Jewett Brook Watershed
Stream Geomorphic Assessment
Laconia and Gilford, New Hampshire
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1.0 EXECUTIVE SUMMARY

A stream geomorphic assessment of Jewett Brook was conducted by Bear Creek Environmental, LLC (BCE) in August 2010. The study is part of a three part feasibility analysis funded by the New England District of the Army Corps of Engineers. A planning strategy based on fluvial geomorphic science (see glossary at end of report for associated definitions) was chosen because it provides a holistic, watershed-scale approach to identifying the stressors on river ecosystem health. The stream geomorphic assessment data can be used by resource managers, community watershed groups, municipalities and others to identify how changes to land use alter the physical processes and habitat of rivers. The stream geomorphic assessment data will be used to identify restoration and protection projects for the Jewett Brook watershed that will be incorporated into a watershed plan.

The stream geomorphic assessment followed the Vermont Agency of Natural Resources Protocols. The Jewett Brook watershed was divided into fourteen reaches for the assessment, encompassing six miles of stream channel. The rapid geomorphic and habitat assessment (Phase 2) protocols were employed for seven of the reaches (five on the main stem and two on a major tributary to Jewett Brook). Four of the reaches were wetland or impounded and two of the reaches were dry and did not receive a full Phase 2 assessment. One tributary of Jewett Brook located on the east side of Pheasant Ridge County Club according to National Hydrography Data could not be located in the field. Bridge and culvert data collected by BCE were used to identify structures that have the potential to fail because of channel adjustments, are having a geomorphic impact on the stream, or are impeding aquatic organism passage.

Major problems in the Jewett Brook watershed include undersized stream crossings, corridor encroachments, increased stormwater runoff from impervious surfaces, channel straightening associated with the construction of roads and development, lack of riparian buffers, and degraded water quality. Many of the tributaries and upper reaches of Jewett Book have undersized culverts that are causing localized geomorphic instability and are reducing or impeding fish passage. Alteration of stream channels has caused major to extreme channel degradation resulting in a disconnection between the channel and adjacent floodplain. High quality streamside buffers are lacking along the lower reaches of Jewett Brook and its major tributary.

A list of 30 potential restoration and conservation projects was developed during project identification. Types of projects include: river corridor protection through conservation easements or adoption of fluvial erosion hazard zones, replacing undersized structures causing localized channel instability, improving riparian buffers and water quality through landowner education and outreach, and improved stormwater treatment.

2.0 BACKGROUND

The Town of Laconia has requested that the New England District of the U.S. Army Corps of Engineers conduct a three part study to determine the feasibility of constructing flood damage reduction measures in the Jewett Brook watershed under the Corps Section 205 authority. This feasibility analysis includes the following three components:

1. A geomorphic assessment of the Jewett Brook using protocols developed by the Vermont River Management Program;
2. Hydrologic and hydraulic analysis of the watershed; and
3. Development of a watershed plan.

As part of the first phase of this project, a stream geomorphic assessment of the Jewett Brook watershed was conducted in 2010 by Bear Creek Environmental, LLC. The Jewett Brook watershed has a drainage area of approximately 5.2 square miles at the mouth, where the brook enters Opechee Bay. A summary of the geomorphic condition of Jewett Brook and major tributaries is described in this report along with the identification of preliminary projects to be further developed as part of the watershed plan. In addition to providing information for the feasibility analysis for flood damage reduction, stream geomorphic assessment data can be used by resource managers, community watershed groups, municipalities and others to identify how changes to land use alter the physical processes of rivers.

The geomorphic assessment of Jewett Brook included a partial Phase 1 assessment and a Phase 2 assessment. As part of the Phase 1 assessment, five stream miles were split into fourteen reaches based on valley confinement, slope, tributary influence, surficial geology, and soils. Each point represents the downstream end of the reach (Figure 2.1). M06 (headwaters to Jewett Brook), the lower end of M04T2.01 (crosses Liberty Hill Road), M01S1.02 (upstream of downtown Laconia), and M04T2.02 (north of Liberty Hill Road crossing in Gilford) were excluded from the Phase 2 assessment because these reaches are wetland or impounded. One reach on a small tributary to Jewett Brook in downtown Laconia (M01S1.01) and one reach on a tributary north of Liberty Hill Road (upper end of M04T2.01) did not receive a Phase 2 assessment because the channel was dry. The lower end of the small tributary that is shown on the topographic map to the south east of Pheasant Ridge Country Club (M04S1.01) could not be located in the field at the confluence with Jewett Brook and also did not receive a Phase 2 assessment.

A total of 3.5 river miles were assessed using Phase 2 protocol, including seven reaches on the main stem of Jewett Brook and its major tributary. These seven reaches (M01 through M05 and M02T1.01 and M02T1.02) were further divided into fourteen segments during the Phase 2 investigation based on changes in channel conditions identified during the field work. A segment is distinct in one or more of the following parameters: degree of floodplain encroachment or channel alteration, presence of grade controls, channel dimensions, channel sinuosity and slope, riparian vegetation and corridor conditions, and degree of flow regulation. Segments are assigned letters starting with “A” at the most downstream end of the reach. Bridge and culvert assessments following the Agency of Natural Resources Bridge and Culvert protocols (Vermont Agency of Natural Resources, 2009) were conducted of the entire watershed. The methods are described in Section 3.0.

