Furnace Brook

Watershed-Based Restoration Plan

March 2010

Submitted to:

New Hampshire Department of Environmental Services

&

US EPA Region 1

Submitted by:

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1. Introduction

Furnace Brook is a small stream situated in New Ipswich, New Hampshire. The Brook flows generally to the east for a distance of approximately 3.5 miles before joining the Souhegan River (Figure 1-1). The Furnace Brook watershed drains 3.9 square miles and includes a wide range of land cover. The upper watershed may be defined roughly as the half of the watershed that drains to an impoundment. This area is primarily forested with some residential and agricultural land use. The middle section of the watershed, including downtown New Ipswich, has dense residential and business development near Furnace Brook and a tributary named Willow Brook. The middle watershed area also has forested and wetland areas. The lower watershed is largely undeveloped and features forested areas with some agricultural fields.

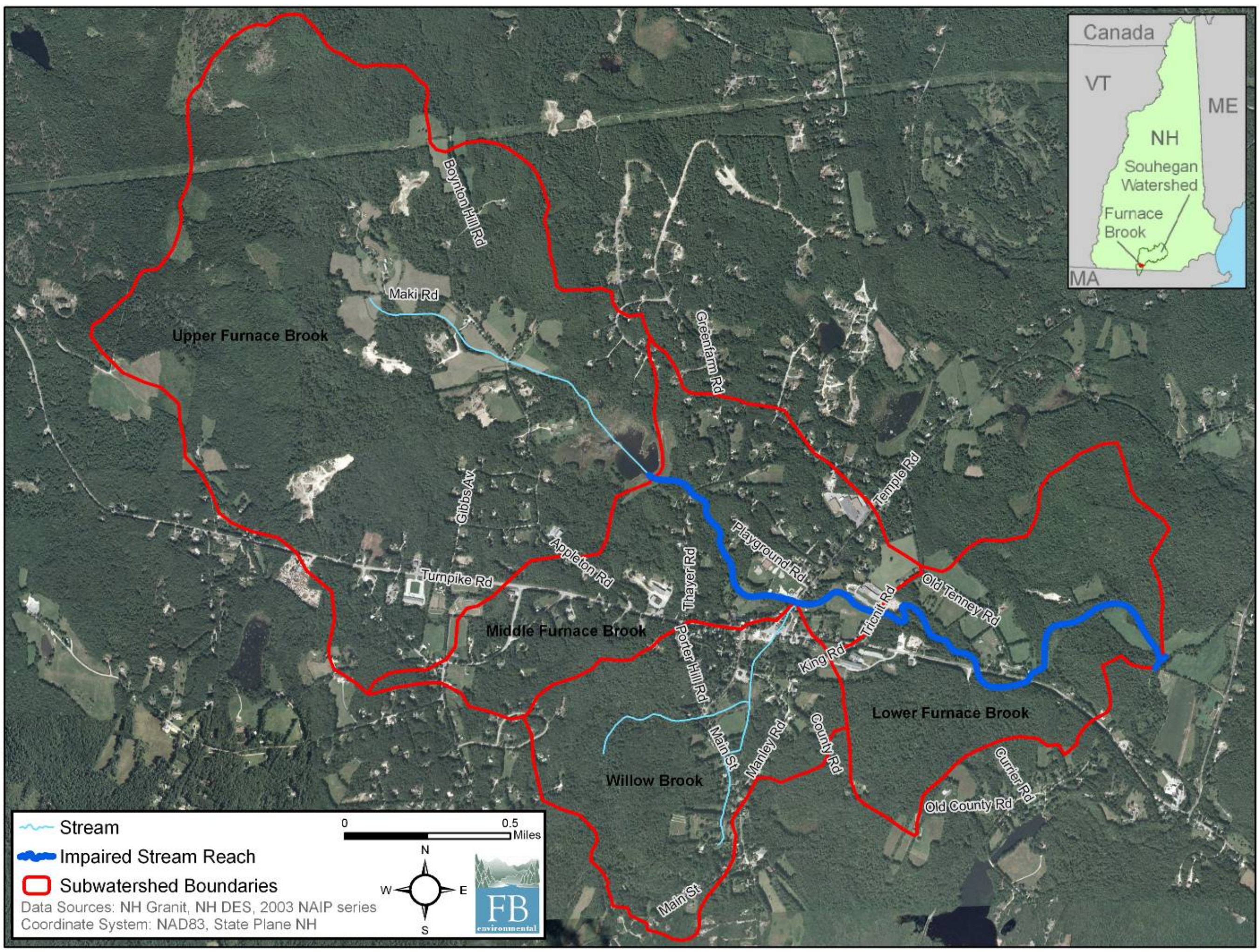


Figure 1-1: Furnace Brook watershed map.

1.1. Statement of Problem

Furnace Brook has been adversely impacted in several important ways. The waters of Furnace Brook have been found to contain elevated levels of potentially harmful bacteria. *Escherichia coli* (*E. coli*) bacteria were measured in Furnace Brook at levels above the water quality standard during field surveys conducted from 1999 through 2003. *E. coli* is used as an indicator organism because it is easily cultured and its presence in water in defined amounts indicates that sewage may be present. If sewage is present in water, pathogenic or disease-causing organisms may also be present, which, if ingested, may cause illness. The presence of elevated levels of indicator bacteria in Furnace Brook therefore represents a potential threat to human health.

The aquatic habitat of Furnace Brook has been adversely impacted by physical modification and excessive loading of pollutants. Physical modification includes an impoundment and associated outlet pipe and pipe culverts at roadway crossings. Movement of and encroachment on Furnace Brook and Willow Brook stream channels in the downtown area also represents a major physical impact. Excessive suspended solids loading to Furnace Brook has been observed throughout the Brook, where impervious surfaces are adjacent to the stream channel. Suspended solids, such as sands and silts, typically contain a variety of pollutants, including bacteria, nutrients and metals that can be harmful to stream ecosystems.

Violations of state water quality standards for *E. Coli* bacteria have resulted in Furnace Brook being listed as an "impaired" stream, meaning that it fails to comply with water quality standards according to state statute RSA 485-A:12. This statute states that impaired waters must be restored. Consequently, a set of analyses and restoration steps are required for Furnace Brook because of its impaired status.

Furnace Brook is included in the Statewide Total Maximum Daily Load (TMDL) report for New Hampshire Bacteria Impaired Waters (NHDES 2010). The TMDL calls for a 49% reduction in *E. coli* (based on the geometric mean of sampling data) in order for Furnace Brook to come into compliance with water quality standards (see Section 8 and Appendix G of the TMDL report, available at **online address**). This watershed-based restoration plan provides detailed information on the sources of bacteria in the Furnace Brook watershed and recommends actions to achieve the reductions called for in the TMDL. This plan may also serve as an example for other impaired streams, specified in the TMDL report, to follow as an important step toward restoration and water quality compliance.

1.2. Goals and Approach

The goals of this project were to develop a watershed based restoration plan that:

- Restores Furnace Brook by removing excess bacteria and other pollutants;

- Is eligible for Section 319 Nonpoint Source funding to implement the restoration plan (see Section 1.4); and
- Can be used as a guide by other stakeholders interested in preparing similar Section 319 eligible watershed based restoration plans for other impaired surface waters.

The approach has included working collaboratively with stakeholders, conducting as much local assessment as possible, and identifying practical, locally-supported mitigation actions to restore Furnace Brook. Specifically, the project consists of the following tasks:

1. Coordinate closely with local stakeholders in all phases of the project;
2. Obtain and review available reports, data, and knowledge related to Furnace Brook;
3. Design and conduct a field investigation, including water sampling;
4. Conduct pollutant source identification surveys and analyses;
5. Estimate bacteria source loading and reductions associated with mitigative actions
6. Prioritize potential pollutant sources to mitigate in coordination with stakeholders; and
7. Develop preliminary mitigation measures for high priority sources.

This watershed-based plan describes each of the tasks above and provides recommended next step actions to restore Furnace Brook.

1.3. Document Organization

This watershed plan is organized as follows:

- *Section 2 – Furnace Brook Watershed Characterization.* This section provides a description of Furnace Brook and its surrounding watershed with photographs and maps. A physical description is provided along with a summary of water quality investigations. This section also provides the reader with the background information about the study area necessary to place the pollution source information in context.
- *Section 3 - Pollutant Source Characterization*. This section describes source identification surveys and 50 potential pollution sources identified in the watershed. Potential pollutant sources are organized by type as follows: developed area runoff, failing septic systems, wildlife, and livestock. Bacteria loads are estimated for each type of pollutant source.

- *<u>Section 4</u> – Nonpoint Source Management Measures to Mitigate Pollution Sources.* This section provides preliminary designs for mitigating a set of high priority sources in the Furnace Brook watershed. Estimated reductions in bacteria loading for mitigating sources are also provided. A set of recommended actions toward implementing the plan and restoring Furnace Brook are also provided. The designs and recommendations provided in this section are directly applicable to support 319 grant applications for NPS restoration.

- *<u>Section 5</u> – Technical and Financial Support*. This section provides an overview of the Section 319 NPS mitigation program and other resources that are available to support implementation of next steps for the restoration of Furnace Brook.

- *<u>Section 6</u> – Public Information and Outreach*. This section provides a summary of local stakeholder involvement in the project to-date and recommendations for next steps for public information and outreach.

- *<u>Section 7</u> – Schedule and Interim Milestones.* This section outlines a preliminary schedule and interim milestones for future activities in the Furnace Brook watershed.

- *<u>Section 8</u> – Monitoring and Evaluation Criteria.* This section describes a new monitoring program undertaken by the Town of New Ipswich and provides recommendations for evaluation criteria for future monitoring programs.

1.4. Required Nine Minimum Measures for Watershed-Based Plans

EPA has developed a set of required elements for watershed-based plans with a goal of ensuring that the plans are complete and capable of supporting restoration. These elements are called “nine minimum measures” and are listed below. Watershed-based plans are required to address these elements in order for projects to qualify for Section 319 NPS mitigation project funding. Each of the required EPA elements is listed below and the sections of this report where they are addressed are indicated parenthetically.

1. Identify pollutant causes and sources (Section 3);
2. Estimate pollutant load reduction (Section 4);
3. Describe NPS mitigation and management measures to be implemented (Section 4);
4. Estimate of technical and financial assistance needed (Section 5);
5. Describe public information and outreach activities (Section 6);
6. Specify implementation schedule (Section 7);
7. Establish interim milestones (Section 7);

8. Describe evaluation criteria (Section 8); and
9. Describe monitoring program (Section 8).

Based on correspondence with the EPA and DES Section 319 coordinators, this watershed based restoration plan includes all of the required EPA elements and is eligible for Section 319 implementation funding.

2. Furnace Brook Watershed Characterization

The Furnace Brook watershed was characterized during a series of field visits conducted in 2008. The goal of watershed characterization is to develop an understanding of current conditions in the Brook, the riparian area, and surrounding watershed. Field visits included reconnaissance surveys, water sampling surveys, and geomorphic surveys. A chronological list of 2008 field visits is provided below:

1. April 4 – Watershed reconnaissance survey;
2. April 10 – Watershed reconnaissance survey;
3. May 8 – Watershed tour and stakeholder meeting with Souhegan River stakeholder group;
4. June 16 – Water quality survey;
5. June 17 – Water quality survey;
6. June 19 – Fluvial geomorphology survey;
7. June 23 – Fluvial geomorphology survey;
8. July 1 – Water quality survey;
9. July 8 – Water quality survey;
10. August 25 – Water quality survey;
11. September 8 – Water quality survey;
12. September 29 – Water quality survey; and
13. September 29 – Watershed tour with New Ipswich stakeholder group.

An overview of Furnace Brook is provided below followed by a summary of historic and recent water quality surveys. In fall 2008 and spring 2009, a set of pollutant source identification surveys were conducted to support watershed based planning. These surveys and the resulting pollutant source characterization are described in Section 3.

2.1. Overview of the Furnace Brook Watershed

Furnace Brook is a small stream situated in New Ipswich, New Hampshire. The Brook flows generally to the east for a distance of approximately 3.5 miles before joining the Souhegan River (Figure 1-1). The Brook is generally between 2 and 20 feet wide and its substrate is primarily gravel and cobble. Figure 2-1 provides a USGS topographic map of the Furnace Brook watershed with elevation contours. Furnace Brook is a moderately high gradient stream with a slope of approximately 75 feet per mile. There are two steep reaches and two low gradient wetland reaches.

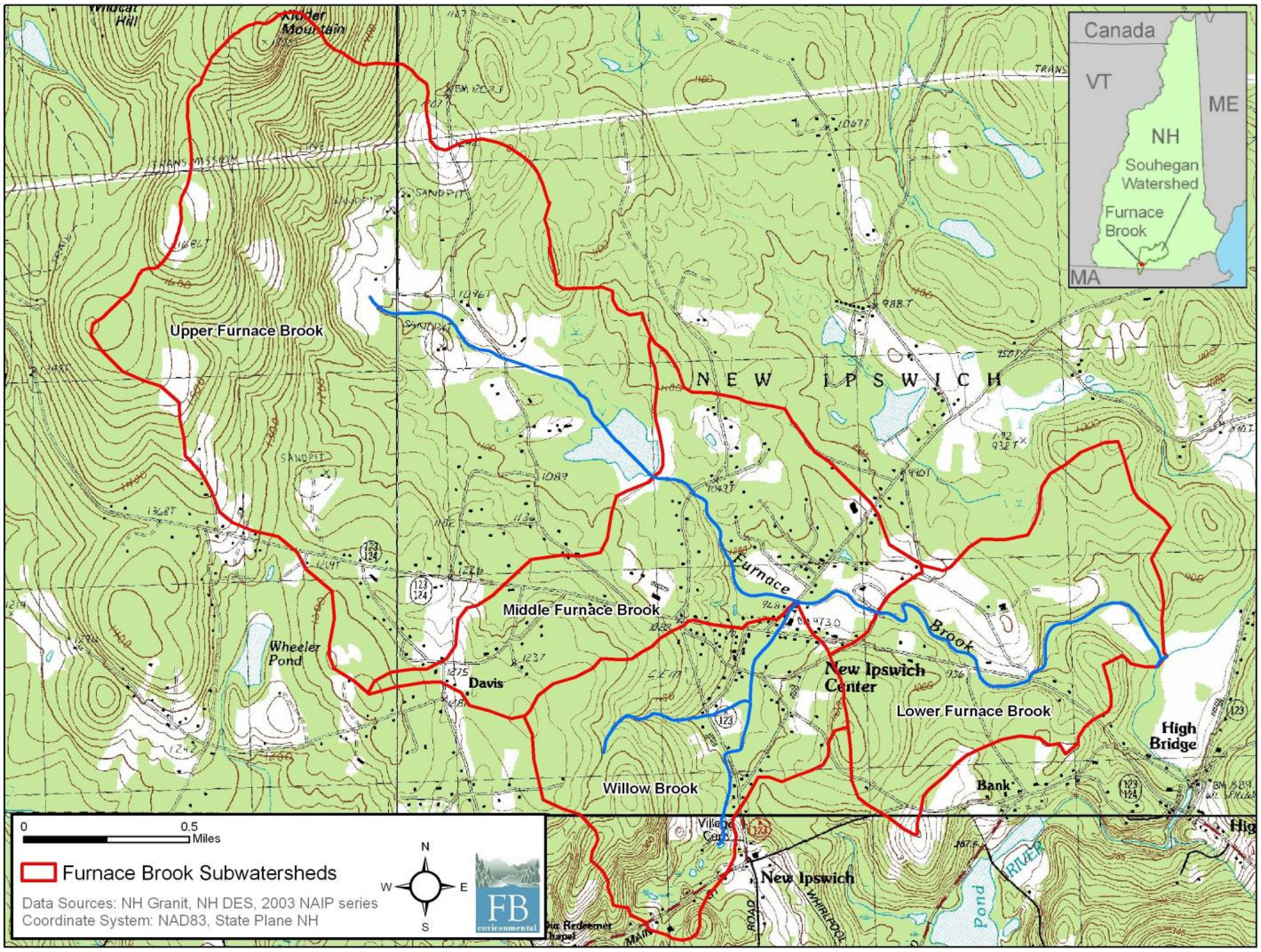


Figure 2-1: Furnace Brook watershed USGS topographic map.

A fluvial geomorphologic survey of Furnace Brook was conducted in June 2008 by Field Geology Services. The survey report is in Appendix A. The report provides a brief geomorphic description of the Brook and identifies numerous locations where the Brook has been physically modified by human activity. The report also describes opportunities for the restoration of Furnace Brook's floodplain access and channel form in several reaches.

The Furnace Brook watershed drains 3.9 square miles and includes a wide range of land cover. The watershed is primarily forested with some residential, commercial, and agricultural land use. Figure 2-2 above provides a map of the watershed with land cover indicated. Furnace Brook may be represented as three components; the upper watershed, the middle watershed (including the Willow Brook tributary), and the lower watershed.

The upper watershed may be defined as roughly ½ of the watershed and drains to the impoundment. This area is primarily forested with some residential and agricultural land use. The middle section of the watershed, including downtown New Ipswich, has dense residential and business development near Furnace Brook and Willow Brook. The middle watershed area also has forested and wetland areas. The lower watershed is largely undeveloped and features forested areas with some agricultural fields. A description of each of these areas is provided below along with maps and photographs.

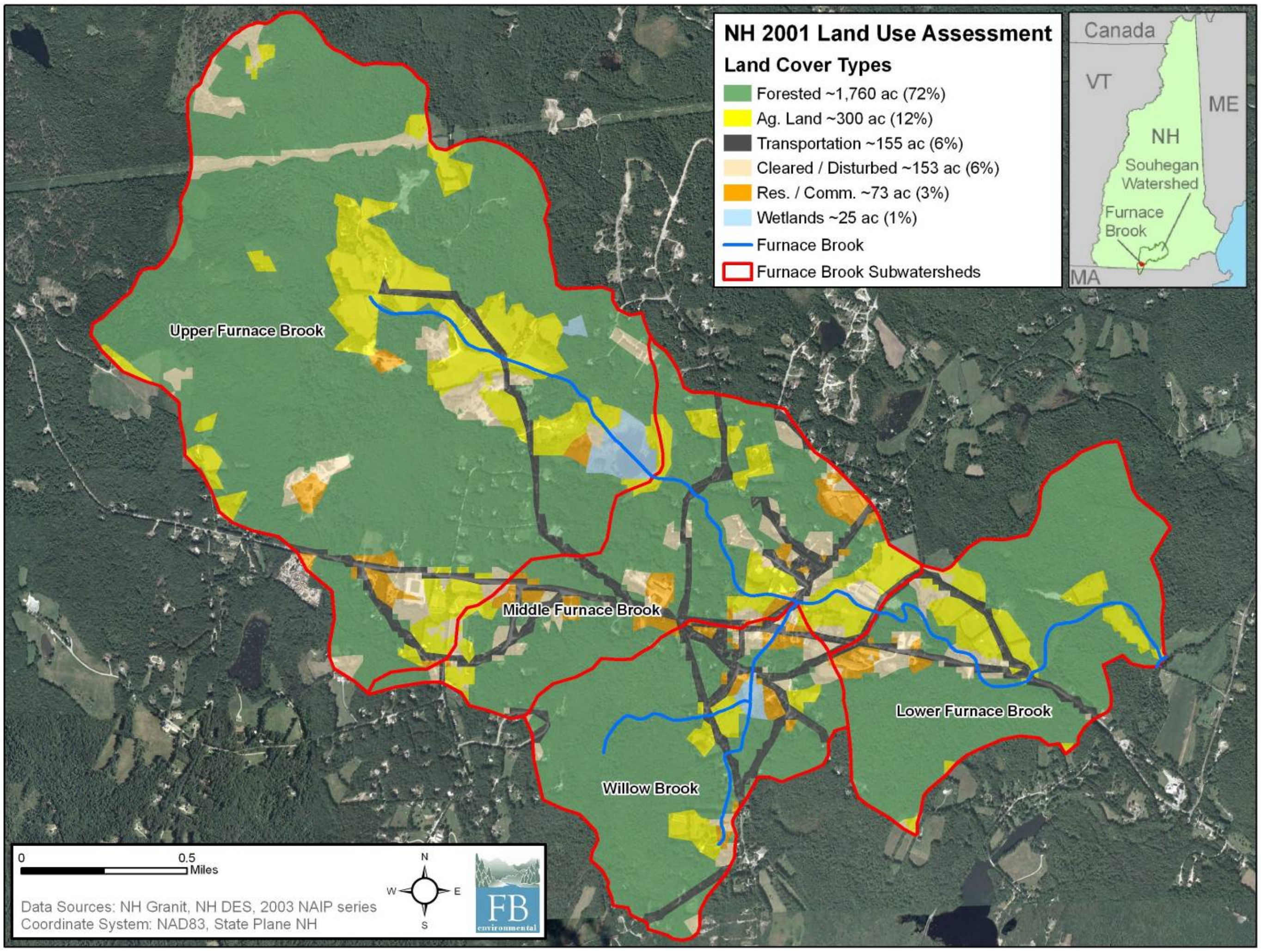


Figure 2-2: Furnace Brook watershed landcover map.

