Phase 2 Stream Geomorphic Assessment
New Haven River Watershed
Addison County, Vermont

September 2004

Bartlett's Falls, Bristol, Vt (Main Stem, Reach M16)

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SMRC is particularly grateful to the many landowners along the New Haven River who granted permission for researchers to pass through their properties.

EXECUTIVE SUMMARY

A fluvial geomorphology assessment of the New Haven River and two of its principal tributaries, Baldwin Creek and Beaver Meadow Brook was completed in the Summer of 2004. The 116-square-mile New Haven River watershed has experienced multiple flood events in recent decades, resulting in substantial infrastructure losses, streambank erosion, and in-stream sedimentation. This study was funded by a Federal Emergency Management Agency (FEMA) Project Impact Grant to assess the present geomorphic condition of the river network, to identify local and regional stressors impacting the channel and watershed, and to characterize the sensitivity of reaches to future lateral and vertical adjustments. Assessments were also conducted to identify structures at risk from expected future channel migration.

The geomorphic condition of the New Haven River was evaluated using a phased approach of stream assessment, following protocols compiled by the Vermont Agency of Natural Resources (2004). A Phase 1 Stream Geomorphic Assessment was completed in October 2003 and updated in June 2004 (SMRC, 2004). This watershed-level, remote-sensing phase of assessment delineated the watershed into 64 geomorphically-defined reaches, based on variation in valley confinement, slope, and sinuosity.

A subset of 25 reaches with potential for conflicts with human infrastructure was identified for additional study. These 25 reaches were assessed through a series of field-based measurements and observations following the Phase 2 Stream Geomorphic Assessment protocols (VTANR, 2004). Phase 2 protocols are field procedures for rapid geomorphic and rapid habitat assessments. Reach-specific and cross-section data gathered during Phase 2 characterized the present geomorphic condition of the river reach and the dominant process(es) of adjustment. Processes of channel adjustment include:

- **Degradation**, or a drop in stream bed elevations due to sediment erosion;
- **Widening** of the channel due to stream bank collapse, as degradation leads to oversteepened banks;
- **Aggradation**, or build up of stream bed elevations due to sediment deposition;
- **Planform adjustment**, or a substantial change of the stream's flow path in the landscape.

Channel dimensions measured at discrete cross sections in each reach and reach-wide observations of channel form and features were compiled in a Rapid Geomorphic Assessment (RGA) score for each reach. Similarly, reach-based observations relating to in-stream and riparian habitat were compiled in a Rapid Habitat Assessment (RHA) score. Quantitative scores for the RGA and RHA were each correlated to a condition: Reference, Good, Fair, or Poor. Geomorphic condition of the 25 reaches targeted for Phase 2 assessment ranged from Poor to Good, as measured by VTANR protocols (2004).

Channel disturbances along the New Haven River, noted through field reconnaissance and historical data gathering, included:

- Apparent and reported channelization;
- Channel armoring (rip-rap);
- Berming;
- Historic floodplain encroachment by town roads and Routes 17 and 116;
- Floodplain encroachment by residential and commercial development;
- Reported historic gravel extraction, dredging and berming through Lincoln and Bristol villages and along reaches M12 and M13, particularly in response to flood events in 1927 and 1938, with the most recent dredging and berming events following the 1998 flood;
- Undersized private and public bridges and in-stream culverts, serving as flow constrictors at bankfull flow or higher-magnitude flood events;
- Minimal or negligible riparian buffers along portions of main stem reaches, particularly those associated with current agricultural land use in the Lower Watershed;
- Active stream crossings (fords).

Watershed stressors to the New Haven River, determined from historical data gathering and field-based observation, included:

- Historic (mid-1880s) deforestation of the Upper Watershed which could be expected to lead to increased runoff and sediment mobilization;
- Recent upland development in the Upper Watershed leading to increased percent imperviousness;
- Recent high-magnitude flood events, particularly the 1998 flood which had watershed-wide impacts.

The most sensitive reaches (High, Very High, or Extreme), susceptible to future adjustments in the face of current and future channel and watershed stressors, include the low- to moderate-gradient (less than 2%) channels dominated by gravels, and absent of grade controls. In the New Haven River watershed those reaches designated as having Extreme sensitivity are M15 through Bristol village, M17-M19 through West Lincoln and Lincoln villages, as well as M22 through South Lincoln. Also, the lower 750 feet of subreach of M16 east of Bristol Village is assigned an Extreme sensitivity due to its position on an alluvial fan at the transition between bedrock-controlled slopes upstream and the broader alluvial valley downstream.

Twenty-eight bridges and in-stream culverts (public and private) were assessed for their constriction status relative to bankfull flows. Twelve structure spans were found to be undersized with respect to the bankfull width. All twenty-eight crossing structures were undersized when compared to flood prone widths (i.e., corresponding to the ten-year to fifty-year storm). Undersized structures can lead to channel aggradation upstream of the structure and vertical and lateral scour on the downstream end of the structure. Such conditions can, in turn, lead to destabilization of the fill and armoring material supporting the bridge or culvert and to undermining of footings or other structural components. In addition to locally constricting channels, undersized bridges and culverts can cause flood hazards to neighboring properties, serving as the location of debris jams or ice jams during spring runoff events or larger magnitude floods.

Other infrastructure in New Haven, Bristol and Lincoln noted to be at particular risk from streambank erosion, meander migration, landslide potential, and/or geomorphic setting of the surrounding stream channel, included River Road in New Haven; residences, businesses, and Route 116 in Bristol village; and residences, businesses and Bristol-Lincoln Road in West Lincoln and Lincoln villages.

Several locations of recent lateral channel adjustments were identified during Phase 2 assessments, particularly in the Lower Watershed reaches of Bristol and New Haven. Average lateral erosion rates ranging from 14 to 19 feet per year were estimated at three separate sites in Bristol and New Haven, based on comparison of current channel positions (located with GPS) to channel positions as displayed on 1995 orthophotographs. Lateral erosion rates may have been particularly influenced by the 1998 flood. For reaches in Bristol (M10 at Sycamore Park) and New Haven (M07 along River Road near the former Ash Farm), a review of past channel positions on historic aerial photographs dated 1942, 1963, and 1974 indicated 60-year channel migration zones with widths up to 950 feet and 400 feet, respectively.

Structures placed along highly-adjusting river corridors are susceptible to fluvial erosion hazards.
To prevent future losses of property, roads, buildings, and lives, streambank setbacks should be developed that recognize the dynamic nature of the river. A standard buffer width or setback from top of bank may be sufficient for relatively stable reaches, but will not be adequate for some reaches where the top of bank is moving laterally at a rate of up to 19 feet per year.

A geomorphically-defined Overlay District would address the dynamic nature of river corridors. Overlay Districts specify an adequate separation distance between human activities and the river, accounting for the actual width of the river at that locality, the size and nature of the watershed draining to that particular reach, the need for the river to adjust itself vertically and laterally to maintain or restore its equilibrium, knowledge of historic migration patterns of the river, and potential instability of steep slopes adjacent to the stream. None of the watershed towns at present incorporate Overlay Districts for fluvial erosion hazards in their zoning. Only one town (Lincoln) presently includes a standard streambank setback (25 feet) in its zoning regulations. FEMA-FIRM maps are designed for protection from inundation flood hazards, and do not account for fluvial erosion hazards.

Many locations of streambank erosion were noted, particularly in the Lower Watershed reaches in Bristol and New Haven. Erosion of stream bed and banks in cultivated areas can result in mobilization of phosphorous and excess sediments to the receiving waters (in this case, Otter Creek and Lake Champlain). Excess sedimentation degrades in-stream habitats for fish and other aquatic insects. Historic water quality sampling (1993 to 2004) by the New Haven River Watch (NHRW) has identified phosphorus and pathogen impacts in New Haven River (ACRWC, 2004). The State of Vermont has listed approximately 10 miles of the New Haven River main stem from the confluence with Otter Creek to the Village of Bristol as being in need of further assessment (Part C List of Waters, draft 2004) for sediment and habitat alteration as a possible result of morphological instability. In addition, the New Haven main stem from the mouth to the York Hill Bridge in West Lincoln (approximately 13 river miles) is listed on Part C for further assessment of *E. coli* impacts from undefined sources (VTDEC WQD, 2004).

1.0 INTRODUCTION

This report presents results of a Phase 2 stream geomorphic assessment of the New Haven River and two principal tributaries, Baldwin Creek and Beaver Meadow. This report has been prepared by South Mountain Research & Consulting (SMRC) of Bristol, Vermont under contract to the Addison County Regional Planning Commission. Funding was provided by a Federal Emergency Management Agency Project Impact Grant.

Phase 2 geomorphic and habitat assessments were completed on 25 reaches (20.5 river miles) of the main stem and two principal tributaries following protocols published by the Vermont Agency of Natural Resources (VTANR, 2004). Reaches targeted for Phase 2 assessment were identified following completion of a Phase 1 (remote-sensing) Stream Geomorphic Assessment in October of 2003 (SMRC, 2004a). Selected reaches were found to contain conflicts with human investments, including bridges, roads, culverts, residential and commercial development, and agricultural use.

Objectives of the Phase 2 geomorphic assessments were to:

- determine the physical condition of targeted reaches, and identify active vertical and lateral adjustment processes;
- identify potential current and historic channel and watershed stressors;
- evaluate the sensitivity of reaches to future channel and watershed stressors given their inherent vulnerability (e.g., valley setting, slope, streambed and streambank sediments, vegetative buffer conditions) and their current geomorphic condition;
- identify bridge and in-stream culvert crossing structures at risk from debris/ice jams and streambank and streambed erosion during future flood events; and
- identify infrastructure in the river corridor at risk from streambank and streambed erosion in annual and higher-magnitude flows;

Assessment results will be used by watershed stakeholders (e.g., landowners, towns, VT Water Quality Division, NRCS, ACOE, FEMA) to:

- prioritize maintenance and replacement of crossing structures and other infrastructure;
- support site-specific channel restoration design and planning;
- provide a watershed and river-network context for site-specific projects (i.e., understand if the river is actively degrading, aggrading, widening, or shifting its planform in the areas upstream and downstream of a project site);
- plan for future development which is compatible with adjusting river channels;
- support the evaluation of Vermont rivers for listing or de-listing of waters pursuant to Part G, State of Vermont List of Priority Surface Waters Outside the Scope of Clean Water Act, Section 303(d) of the Federal Clean Water Act (VTDEC WQD, 2004).

Assessment data were entered into the Vermont Data Management System (VT DMS), a custom database of Phase 1, 2, and 3 geomorphic data developed in Microsoft Access™ by the VTANR. These are publicly-available data.

2.0 BACKGROUND

The New Haven River watershed has experienced multiple flood events in recent decades, resulting in substantial infrastructure losses, streambank erosion, and in-stream sedimentation. Past flood losses are a function of the geologic setting of the watershed as well as the recent history of human occupation of the landscape, channel management choices and land use decisions.

2.1 Geographic Setting

The New Haven River watershed is a 116-square-mile basin located primarily in Addison County, Vermont (see Appendix A). It is one of several smaller watersheds which together comprise the larger Otter Creek Basin that drains northward to Lake Champlain (Figure 1). The New Haven River watershed drains portions of eleven towns in Addison, Chittenden and Washington Counties (see Figure A.2 in Appendix A). However, the majority of the watershed is contained in Lincoln, Bristol, Middlebury, and New Haven townships (35%, 25%, 14%, and 10%, respectively). Land use within the New Haven River watershed is estimated as 33% forested, 28% agricultural fields, 22% cropland, and 11% urbanized, with the remaining 6% wetlands and brush (SMRC, 2004a).

2.2 Regional Geologic Setting

The New Haven River watershed spans two major geologic provinces. Headwaters, including the upper 13.2 miles of the main stem, are located on the till-blanketed bedrock slopes of the Green Mountains in Lincoln, Starksboro, and Ripton. The remainder of the watershed, from Bristol village to the confluence with Otter Creek, is located on the broad Champlain Valley. In recent geologic time (from 20,000 to 13,200 years before present) this landscape was occupied by advancing and retreating glaciers, with ice up to a mile or more in thickness above the present land surface in the Champlain Valley. Deposits of water-washed boulders, cobbles, gravel and sand built up along the ice margins where the Champlain Valley meets the western slopes of the Green Mountains. These kame terrace deposits are visible today as elevated plains stretching from East Middlebury to Bristol Village and beyond (Stewart & MacClintock, 1969; Stewart, 1973).

As the global climate warmed and the glaciers receded, a large fresh-water lake inundated the Champlain Valley. At its highest stage, Lake Vermont's shoreline was located at the foot of the Green Mountains. A large delta deposit was built out into Lake Vermont by a younger New Haven River, over the kame terrace deposits. Today, Bristol village is established on this former delta / kame deposit of highly erodible sediments (Mack, T.J, 1995; Stewart & MacClintock, 1969).

Lake Vermont waters receded in stages as natural dams in southern Vermont and New York gave way. From approximately 12,800 to 10,200 years before present, marine waters filled the valley from the St. Lawrence Seaway as the rate of rise in ocean water levels far exceeded the rate of rise, or isostatic rebound, of the land surface now relieved of its glacial burden (Stewart and MacClintock, 1969; Cronin, 1977; Wagner, 1972; Connally and Calkin, 1972). The maximum elevation of these brackish waters is not believed to have extended into the present-day New Haven watershed (Connally, 1970). Champlain Sea waters had receded from the greater Champlain Valley by approximately 10,000 years before present, as the rate of land rise began to outpace the rate of sea-level rise. River systems, including the New Haven River, then went to work moving sediments left in the wake of the glaciers, and further eroding the Green Mountains. Our surrounding landscape continues in this erosion phase today In the last 10,000 years or so, the New Haven River has eroded more than 170 feet down through Bristol's delta deposits.

2.2.1 Bedrock Geology

In general, bedrock geology of the New Haven River watershed can be grouped into three main categories:

- the PreCambrian and Cambrian crystalline and metamorphosed rocks (e.g., schistose greywacke, phyllites, schist, gneiss) of the north-south trending Green Mountains at the eastern portion of the watershed (DelloRusso & Stanley, 1986; Tauvers, 1989; Cady et al, 1962);
- the Cambrian quartzites forming the Hogback Mountain and South Mountain, which are grouped in the Champlain Valley geographic province (Stewart, 1973; Capen, 1998); and
- the Cambrian and Ordovician limestones, dolostones and marbles of the Champlain Lowland (Stewart, 1973; Connally, 1972).

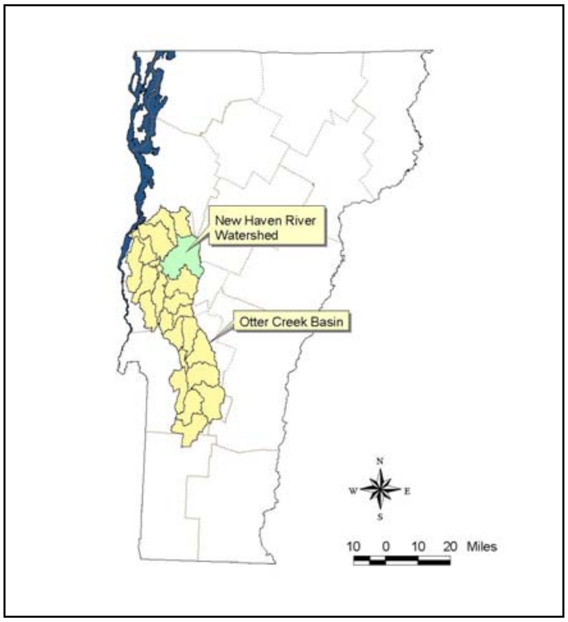


Figure 1. New Haven Watershed Location within the Otter Creek Basin and Vermont.

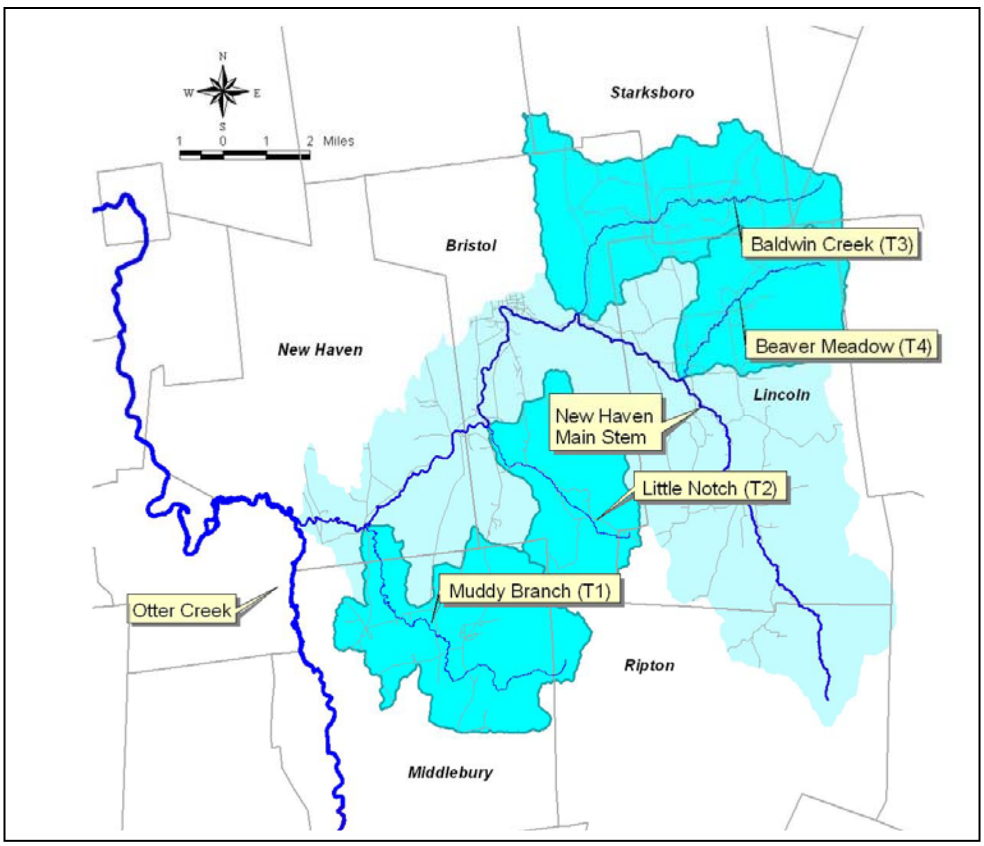


Figure 2. Location of Main Stem and Principal Tributaries, New Haven Watershed

The underlying bedrock geology of the watershed influences the New Haven River in many ways. The phyllites, schists, gneiss, and quartzites are relatively resistant to chemical and physical weathering, while the limestones and other calcitic rocks of the Champlain Lowland are less resistant to erosion. In this way, the bedrock geology of the basin has controlled the regional topographic setting, with the resistant crystalline rocks forming the steeper slopes of the Green Mountains and the Hogback and South Mountains, and the less-resistent limestones and dolostones forming the broad Champlain Valley Lowland.

Frequent bedrock exposures in the Upper Watershed control the channel gradients and valley confinement in many of these upper reaches. Channel-spanning exposures of bedrock also offer local grade control, preventing possible downward erosion of the channel in response to regional or local stressors. In similar ways, bedrock exposures along valley walls have controlled the lateral position of the river channel.

2.2.2 Surficial Geology

The most recent glacial history has influenced the surficial sediments and soil types which are present in the New Haven River watershed today. The Upper Watershed is dominated by thin glacial till deposits overlying bedrock, with alluvial sands, gravels and cobbles found locally in stream corridors (Stewart, 1973). In the high-elevation valleys of West Lincoln, Lincoln and South Lincoln, surficial geologic mapping (Calkin & MacClintock, 1965) indicates predominantly kame terrace deposits, with some isolated deposits of kame moraine and alluvium. Kame terrace deposits are comprised of sands, gravels, and cobbles deposited by meltwaters of receding glaciers in temporary high-level lakes formed at the margin between stagnating ice blocks and the adjacent slopes of the Green Mountains. These ice contact deposits are typically non-cohesive and have moderate to high erodibilities when exposed in stream banks and beds. Review of the NRCS soil survey coverage for the watershed confirms that soil types in the Upper Watershed stream valleys are dominated by the gravelly sandy loams and fine sandy loams of the Adams, Colton, Duane and Stetson series – water-deposited sands and gravels derived from quartzite or schist (Griggs, et al, USDA, 1971).

Kame terrace deposits of sands, gravels and cobbles also developed at the foot of the Green Mountains in the Lower Watershed at the marginal contact between the glaciers and the mountains. These deposits form the terraces recognizable along the east side of Route 116 extending from East Middlebury to Bristol village and beyond. Some of these deposits may have been subsequently re-worked as beach gravels by wave action in Lake Vermont. At the current position of Bristol Village, these kame terrace deposits were overlain by delta deposits as a younger New Haven River transported sediments off the steep slopes of the Green Mountains and out into Lake Vermont. In the more than 10,000 years since the retreat of the glaciers, in response to regional base-level lowering, the New Haven River has eroded downward through these deposits to form the somewhat narrow valley from Bartlett's Falls, past the Claire Lathrop Mill, and downstream beyond the Hewitt Road bridge. During the past 225 years, Bristol Village has been established on the level plain of the former delta / kame deposits which now sit approximately 170 feet above the current river channel.

Out into the broader Champlain Valley, south and west of Bristol village, the landscape is mostly dominated by clay and silt deposits generated during former occupation by Lake Vermont. Layer upon layer of fine-grained silts and clays were deposited in the quiet lake waters in alternating sequences resulting from annual cycles of spring and summer storm activity followed by winter quiet. Exposures of these varved clays, or rhythmites, were observed during this study (e.g., in reaches M07, M10 and M15). These clays are cohesive and relatively more resistant to erosion than the alluvial sands and gravels which are concentrated in the river corridor, and may serve locally to reduce lateral and vertical adjustments of the channel. Local to the river corridor are deposits of alluvial sands and gravels. Like the Upper Watershed stream valleys, the Lower Watershed stream valleys are dominated by gravelly sandy loams and fine sandy loams of the Adams, Colton, Duane and Stetson series – water-deposited sands and gravels derived from quartzite or schist (Griggs, et al, USDA, 1971).

2.3 Geomorphic Setting

In the Phase 1 Stream Geomorphic Assessment (SMRC, 2004a), the New Haven River watershed was delineated into geomorphic reaches using remote sensing methods supported by windshield surveys. Geomorphic reaches were defined based on variation in valley confinement, slope, and sinuosity. Appendix B provides a key to the current orthophotograph and topographic remote sensing coverage for the watershed.

As per guidance contained in the Phase 1 protocol, tributaries contributing 10% or more of the upstream watershed area at their confluence with the main stem are considered principal tributaries and are recommended for reach delineation like the main stem. Following this convention, drainage areas of the larger tributaries in the New Haven River watershed were delineated (Figure 2) and four were found to contribute more than 10% of the upstream watershed area at their point of confluence. These were assigned tributary identifications, T1 through T4, as follows:

Table 1. Identification of Principal Tributaries in the New Haven River Watershed.

Tributary Identification	Name	Drainage Area (sq mi)	Drainage Area Upstream and Including Principal Tributary (sq mi)	% of Watershed Area Upstream of Confluence	Total New Haven Watershed Drainage Area (sq mi)	% of Total New Haven Watershed Area
T1	Muddy Brook	17.0	113.8	14.9%	116.4	14.6%
T2	Little Notch	10.8	85.6	12.6%	116.4	9.3%
T3	Baldwin Creek	17.9	67.6	26.5%	116.4	15.4%
T4	Beaver Meadow	10.6	40.8	26.0%	116.4	9.1%

While substantial development has occurred within the Muddy Brook, Baldwin Creek and Beaver Meadow tributaries, in many cases leading to apparent impacts to the river network (SMRC, 2004a), the Little Notch tributary watershed is largely forested with a lesser degree of development at present. Therefore, the Phase 1 assessment did not include reach delineation for the Little Notch tributary (T3). A Phase 1 addendum can be conducted, if such delineation and reach assessment becomes warranted in the future.

The New Haven River watershed was delineated into a total of 64 reaches during the Phase 1 process (see Table 2). Main-stem reaches are identified with an “M”. Principal tributary reaches are denoted with a “T”. Reach lengths ranged from 1,885 ft to 8,681 ft, with an average length of 4,200 feet.

Table 2. Reach Delineation in the New Haven River Watershed.

Tributary Identification	Name	Drainage Area (sq mi)	Channel Length (mi)	Number Reaches
M	Main Stem	116.4	25.7	31
T1	Muddy Brook	17.0	11.0	15
T3	Baldwin Creek	17.9	8.8	11
T4	Beaver Meadow	10.6	5.5	7
			Total:	64

Detailed Phase 1 results are provided in the VTANR River Management Section Phase 1 and 2 database (Microsoft Access©) included with this report (Appendix H).

The New Haven River watershed is predominantly a mountainous, bedrock-controlled watershed. Approximately 63% of the New Haven River watershed occupies the Northern Green Mountain province (Capen, 1998), where channel gradients and valley confinement are largely controlled by underlying bedrock topography and structure (joints, faults, strike and dip of bedding planes and schistosity) (Canavan, 1989; DelloRusso & Stanley, 1986; Tauvers, 1982). Reaches M16 through M31 along the main stem, upstream reach T1.15 of the Muddy Branch, the upstream reaches of Baldwin Creek (T3.04 – T3.11), and all seven reaches of Beaver Meadow (T4) are located in the Northern Green Mountain province. There are several lower-gradient, broader-valley, C-type reaches or segments of channel within the Upper Watershed coincident with the village settlements of West Lincoln, Lincoln, and South Lincoln. However, these are closely bounded on upstream and downstream ends by steeper-gradient, bedrock-controlled B- and A-type channels. (Note: Stream types are classified after Rosgen (1996) and Montgomery & Buffington (1997). See VTANR protocols for more details.)

The remaining 37% of the watershed is positioned in the Champlain Valley province. Champlain Valley reaches include M01 through M15 along the main stem and reaches T1.01 through T1.14 of the Muddy Branch and T3.01 through T3.03 of the Baldwin Creek. Valley sediments are comprised of boulder clays and silts from former Lake Vermont and local alluvium, punctuated in many locations by outcropping or shallowly buried limestone and dolostone bedrock (Stewart & MacClintock, 1969; Calkin & MacClintock, 1965). Bedrock outcroppings in the Valley have influenced channel planform in reaches M09, M08, M06 and M05.

Figure 3 shows the New Haven main stem and three of its principal tributaries in longitudinal profile. Valley and river channel slopes become significantly more shallow at the intersection between the Green Mountains to the east and the broad Champlain Valley to the west. As a result, the New Haven River main stem transitions at this point from a transport-driven reach of higher gradients with the ability to carry large cobble- and boulder-sized sediments, to a channel of lesser slope carrying gravels and sands, predominantly. The reduction in stream energy given by the reduction in slope, means that the river is no longer able to carry all of its sediment, and there is a tendency for that sediment to accumulate at the point of transition. These are natural locations for a river to meander and split into multiple, braided channels in response to the reduced stream energy and reduced ability to carry sediment. Often, sediment accumulated over hundreds of years to form an alluvial fan - for example, through the community of Rocky Dale east of Bristol Village by the junction of Route 17 / 116 and the Bristol-Lincoln Road, and at the junction of Route 17 (Appalachian Gap Road) and Route 116 in northern Bristol township. Elsewhere in the watershed there are similar, localized reductions in gradient along the channel length, that while they may not result in a traditional alluvial fan deposit, they have similar implications for channel stability.

These transition areas with their relatively broader valley settings, and abundant water sources, are attractive places to establish communities. Since channel adjustments occur over larger geologic timescales, the consequences of settling on these highly sensitive, unstable river corridors to human lives and infrastructure are not often realized within human timescales. The villages of West Lincoln, Lincoln, and Bristol, in particular, have a long history of conflict with the New Haven River. These communities have responded to the river's natural tendency to shift its course by channelizing and dredging the channel, extracting gravel, berming and armoring – an attempt to "keep the river in its place" (Annual reports, Towns of Bristol, Lincoln, New Haven; Paine, 1938; Cahoon, 2004).

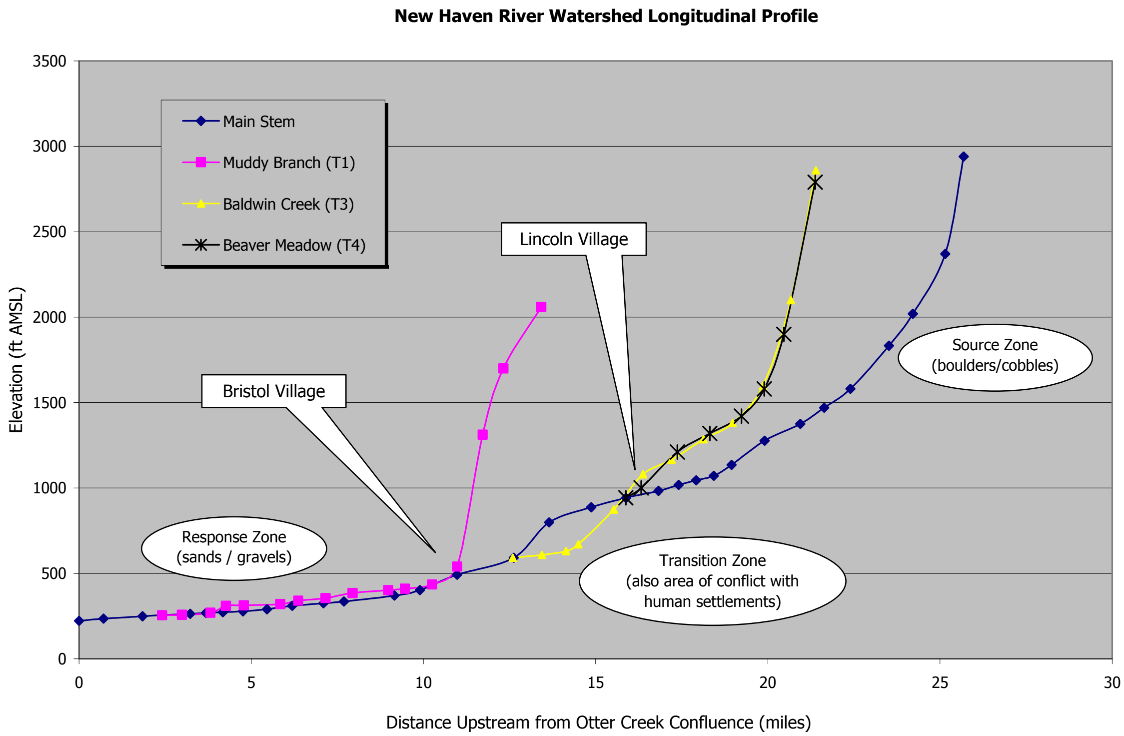


Figure 3. Longitudinal profile of New Haven River main stem and Principal Tributaries.

2.4 Human Settlement Patterns

Human settlement patterns and land use choices in the New Haven River watershed have influenced river dynamics, both regionally and locally. Regionally, the balance of water and sediment loads conveyed within a watershed is altered by the density of settlements on the landscape and its effect on the percent of land area impervious to rainfall. Impermeable (or partially impermeable) surface types associated with development can include roof-tops, pavement, dense gravel-pack roads or driveways, plow-pans created by repeated tilling and compaction of agricultural soils, and compacted forest soils left in the wake of heavy equipment used to harvest timber. Percent imperviousness refers to the proportion of the land surface converted to impermeable or reduced-permeability surfaces. In general, development results in a reduction in total land area remaining pervious to rainfall. Rainfall and snowmelt waters run quickly off the land surface to the nearest swale or stream; they are not able to infiltrate through the surface soil layers and flow diffusely through the subsurface to the river network. As a result, stormwaters are delivered in higher magnitudes to our stream networks and over shorter durations, leading to a prevalence of “flashy” runoff conditions. Stormwaters diverted overland in this way have high velocities and therefore an increased capability to erode soils and debris from the land surface. Locally, we have altered river dynamics by site-specific actions, including channelization, gravel extraction, dredging, berming, floodplain encroachment, and construction of undersized bridges and in-stream culverts.

Due in part to differences in the geologic and topographic settings, land use within the New Haven River watershed has varied somewhat from the Upper to the Lower Watershed.

2.4.1 Upper watershed

From review of census data, it is evident that Lincoln and the other upland communities, such as Starksboro and Ripton, experienced a substantial immigration of residents beginning in the mid-1880s (ACRPC, 2000). This time period roughly coincides with the increase in the lumber trade. Lumber was a booming industry in Northern New England during the mid- to late-1800s, and much of Vermont's forested uplands were stripped of their lumber (Wessels, 1997). The establishment of railroad access to Burlington beginning about 1850 and the ready access to Canadian timber via Lake Champlain, promoted the city to the third largest lumber center in the nation by 1868, behind Albany and Chicago (Amrhein, 1958).

Early historical accounts from watershed towns indicate that several saw mills, grist mills, trip hammers, sash and door factories, chair factories, carding and clothing factory, forges, shingle and clapboard mills, woolen factories, axe factories were present along the New Haven main stem and its tributaries; including the Baldwin Creek, Beaver Meadow (aka Downingsville Brook) and the Little Notch Brook (formerly known as O'Brian Brook after its early settlers) (Swift, 1859; Smith, 1886; Farnsworth, 1984; Beers Atlas, 1871). By 1886 fifteen mills were operating on the New Haven River in Lincoln; as many as eight mill sites were located on the Downingsville Creek (Beaver Meadow, T4) (Smith, 1886; Reed, 1980). Foundation remnants of these mills are still found today along the river (see Appendix E).

As noted in other watersheds across Vermont during the same time frame, widespread deforestation in the Upper Watershed during the mid- to late-1880s would have caused increased water and sediment loads to be mobilized from the New Haven River watershed. Rainfall, which would previously have been intercepted by tree leaves and branches, and which would have been taken up by tree roots and evapo-transpired, instead ran off the land surface. Infiltrative capacities of the soils would have been reduced by compaction of the soils during cutting. And these increased volumes of stormwater runoff would have had increased energies for entrainment of soils and sediments from the land surface, delivering increased sediment loads to the river network.

By the late 1890s the lumber industry in Burlington was declining (Amrhein, 1958), and populations in surrounding lumber towns began to decline. Farms, mills and factories were abandoned, and previously cleared farmlands and areas clear-cut of their lumber began to re-vegetate. As the Upper Watershed began to reforest beginning in the early to mid-1900s, the water and sediment balance would have again shifted (independent of global climate cycles) back to lesser volumes of runoff and reduced sediment loading. Since the late 1900's, populations of the Upper watershed towns have again began to rise. Recent development trends include clearing home lots in the forested uplands or converting previously agricultural land to residential use. These development patterns can lead to increased runoff caused by increased impervious surfaces (i.e., more rooftops, driveways, lawn spaces occupying previously forested surfaces). Upland development can also bring more localized stressors to the river channel including additional bridges and culvert crossings which may be undersized with respect to the bankfull widths and floodplain encroachment by roads, driveways, and structures which reduce the floodplain area available to the river during flood stage. Such floodplain access is a critical need of the river channel in order to dissipate energies associated with flood stage flows – serving as a kind of pressure release valve for the river.

2.4.2 Lower watershed

The New Haven Lower Watershed is comprised largely of the towns of Bristol and New Haven. New Haven saw an early population rise from the mid-1700s to the early 1830s, presumably given its closer proximity to the Otter Creek and Lake Champlain beyond. Through the 1800s, New Haven saw a general decline in population, perhaps as settlers moved further inland and upland to communities like Bristol, Lincoln and Starksboro following the rise in lumber-related trades. Since 1960, New Haven's population has again been on the rise. Bristol has seen reasonably steady growth in population since its first permanent settlement in 1786 (Smith, 1886). Like New Haven there has been a notable rise in population from the 1960s to present (ACRPC, 2004).

Early settlements in the Lower Watershed were characterized by perhaps more channel encroachment than we observe currently. In the 1800s, manufacturing interests (including lumber mills, grist mills, sash and butter-tub factories, iron forges, carding and tanbark mills, plow and tool factories, creameries and cheese factories) were heavily concentrated in the following areas (Farnsworth, 1980; Outlook Club, 1980):

- Brooksville near the current Dog Team Tavern in New Haven, (M02);
- New Haven Mills, Upper, near the current Munger Street bridge crossing (M09);
- New Haven Mills, Lower, approximately 1800 feet downstream of the Munger St crossing (M09);
- Mill Hill near the South Street Bridge below Bristol village (M15/ M14);
- Drake Smith Road near Prayer Rock in Bristol (M15); and
- Rockydale near the confluence with Baldwin Brook (M15 / M16).

These early manufacturing interests saw heavy damage and destruction during the major floods of 1830, 1869, 1927 and 1938 (see Appendix C), and (with a few exceptions) were not rebuilt.

Associated with these early manufacturing interests were several dams located on the main stem. A dam and mill pond was constructed at New Haven Mills circa 1790s and lasted until the flood of 1927 (Farnsworth, 1984). A large dam (so-called Coffin Mill Dam) was located just upstream of the South Street bridge in Bristol to support gristmill, sawmill and various manufacturing interests, notably the Bristol Manufacturing Co. manufacturer of coffins (Outlook Club, 1980; Beers, 1871; Foote, 1945). This dam appears to have been destroyed in the 1938 flood (Paine, 1938). From the early 1890s until the mid-1900s, a series of hydroelectric plants with dams and penstocks for diverting water were developed along the bedrock-controlled channel just upstream of the confluence with Baldwin Creek in Rockydale. The third and largest of these was operated by CVPS. The dam and water wheel were located at Bartlett's Falls, while the power plant was located downstream of the falls (Outlook Club, 1980; Foote, 1945). This dam experienced substantial damage in the 1938 flood, but was rebuilt and operated until sometime into at least the mid-1960s (Outlook Club, 1980).

Dams trap sediments and influence local base levels upstream and downstream to disturb the water and sediment balance of rivers. It is common for lateral and vertical scour to develop downstream of dams and for incision of the stream bed to result, in absence of bedrock or cohesive-sediment controls. Upstream of dams, sediments accumulate due to locally reduced gradients and can result in channel overwidening and planform adjustments. Just as the construction of a dam influences the natural river balance, the removal of dams has an impact on future adjustment of the river channel. As the river readjusts to the lowered base level, incision and widening might be expected to migrate upstream from the former dam site. Sediments mobilized from the incising areas might contribute to aggradation, widening or planform adjustments downstream of the former dam site.

2.5 Hydrology

The New Haven River watershed is currently unregulated (i.e., it has no dams or flood control structures). A United States Geological Survey (USGS) station (# 04282525) is located near the confluence with Otter Creek at the Dog Team Road crossing in Brooksville, VT (Figure 4). This location is at the downstream reach break for M02 (see reach orthophotos in Appendix E). Station # 04282525 measures flow from an approximate drainage area of 115.7 square miles (or 99% of the watershed) and has operated since 1990. The maximum daily mean flow recorded during this 14 year time span was 6,880 cubic feet per second (cfs) on 27 June 1998 (see Figure 5).

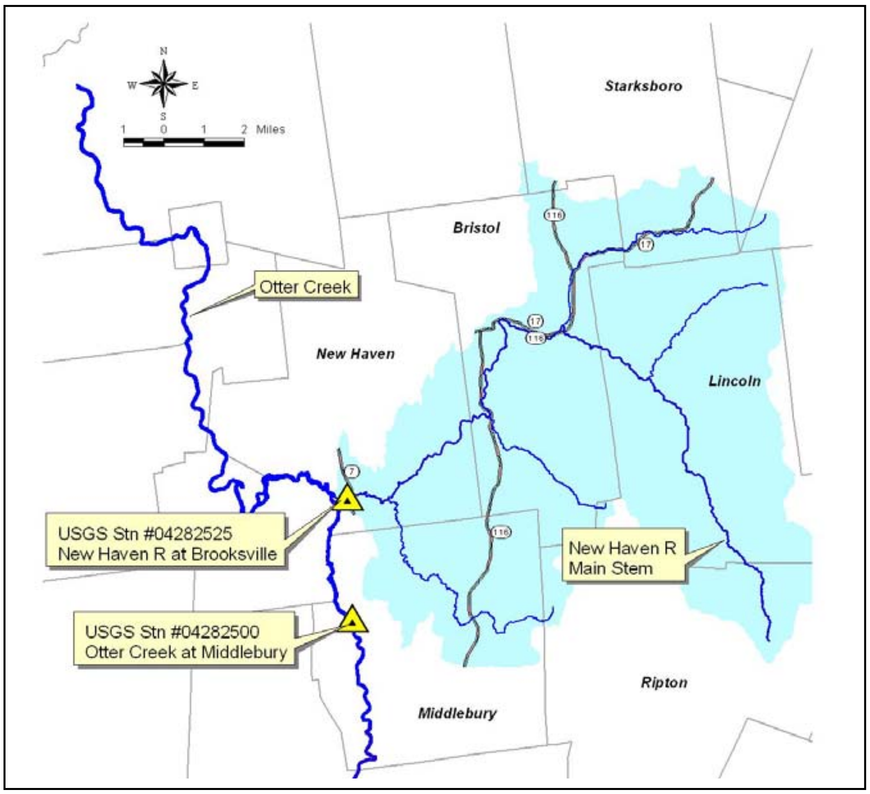


Figure 4. Location of USGS Gaging Station Near Brooksville on New Haven River; Station 04282525 (Drainage Area of 115.7 sq. mi.) operated from 1990 to present.

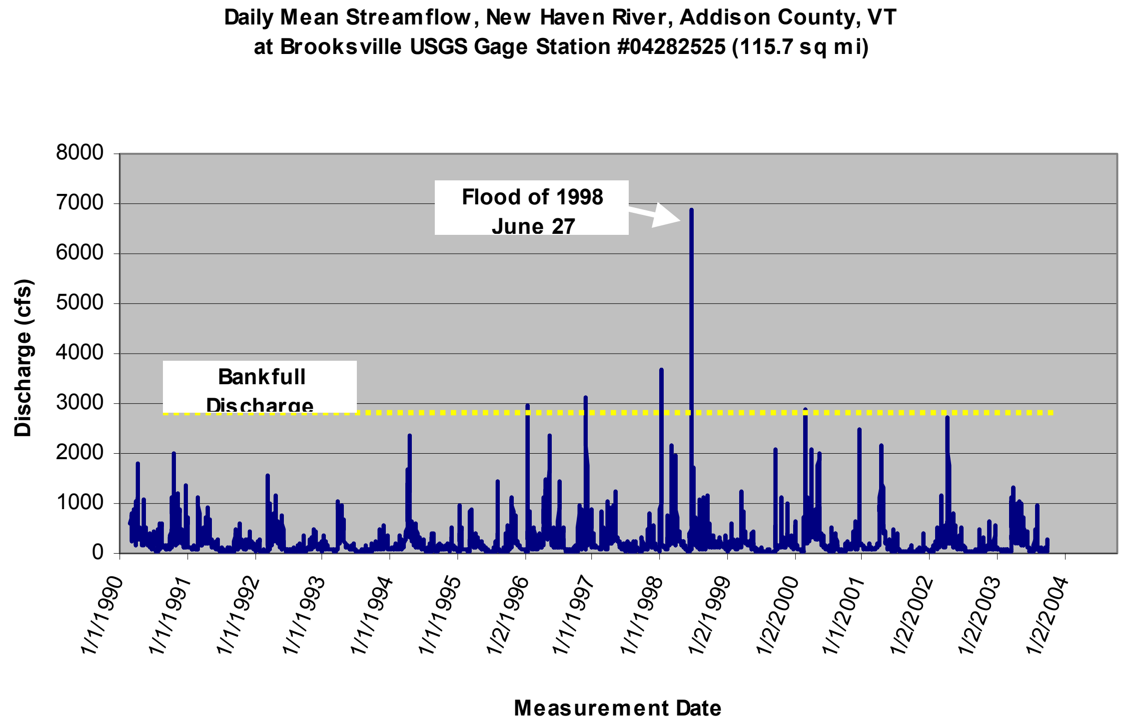


Figure 5. Recorded Daily Mean Flows for New Haven River, Brooksville Gage Station #04282525

Flood magnitudes for the New Haven have been predicted for Gage #04282525 using regional relationships based on watershed size and other hydrologic and climatologic factors (Olson, 2002). These peak flow estimates are summarized in Table 3 and are depicted on Figure 6 in relation to the recorded peak flows for the period from 1990 to 2002.

Table 3. Estimated flood magnitudes for New Haven River watershed
USGS Gage Station #04282525, New Haven River at Brooksville near Middlebury, VT
115.7 sq mi drainage area above Dog Team Road crossing in town of New Haven

Storm Magnitude	Discharge (cfs)
2-year	4,410
10-year	8,870
25-year	11,500
50-year	13,500
100-year	15,700
500-year	21,200

(Olson, 2002)

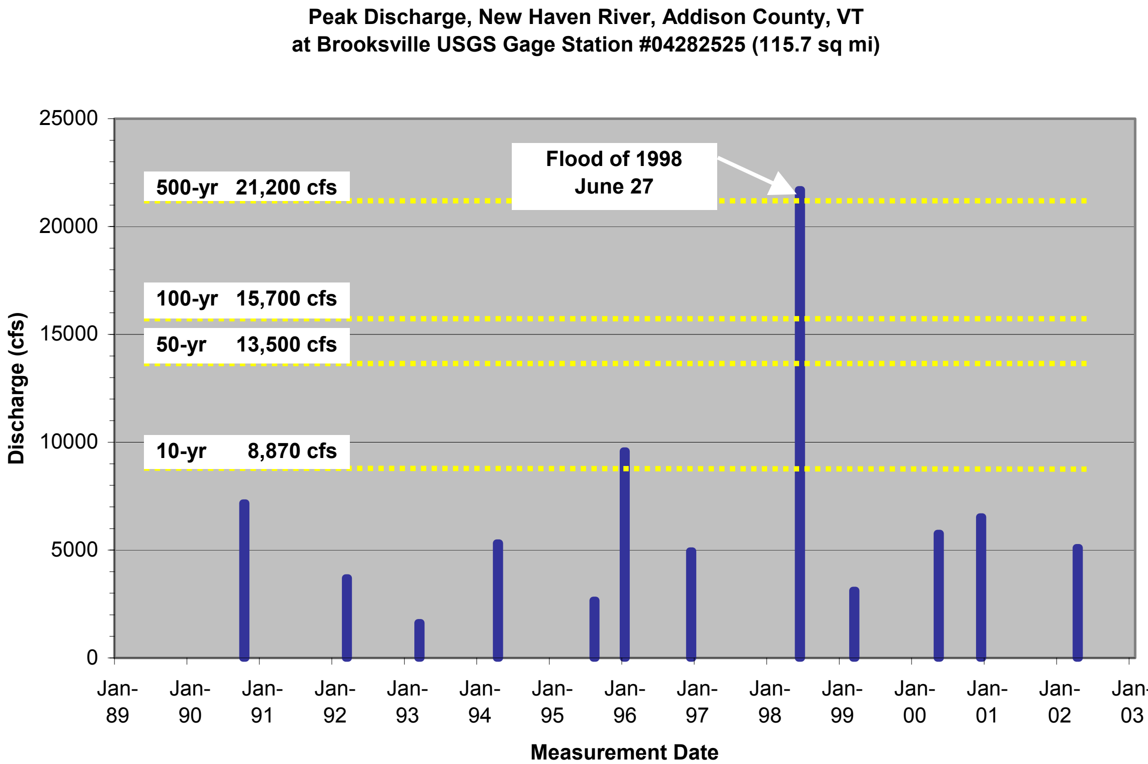


Figure 6. Recorded Peak Flows for New Haven River, Brooksville Gage Station #04282525 (compared to estimated flood peaks after Olson, 2002)

Discharges recorded in Otter Creek (Figure 7) do not necessarily reflect localized or flash floods which have more directly impacted the New Haven watershed. Topographic fluctuations across the watershed are somewhat dramatic as evidenced by the profile of the New Haven River leading from the confluence with Otter Creek to the uppermost extent of the watershed (Figure 3). These changes in topography influence weather patterns and the distribution of precipitation over the landscape. During the same storm event, rainfall amounts can be much higher in the Upper Watershed than they are in the Lower Watershed across the Champlain Valley. In addition, the higher elevations tend to receive more snowfall in a given year than the lowlands and the resultant upland snowpack typically is retained for longer into the spring. This equates to a tendency for higher magnitudes and peaks of flow in the New Haven watershed during spring runoff. Effects of localized or regional storm events, such as those which have impacted the New Haven watershed in 1973 and 1998, did not register as particularly large flood events in the greater Otter Creek basin (Figure 7).

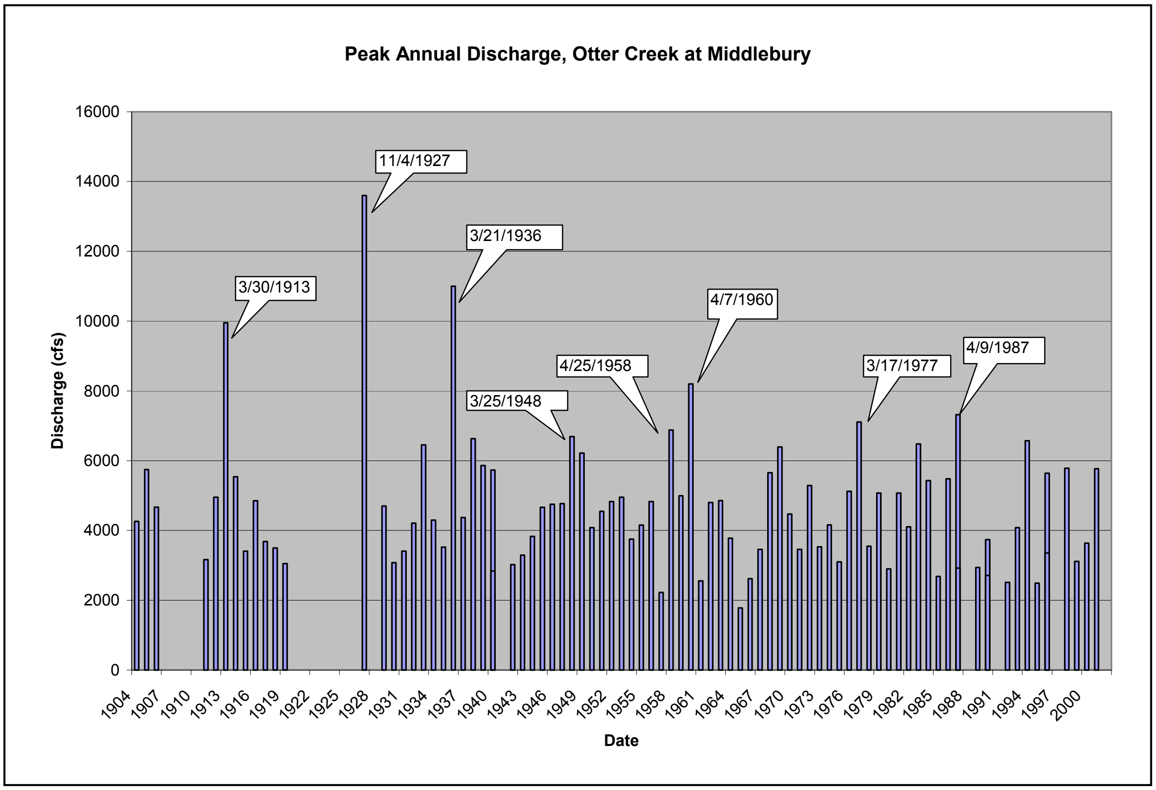


Figure 7. Record of Peak Annual Discharges at USGS Gaging Station #04282500, Otter Creek at Middlebury.

2.6 Flood History

The New Haven River watershed is a flashy watershed, responding quickly to rain and snowmelt events. Several flood events have impacted the basin (see Table 4), with the 1927 flood being the one of largest magnitude. Given the topographic setting of the New Haven River, the Upper Watershed in Lincoln and Starksboro has sometimes experienced a different flood history than that of the Lower Watershed in Bristol, New Haven and Middlebury. In general, precipitation cells impact the Upper and Lower Watersheds differently, due to the substantial differences in elevation and topography. Table 4 denotes with a "**√**" those flood events which have impacted the Upper versus Lower portions of the watershed. Details of these flood events, references, and historic flood photographs are compiled in Appendix C. Flood event summaries were compiled through review of annual reports for watershed towns, town history books, USGS surface water records, FEMA Flood Insurance Study reports, newspaper accounts, and anecdotal information.

Table 4. Notable flood events in New Haven River watershed

Flood Date(s)	Upper	Lower
1830	√	√
1869	√	√
1897		√
1913		√
1927	√	√
1936		√
1938	√	√
1958		√
1960		√
1976	√	√
1989	√	
1998	√	√
2000	√	
2004	√	√

A recent flood in 1998 caused substantial damage to infrastructure (Figure 8). Several riverside homes and developments (e.g., Palmer's Court mobile home park in South Bristol along reaches M11 and M10) were bought out by FEMA following this flood event. Buyout agreements transferred ownership of these lands to the Town of Bristol and specify no future development, measures which should reduce risks to human health and infrastructure in future flood events.

a)

b)

c)

Figure 8. Flood Damage from 1998 Flood.
a) Route 17 / 116 wash out east of Bristol Village;
b) Twin Bridge washout, Route 17 / 116;
c) York Hill Bridge approaches washed out on Bristol / Lincoln Rd.

Also, of note is the flood event occurring during the completion of this report on 28-29 August 2004. Provisional records indicate a peak flow of 4,300 cfs at Midnight on 28 August 2004 (continuing into 29 August 2004) (USGS, 2004). This peak flow occurred as Bristol and New Haven experienced an intense series of thunderstorms (Underwood, personal observations), during the third wettest Summer on record (National Weather Service, 2004). Parts of New Haven township received over 5.5 inches of rain within a two-hour period (Paine, 2004). Newspaper accounts reference farmers with local gages recording over 8 inches of rain (Burlington Free Press, 30 August 2004). Much of the damage associated with this flooding actually occurred along hillsides and upland slopes of the Lower Watershed towns. Numerous road and driveway washouts occurred in the towns of New Haven and Bristol, and isolated sinkholes developed in roadways and parking lots in Bristol village (Underwood, personal observations and scanner reports). The upper streambank along West Street behind the Merchants Bank (above M14) experienced a slope failure (Figure 9). The slide does not extend vertically down to the New Haven River; therefore, streambank erosion does not appear to be a direct contributor to this slide, based on currently available information. This slide is being investigated but is likely related to concentrated stormwater runoff and supersaturated slopes. Mudslides occurred along Mountain Street and Mountain Street Extension at the base of Hogback Mountain, Route 116 east of the village (M15), and along the Notch Road downstream of Hewitt Road Bridge (M13). Portions of Town and State Roads in the New Haven River watershed (and several outside the watershed) were temporarily closed due to flood-water inundation and culvert and road ditch wash outs, including (but not limited to):

Bristol
- South Street (Mill Hill) (M15/ M14),
- Route 116 by Rocky Dale (M15), and
- Route 116 South near former Palmers Court (now Sycamore Park) (M11/M10).

New Haven
- East Street (above M09, M10),
- River Road (near M08 and at the Old Nash Farm bridge M03)

*Figure 9.
Slope failure behind (southwest) of Merchants Bank along West Street (Route 17 / 116) in Bristol, 28 August 2004.*

2.7 Restoration and Channel Modification History

Available histories of channel management in the New Haven River watershed were evaluated, as managed sections can serve as localized or regional stressors to the river, leading to vertical or lateral channel adjustments. In other cases, (e.g., channel armoring) occurrence of channel management or restoration can be an indicator of active channel adjustments in response to another channel stressor(s) located upstream or downstream.

Major restoration or channel modification events were determined from review of annual reports for watershed towns, as well as from newspaper articles, interviews with the NRCS (Lossmann, 2004) and VTDEC Stream Alteration Engineers (Cahoon, 2004), and other published and anecdotal accounts. Channel management activities were recorded by updating Step 5.4 of the Phase 1 database, recently delivered under separate contract (Underwood, 2004a). The Phase 1 & 2 geomorphic database included as Appendix H to this current report contains the updated Phase 1 Step 5.4 data. Specific examples of channel management have been noted in Section 4, where they have particular relevance to the current geomorphic condition of channel reaches.

Generally, locations of repeated channel management have included those reaches of the New Haven river which share the stream valley with commercial and residential development and /or roads (e.g., reach M19 through Lincoln Village; reach M17 through West Lincoln village; reaches M18 – M16 through the narrow gap along the Bristol / Lincoln Road, and M15 and M14 through Bristol Village).

3.0 PHASE 2 ASSESSMENT METHODOLOGY

Geomorphic and habitat assessments were completed on 25 reaches (20.5 river miles) along portions of the New Haven River main stem and two main tributaries (see Table 5). In addition, eight (8) Bridge and Culvert Assessments were completed at crossing structures identified from windshield surveys and Phase 2 study. Access to the river in Bristol reaches M12, M13, and M14 was denied by a majority of landowners. Assessment protocols involve inspection of a reach in its entirety, so assessment of these reaches was canceled and reaches M25 and M26 in South Lincoln were substituted.

Table 5. Reaches Targeted for Phase 2 Assessment
New Haven River watershed, 2004

Reach ID	Town	Channel Length (ft)
New Haven Main Stem		
M03	New Haven	2,997
M04	New Haven	4,300
M05	New Haven	2,425
M06	New Haven	2,590
M07	New Haven	3,083
M08	New Haven	3,675
M09	New Haven	3,859
M10	New Haven, Bristol	4,812
M11	Bristol	3,138
M12 *	Bristol	7,734
M13 *	Bristol	3,886
M14 *	Bristol	5,711
M15	Bristol	8,681
M16	Bristol	5,429
M17	Bristol, Lincoln	6,452
M18	Lincoln	5,332
M19	Lincoln	4,981
M20	Lincoln	3,083
M21	Lincoln	2,702
M22	Lincoln	2,687
M25 *	Lincoln	5,458
M26 *	Lincoln	3,666
Baldwin Creek		
T3.06	Starksboro	4,374
T3.07	Starksboro	4,914
T3.08	Starksboro	4,456
Beaver Meadow		
T4.02	Lincoln	5,539
T4.03	Lincoln	4,979
T4.04	Lincoln	4,858

** NOTE: Reaches M25 and M26 were substituted for targeted reaches M12, M13, M14 due to access issues.*

Geomorphic assessments were conducted in accordance with the VTANR Stream Geomorphic Assessment protocols (VTANR, 2004). Reference is made to these protocols for the specific assessment methods. In general, the assessment process can be summarized as follows. Fluvial geomorphology is an interdisciplinary field of science which recognizes river networks as dynamic systems, in a state of continual adjustment. River networks, in absence of natural or human stressors, are theorized to be in a state of dynamic equilibrium. Sediment and water are transported through the system in balance with the given gradients and available sediment sizes, with no net change in average channel dimensions over the time frame of management interest (Lane, 1955). In reality, over time, watersheds are typically exposed to a variety of physical stressors from both natural and human causes (e.g., extreme flood events, fire, deforestation, increased development, channelization, floodplain encroachment, gravel extraction). A stressor of sufficient type, magnitude, or duration causes the river system to move out of its state of balance and the river channel adjusts by varying its lateral and vertical dimensions (Leopold, 1994; Bull, 1979; Harvey and Watson, 1986). While the stressor to a channel typically lasts a short time (hours to months), channel adjustments in response to the stressor can play out over several years to decades, or longer (Schumm, 1977). Substantial channel-bed and channel-bank erosion can occur during the response period, resulting in mobilization of excess sediment, loss of land, loss of property, and other economic and ecological consequences.

Processes of channel adjustment include:

- **Degradation**, or a drop in stream bed elevations due to sediment erosion;
- **Widening** of the channel due to stream bank collapse, as degradation leads to oversteepened banks;
- **Aggradation**, or build up of stream bed elevations due to sediment deposition;
- **Planform adjustment**, or a substantial change of the stream's position and flow direction in the landscape.

Geomorphic conditions are evaluated with respect to identified human and natural stressors to the watershed, including (but not limited to):

Watershed Stressors
- Deforestation
- Large magnitude flood events
- Increases in impervious surfaces

Corridor and Channel Stressors
- Floodplain encroachment by roads and development
- Removal of riparian buffers
- Channelization
- Gravel extraction
- Dredging and berming
- Streambank armoring

Phase 2 results are evaluated based on the assigned Channel Evolution Model (CEM) Stage, after Schumm (1977, 1984). Often, channels progress through stages of adjustment in a predictable way in response to a stressor (Schumm, 1984; Simon, 1989; Simon and Hupp, 1986). Dominant adjustment processes migrate upstream and downstream within a reach or series of reaches. These channel adjustment processes can also be thought of as migrating through time, since one location in the river network may move through stages of degradation, widening, aggradation and planform adjustment, before returning to an equilibrium state. Certain boundary conditions can influence the progression of these channel adjustments. For example, grade controls such as bedrock exposed in the river channel can stop the process of downward channel erosion, or degradation. Also, structures, such as in-stream metal or concrete culverts can (but will not always) serve as grade controls. CEM Stage has implications for future management strategies of reaches and their contributing watersheds (Simon, 1995; Simon et al, 2001; VTDEC River Management Section, 2003) as further detailed in Section 5.2.

Phase 2 Stream Geomorphic Assessment protocols are field procedures for geomorphic and habitat assessment (VTANR, 2004). Reach-specific and cross-section data gathered during Phase 2 identify the present geomorphic condition of the river reach and the dominant process(es) of adjustment. Phase 2 results, along with Phase 1 assessment results, define the natural and anthropogenic stressors to the watershed over time and the spatial and temporal variability in geomorphic conditions which together have resulted in the present day conditions. The user can then infer possible consequences of land use or watershed management decisions on future geomorphic condition of the watershed to minimize erosion and flooding hazards and to optimize water quality and aquatic habitats.

During Phase 2 assessments, specific features and present channel positions were located using a Garmin™ eTrex Vista global positioning system (GPS) unit. Pictures were recorded with an Olympus™ D-520 zoom, 2.0-megapixel digital camera.

Assessments were performed under a project-specific Quality Assurance Project Plan (QAPP) approved by the Vermont Water Quality Division, River Management Section (SMRC, 2004b). Quality assurance documentation is included in Appendix G.

4.0 PHASE 2 ASSESSMENT RESULTS

Phase 2 assessment results are summarized below by Upper and Lower Watershed and within each division, generally by town or community. Maps in each section note the location of reach-based subwatersheds; reaches targeted for assessment are highlighted in each figure.

Detailed Phase 2 assessment results are tabulated in Appendix D, the standard report output from the Phase 1 & 2 Stream Geomorphic Assessment database. A digital version of the database is included on the Project CD contained in Appendix H. Major channel and geographic features are noted on orthophotograph base maps of each reach in Appendix E. As detailed in Appendix B, orthophotograph coverage for most of the watershed is dated 1995.

During Phase 2 assessments, channel dimensions measured at discrete cross sections, along with observations of channel form and features were compiled in a Rapid Geomorphic Assessment (RGA) score for each reach. Similarly, reach-based observations relating to in-stream and riparian habitat were compiled in a Rapid Habitat Assessment (RHA) score. The reader is referred to VTANR protocols for more details of these assessment methods (VTANR, 2004). As per VTANR protocols, the quantitative scores for the RGA and RHA are each correlated to a condition, ranging from Reference to Poor, based on the following ranking:

Condition	Score
Reference	0.85 – 1.0
Good	0.65 – 0.84
Fair	0.35 – 0.64
Poor	0.00 – 0.34

In all discussions below and in Appendix E notes, left bank (LB) and right bank (RB) of the river are located facing downstream. IR refers to Incision Ratio (Low Bank Height / Bankfull Max Depth) and ER refers to Entrenchment Ratio (Flood Prone Width / Bankfull Width) (see protocols). Stream type designations are after Rosgen (1996) and Montgomery & Buffington (1997).

4.1 Upper Watershed

For purposes of this report, the Upper Watershed is defined as:

- all reaches of the Beaver Meadow Brook (T4) - see Section 4.1.3;
- upper reaches of the Baldwin Creek (T3.04 – T3.11) – see Section 4.1.4;
- the uppermost reach of the Little Notch (T2) (not assessed);
- and the main stem reaches from the headwaters (M31) through M16 - see Sections 4.1.1 & 4.1.2.

Beaver Meadow Brook (T4) joins the main stem at the upstream end of M18. Baldwin Creek joins the main stem just below M16.

4.1.1 South Lincoln - Main Stem Reaches M25 and M26

Reaches M25 and M26 in South Lincoln occupy an isolated high-elevation valley between the upstream steeper slopes of the Green Mountains in Lincoln and Ripton and the downstream bedrock-controlled channel that flows from the vicinity of the Grimes Road bridge downstream along Mill Road. Residential and agricultural development has encroached on the floodplain somewhat along reaches M25 and M26.

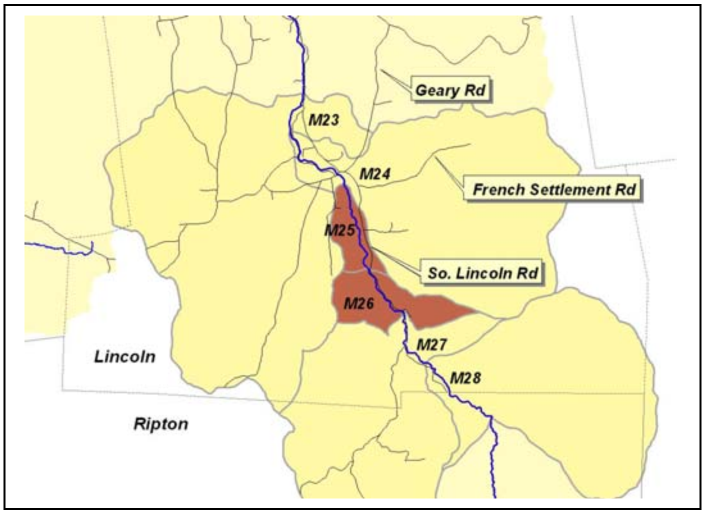


Figure 10. South Lincoln reaches assessed in Phase 2.

Table 6. Summary of Phase 2 results for South Lincoln Main Stem reaches

Reach	Channel Length (ft)	Channel Slope (%)	Drainage Area (sq. mi.)	Stream Type	RHA Condition	RGA Condition	CEM Stage	Adjustment	Sensitivity
M26	3666	2.59	10.4	C3b-S/P	0.72 Good	0.51 Fair	II	Degradation / Widening	High
M25	5458	1.80	10.7	C3-R/P	0.76 Good	0.53 Fair	III	Widening / Aggradation	High

Abbreviations:
S/P = Step/Pool; R/P = Riffle/Pool; PB = Plane Bed; Ref = Reference
CEM Stage (Schumm, 1977, 1984): I=Stable; II=Degrading; III=Widening; IV=Stabilizing; V=Stable

The valley setting for M26 is slightly narrower than that for M25. Hay fields and crops are present in the corridor along right bank on abandoned river terraces above the current channel. A current floodplain, narrower than the valley, is developed along the left valley wall. This floodplain is generally 2 times the channel width, but locally a bit broader or narrower. Along many portions of the reach, the South Lincoln Road and berms along the right bank have encroached upon this floodplain to confine it between the road / berm and the steep left valley wall. At intermittent locations for a total of approximately ¼ of the reach length, rip-rap is present along the right bank, suggesting channelization. Bedrock is exposed along the left valley wall in many places, contributing to a low reach sinuosity. Residential development is present within the reach corridor in a couple of locations. Two private bridges are located in the reach: both have spans which are constrictors of the flood prone width; one near the downstream reach break is an apparent constrictor of bankfull flows (see Figure 11 and Appendix E).


(a) *(b)*

Figure 11. Channel encroachments along reach M26, South Lincoln, VT. (a) Armoring, South Lincoln Road, and residential development along right bank. (b) Private bridge near downstream reach break with span (40.6 ft) less than measured bankfull width (49.1 ft).

The cross section measured in M26 was in a locally widened area just downstream of a length of right bank armoring (background of Figure 11a). Floodplain access was available at the cross section site on the left bank, but incision has disconnected the channel from its floodplain in all but the higher magnitude flows (IR = 1.9). The reach was classified as a C3b-Step/Pool stream type, as it was felt that this stream type is characteristic of a little more than half of the reach. However, locally, the reach exhibits more confinement (approaching stream type departure to an F) between the armored / bermed right bank and the steep, bedrock-controlled left valley wall. Channel degradation leading to abandoned terraces along the right bank appears historic in nature, and may contribute in part to the incision ratio noted in the reach. However, locally, there were noted steep riffles and steps, and scour along both banks with leaning trees, suggesting active incision. SMRC conducted a windshield survey following the August 2004 flood. From observations of matted vegetation and debris traces clinging to trees and shrubs, SMRC noted that the river had not come up over the rip-rap or berms along the South Lincoln Road along this reach, but only accessed the local pockets of floodplain along the left valley wall.

Near the reach break between M26 and M25 is a locally overwidened area with active flood chutes and a braided channel. Proceeding downstream, the greater valley opens up and the channel gains more floodplain access. A private bridge in the upper ¼ of the reach appears to have a span and clearance which may constrict the channel during flood events. An actual span measurement was not conducted, as the private land on either bank was posted. Erosion of the approach ramps to this bridge was apparent from a windshield survey following the August 2004 flood event. Scanner reports during the 28-29 August 2004 flooding indicated an evacuation of the residential property accessed by this bridge.

Channel spanning bedrock is exposed nearly 1/3 of the way down the reach (see Appendix E). Below this point was an apparent channel avulsion and armored right bank erosion next to a residential house. A cross section was measured just downstream, west of the intersection of Masterson Road and South Lincoln Road. This cross section revealed a lesser degree of incision (IR = 1.4) and suggested ample floodplain access (ER > 4.5).

