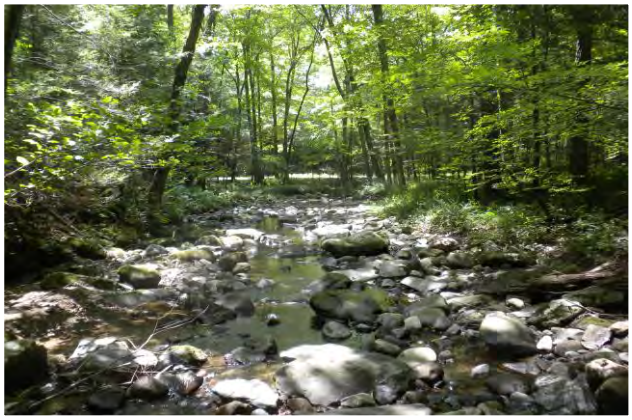

Program Report:

BATTLESWAMP BROOK STREAMWALK

Washington & Roxbury, CT
Summer/Fall 2011

Prepared by
the Housatonic Valley Association
on behalf of
the River Health Monitoring Committee
of the Shepaug River Association

Report Date:
April 1, 2012

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Acknowledgements

Several individuals and organizations contributed to the successful development and implementation of the 2011 Battleswamp Brook Streamwalk program.

A core group of individuals representing the Housatonic Valley Association, the Roxbury Conservation Commission and the Washington Environmental Council, were critical to the development and implementation of the 2011 Battleswamp Brook Streamwalk Program's overall. HVA gratefully acknowledges the contributions of the following individuals, without whom this program would not have been possible: Hugh Rawson, Dan Sherr, Gary Steinman, and Trudy Swenson-McKinna. These individuals also served as the core group of volunteers who carried out the segment surveys described in this report. Additional survey field support was provided by volunteer extraordinaire, Horst Antosch, and HVA's fantastic *River Stewards of Tomorrow* summer interns, Erin Brinton and Carrie Dillaway. Thank you all for your enthusiasm and your bravery in the field!

Todd Bobbowick and Seth Lerman of the USDA Natural Resources Conservation Service (NRCS) provided outstanding program technical support and volunteer training. Streamwalks were conducted according to NRCS protocol using field data sheets and survey materials provided by NRCS.

Program field survey maps were prepared by the fabulous Sam Dziekan, HVA GIS Manager, using map templates and data provided by NRCS.

Meeting space for program development meetings and the summer 2011 volunteer training was generously provided by the Town of Roxbury, a consistent supporter of monitoring efforts along the Shepaug.

Finally, funding for the 2011 Battleswamp Brook Streamwalk program was generously provided by the Connecticut Community Foundation and HVA member contributions. This program would not have been possible without your support.

Thank you!

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Executive Summary

The Battleswamp Brook (CT DEEP basin 6700-25) is a small tributary of the Shepaug River, which straddles the Washington-Roxbury town border in Connecticut. The 2011 Battleswamp Brook Streamwalk Program was a pilot project to test the feasibility of utilizing the USDA Connecticut USDA Natural Resources Conservation Service (NRCS) Streamwalk methodology to assess the health of the Shepaug River's tributary streams, thereby expanding the spatial coverage of the existing Shepaug River health monitoring program.

A streamwalk is a volunteer based assessment of the physical conditions of in-stream and streamside characteristics of the perennial (flow all year) streams in a river basin. It serves two purposes: resource evaluation through data collection and community involvement and education. If successful in the Battleswamp Brook basin, the program would later be expanded to a larger geographic scope within the Shepaug River watershed.

Specific objectives of the 2011 Streamwalk Program included:

1. Collect scientific data about the environmental nature and health of Battleswamp Brook, a little studied tributary of the Shepaug River.
2. Train a core group of volunteers, including SRA River Health Monitoring Committee members, in the USDA NRCS Streamwalk Initiative methodology.
3. Assess the ease of implementation and utility of using the USDA NRCS Streamwalk methodology on a small Shepaug River tributary.

The 2012 Battleswamp Brook Streamwalk Program included five survey areas consisting of a combined total of fifteen reaches. Volunteer teams successfully surveyed and submitted data for four of the survey areas (A, C, D, and E) between August 4, 2011 and August 24, 2011. A total of 50 potential areas of concern (AOC) were reported by the volunteer teams. The most AOCs were reported in the tributary to the brook, and the brook's headwaters. The most common AOCs reported included dams or other barriers to fish passage and unusual water conditions. Erosion, stormwater outfalls and other pipes, buffer degradation, significant trash or debris accumulation, and modified channel segments were also reported.

Recommended action steps include:

- Obtain land owner permission to remove and properly dispose of the debris observed in Reach A.
- Review erosion AOCs with a qualified natural resource expert (e.g., NRCS, Northwest Conservation District, CT DEEP) to determine if restoration efforts are needed.
- Increase awareness among streamside landowners of the importance of riparian buffers in protecting stream health and mitigating flood impacts. Work with interested land owners to implement buffer restoration projects.
- Review winter road treatment practices in the two basin towns to identify potential opportunities to minimize adverse stream health impacts due to the application of road salt, sand, and/or chemical deicers.

- Explore ownership and current use of the pond observed in Reach C-1. If the landowner is willing, explore modifications to the outflow system to improve downstream water quality conditions and flow patterns.
- Determine ownership and use of an unidentified black pipe identified in survey area D.
- Monitor the debris dam observed in Reach A-4; if the dam becomes a flooding or safety hazard, consult with the land owner and CT DEEP to modify or remove the dam.
- Restore natural in-stream flow patterns (and habitat continuity) by removing or modifying the stone dams/rock walls observed in Reach A6, Reach D1, and Reach E1. Ensure that removal or modification does not lead to excessive downstream sediment transport.
- Work with local inland wetland commissions and landowners to better accommodate aquatic organisms passage during driveway culvert replacement projects.
- Work with the Town of Roxbury Public Works Department and Connecticut Department of Transportation to ensure that future town and state culvert replacement projects better protect stream health.
- Revisit observed algal AOCs, if possible. Explore opportunities to limit nutrient runoff within these reaches.
- Review permitted diversions, if any, in the Battleswamp Brook basin. If applicable, work with permitted land owners to explore strategies to minimize stream impacts due to diversions during naturally low flow periods. Identify other potential causes of low flow conditions (both natural and anthropogenic).

Introduction & Program Background

The Housatonic Valley Association (HVA) has successfully conducted community-based streamwalk assessments (also referred to as 'Stream Team' assessments) throughout the Housatonic River watershed for over a decade. To-date, however, an assessment has not been completed for the Shepaug River watershed. Therefore, in the summer of 2010, HVA approached the Roxbury Conservation Commission (RCC) and the Washington Environmental Council (WEC), fellow member organizations of the Shepaug River Association (SRA), to gauge their interest in working with HVA to implement a pilot streamwalk program in the Shepaug River watershed. In addition, whereas the previous HVA stream team assessments focused primarily on citizen engagement and identification of impairments in the watershed, HVA sought to explore opportunities to shift the organization's existing Stream Team program towards a more scientifically rigorous methodology which could be used to identify not only existing impairments, but also to monitor more subtle shifts in the health of the Housatonic River tributaries over time.

A pilot streamwalk program was subsequently developed and implemented during the summer and fall of 2011, through a collaborative effort between HVA, RCC, and WEC on behalf of the River Health Monitoring Committee of the Shepaug River Association. Program funding was provided by the Connecticut Community Foundation. Technical support for the Battleswamp Brook Streamwalk program was provided by USDA Natural Resources Conservation Staff (NRCS) staff.

The 2011 Battleswamp Brook Streamwalk program was implemented to assess the feasibility of utilizing the Connecticut USDA Natural Resources Conservation Service (NRCS) Streamwalk methodology to assess the health of Shepaug River tributaries. (The Battleswamp Brook was chosen as an ideal basin to implement a pilot project due to its relatively small size and location within both Washington and Roxbury, CT.) If successful, the program would later be expanded to a larger geographic scope within the Shepaug River watershed.

The USDA NRCS Streamwalk Initiative was first implemented in the Norwalk River watershed. Since that time, NRCS has worked with community groups to implement Streamwalk programs in additional watersheds including the Farmington River, the Thames River, and the Pomperaug River watersheds. The Streamwalk program has two main foci: community participation/awareness and scientific data collection. NRCS staff have designed the program to allow volunteer groups to document the physical condition of the stream corridor using a 'first cut' approach to data collection. Volunteers are not expected to have any previous experience or a technical background. NRCS staff work with a host organization (typically a river or watershed group) to train interested volunteers to conduct a 'streamwalk.' Volunteer teams then go into the field and literally walk along the length of an assigned stream segment, working together to document key aspects of overall stream environmental condition and to identify potential signs of impairment. Through their involvement in the program, volunteers not only collect valuable data about local environmental and water resource conditions, but they also learn how natural and anthropogenic (human caused) elements affect stream environments. Through participation in the Streamwalk program, volunteers increase their awareness and understanding of potential impairments to the health of our rivers. This public education is a critical first step in addressing and, ultimately,

correcting water resource issues. Additional information about the USDA NRCS Streamwalk Initiative can be found online: www.ct.nrcs.usda.gov/programs/communities/streamwalk_initiative.html

Program Objectives

Several monitoring programs are currently underway along the main stem of the Shepaug River, including biannual macroinvertebrate-based bioassessments and thermal and chemical monitoring. The 2011 Battleswamp Brook Streamwalk Program was a pilot project to test the feasibility of utilizing the USDA NRCS Streamwalk methodology to assess the health of the Shepaug River's tributary streams, thereby expanding the spatial coverage of the existing monitoring program. It was believed that the surveys conducted by Streamwalk program volunteers could potentially not only serve as baseline data for comparison during future environmental health assessments, but could be utilized by the SRA River Health Monitoring Committee member organizations to identify specific stream reaches in need of restoration or enhanced protection, and/or to better identify priority topic areas around which to develop public outreach and education programs and materials.

Specific objectives of the 2011 Battleswamp Brook Streamwalk Program included:

4. Collect scientific data about the environmental nature and health of Battleswamp Brook, a little studied tributary of the Shepaug River. Create a baseline assessment of the brook through recorded notes and photographic documentation of channel morphology and substrate composition, general water conditions (e.g. color and clarity), in-stream aquatic vegetation growth, riparian buffer conditions, and the presence of trash or other sources of pollution.

5. Train a core group of volunteers, including SRA River Health Monitoring Committee members, in the USDA NRCS Streamwalk Initiative methodology. These volunteers could serve as team leaders for future streamwalk/Stream Team programs implemented within the Shepaug River watershed, as well as serve as a pool of likely volunteers for other monitoring programs occurring within the watershed.

6. Assess the ease of implementation and utility of using the USDA NRCS Streamwalk methodology on a small Shepaug River tributary. Determine the suitability of expanding the pilot program to a larger geographic scale within the Shepaug River and Housatonic River watersheds. Identify specific potential benefits of expanding the program as well potential challenges to implementing a larger program.

Program Study Area

The Battleswamp Brook (CT DEEP basin 6700-25) is a small tributary of the Shepaug River, which straddles the Washington-Roxbury town border in Connecticut. The brook's headwaters begin in Washington and flow south into Roxbury, where the brook then turns and flows southwest towards the Shepaug River. The confluence of the brook and the river is located approximately 2.5 miles downstream of the Shepaug River's 'clam shell' bend (Figure 1).

Battleswamp Brook is approximately 3 miles long. Roughly trident-shaped, two smaller unnamed streams, each less than one-mile long in length, converge with the brook's main stem approximately 0.5-mile upstream from the confluence with the Shepaug River. Like the larger Shepaug River watershed, the

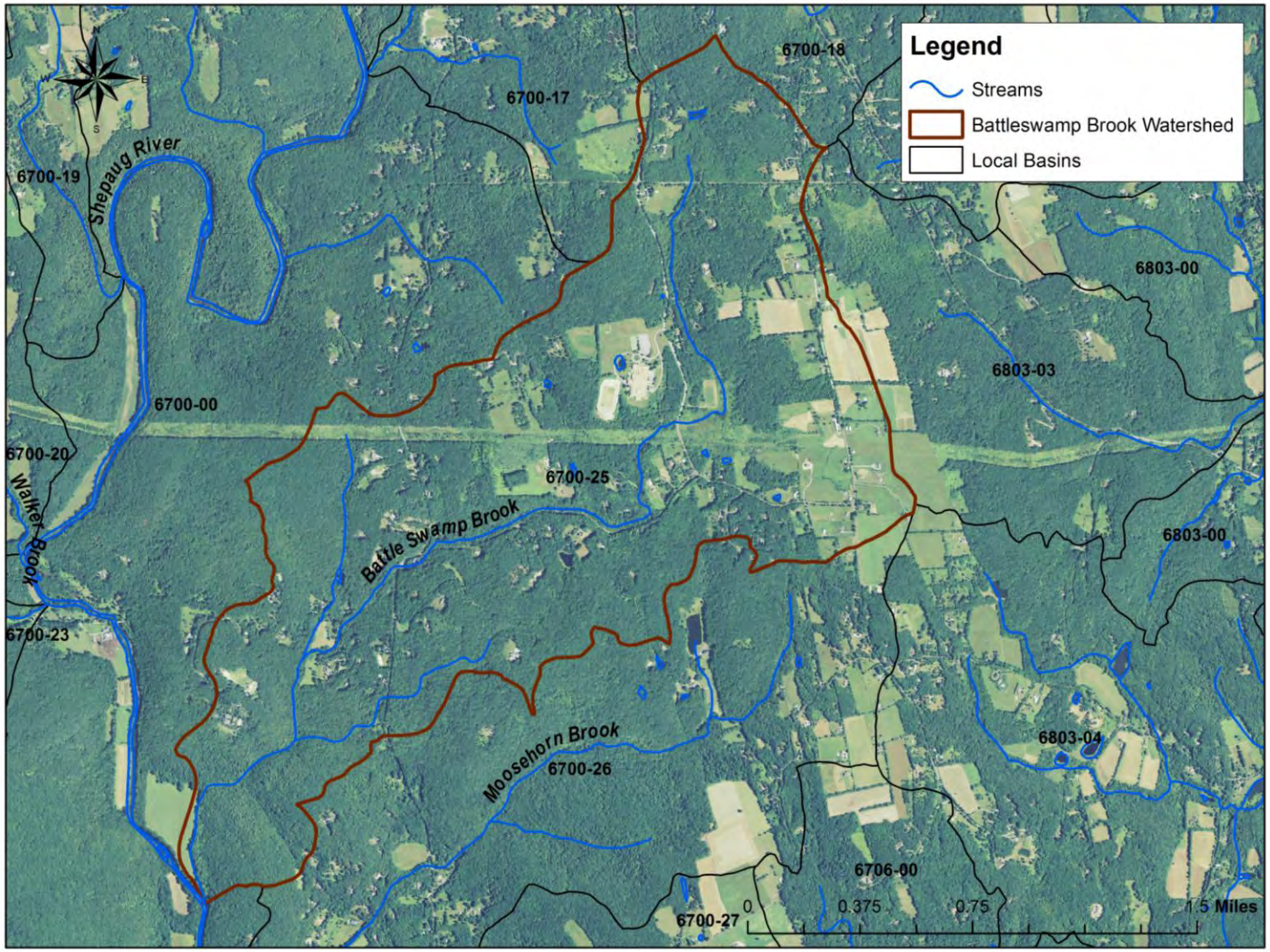


Figure 1. An aerial view of the Battleswamp Brook, a tributary of the Shepaug River. The basin boundary is depicted in brown; streams and rivers are highlighted in blue. (*Map produced by HVA.*)

Battleswamp Brook basin is largely undeveloped. The lower half of the basin is characterized by forested land, including several acres of protected land. The upper half of the basin is characterized by a mix of forest and low-density residential parcels, as well a local high school. A two-lane town road, Davenport Road, follows the stream along the middle third of its length.

Survey areas were delineated by NRCS based upon stream order and Rosgen stream type information (Figure 2). Five segments in total were delineated. The main stem of the brook was divided into three segments (A-C). The two unnamed tributaries were also identified as individual survey areas (D and E).

As depicted in Figure 1, the brook's geomorphology is described by a mixture of Rosgen Level I A, B, and C Type stream segments. Type A segments are 'mountain streams' typically characterized by steep slopes, entrenchment and confined channels. Type B segments are slightly less steep and less entrenched than Type A streams. As opposed to the 'mountain stream' nature of Type A segments, Type B segments are more easily thought of as 'babbling brooks.' Type C segments, described as 'meandering streams,' have even lower gradients than both Type A and Type B segments, and typically possess a well-developed floodplain (Ward et al. 2008).

Streamwalk Methodology

The 2011 Battleswamp Brook Streamwalk Program followed the Streamwalk Initiative protocols outlined by the Connecticut USDA-Natural Resources Conservation Service (Bobowick & Lerman 2005). A streamwalk is a volunteer based assessment of the physical conditions of in-stream and streamside characteristics of the perennial (flow all year) streams in a river basin. It serves two purposes: resource evaluation through data collection and community involvement and education.

