

**Phase 1
Stream Geomorphic Assessment
Blood Brook Watershed
Norwich, Vermont**

**Prepared by
The Two Rivers-Ottawaquechee Regional Commission
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Phase 1 Stream Geomorphic Assessment Blood Brook Watershed

EXECUTIVE SUMMARY

- A Phase 1 Stream Geomorphic Assessment of the Blood Brook and its major tributaries within the Town of Norwich was completed by Two Rivers-Ottawaquechee Regional Commission (TRORC) during 2006. The study followed the Phase 1 assessment protocol developed by the Vermont Agency of Natural Resources. Information for the study came from the Vermont Department of Environmental Conservation, the Vermont Mapping Program, the Vermont Center for Geographic Information, the Town of Norwich and a windshield survey conducted by TRORC.
- The study area included the Blood Brook, from West Norwich to the confluence with the Connecticut River, Charles Brown Brook along Beaver Meadow Road, Bragg Brook along Bragg Hill Road, the New Boston Brook along New Boston Brook, and an unnamed tributary on Upper Turnpike and Needham Roads. The study reach was divided into 30 reaches based on confinement, slope, soils, and tributary influence.
- A rapid assessment of stream crossings was conducted during May 2006 in the Town of Norwich. The objective of the study was to identify structures that are potential barriers to fish and wildlife and/or are flood or erosion hazards. Most of the public structures inventoried were installed near or at grade allowing for aquatic organism passage and were squish tube type culverts or box culverts that matched the channel shape relatively well. Most public structures were approximately 50 to 65% of bankfull. A majority of the private structures were deficient between 35 to 50% of bankfull.
- Of the four impact categories measured during the Phase 1 Assessment, land use and floodplain modification were the primary categories identified as being at risk of causing channel adjustments.
- The meander migration, meander width ratio, and meander wavelength indicate the lower reaches (M02, M03 and M04) of Blood Brook are in adjustment. Based on the review of current and historical orthophotos, meander migration was evident in reaches M03 and M04.
- Four reaches received poor condition rating. These were the three lowest reaches of Blood Brook above I-91 and the first reach of New Boston Brook. Reaches in reference condition were found in the headwaters and all were A or C type streams.
- Two Rivers-Ottawaquechee Regional Commission recommends a Phase 2 Assessment of reaches M03 through M09 on the main stem, all of Bragg Brook and the lowest reach on Charles Brown and New Boston Brooks.

Phase 1 Stream Geomorphic Assessment Blood Brook Watershed

1. INTRODUCTION

The Two Rivers-Ottawaquechee Regional Commission (TRORC) received funding from the Vermont Agency of Natural Resources (ANR) Clean and Clear Capital Fund to conduct a Phase 1 Stream Geomorphic Assessment of the Blood Brook Watershed in the Town of Norwich, including a Bridge and Culvert Survey. The ANR Clean and Clear grant was combined with funding for predisaster mitigation planning that TRORC received from Vermont Emergency Management. The Phase 1 windshield survey and the Bridge and Culvert Survey were conducted in May 2006, by Peter Fellows and Sally Mansur of TRORC, with assistance from Jonathan Frishtick of Norwich.

The study area for the Phase 1 Assessment included the Blood Brook main stem through the Town of Norwich including Charles Brown Brook, Bragg Brook, New Boston Brook, and an unnamed tributary along Needham Road. The primary objectives of the Phase 1 study were to provide data on bridges and culverts for the Town of Norwich's infrastructure planning, inventory the general physical characteristics of the Blood Brook watershed, and to select reaches to be included in a Phase 2 Assessment. The Phase 2 Assessment would then be used to provide the Town of Norwich, the Regional Planning Commission, and the ANR River Management Program with information that can be used for fluvial erosion hazard mapping and planning and restoration recommendations.

A geomorphic and habitat assessment of stream crossings was conducted within the Town of Norwich following ANR Bridge and Culvert Assessment and Survey Protocols (April 2005). The assessment results were entered into the ANR Stream Geomorphic Assessment Data Management System (DMS). The objective of the study was to red-flag structures that are potential barriers to fish and wildlife movement and/or are flood or erosion hazards. A total of 16 bridges, 27 culverts and 2 arches on state and town roads and private driveways were evaluated.

2. BACKGROUND

The Blood Brook has a total watershed size of 18.5 square miles and is located in the Town of Norwich. This watershed is part of basin 16 or the Upper Connecticut River subwatershed. There are no USGS stream gages within the Blood Brook watershed. The Norwich Conservation Commission has collected 2004 and 2005 discharge data for the spring through fall. Several landowners encountered during the field assessment remembered the 1973 flood in Norwich but did not comment on any other flood events.

3. METHODS & DATA

The Phase 1 assessment followed procedures specified in the Vermont Stream Geomorphic Assessment Phase 1 Handbook (Vermont Agency of Natural Resources, March 2006), and used version 4.53 of the Stream Geomorphic Assessment Tool (SGAT) GIS extension with Feature Index Tool (FIT). All assessment data were recorded in the online ANR Stream Geomorphic Assessment database management system.

The Phase 1 assessment used 1:5000 Vermont Hydrography Data for surface waters, 2002 LCLU data from VCGI based on LANDSAT ETM data, Windsor County soils data, and the HYDRODEM data for elevations and valley slope from VCGI (NED and VMP breaklines with VHD). For orthophotography, the staff used paper 1975 (printed series 1978) and digital 1994 Vermont Mapping Program 0.5m black and white orthophotography for historic meander comparison. Staff used 2004 USDA-NAIP 1m color orthophotography for assessing characteristics such as buffers and development.

The Bridge and Culvert Assessment and Survey Protocols specified in Appendix G of the Vermont Stream Geomorphic Assessment Handbook (Vermont Agency of Natural Resources, April 2005) were followed. All assessment data were recorded on the ANR Bridge and Culvert Assessment – Geomorphic & Habitat Parameters data sheet, and were entered into online Stream Geomorphic Assessment structures portion of the database management system.

The bankfull channel width was measured upstream of each structure where depositional features were available. Areas with high bank heights, straightened areas and areas without depositional features used the 2006 Vermont Regional Hydraulic Geometry Curves to calculate bankfull. The assessment included photo documentation of the inlet, outlet, upstream, and downstream of each of the structures as well as any nearby erosion features.

4. PHASE 1 ASSESSMENT RESULTS

A. Reach Descriptions

The Blood Brook was divided into 30 reaches for the Phase 1 Assessment, totaling 14.2 river miles in length. The following is a description of each reach, including the reach locations generated from SGAT. Figure 1 shows the location of study reaches used in the Phase 1 Assessment. Each point represents the downstream end of the reach. Phase 1 reaches are defined according to significant tributary intersections and valley confinement. The three tributaries were selected because of they had largest drainage area of the mainstem tributaries.

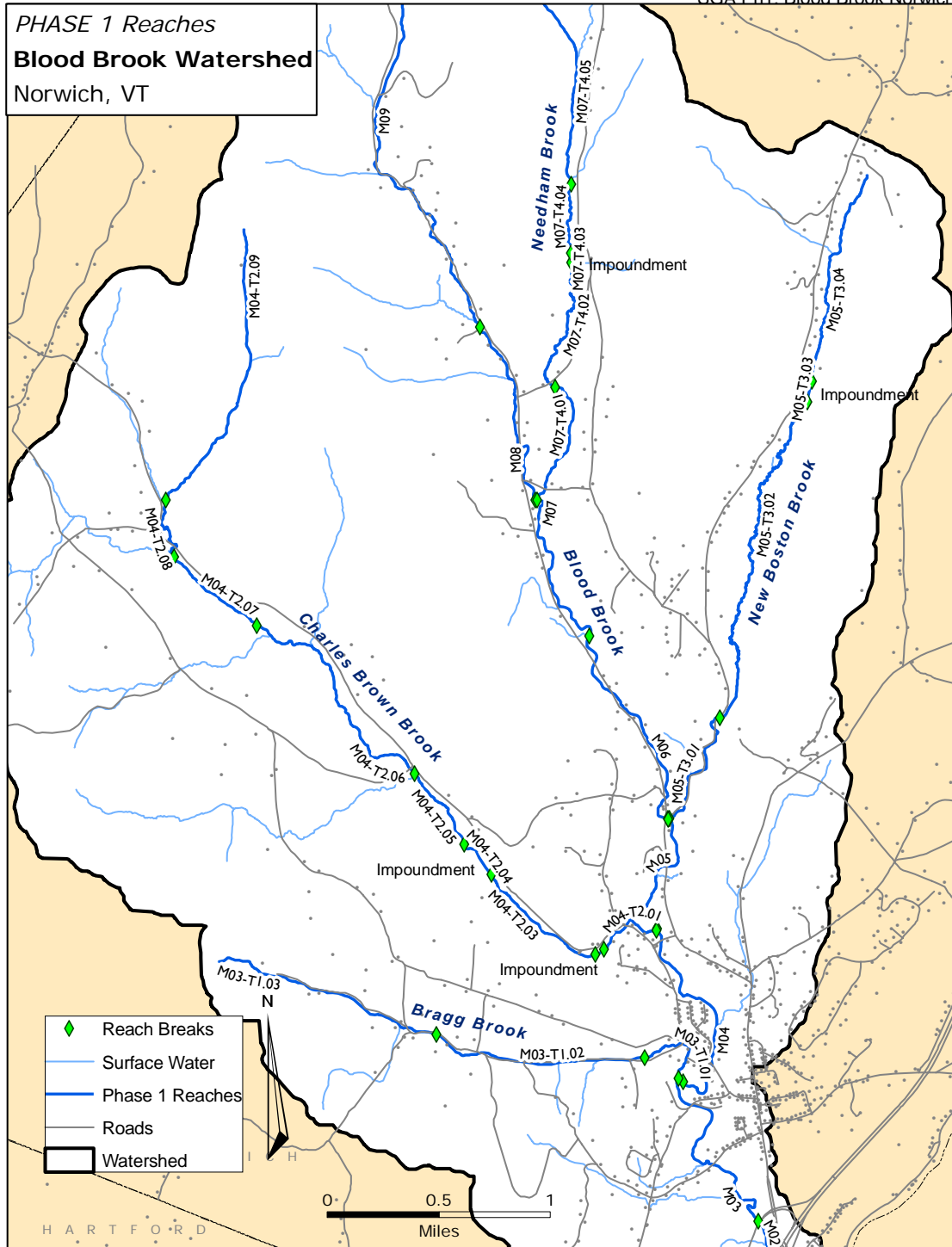


Figure 1 – Study reaches

Blood Brook main stem:

Reach M01 runs from the mouth of Blood Brook at the confluence with the Connecticut River, just to the northeast of the Montshire Museum, to Interstate 91. The reach is 0.36 mile in length and simply consists of an inundation pool from the Wilder Dam pool on the Connecticut. This reach was excluded.

Reach M02 is a valley bottom reach that is highly channelized, and is 0.30 miles in length. Its beginning is characterized by a 250' long concrete arch with a bedrock stepped bottom that acts as a grade control. The top of the reach is a 70' long box culvert that passes underneath US 5.

Reach M03 is 1.06 miles in length, is a highly developed reach, and includes large hay fields. These fields are the largest area of agricultural activity within the river corridor. It starts in a floodplain forest above Route 5 that consist of eroding banks and several meanders and dog legs and passes recently retired hay fields on the right bank. It travels under Elm Street at the site of an old mill and a large complex of grade controls consisting of a waterfall, the bridge constriction with bedrock walls and a smaller ledge grade control above the bridge. There is a large stretch of flat farmland below Brookside Drive on both banks of this reach with active haying right up to the edge of the left bank below Brookside Drive. At Hopson Road, there is another ledge complex below the bridge constriction and a small waterfall above the bridge. The reach then continues through a highly confined portion to the confluence with Bragg Brook

Reach M04 is 1.05 miles long and highly developed. It runs from just above the confluence with Bragg Brook to just above the confluence with Charles Brown Brook. It goes north through the outskirts of Norwich Village, from Hillside Cemetery to just above Moore Lane, and is bordered on the east by recreation fields and on the west by residential development and road embankments.

Reach M05 starts from just above the confluence with Charles Brown Brook, and follows Turnpike Road to New Boston Road intersection and New Boston Brook confluence. It is 0.63 miles long and highly developed. It includes a large bank failure at Sun Lion Drive and Turnpike Road.

The remaining reaches on the Blood Brook main stem follow Turnpike Road to the height of the land in the watershed. Reach M06 begins at New Boston Brook confluence and ends just below Norwich Farms, a small demonstration dairy farm. Again, this reach is highly developed, measuring 1.03 miles.

Reach M07 continues from Norwich Farms, to the intersection with Upper Turnpike Road. It is 0.83 miles long and is residentially developed.

Reach M08 begins at the confluence of the unnamed tributary that follows Needham Road and ends at the intersection with Old Orchard Lane. A developed reach, it measures 0.93 miles in length.

Reach M09, the uppermost reach on the main channel, is wooded and has several structures on it. This reach is 2.32 miles in length, beginning above Old Orchard Lane and ending south of the Gile Mountain parking lot. There is wetland and/or beaver pond with dam about 0.75 miles from the start of Blood Brook.

Bragg Brook

Reach M03-T1.01 on this brook is very heavily developed and measures 0.39 miles. It flows behind a group of condominiums, following Dutton Hill and Bragg Hill Roads.

Reach M03-T1.02 is 0.98 miles long, steeper, and confined, mostly undeveloped and wooded. This reach follows Bragg Hill Road to just below where Happy Hill Road joins the road.

Reach M03-T1.03 is open and more developed than the lower reach, measuring 1.09 miles. It begins just below Cossingham Road and follows Happy Hill Road at a lower slope than the previous reach.

Charles Brown Brook

Reach M04-T2.01 on this brook begins at Brigham Hill and Beaver Meadow Roads, just below the Norwich Fire District swimming pond. This reach is highly developed but fairly open, measuring 0.33 miles and includes an small grade control.

Reach M04-T2.02 comprises the Norwich Fire District swimming pond and was excluded from this assessment.

Reach M04-T2.03 begins above the NFD pond and is 0.63 miles long, ending at the dam below the old NFD impoundment. This reach is slightly developed and fairly wooded, traveling through a steep ravine.

Reach M04-T2.04 comprises the NFD fire impoundment and was excluded from this assessment.

Reach M04-T2.05 begins above the NFD impoundment and continues to the abandoned bridge at Brown Schoolhouse Road. It is more heavily wooded and confined. It measures 0.42 miles and runs parallel along Beaver Meadow Road.

Reach M04-T2.06 begins just above the abandoned Brown Schoolhouse Road bridge and travels 1.16 miles upstream, more or less along Beaver Meadow Road. It is a wooded, highly confined reach.

Reach M04-T2.07 runs parallel to Beaver Meadow Road, extending to where the land opens up below Tucker Hill Road. A wooded reach, it is 0.5 miles in length.

Reach M04-T2.08 crosses Beaver Meadow Road and passes through the open area around Tucker Hill Road. It is 0.35 miles long.

Reach M04-T2.09, the topmost reach on this tributary, is 1.39 miles long and departs the roadside, traveling through forest entirely.

New Boston Brook

Reach M05-T3.01 of this brook is highly confined, beginning at the confluence with the Blood Brook main stem and winding around New Boston Road, past the town transfer station, to where the land opens up into lawns and fields. It is 0.63 miles long. The locals call this reach the Crooked Half Mile and it includes two large bank failures.

Reach M05-T3.02 is open and runs through lawns and fields for 1.89 miles, parallel to New Boston Road, but a fair distance from the road throughout the reach.

Reach M05-T3.03 encompasses a large pond and was excluded from this assessment.

Reach M05-T3.04 begins above an impoundment and travels to Meetinghouse Road, 1.06 miles upstream. The stream passes through open marshes and swamps and is highly developed with several driveway crossings.

Unnamed Tributary to Blood Brook (Needham Brook)

Reach M07-T4.01 begins at the confluence with the main stem and stretches to below the culvert crossing on Needham Road, 0.62 miles.

Reach M07-T4.02 begins at Needham Road, following that road, and ends at a pond just above the Needham Road/Upper Turnpike Road intersection. The reach is 0.73 miles long.

Reach M07-T4.03 encompasses a private pond and was excluded from this assessment.

Reach M07-T4.04 begins just above the impoundment and stretches for 0.36 miles close to Upper Turnpike Road.

Reach M07-T4.05 travels through a forest for 1.33 miles.