A large mass failure greater than 90 feet in height has developed along the left bank just downstream of the cross section location in reach M25 (Figure 12a and Appendix E). The mass failure post-dates the 1995 orthophotograph. Streambank erosion at the toe of this slope has likely contributed to this slope failure. Land use practices or activities at the top of the slope along County Road may also play a role (e.g., concentrated runoff to these highly erodible soils). Sands and gravels are actively eroding from this mass failure into the channel. Enlarged MCBs and PBs are prevalent through rest of the reach. Approximately 250 feet downstream of the mass failure site, a meander bend is developing along right bank (Figure 12b).

(a)

(b)

Figure 12. Streambank erosion on reach M25, South Lincoln, VT. (a) Mass failure over 90 feet high on left bank; sands and fine gravels eroding into the channel. (b) Meander migration and right bank erosion approximately 250 feet downstream of the mass failure site.

4.1.2 Lincoln Village and West Lincoln – Main Stem Reaches M22 to M17

Main stem reaches M22 through M17 pass through the villages of Lincoln and West Lincoln. These reaches represent the more moderately-sloped, broader-valley sections of river located between the highlands to the south and east and the Bristol-Lincoln Gap to the northwest. Given their topographic setting, these reaches historically have been associated with greater degrees of floodplain development and encroachment by roads. For this reason they were targeted for Phase 2 assessment.

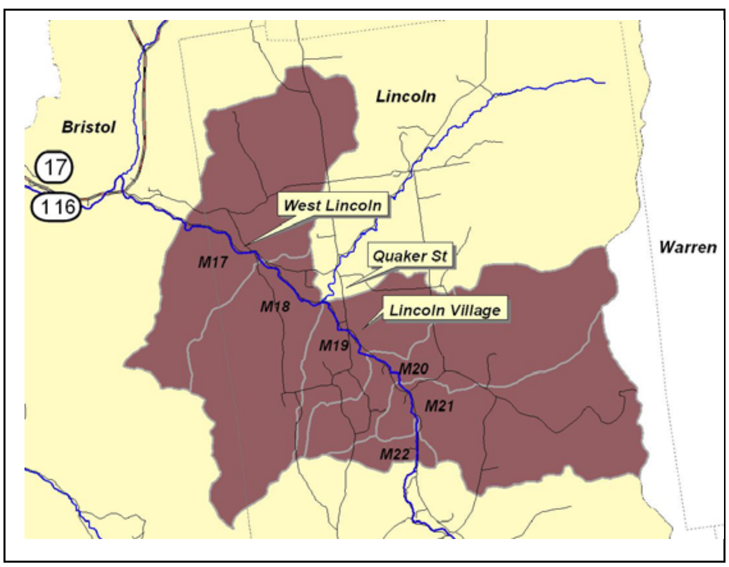


Figure 13. Lincoln reaches assessed in Phase 2.

The Lincoln reaches are largely bedrock-controlled with alluvial deposits dominating the immediate vicinity of the Lincoln and West Lincoln villages. Channel-spanning bedrock offers vertical grade control in reaches M21, M20, and M18, while bedrock is essentially absent in the intermediate reaches of M19 (Lincoln Village) and M17 (West Lincoln Village). Alluvial reach M22, positioned between the upstream bedrock gorge (reach M23) and the downstream bedrock control near Garlands bridge, also has a moderate degree of residential development. Not unexpectedly these alluvial reaches have experienced a greater history of floodplain encroachment, channelization, armoring, berming, and gravel extraction. Although, early settlers took advantage of the bedrock-controlled reaches, also, to establish dams for hydro-power to operate saw mills, grist mills, etc. (Reed, 1980; Beers, 1871).

Table 7. Summary of Phase 2 results for Lincoln Main Stem reaches

Reach	Channel Length (ft)	Channel Slope (%)	Drainage Area (sq. mi.)	Stream Type	RHA Condition	RGA Condition	CEM Stage	Adjustment	Sensitivity
M22	2687	0.97	21.8	F4-PB	0.69 Good	0.44 Fair	IV	Widening	Extreme
M21	2702	1.00	25.3	C3-R/P w/ subreach of B4-S/P	0.68 Good	0.30 Poor	III	Widening / Planform Adjustment	High
M20	3083	1.14	28.5	B1-S/P w/ local B4c-R/P	0.74 Good	0.78 Good	I	None	Low (to reflect the alluvial subreaches)
M19	4981	0.82	30.2	F3-R/P	0.62 Fair	0.44 Fair	III	Widening	Extreme
M18	5332	1.03	43.8	F3-R/P	0.51 Fair	0.38 Fair	III	Widening, Aggradation	Extreme
M17	6452	1.38	48.2	F3-R/P	0.69 Good	0.24 Poor	III	Widening, Aggradation	Extreme

Abbreviations:
S/P = Step/Pool; R/P = Riffle/Pool; PB = Plane Bed; Ref = Reference
CEM Stage (Schumm, 1977, 1984): I=Stable; II=Degrading; III=Widening; IV=Stabilizing; V=Stable

Reach M22 shares a somewhat narrow alluvial valley with the Lincoln-Ripton Road. Residential and agricultural development is present in the valley but appears to be largely outside of the immediate river corridor. Remote-sensing and field-based observations indicate that this reach has been straightened, armored and heavily managed to protect the road along the right bank. Gravel has historically been mined from this reach for flood control (Cahoon, 2004). The river has lost connection with its floodplain along much of the reach; an IR of 3.6 was measured mid-reach. The channel cross section is overwidened as compared to regime equations and the reach exhibits an associated plane bed form. Runs and shallow pools filled with finer sediments were observed to have replaced the expected riffle-pool channel form. The incision and widening of this reach appear to be historic in nature.

At the downstream end of reach M22 is a broader-valley section of river, where the Cota Brook joins the main stem along the right bank. This area was inundated and received much flood damage in the 1998 flood (Appendix C). Subsequent to the flood, Cota Brook was rechannelized to move the confluence with the main stem further upstream (Cahoon, 2004; Tucker, 2004) and to reduce the length of this tributary channel flowing alongside the Ripton-Lincoln Road. Also, rock veins were installed along the right bank of the main stem (Cahoon, 2004), presumably to deflect the channel away from the Ripton-Lincoln Road. During 2004 field assessments, the current channel was observed to be close to the armored section of road (see Appendix E) and an enlarged point bar continues to develop along the left bank through this section.

At this transition from reach M22 to M21, the channel was overwidened. Overwidening and planform adjustment were also characteristic of the downstream end of reach M21. Overall, this reach has a reference stream type of C-riffle/pool. However, the middle of the reach could be separately classified as a B subreach, of steeper gradient flowing through a somewhat narrower valley over channel-spanning bedrock ledges and waterfalls. Bedrock of the last of these waterfalls forms a support for the abutments of the Garlands Bridge of the Lincoln Gap Road.

M20 is a reach largely controlled by bedrock (B1-S/P). Localized subreaches of riffle-pool stream type are present between bedrock exposures (B4c-R/P). The reach shares a narrow valley with the East River Road positioned along left bank. At first glance the reach would appear straightened. However, the road and floodplain development along the left bank are positioned well above the channel on bedrock slopes. Alignment of the river channel is approximately coincident with the structural features revealed in the exposed bedrock. The reach is fairly stable geomorphically exhibiting negligible signs of active adjustment.

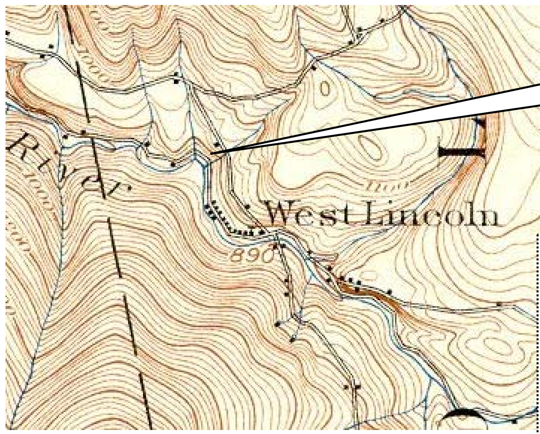
The split channel near the downstream end of the reach was observed to be in the same approximate planform on aerial photographs back to 1942. This reach is the site of the old Grist Mill Dam present in the 1800s (Reed, 1980; Rood, 2004).

Reach M19 passes through Lincoln village. While the broader alluvial valley setting and more gentle gradients (less than 1%) would suggest a reference stream type of C-riffle/pool, the channel is now entrenched over much of its length (ER = 1.2; IR = 1.7), resulting in a stream type departure from C to F. Incision appears to be historic in nature; instead, dominant adjustment processes appear to be widening and aggradation. Leaning trees and scour along both banks were observed just upstream of downtown Lincoln. Armoring is present along both banks through the section of river just upstream of Burnham Hall and the Gove Hill Road bridge. The armored channel width was narrower than the bankfull width measured at an upstream cross section. Residential properties just upstream of this location experienced streambank erosion in the 1998 flood (Benz, 2004). Decades of floodplain encroachment and channel management have likely contributed to the river's loss of connection to the floodplain.

M18 flows through a semi-confined valley punctuated mid-reach by outcroppings of bedrock. Overall the reach has a valley setting and gradient that would suggest a C-riffle/pool stream type with B-step/pool stream type through the 600-ft mid-reach section. Field-based observations suggest historic incision and a loss of floodplain connection. The river shares the narrow valley with the Bristol-Lincoln Road along its right bank. Armored road fill serves as a berm preventing access to the floodplain on the right bank, and the river channel is entrenched below a high abandoned terrace along the left bank for much of the reach. Occasional pockets of flood plain are available along the left bank in the upstream and downstream extents of the reach. A 10-foot high left bank along the mid-portion of the reach adjacent to pasture lands has negligible woody buffer. Fine sandy loams over sands and gravels in the streambank are actively slumping and eroding.

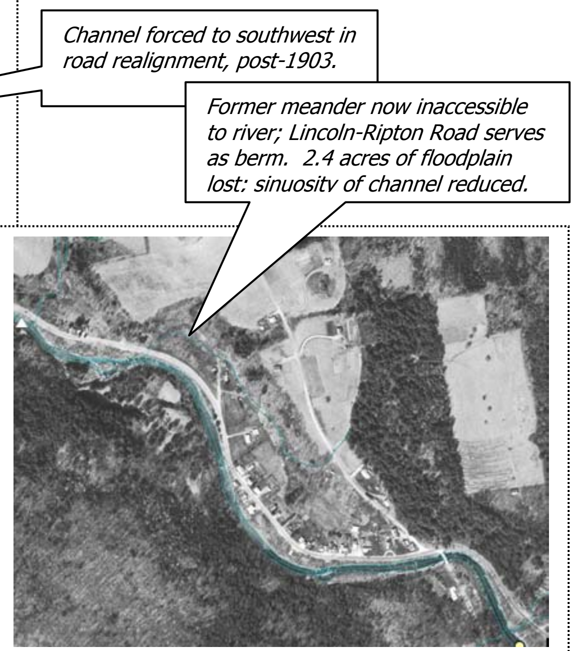
Figure 14. Reach M17 through West Lincoln Village; view downstream from the York Hill Road Bridge.

Like M19 through Lincoln Village, reach M17 is located in a somewhat broader alluvial valley setting that would suggest a reference stream type of C-riffle/pool (Figure 14). However, extensive historic straightening and channel management (human-caused planform adjustments) appear to have resulted in historic incision that has left the river disconnected with its floodplain throughout much of the reach. Figure 15 below documents one such instance of historic channel management associated with the realignment of the Bristol-Lincoln Road in the early to mid 1900s. The main stem channel was moved to the southwest and straightened to make way for the new road alignment. The base material for the new road now serves as a high berm along right bank that has reduced the floodplain in this location by approximately 2.4 acres. As the sinuosity of the river was reduced through this stretch, local channel gradients would have increased, which likely initiated or contributed to channel incision into alluvial materials. Several sets of steep riffles were noted throughout the reach during Phase 2 assessment, suggesting a degree of active incision. An entrenchment ratio of 1.2 and an incision ratio of 2.4 were measured at the reach cross section. Several active flood chutes were noted along the left bank, along with multiple mid-channel bars and enlarged point bars, indicative of aggradation and planform adjustment processes. Locally, scour was noted along both banks through riffle section and along the inside of meander bends. These scour features along with leaning trees and undercut banks suggest active widening. Noted features are consistent with development of a new floodplain at lower elevation.



(a)

Figure 15. Historic channelization for Bristol-Lincoln Road realignment, M17, West Lincoln. Realignment occurred post-1903 and pre-1963 based on review of historic aerial photos and topo maps. (a) USGS 1905 15-min. topographic map – surveyed in 1903; (b) 1995 orthophoto.



(b)

4.1.3 Downingsville – Beaver Meadow Reaches T4.02 to T4.04

The Beaver Meadow Creek drains approximately 10.6 square miles (or 9%) of the New Haven River watershed, and joins the main stem at the upstream end of reach M18 between Lincoln and West Lincoln villages. Phase 2 assessments along the Beaver Meadow targeted three contiguous reaches in the mid-portion of the profile in the village of Downingsville (see Figure 16). Currently these are the reaches of highest concentrations of floodplain development and corridor encroachment in the Beaver Meadow subwatershed.

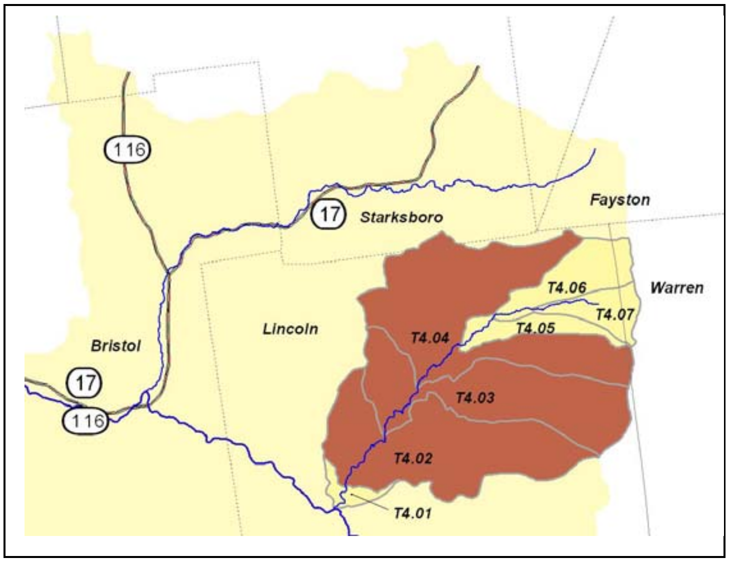


Figure 16. Downingsville reaches assessed in Phase 2.

Table 8. Summary of Phase 2 results for Downingsville reaches

Reach	Channel Length (ft)	Channel Slope (%)	Drainage Area (sq. mi.)	Stream Type	RHA Condition	RGA Condition	CEM Stage	Adjustment	Sensitivity
T4.04	4858	2.08	5.2	B4-R/P	0.80 Good	0.69 Good	III	Widening / Aggradation	Moderate
T4.03-B	3704	1.3	5.2 to 7.6	C3-R/P	0.71 Good	0.63 Fair	IV	Aggradation / Planform Adjustment	High
T4.03-A	1275	4.7	7.6	B1a-CS	NM	NM	I	None	Low to Very Low
T4.02	5539	3.79	10.4	B3-SP w/ local B1-CS, B2-SP	0.81 Good	0.80 Good	I	Minor aggradation, widening	Low (to reflect the B3 subreaches)

Abbreviations:
S/P = Step/Pool; R/P = Riffle/Pool; CS = Cascade; PB = Plane Bed; Ref = Reference
CEM Stage (Schumm, 1977, 1984): I=Stable; II=Degrading; III=Widening; IV=Stabilizing; V=Stable

While ultimately typed as a B4-riffle/pool reach, T4.04 is right on the cusp between a B and C type stream. It has an average slope of 2.08% with locally steeper step-pool channel form in an otherwise riffle-pool / plane bed system. The valley walls alternate between narrow and semi-confining, with some pockets of broader floodplain available along the left bank in the downstream half of the reach. Floodplain development is largely absent along the reach until the downstream 1/3 where the Downingsville Road encroaches in a few spots along right bank. The reach cross section was conducted at the upstream end of one of these, and a moderate entrenchment ratio was noted due to the reduction in floodprone area caused by the road. The channel dimensions here, however, were deemed characteristic of those observed farther upstream in the reach where the channel is naturally confined between the valley walls. A limited section (~400 ft) of channel downstream of a camp along left bank appeared somewhat incised and actively widening as evidenced by scour along both banks and leaning trees.

Residential development is present along both banks at the farthest downstream extent of reach T4.04. A narrow-span in-stream culvert conveys Beaver Meadow under Hall Road at the downstream reach break. Armoring is present along the right bank and a 1 to 3-foot vegetated berm was noted along approximately

400 feet of the left bank on approach to this culvert. The channel appears straightened through this section, with plane-bed channel form. Despite the culvert span being undersized with respect to the bankfull width, there was minimal aggradation noted in the channel upstream of the culvert, and minimal scour noted downstream.

Following Phase 2 assessment, reach T4.03 was segmented to reflect a bedrock-controlled subreach of different stream type in the downstream quarter of the reach (see next paragraph). Valley setting and gradients in the upper ¾ of the reach suggest a reference stream type of C. A cross section conducted near the upstream end reflects an incised condition (IR=1.9) with incipient loss of floodplain connection. This cross section was located proximal to residential development, and road encroachment into the floodplain. Historic channelization is suspected and past dredging was reported (Cahoon, 2004) for the location where the Downingsville Road passes close to the channel approximately 650 feet southwest of the Hall Road intersection with Downingsville Rd. Approximately 250 feet of vegetated gravel berm was noted along the right bank upstream of this section. As noted earlier, berming was also noted along a 400-foot length of the left bank immediately upstream of the reach in T4.04.

Figure 17 Straightened, armored section of Beaver Meadow channel along Downingsville

Proceeding downstream, the channel appears to regain connection to its floodplain, and abundant mid-channel bars, enlarged point bars with steep faces, overwidened channel sections, debris jams, and an apparent avulsion suggest that aggradation, widening and planform adjustments begin to dominate as active adjustment processes. Two tree revetment structures were noted mid-reach upstream of a tight meander bend and residential development on the right bank (see Figure 18). These revetments may have been installed to mitigate right-bank erosion and to protect the Downingsville Road and a culvert which conveys a small tributary under the road (see Figure 19).

Figure 18. Tree revetment along right bank, reach T4.03. Stream flow has breached the revetment and is bifurcated around a mid-channel bar. High bank slumping and erosion of sands and gravels are evident along the downstream right bank of the right-most (western) channel.

The "peninsula" of land formed by the tight meander bend appears regularly mowed, and woody vegetation has been selectively removed. Tightness of this meander bend, removal of woody vegetation and the upstream occurrence of debris jams and channel avulsions would suggest that this tight meander bend is susceptible to a future neck cut-off. A new residence is in process of construction along the right bank opposite this meander (see Figure 19). The foundation appears to be set on bedrock, however. If so, risks to this structure in the event of avulsion-induced bank failures would be reduced.

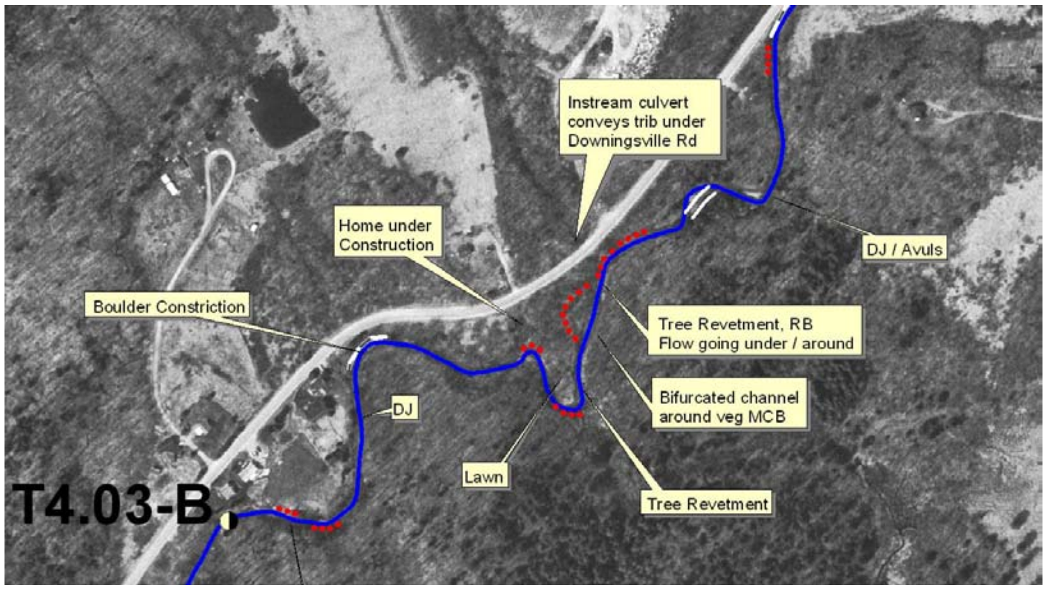


Figure 19. Tight meander bend proximal to upstream avulsions and planform adjustments, reach T4.03, Downingsville Road, Lincoln, VT.

Subreach 1 comprised of the downstream 1275 feet of reach T4.03 (see Appendix E), flows through a steep bedrock valley with an average gradient of 4.7%. Channel form was predominantly bedrock-cascade, interspersed with stretches of boulder-dominated step/pool channel form. While the gradient (> 4%) would suggest an A stream type, the valley setting was semi-confined like a B stream, rather than narrowly-confined. Floodplain development was essentially absent through this subreach. Well-vegetated woody riparian buffers are present along both banks. The former Downingsville Road alignment is present along the right bank, but high above the stream corridor. The subreach is classified in stable geomorphic condition.

Reach T4.02 is a steep-gradient reach confined between the bedrock valley walls on both banks. Channel-spanning bedrock is exposed in the channel throughout much of the reach, especially in the lower half. Historic mills sites were concentrated in this downstream subreach in the 1800s near the intersection of Quaker Street and Downingsville Road (Reed, 1980; Beers, 1871) and remnants of laid-up stone foundations were noted in a few locations along the right bank. Current residential development is located in the downstream portion of the reach within the corridor, but positioned well above the channel on bedrock slopes. Bedrock controls appear to have afforded good stability within the reach. Minor evidence of aggradation and widening were noted and are likely related to sediments working through the reach from past flood events and streambank erosion in upstream reaches.

4.1.4 South Starksboro – Baldwin Creek Reaches T3.08 to T3.06

The Baldwin Creek (T3) drains approximately 17.9 square miles (or 15%) of the New Haven River watershed. Baldwin Creek joins the New Haven main stem at the upstream end of reach M15 north of the twin bridges and the intersection of the Bristol-Lincoln Road and Route 17 / 116 in Bristol (see Figure 20). Phase 2 assessments along the Baldwin Creek targeted three contiguous reaches in the mid-portion of the profile where most floodplain development is currently located in the village of Jerusalem in South Starksboro. These reaches are located in a somewhat broader valley setting on slopes of 1.94% to 2.4% between the steeper slopes of the Green Mountains upstream (4% to 20% slopes) and the steeper slopes and Burnham Falls along Route 17 (Appalachian Gap Rd, a.k.a. Drakes Woods Rd) further downstream (2.1% to 4.6% slopes). Abundant channel-spanning bedrock offers vertical grade controls in these downstream and upstream reaches, but is nearly absent in the South Starksboro reaches. Locally, these reaches represent a transition zone of moderate change in slope where sediments accumulate and active channel adjustments can be expected.

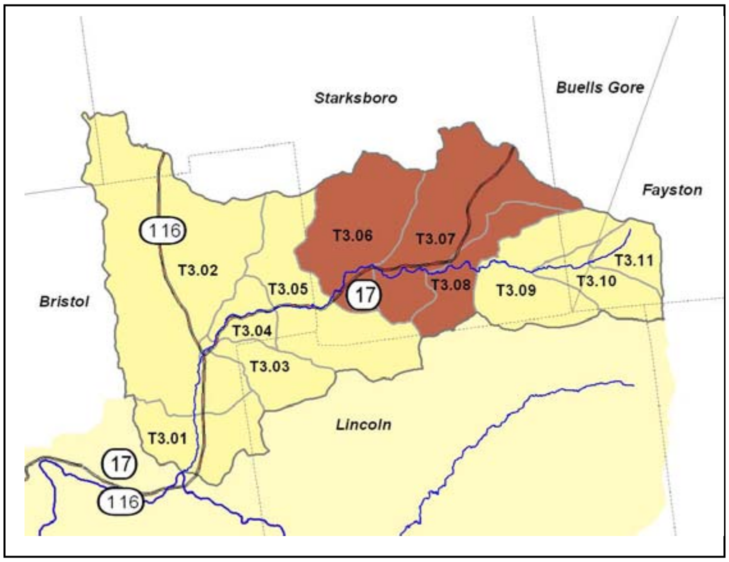


Figure 20. South Starksboro reaches assessed in Phase 2.

Table 9. Summary of Phase 2 results for South Starksboro reaches

Reach	Channel Length (ft)	Channel Slope (%)	Drainage Area (sq. mi.)	Stream Type	RHA Condition	RGA Condition	CEM Stage	Adjustment	Sensitivity
T3.08-B	2756	2.2	2.9 to 3.8	B4-R/P	0.84 Good	0.79 Good	IV	Aggradation	Moderate
T3.08-A	1700	1.9	3.8	NM	0.54 Fair	NM (Beaver-impacted)	NM	NM	NM
T3.07	4914	2.44	6.2	B3-S/P	0.73 Good	0.59 Fair	IV	Aggradation	Moderate
T3.06	4374	1.94	8.1	B4c-S/P	0.84 Good	0.71 Good	I	Widening (minor)	Moderate

<u>Abbreviations:</u>
S/P = Step/Pool; R/P = Riffle/Pool; PB = Plane Bed; Ref = Reference
CEM Stage (Schumm, 1977, 1984): I=Stable; II=Degrading; III=Widening; IV=Stabilizing; V=Stable

Reach T3.08 has a stream type on the margin between C and B. The average channel gradient of the reach is just over 2%. Valley walls alternate between narrowly confined and semi-confined with occasional pockets of wider floodplain. In the upstream end of the reach, the channel appears historically entrenched; the floodplain along right bank is elevated well above the channel bed, resulting in localized undercut banks, scour along both banks through riffle sections, and leaning trees. Proceeding downstream, the reach appears to regain some degree of floodplain access. At the reach cross section site, the river has developed a new floodplain at a lower elevation, leaving the original floodplain abandoned as a river terrace more than 3 times the bankfull elevation. A landowner of the farthest upstream, private bridge crossing in the reach stated that the stage of the annual Spring runoff does not spill over the top of bank, and neither did floodwaters during the 1998 flood (Weightman, 2004).

Commercial and residential development has encroached on the floodplain through the upstream portion of reach T3.08. The river passes under one private driveway bridge, under two town bridges (Jerusalem Road), and through one in-stream culvert under Russell Young Road. The span of each of these structures was measured to be less than the bankfull width at the reach cross section. Approach angles of the river to the two town bridges are highly angled (Figure 21a), and substantial armoring is present on both banks. The 83-foot long instream culvert under Russell Young Road has developed a large scour pool at the downstream end (Figure 21b).

(a) *(b)*

Figure 21. Bridge and instream culvert crossings, Reach T3.08, Baldwin Creek, South Starksboro. (a) highly angled upstream approach to town bridge (TS 400119001601191) on Jerusalem Road; span (13.8 ft) undersized with respect to the measured bankfull width (28.5 ft) – (b) constriction of flow through in-stream culvert under Russell Young Road has lead to lateral and vertical scour on the downstream end of the culvert; span of 17.6 ft.

Near the downstream end of the reach, intense beaver activity, recently breached beaver dams, and related stream bank and bed erosion caused the project team to subreach approximately 1700 feet of the reach. Features noted through this subreach during Phase 2 assessments conducted in June 2004 included erosion on both banks exposing channel deposits high in the bank, channel-braiding and avulsions, headcuts and steep riffles, multiple unvegetated mid-channel bars, enlarged point bars with steep faces, and a current thalweg out of alignment with the channel planform. Active adjustment processes of degradation, widening, aggradation and planform change appear to be localized – perhaps the result of sudden base level change when beaver dams were breached. Some right bank erosion has encroached on adjacent upslope residential properties along Jerusalem Road, placing a satellite dish and garden and lawn areas at risk. Residential structures are located perhaps 40 feet away from the current channel position and perhaps 15 feet in elevation above the channel up a moderate slope.

At the downstream extent of reach T3.08 is a limited exposure of channel-spanning bedrock. Coincident with this grade control are abandoned abutments or a foundation of laid-up stone which may have supported a former bridge or mill site. Proceeding downstream into reach T3.07, a increase in fine sediments (sands and gravels) was noted, likely from erosion occurring through the beaver-impacted subreach upstream. Proceeding downstream, the valley walls become more confining to the channel and the river flows at a steeper gradient. Reach cross section measurements indicated a B3-step/pool channel, although pockets of slightly broader valley and riffle-pool structure were noted throughout. Floodplain development and encroachment by roads are limited through the downstream half of reach T3.07 and the next reach, T3.06. The geomorphic condition in these reaches is fairly stable. Some localized instability was noted, however, at the Route 17 crossing. Baldwin Creek crosses under Route 17 through an 88-foot long culvert that is taller in dimension than it is wide (see Figure 22a). The span of this culvert (11.2 feet) is far undersized with respect to the bankfull widths measured in reaches T3.07 and T3.06 (31.4 ft and 34.8 ft, respectively). Excessive vertical and lateral scour were noted at the downstream end of this structure (see Figures 22b and 22c).

(a)

(b)

(c)

Figure 22. Instream culvert under Route 17 (Appalachian Gap Rd), reach T3.07, Baldwin Creek, South Starksboro, VT.
(a) approach end, view downstream;
(b) outlet, view upstream from scour pool;
(c) scour pool, view downstream from culvert

While reaches further downstream along Baldwin Creek were not targeted for Phase 2 assessment, historical data was obtained for these reaches. Route 17 was initially built in the late 1800s to provide access from Bristol to an iron forge which operated near Burnham Falls (Outlook Club, 1980). Historic topographic maps show this road following closely along Baldwin Creek and crossing it in seven places between Route 116 and Jerusalem Road (see Figure 23). Sometime after the early 1900s, the road was reconstructed in its present alignment, and it is likely that the channel was straightened in several locations to accommodate the new, less sinuous road alignment which now crosses in only three locations. Bristol town reports indicate that this road was washed out during the 1938 flood. The road also required significant reconstruction following the 1998 flood after the river jumped its banks in several locations, and delivered tons of sediment to the alluvial fan at the bottom of the gap near the junction of Route 17 and Route 116. Dredging was required to reopen a channel in the previous planform (Cahoon, 2004; Underwood, personal observations, 1998).

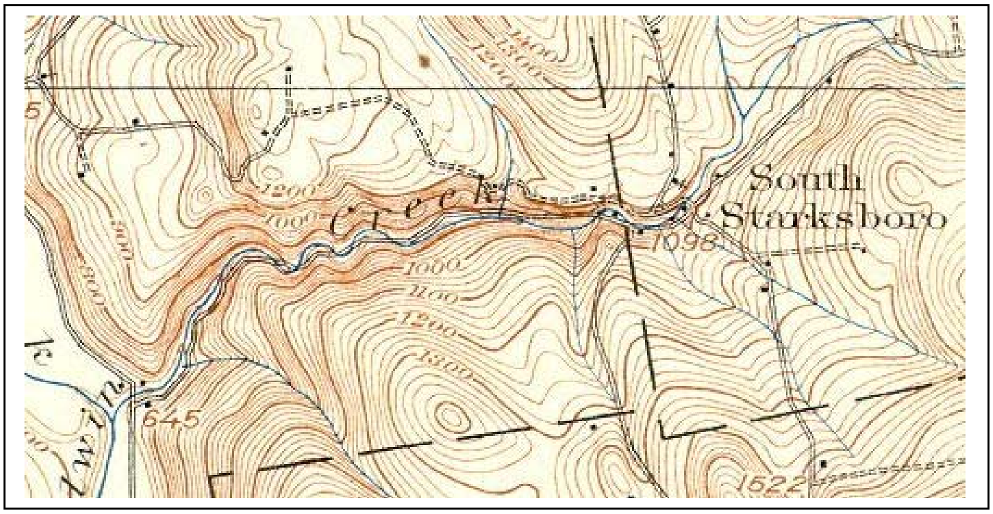


Figure 23. Historic alignment of Drakes Woods Road (now Route 17 – Appalachian Gap Road) included seven crossings of the Baldwin Creek. Today, Route 17 crosses at only three locations downstream of Jerusalem. (USGS, 15-minute topo map, Middlebury, VT, 1905, surveyed 1903)

4.2 Lower Watershed

The Lower Watershed is comprised of main stem reaches from the confluence of Baldwin Creek (M15) to the confluence with Otter Creek near Brooksville and the Dog Team Tavern Road. The Lower Watershed also contains the majority of the Little Notch tributary (T2), the majority of the Muddy Branch tributary (T1), and the lower three reaches of Baldwin Creek (T3.01 – T3.03) which were not scheduled for assessment in Phase 2. The Little Notch tributary joins the main stem in reach M10 downstream of the junction of River Road and Route 116 in Bristol. The Muddy Branch joins the main stem just north of the intersection of River Road and Halpin Road in New Haven. While M16 is considered part of the Upper Watershed, results are presented for this reach in Section 4.2.1 below, to keep this reach in context with the other Bristol township reaches.

4.2.1 Bristol - Main Stem Reaches M16, M15, M11 and M10

Following recommendations in the Phase 1 Stream Geomorphic Assessment for the New Haven watershed (SMRC, 2004a), all main stem reaches in the town of Bristol were scheduled for Phase 2 assessment (see Figure 24). However, reaches M14, M13, M12 were not able to be assessed, as either all or a majority of landowners along their length denied permission for SMRC to access the river.

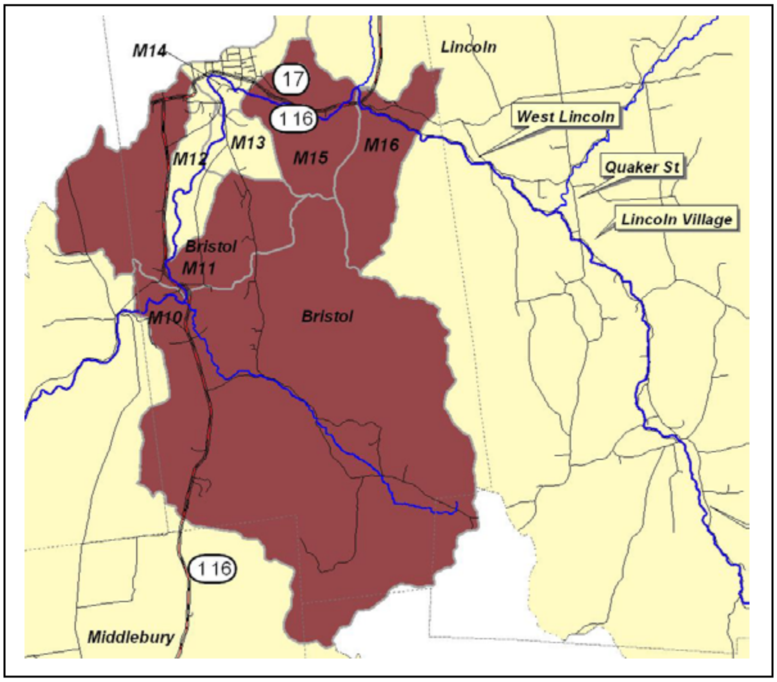


Figure 24. Bristol reaches assessed in Phase 2.

The New Haven main stem in Bristol flows from an elevation of 800 feet alongside the Bristol – Lincoln Road upstream of Bartlett's Falls, down through the Village of Bristol, along the Notch Road past A. Johnson's lumber mill and through agricultural and residential properties of Bristol Flats to the former Palmers Court mobile home park (now Sycamore Park) to New Haven Mills at an approximate elevation of 310 ft AMSL. Over the past several thousand years, the New Haven River has carved a course down through the kame terrace and delta deposits which form the terrace upon which Bristol Village has been settled. The relief from Bristol Village to the vicinity of the Hewitt Road Bridge is approximately 170 feet.

This significant change in slope from Bartlett's Falls to New Haven Mills represents a transition for the New Haven River from a high-energy, steep gradient, "V"-shaped channel capable of carrying boulders to a broad, shallow-gradient channel capable of moving only small cobbles and gravel. Table 10 indicates the river shifts from 3.8% slopes in the vicinity of Bartlett's Falls to 0.3% slopes in the vicinity of Sycamore Park. This transition area is highly sensitive to stressors such as floodplain encroachment, channelization, gravel extraction and removal of woody riparian buffers.

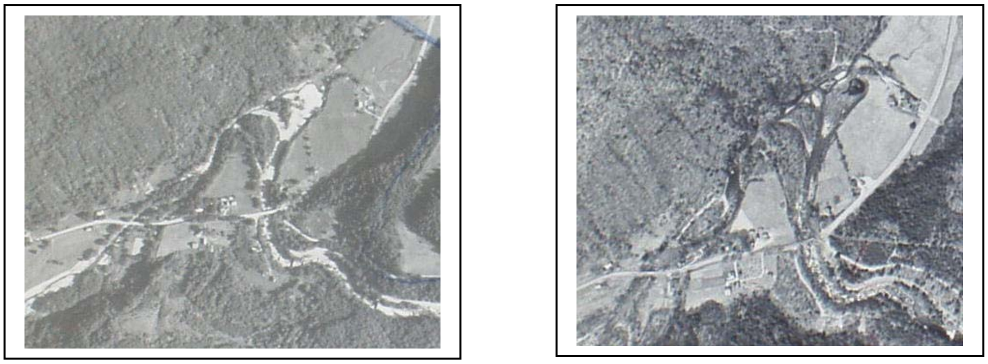
Table 10. Summary of Phase 2 results for Bristol Main Stem reaches

Reach	Channel Length (ft)	Channel Slope (%)	Drainage Area (sq. mi.)	Stream Type	RHA Condition	RGA Condition	CEM Stage	Adjustment	Sensitivity
M16	5429	3.81	49.7	B3-S/P	0.73 Good	0.73 Good	I	None	Low
M16-A Subreach	750	1.9	NM	D3c-Braided	NM	NM	III	Widening, Aggradation, Planform Adjustment	Extreme
M15	8681	1.14	69.2	F4-R/P	0.55 Fair	0.36 Fair	II	Degradation, Aggradation, Widening	Extreme
M14	5711	1.58	69.9	NM	NM	NM	NM	NM	NM
M13	3886	0.82	70.5	NM	NM	NM	NM	NM	NM
M12	7734	0.45	71.3	NM	NM	NM	NM	NM	NM
M11-B	1398	0.32	71.3 to 74.8	C4-R/P	0.47 Fair	0.39 Fair	III	Planform Adjustment / Widening / Aggradation	Very High
M11-A	1740	0.32	74.8	C4-PB	0.53 Fair	0.60 Fair	IV	Aggradation	High
M10	4812	0.31	88.3	C4-R/P	0.52 Fair	0.38 Fair	III	Aggradation / Planform Adjustment	Very High

Abbreviations:
S/P = Step/Pool; R/P = Riffle/Pool; PB = Plane Bed; Ref = Reference; NM = Not Measured
CEM Stage (Schumm, 1977, 1984): I=Stable; II=Degrading; III=Widening; IV=Stabilizing; V=Stable

Frequent occurrences of channel-spanning bedrock and otherwise boulder-dominant streambed materials offer vertical grade controls through the uppermost reach, M16. The most notable occurrence of bedrock falls is Bartlett's Falls (report cover page). Floodplain development is presently minimal within the corridor, although the river must share a narrow valley with the Bristol-Lincoln Road. Armoring is present along the right bank for a large percentage of the reach to protect this infrastructure. Portions of this road have been washed out several times during higher-magnitude flow events (e.g., 1927, 1938, 1976, and 1998). Also, culverts conveying tributaries under the road from the right bank have commonly failed during moderate to high magnitude flood events due to debris jams. The most recent occurrence was during the 28-29 August 2004 flash flooding.

The downstream-most section of M16 was designated as a subreach, as it demonstrates a different reference stream type than the majority of the reach (as it is positioned within the Champlain Valley province). The 750 feet of channel downstream of the easternmost twin bridge along Route 17 / 116 has a significantly lesser gradient than the rest of the reach, and demonstrates channel braiding typical of a D-stream. Substantial sediment loads are delivered to this location in the watershed, particularly during higher magnitude flood events. During Phase 2 assessments on 5 July 2004 (see Appendix E), at least four distinct channels were identified. The easternmost sub-channel actually flows nearly 900 feet to the northeast to join Baldwin Creek (T3) 500 feet upstream of its principal confluence with the main stem. Based on review of historic aerial photographs, this channel has shifted laterally over time (Figure 25).



(a) (b)

Figure 25. Historic Planform Adjustment at Confluence of Baldwin Creek and New Haven main stem north of the Twin Bridges in Bristol; (a) 1942 and (b) 1963 aerial photographs. (images obtained from Natural Resources Conservation Service, Middlebury, VT)

Reach M15 proceeds downstream from the confluence of Baldwin Creek through a somewhat narrow alluvial valley. Floodplain encroachment is significant along the right bank (north side) through this reach, and includes Blaise's Trailer Park and Rockydale commercial and residential development along the Route 17 / 116 corridor. This area sustained major flood damage in 1998 and was isolated for several days when the twin bridges were destroyed and a portion of Route 17/116 west of Rockydale was washed out (see Appendix C, and Figure 8).

During Phase 2 assessments in July and August 2004, signs of active incision were noted within the upstream section of this reach, including abandoned stream terraces, scour along both streambanks through riffle section accompanied by leaning trees and freshly exposed tree roots. The streambed is incised and has lost connection with its flood plain in all but the higher-magnitude flood flows. Incision is less pronounced as one proceeds downstream and aggradation and widening begin to dominate. Excess sedimentation through the reach is derived from streambank and bed erosion both within the reach, and from upstream reaches and tributaries (Lincoln, Starksboro). Large overwidened sections and mid-channel bar deposits with steep bar faces are prevalent through the reach, causing bifurcation of flows. Immediately adjacent to one of these mid-channel bar systems is a newly-constructed (post-1998) home positioned within 10 laterally of a failing bank of highly-erodible sands and gravels (Figure 26).

Figure 26. Newly-constructed home located within 10 feet of the top of an actively eroding sand and gravel stream bank. Reach M15, right bank. Rockydale, Bristol, VT.

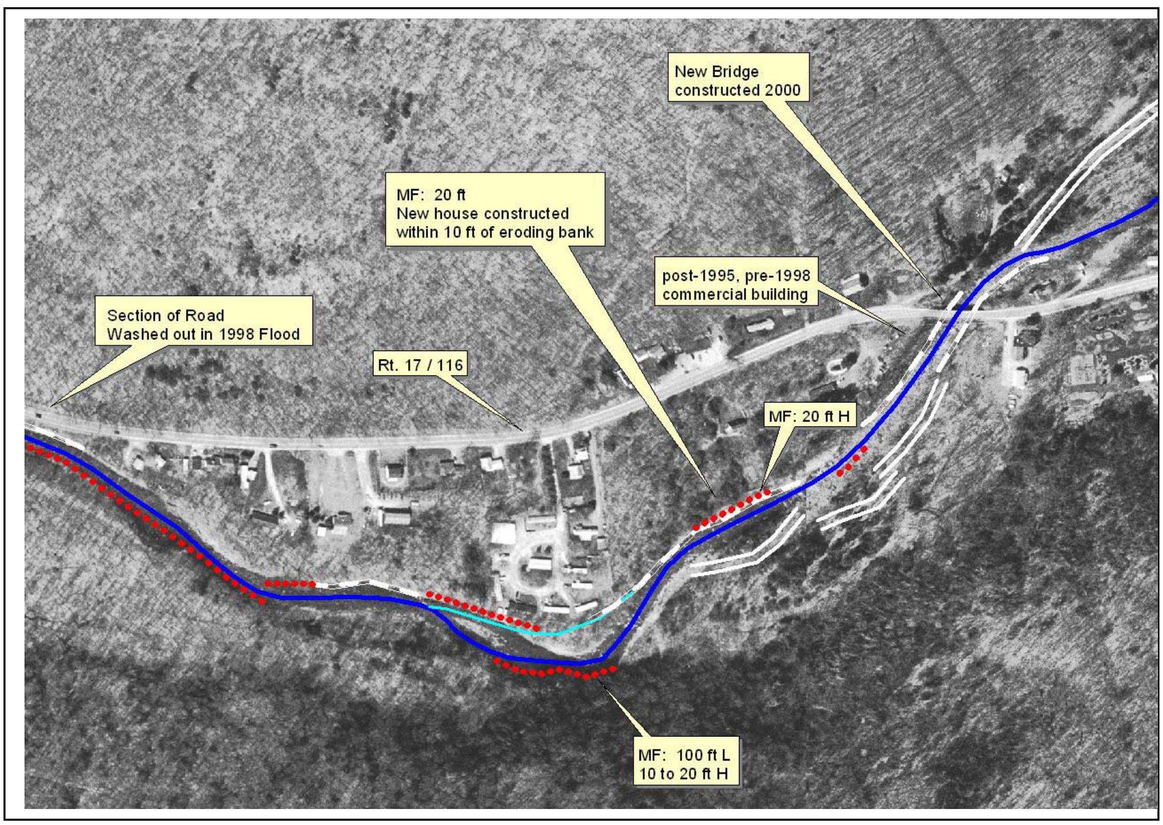


Figure 27. Floodplain encroachment along upstream half of reach M15. Rockydale, Bristol, VT.

While reaches M14, M13, and M12 were unable to be accessed for Phase 2 assessment, some history was available for these reaches from interviews and publications. Reach M14 has a long history of floodplain encroachment. Manufacturing and commercial facilities were established along the left and right streambanks in this reach in the 1800s (Beers, 1871; Estes et al, 1959) (see Figure 28). A mill dam was constructed upstream of the current South Street bridge to generate power (Beers, 1871). Manufacturing buildings sustained considerable damage in the floods of 1830, 1927 and 1938 (Smith, 1886; Estes, et al, 1959, Paine, 1938). A landslide occurred along right bank in reach M14 during the 1938 flood resulting in a garage and car falling into the river from West Street (Estes et al, 1959; Paine, 1938; 1942 aerial photo). Log cribbing and rock walls were installed along the right bank from the South Street Bridge to the Hewitt Road bridge (Estes et al, 1959).

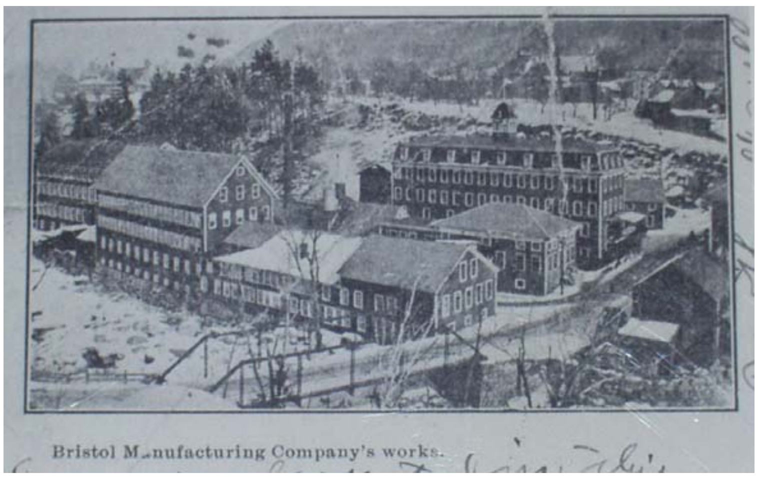


Figure 28.
Postcard circa 1900s of manufacturing facilities developed along New Haven River in vicinity of South Street Bridge. (Lincoln Historical Society)

A debris jam occurred at the Hewitt Road bridge in the 1998 flood. As a result the river avulsed over the bridge and flowed along the Notch Road for some distance destroying the pavement and base materials. As the flow gave way behind the Hewitt Road bridge, a flood pulse moved downstream to cause damage to downstream properties. Flood damages were incurred at the A. Johnson lumber mill; homes were destroyed along the Bristol flats near the Route 116 bridge and in the former Palmer's Court mobile home park. Several homes were subsequently bought out by FEMA and residential encroachment has thus been reduced through reaches M11 and M10.

The channel through M13 was dredged with a steam shovel following the 1938 flood (Paine, 1938). Similar dredging, windrowing and channel management in this reach has occurred in response to more recent flood events (Cahoon, 2004). Intensive channel management activities in reaches M15, M14, and M13 have likely contributed to meander migration into croplands along the right bank through reach M12 and left bank through reach M11. Streambank erosion and recent channel avulsions, particularly in reach M12, have mobilized substantial sediment loads downstream to reaches M12, M11 and M10 (see Appendix E).

Phase 2 observations in Reach M11 resulted in a segmenting of this reach. The upstream half of the reach (Segment B) is dominated by aggradation and associated planform adjustment, while the downstream half (Segment A) has been historically managed (dredged, armored) for protection of Route 116 and the bridge crossing structure. Figure 29 depicts the approximate position of the current (June 2004) channel in light blue on a 1995 orthophoto base. Much of the lateral migration occurring in Segment B has occurred since the 1998 flood, exacerbated by the historic removal of woody riparian buffer and close cropping of herbaceous vegetation along the left bank. The landowner along right bank at the upstream end of the point bar reports that substantial right bank erosion occurred along Route 116 and along their property streambank during the Flood of 1998 (Draper, 2004). Personal observation indicates that this area received substantial damage during the August 2004 flood, as the crossing structure for the right-bank tributary overflowed and the channel avulsed across Route 116, eroding the main stem right bank and taking out some of the post-1998 armoring.

Reach M11, Segment B is something of a response reach, accepting excess sediments which have their source both in the reach itself (active lateral bank erosion on the left bank) and from the extensive lateral erosion and planform adjustments in upstream reaches, M12 and M13. Progressive streambank erosion along the left bank has resulted in a broad, enlarged point bar on the right bank. Mid-channel bars and aggradational steep riffles are present immediately upstream of the Segment break, as the channel makes two sharp turns heading into a somewhat constricted section between a high terrace on the left bank and an armored right bank along Route 116. Until August 2004, stream flow had been directed perpendicular to the armored right bank at Route 116. Flood chutes developed along the left bank were observed to take much of the flow at high river stage, relieving pressure on the right bank (Underwood, personal observations, 1998 – 2004). As a result of the August 2004 flows, this area has widened more, eroding the sharp angle along left bank.

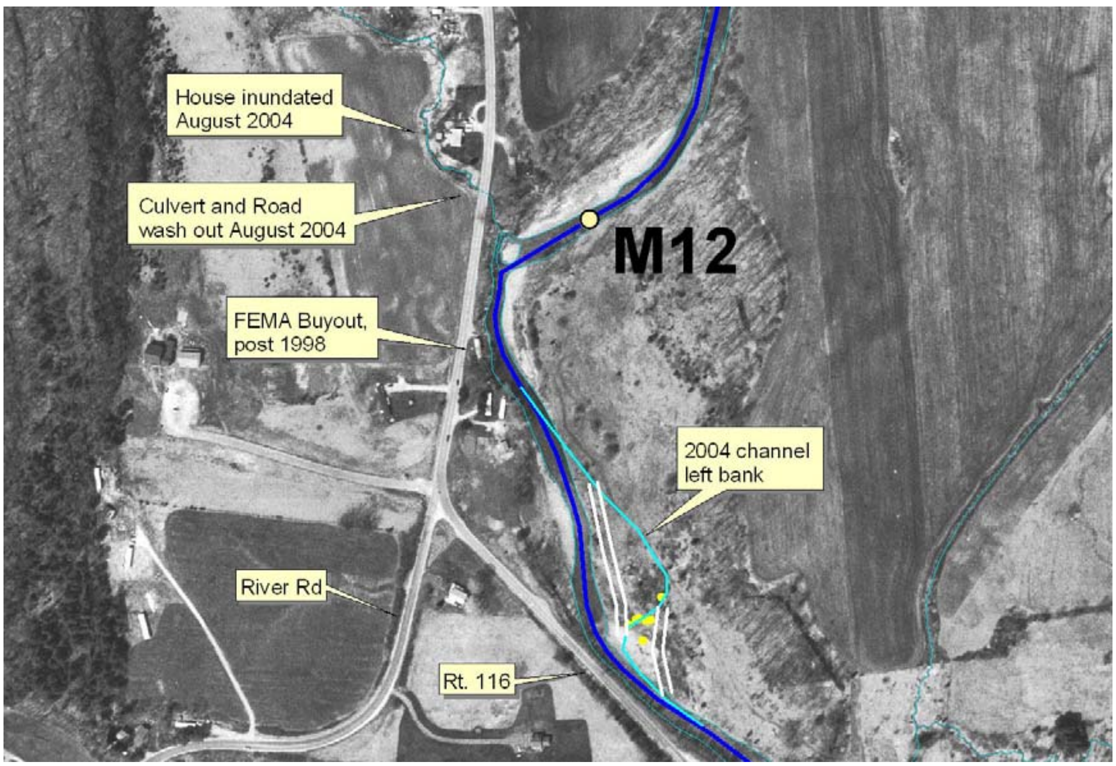


Figure 29. New Haven River main stem, Reach M11 - Segment B.

Figure 29 compares the GPS'd June 2004 left bank to the 1995 left bank position. The channel has eroded up to 170 feet laterally into the fallow field along left bank in the nine years since 1995, equating to an average lateral migration rate of 19 feet per year. The June 2004 position of the top of left bank indicates that approximately 1.4 acres of woody riparian buffer and fallow field have eroded during the elapsed nine years. A conservative estimate of the volume of sediment mobilized from this site since 1995 is 6,600 cubic yards, assuming an average vertical thickness of 3 feet of sediment across the 1.4-acre area.

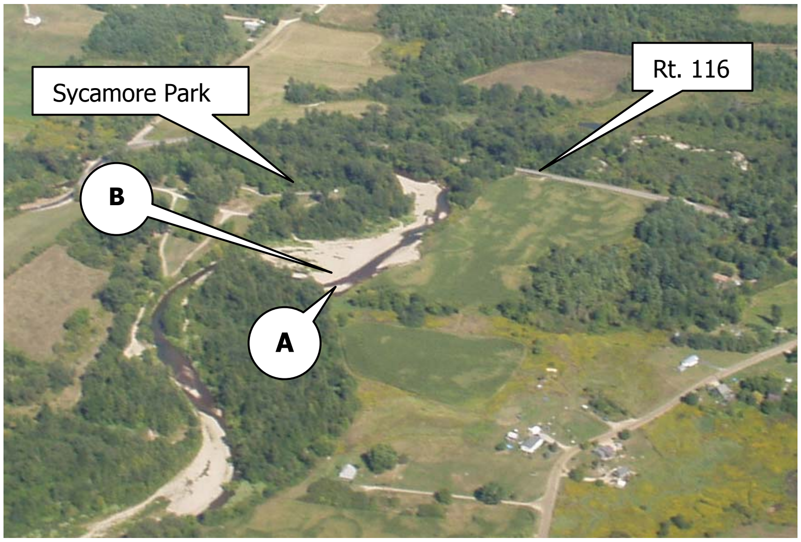
A cross section conducted in Reach M11, Segment B indicates an overwidened channel which has lost some connection with its flood plain. The homeowner along right bank east of Route 116 near the head of this reach reported that the channel bed appeared to drop in elevation as a result of the 1998 flood. Approximately annual bankfull flows occurring since the 1998 flood do not inundate the property to the elevation that they did previous to the flood.

Reach M10 is a response reach dominated by active planform adjustments and aggradation. Excess sediments have their source both in the reach itself (active lateral bank erosion on the left bank in the upstream ¼ of the reach) and from extensive lateral erosion and planform adjustments in upstream reaches, M11 through M13. An enlarged point bar has built up in recent years along the right bank at the head of the reach across from Sycamore Park (see Figure 30). A mid-channel bar and aggradational steep riffles are present immediately downstream of this location as the channel currently makes two sharp 90 degree turns heading into a somewhat constricted section between a high terrace on the left bank and an armored right bank. Locally, the thalweg was observed to be out of alignment with planform. This area receives intense ATV and vehicle use at certain times of the year; multiple trails are present on the point bar and vehicle fords cross shallower sections of the channel.

Cross sections conducted in reach M10 indicate a moderate degree of incision (likely historic) resulting in river disconnection with its floodplain except in higher-than-annual frequency flows. Based on personal observations, the cornfield to the immediate south of the enlarged point bar and floodplains along the Cove Road further downstream in the reach were inundated by flood waters during the 1998 flood (peak flow over 21,000 cfs at Brooksville USGS gage station). However, this field, and other floodplains along the corridor are not accessed during typical Spring bankfull events. Also, the corn field was not accessed during the August 2004 higher-than-bankfull flood stage (provisional peak flow of 4,300 cfs at Brooksville USGS gage station).

Possible contributors to historic incision include flood events, and limited channelization and armoring within the reach. Also, a mill dam was present at New Haven Mills just downstream of reach M10 for several decades from the 1790s to probably the Flood of 1927 (see Section 2.4.2) (Farnsworth, 1984; Smith, 1886; USGS, 1905). Historic channel degradation through reach M10 may have resulted from the base level drop following destruction of the dam at New Haven Mills. While bedrock does outcrop at the surface to provide lateral control along the right bank of reach M10, there were no instances of channel-spanning bedrock or other grade controls observed through reach M10 that would have mitigated an upstream progression of streambed incision through the reach.

During Phase 2 assessment of reach M10, the current position of the channel and the top of the left bank were surveyed using a Garmin eTrex™ GPS unit; these traces are indicated in light blue on Figure 31. As apparent from this 1995 orthophoto, the channel has eroded approximately 130 feet laterally into the corn field to the south of Sycamore Park in the nine years since 1995, equating to an average lateral migration rate of 14 feet per year. Personal observations (Underwood, 2004) indicate that the majority of this erosion has occurred during and in the six years since the 1998 flood (which would indicate an average lateral migration rate of 22 feet per year). The current position of the top of left bank indicates that approximately 2 acres of woody riparian buffer and corn field have eroded during the elapsed six to nine years. Rip-rap installed by NRCS along left bank following the 1973 flood event (Lossmann, 2004) has been outflanked by the river, and remnants of the former armored left bank can be seen in the middle of the current channel. This erosion site represents the site of highest (recent) sediment erosion observed in the New Haven watershed during Phase 2 assessments in 2004 season. A conservative estimate of the volume of sediment mobilized from this site since 1995 is 12,600 cubic yards, assuming an average vertical thickness of 4 feet of sediment across the 2-acre area. A substantial portion of the aerial extent of eroded soils has been cultivated for several decades, which would suggest elevated phosphorus content of the soils.



Sept 2002 aerial view of meander migration / erosion into corn field opposite Sycamore Park, Reach M10, Bristol, VT.

"A" and "B" indicate orientation of ground-based Photos A and B below.

Photo A: Overwidened channel, mid-channel bar in foreground, enlarged point bar at left of center, view to east (upstream), May 2004

Photo B: Left bank eroding into corn field, enlarged point bar along right bank at left of view, view to south (upstream), May 2004

Figure 30. New Haven River main stem reach M10, Bristol, Vermont.

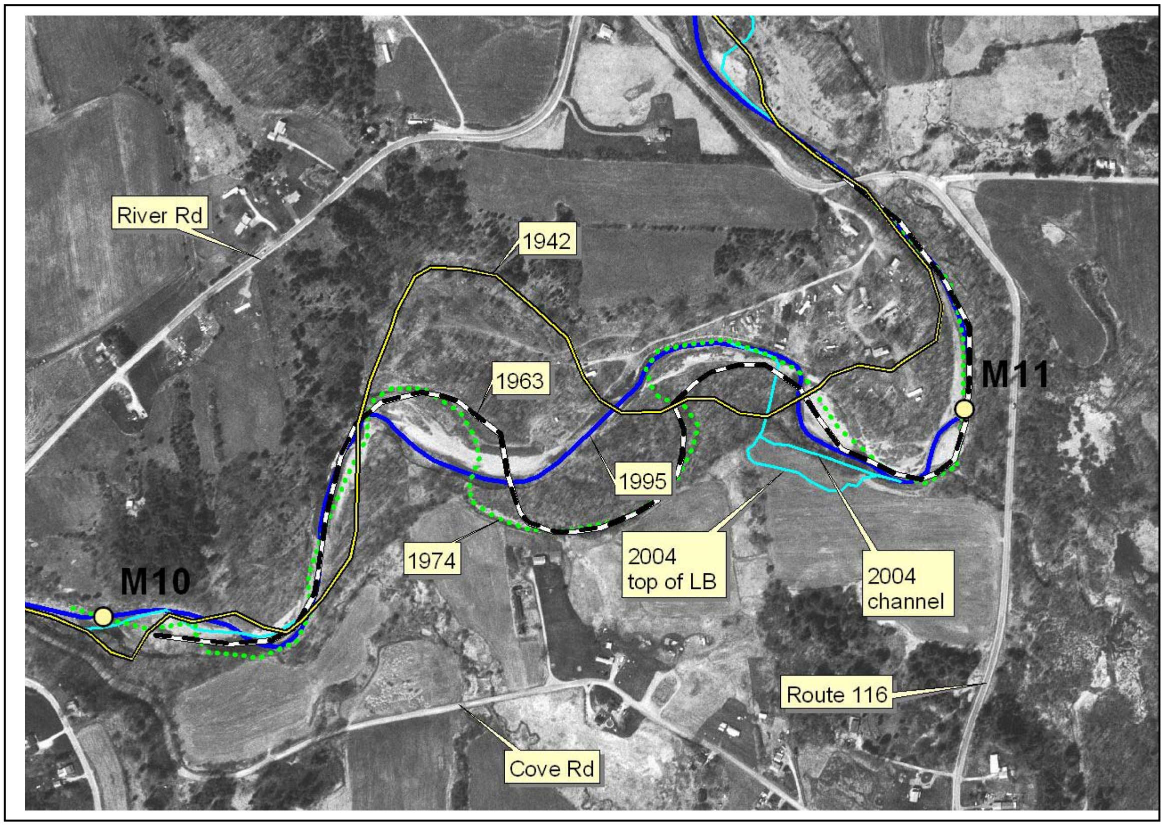


Figure 31. Historic channel migration zone in Reach M10, New Haven River main stem, Bristol, Vermont.

Figure 31 depicts past channel positions in reach M10 derived from review of historic aerial photographs. The base map for the figure is a 1995 orthophotograph (Vermont Mapping Program). Figure 31 indicates a channel migration zone approximately 950 feet wide. While cultivation has been prevalent historically along reach M10, development and floodplain encroachment were fairly limited until the Palmer's Court mobile home park was developed on this spot sometime between 1963 and 1974. As can be seen from Figure 31, the park appears to have been developed on an enlarged point bar which grew southward through meander migration over several years from its 1942 position to its 1963 / 1974 position. The Palmer's Court mobile home park experienced some flood damage in the 1970s (Lossmann, 2004; Diminico, 2004), and extensive damage during the 1998 flood (Underwood, personal observations, 1998; Addison Independent, 1998). While the park is depicted on this 1995 orthophoto base for Figure 31, the homes are no longer present. Following the 1998 flood, FEMA bought out the property and turned it over to the Town of Bristol with the restriction that no future residential or commercial development be allowed. One remaining private landowner exists at the western extent of the former mobile home park; a seasonal camper typically occupies the lot. The Town of Bristol, with assistance from the Bristol Conservation Commission is developing the property into Sycamore Park, a public, day-use recreation area.

4.2.2 New Haven - Main Stem Reaches M09 through M03

The main stem reaches in New Haven township extend from M09 at New Haven Mills downstream to the confluence with the Otter Creek at M01. Reaches M09 through M03 were assessed in Phase 2.

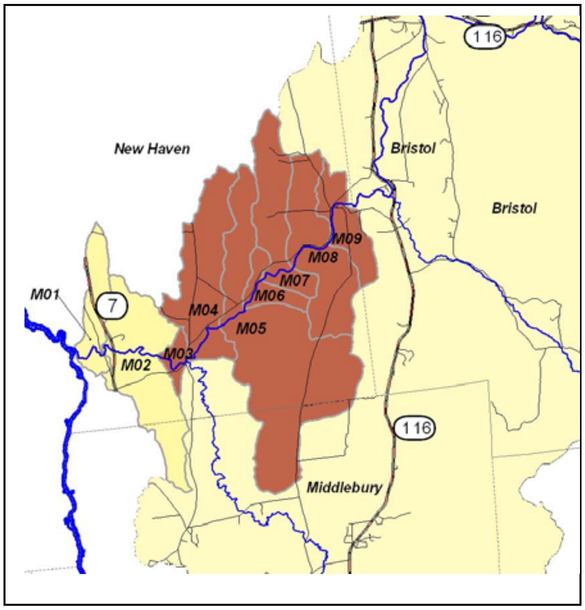


Figure 32. New Haven reaches assessed in Phase 2.

Table 11. Summary of Phase 2 results for New Haven Main Stem reaches

Reach	Channel Length (ft)	Channel Slope (%)	Drainage Area (sq. mi.)	Stream Type	RHA Condition	RGA Condition	CEM Stage	Adjustment	Sensitivity
M09	3858	0.52	89.0	B4c-R/P	0.65 Good	0.69 Good	V	Aggradation (minor)	Moderate
M08	3675	0.33	90.4	F4-R/P	0.68 Good	0.60 Fair	IV	Aggradation	Very High
M07	3083	0.16	91.4	C4-R/P	0.54 Fair	0.40 Fair	III	Planform Adjustment / Widening	Very High
M06	2590	0.19	91.8	F4-PB	0.65 Fair	0.40 Fair	II	Incision / Planform Adjustment	Very High
M05	2425	0.21	95.3	C4-R/P	0.71 Good	0.78 Good	I	Aggradation (minor)	High
M04	4300	0.16	96.8	C4-R/P	0.57 Fair	0.44 Fair	III	Planform Adjustment / Widening	Very High
M03	2997	0.23	114.0	C4-R/P	0.65 Fair	0.33 Poor	III	Planform Adjustment / Widening	Very High

Abbreviations:
S/P = Step/Pool; R/P = Riffle/Pool; PB = Plane Bed; Ref = Reference
CEM Stage (Schumm, 1977, 1984): I=Stable; II=Degrading; III=Widening; IV=Stabilizing; V=Stable

Historically, floodplain development in reach M09 included mill sites and other manufacturing along the left and right banks near the Munger Street intersection as well as further south near the downstream reach break (Beers, 1871). These commercial and manufacturing interests incurred damage in floods of the 1800s and were not rebuilt following severe damage in the flood of 1927 (Farnsworth, 1984). From the late 1790s until it was breached in the 1927 flood, a dam was present just upstream of the Munger Street crossing. The dam formed a narrow mill pond extending upstream east of the New Haven / Bristol line (see Figure 33).

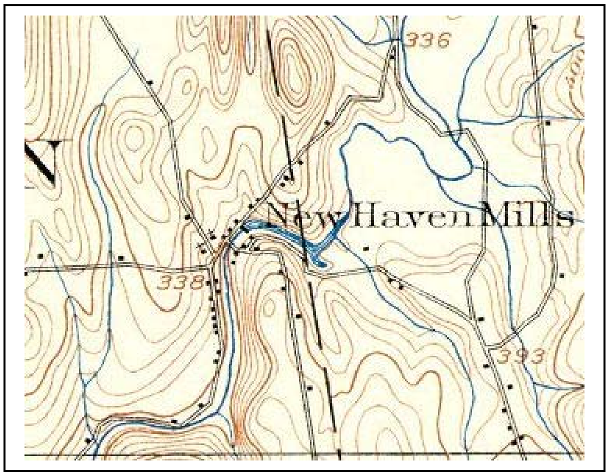


Figure 33. Location of former mill dam at New Haven Mills, Reach M09. USGS 15-minute topo quad, Middlebury, 1905, surveyed 1903.

The adjacent valley side slopes to the northwest and southeast (Munger Hill) of M09 are steep, bedrock-controlled and confine the channel to a narrow valley through this reach. Bedrock controls were noted along the right bank, although bedrock was not observed to be quite channel-spanning. Currently the channel does not exhibit signs of active adjustment, laterally or vertically. The average channel-slope (0.52%) is characteristic of a C channel, while the valley confinement suggests a B-type stream. Field observations and a cross section measured in reach M09 indicate abandoned terraces along right and left bank in the upper portions of the reach that are three to five times the current bankfull height. This incision appears to be historic in nature as there are no major signs of active channel adjustment, laterally or vertically, through the reach. Historic incision in the reach may have occurred during operation of the former mill dam. Dams have been shown to cause localized incision, as they trap sediments behind the impoundment, disturbing the natural water and sediment balance of river systems. Local incision can result downstream of impoundments as erosive energies of the river are increased from the localized base-level changes. In the years since the 1927 breaching of the mill pond dam, the river appears to have created a relatively stable channel at a lower elevation.