Survey Area Delineation

HVA's GIS Manager worked with NRCS staff to divide the Battleswamp Brook basin into distinct survey areas. Survey areas were delineated based upon the river's geomorphology and stream order. Access was considered when delineating survey areas; areas were typically delineated to ensure end and start points corresponded with a road crossing or public property. Survey areas were also delineated to ensure that all survey areas were less than 3-miles in length. Based upon these criteria, the Battleswamp Brook basin was divided into the five survey areas shown in Figure 2.

Emergency Service & Landowner Notification

Local emergency services were notified via mail that volunteers would be walking within stream reaches of the Battleswamp Brook basin between June 12 and August 31to assess stream conditions. The notification was intended to assist with minimizing any land owner conflicts and expediting response to any emergencies that might arise.

Using the most recent available tax maps and parcel data, HVA staff identified property owners along Battleswamp Brook and its two unnamed tributaries. Land owners were contacted directly via phone by program partners (i.e. HVA, RCC or WEC representatives) when possible. A letter was sent to the mailing address on record of each land owner. The letter outlined the streamwalk program's objectives

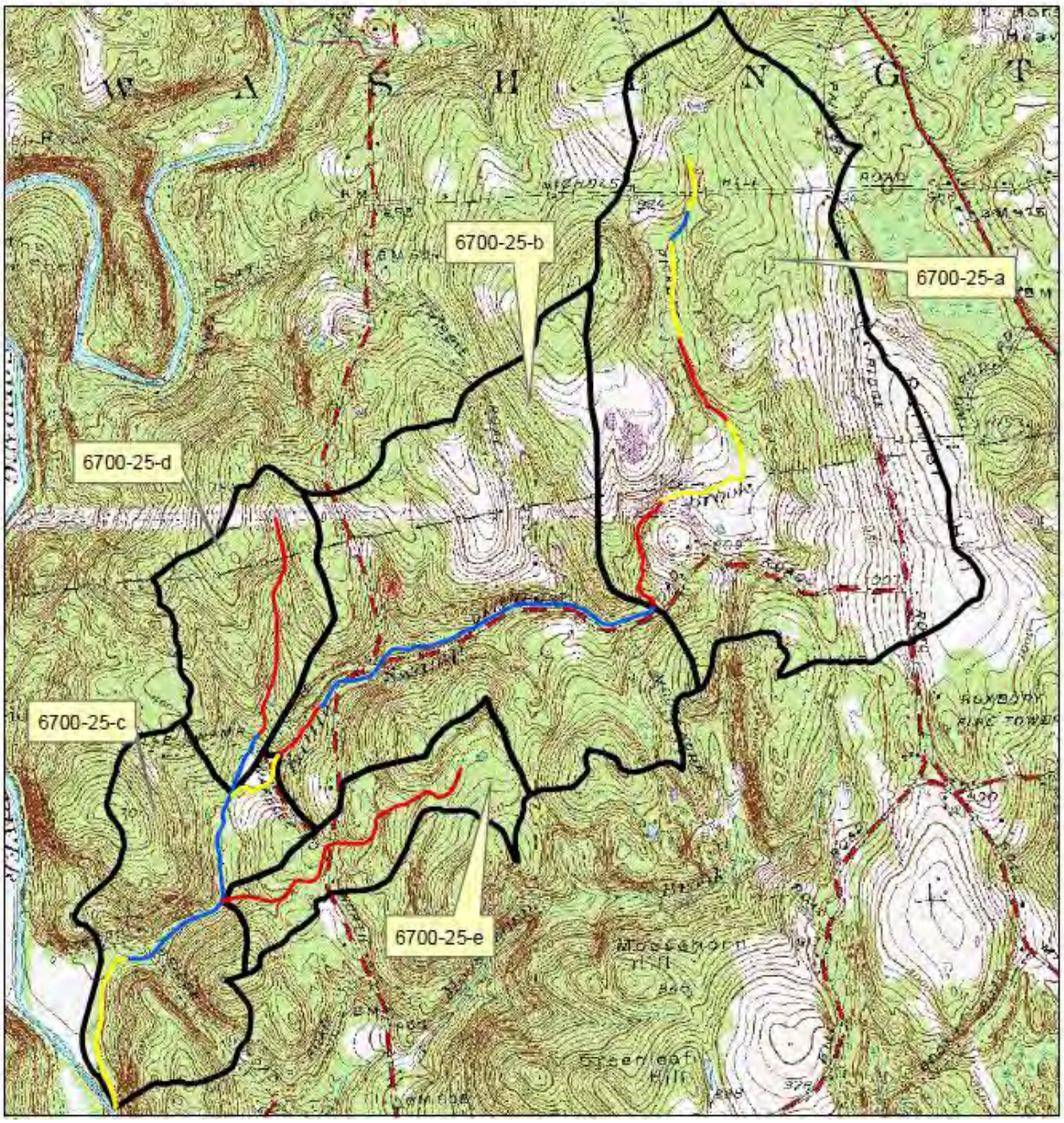


Figure 2. Battleswamp Brook Streamwalk Program survey area boundaries are outlined in black. Stream segments are colored according to Rosgen Type: A (red), B (blue), or C (yellow). (*Map produced by HVA; basin and survey area data courtesy NRCS.*)

and notified the land owner that a volunteer team might be observed walking within the stream corridor on or adjacent to the landowner's property between June 12 and August 31. The letter also provided land owners with contact information for the streamwalk program coordinator (HVA Water Protection Manager) in the event that the land owner did not want the volunteer team to enter the stream on or adjacent to their property. Any land owner that contacted HVA requesting to be excluded from the program was documented and volunteers were instructed not to survey that portion of their survey area.

Volunteer Recruitment & Training

Volunteers were recruited from within the Shepaug River watershed by HVA and program partners, Roxbury Conservation Commission and the Washington Environmental Council. On Saturday, June 11, 2011, volunteers attended a half day training session at Roxbury Town Hall. Volunteers were not expected to have any prior experience or knowledge of stream systems.

The training was intended to help increase volunteers' awareness and understanding of potential concerns to the health of a river and give them a chance to ask questions about the work that was expected of them. During the first half of the training, NRCS staff provided volunteers with an introduction to the program and a general overview of field survey protocol and corresponding data sheets. Volunteers received a basic course in stream ecology, morphology, water quality, non-point source pollution, and the relationship between a community and its river.

The volunteers then travelled to a nearby field location along the Battleswamp Brook, where they conducted a mock streamwalk under the guidance of NRCS staff. At the conclusion of the training, volunteers self-selected into teams of three, and selected a survey area to walk. Volunteer teams were instructed to conduct their streamwalk and submit the related data sheets and photographs to the HVA Water Protection Manager by August 31, 2011.

Figure 3. NRCS Staff Todd Bobowick and Seth Lerman (front row, left to right) demonstrate proper field protocol for determining substrate composition during the June 11, 2011 streamwalk training. (*HVA Photo*)

Streamwalk Protocol

Volunteer teams conducted streamwalk surveys during the summer months. During this period water flows tend to be low and relatively slow, water temperatures tend to be warmer, and aquatic plant growth tends to be abundant. The combination of these factors makes it easier to observe potential water quality concerns, stream morphology, stream substrate (streambed), and vegetation. Low flows during this time also provide safer conditions for the streamwalk volunteers.

Volunteer teams followed the protocols demonstrated by NRCS staff during the June 11 training and outlined in the May 2005 CT USDA-NRCS Streamwalk Guide (Bobowick & Lerman 2005). Prior to the survey NRCS staff used desktop GIS analysis methods to estimate the expected geomorphology of the stream within each survey area; stream segments with different geomorphology were considered distinct 'reaches.' Teams were provided with maps outlining their survey area as well as expected 'reach' locations (Figure 3).

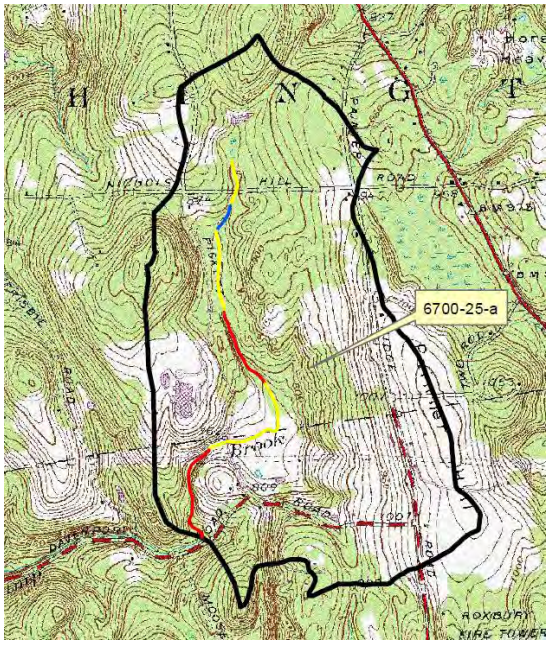


Figure 3. Streamwalk teams were provided with waterproof topographic maps which outlined their survey area (black outline) and corresponding stream reaches (colored line segments).

Volunteers were instructed to complete their surveys starting from the most upstream point of their survey area and heading downstream towards the terminus. Volunteers walked the stream until they observed a distinct change in the physical characteristics of the stream (e.g. a consistent change slope, width, depth, substrate material, streamside vegetation, etc.), which indicated that they had entered a new 'reach' of the stream. At this point, teams completed a *Reach Level Assessment* data sheet, recording information about average conditions within the reach just completed. Information documented included average channel morphology, substrate composition, water conditions, presence of aquatic plants and algae, canopy cover, riparian vegetation and land use. Copies of the field data sheets are provided in Appendix A. To avoid confusion, volunteers were instructed to record 'right' and 'left' observations in reference to the stream channel *facing downstream.*

In addition to the Reach Level Assessment data sheet, volunteers documented any *Areas of Concern (AOC)* observed while walking the reach. AOCs were sections of the stream where the observed physical conditions indicated that a problem may exist for aquatic life and/or human uses. Potential AOCs included evidence of significant erosion, barriers to fish passage (e.g. impoundments, certain culverts), storm water outfalls, modified channel sections, degraded or cleared buffers, significant accumulation of trash and/or debris, or unusual water conditions (e.g., unusual colors, odors, excessive algae). For each AOC observed, a corresponding AOC datasheet (Appendix A) was completed, photographic documentation was taken, and the approximate location of the AOC was noted on the survey area map. (GPS coordinates were also recorded when possible.)

Volunteers continued this process of walking downstream, recording average conditions for each reach and any observed AOCs within the reach, until the team had surveyed all reaches within their survey area. (The number of reaches in a particular survey area ranged from one to six.) At the conclusion of the survey, the team returned their completed data sheets, corresponding photographs, and all streamwalk equipment to the program coordinator.

Results

Overview of Streamwalk Results

The 2012 Battleswamp Brook Streamwalk Program included five survey areas consisting of a combined total of fifteen reaches. Volunteer teams successfully surveyed and submitted data for four of the survey areas (A, C, D, and E) between August 4, 2011 and August 24, 2011. An overview of the volunteer teams' observations are shown in Table 2. The team that volunteered to survey Area B did not submit corresponding data sheets and attempts made by the coordinator to follow-up with the team were unsuccessful. Data for Survey Area B are therefore not included in this report.

Surveyed reaches were typically characterized by either predominantly pool-riffle or step-pool morphological features. Average sediment composition varied considerably among reports, ranging from silt/clay dominated to boulder/bedrock dominated stream beds. The most prevalent sediment type reported was cobble. Water conditions were described as either 'clear' or 'tea stained' with infrequent patches of rusty redness, foam, and dried streambed noted. Aquatic plants were reported in only one of the survey areas. Algae were reported 'in spots' in one third of all reaches assessed. Canopy cover typically exceeded 75%; however, three reaches were characterized by less dense cover (50-75% to 25-50%). A range of riparian vegetation was observed, with trees and shrubs reported most frequently. Adjacent land use was most commonly forested; however several reaches were also characterized by nearby rural residential lands, and, in one reach, by agricultural land.

A total of 50 potential areas of concern (AOC) were reported by the volunteer teams. All seven potential AOC types were reported within the Battleswamp Brook study basin. The most common AOCs reported included dams or other barriers to fish passage (17), and unusual water conditions (14). Erosion (7), stormwater outfalls and other pipes (4), buffer degradation (4), significant trash or debris accumulation (3), and modified channel segments (1) were also reported. The most AOCs (14) were reported in Survey Area D, an unnamed tributary to the north of the Battleswamp. Thirteen (13) AOCs were observed in Survey Area A, the headwaters of the brook, and the longest of the survey areas assessed. Survey Area B,

as noted above, was not assessed. Thirteen (13) AOCs were reported in Survey Areas E, a second unnamed tributary, and ten (10) were reported in Survey Area C, the mouth of the brook.

Volunteer observations reported during the 2011 Battleswamp Brook Streamwalk Program are summarized in Table 2. It should be noted that AOC types are not mutually exclusive categories; a given impairment could be categorized as one or more AOC type. For example, a barrier to fish passage such as an improperly sized culvert or dam may change stream hydrology leading to unusual water conditions and/or debris accumulation. Similarly, reported areas of significant streamside erosion are also likely points of buffer degradation. Volunteers were asked to use their judgment to categorize the impairments observed within the available AOC types.

Table 2. 2011 Battleswamp Brook Streamwalk Program Volunteer Observations

			Observed Stream Conditions								Evidence of Impairment							
Reach Code	Stream Type	Survey Date	Morphology	Dominant Substrate	Average Water Conditions	Aquatic Plants	Algae	Average Canopy Cover	Dominant Riparian Veg.	Land Use	Erosion	Dams/Fish Barriers	Outfalls/Pipes	Modified Channel	Degraded Buffer	Trash /Debris	Unusual Water Conditions	TOTAL #
A1	C	08/08/11	*Not suitable for assessment; predominantly swamp land with no visible stream channel*															*NA*
A2	B	08/08/11	*Not suitable for assessment; predominantly swamp land with no visible stream channel*															*NA*
A3	C	08/08/11	*Not suitable for assessment; predominantly swamp land with no visible stream channel*															*NA*
A4	A	08/08/11	Pool-Riffle	Sand/ Gravel	Clear/Tea Stained	None	None	>75%	Grass/ Shrubs	Rural Residential	1	3	-	-	-	1	1	6
A5	C	08/08/11	*Not suitable for assessment; black bear present in study reach at the time of survey.*															*NA*
A6	A	08/08/11	Pool-Riffle	Cobble	Tea Stained	None	None	>75%	Shrubs	Rural Residential/ Forest	3	2	1	-	-	-	1	7
B1	B	--	*Not Surveyed*															*NA*
B2	A	--	*Not Surveyed*															*NA*
C1	C	08/05/11	Pool-Riffle	Gravel/ Cobble/ Boulder/ Bedrock	Clear	None	Some	50-75%	Trees/ Grasses	Rural Residential/ Forest	-	-	1	-	1	-	1	3
C2	B	08/05/11	Step-Pool	Bedrock/ Boulder	Clear	None	None	>75%	Trees	Forest	-	-	-	-	-	1	-	1
C3	C	08/05/11	**	Cobble	Clear; Dry Sections	None	None	>75%	Trees	Agric./ Forest	2	-	-	-	2	-	2	6
D1	A	08/24/11	Pool-Riffle	Silt/Sand/Cobble	Tea-Stained; Dry Sections	None	Some	25-50%	Ferns/Trees	Forest/ Rural Residential	-	6	1	-	-	-	2	9
D2	B	08/24/11	Pool-Riffle	Silt/Sand/Cobble	Tea-Stained	None	Some	50-75%	Ferns/Trees	Rural Residential	-	1	-	1	1	-	2	5
E1	A	08/04/11	Step-Pool	Boulder/Cobble	Clear	None	None	>75%	Grass/Shrubs/ Trees	Forest	-	5	1	-	-	-	2	8
E2	A	08/04/11	Step-Pool	Cobble	Tea Stained	None	None	>75%	Trees	Forest	1	-	-	-	-	1	3	5
										Program Totals:	***7***	***17***	***4***	***1***	***4***	***3***	***14***	***50***

Survey Area A

Survey Area A (Figure 4), which includes the headwaters and northern most reaches of the Battleswamp Brook main stem, was surveyed on August 8, 2011 by Carrie Dillaway and Erin Brinton, HVA summer interns. The survey area included six reaches A-1 through A-6, labeled in numerical order from north to south.

