Contract #10-01d

2013

Flat Brook Abbreviated Watershed-Based Plan

Photo by ECCD staff

Prepared by the Eastern Connecticut Conservation District, Inc.

www.ConserveCT.org/eastern

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Cover Photograph: Flat Brook looking west, towards Route 12, from Baldwin Hill Road (photo by ECCD staff - 2012).

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Executive Summary

Flat Brook (CT 3000-08_01) is a second order stream located in the Gales Ferry section of Ledyard, Connecticut. Flat Brook flows northerly from its headwaters at a small pond in Groton, CT 1.09 miles to Long Cove and the Thames River. Flat Brook has a water quality classification of A, and its designated uses include potential drinking water supplies, habitat for fish and other aquatic life and wildlife, recreation, navigation, and industrial and agricultural water supply. Flat Brook has been listed as impaired for recreation due to periodic high levels of *Escherichia coli* (*E. coli*) in several cycles of the Connecticut Department of Energy and Environmental Protection's Integrated Water Quality Report 303d list, most recently in 2012, from sources that may include permitted and non-permitted stormwater, illicit discharges, insufficient septic systems, nuisance wildlife and/or pets.

To address this issue, the Eastern Connecticut Conservation District (ECCD) was awarded grant funding by the Connecticut Department of Energy and Environmental Protection (CT DEEP) through the US EPA Clean Water Act Section 319 Nonpoint Source grant program to develop a Watershed Based Plan for Flat Brook. A Watershed Based Plan is a road map for improving the water quality in a watershed, developed in accordance with specific US EPA guidelines.

In order to gather the information needed to create a Watershed Based Plan, the Eastern Connecticut Conservation District (ECCD) conducted a track down survey of Flat Brook and its tributaries to identify potential sources of nonpoint source pollution that have degraded water quality. ECCD staff and local volunteers collected water samples for bacteria analysis from seven locations along Flat Brook and its tributaries for an eight week period in the summer of 2012. ECCD also reviewed existing water quality data, including water quality data collected by the Town of Ledyard under its Small Municipal Separate Storm Sewer System (MS4) program permit and data collected by the CT DEEP Ambient Water Quality Probabilistic Bacteria Monitoring program. ECCD staff and volunteers conducted Streamwalk surveys of Flat Brook and four unnamed perennial tributaries. The Streamwalks were conducted following the protocol established by the USDA Natural Resource Conservation Service (NRCS) and were used to identify and document areas of concern such as stormwater outfalls, impacted riparian buffers, eroded stream banks, and excessive algae which might indicate conditions contributing to degraded water quality. ECCD staff interviewed local officials, area business owners and residents to identify other potential causes of the observed degradation to Flat Brook.

Based on the information gathered, ECCD prepared an abbreviated nine-element watershed based plan. The plan identifies possible pollutant sources, provides pollutant load reduction targets, and recommends specific management measures necessary to improve water quality, enabling Flat Brook to meet the standards for its designated use.

Introduction:

The Eastern Connecticut Conservation District (ECCD) conducted a track down survey of Flat Brook in Ledyard and Groton, CT. in order to identify potential sources of *Escherichia coli* (*E. coli)* bacteria that have degraded water quality (Figure 1). Flat Brook has been listed for several cycles, most recently in 2012, in the State of Connecticut Integrated Water Quality Report as impaired for recreation due to elevated levels of *E. coli*, from sources that may include permitted and non-permitted stormwater, illicit discharges, insufficient septic systems, nuisance wildlife and/or pets.

As part of the track down survey, ECCD recruited and trained local volunteers to collect water samples from Flat Brook and its tributaries to be analyzed for bacteria content, and to conduct Streamwalk surveys, utilizing a protocol developed by the USDA Natural Resource Conservation Service (NRCS). ECCD reviewed CT DEEP's 2012 Statewide Total Maximum Daily Load Analysis for Bacteria Impaired Waters (Appendix 5), and water quality data collected by the Town of Ledyard as part of its MS-4 permit requirements and the CT DEEP Ambient Water Quality Probabilistic Bacteria Monitoring program. ECCD staff also interviewed local officials, area business owners and residents to identify other potential causes of the observed degradation to Flat Brook.

Based on the information gathered, this abbreviated nine-element watershed based plan was prepared. This plan recommends management practices for watershed managers that address the documented areas of concern, with the goal of reducing NPS pollution contributions to Flat Brook, including *E. coli*, allowing it to be de-listed.

Watershed Description

Physical and Natural Features:
The study area is comprised of two local watersheds located in Ledyard and Groton, Connecticut. These two watersheds are part of the Thames Main Stem regional watershed (CT3000), and drain into the Thames River via Long Cove in the Gales Ferry section of Ledyard. The area encompassed by the two watersheds is 1.69 square miles (Figure 2).

The Flat Brook watershed (3000-08) is a 0.54 square mile local watershed located in Ledyard, CT. It flows north 1.09 miles from its headwaters at an unnamed pond in Groton, CT, to the Thames River via Long Cove. A stream network comprised of five unnamed tributaries flows into Flat Brook from a 1.15 square mile watershed (3000-09) located to the northeast of the Flat Brook watershed. For the purposes of this document the two local watersheds will be referred to jointly as the Flat Brook watershed.

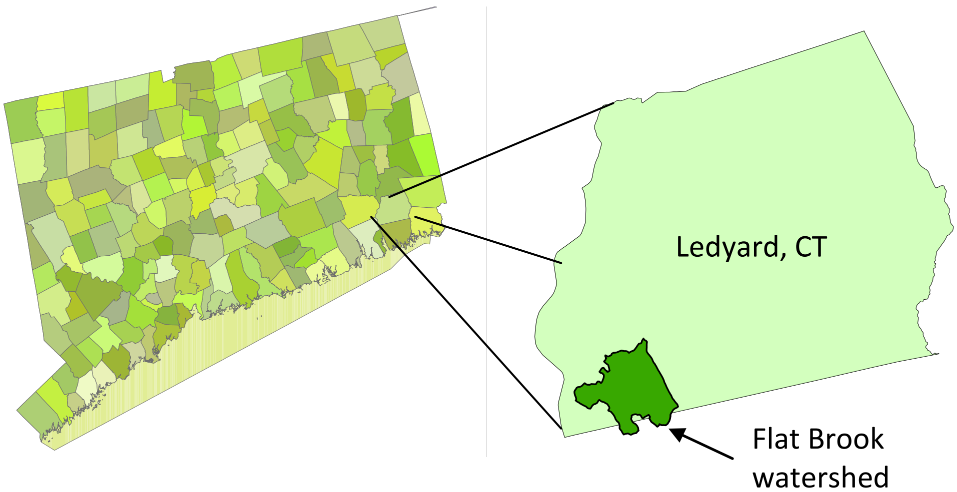

Figure 1: Location of Flat Brook watershed, Ledyard, Connecticut.

Flat Brook and its tributary streams have surface water quality classifications of A (Figure 3). Water quality classifications serve to establish designated uses for surface and ground waters and identify criteria necessary to support those uses. Designated uses in Class A surface waters include habitat for fish and other aquatic life and wildlife; potential drinking water supplies; recreation; navigation; and water supply for industry and agriculture. Permitted discharges to a Class A water may include discharges from public or private drinking water treatment systems, dredging activity and dredge material dewatering operations, including the discharge of dredged or fill material and clean water discharges (State of CT Department of Environmental Protection Water Quality Standards, 2011). Groundwater within the Flat Brook watershed is classified as GA. Designated uses for Class GA groundwater include existing private and potential public or private supplies of water suitable for drinking without treatment; and base flow for hydraulically-connected surface water bodies.

Bedrock geology in the Flat Brook watershed is composed of the Plainfield formation, an interlayered, thinly bedded quartzite, mica schist and dark gray gneiss; and the Potter Hill granite gneiss, a light pink to gray, fine to medium-grained, well-foliated granitic gneiss. These formations are part of the Avalonian Terrane, a volcanic island arc which attached to the proto-Euramerican plate during the Devonian period (420 mya).

Soils in the Flat Brook watershed are comprised of glacial tills and thick tills in the upper elevations and sand and gravels in the lower elevations (Figure 4). Predominant soil types include Canton and Charlton very stony and extremely stony soils (30%), Narragansett silt loams, extremely stony (13%), Charlton-Chatfield complex, very rocky soils (7.5%) and Udorthent (urban land complex) soils (6%) (Figure 5). Udorthents are located primarily in the vicinity of the intersection of Rt. 12, Baldwin Hill Road and Long Cove Road, near sampling sites 2 - 4, and contain commercial and industrial development and several gravel mines.

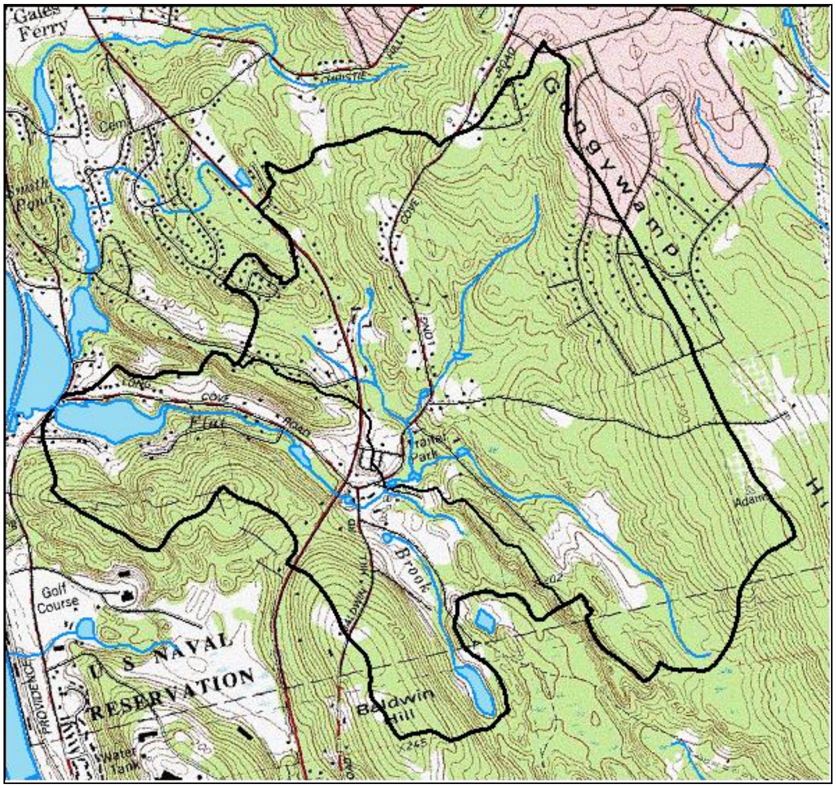

Figure 2: Flat Brook and the Flat Brook watershed in Ledyard and Groton, CT (CT DEEP).

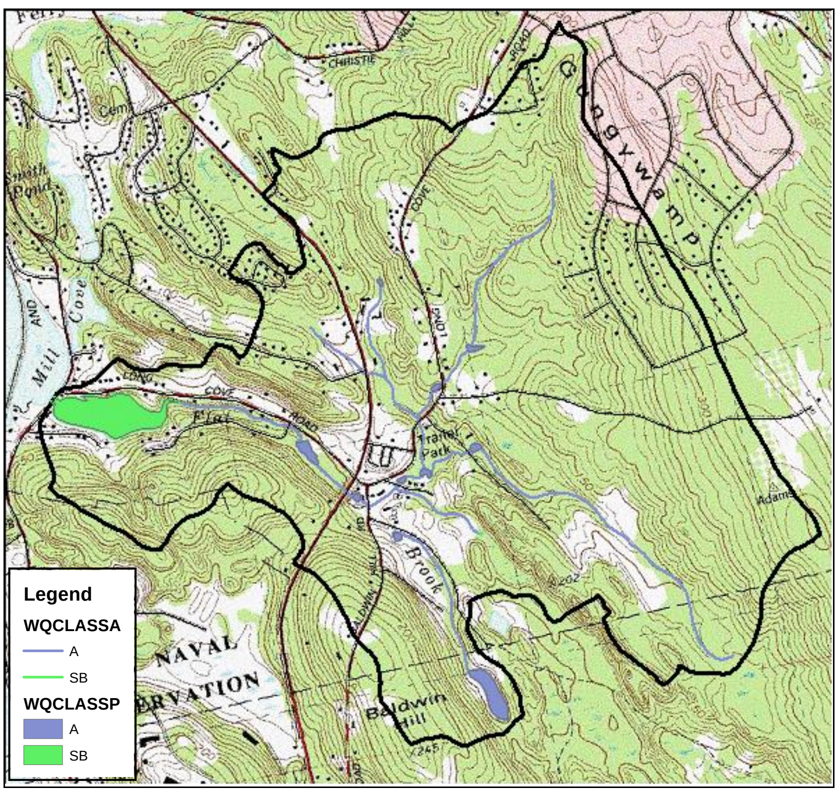

Figure 3: Flat Brook surface water classification (CT DEEP).

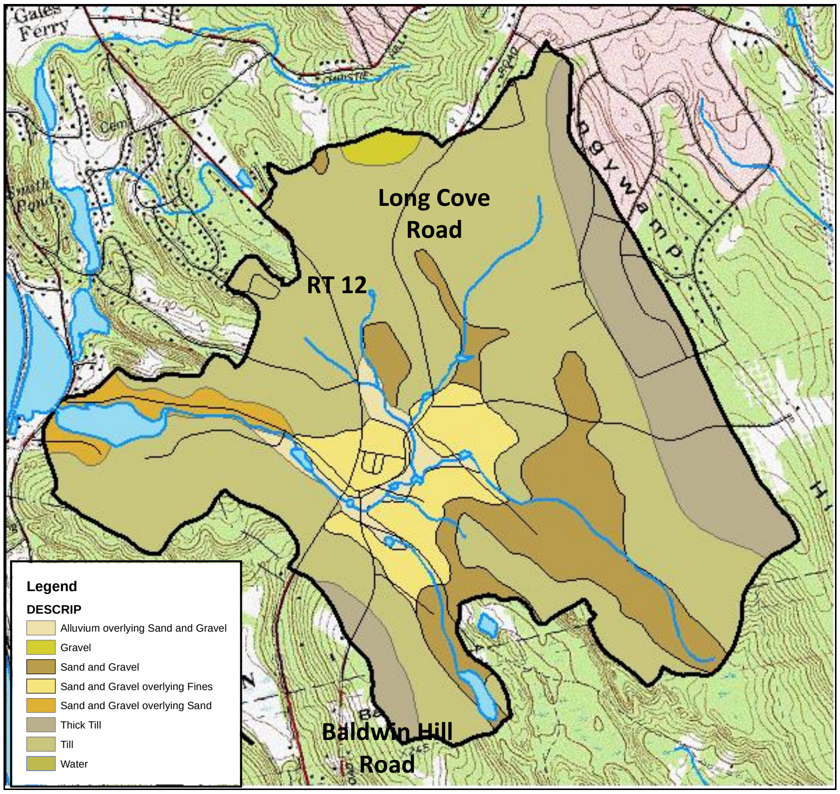

Figure 4: Flat Brook surficial materials (SSURGO 2011).

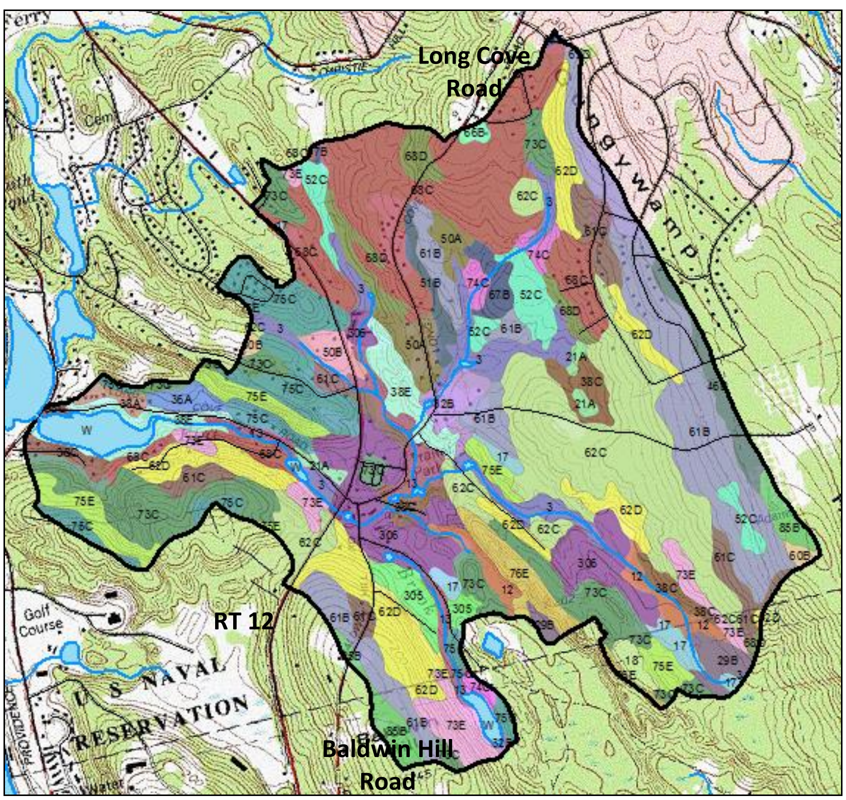

Figure 5: Flat Brook soil types (SSURGO 2011 - see table 1 for soil descriptions).

Table 1: Flat Brook Soil Types (USDA-NRCS)

Soil Symbol	Soil Description
3	Ridgebury, Leicester, and Whitman soils, extremely stony
12	Raypol silt loam
13	Walpole sandy loam
17	Timakwa and Natchaug soils
21A	Ninigret and Tisbury soils, 0 to 5 percent slopes
29B	Agawam fine sandy loam, 3 to 8 percent slopes
32B	Haven and Enfield soils, 3 to 8 percent slopes
36A	Windsor loamy sand, 0 to 3 percent slopes
38A	Hinckley gravelly sandy loam, 0 to 3 percent slopes
38C	Hinckley gravelly sandy loam, 3 to 15 percent slopes
38E	Hinckley gravelly sandy loam, 15 to 45 percent slopes
46B	Woodbridge fine sandy loam, 2 to 8 percent slopes, very stony
50A	Sutton fine sandy loam, 0 to 3 percent slopes
50B	Sutton fine sandy loam, 3 to 8 percent slopes
51B	Sutton fine sandy loam, 2 to 8 percent slopes, very stony
52C	Sutton fine sandy loam, 2 to 15 percent slopes, extremely stony
60B	Canton and Charlton soils, 3 to 8 percent slopes
61B	Canton and Charlton soils, 3 to 8 percent slopes, very stony
61C	Canton and Charlton soils, 8 to 15 percent slopes, very stony
62C	Canton and Charlton soils, 3 to 15 percent slopes, extremely stony
62D	Canton and Charlton soils, 15 to 35 percent slopes, extremely stony
66B	Narragansett silt loam, 2 to 8 percent slopes
67B	Narragansett silt loam, 3 to 8 percent slopes, very stony
68C	Narragansett silt loam, 3 to 15 percent slopes, extremely stony
68D	Narragansett silt loam, 15 to 25 percent slopes, extremely stony
73C	Charlton-Chatfield complex, 3 to 15 percent slopes, very rocky
73E	Charlton-Chatfield complex, 15 to 45 percent slopes, very rocky
74C	Narragansett-Hollis complex, 3 to 15 percent slopes, very rocky
75C	Hollis-Chatfield-Rock outcrop complex, 3 to 15 percent slopes
75E	Hollis-Chatfield-Rock outcrop complex, 15 to 45 percent slopes
76E	Rock outcrop-Hollis complex, 3 to 45 percent slopes
85B	Paxton and Montauk fine sandy loams, 3 to 8 percent slopes, very stony
305	Udorthents-Pits complex, gravelly
306	Udorthents-Urban land complex
W	Water

Vegetation in the Flat Brook watershed is comprised primarily of deciduous and coniferous forest, with mature oaks and maples predominating, and stands of hemlock found along stream corridors and in forested wetlands. Understory shrubs and plants are typical of the Connecticut coastal region and include American Beech, various cherry species, mountain laurel, several willow species, sweet pepper bush, spice bush, and green briar. Invasive species, including multiflora rose, glossy buckthorn, oriental bittersweet, *Phragmites* and Japanese Knotweed, were found in disturbed areas and along the stream corridors.

The Connecticut Department of Energy and Environmental Protection's Natural Diversity Database (NDDB) identifies multiple Natural Diversity Database sites along the lower portion of Flat Brook, from an old mill pond on Long Cove Road, west of Route 12, through Long Cove, to the Thames River (Figure 6). According to CT DEEP, these sites may include both terrestrial and aquatic plant and animal species. For more specific information on listed species, inquiries should be directed to CT DEEP's Natural Diversity Database program.

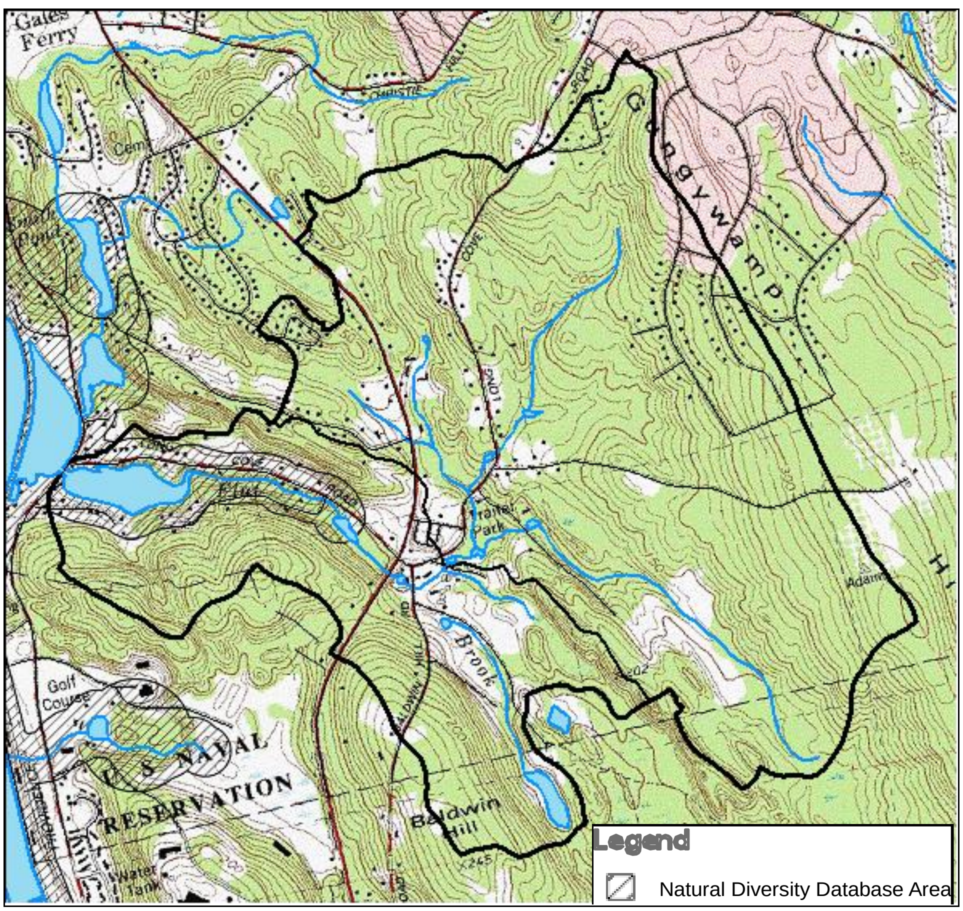

Figure 6: CT DEEP Natural Diversity Database areas in the Flat Brook watershed (CT DEEP 2012).

Land Use and Land Cover:

Land cover in the Flat Brook watershed is dominated by deciduous (58%) and coniferous forest (9%). Developed land comprises 20% of the watershed, and is concentrated along the Route 12 corridor and in the vicinity of the Long Cove Road/Baldwin Hill Road intersection. Turf grasses and other grasses accounted for 7% of the watershed, and 6% of the watershed is comprised of wetlands and waterbodies (Figures 7 and 8).

Residential and commercial development occurs along road frontages, with back lands remaining mostly undeveloped. Most commercial development occurs along the Route 12 corridor, which is the main transportation corridor through the Gales Ferry. Commercial and industrial development is also present along Baldwin Hill Road, near the intersections with Rt. 12 and Long Cove Road, in the form of numerous small commercial and light industrial businesses, and several gravel mining operations.

There is a cluster of protected open space in the northern part of the watershed (Figure 9). The Avalonia Land Conservancy owns the Barrett Preserve, a 72 acre parcel of forested land which straddles the Flat Brook watershed. This property has a well-developed trail system and is open to the public. The Town of Ledyard owns 14.2 acres of forested land in the northeast portion of the Flat Brook watershed in the Hyde Park neighborhood off Long Cove Road. This land is targeted by the Town for possible greenway access and trail development.

Land use data from CLEAR indicates there is no agricultural land in the Flat Brook watershed. No agricultural activity was noted in the watershed during the track down investigation.

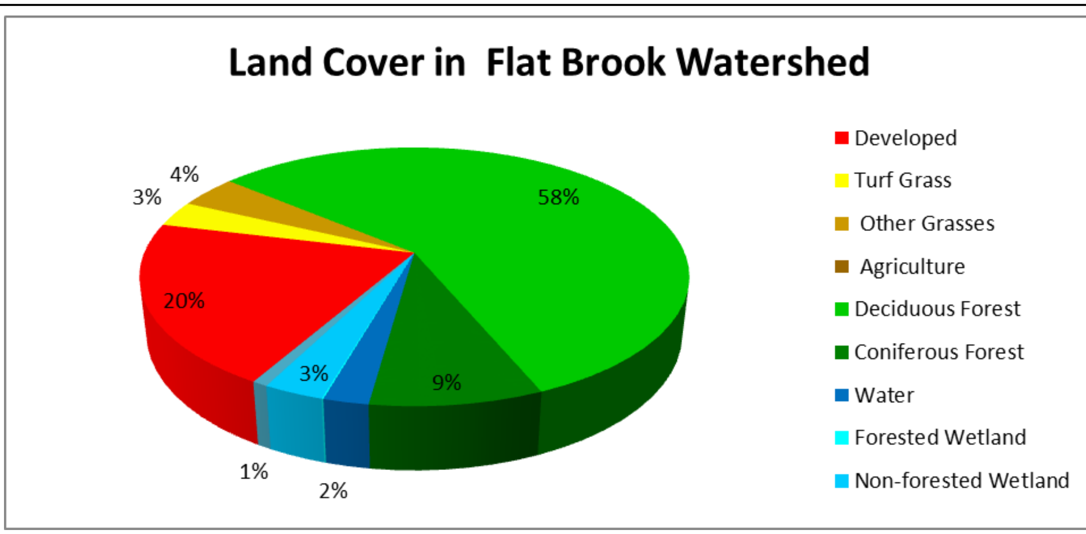

Figure 7: Percent land cover type for the Flat Brook watershed (derived from 2006 Center for Landuse Education and Research land cover data).

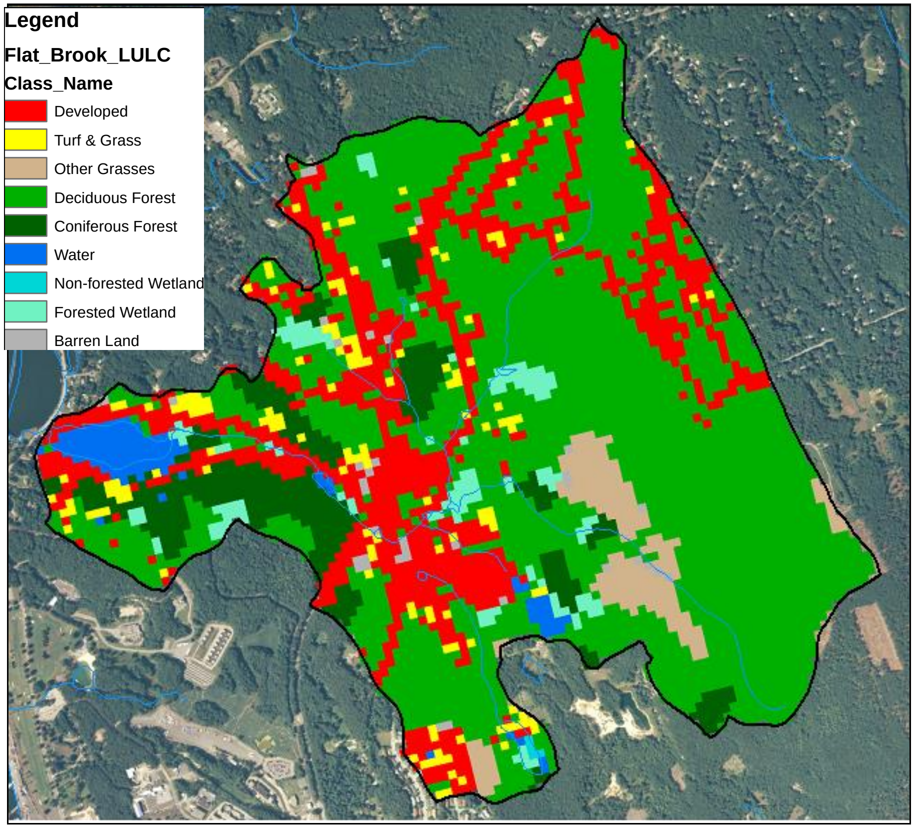

Figure 8: Land use and land cover in the Flat Brook watershed (CLEAR 2006).

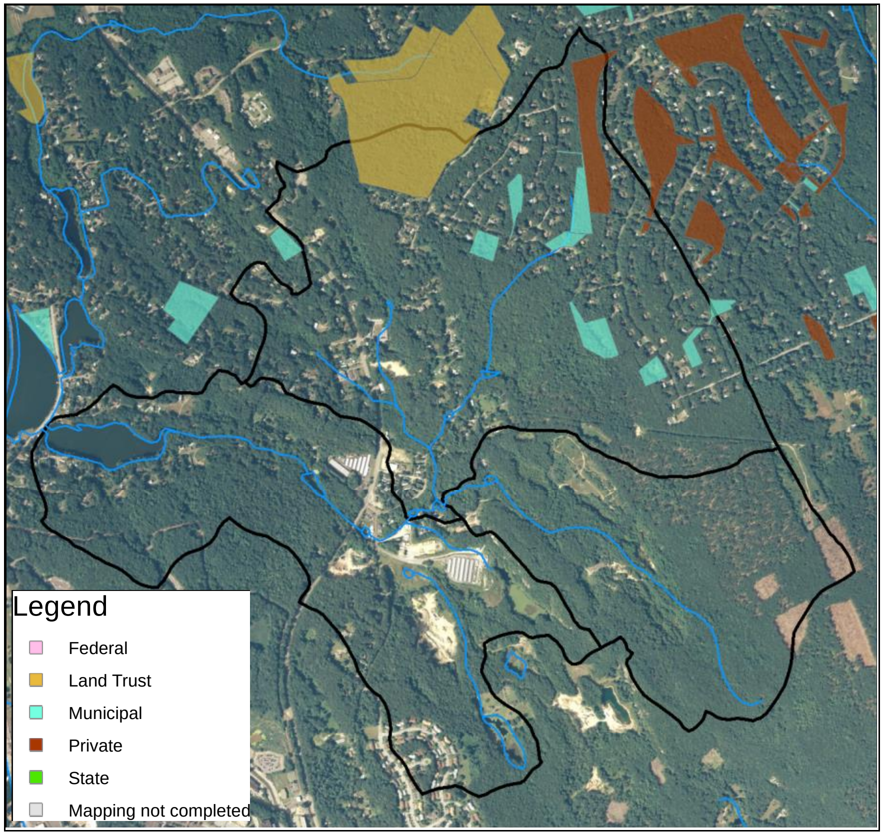

Figure 9: Protected Open Space in the Flat Brook watershed (CT DEEP 2011).

Fisheries Data:

Flat Brook was evaluated by CT DEEP Inland Fisheries Division in 1993 and 2002 (Table 2). The 1993 fisheries survey was conducted in the lower reaches of Flat Brook, near Long Cove. At that time strong populations of American Eel (*Anguilla rostrata*), brook trout (*Salvelinus fontinalis*), Blacknose Dace (*Rhinichthys atratulus*), and Golden Shiners (*Notemigonus crysoleucas*) were documented. Lesser populations of Four-spined Stickleback (*Apeltes quadracus*), Pumpkinseed (*Lepomis gibbosus*), and Redbreast Sunfish (*Lepomis auritus*) were also documented.

The 2002 fisheries survey was conducted in Flat Brook upstream of Baldwin Hill Road. Extremely strong populations of wild brook trout were documented. Additional documented fish species included American Eel, Blacknose Dace, Golden Shiners and Pumpkinseed. DEEP Fisheries staff noted that good cover and undercuts contributed to favorable habitat.

DEEP does not have a working knowledge of river herring presence in the Flat Brook system but would be interested to learn more in the future. There are numerous impoundments along the lower reaches of Flat Brook which would impede fish migration. DEEP staff recommend an assessment of a mill dam upstream of Pinelock Drive to evaluate the enhancement of eel passage.

Table 2: CT DEEP Fish Surveys in Flat Brook

Sample Year	1993	2000
Location	Gorge US of Long Cove	off Baldwin Hill Road
American eel	21	28
Brook Trout	43	*102
Blacknose dace	26	69
Fourspine Stickleback	2	0
Golden Shiner	40	1
Pumpkinseed	5	0
Redbreast Sunfish	2	3
		* Wild

Demographics/Economics:

The land area of Ledyard is 39.2 square miles and the population in 2011 was 15,069 (Connecticut Economic Resource Center, 2012). Although characterized as a suburban community by the Southeastern Connecticut Council of Governments in "Land Use – 2000" a report dated March 2002, the town continues to retain a strong rural flavor. The presence of significant wetlands and ledge and lack of infrastructure limits the density of development in significant parts of the town, which contributes to a more rural characteristic that residents express a desire to protect and preserve (Town of Ledyard Plan of Conservation and Development, 2003).