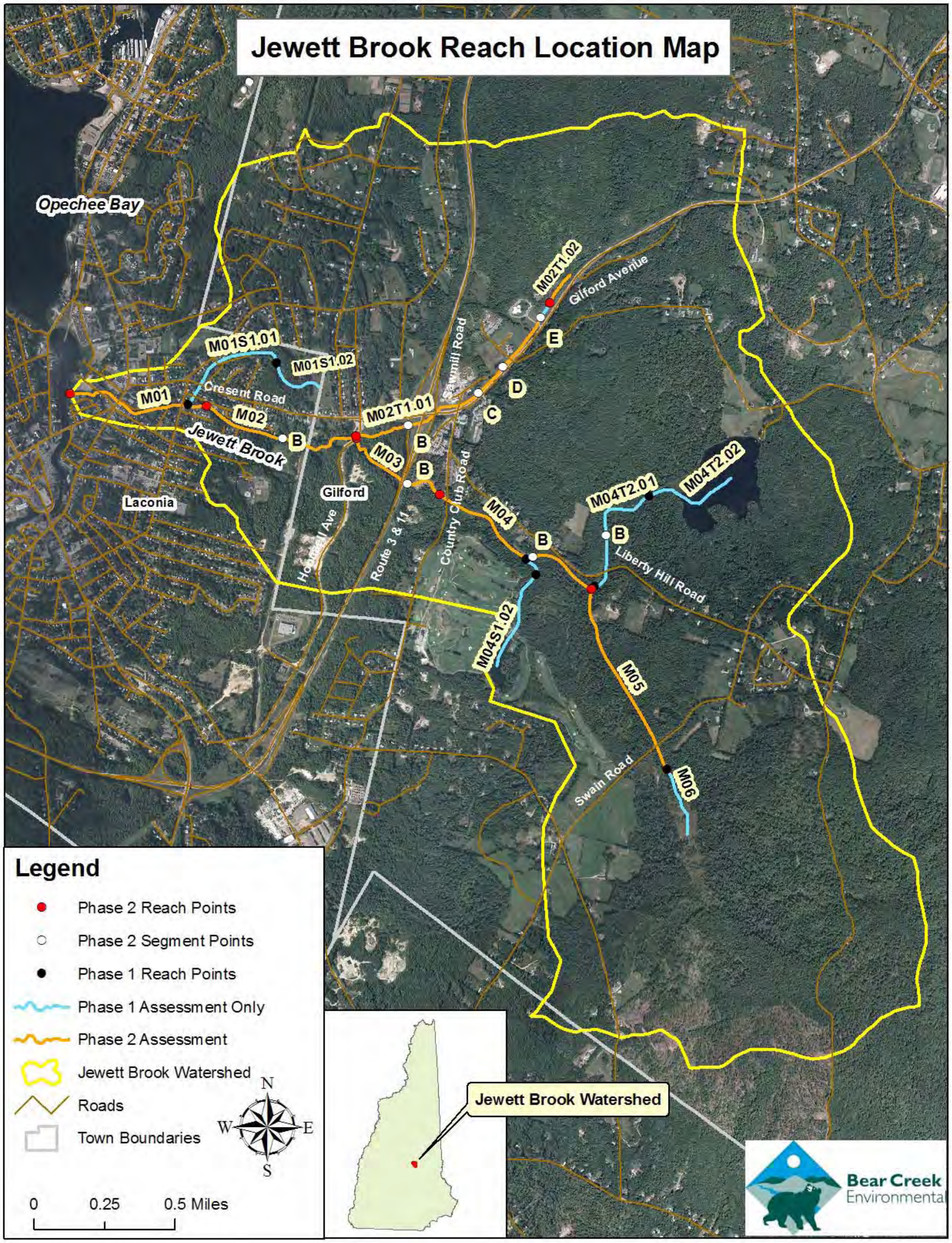

Figure 2.1 Jewett Brook Reach Location Map

3.0 METHODS

This study of the Jewett Brook watershed utilized state-of-the-art Stream Geomorphic Assessment (SGA) protocols developed by the Vermont Department of Environmental Conservation (VTDEC). The SGA protocols are intended to be used by resource managers, community watershed groups, municipalities and others to identify how changes to land use affect hydro-geomorphic processes at the landscape and reach scale, and how these changes alter the physical structure and biological habitat of rivers. The Vermont protocol includes three phases:

1. Phase 1 – Remote sensing and cursory field assessment;
2. Phase 2 – Rapid habitat and rapid geomorphic assessments to provide field data to characterize the current physical condition of a river; and
3. Phase 3 – Detailed survey information for designing "active" channel management projects.

BCE began the Phase 1 assessment of the Jewett Brook watershed during early summer 2010. The fieldwork for the Phase 2 assessment was completed in August 2010 by BCE. These field data were used to develop preliminary river restoration and protection projects presented in this report. Phase 3 surveys for active restoration projects, may be required at some point in the near future for project design and permitting. A summary of the Phase 1, Phase 2, and Bridge and Culvert methodologies is provided in the following sections.

3.1 Phase 1 Methodology

The Phase 1 assessment followed procedures specified in the Vermont Stream Geomorphic Assessment Handbook Phase 1 (Vermont Agency of Natural Resources 2007), and used version 4.59 of the Stream Geomorphic Assessment Tool (SGAT). SGAT is an ArcView extension. Phase 1, the remote sensing phase, involves the collection of data from topographic maps and aerial photographs, from existing studies, and from very limited field studies, called "windshield surveys". The Phase 1 assessment provides an overview of the general physical nature of the watershed. As part of the Phase 1 study, stream reaches are determined based on geomorphic characteristics such as: valley confinement, valley slope, geologic materials, and tributary influence.

3.2 Phase 2 Methodology

The Phase 2 assessment of the Jewett Brook watershed followed procedures specified in the Vermont Stream Geomorphic Assessment (SGA) Handbook Phase 2 (Vermont Agency of Natural Resources 2009a), and used version 4.59 of the Stream Geomorphic Assessment Tool (SGAT) Geographic Information System (GIS) extension to index impacts within each reach. The geomorphic condition for each Phase 2 reach is determined using the rapid geomorphic assessment (RGA) protocol, and is based on the degree of departure of the channel from its reference stream type (Vermont Agency of Natural Resources, 2009). The study also used a new rapid habitat assessment (RHA) protocol (Vermont Agency of Natural Resources, 2008a; Milone and MacBroom, Inc, 2008c).

Reaches determined during Phase 1 were broken up further into segments for the Phase 2 geomorphic assessment as necessary. Topographic maps and orthophotos were used as a first cut in delineating segment breaks. The project team walked the entire length of the reach to confirm preliminary segment breaks determined when reviewing topographic maps and orthophotos. Attributes that were considered when determining segment breaks include: grade controls, changes in channel dimensions, changes in dominant bed material, slope, entrenchment or sinuosity, signs of planform changes, presence of beaver dams, and evidence of aggradation and degradation. The bankfull width and depth were measured occasionally along the reach to track changes in bankfull dimensions. Once segment breaks were determined, the Phase 2 field forms were completed accordingly.

The Project Team walked the entire length of each reach to the extent that conditions were amenable for walking and landowners had granted permission. Valley walls delineated by BCE during the Phase 1 assessment were verified in the field. Human caused changes in valley width due to permanent high embankments that serve as artificial valley walls were also mapped on field sketches with reference to topographic maps and/or orthophotographs. The field verified valley walls were used to evaluate Phase 2 confinement. Adjacent terraces and valley walls were evaluated in terms of their proximity to the channel as outlined in the most current version of the Vermont Phase 2 SGA Handbook. The location, total height and height above water surface were recorded for channel spanning grade controls, both natural and human constructed.

Channel dimensions and bed substrate composition were measured at one to three representative locations within each segment. The channel dimensions and substrate composition were recorded on the Cross-section Worksheet and summarized on the Rapid Stream Assessment Field Notes form under Step 2. Stream type was evaluated based on the channel dimension data, bed substrate composition results, and confirmed channel slope. Dominant bed forms were determined based on the criteria set forth in the most recent version of the Vermont Phase 2 SGA Handbook.

Stream banks were evaluated in terms of their typical slope and dominant texture as outlined in the Vermont Phase 2 SGA Handbook. Areas of bank erosion, mass failures, and gullies were mapped and pertinent information regarding the height and length of such features was recorded. Areas lacking adequate riparian buffers (<25 feet) were mapped and notes were made about the types of vegetation comprising existing riparian buffers. River corridor encroachments including roads, railroads, improved paths, and development were mapped according to their locations, and the height of these encroachments was recorded. Notes were also taken concerning river corridor land use activities.

The locations of springs, seeps, small tributaries, adjacent wetlands, debris jams, beaver dams and channel constrictions were recorded and evaluated in terms of how they may be affecting channel flows. Locations of stormwater inputs from urban runoff, agricultural drainage and road ditching were noted to determine the extent of increased flow status during a storm event. Similarly, locations of flow regulations and water withdrawals were mapped to evaluate potential decreases in channel flows.

Depositional features were mapped to assess the sediment transport regime and storage capacity of the segment. Channel migration features were also mapped in order to determine the amount of channel planform adjustment the segment was undergoing. Sections of the stream where the channel does not appear to be following the natural path of the river and may have been straightened were noted, along with locations where material has been removed from the channel in order to assess the extent to which stream power and morphology have been altered. Steep riffles and headcuts were mapped and used as indicators of active geomorphic processes.

RHA and RGA field forms were completed for the Phase 2 reaches. The appropriate RHA and RGA forms were selected based on segment characteristics and scored according to the data collected from the field assessment. A segment score and corresponding condition were determined for both the RHA and the RGA. Additionally for the RGA, major geomorphic processes were identified, the stage of channel evolution was determined, and a stream sensitivity rating was assigned.

The RHA is used to evaluate the physical components of a stream (channel bed, banks, and riparian vegetation) and how the physical condition of the stream affects aquatic life. The RHA results were used to compare physical habitat condition between sites, streams, or watersheds, and they can also serve as a management tool in watershed planning.

To assure a high level of confidence in the Phase 2 SGA data, strict quality assurance/quality control (QA/QC) procedures were followed by BCE. These procedures involved a thorough in-house review of all data, which took place during November 2010. The Project Team conducted the assessment according to the approved Quality Assurance procedures specified in the Phase 2 handbook.

3.3 Bridge and Culvert Methodology

Bridge and culvert inventory and assessments were conducted by BCE during the Phase 2 assessment to determine if stream crossings were contributing to localized streambank erosion, sedimentation, and reduced fish passage. The Agency of Natural Resources Bridge and Culvert protocols (Vermont Agency of Natural Resources, 2009b) were followed. The Vermont Culvert Geomorphic Screening Tool (Milone and MacBroom, Inc., 2008a) and the Vermont Culvert Aquatic Organism Passage Screening Tool (Milone and MacBroom, Inc, 2008b) were used to identify culverts within the Jewett Brook watershed that are highest priority for replacement/retrofit due to geomorphic incompatibility and/or for being potential barriers to movement and migration of aquatic organisms.