B. Bed and Bank Windshield Survey

The dominant bed form, dominant bank material, bank erosion/bank height, and debris/ice jam potential were recorded during the windshield survey to the greatest extent possible. Staff did not walk each entire reach during the windshield survey. Staff walked upstream and downstream from stream crossing structures. Consequently, features in the middle of reaches between the stream crossing structures may have been missed.

Bank Erosion

The amount of bank erosion observed along a reach and the bank height were evaluated in conjunction with each other to provide a bank erosion impact rating.

Bank erosion was rated as *low* in nine of 25 included reaches, and *not significant* in 12 reaches. Bank erosion was *high* in four reaches, M03, M05 and M06 on the main stem, and in the lowest reach on New Boston Brook, M05-T3-01.



Figure 2 – Typical Bank Erosion in the Blood Brook Watershed at confluence of Beaver Meadow Brook and Mainstem

A 35' bank failure was visible just below Sun Lion Drive on M05 and two smaller 20' failures were visible along the Crooked Half Mile on the first reach of New Boston Brook (M05-T3.01). M05 is heavily armored above the bridge just above Sun Lion Drive and is experiencing significant erosion above the confluence with Charles Brown Brook at a dog leg. Agricultural field bank erosion was visible along M03 with bank erosion heights at 8' near US 5 in the dog leg and floodplain forest area and along an abandoned hay field just above this area. At the next sets of fields that are still being actively hayed below Hopson Rd and Brookside Drive, the bank heights were approximately 2' to 3'. M06 had high banks on the especially on the right side and is more confined than M07 and M05 as it approaches the confluence with New Boston Brook. This reach is experiencing bank erosion along the steep valley walls and before stream crossing structures.

Debris/Ice Jam Potential

Stream crossing structures with widths less than half of the channel width, upstream sediment deposits, poor structure location or alignment, and inlet obstruction were the primary factors associated with potential for ice and debris jams. These structures, which are likely to cause constrictions during high flow events may result in lateral erosion or channel avulsions or may even endanger infrastructure.

36 of the 43 structures evaluated during the bridge and culvert assessment had culvert diameters or bridge spans which were less than the bankfull channel width. Of these 36 structures, 12 culverts were less than 50% of the bankfull width. Overall, many of the town structures assessed were installed slightly above or at grade facilitating organism passage and were greater than 50% of bankfull width. Only eight town structures were less than 50% of bankfull width and seven of these were on the tributaries with the other one on the last mainstem reach M09.

Based on the windshield survey, 11 reaches received an impact rating of *low* for debris/ice jam potential, and five reaches received a *high* impact rating. The reaches given a *high* impact rating are M03, M08 and M09 on the main stem, the middle reach on Bragg Brook (M03-T1.02), and the lowest reach on New Boston Brook (M05-T3.01).

On reach M03, both of the bridges on this reach at Elm and Hopson Streets are 131% and 83% of bankfull width respectively. Both of these bridges are not skewed to the roadway significantly and are part of bedrock grade control complex above and below each structure. The landowner below the Elm Street grade control has noticed more debris coming down over the past few years but has never seen a jam at Elm Street, noting that the power of the river over the waterfall always sweeps the debris away. M08 has three private undersized culverts ranging from 43% to 32% of bankfull at and below Orchard Lane. M09 and the first reach on New Boston Brook (M05-T3.01) both have a set of four structures within a half mile. On M09, these four structures heading downstream have percentages of bankfull width at 56%, 61%, 61%, and 42%. On M05-T3.01, the first structure on the reach near the confluence is an arch with a natural bottom at 55% of bankfull width followed by a box culvert and two bridges that are at or all above 50% of bankfull width on the narrowly confined Crooked Half Mile. Bragg Brook (M03-T1.02) is a semi-confined reach and becomes more confined on the lower portion. The road includes five standard culverts as well as one large new stepped bed box culvert. With the exception of the box culvert all of these structure's bankfull width ranges from 33% to 48%.

C. Stream Typing

Reference stream types are defined as stream channel forms and processes that would exist in the absence of human-related changes to the channel, floodplain, and/or watershed. Stream and valley characteristics including valley confinement and slope gathered with the SGAT tool were used to determine the stream type. The reference reach characteristics were later refined during the windshield survey. Reference reach

typing was based on both the Rosgen (1996) and the Montgomery and Buffington (1996) classification systems.

The reference stream types, based on the Phase 1 Geomorphic Assessment are shown in Table 1. A few of the reaches in the upper part of the watershed were not easily accessible and were not visited during the windshield survey. Bed forms (e.g. step-pool, plane bed) were assigned using the Reference Stream Typing Chart (Table 2.2) found in the Phase 1 protocols. Streams type and bedform were not reclassified based on field observation in this Phase 1 assessment as the Phase 2 assessment was scheduled to follow within a month.

Table 1 – Stream Typing

<i>Reach</i>	<i>Confinement</i>	<i>Type</i>	<i>Bedform</i>
M02	NW	B	Plane Bed
M03	VB	C	Riffle-Pool
M03-T1.01	SC	B	Step-Pool
M03-T1.02	NC	A	Step-Pool
M03-T1.03	NC	A	Step-Pool
M04	VB	C	Riffle-Pool
M04-T2.01	SC	B	Step-Pool
M04-T2.03	NW	B	Plane Bed
M04-T2.05	NW	B	Plane Bed
M04-T2.06	NW	B	Plane Bed
M04-T2.07	NC	A	Step-Pool
M04-T2.08	VB	C	Riffle-Pool
M04-T2.09	NC	A	Step-Pool
M05	VB	C	Riffle-Pool
M05-T3.01	NW	B	Step-Pool
M05-T3.02	VB	C	Riffle-Pool
M05-T3.04	VB	C	Riffle-Pool
M06	NW	B	Plane Bed
M07	VB	C	Riffle-Pool
M07-T4.01	NW	B	Plane Bed
M07-T4.02	VB	C	Riffle-Pool
M07-T4.04	VB	C	Riffle-Pool
M07-T4.05	NC	A	Step-Pool

Ten reaches have “B” stream types, or approximately 29 percent of the study area. The “B” stream types are either step-pool systems or plane bed systems, with semi confined or narrow valleys, and moderate sinuosity. Thirty-six percent of the channel length, or nine reaches, consists of “C” riffle-pool systems. “C” channels are unconfined, have moderate to gentle slopes, and cobble or finer bed material. Approximately 35 percent by channel length within the study area are classified as “A” stream types, a total of 6 reaches. “A” channels are typically step-pool systems, which are narrowly confined, very steep, and are dominated by boulder or cobble bed material.

D. Land Use

The land use within the watershed plays a role in the hydrology of the receiving waters. The percentage of urban and cropland development within the watershed are factors which change a watershed's response to precipitation. Land cover within the stream corridor itself is also an important parameter to evaluate. This land use/land cover plays an influential role in the sediment deposition and erosion which occurs during annual flood events, according to ANR. As outlined in the Phase 1 handbook, impact ratings were assigned for watershed land cover/land use and stream corridor land cover/land use as follows:

- High – 10% or more is crop and/or urban
- Low – Between 2 and 10 % is crop and/or urban
- NS – Not Significant – Less than 2 % is crop and/or urban

The dominant watershed and corridor land use within the Blood Brook Watershed in Norwich is forest. Nineteen of the 25 reaches were measured to have a *high* impact rating for corridor land use.

Riparian buffers provide many benefits. Some of these benefits are protecting and enhancing water quality, providing fish and wildlife habitat, providing streamside shading, and providing root structure to prevent bank erosion. Seventeen reaches have 50 percent or more of the reach with more than 100 feet of riparian buffer on the left bank. Thirteen reaches have 50 percent or more of the reach with more than 100 feet of riparian buffer on the right bank. As a result, the buffer width impact was *low* or *not significant* in every reach, except two that had a *high* impact rating from lack of riparian buffer adjacent to the river. These are M02 on the main stem and the second reach on New Boston Brook (M05-T3.02).

E. Instream and Floodplain Modifications

Channel modifications may impact a stream reach by affecting the hydraulics and the sediment regime. Historic channel modifications were assessed in this Phase 1 study by evaluating flow regulations, bridge and culvert impacts, bank armoring, straightening, and dredging.

The Phase 1 study also evaluated infrastructure and other development that restricts access to the floodplain, resulting in vertical or lateral confinement of flood flows. The parameters included in this step are: berms and roads, river corridor development, depositional features, and lastly meander migration and width and wavelength Ratio.

Flow Regulations

There are two major grade controls on the main stem of Blood Brook, near Elm Street and Hopson Road. The Elm Street grade control is the largest with an approximate 15' waterfall below the bridge and a 10' waterfall above the bridge. In between these two features is a bedrock bed running under the bridge. At Hopson Road, bedrock ledge

occurs below the bridge and immediately above the bridge. Above these features is a small approximately 5' waterfall with a large pool below. The extent and height of these grade controls has a significant influence on aquatic organism passage.

According to Brion McMullan, The Norwich Water Department built a dam on the Charles Brown brook in 1922 and withdrew water from it for fire and drinking water until the early 1980s. The Norwich Fire District (NFD), created in 1922, rented use of the hydrants for fire fighting from the private Water Department. In 1978, the NFD bought the Norwich Water Department, which they continue to operate. In 1982, the NFD developed a new ground water source and have not used the Charles Brown Brook source since. The NFD still owns 900 acres of watershed for the brook, of which they have given development rights to the Town and recreational usage in lieu of not being taxed. The Town does not regulate stream flow on Charles Brown Brook using the NFD dam and pond. They did dredge the center section of the pond several years ago to balance off beaver activity at the pond.

The Town of Norwich has a second dam on the lower Charles Brown Brook above the Beaver Meadow Road and Brigham Hill Road intersection that serves as an impoundment for the Town Beach. The town installs two flash boards in the dam in the late spring to raise the level of the impoundment for swimming. These flash boards are removed in the fall when the beach is closed. Just below the dam and past this road intersection there is a small bedrock grade control.

Bridge and Culvert Impacts

The number of private bridges and culverts within the study reach were counted by identifying stream crossings using the VTrans structure database as well as counting road crossings on the VHD. The percentage of the reach impacted by stream crossing structures was estimated during the windshield survey and from orthophotos.

TRORC also met with Andy Hodgdon, the Town of Norwich Road Foreman, to ask about flood history and structure failures. According to Mr. Hodgdon, several bridges went out during the 1973 flood on Turnpike Road, on the main stem of Blood Brook, and on Bragg Hill Road, on the Bragg Brook tributary.

The impact from bridge and culverts on stream dimension, pattern or profile appeared to be *high* in five reaches: M03, M05 and M06 on the main stem, and the lowest reaches on Bragg Brook and New Boston Brook. Staff noted affected reaches upstream and downstream of these structures because they typically had armoring upstream of the structure.

Bank Armoring

The amount of bank armoring within a watershed often indicates channel processes that result in bank erosion. Bank armor can be made of a variety of material including wooden cribs, gabions, logs, and rock riprap. The most common type of revetment in Vermont is rock riprap and was the only type of revetment noted within the study area.

According to Barry Cahoon, of the ANR River Management Program, light bank armoring was conducted at the intersection of Hopson Road and Brookside Drive. The houses along the north side of Brookside were threatened and there was historic channel realignment at this location so the bank was rip rapped.

The second area with significant armoring was just upstream of the section of US 5 that was relocated when the I-91 interchange was built, now reach M02. There has been some maintenance excavation and realignment due to depositional activity just upstream of the US 5 fill embankment and crossing structure at the beginning of M03 where the large debris catcher is located.

The amount of revetment mapped from the Phase 1 windshield survey may be an underestimation of the total amount with the assessed reaches because the windshield surveys included only a portion of each reach, usually above and below the stream crossing structures. The following criteria were used to provide an impact rating for human placed bank armoring:

- High – Greater than 30% of the reach length is armored
- Low – Between 10 and 30% of the reach length is armored
- Not Significant – Less than 10% of the reach length is armored
- No Info – Bank armoring has not been evaluated for the entire reach and impact at the reach level is unknown

During the windshield survey, rock riprap was noted in seven of the 25 reaches. Of these reaches, riprap received an impact rating of *low* in one reach, M02. The bank armoring impact was *not significant* in the remaining reaches.

Channel Straightening

During the windshield survey evidence of historic channelization projects were recorded. The total reach length (in feet) and the percentage of the reach length directly impacted by the channel modification were noted. Categories considered as part of the Step 5.4 (Channel Modifications) included windrowing and straightening.

The only channel modification noted within the Blood Brook in Norwich was straightening. Channel straightening was identified through field confirmation during the windshield survey. A *high* impact rating is given for channel modifications when greater than 20 percent of the reach has been channelized. *High* impact ratings were assigned to three reaches, M02, M03 and M04. Channel straightening may have occurred on upper mainstem reaches such as M05, M06 and M07 and the first reaches of Charles Brown and Bragg Brooks. Staff marked only small portions of these reaches and did not designate larger portions because further field investigation is needed.

Dredging History

Barry Cahoon of the ANR River Management Program was contacted regarding the dredging and gravel mining history within the study area.

According to Cahoon, there is no significant history of gravel or sediment mining operations for the Blood Brook watershed within the Town of Norwich.

Berms and Roads

Using information from maps, orthophotos, and the windshield survey, the percentage of the river corridor along which berms, roads, railroad, or improved paths run parallel to the stream was measured. Linda Cook, former Road Commissioner and Andy Hodgdon, the Town of Norwich Road Foreman noted that after the 1973 flood, material was removed from the rivers and pushed onto the banks. Berms can be seen on the first reach of Charles Brown Brook at Brigham Hill Road and at the confluence of Charles Brown with the mainstem on upper part of M04 and the lower portion M05. Berms are also visible along M04 above Beaver Meadow Road behind Huntley Road and behind the recreation fields.



Figure 3 – Berm at base of Charles Brown Brook at Brigham Hill

Reaches where berms, roads, railroads or improved paths were located along 20 percent or more of the river corridor were given impacted ratings of *high*. Eleven of the 25 studied reaches received an impact rating of *high* for berms and roads due to the location of state and town roads and driveways within the watershed. Turnpike Road imposes a *high* impact along six out of nine reaches on the main stem. Town roads run along three other tributaries and were found to cause a *high* impact along several reaches.

River Corridor Development

The river corridor development parameter tracks whether developments within the river corridor are effectively decreasing the belt width. The percentage of the reach length with houses, fill, parking lots or other development within the river corridor was tabulated using maps, orthophotos, and knowledge from the windshield survey. Residential development was the most prevalent form of development across the watershed. Nine of 25 reaches were given a river corridor development impact rating of *high*. Reaches M02 through M06, and M08 on the main stem were rated *high* due to development within Norwich Village out along Turnpike Road. The lowest reaches on Bragg Brook, Charles Brown Brook and New Boston Brook were also assigned a *high* impact rating from development. Reaches M04, M05, and M06 in the village and along Turnpike Road and the first reaches of Charles Brown and Bragg Brook have significant residential development with lawns and houses within the SGAT Step 9 delineated river corridor.

Depositional Features

The 2004 USDA-NAIP and the 1994 VMP orthophotos as well as results from the windshield survey were used to evaluate depositional features within the Blood Brook Watershed. The presence of point and mid channel bars and deltas were noted in five of the 25 study reaches. The ANR has included depositional features as a component of the Phase 1 analysis because these features are indicative of an increased sediment load and a *high* likelihood that the streambed is actively aggrading and/or undergoing lateral migration. An unvegetated bar indicates that the bar has recently formed or is in the process of growing. Five of the 25 reaches had an impact rating of *low* for depositional features. Because of the small size of the Blood Brook watershed and corresponding small belt width as well as the forested buffers, staff found that identifying the bars using the orthophotos was difficult. This Phase 1 count of depositional features may underestimate the actual numbers and further Phase 2 investigation is needed.

Meander Migration

The 2004 USDA-NAIP and the 1994 VMP orthophotos were used to evaluate areas where the Blood Brook has migrated, bifurcated, or avulsed. Current orthophotos from 1994 and historic orthophotos from 1975 (printed series 1978) were compared to evaluate changes in the location of the river channel over time. The current and the historic orthophotos span 19 years. Four reaches on the main stem of the Blood Brook received an impact rating of *low* for meander migration. There were no recent channel avulsions noted for the study area.

