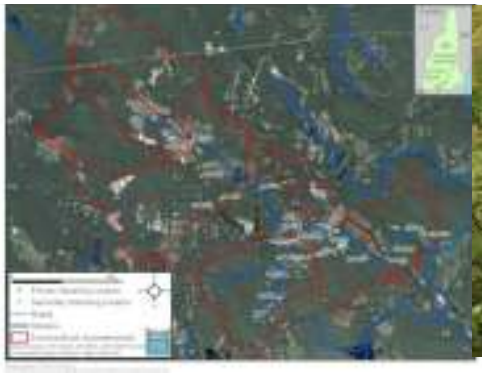


Holistic Assessment and Mitigation of the Bacteria-Impaired Furnace Brook Watershed

A Case Study for New Hampshire

Steve Landry and Ken Hickey

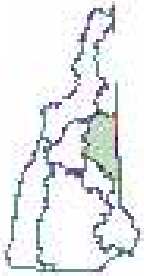
NEW HAMPSHIRE DEPARTMENT OF Environmental Services

FB environmental

Where We've Been

NEW HAMPSHIRE DEPARTMENT OF ENVIRONMENTAL SERVICES

319 WATERSHED ASSISTANCE GRANTS – SUCCESS STORY # 1



Pollutants Captured on Route 16

Since the installation of stormwater best management practices (BMPs) along the Route 16 side of Lake Chocorua there has been an 84-92% decrease in the phosphorus levels of runoff entering the lake through the BMPs.

Stone lined gully to the right of the footpath beside Chocorua Lake. Mount Chocorua can be seen in the background.

Project: Chocorua Lake Project

Location: Chocorua Lake, Tamworth, NH

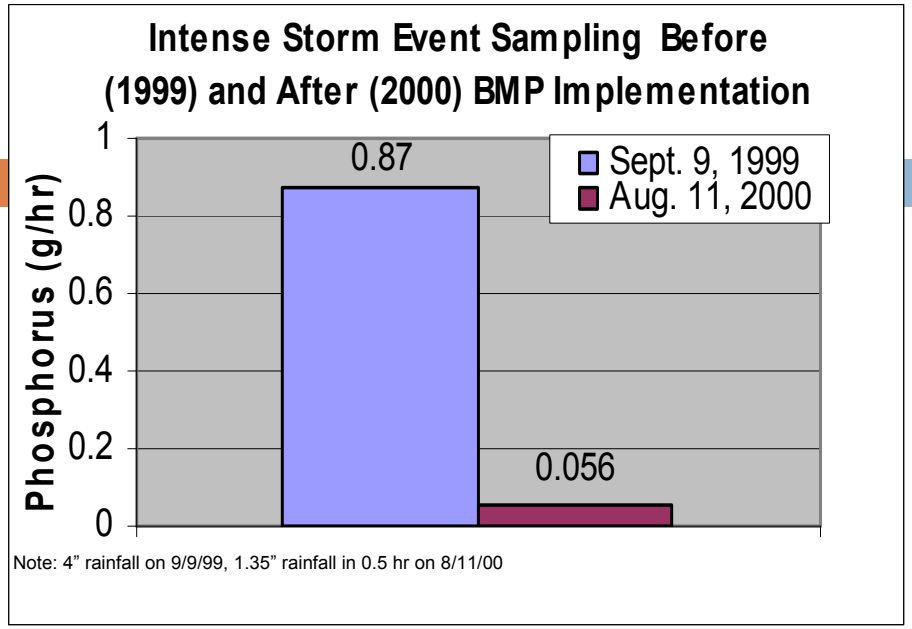
Watershed: Chocorua Lake - Saco River

Duration: April 2000 to Present

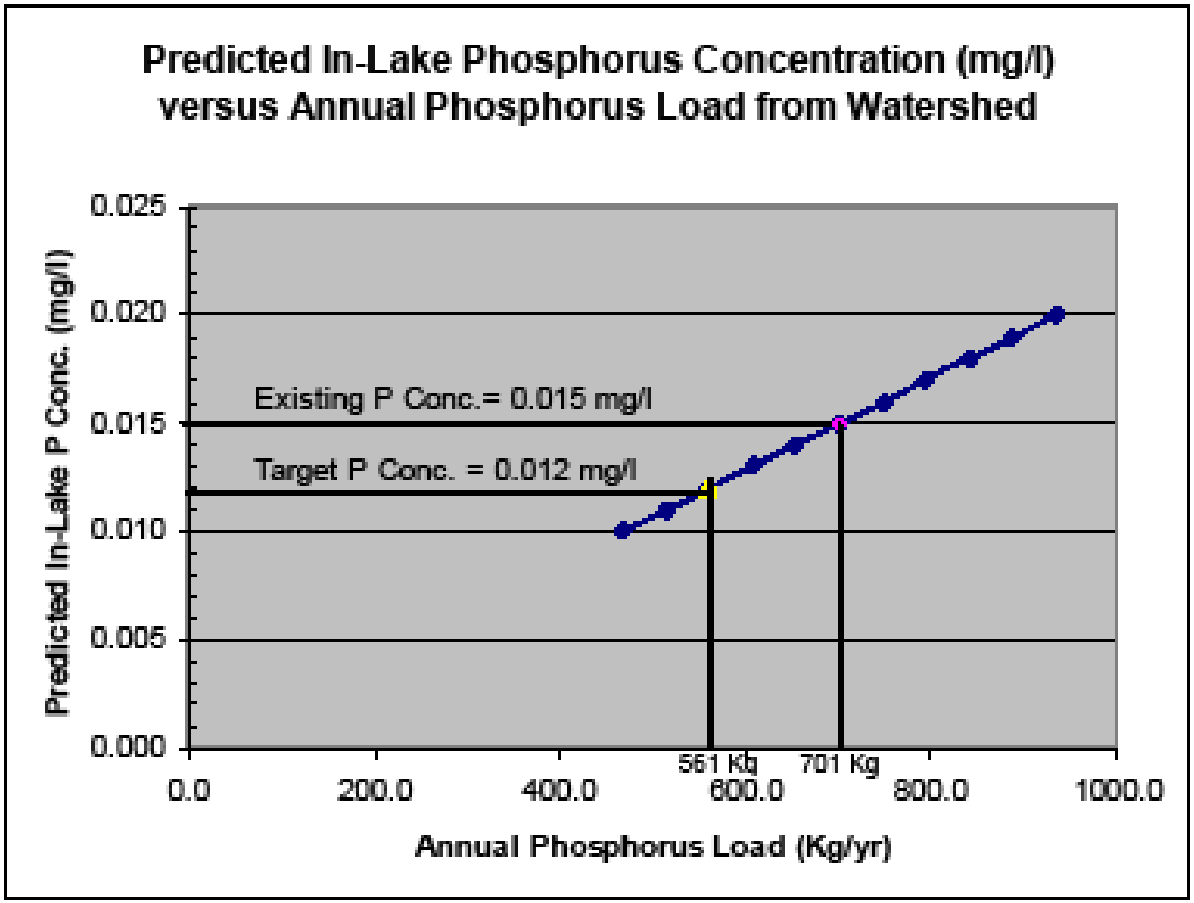
Grant Award: $41,950.00

Project Cost: $70,597.00

Partners: North Country Resource Conservation and Development Area, Inc., Carroll County Conservation District, USDA/Natural Resource Conservation Services, NH Department of Environmental Services, UNH Cooperative Extension, NH Department of Transportation, Town of Tamworth, Chocorua Lake Association, and Chocorua Lake Conservation Foundation.

