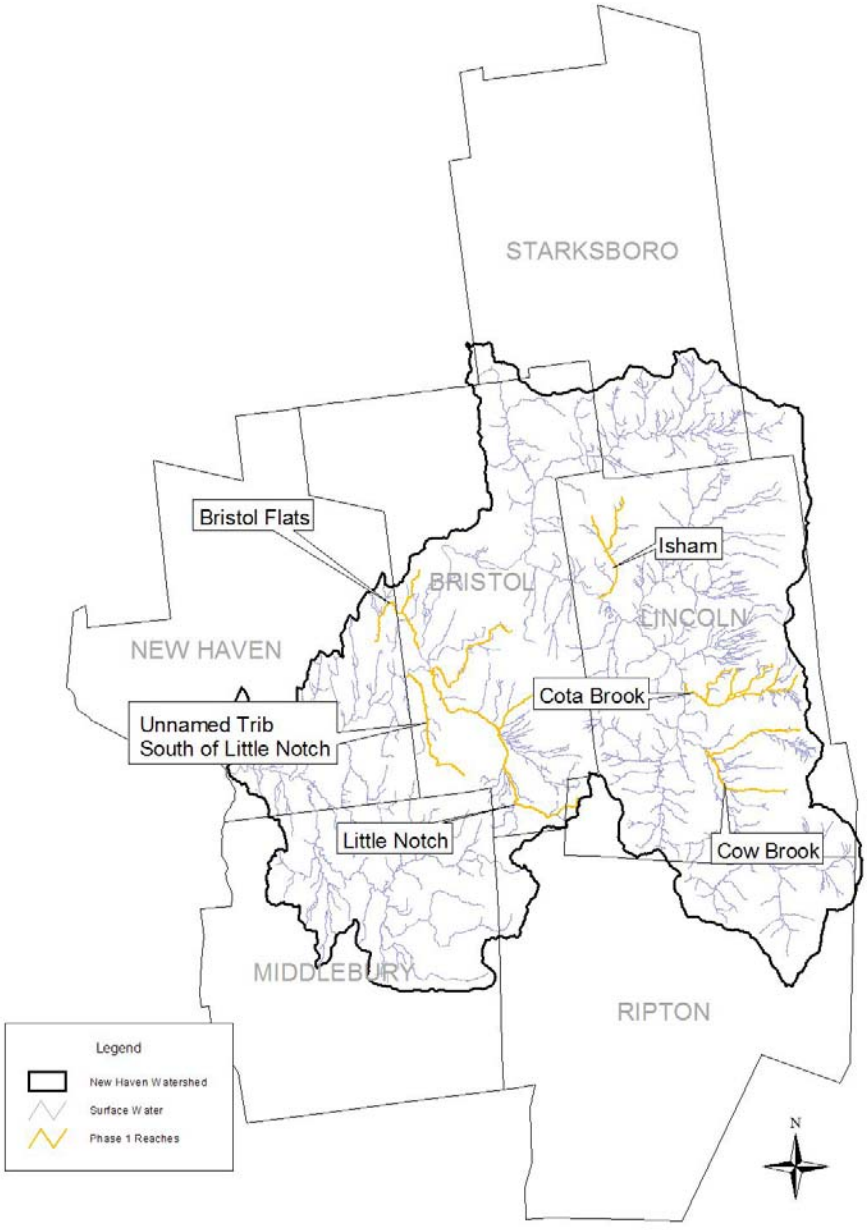
New Haven Tributaries
Phase 1 Geomorphic Assessment
Addison County, Vermont
September, 2006



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1.0 Executive Summary

The Addison County Regional Planning Commission (ACRPC) contracted with Landslide Natural Resource Planning (LNRP) to complete a Phase 1 Geomorphic Assessment on 43 reaches of Tributaries of the New Haven River. The study was paid for by a grant from the Vermont Emergency Management Agency and the Vermont Department of Environmental Conservation with funding from the Federal Emergency Management Agency (FEMA). The New Haven River is located in the Towns of Bristol, Lincoln, Middlebury, New Haven, Ripton and Starksboro and is a tributary of the Otter Creek River. The watershed encompasses approximately 75,000 acres. Ninety-four stream miles were assessed for this study.