4.0 STREAM TYPES

Reference stream types are based on the valley type, geology and climate of a region and describe what the channel would look like in the absence of human-related changes to the channel, floodplain, and/or watershed. Stream and valley characteristics including valley confinement, and slope were determined from digital United States Geological Survey (USGS) topographic maps. The reference reach characteristics were refined during the Phase 2 Assessment. Reference reach typing was based on both the Rosgen (1996) and the Montgomery and Buffington (1997) classification systems. Table 1 shows the typical characteristics used to determine reference stream types (Vermont Agency of Natural Resources, 2009).

Table 1. Reference Stream Type

Stream Type	Confinement	Valley Slope	Bed Form
A	Narrowly Confined	Very steep > 6.5 %	Cascade
A	Confined	Very steep 4.0 - 6.5 %	Step-Pool
B	Confined or Semi-confined	Steep 3.0 – 4.0 %	Step-Pool
B	Confined, Semi-confined or Narrow	Moderate to Steep 2.0 – 3.0 %	Plane Bed
C or E	Unconfined (Narrow, Broad or Very Broad)	Moderate to Gentle <2.0 %	Riffle-Pool or Dune-Ripple
D	Unconfined (Narrow, Broad or Very Broad)	Moderate to Gentle <4.0 %	Braided Channel

Table 2 lists the reference stream types for assessed reaches in the Jewett Brook watershed. Reaches assessed for Phase 2 on the Jewett Brook mainstem are "C" channels by reference. Reference "C" channels have unconfined valleys with moderate to gentle valley slopes and moderate to high width to depth ratios and sinuosity. The major tributary to Jewett Brook is either a "C" or "E" channel by reference. The upper portion of the tributary is a wetland channel with a low width to depth ratio, which is typical of an E-channel. All the reaches, with the exception of M04, which is steeper, have an overall confinement type of very broad. Reaches M03, M04 and M02T1.02 have channel slopes greater than 2.0 percent, and are therefore, assigned a subclass slope of "b".

Table 2. Geomorphic Setting of Assessed Reaches					
Stream	**Reach ID**	**Reference Stream Type**	**Confinement**	**Valley Slope**	**Bedform**
Jewett Brook	M01	C	Very Broad	1.07	Riffle-Pool
	M02	C	Very Broad	1.38	Riffle-Pool
	M03	C	Very Broad	3.03	Riffle-Pool
	M04	C	Broad	5.04	Riffle-Pool
	M05	C	Very Broad	2.27	Riffle-Pool
Tributary to Jewett Brook	M02T1.01	C/E	Very Broad	1.73	Riffle-Pool/Ripple-Dune
	M02T1.02	E	Very Broad	3.23	Ripple-Dune

During the Phase 2 assessment, the seven reaches listed in Table 2 were broken into 14 segments based on detailed field observations. The existing stream type is based on channel dimensions measured during the Phase 2 assessment. The reference and existing stream type for each assessed reach/segment is included in Figures 4.1 and 4.2, respectively. Detailed segment summary data are provided in Appendix A. The existing stream type is "C" for all the segments on the Jewett Brook main stem. For the main stem the reference and existing stream type is the same for all reaches/segments. Downstream of Maple Street, on the major tributary to Jewett Brook, the existing stream type differs from the reference stream type and a stream type departure has taken place. A stream type departure occurs when the channel dimensions deviate so far from the reference condition that the existing stream type is no longer the reference stream type. In segment M02T1.01-C (just downstream of Maple Street crossing) a stream type departure from a reference "C" channel with slight entrenchment to a "B" channel with moderate entrenchment has occurred due to the encroachment of Gilford Avenue. A stream type departure from a "C" to an "E" stream has occurred in the two most downstream segments of the tributary where the stream is channelized and the width to depth ratio is lower than the reference condition.

These stream type departures represent a significant change in floodplain access and stability. Watersheds which have lost attenuation or sediment storage areas due to human related constraints are generally more sensitive to erosion hazards, transport greater quantities of sediment and nutrients to receiving waters, and lack the sediment storage and distribution processes that create and maintain habitat (Vermont Agency of Natural Resources, 2009).