2.2. Upper Furnace Brook

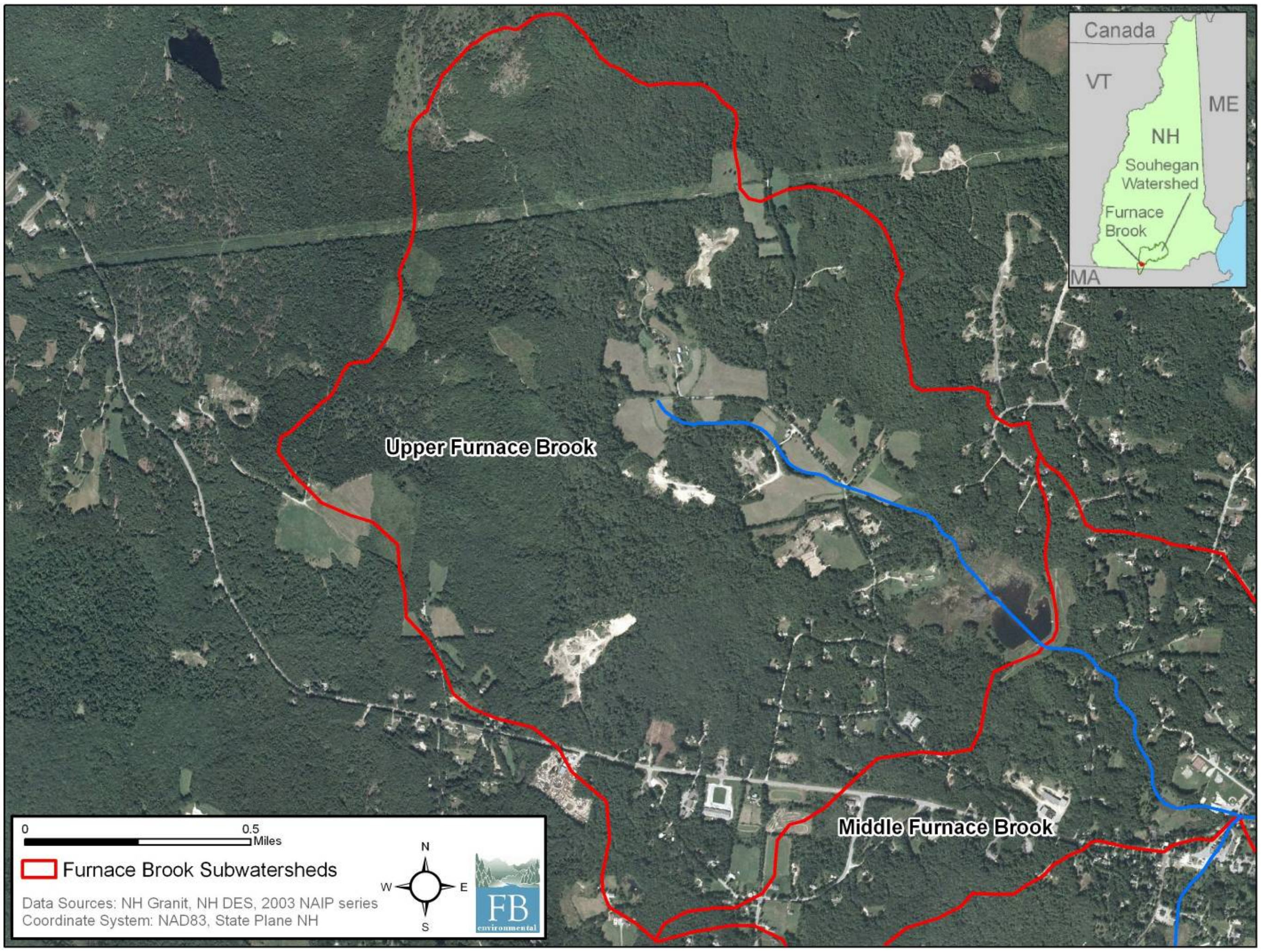


Figure 2-3: Upper Furnace Brook watershed map.

Upper Furnace Brook is defined as the headwaters to the outlet of the impoundment and represents roughly ½ (2.0 of 3.9 square miles) of the Furnace Brook watershed (Figure 2-3). At its headwaters, Furnace Brook drains the eastern slope of Kidder Mountain (elevation 1,805 feet) and two smaller hills. The Brook forms two braids as it flows across agricultural fields and under Appleton Road towards the impoundment. At this point, the Brook is typically 2 to 5 feet wide and 1 to 2 feet deep. Photographs of Furnace Brook above and below Appleton Road are provided in Figure 2-4 (below).

Figure 2-4: Photos of Furnace Brook above and below Appleton Road.

From the Appleton Road crossing (elevation approximately 1,100 feet), Furnace Brook flows through a low gradient reach and into the impoundment. Another unnamed brook enters the impoundment from the southeast after crossing Appleton Road near the Appleton Gates Apartment Building. Figure 2-5 (next page) provides photographs taken facing west across the impoundment and show Kidder Mountain on the right and the small ridges to the left. The two white buildings visible in the distance are situated near Furnace Brook at Appleton Road. Furnace Brook exits the impoundment via a pipe, shown in Figure 2-5.

The Upper Watershed is primarily forested and some agricultural fields and some residential and commercial development. Residential development is primarily located along Appleton Road and the neighborhood to the west of the impoundment. Commercial development centered along Route 124 and in the New Ipswich Plaza, is situated more than a ½ mile from the Brook.

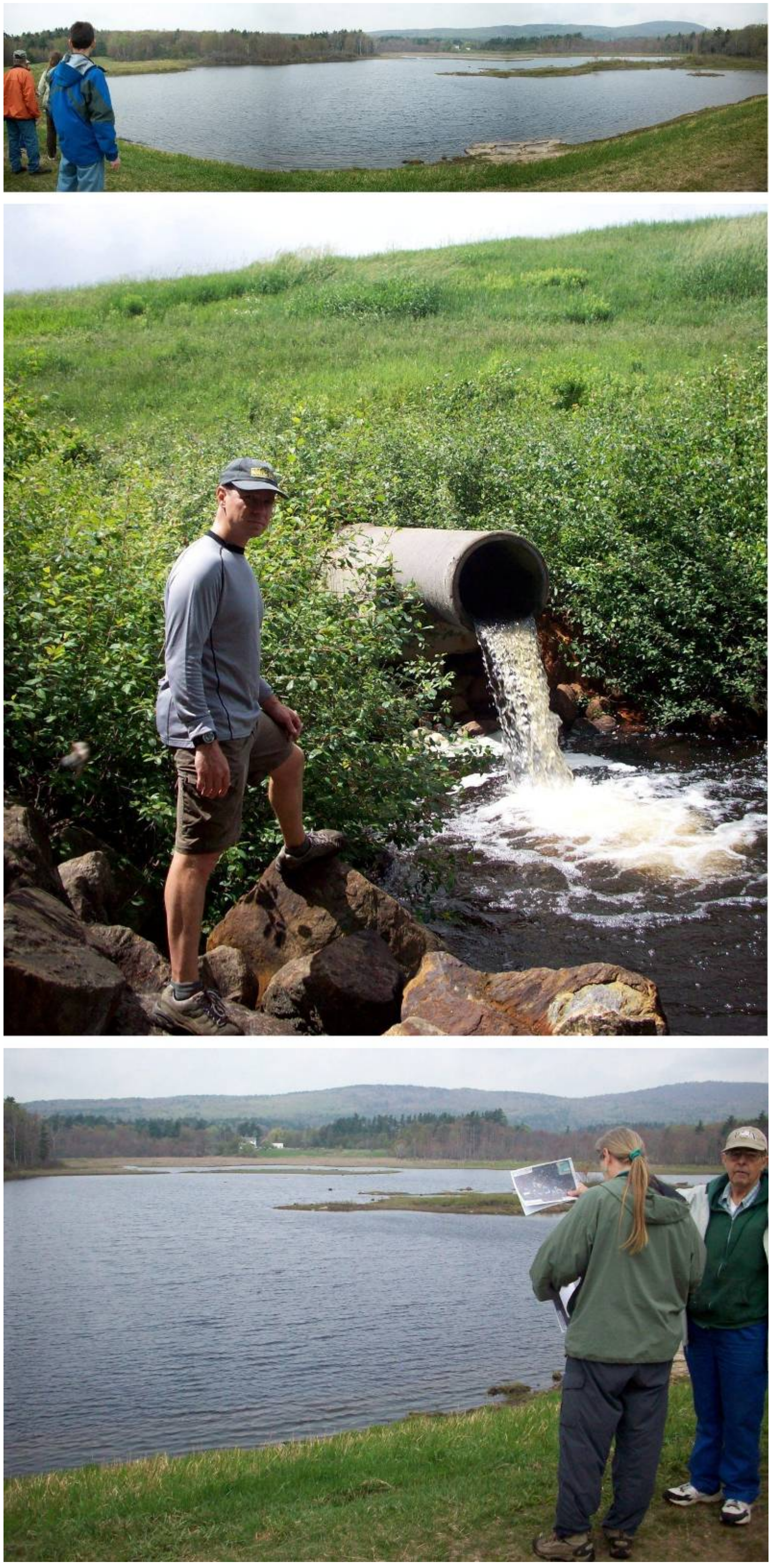


Figure 2-5: Photos of Furnace Brook facing west across the impoundment.

2.3. Middle Furnace Brook

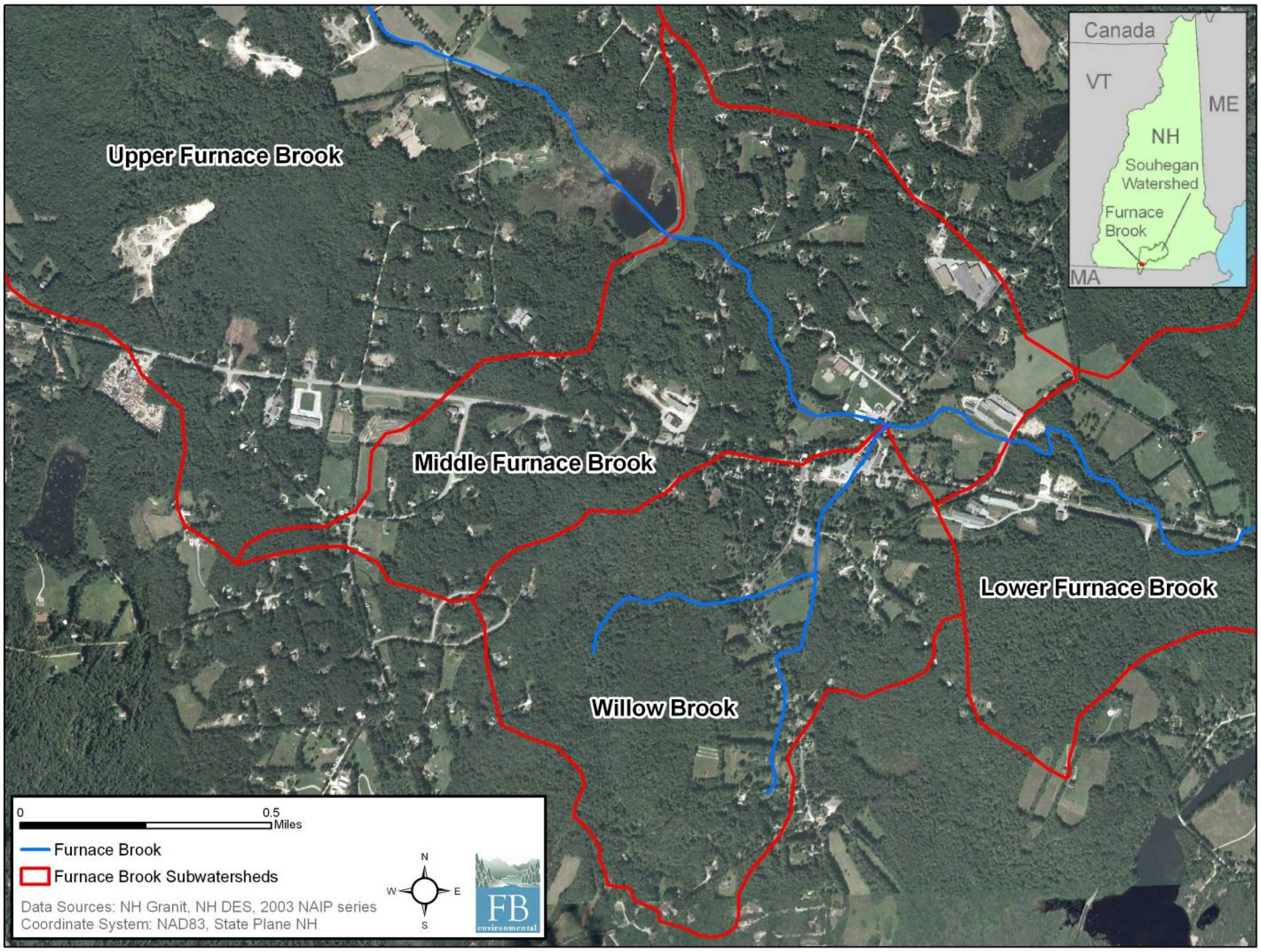


Figure 2-6: Middle Furnace Brook watershed map.

Middle Furnace Brook begins at the outlet of the impoundment and extends to the Tricnit Road crossing (Figure 2-6). The length of Furnace Brook in this reach is approximately 1.0 miles and the drainage area is approximately 1.2 square miles. Middle Furnace Brook includes the Willow Brook watershed and is the most adversely impacted reach of Furnace Brook.

At the outlet of the impoundment, Furnace Brook flows steeply downhill, crossing Thayer Road and into Temple Road and the downtown area. Furnace Brook drops roughly 100 feet, from approximately 1,070 at the impoundment outlet to approximately 970 at Temple Road in the downtown area. The downtown area is relatively flat and development has impacted Furnace Brook in this area. Figure 2-7 provides photographs of Furnace Brook at the Temple Road crossing and illustrates the proximity of the park and nearby residences to the Brook.

Figure 2-7: Photos of Furnace Brook at the Temple Road crossing.

Figure 2-8: Photos of Willow Brook at Route 124.

Immediately south of Temple Road (within 10 feet), Willow Brook enters Furnace Brook along its southern bank. Willow Brook is a tributary to Furnace Brook that flows northward along Temple Road and joins Furnace Brook in the downtown area. Willow Brook is a roadway swale in the reach from Route 124 to Furnace Brook confluence (Figures 2-8 and 2-9). Upstream (and south) of Route 124, Willow Brook flows around a parking lot and becomes a wetland stream.

Directly-connected impervious cover (DCIC) was observed throughout the Middle Watershed area. Impervious cover (IC) is land covered with materials that do not allow rainwater to soak in. IC areas are impervious to rainwater and the water runs off of these areas. Examples of IC include parking lots, roadways, and roofs. At numerous locations along Furnace Brook and Willow Brook, IC areas are directly connected to the stream, such that rainwater flows directly across the IC area and into the Brook. DCIC can have an acutely adverse impact on small streams because rainwater runoff delivers excessive solids loads and a variety of pollutants to the stream. DCIC runoff also brings excessive hydrologic energy that tends to damage the stream channel (e.g., flash floods).

Areas of DCIC in Furnace Brook include the town park adjacent to the Temple Road crossing (Figure 2-7). DCIC is present along Willow Brook from Route 124 to the confluence with Furnace Brook at Temple Road. During rain events, sheet flow of stormwater across the ballfield parking lot into Furnace Brook and from Temple Road into Willow Brook has been observed. This DCIC is likely to be causing adverse impacts on the Brooks. Furnace Brook and Willow Brook have been physically modified and adversely impacted by development activities in the downtown area.

Downstream of the Temple Road crossing, Furnace Brook flows into a wetland area and then crosses Tricnit Road (Figure 2-10). The wetland reach of Furnace Brook at Tricnit Road is bordered by a commercial building to the north and several residences to the south. The stream forms two braids as it flows through the wetland. There is a small historic dam just below the Tricnit Road crossing. Below the dam, the stream is straight and widens as it flows over cobbles.

Figure 2-9: Photos of Willow Brook at Route 124.

Figure 2-10: Photos of middle Furnace Brook at Tricnit Road.

2.4. Lower Furnace Brook

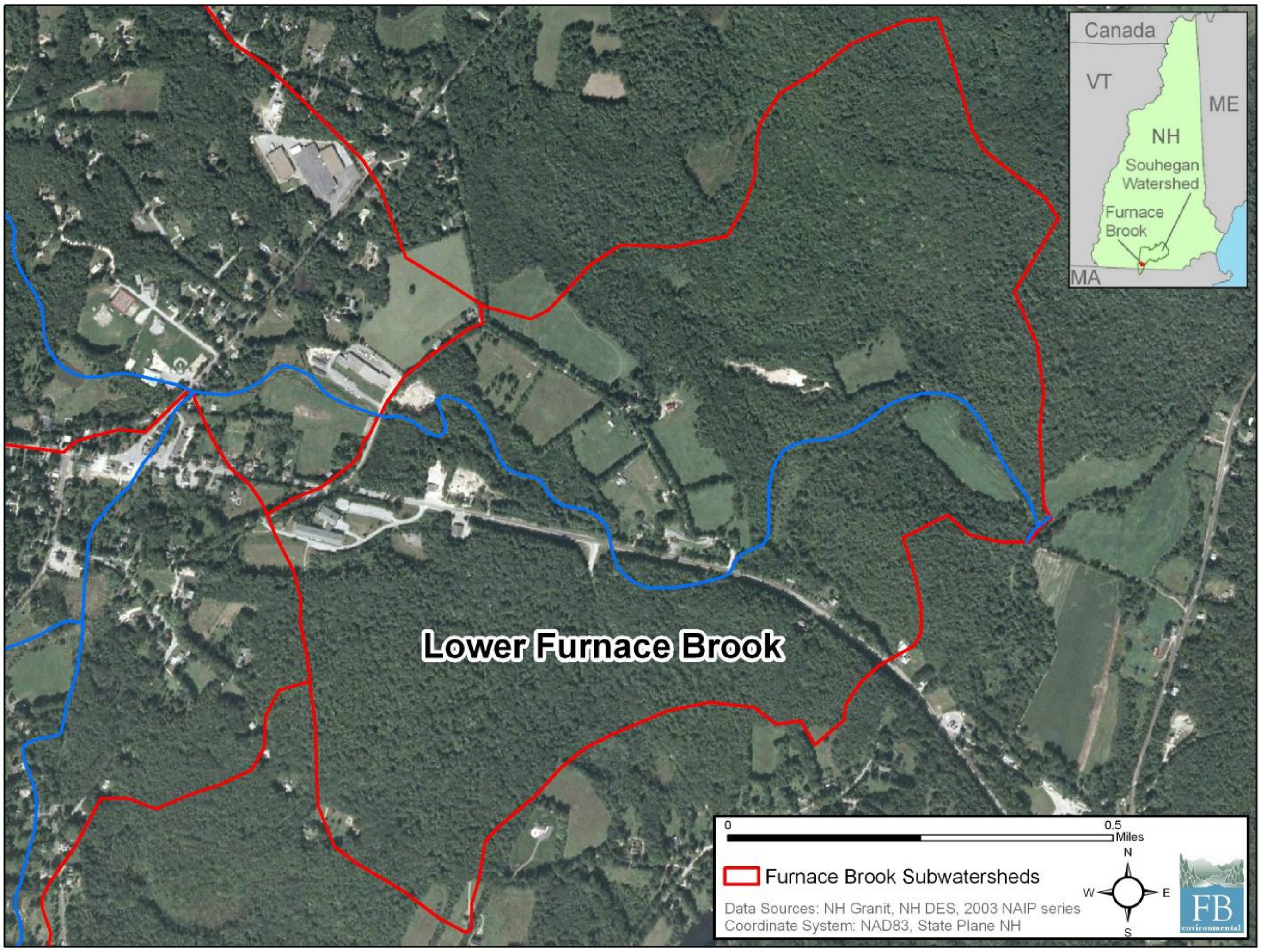


Figure 2-11: Lower Furnace Brook watershed map.

Lower Furnace Brook extends from the Tricnit Road crossing to the confluence with the Souhegan River (Figure 2-11). The lower reach is approximately 1.4 miles long and drains an area of approximately 0.7 square miles. This reach of Furnace Brook is relatively steep with a vertical drop of approximately 90 feet, from approximately 960 feet at the Tricnit Road crossing to approximately 850 feet at the Souhegan River confluence. The Lower Furnace Brook watershed is less developed than the middle Furnace Brook area and is forested along its banks (Figure 2-12). A conservation easement and nature walk are present in the Lower Reach from Route 124 to the confluence.