The New Haven River is located in both the Champlain Valley and Green Mountain regions of Vermont. The primary land use in the watershed is forest. With the exception of the Village of Bristol, there is limited but increasing residential development in the watershed with much of it occurring along streams due to the narrow valleys. Primary human impacts (45%) to the tributaries assessed here are from land use changes, indicating changes to the natural forested land cover in both the river corridor and the sub-watersheds. Floodplain modification and planform changes account for next highest percent of impact scores (28%). This is due primarily to high scores for Meander Width Ratio and Meander Wavelength Ratio.

A Phase 1 compiles and analyzes existing data on the physical characteristics of the watershed and stream corridor. This information includes geology, soils, slope, and watershed size and results in "reference stream typing". The reference stream type offers a description of the physical characteristics of a stream reach in the absence of human impacts. Of the 43 reaches assessed in this study, eighteen are reference stream type A, eight are B, sixteen are C and one is E. A and B stream types occur in steeper, confined valleys and typically have bedrock, boulder, cobble or plane bed forms, while C and E stream types occur in unconfined valleys with moderate to gentle slopes and have riffle-pool or dune-ripple bed forms.

The Phase 1 study also evaluates impacts to the watershed that may result in channel adjustment. These include: land cover and reach hydrology, instream channel modifications, planform changes and floodplain modifications and a bed and bank windshield survey. Overall impacts in the watershed are primarily related to land clearing in the riparian corridor resulting in a lack of vegetated buffers.

It is recommended that Phase 2 Assessments be completed on the 20 stream reaches that have the highest potential for conflict with human land uses and on streams that are more sensitive to human alterations of the landscape. This includes streams that have the highest potential for future development as well as streams that are already experiencing development.

2.0 Project Overview and Background

2.1 Study Goals and Objectives

The Addison County Regional Planning Commission (ACRPC), as part of a Federal Emergency Management Administration (FEMA) grant through Vermont Emergency Management (VEM) and the Department of Environmental Conservation River Management Section, hired Landslide Natural Resource Planning (LNRP) to complete a Phase I Stream Geomorphic Assessment of select tributaries of the New Haven River in Addison County, Vermont. A Stream Geomorphic Assessment as outlined by the Vermont ANR Protocols is an important step in learning the factors that shape a watershed and its channels. The study provides a priority ranking for Phase 2 assessments, based on ACRPC's goal of developing Fluvial Erosion Hazard maps for these streams. The maps will be available to the towns of Lincoln and Bristol to incorporate in their local planning efforts. The Vermont ANR Phase I Watershed Assessment Protocols were followed completely and exclusively for completion of this assessment.

2.2 Description of Study Area

The New Haven River is located in both the Champlain Valley and Green Mountain regions of Vermont. It is a tributary of the Otter Creek River and is 116 square miles. The River is located in the Addison County towns of Bristol, Lincoln, Middlebury, New Haven, Ripton and Starksboro in the north half of Addison county. Like most of the rest of Vermont, the watershed was primarily forested prior to European settlement. With the introduction of agriculture in the late 1800's (originally sheep farming, now dairy) the area was deforested for pasture and crop production (Albers). Today, this watershed has returned to forest land with increasing amounts of land being converted to residential use. A Phase 1 Assessment was completed on the main stem of the New Haven River and several major tributaries (Muddy Branch, Baldwin Creek, and Beaver Meadow Brook) in 2004.

2.3 Reach Locations

Forty-three reaches totaling 94.4 stream miles were assessed for this study. Reach descriptions, town name, and latitude and longitude can be found in Appendix A at the end of this report. Stream length and number of reaches are summarized below by tributary.

2.4 Table 1 Stream Lengths and Number of reaches

Tributary Name	Length (Miles)	Number of Reaches
Unnamed Trib. South of Little Notch	5.4	4
Bristol Flats	8.7	4
Isham Brook	7.4	5
Little Notch	39.6	11
Cota Brook	15.9	11
Cow Brook	17.4	8
Total	94.4	43

2.5 Flood History

Major flood events can have a significant impact on stream channel planform (ANR Phase 2 Protocols). Flow gauges provide a record of these channel altering events. The nearest United States Geologic Survey flow gauge is located on the New Haven River at Brooksville. Data has been collected at this site since October 1st, 1989. In 1995 there was a ten year discharge and in June of 1998 there was a major flood (approximately a five hundred year flood event) on the New Haven with flows in excess of 20,000 cubic feet per second (cfs). Annual peak flows on the New Haven River are typically less than 10,000 cfs and often well less than 5,000 cfs. The Otter Creek, into which the New Haven drains, has been gauged since 1904. Prior to 1947 when the Otter Creek was dammed, there were fifty year flood events in 1912, 1927 and 1936.