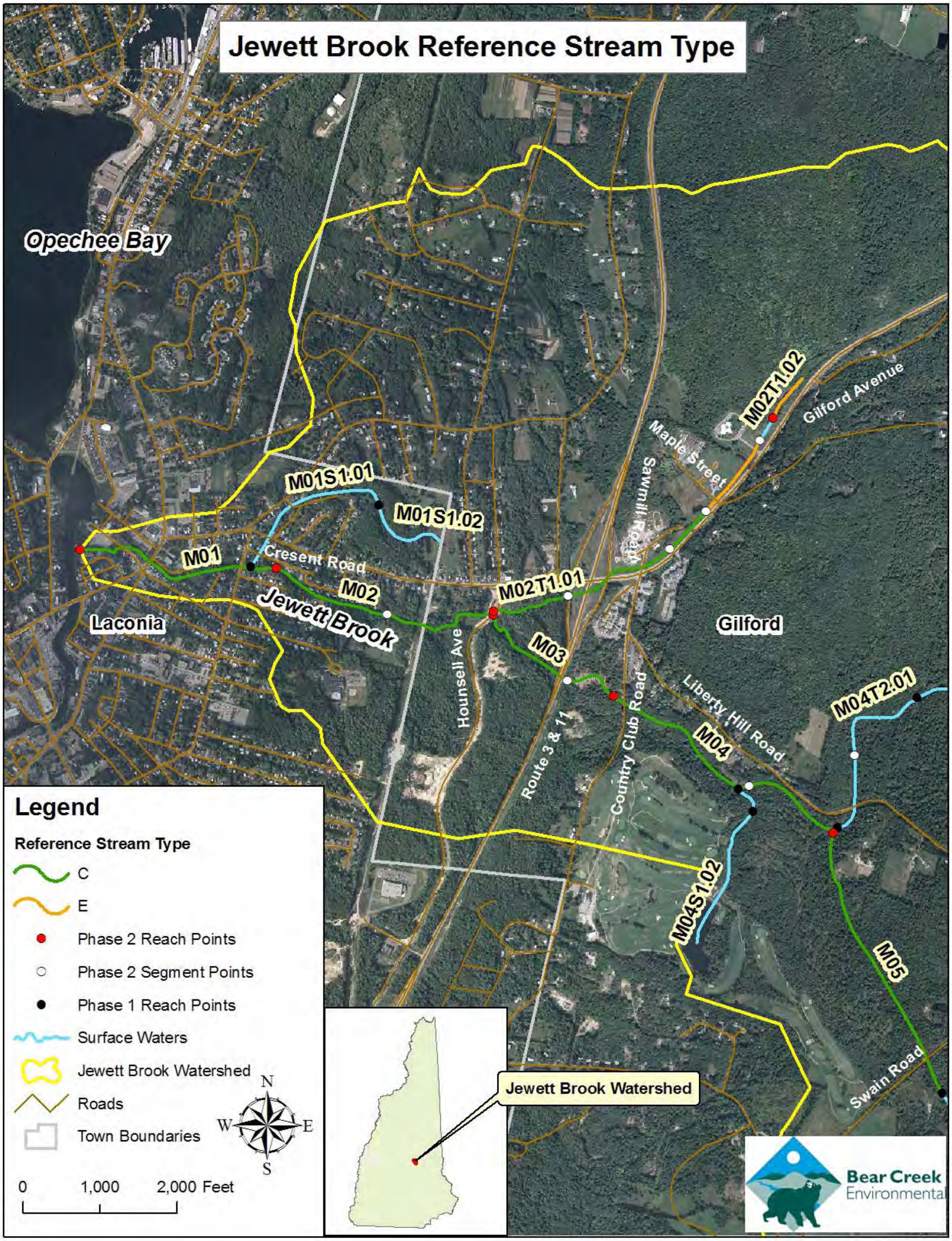

Figure 4.1 Jewett Brook Reference Stream Types for Phase 2 Assessment

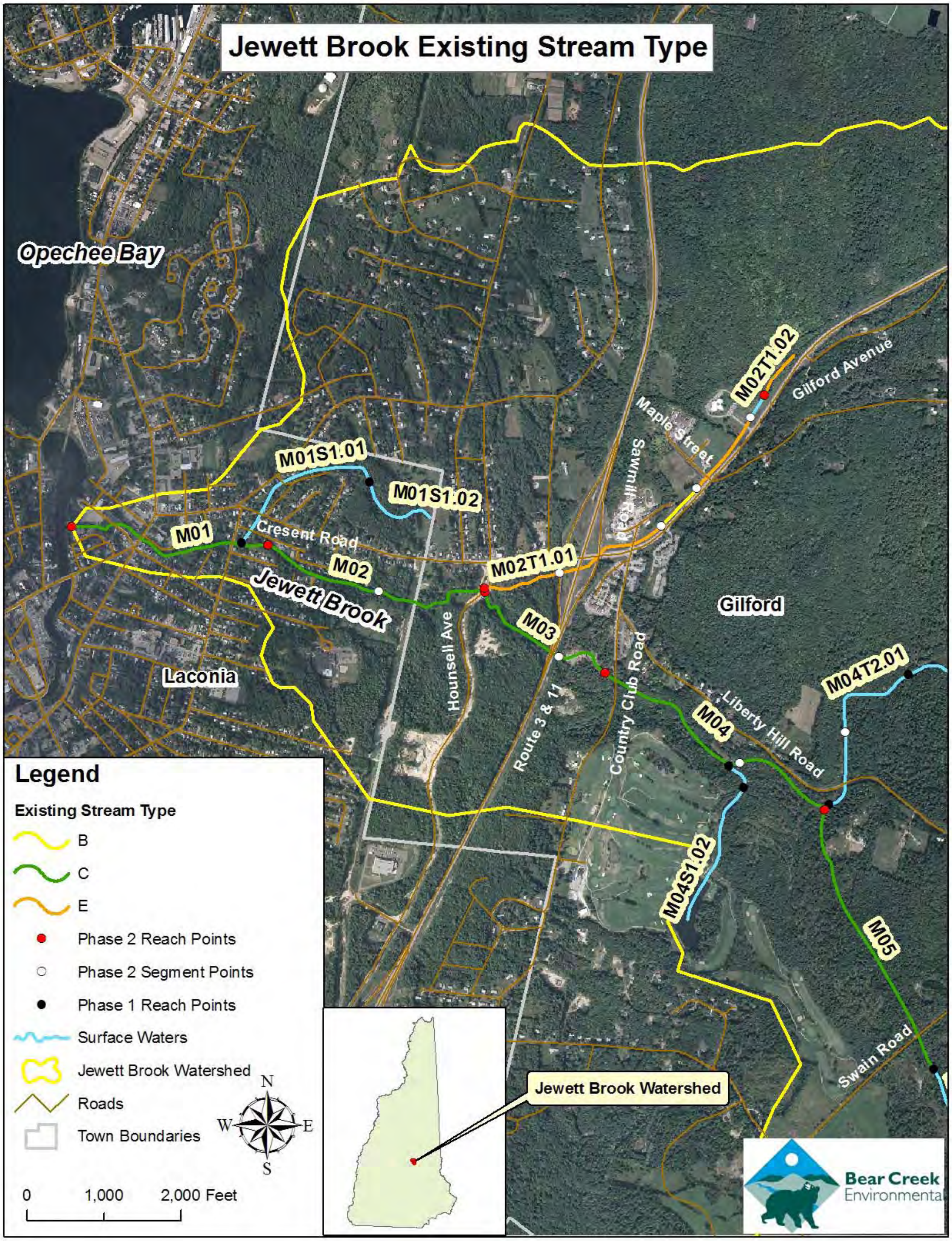

Figure 4.2 Existing Stream Type for Phase 2 Geomorphic Assessments

5.0 GEOMORPHIC CONDITION

The existing geomorphic condition is depicted in Figure 5.1. Geomorphic condition is determined based on the degree (if any) of channel degradation, aggradation, widening and planform adjustment. Degradation is the term used to describe the process whereby the stream bed lowers in elevation through erosion, or scour, of bed material. Aggradation is a term used to describe the raising of the bed elevation through an accumulation of sediment. The planform of a channel is its shape as seen from the air. Planform change can be the result of a straightened course imposed on the river through different channel management activities, or a channel response to other adjustment processes such as aggradation and widening. Channel widening occurs when stream flows are contained in a channel as a result of degradation or floodplain encroachment or when sediments overwhelm the stream channel and the erosive energy is concentrated into both banks.

The main stem of Jewett Brook is in "good" geomorphic condition from the headwaters downstream to the Route 3 & 11 stream crossing (Reaches M05 and M04 and segment M03-b). Below the Route 3 & 11 crossing, Jewett Brook is in "fair" geomorphic condition, and the channel and stream corridor is influenced by development. With the exception of the very most upstream end, the major tributary to Jewett Brook (M02T1) is in "fair" geomorphic condition. Development adjacent to this major tributary has resulted in significant instream modifications and floodplain encroachment leading to a loss of functioning floodplains.

Functioning floodplains play a crucial role in providing long term stability to a river system. Natural and anthropogenic impacts may alter the equilibrium of sediment and discharge in natural stream systems and set in motion a series of morphological responses (aggradation, degradation, and widening and/or planform adjustment) as the channel tries to reestablish a dynamic equilibrium. Small to moderate changes in slope, discharge, and/or sediment supply can alter the size of transported sediment as well as the geometry of the channel; while large changes can transform reach level channel types (Ryan 2001). Human-induced practices that have contributed to stream instability within the Jewett Brook watershed include:

- Forest clearing
- Channelization and bank armoring
- Removal of woody riparian vegetation
- Floodplain encroachments
- Poor road maintenance and installation of infrastructure
- Loss of wetlands

These anthropogenic practices have altered the balance between water and sediment discharges within the Jewett Brook watershed. Channel morphologic responses to these practices contribute to channel adjustment that may further create unstable channels. All three adjustment processes, aggradation, widening and planform migration as a result of historic degradation within the channel are common within the Jewett Brook watershed.