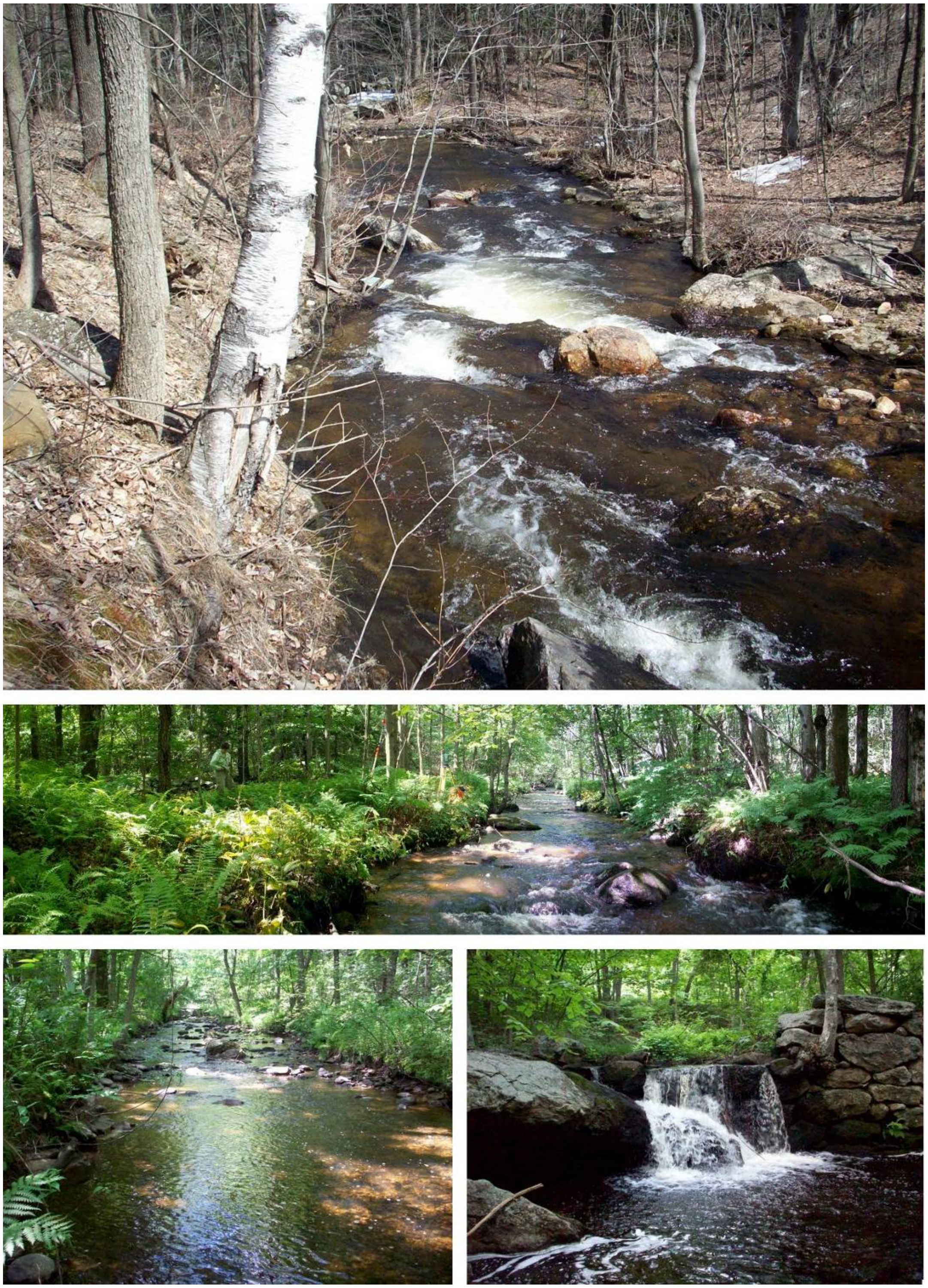


Figure 2-12: Photos of Lower Furnace Brook.

2.5. Summary of Historic Water Quality Measurements in Furnace Brook

The New Hampshire Department of Environmental Services conducted bacteria (Escherichia coli) sampling in Furnace Brook during the period from 1999 to 2003 and found numerous violations of the water quality standard. *Escherichia coli* (*E. coli*) is measured because it is an indicator of pathogenic bacteria. Infections due to pathogen-contaminated recreational waters include gastrointestinal, respiratory, eye, ear, nose, throat, and skin diseases (USEPA, 1986). Wastes from warm-blooded animals are a source for many types of bacteria found in waterbodies, including the coliform group and Streptococcus, Lactobacillus, Staphylococcus, and Clostridia. Each gram of human feces contains approximately 12 billion bacteria, among them may include pathogenic bacteria, such as Salmonella, associated with gastroenteritis. In addition, feces may contain pathogenic viruses, protozoa and parasites (MADEP, 2007).

The numbers of pathogenic organisms present in waters are generally difficult to identify and isolate, and are often highly varied in their characteristic or type. Therefore, scientists and public health officials usually monitor nonpathogenic bacteria, such as *E. coli*, that are typically associated with harmful pathogens in fecal contamination but are more easily sampled and measured. These associated bacteria are called indicator organisms. Indicator bacteria are not themselves a health risk but are used to indicate the presence of pathogenic organisms. High densities of indicator bacteria increase the likelihood of the presence of pathogenic organisms (USEPA, 2001).

The State of New Hampshire uses *E. coli* as indicator organisms of potential harmful pathogens in fresh waters (RSA 485-A:8). The *Escherichia coli* (*E. coli*) water quality standard is 406 counts/100 ml based on a single sample or 126 counts/100ml based on the geometric mean of at least 5 samples collected over a 60 day period, unless naturally occurring. Several examples of bacteria water quality violations in Furnace Brook are provided below.

- At Tricnit Road crossing on August 19, 2009: 2,000 *E. coli* counts/100ml;
- At Tricnit Road crossing on July 17, 2001: 1,350 *E. coli* counts/100 ml; and
- At Temple Road crossing on July 17, 2001: 2,000 *E. coli* counts/100 ml.

A full set of NHDES bacteria sampling data from Furnace Brook during the period of 1999 to 2003 is provided in Appendix B.

2.6. Summary of the Summer 2008 Field Investigation

A field investigation was conducted during the summer of 2008 and included measurement of bacteria and other pollutant loads during a variety of conditions. Seven surveys were conducted from June 16 through September 29, 2008. Water samples were collected and analyzed for the indicator bacteria, *E. coli*, and two nutrients, total phosphorus and nitrogen (TKN).

Samples were collected at 19 locations throughout Furnace Brook and its tributaries. Sampling locations are shown in Figure 2-13. Bacteria analysis results are provided in Table 2-1 and nutrient analysis results are provided in Table 2-2. Figure 2-14 provides a rainfall record for the summer of 2008 with sampling dates indicated to place the sampling results in a meteorological context.

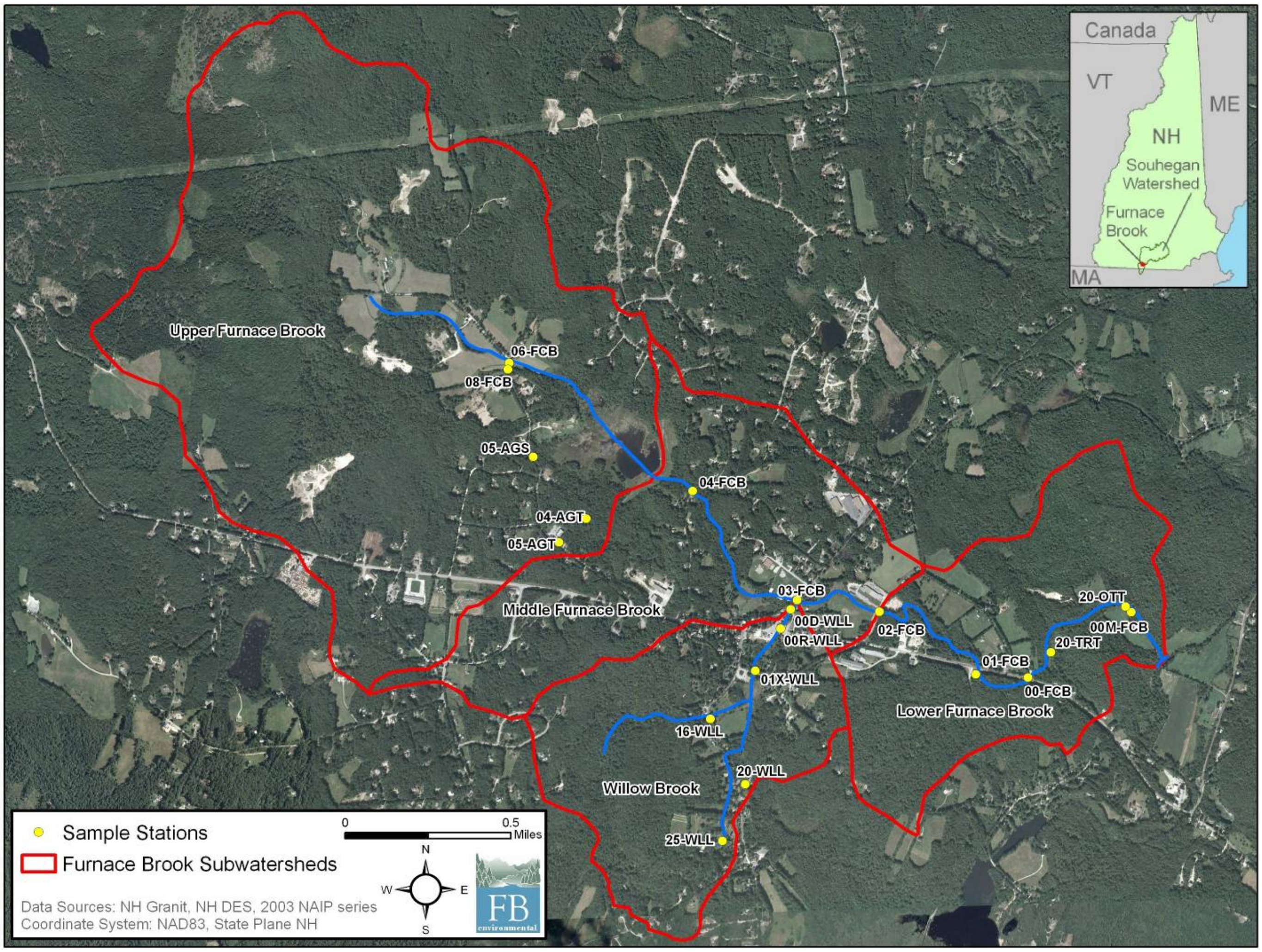


Figure 2-13: Furnace Brook sampling location map.

Samples were collected for analysis of ambient bacteria (*E. coli*) counts during both wet and dry weather conditions to support characterization of contributing pollution sources. Bacteria sources tend to be diffuse and intermittent (rather than flowing from an identifiable source on a regular basis). High levels of bacteria measured during dry conditions can be indicative of the presence of direct wastewater discharges, contamination from groundwater leachate from failing septic systems, illicit discharges, or from wildlife. High levels of bacteria measured during wet conditions (rainfall) can be indicative of the presence of contamination from stormwater runoff or from wildlife and domesticated animals (including pets)

Table 2-1: Furnace Brook bacteria analysis results.

		Escherichia Coli Analysis Results (counts/100 ml)					
		Date of Sampling Event					
Sampling Station	Description	June 16 2008	June 17 2008	July 1 2008	July 8 2008	Aug 26 2008	Sept 8 2008
Furnace Brook Mainstem							
00M-FCB	Trail bridge			140	80	5	2,950
00-FCB	Old Tenney	250	190	90	50	20	1,900
01-FCB	Currier/Rt 124		130				
02-FCB	Tricnit		220	120	200	50	3,100
03-FCB	Temple/fields	260	210	50	100	>2,000	2,700
04-FCB	Thayer		360	50	20	10	5,000
06-FCB	Appleton N	90	1,300	7,800	20	50	150
08-FCB	Appleton S	40	120	50	110	160	500
Impoundment Tributaries							
05-AGT	Appleton Apts		1,200	50	50	50	760
04-AGT	Behind Apts		700	130	9	<10	590
05-AGS	Near Gibbs		30	20	20		
Willow Brook Tributary							
01-WLL							
00D-WLL	Temple swale	340	390	50	60	1,320	170
00R-WLL	Rt 124 grocery	260	230	10	20	1,410	795
01X-WLL	Academy	340	240	40	70	180	180
16-WLL	Main		20	<10	<10		
20-WLL	Marley		330	40	9		
25-WLL	Villa				40		
Downstream Tributaries							
20-TRT				10	20		
20-OTT				60	60		
Wet Weather Status:		**Yes**	**Yes**	**Yes**	**No**	**No**	**Yes**
rainfall in inches prior to samplng:							
24 hrs (>0.1")		**0.17+**	**0.48**	**0.19**	**0**	**0**	**0.97**
48 hrs (>.25")		**0.17+**	**0.65**	**0.38**	**0**	**0**	**4.06**
96 hours (>2.0")		**0.17+**	**0.65**	**0.71**	**0.13**	**0.01**	**4.06**

Water Quality Standard to Bacteria

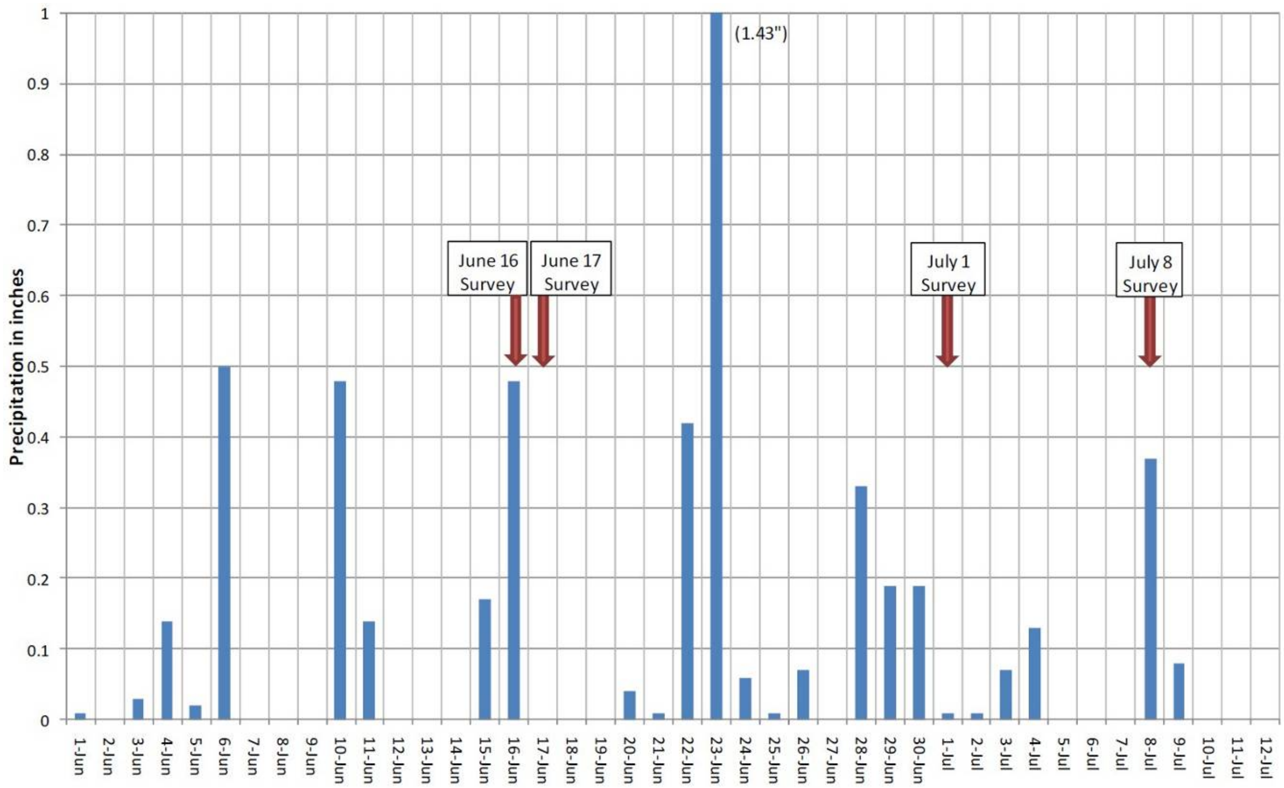
E. coli bacteria is an indicator of bacteria pollution that can be harmful to human health.
The New Hampshire water quality standards for *E. coli* (in freshwater Class B waters) are:
Maximum for a single sample: 406 counts/100 mL, unless naturally occurring
Maximum for a geometric mean: 126 counts/100mL, unless naturally occurring

Note 1: Weather data obtained from the Jaffrey Airport via WeatherUnderground.com
Jaffrey airport is located approximately 10 miles from the Furnace Brook watershed
Note 2: Red color is used to indicate exceedances of the single sample standard and orange is used to indicate an single measurement above the geometric mean standard.

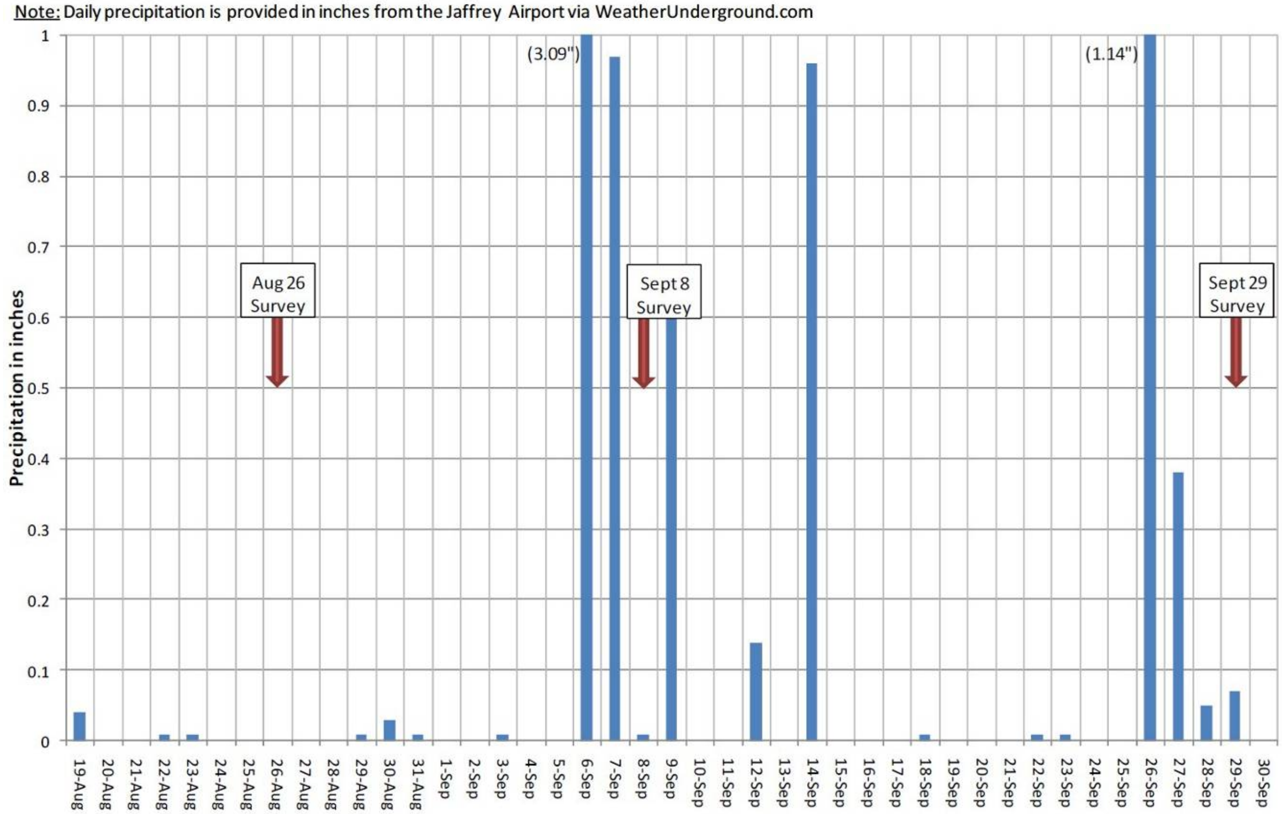
Table 2-2: Furnace Brook nutrient analysis results.

Sampling Location	*Description*	***Total Phosphorus (mg/l)*** *Date of Sampling Event (2008)*			***TKN (mg/l)*** *Date of Sampling Event (2008)*		
		Aug 26	**Sept 8**	**Sept 29**	**Aug 26**	**Sept 8**	**Sept 29**
Furnace Brook Mainstem							
00M-FCB	Trail bridge						
00-FCB	Old Tenney	0.023	0.046	0.029	ND (0.25)		0.40
01-FCB	Currier/Rt 124						
02-FCB	Tricnit						
03-FCB	Temple/fields	0.028	0.050	0.030	0.28		0.34
04-FCB	Thayer	0.025	0.053	0.029	0.30		0.37
04-FCB Dup		0.026			0.35		
06-FCB	Appleton N	0.014	0.021	0.014	ND (0.25)		0.28
06-FCB Dup				0.014			ND (0.25)
08-FCB	Appleton S			0.0081			ND (0.25)
Impoundment Tributaries							
05-AGT	Appleton Apts	0.018	0.023	0.016	0.28		0.42
04-AGT	Behind Apts						
05-AGS	Near Gibbs						
Willow Brook Tributary							
01-WLL							
00D-WLL	Temple swale		0.027	0.026			0.33
00R-WLL	Rt 124 grocery						
01X-WLL	Academy						
16-WLL	Main						
20-WLL	Marley						
25-WLL	Villa						
Downstream Tributaries							
20-TRT							
20-OTT							
Wet Weather Status:		**No**	**Yes**	**Yes**	**No**	**Yes**	**Yes**
		rainfall in inches prior to sampling					
	24 hrs (>0.1")	**0**	**0.97**	**0.12**	**0**	**0.97**	**0.12**
	48 hrs (>.25")	**0**	**4.06**	**0.5**	**0**	**4.06**	**0.5**
	96 hours (>2.0")	**0.01**	**4.06**	**1.64**	**0.01**	**4.06**	**1.64**

Note: Weather data obtained from the Jaffrey Airport via WeatherUnderground.com



Note: Daily precipitation is provided in inches from the Jaffrey Airport via WeatherUnderground.com



Note: Daily precipitation is provided in inches from the Jaffrey Airport via WeatherUnderground.com

Figure 2-14: Rainfall record for the summer of 2008 with sampling dates indicated.