Municipal Land Management Policies:

The Town of Ledyard addresses land management policies in a variety of documents, including its Plan of Conservation and Development, Stormwater management Plan and municipal ordinances. Following is a summary of land management policies that address water quality concerns.

The Town of Ledyard Plan of Conservation and Development (2003): The Plan of Conservation and Development addresses issues of water quality and natural resource protection, and makes the following recommendations:

- Open space: "Preserve more valuable open space. Develop a comprehensive open space plan to be adopted by the town council and appended to this Plan. Such a plan should consider a town wide and inter-town network of trails. Develop an integrated and linked pattern of open space that is strategic in location in order to buffer incompatible land uses from one another, conserve environmentally sensitive lands and wildlife habitat, and provide opportunities for public access and recreation wherever possible. Establish a municipal property management program encouraging forest stewardship and long-term conservation objectives for the largest tracts of Town-owned land."
- Public Sewer: Protect groundwater and surface water supplies through proper septic system design. This recommendation recognizes soil limitations due to shallow depth to bedrock, steep slopes, a high groundwater table, and/or the presence of wetlands.
- Public Water and Water Supply Source Protection: Protect water quality and implement a source protection strategy through: 1) proactive zoning; 2) natural resource based planning and site design; 3) use of best management practices; and 4) water company review of proposed development projects located within designated source protection areas. Effectively manage and control stormwater drainage to minimize impacts to the environment.
- Coastal Area Management: Develop and implement best management practices to guard against degradation of visual and ecological characteristics of the Thames River, Poquetanuck Cove, other smaller embayments, and adjoining freshwater and tidal wetlands.

Stormwater Management Plan (2004): The Town of Ledyard is subject to the National Pollutant Discharge Elimination System (NPDES) General Permit for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems (Small MS4 Permit). In compliance with the General Permit, Ledyard has prepared and submitted a Stormwater Management Plan to CT DEEP, has enacted the Plan recommendations, and has complied with annual reporting requirements.

The Town adopted a Stormwater Runoff Management Ordinance in 1995. This ordinance requires design of a stormwater drainage system for various proposed developments, as defined in the Ordinance, to "…adequately mitigate downstream impacts resulting from any alteration of the stormwater discharge characteristics (i.e., rate of discharge, duration of discharge, time to peak discharge) resulting from the proposed development." This ordinance was updated and strengthened in order to comply with the requirements of the National Pollutant Detection and Elimination System (NPDES) permit process in 2012.

<u>Municipal Land Management Regulations:</u>

The Town of Ledyard has adopted land use regulations to protect water quality and natural resources, including subdivision, planning and inland wetland regulations. The Town is also subject to State of Connecticut Coastal Area Management regulations. Following is a summary of land use regulations that address water quality concerns.

Subdivision Regulations:

- <u>Conservation subdivisions</u>: Alternative to traditional residential subdivision design which "provides flexibility in clustering of residential units on areas of a project site best suited for development and to protect the remaining land as open space."
- <u>Erosion & Sedimentation Control Plan</u>: Requires preparation and submittal of an Erosion & Sediment Plan for the disturbance of ½ acre of land or more, "based on the best available technology as set forth in *Connecticut Guidelines for Soil Erosion and Sediment Control*, available from the Connecticut Department of Environmental Protection."
- <u>Stormwater Management Plan</u>: Regulations require the development of and adherence to a Construction Activity Stormwater Pollution Control Plan, in compliance with the General Permit for the Discharge of Stormwater and Dewatering Wastewaters from Construction Activities, pursuant to Section 22a-430b of the Connecticut General Statutes, as amended, if an applicant proposes to disturb 5 acres or more total land area on a site.

Planning Regulations:

- <u>Floodways</u>: In areas where floodways have been designated or determined, Planning regulations prohibit encroachments, "including fill, new construction, substantial improvements and other developments within the floodway unless demonstrated through hydraulic and hydrologic analysis performed in accordance with standard engineering practice and certified by a Licensed Professional Engineer that encroachments shall not result in any (0.00) increase in flood levels during occurrence of the base flood discharge."

- Coastal Area Management: All buildings, uses, and structures fully or partially within the coastal boundary, as defined in Chapter 444, §22a---94 of the Connecticut General Statutes and depicted on the Town Of Ledyard Zoning Map, shall be subject to the Coastal Site Plan Review requirements and procedures in Sections 22a---105 Through 22a---109 of the Connecticut General Statutes.

Inland Wetlands Regulations:

- The Inland Wetlands and Watercourses Commission of the Town of Ledyard, established in accordance with an ordinance adopted October 10, 1973, is charged with enforcing the provisions of the Inland Wetlands and Watercourses Act, Sections 22a-36 through 22a-45, inclusive, of the Connecticut General Statutes, as amended. The Inland Wetlands Commission is authorized to regulate any activity within 100 feet "measured horizontally from the boundary of any wetland or watercourse."

Watershed Conditions

Water Quality Standards:

The 1972 Federal Clean Water Act requires all states to designate uses for all waterbodies within their jurisdictional boundaries, and to test waters to determine if they are meeting their designated use(s). Flat Brook's designated uses include potential drinking water supplies, habitat for fish and other aquatic life and wildlife, recreation, navigation, and industrial and agricultural water supply. Flat Brook has not been meeting its designated use for recreation due to periodic high levels of *Escherichia coli* from unknown sources.

The State of Connecticut Department of Energy and Environmental Protection Water Quality Standards (effective February 25, 2011) set water quality criteria for *E. coli* as defined in Table 3. For Flat Brook, the criteria for *Freshwater – All other recreational uses* was applied. For recreational contact, excluding designated and non-designated swimming areas, the single sample maximum is 576 colony-forming units (cfu) per 100 milliliters of water and the maximum sample set geometric mean is less than 126 cfu/100 ml.

Available Monitoring/Resource Data:

Bacteria Data:
In 2012, ECCD collected bacteria data from seven sites on Flat Brook and its tributaries over an eight week period. In addition, water quality data from several sources was reviewed as part of this investigation. ECCD reviewed data from the CT DEEP Ambient Water Quality Probabilistic Bacteria Monitoring program from 2002 to 2009 (Appendix A), and the Town of Ledyard MS-4 program from 2006 to 2012 (Appendix B). The locations of the sampling sites for the three agencies are depicted in Figure 10.

Table 3: State of Connecticut Water Quality Criteria for Indicator Bacteria for Freshwater

DESIGNATED USE	CLASS	INDICATOR	CRITERIA
Freshwater			
Drinking Water Supply (1) Existing / Proposed	AA	Total coliform	• Monthly Moving Average less than 100/100ml • Single Sample Maximum 500/100ml
Potential	A	----	--------
Recreation (2)(3) Designated Swimming (4)	AA, A, B	*Escherichia coli*	• Geometric Mean less than 126/100ml • Single Sample Maximum 235/100ml
Non-designated Swimming (5)	AA, A, B	*Escherichia coli*	• Geometric Mean less than 126/100ml • Single Sample Maximum 410/100ml
All Other Recreational Uses	**AA, A, B**	***Escherichia coli***	• **Geometric Mean less than 126/100ml** • **Single Sample Maximum 576/100ml**

Table Notes:
(1) Criteria applies only at the drinking water supply intake structure.
(2) Criteria for the protection of recreational uses in Class B waters do not apply when disinfection of sewage treatment plant effluents is not required consistent with Standard 23.
(3) See Standard # 25.
(4) Procedures for monitoring and closure of bathing areas by State and Local Health Authorities are specified in: Guidelines for Monitoring Bathing Waters and Closure Protocol, adopted jointly by the Department of Environmental Protection and the Department of Public Health, May 1989, revised April 2003 and updated December 2008.
(5) Includes areas otherwise suitable for swimming but which have not been designated by State or Local authorities as bathing areas, waters which support tubing, water skiing, or other recreational activities where full body contact is likely.

Bacteria levels at six of the seven sites sampled by ECCD failed to meet Connecticut water quality standards (Table 4). The only site that met water quality standards was Site 01, Flat Brook at Pinelock Drive. Bacteria levels generally increased toward the upper parts of the watershed. The three sampling locations at Long Cove Road (sites 05, 06, and 07) had the highest levels of bacteria (Figure 11), exceeding allowable limits by 355% (Site 05), 340% (Site 06) and 488% (Site 07).

During the bacteria sampling, volunteers recorded the weather for the past three days on the field form. The bacteria results were plotted against rainfall for the months of July and August (Figure 12). It was noted that bacteria levels spiked during and immediately after periods of rainfall, and that during dry periods, bacteria levels were generally low (Table 4).

Figure 10: Flat Brook Bacteria Sampling Locations

Streamwalk Data:

ECCD staff members and trained volunteers conducted Streamwalks in October and November of 2012, utilizing a stream corridor assessment protocol developed by the USDA Natural Resource Conservation Service. Stream corridor data, including the type and extent of riparian vegetation, land use adjacent to the stream, the presence, absence and/or extent of conditions (called areas of concern) such as impacted riparian buffers, stream bank erosion, stormwater outfalls, modified stream channels, algae, visual water conditions, fish passage barriers, and trash, were documented on field forms developed by NRCS. Photographs and GPS (Global Positioning System) locations, or waypoints, were taken of the noted conditions. The GPS data was downloaded into a geographic information system (GIS) data layer for analysis. The Streamwalk field data was tabulated and evaluated by ECCD, in order to identify and prioritize areas where watershed management implementation practices would be most beneficial.

Streamwalks were conducted on 2.5 stream miles along Flat Brook and four out of five tributaries (Figure 13). Tributary 2 was not surveyed because it was an intermittent, not perennial, stream. The approved Streamwalk protocol specifies that only perennial streams should be surveyed. The Streamwalk data, including field notations, GPS data and digital photographs, was processed and compiled into a database. The documented areas of concern are quantified by stream in Table 5. The locations of the Areas of Concern are displayed in Figure 14. Descriptions of each Area of Concern are provided in Appendix C. Areas of Concern are depicted on reach-level maps in Appendix D.

Table 4. ECCD Flat Brook Bacteria Data Summary

Site		7/9/12	7/16/12	7/23/12	7/30/12	8/6/12	8/13/12	8/20/12	8/27/12	Geomean
FB01	Flat Brook at	86	**1400**	10	**910** (1)	310	50	40	20	117
FB01D	Pinelock Drive		**690**						52	
FB01B						<10				
FB02	Flat Brook at	170	**790**	150	**730**	**750**	150	63	120	**229**
FB02D	1636 Baldwin Hill Road Pond	140								
FB2B				<10			<10		<10	
FB03	Flat Brook at	130	360	31	370	**960**	70	200	120	**175**
FB03D	Baldwin Hill Road									
FB03B		<10	<10							
FB04	Tributary 1	86	**930**	150	**910**	**670**	150	74	160	**245**
FB04D	Baldwin Hill Road									
FB04B								<10		
FB05	Below Confluence of Tribs 3 & 5	150	**990**	130	**1000**	**1000**	**860**	290	350	**448**
FB05D	Long Cove Road			160		**1200**				
FB05B					<10					
FB06	Tributary 3	270	**750**	110	**770**	**810**	570	280	200	**428**
FB06D	Long Cove Rd				**990**		470			
FB06B										
FB07	Tributary 5	300	**800**	110	**690**	**1200**	**670**	400	**4900** (2)	**615**
FB07D	Long Cove Rd							440		
FB07B										
wet/dry past 3 days		dry	wet	dry	wet	wet	wet	wet	dry	
(1) lab comment – FB01 – 7.30.12: " bacteriological results may be unreliable. Insufficient airspace was left in sample container."										
(2) FB07 – 7.27.12: stream very low – believe sample collector may have disturbed sediment – jcr										
old text indicates the single sample or geometric mean exceeded the allowable limit.										

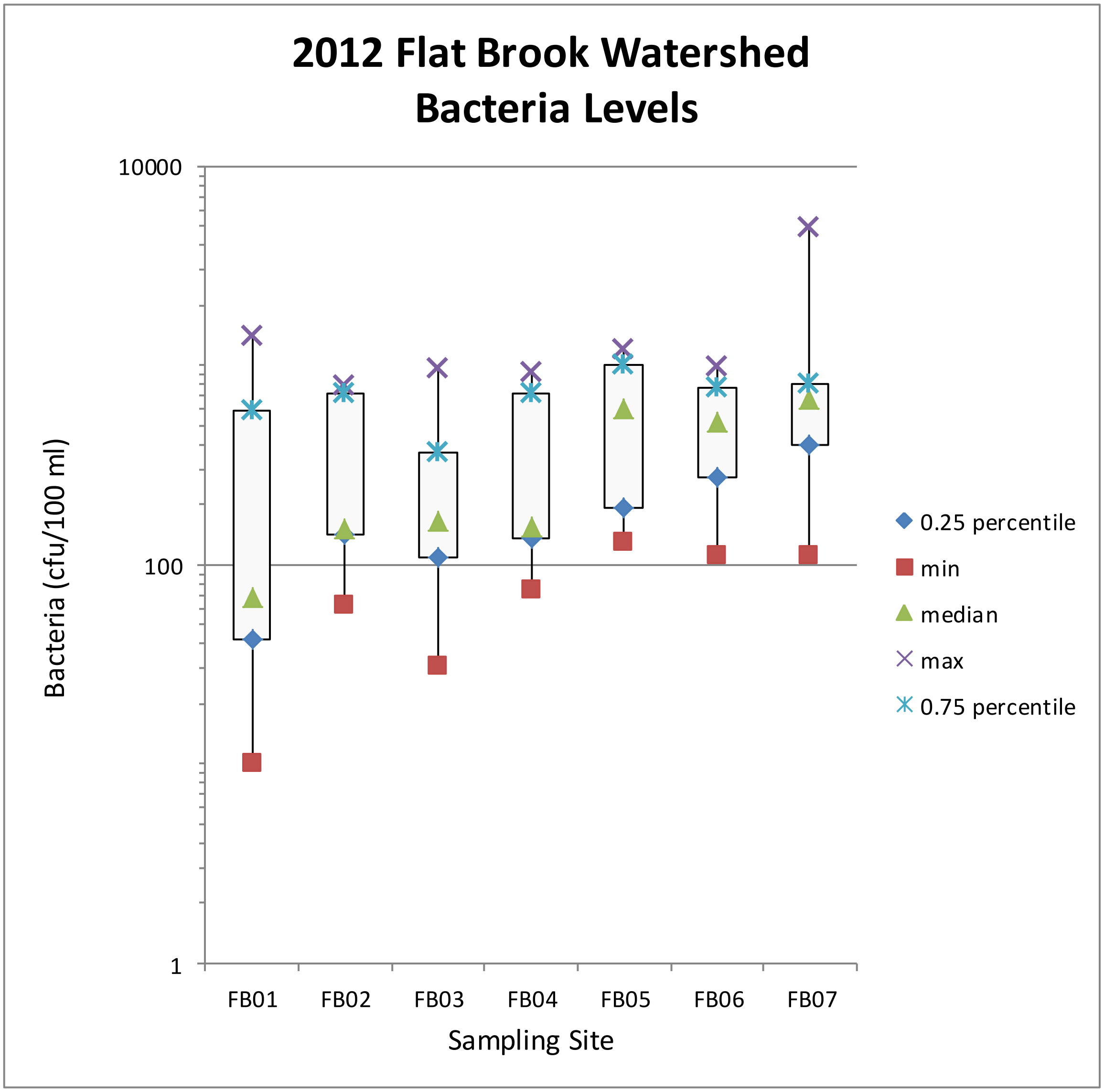

Figure 11: Distribution of bacteria sample results by sampling site.

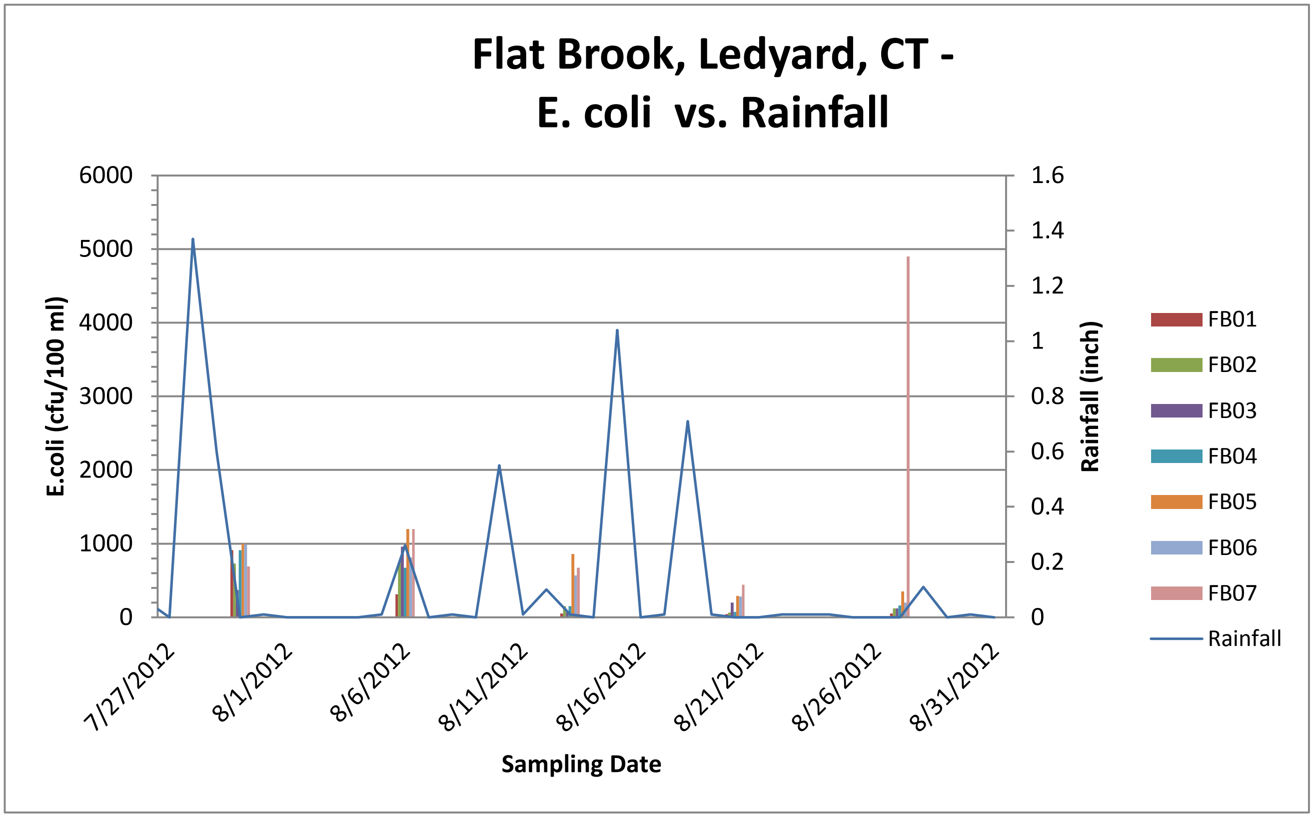

Figure 12: Stream sample bacteria levels plotted against rainfall

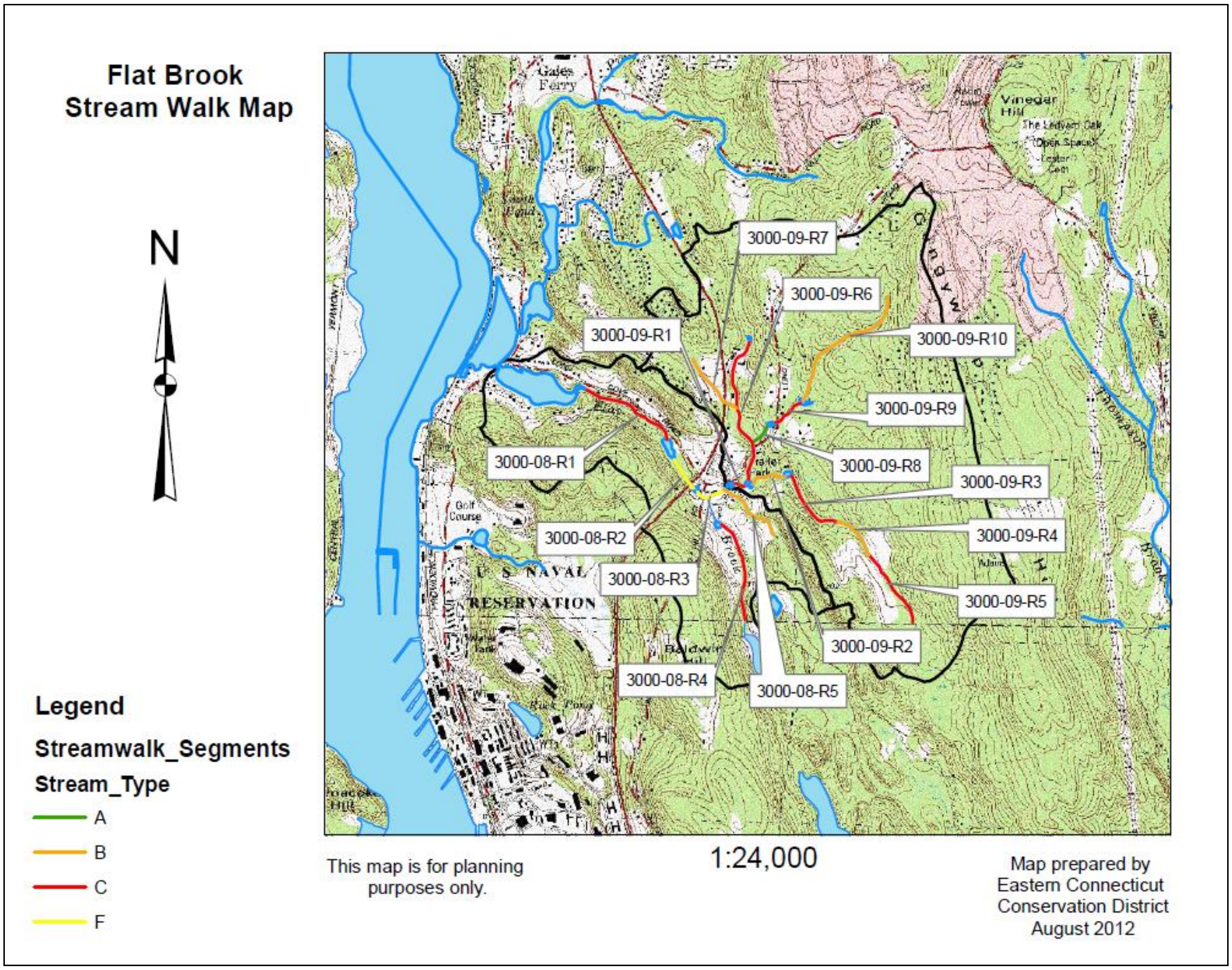

Figure 13: Streamwalk segments and stream types of Flat Brook and tributaries, Ledyard, CT.

Table 5: Summary of Identified Areas of Concern by Stream

Area of Concern	Flat Brook	Tributary 1	Tributary 2	Tributary 3	Tributary 4	Tributary 5	Total
Erosion	3	0	-	1	0	2	**6**
Fish Barrier	3	2	-	1	0	3	**9**
Stormwater Outfall	12	1	-	9	0	4	**26**
Modified Channel	3	1	-	1	0	0	**5**
Degraded Buffer	7	2	-	6	0	3	**18**
Trash/Debris	2	0	-	3	0	0	**5**
Visual Water Conditions	5	2	-	1	0	0	**8**

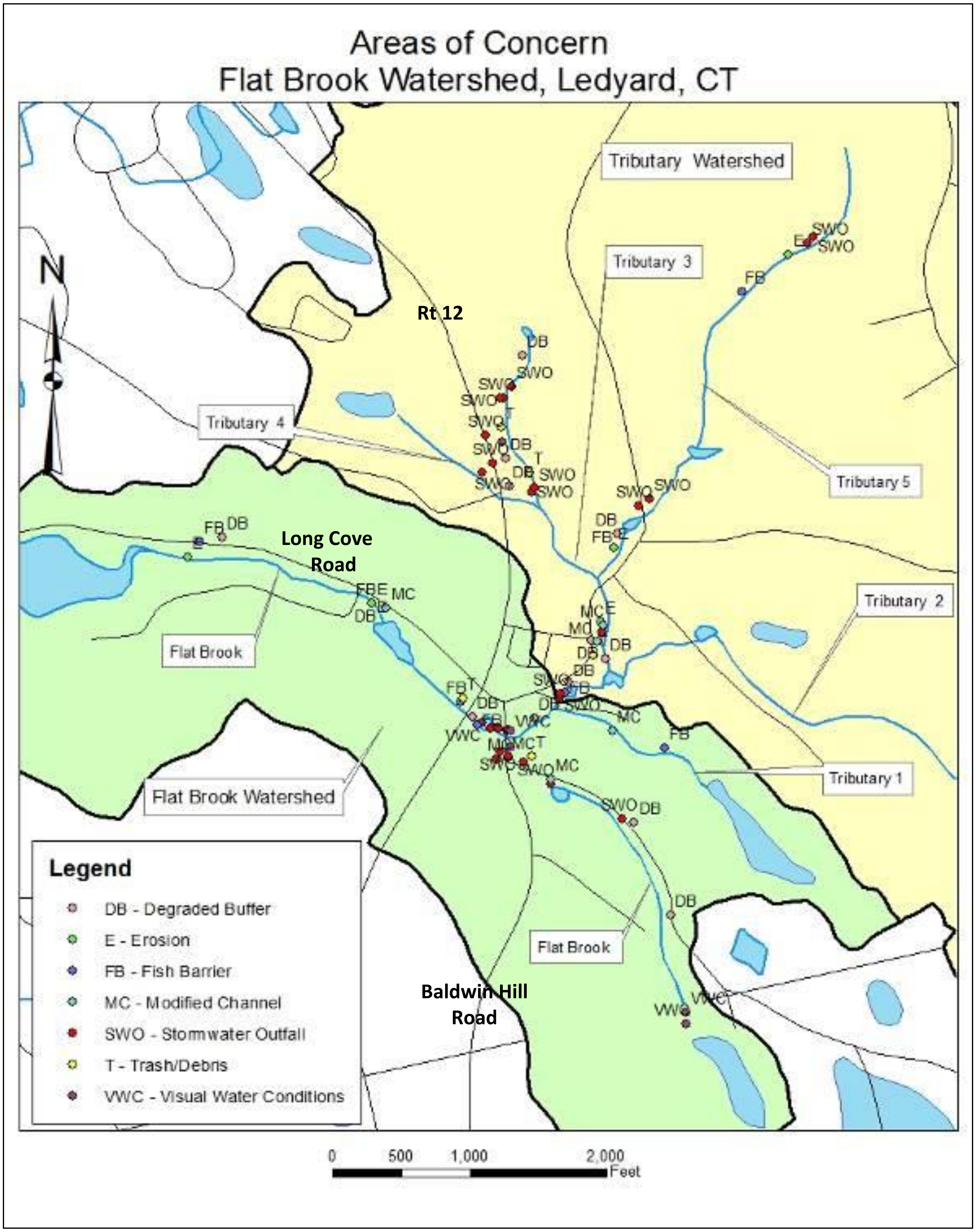

Figure 14: Locations and distribution of Areas of Concern identified during the Flat Brook Streamwalks.

EPA Nine-Element Abbreviated Watershed-based Plan for Flat Brook

A. Identification of Pollutant Causes and Sources

The Eastern Connecticut Conservation District (ECCD) and volunteers conducted a track down survey in the Flat Brook watershed in the Gales Ferry section of Ledyard, Connecticut in 2012 to identify potential sources of nonpoint source pollution that have degraded water quality in Flat Brook. Flat Brook was listed in the 2008 State of Connecticut 303d report as impaired for recreation due to periodic elevated levels of *Escherichia coli*. As part of the trackdown, ECCD and volunteers collected water samples for bacteria analysis from multiple sites on Flat Brook and its tributaries. ECCD reviewed water quality data from the CT Department of Energy and Environmental Protection Ambient Water Quality Monitoring program and the Town of Ledyard's MS-4 program.

While the primary purpose of the Flat Brook track down survey was to identify possible sources of indicator bacteria that have impaired Flat Brook for recreational contact, ECCD and volunteers also conducted stream corridor assessments of Flat Brook and perennial tributaries to document conditions that may contribute to nonpoint source (NPS) pollution to Flat Brook, including stormwater outfalls, degraded riparian buffers, stream bank erosion, trash and visual water conditions.

Possible sources of indicator bacteria and other NPS contaminants to Flat Brook are listed in Table 6.

Table 6: Possible Sources of Bacterial and Other NPS Contaminants to Flat Brook

Possible Source	Location	Number of Occurrences
Urban Runoff/ Stormwater Outfalls	Along Rt. 12, Long Cove Road, Baldwin Hill Road	20% of watershed/ 26 outfalls
Septic Systems	Watershed-wide	One known failure, multiple repairs
Wildlife/Pets	Watershed-wide	~73% of watershed undeveloped
Geese/Waterfowl	Headwater pond in Groton; 1636 Baldwin Hill Road Pond	80 – 120 Canada geese (spring/fall migrations)
Degraded Buffer	Long Cove Road & Baldwin Hill Road	13
Erosion	Multiple locations	6
Trash/Debris	Multiple locations	5
Gravel Mining/Silviculture	Baldwin Hill Road	3
Agriculture/Livestock	Long Cove Road	1
Atmospheric Deposition	Watershed-wide	unknown

Potential Sources of Fecal Coliform Bacteria and Nonpoint Source Pollution (NPS) in the Flat Brook Watershed:

Nonpoint Sources:

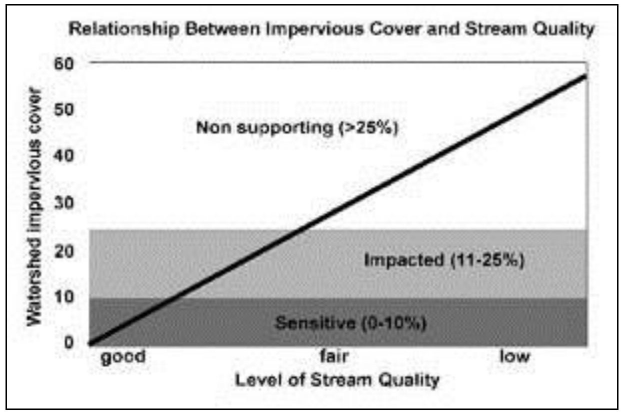

Figure 15: Relationship between impervious cover and stream quality (Schueler, 1994).

Urban Runoff/Stormwater Systems: Numerous studies, including those conducted by Schueler (1994) have established that the amount of impervious cover in a watershed directly impacts stream quality (Figure 15). Approximately 20% of the Flat Brook watershed is developed, exceeding the recommended impervious cover of 10% or less for good stream quality. The developed area is focused along main transportation corridors including Route 12, which has significant commercial and high density residential development, including apartments and condominiums; Baldwin Hill Road, which has a cluster of industrial/commercial development; and Long Cove Road, which has several older homes and high density mobile home parks. These areas have locally high levels of impervious cover which contribute to stormwater runoff and NPS loading.

Twenty-six stormwater outfalls were identified during the Streamwalk survey, including pipe outfalls, leak offs and catch basins placed directly over, and discharging to, stream channels. All of these outfalls discharge untreated stormwater directly into the receiving streams. In areas of urban development, these outfalls can contribute multiple pollutants to Flat Brook, including bacteria, nutrients from pets and lawn care products, trash and debris, and oils, greases and other chemicals from vehicles.

Traditional storm drain systems may be a significant source of fecal bacterial loading, either via the transmission of contaminated surface stormwater runoff to the receiving waterbody, or by loading of bacteria originating in the storm drain. Recent studies have indicated that *E. Coli* and other fecal coliform bacteria, once introduced into the environment, can survive and proliferate in the biofilm (scum) layer that forms in storm drain pipes (Skinner *et al*, 2010).

Septic systems: Bacteria loading as a result of malfunctioning or under-functioning septic systems is distinctly possible in the Flat Brook watershed. There is no public sewer service in the Flat Brook watershed; rather, all structures have on-site subsurface sewage treatment (septic) systems. Figure 16 depicts the septic suitability of soils in the

Flat Brook watershed. Note that the least suitable soils occur in the most heavily developed areas, along RT 12, Long Cove Road, and Baldwin Hill Road.

Conditions in the Flat Brook watershed that could contribute to bacterial loading from septic systems include:

- Poor soils - shallow depth to bedrock; excessively well-drained soils; poorly drained soils.
- Seasonal high groundwater - in areas with poor soil and shallow depth to bedrock, septic systems could become temporarily seasonally inundated
- Designated Floodways and Flood Zones - threats from septic system inundation due to flooding along Flat Brook, especially in Baldwin Hill Road area. Figure 17 depicts Federal Emergency Management Agency (FEMA) flood zones and designated floodways.
- Older structures – septic systems and other waste treatment systems (cess pools, etc.) installed prior to adoption of current standards, or systems at or nearing the end of design life. At least one septic system failure and numerous repairs are known in the area immediately adjacent to Flat Brook at Baldwin Hill Road/Long Cove Road.

