United States Department of Agriculture
Natural Resources Conservation Service

Steele Brook Watershed Based Plan

Including Heminway Pond Dam Removal Feasibility Analysis

(Photo: USDA NRCS)

Prepared by the USDA Natural Resources Conservation Service

June 2009

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CT-TP-2009-1

Steele Brook Watershed

Steele Brook Watershed Based Plan
Including the Heminway Pond Dam Removal Feasibility Analysis

Watertown, Connecticut

(DEP-NRCS Agreement No. 67-1106-7-17)

Prepared for:

CT Department of Environmental Protection
179 Elm Street
Hartford, Connecticut 06106

Prepared By:

USDA, Natural Resources Conservation Service
344 Merrow Rd., Suite A
Tolland, Connecticut 06084

NRCS Project Manager: Carol Donzella, Community Planner

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For additional information regarding this plan please contact:

Carol Donzella, Community Planner
USDA Natural Resources Conservation Service
1 Bradley Road, Suite 506-A
Woodbridge, CT 06525
(203) 389-6925
carol.donzella@ct.usa.gov

EXECUTIVE SUMMARY

Steele Brook, which drains a watershed of approximately 17 square miles (10,904 acres), begins in the northern reaches of Watertown and flows in a southeasterly direction to its ultimate confluence with the Naugatuck River in Waterbury. The drainage to the brook encompasses approximately 14.9 square miles in Watertown, and 2.1 square miles in Waterbury. The drainage area can be divided into two distinct regions: the upper basin which is located entirely within Watertown and is dominated by residential, forested and agricultural areas; and the lower basin which lies within both Watertown and Waterbury and is characterized by highly developed residential, commercial and industrial areas.

Water quality issues identified in the lower sections of Steele Brook (from Heminway Pond Dam south) have resulted in the Connecticut Department of Environmental Protection (CT DEP) including a portion of Steele Brook on its "Impaired Waters List". Two pollutants of concern that have been identified are: 1) Escherichia coli (*E. Coli*) an indicator bacteria which has been found throughout the lower reaches of the brook and impacts recreational use, and 2) Iron precipitate which forms immediately below Heminway Pond dam during hot, dry spells and impacts aquatic habitat for fish and other aquatic life.

In early 2007 the USDA Natural Resources Conservation Service (NRCS), the Connecticut Department of Environmental Protection (CT DEP), and the Town of Watertown entered into a cooperative partnership to develop a watershed-based plan for the Steele Brook drainage basin in Watertown, CT. This undertaking followed guidelines established by the U.S. Environmental Protection Agency (EPA) for the development of watershed-based plans. The primary goal of this project is to develop an effective watershed-based plan for Steele Brook which addresses the pollutants of concern, and lays the groundwork for ultimately removing Steele Brook from the "Impaired Waters List".

Towards this end, NRCS has developed a watershed-based plan which assesses land use and land cover throughout the Steele Brook watershed and along the stream corridor, and provided recommendations to improve water quality. As part of this, an extensive dam removal feasibility analysis was performed for Heminway Pond dam.

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“A river seems a magic thing.
A magic, moving, living part of the very earth itself.”
- Laura Gilpin

(Photo: USDA NRCS)

Pin Shop Pond

(Photo: USDA NRCS)

Echo Lake

(Photo: USDA NRCS)

Sylvan Lake

(Photo: USDA NRCS)

Lake Winnemaug

(Photo: USDA NRCS)

Morehouse Pond

(Photo: USDA NRCS)

Smith Pond

(Photo: USDA NRCS)

Lockwood Pond

(Photo: USDA NRCS)

Hominnway Pond

INTRODUCTION

Steele Brook begins in the northern reaches of Watertown and flows in a southeasterly direction to its ultimate confluence with the Naugatuck River in Waterbury. The drainage area can be divided into two distinct regions: the upper basin which is located entirely in Watertown, and the lower basin which lies within both Watertown and Waterbury. The Steele Brook watershed is within the Housatonic River Major basin. See **Map 1: Steele Brook Watershed-Based Planning – Hydrography and Rivers,** and **Map 2: Steele Brook Major Basins and Rivers**.

Water quality issues identified in the lower sections of Steele Brook (from Heminway Pond dam south) have resulted in the Connecticut Department of Environmental Protection (CT DEP) including a portion of Steele Brook on its "Impaired Waters List". Two pollutants of concern that have been identified are: 1) Escherichia coli (*E. coli*) an indicator bacteria which has been found throughout the lower reaches of the brook and impacts recreational use, and 2) Iron precipitate which forms immediately below Heminway Pond dam and impacts aquatic habitat for fish and other aquatic life.

Steele Brook is considered an impaired waterbody by the CT DEP and has been included on the *List of Connecticut Waterbodies Not Meeting Water Quality Standards* since 1998. In that year, the heavy metal *copper* was identified as the critical pollutant contributing to the impairment in the brook. As required under Section 303(d) of the Federal Clean Water Act, the CT DEP developed *A Total Maximum Daily Load Analysis (TMDL) for Steele Brook* to address this impairment. In 2000, one source contributing this impairment was eliminated by redirecting the Watertown Fire District wastewater treatment discharge from Steele Brook to the newly constructed Waterbury wastewater treatment facility. The other source of copper – the former Sherwood Medical site in Waterbury – is undergoing remediation. TMDLs can be viewed on CT DEP website at http://www.ct.gov/dep/tmdl; go to "Final TMDL Analyses" table; locate appropriate document and click on link.

Subsequently, in 2006, Steele Brook was listed on the *Impaired Waters List (CT Waterbodies Not Meeting Water Quality Standards)* for *E. coli* and iron precipitate. These two pollutants are the focus of this watershed-based plan.

The "Impaired Waters List" can be found in the *2008 State of Connecticut Integrated Water Quality Report* which can be viewed on the CT DEP website at http://www.ct.gov/dep/iwqr.

Bacteria

From May 2004 to September 2005, water quality data was collected along the main stem of Steele Brook by the CT DEP. The data revealed, among other things, that elevated levels of bacteria were present in the river. In 2008, *A Total Maximum Daily Load Analysis for Recreational Uses of the Naugatuck River Regional Basin*, (Naugatuck TMDL), which includes the Steele Brook watershed, was finalized to address the high levels of bacteria. The Naugatuck TMDL can be viewed on CT DEP website at http://www.ct.gov/dep/tmdl; go to "Final TMDL Analyses" table; locate appropriate document and click on link.

According to the U.S. Environmental Protection Agency (EPA), there is a statistical relationship between the levels of *Escherichia coli* (*E. coli*), an indicator bacteria, and human illness rates. *E. coli*, like some other bacteria, originates from the intestinal tracts of humans as well as other warm-blooded animals. Some potential sources include: crop-related sources (manure spreading); intensive animal feeding operations; residential septic failures; wildlife (particularly waterfowl); domestic pet waste; illicit discharges; stormwater runoff and public swimming areas. The presence of these bacteria in Steele Brook indicates that human waste or animal manure is present. Though not necessarily harmful themselves, they are indicators of other disease-causing organisms and are used as a general indicator of sanitary water quality conditions.

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

- Not to exceed 235 colonies/100ml (for official bathing areas) or 576 colonies/100ml (for all 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 protecting recreational uses such as swimming, canoeing, kayaking, wading, water skiing, fishing, and others. When the bacteria counts exceed the criteria, there

may be an associated health risk from water contact. The Connecticut Water Quality Standards can be viewed on CT DEP website at http://www.ct.gov/dep/wqsc.

The Naugatuck River TMDL establishes the maximum loading of bacteria that Steele Brook can receive without exceeding the water quality criteria established by CT Water Quality Standards. TMDLs in general establish the maximum concentration of a pollutant that a waterbody can have without an adverse impact to fish, wildlife, recreation, or other designated uses. The end result is a quantitative goal to reduce pollutant loading to the waterbody, expressed as an average percent reduction from current loadings that must be achieved to meet water quality standards.

Potential sources of bacterial pollution in Steele Brook, as identified in the TMDL, include stormwater runoff, sanitary sewer overflows (collection systems failures), and illicit discharges. For more detailed information, please refer to *A Total Maximum Daily Load Analysis for the Naugatuck River Regional Basin* and the Connecticut Department of Environmental Protection *Water Quality Standards.*

Much of the bacterial pollutant loading, and associated poor water quality conditions in Steele Brook and its tributaries can be attributed to non point source (NPS) pollution. NPS pollution, simply stated, is polluted runoff. Surface runoff from rainfall or snowmelt moves over 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 a discharge pipe or outfalls. Point sources can be easily identified, monitored and regulated. Non-point sources are often hard to identify and therefore more difficult to monitor and control or regulate. However, by examining land use patterns and activities throughout the watershed, and along the river corridor, we can begin to identify sources of bacteria and begin to address them.

What is NPS Pollution?
Common and widespread, NPS pollution is considered by the Environmental Protection Agency to be a leading cause of water quality impairment nationwide. NPS pollution results when rainfall and snowmelt carry accumulated pollutants into nearby water resources (vs. point source pollution, such as that coming from sewage treatment plans). Since these sources are so diffuse, addressing them is a considerable challenge.

Common NPS Pollutants
Nutrients (from fertilizers, yard waste, animal manure)
Sediments (road sand)
Pathogens (in bacteria)
Toxics (heavy metals, pesticides, herbicides)
Debris or litter

Common Sources
Construction sites, Roads, Parking lots, Roofs, Lawns, Farms, Failing Septic Systems

Iron Precipitant

A section of Steele Brook just upstream of Echo Lake Road and near Heminway Pond dam, has been a concern due to orange discoloration, turbidity and loss of habitat caused by flocculation. This condition was noted during hot summer weather, and low water flow conditions. The exact cause of this is unknown, but may be related to historic filling of adjacent wetlands (where ball fields are now located), or through natural organic chemical processes. This condition can impact aquatic habitat for fish and other aquatic life. Because the source of the iron precipitate is not being introduced to Steele Brook from one point, it is also considered a form of non point source pollution. This impairment develops below Heminway Pond dam and extends downstream to the mouth of Steele Brook. Due to the ephemeral nature of this situation, this impairment is not easily quantified. However, CT DEP's theory is that by improving flow will alleviate this problem. Removing Heminway Pond dam or otherwise improving flow through this section is a possible solution to addressing this water quality issue.

Watershed-based Planning Concept

TMDLs, as described for copper and bacteria are one type of tool that water quality managers use to address water quality problems. TMDLs are required by the Federal Clean Water Act, unless there are other pollution control requirements in place that are expected to address the impairment.

Watershed-based plans are a complimentary tool for addressing water quality impairments. They take a broader look at the watershed and include recommendations for best management practices, which upon implementation, are anticipated to eliminate or reduce impairments. The type of watershed-based plan described here refers specifically to guidance that has been developed by EPA under its non point source program, and associated grant program. (Funded by FED CWA Sec. 319) These watershed-based plans must address "9 elements" which start with identifying causes/sources and include measures to address problems and ways to measure success. This will be discussed in more detail in following sections of this report. This watershed-based plan, a cooperative effort between NRCS, CT DEP and the Town of Watertown has been developed specifically to address *E. coli* and iron precipitant impairments. While this

report includes some information on the small portion of Steele Brook watershed that lies in Waterbury, the primary focus of this watershed-based plan is the Town of Watertown.

Map 1: Steele Brook Watershed-Based Planning Project – Hydrography and Roads

Map 2: Steele Brook Watershed Location Including Major Rivers and Basins

STEELE BROOK WATERSHED AND WATER QUALITY

CT Water Quality Standards & Classifications

Under the federal Clean Water Act, CT DEP has responsibilities to monitor and assess waters of the state to determine if they are meeting designated uses established by the Water Quality Standards and Classifications. Aquatic habitat quality is evaluated using biological indicators such as fish and aquatic insects known as macroinvertebrates. The section of Steele Brook immediately below Heminway Pond is listed as not meeting designated use goals for aquatic habitat. Iron flocculation and precipitate have been identified as one of the causes of poor aquatic habitat quality. Other possible sources include urban stormwater, land fills and other unknown sources.

According to the Connecticut Surface Water Quality Classifications, Steele Brook is classified as Class A from its headwaters to the former outfall of the Watertown Fire District sewage treatment plant upstream of Pin Shop Pond, and as Class B from Hemingway Pond to its mouth at the Naugatuck River. Its tributaries: Smith Pond Brook, Lockwood Pond Brook, Echo Lake Brook and Clough Brook are designated as Class A. Wattles Brook and Turkey Brook are designated as Class B. See **Map 3: Surface Water Quality**.

Water Quality Monitoring and Assessment

Recreational Use Water Quality Impairment and E. coli

From May 2004 to September 2005, water quality data was collected by CT DEP along the main stem of Steele Brook at three locations below Heminway Pond dam. The data revealed, among other things, that elevated levels of bacteria were present in the river. It should be noted that high levels of bacteria were present in samples taken under both wet and dry conditions. See **Table 1: CT DEP Steele Brook *E. coli* Results Summary**.

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".

Map 3: Surface Water Quality

According to CT Water Quality Standards acceptable levels of *E. coli* bacteria levels should not exceed 235 colonies/100ml for official bathing areas or 576 colonies/100ml for all other water contact recreation for single samples, and not exceed a geometric mean of 126 colonies/100ml for any group of samples.

The high levels in these samples indicate that urban stormwater runoff is not the only source of significant bacteria loading. Instead, these data suggest the presence of another local persistent source or sources contributing to the high bacteria levels. Such as, illicit connections and discharges to stormwater sewers.

Table 1 CT DEP Steele Brook E.coli Results Summary
Sites are listed downstream to upstream. Results are reported for the sampling season as a geometric mean, an average value that reduces the influence of very high and very low values.

Site #	**Location**	***E. coli* Results Colonies/100 ml**
331	Steele Brook at Municipal Stadium	2004 Dry 1412 2004 Wet 4011 2005 Dry 220 2005 Wet 693
514	Steele Brook at Mouth	2004 Dry 1142 2004 Wet 4199 2005 Dry 860 2005 Wet 1675
696	Steele Brook at Echo Lake Road	2004 Dry 571 2004 Wet 2146 2005 Dry 526 2005 Wet 1135

(CT DEP, September 2005)

Based upon these findings, CT DEP completed the TMDL for the Naugatuck River Regional Basin. The TMDL lists the impaired use as recreation and the cause as *E. coli*, an indicator bacteria.

To determine whether the State's surface water resouces are meeting the designated use goals assigned to them per the Water Quality Classifications, CT DEP periodically assesses selected water bodies throughout the state. Generally, three basic designated uses are assessed for each surface water resource: fish consumption; recreation, and habitat for fish, other aquatic life and wildlife. These results are reported biennially to the federal government in the "Integrated Water Quality Report to Congress".

For more information visit the CT DEP's website at http://www.ct.gov/dep/lib/dep/water/water_quality_management/305b/2006_305(b)fulplusapps.pdf.

Impaired Waters

Through the water quality assessment process, a subset of water bodies have been identified as not meeting Connecticut's "Water Quality Standards". These water bodies are called "impaired waters" and are indentified in a separate section of the "Integrated Water Quality Report to Congress", generally referred to as the "Impaired Waters List", which can be viewed on the CT DEP website at: http://www.ct.gov/dep/iwqr.

Water Quality Standards, Classification and Criteria

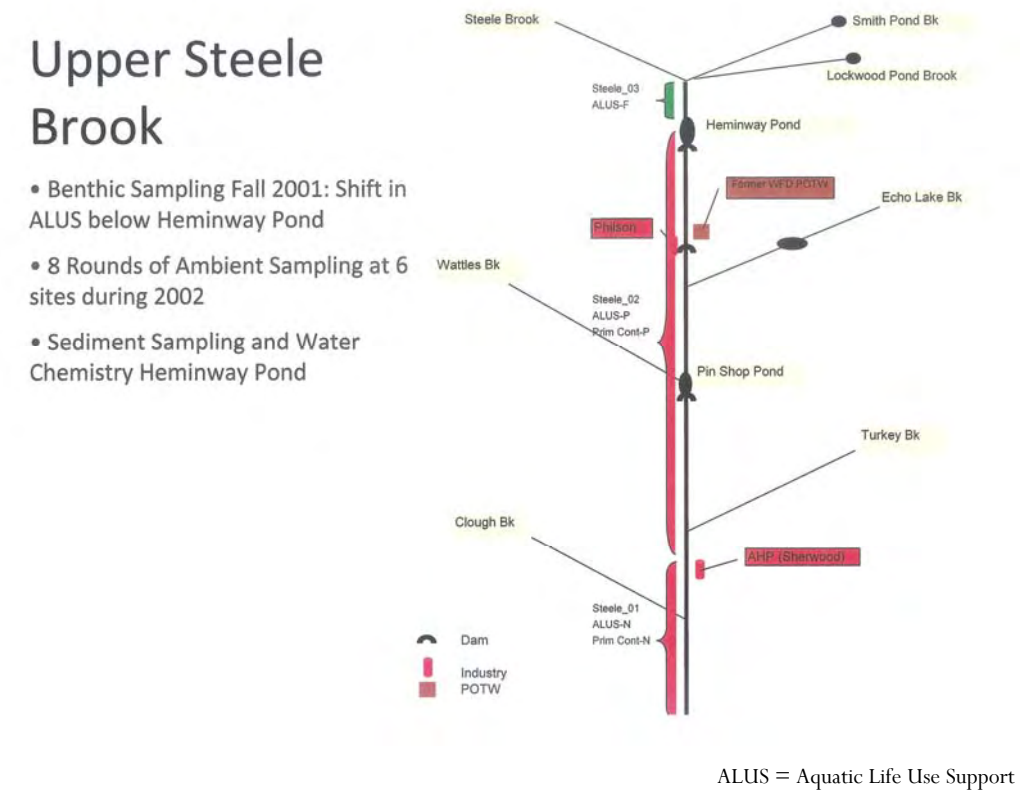
Per federal Clean Water Act requirements as well as Connecticut's own Clean Water Act, the State has adopted "Water Quality Standards" (WQS) that establish water quality management goals and policies for the State's surface and ground waters. There are three basic elements associated with the WQS: standards, classifications and criteria, and classification maps. Connecticut's Water Quality Standards can be viewed on CT DEP's website at: http://www.ct.gov/dep/lib/dep/water/water_quality_standardsl/wqs.pdf.

Aquatic Habitat Impairment and Iron Precipitate

Upper Steele Brook was the focus of a water quality investigation conducted during the summer of 2001 by the CT DEP. This section was listed on the 2002 "Impaired Waters List" for not meeting Aquatic habitat goals due to poor benthic macroinvertebrate community. However, the cause of the impairment has not been identified. Poor macroinvertebrate community was found to extend from just below Heminway Pond dam in the vicinity of Echo Lake Road to the mouth of Steele Brook. Sites upstream of Heminway Pond were found to have good benthic macroinvertebrate communities which indicate that water quality standards are being met. The sampling was conducted at six sites along the main stem of Steele Brook at the confluences of: Smith Pond Brook, Lockwood Pond Brook, Echo Lake Brook, Wattles Brook, Turkey Brook and Clough Brook. See **Figure 1: CT DEP Sampling Sites for Macroinvertibrates**.

In addition, water samples were taken from Steele Brook, and preliminary sediment grabs and water chemistry were taken from Heminway Pond.

Figure 1: CT DEP Sampling Sites for Macroinvertebrates



ALUS = Aquatic Life Use Support

CT DEP found that subsurface water in the vicinity of Steele Brook below Heminway Pond contains dissolved ferrous iron. Under low flow conditions, this subsurface water becomes a dominant component of the surface water in Steele Brook. When this happens, the ferrous iron gets exposed to oxygenated water in Steele Brook, and the iron becomes oxidized and forms iron precipitate and flocculation in the section below Heminway Pond. The iron precipitate and flocculent causes a generally poor aesthetic quality, excessive turbidity, and smothers benthic habitat in Steele Brook (See **Figure 2)**.

The iron flocculent and precipitate can cause episodic stress to aquatic organisms by filling interstitial spaces in the stream bottom that are critical for macroinvertebrate living space and fish spawning. In extreme cases like those observed in Steele Brook, the iron precipitate can

cement the stream bottom and smother macroinvertebrates and young fish (e.g. egg and larvae) and cause mortality. These conditions have been observed to co-occur with dead fish in Steele Brook **(**See **Figure 3).** In addition, iron precipitate can negatively affect the respiration of aquatic organisms by coating the gills of fish and macroinvertebrates.

A section of Steele Brook just upstream of Echo Lake Road, adjacent to Heminway Park School, and near Heminway Pond dam, has been a concern due to orange discoloration, turbidity and loss of habitat caused by flocculation. The orange discoloration was first observed at a pipe which drains the ball field located on the lower end of the west bank. The orange condition ends approximately at the end of the broken wall on the west bank. There is some anecdotal evidence that the area where the ball field is located was a landfill at some point. Old aerial photos dating back to 1934 show the ball field was present so the landfill would have to predate this date. Aerial photos also indicate that there may have been some wetlands lost over the years that were adjacent to the pond and stream.

There is a stretch of Steele Brook below the dam at Heminway Pond that does not exhibit this condition, (i.e. the water is clear and normal above the broken wall to the dam) which seems to rule out the pond as a source.

It should be noted that iron preciptate is a naturally occuring process, and although it is not aesthetically pleasing, it does not pose any environmental health risks to humans or wildlife.

For additional information on the impact of stormwater on aquatic life refer to CT DEP article *Stormwater and Aquatic Life: Making the Connection between Impervious Cover and Aquatic Life Impairments for TMDL Development in Connecticut Streams* in **Appendix D**.

(Photo: CT DEP)

Figure 2: Iron flocculation and precipitate observed in Steele Brook below Heminway Pond on July 23, 2002. These conditions can be stressful and cause mortality to macroinvertebrates and fish.

(Photo: CT DEP)

Figure 3: Iron flocculation and dead yellow perch (see blue box) observed in Steele Brook below Heminway Pond on August 28, 2002.

PURPOSE

Because land planning decisions are made at a local municipal level in Connecticut, this watershed-based plan is intended to help watershed residents and decision makers understand the impact of non point source pollution on Steele Brook and provide options for reducing or eliminating it. More specifically, this planning effort is intended to provide the Town of Watertown with recommendations to address the impairments associated with bacteria and iron precipitate, with the ultimate goal of assisting CT DEP with removing Steele Brook from the "Impaired Waters List". Towards that end, this watershed-based plan has two distinct, but related purposes: 1) to provide general recommendations for best management practices (BMPs) to be implemented along the stream corridor and throughout the watershed to reduce bacterial loading to Steele Brook, 2) to evaluate the feasibility of removing Heminway Pond dam so as to improve flows in this section of the stream and address the iron precipitate issue. This plan is also intended to satisfy the guidance set out by the EPA in Section 319 of the Clean Water Act regarding the development of a watershed-based plan.

With regard to the BMP recommendations, it should be noted that these are intended to help address the objectives of the Naugatuck TMDL. While the TMDL describes the bacteria reductions needed to meet the water quality standards for bacteria, it does not describe the appropriate measures that may be implemented within the watershed to achieve these reduction goals.

That being said, it is also important to point out that the BMP recommendations provided in this plan were developed on a watershed scale. As such, the suggested practices highlight the relationship between existing land use conditions and water quality, and can be used as guidance to develop more site specific measures.

This plan also provides information to help the Town of Watertown and other watershed stakeholders to understand 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 various ways to obtain the necessary resources, including allocations in municipal budgets, applying for grant money and fundraising activities.

Implementing the measures as outlined in this report, in whole or in part, will help to improve and maintain the health of Steele Brook and its watershed.

This watershed-based plan provides information for two groups: stakeholders within the Steele Brook watershed; and individuals, entities and groups interested or involved in implementing watershed-based planning. For the watershed stakeholders (e.g. municipal officials and staff, members of local land use commissions, landowners, and individuals interested in watershed natural resource issues) this watershed-based plan offers:

- General information about the Steele Brook watershed and broad understanding of current watershed conditions;
- A management guide for reducing iron precipitate and bacterial loading and addressing general non-point source pollution concerns;
- A starting point from which local stakeholders can prioritize implementation projects;
- A funding document – information that can be used to support requests for future funding of projects designed to improve the health of the Steele Brook watershed.

SCOPE

As described in the previous section, the purpose of this project is to provide general recommendations for the implementation of BMPs, and evaluate the feasibility of removing Heminway Pond dam.

Section 319

Congress enacted Section 319 of the Federal Clean Water Act in 1987, establishing a national program to control non point sources of water pollution. This program is overseen by EPA and delegated to states. During the last several years EPA has been working with the states to strengthen its support for watershed-based environmental protection by encouraging local stakeholders to work together to develop and implement watershed-based plans appropriate for their community. In particular, EPA and the states have focused attention on waterbodies listed by states as impaired under Section 303(d) of the Federal Clean Water Act. Toward this end, states are directing a portion of Section 319 funds towards development and implementation of watershed-based plans to address waterbodies on the state "Impaired Waters List" aka 303(d) list. These watershed-based plans may also include activities that address waterbodies within the watershed that are not currently impaired, where appropriate, to prevent future impairments of that waterbody. Watershed-based planning offers a more holistic approach for identifying and addressing sources causing impairments. In this case, CT DEP has provided 319 funding to NRCS to create a WBP for the Steele Brook watershed in Watertown, CT.

319 Watershed-based Plan "9 Elements"

EPA mandates that certain criteria be met in order for an implementation project to be considered for funding using Section 319 monies. Beginning in the federal fiscal year 2004, one such criterion required by EPA is that a watershed-based plan exists and that the watershed-based plan addresses nine specific criteria. They are:

1. The identification of the causes and sources of pollution that will need to be controlled to achieve load reductions estimated to fix the impairment, and to achieve any other watershed goals identified in the watershed-based plan.
2. An estimate of the load reductions expected from the management measures described.

3. A description of the non-point source management measures that will need to be implemented to achieve the estimated load reductions.
4. An estimate of the amounts of financial and technical assistance needed, and/or the sources and authorities that will be replied on, to implement this watershed-based plan.
5. An information/education component that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented.
6. A schedule for implementing the non-point source management measures identified in the watershed-based plan.
7. A description of interim, measurable milestones that can be used to determine whether non-point source management measures or other control actions are being implemented.
8. A set of criteria to determine whether loading reductions are being achieved over time, and if progress is being made towards attaining water quality standards and, if not, the criteria to determine if this watershed-based plan, or a related TMDL, needs to be revised.
9. A monitoring component to evaluate the effectiveness of the implementation efforts over time.

The need to include the 9 criteria, in essence, establishes the structure of the watershed-based plan. "These 9 elements include explicit short- and long-term goals, objectives and strategies to protect and restore water quality; ways to strengthen working partnerships; balance approaches that emphasize both state-wide programs and on-the-ground management of individual watersheds where waters are impaired or threatened; focus on both abating existing problems and preventing new ones, and use a periodic feedback loop to evaluate progress and make appropriate program revisions." (From EPA Section 319 website: http://www.epa.gov/fedrgstr/EPA-WATER/2003/October/Day-23/w26755.htm).

While stakeholders may have identified other issues and concerns within the watershed, such as the proposed greenway and trail system, alternate energy sources and contaminants in Pin Shop Pond, this watershed-based plan is not designed to address those matters directly. The

implementation of the BMPs suggested in this report may, however, provide ancillary benefits to those concerns.

PUBLIC INVOLVEMENT

An important part of developing this watershed-based plan has been the involvement of the public. Direct public involvement came through the development of an Advisory Committee and a Working Group Committee. Comprised of a cross-section of the community – local citizens, municipal representatives, land trust members, local business owners, as well as council of government members, non-profit environmental organizations, and state and federal agency personnel, these committees served as a mechanism for incorporating local, regional, state and federal input into the watershed-based plan. Individual committee member participation in these committees also served as a tool for disseminating information about the effort to the broader public. Likewise, committee members also acted as a conduit for information to be brought into the planning process. In addition to enabling the flow of information, this approach also allowed the process to be transparent and fully open.

This public forum also allowed the opportunity to have productive discussions about other issues, projects, and activities in the watershed. For example, while reviewing the municipal regulations it was noted that there were many horses in the watershed, but there are no regulations in place to address their environmental impact on Steele Brook. This led to a search of Connecticut towns that had horse regulations in place for the Town of Watertown to review and consider adopting in the future. In another case, wind power as an alternative energy source was discussed and information was gathered for future review.

Also, the establishment of a Steele Brook greenway and multi-use trail has been a topic of great interest with the Town of Watertown. This led to inviting a representative from the CT DEP State Trails and Greenway Program to talk about the program, and the Town submitting applications for a small greenway grant and state greenway designation, both of which they received.

The development of a Steele Brook greenway is seen as a complementary activity to the development of the watershed-based plan. Improving water quality is intrinsic to resident's enjoyment of Steele Brook. Likewise, development of a greenway may increase concern about the health of this waterbody.

In addition to regular committee meetings, outreach activities were organized throughout the process. These efforts were designed to generate awareness of the watershed-based planning effort, and engage local citizens so as to better connect them with Steele Brook and its watershed. Outreach activities included:

- A map exercise, posted in the local newspaper, encouraged citizens to identify polluted places in town by circling blighted areas. They were also encouraged to circle areas that they would like to see preserved or protected. The maps were returned to the Town's Public Works Department for review and consideration.
- A table was set up at the annual Fall Festival with maps of the watershed and information on the Steele Brook watershed-based plan, the proposed greenway, and other Town initiatives. Citizens were encouraged to locate their homes on the watershed map and report areas of concerns.
- Several articles about the project were posted in local newspapers.
- A Channel 3 news segment, shown statewide, highlighted the project.

The continued involvement of the public will be critical to achieving the goals of the Steele Brook watershed-based plan.

METHODOLOGY

In order to better understand the causes of bacteria and iron precipitate related impairments, or develop recommendation to address these water quality issues, NRCS conducted a watershed analysis. The watershed analysis was divided into two parts: data collection and analysis, and evaluation of findings and development of recommendations.

During data collection, NRCS gathered existing data and developed various studies that would help to characterize and accurately access the current physical conditions of the Steele Brook watershed. NRCS:

1. Generated a detailed GIS land use/land cover map based on interpretation of aerial photography.
2. Generated a detailed corridor map for the area between Route 6 (above Heminway Pond) to the Pin Shop dam for the proposed greenway/trail system. The corridor analysis examined wetlands, riparian vegetation and stormwater inlet/outlets.
3. Generated a riparian map to evaluate corridor characteristics along the main stem of Steele Brook upstream and downstream of the detailed corridor analysis area.
4. Performed a municipal regulations review focused on water quality and water quantity issues.
5. Conducted a watershed Phase 1 fluvial geomorphic and stream ordering assessment.
6. Conducted an inventory of fish barriers along the main stem of Steele Brook.
7. Produced a set of maps describing appropriate stormwater runoff management techniques based on soil types.
8. Conducted an analysis of pervious/impervious cover.
9. Conducted a hydraulic analysis from Echo Lake Road to Route 6 to evaluate the present conditions and dam removal options.
10. Conducted a dam removal option evaluation.

During the course of the project, the Advisory Committee and Working Group Committee were requested to provide input and/or comment as deemed appropriate.

NRCS examined the findings from the studies and developed recommendations to address impairments by comparing ways in which watershed conditions and characteristics related to each other and to water quality conditions.

First, all of the watershed and river corridor areas were evaluated to determine possible locations, and likely sources of pollutant bacteria loading. Factors in the analysis included land use and land cover data to determine if there might be particular land uses contributing to bacteria loading such as agriculture, un-buffered sections of stream, and soil suitability for sub-surface sewage disposal systems, amongst others.

This assessment and evaluation of watershed conditions creates a way for local decision makers to comprehend the connection between existing land use and water quality impairments, and provides information to help make appropriate changes to correct the situation. NRCS used this information to develop recommendations for the BMPs that would be suitable for issues identified, and provide the greatest impact for the watershed as a whole.

Land Use/Land Cover GIS Data Set

The primary objective of the Land Use/Land Cover (LULC) data set is to provide a picture of the Steele 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) entering into surface water and/or ground water. Using 2006 aerial photo imagery, a total of 30 classes of land use and land cover were established. 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.

NRCS mapped the watershed land use and land cover types at three levels of classification. The Level 1 classification shows the watershed land use and land cover types consolidated into seven (7) broad categories. Level II subdivides the seven broad categories into 22 detailed land use/land cover classifications, and Level III sub-divides the detailed land use/land cover classifications to a finer level of detail; six (6) categories that have subtle differences. **(**See **Map 4: Land Use/Land Cover)**. For additional details on the Land Use Land Cover map see **Appendix A**.

LULC Findings

The LULC findings support the perception of the Steele Brook watershed as a complex landscape with a mix of land uses, as can be seen from the totals in **Table 2: Levels I, II and III Watershed Land Use/Land Cover Summary.** Developed land cover comprises a little over half of the watershed (52.8%), while a little over thirty-six percent of the watershed is classified as forested land, and just over five percent is in agriculture.

The LULC data, in conjunction with the USGS hydrology layer, was used to determine the location and extent of potentially non-buffered areas. When these data layers were analyzed for the adjacency of polygons of development or agriculture to perennial waters, stretches of streambank and shoreline were highlighted that were 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.

Map 4: Land Use Land Cover Map

Table 2: Levels I, II and III Watershed Land Use/Land Cover Summary

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.
		Low density	**drl**	This unit is typically comprised of residences outside of urban centers that exceed the threshold of 20% cover of constructed material, but do not meet the requirement of High Density Residential.
	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. Along with roadways and railroad corridors, this includes rights-of-way, areas used for interchanges, and service and terminal facilities. Rail facilities include 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 ### 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.
		Ball Fields	**dob**	Baseball, soccer, football and other heavily used active recreation areas
		Cemeteries	**doc**	Self-explanatory
		Golf Courses	**dog**	Self-explanatory
		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

Level I	Level II	Level III	Symbol	Definition
				both. Hay land 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.
	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 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
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/ Coniferous		**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.
WATER			**w**	Water includes all areas that are persistently water covered.
	Lakes &Reservoirs		**wl**	A natural inland body of water, fresh or salt, extending over 40 acres or more and occupying a basin or hollow on the earth's surface, which may or may not have a current or single direction of flow.
	Streams & Rivers		**ws**	The Streams and Canals category includes rivers, creeks, canals, and other linear water bodies. Where the watercourse is interrupted by a control structure, the impounded area will be placed in the Reservoirs category.
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.
	Beaches		**bb**	This unit includes the area adjacent to the shore of an ocean, sea, large river, or lake that is washed by the tide or waves.
	Strip mines, Quarries, Pits		**bm**	This unit includes land that is actively used for extraction of ores, minerals, and rock materials.
	Permanently bare soil/rock		**br**	This unit consists of areas that are large enough to meet size requirements, and that consist of permanently bare rock or soil.
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.

Level I	Level II	Level III	Symbol	Definition
	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.

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. Data that could be captured in separate datasets was not classified in this one. Therefore, the classification of wetlands will come through a combination of the inland wetland soils database, the land cover types classified here and any ground-truthing or further information gathered through the wetland assessment protocol. General values for percentage impervious surface will likely be assigned based upon the artificial cover types classified under Developed Lands. The presence/absence of pollutants could be affected by the use of the land. Therefore, areas where fertilizers and nutrients may be applied were separated from areas where there are animals actively grazing and also from areas that are currently fallow or abandoned.

Soil Based Recommendations for Storm Water Management Practices

Parent Material

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 type of minerals are in the soil and 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. The following is a summary of the soil parent materials in the watershed.

Organic deposits are rare in the Steele Brook watershed, occupying less than one 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 wetlands.

There are slightly more than two percent of alluvial or floodplain deposits in the watershed which are mostly found along Steele and Smith Pond Brooks. These materials are transported by overflowing streams and occur on level to nearly level floodplains. 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. 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 agricultural and forestry production. Less well drained alluvial soils provide wildlife food and habitat and buffer streams. They are all important areas for storing flood waters and are regulated as Connecticut wetlands.

Glaciofluvial materials are of moderate extent in the watershed, covering between 10 and 15 percent of the area. 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 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. A significant portion of these soils in the Steele Brook watershed have been impacted by urbanization.

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). Glacial till is not only the most common parent material in the watershed, but in Connecticut as a whole. 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 moderate shallow (20-40"). They have less capacity to absorb runoff or hold water for plants.

Twenty-five percent of the soils in the watershed are characterized Urban influenced. These areas have been altered by human activity and show extreme variability from one location to another. They include paved or otherwise impervious areas that increase their runoff potential. Many urban areas have little capacity to store rain water unless specific practices are installed.

As it rains in the watershed, water will make its way from the upland till areas towards the lakes and streams. The forest canopy and ground cover, 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 man-made or compacted 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 either seep into the soils, evaporate, or be taken up by plants. The rest will run directly into surface waters.

The following section will illustrate in more detail how soil characteristics and land use can influence water movement in the watershed. Refer to **Map 5: Parent Material**.

Map 5: Stormwater Runoff Management: Parent Material

Stormwater Runoff Management

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. They do not replace an on-site soil evaluation or site specific engineered design for site development (Refer to **Appendix B** for more detailed discussion of soil based recommendations for storm water management practices). The planning limitations shown on the maps that follow highlight the importance of detailed site specific placement and design.

Findings

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. Very 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. Refer to **Map 6: Stormwater Runoff Management: Soil Suitability for Stormwater Infiltration Systems.**

Map 6: Stormwater Runoff Management: Soils Suitability for Stormwater Infiltration Systems

Wet-Extended Detention 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. Refer to **Map 7: Stormwater Runoff Management: Soil Suitability for Wet-Extended Detention Basins**.

Map 7: Stormwater Runoff Management: Soil Suitability for Wet-Extended Detention Basins*

Dry Detention Basins*

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. Refer to **Map 8: Stormwater Runoff Management: Soil Suitability for Dry Detention Basins**.