Summary of observations based on sampling data

Review of Furnace Brook sampling data yields the following observations:

1. Pollutant sources appear to be spatially distributed. Exceedances of the bacteria water quality standard (*E. coli* > 406 counts/100ml) were measured throughout Furnace Brook and its tributaries;

2. Pollutant sources appear to be active at multiple times (i.e., temporally distributed). Exceedances of the bacteria standard were measured during 4 of 7 surveys including under both wet and dry weather conditions;

3. Highest bacteria counts were observed during the largest rainfall event (4.06" on Sept 8) and resulted in exceedances in nearly all mainstem sampling locations. The presence of elevated bacteria counts during wet weather suggests stormwater runoff is an important source of bacteria pollution;

4. Mainstem bacteria counts tended to remain roughly constant or decrease with distance downstream. This trend suggests a lack of major bacteria sources towards the mouth of the Brook;

5. In the Upper Watershed, elevated bacteria counts are observed only during wet weather events. This observation suggests the presence of wet weather sources;

6. In the Middle Watershed, elevated bacteria counts are observed during both wet and dry surveys. The presence of elevated bacteria counts during dry weather conditions suggests the presence of failing septic systems and illicit discharge sources of bacterial pollution in the area;

7. In the Lower Watershed, no elevated bacteria counts were observed (other than those traveling along the mainstem) suggesting a lack of major bacteria sources in the lower portion;

8. Total phosphorus concentrations ranged from roughly 10 to 50 ppb; and

9. TKN concentrations ranged from roughly 200 to 400 ppb.

Observations based on field reconnaissance

Through numerous visits to Furnace Brook, we observed several important characteristics of Furnace Brook and Willow Brook, as follows:

- Furnace Brook is a beautiful stream with a bed typically consisting of gravel and cobble.
- In some reaches, the Brook's riparian areas are well vegetated and transition to pine forest.
- In terms of slope, Furnace Brook may be described as having two low gradient and two high gradient reaches, configured as two steps as follows:
    - Upper low gradient reach - above and at the impoundment area;
    - Middle high gradient reach – from the impoundment outlet to downtown;
    - Middle low gradient reach – through the downtown area, ending at Tricnit Road crossing;
    - Lower high gradient reach – from Tricnit Road to confluence with Souhegan River.
- Furnace Brook is physically bisected by a flood control impoundment at its mid-point.
- Furnace Brook has been physically modified and re-routed by human activity in several reaches including adjacent to the town park and at road crossings.
- Directly-connected impervious cover (DCIC) is present at numerous locations throughout the stream, primarily in the Middle Watershed area. Adverse impacts including excess solids loading and stream erosion have been observed at several locations. This problem is acute in the downtown area.
- Several septic systems situated on lots abutting Furnace Brook and Willow Brook are failing, according to anecdotal information provided by town officials.

The field investigation was successful in documenting elevated bacteria levels and provided insights to the nature and extent of bacteria pollution sources. Furnace Brook was characterized by conducting numerous surveys and by consulting with local stakeholders. This characterization provides the information necessary to support pollutant source characterization activities described in Section 3 below.

2.7. Summary of New Ipswich Conservation Commission 2009 Sampling Program

The New Ipswich Conservation Commission (NICC) designed and conducted a field sampling program during the summer of 2009. The goal of the sampling program was to continue the monitoring work conducted in 2008 and to obtain a baseline of water quality conditions prior to commencement of restoration activities. Six surveys were conducted from July 7 and September 15, 2009.

Table 2-3 provides a summary of bacteria measurements collected by NICC during the 6 surveys. These data are considered informational-only as they have not yet been reviewed and approved by NHDES. The 2009 bacteria data include exceedances of the *E. coli* water quality standard of 406 cts/100ml at several locations in both Furnace Brook and Willow Brook. The highest bacteria counts were observed in Willow Brook on July 21, 2009. Elevated bacteria were also observed in the upper Furnace Brook reach (at 06-FCB and 08-FCB) on July 21.

The 2009 NICC bacteria data represents a valuable contribution to the Furnace Brook water quality assessment. The NICC has and will continue to serve as an important stakeholder in the Furnace Brook restoration project.

Table 2-3: Summary bacteria measurements collected by NICC.

		Escherichia Coli Analysis Results (counts/100 ml) Date of Sampling Event					
Sampling Station	Description	July 7 2009	Jul 21 2009	Aug 4 2009	Aug18 2009	Sep1 2009	Sep 15 2009
Furnace Brook Mainstem							
00M-FCB	Trail bridge						
00-FCB	Old Tenney						
01-FCB	Currier/Rt 124						
02-FCB	Tricnit	260	191	220	326	135	222
03-FCB	Temple/fields	23	195	23	93	37	285
04-FCB	Thayer	5	4	37	7	25	98
06-FCB	Appleton	93	547	32	98	25	23
08-FCB		54	461	84	261	137	93
Impoundment Tributaries							
05-AGT		101	186	96	30	290	104
04-AGT		95	73	69	5	156	201
05-AGS							
Willow Brook Tributary							
01-WLL							
00D-WLL	Temple swale	96	1732	113	228	145	201
00R-WLL	Rt 124 grocery	81	435	142	290	90	61
01X-WLL		42	2419	117	517	101	44
16-WLL					2	12	8
20-WLL					17	43	11
25-WLL							

3. Pollutant Source Characterization

This section describes the process of identifying and quantifying pollutant sources in the Furnace Brook watershed. A set of surveys was conducted to identify potential pollutant sources, and a variety of types of pollutants, including bacteria, suspended solids, and nutrients. For bacteria sources, total pollutant loads were estimated and these estimates were applied to support prioritization of pollutant sources for mitigation.

3.1. Pollutant Source Identification

A goal of the Furnace Brook watershed restoration project is to identify, assess, and remove pollutant sources to the Brook. To support that goal a preliminary list of known and suspected sources of pollution was compiled. These sources were identified through field surveys, review of sampling survey data, and discussions with local stakeholders.

A total of 50 potential pollutant sources have been identified and are listed in Table 3-1 (below). Bacteria pollution is a focus of the restoration project, but other pollutants are also believed to be significant contributors. Thus, several different types of pollutant sources, including bacteria, nutrients, and suspended solids, are included in this summary. Potential pollution sources are organized by type of source (with number of sources in parentheses), as follows:

- Septic systems (9);
- Roadways (10);
- Parking lots (9);
- In-stream channel modification (7);
- Wild animals (4);
- Horse farms (4);
- Agricultural crop lands (2);
- Dog parks (3); and
- Point sources (2).

A summary of each type of source is provided below along with a set of recommended next steps.

Table 3-1: Preliminary Furnace Brook potential pollutant source list.

Source ID Number	Type of Source	Streams Adjacent	Location Relative to Streets	Subw'shed Number(s)	Sampling Location	Descriptions
SS 1	Septic systems	Willow, Furnace	Temple Rd, Rt 124	9	00D-WLL	Residences and businesses very close to streams
SS 2	Septic systems	Willow Brook	Wyman, Thayer	6, 8	03-FCB	Businesses and Residential south of Rt 124
SS 3	Septic systems	Furnace Brook	Rt 124, Thayer	7	03-FCB	Residential neighborhoods
SS 4	Septic systems	Furnace Brook	Temple Rd	6	03-FCB	Swimming pool facilities and associated septic system
SS 5	Septic systems	Furnace Brook	Playground, Beechwood	6	03-FCB	Residential neighborhoods
SS 6	Septic systems	Unnamed tribs	Appleton	5	04-AGT	Apartment building septic system; history of problems
SS 7	Septic systems	Unnamed tribs	Gibbs, Appleton Rds.	5	05-AGS	Residential neighborhood
SS 8	Septic systems	Furnace Brook	Tricnit Rd	7	02-FCB	Large septic mound in field just west of Tricnit Rd
SS 9	Septic systems	Furnace Brook	Tricnit Rd	6	02-FCB	Tricnit Industrial Park; large septic system in front
RW 1	Paved rd. w/ drains	Willow Brook	Temple Rd	9	00D-WLL	Stormdrains and swales are very close to Willow Brook
RW 2	Paved rd. w/ drains	Willow Brook	Rt 124	9	00R-WLL	Stormdrains routed to Willow Brook wetland behind library
RW 3	Paved road	Furnace Brook	Appleton Rd	5	04-FCB	Roadway runoff observed; sediment deposition to wetland
RW 4	Dirt road	Furnace Brook	Old Tenney Rd	10	00-FCB	Dirt road close to Brook; erosion to Brook evident
RW 5	Paved rd. w/ drains	Furnace Brook	Rt 124	7	03-FCB	Rt 124 stormwater surface runoff
RW 6	Dirt road	Unnamed tribs	Gibbs, Appleton Rds.	5	05-AGS	Dirt roads with active swales; erosion evident along roads
RW 7	Paved road	Unnamed tribs	Rt 124	5	05-AGT	Rt 124 runoff
RW 8	Paved road	Furnace Brook	Tricnit Rd	11, 10	01-FCB	Roadway surface runoff observed
RW 9	Paved road	Willow Brook	Rt 124	11,10,13	01-FCB	Rt 124 stormwater runoff
RW 10	Paved road	Furnace Brook	Thayer Rd	7, 6	03-FCB	Roadway surface runoff observed
LT 1	Parking lot	Willow Brook	Rt 124	9	00R-WLL	Parking lots of business south of Rt 124
LT 2	Parking lot	Furnace Brook	Temple Rd	6	03-FCB	Parking lots at ballfield and pool area
LT 3	Parking lot	Willow Brook	Rt 124-Temple	9	00D-WLL	Elem. School parking lot
LT 4	Parking lot	Furnace Brook	Tricnit Rd	6	02-FCB	Tricnit Industrial Park and adjacent work area
LT 5	Parking lot	Furnace Brook	Rt 124	7	03-FCB	Highway Dept. and Town offices parking areas
LT 6	Sand pile	Furnace Brook	Rt 124	11	01-FCB	Town sand and salt piles

Table 3-1: Preliminary Furnace Brook potential pollutant source list (continued).

Source ID Number	Type of Source	Streams Adjacent	Location Relative to Streets	Subw'shed Number(s)	Sampling Location	Descriptions
LT 7	Parking lot	Furnace Brook	Temple Rd	8	03-FCB	Industrial plant parking lots
LT 8	Parking lot	Unnamed tribs	Rt 124	5	05-AGT	Commercial plaza parking lot, post office
LT 9	Parking lot	Furnace Brook	Rt 124	11	01-FCB	Middle School with large parking lots
CM 1	Channel mod.	In Furnace Brook	none	4,5	04-FCB	Impoundment outfall pipe has > 3 foot drop
CM 2	Culvert	In Furnace Brook	Appleton Rd	4	04-FCB	Roadway culverts at Appleton Road
CM 3	Culvert	In Furnace Brook	Thayer Rd	6,7	03-FCB	Roadway culvert at Thayer Road
CM 4	Culvert	In Furnace Brook	Temple Rd	6,7	02-FCB	Roadway culvert at Temple Road
CM 5	Culvert	In Furnace Brook	Tricnit Rd	10,11	01-FCB	Roadway culvert at Tricnit Road
CM 6	Dam	In Furnace Brook	Tricnit Rd	6, 7	01-FCB	Old dam at Tricnit Rd bridge
CM 7	Dam	In Furnace Brook	Old Tenney Rd	12, 13	00M-FCB	Old dam just below Old Tenney
WA 1	Wild animals	Furnace Brook	none	4, 5	04-FCB	Impoundment has significant populations of birds
WA 2	Wild animals	Willow Brook	Main St, Villa Rd	9	01X-WLL	Small cemetery impoundment; birds observed
WA 3	Wild animals	Willow Brook	Academy, Main St.	9	01X-WLL	Wetland with beaver dam
WA 4	Wild animals	Furnace Brook	Tricnit Rd	6, 7	02-FCB	Wetland in Furnace Brook just west of Tricnit Rd
HF 1	Horse farm	Furnace Brook	Appleton	5, 3	08-FCB	Horse farm, large stable
HF 2	Horse farm	Furnace Brook	Appleton	1	06-FBC	Small horse farm
HF 3	Horse farm	Furnace Brook	Rt 124	9, 7	00D-WLL	Small horse farm
HF 4	Horse farm	Willow Brook	Main St	9	16-WLL	Small horse farm
AG 1	Hay fields	Furnace Brook	Appleton	1,2,3, 4	08-FCB	Fields close to Brook
AG 2	Corn fields	Furnace Brook	none	13, 12	00M-FCB	Corn fields; generally good buffer
Pk 1	Dogs	Furnace Brook	Thayer Rd	4,5	04-FCB	People walk dogs around impoundment
Pk 2	Dogs	Nearby	Temple Rd	6	03-FCB	Public park and ballfield may be frequented by dogs
Pk 3	Dogs	Willow Brook	Main St, Villa Rd	9	01X-WLL	Small cemetery impoundment; likely location for dogs
PS 1	Pipes, bucket	Willow Brook	Temple Rd - Rt 124	9	00D-WLL	Behind grocery, small pipes and grease bucket observed
PS 2	Pipe	Furnace Brook	Temple Rd	6	03-FCB	Pipe from swimming pool building (no flow observed)

3.1.1. Potential Septic System Sources

Septic systems appear likely to be major sources of bacteria loading to Furnace Brook. This observation is based on the locations of high bacteria measurements, septic system information, and the close proximity of buildings and septic systems to Furnace Brook and Willow Brook, particularly in the downtown area.

Table 3-1 (above) provides a list of 9 septic system areas that represent potential bacteria pollution loads. Figure 3-1 provides a map of the location of these septic system areas overlying an aerial photo map. Figure 3-2 provides the septic system areas overlying a property map. Each pollution source has an ID number, such as “SS 1”. The ID number appears in Table 3-1, on the maps, and in the summary below. Top priority septic systems requiring further investigation are:

- SS 1 - Downtown neighborhood along Temple Road. This area appears to be the most adversely impacted section of the watershed and should be highest priority for further investigation and restoration. Septic systems in this area that should be investigated include:
  - Residences along Temple Road between Route 124 and the baseball field (e.g., lots 115, 116, 117, and 118). These residences are situated very close to Willow Brook and it appears likely that their septic systems may impact the stream.
  - The elementary school system (lot 120) and the New Ipswich Grocery (lot 119) with septic systems near Willow Brook.
- SS 2 – Downtown neighborhood south of Route 124.
  - Businesses along the south side of Route 124 including the gas station, restaurant, and other businesses on the south side (e.g., lots 143, 138, and 139).
  - Buildings along Main Street immediately south of Route 124, including the library, pizza shop, and residences (e.g., lots 140, 141, 142, and 153).
- SS 3 – Residential neighborhoods south of Furnace Brook along Route 124 and Thayer Road.
- SS 4 - Town Pool and Ballfield Facilities. The town ballfield and community pool area reportedly has a septic system. This system is immediately adjacent to Furnace Brook near Temple Road and should be investigated.
- SS 5 - Playground and Beechwood Road Neighborhoods. This area is situated close to the downtown area described above. The neighborhood is off Temple Road just north of Furnace Brook and abuts the town ballfield and pool area.
- SS 6 – Appleton Apartments. This apartment building has a septic system that appears unusual in that the system is set on a large bank of fill with a steep slope. Town officials report historic problems with the system, but its current status is unknown.

There are several other areas with potential septic system problems as listed in Table 3-1 and shown in Figures 3-1 and 3-2. All of the potential septic system problem areas should be investigated and mitigated, as needed.

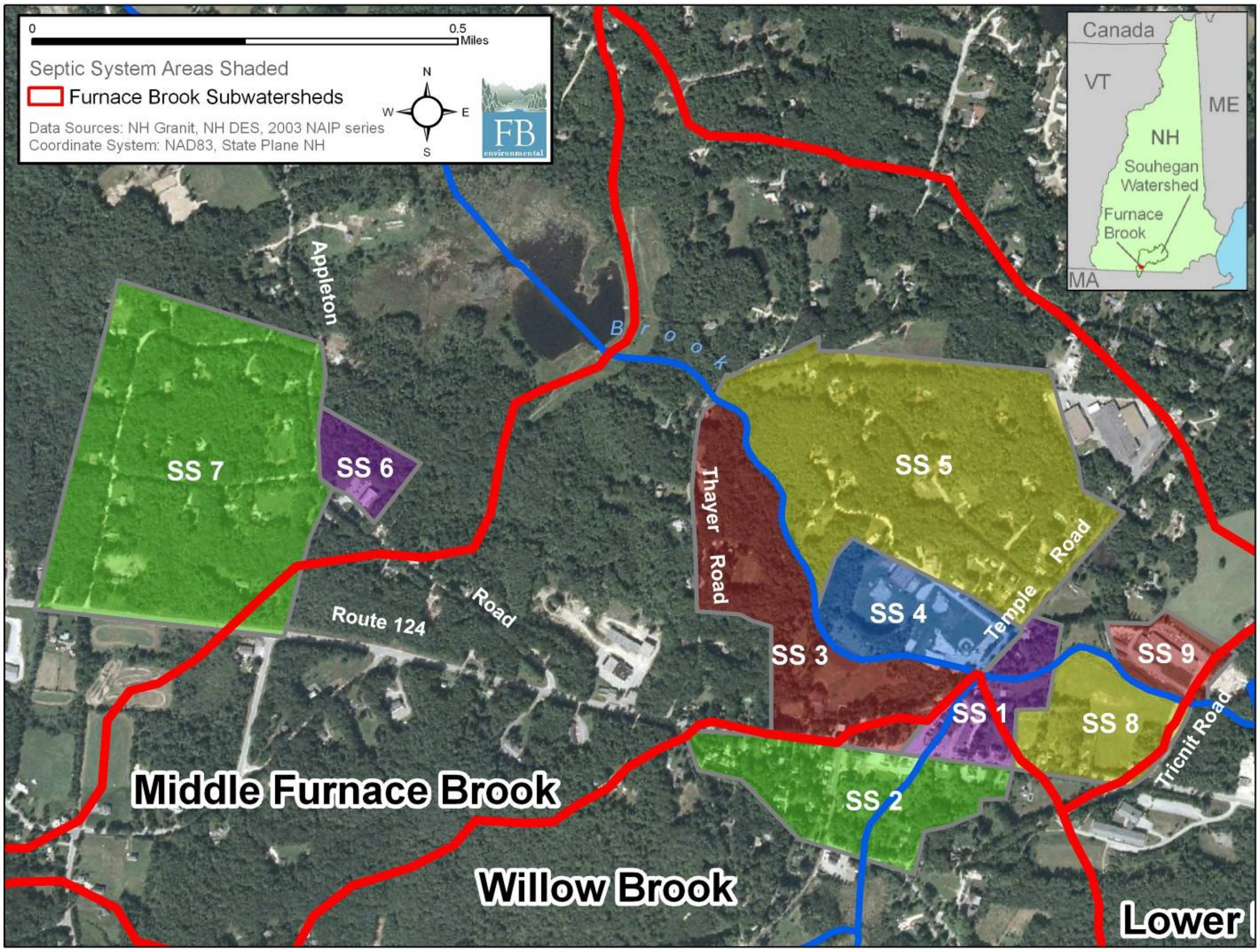


Figure 3-1: Locations of septic system areas representing potential bacteria pollution loads.

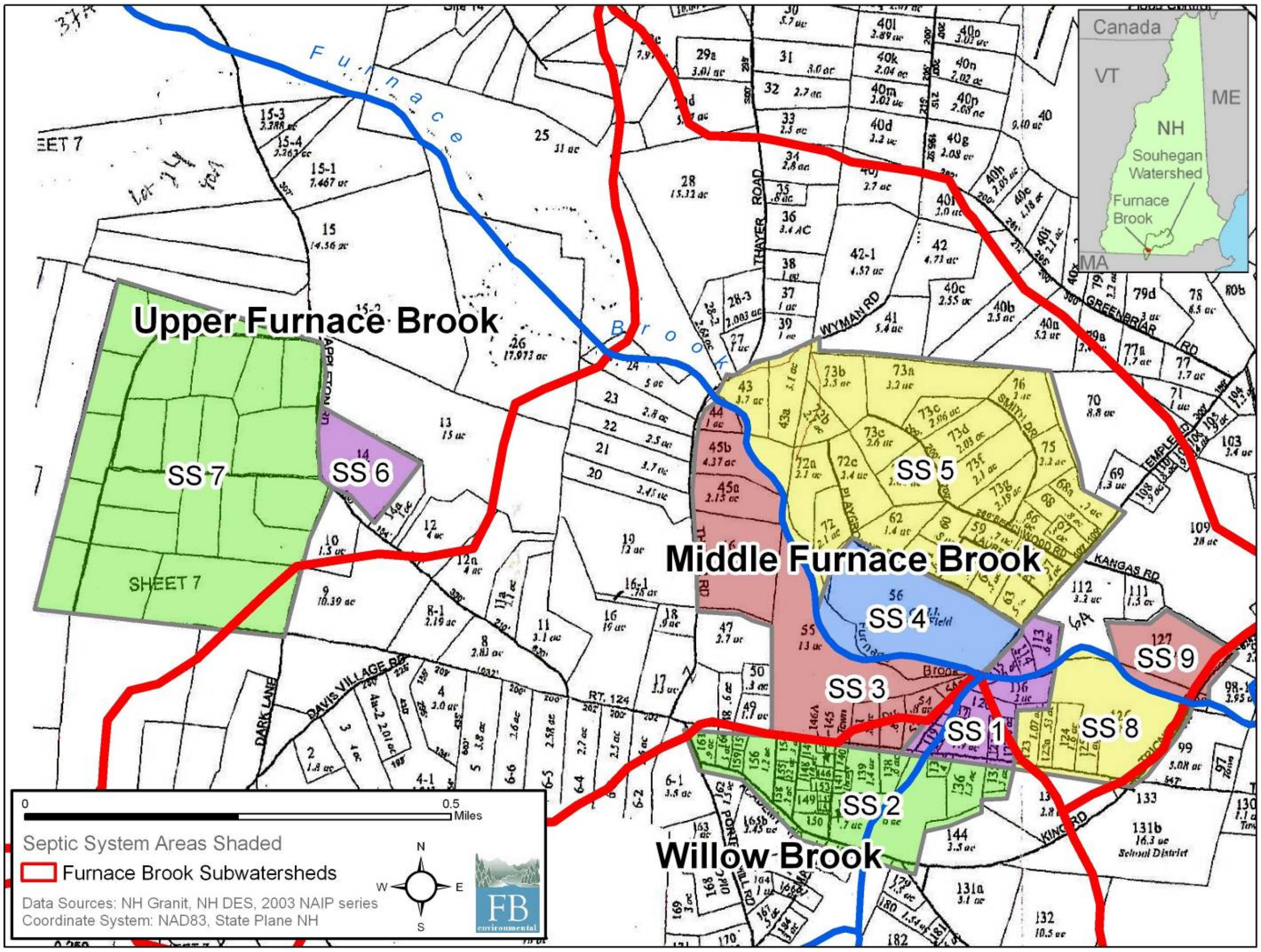


Figure 3-2: Septic system areas representing potential bacteria pollution loads, shown by parcel.