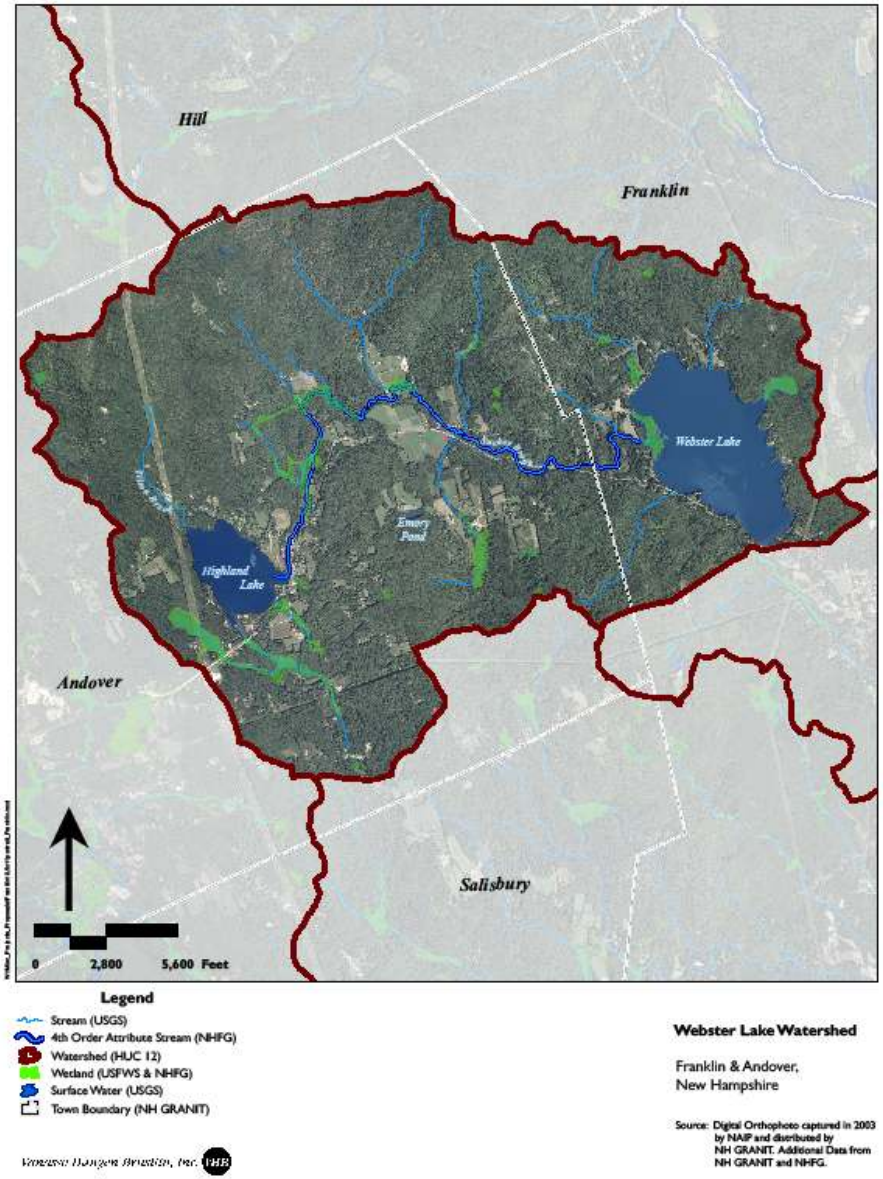

Intense Storm Event Sampling Before (1999) and After (2000) BMP Implementation
Phosphorus (g/hr)
1
0.8
0.6
0.4
0.2
0
0.87
0.056
Sept. 9, 1999
Aug. 11, 2000
Note: 4" rainfall on 9/9/99, 1.35" rainfall in 0.5 hr on 8/11/00

What Was Missing…



A Revised (*Holistic*) Approach

- Watershed-based Plans required
- High Quality Waters
- Impaired Waters



Nine Elements of Watershed Plan

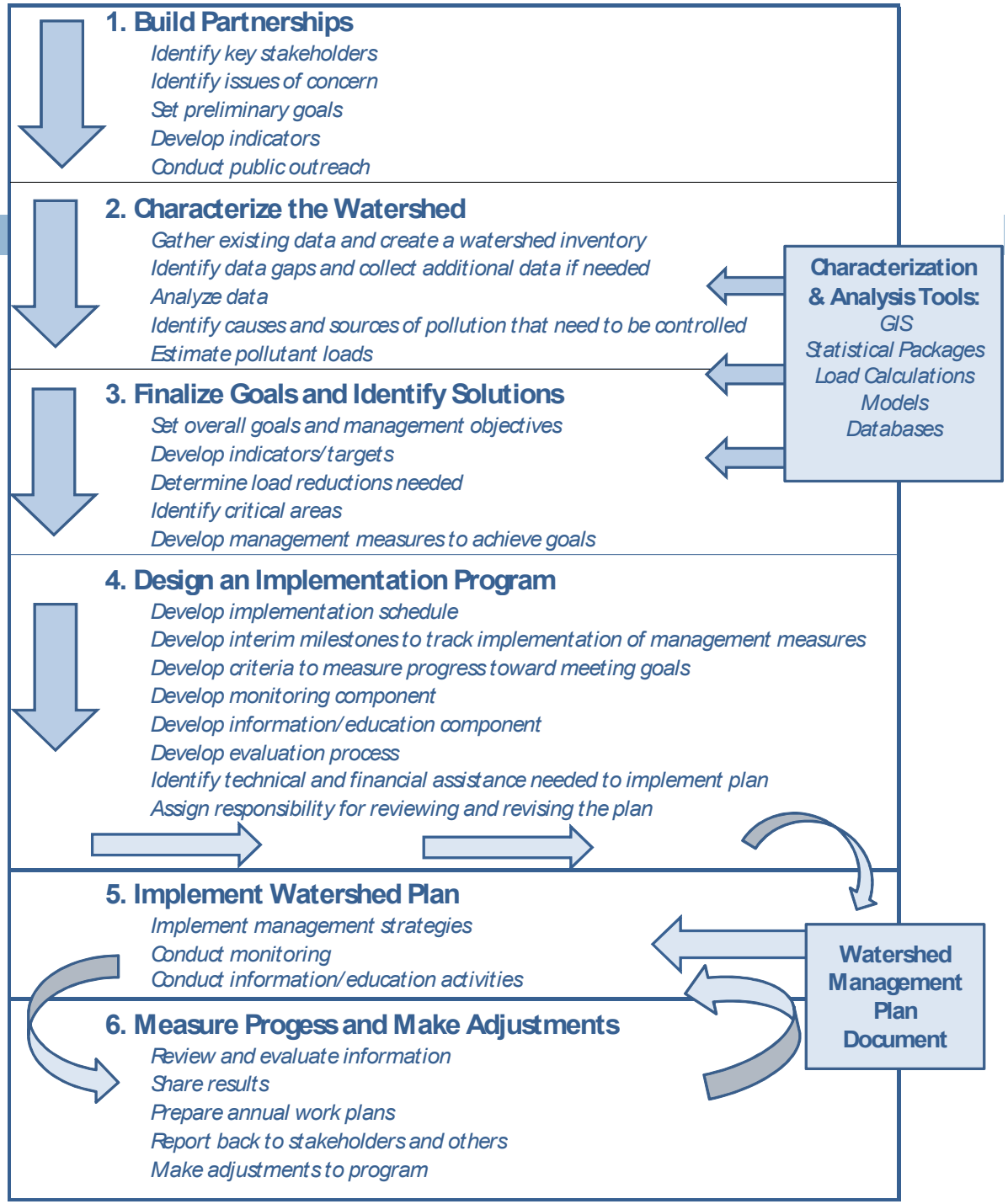
1. Identification and quantification of causes and sources
2. Estimate of needed load reductions to achieve WQS
3. ID BMP's needed to achieve the load reductions, and ID the critical areas for implementing the BMP's

Nine Elements (cont.)

4. Estimate of needed technical & financial resources
5. Information/ Education component
6. Schedule (who does what, when)
7. Description of measurable milestones for implementation
8. Criteria to determine if loadings/ targets are being achieved
9. Monitoring component for above criteria

Watershed Based Plans

Characterization and analysis of watersheds supports development of Watershed Plans and implementation of mitigative actions.



Source: U.S. EPA. 2008. Handbook for Developing Watershed Based Plans to Restore and Protect our Waters.