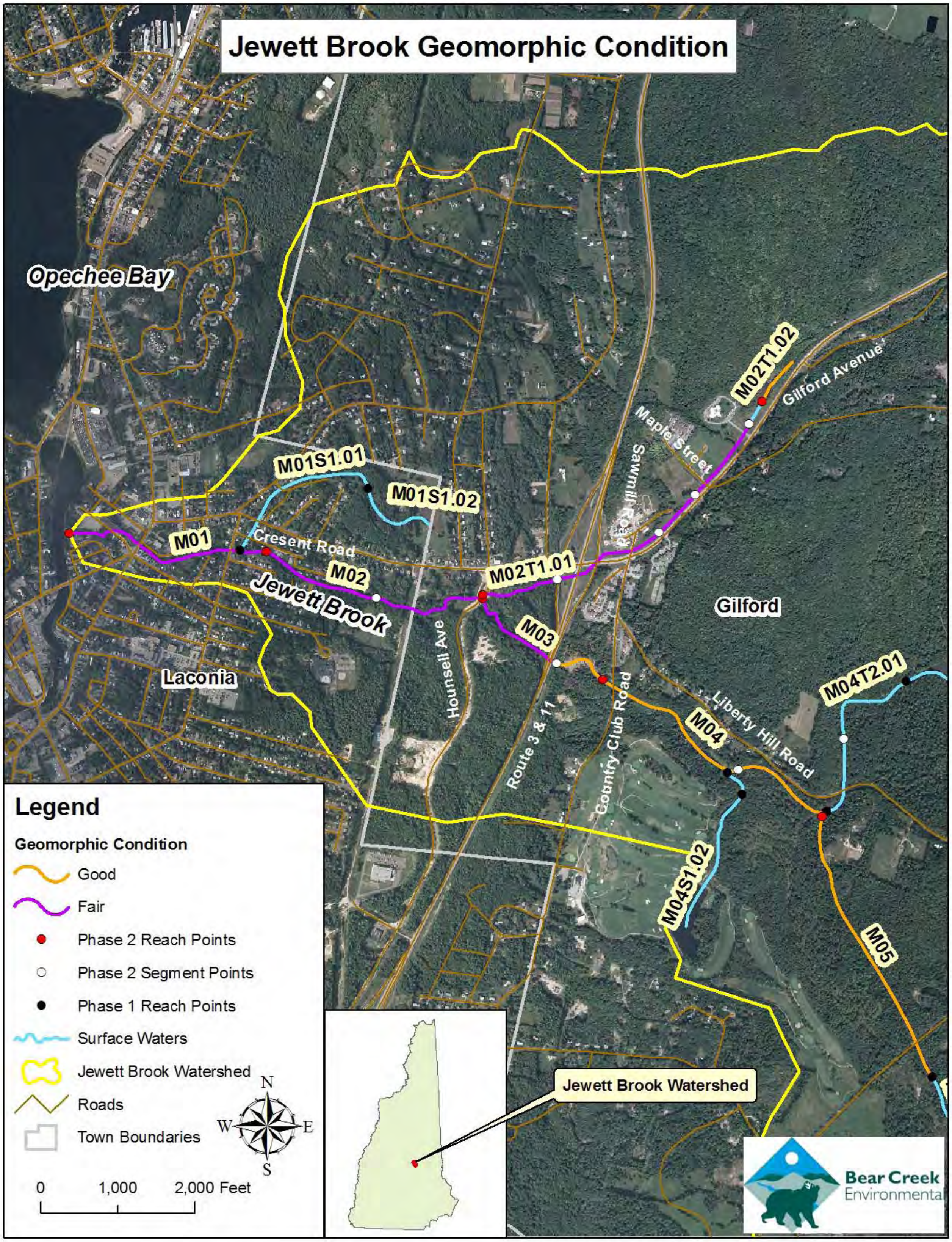

Figure 5.1. Phase 2 Geomorphic Condition of the Jewett Brook Watershed

The reach condition ratings of the Jewett Brook watershed indicate that most of the reaches/segments are actively or have historically undergone a process of minor or major geomorphic adjustment. Many of the reaches studied in the Jewett Brook watershed are undergoing a channel evolution process in response to large scale changes in its sediment, slope, and/or discharge associated with the human influences on the watershed. Table 3 below summarizes the channel evolution of each study reach and the primary adjustment processes that are occurring.

Both the "D" stage and "F" stage channel evolution model (Vermont Agency of Natural Resources, 2009a; Vermont Agency of Natural Resources, 2004) are helpful for explaining the channel adjustment processes underway in the Little River watershed. The "F" stage channel evolution model is used to understand the process that occurs when a stream degrades (incises). The common stages of the "F" channel evolution stage, as depicted in Figure 5.2 include:

- A pre-disturbance period
- Incision – channel degradation
- Aggradation and channel widening
- The gradual formation of a stable channel with access to its floodplain at a lower elevation

The "D-stage" channel evolution model applies to reaches where there may have been some minor historic incision; however, the more dominant active adjustment process is aggradation, which in turn leads to channel widening and planform adjustment. The D-stage adjustment process typically occurs in unconfined, low to moderate gradient valleys where the stream is not entrenched and has access to its floodplain or flood prone area at the 1-2 year flood stage.

Table 3. Stream Type and Channel Evolution Stage

Segment Number	Entr. Ratio	Width to Depth Ratio	Incision Ratio	Reference Stream Type	Existing Stream Type	Channel Evolution Stage	Active Adjustment Process
Jewett Brook							
M01	4.5	13.5	1.43	C4	C4	F-II	**Aggradation** Widening Planform
M02-A	3.7	10.4	1.74	C4	C4	F-II	Aggradation Widening Planform
M02-B	4.1	32.2	1.0	C4	C4	D-IId	**Aggradation** **Widening** **Planform**
M03-A	5.3	17.6	1.2	C4b	C4b	F-III	**Aggradation** Widening **Planform**

Table 3. Stream Type and Channel Evolution Stage

Segment Number	Entr. Ratio	Width to Depth Ratio	Incision Ratio	Reference Stream Type	Existing Stream Type	Channel Evolution Stage	Active Adjustment Process
M03-B	2.3	19.1	1.0	C3b	C3b	F I	Aggradation Widening Planform
M04-A	2.1	17.1	1.0	C4b	C4b	F-I	Aggradation **Planform**
M04-B	2.4	35.8	1.0	C4b	C4b	F-I	Aggradation Planform
M05	3.1	20.6	1.17	C4b	C4b	F-I	Aggradation Widening Planform
M06	Wetland – not assessed						
Tributary to Jewett Brook							
M02T1.01-A	5.8	8.5	1.55	C4	E4	F-III	**Aggradation Widening Planform**
M02T1.01-B	2.6	7.8	3.95	C4	E4	F-II	Aggradation Widening Planform
M02T1.01-C	2.0	10.0	4.10	C4b	B4c	F-II	Aggradation Widening Planform
M02T1.01-D	9.7	10.4	1.37	E4	E4	F-II	Aggradation Widening Planform
M02T1.01-E	Wetland – not assessed						
M02T1.02	23.4	8.6	1.0	E4b	E4b	F-I	Aggradation Planform
	Bold Black lettering – denotes major adjustment process Black lettering (no bold) – denotes minor adjustment process Red denotes severe incision ratio Blue denotes moderate incision ratio Green denotes a stream type departure						

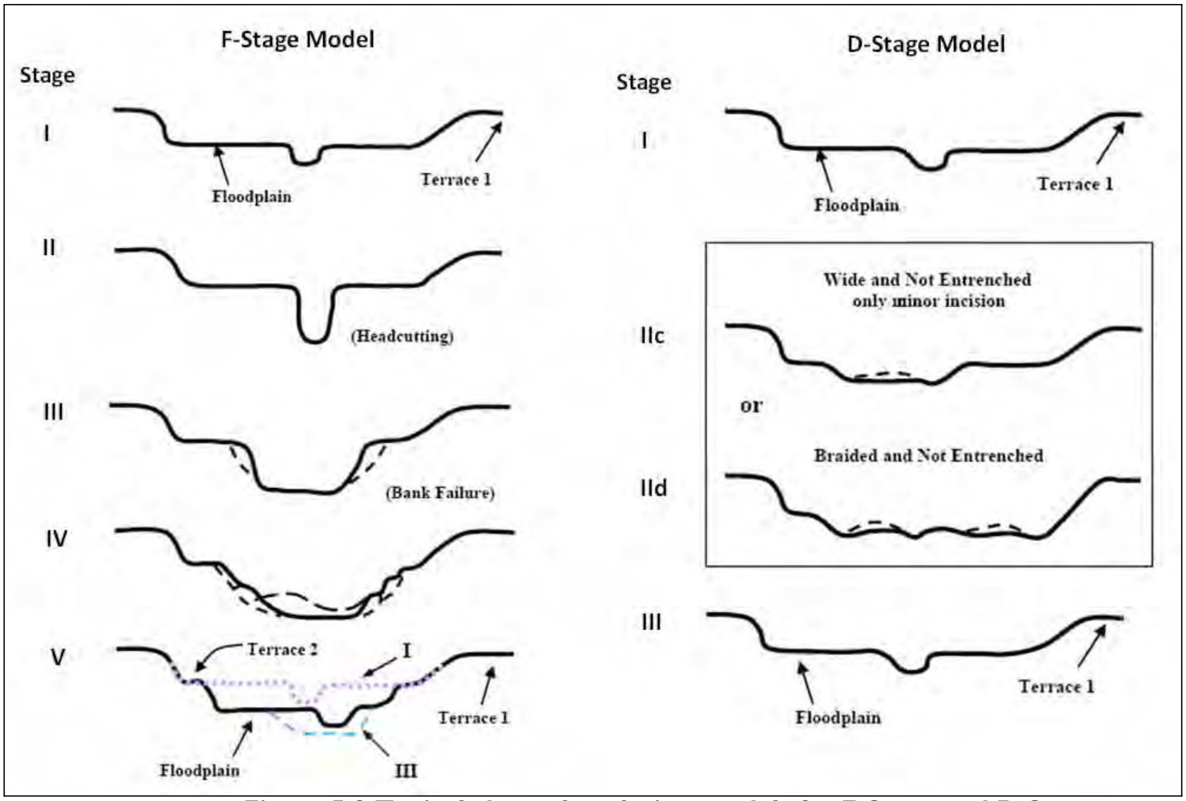

Figure 5.2 Typical channel evolution models for F-Stage and D-Stage (Vermont Agency of Natural Resources, 2009)

