other stormwater requirements. Removing the requirement is not recommended without a comprehensive review of stormwater management. LID methods typically allow the reduction in the use of curbs and enclosed drainage systems. Curbless roads with grass lined swales have been used in Connecticut as an alternative.

Section 6.1.5 – Street Width: This section contains the required pavement width for the various types of streets, consisting of: major collector street (determined by Commission), minor collector street thirty-six feet (36'), minor local street twenty-six feet (26'), and cul-de-sacs serving less than twenty (20) lots twenty-two feet (22').

Comments: The 2004 Connecticut Stormwater Quality Manual recommends paved widths of twenty feet (20') to twenty-four feet (24') for low density residential developments and increased pavement width based on terrain and development density thereafter. Consider amending the pavement width requirements to reflect the guidelines identified in Table 4-3 of the 2004 Connecticut Stormwater Quality Manual.

Recommendations:

1. Consider allowing pavement widths consistent with the guidelines listed in Table 4-3 of the 2004 Connecticut Stormwater Quality Manual.

Section 6.1.7 – Cul-De-Sac Streets: This section contains the minimum standards for the design and construction of cul-de-sacs in new subdivisions.

Comments: Cul-de-sac's create a large amount of impervious surface due to the bulb shaped configuration of the turn around area. The 2004 Connecticut Stormwater Quality Manual indicates that a cul-de-sac with a dimension of thirty feet (30') can accommodate most vehicle types. East Windsor's subdivision regulations only permit a cul-de-sac on streets serving twenty (20) or less homes. In such a low density development, traffic volume is low, consistent with a layout that would function well with a cul-de-sac radius of thirty (30') to forty (40') feet. The inclusion of a center vegetated island or bioretention area provides an even greater reduction in the amount of impervious surface. Also, alternative construction methods could be installed using pavers or porous paving materials in the center of the cul-de-sac.

Recommendations:

1. Consider allowing cul-de-sacs with smaller radii such as thirty (30') to forty (40') feet contingent upon accommodation of local emergency vehicles. Also consider allowing the installation of center vegetated islands, bioretention areas, and alternative construction methods.

Section 6.1.10 – Relation to Topography: This section requires that streets within new subdivisions relate as much as possible to the topography of the land on which it is located.

Comments: The use of techniques that limit land disturbance and are designed to fit the natural features of the land require less grading and soil disruption than projects that require extensive alteration. Designing a site that takes advantage of natural drainage features and terrain can dramatically reduce the amount of stormwater infrastructure. This method also minimizes the potential for erosion and sedimentation.

Section 6.3 – Sidewalks: This section outlines the conditions for the provision of sidewalks within new subdivisions.

Comments: East Windsor allows several options for the installation of sidewalks, including: on-site or off-site sidewalks, on-site trails, or a "fees in lieu of sidewalks" alternative. These options allow the Commission to make the determination of whether sidewalks are appropriate in a new subdivision. This is consistent with a site specific approach that includes placing sidewalks in areas where they will provide the greatest benefit.

Construction materials for sidewalks could also provide a means of reducing total impervious surface area. Encouraging the use of alternative materials such as pavers, stone dust, or pervious concrete provide significant advantages for stormwater management. The regulations do permit the use of alternative treatment for pathways that could also be extended to sidewalks. Also, consider allowing sidewalks with widths of three feet in areas with low pedestrian traffic.

Recommendations:

1. In areas where sidewalks are required, consider installation on only one side of a street where practical.

2. Consider encouraging the use of alternative materials such as pavers, stone dust, or pervious concrete for sidewalk construction.
3. Consider allowing sidewalks with widths of three feet in areas with low pedestrian traffic.

Section 6.6.8 – Space for Off-Street Parking: This section requires all lots within a new subdivision to have space to accommodate off-street parking.