Proceeding downstream, reach M08 exhibits similar signs of the historic incision (IR = 2.0), in a somewhat broader valley setting of gentler gradient (0.33%). While the incision appears historic in nature (i.e., no headcuts or steep riffles present), there are some signs of more active widening and aggradation, including high width to depth ratio, transverse riffles and accumulation of sediments. A section of the right bank along River Road failed in the 1998 flood and is now a high armored bank ("Smiley's washout"; New Haven annual report, 1999) (see Appendix E). Downed trees along the left bank across from the armored bank are the result of blowdown during a 2003 wind storm and not channel widening (Underwood, personal observations). A tributary joining reach M08 along right bank was observed to overwhelm its in-stream culvert and flow over River Road during the 2004 flood (Underwood, 2004).

Reach M07 has experienced some planform adjustments over recorded history as apparent from review of historic aerial photographs (see Figure 34). A channel migration zone ranging from 250 to 400 feet wide is indicated by past channel positions. Within the last 6 years since the 1998 flood, there has been accumulation of sediment on point bars and substantial filling of pools in the reach (Manley, 2004). Meander migration in the downstream half of the reach has created a narrow meander with high potential for neck cutoff. The upstream meander bend has migrated southward into an adjacent corn field (see Figure 34) eroding approximately 1.1 acres of land. The downstream meander has eroded northward into the tributary channel that enters the main stem along right bend into a position similar to the channel position reflected on the 1963 aerial photograph. An estimated 7,000 cubic yards of sediment have mobilized from this site since 1995, assuming an average vertical thickness of 4 feet of sediment across the 1.1-acre area. The long cultivation history of these soils would suggest elevated phosphorus content.

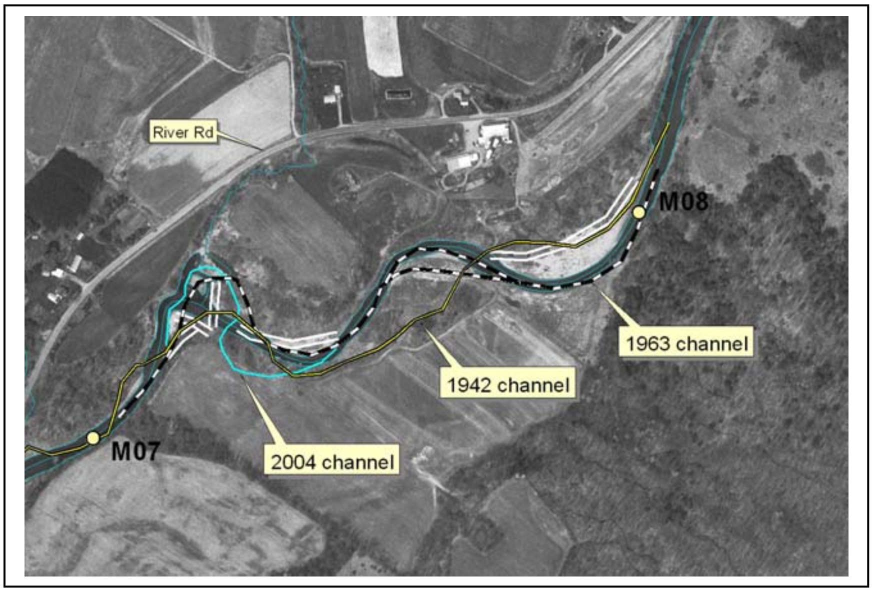


Figure 34. History of planform adjustments (meander migration) in Reach M07 discerned from review of historic aerial photographs.

Reach M07 has good floodplain access in moderate to high flow events. Water crossed River Road to the northwest in the 1998 flood (Manley, 2004). Water was observed out of the banks along the right bank but did not come up over the River Road in the 2004 flood (Underwood, personal observations). Also, during the 2004 flood, the tributary entering from right bank at the apex of the tight meander was observed to surround the home on the north side of River Road and fill an old meander channel along the south side of River Road.

(a) *(b)*

Figure 35. Reach M07, New Haven River main stem, New Haven. (a) Recent (post-1995) meander migration into corn fields; (b) overwidened channel with enlarged point bars of steep faces, multiple flood chutes, and large woody debris.

Based on available data, reach M06 exhibits signs of historic incision as well as signs of current, localized incision. The upstream half of the reach is entrenched between a high terrace on the left bank which has had regular cultivation over the past several decades and a high bank on the right bank, along which River Road passes. Buffer widths are minimal along the cultivated right and left corridors. The upstream half of the reach has a plane-bed channel form with a pavement of smaller gravels and sands and the occasion cobble or boulder. The reach cross section was performed in this upper half of the reach just downstream of a vehicle ford in a riffle / run. The cross section demonstrated negligible floodplain access (ER = 1.8 and IR = 1.4). At this location, the river stage was not observed to rise out of the left bank (which is the low bank) during the August 2004 flood.

At the downstream end of M06, two steep riffles (head cuts?) were encountered on approach to a pair of meander bends that have migrated considerably into woody riparian buffer along left bank and into the corn field along right bank in the years since the 1995 orthophoto was flown. An enlarged series of point bars was evident with several non-channel-spanning jams of large woody debris. Two shallow depressions and bulldozer traces on the downstream point bar indicated past bar scalping (see Appendix E). Based on the current GPS'd channel position through this series of meander bends, approximately 0.8 acre land on both banks has been eroded. This equates to approximately 6,100 cubic yards of sediment, assuming an average vertical thickness of 5 feet of sediment.

The River Road moves away from the river along reach M05. Overall, this reach has good access to a relatively narrow floodplain developed mostly along right bank in a narrow band of woody riparian buffer visible on orthophotos (see Appendix E). The left bank throughout much of the reach is a forested, abandoned river terrace slightly higher in elevation than the right bank floodplain and extends one to three channel widths to a forested, moderately steep valley wall. Some level of historic channel straightening in this reach is suggested by its proximity to cultivated fields and the very low sinuosity in absence of lateral bedrock control. At present, a minor amount of planform adjustment appears to be occurring in the form of meander migration in the downstream extent of the reach. Associated with this lateral adjustment is minor enlargement of point bars and side bars.

In reach M04, the high bank for much of the reach is the moderately sloped, bedrock-controlled forested valley wall along right bank. The reach appears somewhat incised below this higher right valley wall and the cultivated left valley corridor (IR = 1.7), but retains floodplain access through much of the reach for moderate to high flow events (ER = >2.4). Evidence of historic straightening, includes berming along the right bank, armoring along much of the left bank, and proximity of cultivated fields along the left corridor. While the sinuosity for the reach is very low, there is some evidence of bedrock controls along the right bank mid-reach (see Appendix E). Average buffer widths along the left bank are less than 20 feet, with an occasional pocket of absent buffer.

At the downstream end of reach M04 in vicinity of the old Nash Farm, there is active planform adjustment and associated localized aggradation just upstream of channel constriction by past channelization and armoring (see Figure 36). An estimated 6,700 cubic yards of sediment have mobilized from this site since 1995, assuming an average vertical thickness of 5 feet of sediment across the approximately 0.8-acre area. An average lateral migration rate of the channel is estimated as 17 feet per year (150 feet in 9 years). This downstream portion of reach M04 has considerable floodplain access. Floodwaters (e.g., 1998, 2004) regularly inundate the River Road upstream of the bridge over the main stem (Underwood, personal observations).

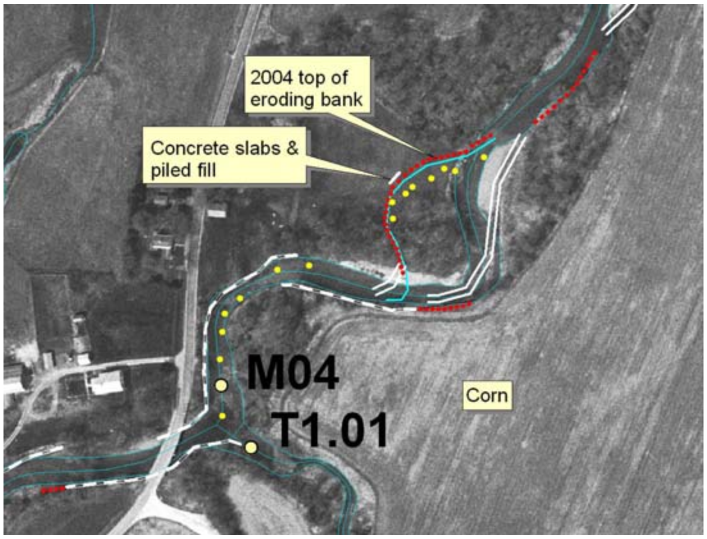


Figure 36. Recent (post-1995) planform adjustments in reach M04. Yellow dots represent mid-channel position recorded with GPS, 9 August 2004.

Figure 37. Less than 5-foot riparian buffer along an eroding meander in reach M04. Buffer in this location is dominated by grasses which provide little root-binding capacity to streambank soils and negligible shade to the river channel.

Reach M03 is the most downstream reach to be assessed during 2004 Phase 2 assessments. The upstream portion of the reach has been heavily managed (channelized, armored) to protect the River Road crossing and River Road intersection with Halpin Road. The confluence with Muddy Branch (T1) also joins the main stem just upstream of the bridge crossing. Downstream of the managed sections of reach, the river has taken opportunity to widen its floodplain through meander migration and flood chute development. The two major meanders in this reach are demonstrating current meander migration (see Figure 38). The upstream meander historically was tight to the former alignment of River Road in the 1942 aerial photograph and appears to have shifted or been channelized to a location farther north by 1963 (based on review of 1963 aerial photos). The upstream meander bend was armored in 1995 or 1996 under NRCS programs (Lossmann, 2004) to protect the adjacent corn field from meander migration. This armoring is still intact. However, erosive forces and meander migration upstream to the south and east appear to be outflanking the armoring. Lateral migration is currently directed at River Road once again (see Figure 38). The downstream meander is encroaching on woody riparian buffer and cultivated fields to the north.

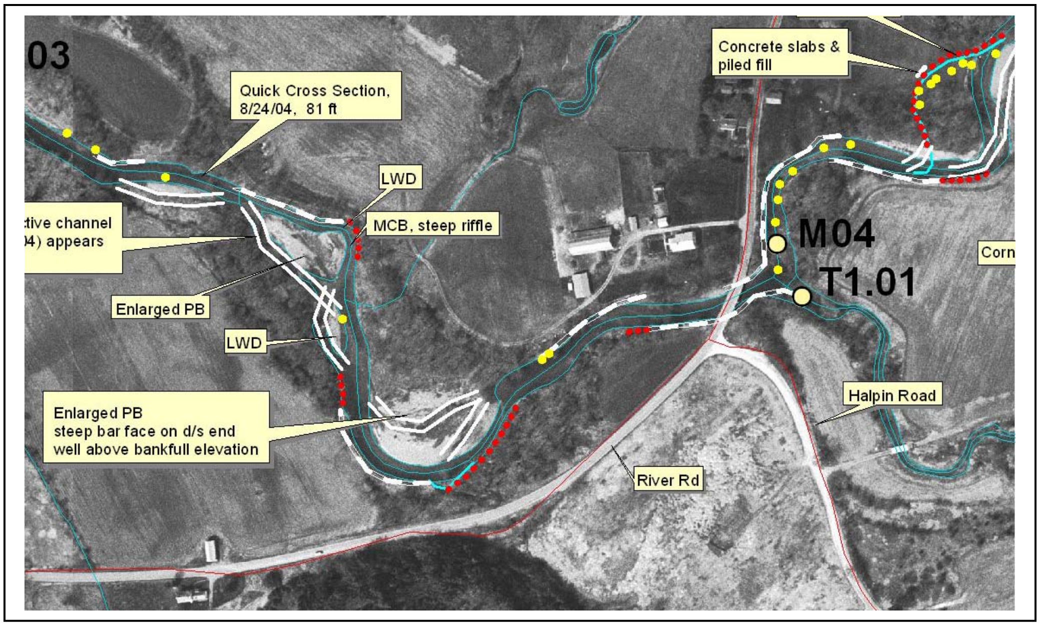


Figure 38. Planform adjustments in reach M03, migrating toward River Road.

Anecdotal accounts (Bouton, 2004) and review of 1942, 1963 and 1974 orthophotos indicate that drainage from wetlands and/or a tributary formerly crossed Halpin Road and flowed under River Road to join the main stem in the vicinity of this upstream meander bend. Crossing structures are still evident on the Halpin Road and a former alignment of River Road. River Road was realigned and raised in elevation in the early 1980s to soften curves on approach to the River Road bridge and to reduce inundation hazards along the road (Lossmann, 2004; Bouton, 2004). In the process, River Road encroached slightly on the meander, based on review of 1974 aerial photographs and the 1995 orthophoto.

Reach M03 is currently dominated by planform adjustments, aggradation and associated widening. It still appears to have some connection to its floodplain in moderate to high flow events, but exhibits moderate incision (IR = 1.4), probably historic in nature.

5.0 Summary and Discussion

Phase 1 and Phase 2 assessment results begin to characterize the watershed and channel stressors to the New Haven watershed over time, and the spatial and temporal variability in geomorphic conditions which together have resulted in the present day conditions. These interpretations can be used by watershed stakeholders to identify possible consequences of land use and watershed management decisions on future geomorphic condition of the river to minimize erosion and flooding hazards and to optimize water quality and aquatic habitats.

5.1 Watershed and Channel Stressors

Watershed stressors identified to date for the New Haven River watershed include:

- deforestation in the 1800s, particularly in the Upper Watershed;
- clearing of land in the Lower Watershed for agricultural use (1800s to 1900s);
- more recent (late 1900s) increases in impervious surfaces related to:
    - more recent upland development and clearing of forests which had revegetated since the 1800s;
    - conversion of agricultural lands in the valley areas to residential and commercial use;
    - increases in road and driveway densities; and
- large-magnitude flood events (1830, 1869, 1927, 1938, and 1998);

Evidence of channel stressors logged in each reach during Phase 2 assessments are summarized in Table 12.

5.2 Dominant Adjustment Processes and Reach Sensitivity

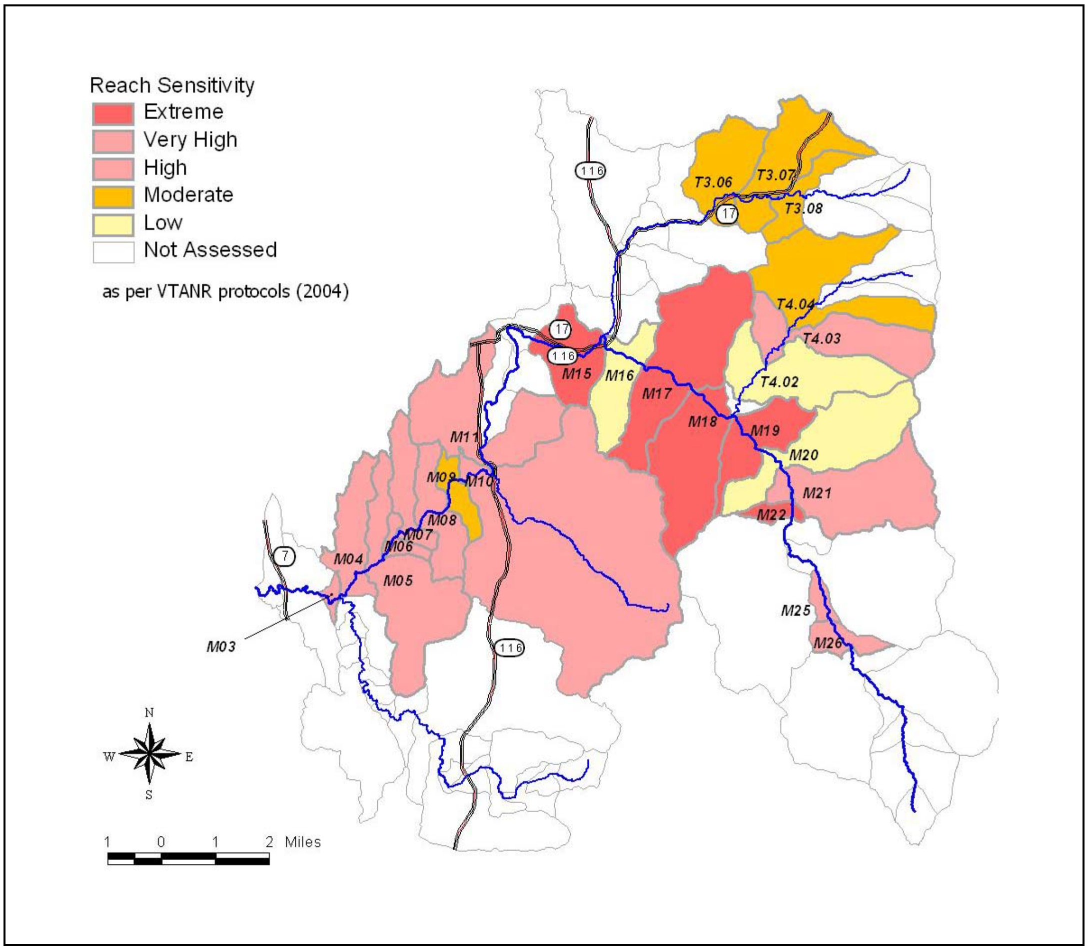
Dominant adjustment processes and sensitivity for the targeted reaches within the New Haven River watershed are summarized in Figure 39. The present stage of channel adjustment for a given reach or sub-reach can be classified by reference to a channel evolution model (CEM) after Schumm (1984). The reader is referred to the VTANR stream geomorphic assessment protocols for more details (VTANR, 2004). In brief, a reach which is evidenced to be in an equilibrium state, able to effectively mobilize its water and sediment loads, is either in Stage I (pre-disturbance equilibrium) or State V (post-disturbance equilibrium, following adjustment through the intermediate phases). Adjusting reaches, in Stage II, III, or IV, are those which are actively degrading, widening, or aggrading, respectively. These channels are not effectively transporting their water and sediment loads, and may be associated with substantial streambank and streambed erosion. Particularly, reaches in Stage II or III (actively deepening and widening) should be further evaluated through detailed survey work and more in-depth historic assessments prior to consideration of labor- and resource- intensive restoration options (Simon, et al, 2001). For example, a well-intentioned streambank armoring project may be washed downstream in the next Spring runoff or minor flood event, when a Stage II channel continues to drop its bed and stabilization structures are undermined and collapse into the channel.

A few reaches exhibited signs of active degradation through a portion of their length (Stage II). These were M06 in New Haven, M15 through Bristol Village, and M26 in South Lincoln. In Bristol Village, extensive channel management in reaches M14, M13 and M12 may have initiated or contributed to channel incision that has migrated upstream. Assessment of these reaches is critical for the village of Bristol to understand the context of channel adjustments occurring in M15 and also downstream in reaches M11 and M10.

Remaining reaches were dominated by widening (Stage III), with associated aggradation and planform adjustments. In most cases, widening appears to be initiated by excess sedimentation rather than a response to nearby or recent channel incision. While many reaches are moderately entrenched, having lost connection with the floodplain for all but the highest magnitude flow events, the entrenchment appears historic in nature and not related to active channel incision (with the exception of the three reaches noted above).

Table 12. Summary of Reported and Field-observed Channel Stressors by Reach, New Haven River Watershed, 2004

Reach	Vertical Grade Control	Channelization	Dredging (Blasting)	Berming	Bank Armoring	Revetment	Gravel Extraction	Undersized Bridge / Culvert	Ford	Beaver Activity	Floodplain Encroachment	Segment of Minimal Riparian Buffer	
Main Stem													
M03		√			√			√			√	√	
M04		√		√	√		√					√	
M05		√			√							√	
M06		√			√		√		√		√	√	
M07					√				√			√	
M08		√			√				√		√	√	
M09					√						√	√	
M10				√	√				√		√	√	
M11		√	√	√	√		√	√			√	√	
M15		√			√		√				√	√	
M16	Bedrock	√	√		√						√	√	
M17		√		√	√				√		√	√	
M18	Bedrock	√			√						√	√	
M19		√	√	√	√				√		√	√	
M20	Bedrock	√			√						√	√	
M21	Bedrock	√			√		√					√	
M22		√			√	√	√				√	√	
M25	Bedrock				√			√	√		√	√	
M26		√		√	√			√	√		√	√	
Baldwin Creek (T3)													
T3.06				√	√								
T3.07	Culvert				√			√				√	
T3.08	Bedrock, Culvert	√			√			√		√	√	√	
Beaver Meadow (T4)													
T4.02	Bedrock				√								
T4.03	Bedrock	√		√	√	√					√	√	
T4.04	Culvert, Bedrock	√		√	√			√			√	√	



Reach	CEM	Sensitivity	Reach	CEM	Sensitivity
M03	III	Very High	M18	III	Extreme
M04	III	Very High	M19	III	Extreme
M05	I	High	M20	I	Low
M06	II	Very High	M21	III	High
M07	III	Very High	M22	IV	Extreme
M08	IV	Very High	M25	III	High
M09	V	Moderate	M26	II	High
M10	III	Very High	T3.06	I	Moderate
M11-A	IV	High	T3.07	IV	Moderate
M11-B	III	Very High	T3.08-B	IV	Moderate
M15	II	Extreme	T4.02	I	Low
M16-A	III	Extreme	T4.03-A	I	Low
M16	I	Low	T4.03-B	IV	High
M17	III	Extreme	T4.04	III	Moderate

Figure 39. Reach-based channel-evolution-model stage and sensitivity (VTANR, 2004) New Haven River watershed. 2004 Phase 2 assessment results.

Excess sediments in the channel may originate from a few sources:

- Streambank and streambed erosion within the reach and upstream reaches related to widening and planform adjustments (e.g., in reaches M04, M06, M07, M10, and M11);
- Flood-related sediments mobilized in the 1998 flood, that are still working through the system;
- Localized contribution of sediments from road and stormwater runoff;

Reaches were classified in terms of their sensitivity to future stressors after VTANR protocols (see Figure 39). High to extreme sensitivity reaches are those which are especially susceptible to future adjustments due to a combination of factors which can include:

- lack of grade controls (channel-spanning bedrock);
- lower gradient settings with smaller (mobile) grain sizes (sands and gravels) dominating the stream bed;
- absent or minimal forested riparian buffers;
- loss of connection with the floodplain;
- active adjustments, particularly degradation or widening, in response to past stressors.

As displayed on Figure 39, those reaches exhibiting extreme sensitivity tend to be those reaches at the transition from steeper slopes to shallower slopes (reference Figure 3 in Section 2.3). They are also coincident with some of the higher concentrations of floodplain development: M15 through Bristol village and Rockydale; M17 – M19 through West Lincoln and Lincoln villages and M22 through South Lincoln. Also, the lower 750-feet subreach of M16 east of Bristol Village is assigned an Extreme sensitivity due to its position on an alluvial fan at the transition between bedrock-controlled slopes upstream and the more broad alluvial valley downstream. The relatively low sensitivity rankings of reaches T4.02, M20 and M16 are due to the substantial bedrock controls through these reaches.

5.3 Infrastructure

Select bridges and in-stream culverts providing road crossings over the New Haven River main stem and tributaries were evaluated to determine if their spans (openings normal to stream flow) were undersized with respect to the bankfull flow (see Figure 40). Undersized structures can lead to channel aggradation upstream of the structure and vertical and lateral scour on the downstream side of the channel. Such conditions can, in turn, lead to destabilization of the fill and armoring material supporting the crossing structure and to undermining of footings or other structural components. In addition to locally constricting channels, undersized bridges and culverts can be a source for flood hazards to neighboring properties, serving as the location of debris jams or ice jams during spring runoff events or larger magnitude floods.

Twenty-eight (28) structures were assessed, including those encountered during Phase 2 assessments on targeted reaches and a few additional structures selected for Bridge & Culvert Assessments following Appendix G of the VTANR protocols. General locations within the watershed are displayed in Figure 40; specific structure locations can be determined by reference to Appendix E and Table F.1 in Appendix F. All crossing structures were undersized when compared to flood prone widths (i.e., corresponding to the ten-year to fifty-year storm). Twelve of these bridges / culverts were found to be constrictors of the approximately annual bankfull flows and are noted in red on Figure 40. These are structures to watch in future flooding conditions.

In general, the bankfull-constricting structures were Town crossing structures rather than State structures. This may reflect the relatively lesser degree of resources available to towns for design, acquisition and construction of crossings. Typically, bankfull-constricting structures were culverts rather than bridges. Culverts are more commonly installed on town roads rather than state roads given the generally smaller width of roads under town jurisdiction. These findings are consistent with results of bridge and culvert assessments in other watersheds State-wide (e.g., Middlebury River and Lewis Creek in the Otter Creek basin or Trout River and Black Creek watersheds in the Missisquoi River basin).

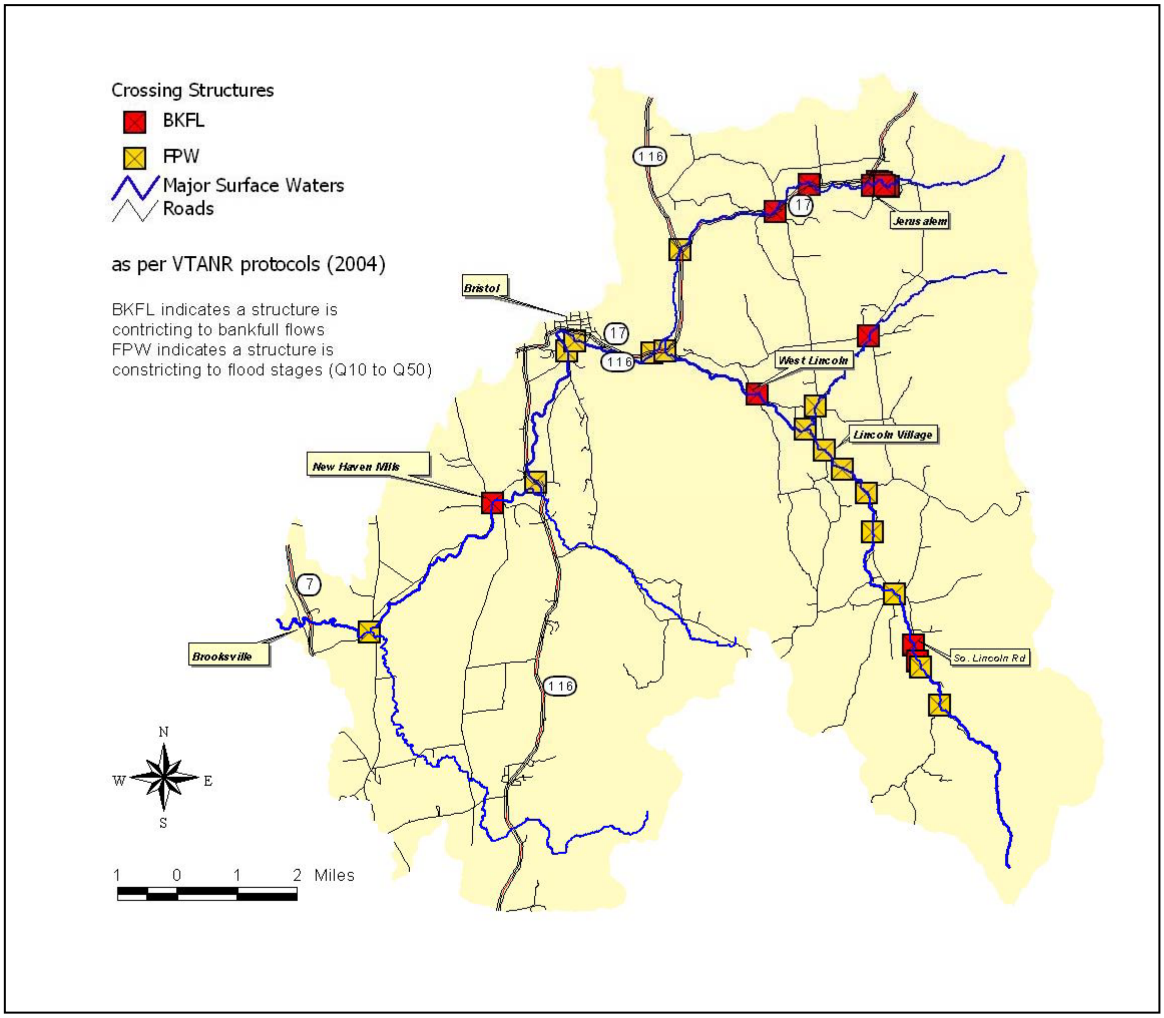


Figure 40. Geomorphic status of major bridge and in-stream culvert crossings.
New Haven River watershed, 2004 Phase 2 assessment results.

Examples of other infrastructure noted to be at particular risk from streambank erosion, meander migration, landslide potential, and/or geomorphic setting of the surrounding stream channel, are presented in Table 13. Table 13 is not intended to be a comprehensive inventory of infrastructure at risk in the watershed. It is simply a listing of some of the more prominent examples noted during the assessment. Other risks to infrastructure have been noted within Section 4.0. In particular, roads (River Road, Bristol-Lincoln Road, Route 17 / 116) and development close to the river channel (through Bristol Village, West Lincoln, Lincoln, and South Lincoln villages, Downingsville, South Starksboro) are at particular risk from fluvial erosion hazards and inundation hazards.

Table 13. Notable examples of infrastructure at risk, New Haven River watershed.

Reach	Town	Structure	Description
Main Stem			
M03	New Haven	River Road	Meander migration has outflanked armoring on left bank and meander migration is directed southward toward River Road.
M10	Bristol	residence, LB	One residence is positioned mid-way along the reach at the southern boundary of the historic channel migration zone and could be subject to future erosion hazards if the channel migrates to the south.
M11	Bristol	Route 116	A series of 90-degree meander bends in the reach has resulted in low-to-moderate flows directed nearly perpendicular to Route 116 armoring along right bank at the upstream extent and mid-reach. At the upstream extent, flows from a right bank tributary ar
M11	Bristol	residence, RB	A residence along right bank has experienced erosion and inundation hazards in past floods including the recent 2004 flood.
M15	Bristol	residences, RB	The newly-constructed home (see Section 5.2.1) and Blaises Trailer Park homes along right bank are at imminent risk from streambank erosion and failures in this actively adjusting reach. Other homes and businesses in the Rockydale development, particularl
M15	Bristol	Route 17 / 116	Route 17 / 116 is highly susceptible to failures from streambank erosion particularly mid-way along the reach.
M16	Bristol	potential infrastructure	The downstream 750 feet of reach M16 near the confluence with Baldwin Brook is a highly-adjusting subreach of river channel subject to braiding flows and lateral channel migration. Future development and placement of infrastructure in this area should be
M18	Lincoln	Bristol-Lincoln Road	Bedrock deflects flow at moderate to high stages directly at the right bank and Bristol-Lincoln Road. A length of armoring is present at this location presently.
M25	Lincoln	residences, RB	Active, recent meander migration in two locations along the reach is encroaching on two residences along right bank. Channel adjustments at the downstream residence may be influenced by a large mass failure immediately upstream.
Beaver Meadow (T4)			
T4.03	Lincoln	residence, RB	Potential for neck cutoff of tight meander.

5.4 River Corridor Management

Several highly-adjusting reaches identified in the New Haven River have implications for river corridor management. Average lateral erosion rates ranging from 14 to 19 feet per year were estimated at three separate sites in Bristol and New Haven, based on comparison of current channel positions (located with GPS) to channel positions as displayed on 1995 orthophotographs. Review of past channel positions on historic aerial photographs dated 1942, 1963, and 1974 for reaches in Bristol (M10 at Sycamore Park) and New Haven (M07 along River Road near the former Ash Farm) indicated 60-year channel migration zones with widths that are up to 950 feet and 400 feet, respectively.

These Phase 2 results demonstrate three major findings with implications for management of river corridors:

1) Rivers adjust their width and their planform considerably over relatively brief timeframes (decades);
2) Structures placed in an adjusting river corridor may be safe from inundation hazards (i.e., positioned above 100- or 500-year floodplains) but very susceptible to fluvial erosion hazards (e.g., the residence located within 10 feet of an eroding streambank in Bristol (Rockydale) along reach M15).
3) A so-called 100-year magnitude flood can occur much more frequently than once every 100 years.

The findings present a challenge for landowners, developers, and municipal planners in the watershed. To prevent future losses of property, roads, buildings, and lives, setbacks from the river should be developed that recognize the dynamic nature of the river. The traditional buffer width or setback from top of bank will not be sufficient for some reaches where the top of bank is moving laterally at a rate of up to 19 feet per year. A standard buffer of "x" number of feet may be sufficient for relatively stable (Stage I or V) reaches but inadequate for highly adjusting reaches (Stage II or III).

Based on a cursory review of existing Town Plans and Zoning Ordinances, Lincoln is currently the only watershed town with specified setbacks from streambanks of 25 feet. Lincoln is reportedly considering more comprehensive streambank buffers based on size of the stream (minor versus major streams) and based on adjacent side slopes (Behm, personal communication, 16 August 2004). While Starksboro requires a zoning permit for new construction within 100 feet of a stream or waterbody, the Zoning Regulations simply state that the applicant must demonstrate that there is no adverse effect on the waterbody. No specific guidelines are offered to clarify what constitutes an adverse effect. The geomorphic condition of the waterbody is not listed as an item of consideration. Bristol and New Haven presently do not include streambank setbacks in their zoning regulations.

There is growing recognition at State and Federal levels, that the FEMA-FIRM maps, while they may be adequate for protection of inundation flood hazards, do not presently account for fluvial erosion hazards. A house positioned 10 feet from a highly-eroding bank may be well elevated above the predicted flood stage of a 100-year storm, and incorporate design elements to protect against interior flooding. However, if the nearby channel is incising into its streambed and widening in response to past stressors, the house may easily fall into the river in the next minor to major flood event, despite the homeowner's best intentions and attempts to armor the bank.

Ideally, geomorphic conditions and surficial geologic settings along the river corridor should be interpreted by watershed towns to develop suggested Overlay Districts for New Haven surface waters. These Overlay Districts would be more comprehensive than simple setbacks from streams or default minimum buffer widths. Overlay Districts specify an adequate separation distance between human activities and the river, accounting for the actual width of the river at that locality, the size and nature of the watershed draining to that particular reach, the need for the river to adjust itself vertically and laterally to maintain or restore its equilibrium, knowledge of historic migration patterns of the river, and potential instability of steep slopes adjacent to the stream. For example, given the past channel migration history, reach M10 near Sycamore Park in Bristol may require a streambank setback of several hundred feet, while a setback on the order of 50 feet may be more realistic for a reach like M09 south of New Haven Mills in New Haven which has experienced very little lateral migration over recorded history and geomorphically is in relatively stable condition.

5.5 Water Quality

Several areas of streambank erosion were identified during the study. Some were substantial, related to meander migration in reaches experiencing planform adjustments (Table 14). Erosion of the streambed and banks, particularly in areas which have historically been cultivated, can result in mobilization of phosphorous and excess sediments to the receiving waters. Streambank erosion can also be aggravated by animal crossings and by four-wheel drive and snowmobile fords, which trample stabilizing vegetation and create weak points in the streambanks and riparian buffer. Excess sedimentation degrades in-stream habitats for fish and aquatic insects.

Table 14. Estimated Sediment Losses from Major Sites of Lateral Channel Adjustments, 1995 – 2004: New Haven River main stem, Bristol and New Haven, VT

Reach	Approximate Area (acres)	Approximate Vertical Thickness (ft)	Approximate Sediment Volume (yd^3)
M04	0.8	5	6,700
M06	0.8	5	6,100
M07	1.1	4	7,000
M10	2.0	4	12,600
M11	1.4	3	6,600

Historic water quality sampling (1993 to 2004) by the New Haven River Watch (NHRW) has identified phosphorus and pathogen impacts in New Haven River, as well as sedimentation from unstable stream reaches and road / culvert maintenance practices (ACRWC, 2004). The State of Vermont has listed approximately 10 miles of the New Haven River main stem from the confluence with Otter Creek to the Village of Bristol as being in need of further assessment (Part C List of Waters, draft 2004) for sediment and habitat alteration as a possible result of morphological instability. In addition, the New Haven main stem from the mouth to the York Hill Bridge in West Lincoln (approximately 13 river miles) is listed on Part C for further assessment of *E. coli* impacts from undefined sources (VTDEC WQD, 2004).

The main stem reaches assessed in Phase 2 include a majority of the C-Listed waters identified by the VT Water Quality Division and all but the two downstream-most Addison County River Watch sampling sites. Water quality sampling results can be reviewed in the context of these geomorphic and habitat assessment results to inform strategic revisions to NHRW's 11-year water quality monitoring program.

6.0 CONCLUSIONS

The following conclusions are offered from the fluvial geomorphic assessment conducted in the New Haven River watershed during the Summer of 2004:

- Channel disturbances along the New Haven River, noted through field reconnaissance and review of historical data, include:

  - Apparent or reported channelization;
  - Channel armoring (rip-rap);
  - Berming;
  - Historic floodplain encroachment by town roads and Routes 17 and 116;
  - Floodplain encroachment by commercial and residential development;
  - Reported historic gravel extraction, dredging and berming through Lincoln and Bristol villages and along reaches M12 and M13, particularly in response to flood events in 1927 and 1938, with the most recent dredging and berming events following the 1998 flood;
  - Undersized private and public bridges and in-stream culverts, serving as flow constrictors at the bankfull flow or higher-magnitude flood events;
  - Minimal or negligible riparian buffers along portions of main stem reaches, particularly those associated with current agricultural land use in the Lower Watershed;
  - Active stream crossings (fords).

- Watershed stressors noted for the New Haven River, determined from historical data gathering, include:

  - Historic (mid-1880s) deforestation of the Upper Watershed leading to historic increased percent imperviousness and sediment mobilization;
  - Recent upland development in the Upper Watershed leading to increased percent imperviousness.
  - Recent high-magnitude flood events particularly the 1998 flood which had watershed-wide impacts.

- Geomorphic condition of the reaches targeted for Phase 2 assessment ranged from Poor to Good, as measured by VTANR protocols (2004).

- The most sensitive reaches (High, Very High, or Extreme), susceptible to future adjustments in the face of current and future channel and watershed stressors, include the low- to moderate-gradient (less than 2%) channels dominated by gravels, and absent of grade controls. In the New Haven River watershed those reaches designated as having Extreme sensitivity are M15 through Bristol village, M17-M19 through West Lincoln and Lincoln villages, as well as M22 through South Lincoln. Also, the lower 750 feet of subreach of M16 east of Bristol Village is assigned an Extreme sensitivity due to its position on an alluvial fan at the transition between bedrock-controlled slopes upstream and the broader alluvial valley downstream.

- Twenty-eight bridges and in-stream culverts were assessed for their constriction status relative to bankfull flows. Twelve structure spans were found to be undersized with respect to the bankfull width, indicating the potential for flood damages related to debris / ice jams and the potential for localized scour and aggradation that can undermine fill and foundational elements of the structures.

- Other infrastructure in New Haven, Bristol and Lincoln noted to be at particular risk from streambank erosion, meander migration, landslide potential, and/or geomorphic setting of the surrounding stream channel, included River Road in New Haven; residences, businesses, and Route 116 in Bristol village; and residences, businesses and Bristol-Lincoln Road in West Lincoln and Lincoln villages.

7.0 RECOMMENDATIONS

Fluvial geomorphic assessments highlight watershed management challenges to our communities to:

- recognize streams as dynamic systems conveying both water and sediment / debris;
- understand the consequences of our land use choices on our natural systems; and
- recognize that consequences play out over substantial temporal and spatial scales.

Fortunately, planning tools and management strategies exist to minimize negative consequences of our land use choices. Following, are recommendations for the New Haven River watershed communities, organized by topic.

7.1 Infrastructure

Consider the geomorphic context when designing new and rehabilitated infrastructure.

- New or replacement bridges should ideally have openings which pass the bankfull width to flood-prone-width without constriction.

- Bridges and culverts should be designed to cross the river without creating channel approaches at an angle to structures. Such sharp angles can lead to undermining of fill materials and structural components.

- The historic channel migration pattern (i.e., channel migration zone) of the river should be considered when installing new or replacement crossing structures, and when constructing new roads, driveways, and buildings.

- Planned build-out for watershed communities and resultant channel enlargement (from increased percent imperviousness) should be considered when designing new or replacement bridges and crossing structures.

- Divert road ditch runoff to side-slopes where energy can be dissipated, stormwaters can infiltrate, and sediment / detritus loads can be deposited on the land and not directly to streams.

- Avoid concentrating stormwater runoff to highly erodible soils (e.g., sand and gravel delta / kame terrace deposits underlying Bristol village).

7.2 Community Planning

- Require geomorphically-defined setbacks from streambanks for structures and roads. Recognize river dynamics when creating local buffer guidelines or ordinances. Recognize that specific reaches of the river may be laterally adjusting far more than others (e.g., up to 950 feet lateral adjustment in reach M10 near Sycamore Park in Bristol; up to 400 feet lateral adjustment in reach M07 along River Road in New Haven).

- Adopt planning and zoning programs which minimize the creation of connected impervious surfaces (roof-tops, pavement, roads, expansive lawns). Increases of percent imperviousness in the basin lead to increased frequency and magnitude of stormwater runoff, which in turn leads to deeper and wider channels in receiving streams and increased sedimentation. Concentrated stormwater runoff to highly erodible soils can also result in catastrophic landslides and bank failures. The slope failure behind the Merchants Bank on West Street in Bristol likely resulted from concentration stormwater runoff to the highly erodible, noncohesive sand and gravel deposits of glacial-fluvial origin which underlie the main village of Bristol.

- Conduct build-out analyses for watershed townships and apply study results to published channel relaxation curves for the prediction of channel enlargement with increased percent imperviousness (e.g., after Center for Watershed Protection et al, 1999). Management and planning for reduced impervious surfaces in the upstream watershed towns of Lincoln, Starksboro, and eastern Bristol will have the most effect in reducing impacts in the watershed as a whole.

7.3 Restoration / Water Quality

- Results of this fluvial geomorphic study should be reviewed to help understand spatial and temporal trends in historic and ongoing *E.coli* and phosphorus monitoring in the New Haven River. Streambank erosion from adjusting channels and avulsions can mobilize significant quantities of sediment. In those areas presently or historically in agricultural use, phosphorus content of near-surface streambank sediments can be particularly elevated.

- Fluvial geomorphology results should be reviewed to help plan future channel restoration projects. Dominant adjustment processes ongoing in the river channel should be considered prior to design of restoration solutions. For example, streambank armoring and other substantial economic investments may not be prudent in a reach which is actively degrading or aggrading.

7.4 Habitat / Riparian Health

- Results of this fluvial geomorphic study should be reviewed to prioritize sites for reestablishment of forested riparian buffers, particularly in the Lower Watershed. Review of the Phase 2 database will help to identify those reaches with greatest room for buffer improvement. Also important would be to restore connectivity of woody riparian buffers from reach to reach. Restoration and preservation of forested riparian buffers in the watershed will help to restore and maintain equilibrium in the channel and reduce streambank erosion and downstream sedimentation.

7.5 Further Technical Studies

- Pending landowner approvals, Phase 2 assessments should be conducted on the reaches which were unable to be assessed during Summer of 2004. Assessments in these reaches would provide continuity for the Bristol section of the New Haven River and support recommended planning and river management strategies to protect roads, homes, and mitigate future flood losses. Assessment results would also be used by NRCS in the reaches directly to aid landowners in restoration designs to conserve actively eroding agricultural lands. Knowledge of active adjustment processes in these reaches would also inform channel management activities further upstream and downstream.

- Detailed surficial geologic mapping in the basin, particularly in the vicinity of Bristol Village would support fluvial erosion hazard assessments to mitigate future flood losses and damage to infrastructure. These data would also help watershed communities in stormwater planning to reduce concentrated runoff to highly erodible soils.

- Additional stream discharge gages and precipitation gages in the basin would aid pre-disaster mitigation efforts by improving flood forecasting in this flashy basin and enabling modeling of the impacts of inundation and erosion damages in future flood events.

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APPENDIX A

New Haven River Watershed Municipal Boundaries

Figure A.1 County Proportions
New Haven River Watershed

County	Area (sq. mi.)	Area (%)
Addison	114.6	98.5
Chittenden	0.5	0.4
Washington	1.3	1.1
Total	**116.4**	**100.0**

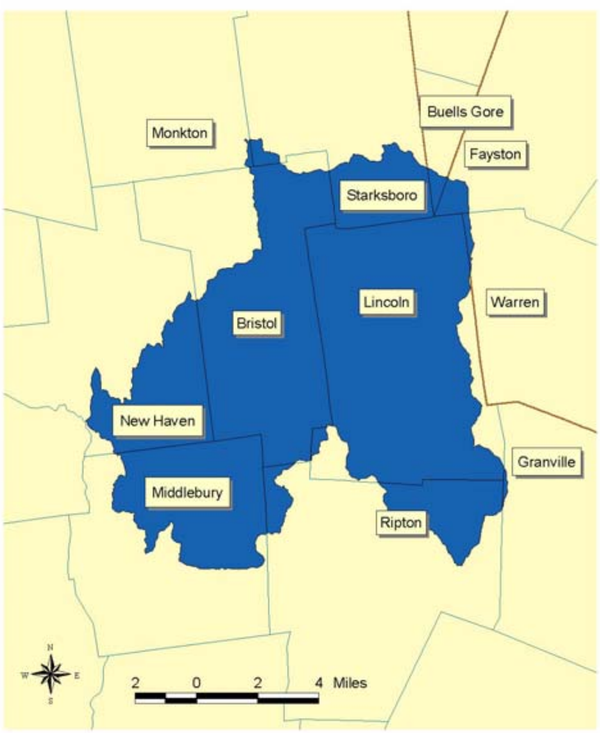


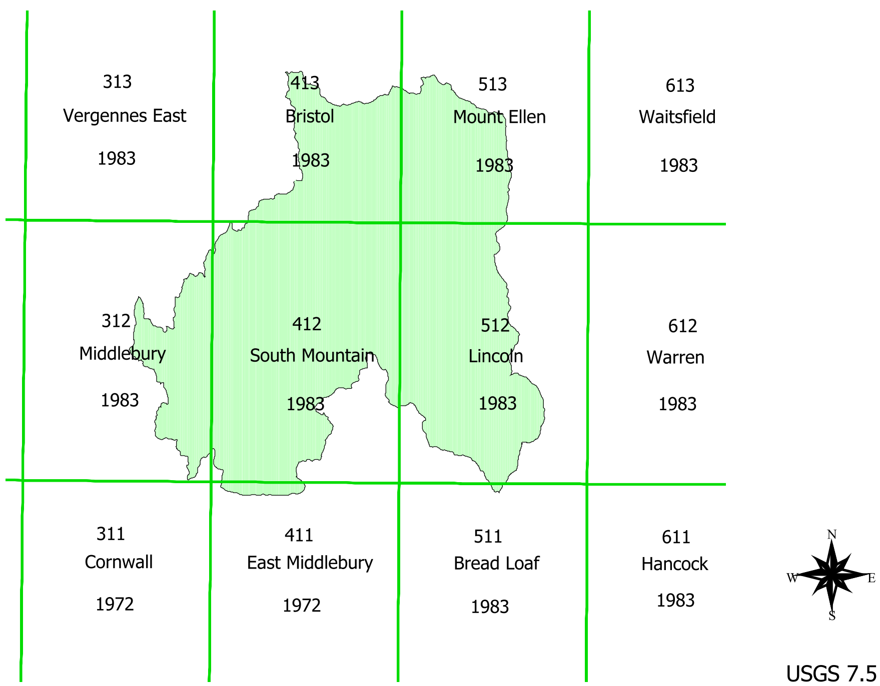
Figure A.2 Town Proportions
New Haven River Watershed

Town	Area (sq. mi.)	Area (%)
Bristol	29.4	25.2
Buells Gore	0.5	0.4
Fayston	1.0	0.8
Granville	0.1	0.1
Lincoln	41.1	35.3
Middlebury	16.6	14.3
Monkton	0.1	0.1
New Haven	11.8	10.2
Ripton	7.9	6.8
Starksboro	7.5	6.4
Warren	0.3	0.3
Total	**116.4**	**100.0**

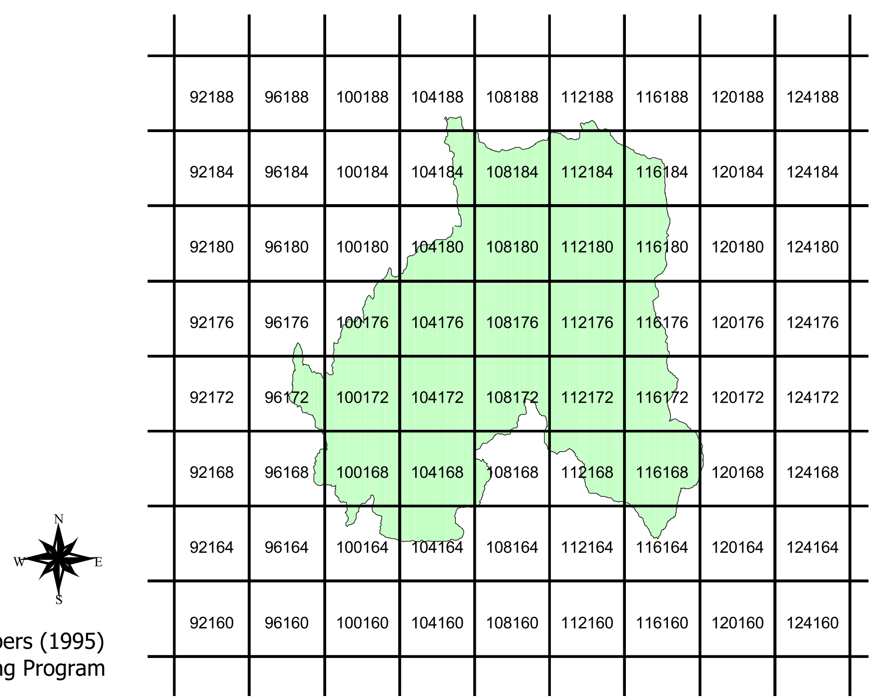
APPENDIX B

Remote Sensing Resources

Appendix B.
Remote Sensing Resources
New Haven River Watershed
Addison County, Vermont



USGS 7.5 min Topographic Map Index



Orthophotograph Grid Numbers (1995)
Vermont Mapping Program

APPENDIX C

Historic Flood Accounts and Photographs

Table C.1 Notable Flood Events, New Haven River Watershed

Flood Date(s)	Upper	Lower	Description	Data Source
1830, July	√	√	*New Haven (Brooksville – M01 & M02):* "…continued and heavy rains swelled the sources of New Haven River until the latter became a torrent of devastations. Buildings, bridges, crops, and stock were swept to destruction." At least 14 people died. Significant commercial and manufacturing facilities built up along the river including tool manufacturing facilities, wagon shops, saw-mills, furnaces, and a blacksmith shop, were destroyed in the Flood of 1830.	Smith, 1886; Farnsworth, 1984
			New Haven (New Haven Mills and Lower Mills, M09): Early manufacturing facilities were built up along the river near the Munger Street crossing, including a Mill Dam upstream of the current bridge location, a bark-mill tannery, gristmill, sawmill, and triphammer shop; all were damaged or destroyed in the Flood of 1830. Also destroyed were a tannery, carding-machine and triphammer shop along the right bank somewhat downstream of the mill dam at a location referred to as the Lower Mills.	Farnsworth, 1984
			Bristol (M14 & M15): Manufacturing interests along the river near the Village of Bristol were also swept away by the Flood of 1830 including an iron forge and carding and clothing business. "Ten bridges were destroyed and the road just below the spot where Baldwin Creek joins New Haven River was completely removed together with trees and stones, weighing from 25 to 30 tons, and carried down stream some distance by the force of the torrent."	Smith, 1886; Estes, et al, 1959
			Lincoln (West Lincoln, M17): Burnham whetstone factory and dam destroyed. Two small bridges from Isham Brook washed into the main stem. Sawmill, iron forge, and stock washed downstream.	Reed, 1980

			Lincoln (South Lincoln, M26-M24): "A wall of water, reaching up to twenty-five feet above the river's normal level began its path of destruction at Jones' Bridge in South Lincoln" Sawmills, homes, and croplands washed away.	
1869 October	√	√	*Bristol (M14):* Stewart gristmill and Howden & Bosworth sawmill and factory for manufacturing of doors, sashes, and blinds along South Street damaged/destroyed *Lincoln* Cain mills washed out *(South Lincoln, M24).* Cain mill washed out *(Lincoln Center, M19).* Generally, much damage to mill sites and businesses located along the river; less in magnitude than the 1830 flood.	Estes, et al, 1959 Beers, 1871 Outlook Club, 1980 Reed, 1980
1897		√	*Bristol:* *(M14)* South Street Bridge by Bristol Manufacturing Company destroyed (M14); *(M13)* Cold Spring covered bridge (Hewitt Road) destroyed; *(T2)* Bridge on O'Brian Brook (Little Notch Brook) destroyed (T2)	Estes, et al, 1959
1913, March		√	Third highest peak flow on record for the Otter Creek at Middlebury USGS station. Flood Insurance Study for New Haven watershed to the north cites flood damage for 1913. New Haven town report indicates expenses related to "work on breakwater".	USGS, 2003 Anderson-Nichols, 1986 New Haven town report, 1913
1927, November	√	√	Most severe flood in the recorded history of the State. Estimated 5 to 10 inches rain. *Middlebury:* Highest peak flow on record for the Otter Creek at Middlebury USGS station, November 4, 1927. "Largest flood of record in the Middlebury area" *New Haven (New Haven Mills, M09):* Buildings around the Mill Dam upstream of the current bridge location were damaged or destroyed in the Flood of 1927.	USGS, 1990 USGS, 2003 Dufresne-Henry, 1984 Farnsworth, 1984

			<u>*Bristol (M13):*</u> Frary mill (east of Bristol Village – M15) Drake & Smith Company (M14) Fred Hammond farm (current location of A. Johnson lumber mill) – M12, M13 Town report notes labor and expenses for repairs to small bridges, culverts, and road wash-outs associated with Rocky Dale Bridge No. 2, and the Eastman Brook Bridge and approaches. <u>*Lincoln*</u> (West Lincoln, M17): Band stand along low river terrace below the village washed away. (South Lincoln, M??): Poland bridge destroyed. (Center, M19) "Burnham Hall was surrounded by water right up to the window sills on the ground floor, and more than a foot deep inside."	Estes, et al, 1959 Outlook Club, 1980 Brown, 1980 Bristol Town Report, 1927 Reed, 1980
1936, March 11 - 21		√	Two flood events hit southern and northern Vermont primarily: rain and snowmelt caused the first flood (March 11); intense rains falling on saturated ground caused the 2nd event (March 16). Peak annual flood value (second highest on record) for Otter Creek at Middlebury was recorded on March 21.	USGS, 1990 USGS, 2004
1938, Sept. 12 to 21	√	√	Large quantities of rainfall followed by a hurricane caused flooding in the central and southern portions of Vermont Ninth highest peak annual flow on record for Otter Creek at Middlebury was recorded on September 25. <u>*Bristol / Lincoln (M14, M15, M16, M17, M18, M19)*</u> *(M12/M13)* A. Johnson lumber mill damaged extensively. Town report notes labor/expenses related to "channeling river at Johnson's Mill" including use of a power shovel.	USGS, 1990 USGS, 2003 Estes, et al, 1959 Bristol Town Report, 1938 Charles Paine film, 1938

			(M14) Extensive mass failure of the bank below West Street, resulting in one garage falling into the river. A hemlock log retaining wall was built to stabilize the bank from Bristol Manufacturing Company (near the South Street Bridge) for approximately ¼ mile downstream. Stone wall was laid by the highway department downstream of the hemlock wall to secure the highway (South Street). Town report notes labor / expenses for "cribbing New Haven river bank", including use of power shovel.	Bristol Town Report, 1938 Charles Paine film, 1938 Addison Independent, 7 Oct 1938
			(M14) Coffin Dam just upstream of South Street bridge washed out (M14)	Addison Independent,
			(M16-M19) Bristol / Lincoln Road completely washed out; traffic re-routed for several weeks.	Addison Independent, 7 Oct 1938
			(T3 & T2) Drakes Woods (Appalachian Gap Rd) and Bristol Notch Rd washouts. *(M14)* Cold Spring Bridge (now Hewitt Road) destroyed along with several smaller bridges.	Estes, et al, 1959
			<u>Bristol (T3.03)</u> Town report notes labor and expenses related to Drake Woods flood repairs, including use of a power shovel.	Bristol Town Report, 1938
			<u>Lincoln</u> *(M19)* Iron bridge at Lincoln Center across from General Store destroyed. *(M19)* Burnham Hall inundated by debris and sediment up to two-feet thick. Windows and doors destroyed by flood debris. Book collections of the Ladies' Aid Library on the ground floor were destroyed. Poland and Lathrop bridges swept away.	Reed, 1980
			<u>Lincoln (West Lincoln)</u> *(M17)* Road approaches to the York Hill Road bridge were washed away.	
			<u>New Haven</u> Expenses recorded in 1938 town report refer to Sept. Flood on New Haven River, restoring road and rocking stream bank by Halpin residence (near Muddy Branch confluence with New Haven)	New Haven town report, 1938

1958, April 25		√	Seventh highest peak flow on record for the Otter Creek at Middlebury USGS station. Flood Insurance Study for New Haven cites flood damage for 1958. No special mention of flood damage in town reports.	USGS, 2003 Anderson-Nichols, 1986
1960, April 7		√	Fourth highest peak flow on record for the Otter Creek at Middlebury USGS station. Flood Insurance Study for New Haven cites flood damage for 1960. No special mention of flood damage in town reports.	USGS, 2003 Anderson-Nichols, 1986
1976, August 9 - 10	√	√	Statewide flooding related to Hurricane Belle <u>Lincoln</u> Road approaches to the York Hill Road bridge washed away (West Lincoln, M17). Portions of the Bristol / Lincoln Road were washed out. (M16, M17, M18, M19) River Haven store and camp site washed out (M17) Burnham Hall inundated by water up to one foot high in the ground floor (M19). <u>Bristol</u> Some homes damaged in Palmer's Mobile Home Park along Route 116 at the south end of Bristol Flats (M10). Notch Road closed due to wash outs. (T2) Area at the foot of Mill Hill (South Street) flooded (M14)	USGS, 1990 Reed, 1980 Addison Independent, 12 August 1976 Addison Independent, 12 August 1976
1989, August 4 - 5	√		<u>Lincoln:</u> More than 6 inches of rain fell in Ripton. Similar flooding was reported in Lincoln, with high waters inundating Burnham Hall again. Damage to roads, including Bristol Notch Road, Ripton Road, French Settlement Road, Natural Turnpike Rd, Masterson Road and Town Road #1.	 Ripton Town Report, 1989 Lincoln Town Report, 1989
1998, late June and early July	√	√	This Summer storm event followed an exceptionally wet Spring and caused extensive damage in central Vermont particularly in upland towns of Addison and Washington Counties. "The most heavily damaged areas received up to 6 inches of rain over approximately six hours."	VTDEC, 1999, App. 8

			<u>_New Haven:_</u> Large washout occurred at the Smiley's along River Road (M08). Also, expenses related to the River Road project along New Haven including the Old Nash Farm, the cemetery, and the Mills. (M09) Flood waters jumped the bank and inundated the cemetery along River Road. Streambank and washed out a portion of River Road. (M04) Old Nash Farm and river road crossing was inundated and the road temporarily closed.	New Haven Town Report, 1998
			<u>_Lincoln_</u>: Town report notes 103 culverts replaced due to the Flood of 1998. Also substantial damage to several bridges including the South Lincoln Road bridge, Masterson Road bridge, Garland Bridge, and French Settlement Road bridge.	Lincoln Town Report, 1998
			Bank erosion and mass failures associated with the 1998 flood along a portion of the Downingsville Road – road subsequently realigned away from the Beaver Meadow Brook in 1998-2000.	Lincoln Town Report, 1999
			_(M25, M24, M23)_ Flooding at junction of French Settlement Road and South Lincoln Rd. Portions of South Lincoln Road washed out.	Jimmo, 1998
			_(M21, M22)_ Flooding at junction of Cota Brook and New Haven main stem eroded streambanks, washed out driveways and inundated residential properties.	Tucker, S. pictures, 27, 30 June 1998
			_(M19)_ Burnham Hall inundated with floodwaters, library collection destroyed. _(M19, M18, M17)_ Bristol / Lincoln Road washed out in several places. _(M17)_ Approaches to West Lincoln Bridge washed out.	Jimmo, 1998
			<u>_Bristol:_</u> _(M16, M17)_ Bristol / Lincoln Road washed out in several places. _(M15)_ Twin Bridges washed out and sections of Route 116/17, isolating several Rocky Dale families and businesses. _(M14)_ South Street bridge approaches washed out, foundation of home downstream along left bank undermined. _(M14)_ Streambanks on Claire Lathrop Mill property washed out. _(M14)_ Hewitt Road bridge outflanked by flood waters when debris jam of lumber from Claire Lathrop Mill and flood debris dammed the flood waters behind the bridge temporarily _(M11)_ Streambank properties washed out and subsequently bought out by FEMA. _(M10)_ Rt 116 bridge inundated by flood waters. Homes at the Palmer's Court Mobile Home Park were damaged or destroyed and residents stranded when the	Underwood, K. pictures, 27 June 1998

			"wall of water" from the Hewitt Road bridge debris jam let go. The Park was subsequently bought out by FEMA and residents relocated. Flood waters inundated croplands downstream of the Park and overtopped portions of Route 116 and the Cove Road. *(T3.03, T3.04, T3.05)* Appalachian Gap Road was washed out in several places. Flood debris and sediment filled the channel and overbank areas inundating residential properties at the alluvial fan area near the junction of Route 116 and 17.	
2000, July	√		Lincoln: A concentration of storm cells over the Green Mountains caused locally high rainfalls over Ripton and Lincoln. The "unrelenting rainfall prompted the New Haven River to crest approximately 8 feet in a matter of hours, sending water gushing into the South Lincoln Road. The surging water ripped away portions of the gravel road…" isolating one family and causing South Lincoln traffic to be re-routed through Ripton. Sand bags placed along the Burnham Hall foundation prevented flood waters from inundating the building.	Ripton Town Report, 2000 Addison Independent, 20 July 2000 Hanson, 2003 Addison Independent, 20 July 2000
2004, August 28-29	√	√	28 August, 5:30 pm to 7:30 pm (approx.): A concentration of storm cells over New Haven and Bristol resulted in well over 4 inches rain within 2 hours. New Haven water levels rose rapidly in Bristol Village. The "flood wave" progressed downstream to the Brooksville USGS gage station by approximately 8 pm, and discharge peaked at approximately Midnight; 29 August: Late day thunderstorms caused a second peaking of water levels in the New Haven, lower in elevation than stages experienced the day before. Bristol: 28 August: Numerous road and driveway washouts; a cave in along West Street behind the Merchants Bank (above M14); mudslides along Mountain Street at the base of Hogback Mountain, Route 116 east of the village (M15), and the Notch Road downstream of Hewitt Road Bridge (M13). Portions of Town and State Roads were shut down due to water over the road and wash outs, including South Street (Mill Hill) (M15/ M14), Route 116 by Rockydale (M15), and Route 116 South near former Palmers Court (now Sycamore Park) (M11/M10).	Paine, 2004, pers.communication; Underwood, personal observations and scanner reports; USGS, http://waterdata.usgs.gov/vt/nwis Rutland Herald, 30 August 2004 Underwood, personal observations and scanner reports;

			<u>*New Haven:*</u> 28 August: Numerous upland road and driveway washouts due to intensity and magnitude of stormwater runoff and undersized culverts. Damage particularly along East Street, Route 17, Lime Kiln, Sumner Road, Plank Road, Town Hill Road, caused roads to be closed on 28 and 29 August. Portions of Route 17, River Road, and the Route 7 & 17 junction closed due to inundation of flood waters. <u>*Lincoln:*</u> 29 August: Late day thunderstorms following storms the previous day, in an otherwise wetter-than-normal Summer, caused waters to rise quickly in South Lincoln. One residence was evacuated.	Underwood, personal observations and scanner reports; Local scanner reports

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Photo 1. Smith property, Cota Brook crossing on South Lincoln Rd, just upstream from confluence with main stem (M21), 1998 flood.
Susan Tucker collection.

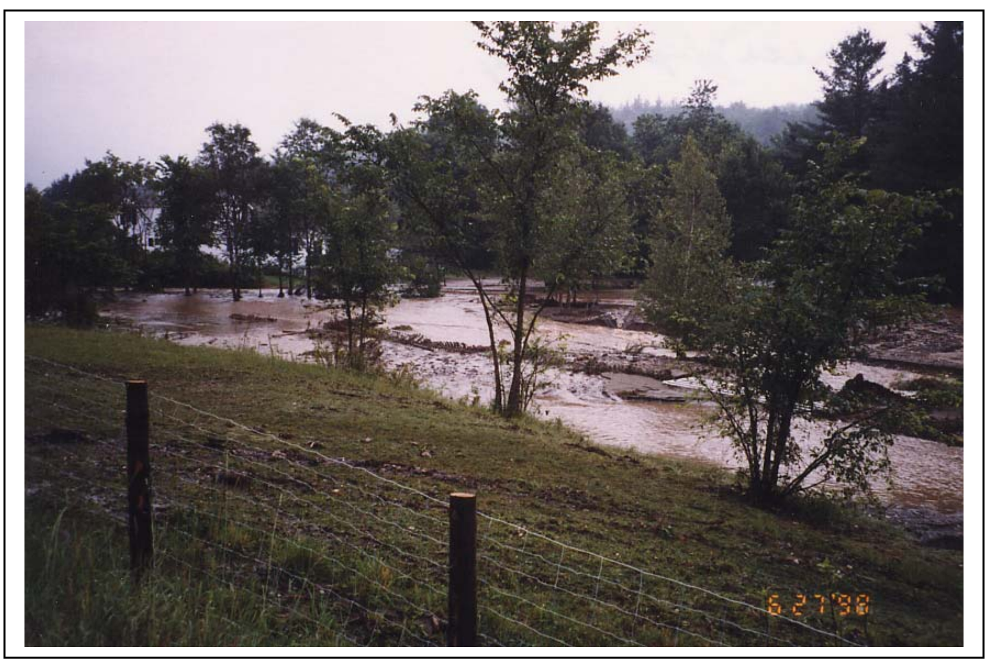

Photo 2. Smith Property inundated by Cota Brook and New Haven main stem (M21), 1998 flood. *Susan Tucker collection*.

..

Photo 3. (M17) York Hill Road Bridge, approaches washed out, 1998 flood. View from west.
Susan Tucker collection.

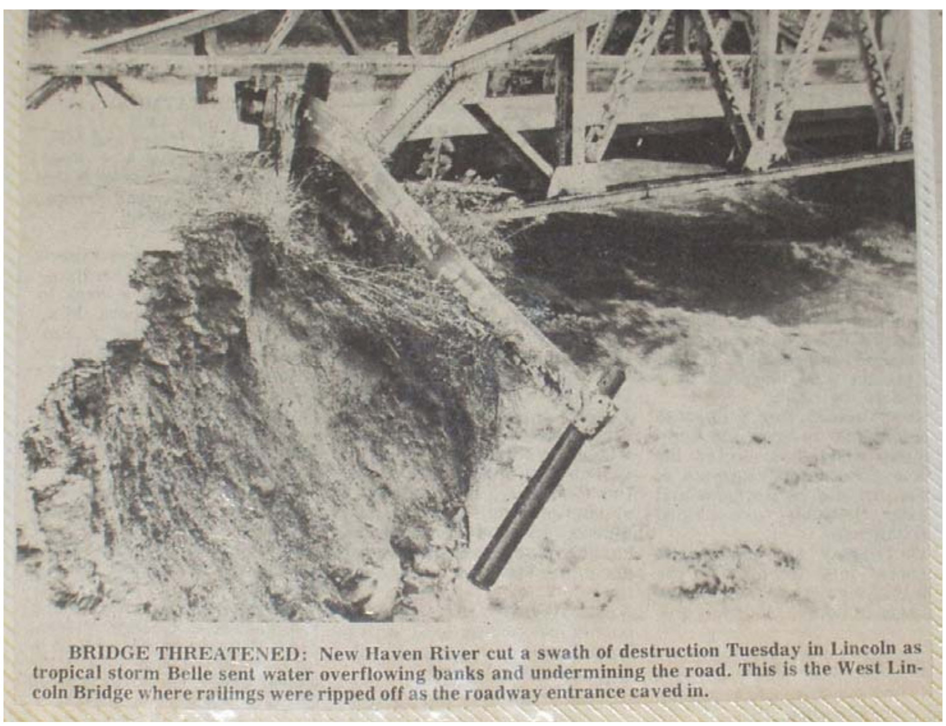

Photo 4. (M17) York Hill Road Bridge, approaches washed out in 1976 flood. View from west.
Addison Independent, 1976.

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Photo 5. (M17) York Hill Road Bridge, approaches washed out in 1976 flood. View from east.
Addison Independent, 1976.

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Photo 6. Bristol / Lincoln Road washout, 1998 flood. Just downstream of Bartlett's Falls.
Susan Tucker collection.

Photo 7. Bristol / Lincoln Road washout, 1938 flood. Just downstream of West Lincoln (M17)?
Lincoln Historical Society collection

Photo 8. (M15) Route 116 bridge (western of the twin bridges), washed out in 1998 flood.
K. Underwood collection.

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Photo 9. (M15) Route 116 washout, 1998 flood.
K. Underwood collection.

Photo 10. (M14) South Street Bridge approaches eroded, 1998 flood.
K. Underwood collection.

Photo 11. Streambank erosion and undermining of residence, immediately downstream of South Street Bridge, 1998 flood. *K. Underwood collection*.

Photo 12. Hewitt Road Bridge outflanked and Notch Road washed out, 1998 flood. *K. Underwood collection*.

Photo 13. (M11) Draper residence along 116 inundated by flood waters, 1998.
K. Underwood collection.