The largest meander migration occurred behind the Beaver Meadow Road condominiums and was clearly visible on the 1975 orthophotography. Smaller channel shifts were visible along the mainstem on M03 at and below the farm fields and above the US 5 culvert, and along most of M05 and M06.

Meander Width Ratio

The 2004 USDA-NAIP and the 1994 VMP orthophotos were used to determine the meander belt width and the meander wavelength for streams typed in Step 2.10 as B or C streams with plane bed or riffle pool bedforms. Topographic maps were used to determine the valley direction, while the most current orthophoto series was used to provide the accurate location of channel meanders.

The meander belt width is the horizontal distance between two opposite, outside banks on fully developed meanders. The meander width ratio is calculated by dividing the average belt width for the reach by the bankfull width. The ANR Phase 1 protocol considers unconfined, gravel dominated streams with moderate to gentle gradients, which are in regime, to have belt widths in the range of 5 to 8 times the channel width. Six out of nine unconfined reaches had a *high* impact rating for meander belt width ratio because they fell outside of the range expected for channels that are in regime. One narrow reach was given a *high* impact rating.

All of the stream reaches with meander width ratios that resulted in a *high* impact rating had meander width ratios of less than five. These low values may indicate that the stream has become straighter and steeper, possibly resulting in degradation and loss of access to its floodplain.

Wavelength Ratio

The meander wavelength consists of two bendways. The wavelength ratio is calculated by dividing the average wavelength by the bankfull channel width. Four of the reaches resulted in a *high* impact rating for meander wavelength.

The combination of the *low* meander width ratio and the *low* meander wavelength ratio on many of the reaches appears to be a response to historical channel straightening.

Staff noted that finding representative meander patterns for width and wavelength calculations was difficult on several reaches, especially M03, M04 and M05, as these reaches may be been straightened. M03 and M04 were straightened 38.5% and 30% respectively but these values could be well above 50% when field verified. M03 was rated as *high* on both meander width ratio and wavelength ratio but M04 has a *not significant* rating for wavelength ratio. Phase 2 field investigations could reveal more straightening and M04 may have a *high* rating for wavelength ratio.

Summary

Overall development in the Blood Brook watershed has contributed significantly to the current stream geomorphic conditions. Many private driveways and culverts have been built on the main stem and several of the reference portions that have no roadside impacts such as the upper reaches of New Boston Brook have impacts from driveways. Channelization has also had a significant impact in the village and on the lowest reaches of Bragg and Charles Brown Brooks. The impact from farming is negligible.

Channel impacts are largest where roads follow the channels as they do along Bragg Brook, the first reach of New Boston Brook and the main stem. Where streams follow roads, the valley is usually narrow or semi-confined. The roads create additional constraints and these streams are responding to these stressors. This stress is particularly evident in the lower portion of New Boston Brook where there were two major bank failures. Deposition of boulders and big cobbles upstream of the first culvert on the tributary shows how the river is constrained by the structure. This deposition may have been caused by the road embankments, the valley walls and the arch at this location. Because of these constraints, the river may be unable transport sediment effectively.

5. SGA ANALYSIS OUTPUT

A. Impact Scores

The Phase 1 SGAT GIS Tool and the SGA Database Management System evaluates parameters that may cause channel adjustment. These parameters are grouped into four major categories and the scores by category for the Blood Brook watershed were 40.7% for land use, 9.3% for instream modifications, 34.6% for floodplain modifications and 15.4% for bed and bank characteristics. Land use followed by floodplain modifications are the two largest impacts in the Blood Brook watershed. These *high* values can be traced to the large amount of residential development near and within the river corridor that includes transportation, residential, and village center development that are restricting access to the floodplain and increasing impervious surfaces.

B. Reach Condition and Sensitivity

Table 2 below shows the reach condition ratings assigned to each reach. Reaches that received a *poor* condition rating have undergone significant channel and floodplain modifications. Streams in *fair* condition are fully in adjustment and are experiencing major and rapid changes due to recent floodplain and channel modifications, land cover changes, and/or loss of riparian buffer. Streams in the *good* category had experienced some degree of human-induced change to their watershed, floodplain and/or channel and appeared to be undergoing only minor adjustments. A *reference* reach has no significant channel or floodplain modifications and has a forested buffer, adjacent to the channel. These reaches are close to the natural condition.

The Phase 1 SGAT GIS Tool and the SGA Database Management System assigned a stream sensitivity rating based on existing stream type and condition. Highly sensitive reaches are more likely to be in adjustment, and are very sensitive to land use changes within the watershed. The reach sensitivity is summarized in Table 2 as well.

C. Adjustment Processes

Table 2 is a summary of the primary adjustment processes that were predicted based on the Phase 1 Stream Geomorphic Assessment.

The Phase 1 data suggest that most of the stream reaches are experiencing more than one type of channel adjustment process. Based on the Phase 1 database, aggradation and degradation were the main processes identified.

Table 2 – Reach sensitivity

Reach ID	Confinement Type	Stream Type				Watershed Area	Total Impact	9.1 Predicted Adjustment Scores				9.2 Reach Condition		9.3 Reach Sensitivity
		Stream Type	Bed Material	Subclass Slope	Bedform			Degrad.	Aggrad.	Widen.	Planf.	Project	Statewide	
M02	NW	B	Bedrock		Plane Bed	18.43	19	10	8	7	10	Poor	Fair	Very Low
M03	VB	C	Gravel		Riffle-Pool	17.64	21	12	12	7	10	Poor	Fair	High
M03-T1.01	SC	B	Cobble		Step-Pool	1.21	11	8	9	5	5	Fair	Good	Moderate
M03-T1.02	NC	A	Cobble		Step-Pool	1.17	12	7	9	5	0	Fair	Good	High
M03-T1.03	NC	A	Cobble		Step-Pool	0.59	9	6	6	5	0	Good	Good	High
M04	VB	C	Cobble		Riffle-Pool	15.73	16	10	6	5	8	Fair	Fair	Moderate
M04-T2.01	SC	B	Cobble		Step-Pool	5.64	10	8	6	5	3	Fair	Good	Moderate
M04-T2.03	NW	B	Cobble		Plane Bed	5.52	5	4	4	2	0	Good	Reference	Moderate
M04-T2.05	NW	B	Cobble		Plane Bed	4.87	4	4	4	2	0	Good	Reference	Moderate
M04-T2.06	NW	B	Cobble		Plane Bed	3.70	3	4	3	2	0	Good	Reference	Moderate
M04-T2.07	NC	A	Cobble		Step-Pool	1.99	3	4	3	2	0	Good	Reference	High
M04-T2.08	VB	C	Cobble		Riffle-Pool	1.71	9	3	3	0	1	Reference	Reference	Moderate
M04-T2.09	NC	A	Cobble		Step-Pool	0.65	1	2	1	0	0	Reference	Reference	High
M05	VB	C	Cobble	b	Riffle-Pool	9.27	15	11	10	7	8	Poor	Fair	Moderate
M05-T3.01	NW	B	Cobble		Step-Pool	2.79	16	12	13	7	8	Poor	Fair	Moderate
M05-T3.02	VB	C	Gravel		Riffle-Pool	2.63	11	5	8	7	7	Fair	Good	High
M05-T3.04	VB	C	Gravel	b	Riffle-Pool	0.90	9	4	5	4	2	Good	Good	High
M06	NW	B	Cobble		Plane Bed	6.04	15	12	10	7	8	Poor	Fair	Moderate
M07	VB	C	Cobble		Riffle-Pool	5.54	11	6	7	5	4	Fair	Good	Moderate
M07-T4.01	NW	B	Cobble		Plane Bed	1.87	3	4	3	2	0	Good	Reference	Moderate
M07-T4.02	VB	C	Gravel		Riffle-Pool	1.75	12	5	7	5	5	Fair	Good	High
M07-T4.04	VB	C	Cobble	b	Riffle-Pool	1.36	5	2	2	0	0	Reference	Reference	Moderate
M07-T4.05	NC	A	Cobble		Step-Pool	1.14	2	2	2	0	0	Reference	Reference	High
M08	SC	B	Cobble		Step-Pool	2.49	13	9	9	5	4	Fair	Good	Moderate
M09	NC	A	Bedrock		Step-Pool	1.94	11	7	8	5	0	Fair	Good	Very Low

6. BRIDGE AND CULVERT ASSESSMENT

A. Methods

In sum, 16 bridges, 27 culverts, and 2 arches were included in the bridge and culvert assessment (see Appendix A). The geomorphic data from the bridge and culvert assessment were used to identify structures that have the potential to fail because of erosion, scour or alignment problems, or structures that may have an impact on the stream. 40 of the 43 structures surveyed were flagged on ANR's Failure Modes Report for geomorphic incompatibility. Two structures at the mouth of Blood Brook below VT 5 and I-91 were not assessed because of their size.

The habitat data from the ANR bridge and culvert assessment were used to identify potential barriers to movement and migration of organism through culverts. The Wildlife Passage Report and the Culvert Aquatic Organism Passage Report from the assessment are provided in Appendix A. Twenty-two of the 25 culverts assessed were identified as blocking aquatic organism passage (AOP), including adult salmonids, under flow conditions that existed at the time of the survey (May 2006).



Figure 4 – Perched Outlet Poor Installation on Bragg Hill Road

Culverts that are not installed at or slightly below the stream grade block organism passage. Organisms cannot pass through these culverts because of they cannot access the outlet and then they may not be able to travel up the bare culvert bottom. Erosion or scour at the inlet and outlet can occur at these culverts if the culverts were installed above grade because the water backs up at the inlet and cascades out the outlet. Aggradation or sedimentation can also occur upstream of the culvert resulting in debris jams.

Culverts that are installed at grade allow sediment and debris to pass through more readily than above grade culverts resulting in less erosion and debris jams. Organisms can negotiate these culverts because of the deposits inside the structure.



Figure 5 – Natural bed, at grade, Turnpike Road & Upper Turnpike intersection

In order to assist the Town of Norwich with priorities for replacement of these structures, two priority lists were generated using the information and photographs taken during the assessment. The bridge span and the culvert diameter as a percentage of the channel width were used as a first cut in prioritizing the structures for replacement. As shown below, a total of eight structures have a bankfull width of less than 50%.

Bridges and culverts with channel widths of less than 40 percent of the bankfull width, which significantly impede natural sediment transport or which block AOP, were placed in Category One. Category One contains structures that have highest priority for replacement, primarily due to geomorphic incompatibility, erosion, scour or alignment problems.

Structures with channel widths of between 40 and 49 percent of the bankfull width, which impede natural sediment transport or which block AOP, were placed in Category Two. Category Two is of lower priority for replacement, but still contains structures that may be incompatible in terms of sediment transport.

B. Results

The Phase 1 windshield survey and the Bridge and Culvert Assessment indicate that eight of the public and private bridges within the Town of Norwich are undersized and represent some degree of risk for impeding sediment transport. Of these eight structures, three structures were less than 40% of the bankfull width, and five structures had bankfull widths of 40 to 49 percent.

Two structures at the mouth of Blood Brook below US 5 and I-91 were not assessed because of their size but they are clearly barriers to organism passage and may have a significant effect on sediment transport. The US 5 box culvert is approximately 260' in length and the I-91 concrete arch is 700' in length. The US 5 box has a large steel debris catcher at the inlet that VTrans cleans periodically. This catcher acts as a sediment impediment as debris accumulates. The I-91 culvert's complete bedrock ledge bottom acts as a constant grade control with a hardened bedrock bottom. No sediment had accumulated in the base of the box culvert and there did not appear to be any sediment in the concrete arch. The reach between these structures is hardened on the left bank from the road embankments and straightened as well. These two culverts and the intervening reach clearly prevent most organism movement and some sediment transport.

1. Category One Structures

The Category One structures are summarized below in Table 3. All structures in this category are culverts and are top priorities for replacement because of their size.

Table 3 – Category One Structures

Road	Stream Name	Structure	% Bankfull Width	Blocks AOP *	Other problems noted
Bragg Hill Rd.	Bragg Brook	100052000614111	38%	Yes	Upstream sedimentation
Needham Rd.	Needham	401411003614111	27%	Yes	Poor location or alignment
Upper Turnpike Rd.	Needham	401411001414111	35%	Yes	Upstream sedimentation, downstream scour & erosion

* Culvert blocks aquatic organism passage of all fish and stream salamanders including adult salmonids.



Figure 6 – Sediment Transport Impeded at Old Orchard Lane on mainstem

This private culvert on Old Orchard Lane is 29% of the bankfull width. This culvert is impeding the natural movement of sediment. The mid-channel bar immediately upstream of the inlet illustrates that deposition is occurring.

Blocked Aquatic Organism Passage

Each of the culverts that have been included as Category One structures were identified as blocking aquatic organism passage under flow conditions found at the time of the assessment. The following conditions must be met at the time of the assessment for a culvert to be considered to block AOP of all fish (including adult salmonids) and stream salamanders:

1. The culvert outlet configuration is free fall and the invert to the water surface distance is greater than or equal to 1.0 foot;
or
2. The water depth in the culvert at the outlet is less than 0.3 feet.

It is the opinion of TRORC that this issue is less critical to evaluation of structures in this watershed. Bedrock grade controls at the outlet of the arch at the mouth of Blood Brook (20009147214112) and at the nearby Elm Street bridge (101411004314111) are so steep, that it would be almost impossible for aquatic organisms to make it upstream

from there (see photo below). Further, since the arch at the mouth of the watershed is 700' long and has an extremely ledgy bottom, most aquatic creatures will not be driven to attempt passage of this structure. Based on this information, we believe the only aquatic organisms that use this watershed are local residents, not in-migrants.



Figure 7 – I-91 Concrete Arch at Mouth of Blood Brook

2. Category Two Structures

The category 2 structures are summarized below in Table 4. All structures in this category are culverts. Category 2 structures do not necessarily need replacement but should be monitored for significant upstream sediment deposition, upstream and downstream scour and erosion. Debris should be removed after the spring runoff and before the winter as well as after major storm events since these structures have smaller capacity to handle runoff with lower percentage of bankfull widths. They should be prioritized for replacement based on their condition and the amount of erosion, sedimentation, and debris jams they typically experience as well as their position on the reach and in the watershed.

Table 4 – Category Two Structures

Road	Stream Name	Structure	% BFW	Blocks AOP *	Other problems noted
New Boston Rd	New Boston	401411000414111	49%	Yes	Upstream sedimentation, upstream & downstream scour & erosion, poor location or alignment
New Boston Rd	New Boston	401411000614111	49%	Yes	Upstream sedimentation, upstream scour & erosion, poor location or alignment
Bragg Hill Rd	Bragg Brook	401411001714111	48%	**	Downstream scour & erosion
Bragg Hill Rd	Bragg Brook	401411004814111	40%	**	Upstream sedimentation, downstream scour & erosion, poor location or alignment
Turnpike Rd	Blood Brook	401411003814111	42%	Yes	Upstream sedimentation, downstream scour & erosion

* Culvert blocks aquatic organism passage of all fish and stream salamanders including adult salmonids.

** Culvert blocks aquatic organism passage of all fish and stream salamanders, except for adult salmonids.

7. RECOMMENDATIONS

A. Phase 2 Assessment

The Phase 1 results are valuable for providing recommendations for a Phase 2 Assessment. Based on the Phase 1 Assessment, Two Rivers-Ottawaquechee Regional Commission recommends reaches M03 through M09 on the main stem, all reaches on Bragg Brook, reach T2.01 on Charles Brown Brook, and reaches T3.01, T3.02 and T3.04 on New Boston Brook be included in the Phase 2 Assessment. M01 and M02 were excluded from this analysis because M01 was within the inundation pool of the Wilder Dam and M02 is fully straightened and bounded on three sides by the US5 and I-91 road embankments. The upper reaches on the Charles Brown Brook were excluded because they are in an undeveloped and highly confined valley and include two large impoundments. All of Needham Brook was excluded because it has limited development and is mostly wooded on the upper two reaches.

These reaches were selected for the Phase 2 Assessment for the following reasons:

1. Five were in poor geomorphic condition and nine were found to be in only fair condition. These reaches are located in areas where the river is or has the potential to create land use conflicts.
2. The upper two reaches on New Boston Brook were rated in moderate and *high* geomorphic condition and offer the most likely opportunity for “reference” reaches to be used in restoration design work.

3. The lowest reach on each of the three larger tributaries is recommended because these reaches appear to have been historically straightened or in Beaver Meadow Brook's case is confined between the valley and road; and
4. The majority of these reaches have stream types which are highly sensitive to changes in the watershed.