Map 8: Stormwater Runoff Management: Soil Suitability for Dry Detention Basins*

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. Refer to **Map 9: Stormwater Runoff Management: Soil Suitability for Pervious Pavement**.

* The Connecticut DEP requires that field-measured soil infiltration rates be less than 3.0 inches per hour for primary treatment systems. For more information on field infiltration measurements refer to Chapter 11-P3 of the *2004 Connecticut Stormwater Quality Manual*.

Map 9: Stormwater Runoff Management: Soil Suitability for Pervious Pavement

Pervious/Impervious Surface Analysis

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.

Soils 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 an-undisturbed woodland on the same soil.

Land use/land cover classes are divided into 3 categories of runoff potential: high, moderate and low. The highest runoff potential is assigned to highly urbanized, commercial and industrial areas. In addition, ball fields, picnic and grassed parking areas are 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.

A sense of the overall balance in the watershed and how much of the area remains 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 are necessary to verify conditions for site specific analysis and engineered designs.

Areas with low runoff potential, based on soils and land use, are providing the most protection to Steele Brook from runoff, and have the greatest potential for recharge in the watershed. Some of these 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. For the areas that have low runoff potential for both land use/land cover and soil, refer to **Maps 10-12**. When these areas are developed, the impact on the overall watershed condition may be more significant than in less pervious locations.

The 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 to address water quality and quantity are recommended.

Findings

Runoff potential based on soils

Watershed wide, approximately 50% of the acreage has low soil runoff potential, 30% has medium soil runoff potential and 20% has high soil runoff potential. As shown on the map, approximately 35% of the map units may be in urban land and have a very high runoff potential. The primary reasons for high soil runoff potential in the watershed are shallow bedrock, steep slopes and urbanization. See **Map 10: Potential for Runoff Based on Soil Properties**.

Runoff potential based on land use/land cover

Watershed wide, approximately 50% of the acreage rates high for runoff potential based on land use/land cover. This area is in high density residential, commercial, industrial, and transportation areas and includes ball fields, compacted grass, farmsteads, mixed-development, and mined/quarries. An additional 20% is rated medium and is in low density residential, cemeteries, land fills, beaches, bare rock, agricultural areas (except farmsteads) and golf courses. Approximately 30% is rated low and is mostly in forested lands and transitional areas. See **Map 11: Potential for runoff based on land use/land cover classifications**.

Combined runoff potential – soil properties and land use/land cover

Approximately 20% of the acreage with high soil based runoff potential is occupied by high runoff potential land uses or medium runoff potential land uses. These uses are found along Routes 6, 63, and 73 and along the main stem of Steele Brook and its tributaries. They include high density residential, commercial, industrial, and transportation areas along with ball fields, compacted grass, farmsteads, mixed-development and mine/quarries.

Some possible recommendations based on these findings include:

- Conduct site specific visit for areas rated high for both soils and land use and design BMP if needed
- High density residential areas, especially those occupying areas with high and medium 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 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 impact 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.

See **Map 12: Potential for runoff based on combination of soil properties and land use/land cover classifications**.

Map 10: Potential for Runoff Based on Soil Properties

Map 11: Potential for runoff based on land use/land cover classifications

Map 12: Potential for runoff based on combination of soil properties and land use/land cover classifications

Corridor Analysis

One of the environmental goals listed in the Town of Watertown's Plan of Conservation and Development (2007) is to establish bikeways, hiking trails and other recreational opportunities to improve the quality of life for its citizens. In that respect a corridor analysis was conducted from Route 6 to the Pin Shop Pond dam to help the Town of Watertown with the placement of a proposed greenway. The data gathered in the corridor analysis area also provided information for the watershed-based plan in addressing water quality issues.

The corridor analysis documents the types of land uses and land covers, stormwater inlet/outs, wetlands (based on soil types) and riparian vegetation within the study area. It also helps locate areas that have the potential to contribute bacteria and other possible sources of pollution to Steele Brook, and helps identify environmentally sensitive areas that the Town of Watertown may want to consider preserving and protecting. It also shows where possible linkages can be made to other recreational areas and neighborhoods to help with the placement of the proposed greenway and other local planning initiatives.

Findings

Utilizing Geographic Information System (GIS) imagery, the location of Connecticut's inland wetlands, riparian vegetation, stormwater inlets/outlets, land uses and land covers within this study area were layered together and put into map format.

The inland wetlands, as mapped, are based on the *Connecticut State Soil Survey (2002)* Inland Wetland status. The wetland soils are coincident with a number of land uses and land covers. Of the 46 acres of wetlands that have been mapped in the corridor, 66% are in deciduous forested cover and 29% have been developed in some way. The remainder is considered to be in agriculture. Refer to **Table 3: Acres of Land Use Cover in Wetland Soils**.

Table 3: Acres of Land Use Cover in Wetland Soils

fd: forest-deciduous	Acres of cover in wetland soils	30.42
	Percentage of Corridor Wetlands in cover	66%
drh: developed-residential-high density	Acres of cover in wetland soils	5.58
	Percentage of Corridor Wetlands in cover	12%
dc: developed-commercial	Acres of cover in wetland soils	5.41
	Percentage of Corridor Wetlands in cover	12%
au: agriculture-nursery	Acres of cover in wetland soils	1.55
	Percentage of Corridor Wetlands in cover	3%
di: developed-industrial	Acres of cover in wetland soils	1.38
	Percentage of Corridor Wetlands in cover	3%
dt: developed-transportation	Acres of cover in wetland soils	0.64
	Percentage of Corridor Wetlands in cover	1%
doc: developed-other:cemetery	Acres of cover in wetland soils	0.58
	Percentage of Corridor Wetlands in cover	1%
ag: agriculture-grazed	Acres of cover in wetland soils	0.27
	Percentage of Corridor Wetlands in cover	1%
dob: developed-other: ball fields	Acres of cover in wetland soils	0.15
	Percentage of Corridor Wetlands in cover	0%
wl: water-lake	Acres of cover in wetland soils	0.02
	Percentage of Corridor Wetlands in cover	0%
ws: water-stream	Acres of cover in wetland soils	0.00
	Percentage of Corridor Wetlands in cover	0%
Total Acres of cover in wetland soils		**46.00**
Total Percentage of Corridor Wetlands in cover		**100%**

The locations of the stormwater catch basins in this study area appear as tiny green circles on **Map 13: Corridor Analysis**. This notes the large number of catch basins that have the ability to transport contaminated stormwater into Steele Brook. By identifying their locations, and the land use around them, this may help in identifying possible sources of bacteria and other sources of pollutant loading. There are also outfalls noted on the map (tiny brown circles), indicating points of direct discharge of stormwater flow. For definitions of land use covers see Table 2.

The corridor analysis divides the watershed into three sections for easier interpretation. Starting upstream and working downstream, the first section is from Route 6 to French Street, the second from French Street to Pleasant View Avenue, and the third from Pleasant View Avenue to the Pin Shop Pond.

The section from Route 6 to French Street is mostly developed with high density residential, industrial and commercial land uses, some forested areas, a wetland system that runs from Princeton Road to French Street, a ball field near Echo Lake Road, a cemetery near French Street, and Heminway Pond in the northern reaches. There are a large number of catch basins in this section, many located in the industrial areas, and a few outfalls, one of which is on the main stem of Steele Brook. The stormwater runoff from impervious surfaces in the developed areas (i.e. streets, parking lots, roofs, etc.), along with geese congregation at the ball field and pond and pet waste from dog walking in residential neighborhoods, have the potential to increase pollutant loading in Steele Brook. Catch basin inserts, street sweeping, vegetative buffers and geese and pet waste management are some best management practices that can be used to address these possible sources of non point pollution.

The section from French Street to Pleasant View Avenue is mostly developed with commercial and high density residential land use. A wetland system runs through the center of this section from French Street to Main Street, with smaller wetland systems located near Harper Road, Charles Street, Colonial Road and Straits Turnpike. This section also contains a forested area that runs along the main stem of Steele Brook. This forested area is extremely important to the health of Steele Brook due to its location near the commercial areas and its ability to act as a buffer, filtering out pollutants from surface runoff before entering the stream. Three ball fields are also located in this section and are known areas for geese congregation.

A large number of catch basins are located in the commercial area along Main Street with outfalls located on a tributary that drains into Steele Brook.

The section from Pleasant View Avenue to the Pin Shop Pond is mostly developed with high density residential and commercial land uses. There are some areas of deciduous forest in the northern reaches of this section and along the east side of Steele Brook from Pleasant View Avenue to Davis Street. This forested area is extremely important as it acts as a buffer, filtering out pollutants from surface runoff before entering the stream.

Commercial areas border the west side of Steele Brook along Watertown Avenue with a minimal buffer to the stream. A ball field and a large scrub shrub wetland are located near Pin Shop Pond, with an industrial area just below the pond. A number of catch basins are found in this section, most along Watertown Avenue and Riverside Street. Two outfalls are located along Wattles Brook, a tributary to Steele Brook.

In addition to utilizing GIS imagery in this corridor analysis, a field investigation was conducted to check current conditions, and document the types of riparian vegetation found within this study area. The investigation showed that this area has been highly modified by historical industrial use: straightening, channelization and elimination of adjacent wetlands and floodplain. A section of stream channel just below Heminway Pond dam has vertical banks of stone and concrete walls. The former flood plain areas have been mostly filled in, and developed with industrial and commercial buildings and some residential areas. Some athletic fields (baseball and soccer) have been constructed in the adjacent flood plain area by filling and grading. Various attempts at providing flood control dikes also exist in areas near commercial development. No comprehensive or consistent flood control efforts are in place.

Vegetative riparian buffers are largely a mix of upland and lowland tree species. Typical lowland tree species observed along the lower portion of the riparian areas include red maple, eastern cottonwood, sycamore (Pin Shop Pond), catalpa and black willow. On the upper banks, mixed hardwoods of black and yellow birch, white oak, red and black oaks, hickories, American beech (in some areas) dogwood and elm. Very few areas of evergreen trees were observed with the notable exception of the white pine grove west of the Watertown High School. A few Norway spruces and individual white pines were observed. Shrubs and small trees noted in the

riparian areas included viburnams, silky and flowering dogwoods, smooth and staghorn sumac, witchhazel and speckled alder.

The invasive species of Japanese knotweed and oriental bittersweet are well established along the entire channel and are overcoming and reducing native species. The knotweed, in many cases, has eliminated the access and view of the stream corridor and is eliminating the survival of native species seedlings. The oriental bittersweet is overwhelming the established and desirable native trees and shrubs in the riparian area. Other invasive species that were observed in various locations are multiflora rose, autumn olive, tree of heaven, black locust, winged euonymus (burning bush) and Norway maple.

Nutrient retention and sediment trapping is primarily occurring in Heminway and Pin Shop Ponds, both of which are exhibiting a slow conversion to scrub shrub wetlands. Stream bank erosion was observed in the Rockdale Road area which may require repair and protection.

Also observed were the locations of many parking lot and building drainage systems discharging directly into the Steele Brook without any detention or treatment.

Map 13: Corridor Analysis

Riparian Analysis

A riparian analysis was conducted to evaluate the corridor's characteristics of the main stem of Steele Brook by extrapolating data from the land use/land cover GIS layer. The evaluated area was the Steele Brook main stem upstream of Heminway Pond and downstream of the Pin Shop dam, and 1000 feet on each side of the stream.

The information gathered from this riparian analysis will help the Town of Watertown identify the types of land uses and land covers within the study areas and the location of potentially un-buffered areas and stormwater inlets and outfalls. It will also help the Town of Watertown in developing a strategy to protect and enhance this area to improve water quality in Steele Brook – a goal in their Plan of Conservation and Development.

Findings

Utilizing Geographic Information System (GIS) imagery, the location of the land uses and land covers, potentially un-buffered areas and stormwater inlet/outlets within these two study areas were layered together and put into a map format.

The potentially un-buffered areas are highlighted on the maps**.** This shows areas where the mapped water is within 75-feet of either developed land or agricultural land. (It should be noted that the extent of the potentially un-buffered edges is exaggerated for purposes of display at the map scale.) Approximately 53,700 linear feet of stream may be un-buffered in the watershed. An on-site investigation is needed to verify the extent of the un-buffered areas; which is beyond the scope of this project.

The location of the stormwater catch basins in this study area appear as tiny green circles on the maps**.** This visually shows the number of catch basins that have the ability to transport contaminated stormwater into Steele Brook. Noting the land use and the location and can help identify possible sources of bacteria and other sources of pollution. There are also outfalls noted on the map as tiny brown circles, indicating points of direct discharge of stormwater flow.

Upstream of Heminway Pond

Most of the land cover/land use upstream of Heminway Pond in the riparian corridor is developed. In the upper reaches of this section, more than half (65%) is in developed high and low density residential and golf course cover. About 17% is in deciduous forest cover, 10% in cultivated and non-cultivated agriculture cover and the remainder in transitional mix and other herbaceous cover. Three quarters of this section is manipulated land, with one quarter left in some un-developed state. **Table 4** below shows the percentages and acreage of each land use/land cover in the study area upstream of Heminway Pond dam. **(See Map 14: Riparian Analysis: Upstream of Heminway Pond Dam.)** For definitions of land use covers see Table 2.

Table 4: Percentages and Acreage of each Land Use/Land Cover Upstream of Heminway Pond.

Label	Data	Total
drl: Developed-Residential: low density	Acres	259.42
	Percentage of Corridor	32%
drh: Developed-Residential: high density	Acres	181.07
	Percentage of Corridor	23%
fd: Forested-Deciduous	Acres	140.50
	Percentage of Corridor	17%
dog: Developed-Other: Golf course	Acres	76.41
	Percentage of Corridor	9%
tm: Transitional-Mixed	Acres	56.10
	Percentage of Corridor	7%
an: Agriculture-Non-cultivated	Acres	46.11
	Percentage of Corridor	6%
ac: Agriculture-Cultivated	Acres	21.76
	Percentage of Corridor	3%
ap: Agriculture-Pasture or Idle Field	Acres	7.59
	Percentage of Corridor	1%
oh: Other-Herbaceous	Acres	4.30
	Percentage of Corridor	1%
ag: Agriculture-Grazed	Acres	3.83
	Percentage of Corridor	0%
osu: Other-Shrub: Utility ROW	Acres	3.55
	Percentage of Corridor	0%
ws: Water-Stream	Acres	2.01
	Percentage of Corridor	0%
wl: Water-Lake	Acres	1.41
	Percentage of Corridor	0%
dt: Developed-Transportation	Acres	0.47
	Percentage of Corridor	0%

The area north of West Road is in low density residential and golf course cover and abuts Steele Brook. It was noted during field investigation that there is no riparian buffer along the section of stream that passes through the golf course. These land uses may have a direct impact on the stream and water quality as any overland flows will go directly into the stream without any treatment.

The stream south of Route 63 has more riparian vegetation and is better protected. The residential cover in this area is not directly adjacent to the stream. Most of this area is deciduous forest cover which forms a natural buffer between land uses. The agricultural cover located at the confluence with Smith Pond Brook abuts the stream and is un-buffered. This land use has the potential of being a source of non-point pollution.

A large number of catch basins are located in this section, many along Route 63. There are also many outfalls in this section, some are located right on Steele Brook. Some of the outfalls appear to be detention basins as they are not located on or near a stream. An on-site investigation is needed to verify this, which is beyond the scope of this project.

The maintenance and protection of the existing buffered areas upstream of Heminway Pond are recommended and encouraged. Consideration should be given to installing additional riparian buffers along the upper reaches in the developed areas, especially along the golf course, at the agricultural land use at the Smith Pond confluence and near the outfalls. Catch basin inserts, street sweeping and geese management are other best management practices that can be used to address non-point source pollution.

Map 14: Riparian Analysis: Upstream of Hemingway Pond

Downstream of Pin Shop Pond Dam

Most of the corridor downstream of Pin Shop Pond dam shown on the map is in the City of Waterbury, which is beyond the scope of this project. The small area that is within the Town of Watertown is mostly developed with high density residential, commercial and industrial land uses. About one third is deciduous forest cover. The industrial cover abuts Steele Brook and is un-buffered. Consideration should be given to installing riparian buffers in this area. The residential areas are not adjacent to the stream. The forest cover does provide some protection and pollution uptake on the west side of the river. (See **Map 15: Riparian Analysis: Downstream of Pin Shop Pond Dam**.)

A number of catch basins are located in this area with several outfalls located on two tributaries that flow into Steele Brook - Wattles Brook and Turkey Brook. The addition of vegetative riparian buffers on the east side of the stream and near the outfalls is highly recommended. Catch basin inserts, street sweeping, and geese management are other best management practices that can be used to address possible sources of non-point pollution.

Table 5 below shows the percentages and acreage of each land use/land cover in the study area downstream of the Pin Shop dam. Please note that this table includes the area in the City of Waterbury, which is outside the scope of this project.

Table 5: Percentages and Acreage of Land Use/Land Cover Downstream of the Pin Shop Pond Dam.

Label	Data	Total
fd: Forested-Deciduous	Acres	150.58
	Percent of Corridor	30%
drh: Developed-Residential: high density	Acres	128.99
	Percent of Corridor	26%
di: Developed Industrial	Acres	120.11
	Percent of Corridor	24%
dc: Developed Commercial	Acres	52.14
	Percent of Corridor	10%
dt: Developed-Transportation	Acres	17.04
	Percent of Corridor	3%
dob: Developed-Other: ball fields	Acres	16.30
	Percent of Corridor	3%
drl: Developed-Residential: low density	Acres	6.61
	Percent of Corridor	1%
osu: Other-Shrub: Utility ROW	Acres	3.62
	Percent of Corridor	1%
br: Barren Rock	Acres	3.52
	Percent of Corridor	1%
dm: Developed Mixed	Acres	0.51
	Percent of Corridor	0%

Map 15: Riparian Analysis: Downstream of Pin Shop Pond Dam

Potential Sources of Bacteria

By analyzing the land use/land cover data, the CT DEP TMDL monitoring sites, the USDA farm and tract data, the septic soil potential ratings, the potentially non-buffered areas data and local knowledge of geese congregation, some assumptions can be made as to where potential sources of bacteria may be entering into Steele Brook. (See **Map 16: Potential Sources of Bacteria**)

Starting at the headwaters of Steele Brook (above Route 6); the land use/land cover map shows this section of the watershed is the least developed. This area has a large percentage of low density residential and forested areas. There are some small sections of high density residential use along and to the west of Route 63 and also along Route 6. Some commercial areas are also found in this area, the majority along Route 6.

A large percentage of agricultural uses, including horses, are found in the upper reaches of the watershed. They include a mix of cultivated, non-cultivated, pasture and farmstead land uses. USDA Farm and Tract numbers have been assigned to most of the agricultural uses in this section, which means that conservation plans have (or had) been developed to address environmental issues.

Two major waterbodies, Smith Pond and Lockwood (Merriman) Pond are located in this area and are sites for passive recreation and geese congregation. Two 18-hole golf courses and a large ball field adjacent to a private school also provide recreational opportunities.

Sections of the main stem of Steele Brook and its tributaries have potentially non-buffered segments located along the southern ends of both Smith Pond and Lockwood (Merriman) Pond; through the two golf courses, and alongside agricultural uses.

A large percentage of residential areas without sewer mains are also located in this upper reach of the watershed. This includes areas on the south and west side of Smith Pond, the upper reaches of Route 63 (below Big Meadow Pond) and northwest of Route 6 between Route 63 and Smith Pond Road. The septic potential ratings (soils) for this area range from low potential, to very low potential to extremely low potential.

CT DEP TMDL monitoring point #696, located at Echo Lake Road, has *E. coli* results for 2004 at 571 colonies/100 ml during dry conditions and 2146 colonies/100 ml during wet conditions, and 526 colonies/100 ml during dry conditions and 1135 colonies/100 ml during wet conditions in 2005.

The Connecticut Water Quality Standards established the following criteria for *E. coli* bacteria in the State's surface water: 1) not to exceed 235 colonies/100 ml (for official bathing area) or 576 colonies/100 ml (all other water contact recreation) for single samples, 2) not to exceed a geometric mean of 126 colonies/100 ml for any group of samples.

A large number of catch basins are located throughout this upper section of the watershed. Most are located along Routes 63 and 6, in the high density residential areas and in the commercial areas. A number of outfalls are located throughout this section, some on the main stem of Steele Brook, others on its tributaries. Some of the outfalls appear to be detention basins as they are not located on or near a stream. An on-site investigation is needed to verify this, which is beyond the scope of this project.

The middle section of the watershed (above Route 73) is more developed than the upper reaches. This area has a large percentage of high density residential, commercial and industrial uses. Most of the industrial uses are east of Route 855, Buckingham Street. Some agricultural uses are located in this section of the watershed and include cultivated, non-cultivated, idle pasture, nursery and farmstead uses. Most are located east and west of Route 855. USDA Farm and Tract numbers are assigned to some of the agricultural uses in this section, which means that conservation plans have (or had) been developed to address environmental issues.

Three major waterbodies, Heminway Pond, Echo Lake and Sylvan Lake are located in this section and are sites for passive recreation and geese congregation. A number of ball fields also provide recreational opportunities. They are located near Heminway Pond, at Watertown High School and along the old railroad bed off Knight Street. The latter is the proposed site of a walking trail – the beginning of a greenway system.

A large percentage of this section of the watershed is in forest cover. This cover buffers sections of Steele Brook and its tributaries. Other sections of the main stream and its tributaries have potentially non-buffered segments located along the lower section of Turkey Brook; west of Pin Shop Pond and west of Route 63. Residential, commercial and industrial uses are connected to sewer mains.

A huge number of catch basins are located throughout this section of the watershed, along with a large number of outfalls. Some of the outfalls are located on the main stem of Steele Brook, others on its tributaries. Some of the outfalls appear to be detention basins as they are not located on or near a stream. An on-site investigation is needed to verify this, which is beyond the scope of this project.

A large portion of the lower section of the watershed crosses the Town of Watertown boundary into the City of Waterbury, which is outside the study area. The land uses in this section (south and west of Route 73) are a mix of high density residential, forested and agricultural uses. Some commercial uses are also found in this area, the majority along Route 63.

Agricultural uses are located west of Route 63 around the Lake Winnemaug area. They include cultivated, non-cultivated, idle and grazed pasture, nursery and farmstead land uses. USDA Farm and Tract numbers have been assigned to most of the agricultural land in this section which means that conservation plans have (or had) been developed at some time to address environmental issues.

One major waterbody, Lake Winnemaug, and two smaller ones, Morehouse Pond and Pin Shop Pond, are located in this area and are sites for passive recreation and geese congregation. Lake Winnemaug is potentially un-buffered, as is an un-named tributary that flows into Steele Brook below Pin Shop Pond. This tributary flows through a high density residential land use and has a number of outfalls on it that discharge directly into Steele Brook.

A large percentage of residential areas without sewer mains are also located in this lower section of the watershed; especially around the Lake Winnemaug area. The septic potential ratings

(soils) for this area range from low potential, to very low potential to extremely low potential. Most are rated medium potential, high potential or not rated.

CT DEP TMDL monitoring point #331, located at Municipal Stadium in the City of Waterbury, just outside the Town of Watertown boundary, has *E. coli* results for 2004 at 1412 colonies/100 mL during dry conditions and 4011 colonies/100 mL during wet conditions and 220 colonies/100 mL during dry conditions and 693 colonies/100 mL during wet conditions in 2005.

The third CT DEP TMDL monitoring point #514, located at the mouth of Steele Brook in the City of Waterbury has *E. coli* results for 2004 at 1142 colonies/100 mL during dry conditions and 4199 colonies/100 mL during wet conditions and 860 colonies/100 mL during dry conditions and 1675 colonies/100 mL during wet conditions in 2005.

Although the lower portion of the Steele Brook watershed is located in the City of Waterbury, and outside the study area, it's worth noting that the land uses in this section include high density residential, commercial and industrial uses. These land uses have the potential to contribute sources of bacteria to Steele Brook thus increasing the levels at the two CT DEP TMDL monitoring points.

A large number of catch basins are located throughout this section of the watershed, along with a large number of outfalls. Most of the outfalls are located on the tributaries (many unnamed) that drain into Steele Brook; Wattles Brook is the only named tributary with outfalls. Some of the outfalls appear to be detention basins as they are not located on or near a stream. An on-site investigation is needed to verify this; which is beyond the scope of this project.

From this analysis - the presence of indicator bacteria, *E. Coli*, in the Steele Brook watershed could potentially be coming from a number of sources: crop-related sources (manure spreading); animal feeding operations; residential septic failures; wildlife (particularly waterfowl); domestic pet waste; illicit discharges; stormwater runoff and public swimming areas.

Map 16: Potential Sources of Bacteria

Municipal Regulations Review

In Connecticut, each of the 169 municipalities develops and implements its own local land use regulations. Consequently, local land use regulations create the framework for managing growth and balancing the social and ecological needs of a community without requiring a consideration of the neighboring municipalities.

The purpose of the Steele Brook watershed regulations review was to examine the existing municipal regulations in order to identify the controls, policies and plans which are in place to protect and enhance the natural resources in the watershed. The regulations assessed included Zoning, Inland Wetlands, Subdivision and Stormwater Management. The Plan of Conservation and Development was also reviewed. Because the focus of the Steele Brook Watershed-Based Plan is water quality, the regulations review concentrated on water quality and water quantity. Specific information was attained by developing a set of questions about the local regulations and the ways in which they address water quality and water quantity concerns. The questions were reviewed by the Advisory Committee. **(**See **Table 6: Citings of Municipal Regulations.)**

The Town of Watertown can also use the regulations review to consider modifications to their regulations or the establishment of new regulations in order to strengthen environmental and natural resources considerations.

The questions which address use practices, relevant to water quality and water quantity included:

Water Quality

1. Does the town recommend the use of the State Stormwater Design manual for development of stormwater management plans?
   Rationale: State recommendations and proactive approach

2. Does the town recommend the use of the CT Erosion and Sediment Control Guidelines for stormwater management and control?
   Rationale: Control erosion and sedimentation – which has detrimental impact on water quality

3. Does the town have any limits for impervious surfaces?
   Rationale: Potential impact from impervious surface

4. Are the road widths defined? If yes, what are they?
   Rationale: Tied to impervious surface impact – minimize potential imperviousness

5. Are cul-de-sac specifications provided?
   Rationale: Tied to impervious surface impact

6. Are grassed swales or curbing required?
   Rationale: A way, or tool, to reduce runoff

7. Is the sizing for commercial parking defined? If yes, what is the square footage per vehicle?
   Rationale: Impervious surface impact

8. Is the construction of an alternative development (e.g. open space subdivision, cluster housing) left to the discretion of the town? Does the town have the power to require an alternative development or is the ultimate choice left up to the applicant?
   Rationale: A way to keep natural spaces – ecosystems functions

9. Are any areas in town identified as "by right" areas for alternative developments?
   Rationale: Potential impact of development on stream systems

10. Are alternative developments identified as a way to maximize open space?
    Rationale: A way to manage growth

11. Is minimizing impervious surface a stated goal in cluster subdivision regulations?
    Rationale: All purpose concept to impervious surface impact

12. Do buffers and/or setback areas exist for wetlands and watercourses? If yes, what is the width?
    Rationale: A way to protect streams through buffers

13. Are any aquifer protection regulations in place?
    Rationale: Water quality protection – drinking water

14. Are E&S controls required for disturbed areas less than ½ acre cumulatively?
    Rationale: Looking at scale/scope – cumulative impacts/connections

15. Is there a specific distance between a septic system and wetlands or watercourses?
    Rationale: Potential failed septic/or septic effluent impacts

16. Are engineered septic systems permitted?
    Rationale: Ways around installing septic systems in unsuitable soils

17. Are soil limitations cited as a limiting factor for septic placement and installation?
    Rationale: Soil suitability for septic – link between effluent and water quality

18. Are *Net Buildable Area* regulations in place?
    Rationale: Looking at potential footprint

19. Are slopes used as a limiting factor for development? If yes, what is the slope percentage?
    Rationale: Suitability of soils – erosion and sedimentation/septic systems

20. Do local regulations or guidance exist regarding timber cutting or clear cuts?
    Rationale: Impact of forestry practices on water quality/soil condition/ecosystem/habitat

Water Quantity

21. Has the town established a limit on the net increase that can result in stormwater flow as a result of development? If yes, what is the net outflow permitted?
    Rationale: Potential effect on stream flows/inputs into stream – velocity/hydrograph

22. Does the town use a certain sized storm for the design of its stormwater management practices? If yes, what sized storm?
    Rationale: How much can the stormwater structures handle – potential fail point

23. Are detention or retention systems recommended in the regulations?
    Rationale: A way to moderate/mitigate stormwater input

24. Who is responsible for maintenance or stormwater management installations/structures?
    Rationale: Long term life/effectiveness of systems

25. Are regulations in place preventing development in identified floodplains?
    Rationale: Potential impact of development on stream systems

26. Do the towns have jurisdiction over dams and diversions?
    Rationale: Maintenance/decisions over existence

27. Is groundwater hydrology a consideration in resource extraction regulations?
    Rationale: Effect of resource extraction on groundwater flow and groundwater quality and groundwater as source of recharge

Findings

The overall regulatory approach of the Town of Watertown is that it has adopted a set of basic regulations designed to protect the natural resources in its community. It has incorporated the standard State model regulations for flood plain management and erosion and sedimentation control regulations for stormwater management.

The Town of Watertown has adopted regulations that provide protection and consideration of natural resources in the land use decision making process. The regulations tend to be basic and conventional in nature. For example, the Town has incorporated standard language State model regulations to address erosion and sedimentation control measures; uses the State model wetland regulations; uses the State stormwater design manual for the development of a stormwater management plan, and requires the typical procedures for siting and engineering septic systems.

Some of the regulations suggest that the Town of Watertown is addressing the potential impacts that development may have on water quality. Incorporation of these regulations demonstrates that the Town of Watertown is taking additional steps to balance growth with ecological integrity. By adopting regulations that set limits on impervious surface, that include aquifer protection, and that recommend the use of retention and detention systems, the Town of

Watertown shows recognition of the relationship between development and water quality and quantity.

While reviewing the municipal regulations it was noted that there were many horses in the watershed and no regulations in place to address their environmental impact on Steele Brook. This led to a search of CT Towns that have horse regulations in place for the Town of Watertown to review and possibly adopt in the future. (See **Appendix C**) In another case, wind power as an alternative energy source was discussed and information was gathered for future review.

Table 6: Citings of Municipal Regulations

Are soil limitations cited as a limiting factor for septic placement and installation? Rationale: Suitability of soils for septic system leach fields to ensure adequate water quality	**Yes** **Subdivision Regs, Sect. 5.11.1, Pg. 41**
Water Quality	**Subdivision Regs, Appendix J**
Does the town recommend the use of the State Stormwater Design Manual for development of a stormwater management plan? Rationale: Looking at potential footprint Rationales: State recommendations and proactive approach	**Yes – Adoption date Spring 2006** **Stormwater Mgmt. Plan, Sect. 5-3, Pg. 22**
Are slopes used as a limiting factor for development? If yes, what is the slope percentage? Rationale: Suitability of soils – E&S/septic systems	**None found**
Does the town recommend the use of the E&S Guidelines for stormwater management and control? Rationale: Control E&S – which has detrimental impact on water quality	**Yes** **Stormwater Mgmt. Plan, Sect, 1.1, Pg. 3**
Are Net Buildable Area regulations in place? Rationale: Impact of forestry practices on water quality/soil condition/ecosystems/habitat	**None found**
Does local regulation or guidance exist regarding timber cutting or clear cuts?	**Subdivision Regs, Sect. 4.11.1 and 4.11.3, Pg. 28** **Zoning Regs, Sect. 69.6.1 and 69.6.3, Pg. 136**
Does the town have any limits for impervious surface? Rationale: Potential impact from impervious surface	**Yes – Maximum Impervious Surface Coverage for Residential (20-60%), Commercial (75-90%) and Industrial (50-80%) Districts.** **Zoning Regs, Art. 11, Sects. 21 – 30, Art. 111, Sect. 3, Art. IV, Sects 41-44, Pgs. 38-84**
Are road widths defined? If yes, what are they? Rationale: Tied to impervious surface impact – minimize potential imperviousness	**Yes - 20 to 60 feet** **Subdivision Regs, Sect. 5.3.2, Pg. 33** **Zoning Regs, Text Amendment, Sect. 29A7.6, Pg. 2**
Are cul-de-sac (turnarounds) specifications provided? Rationale: Tied to impervious surface impact	**Yes –100 ft diameter right-of-way for permanent dead-end streets, grassed center islands required. 80 ft for temporary, no grassed islands** **Subdivision Regs, Sect. 5.3.12, Pg. 36 and 37**
Are grassed swales or curbing required? Rationale: A way, or tool, to reduce run off	**Yes – Bituminous concrete curbs on local and private streets, cement curbs on commercial and industrial streets.** **Subdivision Regs, Sect. 5.7, Pg. 38**
Is the sizing for commercial parking defined? If yes, what is the footage per vehicle? Rationale: Impervious surface impact	**Yes - Nine feet wide by 15 feet long.** **Zoning Regs, Sect. 63.11, Pg. 117**
Is the construction of an alternative development (e.g. open space subdivision, cluster housing) left to the discretion of the towns? Do the towns have the power to require an alternative development or is the ultimate choice left up to the applicant? Rationale: A way to keep natural spaces – ecosystems functions	**Yes – Planned Community Development (PCD), at Town's discretion.** **Zoning Regs, Sect. 27.5 and 27.6, Pgs. 57 and 58**
Are any areas in town identified as "by right "areas for alternative developments? Rationale: A way to keep natural spaces – ecosystems functions	**None found**
Are alternative developments identified as a way to maximize open space? Rationale: A way to manage growth	**Yes – Planned Community Development (PCD), at Town's discretion.** **Zoning Regs, Sect. 27.5 and 27.6, Pgs. 57 and 58**
Is minimizing impervious surface a stated goal in cluster subdivision regulations? Rationale: All purpose concept to impervious surface impact	**None found**
Do buffer and or setback areas exist for wetlands and watercourses? If yes, what is the width? Rationale: A way to protect streams through buffers	**Yes - 50' from a wetland boundary and 50' from top of bank of any watercourse with the exception of septic system location which is 100'.** **IWWR, Sect. 2.1.cc, Pg. 9**
Are any aquifer protection regulations in place? Rationale: Water quality protection – drinking water	**Yes** **Zoning Regs, Sect. 68, Pgs. 132-134**
Are E&S controls required for disturbed areas less than ½ acre cumulatively? Rationale: Looking at scale/scope – cumulative impacts/connections	**No – more than one-half acre, cumulatively.** **Stormwater Mgmt. Plan, Sect. 4.3, Pg. 20** **Zoning Regs, Sect. 69, Pg. 135**
Is there a specified distance between a septic system and wetlands or watercourses? Rationale: Potential failed septic/or septic effluent impact	**Yes – 100' from wetlands and watercourses.** **IWWR, Sect. 2.1.cc, Pg. 9, Sect. 6.2, Pg. 20**
Are engineered septic systems permitted? Rationale: Ways around installing septic systems in unsuitable soils	**None found**

Water Quantity	
Has the town established a limit on the net increase that can result in stormwater flow as a result of development? If yes, what is the net outflow permitted? Rationale: Potential affect on stream flows/inputs into stream – velocity/hydrograph	**Yes - Zero percent increase at 2-10-25-50 yr frequency, with spillway designed for 100 yr frequency** **Subdivision Regs, Sect. 5.10.3, Pg. 38**
Does the town use a certain sized storm for the design of its stormwater management practices? If yes, what sized storm? Rationale: How much can the stormwater structures handle? Potential fail point	**Yes – 25 year storm** **Subdivision Regs, Sect. 5.10.1, Pg. 38**
Are detention and or retention systems recommended in the regulations? Rationale: A way to moderate/mitigate stormwater input	**Yes** **Subdivision Regs, Sect. 5.10.3, Pg. 38**
Who is responsible for maintenance of stormwater management installations/structures? Rationale: Long term life/effectiveness of systems	**The Town of Watertown** **Stormwater Regs., Sect. 5.4, Pg. 22**
Are regulations in place preventing development in identified floodplains? Rationale: Potential impact of development on stream systems	**Yes** **Subdivision Regs, Sect. 5.16.1, Pg. 44** **Zoning Regs, Sect. 66, Pgs. 125-129**
Do the towns have jurisdiction over dams and diversions? Rationale: Maintenance/ decisions over existence	**No – the State of Connecticut has jurisdiction.** **IWWR, Sect. 5.1, Pg. 18**
Is groundwater hydrology a consideration in resource extraction regulations? Rationale: Affect of resource extraction on groundwater flow and groundwater quality and groundwater as source of recharge	**None found**

Level 1 Geomorphic Assessment

The objective of the NRCS Level 1 Geomorphic Assessment is to provide a base level classification of the fluvial network within the basin, including both stream type (Rosgen Methodology) and stream order. The base level classification then allows for the prediction of a river's behavior, based on morphological attributes, and enables the comparison and/or extrapolation of site-specific data or stream tendencies from a particular stream reach to other stream reaches which exhibit similar morphological characteristics. It should be noted that a Level 1 geomorphic assessment is derived from an investigation and analysis of only channel slope, shape and patterns. As such, the presented information is useful for broad-scale planning purposes and not site specific design. A Level II and Level III analysis would be needed to develop site specific designs and remediation measures.

The NRCS Level I Geomorphic Assessment included the entire fluvial network for the Steele Brook Watershed (6912), which is a sub-regional basin of the Naugatuck River (69). The Naugatuck River is within the Housatonic River Major Basin (6). The majority of the Steele Brook watershed is located within the Town of Watertown, with the lower portion of the main stem located in the City of Waterbury.

<u>Findings</u>

Stream Order

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 pre-existing higher order.

Steele Brook is a 4th order tributary to the Naugatuck River. The 17 square mile watershed exhibits a dentric drainage pattern, with approximately 36.25 miles of stream comprising the fluvial network. Subsequently, the drainage basin density or stream density is 2.13 mi/sqmi.