Comments: This provision has a direct affect on the width of new roads. Requiring off-street parking allows the width of new roads to be narrower and thus reduces impervious coverage. This allows streets to be designed with the minimum amount of paving necessary to accommodate travel lanes and meet emergency vehicle and maintenance needs.

Section 6.6.9 – Rear Lots: This section outlines the design standards for the creation and layout of rear lots within new subdivisions.

***Comments*:** The regulations permit driveways that have a durable or dustless surface. The wording of this provision allows for alternative materials such as pervious concrete or pavers. Also, the regulation requires only one driveway cut when two access ways serving rear lots are adjacent to one another. The regulation could also require a shared drive to serve both lots, thus reducing long, side by side lengths of impervious surface.

***Recommendations*:**
Consider shared driveway in cases where two access ways are adjacent to one another.

3.2 Ellington's Subdivision Regulations

Section 4.07 Design Standards for Roads: Pavement width for collector roads is 32 feet, and for local roads is 26 feet. Curbs are required on all streets.

Comments: The 2004 Connecticut Stormwater Quality Manual recommends twenty feet (20') to twenty-four feet (24') for low density residential developments and increased pavement width based on terrain and development density thereafter. Consider amending the pavement width requirements to reflect the guidelines identified in Table 4-3 of the 2004 Connecticut Stormwater Quality Manual. Allowing some flexibility in the regulations may also be beneficial. There may be situations where a "minor local street" could function quite successfully with a pavement width of twenty-two (22) or twenty-four (24') rather than the required twenty-six feet (26'). Eliminating the requirement for curbs alone, without addressing drainage comprehensively in the context of LID is not recommended.

Section 4.09 Drainage and Storm Sewers and 4.10 Drainage Design: This section contains general standards to ensure that surface waters receiving stormwater have adequate capacity and that additional discharges do not increase flooding. Open ditches are discouraged in favor of closed storm drains. The most recent revisions to the regulation discourage the use of traditional detention (ponds) and encourage the use of other methods to achieve a zero increase in the rate of stormwater.

Recommendations: LID concepts are not directly discussed in this section, so it is unclear if these are the alternative measures being encouraged. Acceptable methods such as infiltration basins, infiltration swales, curbless road etc could be discussed in this section as possible means to achieve the zero runoff. The 2004 Connecticut Stormwater Quality Manual could also be referenced in this section. In order to comply with the MS4 General Permit, a general requirement that 80% of total suspended solids must be removed from the post-construction stormwater discharges should be added. Comprehensive improvements allowing LID measures could be inserted in the regulations in this section.

Section 4.13: Sidewalks: Sidewalks are required on one side of the street. Zoning regulations require 4' wide sidewalks. There are no additional technical standards for sidewalks outlined in this section.

Recommendation: Consider providing standards for alternative methods allowing the installation of sidewalks using permeable materials where appropriate.

Section 4.14 Soil Erosion and Sediment Control Plan: This Section requires submission of an erosion control plan for soil disturbance in excess of ½ acre. The standard referenced is the 1965 "Connecticut "Guidelines for Soil Erosion and Sediment Control".

Recommendation: The reference standard should be updated to the 2004 Connecticut "Guidelines for Soil Erosion and Sediment Control".

Section 4.17 Open Space: The open space section of the regulations was updated 2/15/08. The general goals and objectives of the towns open space policy are clearly stated, providing a rational for the requirements. For subdivisions, the required amount of open space is 20% and payment of a fee in lieu of the open space dedication is permitted. A detailed set of criteria is provided to assist the applicant.

Appendices: The appendices include detailed administrative requirements for plans and site plans, and various specifications for road and other infrastructure.

4.04 Plan of Conservation and Development

As previously discussed, a POCD is an important policy guide to assist a community in shaping patterns for future growth and to determine long-term development policies. Connecticut General Statutes require municipalities to update its POCD every ten (10) years. Recommendations in the POCD have a direct influence on all land use regulation and often provide comprehensive changes that shape the land use review process. Implementing recommendations from a POCD is an integral process that may include, amendments to land use regulations, guidance for capital improvement, adopting new polices or procedures, or evaluating development proposals in terms of POCD's goals and objectives.