When stream channels are altered through straightening, it can set this evolution process into motion and cause adjustment processes to occur. The bed erosion that occurs when a meandering river is straightened in its valley is a problem that translates to other sections of the stream. Localized incision will travel upstream and into tributaries, thereby eroding sediments from otherwise stable streambeds. These bed sediments will move into and clog reaches downstream, leading to lateral scour and erosion of the streambanks. Channel evolution processes may take decades to play out. Even landowners that have maintained wooded areas along their stream and riverbanks may have experienced eroding banks as stream channel slopes adjust to match the valley slopes. It is difficult for streams to attain a new equilibrium where the placement of roads and other infrastructure has resulted in little or no valley space for the stream to access or to create a floodplain.

Channel equilibrium can be assessed by looking at the regimes of sediment transport within the watershed. The analysis of sediment regimes at the watershed scale is useful for summarizing the stressors affecting the equilibrium condition of river channels. Sediment regime mapping provides a context for understanding the sediment transport and channel evolution processes which govern changes in geometry and planform for river channels in a state of disequilibrium.

In terms of the channel evolution model, the upper Jewett Brook main stem (upstream of the Route 3 & 11 crossing) and the most upstream reach on the major tributary (M02T1.02) is predominately at stage I of the “F-stage” channel evolution model. This means these reaches have not undergone a channel incision process, and generally the sediment transport capacity is equilibrium with the sediment load.

In contrast, many of the lower segments on the main stem and the major tributary have undergone historic degradation. These channels are either in stage F-II or F-III of the "F-stage" channel evolution model. Segments that have been heavily armored and extensively straightened (M01, M02-A, M02T1.01-B, M02T1.01-C and M02T1.01-D) have lost access to the floodplain as a result of channel incision or floodplain build up. These segments have remained in stage F-II because the armoring has prevented the channel from widening. Stream power is increased within the channel due to the increased slope and loss of floodplain access. Two of the segments (M03-A and M02T1.01-A) are in stage F-III. These segments are still entrenched and are widening and migrating laterally through bank erosion caused by the increased stream power.

One segment within the Jewett Brook study area (M02-B) falls into the "D-stage" evolution model, where the more dominant active adjustment process is aggradation. This build up of sediment leads to channel widening and planform adjustment. In the D-IId stage, the channel becomes extremely depositional and may even be braided under low flow conditions. The channel width narrows through aggradation as bar features develop. Transverse (diagonal bars) may be common. In segment M02-B, the channel is not incised. The high number of diagonal bars and steep riffles indicate the segment is aggradational and the large number of flood chutes reflects planform adjustment. Reach M02-B is currently acting as an important attenuation reach for sediment and flood flows.

6.0 HABITAT CONDITION

Table 4 below shows a comparison of the habitat condition based on the Rapid Habitat Assessment (RHA) and the geomorphic condition based on the Rapid Geomorphic Assessment (RGA). The stream condition is determined using the scores on the RGA and RHA field forms, and is defined in terms of departure from the reference condition. There are four categories to describe the condition (reference, good, fair and poor). These ratings are defined below.

- Reference – no departure
- Good – minor departure
- Fair – major departure
- Poor – severe departure

A summary of the rapid habitat assessment values for each reach/segment is included on page 2 of Appendix A. For six of the 13 assessed segments, both the habitat score and the geomorphic score resulted in a "fair" rating. Two segments (M04-B and M02T1.02) had a rating of "good" for both habitat and geomorphic condition. A few of the segments that were extensively channelized (M01 and M02T1.01-B) had a poor habitat condition, but a fair geomorphic condition. Many of the segments that had been straightened or had floodplain alterations lacked a strong riffle-pool bedform and the diversity of habitat features that this brings. Numerous segments had major intrusion into their river corridor from roads, and many segments had inadequate riparian buffers due to historic and /or recent land clearing. Overall, the habitat score was similar to the geomorphic score, implying that the ecological health of Jewett Brook is closely related to the geomorphic condition of the stream.

Table 4. Comparison of Habitat and Geomorphic Condition
Jewett Brook and Major Tributary

Segment Number	Habitat Score	Geomorphic Score	Habitat Condition	Geomorphic Condition
M01	0.33	0.56	Poor	Fair
M02-A	0.42	0.60	Fair	Fair
M02-B	0.64	0.48	Fair	Fair
M03-A	0.52	0.56	Fair	Fair
M03-B	0.59	0.83	Fair	Good
M04-A	0.55	0.75	Fair	Good
M04-B	0.65	0.78	Good	Good
M05	0.61	0.68	Fair	Good
M02T1.01-A	0.59	0.39	Fair	Fair
M02T1.01-B	0.18	0.55	Poor	Fair
M02T1.01-C	0.42	0.55	Fair	Fair
M02T1.01-D	0.41	0.64	Fair	Fair
M02T1.02	0.83	0.81	Good	Good

7.0 BRIDGE AND CULVERT ASSESSMENT RESULTS

A total of 24 stream crossings (one arch, eight bridges and fifteen culverts) within the Jewett Brook watershed were evaluated using the Vermont bridge and culvert assessment protocol. The geomorphic compatibility and AOP screening tools, photographs and Phase 2 constriction notes were used to prioritize structures for replacement/retrofit. A detailed summary of each crossing with photographs of the inlet, outlet and channel upstream and downstream of the structure is provided in Appendix B.

Table 5 summarizes the data collected for the assessed structures within the Phase 2 study reach. The final column of Table 5 includes a prioritization of structures for replacement or retrofit based on three criteria: structure width in relation to bankfull channel width, aquatic organism passage (AOP) and geomorphic compatibility, and notes from the Phase 2 study. One of three priorities for replacement was assigned (low, moderate or high). The following criteria explain the priority level assigned to each structure:

> **High Priority**: Structures with spans of approximately 50 percent of the bankfull width or less, which are significantly impeding natural sediment transport. In general, culverts that have a geomorphic compatibility rating of fully incompatible or mostly incompatible are given a high priority. Culverts that are impeding the passage of aquatic organisms

are automatically placed in the high priority category (e.g. free fall outlet) unless the habitat value in the vicinity of the structure is lacking.

Moderate Priority: Structures with spans less than 50 percent that are not causing significant geomorphic instability and structures with spans greater than 50 percent that are causing instability. Culverts that are resulting in reduced aquatic organism passage (e.g. do not have material throughout the structure or have a cascade outfall) result in at least moderate priority.

Low Priority: Stream crossing structures that are not included in either of the two categories above.

A total of 12 structures were identified as high priority for replacement. Seven of the high priority structures are culverts with no aquatic organism passage including adult salmonids. Of these seven structures, four of the culverts were partially compatible and three were mostly incompatible. One of the high priority culverts (Sawmill Road) are mostly incompatible with reduced AOP. The Swain Road, Bypass #2 and Rout 3 & 11 crossings did not meet the criteria of high priority above, but were placed in the high priority category because of the poor condition of the structures. The Davis Street and Mill Building is the only non-culvert crossing identified as high priority. DuBois and King, Inc. is working on solutions for sediment transport and flooding in this area as part of hydraulic and Hydraulic analysis.