Table 5 – Phase 2 Assessment Reaches

Name	ID	ReachID	Miles	Description
Blood	1	M03	1.1	more developed floodplain forest/farmland
Blood	2	M04	1.1	more developed
Blood	3	M05	0.6	highly developed
Blood	4	M06	1.0	highly developed
Blood	5	M07	0.8	highly developed
Blood	6	M08	0.9	more developed
Blood	7	M09*	2.3	wooded w/several bridges
Bragg	8	M03-T1.01	0.4	highly developed
Bragg	9	M03-T1.02	1.0	confined wooded undeveloped
Bragg	10	M03-T1.03	1.1	open more developed
Charles Brown	11	M04-T2.01	0.3	highly developed more open
New Boston	12	M05-T3.01	0.6	highly confined with 4 bridge/culverts
New Boston	13	M05-T3.02	1.9	open far from road
New Boston		M05-T3.03	NAN	Pond
New Boston	14	M05-T3.04	1.1	highly developed
Total River Miles			14.2	

NAN no assessment needed **higher portion of M09 can be excluded from Phase II*
M01 is in CT inundation, M02 channelized under US5-I91

Because of the involvement of the Norwich Conservation Commission, and input from the Norwich Planning Commission and other town officials, assessment work at the Phase 2 level will likely lead to the development of restoration and protection projects. TRORC will continue to work with the Town of Norwich to secure landowner interest.

B. Bridge and Culverts

Two Rivers-Ottawaquechee Regional Commission is working with several towns on an infrastructure capital planning process. TRORC wants to develop two parameters address percentage of bankfull width and if the structure has a perched outlet invert within its replacement prioritization process in order to flag geomorphically sensitive structures. These two parameters will be included with a larger set of structure parameters and will receive various weights. TRORC has flagged the three Category One culverts for replacement in Norwich's capital planning process based on their percentage of bankfull width.

The Vermont Fish and Wildlife Department and the Agency of Natural Resources are in the process of preparing a publication for the design and construction of stream crossings. This publication is expected to be available at some point in the near future for public review. Two Rivers-Ottawaquechee Regional Commission recommends that the Town of Norwich acquire this design publication when available and work with the

Agency of Natural Resources to provide stream crossings that offer geomorphic compatibility and passage for aquatic organisms and wildlife.

C. Fluvial Erosion Hazard Mapping

The Planning Commission is also interested in site specific data on the buffer distances to protect the river corridor throughout the watershed. Currently, the planning commission is investigating buffer widths and is concerned about the impact of these widths on development. The Commission wants to maintain and improve overall watershed health and water quality. The Commission is interested in implement corridor protections that allow landowners to continue to realize reasonable uses of their parcels while protecting protects the river corridor from erosion and runoff. The Regional Commission plans to develop fluvial erosion mapping with erosion sensitivity ratings using the completed Phase 2 assessment data. These fluvial erosion hazard corridors and their corresponding ratings will be the first step to address the erosion risks in the watershed.

D. River Corridor Planning, Education & Restoration Projects

The Blood Brook Watershed in Norwich is highly developed watershed. The residents that the staff encountered during field work took a keen interest in the watershed and the nearby reaches. Residents had stories to tell about their section of stream and were very concerned about water quality and erosion. Several residents we saw in the field were curious about ways to prevent erosion without using conventional bank armoring approaches.

Norwich officials are a highly motivated group and the Conservation Commission and the Marion Cross School have completed discharge and water quality monitoring respectively. Staff saw many opportunities along the reaches to implement simple buffer protection projects as a way to lay the groundwork for larger projects. Restoration projects can be prioritized using the fluvial erosion hazard reach sensitivity ratings that will be generated following the Phase 2 assessment. Additionally, project rankings can be refined through a River Corridor Management Plan. The development of this plan is a community process where project identification and prioritization can occur as well as education about river change processes and specific issues such as landowner bank erosion. With the assistance of the VT River Management Program and the Regional Commission, the Town of Norwich can begin this community-based process, providing an ongoing local perspective with landowner knowledge and input.

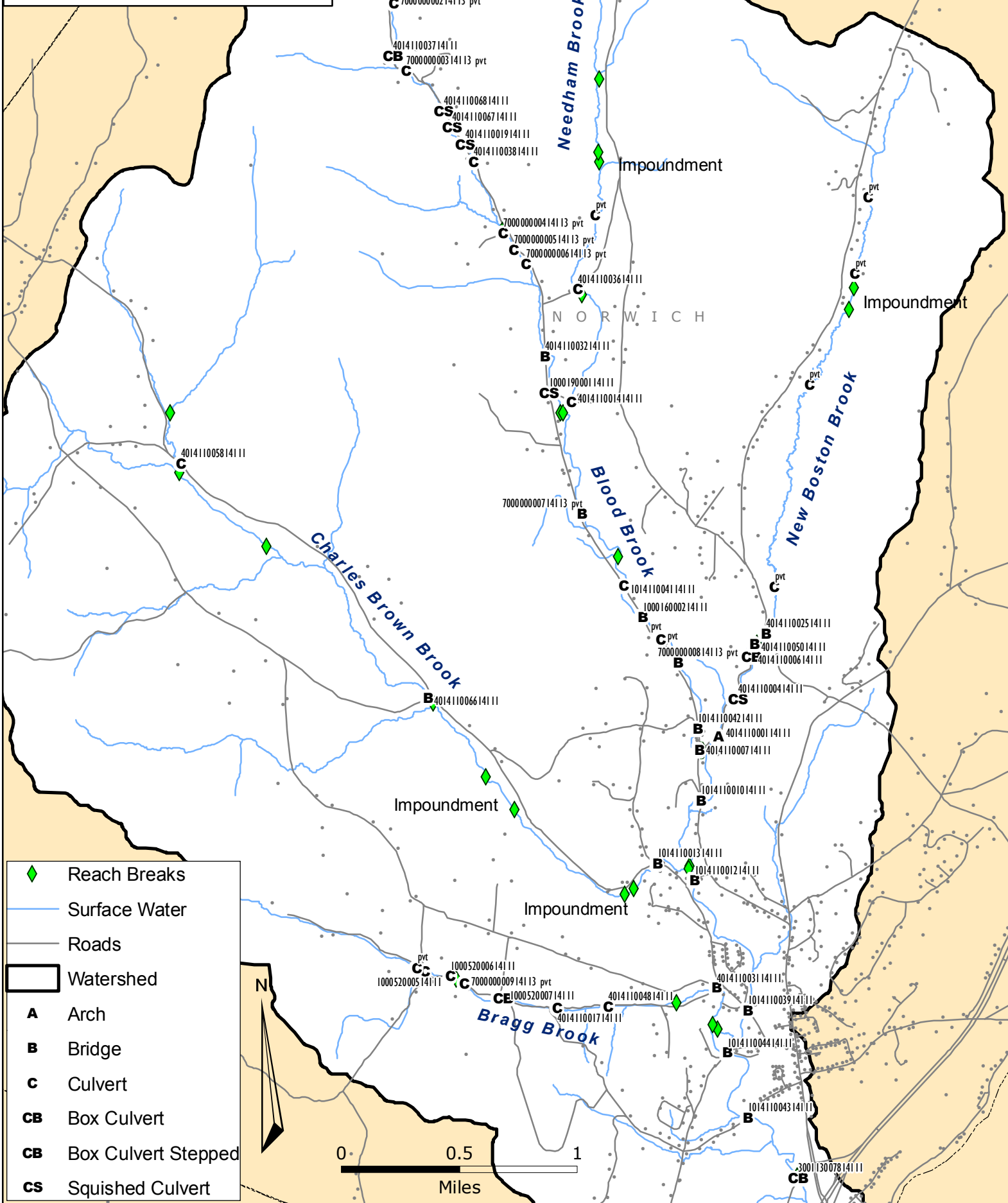
Appendix A: Culvert Bankfull Width Data, Phase 1 SGA DMS reports





STREAM	NUM	STRUCTNUM	TYPE	Private	YEAR	sqmi	BFW06	BFW01	Road	Width
BLOOD	27	20009147-214112	Arch		1968	18.3	47.11	43.59	MONTSHIRE RD	--- %
BLOOD	26	300113007814111	Box Culvert		1968	17.6	46.29	42.73	Route 5	--- %
BLOOD	25	101411004314111	Bridge		1956	17.2	45.79	42.21	ELM ST	131%
BLOOD	24	101411004414111	Bridge		1928	17	45.62	42.02	HOPSON RD	83%
BLOOD	23	101411003914111	Bridge		1973	15.7	44.02	40.35	BEAVER MEADOW RD	102%
BLOOD	22	101411001214111	Bridge		1989	14.9	43.04	39.34	MOORE LN	82%
BLOOD	21	101411001014111	Bridge		1928	8.92	34.31	30.4	TURNPIKE RD	97%
BLOOD	20	401411000714111	Bridge		1929	5.95	28.71	24.83	TURNPIKE RD	62%
BLOOD	19	101411004214111	Bridge			5.91	28.62	24.74	TURNPIKE RD	90%
BLOOD	18	700000000814113	Bridge	Private		5.83	28.45	24.58	TURNPIKE RD	169%
BLOOD	16	100016000214111	Bridge			5.66	28.09	24.22	TURNPIKE RD	92%
BLOOD	15	101411004114111	Culvert		1931	5.54	27.83	23.97	TURNPIKE RD	69%
BLOOD	14	700000000714113	Bridge	Private		5.04	26.69	22.86	TURNPIKE RD	161%
BLOOD	13	100019000114111	Squished Culvert			2.43	19.38	15.88	UPPER TPKE RD	65%
BLOOD	12	401411003214111	Bridge			2.37	19.16	15.68	TURNPIKE RD	67%
BLOOD	11	700000000614113	Culvert	Private		1.98	17.7	14.33	TURNPIKE RD	43%
BLOOD	10	700000000514113	Culvert	Private		1.96	17.62	14.26	TURNPIKE RD	43%
BLOOD	9	700000000414113	Culvert	Private		1.93	17.5	14.14	OLD ORCHARD LN	32%
BLOOD	8	401411003814111	Culvert			1.63	16.24	13	TURNPIKE RD	42%
BLOOD	7	401411001914111	Squished Culvert			1.54	15.82	12.62	TURNPIKE RD	61%
BLOOD	6	401411006714111	Squished Culvert			1.5	15.64	12.45	TURNPIKE RD	56%
BLOOD	5	401411006814111	Squished Culvert			1.43	15.33	12.17	TURNPIKE RD	59%
BLOOD	4	700000000314113	Culvert	Private		1.27	14.55	11.47	TURNPIKE RD	41%
BLOOD	3	401411003714111	Box Culvert		NEW	1.06	13.46	10.5	TURNPIKE RD	59%
BLOOD	2	700000000214113	Culvert	Private		0.88	12.37	9.534	TURNPIKE RD	29%
BLOOD	1	700000000114113	Culvert	Private		0.59	10.4	7.835	BIRCH HILL LN	29%
BRAGG	8	401411003114111	Bridge		1958	1.19	14.15	11.11	BRAGG HILL RD	85%
BRAGG	7	401411004814111	Culvert			1.07	13.49	10.52	BRAGG HILL RD	40%
BRAGG	6	401411001714111	Culvert			0.97	12.92	10.02	BRAGG HILL RD	48%
BRAGG	5	100052000714111	Box Culvert Stepped		NEW	0.8	11.86	9.088	BRAGG HILL RD	115%
BRAGG	4	700000000914113	Culvert	Private		0.6	10.46	7.884	BRAGG HILL RD	33%
BRAGG	3	100052000614111	Culvert			0.59	10.36	7.796	BRAGG HILL RD	38%
BRAGG	2	100052000514111	Culvert			0.57	10.23	7.686	BRAGG HILL RD	62%
CHARLES BROWN	5	101411001314111	Bridge			5.62	28.01	24.14	BEAVER MEADOW RD	117%
CHARLES BROWN	2	401411006614111	Bridge			3.67	23.21	19.5	BROWN SCHOOLHOUSE RD	54%
CHARLES BROWN	1	401411005814111	Culvert			1.71	16.6	13.32	BEAVER MEADOW RD	50%
NEEDHAM	3	401411001414111	Culvert			1.87	17.24	13.91	UPPER TPKE RD	35%
NEEDHAM	2	401411003614111	Culvert			1.75	16.75	13.46	NEEDHAM RD	27%
NEW BOSTON	8	401411000114111	Arch			2.85	20.75	17.17	NEW BOSTON RD	55%
NEW BOSTON	8	401411000414111	Squished Culvert			2.8	20.59	17.02	NEW BOSTON RD	49%
NEW BOSTON	7	401411000614111	Concrete Box			2.74	20.42	16.85	NEW BOSTON RD	49%
NEW BOSTON	6	401411005014111	Bridge			2.73	20.39	16.83	NEW BOSTON RD	69%
NEW BOSTON	5	401411002514111	Bridge			2.61	19.98	16.44	NEW BOSTON RD	55%

Structures

Blood Brook Watershed

Norwich, VT



-  Reach Breaks
-  Surface Water
-  Roads
-  Watershed
- A** Arch
- B** Bridge
- C** Culvert
- CB** Box Culvert
- CB** Box Culvert Stepped
- CS** Squished Culvert

Stream Geomorphic Assessment



Failure Modes Report - Geomorphic Incompatibility

Explanation of codes used in table header

Failure Modes		Existing Problems	
F1	Concern for structure due to fluvial condition or process	P1	Upstream sediment deposit
F2	Potential failure due to out-flanking	P2	Upstream Scour and/or erosion present
F3	Potential failure due to scour	P3	Downstream Scour and/or erosion present
F4	Potential failure due to ice or debris jam	P4	Inlet obstruction present
F5	Structure related damage due to flooding of adjacent property	P5	Poor location or alignment
F6	Structure related damage due to erosion of adjacent property	P6	Beaver activity
		P7	Floodplain filled entirely or partially by roadway approaches
Width	Structure width divided by channel width as a percent (% bankfull width)		

Town	Road	Stream Name	Structure	Type	X = meets criteria MD = missing data														Width
					F1	F2	F3	F4	F5	F6	P1	P2	P3	P4	P5	P6	P7		
Norwich	BEAVER MEADOW RD	Charles Brown Brook	101411001314111	Bridge	-	-	X	X	-	X	X	-	X	X	-	-	X	117	
Norwich	OLD ORCHARD LN	Blood Brook	700000000414113	Culvert	-	X	X	X	X	X	X	-	X	X	-	-	X	32	
Norwich	TURNPIKE RD	Blood Brook	700000000514113	Culvert	-	X	X	X	-	X	-	-	X	X	-	-	-	43	
Norwich	TURNPIKE RD	Blood Brook	700000000614113	Culvert	-	X	X	X	-	-	X	-	X	-	-	-	X	43	
Norwich	UPPER TPKE RD	Blood Brook	100019000114111	Culvert	-	X	X	X	X	X	X	-	-	X	-	-	X	65	
Norwich	TURNPIKE RD	Blood Brook	700000000714113	Bridge	-	-	-	-	-	X	X	-	-	-	-	-	X	161	
Norwich	TURNPIKE RD	Blood Brook	100016000214111	Bridge	-	-	-	X	-	X	X	-	-	-	-	-	X	92	
Norwich	BRAGG HILL RD	Bragg Brook	100052000514111	Culvert	-	X	-	X	X	-	-	-	-	-	-	-	X	62	
Norwich	BRAGG HILL RD	Bragg Brook	100052000614111	Culvert	-	X	X	X	-	X	-	-	X	-	-	-	-	38	
Norwich	TURNPIKE RD	Blood Brook	401411003714111	Culvert	-	X	X	X	X	X	X	-	X	X	X	-	X	59	
Norwich	TURNPIKE RD	Blood Brook	401411000714111	Bridge	-	X	X	X	X	X	X	-	-	X	-	-	X	62	
Norwich	TURNPIKE RD	Blood Brook	101411001014111	Bridge	-	-	-	-	-	-	-	-	-	-	-	-	X	97	
Norwich	MOORE LN	Blood Brook	101411001214111	Bridge	-	-	-	-	-	-	-	-	-	-	-	-	X	82	
Norwich	BEAVER MEADOW RD	Blood Brook	101411003914111	Bridge	-	-	-	-	-	-	-	-	-	-	X	-	X	102	
Norwich	ELM ST	Blood Brook	101411004314111	Bridge	X	-	-	-	-	-	X	-	-	-	-	-	X	131	
Norwich	HOPSON RD	Blood Brook	101411004414111	Bridge	-	-	-	X	-	-	X	-	-	-	-	-	X	83	
Norwich	Route 5	Blood Brook	300113007814111	Culvert	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	---	
Norwich	MONTSHIRE RD	Blood Brook	20009147-214112	Arch	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	---	
Norwich	BEAVER MEADOW RD	Charles Brown Brook	401411005814111	Culvert	-	X	X	X	X	X	X	-	X	X	X	-	X	50	