3.0 Methodology

3.1 Phase I parameters

The State of Vermont has developed a three phase geomorphic based assessment protocol for watershed assessment. The first phase, completed here, is considered the "remote sensing" level which evaluates geology, soils, slope, and watershed size to establish a provisional reference stream type for each reach. The Stream Geomorphic Assessment Tool Version 4.5 (SGAT), an ArcView extension, was used to facilitate the collection of data (Davis). The Phase 1 study also quantifies human impacts in the watershed and assigns a provisional impact rating to each reach based on the following parameters.

3.2 Table 2. Parameters included in impact scores.

Step Number	Parameter
4.1	Watershed Land Cover/Land Use
4.2	Corridor Land Cover/Land Use
4.3	Riparian Buffer Width
4.4	Groundwater and Small Tributary Inputs
5.1	Flow Regulations and Water Withdrawls
5.2	Bridges and Culverts
5.3	Bank Armoring or Revetments
5.4	Channel Straightening
5.5	Dredging and Gravel Mining History
6.1	Berms and Roads
6.2	River Corridor Development
6.3	Depositional Features
6.4	Meander Migration / Channel Avulsion
6.5	Meander Width Ratio
6.6	Wavelength Ratio
7.1	Dominant Bedform / Material
7.2	Bank Erosion – Relative Magitude
7.3	Debris and Ice Jam Potential

The Phase 1 information helps set the stage for understanding what the major watershed impacts are and can assist in identifying areas to focus additional assessment resources. The Phase 2 Assessment (not completed here) includes the collection of field measurements and observations to check against the Phase 1 reference stream types and impact ratings. This information can be

used to identify Fluvial Erosion Hazard (FEH) zones as well as for identification of areas for different types of restoration activities. Phase 3 assessments are completed only on those reaches that will benefit from active stream restoration activities. Specific parameters assessed here will be discussed in the results section below. All data is located in Appendix A.

3.3 Phase I Quality Assurance Review

To assure a high level of confidence in this Phase 1 Assessment, strict quality assurance and quality controls were followed. These procedures included both manual and automated reviews of all data by LNRP as well as by the Department of Environmental Conservation River Management Program. The three base GIS themes developed by Landslide (valley walls, meander center line and sub-watersheds) were submitted to the State for their review prior to running the SGAT 4.5 extension. The third Quality Assurance check was completed in May, 2006 after the completion of Step 7.

Shannon Hill, River Scientist with the State of Vermont, Agency of Natural Resources, Department of Environmental Conservation River Management Section was the State team leader for this project and performed the Quality Assurance checks. The State's Phase 1 Assessment Protocol was used exclusively for completion of this project.

4.0 Phase 1 Data and Analysis

4.1 Reference Stream Types

Reference stream types provide a framework for describing streams with similar physical characteristics in the absence of human impacts. Reference stream types are determined by reach valley slope and confinement. Of the 43 reaches assessed, 18 are reference stream type A, eight are B, 16 are C and one is an E. A and B stream types occur in steeper, confined valleys typically with bedrock, boulder, cobble or plane bed forms, while C and E stream types occur in unconfined valleys with moderate to gentle slopes and have riffle-pool or dune-ripple bed forms. C and E stream types are also typically warmer and slower moving thus impacting the aquatic species that can live in them (ANR Phase 1 Handbook). A Phase 2 Assessment field checks reference stream types and identifies stream type departures. See Figure 2 on page 10 for a map of Reference Stream Types.

4.2 Basin Geology and Soils

The New Haven River Watershed is located in two of Vermont's major geologic regions: About three quarters of the watershed, including the headwaters and the steeper streams assessed here, is located in the Green Mountains, the remaining western quarter of the watershed is located in the Champlain Valley. The Green Mountains are dominated by glacial till and bedrock geology with very steep slopes. The Champlain Valley is comprised of clay and sand deposits from ancient Lake Vermont (Meeks, Johnson). The underlying geology and the resultant soils drive the physical characteristics of streams and also affect water chemistry and aquatic habitat. Twenty-eight of the forty-three reaches assessed have till as their dominant geologic material. Six reaches have Ice-Contact, four Glacial Lake, four Alluvial and one "Other" as their dominant geologic material.