Table: Municipal Plans of Conservation and Development

	Adopted Plans	**Selected POCD Strategies With Watershed Related Implications**
East Windsor	• 1967 (first plan), • 1986 updated in 1998, • 2004 (current POCD)	From 2004 POCD • Adopt standards for maximum amount of impervious surface per parcel, • Establish open space corridors and greenways, including establishment of regional greenways along the Connecticut River and Scantic River corridors, • Establish a separate Conservation Commission to manage

		the town’s open space program, distinct from the inland wetlands and watercourses commission.
Ellington	• 2006 (Plan of Conservation, prepared by Conservation Commission) • 2008 (current POCD)	From 2008 POCD : • Support programs that preserve farmland and that allow more flexible farm use regulations to encourage ‘ecotourism’, • Explore the need for water quality protection overlay zones for public water well fields and surface reservoirs, • Evaluate the threat of underground storage tanks to groundwater resources and, if warranted, adopt a regulating ordinance, • Adopt a septic management program to minimize the threat of septic system failures on surface and ground drinking water supplies, • Adopt effective impervious coverage requirements to encourage reductions in stormwater runoff, • Require natural and/or mechanical treatment of stormwater before its release, • Limit the extent to which watercourses, wetlands, and steep slopes may be counted towards the number of lots that a property may yield, • Apply a density factor to regulate lot yield of residential subdivisions, • Increase open space set-asides from ten percent (10%) to twenty percent (20%), • Revise regulations to provide adequate incentives to encourage open space residential developments, • Utilize greenway systems to create linkages between open space areas, • Protect forests in Eastern Highlands.

In terms of natural resource protection, the most recent POCD’s from both municipalities focus on minimizing the impacts from development on sensitive areas, wetlands, and water resources.

<u>Section 6: Inland Wetlands and Watercourses</u>

Inland wetland regulations for each town are guided by state statute. In 2006 the CT DEP published a new model inland wetland and watercourses regulation that encompasses statutory changes that occurred since the last model regulations were published in 1997. Also, several important court cases in the last few years have clarified municipal authority under the statute and generally speaking, have served to restrict the jurisdiction of inland wetland agencies (IWWA), particularly relative to activities that occur in uplands.

Consideration of activities within the upland can only pertain to activities that are likely to have a negative physical or chemical impact on a wetland or watercourse.

Inland wetlands regulations are reactive, not prescriptive. They require that municipal IWWA's review each proposed activity within a wetland, watercourse or a defined upland review area (the area adjacent to a wetland or watercourse where proposed activities may affect a wetland or watercourse). An agency may approve, deny, or request modification of the proposal based on a "criteria of decision" described in the statute and model regulations. The structure of the regulations and process do not allow much variation in the regulations from town to town, although the actual decision-making process can vary considerably between towns. The structure of the regulations also does not allow for prescriptive application of techniques, such as LID. These measures are best applied through the planning and zoning process.

Towns may determine the distance of the upland review area based on local conditions. The Town of East Windsor has a 150 foot upland review area, and the Town of Ellington has a 100 foot review area. In Ellington, wetlands or watercourses within a drinking water supply watershed is 250. The DEP recommends a 100 foot upland review area, which is generally considered to be protective of wetland and watercourses.

7.0 Final Analysis/General Recommendations

Neither the Ellington or East Windsor zoning or subdivision regulations address stormwater quality comprehensively. Zoning regulations from both towns have limits on impervious surface coverage. These limits are relatively high (15-25%) in terms of water quality protection. However, it is difficult to determine the real impact of such limits without analyzing the location of zones relative to water resources, existing site specific stormwater management, and other land use impacts in the context of the whole watershed. Ellington zoning regulations, which were updated recently to add provisions for age restricted developments, include provisions for alternative stormwater management systems to be used in these types of development.