3.1.2. Potential Roadways and Parking Lot Sources

Roadways

Roadways can adversely impact streams in a variety of ways including by conveying stormwater to the stream and by physically modifying the stream channel at road overpasses. Roadways that appear to convey polluted stormwater to Furnace Brook and Willow Brook are summarized below. Streamflow modification due to roadways is described under the “Channel Modification” description below. Roadway pollution sources are listed in Table 3-1 and shown in Figure 3-3.

Route 124 is the largest road in the watershed and is oriented east-west, nearly parallel to Furnace Brook (Figure 3-3). Route 124 crosses Willow Brook in the low lying downtown area of New Ipswich and crosses Furnace Brook twice further downstream. Several smaller roads are oriented north-south and cross Furnace Brook. These roads include (moving from west to east and downstream) Appleton Road, Thayer Road, Temple Road, and Tricnit Road. Several of the top priority roadways for further investigation and potential mitigation are briefly described below.

- RW 1 – Downtown Temple Road. Temple Road runs parallel to Willow Brook and bridges Furnace Brook. Roadway stormwater runoff appears to be routed in two ways along this stretch of road. Firstly, surface flow is routed to Willow Brook directly as the Brook serves as a roadside swale. Secondly, roadway runoff is routed to a subsurface stormwater drainage system. The maps for this system have not been obtained.
- RW 2 – Downtown Route 124. Relatively steep hills reach a low point in downtown New Ipswich and Route 124 conveys stormwater down to Willow Brook. Roadway stormwater is routed on the road surface and via stormdrains. Route 124 roadway sources are organized by subwatershed drainage area. RW 2 is situated in the Willow Brook subwatershed (#9). The stormdrains to the west appear to travel across Main Street and into the Willow Brook wetland to the south of Route 124. Due to the size and relatively steep slope of the valley, stormwater flowing into downtown along Route 124 is likely to have relatively high velocity and can carry significant pollutant loads to Willow Brook.
- RW 3 - Appleton Road. The section of Appleton Road just north of Gibbs Road is relatively low and adjacent to wetlands that drain to the Furnace Brook impoundment. Erosion and blown out check dams were observed during several surveys. In other sections of Appleton Road, including the Furnace Brook bridge, sediment deposition was evident.
- RW 4 – Old Tenney Road. This dirt road was re-graded in 2008 and large quantities of sand were observed to be transported from the roadway to Furnace Brook below, near the Route 124-Old Tenney Road intersection.

Several other roadways are identified as potential pollutant sources in Table 3-1 and Figure 3-3.

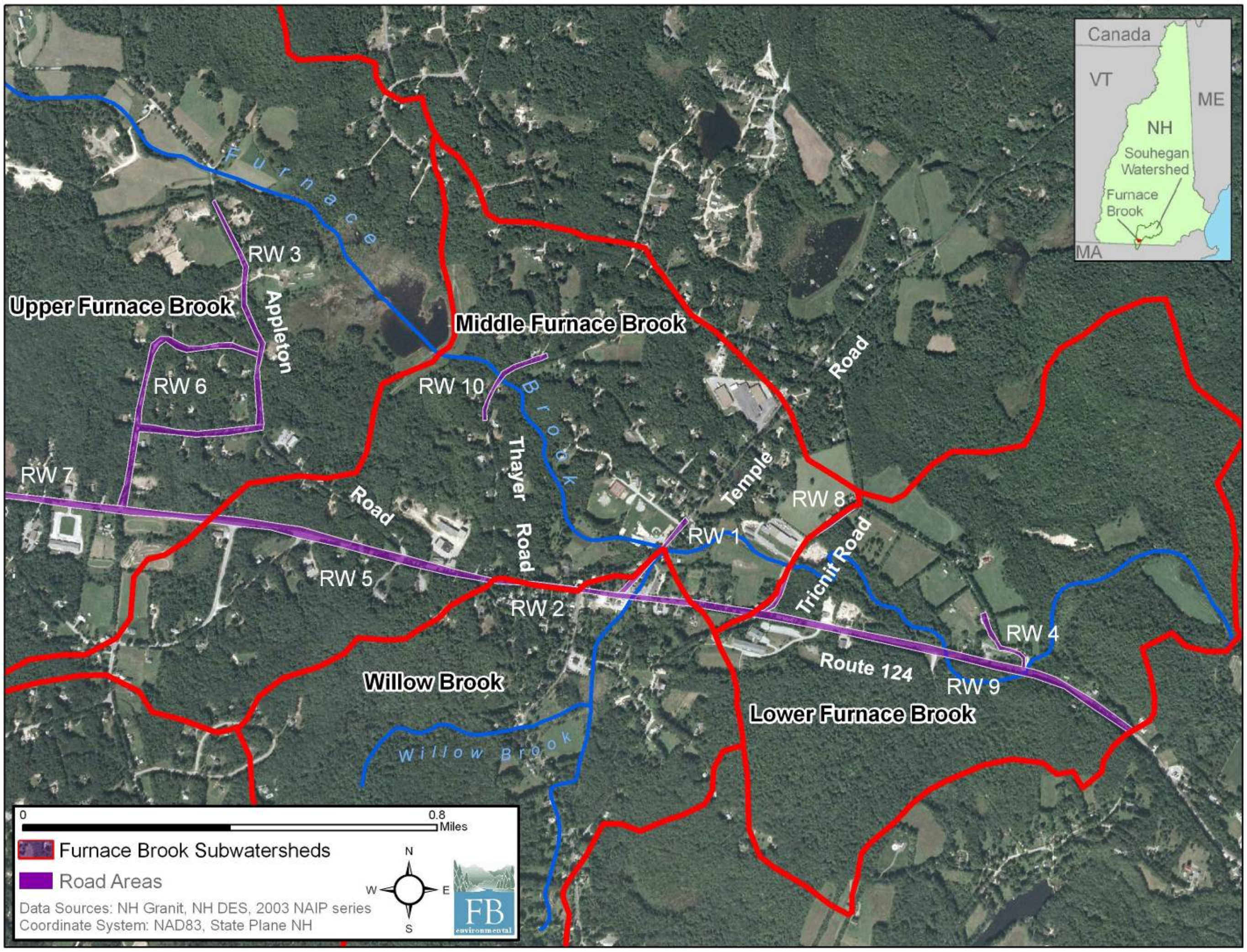


Figure 3-3: Roadway pollution sources.

Parking Lots

Parking lot sources are listed in Table 3-1 and shown in Figure 3-4. Parking lots are impervious to rainwater and have been identified as major causes of adverse impacts to adjacent streams. Pollutants, such as solids, oils, nutrients, and bacteria accumulate over time in parking lots and can be transported to streams during storm events. Parking lots can directly convey stormwater and pollutants to streams causing excessive flows (i.e., flooding and erosion) and harm to aquatic habitat. There are many parking lots in the Furnace Brook watershed. Parking lots that are largest (with associated large pollutant load) and closest (and most directly connected to streams) are prioritized in the list below.

- LT 1 – Commercial Parking Areas associated with small businesses on the south side of Route 124 across from Temple Road. These parking areas are close to Willow Brook and its wetland and are likely significant sources of pollutants to the Brook.
- LT 2 – Town of New Ipswich ballfield and swimming pool parking lots are immediately adjacent to Furnace Brook. This area is just upstream and west of the Temple Road culvert and sediment erosion and sheet flow from the parking lot to Furnace Brook has been observed.
- LT 3 – The elementary school parking lot is situated along the eastern side of Willow Brook in the downtown area and appears to be directly connected to the Brook.
- LT 4 – The industrial park situated along Furnace Brook near the Tricnit Road culvert has a parking area to the west and a work yard to the east. Each of these areas may be contributing pollutants to the Brook.

Several other parking areas were identified as potential pollutant sources and are listed in Table 3-1 and shown in Figure 3-4 below.

3.1.3. Stream Channel Modification

Furnace Brook's stream channel has been extensively modified by development activities. Channel modification includes dams, undersized road culverts, and channel relocation. Stream channel modification can adversely impact stream flow, increase erosion, and increase pollutant loading. Aquatic habitat is adversely impacted by stream channel modification. Modifications, such as dams and undersized road culverts, can be barriers to fish passage and can ultimately lead to removal of fish and other aquatic life from the stream.

Table 3-1 provides a list of some of the major channel modifications observed in Furnace Brook and Figure 3-4 shows their locations. Channel modification is likely less significant in terms of bacteria loading and very significant in terms of reducing loading of suspended solids and restoring aquatic habitat in Furnace Brook.

- <u>CM 1 – Furnace Brook Impoundment Outlet.</u> Furnace Brook flows into a large flood control impoundment above Thayer Road. The outlet of the impoundment is a large pipe elevated more than 3 feet above the streambed (Figure 2-5). This impoundment outlet is a barrier to fish passage and introduces excessive hydrologic force resulting in erosion of downstream stream banks.
- <u>CM 2, 3, 4, 5 – Undersized Roadway Culverts.</u> As it flows downstream, Furnace Brook flows under Appleton Road, Thayer Road, Temple Road, and Tricnit Road. Each of these road

crossings has pipe culverts. These culverts are barriers to fish movement and increase the adverse impacts of flooding.

- CM 6 and 7 – Abandoned Dams. At Tricnit Road and just below Old Tenney Road, Furnace Brook flows over abandoned dams. These dams adversely impact aquatic habitat and may increase flooding impacts.

As is the case in many developed watersheds, there are many more locations in the Furnace Brook watershed where the natural channel has been modified by development activities. For example, the channel has been straightened as part of agricultural activities above the impoundment. Also, extensive filling of wetlands and movement of the channel has occurred as part of historical development in the downtown area near the Temple Road – Route 124 intersection.

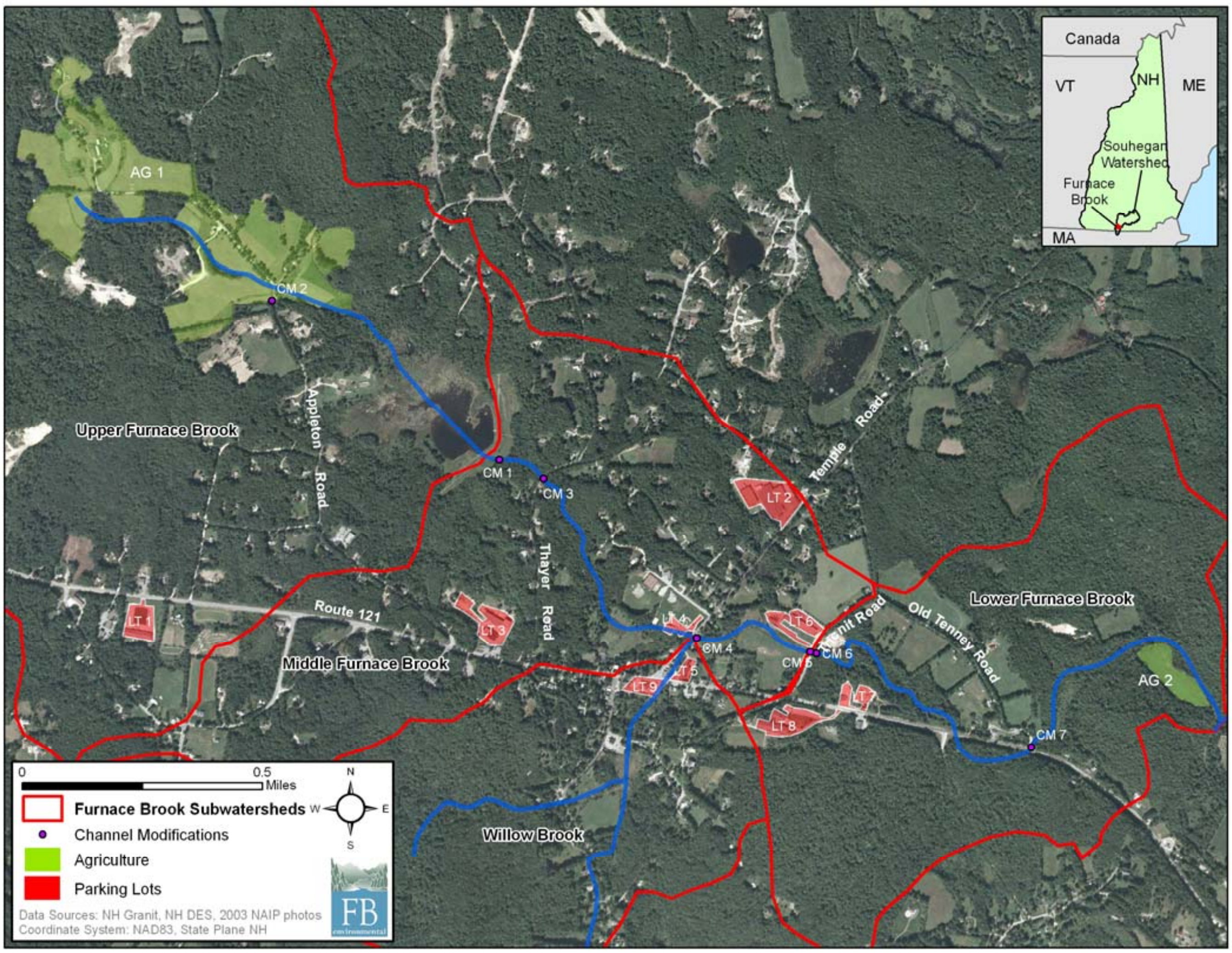


Figure 3-4: Parking lot, channel modification and agriculture pollution sources.

3.1.4. Wild Animals

Although “naturally occurring” bacteria is not considered a violation of the water quality standard, bacteria from wild animals can still contain harmful bacteria. Wild animals, such as deer, geese, and raccoons, can be located nearly anywhere. In the Furnace Brook watershed, several locations where wild animals have been observed to congregate have been identified. These areas include the impoundment and several wetlands situated throughout the watershed.

3.1.5. Agricultural Sources

<u>Horse Farms</u>

Four small horse farms were identified in the Furnace Brook watershed (Table 3-1). Each of the horse farms is situated near either Furnace Brook or Willow Brook. Direct transport of pollutants from these farms has not been observed. Horse farms are included in this list of potential pollutant sources because horse farms, in general, have the potential to be large sources of bacteria, nutrients, and other pollutants.

- HF 1 and HF 2 – Two horse farms located in the headwaters of Furnace Brook. These farms appear to have numerous horses and are reported to host horse shows during the summer months.
- HF 3 and HF 4 – Two horse farms are very small and are situated in the downtown area.

These horse farms should be investigated to determine whether or not they are significant pollutant sources.

<u>Hay and Corn Fields</u>

There are hay fields situated in the Furnace Brook headwaters (AG 1 in Figure 3-4). There is very little buffer between these fields and the Brook. The fields are reportedly not in active use and manure is not believed to be applied.

Corn fields are located in the Furnace Brook watershed near its mouth (AG 2 in Figure 3-4). In general, there is a sufficient forested buffer (e.g., greater than 50 feet) between the fields and the Brook. In a couple of places, the corn fields are closer to the Brook and this could potentially be a source of pollutants.

3.1.6. Domestic Animals

Pets have been identified as sources of bacteria to streams in numerous studies. Pet waste, if not properly disposed, can result in large bacteria loads. Pets are likely to be present in numerous locations in the watershed. Parks or locations with large numbers of pets or evidence of pet leavings were not observed. There are several locations that appear to be likely places for pets to frequent including around the impoundment and at the ballfields.

Pet waste will be evaluated as a component of developed area runoff in this management plan. In addition, public outreach and education may be recommended if pet waste is observed in areas adjacent to the Brook.

3.1.7. Point Sources

Point sources are typically discrete discharges from a pipe or ditch. Some point sources, such as those associated with wastewater treatment facilities and certain stormwater discharges, require permits under the National Pollution Discharge Elimination System (NPDES) program. According to New Hampshire state law (RSA 485-A:13) any discharge containing sewage or waste must obtain a permit from DES.

There are no permitted point source discharges in the Furnace Brook watershed. Consequently, they should either be removed or required to obtain a permit. However, the following two point sources were observed that appear to discharge sewage or waste. Consequently, they should either by removed or required to obtain a permit.

- PS 1 New Ipswich Grocery – Situated on the corner of Temple Road and Route 124. The back of the grocery store building is within 15 feet of Willow Brook. A small pipe was observed entering Willow Brook and an overflowing grease bucket was observed within 10 feet of the Brook. These sources of pollution should be removed.
- PS 2 Town of New Ipswich Pool – Situated just west of Temple Road. There is a pipe and concrete drainage gulley coming out of a small building next to the pool and directed toward the Brook. No flow was observed.

3.1.8. Summary

This preliminary pollutant source summary provides an initial inventory of potential sources and support development of bacteria load estimates described below.

3.2. Bacteria Load Estimation

A goal of the Furnace Brook watershed based restoration plan is to estimate bacteria loads. Bacteria load estimates and load estimate reductions associated with mitigative actives were calculated to support watershed based planning. These estimates will support prioritization of bacteria sources for mitigation. A review of available estimation methods and literature values was conducted to identify appropriate bacteria source loads. A list of documents reviewed, including brief summaries, is provided in Appendix C. Appropriate methods and parameter values were selected and applied to estimate the following types of bacteria source loads:

1. Developed area runoff;
2. Failing septic systems; and
3. Natural area runoff from wildlife.

The process of estimating bacteria loads for each type of source is described below, including approach, methods, input parameter values, and resulting estimates. Estimated bacteria loads are then summed by type. Once bacteria load estimates are established for sources, simple estimates of bacteria load reduction associated with source mitigation will be obtained. These load reduction estimates will prove useful in compiling and prioritizing bacteria sources for mitigation.

Limitations

Estimation of bacteria loading is difficult because there are many dispersed sources and ambient bacteria counts can change dramatically and very quickly based on environmental conditions. There is significant uncertainty in terms of several components of bacteria load estimation and the resulting estimates should be considered to be order-of-magnitude types of estimates. Specifically, key source characteristics, such as magnitude of sources and their proximity to streams, and key transport information, such as bacteria die-off rates, cannot be precisely specified. The bacteria load estimates provided herein are screening level and are intended to support planning of source removal and restoration activities.

3.2.1. Developed Area Runoff

Developed area runoff is surface water flowing from developed areas during precipitation events and entering the stream. Roadways, parking lots, roofs, and lawns are included as developed area runoff. There are many developed areas in the Furnace Brook watershed including the downtown area, residential neighborhoods, and businesses.

Bacteria load contributions from developed areas were estimated using the widely applied event mean concentration (EMC) method. This method has been applied by the Center for Watershed Protection

(CWP) (Schueler, 1987). Input parameter values were obtained from studies conducted by the CWP and other investigators. The approach consists of estimating two components: (1) runoff water volume and (2) average bacteria concentration in runoff water. As shown in Equation 3-1, the product of these components is the bacteria load, expressed in bacteria counts per year.

Bacteria concentrations estimated herein are for fecal coliform (FC) bacteria, which include *E. coli.* In this analysis, field data and TMDL reduction targets are estimated and expressed in terms of *E. coli* and load estimates are estimated in terms of fecal coliform. FC was selected because it is the form of bacteria with the greatest amount of available research results and related available data to support load estimation. This approach is appropriate and useful because the relative load differences among sources are going to be comparable for both fecal coliform and *E. coli* and it is these relative values that are most important in this case. Bacteria load estimates are also provided herein on an annual basis (i.e., counts/year) to provide uniform units for comparison.

Runoff Volume

The hydrologic component is runoff volume and is estimated using developed land area, precipitation amount, and budgeting of water volume (e.g., infiltration, evaporation, and runoff). Runoff volume is calculated, as shown in Equation 3-1, using the simple method for estimating stormwater runoff pollutant loads developed by Schueler (1987) at the CWP. Runoff volume is a function of impervious cover, as shown in Equation 3-1. Total developed area was estimated to be 0.6 square miles using NH Land Use Assessment data (2001). Total annual precipitation was obtained from weather data at the Jaffrey Airport, near the study area. Each component of the runoff calculation is shown in Equation 3-1.