Twenty-two of the reaches are in hydrologic group B, which mean that they have a medium to high water infiltration rate. Ten reaches are in group D, which has a slow water infiltration

rate/high runoff potential; six reaches are in group C, which has a medium to slow water infiltration rate and four reaches are in hydrologic group A, with a high water infiltration rate and low runoff potential. One reach is not rated. Soil erodability is severe or very severe in 32 of the 43 reaches assessed.

4.3 Land Cover and Reach Hydrology

Land cover affects the rate and volume of water runoff into streams and this in turn, affects the physical characteristics of that stream (ANR Phase 1 Protocols). By far the dominant watershed and corridor land cover for the reaches assessed here is forest. 1970's aerial photos were reviewed to determine historic land cover and land use in the watershed, which was also forested. Fourteen reaches of the 43 reaches have a high impact for watershed landcover, 21 have a high impact for corridor landcover and five are rated high impact for riparian buffer width with the majority of the reaches having greater than 100' of buffer on both banks. The river corridor is defined as six times the reference channel width and the riparian buffer is the land immediately adjacent to the channel within 100' (ANR Phase 1 Protocols).

Groundwater inputs are important to aquatic ecosystems, especially during periods of extreme high and low temperatures, when they can moderate extreme water temperatures. They are also important to maintaining base flows during normal low flow periods in the summer months and during droughts. Sixteen reaches have abundant groundwater inputs and seven have none.

4.4 Historic Channel Modifications

Structures, such as dams and undersized bridges and culverts affect the quantity and duration of water and sediment runoff. They also act as physical barriers to streambed incision upstream of them. There are no regulated dams on any of these six tributaries. No private dams have been identified. There are 39 bridges and culverts on the 43 reaches. All of these have been rated with a low impact to the streams. The Phase 2 Assessment will include a Bridge and Culvert Assessment which will elucidate potential impacts from these structures. Eight of the reaches assessed have a high impact for straightening. There is no known history of dredging or gravel removal on these tributaries (Cahoon, Nicholson).

4.5 Floodplain Modifications

Floodplain access is important for flood storage but also for allowing the river room to meander. Six reaches have high impact for roads. Berms will be inventoried during Phase 2 assessments. Due to the dispersed and limited nature of development in these tributaries, corridor development at this time is minimal for all reaches. Twelve reaches have a high impact for meander width ratio (MWR). The MWR is an indicator of stream straightening and potential loss of access to floodplain. Eight of the reaches are rated high for belt width ratios (BWR). The BWR is an indicator of either straightening and loss of access to floodplain (a high value) or of streambed aggradation (a low value) (ANR Phase 1 Protocols).

4.6 Bed and Bank Windshield Survey

A windshield survey consists of driving by the reaches that are visible from the road and corroborating the remotely collected Phase 1 data. Sixteen of the reaches were not viewed from the road. The windshield survey revealed three reaches with hard bank armoring (riprap). Bank erosion was either "none" or "low" for all reaches. However, the windshield survey provides a limited view of the river and should not be considered a complete erosion inventory. A Phase 2

Assessment will provide a more accurate measure of riprap, straightening, and erosion. There were no potential or existing ice or debris jams recorded for any of the reaches assessed here.

5.0 Results

5.1 Impact Scores

Impact scores are assigned to allow for comparison among reaches which can help in setting priorities for further evaluation and also aid in gaining a general understanding of overall watershed health. Impacts are measured and then rated according to the following: Not Significant (NS), low impact, high impact or no information. A zero is scored for options NS and No Information, a one for low impact and a two for high impact. Impacts are divided into four categories based on steps 4 through 7 of the Phase 1 Assessment: Land Use; Instream Modification; Floodplain Modification; and Bed and Bank Survey. Impact scores for these tributaries ranged from a high of 17 to a low of 0 out of a possible total score of 32. Primary human impacts (45%) to the tributaries assessed here are from land use changes, indicating changes to the natural forested land cover in both the river corridor and the sub-watersheds. Floodplain modification and planform changes account for next highest percent of impact scores (28%). This is due primarily to high scores for Meander Width Ratio and Meander Wavelength Ratio (See discussion in Section 4.5 above).

5.2 Adjustment Process and Reach Condition

As the Phase 2 ANR Protocols explain:

> A channel adjustment process occurs due to natural causes or human activity that has or will result in a change to the floodplain and/or channel condition and, in some cases, even the valley characteristics. An analysis of channel adjustment involves determining the departure of the stream's existing condition from those of a reference stream of the same type, and understanding the physical processes at work in the stream as it comes into balance with the flow and sediment regimes of its watershed (page 70).