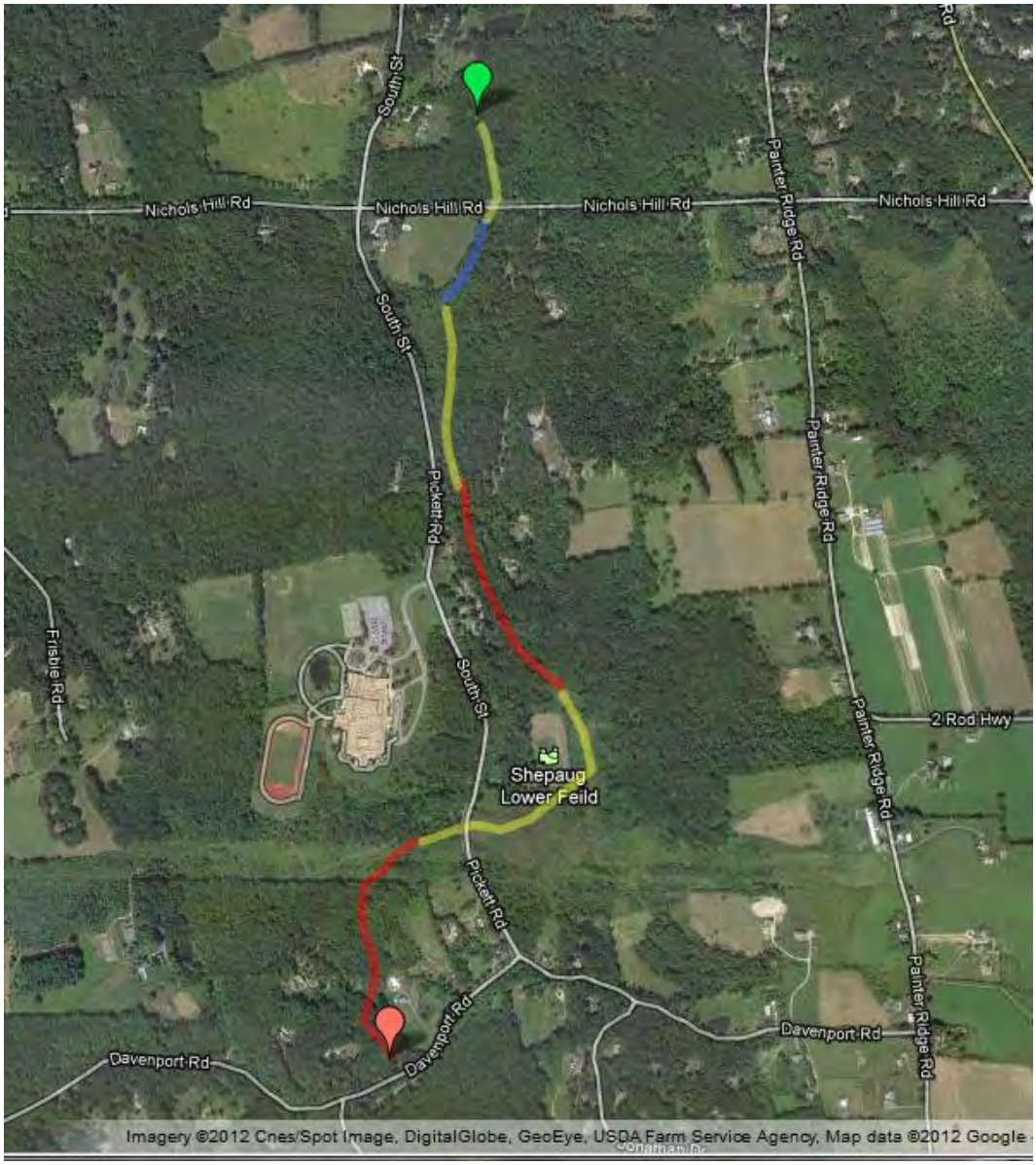


Figure 4. Aerial view of Survey Area A. Streamwalk start and end points are located at the green and red place marks, respectively. Individual reach segments A-1 (northernmost) through A-6 (southernmost) are shown as colored line segments. (*Aerial photo courtesy of Google Maps.*)

Survey Reach A-1

Start Location: 41.61245,-73.302993
End Location: 41.610469,-73.303063

Survey Reach A-1 was classified by NRCS staff as a Rosgen Level I Type C stream (yellow on map). This reach is the northernmost reach of the Battleswamp Brook main stem. The reach begins slightly west of the Nichols Hill Road and Pickett Road (South Street) intersection in Washington, CT.

During the streamwalk, the volunteer team determined that this area was not suitable for assessment using the NRCS protocols. The volunteer team was unable to locate a defined stream corridor and the reach was dominated by swamp land.

Survey Reach A-2

Start Location: 41.610469,-73.303063
End Location: 41.609186,-73.30405

Survey Reach A-2 was classified by NRCS staff as a Rosgen Level I Type B stream (blue on map). This is second northernmost reach of the headwaters of the Battleswamp Brook main stem. The reach began immediately south of Nichols Hill Road stream crossing in Washington, CT.

Similar to Reach A-1, the volunteer team determined that this area was not suitable for assessment using the NRCS protocols. The volunteer team was unable to locate a defined stream corridor and the reach was dominated by swamp land.

Survey Reach A-3

Start Location: 41.609186,-73.30405
End Location: 41.603955,-73.302977

Survey Reach A-3 was classified by NRCS staff as a Rosgen Level I Type C stream (yellow on map). Description: The reach is a short, southward flowing section of the northern portion of the Battleswamp Brook main stem. The reach is located to the west of South Street in Washington, CT. (The reach is located between the Nichols Hill Road/Pickett Road (South Street) intersection and the Pickett Road (South Street)/Davenport Road intersection.)

The volunteer team determined that this area was also not suitable for assessment using the NRCS protocols. The volunteer team was unable to locate a defined stream corridor and the reach was dominated by swamp land.

Survey Reach A-4

Start Location: 41.603955,-73.302977
End Location: 41.602022,-73.301169

Survey Reach A-4 was classified by NRCS staff as a Rosgen Level I Type A stream (red on map). Reach A-4 is a northern segment of the Battleswamp Brook main stem. The southward flowing reach is located

to the west of Pickett Road (South Street) in Washington, CT. (Reach A-4 is located south of the Nichols Hill Road/South Street intersection and north of the South Street/Davenport Road intersection.)

Reach A-4 was characterized by predominantly pool-riffle morphological features, with an average riffle depth of 2 inches and an average pool depth of 4 inches. Right bank height was approximately 1-foot high on average, and left bank height was approximately 1.5-2 feet high on average. The substrate was composed of 25-50% each of sand and boulders, 5-25% cobble, and less than 5% each of silt/clay, gravel, or bedrock. Water conditions were typically clear to 'tea stained' in appearance, with one point of unusual water conditions noted (see AOC descriptions below). Aquatic plants and algae were not observed in the study reach. Stream canopy cover exceeded 75% on average, with adjacent land characterized by mostly rural residential parcels. Riparian vegetation was composed of moderate amounts of grasses and shrubs, and lesser amounts of trees and turf grass.

Six areas of concern (AOC) were reported, including potential fish barriers, erosion, unusual water conditions, and an accumulation of trash and debris. Photographs and descriptions of each area of concern are provided below. A4-AOC1, -AOC2, and -AOC3 were located in close proximity to each other. A4-AOC4, -AOC5, and –AOC6 were similarly located in close proximity to one another.

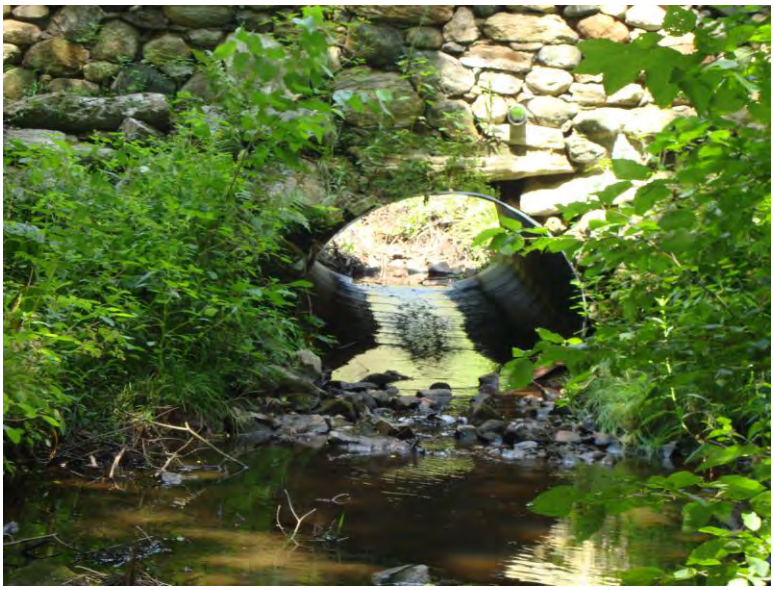


Figure 5. A4-AOC1: Potential Fish Barrier. A metal pipe culvert observed beneath a driveway crossing the stream, may serve as a potential fish barrier. The culvert is approximately 3.3 feet high, 5.25 feet wide and 23.1 feet long. Volunteers observed flow upstream of the culvert to be 'very full' and 'swampy.' Downstream flow was described as 'only trickled.' (Location: 41 36.255, -73 18.224)

Figures 6. A4-AOC2: Potential Fish Barrier. A corrugated metal pipe culvert, located beneath a driveway downstream of A4-FB1, may serve as a potential fish barrier. The culvert is approximately 4.3 feet in diameter, 4.3 feet high, 4.3 feet wide, and 29.7 feet long. Flow exiting the culvert was described as 'slow and low.' (Location: 41 36.318, -73 18.248)

Figure 7. A4-AOC3: Unusual Water Conditions (Foam). A slight odor and was observed near the culvert documented in A4-AOC2. Volunteers recorded that there was a 'possible dead deer inside of pipe under gravel/dirt driveway.' 'Scum' was observed within a pool located just downstream of the culvert. (Location: 41 36.296, -73 18.241)

Figures 8 (top) and 9 (bottom). A4-AOC4: Potential Fish Barrier. A large debris dam, which could serve as a potential barrier to fish passage, was observed by volunteers in Reach A-4. The dam was described as consisting of 'large branches and leaf matter' which appeared 'packed.' The dam measured approximately 4 feet tall and 23 feet across. A private residence and agricultural practices were observed along the right bank of the stream, less than 50 feet from the water. A second residence was located on the left bank, more than 100 feet from the stream. Volunteers noted observing a 'small amount of scum immediately downstream of the barrier.' Erosion along the left bank is observed in Figure 8 (yellow arrow; photo facing upstream). (Location: 41 36.275, -73 18.228)

Figure 10. A4-AOC5: Erosion. A section of eroding stream bank approximately 100 feet long and 6.6 feet tall was observed along the right bank of reach A4. (Note: photo taken facing upstream.) (Location: 41 36.255, -73 18.224).

Figure 11. A4-AOC6: Trash/Debris. An area of scattered debris, including a variety of metal items and cans and 'chicken wire' fencing, was observed at the terminus of reach A-4. (Note: photo taken facing upstream.) (Location: 41 36.242, -73 18.221).

Survey Reach A-5

Start Location: 41.602022,-73.301169
End Location: 41.599334,-73.304436

Survey Reach A-5 was classified by NRCS staff as a Rosgen Level I Type C stream (yellow on map). Reach A-5 is a northern segment of the Battleswamp Brook main stem. The reach flow south from south from its starting point in Washington, CT before turning west to flow across the town border into Roxbury, CT. The reach continues to flow west-southwest and ends shortly after flowing under Pickett Road (South Street).

The volunteer team determined that this area was also not suitable for assessment due to the presence of an adult black bear near the start of the stream reach. The volunteer team (which was surveying the segments from south to north) returned to Pickett Road and travelled by car upstream to the next reach.

Figure 12. View from the starting point of reach A6 upstream towards the terminus of Reach A5. Reach A5 was not surveyed due to the observed presence of an adult black bear.

Survey Reach A-6

Start Location: 41.599334,-73.304436
End Location: 41.595258,-73.305295 (Start of Reach B-1)

Survey Reach A-6 was classified by NRCS staff as a Rosgen Level I Type A stream (red on map). Reach A-6 is a northern segment of the Battleswamp Brook main stem, and is the southernmost segment of Survey Area A. The reach begins shortly after the brook flows under Pickett Road/South Street, and flows south towards Davenport Road.

Reach A-6 was characterized by predominantly pool-riffle morphological features, with an average riffle depth of 3 inches and an average pool depth of 6 inches. The active channel width was, on average, 4 feet wide. Both right and left bank height were approximately 2-foot high on average. The substrate was

dominated by cobble (50-75% of substrate), with lesser amounts of gravel and boulders (25-50% each), 5-25% sand, and less than 5% each of silt/clay and bedrock. The stream was typically 'tea stained' in appearance. Algae were not observed in the study reach, however a location of heavily matted aquatic plant growth was observed. Stream canopy cover exceeded 75% on average, with adjacent land characterized by a mix of forested and rural residential parcels. Riparian vegetation was composed of predominantly shrubs, with moderate amounts of deciduous trees, and low amounts of herbaceous vegetation and coniferous trees.

Eight areas of concern (AOC) were reported, including potential fish barriers, erosion, a stormwater outfall, unusual water conditions, and an accumulation of trash and debris. Photographs and descriptions of each area of concern are provided below.

Figure 13. A6-AOC1: Erosion. An area of significant erosion, approximately 198 feet long and 35 feet high was observed along the left bank of a meander bend in Reach A6. Adjacent land use appeared forested with no sign of nearby infrastructure. (Location: 41.599105, -73.304999)

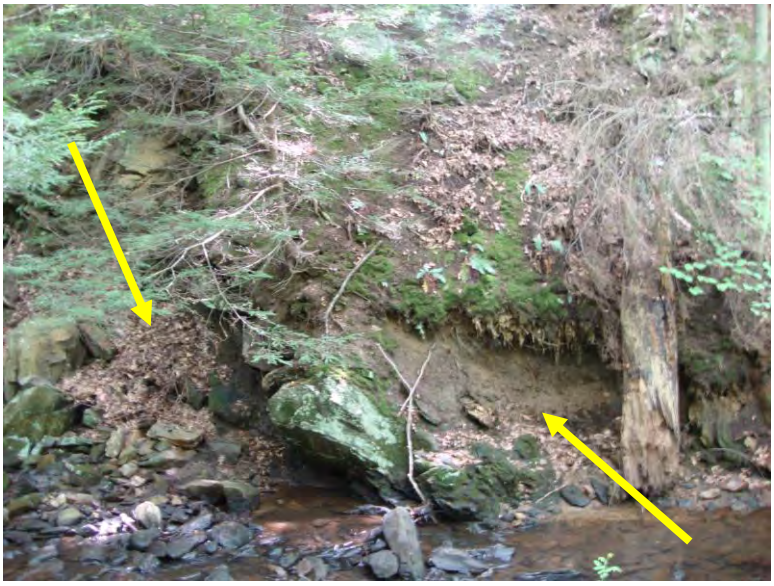


Figure 14. A6-AOC2: Erosion. A second area of erosion was observed along the left bank of the brook within Reach A6. The eroded section measured approximately 60 feet long and 35 feet tall. Several large boulders, which appeared to have broken off from the bank and fallen into the stream channel, were observed near the eroded bank. The eroded section is located within 100 yards of a residential building. (Location: 41 35.830, -73 18.380)

Figures 15 (left) & 16 (right). A6-AOC3: Dam/Potential Fish Barrier. A rock dam, which appeared to be manmade, was observed within Reach A-6. The dam measured 2 feet tall and 12.5 feet wide across the channel. It appeared covered with a strip of thick black plastic, which was partially buried under the substrate. The construction appears to have led to the formation of a small pool upstream of the dam. Residential and agricultural buildings were observed within 50 yards of the left bank, with a house visible, but located more than 100 yards away from, the right bank. (Location: 41 35.794, -73 18.375)

Figure 17. A6-AOC4: Outfalls/Pipes. A large box culvert was observed under a long driveway off of Davenport Road. The culvert measured approximately 13.5 feet long, 12.5 feet wide and 6.75 feet high. Four stormwater outfall pipes (highlighted by yellow circles), which drain directly to the stream, were visible within the culvert walls. (Location: 41 35.783, -73 18.377)

Figures 18 (left) & 19 (right). A6-AOC5: Potential Fish Barrier. A corrugated metal pipe culvert was observed beneath a driveway located off of Davenport Road. The pipe measured 2.9 feet in diameter and 26.7 feet in length, and appeared slightly perched above the stream surface. Volunteers noted that they observed 'sediment buildup' at the culvert location, and noted that the culvert 'was directly impacting [a] small trib[utary] to Battleswamp Brook, less than 5 meters from mainstem.' (No further explanation was provided.) (Location 41 35.716, -73 18.347)

Figures 20, 21 & 22 (clockwise from top left). A6-AOC6: Unusual Water Conditions (Vascular plant growth). An area of extensive aquatic plant growth was observed within Reach A6. The area of growth was located approximately 100 yards from Davenport road, within close proximity to a stone driveway (10 yards away) and a residential dwelling (75 yards away). No discoloration or water odors were observed. (Location 41 35.715, -73 18.349)

Figure 23. A6-AOC7: Erosion. An area of erosion was observed near the terminus of Reach A6 just downstream of a sharp meander bend. The eroding right bank measured approximately 52.8 feet long and 8 feet high and was located approximately 100 yards north of Davenport Road. (Location 41 35.706, -73 18.366)

Survey Area B

Survey Area B (Figure 24), which includes the middle reaches of the Battleswamp Brook main stem, was not surveyed during the 2011 Streamwalk Program. Attempts made by the program coordinator to follow-up with the team that volunteered to survey Area B were unsuccessful. Field data and observations for Survey Area B are therefore not included in this report.