The foregoing review and recommendations address specific issues in the ***existing*** regulations, but do not address stormwater management in a comprehensive manner. If municipalities wish to address water quality comprehensively, there are several models that can be used. However, the authors believe the easiest way to address the issue is set water quality goals and standard in the regulations and then provide guidance documents or technical standards that may be used to achieve those goals. For instance, if the goal of the municipality is to require that all post construction stormwater discharges remove 80% of total solids (which is consistent with Phase II stormwater requirements), than a standard can be incorporated into the zoning and subdivision regulations with a requirement that the ***methods*** to achieve those results be taken from the 2004 Connecticut Stormwater Quality Manual or other set of technical standards, as discussed below.

The other method is to adopt a stand alone stormwater ordinance. A model ordinance can be found in the 2004 Connecticut Stormwater Quality Manual. The disadvantage of a stand alone ordinance is that it does not incorporate existing regulations and may be more difficult to implement in the context of existing town procedures.

7.1 LID Development and Public Improvement Standards

There is no single method for addressing stormwater quality issues within regulations. Requirements for compliance with Phase II standards are currently driving some municipalities to review all of their regulations to incorporate stormwater quality measures.

One model that avoids the need to significantly revise existing regulations is to prepare a stand alone document of ***Public Improvement Standards.*** Such a document includes technical standards for streets and storm drainage and can be modified to reflect improved engineering standards without the need to alter regulations. Examples from the **Town of Manchester** are included in Appendix 1. **A Public Improvement Standards** manual could include LID methods and would allow new methods to be incorporated based on technical improvements.

Finally, stand alone LID regulations or public improvement standards can be adopted by a municipality. LID regulations were recently adopted by the town of Tolland, Connecticut. The authors have not conducted a comprehensive review of the regulations, but in a preliminary review of the regulations commented that they should be simplified for easier application. Both the EPA and Connecticut DEP have committed resources to advancing LID methods and the DEP now has two full-time LID Coordinators. There are a number of references available to provide technical assistance to municipalities. A partial list follows:

nemo.uconn.edu/tools/stormwater/index.htm

http://www.epa.gov/nps/lid/

Appendix D: Potentially Impaired buffers

Potentially Impaired Buffers (Segment Length -linear feet): Stream or Waterbody Name and Adjacent Land Use				
Stream/Waterbody Name	*Classification Level I*	*Label*	*Linear Feet*	Percent of Impaired Segments
Broad Brook	Agriculture	cultivated	2,340.2	4%
		non-cultivated (hayland)	1,485.1	2%
		pasture-idle	314.7	0%
	Agriculture Total		4,140.0	6%
	Developed	commercial	1,609.4	2%
		residential	2,740.7	4%
		transportation	55.1	0%
	Developed Total		4,405.2	7%
Broad Brook Total			**8,545.2**	**13%**
Kibbes Brook	Agriculture	cultivated	2,086.1	3%
		farmstead	641.0	1%
		pasture-grazed	795.6	1%
		non-cultivated (hayland)	862.9	1%
	Agriculture Total		4,385.7	7%
	Developed	residential	724.6	1%
	Developed Total		724.6	1%
Kibbes Brook Total			**5,110.3**	**8%**
Bahlers Brook	Agriculture	cultivated	1,593.6	2%
		farmstead	750.9	1%
		pasture-grazed	555.6	1%
		non-cultivated (hayland)	459.2	1%
		pasture-idle	532.3	1%
	Agriculture Total		3,891.7	6%
	Developed	residential	1,167.9	2%
	Developed Total		1,167.9	2%
Bahlers Brook Total			**5,059.6**	**8%**
Hydes Brook	Agriculture	cultivated	250.3	0%
		non-cultivated (hayland)	2,296.1	3%
	Agriculture Total		2,546.4	4%
	Developed	commercial	41.3	0%
		residential	1,197.9	2%
	Developed Total		1,239.3	2%
Hydes Brook Total			**3,785.7**	**6%**
Muddy Brook	Agriculture	cultivated	1,742.7	3%
		pasture-grazed	409.1	1%
		non-cultivated (hayland)	331.4	0%
	Agriculture Total		2,483.2	4%
	Developed	residential	378.8	1%
	Developed Total		378.8	1%
Muddy Brook Total			**2,862.0**	**4%**
Kimballs Brook	Agriculture	cultivated	1,893.6	3%
		farmstead	202.7	0%
		pasture-grazed	405.5	1%
		non-cultivated (hayland)	49.6	0%
	Agriculture Total		2,551.6	4%
	Developed	residential	139.9	0%
	Developed Total		139.9	0%
Kimballs Brook Total			**2,691.5**	**4%**
Creamery Brook	Agriculture	cultivated	1,475.3	2%