The following table describes the different adjustment processes that streams undergo (ANR Phase 1 Protocols).

Table 3 Phase 1 Adjustment Process Options	
Degrading	Downward erosion of stream bed via a head-cutting process
Aggrading	Excessive sediment build up on streambed and bars
Widening	Erosion of both banks leading to an over-widened streambed
Planform	Rapid and/or irregular meander movement and pattern
None	No significant adjustment process indicated
Multiple	Multiple adjustments indicated

A reach condition rating is assigned based on impact scores and potential adjustment process. Seven reaches are in "poor" condition, 16 are in "fair" condition, 5 are in "good" condition and 15 are in "reference" condition.

5.3 Reach Sensitivity

Stream sensitivity relates to the "inherent characteristics of the stream "in regime" and does not take into consideration any adjustments" (ANR Phase 1 Handbook). Sensitivity is only assigned

in the Phase 1 where bed material data was available. Twenty five of the reaches have “high” sensitivity, 10 have “moderate” sensitivity and 4 are “very low”.

6.0 Recommendations

6.1 Discussion

It is recommended that Phase 2 Assessments be completed on stream reaches that have the highest potential for conflict with human land uses and on streams that are more sensitive to human alterations of the landscape. This includes streams that have the highest potential for future development as well as streams that are already experiencing development. Lower gradient streams and streams with more erodable bedtypes are a priority. Smaller, higher gradient streams with bedrock and boulder bed materials are a lower priority, unless they have high potential for human conflict. Below is a priority list of reaches recommended for Phase 2 assessment.

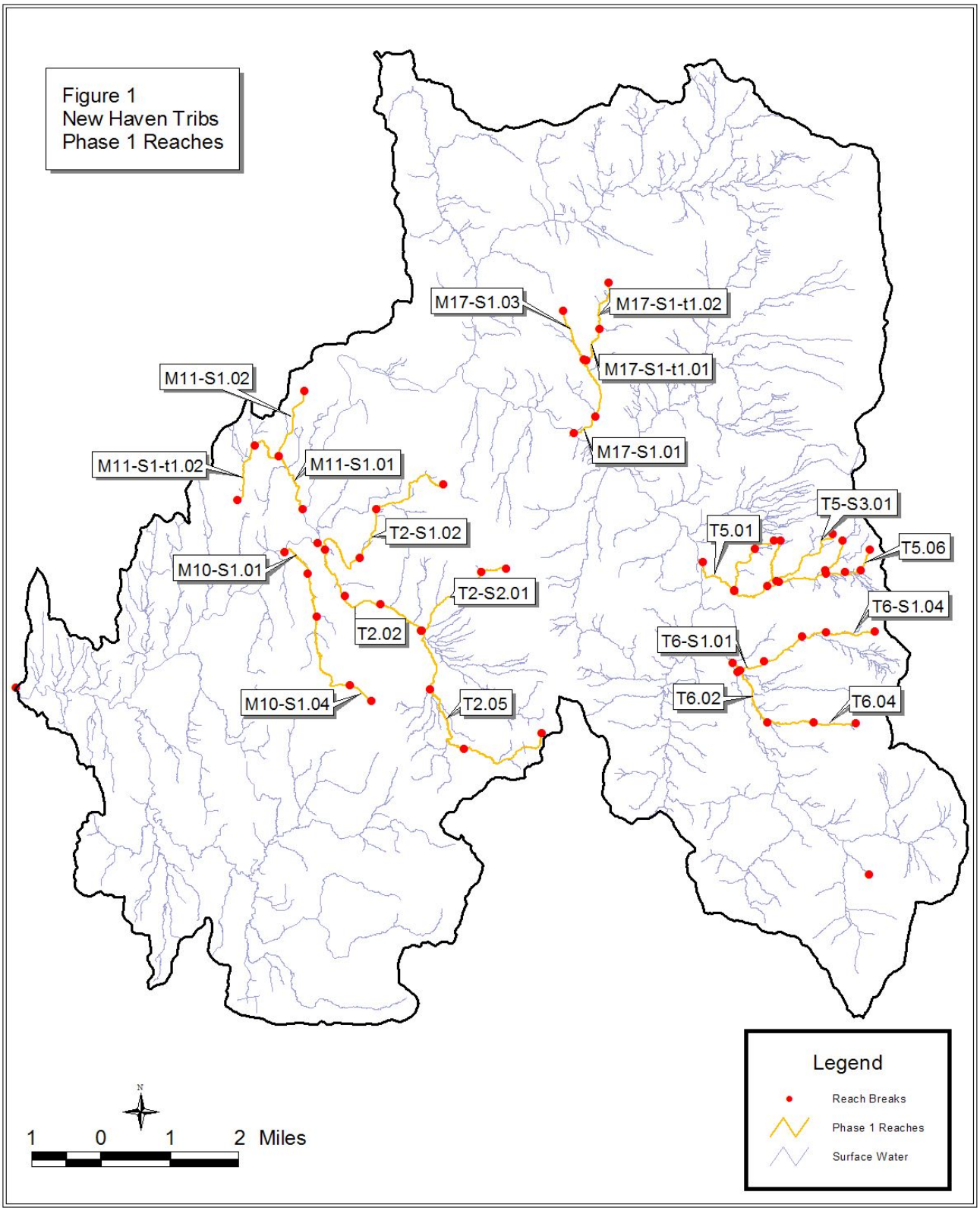
The following reaches have been selected for Phase 2 assessment based on total impact score, stream type, bed type, contiguity within a stream and finally, channel width/stream size.