Photo 14. (M09) 1998 flood waters a few hours after peak, 27 June, Munger Street Bridge crossing, New Haven Mills. *K. Underwood collection.*

APPENDIX D

Phase 2 Stream Geomorphic Assessment Results

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** Reach # **M16** Segment: **Reach**

Segment Length (ft): **5429** Date: **7/5/2004** Rain: **Yes** Observers: **KU, EE** Organization: **SMRC**

Town: **Bristol** Location: **Entire reach from Rt. 116 bridge to former campground at Town of Bristol lands - exclu**

Step 1 Valley and Floodplain:

1.1 Water Zone **Transfer**
1.2 Alluvial Fan **No**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) **0** Right (ft) **0**

Roads
Length: Left (ft) **0** Right (ft) **5429**

Railroads
Length: Left (ft) **0** Right (ft) **0**

Improved Paths
Length: Left (ft) **480** Right (ft) **0**

Development
Length: Left (ft) **400** Right (ft) **380**

1.4 Adjacent Side Slope

Left Slope **moderate** Texture **Boulder**
Cont. w/bank: **Sometimes**
W/in 1x Bkf: **Sometimes**

Right Slope **steep** Texture **Boulder**
Cont. w/bank **Sometimes**
W/in 1x Bkf: **Sometimes**

1.5 Confinemen **Narrowly Confined**
ValleyWidth: **125** Rock Gorge ☑

1.6 Grade Controls

Waterfall **M** Photo: ☑
Total Height (ft)
FMB (Phase 2 B/C survey)

Ledge: **M** Photo: ☑
Total Height (ft)
FMB (Phase 2 B/C survey)

Dam: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Weir: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft) **68.7**
2.2 Max Depth (ft) **4.2**
2.3 Mean Depth (ft) **2.6**
2.4 Flood Prone Width (ft) **82.0**
2.5 Low Bank Height (ft) **13.3**
2.6 Ratio W/D **26.4**
2.7 Entrenchment **1.2**
2.8 Incision Ratio **3.17**
2.9 Sinuosity **Low**
2.10 Riffle/Steps
complete: **Yes** partial: diagonal:
continuous none **0**

2.11 Riffle/Steps Spacing (ft)
Riffle/Step Spacing NA ☐

2.12 Bed Substrate Composition :

% Bedrock **0** % Boulder **40**
% Cobble **18** %CourseGravel: **22**
% Gravel **10** % Sand **10**
% Detritus **5** # LWD **19**
Silt/Clay **No**

2.13 Largest Particle on:

Bed **1400** Bar **1200** Units **Millimeter**

2.14 Stream Type **B 3 Step-Pool**

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:

Typical Bank Slope **Moderate**
Lower Bank Texture **Boulder/Cob**
Consistency: **Non-cohesiv**
Upper Bank Textue **Boulder/Cob**
Consistency: **Non-cohesiv**

Left Bank
Erosion Length (ft) **500** Height (ft) **2**
Revetment Type **Rip-rap** Length (ft) **200**
Dom. Veg. Type **Coniferous**
SubDom. Veg. Type
Left Bank Canopy **76-100%**

Right Bank
Erosion Length (ft) **500** Height (ft) **2**
Revetment Type **Rip-rap** Length (ft) **2190**
Dom. Veg. Type **Herbaceous**
SubDom Veg. Type:
Right Bank Canopy **1-25%**

Channel Canopy Cover: **Open**

3.2 Buffer:

Left Buffer: Dom.Width (ft) **>100**
SubDom Width:(ft)
Dom. Veg. Type **Mixed Trees**
SubDom Veg. Type:

Right Buffer Dom.Width (ft) **5-25**
SubDom Width:(ft)
Dom. Veg. Type **Herbaceous**
SubDom Veg Type

3.3 Riparian Corridor

Left Dom **Forest** SubDo
Righ Dom **Forest** SubDo

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps **Some**
4.2 Adjacent Wetlands **None**
4.3 Flow Status **Moderate**
4.4 # Current Debris Jams **0**
4.5 Upstream Impoundment **None**
4.6 # Stormwater Inputs **9**
4.7 Flow Regulations **None**
4.8 # Channel Constrictions **4**
None: **0** Culvert: Bridge: **Yes**
Abutments Bedrock: **Yes** Other **Yes**
Problems: DepAbove: DepBelow: **Yes**
Scour Below: Angle: None: **0**
Flood Prone Constriction: **Yes**
Bridge Survey Phase1 Phase 2 None ☐
BeaverDams: **0** Length Affected (ft):

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid **Yes**
Point **Yes** Side: **Yes** Diagonal
Delta Island None: **0**

5.2 Neck or Chute Cut Offs
Flood Chute: **Yes** Neck Cut-Off: **No**
Channel Avulsions **No** Braiding **Yes**

5.3 Steep Riffles or Head Cuts:
Steep Riffle: **Yes** Head Cut: **No**

5.6 Stream Ford/Animal Crossing **No**

5.5 Channel Alterations:
Dredging **Yes** Straightening **Yes**
Bar Scalping Gravel Mining:
None **0**

Comments: **Downstream 750 feet of reach was identified as a subreach with different reference (and assessed) stream type of D3-braided.**

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River**

Reach # M16

Segment: Reach

Rapid Habitat Assessment Field Data

Gradient Type:	**High**

8.1 Epifaunal Substrate/Available Cover		**18**
8.2 Pool Substrate Character (low)/ Embededness (high)		**13**
8.3 Pool Variability (low) / Velocity Depth Regime (high)		**18**
8.4 Sediment Deposition		**18**
8.5 Channel Flow Status		**13**
8.6 Channel Alterations		**10**
8.7 Morphological Diversity		**18**
8.8 Bank Stability	Left	**8**
	Right	**6**
8.9 Vegetative Protection	Left	**10**
	Right	**3**
8.10 Riparian Vegetative Zone Width	Left	**10**
	Right	**1**
	TOTAL:	**0.73**
8.11 Habitat Condition:		**2-Good**

Rapid Geomorphic Assessment Field Data

Confinement Type:	**Confined**

			STD	Historic Adjustment
9.1 Deegre of Channel Degradation	**13**	**Good**	☐	☑
9.2 Deegre of Channel Aggradation	**16**	**Reference**	☐	☐
9.3 Over Widened Channel	**16**	**Reference**		☐
9.4 Change in Plaform	**13**	**Good**		☐
Adjustment Process(s)				

9.5 Stage of Channel Evolution	**I**
TOTAL:	**0.73**
9.5 Geomorphic Condition:	**2-Good**

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** | **Reach #** **M16** | **Segment:** **A**

Segment Length (ft): **750** | Date: **7/5/2004** | Rain: | Observers: **KU, EE** | Organization: **SMRC**

Town: **Bristol** | Location: **Subreach of M16 at downstream end**

Step 1 Valley and Floodplain:

1.1 Water Zone **Response**

1.2 Alluvial Fan **Yes**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) Right (ft)

Roads
Length: Left (ft) Right (ft)

Railroads
Length: Left (ft) Right (ft)

Improved Paths
Length: Left (ft) Right (ft)

Development
Length: Left (ft) Right (ft)

1.4 Adjacent Side Slope

Left Slope Texture
Cont. w/bank:
W/in 1x Bkf:

Right Slope Texture
Cont. w/bank
W/in 1x Bkf:

1.5 Confinemen **Semi-Confined**
ValleyWidth: **200** Rock Gorge ☐

1.6 Grade Controls

Waterfall Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Ledge: Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Dam: Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Weir: Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft)

2.2 Max Depth (ft)

2.3 Mean Depth (ft)

2.4 Flood Prone Width (ft)

2.5 Low Bank Height (ft)

2.6 Ratio W/D

2.7 Entrenchment

2.8 Incision Ratio

2.9 Sinuosity

2.10 Riffle/Steps
complete: partial: diagonal:
continuous none **0**

2.11 Riffle/Steps Spacing (ft)
Riffle/Step Spacing NA ☐

2.12 Bed Substrate Composition :
% Bedrock % Boulder
% Cobble %CourseGravel:
% Gravel % Sand
% Detritus # LWD
Silt/Clay

2.13 Largest Particle on:
Bed Bar Units

2.14 Stream Type **D 3 c Braided**

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:
Typical Bank Slope
Lower Bank Texture
Consistency:
Upper Bank Textue
Consistency:

Left Bank
Erosion Length (ft) Height (ft)
Revetment Type Length (ft)
Dom. Veg. Type
SubDom. Veg. Type
Left Bank Canopy

Right Bank
Erosion Length (ft) Height (ft)
Revetment Type Length (ft)
Dom. Veg. Type
SubDom Veg. Type:
Right Bank Canopy

Channel Canopy Cover:

3.2 Buffer:
Left Buffer: Dom.Width (ft)
SubDom Width:(ft)
Dom. Veg. Type
SubDom Veg. Type:

Right Buffer Dom.Width (ft)
SubDom Width:(ft)
Dom. Veg. Type
SubDom Veg Type

3.3 Riparian Corridor
Left Dom SubDo
Righ Dom SubDo

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps
4.2 Adjacent Wetlands
4.3 Flow Status
4.4 # Current Debris Jams
4.5 Upstream Impoundment
4.6 # Stormwater Inputs
4.7 Flow Regulations
4.8 # Channel Constrictions
None: **0** Culvert: Bridge:
Abutments Bedrock: Other
Problems: DepAbove: DepBelow:
Scour Below: Angle: None: **0**
Flood Prone Constriction:
Bridge Survey Phase1 Phase 2 None ☐
BeaverDams: Length Affected (ft):

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid
Point Side: Diagonal
Delta Island None: **0**

5.2 Neck or Chute Cut Offs
Flood Chute: Neck Cut-Off:
Channel Avulsions Braiding

5.3 Steep Riffles or Head Cuts:
Steep Riffle: Head Cut:

5.6 Stream Ford/Animal Crossing

5.5 Channel Alterations:
Dredging Straightening
Bar Scalping Gravel Mining:
None **0**

Comments: **This is a subreach of reach M16 that has a different reference stream type, i.e., D3-braided. Ideally, this subreach should have been delineated as a separate reach during the Phase 1.**

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River**

Reach # M16

Segment: A

Rapid Habitat Assessment Field Data

Gradient Type:

8.1 Epifaunal Substrate/Available Cover		
8.2 Pool Substrate Character (low)/ Embededness (high)		
8.3 Pool Variability (low) / Velocity Depth Regime (high)		
8.4 Sediment Deposition		
8.5 Channel Flow Status		
8.6 Channel Alterations		
8.7 Morphological Diversity		
8.8 Bank Stability	Left	
	Right	
8.9 Vegetative Protection	Left	
	Right	
8.10 Riparian Vegetative Zone Width	Left	
	Right	
	TOTAL:	**0.00**
8.11 Habitat Condition:		**4-Poor**

Rapid Geomorphic Assessment Field Data

Confinement Type:

			STD	Historic Adjustment
9.1 Deegre of Channel Degradation			☐	☐
9.2 Deegre of Channel Aggradation			☐	☐
9.3 Over Widened Channel				☐
9.4 Change in Plaform				☐

Adjustment Process(s)

9.5 Stage of Channel Evolution	
TOTAL:	**0.00**
9.5 Geomorphic Condition:	**4-Poor**

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** Reach # **M03** Segment: **Reach**

Segment Length (ft): **2997** Date: **8/24/2004** Rain: **Yes** Observers: **KU, PU** Organization: **SMRC**

Town: **New Haven** Location: **Beginning 2000 feet west of and ending at River Rd brige**

Step 1 Valley and Floodplain:

1.1 Water Zone **Response**

1.2 Alluvial Fan **No**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) Right (ft)

Roads
Length: Left (ft) **1300** Right (ft) **575**

Railroads
Length: Left (ft) Right (ft)

Improved Paths
Length: Left (ft) Right (ft) **650**

Development
Length: Left (ft) Right (ft) **860**

1.4 Adjacent Side Slope

Left Slope **shallow** Texture **Sand**
Cont. w/bank: **Always**
W/in 1x Bkf: **Always**

Right Slope **shallow** Texture **Sand**
Cont. w/bank **Sometimes**
W/in 1x Bkf: **Sometimes**

1.5 Confinemen **Broad**
ValleyWidth: Rock Gorge ☐

1.6 Grade Controls

Waterfall **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Ledge: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Dam: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Weir: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft) **137.0**
2.2 Max Depth (ft) **3.6**
2.3 Mean Depth (ft) **2.2**
2.4 Flood Prone Width (ft) **250.0**
2.5 Low Bank Height (ft) **5.0**
2.6 Ratio W/D **62.3**
2.7 Entrenchment **1.8**
2.8 Incision Ratio **1.39**
2.9 Sinuosity **Moderate**
2.10 Riffle/Steps
complete: **Yes** partial: **No** diagonal: **Yes**
continuous **No** none **0**

2.11 Riffle/Steps Spacing (ft) **600**
Riffle/Step Spacing NA ☐

2.12 Bed Substrate Composition :
% Bedrock **0** % Boulder **0**
% Cobble **3** %CourseGravel: **94**
% Gravel % Sand **4**
% Detritus **5** # LWD **50**
Silt/Clay **No**

2.13 Largest Particle on:
Bed Bar **50** Units **Millimeter**

2.14 Stream Type **C** **4** **Riffle-Pool**

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:
Typical Bank Slope **Steep**
Lower Bank Texture **Gravel**
Consistency: **Non-cohesiv**
Upper Bank Textue **Sand**
Consistency: **Non-cohesiv**

Left Bank
Erosion Length (ft) **500** Height (ft) **6**
Revetment Type **Rip-rap** Length (ft) **700**
Dom. Veg. Type **Deciduous**
SubDom. Veg. Type
Left Bank Canopy **51-75%**

Right Bank
Erosion Length (ft) **125** Height (ft) **7**
Revetment Type **Rip-rap** Length (ft) **950**
Dom. Veg. Type **Herbaceous**
SubDom Veg. Type:
Right Bank Canopy **26-50%**

Channel Canopy Cover: **Open**

3.2 Buffer:
Left Buffer: Dom.Width (ft) **>100**
SubDom Width:(ft) **51-100 ft**
Dom. Veg. Type **Deciduous**
SubDom Veg. Type:

Right Buffer Dom.Width (ft) **5-25**
SubDom Width:(ft) **>100 ft**
Dom. Veg. Type **Shrub-sapling**
SubDom Veg Type

3.3 Riparian Corridor
Left Dom **Crop** SubDo
Righ Dom **Crop** SubDo **Residential**

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps **None**
4.2 Adjacent Wetlands **Some**
4.3 Flow Status **Moderate**
4.4 # Current Debris Jams **0**
4.5 Upstream Impoundment **None**
4.6 # Stormwater Inputs **0**
4.7 Flow Regulations **None**
4.8 # Channel Constrictions **1**
None: **0** Culvert: **No** Bridge: **Yes**
Abutments **No** Bedrock: **No** Other **No**
Problems: DepAbove: **No** DepBelow: **No**
Scour Below: **No** Angle: **Yes** None: **0**
Flood Prone Constriction: **Yes**
Bridge Survey Phase1 Phase 2 None ☐
BeaverDams: **0** Length Affected (ft):

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid **Yes**
Point **Yes** Side: **Yes** Diagonal **Yes**
Delta **No** Island **No** None: **0**

5.2 Neck or Chute Cut Offs
Flood Chute: **Yes** Neck Cut-Off: **No**
Channel Avulsions **No** Braiding **No**

5.3 Steep Riffles or Head Cuts:
Steep Riffle: **Yes** Head Cut: **No**

5.6 Stream Ford/Animal Crossing **No**

5.5 Channel Alterations:
Dredging Straightening
Bar Scalping Gravel Mining:
None **-1**

Comments:

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River**

Reach # M03

Segment: Reach

Rapid Habitat Assessment Field Data

Gradient Type:	**High**

8.1 Epifaunal Substrate/Available Cover		**13**
8.2 Pool Substrate Character (low)/ Embededness (high)		**8**
8.3 Pool Variability (low) / Velocity Depth Regime (high)		**18**
8.4 Sediment Deposition		**8**
8.5 Channel Flow Status		**15**
8.6 Channel Alterations		**13**
8.7 Morphological Diversity		**18**
8.8 Bank Stability	Left	**7**
	Right	**8**
8.9 Vegetative Protection	Left	**4**
	Right	**5**
8.10 Riparian Vegetative Zone Width	Left	**8**
	Right	**4**
	TOTAL:	**0.65**
8.11 Habitat Condition:		**3-Fair**

Rapid Geomorphic Assessment Field Data

Confinement Type:	**Unconfined**

			STD	Historic Adjustment
9.1 Deegre of Channel Degradation	**10**	**Fair**	☐	☑
9.2 Deegre of Channel Aggradation	**8**	**Fair**	☐	☐
9.3 Over Widened Channel	**5**	**Poor**		☐
9.4 Change in Plaform	**3**	**Poor**		☐

Adjustment Process(s)	planform adjustment / widening

9.5 Stage of Channel Evolution	**III**
TOTAL:	**0.33**
9.5 Geomorphic Condition:	**4-Poor**

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** Reach # **M04** Segment: **Reach**

Segment Length (ft): **4300** Date: **8/24/2004** Rain: **Yes** Observers: **KU, PU, EE** Organization: **SMRC**

Town: **New Haven** Location: **from River Rd bridge crossing NE along River Rd**

Step 1 Valley and Floodplain:

1.1 Water Zone **Response**

1.2 Alluvial Fan **No**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) Right (ft) **300**

Roads
Length: Left (ft) Right (ft) **650**

Railroads
Length: Left (ft) Right (ft)

Improved Paths
Length: Left (ft) Right (ft) **250**

Development
Length: Left (ft) Right (ft) **700**

1.4 Adjacent Side Slope

Left Slope **shallow** Texture **Sand**
Cont. w/bank: **Always**
W/in 1x Bkf: **Always**

Right Slope **shallow** Texture **Sand**
Cont. w/bank **Always**
W/in 1x Bkf: **Always**

1.5 Confinemen **Very Broad**
ValleyWidth: Rock Gorge ☐

1.6 Grade Controls

Waterfall **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Ledge: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Dam: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Weir: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft) **76.8**
2.2 Max Depth (ft) **3.8**
2.3 Mean Depth (ft) **3.4**
2.4 Flood Prone Width (ft) **182.0**
2.5 Low Bank Height (ft) **6.3**
2.6 Ratio W/D **22.6**
2.7 Entrenchment **2.4**
2.8 Incision Ratio **1.66**
2.9 Sinuosity **Moderate**
2.10 Riffle/Steps
complete: **Yes** partial: **No** diagonal: **Yes**
continuous **No** none **0**

2.11 Riffle/Steps Spacing (ft) **450**
Riffle/Step Spacing NA ☐

2.12 Bed Substrate Composition :

% Bedrock **0** % Boulder **2**
% Cobble **7** %CourseGravel: **64**
% Gravel **12** % Sand **9**
% Detritus **5** # LWD **39**
Silt/Clay **Yes**

2.13 Largest Particle on:
Bed **60** Bar **60** Units **Millimeter**

2.14 Stream Type **C** **4** **Riffle-Pool**

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:

Typical Bank Slope **Steep**
Lower Bank Texture **Gravel**
Consistency: **Non-cohesiv**
Upper Bank Textue **Sand**
Consistency: **Cohesive**

Left Bank
Erosion Length (ft) **1280** Height (ft) **7**
Revetment Type **Rip-rap** Length (ft) **1275**
Dom. Veg. Type **Deciduous**
SubDom. Veg. Type **Herbaceous**
Left Bank Canopy **26-50%**

Right Bank
Erosion Length (ft) **1310** Height (ft) **7**
Revetment Type **Rip-rap** Length (ft) **410**
Dom. Veg. Type **Deciduous**
SubDom Veg. Type:
Right Bank Canopy **76-100%**

Channel Canopy Cover: **Open**

3.2 Buffer:

Left Buffer: Dom.Width (ft) **5-25**
SubDom Width:(ft) **51-100 ft**
Dom. Veg. Type **Deciduous**
SubDom Veg. Type:

Right Buffer Dom.Width (ft) **>100**
SubDom Width:(ft) **51-100 ft**
Dom. Veg. Type **Deciduous**
SubDom Veg Type

3.3 Riparian Corridor

Left Dom **Crop** SubDo
Righ Dom **Forest** SubDo

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps **None**
4.2 Adjacent Wetlands **Some**
4.3 Flow Status **Moderate**
4.4 # Current Debris Jams **0**
4.5 Upstream Impoundment **None**
4.6 # Stormwater Inputs **0**
4.7 Flow Regulations **None**
4.8 # Channel Constrictions **0**
None: **-1** Culvert: Bridge:
Abutments Bedrock: Other
Problems: DepAbove: DepBelow:
Scour Below: Angle: None: **-1**
Flood Prone Constriction:
Bridge Survey Phase1 Phase 2 None ☐
BeaverDams: **0** Length Affected (ft):

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid **Yes**
Point **Yes** Side: **Yes** Diagonal **Yes**
Delta **No** Island **No** None: **0**

5.2 Neck or Chute Cut Offs
Flood Chute: **Yes** Neck Cut-Off: **No**
Channel Avulsions **Yes** Braiding **No**

5.3 Steep Riffles or Head Cuts:
Steep Riffle: **Yes** Head Cut: **No**

5.6 Stream Ford/Animal Crossing **No**

5.5 Channel Alterations:
Dredging Straightening **Yes**
Bar Scalping Gravel Mining:
None **0**

Comments:

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** Reach # **M04** Segment: **Reach**

Rapid Habitat Assessment Field Data

Gradient Type: **High**

8.1 Epifaunal Substrate/Available Cover			6
8.2 Pool Substrate Character (low)/ Embededness (high)			8
8.3 Pool Variability (low) / Velocity Depth Regime (high)			16
8.4 Sediment Deposition			8
8.5 Channel Flow Status			18
8.6 Channel Alterations			10
8.7 Morphological Diversity			18
8.8 Bank Stability		Left	4
		Right	5
8.9 Vegetative Protection		Left	4
		Right	4
8.10 Riparian Vegetative Zone Width		Left	4
		Right	8
		TOTAL:	0.57
8.11 Habitat Condition:			3-Fair

Rapid Geomorphic Assessment Field Data

Confinement Type:

			STD	Historic Adjustment
9.1 Deegre of Channel Degradation	10	Fair	☐	☑
9.2 Deegre of Channel Aggradation	10	Fair	☐	☐
9.3 Over Widened Channel	10	Fair		☐
9.4 Change in Plaform	5	Poor		☐

Adjustment Process(s): planform / widening

9.5 Stage of Channel Evolution	III
TOTAL:	0.44
9.5 Geomorphic Condition:	3-Fair

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** | Reach # **M05** | Segment: **Reach**

Segment Length (ft): **2425** | Date: **8/25/2004** | Rain: **Yes** | Observers: **KU, EE** | Organization: **SMRC**

Town: **New Haven** | Location: **along River Rd to point approx 700 ft SE of intersection w/Sargent Cross Rd**

Step 1 Valley and Floodplain:

1.1 Water Zone **Response**

1.2 Alluvial Fan **No**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) Right (ft)

Roads
Length: Left (ft) Right (ft)

Railroads
Length: Left (ft) Right (ft)

Improved Paths
Length: Left (ft) Right (ft)

Development
Length: Left (ft) Right (ft)

1.4 Adjacent Side Slope

Left Slope **shallow** Texture **›t Evaluat**
Cont. w/bank: **Always**
W/in 1x Bkf: **Always**

Right Slope **shallow** Texture **›t Evaluat**
Cont. w/bank **Always**
W/in 1x Bkf: **Always**

1.5 Confinemen **Broad**
ValleyWidth: Rock Gorge ☐

1.6 Grade Controls

Waterfall **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Ledge: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Dam: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Weir: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft) **112.0**
2.2 Max Depth (ft) **4.4**
2.3 Mean Depth (ft) **3.2**
2.4 Flood Prone Width (ft) **306.0**
2.5 Low Bank Height (ft) **4.5**
2.6 Ratio W/D **35.0**
2.7 Entrenchment **2.7**
2.8 Incision Ratio **1.02**
2.9 Sinuosity **Low**
2.10 Riffle/Steps
complete: **Yes** partial: **No** diagonal: **Yes**
continuous **No** none **0**

2.11 Riffle/Steps Spacing (ft) **750**
Riffle/Step Spacing NA ☐

2.12 Bed Substrate Composition :

% Bedrock **0** % Boulder **2**
% Cobble **9** %CourseGravel: **63**
% Gravel **9** % Sand **12**
% Detritus **3** # LWD **15**
Silt/Clay **Yes**

2.13 Largest Particle on:
Bed **60** Bar **70** Units **Millimeter**

2.14 Stream Type **C** **4** **Riffle-Pool**

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:

Typical Bank Slope **Steep**
Lower Bank Texture **Gravel**
Consistency: **Non-cohesiv**
Upper Bank Textue **Sand**
Consistency: **Cohesive**

Left Bank
Erosion Length (ft) **500** Height (ft) **6**
Revetment Type **None** Length (ft)
Dom. Veg. Type **Deciduous**
SubDom. Veg. Type
Left Bank Canopy **76-100%**

Right Bank
Erosion Length (ft) **300** Height (ft) **6**
Revetment Type **Rip-rap** Length (ft) **290**
Dom. Veg. Type **Herbaceous**
SubDom Veg. Type:
Right Bank Canopy **51-75%**

Channel Canopy Cover: **Open**

3.2 Buffer:

Left Buffer: Dom.Width (ft) **>100**
SubDom Width:(ft)
Dom. Veg. Type **Mixed Trees**
SubDom Veg. Type:

Right Buffer Dom.Width (ft) **>100**
SubDom Width:(ft)
Dom. Veg. Type **Herbaceous**
SubDom Veg Type

3.3 Riparian Corridor
Left Dom **Forest** SubDo
Righ Dom **Crop** SubDo

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps **None**
4.2 Adjacent Wetlands **None**
4.3 Flow Status **Moderate**
4.4 # Current Debris Jams **0**
4.5 Upstream Impoundment **None**
4.6 # Stormwater Inputs **0**
4.7 Flow Regulations **None**
4.8 # Channel Constrictions **0**
None: **-1** Culvert: Bridge:
Abutments Bedrock: Other
Problems: DepAbove: DepBelow:
Scour Below: Angle: None: **-1**
Flood Prone Constriction:
Bridge Survey Phase1 Phase 2 None ☐
BeaverDams: **0** Length Affected (ft):

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid **Yes**
Point **Yes** Side: **Yes** Diagonal **Yes**
Delta **No** Island **No** None: **0**

5.2 Neck or Chute Cut Offs
Flood Chute: **No** Neck Cut-Off: **No**
Channel Avulsions **No** Braiding **No**

5.3 Steep Riffles or Head Cuts:
Steep Riffle: **No** Head Cut: **No**

5.6 Stream Ford/Animal Crossing **No**

5.5 Channel Alterations:
Dredging Straightening
Bar Scalping Gravel Mining:
None **-1**

Comments:

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** | Reach # **M05** | Segment: **Reach**

Rapid Habitat Assessment Field Data

Gradient Type: **High**

8.1 Epifaunal Substrate/Available Cover		18
8.2 Pool Substrate Character (low)/ Embededness (high)		8
8.3 Pool Variability (low) / Velocity Depth Regime (high)		13
8.4 Sediment Deposition		13
8.5 Channel Flow Status		15
8.6 Channel Alterations		13
8.7 Morphological Diversity		16
8.8 Bank Stability	Left	5
	Right	8
8.9 Vegetative Protection	Left	6
	Right	9
8.10 Riparian Vegetative Zone Width	Left	10
	Right	8
	TOTAL:	0.71
8.11 Habitat Condition:		**2-Good**

Rapid Geomorphic Assessment Field Data

Confinement Type: **Unconfined**

			STD	Historic Adjustment
9.1 Deegre of Channel Degradation	18	Reference	☐	☐
9.2 Deegre of Channel Aggradation	13	Good	☐	☐
9.3 Over Widened Channel	15	Good		☐
9.4 Change in Plaform	16	Reference		☐

Adjustment Process(s): Aggradation (minor)

9.5 Stage of Channel Evolution	I
TOTAL:	0.78
9.5 Geomorphic Condition:	**2-Good**

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** Reach # **M06** Segment: **Reach**

Segment Length (ft): **2590** Date: **8/9/2004** Rain: **Yes** Observers: **KU, EE** Organization: **SMRC**

Town: **New Haven** Location: **from point SE of jct of Sargent Cross Rd and River Rd paralleling south and east of Riv**

Step 1 Valley and Floodplain:

1.1 Water Zone **Response**
1.2 Alluvial Fan **No**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) **0** Right (ft) **0**

Roads
Length: Left (ft) **0** Right (ft) **1480**

Railroads
Length: Left (ft) **0** Right (ft) **0**

Improved Paths
Length: Left (ft) **0** Right (ft) **0**

Development
Length: Left (ft) **0** Right (ft) **0**

1.4 Adjacent Side Slope

Left Slope **shallow** Texture **t Evaluat**
Cont. w/bank: **Always**
W/in 1x Bkf: **Always**

Right Slope **moderate** Texture **t Evaluat**
Cont. w/bank **Sometimes**
W/in 1x Bkf: **Always**

1.5 Confinemen **Semi-Confined**
ValleyWidth: **300** Rock Gorge ☐

1.6 Grade Controls

Waterfall **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Ledge: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Dam: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Weir: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft) **103.0**
2.2 Max Depth (ft) **4.1**
2.3 Mean Depth (ft) **3.3**
2.4 Flood Prone Width (ft) **187.0**
2.5 Low Bank Height (ft) **5.6**
2.6 Ratio W/D **31.2**
2.7 Entrenchment **1.8**
2.8 Incision Ratio **1.37**
2.9 Sinuosity **Low**
2.10 Riffle/Steps
complete: **Yes** partial: diagonal: **Yes**
continuous none **0**

2.11 Riffle/Steps Spacing (ft) **400**
Riffle/Step Spacing NA ☐

2.12 Bed Substrate Composition :

% Bedrock **0** % Boulder **2**
% Cobble **9** %CourseGravel: **68**
% Gravel % Sand **20**
% Detritus **10** # LWD **25**
Silt/Clay **Yes**

2.13 Largest Particle on:
Bed Bar Units

2.14 Stream Type **F 4 Plane Bed**

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:

Typical Bank Slope **Steep**
Lower Bank Texture **Gravel**
Consistency: **Non-cohesiv**
Upper Bank Textue **Sand**
Consistency: **Non-cohesiv**

Left Bank
Erosion Length (ft) **240** Height (ft) **8**
Revetment Type **Rip-rap** Length (ft) **265**
Dom. Veg. Type **Herbaceous**
SubDom. Veg. Type
Left Bank Canopy **51-75%**

Right Bank
Erosion Length (ft) **290** Height (ft) **6**
Revetment Type **Rip-rap** Length (ft) **0**
Dom. Veg. Type **Herbaceous**
SubDom Veg. Type:
Right Bank Canopy **76-100%**

Channel Canopy Cover: **Open**

3.2 Buffer:

Left Buffer: Dom.Width (ft) **5-25**
SubDom Width:(ft)
Dom. Veg. Type **Deciduous**
SubDom Veg. Type:

Right Buffer Dom.Width (ft) **5-25**
SubDom Width:(ft)
Dom. Veg. Type **Deciduous**
SubDom Veg Type **Herbaceous**

3.3 Riparian Corridor

Left Dom **Forest** SubDo
Righ Dom **Pasture** SubDo **Forest**

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps **None**
4.2 Adjacent Wetlands **Some**
4.3 Flow Status **Moderate**
4.4 # Current Debris Jams **1**
4.5 Upstream Impoundment **None**
4.6 # Stormwater Inputs **0**
4.7 Flow Regulations **None**
4.8 # Channel Constrictions **1**
None: **0** Culvert: **No** Bridge: **No**
Abutments **No** Bedrock: **No** Other **Yes**
Problems: DepAbove: **Yes** DepBelow:
Scour Below: Angle: None: **0**
Flood Prone Constriction: **Yes**
Bridge Survey Phase1 Phase 2 None ☐
BeaverDams: **0** Length Affected (ft):

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid **Yes**
Point **Yes** Side: **Yes** Diagonal **Yes**
Delta **No** Island **No** None: **0**

5.2 Neck or Chute Cut Offs
Flood Chute: **No** Neck Cut-Off: **No**
Channel Avulsions **No** Braiding **No**

5.3 Steep Riffles or Head Cuts:
Steep Riffle: **Yes** Head Cut: **Yes**

5.6 Stream Ford/Animal Crossing **Yes**

5.5 Channel Alterations:
Dredging **No** Straightening **No**
Bar Scalping **Yes** Gravel Mining: **No**
None **0**

Comments:

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** | **Reach # M06** | **Segment: Reach**

Rapid Habitat Assessment Field Data

Gradient Type: **High**

8.1 Epifaunal Substrate/Available Cover			15
8.2 Pool Substrate Character (low)/ Embededness (high)			8
8.3 Pool Variability (low) / Velocity Depth Regime (high)			13
8.4 Sediment Deposition			8
8.5 Channel Flow Status			13
8.6 Channel Alterations			18
8.7 Morphological Diversity			18
8.8 Bank Stability		Left	8
		Right	8
8.9 Vegetative Protection		Left	8
		Right	8
8.10 Riparian Vegetative Zone Width		Left	2
		Right	2
		TOTAL:	0.65
8.11 Habitat Condition:			3-Fair

Rapid Geomorphic Assessment Field Data

Confinement Type: **Unconfined**

			STD	Historic Adjustment
9.1 Deegre of Channel Degradation	5	Poor	☑	☑
9.2 Deegre of Channel Aggradation	8	Fair	☐	☐
9.3 Over Widened Channel	11	Good		☐
9.4 Change in Plaform	8	Fair		☐

Adjustment Process(s): Incision/PF. Localized.

9.5 Stage of Channel Evolution	II
TOTAL:	0.40
9.5 Geomorphic Condition:	3-Fair

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** — Reach # **M07** — Segment: **Reach**

Segment Length (ft): **3083** Date: **8/9/2004** Rain: **Yes** Observers: **KU, EE** Organization: **SMRC**

Town: **New Haven** Location: **meandering section east of River Rd**

Step 1 Valley and Floodplain:

1.1 Water Zone **Response**

1.2 Alluvial Fan **No**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) Right (ft)

Roads
Length: Left (ft) Right (ft) **50**

Railroads
Length: Left (ft) Right (ft)

Improved Paths
Length: Left (ft) Right (ft)

Development
Length: Left (ft) Right (ft)

1.4 Adjacent Side Slope

Left Slope **shallow** Texture **t Evaluat**
Cont. w/bank: **Sometimes**
W/in 1x Bkf: **Sometimes**

Right Slope **shallow** Texture **t Evaluat**
Cont. w/bank **Sometimes**
W/in 1x Bkf: **Sometimes**

1.5 Confinemen **Broad**
ValleyWidth: Rock Gorge ☐

1.6 Grade Controls

Waterfall **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Ledge: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Dam: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Weir: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft) **149.0**
2.2 Max Depth (ft) **2.7**
2.3 Mean Depth (ft) **1.0**
2.4 Flood Prone Width (ft) **350.0**
2.5 Low Bank Height (ft) **2.7**
2.6 Ratio W/D **141.9**
2.7 Entrenchment **2.3**
2.8 Incision Ratio **1.00**
2.9 Sinuosity **Moderate**
2.10 Riffle/Steps
complete: **Yes** partial: **No** diagonal: **Yes**
continuous **No** none **0**

2.11 Riffle/Steps Spacing (ft) **500**
Riffle/Step Spacing NA ☐

2.12 Bed Substrate Composition :

% Bedrock **0** % Boulder **1**
% Cobble **41** %CourseGravel: **41**
% Gravel **10** % Sand **7**
% Detritus **5** # LWD **26**
Silt/Clay **Yes**

2.13 Largest Particle on:
Bed Bar Units

2.14 Stream Type **C 4 Riffle-Pool**

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:

Typical Bank Slope **Steep**
Lower Bank Texture **Gravel**
Consistency: **Non-cohesiv**
Upper Bank Textue **Sand**
Consistency: **Non-cohesiv**

Left Bank
Erosion Length (ft) **1376** Height (ft) **10**
Revetment Type **Rip-rap** Length (ft) **520**
Dom. Veg. Type **Herbaceous**
SubDom. Veg. Type **Shrubs-sapling**
Left Bank Canopy **1-25%**

Right Bank
Erosion Length (ft) **460** Height (ft) **10**
Revetment Type **Rip-rap** Length (ft) **828**
Dom. Veg. Type **Herbaceous**
SubDom Veg. Type: **Shrubs-sapling**
Right Bank Canopy **1-25%**

Channel Canopy Cover: **Open**

3.2 Buffer:

Left Buffer: Dom.Width (ft) **5-25**
SubDom Width:(ft)
Dom. Veg. Type **Mixed Trees**
SubDom Veg. Type: **Herbaceous**

Right Buffer Dom.Width (ft) **51-100**
SubDom Width:(ft)
Dom. Veg. Type **Mixed Trees**
SubDom Veg Type **Herbaceous**

3.3 Riparian Corridor

Left Dom **Crop** SubDo
Righ Dom **Crop** SubDo **Residential**

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps **Some**
4.2 Adjacent Wetlands **Some**
4.3 Flow Status **Moderate**
4.4 # Current Debris Jams **1**
4.5 Upstream Impoundment **None**
4.6 # Stormwater Inputs **0**
4.7 Flow Regulations **None**
4.8 # Channel Constrictions **0**
None: **-1** Culvert: **No** Bridge: **No**
Abutments **No** Bedrock: **No** Other **No**
Problems: DepAbove: DepBelow:
Scour Below: Angle: None: **-1**
Flood Prone Constriction:
Bridge Survey Phase1 Phase 2 None ☐
BeaverDams: **0** Length Affected (ft):

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid **Yes**
Point **Yes** Side: **Yes** Diagonal **No**
Delta **No** Island **No** None: **0**

5.2 Neck or Chute Cut Offs
Flood Chute: **Yes** Neck Cut-Off: **No**
Channel Avulsions **No** Braiding **No**

5.3 Steep Riffles or Head Cuts:
Steep Riffle: **Yes** Head Cut: **Yes**

5.6 Stream Ford/Animal Crossing **Yes**

5.5 Channel Alterations:
Dredging Straightening
Bar Scalping Gravel Mining:
None **-1**

Comments:

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River**

Reach # M07

Segment: Reach

Rapid Habitat Assessment Field Data

Gradient Type:	**High**

8.1 Epifaunal Substrate/Available Cover		**15**
8.2 Pool Substrate Character (low)/ Embededness (high)		**8**
8.3 Pool Variability (low) / Velocity Depth Regime (high)		**13**
8.4 Sediment Deposition		**6**
8.5 Channel Flow Status		**8**
8.6 Channel Alterations		**13**
8.7 Morphological Diversity		**18**
8.8 Bank Stability	Left	**3**
	Right	**7**
8.9 Vegetative Protection	Left	**4**
	Right	**7**
8.10 Riparian Vegetative Zone Width	Left	**1**
	Right	**5**
	TOTAL:	**0.54**
8.11 Habitat Condition:		**3-Fair**

Rapid Geomorphic Assessment Field Data

Confinement Type:	**Unconfined**

			STD	Historic Adjustment
9.1 Deegre of Channel Degradation	**16**	**Reference**	☐	☑
9.2 Deegre of Channel Aggradation	**8**	**Fair**	☐	☐
9.3 Over Widened Channel	**5**	**Poor**		☐
9.4 Change in Plaform	**3**	**Poor**		☐

Adjustment Process(s)	Planform/Widening

9.5 Stage of Channel Evolution	**III**
TOTAL:	**0.40**
9.5 Geomorphic Condition:	**3-Fair**

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** Reach # **M08** Segment: **Reach**

Segment Length (ft): **3675** Date: **8/9/2004** Rain: **Yes** Observers: **KU, EE** Organization: **SMRC**

Town: **New Haven** Location: **parallel south and east of River Rd to point 600 ft east of Riverside Cemetery**

Step 1 Valley and Floodplain:

1.1 Water Zone **Transfer**

1.2 Alluvial Fan **No**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) Right (ft)

Roads
Length: Left (ft) Right (ft) **3000**

Railroads
Length: Left (ft) Right (ft)

Improved Paths
Length: Left (ft) Right (ft)

Development
Length: Left (ft) Right (ft) **1000**

1.4 Adjacent Side Slope

Left Slope **moderate** Texture **Gravel**
Cont. w/bank: **Sometimes**
W/in 1x Bkf: **Sometimes**

Right Slope **moderate** Texture **Gravel**
Cont. w/bank **Sometimes**
W/in 1x Bkf: **Sometimes**

1.5 Confinemen **Semi-Confined**
ValleyWidth: Rock Gorge ☐

1.6 Grade Controls

Waterfall **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Ledge: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Dam: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Weir: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft) **95.3**
2.2 Max Depth (ft) **3.9**
2.3 Mean Depth (ft) **2.5**
2.4 Flood Prone Width (ft) **109.0**
2.5 Low Bank Height (ft) **7.8**
2.6 Ratio W/D **38.1**
2.7 Entrenchment **1.1**
2.8 Incision Ratio **2.00**
2.9 Sinuosity **Low**
2.10 Riffle/Steps
complete: **Yes** partial: **Yes** diagonal: **No**
continuous **No** none **0**

2.11 Riffle/Steps Spacing (ft) **700**
Riffle/Step Spacing NA ☐

2.12 Bed Substrate Composition :

% Bedrock **2** % Boulder **8**
% Cobble **27** %CourseGravel: **38**
% Gravel **7** % Sand **16**
% Detritus **10** # LWD **15**
Silt/Clay **Yes**

2.13 Largest Particle on:
Bed Bar Units

2.14 Stream Type **F 4 Riffle-Pool**

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:

Typical Bank Slope **Moderate**
Lower Bank Texture **Boulder/Cob**
Consistency: **Non-cohesiv**
Upper Bank Textue **Gravel**
Consistency: **Non-cohesiv**

Left Bank
Erosion Length (ft) **200** Height (ft) **4**
Revetment Type **None** Length (ft)
Dom. Veg. Type **Herbaceous**
SubDom. Veg. Type
Left Bank Canopy **26-50%**

Right Bank
Erosion Length (ft) **80** Height (ft) **4**
Revetment Type **Rip-rap** Length (ft) **248**
Dom. Veg. Type **Shrubs-sapling**
SubDom Veg. Type:
Right Bank Canopy **51-75%**

Channel Canopy Cover: **Open**

3.2 Buffer:

Left Buffer: Dom.Width (ft) **>100**
SubDom Width:(ft)
Dom. Veg. Type **Mixed Trees**
SubDom Veg. Type: **Shrubs-sapling**

Right Buffer Dom.Width (ft) **5-25**
SubDom Width:(ft)
Dom. Veg. Type **Mixed Trees**
SubDom Veg Type **Herbaceous**

3.3 Riparian Corridor

Left Dom **Forest** SubDo
Righ Dom **Forest** SubDo

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps **None**
4.2 Adjacent Wetlands **None**
4.3 Flow Status **Moderate**
4.4 # Current Debris Jams **0**
4.5 Upstream Impoundment **None**
4.6 # Stormwater Inputs **0**
4.7 Flow Regulations **None**
4.8 # Channel Constrictions **0**
None: **-1** Culvert: Bridge:
Abutments Bedrock: Other
Problems: DepAbove: DepBelow:
Scour Below: Angle: None: **0**
Flood Prone Constriction:
Bridge Survey Phase1 Phase 2 None ☐
BeaverDams: **0** Length Affected (ft):

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid **Yes**
Point **Yes** Side: **Yes** Diagonal **Yes**
Delta **No** Island **No** None: **0**

5.2 Neck or Chute Cut Offs
Flood Chute: **No** Neck Cut-Off: **No**
Channel Avulsions **No** Braiding **No**

5.3 Steep Riffles or Head Cuts:
Steep Riffle: **Yes** Head Cut: **No**

5.6 Stream Ford/Animal Crossing **Yes**

5.5 Channel Alterations:
Dredging Straightening
Bar Scalping Gravel Mining:
None **-1**

Comments:

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** Reach # **M08** Segment: **Reach**

Rapid Habitat Assessment Field Data

Gradient Type: **High**

8.1 Epifaunal Substrate/Available Cover		13
8.2 Pool Substrate Character (low)/ Embededness (high)		8
8.3 Pool Variability (low) / Velocity Depth Regime (high)		13
8.4 Sediment Deposition		10
8.5 Channel Flow Status		13
8.6 Channel Alterations		15
8.7 Morphological Diversity		18
8.8 Bank Stability	Left	9
	Right	9
8.9 Vegetative Protection	Left	9
	Right	9
8.10 Riparian Vegetative Zone Width	Left	9
	Right	1
	TOTAL:	0.68
8.11 Habitat Condition:		**2-Good**

Rapid Geomorphic Assessment Field Data

Confinement Type: **Unconfined**

			STD	Historic Adjustment
9.1 Deegre of Channel Degradation	5	Poor	☑	☑
9.2 Deegre of Channel Aggradation	15	Good	☐	☐
9.3 Over Widened Channel	10	Fair		☑
9.4 Change in Plaform	18	Reference		☐

Adjustment Process(s): Aggradation (minor); Widening & incision historic

9.5 Stage of Channel Evolution	IV
TOTAL:	0.60
9.5 Geomorphic Condition:	**3-Fair**

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** Reach # **M09** Segment: **Reach**

Segment Length (ft): **3858** Date: **7/16/2004** Rain: **Yes** Observers: **KU, PU, NF** Organization: **SMRC, ACRP**

Town: **New Haven** Location: **from point 600 ft east of Riverside Cemetery along River Rd to point 1000 ft upstream o**

Step 1 Valley and Floodplain:

1.1 Water Zone **Transfer**

1.2 Alluvial Fan **No**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) Right (ft)

Roads
Length: Left (ft) **800** Right (ft) **3200**

Railroads
Length: Left (ft) Right (ft)

Improved Paths
Length: Left (ft) Right (ft)

Development
Length: Left (ft) **700** Right (ft) **2500**

1.4 Adjacent Side Slope

Left Slope **steep** Texture **t Evaluat**
Cont. w/bank: **Sometimes**
W/in 1x Bkf: **Sometimes**

Right Slope **moderate** Texture **t Evaluat**
Cont. w/bank **Sometimes**
W/in 1x Bkf: **Sometimes**

1.5 Confinemen **Narrowly Confined**
ValleyWidth: Rock Gorge ☐

1.6 Grade Controls

Waterfall **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Ledge: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Dam: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Weir: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft)	**98.9**
2.2 Max Depth (ft)	**5.3**
2.3 Mean Depth (ft)	**3.8**
2.4 Flood Prone Width (ft)	**156.0**
2.5 Low Bank Height (ft)	**13.8**
2.6 Ratio W/D	**26.0**
2.7 Entrenchment	**1.6**
2.8 Incision Ratio	**2.60**
2.9 Sinuosity	**Low**

2.10 Riffle/Steps
complete: **Yes** partial: **Yes** diagonal: **Yes**
continuous **No** none **0**

2.11 Riffle/Steps Spacing (ft)
Riffle/Step Spacing NA ☑

2.12 Bed Substrate Composition :

% Bedrock	**0**	% Boulder	**10**
% Cobble	**12**	%CourseGravel:	**30**
% Gravel	**28**	% Sand	**20**
% Detritus	**5**	# LWD	**32**
Silt/Clay	**No**		

2.13 Largest Particle on:
Bed Bar Units

2.14 Stream Type **B 4 c** **Riffle-Pool**

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:

Typical Bank Slope **Moderate**
Lower Bank Texture **Boulder/Cob**
Consistency: **Non-cohesiv**
Upper Bank Textue **Mix**
Consistency: **Cohesive**

Left Bank
Erosion Length (ft) **100** Height (ft) **2**
Revetment Type **Rip-rap** Length (ft) **300**
Dom. Veg. Type **Deciduous**
SubDom. Veg. Type
Left Bank Canopy **51-75%**

Right Bank
Erosion Length (ft) **100** Height (ft) **2**
Revetment Type **Rip-rap** Length (ft) **700**
Dom. Veg. Type **Deciduous**
SubDom Veg. Type:
Right Bank Canopy **51-75%**

Channel Canopy Cover: **Open**

3.2 Buffer:

Left Buffer: Dom.Width (ft) **5-25**
SubDom Width:(ft)
Dom. Veg. Type **Mixed Trees**
SubDom Veg. Type: **Herbaceous**

Right Buffer Dom.Width (ft) **5-25**
SubDom Width:(ft)
Dom. Veg. Type **Mixed Trees**
SubDom Veg Type **Invasive**

3.3 Riparian Corridor

Left Dom **Hay** SubDo
Righ Dom **Residential** SubDo

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps	**Some**
4.2 Adjacent Wetlands	**Some**
4.3 Flow Status	**Moderate**
4.4 # Current Debris Jams	**0**
4.5 Upstream Impoundment	**None**
4.6 # Stormwater Inputs	**4**
4.7 Flow Regulations	**None**
4.8 # Channel Constrictions	**3**

None: **0** Culvert: **No** Bridge: **Yes**
Abutments **No** Bedrock: **Yes** Other **Yes**
Problems: DepAbove: **No** DepBelow: **No**
Scour Below: **Yes** Angle: **No** None: **0**
Flood Prone Constriction: **Yes**
Bridge Survey Phase1 Phase 2 None ☐
BeaverDams: **0** Length Affected (ft):

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid **Yes**
Point **Yes** Side: **No** Diagonal **Yes**
Delta **No** Island **No** None: **0**

5.2 Neck or Chute Cut Offs
Flood Chute: **No** Neck Cut-Off: **No**
Channel Avulsions **No** Braiding **No**

5.3 Steep Riffles or Head Cuts:
Steep Riffle: **No** Head Cut: **No**

5.6 Stream Ford/Animal Crossing **No**

5.5 Channel Alterations:
Dredging Straightening
Bar Scalping Gravel Mining:
None **-1**

Comments:

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River**

Reach # M09

Segment: Reach

Rapid Habitat Assessment Field Data

Gradient Type: **High**

8.1 Epifaunal Substrate/Available Cover			15
8.2 Pool Substrate Character (low)/ Embededness (high)			8
8.3 Pool Variability (low) / Velocity Depth Regime (high)			18
8.4 Sediment Deposition			10
8.5 Channel Flow Status			13
8.6 Channel Alterations			13
8.7 Morphological Diversity			16
8.8 Bank Stability		Left	6
		Right	8
8.9 Vegetative Protection		Left	10
		Right	9
8.10 Riparian Vegetative Zone Width		Left	3
		Right	1
		TOTAL:	0.65
8.11 Habitat Condition:			**2-Good**

Rapid Geomorphic Assessment Field Data

Confinement Type: **Confined**

			STD	Historic Adjustment
9.1 Deegre of Channel Degradation	13	Good	☑	☑
9.2 Deegre of Channel Aggradation	13	Good	☐	☐
9.3 Over Widened Channel	13	Good		☑
9.4 Change in Plaform	16	Reference		☐

Adjustment Process(s): Aggradation

9.5 Stage of Channel Evolution	V
TOTAL:	0.69
9.5 Geomorphic Condition:	**2-Good**

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **Beaver Meadow** Reach # **T4.03** Segment: **A**

Segment Length (ft): **1275** Date: **7/26/2004** Rain: **Yes** Observers: **KU, EE** Organization: **SMRC**

Town: **Lincoln** Location: **downstream 1/3 of reach**

Step 1 Valley and Floodplain:

1.1 Water Zone **Transfer**

1.2 Alluvial Fan **No**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) **0** Right (ft) **0**

Roads
Length: Left (ft) **0** Right (ft) **140**

Railroads
Length: Left (ft) **0** Right (ft) **0**

Improved Paths
Length: Left (ft) **0** Right (ft) **0**

Development
Length: Left (ft) **0** Right (ft) **50**

1.4 Adjacent Side Slope

Left Slope **steep** Texture **Bedrock**
Cont. w/bank: **Sometimes**
W/in 1x Bkf: **Always**

Right Slope **steep** Texture **Bedrock**
Cont. w/bank **Sometimes**
W/in 1x Bkf: **Always**

1.5 Confinemen **Narrowly Confined**
ValleyWidth: Rock Gorge ☑

1.6 Grade Controls

Waterfall **B** Photo: ☑
Total Height (ft) **8**
FMB (Phase 2 B/C survey)

Ledge: **B** Photo: ☑
Total Height (ft) **2**
FMB (Phase 2 B/C survey)

Dam: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Weir: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft)
2.2 Max Depth (ft)
2.3 Mean Depth (ft)
2.4 Flood Prone Width (ft)
2.5 Low Bank Height (ft)
2.6 Ratio W/D
2.7 Entrenchment
2.8 Incision Ratio
2.9 Sinuosity
2.10 Riffle/Steps
complete: partial: diagonal:
continuous none **0**

2.11 Riffle/Steps Spacing (ft)
Riffle/Step Spacing NA ☐

2.12 Bed Substrate Composition :
% Bedrock % Boulder
% Cobble %CourseGravel:
% Gravel % Sand
% Detritus # LWD
Silt/Clay

2.13 Largest Particle on:
Bed Bar Units

2.14 Stream Type **B 1 a Cascade**

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:

Typical Bank Slope **Steep**
Lower Bank Texture **Bedrock**
Consistency: **Cohesive**
Upper Bank Textue **Mix**
Consistency: **Cohesive**

Left Bank
Erosion Length (ft) **0** Height (ft)
Revetment Type **None** Length (ft)
Dom. Veg. Type **Coniferous**
SubDom. Veg. Type
Left Bank Canopy **76-100%**

Right Bank
Erosion Length (ft) **0** Height (ft)
Revetment Type **None** Length (ft)
Dom. Veg. Type **Coniferous**
SubDom Veg. Type:
Right Bank Canopy **76-100%**

Channel Canopy Cover: **Closed**

3.2 Buffer:

Left Buffer: Dom.Width (ft) **>100**
SubDom Width:(ft)
Dom. Veg. Type **Coniferous**
SubDom Veg. Type:

Right Buffer Dom.Width (ft) **51-100**
SubDom Width:(ft)
Dom. Veg. Type **Coniferous**
SubDom Veg Type

3.3 Riparian Corridor

Left Dom **Forest** SubDo
Righ Dom **Forest** SubDo

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps **Some**
4.2 Adjacent Wetlands **None**
4.3 Flow Status **Moderate**
4.4 # Current Debris Jams **1**
4.5 Upstream Impoundment **None**
4.6 # Stormwater Inputs **0**
4.7 Flow Regulations **None**
4.8 # Channel Constrictions **2**
None: **0** Culvert: Bridge:
Abutments Bedrock: **Yes** Other
Problems: DepAbove: DepBelow:
Scour Below: Angle: None: **-1**
Flood Prone Constriction: **Yes**
Bridge Survey Phase1 Phase 2 None ☐
BeaverDams: **0** Length Affected (ft):

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid **Yes**
Point **No** Side: **No** Diagonal **No**
Delta **No** Island **Yes** None: **0**

5.2 Neck or Chute Cut Offs
Flood Chute: **Yes** Neck Cut-Off: **No**
Channel Avulsions **No** Braiding **Yes**

5.3 Steep Riffles or Head Cuts:
Steep Riffle: **No** Head Cut: **No**

5.6 Stream Ford/Animal Crossing **No**

5.5 Channel Alterations:
Dredging Straightening
Bar Scalping Gravel Mining:
None **-1**

Comments: **Segment is downstream 1/3 of reach. Has channel form and condition very similar to next downstream reach, T4.02.**

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **Beaver Meadow**

Reach # T4.03

Segment: A

Rapid Habitat Assessment Field Data

Gradient Type:

8.1 Epifaunal Substrate/Available Cover			
8.2 Pool Substrate Character (low)/ Embededness (high)			
8.3 Pool Variability (low) / Velocity Depth Regime (high)			
8.4 Sediment Deposition			
8.5 Channel Flow Status			
8.6 Channel Alterations			
8.7 Morphological Diversity			
8.8 Bank Stability		Left	
		Right	
8.9 Vegetative Protection		Left	
		Right	
8.10 Riparian Vegetative Zone Width		Left	
		Right	
		TOTAL:	**0.00**
8.11 Habitat Condition:			**4-Poor**

Rapid Geomorphic Assessment Field Data

Confinement Type:

			STD	Historic Adjustment
9.1 Deegre of Channel Degradation			☐	☐
9.2 Deegre of Channel Aggradation			☐	☐
9.3 Over Widened Channel				☐
9.4 Change in Plaform				☐

Adjustment Process(s)

9.5 Stage of Channel Evolution	**I**
TOTAL:	**0.00**
9.5 Geomorphic Condition:	**4-Poor**

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** | Reach # **M10** | Segment: **Reach**

Segment Length (ft): **4812** | Date: **6/7/2004** | Rain: **Yes** | Observers: **KU, CA, JH** | Organization: **SMRC**

Town: **New Haven, Bristol** | Location: **meandering section between Cove Rd and Rt 116**

Step 1 Valley and Floodplain:

1.1 Water Zone **Response**

1.2 Alluvial Fan **No**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) Right (ft) **200**

Roads
Length: Left (ft) **400** Right (ft) **600**

Railroads
Length: Left (ft) Right (ft)

Improved Paths
Length: Left (ft) Right (ft)

Development
Length: Left (ft) **50** Right (ft) **50**

1.4 Adjacent Side Slope

Left Slope **shallow** Texture **t Evaluat**
Cont. w/bank: **Always**
W/in 1x Bkf: **Always**

Right Slope **shallow** Texture **t Evaluat**
Cont. w/bank **Sometimes**
W/in 1x Bkf: **Always**

1.5 Confinemen **Broad**
ValleyWidth: Rock Gorge ☐

1.6 Grade Controls

Waterfall **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Ledge: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Dam: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Weir: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft) **96.2**

2.2 Max Depth (ft) **3.9**

2.3 Mean Depth (ft) **2.5**

2.4 Flood Prone Width (ft) **300.0**

2.5 Low Bank Height (ft) **6.4**

2.6 Ratio W/D **38.5**

2.7 Entrenchment **3.1**

2.8 Incision Ratio **1.64**

2.9 Sinuosity **Moderate**

2.10 Riffle/Steps
complete: **Yes** partial: **Yes** diagonal: **Yes**
continuous **No** none **0**

2.11 Riffle/Steps Spacing (ft) **632**
Riffle/Step Spacing NA ☐

2.12 Bed Substrate Composition :

% Bedrock **0** % Boulder **0**
% Cobble **15** %CourseGravel: **49**
% Gravel **17** % Sand **19**
% Detritus **5** # LWD **43**
Silt/Clay **No**

2.13 Largest Particle on:
Bed Bar Units

2.14 Stream Type **C 4 Riffle-Pool**

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:

Typical Bank Slope **Steep**
Lower Bank Texture **Gravel**
Consistency: **Non-cohesiv**
Upper Bank Textue **Sand**
Consistency: **Non-cohesiv**

Left Bank
Erosion Length (ft) **1480** Height (ft) **5**
Revetment Type **Rip-rap** Length (ft) **355**
Dom. Veg. Type **Herbaceous**
SubDom. Veg. Type
Left Bank Canopy **26-50%**

Right Bank
Erosion Length (ft) **300** Height (ft) **3**
Revetment Type **Rip-rap** Length (ft) **670**
Dom. Veg. Type **Herbaceous**
SubDom Veg. Type:
Right Bank Canopy **51-75%**

Channel Canopy Cover: **Open**

3.2 Buffer:

Left Buffer: Dom.Width (ft) **>100**
SubDom Width:(ft)
Dom. Veg. Type **Shrubs-sapling**
SubDom Veg. Type:

Right Buffer Dom.Width (ft) **>100**
SubDom Width:(ft)
Dom. Veg. Type **Deciduous**
SubDom Veg Type

3.3 Riparian Corridor

Left Dom **Crop** SubDo **Shrub**
Righ Dom **Forest** SubDo **Shrub**

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps **Some**
4.2 Adjacent Wetlands **Some**
4.3 Flow Status **Moderate**
4.4 # Current Debris Jams **0**
4.5 Upstream Impoundment **None**
4.6 # Stormwater Inputs **0**
4.7 Flow Regulations **None**
4.8 # Channel Constrictions **1**

None: **0** Culvert: **No** Bridge: **No**
Abutments **No** Bedrock: **No** Other **Yes**
Problems: DepAbove: **Yes** DepBelow: **No**
Scour Below: **Yes** Angle: **No** None: **0**
Flood Prone Constriction: **Yes**
Bridge Survey Phase1 Phase 2 None ☐
BeaverDams: **0** Length Affected (ft):

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid **Yes**
Point **Yes** Side: **Yes** Diagonal **Yes**
Delta **Yes** Island **No** None: **0**

5.2 Neck or Chute Cut Offs
Flood Chute: **Yes** Neck Cut-Off: **No**
Channel Avulsions **No** Braiding **No**

5.3 Steep Riffles or Head Cuts:
Steep Riffle: **Yes** Head Cut: **No**

5.6 Stream Ford/Animal Crossing **Yes**

5.5 Channel Alterations:
Dredging Straightening
Bar Scalping Gravel Mining:
None **0**

Comments:

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River**

Reach # M10

Segment: Reach

Rapid Habitat Assessment Field Data

Gradient Type: **High**

8.1 Epifaunal Substrate/Available Cover			5
8.2 Pool Substrate Character (low)/ Embededness (high)			6
8.3 Pool Variability (low) / Velocity Depth Regime (high)			13
8.4 Sediment Deposition			6
8.5 Channel Flow Status			10
8.6 Channel Alterations			11
8.7 Morphological Diversity			16
8.8 Bank Stability		Left	5
		Right	7
8.9 Vegetative Protection		Left	5
		Right	8
8.10 Riparian Vegetative Zone Width		Left	4
		Right	7
		TOTAL:	0.52
8.11 Habitat Condition:			**3-Fair**

Rapid Geomorphic Assessment Field Data

Confinement Type: **Unconfined**

			STD	Historic Adjustment
9.1 Deegre of Channel Degradation	10	Fair	☐	☑
9.2 Deegre of Channel Aggradation	5	Poor	☐	☐
9.3 Over Widened Channel	8	Fair		☐
9.4 Change in Plaform	7	Fair		☐

Adjustment Process(s): Aggradation/planform adjustment

9.5 Stage of Channel Evolution	III
TOTAL:	0.38
9.5 Geomorphic Condition:	**3-Fair**

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** | Reach # **M11** | Segment: **A**

Segment Length (ft): **1740** | Date: **6/7/2004** | Rain: **Yes** | Observers: **KU, CA** | Organization: **SMRC, VT F&W**

Town: **Bristol** | Location: **downstream segment of M11**

Step 1 Valley and Floodplain:

1.1 Water Zone **Transfer**

1.2 Alluvial Fan **No**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) Right (ft)

Roads
Length: Left (ft) **995** Right (ft) **930**

Railroads
Length: Left (ft) Right (ft)

Improved Paths
Length: Left (ft) Right (ft)

Development
Length: Left (ft) Right (ft)

1.4 Adjacent Side Slope

Left Slope **shallow** Texture **Gravel**
Cont. w/bank: **Always**
W/in 1x Bkf: **Always**

Right Slope **moderate** Texture **Gravel**
Cont. w/bank **Sometimes**
W/in 1x Bkf: **Sometimes**

1.5 Confinemen **Narrow**
ValleyWidth: Rock Gorge ☐

1.6 Grade Controls

Waterfall **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Ledge: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Dam: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Weir: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft)	**66.0**
2.2 Max Depth (ft)	**5.3**
2.3 Mean Depth (ft)	**3.8**
2.4 Flood Prone Width (ft)	**200.0**
2.5 Low Bank Height (ft)	**6.8**
2.6 Ratio W/D	**17.4**
2.7 Entrenchment	**3.0**
2.8 Incision Ratio	**1.28**
2.9 Sinuosity	**Low**

2.10 Riffle/Steps
complete: partial: diagonal:
continuous none **-1**

2.11 Riffle/Steps Spacing (ft)
Riffle/Step Spacing NA ☑

2.12 Bed Substrate Composition :
% Bedrock % Boulder
% Cobble %CourseGravel:
% Gravel % Sand
% Detritus # LWD **34**
Silt/Clay

2.13 Largest Particle on:
Bed Bar Units

2.14 Stream Type **C 4 Plane Bed**

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:

Typical Bank Slope **Steep**
Lower Bank Texture **Mix**
Consistency: **Cohesive**
Upper Bank Textue **Mix**
Consistency: **Cohesive**

Left Bank
Erosion Length (ft) **820** Height (ft) **4**
Revetment Type Length (ft)
Dom. Veg. Type **Deciduous**
SubDom. Veg. Type
Left Bank Canopy **51-75%**

Right Bank
Erosion Length (ft) **300** Height (ft) **2**
Revetment Type **Rip-rap** Length (ft) **730**
Dom. Veg. Type **Deciduous**
SubDom Veg. Type:
Right Bank Canopy **26-50%**

Channel Canopy Cover: **Open**

3.2 Buffer:

Left Buffer: Dom.Width (ft) **26-50**
SubDom Width:(ft)
Dom. Veg. Type **Deciduous**
SubDom Veg. Type: **Shrubs-sapling**

Right Buffer Dom.Width (ft) **5-25**
SubDom Width:(ft)
Dom. Veg. Type **Deciduous**
SubDom Veg Type **Shrubs-sapling**

3.3 Riparian Corridor
Left Dom **Forest** SubDo **Pasture**
Righ Dom **Hay** SubDo **Forest**

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps	**None**
4.2 Adjacent Wetlands	**Some**
4.3 Flow Status	**Moderate**
4.4 # Current Debris Jams	**0**
4.5 Upstream Impoundment	**None**
4.6 # Stormwater Inputs	**0**
4.7 Flow Regulations	**None**
4.8 # Channel Constrictions	**2**

None: **0** Culvert: **No** Bridge: **Yes**
Abutments **No** Bedrock: **No** Other **Yes**
Problems: DepAbove: **No** DepBelow: **No**
Scour Below: **Yes** Angle: **No** None: **0**
Flood Prone Constriction: **Yes**
Bridge Survey Phase1 Phase 2 None ☐
BeaverDams: **0** Length Affected (ft):

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid **No**
Point **No** Side: **Yes** Diagonal **No**
Delta **No** Island **No** None: **0**

5.2 Neck or Chute Cut Offs
Flood Chute: **Yes** Neck Cut-Off: **No**
Channel Avulsions **No** Braiding **No**

5.3 Steep Riffles or Head Cuts:
Steep Riffle: **No** Head Cut: **No**

5.6 Stream Ford/Animal Crossing **No**

5.5 Channel Alterations:
Dredging **No** Straightening **Yes**
Bar Scalping **No** Gravel Mining: **Yes**
None **0**

Comments:

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River**

Reach # M11

Segment: A

Rapid Habitat Assessment Field Data

Gradient Type:	High

8.1 Epifaunal Substrate/Available Cover			11
8.2 Pool Substrate Character (low)/ Embededness (high)			10
8.3 Pool Variability (low) / Velocity Depth Regime (high)			13
8.4 Sediment Deposition			8
8.5 Channel Flow Status			13
8.6 Channel Alterations			10
8.7 Morphological Diversity			13
8.8 Bank Stability		Left	4
		Right	7
8.9 Vegetative Protection		Left	4
		Right	7
8.10 Riparian Vegetative Zone Width		Left	4
		Right	2
		TOTAL:	0.53
8.11 Habitat Condition:			3-Fair

Rapid Geomorphic Assessment Field Data

Confinement Type:	Unconfined

			STD	Historic Adjustment
9.1 Deegre of Channel Degradation	8	Fair	☐	☑
9.2 Deegre of Channel Aggradation	11	Good	☐	☐
9.3 Over Widened Channel	13	Good		☐
9.4 Change in Plaform	16	Reference		☐

Adjustment Process(s)	Minor Aggradation. Incision is historic.