Steele Brook becomes a 4th order stream after the confluence of Turkey Brook, a 3rd order tributary. Turkey Brook and Smith Pond are the only 3rd order tributaries in the watershed with all other tributary streams entering Steele Brook being either 1st or 2nd order streams. The delineation of stream order for the entire watershed is shown on **Map 17: Stream Order Classification.**

Map 17: Stream Order

Stream Type

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. No distinction is made between intermittent and perennial stream within the fluvial network.

The Steele Brook watershed is an urbanized watershed, the effects of which can be seen in the classification of the various stream reaches throughout the watershed. From Heminway Pond Dam to the confluence with the Naugatuck River, Steele Brook is classified as an F stream type. The only exception is a short reach just upstream of the Municipal Stadium in the City of Waterbury that can be classified as a C stream type.

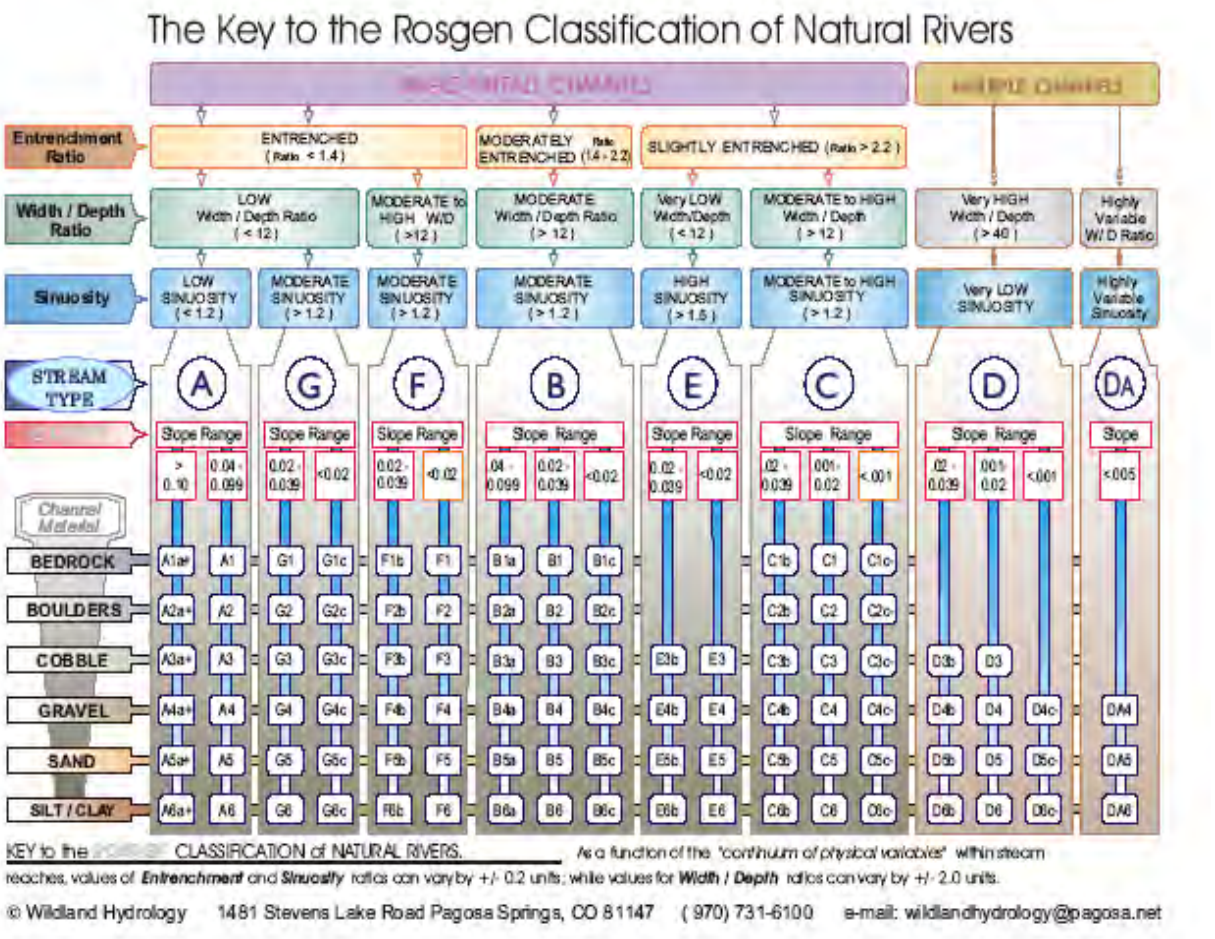
The F stream types can be described as both incised and entrenched with limited if any access to a floodplain. The F stream types have a homogeneous channel with a high width/depth ratio, and very low sinuosity. Typical channel gradients for an F stream type are less than 2%. The channelizations, construction of flood dikes, filling of the floodplain along the main stem of Steele Brook, as well as the expanse of impervious surfaces are the anthropogenic factors that have contributed to this stream classification. Based on slope and valley type, historically Steele Brook transitioned between a B and C stream type all the way down to its confluence with the Naugatuck River.

Upstream of Heminway Pond Dam, although there is still evidence of channel manipulation, Steele Brook and its tributaries do transition between A, B and C stream types, with B stream types being the most common.

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%. 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 delineation of stream type for the entire watershed is shown on **Map 18: Stream Type Classification**.

Figure 4: The Key to the Rosgen Classification of Natural Rivers



Map 18: Stream Type

Fisheries Barrier Inventory

The objective of the NRCS Fisheries Barrier Inventory is to identify all barriers to fish passage within the main stem of Steele Brook. Both anthropogenic and natural barriers were documented, and recommendations to facilitate fish passage are presented. Although diadromous fish currently do not have access to the watershed, both resident and diadromous fish species were considered in the inventory. The NRCS Fisheries Barrier Inventory includes only the main stem of Steele Brook (6912).

Findings

Barrier Inventory

Migratory barriers were assessed according to one of four (4) categories: dam, culvert, velocity barrier and natural barriers. The barriers were then photo documented, located with GPS, inventoried, assigned a site I.D., and recommendation(s) for fish passage presented. The site I.D. is based on the type of barrier and is ordered numerically as the sites occur from downstream to upstream. There were six (6) dams, given site I.D. D-1 through D-6, one (1) culvert, given the site I.D. C-1, four (4) velocity barriers, given the site I.D. VB-1 through VB-4 and one (1) natural barrier given the site I.D. NB-1.

It should be noted that the CT DEP Dam Layer only identifies 3 dams on the main stem of Steele Brook. Those structures are the East Aurora Street Dam (Site I.D.: D-1), Pin Shop Pond Dam (Site I.D.: D-3) and Heminway Pond dam (Site I.D.: D-5). The barrier inventory identified a total of six (6) dams on the main stem, with an additional six (6) barriers or flow dependent impediments to fish passage. In addition, there was one additional stone and concrete dam that is neither presented in this report, nor is identified on the CT DEP Dam Layer. This dam has been breached and is no longer a concern for fish passage. The structure is located approximately 1.0 miles upstream of Heminway Pond dam.

The discrepancies between the CT DEP Dam Layer and the NRCS barrier inventory are expected. Although the CT DEP Dam Layer identifies 3,633 dams in the State of Connecticut, it is recognized that this is an underrepresentation of the actual number of dams in the State. In addition, there are countless impediments to fish passage in the form of culverts or velocity

barriers across the State that have never been identified. These discrepancies demonstrate the need to conduct comprehensive barrier inventories whenever looking at fish passage on a watershed scale.

Although diadromous fish do not have access to the watershed, providing both upstream and downstream passage for fish within the fluvial network is important. Diadromous fish include both anadromous fish (e.g. river herring), and catadromous fish (e.g. American eel). Often the focus of fish passage is on the diadromous species and their associated annual migratory needs. However, many resident fish species also have annual, and / or seasonal migratory needs. The ability of the resident fish species to move up and down the stream system unimpeded is necessary to facilitate reproduction, avoid adverse flow or temperature conditions, occupy new habitat or even re-colonize a reach of stream where the fish population has been decimated either from natural or anthropogenic stressors.

The following descriptions and photos are arranged in order as the barrier occurs from downstream to upstream, regardless of the type of barrier. The location of each barrier is identified on **Map 19: Fisheries Barrier Inventory**. The latitude and longitude location of each barrier is provided in **Table 7** below.

Table 7: Fisheries Barrier Inventory Location Table

Site I.D.	Latitude	Longitude
D-1	41.57253	-73.060062
D-2	41.57600	-73.065075
VB-1	41.58383	-73.074323
D-3	41.58694	-73.085129
NB-1	41.59009	-73.098010
D-4	41.59002	-73.098566
VB-2	41.60259	-73.111713
D-5	41.60483	-73.112926
VB-3	41.61258	-73.119379
D-6	41.61622	-73.128903
VB-4	41.61745	-.73.130834

East Aurora Street Dam: (Site I.D. D-1)

This is the first upstream migratory barrier on Steele Brook. The dam is located approximately 415 feet upstream of East Aurora Street in the City of Waterbury, and approximately 0.35 miles upstream of the confluence with the Naugatuck River. The CT DEP database identifies the dam as dam #15129, being under private ownership with an unknown name. The dam is constructed of steel sheet-pile with riprap abutments. The spillway is approximately 38 feet long, and the vertical rise between the crest of the spillway and the tailwater elevation is 4.3 feet. The channel upstream and downstream of the dam can be classified as a 4th order F stream type. The stream has been channelized and is deeply incised. Reconnection of the stream to its floodplain is not feasible given the extensive development adjacent to the stream and construction of flood dikes. Complete removal of the dam would cause further incision of the channel and therefore initiate instability. Notching the center section of the dam and installing a rock ramp fishway is the most feasible means of providing passage. Currently this serves as an upstream migratory barrier for all fish species under all flow conditions when migration could be expected. See **Figure 5: East Aurora Street Dam** below.

Figure 5: East Aurora Street Dam *Photo: USDA NRCS, July 1, 2008*

Tomkins Street Dam: (Site I.D. D-2)

This is an unnamed dam, which is not listed in the CT DEP database. The structure is located approximately 380 feet upstream of Tomkins Street in the City of Waterbury, and approximately 0.4 miles upstream of the East Aurora Street Dam. The dam is constructed of stone and concrete. The vertical rise between the crest of the spillway and the tailwater elevation is 2.7 feet. The channel upstream and downstream of the dam can be classified as a 4^{th} order F stream type. Just prior to the field survey, a bypass fishway was constructed on the right side (facing downstream) of the dam. At the time of the field inspection there was a significant amount of "leakage" from the bypass structure and diversion structure above the dam. Subsequently attractant flows to the entrance of the fishway are diminished and may reduce the efficiency of the structure. As bed load material moves downstream this condition is likely to improve. In addition, the size of the rock used to construct the pool weirs may be subject to movement from larger storm events. Therefore this structure should be monitored over time to ensure that it facilitates fish passage. In its current state, this dam is no longer an upstream barrier to fish. See ***Figure 6: Tomkins Street Dam*** below.

Figure 6: Tomkins Street Dam *Photo: USDA NRCS, July 1, 2008*

Unnamed Pipe Crossing #3 (Site I.D. VB-1)

This is a concrete apron in the stream, and is likely a pipe crossing. The concrete apron extends across the entire channel cross-section, with rock riprap on either bank. The vertical rise is approximately 1.2 feet, and the apron extends approximately 4.2 feet upstream. The structure is located within a transitional reach between a 4th order F and a 4th order C stream type. Both anadromous and resident fish species should be able to overcome this impediment during the range of flows that migration is expected. However, under certain flow conditions, and/or in the event that the channel immediately downstream of this pipe crossing incises, this could become a more significant barrier. Therefore, currently it is considered a flow-dependent impediment. Mild enhancement of the riffle section immediately downstream of this structure would alleviate any passage difficulties. **See Figure 7: Unnamed Pipe Crossing #3** below.

Figure 7: Unnamed Pipe Crossing #3 ***Photo: USDA NRCS, July 1, 2008***

Pin Shop Pond Dam: (Site I.D. D-3)

This dam is located just off of Route-73 in the center of Oakville. It is located approximately 1.6 miles upstream of the unnamed dam identified as D-2, and approximately 2.0 miles upstream of the dam at East Aurora Street. The CT DEP dam database identifies the dam as dam #15315, being under private ownership and having a "C" hazard class rating. The dam is constructed of stone and concrete with a sloped concrete splash pad. The length of the spillway is approximately 106 feet. The lip of the splash pad is perched approximately 2.8 feet above the tailwater elevation, while the crest of the spillway is approximately 12.5 feet above the elevation of the sloped splash pad resulting in a total vertical rise of approximately 16.0 feet from the crest of the spillway to the tail water elevation. The flood pool created by the dam is almost completely occluded with sediment, and in fact, in a number of locations the elevation of the top of the sediment is higher than the elevation of the spillway. The channel above the flood pool and below the dam can be classified as a 3rd order F stream type. It is likely that partial or complete removal of the dam, coupled with the removal of the impounded sediment and the creation of a new channel floodplain system, would prove to be the most desirable in terms of fish passage. At the time of this publication, a dam removal feasibility analysis is being conducted by the current dam owner. See **Figure 8: Pin Shop Pond Dam** below.

Figure 8: Pin Shop Pond Dam: *Photo: USDA NRCS, September 15, 2008*

Bedrock Cascades: (Site I.D. NB-1)

Approximately 0.8 miles upstream of the Pin Shop Pond Dam is a series of bedrock cascades. The cascades extend from an old railroad crossing just north of Route-73 in Oakville, and extends for a distance of approximately 170 feet. This is a natural impediment to upstream fish passage, and is likely the historic limit of anadromous fish within the basin. However, catadromous fish (American eel) as well as resident salmonids should be able to overcome this impediment under a range of flow conditions. The bedrock cascades are classified as a flow dependent barrier. It should be noted that a stone and concrete dam is constructed at the upstream end of the cascades and in fact forms a portion of the left dam abutment. It is likely that the bedrock cascades extend under the existing dam. Although this short reach could be classified as an A stream type, the reach above and below the cascades are both classified as a 3rd order F stream type. See **Figure 9: Bedrock Cascades** below.

Figure 9: Bedrock Cascades ***Photo: USDA NRCS, September 15, 2008***

Bedrock Cascades Dam: (Site I.D. D-4)

At the upstream end of the bedrock cascades is the bedrock cascades dam. This dam is not listed in the CT DEP dam database. The dam is constructed of stone and concrete, with a wooden crest plate. The crest of the spillway is approximately 12 feet above the tail water elevation. The primary spillway is approximately 49 feet long, however an additional 15 feet of spillway is provided by the bedrock cascades that the dam structure is build into. The reach of stream above and below the dam is classified as a 3rd order F stream type. The dam is a barrier to all fish species under all flow conditions, with the exception of the American eel. Although the American eel have not been documented in the watershed, given the opportunity, the American eel could overcome the barrier by using the bedrock cascades to the left of the dam. Additional investigation is needed, including ground penetrating radar to map the extent of the bedrock, to determine if fish passage can be achieved through the removal of the dam. See **Figure 10: Bedrock Cascades Dam** below.

Figure 10: Bedrock Cascades Dam ***Photo: USDA NRCS, September 15, 2008***

Unnamed Pipe Crossing #4: (Site I.D. VB-2)

This impediment to fish passage is located approximately 620 feet downstream of Echo Lake Road in the town of Watertown. Approximately 1.3 miles upstream of the Bedrock Cascades Dam, this impediment is within a 3rd order F stream type. Although the actual pipe is elevated above stream bottom, there is a concrete apron which imposes a flow dependent velocity barrier on the upstream migration of fish. Extending across the entire channel cross section, the downstream half is flat, while the upstream half gains approximately 1.2 vertical feet. The downstream half of the 22 foot long apron is under backwater from a downstream gravel bar. At the time of the field inspection this apron did not present an impediment to fish migration. However, under low flow conditions, or if the downstream gravel bar is scoured, this apron can impose a significant velocity barrier to fish passage. Immediately downstream of the apron there is a scour hole approximately 2.5 feet deep. If the downstream gravel bar scours and changes the backwater conditions on the downstream end of the apron, the apron will become perched and would prevent the migration of fish. The installation of an armored riffle immediately downstream of the apron and extending onto the apron would eliminate any fish migration issues. See **Figure 11: Unnamed Pipe Crossing #4** below.

Figure 11: Unnamed Pipe Crossing #4 ***Photo: USDA NRCS, September 15, 2008***

Heminway Pond Dam: (Site I.D. D-5)

Heminway Pond Dam is located approximately 233 feet upstream of Echo Lake Road in the town of Watertown. Approximately 1.5 miles upstream from the Bedrock Cascades Dam, the reach below the dam is classified as a 3rd order F stream type, while the reach above the flood pool is classified as a 3rd order B stream type. Identified in the CT DEP dam database as dam #15304, the dam is owned by the town of Watertown. The dam is constructed of concrete, with a spillway approximately 82 feet long. The spillway crest is approximately 10 feet above the concrete splash pad, which is perched approximately 0.6 feet above the tail water elevation. This dam is a barrier to all fish species under all flow conditions. Full removal of the spillway, and construction of a new channel-floodplain system as described in Alternative 4 of the Heminway Pond Dam Removal Feasibility Analysis is the most feasible means of providing fish passage. See **Figure 12: Heminway Pond dam** below.

Figure 12: Heminway Pond Dam ***Photo: USDA NRCS, September 15, 2008***

Northfield Road Bridge Velocity Barrier: (Site I.D. VB-3)

The bridge for Northfield Road in the town of Watertown includes a sloped concrete apron which is a flow dependent velocity barrier. The concrete apron extends for a length of approximately 36 feet upstream, and although the slope of the apron is variable, the approximate total rise is 2.3 vertical feet. This impediment is located approximately 0.7 miles upstream of the Heminway Pond Dam. This impediment is located in the upper portion of the watershed and would be passable by resident cold water fish under a range of flow conditions. However, under low flow conditions, this would serve as an impediment to fish passage. See **Figure 13: Northfield Road Bridge Velocity Barrier** below.

Figure 13: Northfield Road Bridge Velocity Barrier ***Photo: USDA NRCS, September 16, 2008***

Unnamed Dam: (Site I.D. D-6)

This is a relatively small concrete dam located to the East of Route 63 and approximately 775 feet downstream of West Road in the town of Watertown. The dam is constructed of concrete and is within a concrete-lined trapezoidal channel. As a result, the immediate stream reach above and below this barrier is classified as a 2nd order F stream type. Both the stream reach above and the stream reach below the trapezoidal section are classified as a 2nd order C stream types. The spillway is 26 feet long, the crest of which is approximately 3.2 feet above the tail water elevation. This is a barrier to all fish species under all flow conditions where migration could be expected. This barrier is located approximately 1.7 miles upstream of Heminway Pond Dam. Complete removal of this structure, or removal of most of the structure with the incorporation of a small rock ramp, is the most feasible means of providing fish passage.

See **Figure 14: Unnamed Dam** below.

Figure 14: Unnamed Dam ***Photo: USDA NRCS, September 16, 2008***

West Road Bridge Velocity Barrier: (Site I.D. VB-4)

The bridge for West Road in the town of Watertown includes a concrete apron, which is a flow dependent velocity barrier. The stream reach is classified as a 2nd order B stream type. The concrete apron extends for a length of approximately 34 feet upstream, and the channel cross section is 17 feet wide. Although the apron is level for its entire length, there is a 0.7 foot vertical rise at the downstream end and there is no plunge pool. This impediment is located approximately 850 feet upstream of the unnamed concrete dam identified as Site D-6. This impediment is located in the upper portion of the watershed and would be passable by resident cold water fish under a range of flow conditions. However, under low flow conditions, this would serve as an impediment to fish passage. The enhancement of the riffle section immediately downstream of the apron would eliminate this barrier under all flow conditions. See **Figure 15: West Road Bridge Velocity Barrier** below.

Figure 15: West Road Bridge Velocity Barrier ***Photo: USDA NRCS, September 16, 2008***

Route 63 Culvert: (Site I.D. C-1)

This culvert is the last barrier on the main stem of Steele Brook. The culvert is located under Route-63 in the town of Watertown. The culvert drains the pond on the west side of Route-63 and the intermittent stream above the pond. The stream reach above the culvert can be classified as a 1st order C stream type, while the reach below the culvert can be classified as a 1st order B stream type. Due to the lack of habitat upstream of the culvert there is no reason to try and provide fish passage beyond this point. **See Figure 16: Route 63 Culvert** below.

Figure 16: Route 63 Culvert ***Photo: USDA NRCS, September 16, 2008***

Quality Control

The entire length of the main stem of Steele Brook was walked and surveyed. Measurements of barrier heights and lengths were made in the field by NRCS staff. Weir crest heights were determined using a standard survey rod held at the face of the dam and measured from the tail water or splash pad elevation to the weir crest. Measurements were taken to the nearest 0.1 foot. Measurement of the weir length were taken using a laser rangefinder, and taken to the nearest 0.5 meter. The accuracy of the laser range finder is +/- 0.5 meters. Measurements of distance between barriers were taken from point to point along the centerline of the channel using the line measurement tool in ArcMap.

Map 19: Fisheries Barrier Inventory

Heminway Pond Dam Removal Feasibility Analysis

As part of this Watershed Based Plan, a dam removal feasibility analysis was completed for Heminway Pond Dam. The purpose of the Heminway Pond Dam Removal Feasibility Analysis is to evaluate options to meet four primary goals for Steele Brook in Watertown, CT. The four primary goals are:

1. Water quality improvement in Heminway Pond and Steele Brook downstream of Heminway Pond Dam
2. Improve fish passage through the dam and pond area
3. Remove liability of an aged dam from the Town of Watertown
4. Encourage incorporation of this project with a larger Town greenway project

The primary objective for achieving these goals would be to modify the existing dam and pond area by means of removing all or part of the dam or providing a bypass channel around the dam. The feasibility of each alternative was assessed with respect to ecological resources including fisheries, wetlands, and wildlife, water quality, hydrology and hydraulics, sediment, infrastructure, sociologic issues and recreation, and cultural and historic resources. A summary of the level of intensity of the effects on each of these resources can be found in **Table 8**.

Heminway Pond Dam is owned by the Town of Watertown. It is a dam on Steele Brook and is located just upstream of Echo Lake Road in Watertown, CT adjacent to Deland Field and Heminway Park School. The dam currently restricts fish passage in Steele Brook, creates a pond with increased water temperatures and high bacteria levels due to high geese populations, and encourages deposition of iron precipitate in the stream channel just downstream of the dam.

Four primary alternatives for achieving the project goals are presented in the Feasibility Analysis. The four alternatives are:

1. No Action
2. Leave dam in place and provide a bypass channel capable of fish migration
3. Notch the spillway and provide a ramp capable of fish migration
4. Full removal of the spillway

Alternative 1: No Action does not achieve the project goal of water quality improvement in Heminway Pond and Steele Brook, does not achieve the goal of improved fish passage through the dam and pond area, does not remove the liability of an aged dam from the Town, and is a less favorable option to incorporate this project with the Town greenway project. This alternative was used as a baseline for comparing the affects of the other alternatives. The cost estimate for this alternative is $0.00. However, there would be additional future costs related to maintenance and liability of the dam for the Town. Also, the ecological costs will be large due to the continued water quality concerns and lack of fish passage in this portion of Steele Brook.

Alternative 2: Bypass Channel does not achieve the project goal of water quality improvement in Heminway Pond and Steele Brook, marginally achieves the goal of improved fish passage through the dam and pond area, does not remove the liability of an aged dam from the Town, and is a less favorable option to incorporate this project with the Town greenway project. A cost estimate was not created for this alternative due to the fact that it does not achieve or only marginally achieves the project goals. Although technically a feasible option, this alternative will not produce the desired results based on the stated project goals.

Alternative 3: Partial Removal with Fish Ramp substantially achieves the project goal of water quality improvement in Heminway Pond and Steele Brook, substantially achieves the goal of improved fish passage through the dam and pond area, substantially achieves the goal of removing the liability of an aged dam from the Town, although a portion of the dam will remain in place and be fortified, and is a more favorable option to incorporate this project with the Town greenway project. The cost estimate for this alternative is $500,000.00.

Alternative 4: Full Removal of Spillway substantially achieves the project goal of water quality improvement in Heminway Pond and Steele Brook, substantially achieves the goal of improved fish passage through the dam and pond area, substantially achieves the goal of removing the liability of an aged dam from the Town, and is a more favorable option to incorporate this project with the Town greenway project. The cost estimate for this alternative is $1,100,000.00. Depending on the quantity of sediment that can be utilized onsite, this cost estimate may be reduced to $700,000.00.

The preferred alternative is Alternative 4: Full Removal of Spillway based on its ability to achieve the project goals and also maximize the environmental benefits associated with the project. This alternative appears to be the highest alternative in terms of cost, but cost should only be one facet to look at in the project. The added benefits of the full removal option outweigh the additional cost.

The Heminway Pond Dam Feasibility Analysis was completed by the United States Department of Agriculture, Natural Resources Conservation Service based in Tolland, Connecticut. The Feasibility Analysis is included in the Steele Brook Watershed Based Plan and can be viewed in its entirety in Appendix E. Note that Appendix E is bound separately from the Steele Brook Watershed Based Plan.

Table 8: Summary Table, Level of Intensity of Effects

Project Goals	**Alternative 1:**		**Alternative 2:**		**Alternative 3:**		**Alternative 4:**	
	No Action		**Bypass Channel**		**Partial Dam Removal**		**Full Dam Removal**	
Goal 1: Water Quality Improvement	Does not achieve		Does not achieve		Substantially achieves		Substantially achieves	
Goal 2: Improved Fish Passage	Does not achieve		Marginally achieves		Substantially achieves		Substantially achieves	
Goal 3: Liability of Dam on Town	Does not achieve		Does not achieve		Substantially achieves*		Substantially achieves	
Goal 4: Incorporation with Greenway	Less favorable option		Less favorable option		Favorable option		Favorable Option	
	Impact Intensity							
Affected Environments and Other Considerations	**Adverse Impacts**	**Beneficial Impacts**	**Adverse Impacts**	**Beneficial Impacts**	**Adverse Impacts**	**Beneficial Impacts**	**Adverse Impacts**	**Beneficial Impacts**
Ecological Resources: Fisheries	Major	None	Negligible	Significant	None	Major	None	Major
Ecological Resources: Wetlands	Minor	Minor	None	Minor	Significant	Major	Major	Minor
Ecological Resources: Wildlife	Negligible	Negligible	None	Significant	Significant	Major	Major	Minor
Water Quality	Major	Negligible	Major	Minor	Negligible	Major	Negligible	Major
Hydrology and Hydraulics	Minor	None	Minor	None	Minor	Major	Significant	Major
Sediment	Significant	None	Significant	None	Significant	Significant	Major	Significant
Infrastructure	Significant	None	Significant	Major	Negligible	Major	Minor	Major
Sociologic Issues and Recreation	Minor	None	None	Major	None	Major	None	Major

Description of Intensity Levels:
None – No measurable effects will occur
Negligible – The effects will be very slight and may not be measurable or observable
Minor – Impacts would be noticeable but there would be no overall effect on the affected environment
Significant – Impacts would be noticeable and could have short term and long term effects on the affected environment
Major – Impacts would be very noticeable and would have a definite short term and long term impact on the affected environment

Notes:
*A portion of the spillway will remain in place; however, the rock ramp will buttress the remaining spillway reducing chances of a breach

BEST MANAGEMENT PRACTICES

The intent of providing BMP recommendations on a watershed-wide basis is to offer basic measures that can be implemented relatively easily anywhere within the Steele Brook watershed. While not focused on specific locations that may be more direct contributors to water quality concerns, these measures, when put into place, will help to control inputs from stormwater run-off. Along with addressing possible bacterial concerns, these practices may help to reduce the non-point source pollution contributions entering the stream system.

Cost estimates for BMPs are required in 319 watershed-based plans. NRCS developed cost estimates for each BMP recommendation that specifically addresses bacteria. The cost estimates also help local stakeholders 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). The cost of the BMP includes the construction cost, design, permitting and other contingency costs. The cost tables developed by NRCS, the cost of the design, permitting and other contingency costs are calculated as percentages of the total construction cost. In most cases this amount is twenty-five percent. The percentage for manufactured devices was lower because some of the design has already been completed. These costs are in 2006 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). The construction costs for the structural stormwater BMPs were typically dependent on

the water volume or watershed area. All dollar amounts were adjusted to 2006 dollars. 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 form manufacturers estimates and/or using RS Means Building Construction Cost Data, 2006. Annual O&M costs were calculated as a percentage of the construction costs. The percentage was taken from within the ranges listed by the U.S. EPA.

Catch basin (CB) Inserts, Street Sweeping and UV Treatment

CB inserts that target bacteria and street sweeping cost estimates 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. The cost estimates for the UV filtration treatment were based on a per unit cost relative to the expected outflow of the targeted waterbody.

Buffers, Agricultural Practices and other Source Control and Management Practices

The cost estimate 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

By estimating BMP efficiencies, the potential reduction of bacterial loads to Steele Brook was determined. This information provides a sense of the effectiveness of implementing the various BMPs in the Steele Brook watershed. The percent contribution of different sources was estimated and then used to weight the efficiencies of the applicable BMPs. Finally, the load reductions set forth in the Naugatuck River TMDL were compared to the expected potential reductions at monitoring point 514. Refer to **Table 9**.

Table 9: Estimated Efficiencies of Watershed-wide BMPs

ESTIMATED EFFICIENCIES OF WATERSHED-WIDE BMPS		
BMP	**BMP Efficiency**	**Reference**
Street Sweeping/Catch Basin Cleanout	70%	Watershed Protection Techniques Vol. 3 No. 1 – April 1999 by Center for Watershed Protection
Pet Waste Pickup	50%	Watershed Protection Techniques Vol. 3 No. 1- April 1999 by Center for Watershed Protection 66% comply, and it is 75% effective (animal waste management)
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
Wildlife/Other*	0%	
*Wildlife, excluding geese, is contributing bacteria to the watershed but no management practices are considered for them so the efficiency of wildlife BMPs is 0%. This estimate also includes other, unknown sources of bacteria.		

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 help to assess the effectiveness of the individual BMPs and to evaluate the overall impact of bacterial loading on Steele Brook. Based on the findings, modifications could be made to the BMPs to more aptly address pollutant loading concerns, and the TMDL could be revised as deemed necessary.

WATERSHED-WIDE BMP RECOMMENDATIONS

Listed below are the watershed-wide BMP recommendations. The costs associated with these practices can be found in **Tables 10-13.**

It should be noted that the costs developed by NRCS for the implementation of the BMPs described in this report represent a best estimate based on a variety of sources. Estimates are not able to consider all of the site specific conditions that may influence the final cost for implementation. Additionally, the estimates used in this report are based on costs as researched in 2006. Costs may change in subsequent years.

Vacuum-assisted street sweeping:
Conducting regular street sweeping is recommended. 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. 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. All streets in the basin should be swept at least twice each year.

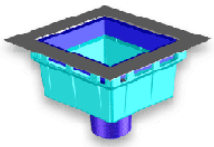
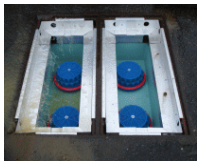
Regular Maintenance of Catch Basins

Catch basins are the entry point for stormwater into a storm sewer system. Typically, catch basins have a sump area designed to trap sediment and limit its direct transport and discharge into a watercourse or waterbody. Over time the sump area 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 re-suspended. Studies have indicated 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 Sigh, 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 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 weighted 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. Research indicated that costs for 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 between $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 its 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.

Examples of catch basin inserts:

Images from www.stormwaterworks.com

www.deq.state.or.us/

Domestic Pet Waste Management (including dog walking areas)

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 or 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 shell fishing. (EPA, 1993) In comparison, the Steele Brook watershed is approximately 14.9 square miles in Watertown and has an estimated 900 licensed dogs.

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

- In-ground pet waste "septic systems" could be installed. Bacteria degrading enzyme is often used to aid in the decomposition of the waste. Minimal maintenance is required. Each system can serve between 1 and 4 dogs depending on the size of the dog and the size of the system.
- 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". Dogs are attracted to areas with long grass to defecate. Keeping a portion of a dog walking area un-mowed (approximately 4-5 inches high will

provide a localized area for dogs to defecate. The un-mowed area should be situated 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 Nutrient Management Plans (for all agricultural operations, including horse farms)

Numerous livestock agricultural operations exist in the Steele Brook watershed. The waste produced by the livestock contains fecal coliform bacteria, regardless of the number of animals or the type of livestock. Without proper 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 increased chances for animal feces to be deposited into 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.

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 include practices that could be implemented to improve control of stormwater runoff, protection of watercourses, pasture management and waste management. Technical and financial resources information would 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 of what is being produced.

Subsurface Sewage Disposal System Maintenance Repair

Failing private septic systems may potentially contribute to pollutant loading. Many factors will directly influence the degree to which a failing septic system may add to pollutant loading: proximity to a waterbody, type of soils and the degree to which the septic system is failing. Watershed residents with private septic systems should be made aware of the potential problems associated with a failing septic system and should be encouraged to provide regular maintenance of their septic system along with timely repair when necessary. Costs for maintenance and repair may vary depending on the size of the septic 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 septic 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 observable (visibly or through odor) above ground.

Vegetated Buffers along Streams

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.

Geese Management

Large flocks of geese on ball fields, parks, golf courses, residential lawns and other open areas can create nuisance and public health problems. Geese droppings can contribute to bacteria loading in streams and ponds. There are no easy solutions in controlling geese problems, especially if they have become habituated to an area. Some control methods that may help include: modifying their habitat by planting unpalatable vegetation, allowing grasses to grow tall

and planting hedges or visual barriers; installing fencing between water and food sources; frightening them away with pyrotechnics, balloons, flags, scarecrows, flash tape and free range dogs, and discouraging artificial feeding by educating the public and installing signage.

Low Impact Development (LID)

LID can protect water quality, regulate water quantity, preserve features that are important to a town's character, help balance the need for growth with environmental protection, reduce the costs associated with infrastructure maintenance, and calm traffic. Some LID techniques include: decreased road widths where possible; maximum right-of-ways for residential streets; decreased cul-de-sac diameters; examine parking ratios, shared parking and bioretention in parking lots; examine sidewalk widths and requirements; examine driveway widths, two track design, shared driveways, and pervious alternatives; research tree preservation requirements; research wider buffer areas; require stormwater to be treated before it is discharged, and consider local design criteria for BMPs. For more information visit the CT DEP website at http://www.ct.gov/dep/lib/dep/water_inland/wetlands/segmentii2009lidlinks.pdf.

Municipal Regulations

A wide range of practices can be incorporated into municipal regulations to address these potential impacts. Preservation of open space or the use of cluster subdivisions are methods designed to protect natural resources by limiting development. Other techniques specifically address stormwater runoff. These techniques are designed to increase infiltration (e.g. rain gardens, curb-less 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 vegetative buffers, setbacks, impervious/pervious surface, etc.). Many of these techniques are part of the broader concept of Low Impact Development.

At a minimum, stormwater management regulations can be used to strongly encourage and at a maximum, require measures or practices that attend to water quality and/or water quantity issues. By identifying mutually acceptable solutions for stormwater management in a given area, municipalities, developers and engineers can find ways to effectively manage stormwater.

The decreased use of bituminous curbing is an example of a regulatory modification that could be used in the Town of Watertown. In some cases, concentrating stormwater runoff and directing it to a catch basin system is appropriate. In other instances, curbing prevents runoff from reaching a pervious surface where infiltration can occur. Limited infiltration diminishes the potential for stormwater to be filtered as it travels over and through the soil and it increases the chances for pollutants to be discharged directly into watercourses and waterbodies.

The filtering capacity of soils is one of the factors influencing the requirements for siting and installation of septic systems. Permitting engineered septic systems is an understandable approach to developing a parcel of land constrained by soil limitations. Using this information the Town of Watertown can reconsider the way private septic systems are currently regulated. General considerations can be given to the allowances for engineered systems. Regulations regarding the maintenance of septic systems can be re-examined. The Town of Watertown may consider establishing stricter requirements for maintenance and proof of maintenance for areas with soils rated from low to extremely low potential.

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.

General BMP Costs

To assist local stakeholders, and as one of the 319 watershed based plan requirements, a cost estimate has been developed for two possible scenarios that are not specific to any sites in the watershed. These estimates can be used as a general guideline for planning structural BMPs.

The first scenario is a small scale project, one acre in size, with 95% impervious area. For a parcel this size the Connecticut Stormwater Quality Manual (2004) has calculated the Water Quality Volume (WQV) to be 0.0754 ac-ft. The WQV is the volume of runoff generated by one inch of rainfall. See **Table 10** below.

Table 10: General BMP Costs – Scenario 1

Scenario One: 1 acre watershed at 95% impervious CT Water Quality Volume (WQV) = 0.0754 ac-ft									
		Design & Contingency				Annual Cost Over Lifespan ($/yr)	Operation & maintenance (O&M)		Total Cost /yr over Lifespan
	Const ($)	% Const	Cost	Total	Lifespan (Yrs)		% Const	$/yr	
Stormwater Ponds	$8,800	25%	$2,200	$11,000	30	$886	4.5%	$396	$1,282
Stormwater Wetlands	$12,000	25%	$3,000	$15,000	30	$1,209	4.5%	$540	$1,749
Gravel Wetland	$21,600	25%	$5,400	$27,000	20	$2,549	5%	$1,080	$3,629
Infiltration									
Basin	$6,400	25%	$1,600	$8,000	10	$1,139	7.5%	$480	$1,619
Trench	$22,400	25%	$5,600	$28,000	12	$3,525	7.5%	$1,680	$5,205
Filtration									
Surface Sand Filter	$20,800	25%	$5,200	$26,000	15	$2,855	12%	$2,496	$5,351
Underground Sand Filter	$21,600	25%	$5,400	$27,000	15	$2,964	12%	$2,592	$5,556
Bioretention (Rain Gardens)	$24,000	25%	$6,000	$30,000	15	$3,294	6%	$1,440	$4,734
Manufactured Tech Devices									
Biofilters (e.g. Storm Treat)	$24,000	15%	$3,600	$27,600	15	$3,030	5%	$1,200	$4,230

The second scenario is a 40 acre suburban/residential area with 35% impervious cover. The Water Quality Value for this scenario is 1 ac-ft. Refer to **Table 11**.