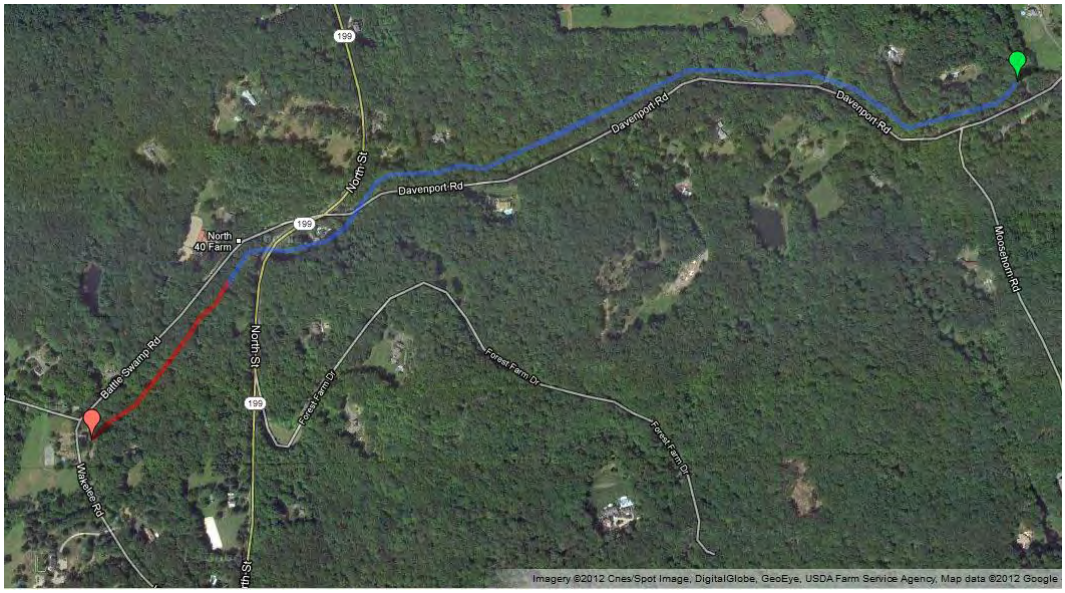


Figure 24. Aerial view of Survey Area B. Streamwalk start and end points are located at the green and red place marks, respectively. Individual reach segments B-1 (blue) and B-2 (red) are shown as colored line segments. (*Aerial photo courtesy of Google Maps.*)

Survey Area B includes two reaches B-1 and B-2. Although field data was not collected for these reaches we can see in Figure 24 that there are two major road crossings in reach B-2, which would be expected to potentially have impacts upon the Battleswamp Brook. Forest cover in the area where the brook is expected to flow in reaches B-1 and B-2 appears relatively dense, making it difficult to identify areas of concern based upon the aerial photography, but also indicating that it appears that the brook has a relatively health vegetative buffer in these two reaches. There does appear to be, based upon aerial photography, at least two additional driveway crossings over the brook in Reach B-1. The brook appears to also flow very close to a residential dwelling just before it flows under Davenport Road, increasing the likelihood that anthropogenic impacts may be present in this section of the brook.

Survey Reach B-1

Start Location: 41.595258, -73.305295 (End of Reach A-6)
End Location: 41.591952, -73.322285

Survey Reach B-1was classified by NRCS staff as a Rosgen Level I Type B stream (blue on map). Reach B-1 begins at the terminus of reach A-6, and flows westward following Davenport Road, eventually crossing under Davenport Road and Route 199/North Street.

Survey Reach B-1was not surveyed during the 2011 Battleswamp Brook Streamwalk due to volunteer drop out.

Survey Reach B-2

Start Location: 41.591952, -73.322285
End Location: 4141.589361,-73.325163 (Start of Reach C-1)

Survey Reach B-2was classified by NRCS staff as a Rosgen Level I Type A stream (red on map). Reach B-2 begins shortly after Battleswamp Brook flows under Route 199/North Street. The reach flows southwest and ends just before the brook crosses under Wakelee Road in Roxbury, CT.

Survey Reach B-2 was not surveyed during the 2011 Battleswamp Brook Streamwalk due to volunteer drop out.

Survey Area C

Survey Area C (Figure 25), which includes the lowest reaches of the Battleswamp Brook main stem, was surveyed on August 5, 2011, by Hugh Rawson, Trudy Swenson McKinna, and Gary Steinman, members of the Roxbury Conservation Commission. The survey area included three reaches C-1 through C-3, labeled in numerical order from north to south.

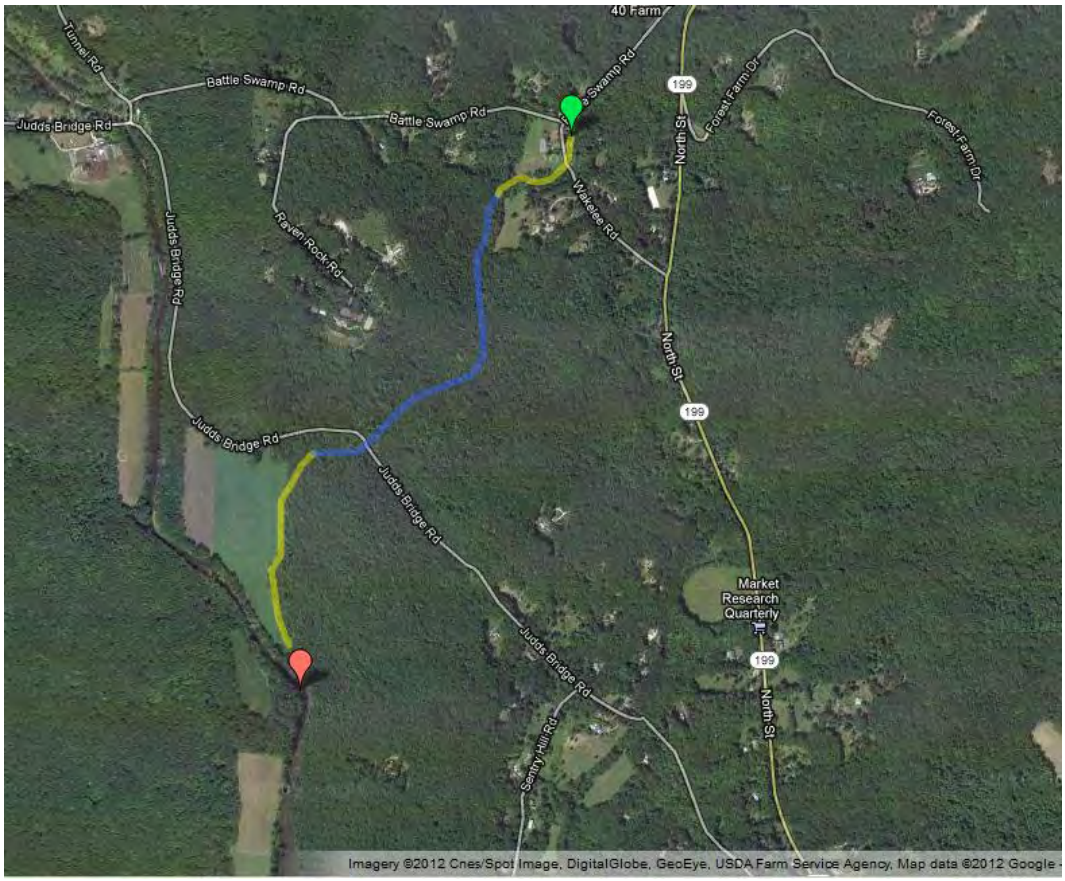


Figure 25. Aerial view of Survey Area C. Streamwalk start and end points are located at the green and red place marks, respectively. Individual reach segments C-1, C-2, and C-3 are shown as colored line segments. (*Aerial photo courtesy of Google Maps.*)

Survey Reach C-1

Start Location: 41.589361,-73.325163 (End of Reach B-2)
End Location: 41.588085,-73.327509 (Confluence with unnamed tributary #1)

Survey Reach C-1 was classified by NRCS staff as a Rosgen Level I Type C stream (yellow on map). Reach C-1is a downstream segment of the Battleswamp Brook main stem. The reach flow south-southwest to cross Wakelee Road in Roxbury, CT just west of its staring point, before continuing to flow southwest. The entire reach is approximately 0.2 mile long.

Reach C-1 was characterized by predominantly pool-riffle morphological features, with an average riffle depth of 6 inches and an average pool depth of 1 foot. The active channel was approximately 12 to 15 feet wide on average, average right bank height was approximately 2-feet, and average left bank height was approximately 4 feet. The substrate was composed of 5-25% each of bedrock, boulders, cobbles, and gravel, and less than 5% each of silt and clay. (Percent composition for sand was not reported.) Water conditions were typically clear in appearance, with points of unusual water conditions noted (see AOC descriptions below). Aquatic plants were not observed in the study reach. Floating algae was observed 'in spots.' Stream canopy cover averaged 50-75%, with the upstream portion characterized by 'hardly any canopy' and the downstream portion approaching 100% cover. Riparian vegetation was composed of predominantly of deciduous trees and grasses, with low amounts of coniferous trees also reported. Adjacent land use in the reach included a mix of rural residential and forested lands. (The right bank appeared mostly forested, while the left bank was predominantly residential.) A small pond that appeared to be connected to the brook via an overflow pipe was observed within the reach.

Three areas of concern (AOC) were reported, including a discharge pipe, unusual water conditions, and buffer degradation. Photographs and descriptions of each area of concern are provided below. The volunteer team concluded their survey at the Wakelee Road crossing. The road crossing was not documented by the team as an AOC, however road crossings have a high potential for contributing to water quality and aquatic habitat degradation, and is therefore intentionally noted here.

Figure 26. The Wakelee Road stream crossing located in the upstream portion of reach C-1 was not identified by the volunteer team as a potential AOC. However, stream crossings commonly cause negative water quality impacts due to stormwater runoff and aquatic habitat alteration and is therefore intentionally noted in this report.

Figures 27-30 (from top left; clockwise). C1-AOC1: Unusual water conditions (Rusty Redness) & C1-AOC2: Outfall/Pipe. A pond was visible uphill from the stream along the right bank. Unusual water quality conditions, including rusty-red discoloration and heavy algae growth, were observed in the drainage ditch as well as in the brook at the point where the drainage ditch discharged (Figure 27, top left, and Figure 28, top right). Volunteers observed an apparent overflow pipe in the pond (Figure 29, bottom right), which may be connected to a partially submerged pipe that was observed in a drainage ditch (Figure 30, bottom left) which empties into the stream channel.

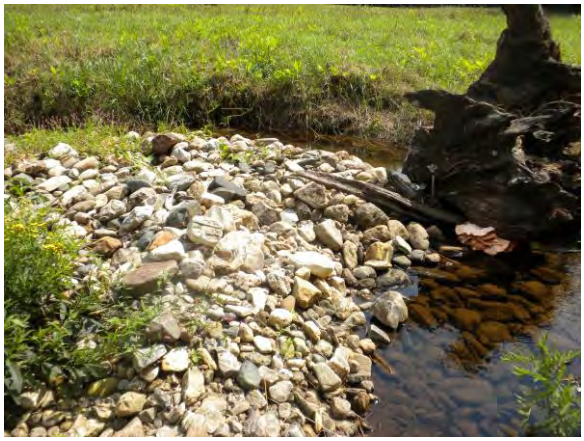


Figure 31 & 32 (left to right). C1-AOC3: Degraded Buffer. Canopy cover was highly variable within Reach C1. The most upstream portion of the reach (left) appeared to have a relatively intact buffer and canopy cover. Approximately 100 yards downstream from the Wakelee Road crossing, within the vicinity of two residential properties, the riparian buffer vegetation changed dramatically. At this point, buffer vegetation changes from forested to entirely turf grass up to the stream edge, resulting in a complete loss of canopy cover (right). Signs of water quality degradation including areas of 'rusty red' water, foam, and algae growth were observed in the vicinity of the buffer degradation.

Figure 33. An aerial photo of Reach C1 confirms that a pond (yellow oval) is located in close proximity to the stream. Note that C1-AOC3, an area of buffer degradation along the stream, is also visible in the photo (yellow arrow).

Survey Reach C-2

Start Location: 41.588085,-73.327509 (Confluence with unnamed tributary #1)
End Location: 41.588085,-73.327509 (Confluence with unnamed tributary #2)

Survey Reach C-2was classified by NRCS staff as a Rosgen Level I Type B stream (blue on map). Reach C-2 is the second most downstream segment of the Battleswamp Brook main stem. The reach flows south from the terminus of Reach C-1 and an intersection with an unnamed tributary, before turning southwest at the point that a second unnamed tributary enters the brook. The brook then continues southwest to pass eventually under Judd's Bridge Road in Roxbury, CT. The entire reach is approximately 0.6 miles long.

Reach C-2 was characterized by predominantly step-pool morphological features, with an average pool depth of 12 inches and step heights ranging from one to four feet high. The active channel typically ranged from 18 to 30 feet wide, with sections as wide as 60 feet observed. Average right and left bank height was approximately three feet each.

The substrate was composed of 25-50% each of bedrock and boulders. Lesser amounts of gravel and cobble (5-25% each) were also noted with minimal amounts of sand (<5%). (Percent composition for silt or clay was not reported.) Water conditions were typically clear in appearance. Neither aquatic plants nor algae were observed in the study reach. Stream canopy cover exceeded 75% on average. The riparian buffer was dominated by forest land, and riparian vegetation was composed of a mix of deciduous and coniferous trees, with no other vegetation types reported. (Notably, much of the land bordering the brook between Wakelee Road and Judd's Bridge Road is under protection by local land trusts, including the Roxbury Land Trust and Weantinoge Heritage.)

Erosion was the only area of concern (AOC) reported in the reach; photographs and descriptions are provided below. The volunteer team also noted that the stream was characterized by 'low water throughout' the reach. In addition, the reach included a road crossing at Judd's Bridge Road; however an AOC data sheet was not completed for the crossing, and was therefore presumably determined by the team to not be a barrier to fish passage. The volunteer team did note on their reach level assessment form that there was rip rap observed along both sides of the brook in the vicinity of the road crossing. Therefore, while not officially documented by the team as an AOC, road crossings have a high potential for contributing to water quality and habitat degradation, and is therefore intentionally noted here.

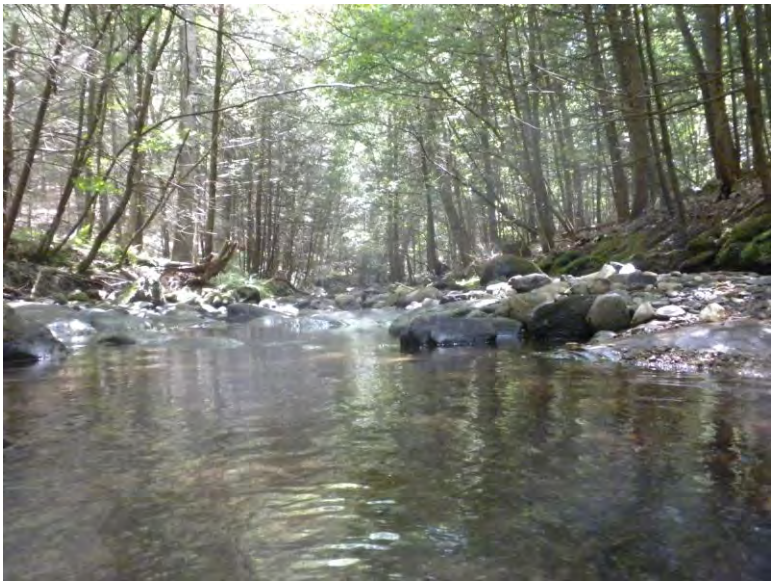


Figure 34. Reach C2 was characterized by an intact forested buffer on both sides of the stream channel.

Figure 35. Volunteers observed what appeared to be a dry tributary streambed entering the brook from the right within the upper portion of Reach C2. This is likely the confluence of Battleswamp Brook and the tributary assessed in survey area D.

Figure 36. Volunteers observed a second tributary in Reach C2. The tributary entered the brook from the left, and is likely the confluence of Battleswamp Brook and the tributary assessed in survey area E.