Watershed Based Plans

Table 5-1: 10-Year Watershed Restoration Program Capital Improvement Program Budget									
Option	Capital Cost	Potential Offset Revenues (e)	Source	Number of Sites Addressed in 10-Year Period		Lbs Removed per Year	Lbs Removed Over 10 Years	$/lb	Year
1. Public Education									
1A. Complete Part 2 of Education Program - Stump Pond	$20,000	$20,000	grant						
1B. Develop Web site and Populate with Watershed Resources	$6,000	$6,000	grant						
1C. Door Hangar and other Public Education Recommended from 1A	$12,000	$12,000	grant						
1D. Develop School Education Program Through Teachers	$15,000								
1E. Coordinate with Phase II Coalition/NRPC	$10,000								
1F. Garden Club Coordination	$15,000								
Total	$78,000	$38,000				285	2,846	$27	1 - 10
2. Increased Maintenance in Commercial Areas									
2A. Evaluate issues and on going costs to sweep and vac	$10,000								
2B. Purchase Street Sweeper for Prioritized Operations 2-6X/year	$200,000	$120,000	grants	2,378	acres	96	959		1 - 10
2C. Purchase Vac Truck for Prioritized Cleanouts Private Areas	$120,000	$72,000	grants			280	2,798		1 - 10
Total	$330,000	$192,000				376	3,757	$88	1 - 10
3. Retrofit Detention Basins									
3A. Evaluate Existing BMPs, Prioritize Top 10	$10,000								1
3B. Design BMPs for 10 Sites (a)	$195,000								2
3C. Construct Detention Basin Retrofits	$650,000	$200,000	grants	10	BMPs				3-5
Total	$855,000	$200,000				50	501	$1,706	

Watershed Based Plans

Figure 5-1. 10-Year Watershed Restoration Program Milestone Schedule

Option	Year									
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
2. Increased Maintenance in Commercial Areas										
Evaluate issues and on going costs to sweep parking areas and driveways and clean catch basins and BMPs on private properties										
Implement sweeping/cleaning program to continuously sweep between April and November and clean catch basins and BMPs twice a year										
Adjust sweeping and cleaning schedule based on sediment accumulation										
3. Retrofit Detention Basins										
Evaluate Existing BMPs, Prioritize Top 10										
Design BMPs for 10 Sites (a)										
Construct Detention Basin Retrofits										
4. Encourage LID in Commercial Redevelopment										
Present grant program idea to watershed communities at Phase II Coalition meeting										
Develop application process										
Contract professional review of LID developments and issue funds to watershed communities										
5. Encourage Local Adoption of State Stormwater Standards										
Present local adoption of AoT rules and watershed regulations at Phase II Coalition meeting										
Provide funding to NRPC to assist communities with adoption of state standards. State standards adopted locally										
Review developments within the watershed										
6. Tinker Road Detention Basin Retrofit										
Secure grant funding										
Finalize BMP designs and obtain permits										
Construct BMPs										

Furnace Brook – In the *RED*

WATERSHED 305(b) ASSESSMENT SUMMARY REPORT:

HUC 12 010700060901

HUC 12 NAME HEADWATER BRANCH TRIBUTARIES

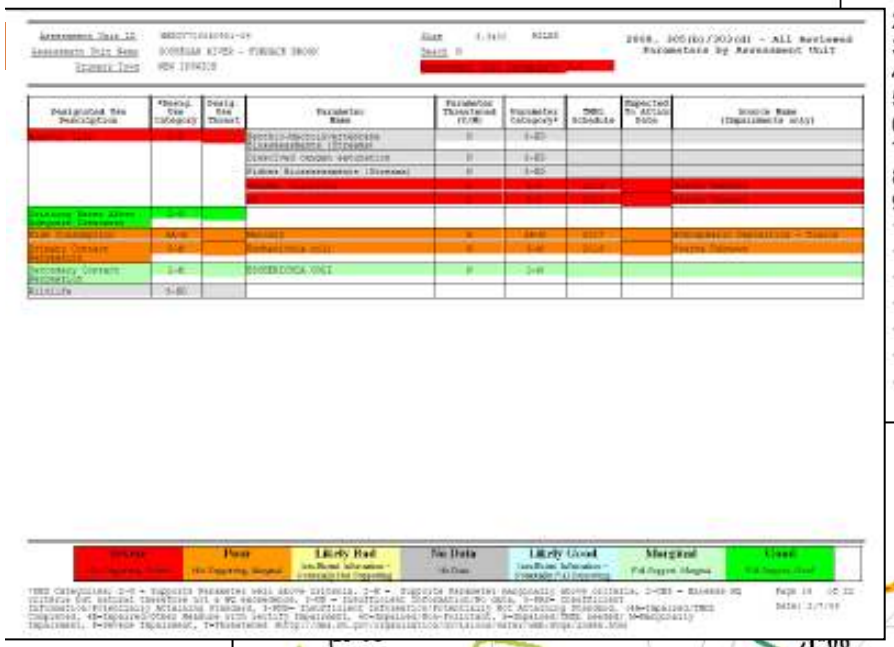
(Locator map on next page only applies to this HUC12)