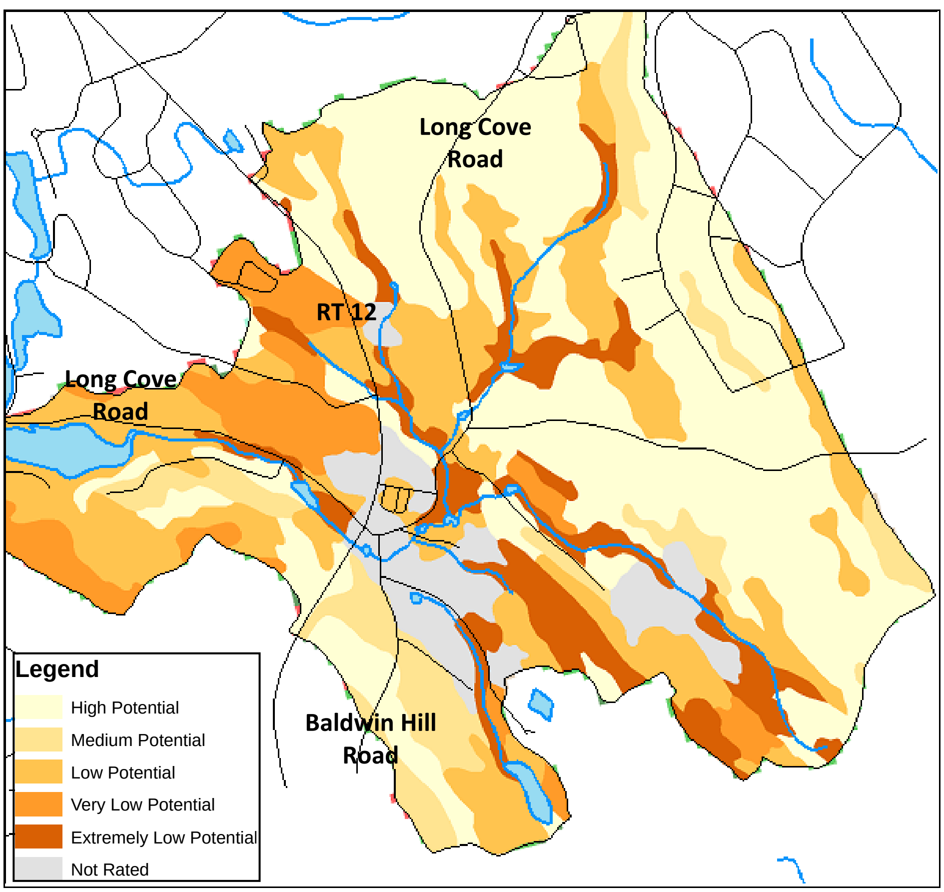

Figure 16: Septic Suitability of soils in the Flat Brook watershed (USDA-NRCS Web Soil Survey).

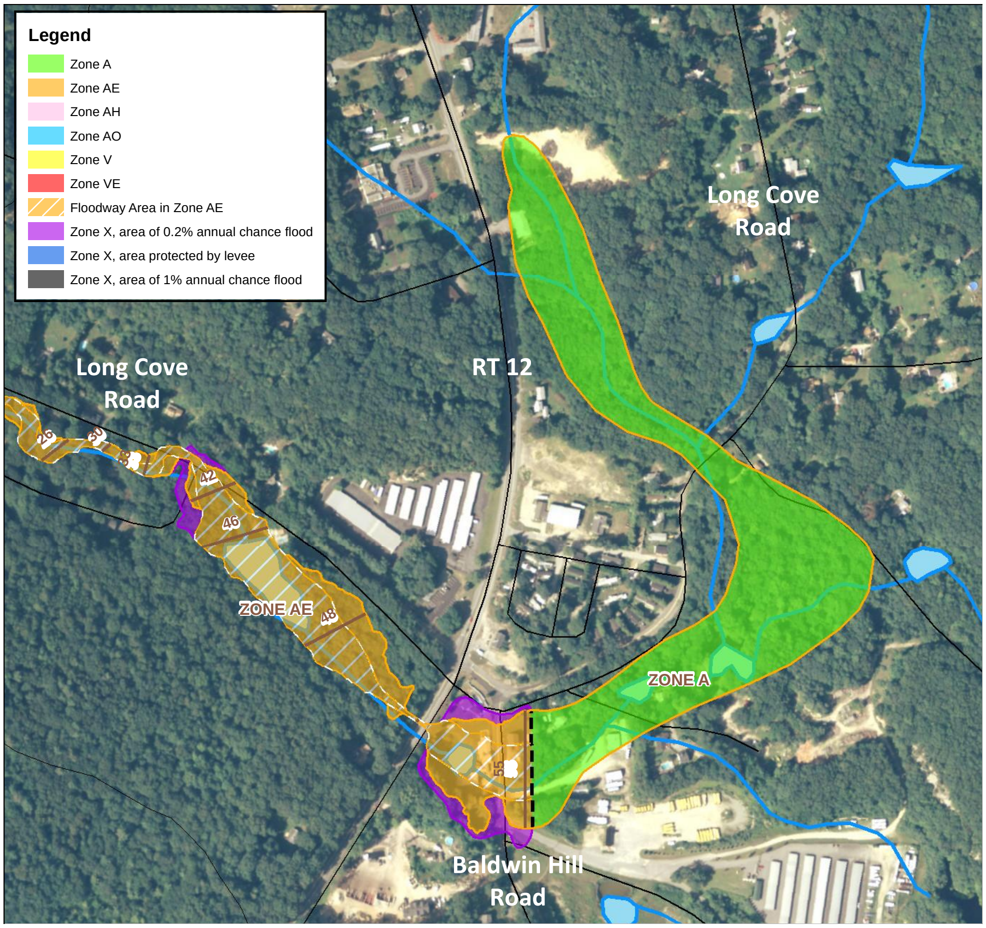

Figure 17: Flood zones and designated floodways in the RT 12/Baldwin Hill Road/Long Cove Road area (FEMA 2012).

<u>Geese/Waterfowl</u>: Flocks of approximately 80 to 120 migratory Canada geese stop over at the Flat Brook headwater ponds in Groton each year, and approximately 10 - 12 birds stay and nest. Numerous Canada geese also stop at 1363 Baldwin Hill Road, and several will stay and nest. Migratory geese can produce seasonal plugs of bacteria, temporarily inflating bacteria levels in watercourses. According to a study conducted by Alderisio and DeLuca (1999), the "average [wet] weights ranged from 5.85 to 9.98 grams, depending on the season. Fecal coliform bacteria contents (probably mostly Escherichia coli) averaged from 4,500 to 24,200,000 colony-forming units per gram of feces, depending on the season and year of observation." No geese were noted during the watershed investigation, which was conducted from July to November 2012.

<u>Wildlife/Pets:</u> With approximately 70% of the watershed undeveloped (forest or forested wetlands), wildlife could make up a portion of the bacterial load. For instance, CT DEEP (2007) conservatively estimates the population of whitetail deer

in southeast Connecticut to be 40 – 60 animals per square mile, contributing to "background" or natural levels of bacteria found in the watershed.

In urban settings, pet feces, particularly dog feces, can be a significant source of bacteria. However, during the watershed investigation, few dogs were noted. No areas in the Flat Brook watershed, such as dog parks, where dog populations might be concentrated, were identified. In one area, a dog tie-out was noted by the bank of Flat Brook; however, no bacteria sampling was conducted downstream of that site to determine potential effects.

Degraded Riparian Buffers: Eighteen instances of degraded riparian buffers were noted during the Streamwalks. Degraded riparian buffers included areas with minimal buffer width, minimal riparian vegetation and the presence of invasive plant species. Degradation reduces the capacity of the buffer vegetation to slow stormwater run-off and absorb any nutrients or contaminants contained in the run-off. The presence of invasive plants within riparian buffers diminishes buffer quality. Invasive plant species out-compete native plants and reduce the habitat benefits that native plants provide for native biota.

Stream Bank Erosion: Six instances of stream bank erosion were noted along Flat Brook and its perennial tributaries. Stream bank erosion delivers sediment to the stream, and ultimately to the receiving waterbody, along with any nutrients or contaminants that may be adsorbed to the eroded sediments. Re-deposited sediments can degrade the stream substrate, damaging in-stream habitat for aquatic species. Several instances of stream bank erosion were associated with degraded buffers.

Trash/Debris: Five instances of trash and debris in the streams or riparian corridor were observed during Streamwalks. In some instances, the debris appeared to be windblown or waterborne, and could have been the result of recent flood events. In other instances, materials, such as bicycles and other items appeared to be deliberately placed, and were very old. Trash and debris has the capacity to introduce a number of pollutants into Flat Brook, including bacteria, particularly if it contains human or animal fecal waste. However, no such trash was noted during the streamwalk of Flat Brook or tributaries.

Gravel Mining/Silviculture: There are two gravel operations and a tree harvesting operation on Baldwin Hill Road. These activities, while not necessarily significant sources of bacteria, can contribute to water quality degradation by opening up large tracts of land to erosion.

Agriculture/Livestock: Despite the generally rural nature of Ledyard and the Flat Brook watershed, there was no significant agricultural activity located in the watershed that could contribute to bacterial loading, and there were no large livestock operations located within the watershed. One property with two to three animals was noted on Long Cove Road. However, the property was of a sufficiently small scale and location that it was determined to not be a likely source of bacteria.

Atmospheric Deposition: Atmospheric deposition is not a known source of *E. coli*, though it could be a source of other contaminants (atmospheric nitrogen and other airborne particulates).

Potential Sources of Habitat Degradation:

Fish Barrier: Nine fish barriers were noted during the Streamwalk of Flat Brook and tributaries, including five dams, two debris dams, and two stonewalls which had been constructed across the stream channel. While fish barriers do not contribute to nonpoint source pollution, they do inhibit the passage of fish up and downstream, and result in degradation of habitat, and fragmentation and isolation of fish populations. In coastal areas, this can be especially critical for fish species such as alewife and herring that need to access inland spawning habitats.

Modified Channel: Five modified channels were noted during the streamwalk, including channelization associated with dams, and channelization as part of residential landscaping schemes. Stream channelization can contribute to NPS pollution by increasing storm flow velocities, which can result in bank erosion, channel scouring and downstream deposition, degrading water quality and in-stream habitat.

Visual Water Conditions: Eight instances of visual water conditions were noted. Orange flocculent associated with iron bacteria was observed in several locations along Flat Brook and tributaries. "Oily" deposits associated with iron bacteria were also noted on the water surface in many areas. An intermittent tributary to Flat Brook that originated at a stormwater pond at the base of Baldwin Hill exhibited significant algal growth, indicating potentially high nutrient loads. Excessive growth of Eurasian water milfoil (Myriophyllum spicatum) was noted in a pond at the headwaters of Flat Brook, just over the town line in Groton.

Possible Point Sources:

Potential point sources can include National Pollutant Discharge Elimination System (NPDES) permits, Phase I and ll Stormwater permits and confined animal feeding operation (CAFO) permits. A review of existing CT DEEP and US EPA data indicated that no NPDES Industrial Stormwater Permits have been issued in the Flat Brook watershed. The Town of Ledyard is subject to and in compliance with a Phase ll Small Municipal Separate Storm Sewer System (MS4) permit. Two commercial/industrial discharge sites, identified as CIP1 and CIP2, are located in the vicinity of Flat Brook on Baldwin Hill Road (see Figure 10 for sampling locations). There are no CAFOs located in the Flat Brook watershed.

Hazardous waste:

There are two known hazardous waste sites in the Flat Brook watershed. The first is a former gasoline station located on Route 12 at the intersection with Long Cove Road. This gasoline station is listed in the CT DEEP *List of Contaminated or Potentially Contaminated Sites* (as defined by §22a-134f of the Connecticut General Statutes) due to a leaking underground storage tank. CT DEEP records indicate that remediation of this site is completed. The second is a former asphalt plant/sand and gravel quarry located on Baldwin Hill Road. This site is listed in CT DEEP'S *Brownfield Sites in Connecticut* (as defined by Connecticut General Statutes §32-9kk(a)(1)) due a trichloroethylene (TCE) leak. TCE is a volatile organic chemical primarily used to remove grease from fabricated metal parts and in the production of some textiles (US EPA).

Numerous commercial and industrial businesses located in the vicinity of Baldwin Hill Road, including a plumbing and heating business, a school bus depot, a landscaping business, storage facilities, a logging operation, and sand and gravel operations, use or store a variety of chemicals that could pose environmental problems should leaks or spills occur.

B. Load Reduction Assessment

1. Estimation of Pollutant Load Reductions

E. coli load reductions are proposed in Table 7, based on the results of bacteria sampling conducted by ECCD and volunteers in 2012. ECCD utilized this data in lieu of data collected by CT DEEP from 2006-2009, which was used to develop a bacteria TMDL for Flat Brook, both because the ECCD data is more recent, and because it covers a larger geographic area and is more representative of varying water conditions within the watershed.

Table 7: Bacteria Load Reduction Targets for Flat Brook

Site	Description	Geomean	% Limit	% Reduction Needed
1	Flat Brk @ Pinelock Dr	117	93	0
2	Flat Brk @ 1636 Baldwin Hill Road pond	229	182	45
3	Flat Brk @ Baldwin Hill Rd	175	139	28
4	Tributary 1 at Baldwin Hill Rd	245	194	49
5	Confluence of Tributaries 3 & 5 @ Long Cove Rd	448	355	72
6	Tributary 3 @ Long Cove Rd	428	340	71
7	Tributary 5 @ Long Cove Rd	615*	488	80

* Includes outlier value that may be result of sampling error, actual figure may be lower.

2. Load Reduction Estimates for each Pollutant to be targeted in the watershed-based plan

While E. coli is the primary pollutant of concern as the cause of the impairment to Flat Brook, it is important to evaluate other pollutants that may degrade water quality as well. To estimate loads and load reductions, EPA recommends the use of models which have been developed for these purposes. In the absence of available pollutant data, ECCD selected the Simple Method (Schueler, 1987) to estimate pollutant loads and load reductions in the Flat Brook watershed:

$L = 0.226(P)(P_j)(R_v)(C)(A)$, where:

L = pollutant loading in pounds per year
P = annual precipitation in inches
P_j = the fraction of annual rainfall that does not produce measurable runoff
R_v = runoff coefficient
C = pollutant concentration in mg/l
A = site area in acres
0.226 = conversion factor

The Simple Method calculates pollutant loading in pounds per year, based on watershed drainage area, impervious cover, annual precipitation and storm water runoff pollutant concentrations. Pollutant load reductions required to meet Connecticut water quality standards are depicted in Table 8.

Table 8: Pollutant Load reductions required to meet water quality standards

Pollutant Load in Lbs/year	**TSS**	**TP**	**TN**	**Zn**	**TPH**	**DIN**
Current Pollutant Loads (Σ Tables 10-12)	268,387	537	4544	105	1370	648
Pre-developed Watershed Loads	55,741	75	972	0	0	132
% Load Reduction Required	**79%**	**86%**	**79%**	**100%**	**100%**	**80%**

Pollutant load contributions for various land use/land covers were gleaned from several sources including the National Stormwater Quality Database (Maestre & Pitt, 2005), the National Urban Runoff Program (EPA, 1993) and the University of New Hampshire Stormwater Center (Table 9). Pollutant load concentrations for seven common pollutants associated with Non-Point Source pollution, including total suspended solids (TSS), total phosphorous (TP), total nitrogen (TN), zinc (Zn) as an indicator for other metals, total petroleum hydrocarbons (TPH), and dissolved inorganic nitrogen (DIN), as an indicator of industrial, municipal and agricultural waste, were calculated.

In order to better characterize pollutant loading, the Flat Brook watershed was divided into three sub-watersheds of less than 1 square mile each. The sub-watersheds are depicted in Figure 18. In order to calculate load reductions, a forested condition was assumed as a typical pre-development land cover for Connecticut. Pollutant loads for each sub-watershed are depicted in Tables 10, 11 and 12.

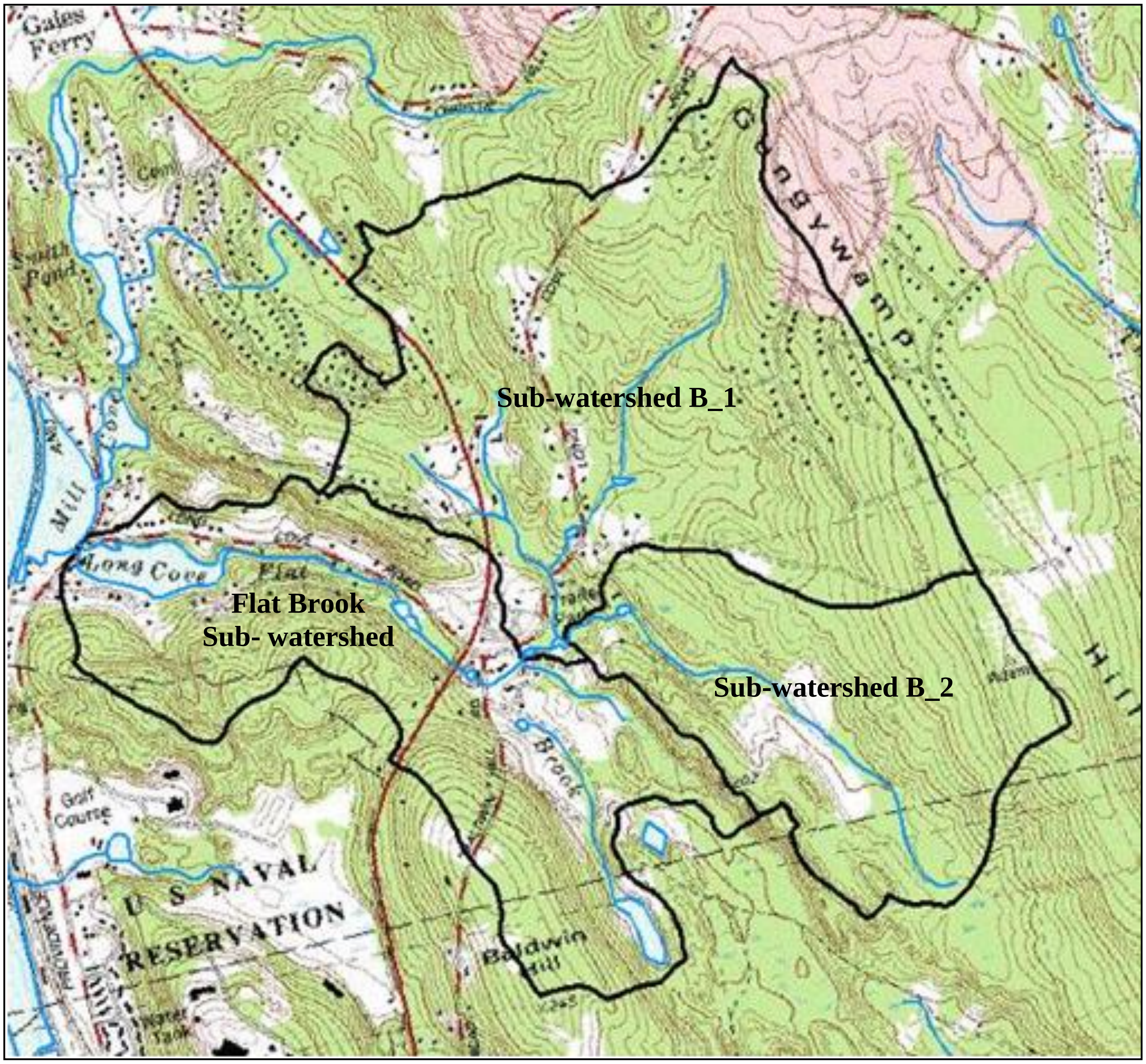

Figure 18: Local watersheds delineated for pollutant loading calculations.

Table 9: Pollutant Load Contribution “C” for each Land Use/Land Cover Type
(pollutant concentration contained in runoff mg/l)

Land use/Land cover	TSS	TP	TN	Zn	TPH	DIN
Low Density Residential	60	0.38	2.1	0.16	0.5	0.51
Medium Density Residential	60	0.3	2.1	0.18	1.25	0.344
High Density Residential	60	0.3	2.1	0.22	1.5	0.344
Commercial Development	58	0.25	2.6	0.15	3	0.324
Industrial Development	50	0.23	2.1	0.17	3	0.324
Institutional Development	58	0.27	2.1	0.67	3	0.521
Transportation	99	0.25	2.3	0.15	3	0.375
Turf and Grass	357	1	2.92	0	0	0.215
Pasture	145	0.38	2.2	0	0	0.65
Forest	90	0.1	1.5	0	0	0.215
Wetlands	0	0.38	1.5	0	0	0
Bare Ground	1000	0.38	1.5	0	0	0
Sources: 1) National Stormwater Quality Database (NSQD), v. 1.1-9/4/05 by Maestre &Pitt						
2) National Urban Runoff Program (NURP), 1983						
3) University of New Hampshire Stormwater Center						

Table 10: Pollutant Loading (lb/yr) for each Land Use/Land Cover Type in the Flat Brook sub-watershed

Land use/Land cover	**TSS**	**TP**	**TN**	**Zn**	**TPH**	**DIN**
Low Density Residential	3727.22	23.61	130.45	9.94	31.06	31.68
Medium Density Residential	1646.91	8.23	57.64	4.94	34.31	9.44
High Density Residential	1776.93	8.88	62.19	6.52	44.42	10.19
Commercial Development	2010.96	8.67	90.15	5.20	104.02	11.23
Industrial Development	3936.69	18.11	165.34	13.38	236.20	25.51
Institutional Development	0.00	0.00	0.00	0.00	0.00	0.00
Transportation	7365.59	18.60	171.12	11.16	223.20	27.90
Turf and Grass	22171.52	62.11	181.35	0.00	0.00	13.35
Pasture	2409.68	6.32	36.56	0.00	0.00	10.80
Forest	52008.19	57.79	866.80	0.00	0.00	124.24
Wetlands	0.00	44.46	175.51	0.00	0.00	0.00
Bare Ground	28156.78	10.70	42.24	0.00	0.00	0.00
Σ (lbs/yr)=	**125210.48**	**267.47**	**1979.35**	**51.14**	**673.21**	**264.35**

Table 11: Pollutant Loading (lb/yr) for each Land Use/ Land Cover Type in Sub-watershed B_1

Land use/Land cover	TSS	TP	TN	Zn	TPH	DIN
Low Density Residential	5428.38	34.38	189.99	14.48	45.24	46.14
Medium Density Residential	2714.19	13.57	95.00	8.14	56.55	15.56
High Density Residential	535.19	2.68	18.73	1.96	13.38	3.07
Commercial Development	1884.64	8.12	84.48	4.87	97.48	10.53
Industrial Development	0.00	0.00	0.00	0.00	0.00	0.00
Institutional Development	0.00	0.00	0.00	0.00	0.00	0.00
Transportation	15958.29	40.30	370.75	24.18	483.58	60.45
Turf and Grass	13419.95	37.59	109.77	0.00	0.00	8.08
Pasture	92.38	0.24	1.40	0.00	0.00	0.41
Forest	84464.81	93.85	1407.75	0.00	0.00	201.78
Wetlands	0.00	15.74	62.12	0.00	0.00	0.00
Bare Ground	4459.94	1.69	6.69	0.00	0.00	0.00
Σ (lbs/yr)=	**128,957.76**	**248.16**	**2,346.68**	**53.63**	**696.23**	**346.02**

Table 12: Pollutant Loading (lb/yr) for each Land Use/Land Cover Type in Sub-watershed B_2

Land use/Land cover	TSS	TP	TN	Zn	TPH	DIN
Low Density Residential	30.81	0.20	1.08	0.08	0.26	0.26
Medium Density Residential	0.00	0.00	0.00	0.00	0.00	0.00
High Density Residential	0.00	0.00	0.00	0.00	0.00	0.00
Commercial Development	0.00	0.00	0.00	0.00	0.00	0.00
Industrial Development	0.00	0.00	0.00	0.00	0.00	0.00
Institutional Development	0.00	0.00	0.00	0.00	0.00	0.00
Transportation	25.42	0.06	0.59	0.04	0.77	0.10
Turf and Grass	275.02	0.77	2.25	0.00	0.00	0.17
Pasture	3071.81	8.05	46.61	0.00	0.00	13.77
Forest	9660.32	10.73	161.01	0.00	0.00	23.08
Wetlands	0.00	1.17	4.62	0.00	0.00	0.00
Bare Ground	1155.54	0.44	1.73	0.00	0.00	0.00
Σ (lbs/yr)=	**14,218.93**	**21.42**	**217.89**	**0.12**	**1.03**	**37.37**

C. Watershed Best Management Practices

1. Identification of Critical Areas

Best Management Practices (BMPs) may have the greatest impact on water quality if they are implemented in critical areas, e.g. areas in which the greatest potential for pollutant loading occurs, or areas which have extenuating conditions (such as seasonal flooding or poor soils) which increase the likelihood of pollutant loading. Critical areas identified in the Flat Brook watershed include:

- Commercial development on Rt. 12: Commercial development along Route 12 is subject to greater amounts of impervious cover, due to the presence of commercial buildings, parking lots and driveways. This area also has older, traditional storm water conveyance systems which deliver untreated storm water runoff to the receiving waterbodies.
- Long Cove Road: Soils along Long Cove Road east of Route 12 are rated as extremely low and very low septic suitability. Older homes may have subsurface sewage waste systems that were installed prior to the adoption of current standards.
- Mobile Home Park on Long Cove Road: This mobile home park represents intensified development which may increase runoff due to impervious cover, and is located in soils of very low septic suitability.
- Cluster of homes on shared driveway off Long Cove Road: These homes are located an area designated by FEMA as flood zone A, and are subject to periodic flooding which could temporarily inundate existing septic systems.
    - Commercial/industrial development on Baldwin Hill Road: These businesses are located an area designated by FEMA as flood zones A and AE, and a floodway, and are subject to periodic flooding which could temporarily inundate existing septic systems.

2. Location of Potential Best Management Practices

The locations of Potential Best Management Practices are described in Table 13. The table identifies the target pollutants and pollutant sources; BMP locations based on Areas of Concern identified during the Flat Brook Streamwalks; GPS locations, street address if no GPS location is available, or watershed-wide if the implementation should target the entire watershed; recommended management measures; and if the BMP is located in critical area. Locations of potential BMPs are depicted on reach level maps in Appendix D. Additional information on Areas of Concern, including photo-documentation, is included in the Flat Brook Stream Assessment database, which was submitted to CT DEEP with this report.

Table 13: Recommended Best Management Practices for Specific Areas of Concern, with Cost Estimates

Pollutant Source	Pollutant	Reach/ Waypoint	Site ID Number	Location	Critical Area?	BMP Recommendation	Cost Estimate
Urban Runoff	Storm Water Volume	Flat Brook 3000-08-R2	-	Pond behind 1636 Baldwin Hill Road	Yes	Dredge accumulated sediment from pond to increase storage capacity	$5000 (Est. 400 cy removed @ $12.50/cy)
		Intermittent Tributary to Flat Brook 3000-08	-	Pond at Base of Baldwin Hill, south of 1636 Baldwin Hill Road	Yes	Dredge accumulated sediment from pond to increase storage capacity	$3937.50 (Est. 315 cy removed @$12.50/cy)
		Tributary 1 3000-08-R3/ Tributary 3 3000-09-R1	-	Baldwin Hill Road/ Long Cove Road	Yes	Evaluate tributaries upstream of Baldwin Hill Road for stormwater detention potential	Professional Engineer @ $100/hr
		Flat Brook 3000-08-R1, R2 & R3	-	Baldwin Hill Road/ Long Cove Road/ Pinelock Drive	Yes	Enforce "Zero Run-off" in floodway areas	Municipal staff time/salaries
	Storm Water Volume/NPS	-	-	Watershed-wide	-	Promote use of low impact development techniques (LID) to maintain on-site infiltration of storm water	Municipal staff time/salaries
	NPS	-	-	Watershed-wide	-	Employ municipal "good housekeeping" practices	Municipal staff time/salaries

Table 13: Recommended Best Management Practices for Specific Areas of Concern, with Cost Estimates (cont.)

Pollutant Source	Pollutant	Reach/ Waypoint	Site ID Number	Location	Critical Area?	BMP Recommendation	Cost Estimate
Storm Water Outfalls	NPS	Flat Brook 3000-08-R1 #120	SWO 1	Pinelock Drive	No	Install catch basin insert to provide stormwater treatment	$200 - $6500 per unit
		Flat Brook 3000-08-R2 #136	SWO 3	At 1636 Baldwin Hill Road, over stream	Yes	Remove storm drain, install bio-retention basin connected to existing storm drain system	$7,000 ($2,000 storm drain removal, $5,000 bio-retention basin)
		Flat Brook 3000-08-R2 #137	SWO 4	Near 1636 Baldwin Hill Road, over stream	Yes	Install catch basin insert to provide stormwater treatment	$200 - $6500 per unit
		Flat Brook 3000-08-R2 #138	SWO 5	Baldwin Hill Rd At Flat Brook	Yes	Install catch basin insert to provide stormwater treatment	$200 - $6500 per unit
		Flat Brook 3000-08-R3 #139	SWO 6	Storm drain pipe at Flat Brook headwall, Baldwin Hill Rd	Yes	Install up to 3 tree filter units at existing catch basins up-gradient of stormwater outfall	$25,500 ($8,500/unit x 3 units)
	Sediment	Flat Brook 3000-08-R4 #175	SWO 8	Dbl. stormwater outfall at Baldwin Hill Rd, opp. 1348 Baldwin Hill Road	Yes	Remove accumulated sediment, install sediment forebay	$2,500 -$5,000 (dependent on forebay size)
		Flat Brook 3000-08-R4 #176	SWO 9	Asphalt leak-off near 1636 Baldwin Hill Road	Yes	Remove accumulated sediments	Municipal staff time/salaries

Table 13: Recommended Best Management Practices for Specific Areas of Concern, with Cost Estimates (cont.)

Pollutant Source	Pollutant	Reach/ Waypoint	Site ID Number	Location	Critical Area?	BMP Recommendation	Cost Estimate
Storm Water Outfalls	Sediment	Tributary 1 3000-09-R3 #146	SWO 13	Dirt leak-off into Tributary 3 at shared drive off Long Cove Rd, north of Baldwin Hill Rd	Yes	Remove deposited sediments in Tributary 3, stabilize stream bank with erosion control blanket and seed	$350 (materials, municipal staff time/salaries)
	NPS	Tributary 3 3000-09-R6 #204	SWO 15	Stormwater outfall along Long Cove Road, north of shared driveway	Yes	Move outfall away from stream, install energy dissipater	$2200 (materials, municipal staff time/salaries)
		Tributary 3 3000-09-R6a #225	SWO 16	Asphalt leak-off to Tributary 3 at Christie Hills Condos, Rt. 12	Yes	Remove leak-off, re-grade to direct stormwater flow onto grassed area	$1,000 (materials, labor)
		Tributary 3 3000-09-R6a #226	SWO 20	Large asphalt leak-off and storm drain directly over Trib. 3 at Christie Hills Condos, Rt. 12	Yes	Install 25 ft. of asphalt curb to redirect water to storm drain, install catch basin insert to provide stormwater treatment	Curb: $500 (25 ft x $20 lineal ft) CB Insert: $200 - $6500 per unit
		Tributary 5 3000-09-R8 #238	SWO 23	Stormwater outfall to Tributary 5 near 986 Long Cove Road	Yes	Install catch basin insert to provide stormwater treatment	$200 - $6500 per unit
		Tributary 5 3000-09-R10 #248 & #249	SWO 25 SWO 26	Catch basins over Tributary 5 at Hyde Park Road	No	Install catch basin inserts to provide stormwater treatment	$200 - $6500 per unit

Table 13: Recommended Best Management Practices for Specific Areas of Concern, with Cost Estimates (cont.)

Pollutant Source	Pollutant	Reach/ Waypoint	Site ID Number	Location	Critical Area?	BMP Recommendation	Cost Estimate
Septic Systems	Bacteria/ Nutrients	-	-	Watershed-wide	-	Conduct education program for homeowners on septic system BMPs	$500 (1000 brochures @ $0.50/pc)
		-	-	Watershed-wide	-	Initiate septic system inspection program	Ledge Light Health District staff time/salaries
		3000-09-R6 to R10	-	Tributaries 3 and 5	Yes	Conduct additional bacteria sampling to bracket potential bacteria source location	$0 – Water Quality Monitor Volunteers
		-	-	Watershed-wide	Yes	Conduct bacteria DNA source tracking to determine host species	$700 per sample ($175 per test for 4 host species)
		3000-08-R3/R5 3000-09-R1/R6/ R8/R9	-	Long Cove Road/ Baldwin Hill Road	Yes	Deploy optical brightener pads in critical areas	$0 – Water Quality Monitor Volunteers
		3000-08-R3/R5 3000-09-R1/R6/ R8/R9	-	Long Cove Road/ Baldwin Hill Road	Yes	Encourage or facilitate dye testing if optical brightener pad testing is positive, or if septic system failure is suspected	$75 - $125 per test
		-	-	RT 12, Baldwin Hill Road, Long Cove Road	Yes	Install sewer lines to relieve suspected under-functioning septic systems and septic systems in flood-prone areas	To be determined by qualified engineer

Table 13: Recommended Best Management Practices for Specific Areas of Concern, with Cost Estimates (cont.)

Pollutant Source	Pollutant	Reach/ Waypoint	Site ID Number	Location	Critical Area?	BMP Recommendation	Cost Estimate
Wildlife/ Pets	Nutrients/ Bacteria	-	-	Watershed-wide	-	Encourage pet waste management BMPS	$500 (1000 brochures @ $0.50/pc)
		-	-	Long Cove Road	No	Manure BMPS - Cover manure piles, compost manure, remove manure from site	Lg. tarp: $80 - $100 3-bay Composter: $1200 - $1500 Dumpster: $50 - $300/mo
Geese/ Waterfowl	Nutrients/ Bacteria	3000-08-R2 #106	-	Pond at 1636 Baldwin Hill Road	Yes	Establishment of riparian buffer to discourage waterfowl	$0 (allow existing riparian vegetation to grow)
		3000-08-R4 #193	-	Headwater ponds in Groton	No	Establishment of riparian buffer to discourage waterfowl	$0 (allow existing riparian vegetation to grow)
Degraded Riparian Buffers	Nutrients/ Sediment/ Bacteria	-	-	Watershed-wide	-	Conduct public outreach and education on function and value of riparian buffers	$500 (1000 brochures @ $0.50/pc)
		Flat Brook 3000-08-R1 #124	DB 1	Pinelock Drive	No	Revegetate 70 linear ft of 15 ft wide buffer	$100-$500 (0.02 acres @ $500 - $4500 per acre)

Table 13: Recommended Best Management Practices for Specific Areas of Concern, with Cost Estimates (cont.)