Included in the cost estimates for the two scenarios are BMPs which are in the range of somewhat effective to effective for bacteria, and that are generally considered suitable for the size of the scenario. Stormwater ponds, stormwater wetlands and infiltration basins are not typically suitable for urban areas due to the large area requirements. They are included as part of the small scale project scenario because they may be suitable for a smaller site within a residential or rural area. Refer to **Tables 12 and 13**.

Catch basin inserts with media filters that target bacteria were not included since they are on a per unit basis and do not depend solely on watershed size or WQV. Nor were rain gardens (bioretention) included in the suburban/residential scenario. Although rain gardens are suitable for a parcel in a residential area, a single rain garden would have a limited effect in area with a WQV of 1 ac-ft.

Table 11: General BMP Costs – Scenario 2

Scenario Two – 40 acres at 35% impervious CT Water Quality Volume (WQV) – 1 ac-ft									
		Design & Contingency				Annual Cost Over	Operations & Maintenance (O&M)		Total Cost /yr over Lifespan
	Const ($)	% Const	Cost	Total	Lifespan (Yrs)	Lifespan ($/yr)	% Const	$/yr	
Stormwater Pond	$56,000	25%	$14,000	$70,000	30	$5,614	4.5%	$2,520	$8,161
Stormwater Wetland	$76,000	25%	$19,000	$95,000	30	$7.656	4.5%	$3,420	$11,076
Gravel Wetland	$132,000	25%	$33,000	$165,000	20	$15,574	5%	$6,600	$22,174
Infiltration									
Basin	$52,000	25%	$13,000	$65,000	10	$9,255	7.5%	$3,900	$13,155
Filtration									
Surface Sand Filter	$80,000	25%	$20,000	$100,000	15	$10,979	12%	$9,600	$20,579

Table 12: Summary of BMPs – with References

	Initial Cost ($)	Lifespan (yrs)	Capital cost Over Lifespan^		Operation & Maintenance		Total	
			($/yr)	units	($/yr)	units	($/yr)	units
Street Sweeping – regen. air/vac sweeper serving 8160 curb miles/yr*	$185,000	8	$3.80	Curb mi	$18.50	Curb mi	$22.30	Curb mi
Catch basin insert for Bacteria (e.g. AbTech Ultra Urban Filter with Smart Sponge)#	$1,100	1 to 3	$420 To $1,100	Ea	$180.00	Ea	$600 To $1,100	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 it's lifespan at an interest rate of 7%

Table 13: Best Management Practices Costs

Best Management Practices Costs				
	Amount	Units	Comments	Reference
Pet Waste Station with bags & receptacle on post	$500.00	Ea		On-line products Paw Pal & JJB Solutions Inc. plus installation
Pet Waste Flyer mailing				
Pet Waste ad-TV				
ad-newspaper				
Riparian Buffer- Herbaceous	$450.00	Ac		In-house draft cost sheet for EQIP & WHIP
-Shrub/Tree	$2,400.00	Ac		In-house draft cost sheet for EQIP & WHIP
-Warm season grasses for goose management	$850.00	Ac		In-house draft cost sheet for EQIP & WHIP
Fencing – Woven Wire	$10.00	Lf		In-house draft cost sheet for EQIP & WHIP
-4/5 strand barbed wire	$5.70	Lf		In-house draft cost sheet for EQIP & WHIP
-4/5 strand electric	$9.00	Lf		In-house draft cost sheet for EQIP & WHIP
-solar charger for elec.	$300.00	Ea		In-house draft cost sheet for EQIP & WHIP
Wetland Restoration-broadcast seed	$2,600.00	Ac		In-house draft cost sheet for EQIP & WHIP
Livestock Watering Facility	$525.00	Ea		In-house draft cost sheet for EQIP & WHIP
Well for watering facility	$6,300.00	Ea (Avg.)	Can vary widely	In-house draft cost sheet for EQIP & WHIP
Pumping Plant for water facility	$2,500.00	Ea		In-house draft cost sheet for EQIP & WHIP
2” Underground supply pipe	$7.00	Lf		In-house draft cost sheet for EQIP & WHIP

NEXT STEPS

Each component developed for this study was designed to be replicable. While there are advantages to using the components in conjunction with one another, each can be used as a stand alone element. In some cases, groups conducting watershed-based planning can employ the applicable components from this study as a foundation for the work in their own watershed.

For the most part, each component uses readily available data. Only the Land Use/Land Cover required the acquisition and creation of additional data in order to make the dataset as useful as possible. Most of the analyses using these components can be accomplished with minimal field work; however, ground truthing the findings is beneficial. The ability to conduct analyses this way decreases the need for a larger volunteer corps or for extensive staff time in the field.

The availability of technical and financial resources does present an obstacle to making use of some of the components. Some of the components (e.g. geomorphic assessment and the LULC) do require trained individuals. This might require contracting with professional staff to perform the services or to provide training to staff or volunteers. Groups will need access to a Geographic Information System. It would be difficult to complete a watershed-based plan, on this scale, on a strictly volunteer basis or with limited staffing. Finally, sufficient funding would be needed to cover the cost for paid staff as well as any necessary equipment.

The measure of effectiveness of BMPs is contingent upon current and sufficient water quality data. One of the problems encountered with this watershed-based planning effort is the age of the data. The most recent data available was collected in 2004 and portions of the data were collected in 2001.

The second limiting factor is the number of monitoring sites. Three monitoring sites, all along the main stem of Steele Brook were used as the basis for the determination of the TMDL that was developed for the river. While this information is invaluable in showing that the river's water quality is degraded, the number of monitoring sites is inadequate to accurately determine the sources of bacterial loading. Because all of the sites are located along the main stem of

Steele Brook, there is no way to determine the level of bacterial contribution from tributaries as opposed to the inputs directly into the main stem.

By establishing a monitoring site for each tributary at the confluence with Steele Brook, it will be possible to assess how much bacteria, as well as other pollutants, are being transported into Steele Brook through its tributary network. This will improve the understanding of the relationship between watershed water quality conditions and watershed land use and land cover conditions. It will enable planners to determine more precisely and with a greater level of confidence the source of pollutant loading down to the sub-watershed level. Selection of appropriate place-based BMPs will be improved and potential pollutant removal efficiency enhanced. It is also strongly recommended that a monitoring component be established for each BMP that is implemented, regardless of its location in the watershed so that the efficiency of the BMP can be determined. This information will be helpful to other watershed planning efforts.

The contributions of an involved and knowledgeable advisory committee can provide valuable local contracts and integrate crucial local knowledge. Positive press coverage created an opportunity to expand awareness of the effort and inform the public about water quality issues. While the public outreach component was effective, a way to strengthen it would be to organize a series of meetings each designed to focus on the needs of a target group (e.g. professional municipal staff, municipal commission chairs, local land trusts, agricultural producers, etc.).

Below is a proposed schedule of implementation. This schedule, one of the nine criteria required by EPA, can be considered to be a working document, the foundation which watershed stakeholders can modify or adapt as necessary. The objectives listed below have not been prioritized. (Refer to **Table 14: Proposed Schedule of Implementation.**)

Table 14: Proposed Schedule of Implementation

Goal	Improved water quality of the Steele Brook watershed by reducing bacterial contamination as well as degradation from other non-point source pollutants, including iron precipitate.
Objective 1	Identify potential sources of funding
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, NVCOG, Town of Watertown, Private Landowners, NGOs
Timeline	1-3 years
Anticipated Products	Section of WBP with funding potential sources identified
Estimated Cost	N/A
Evaluation	N/A
Timeline	1-3 years
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 Environmental Awareness Program (HEAP) and work to involve horse farm operations 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	NVCOG, NRCS, RC&D, CT DOA, CT DEP, FSA, AFT, Farm Bureau, Town of Watertown
Timeline	1-10 years
Anticipated Products	Educational materials
Estimated Cost	N/A
Evaluation	Surveys regarding produce effectiveness, participant feedback
Timeline	1-10 years

Objective 3	Build awareness of non-point source management practices and reduce non-point 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	N/A
Responsible Parties	NVCOG, NRCS, CT DEP, Watertown Land Trust, Town of Watertown
Timeline	1-10 years
Anticipated Products	Educational materials and workshops
Estimated Costs	N/A
Evaluation	Surveys regarding product effectiveness, participant feedback
Timeline	1-10 years

Objective 4	Establish riparian buffers in priority areas
Actions/Milestones	Identify priority sites for establishment of buffers
	Contact landowners to determine level of interest, cooperation and obtain permission
	Obtain funding for implementation buffer sites
	Design the riparian plantings (develop a planting plan)
	Plant the buffers
	Water quality monitoring
BMPs	Establish riparian buffers
Responsible Parties	NVCOG, NRCS, CT DEP, Town of Watertown, Landowners
Timeline	2-4 years
Anticipated Products	Planting/Buffer design plans, before and after photo documentation of sites
Estimated Costs	$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	Address pollution from failing septic systems and illicit discharges in priority areas
Actions/Milestones	Work with Town of Watertown Sanitarian 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
	Asses the sites
	Report findings
	Select sites for repair or enforcement
	Work with landowners to implement repairs
	Select and hire contractors
	Repair systems
BMPs	Repair septic systems and eliminate illicit discharges
Responsible Parties	Town of Watertown Sanitarian, landowners
Timeline	5-10 years
Anticipated Produces	Fixed septic systems, elimination of illicit discharges
Estimated Cost	N/A
Evaluation Timeline	Photo documentation, sanitarian confirmation, municipal testing and monitoring 1-3 years

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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 (5-10 years). Sites should include at least one location (e.g. confluence) for each of the tributaries to the main stem
	Obtain funding for monitoring program
	Develop monitoring parameters and program details
	Train volunteers (if necessary)
	Monitor sites
	Report results
BMP	Report that improves knowledge of originating locations of bacteria and other non-point source pollutants
Responsible Parties	CT DEP, USGS, NVCOG, Town of Watertown, local stakeholders
Timeline	1-5 years
Anticipated Products	Monitoring data, report describing data, recommendations for focus areas
Estimated Costs	N/A
Evaluation	Review data with appropriate agencies

Timeline	1 year

Objective 7	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 (conduct as part of the WBP effort) with municipal officials and commissions (examine regulations including but not limited to zoning, subdivision, wetlands, erosion and sedimentation, etc.)
	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	Town of Watertown, NVCOG, NRCS, CT DEP
Timeline	2-10 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

Potential Funding Sources

A table of potential funding sources was developed by DEP, with assistance of NRCS (See **Table 15: Potential Funding Sources**). The funding entities and grant programs listed in the table are 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 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.

Table 15: Potential Funding Sources

Grant Name	Sponsor	Type	Dollar Amount	Required Match	Applications Open - Deadline	Contact	Remarks
DEP CT Landowner Incentive Program	DEP	State	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	DEP	State	$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	DEP	State			March-June	http://www.ct.gov/dep/cwp/view.asp?a=2706&q=323834&depNav GID=1641	Contact: 860-424-3016 david.stygar@ct.gov David Stygar
DEP Recreation and Natural Heritage Trust Program	DEP	State				http://www.ct.gov/dep/cwp/view.asp?a=2706&q=323840&depNav GID=1641	
Eastman Kodak/National Geographical American Greenways Awards Optional Program	Eastman Kodak, Conservation Fund, Nat'l Geographic	Private	$500 - $2500	Optional	April-June	jwhite@conservationfund.org Jen White	
EPA Healthy Communities Grant Program	EPA	Federal	$5,000 - $35,000	Optional Up to 5%	March-May	617-918-1698 Padula.Jennifer@epa.gov Jenifer Padula	
Northeast Utilities Environmental Community Grant Program	Northeast Utilities	Private	$250-$1000		April 15th	http://www.nu.com/environmental/grant.asp Cash incentives for non-profits	
EPA Targeted Watershed Grants Program	EPA	Federal		25% of total project costs (non-federal)		http://www.epa.gov/twg/	Requires Governor nomination
DEP CWA – Section 319 NPS	EPA/ DEP	State		40% of total project costs (non-federal)	October 15th	http://www.ct.gov/dep/nps Nonpoint Source Management	20-25 projects targeting both priority watersheds and statewide issues

DEP Section 6217 Coastal NPS	DEP	State		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 non point source 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	
The DEP Hazard Mitigation Grant Program provides financial assistance to state and local governments for projects that reduce or eliminate the long-term risk to human life and property form the effects from natural hazards.							
NRCS Conservation Reserve Program	Farm Service Agency/NRCS	Federal				Jan.dybdahl@ct.usda.gov Jan Dybdahl	
American Rivers – NOAA Community-Based Restoration Program Partnership	American Rivers/NOAA	Federal Private				http://www.amrivers.org/feature/restorationgrants.htm	
The American Rivers-NOAA Community-Based Restoration 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 reives and improve freshwater habitats important to migratory fish.							
Fish America Foundation Conservation Grants	Fish America Foundation	Private	Average $7,500			703-519-9691 x247 fishamerica@asafishing.org	
Municipal Flood & Erosion Control Board	Municipality	Municipal/ State	1/3 project cost	2/3 project cost		http://www.ct.gov/dep/lib/dep/water_inland/flood_mgmt/fecb_program.pdf	
NFWF Long Island Sound Futures Fund Small Grants	NFWF, EPA, FWS, NOAA, NY DEC, CT DEP	Partnership	$1,000 - $6,000	Optional (non-federal)	Fall – February	631-289-0150 Lynn Dwyer LISFFAnfwf.org	
NFWF Long Island Sound Futures Fund Large Grants	NFWF, EPA, FWS, NOAA, NY DEC, CT DEP	Partnership	$10,000 - $150,000	Optional (non-federal)	Fall - February	631-289-0150 Lynn Dwyer LISFFAnfwf.org	
NRCS Wildlife Habitat Incentives Program	NRCS	Federal	$1,000 - $50,000/year	25-50%	Continuous sign up	860-871-4018 jan.dybdahl@ct.usda.gov Jan Dybdahl	
The Wildlife Habitat Incentives program is for creation, enhancement, and maintenance of wildlife habitat; for privately owned lands.							
Environmental Quality Incentives Program	NRCS	Federal	Up to $300,000		Continuous Sign up	860-871-4018 jan.dybdahl@ct.usda.gov Jan Dybdahl	For implementation of conservation measures on agricultural lands.

NRCS Healthy Forests Reserve Program	NRCS	Federal				860-871-4018 jan.dybdahl@ct.usda.gov Jan Dybdahl	
NRCS Wetlands Reserve Program	NRCS	Federal				860-871-4015 nels.barrett@ct.usda.gov Nels Barrett	
USFS Watershed and Clean Water Action and Forestry Innovation Grants	USFS	Federal				http://na.fs.fed.us/watershed/gp_innovation.shtm	
The USFS Watershed and Clean Water Action and Forestry Innovation grant program is an effort between the USDA Forestry Service -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	Partnership	Private	Typically $5,000 - $20,000	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	Rivers Alliance of CT	Federal		40% of total project costs (non-federal)		860-361-9349 rivers@riversalliance.org	
Trout Unlimited EmbraceAStream	Trout Unlimited	Private	$5,000			http://www.tu.org/site/c.kkLRJ7MSKtH/b.3198137/k.9DD6/EmbraceAStream.htm	
USFWS National Coastal Wetlands Conservation Grant Program	USFWS	Federal	$1 million	50%		703-358-2229 Ken Burton	Only states can apply
YSI Foundation	YSI Foundation	Private	$60,000	Optional	March-April	937-767-7241 x406 smiller@ysi.com Susan Miller	
Other Financial Opportunities							
Private Foundation Grants and Awards Private foundations are potential sources of funding to support watershed management activities. Many private foundations post grant guidelines on their websites.							
Congressional Appropriation **Direct Federal Funding**	Congressional	Federal				Rep Larson 860-278-8888 Rep Courtney 860-886-0139 Rep DeLauro 203-562-3718 Rep Shays 203-357-8277 Rep Murphy 860-223-8412	
State Appropriations **Direct State Funding**	State Appropriations	State				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 Taxes 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 specific 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 nonpoint sources only, or between point sources and nonpoint sources.
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.

Interim Milestones

Described below are interim, measurable milestones that may be used to ascertain the progress that the Town of Watertown is making over time toward reducing bacteria loading in the Steele Brook watershed. The primary goal of reducing the bacteria is to attain the water quality standards for the Steele Brook watershed as outlined in the Naugatuck River Regional Basin TMDL. The milestones, and the progress marked, will also provide an indication of whether the TMDL should be revised. Working toward the goals of the TMDL will enable the Town of Watertown to be eligible for future Section 319 grant funds.

It is not anticipated that the Town of Watertown will implement each of these measures. The intent of the milestones is to present attainable goals that will help to increase awareness and understanding of potential pollution sources in the watershed. Through improved understanding, the Town of Watertown and individuals can focus on ways to minimize potential threats. The development of new policies and programs, and the amendment of local regulations can help the Town of Watertown proactively address potential water quality concerns that arise as part of the growth process in their community. Not every objective is expected to be met, with the exception of those that are required pursuant to State stormwater discharge permits. All efforts to restore, remediate, renovate or retrofit existing or potential threats are encouraged as resources and funding allow.

Municipal compliance with the General Permit for the Discharge of Stormwater from Small Municipal Separate Storm Sewer Systems (MS4**)**

Six minimum Control Measures:

- Public Education and Outreach on stormwater impacts and BMPs
- Public Participation/Involvement
- Detection and Elimination of Illicit Discharges
- Construction Site Stormwater Runoff Control BMPs
- Post-construction Stormwater Management BMPs for new development and re-development
- Pollution Prevention/Good Housekeeping BMPs for municipal operations

Stormwater Monitoring

All outfalls shall be monitored annually from areas of industrial development, commercial development and residential development, according to the parameters identified in the MS4 General Permit.

Municipal compliance with the General Permit for the Discharge of Stormwater Associated with Industrial Activities

Permit Coverage applies to public works facilities, transfer stations and road salt storage sites

Preparation and Implementation of Pollution Prevention Plan to address sources of pollution

Sample stormwater discharges annually

Indication of pollutant load reductions of bacteria on water quality monitoring. This is to be provided by either DEP, the Town of Watertown in accordance with the requirements of the MS4 General Permit, or other entities, e.g. USGS, Northwest CT Conservation District, academic institutions, volunteer watershed organizations, etc.

Municipal adoption of ordinances/regulations that allow for new, innovative or emerging technologies or construction techniques and other practices. The goal is to reduce and minimize non-point source pollution runoff and to preserve the pre-development hydrology of a site. These techniques and technologies may include:

Structural and non-structural measures such as stormwater treatment retrofits and secondary treatment practices

Reduction of land disturbance to decrease compaction and runoff

Infiltration measures

Use of existing natural buffers and establishment of vegetative plantings or preservation of open space (a.k.a. Low Impact Development)

Municipal adoption of impervious surface ordinances/regulations. These ordinances/regulations would limit the amount of impervious cover allowed for new site development or re-

development and include site design requirements that promote infiltration, where appropriate, and decrease the amount of effective impervious surface (i.e. direct discharge of stormwater runoff into surface water bodies).

Municipal adoption of zoning or planning and zoning ordinances/regulations requiring project construction design and post-construction operation in accordance with, or in reference to the 2004 Connecticut Stormwater Quality Manual.

Municipal adoption of illicit discharge and stormwater connection ordinance/regulation (see DEP's 2004 Connecticut Stormwater Quality Manual) http://www.ct.gov/dep/lib/dep/water_regulating_and_discharges/stormwater/manual/Apx_C_Model_Ordinances.pdf)

Municipal adoption of septic system inspection and maintenance ordinance/regulation policy.

Development and adoption of homeowner septic system educational management program.

Municipal adoption of policy on the avoidance of fertilizer use in or near wetlands, riparian buffer areas and watercourses.

Municipal adoption of riparian buffer ordinance/regulation/policy to conserve or preserve natural vegetation along rivers and streams, especially in areas that have a high potential for pollution sources. Restoration of buffers should follow guidance given in DEP white paper on *Hydraulic Impacts of Re-Vegetation Projects within Floodplains, August 2002*, for the appropriate choice of floodplain vegetation for hydraulic conveyance.

Adoption or revision of the municipal Plan of Conservation and Development to include a goal to protect water quality now and in the future.

Municipal adoption and use of updated Land Use/Land Cover maps as reference for land use commissions and Plan of Conservation and Development.

Municipal adoption of ordinance/regulation/policy to ban the feeding of nuisance wildlife (e.g. geese). This ordinance/regulation/policy should include a public education and outreach component.

Municipal adoption of ordinance/regulation/policy to require proper disposal of pet waste. This ordinance/regulation/policy should include a public education and outreach component.

Adoption/revision and implementation of a comprehensive farm management plan for all agricultural operations. This includes pasture management and waste management plans.

Municipal adoption and implementation of a policy or program to preserve open space, including farmland.

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Appendix A: Land Use/Land Cover Data Set

Methodology and LULC Tables

Objective

The main objective of the Steele Brook Watershed Land Use/Land Cover data set developed by NRCS (NRCS LULC) was to provide a foundation for the Watershed Based Plan for the Steele Brook Watershed. The focus of the resulting plan is the design of Best Management Practices which address non-point source pollutants in the most efficient manner; specifically pathogens (bacteria). With this in mind, the NRCS LULC classification scheme was designed to separate out classes of land cover by their potential impacts on the levels of these pollutants entering into surface water and/or ground water. In cases where use of the land was determined to be an important variable, the classification scheme was expanded to include use as well as cover.

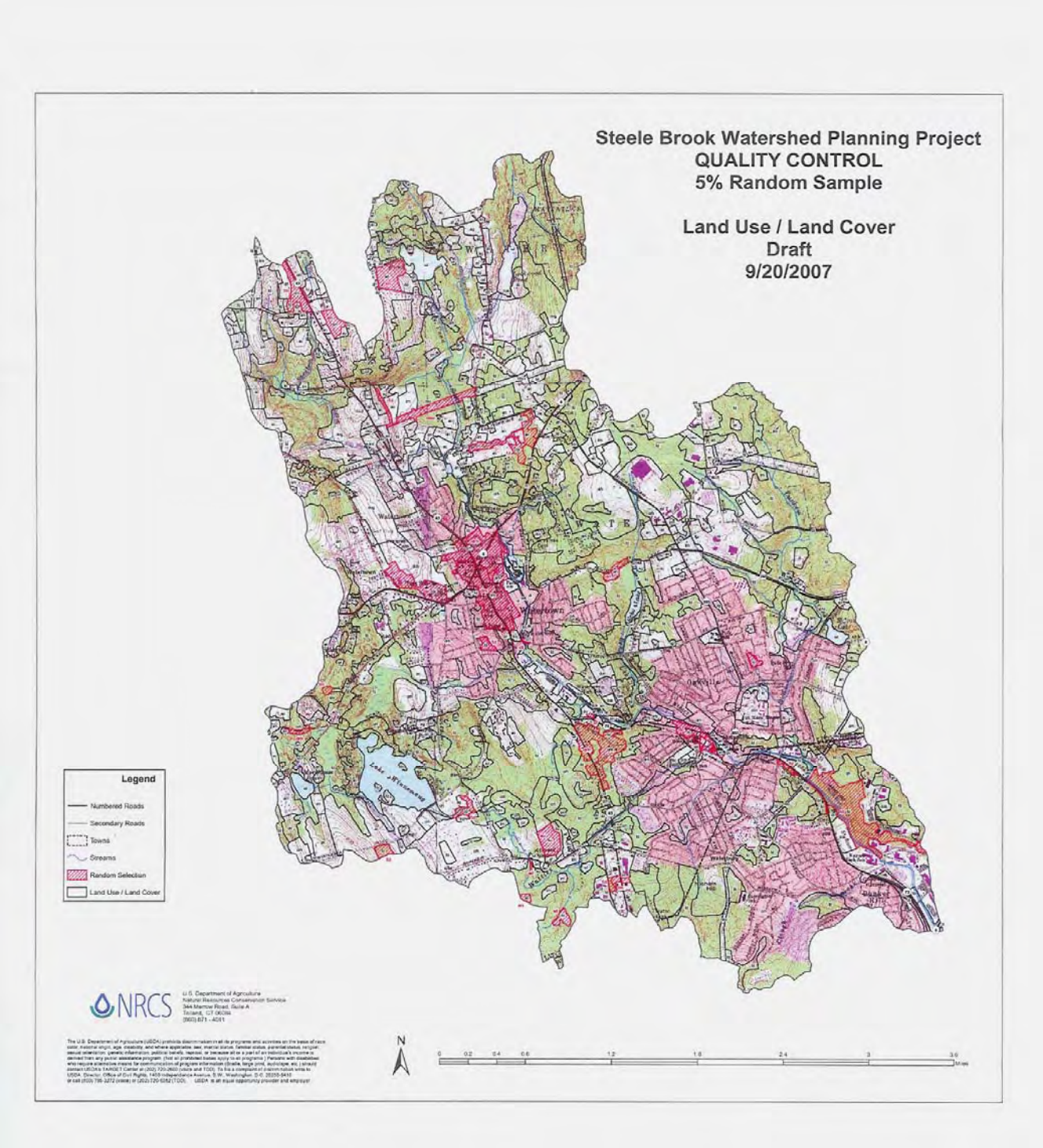
Imagery

The imagery used for remote sensing was the 2006 flight by SBC (AT&T), leaf off, 6-inch resolution, true color, uncompressed. The "Null" holes were mapped using 2006 imagery from USDA-FSA-APFO NAIP (USDA FSA Aerial Photography Field Office, National Agriculture Imagery Program); Litchfield County Mosaic, leaf on, 2 meter resolution (2 meter Ground Sample Distance (GSD) imagery that matches within 10 meters of reference ortho imagery, true color, compressed to MrSID MG3 at a ratio of 15:1.

Quality Control

Approximately 3% of the polygons were field checked when cover or use could not be discerned through remote sensing. An additional 5% was verified through ground truthing of a random sample. The entire dataset was reviewed by the Advisory Committee. (**See Map 20** below)

Map 20: Quality Control 5% Random Sample



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 30 classes in this data set will be used to consider land use/land cover by its potential affect on water quality issues. 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.

The University of Connecticut Center for Land Use Education and Research data set, 2002, (CLEAR 2002), was used as a resource base. We found that we were unable to use the CLEAR 2002 data set directly as the foundation land use/land cover data set for our analysis. The methodology of spectral reflectance used in the CLEAR 2002 processing creates a data set that classifies land based up the color value of a 30 sq m pixel of satellite imagery. Thus, each pixel's value is based upon the spectral value that is dominant in a 0.22 acre square. In our initial analysis of the CLEAR data, we were able to see that the data was not only several years out of date, but it also did not have enough resolution to capture the diversity of land cover that is found on Connecticut's landscape at the scale at which we were working.

Also, the CLEAR 2002 data set was not designed to ascertain land use from land cover. In the NRCS LULC data set, detailed class of land use were used to separate and recombine classes of CLEAR 2002 data. For example, land use categories such as "Developed: Other: golf course", "Developed: Residential: low density" and "Agriculture: Non-cultivated" partially replace the CLEAR 2002 land cover category of "Turf and Grass". The CLEAR 2002 dataset was found to be particularly useful in determining forest type and as a quality control reference.

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 calculations of acres. A topology was used to eliminate polygon node errors.

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). Sub-region 6912, Steele Brook, was used as the boundary of the watershed and includes 30 local basins.

The Attribute table for the LULC was designed to contain three levels of classification, area measurement and label. The definitions for these classifications can be found in **Table 17: Classification Table for Land Use/Land Cover Categories**. An example of the attribute table can be seen below in **Table 16: Example of Attribute Table for Steele Brook Land Use/Land Cover**. 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 either Level I, or Level II or complete classification.

Table 16: Example of Attribute Table for Steele Brook LULC

OBJECTID_1 *	Shape *	OBJECTID	class_1	class_2	class_3	Label	Acre
499	Polygon		d	dr	drl	drl	0.731858886023272
544	Polygon		d	dr	drh	drh	89.5153094507254
415	Polygon		a	an		an	3.8846335394168
416	Polygon		a	ac		ac	18.1278621872613
405	Polygon		f	fd		fd	3.3645312820714
418	Polygon		o	os	osu	osu	5.48253429149445
406	Polygon		t	tm		tm	9.50672224036828
404	Polygon		d	dr	drl	drl	27.7922889112887
413	Polygon		t	tm		tm	2.33289579549283
398	Polygon		f	fd		fd	5.55113932234632
397	Polygon		d	dr	drl	drl	0.863060174571976
396	Polygon		d	dr	drl	drl	8.22108879115208
425	Polygon		f	fd		fd	0.625556259997908
404	Polygon		f	fd		fd	5.72238321207777

Throughout the data collection, a variety of resource materials were used to support the remote sensing of the imagery and to further the analysis of resources in the watershed. Most of these data layers are available over the internet. A list of data sets used and available from the CT DEP GIS website is included in **Table 18**. 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.

Topographic layers were useful to find rural residences and to pick out cultural features like cemeteries, golf courses and ball fields. 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 or be affected by non-point source pollution.

Table 17: Classification Table for Land Use / Land Cover Categories

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.
		Low density	**drl**	This unit is typically comprised of residences outside of urban centers that exceed the threshold of 20% cover of constructed material, but do not meet the requirement of High Density Residential.
	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. Along with roadways and railroad corridors, this includes rights-of-way, areas used for interchanges, and service and terminal facilities. Rail facilities include 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.
			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 ### 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**	Self-explanatory
		Golf Courses	**dog**	Self-explanatory
		Playgrounds	**dop**	Self-explanatory
		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).

Level I	Level II	Level III	Symbol	Definition
	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 hay land. The crop may be grasses, legumes, or a combination of both. Hay land 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.
	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 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
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 and Coniferous		**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.
WATER			**w**	Water includes all areas that are persistently water covered.
	Streams & Rivers		**ws**	The Streams and Canals category includes rivers, creeks, canals, and other linear water bodies. Where the watercourse is interrupted by a control structure, the impounded area will be placed in the Reservoirs category.
	Lakes & Reservoirs		**wl**	A natural inland body of water, fresh or salt, extending over 40 acres or more and occupying a basin or hollow on the earth's surface, which may or may not have a current or single direction of flow.
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.
	Beaches		**bb**	This unit includes the area adjacent to the shore of an ocean, sea, large river, or lake that is washed by the tide or waves.
	Strip mines, Quarries, Pits		**bm**	This unit includes land that is actively used for extraction of ores, minerals, and rock materials.
	Permanently bare soil/rock		**br**	This unit consists of areas that are large enough to meet size requirements, and that consist of permanently bare rock or soil.

Level I	Level II	Level III	Symbol	Definition
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.

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. Data that could be captured in separate datasets was not classified in this one. Therefore, the classification of wetlands will come through a combination of the inland wetland soils database, the land cover types classified here and any ground-truthing or further information gathered through the wetland assessment protocol. General values for percentage impervious surface will likely be assigned based upon the artificial cover types classified under Developed Lands. The presence/absence of pollutants could be affected by the use of the land. Therefore, areas where fertilizers and nutrients may be applied were separated from areas where there are animals actively grazing and also from areas that are currently fallow or abandoned.

Table 18: GIS Resource Data Layers

An important consideration when starting out is to decide which coordinate system you will be working in. Below is a list of data layers used in the GIS analysis of the Steele Brook watershed. All data was re-projected to UTM NAD 1983, zone 18. In this table, the Data Layer Source column shows where this data is available to the public. It may also be available in other places, and may have been projected into other coordinate systems. In general, the CT DEP website is regularly updated and their data is in CT State Plane, (ft) NAD 83. Some of this data is also available from the NRCS Geospatial Gateway (http://datagateway.nrcs.usda.gov). This data is in UTM NAD 1983.

Name	Date of Update	File type	Scale / Ground Resolution	File Size	Coordinate System	Data Layer Source
SBC true color, leaf-on	2006	.tif	6 inches	140 mb ea.	Connecticut State Plane NAD 1983	Purchased by town of Watertown
USDA-FSA-APFO NAIP County Mosaic (true color)	2006	MrSid	2 m	117 mb	UTM Nad 1983, zone 18	http://datagateway.nrcs.usda.gov
USGS 7.5 Minute Topographic Maps	1969 - 1984	MrSid	1:24000	3.4 mb +/- ea.	Connecticut State Plane NAD 1983	CT DEP GIS Data Website (see above)
Planimetric data files	2006	Geodatabase	1:100	Various	Connecticut State Plane NAD 1983	Tighe & Bond, consultants – owned by town of Watertown
Towns	1969 - 1984	Polygon .shp	1:24000	604 kb	Connecticut State Plane NAD 1983	CT DEP GIS Data Website (see above)
Basin	1978 - 1988	Polygon .shp	1:24000	14.7 mb	Connecticut State Plane NAD 1983	CT DEP GIS Data Website (see above)
Hydrography Lines	1969-1984	Polyline .shp	1:24000	20.9 mb	Connecticut State Plane NAD 1983	CT DEP GIS Data Website (see above)
DEP Property	5/2007	Polygon .shp	1:24000	1.1 mb	Connecticut State Plane NAD 1983	CT DEP GIS Data Website (see above)
Municipal and Private Open Space Property	1994	Polygon .shp	1:24000	2.3 mb	Connecticut State Plane NAD 1983	CT DEP GIS Data Website (see above)
Wetland Soils	2005	Polygon .shp	1:12000	57.8 mb	Connecticut State Plane NAD 1983	CT DEP GIS Data Website (see above)
County Soils	2005	Polygon .shp	1:12000	19.6 - 45.8 mb	Connecticut State Plane NAD 1983	CT DEP GIS Data Website (see above)
Connecticut Routes	2003	Polyline .shp	1:100000	393 kb	Connecticut State Plane NAD 1983	CT DEP GIS Data Website (see above)
Dams	1996	Point	1:24000	175 kb	Connecticut State Plane NAD 1983	CT DEP GIS Data Website (see above)

Name	Date of Update	File type	Scale / Ground Resolution	File Size	Coordinate System	Data Layer Source
Stream Barriers	2008	Point	+ - 5 m	23 kb	UTM NAD83	Collected on the ground, using USDA Config 1 – Garmin Map76s w/ DGPS. Dataset available from CT NRCS on request
CLEAR 2002 LULC	2002	Polygon .shp	30 m	49 mb	Connecticut State Plane NAD 1983	http://clear.uconn.edu/projects/landscape/statewide_landcover.htm

Appendix B: Soil Based Recommendations for Stormwater Management Practices

Objective

Planners and others use soil survey information as a screening tool for successful selection and implementation of best management practices for storm water runoff in the watershed.

Imagery/Data/Mapping

Certified Spatial and Tabular data from the National Cooperative Soil Survey (NCSS), State of Connecticut produced by the USDA NRCS, Connecticut was used.

Quality Control

NCSS maps and data meet all agency standards. Maps are produced based solely on these products. No field checking was performed. Map units have a three acre minimum and may include areas of dissimilar soils. These maps are meant to be used for planning and review and do not replace an on-site evaluation.

General Approach

Soil and landscape criteria used to rate soil suitability were identified using specifications in the **CT/RI-NRCS Runoff Management System Standard (570)** and the DEP *2004 Connecticut Stormwater Quality Manual*, and through interviews with engineering staff. The National Soil Information System (NASIS) was used to write queries that access the state's soil survey data and assign ratings and limitations to each map unit in the soil survey legend. Rating classes indicate the extent to which the soils are suitable based on the soil properties that affect the management system. A most suitable rating indicates that the soil has features that are very favorable for the practice. Good performance and relatively low installation and maintenance costs can be expected. A soil rated somewhat suitable has features that are moderately favorable. The limitations can be overcome or minimized by special planning, design, installation, and maintenance. Increased installation costs and maintenance will be required to sustain performance. A least suitable rating indicates that at least one soil feature is unfavorable for infiltration

systems. The limitation generally cannot be overcome. Sometimes expensive design, installation and maintenance can be employed, but performance may still be poor.

Specific Approach

Four stormwater management maps were generated for the watershed:

- Stormwater Infiltration Systems
- Wet Extended Detention Basins
- Dry Detention Basins
- Pervious Pavement

For more information about specific practices, please see the *2004 Connecticut Stormwater Quality Manua*l, specifically Chapters 11-3P, Infiltration Practices, 11-P1, Stormwater ponds, 11-S1, Dry Detention ponds, in chapter 11-S6, Permeable Pavement. http://www.ct.gov/dep/cwp/view.asp?a=2721&q=325704&depNav_GID=1654

For more information about the development of soil ratings, see Soil Based Recommendations for Storm Water Management Practices, CT-TP-2005-3. To view or download this publication visit ftp://ftp.fc.sc.egov.usda.gov/CT/water/CT-TP-2005-3.pdf.

Additional information about the soils in the watershed can be found on maps showing soils parent material and potential runoff based on soil properties and land use land cover classifications (3 maps).

Appendix C: Municipal Regulations: Horses

Andover Zoning Regulations

SECTION 20 - THE KEEPING OF ANIMALS

The intent of this regulation is to regulate the keeping of animals so they will not endanger the general public or in any other way create a nuisance, constitute a health hazard, or adversely affect the environment.