Norwich	NEEDHAM RD	Unnamed Blood Brook tributary	401411003614111	Culvert	-	X	X	X	X	X	-	-	-	-	X	-	X	27'
Norwich	UPPER TPKE RD	Unnamed Blood Brook tributary	401411001414111	Culvert	-	X	X	X	-	-	X	-	X	-	-	-	X	35'
Norwich	NEW BOSTON RD	New Boston trib	401411000114111	Arch	-	X	X	X	X	X	X	X	-	X	-	-	X	55'
Norwich	NEW BOSTON RD	New Boston trib	401411000414111	Culvert	-	X	X	X	X	X	X	X	X	X	X	-	X	49'
Norwich	NEW BOSTON RD	New Boston tributary	401411000614111	Culvert	-	X	X	X	X	X	X	X	-	X	X	-	X	49'
Norwich	NEW BOSTON RD	New Boston trib	401411005014111	Bridge	-	X	-	X	-	X	-	-	-	-	X	-	X	69'
Norwich	NEW BOSTON RD	New Boston tributary	401411002514111	Bridge	-	X	X	X	X	-	-	X	X	-	-	-	X	55'
Norwich	BRAGG HILL RD	Bragg Brook	401411001714111	Culvert	-	X	X	X	X	-	-	-	X	-	-	-	X	48'
Norwich	TURNPIKE RD	Blood Brook	700000000214113	Culvert	-	X	X	X	X	X	-	-	X	X	-	-	X	29'
Norwich	BRAGG HILL RD	Bragg Brook	700000000914113	Culvert	-	X	X	X	-	X	X	X	X	X	X	-	-	33'
Norwich	BRAGG HILL RD	Bragg Brook	100052000714111	Culvert	-	-	X	-	-	X	X	X	-	-	-	-	X	115'
Norwich	TURNPIKE RD	Blood Brook	401411006814111	Culvert	-	X	X	X	-	X	X	-	X	-	X	-	X	59'
Norwich	BRAGG HILL RD	Bragg Brook	401411004814111	Culvert	-	X	X	X	X	X	X	-	X	-	X	-	X	40'
Norwich	TURNPIKE RD	Blood Brook	700000000814113	Bridge	-	-	-	X	-	X	-	-	X	-	-	-	X	169'
Norwich	TURNPIKE RD	Blood Brook	401411006714111	Culvert	-	X	X	X	X	X	X	-	-	X	X	-	X	56'
Norwich	TURNPIKE RD	Blood Brook	401411001914111	Culvert	-	X	X	X	-	X	X	-	X	-	X	-	X	61'
Norwich	BROWN SCHOOLHOUSE RD	Charles Brown Brook	401411006614111	Bridge	-	X	X	X	X	-	X	-	-	-	-	-	X	54'
Norwich	BRAGG HILL RD	Bragg Brook	401411003114111	Bridge	-	X	-	X	-	-	-	-	-	-	X	-	X	85'
Norwich	TURNPIKE RD	Blood Brook	700000000314113	Culvert	-	X	X	X	-	X	X	-	X	-	-	-	X	41'
Norwich	TURNPIKE RD	Blood Brook	401411003814111	Culvert	-	X	X	X	X	X	X	-	X	X	-	-	X	42'
Norwich	TURNPIKE RD	Blood Brook	401411003214111	Bridge	-	X	X	X	X	X	X	-	X	-	X	-	X	67'
Norwich	TURNPIKE RD	Blood Brook	101411004114111	Culvert	-	X	X	X	X	X	X	-	-	-	X	-	X	69'
Norwich	TURNPIKE RD	Blood Brook	101411004214111	Bridge	-	X	-	X	X	X	X	X	-	X	X	-	X	90'
Norwich	BIRCH HILL LN	Blood Brook	700000000114113	Culvert	-	X	X	X	X	-	-	-	X	-	-	-	X	29'

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Norwich	UPPER TPKE RD	Unnamed Blood Brook tributary	401411001414111	Culvert	35 %	No	No	Yes	No	No	No	No	No	No	Yes	No	No	No
Norwich	NEW BOSTON RD	New Boston trib	401411000114111	Arch	55 %	Yes	Yes	Yes	No	Yes	No	No	No	No	No	No	No	No
Norwich	NEW BOSTON RD	New Boston trib	401411000414111	Culvert	49 %	No	Yes	Yes	No	Yes	No	No	Yes	No	No	Yes	No	Ye
Norwich	NEW BOSTON RD	New Boston tributary	401411000614111	Culvert	49 %	Yes	Yes	Yes	Yes	No	No	No	No	No	No	Yes	No	No
Norwich	NEW BOSTON RD	New Boston trib	401411005014111	Bridge	69 %	No	No	No	No	No	No	No	No	No	No	No	No	Ye
Norwich	NEW BOSTON RD	New Boston tributary	401411002514111	Bridge	55 %	No	No	No	No	No	Yes	No	No	No	Yes	No	No	No
Norwich	BRAGG HILL RD	Bragg Brook	401411001714111	Culvert	48 %	No	No	No	No	No	No	No	Yes	No	Yes	No	No	No
Norwich	TURNPIKE RD	Blood Brook	70000000214113	Culvert	29 %	No	No	No	No	No	No	No	No	Yes	Yes	No	No	No
Norwich	BRAGG HILL RD	Bragg Brook	700000000914113	Culvert	33 %	Yes	No	Yes	Yes	Yes	No	Yes	Yes	No	No	Yes	Yes	Ye
Norwich	BRAGG HILL RD	Bragg Brook	100052000714111	Culvert	115 %	No	No	No	Yes	Yes	No	No	No	No	Yes	No	No	No
Norwich	TURNPIKE RD	Blood Brook	401411006814111	Culvert	59 %	No	No	Yes	No	No	No	No	No	No	Yes	Yes	No	Ye
Norwich	BRAGG HILL RD	Bragg Brook	401411004814111	Culvert	40 %	No	No	Yes	No	No	No	No	No	No	Yes	No	No	Ye
Norwich	TURNPIKE RD	Blood Brook	700000000814113	Bridge	169 %	Yes	No	No	No	No	No	No	No	No	No	No	No	No
Norwich	TURNPIKE RD	Blood Brook	401411006714111	Culvert	56 %	Yes	No	Yes	No	No	No	No	No	No	No	No	No	Ye
Norwich	TURNPIKE RD	Blood Brook	401411001914111	Culvert	61 %	No	No	Yes	No	No	No	No	No	No	Yes	No	No	Ye
Norwich	BROWN SCHOOLHOUSE RD	Charles Brown Brook	401411006614111	Bridge	54 %	No	No	Yes	No	No	No	No	No	No	No	No	No	No
Norwich	BRAGG HILL RD	Bragg Brook	401411003114111	Bridge	85 %	No	No	No	No	No	No	No	No	No	No	Yes	No	No
Norwich	TURNPIKE RD	Blood Brook	700000000314113	Culvert	41 %	No	No	Yes	No	No	No	No	Yes	No	No	No	No	No
Norwich	TURNPIKE RD	Blood Brook	401411003814111	Culvert	42 %	Yes	No	Yes	No	No	No	No	Yes	No	No	No	No	No
Norwich	TURNPIKE RD	Blood Brook	401411003214111	Bridge	67 %	No	No	Yes	No	No	No	No	No	No	No	No	No	Ye
Norwich	TURNPIKE RD	Blood Brook	101411004114111	Culvert	69 %	No	Yes	Yes	No	No	No	No	No	No	No	No	No	Ye
Norwich	TURNPIKE RD	Blood Brook	101411004214111	Bridge	90 %	Yes	Yes	Yes	No	Yes	No	No	No	No	No	Yes	No	Ye
Norwich	BIRCH HILL LN	Blood Brook	700000000114113	Culvert	29 %	No	No	No	No	No	No	No	No	No	Yes	Yes	No	No

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Stream Geomorphic Assessment



Culvert Aquatic Organism Passage Report - Potential Barriers to Movement and Migration

				X = meets criteria MD = missing data				
				all fish and stream salamanders				
AOP = Aquatic Organism Passage				except adult salmonids	including adult salmonids			
Town	Road	Stream Name	Structure	[RED] Blocks AOP	[RED] Blocks AOP	[GRAY] Potentially blocks AOP	[GREEN] Does not block AOP	Percent Bankfull Width
Norwich	OLD ORCHARD LN	Blood Brook	700000000414113	-	-	X	-	32 %
Norwich	TURNPIKE RD	Blood Brook	700000000514113	-	-	X	-	43 %
Norwich	TURNPIKE RD	Blood Brook	700000000614113	-	-	X	-	43 %
Norwich	UPPER TPKE RD	Blood Brook	100019000114111	-	-	X	-	65 %
Norwich	BRAGG HILL RD	Bragg Brook	100052000514111	-	-	X	-	62 %
Norwich	BRAGG HILL RD	Bragg Brook	100052000614111	-	-	X	-	38 %
Norwich	TURNPIKE RD	Blood Brook	401411003714111	-	-	X	-	59 %
Norwich	Route 5	Blood Brook	300113007814111	-	MD	MD	MD	--- %
Norwich	BEAVER MEADOW RD	Charles Brown Brook	401411005814111	-	-	X	-	50 %
Norwich	NEEDHAM RD	Unnamed Blood Brook tributary	401411003614111	-	-	X	-	27 %
Norwich	UPPER TPKE RD	Unnamed Blood Brook tributary	401411001414111	-	-	X	-	35 %
Norwich	NEW BOSTON RD	New Boston trib	401411000414111	-	-	X	-	49 %
Norwich	NEW BOSTON RD	New Boston tributary	401411000614111	-	-	X	-	49 %
Norwich	BRAGG HILL RD	Bragg Brook	401411001714111	-	X	-	-	48 %
Norwich	TURNPIKE RD	Blood Brook	700000000214113	-	-	X	-	29 %
Norwich	BRAGG HILL RD	Bragg Brook	700000000914113	-	-	X	-	33 %
Norwich	BRAGG HILL RD	Bragg Brook	100052000714111	-	-	X	-	115 %
Norwich	TURNPIKE RD	Blood Brook	401411006814111	-	-	X	-	59 %
Norwich	BRAGG HILL RD	Bragg Brook	401411004814111	-	X	-	-	40 %
Norwich	TURNPIKE RD	Blood Brook	401411006714111	-	-	X	-	56 %
Norwich	TURNPIKE RD	Blood Brook	401411001914111	-	-	X	-	61 %
Norwich	TURNPIKE RD	Blood Brook	700000000314113	-	-	X	-	41 %
Norwich	TURNPIKE RD	Blood Brook	401411003814111	-	-	X	-	42 %
Norwich	TURNPIKE RD	Blood Brook	101411004114111	-	-	X	-	69 %
Norwich	BIRCH HILL LN	Blood Brook	700000000114113	-	-	X	-	29 %

Stream Geomorphic Assessment



Wildlife Passage Report - Structures Potentially Suitable for Terrestrial Wildlife Movement

Large Wildlife = deer, moose, bear

Medium Wildlife = fisher, otter, coyote, fox

Small Wildlife = herps, small mammals

Town	Road	Stream Name	Structure	Type	X = meets criteria MD = missing data			Wildlife Species Observed		
					Small Wildlife	Medium Wildlife	Large Wildlife	Roadkill	Outside Structure	Inside Structure
Norwich	BEAVER MEADOW RD	Charles Brown Brook	101411001314111	Bridge	-	-	-	None	None	None
Norwich	OLD ORCHARD LN	Blood Brook	70000000414113	Culvert	-	-	-	None	Deer - Tracks	None
Norwich	TURNPIKE RD	Blood Brook	70000000514113	Culvert	-	-	-	None	None	None
Norwich	TURNPIKE RD	Blood Brook	70000000614113	Culvert	-	-	-	None	None	None
Norwich	UPPER TPKE RD	Blood Brook	100019000114111	Culvert	-	-	-	None	None	None
Norwich	TURNPIKE RD	Blood Brook	70000000714113	Bridge	-	-	-	None	None	None
Norwich	TURNPIKE RD	Blood Brook	100016000214111	Bridge	X	X	-	---	---	---
Norwich	BRAGG HILL RD	Bragg Brook	100052000514111	Culvert	-	-	-	None	None	None
Norwich	BRAGG HILL RD	Bragg Brook	100052000614111	Culvert	-	-	-	None	None	None
Norwich	TURNPIKE RD	Blood Brook	401411003714111	Culvert	-	-	-	None	None	None
Norwich	TURNPIKE RD	Blood Brook	401411000714111	Bridge	-	-	-	None	None	None
Norwich	TURNPIKE RD	Blood Brook	101411001014111	Bridge	X	X	-	None	None	None
Norwich	MOORE LN	Blood Brook	101411001214111	Bridge	-	-	-	None	Deer - Tracks	None
Norwich	BEAVER MEADOW RD	Blood Brook	101411003914111	Bridge	-	-	-	None	None	None
Norwich	ELM ST	Blood Brook	101411004314111	Bridge	X	X	X	None	None	None
Norwich	HOPSON RD	Blood Brook	101411004414111	Bridge	-	-	-	None	None	None
Norwich	Route 5	Blood Brook	300113007814111	Culvert	MD	MD	MD	None	Unsure - Scat	None
Norwich	MONTSHIRE RD	Blood Brook	20009147-214112	Arch	MD	MD	MD	None	None	None
Norwich	BEAVER MEADOW RD	Charles Brown Brook	401411005814111	Culvert	-	-	-	None	None	None
Norwich	NEEDHAM RD	Unnamed Blood Brook tributary	401411003614111	Culvert	-	-	-	None	None	None
Norwich	UPPER TPKE RD	Unnamed Blood Brook tributary	401411001414111	Culvert	-	-	-	None	None	None
Norwich	NEW BOSTON RD	New Boston trib	401411000114111	Arch	-	-	-	None	None	None
Norwich	NEW BOSTON RD	New Boston trib	401411000414111	Culvert	-	-	-	None	None	None
Norwich	NEW BOSTON RD	New Boston tributary	401411000614111	Culvert	-	-	-	None	None	None
Norwich	NEW BOSTON RD	New Boston trib	401411005014111	Bridge	-	-	-	None	None	None
Norwich	NEW BOSTON RD	New Boston tributary	401411002514111	Bridge	-	-	-	None	None	None

Norwich	BRAGG HILL RD	Bragg Brook	401411001714111	Culvert	-	-	-	None	None	None
Norwich	TURNPIKE RD	Blood Brook	700000000214113	Culvert	-	-	-	None	None	None
Norwich	BRAGG HILL RD	Bragg Brook	700000000914113	Culvert	-	-	-	None	None	None
Norwich	BRAGG HILL RD	Bragg Brook	100052000714111	Culvert	-	-	-	None	None	None
Norwich	TURNPIKE RD	Blood Brook	401411006814111	Culvert	-	-	-	None	None	None
Norwich	BRAGG HILL RD	Bragg Brook	401411004814111	Culvert	-	-	-	None	None	None
Norwich	TURNPIKE RD	Blood Brook	700000000814113	Bridge	X	X	-	None	None	None
Norwich	TURNPIKE RD	Blood Brook	401411006714111	Culvert	-	-	-	None	None	None
Norwich	TURNPIKE RD	Blood Brook	401411001914111	Culvert	-	-	-	None	None	None
Norwich	BROWN SCHOOLHOUSE RD	Charles Brown Brook	401411006614111	Bridge	-	-	-	None	None	None
Norwich	BRAGG HILL RD	Bragg Brook	401411003114111	Bridge	X	X	-	None	None	None
Norwich	TURNPIKE RD	Blood Brook	700000000314113	Culvert	-	-	-	None	None	None
Norwich	TURNPIKE RD	Blood Brook	401411003814111	Culvert	-	-	-	None	None	None
Norwich	TURNPIKE RD	Blood Brook	401411003214111	Bridge	-	-	-	None	None	None
Norwich	TURNPIKE RD	Blood Brook	101411004114111	Culvert	-	-	-	None	None	None
Norwich	TURNPIKE RD	Blood Brook	101411004214111	Bridge	X	X	-	None	None	None
Norwich	BIRCH HILL LN	Blood Brook	700000000114113	Culvert	-	-	-	None	None	None