9.5 Stage of Channel Evolution	IV
TOTAL:	0.60
9.5 Geomorphic Condition:	3-Fair

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** Reach # **M11** Segment: **B**

Segment Length (ft): **1398** Date: **6/7/2004** Rain: **Yes** Observers: **KU, CA** Organization: **SMRC, VT F&W**

Town: **Bristol** Location: **upstream section of M11**

Step 1 Valley and Floodplain:

1.1 Water Zone **Response**

1.2 Alluvial Fan **No**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) Right (ft)

Roads
Length: Left (ft) Right (ft) **855**

Railroads
Length: Left (ft) Right (ft)

Improved Paths
Length: Left (ft) Right (ft)

Development
Length: Left (ft) Right (ft) **150**

1.4 Adjacent Side Slope

Left Slope **shallow** Texture **Gravel**
Cont. w/bank: **Always**
W/in 1x Bkf: **Always**

Right Slope **moderate** Texture **Gravel**
Cont. w/bank **Sometimes**
W/in 1x Bkf: **Sometimes**

1.5 Confinemen **Broad**
ValleyWidth: Rock Gorge ☐

1.6 Grade Controls

Waterfall **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Ledge: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Dam: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Weir: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft) **107.0**

2.2 Max Depth (ft) **3.5**

2.3 Mean Depth (ft) **1.2**

2.4 Flood Prone Width (ft) **707.0**

2.5 Low Bank Height (ft) **3.5**

2.6 Ratio W/D **89.2**

2.7 Entrenchment **6.6**

2.8 Incision Ratio **1.00**

2.9 Sinuosity **Moderate**

2.10 Riffle/Steps
complete: **Yes** partial: **No** diagonal: **Yes**
continuous **No** none **0**

2.11 Riffle/Steps Spacing (ft) **620**
Riffle/Step Spacing NA ☐

2.12 Bed Substrate Composition :

% Bedrock **0** % Boulder **0**
% Cobble **35** %CourseGravel: **43**
% Gravel **12** % Sand **10**
% Detritus **5** # LWD **34**
Silt/Clay **No**

2.13 Largest Particle on:
Bed **120** Bar **180** Units **Millimeter**

2.14 Stream Type **C** **4** **Riffle-Pool**

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:

Typical Bank Slope **Undercut**
Lower Bank Texture **Gravel**
Consistency: **Non-cohesiv**
Upper Bank Textue **Sand**
Consistency: **Non-cohesiv**

Left Bank
Erosion Length (ft) **800** Height (ft) **4**
Revetment Type **Rip-rap** Length (ft) **100**
Dom. Veg. Type **Herbaceous**
SubDom. Veg. Type **Bare**
Left Bank Canopy **0**

Right Bank
Erosion Length (ft) **230** Height (ft) **2**
Revetment Type **Rip-rap** Length (ft) **420**
Dom. Veg. Type **Herbaceous**
SubDom Veg. Type: **Lawn**
Right Bank Canopy **1-25%**

Channel Canopy Cover: **Open**

3.2 Buffer:

Left Buffer: Dom.Width (ft) **5-25**
SubDom Width:(ft)
Dom. Veg. Type **Herbaceous**
SubDom Veg. Type:

Right Buffer Dom.Width (ft) **5-25**
SubDom Width:(ft)
Dom. Veg. Type **Herbaceous**
SubDom Veg Type

3.3 Riparian Corridor

Left Dom **Hay** SubDo
Righ Dom **Residential** SubDo

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps **None**
4.2 Adjacent Wetlands **Some**
4.3 Flow Status **Moderate**
4.4 # Current Debris Jams **0**
4.5 Upstream Impoundment **None**
4.6 # Stormwater Inputs **1**
4.7 Flow Regulations **None**
4.8 # Channel Constrictions **0**

None: **-1** Culvert: **No** Bridge: **No**
Abutments **No** Bedrock: **No** Other **No**
Problems: DepAbove: DepBelow:
Scour Below: Angle: None: **-1**
Flood Prone Constriction:
Bridge Survey Phase1 Phase 2 None ☐
BeaverDams: **0** Length Affected (ft):

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid **Yes**
Point **Yes** Side: **Yes** Diagonal **Yes**
Delta **Yes** Island None: **0**

5.2 Neck or Chute Cut Offs
Flood Chute: **Yes** Neck Cut-Off: **No**
Channel Avulsions **No** Braiding **No**

5.3 Steep Riffles or Head Cuts:
Steep Riffle: **Yes** Head Cut: **No**

5.6 Stream Ford/Animal Crossing **No**

5.5 Channel Alterations:
Dredging Straightening **Yes**
Bar Scalping Gravel Mining: **Yes**
None **0**

Comments:

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River**

Reach # M11

Segment: B

Rapid Habitat Assessment Field Data

Gradient Type:	**High**

8.1 Epifaunal Substrate/Available Cover		**5**
8.2 Pool Substrate Character (low)/ Embededness (high)		**6**
8.3 Pool Variability (low) / Velocity Depth Regime (high)		**13**
8.4 Sediment Deposition		**5**
8.5 Channel Flow Status		**8**
8.6 Channel Alterations		**16**
8.7 Morphological Diversity		**18**
8.8 Bank Stability	Left	**6**
	Right	**8**
8.9 Vegetative Protection	Left	**2**
	Right	**4**
8.10 Riparian Vegetative Zone Width	Left	**1**
	Right	**2**
	TOTAL:	**0.47**
8.11 Habitat Condition:		**3-Fair**

Rapid Geomorphic Assessment Field Data

Confinement Type:	**Unconfined**

			STD	Historic Adjustment
9.1 Deegre of Channel Degradation	**15**	**Good**	☐	☐
9.2 Deegre of Channel Aggradation	**7**	**Fair**	☐	☐
9.3 Over Widened Channel	**5**	**Poor**		☐
9.4 Change in Plaform	**4**	**Poor**		☐

Adjustment Process(s)	planform adjustment/ widening / aggradation

9.5 Stage of Channel Evolution	**III**
TOTAL:	**0.39**
9.5 Geomorphic Condition:	**3-Fair**

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** Reach # **M15** Segment: **Reach**

Segment Length (ft): **8681** Date: **8/6/2004** Rain: **Yes** Observers: **KU, SH, ES** Organization: **SMRC**

Town: **Bristol** Location: **section parallel to Rte 116/17 east of Bristol village, ending at confluence of Baldwin Cr**

Step 1 Valley and Floodplain:

1.1 Water Zone **Transfer**

1.2 Alluvial Fan **Yes**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) Right (ft)

Roads
Length: Left (ft) **840** Right (ft) **4320**

Railroads
Length: Left (ft) Right (ft)

Improved Paths
Length: Left (ft) Right (ft)

Development
Length: Left (ft) **950** Right (ft) **2270**

1.4 Adjacent Side Slope

Left Slope **moderate** Texture **Gravel**
Cont. w/bank: **Sometimes**
W/in 1x Bkf: **Sometimes**

Right Slope **shallow** Texture **Gravel**
Cont. w/bank **Sometimes**
W/in 1x Bkf: **Sometimes**

1.5 Confinemen **Narrowly Confined**
ValleyWidth: Rock Gorge ☐

1.6 Grade Controls

Waterfall **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Ledge: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Dam: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Weir: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft) **93.4**
2.2 Max Depth (ft) **4.9**
2.3 Mean Depth (ft) **2.7**
2.4 Flood Prone Width (ft) **150.0**
2.5 Low Bank Height (ft) **8.6**
2.6 Ratio W/D **34.6**
2.7 Entrenchment **1.6**
2.8 Incision Ratio **1.76**
2.9 Sinuosity **Low**
2.10 Riffle/Steps
complete: **Yes** partial: **No** diagonal: **Yes**
continuous **Yes** none **0**

2.11 Riffle/Steps Spacing (ft) **200**
Riffle/Step Spacing NA ☐

2.12 Bed Substrate Composition :

% Bedrock **0** % Boulder **11**
% Cobble **17** %CourseGravel: **22**
% Gravel **26** % Sand **22**
% Detritus **5** # LWD **43**
Silt/Clay **Yes**

2.13 Largest Particle on:
Bed Bar Units

2.14 Stream Type **F 4 Riffle-Pool**

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:

Typical Bank Slope **Steep**
Lower Bank Texture **Boulder/Cob**
Consistency: **Non-cohesiv**
Upper Bank Textue **Sand**
Consistency: **Non-cohesiv**

Left Bank
Erosion Length (ft) **2950** Height (ft) **7**
Revetment Type **Rip-rap** Length (ft) **410**
Dom. Veg. Type **Deciduous**
SubDom. Veg. Type
Left Bank Canopy **76-100%**

Right Bank
Erosion Length (ft) **1810** Height (ft) **4**
Revetment Type **Rip-rap** Length (ft) **1890**
Dom. Veg. Type **Deciduous**
SubDom Veg. Type: **Shrubs-sapling**
Right Bank Canopy **26-50%**

Channel Canopy Cover: **Open**

3.2 Buffer:

Left Buffer: Dom.Width (ft) **>100**
SubDom Width:(ft)
Dom. Veg. Type **Mixed Trees**
SubDom Veg. Type:

Right Buffer Dom.Width (ft) **>100**
SubDom Width:(ft) **5-25 ft**
Dom. Veg. Type **Mixed Trees**
SubDom Veg Type

3.3 Riparian Corridor

Left Dom **Forest** SubDo
Righ Dom **Forest** SubDo

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps **Some**
4.2 Adjacent Wetlands **None**
4.3 Flow Status **Moderate**
4.4 # Current Debris Jams **0**
4.5 Upstream Impoundment **None**
4.6 # Stormwater Inputs **6**
4.7 Flow Regulations **None**
4.8 # Channel Constrictions **2**

None: **0** Culvert: **No** Bridge: **Yes**
Abutments **No** Bedrock: **No** Other **Yes**
Problems: DepAbove: **Yes** DepBelow: **No**
Scour Below: **No** Angle: **No** None: **0**
Flood Prone Constriction: **Yes**
Bridge Survey Phase1 Phase 2 None ☐
BeaverDams: **0** Length Affected (ft):

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid **Yes**
Point **Yes** Side: **Yes** Diagonal **Yes**
Delta **No** Island **Yes** None: **0**

5.2 Neck or Chute Cut Offs
Flood Chute: **Yes** Neck Cut-Off: **No**
Channel Avulsions **No** Braiding **Yes**

5.3 Steep Riffles or Head Cuts:
Steep Riffle: **Yes** Head Cut: **No**

5.6 Stream Ford/Animal Crossing **No**

5.5 Channel Alterations:
Dredging **Yes** Straightening **Yes**
Bar Scalping **No** Gravel Mining: **No**
None **0**

Comments:

Phase 2 Geomorphic Assessment Data

Stream Name: **New Haven River**

Reach # M15

Segment: Reach

Rapid Habitat Assessment Field Data

Gradient Type: **High**

8.1 Epifaunal Substrate/Available Cover		11
8.2 Pool Substrate Character (low)/ Embededness (high)		8
8.3 Pool Variability (low) / Velocity Depth Regime (high)		18
8.4 Sediment Deposition		6
8.5 Channel Flow Status		13
8.6 Channel Alterations		8
8.7 Morphological Diversity		18
8.8 Bank Stability	Left	3
	Right	5
8.9 Vegetative Protection	Left	2
	Right	4
8.10 Riparian Vegetative Zone Width	Left	9
	Right	4
	TOTAL:	0.55
8.11 Habitat Condition:		3-Fair

Rapid Geomorphic Assessment Field Data

Confinement Type: **Unconfined**

			STD	Historic Adjustment
9.1 Deegre of Channel Degradation	5	Poor	☑	☐
9.2 Deegre of Channel Aggradation	5	Poor	☐	☐
9.3 Over Widened Channel	8	Fair		☐
9.4 Change in Plaform	11	Good		☐

Adjustment Process(s): Incision, widening, aggradation

9.5 Stage of Channel Evolution	II
TOTAL:	0.36
9.5 Geomorphic Condition:	3-Fair

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** — **Reach # M17** — **Segment: Reach**

Segment Length (ft): **6452** Date: **7/3/2004** Rain: **Yes** Observers: **KU, EE** Organization: **SMRC**

Town: **Bristol, Lincoln** Location: **section parallel to Lincoln Rd through the village of West Lincoln**

Step 1 Valley and Floodplain:

1.1 Water Zone **Transfer**

1.2 Alluvial Fan **No**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) Right (ft)

Roads
Length: Left (ft) **780** Right (ft) **5780**

Railroads
Length: Left (ft) Right (ft)

Improved Paths
Length: Left (ft) Right (ft)

Development
Length: Left (ft) **305** Right (ft) **2240**

1.4 Adjacent Side Slope

Left Slope **moderate** Texture **Cobble**
Cont. w/bank: **Sometimes**
W/in 1x Bkf: **Sometimes**

Right Slope **steep** Texture **Boulder**
Cont. w/bank **Sometimes**
W/in 1x Bkf: **Sometimes**

1.5 Confinemen **Narrowly Confined**
ValleyWidth: **150** Rock Gorge ☐

1.6 Grade Controls

Waterfall **D** Photo: ☑
Total Height (ft)
FMB (Phase 2 B/C survey)

Ledge: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Dam: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Weir: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft) **70.4**
2.2 Max Depth (ft) **3.5**
2.3 Mean Depth (ft) **2.5**
2.4 Flood Prone Width (ft) **85.0**
2.5 Low Bank Height (ft) **8.4**
2.6 Ratio W/D **28.2**
2.7 Entrenchment **1.2**
2.8 Incision Ratio **2.40**
2.9 Sinuosity **Low**
2.10 Riffle/Steps
complete: **Yes** partial: **Yes** diagonal: **Yes**
continuous **No** none **0**

2.11 Riffle/Steps Spacing (ft)
Riffle/Step Spacing NA ☐

2.12 Bed Substrate Composition :
% Bedrock **5** % Boulder **21**
% Cobble **42** %CourseGravel: **17**
% Gravel **6** % Sand **8**
% Detritus **5** # LWD **48**
Silt/Clay **No**

2.13 Largest Particle on:
Bed **500** Bar Units **Millimeter**

2.14 Stream Type **F 3 Riffle-Pool**

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:
Typical Bank Slope **Steep**
Lower Bank Texture **Mix**
Consistency: **Non-cohesiv**
Upper Bank Textue **Mix**
Consistency: **Non-cohesiv**

Left Bank
Erosion Length (ft) **425** Height (ft) **10**
Revetment Type **None** Length (ft)
Dom. Veg. Type **Deciduous**
SubDom. Veg. Type
Left Bank Canopy **76-100%**

Right Bank
Erosion Length (ft) **210** Height (ft) **8**
Revetment Type **Rip-rap** Length (ft) **3250**
Dom. Veg. Type **Bare**
SubDom Veg. Type:
Right Bank Canopy **1-25%**

Channel Canopy Cover: **Open**

3.2 Buffer:
Left Buffer: Dom.Width (ft) **>100**
SubDom Width:(ft)
Dom. Veg. Type **Mixed Trees**
SubDom Veg. Type:

Right Buffer Dom.Width (ft) **5-25**
SubDom Width:(ft)
Dom. Veg. Type **Herbaceous**
SubDom Veg Type

3.3 Riparian Corridor
Left Dom **Forest** SubDo
Righ Dom **Residential** SubDo **Shrub**

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps **Abundant**
4.2 Adjacent Wetlands **Some**
4.3 Flow Status **Moderate**
4.4 # Current Debris Jams **0**
4.5 Upstream Impoundment **None**
4.6 # Stormwater Inputs **3**
4.7 Flow Regulations **None**
4.8 # Channel Constrictions **2**
None: **0** Culvert: **No** Bridge: **Yes**
Abutments **No** Bedrock: **No** Other **Yes**
Problems: DepAbove: **No** DepBelow: **No**
Scour Below: **Yes** Angle: **No** None: **0**
Flood Prone Constriction: **Yes**
Bridge Survey Phase1 Phase 2 **Yes** None ☐
BeaverDams: **0** Length Affected (ft):

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid **Yes**
Point **Yes** Side: **Yes** Diagonal **Yes**
Delta **No** Island **Yes** None: **0**

5.2 Neck or Chute Cut Offs
Flood Chute: **Yes** Neck Cut-Off: **No**
Channel Avulsions Braiding **Yes**

5.3 Steep Riffles or Head Cuts:
Steep Riffle: **Yes** Head Cut: **No**

5.6 Stream Ford/Animal Crossing **Yes**

5.5 Channel Alterations:
Dredging **No** Straightening **Yes**
Bar Scalping **No** Gravel Mining: **No**
None **-1**

Comments:

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River**

Reach # M17

Segment: Reach

Rapid Habitat Assessment Field Data

Gradient Type:	High

8.1 Epifaunal Substrate/Available Cover		13
8.2 Pool Substrate Character (low)/ Embededness (high)		18
8.3 Pool Variability (low) / Velocity Depth Regime (high)		18
8.4 Sediment Deposition		11
8.5 Channel Flow Status		15
8.6 Channel Alterations		11
8.7 Morphological Diversity		18
8.8 Bank Stability	Left	8
	Right	5
8.9 Vegetative Protection	Left	9
	Right	1
8.10 Riparian Vegetative Zone Width	Left	10
	Right	1
	TOTAL:	0.69
8.11 Habitat Condition:		**2-Good**

Rapid Geomorphic Assessment Field Data

Confinement Type:	Unconfined

			STD	Historic Adjustment
9.1 Deegre of Channel Degradation	3	Poor	☑	☑
9.2 Deegre of Channel Aggradation	5	Poor	☐	☐
9.3 Over Widened Channel	6	Fair		☐
9.4 Change in Plaform	5	Poor		☐

Adjustment Process(s)	Aggradation/widening in resp to historic degrad.

9.5 Stage of Channel Evolution	III
TOTAL:	0.24
9.5 Geomorphic Condition:	**4-Poor**

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** Reach # **M18** Segment: **Reach**

Segment Length (ft): **5332** Date: **6/26/2004** Rain: **Yes** Observers: **KU, PNG** Organization: **SMRC**

Town: **Lincoln** Location: **upstream of York Hill Rd crossing to confluence of Beaver Meadow trib (T4)**

Step 1 Valley and Floodplain:

1.1 Water Zone **Transfer**

1.2 Alluvial Fan **No**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) Right (ft)

Roads
Length: Left (ft) Right (ft) **5330**

Railroads
Length: Left (ft) Right (ft)

Improved Paths
Length: Left (ft) Right (ft)

Development
Length: Left (ft) Right (ft) **1020**

1.4 Adjacent Side Slope

Left Slope **steep** Texture **Boulder**
Cont. w/bank: **Sometimes**
W/in 1x Bkf: **Sometimes**

Right Slope **moderate** Texture **Cobble**
Cont. w/bank **Sometimes**
W/in 1x Bkf: **Sometimes**

1.5 Confinemen **Semi-Confined**
ValleyWidth: **300** Rock Gorge ☐

1.6 Grade Controls

Waterfall **U** Photo: ☑
Total Height (ft) **2**
FMB (Phase 2 B/C survey)

Ledge: **B** Photo: ☑
Total Height (ft) **2**
FMB (Phase 2 B/C survey)

Dam: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Weir: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft) **93.5**

2.2 Max Depth (ft) **3.0**

2.3 Mean Depth (ft) **1.7**

2.4 Flood Prone Width (ft) **105.0**

2.5 Low Bank Height (ft) **6.7**

2.6 Ratio W/D **55.0**

2.7 Entrenchment **1.1**

2.8 Incision Ratio **2.23**

2.9 Sinuosity **Low**

2.10 Riffle/Steps
complete: **Yes** partial: **No** diagonal: **Yes**
continuous **No** none **0**

2.11 Riffle/Steps Spacing (ft) **718**
Riffle/Step Spacing NA ☐

2.12 Bed Substrate Composition :

% Bedrock **0** % Boulder **16**
% Cobble **34** %CourseGravel: **22**
% Gravel **16** % Sand **11**
% Detritus **5** # LWD **15**
Silt/Clay **No**

2.13 Largest Particle on:
Bed **525** Bar **450** Units **Millimeter**

2.14 Stream Type **F** **3** **Riffle-Pool**

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:

Typical Bank Slope **Steep**
Lower Bank Texture **Boulder/Cob**
Consistency: **Non-cohesiv**
Upper Bank Textue **Sand**
Consistency: **Non-cohesiv**

Left Bank
Erosion Length (ft) **1200** Height (ft) **10**
Revetment Type Length (ft)
Dom. Veg. Type **Deciduous**
SubDom. Veg. Type
Left Bank Canopy **76-100%**

Right Bank
Erosion Length (ft) **400** Height (ft) **6**
Revetment Type **Rip-rap** Length (ft) **1850**
Dom. Veg. Type **Deciduous**
SubDom Veg. Type:
Right Bank Canopy **51-75%**

Channel Canopy Cover: **Open**

3.2 Buffer:

Left Buffer: Dom.Width (ft) **>100**
SubDom Width:(ft)
Dom. Veg. Type **Mixed Trees**
SubDom Veg. Type:

Right Buffer Dom.Width (ft) **5-25**
SubDom Width:(ft)
Dom. Veg. Type **Mixed Trees**
SubDom Veg Type

3.3 Riparian Corridor
Left Dom **Forest** SubDo **Pasture**
Righ Dom **Forest** SubDo **Residential**

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps **Abundant**

4.2 Adjacent Wetlands **Some**

4.3 Flow Status **Moderate**

4.4 # Current Debris Jams **0**

4.5 Upstream Impoundment **None**

4.6 # Stormwater Inputs **1**

4.7 Flow Regulations **None**

4.8 # Channel Constrictions **1**

None: **0** Culvert: Bridge:
Abutments Bedrock: **Yes** Other
Problems: DepAbove: **Yes** DepBelow:
Scour Below: Angle: None: **0**
Flood Prone Constriction: **Yes**
Bridge Survey Phase1 Phase 2 None ☐
BeaverDams: **0** Length Affected (ft):

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid **Yes**
Point **Yes** Side: **Yes** Diagonal **Yes**
Delta Island **Yes** None: **0**

5.2 Neck or Chute Cut Offs
Flood Chute: **Yes** Neck Cut-Off: **No**
Channel Avulsions **No** Braiding **Yes**

5.3 Steep Riffles or Head Cuts:
Steep Riffle: **Yes** Head Cut: **No**

5.6 Stream Ford/Animal Crossing **No**

5.5 Channel Alterations:
Dredging **Yes** Straightening
Bar Scalping Gravel Mining:
None **0**

Comments:

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** Reach # **M18** Segment: **Reach**

Rapid Habitat Assessment Field Data

Gradient Type: **High**

8.1 Epifaunal Substrate/Available Cover		10
8.2 Pool Substrate Character (low)/ Embededness (high)		6
8.3 Pool Variability (low) / Velocity Depth Regime (high)		13
8.4 Sediment Deposition		6
8.5 Channel Flow Status		10
8.6 Channel Alterations		10
8.7 Morphological Diversity		15
8.8 Bank Stability	Left	6
	Right	7
8.9 Vegetative Protection	Left	6
	Right	4
8.10 Riparian Vegetative Zone Width	Left	8
	Right	1
	TOTAL:	0.51
8.11 Habitat Condition:		3-Fair

Rapid Geomorphic Assessment Field Data

Confinement Type: **Unconfined**

			STD	Historic Adjustment
9.1 Deegre of Channel Degradation	5	Poor	☑	☑
9.2 Deegre of Channel Aggradation	10	Fair	☐	☐
9.3 Over Widened Channel	3	Poor		☐
9.4 Change in Plaform	13	Good		☐

Adjustment Process(s): Widening, Aggradation

9.5 Stage of Channel Evolution	III
TOTAL:	0.39
9.5 Geomorphic Condition:	3-Fair

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** Reach # **M19** Segment: **Reach**

Segment Length (ft): **4981** Date: **6/19/2004** Rain: **Yes** Observers: **KU, EE** Organization: **SMRC**

Town: **Lincoln** Location: **from confluence of Beaver Meadow trib (T4) through Lincoln Village to a point just dow**

Step 1 Valley and Floodplain:

1.1 Water Zone **Transfer**

1.2 Alluvial Fan **No**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) **200** Right (ft) **100**

Roads
Length: Left (ft) **1280** Right (ft) **3500**

Railroads
Length: Left (ft) Right (ft)

Improved Paths
Length: Left (ft) Right (ft)

Development
Length: Left (ft) **2500** Right (ft) **4900**

1.4 Adjacent Side Slope

Left Slope **shallow** Texture **Boulder**
Cont. w/bank: **Sometimes**
W/in 1x Bkf: **Sometimes**

Right Slope **moderate** Texture **Boulder**
Cont. w/bank **Sometimes**
W/in 1x Bkf: **Sometimes**

1.5 Confinemen **Semi-Confined**
ValleyWidth: Rock Gorge ☐

1.6 Grade Controls

Waterfall **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Ledge: **D** Photo: ☑
Total Height (ft) **3**
FMB (Phase 2 B/C survey)

Dam: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Weir: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft) **45.4**
2.2 Max Depth (ft) **3.2**
2.3 Mean Depth (ft) **2.2**
2.4 Flood Prone Width (ft) **72.5**
2.5 Low Bank Height (ft) **8.4**
2.6 Ratio W/D **20.6**
2.7 Entrenchment **1.6**
2.8 Incision Ratio **2.62**
2.9 Sinuosity **Low**
2.10 Riffle/Steps
complete: **Yes** partial: diagonal: **Yes**
continuous none **0**

2.11 Riffle/Steps Spacing (ft)
Riffle/Step Spacing NA ☐

2.12 Bed Substrate Composition :

% Bedrock **0** % Boulder **7**
% Cobble **56** %CourseGravel: **23**
% Gravel **5** % Sand **9**
% Detritus # LWD **48**
Silt/Clay **No**

2.13 Largest Particle on:
Bed **145** Bar **150** Units **Millimeter**

2.14 Stream Type **F 3 Riffle-Pool**

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:

Typical Bank Slope **Steep**
Lower Bank Texture Consistency: **Mix**
Upper Bank Textue Consistency: **Mix**

Left Bank
Erosion Length (ft) **800** Height (ft) **2**
Revetment Type **Rip-rap** Length (ft) **200**
Dom. Veg. Type **Deciduous**
SubDom. Veg. Type
Left Bank Canopy **26-50%**

Right Bank
Erosion Length (ft) **800** Height (ft) **2**
Revetment Type **Rip-rap** Length (ft) **2500**
Dom. Veg. Type **Shrubs-sapling**
SubDom Veg. Type:
Right Bank Canopy **1-25%**

Channel Canopy Cover: **Open**

3.2 Buffer:

Left Buffer: Dom.Width (ft) **26-50**
SubDom Width:(ft)
Dom. Veg. Type **Mixed Trees**
SubDom Veg. Type:

Right Buffer Dom.Width (ft) **5-25**
SubDom Width:(ft)
Dom. Veg. Type **Shrub-sapling**
SubDom Veg Type

3.3 Riparian Corridor
Left Dom **Residential** SubDo
Righ Dom **Residential** SubDo

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps **None**
4.2 Adjacent Wetlands **None**
4.3 Flow Status **Moderate**
4.4 # Current Debris Jams **0**
4.5 Upstream Impoundment **None**
4.6 # Stormwater Inputs **4**
4.7 Flow Regulations **None**
4.8 # Channel Constrictions **2**
None: **0** Culvert: Bridge: **Yes**
Abutments Bedrock: Other **Yes**
Problems: DepAbove: DepBelow: **Yes**
Scour Below: Angle: None: **0**
Flood Prone Constriction: **Yes**
Bridge Survey Phase1 **Yes** Phase 2 **Yes** None ☐
BeaverDams: **0** Length Affected (ft):

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid **Yes**
Point **Yes** Side: **Yes** Diagonal **Yes**
Delta Island None: **0**

5.2 Neck or Chute Cut Offs
Flood Chute: **Yes** Neck Cut-Off: **No**
Channel Avulsions **No** Braiding **Yes**

5.3 Steep Riffles or Head Cuts:
Steep Riffle: **Yes** Head Cut: **No**

5.6 Stream Ford/Animal Crossing **Yes**

5.5 Channel Alterations:
Dredging **Yes** Straightening
Bar Scalping Gravel Mining:
None **0**

Comments:

Phase 2 Geomorphic Assessment Data

Stream Name: **New Haven River**

Reach # M19

Segment: Reach

Rapid Habitat Assessment Field Data

Gradient Type: **High**

8.1 Epifaunal Substrate/Available Cover		**13**
8.2 Pool Substrate Character (low)/ Embededness (high)		**16**
8.3 Pool Variability (low) / Velocity Depth Regime (high)		**18**
8.4 Sediment Deposition		**8**
8.5 Channel Flow Status		**18**
8.6 Channel Alterations		**8**
8.7 Morphological Diversity		**18**
8.8 Bank Stability	Left	**6**
	Right	**5**
8.9 Vegetative Protection	Left	**7**
	Right	**2**
8.10 Riparian Vegetative Zone Width	Left	**4**
	Right	**1**
	TOTAL:	**0.62**
8.11 Habitat Condition:		**3-Fair**

Rapid Geomorphic Assessment Field Data

Confinement Type: **Unconfined**

			STD	Historic Adjustment
9.1 Deegre of Channel Degradation	**3**	**Poor**	☑	☑
9.2 Deegre of Channel Aggradation	**13**	**Good**	☐	☐
9.3 Over Widened Channel	**8**	**Fair**		☐
9.4 Change in Plaform	**11**	**Good**		☐

Adjustment Process(s): widening

9.5 Stage of Channel Evolution	**III**
TOTAL:	**0.44**
9.5 Geomorphic Condition:	**3-Fair**

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** | Reach # **M20** | Segment: **Reach**

Segment Length (ft): **3083** | Date: **6/19/2004** | Rain: **Yes** | Observers: **KU, EE, ST** | Organization: **SMRC**

Town: **Lincoln** | Location: **just downstream of lower Lincoln Gap crossing to just downstream upper Lincoln Gap**

Step 1 Valley and Floodplain:

1.1 Water Zone **Transfer**

1.2 Alluvial Fan **No**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) Right (ft)

Roads
Length: Left (ft) **1220** Right (ft) **160**

Railroads
Length: Left (ft) **0** Right (ft) **0**

Improved Paths
Length: Left (ft) **0** Right (ft) **0**

Development
Length: Left (ft) **2690** Right (ft) **400**

1.4 Adjacent Side Slope

Left Slope **moderate** Texture **Sand**
Cont. w/bank: **Sometimes**
W/in 1x Bkf: **Sometimes**

Right Slope **steep** Texture **Boulder**
Cont. w/bank **Sometimes**
W/in 1x Bkf: **Sometimes**

1.5 Confinemen **Narrowly Confined**
ValleyWidth: Rock Gorge ☐

1.6 Grade Controls

Waterfall **B** Photo: ☑
Total Height (ft) **3**
FMB (Phase 2 B/C survey)

Ledge: **B** Photo: ☑
Total Height (ft) **2**
FMB (Phase 2 B/C survey)

Dam: Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Weir: Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft) **62.3**
2.2 Max Depth (ft) **3.2**
2.3 Mean Depth (ft) **1.8**
2.4 Flood Prone Width (ft) **86.3**
2.5 Low Bank Height (ft) **6.8**
2.6 Ratio W/D **34.6**
2.7 Entrenchment **1.4**
2.8 Incision Ratio **2.13**
2.9 Sinuosity **Low**
2.10 Riffle/Steps
complete: **Yes** partial: **Yes** diagonal: **Yes**
continuous none **0**

2.11 Riffle/Steps Spacing (ft) **125**
Riffle/Step Spacing NA ☐

2.12 Bed Substrate Composition :

% Bedrock **0** % Boulder **2**
% Cobble **29** %CourseGravel: **43**
% Gravel **16** % Sand **9**
% Detritus **5** # LWD **78**
Silt/Clay **Yes**

2.13 Largest Particle on:
Bed **100** Bar **240** Units **Millimeter**

2.14 Stream Type **B 4 c** **Riffle-Pool**

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:

Typical Bank Slope **Steep**
Lower Bank Texture **Boulder/Cob**
Consistency: **Non-cohesiv**
Upper Bank Textue **Sand**
Consistency: **Non-cohesiv**

Left Bank
Erosion Length (ft) **300** Height (ft) **5**
Revetment Type **Rip-rap** Length (ft) **350**
Dom. Veg. Type **Shrubs-sapling**
SubDom. Veg. Type **Deciduous**
Left Bank Canopy **26-50%**

Right Bank
Erosion Length (ft) **250** Height (ft) **5**
Revetment Type **Rip-rap** Length (ft) **300**
Dom. Veg. Type **Deciduous**
SubDom Veg. Type:
Right Bank Canopy **76-100%**

Channel Canopy Cover: **Open**

3.2 Buffer:

Left Buffer: Dom.Width (ft) **5-25**
SubDom Width:(ft)
Dom. Veg. Type **Deciduous**
SubDom Veg. Type:

Right Buffer Dom.Width (ft) **>100**
SubDom Width:(ft)
Dom. Veg. Type **Deciduous**
SubDom Veg Type

3.3 Riparian Corridor
Left Dom **Commercial** SubDo **Residential**
Righ Dom **Forest** SubDo

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps **None**
4.2 Adjacent Wetlands **None**
4.3 Flow Status **Moderate**
4.4 # Current Debris Jams **0**
4.5 Upstream Impoundment **None**
4.6 # Stormwater Inputs **2**
4.7 Flow Regulations **None**
4.8 # Channel Constrictions **4**
None: **0** Culvert: Bridge: **Yes**
Abutments Bedrock: **Yes** Other **Yes**
Problems: DepAbove: **Yes** DepBelow: **Yes**
Scour Below: Angle: **Yes** None: **0**
Flood Prone Constriction: **Yes**
Bridge Survey Phase1 Phase 2 None ☐
BeaverDams: **0** Length Affected (ft):

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid **Yes**
Point **Yes** Side: **Yes** Diagonal **Yes**
Delta Island **Yes** None: **0**

5.2 Neck or Chute Cut Offs
Flood Chute: **No** Neck Cut-Off: **No**
Channel Avulsions **No** Braiding **No**

5.3 Steep Riffles or Head Cuts:
Steep Riffle: **Yes** Head Cut: **No**

5.6 Stream Ford/Animal Crossing **No**

5.5 Channel Alterations:
Dredging Straightening
Bar Scalping Gravel Mining:
None **0**

Comments: **Cross section was selected in subreach of B4c-R/P, to understand the worst-case sensitivity for portions of the reach. Majority of reach was B1-Step Pool.**

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** Reach # **M20** Segment: **Reach**

Rapid Habitat Assessment Field Data

Gradient Type:	High

Parameter		Score
8.1 Epifaunal Substrate/Available Cover		18
8.2 Pool Substrate Character (low)/ Embededness (high)		18
8.3 Pool Variability (low) / Velocity Depth Regime (high)		18
8.4 Sediment Deposition		8
8.5 Channel Flow Status		18
8.6 Channel Alterations		13
8.7 Morphological Diversity		18
8.8 Bank Stability	Left	7
	Right	7
8.9 Vegetative Protection	Left	5
	Right	7
8.10 Riparian Vegetative Zone Width	Left	2
	Right	9
	TOTAL:	0.74
8.11 Habitat Condition:		**2-Good**

Rapid Geomorphic Assessment Field Data

Confinement Type:	Confined

Parameter	Score	Rating	STD	Historic Adjustment
9.1 Deegre of Channel Degradation	18	Reference	☐	☐
9.2 Deegre of Channel Aggradation	13	Good	☐	☐
9.3 Over Widened Channel	13	Good		☐
9.4 Change in Plaform	18	Reference		☐
Adjustment Process(s)				
9.5 Stage of Channel Evolution	I			
TOTAL:	0.78			
9.5 Geomorphic Condition:	**2-Good**			

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** Reach # **M21** Segment: **Reach**

Segment Length (ft): **2702** Date: **6/12/2004** Rain: **Yes** Observers: **KU, HS, EE** Organization: **SMRC**

Town: **Lincoln** Location: **from just downstream upper Lincoln Gap crossing and parallel/west of Lincoln/Ripton**

Step 1 Valley and Floodplain:

1.1 Water Zone **Response**

1.2 Alluvial Fan **No**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) Right (ft)

Roads
Length: Left (ft) **150** Right (ft) **310**

Railroads
Length: Left (ft) Right (ft)

Improved Paths
Length: Left (ft) Right (ft)

Development
Length: Left (ft) **200** Right (ft) **100**

1.4 Adjacent Side Slope

Left Slope **moderate** Texture **t Evaluat**
Cont. w/bank: **Sometimes**
W/in 1x Bkf: **Sometimes**

Right Slope **moderate** Texture **t Evaluat**
Cont. w/bank **Sometimes**
W/in 1x Bkf: **Sometimes**

1.5 Confinemen
ValleyWidth: Rock Gorge ☐

1.6 Grade Controls

Waterfall **B** Photo: ☑
Total Height (ft) **4**
FMB (Phase 2 B/C survey)

Ledge: **B** Photo: ☑
Total Height (ft) **2**
FMB (Phase 2 B/C survey)

Dam: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Weir: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft) **59.9**
2.2 Max Depth (ft) **2.0**
2.3 Mean Depth (ft) **1.0**
2.4 Flood Prone Width (ft) **74.8**
2.5 Low Bank Height (ft) **4.0**
2.6 Ratio W/D **59.9**
2.7 Entrenchment **1.2**
2.8 Incision Ratio **2.00**
2.9 Sinuosity **Low**
2.10 Riffle/Steps
complete: **Yes** partial: diagonal: **Yes**
continuous none **0**

2.11 Riffle/Steps Spacing (ft)
Riffle/Step Spacing NA ☐

2.12 Bed Substrate Composition :

% Bedrock **0** % Boulder **8**
% Cobble **46** %CourseGravel: **24**
% Gravel **7** % Sand **11**
% Detritus **5** # LWD **5**
Silt/Clay **Yes**

2.13 Largest Particle on:
Bed Bar Units

2.14 Stream Type **C 3 Riffle-Pool**

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:

Typical Bank Slope **Moderate**
Lower Bank Texture **Boulder/Cob**
Consistency: **Non-cohesiv**
Upper Bank Textue **Sand**
Consistency: **Non-cohesiv**

Left Bank
Erosion Length (ft) **680** Height (ft) **2**
Revetment Type Length (ft)
Dom. Veg. Type **Shrubs-sapling**
SubDom. Veg. Type **Deciduous**
Left Bank Canopy **76-100%**

Right Bank
Erosion Length (ft) **400** Height (ft) **6**
Revetment Type **Rip-rap** Length (ft) **980**
Dom. Veg. Type **Herbaceous**
SubDom Veg. Type: **Deciduous**
Right Bank Canopy **1-25%**

Channel Canopy Cover: **Open**

3.2 Buffer:

Left Buffer: Dom.Width (ft) **>100**
SubDom Width:(ft) **51-100 ft**
Dom. Veg. Type **Mixed Trees**
SubDom Veg. Type:

Right Buffer Dom.Width (ft) **<5**
SubDom Width:(ft) **5-25 ft**
Dom. Veg. Type **Herbaceous**
SubDom Veg Type

3.3 Riparian Corridor

Left Dom **Forest** SubDo **Residential**
Righ Dom **Hay** SubDo **Shrub**

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps **Some**
4.2 Adjacent Wetlands **Some**
4.3 Flow Status **Moderate**
4.4 # Current Debris Jams **0**
4.5 Upstream Impoundment **None**
4.6 # Stormwater Inputs **1**
4.7 Flow Regulations **None**
4.8 # Channel Constrictions **3**
None: **0** Culvert: Bridge: **Yes**
Abutments Bedrock: **Yes** Other
Problems: DepAbove: **Yes** DepBelow:
Scour Below: **Yes** Angle: None: **0**
Flood Prone Constriction: **Yes**
Bridge Survey Phase1 Phase 2 None ☐
BeaverDams: **0** Length Affected (ft):

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid **Yes**
Point **Yes** Side: **Yes** Diagonal **Yes**
Delta Island None: **0**

5.2 Neck or Chute Cut Offs
Flood Chute: **Yes** Neck Cut-Off: **No**
Channel Avulsions **No** Braiding **No**

5.3 Steep Riffles or Head Cuts:
Steep Riffle: **Yes** Head Cut: **No**

5.6 Stream Ford/Animal Crossing **No**

5.5 Channel Alterations:
Dredging Straightening **Yes**
Bar Scalping Gravel Mining:
None **0**

Comments:

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River**

Reach # M21

Segment: Reach

Rapid Habitat Assessment Field Data

Gradient Type: **High**

8.1 Epifaunal Substrate/Available Cover		16
8.2 Pool Substrate Character (low)/ Embededness (high)		13
8.3 Pool Variability (low) / Velocity Depth Regime (high)		18
8.4 Sediment Deposition		10
8.5 Channel Flow Status		13
8.6 Channel Alterations		13
8.7 Morphological Diversity		18
8.8 Bank Stability	Left	6
	Right	8
8.9 Vegetative Protection	Left	6
	Right	4
8.10 Riparian Vegetative Zone Width	Left	9
	Right	1
	TOTAL:	0.68
8.11 Habitat Condition:		**2-Good**

Rapid Geomorphic Assessment Field Data

Confinement Type: **Unconfined**

			STD	Historic Adjustment
9.1 Deegre of Channel Degradation	5	Poor	☑	☑
9.2 Deegre of Channel Aggradation	11	Good	☐	☐
9.3 Over Widened Channel	3	Poor		☐
9.4 Change in Plaform	5	Poor		☐

Adjustment Process(s): Widening, planform

9.5 Stage of Channel Evolution	III
TOTAL:	0.30
9.5 Geomorphic Condition:	**4-Poor**

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** Reach # **M22** Segment: **Reach**

Segment Length (ft): **2687** Date: **6/12/2004** Rain: **Yes** Observers: **KU, HS, EE** Organization: **SMRC**

Town: **Lincoln** Location: **parallel/west of Lincoln/Ripton Rd to point downstream of intersection with Page Hill R**

Step 1 Valley and Floodplain:

1.1 Water Zone **Transfer**

1.2 Alluvial Fan **No**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) **20** Right (ft)

Roads
Length: Left (ft) Right (ft) **1900**

Railroads
Length: Left (ft) Right (ft)

Improved Paths
Length: Left (ft) Right (ft)

Development
Length: Left (ft) **200** Right (ft)

1.4 Adjacent Side Slope

Left Slope **moderate** Texture **Cobble**
Cont. w/bank: **Sometimes**
W/in 1x Bkf: **Sometimes**

Right Slope **moderate** Texture **Cobble**
Cont. w/bank **Sometimes**
W/in 1x Bkf: **Sometimes**

1.5 Confinemen **Narrowly Confined**
ValleyWidth: Rock Gorge ☐

1.6 Grade Controls

Waterfall **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Ledge: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Dam: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Weir: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft) **64.0**
2.2 Max Depth (ft) **2.4**
2.3 Mean Depth (ft) **1.2**
2.4 Flood Prone Width (ft) **74.8**
2.5 Low Bank Height (ft) **8.6**
2.6 Ratio W/D **53.3**
2.7 Entrenchment **1.2**
2.8 Incision Ratio **3.58**
2.9 Sinuosity **Low**
2.10 Riffle/Steps
complete: **Yes** partial: diagonal: **Yes**
continuous none **0**

2.11 Riffle/Steps Spacing (ft) **250**
Riffle/Step Spacing NA ☐

2.12 Bed Substrate Composition :

% Bedrock **0** % Boulder **13**
% Cobble **37** %CourseGravel: **35**
% Gravel **10** % Sand **5**
% Detritus # LWD **1**
Silt/Clay **Yes**

2.13 Largest Particle on:
Bed Bar Units

2.14 Stream Type **F** **4** **Plane Bed**

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:

Typical Bank Slope **Steep**
Lower Bank Texture **Boulder/Cob**
Consistency: **Non-cohesiv**
Upper Bank Textue **Mix**
Consistency: **Cohesive**

Left Bank
Erosion Length (ft) **500** Height (ft) **3**
Revetment Type Length (ft)
Dom. Veg. Type **Deciduous**
SubDom. Veg. Type
Left Bank Canopy **76-100%**

Right Bank
Erosion Length (ft) **500** Height (ft) **2**
Revetment Type **Rip-rap** Length (ft) **100**
Dom. Veg. Type **Bare**
SubDom Veg. Type:
Right Bank Canopy **1-25%**

Channel Canopy Cover: **Open**

3.2 Buffer:

Left Buffer: Dom.Width (ft) **51-100**
SubDom Width:(ft)
Dom. Veg. Type **Deciduous**
SubDom Veg. Type:

Right Buffer Dom.Width (ft) **5-25**
SubDom Width:(ft)
Dom. Veg. Type **Herbaceous**
SubDom Veg Type

3.3 Riparian Corridor

Left Dom **Forest** SubDo **Residential**
Righ Dom **Bare** SubDo **Residential**

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps **Some**
4.2 Adjacent Wetlands **None**
4.3 Flow Status **Moderate**
4.4 # Current Debris Jams **0**
4.5 Upstream Impoundment **None**
4.6 # Stormwater Inputs **2**
4.7 Flow Regulations **None**
4.8 # Channel Constrictions **1**
None: **-1** Culvert: Bridge: **Yes**
Abutments Bedrock: Other
Problems: DepAbove: DepBelow:
Scour Below: Angle: None: **0**
Flood Prone Constriction: **Yes**
Bridge Survey Phase1 Phase 2 None ☐
BeaverDams: **0** Length Affected (ft):

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid
Point Side: **Yes** Diagonal
Delta Island None: **0**

5.2 Neck or Chute Cut Offs
Flood Chute: **No** Neck Cut-Off: **No**
Channel Avulsions **No** Braiding **No**

5.3 Steep Riffles or Head Cuts:
Steep Riffle: **No** Head Cut: **No**

5.6 Stream Ford/Animal Crossing **No**

5.5 Channel Alterations:
Dredging Straightening **Yes**
Bar Scalping Gravel Mining:
None **0**

Comments:

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** Reach # **M22** Segment: **Reach**

Rapid Habitat Assessment Field Data

Gradient Type: **High**

8.1 Epifaunal Substrate/Available Cover		7
8.2 Pool Substrate Character (low)/ Embededness (high)		16
8.3 Pool Variability (low) / Velocity Depth Regime (high)		18
8.4 Sediment Deposition		13
8.5 Channel Flow Status		18
8.6 Channel Alterations		10
8.7 Morphological Diversity		18
8.8 Bank Stability	Left	8
	Right	8
8.9 Vegetative Protection	Left	8
	Right	2
8.10 Riparian Vegetative Zone Width	Left	9
	Right	2
	TOTAL:	0.69
8.11 Habitat Condition:		2-Good

Rapid Geomorphic Assessment Field Data

Confinement Type: **Unconfined**

			STD	Historic Adjustment
9.1 Deegre of Channel Degradation	3	Poor	☑	☑
9.2 Deegre of Channel Aggradation	11	Good	☐	☐
9.3 Over Widened Channel	5	Poor		☑
9.4 Change in Plaform	16	Reference		☐

Adjustment Process(s): Widening

9.5 Stage of Channel Evolution	IV
TOTAL:	0.44
9.5 Geomorphic Condition:	3-Fair

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** Reach # **M25** Segment: **Reach**

Segment Length (ft): **5458** Date: **8/26/2004** Rain: **Yes** Observers: **KU, EE** Organization: **SMRC**

Town: **Lincoln** Location:

Step 1 Valley and Floodplain:

1.1 Water Zone **Transfer**

1.2 Alluvial Fan **No**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) Right (ft)

Roads
Length: Left (ft) Right (ft)

Railroads
Length: Left (ft) Right (ft)

Improved Paths
Length: Left (ft) Right (ft)

Development
Length: Left (ft) Right (ft) **300**

1.4 Adjacent Side Slope

Left Slope **steep** Texture **Boulder**
Cont. w/bank: **Sometimes**
W/in 1x Bkf: **Sometimes**

Right Slope **shallow** Texture **Boulder**
Cont. w/bank **Sometimes**
W/in 1x Bkf: **Sometimes**

1.5 Confinemen **Semi-Confined**
ValleyWidth: **150** Rock Gorge ☐

1.6 Grade Controls

Waterfall **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Ledge: **U** Photo: ☑
Total Height (ft) **1**
FMB (Phase 2 B/C survey)

Dam: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Weir: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft) **40.0**
2.2 Max Depth (ft) **3.2**
2.3 Mean Depth (ft) **1.8**
2.4 Flood Prone Width (ft) **180.0**
2.5 Low Bank Height (ft) **4.5**
2.6 Ratio W/D **22.2**
2.7 Entrenchment **4.5**
2.8 Incision Ratio **1.41**
2.9 Sinuosity **Low**
2.10 Riffle/Steps
complete: **Yes** partial: **Yes** diagonal: **Yes**
continuous none **0**

2.11 Riffle/Steps Spacing (ft) **250**
Riffle/Step Spacing NA ☐

2.12 Bed Substrate Composition :

% Bedrock **0** % Boulder **19**
% Cobble **40** %CourseGravel: **22**
% Gravel **8** % Sand **11**
% Detritus **3** # LWD **30**
Silt/Clay **No**

2.13 Largest Particle on:
Bed **350** Bar **400** Units **Millimeter**

2.14 Stream Type **C** **3** **Riffle-Pool**

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:

Typical Bank Slope **Steep**
Lower Bank Texture **Boulder/Cob**
Consistency: **Non-cohesiv**
Upper Bank Textue **Boulder/Cob**
Consistency: **Non-cohesiv**

Left Bank
Erosion Length (ft) **725** Height (ft) **10**
Revetment Type **Rip-rap** Length (ft) **60**
Dom. Veg. Type **Coniferous**
SubDom. Veg. Type
Left Bank Canopy **76-100%**

Right Bank
Erosion Length (ft) **1125** Height (ft) **8**
Revetment Type **Rip-rap** Length (ft) **410**
Dom. Veg. Type **Deciduous**
SubDom Veg. Type:
Right Bank Canopy **51-75%**

Channel Canopy Cover: **Open**

3.2 Buffer:

Left Buffer: Dom.Width (ft) **>100**
SubDom Width:(ft)
Dom. Veg. Type **Mixed Trees**
SubDom Veg. Type:

Right Buffer Dom.Width (ft) **26-50**
SubDom Width:(ft)
Dom. Veg. Type **Mixed Trees**
SubDom Veg Type

3.3 Riparian Corridor

Left Dom **Forest** SubDo
Righ Dom **Hay** SubDo

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps **Some**
4.2 Adjacent Wetlands **Some**
4.3 Flow Status **Moderate**
4.4 # Current Debris Jams **2**
4.5 Upstream Impoundment **None**
4.6 # Stormwater Inputs **0**
4.7 Flow Regulations **None**
4.8 # Channel Constrictions **1**
None: **0** Culvert: Bridge: **Yes**
Abutments Bedrock: Other
Problems: DepAbove: **Yes** DepBelow:
Scour Below: Angle: None: **0**
Flood Prone Constriction: **Yes**
Bridge Survey Phase1 Phase 2 None ☐
BeaverDams: **0** Length Affected (ft):

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid **Yes**
Point **Yes** Side: **Yes** Diagonal **Yes**
Delta Island None: **0**

5.2 Neck or Chute Cut Offs
Flood Chute: **Yes** Neck Cut-Off: **No**
Channel Avulsions **No** Braiding **No**

5.3 Steep Riffles or Head Cuts:
Steep Riffle: **Yes** Head Cut: **No**

5.6 Stream Ford/Animal Crossing **Yes**

5.5 Channel Alterations:
Dredging Straightening **Yes**
Bar Scalping Gravel Mining:
None **0**

Comments:

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** Reach # **M25** Segment: **Reach**

Rapid Habitat Assessment Field Data

Gradient Type: **High**

8.1 Epifaunal Substrate/Available Cover		18
8.2 Pool Substrate Character (low)/ Embededness (high)		18
8.3 Pool Variability (low) / Velocity Depth Regime (high)		18
8.4 Sediment Deposition		8
8.5 Channel Flow Status		13
8.6 Channel Alterations		18
8.7 Morphological Diversity		18
8.8 Bank Stability	Left	7
	Right	5
8.9 Vegetative Protection	Left	10
	Right	4
8.10 Riparian Vegetative Zone Width	Left	10
	Right	5
	TOTAL:	0.76
8.11 Habitat Condition:		**2-Good**

Rapid Geomorphic Assessment Field Data

Confinement Type: **Unconfined**

			STD	Historic Adjustment
9.1 Deegre of Channel Degradation	13	Good	☐	☑
9.2 Deegre of Channel Aggradation	10	Fair	☐	☐
9.3 Over Widened Channel	8	Fair		☐
9.4 Change in Plaform	11	Good		☐

Adjustment Process(s): Widening/aggradation

9.5 Stage of Channel Evolution	III
TOTAL:	0.53
9.5 Geomorphic Condition:	**3-Fair**

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River** Reach # **M26** Segment: **Reach**

Segment Length (ft): **3666** Date: **8/26/2004** Rain: **Yes** Observers: **KU, EE** Organization: **SMRC**

Town: **Lincoln** Location:

Step 1 Valley and Floodplain:

1.1 Water Zone **Transfer**

1.2 Alluvial Fan **No**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) Right (ft) **200**

Roads
Length: Left (ft) Right (ft) **2600**

Railroads
Length: Left (ft) Right (ft)

Improved Paths
Length: Left (ft) Right (ft)

Development
Length: Left (ft) **100** Right (ft) **100**

1.4 Adjacent Side Slope

Left Slope **steep** Texture **Boulder**
Cont. w/bank: **Sometimes**
W/in 1x Bkf: **Sometimes**

Right Slope **shallow** Texture **Boulder**
Cont. w/bank **Sometimes**
W/in 1x Bkf: **Sometimes**

1.5 Confinemen **Semi-Confined**
ValleyWidth: **150** Rock Gorge ☐

1.6 Grade Controls

Waterfall **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Ledge: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Dam: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Weir: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft) **49.1**
2.2 Max Depth (ft) **2.6**
2.3 Mean Depth (ft) **1.7**
2.4 Flood Prone Width (ft) **112.0**
2.5 Low Bank Height (ft) **5.0**
2.6 Ratio W/D **28.4**
2.7 Entrenchment **2.3**
2.8 Incision Ratio **1.92**
2.9 Sinuosity **Low**
2.10 Riffle/Steps
complete: **Yes** partial: **Yes** diagonal: **Yes**
continuous **Yes** none **0**

2.11 Riffle/Steps Spacing (ft)
Riffle/Step Spacing NA ☐

2.12 Bed Substrate Composition :

% Bedrock **0** % Boulder **15**
% Cobble **37** %CourseGravel: **38**
% Gravel % Sand **10**
% Detritus **5** # LWD **19**
Silt/Clay **Yes**

2.13 Largest Particle on:
Bed Bar Units

2.14 Stream Type **C 3 b Step-Pool**

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:

Typical Bank Slope **Steep**
Lower Bank Texture **Boulder/Cob**
Consistency: **Non-cohesiv**
Upper Bank Textue **Boulder/Cob**
Consistency: **Non-cohesiv**

Left Bank
Erosion Length (ft) **260** Height (ft) **4**
Revetment Type **Rip-rap** Length (ft) **265**
Dom. Veg. Type **Deciduous**
SubDom. Veg. Type
Left Bank Canopy **51-75%**

Right Bank
Erosion Length (ft) **450** Height (ft) **4**
Revetment Type **Rip-rap** Length (ft) **945**
Dom. Veg. Type **Herbaceous**
SubDom Veg. Type:
Right Bank Canopy **1-25%**

Channel Canopy Cover: **Open**

3.2 Buffer:

Left Buffer: Dom.Width (ft) **>100**
SubDom Width:(ft)
Dom. Veg. Type **Deciduous**
SubDom Veg. Type:

Right Buffer Dom.Width (ft) **5-25**
SubDom Width:(ft)
Dom. Veg. Type **Herbaceous**
SubDom Veg Type

3.3 Riparian Corridor

Left Dom **Forest** SubDo
Righ Dom **Crop** SubDo

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps **None**
4.2 Adjacent Wetlands **None**
4.3 Flow Status **Moderate**
4.4 # Current Debris Jams **0**
4.5 Upstream Impoundment **None**
4.6 # Stormwater Inputs **0**
4.7 Flow Regulations **None**
4.8 # Channel Constrictions **3**
None: **0** Culvert: Bridge: **Yes**
Abutments Bedrock: **Yes** Other **Yes**
Problems: DepAbove: **Yes** DepBelow:
Scour Below: **Yes** Angle: None: **0**
Flood Prone Constriction: **Yes**
Bridge Survey Phase1 Phase 2 None ☐
BeaverDams: **0** Length Affected (ft):

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid **Yes**
Point **Yes** Side: **Yes** Diagonal
Delta Island **Yes** None: **0**

5.2 Neck or Chute Cut Offs
Flood Chute: **Yes** Neck Cut-Off: **No**
Channel Avulsions **Yes** Braiding **No**

5.3 Steep Riffles or Head Cuts:
Steep Riffle: **Yes** Head Cut: **No**

5.6 Stream Ford/Animal Crossing **Yes**

5.5 Channel Alterations:
Dredging Straightening **Yes**
Bar Scalping Gravel Mining:
None **0**

Comments:

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **New Haven River**

Reach # M26

Segment: Reach

Rapid Habitat Assessment Field Data

Gradient Type: **High**

8.1 Epifaunal Substrate/Available Cover		18
8.2 Pool Substrate Character (low)/ Embededness (high)		18
8.3 Pool Variability (low) / Velocity Depth Regime (high)		18
8.4 Sediment Deposition		13
8.5 Channel Flow Status		13
8.6 Channel Alterations		8
8.7 Morphological Diversity		18
8.8 Bank Stability	Left	8
	Right	7
8.9 Vegetative Protection	Left	7
	Right	4
8.10 Riparian Vegetative Zone Width	Left	10
	Right	1
	TOTAL:	0.72
8.11 Habitat Condition:		2-Good

Rapid Geomorphic Assessment Field Data

Confinement Type: **Unconfined**

			STD	Historic Adjustment
9.1 Deegre of Channel Degradation	8	Fair	☐	☑
9.2 Deegre of Channel Aggradation	13	Good	☐	☐
9.3 Over Widened Channel	9	Fair		☐
9.4 Change in Plaform	11	Good		☐

Adjustment Process(s): Degradation/widening. STD due to Deg is imminent.

9.5 Stage of Channel Evolution	II
TOTAL:	0.51
9.5 Geomorphic Condition:	3-Fair

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **Baldwin Creek** | **Reach # T3.06** | **Segment: Reach**

Segment Length (ft): **4374** | Date: **6/11/2004** | Rain: **Yes** | Observers: **KU, PG, SH** | Organization: **SMRC, DEC**

Town: **Starksboro** | Location: **from point north of Rt 17/Quaker St jct in S Starksboro parallel and northwest of Rt 17**

Step 1 Valley and Floodplain:

1.1 Water Zone **Transfer**

1.2 Alluvial Fan **No**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) **400** Right (ft)

Roads
Length: Left (ft) **0** Right (ft)

Railroads
Length: Left (ft) Right (ft)

Improved Paths
Length: Left (ft) Right (ft) **300**

Development
Length: Left (ft) Right (ft)

1.4 Adjacent Side Slope

Left Slope **steep** Texture **Boulder**
Cont. w/bank: **Sometimes**
W/in 1x Bkf: **Sometimes**

Right Slope **steep** Texture **Boulder**
Cont. w/bank **Sometimes**
W/in 1x Bkf: **Sometimes**

1.5 Confinemen **Semi-Confined**
ValleyWidth: Rock Gorge ☐

1.6 Grade Controls

Waterfall **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Ledge: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Dam: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Weir: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft) **34.8**

2.2 Max Depth (ft) **1.4**

2.3 Mean Depth (ft) **0.9**

2.4 Flood Prone Width (ft) **39.6**

2.5 Low Bank Height (ft)

2.6 Ratio W/D **38.7**

2.7 Entrenchment **1.1**

2.8 Incision Ratio

2.9 Sinuosity **Low**

2.10 Riffle/Steps
complete: **Yes** partial: diagonal:
continuous none **0**

2.11 Riffle/Steps Spacing (ft)
Riffle/Step Spacing NA ☐

2.12 Bed Substrate Composition :

% Bedrock **0** % Boulder **11**
% Cobble **24** %CourseGravel: **46**
% Gravel **9** % Sand **10**
% Detritus **0** # LWD **41**
Silt/Clay **No**

2.13 Largest Particle on:
Bed Bar Units

2.14 Stream Type **B 4 c Step-Pool**

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:

Typical Bank Slope **Undercut**
Lower Bank Texture **Boulder/Cob**
Consistency: **Non-cohesiv**
Upper Bank Textue **Gravel**
Consistency: **Non-cohesiv**

Left Bank
Erosion Length (ft) **3000** Height (ft) **1**
Revetment Type **Rip-rap** Length (ft) **60**
Dom. Veg. Type **Coniferous**
SubDom. Veg. Type
Left Bank Canopy **76-100%**

Right Bank
Erosion Length (ft) **3000** Height (ft) **1**
Revetment Type **Rip-rap** Length (ft) **20**
Dom. Veg. Type **Coniferous**
SubDom Veg. Type:
Right Bank Canopy **76-100%**

Channel Canopy Cover: **Closed**

3.2 Buffer:

Left Buffer: Dom.Width (ft) **>100**
SubDom Width:(ft)
Dom. Veg. Type **Mixed Trees**
SubDom Veg. Type:

Right Buffer Dom.Width (ft) **>100**
SubDom Width:(ft)
Dom. Veg. Type **Mixed Trees**
SubDom Veg Type

3.3 Riparian Corridor
Left Dom **Forest** SubDo
Righ Dom **Forest** SubDo

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps **Abundant**

4.2 Adjacent Wetlands **Some**

4.3 Flow Status **Moderate**

4.4 # Current Debris Jams **1**

4.5 Upstream Impoundment **None**

4.6 # Stormwater Inputs **4**

4.7 Flow Regulations **None**

4.8 # Channel Constrictions **3**

None: **0** Culvert: Bridge:
Abutments Bedrock: **Yes** Other **Yes**
Problems: DepAbove: **Yes** DepBelow:
Scour Below: **Yes** Angle: None: **0**
Flood Prone Constriction: **Yes**
Bridge Survey Phase1 Phase 2 None ☐
BeaverDams: **0** Length Affected (ft):

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid **Yes**
Point **Yes** Side: **Yes** Diagonal
Delta Island None: **0**

5.2 Neck or Chute Cut Offs
Flood Chute: **Yes** Neck Cut-Off: **No**
Channel Avulsions **No** Braiding

5.3 Steep Riffles or Head Cuts:
Steep Riffle: **No** Head Cut: **No**

5.6 Stream Ford/Animal Crossing **No**

5.5 Channel Alterations:
Dredging Straightening
Bar Scalping Gravel Mining:
None **0**

Comments:

Phase 2 Geomorphic Assessment Data

Stream Name: **Baldwin Creek**

Reach # T3.06

Segment: Reach

Rapid Habitat Assessment Field Data

Gradient Type:	**High**

8.1 Epifaunal Substrate/Available Cover			**16**
8.2 Pool Substrate Character (low)/ Embededness (high)			**13**
8.3 Pool Variability (low) / Velocity Depth Regime (high)			**18**
8.4 Sediment Deposition			**15**
8.5 Channel Flow Status			**18**
8.6 Channel Alterations			**18**
8.7 Morphological Diversity			**18**
8.8 Bank Stability		Left	**7**
		Right	**7**
8.9 Vegetative Protection		Left	**9**
		Right	**9**
8.10 Riparian Vegetative Zone Width		Left	**10**
		Right	**10**
		TOTAL:	**0.84**
8.11 Habitat Condition:			**2-Good**

Rapid Geomorphic Assessment Field Data

Confinement Type:	**Unconfined**

			STD	Historic Adjustment
9.1 Deegre of Channel Degradation	**13**	**Good**	☐	☑
9.2 Deegre of Channel Aggradation	**16**	**Reference**	☐	☐
9.3 Over Widened Channel	**13**	**Good**		☐
9.4 Change in Plaform	**15**	**Good**		☐

Adjustment Process(s)	Widening

9.5 Stage of Channel Evolution	**V**
TOTAL:	**0.71**
9.5 Geomorphic Condition:	**2-Good**

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **Beaver Meadow** Reach # **T4.03** Segment: **B**

Segment Length (ft): **3704** Date: **7/26/2004** Rain: **Yes** Observers: **KU, EE** Organization: **SMRC**

Town: **Lincoln** Location: **from point midway between Quaker Rd and Downingsville Village, parallel to Downings**

Step 1 Valley and Floodplain:

1.1 Water Zone **Response**

1.2 Alluvial Fan **No**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) Right (ft) **250**

Roads
Length: Left (ft) Right (ft) **540**

Railroads
Length: Left (ft) Right (ft)

Improved Paths
Length: Left (ft) Right (ft) **150**

Development
Length: Left (ft) **50** Right (ft) **540**

1.4 Adjacent Side Slope

Left Slope **moderate** Texture **Boulder**
Cont. w/bank: **Sometimes**
W/in 1x Bkf: **Sometimes**

Right Slope **moderate** Texture **Boulder**
Cont. w/bank **Sometimes**
W/in 1x Bkf: **Sometimes**

1.5 Confinemen **Narrow**
ValleyWidth: Rock Gorge ☐

1.6 Grade Controls

Waterfall **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Ledge: **D** Photo: ☑
Total Height (ft) **2**
FMB (Phase 2 B/C survey)

Dam: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Weir: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft) **26.5**
2.2 Max Depth (ft) **1.6**
2.3 Mean Depth (ft) **1.0**
2.4 Flood Prone Width (ft) **76.0**
2.5 Low Bank Height (ft) **3.0**
2.6 Ratio W/D **26.5**
2.7 Entrenchment **2.9**
2.8 Incision Ratio **1.88**
2.9 Sinuosity **Moderate**
2.10 Riffle/Steps
complete: **Yes** partial: diagonal: **Yes**
continuous **Yes** none **0**

2.11 Riffle/Steps Spacing (ft) **120**
Riffle/Step Spacing NA ☐

2.12 Bed Substrate Composition :

% Bedrock **0** % Boulder **6**
% Cobble **48** %CourseGravel: **24**
% Gravel **15** % Sand **6**
% Detritus **20** # LWD **43**
Silt/Clay **No**

2.13 Largest Particle on:
Bed Bar Units

2.14 Stream Type **C 3 Riffle-Pool**

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:

Typical Bank Slope **Steep**
Lower Bank Texture **Boulder/Cob**
Consistency: **Non-cohesiv**
Upper Bank Textue **Gravel**
Consistency: **Non-cohesiv**

Left Bank
Erosion Length (ft) **317** Height (ft) **5**
Revetment Type **Rip-rap** Length (ft) **480**
Dom. Veg. Type **Shrubs-sapling**
SubDom. Veg. Type
Left Bank Canopy **76-100%**

Right Bank
Erosion Length (ft) **487** Height (ft) **3**
Revetment Type **Rip-rap** Length (ft) **50**
Dom. Veg. Type **Shrubs-sapling**
SubDom Veg. Type:
Right Bank Canopy **51-75%**

Channel Canopy Cover: **Open**

3.2 Buffer:

Left Buffer: Dom.Width (ft) **>100**
SubDom Width:(ft)
Dom. Veg. Type **Mixed Trees**
SubDom Veg. Type:

Right Buffer Dom.Width (ft) **26-50**
SubDom Width:(ft)
Dom. Veg. Type **Mixed Trees**
SubDom Veg Type

3.3 Riparian Corridor

Left Dom **Forest** SubDo **Residential**
Righ Dom **Forest** SubDo **Residential**

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps **Abundant**
4.2 Adjacent Wetlands **Some**
4.3 Flow Status **Moderate**
4.4 # Current Debris Jams **7**
4.5 Upstream Impoundment **None**
4.6 # Stormwater Inputs **2**
4.7 Flow Regulations **None**
4.8 # Channel Constrictions **3**
None: **0** Culvert: **No** Bridge: **No**
Abutments **No** Bedrock: **Yes** Other **Yes**
Problems: DepAbove: **Yes** DepBelow: **No**
Scour Below: **Yes** Angle: **No** None: **0**
Flood Prone Constriction: **Yes**
Bridge Survey Phase1 Phase 2 None ☐
BeaverDams: **0** Length Affected (ft):

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid **Yes**
Point **Yes** Side: **Yes** Diagonal **Yes**
Delta **No** Island **No** None: **0**

5.2 Neck or Chute Cut Offs
Flood Chute: **Yes** Neck Cut-Off: **Yes**
Channel Avulsions **Yes** Braiding **Yes**

5.3 Steep Riffles or Head Cuts:
Steep Riffle: **Yes** Head Cut: **No**

5.6 Stream Ford/Animal Crossing **No**

5.5 Channel Alterations:
Dredging Straightening **Yes**
Bar Scalping Gravel Mining:
None **0**

Comments: **LWD is count for entire reach. Majority of LWD was noted within this Segment (B).**

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **Beaver Meadow**

Reach # T4.03

Segment: B

Rapid Habitat Assessment Field Data

Gradient Type: **High**

8.1 Epifaunal Substrate/Available Cover			16
8.2 Pool Substrate Character (low)/ Embededness (high)			13
8.3 Pool Variability (low) / Velocity Depth Regime (high)			18
8.4 Sediment Deposition			8
8.5 Channel Flow Status			18
8.6 Channel Alterations			11
8.7 Morphological Diversity			18
8.8 Bank Stability		Left	8
		Right	5
8.9 Vegetative Protection		Left	8
		Right	6
8.10 Riparian Vegetative Zone Width		Left	9
		Right	4
		TOTAL:	0.71
8.11 Habitat Condition:			**2-Good**

Rapid Geomorphic Assessment Field Data

Confinement Type: **Unconfined**

			STD	Historic Adjustment
9.1 Deegre of Channel Degradation	12	Good	☐	☑
9.2 Deegre of Channel Aggradation	13	Good	☐	☐
9.3 Over Widened Channel	13	Good		☐
9.4 Change in Plaform	12	Good		☐

Adjustment Process(s): Aggradation/Planform. Some widening

9.5 Stage of Channel Evolution	IV
TOTAL:	0.63
9.5 Geomorphic Condition:	**3-Fair**

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **Beaver Meadow** | Reach # **T4.04** | Segment: **Reach**

Segment Length (ft): **4858** | Date: **7/31/2004** | Rain: **Yes** | Observers: **KU, EE, ZG** | Organization: **SMRC**

Town: **Lincoln** | Location: **from point downstream of Hall Rd. bridge crossing, parallel but somewhat distant from**

Step 1 Valley and Floodplain:

1.1 Water Zone **Transfer**

1.2 Alluvial Fan **No**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) **400** Right (ft)

Roads
Length: Left (ft) **0** Right (ft) **1475**

Railroads
Length: Left (ft) Right (ft)

Improved Paths
Length: Left (ft) Right (ft)

Development
Length: Left (ft) **100** Right (ft) **50**

1.4 Adjacent Side Slope

Left Slope **steep** Texture **Boulder**
Cont. w/bank: **Sometimes**
W/in 1x Bkf: **Sometimes**