20.1 Definitions

a. ANIMALS, ENDANGERED AND RARE SPECIES - shall be as defined in Section 26-40c of the Connecticut General Statutes or any amendments thereto.

b. ANIMALS, FARM - shall be those domesticated animals customarily found on farm in the Tolland County area and shall include, but not necessarily be limited to: cattle, horses, fowl, sheep, goats, etc.

c. ANIMALS, GAME - shall be as defined in Section 26-40 of the Connecticut General Statutes or any amendments thereto.

d. ANIMALS, POTENTIALLY DANGEROUS WILD - shall be as defined in Section 26-40a of the Connecticut General Statutes or any amendments thereto.

e. PETS, HOUSEHOLD - shall be those animals customarily found in homes in the Andover area including, but not necessarily limited to: dogs, cats, rabbits, and indoor-type such as gerbils, hamsters, guinea pigs, tropical fish, parakeets, and canaries, etc.

20.2 The Keeping of Horses for Personal Use Including Breeding Purposes

The keeping of horses for personal use is permitted in alt Zoning Districts.

20.2.1 No horse shall be permitted on any parcel of land less than 2 acres. Horses shall be allowed on parcels of land, at the rate of one for the first two acres of land and one for each 1/2 acre of land thereafter.

20.2.2 On a residential building lot, the keeping of horses and accessory structures shall be restricted to the rear yard.

20.2.3 No horse stable, barn, or feed or watering trough shall be constructed, established or moved within 75 feet of any adjoining property line or within 100 feet of any off site dwelling.

20.2.4 No horse stable, barn, or feed or watering trough shall be constructed, established or moved within 50 feet of any stream, water body or Wetland as shown on the official Wetlands reap of the Town of Andover.

20.2.5 The use of trailers for stabling horses is prohibited.

20.2.6 Stable manure shall not be allowed to accumulate within 100 feet of any stream, water body or Wetland as shown on the Official Wetlands Map of the Town of Andover nor shall it be allowed to create a health hazard or any other kind of nuisance.

20.2.7 Horses shall be confined to the premises by a sound fence or some other suitable device.

20.3 The Keeping of Horses for Commercial Use - Special Permit

(See Section 23)

The keeping of horses for commercial use shall be permitted in all Zoning Districts except Andover Lake District and Flood Prone District and shall be subject to the requirements hereunder and subject to Commission approval.

20.3.1 Permitted commercial uses shall be limited to, or closely related to the following:

a. Riding Stables.

b. Breeding services

c. Training services.

d. Stabling services.

20.3.2 Accessory uses to the above are permitted and

a. Stables

b. Paddocks (corrals & rings).

c. Fences.

d. Feed and watering troughs.

e. Running track.

f. Any other devices used for the training of horses and riders.

20.3.3 Area Requirements include such structures as:

a. Any site occupied by a residence, used for commercial purposes pursuant to 20.3.1, shall be a minimum of 3 acres and shall accommodate no more than three horses on a permanent basis. One half acre of land shall be required for each additional horse permanently kept on the premises.

b. On any site not occupied by a residence and not shown as a building lot on a legally recorded subdivision, there shall be a minimum of two acres for up to three horses kept on a permanent basis. One half acre of land shall be required for each additional horse kept on the premises.

20.3.4 Site Requirements and restrictions

a. Site requirements and restrictions shall be in accordance with the provisions of Sections 20.2.2, 20.2.3, 20.2.4, 20.2.5, 20.2.6, and 20.2.7 and;

b. Off street parking shall be required at the discretion of the Commission after reviewing the proposal.

c. Automobile parking, if required, shall be no closer than 25 feet from adjacent property lines and shall be screened from adjacent residentially zoned property by a fight-proof barrier at least five feet in height.

d. In addition to the above requirement, the Commission may require the parking area to comply with any or all of the provisions of Section 12.1.

e. There shall be no external lighting which transmits outside the property from which it originates or any other fighting which is objectionable due to brightness.

20.3.5 Application Procedure

Application for a permit to keep horses for Commercial purposes shall be submitted to the Zoning Enforcement Officer 10 days prior to next regular meeting of the Commission.

20.3.6 complete application shall include:

a. All applicable data and plans called for on the Planning and Zoning Commission application form.

b. The plot plan required on the above form shall show thereon the location of all fences, stables, outside food and watering troughs, tracks, parking areas, and any other permanent structures existing or proposed which will be accessory to the proposed use. The distances from such structures to the nearest property line shall be clearly indicated on the plan.

c. A letter of intent or description of the type of operation planned including hours of operation, etc.

d. Any other information the Commission deems appropriate to make a sound decision.

e. Fee - Per Town Ordinance (Revised 1/20/04 Effective 2/20/04)

20.3.7 Action of the Commission

The Commission shall take action in accordance with the provisions of Section 19.2.3.

20.4 The Keeping of Farm Animals

The Keeping of Farm Animals is permitted on farms in R 80 and R-40 Districts or any farm in any District legally existing at the time these regulations are adopted. The Keeping of Farm Animals shall be subject to the following requirements:

20.4.1 The provisions of Sections 20.2 and 20.3.

20.4.2 No barn, stable, corn crib, feed or water trough, salt-lick or any similar structure shall be constructed, established or moved and no processed feed, fodder, animal bedding material, fertilizer or manure shall be stored or allowed to accumulate within 75 feet of any adjoining property line or within 100 feet of any off site dwelling.

20.4.3 No barn, stable, corn crib, feed or water trough, salt-lick or any similar structure shall be constructed, established or moved within 50 feet, and no fertilizer pr manure shall be stored or allowed to accumulate within 100 feet, of any potable well or any stream, water body or wetland as shown on the official Wetlands Map of the Town of Andover.

20.4.4 No farm shall be maintained in such a state that it creates a health hazard, adversely affects the environment, or in any other way creates a public nuisance.

20.4.5 All animals shall be confined to the premises by a sound fence, enclosure, or any other acceptable retaining structure or device.

20.4.6 Animals shall be provided with shelter, food, water, and veterinarian care in accordance with current acceptable standards as required or recommended by the Connecticut General Statutes as amended, the Connecticut Humane Society, the Connecticut Department of Agriculture, or any other agency with the authority to regulate the keeping and care of animals.

20.5 The Keening of Farm Animals for Personal

(see Section 23)

The purpose of this section is to permit, under certain circumstances, the keeping of a specific amount of Farm Animals for personal use or consumption as an accessory use to a residential use on parcels containing 1 to 3 contiguous acres in R-40 or R 80 Districts.

The Keeping of such animals must be approved by the Commission and such approval may have reasonable conditions attached and may be for any time period deemed appropriate by the Commission.

20.5.1 Application Procedure

Application for a permit to keep farm animals for personal use may be submitted at any regular meeting of the Commission.

20.5.2 A complete application shall include:

a. All applicable data and plans called for on the Planning and Zoning Commission application form.

b. The plot plan required on the above form shall show thereon the location of all fences, stables, outside food and watering troughs, feed and fodder storage areas, animal shelter, and any other structures related to the proposed use. The plan shall show thereon the approximate distances from the side and rear property lines to any off-site residential dwelling within 100 feet.

c. A letter of intent describing, in detail, the proposed use, the number of animals to be kept, for what purposes they will be used, where they will be kept, how they will be sheltered, type of food to be used, and provisions for storing or disposing of manure.

d. Any other information the Commission deems necessary to make a sound decision.

e. Fee - Per Town Ordinance (Revised 1/20/04 Effective 2/20/04)

20.5.3 Action of the Commission

The Commission shall render a decision in accordance with the provisions of Section 19.2.3 if it finds that:

a. The site meets area requirements, if applicable

b. The proposal will not have an adverse effect on the environment

c. The proposal will not create a health or safety hazard or create a nuisance to abutting property owners or the general public

d. The proposed use, (number and size of animals, etc.), is not too intense for the site.

20.5.4 General Requirements

a. Any animal permitted by the Commission under Section 20.5 shall be confined to the premises by a sound fence, enclosure, or any other acceptable retaining structure or devices.

20.6 The Keeping of Unusual Animals

For the purpose of this section, "unusual animals" shall include, but not necessarily be limited to the following:

a. Endangered and rare species as defined in Section 26-40a of the Connecticut General Statutes as amended.

b. Potentially dangerous wild animals as defined in Section 26-40a of the Connecticut General Statutes as amended.

c. Game animals as defined Section 26-40 of the Connecticut General Statutes.

d. Any animal not considered to be a customary household pet or a customary farm animal in the Tolland County area.

e. Any animal not noted above, which is distinguished by its size, habits, temperament, or behavior, or by its wild or dangerous character,

20.6.1 Regulated H spa

a. Endangered and Rare Species - No person shall keep any rare or endangered species or as otherwise provided by the Connecticut Statutes as amended.

b. Potentially dangerous wild animals - No person. Shaw possess a potentially dangerous wild animal without first obtaining a permit from the chief executive authority of the Town, or as otherwise provided by the Connecticut General Statutes as amended. The keeping of any such animals for which a permit has been received shall be in accordance with the provisions of Section 19.2.3.

c. Game Animals may be kept in accordance with the Connecticut General Statutes as amended and in accordance with the provisions of Sections 20.5.3 and 20.6.5. The keeping of fox and mink is specifically prohibited.

d. Any other unusual animals provided for in Section 20.6.d and e. are permitted only after Commission approval. The Commission may require a public hearing if it thinks the request warrants such action. (see Section 23)

20.6.2 Application Procedure

Application for a permit to keep "unusual animals" may be submitted at any regular meeting of the Commission. If the Commission elects to hold a public hearing, a hearing date will be set and the applicant will be so notified.

20.6.3 A complete application shall include:

a. All the requirements of Section 20.5.2 a, b, c, d, and e.

20.6.4 Action of the Commission

a. The Commission shall render a decision in accordance with the provisions of Section 20.5.3.

20.6.5 General Requirements

a. Any animal permitted by the Connecticut General Statutes under Sections 20.6.1b and c, and as permitted by the Commission under Section 20.6.1 d, shall be confined to the premises by a sound fence, enclosure, or any other acceptable retaining structure or device.

b. The number of any such animals shall not be increased without receiving written permission from the agency empowered to issue such permit.

Bethany Zoning Regulations

Appendix 2 - Best Management Practices for the Keeping of Horses in Residential Areas

KEEPING HORSES IN RESIDENTIAL AREAS

By Jim Gibbons, Cooperative Extension, Community Resource Development Agent

Introduction

According to the American Horse Council and the Animal Science Department of the College of Agriculture at The University of Connecticut there were approximately 46,000 horses in Connecticut in 1985. Connecticut had the largest horse population of any New England state and had more horses per square mile (11) than any other state. Horses provide economic benefits to the state. The annual contribution to the state's economy by horse owners is approximately $56 million. Trailer registrations alone contribute $20,000. Several industrial plants in the state are involved in the manufacture of horse products including: Smith Worthington in Hartford, the oldest continuous saddle maker in the United States; North and Judd in New Britain, the nation's leading manufacturer of saddle and harness hardware and second in the nation in manufacturing bits, stirrups and spurs; and Capewell Manufacturing in Hartford, the world's largest manufacturer of horseshoe nails. At the turn of the century there were 17 million horses in the U.S. By 1915 that figure

peaked at 21 million: most of the horses were on farms and ranches and were used for work. By 1957 horse numbers had drastically declined to 3 million. Since then there has been a smashing comeback. This comeback has occurred not on the farm, but in suburbia where horses are kept for pleasure instead of work. In the U.S. 80% of the-horses are kept for recreation; 20% for breeding, racing, and for working. In addition to their economic and recreational value, horses also serve educational and therapeutic functions. More than 1,300 Connecticut youngsters are involved in 4-H horse projects under the guidance of 100 adult leaders. Horseback riding is being increasingly used as a form of therapy for handicapped individuals. As the horse has moved from the farm to built-up areas it has encountered a few people who are not happy to have it as a neighbor. In some instances conflicts have developed when neighbors claim a horse is not cared for properly or is creating a neighborhood nuisance. Poor management may cause state and local agencies to establish restrictive regulations that might affect all horse owners. These conflicts can be reduced if a few basic management practices are followed. Good management can protect the horse owner from legal sanctions and will prevent soil erosion and water pollution. Finally, good management is the key to having a healthy horse.

Horse Waste

A horse drinks 8 to 12 gallons of water a day and sometimes more during warm weather. A 1,000 lb. horse ridden 1 to 3 hours daily will eat 10 to 15 lbs. of hay and 4 to 10 lbs. of grain. Each horse will generate 9 to 10 tons of manure per year. In addition to manure, urine and used bedding should also be considered horse generated wastes. The most common stall bedding is a 6" layer of wood chips, which are replaced daily in a well managed stable. These wastes, if improperly managed, may attract flies or rodents and may generate odors. However, the major concern about horse wastes is as a water contaminant, because of nutrient or coli form bacteria generation. Unmanaged horse wastes can become a part of the ground surface runoff. Nutrient elements or coli form bacteria present in horse wastes may enter wetlands or watercourses and pollute ponds, lakes or reservoirs or percolate into the groundwater. Nutrients produce plants and algae and damage the water by over-fertilization. One pollutant is the nitrate form of nitrogen in horse urine. Excessive nitrate levels in drinking water can be a health problem, especially to infants (Blue Baby Syndrome). Coli form organisms are always present in human and animal waste and indicate that more serious disease-causing bacteria may be present. Bacterial pollutant sources should be kept out of drinking water supplies and water used for recreation.

Existing Regulations Pertaining to Animal Wastes

The Connecticut Public Health Code, enforced by the local health officer, can require that manure be kept covered, stored in watertight pits or chambers and be removed at least once a week during the period from May 1st to October 1st. Also a 100' setback of manure piles from reservoirs and a 50' setback from a tributary to public water supply is mandated by the code. The health code also states that barns, stables and manure piles which are a breeding place for flies may be declared a public nuisance and can be shut down by the health director. The Department of Environmental Protection has the authority to regulate any activity where animals are kept in such a manner as to pollute the waters of the state. Serious horse-related pollution problems have resulted in the issuance of formal abatement orders to both horse and property owners. Section 22-279 of the General Statutes states that the Commissioner of Agriculture may quarantine all animals that are kept in unsanitary conditions which endanger the public health or health of the animal. Connecticut's Inland-Wetlands Act generally excludes agriculture from regulation but one cannot engage in a farming activity that blatantly destroys a wetland or pollutes the waters of the state. Some local zoning regulations limit the number and types of animals one can keep, limit animals to certain areas, or require minimum lot sizes before animals are allowed. Some municipalities also have ordinances that control the keeping of animals.

Site Planning and Waste Management

Before purchasing a horse, the land where the horse will be kept should be examined. Areas that are poorly drained, contain steep slopes or are excessively rocky should be avoided as they present conditions that could adversely affect the horse. Ideal sites are level and well drained, requiring little or no landscaping for fence and barn construction. However, even the best land and facilities can be ruined by poor management, particularly waste management. Large acreage and expensive barns do not guarantee a successful operation, but good management will. Probably the most famous horses in the world, the Lipizzaner Stallions of the Spanish Riding School of Vienna, are kept in a major city with no adverse effects because they are properly managed.

Generally, horse wastes are stockpiled before final disposal. Some suggestions for storage and disposal to reduce problems are listed below:

1) Keep manure away from wetlands, wells, water bodies and watercourses and avoid manure piles.

2) Manage areas should be easily accessible by human and farm equipment to facilitate proper removal.

3) Spread manure whenever possible as piles can breed diseases. The recommended application rate on pasture is 10 tons of manure per acre in the fall after the pasture season and before the ground freezes. Avoid spreading manure on pastures during the grazing season for internal parasite control.

4) Periodically cover manure with lime to reduce odor. Cover manure with plastic sheets or a roof to keep moisture out and minimize runoff.

5) As horse manure quickly breaks down to inoffensive organic material with some nutrients, people find it valuable for fertilizer. It also improves friability of soil. Placing an ad in your local paper for free manure could result in a quick disappearance of your manure pile. Some horse owners sell manure to neighbors, landscapers, or nurseries.

6) As flies breed where decaying organic material accumulates, manure piles should be removed and if possible spread thinly on fields to kill fly eggs and maggots by drying. In cases of heavy fly infestation, apply insecticides at 10 to 14 day intervals to reduce the fly population. Spray when larvae are first seen for better control. The latest pesticide information is available through your county Cooperative Extension Service.

7) In densely built-up areas it may be necessary to daily bag manure during the summer months and take it to a suitable disposal area. In other areas weekly removal of manure in pastures and paddocks is suggested.

8) Large operations should have a complete manure management system.

9) Avoid keeping horses on hills. Especially avoid slopes where manure might move downhill toward homes, watercourses or public rights-of-way.

Soil Erosion and Management Practices

Soil erosion caused by horses is directly related to the system of management used by the owner. At one extreme are management practices where horses are kept in the stall most of the time with appropriate exercise directed by a human. At the other extreme are horses who are continually kept outdoors. The more time a horse spends on the land, the more potential exists for overgrazing and destruction of the ground cover. When the ground is not stabilized by vegetative cover, soil particles can be easily moved by rain and wind. These soil particles may eventually find their way into

watercourses or wetlands and pollute these areas through siltation, which can kill fish, wildlife and flora and destroy a stream's ability to carry water and prevent floods. Many horses used for recreation spend most of their time in a stall with limited "turn out" time. This type of management helps to reduce ground cover destruction and is especially suitable in areas with limited acreage. With this management plan in mind, let us consider "turn out" areas as they relate to soil erosion. Turnout areas fall into two categories, paddocks and pastures. Paddocks are well fenced, rather small holding areas ranging in size from 1000 sq. ft. to 1/4 acre per horse. Paddocks are heavily used and due to their small size are usually bare of ground cover. Hence, it is important that paddocks be located in areas that are level and contain well-drained soils. In some locations it may be necessary to install diversion ditches, berms or curtain drains to divert water away from these exposed areas. In heavy rain, hay bales might be used as temporary silt screens to prevent paddock soil from entering adjacent streams or wetlands. Of all types of horsekeeping areas, paddocks are the areas which should be located furthest away from water bodies. Animal access to streams should be avoided or limited as horses will push soil into the watercourse when they go to drink. Bridges should be provided where horses must cross streams. Pastures are used to provide feed for the horse. if using improved pasture, 1 to 1-1/2 acres per horse should be provided, depending on the quality of the pasture. This area should be divided into thirds and the horse rotated to a new section every 3 weeks or when the grass has been grazed off. This system of rotational grazing helps prevent overgrazing and thus reduces soil erosion. Whichever system of horse management you prefer, carefully analyze its impact on the land and water. Choose a management plan that will not cause soil erosion and water pollution. If you are to be a good neighbor these practices are as important as how you feed and water your horse.

Other Management Suggestions

1) Keep animals off septic systems as they can punch through grass to expose seepage.

2) Exposed areas should be set back from toads, side yards and neighbors.

3) Screen paddocks and barns. Good landscaping creates a good impression. Buffer areas along property lines. Evergreens provide a year-round buffer that reduces noise, odor and dust.

4) Clear area of trees that horses might bite. They can girdle the tree by chewing off bark and the tree may eventually fall on the horse, house, or a neighbor. If horses gnaw the bark off trees check their diet for fiber deficiencies. If trees are desired in pastures or paddocks put fencing around the tree trunks to protect them from being girdled.

5) Fill or avoid low areas; puddles breed flies and attract rodents.

6) Clean up paddock area to reduce odors and parasites.

7) Horses require 50 to 60 sq. ft. of shade in warm weather. In some cases artificial shade such as an overhang or a three sided shed will have to be provided.

8) Remove any wild black cherry trees from keeping areas as they can be poisonous to horses.

Fences

It has been said that good fences make good neighbors. This is particularly true when one has animals. Connecticut state law requires that animals must be confined on the property of their owner or keeper and that fences must be maintained so as to properly enclose animals. Any damage caused by a wandering horse is the legal responsibility of the horse owner. Fences keep horses in and people and predators out. They also separate stallions and mares, restrict animal access to lush spring pastures or help in rotating animals on pastures. Fence costs have risen sharply: as a result many people put up poorly-made fences or postpone making needed repairs. Some owners don't pay attention to their fence until part of it is on the ground and the horse is consuming the neighbor's lawn and shrubs.

Fence Materials

Barbed wire should never be used to confine horses as it can cause severe injuries.

Wood, - plank, board, split rail, rail, etc. - is safest for horses. Wood fencing is "pensive to put up and maintain, but it is effective and attractive if properly cared for. A very common fence in Connecticut is the post and rail fence made with red

cedar posts and native hardwood rails. Railroad ties are also used as posts. Posts should not be more than 10 feet apart. Metal fences include woven wire, chain link, cable, barb-less wire and plain wire. One of the most common fences used for horses is woven wire with 4" openings usually installed at a height of 48". This type of fencing has a long life with reasonable initial cost and maintenance requirements that are less than wood. If you are introducing a horse to an area with wire fence, tie strips of ribbon or cloth every 4 feet on the top strand to help the horse see the wire so it will not run into the fence. If electric fencing is desired it is important to use only approved safe systems. Horses must be trained to avoid an electric fence as some animals don't naturally respect them. Electric fencing is often used in conjunction with some other type of fencing.

Shelter

In the Northeast rapid changes in weather demand that shelter be provided for animals.

Shelters do not have to be elaborate. In many cases existing structures can be converted into barns. A three-sided shed open to the south, well bedded and free from drafts and rain is in most cases the ideal shelter. Flooring in barns is important in keeping stalls dry and clean and preventing injury to horses. Brick, concrete, wood and asphalt are all used. A most satisfactory base for a stall is 8" - 12" of free-draining sand and gravel, set on a level, well-drained site. This base is then covered with 6" of fine sand, silt or clay found in sand washing tailings purchased from sand washing operations. This material compacts to a desired density, gives a good "cushion" and has enough vertical permeability to allow excess urine to drain off. In addition, this material is free from stones and is inexpensive. The one disadvantage is that the silt will have to be restored every two years or so, as cleaning gradually removes it. Many horsemen desire a hard aisle surface paved with asphalt, roughed concrete or paving brick. This makes for ease of cleaning and permanence. These surfaces, however, can be slippery to flat-shoed horses. It may therefore be desirable to cover hard aisle surfaces with rubber floor mats.

Enclosed stables must be properly ventilated and free from drafts. This-helps reduce odors and is necessary for the good health of the horse. Daily cleaning of stalls is the most important chore needed to keep neighbors and animals happy. Top-quality stable management calls for performance horses to be fed a grain ration three times a day, the stall thoroughly cleaned after the first feeding, and manure removed after each of the other two feedings. A good barn design with attractive fencing does much to make a horse acceptable in a suburban area. Build a barn, large enough to not only shelter animals, but to provide storage for bulky feeds and equipment as well. As a rule of thumb, devote 1/3 of your barn

space for animal shelter, 1/3 for roughage and bedding and 1/3 for alleyway and feed grain. Feed should be stored out of the reach of horses. Keep feed in rodent free containers. One rat will cat 27 pounds of feed a year. A 30 gallon metal trashcan will hold a 100 pound sack of feed and makes an excellent rodent-proof container. A cat can also help reduce rodent population. Don't build barns in wet, rocky or steep slope areas. Build in areas that are reasonably high and well drained yet level enough to easily place building and exercise areas. A site with a gentle south or southwest slope is ideal. Barns built in wet areas tend to attract rats as they prefer to live close to food, shelter and water. Use the soil survey of your area to help plan your animal operation and conservation measures. The Soil Conservation Service can assist you with conservation and site planning.

Land Requirements

One of the most common misconceptions regarding horses is the amount of land needed to keep them in a safe and healthy manner. Many zoning regulations have established land requirements for keeping horses that are excessive and arbitrary when compared to what livestock experts suggest. Some zoning regulations require 2, 3 or even 5 acres before a horse will be allowed. These requirements are much greater than the keeping area of 1,000 sq. ft. often cited by those familiar with horses. Most horses are kept in stalls, in fully enclosed barns or in three-sided sheds surrounded by a fenced exercise area. Stalls range in size from 8' x 8' for a pony to 16' x l6' for a stallion or 16' x 20' or larger for foaling mares. The average horse needs a 10' x 10' or 12' x 12' stall. Stalls should be able to safely accommodate the horse and its attendant. A minimum ceiling height of 8' should be provided for the horse while at least 12' is needed for a horse and rider. Many horses are fed a purchased feed of grain and hay and hence do not need large pastures for their basic supply of food. A paddock of 1,000 sq. ft. will serve most hobby or 4-H horse keeping operations. If competitive riding is planned, The National Horse Show Association recommends 110' x 220' for indoor horse show rings and 120' x 240' for outdoor rings.

Pastures

Fields can be used either as exercise areas or as pasture. The function of a pasture is to produce nutritious feed for the horse. Pastures are frequently overgrazed, reducing yields and encouraging weed growth. As horses move around the weed infested lot looking for edible plants, the sod is churned-up, further reducing grass growth. To avoid these conditions, feedlots and exercise areas should be separated from improved pastures. There are basically two types of pasture: permanent and improved cropland. Permanent pasture is land left unplowed or unseeded for many years and is

usually located on wet, rocky or steep sites. Cropland is tillable land that is more productive than permanent pastures when it is limed, fertilized and seeded. In most areas of Connecticut, lime is needed to correct soil acidity and fertilizer must be applied periodically. Before making these improvements to your pasture, obtain a soil test kit from your nearest Extension Service office.

How Much Pasture

As a general rule provide 1 acre of improved pasture per animal unit to provide grazing through the growing season in Connecticut. An animal unit equals 1 horse or cow or 5 to 7 sheep or goats. It must be emphasized, however, that a horse does not necessarily require I acre of land. This standard only applies when pasturing is used as a management system to provide feed.

Use Rotational Grazing

A system of alternate grazing produces more feed than continuous grazing on the same field. Divide the acre into thirds and rotate animal every 3 weeks or more frequently if grass is grazed off. Avoid grazing when soils are wet and soft as the soil becomes packed and poor pasture results. Grasses should reach 5 inches before grazing is begun. Cut at least once a season to control weeds. Cutting once in June and again in August results in even better weed control. Remove animals from pasture in late September to mid-October so a fall growth of 3" is achieved before winter. Whenever a horse is introduced to fresh green grass after long periods of stabling or confinement in paddocks, care should be taken to provide short initial grazing sessions to minimize the chances of the horse getting colic.

Riding Horses on Public Highways

As more people are using public highways to exercise their horse, it is important that they know the laws pertaining to this activity. According to Section 14-293a of the Connecticut General Statutes, any person riding a horse on a public highway shall conform to the regulations governing highway use, traffic control and highway safety. In municipalities with charters, laws can be established to regulate the driving or leading of animals through the streets and to provide for the removal of any offensive manure found in the streets. Connecticut has also passed a law protecting the horse and rider from motorists who frighten the animal by honking horns, speeding or other thoughtless behavior. Such drivers could be cited for a motor vehicle violation.

HELPFUL HINTS TO MAKE YOUR HORSE A GOOD "NEIGH" BOR

-Before you build a barn or fence, put in an electrical hookup, dig a well, etc., contact your local building inspector to see what permits are needed.

-Comply with local zoning laws and pertinent state statutes. See "State Regulations Pertaining To Keeping Animals And Farming" by C. James Gibbons, The University of Connecticut Cooperative Extension Service, 1984.

-Let your neighbors know what you intend to do. Talk over proposed plans for barns and fences and ask for their opinions when your operation might affect them or their property.

-Become involved in public policy issues related to farming and keeping animals. -Cruelty to animals is the quickest way to call attention to your place. Know proper horse management and have your veterinarian or certified animal scientist periodically visit your horse.

-Don't ride on other people's property without their permission.

-Remind other horse owners of potential problems. Constructive criticism, well taken, can help avoid larger problems later on.

-Know what you are getting into. Ask yourself if you can truly afford to keep animals and properly maintain the areas where they will be kept. Contact your Extension agent and ask for farm planning assistance.

Two-Stall Barn USDA 5838

Two 12' x 12' box stalls with clay floors, a 6' x 8' tack room, and an 8' x 12' feed room are. features of this 22, x 34' horse-barn. There is a useful covered way, and Dutch doors provide entry to the stalls. The barn may be expanded to house more horses.

Three-Stall 1 1/2 Story, Barn USDA 6024

This plan features three stalls, a feed room, a tack room and a 12' x 36' working alley. There is ample overhead storage for hay and bedding. The barn is 24' x 48'.

Litchfield Zoning Regulations

Section 14 Horses for Personal Use

Occupants of a dwelling in an RR-160, R-80, RHC-40, R-30H, R-20 and R-20H Zone only are permitted to keep horses for their personal use provided the following standards or conditions are met:

1. Ownership. The horses must be owned by the resident-occupants, and are not for pin, direct or indirect except that occasional and temporary boarding of horses not for pin, direct or indirect, is permissible.

2. Acreage and Intensity. There shall be two acres as the minimum size lot for the first horse being kept and an additional one-half acre for each additional horse.

3. Health. Stable manure must not create a health hazard from an air and water pollution standpoint to the community in general or the person inhabiting or using the surrounding acreage, and the stabling of horses shall conform to all regulations of all Local and State Health Authorities.

4. Safety. Adequate fencing must be installed and maintained to reasonably contain the horses within the property.

5. Set Back. All structures shall conform to the setback requirements for the zone in which located, except that a stable shall not be closer than fifty (50) feet from a dwelling on an adjacent lot.

6. Use of Buildings. The use of temporary buildings or trailers for the stabling of horses in excess of 15 days is prohibited.

7. Maintenance. The area should be landscaped so as to harmonize with the character of the neighborhood. The land shall be so maintained that it will not create a nuisance as determined by the Commission. The manure storage area shall

be so screened that it will not be unsightly. There shall be no storage of supplies outside of permanent buildings, except that the storage of wood chips used in the open is permissible, provided there is no conflict with Subsection 3 above.

8. A permit shall be issued by the Zoning Enforcement Officer, upon application, for the keeping of horses. The permit shall contain the owner's name, the number of horses to be kept, and the location and area of their quarters. The cost of such permit will be $1.00.

Plymouth Zoning Regulations

4.32 (L) KEEPING OF LIVESTOCK AS HOME AGRICULTURE USE ON LESS THAN FIVE ACRES.

(11/1/03)

1. General.

Keeping of livestock including horses, cattle, sheep, goats, swine, rabbits and poultry for home agriculture use on less than five (5) acres may be permitted by the Commission by special permit provided the following conditions. are met:

1.1 Ownership.

Keeping of livestock must be owned by the residents or owner of the premises on which they are kept.

1.2 Use.

The livestock shall be for the personal use of the residents or owners of the premises on which they are kept. Stabling of livestock other than those of the owner or resident of the lot is prohibited and no 4-H project shall be conducted simultaneously with a Home Agriculture use.

1.3 Land Requirements.

Livestock may be permitted on a lot of not less than two (2) acres and poultry on a lot of not less than one (1) acre and as long as they are kept in conformance with the "Table of Shelter and Keeping Area Requirements for Specific Livestock" and with the standards contained in the "Table of Type Bird, Bird Unit and Density" set forth -below. The required area for keeping animals should be level, well drained land free from major obstructions such as boulders and ledge outcroppings.

The "Keeping Area Requirement" shall be in addition to the "Shelter Area". Not more than five percent of the lot area may be used for the "Keeping of Livestock as Home Agricultural Use".

1.6 Special Permit.

No person or firm shall keep, stable, or maintain livestock on less than five (5) acres of land without first obtaining a special permit from the Planning and Zoning Commission.

(a) Application for the special permit shall be made in writing signed by the owner- of the land on which the livestock and/or poultry are to be kept and upon forms furnished by the Planning and Zoning Commission. Each application shall contain:

(i) A sketch map showing the boundary lines of the property;

(ii) Names and addresses of record owners of abutting properties and the name and address of the owner of the land on which the livestock is to be kept;

(iii) The areas designated for the keeping of the livestock and/or poultry;

(iv) The total number and type of livestock and/or poultry, to be kept;

(v)The location, type and size of shelters, keeping areas and fences;

(vi) The location and size of buildings on the lot including accessory facilities;

(vii) The location of existing and/or proposed on-site utility facilities including wells, septic tanks and leaching fields.

(b) The Planning and Zoning Commission, or its appointed agent, shall inspect or have inspected the premises before issuing a special permit to insure that the land is capable of housing livestock and/or poultry in accordance with the regulations contained herein.

(c) The Planning and Zoning Commission may refer the application for a permit to the Cooperative Extension Service for its technical review and advisory opinion and may limit the length of permit that will be issued.

1.7 Standards far Keeping Livestock and Poultry

(a) Confinement. Adequate fencing and structures shall be installed and maintained so as to confine all livestock and poultry within the premises or their owner. The area used to provide for exercise and grazing must be fenced in a manner safe to the animals and man and located so that the livestock will not cause damage to adjacent property and people.

(b) Health. The shelters and keeping areas for the livestock and/or poultry and the handling and disposal of solid and liquid waste(s) shall be maintained in such a manner so as to conform with all applicable local, state and federal health, air, water and noise pollution standards and regulations.

(c) Buffer Area. A buffer area of not less than five (5) feet, either in its natural state or landscaped shall be maintained between the property line and all fencing or- corrals for livestock.

(d) Setback. No portion of the fence used to confine livestock or poultry shall be less than five (5) feet from any property line or located within the front yard of the lot on which the livestock or poultry are kept. No shelters or structures used in conjunction with the keeping of livestock shall be erected or maintained within twenty-five (25) feet of any property line.

(e) Manure Pile. No manure pile shall be within twenty-five (25) feet of any property line. Manure piles shall be maintained so as to prevent run off to adjacent land or to water courses.

Portland Zoning Regulations

13.09. HORSES FOR PERSONAL USE/NON-COMMERCIAL STABLES:

Only occupants of a dwelling in an RR, R-25 or FP Zone may be permitted to keep horses for their personal use provided the following standards or conditions are met:

13.09.01. Ownership:

The horses must be owned by the resident-occupants and not for direct or indirect gain.

13.09.02. Acreage and Intensity:

There shall be one (1) acre as the minimum size lot for the first horse being kept and an additional one-half acre for each additional horse, but there shall not be more than three (3) horses.

13.09.03. Health:

Stable manure must not create a health hazard to the community in general or to the persons in the surrounding neighborhood from an air, drainage and water pollution standpoint.

13.09.04. Safety:

Adequate fencing must be installed and maintained to reasonably contain the horses within the property and shall conform to section 13.08.

13.09.05. Setback:

No building or other structure shall be located less than 100 feet from the street, side or rear lot lines.

13.09.06. Use of Buildings:

The use of temporary buildings or trailers for the stabling of horses in excess of fifteen (15) days is prohibited. There shall be no storage of supplies outside of permanent buildings.

13.09.07. Maintenance:

The area shall be landscaped to harmonize with the character of the neighborhood. The land shall be maintained to not create a nuisance as determined by the Commission. The manure storage area shall be screened and located so as not to be unsightly nor create offensive odors off the premises.

13.09.08. Lighting:

There shall be no external floodlighting that transmits outside of the property from where it originates and no light shall be permitted which is considered objectionable due to brightness or intensity.

13.10. COMMERCIAL STABLES:

Land, buildings, and other structures in an RR, R-25 or FP Zone shall only be used for the following after granting of a special permit by the Commission: commercial stables, riding academies, livery and boarding stables, animal and convalescent stables, rental and hacking stables, breeding stock farms, and private club riding stables. The following standards or conditions shall be met before a special permit is granted:

13.10.01. Acreage:

The barns, riding rings, corrals, and accessory facilities shall be contained within a parcel or contiguous parcels of land consisting of at least 10 (ten) acres.

13.10.02. Parking:

Sufficient off-street parking facilities shall be provided to accommodate all users and visitors to the property, including spectators, for horse shows or other equestrian events. The roads for entering and leaving the property shall be located or placed in such a manner so as not to create pedestrian or vehicular traffic hazards on public streets or highways. There

shall be a minimum of one (1) off-street parking space for each five (5) users of the facility or visitors to the property, including spectators for horse shows or similar events.

13.10.03. Health:

Stable manure shall not create a health hazard to the community in general or to the persons in the surrounding neighborhood from an air, drainage and water pollution standpoint. The stabling of horses shall conform to all State and local laws, regulations and codes. Sanitary facilities shall be provided for workers, patrons and visitors in accordance with State and Local health requirements for normal operations as well as for horse shows and similar activities.

13.10.04. Safety:

Adequate fencing shall be installed and maintained to reasonably contain the horses within the property and shall conform to Section 13.08.

13.10.05. Fire:

Fire control facilities and/or structures for the barns, buildings, and other amenities used for normal operations as well as for horse shows and similar activities shall be approved by the Town Fire Marshal.

13.10.06. Noise:

The use of Public Address Systems for the conduct of the instruction of riders, training of horses, and the spectator participation in competitions should be modulated and continuously controlled in order to avoid becoming a nuisance to surrounding property owners/residents.

13.10.07. Setback:

No part of any building, riding ring, corral, or manure storage area used for or in conjunction with the operation shall be located less than 100 feet from the street, side or rear lot lines.

13.10.08. Use of Buildings:

The use of temporary buildings or trailers for the stabling of horses in excess of fifteen (15) days is prohibited.

13.10.09. Maintenance:

The premises shall be landscaped to harmonize with the character of the neighborhood. The land shall be maintained so as not to create a nuisance. The manure storage area shall be screened and located so as not to be unsightly or create offensive odors off the premises.

13.10.10. Lighting:

There shall be no external floodlighting that transmits outside of the property from where it originates, and no light shall be permitted which is considered to be objectionable due to brightness or intensity.

3.9 Livestock

3.9.1 All livestock or poultry shall be kept in approved enclosures and shall not be allowed to roam at large.

3.9.2 No stable, pig pen, chicken house or other structure used for the housing of animals shall be located within fifty (50) feet of any pond, lake, river or watercourse.

3.9.3 No building for the housing of animals other than small domestic animals such as dogs or cats shall be located within 100 feet of any street line or the side boundary line of an adjoining lot.

3.9.4 No fenced yard for livestock shall be located closer than 100 feet of any street line or 100 feet of the side boundary line of an adjoining lot. A fenced yard for livestock is an enclosure or fenced area designed to contain or confine animals. Said yard or enclosure may be commonly referred to as a barnyard, paddock, pen, etc. and is not to be confused with a fenced pasture used for grazing or hay production.