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Stream Geomorphic Assessment



Blood Brook

Phase 1 - Step 2. Preliminary Reference Stream Type

Basin: **Upper Connecticut** Watershed: **Middle Northern Connecticut River** Sub-watershed: **Connecticut River -- Hewes Brook to White River**

Step	2.1		2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	2.10		2.11	
Reach ID	Elevation Up (ft.)	Elevation Down (ft.)	Valley Length (ft.)	Valley Slope (%)	Channel Length (ft.)	Channel Slope (%)	Sinuosity	Watershed Area (sq. mi.)	Channel Width (ft.)	Valley Width (ft.)	Confinement Ratio	Type	Reference Stream Type	Bedform
M02	431	387	1565	2.81	1603	2.74	1.02	18.43	47.2	240	5.1	NW	B	Plane Bed
M03	501	431	4576	1.53	5599	1.25	1.22	17.64	46.3	475	10.3	VB	C	Riffle-Pool
M03-T1.01	607	505			2080	4.90		1.21	14.3			SC	B	Step-Pool
M03-T1.02	916	607			5200	5.94		1.17	14.0			NC	A	Step-Pool
M03-T1.03	1335	916			5780	7.25		0.59	10.4			NC	A	Step-Pool
M04	550	501	5084	0.96	5576	0.88	1.10	15.73	44.0	748	17.0	VB	C	Riffle-Pool
M04-T2.01	607	550			1760	3.24		5.64	28.0			SC	B	Step-Pool
M04-T2.03	702	607			3342	2.84		5.52	27.8			NW	B	Plane Bed
M04-T2.05	776	716			2224	2.70		4.87	26.3			NW	B	Plane Bed
M04-T2.06	932	776			6145	2.54		3.70	23.3			NW	B	Plane Bed
M04-T2.07	1047	932			2657	4.33		1.99	17.7			NC	A	Step-Pool
M04-T2.08	1079	1047	1399	2.29	1872	1.71	1.34	1.71	16.6	376	22.7	VB	C	Riffle-Pool
M04-T2.09	1468	1079			7330	5.31		0.65	10.9			NC	A	Step-Pool
M05	617	550	2772	2.42	3344	2.00	1.21	9.27	34.9	396	11.3	VB	C	Riffle-Pool
M05-T3.01	712	616			3302	2.91		2.79	20.6			NW	B	Step-Pool
M05-T3.02	792	712	8215	0.97	9995	0.80	1.22	2.63	20.1	525	26.2	VB	C	Riffle-Pool
M05-T3.04	918	806	5181	2.16	5584	2.01	1.08	0.90	12.5	376	30.0	VB	C	Riffle-Pool
M06	734	617			5444	2.15		6.04	28.9			NW	B	Plane Bed
M07	814	734	3703	2.16	4380	1.83	1.18	5.54	27.8	588	21.1	VB	C	Riffle-Pool
M07-T4.01	905	814			3256	2.79		1.87	17.3			NW	B	Plane Bed
M07-T4.02	930	905	3231	0.77	3789	0.66	1.17	1.75	16.8	384	22.9	VB	C	Riffle-Pool
M07-T4.04	969	930	1696	2.30	1877	2.08	1.11	1.36	15.0	469	31.2	VB	C	Riffle-Pool
M07-T4.05	1414	969			7035	6.33		1.14	13.9			NC	A	Step-Pool
M08	961	814			4892	3.00		2.49	19.6			SC	B	Step-Pool
M09	1502	961			12260	4.41		1.94	17.5			NC	A	Step-Pool

Stream Geomorphic Assessment



Blood Brook

Phase 1 - Step 3. Basin Characteristics: Geology

Basin: **Upper Connecticut** Watershed: **Middle Northern Connecticut River** Sub-watershed: **Connecticut River -- Hewes Brook to White River**

Step	3.1	3.2	3.3 Geologic Materials			3.4 Valley Side Slope	
Reach ID	Alluvial Fan	Grade Control	Dominant	%	Sub-Dominant	Left	Right
M02	None	Ledge	Glacial Lake	99.0	Other	Very Steep	Very Steep
M03	Yes	Multiple	Alluvial	65.0	Till	Flat	Flat
M03-T1.01	Yes	None	Ice-Contact	63.0	Till	Flat	Hilly
M03-T1.02	None	None	Till	99.0	Ice-Contact	Very Steep	Very Steep
M03-T1.03	None	None	Till	99.0	---	Steep	Steep
M04	Yes	None	Alluvial	86.0	Ice-Contact	Flat	Flat
M04-T2.01	None	None	Ice-Contact	71.0	Till	Steep	Hilly
M04-T2.03	None	None	Till	97.0	Ice-Contact	Very Steep	Extremely Steep
M04-T2.05	None	None	Ice-Contact	74.0	Till	Very Steep	Very Steep
M04-T2.06	None	None	Ice-Contact	67.0	Till	Steep	Very Steep
M04-T2.07	None	None	Till	86.0	Ice-Contact	Very Steep	Very Steep
M04-T2.08	None	None	Till	80.0	Alluvial	Steep	Very Steep
M04-T2.09	Yes	None	Till	90.0	Alluvial	Steep	Steep
M05	Yes	None	Ice-Contact	76.0	Alluvial	Steep	Hilly
M05-T3.01	None	None	Till	83.0	Ice-Contact	Very Steep	Very Steep
M05-T3.02	None	None	Alluvial	90.0	Till	Steep	Hilly
M05-T3.04	None	None	Till	52.0	Alluvial	Steep	Very Steep
M06	None	None	Ice-Contact	94.0	Till	Very Steep	Very Steep
M07	Yes	None	Ice-Contact	49.0	Alluvial	Flat	Hilly
M07-T4.01	None	None	Till	68.0	Ice-Contact	Very Steep	Very Steep
M07-T4.02	None	None	Till	99.0	---	Hilly	Steep
M07-T4.04	None	None	Till	99.0	---	Hilly	Steep
M07-T4.05	None	None	Till	99.0	---	Very Steep	Very Steep
M08	None	None	Till	62.0	Ice-Contact	Hilly	Steep
M09	None	Ledge	Till	99.0	---	Very Steep	Very Steep

Stream Geomorphic Assessment

VT DEC

Blood Brook**Phase 1 - Step 3. Basin Characteristics: Soils**

Basin: **Upper Connecticut** Watershed: **Middle Northern Connecticut River** Sub-watershed: **Connecticut River -- Hewes Brook to White River**

Reach ID	3.5 Soil Properties									
	Hydrologic Group	%	Flooding	%	Deep	%	Shallow	%	Erodibility	%
M02	B	99.0	None/Rare	100.0	6.0	100.0	6.0	99.0	Very Severe	99.0
M03	C	61.0	Frequent	56.0	1.5	56.0	0.0	56.0	Moderate	32.0
M03-T1.01	A	58.0	None/Rare	88.0	6.0	63.0	6.0	63.0	Very Severe	83.0
M03-T1.02	C	99.0	None/Rare	100.0	2.0	99.0	1.0	99.0	Very Severe	99.0
M03-T1.03	C	51.0	None/Rare	100.0	6.0	68.0	6.0	68.0	Very Severe	99.0
M04	B	83.0	Occasional	76.0	3.0	67.0	1.5	69.0	Slight	12.0
M04-T2.01	B	76.0	None/Rare	94.0	2.5	71.0	1.5	76.0	Very Severe	94.0
M04-T2.03	C	96.0	None/Rare	100.0	2.0	95.0	1.0	95.0	Very Severe	99.0
M04-T2.05	B	76.0	None/Rare	100.0	2.5	74.0	1.5	74.0	Very Severe	99.0
M04-T2.06	B	89.0	None/Rare	100.0	2.5	67.0	1.5	67.0	Very Severe	99.0
M04-T2.07	C	86.0	None/Rare	100.0	2.0	85.0	1.0	85.0	Very Severe	99.0
M04-T2.08	C	62.0	None/Rare	81.0	2.0	43.0	1.0	43.0	Very Severe	81.0
M04-T2.09	C	71.0	None/Rare	90.0	6.0	72.0	6.0	72.0	Very Severe	90.0
M05	B	100.0	None/Rare	77.0	2.5	74.0	1.5	97.0	Very Severe	76.0
M05-T3.01	C	83.0	None/Rare	100.0	2.0	83.0	1.0	83.0	Very Severe	98.0
M05-T3.02	D	71.0	Frequent	90.0	0.5	71.0	0.0	90.0	Slight	8.0
M05-T3.04	C	96.0	None/Rare	53.0	1.5	46.0	0.0	46.0	Severe	52.0
M06	B	94.0	None/Rare	100.0	2.5	93.0	1.5	93.0	Very Severe	99.0
M07	B	89.0	None/Rare	60.0	2.5	46.0	1.5	86.0	Severe	59.0
M07-T4.01	C	68.0	None/Rare	96.0	2.0	68.0	1.0	68.0	Very Severe	95.0
M07-T4.02	D	80.0	None/Rare	100.0	1.5	80.0	0.0	80.0	Very Severe	99.0
M07-T4.04	D	91.0	None/Rare	100.0	1.5	91.0	0.0	91.0	Very Severe	99.0
M07-T4.05	C	88.0	None/Rare	100.0	2.0	67.0	1.0	67.0	Very Severe	99.0
M08	C	62.0	None/Rare	95.0	2.0	62.0	1.0	62.0	Very Severe	95.0
M09	C	100.0	None/Rare	100.0	6.0	61.0	6.0	61.0	Very Severe	99.0

Blood Brook

Phase 1 - Step 3. Soils Data

Soil Parent Material

Reach ID	Alluvial	Glacial Lake	Glacio Fluvial / Glacio Lacustrine	Ice- contact	No Data	Other	Till	Till / Outwash	Total
M01		88.0				11.0			99.0
M02		99.0				0.0			99.0
M03	65.0	9.0		9.0			14.0		97.0
M03- T1.01	11.0			63.0			25.0		99.0
M03- T1.02				0.0			99.0		99.0
M03- T1.03							99.0		99.0
M04	86.0			13.0					99.0
M04- T2.01	5.0			71.0			23.0		99.0
M04- T2.02				78.0			21.0		99.0
M04- T2.03				1.0			97.0		98.0
M04- T2.04				72.0			26.0		98.0
M04- T2.05				74.0			25.0		99.0
M04- T2.06				67.0			31.0		98.0
M04- T2.07				12.0			86.0		98.0
M04- T2.08	18.0						80.0		98.0
M04- T2.09	9.0						90.0		99.0
M05	22.0			76.0			0.0		98.0
M05- T3.01				15.0		1.0	83.0		99.0
M05- T3.02	90.0			1.0			7.0		98.0
M05- T3.03	35.0						64.0		99.0
M05- T3.04	46.0					0.0	52.0		98.0
M06				94.0			4.0		98.0
M07	39.0			49.0			10.0		98.0
M07- T4.01	3.0			28.0			68.0		99.0
M07- T4.02							99.0		99.0
M07- T4.03							99.0		99.0
M07- T4.04							99.0		99.0
M07- T4.05							99.0		99.0
M08	4.0			33.0			62.0		99.0
M09							99.0		99.0

Stream Geomorphic Assessment



Blood Brook

Phase 1 - Step 4. Land Cover - Reach Hydrology

Basin: **Upper Connecticut** Watershed: **Middle Northern Connecticut River** Sub-watershed: **Connecticut River -- Hewes Brook to White River**

Step	4.1 Watershed Land Cover - Land Use							4.2 Corridor Land Cover - Land Use							4.3 Riparian Buffer		
	Reach ID	Historic	Current					Historic	Current					Width (ft.)			
Dom.			%	Sub-D.	Urban	Crop	Impact		Dom.	%	Sub-D.	Urban	Crop	Impact	L Bank	R Bank	Impact
M02		Forest	69.0	Urban	12.0	8.0	High		Urban	51.0	Forest	51.0	1.0	High	0-25	0-25	High
M03		Forest	70.0	Urban	11.0	8.0	High		Forest	30.0	Urban	17.0	7.0	High	>100	26-50	N.S.
M03-T1.01		Forest	53.0	Urban	19.0	10.0	High		Urban	40.0	Forest	40.0	2.0	High	>100	0-25	Low
M03-T1.02		Forest	52.0	Urban	17.0	10.0	High		Urban	42.0	Forest	42.0	1.0	High	0-25	>100	Low
M03-T1.03		Forest	55.0	Urban	17.0	7.0	High		Urban	40.0	Forest	40.0	2.0	High	26-50	>100	N.S.
M04		Forest	72.0	Urban	10.0	7.0	High		Urban	27.0	Forest	27.0	10.0	High	26-50	26-50	N.S.
M04-T2.01		Forest	73.0	Crop	8.0	8.0	High		Forest	30.0	Urban	29.0	0.0	High	26-50	51-100	N.S.
M04-T2.03		Forest	72.0	Crop	8.0	8.0	High		Urban	32.0	Forest	32.0		High	>100	>100	N.S.
M04-T2.05		Forest	74.0	Crop	6.0	7.0	High		Forest	24.0	Urban	13.0		High	>100	>100	N.S.
M04-T2.06		Forest	76.0	Crop	6.0	6.0	High		Forest	43.0	Urban	7.0		Low	>100	>100	N.S.
M04-T2.07		Forest	77.0	Urban	6.0	5.0	High		Forest	52.0	Urban	8.0		Low	>100	>100	N.S.
M04-T2.08		Forest	79.0	Urban	5.0	4.0	Low		Forest	34.0	Urban	33.0		High	>100	26-50	N.S.
M04-T2.09		Forest	89.0	Crop		2.0	Low		Forest	68.0	Crop		0.0	N.S.	>100	>100	N.S.
M05		Forest	75.0	Urban	9.0	7.0	High		Forest	35.0	Urban	13.0	1.0	High	>100	>100	N.S.
M05-T3.01		Forest	75.0	Urban	10.0	6.0	High		Urban	59.0	Forest	59.0	0.0	High	>100	>100	Low
M05-T3.02		Forest	78.0	Urban	9.0	6.0	High		Forest	57.0	Wetland	5.0	8.0	High	0-25	0-25	High
M05-T3.04		Forest	78.0	Urban	10.0	5.0	High		Forest	38.0	Urban	9.0	5.0	High	>100	0-25	Low
M06		Forest	74.0	Crop	8.0	8.0	High		Urban	37.0	Forest	37.0		High	>100	26-50	N.S.
M07		Forest	76.0	Crop	8.0	8.0	High		Urban	23.0	Forest	23.0	12.0	High	26-50	0-25	Low
M07-T4.01		Forest	75.0	Crop	7.0	7.0	High		Forest	61.0	Urban	5.0	0.0	Low	>100	>100	N.S.
M07-T4.02		Forest	78.0	Crop	6.0	7.0	High		Forest	52.0	Urban	8.0	5.0	High	>100	>100	Low
M07-T4.04		Forest	84.0	Crop	4.0	4.0	Low		Forest	59.0	Urban	4.0	0.0	Low	>100	>100	N.S.
M07-T4.05		Forest	84.0	Crop	4.0	5.0	Low		Forest	58.0	Crop	0.0	3.0	Low	>100	>100	N.S.
M08		Forest	75.0	Crop	8.0	8.0	High		Urban	53.0	Forest	53.0	0.0	High	0-25	>100	Low
M09		Forest	78.0	Crop	7.0	7.0	High		Urban	38.0	Forest	38.0	1.0	High	>100	>100	N.S.