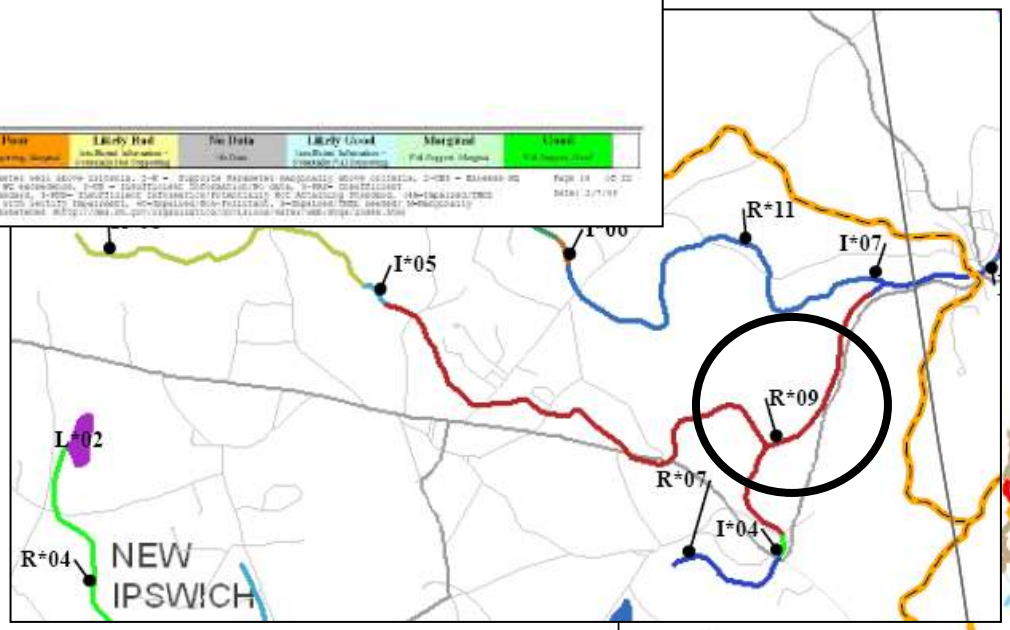
Assessment Cycle 2008

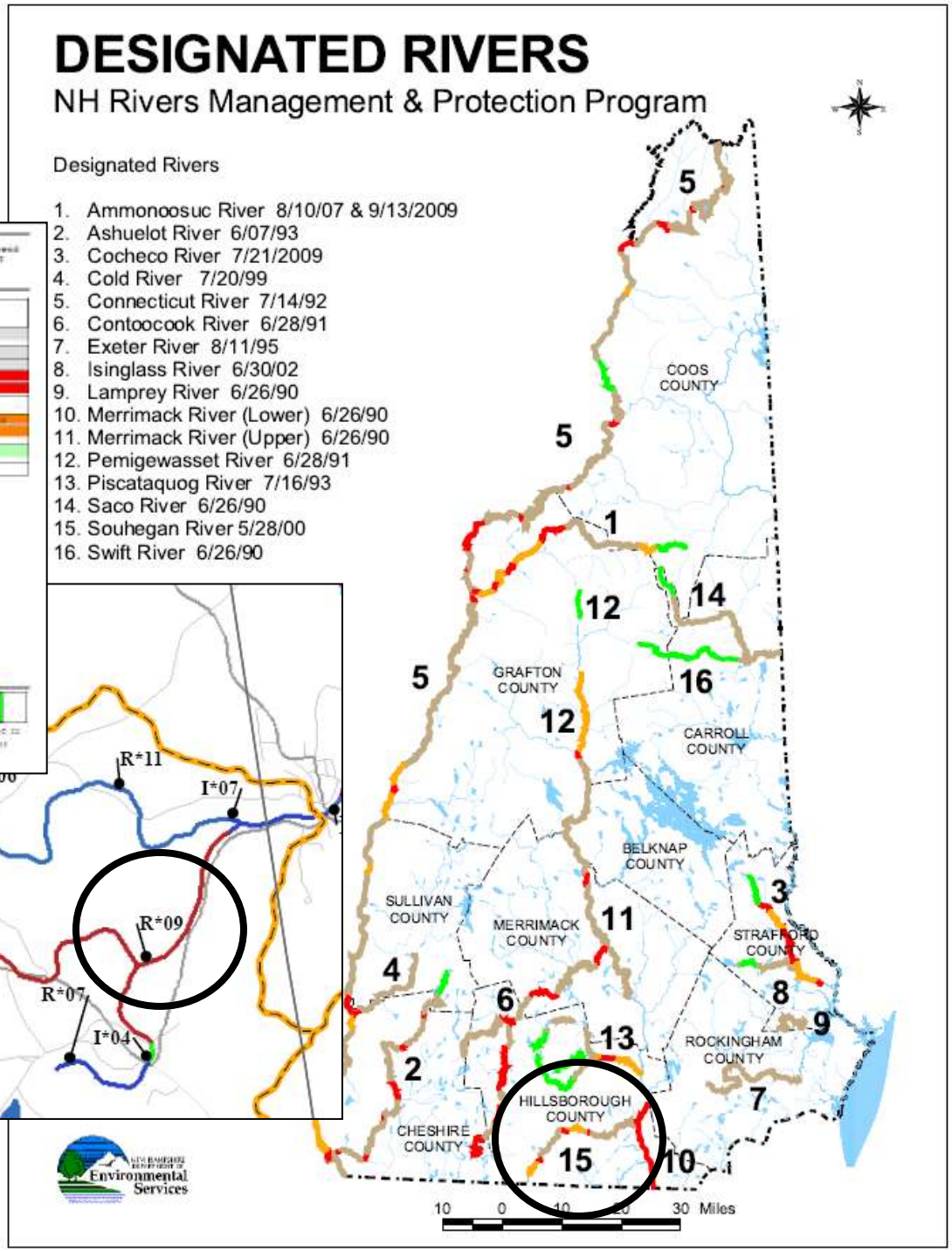
Good	Full Support Good
Marginal	Full Support Marginal
Likely Good	Insufficient Information – Potentially Full Support
No Data	No Data
Likely Bad	Insufficient Information – Potentially Not Support
Poor	Not Support Marginal
Severe	Not Support Severe

ASSESSMENT UNIT ID	MAP LABEL	ASSESSMENT UNIT NAME	AQUATIC LIFE	SWIMMING	BOATING	FISH CONSUMP.
NHIMP700060901-01	I*01	UNKNOWN RIVER - SOUHEGAN RIVER, SITE 35	3-ND	3-ND	3-ND	4A-N
NHIMP700060901-02	I*02	WEST SOUHEGAN RIVER	3-ND	3-ND	3-ND	4A-N
NHIMP700060901-03	I*03	SOUHEGAN RIVER - SOUHEGAN RIVER , SITE 19	3-ND	3-ND	3-ND	4A-N
NHIMP700060901-04	I*04	SOUHEGAN RIVER	3-ND	3-ND	3-ND	4A-N
NHIMP700060901-05	I*05	FURNACE BROOK - FURNACE BROOK DAM POND	3-ND	3-ND	3-ND	4A-N
NHIMP700060901-06	I*06	UNKNOWN RIVER - SOUHEGAN RIVER, SITE 13	3-ND	3-ND	3-ND	4A-N
NHIMP700060901-07	I*07	SOUHEGAN RIVER - OTIS DAM	5-P	2-M	2-F	4A-N
NHLAK700060901-01	L*01	WATER LOOM POND	3-PAS	2-M	2-F	4A-N
NHLAK700060901-02	L*02	WHEELER POND	3-ND	3-ND	3-ND	4A-N
NHLAK700060901-03	L*03	PRATT POND	4A-P	2-M	2-F	4A-N
NHRIV700060901-01	R*01	SOUHEGAN RIVER	3-ND	3-ND	3-ND	4A-N
NHRIV700060901-02	R*02	UNNAMED BROOK - TO SOUTH BRANCH	3-ND	3-ND	3-ND	4A-N
NHRIV700060901-03	R*03	PRATT POND BROOK	3-N	3-PAS	3-PAS	4A-N
NHRIV700060901-04	R*04	STARK BROOK	5-P	3-ND	3-ND	4A-N
NHRIV700060901-05	R*05	SOUHEGAN RIVER - WEST SOUHEGAN RIVER	5-P	2-M	2-F	4A-N
NHRIV700060901-06	R*06	UNNAMED BROOK - TO WATER LOOM POND	3-ND	3-ND	3-ND	4A-N
NHRIV700060901-07	R*07	SOUHEGAN RIVER	3-ND	3-ND	3-ND	4A-N
NHRIV700060901-08	R*08	FURNACE BROOK	3-ND	3-ND	3-ND	4A-N
NHRIV700060901-09	R*09	SOUHEGAN RIVER - FURNACE BROOK	5-P	2-M	2-M	4A-N
NHRIV700060901-10	R*10	UNNAMED BROOK - TO UNNAMED POND	3-ND	3-ND	3-ND	4A-N
NHRIV700060901-11	R*11	UNNAMED BROOK - FROM UNNAMED POND TO SOUHEGAN RIVER	3-ND	3-ND	3-ND	4A-N
NHRIV700060901-12	R*12	UNNAMED TRIB TO PRATT POND	5-P	3-PAS	2-F	4A-N