3.9.5 No poultry house in Zones A or B shall house more than 100 birds, or have a floor area of more than 300 square feet; there shall not be more than one house to each residence to which it is appurtenant.

3.9.6 The density of horses on a lot shall not exceed 40,000 square feet of gross lot area per animal six months or older per horse.

3.9.7 No indoor riding arena shall be located closer than 50 feet of any street line or side boundary. The arena may only be used for the purpose of riding and may not be used for the housing of animals. Eff. 9/23/95

3.9.8 Manure shall be stored not less than 100 feet from street and property lines.

3.9.9 Manure shall be removed at intervals sufficiently frequent to maintain a sanitary, fly-free condition.

3.9.10 Manure drainage shall not run into a wetland or onto other property.

Salisbury Zoning Regulations

729 COMMERCIAL HORSE BOARDING OR RIDING STABLE

729.1 The purpose of this section is to permit the use of land, buildings and other structures for commercial horse-related activities that involve more than two horses. This shall include but not be limited to commercial horse boarding stables or riding schools.

729.2 STANDARDS:

a. Lot size. The barns, riding rings, corrals and accessory facilities shall be contained within a parcel of suitably drained land. The minimum lot size shall be 5 acres plus for each horse over two.

b. Parking and Circulation. Sufficient off street parking shall be provided to accommodate all users and visitors to the property.

The roads for entering and leaving the property shall be located with adequate sight lines.

For a commercial boarding stable a minimum of one parking space per animal boarding space shall be Provided.

For riding school or instructional programs the number of parking spaces shall be subject to the approval of the Commission depending upon the size of classes, age of students, scheduling of classes and the like.

c. HEALTH. The applicant shall present with the application a letter from the Health District commenting on the adequacy of plans for the storage and handling of manure or any other material with the potential to pose a risk to water quality and to groundwater, surface water and well locations on site and on adjacent properties. Locations for storage of manure shall be identified on the site plan. Manure storage shall be located a minimum of 100' from property lines and water bodies.

d. SAFETY. Adequate perimeter fencing shall be installed and maintained to reasonably contain horses.

e. FIRE. Fire control access and facilities shall be acceptable to the Fire Marshal.

f. NOISE AND LIGHTING. The applicant shall demonstrate that the type and location of all lighting fixtures and parking areas will not produce an arc of lighting or glare visible off the premises.

The applicant shall identify the projected decibel level for all projected activities and installations with a potential to generate a noise level which could be heard off premises including but not limited to a public address systems or similar voice projection system, rider instruction program, horse training program and spectator activity.

g. SET BACK. No part of a building associated with the use shall be less than 100 feet from the nearest line of any road, street or highway abutting the property or less than 100 feet from any side and rear boundary line. Riding rings and corrals shall not be within 75 feet of any off site residential use.

h. SPECIAL EVENTS, such as shows, exhibitions, and contests shall be permitted only where expressly requested and approved as part of the Special Permit. The Commission may establish conditions limiting such events where necessary to safeguard the neighborhood.

STORMWATER AND AQUATIC LIFE: MAKING THE CONNECTION BETWEEN IMPERVIOUS COVER AND AQUATIC LIFE IMPAIRMENTS FOR TMDL DEVELOPMENT IN CONNECTICUT STREAMS

Christopher Bellucci, State of Connecticut, Department of Environmental Protection, Bureau of Water Protection and Land Reuse, 79 Elm Street, Hartford, Connecticut 06106

ABSTRACT

Stormwater can be a significant source of stressors to aquatic stream biota in many urban areas. The *2006 List of Connecticut Waterbodies Not Meeting Water Quality Standards* has a total of 105 stream segments that do not meet aquatic life goals established in Connecticut's Water Quality Standards. At least 58% of these waterbodies have stressors related to urbanization as the suspected cause of the impairment (e.g. stormwater, habitat modifications, erosion, sedimentation etc.).

Modeling stormwater impacts can be challenging due to their episodic nature. In many instances, surrogate measures of stormwater impacts may provide useful benchmarks when data are unavailable to support more complex stormwater models. The State of Connecticut, Department of Environmental Protection (DEP), has developed an Impervious Cover (IC) model applicable in situations where the most probable cause of the aquatic life support impairment is stormwater. An IC target of 12% was established for developing Total Maximum Daily Loads (TMDLs) based on correlating the percent IC upstream of macroinvertebrate monitoring locations with a final assessment of passing or failing Connecticut's aquatic life standards. Connecticut DEP has used the IC Model to develop a TMDL for a small stream in Eastern Connecticut and has engaged stakeholders to focus stormwater management efforts to restore aquatic life in the brook.

KEYWORDS

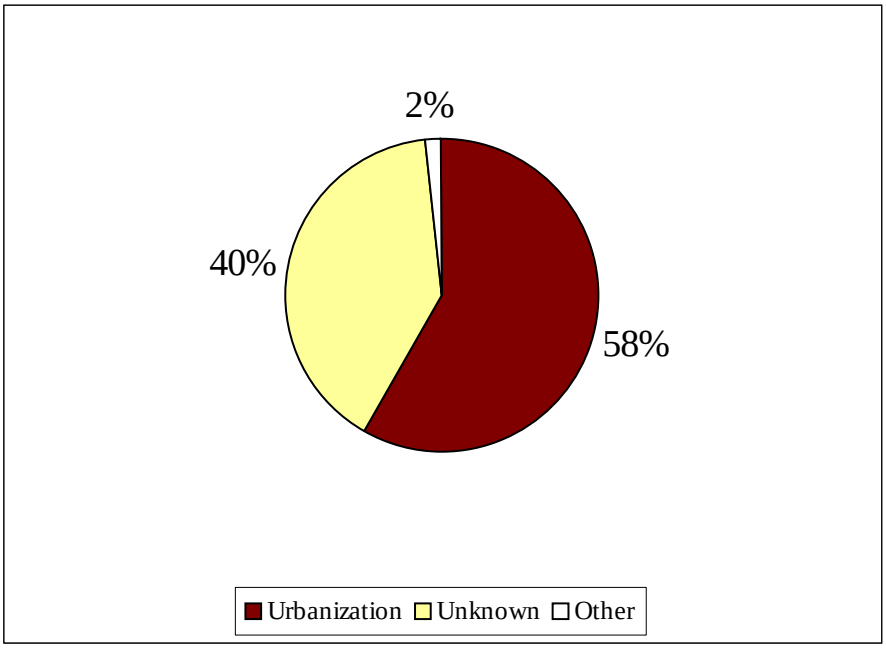
Aquatic Life, Impervious Cover, Multiple Stressor Syndrome, Stormwater, Urbanization, TMDL

INTRODUCTION

It is well documented that changes in land use impact the ecological characteristics of streams, including the distribution and abundance of biota (Allan, 2004; Arnold and Gibbons, 1996; Chadwick et al., 2006; Coles et al., 2004; Gergel et al., 2002; Schueler, 1994). In particular, measures of urban land use have negative impacts on biotic integrity (Bilkovic et al., 2006; Miltner et al., 2003; Morse et al., 2003; Ourso and Frenzel, 2003; Stanfield and Kilgour, 2006; Wang et al., 2001; Wang and Kanehl, 2003). In effect, urbanization and stormwater runoff result in "urban stream syndrome" (Meyer et al., 2005; Walsh et al., 2005) in many of our nations waterways. That is, as watersheds become more urbanized, stormwater runoff results in a flashier hydrograph, elevated concentrations of pollutants transported from impervious surfaces to streams, altered channel morphology, and reduced biotic integrity with a dominance of more tolerant species.

Stormwater runoff from urban land development with impervious surfaces is currently the largest contributor to the impairment of water quality in New England, as well as in many other parts of the country (ENSR 2006). In Connecticut, the *2006 List of Connecticut Waterbodies Not Meeting Water Quality Standards* (CTDEP, 2006a) has listed a total of 105 stream segments that do not meet aquatic life goals established in Connecticut's Water Quality Standards (CTDEP, 2002). At least 58% of these waterbodies have stressors related to urbanization (e.g. stormwater, habitat modifications, erosion, sedimentation) as the suspected cause of the impairment (Figure 1). Under Section 303 (d) of the Federal Clean Water Act, Connecticut is required to develop Total Maximum Daily Loads (TMDLs) for these 105 stream segments.

Figure 1 - Potential causes of the 105 stream segments listed in the 2006 List for not meeting Connecticut's aquatic life use support designated use.



Developing TMDLs for "urbanization" presents an enormous challenge for Connecticut because of the number of impairments and the complicated nature of urban stream syndrome. Simply stated, urban stream syndrome is generally a result of what I will call "multiple stressor syndrome," the fact that many complex and interactive impacts are associated with this phenomenon (Figure 2). These characteristics of "multiple stressor syndrome" make it difficult to identify which pollutant is the most suitable for TMDL analyses. Often, there is insufficient information that indicates any specific pollutant is causing or contributing to an exceedance of a particular water quality criterion. Rather, given the variability in types and concentrations of pollutants associated with storm water, and the range in magnitude of storm events, a surrogate approach that aggregates the effects of multiple stressor syndrome is perhaps a more appropriate measure of impact.

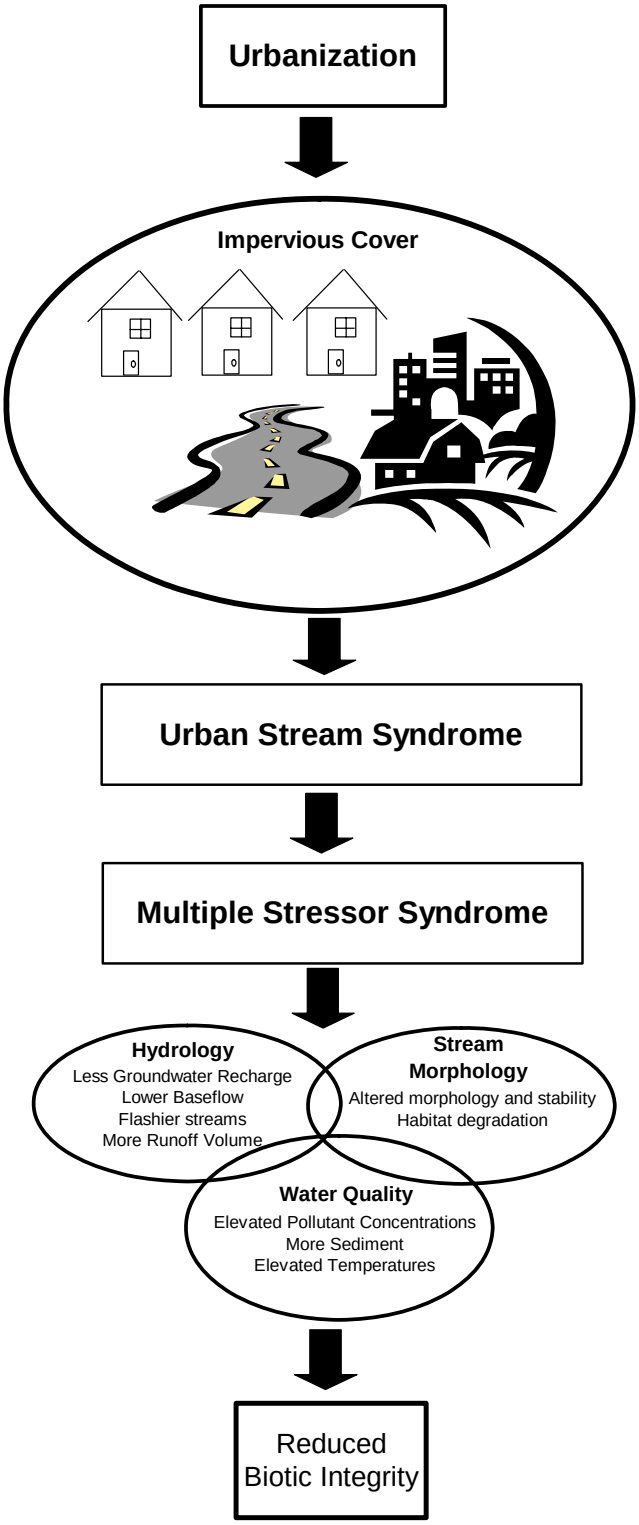
The Connecticut Department of Environmental Protection (CTDEP) has developed a TMDL approach for situations where aquatic life goals are not met and it has been identified that stormwater is the most probable cause of the impairment. The approach uses a surrogate measure, impervious land cover (IC), to develop TMDL targets, wasteload allocations, load allocations, and margin of safety using a percent reduction approach. IC in the watershed was chosen as a good surrogate measure of stormwater because it aggregates pollutant loads, storm water flows, and has a direct relationship with benthic macroinvertebrate assessments, the primary measure of aquatic life goals in Connecticut. A target of 12% IC in the contributing watershed was chosen based on an analysis of 125 stream monitoring locations and IC estimated using GIS. The 12% IC threshold represents a level of imperviousness in the upstream watershed that, if exceeded, is not likely to support a macroinvertebrate community that would meet aquatic life use goals established in Connecticut’s Water Quality Standards.

METHODOLOGY

Estimates of Impervious Cover

Estimates of the percent impervious cover of the total land cover (% IC) for 1985, 1990, 1995, and 2002 by basin were obtained from the Center for Land Use Education and Research at the University of Connecticut (E. Wilson, Personal Communication). The % IC values were derived from land cover data using an ArcView® Impervious Surface Analysis Tool (ISAT). ISAT multiplies IC coefficients by each land cover class to obtain an estimate of total impervious cover by area (such as a local drainage basin). These IC coefficients were developed using nine Connecticut towns that have accurately measured IC (Prisloe et al., 2002). Actual IC measurements from these nine towns were used to "truth" the computer interpretation of IC and provide more accurate IC coefficients for use statewide. Further information on ISAT can be found at http://nemo.uconn.edu/tools/impervious_surfaces/measure/isat.htm and http://www.csc.noaa.gov/crs/cwq/isat.html.

Figure 2 – Conceptual model of multiple stream syndrome which provides linkages between urbanization, impervious cover and biotic integrity. The term Urban Stream Syndrome was initially referenced in Meyer et al. (2005).



Applicable Streams

Monitoring locations (Figure 3, Appendix 1) included in this analysis represent benthic monitoring sites that were sampled by CTDEP as part of a rotating basin approach from 1996 to 2001 and more recently a group of sites selected based on a probabilistic sampling design (CTDEP, 1999). Sites were limited to only those in which Rapid Bioassessment Protocol (RBP III) level of effort were completed (Plafkin et al., 1989). In Connecticut, the RBP III level of effort consists of a two square meter kick net sample collected from erosional riffle habitat, 200 organism sub sample, and organism identification to the lowest taxon possible (generally species level).

The ISAT estimates of IC were estimated as the % IC of the total land cover upstream of the monitoring location. For monitoring locations in smaller streams (e.g. local basins), IC measurements were delineated to the upstream extent of the local basin boundary. Similarly, for monitoring locations contained in subregional basins, IC measurements were delineated to the upstream extent of the subregional basin boundary. Since the influence of IC is greater at smaller scales, the analysis was limited to monitoring locations with upstream drainage areas of < 50 square miles. Watersheds > 50 square miles were excluded because IC clusters located far upstream of the monitoring location may not affect the macroinvertebrates at the monitoring location.

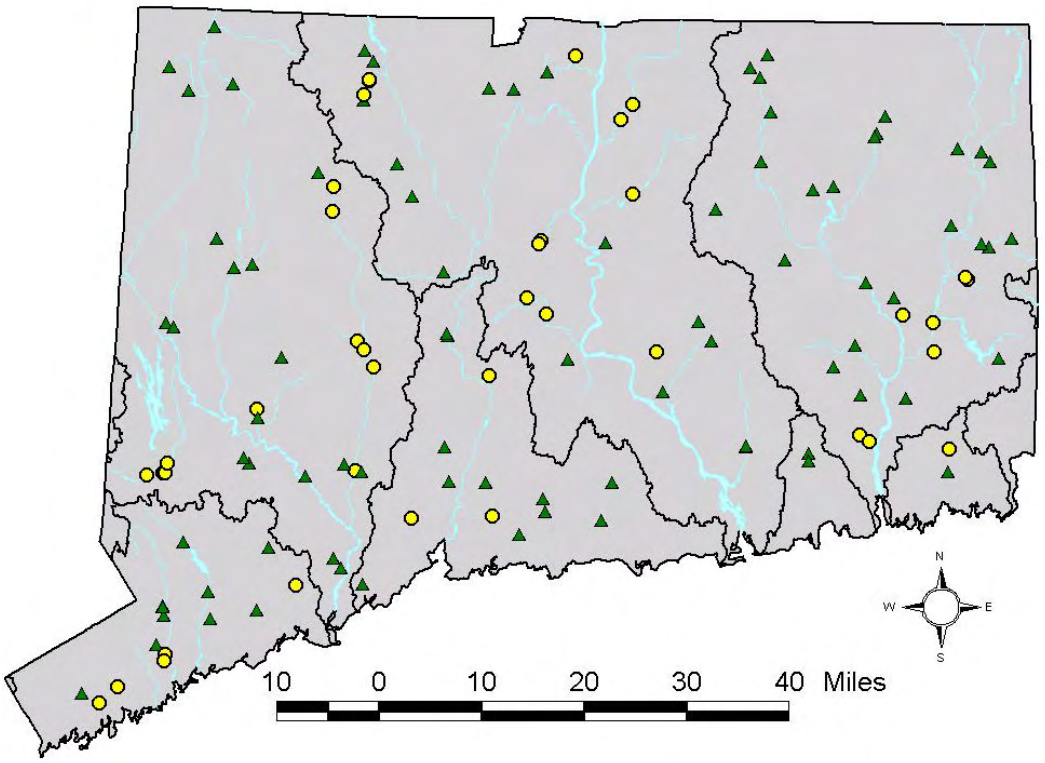
In addition to excluding monitoring locations with large watersheds upstream, monitoring locations within one mile downstream of a sewage treatment plant discharge were also excluded from the analysis. Also, monitoring sites on streams that have a portion of the upstream basin in states bordering Connecticut were excluded because IC estimates were not readily available for other states.

As a result of the qualifiers mentioned above, the Applicable Streams effectively are those with monitoring locations with RPB III level of effort on streams with < 50 square miles drainage upstream, beyond 1 mile of a sewage treatment plant discharge, and no portion of the drainage in another state. Care should be taken when making inferences to monitoring sites in streams that may exhibit different characteristics.

Linking Impervious Cover with Benthic Macroinvertebrates Data to Develop TMDL Targets

The % IC in the contributing watershed and benthic macroinvertebrates data from Applicable Streams were analyzed graphically using scatterplots and box and whisker plots to determine potential TMDL targets. Since IC estimates were available for four years - 1985, 1990, 1995, and 2002 – and the macroinvertebrate sampling years were variable, the IC dataset from the closest year preceding the monitoring date was used in all cases.

Figure 3 - Applicable streams: benthic monitoring sites considered for this analysis. Thick black lines show major drainage basin divides. Green triangles are sites that met Connecticut's aquatic life criteria (n=86) and yellow circles are sites that did not meet Connecticut's aquatic life criteria (n= 39).



The % IC was plotted against final benthic metric scores as a percent of the reference community. The final percent of reference score integrates seven metrics: taxa richness, modified Hilsenhoff Biotic Index, ratio of scraper and filtering collector functional feeding groups, ratio of EPT (taxa in the orders Ephemeroptera, Plecoptera, and Trichoptera) and Chironomidae abundance, percent contribution of dominant taxa, EPT index, and community loss (Plafkin et al., 1989).

Connecticut currently has a pass/fail methodology of assessing attainment of aquatic life use goals based primarily on the benthic macroinvertebrate community in a stream. Benthic macroinvertebrates integrate the effects of pollutants and other conditions over time, and therefore are felt to have the best and most direct measure of aquatic life use support goals. In general, monitoring locations that score >54% of reference community pass aquatic life standards, while those that score < 54% of reference community fail aquatic life standards. Other factors such as species composition and age class distribution of the fish community, evaluation of chemical criteria, and water diversions factor into aquatic life assessments for streams as decribed in Connecticut's Consolidated Assessment and Listing Methodology (CTDEP 2006b), but for the majority of cases, the macroinvertebrate scores are the primary measure of aquatic life

goals. Therefore, for this analysis, the pass/fail demarcation of 54% of reference condition was used as a measure to assess TMDL targets since aquatic life assessments in Connecticut are strongly influenced by this result.

RESULTS

A total of 125 sites met the criteria as outlined in Applicable Streams above and were considered in this analysis. The median drainage area upstream of these 125 sites was 14.8 square miles (range 5.3 - 46.4 square miles) and the percentage of impervious cover ranged from 2.3-28.0 % with a median value of 4.4% (Figure 4). Scatter plots from the Applicable Streams in Connecticut showed that taxa richness and EPT taxa generally decreased with increasing IC (Figure 5). As a group, EPT taxa can be characterized as sensitive taxa and often occur in decreased abundance in response to environmental stress (Lenat and Penrose, 1996).

Applicable Streams were further separated in two groups - 1) those that met Connecticut's aquatic life criteria as assessed using RBP III % of reference score and 2) those that did not meet Connecticut's aquatic life criteria. The general trend observed in these data was that the % IC was lower for streams that met Connecticut's aquatic life criteria than sites that did not meet Connecticut's aquatic life criteria, although there was some overlap in the upper quartile of the "meet" group with the lower quartile of the "do not meet" group (Figure 6).

Figure 7 demonstrates a "threshold" effect in that as the % IC in the contributing watershed increases to approximately 12%, no Applicable Streams met Connecticut's aquatic life criteria (i.e. >54% reference community).

Figure 4 -Box and whisker plot of upstream drainage area (left) and percent impervious cover (IC) in the upstream watershed(right) for 125 sites that were included as Applicable Streams in this study. The notched box shows the median and lower and upper quartiles. The dotted line extending from the quartile boxes shows the nearest observations within 1.5 interquartile ranges (IQR). Crosses indicate observations exceeding 1.5 IQRs and circles indicate observations exceeding 3.0 IQRs

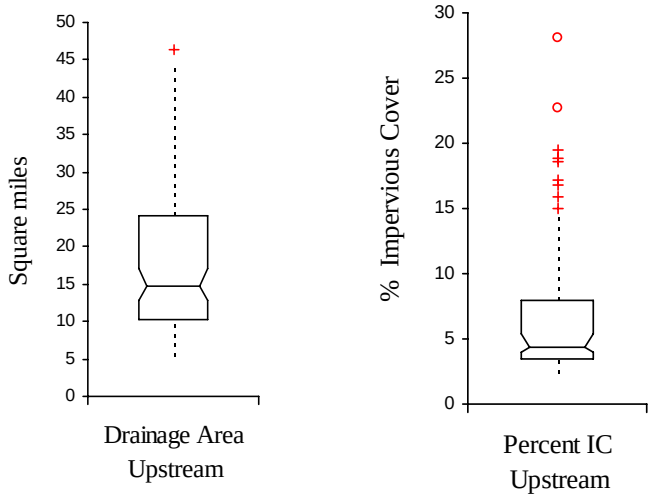


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Figure 5 – Scatter plots of taxa richness (upper) and EPT taxa (lower) and percent impervious cover upstream of macroinvertebrate monitoring locations from Applicable Streams in Connecticut.

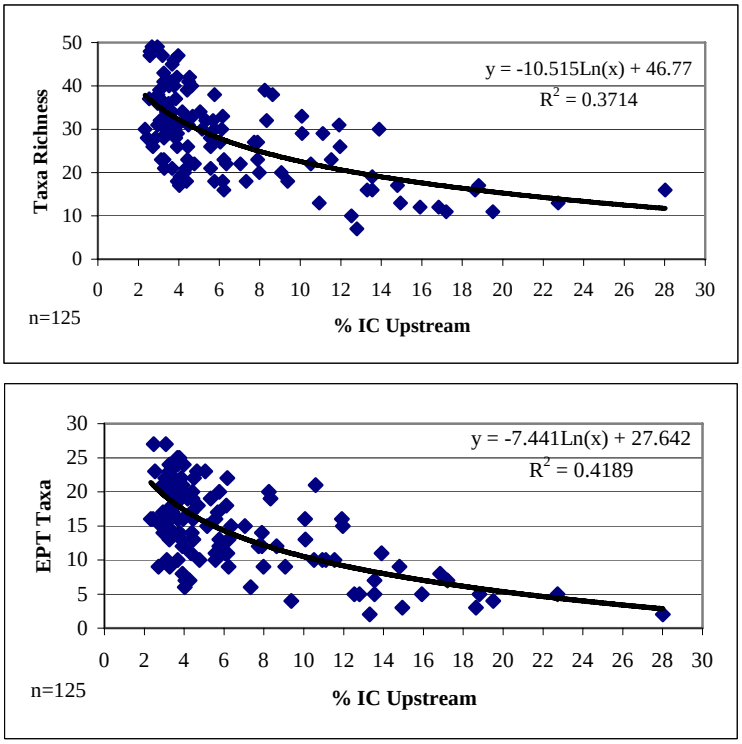


Figure 6. Box and whisker plot of sites that meet Connecticut's Water Quality Criteria (WQC) for aquatic life (n=86) and sites that do not meet Connecticut's aquatic life criteria (n=39). The notched box shows the median and lower and upper quartiles. The dotted line extending from the quartile boxes shows the nearest observations within 1.5 interquartile ranges (IQR). Crosses indicate observations exceeding 1.5 IQRs.

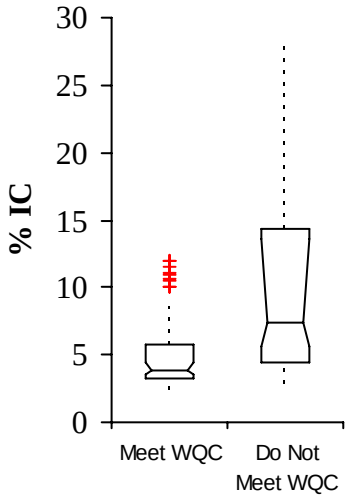
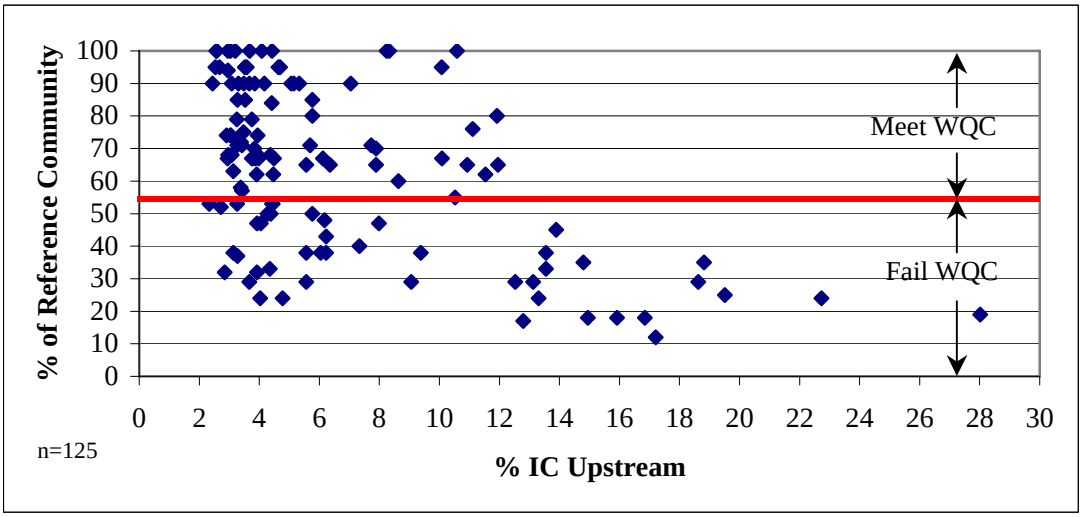


Figure 7. Scatter plot of percent impervious cover (IC) upstream of monitoring locations and % of reference macroinvertebrate community as assessed using Connecticut's Consolidated Assessment and Listing Methodology. Points that plot above the horizontal red line meet Connecticut's water quality criteria (WQC) to support aquatic life. Points that plot below the horizontal red line do not meet Connecticut's water quality criteria to support aquatic life.



Impervious Cover Target for TMDLs in Connecticut

Based on the results of this analysis, CTDEP believes that 12% IC is a reasonable TMDL target for aquatic life impairments in Applicable Streams where stormwater has been identified as the most probable cause of the impairment. It is recognized these correlations do not demonstrate causation, but given the known effects of urbanization and impervious cover on biotic integrity due to multiple stressor syndrome, this approach seems reasonable. The 12 % IC target value has been used as the surrogate TMDL target, and to further define a surrogate Wasteload Allocation (WLA) and Load Allocation (LA) target for stormwater caused aquatic life impairments in Connecticut.

DISCUSSION

This 12% IC target observed for Applicable Streams in Connecticut represents a level of imperviousness in the upstream watershed that, if exceeded, is not likely to support a macroinvertebrate community that would meet aquatic life use goals. The 12% IC threshold is within the range of % IC values causing impacts to aquatic life generally reported in the literature (Schueler, 1994; Center for Watershed Protection, 2003), and is within the range of % IC values from other New England States. For example, the State of Maine recently proposed IC targets that ranged from 6-15 % to support their tiered aquatic life use categories based on an analysis of macroinvertebrate and IC data (Maine Department of Environmental Protection, 2005).

CTDEP has developed a TMDL approach using the 12% IC target that is recommended for use in situations where there is a clear linkage between measured aquatic life impacts and stormwater discharging from areas dominated by IC (e.g. urbanized areas). Protocols such as EPA's Stressor Identification Guidance (US EPA 2000) can provide support to establish linkages between aquatic life in streams and stormwater. The IC target has been used to develop a TMDL using IC as a surrogate for stormwater impacts to a small brook in eastern Connecticut (CTDEP 2007). This TMDL is available for review at the Department's website http://www.ct.gov/dep.

This approach to stormwater TMDLs has several benefits. First, the IC TMDL was a useful tool to describe the connection between urbanization, impervious cover, stormwater, and biotic integrity to stakeholders during the public participation process of TMDL development. The concepts were well understood by stakeholders and provided a link between stormwater impacts and poor aquatic life in their local waterbody. In this sense, the TMDL provides a template to educate local decision makers and can assist local officials to obtain funding to reduce stormwater impacts among strongly competitive local budgets. Second, using a quantifiable surrogate measure such as impervious cover allows for calculations of TMDLs anywhere in the state, since IC data are already available statewide (and can be updated when land cover data are updated). This allows for TMDL calculation in any situation where stormwater and its complex and interactive impacts cause degradation to aquatic life in Connecticut's streams (i.e. urban stream syndrome caused by multiple stressor syndrome). Third, many more TMDLs for "urbanization" will be required in the future since there are 105 stream segments on the *2006 Connecticut List of Waterbodies Not Meeting Water Quality Standards*, of which at least 58 % have potential causes linked to urbanization. This methodology provides a template for those TMDLs.

Given the concept is easily understood by the public, statewide availability of IC data, and number of potential TMDL's for stormwater related impacts to aquatic life in Connecticut, a streamlined approach such as the one described here will advance the process to the TMDL implementation phase sooner than would happen if each stream required more complex stormwater modeling. For example, in a pilot study using the IC TMDL methodology (CTDEP 2007), stakeholder involvement with implementation of stormwater controls has been initiated even prior to formal approval of the TMDL. Thus using this surrogate approach for a complex issue such as characterizing stormwater impairments will bring us closer to the ultimate goal - achievement of water quality standards.

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APPENDIX 1. Benthic monitoring sites selected for analysis (Applicable Streams).

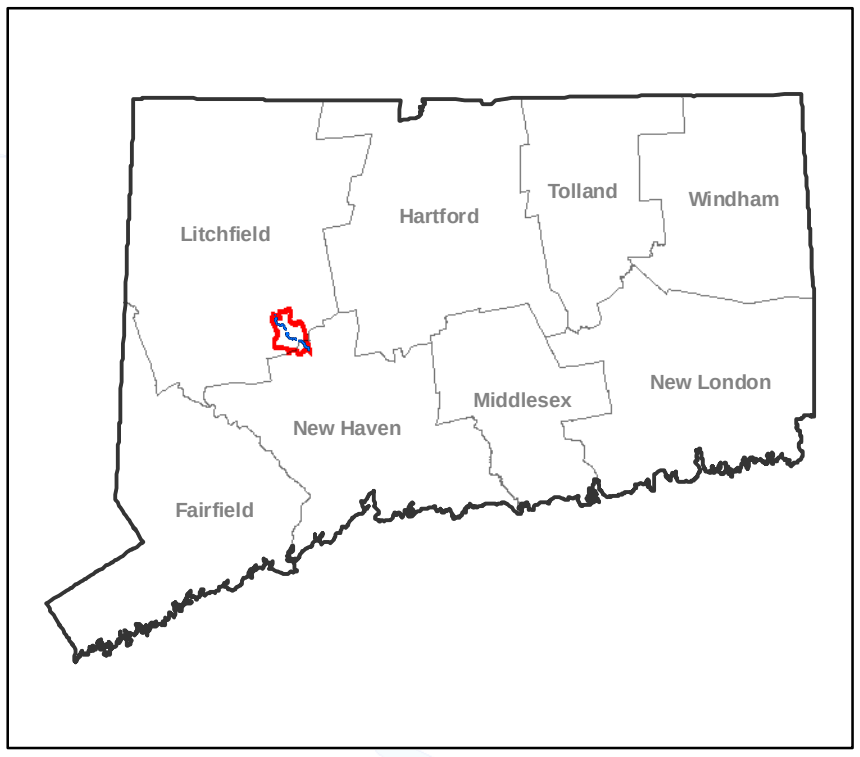
Sample Date	Stream Name	Drainage Area Upstream (square miles)	Percent IC upstream of site	Percent of Reference [1]
10/17/2002	Ekonk Brook	5.3	2.9	67
10/28/1998	Pocotopaug Creek	5.4	3.7	29
10/13/1998	Stony Brook	5.7	2.7	52
11/2/2000	Hewitt Brook (Poquetanuck Brook)	5.8	3.4	72
10/30/2002	Lake Waramaug Brook	5.8	3.3	90
10/15/2002	Latimer Brook	5.9	3.8	67
11/13/1997	Pequonnock River	5.9	8.6	60
10/20/1998	Burlington Brook	5.9	4.5	62
10/26/1999	Tenmile River	6.0	3.5	95
10/6/1999	Myron Kinney Brook	6.1	2.3	53
10/19/2000	Seth Williams Brook	6.2	4.3	50
10/16/2000	Farm River	6.3	4.1	47
10/9/2002	Pond Meadow Brook	6.4	3.5	85
11/5/1996	Naugatuck River	6.7	7.3	40
11/5/1997	Norwalk River	6.8	7.9	65
10/29/1997	Norwalk River	6.8	7.9	70
10/3/2002	Norwalk River	6.8	8.0	47
10/4/2000	Transylvania Brook	6.9	4.3	33
10/23/1997	West River	7.2	3.0	94
10/21/1997	West River	7.2	3.0	100
10/17/2000	Sympaug Brook	7.2	13.1	29
10/2/1997	Salmon Creek	7.4	3.6	95
11/9/1999	Factory Brook	7.5	3.9	67
10/14/1997	Mill River	7.7	8.2	100
10/17/1997	Branford River	8.3	5.7	71
11/13/1997	Mill River	8.4	7.0	90
10/24/2000	Still River	8.5	9.4	38
10/23/1998	Salmon Brook	8.8	10.1	67
10/6/2000	Willow Brook	9.2	18.6	29
11/3/2000	Oxoboxo Brook	10.2	5.6	29
11/2/2000	Oxoboxo Brook	10.2	5.6	38
11/2/2000	Trading Cove Brook	10.2	4.6	95
10/22/1999	Whetstone Brook	10.3	3.4	58
10/20/2000	Gardner Brook	10.5	3.4	71
10/20/1998	Nepaug River	10.7	3.7	90
10/16/2000	Bladdens River	10.7	6.2	48
10/31/1996	Bladdens River	10.7	6.2	105

[1] Percent of Reference is calculated as described in Plafkin et al., (1989). In general, sites > 54 % of reference community meet Connecticut's narrative aquatic life use in wadeable streams, although others factors are involved in the assessment.