Stream Geomorphic Assessment

VT DEC

Blood Brook

Phase 1 - Step 4. Land Cover - Land Use Data

Watershed Land Cover - Land Use

Reach ID	Commercial	Crop	Field	Forest	Industrial	Residential	Shrub	Water	Wetland	Total
M01	0.0	8.0	3.0	69.0		12.0		5.0	0.0	97.0
M02		8.0	3.0	69.0		12.0		4.0	0.0	96.0
M03		8.0	3.0	70.0		11.0		4.0	0.0	96.0
M03-T1.01		10.0	9.0	53.0		19.0		6.0		97.0
M03-T1.02		10.0	10.0	52.0		17.0		5.0		94.0
M03-T1.03		7.0	13.0	55.0		17.0		5.0		97.0
M04		7.0	2.0	72.0		10.0		4.0	0.0	95.0
M04-T2.01		8.0	2.0	73.0		8.0		5.0	0.0	96.0
M04-T2.02		8.0	2.0	73.0		8.0		5.0	0.0	96.0
M04-T2.03		8.0	2.0	72.0		8.0		5.0	0.0	95.0
M04-T2.04		7.0	2.0	74.0		7.0		5.0	0.0	95.0
M04-T2.05		7.0	2.0	74.0		6.0		6.0		95.0
M04-T2.06		6.0	1.0	76.0		6.0		5.0		94.0
M04-T2.07		5.0	1.0	77.0		6.0		7.0		96.0
M04-T2.08		4.0	0.0	79.0		5.0		7.0		95.0
M04-T2.09		2.0		89.0				6.0		97.0
M05		7.0	2.0	75.0		9.0		3.0	0.0	96.0
M05-T3.01		6.0	2.0	75.0		10.0		2.0	0.0	95.0
M05-T3.02		6.0	1.0	78.0		9.0		2.0	0.0	96.0
M05-T3.03		4.0	0.0	82.0		7.0		3.0		96.0
M05-T3.04		5.0	0.0	78.0		10.0		4.0		97.0
M06		8.0	2.0	74.0		8.0		4.0		96.0
M07		8.0	1.0	76.0		8.0		4.0		97.0
M07-T4.01		7.0	2.0	75.0		7.0		4.0		95.0
M07-T4.02		7.0	1.0	78.0		6.0		3.0		95.0
M07-T4.03		4.0	0.0	83.0		4.0		4.0		95.0
M07-T4.04		4.0	0.0	84.0		4.0		4.0		96.0
M07-T4.05		5.0	0.0	84.0		4.0		4.0		97.0
M08		8.0	0.0	75.0		8.0		4.0		95.0
M09		7.0	0.0	78.0		7.0		4.0		96.0

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Stream Geomorphic Assessment

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Blood Brook

Phase 1 - Step 4. Land Cover - Land Use Data

Corridor Land Cover - Land Use

Reach ID	Commercial	Crop	Field	Forest	Industrial	Residential	Shrub	Water	Wetland	Total
M01				12.0		3.0		82.0		97.0
M02		1.0		21.0		51.0		24.0		97.0
M03		7.0	5.0	30.0		17.0		36.0		95.0
M03-T1.01		2.0	0.0	7.0		40.0		47.0		96.0
M03-T1.02		1.0		18.0		42.0		36.0		97.0
M03-T1.03		2.0	0.0	24.0		40.0		29.0		95.0
M04		10.0	8.0	19.0		27.0		33.0		97.0
M04-T2.01		0.0	5.0	30.0		29.0		32.0		96.0
M04-T2.02				75.0		5.0		19.0		99.0
M04-T2.03				20.0		32.0		44.0	0.0	96.0
M04-T2.04				61.0		2.0		31.0	4.0	98.0
M04-T2.05				24.0		13.0		60.0		97.0
M04-T2.06				43.0		7.0		47.0		97.0
M04-T2.07				52.0		8.0		38.0		98.0
M04-T2.08				34.0		33.0		31.0		98.0
M04-T2.09		0.0		68.0				29.0		97.0
M05		1.0	2.0	35.0		13.0		46.0		97.0
M05-T3.01		0.0		17.0		59.0		22.0		98.0
M05-T3.02		8.0	0.0	57.0		5.0		17.0	9.0	96.0
M05-T3.03				34.0				65.0		99.0
M05-T3.04		5.0	0.0	38.0		9.0		43.0		95.0
M06				27.0		37.0		33.0		97.0
M07		12.0	6.0	17.0		23.0		39.0		97.0
M07-T4.01		0.0	0.0	61.0		5.0		31.0		97.0
M07-T4.02		5.0	1.0	52.0		8.0		31.0		97.0
M07-T4.03		7.0	9.0	37.0				44.0		97.0
M07-T4.04		0.0		59.0		4.0		33.0		96.0
M07-T4.05		3.0		58.0		0.0		36.0		97.0
M08		0.0	1.0	8.0		53.0		34.0		96.0
M09		1.0	0.0	26.0		38.0		31.0		96.0

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Stream Geomorphic Assessment



Blood Brook

Phase 1 - Step 4. Riparian Condition Summary

Basin: **Upper Connecticut** Watershed: **Middle Northern Connecticut River** Sub-watershed: **Connecticut River -- Hewes Brook to White River**

Reach ID	Riparian Corridor				Riparian Buffer								
	Dominant Corridor Land Cover	Urban %	Crop %	Corridor Land Cover Impact	Buffer Width	Left Bank				Buffer Width	Right Bank		
						Percent of each Buffer Width					Percent of each Buffer Width		
						0-25	26-50	51-100	>100		0-25	26-50	51-100
M02	Urban	51.0	1.0	High	0-25	80	0	10	10	0-25	40	0	40
M03	Forest	17.0	7.0	High	>100	20	20	0	60	26-50	20	40	10
M03-T1.01	Urban	40.0	2.0	High	>100	20	30	10	40	0-25	40	30	10
M03-T1.02	Urban	42.0	1.0	High	0-25	30	30	20	20	>100	10	10	0
M03-T1.03	Urban	40.0	2.0	High	26-50	20	40	10	30	>100	0	10	10
M04	Urban	27.0	10.0	High	26-50	10	40	30	20	26-50	10	40	20
M04-T2.01	Forest	29.0	0.0	High	26-50	0	60	10	30	51-100	0	30	50
M04-T2.03	Urban	32.0		High	>100	10	20	10	60	>100	0	0	0
M04-T2.05	Forest	13.0		High	>100	0	20	0	80	>100	0	0	0
M04-T2.06	Forest	7.0		Low	>100	0	0	0	100	>100	0	0	0
M04-T2.07	Forest	8.0		Low	>100	0	0	20	80	>100	0	0	0
M04-T2.08	Forest	33.0		High	>100	0	0	0	100	26-50	0	50	0
M04-T2.09	Forest		0.0	N.S.	>100	0	0	0	100	>100	0	0	0
M05	Forest	13.0	1.0	High	>100	0	0	10	90	>100	10	30	20
M05-T3.01	Urban	59.0	0.0	High	>100	30	10	10	50	>100	20	30	10
M05-T3.02	Forest	5.0	8.0	High	0-25	50	0	0	50	0-25	80	10	0
M05-T3.04	Forest	9.0	5.0	High	>100	25	25	0	50	0-25	50	10	20
M06	Urban	37.0		High	>100	0	5	0	95	26-50	10	50	10
M07	Urban	23.0	12.0	High	26-50	20	50	0	30	0-25	50	50	0
M07-T4.01	Forest	5.0	0.0	Low	>100	0	10	0	90	>100	0	20	0
M07-T4.02	Forest	8.0	5.0	High	>100	30	10	0	60	>100	20	0	30
M07-T4.04	Forest	4.0	0.0	Low	>100	0	0	0	100	>100	0	0	0
M07-T4.05	Forest	0.0	3.0	Low	>100	0	0	10	90	>100	0	0	10
M08	Urban	53.0	0.0	High	0-25	30	30	20	20	>100	20	30	0
M09	Urban	38.0	1.0	High	>100	5	0	5	90	>100	5	0	5

Stream Geomorphic Assessment



Blood Brook

Phase 1 - Step 5. Instream Channel Modification

Basin: **Upper Connecticut** Watershed: **Middle Northern Connecticut River** Sub-watershed: **Connecticut River -- Hewes Brook to White River**

Step Reach ID	5.1 Flow Regulation		5.2 Bridges - Culverts			5.3 Bank Armoring			5.4 Channel Straightening			5.5 Dred Type
	Type	Impact	Number	Length	Percent Impact	Length	Percent Impact	Length	Percent Impact	Length	Percent Impact	
M02	None	N.S.	0	0	0.0 N.S.	586	18.3 Low	1603	100.0 High			Not Evaluated
M03	None	N.S.	2	1184	21.2 High	916	8.2 N.S.	2155	38.5 High			Not Evaluated
M03-T1.01	None	N.S.	1	482	23.2 High	None	N.S.	None	N.S.			Not Evaluated
M03-T1.02	None	N.S.	2	517	9.9 Low	None	N.S.	None	N.S.			Not Evaluated
M03-T1.03	None	N.S.	3	0	0.0 N.S.	None	N.S.	None	N.S.			Not Evaluated
M04	None	N.S.	2	0	0.0 N.S.	631	5.7 N.S.	1674	30.0 High			Not Evaluated
M04-T2.01	None	N.S.	1	0	0.0 N.S.	None	N.S.	None	N.S.			Not Evaluated
M04-T2.03	None	N.S.	0	0	0.0 N.S.	None	N.S.	None	N.S.			Not Evaluated
M04-T2.05	None	N.S.	0	0	0.0 N.S.	None	N.S.	None	N.S.			Not Evaluated
M04-T2.06	None	N.S.	1	0	0.0 N.S.	None	N.S.	None	N.S.			Not Evaluated
M04-T2.07	None	N.S.	0	0	0.0 N.S.	None	N.S.	None	N.S.			Not Evaluated
M04-T2.08	None	N.S.	1	194	10.4 Low	None	N.S.	None	N.S.			Not Evaluated
M04-T2.09	None	N.S.	0	0	0.0 N.S.	None	N.S.	None	N.S.			Not Evaluated
M05	None	N.S.	2	1134	33.9 High	311	4.7 N.S.	None	N.S.			Not Evaluated
M05-T3.01	None	N.S.	4	1164	35.3 High	None	N.S.	None	N.S.			Not Evaluated
M05-T3.02	None	N.S.	1	88	0.9 Low	None	N.S.	None	N.S.			Not Evaluated
M05-T3.04	None	N.S.	2	0	0.0 N.S.	None	N.S.	None	N.S.			Not Evaluated
M06	None	N.S.	3	1101	20.2 High	171	1.6 N.S.	None	N.S.			Not Evaluated
M07	None	N.S.	1	0	0.0 N.S.	699	8.0 N.S.	None	N.S.			Not Evaluated
M07-T4.01	None	N.S.	1	0	0.0 N.S.	None	N.S.	None	N.S.			Not Evaluated
M07-T4.02	None	N.S.	1	220	5.8 Low	None	N.S.	None	N.S.			Not Evaluated
M07-T4.04	None	N.S.	0	0	0.0 N.S.	None	N.S.	None	N.S.			Not Evaluated
M07-T4.05	None	N.S.	0	0	0.0 N.S.	None	N.S.	None	N.S.			Not Evaluated
M08	None	N.S.	1	404	8.2 Low	447	4.6 N.S.	None	N.S.			Not Evaluated
M09	Impoundment	N.S.	3	1186	9.7 Low	None	N.S.	None	N.S.			Not Evaluated

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Stream Geomorphic Assessment

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Blood Brook

Phase 1 - Step 5. Bank Armoring And Straightening

Lengths summed for each Reach, Feature, and SubFeature

Reach ID	Feature	SubFeature	Total Length
M02	Bank Armoring or Revetment	Rip-Rap	586
M02	Straightening	Straightening	1603
M03	Bank Armoring or Revetment	Rip-Rap	916
M03	Straightening	Straightening	2155
M04	Bank Armoring or Revetment	Rip-Rap	631
M04	Straightening	Straightening	1674
M05	Bank Armoring or Revetment	Rip-Rap	311
M06	Bank Armoring or Revetment	Rip-Rap	171
M07	Bank Armoring or Revetment	Rip-Rap	699
M08	Bank Armoring or Revetment	Rip-Rap	447

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Stream Geomorphic Assessment



Blood Brook

Phase 1 - Step 6. Floodplain Modification and Planform Changes

Basin: **Upper Connecticut** Watershed: **Middle Northern Connecticut River** Sub-watershed: **Connecticut River -- Hewes Brook to White River**

Step	6.1 Berms & Roads			6.2 Corridor Development			6.3 Depositional Features		6.4 Meander Migration		6.5 Meander Width Ratio			6.6 Wa
Reach ID	Length	Percent	Impact	Length	Percent	Impact	Type	Impact	Type	Impact	Width	Ratio	Impact	Length
M02	1566	97.7	High	1554.0	96.9	High	None	N.S.	Not Evaluated	N.S.	47	1.0	High	47
M03	562	10.0	Low	1748.4	31.2	High	Point	Low	Migration	Low	101	2.2	High	155
M03-T1.01	None		N.S.	983.9	47.3	High	None	N.S.	None	N.S.	Not Applicable		Unk.	Not Applic
M03-T1.02	4711	90.6	High	839.2	16.1	Low	None	N.S.	None	N.S.	Not Applicable		Unk.	Not Applic
M03-T1.03	4188	72.5	High	370.8	6.4	Low	None	N.S.	None	N.S.	Not Applicable		Unk.	Not Applic
M04	1825	32.7	High	4047.7	72.6	High	Delta	Low	Migration	Low	58	1.3	High	360
M04-T2.01	1072	60.9	High	865.6	49.2	High	None	N.S.	Migration	N.S.	Not Applicable		Unk.	Not Applic
M04-T2.03	634	19.0	Low	0.0	0.0	N.S.	None	N.S.	None	N.S.	Not Applicable		Unk.	Not Applic
M04-T2.05	None		N.S.	0.0	0.0	N.S.	None	N.S.	None	N.S.	Not Applicable		Unk.	Not Applic
M04-T2.06	None		N.S.	113.3	1.8	N.S.	None	N.S.	Migration	N.S.	Not Applicable		Unk.	Not Applic
M04-T2.07	None		N.S.	0.0	0.0	N.S.	None	N.S.	None	N.S.	Not Applicable		Unk.	Not Applic
M04-T2.08	873	46.6	High	261.6	14.0	Low	None	N.S.	None	N.S.	93	5.6	N.S.	116
M04-T2.09	None		N.S.	0.0	0.0	N.S.	None	N.S.	None	N.S.	Not Applicable		Unk.	Not Applic
M05	None		N.S.	957.5	28.6	High	Delta	Low	Migration	Low	138	4.0	Low	500
M05-T3.01	3291	99.7	High	1176.6	35.6	High	Mid-channel	Low	None	N.S.	Not Applicable		Unk.	Not Applic
M05-T3.02	432	4.3	N.S.	396.0	4.0	N.S.	None	N.S.	None	N.S.	46	2.3	High	90
M05-T3.04	None		N.S.	386.7	6.9	Low	None	N.S.	None	N.S.	33	2.6	High	163
M06	1901	34.9	High	1706.2	31.3	High	Multiple	Low	Migration	Low	Not Applicable		Unk.	Not Applic
M07	963	22.0	High	732.6	16.7	Low	None	N.S.	None	N.S.	110	4.0	Low	335
M07-T4.01	None		N.S.	125.5	3.9	N.S.	None	N.S.	None	N.S.	Not Applicable		Unk.	Not Applic
M07-T4.02	None		N.S.	198.9	5.3	Low	None	N.S.	None	N.S.	44	2.6	High	95
M07-T4.04	None		N.S.	0.0	0.0	N.S.	None	N.S.	None	N.S.	30	2.0	High	119
M07-T4.05	None		N.S.	0.0	0.0	N.S.	None	N.S.	None	N.S.	Not Applicable		Unk.	Not Applic
M08	3126	63.9	High	993.3	20.3	High	None	N.S.	None	N.S.	Not Applicable		Unk.	Not Applic
M09	5603	45.7	High	1324.0	10.8	Low	None	N.S.	Migration	N.S.	Not Applicable		Unk.	Not Applic

Stream Geomorphic Assessment

VT DEC

Blood Brook

Phase 1 - Step 6. Berms and Roads

Lengths summed for each Reach, Feature, and SubFeature

Reach ID	Feature	SubFeature	Total Length
M02	Encroachment	Road	1566
M03	Encroachment	Road	562
M03-T1.02	Encroachment	Road	4711
M03-T1.03	Encroachment	Road	4188
M04	Encroachment	Road	1825
M04-T2.01	Encroachment	Road	1072
M04-T2.03	Encroachment	Road	634
M04-T2.08	Encroachment	Road	873
M05-T3.01	Encroachment	Road	3291
M05-T3.02	Encroachment	Road	432
M06	Encroachment	Road	1901
M07	Encroachment	Road	963
M08	Encroachment	Road	3126
M09	Encroachment	Road	5603

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Stream Geomorphic Assessment