Equation 3-1: Developed area runoff equation.

Runoff Bacteria Load (counts/year) = (Bacteria Event Mean Concentration) x (Annual Runoff Volume)

where,

Annual Runoff Volume (inches) = (Area) x (Annual Rainfall) x (Pj) x (Rv)

Pj = Fraction of annual rainfall events that produce runoff (typically set at 0.9)

Rv = Runoff coefficient = 0.05 + (0.9 x (impervious cover fraction of 0.14)).

Rv is empirically derived.

Bacteria Event Mean Concentration

The average bacteria concentration in runoff is estimated using data provided by major investigations that have compiled over 1,000 stormwater pollutant load samples from similar land areas. Event mean concentration (EMC) is defined as the mean concentration of a pollutant over the duration of a storm event. This metric is widely applied in estimating pollutant concentrations associated with stormwater in developed areas. The Center for Watershed Protection and other investigators have compiled stormwater pollutant data and correlated pollutant concentration with land cover type and other factors. The EMC value for stormwater run-off from residential areas of 7,000 Fecal Coliform/100ml (Schueler, *et al*. 2007) was chosen for this application. This value was selected following a review of available data (see Appendix C) because this land cover type most closely matches the development characteristics of the Furnace Brook watershed.

In the Furnace Brook watershed, the developed land area is estimated to be 0.60 square miles with 14.4% impervious cover (0.14 expressed as a fraction). Equation 3-2 provides the values applied to estimate annual developed area runoff and the resulting annual bacteria load estimate (as FC counts/year) for developed area in the Furnace Brook watershed.

Equation 3-2: Developed area runoff calculation.

EMC (org/100mL)		Developed Land Area (square miles)		Annual Precipitation (inches/year)		Fraction Runoff (P_j)		Runoff Coefficient (R_v; inches)		Conversion Factor		Annual Bacteria Load Estimate
7,000	**X**	**0.60**	**X**	**31.6**	**X**	**0.9**	**X**	**0.18**	**x**	**6.6E+08**	**=**	**1.4E+13**

3.2.2. Failing Septic Systems

Failing septic systems are treatment systems that do not function properly, allowing human waste to be transported off site. Bacteria loads from failing septic systems were estimated using two components: (1) population on failing septic systems and (2) the associated bacteria load per person on failing systems. These estimates were then applied to each watershed to support estimation of total bacteria loading due to failing septic systems.

<u>Population on Failing Septic Systems (FSS)</u>

To estimate the population on failing septic systems, it was necessary to first estimate the number of septic systems and average number of people per septic system in the Furnace Brook watershed. These estimates were obtained using parcel maps and a per parcel population estimate. Using tax parcel maps provided by the Town of New Ipswich, a total of 350 parcels were counted within the Furnace Brook watershed. An average occupancy of 2 people per parcel was estimated based on surveys of other New Hampshire towns.

It is difficult to estimate how many of the total number of septic systems are failing. After conducting a literature review and meeting with experts, a septic system failure rate of 10% was selected. This rate corresponds to one septic system in ten operating in failure mode. The 10% failure rate is based on the findings of a septic system study in Maine (Dix and Hoxie, 2001). This rate may appear high, but groundwater transport of failing septic system waste to adjacent surface waters is common and is typically not detected. Further, several studies have shown that subsurface bacterial transport from septic leach fields is significantly increased when the leach field is saturated with groundwater (Viraraghavan, 1978; McCoy and Hagedorn, 1979). Thus, the 10% estimate of septic system failure rate was selected as conservative and consistent with the findings of several studies.

<u>Bacteria Loading per Person on Failing Septic Systems</u>

The human organism sheds approximately 2 x 10^9 fecal coliform daily (US EPA, 2001). Significant attenuation within failing septic systems and in the surrounding environment is believed to occur in the failing septic system scenario, likely significantly reducing the total per person loading rate of 2 x 10^9 fecal coliform/day. Some ambient attenuation of bacteria (e.g., via soil filtration) likely occurs within failing systems. This attenuation is believed to occur as waste goes through the failing system, settles within a tank or cesspool, and travels through failing leach-field soils. Therefore, the loading value directly from a human organism likely overestimates the actual loading to the environment by a human organism using a failing wastewater system. For our purposes, we assumed a one order of magnitude reduction in fecal coliform loading from people served by failing septic systems. This attenuation is approximately equal to the average attenuation through groundwater presented by Viraraghavan (1978) in two test trials in Ottawa, Canada. The resulting bacteria loading rate per person is 2 x 10^8 fecal coliform daily.

Equation 3-3 summarizes estimates of the population on failing septic systems and the resulting estimated annual bacteria loading from failing septic systems in the Furnace Brook watershed.

Equation 3-3: Failing septic system load estimate.

People per Parcel		Parcels on Septic in Watershed		Septic Failure Rate		Daily Bacteria Load per Person with Attenuation		Days per Year		Annual Bacteria Load Estimate
2.0	**X**	**350**	**X**	**10%**	**X**	**2.0E+08**	**X**	**365**	**=**	**5.1E+12**

3.2.3. Wildlife

A review of microbial source tracking (MST) studies in the southern New Hampshire was conducted to support identification of dominant wildlife. Dr. Steve Jones, a microbiologist at UNH, conducted the review and compiled a wildlife bacteria sources report, as part of similar bacteria investigation in the seacoast region (Jones, 2009). The Jones report identifies deer, raccoons, coyotes, foxes, otters, rabbits, Canada geese, and herring gulls as present in the seacoast study area, based on microbial source tracking results. The report also provides rough estimates of the magnitude of each wildlife source and identifies several dominant species including deer, geese, and raccoons. These three species are selected and applied to represent large mammal, bird, and small mammal bacteria loads, respectively, in the New Hampshire area, given their high population densities. The method of estimating each of these wildlife bacteria sources is provided below.

Equation 3-4: Wildlife bacteria loading equation.

Wildlife Bacteria Load (counts/year) = (Animal Population) x (Bacteria load/animal/year) x (Die-off Rate)

Where:

Animal Population = (Habitat Land Area) x (Species density)

Deer

Deer bacteria loads were estimated using Equation 3-4 above and parameter values shown in Equation 3-5 below. NH Fish and Game (NH F&G) biometrician Kent Gustafson provided the project team with a deer density estimate of 22 deer per square mile. Habitat land cover types for deer were specified as forest, crop land, pasture land, forested, and wetlands. Using GIS, the total area of deer habitat per watershed was calculated and multiplied by deer density to provide an estimated deer population per watershed. Using the equation provided above, the estimated deer population was multiplied by the estimated fecal coliform load per deer of $1.4x10^8$ counts/year (Jones, 2009). Lastly, an overland die-off rate of 0.9 was applied to account for bacteria die-off as it is transported from the land area to the receiving waterbody (Evans, *et al.*).

Raccoons

Equation 3-5 provides a summary of bacteria loading estimates for raccoons by watershed. Raccoon population estimates could not be located for NH, so a literature value (DeGraaf and Yamanski, 2001) taken from another northeastern habitat (New Jersey) was applied. An estimate of 40 raccoon per square mile was within the range provided by DeGraff and Yaminski and was selected as representative of the Furnace Brook watershed. Patrick Tate, wildlife biologist for NH F&G, assisted the project team in identifying raccoon habitat. Using GIS, the total area of raccoon habitat per watershed was determined and multiplied by density to provide a raccoon population estimate for each watershed. Using Equation 3-5, the estimated raccoon population was multiplied by the estimated fecal coliform load per raccoons of $1.2x10^9$ counts/year (Jones, 2009). Lastly, an overland die-off rate of 0.9 was applied to account for bacteria die-off as it is transported from the land area to the receiving waterbody (Evans *et al.*).

Canada Geese

Equation 3-5 provides a summary of bacteria loading estimates for geese in the Furnace Brook watershed. New Hampshire Fish and Game estimated goose population in New Hampshire south of Franconia Notch of approximately 22,000 geese. In order to get a rough estimate of goose population in the watersheds, FB Environmental used a population estimate of 20,000 in the area south of the lakes region to determine an order of magnitude goose population density estimate. Using this population density estimate and assuming uniform distribution of geese, we then estimated goose population for the Furnace Brook watershed. Using Equation 3-5, the estimated goose population was multiplied by the estimated fecal coliform load per goose of $1.2x10^7$ counts/year (Jones 2009). Lastly, an overland die-off rate of 0.9 was applied to account for bacteria die-off as it is transported from the land area to the receiving waterbody (Evans, *et al*.).

Other Wildlife Sources

Other wildlife, beyond deer, geese, and raccoons, are present in the study area. These species include foxes, rabbits, and various birds. The Jones report estimated that these additional species likely contributed significantly less bacteria load that the three species analyzed herein. Thus, it appears reasonable to select three dominant species and sum the estimated loadings of these species. If additional analysis of wildlife bacteria sources is deemed worthwhile, then more detailed information about these species may be obtained and additional species may be added to the analysis.

Equation 3-5: Wildlife bacteria load estimates.

Deer

Habitat Area (sq miles)		Species Density (per sq mi.)		Daily Bacteria Load per Animal		1 minus Die-off Rate of 0.9		Days per Year		Annual Bacterial Load Estimate
3.2	X	22	X	1.4E+08	X	0.1	X	365	=	3.6E+11

71 estimated number of animals

Raccoon

Habitat Area (sq miles)		Species Density (per sq mi.)		Daily Bacteria Load per Animal		1 minus Die-off Rate of 0.9		Days per Year		Annual Bacterial Load Estimate
2.9	X	40	X	1.2E+09	X	0.1	X	365	=	5.1E+12

116 estimated number of animals

Goose

Habitat Area (sq miles)		Species Density (per sq mi.)		Daily Bacteria Load per Animal		1 minus Die-off Rate of 0.9		Days per Year		Annual Bacterial Load Estimate
0.6	X	29	X	1.2E+07	X	0.1	X	365	=	8.0E+09

18 estimated number of animals

Wildlife Summary

The total wildlife bacteria load estimate was obtained by summing the contributions calculated above and results in an annual estimated load of 5×10^{12} FC for wildlife in the Furnace Brook watershed.

3.2.4. Summary of Bacteria Load Estimates

Bacteria load was estimated for each major type of source and are provided in Equation 3-6. These are screening level estimates intended for planning purposes only. There is significant uncertainty in these estimates associated with the magnitude and duration of bacteria sources and with the fate and transport of bacteria in the ambient environment (e.g., how quickly it dies off and how fast it travels). As a result of this uncertainty, it is appropriate to use ranges rather than specific values in assessing loads. The estimated percent contribution of each type of source is approximately:

- Developed area runoff - 50 to 70%;
- Failing septic systems - 10 to 30%; and
- Wildlife - 10 to 30%.

These estimates are shown in Figure 3-5 and serve as a guide in selecting and prioritizing specific sites for bacteria mitigation. Section 4 provides bacteria load reduction estimates per unit of developed area and failing septic systems.

Equation 3-6: Sum of estimated annual fecal coliform bacteria loads in the Furnace Brook watershed

	Annual Load from Septic Systems		Annual Load from Developed Land Runoff		Annual Load from Wildlife		Sum Total
	5.1E+12	+	1.6E+13	+	5.4E+12	=	2.6E+13
Percent of total	20%		60%		21%		100%

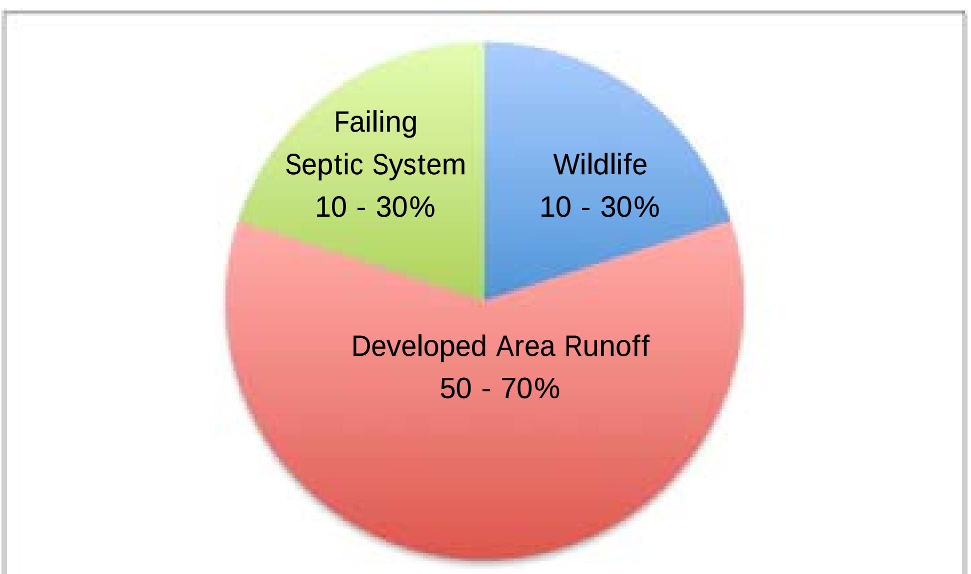


Figure 3-5: Estimated annual fecal coliform bacteria loads in the Furnace Brook watershed.

4. Nonpoint Source Measures to Mitigate Pollutant Sources

Developed area runoff, failing septic systems, and wildlife have been identified as the largest sources of bacteria in the Furnace Brook watershed. Estimates of bacteria load reduction, expressed as fecal coliform and associated with mitigation of these areas, are provided below for developed area runoff and failing septic systems. Planning level estimated cost ranges and estimated total mitigation required to restore Furnace Brook is also provide along with site-specific conceptual designs for mitigation.

4.1. Bacteria Source Area Mitigation Estimates

This section provides an estimate of the benefits of remediating one unit of bacteria source pollution, in terms of estimated bacteria load reduction. One unit is defined as follows:

- For Developed Area Runoff, eliminating the runoff from one acre of developed land through diversion, treatment, or other means of disconnection of the runoff source from the receiving waterbody; and
- For Failing Septic Systems, eliminating one septic system by taking a failing system offline.

Wildlife sources do not require mitigation because they are "natural sources", however, many best management practices (BMPs) designed to disconnect stormwater runoff from the receiving waterbody will also reduce wildlife source contributions.

The estimated bacteria source mitigation values are designed to support watershed based restoration planning and are screening level (i.e., order of magnitude) estimates only. These load reductions values will be applied to support prioritization of bacteria sources for mitigation and to characterize the environmental benefits associated with specific mitigative actions.

4.1.1. Developed Area Runoff Mitigation Estimates

> ***Mitigating one acre of developed area runoff yields an estimated bacteria load reduction of $4.2\text{x}10^{10}$ FC cts/year.***

The estimated total developed area in the Furnace Brook watershed is 0.60 square miles or 380 acres, as shown in Equation 3-2. The bacteria load reduction benefit of mitigating one acre of developed area would be 1/380 of the total estimated bacteria load of $1.6\text{x}10^{13}$ fecal coliform (FC) cts/yr (Equation 3-2). The estimated bacterial load reduction of mitigating one acre of developed area runoff is $4.2\text{x}10^{10}$cts/year. This estimate is linearly scalable so that, for example, mitigating three acres yields an estimated load reduction of $1.3\text{x}10^{11}$cts/yr.

There are a wide range of best management practices (BMPs) for mitigating the impacts of developed area runoff. A fundamental goal of these BMPs is to disconnect runoff from the stream and to infiltrate that water to the subsurface. There are several excellent resources available for obtaining information about specific stormwater BMPs and the process of selecting and installing appropriate BMPs. These resources include the Center for Watershed Protection (online at www.cwp.org) and the University of New Hampshire Stormwater Center (online at www.unh.edu/erg/cstev).

Developed area runoff mitigation cost estimates

The estimated cost of specific Furnace Brook stormwater runoff mitigation are provided in Section 4.5 below and range from $1,000 to over $30,000 per site mitigated. Planning level mitigation estimates range from $10,000 to $25,000 per acre of impervious area treated (CWP. 2009). Costs range significantly depending on site factors including availability to treatment space, slope, soil type, and elevation of water table.

4.1.2 Failing Septic System Mitigation Estimates

There are an estimated 35 failing septic systems in the Furnace Brook watershed, based on 350 total systems and an estimated 10% failure rate (Equation 3-3). The bacteria load reduction benefit of mitigating one failing septic system would be 1/35 of the total estimated bacteria load of $5.1\text{x}10^{12}$ cts/yr (Equation 3-3). The estimated bacterial load reduction of mitigating one failing septic system is $1.5\text{x}10^{11}$cts/year. This estimate is linearly scalable making estimation of removal of several failing septic systems straightforward.

Septic system mitigation cost estimates

The cost of an onsite wastewater treatment system comprised of a conventional septic system (septic tank and a dispersal leach field/trenches) for a typical 3-bedroom home in southern New Hampshire, without any site and environmental complications (issues of soils, shallow groundwater, bedrock, etc.), is $8,000 - $10,000, plus another $1,000 for design and preliminary field assessment, $300 for state onsite permit, and any additional local fees charge by the community (personal communication, R. Tardif, NHDES Water Division, Subsurface Bureau).

In many cases, failing septic systems are in need of more moderate remedies, such a simple pipe repair or leach field revitalization. Cost estimates for these repairs can ranges from several hundred dollars to $2,500 (EPA 1999) and can restore a septic system to proper functioning condition.

Mitigating one failing septic system yields an estimated bacteria load reduction of $1.5\text{x}10^{11}$ FC cts/year

4.2 Estimated Mitigation Required to Remove Bacteria Impairment

A statewide bacteria TMDL has been developed for New Hampshire (NHDES 2010). Bacteria data from each impaired surface water segment, including Furnace Brook, was compiled and analyzed in the statewide TMDL. For each impaired segment, the bacteria loading reduction required to remove impairment (i.e., meet water quality standards) was estimated. For Furnace Brook, a 49% reduction in bacteria loadings was estimated as the amount required to remove bacteria impairment (based on the geometric mean of bacteria sampling data).

A goal of the Furnace Brook watershed based restoration plan is to mitigate bacteria sources sufficiently to remove impairment. The total bacteria load estimate for Furnace Brook is 2.6×10^{13} FC cts/year. A 49% reduction in the total estimate, as specified by the TMDL, would require removing a bacteria load of approximately 1.27×10^{13} FC cts/year. A preliminary plan to remove 49% of the total bacteria load through mitigation is summarized in Table 4-1, along with planning level cost estimates.

Table 4-1: Planning Level Mitigation Plans with Estimated Bacterial Load Reductions and Costs.

	Total	Recommended	Estimated Bacteria		Estimated		
	Est. Load	Mitigation	Reductions (FC cts/year)		Mitigation Costs		
Type of Bacteria Source	FC counts/year	by unit	per unit	total	per unit		total
Developed Area Runoff	1.6E+13	177 of 380 acres	4.2E+10	7.4E+12	$10,000	1	$1,770,000
Failing Septic System	5.1E+12	35 systems (all)	1.5E+11	5.3E+12	$8,000	2	$280,000
Wildlife	5.4E+12	none					
Total	2.6E+13			1.27E+13			$2,050,000

Notes:

[1] Developed area mitigation cost estimate taken from the lower end of a range provided for residential area retrofits by the Center for Watershed Protection (CWP 2009).

[2] In estimating septic system costs, assumed 1/2 of septic systems required replacement at $15,000/ea and 1/2 required simple repair at $1,000 each (from ranges provided by EPA 1999).

The bacteria load estimates and cost estimates provided in Table 4-1 are planning level and should be evaluated as rough estimates only. These estimates are required to support watershed based restoration planning. The Furnace Brook restoration project will be conducted following an adaptive management approach. Specifically, a set of highest priority sites will be mitigated and the resulting reduction in bacteria levels will be monitored in Furnace Brook. Additional mitigation will be conducted iteratively, on an as-needed basis, depending on the results of ongoing bacteria sampling in the Brook. Through this adaptive management process, more accurate estimates of the bacteria load reductions required and the costs of implementing load reductions will be developed. The estimates provided in Table 4-1 are sufficient to support initial planning and the first phase of the watershed restoration process.

A description of the highest priority mitigation steps for the first phase on the project is provided below. The prioritization process is described in Section 4.3. Recommended next steps to support identification and removal of failing septic systems are provided in Section 4.4. A set of site-specific conceptual designs for mitigating high-priority developed area runoff is provided in Section 4.5.

4.3 Prioritization of Bacteria Sources for Mitigation

A total of 50 potential bacteria sources were identified and compiled, as presented in Section 3. A stakeholder group reviewed the list of bacteria sources and worked collaboratively to prioritize sites for mitigation. The stakeholder group included members of the New Ipswich Board of Selectmen, the New Ipswich Conservation Commission, NHDES and EPA. Through a series of meetings and field tours, the stakeholder group learned about the bacteria sources and developed a set of key factors to apply in prioritizing areas for mitigation.

Key factors considered in prioritizing bacteria sources for mitigation included:

- Expected benefit in terms of bacteria load reduction;
- Proximity to Brook – sources close to impaired reaches of the Brook were given higher priority;
- Expected cost of mitigation (together with expected benefit);
- Property ownership and access – town owned land was deemed more feasible for restoration; and
- Supported other town goals – projects in the downtown area would support ongoing restoration work in that area.