Table 5
Jewett Brook
Evaluation using Vermont Geomorphic Compatibility and AOP Screening Tools

Stream Name	Reach/ Segment Number	Road Name	Structure Type	Percent Bankfull Channel Width[1,2]	Aquatic Organism Passage (AOP)	Geomorphic Compatibility	Phase 2 Notes	Priority for Replacement or Retrofit
Jewett Brook	M01	Trail Below Davis Street	Bridge	93	NA	NA	Upstream alignment is poor; water hits the wing wall	Low
	M01	Davis Street and Mill Building	Bridge	86	NA	NA	Sediment transport and flooding problem	High
	M01	Union Avenue	Bridge	66	NA	NA	Deposition above and below bridge	Low
	M01	Pedestrian crossing above Union Avenue	Bridge	47	NA	NA	Encroachments limit increasing span	Low
	M01	Highland Street	Bridge	90	NA	NA	Structure looks new and in good condition	Low
	M01	Pedestrian crossing at private home	Bridge	84	NA	NA	Bridge is not a floodprone constriction	Low
	M02-A	Pedestrian crossing at Tardiff Park	Bridge	76	NA	NA	Bridge is minimally impacting channel	Low
	M03-A	Hounsell Avenue	Arch	97	NA	NA	Structure is causing localized geomorphic instability as a result of poor alignment. Low priority assigned because structure appears new and is not a fish passage barrier	Low
	M03-A	Route 3 & 11	Culvert	53	No AOP including adult salmonids	Mostly Incompatible	Culvert is perched 2.3; retrofit would be difficult given significant perch	High
	M04-A	Country Club Road	Twin Culverts	41	No AOP including adult salmonids	Mostly Incompatible	Water depth is culverts is shallow	High

Table 5
Jewett Brook
Evaluation using Vermont Geomorphic Compatibility and AOP Screening Tools

Stream Name	Reach/ Segment Number	Road Name	Structure Type	Percent Bankfull Channel Width[1,2]	Aquatic Organism Passage (AOP)	Geomorphic Compatibility	Phase 2 Notes	Priority for Replacement or Retrofit
	M05	Swain Road	Culvert	26	Reduced AOP	Partially Compatible	Structure in poor condition and reducing AOP	Moderate
Unnamed Tributary to Jewett Brook In Gilford	M02T1.01-A	Hounsell Avenue	Culvert	26	No AOP Including Adult Salmonids	Partially Compatible	Culvert in good condition – consider retrofit. Water depth in culvert is shallow. Culvert has perch of 0.2 feet and is free fall.	High
	M02T1.01-A	Trail at Private House	Bridge	101	NA	NA	Sharp bend appears to be contributing to deposition	Low
	M02T1.01-B	Bypass #2	Culvert	52	Reduced AOP	Partially Compatible	Culvert is at grade, but in poor condition. Water depth in culvert is shallow and velocity is fast relative to stream channel	High
	M02T1.01-B	Route 3 and 11	Culvert	58	Reduced AOP	Partially Compatible	Culvert in poor condition and is rusted out on bottom near inlet.	High
	M02T1.01-B	Bypass #1	Culvert	57	No AOP Including Adult Salmonids	Partially Compatible	Culvert is free fall and perch is 0.3 feet. Water depth in culvert is shallow.	High
	M02T1.01-B	Sawmill Road	Culvert	52	Reduced AOP	Mostly Incompatible	Outlet is cascade with estimated drop of two feet.	High
	M02T1.01-D	Maple Street	Culvert	32	No AOP Including Adult Salmonids	Mostly Incompatible	Culvert outlet invert is freefall and perch is 0.3 feet. Consider retrofit options if culvert cannot be replaced.	High
	M02T1.01-D	Wesley Road	Culvert	37	No AOP Including Adult Salmonids	Partially Compatible	Culvert outlet invert is freefall and has a perch of 0.9 feet. Culvert is in poor condition.	High
	M02T1.02	Snowmobile Trail	Bridge	110	NA	NA	Minor scour associated with bridge	Low

Table 5
Jewett Brook
Evaluation using Vermont Geomorphic Compatibility and AOP Screening Tools

Stream Name	Reach/ Segment Number	Road Name	Structure Type	Percent Bankfull Channel Width[1,2]	Aquatic Organism Passage (AOP)	Geomorphic Compatibility	Phase 2 Notes	Priority for Replacement or Retrofit
Unnamed Tributary to Jewett Brook in Laconia	M01S1.01	Cresent Street	Culvert	36	No AOP Including Adult Salmonids	Partially Compatible	No water in structure. Stream is intermittent and has limited habitat value.	Moderate
	M01S1.01	Gilford Avenue	Culvert	54	Full AOP	Partially Compatible	Gravel substrate throughout structure. Culvert is at grade.	Low
	M01S1.01	Gilman Street	Culvert	24	Reduced AOP	Fully Incompatible	Culvert outlet is at grade, no material in structure. Stream is intermittent and has limited habitat value.	Moderate
Unnamed Tributary to Jewett Brook (Liberty Hill Road Brook)	M04T2.01	Liberty Hill Road	Culvert	28	No AOP Including Adult Salmonids	Partially Compatible	Culvert outlet is free fall with 0.25 foot perch.	High

[1]Shaded for bankfull width percentage less than 50%, [2]Percent bankfull width based on New Hampshire Hydraulic Geometry Curve; NA – not applicable

8.0 PRELIMINARY PROJECT IDENTIFICATION AND PRIORITIZATION

The stream reaches evaluated in this study present a variety of planning and management strategies which can be classified under one of the following categories: Active Geomorphic Restoration, Passive Geomorphic Restoration, and Conservation.

Active Geomorphic Restoration implies the management of rivers to a state of geomorphic equilibrium through active, physical alteration of the channel and/or floodplain. Often this approach involves the removal or reduction of human constructed constraints or the construction of meanders, floodplains or stable banks. Active riparian buffer revegetation and long-term protection of a river corridor is essential to this alternative.

Passive Geomorphic Restoration allows rivers to return to a state of geomorphic equilibrium by removing factors adversely impacting the river and subsequently using the river's own energy and watershed inputs to re-establish its meanders, floodplains and equilibrium conditions. In many cases, passive restoration projects may require varying degrees of active measures to achieve the ideal results. Active riparian buffer revegetation and long-term protection of a river corridor is also essential to this alternative.

Conservation is an option to consider when stream conditions are generally good and nearing a state of dynamic equilibrium. Typically, conservation is applied to minimally disturbed stream reaches where river structure and function and vegetation associations are relatively intact.

8.1 Watershed-Level Opportunities

There are a number of watershed-level opportunities available to improve the geomorphic stability and water quality of the Jewett Brook watershed. Watershed opportunities include the development and adoption of fluvial erosion hazard zones, improved stormwater treatment, and community stream clean-up activities.

FLUVIAL EROSION HAZARD ZONES

The purpose of defining Fluvial Erosion Hazard Zones is to prevent increases in man-made conflicts that can result from development in identified fluvial erosion hazard areas; minimize property loss and damage due to fluvial erosion; and prohibit land uses and development in fluvial erosion hazard areas that pose a danger to health and safety. The basis of a Fluvial Erosion Hazard Zone is a defined river corridor which includes the course of a river and its adjacent lands. The width of the corridor is defined by the lateral extent of the river meanders, called the meander belt width, which is governed by valley landforms, surficial geology, and the length and slope requirements of the river channel. The width of the corridor is also governed by the stream type and sensitivity of the stream. River corridors, as defined by the Vermont Agency of Natural Resources (2008b), are intended to provide landowners, land use planners, and river managers with a meander belt width which would accommodate the meanders and slope of a balanced or equilibrium channel, which when achieved, would serve to maximize channel stability and minimize fluvial erosion hazards. Information collected during the Phase 2 Assessment including reach sensitivity, reach condition, and stream type is used to develop these zones. Towns have the opportunity to work with the New Hampshire Department of Environmental Services (NHDES) to develop fluvial erosion hazard zones to reduce conflicts within the river corridor. Additional information regarding Fluvial Erosion Hazard Zones is available on the NHDES website (http://des.nh.gov/organization/commissioner/pip/factsheets/geo/documents/geo-10.pdf) in the Environmental Fact Sheet (New Hampshire Department of Environmental Services, 2010a; and in Chapter 2.9 of the Innovative Land Use Planning and Techniques Handbook: New Hampshire Department of Environmental Services, 2010b).