Blood Brook

Phase 1 - Step 7. Bed and Bank Windshield Survey

Basin: **Upper Connecticut** Watershed: **Middle Northern Connecticut River** Sub-watershed: **Connecticut River -- Hewes Brook to White River**

Step Reach ID	7.1 Stream Type					7.2 Bank Erosion - Bank Height			7.3 Ice & Debris Jam Potential	
	Reference Stream Type	Mod. Ref. Stream Type	Dominant Bedform	Subclass Slope	Dominant Bed Material	Bank Erosion	Bank Height	Impact	Type	Impact
M02	B	No	Plane Bed		Bedrock	Low	Medium	Low	Culvert	Low
M03	C	No	Riffle-Pool		Gravel	Low	Medium	High	Multiple	High
M03-T1.01	B	No	Step-Pool		Cobble	Low	Low	Low	Multiple	Low
M03-T1.02	A	No	Step-Pool		Cobble	Low	Low	Low	Culvert	High
M03-T1.03	A	No	Step-Pool		Cobble	Low	Low	Low	Multiple	Low
M04	C	No	Riffle-Pool		Cobble	Low	Low	Low	Multiple	Low
M04-T2.01	B	No	Step-Pool		Cobble	Low	Medium	Low	Multiple	Low
M04-T2.03	B	No	Plane Bed		Cobble	Low	Low	N.S.	None	N.S.
M04-T2.05	B	No	Plane Bed		Cobble	None	Low	N.S.	None	N.S.
M04-T2.06	B	No	Plane Bed		Cobble	None	Low	N.S.	None	N.S.
M04-T2.07	A	No	Step-Pool		Cobble	None	Low	N.S.	None	N.S.
M04-T2.08	C	No	Riffle-Pool		Cobble	None	Low	N.S.	Culvert	Low
M04-T2.09	A	No	Step-Pool		Cobble	None	Low	N.S.	None	N.S.
M05	C	No	Riffle-Pool	b	Cobble	Low	Medium	High	Multiple	Low
M05-T3.01	B	No	Step-Pool		Cobble	Low	Medium	High	Culvert	High
M05-T3.02	C	No	Riffle-Pool		Gravel	Low	Low	N.S.	None	N.S.
M05-T3.04	C	No	Riffle-Pool	b	Gravel	Low	Low	N.S.	Culvert	Low
M06	B	No	Plane Bed		Cobble	Low	Medium	High	Culvert	Low
M07	C	No	Riffle-Pool		Cobble	Low	Low	Low	Multiple	Low
M07-T4.01	B	No	Plane Bed		Cobble	Low	Low	N.S.	None	N.S.
M07-T4.02	C	No	Riffle-Pool		Gravel	Low	Low	N.S.	Culvert	Low
M07-T4.04	C	No	Riffle-Pool	b	Cobble	None	Low	N.S.	None	N.S.
M07-T4.05	A	No	Step-Pool		Cobble	None	Low	N.S.	None	N.S.
M08	B	No	Step-Pool		Cobble	Low	Low	Low	Culvert	High
M09	A	No	Step-Pool		Bedrock	Low	Low	Low	Culvert	High

Stream Geomorphic Assessment



Blood Brook

Phase 1 - Step 7. Channelization Report

Basin: **Upper Connecticut** Watershed: **Middle Northern Connecticut River** Sub-watershed: **Connecticut River -- Hewes Brook to White River**

Step	2.5 Channel Slope	2.11 (also 7.1) Stream Type			5.4 Channel Straightening			6.5 Meander Width Ratio			6.6 Wavelength Ratio			
		Reference Stream Type	Dominant Bedform	Subclass Slope	Dominant Bed Material	Length	Percent	Impact	Width	Ratio	Impact	Length	Ratio	Impact
M02	2.74	B	Plane Bed		Bedrock	1603	100.0	High	47	1.0	High	47	1.0	High
M03	1.25	C	Riffle-Pool		Gravel	2155	38.5	High	101	2.2	High	155	3.3	High
M03-T1.01	4.90	B	Step-Pool		Cobble	None		N.S.			Unk.			Unk.
M03-T1.02	5.94	A	Step-Pool		Cobble	None		N.S.			Unk.			Unk.
M03-T1.03	7.25	A	Step-Pool		Cobble	None		N.S.			Unk.			Unk.
M04	0.88	C	Riffle-Pool		Cobble	1674	30.0	High	58	1.3	High	360	8.2	N.S.
M04-T2.01	3.24	B	Step-Pool		Cobble	None		N.S.			Unk.			Unk.
M04-T2.03	2.84	B	Plane Bed		Cobble	None		N.S.			Unk.			Unk.
M04-T2.05	2.70	B	Plane Bed		Cobble	None		N.S.			Unk.			Unk.
M04-T2.06	2.54	B	Plane Bed		Cobble	None		N.S.			Unk.			Unk.
M04-T2.07	4.33	A	Step-Pool		Cobble	None		N.S.			Unk.			Unk.
M04-T2.08	1.71	C	Riffle-Pool		Cobble	None		N.S.	93	5.6	N.S.	116	7.0	Low
M04-T2.09	5.31	A	Step-Pool		Cobble	None		N.S.			Unk.			Unk.
M05	2.00	C	Riffle-Pool	b	Cobble	None		N.S.	138	4.0	Low	500	14.3	Low
M05-T3.01	2.91	B	Step-Pool		Cobble	None		N.S.			Unk.			Unk.
M05-T3.02	0.80	C	Riffle-Pool		Gravel	None		N.S.	46	2.3	High	90	4.5	High
M05-T3.04	2.01	C	Riffle-Pool	b	Gravel	None		N.S.	33	2.6	High	163	13.0	N.S.
M06	2.15	B	Plane Bed		Cobble	None		N.S.			Unk.			Unk.
M07	1.83	C	Riffle-Pool		Cobble	None		N.S.	110	4.0	Low	335	12.0	N.S.
M07-T4.01	2.79	B	Plane Bed		Cobble	None		N.S.			Unk.			Unk.
M07-T4.02	0.66	C	Riffle-Pool		Gravel	None		N.S.	44	2.6	High	95	5.7	High
M07-T4.04	2.08	C	Riffle-Pool	b	Cobble	None		N.S.	30	2.0	High	119	7.9	Low
M07-T4.05	6.33	A	Step-Pool		Cobble	None		N.S.			Unk.			Unk.
M08	3.00	B	Step-Pool		Cobble	None		N.S.			Unk.			Unk.
M09	4.41	A	Step-Pool		Bedrock	None		N.S.			Unk.			Unk.

Stream Geomorphic Assessment



Blood Brook

Phase 1 - Step 8. Stream and Watershed Impact Rating

Basin: **Upper Connecticut** Watershed: **Middle Northern Connecticut River** Sub-watershed: **Connecticut River -- Hewes Brook to White River**

Reach ID	Stream Type	Bed Material	Stream Type		Confine-ment Type	Water-shed Area	Step Number with Impact Score														Tot Scc		
			Subclass Slope	Bed Feature			0 = Not Significant or No Data 1 = Low 2 = High																
							4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.2	7.3	
M02	B	Bedrock		Plane Bed	NW	18.4	2	2	2	0	0	1	2	0	2	2	0	0	2	2	1	1	
M03	C	Gravel		Riffle-Pool	VB	17.6	2	2	0	0	2	0	2	0	1	2	1	1	2	2	2	2	
M03-T1.01	B	Cobble		Step-Pool	SC	1.2	2	2	1	0	2	0	0	0	0	2	0	0	0	0	0	1	1
M03-T1.02	A	Cobble		Step-Pool	NC	1.2	2	2	1	0	1	0	0	0	2	1	0	0	0	0	0	1	2
M03-T1.03	A	Cobble		Step-Pool	NC	0.6	2	2	0	0	0	0	0	0	2	1	0	0	0	0	0	1	1
M04	C	Cobble		Riffle-Pool	VB	15.7	2	2	0	0	0	0	2	0	2	2	1	1	2	0	1	1	
M04-T2.01	B	Cobble		Step-Pool	SC	5.6	2	2	0	0	0	0	0	0	2	2	0	0	0	0	0	1	1
M04-T2.03	B	Cobble		Plane Bed	NW	5.5	2	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
M04-T2.05	B	Cobble		Plane Bed	NW	4.9	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M04-T2.06	B	Cobble		Plane Bed	NW	3.7	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M04-T2.07	A	Cobble		Step-Pool	NC	2.0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M04-T2.08	C	Cobble		Riffle-Pool	VB	1.7	1	2	0	0	1	0	0	0	2	1	0	0	0	0	1	0	1
M04-T2.09	A	Cobble		Step-Pool	NC	0.7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M05	C	Cobble	b	Riffle-Pool	VB	9.3	2	2	0	0	2	0	0	0	0	2	1	1	1	1	1	2	1
M05-T3.01	B	Cobble		Step-Pool	NW	2.8	2	2	1	0	2	0	0	0	2	2	1	0	0	0	0	2	2
M05-T3.02	C	Gravel		Riffle-Pool	VB	2.6	2	2	2	0	1	0	0	0	0	0	0	0	2	2	0	0	0
M05-T3.04	C	Gravel	b	Riffle-Pool	VB	0.9	2	2	1	0	0	0	0	0	0	1	0	0	2	0	0	0	1
M06	B	Cobble		Plane Bed	NW	6.0	2	2	0	0	2	0	0	0	2	2	1	1	0	0	0	2	1
M07	C	Cobble		Riffle-Pool	VB	5.5	2	2	1	0	0	0	0	0	2	1	0	0	1	0	1	1	1
M07-T4.01	B	Cobble		Plane Bed	NW	1.9	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M07-T4.02	C	Gravel		Riffle-Pool	VB	1.8	2	2	1	0	1	0	0	0	1	0	0	2	2	0	0	1	1
M07-T4.04	C	Cobble	b	Riffle-Pool	VB	1.4	1	1	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0
M07-T4.05	A	Cobble		Step-Pool	NC	1.1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M08	B	Cobble		Step-Pool	SC	2.5	2	2	1	0	1	0	0	0	2	2	0	0	0	0	0	1	2
M09	A	Bedrock		Step-Pool	NC	1.9	2	2	0	0	1	0	0	0	2	1	0	0	0	0	0	1	2

Blood Brook

Phase 1 - Step 8. Summary of Categorical Impacts

Basin: **Upper Connecticut** Watershed: **Middle Northern Connecticut River** Sub-watershed: **Connecticut River -- Hewes Brook to White River**

Reach ID	Stream or Tributary	Stream Type				Total (out of 32)	Step 4	Step 5	Step 6
		Stream Type	Bed Material	Subclass Slope	Bedform		Land Use (out of 6)	Instream Modification (out of 10)	Floodplain Modification (out of 12)
M02	Blood Brook	B	Bedrock		Plane Bed	19	6	3	8
M03	Blood Brook	C	Gravel		Riffle-Pool	21	4	4	9
M03-T1.01	Bragg Brook	B	Cobble		Step-Pool	11	5	2	2
M03-T1.02	Bragg Brook	A	Cobble		Step-Pool	12	5	1	3
M03-T1.03	Bragg Brook	A	Cobble		Step-Pool	9	4	0	3
M04	Blood Brook	C	Cobble		Riffle-Pool	16	4	2	8
M04-T2.01	Charles Brown Brook	B	Cobble		Step-Pool	10	4	0	4
M04-T2.03	Charles Brown Brook	B	Cobble		Plane Bed	5	4	0	1
M04-T2.05	Charles Brown Brook	B	Cobble		Plane Bed	4	4	0	0
M04-T2.06	Charles Brown Brook	B	Cobble		Plane Bed	3	3	0	0
M04-T2.07	Charles Brown Brook	A	Cobble		Step-Pool	3	3	0	0
M04-T2.08	Charles Brown Brook	C	Cobble		Riffle-Pool	9	3	1	4
M04-T2.09	Charles Brown Brook	A	Cobble		Step-Pool	1	1	0	0
M05	Blood Brook	C	Cobble	b	Riffle-Pool	15	4	2	6
M05-T3.01	New Boston Brook	B	Cobble		Step-Pool	16	5	2	5
M05-T3.02	New Boston Brook	C	Gravel		Riffle-Pool	11	6	1	4
M05-T3.04	New Boston Brook	C	Gravel	b	Riffle-Pool	9	5	0	3
M06	Blood Brook	B	Cobble		Plane Bed	15	4	2	6
M07	Blood Brook	C	Cobble		Riffle-Pool	11	5	0	4
M07-T4.01	Unnamed (Needham) Brook	B	Cobble		Plane Bed	3	3	0	0
M07-T4.02	Unnamed (Needham) Brook	C	Gravel		Riffle-Pool	12	5	1	5
M07-T4.04	Unnamed (Needham) Brook	C	Cobble	b	Riffle-Pool	5	2	0	3
M07-T4.05	Unnamed (Needham) Brook	A	Cobble		Step-Pool	2	2	0	0
M08	Blood Brook	B	Cobble		Step-Pool	13	5	1	4
M09	Blood Brook	A	Bedrock		Step-Pool	11	4	1	3
Total Scores						246	100	23	85
Percent of Each Impact Category							40.7 %	9.3 %	34.6 %

Blood Brook

Phase 1 - Step 9. Adjustment Process and Reach Condition

Rough Draft

Basin: **Upper Connecticut** Watershed: **Middle Northern Connecticut River** Sub-watershed: **Connecticut River -- Hewes Brook to White River**

Reach ID	Confinement Type	Stream Type				Watershed Area	Total Impact	9.1 Predicted Adjustment Scores				9.2 Reach Condition	
		Stream Type	Bed Material	Subclass Slope	Bedform			Degrad.	Aggrad.	Widen.	Planf.	Project	Statewide
M02	NW	B	Bedrock		Plane Bed	18.43	19	10	8	7	10	Poor	Fair
M03	VB	C	Gravel		Riffle-Pool	17.64	21	12	12	7	10	Poor	Fair
M03-T1.01	SC	B	Cobble		Step-Pool	1.21	11	8	9	5	5	Fair	Good
M03-T1.02	NC	A	Cobble		Step-Pool	1.17	12	7	9	5	0	Fair	Good
M03-T1.03	NC	A	Cobble		Step-Pool	0.59	9	6	6	5	0	Good	Good
M04	VB	C	Cobble		Riffle-Pool	15.73	16	10	6	5	8	Fair	Fair
M04-T2.01	SC	B	Cobble		Step-Pool	5.64	10	8	6	5	3	Fair	Good
M04-T2.03	NW	B	Cobble		Plane Bed	5.52	5	4	4	2	0	Good	Reference
M04-T2.05	NW	B	Cobble		Plane Bed	4.87	4	4	4	2	0	Good	Reference
M04-T2.06	NW	B	Cobble		Plane Bed	3.70	3	4	3	2	0	Good	Reference
M04-T2.07	NC	A	Cobble		Step-Pool	1.99	3	4	3	2	0	Good	Reference
M04-T2.08	VB	C	Cobble		Riffle-Pool	1.71	9	3	3	0	1	Reference	Reference
M04-T2.09	NC	A	Cobble		Step-Pool	0.65	1	2	1	0	0	Reference	Reference
M05	VB	C	Cobble	b	Riffle-Pool	9.27	15	11	10	7	8	Poor	Fair
M05-T3.01	NW	B	Cobble		Step-Pool	2.79	16	12	13	7	8	Poor	Fair
M05-T3.02	VB	C	Gravel		Riffle-Pool	2.63	11	5	8	7	7	Fair	Good
M05-T3.04	VB	C	Gravel	b	Riffle-Pool	0.90	9	4	5	4	2	Good	Good
M06	NW	B	Cobble		Plane Bed	6.04	15	12	10	7	8	Poor	Fair
M07	VB	C	Cobble		Riffle-Pool	5.54	11	6	7	5	4	Fair	Good
M07-T4.01	NW	B	Cobble		Plane Bed	1.87	3	4	3	2	0	Good	Reference
M07-T4.02	VB	C	Gravel		Riffle-Pool	1.75	12	5	7	5	5	Fair	Good
M07-T4.04	VB	C	Cobble	b	Riffle-Pool	1.36	5	2	2	0	0	Reference	Reference
M07-T4.05	NC	A	Cobble		Step-Pool	1.14	2	2	2	0	0	Reference	Reference
M08	SC	B	Cobble		Step-Pool	2.49	13	9	9	5	4	Fair	Good
M09	NC	A	Bedrock		Step-Pool	1.94	11	7	8	5	0	Fair	Good