Pollutant Source	Pollutant	Reach/ Waypoint	Site ID Number	Location	Critical Area?	BMP Recommendation	Cost Estimate
Degraded Riparian Buffers	Nutrients/ Sediment/ Bacteria	Flat Brook 3000-08-R1 #125	DB 2	Long Cove Road	No	Revegetate 75 linear feet of 15 ft wide buffer	$100-$500 (0.03 acres @ $500 - $4500 per acre)
		Flat Brook 3000-08-R1 #127	DB 3	Long Cove Road	No	Revegetate 100 linear ft of 15 ft wide buffer	$100 - $500 (0.03 acres @ $500 - $4500 per acre)
		Flat Brook 3000-08-R2 #102-110	DB 5	1636 Baldwin Hill Road	Yes	Revegetate 350 linear ft of 5 ft wide buffer around pond	$0 (Allow existing vegetation to grow in)
		Tributary 3 3000-08-R3 #144	DB 6	Behind 1360 Baldwin Hill Road	Yes	Manage invasive plant species and increase width of 425 linear ft long buffer	$150 - $700 (0.05 acres @ $500 - $4500 per acre)
		Flat Brook 3000-08-R4 #193	DB 7	Headwater ponds in Groton	No	Revegetate 1400 linear ft of 10 ft wide buffer	$0 (Allow existing vegetation to grow in)
		Flat Brook 3000-08-R4 #178 & #180	DB 10 & DB 11	Ponds at 1348 Baldwin Hill Road	Yes	Remove invasive plants along 625 linear feet of pond perimeters, plant large shade trees	$600 - $1000 (15 shade trees at $50/tree, labor)

Table 13: Recommended Best Management Practices for Specific Areas of Concern, with Cost Estimates (cont.)

Pollutant Source	Pollutant	Reach/ Waypoint	Site ID Number	Location	Critical Area?	BMP Recommendation	Cost Estimate
Degraded Riparian Buffers	Nutrients/ Sediment/ Bacteria	Tributary 3 3000-09-R1 #199-200	DB 14 & DB 15	Two ponds on Tributary 3 on shared drive off Long Cove Road	Yes	Revegetate 550 linear feet of 15 ft wide buffer along two ponds	$100 - $500 (0.03 acres @ $500 - $4500 per acre)
		Tributary 3 3000-09-R6a #226-229	DB 18	Christie Hills Condos, RT 12	Yes	Revegetate 375 linear feet of 15 ft wide buffer	$600 - $2000 (0.2 acres @ $500 - $4500 per acre)
		Tributary 3 3000-09-R6a #219	DB 19	Commercial site for sale on RT 12	Yes	Revegetate 270 linear feet of 15 ft wide buffer	$300 - $1500 (0.09 acres @ $500 - $4500 per acre)
		Tributary 5 3000-09-R9 #241	DB 21	979 Long Cove Road	Yes	Revegetate 100 linear feet of 15 ft wide buffer	$100 - $500 (0.03 acres @ $500 - $4500 per acre)
		Tributary 5 3000-09-R10 #250	DB 22	20 Hyde Park Road	No	Revegetate 65 linear feet of 15 ft wide buffer, manage invasive plant species	$0 (Allow existing vegetation to grow in)
Stream Bank Erosion	Sediment	Flat Brook 3000-08-R1 #123	ER 1	DS of Pinelock Drive	No	Stabilize and restore 35 ft of stream bank	$300 (0.007 mi @ $46,000/mi)
		Flat Brook 3000-08-R1 #127	ER 2	DS of Pinelock Drive	No	Stabilize and restore100 ft of stream bank	$870 (0.02 mi @ $46,000/mi)

Table 13: Recommended Best Management Practices for Specific Areas of Concern, with Cost Estimates (cont.)

Pollutant Source	Pollutant	Reach/ Waypoint	Site ID Number	Location	Critical Area?	BMP Recommendation	Cost Estimate
Stream Bank Erosion	Sediment	Flat Brook 3000-08-R1 #131	ER 3	Gorge just US of Long Cove	No	Stabilize and restore 20 ft of stream bank	$175 (0.004 mi @ $46,000/mi)
		Tributary 3 3000-09-R6 #206	ER 4	Long Cove Road	Yes	Stabilize and restore 30 ft of stream bank	$260 (0.006 mi @ $46,000/mi)
Trash/ Debris Reduction	NPS	Flat Brook 3000-08-R2 #113	TD 1	DS of RT 12	Yes	Organize/conduct stream clean-up.	Volunteer time
		Flat Brook 3000-08-R4 #168	TD 2	Near 1358 Baldwin Hill Road	Yes	Organize/conduct stream clean-up.	Volunteer time
		Tributary 3 3000-09-R6a #201	TD 3	East side Long Cove Road, US of shared drive	Yes	Organize/conduct stream clean-up.	Volunteer time
		Tributary 3 3000-09-R6a #222	TD 4	Behind houses south of Christie Hills Condos	No	Organize/conduct stream clean-up.	Volunteer time
		Tributary 3 3000-09-R6a #218	TD 5	Behind Gales Ferry Animal Hospital	No	Organize/conduct stream clean-up.	Volunteer time

Table 13: Recommended Best Management Practices for Specific Areas of Concern, with Cost Estimates (cont.)

Pollutant Source	Pollutant	Reach/ Waypoint	Site ID Number	Location	Critical Area?	BMP Recommendation	Cost Estimate
Gravel Mining/ Silviculture	Sediment/ Chemicals	Flat Brook 3000-08-R4/ Tributary 1 3000-08-R5		Behind 1015 Long Cove Road and at 1348 Baldwin Hill Road	Yes	Employ municipal permitting and oversight, approved E&S plan, stormwater mgmt. plan, operator BMPs	Municipal staff time/salaries, property owner staff time/salaries
Modified Channels	Habitat Degradation/ Storm water volume	Flat Brook 3000-08-R4 #171-182	MC 3 & MC 4	1358 Baldwin Hill Road	Yes	Restore 530 ft of culverted stream channel	$6,425 (0.1 mi @ $64,000/mi)
Fish Barriers	Habitat Degradation	Flat Brook 3000-08-R1 #126	FB 1	DS of Pinelock Drive	No	Remove remains of stone wall across stream channel	$0 – manually remove stones from stream channel
		Flat Brook 3000-08-R1 #130	FB 2	Just upstream of mouth of Long Cove	No	Remove 4 ft high concrete dam, or install fish passage	Dam removal: $1,500 - $50,000
		Flat Brook 3000-08-R2 #112	FB 3	Historic stone mill dam DS of RT 12 on Long Cove Road	No	Install fish passage	To be determined by qualified engineer
		Tributary 1 3000-08-R5 #151	FB 4	Behind 1358 Baldwin Hill Road	Yes	Remove rip rap that has been placed across stream channel, reducing flow	$500 (labor and materials)

Table 13: Recommended Best Management Practices for Specific Areas of Concern, with Cost Estimates (cont.)

Pollutant Source	Pollutant	Reach/ Waypoint	Site ID Number	Location	Critical Area?	BMP Recommendation	Cost Estimate
Fish Barriers	Habitat Degradation	Tributary 1 3000-08-R5 #164	FB 5	Behind 1358 Baldwin Hill Road	Yes	Remove large concrete blocks placed across stream channel to access rear land, install culvert	$12,000 (materials and labor)
		Tributary 3 3000-09-R1 #197	FB 6	Two small dams at pond on the shared drive off Long Cove Road	Yes	Remove 2 ft high dams or install fish passage	Dam removal: $1,500 - $50,000

3. **Description of Potential Best Management Practices**

Urban Runoff BMPs – Urban sources of pollution are inherently diverse, and cover the spectrum of nonpoint source pollutants. Successful efforts to reduce NPS are equally diverse and involve participation from the municipal and public sectors.

Municipalities are responsible for maintaining much of the impervious surface in urban settings, including roads, sidewalks, municipal buildings and parking lots. Employment of municipal "Good Housekeeping" or Best Management Practices, such as frequent street sweeping and storm drain cleaning, may reduce the amount of NPS discharging to local waterways. Municipalities may also replace older catch basins with newer units that treat grease and oils, trash, sediment and so forth.

Municipal land-use boards and staff are able to influence the management of NPS through encouragement of thoughtful site design, enforcement of erosion and sediment control regulations, and utilization of the effective reduction of impervious surfaces. This includes incorporating low impact development (LID) techniques in site plans located in highly developed areas (those exceeding 25% impervious cover), and retrofitting existing stormwater infrastructure to treat and reduce the volume of storm runoff. Land use boards can also improve the quality of runoff by increasing the width of upland review areas for inland wetland permitting functions and mandating wider vegetative buffers when issuing building and subdivision permits in areas adjacent to water courses. Municipal land use staff should continue to enforce the zero stormwater runoff requirements in the FEMA floodway on Baldwin Hill and Long Cove Roads.

Outreach programs informing the public about the causes and consequences of water quality impairments, and educational programs identifying behavioral change required to reduce impairments should be undertaken. Educational programs may address simple behavior changes that will protect and improve water quality such as properly managing animal waste, reducing the use of lawn chemicals, washing cars on lawns (rather than paved surfaces where runoff may enter the storm drain system) or using commercial carwash facilities.

While water quality watershed-wide would benefit from the utilization of these recommendations, commercial areas along Route 12 and commercial/industrial development in the Baldwin Hill Road area would benefit most from utilization of runoff BMPs.

Storm Water Outfalls Retrofits – Water quality retrofits of stormwater outfalls identified during the Streamwalks should be evaluated. The replacement of existing storm drain units with units containing sediment traps, bio-skirts, trash hoods, inserts, et cetera, will provide some measure of water quality treatment that is currently lacking. Where possible and feasible, additional treatment methods, including level spreaders, infiltration trenches, sediment forebays, and/or bio-retention systems should be considered. These methods would be most effective along the Route 12 corridor, Baldwin Hill Road and Long Cove Road, where the majority of stormwater outfalls were identified.

Septic Systems Inspections and BMPs – Homeowners should be encouraged to engage in septic system best management practices, including regular pumping of their holding tanks in accordance with the manufacturer or installer's recommendations (usually every two years). This recommendation would be most effective along Baldwin Hill Road and Long Cove Road, in flood-prone areas and in areas with soils with poor septic suitability.

Pet Waste Management - Residents should be encouraged to employ pet waste best management practices, including picking up and disposing of pet waste, covering manure piles, composting manure, or removing manure from the site. Pet waste management would be most effective on a watershed-wide scale.

Geese/Waterfowl - Migratory geese and other waterfowl appeared to be problematic only during spring and fall migrations, when they utilized ponds at the headwaters of Flat Brook in Groton, and the small pond at 1363 Baldwin Hill Road. A few waterfowl were reported to stay and nest after migration. The establishment of riparian vegetation around these ponds will discourage geese from utilizing the ponds and surrounding lawns for foraging.

Riparian Buffer Restoration – Most of the degraded riparian buffers noted during the Streamwalks were located on private land, along Long Cove Road and Baldwin Hill Road, which presents a challenge to implementing buffer restoration. Public education on the benefits and services of riparian buffers may encourage some landowners to restore or manage riparian buffers on their land. Expanded monitoring and enforcement of permitted riparian land uses by municipal land use commissions could lead to enhanced maintenance of vegetative buffers in these areas.

Stream Bank Erosion Mitigation – Stream bank erosion documented during the Streamwalks appeared to be on private land, presenting a challenge to mitigation. Several areas, particularly along Long Cove Road, were associated with degraded riparian buffers, indicating that restoration of the degraded vegetative buffers would likely stabilize the stream banks. Public education on the benefits of riparian buffers may reduce instances of stream bank erosion.

Trash/Debris Reduction – A public education/social marketing campaign on the link between littering and water quality should be instituted watershed-wide.

Local organizations and business may want to sponsor clean-up days, either watershed-wide or focused on the watershed streams. The municipalities should enact ordinances regarding littering, if none exist, and enforce any existing ordinances.

Gravel Mining/Silviculture - Gravel mine and logging operators at the facilities at 1348 Baldwin Hill Road and 1015 Long Cove Road should be encouraged to use best management practices in order to minimize the effects of their activities on water quality, including erosion and sedimentation control, stormwater management, and management and handling of on-site chemicals. Municipal staff should enforce any applicable permit requirements or other oversight.

Modified Channel Retrofits – Where practicable, areas where the watershed streams have been channelized should be restored to their natural state, reconnecting the streams to their flood plains and providing attenuation of storm flows. Where this is not possible, the channelized stream sections should be evaluated to determine if they are properly sized to convey peak storm run-off, especially in the flood-prone areas on Baldwin Hill Road and Long Cove Road.

Fish Passage Barriers - Fish passage barriers degrade aquatic wildlife habitat by fragmenting fish populations and excluding anadromous fish from their historic spawning grounds. Fish barriers along the lower reaches of Flat Brook should be evaluated to determine if removal or installation of alternative fish passageways are feasible. Fish passage barriers on Tributary 1 on Baldwin Hill Road should be evaluated for removal and/or replacement, including a large pile of cobbles placed across the stream channel, and large concrete blocks also placed across the stream channel to create a driveway crossing, both of which restrict the free flow of water.

D. Financial and Technical Assistance Needed

Reasonable financial estimates for each management practice have been provided in Table 13 above, however costs associated with the development and implementation of each proposed measure will need to be estimated individually as management strategies are undertaken, and as cost estimates may change over time. Financial assistance in the form of grants is available from multiple sources, including federal, state, and local sources, including but not limited to Community Development grants, Clean Water Act §319 grants, Long Island Sound program grants, National Fish and Wildlife Fund grants, and environmental and professional organizations grants. Funds may also be available in the form of donations and in-kind services provided by local businesses, environmental organizations, and local volunteers. Municipalities can build funding for stormwater management improvements into their operating budgets.

Numerous grant applications are strengthened by the availability of cost matches and in-kind services. A sampling of funding opportunities is listed in Table 14.

Technical assistance may be provided by organizations such as the USDA/NRCS, CT DEP, Conservation Districts, US Fish & Wildlife Service, and others, depending on the nature of the implementation. Watershed stakeholders, who may be instrumental in implementing plan recommendations and assisting with obtaining funding, are identified in Table 15.

Table14: Potential Funding Sources		
Funding Source	**Award Amount**	**Contact Information**
CT DEEP CWA §319 Grant Program		MaryAnn Nusom Haverstock (860) 424-3347
http://www.ct.gov/dep/cwp/view.asp?a=2719&q=325588&depNav_GID=1654		
CT DEEP Clean Water Fund		Susan Hawkins (860) 424-3325
http://www.ct.gov/dep/cwp/view.asp?a=2719&q=325578&depNav_GID=1654		
CT DEEP Long Island Sound License Plate Program	$25,000.	Kate Brown (860) 424-3034
http://www.ct.gov/dep/cwp/view.asp?a=2705&q=323782&depNav_GID=1635		
CT OPM Small Town Economic Assistance Program (STEAP)		Barbara Rua (860) 418-6303
http://www.ct.gov/opm/cwp/view.asp?a=2965&q=382970&opmNav_GID=1793		
US EPA Healthy Communities Grant Program		Jennifer Padula (617) 918-1698
http://www.epa.gov/region1/eco/uep/hcgp.html		
NOAA Coastal Management Programs		
http://coastalmanagement.noaa.gov/funding/welcome.html		
US EPA Five Star Restoration Grant Program	$20,000 average	Myra Price (202) 566-1225
http://www.epa.gov/owow/wetlands/restore/5star		
NFWF Long Island Sound Futures Fund		Lynn Dwyer lynn.dwyer@nfwf.org
http://www.nfwf.org/AM/Template.cfm?Section=Charter_Programs_List&Template=/TaggedPage/TaggedPageDisplay.cfm&TPLID=60&ContentID=19108		
NRCS Wetlands Reserve Program (WRP)		Javier Cruz (860) 887-3604 x307
http://www.ct.nrcs.usda.gov/programs/whip/whip.html		
NRCS Environmental Quality Incentives Program (EQIP)	$300,000 over a six year period	Javier Cruz (860) 887-3604 x307
http://www.ct.nrcs.usda.gov/programs/eqip/eqip.html		
Wildlife Habitat Incentive Program (WHIP)		Javier Cruz (860) 887-3604 x307
http://www.ct.nrcs.usda.gov/programs/whip/whip.html		
Rivers Alliance of CT Watershed Assistance Small Grants Program	$5000, 40% non-federal funding match req’t	Rivers Alliance of CT (860) 361-9349
http://www.riversalliance.org/watershedassistancegrantrfp.cfm		
Corporate Wetlands Restoration Partnership (CWRP)		
http://ctcwrp.com/home		
CLP Environmental Community Grant Program	$1500	Patricia Baxa
http://www.nu.com/environmental/grant.asp		

Table15: Watershed Stakeholders Roles and Responsibilities	
Stakeholder	Roles/Responsibilities
Town of Ledyard	Administration of MS4 program, enforcement of land use regulations, site plan review/permitting
Ledge Light Health District	Review and approval of septic systems
CT DEEP	Bacteria TMDL, Ambient WQM program
CT DOT	Maintenance of State highways/stormwater systems
ECCD	Water Quality Investigation, Implementations
SCCOG	Regional land use planning
Local Businesses	Conformance with local regulations, BMPs
Watershed Residents	Conformance with local regulations, BMPs

E. Education/Outreach Component

The objective of the education/outreach component of this plan is to raise public awareness of the water quality issues associated with Flat Brook, in order to create an educated public that understands both the issues of nonpoint source pollution and its effects on water quality, and also, actions that can be taken to address the problem. By successfully educating the public, this plan should lead to behavioral change that should result in reduction of NPS to Flat Brook. The Town of Ledyard conducts NPS outreach and education on stormwater pollution prevention through the Public Works page on the Town website (http://www.town.ledyard.ct.us/index.aspx?NID=322) in compliance with requirements of the Small Municipal MS4 permit. The website should be updated to include sources and management measures for bacteria, including septic system BMPs. Potential education topics and potential partners are listed in Table 16 below.

Table 16: Outreach & Education Topics and Partners	
Outreach Topic	**Potential Outreach Partner**
Understanding Non-point Source (NPS) Pollution	CT NEMO, Town of Ledyard
Low impact development (LID)	CT NEMO/CLEAR
Septic System BMPs for Homeowners	Ledge Light Health District
The benefits of vegetated riparian buffers	CT SeaGrant
Invasive plant species identification and control	CT Invasive Plant Work Group (CIPWG), Invasive Plant Atlas of New England (IPANE)
Pet waste management	Town of Ledyard, Ledge Light Health District
Migratory geese/waterfowl mgmt.	CT DEEP Wildlife Division
Anadromous fish mgmt.	CT DEEP Anadromous Fish Program

F. Implementation Schedule

An implementation schedule is beneficial to achieving the goals and objectives of this plan in an expeditious manner. Implementation of the recommended management strategies is scheduled over a 5 year period. A reduction of nonpoint source pollutants, including indicator bacteria, should be noted after implementation of year 1 and 2 recommendations, which target municipal best management practices and home and business owner education. Stormwater pollutant reductions should continue over years 3, 4 and 5 as stormwater retrofits are installed. Successful implementation should yield measurable reductions in the levels of indicator bacteria, with the goal of reducing the level of indicator bacteria for recreational contact to below the standard set by the State of Connecticut Water Quality Standards. Management objectives, milestones, interim measures, and responsible entities are identified in Table 17 below.

G. Measurable Milestones

Measurable milestones are useful to ensure that progress is being made in achieving plan goals. Described in Table 17 below are management objectives and milestones that may be used to measure the progress that the watershed stakeholders are making toward meeting the goals of this watershed plan.

Table 17: Management Objectives & Milestones to Achieve Plan Recommendations

Management Objective 1: Build public awareness of NPS, including sources of nonpoint source pollution and management practices through outreach and education	
Actions/Milestones:	• Identify target audiences • Gather existing educational materials • Create new educational materials as needed • Identify most appropriate venues to disseminate information (e.g. Newspaper, Town website) • Distribute materials to residential and urban watershed residents • Conduct workshops focusing on non-point source issues
BMPs:	Urban Bacteria/NPS Sources
Responsible Parties:	ECCD, CT DEEP, Municipality
Anticipated Products:	Educational materials/workshops
Evaluation:	# educational materials distributed, # workshops conducted
Timeline:	2013-2014

Management Objective 2: Promote Good Housekeeping Practices among municipalities and property owners	
Actions/Milestones:	• Review municipal Good Housekeeping Practices (GHP) • Adopt revised GHPs in priority areas identified in WBP, as needed • Gather existing educational materials • Create new educational materials as needed • Distribute information regarding GHPs to residents in priority areas as identified by WBP
BMPs:	Urban Bacteria/NPS Sources
Responsible Parties:	Municipality/DPW, stakeholders
Anticipated Products:	Revised municipal and property owner maintenance practices
Evaluation:	Adoption of improved GHPs, # educational brochures distributed, reduction in measured bacteria levels
Timeline:	2013-2014

Management Objective 3: Review and strengthen land use regulations pertaining to water quality, erosion and sediment control, stormwater management	
Actions/Milestones:	• Form regulation review team • Review existing land use regulations, municipal ordinances, etc. • Review sample/model regulations pertaining to water quality, E&S control, stormwater mgmt.. • Work with land use staff and boards to develop revised regulations • Adopt new regulations
BMPs:	Stormwater management, E&S control
Responsible Parties:	Municipality, ECCD, NEMO, CT DEEP, SECCOG
Anticipated Products:	Proposed regulation amendments, revised regulations
Evaluation:	Adoption/revision of regulation amendments that effectively address water quality issues
Timeline:	2013-2015

Management Objective 4: Bracket bacteria sources, identify bacteria source hosts	
Actions/Milestones:	• Implement additional bacteria sampling, especially in Tributaries 3 and 5, upstream of sampling sites 5, 6 & 7 • Identify locations for monitoring, based on 2012 bacteria sampling • Design water quality monitoring program • Obtain funding for training and equipment • Recruit and train volunteers • Conduct site monitoring, including DNA source tracking • Report water quality results
BMPs:	Additional data necessary to narrow down sources of bacteria and other NPS
Responsible Parties:	ECCD, CT DEP, Municipality, TLGV
Anticipated Products:	Water quality data, summary report, identification of bacteria host(s)
Evaluation:	# sites monitored, data submitted to appropriate agencies
Timeline:	Begin 2014, ongoing thereafter, as needed

Management Objective 5: Implement structural measures to reduce bacteria and other NPS loading	
Actions/Milestones:	• Review and prioritize implementation sites • Select sites, contact landowners (if private property) to determine level of interest and cooperation • Identify and obtain funding • Develop construction design for BMP implementation • Obtain necessary permits • Construct structural measures • Design and conduct pre- and post-construction monitoring program to assess practice effectiveness
BMPs:	Stormwater management practices
Responsible Parties:	Municipalities, ECCD, private land owners
Anticipated Products:	Prioritized list of implementation sites, BMP design plans, water monitoring data
Evaluation:	# structural measures installed, measured reduction in NPS/bacteria
Timeline:	2014-2018

Management Objective 6: Address pollution from under-performing septic systems	
Actions/Milestones:	• Work with Health District sanitarians to evaluate the residential septic systems in the priority areas as defined by the WBP • Identify potential funding sources for septic repairs • Work with property owners to repair failing systems • Provide educational materials to property owners about septic system BMPs
BMPs:	Septic System BMPs
Responsible Parties:	Municipality, Ledge Light Health District, property owners
Anticipated Products:	Repaired/upgraded septic systems
Evaluation:	# failing systems repaired, # educational brochures distributed
Timeline:	2013-2018

Management Objective 7: Install municipal sewer system	
Actions/Milestones:	• Conduct feasibility study • Conduct outreach on need for municipal sewer • Identify potential funding sources • Obtain funding • Conduct necessary planning/engineering • Install sewer lines in critical areas as identified by WBP
BMPs:	Sewer Line installation
Responsible Parties:	State of CT, Municipality, Ledge Light Health District, property owners
Anticipated Products:	Disconnection of under-performing septic systems
Evaluation:	Ft sewer installed, # connections
Timeline:	2013-2028

Management Objective 8: Restore functionality of riparian corridors	
Actions/Milestones:	• Evaluate and identify priority areas for buffer establishment or invasive species removal • Select sites, contact landowners (if private property) to determine level of interest and cooperation • Identify and obtain funding • Develop site design • Conduct buffer planting or invasive species removal • Conduct pre- and post-planting water quality monitoring
BMPs:	Riparian buffer restoration
Responsible Parties:	Municipalities, ECCD, private land owners
Anticipated Products:	List of priority areas, construction design, photo-documentation, water quality data
Evaluation:	# acres or stream feet restored, reduction in NPS/bacteria
Timeline:	2014-2018

Management Objective 9: Reduce sedimentation	
Actions/Milestones:	• Evaluate and identify priority areas for erosion restoration • Select sites, contact landowners (if private property) to determine level of interest and cooperation • Identify and obtain funding • Develop site design • Conduct stream bank erosion restoration • Conduct pre- and post-planting water quality monitoring
BMPs:	Stream bank erosion restoration
Responsible Parties:	Municipalities, ECCD, private land owners
Anticipated Products:	List of priority areas, construction design, photo-documentation, water quality data
Evaluation:	# acres or stream feet restored, reduction in sediment
Timeline:	2014-2018

Management Objective 10: Improve fish passage	
Actions/Milestones:	• Evaluate and identify priority areas for fish barrier removal or fish ladder installation • Select sites, contact landowners (if private property) to determine level of interest and cooperation • Identify and obtain funding • Develop site design • Conduct fish barrier removal or fish ladder installation
BMPs:	Fish passage improvement
Responsible Parties:	CT DEEP, private land owners
Anticipated Products:	List of priority areas, construction design, removal of barriers/installation of fish ladders
Evaluation:	Number of fish passing
Timeline:	2014-2018

H. Monitoring and Assessment Component

Monitoring is an essential component to determining the effectiveness of Plan implementations. On-going monitoring will provide necessary water quality data to allow watershed managers to assess the effectiveness of BMPs. Water quality monitoring should be coordinated with the implementation of management measures to determine if the desired results (a reduction in the amounts of indicator bacteria) are being achieved.

The following items should be included as part of the monitoring and assessment of Watershed Plan implementations.

1) Establishment and implementation of monitoring activities should be coordinated with watershed project partners.
2) Continuation of municipal MS4 sample collection at the two sites (CIP-1 and CIP-2) on Baldwin Hill Road to assess post-BMP implementation load reductions.
3) Continuation of CT DEEP Ambient Water Quality Probabilistic Bacteria Monitoring program at Flat Brook at Baldwin Hill Road, as part of the five-year rotational basin assessments. This site, just below the confluences of the multiple tributaries to Flat Brook, is an excellent location to document upstream improvements to water quality.
4) If existing data is not available, BMP implementations should include pre- and post-implementation water quality monitoring, as is practicable, to determine effectiveness of BMP in reducing pollutant loading.

5) Comparison of post-BMP water quality monitoring data to bacteria TMDL targets to determine if bacteria load reductions have been achieved. If no load reductions have been achieved, the TMDL may be reassessed, as needed.
6) Comparison of post-BMP implementation data collection to NPS pollutant load targets to determine if NPS pollutant load reductions have been achieved.
7) If monitoring indicates load reduction expectations are not being achieved, watershed stakeholders may investigate the effectiveness of selected BMP practices, and may revise the watershed plan.

I. Implementation Effectiveness

The Connecticut Department of Energy and Environmental Protection's *A Statewide Total Maximum Daily Load Analysis for Bacteria Impaired Waters*, *Appendix 5 – Thames River Watershed Summary* (Appendix E of this document), recommends an 81% reduction of the geometric mean of bacteria data collected from of the 2006-2009 to meet the recently adopted bacteria TMDL, and a 97% reduction to meet the single sample limit of 410 colonies/100 ml.

As implementations are undertaken and completed, water quality data should continue to be collected, evaluated and compared to the TMDL to determine if the implementations are achieving the desired results. Implementation should be considered complete when the above targets are reached or exceeded. Periodic bacteria sampling should be continued, through the Town's MS4 permit, or other water quality monitoring program, to ensure water quality improvements are sustained.

If implementations are not as effective as planned, watershed stakeholders may investigate the effectiveness of selected BMP practices, and may revise the watershed plan.

Next Steps

Following acceptance of the Flat Brook Abbreviated Watershed-based Plan by the CT DEEP, this Plan should be distributed to all the watershed stakeholders for implementation. The plan should also be made available for review by the general public via posting on the CT DEEP, ECCD and Town of Ledyard municipal websites.

In order to ensure the success of the Flat Brook Abbreviated Watershed-based Plan, it is recommended that the stakeholders form a watershed management team to plan and coordinate implementation of Plan recommendations, and meet periodically to review the progress of the implementation strategies outline in this Plan.

The team should develop a work plan based on the plan recommendations, and should devise a process to determine steps to take to implement the plan strategies.

The team should develop and maintain an evaluation process, such as a watershed progress report card, to document completion of Plan recommendations and other activities within the watershed, in order to demonstrate progress towards water quality improvements.

The management team should review and revise the Plan as implementations are completed and as new technology and information becomes available. The management team should solicit input from local, state and federal agencies as appropriate.

The management team should consider initiating additional water quality investigation to further narrow down sources of indicator bacteria identified in this watershed plan, particularly in the tributaries to the north of Long Cove Road, including DNA source tracking to determine the bacterial host species. Identification of the host species will allow watershed managers to target BMPs to the most likely sources, maximizing BMP effectiveness.

Closing

Addressing Flat Brook's water quality issues will be a long term effort. The Eastern Connecticut Conservation District intends to remain an active participant and central point of contact as implementations recommended by this Watershed Based Plan are undertaken.

Any comments or questions regarding this plan should be directed to the Eastern Connecticut Conservation District:

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Appendix A

CT DEEP Ambient Water Quality Probabilistic Bacteria Monitoring Program Data (2002 to 2009)

Trip date	StreamName/ FacilityName	Basin id	Site number	run name	proximity	landmark/facility name	Municipality	Chem Parameter	Value cfu/ 100 ml
8/20/2009	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2009	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	97
8/20/2009	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2009	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	160
8/13/2009	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2009	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	340
8/13/2009	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2009	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	220
7/29/2009	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2009	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	120
7/23/2009	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2009	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	230
7/16/2009	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2009	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	98
7/9/2009	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2009	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	180
6/25/2009	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2009	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	150
6/25/2009	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2009	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	150
6/11/2009	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2009	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	140
6/11/2009	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2009	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	140
6/3/2009	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2009	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	110
8/21/2008	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2008	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	73
8/13/2008	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2008	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	110
8/6/2008	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2008	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	14000
7/30/2008	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2008	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	120
7/23/2008	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2008	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	110
7/16/2008	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2008	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	130
7/9/2008	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2008	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	310
7/2/2008	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2008	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	120
7/2/2008	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2008	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	110

Trip date	StreamName/ FacilityName	Basin id	Site number	Run name	proximity	landmark/facility name	Municipality	Chem Parameter	Value cfu/ 100 ml
6/25/2008	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2008	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	380
6/19/2008	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2008	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	400
6/19/2008	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2008	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	400
6/11/2008	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2008	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	340
6/4/2008	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2008	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	4400
6/4/2008	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2008	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	6100
9/12/2007	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2007	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	10000
9/4/2007	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2007	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	340
9/4/2007	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2007	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	360
8/23/2007	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2007	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	390
8/9/2007	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2007	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	1000
7/26/2007	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2007	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	350
7/26/2007	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2007	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	580
7/19/2007	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2007	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	1300
7/11/2007	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2007	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	450
6/20/2007	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2007	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	380
6/13/2007	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2007	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	420
6/6/2007	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2007	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	350
9/11/2006	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2006	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	96
8/23/2006	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2006	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	85
8/16/2006	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2006	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	220
8/9/2006	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2006	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	120
8/2/2006	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2006	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	200
8/2/2006	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2006	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	240
7/27/2006	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2006	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	61
7/18/2006	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2006	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	220
7/11/2006	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2006	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	1100

Trip date	StreamName/ FacilityName	Basin id	Site number	run name	proximity	landmark/facility name	Municipality	Chem Parameter	Value cfu/ 100 ml
7/3/2006	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2006	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	220
7/3/2006	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2006	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	97
6/28/2006	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2006	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	2600
6/21/2006	Flat Brook	3000	CT 51-02	Probabilistic bacteria 2006	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	300
4/14/2003	Flat Brook	3000	CT 51-02	Probabilistic monitoring winter chem yr. 1	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	10
4/14/2003	Flat Brook	3000	CT 51-02	Probabilistic monitoring winter chem yr. 1	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	30
10/15/2002	Flat Brook	3000	CT 51-02	Probabilistic Monitoring Macroinvertebrate Year 1	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	31
8/13/2002	Flat Brook	3000	CT 51-02	Probabilistic monitoring periphyton/EPA chem yr. 1	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	10
5/8/2002	Flat Brook	3000	CT 51-02	Probabilistic Monitoring Field Checking Year 1	upstream	Baldwin Hill Road	Ledyard	Escherichia coli	10

Appendix B

Town of Ledyard MS-4 Program Data (2006 to 2012)

SAMPLE DATE	LOCATION	TYPE	RECEIVING WATER	RECEIVING BASIN	E.COLI cfu/100 ml
7/12/2006	CIP-1 Baldwin Hill Rd 41°24'21.83"N72°04'30"W	Industrial/Commercial	Thames River	3000	900
12/1/2006	CIP-1 Baldwin Hill Rd 41°24'21.83"N72°04'30"W	Industrial/Commercial	Thames River	3000	220
1/11/2008	CIP-1 Baldwin Hill Rd 41°24'21.83"N72°04'30"W	Industrial/Commercial	Thames River	3000	20
4/28/2008	CIP-1 Baldwin Hill Rd 41°24'21.83"N72°04'30"W	Industrial/Commercial	Thames River	3000	40
6/9/2009	CIP-1 Baldwin Hill Rd 41°24'21.83"N72°04'30"W	Industrial/Commercial	Thames River	3000	4610
7/13/2010	CIP-1 Baldwin Hill Rd 41°24'21.83"N72°04'30"W	Industrial/Commercial	Thames River	3000	>24200
11/10/2011	CIP-1 Baldwin Hill Rd 41°24'21.83"N72°04'30"W	Industrial/Commercial	Thames River	3000	>24200
10/19/2012	CIP-1 Baldwin Hill Rd 41°24'21.83"N72°04'30"W	Industrial/Commercial	Thames River	3000	9210
7/12/2006	CIP-2 Flat Brook Dr 41°24'21.90"N72°04'39"W	Industrial/Commercial	Thames River	3000	500
12/1/2006	CIP-2 Flat Brook Dr 41°24'21.90"N72°04'39"W	Industrial/Commercial	Thames River	3000	100
1/11/2008	CIP-2 Flat Brook Dr 41°24'21.90"N72°04'39"W	Industrial/Commercial	Thames River	3000	100
4/28/2008	CIP-2 Flat Brook Dr 41°24'21.90"N72°04'39"W	Industrial/Commercial	Thames River	3000	600
6/9/2009	CIP-2 Flat Brook Dr 41°24'21.90"N72°04'39"W	Industrial/Commercial	Thames River	3000	24200
7/13/2010	CIP-2 Flat Brook Dr 41°24'21.90"N72°04'39"W	Industrial/Commercial	Thames River	3000	>24200
11/10/2011	CIP-2 Flat Brook Dr 41°24'21.90"N72°04'39"W	Industrial/Commercial	Thames River	3000	>24200
10/19/2012	CIP-2 Flat Brook Dr 41°24'21.90"N72°04'39"W	Industrial/Commercial	Thames River	3000	8160

CIP-1: double HDPE outlets at the small pond at the base of Baldwin Hill opposite the Terra Firma Storage driveway.