Sample Date	Stream Name	Drainage Area Upstream (square miles)	Percent IC upstream of site	Percent of Reference
10/13/1999	Middle River	10.9	4.4	68
10/10/2000	Noroton River	11.0	19.5	25
10/13/1998	Muddy Brook	11.1	4.0	24
10/25/1999	Mill Brook	11.2	3.9	32
10/27/1998	Jeremy River	11.4	4.0	67
10/13/1999	Furnace Brook	11.6	3.3	53
10/4/2000	Shepaug River	11.8	2.4	90
10/6/1999	Pachaug River	11.9	3.3	37
10/3/2000	Middle River	12.0	4.4	53
11/4/1997	Harbor Brook	12.1	18.8	35
10/28/1998	Pine Brook	12.3	3.8	67
10/31/2000	Latimer Brook	12.4	4.2	90
10/24/2002	Whitford Brook	12.5	4.1	100
10/25/1999	Quanduck Brook	12.9	3.0	68
10/7/1999	Merrick Brook	13.0	3.0	74
10/17/2003	Eightmile River	13.1	10.6	100
10/12/1999	Eightmile River	13.1	10.1	95
10/14/1999	Willimantic River	13.5	3.8	79
10/20/1997	Mianus River	13.6	10.5	55
11/9/2000	Silvermine River	13.8	10.9	65
10/19/1999	Bungee Brook	14.2	2.9	74
10/21/1998	Still River	14.5	6.2	43
10/5/2000	Still River	14.5	6.2	38
11/14/1996	Farmill River	14.7	12.0	65
10/14/2003	Saugatuck River	14.8	4.4	100
10/6/1998	Trout Brook	15.1	22.7	24
11/7/1996	Farmill River	15.1	11.9	80
10/6/1999	Broad Brook	15.2	2.9	32
10/29/1998	East Branch Eightmile River	15.3	3.3	71
10/20/2000	Susquetonscut Brook	15.3	3.5	90
11/1/1996	Little River	15.5	5.1	90
10/22/1998	Broad Brook	15.8	4.8	24
10/28/1999	Moosup River	15.8	4.4	84
10/19/1999	Still River	16.0	3.0	74
10/6/1998	Piper Brook	16.3	28.0	19
10/12/2000	Steele Brook	17.0	13.5	38
10/12/2000	Steele Brook	17.0	13.5	33
10/1/1998	Coppermine Brook	17.4	11.5	62
11/7/1996	Eightmile Brook	17.4	4.5	105
11/6/1996	Hollenbeck River	17.6	2.5	105
10/14/1997	Mill River	18.4	8.3	100
11/13/1996	East Aspetuck River	18.7	4.7	95
11/4/1998	Pootatuck River	18.9	5.3	90

Sample Date	Stream Name	Drainage Area Upstream (square miles)	Percent IC upstream of site	Percent of Reference
10/10/2000	Rippowam River	19.1	17.2	12
10/16/1997	Muddy River	19.3	7.7	71
10/30/1996	West Aspetuck River	19.6	3.3	85
11/6/1997	Wepawaug River	19.9	11.1	76
11/4/1998	Pootatuck River	20.8	5.8	80
11/4/1998	Pootatuck River	20.8	5.8	85
11/13/1996	Nonewaug River	21.3	3.8	90
10/2/2003	Roaring Brook	22.0	3.0	100
11/19/1997	Aspetuck River	23.1	5.1	90
10/22/1999	Blackwell Brook	23.4	3.3	79
10/27/1998	Blackledge River	23.8	4.5	67
10/8/2002	Sandy Brook	24.2	2.6	100
11/14/1996	Mad River	24.3	15.9	18
10/29/1998	Eightmile River	24.4	2.7	95
10/30/1997	Norwalk River	25.2	14.8	35
10/19/1999	Bigelow Brook	25.2	2.5	95
10/24/2000	Still River	26.3	12.5	29
10/21/1997	Hammonasset River	26.4	3.7	106
10/19/1998	West Branch Salmon Brook	26.6	3.1	90
11/12/2003	Sandy Brook	26.8	2.6	100
11/6/1996	Blackberry River	26.9	3.5	75
10/14/1999	Fenton River	27.3	3.9	68
10/21/1998	Mad River	27.6	3.4	57
10/10/2000	Pequonnock River	27.9	16.8	18
10/26/1999	Mount Hope River	28.1	3.1	68
10/2/1998	Coginchaug River	28.3	6.1	67
10/22/2002	Mashamoquet Brook	28.5	3.2	100
11/5/1996	West Branch Naugatuck River	28.8	3.8	70
11/1/1999	Skungamaug River	30.7	3.9	74
10/17/1997	West River	31.7	14.9	18
10/22/1998	Scantic River	32.0	6.0	38
10/19/1998	Salmon Brook	34.5	3.9	62
11/19/1997	Saugatuck River	34.7	5.6	65
10/7/1999	Little River	36.7	3.1	63
10/16/1996	Mattabesset River	36.9	13.3	24
10/28/1999	Fivemile River	38.2	4.4	53
10/9/1997	Bantam River	38.7	3.7	100
10/24/2000	Still River	39.5	12.8	17
10/26/1998	Hockanum River	41.7	9.1	29
10/5/2000	Still River	41.7	4.4	50
11/1/2000	Little River	41.9	3.1	38
11/5/1996	East Branch Naugatuck River	43.8	5.8	50
10/29/1997	Norwalk River	46.4	13.9	45

STEELE BROOK WATERSHED BASED PLANNING PROJECT
HYDROGRAPHY AND ROADS



SMITH POND
Merriman Pond
Smith Pond Brook
Steele Brook
HEMINWAY POND
Steele Brook
Echo Lake Brook
Watertown
Echo Lake
Turkey Brook
Sylvan Lake
Steele Brook
PIN SHOP POND
LAKE WINNEMAUG
Morehouse Pond
Wattles Brook
Steele Brook
Waterbury
Clough Brook

6
63
6
262
6
262
63
855
73
63
73

Roads

Road Type

- Major Roads
- Secondary Roads
- Local Roads

Streams

- Steele Brook
- All Other Streams

Towns

- Towns

N

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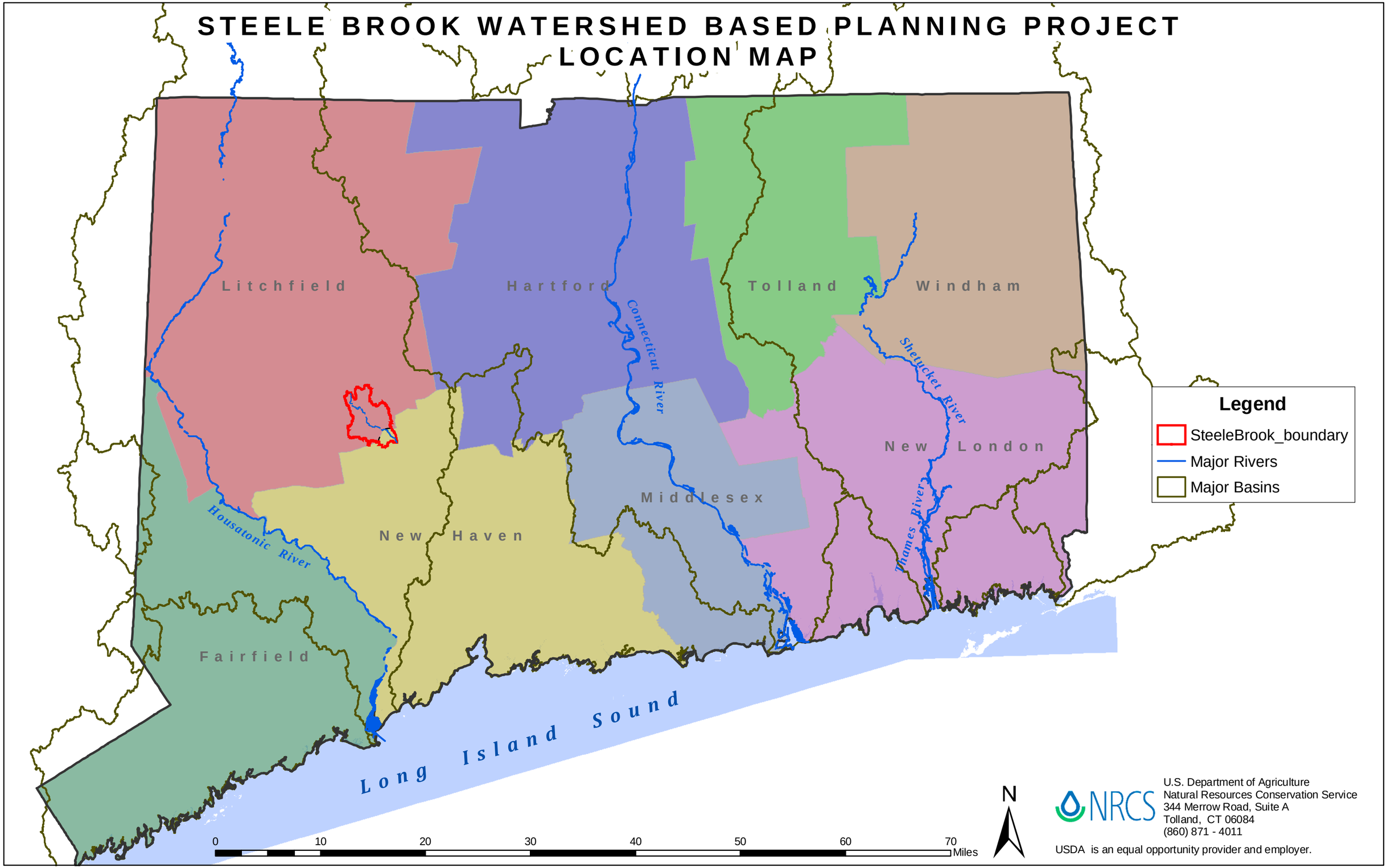
0 1 2 3 Miles

STEELE BROOK WATERSHED BASED PLANNING PROJECT
LOCATION MAP



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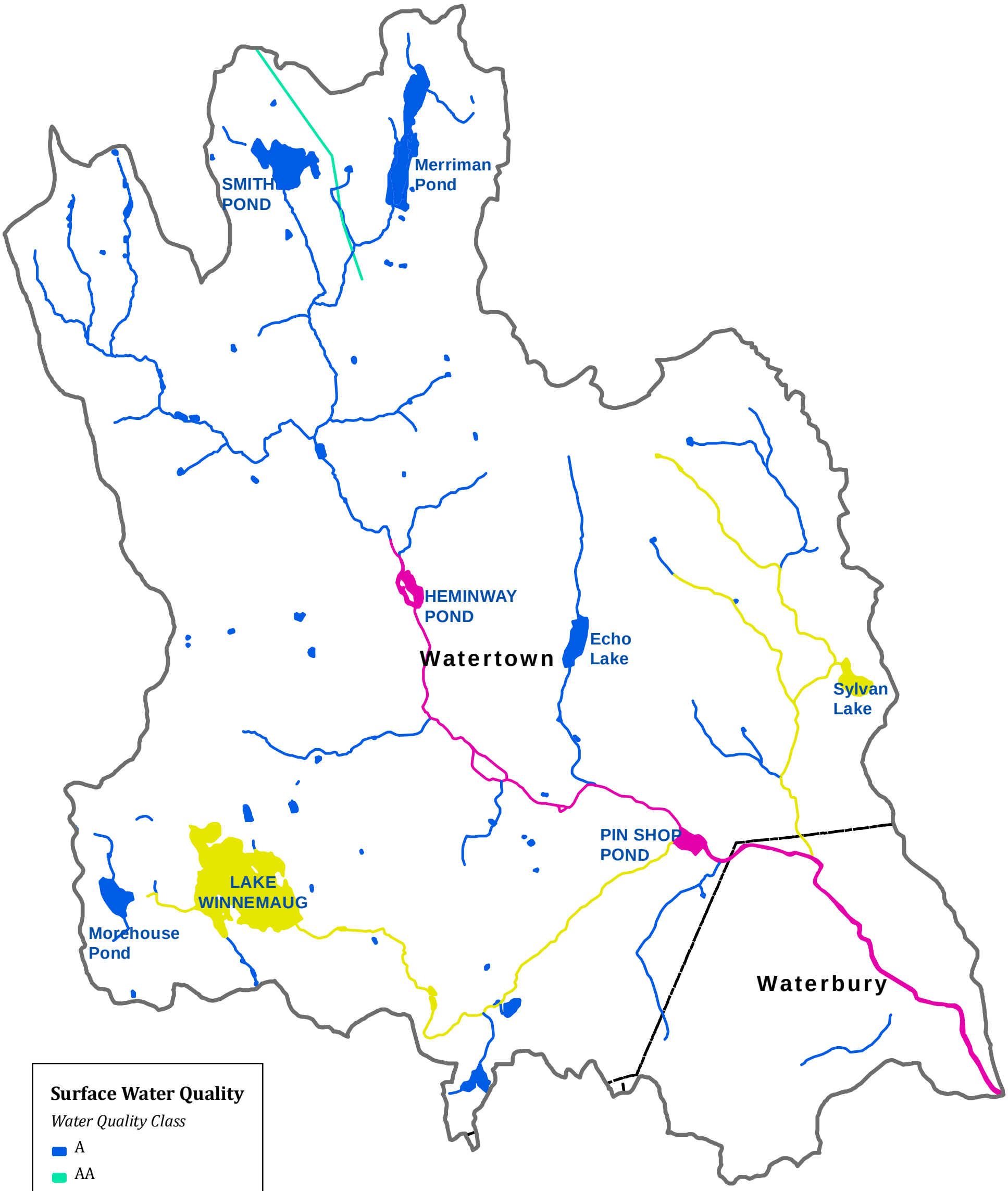
STEELE BROOK WATERSHED BASED PLANNING PROJECT
SURFACE WATER QUALITY



Surface Water Quality

Water Quality Class

- A
- AA
- B
- B,C,D to A
- C,D to B

Towns

- Boundary

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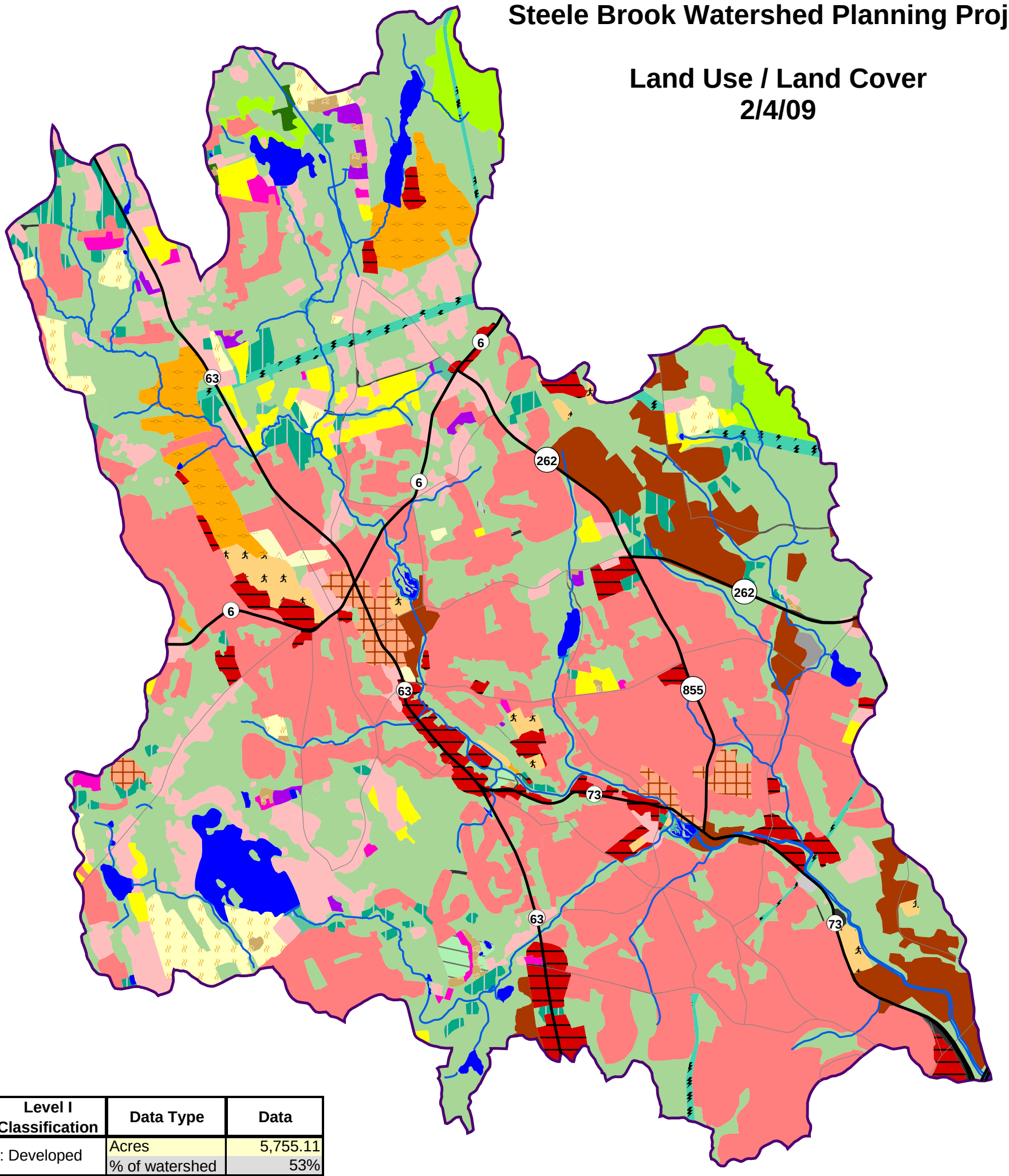
Originator:
State of Connecticut, Department of Environmental Protection
(data compiler, editor and publisher)
Publication_Date: 1999

N

0 0.5 1 1.5 2 2.5 3 Miles

Steele Brook Watershed Planning Project

Land Use / Land Cover
2/4/09



Level I Classification	Data Type	Data
d: Developed	Acres	5,755.11
	% of watershed	53%
f: Forest	Acres	3,978.00
	% of watershed	36%
a: Agriculture	Acres	568.11
	% of watershed	5%
w: Water	Acres	237.08
	% of watershed	2%
t: Transitional	Acres	211.96
	% of watershed	2%
o: Other	Acres	140.04
	% of watershed	1%
b: Barren	Acres	13.87
	% of watershed	0%
Total Acres		10,904.17

Land Use / Land Cover

Label

- ac: agriculture-cultivated
- an: agriculture-noncultivated
- ag: agriculture-pasture grazed
- ap: agriculture-pasture idle
- af: agriculture-farmstead
- au: agriculture-nursery
- barren: mined/quarry
- br: barren-rock
- bb: barren-beach
- dr:l developed-low density residential
- drh: developed-high density residential
- dc: developed-commercial
- di: developed-industrial
- dm: developed-mixed
- dob: developed-other: ballfields
- doc: develped-other: cemeteries
- dog: developed-other: golf course
- dok: developed-other: compacted grass
- dt: developed-transportation
- fd: forest-deciduous
- fc: forest-coniferous
- fm: forest-mixed
- oh: other-herbaceous
- os:other-shrub
- osu:other-utility right of way
- tm: transitional-mixed
- wl/ws: water-lake or stream

Streams

- Streams

Roads

- Secondary Roads
- Numbered Roads

N

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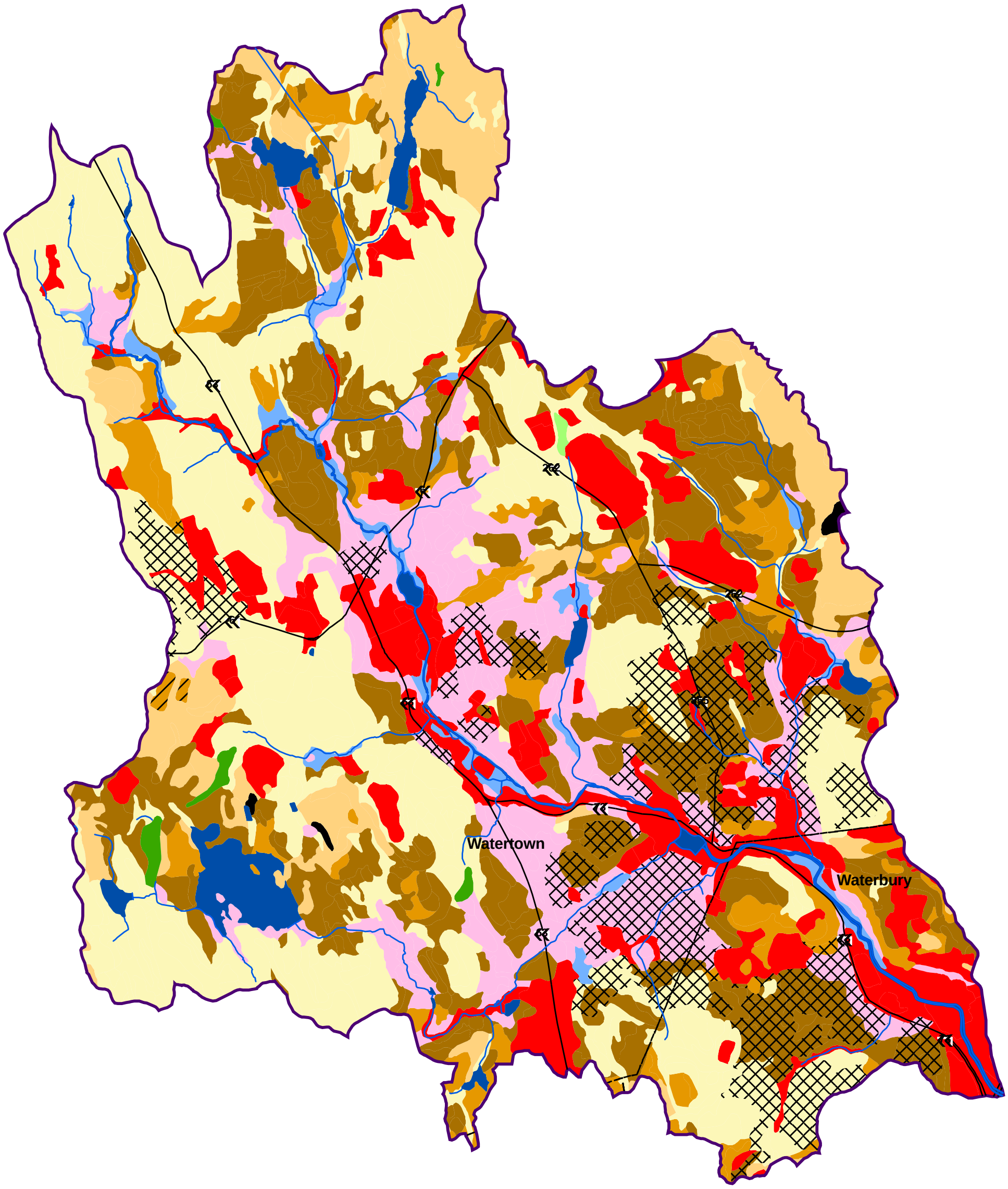
0 0.2 0.4 0.6 1.2 1.8 2.4 3 Miles

PARENT MATERIAL

STEELE BROOK WATERSHED PLANNING PROJECT
2/26/2009



Parent Material

Glacial Deposits
- Glaciofluvial

Organic
- Deep Organic (inland)
- Shallow Organic (inland)

Till
- Ablation Till
- Ablation Till - Moderate to Bedrock
- Ablation Till - Shallow to Bedrock
- Basal Till

Urban Influenced
- Urban Land Use
- Glaciofluvial
- Ablation Till
- Ablation Till - Moderate to Bedrock
- Moderate to Bedrock
- Basil Till

Other
- Shallow to Bedrock
- Alluvial Floodplain
- Water

Roads
- Numbered Roads

Steele Brook Hydrography
- Steele Brook
- Other Streams

Towns
- Boundary

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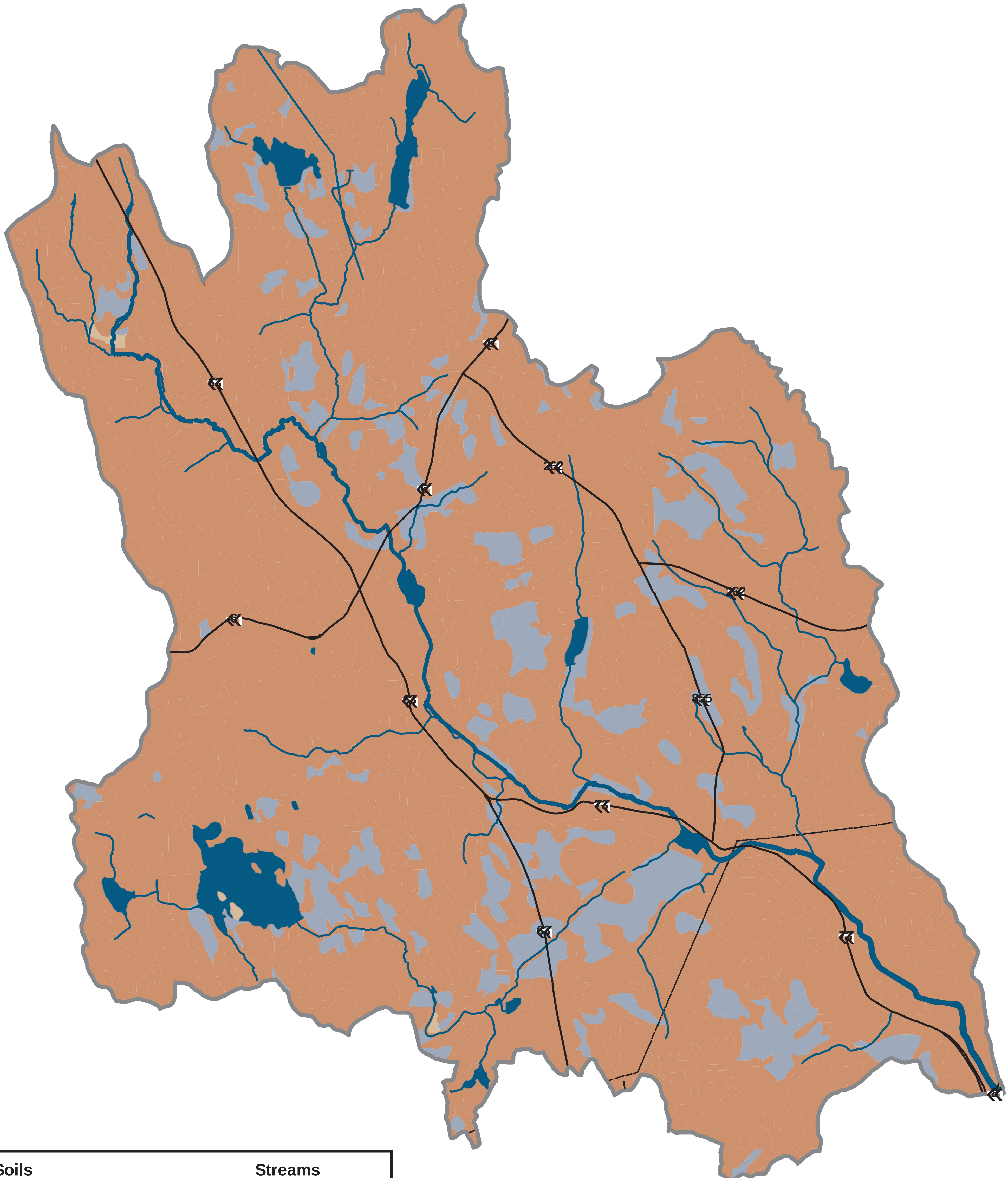
0 0.25 0.5 1 1.5 2 Miles

STORMWATER RUNOFF MANAGEMENT:
SOIL SUITABILITY FOR STORM WATER INFILTRATION SYSTEMS

Steele Brook Watershed Planning Project
2/20/2009

DRAFT



Soils

Infiltration Systems Interpretation

- **Most suitable**
- **Somewhat suitable**
- **Least suitable**
- **Water**

Streams

- **Other Streams**
- **Steele Brook**

Roads

- **Major Roads**

Towns

- **Boundary**

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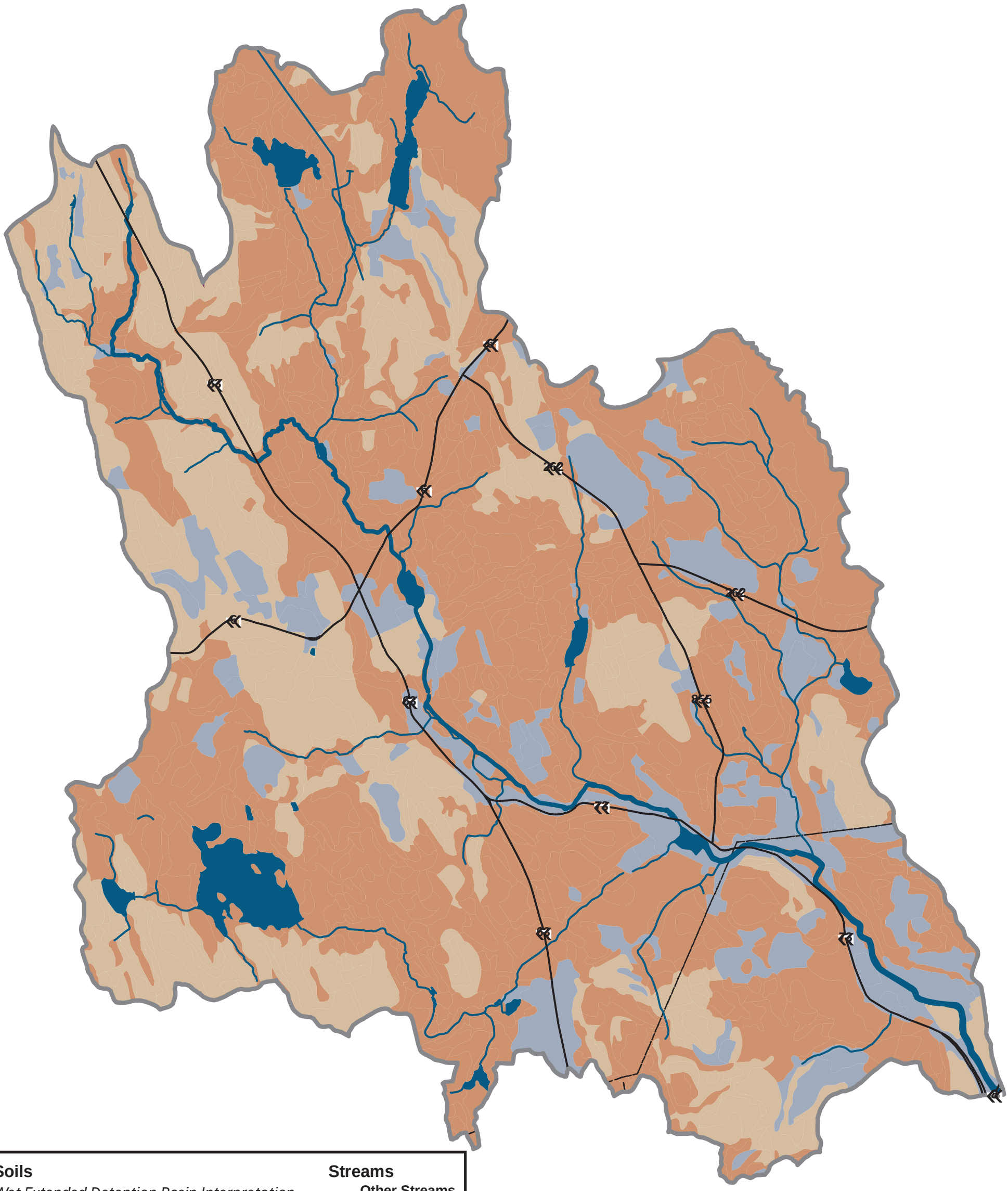
0 0.25 0.5 1 1.5 2 Miles

STORMWATER RUNOFF MANAGEMENT:
SOIL SUITABILITY FOR WET EXTENDED DETENTION BASINS

Steele Brook Watershed Planning Project
3/9/2009

DRAFT



Soils

Wet Extended Detention Basin Interpretation

- Most suitable
- Somewhat suitable
- Least suitable
- water

Streams

- Other Streams
- Steele Brook

Roads

- Major Roads

Towns

- Boundary

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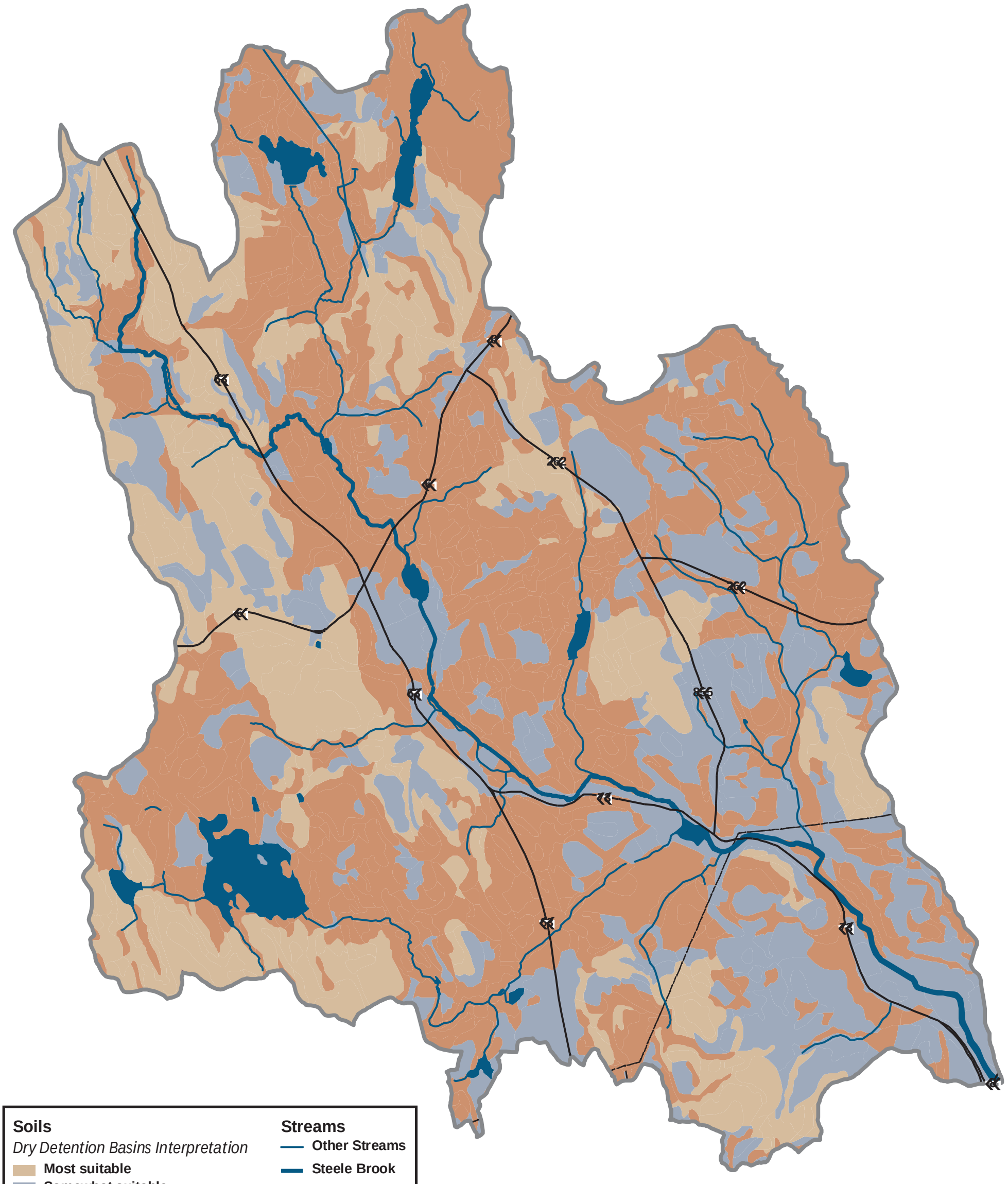
0 0.25 0.5 1 1.5 2 Miles

STORMWATER RUNOFF MANAGEMENT:
SOIL SUITABILITY FOR DRY DETENTION BASINS

Steele Brook Watershed Planning Project
2/20/2009

DRAFT



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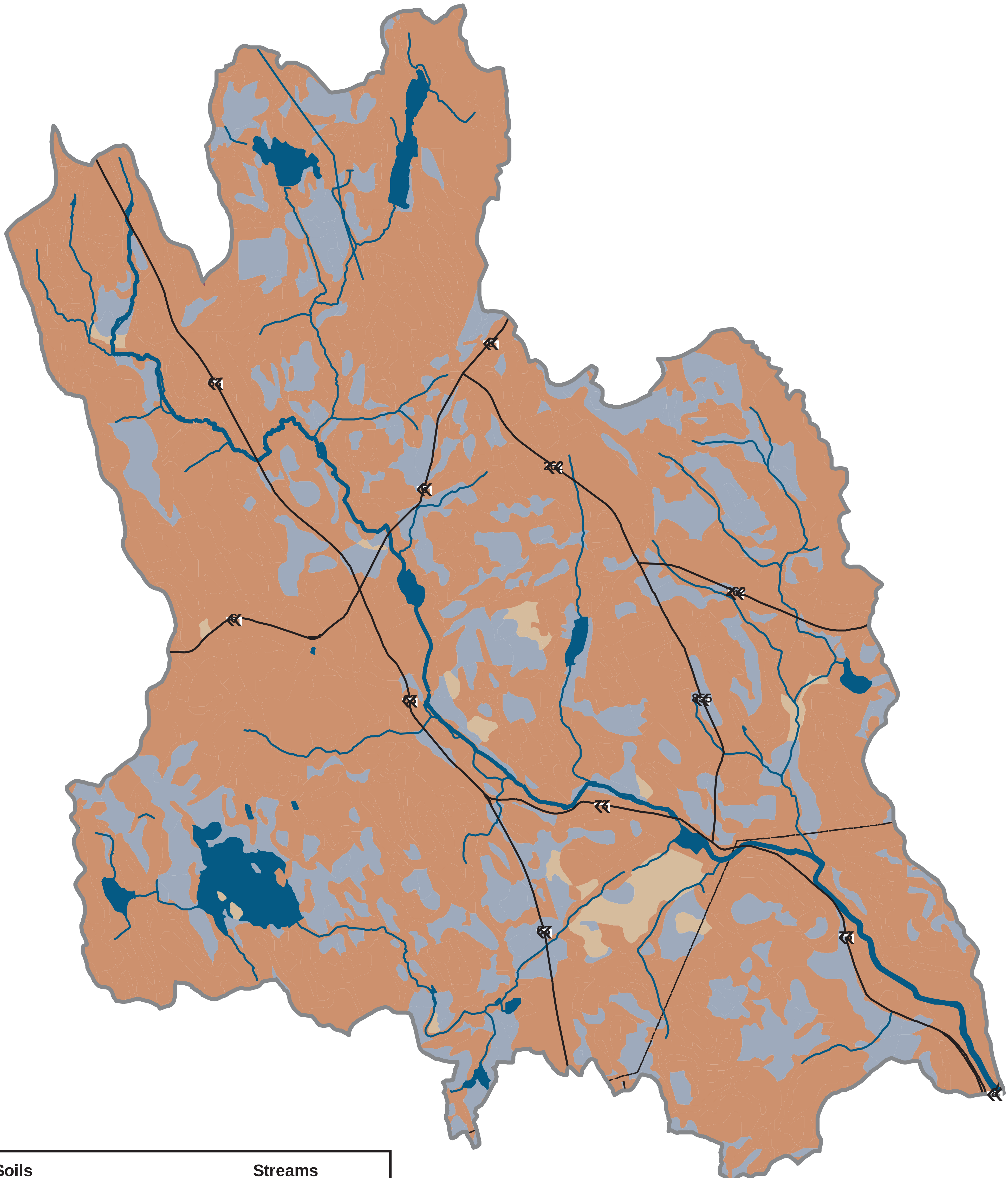
STORMWATER RUNOFF MANAGEMENT:
SOIL SUITABILITY FOR PERVIOUS PAVEMENT

Steele Brook Watershed Planning Project
2/20/2009

DRAFT



Soils

Pervious Pavement Interpretation

- **Most suitable**
- **Somewhat suitable**
- **Least suitable**
- **Water**

Streams

- **Other Streams**
- **Steele Brook**

Roads

- **Major Roads**

Towns

- **Boundary**

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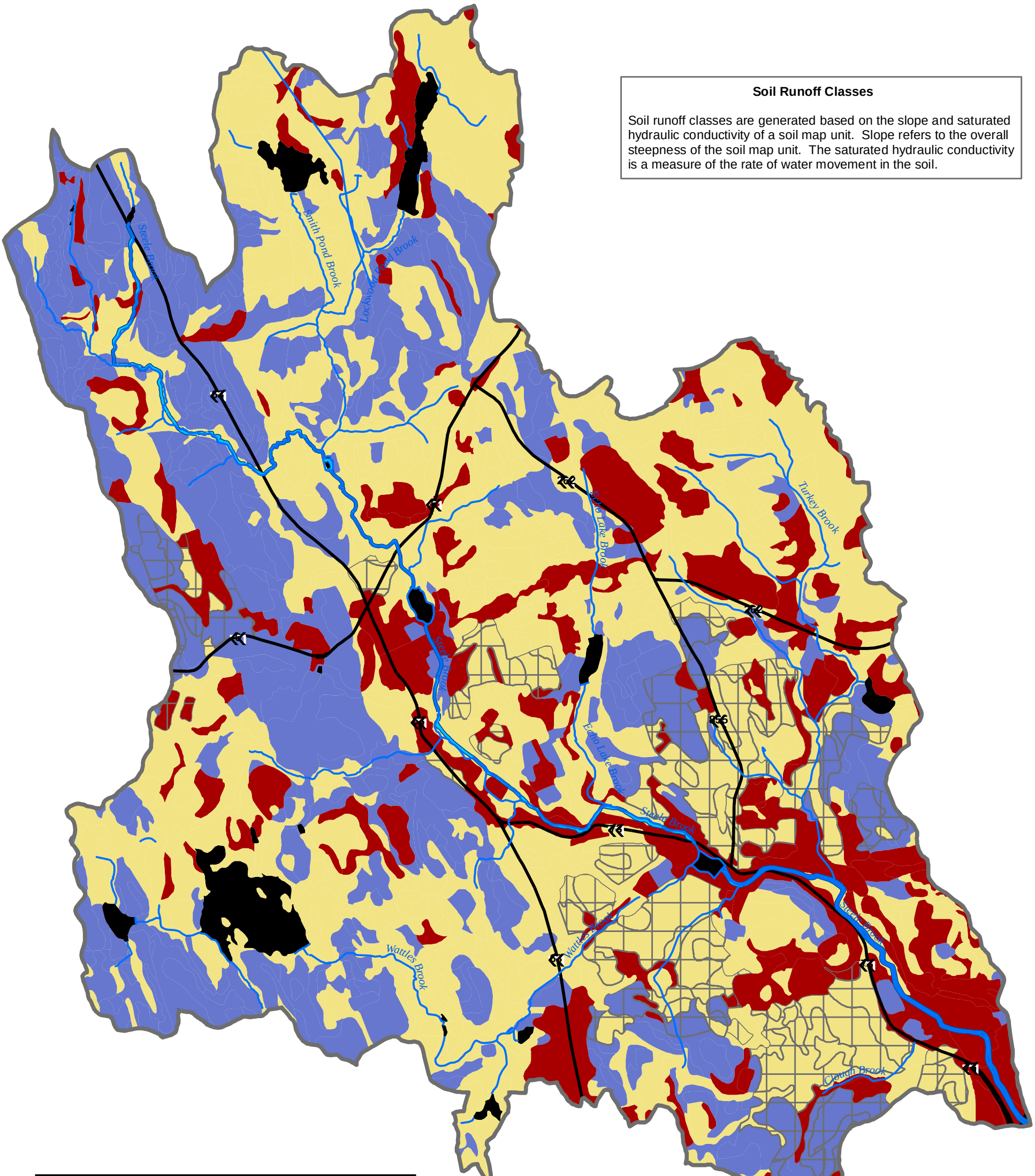
0 0.25 0.5 1 1.5 2 Miles

POTENTIAL FOR RUNOFF BASED ON SOIL PROPERTIES

STEELE BROOK WATERSHED PLANNING PROJECT
9/2/08



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.