6.2 Table 3 Reaches Recommended for further Assessment

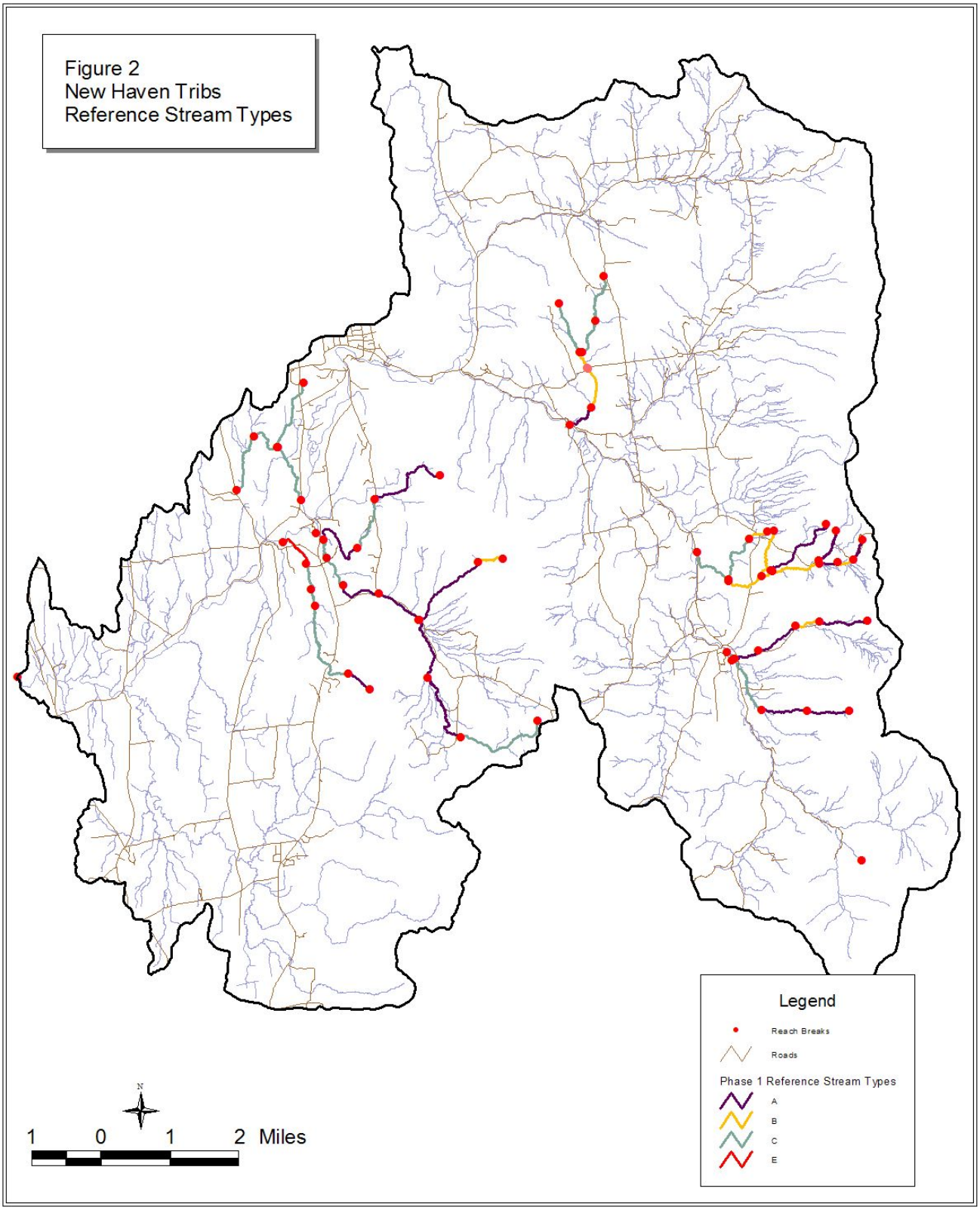
Stream Name	Reach Number	Reference Stream Type	Bedform	Bed Material	Total Impact	Channel Width	Phase 2 Recommended
Unnamed Trib South of Little Notch	M10-S1.01	E	Riffle-Pool	Gravel	12	19	Yes
Unnamed Trib South of Little Notch	M10-S1.02	C	Riffle-Pool	Gravel	13	19	Yes
Unnamed Trib South of Little Notch	M10-S1.03	C	Dune-Ripple	Sand	10	17	Yes
Bristol Flats	M11-S1.01	C	Riffle-Pool	Gravel	17	18	Yes
Bristol Flats	M11-S1.02	C	Dune-Ripple	Sand	13	8	Yes
First Trib of Bristol Flats	M11-S1-t1.01	C	Riffle-Pool	Gravel	9	13	Yes
First Trib of Bristol Flats	M11-S1-t1.02	C	Riffle-Pool	Not Evaluated	12	11	Yes
Isham	M17-S1.01	A	Step-Pool	Cobble	8	19	Yes
Isham	M17-S1.02	B	Step-Pool	Cobble	5	18	Yes
Isham	M17-S1.03	C	Riffle-Pool	Gravel	7	10	Yes
First Trib of Isham	M17-S1-t1.02	C	Riffle-Pool	Gravel	11	9	Yes
Little Notch	T2.01	C	Riffle-Pool	Gravel	10	37	Yes
First Trib of Little Notch	T2-S1.02	C	Dune-Ripple	Sand	7	14	Yes
Cota	T5.01	C	Riffle-Pool	Cobble	10	22	Yes
Fourth Trib of Cota	T5-S4.01	A	Step-Pool	Cobble	7	10	Yes
Cow	T6.01	C	Riffle-Pool	Gravel	5	24	Yes
Cow	T6.02	C	Riffle-Pool	Gravel	8	19	Yes
First Trib of Cow	T6-S1.01	A	Step-Pool	Cobble	9	16	Yes