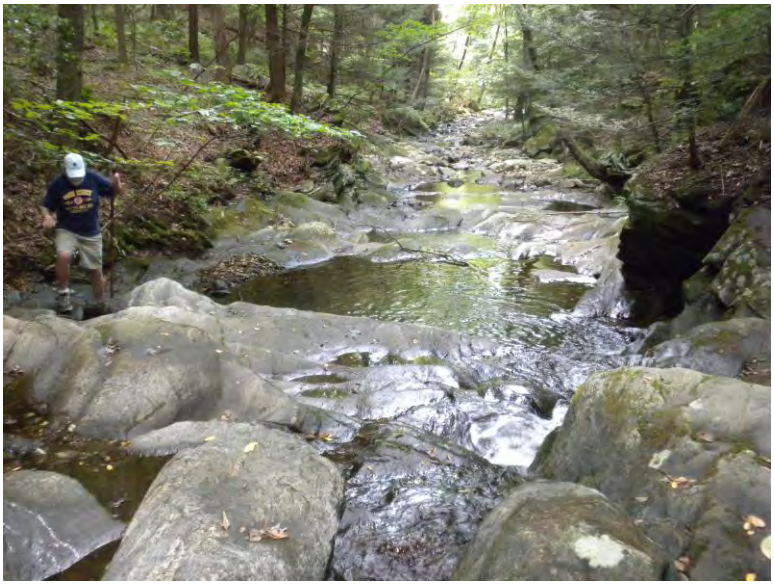
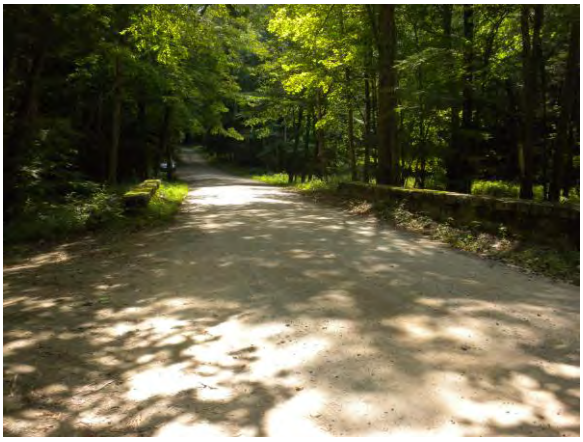


Figure 37. Reach C2 was dominated by step-pool morphological features, including a bedrock and boulder dominated substrate, as shown in the figure above.

Figure 38. C2-AOC1: Debris Accumulation. Several patches of large woody debris accumulation in the stream were observed. Locations of limited erosion and bank undercutting were also observed along both banks within the lower portions of Reach C2. Eroded areas averaged 3 to 4 feet high and approximately 30 feet long.



Figures 39 & 40 (left to right). Judd's Bridge Road crossing the brook near the downstream end of Reach C2. The road crossing is characterized by an open bottom culvert which was determined not to be a barrier to fish passage. Runoff from the road could potentially negatively impact downstream water quality and habitat, however.

Survey Reach C-3

Start Location: 41.588085,-73.327509 (Confluence with unnamed tributary #2)
End Location: 41.576167,-73.333796 (Confluence with Shepaug River)

Survey Reach C3 was classified by NRCS staff as a Rosgen Level I Type C stream (yellow on map). Reach C3 is the most downstream segment of the Battleswamp Brook main stem. The reach flows south from the terminus of Reach C2, just downstream of the Judd's Bridge Road Crossing, to the brook's confluence with the Shepaug River. The entire reach is approximately 0.3 miles long.

Reach C3 was characterized by an active channel width averaging 24-30 feet wide. Substrate was dominated by cobble (>75%) with lesser amounts of sand and gravel (5-25%) also present. (Channel morphology conditions were not recorded.) Water conditions were typically clear in appearance, with sections of dry streambed observed. Aquatic plants were not observed within the study reach; however algae were documented in within the lower reach. Stream canopy cover exceeded 75% on average. The riparian buffer along the left bank was dominated by forest land, with vegetation composed of a mix of deciduous and coniferous trees, and low amounts of shrubs. The riparian buffer along the left bank was similar in composition, but narrower in width, with agricultural lands visible beyond the buffer. At the conclusion of the reach, where the brook empties into the Shepaug River, volunteers noted a small playground with mowed lawns and a jungle gym.

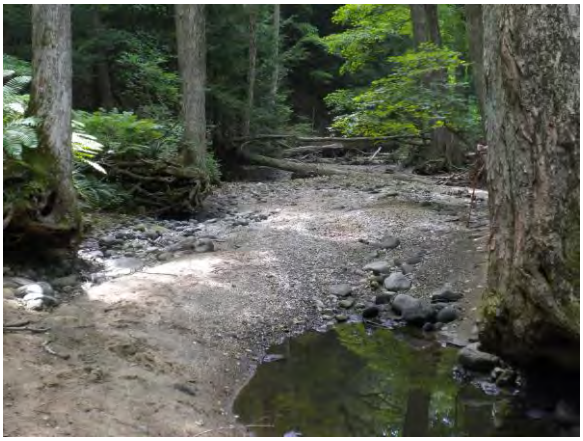
Five areas of concern (AOCs) were reported in the reach, including stretches of eroded stream bank and buffer degradation, sections of dry streambed, and points of water discoloration. Notably volunteers documented that the lower 75% of the reach was dry. Photographs and descriptions are provided below.

Figure 41. A view of the upstream portion of Reach C3. Some slight bank undercutting is visible along the left-hand side of the photograph, but the buffer appears otherwise intact.

Figure 42. C3-AOC1: Unusual Water Conditions (Dry channel). Stream flow throughout Reach C3 was generally very low. However, in the lower 75% of the reach, volunteers observed that the stream was almost completely dry.

Figures 43 & 44 (left to right). C3-AOC2: Unusual Water Conditions (Cloudiness; Algae). Volunteers observed several points of unusual water color in Reach C3. Discoloration appeared to occur in pools located between stretches of dry streambed.

Figures 45 & 46. C3-AOC3: Buffer Degradation. Reach C3 is characterized by agricultural land use along the right bank for most of the reach length. A forested buffer has been maintained between the stream and the agricultural fields; however there is evidence of buffer degradation, including points of erosion contributing sediment to the streambed (Figure 45) and deeply undercut banks (Figure 46).



Figures 47. C3-AOC4: Erosion. Evidence of erosion, including points of sediment deposition within the stream channel, was observed throughout reach C3.

Figure 47.

Figure 48.

Figure 49.

Figure 50.

Figure 51.

Figure 52.

Figures 47-52 (from top, right to left). C3-AOC5: Buffer Degradation & C3-AOC6: Erosion. Volunteers observed significant buffer degradation and erosion along the most downstream portion of Reach C3 along the right bank (Figure 47, top left, and Figure 48, top right). The erosion is likely associated with a severely degraded buffer, including the removal of native vegetation (Figures 49 & 50; note the jungle gym and picnic tables highlighted in orange for reference). A large accumulation of sediment was observed at the mouth of the brook, adjacent to the degraded buffer (Figures 50-52; the Shepaug River can be seen in the foreground of Figure 52).

Survey Area D

Survey Area D (Figure 53), which encompasses an unnamed tributary of the Battleswamp Brook, was surveyed on August 24, 2011 by Dan Sherr, a member of WEC and HVA, and Horst Antosch, also an HVA member. The tributary begins just north of the Washington-Roxbury town line at the southern edge of the utility right of way, and flows south into an unnamed pond. The outflow of the pond continues southwest, flowing under Battleswamp Brook Road before ultimately emptying into Battleswamp Brook southwest of the Battleswamp Brook/Wakelee Road intersection in Roxbury. Survey Area D includes two reaches, D-1 and D-2, from north to south.

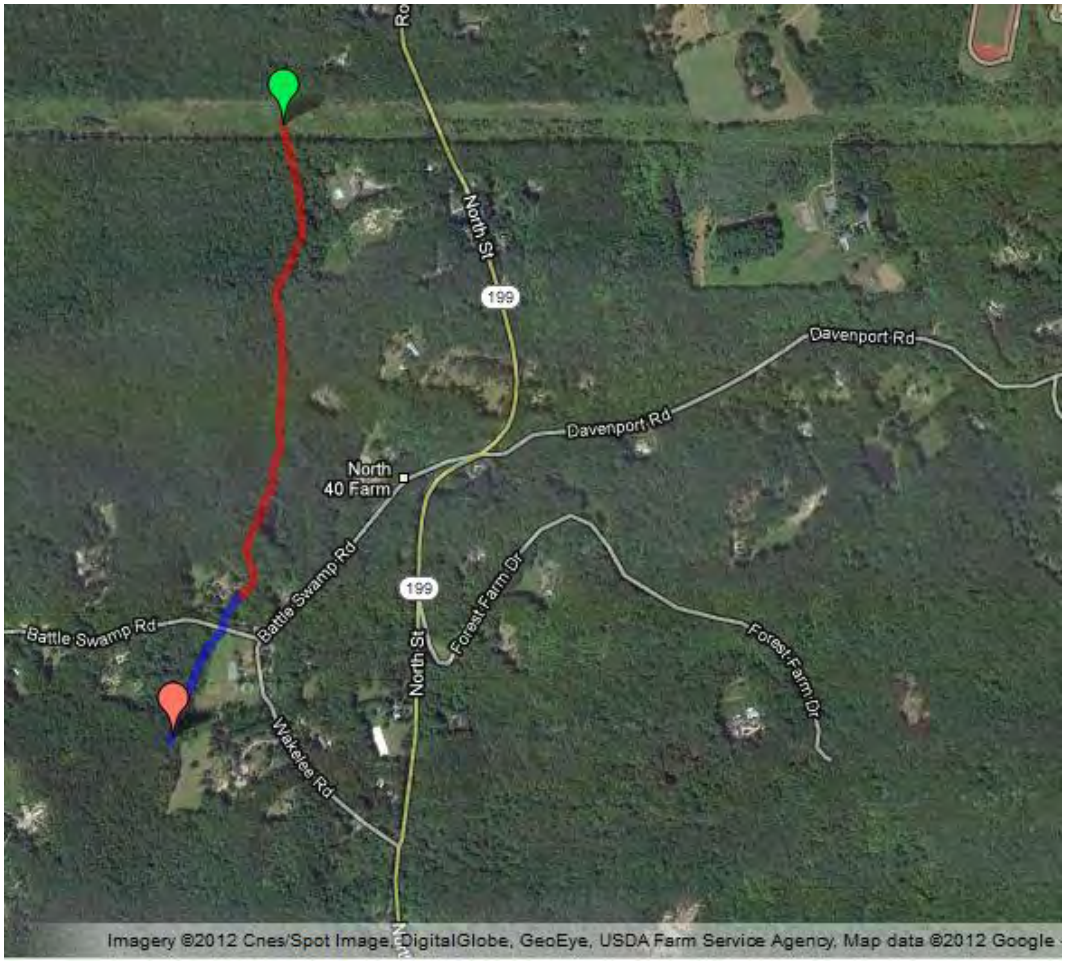


Figure 53. Aerial view of Survey Area D. Streamwalk start and end points are located at the green and red place marks, respectively. Individual reach segments D-1 and D-2 are indicated by the red and blue line segments. (*Aerial photo courtesy of Google Maps*.)

Survey Reach D-1

Start Location: 41.599233, -73.322266
End Location: 41.5924, -73.325266 (Pond Inflow)

Survey Reach D-1 was classified by NRCS staff as a Rosgen Level I Type A (red on map) stream. Reach D-1 is the upstream portion of the unnamed tributary located to the north of the lower reaches of the Battleswamp Brook main stem. Reach D-1 flows south from the utility right of way, across the Washington-Roxbury town line and empties into an unnamed pond located north of the Battleswamp Road/Wakelee Road intersection. The entire reach is approximately 0.5 mile long.

Channel morphology and substrate details were not documented for Reach D-1. Water flow was low throughout the reach and dry in several areas. Based upon photographs, active channel width averaged approximately 3 feet wide. The predominant morphological features appear to have been pool-riffle features characterized by a mixture of silt/clay, sand, gravel and cobble substrate. Few boulders or sections of exposed bedrock were observed. Average depth did not appear to exceed 8 inches. Right and left bank heights appear to be at or only slight above (i.e. 6 inches) water surface on average.

Water conditions appear typically clear to 'ice tea stained' in color, with several areas of dry streambed and points of unusual water color observed. Aquatic plants were not observed in the study reach. Volunteers reported observing attached algae in spots. Stream canopy cover was approximately 50-75% on average, with adjacent land characterized predominantly by forested land. Riparian vegetation, on average, was comprised of high amounts of herbaceous vegetation including ferns, and moderate to low amounts of coniferous and deciduous trees.

Ten areas of concern (AOC) were observed, including potential fish barriers due to sections of modified channel, unidentified piping in the channel, culverts, and unusual water conditions. Photographs and descriptions of each area of concern are provided below.

Figure 54 & 55 (left to right). Reach D-1 began along the southern border of the utility line located just north of the Washington-Roxbury town line.

Figure 56 & 57 (left to right). D1-AOC1: Potential Fish Barrier & D1-AOC2: Potential Fish Barrier. Within the first 10 yards of the reach, two corrugated metal pipe culverts were observed, designed apparently to accommodate dirt trails crossing the stream. The pipe in Figure 56 measured approximately 4 inches in diameter, while the opening of the culvert in Figure 57 was recorded to be 2 feet in diameter. The water flowing between the two culverts appeared rusty-red as seen in Figure 57. (Location: 41 35.910, -73 19.467)

Figure 58-60 (right to left; top to bottom). The headwaters of Reach D-1 (Figure 58-59) were characterized by a relatively shallow, occasionally braided, stream channel with a substrate dominated by relatively small particle sizes. Canopy cover ranged from 25-75%, with riparian vegetation dominated by ferns. Channel substrate shifted to slightly larger particle sizes midway down the reach (Figure 59-60); channel slope also increased slightly.

Figure 62 & 63. D1-AOC3: Dam/Potential Fish Barrier. Stone walls constructed across the stream channel acted as dams, resulting in changes in stream hydrology and a deposition of fine sediments upstream from the barrier. (Location 41 35.706, -73 19.495)

Figure 64 & 65. D1-AOC4: Unusual Water Conditions (Foam, Rusty Redness, Dry Sections). Points of unusual water conditions, including foam, water that was rusty-red in color, and areas of 'lost' stream channel, were observed in spots throughout the reach. Unusual water conditions were typically associated with a downstream barrier to flow.

Figure 66-68. D1-AOC5: Dam/Fish Barrier, D1-AOC6: Dam/Fish Barrier, & D1-AOC7: Dam/Fish Barrier. Three large rock walls obstruct streamflow within the upstream portion of Reach D-1, impounding flow and causing sediment deposition. (Locations: 41 35.679, -73 19.449; 41 35.649, -73 19.460; 41 35.626, -73 19.486)

Figure 69-71. D1-AOC8: Outflow/Pipe. Volunteers observed a black plastic pipe which followed the stream channel. One opening was eventually observed several feet downstream within the stream channel. (First observation; 41 35.851, -73 19.450; Downstream opening: 41 35.609, -73 19.497)

Figure 72. D1-AOC9: Unusual Water Conditions (Algae). Algae growth was observed within a meander bend of the stream (located upstream of the unnamed pond). (Location: 41 35.577, -73 19.508)

Figure 73. Reach D-1 concludes where the stream empties into an unnamed pond. (Location: 41 35.544, -73 19.516)

Survey Reach D-2

Start Location: 41.590383, -73.325083 (Downstream of Pond Outflow)
End Location: 41.58845, -73.3272 (Confluence with Battleswamp)

Survey Reach D-2 was classified by NRCS staff as a Rosgen Level I Type B (blue on map) stream. Reach D-2 is the lowest portion of the unnamed tributary located to the north of the lower reaches of the Battleswamp Brook main stem. Reach D-2 flows south from outlet of the unnamed pond, under Battleswamp Road to the confluence with Battleswamp Brook. The reach is approximately 0.2 miles long.

Channel morphology and substrate details were not documented for Reach D-2. Water flow was low throughout the reach. Based upon photographs, active channel width averaged approximately 3-4 feet wide. The predominant morphological features appear to have been pool-riffle features characterized by a mixture of silt/clay, sand, gravel and cobble substrate. Few boulders or sections of exposed bedrock were observed. Average depth did not appear to exceed 12 inches. Right and left bank heights appear to be approximately 12-24 inches high on average.

Water conditions appear typically 'ice tea stained' in color, with points of unusual water color commonly observed. Aquatic plants were not observed in the study reach; however volunteers reported observing attached algae in spots. Stream canopy cover likely approached 75% on average, as volunteers noted it was very difficult to travel through the dense growth along the stream channel, however. Adjacent land, however, was characterized by rural residential land with only a thin vegetative buffer in several places.

Five areas of concern (AOC) were observed, including a potential fish barriers due to an undersized culvert, channel modifications, unusual water conditions, and buffer degradation. Photographs and descriptions of each area of concern are provided below.