Right Slope **moderate** Texture **Boulder**
Cont. w/bank **Sometimes**
W/in 1x Bkf: **Sometimes**

1.5 Confinemen **Semi-Confined**
ValleyWidth: Rock Gorge ☐

1.6 Grade Controls

Waterfall **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Ledge: **D** Photo: ☐
Total Height (ft) **3**
FMB (Phase 2 B/C survey)

Dam: **U** Photo: ☑
Total Height (ft) **1**
FMB (Phase 2 B/C survey)

Weir: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft) **21.9**

2.2 Max Depth (ft) **1.8**

2.3 Mean Depth (ft) **1.1**

2.4 Flood Prone Width (ft) **28.9**

2.5 Low Bank Height (ft)

2.6 Ratio W/D **19.9**

2.7 Entrenchment **1.3**

2.8 Incision Ratio

2.9 Sinuosity **Low**

2.10 Riffle/Steps
complete: **Yes** partial: **No** diagonal: **Yes**
continuous **No** none **0**

2.11 Riffle/Steps Spacing (ft) **55**
Riffle/Step Spacing NA ☐

2.12 Bed Substrate Composition :

% Bedrock **0** % Boulder **6**
% Cobble **37** %CourseGravel: **31**
% Gravel **8** % Sand **17**
% Detritus **5** # LWD **41**
Silt/Clay **Yes**

2.13 Largest Particle on:
Bed Bar Units

2.14 Stream Type **B** **4** **Riffle-Pool**

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:

Typical Bank Slope **Steep**
Lower Bank Texture **Boulder/Cob**
Consistency: **Non-cohesiv**
Upper Bank Textue **Boulder/Cob**
Consistency: **Cohesive**

Left Bank
Erosion Length (ft) **70** Height (ft) **3**
Revetment Type **None** Length (ft)
Dom. Veg. Type **Deciduous**
SubDom. Veg. Type
Left Bank Canopy **76-100%**

Right Bank
Erosion Length (ft) **410** Height (ft) **2**
Revetment Type **Rip-rap** Length (ft) **450**
Dom. Veg. Type **Deciduous**
SubDom Veg. Type:
Right Bank Canopy **76-100%**

Channel Canopy Cover: **Closed**

3.2 Buffer:

Left Buffer: Dom.Width (ft) **>100**
SubDom Width:(ft)
Dom. Veg. Type **Mixed Trees**
SubDom Veg. Type:

Right Buffer Dom.Width (ft) **51-100**
SubDom Width:(ft)
Dom. Veg. Type **Mixed Trees**
SubDom Veg Type

3.3 Riparian Corridor

Left Dom **Forest** SubDo
Righ Dom **Forest** SubDo

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps **Abundant**

4.2 Adjacent Wetlands **Some**

4.3 Flow Status **Moderate**

4.4 # Current Debris Jams **5**

4.5 Upstream Impoundment **None**

4.6 # Stormwater Inputs **2**

4.7 Flow Regulations **None**

4.8 # Channel Constrictions **2**

None: **0** Culvert: **No** Bridge: **No**
Abutments **No** Bedrock: **No** Other **Yes**
Problems: DepAbove: DepBelow:
Scour Below: Angle: None: **-1**
Flood Prone Constriction: **Yes**
Bridge Survey Phase1 **Yes** Phase 2 **Yes** None ☐
BeaverDams: **0** Length Affected (ft):

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid **Yes**
Point **Yes** Side: **Yes** Diagonal **Yes**
Delta **No** Island **No** None: **0**

5.2 Neck or Chute Cut Offs
Flood Chute: **Yes** Neck Cut-Off: **No**
Channel Avulsions **Yes** Braiding **No**

5.3 Steep Riffles or Head Cuts:
Steep Riffle: **Yes** Head Cut: **No**

5.6 Stream Ford/Animal Crossing **No**

5.5 Channel Alterations:
Dredging Straightening
Bar Scalping Gravel Mining:
None **0**

Comments:

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **Beaver Meadow** Reach # **T4.04** Segment: **Reach**

Rapid Habitat Assessment Field Data

Gradient Type: **High**

8.1 Epifaunal Substrate/Available Cover		**16**
8.2 Pool Substrate Character (low)/ Embededness (high)		**13**
8.3 Pool Variability (low) / Velocity Depth Regime (high)		**18**
8.4 Sediment Deposition		**10**
8.5 Channel Flow Status		**18**
8.6 Channel Alterations		**15**
8.7 Morphological Diversity		**18**
8.8 Bank Stability	Left	**9**
	Right	**9**
8.9 Vegetative Protection	Left	**9**
	Right	**9**
8.10 Riparian Vegetative Zone Width	Left	**9**
	Right	**7**
	TOTAL:	**0.80**
8.11 Habitat Condition:		**2-Good**

Rapid Geomorphic Assessment Field Data

Confinement Type: **Confined**

			STD	Historic Adjustment
9.1 Deegre of Channel Degradation	**10**	**Fair**	☐	☑
9.2 Deegre of Channel Aggradation	**15**	**Good**	☐	☐
9.3 Over Widened Channel	**13**	**Good**		☐
9.4 Change in Plaform	**17**	**Reference**		☐

Adjustment Process(s): Widening/Aggradation

9.5 Stage of Channel Evolution	**III**
TOTAL:	**0.69**
9.5 Geomorphic Condition:	**2-Good**

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **Baldwin Creek** Reach # **T3.07** Segment: **Reach**

Segment Length (ft): **4914** Date: **6/11/2004** Rain: **Yes** Observers: **KU, PG, SH** Organization: **SMRC, DEC**

Town: **Starksboro** Location: **from point approx 1000 ft west of jct Lafayette Rd and crossing under Rt 17 south of Ro**

Step 1 Valley and Floodplain:

1.1 Water Zone **Transfer**

1.2 Alluvial Fan **No**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) Right (ft)

Roads
Length: Left (ft) Right (ft) **600**

Railroads
Length: Left (ft) Right (ft)

Improved Paths
Length: Left (ft) Right (ft)

Development
Length: Left (ft) Right (ft)

1.4 Adjacent Side Slope

Left Slope **steep** Texture **Boulder**
Cont. w/bank: **Sometimes**
W/in 1x Bkf: **Sometimes**

Right Slope **steep** Texture **Boulder**
Cont. w/bank **Sometimes**
W/in 1x Bkf: **Sometimes**

1.5 Confinemen **Narrowly Confined**
ValleyWidth: **60** Rock Gorge ☐

1.6 Grade Controls

Waterfall **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Ledge: **U** Photo: ☐
Total Height (ft) **1**
FMB (Phase 2 B/C survey)

Dam: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Weir: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: **D** Photo ☑
Total Height (ft) **8**
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft) **31.4**

2.2 Max Depth (ft) **2.0**

2.3 Mean Depth (ft) **0.8**

2.4 Flood Prone Width (ft) **38.9**

2.5 Low Bank Height (ft)

2.6 Ratio W/D **39.3**

2.7 Entrenchment **1.2**

2.8 Incision Ratio

2.9 Sinuosity **Low**

2.10 Riffle/Steps
complete: **Yes** partial: diagonal: **Yes**
continuous none **0**

2.11 Riffle/Steps Spacing (ft)
Riffle/Step Spacing NA ☐

2.12 Bed Substrate Composition :

% Bedrock **0** % Boulder **22**
% Cobble **31** %CourseGravel: **21**
% Gravel **10** % Sand **15**
% Detritus **5** # LWD **18**
Silt/Clay **Yes**

2.13 Largest Particle on:
Bed Bar Units

2.14 Stream Type **B 3 Step-Pool**

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:

Typical Bank Slope **Steep**
Lower Bank Texture **Boulder/Cob**
Consistency: **Non-cohesiv**
Upper Bank Textue **Mix**
Consistency: **Cohesive**

Left Bank
Erosion Length (ft) **300** Height (ft) **1**
Revetment Type Length (ft)
Dom. Veg. Type **Coniferous**
SubDom. Veg. Type
Left Bank Canopy **76-100%**

Right Bank
Erosion Length (ft) **500** Height (ft) **1**
Revetment Type **Rip-rap** Length (ft) **100**
Dom. Veg. Type **Coniferous**
SubDom Veg. Type:
Right Bank Canopy **76-100%**

Channel Canopy Cover: **Closed**

3.2 Buffer:

Left Buffer: Dom.Width (ft) **>100**
SubDom Width:(ft)
Dom. Veg. Type **Mixed Trees**
SubDom Veg. Type:

Right Buffer Dom.Width (ft) **>100**
SubDom Width:(ft)
Dom. Veg. Type **Mixed Trees**
SubDom Veg Type

3.3 Riparian Corridor

Left Dom **Forest** SubDo
Righ Dom **Forest** SubDo

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps **Abundant**

4.2 Adjacent Wetlands **Some**

4.3 Flow Status **Moderate**

4.4 # Current Debris Jams **2**

4.5 Upstream Impoundment **None**

4.6 # Stormwater Inputs **2**

4.7 Flow Regulations **None**

4.8 # Channel Constrictions **4**

None: **0** Culvert: **Yes** Bridge:
Abutments **Yes** Bedrock: **Yes** Other **Yes**
Problems: DepAbove: **Yes** DepBelow:
Scour Below: **Yes** Angle: **Yes** None: **0**
Flood Prone Constriction: **Yes**

Bridge Survey Phase1 **Yes** Phase 2 **Yes** None ☐
BeaverDams: **0** Length Affected (ft):

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid **Yes**
Point **Yes** Side: **Yes** Diagonal **Yes**
Delta Island **Yes** None: **0**

5.2 Neck or Chute Cut Offs
Flood Chute: **Yes** Neck Cut-Off: **No**
Channel Avulsions **No** Braiding **Yes**

5.3 Steep Riffles or Head Cuts:
Steep Riffle: **Yes** Head Cut: **No**

5.6 Stream Ford/Animal Crossing **No**

5.5 Channel Alterations:
Dredging Straightening
Bar Scalping Gravel Mining:
None **-1**

Comments:

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **Baldwin Creek** Reach # **T3.07** Segment: **Reach**

Rapid Habitat Assessment Field Data

Gradient Type: **High**

8.1 Epifaunal Substrate/Available Cover		15
8.2 Pool Substrate Character (low)/ Embededness (high)		10
8.3 Pool Variability (low) / Velocity Depth Regime (high)		18
8.4 Sediment Deposition		11
8.5 Channel Flow Status		18
8.6 Channel Alterations		13
8.7 Morphological Diversity		18
8.8 Bank Stability	Left	7
	Right	5
8.9 Vegetative Protection	Left	8
	Right	6
8.10 Riparian Vegetative Zone Width	Left	9
	Right	8
	TOTAL:	0.73
8.11 Habitat Condition:		**2-Good**

Rapid Geomorphic Assessment Field Data

Confinement Type: **Confined**

			STD	Historic Adjustment
9.1 Deegre of Channel Degradation	13	Good	☐	☐
9.2 Deegre of Channel Aggradation	10	Fair	☐	☐
9.3 Over Widened Channel	13	Good		☐
9.4 Change in Plaform	11	Good		☐

Adjustment Process(s): Aggradation

9.5 Stage of Channel Evolution	IV
TOTAL:	0.59
9.5 Geomorphic Condition:	**3-Fair**

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **Baldwin Creek** | **Reach # T3.08** | **Segment: A**

Segment Length (ft): **1700** | Date: **6/5/2004** | Rain: **Yes** | Observers: **KU, BE, HS, PG** | Organization: **SMRC**

Town: **Starksboro** | Location: **Downstream 1/3 of T3.08**

Step 1 Valley and Floodplain:

1.1 Water Zone **Response**

1.2 Alluvial Fan **No**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) Right (ft)

Roads
Length: Left (ft) **100** Right (ft)

Railroads
Length: Left (ft) Right (ft)

Improved Paths
Length: Left (ft) Right (ft)

Development
Length: Left (ft) Right (ft) **60**

1.4 Adjacent Side Slope

Left Slope **shallow** Texture **›t Evaluat**
Cont. w/bank: **Sometimes**
W/in 1x Bkf: **Sometimes**

Right Slope **moderate** Texture **›t Evaluat**
Cont. w/bank **Sometimes**
W/in 1x Bkf: **Sometimes**

1.5 Confinemen **Semi-Confined**
ValleyWidth: Rock Gorge ☐

1.6 Grade Controls

Waterfall **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Ledge: **U** Photo: ☑
Total Height (ft) **1**
FMB (Phase 2 B/C survey)

Dam: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Weir: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft)
2.2 Max Depth (ft)
2.3 Mean Depth (ft)
2.4 Flood Prone Width (ft)
2.5 Low Bank Height (ft)
2.6 Ratio W/D
2.7 Entrenchment
2.8 Incision Ratio
2.9 Sinuosity
2.10 Riffle/Steps
complete: partial: diagonal:
continuous none **0**

2.11 Riffle/Steps Spacing (ft)
Riffle/Step Spacing NA ☐

2.12 Bed Substrate Composition :
% Bedrock % Boulder
% Cobble %CourseGravel:
% Gravel % Sand
% Detritus # LWD
Silt/Clay

2.13 Largest Particle on:
Bed Bar Units

2.14 Stream Type

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:

Typical Bank Slope **Moderate**
Lower Bank Texture **Gravel**
Consistency: **Non-cohesiv**
Upper Bank Textue **Sand**
Consistency: **Cohesive**

Left Bank
Erosion Length (ft) **500** Height (ft) **4**
Revetment Type Length (ft)
Dom. Veg. Type **Herbaceous**
SubDom. Veg. Type
Left Bank Canopy **1-25%**

Right Bank
Erosion Length (ft) **500** Height (ft) **4**
Revetment Type Length (ft)
Dom. Veg. Type **Herbaceous**
SubDom Veg. Type:
Right Bank Canopy **1-25%**

Channel Canopy Cover: **Open**

3.2 Buffer:

Left Buffer: Dom.Width (ft) **>100**
SubDom Width:(ft)
Dom. Veg. Type **Shrubs-sapling**
SubDom Veg. Type:

Right Buffer Dom.Width (ft) **51-100**
SubDom Width:(ft)
Dom. Veg. Type **Shrub-sapling**
SubDom Veg Type

3.3 Riparian Corridor

Left Dom **Forest** SubDo
Righ Dom **Shrub** SubDo

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps **Some**
4.2 Adjacent Wetlands **Some**
4.3 Flow Status **Moderate**
4.4 # Current Debris Jams **19**
4.5 Upstream Impoundment **Unknown**
4.6 # Stormwater Inputs **0**
4.7 Flow Regulations **None**
4.8 # Channel Constrictions **2**
None: **0** Culvert: Bridge:
Abutments **Yes** Bedrock: **Yes** Other
Problems: DepAbove: DepBelow:
Scour Below: Angle: None: **-1**
Flood Prone Constriction: **Yes**
Bridge Survey Phase1 Phase 2 None ☐
BeaverDams: **3** Length Affected (ft): **950**

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid **Yes**
Point **Yes** Side: **Yes** Diagonal **Yes**
Delta **No** Island **Yes** None: **0**

5.2 Neck or Chute Cut Offs
Flood Chute: **Yes** Neck Cut-Off: **No**
Channel Avulsions **Yes** Braiding **Yes**

5.3 Steep Riffles or Head Cuts:
Steep Riffle: **Yes** Head Cut: **Yes**

5.6 Stream Ford/Animal Crossing **No**

5.5 Channel Alterations:
Dredging Straightening
Bar Scalping Gravel Mining:
None **-1**

Comments:

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **Baldwin Creek** | **Reach # T3.08** | **Segment: A**

Rapid Habitat Assessment Field Data

Gradient Type: **High**

8.1 Epifaunal Substrate/Available Cover		13
8.2 Pool Substrate Character (low)/ Embededness (high)		8
8.3 Pool Variability (low) / Velocity Depth Regime (high)		8
8.4 Sediment Deposition		8
8.5 Channel Flow Status		8
8.6 Channel Alterations		16
8.7 Morphological Diversity		13
8.8 Bank Stability	Left	4
	Right	4
8.9 Vegetative Protection	Left	5
	Right	5
8.10 Riparian Vegetative Zone Width	Left	9
	Right	7
	TOTAL:	0.54
8.11 Habitat Condition:		**3-Fair**

Rapid Geomorphic Assessment Field Data

Confinement Type: **Confined**

			STD	Historic Adjustment
9.1 Deegre of Channel Degradation	13	Good	☐	☐
9.2 Deegre of Channel Aggradation	3	Poor	☐	☐
9.3 Over Widened Channel	7	Fair		☐
9.4 Change in Plaform	11	Good		☐

Adjustment Process(s): Aggradation

9.5 Stage of Channel Evolution	
TOTAL:	0.43
9.5 Geomorphic Condition:	**3-Fair**

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **Baldwin Creek** Reach # **T3.08** Segment: **B**

Segment Length (ft): **2756** Date: **6/5/2004** Rain: **Yes** Observers: **KU, EE, PG, HS** Organization: **SMRC**

Town: **Starksboro** Location: **Upper 1/3 of T3.08**

Step 1 Valley and Floodplain:

1.1 Water Zone **Transfer**
1.2 Alluvial Fan **No**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) Right (ft) **20**

Roads
Length: Left (ft) **300** Right (ft) **1000**

Railroads
Length: Left (ft) Right (ft)

Improved Paths
Length: Left (ft) Right (ft)

Development
Length: Left (ft) **200** Right (ft)

1.4 Adjacent Side Slope

Left Slope **moderate** Texture **t Evaluat**
Cont. w/bank: **Sometimes**
W/in 1x Bkf: **Sometimes**
Right Slope **moderate** Texture **t Evaluat**
Cont. w/bank **Sometimes**
W/in 1x Bkf: **Sometimes**

1.5 Confinemen **Semi-Confined**
ValleyWidth: Rock Gorge ☐

1.6 Grade Controls

Waterfall **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Ledge: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Dam: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Weir: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: **U** Photo ☑
Total Height (ft) **2**
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft) **28.5**
2.2 Max Depth (ft) **2.2**
2.3 Mean Depth (ft) **1.5**
2.4 Flood Prone Width (ft) **41.0**
2.5 Low Bank Height (ft)
2.6 Ratio W/D **19.0**
2.7 Entrenchment **1.4**
2.8 Incision Ratio
2.9 Sinuosity **Moderate**
2.10 Riffle/Steps
complete: **Yes** partial: diagonal:
continuous none **0**
2.11 Riffle/Steps Spacing (ft) **44**
Riffle/Step Spacing NA ☐

2.12 Bed Substrate Composition :

% Bedrock **0** % Boulder **0**
% Cobble **43** %CourseGravel: **39**
% Gravel **3** % Sand **15**
% Detritus # LWD **17**
Silt/Clay **No**

2.13 Largest Particle on:

Bed Bar Units

2.14 Stream Type **B 4 Riffle-Pool**

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:

Typical Bank Slope **Steep**
Lower Bank Texture **Mix**
Consistency: **Cohesive**
Upper Bank Textue **Mix**
Consistency: **Cohesive**

Left Bank
Erosion Length (ft) **50** Height (ft) **2**
Revetment Type **Rip-rap** Length (ft) **100**
Dom. Veg. Type **Deciduous**
SubDom. Veg. Type
Left Bank Canopy **76-100%**

Right Bank
Erosion Length (ft) **60** Height (ft) **4**
Revetment Type **Rip-rap** Length (ft) **100**
Dom. Veg. Type **Deciduous**
SubDom Veg. Type:
Right Bank Canopy **76-100%**

Channel Canopy Cover: **Open**

3.2 Buffer:

Left Buffer: Dom.Width (ft) **>100**
SubDom Width:(ft)
Dom. Veg. Type **Deciduous**
SubDom Veg. Type:

Right Buffer Dom.Width (ft) **26-50**
SubDom Width:(ft)
Dom. Veg. Type **Deciduous**
SubDom Veg Type

3.3 Riparian Corridor

Left Dom **Forest** SubDo **Residential**
Righ Dom **Forest** SubDo **Residential**

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps **Some**
4.2 Adjacent Wetlands **Some**
4.3 Flow Status **Moderate**
4.4 # Current Debris Jams **12**
4.5 Upstream Impoundment **Unknown**
4.6 # Stormwater Inputs **2**
4.7 Flow Regulations **None**
4.8 # Channel Constrictions **6**
None: **0** Culvert: **Yes** Bridge: **Yes**
Abutments Bedrock: Other **Yes**
Problems: DepAbove: DepBelow:
Scour Below: **Yes** Angle: **Yes** None: **0**
Flood Prone Constriction: **Yes**
Bridge Survey Phase1 Phase 2 **Yes** None ☐
BeaverDams: **0** Length Affected (ft):

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid **Yes**
Point **Yes** Side: **Yes** Diagonal **Yes**
Delta Island **Yes** None: **0**
5.2 Neck or Chute Cut Offs
Flood Chute: **Yes** Neck Cut-Off: **No**
Channel Avulsions **No** Braiding **Yes**
5.3 Steep Riffles or Head Cuts:
Steep Riffle: **Yes** Head Cut: **No**
5.6 Stream Ford/Animal Crossing **No**
5.5 Channel Alterations:
Dredging Straightening
Bar Scalping Gravel Mining:
None **0**

Comments:

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **Baldwin Creek** | Reach # **T3.08** | Segment: **B**

Rapid Habitat Assessment Field Data

Gradient Type: **High**

8.1 Epifaunal Substrate/Available Cover		18
8.2 Pool Substrate Character (low)/ Embededness (high)		18
8.3 Pool Variability (low) / Velocity Depth Regime (high)		13
8.4 Sediment Deposition		18
8.5 Channel Flow Status		18
8.6 Channel Alterations		16
8.7 Morphological Diversity		18
8.8 Bank Stability	Left	9
	Right	9
8.9 Vegetative Protection	Left	8
	Right	8
8.10 Riparian Vegetative Zone Width	Left	9
	Right	5
	TOTAL:	0.84
8.11 Habitat Condition:		**2-Good**

Rapid Geomorphic Assessment Field Data

Confinement Type: **Unconfined**

			STD	Historic Adjustment
9.1 Deegre of Channel Degradation	15	Good	☑	☑
9.2 Deegre of Channel Aggradation	15	Good	☐	☐
9.3 Over Widened Channel	17	Reference		☐
9.4 Change in Plaform	16	Reference		☐

Adjustment Process(s): Aggradation

9.5 Stage of Channel Evolution	IV
TOTAL:	0.79
9.5 Geomorphic Condition:	**2-Good**

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **Beaver Meadow** | Reach # **T4.02** | Segment: **Reach**

Segment Length (ft): **5539** | Date: **7/26/2004** | Rain: **Yes** | Observers: **KU, EE, ZG** | Organization: **SMRC**

Town: **Lincoln** | Location: **Downstream of Quaker Rd and Forge Hill junction**

Step 1 Valley and Floodplain:

1.1 Water Zone **Transfer**

1.2 Alluvial Fan **No**

1.3 River Corridor Encroachments

Berms
Length: Left (ft) Right (ft)

Roads
Length: Left (ft) **130** Right (ft) **1025**

Railroads
Length: Left (ft) Right (ft)

Improved Paths
Length: Left (ft) Right (ft)

Development
Length: Left (ft) **130** Right (ft) **400**

1.4 Adjacent Side Slope

Left Slope **steep** Texture **Boulder**
Cont. w/bank: **Sometimes**
W/in 1x Bkf: **Sometimes**

Right Slope **steep** Texture **Boulder**
Cont. w/bank **Sometimes**
W/in 1x Bkf: **Sometimes**

1.5 Confinemen **Narrowly Confined**
ValleyWidth: Rock Gorge ☐

1.6 Grade Controls

Waterfall **B** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Ledge: **B** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Dam: **None** Photo: ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Weir: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Culverts: **None** Photo ☐
Total Height (ft)
FMB (Phase 2 B/C survey)

Step 2 Stream Channel:

2.1 Bankfull Width (ft) **43.6**

2.2 Max Depth (ft) **2.9**

2.3 Mean Depth (ft) **1.2**

2.4 Flood Prone Width (ft) **59.6**

2.5 Low Bank Height (ft)

2.6 Ratio W/D **36.3**

2.7 Entrenchment **1.4**

2.8 Incision Ratio

2.9 Sinuosity **Low**

2.10 Riffle/Steps
complete: **Yes** partial: **Yes** diagonal: **Yes**
continuous none **0**

2.11 Riffle/Steps Spacing (ft)
Riffle/Step Spacing NA ☐

2.12 Bed Substrate Composition :

% Bedrock **32** % Boulder **6**
% Cobble **18** %CourseGravel: **16**
% Gravel **18** % Sand **9**
% Detritus **5** # LWD **44**
Silt/Clay **Yes**

2.13 Largest Particle on:
Bed Bar Units

2.14 Stream Type **B** **3** **Step-Pool**

Step 3 Riparian Banks, Buffers and Corridors:

3.1 Stream Bank:

Typical Bank Slope **Steep**
Lower Bank Texture **Bedrock**
Consistency: **Cohesive**
Upper Bank Textue **Boulder/Cob**
Consistency: **Non-cohesiv**

Left Bank
Erosion Length (ft) **140** Height (ft) **2**
Revetment Type **Rip-rap** Length (ft) **30**
Dom. Veg. Type **Coniferous**
SubDom. Veg. Type
Left Bank Canopy **76-100%**

Right Bank
Erosion Length (ft) **225** Height (ft) **2**
Revetment Type **Rip-rap** Length (ft) **150**
Dom. Veg. Type **Coniferous**
SubDom Veg. Type:
Right Bank Canopy **76-100%**

Channel Canopy Cover: **Closed**

3.2 Buffer:

Left Buffer: Dom.Width (ft) **>100**
SubDom Width:(ft)
Dom. Veg. Type **Mixed Trees**
SubDom Veg. Type:

Right Buffer Dom.Width (ft) **26-50**
SubDom Width:(ft)
Dom. Veg. Type **Mixed Trees**
SubDom Veg Type

3.3 Riparian Corridor

Left Dom **Forest** SubDo
Righ Dom **Forest** SubDo **Residential**

Step 4 Flow and Flow Modifiers:

4.1 Springs and Seeps **Abundant**

4.2 Adjacent Wetlands **None**

4.3 Flow Status **Moderate**

4.4 # Current Debris Jams **2**

4.5 Upstream Impoundment **None**

4.6 # Stormwater Inputs **1**

4.7 Flow Regulations **None**

4.8 # Channel Constrictions **2**

None: **0** Culvert: Bridge: **Yes**
Abutments Bedrock: Other **Yes**
Problems: DepAbove: DepBelow:
Scour Below: Angle: **Yes** None: **0**
Flood Prone Constriction: **Yes**

Bridge Survey Phase1 Phase 2 None ☐
BeaverDams: **0** Length Affected (ft):

Step 5 Channel Bed and Planfom Changes:

5.1 Bed Sediment Storage Bars Mid **Yes**
Point **Yes** Side: **Yes** Diagonal **Yes**
Delta Island None: **0**

5.2 Neck or Chute Cut Offs
Flood Chute: **Yes** Neck Cut-Off: **No**
Channel Avulsions **No** Braiding **No**

5.3 Steep Riffles or Head Cuts:
Steep Riffle: **Yes** Head Cut: **No**

5.6 Stream Ford/Animal Crossing **No**

5.5 Channel Alterations:
Dredging Straightening
Bar Scalping Gravel Mining:
None **-1**

Comments:

Phase 2 Geomorphic Assessment Data

Printed On: Thursday, September 30, 2004

Stream Name: **Beaver Meadow**

Reach # **T4.02**

Segment: **Reach**

Rapid Habitat Assessment Field Data

Gradient Type: **High**

8.1 Epifaunal Substrate/Available Cover			**16**
8.2 Pool Substrate Character (low)/ Embededness (high)			**12**
8.3 Pool Variability (low) / Velocity Depth Regime (high)			**18**
8.4 Sediment Deposition			**12**
8.5 Channel Flow Status			**18**
8.6 Channel Alterations			**18**
8.7 Morphological Diversity			**18**
8.8 Bank Stability		Left	**9**
		Right	**9**
8.9 Vegetative Protection		Left	**9**
		Right	**9**
8.10 Riparian Vegetative Zone Width		Left	**10**
		Right	**4**
		TOTAL:	**0.81**
8.11 Habitat Condition:			**2-Good**

Rapid Geomorphic Assessment Field Data

Confinement Type: **Confined**

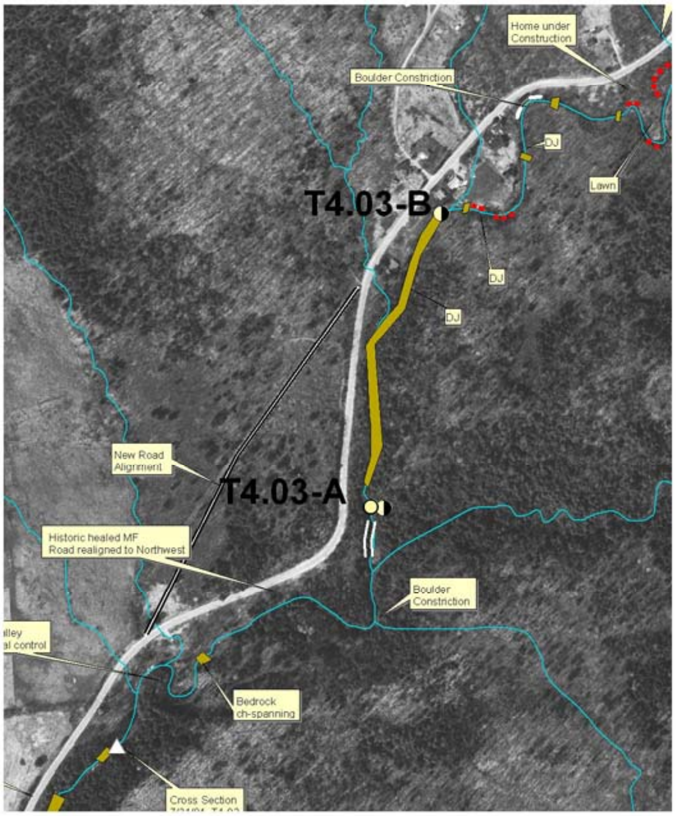
			STD	Historic Adjustment
9.1 Deegre of Channel Degradation	**18**	**Reference**	☐	☐
9.2 Deegre of Channel Aggradation	**16**	**Reference**	☐	☐
9.3 Over Widened Channel	**15**	**Good**		☐
9.4 Change in Plaform	**15**	**Good**		☐

Adjustment Process(s): Aggradation induced widening (minor)

9.5 Stage of Channel Evolution	**I**
TOTAL:	**0.80**
9.5 Geomorphic Condition:	**2-Good**

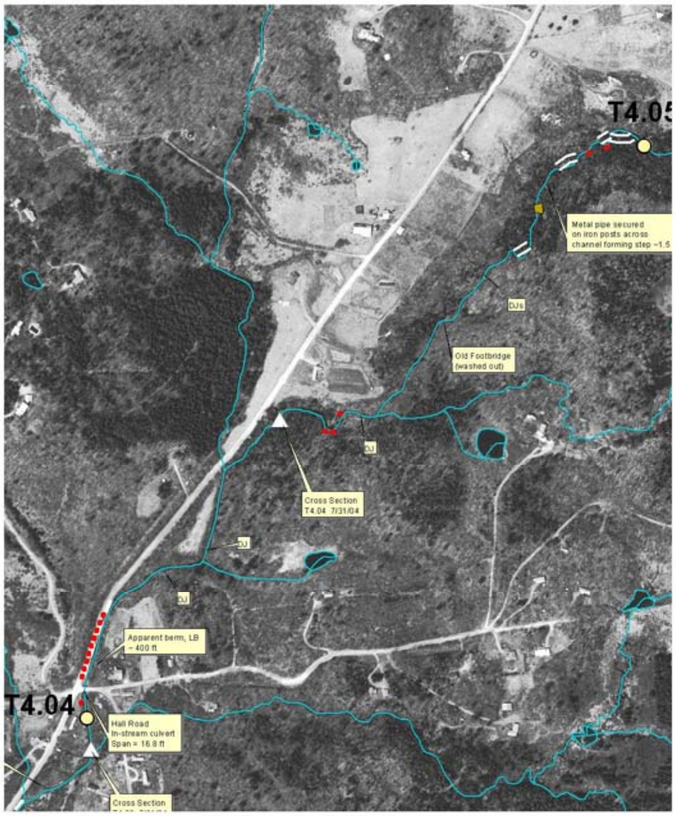
APPENDIX E

Annotated Reach-based Orthophotos



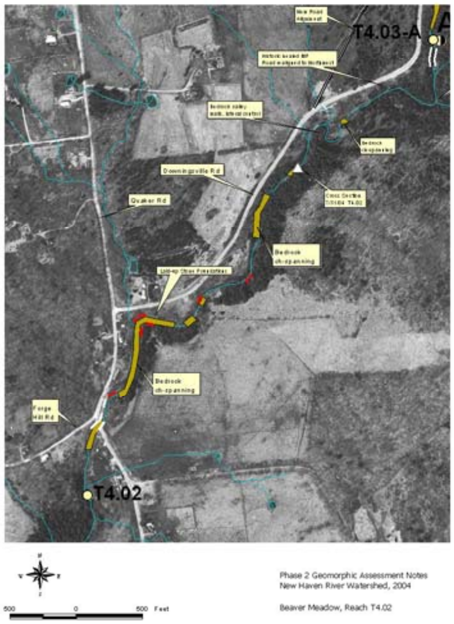
Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

Beaver Meadow, Reach T4.03-A



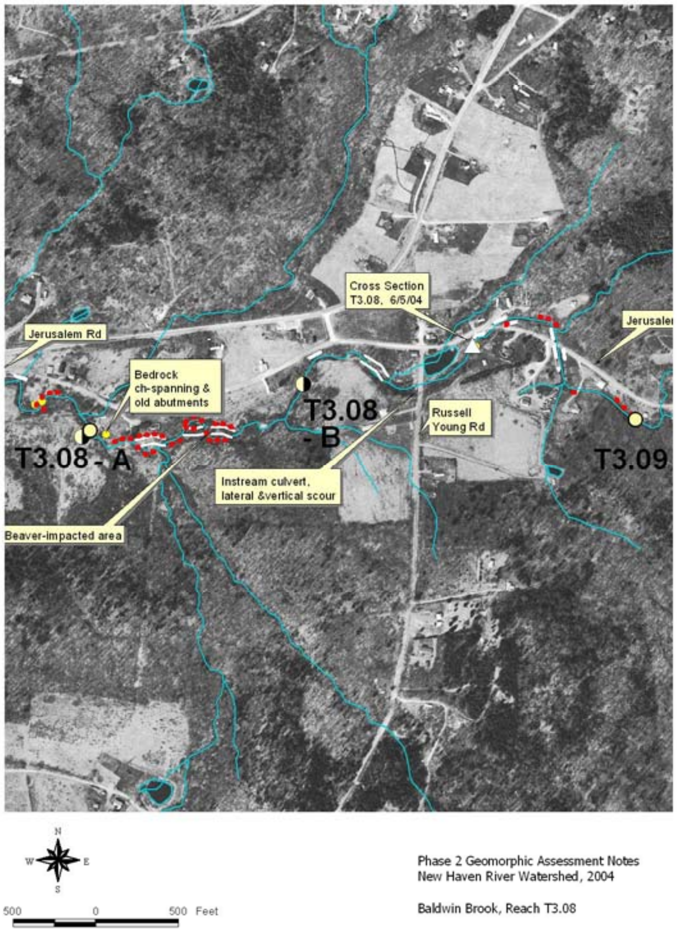
Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

Beaver Meadow, Reach T4.04



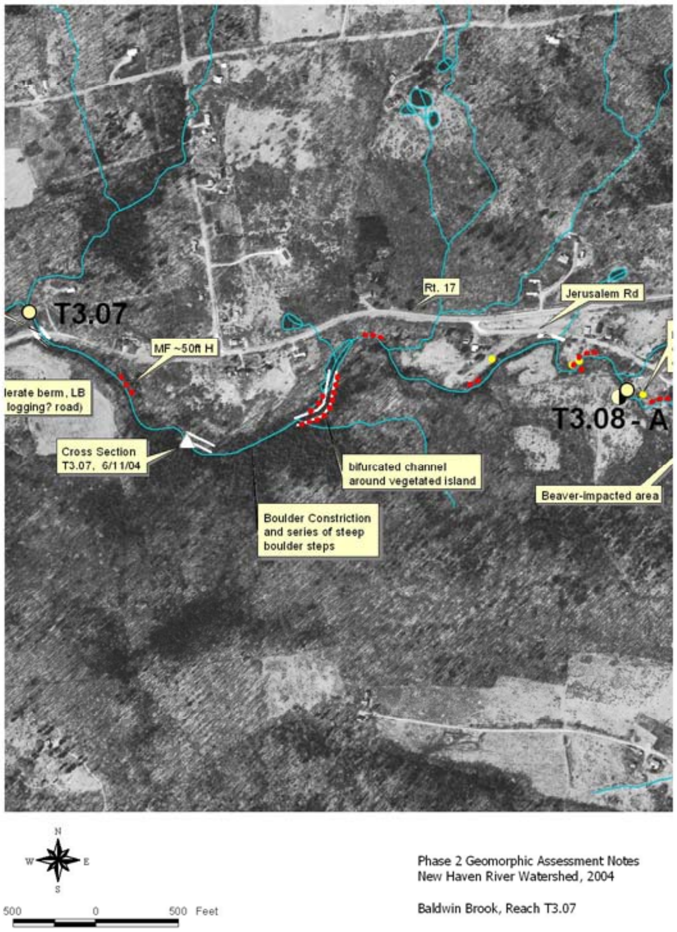
Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

Beaver Meadow, Reach T4.02



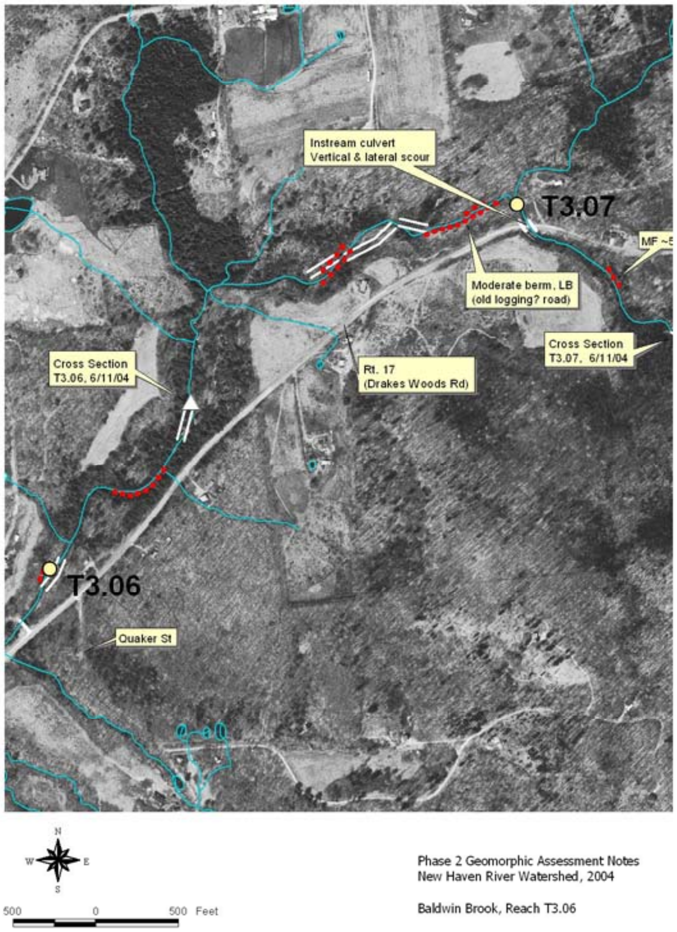
Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

Baldwin Brook, Reach T3.08



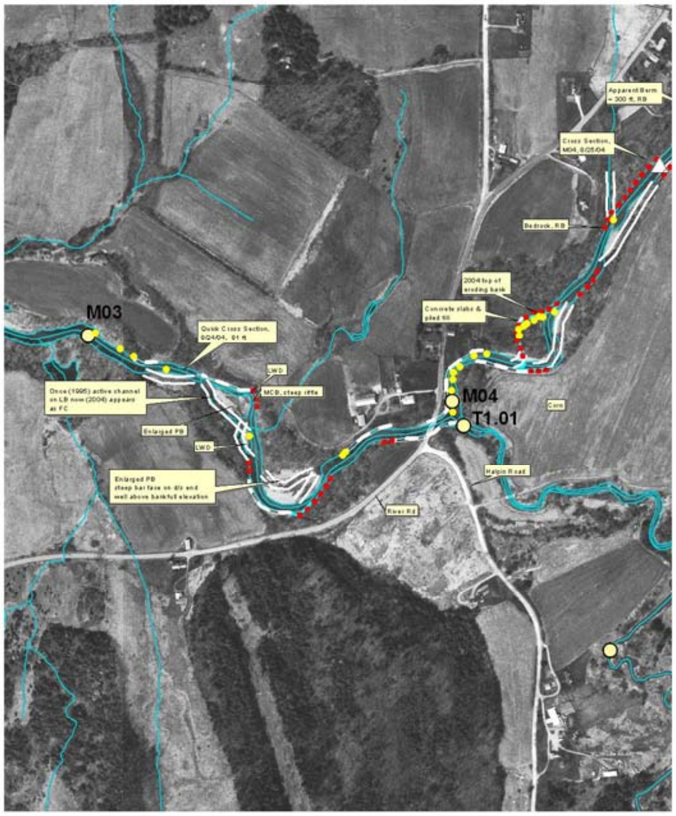
Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

Baldwin Brook, Reach T3.07



Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

Baldwin Brook, Reach T3.06



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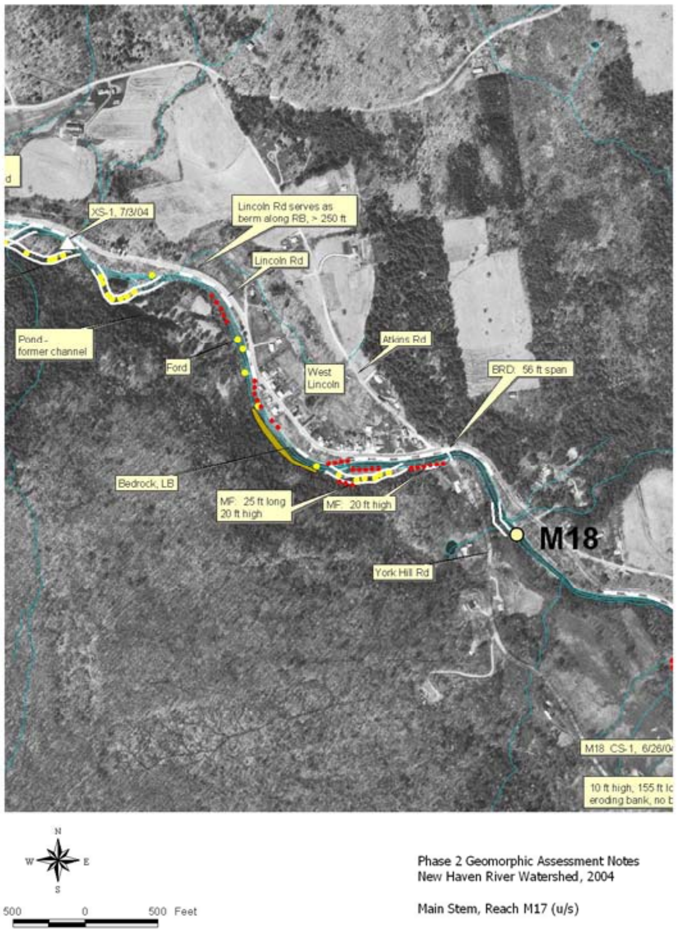
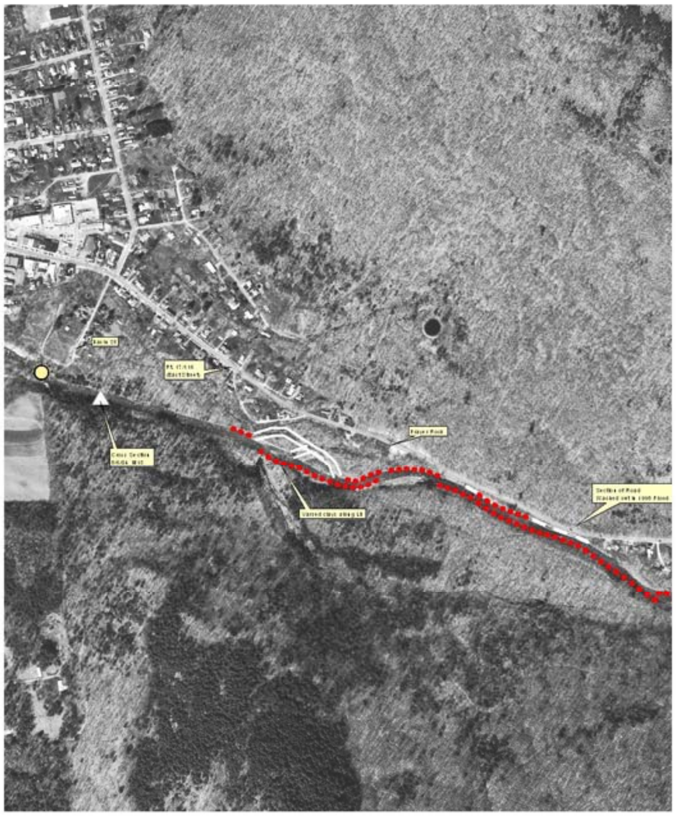
Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

Main Stem, Reach M03



Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

Main Stem, Reach M17 (u/s)



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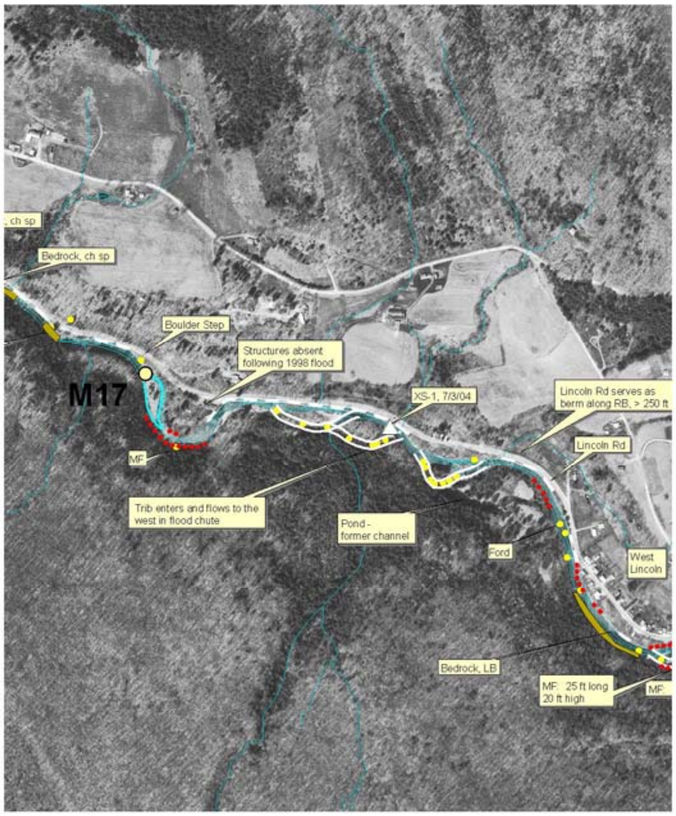
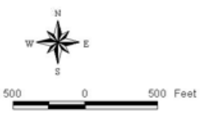
Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

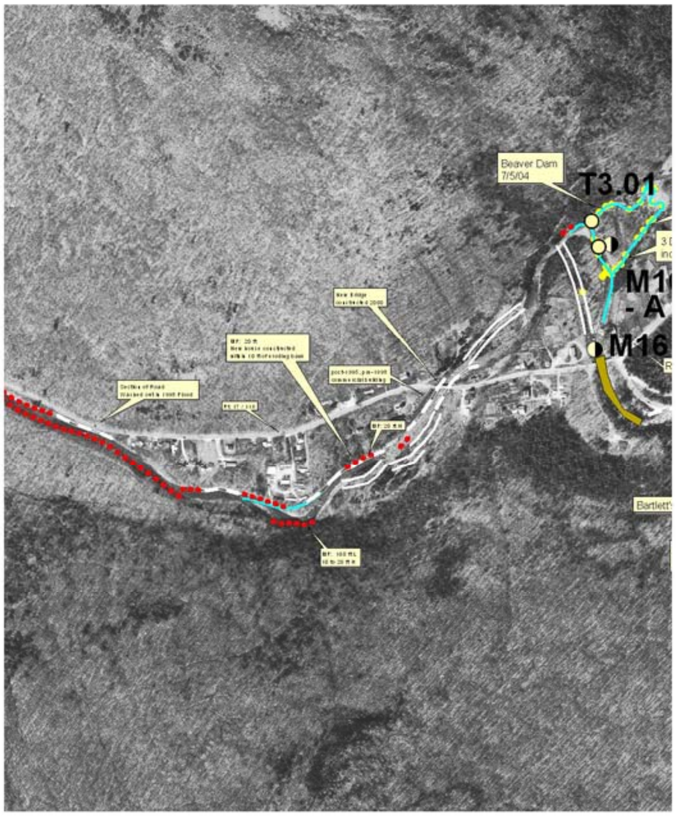
Main Stem, Reach M15 downstream

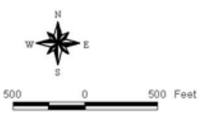




Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

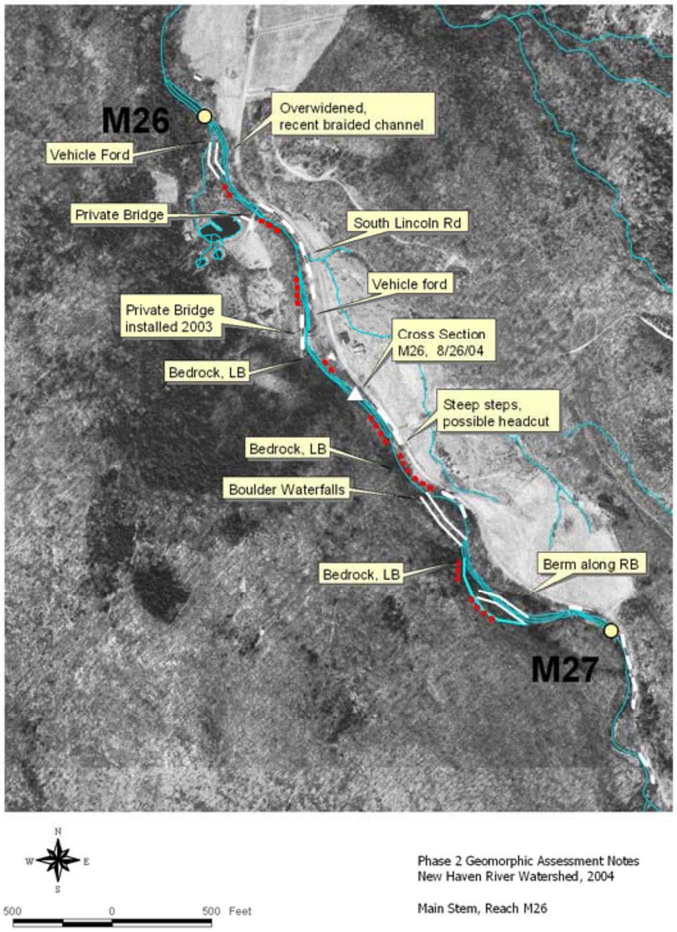
Main Stem, Reach M17 (d/s)





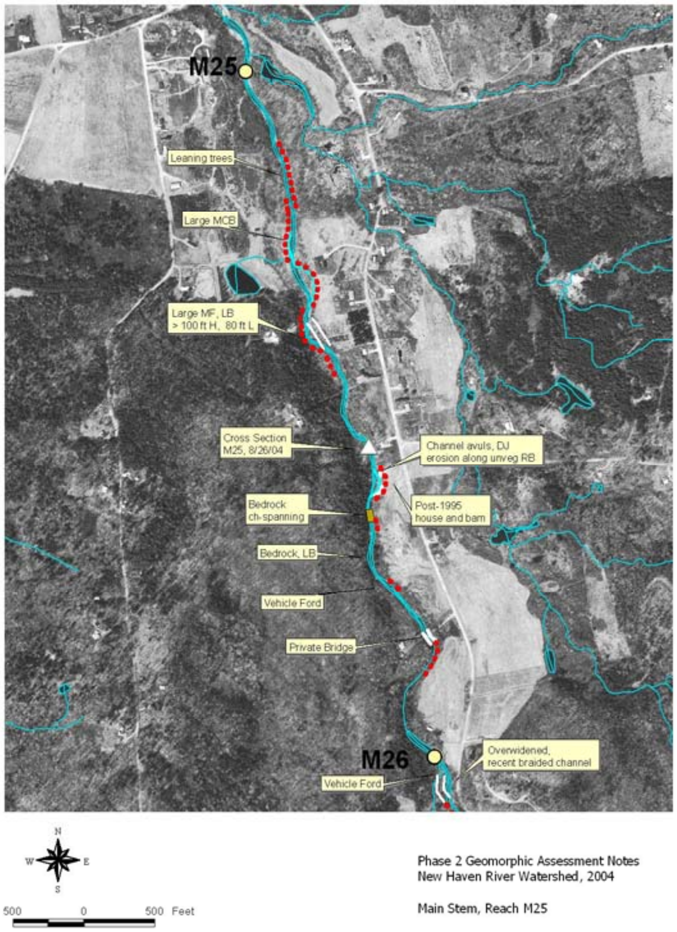
Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

Main Stem, Reach M15 upstream



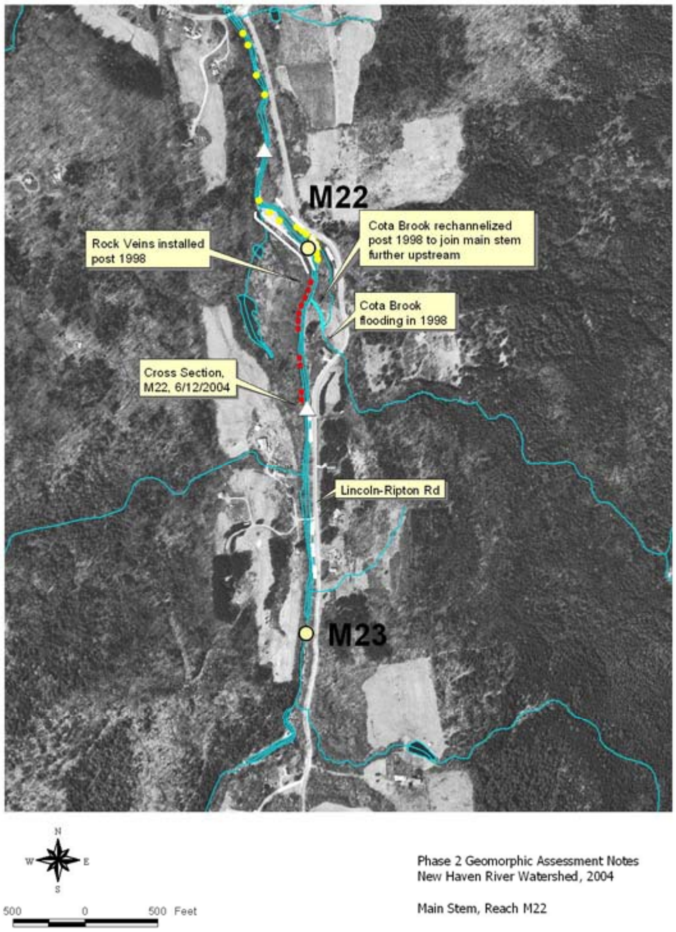
Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

Main Stem, Reach M26



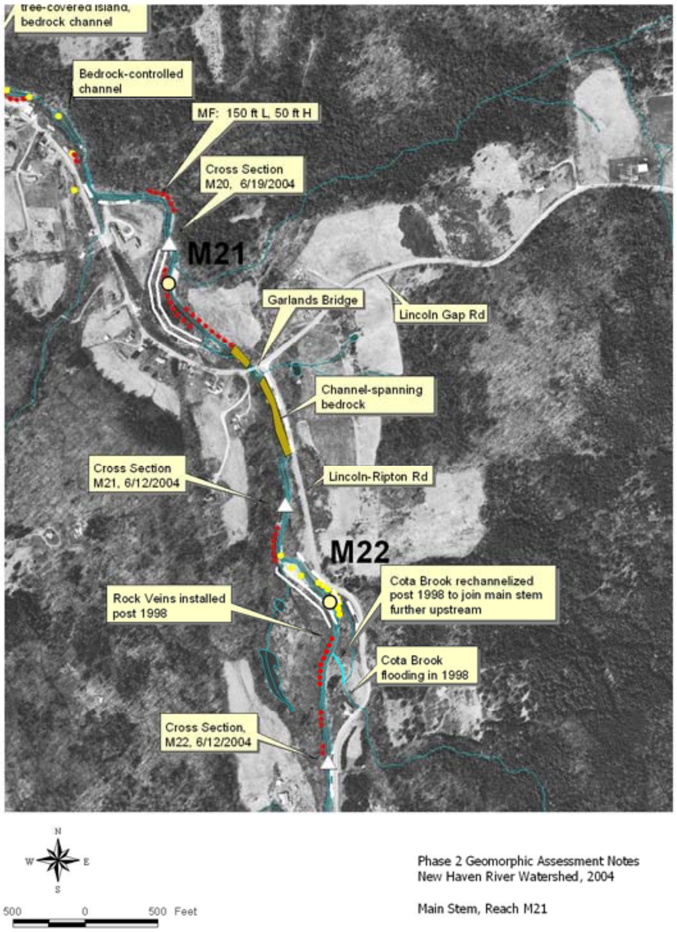
Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

Main Stem, Reach M25



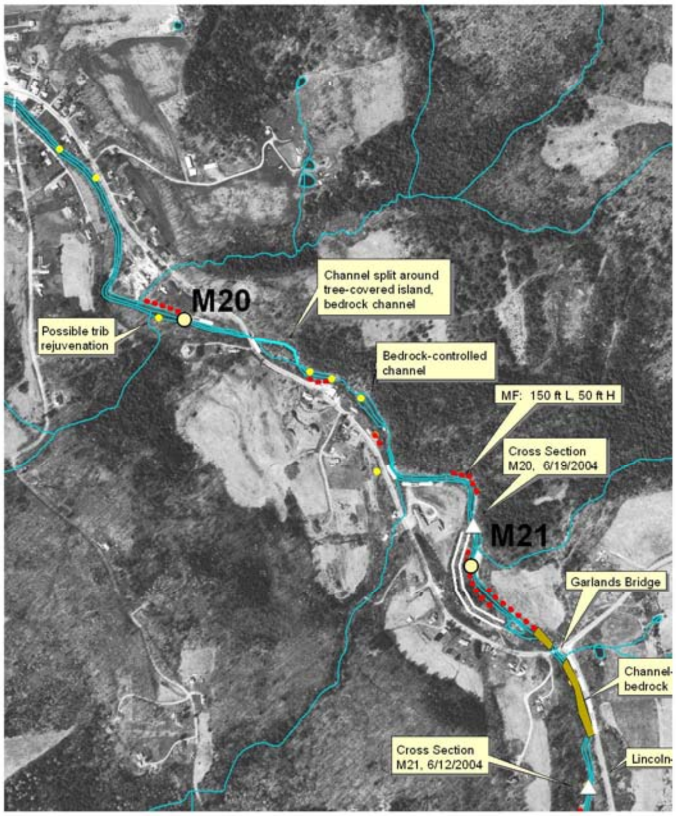
Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

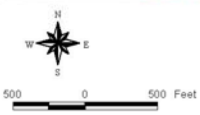
Main Stem, Reach M22



Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

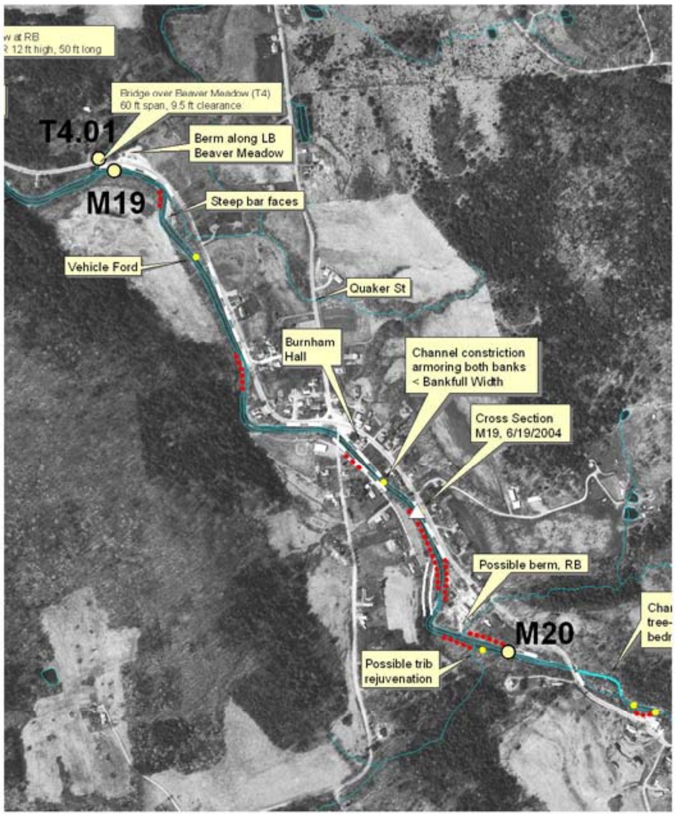
Main Stem, Reach M21

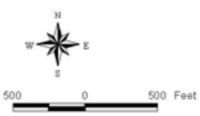




Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

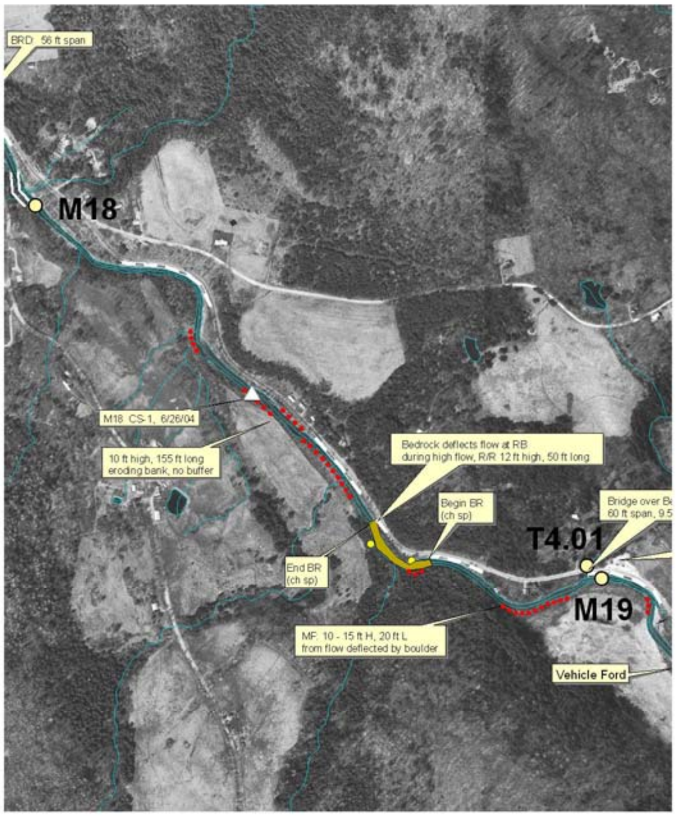
Main Stem, Reach M20





Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

Main Stem, Reach M19



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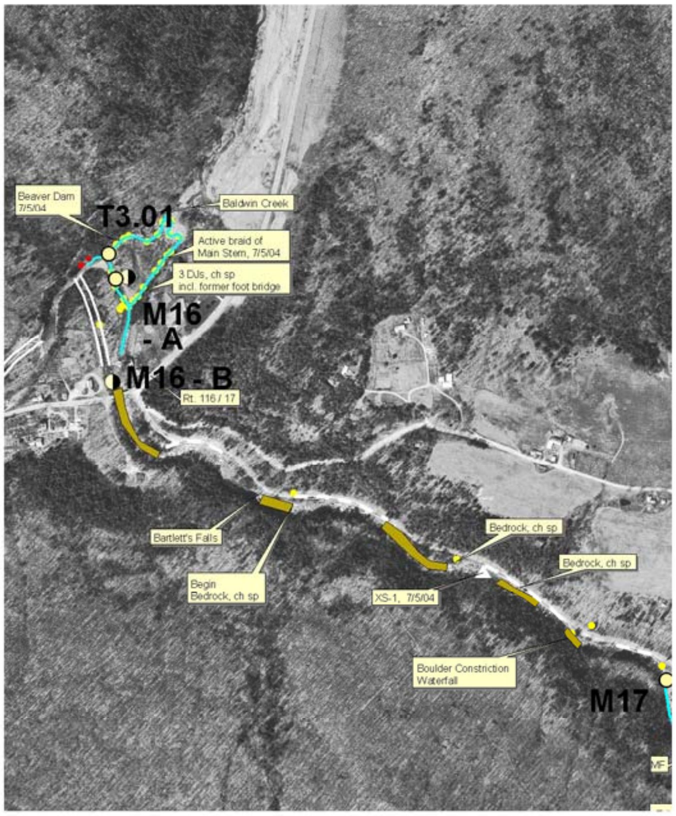
Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

Main Stem, Reach M18



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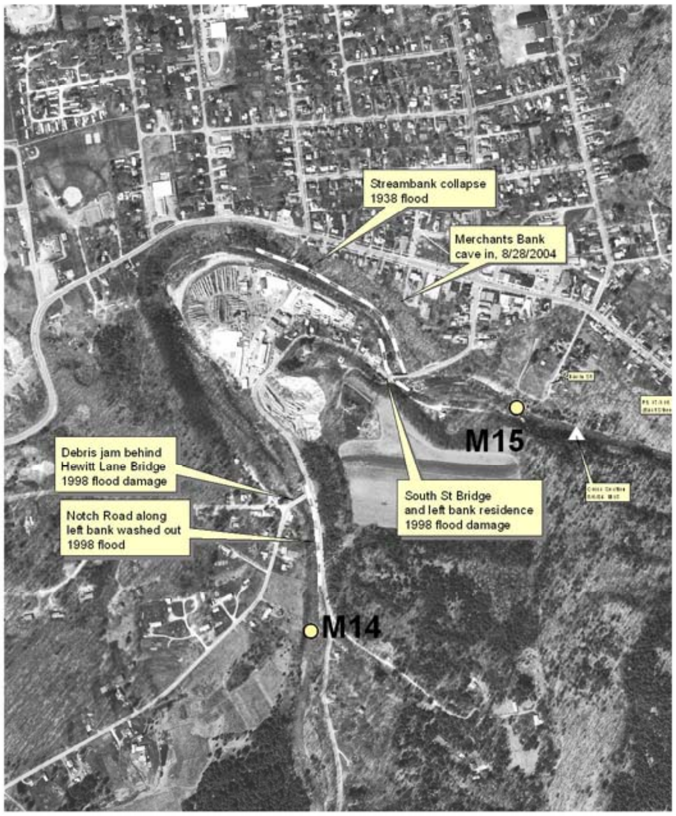
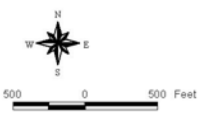
Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

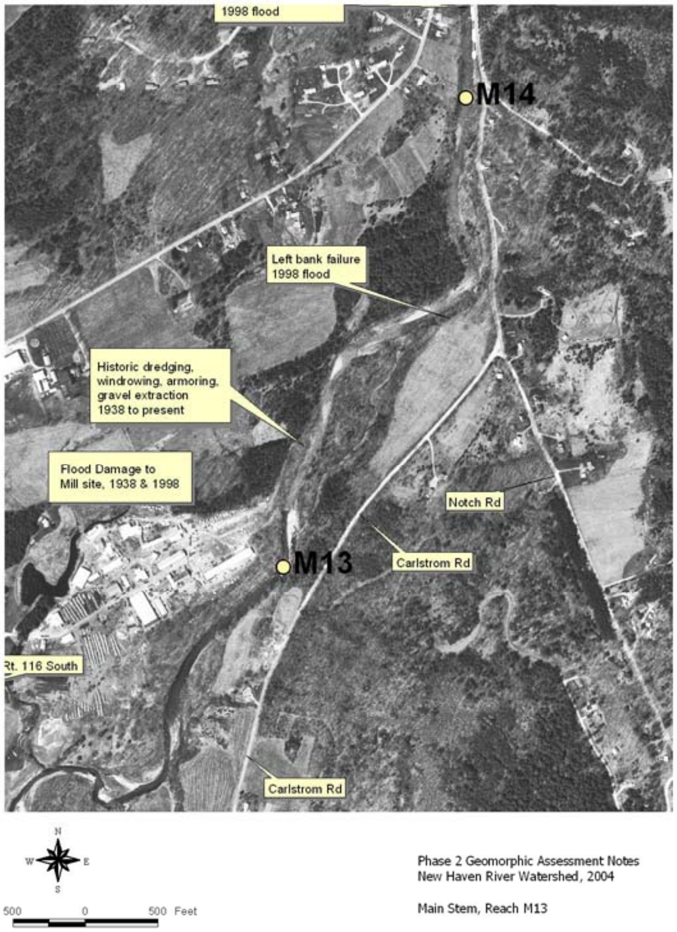
Main Stem, Reach M16





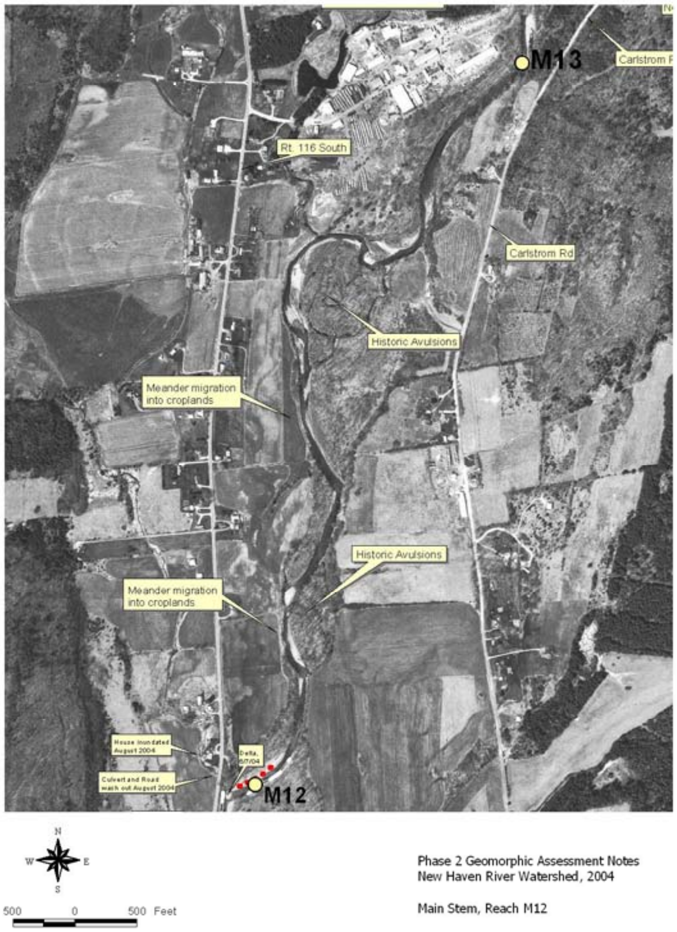
Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