		non-cultivated (hayland)	308.5	0%
	Agriculture Total		1,783.8	3%
Creamery Brook Total			**1,783.8**	**3%**
Thompson Pond	Agriculture	pasture-idle	1,291.4	2%
	Agriculture Total		1,291.4	2%
Thompson Pond Total			**1,291.4**	**2%**
Chestnut Brook	Developed	other-compact grasses	31.1	0%
		residential	1,177.3	2%
		transportation	42.4	0%
	Developed Total		1,250.8	2%
Chestnut Brook Total			**1,250.8**	**2%**
Bradleys Brook	Agriculture	cultivated	363.5	1%
		non-cultivated (hayland)	124.3	0%
	Agriculture Total		487.8	1%
	Barren	mine/quarry/gravel	168.3	0%
	Barren Total		168.3	0%
Bradleys Brook Total			**656.1**	**1%**
Thompson Brook	Agriculture	pasture-grazed	636.9	1%
	Agriculture Total		636.9	1%
Thompson Brook Total			**636.9**	**1%**
Unnamed Stream(s)	Agriculture	cultivated	7,352.2	11%
		farmstead	1,197.1	2%
		pasture-grazed	955.2	1%
		non-cultivated (hayland)	2,937.2	4%
	Agriculture Total		12,441.6	19%
	Developed	other-ballfields	1,030.9	2%
		other-golf courses	1,031.3	2%
		residential	1,555.0	2%
		high density residential	731.9	1%
	Developed Total		4,349.0	7%
Unnamed Stream(s) Total			**16,790.6**	**25%**
Stream Segment Total			**50,463.9**	**76%**
Broad Brook Millpond	Developed	commercial	387.7	1%
		residential	609.8	1%
		high density residential	2,214.8	3%
	Developed Total		3,212.2	5%
Broad Brook Millpond Total			**3,212.2**	**5%**
Pond(s) - Broad Brook	Agriculture	cultivated	1,170.4	2%
		farmstead	884.0	1%
	Agriculture Total		2,054.4	3%
Pond(s) - Broad Brook Total			**2,054.4**	**3%**
Sadds Mill Pond	Agriculture	cultivated	1,339.5	2%
	Agriculture Total		1,339.5	2%
Sadds Mill Pond Total			**1,339.5**	**2%**
Pond - Bradley's Brook	Agriculture	cultivated	484.8	1%
		non-cultivated (hayland)	533.9	1%
	Agriculture Total		1,018.7	2%
Pond(s) - Bradley's Brook Total			**1,018.7**	**2%**
Broad Brook Reservoir	Developed	other-compact grasses	936.2	1%
	Developed Total		936.2	1%
Broad Brook Reservoir Total			**936.2**	**1%**
Pond - Broad Brook Village Brook	Agriculture	non-cultivated (hayland)	660.3	1%
	Agriculture Total		660.3	1%
Pond(s) - Broad Brook Village Brook Total			**660.3**	**1%**
Broad Brook Village Brook	Developed	residential	280.0	0%
		transportation	46.3	0%