Figures 74 & 75. The outfall of the unnamed pond dam (Figure 74), flows down into a second detention area (Figure 75). Reach D-2 began downstream of this second detention area. Blue arrows indicate flow direction. (Location: 41 35.544, -73 19.516)

Figure 76. D2-AOC1: Modified Channel & D2-AOC2: Unusual Water Conditions (Foam). A section of modified channel and areas of unusual water color were observed near a residential parcel located within the northern end of Reach D-2.

Figure 77 & 78. D2-AOC3: Degraded Buffer. Just upstream of the Battleswamp Brook Road crossing, the riparian buffer along Reach D-2 appeared degraded, lacking significant vegetation.

Figures 79 & 80. D2-AOC4: Potential Fish Barrier. The reach flows beneath Battleswamp Brook Road via a road crossing which appeared to be undersized. (Location 41 35.394, -73 19.582)

Figure 81 & 82. D2-AOC5: Unusual Water Conditions (Rusty Redness). The flow exiting the Battleswamp Brook Road culvert appeared discolored. Volunteers observed that the stream channel lost definition downstream of the culvert and was difficult to locate for several yards. (Location 41 35.394, -73 19.582)

Figure 83. The confluence of the unnamed tributary in Survey Area D and the Battleswamp Brook. (Location 41 35.307, -73 19.632)

Survey Area E

Survey Area E (Figure 84), which encompasses a second unnamed tributary of the Battleswamp Brook, was surveyed on August 4, 2011 by HVA interns Erin Brinton and Carrie Dillaway, and HVA staff, Meghan Ruta. The tributary begins southwest of Forest Farm Drive in Roxbury, CT and flows southwest, passing under the Route 199/Wakelee Road intersection, before emptying into the Battleswamp Brook midway between Judds Bridge Road and Route 199. Survey Area E includes two reaches, reach E-1 and E-2. Although initially delineated by NRCS as one reach, as shown in Figure 84, the stream was dry in the vicinity of the Route 199/Wakelee Road road crossing and the channel disappeared downstream. Volunteers divided their observations into the portion of the survey area from the headwaters to the road crossing (reach E-1), and the section from the confluence with the Battleswamp to the most upstream point that the team could locate below the dried section at the road crossing (reach E-2).

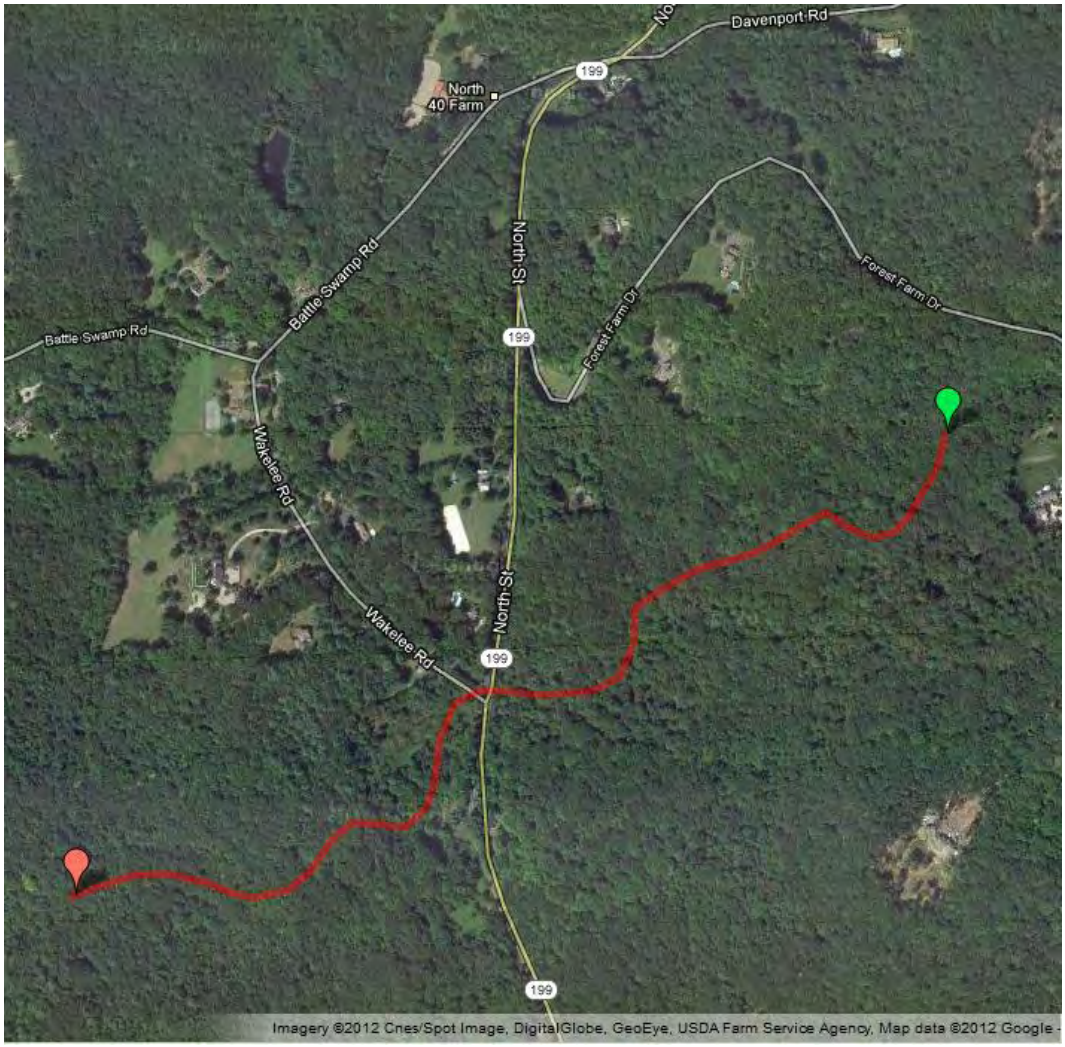


Figure 84. Aerial view of Survey Area E. Streamwalk start and end points are located at the green and red place marks, respectively. The survey area which is highlighted in red included two reaches. Reach E-1 includes the portion of the survey area upstream of Route 199/Wakelee Road. Reach E-2 includes the portion of the survey area downstream of Route 199/Wakelee Road. (*Aerial photo courtesy of Google Maps.*)

Survey Reach E-1

Start Location: 41.588100, -73.316633
End Location: 41.586147,-73.322015 (Route 199/North Street)

Survey Reach E-1 was classified by NRCS staff as a Rosgen Level I Type A stream (red on map). Reach E-1 is the upstream portion of the unnamed tributary located to the south of the Battleswamp Brook main stem. Reach E-1 flows southwest from its headwaters to Route 199/North Street. The entire reach is approximately 0.5 mile long.

Reach E-1 was characterized by predominantly step-pool morphological features, with an average pool depth of 2 inches and an average step height of 12 inches. Right and left bank heights were approximately 2.5-3.0 feet high on average. The substrate was composed of primarily bedrock (50-75%) and cobbles (50-75%), with moderate amounts (5-25%) of sand, gravel, and bedrock. Silt or clay comprised a minimal (<5%) proportion of the substrate.

Water conditions were typically clear, with several areas of dry streambed and one point of unusual water conditions observed (see AOC descriptions below). Neither aquatic plants nor algae were observed in the study reach. Stream canopy cover exceeded 75% on average, with adjacent land characterized by forested land. Riparian vegetation was composed of moderate amounts of mixed grasses, shrubs, and deciduous trees.

Eight areas of concern (AOC) were reported, including potential fish barriers, a stormwater outfall, sections of modified channel, and unusual water conditions. Photographs and descriptions of each area of concern are provided below.

Figure 85. E1-AOC1: Unusual Water Conditions (Dry Section). The most upstream portion of the stream channel in Reach E-1. Throughout the reach sections of dried streambed, such as the one shown in the figure above, were observed.

Figures 86 & 87 (left to right). E1-AOC2: Potential Fish Barrier. The view facing downstream (left) and upstream (right) of a likely vertical barrier to upstream aquatic organism passage. The bedrock step measured approximately 30 feet long and had a vertical rise of approximately 15-20 feet. The channel, which contained very minimal flow, was obstructed by large woody debris. (Location 41 35.260, -73 19.165)

Figures 88 & 89 (left to right). Travelling downstream, Reach E-1 was characterized by alternating stretches of relatively defined stream channel (left, yellow arrow) and stretches with an apparent absence of channel.

Figure 90. A small pile of metal debris was observed mid-way downstream Reach E-1.

Figures 91 & 92. E1-AOC3: Dam/Potential Fish Barrier. A rock wall (left, looking upstream at wall) constructed perpendicular to the stream channel, appeared to result in upstream sediment deposition (right; looking upstream above wall). The wall measured 4 feet wide and 5.75 feet high and completely bisected the stream channel, obscuring upstream aquatic organism passage. Flow through the wall (at left, yellow arrow) was minimal at the time of observation. (Location 41 35.235, -73 19.213)

Figures 93 & 94. E1-AOC4: Dam/Potential Fish Barrier. A second rock wall (left, facing perpendicular to the channel) was observed downstream of E1-AOC3. Constructed perpendicular to the stream channel, the second wall also appeared to result in upstream sediment deposition (left) and obscured upstream aquatic organism passage. Flow through the wall was minimal, and discolored (see E1-AOC5) at the time of observation. (Location 41 35.192, -73 19.180)

Figures 95 & 96. E1-AOC5: Unusual Water Conditions (Rusty Redness). Flow downstream of a third rock wall stream crossing was noticeably discolored. An aquatic worm observed in the rusty-red stream section is shown at right. (Location 41 35.172, -73 19.261)

Figures 97 & 98. E1-AOC6: Dam/Potential Fish Barrier. A fourth stone wall was observed approximately 30 yards upstream of the Wakelee Road crossing. The wall, which appeared constructed in association with an adjacent structure (possibly a former well house), measured 3.6 feet high and 13.9 feet across. Significant sediment deposition was observed behind the wall (right). The upstream stream channel (yellow arrow) is visible in the background of the photo for comparison. (Location 41 35.179, -73 19.320)

Figures 99 & 100. E1-AOC7: Outfall/Pipe. A stormwater outfall was observed just upstream of the Wakelee Road crossing along the right bank. No flow was observed exiting from the metal pipe, which was approximately 1.5 feet in diameter and located 2 feet above the stream surface. (Location 41 35.168, -73 19.345)

Figures 101 & 102. E1-AOC8: Potential Fish Barrier. Due to the narrow construction of the Route 199/Wakelee Road stream crossing, it was documented as a potential velocity barrier to aquatic organism passage during periods of higher flow. The concrete and stone construction box culvert measured 23.5 feet long, 4.3 feet wide, and 6.9 feet high. (Location 41 35.170, -73 19.345)

Survey Reach E-2

Start Location: 41.586103,-73.322363 (Wakelee Road)
End Location: 41. 0.584533, -73.328283 (Battleswamp Brook Confluence)

Survey Reach E-2 was classified by NRCS staff as a Rosgen Level I Type A stream (red on map). Reach E-2 is the downstream portion of an unnamed tributary located to the south of Battleswamp Brook. The reach begins below the Route 199/Wakelee Road crossing and extends southwest to the confluence with the brook. The entire reach is approximately 0.5 mile long.

Reach E-2 was characterized by predominantly step-pool morphological features, with an average pool depth of 6 inches and an average step height of 6 inches. Right and left bank heights were approximately 1-1.5 feet high on average. The substrate was composed of cobble substrate (25-50%), with lesser amounts (5-25% each) of sand, gravel, boulder, and bedrock. Silt or clay comprised a minimal (<5%) proportion of the substrate.

Where present, water conditions were 'iced tea stained', however the majority of the streambed was dry during the time of observation. Neither aquatic plants nor algae were observed in the study reach. Stream

canopy cover exceeded 75% on average, with adjacent land characterized by forested land. Riparian vegetation was composed of moderate amounts of deciduous trees, and lesser amounts of grasses, shrubs, and coniferous trees.

Five areas of concern (AOC) related to debris accumulation, dry stream channel sections and eroding stream banks, were reported in Reach E-2. Photographs and descriptions of each area of concern are provided below.

Figure 103. E2-AOC1: Unusual Water Conditions (Other). The survey team was unable to locate the stream channel, which was assumed to be dry, in the upper part of Reach E2. A large water filled pit, which appeared based upon its rectangular shape to have been dug, was observed near the point where the channel (which was dry) was first relocated. (Location 41 35.029, -73 19.416)

Figure 104. E2-AOC2: Trash/Debris. Multiple large piles of woody debris were observed within the vicinity of the ponded area noted in Figure 103.

Figures 105–107 (left to right). E2-AOC3: Unusual Water Conditions (Dry Channel). The stream channel was dry at the time of observation for most its length. (The stream bed was observed to be dry from its confluence with the Battleswamp upstream to 41 35.050, 73 19.575. The stream dried up again at 41 35.06, -73 19.479 and was no longer able to be located by the survey team.

Figure 108. E2-AOC4: Unusual Water Conditions (Rusty Redness). The small pockets of water observed within the channel were typically stagnant and discolored.

Figure 109. E2-AOC5: Erosion. Evidence of stream bank erosion and bank undercutting was observed along both banks of the stream channel in the lower portion of Reach E2. (Location 41 35.058, 73 19.610).

Figures 110 & 111 (left to right). Channel morphology was notably different between upstream (Figures 105-107) and downstream portions of Reach E2.

Figure 112. The confluence of Reach E-2 and Battleswamp Brook (shown in foreground).

Discussion & Recommended Action

The 2011 Battleswamp Brook Streamwalk program was initiated by the Housatonic Valley Association (HVA) and developed and implemented with support from fellow Shepaug River Association stakeholder groups, the Roxbury Conservation Commission (RCC) and the Washington Environmental Council (WEC). The program was initiated to explore the suitability of using the NRCS Streamwalk Initiative program to better understand current trends in riparian and in-stream conditions within the tributaries of the Shepaug River watershed.

The streamwalk program, as designed by CT NRCS, is intended to be a preliminary 'first glance' survey to document current conditions along the stream corridor, with emphasis on identifying potential areas of concern (AOCs) adjacent to or within the stream corridor. It is important to understand that AOCs are locations that based on the observed conditions at the time of the survey, have the *potential* to be a sign of or a cause of stream impairment. In addition, each AOC identified in this report typically represents a single point along a much larger reach. Further investigation by a trained natural resource expert is needed to determine whether a given AOC is an actual impairment to stream health, and if so, what action, if any, is appropriate to correct or improve the situation.

Nine reaches within the Battleswamp Brook watershed were surveyed and assessed according to NRCS protocols during the 2011 Streamwalk program. (Three additional reaches were surveyed but, due to the presence of extensive wetlands, determined to be unsuitable for assessment according to NRCS protocols.) Three reaches were neither surveyed nor assessed. At least one AOC was identified in each

assessed reach and all seven AOC types (i.e., erosion, dams and/or potential fish barriers, outfalls and/or pipes, modified channel sections, degraded buffers, trash and/or debris, unusual water conditions) were observed within the Battleswamp Brook basin. In total, fifty AOCs were documented by the Streamwalk teams.

Trash & Debris

Trash and debris accumulation within the riparian corridor can adversely impact wildlife health (i.e. if ingested), degrade habitat conditions, and reduce the aesthetic quality of a particular location. In general, areas of trash and debris accumulation were not a problem in the Battleswamp Brook basin. Only two points of relatively small debris accumulation, one entirely organic in composition, were observed by volunteers.

Recommended Action:

- Obtain land owner permission to remove and properly dispose of the debris observed in Reach A-4 (A4-AOC6).

Degraded Buffers, Erosion, & Modified Channels

Areas of buffer degradation, modified channels, and erosion are often interrelated. For this program, buffer degradation was defined as the partial or complete removal of native vegetation from the land adjacent to the stream corridor. This natural vegetation is important wildlife habitat, and also serves a variety of critical functions in relation to stream health. Buffers assist with flood mitigation by detaining and absorbing floodwater and stormwater. They also provide shading which is critical to regulating stream temperature, and maintaining stream flow by protecting against evaporative losses and encouraging groundwater recharge. Finally, buffers protect stream water chemistry by serving as a barrier to slow or prevent sources of pollution such as stormwater and agricultural runoff, from entering the stream.

Degraded buffers, particularly those located on stream banks that are high and/or characterized by steep bank angles, often are associated with erosion. The root system of a healthy buffer provides stability to the stream bank and protects it against erosive forces, including gravity, precipitation, runoff, and the stream flow itself. This protection helps prevent the loss and downstream transport of sediment, which can degrade stream health by increasing turbidity and degrading both riparian and in-stream aquatic habitat conditions.

In some cases, buffer degradation does not necessarily lead to erosion because a channel modification was implemented at the site to protect the bank against erosion. Channel modifications, or alterations, are often commonly found in streams in agricultural and urban areas (or those areas that were previously agricultural or urban). Common modifications, which are often implemented for flood control purposes, include straightening, deepening, armoring (i.e. lining with riprap), or diverting the stream into an artificially lined (i.e. concrete) channel. Channel modifications can provide flood and erosion protection, but, unfortunately, have potential adverse impacts on stream health, most notably habitat loss. Improperly designed modifications can also inadvertently exacerbate flood issues downstream of the modification.