CIP-2: Storm water outfall at the headwall on the upstream side of Flat Brook at Baldwin Hill Road.

Appendix C

Streamwalk Area of Concern Summary

Area of Concern Number	Area of Concern Type	GPS	Latitude	Longitude	Date Acquired	Stream/Basin Code/Reach	Location	Description
ER 1	Streambank Erosion	123	41.40928815	-72.0772305	10/15/12	Flat Brook 3000-08-R1	DS of Pinelock Drive	LB erosion 35 ft
ER 2	Streambank Erosion	127	41.40928815	-72.0772305	10/15/12	Flat Brook 3000-08-R1	DS of Pinelock Drive	eroded bank 60-80 ft, no buffer veg
ER 3	Streambank Erosion	131	41.41104424	-72.08153243	10/15/12	Flat Brook 3000-08-R1	gorge just US of Long Cove	LB erosion
ER 4	Streambank Erosion	206	41.40922034	-72.07085883	10/26/12	Tributary 3 3000-09-R6	along Long Cove Road, north of shared drive	erosion RB
ER 5	Streambank Erosion	234	41.41401655	-72.06460183	11/16/12	Tributary 5 3000-09-R8	west side of Long Cove Road	LB erosion
ER 6	Streambank Erosion	251	41.40784973	-72.07166844	11/16/12	Tributary 5 3000-09-R10	20 Hyde Park Drive	right bank erosion
FB 1	Fish Passage Barrier	126	41.40928815	-72.0772305	10/15/12	Flat Brook 3000-08-R1	DS of Pinelock Drive	old dam?
FB 2	Fish Passage Barrier	130	41.41129511	-72.08112147	10/15/12	Flat Brook 3000-08-R1	DS of Pinelock Drive	stone dam with weir boards
FB 3	Fish Passage Barrier	112	41.40698506	-72.07566258	10/15/12	Flat Brook 3000-09-R2	DS Rt 12	rocks, branches, leaves
FB 4	Fish Passage Barrier	151	41.40511111	-72.07086856	10/23/12	Tributary 1 3000-08-R5	behind Terra Firma storage	debris dam 10- 12 ft wide - stone/rip rap placed in stream

Area of Concern Number	**Area of Concern Type**	**GPS**	**Latitude**	**Longitude**	**Date Acquired**	**Stream/Basin Code/Reach**	**Location**	**Description**
FB 5	Fish Passage Barrier	164	41.40502453	-72.07021552	10/23/12	Tributary 1 3000-08-R5	rear of Terra Firma storage facility, dirt road	DS driveway crossing to logging yard - no apparent culvert, made of large concrete blocks, severely restricts stream flow
FB 6	Fish Passage Barrier	197	41.40665003	-72.07298784	10/26/12	Tributary 3 3000-09-R1	shared drive off Long Cove Road	2 small waterfalls in close proximity
FB 7	Fish Passage Barrier	235	41.40946258	-72.07066244	11/16/12	Tributary 5 3000-09-R8	986 Long Cove Road	top of dam at pond at 986 Long Cove Road
FB 8	Fish Passage Barrier	253	41.41386425	-72.06528738	11/16/12	Tributary 5 3000-09-R10	north of Hyde Park Drive	stone wall across stream
FB 9	Fish Passage Barrier	254	41.41379912	-72.06569457	11/16/12	Tributary 5 3000-09-R10	north of Hyde Park Drive	stone wall across stream
SWO 1	Stormwater Outfall	120	41.40928815	-72.0772305	10/15/12	Flat Brook 3000-08-R1	Pinelock Drive directly over brook	storm drain o/Flat Brk
SWO 2	Stormwater Outfall	103	41.40631551	-72.07508792	10/15/12	Flat Brook 3000-08-R2	1636 Baldwin Hill Road	roof gutter outfall
SWO 3	Stormwater Outfall	136	41.40630201	-72.07490587	10/23/12	Flat Brook 3000-08-R2	Baldwin Hill Road	stormdrain at 1636 Baldwin Hill Road
SWO 4	Stormwater Outfall	137	41.40629179	-72.07487309	10/23/12	Flat Brook 3000-08-R2	Baldwin Hill Road	stormdrain at 1636 Baldwin Hill Road
SWO 5	Stormwater Outfall	138	41.40621141	-72.07470076	10/23/12	Flat Brook 3000-08-R2	Baldwin Hill Road	stormdrain over stream at Baldwin Hill Rd
SWO 6	Stormwater Outfall	139	41.40621048	-72.07465961	10/23/12	Flat Brook 3000-08-R3	BaldwinHill Road	SWO at Baldwin Hill Rd

Area of Concern Number	Area of Concern Type	GPS	Latitude	Longitude	Date Acquired	Stream/Basin Code/Reach	Location	Description
SWO 7	Stormwater Outfall	173	41.40569785	-72.07481786	10/23/12	Flat Brook 3000-08-R4	Baldwin Hill Rd at 1st pond, from CB up road	storm outfall 1 ft CPP
SWO 8	Stormwater Outfall	175	41.40569592	-72.07514207	10/23/12	Flat Brook 3000-08-R4	Baldwin Hill Rd	two storm outfalls loaded with sediment
SWO 9	Stormwater Outfall	176	41.40582282	-72.07501617	10/23/12	Flat Brook 3000-08-R4	Baldwin Hill Rd - near 1636 Baldwin Hill Road	leak off towards 1636 Baldwin Hill Road
SWO 10	Stormwater Outfall	177	41.40551219	-72.0744835	10/23/12	Flat Brook 3000-08-R4	Baldwin Hill Rd Terra Firma drive to pond 1	rip-rapped leak-off to pond 1
SWO 11	Stormwater Outfall	179	41.40497533	-72.07392678	10/23/12	Flat Brook 3000-08-R4	Baldwin Hill Rd parking area to pond 2	10" PVC pipe from parking lot near gravel operation (couldn't find inlet)
SWO 12	Stormwater Outfall	187	41.40395651	-72.07240873	10/23/12	Flat Brook 3000-08-R4	road past Terra Firma storage/entrance to gravel operation	leak off channel from gravel operation
SWO 13	Stormwater Outfall	146	41.40655699	-72.07317626	10/23/12	Tributary 1 3000-08-R3	shared drive off Long Cove rd	runoff rill from road, sand deposits in stream,
SWO 14	Stormwater Outfall	198	41.4066621	-72.07311373	10/26/12	Tributary 3 3000-09-R1	shared drive off Long Cove Rd	14" cpp of unknown origin discharging to pond, no obvious flow
SWO 15	Stormwater Outfall	204	41.40763918	-72.07169166	10/26/12	Tributary 3 3000-09-R6	along Long Cove Road	18" RCP

Area of Concern Number	Area of Concern Type	GPS	Latitude	Longitude	Date Acquired	Stream/Basin Code/Reach	Location	Description
SWO 16	Stormwater Outfall	225	41.41261065	-72.07263722	10/26/12	Tributary 3 3000-09-R6	Christie Hills Condos RT 12	leak-off
SWO 17	Stormwater Outfall	228	41.41277653	-72.07234637	10/26/12	Tributary 3 3000-09-R6	Christie Hills Condos RT 12	leak-off
SWO 18	Stormwater Outfall	230	41.41196575	-72.07331096	10/26/12	Tributary 3 3000-09-R6	RT 12 south of condos	leak-off from Rt 12
SWO 19	Stormwater Outfall	231	41.4114128	-72.07332848	10/26/12	Tributary 3 3000-09-R6	RT 12 south of condos	leak-off from Rt 12 to detention pond
SWO 20	Stormwater Outfall	226	41.41263169	-72.07272389	10/26/12	Tributary 3 3000-09-R6a	RT 12 Christie Hills Condos	leak-off with stormdrain over stream
SWO 21	Stormwater Outfall	215	41.41067192	-72.0725389	10/26/12	Tributary 3 3000-09-R6a	Gales Ferry Animal Hospital parking lot	leak off in Vet parking lot
SWO 22	Stormwater Outfall	216	41.41074132	-72.07244318	10/26/12	Tributary 3 3000-09-R6a	Gales Ferry Animal Hospital parking lot	leak off back rt corner Vet parking lot
SWO 23	Stormwater Outfall	238	41.40989542	-72.06996507	11/16/12	Tributary 5 3000-09-R8	986 Long Cove Road	18" CMP from WP 237, perched
SWO 24	Stormwater Outfall	241	41.40998469	-72.06964195	11/16/12	Tributary 5 3000-09-R9	979 Long Cove Road	asphalt leak-off
SWO 25	Stormwater Outfall	248	41.41422392	-72.06387327	11/16/12	Tributary 5 3000-09-R10	Hyde Park Drive	CB discharges directly over stream
SWO 26	Stormwater Outfall	249	41.41415267	-72.06406589	11/16/12	Tributary 5 3000-09-R10	Hyde Park Drive	CB discharges directly over stream
MC 1	Modified Channel	115	41.40912135	-72.07691568	10/15/12	Flat Brook 3000-08-R1	DS of historic mill pond on Long Cove Road	stone channel DS of dam
MC 2	Modified Channel	102	41.40571562	-72.0750984	10/15/12	Flat Brook 3000-08-R2	1636 Baldwin Hill Road Baldwin Hill Road	modified channel under building

Area of Concern Number	Area of Concern Type	GPS	Latitude	Longitude	Date Acquired	Stream/Basin Code/Reach	Location	Description
MC 3	Modified Channel	171(begin)	41.40568754	-72.07483445	10/23/12	Flat Brook 3000-08-R4	Terra Firma driveway off Baldwin Hill Road	US 3 ft CMP culvert at base of pond
MC 4	Modified Channel	182 (end)	41.4048926	-72.07322932	10/23/12	Flat Brook 3000-08-R4	Terra Firma driveway off Baldwin Hill Road	start stream channel
MC 5	Modified Channel	147 (begin)	41.40662681	-72.07306352	10/23/12	Tributary 1 3000-08-R5	along right side of common drive off Long Cove Road	rough stone wall channelizing stream
MC 6	Modified Channel	150 (end)	41.40569324	-72.07207957	10/23/12	Tributary 1 3000-08-R5	along right side of common drive off Long Cove Road	end of channel (rough stone wall) at 2 ft conc pipe under drive
MC 7	Modified Channel	203 (begin)	41.40747707	-72.07187774	10/26/12	Tributary 3 3000-09-R6	along Long Cove Road	begin modified channel, stream contained by stonewall
MC 8	Modified Channel	208 (end)	41.40777513	-72.07161262	10/26/12	Tributary 3 3000-09-R6	along Long Cove Road	end of stonewall containing stream
DB 1	Degraded Riparian Buffer	124	41.40928815	-72.0772305	10/15/12	Flat Brook 3000-08-R1	DS of Pinelock Drive, along Pinelock Dr	impacted buffer - lawn to stream
DB 2	Degraded Riparian Buffer	125	41.40928815	-72.0772305	10/15/12	Flat Brook 3000-08-R1	DS of Pinelock Drive, along Long Cove Rd	degraded buffer 60-80 ft long
DB 3	Degraded Riparian Buffer	127	41.40928815	-72.0772305	10/15/12	Flat Brook 3000-08-R1	DS of Pinelock Drive, along Long Cove Rd	eroded bank 60-80 ft, no buffer veg
DB 4	Degraded Riparian Buffer	128	41.41127533	-72.08053364	10/15/12	Flat Brook 3000-08-R1	along Long Cove Rd near Long Cove	house close to stream

Area of Concern Number	Area of Concern Type	GPS	Latitude	Longitude	Date Acquired	Stream/Basin Code/Reach	Location	Description
DB 5	Degraded Riparian Buffer	102 to 110	41.40663528	-72.07545471	10/15/12	Flat Brook 3000-08-R2	1636 Baldwin Hill Road Baldwin Hill Road	no buffer vegetation - lawn
DB 6	Degraded Riparian Buffer	144	41.40630696	-72.07393415	10/23/12	Tributary 3 3000-08-R3	behind 1015 Long Cove Road	LB degraded buffer, deteriorated metal shed 6 ft from bank, many invasives
DB 7	Degraded Riparian Buffer	193	41.39970663	-72.07212425	10/23/12	Flat Brook 3000-08-R4	headwater ponds in Groton	lawn to edge of ponds
DB 8	Degraded Riparian Buffer	185 (begin)	41.4038281	-72.07211411	10/23/12	Tributary 1 3000-08-R5	gravel operation/Terra Firma driveway	degraded buffer - Flat Brook LB
DB 9	Degraded Riparian Buffer	189 (end)	41.40187444	-72.0718137	10/23/12	Tributary 1 3000-08-R5	gravel operation/Terra Firma driveway	end of degraded buffer 100 ft west of this point
DB 10	Degraded Riparian Buffer	178	41.40552174	-72.07457436	10/23/12	Flat Brook 3000-08-R4	pond 1 along driveway at Terra Firma	mid-pt RB pond, minimal veg, invasives
DB 11	Degraded Riparian Buffer	180	41.40505864	-72.07392938	10/23/12	Flat Brook 3000-08-R4	pond 2 along driveway at Terra Firma	start pond 2 on terra firma driveway, minimal veg, invasives
DB 12	Degraded Riparian Buffer	147 (begin)	41.40662681	-72.07306352	10/23/12	Tributary 1 3000-08-R5	entire length of reach	start R5, along edge of bus depot, min. veg on developed side
DB 13	Degraded Riparian Buffer	152 (end)	41.40503031	-72.0703208	10/23/12	Tributary 1 3000-08-R5	entire length of reach	stop - stream becomes intermittent

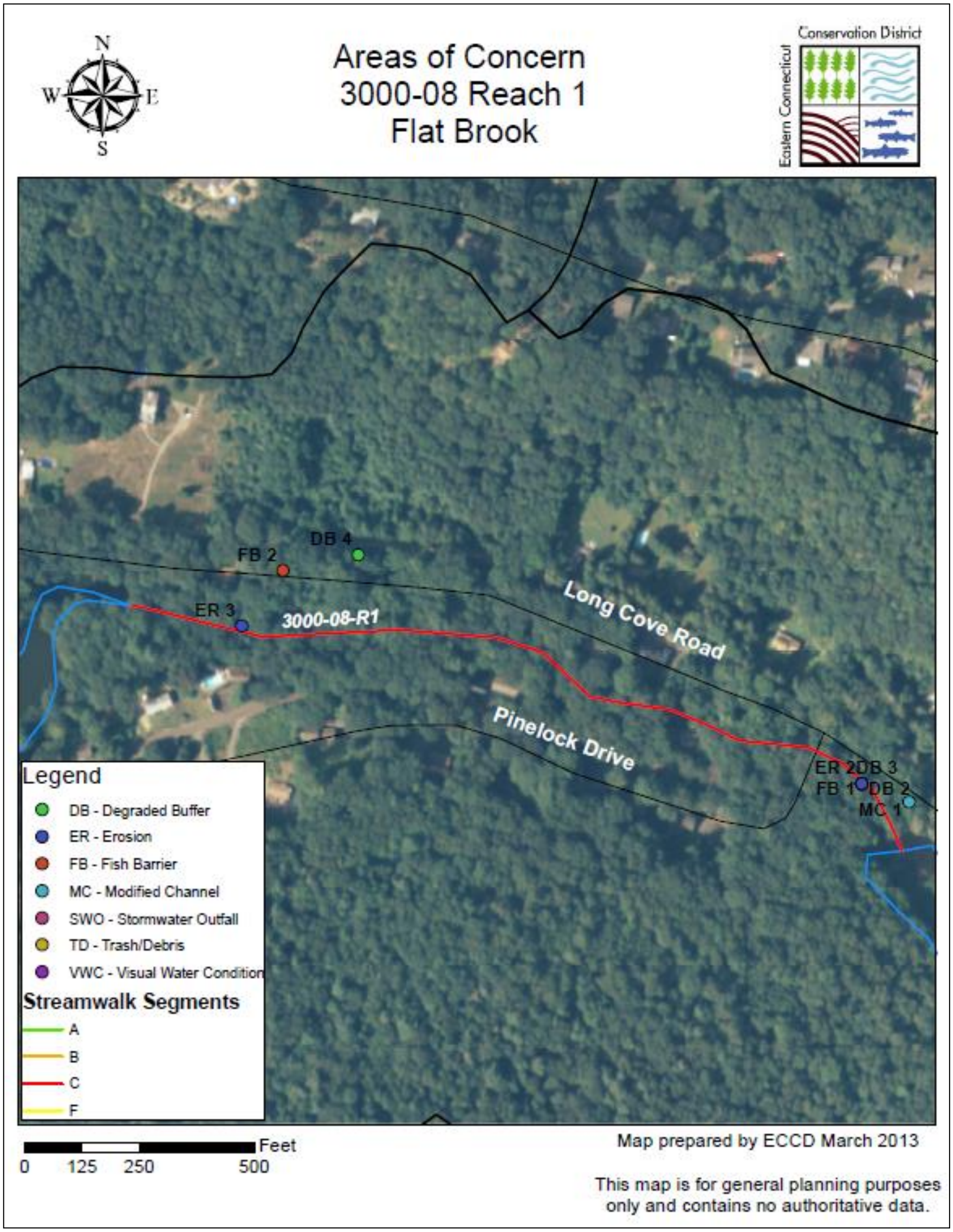
Area of Concern Number	Area of Concern Type	GPS	Latitude	Longitude	Date Acquired	Stream/Basin Code/Reach	Location	Description
DB 14	Degraded Riparian Buffer	199 (begin)	41.4068341	-72.07284115	10/26/12	Tributary 3 3000-09-R1	north of shared drive off Long Cove Road	degraded buffer 1009 Long Cove Road, 300 ft long, min veg
DB 15	Degraded Riparian Buffer	200 (end)	41.40711707	-72.07177397	10/26/12	Tributary 3 3000-09-R1	north of shared drive off Long Cove Road	begin R6, end degraded buffer
DB 16	Degraded Riparian Buffer	202	41.40753399	-72.07201201	10/26/12	Tributary 3 3000-09-R6	along Long Cove Road	degraded buffer along Long Cove Road, 500 ft US, 100 ft DS this WP, btw stream and rd, min width, invasives
DB 17	Degraded Riparian Buffer	217	41.41088155	-72.07306394	10/26/12	Tributary 3 3000-09-R6	behind Gales Ferry Animal Hospital RT 12	from this WP, 100 ft north along stream
DB 18	Degraded Riparian Buffer	226-229	41.412632	-72.072724	10/26/12	Tributary 3 3000-09-R6a	RT 12 to Christie Hills Condos	end DB that began at WP 219
DB 19	Degraded Riparian Buffer	219	41.41143207	-72.07297878	10/26/12	Tributary 3 3000-09-R6a	RT 12 commercial site for sale	degraded buffer at cleared site, from this WP 300 ft north
DB 20	Degraded Riparian Buffer	236-239	41.40946258	-72.07066244	11/16/12	Tributary 5 3000-09-R8	986 Long Cove Road	minimal vegetation
DB 21	Degraded Riparian Buffer	241	41.40998469	-72.06964195	11/16/12	Tributary 5 3000-09-R9	979 Long Cove Rd	minimal vegetation
DB 22	Degraded Riparian Buffer	250	41.41400876	-72.06433595	11/16/12	Tributary 5 3000-09-R10	20 Hyde Park Drive	minimal vegetation

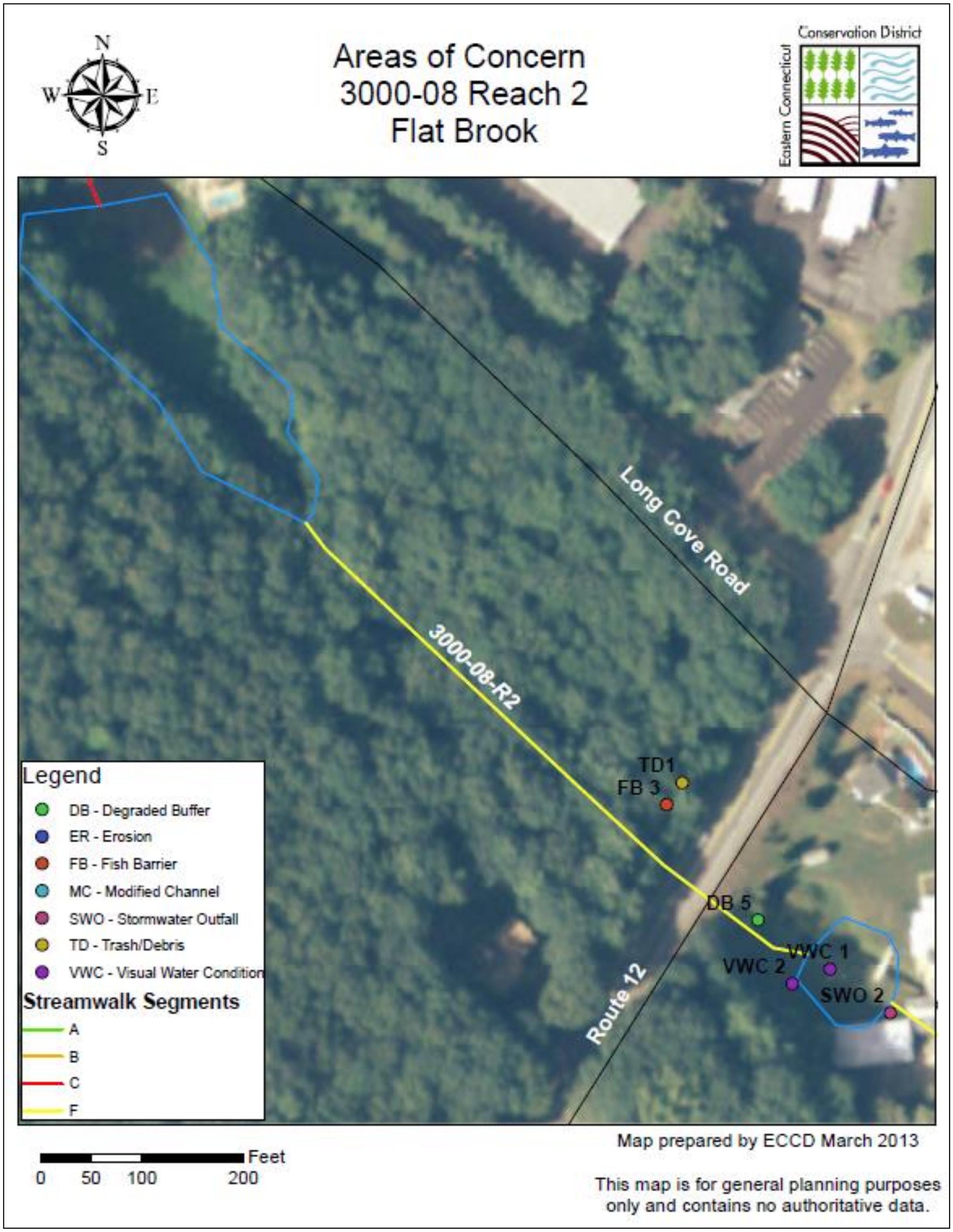
Area of Concern Number	Area of Concern Type	GPS	Latitude	Longitude	Date Acquired	Stream/Basin Code/Reach	Location	Description
TD 1	Degraded Riparian Buffer	113	41.40702998	-72.07559184	10/15/12	Flat Brook 3000-08-R2	DS RT 12	trash - misc
TD 2	Degraded Riparian Buffer	168	41.40559374	-72.07424713	10/23/12	Flat Brook 3000-08-R4	to left of Terra Firma Drive off Baldwin Hill Rd	tires by short stream from little pond
TD 3	Degraded Riparian Buffer	201	41.40722629	-72.07204563	10/26/12	Tributary 3 3000-09-R6a	east side of Long Cove Road US of shared driveway	metal debris in stream
TD 4	Degraded Riparian Buffer	222	41.4120551	-72.07289681	10/26/12	Tributary 3 3000-09-R6a	behind house south of Christie Hills Condos	trash
TD 5	Degraded Riparian Buffer	218	41.41106377	-72.07245559	10/26/12	Tributary 3 3000-09-R6a	Behind Gales Ferry Animal Hospital	trash
VWC 1	Visual Water Conditions	105	41.40646462	-72.0752533	10/15/12	Flat Brook 3000-08-R2	1636 Baldwin Hill Road pond	iron bacteria
VWC 2	Visual Water Conditions	108	41.40645197	-72.07539235	10/15/12	intermittent brook 3000-08	1636 Baldwin Hill Road intermittent tributary to pond	headwall side stream
VWC 3	Visual Water Conditions	193	41.39970663	-72.07212425	10/23/12	Flat Brook 3000-08-R4	North-most headwater pond in Groton	inlet to lower pond inundated with milfoil
VWC 4	Visual Water Conditions	180	41.40505864	-72.07392938	10/23/12	Flat Brook 3000-08-R4	Pond 2 on Terra Firma driveway	start pond 2 on terra firma driveway
VWC 5	Visual Water Conditions	178	41.40552174	-72.07457436	10/23/12	Flat Brook 3000-08-R4	Pond 1 on Terra Firma driveway	mid-pt RB pond very murky

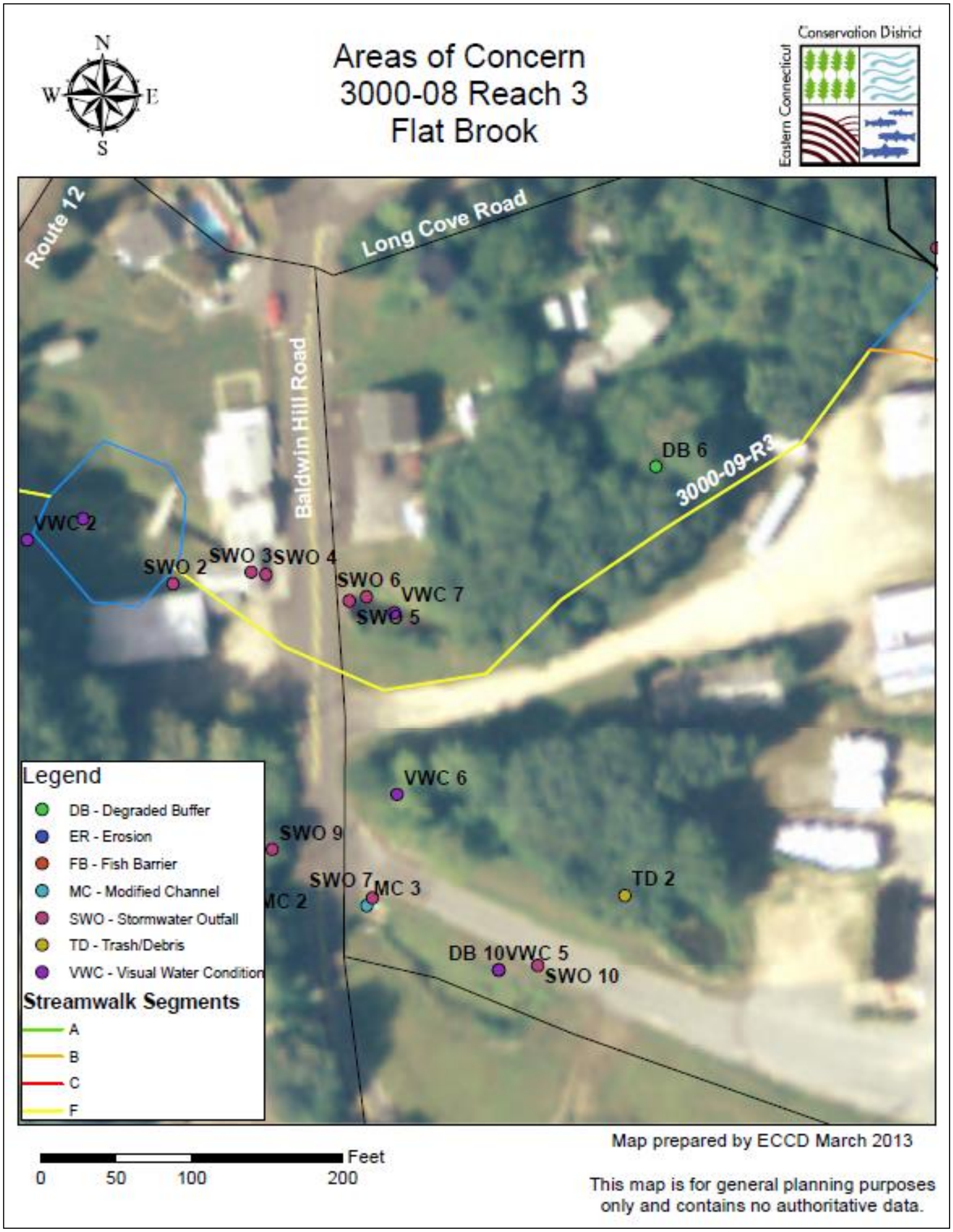
Area of Concern Number	Area of Concern Type	GPS	Latitude	Longitude	Date Acquired	Stream/Basin Code/Reach	Location	Description
VWC 6	Visual Water Conditions	167	41.40586238	-72.07470319	10/23/12	Flat Brook 3000-08-R4	culvert under Terra Firma driveway	Flat Brook DS of Terra Firma driveway high Fe bacteria from groundwater seepage around culvert
VWC 7	Visual Water Conditions	140	41.40617176	-72.07460621	10/23/12	Tributary 1 3000-08-R5	US Baldwin Hill Rd culvert	foam at Baldwin Hill Rd
VWC 8	Visual Water Conditions	165	41.40494297	-72.07013606	10/23/12	Tributary 1 3000-08-R5	US drive crossing behind Terra Firma	US side driveway crossing
VWC 9	Visual Water Conditions	220	41.41175805	-72.0729409	10/26/12	Tributary 3 3000-09-R6	RT 12 cleared site for sale, DS of triple culvert	excess vegetation in stream DS of triple cpp arch culvert