	Developed Total		326.3	0%
Broad Brook Village Brook Total			**326.3**	**0%**
Pond - Thompson Brook	Agriculture	pasture-idle	228.6	0%
	Agriculture Total		228.6	0%
Pond(s) - Thompson Brook Total			**228.6**	**0%**
Unnamed Pond(s)	Agriculture	cultivated	790.2	1%
		farmstead	649.3	1%
		pasture-grazed	810.6	1%
		non-cultivated (hayland)	1,677.8	3%
		nursery	236.1	0%
	Agriculture Total		4,164.0	6%
	Developed	other-golf courses	1,449.2	2%
		residential	745.4	1%
	Developed Total		2,194.6	3%
Unnamed Pond(s) Total			**6,358.6**	**10%**
Waterbody Total			**16,134.8**	**24%**
Total All Segments			**66,598.6**	100%

Potentially Impaired Buffers (Area - acres):
Stream or Waterbody Name and Adjacent Land Use

Stream/Waterbody Name	*Classification Level I*	*Label*	*Acres*	*Percent of Impaired Buffers*
Broad Brook	Agriculture	cultivated	9.3	5%
		farmstead	0.2	0%
		pasture-grazed	0.1	0%
		non-cultivated (hayland)	2.9	2%
		pasture-idle	0.8	0%
	Agriculture Total		13.3	7%
	Developed	commercial	5.2	3%
		other-ballfields	0.3	0%
		residential	8.6	5%
		transportation	0.2	0%
	Developed Total		14.4	8%
Broad Brook Total			**27.8**	**15%**
Bahlers Brook	Agriculture	cultivated	5.1	3%
		farmstead	2.7	1%
		pasture-grazed	2.6	1%
		non-cultivated (hayland)	1.5	1%
		pasture-idle	0.8	0%
	Agriculture Total		12.7	7%
	Developed	residential	3.5	2%
	Developed Total		3.5	2%
Bahlers Brook Total			**16.2**	**9%**
Kibbes Brook	Agriculture	cultivated	5.1	3%
		farmstead	1.7	1%
		pasture-grazed	2.6	1%
		non-cultivated (hayland)	2.2	1%
		pasture-idle	0.1	0%
	Agriculture Total		11.7	6%
	Developed	residential	2.5	1%
	Developed Total		2.5	1%
Kibbes Brook Total			**14.2**	**8%**
Hydes Brook	Agriculture	cultivated	1.2	1%
		non-cultivated (hayland)	6.2	3%
	Agriculture Total		7.4	4%
	Developed	commercial	0.3	0%