Main Stem, Reach M14



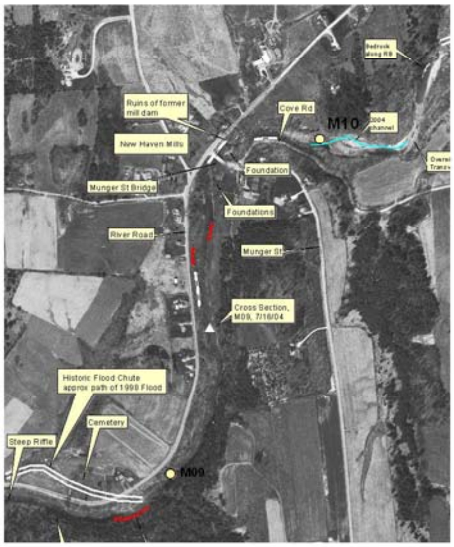
Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

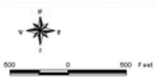
Main Stem, Reach M13



Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

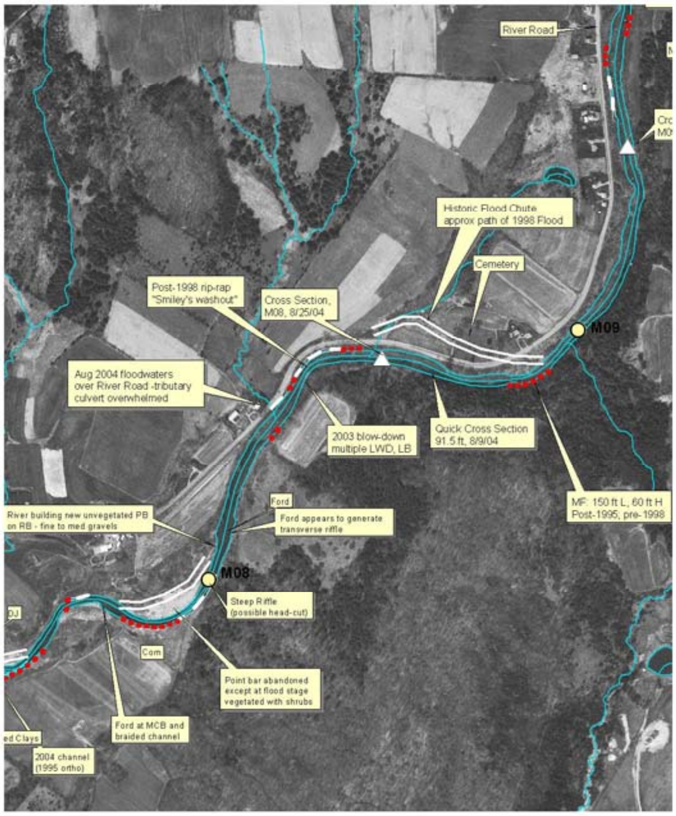
Main Stem, Reach M12





Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

Main Stem, Reach M09



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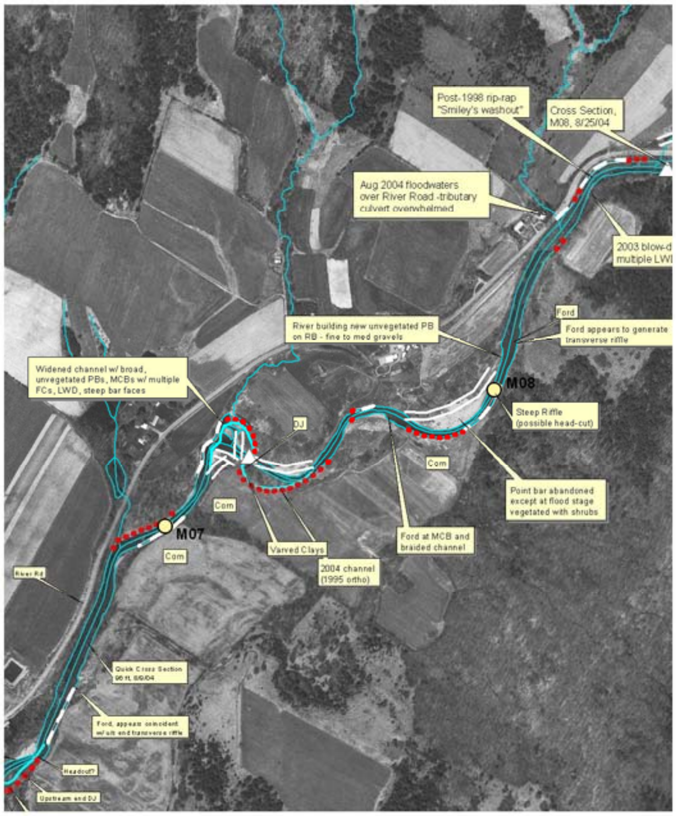
Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

Main Stem, Reach M08



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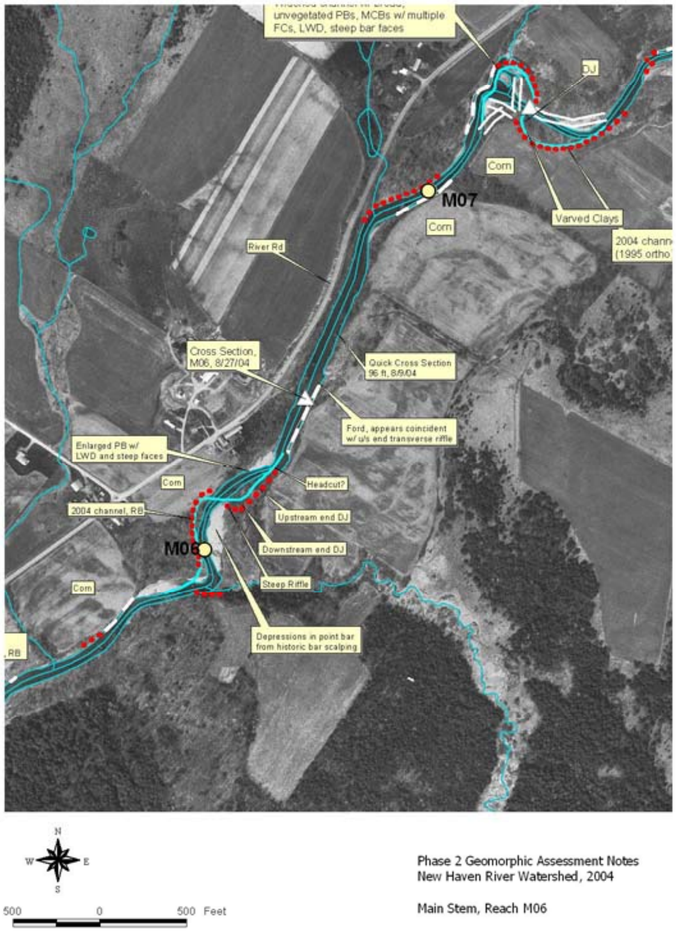
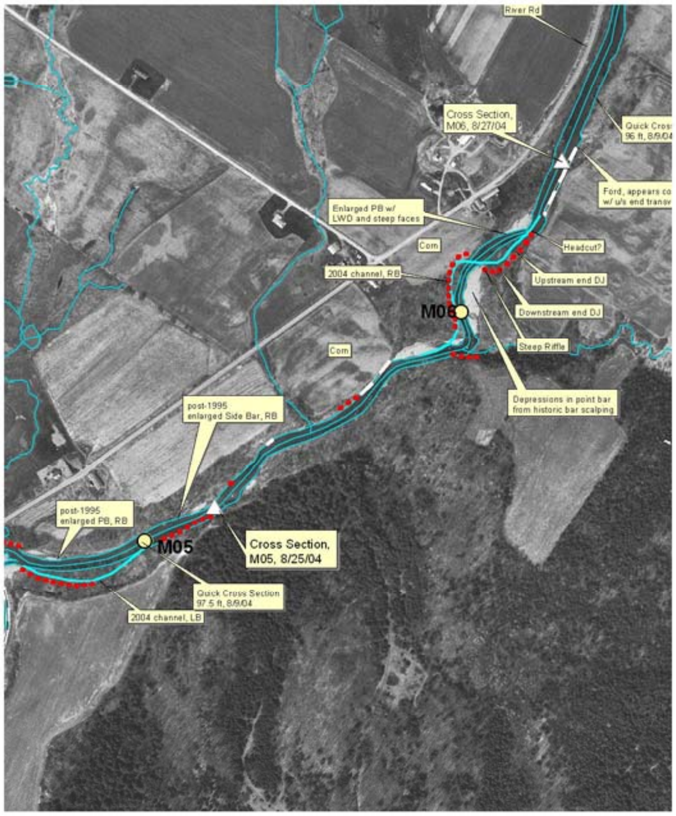
Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

Main Stem, Reach M07



Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

Main Stem, Reach M06



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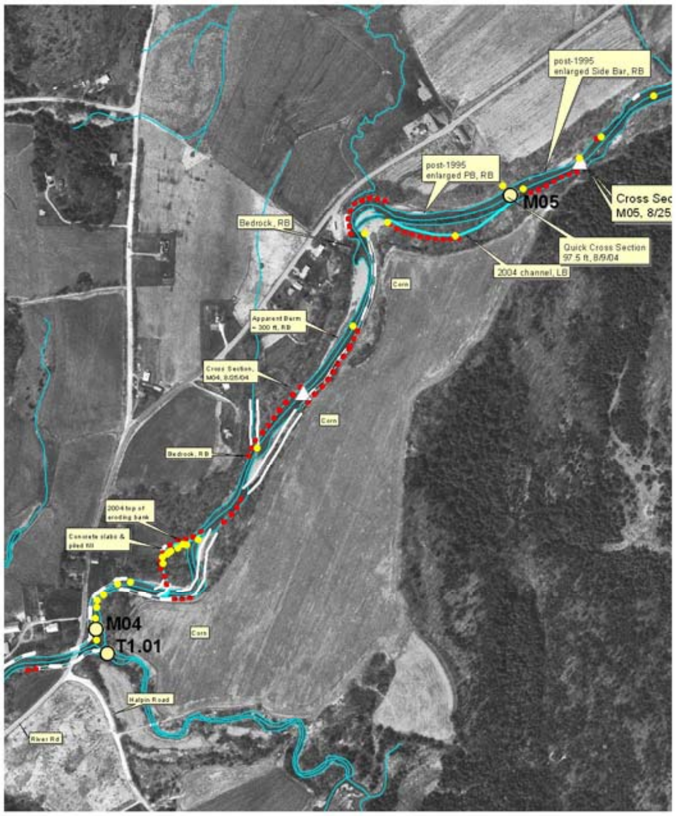
Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

Main Stem, Reach M05



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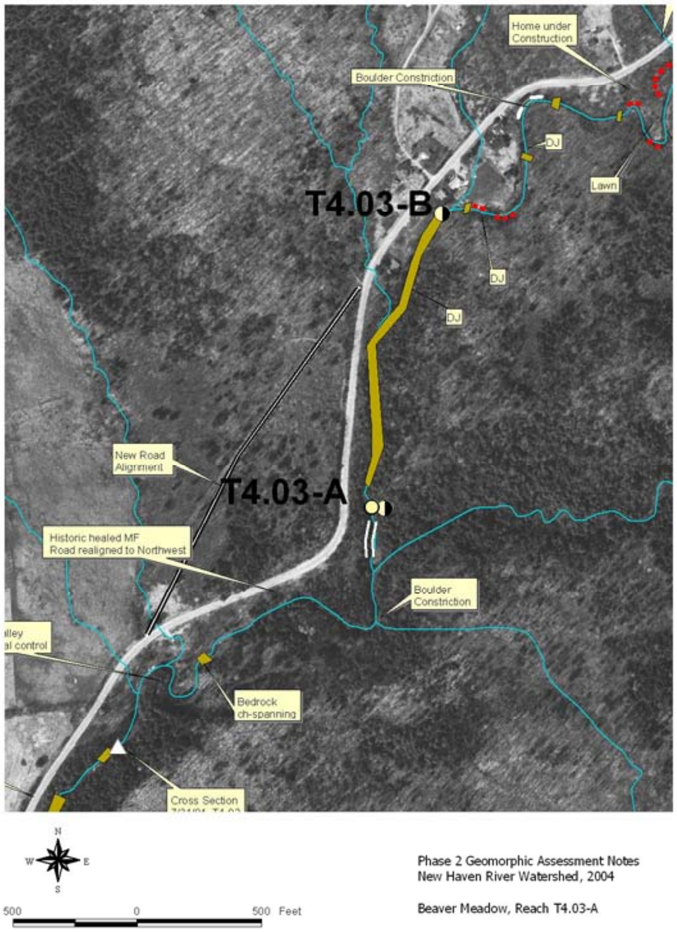
Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

Main Stem, Reach M04



Phase 2 Geomorphic Assessment Notes
New Haven River Watershed, 2004

Beaver Meadow, Reach T4.03-A

APPENDIX F

Bridge and In-stream Culvert Data

Table F.1 Select bridge and in-stream culvert data, New Haven River Watershed.

Bridge Number	Structure Type	Bridge Name	Description	Road Name	Town	Reach Number	Date Constructed	Bridge Span (ft)	Bridge and Culvert Survey	Status	Basis
200183001001132	State Long - Bridge	B10	by Old Nash Farm	River Road	New Haven	M03		NM		FPW	M
100113001101131	Town Long - Bridge	B11	New Haven Mills Bridge	Munger Street	New Haven	M09		79	yes	BKFL	M
200021000801032	State Long - Bridge	B8	Sycamore Park (frmr Palmer'	Route 116	Bristol	M11		99		FPW	M
100103001101031	Town Long - Bridge	B11	Hewitt Lane Bridge	Hewitt Lane	Bristol	M14		NM		FPW	R
100103003101031	Town Long - Bridge	B31	South Street Bridge	South Street	Bristol	M14		NM		FPW	R
200021001001032	State Long - Bridge	B10	Twin Bridge - West	Route 17 / 116	Bristol	M15		NM		FPW	M
200021001101032	State Long - Bridge	B11	Twin Bridge - East	Route 17 / 116	Bristol	M16		NM		FPW	M
100110004601101	Town Long - Bridge	B46	West Lincoln	York Hill Road	Lincoln	M17		58.0		BKFL	M
100110004801101	Town Long - Bridge	B48	Lincoln Village Bridge	Gove Hill Road	Lincoln	M19		78.7	**yes**	FPW	M
200188001901102	State Long - Bridge	B19	Lincoln Village - East	Bristol-Lincoln Rd	Lincoln	M20		79.2		FPW	M
200188001701102	State Long - Bridge	B17	Garlands Bridge	Bristol-Lincoln Rd	Lincoln	M21		68.8		FPW	M
100110004701101	Town Long - Bridge	B47		Sugar Bush Hill Rd	Lincoln	M22		63		FPW	M
100110001801101	Town Long - Bridge	B18	South Lincoln	Grimes Road	Lincoln	M24	1941	114	**yes**	FPW	R
N/A - Priv Brd M25	Private Bridge		Bucks Bridge	private drive	Lincoln	M25		NM		BKFL	M
N/A - Priv Brd M26-Sou	Private Bridge			private drive	Lincoln	M26	2003	65.0		FPW	M
N/A - Priv Brd M26-Nor	Private Bridge			private drive	Lincoln	M26		40.6		BKFL	M
100110004401101	Town Long - Bridge	B44	near forest service rd	South Lincoln Rd	Lincoln	M27	2003	34.8	**yes**	FPW	R
200021001201032	State Long - Bridge	B12	by Mary's at Baldwin Cr	Route 116	Bristol	T3.03		60.5	**yes**	FPW	R
100119005301191	Town Long - Bridge	B53		Dan Sargeant Rd	Starksboro	T3.05	1918	38		BKFL	M
300200001701191	State Short - Culvert	B17	culvert	Jerusalem Rd	Starksboro	T3.07		11.2	**yes**	BKFL	M
400119001501191	Town Short - Bridge	B15		Jerusalem Rd	Starksboro	T3.08		17.4		BKFL	M
400119001601191	Town Short - Bridge	B16		Jerusalem Rd	Starksboro	T3.08		13.8		BKFL	M
N/A - Priv Brd T3.08	Private Bridge			private drive	Starksboro	T3.08		13		BKFL	M
400119005201191	Town Short - Culvert	B52	culvert	Russell Young Rd	Starksboro	T3.08		17.6		BKFL	M
400119000901191	Town Short - Bridge	B9		Jerusalem Rd	Starksboro	T3.09		9.8	**yes**	BKFL	M
200188001501102	State Long - Bridge	B15	Beaver Meadow confluence	Bristol-Lincoln Rd	Lincoln	T4.01		60.0	**yes**	FPW	R
100110001601101	Town Long - Bridge	B16	Quaker Street Bridge	Quaker Street	Lincoln	T4.02		NM		FPW	M
400110004301101	Town Short - Culvert	B43	culvert	Hall Road	Lincoln	T4.04		16.8	**yes**	BKFL	M

Note: Unless otherwise noted, bridge widths obtained from field taped measurements, and dates constructed determined from field inspection of bridge plaques.

Abbreviations:
N/A = Not Applicable
BKFL = Bankfull; i.e., expected to be a constrictor of flows at the bankfull discharge.
FPW = Flood Prone Width; i.e., expected to be a constrictor of flows at discharges greater than the bankfull discharge, in the Q10 to Q50 range.
M = Structure span compared to bankfull width measured in the reach(es) adjacent to the structure.
R = Structure span compared to bankfull width predicted from Regional Hydraulic Geometry Curves (VTDEC, 2001)

APPENDIX G

Phase 2 Quality Assurance Documentation

Appendix G. Phase 2 Quality Assurance Documentation

The Phase 2 Stream Geomorphic Assessment was conducted in accordance with VTANR protocols (VTANR, 2004) and a Quality Assurance Project Plan (QAPP) approved by Addison County Regional Planning Commission (ACRPC) and the Vermont Department of Environmental Conservation (VTDEC):

> SMRC, 2004, *Quality Assurance Project Plan for Geomorphic Assessment of the New Haven River, Addison County, VT*. Prepared for Addison County Regional Planning Commission

As per the QAPP, a QA/QC log book was maintained during field assessments to document QA/QC issues that arose and the corrective action measures implemented to resolve these issues. The QA/QC log book is maintained at SMRC offices and is available for review upon request.

VTDEC refresher training in Phase 2 assessment methods was received by SMRC on 12 July 2004. In addition, representatives of VTDEC and the Vermont Fish & Wildlife Department participated in field assessments on five New Haven River reaches: M10, M11, M15, T3.06, and T3.07

Field data were recorded on standard field data sheets included with VTANR protocols. Original field data sheets are maintained at SMRC offices and are available for review upon request. Data were entered into the VTANR River Management Section Phase 1 and 2 database (Microsoft Access©) and Bridge & Culvert database (Microsoft Access©). Following data entry, SMRC conducted a 100% data-entry check. Errors and omissions were corrected accordingly.

The VTDEC performed a QC check of Phase 2 assessment results by conducting repeat assessments on three separate reaches: M18, M22, and M26. A 23 September 2004 report of this QA review is included in this Appendix. The VTDEC QAQC Report concludes that a "thorough and accurate assessment of the New Haven watershed" was conducted.

New Haven QAQC Report
Phase II Geomorphic & Habitat Assessment
Shannon Hill, DEC River Management
September 23, 2004

Project Manager: Kristen Underwood, South Mountain Research and Consulting (SMR&C)

Project Manager Training Date: Refresher training conducted on Lewis Creek on 7/12/04

Additional QA check: DEC QA Officer, Shannon Hill, attended assessment of reach M15 on 8/6/04.

Field verification of Phase II data: conducted on September 22, 2004 by Shannon Hill & Shayne Jaquith of VT DEC and Christa Alexander of VT F&W. During the field verification on September 21, 2004 the group reviewed the Phase II Geomorphic Assessment data on reaches M18, M22 and M26.

M18

The QA team walked a small section of the reach to the area where the cross section data was collected by SMR&C. They conducted a cross section survey of the stream and found approximately the same channel dimensions as SMR&C. The team agreed with the RGA, RHA and field notes data. The QA team also agreed with the consultants conclusions that the stream had departed from a reference of a C to an F stream type.

M22

The QA team conducted a cross section survey at approximately the same location as the consultant. The bankfull elevation was determined to be located at the back of a sandy bench. It was noted that the consultant chose to conduct the cross section survey just down stream from a rip-rap bank in a straight section of river. Without walking the entire reach the QA team could not determine if this was representative of the reach. The max depth was estimated by the QA team to be 3.9 ft above the thalweg, 1.5 ft higher than the consultant measured. The QA team estimated the low bank height at 6.3 ft above the thalweg, resulting in an incision ratio of approximately 2.

Although the QA team selected a bankfull that was higher off the stream bed, they agreed with the consultants assessment that the stream had departed from its reference stream type of C to an F. The QA team also agreed with the RGA results. Based on the short section of stream that the QA team walked, they felt that the Habitat parameters 8.2 (Embeddedness), 8.3 (Velocity Depth Regime) and 8.7 (Morphological Diversity) were rated high and that the habitat condition would be more likely in the Fair range. Considering the recent flood it is difficult to determine if the stream has changed since the consultant walked the reach.

M26

The QA team walked the majority of the reach and conducted a cross section survey at approximately the same location as the consultant. The results of the cross section survey were very similar to the consultants. Both the QA team and the consultant found that the reach was borderline between a C stream type and a B stream type based on the entrenchment and slope. The reach is characterized by alternating areas of entrenched B stream type sections with areas of more flood plane access. The consultant selected a C stream type the QA team selected a B. The QA team reviewed the filed notes as well as the results of the RGA and RHA. The QA team agreed with SMR&C assessment of the RGA and RHA.

Conclusion

It is difficult to determine what effect the recent flooding had on the stream morphology and habitat condition and therefore the QA team cannot say conclusively that the minor differences they found were not changes to the river from the flooding. Overall the QA team felt that the consultant completed a thorough and accurate assessment of the New Haven watershed. Kristen Underwood, the project leader, has had adequate training the VT ANR Stream Geomorphic Assessment and has provided the state with accurate data in the past. The New Haven Phase II report is comprehensive and informative and will provide the framework for good decision making relating to river management.

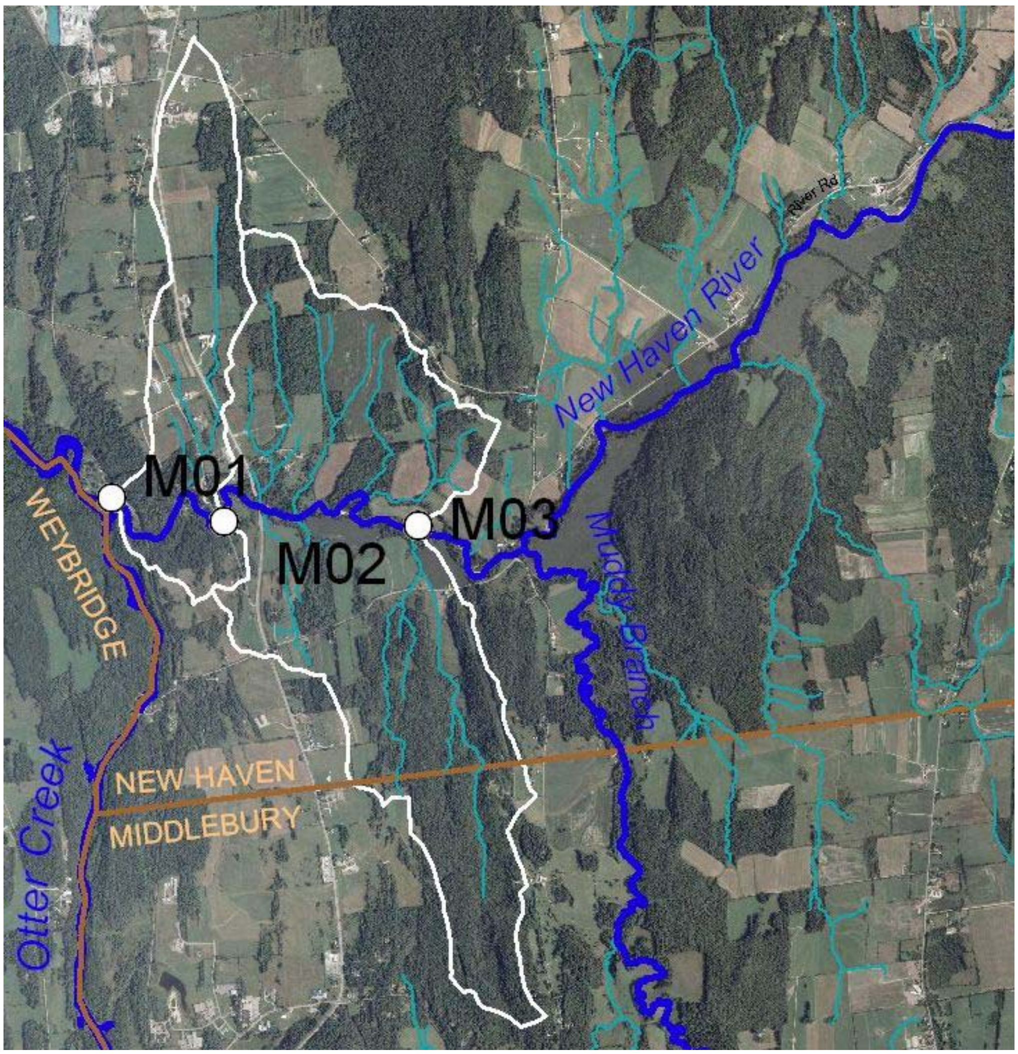
APPENDIX H

Project CD

- Report Text
- Appendices
- VTANR River Management Section Phase 1 and 2 database (Microsoft Access©)
- VTANR River Management Section Bridge & Culvert database (Microsoft Access©)
- ArcView™ Shape Files

Phase 2 Stream Geomorphic Assessment
New Haven River Watershed – Addendum
Reaches M01, M02
Town of New Haven, Addison County, Vermont

January 2008 (DRAFT)



Prepared by | *Prepared under contract to*

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2852 South 116 Road, Bristol, VT 05443
802-453-3076

Addison County
Regional Planning Commission
14 Seminary Street
Middlebury, VT 05753

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APPENDICES

ACKNOWLEDGEMENTS

This study was made possible through funding received from the FEMA Pre-Disaster Mitigation Competitive grant program, administered by the Addison County Regional Planning Commission.

Field work was conducted with the cooperation of New Haven landowners who granted permission to cross their property to access the river.

EXECUTIVE SUMMARY

Phase 2 stream geomorphic assessments were completed in 2007 on two reaches (1.9 river miles) of the New Haven River main stem in New Haven, Vermont: reaches M02 and M01. Assessments were conducted following protocols published by the Vermont Agency of Natural Resources (VTANR, 2007). Geomorphic data will be used by watershed stakeholders (including landowners, community members, watershed organizations, and state and federal resource agencies) to identify potential site-level, town-level, and watershed-level strategies for reducing streambank erosion and sediment and nutrient loading in the New Haven River watershed, by managing toward the equilibrium channel. The geomorphic condition of a given river reach or segment will help to define the short-term compatibility and long-term sustainability of various restoration or conservation projects and inform future land use or channel management choices.

Field investigations and limited historical data reviews have identified various watershed and channel disturbances that have impacted these reaches of the New Haven River, including:

Watershed-scale Modifiers:

- Historic deforestation and subsequent reforestation from the mid-1800s through the early 1900s;
- Significant flood events in 1998, 1976, 1938, 1936 and 1927; and
- Upstream erosion and tributary sources of sediment.

Reach-scale Modifiers:

- Channelization (straightening) inferred near the VT Route 7 bridge crossing;
- Berming along the banks (short lengths in M02);
- Streambank armoring (rip-rap);
- Floodplain encroachment by roads, railroads, residential development, and agricultural fields;
- Bridges which constrict channel flows at flood stage (VT Rt 7 and Dog Team Rd);
- Stormwater runoff from crop fields (one field ditch noted in M02);
- Minimal or absent forested buffers along portions of the study reaches;

The uppermost assessed reach (M02) flows through a broad to very broad valley setting (unconfined), and has been minimally constrained by human land use changes or channel and floodplain modifications. This is a natural deposition-dominated reach, positioned immediately upstream of a naturally-confined, bedrock gorge (M01-B). It shows signs of increased sediment deposition in recent years, related to the upstream and in-reach production of sediments, and likely related to the 1998 flood (an estimated 500-year event). Locally, sediment deposition has been enhanced at the Route 7 bridge, a flood-prone-width constrictor. The reach-wide prevalence of depositional bars and active lateral adjustments suggests that sediment transport capacity in reach M02 may have been further reduced by sediment loading from upstream sources.

At present, the channel has reasonable access to a broad floodplain and channel-contiguous wetlands associated with recently-abandoned meander sites (although a minor degree of historic incision persists). A channel evolution stage of IV (F-stage model) and a "Very High" sensitivity rating were assigned to reach M02 following guidance presented in the geomorphic assessment protocols (VTANR, 2007). The reach appears to be near the latter stages (stage IV) of a channel evolution process which may have been initiated historically by incision related to past flood events, and/or limited channelization. The "Very High" sensitivity assigned reflects the erodible materials (gravels, silts) in the bed and banks and the high likelihood for further channel adjustments in response to future changes in water and sediment

loading. This sensitivity rating also reflects the current geomorphic condition of the reach ("Fair" – in Major Adjustment); planform adjustment is the dominant adjustment process. It would be prudent to avoid future developments and encroachments along reach M02 to protect public safety and avoid future fluvial erosion losses. Management options advised for this reach include preservation and restoration of floodplain connection and reference meander expression through passive geomorphic approaches including avoidance measures and possible corridor easements (with landowner willingness). Restoration of forested buffers (where absent) would increase streambank stability and reduce erosion in the long term.

Downstream reach (M01) flows through a Narrowly-confined valley setting; the channel is constrained, both laterally and vertically by bedrock outcroppings in the bed and bank. The higher-gradient segment of the reach, M01-B, is naturally transport-dominated. Most of the sediment and debris supplied to this segment from the upstream watershed is likely conveyed through to M01-A and the Otter Creek; there is minimal opportunity for flow and sediment attenuation. The "Low" sensitivity assigned to this segment (by protocol) reflects the stability offered by the underlying bedrock and suggests minimal likelihood of vertical and lateral adjustments. This is a segment considered "In regime" (VTANR protocols, 2007).

Similarly, segment M01-A is in a Narrowly-confined valley setting. Lateral adjustments of the channel are naturally constrained by bedrock along the left bank and an elevated post-glacial terrace along the right bank followed by a bedrock-controlled valley wall within one bankfull width. Potential vertical adjustments would be moderated by bedrock ledge exposed at the upstream end of the segment and within the Otter Creek just downstream of the New Haven River confluence. M01-A is a natural transport-dominated segment with limited opportunity for sediment and flow attenuation. Sediments and large woody debris supplied from the upstream watershed appear to be conveyed through the segment to the Otter Creek; a small tributary confluence bar was noted. The observed stream type (entrenchment ratio, channel dimensions, slope) was consistent with reference, or expected, stream type for the valley setting. A channel evolution stage of I (F-stage model) was assigned. The "High" sensitivity assigned to M01-A reflects the erodible materials (gravel-dominated) in the bed and the potential (though limited in extent) for vertical channel adjustments in response to future changes in water and/or sediment loading. This sensitivity rating also reflects the current geomorphic condition of the reach ("Good" – minimal adjustment); a Very High or Extreme sensitivity would have been assigned if the segment were exhibiting major adjustments or a departure from reference condition.

At present, enhanced erosive energies within segment M01-A appear to be balanced by the resisting forces of the channel margins (e.g., bedrock along the left bank and occasional single-line tree buffers and armoring along the right bank). Still, Segment M01-A remains susceptible to channel adjustments and associated fluvial erosion losses in future flood events, given its naturally-entrenched status and moderately erodible streambank sediments (along right bank). Tree buffers should be preserved and enhanced, where possible, to maintain streambank stability and minimize erosion. It would be prudent to limit future, more-permanent development along this right-bank terrace to avoid fluvial erosion hazards.

1.0 INTRODUCTION

Phase 2 geomorphic assessments were completed in 2007 on 2 reaches (1.9 river miles) near the mouth of the New Haven River main stem following protocols published by the Vermont Agency of Natural Resources (VTANR, 2007a). Objectives of the Phase 2 assessments were to:

- determine the geomorphic condition of targeted reaches, and identify active vertical and lateral adjustment processes;
- identify current and historic disturbances to the channel at the reach and watershed levels; and
- evaluate the sensitivity of reaches to future channel and watershed stressors given their current geomorphic condition and inherent vulnerability (e.g., valley setting, slope, streambed and streambank sediments, vegetative buffer conditions).

Assessment data were entered into the online Data Management System (DMS), a custom database of geomorphic data developed and maintained by the Vermont Water Quality Division. This summary report has been prepared by South Mountain Research & Consulting (SMRC) of Bristol, Vermont under contract to the Addison County Regional Planning Commission (ACRPC). This report serves as an addendum to the 2004 *Phase 2 Stream Geomorphic Assessment of the New Haven River Watershed* prepared by SMRC, also under contract to the ACRPC (SMRC, 2004a).

Assessment results will be used by landowners and other watershed stakeholders to:

- support restoration and conservation project planning and design;
- plan for future development which is compatible with adjusting river channels;
- support the evaluation of Vermont rivers for listing or de-listing of waters pursuant to Part G, State of Vermont List of Priority Surface Waters Outside the Scope of Clean Water Act, Section 303(d) of the Federal Clean Water Act (VTDEC WQD, 2006a); and
- understand water quality and temperature monitoring trends in the river.

The New Haven River main stem reaches assessed were M01 and M02 located in the town of New Haven. These reaches span VT Route 7 and the Dog Team Road.

2.0 BACKGROUND

The assessed river reaches are located within the greater New Haven River watershed, which drains approximately 116 square miles of land area located in Addison, Chittenden and Washington Counties of Vermont. The New Haven River watershed is a subwatershed of the larger Otter Creek Basin that drains to the north to Lake Champlain at the western border of Vermont (Figure 1).

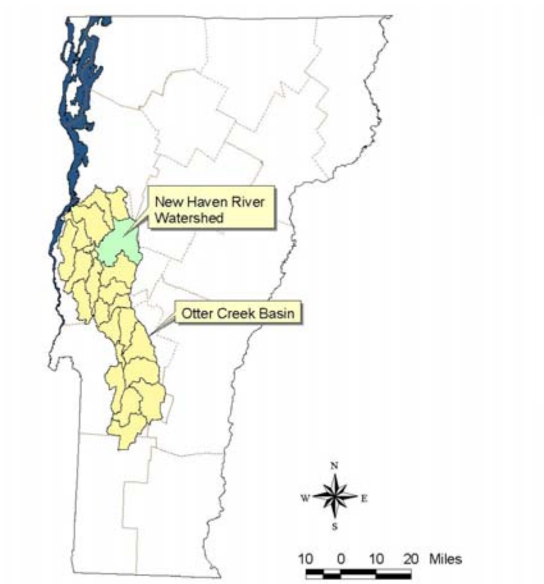

Figure 1. New Haven Watershed Location within the Otter Creek Basin and Vermont.

The subwatersheds draining to New Haven River main stem reaches M01 and M02 are located at the southern end of the town of New Haven and the northwestern corner of Middlebury (see Figure 2).

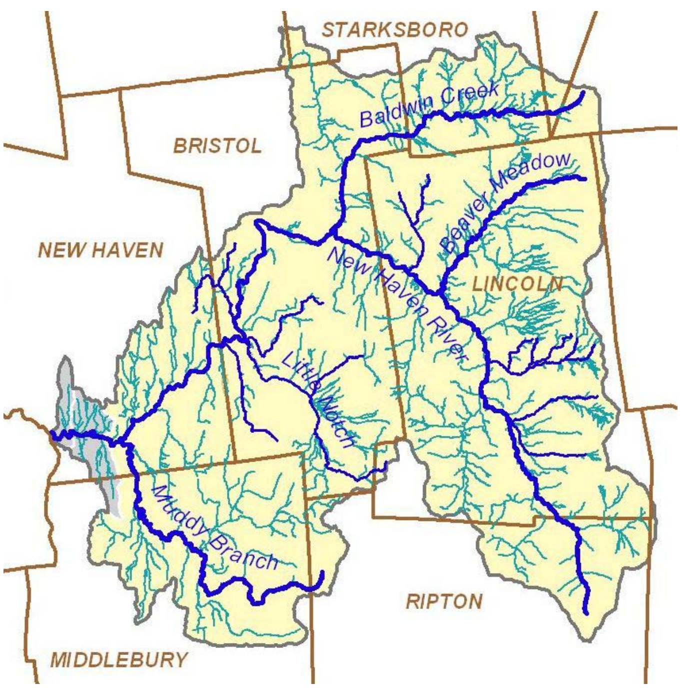

Figure 2. Location of subwatersheds (shaded gray) draining to reaches M01 and M02 in the New Haven River watershed.

Reaches M01 and M02 are located in a section of the main stem just downstream of the Muddy Branch confluence and upstream of the New Haven River confluence with Otter Creek (Figure 3). The subwatersheds draining to reaches M01 and M02 are located in the Champlain Valley physiographic province (Stewart, 1973). Soil types in these subwatersheds are derived dominantly from glacio-lacustrine and glacial till parent materials, although soils along the immediate corridor surrounding the river in M02 are dominantly derived from alluvial and glaciofluvial sediments (USDA NRCS, 2005; USDA NRCS, 2001; Calkin, no date; Stewart & MacClintock, 1969). Bedrock (limestone, dolomite) provides lateral and vertical controls along reach M01 (and in the Otter Creek in vicinity of the New Haven River confluence) (Stewart, 1973).

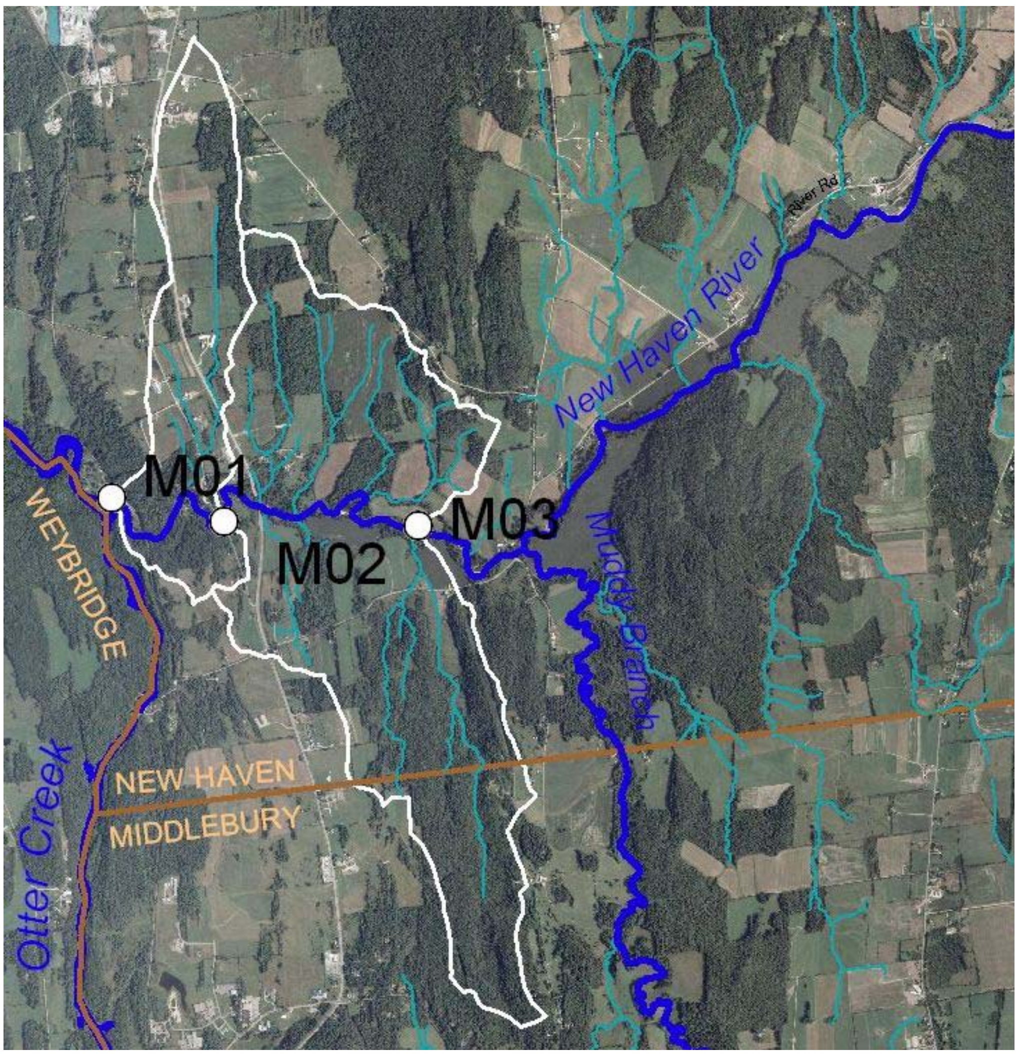

Figure 3. Location of subwatersheds (outlined in white) draining to reaches M01 and M02 in the towns of New Haven and Middlebury.

At present, land uses in these subwatersheds are comprised of low-density residential and commercial properties as well as agricultural fields and forested areas. Historically, an industrial and manufacturing center was present in Brooksville along the Dog Team Road near the New Haven River crossing and the bedrock falls approximately 500 feet downstream of this crossing (see Figure 4). A dam was first constructed at this site in the late 1700s or early 1800s (Farnsworth, 1984). At that time, industry in this area included a trip-hammer shop, wagon shop, sawmills, furnaces, blacksmith shop and (flax seed) oil

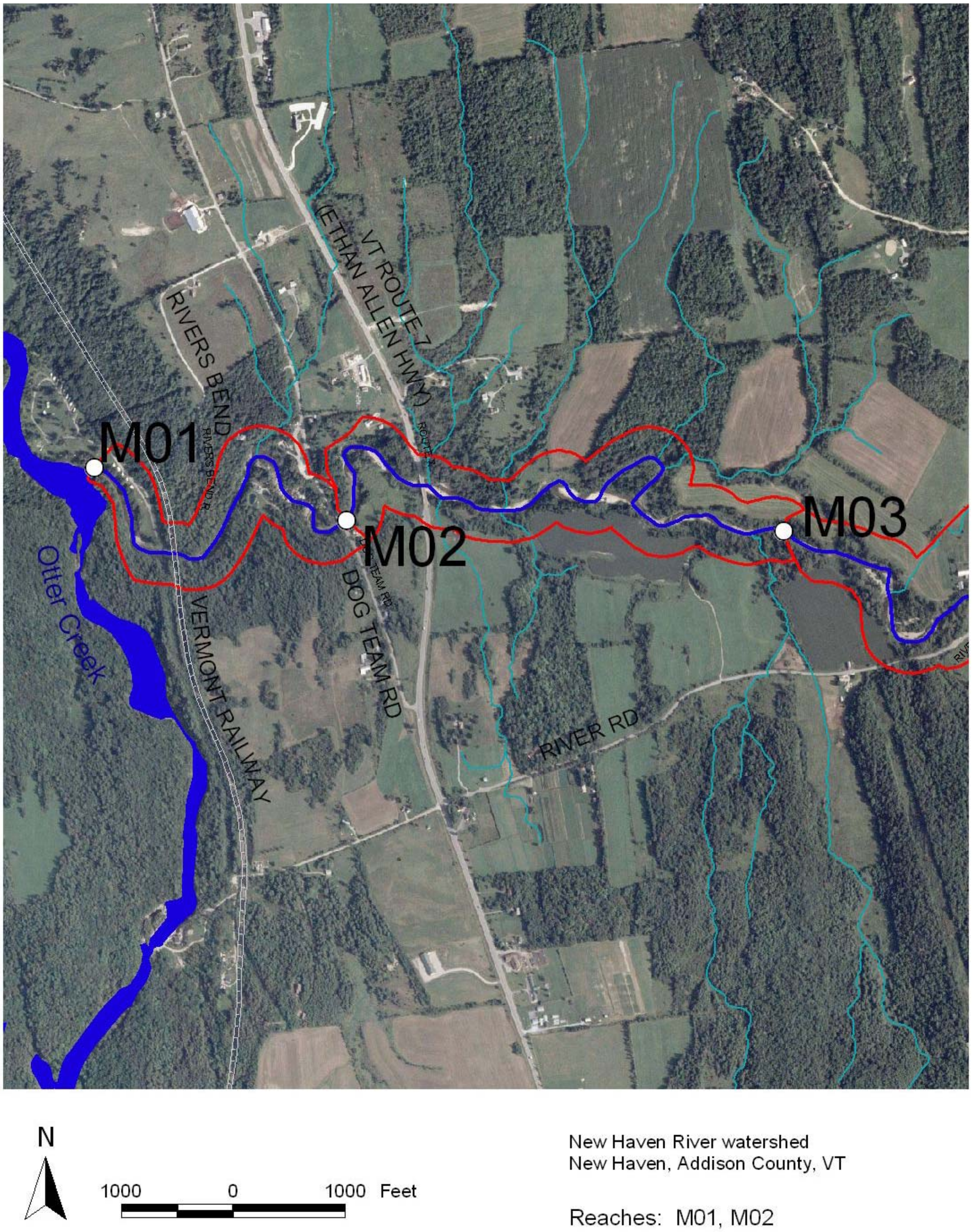

Figure 4. New Haven River reaches, M01 and M02, New Haven, VT (red boundary indicates Phase 1 corridor [SGAT version 2; SMRC, 2004b]). (Flow in New Haven River is from right to left of the picture; flow in Otter Creek is from bottom to top of the picture).

mill (Smith, 1886; Farnsworth, 1984). A majority of these buildings were washed out in the flood of 1830. Some of these interests were rebuilt. Beginning in the 1840s, the dam and associated mill buildings were owned and operated by the Brooks Brothers Company (later Brooks Edge Tool Company), best known for manufacture of axes which were distributed nationwide (Brooks, 2005; Beers, 1871; Farnsworth, 1984). This enterprise operated into the late 1800s. Brooksville Manufacturing Company and other interests including the Vermont Marble Company conducted manufacturing and industrial operations at the site into the early 1900s (Farnsworth, 1984; Brooks, 2005). A dam is no longer present at the site; the exact date of dam breach was not able to be ascertained in the limited historical research conducted for this assessment. It is possible that the floods of 1927, 1936 and/or 1938 may have damaged the dam.

Two dams are present on the Otter Creek within close proximity to the New Haven River confluence (EmergyOther_DAMS coverage: VCGI, 2005); both are owned and operated by OMYA, Inc. (formerly Vermont Marble Company):

- Huntington Falls Dam – located approximately 1.3 river miles downstream of the confluence; constructed 1910 for purposes of generating hydro-electric power.

- Beldens Dam – located approximately 0.9 river mile upstream of the confluence; constructed in 1913 for purposes of hydro-electric power generation.

Both dams are constructed on bedrock. The Huntington Falls Dam may possibly impound flows and sediments in the Otter Creek in such a way as to influence the base level of the New Haven River. Since bedrock grade controls exist in the New Haven River within one-third of a mile upstream of the Otter Creek confluence, the potential influence of this dam on water and sediment transport in the New Haven River is likely limited.

The Vermont Railway (previously the Rutland & Burlington Railroad [USGS. 1905]) crosses the New Haven River in reach M01 high above the channel (Figure 4). The exact construction date of this railroad is not known, but the railroad was present in the 1871 Beers Atlas of Addison County. The Dog Team Road crosses reach M01 near the reach break with M02. This road also predates the 1871 Beers Atlas. A USGS bridge scour report (Burns & Wild, 1998) indicates that the current bridge on this road over the New Haven River was constructed in 1927. Vermont Route 7 crosses in reach M02. Based on a review of historic aerial photographs, Vermont Route 7 was constructed sometime between 1942 and 1962. VTrans bridge and culvert databases indicate that the VT Route 7 bridge was constructed in 1960.

Major flood events which have impacted the New Haven River watershed include large events in 1998, 1976, 1938, 1936, 1927, 1869 and 1830 (SMRC, 2004a). Additional discussion of the geology, geomorphology, hydrology, and flood history of the New Haven River watershed is provided in the *Phase 2 Stream Geomorphic Assessment of the New Haven River Watershed* (SMRC, 2004a).

3.0 ASSESSMENT METHODOLOGY

Stream geomorphic assessments conducted in reaches M01 and M02 of the New Haven River utilized protocols published by the Vermont Agency of Natural Resources (2007 version) and available at: http://www.vtwaterquality.org/rivers/htm/rv_geoassesspro.htm. Reference is made to these protocols for a description of specific methods followed to complete Phase 2 Stream Geomorphic Assessments and Bridge and Culvert Assessments.

3.1 Phase 2 Stream Geomorphic Assessment

Phase 2 Stream Geomorphic Assessment protocols are field procedures for geomorphic and habitat assessment. Reach-specific and cross-section data gathered during Phase 2 characterize the present geomorphic condition of the river reach and the dominant process(es) of adjustment (i.e., degradation, widening, aggradation and/or planform adjustment). Phase 2 results, along with Phase 1 assessment results, define the natural and human disturbances to the watershed and channel over time and the composite response or adjustment of the channel to these stressors.

Reaches M01 and M02 were assessed by kayak (12 September 2007) and additional cross sections were measured in reach M02 on foot (11 December 2007). During Phase 2 assessments, specific features and present channel positions were located using a Garmin™ eTrex Vista global positioning system (GPS) unit. Pictures were recorded with a digital camera.

In accordance with protocols, specific features were digitized in ArcView© 3.x. Features were referenced to the Vermont Hydrography Dataset (VHD), using the Feature Indexing Tool, a component of the Stream Geomorphic Assessment Tool (SGAT, v. 4.56). The original Phase 1 Stream Geomorphic Assessment for these reaches (SMRC, 2004a) was completed using SGAT version 2. A more recent SGAT project (version 4.56) was obtained in January of 2008 from the VTDEC River Management Section to enable feature indexing of Phase 2 features (and Phase 1 updates) for this project. Certain parameters documented during the original Phase 1 Stream Geomorphic Assessment were updated based on field observations in Phase 2 (see Section 3.2).

Phase 2 assessment data were entered into the online Data Management System (DMS, v.4.56) maintained by the VTDEC WQD. Phase 2 reach summary reports, standard output from the DMS, are compiled in Appendix A.

Two road crossing structures were encountered during Phase 2 assessments. Structure spans, clearance and width measurements were conducted at each structure. The span of each crossing was compared to measured or predicted bankfull widths (VTDEC WQD, 2006b), to determine if the structure was a constrictor of flows at the bankfull stage or the flood-prone-width elevation (10-year to 50-year flood). Appendix B of this report provides a summary of the bridge and culvert assessments completed for these bridge crossings in accordance with Appendix G of the VTANR protocols (July 2007 version). Bridge and culvert data were entered into the Structures portion of the DMS (under the "New Haven River" database).

3.2 Phase 1 Updates

Phase 1 assessment data (from 2004) for reaches M01 and M02 were reviewed and verified during field work as per VTANR protocols. Necessary corrections or updates were documented on Phase 1 summary sheets for each reach (see original field data sheets). As appropriate, GIS shape files were corrected or updated (using the Feature Indexing Tool). Phase 1 data in the DMS was updated, and Phase 1 reach summary reports (standard output from the DMS) are presented in Appendix A.

Elevation data were revised slightly for both reaches following field-based observations (see Appendix D). Also, the position of the valley wall was updated, based on field observations and following clarifications to valley wall delineation procedures articulated in protocol updates between 2004 and 2007. A revised valley wall shape file is contained on the Project CD.

Valley wall revisions resulted in a change to the reference stream type for reach M02 – from a Bc channel to a C channel. In the former Phase 1 assessment, meander geometries were not estimated for this reach due to the assigned stream type of Bc. Now that the reach has been corrected to a C stream type, estimation of meander geometry and associated impact scores are required under Phase 1 Steps 6.5 and 6.6. These data were developed and are summarized in Appendix E. Shape files of the meander belt widths and wavelengths are included on the Project CD.

Other Phase 1 parameters reviewed and updated (where appropriate), included:

- presence of alluvial fans (Phase 1 Step 3.1);
- presence and location of bedrock or other grade controls (Phase 1 Step 3.2)
- steepness of valley side slopes (Phase 1 Step 3.4);
- width of riparian buffers (Phase 1 Step 4.3);
- groundwater inputs (Phase 1 Step 4.4);
- revetment lengths and locations (Phase 1 Step 5.3);
- channel straightening (Phase 1 Step 5.4);
- location and lengths of berms and roads (Phase 1 Step 6.1);
- location and lengths of development (Phase 1 Step 6.2);
- occurrence of depositional bars and bedforms (Phase 1 Step 6.3);
- occurrence of channel avulsions, neck cut-offs, flood chutes (Phase 1 Step 6.4);
- erosion lengths and heights (Phase 1 Step 7.2);
- occurrence of, or potential for, ice/debris jams (Phase 1 Step 7.3)

The above features are more comprehensively inventoried for the study reaches during field assessments, than they are able to be during a Phase 1 which is accomplished through remote sensing and limited windshield surveys. The metadata for each Phase 1 step in the database were reviewed and updated (where necessary) to reflect that data were supported by field observations.

3.3 Quality Assurance / Quality Control

Assessments were performed under a programmatic Quality Assurance Project Plan (QAPP) generated by the Vermont Water Quality Division, River Management Section (VTDEC WQD, 2003).
Following completion of standard DMS Phase 2 quality control checks (X.1 through X.4), Phase 2 data were submitted to the River Management Section for a quality assurance review. Quality assurance documentation is included in Appendix C.

Select Phase 2 features (including, grade control locations, stormwater inputs, streambank erosion, revetment locations, and more) were geo-located using the Feature Indexing Tool (FIT) in SGAT. These features are indexed to the available Vermont Hydrography Dataset (VHD) for the New Haven River watershed which appears to have been generated from 1995 orthophotographs. In reach M02, the actual channel position has moved from its 1995 position as a result of a neck cutoff and meander extension and translation, as revealed by comparison of the 1995 orthophotos with the 2003 aerial imagery (NAIP, 2003), and by review of 2007 channel positions recorded with a hand-held GPS. Thus, locations and lengths of features indexed to the VHD should be considered approximate. Waypoint logs and sketch maps contained on the Project CD provide more insight into the recorded locations of these features.

4.0 PHASE 2 ASSESSMENT RESULTS

Geomorphic and habitat assessments were completed on 2 reaches (1.9 river miles) of the New Haven River main stem: M01 and M02. Phase 2 assessment results are summarized in Table 1 and are discussed below for each reach (Sections 4.1 and 4.2). Detailed Phase 2 assessment results are tabulated in Appendix A, the standard report output from the online DMS for Phase 1 & 2 Stream Geomorphic Assessment data.

A reference stream type (Phase 1) and an existing stream type (Phase 2) have been classified for each reach. Stream type designations are based on Rosgen (1996) and Montgomery & Buffington (1997). A sensitivity classification was also assigned to each reach based on the Phase 2 stream geomorphic assessment data. The sensitivity classification is intended to identify "the degree or likelihood that vertical and lateral adjustments (erosion) will occur, as driven by natural and/or human-induced fluvial processes" (VTANR guidance, 11 July 2007). Inherent in the stream sensitivity rating are:

- the natural sensitivity of the reach given the topographic setting (confinement, gradient) and geologic boundary conditions (sediment sizes) – as reflected in the reference stream type classification; and
- the enhanced sensitivity of the reach given by the degree of departure from reference (or dynamic equilibrium) condition – as reflected in the existing stream type classification and the condition (Reference, Good, Fair to Poor) rating of the Rapid Geomorphic Assessment).

Abbreviations used in the sections below include the following (see protocols for further description):

- Left Bank, facing downstream (abbreviated, "LB")
- Right Bank, facing downstream (RB).
- Incision Ratio (IR) = Low Bank Height / Bankfull Max Depth
    - IR_{RAF} = Recently Abandoned Floodplain Incision Ratio
    - IR_{HEF} = Human-Elevated Floodplain Incision Ratio
- Entrenchment Ratio (ER) = Flood Prone Width / Bankfull Width
- Flood Prone Width (FPW) – estimated as the 10- to 50-year flood event
- Large Woody Debris (LWD)
- Debris Jams (DJs)
- Rapid Geomorphic Assessment (RGA)
- Rapid Habitat Assessment (RHA)
- Vermont Hydrography Dataset (VHD)
- National Wetlands Inventory (NWI)
- Vermont Significant Wetlands Inventory (VSWI)

Table 1. Results of Phase 2 Geomorphic Assessments, New Haven River reaches M01 and M02 completed in 2007.

Reach	Seg-ment	Channel Length (ft)	Channel Slope (%)	Drainage Area (sq mi)	Stream Type	Incision Ratio	RHA Condition	RGA Condition	Adjustment	Channel Evolution Stage	Stream Type Departure?	Sensitivity
M02	--	5,994	0.2	115.7	C4-R/P	1.2 (RAF)	0.65 Good	0.60 Fair	Mod PF / Aggr	IV (F)	No	Very High
M01	B	2,173	***0.7***		A1c-S/P *	NM	Not Assessed - Bedrock Gorge					Low
	A	1,580	***0.1***	116.4	A4c-R/P	1.0 (RAF)	0.76 Good	0.83 Good	None	I (F)	No	High

Notes / Abbreviations:

Channel Slope: Values in italic bold have been updated since the Phase 1 SGA, due to field-truthing and/or segmentation.
Stream Type: S/P = Step/Pool; R/P = Riffle/Pool; R/D = Ripple/Dune; PB = Plane Bed; Casc = Cascade; Ref = Reference
Incision Ratio: RAF = Recently Abandoned Floodplain; HEF = Human-elevated Floodplain (following protocols, VTANR, 2007).
Condition: RHA = Rapid Habitat Assessment; RGA = Rapid Geomorphic Assessment (VTANR, 2007).
Adjustment: PF = Planform Adjustment; Aggr = Aggradation; Wid = Widening; Deg = Degradation; NM = Not Measured.
Channel Evolution Stage: F = F-stage model; D = D-stage model (see Appendix C of protocols, VTANR, 2007).

* Note: Segment B of M01 is a subreach of alternate stream type (with sections of bedrock-cascade, bedrock & boulder step/pool, and plane-bed bedrock gorge.

Note: Above data are provisional; not yet quality-assured by VTDEC River Management Section.

4.1 Reach M02

Reach M02 is 1.1 mile long (5,994 feet) and extends from the vicinity of the CVPS / Velco power line crossing downstream to the Dog Team Road bridge crossing (Figure 5). The valley setting is unconfined. Estimated valley widths vary from 430 feet 1,340 feet, averaging 820 feet. Generally, the reference valley confinement is Broad (6 to 10 times bankfull width), with localized areas of Narrow (4 to 6 times) or Very Broad (greater than 10 times) confinement. Overall channel gradient is estimated as 0.2%. Thus, a reference C4-riffle/pool stream type was assigned to reach M02.

Corridor soil types are dominated by sediments of recent alluvial origin as well as sediments of glaciolacustrine origin (USDA NRCS, 2005; USDA NRCS, 2001; Calkin, no date; Stewart & MacClintock, 1969). Generally, the contact between lacustrine sediments and recent alluvium is thought to represent the valley wall. Most often, exposed stream bank soils were layered silts with overlying fine- to medium-grained sands. Varved clays were noted in a few locations typically exposed near the thalweg on the outside of a meander bend. Bedrock offers lateral grade control along the right bank at the prominent meander bend near the downstream end of the reach between the VT Route 7 and Dog Team Road crossings. Several pockets of channel-contiguous wetlands are mapped along the reach corridor, often associated with tributary confluences and abandoned channel meanders (NWI, VSWI). Hydric soils are also prevalent within the floodplain and uplands immediately surrounding the stream valley; often areas of mapped hydric soils are coincident with crop fields (USDA NRCS, 2005; USDA NRCS, 2001).

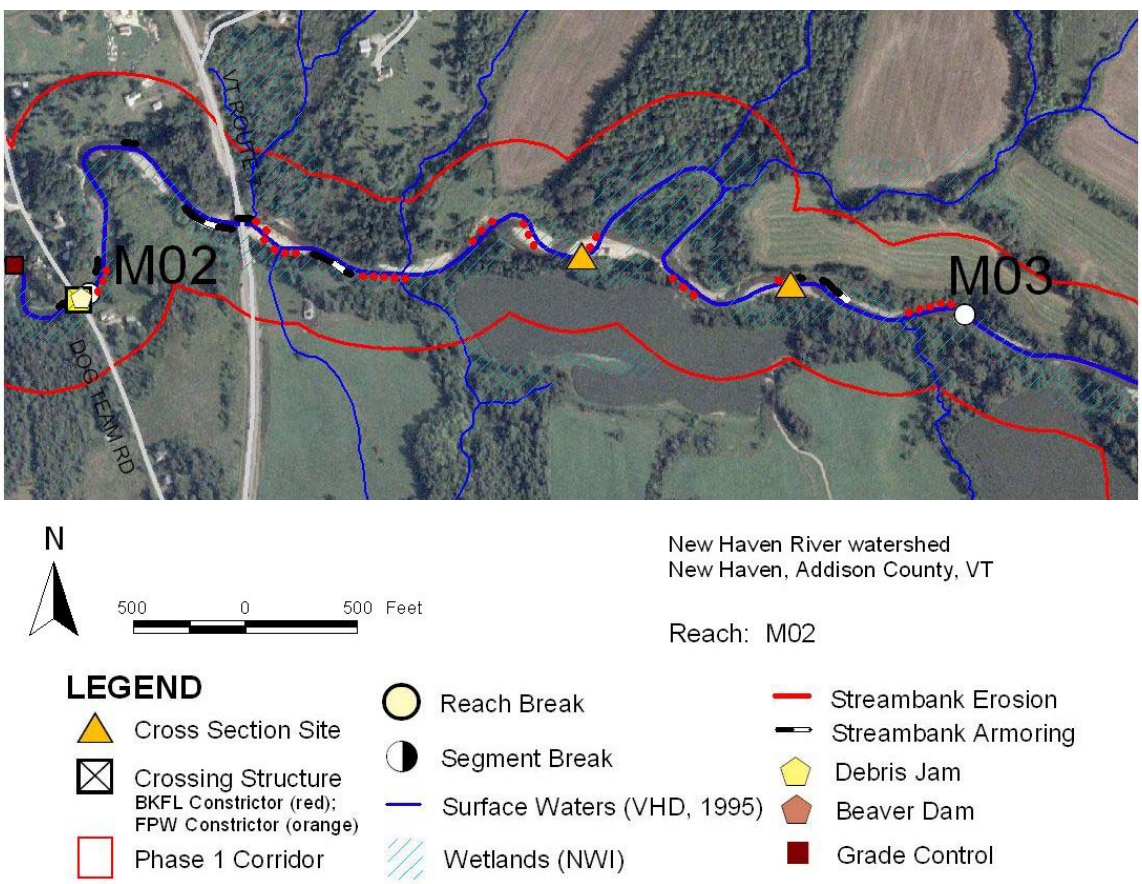

Figure 5. Reach M02 (flow is from picture right to picture left).
(Red boundary indicates Phase 1 corridor [SGAT version 2; SMRC, 2004b]).

Human encroachments within the reach corridor are minimal. The LB corridor is dominated by a mixture of crop (and some hay) fields, as well as limited forest and scrub/shrub cover. The RB corridor is dominated by forest cover, with some corn fields. A few residential homes and outbuildings are located along the left and right banks in the vicinity of the Route 7 and Dog Team Road crossings. Rip-rap armoring is present along the banks in the vicinity of these homes, and also at select locations elsewhere in the reach to protect adjacent crop fields. A boulder berm (apparent field stone) was noted for an approximately length of 80 feet along a former channel position (now flood chute) in the LB corridor near the mid-point of the reach. This feature varied in height and width; at one measurement site adjacent to cross section site, CS-2, the berm had a measured thalweg height of approximately 9.6 feet (higher than bankfull elevation, but not higher than the estimated flood-prone-width elevation; IR_{HEF} = 1.5). Fill material supporting bridge approaches fills the floodplain at the VT Route 7 crossing. The span from abutment to abutment of this bridge is wider than measured and reference bankfull width values, but is expected to constrict flood flows. A large mid-channel bar and island were noted upstream of this bridge; a small mid-channel bar was located immediately downstream of the bridge. A subtle berm was noted along the LB for a short distance downstream of the VT Route 7 crossing (thalweg height of approximately 9 feet). Historic straightening of the channel upstream and immediately downstream of this bridge crossing is inferred from the linear planform.

Depositional bars (point bars, side bars, mid-channel bars, transverse bars) are frequent within the reach; some pools are relatively shallow and bar heights are occasionally greater the one-half bankfull height. Active recruitment of large woody debris (LWD = 65) is generating local scour holes, providing variability in velocity/depth patterns and contributing to morphological diversity. At the low to moderate flow stage of the assessment date (9/12/2007), many of the riffle substrates were exposed. Forested buffer widths are moderate to occasionally absent; this fact combined with the large size of the channel and its open canopy result in limited shading for the river. Moderate streambank erosion was noted, related to active meander extension and a recent (post-1995, pre-2003) neck cut-off. Active recruitment of large woody debris and detritus is occurring, providing epiphaunal substrates and organic matter for instream habitats. Overall, a "Good" habitat condition rating (0.65) was assigned following the RHA (on the cusp with a "Fair" rating).

Figure 6.
Transverse depositional bars and point bars are frequent along Reach M02.

(View upstream, 12 September 2007).

Two cross sections were completed in reach M02 and confirmed a gravel-dominated C-riffle/pool stream type. The river has access to a wide floodplain. A minor degree of historic incision is indicated by the measured incision ratios of 1.18 and 1.22; no indications of active incision were noted in the reach (e.g., headcuts, coincident undercut banks on both LB and RB). Historic incision may be related to inferred channelization near the VT Route 7 bridge (circa 1960s). Perhaps, historic breaching of a dam(s) at Brooksville, which operated in downstream reach M01 from the 1700s through the early 1900s may have contributed to historic incision (the construction specifications and potential impoundment heights of this former dam(s) are not known). Historic incision in M02 may also have been associated with past flood events and deforestation / reforestation cycles in the late 1800s and early 1900s. It is possible that aggradational processes and planform adjustments have offset the potential for channel incision in the reach.

Minimal indications of widening were noted. One of the cross section sites had an estimated width/depth ratio of 46.7; however, this ratio appears to be more related to aggradation and planform adjustment processes than active channel widening. (The second cross section site had a measured W/D ratio of 21). While undercut banks, exposed root systems, and leaning trees were evident along the channel, these features tended to be located along either bank (not both banks in one location) and were associated with meander extension (planform adjustment processes). Moderate aggradation and planform adjustment were indicated by the prevalence of depositional bars, meander migration sites, the recent neck cut-off, as well as several bankfull-elevation flood chutes. The channel has a different planform at present than is represented by the 1995 VHD. The blue line in Figure 5 represents the approximately 1995 channel position (VHD), superimposed on the 2003 aerial photograph.

The geomorphic condition of reach M02 was rated as "Fair" following the RGA (score of 0.60). Overall, this reach appears to be operating as a deposition-dominated reach. A reduced sediment transport capacity is inferred, due to increased sediment and debris from in-reach and upstream sources. It is likely that flood sediments associated with the 1998 flood event are still working their way through the river network; this was an estimated 500-year flood event (Olson, 2002). Also, streambank erosion is prevalent in upstream reaches (e.g., M03 through M08), due to ongoing channel adjustments, and areas of absent forest buffers in erodible soils (SMRC, 2004a). A channel evolution stage of "IV (F)" and a "Very High" sensitivity rating were assigned to reach M02 following guidance presented in the geomorphic assessment protocols (VTANR, 2007).