A total of twelve AOCs related to erosion (7), channel modification (1), and buffer degradation (4) were observed by streamwalk volunteers. The one point of channel modification observed was a small, localized section of the stream that appeared to have been a historical modification. Buffer degradation was most commonly observed as the replacement of native vegetation with lawn or turf grass. Three locations were observed were the lawn was maintained as turf down to the stream's edge. As noted above, replacing the natural buffer with turf grass eliminates the buffer's natural ability to mitigate stormwater and flood impacts by slowing and absorbing runoff before it enters the stream channel. In addition, turf is often treated with fertilizers and pesticides, which if not properly applied can be carried by runoff into the stream channel leading to undesirable algae growth and adverse impacts to aquatic wildlife.

Many of the points of erosion observed were relatively small, likely due to natural stream processes that occur in high walled, narrow valley streams in temperate climates. However, several points of significant erosion were observed in the most downstream section of the brook, near its confluence with the Shepaug River. Heavy flooding occurred in the spring of 2011 due to heavy rainfall falling on frozen ground early in the year and likely exacerbated existing points of erosion. These flood waters are a probable source of the sediment deposition observed at the mouth of the Battleswamp. Protecting, and restoring as needed, the stream's riparian buffer and discouraging further channel modifications will help minimize future stream impacts due to flooding and erosion (in both the Battleswamp and the downstream Shepaug River).

Recommended Actions:

- Review observed erosion-related AOCs, particularly those located near the mouth of the brook, with a qualified natural resource expert (e.g., NRCS, NW Conservation District, or CT DEEP staff). Determine if restoration efforts are necessary at any locations, and, if so, follow-up accordingly.

- Increase awareness of the importance of riparian buffers in protecting stream health and mitigating downstream flood impacts, and provide resources as appropriate regarding suggested landscaping alternatives. Work with interested land owners to implement buffer restoration projects at the identified AOC locations.

Stormwater Outfalls & Miscellaneous Pipes

Stormwater is one of the biggest threats to stream health in the Northeastern United States. As stormwater runoff moves over and through the ground, it picks up natural and human-made pollutants and eventually depositing them into nearby waterways. Stormwater-related pollutants include fertilizers, herbicides and insecticides from lawns and agricultural operations; oil, grease, toxic chemicals, road salt and sand from roads and parking lots; eroded sediment from construction activities; and bacteria and nutrients from livestock and pet wastes. Stormwater outfalls are pipe or channels that provide a direct connection from the source of the stormwater (often a paved surface such as a road, driveway or parking area), to a nearby water body, bypassing the natural filtration services provided by riparian buffers and upland vegetation.

Volunteers observed four AOCs related to stormwater outfalls and other miscellaneous pipes which may either discharge to or withdraw from the brook. Of these two were stormwater outfalls associated with a road or driveway, one appeared to provide overflow drainage from a nearby pond, and the last was of unknown origin and purpose. Notably, the drainage from the apparent pond overflow pipe was associated with an area of extensive unusual water conditions (i.e., rusty-red water and algal growth).

Recommended Actions:

- To minimize the impact of stormwater outfalls on the water quality of the brook, it is recommended that the committee review winter road treatment practices in the two basin towns to identify potential opportunities to minimize adverse stream health impacts due to the application of road salt, sand, and/or chemical deicers.
- Follow-up with the owner of the pond discharging to the brook to determine the cause of the unusual water conditions exiting the apparent overflow pipe. Identify potential opportunities to minimize the impact of the outflow on the brook.
- Determine ownership and use of the black pipe identified in survey area D.

Dams & Potential Fish Barriers

As long linear ecosystems, rivers and streams are particularly vulnerable to fragmentation and in-stream habitat alteration due to dams, culverts, and other potential fish barriers (e.g. large organic debris dams). The fragmentation of smaller tributaries in the region is of particular concern, as these streams often serve as vital thermal refuges for sensitive fish species, including native brook trout.

Most existing small (or 'low-head') dams and culverts were designed decades ago with little regard for ecosystem processes and needs. Today, small dams and culverts often serve as seasonal or year round barriers to the movement of aquatic organisms. Large debris dams can also effectively serve as barriers to aquatic organism passage. These naturally occurring dams develop when trees fall into or across the stream channel, causing a subsequent upstream buildup of organic material (e.g. leaf packs) and other debris.

Culverts in particular are of increasing concern. In Connecticut, the most common stream crossing problems include perched culverts, shallow water depth, excessive water velocity, and debris accumulation (CTDEP 2008). Perched culverts sit above the level of the stream bottom at the downstream end, making upstream passage difficult or impossible for fish and other aquatic organisms. Perching can result from either improper installation or from years of downstream bed erosion. Perched and incorrectly sized culverts can lead to low-flow and warm-water conditions, affecting fish spawning behavior and success, and reducing the overall habitat value of streams. Undersized crossings restrict natural stream flow, particularly during flood events, causing several problems, including scouring and erosion, high flow velocity, clogging and ponding. Similarly, shallow crossings have water depths too low for many organisms to move through and may lack appropriate bed material.

Dams and undersized culverts can not only serve as fish barriers, but can change the hydrology of a stream reach by causing stream impoundment and areas of localized stagnant water, leading to additional changes in water quality, including decreased oxygen levels. If not properly designed for current weather

patterns and stream hydrology, these obstructions can also create problems during storm events, leading to localized flooding and infrastructure damage.

Aquatic species are incredibly sensitive to changes in habitat and water quality conditions. Dams and culverts can even lead to a shift in the species composition and overall health of the aquatic community. Dam modification and properly redesigning culverts are proven, effective ecological restoration techniques that restore or enhance water quality, aquatic species habitat, and the overall health and success of fish populations, while also improving local flood preparedness, therefore minimizing economic losses due to storm events.

Dams and other potential barriers to fish passage were the most commonly reported area of concern during the 2011 Battleswamp Brook Streamwalk program. A total of 15 dams, culverts, and other potential in-stream barriers were documented. Only one debris dam was reported, a modest sized debris dam located in reach A-4. A total of six culverts were reported, including two small stream-trail crossings located in the most upstream portion of the unnamed tributary in Survey Area E. Two driveway culverts were documented, both of which appeared to be undersized with shallow flow. Two road culverts were also documented, including the Battleswamp Brook Road crossing, which appeared undersized, and the Route 199 culvert, which also appeared potential undersized in width. Eight rock wall dams were observed, one of which included a plastic lining along the length of the dam. These dams all appeared to severely restrict downstream streamflow and have resulted in an accumulation of sediment.

Recommended Actions:

- Monitor the debris dam observed in reach A-4. When possible it is best to allow naturally occurring debris dams to run their course. However, if the dam continues to grow, and becomes a flooding or safety hazard, it is recommended that the committee consult with the land owner and CT DEEP Inland Fisheries Division for recommendations for how to best modify or remove the dam.

- Restore natural in-stream flow patterns (and habitat continuity) by removing or modifying the stone dams/rock walls observed in Reach A6 (A6-AOC3), Reach D1 (D1-AOC3, D1-AOC5, D1-AOC6, and D1-AOC7), and Reach E1 (E1-AOC3, E1-AOC4, and E1-AOC6). Work with qualified experts (e.g. NRCS, CT DEEP) to ensure that removal or modification does not lead to excessive downstream sediment transport, as significant sediment accumulation was observed in association with each barrier.

- Work with local inland wetland commissions and landowners in the Battleswamp Brook basin and other nearby basins to encourage ecological considerations, specifically aquatic organism passage, during driveway culvert replacement projects. Proper culvert design will not only improve overall stream health, but can also better ensure that culverts are designed to accommodate future large storm events (which are expected to increase in frequency), and therefore avoid unnecessary economic losses.

- Work with the Town of Roxbury Public Works Department and Connecticut Department of Transportation to ensure that future culvert replacement projects better protect stream health. Consult with CT DEEP Inland Fisheries Division as needed for design guidance.

Unusual Water Conditions

Unusual water conditions, including unusual colors or odors, decreased clarity, cloudiness, increased turbidity, foam, oily sheens, and/or excessive algae and aquatic plant growth can arise from both natural and anthropogenic (i.e. human caused) sources. Because unusual water conditions can arise from natural sources as well as pollution, it is often difficult to determine whether the AOC indicates impairment. If conditions are found over a broad area and persist through various weather and flow conditions, follow-up study is strongly recommended.

Unusual Water Color

'Tea stained' or yellowish water conditions often occur when a stream passes through an area reach in soils with a high organic matter content. The natural decaying of leaves, which also releases humic acid, can cause 'tea stained' coloring as well.

'Rusty-red' or brownish water color is often associated with elevated iron levels. Iron sources may include natural sources such as iron-rich soils or decomposing organic matter, or anthropogenic sources, such as decaying older steel pipes. Bacterial breakdown of iron in water will produce an iron oxide deposit, easily identifiable by its bright orange, 'fuzzy' or slimy appearance. While aesthetically undesirable, these deposits are not toxic and not necessarily associated with pollution. In areas with iron rich soils, iron oxide deposition is exacerbated during period of low flows, when iron-rich groundwater becomes the main source of streamflow.

The reaches surveyed during the streamwalk were described by volunteers as predominantly clear or 'tea stained', which is within the range of conditions expected of healthy streams in the region. Five areas of 'rusty redness' and the corresponding 'fuzzy' appearance typical of iron oxide bacteria growth were recorded during the streamwalk. These AOCs were most often associated with low flow or stagnant water conditions and are likely the result of natural processes. Conditions could be improved, however, by removing or modifying any nearby in-stream barriers to flow, such as the rock walls noted in Reach E-1. The unusual water conditions recorded in C1-AOC1 appear to be associated with an apparently man-made pond observed to the right of the stream channel. There may be opportunity to modify to modify the outflow of the pond to improve downstream water conditions.

Recommended Actions:

- Restore natural flow patterns (and habitat continuity) by removing or modifying man-made in-stream barriers. Specifically, it is recommended, that the rock walls observed in Reach E-1 be opened within the stream channel to prevent ponding and restore a more continuous, natural flow pattern. It is also recommended that the culvert observed in Reach D-2 be evaluated to determine if it is appropriately sized. (An undersized culvert can result in back flowing water and ponding, which, in turn can cause lead to altered streamflow below the culvert.)

- Explore ownership and current use of the pond observed in C1-AOC1. The pond appears man-made. If it is no longer serving an active, the landowner may be willing to explore modifications to the outflow system to improve downstream water quality conditions and flow patterns.

Cloudiness, Foam, & Oily Sheens

Cloudiness or unusual color may be a result of natural processes or pollution from land use within the watershed. Water clarity, color, and turbidity may indicate elevated concentration of algae or suspended solids (either organic or inorganic). Algae, decomposing plant materials, sands, silts, and clays are some of the materials that may cause turbidity or color in a stream.

Foam, suds and bubbles can be an indicator of human pollution (e.g., waste water discharge or detergents), but also can result from similar natural processes as those that cause 'rusty red' water conditions. Natural foam is produced when organic matter decomposes, releasing fatty acids that act as surfactants. (Surfactants are also found in shampoos and dish soap; they cause a lather to develop.) These fatty acids are lighter than water and polarized, causing them to float on the surface of the water as a thin film. Turbulence from riffles or eddies in the stream or wind, can then cause the fatty acids to entrain small bubbles creating patches of foam. This foam will then accumulate when it hits a downstream barrier or a pool of slower moving water. A drier than usual winter and early spring can contribute to a buildup of natural factors that cause foam, suds or bubbles in the water. The easiest way to differentiate foam resulting from natural sources versus man-made sources in the field is to consider the smell of the foam. If the area has an earthy dirt or fishy smell it is likely due to natural processes. If the foam has a sweet or perfumed aroma, however, it may be the result of pollution.

Oily multicolored reflections on the water surface may indicate the presence of petroleum based products (e.g., gasoline, motor oil). However natural vegetation decay processes, particularly during low flow periods, can produce a similar sheen. Often a rainbow or blue oily sheen is associated with iron oxide bacterial growth.

Volunteers observed one area of cloudy water conditions in Reach C-3. The AOC appears to be associated with a small amount of algae growth and low flow conditions. Volunteers also documented two areas of foam within the basin. Review of the corresponding photographs, however, suggest that both the area of cloudiness and the areas of foam are relatively small in size and associated with areas of stagnant or obstructed flow. It is assumed that these AOCs are therefore natural in origin and do not warrant further follow-up. No oily sheens were reported by the survey teams.

Algae & Vascular Plant Growth

For the purpose of this survey, algae refer to all microscopic photosynthetic organisms including diatoms and blue-green algae. Algae, usually single celled and microscopic, sometimes occur in such abundance that they color the water and give it a distinctive odor. Green water is often an indicator of excessive green and blue-green algal growth, which is stimulated by excess nutrient inputs. These nutrient sources are typically human caused, such as runoff carrying fertilizers and animal wastes from adjacent lands. While algae are important food producers in the aquatic environment, when overabundant, their decay may deplete the oxygen in the water and cause "summer kills" of aquatic organisms (fish and macroinvertebrates).

Similar to algae, vascular aquatic plants generally have roots, stems, and leaves with tube-like conductive tissues that transfer food and water and aid in supporting the plant. Some vascular plants grow completely submerged, others are rooted in the bottom, but their leaves or flowers may be on or above the surface. Vascular plant growth can also be stimulated by excess nutrient inputs into the stream.

Volunteers documented three AOCs related to either algae or vascular plant growth. A6-AOC6 was an area of apparently heavily matted vascular plant root growth located between a roadway and a private residential property. C3-AOC2, which appears to contain a small amount of algal growth in an area of stagnant water in the stream channel, was previously mentioned as the AOC observed with slight cloudiness. Both of these AOCs appear to be associated with extreme low flow conditions. D1-AOC9 appears to contain an area of algal growth in a meander bend of the stream channel. Information provided about this AOC was limited, however, and it is difficult to confirm from the photograph provided whether the observed conditions are in fact algal growth.

Recommended Actions:

- Revisit A6-AOC6 and C3-AOC2 during higher flow periods, if possible. Observed conditions did not appear drastically impaired, and may be due to extreme low flow conditions. Both AOCs are associated with adjacent land uses that may contribute nutrient runoff to the stream channel (e.g., residential land, agricultural land). Explore opportunities to limit nutrient runoff within these reaches.

- Revisit D1-AOC9 if possible to confirm that the observed AOC was algal growth, and, if so, to better understand local site conditions.

Dry Stream Channels

The streamwalk was intentionally conducted during low flow conditions. It is not unexpected therefore that areas of low flow conditions were commonly reported in Survey Areas C, D, and E. However, it is potentially alarming that several areas of completely dry stream channel were observed in these survey areas, particularly in Survey Area C, which as the lowest reach in the watershed, would typically be expected to be carry higher water volumes than upper reaches. This streamwalk survey did not explore permitted diversions within the watershed, however, which, if present, may explain observed low flow conditions.

Recommended Actions:

- Review permitted diversions, if any, in the Battleswamp Brook basin. If applicable, work with permitted land owners to explore strategies to minimize stream impacts due to diversions during naturally low flow periods. If no permits exist within the basin, it is recommended that potential causes of low flow conditions (both natural and anthropogenic) be explored and an action plan developed, as appropriate.

References

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Connecticut Department of Environmental Protection (CTDEP). *Stream Crossing Guidelines*. February 26, 2008. Habitat Conservation & Enhancement Program, Inland Fisheries Division, Connecticut Department of Environmental Protection: Hartford, CT. 14 pp. Available online: http://www.ct.gov/dep/lib/dep/fishing/restoration/streamcrossingguidelines.pdf

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Appendix A: Field Data Sheets

CT-NRCS
Stream Assessment Sheet

Reach Level Assessment

Survey Basin Code:	Date(s):
Name of Stream:	Assessed By:
Reach Code:	
Designated Stream Type:	

Make All Observations Facing *Downstream*

Was the entire reach of stream surveyed? ☐ Yes ☐ No, Which section(s) were not surveyed? Why?

Channel Morphology: Mark the predominate condition(s), and indicate the average measurements.				
☐ Step-Pool	☐ Pool-Riffle	☐ Run	☐ Glide	*☐ Manipulated Channel (piped, lined, etc.)