		residential	4.2	2%
	Developed Total		4.5	2%
Hydes Brook Total			**11.9**	**6%**
Kimballs Brook	Agriculture	cultivated	3.3	2%
		farmstead	0.8	0%
		pasture-grazed	1.1	1%
		non-cultivated (hayland)	0.4	0%
	Agriculture Total		5.6	3%
	Developed	residential	0.8	0%
	Developed Total		0.8	0%
Kimballs Brook Total			**6.5**	**3%**
Muddy Brook	Agriculture	cultivated	3.6	2%
		pasture-grazed	0.5	0%
		non-cultivated (hayland)	1.3	1%
	Agriculture Total		5.4	3%
	Developed	residential	0.6	0%
	Developed Total		0.6	0%
Muddy Brook Total			**6.1**	**3%**
Creamery Brook	Agriculture	cultivated	4.4	2%
		non-cultivated (hayland)	1.2	1%
	Agriculture Total		5.6	3%
	Developed	other-landfills	0.2	0%
	Developed Total		0.2	0%
Creamery Brook Total			**5.7**	**3%**
Chestnut Brook	Agriculture	nursery	0.4	0%
	Agriculture Total		0.4	0%
	Developed	commercial	0.1	0%
		other-compact grasses	0.1	0%
		residential	3.6	2%
		transportation	0.1	0%
	Developed Total		4.0	2%
Chestnut Brook Total			**4.3**	**2%**
Thompson Pond	Agriculture	pasture-idle	2.6	1%
	Agriculture Total		2.6	1%
Thompson Pond Total			**2.6**	**1%**
Bradleys Brook	Agriculture	cultivated	1.3	1%
		pasture-grazed	0.0	0%
		non-cultivated (hayland)	0.2	0%
	Agriculture Total		1.5	1%
	Barren	mines/quarry/gravel	0.8	0%
	Barren Total		0.8	0%
Bradleys Brook Total			**2.3**	**1%**
Thompson Brook	Agriculture	cultivated	0.1	0%
		pasture-grazed	1.6	1%
	Agriculture Total		1.8	1%
	Barren	mines/quarry/gravel	0.0	0%
	Barren Total		0.0	0%
Thompson Brook Total			**1.8**	**1%**
Broad Brook Village Brook	Agriculture	non-cultivated (hayland)	0.3	0%
	Agriculture Total		0.3	0%
	Developed	residential	0.5	0%
		transportation	0.2	0%
	Developed Total		0.7	0%
Broad Brook Village Brook Total			**0.9**	**1%**
Unnamed Stream(s)	Agriculture	cultivated	26.7	14%
		farmstead	3.1	2%

		pasture-grazed	3.1	2%
		non-cultivated (hayland)	9.1	5%
	Agriculture Total		42.0	23%
	Developed	commercial	0.1	0%
		mixed development	0.3	0%
		other-ballfields	3.6	2%
		other-golf course	5.3	3%
		residential	4.5	2%
		high density residential	3.8	2%
		transportation	0.0	0%
	Developed Total		17.6	10%
Unnamed Stream(s) Total			**59.6**	**32%**
Stream Segment Total			**159.8**	**86%**
Unnamed Pond(s) Total			**10.7**	**6%**
Broad Brook Millpond	Developed	commercial	0.4	0%
		residential	1.4	1%
		high density residential	3.8	2%
	Developed Total		5.6	3%
Broad Brook Millpond Total			**5.6**	**3%**
Pond(s) - Broad Brook	Agriculture	cultivated	1.6	1%
		farmstead	1.8	1%
	Agriculture Total		3.4	2%
Pond(s) - Broad Brook Total			**3.4**	**2%**
Pond(s) - Bradley's Brook	Agriculture	cultivated	1.3	1%
		pasture-grazed	0.1	0%
		non-cultivated (hayland)	0.5	0%
	Agriculture Total		1.9	1%
Pond(s) - Bradley's Brook Total			**1.9**	**1%**
Broad Brook Reservoir	Developed	other-compact grasses	1.3	1%
	Developed Total		1.3	1%
Broad Brook Reservoir Total			**1.3**	**1%**
Pond-Broad Brook Village Brook	Agriculture	non-cultivated (hayland)	1.0	1%
	Agriculture Total		1.0	1%
Pond-Broad Brook Village Brook Total			**1.0**	**1%**
Pond-Thompson Brook	Agriculture	pasture-idle	0.6	0%
	Agriculture Total		0.6	0%
Pond-Thompson Brook Total			**0.6**	**0%**
Sadds Mill Pond	Agriculture	cultivated	0.4	0%
	Agriculture Total		0.4	0%
Sadds Mill Pond Total			**0.4**	**0%**
Unnamed Pond(s)	Agriculture	cultivated	2.1	1%
		farmstead	0.7	0%
		pasture-grazed	2.0	1%
		non-cultivated (hayland)	3.4	2%
		pasture-idle	0.0	0%
		nursery	0.6	0%
	Agriculture Total		8.7	5%
	Developed	residential	2.0	1%
	Developed Total		2.0	1%
Waterbody Total			**25.0**	**14%**
Grand Total			**184.8**	100%

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