Appendix D

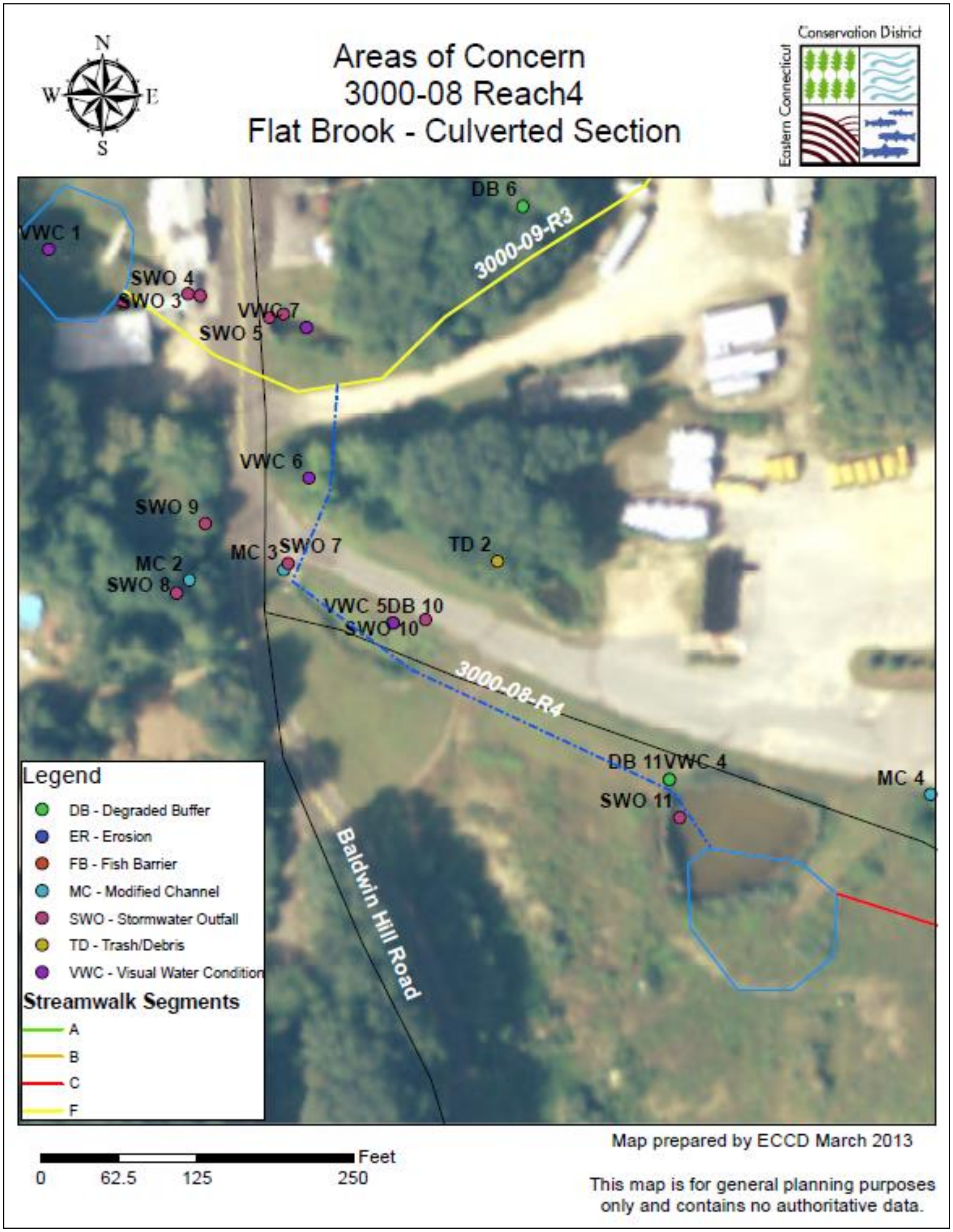
Reach Level Maps

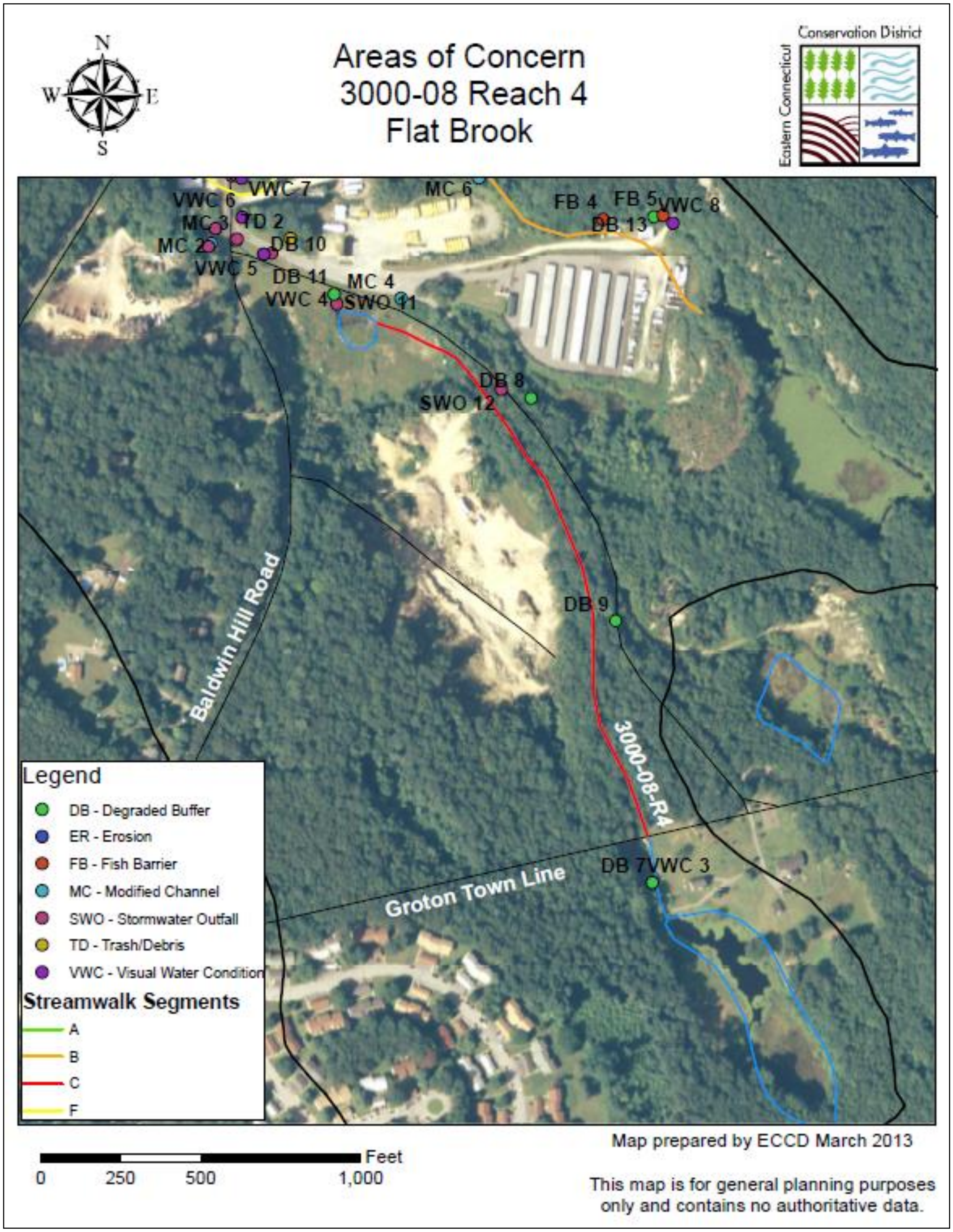


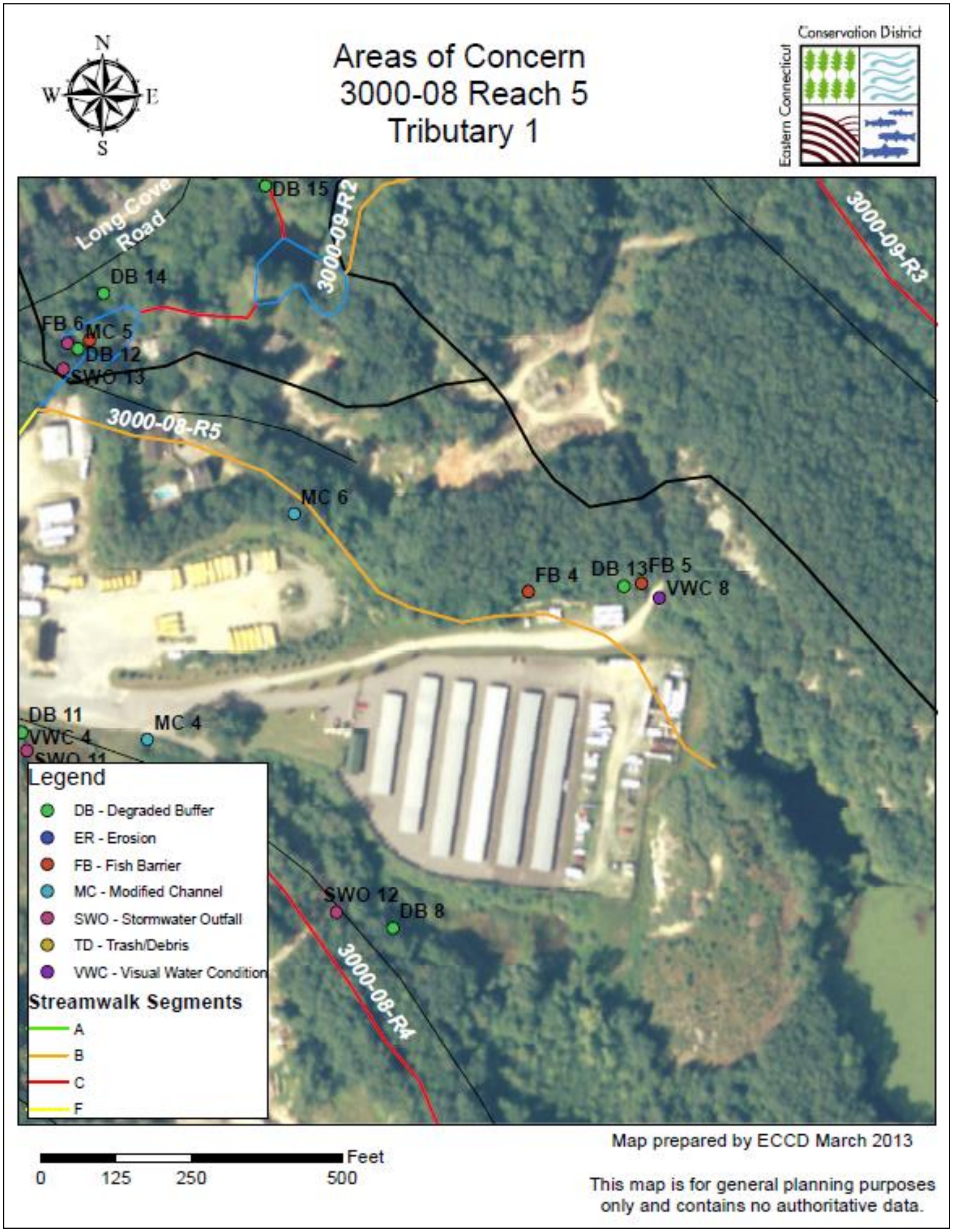

Areas of Concern
3000-08 Reach 2
Flat Brook
N
W
E
S
Conservation District
Eastern Connecticut
Long Cove Road
3000-08-R2
TD1
FB 3
DB 5
VWC 1
VWC 2
SWO 2
Route 12
Legend
DB - Degraded Buffer
ER - Erosion
FB - Fish Barrier
MC - Modified Channel
SWO - Stormwater Outfall
TD - Trash/Debris
VWC - Visual Water Condition
Streamwalk Segments
A
B
C
F
Feet
0 50 100 200
Map prepared by ECCD March 2013
This map is for general planning purposes only and contains no authoritative data.



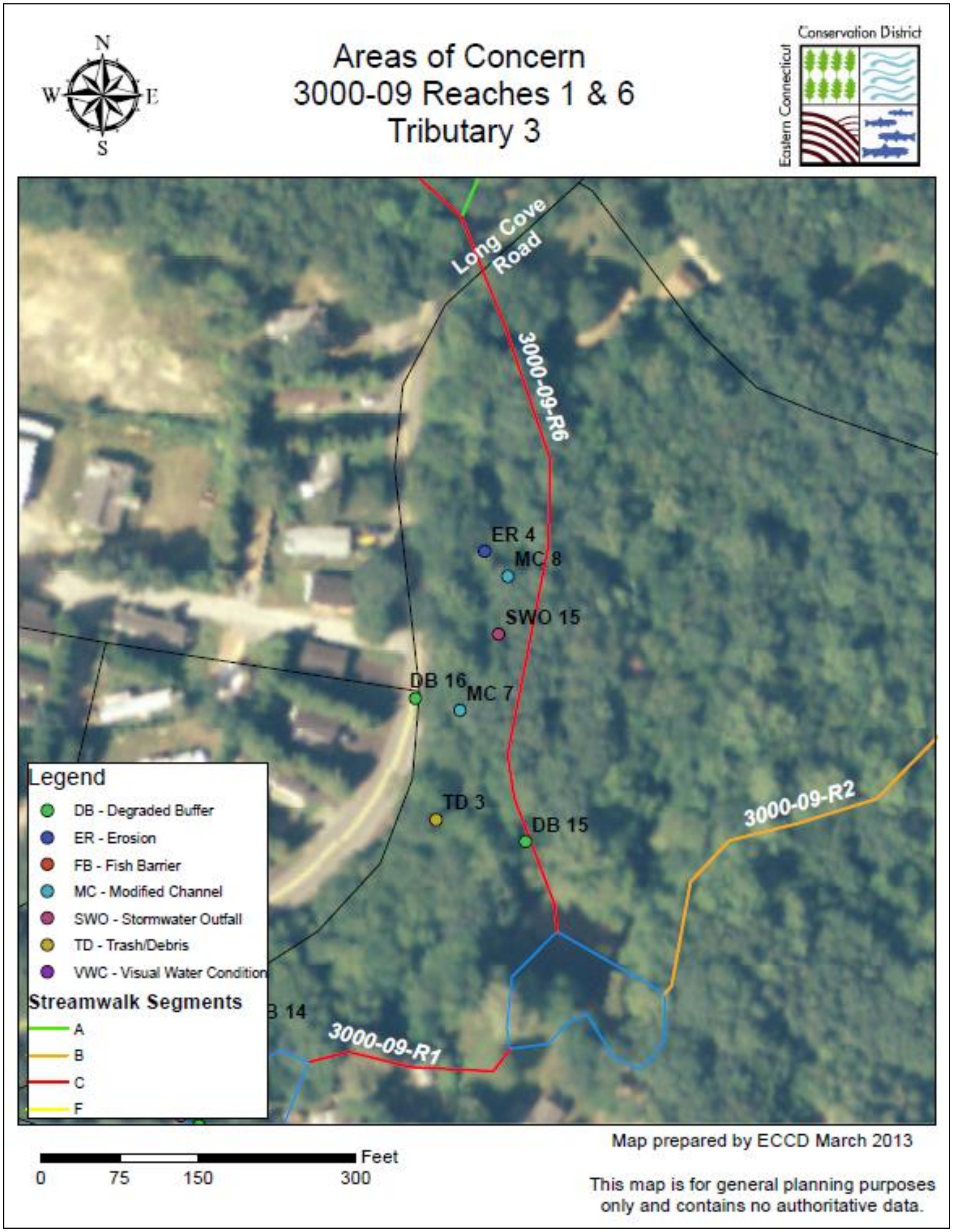
Areas of Concern
3000-08 Reach 3
Flat Brook
Conservation District
Eastern Connecticut
N
S
E
W
Route 12
Long Cove Road
Baldwin Hill Road
3000-09-R3
DB 6
VWC 2
SWO 2
SWO 3
SWO 4
SWO 6
VWC 7
SWO 5
VWC 6
SWO 9
SWO 7
MC 3
MC 2
TD 2
DB 10
VWC 5
SWO 10
Legend
DB - Degraded Buffer
ER - Erosion
FB - Fish Barrier
MC - Modified Channel
SWO - Stormwater Outfall
TD - Trash/Debris
VWC - Visual Water Condition
Streamwalk Segments
A
B
C
F
Feet
0
50
100
200
Map prepared by ECCD March 2013
This map is for general planning purposes only and contains no authoritative data.

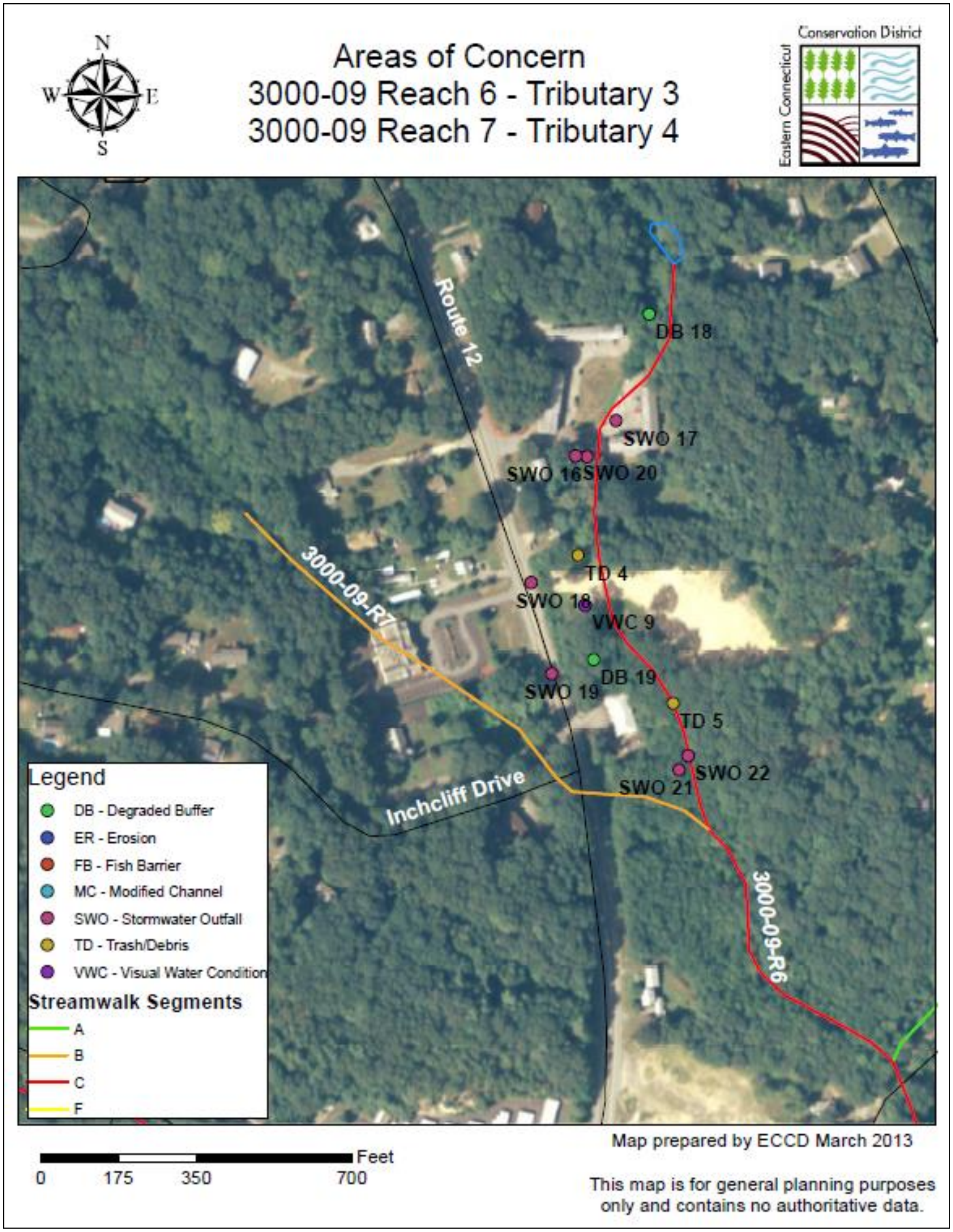

Areas of Concern
3000-08 Reach4
Flat Brook - Culverted Section
Conservation District
Eastern Connecticut
N
S
E
W
DB 6
VWC 1
SWO 4
SWO 3
VWC 7
SWO 5
3000-09-R3
VWC 6
SWO 9
MC 3
SWO 7
TD 2
MC 2
SWO 8
VWC 5
DB 10
SWO 10
3000-08-R4
DB 11
VWC 4
MC 4
SWO 11
Baldwin Hill Road
Legend
DB - Degraded Buffer
ER - Erosion
FB - Fish Barrier
MC - Modified Channel
SWO - Stormwater Outfall
TD - Trash/Debris
VWC - Visual Water Condition
Streamwalk Segments
A
B
C
F
Feet
0
62.5
125
250
Map prepared by ECCD March 2013
This map is for general planning purposes only and contains no authoritative data.


Areas of Concern
3000-08 Reach 4
Flat Brook
N
S
E
W
Conservation District
Eastern Connecticut
VWC 7
VWC 6
MC 6
FB 4
FB 5
VWC 8
DB 13
MC 3
TD 2
MC 2
DB 10
VWC 5
DB 11
MC 4
VWC 4
SWO 11
DB 8
SWO 12
DB 9
Baldwin Hill Road
3000-08-R4
DB 7
VWC 3
Groton Town Line
Legend
DB - Degraded Buffer
ER - Erosion
FB - Fish Barrier
MC - Modified Channel
SWO - Stormwater Outfall
TD - Trash/Debris
VWC - Visual Water Condition
Streamwalk Segments
A
B
C
F
Feet
0
250
500
1,000
Map prepared by ECCD March 2013
This map is for general planning purposes only and contains no authoritative data.

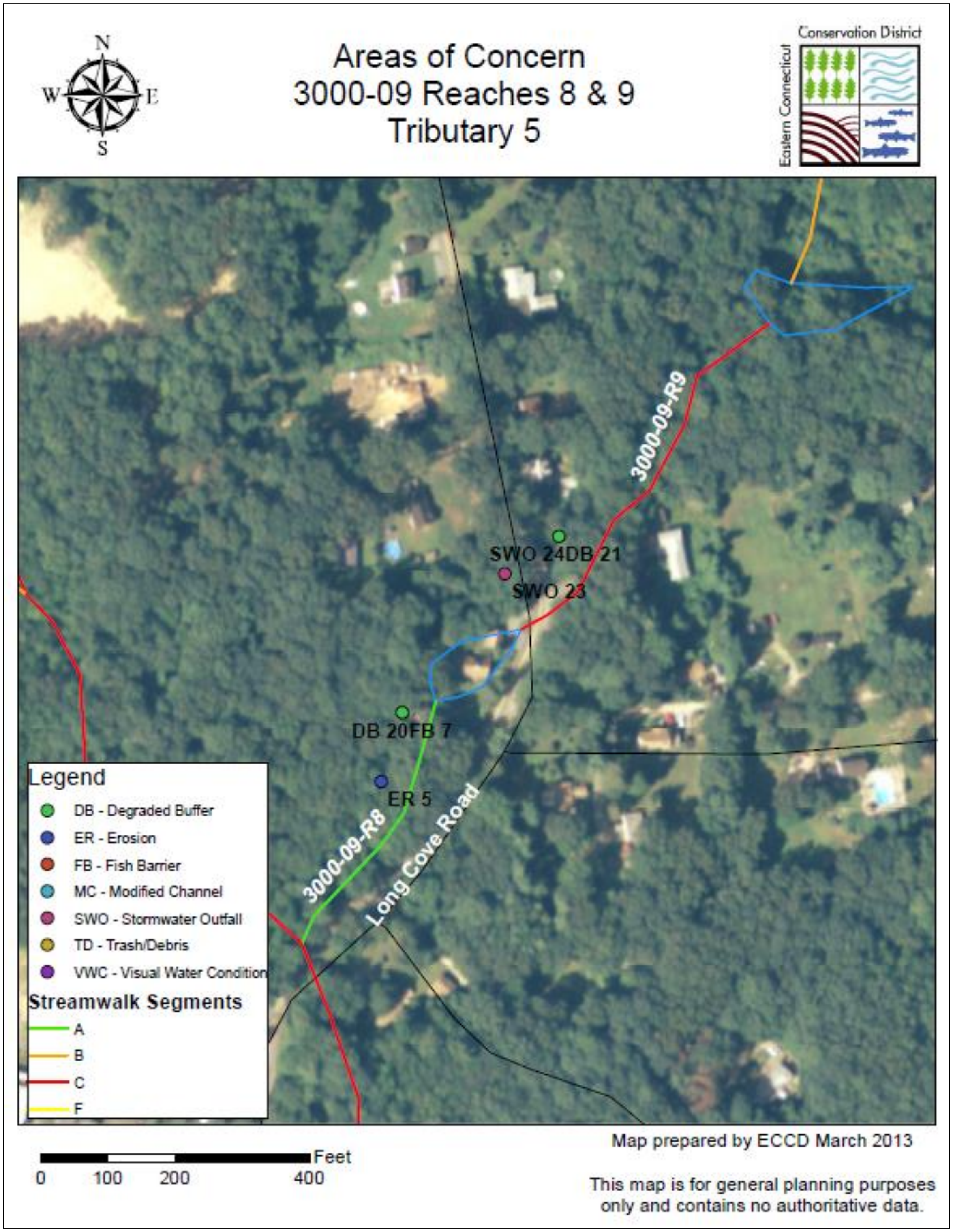


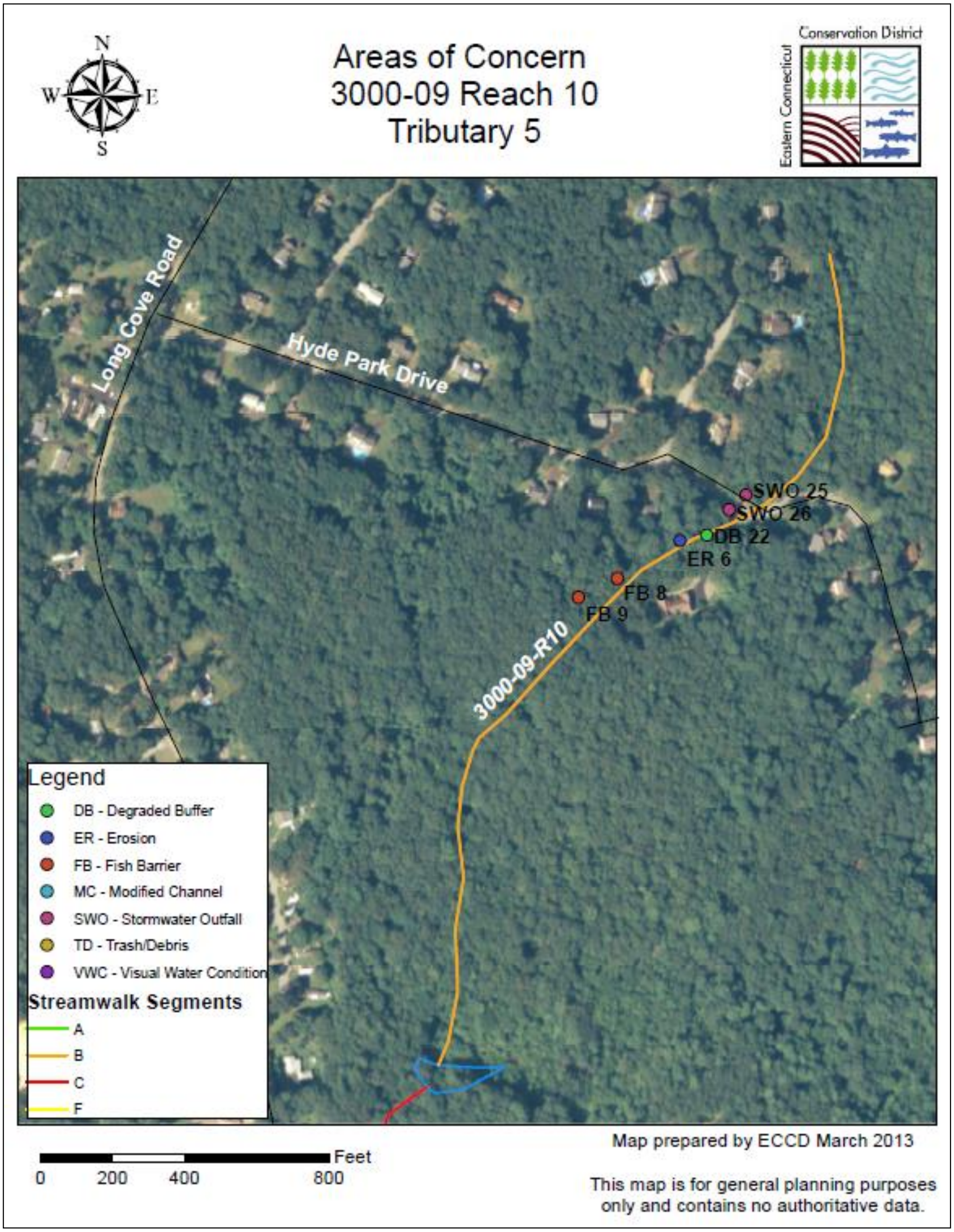
Areas of Concern
3000-08 Reach 5
Tributary 1
N
S
E
W
Eastern Connecticut Conservation District
Long Cove Road
DB 15
3000-09-R2
3000-09-R3
DB 14
FB 6
MC 5
DB 12
SWO 13
3000-08-R5
MC 6
FB 4
DB 13
FB 5
VWC 8
DB 11
VWC 4
SWO 11
MC 4
SWO 12
DB 8
3000-08-R4
Legend
DB - Degraded Buffer
ER - Erosion
FB - Fish Barrier
MC - Modified Channel
SWO - Stormwater Outfall
TD - Trash/Debris
VWC - Visual Water Condition
Streamwalk Segments
A
B
C
F
0
125
250
500
Feet
Map prepared by ECCD March 2013
This map is for general planning purposes only and contains no authoritative data.


Areas of Concern
3000-09 Reaches 1 & 6
Tributary 3
N
S
W
E
Conservation District
Eastern Connecticut
Long Cove Road
3000-09-R6
ER 4
MC 8
SWO 15
DB 16
MC 7
TD 3
DB 15
3000-09-R2
B 14
3000-09-R1
Legend
DB - Degraded Buffer
ER - Erosion
FB - Fish Barrier
MC - Modified Channel
SWO - Stormwater Outfall
TD - Trash/Debris
VWC - Visual Water Condition
Streamwalk Segments
A
B
C
F
0 75 150 300 Feet
Map prepared by ECCD March 2013
This map is for general planning purposes only and contains no authoritative data.



N
W
E
S
Areas of Concern
3000-09 Reach 6 - Tributary 3
3000-09 Reach 7 - Tributary 4
Eastern Connecticut Conservation District
Route 12
DB 18
SWO 17
SWO 16
SWO 20
3000-09-R7
TD 4
SWO 18
VWC 9
DB 19
SWO 19
TD 5
SWO 22
SWO 21
Inchcliff Drive
3000-09-R6
Legend
DB - Degraded Buffer
ER - Erosion
FB - Fish Barrier
MC - Modified Channel
SWO - Stormwater Outfall
TD - Trash/Debris
VWC - Visual Water Condition
Streamwalk Segments
A
B
C
F
Feet
0 175 350 700
Map prepared by ECCD March 2013
This map is for general planning purposes only and contains no authoritative data.


Areas of Concern
3000-09 Reaches 8 & 9
Tributary 5
N
S
E
W
Conservation District
Eastern Connecticut
3000-09-R9
SWO 24
DB 21
SWO 23
DB 20
FB 7
ER 5
3000-09-R8
Long Cove Road
Legend
DB - Degraded Buffer
ER - Erosion
FB - Fish Barrier
MC - Modified Channel
SWO - Stormwater Outfall
TD - Trash/Debris
VWC - Visual Water Condition
Streamwalk Segments
A
B
C
F
Map prepared by ECCD March 2013
Feet
0 100 200 400
This map is for general planning purposes only and contains no authoritative data.


N
W
E
S
Areas of Concern
3000-09 Reach 10
Tributary 5
Conservation District
Eastern Connecticut
Long Cove Road
Hyde Park Drive
SWO 25
SWO 26
DB 22
ER 6
FB 8
FB 9
3000-09-R10
Legend
DB - Degraded Buffer
ER - Erosion
FB - Fish Barrier
MC - Modified Channel
SWO - Stormwater Outfall
TD - Trash/Debris
VWC - Visual Water Condition
Streamwalk Segments
A
B
C
F
Feet
0
200
400
800
Map prepared by ECCD March 2013
This map is for general planning purposes only and contains no authoritative data.

Appendix E

Statewide Bacteria TMDL Appendix 5 – Thames River

(See next page)

Thames River Watershed Summary

Flat Brook

WATERSHED DESCRIPTION AND MAPS

The Thames River watershed covers an area of approximately 19,447 acres in the southeastern corner of Connecticut (Figure 1). The watershed is located in the Towns of New London, Groton, Waterford, Ledyard, Montville, Norwich, and Preston, CT.

The Thames River watershed includes one tributary segment impaired for recreation due to elevated bacteria levels. This segment was assessed by Connecticut Department of Energy and Environmental Protection (CT DEEP) and included in the CT 2010 303(d) list of impaired waterbodies. An excerpt of the Integrated Water Quality Report is included in Table 1 to show the status of this tributary (CTDEEP, 2010).

The Thames River begins at the confluence with the Quinebaug River and the Yantic River at the intersection of Route 12 and Route 2 in the City of Norwich, CT, flows south following Route 12, follows the Montville-Preston border after Trading Cove, follows the Montville-Ledyard border after Poquetanuck Cove, follows the Waterford-Ledyard border downstream of Horton Cove, follows the Groton-Waterford border downstream of Smith Cove, then follows the Groton-New London border downstream of Mamacoke Cove, and outlets at New London Harbor before reaching Long Island Sound. The bacteria impaired segment, Flat Brook (CT3000-08_01), consists of 1.09 miles of tributary to the Thames River in Ledyard and Groton, CT (Figure 2). This impaired segment begins at an unnamed pond at the base of Baldwin Hill in Groton, CT, flows north downstream to cross Route 12, follows Long Cove Road, and outlets to Long Cove north of the United States Naval Reserve Base at the confluence with the Thames River in Ledyard, CT.

Flat Brook has a water quality classification of A. Designated uses include potential drinking water supplies, habitat for fish and other aquatic life and wildlife, recreation, navigation, and industrial and agricultural water supply. As there are no designated beaches in this segment of Flat Brook, the specific recreation impairment is for non-designated swimming and other water contact related activities.