Furnace Brook is Red and Brown? That can't be good…





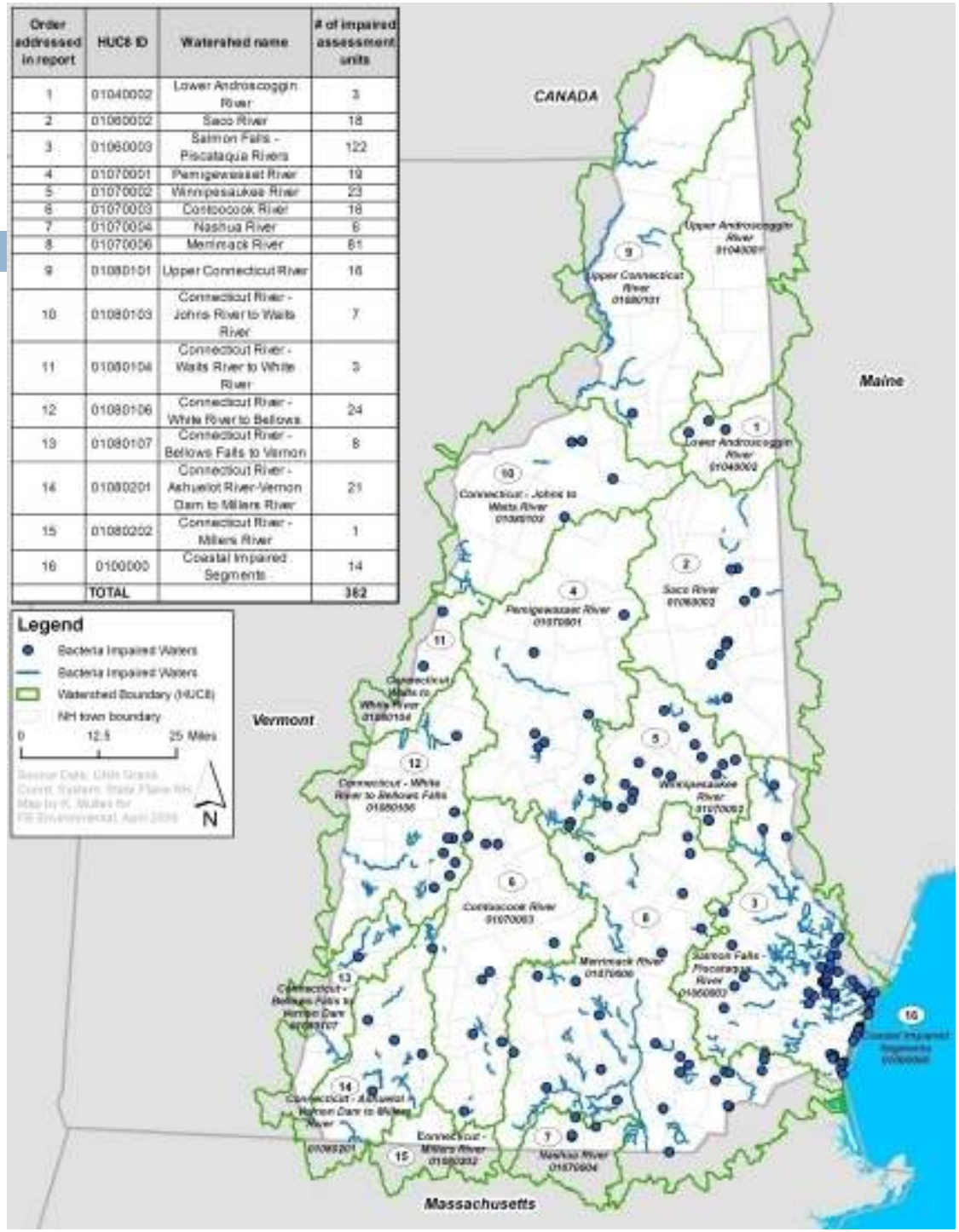


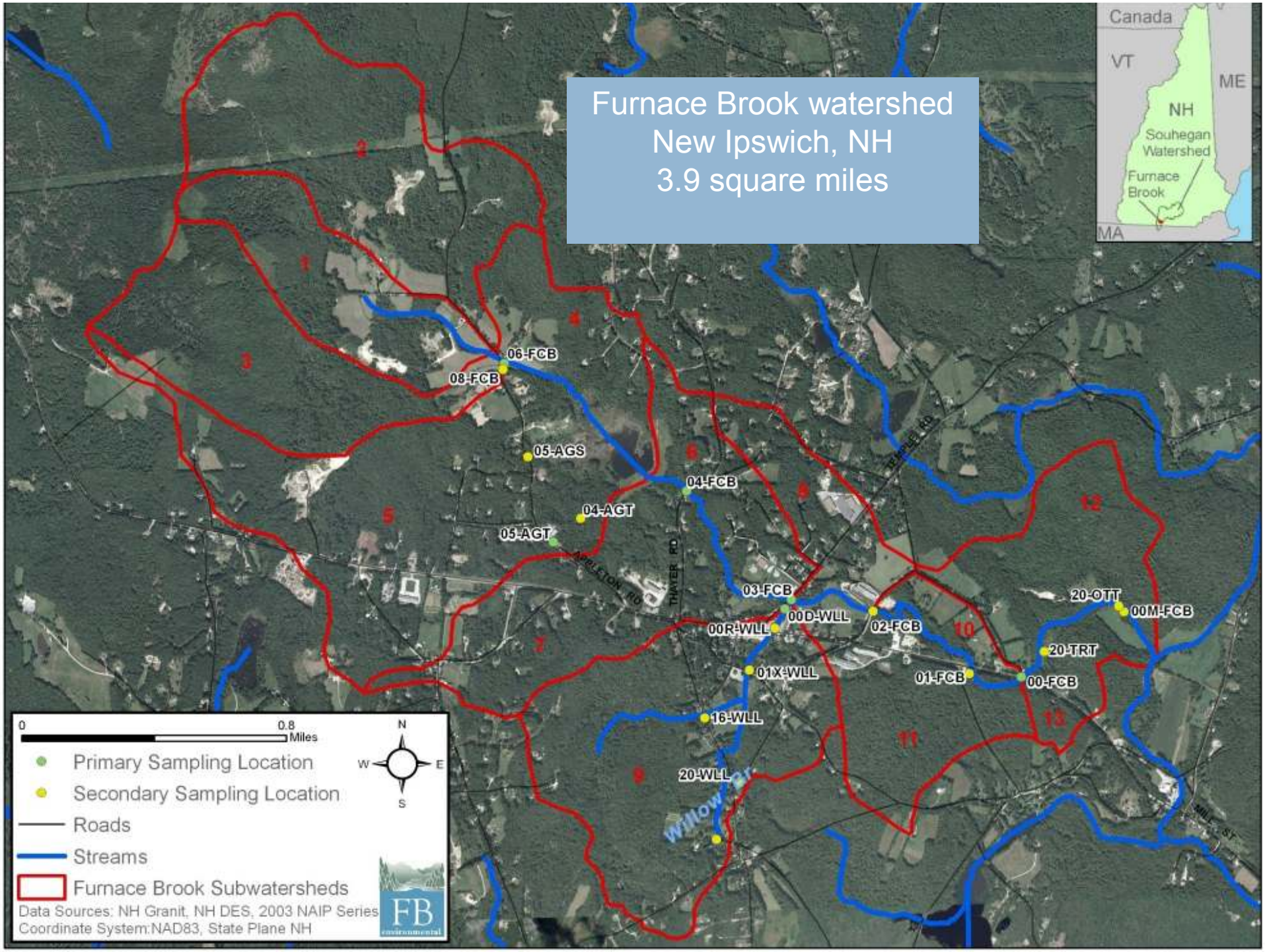
Furnace Brook is not alone in NH…

New Hampshire Statewide Bacteria TMDL Development

- 382 bacteria-impaired segments throughout New Hampshire
- 204 bacteria-impaired segments in Maine
- Over 200 bacteria-impaired segments in Massachusetts

Order addressed in report	HUC8 ID	Watershed name	# of impaired assessment units
1	01040002	Lower Androscoggin River	3
2	01060002	Saco River	18
3	01060003	Salmon Falls - Piscataqua Rivers	122
4	01070001	Pemigewasset River	19
5	01070002	Winnipesaukee River	23
6	01070003	Contoocook River	18
7	01070004	Nashua River	6
8	01070006	Merrimack River	61
9	01080101	Upper Connecticut River	16
10	01080103	Connecticut River - Johns River to Waits River	7
11	01080104	Connecticut River - Waits River to White River	3
12	01080106	Connecticut River - White River to Bellows	24
13	01080107	Connecticut River - Bellows Falls to Vernon	8
14	01080201	Connecticut River - Ashuelot River-Vernon Dam to Millers River	21
15	01080202	Connecticut River - Millers River	1
16	0100000	Coastal Impaired Segments	14
	TOTAL		382




Furnace Brook watershed
New Ipswich, NH
3.9 square miles
Canada
VT
ME
NH
Souhegan Watershed
Furnace Brook
MA
06-FCB
08-FCB
05-AGS
04-FCB
04-AGT
05-AGT
03-FCB
00D-WLL
00R-WLL
02-FCB
01X-WLL
01-FCB
00-FCB
20-OTT
00M-FCB
20-TRT
16-WLL
20-WLL
Willow Br
APPLETON RD
THAYER RD
TEMPLE RD
MILL ST
0
0.8
Miles
N
W
E
S
Primary Sampling Location
Secondary Sampling Location
Roads
Streams
Furnace Brook Subwatersheds
Data Sources: NH Granit, NH DES, 2003 NAIP Series
Coordinate System:NAD83, State Plane NH
FB
environmental