These factors were applied to prioritize a set of septic system management planning and site-specific developed area runoff tasks to support restoration of Furnace Brook and Willow Brook. These tasks are described in Sections 4.3 and 4.4 below.

4.4. Septic System Management Plan

Development of a septic system management plan is recommended to address potential bacteria loadings from failing septic systems. A plan is needed to support identification and removal of failing septic systems in the Furnace Brook watershed. The plan would be developed collaboratively with the community and would include creating an updated database and map of systems. Septic system inspections would also be conducted and enforcement actions taken, as needed. The following are components of the recommended septic system management plan:

1. Coordinate with the town health officer and obtain all available information;
2. Conduct a homeowner survey;
3. Create a database of septic information including a system inventory with age, size, location, estimated lateral distance to surface water, estimated vertical distance from the bottom of the leach field to seasonal high groundwater elevation, and other information;
4. Create a GIS-based map of septic systems;
5. Prioritize systems for further investigation;
6. Establish a program and schedule for inspection and testing beginning with the highest priority areas;
7. Consider establishing a septic system maintenance ordinance;
8. Conduct dye studies to test for connectivity of septic system to stream;
9. Take enforcement action, as needed; and
10. Provide support with funding for septic system repair and/or replacement activities, as needed.

Estimated cost range: $8,000 to $20,000.

4.5. Developed Area Runoff Mitigation Plan

A goal of the Furnace Brook watershed restoration project was to identify, assess, and remove pollutant sources to the Brook. Threats to the water quality of Furnace Brook have been found to stem primarily from nonpoint sources in the watershed. Mitigation of nonpoint sources is challenging because they tend to be many, spatially distributed, and labor intensive to remove. Developed area pollutant sources identified in Furnace Brook include directly-connected roadways, parks, and parking lots.

This document outlines recommendations for mitigative action plans using Best Management Practices (BMPs) and Low Impact Development (LID) techniques to achieve the goal of reducing polluted stormwater from entering the stream. Utilizing BMP and LID techniques to address stormwater issues in this watershed could greatly reduce the amount of polluted runoff reaching both Furnace Brook and Willow Brook, by catching the water and treating it before it enters the water bodies.

Best management practices (BMPs) can be defined as management practices (such as nutrient management or street sweeping) or structural practices (such as properly sited ditches and culverts) designed to reduce the quantities of pollutants, such as sediment, bacteria, and nutrients, that are washed by rain and snow melt from surrounding land into nearby receiving waters, such as lakes, streams, rivers, estuaries, and ground water.

The core conceptual goal of Low Impact Development (LID) is for the landscape to be functionally equivalent to predevelopment hydrologic conditions, which means less surface runoff and less pollution damage to lakes, streams and coastal waters. To achieve this goal, LID solutions reduce runoff volume by infiltrating rainfall water to groundwater, evaporating rainwater back to the atmosphere after a storm and finding beneficial uses for water rather than exporting it as a waste product down storm sewers. The mitigation measures described below are consistent with the conceptual approach of LID.

The following locations were identified as the highest priority restoration sites for developed area runoff in the watershed:

- *Site RW1(sites A-E): Temple Road*
- *Site RW3: Appleton Road*
- *Site RW4: Old Tenney Rd*
- *Site RW8: Tricnit Road*
- *Site LT2: Town of New Ipswich Ballfield*
- *Site HF4 – Horse Farm*

Recommended site-specific BMPs for each of these sites are provided below.

SITE RW1: TEMPLE RD.

Background: Temple Road runs parallel to Willow Brook and bridges Furnace Brook. Roadway stormwater runoff appears to be routed in two ways along this stretch of road. Firstly, surface flow is routed to Willow Brook directly as the brook serves as a roadside swale. Secondly, roadway runoff is routed to a subsurface stormwater catch basin system.

A set of recommendations has been created for the extensive problems along this one stretch of Temple Road and have been broken down into sub-sites RW1: A, B, C, D and E on the following pages. The runoff issues are mostly related to the roadway and parking lot issues, except for one commercial location.

The highlighted area indicates the location along Temple Road in which a multitude of runoff problems exist.

SITE RW1 (A): TEMPLE RD.

Problems: Willow Brook lies directly next to Temple Rd and is completely unprotected from runoff and other contaminants entering its waters.

Recommended Solutions: Rip rap slope or coil logs and re-armor the outlet of the culvert. Installing a vegetated buffer would also help to catch sediment from the roadway before entering the brook. Another option to vegetation would be installing curbing on this stretch of road which would channel the flow of water to the nearest storm drain.

Preliminary Cost Estimate: $1,500—$2,000 including labor and materials.

SITE RW1 (B): TEMPLE RD.

Problems: Runoff from Temple Rd. is entering Willow Brook due to a lack of an appropriate system to divert or absorb runoff. Brook also lacks a healthy buffer of vegetation.

Recommended Solutions: Installation of an infiltration trench (20' x 30') would help mitigate the runoff issues along this stretch of Temple Road. Placement of the basin should be between Temple Road and Willow Brook and should be engineered as such to be able to receive and absorb the water sheeting off the road. Installation of a vegetated buffer is also recommended.

Preliminary Cost Estimate: $2,500 $3,500 with labor and materials.

This image highlights the unprotected banks of Willow Creek. Install native riparian vegetation to increase bank stability and increase absorption.

SITE RW1 (C): TEMPLE RD.

Problem: Location of grocery store is directly next to Willow Brook. The grocery store appears to lack protocols for care of its' outdoor areas, in particular the dumpster area, and for storing and disposing of waste and various store supplies. Garbage is presently transported to the brook via runoff from their property. To add to the issue, the banks of Willow Brook adjacent to the store are devoid of healthy vegetation that would assist in the catchment of runoff and garbage.

Recommended Solutions: Install buffer plantings that extend from the road overpass back 50-75'. Have grocery store owners develop a Stormwater Pollution Prevention Plan (SWPPP) that addresses garbage disposal and dumpster maintenance. Outdoor storage of store supplies also needs to be addressed.

Preliminary Cost Estimate: Multiple management practices and plantings, $3,500—$5,000 including labor and materials and a completed SWPPP.

Outdoor storage of hazardous store supplies is a potential cause of pollution to the brook.

The bare banks of Willow Brook provide no protection against the flow of runoff.

Recommend vegetating area with native species.

Poorly maintained dumpster area results in trash entering brook.

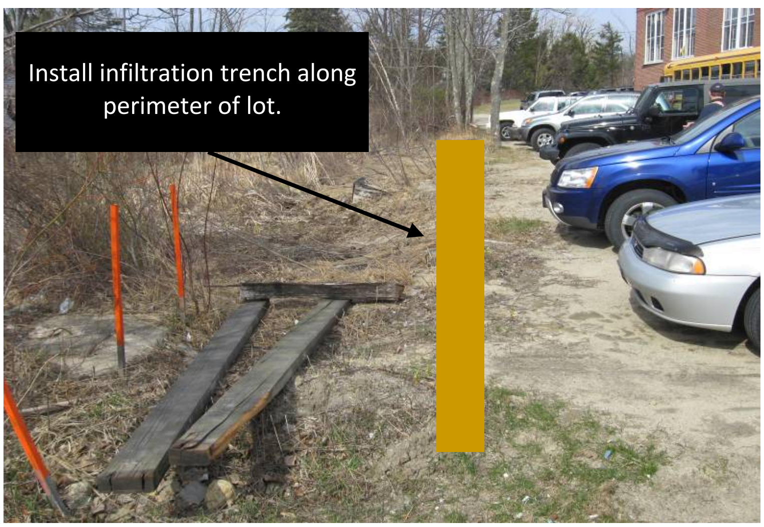
Roof runoff from house across the street runs directly into the brook.

Site RW1 (D): Temple Rd.

Problems: Parking lot of school is located directly next to Willow Brook and lacks appropriate structures to divert water away from the brook. Therefore, runoff travels off the lot, across an unvegetated area of land and then into the brook. Snow is plowed into brook.

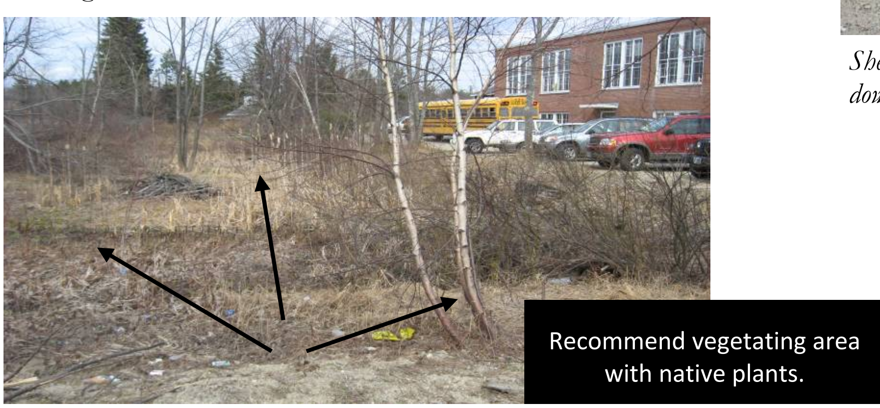
Recommended Solutions: Remove some parking spaces in order to create more of a buffer between the brook and the lot. This will also reduce the amount of impervious surface of the lot. Another option is to repave lot with permeable pavement. Recommend installing an infiltration strip along edge of parking lot closest to brook to catch runoff from the lot. A snow plowing maintenance plan is also needed for this parking lot. Fill in unvegetated land between the lot and the brook with native plantings. This will help improve infiltration of water that travels off the lot. Curbing or vegetated swales are an option in this case as well.

Preliminary Cost Estimate: At least $10,000 with some permeable paving and native plantings.



Lack of appropriate buffer between parking lot and brook results in runoff traveling unobstructed towards the water.

Sheet flow across parking area moves sediment down slope and towards brook.



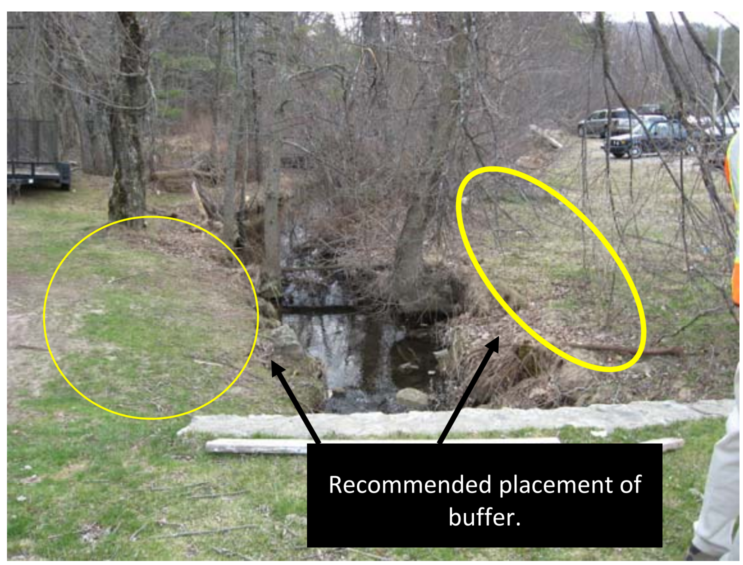
<u>SITE RW1 (E): TEMPLE RD.</u>

Problems: The parking lot of the Mobil Station is very close to Willow Brook and delivers contaminated runoff from the parking lot to the brook due to a lack of any type of buffer.

Recommended Solutions: Install a vegetated buffer.

Preliminary Cost Estimate: $1,000—$1,500 including labor and materials.

View of Mobil Gas Station parking area, next to Willow Brook. Installing a vegetated buffer will reduce the ability of stormwater to enter the brook.

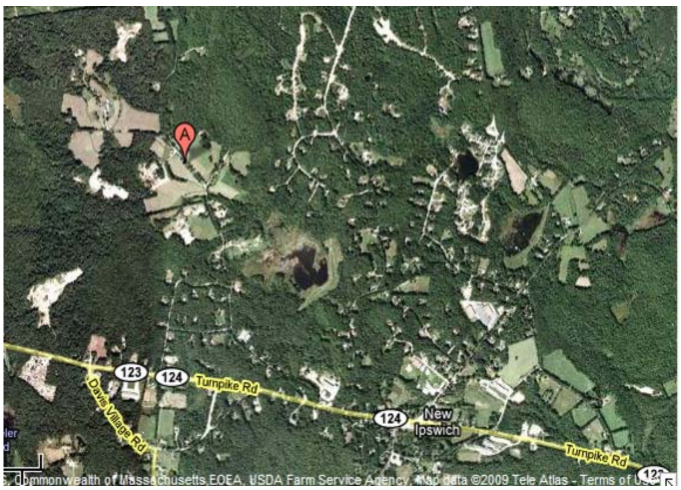


SITE RW3: APPLETON RD.

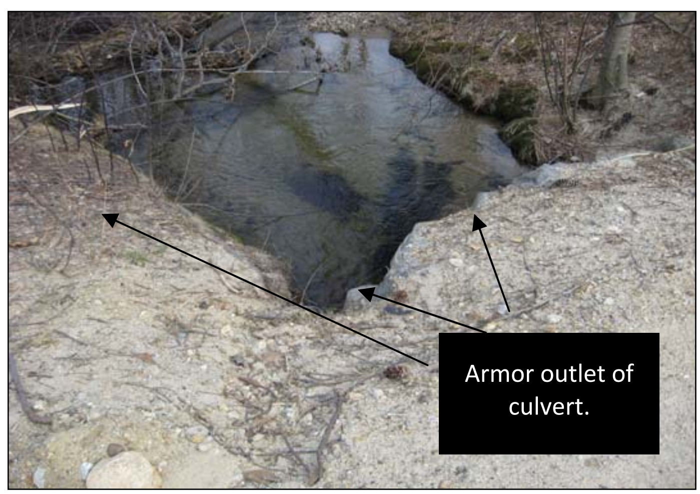
Problems: Excessive sediment build-up on road. Sediment then enters the brook via severely eroded banks surrounding the culvert.

Recommended Solutions: Remove existing sediment from road. Reduce sediment entering the brook by stabilizing the area surrounding the culvert. Apply erosion control mulch to the upland area, armor the mouth of the culvert and rip rap or coil log the banks in the surrounding area. Additional planting of native species is also recommended for the bare low lying banks adjacent to the culvert opening.

Preliminary Cost Estimate: $2,500-$3,000 including materials, labor, and equipment.



Built up sediment along roadway enters brook through unprotected areas around culvert.



Evidence of severe erosion around mouth of culvert.

SITE RW3: APPLETON RD.

Erosion evident around mouth of culvert and surrounding banks.

Denuded banks of the brook are more susceptible to erosive action. Installation of native plant species would help support and stabilize this area.

SITE RW4: OLD TENNEY RD. - RTE. 124

Background: This dirt road was re-graded in 2008 and large quantities of sand were observed to be transported from the roadway to Furnace Brook below, near the Rte. 124-Old Tenney Road intersection.

Problems: Runoff from Old Tenney Rd. is entering the brook and causing erosion of the slope leading to the brook. An additional problem is the culvert design, which could possibly limit fish passage.

Recommended Solutions: Control sediment entering the stream from the road. Several different BMPs can be installed at this site to accomplish this. The suggestions are as follows:

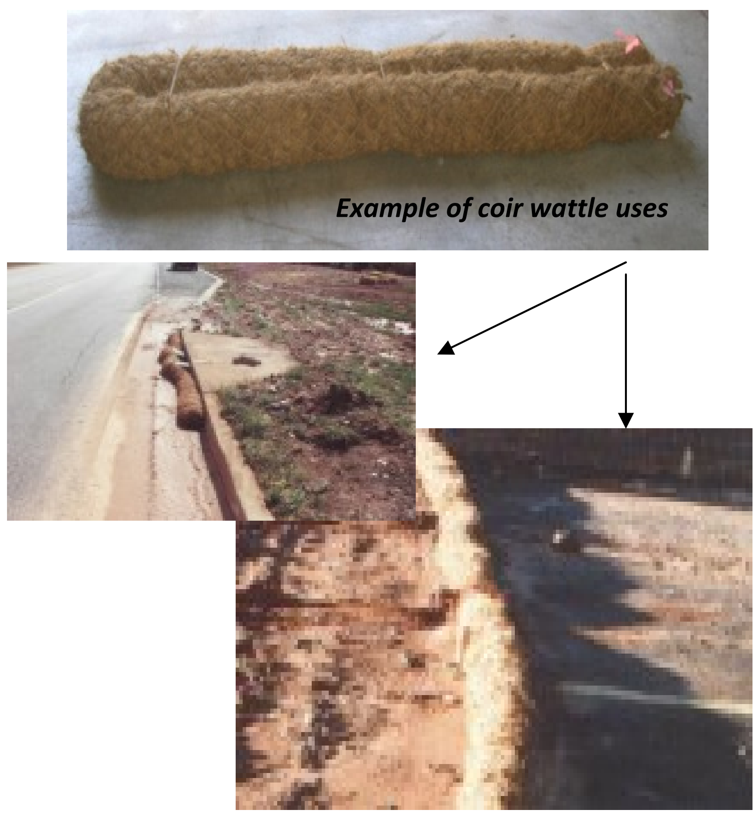
1) Install coir wattles or mulch rolls along Old Tenney Rd., extending from the intersection and leading north along the road for approximately 60'**.** This would provide a natural, low cost and effective way of controlling sediment runoff. Lightly packed fibers allow water to travel through freely while filtering sediment from stormwater.

2) Enhance and maintain existing turnout on Old Tenney Rd. Apply crushed stone to the area to cut down on sediment transport and reinforce the existing berm by applying erosion control mulch to armor the structure.

3) Further study is recommended to find out if this culvert design limits fish passage.

Preliminary Cost Estimate: $1,500—$2,000 including labor and materials.

Design of culvert needs to be re-assessed for fish passage.



Example of coir wattle uses

SITE RW4: OLD TENNEY RD. - RTE. 124

SITE RW8: TRICNIT RD.

Problems: Severe erosion of ditch lining the roadway, resulting in sediment deposition into brook. The unprotected areas around the overpass and the slope down to the brook are prime areas for sediment transport into brook.

Recommended Solutions: The area adjacent to the abandoned dam needs to be stabilized to prevent the sediment from traveling over the edge of the slope and into the brook. This can be accomplished by either installing a stone lined catch basin or lining the area with crushed stone or rip rap. On the other side of the brook, near the edge of the guardrail is the additional area that needs to be stabilized. The same treatment can be applied to this area as the other side, but considering that the conditions are more severe on this side, a large and/or deeper basin needs to be constructed.

Consideration should be made to the length of road and volume of sediment that these structures are receiving. Also recommend assessing the slopes of the stream channel itself for the possibility of reinforcement.

Preliminary Cost Estimate: $3,000—$5,000 including labor and materials.

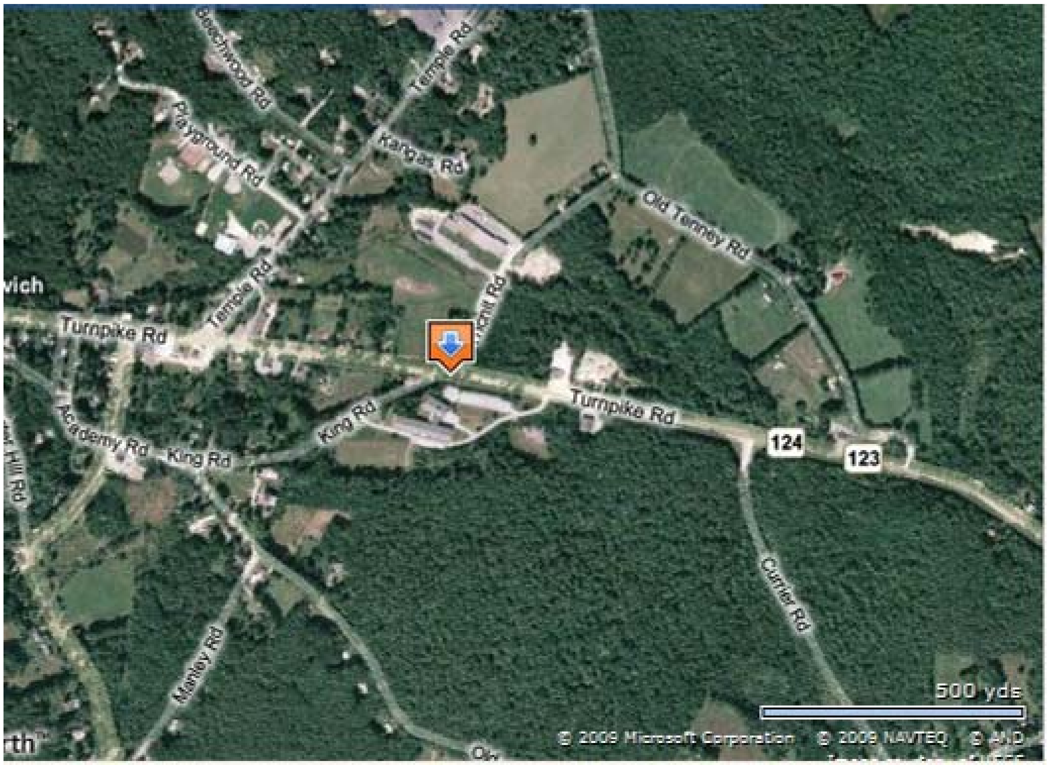
Excessive sediment on roadway, leading to unprotected slope next to overpass.

Rip rap area or install catch basin.