Soils

Potential for Runoff

- High; Very High
- High*
- Medium
- Medium*
- Negligible; Very Low; Low
- Low*; Very low*
- Not Classified

Streams

- Other Streams
- Steele Brook

Roads

- Numbered Roads

Very Low*, Low *, Medium * and High* : About 35% of these mapunits may be in Urban Land, and have a Very High Runoff Potential

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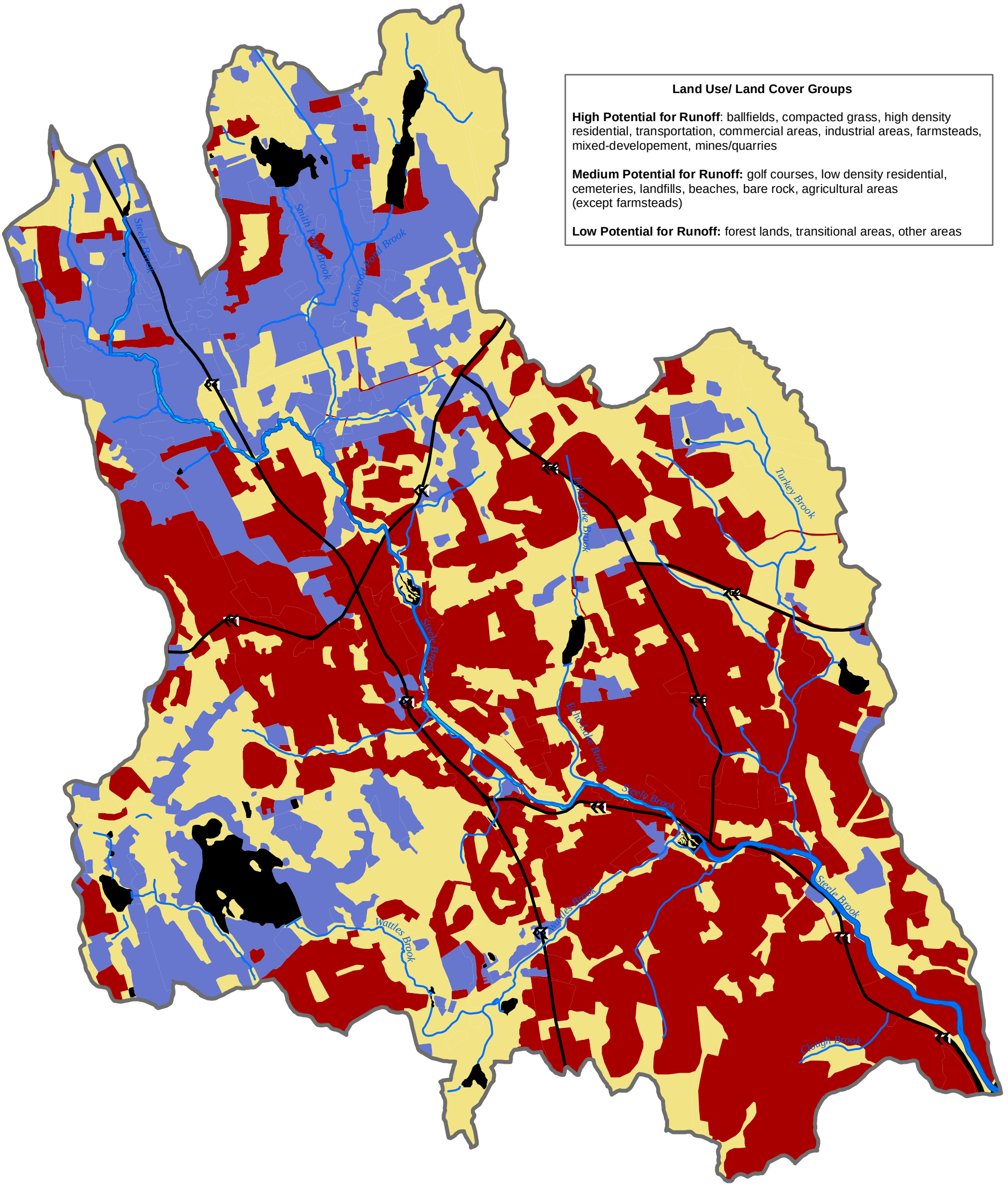
0 0.3 0.6 1.2 1.8 2.4 Miles

POTENTIAL FOR RUNOFF BASED ON LAND USE/ LAND COVER CLASSIFICATIONS

STEELE BROOK WATERSHED PLANNING PROJECT
9/2/08



Land Use/ Land Cover Groups

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

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

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

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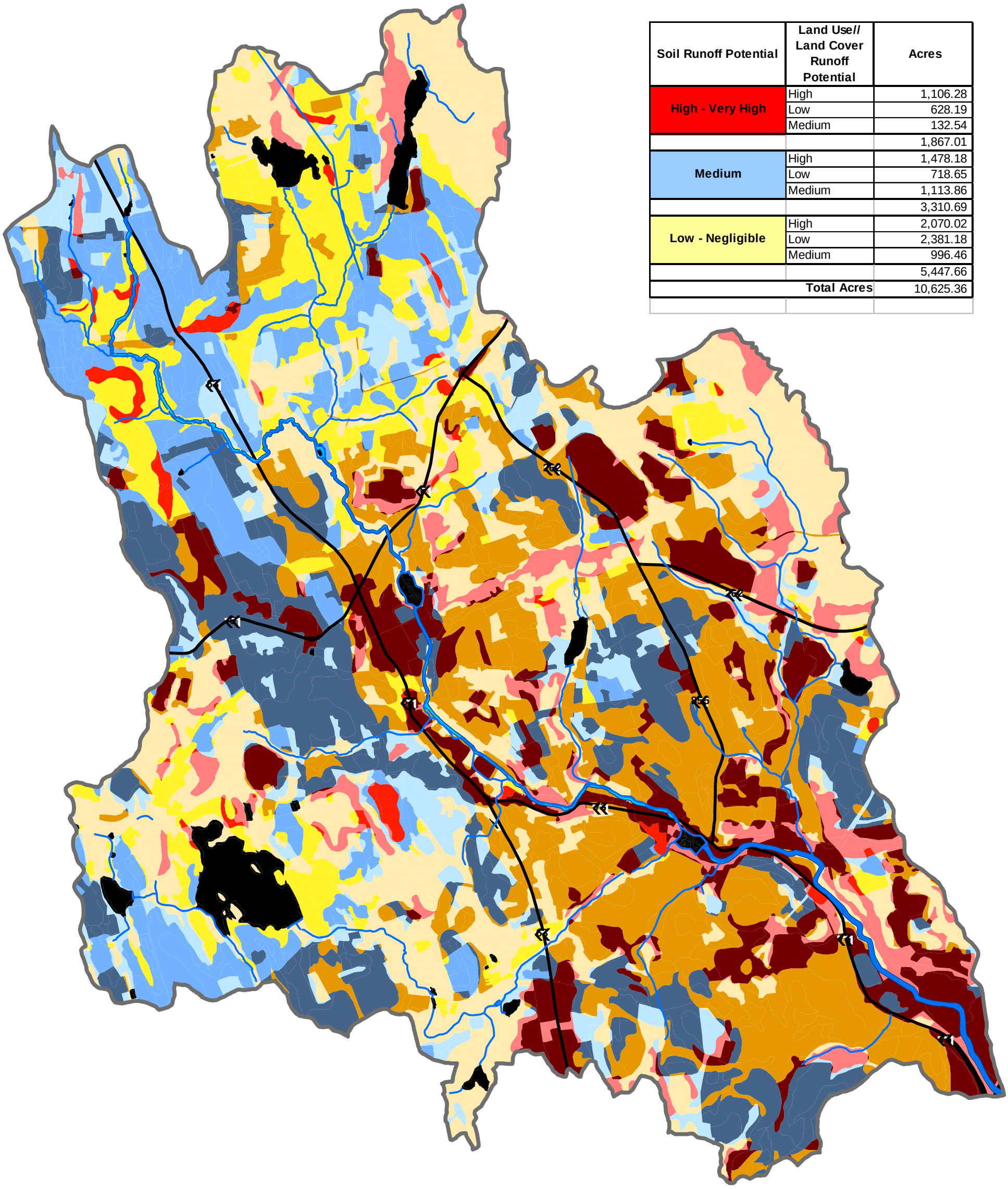
0 0.3 0.6 1.2 1.8 2.4 Miles

POTENTIAL FOR RUNOFF BASED ON THE COMBINATION OF SOIL PROPERTIES AND LAND USE/ LAND COVER CLASSIFICATIONS

STEELE BROOK WATERSHED PLANNING PROJECT
9/2/08

Soil Runoff Potential	Land Use// Land Cover Runoff Potential	Acres
High - Very High	High	1,106.28
	Low	628.19
	Medium	132.54
		1,867.01
Medium	High	1,478.18
	Low	718.65
	Medium	1,113.86
		3,310.69
Low - Negligible	High	2,070.02
	Low	2,381.18
	Medium	996.46
		5,447.66
	Total Acres	10,625.36



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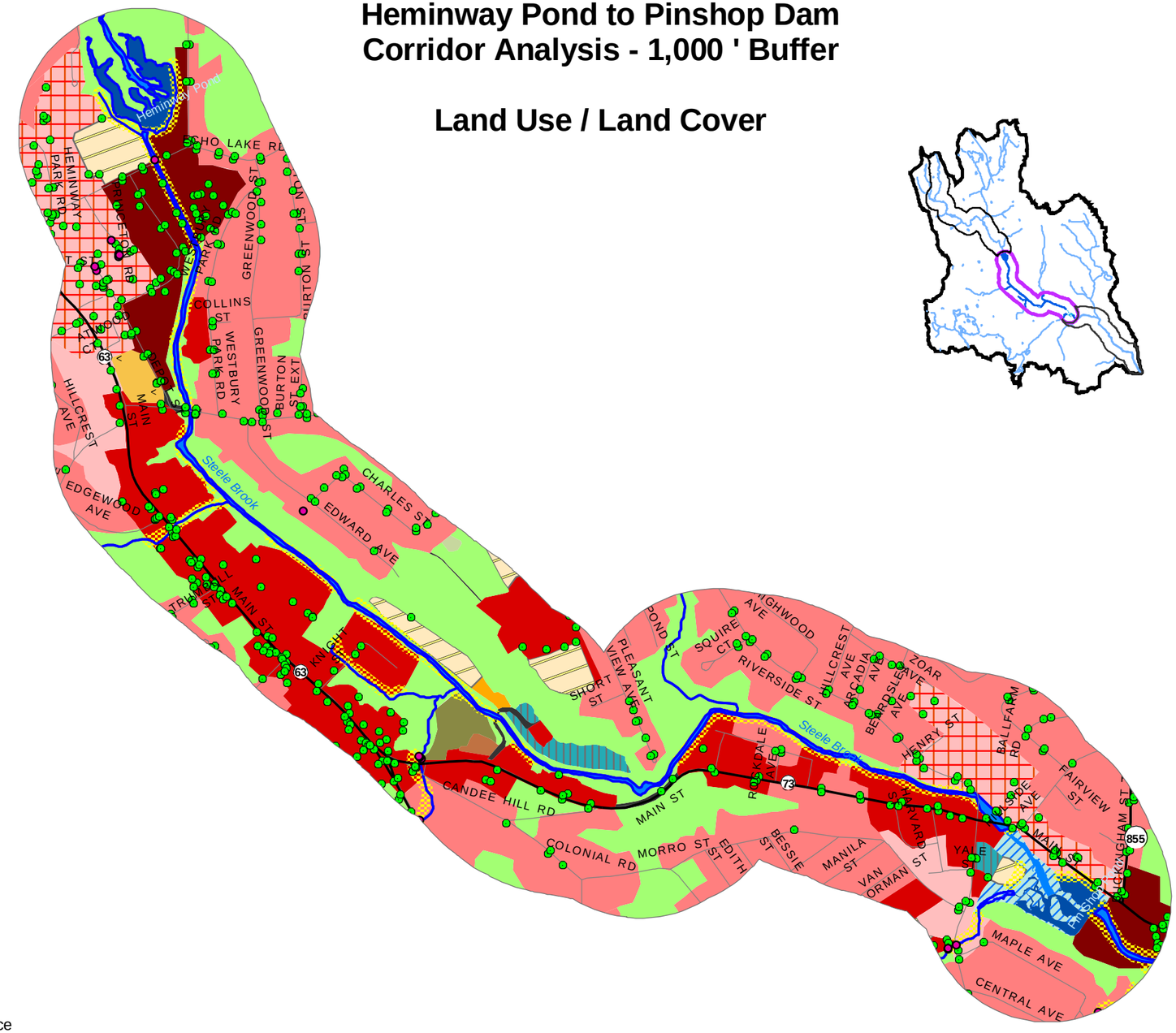
0 0.25 0.5 1 1.5 2 Miles

Steele Brook Watershed
Heminway Pond to Pinshop Dam
Corridor Analysis - 1,000 ' Buffer

Land Use / Land Cover

Label	Data	Total
drh: Developed-Residential:high density	Acres	223.85
	Percentage of Corridor	37%
fd: Forested-Deciduous	Acres	140.88
	Percentage of Corridor	23%
dc: Developed Commercial	Acres	95.94
	Percentage of Corridor	16%
dm: Developed Mixed	Acres	51.27
	Percentage of Corridor	8%
di: Developed Industrial	Acres	33.31
	Percentage of Corridor	5%
drl: Developed-Residential:low density	Acres	17.35
	Percentage of Corridor	3%
dob: Developed-Other:ballfields	Acres	13.79
	Percentage of Corridor	2%
wl: Water-Lake	Acres	8.10
	Percentage of Corridor	1%
oh: Other-Herbaceous	Acres	4.66
	Percentage of Corridor	1%
tm: Transitional-Mixed	Acres	4.56
	Percentage of Corridor	1%
au: Agriculture-Nursery	Acres	3.72
	Percentage of Corridor	1%
doc: Developed-Other:cemetery	Acres	2.79
	Percentage of Corridor	0%
ws: Water-Stream	Acres	1.86
	Percentage of Corridor	0%
dt: Developed-Transportation	Acres	1.86
	Percentage of Corridor	0%
af: Agriculture-Farmstead	Acres	0.79
	Percentage of Corridor	0%
dok: Developed-Other:compacted grass	Acres	0.74
	Percentage of Corridor	0%
ag: Agriculture-Grazed	Acres	0.32
	Percentage of Corridor	0%



Legend

Stormwater Features
- Catch Basin
- Outfall

Roads
- Roads
- Numbered_Roads

Streams
- Streams

Segments of Water Missing Buffer
- Exaggerated Extent

Land Use / Land Cover
- af: agriculture-farmstead
- ag: agriculture-grazed pasture
- au: agriculture-nursery
- drl: developed-low density residential
- drh: developed-high density residential
- dc: developed-commercial
- di: developed-industrial
- dm: developed-mixed
- dob: developed other-ballfields
- doc: developed other-cemeteries
- dok: developed other-compacted grass
- dt: developed-transportation
- fd: forest-deciduous
- oh: other-herbaceous
- osu:other-utility right of way
- tm: transitional-mixed
- ws/wr: water-stream/river
- wl/wld: water-lake/reservoir

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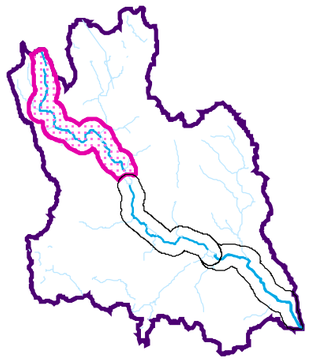
0 0.1 0.2 0.4 0.6 0.8 Miles

N

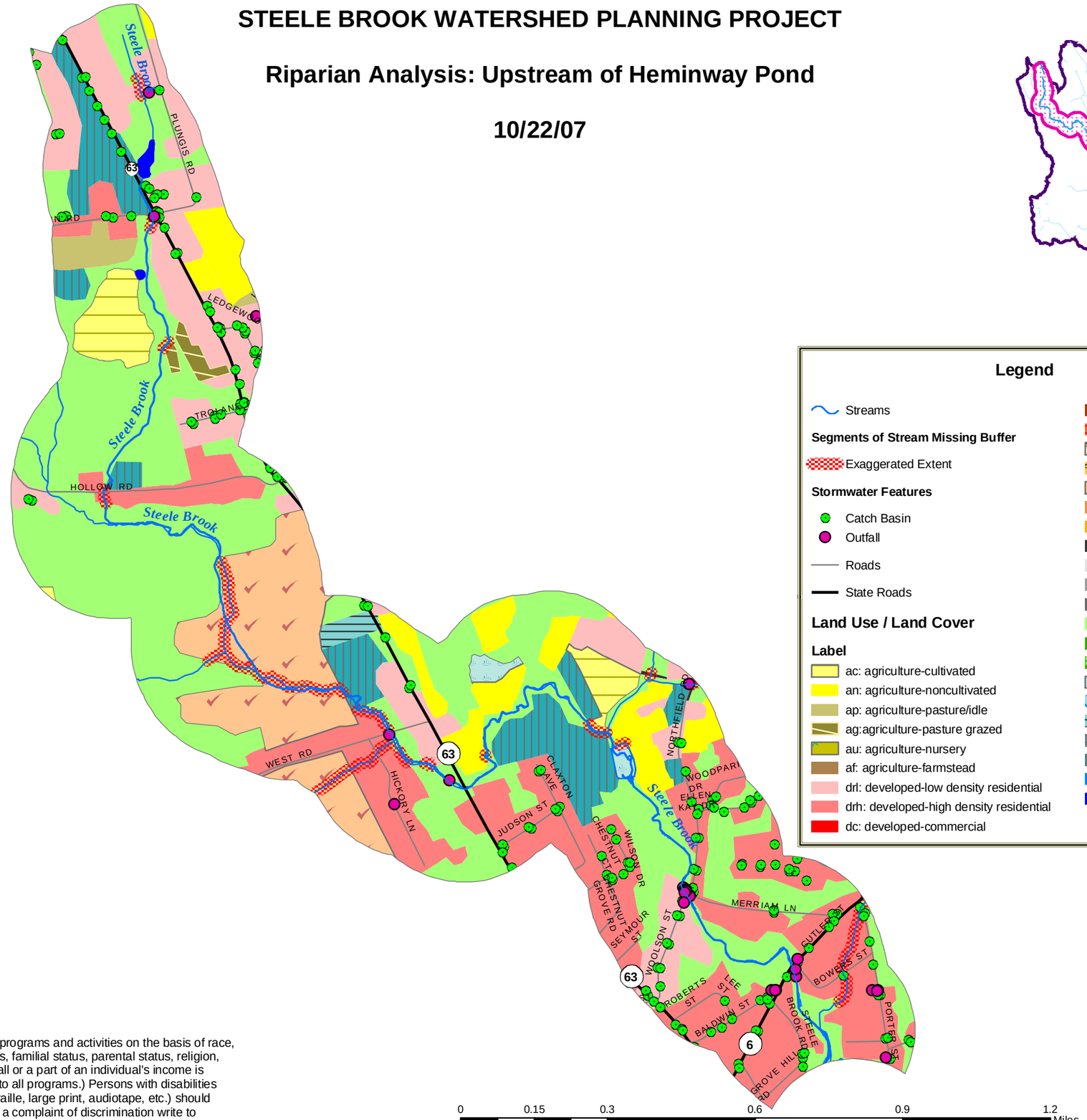
STEELE BROOK WATERSHED PLANNING PROJECT

Riparian Analysis: Upstream of Heminway Pond

10/22/07



Label	Data	Total
drl: Developed-Residential:low density	Acres	259.42
	Percentage of Corridor	32%
drh: Developed-Residential:high density	Acres	181.07
	Percentage of Corridor	23%
fd: Forested-Deciduous	Acres	140.50
	Percentage of Corridor	17%
dob: Developed-Other:golf course	Acres	76.41
	Percentage of Corridor	9%
tm: Transitional-Mixed	Acres	56.10
	Percentage of Corridor	7%
an: Agriculture-Noncultivated	Acres	46.11
	Percentage of Corridor	6%
ac: Agriculture-Cultivated	Acres	21.76
	Percentage of Corridor	3%
ap: Agriculture-Pasture or Idle Field	Acres	7.59
	Percentage of Corridor	1%
oh: Other-Herbaceous	Acres	4.30
	Percentage of Corridor	1%
ag: Agriculture-Grazed	Acres	3.83
	Percentage of Corridor	0%
osu: Other-Shrub:Utility ROW	Acres	3.55
	Percentage of Corridor	0%
ws: Water-Stream	Acres	2.01
	Percentage of Corridor	0%
wl: Water-Lake	Acres	1.41
	Percentage of Corridor	0%
dt: Developed-Transportation	Acres	0.47
	Percentage of Corridor	0%



Legend

Streams

Segments of Stream Missing Buffer

Exaggerated Extent

Stormwater Features

Catch Basin

Outfall

Roads

State Roads

Land Use / Land Cover

Label

ac: agriculture-cultivated

an: agriculture-noncultivated

ap: agriculture-pasture/idle

ag:agriculture-pasture grazed

au: agriculture-nursery

af: agriculture-farmstead

drl: developed-low density residential

drh: developed-high density residential

dc: developed-commercial

di: developed-industrial

dm: developed-mixed

dob: developed other-ballfields

doc: developed other-cemeteries

dog: developed other-golf courses

dol: developed other-landfill

dok: developed other-compacted grass

dt: developed-transportation

bb: barren-beach

br: barren-rock

bm: barren-mine/quarry

fd: forest-deciduous

fc: forest-coniferous

fm: forest-mixed

oh: other-herbaceous

os:other-shrub

osu:other-utility right of way

tl: transitional-partial canopy

tm: transitional-mixed

ws/wr: water-stream/river

wl/wld: water-lake/reservoir

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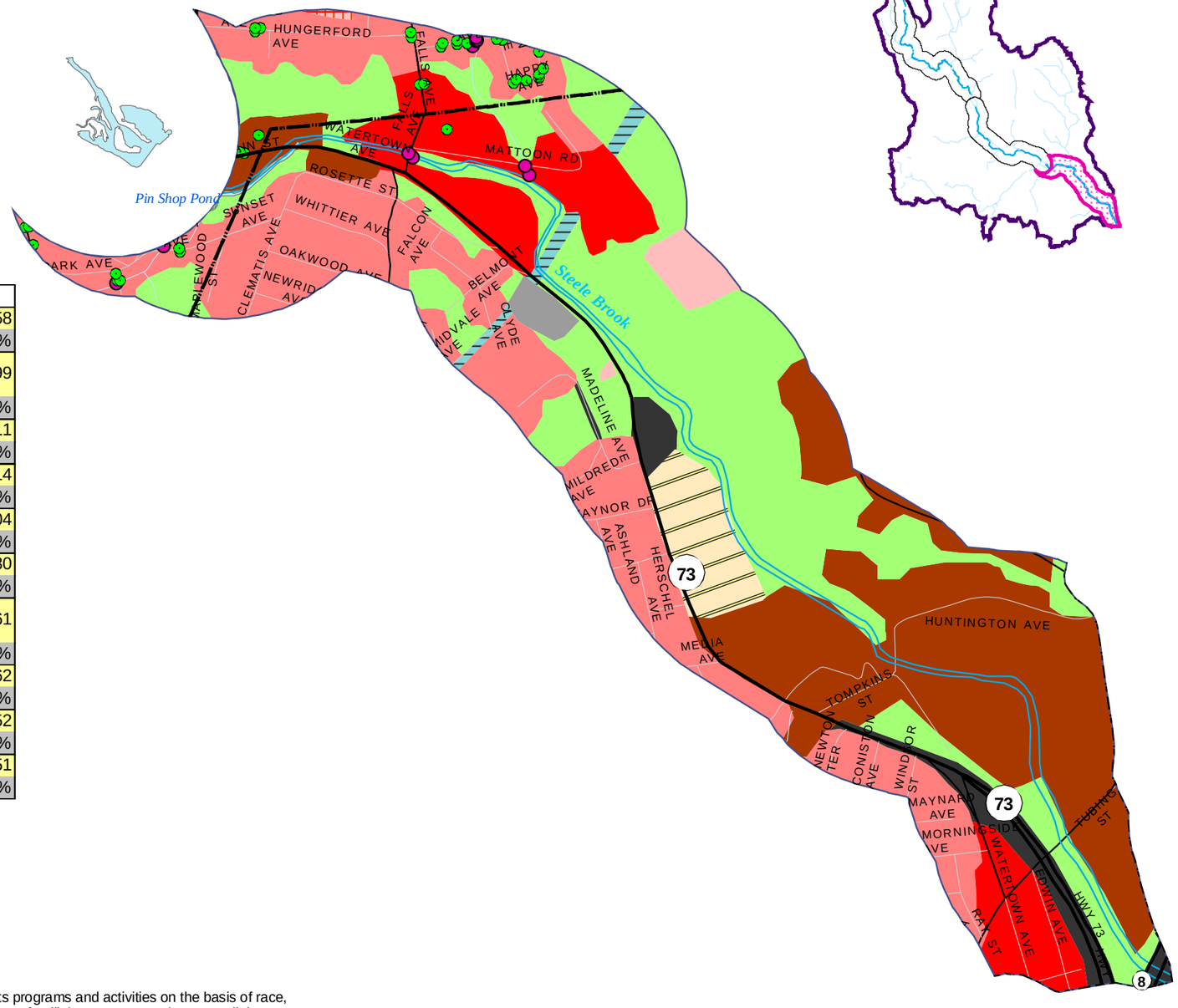
STEELE BROOK WATERSHED PLANNING PROJECT

Riparian Analysis: Downstream of Pin Shop Pond



Label	Data	Total
fd: Forested-Deciduous	Acres	150.58
	Percent of Corridor	30%
drh: Developed-Residential:high density	Acres	128.99
	Percent of Corridor	26%
di: Developed Industrial	Acres	120.11
	Percent of Corridor	24%
dc: Developed Commercial	Acres	52.14
	Percent of Corridor	10%
dt: Developed-Transportation	Acres	17.04
	Percent of Corridor	3%
dob: Developed-Other:ballfields	Acres	16.30
	Percent of Corridor	3%
drl: Developed-Residential:low density	Acres	6.61
	Percent of Corridor	1%
osu: Other-Shrub:Utility ROW	Acres	3.62
	Percent of Corridor	1%
br: Barren Rock	Acres	3.52
	Percent of Corridor	1%
dm: Developed Mixed	Acres	0.51
	Percent of Corridor	0%

Legend

Stormwater Features
- Catch Basin
- Outfall

Streams
- Steele Brook
- other streams

Roads
- Secondary Roads
- Local Roads

Land Use / Land Cover
- drl: developed-low density residential
- drh: developed-high density residential
- dc: developed-commercial
- di: developed-industrial
- dm: developed-mixed
- dob: developed other-ballfields
- dt: developed-transportation
- br: barren-rock
- fd: forest-deciduous
- osu:other-utility right of way

U.S. Department of Agriculture
Natural Resources Conservation Service
344 Merrow Road, Suite A
Tolland, CT 06084
(860) 871 - 4011

0 0.125 0.25 0.5 0.75 1 Miles

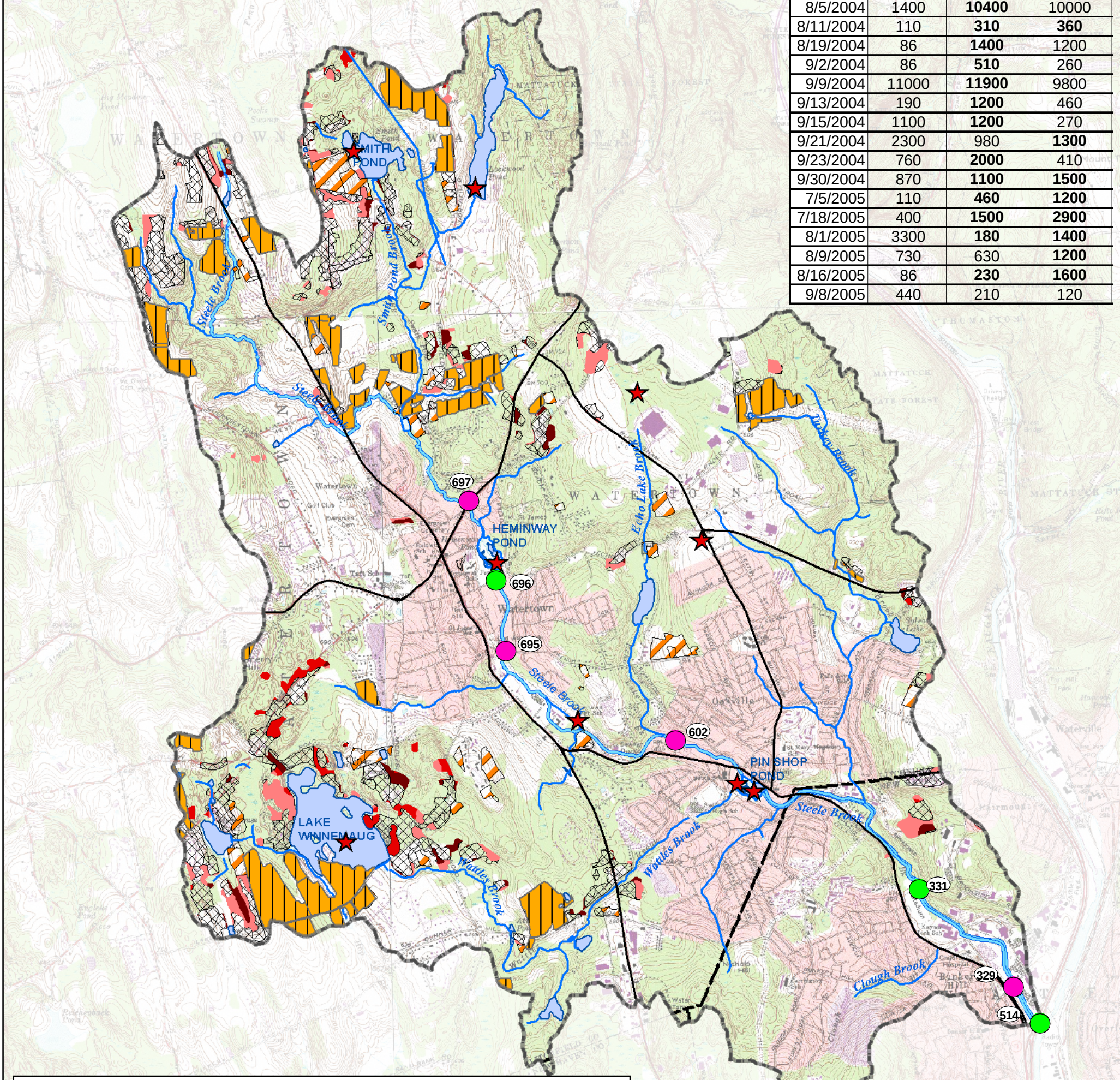
N

Note: Catch Basin and Outfall data only available for Watertown

POTENTIAL SOURCES OF BACTERIA

Steele Brook Watershed Planning Project

Date	Site 696 E. coli (col./100 ml)	Site 331 E. coli (col./100 ml)	Site 514 E. coli (col./100 ml)
5/27/2004	1100	**3300**	**6100**
6/3/2004	350	**530**	530
6/10/2004	560	**1600**	**1800**
6/17/2004	190	**540**	**1100**
6/24/2004	210	**610**	**990**
7/1/2004	160	**1300**	**1700**
7/8/2004	300	**1900**	**4100**
7/15/2004	930	**3900**	660
7/22/2004	270	**750**	690
7/29/2004	471	**1000**	1000
8/5/2004	1400	**10400**	10000
8/11/2004	110	**310**	**360**
8/19/2004	86	**1400**	1200
9/2/2004	86	**510**	260
9/9/2004	11000	**11900**	9800
9/13/2004	190	**1200**	460
9/15/2004	1100	**1200**	270
9/21/2004	2300	980	**1300**
9/23/2004	760	**2000**	410
9/30/2004	870	**1100**	**1500**
7/5/2005	110	**460**	**1200**
7/18/2005	400	**1500**	**2900**
8/1/2005	3300	**180**	**1400**
8/9/2005	730	630	**1200**
8/16/2005	86	**230**	**1600**
9/8/2005	440	210	120



USDA CLU
- Farm & Tract # available

LULC classification
- Agriculture - No USDA CLU

Monitoring Points
- TMDL Points: 331; 514; 696
- Other Points: 329; 602; 695; 697

Residential Areas outside Sewer Extent

Septic Potential Rating
- Extremely Low potential
- Very Low Potential
- Low Potential
- Medium Potential; High Potential; Not Rated

Waterfowl
- congregation points

Streams

Stream Name
- Steele Brook
- Other Streams

Waterbodies
- Waterbodies

Towns
- Boundary

N

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0 0.5 1 1.5 2 2.5 3 Miles