Active Channel Width:	Glide Depth:
Riffle Depth:	Step Height:
Pool Depth:	Bank Height (Right Bank):
Run Depth:	Bank Height (Left Bank):

Substrate Composition: Mark approximate percentages for each substrate type observed.					
Silt or Clay	☐ <5%	☐ 5-25%	☐ 25-50%	☐ 50-75%	☐ >75%
Sand	☐ <5%	☐ 5-25%	☐ 25-50%	☐ 50-75%	☐ >75%
Gravel (0.1-2 inches)	☐ <5%	☐ 5-25%	☐ 25-50%	☐ 50-75%	☐ >75%
Cobble (2-10 inches)	☐ <5%	☐ 5-25%	☐ 25-50%	☐ 50-75%	☐ >75%
Boulder (>10 inches)	☐ <5%	☐ 5-25%	☐ 25-50%	☐ 50-75%	☐ >75%
Bedrock	☐ <5%	☐ 5-25%	☐ 25-50%	☐ 50-75%	☐ >75%

Describe Water Conditions: Mark all that apply.		
☐ Clear	☐ Stained ("iced tea")	*☐ Turbid (muddy / silty)
*☐ Green	*☐ Rusty-Red	*☐ Milky
*☐ Odors	*☐ Other (foam, dyes, chemicals)	

Aquatic Plants in Stream:			
Floating: (e.g. duck weed)	☐ Absent	☐ In Spots	*☐ Everywhere
Attached: (e.g. water lily)	☐ Absent	☐ In Spots	*☐ Everywhere

Algae in Stream:			
Floating: (e.g. planktonic)	☐ Absent	☐ In Spots	*☐ Everywhere
Attached: (e.g. filamentous)	☐ Absent	☐ In Spots	*☐ Everywhere

Area of Concern Worksheets
Indicate # and type of sheets completed for this reach assessment

Erosion_____
Fish Barrier_____
Storm Water Outfall_____
Modified Channel_____
Degraded Buffer_____
Trash / Debris_____
Unusual Water Conditions / Excessive Algae_____

Canopy Cover: Mark approximate percentage of stream covered by tree canopy.			
☐ >75% covered	☐ 75-50% covered	☐ 50%-25% covered	☐ < 25% covered

Note: Items marked with an asterisk (*) indicate a potential area of concern. Please record all relevant information on the appropriate Area of Concern Worksheet(s).

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January 2008

CT-NRCS
Stream Assessment Sheet

Reach Level Assessment

Riparian Vegetation: Characterize the average density of vegetation in the first 35 feet adjacent to the stream for both banks.						
	Left Bank	Right Bank	Left Bank	Right Bank	Left Bank	Right Bank
Turf Grass	☐ Low	☐ Low	☐ Moderate	☐ Moderate	☐ High	☐ High
Grass	☐ Low	☐ Low	☐ Moderate	☐ Moderate	☐ High	☐ High
Shrubs	☐ Low	☐ Low	☐ Moderate	☐ Moderate	☐ High	☐ High
Deciduous Trees	☐ Low	☐ Low	☐ Moderate	☐ Moderate	☐ High	☐ High
Coniferous Trees	☐ Low	☐ Low	☐ Moderate	☐ Moderate	☐ High	☐ High

Surrounding Land Use: Mark the dominate land use(s) for each "zone", if known or observed.					
Immediately adjacent to stream		**< ¼ Mile from stream**		**> ¼ Mile from stream**	
☐ Rural Residential	☐ Agricultural	☐ Rural Residential	☐ Agricultural	☐ Rural Residential	☐ Agricultural
☐ Suburban Residential	☐ Forested	☐ Suburban Residential	☐ Forested	☐ Suburban Residential	☐ Forested
☐ Urban Residential	☐ Recreational	☐ Urban Residential	☐ Recreational	☐ Urban Residential	☐ Recreational
☐ Industrial	☐ Other	☐ Industrial	☐ Other	☐ Industrial	☐ Other
☐ Commercial		☐ Commercial		☐ Commercial	

Areas of Concern Checklist: Marking "Yes" to any of the following questions indicates that an Area of Concern Worksheet should be filled out for the appropriate concern. For each occurrence observed, complete and area of concern sheet.		
Is there evidence of either stream bank erosion or streambed instability within the reach?	☐ Yes	☐ No
Are there any dams or any other possible natural or artificial barriers to fish migration?	☐ Yes	☐ No
Are there any storm water outfalls, discharge pipes or discharges within the reach? Indicate the number observed:_____.	☐ Yes	☐ No
Is there any portion of the channel that has been modified (not culvert) (channeled, piped, rip rap)?	☐ Yes	☐ No
Is there any portion of the reach where the riparian buffer has been compromised or is nonexistent?	☐ Yes	☐ No
Is there any portion of the reach that contains trash or other debris (cars, appliances, construction waste)?	☐ Yes	☐ No
Is there any portion of the reach that has a change in water conditions?	☐ Yes	☐ No

Notes: Use the space provided to record important observations otherwise not captured on the Reach Assessment Sheet or the Areas of Concern Worksheets.

CT – NRCS
Stream Assessment Worksheet

Erosion Assessment

Survey Basin Code:	Date:
Name of Stream:	Assessed By:
Reach Code:	
Designated Stream Type:	
Site ID:	

Make All Observations Facing *Downstream*

Location of Bank Erosion: 1) Mark and label the location of the erosion on the **map**. 2) Briefly describe the location of the site relative to roads or other landmarks.

Mark where erosion is occurring:

☐ Meander Bend	☐ Straight Section	☐ Steep Slope/Valley Wall	☐ Other

Site Dimensions: Indicate all applicable measurements associated with the erosion site		
Length:	Left Bank: ft.	Right Bank: ft.
Bank Height:	Left Bank: ft.	Right Bank: ft.
Bank Angle:	Left Bank: deg.	Right Bank: deg.

What is the proximity of the erosion site to infrastructure (e.g. road, bridge, building, etc.)**?**

☐ < 15 ft.	☐ 15 - 30 ft	☐ 30 - 45 ft	☐ 45 – 60 ft	☐ 60 - 100 ft	☐ > 100 ft.

Immediately Adjacent Land Use: Mark the land use(s) immediately adjacent to the erosion site.

☐ Rural Residential	☐ Urban Residential	☐ Commercial	☐ Forested
☐ Suburban Residential	☐ Industrial	☐ Agricultural	☐ Recreational

Land Ownership: Mark land ownership at the location of the erosion site.

☐ Public	☐ Private	☐ Unknown

Existing Width of Riparian Vegetation: Mark the average width of riparian vegetation at the erosion site.

☐ < 15 ft.	☐ 15 – 35 ft.	☐ 35 – 50 ft.	☐ 50 – 100 ft	☐ > 100 ft

Notes: Use the space provided to record important observations otherwise not captured on this sheet.

CT – NRCS
Stream Assessment Worksheet

Fish Barrier

Survey Basin Code:	Date:
Name of Stream:	Assessed By:
Reach Code:	
Designated Stream Type:	
Site ID:	

Make All Observations Facing ***Downstream***

Location of Barrier: Mark and label the location of the barrier on the **map** and provide a brief description of the location of the barrier relative to roads or other landmarks.

Type of Barrier: Mark the type of fish barrier.

☐ Dam	☐ Culvert	☐ Velocity Barrier	☐ Other

Dam Data: Provide all relevant data.

Height of Dam: ft.	**Length of Spillway:** ft.	**Shape of Spillway:** ☐ Straight ☐ Crescent		
Materials:	☐ Stone	☐ Concrete	☐ Stone & Concrete	☐ Timber-Crib ☐ Other
Is there other infrastructure associated with the Dam? ☐ No ☐ Yes (If yes mark the type below)				
☐ Factory	☐ Hydro Facility	☐ Mill	☐ Residence	☐ Other

Culvert Data: Provide all relevant data.

Type of Culvert:	☐ Box	☐ Pipe	☐ Pipe-Arch	☐ Arch
Culvert Material:	☐ Concrete	☐ Corrugated Metal	☐ Plastic	☐ Stone
Culvert Outlet:	☐ Perched:……_____ft.	☐ Ramped	☐ Submerged	
Culvert Size:	Diameter: ft.	Height: ft.	Width: ft.	
# of Culverts:	**Culvert Length:** ft.			

Velocity Barrier Data: Provide all relevant data.

Nature of Barrier:	☐ Grade Control Sill	☐ Concrete Apron	☐ Channel Cross-Section	☐ Other
Length of Barrier: ft.	**Approx. Vertical Rise:** ft.			

Notes: Use the space provided to record important observations otherwise not captured on this sheet.

CT – NRCS
Stream Assessment Worksheet

Storm Water Outfall

Survey Basin Code:	Date:
Name of Stream:	Assessed By:
Reach Code:	
Designated Stream Type:	
Site ID:	

Make All Observations Facing ***Downstream***

Location of Outfall: ☐ Right Bank ☐ Left Bank Mark and label the location of the outfall on the **map** and provide a brief description of the location of the outfall relative to roads or other landmarks.

Outfall Type:	☐ Pipe	☐ Leak Off	☐ Channel	
Flow:	☐ None	☐ Trickle	☐ Moderate	☐ Substantial
Odor:	☐ None	☐ Sewage	☐ Rancid / Sour	☐ Sulfur (rotten eggs)
Deposits / Stains	☐ None	☐ Sediment Delta	☐ Oily Stain	☐ Black
Benthic Growth	☐ None	☐ Brown	☐ Green	☐ Orange

Pipe Data: Provide all relevant data.

Pipe Material:	☐ Concrete	☐ Corrugated Metal	☐ Plastic	☐ Other
Contributing Source(s):	☐ Road	☐ Parking Lot	☐ Other	☐ Unknown
Pipe Outlet:	☐ Perched……_____ft.	☐ Ramped	☐ At Stream Level	
Pipe Size:	Diameter: ft.			
# of Pipes:	☐ 1	☐ 2	☐ 3 +	

Leak-Off Data: Provide all relevant data.

Leak-Off Swale:	☐ Concrete	☐ Asphalt	☐ Stone	☐ Earthen
Contributing Source (s):	☐ Road	☐ Parking Lot	☐ Recreational Field	☐ Other
Length of Swale: ft.				
Width of Swale: ft.				

Channel Data: Provide all relevant data.

Channel Material:	☐ Concrete	☐ Asphalt	☐ Stone	☐ Earthen	
Contributing Source (s):	☐ Road	☐ Parking Lot	☐ Recreational Field	☐ Other	☐ Unknown
Channel Length: ft.					
Channel Width: ft.					

Notes: Use the space provided to record important observations otherwise not captures on this sheet.

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January 2008

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Stream Assessment Worksheet

Storm Water Outfall

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January 2008

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Stream Assessment Worksheet

Modified Channel

Survey Basin Code:	Date:
Name of Stream:	Assessed By:
Reach Code:	
Designated Stream Type:	
Site ID:	

Make All Observations Facing *Downstream*

Location / Extent of Modified Channel: Mark and label the location of the modified channel on the **map** and provide a brief description of the location of the channel section relative to roads or other landmarks.

Mark where channel modification occurs:

☐ Meander Bend	☐ Straight Section	☐ Steep Slope/Valley Wall	☐ Other

Estimate length of channel modification: ft.

Estimate height of bank modification: ft.

Type of Manipulation:	☐ Channelization	☐ Bank Armoring	☐ Concrete Channel	☐ Other	
Extent of Manipulation:	☐ Right Bank	☐ Left Bank	☐ Channel Bottom		
Channel / Bank Materials:	☐ Natural	☐ Rip Rap	☐ Concrete	☐ Gabions	☐ Metal

Immediately Adjacent Land Use: Mark the land use(s) immediately adjacent to the modified section.

☐ Rural Residential	☐ Urban Residential	☐ Commercial	☐ Forested
☐ Suburban Residential	☐ Industrial	☐ Agricultural	☐ Recreational

Existing Width of Riparian Vegetation: Mark the average width of riparian vegetation to the modified section.

☐ < 15 ft.	☐ 15 – 35 ft.	☐ 35 – 50 ft.	☐ 50 – 100 ft	☐ > 100 ft

Is there a change in the average width of the active channel?	☐ Yes / Estimate Width: ft	☐ No
Is there evidence of sediment deposition in the channel?	☐ Yes	☐ No
Is the channel connected to a floodplain?	☐ Yes	☐ No

Notes: Use the space provided to record important observations otherwise not captures on this sheet.

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Stream Assessment Worksheet

Modified Channel

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Stream Assessment Worksheet

Degraded Buffer

Survey Basin Code:	Date:
Name of Stream:	Assessed By:
Reach Code:	
Designated Stream Type:	
Site ID:	

Make All Observations Facing *Downstream*

Location / Extent of Degraded Buffer: 1) Mark and label the location of the degraded buffer on the **map**. 2) Briefly describe the location of the site relative to roads or other landmarks.

Mark where the degraded buffer occurs.

☐ Meander Bend	☐ Straight Section	☐ Steep Slope/Valley Wall	☐ Other
☐ **Left Bank**		Estimate length of degraded buffer: ft.	
☐ **Right Bank**		Estimate length of degraded buffer: ft.	

Type of Degradation:				
Left Bank:	☐ Minimal Vegetation	☐ Minimal Width	☐ Invasive Plants	☐ Other
Right Bank:	☐ Minimal Vegetation	☐ Minimal Width	☐ Invasive Plants	☐ Other

Dominate Land Cover	Paved	Bare Ground	Turf / Lawn	Tall Grass	Scrub / Shrub	Trees	Other
Left Bank	☐	☐	☐	☐	☐	☐	☐
Right Bank	☐	☐	☐	☐	☐	☐	☐

Immediately Adjacent Land Use: Mark the land use(s) immediately adjacent to the modified section.				
Left Bank:	☐ Rural Residential	☐ Urban Residential	☐ Commercial	☐ Forested
	☐ Suburban Residential	☐ Industrial	☐ Agricultural	☐ Recreational
Right Bank:	☐ Rural Residential	☐ Urban Residential	☐ Commercial	☐ Forested
	☐ Suburban Residential	☐ Industrial	☐ Agricultural	☐ Recreational

Existing Width of Riparian Vegetation: Mark the average width of riparian vegetation to the modified section.					
Left Bank:	☐ < 15 ft.	☐ 15 – 35 ft.	☐ 35 – 50 ft.	☐ 50 – 100 ft	☐ > 100 ft
Right Bank:	☐ < 15 ft.	☐ 15 – 35 ft.	☐ 35 – 50 ft.	☐ 50 – 100 ft	☐ > 100 ft

Notes: Use the space provided to record important observations otherwise not captures on this sheet.

CT – NRCS
Stream Assessment Worksheet

Trash / Debris

Survey Basin Code:	Date:
Name of Stream:	Assessed By:
Reach Code:	
Designated Stream Type:	
Site ID:	

Make All Observations Facing *Downstream*

Location / Extent of Trash or Debris: Mark and label the location of the trash or debris on the **map** and provide a brief description of the location relative to roads or other landmarks.

☐ Within Stream	☐ Riparian Area: ☐ Left Bank ☐ Right Bank

Type:	☐ Residential	☐ Commercial	☐ Industrial	
Material:	☐ Plastic ☐ Paper ☐ Yard Waste	☐ Tires ☐ Metal ☐ Construction	☐ Appliances ☐ Automotive ☐ Medical	☐ Other
Source:	☐ Unknown	☐ Flooding	☐ Illegal Dumping	☐ Local Outfall
Land Ownership:	☐ Private	☐ Public	☐ Unknown	

Notes: Use the space provided to record important observations otherwise not captures on this sheet.

CT – NRCS
Stream Assessment Worksheet

Unusual Water Conditions /
Excessive Plant or Algae Growth

Survey Basin Code:	Date:
Name of Stream:	Assessed By:
Reach Code:	
Designated Stream Type:	
Site ID:	

Make All Observations Facing *Downstream*

Location / Extent of Visual Water Conditions and/or Excessive Plant or Algae Growth: 1) Mark and label the location on the **map**. 2) Briefly describe the location of the site relative to roads or other landmarks.

Immediately Adjacent Land Use: Mark the land use(s) immediately adjacent to the modified section.			
☐ Rural Residential	☐ Urban Residential	☐ Commercial	☐ Forested
☐ Suburban Residential	☐ Industrial	☐ Agricultural	☐ Recreational

Describe Water Conditions: Mark all that apply.			
☐ Clear	☐ Stained (“iced tea”)	☐ Turbid (muddy / silty)	☐ Odors
☐ Green	☐ Rusty-Red	☐ Milky	☐ Other (foam, dyes, chemicals)

Canopy Cover: Mark approximate percentage of stream covered by tree canopy.			
☐ >75% covered	☐ 75-50% covered	☐ 50%-25% covered	☐ < 25% covered

Aquatic Plants in Stream:			
Floating: (e.g. duck weed)	☐ Absent	☐ In Spots	☐ Everywhere
Attached: (e.g. water lily)	☐ Absent	☐ In Spots	☐ Everywhere

Algae in Stream:			
Floating: (e.g. planktonic)	☐ Absent	☐ In Spots	☐ Everywhere
Attached: (e.g. filamentous)	☐ Absent	☐ In Spots	☐ Everywhere

Is the change in water condition or excessive plant / algae growth located at or directly below a storm water outfall?	☐ Yes	☐ No
Is the change in water conditions or excessive plant / algae growth associated with a change in channel dimensions (depth & width)?	☐ Yes	☐ No
Is the change in water conditions or excessive plant / algae growth associated with an impoundment / dam on the stream?	☐ Yes	☐ No

Notes: Use the space provided to record important observations otherwise not captures on this sheet.

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January 2008