This image provides visual evidence that brook is susceptible to runoff from both sides of overpass.

Suggested placement of stone lined catch basin.

SITE RW8: TRICNIT RD.



SITE LT2: TOWN OF NEW IPSWICH BALLFIELD

Problems: Town of New Ipswich ball field and swimming pool parking lots are immediately adjacent to Furnace Brook. Sediment is flowing off parking lot , across grassy area and entering Furnace Brook by way of a severely eroded gully.

Recommended Solutions: There are several recommendations for improvements to this area to reduce sheet flow off of the parking lot. A recommendation is to install a type of permeable paving in the parking area—or for a portion of the parking area as a demonstration site. This is a LID (Low Impact Development) application that will result in increased absorption of water during a storm event which will help lessen the flow of sediment towards the brook. Second, a vegetated infiltration trench (120') is recommended for the area adjacent to the edge of the parking lot closest to the brook. Several other solutions are recommended including stabilizing a gully, posting signage that promotes good pet waste practices, and eliminating a pipe in the swimming pool area.

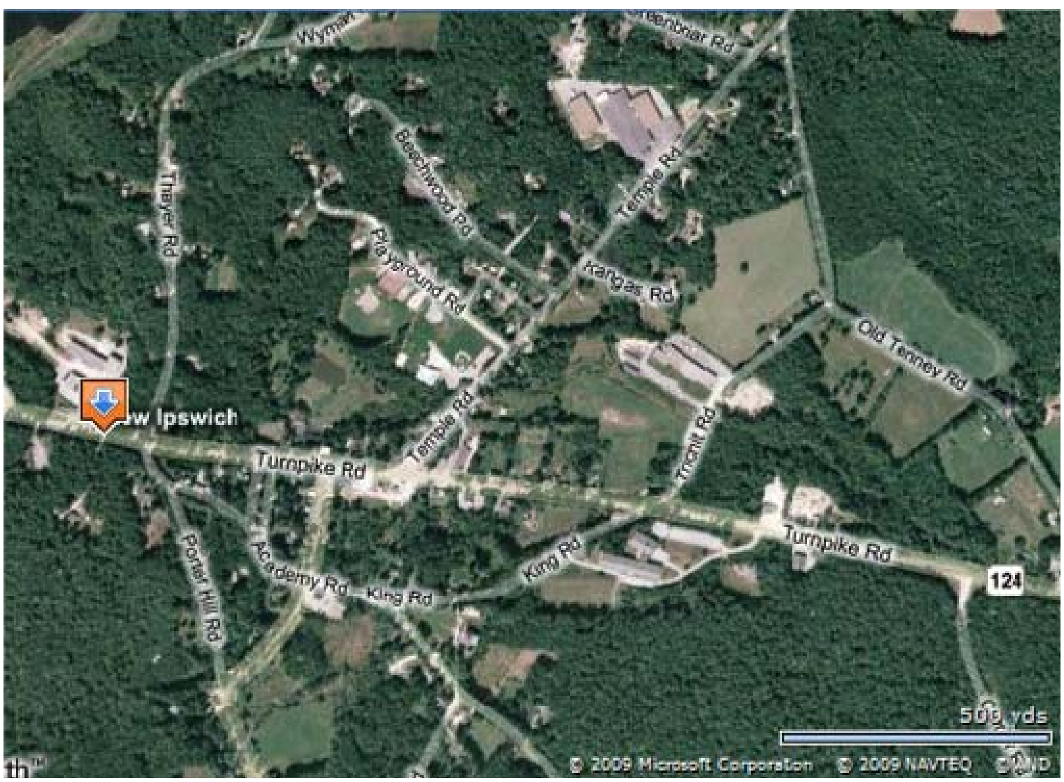
Preliminary Cost Estimate: Permeable paving—approx. $10/sq foot—total will vary based on size but could exceed $30,000 (for 3,000 sq. ft). Other site work is estimated at $4,000—$6,000 including labor and materials.

View of parking lot, lacking an appropriate buffer to the brook.

SITE LT2: TOWN OF NEW IPSWICH BALLFIELD

Severe erosion of this gully increases flow of runoff to the brook.

Image shows the location of the parking lot in respect to the brook. Installation of some type of permeable paving will assist in reducing the flow of runoff to the brook.



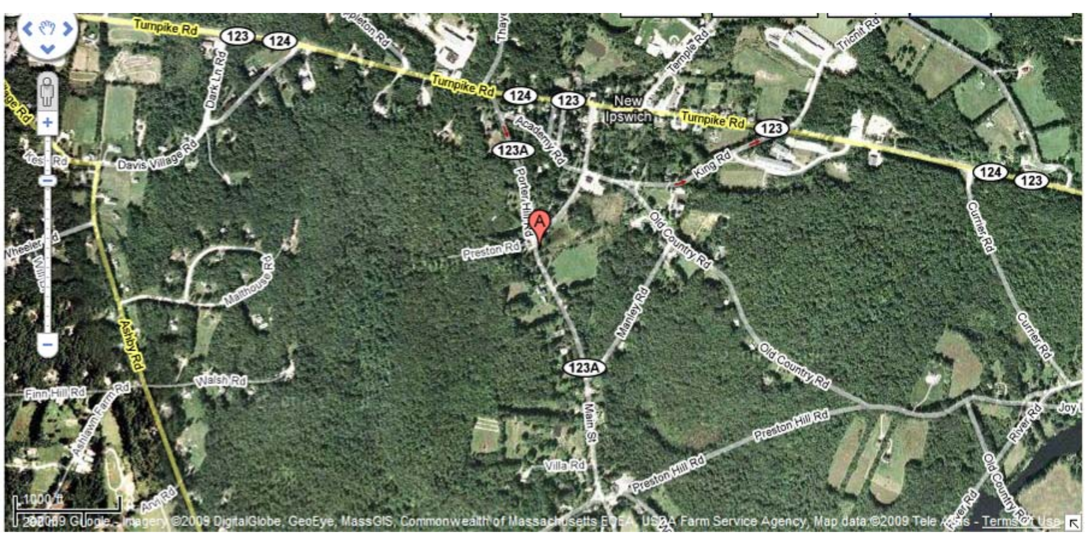
SITE HF4

Background: Small horse farm situated in the downtown area.

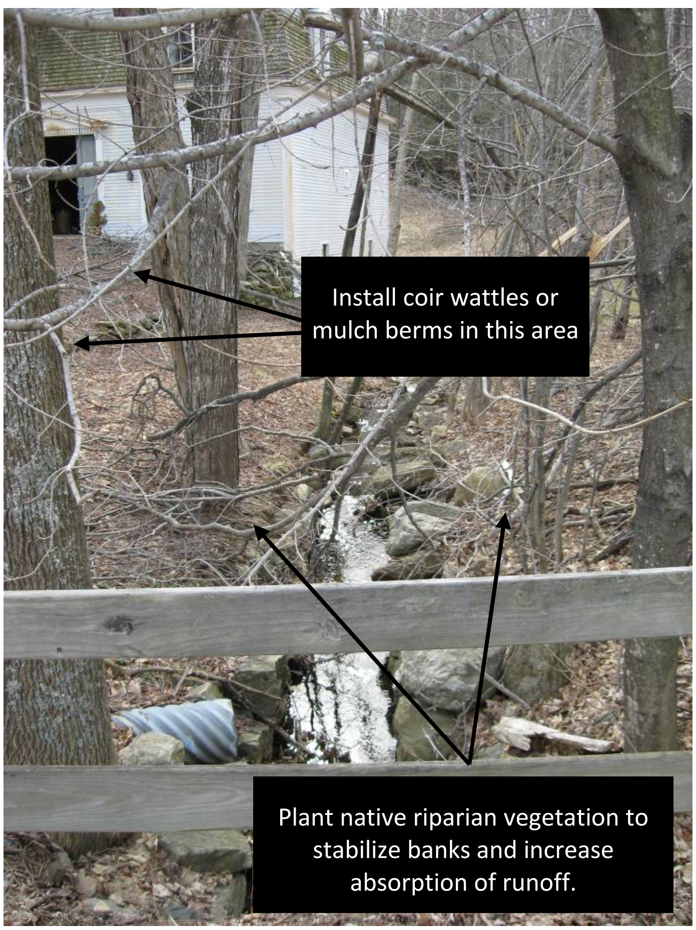
Problems: This horse farm is located adjacent to Furnace Brook. With the horse farm being a potential source of pollutants, BMPs are recommended to prevent polluted runoff from entering the brook. Problem areas include the denuded bank of the brook close to the horse farm, and the culvert, which is not armored and has severe erosion occurring around it.

Recommended Solutions: Recommended BMPs for this site are as follows: 1) Line the perimeter of the horse pasture (abutting the brook) with coir wattles or a mulch berm 2) stabilize banks surrounding the culvert with rip-rap and armor the outlet 3) install buffer plantings along brook where there is barren and eroding soil. Owners are encouraged to work with the Hillsborough County Conservation District and NRCS District Engineer to develop a nutrient management plan for the property.

Preliminary Cost Estimate: $1200—$2,500 including labor and materials.




This area needs stabilization and culvert needs to be re-armored.


Install coir wattles or mulch berms in this area
Plant native riparian vegetation to stabilize banks and increase absorption of runoff.


Sediment visible on roadway near culvert.

5. Technical and Financial Support

Implementation of the bacteria mitigation actions recommended in this report will require technical and financial support.

5.1. Technical Support

The septic system management planning task will likely require the following technical support:

- Geographic information system (GIS) support to develop maps of septic systems with associated information such as type, size, age, and maintenance records. GIS provides a spatial database that is highly useful for managing septic system data;
- Septic system testing support to conduct dye tests, visual inspections and other analyses of potentially failing septic systems; and
- Preliminary engineering design for replacement systems or short-term holding systems to support removal of failing systems.

The developed area runoff mitigation actions will likely require the following technical support:

- Engineering surveys, BMP designs, Nutrient Management Plan development, permitting, and other services; and
- Wetland delineation and permitting.

These forms of technical support may be provided by the Town of New Ipswich, NHDES, County Conservation Districts, or contractors.

5.2. Financial Support

Planning level cost estimates for the septic system mitigation and developed area runoff BMP treatments required for Furnace Brook are provided below followed by a compilation of potential sources of financial support.

5.2.1 Cost Estimates

<u>Septic system mitigation cost estimates</u>
Cost estimates for the septic system management planning tasks outlined above range from $8,000 to $20,000. Septic system visual inspections and dye tests can cost $200 to $325 per system (CWP. 2009; Glasoe and Tompkins 1996). Once planning is complete, repair and replacement of specific failing septic systems should be conducted.

The cost of an onsite wastewater treatment system comprised of a conventional septic system (septic tank and a dispersal leach field/trenches) for a typical 3-bedroom home in southern New Hampshire, without any site and environmental complications (issues of soils, shallow groundwater, bedrock, etc.), is $8,000 - $10,000, plus another $1,000 for design and preliminary field assessment, $300 for state onsite permit, and any additional local fees charge by the community (personal communication, R. Tardif, NHDES Water Division, Subsurface Bureau). In many cases, failing septic systems are in need of more moderate remedies, such as simple pipe repair or leach field revitalization. Cost estimates for these repairs can ranges from several hundred dollars to $2,500 (EPA 1999) and can restore a septic system to proper functioning condition.

Developed area runoff mitigation cost estimates

Costs of specific stormwater runoff mitigations are provided in Section 4 and range from $1,000 to over $30,000 per site mitigated. Planning level mitigation estimates range from $10,000 to $25,000 per acre of impervious area treated (CWP. 2009). Engineering surveys have not yet been conducted to delineate the precise areas treated by the mitigation measures described above, but the Furnace Brook mitigation estimates appear to be toward the lower end of this range.

5.2.2 Funding Sources

Financial support will be required to conduct the restoration work. Sources of financial support may include U.S. EPA Clean Water Act Section 319 nonpoint source mitigation funding managed by NHDES, and several other NHDES, EPA, USDA, NRCS, and non-profit organizations and programs. Potential sources of funding assistance are described below.

Non-Point Source Pollution

Section 319 Watershed Restoration Grants

Watershed Restoration Grants are available to assist in restoration of waterbodies that have been impaired by non-point source pollution. Projects must implement a watershed-based plan that identifies and quantifies the sources of pollution that caused the impairment, the load reduction required for the water to meet water quality standards, and the best management practices needed to achieve the required load reduction.

In March 2010, the Town of New Ipswich was awarded over $70,000 in Section 319 Watershed Restoration Grant funding to conduct phase I of the Furnace Brook restoration project. This 319 grant award demonstrates the federal and state government financial assistance available to support communities in their efforts to restore surface waterbodies.

Eligible applicants: Statewide. Eligible applicants include non-profits, government units, conservation districts, regional planning commissions, and watershed organizations.

Online at: http://des.nh.gov/organization/divisions/water/wmb/was/categories/grants.htm#warg

Contact: NHDES Watershed Assistance section, 29 Hazen Drive, Concord, NH 03301. (603) 271-2457

Section 319 Watershed Assistance Grants

Watershed Assistance Grants are available to address non-point source problems in high quality waters. Applicants must implement watershed-based plans with quantifiable water quality goals that make reasonable progress toward maintaining or improving high quality waters as specified in the watershed-based plan.

Eligible applicants: Statewide. Eligible applicants include non-profits, government units, conservation districts, regional planning commissions, and watershed organizations.

Online at: http://des.nh.gov/organization/divisions/water/wmb/was/categories/grants.htm#warg

Contact: NHDES Watershed Assistance section, 29 Hazen Drive, Concord, NH 03301. (603) 271-2457

Regional Planning

Regional Environmental Planning Program Grants

The Regional Environmental Planning Program (REPP) provides $25,000 in state general funds per year to each of the nine regional planning commissions for a total of $225,000 per year. The grant money supports projects that address environmental quality through local and regional land use planning and land use regulations.

Eligible applicants: The nine regional planning commissions.

Online at: http://des.nh.gov/organization/divisions/water/wmb/was/categories/grants.htm#wqp

Contact: NHDES Watershed Assistance section, 29 Hazen Drive, Concord, NH 03301. (603) 271-2457

Water Quality Planning 604(b) Grants

These grants are available to Regional Planning Commissions and/or the Connecticut River Joint Commissions for water quality planning purposes. Funding priority is given to projects developing and implementing lake management/shoreland protection plans, river corridor/river watershed plans, designated river nominations or comprehensive lake inventories. A total award amount of $80,000 is usually available every two years.

Eligible applicants: The nine regional planning commissions and/or the Connecticut River Joint Commissions.

Online at: http://des.nh.gov/organization/divisions/water/wmb/was/categories/grants.htm#wqp

Contact: NHDES Watershed Management Bureau, 29 Hazen Drive, Concord, NH 03301. (603) 271-2457

Municipal Planning

Clean Water State Revolving Fund (CWSRF)

Since 1989 the New Hampshire Department of Environmental Services (DES) has provided millions of dollars in low interest loans to towns and cities for sewer and wastewater treatment projects. With the advent of stimulus funds in 2009, the program has broadened eligibility to include non-point source projects and private, non-profit entities.

Eligible applicants: Municipalities and private, non-profit entities. .

Online at: http://des.nh.gov/organization/commissioner/pip/factsheets/wwt/documents/web-6.pdf

Contact: NHDES, Water Division, Wastewater Engineering Bureau, 29 Hazen Drive, Concord, NH 03301. (603) 271-3448.

Community Development Block Grants (CDBG) for Public Facilities

Title 1 of the Housing and Community Development Act of 1974 authorized the Community Development Block Grant (CDBG) program. The program is sponsored by the US Department of Housing and Urban Development (HUD) and the New Hampshire program is administered through the Community Development Finance Authority (CDFA). Public Facilities grants include water and sewer system improvements.

Eligible applicants: Municipalities.

Online at: http://www.nhcdfa.org/web/cdbg/cdbg_grants.html

Contact: New Hampshire CDFA, 14 Dixon Ave., Suite 102, Concord, NH 03301. (603) 226-2170

Resource Protection and Restoration

Local Source Water Protection Grants

Since 1997, DES has made small grants to water suppliers, municipalities, and other local organizations for the purpose of protecting drinking water sources. Protection projects funded through this program have included delineation of wellhead protection areas, inventorying potential contamination sources, development of local protection ordinances, performing land surveys as a precursor to land acquisitions, groundwater reclassification, shoreline surveys, drinking water education and outreach activities, and controlling access to sources.

Eligible applicants: Statewide. Water suppliers, municipalities, regional planning commissions, county conservation districts, and non-profit organizations are welcome to apply. Applicants must have endorsement of a public water supplier.

Online at: http://des.nh.gov/organization/divisions/water/dwgb/dwspp/lswp_grants.htm

Contact: NHDES Source Water Protection Program, 29 Hazen Drive, Concord, NH 03301 (603) 271-7017

Agricultural Nutrient Management Grant Program

The primary purpose of the Agricultural Nutrient Management (ANM) grants is to assist agricultural land and livestock owners with efforts to minimize adverse effects to waters of the state by better managing agricultural nutrients including commercial fertilizers, animal manures and agricultural composts. Applicants may apply for cost assistance of up to $2,500 per year. The majority of funding will be used for on-farm projects that address or prevent water pollution and some funding is available for education projects. This grant program is administered through the NH Department of Agriculture, Markets and Food, Bureau of Markets and is funded in NHDAMF's budget. Application deadlines are December 1 and June 1 of each year.

Eligible applicants: Statewide. Individuals, businesses, or organizations are welcome to apply. Priority is given to projects that most clearly address protection of surface water and public drinking water sources.

Online at: http://des.nh.gov/organization/divisions/water/wmb/was/categories/grants.htm

Contact: NHDES Department of Agriculture, Markets & Food Division of Regulatory Services, PO Box 2047, Concord, NH 03301 (603) 271-2753

Conservation License Plate Program

These grants, administered through the State Conservation Committee, funds projects that enhance the environment by promoting the sustainability of the state's public and private land, air, water, and cultural resources to prevent their pollution or degradation. Applications are accepted in January.

Eligible applicants: Statewide. County conservation districts, municipalities, cooperative extension natural resource programs, conservation commissions, schools, scout troops, nonprofit groups, and conservation organizations.

Online at: http://des.nh.gov/organization/divisions/water/wmb/was/categories/grants.htm

Contact: NH State Conservation Committee, c/o NH Department of Agricultural Markets & Foods Division, PO Box 2042, Concord, NH 03302-2042 (603) 868-6112

6. Public Information and Outreach

Public participation and support is critically important to the success of watershed restoration planning and implementation. The New Hampshire Department of Environmental Services, Watershed Assistance Section provides guidance in developing plans and conducting public outreach (NHDES 2009). This guidance will be followed in conducting the Furnace Brook watershed restoration project.

Public information and outreach will be conducted through continued coordination with the Town of New Ipswich. The study area is situated entirely within the Town of New Ipswich and the Board of Selectmen and Conservation Commission have been involved with the project from the outset. Upcoming and ongoing public information and outreach activities include:

- Furnace Brook restoration news release – One round of news releases was completed in late 2008 and a second release will be completed in the near future;
- Furnace Brook volunteer monitoring – Dixie Rhoads and other New Ipswich residents formed a stream team to monitor bacteria and other pollutants and collected samples during the summer of 2009;
- Furnace Brook restoration project brochure – An informational flyer will be developed in spring 2010 to provide a brief overview of the project and its benefits to the public;
- Introduction of the idea of creating a Furnace Brook stream trail along the town park property to encourage public awareness and enjoyment of the Brook;
- Furnace Brook and Willow Brook Cleanup Day – Tentatively scheduled for spring 2010. A stream clean up day will raise public awareness of the Brooks and encourage involvement with the restoration project; and
- Continued discussions at Town Board of Selectmen and Conservation Commission meetings to keep the public informed regarding the status of the restoration project.

Public awareness will lead to public support for restoring Furnace Brook and enhancing public enjoyment of the downtown area.

7. Schedule and Interim Milestones

A Section 319 Watershed Restoration grant application for implementing the Furnace Brook restoration plan has been submitted to NHDES for review and consideration. A preliminary schedule is provided below.

- *July 1, 2010* – Commence first phase of the Furnace Brook Watershed Based Restoration Project.
- *Throughout Project* – Conduct public education and outreach
- *July 1 through September 30, 2010* – Conduct bacteria sampling program in Furnace Brook
- *August 1, 2010* – Submit secondary data Quality Assurance Project Plan for bacteria load estimation.
- *September 15, 2010* – Complete Furnace Brook Shoreline Surveys
- *September 30, 2010* – Complete roadway BMPs at Appleton Road and Old Tenney Road
- *October 15, 2010* – Submit Stormwater Pollution Prevention Plan for the Temple Road grocery store
- *October 30, 2010* – Submit detailed designs and cost estimates for Temple Road ballfield and roadway BMPs
- *November 30, 2010* – Submit Septic System Management Plan
- *May 1, 2011* – Commence septic system repair and replacement program
- *June 1 through September 30, 2011* – Conduct bacteria sampling program in Furnace Brook
- *September 30, 2011* – Complete Temple Road Ballfield and roadway BMPs
- *February 28, 2012* – Submit Draft Phase I Report

8. Evaluation Criteria and Monitoring

The Town of New Ipswich Conservation Commission (NICC) has formed a stream monitoring team for Furnace Brook and successfully monitored for bacteria during the summer of 2009. The monitoring plan is for the NICC to continue to monitor bacteria levels in the study area. The evaluation criteria are in compliance with the water quality standard for *E. coli* of 406 cts/100ml.

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