First Trib of Cow	T6-S1.02	A	Step-Pool	Cobble	2	16	Yes
First Trib of Cow	T6-S1.03	B	Step-Pool	Cobble	8	15	Yes
Unnamed Trib South of Little Notch	M10-S1.04	A	Cascade	Boulder	0	6	
First Trib of Isham	M17-S1-t1.01	C	Riffle-Pool	Cobble	4	12	
Little Notch	T2.02	A	Step-Pool	Cobble	4	34	
Little Notch	T2.03	A	Step-Pool	Boulder	6	33	
Little Notch	T2.04	A	Step-Pool	Cobble	2	28	
Little Notch	T2.05	A	Step-Pool	Cobble	4	21	
Little Notch	T2.06	C	Riffle-Pool	Cobble	4	11	
First Trib of Little Notch	T2-S1.01	A	Step-Pool	Boulder	5	15	
First Trib of Little Notch	T2-S1.03	A	Cascade	Bedrock	3	11	
Second Trib of Little Notch	T2-S2.01	A	Step-Pool	Cobble	2	16	
Second Trib of Little Notch	T2-S2.02	B	Step-Pool	Cobble	0	10	
Cota	T5.02	B	Riffle-Pool	Cobble	5	20	
Cota	T5.03	B	Step-Pool	Cobble	4	16	
Cota	T5.04	A	Step-Pool	Cobble	0	11	
Cota	T5.05	B	Step-Pool	Cobble	4	9	
Cota	T5.06	A	Cascade	Not Evaluated	7	5	
First Trib of Cota	T5-S1.01	C	Riffle-Pool	Not Evaluated	4	8	
First Trib of Cota	T5-S1.02	B	Step-Pool	Not Evaluated	8	3	Backup
Second Trib of Cota	T5-S2.01	B	Plane Bed	Sand	8	7	Backup
Third Trib of Cota	T5-S3.01	A	Step-Pool	Cobble	3	8	
Cow	T6.03	A	Cascade	Cobble	1	14	
Cow	T6.04	A	Cascade	Cobble	1	10	
First Trib of Cow	T6-S1.04	A	Step-Pool	Cobble	2	8	