4.2 Reach M01

Reach M01 is approximately ¾ of a mile in length (3,753 feet) and continues from the Dog Team Road crossing, over the falls at Brooksville and on to join the Otter Creek at Rivers Bend campground. Within reach M01, the New Haven River crosses north-south strike of limestone and dolomite formations; bedrock provides both lateral and vertical grade controls to the New Haven River channel. Bedrock falls are also located along the Otter Creek within close proximity to the New Haven River confluence (e.g., Huntington Falls, Beldens Falls). Reach M01 was segmented to capture a subreach of bedrock-controlled channel in the upstream 2/3 of the reach (see Figure 7): Segment B = 2,173 feet, 0.7% gradient; Segment A = 1,580 feet, 0.1% gradient.

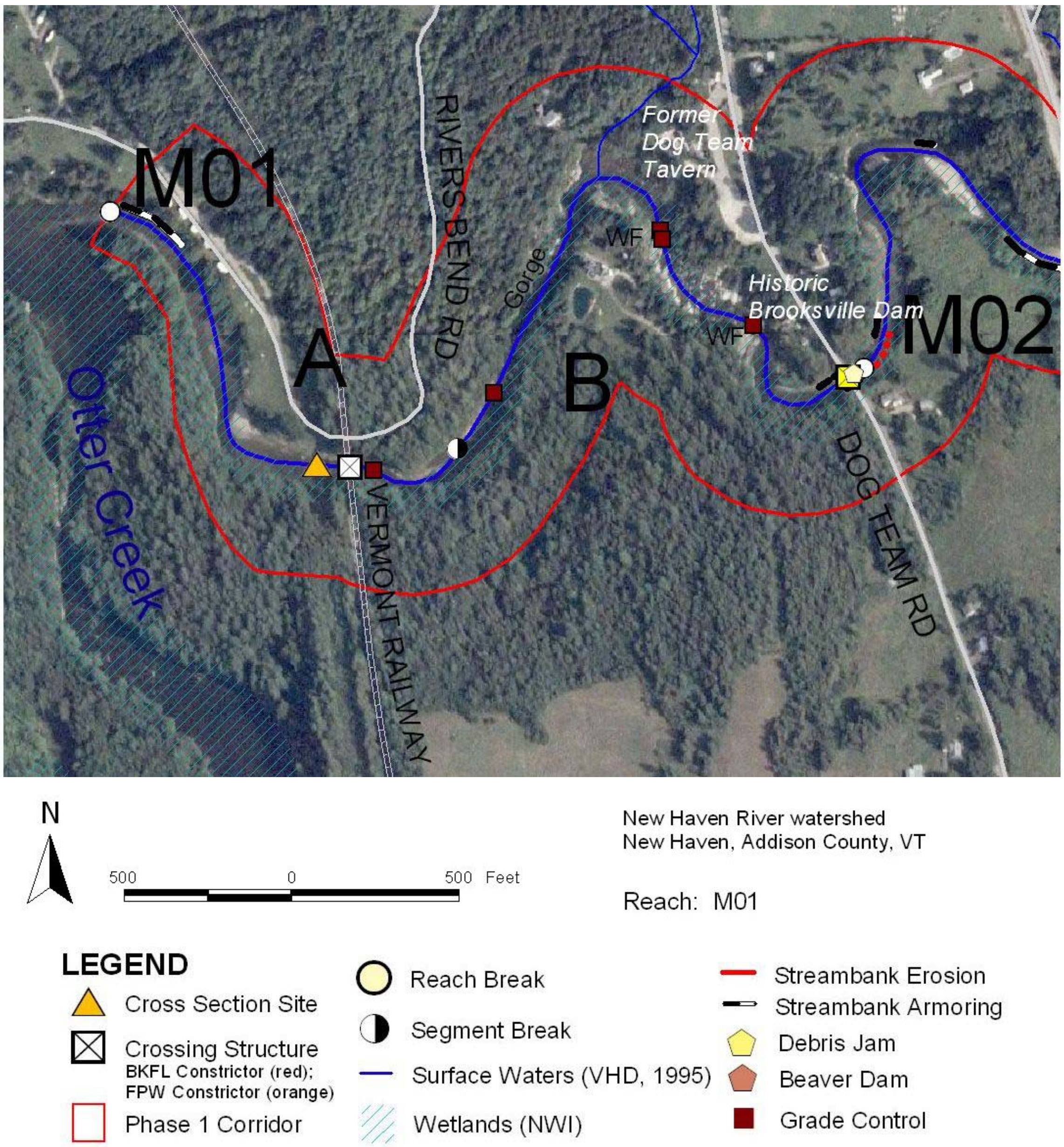

Figure 7. Segmentation and Phase 2 results for reach M01 (flow is from picture right to left).
Red line represents Phase 1 corridor (SGAT v.2; SMRC, 2004b).
WF = waterfall, as defined in VTANR protocols, 2007.

Segment B

Segment B of reach M01 is a 2,173-foot section of channel where bedrock dominates the channel margins. In the upstream end of the segment, cascade and step/pool bedforms dominate the channel which is flanked by moderately-sloped bedrock banks. The upstream end of this section is marked by a waterfall (at the historic site of mill operations and the Brooksville dam; Figure 8), followed by several shallower bedrock steps and a second waterfall across from the former Dog Team Tavern. In this section, an approximate drop of 13 feet occurs over a length of 450 feet (equivalent to a 3% slope). The channel then turns abruptly to the southwest and enters a short gorge with near-vertical bedrock walls (see Figures 7 and 9). Although submerged bedrock ledge forms the channel bottom in this section, the vertical drop of the channel is not as pronounced as in the upstream section (subcategory "c" slope). While individual sections of Segment B have more pronounced gradient, the overall estimated segment slope is 0.7%.

The corridor surrounding Segment B is dominated by bedrock and cohesive sediments of glacial till and lacustrine origin with an occasional pocket of glaciofluvial sediments (USDA NRCS, 2005; USDA NRCS, 2001; Stewart & MacClintock, 1969; Calkin, no date). The overall valley setting (Narrowly Confined) and the channel gradient (0.7%) of segment M01-B suggest a reference stream type of A1c-step/pool. This segment has been characterized as a "subreach" with a reference stream type different from the remainder of the reach which is classified as a reference Ac-riffle/pool gravel channel. Since this segment was characterized as a "gorge", an RGA and RHA were not completed (by protocols), and a "Low" sensitivity was assigned (page 77 of VTANR protocols, 2007 version).

Figure 8.
Waterfall at top of bedrock cascade and step/pool section in the vicinity of historic Brooksville dam.
Segment M01-B.

(View upstream,
12 September 2007).

Figure 9.
Gorge section downstream of the former Dog Team Tavern.
Segment M01-B.

(View upstream,
12 September 2007).

Segment A

Segment A of reach M01 is approximately 1,580 feet in length and extends from the vicinity of the Vermont Railway crossing downstream to the confluence with the Otter Creek. The river flows through a narrow, bedrock-controlled valley, estimated between 1.3 and 2.3 times bankfull width (dominantly, Narrowly-Confined). A reference stream type of A4c-riffle/pool is inferred from the valley setting and channel features.

The Rivers Bend Campground is located along a terrace of glaciofluvial sediments within the RB corridor (USDA NRCS, 2005; USDA NRCS, 2001). Aerial photographs indicate that this campground was developed between 1962 and 1974; prior to this (1942), the terrace was cleared and possibly in agricultural use. Seasonal development associated with this campground is located within the RB corridor of segment M01-A, including a gate house on a foundation near the right valley wall and campers during the summer months. The campground is accessed from the Dog Team Road via the Rivers Bend Road (gravel). At a few locations the Rivers Bend Road encroaches within the M01-A RB corridor. However, it is above the estimated flood-prone-width elevation; the thalweg height of this road was measured at two locations - 15.7 feet and 19.5 feet. The slight encroachment by Rivers Bend Road does not significantly change the confinement status of the channel (Narrowly Confined).

*Figure 10.
Confluence of New Haven River with Otter Creek; sediment deposition is evident at the confluence, slightly left of picture center.*

(View downstream from New Haven River, 12 September 2007).

A cross section was completed near the mid-point of Segment A (Figure 11). Measured channel and floodplain dimensions suggest an A4c-riffle/pool stream type, consistent with the reference stream type for the reach. Overall, a riffle/pool bedform was apparent, with two small point bars. A plane-bed form was evident at the upstream extent of the segment where a submerged bedrock "ledge" comprised the channel bed.

Instream habitats were somewhat compromised by the minimal buffer widths along much of the RB. On the other hand, coniferous tree buffers were of ample width along the LB, offering shading, detritus and organic materials to the channel. Large woody debris was reasonably frequent in the segment (LWD = 8). Habitat was rated as "Good" (0.76) following the RHA.

Figure 11.
Riffle cross section site just downstream of the Vermont Railway bridge.

(View upstream, 12 September 2007).

No signs of active channel incision were observed within Segment M01-A. It is likely that bedrock grade controls within the reach and in the nearby Otter Creek have limited vertical and lateral channel adjustments. A high terrace approximately 2 to 2.6 times bankfull height is present along the RB corridor within one bankfull width of the channel. VTANR protocols state that higher terraces "that were active flood plains before historic times [greater than 200 years ago]" should be avoided in the identification of the Recently Abandoned Floodplain for measurement of Incision Ratio in Phase 2 Step 2.5 (page 27 of VTANR protocols, May 2007 version). Protocols suggest avoiding terraces that are greater than 3 times the bankfull height. While this terrace is somewhat lower than 3 times the bankfull height, USDA NRCS mapping suggests that the parent materials for soils comprising this terrace have a glaciofluvial origin (thousands of years before present), rather than a more recent alluvial origin. On the other hand, available surficial geologic mapping (Calkin, no date; Stewart & MacClintock, 1969) suggests that sediments comprising this terrace are bouldery clays of glacio-lacustrine origin. No more detailed (or more recent) surficial geologic mapping was noted for this study area in Vermont Geological Survey records. More intensive surficial geologic mapping and analysis would be required to determine with greater certainty the age of these terrace sediments and the processes which created this terrace; such analysis was beyond the scope of work for this geomorphic study. Thus, best professional judgment was applied to infer that the origin of this terrace was the result of processes occurring greater than 200 years before present. The current degree of vertical separation of the channel bed (thalweg) from the terrace surface is not believed to represent a process of incision occurring within the last 200 years.

The low width/depth ratio (23.2) and minimal streambank erosion indicate very minimal widening in Segment A. Very limited aggradation is apparent; only two minor point bars were observed. No significant changes to the channel planform appear to have occurred in recent decades based on review of historic aerial photographs (back to 1942). Overall, Segment A was rated in "Good" condition (0.83) following the RGA. Despite the presence of lateral and vertical bedrock controls, a "High" sensitivity rating was assigned, following protocols, due to the subclass slope category ("c") and the dominance of gravel substrates. A channel evolution stage of "I" (F-stage) was assigned.

5.0 STRESSORS, DEPARTURE ANALYSIS AND SENSITIVITY

Phase 1 and Phase 2 stream geomorphic assessments of the New Haven River reaches provide for a better understanding of how human-caused disturbances at the watershed and reach level may have altered or constrained the river's ability to convey the water and sediment inputs to the watershed. Consideration of the current state of channel evolution and reach sensitivity will help to ensure that identified river management strategies and restoration or conservation projects will be successful over the long term.

Within a given reach, the watershed-level and reach-level flow and sediment load modifications, combined with reach-scale modifiers of stream power and boundary resistance, together govern adjustments in the channel dimensions, profile and planform over time. These lateral and vertical adjustments, in turn, influence how the river channel transports its sediment and water inputs.

Channel and watershed disturbances that exceed thresholds for change can upset the dynamic equilibrium of stream systems. Imbalance in the channel affects the sediment transport capacity of the stream system, and has significant consequences for erosion hazards, water quality and riparian habitats. Equilibrium can be disturbed locally and result in channel adjustments that are limited in magnitude and extent (for example, scour at an undersized culvert crossing). Alternately, the disturbance (or an overlapping combination of disturbances) can be of sufficient size, duration, or frequency to cause substantial channel adjustments that result in a system-wide imbalance extending far upstream and downstream through the river network.

Such imbalances, whether localized or systemic, can interfere with the river's ability to efficiently convey its water and sediment loads. These interruptions may be expressed as a sediment transport deficiency where sediment accumulates in the channel (which itself may lead to further imbalances - e.g., flow widens and splits to erode streambanks on either side, or flow may avulse or jump its banks in a flood event). Alternately, the imbalance can be expressed as an increase in sediment transport capacity. For example, a channel that has been straightened, dredged, armored and bermed has a local increase in channel slope and channel entrenchment, which creates higher flow velocities, and an increased power to erode the streambed. If the channel bed is scoured, this condition often leads to further channel adjustments including streambank collapse and widening.

Sediment transport capacity of the channel can be inferred from the geomorphic features observed during field work and from the identified reach-scale and watershed-scale stressors. Even a qualitative understanding of features and fluvial processes can help to identify and prioritize appropriate management strategies for the river that will facilitate a return toward a more balanced (dynamic equilibrium) condition.

5.1 Stressor Identification

Field investigations and limited historical reviews have identified various watershed and channel disturbances that have impacted reaches M01 and M02 of the New Haven River during recent decades, including:

<u>Watershed-scale Modifiers</u>:

- Historic deforestation and subsequent reforestation from the mid-1800s through the early 1900s;
- Significant flood events in 1998, 1976, 1938, 1936 and 1927;
- Upstream erosion and tributary sources of sediment; and

Reach-scale Modifiers:

- Channelization (straightening) inferred near the VT Route 7 bridge crossing;
- Berming along the banks (short lengths in M02);
- Streambank armoring (rip-rap);
- Floodplain encroachment by roads, railroads, residential development, and agricultural fields;
- Bridges which constrict channel flows at flood stage (VT Rt 7 and Dog Team Rd);
- Stormwater runoff from crop fields (one field ditch noted in M02);
- Minimal or absent forested buffers along portions of the study reaches;

In Table 2 (next page), significant stressors are summarized in terms of how each might be expected to modify stream power within each reach/ segment and/or modify boundary conditions, or the resistance to erosion along the channel margins.

5.2 Departure Analysis and Sensitivity

The uppermost assessed reach (M02) flows through a broad to very broad valley setting (unconfined), and has been minimally constrained by human land use changes or channel and floodplain modifications. This is a natural deposition-dominated reach, positioned immediately upstream of a naturally-confined, bedrock gorge (M01-B). It shows signs of increased sediment deposition in recent years, related to the upstream and in-reach production of sediments, and likely related to the 1998 flood (an estimated 500-year event). Locally, sediment deposition has been enhanced at the Route 7 bridge, a flood-prone-width constrictor. The reach-wide prevalence of depositional bars and active lateral adjustments suggests that sediment transport capacity in reach M02 may have been further reduced by sediment loading from upstream sources.

At present, the channel has reasonable access to a broad floodplain and channel-contiguous wetlands associated with recently-abandoned meander sites (although a minor degree of historic incision persists). A channel evolution stage of IV (F-stage) and a "Very High" sensitivity rating were assigned to reach M02 following guidance presented in the geomorphic assessment protocols (VTANR, 2007). The reach appears to be near the latter stages (stage IV) of a channel evolution process which may have been initiated historically by incision related to past flood events, and/or limited channelization. The "Very High" sensitivity assigned reflects the erodible materials (gravels, silts) in the bed and banks and the high likelihood for further channel adjustments (especially planform adjustment) as the channel responds to future changes in water and sediment loading. This sensitivity rating also reflects the current geomorphic condition of the reach ("Fair" – in Major Adjustment); planform adjustment as the dominant adjustment process.

Downstream reach (M01) flows through a Narrowly-confined valley setting; the channel is constrained, both laterally and vertically by bedrock outcroppings in the bed and bank. The higher-gradient segment M01-A is a natural transport-dominated reach. Most of the sediment and debris supplied to this segment from the upstream watershed is likely conveyed through to M01-A and the Otter Creek; there is minimal opportunity for flow and sediment attenuation. The "Low" sensitivity assigned to this segment (by protocol) reflects the stability offered by the underlying bedrock and suggests minimal likelihood for vertical and lateral adjustments. This is a segment considered "In regime" (VTANR protocols, 2007).

Similarly, segment M01-A is in a Narrowly-confined valley setting. Lateral adjustments of the channel are naturally constrained by bedrock along the left bank and an elevated post-glacial terrace along the right bank followed by a bedrock-controlled valley wall within one bankfull width. Potential vertical adjustments would be moderated by bedrock ledge exposed at the upstream end of the segment and within the Otter Creek just downstream of the New Haven River confluence.

Table 2. River Stressor Identification Table (Reach Level)

	Watershed-Scale Stressors				Reach-Scale Stressors					
Reach / Segment	Hydrologic		Sediment Load		Stream Power			Boundary Resistance		
M02	I	Flood of 1998	I	Flood of 1998	I	Slope	Straightening (limited, VT Rt 7 bridge crossing)	I	Bank	Armoring (some)
	I	Deforestation (1800s)	I	Deforestation (1800s)	I	Depth	Berms (limited in extent, left bank)	D	Bank	(Limited) Removal of woody vegetation related to agricultural fields and residential use.
			I	Upstream erosion & tributary sources	D	Slope	Route 7 bridge is FPW constrictor; mid-channel bar / island - localized impact.			
	D	Reforestation (1900s)	D	Reforestation (1900s)	D	Slope	Moderate constriction at downstream end of reach as channel transitions from Very Broad to Narrowly-Confined (bedrock-controlled).			
M01-B	I	Flood of 1998	I	Flood of 1998	D	Slope	Dog Team Road bridge is FPW constrictor; absence of significant upstream deposition suggests impact is minor.	I	Bed	Bedrock outcroppings (waterfalls, ledge, gorge)
	I	Deforestation (1800s)	I	Deforestation (1800s)				I	Bank	Bedrock outcroppings (waterfalls, ledge, gorge)
			I	Upstream erosion & tributary sources				D	Bank	Removal of woody buffers related to road crossings and residential/commercial development.
	D	Reforestation (1900s)	D	Reforestation (1900s)						
M01-A	I	Flood of 1998	I	Flood of 1998				I	Bank	Armoring (some, RB)
	I	Deforestation (1800s)	I	Deforestation (1800s)				D	Bank	Reduction of woody buffers related to campground, RB.
			I	Upstream erosion & tributary sources				I	Bank	Bedrock outcroppings (left bank)
	D	Reforestation (1900s)	D	Reforestation (1900s)				I	Bed	Bedrock outcroppings (ledge)

Abbreviations:

I = Increase; D = Decrease

Notes:
Text in blue denotes a natural stressor or modifier. Text in black indicates a human-caused modification.

M01-A is a natural transport-dominated segment with limited opportunity for sediment and flow attenuation. Sediments and LWD supplied from the upstream watershed appear to be conveyed through the segment to the Otter Creek; a small tributary confluence bar was noted. The observed stream type (entrenchment ratio, channel dimensions, slope) was consistent with reference, or expected, stream type for the valley setting. A channel evolution stage of I (F-stage model) was assigned. The "High" sensitivity assigned to M01-A reflects the erodible materials (gravel-dominated) in the bed and the potential (though limited in extent) for vertical channel adjustments in response to future changes in water and/or sediment loading. This sensitivity rating also reflects the current geomorphic condition of the reach ("Good" – minimal adjustment); a Very High or Extreme sensitivity would have been assigned if the segment were exhibiting major adjustments or a departure from reference condition.

At present, enhanced erosive energies within this segment appear to be balanced by the resisting forces of the channel margins (e.g., bedrock along the left bank and occasional single-line tree buffers and armoring along the right bank). Still, Segment M01-A remains highly susceptible to channel adjustments and associated fluvial erosion losses in future flood events, given its naturally-entrenched status and erodible streambank sediments (along RB). Tree buffers should be preserved and enhanced, where possible, to maintain streambank stability and minimize erosion.

6.0 PRELIMINARY PROJECT IDENTIFICATION

Landowners, New Haven community members, and resource agencies, including the Addison County Regional Planning Commission, the Natural Resources Conservation Service, and Vermont Agency of Natural Resources, can use geomorphic data to inform future management strategies for the river corridor. For a given reach or segment, the active adjustment processes, degree of departure from reference, and sensitivity ranking will define the short-term compatibility and long-term sustainability of various restoration or conservation options and future land use or channel management activities.

The preliminary identification and prioritization of corridor restoration and protection projects and practices outlined below has been informed by:

- stream sensitivity data (Table 1 and Sections 4.1 and 4.2);
- qualitative observations of sediment transport and attenuation characteristics (summarized for each reach in Sections 4.1 and 4.2); and
- preliminary departure analysis contained in Sections 4.1 and 4.2.

This provisional listing follows the outline of management actions identified in the *Step-Wise Procedure for Identifying Technically Feasible River Corridor Restoration and Protection Projects* included in VTANR guidance (11 July 2007 draft). Per VTANR guidance, the listed approaches can be classified under three broad management approaches:

> Active Geomorphic: Restore or manage rivers to a geomorphic state of dynamic equilibrium through an **active** approach that may include the removal or reduction of human-placed constraints or the construction of meanders, floodplains, and bank stabilization techniques. Active riparian buffer revegetation and long-term protection of a river corridor is essential to this alternative.
>
> Passive Geomorphic: Allow rivers to return to a state of dynamic equilibrium through a **passive** approach that involves the removal of constraints from a river corridor thereby allowing the river, utilizing its own energy and watershed inputs to re-establish its meanders, floodplains, and self maintaining equilibrium condition over an extended time period. Active riparian buffer revegetation and long-term protection of a river corridor is essential to this alternative.

Active-Passive Combination: Use a sequenced combination of active and passive approaches to accommodate the varying constraints that typically occur along a project reach.
(VTANR, 2007; 1 June draft)

The work scope for this Phase 2 Assessment has not included public outreach or analysis to determine the technical, financial and social feasibility and relative priorities of these listed project opportunities. Instead, this listing will form the basis for future project development and implementation efforts in the context of watershed, community, and corridor planning projects. A few of these projects (e.g., buffer plantings) can be considered for immediate implementation, independent of other watershed projects, and will require only minimal feasibility analysis and project development activities. Other identified projects may require further evaluation and efforts to conduct alternatives analyses, conduct landowner outreach and negotiations, and identify potential stakeholders and funding sources.

Watershed stakeholders which may look to this data for guidance include (but are not necessarily limited to):

- landowners,
- town of New Haven,
- VT Department of Environmental Conservation, Water Quality Division –
  - River Management Section and
  - Wetlands Section,
- Vermont Agency of Agriculture,
- Vermont Department of Transportation,
- Vermont Land Trust,
- Vermont River Conservancy,
- Northern Vermont Resource Conservation and Development Council (Better Back Roads),
- US Fish and Wildlife, and
- US Department of Agriculture, Natural Resources Conservation Service.

6.1 Protecting River Corridors

Protection of river corridors is an essential element to all passive and active geomorphic restoration and conservation projects. River corridor protection can support multiple objectives:

- **Dynamic Equilibrium** - Preserve (or support a return to) reference sinuosity, slope, and channel dimensions through active or passive geomorphic approaches. Refrain from future channel management, such as channelization, dredging, berming, armoring.

- **Floodplain Access** – Preserve or restore a channel's access to its surrounding floodplain in bankfull and higher flow events through active or passive geomorphic approaches. Refrain from future channel management, such as channelization, dredging, berming, armoring.

- **Sediment Attenuation** – Preserve, restore, or enhance the storage of sediments (from in-reach or upstream sources) within the channel margins, floodplain, and channel-contiguous wetlands.

- **Flow Attenuation** – Preserve, restore, or enhance the storage and detainment of flood flows through overbank flooding, increased channel length (sinuosity), increased channel roughness (e.g., buffers), and inundation of channel-contiguous wetlands.

- **Avoidance** – Refrain from developments and infrastructure in the corridor to minimize future fluvial erosion losses.

Under a passive geomorphic approach, the river channel is allowed to freely meander within the area defined as the belt-width-derived river corridor. For a reach that is already close to reference condition or exhibiting only minor adjustments, preserving a river corridor will ensure the river's ability to continue to meander through the valley unconstrained by human infrastructure. In turn, human investments in the landscape will be protected from future channel adjustments. For a reach that has seen significant channel management in the past, and has lost some degree of floodplain connection and some measure of its sinuosity and balanced planform and profile, the channel is allowed to adjust unimpeded to a more sinuous, meandering planform closer to regime conditions. During ongoing adjustments, the river will re-establish greater floodplain access (where access has been lost) and adjust channel dimensions for optimum conveyance of its water and sediment loads. Restoring channel equilibrium will reduce instream production of sediment and nutrients and enhance sediment and nutrient attenuation over the long term.

Under an active geomorphic approach, protection of the river corridor will prevent future channel management that might unravel constructed features of a recently restored reach.

Higher-priority reaches/segments – **M02**
Higher-priority reaches for river corridor protection include "highly sensitive reaches critical for flow and sediment attenuation from upstream sources or sensitive reaches where there is a major departure from equilibrium conditions and threats from encroachment (11 July 2007, VTANR guidance)". Limited term or permanent corridor easements are possible mechanisms for corridor protection, with the willingness of landowners.

Very High sensitivity reach M02 is identified in this category based on the following rationale:

- Sediment attenuation areas - preservation and enhancement.
  This reach has reasonable access to the surrounding floodplain (IR_{RAF} = 1.18), including channel-contiguous wetlands in abandoned meander sites. The channel is relatively free to adjust its planform, local gradient, and channel dimensions as it responds to increased sediment loading from upstream reaches. The reach appears to be serving an important flow and sediment (and possibly nutrient) attenuation role in the watershed. It is strategically located downstream of reaches where streambank erosion and lateral adjustments are leading to sediment loading (e.g., reaches M03 through M11 and upstream reaches along the Bristol Flats).

- Protection Upstream of Constrained Reaches
  Reach M02 is located immediately upstream of a reach (M01) that is naturally constrained by the topographic setting and bedrock outcrops, unable to adjust its dimensions, planform, and profile in response to excess sediment and water loads delivered from upstream. Reach M02 is therefore a critical reach for preserving and enhancing sediment and flow attenuation functions to reduce sediment (and potential nutrient) loading to the Otter Creek and Lake Champlain.

- Fluvial Erosion Hazard protection
  At present, land uses adjacent to reach M02 do not involve many buildings or other human infrastructure in conflict with channel adjustment processes. This condition represents an opportunity to protect the floodplain access, sediment and flow attenuation properties of the reach and refrain from developments within the corridor to avoid erosion losses in future flood events.

Lower-priority reaches/segments – **M01-B, M01-A**
Lower-priority reaches for river corridor protection include "wooded corridors experiencing very little threat from encroachment and less sensitive reaches not playing a significant flow or sediment load attenuation role in the watershed (11 July 2007, VTANR guidance)".

Low-sensitivity bedrock subreach, **M01-B,** adjacent to the former Dog Team Tavern site is afforded stability by the underlying bedrock, and has reasonably well-developed forested buffers along much of its length. The few residential and commercial encroachments within the segment corridor appear to be founded on bedrock and would therefore be at reduced risk from sudden streambank erosion during a flood (as compared to development founded on unconsolidated sediments). However, refraining from infrastructure in this segment corridor is still advised to protect against risk of inundation (rising water) losses during a flood.

Segment **M01-A** has been assigned a "High" sensitivity by virtue of its gradient and the gravel sediment sizes dominating the bed. However, bedrock-controlled close valley walls confine the channel and bedrock outcrops provide lateral and vertical grade controls within the reach; thus, the potential for future channel adjustments is moderated. This segment has had much the same planform on aerial photographs dating back to 1942. The left-bank corridor has very wide, forested buffers with minimal encroachments (railroad). Along the right bank is a seasonal campground with minimal width buffers. This segment is in a narrowly-confined setting with very limited opportunities for flow or sediment attenuation. As such, the priority for river corridor protection would be lower than that of M02. There is some potential for erosion hazards (during high-magnitude floods) along the right-bank corridor consisting of a glacio-fluvial terrace developed with a seasonal campground. It would be prudent to limit future, more-permanent development along this terrace to avoid fluvial erosion hazards.

6.2 Planting Stream Buffers

Forested riparian buffers serve to improve water quality and contribute to greater flow and sediment attenuation in the floodplain. They will also help to restore and maintain dynamic equilibrium of the channel by increasing resistance to boundary shear stresses along the channel margins. Tree buffers will provide the additional benefits of organic matter, detritus, and LWD recruitment for aquatic and riparian habitats, as well as increased shading to reduce river temperatures. Connectivity of buffer areas from reach to reach along a river network is also supportive of mammalian terrestrial habitats by providing wildlife corridors. Of the segments assessed in this project, M01-A (right-bank) and M02 would benefit most from buffer plantings.

6.3 Stabilizing Stream Banks

Streambank stabilization can be considered in "laterally unstable [but vertically stable] reaches where human-placed structures are at high risk and not taking action may result in increased risk of erosion, to not only the structure, but lands that would provide the opportunity to establish a buffer (11 July 2007 draft VTANR guidance)".

Any bank stabilization project should be considered in the broader context (both in time and space) for the channel adjustment processes such management will set in motion and for the consequences to upstream and downstream reaches. Bank stabilization projects should not be considered in highly aggradational reaches where progressive lateral adjustments, driven by sediment deposition, would be expected to increase the risk of revetment failure.

One possible bank stabilization project has been identified for further feasibility assessment along reach M02 at the downstream-most end of the reach along the left bank (see Figures 12 and 13). Landowners at this location have previously contacted the ACRPC with concern for erosion along their bank.

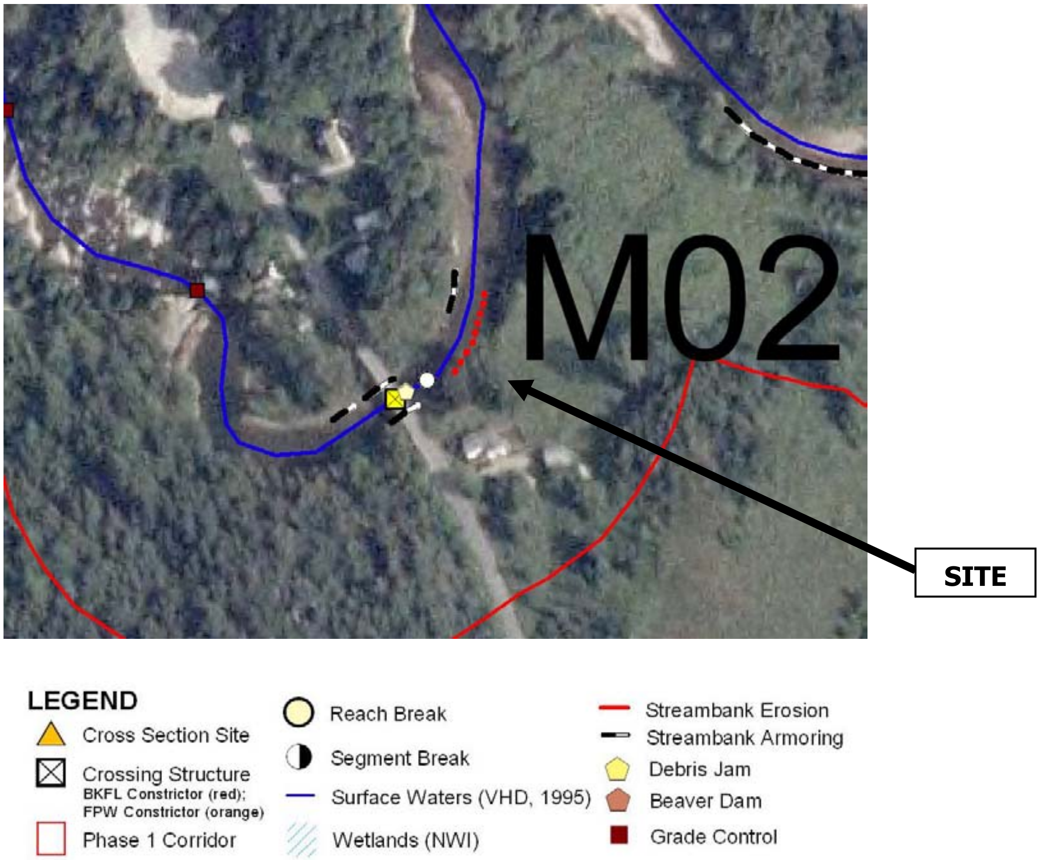

Figure 12. Location of LB erosion adjacent to residence just upstream of Dog Team Road bridge crossing at the reach break between M02 and M01.

Figure 13. Site of LB erosion upstream of Dog Team Road bridge, reaches M01 and M02. (View upstream from the bridge, 10 December 2007).

The LB is at the outside of a meander bend on approach to the Dog Team Road bridge, and streambank erosion along this bank in recent years has progressed to the southeast. The top of this undercut bank is located within 90 feet of a residence. Erosion could progress downstream to outflank the LB pier and the LB stone-filled spill-through embankment of the Dog Team Road bridge (see Figure 14).

Figure 14. Site of LB erosion upstream of Dog Team Road bridge, reaches M01 and M02. (View downstream to the bridge, 12 September 2007).

There would appear to be room for establishment of a minimal-width forested buffer between the streambank and the residence at this site, if the bank could be stabilized through some combination of toe armoring or revetments combined with bioengineering along the upper two-thirds of the bank.

Until sediment sources upstream of this site and reach M02 can be addressed, bank stabilization is considered a lower priority (from a reach and watershed perspective, following the guidance contained in the *Step-Wise Procedure for Identifying Technically Feasible River Corridor Restoration and Protection Projects*, VTANR, 11 July 2007). Success of a possible bank stabilization project at this location would be increased if corridor protection and restoration measures undertaken in upstream reaches enhanced sediment attenuation and reduced sediment mobilization to this location.

Any plans for streambank stabilization at this site should be considered for compatibility with design plans for rehabilitation or replacement of the Dog Team Road bridge. This bridge was constructed in 1927 and has been identified by the town of New Haven as a high-priority bridge in need of rehabilitation or replacement.

6.4 Arresting Head Cuts and Nick Points

No head cut / nick point sites or actively incising sections were identified in reaches M01 or M02 during September 2007 assessments.

6.5 Removing Berms / Other Constraints to Flood & Sediment Load Attenuation

Removing berms or other constraints to the full meander expression and floodplain connection of a river channel may accelerate a return to dynamic equilibrium in the channel, and reduce impacts to downstream segments, by creating more opportunities for sediment and flow attenuation along the corridor. Further study is necessary to evaluate the feasibility of various active geomorphic and engineering techniques. The benefits of such projects would need to be evaluated in light of the costs and potential short-term consequences in terms of sediment and nutrient mobilization, and risk to infrastructure and public safety. Ideally, removal of berms or other channel constraints would be accompanied by corridor protection measures.

Only two short berms were identified during September 2007 assessments – both in reach M02.
One length of boulders was noted at approximately floodprone width elevation (local IR_{HEF} = 1.5) along the LB corridor of reach M02. This line of boulders appeared to represent a line of protection along a former channel position at the edge of a cultivated field currently in corn. Lateral channel adjustments in recent years have now resulted in a channel position that is approximately one bankfull width to the north of this former berm. The line of boulders represents a minor constraint for the current channel. As such, removal of this berm does not appear warranted or worth the likely cost associated with removal, at this time.

A second minor berm was noted in reach M02 along the armored LB immediately downstream of the VT Route 7 bridge. This is a relatively short berm, coincident with the estimated position of the valley wall. Thus, berm removal would not result in significantly increased floodplain access at this location, and is therefore not identified as a high-priority active restoration project for the reach.

6.6 Removing / Replacing Structures

Human-placed structures which span and "constrain the vertical and lateral movement of the channel and/or result in a significant constriction of the floodplain" can be considered for removal or replacement to support dynamic equilibrium of the channel (11 July 2007 draft VTANR guidance)".

Two road bridges and one railroad bridge were encountered spanning the study reaches. The road bridge crossings were estimated as constrictors of the flood prone width. The railroad crossing is elevated high above the channel, well above the flood-prone-width elevation. Additional bridge and culvert assessment data are provided in Appendix B. These data can be utilized by VTrans, and by the New Haven road crews and Addison County Regional Planning Commissions when establishing schedules and budgets for crossing rehabilitation and replacement.

At the next opportunity for bridge rehabilitation or replacement (or if new road or driveway crossings are being considered in these reaches), the geomorphic context should be considered in crossing design.

- New or replacement bridges should ideally have openings which pass the bankfull width to flood-prone-width without constriction.
- Bridges and culverts should be designed to cross the river without creating channel approaches at an angle to structures. Such sharp angles can lead to undermining of fill materials and structural components.
- The historic channel migration pattern of the river should be considered when installing new or replacement crossing structures.

6.7 Restoring Incised Reaches

Further study could evaluate the feasibility of various active geomorphic and engineering techniques to restore incising reaches which could accelerate a return to dynamic equilibrium of the channel, and reduce impacts to downstream segments, by creating more opportunities for sediment and flow attenuation along the corridor.

Neither reach M01 nor reach M02 was identified as an actively incising reach.

6.8 Restoring Aggraded Reaches

Further study is sometimes warranted to evaluate the feasibility of various active geomorphic and engineering techniques to restore aggraded reaches which could accelerate a return to dynamic equilibrium of the channel, by restoring equilibrium of sediment transport processes.

Neither reach M01 nor reach M02 was identified as an aggraded reach to the degree that has resulted in widespread braiding or a stream type departure. The moderate aggradation in reach M02 can be addressed through passive restoration techniques in the context of river corridor protection (Section 6.1 above). The channel in this reach is reasonably free to adjust its planform, dimensions and profile in response to changes in sediment and water loading. Active restoration of the moderately-aggraded conditions in reach M02 is not recommended at this time, because upstream (watershed-scale) sediment loading is thought to be the dominant stressor governing adjustment processes in this reach. Until such watershed-scale sediment loading can be addressed, an active geomorphic restoration project in reach M02 would be at high risk of failure.

6.9 Other Related Projects

6.9.1 Controlling Sources of Sediment

Addressing upstream sources of sediment to reach M02 would be important in the long-term objectives of restoring equilibrium and reducing sediment and nutrient mobilization to the Otter Creek and Lake Champlain. Select upstream reaches have been assessed (SMRC, 2004a) and a subset of the reaches (M06 – M11) have been addressed in a New Haven River corridor protection plan completed in November 2007 (SMRC, 2007). This corridor plan identified various channel and watershed restoration and conservation projects that will serve to reduce streambank erosion and sediment mobilization over the long term. Corridor planning recommendations are being implemented on an ongoing basis, subject to available funding and contingent upon landowner willingness.

Expanding the scope of corridor planning to reaches M02 through M05 could further reduce sources of sediment to reach M02.

6.9.2 Protection and Restoration of Channel-Contiguous Wetlands

Flow and sediment attenuation can be enhanced along reach M02 through the protection and rehabilitation of channel-contiguous wetlands. At present, the channel appears to have reasonable access to abandoned meanders (from post 1995 and post-1962 neck cut-off sites). It would be important to preserve these areas and refrain from filling or otherwise constraining channel connection to these areas.

7.0 RECOMMENDATIONS

7.1 Corridor Planning Project

Corridor planning projects should be undertaken in reach M02 to identify landowner-approved and conservation and restoration projects that will protect the river corridor and generally support the restoration or preservation of dynamic equilibrium. Public and private benefits associated with dynamic equilibrium of the river include reduced fluvial erosion hazards, and improved water quality and instream and riparian habitats. For increased efficiency and effectiveness, the scope of such a corridor planning project should be increased to include upstream reaches M03 through M05.

A corridor planning project in reaches M05 through M02 should be considered a high priority, since residential and commercial development is sparse along these river sections at this time. This condition offers a strategic opportunity for corridor protection that will help landowners and the town of New Haven to avoid erosion hazards in the future.

Corridor planning efforts would involve a combination of site-level conservation and restoration projects as well as town-and watershed-scale planning approaches. A variety of technical and financial resources are available to assist landowners and the town of New Haven with project development and planning initiatives. In reach M02, a majority of corridor lands are in agricultural use. Resources are currently available through the VT Agency of Agriculture (e.g., Conservation Reserve Enhancement Program, Best Management Practices cost-share program) and the USDA Natural Resources Conservation Service (e.g., Agricultural Management Assistance, Conservation Reserve Program, Environmental Quality Incentives Program).

Phase 2 geomorphic assessment data can be used to define a Fluvial Erosion Hazard corridor overlay district for consideration in town zoning regulations. Currently, funding and technical resources are available to New Haven for such planning processes through the Governor's Clean and Clear Action program.

7.2 Buffer Restoration

With landowner approval, buffer plantings should be implemented in reaches M01-A and M02 to preserve and support a return to dynamic equilibrium conditions, reduce erosion, and improve water quality and riparian habitats. Technical and financial resources are currently available from various regional, state and federal agencies for buffer plantings. In addition to the agricultural resource agencies of and programs listed under Section 7.1 for lands in agricultural use, the following agencies / programs can provide resources to landowners and towns for buffer plantings.

- Vermont Department of Environmental Conservation (Vermont Watershed Grant Program, Nonpoint Source Management Grant [Section 319] Program, River Corridor Grant Program)
- USDA Natural Resources Conservation Service (Wildlife Habitat Incentives Program)
- US Fish & Wildlife (Partners Program)

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APPENDIX A

Phase 1 and 2 Stream Geomorphic Assessment
Reach Summary Reports

New Haven River

Phase 1 - Reach Summary Report

Basin: **Otter, Little Otter, Lewis**
Stream Name: **New Haven River** Reach **M01**
Topo Maps: **312**
Date Last Edited: **Mon, January 07, 2008**
Watershed: **Otter Creek**
Sub-watershed: **New Haven River**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

Step 1. Reach Location

1.1 Reach Description: **Dog Team Road bridge crossing downstream to confluence with Otter**
1.2 Towns: **New Haven**
1.3 Downstream Latitude: **44.06**
1.3 Downstream Longitude: **-73.18**

Step 2. Stream Type

2.1 Elevation Upstream: **238**
2.1 Elevation Downstream: **220**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **3527** feet. **0.67** Miles.
2.3 Valley Slope: **0.51** %
2.4.Channel Length: **3753** feet. Miles.
2.5 Channel Slope: **0.48** %
2.6 Sinuosity: **1.06**
2.7 Watershed Area: **116** Square Miles
2.8 Channel Width: **106** feet.
2.9 Valley Width: **160** feet.
2.10 Confinement Ratio: **2**
2.10 Confinement Type: **Narrowly Confined**
2.11 Reference Stream Type: **A**
Bedform: **Riffle-Pool**
Sub-class Slope: **c**
Bed Material: **Gravel**

Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **Multiple**
3.3 Dominant Geologic Mat.: **Till** **49.0** %
3.3 Sub-dominant Geological Mat.: **Glacial**
3.4 Left Valley Side **Extremely Steep**
3.4 Right Valley Side **Very Steep**
3.5 Soils
Hydrologic Group: **D** **84.1** %
Flooding: **None/Rare** **98.3** %
Water Table Deep: **6.0** **63.3** %
Water Table Shallow: **6.0** **63.3** %
Erodibility: **High -** **84.1** %

7.4 Comments:

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
Historic Land Cover:
Current Dominant land Cover: **Forest** **76.4** %
Current Sub-Dominant Land Cover: **Field**
4.2 Corridor
Historic Land Cover:
Current Dominant land Cover: **Forest** **38.7** %
Current Sub-Dominant Land Cover: **Urban**

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**>100**	**51-100**
Sub-dominant:	**51-100**	**0-25**
Length w/ less than 25 ft.:	**170**	**1393**

4.4 Ground Water Inputs: **Minimal**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
Type: **None**
Use:
5.2 Bridges and Culverts: **2** **10** %
5.3 Bank Armoring: **5 %**
Left **85** Right **331**
5.4 Channel Straightening: **0.0** **0.0**
5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms and Roads old **1516** ft. **40 %**

	One Side		Both Sides	
Road:	**1989.3**	ft.	**1100**	ft.
Railroad:	**855.3**	ft.	**0.0**	ft.
Berm:	**0.0**	ft.	**0.0**	ft.
Improved Path:	**0.0**	ft.	**0.0**	ft.
6.2 Development:	**416**	ft.	**376**	ft.

6.3 Channel Bars: **Point**
6.4 Meander Migration: **None**
6.5 Meander Width: **N/A** Ratio: **0.0**
6.6 Wavelength: **N/A** Ratio: **0.0**

Step 7. Windshield Survey

7.2 Bank Erosion: **0.00 ft.**
7.2 Bank Height: **0.00 ft.**
7.3 Ice/Debris Jam Potential: **Multiple**

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	7.1	7.2	Total
1 Low	2 High	2 High	0 N.S.	1 Low	1 Low	0 N.S.	0 N.S.	2 High	2 High	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	1 Low	12

New Haven River

Basin: **Otter, Little Otter, Lewis**
Stream Name: **New Haven River** Reach **M02**
Topo Maps: **312**
Date Last Edited: **Mon, January 07, 2008**
Watershed: **Otter Creek**
Sub-watershed: **New Haven River**
Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

Step 1. Reach Location
1.1 Reach Description: **From 2000 ft west of River Road bridge crossing (just downstream of**
1.2 Towns: **New Haven**
1.3 Downstream Latitude: **44.06**
1.3 Downstream Longitude: **-73.17**

Step 2. Stream Type
2.1 Elevation Upstream: **249**
2.1 Elevation Downstream: **238**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **5150** feet. **0.98** Miles.
2.3 Valley Slope: **0.21** %
2.4.Channel Length: **5994** feet. Miles.
2.5 Channel Slope: **0.18** %
2.6 Sinuosity: **1.16**
2.7 Watershed Area: **116** Square Miles
2.8 Channel Width: **106** feet.
2.9 Valley Width: **820** feet.
2.10 Confinement Ratio: **8**
2.10 Confinement Type: **Broad**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope: **None**
Bed Material: **Gravel**

Step 3. Basin Characteristics:
3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Alluvial** **53.7** %
3.3 Sub-dominant Geological Mat.: **Glacial**
3.4 Left Valley Side **Steep**
3.4 Right Valley Side **Very Steep**
3.5 Soils
Hydrologic Group: **D** **36.6** %
Flooding: **Frequent** **45.5** %
Water Table Deep: **3.0** **41.0** %
Water Table Shallow: **1.0** **28.3** %
Erodibility: **High -** **29.4** %

7.4 Comments:

Step 4. Land Cover - Reach Hydrology
4.1 Watershed
Historic Land Cover:
Current Dominant land Cover: **Forest** **76.7** %
Current Sub-Dominant Land Cover: **Field**
4.2 Corridor
Historic Land Cover:
Current Dominant land Cover: **Forest** **29.5** %
Current Sub-Dominant Land Cover: **Crop**

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**51-100**	**>100**
Sub-dominant:	**>100**	**51-100**
Length w/ less than 25 ft.:	**661**	**442**

4.4 Ground Water Inputs: **Abundant**

Step 5. Instream Channel Modifications
5.1 Flow Regulation - (old):
Type: **None**
Use:
5.2 Bridges and Culverts: **1** **4** %
5.3 Bank Armoring: **700.0** **6 %**
Left **429** Right **344**
5.4 Channel Straightening: **882** **14 %**
5.5 Dredging History: **None**

Step 6. Floodplain Modifications
6.1 Berms and Roads old **483** ft. **8 %**

	One Side	Both Sides
Road:	**0.0** ft.	**0.0** ft.
Railroad:	**0.0** ft.	**0.0** ft.
Berm:	**252** ft.	**0.0** ft.
Improved Path:	**0.0** ft.	**0.0** ft.
6.2 Development:	**483** ft.	**193** ft.

6.3 Channel Bars: **Multiple**
6.4 Meander Migration: **Multiple**
6.5 Meander Width: **167.0** Ratio: **1.6**
6.6 Wavelength: **668.0** Ratio: **6.3**

Step 7. Windshield Survey
7.2 Bank Erosion: **1,466.72 ft.**
7.2 Bank Height: **5.00 ft.**
7.3 Ice/Debris Jam Potential: **Multiple**

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	7.1	7.2	Total
1 Low	2 High	1 Low	0 N.S.	0 N.S.	1 Low	1 Low	0 N.S.	0 N.S.	1 Low	2 High	2 High	2 High	1 Low	2 High	1 Low	17

Project: New Haven River — **Phase 2 Segment Summary** — January 8, 2008 SGAT Version: 4.56

Stream: **New Haven River** Reach # **M01** Segment: **A** Completion Date: **September 12, 2007**

Organization: **Addison County RPC** Observers: **KLU, BOS - SMRC; AD - ACRPC** Why Not assessed: Rain: **Yes**

Segment Length (ft): **1,580** Segment Location: **From just upstream of VT Railway crossing downstream to confluence with Otter Creek.**

QC Status - Staff: Provisional Cons Provisional

Step 1. Valley and Floodplain

1.1 Segmentation **Grade Controls**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	1,554	0
height	16	0
Railroads	855	0
height	75	0
Improved Paths	0	0
height	0	0
Development	47	88

1.4 Adjacent Side	Left	Right
Hillside Slope	Extremely	Very Steep
Continuous w/	Always	Sometimes
W/in 1 Bankfill	Always	Sometimes
Texture	Bedrock	Not Evalua

1.5 Valley Features

- Valley Width (ft) **155**
- Width Determination **Measured**
- Confinement Type **Narrowly**
- Rock Gorge? **No**

Human-caused Change? **Yes**

Step 2. Stream Channel

- 2.1 Bankfull Width **107**
- 2.2 Max Depth (ft) **6.30**
- 2.3 Mean Depth (ft) **4.60**
- 2.4 Floodprone Width (ft) **115**

Notes:

Valley width (measured) varies from approximately 92 to 233 feet. Confinement is dominantly Narrowly-Confined, but there are brief sections of Semi-confined. The River Bend Road passes within the RB corridor near the railroad crossing and constitutes a

Step 2. (Contued)

- 2.5 Aband. Floodpln **6.30** ft.
- Human Elev Floodpln **0.00** ft.
- 2.6 Width/Depth Ratio **23.24**
- 2.7 Entrenchment Ratio **1.08**
- 2.8 Incision Ratio **1.00**
- Human Elevated Inc Rat **0.00**
- 2.9 Sinuosity **Low**
- 2.10 Riffles Type **Complete**
- 2.11 Riffle/Step Spacing (ft) **600**

2.12 Substrate Composition

Bedrock	2 %
Boulder	10 %
Cobble	24 %
Coarse Gravel	21 %
Fine Gravel	27 %
Sand	15 %
Silt and smaller	1 %

- Silt/Clay Present? **No**
- Detritus **5** %
- # Large Woody **8**

2.13 Average Largest Particle on

Bed	344.0	mm
Bar	23.0	mm

2.14 Stream Type

- Stream Type: **A**
- Bed Material: **Gravel**
- Subclass Slope: **c**
- Bed Form: **Riffle-Pool**
- Field Measured Slope:

2.15 Reference Stream Type

(if different from Phase 1)

3.3 old	Amount	Mean Height
Failures	None	0.00
Gullies	None	0.00

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

Bank Texture	Left	Right
Upper		
Material Type	Bedrock	Mix
Consistency	Cohesive	Cohesive
Lower		
Material Type	Bedrock	Mix
Consistency	Cohesive	Cohesive

Bank Erosion	Left	Right
Erosion Length (ft)	0	0
Erosion Height (ft)	0.00	0.00
Revetmt. Type	Rip-Rap	Rip-Rap
Revetmt. Length (ft)	42	246

Near Bank Veg. Type	Left	Right
Dominant	Coniferous	Deciduous
Sub-dominant	None	Herbaceous

Bank Canopy	Left	Right
Canopy %	76-100	1-25
Mid-Channel Canopy	Open	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	>100	0-25
Sub-dominant	None	26-50
W less than 25	59	1,224

Buffer Veg. Type	Left	Right
Dominant	Coniferous	Deciduous
Sub-dominant	None	Herbaceous

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Forest	Shrubs/Saplin
Sub-dominant	None	Residential
Mass Failures	0	0
Height	0	0
Gullies	0	0
Height	0	0

Step 4. Flow & Flow Modifiers

- 4.1 Springs / Seeps **None**
- 4.2 Adjacent Wetlands **None**
- 4.3 Flow Status **Moderate**
- 4.4 # of Debris Jams **0**
- 4.5 Flow Regulation Type **None**
  - Flow Regulation Use
  - Impoundments
  - Impoundmt. Location
- 4.6 Up/Down strm flow reg **None**
  - (old) Upstrm Flow Reg

4.7 StormwaterInputs

Field Ditch	0	Road Ditch	0
Other	0	Tile Drain	0
Overland Flow	0	Urb Strm Wtr Pipe	0

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types

Mid	Point	Side
0	2	0
Diagonal	**Delta**	**Island**
0	0	0

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
0	0	0	0

5.3 Steep Riffles and Head Cuts

Steep Riffles	Head Cuts	Trib Rejuv.
0	0	No

- 5.4 Stream Ford or Animal **No**
- 5.5 Straightening **None**
  - Straightening Length: **0**
- 5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Phase 2 Segment Summary

Stream: **New Haven River** Reach # **M01** Segment: **B** Completion Date: **September 12, 2007**

Organization: **Addison County RPC** Observers: **KLU, BOS - SMRC; AD - ACRPC** Why Not assessed: **bedrock gorge** Rain: **Yes**

Segment Length (ft): **2,173** Segment Location: **From Dog Team Rd bridge crossing downstream nearly to Vermont Railway crossing.**

QC Status - Staff: **Provisional Cons**

Step 1. Valley and Floodplain

1.1 Segmentation **Grade Controls**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	435	1,100
height	16	25
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	370	289

1.4 Adjacent Side	Left	Right
Hillside Slope	Very Steep	Very Steep
Continuous w/	Sometimes	Sometimes
W/in 1 Bankfill	Always	Sometimes
Texture	Bedrock	Bedrock

1.5 Valley Features

- Valley Width (ft) **150**
- Width Determination **Estimated**
- Confinement Type **Narrowly**
- Rock Gorge? **Yes**
- Human-caused Change? **No**

Step 2. Stream Channel

- 2.1 Bankfull Width **0**
- 2.2 Max Depth (ft) **0.00**
- 2.3 Mean Depth (ft) **0.00**
- 2.4 Floodprone Width (ft) **0**

Notes:

Segment is a subreach of alternate stream type - a bedrock-controlled channel and gorge. Driveway is present within LB corridor; Dog Team Rd is present within RB corridor. However, both are elevated well above FPW. Therefore, no significant human

Provisional *Step 2. (Contued)*

- 2.5 Aband. Floodpln **0.00** ft.
- Human Elev Floodpln **0.00** ft.
- 2.6 Width/Depth Ratio **0.00**
- 2.7 Entrenchment Ratio **0.00**
- 2.8 Incision Ratio **0.00**
- Human Elevated Inc Rat **0.00**
- 2.9 Sinuosity **Low**
- 2.10 Riffles Type **Not Applicable**
- 2.11 Riffle/Step Spacing (ft) **0**
- 2.12 Substrate Composition

- Silt/Clay Present? **No**
- Detritus **2** %
- # Large Woody **11**

2.13 Average Largest Particle on

- Bed **0.0**
- Bar **N/A**

Not Evaluated

2.14 Stream Type

- Stream Type: **A**
- Bed Material: **Bedrock**
- Subclass Slope: **c**
- Bed Form: **Step-Pool**
- Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

A 1 c Step-Pool

3.3 old	Amount	Mean Height
Failures	None	0.00
Gullies	None	0.00

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

Bank Texture	Left	Right
Upper		
Material Type	Bedrock	Bedrock
Consistency	Cohesive	Cohesive
Lower		
Material Type	Bedrock	Bedrock
Consistency	Cohesive	Cohesive

Bank Erosion	Left	Right
Erosion Length (ft)	0	0
Erosion Height (ft)	0.00	0.00
Revetmt. Type	Rip-Rap	Multiple
Revetmt. Length (ft)	43	85

Near Bank Veg. Type	Left	Right
Dominant	Coniferous	Shrubs/Saplin
Sub-dominant	Deciduous	Coniferous

Bank Canopy	Left	Right
Canopy %	76-100	26-50

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	>100	51-100
Sub-dominant	51-100	>100
W less than 25	111	169

Buffer Veg. Type	Left	Right
Dominant	Coniferous	Deciduous
Sub-dominant	Deciduous	Coniferous

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Forest	Forest
Sub-dominant	Residential	Residential
Mass Failures	0	0
Height	0	0
Gullies	0	0
Height	0	0

Step 4. Flow & Flow Modifiers

- 4.1 Springs / Seeps **Minimal**
- 4.2 Adjacent Wetlands **None**
- 4.3 Flow Status **Moderate**
- 4.4 # of Debris Jams **1**
- 4.5 Flow Regulation Type **None**
  - Flow Regulation Use
  - Impoundments
  - Impoundmt. Location
- 4.6 Up/Down strm flow reg **None**
  - (old) Upstrm Flow Reg

4.7 StormwaterInputs

Field Ditch	0	Road Ditch	0
Other	0	Tile Drain	0
Overland Flow	0	Urb Strm Wtr Pipe	0

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types

Mid	Point	Side
0	1	0
Diagonal	**Delta**	**Island**
0	0	0

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
0	0	0	0

5.3 Steep Riffles and Head Cuts

Steep Riffles	Head Cuts	Trib Rejuv.
0	0	No

- 5.4 Stream Ford or Animal **No**
- 5.5 Straightening **None**
  - Straightening Length: **0**
- 5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: New Haven River

Phase 2 Segment Summary page 1 of 2 January 8, 2008 SGAT Version: 4.56

Stream: **New Haven River** Reach # **M02** Segment: **0** Completion Date: **September 12, 2007**

Organization: **Addison County RPC** Observers: **KLU, BOS - SMRC; AD - ACRPC** Why Not assessed: Rain: **Yes**

Segment Length (ft): **5,994** Segment Location: **From 2000 ft west of River Road bridge crossing (just downstream of powerline crossing)**

QC Status - Staff: Provisional Cons

Step 1. Valley and Floodplain

1.1 Segmentation **None**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	252	0
height	10	0
Roads	0	0
height	0	0
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	484	194

1.4 Adjacent Side	Left	Right
Hillside Slope	Steep	Very Steep
Continuous w/	Sometimes	Sometimes
W/in 1 Bankfill	Sometimes	Sometimes
Texture	Not Evalua	Not Evalua

1.5 Valley Features

Valley Width (ft) **820**

Width Determination **Estimated**

Confinement Type **Broad**

Rock Gorge? **No**

Human-caused Change? **No**

Step 2. Stream Channel

2.1 Bankfull Width **93**

2.2 Max Depth (ft) **6.50**

2.3 Mean Depth (ft) **4.40**

2.4 Floodprone Width (ft) **553**

Notes:

LB berm downstream of Rt 7 bridge. Also, LB berm of field boulders along corridor (old channel position) at edge of corn field in middle of reach. Residential development (sparse) along LB and RB. Revetments (rip-rap and stone walls) are present adjacent to

Provisional *Step 2. (Contued)*

2.5 Aband. Floodpln **7.70** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **21.14**

2.7 Entrenchment Ratio **5.95**

2.8 Incision Ratio **1.18**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Sedimented**

2.11 Riffle/Step Spacing (ft) **360**

2.12 Substrate Composition

Bedrock	0 %
Boulder	0 %
Cobble	5 %
Coarse Gravel	65 %
Fine Gravel	27 %
Sand	3 %
Silt and smaller	0 %

Silt/Clay Present? **No**

Detritus **5** %

Large Woody **65**

2.13 Average Largest Particle on

Bed **60.0** mm

Bar **40.0** mm

2.14 Stream Type

Stream Type: **C**

Bed Material: **Gravel**

Subclass Slope: **None**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type

(if different from Phase 1)

3.3 old	Amount	Mean Height
Failures	None	0.00
Gullies	None	0.00

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

Bank Texture	Left	Right
Upper		
Material Type	Sand	Sand
Consistency	Non-cohesive	Non-cohesive
Lower		
Material Type	Silt	Silt
Consistency	Cohesive	Cohesive

Bank Erosion	Left	Right
Erosion Length (ft)	798	669
Erosion Height (ft)	5.20	4.80
Revetmt. Type	Rip-Rap	Multiple
Revetmt. Length (ft)	429	344

Near Bank Veg. Type	Left	Right
Dominant	Shrubs/Saplin	Shrubs/Saplin
Sub-dominant	Deciduous	Deciduous

Bank Canopy	Left	Right
Canopy %	26-50	26-50

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	51-100	>100
Sub-dominant	>100	51-100
W less than 25	661	442

Buffer Veg. Type	Left	Right
Dominant	Deciduous	Deciduous
Sub-dominant	Shrubs/Saplin	Shrubs/Saplin

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Crop	Forest
Sub-dominant	Shrubs/Saplin	Crop
Mass Failures	0	0
Height	0	0
Gullies	0	0
Height	0	0

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **Abundant**

4.2 Adjacent Wetlands **Abundant**

4.3 Flow Status **Moderate**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

Field Ditch	1	Road Ditch	0
Other	0	Tile Drain	0
Overland Flow	0	Urb Strm Wtr Pipe	0

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types

Mid	Point	Side
2	10	2
Diagonal	**Delta**	**Island**
3	0	1

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
4	2	0	0

5.3 Steep Riffles and Head Cuts

Steep Riffles	Head Cuts	Trib Rejuv.
0	0	No

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **883**

5.5 Dredging **None**

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

APPENDIX B

Bridge & Culvert Assessment Reports

Stream Geomorphic Assessment VT DEC

Bridge Summary Report

General Information

Structure ID	200019012901132	**Local Structure ID**	---
VOBCIT Struct Num	990002000101131		
Observers	KLU, BOS - SMRC	**Assessment Date**	12/10/2007
Town	New Haven	**Project Name:**	New Haven River
Location	0.54 mile north of Jct w/ River Road.	**Reach VTID**	M02
Latitude	44.06	**Longitude**	-73.17
Road Name	VT Route 7	**Road Type**	Paved
Stream Name	New Haven River	**High flow stage**	No
		Channel width	106 ft. (Curve)

Bridge/Arch Information

Bridge Width	31 ft.	**Material**	Concrete
Bridge Clearance	17 ft.	**Number of bridge piers/arches**	2
Bridge/Arch Span	251 ft.	**Skewed to roadway?**	No

Geomorphic Information

General	
Floodplain filled by roadway approaches	Entirely
Structure is located at significant break in valley slope	No
Upstream	
Obstructions at the opening of the structure	None
Steep riffle present immediately upstream of structure	No
If channel avulses, stream will	Cross Road
Estimated distance avulsion would follow road	--- ft.
Angle of stream flow approaching structure	Mild Bend
Downstream	
Pool present immediately downstream of structure	No
Downstream bank heights are substantially higher than upstream bank heights	No
Stepped footers	No

More Geomorphic Information

	Upstream	Downstream	In Structure
Dominant Bed Material	Gravel	Gravel	Gravel
Bedrock Present	No	No	No
Type of Sediment Deposits	Mid-channel	Mid-channel	None
Elevation of sediment deposits greater than 1/2 bankfull	No	No	No
Bank Erosion	High	None	
Hard Bank Armoring	Intact	Intact	
Stream bed scour causing undermining around or under structure	None	None	
Beaver Dam near Structure	No	No	
Beaver Dam distance (ft.)	---	---	

Vegetation

	Upstream	Downstream	In Structure
Dominant Vegetation Type - Left	Deciduous Forest	Deciduous Forest	
Dominant Vegetation Type - Right	Deciduous Forest	Deciduous Forest	

Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?

Vegetation Band - Left	No	No	

Vegetation Band - Right	Yes	Yes	

Wildlife

	Roadkill	Outside Structure	Inside Structure
Species	None	None	None

Other Information

Spatial location data collected with GPS?	Yes	**Photos taken?**	Yes
Comments	Bridge built 1960 according to Vtrans inventory table.		

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Stream Geomorphic Assessment VT DEC

Bridge Summary Report

General Information

Structure ID	100113003001131	**Local Structure ID**	---
VOBCIT Struct Num	700034016401133		
Observers	KLU, BOS	**Assessment Date**	12/10/2007
Town	New Haven	**Project Name:**	New Haven River
Location	1800 ft northwest of Jct w/ VT Route 7.	**Reach VTID**	M01
Latitude	44.06	**Longitude**	-73.17
Road Name	DOG TEAM RD	**Road Type**	Paved
Stream Name	New Haven River	**High flow stage**	No
		Channel width	106 ft. (Curve)

Bridge/Arch Information

Bridge Width	23 ft.	**Material**	Concrete
Bridge Clearance	16 ft.	**Number of bridge piers/arches**	3
Bridge/Arch Span	178 ft.	**Skewed to roadway?**	No

Geomorphic Information

General	
Floodplain filled by roadway approaches	Entirely
Structure is located at significant break in valley slope	No
Upstream	
Obstructions at the opening of the structure	Wood debris
Steep riffle present immediately upstream of structure	No
If channel avulses, stream will	Unsure
Estimated distance avulsion would follow road	--- ft.
Angle of stream flow approaching structure	Sharp Bend
Downstream	
Pool present immediately downstream of structure	No
Downstream bank heights are substantially higher than upstream bank heights	No
Stepped footers	No

More Geomorphic Information

	Upstream	Downstream	In Structure
Dominant Bed Material	Gravel	Gravel	Gravel
Bedrock Present	No	No	No
Type of Sediment Deposits	None	None	None
Elevation of sediment deposits greater than 1/2 bankfull	No	No	No
Bank Erosion	High	Low	
Hard Bank Armoring	None	None	
Stream bed scour causing undermining around or under structure	None	None	
Beaver Dam near Structure	No	No	
Beaver Dam distance (ft.)	---	---	

Vegetation

	Upstream	Downstream	In Structure
Dominant Vegetation Type - Left	Herbaceous/Grass	Coniferous Forest	
Dominant Vegetation Type - Right	Deciduous Forest	Herbaceous/Grass	
Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?			
Vegetation Band - Left	No	No	

Vegetation Band - Right	No	No	

Wildlife

	Roadkill	Outside Structure	Inside Structure
Species	None	None	None

Other Information

Spatial location data collected with GPS?	Yes	**Photos taken?**	Yes
Comments	Bedrock falls (at former Dog Team Tavern) located within 400 ft downstream. Site of USGS Gage at Brooksville (Stn #04282525) - downstream left bank. Bridge constructed in 1927 according to Vtrans inventory table.		

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APPENDIX D

Reach Segmentation

Appendix D. Reach Segmentation, Phase 2 Stream Geomorphic Assessment of reaches M01 and M02, New Haven River

									Comparison to Phase 1 Slope	
Reach	Segment	Feature	Point	Total Reach Length (ft)	Segment Lengths (ft)	Elevation (ft)	Segment Slopes	Reach Slope	Elevation (ft)	Reach Slope
M02	--	d/s end reach	--			238			235	
	--	u/s end reach	--	5,994		249		0.2%	249	0.23%
M01		d/s end reach				220			222	
	A	segment break	A/B		1,580	222	0.1%			
	B	u/s end reach		3,753	2,173	238	0.7%	0.5%	235	0.35%

APPENDIX E

Meander Geometry
(Revised Phase 1 Steps 6.5, 6.6)

Appendix E. Meander Geometry, Revised Phase 1 Steps 6.5, 6.6; Reaches M02 and M01, New Haven River

								MEANDER BELT WIDTH									**MEANDER WAVELENGTH**			
				Phase 1				***Williams Eq. 32***	Range, Williams (SD)		Belt Width					***Williams Eq. 30***	Range, Williams (SD)		Wavelength	
C-type	Phase 1	Phase 1 Channel	Phase 1 Estimated	(Regime) Channel	Meander Belt Width	Meander Belt Width	Belt Width	Belt Width	Low	High	Ratio	Belt Width	Wavelength	Wavelength	Wavelength	Wavelength	Low	High	Ratio	Wavelength
Reach	Sinuosity	Slope	Straightened	Width	Measured	Avg	Ratio Actual	Predicted	- 42 %	+ 74 %	Predicted	RPD	Measured	Avg	Ratio Actual	Predicted	- 39 %	+ 65 %	Predicted	RPD
		(%)	(%)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(%)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(%)
M02	1.16	0.20	14	106	200	167	1.6	686	*398*	*1,194*	6.5	-76%	590	668	6.3	1,206	*736*	*1,989*	11.4	-45%
					150								765							
					150								650							
M01					NM	#DIV/0!	#DIV/0!	0	*0*	*0*	#DIV/0!	#DIV/0!	NM	#DIV/0!	#DIV/0!	0	*0*	*0*	#DIV/0!	#DIV/0!
Not Applicable																				
Bedrock-controlled Reach																				

(orange)	outside range: less than low end	outside range: less than low end
(blue)	outside range: greater than high end	outside range: greater than high end
RPD ↑	minus means actual is less than predicted	minus means actual is less than predicted

From Williams, 1986; *Journal of Hydrology*, 88 (147-164).

Equation 32: Meander Belt Width, B = 3.7*W^1.12 (in feet); applicable Width (W) range (4.9 to 13,000 feet); applicable sinuosity range: >= 1.2; 153 data points, worldwide; Sample correlation coefficient of 0.96; Standard Deviation of -42 % to +74 %.

Equation 30: Meander Wavelength, L = 6.5*W^1.12 (in feet); applicable Width (W) range (4.9 to 13,000 feet); applicable sinuosity range: >= 1.2; 191 data points, worldwide; Sample correlation coefficient of 0.96; Standard Deviation of -39 % to +65 %.