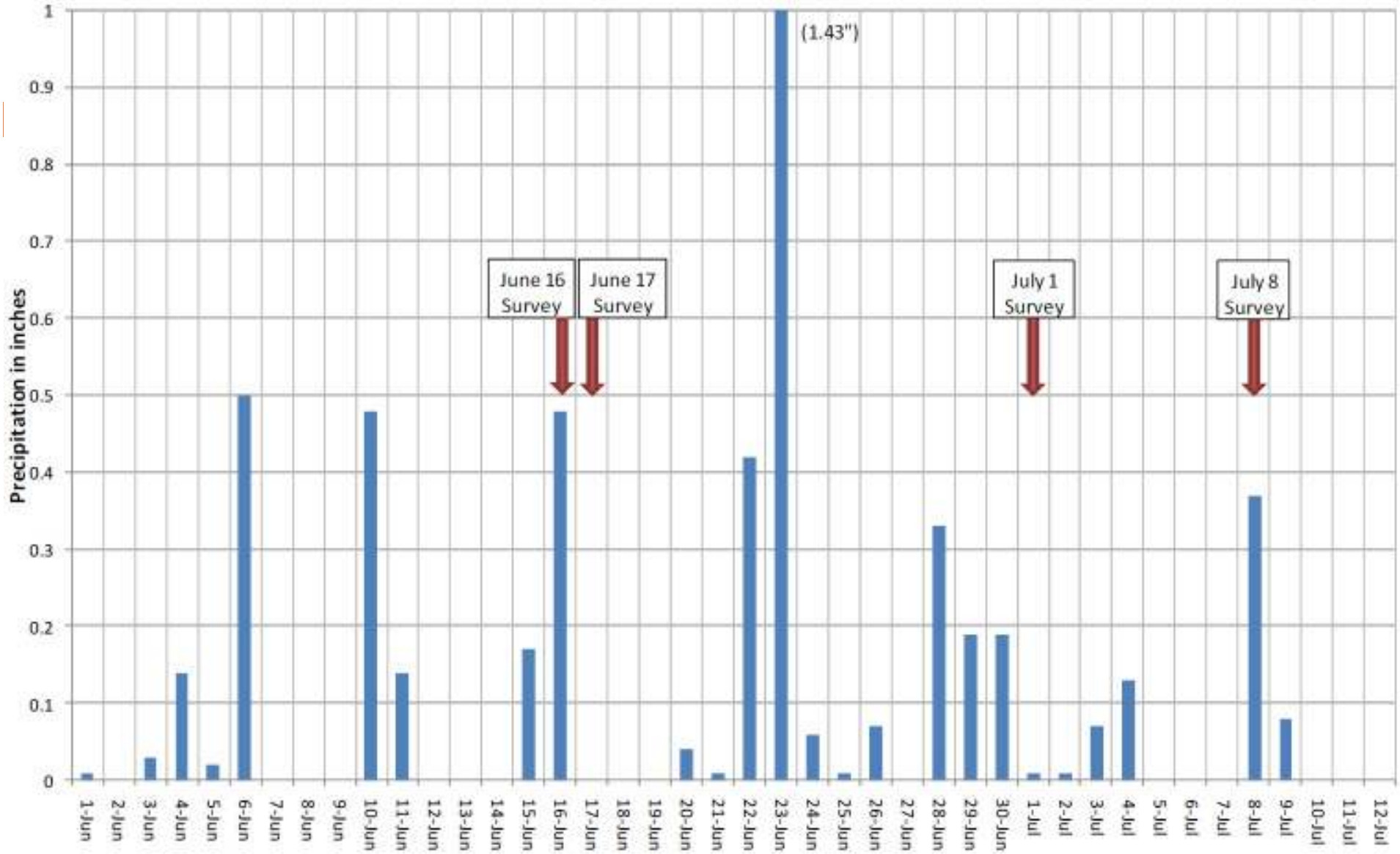
Furnace Brook
Statement of Problem

- Bacteria - Impaired due to excess bacteria
- Sediments - Adversely impacted by excess sediment loading with associated pollutants
- Physical modification – Aquatic habitat of Brook and tributary have been impacted

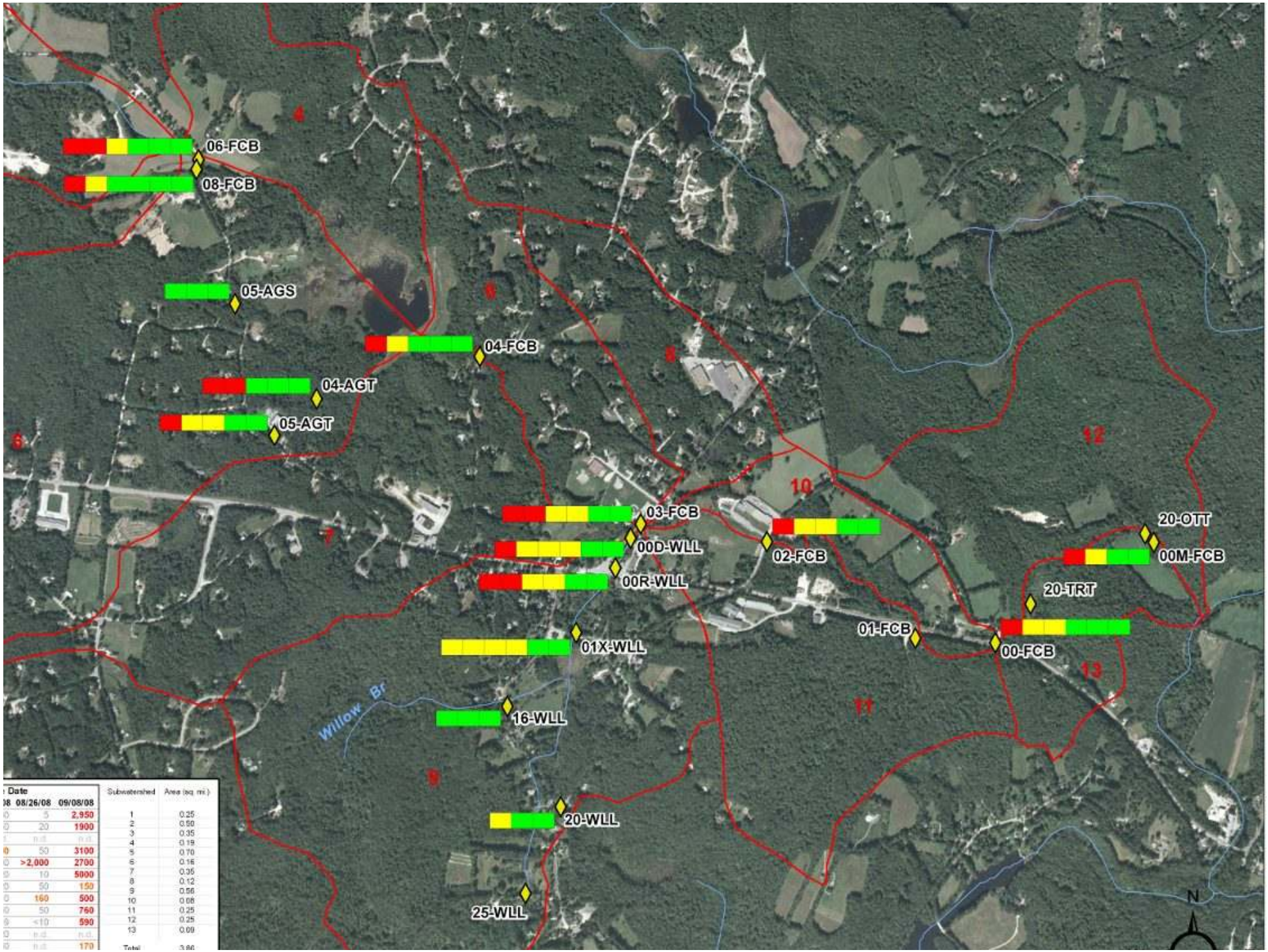
- A watershed based planning challenge: how best to characterize and prioritize the pollutant sources for mitigation.

Temple Rd
Turnpike Rd
124
123

		Escherichia Coli Analysis Results (counts/ 100 ml)						
Sampling		*Date of Sampling Event (2008)*						
Location	*Description*	**June 16**	**June 17**	**July 1**	**July 8**	**Aug 26**	**Sept 8**	**Sept 29**
Furnace Brook Mainstem								
00M-FOB	Trail bridge			140	80	5	2,950	150
00-FOB	Old Tenney	250	190	90	50	20	1,900	120
01-FOB	Currier/Rt 124		130					
02-FOB	Tricnit		220	120	200	50	3,100	240
03-FOB	Temple/fields	260	210	50	100	>2,000	2,700	220
04-FOB	Thayer		360	50	20	10	5,000	200
06-FOB	Appleton N	90	1,300	7,800	20	50	150	40
08-FOB	Appleton S	40	120	50	110	160	500	30
Impoundment Tributaries								
05-AGT	Appleton Apts		1,200	50	50	50	760	200
04-AGT	Behind Apts		700	130	9	<10	590	160
05-AGS	Near Gibbs		30	20	20			
Willow Brook Tributary								
01-WLL								
00D-WLL	Temple swale	340	390	50	60	1,320	170	110
00R-WLL	Rt 124 grocery	260	230	10	20	1,410	795	70
01X-WLL	Academy	340	240	40	70	180	180	60
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**	**Yes**
rainfall in inches prior to samplng:								
24 hrs (>0.1")		**0.17+**	**0.48**	**0.19**	**0**	**0**	**0.97**	**0.12**
48 hrs (>.25")		**0.17+**	**0.65**	**0.38**	**0**	**0**	**4.06**	**0.5**
96 hours (>2.0")		**0.17+**	**0.65**	**0.71**	**0.13**	**0.01**	**4.06**	**1.64**
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								
Maximum for a geometric mean: 126 counts/ 100mL								