7.0 Maps

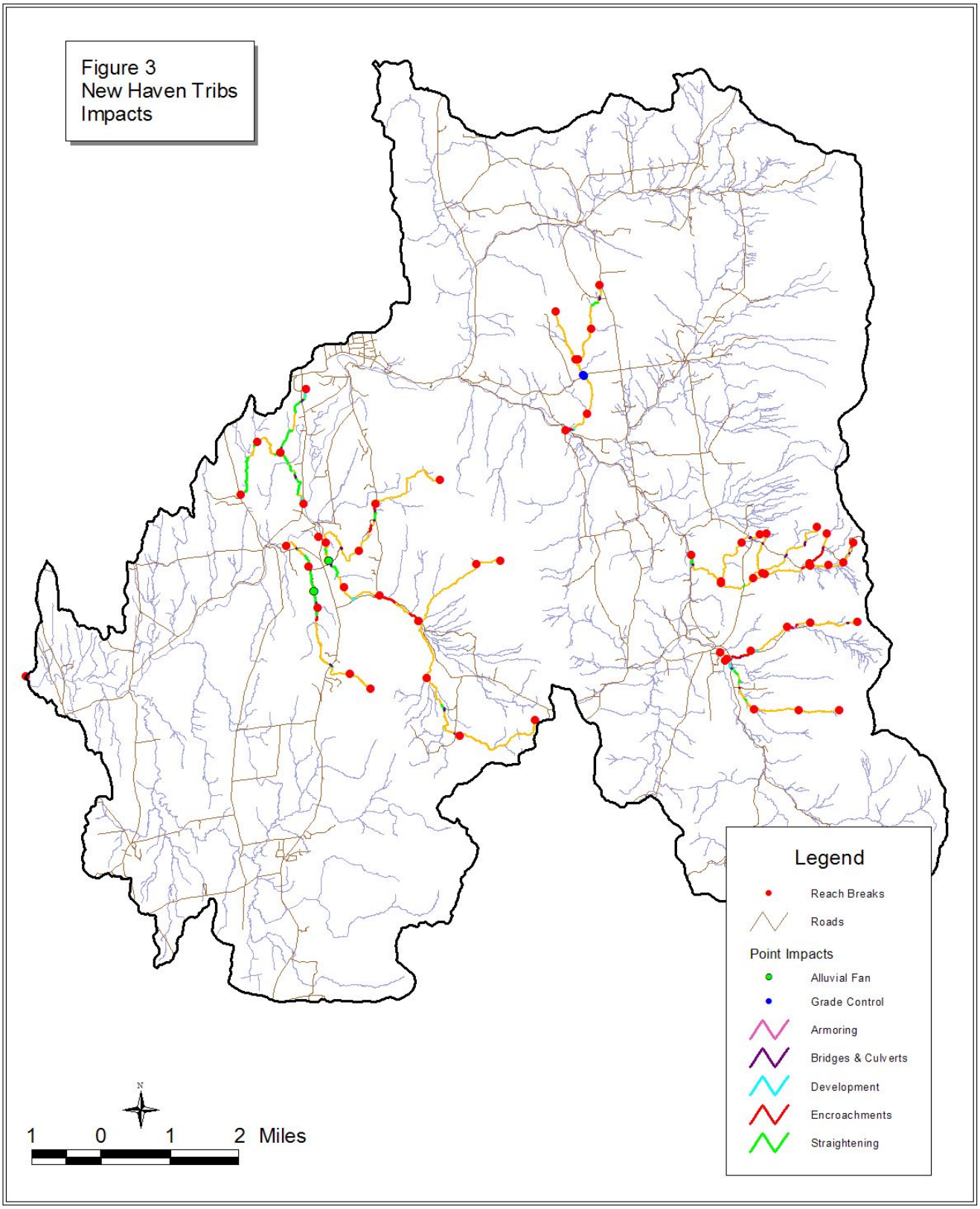
7.1 Figure 1: Phase 1 Reaches



7.2 Figure 2: Stream Types



7.3 Figure 3: Impacts



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Appendices

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Appendix A

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