Impaired Segment Facts

Impaired Segment: Flat Brook (CT3000-08_01)

Municipalities: Ledyard, Groton

Impaired Segment Length (miles): 1.09

Water Quality Classification: Class A

Designated Use Impairment: Recreation

Sub-regional Basin Name and Code: Thames River, 3000

Regional Basin: Thames Main Stem

Major Basin: Thames

Watershed Area (acres): 19,447

MS4 Applicable? Yes

Applicable Season: Recreation Season (May 1 to September 30)

Figure 1: Watershed location in Connecticut

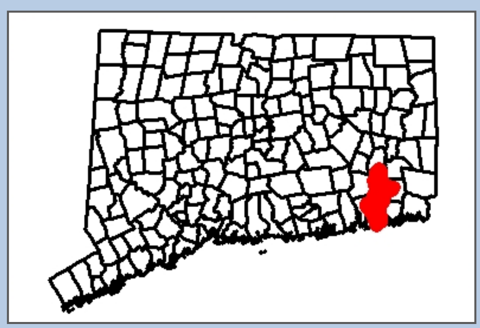
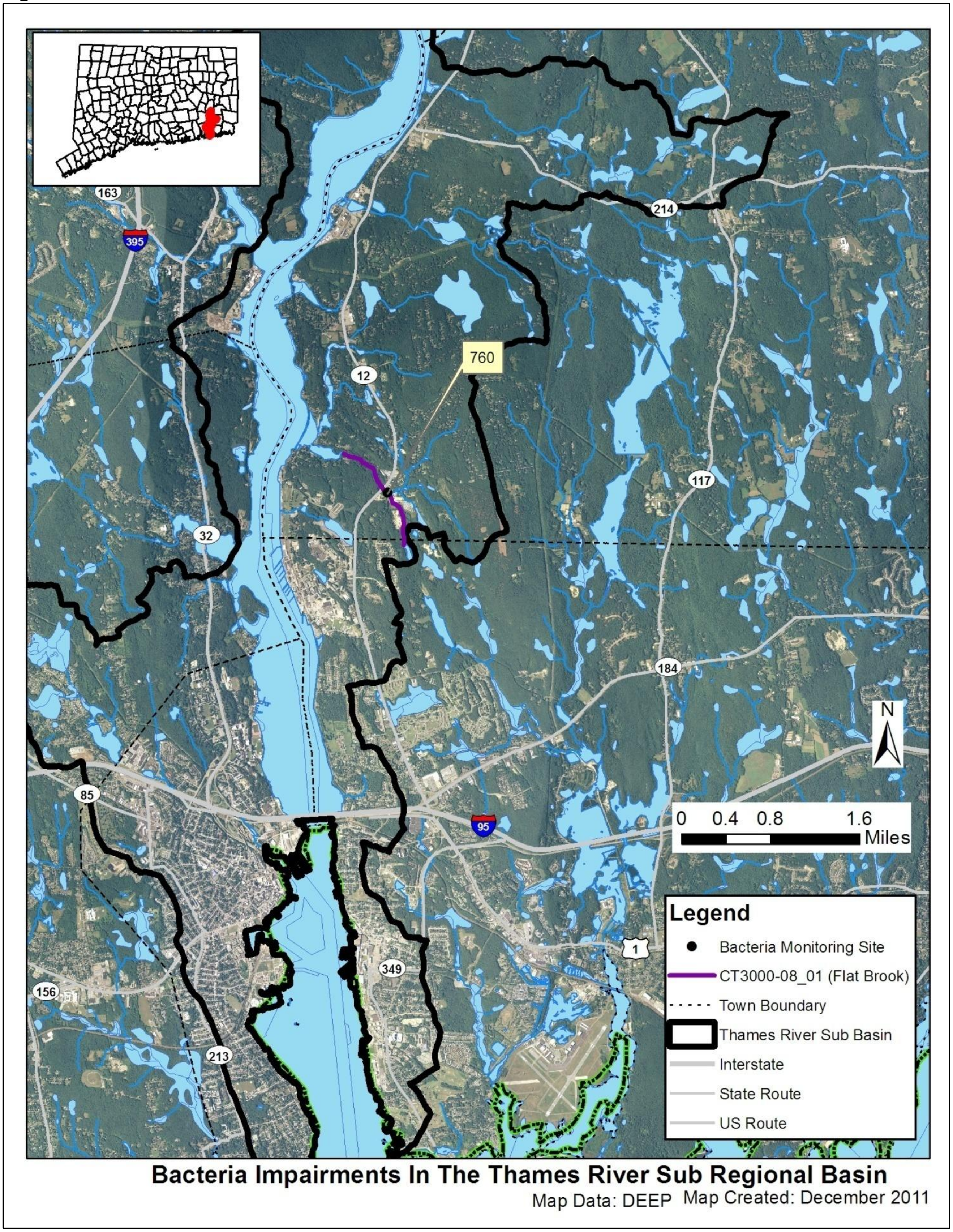


Table 1: Impaired segment and nearby waterbodies from the Connecticut 2010 Integrated Water Quality Report

Waterbody ID	Waterbody Name	Location	Miles	Aquatic Life	Recreation	Fish Consumption
CT3000-08_01	Flat Brook (Ledyard)-01	From mouth at confluence with Thames River (inlet to Long Cove, North of Navy Base) Gales Ferry/Ledyard, US to headwaters at unnamed pond, Groton (Brook runs North).	1.09	U	NOT	FULL
FULL = Designated Use Fully Supported **NOT = Designated Use Not Supported** **U = Unassessed**						

Figure 2: GIS map featuring general information of the Thames River watershed at the sub-regional level



Land Use

Existing land use can affect the water quality of waterbodies within a watershed (USEPA, 2011c). Natural processes, such as soil infiltration of stormwater and plant uptake of water and nutrients, can occur in undeveloped portions of the watershed. As impervious surfaces (such as rooftops, roads, and sidewalks) increase within the watershed landscape from commercial, residential, and industrial development, the amount of stormwater runoff to waterbodies also increases. These waterbodies are negatively affected as increased pollutants from nutrients and bacteria from failing and insufficient septic systems, oil and grease from automobiles, and sediment from construction activities become entrained in this runoff. Agricultural land use activities, such as fertilizer application and manure from livestock, can also increase pollutants in nearby waterbodies (USEPA, 2011c).

As shown in Figures 3 and 4, the Thames River watershed consists of 44% urban, 35% forest, 19% water, and 2% agriculture land uses. The Thames River watershed is mostly developed around the Thames River main stem, particularly at the headwaters in Norwich, CT and the lower portion south of Smith Cove in Waterford, CT. Agricultural areas, including hayfields and row crops, are scattered throughout the watershed. The middle portion of the Thames River watershed is characterized by tracts of forested open space areas, including Crandall Property and Crouch Pond, Stoddard Hill State Park Scenic Reserve, PTA Lane Open Space, FW Brown Tract, Connecticut Arboreum, and Ledyard's Glacial Park-Kettle Hole. There are also several developed open spaces, including Norwich Country Club golf course and Milton Green Memorial Field. Dense commercial and industrial development adjacent to the Thames River can be found south of the Route 95 overpass. The impaired tributary to the Thames River, Flat Brook, begins in an open residential development adjacent to a dense suburban neighborhood along Michigan Drive in Groton, CT, and continues north downstream into commercial development, including a large sand and gravel pit with exposed soil, Aqua Sports Diving Center, Terra Firma Self Storage, Student Transportation of America along Baldwin Hill Road, CubeSmart Self Storage, and Baroco Corporation along Route 12 in Ledyard, CT. Flat Brook continues through forested residential development before its outlet to Long Cove.

Figure 3: Land use within the Thames River watershed

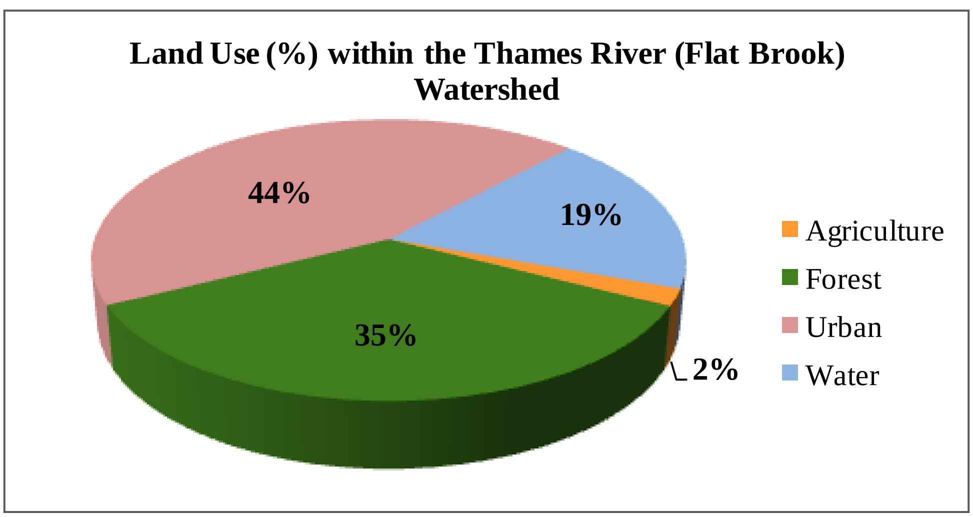
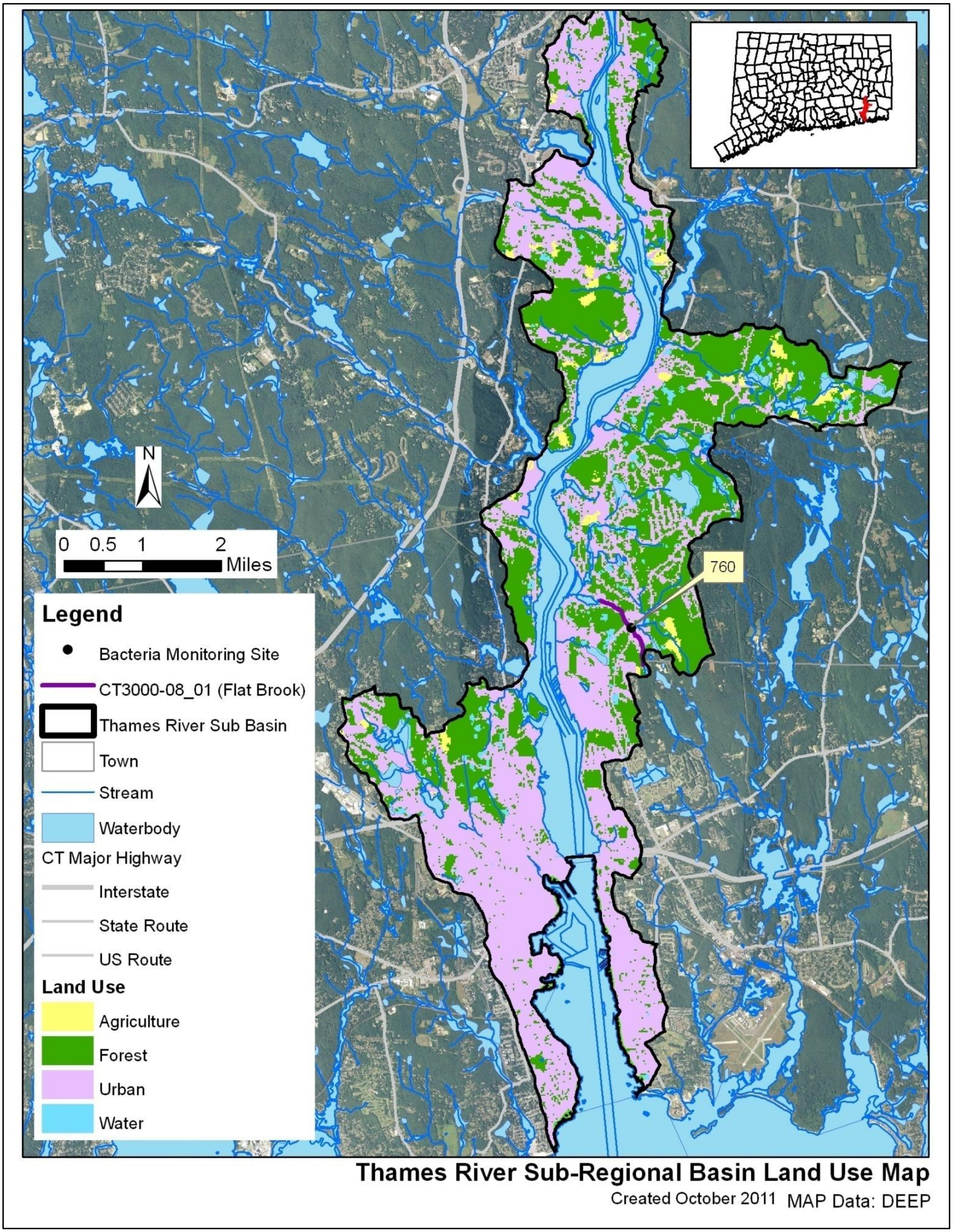


Figure 4: GIS map featuring land use for the Thames River watershed at the sub-regional level



WHY IS A TMDL NEEDED?

E. coli is the indicator bacteria used for comparison with the CT State criteria in the CT Water Quality Standards (WQS) (CTDEEP, 2011). All data results are from CT DEEP, USGS, Bureau of Aquaculture, or volunteer monitoring efforts at stations located on the impaired segments.

Table 2: Sampling station location description for the impaired segment in the Thames River watershed

Waterbody ID	Waterbody Name	Station	Station Description	Municipality	Latitude	Longitude
CT3000-08_01	Flat Brook	760	Baldwin Hill Road	Ledyard	41.406172	-72.074675

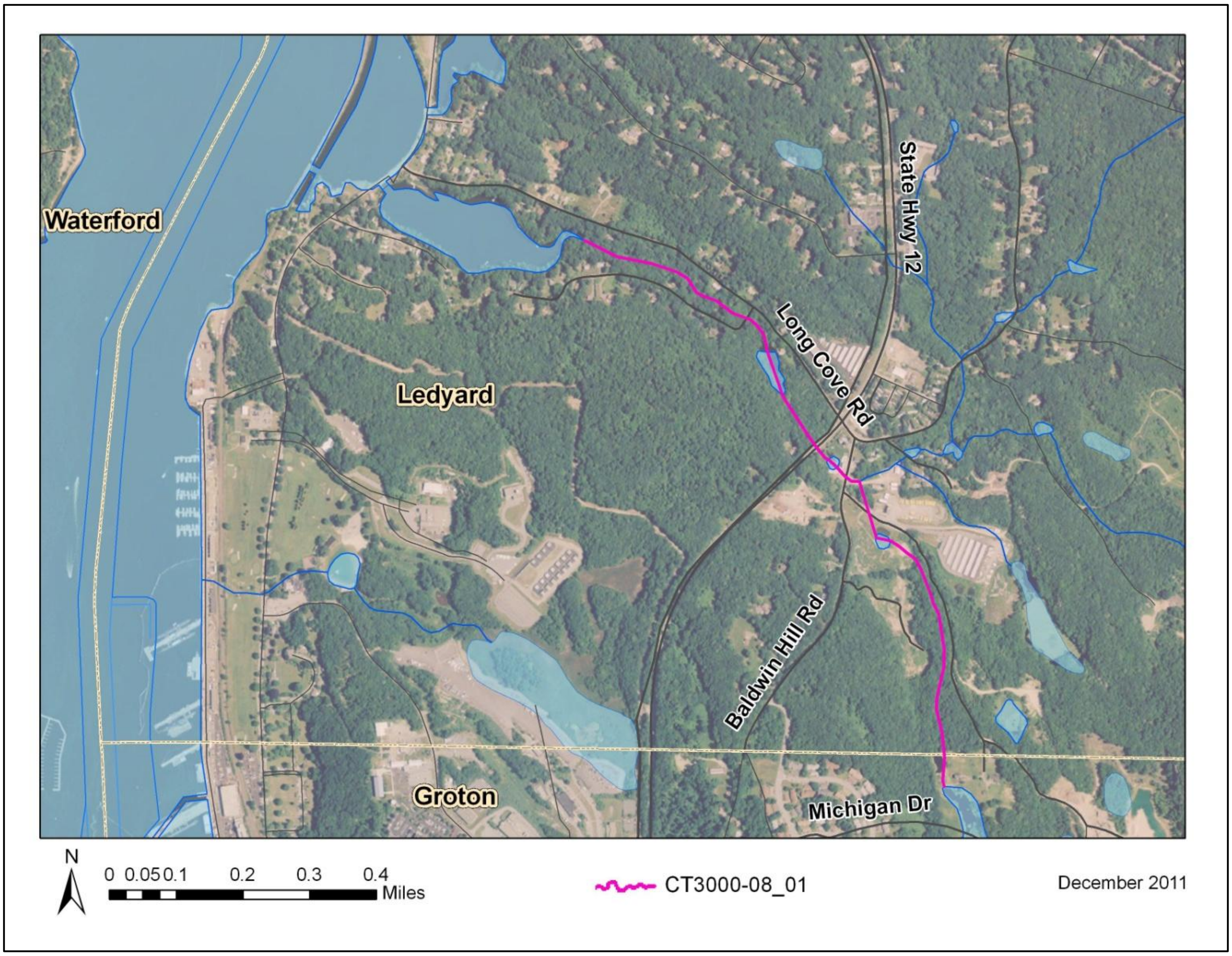
Flat Brook (CT3000-08_01) is a Class A freshwater river (Figure 5). Its applicable designated uses are potential drinking water supplies, habitat for fish and other aquatic life and wildlife, recreation, navigation, and industrial and agricultural water supply. Water quality analyses were conducted using data from one sampling location from 2006-2009 (Station 760) (Table 2).

The water quality criteria for *E. coli*, along with bacteria sampling results for Station 760 from 2006-2009, are presented in Table 9. The annual geometric mean was calculated for Station 760 and exceeded the WQS for *E. coli* for all years. Single sample values at this station also exceeded the WQS for *E. coli* multiple times from 2006-2008.

To aid in identifying possible bacteria sources, the geometric mean was also calculated for each station for wet-weather and dry-weather sampling days, where appropriate (Table 9). For Flat Brook, geometric mean values at Station 760 exceeded the WQS for *E. coli* during both wet and dry-weather conditions.

Due to the elevated bacteria measurements presented in Table 9, Flat Brook did not meet CT's bacteria WQS, was identified as impaired, and was placed on the CT List of Waterbodies Not Meeting Water Quality Standards, also known as the CT 303(d) Impaired Waters List. The Clean Water Act requires that all 303(d) listed waters undergo a TMDL assessment that describes the impairments and identifies the measures needed to restore water quality. The goal is for all waterbodies to comply with State WQS.

Figure 5: Aerial map of Flat Brook



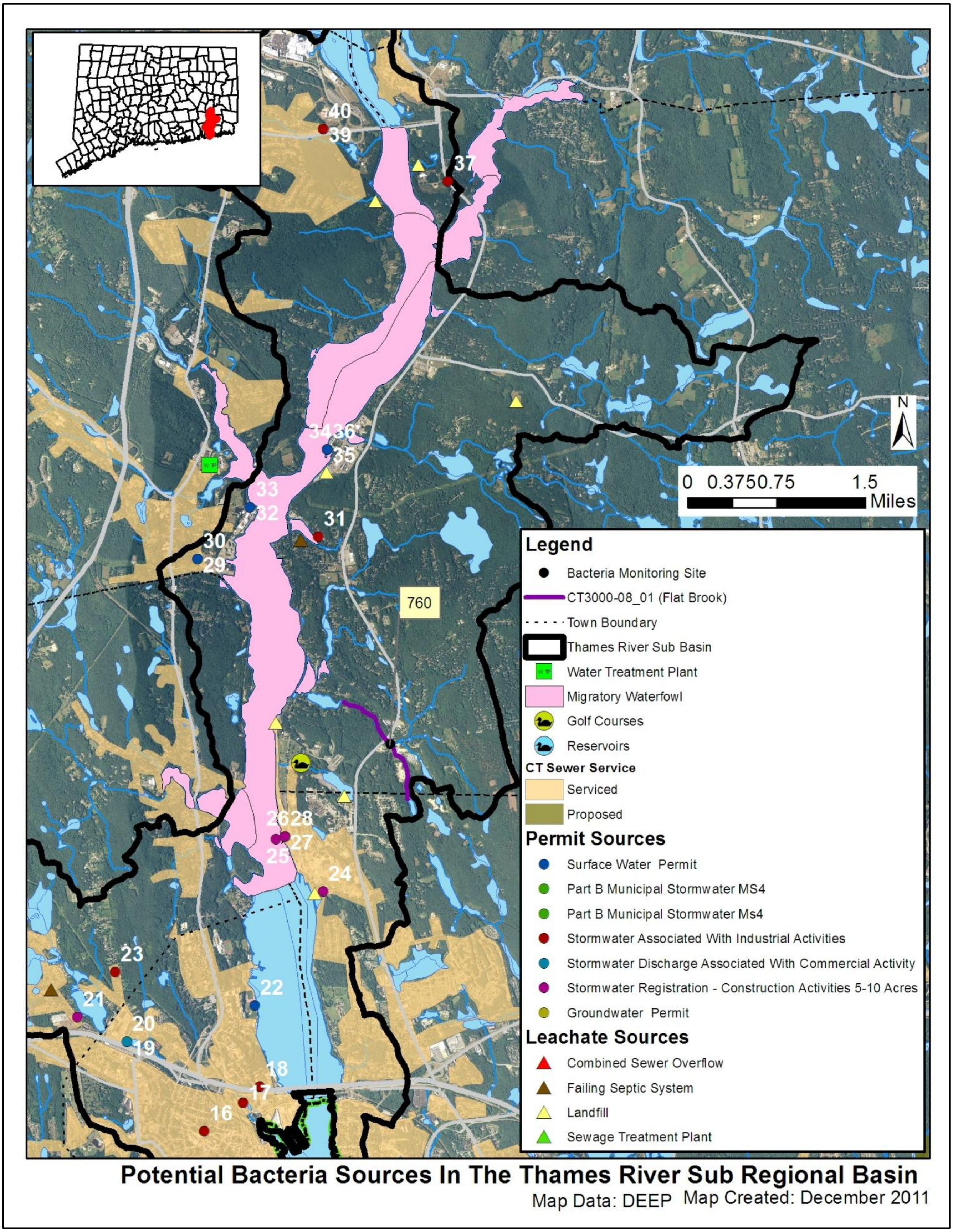
POTENTIAL BACTERIA SOURCES

Potential sources of indicator bacteria in a watershed include point and non-point sources, such as stormwater runoff, agriculture, sanitary sewer overflows (collection system failures), illicit discharges, and inappropriate discharges to the waterbody. Potential sources that have been tentatively identified in the watershed based on land use (Figures 3 and 4) and a collection of local information for the impaired waterbody is presented in Table 3 and Figure 6. However, the list of potential sources is general in nature and should not be considered comprehensive. There may be other sources not listed here that contribute to the observed water quality impairment in the study segments. Further monitoring and investigation will confirm listed sources and discover additional ones. Some segments in this watershed are currently listed as unassessed by CT DEEP procedures. This does not suggest that there are no potential issues on this segment, but indicates a lack of current data to evaluate the segment as part of the assessment process. For some segments, there are data from permitted sources, and CT DEEP recommends that any elevated concentrations found from those permitted sources be addressed through voluntary reduction measures. More detailed evaluation of potential sources is expected to become available as activities are conducted to implement these TMDLs.

Table 3: Potential bacteria sources in the Thames River watershed

Impaired Segment	Permit Source	Illicit Discharge	CSO/SSO Issue	Failing Septic System	Agricultural Activity	Stormwater Runoff	Nuisance Wildlife/ Pets	Other
Flat Brook CT3000-08_01	x	x		x		x	x	

Figure 6: Potential sources in the Thames River watershed at the sub-regional level



The potential sources map for the impaired basin was developed after thorough analysis of available data sets. If information is not displayed in the map, then no sources were discovered during the analysis. The following is the list of potential sources that were evaluated: problems with migratory waterfowl, golf course locations, reservoirs, proposed and existing sewer service, cattle farms, poultry farms, permitted sources of bacteria loading (surface water discharge, MS4 permit, industrial stormwater, commercial stormwater, groundwater permits, and construction related stormwater), and leachate and discharge sources (agricultural waste, CSOs, failing septic systems, landfills, large septic tank leach fields, septage lagoons, sewage treatment plants, and water treatment or filter backwash).

Point Sources

Permitted sources within the watershed that could potentially contribute to the bacteria loading are identified in Table 4. This table includes permit types that may or may not be present in the impaired watershed. Additional investigation and monitoring may reveal the presence of additional discharges in the watershed. Available effluent data from each of these permitted categories found within the watershed are compared to the CT State WQS for the appropriate receiving waterbody use and type.

Table 4: General categories list of other permitted discharges

Permit Code	Permit Description Type	Number in watershed
CT	Surface Water Discharges	0
GPL	Discharge of Swimming Pool Wastewater	0
GSC	Stormwater Discharge Associated with Commercial Activity	0
GSI	Stormwater Associated with Industrial Activity	0
GSM	Part B Municipal Stormwater MS4	0
GSN	Stormwater Registration – Construction	0
LF	Groundwater Permit (Landfill)	0
UI	Underground Injection	0

Permitted Sources

As shown in Table 7, there are no permitted discharges to Flat Brook. Since the MS4 permits are not targeted to a specific location, but the geographic area of the regulated municipality, there is no one accurate location on the map to display the location of these permits. One dot will be displayed at the geographic center of the municipality as a reference point. Sometimes this location falls outside of the targeted watershed and therefore the MS4 permit will not be displayed in the Potential Sources Map. Using the municipal border as a guideline will show which areas of an affected watershed are covered by an MS4 permit.

Municipal Stormwater Permitted Sources

Per the EPA Phase II Stormwater rule all municipal storm sewer systems (MS4s) operators located within US Census Bureau Urbanized Areas (UAs) must be covered under MS4 permits regulated by the appropriate State agency. There is an EPA waiver process that municipalities can apply for to not participate in the MS4 program. In Connecticut, EPA has granted such waivers to 19 municipalities. All participating municipalities within UAs in Connecticut are currently regulated under MS4 permits by CT DEEP staff in the MS4 program.

The US Census Bureau defines a UA as a densely settled area that has a census population of at least 50,000. A UA generally consists of a geographic core of block groups or blocks that exceeds the 50,000 people threshold and has a population density of at least 1,000 people per square mile. The UA will also include adjacent block groups and blocks with at least 500 people per square mile. A UA consists of all or part of one or more incorporated places and/or census designated places, and may include additional territory outside of any place. (67 FR 11663)

For the 2000 Census a new geographic entity was created to supplement the UA blocks of land. This created a block known as an Urban Cluster (UC) and is slightly different than the UA. The definition of a UC is a densely settled area that has a census population of 2,500 to 49,999. A UC generally consists of a geographic core of block groups or blocks that have a population density of at least 1,000 people per square mile, and adjacent block groups and blocks with at least 500 people per square mile. A UC consists of all or part of one or more incorporated places and/or census designated places; such a place(s) together with adjacent territory; or territory outside of any place. The major difference is the total population cap of 49,999 people for a UC compared to >50,000 people for a UA. (67 FR 11663)

While it is possible that CT DEEP will be expanding the reach of the MS4 program to include UC municipalities in the near future they are not currently under the permit. However, the GIS layers used to create the MS4 maps in this Statewide TMDL did include both UA and UC blocks. This factor creates some municipalities that appear to be within an MS4 program that are not currently regulated through an MS4 permit. This oversight can explain a municipality that is at least partially shaded grey in the maps and there are no active MS4 reporting materials or information included in the appropriate appendix. While these areas are not technically in the MS4 permit program, they are still considered urban by the cluster definition above and are likely to contribute similar stormwater discharges to affected waterbodies covered in this TMDL.

As previously noted, EPA can grant a waiver to a municipality to preclude their inclusion in the MS4 permit program. One reason a waiver could be granted is a municipality with a total population less than 1000 people, even if the municipality was located in a UA. There are 19 municipalities in Connecticut that have received waivers, this list is: Andover, Bozrah, Canterbury, Coventry, East Hampton, Franklin, Haddam, Killingworth, Litchfield, Lyme, New Hartford, Plainfield, Preston, Salem, Sherman, Sprague, Stafford, Washington, and Woodstock. There will be no MS4 reporting documents from these towns even if they are displayed in an MS4 area in the maps of this document.

The list of US Census UCs is defined by geographic regions and is named for those regions, not necessarily by following municipal borders. In Connecticut the list of UCs includes blocks in the following Census Bureau regions: Colchester, Danielson, Lake Pocotopaug, Plainfield, Stafford, Storrs, Torrington, Willimantic, Winsted, and the border area with Westerly, RI (67 FR 11663). Any MS4 maps showing these municipalities may show grey areas that are not currently regulated by the CT DEEP MS4 permit program.

The impaired segment of the Thames River watershed is located within the Towns of Ledyard and Groton, CT. The towns are largely urbanized, as defined by the U.S. Census Bureau, and are required to comply with the General Permit for the Discharge of Stormwater from Small Municipal Storm Sewer Systems (MS4 permit) issued by the Connecticut Department of Energy and Environmental Protection

(DEEP) (Figure 7). This general permit is only applicable to municipalities that are identified in Appendix A of the MS4 permit that contain designated urban areas and discharge stormwater via a separate storm sewer system to surface waters of the State. The permit requires municipalities to develop a Stormwater Management Plan (SMP) to reduce the discharge of pollutants and protect water quality. The MS4 permit is discussed further in the "TMDL Implementation Guidance" section of the core TMDL document. Additional information regarding stormwater management and the MS4 permit can be obtained on CTDEEP's website:
(http://www.ct.gov/dep/cwp/view.asp?a=2721&q=325702&depNav_GID=1654).

Multiple MS4 outfalls have been sampled for *E. coli* bacteria in the watershed (Table 5). In Groton, six MS4 outfalls were sampled from 2005-2008. Of these outfalls, four exceeded the single sample water quality standard of 410 colonies/100 mL. In Ledyard, four MS4 outfalls were sampled in 2006, 2008, and 2009. All outfalls in Ledyard exceeded the single sample water quality standard of 410 colonies/100 mL. In Waterford, two MS4 outfalls were sampled in 2004, 2005, 2007, and 2009. Of these outfalls, none exceeded the single sample water quality standard of 410 colonies/100 mL.

Figure 7: MS4 areas of the Thames River watershed

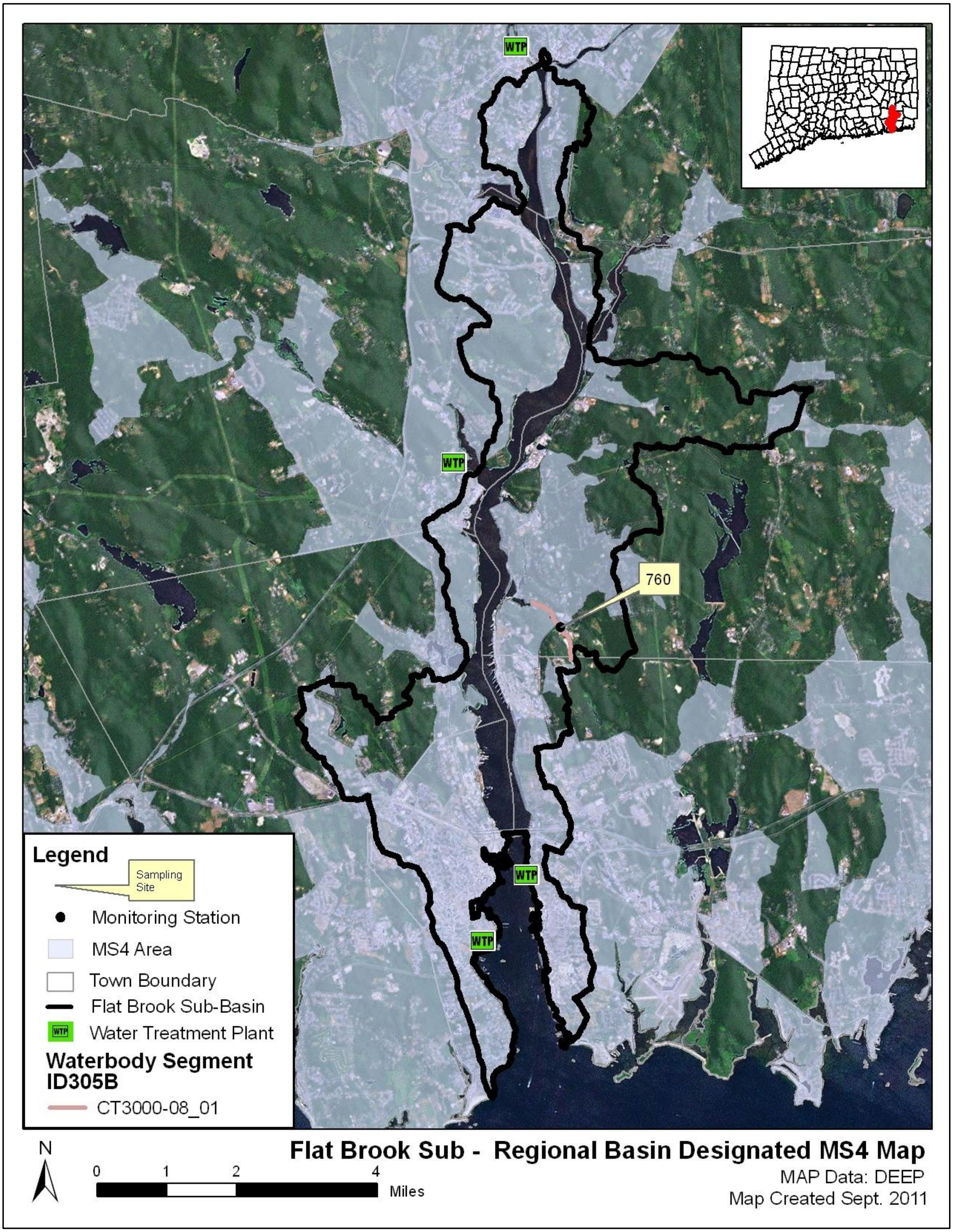


Table 5: List of MS4 sample locations and *E. coli* (colonies/100 mL) results in the Thames River watershed

Town	Location	MS4 Type	Receiving Waters	Sample Date	Result
Groton	#12 Thames Street & Pleasant Street	Residential	Thames River	11/10/05	510
Groton	#12 Thames Street & Pleasant Street	Residential	Thames River	12/01/06	920
Groton	#12 Thames Street & Pleasant Street	Residential	Thames River	01/11/08	50
Groton	#18 Shore Avenue & Prospect Street	Residential	Thames River	11/10/05	30
Groton	#19 Shore Avenue & Tylon Avenue	Residential	Thames River	11/10/05	20
Groton	#26 Shennecossette Road & Plant Street	Residential	Thames River	11/10/05	10
Groton	#26 Shennecossette Road & Plant Street	Residential	Thames River	12/01/06	550
Groton	#8 Grove Avenue & Bliven Street	Residential	Thames River	11/10/05	10
Groton	#8 Grove Avenue & Bliven Street	Residential	Thames River	12/01/06	580
Groton	Military Highway & Lestertown Road (outfall 3630R)	Residential	Thames River	07/08/05	3,800
Groton	Military Highway & Lestertown Road (outfall 3630R)	Residential	Thames River	11/30/05	200
Groton	Military Highway & Lestertown Road (outfall 3630R)	Residential	Thames River	12/01/06	1,360
Groton	Military Highway & Lestertown Road (outfall 3630R)	Residential	Thames River	11/06/07	1,250
Groton	Military Highway & Lestertown Road (outfall 3630R)	Residential	Thames River	06/04/08	3,200
Groton	Military Highway & Lestertown Road (outfall 3630R)	Residential	Thames River	06/04/08	4,400
Ledyard	CIP-1 Baldwin Hill Road	Industrial/Commercial	Thames River	07/12/06	900
Ledyard	CIP-1 Baldwin Hill Road	Industrial/Commercial	Thames River	12/01/06	220
Ledyard	CIP-1 Baldwin Hill Road	Industrial/Commercial	Thames River	01/11/08	20
Ledyard	CIP-1 Baldwin Hill Road	Industrial/Commercial	Thames River	04/28/08	40
Ledyard	CIP-1 Baldwin Hill Road	Industrial/Commercial	Thames River	06/09/09	4,610
Ledyard	CIP-2 Flat Brook Drive	Industrial/Commercial	Thames River	07/12/06	500
Ledyard	CIP-2 Flat Brook Drive	Industrial/Commercial	Thames River	12/01/06	100
Ledyard	CIP-2 Flat Brook Drive	Industrial/Commercial	Thames River	01/11/08	100
Ledyard	CIP-2 Flat Brook Drive	Industrial/Commercial	Thames River	04/28/08	600
Ledyard	CIP-2 Flat Brook Drive	Industrial/Commercial	Thames River	06/09/09	24,200
Ledyard	R-1 Whalehead Road	Residential	Thames River	07/12/06	>2000

Table 5: List of MS4 sample locations and *E. coli* (colonies/100 mL) results in the Thames River watershed (continued)

Town	Location	MS4 Type	Receiving Waters	Sample Date	Result
Ledyard	R-1 Whalehead Road	Residential	Thames River	12/01/06	250
Ledyard	R-1 Whalehead Road	Residential	Thames River	01/11/08	30
Ledyard	R-1 Whalehead Road	Residential	Thames River	04/28/08	20
Ledyard	R-1 Whalehead Road	Residential	Thames River	06/09/09	2,360
Ledyard	R-4 Eagle Ridge Drive detention basin inlet	Residential	Thames River	07/12/06	700
Ledyard	R-4 Eagle Ridge Drive detention basin inlet	Residential	Thames River	12/01/06	200
Ledyard	R-4 Eagle Ridge Drive detention basin inlet	Residential	Thames River	01/11/08	20
Ledyard	R-4 Eagle Ridge Drive detention basin inlet	Residential	Thames River	04/28/08	10
Ledyard	R-4 Eagle Ridge Drive detention basin inlet	Residential	Thames River	06/09/09	3,870
Waterford	Bolles Court Residential	Residential	Smith Cove, Thames River	10/25/05	10
Waterford	Bolles Court Residential	Residential	Smith Cove, Thames River	05/02/07	10
Waterford	Bolles Court Residential	Residential	Smith Cove, Thames River	01/07/09	10
Waterford	Hickory Lane #10127	Residential	Thames River	09/08/04	178
Shaded cells indicate an exceedance of single-sample based water quality criteria (410 colonies/100 mL)					

Publicly Owned Treatment Works

As shown in Figure 7, there are two publicly owned treatment works (POTWs), or wastewater treatment plants, in the Thames River watershed in Groton and New London downstream of the impaired tributary. There are no POTWs near Flat Brook, and therefore, POTWs are not a potential source of loading to Flat Brook.