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



Date		
08	08/26/08	09/08/08
0	5	2,950
0	20	1900
1	n.d.	n.d.
0	50	3100
0	>2,000	2700
0	10	5000
0	50	150
0	160	500
0	50	760
0	<10	590
0	n.d.	n.d.
0	n.d.	170

Subwatershed	Area (sq. mi.)
1	0.25
2	0.50
3	0.35
4	0.19
5	0.70
6	0.16
7	0.35
8	0.12
9	0.56
10	0.08
11	0.25
12	0.25
13	0.09
Total	3.86

Identifying, Characterizing, and Prioritizing Pollutant Sources for Mitigation

Developed "Top 50" Potential Pollution Sources List:

- Areas with Septic Systems (9)
- Roadway runoff (10)
- Parking lot runoff (9)
- Channel modification (7)
- Wild animals and pets (7)
- Horse farms and agricultural fields (6)
- Illicit Point sources (2)

High Priority Mitigation

Stormwater Runoff BMPs

Site selection for re-direction and infiltration projects

Conceptual designs and cost estimates

Septic System Management

Compilation of locations, ages, etc

Inspections and performance tests

Roadway and Parking Lot Impacts

Roadway and Parking Lot Impacts

- **Coordination** - Coordinate with town road agent and NHDOT and obtain available information including stormdrain maps and road maintenance records
- **Maintenance Program** - Review and potentially improve maintenance activities including storm drain clean outs and street sweeping programs.
- **Design and Implement Stormwater BMPs** – re-direct and infiltrate stormwater flow.

Town Ballfields and Parking Lots

Town Ballfields and Parking Lots

Temple Road Impacts on Willow Brook

A combination of curbing and vegetated buffer is advised for this area. Rip rap and re-armor for the outlet of the culvert is also recommended.

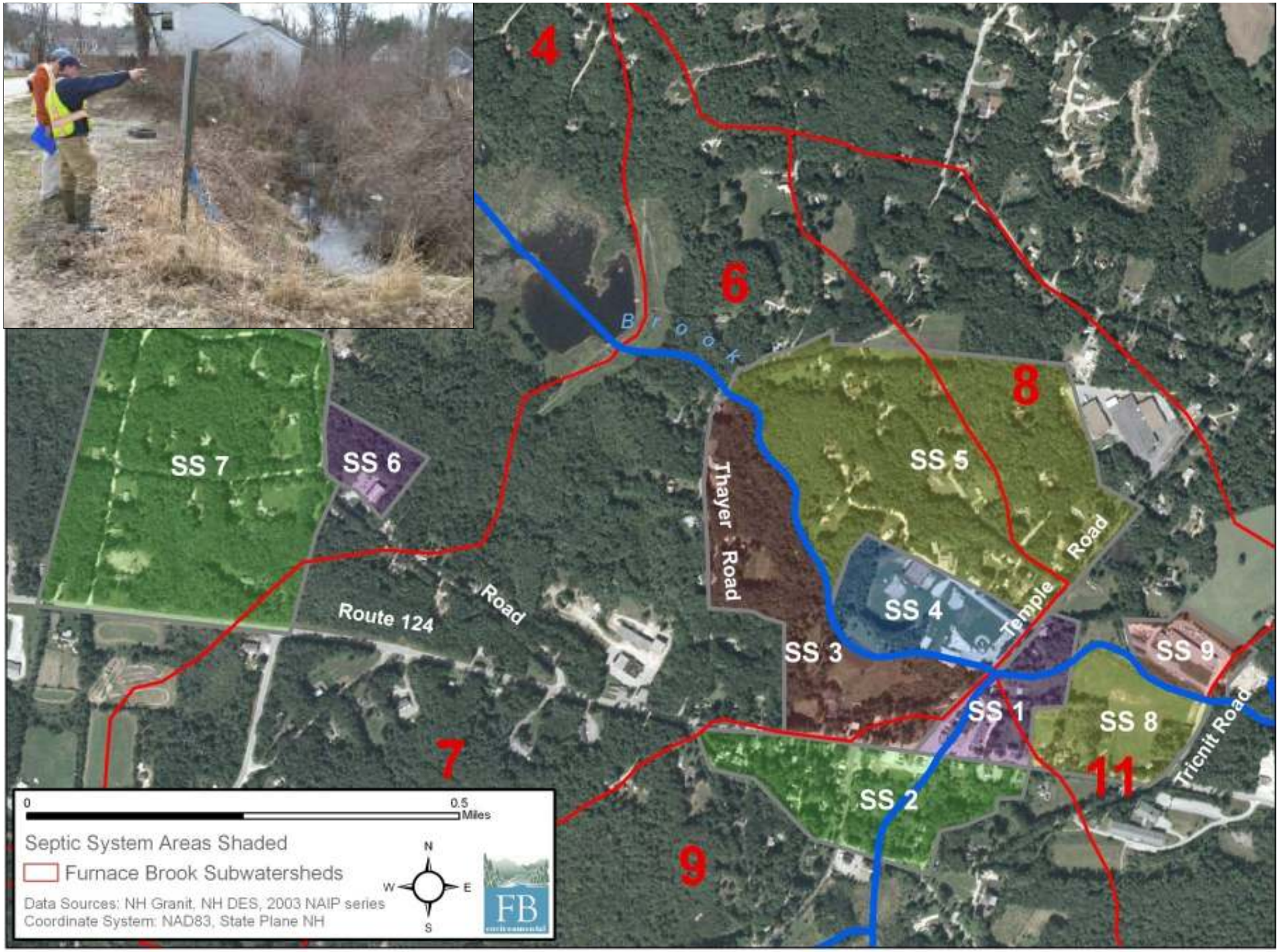
Downtown Impacts on Willow Brook

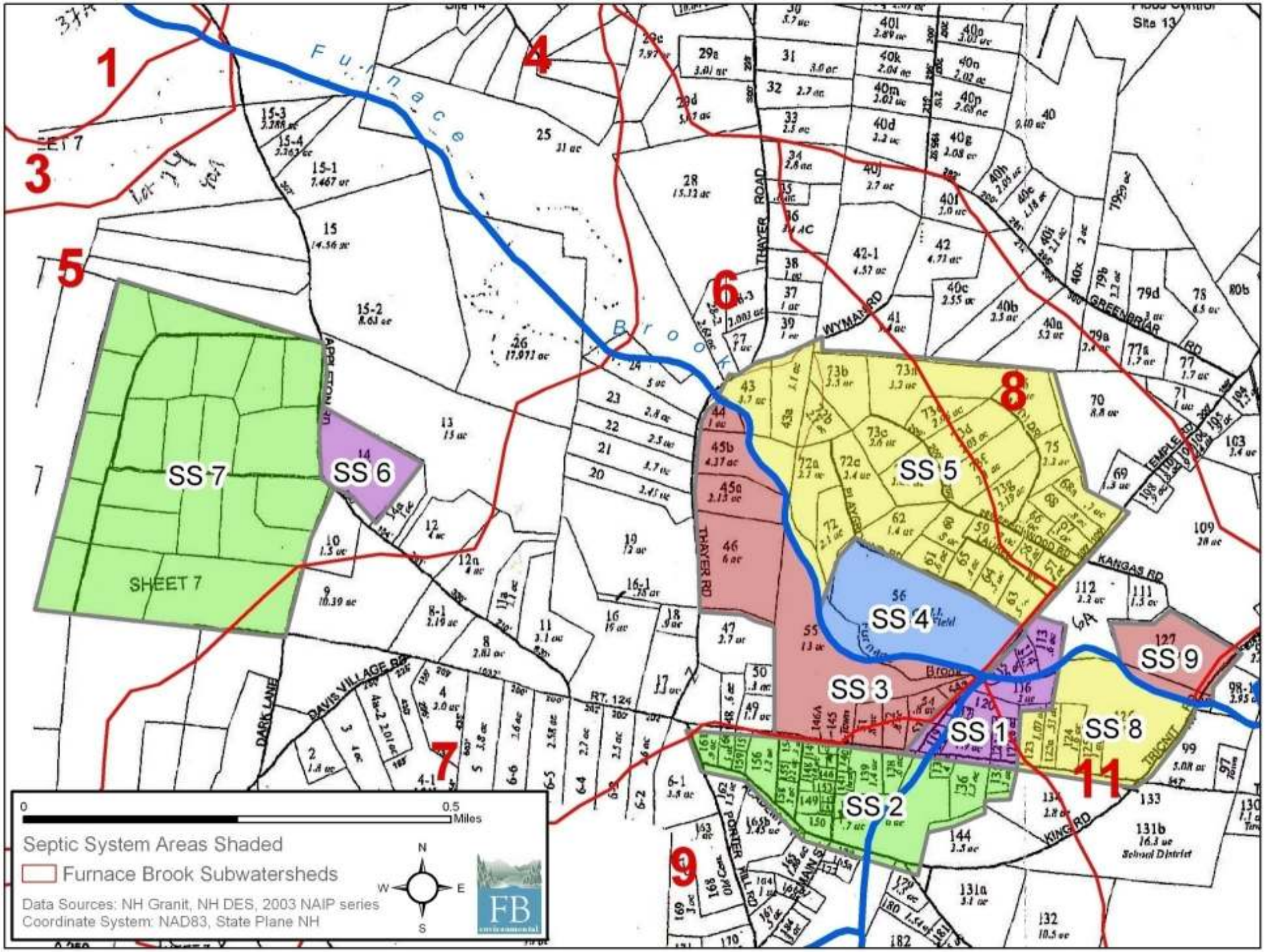
The bare banks of Willow Brook provide no protection against the flow of runoff. Recommend vegetating area with native species.