<u>Non-point Sources</u>

Non-point source pollution (NPS) comes from many diffuse sources and is more difficult to identify and control. NPS pollution is often associated with land-use practices. Examples of NPS that can contribute bacteria to surface waters include insufficient septic systems, pet and wildlife waste, agriculture, and contact recreation (swimming or wading). Potential sources of NPS within the Thames River watershed are described below.

Stormwater Runoff from Developed Areas

The majority of the Thames River watershed is developed. Approximately 44% of the land use in the watershed is considered urban (Figures 4 and 9). Urban areas are often characterized by impervious cover, or surface areas such as roofs and roads that force water to run off land surfaces rather than infiltrate into the soil. Studies have shown a link between increasing impervious cover and degrading water quality conditions in a watershed (CWP, 2003). In one study, researchers correlated the amount of fecal coliform to the percent of impervious cover in a watershed (Mallin *et al.*, 2000).

As shown in Figure 8, approximately 36% of the Thames River watershed contains more than 16% impervious cover (Figure 9). Flat Brook is located in the area characterized by 7-11% impervious cover, but flows through commercial development along Route 12, particularly a large sand and gravel pit, Aqua Sports Diving Center, Terra Firma Self Storage, Student Transportation of America, CubeSmart Self Storage, and Baroco Corporation. Water quality data taken at Station 760, located within the urbanized portion of Flat Brook, exceeded the geometric mean during wet-weather, which suggests that stormwater runoff may be a source of bacteria to Flat Brook (Table 11).

Figure 8: Range of impervious cover (%) in the Thames River watershed

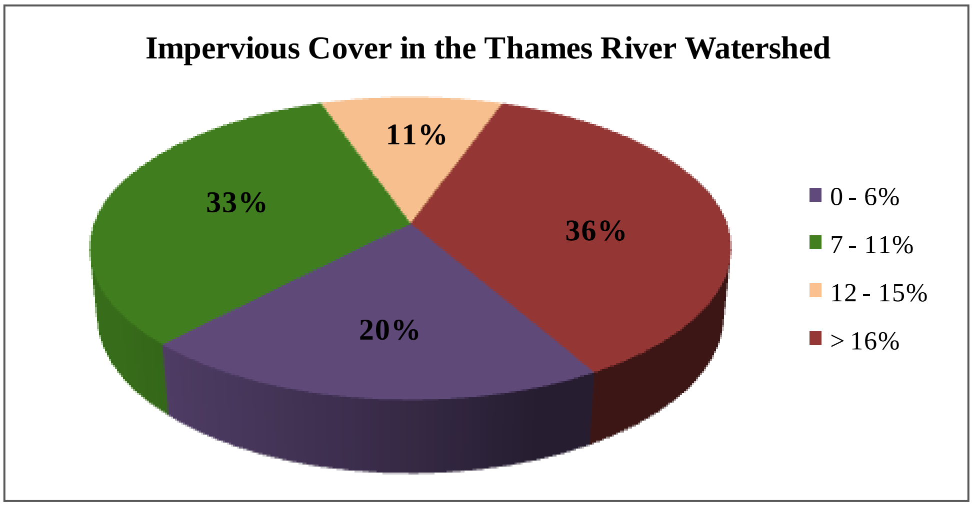
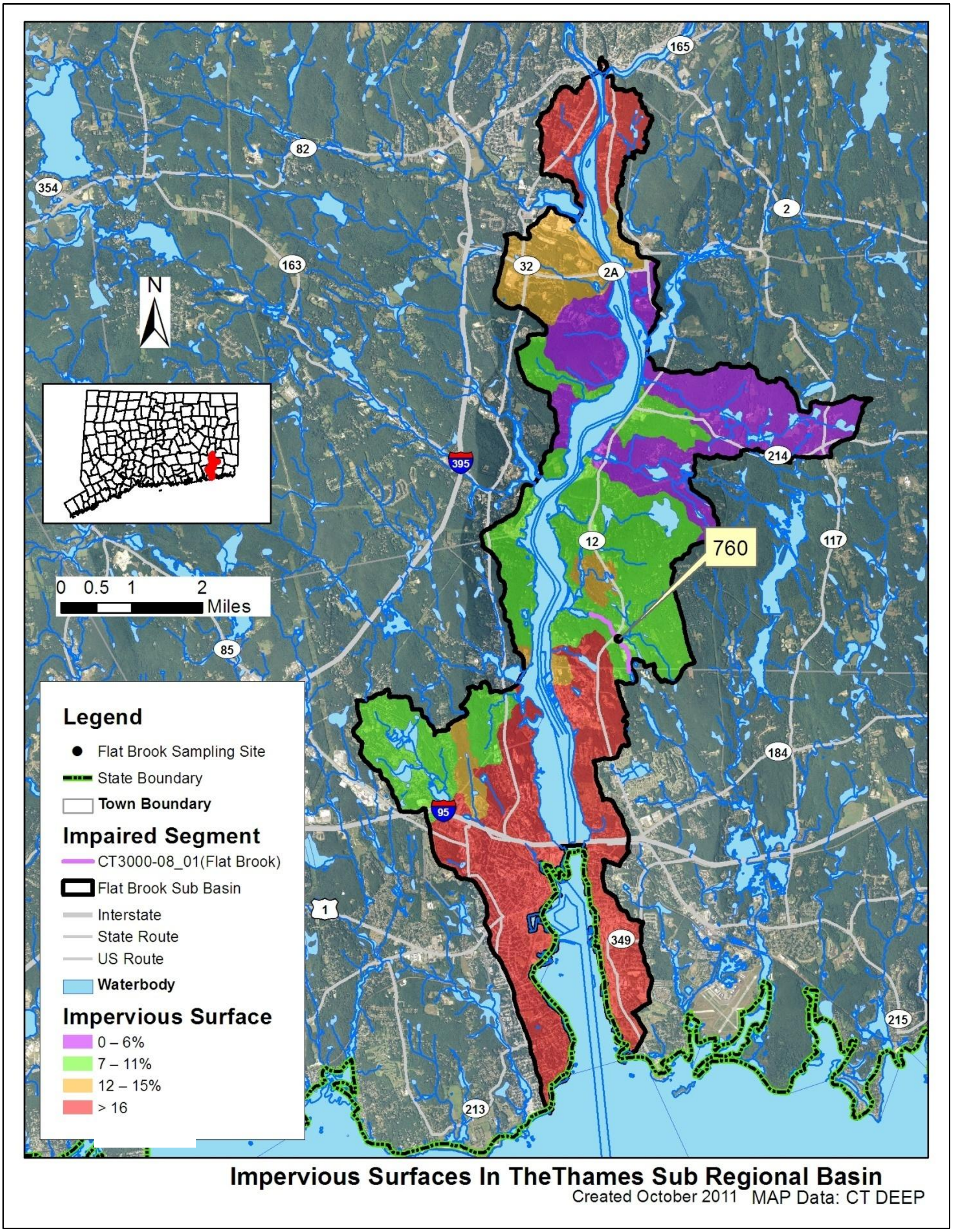


Figure 9: Impervious cover (%) for the Thames River watershed at the sub-regional level



Insufficient Septic Systems and Illicit Discharges

As shown in Figure 6, the portion of the watershed within the drainage area of Flat Brook relies on onsite wastewater treatment systems, such as septic systems. Insufficient or failing septic systems can be significant sources of bacteria by allowing raw waste to reach surface waters. A failing septic system north of Flat Brook near Clark Cove and downstream of Flat Brook was identified in Figure 6. Water quality data taken at Station 760 exceeded the geometric mean during dry-weather, which suggests that failing septic systems may be a source of bacteria to Flat Brook (Table 11). In Connecticut, local health directors or health districts are responsible for keeping track of any reported insufficient or failing septic systems in a specific municipality. The Towns of Ledyard (a sovereign nation) and Groton are part of the Ledge Light Health District (http://www.ledgelighthd.org/).

The Flat Brook drainage area is an MS4 area, and is likely to have piped storm drainage. It is possible that improper connection between wastewater systems and the stormwater drainage network exist, either through error, illicit connections, or leaks. Therefore, illicit discharges are a potential source of bacteria. The drainage area surrounding Flat Brook is not serviced by the municipal sewer system (Figure 6). As such, sewer system leaks are not a potential source of bacteria.

Wildlife and Domestic Animal Waste

Wildlife and domestic animals within the Thames River watershed represent another potential source of bacteria. Wildlife, including waterfowl, may be a significant bacteria source to surface waters. With the construction of roads and drainage systems, these wastes may no longer be retained on the landscape, but instead may be conveyed via stormwater to the nearest surface water. These physical land alterations can exacerbate the impact of natural sources on water quality (USEPA, 2001). As Flat Brook flows through forested residential areas near identified migratory waterfowl habitat along the Thames River, waste from wildlife and domestic animals, such as dogs, may be contributing to bacteria concentrations in Flat Brook.

As shown in Figure 6, the Goose Run golf course is located along the Thames River south of Flat Brook and out of Flat Brook drainage area. However, Flat Brook flows into identified migratory waterfowl habitat along the Thames River, which increases the probability that waterfowl are impacting the impaired tributary. Geese and other waterfowl are known to congregate in open areas including recreational fields, agricultural crop fields, and golf courses. In addition to creating a nuisance, large numbers of geese can also create unsanitary conditions on the grassed areas and cause water quality problems due to bacterial contamination associated with their droppings. Large populations of geese can also lead to habitat destruction as a result of overgrazing on wetland and riparian plants.

Agricultural Activities

Agricultural operations are an important economic activity and landscape feature in many areas of the State. Runoff from agricultural fields may contain pollutants such as bacteria and nutrients (USEPA, 2011a). This runoff can include pollutants from farm practices such as storing manure, allowing livestock to wade in nearby waterbodies, applying fertilizer, and reducing the width of vegetated buffer along the shoreline. Agricultural land use makes up 2% of the Thames River watershed. As there are no major agricultural areas near the impaired tributary, agricultural activities are most likely a small source of bacteria to Flat Brook.

Additional Sources

As shown in Figure 6, four landfills were identified upstream of the impaired tributary and three were identified downstream of the impaired tributary. However, there are no landfills identified within the drainage area of Flat Brook, so this is not a likely potential source of bacteria.

There may be other sources not listed here or identified in Figure 6 that contribute to the observed water quality impairment in Flat Brook. Further monitoring and investigation will confirm the listed sources and discover additional ones. More detailed evaluation of potential sources is expected to become available as activities are conducted to implement this TMDL.

Land Use/Landscape

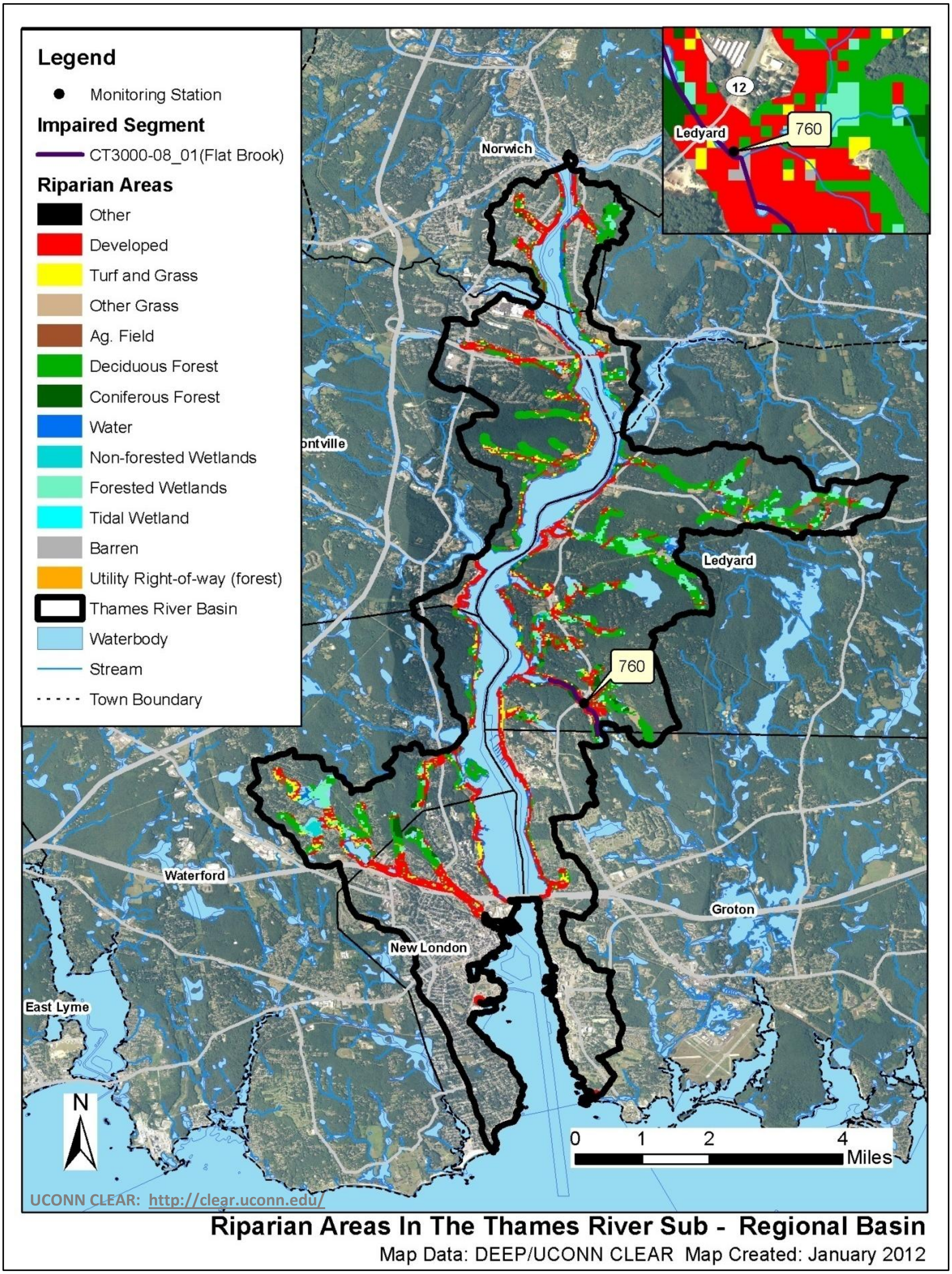
Riparian Buffer Zones

The riparian buffer zone is the area of land located immediately adjacent to streams, lakes, or other surface waters. The boundary of the riparian zone and the adjoining uplands is gradual and not always well-defined. However, riparian zones differ from uplands because of high levels of soil moisture, frequent flooding, and the unique assemblage of plant and animal communities found there. Through the interaction of their soils, hydrology, and vegetation, natural riparian areas influence water quality as contaminants are taken up into plant tissues, adsorbed onto soil particles, or modified by soil organisms. Any change to the natural riparian buffer zone can reduce the effectiveness of the natural buffer and has the potential to contribute to water quality impairment (USEPA, 2011b).

The CLEAR program at UCONN has created streamside buffer layers for the entire State of Connecticut (http://clear.uconn.edu/), which have been used in this TMDL. Analyzing this information can reveal potential sources and implementation opportunities at a localized level. The land use directly adjacent to a waterbody can have direct impacts on water quality from surface runoff sources.

The majority of the riparian zone for Flat Brook is characterized by developed land use (Figure 10). As previously noted, if not properly treated, runoff from developed areas may contain pollutants such as bacteria and nutrients.

Figure 10: Riparian buffer zone information for the Thames River watershed



CURRENT MANAGEMENT ACTIVITIES

CT DEEP's Non-Point Source Pollution Program administers a Non-Point Source Grant Program with funding from EPA under Section 319 of the Clean Water Act (319 grant). A $75,000 319 grant was awarded to the University of Connecticut's Departments of Plant Science and Cooperative Extension to create several on-site demonstration projects and season-long consultations on proper agricultural BMPs with the goal of quantifying reductions in pesticide and nutrient loading (http://www.depdata.ct.gov/maps/nps/npsmap.htm). A $25,664 319 grant was awarded to the Thames River Basin Partnership to hire a coordinator to facilitate nonpoint source activities and projects to reduce NPS pollution in the Thames River basin. In addition, a $35,000 319 grant was awarded to the Eastern Connecticut Conservation District to improve the water quality and recreational swimming area at Spaulding Pond of Mohegan Park in Norwich, CT.

As indicated previously, Ledyard and Groton are regulated under the MS4 program. The MS4 General Permit is required for any municipality with urbanized areas that initiates, creates, originates or maintains any discharge of stormwater from a storm sewer system to waters of the State. The MS4 permit requires towns to design a Stormwater Management Plan (SMP) to reduce the discharge of pollutants in stormwater to improve water quality. The plan must address the following 6 minimum measures:

1. Public Education and Outreach.
2. Public Involvement/Participation.
3. Illicit discharge detection and elimination.
4. Construction site stormwater runoff control.
5. Post-construction stormwater management in new development and redevelopment.
6. Pollution prevention/good housekeeping for municipal operations.

Each town is also required to submit an annual update outlining the steps they are taking to meet the six minimum measures. All updates that address bacterial contamination in the watershed are summarized in Tables 6 and 7.

Table 6: Summary of MS4 requirement updates related to the reduction of bacterial contamination from Ledyard, CT (Permit # GSM000099)

Minimum Measure	Ledyard MS4 General Permit (2011)
Public Outreach and Education	1) No updates.
Public Involvement and Participation	1) Involved in Hazardous Waste Recycling program.
Illicit Discharge Detection and Elimination	1) Completed storm sewer outfall mapping and GIS data imported. 2) Town employees trained to note potential illicit discharges during storm drainage inspections.
Construction Site Stormwater Runoff Control	1) Conducted site inspections to ensure implementation of BMPs.
Post Construction Stormwater Management	1) Required mitigation measure when proposed development would likely cause an increase in volume or rate of stormwater runoff.
Pollution Prevention and Good Housekeeping	1) Conducted annual street sweeping and catch basin cleaning. 2) Reduced sediment load by switching to Ice-B-Gone, a treated salt for winter road deicing.

Table 7: Summary of MS4 requirement updates related to the reduction of bacterial contamination from Groton, CT (Permit # GSM000055)

Minimum Measure	Groton MS4 General Permit (2011)
Public Outreach and Education	1) Included stormwater runoff information in the Department of Parks and Recreation 'Discover' magazine. 2) Aired a video on non-point pollution on local cable access channel. 3) Developed a stormwater webpage to inform citizens on improper waste disposal and illegal discharges to the MS4. 4) Distributed brochure on picking up dog waste with every issued dog license.
Public Involvement and Participation	1) Encouraged public involvement in implementing the draft SWMP, annual report, and stormwater committee meetings. 2) Sponsored a Household Hazardous Waste Collection Day.
Illicit Discharge Detection and Elimination	1) Conducted dry weather outfall screening. 2) Mapped all catch basins, drain manholes, stormwater pipes, and outfalls (greater than 12").
Construction Site Stormwater Runoff Control	1) Updated stormwater quality and stormwater management standards.
Post Construction Stormwater Management	1) Will propose zoning regulations requiring developers to use specific standards in designing and constructing stormwater controls.
Pollution Prevention and Good Housekeeping	1) Conducted annual street sweeping and catch basin cleaning. 2) Switched to salt for winter road deicing. 3) Installed five dog waste stations at various parks.

RECOMMENDED NEXT STEPS

The Towns of Ledyard and Groton have developed and implemented programs to protect water quality from bacterial contamination. Future mitigative activities are necessary to ensure the long-term protection of Flat Brook and have been prioritized below.

1) Continue monitoring of permitted sources.

Previous MS4 outfall sampling at CIP-1 at Baldwin Hill Road and CIP-2 at Flat Brook Drive in Ledyard, CT have exceeded single sample values for *E. coli* WQS multiples times in 2006, 2008, and 2009 (Table 5). Further monitoring will provide information essential to better locate, understand, and reduce pollution sources. If any current monitoring is not done with appropriate bacterial indicator based on the receiving water, then a recommended change during the next permit reissuance is to include the appropriate indicator species. If facility monitoring indicates elevated bacteria, then implementation of permit required, and voluntary measures to identify and reduce sources of bacterial contamination at the facility are an additional recommendation. Regular monitoring should be established for all permitted sources to ensure compliance with permit requirements and to determine if current requirements are adequate or if additional measures are necessary for water quality protection.

Section 6(k) of the MS4 General Permit requires a municipality to modify their Stormwater Management Plan to implement the TMDL within four months of TMDL approval by EPA if stormwater within the municipality contributes pollutant(s) in excess of the allocation established by the TMDL. For discharges to impaired waterbodies, the municipality must assess and modify the six minimum measures of its plan, if necessary, to meet TMDL standards. Particular focus should be placed on the following plan components: public education, illicit discharge detection and elimination, stormwater structures cleaning, and the repair, upgrade, or retrofit of storm sewer structures. The goal of these modifications is to establish a program that improves water quality consistent with TMDL requirements. Modifications to the Stormwater Management Plan in response to TMDL development should be submitted to the Stormwater Program of DEEP for review and approval.

Table 8 details the appropriate bacteria criteria for use as waste load allocations established by this TMDL for use as water quality targets by permittees as permits are renewed and updated, within the Thames watershed.

For any municipality subject to an MS4 permit and affected by a TMDL, the permit requires a modification of the SMP to include BMPs that address the included impairment. In the case of bacteria related impairments municipal BMPs could include: implementation or improvement to existing nuisance wildlife programs, septic system monitoring programs, any additional measures that can be added to the required illicit discharge detection and elimination (IDDE) programs, and increased street sweeping above basic permit requirements. Any non-MS4 municipalities can implement these same types of initiatives in effort to reduce bacteria source loading to impaired waterways.

Any facilities that discharge non-MS4 regulated stormwater should update their Pollution Prevention Plan to reflect BMPs that can reduce bacteria loading to the receiving waterway. These BMPs could include nuisance wildlife control programs and any installations that increase surface infiltration to reduce overall stormwater volumes. Facilities that are regulated under the Commercial Activities Stormwater Permit should report any updates to their SMP in their summary documentation submitted to DEEP.

Table 8. Bacteria (*e.coli*) TMDLs, WLAs, and LAs for Recreational Use.

		Instantaneous *E. coli* (#/100mL)						Geometric Mean *E. coli* (#/100mL)	
Class	**Bacteria Source**	**WLA**[6]			**LA**[6]			**WLA**[6]	**LA**[6]
	Recreational Use	1	2	3	1	2	3	**All**	**All**
A	Non-Stormwater NPDES	0	0	0				0	
	CSOs	0	0	0				0	
	SSOs	0	0	0				0	
	Illicit sewer connection	0	0	0				0	
	Leaking sewer lines	0	0	0				0	
	Stormwater (MS4s)	235[7]	410[7]	576[7]				126[7]	
	Stormwater (non-MS4)				235[7]	410[7]	576[7]		126[7]
	Wildlife direct discharge				235[7]	410[7]	576[7]		126[7]
	Human or domestic animal direct discharge[5]				235	410	576		126

(1) **Designated Swimming.** Procedures for monitoring and closure of bathing areas by State and Local Health Authorities are specified in: Guidelines for Monitoring Bathing Waters and Closure Protocol, adopted jointly by the Department of Environmental Protections and the Department of Public Health. May 1989. Revised April 2003 and updated December 2008.

(2) **Non-Designated Swimming.** Includes areas otherwise suitable for swimming but which have not been designated by State or Local authorities as bathing areas, waters which support tubing, water skiing, or other recreational activities where full body contact is likely.

(3) **All Other Recreational Uses.**

(4) Criteria for the protection of recreational uses in Class B waters do not apply when disinfection of sewage treatment plant effluents is not required consistent with Standard 23. (Class B surface waters located north of Interstate Highway I-95 and downstream of a sewage treatment plant providing seasonal disinfection May 1 through October 1, as authorized by the Commissioner.)

(5) Human direct discharge = swimmers

(6) Unless otherwise required by statute or regulation, compliance with this TMDL will be based on ambient concentrations and not end-of-pipe bacteria concentrations

(7) Replace numeric value with “natural levels” if only source is naturally occurring wildlife. Natural is defined as the biological, chemical and physical conditions and communities that occur within the environment which are unaffected or minimally affected by human influences (CT DEEP 2011a). Sections 2.2.2 and 6.2.7 of this Core Document deal with BMPs and delineating type of wildlife inputs.

2) Identify areas along Flat Brook to implement Best Management Practices (BMPs) to control stormwater runoff.

As noted previously, 44% of the Thames River watershed is considered urban, and the Towns of Ledyard and Groton are MS4 communities regulated by the MS4 program. Station 760, located within the urban portion of Flat Brook, exceeded the geometric mean during wet-weather. As such, stormwater runoff is most likely contributing bacteria to the waterbodies. To identify other areas that are contributing bacteria to the impaired tributary, the towns should continue to conduct wet-weather sampling at stormwater outfalls that discharge directly to Flat Brook. Outfalls that have previously shown high bacteria concentrations should be prioritized for BMP installation (Table 5). To treat stormwater runoff, the towns should identify areas along the impaired segment to install BMPs that encourage stormwater to infiltrate into the ground before entering the waterbodies. These BMPs would disconnect impervious areas and reduce pollutant loads to the river. More detailed information and BMP recommendations can be found in the core TMDL document.

3) Evaluate municipal education and outreach programs regarding animal waste.

As most of the riparian zone of Flat Brook is developed and flows through forested residential areas, any education and outreach program should highlight the importance of managing waste from horses, dogs, and other pets and not feeding waterfowl and wildlife. The town and residents can take measures to minimize waterfowl-related impacts such as allowing tall, coarse vegetation to grow in the riparian areas of Flat Brook that are frequented by waterfowl. Waterfowl, especially grazers like geese, prefer easy access to water. Maintaining an uncut vegetated buffer along the shore will make the habitat less desirable to geese and encourage migration. In addition, any educational program should emphasize that feeding waterfowl, such as ducks, geese, and swans, may contribute to water quality impairments in Flat Brook and can harm human health and the environment. Animal wastes should be disposed of away from any waterbody or storm drain system. BMPs effective at reducing the impact of animal waste on water quality include installing signage, providing pet waste receptacles in high-use areas, enacting ordinances requiring the clean-up of pet waste, and targeting educational and outreach programs in problem areas.

4) Develop a system to monitor septic systems.

Though the lower portion of the Thames River watershed relies on the municipal sanitary sewer system, residents in the drainage area of Flat Brook rely on septic systems. If not already in place, Ledyard and Groton should establish a program to ensure that existing septic systems are properly operated and maintained, and create an inventory of existing septic systems through mandatory inspections. Inspections help encourage proper maintenance and identify failed and sub-standard systems. Policies that govern the eventual replacement of sub-standard systems within a reasonable timeframe can be adopted. Ledyard and Groton can also develop a program to assist citizens with the replacement and repair of older and failing systems.

Table 9: Flat Brook Bacteria Data

Waterbody ID: CT3000-08_01

Characteristics: Freshwater, Class A, Potential Drinking Water Supplies, Habitat for Fish and other Aquatic Life and Wildlife, Recreation, Navigation, and Industrial and Agricultural Water Supply

Impairment: Recreation (*E. coli bacteria)*

Water Quality Criteria for E. coli:

Geometric Mean: 126 colonies/100 mL

Single Sample: 410 colonies/100 mL

Percent Reduction to meet TMDL:

Geometric Mean: **81%**

Single Sample: **97%**

Data: 2006-2009 from CT DEEP targeted sampling efforts, 2012 TMDL Cycle

Single sample *E. coli* (colonies/100 mL) data from Station 760 on Flat Brook with annual geometric means calculated

Station Name	Station Location	Date	Results	Wet/Dry	Geomean
760	Baldwin Hill Road	6/21/2006	300	dry	
760	Baldwin Hill Road	6/28/2006	2600	dry	
760	Baldwin Hill Road	7/3/2006	159†	dry	
760	Baldwin Hill Road	7/11/2006	1100	dry	
760	Baldwin Hill Road	7/18/2006	220	dry	
760	Baldwin Hill Road	7/27/2006	61	dry	228
760	Baldwin Hill Road	8/2/2006	220	dry	
760	Baldwin Hill Road	8/9/2006	120†	dry	
760	Baldwin Hill Road	8/16/2006	220	wet	
760	Baldwin Hill Road	8/23/2006	85	dry	
760	Baldwin Hill Road	9/11/2006	96	dry	

Single sample *E. coli* (colonies/100 mL) data from Station 760 on Flat Brook with annual geometric means calculated (continued)

Station Name	Station Location	Date	Results	Wet/Dry	Geomean
760	Baldwin Hill Road	6/6/2007	350	wet	**679* (81%)**
760	Baldwin Hill Road	6/13/2007	420	dry	
760	Baldwin Hill Road	6/20/2007	380	dry	
760	Baldwin Hill Road	7/11/2007	450	dry	
760	Baldwin Hill Road	7/19/2007	1300	wet	
760	Baldwin Hill Road	7/26/2007	465†	dry	
760	Baldwin Hill Road	8/9/2007	1000	wet	
760	Baldwin Hill Road	8/23/2007	390	wet	
760	Baldwin Hill Road	9/4/2007	350†	dry	
760	Baldwin Hill Road	9/12/2007	10000	wet	
760	Baldwin Hill Road	6/4/2008	5300†	wet**	333
760	Baldwin Hill Road	6/11/2008	340	dry**	
760	Baldwin Hill Road	6/19/2008	400†	dry**	
760	Baldwin Hill Road	6/25/2008	380	wet**	
760	Baldwin Hill Road	7/2/2008	115†	dry**	
760	Baldwin Hill Road	7/9/2008	310	dry**	
760	Baldwin Hill Road	7/16/2008	130	dry**	
760	Baldwin Hill Road	7/23/2008	110	wet**	
760	Baldwin Hill Road	7/30/2008	120	dry**	
760	Baldwin Hill Road	8/6/2008	**14000* (97%)**	wet**	
760	Baldwin Hill Road	8/13/2008	110	dry**	
760	Baldwin Hill Road	8/21/2008	73	dry**	

Single sample *E. coli* (colonies/100 mL) data from Station 760 on Flat Brook with annual geometric means calculated (continued)

Station Name	Station Location	Date	Results	Wet/Dry	Geomean
760	Baldwin Hill Road	6/3/2009	110	dry**	151
760	Baldwin Hill Road	6/11/2009	140†	wet**	
760	Baldwin Hill Road	6/25/2009	150†	dry**	
760	Baldwin Hill Road	7/9/2009	180	wet	
760	Baldwin Hill Road	7/16/2009	98	dry	
760	Baldwin Hill Road	7/23/2009	230	wet	
760	Baldwin Hill Road	7/29/2009	120	dry	
760	Baldwin Hill Road	8/13/2009	280†	dry	
760	Baldwin Hill Road	8/20/2009	129†	dry	

Shaded cells indicate an exceedance of water quality criteria

†Average of two duplicate samples

**** Weather conditions for selected data taken from Hartford because local station had missing data**

***Indicates single sample and geometric mean values used to calculate the percent reduction**

Wet and dry weather geometric mean values for Station 760 on Flat Brook

Station Name	Station Location	Years Sampled	Number of Samples		Geometric Mean		
			Wet	Dry	All	Wet	Dry
760	Baldwin Hill Road	2006-2009	13	29	302	683	209

Shaded cells indicate an exceedance of water quality criteria

Weather condition determined from rain gages at Norwich Public Utility Plant in Norwich, CT and Hartford Bradley International Airport

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