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

Appleton Road Impacts on Furnace Brook

Re-direct runoff by creating berm of erosion control mulch .


4
6
8
7
9
11
Brook
SS 7
SS 6
SS 5
SS 4
SS 3
SS 2
SS 1
SS 8
SS 9
Thayer Road
Temple Road
Route 124
Road
Tricnit Road
0
0.5
Miles
Septic System Areas Shaded
Furnace Brook Subwatersheds
Data Sources: NH Granit, NH DES, 2003 NAIP series
Coordinate System: NAD83, State Plane NH
N
W
E
S
FB



Friday, February 20, 2009 2:29:20 PM
E:\FTP\FBE_Staff\Common\GIS_Data\FBEnviro\2008_NH_TMDL\NH_GNI_data5_Septic_Propertymap_map.mxd

Septic System Management Plan

1. Coordinate with the town health officer
2. Conduct a homeowner survey
3. Create a database of septic system information (w/GIS-component)
4. Prioritize systems for further investigation
5. Inspection and test systems beginning in highest priority areas.
6. Establish a septic system maintenance ordinance
7. Take enforcement action, as needed
8. Provide support with funding system repair/replace

Nine Elements of Watershed Plan

1. Identification and quantification of causes and sources
2. Estimate of needed load reductions to achieve WQS
3. ID BMP's needed to achieve the load reductions, and ID the critical areas for implementing the BMP's
4. Estimate of needed technical & financial resources

Estimating Bacteria Loads and Reductions

Problem #1: Bacteria loads are difficult to measure in the environment and difficult to predict using a model.

Problem #2: The Watershed Based Planning process requires estimates of pollutant load and reductions needed to meet WQS.

Problem #3: There is a paucity of funding available for WBP in general and bacteria load estimation in particular.

Estimating Bacteria Loads and Reductions

Solution: Review the literature and obtain reasonable estimates of each type of source.

For developed area runoff, using the Center for Watershed Protection's simple method for estimating stormwater runoff pollutant loads.

For failing septic systems, estimate loads based on literature values.

For wildlife, estimate loads based on population estimates and per animal loads.

Developed Area Runoff

For developed area runoff, using the Center for Watershed Protection's simple method for estimating stormwater runoff pollutant loads.

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

where,

Annual Runoff Volume = (Annual Precipitation Volume) x (Runoff Fraction)

Runoff Fraction = 0.05 + (0.9 x %IC)

Note: additional calculation conducted to include percentage of storms (and volume) generating runoff.

Developed Area Runoff Estimation

Event Mean Concentration (EMC) obtained from the literature and applied to represent bacteria concentration

Table B.4: Summary of Pollutant EMCs in Stormwater Runoff

	All Data	Residential	Commercial	Industrial	Freeways	Open Space
# of Storms Sampled	*3,765*	*1,042*	*527*	*566*	*185*	*49*
Median Event Mean Concentrations (mg/L or ppm, except where noted)						
TDS	80	72	72	86	77.5	125
TSS	59	49	43	81	99	48.5
BOD_5	8.6	9.0	11.0	9.0	8.0	5.4
COD	53	54.5	58	58.6	100	42.1
Fecal Coliform[1]	5,091	7,000	4,600	2,400	1,700	7,200
NO2 + NO3	0.60	0.60	0.6	0.69	0.28	0.59
TKN	1.4	1.5	1.5	1.4	2.0	0.74
Total N	2.0	2.1	2.1	2.09	2.28	1.33
Dissolved P	0.13	0.18	0.11	0.10	0.20	0.13
Total P	0.27	0.31	0.22	0.25	0.25	0.31
Dissolved Cu[2]	8.0	7.0	7.57	8.0	10.9	--
Total Cu[2]	16	12	17	20.8	34.7	10
Dissolved Zn[2]	52	31.5	59	112	51	--
Total Zn[2]	116	73	150	199	200	40

Source: Pitt *et al.*, 2004.
[1] MPN/100 mL, which represents the most probable number (MPN) of bacteria that would be found in 100 mL of water
[2] Cu and Zn values are shown in μg/l

Source: Center for Watershed Protection

Estimating Failing Septic System Loads

Failing septic system bacteria load =

= (# of failing systems) x (# people/system) x (bacteria load/person)

<u>Assumptions:</u>

1. 1 structure/parcel and 2 people/structure
2. 5 to 10% of septic systems are failing (Dix and Hoxie 2001)
3. 2×10^9 FC per person per day (US EPA 2001)

Estimating Pollutant Loads

Estimating bacteria loads reductions associated with mitigative actions supports prioritization of sources for removal.

Mitigating one failing septic system yields an estimated bacteria load reduction of $1.5x10^{11}$cts FC/year

Mitigating one acre of developed area runoff yields an estimated bacteria load reduction of $4.2x10^{10}$cts FC/year.

Watershed Based Plans

Table 5-1: 10-Year Watershed Restoration Program Capital Improvement Program Budget									
Option	Capital Cost	Potential Offset Revenues (e)	Source	Number of Sites Addressed in 10-Year Period		Lbs Removed per Year	Lbs Removed Over 10 Years	$/lb	Year
1. Public Education									
1A. Complete Part 2 of Education Program - Stump Pond	$20,000	$20,000	grant						
1B. Develop Web site and Populate with Watershed Resources	$6,000	$6,000	grant						
1C. Door Hangar and other Public Education Recommended from 1A	$12,000	$12,000	grant						
1D. Develop School Education Program Through Teachers	$15,000								
1E. Coordinate with Phase II Coalition/NRPC	$10,000								
1F. Garden Club Coordination	$15,000								
Total	$78,000	$38,000				285	2,846	$27	1 - 10
2. Increased Maintenance in Commercial Areas									
2A. Evaluate issues and on going costs to sweep and vac	$10,000								
2B. Purchase Street Sweeper for Prioritized Operations 2-6X/year	$200,000	$120,000	grants	2,378	acres	96	959		1 - 10
2C. Purchase Vac Truck for Prioritized Cleanouts Private Areas	$120,000	$72,000	grants			280	2,798		1 - 10
Total	$330,000	$192,000				376	3,757	$88	1 - 10
3. Retrofit Detention Basins									
3A. Evaluate Existing BMPs, Prioritize Top 10	$10,000								1
3B. Design BMPs for 10 Sites (a)	$195,000								2
3C. Construct Detention Basin Retrofits	$650,000	$200,000	grants	10	BMPs				3-5
Total	$855,000	$200,000				50	501	$1,706	

Stakeholder Participation

- Town Board of Selectmen
- Town Con Com
- Watershed Association
- Road Agent
- Board of Health Officer
- Various State Agencies

Thank you

Questions?

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