STORMWATER

Stormwater runoff rates are of particular concern in urbanized and agricultural watersheds because stormwater runs off from impervious surfaces rather than naturally infiltrating the soil. The cumulative effect of the increased frequency, volume, and rate of stormwater runoff results in increases in wash-off pollutant loading to streams and destabilization of stream channels. Stormwater improvement projects to increase baseflow and decrease peak flow are recommended for the Jewett Brook watershed.

STREAM CLEAN-UP

Discarded tires and other trash were common in stream channels within the Jewett Brook watershed. A significant number of tires were observed even in the upper reaches of the main stem (Figure 8.1). Towns and community groups have the opportunity to sponsor stream cleanup days to remove trash from Jewett Brook and tributaries. This cleanup effort improves water quality and offers a connection between local citizens and the stream that runs through their community.

Figure 8.1 Tire in Reach M05

8.2 Reach-Level Opportunities

A description of each reach/segment is provided in this section along with general recommendations for restoration and protection strategies. The reaches are listed from downstream to upstream. The reaches are broken into sections based on the stream they are located in: Jewett Brook main stem and Tributary to Jewett Brook.

Jewett Brook Main Stem

Reach M01

The most downstream reach of Jewett Brook (M01) starts about 500 feet upstream of the Highland Street crossing and goes downstream approximately 2,750 feet to Opechee Bay. The mouth of Jewett Brook flows through an urban setting. Reach M01 has been extensively straightened and armored and the floodplain has been filled by parking lots and other encroachments. This has led to increased stream power and channel incision. There is approximately 1600 feet of armoring along each bank. Encroachments, such as buildings, parking lots, and roads, have caused a human change in valley with but no change from the reference valley type of very broad.

There are six stream crossings in M01, which contribute to channel and floodprone constrictions. The crossings include: a pedestrian crossing at Victoria Woods Senior Center, Davis Street and Mill Building, Union Avenue, pedestrian crossing at Union Street, Highland Street, and a pedestrian crossing at a private home. The Davis Street Bridge and a former Mill Building were previously identified by the Town of Laconia as a flooding and sediment transport issue. This crossing/location has been given a high priority rating for a potential project. (Project #1 and #2 on page 1 of Appendix C).

Multiple stormwater inputs were mapped within Reach M01. A project to minimize stormwater runoff and increase infiltration (Project #3 on Page 1 of Appendix C) is recommended to reduce peak flows and improve water quality of Jewett Brook. A stormwater ditch (Figure 8.2) has eroded to create a gully that enters Jewett Brook from the north downstream of Highland Street. The remediation of this gully and improved stormwater management are recommended (Project #6 on Page 1 of Appendix C) to reduce the amount of sediment reaching Jewett Brook.

The rock wall banks of Jewett Brook near the TD Bank North Parking lot is deteriorating in places (Figure 8.3). An alternatives analysis is recommended (Project #4 on Page 1 of Appendix C) for removing, replacing or repairing the bank. Over 80 percent of each bank has buffers that are less than 25 feet in width. Near bank vegetation and vegetation within the buffer is dominated by herbaceous plants, such as grass. In many locations the buffer is narrow or lacking due to the close proximity of development. Buffers less than 25 feet are common in backyards that abut Jewett Brook, such as the yard shown in Figure 8.4, which is located downstream of Highland Street.

Figure 8.2. Gully erosion on north bank downstream of Highland Street

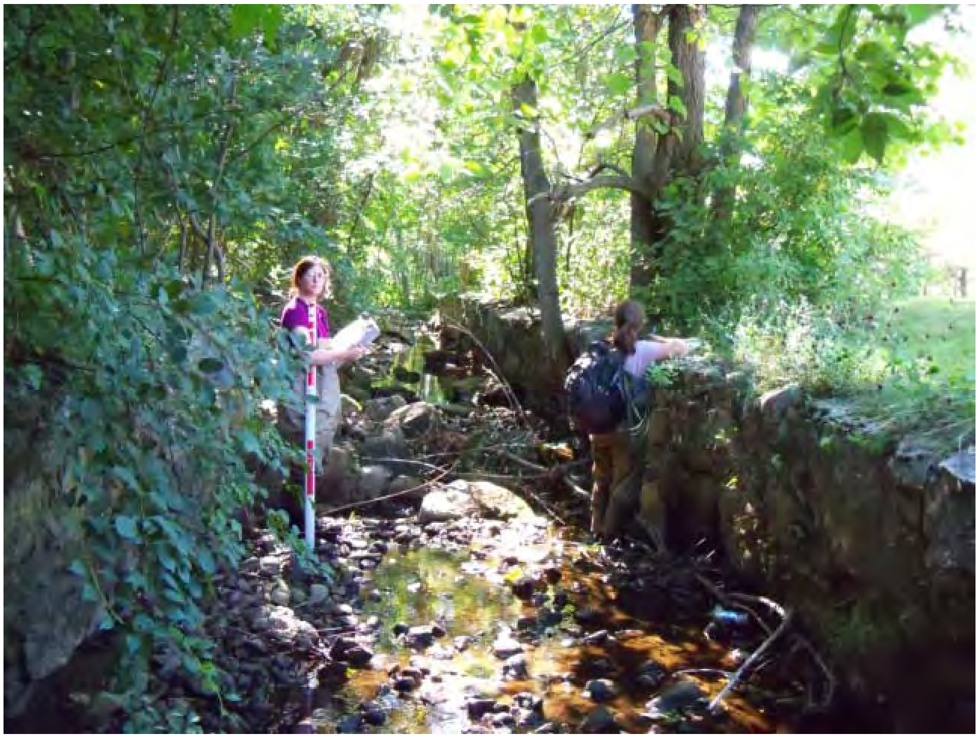

Figure 8.3. Rock wall (armored banks) near TD Bank North Parking Lot

Floodplain access (i.e. incision) is variable within the reach. The yard shown in Figure 8.4 has good floodplain access. It is recommended that locations with good floodplain access and no existing encroachments within the river corridor be protected to provide flood and sediment attenuation within the reach through the adoption of fluvial erosion hazard (FEH) zones or corridor easements (Project #7 on Page 1 of Appendix C). Floodplain access is poor in other sections of this reach, such as at the top of the reach (Figure 8.5). A cross section was measured between Highland Street and Union Street that represents an average reach condition for incision. The incision ratio of the cross section (1.43) reflects Jewett Brook in M01 being moderately incised.

Figure 8.4. Buffer less than 25 feet and good floodplain access downstream of Highland Street

Figure 8.5. Incised channel with poor floodplain access at top of reach M01

The rapid geomorphic assessment scored in the "fair" category due to the major historic degradation, major aggradation, and minor widening and planform adjustment. In many locations, the channel is in Stage F-II of the channel evolution model, reflecting the channel has incised, but has not yet widened. Bank revetments are preventing the channel from widening along much of the reach, thereby preventing the channel from moving into Stage F-III.

Reach M01 is a "C" cobble dominated segment with a weak riffle-pool bedform. There is a deviation from the reference bedform of riffle-pool to planebed in some locations because of the extensive straightening. The rapid habitat assessment (RHA) rated in the "poor" category due to the lack of large woody debris and large pools, the straightened and incised channel morhphology, hydrologic characteristics, lack of refuge areas, extensive bank revetments and developed riparian corridor.

Dense algae were noted along much of the reach. Reach M01 would benefit from a landowner education program to better manage yard waste, such as grass clippings (Figure 8.6), pet waste, etc. (Project #5 on Page 1 of Appendix C). The landowner education program could also provide landowners information regarding the benefits of riparian buffers. Riparian buffers provide many benefits. Some of these benefits are protecting and enhancing water quality, providing fish and wildlife habitat, providing streamside shading, and providing root structure to prevent bank erosion.

Figure 8.6. Grass clippings on the stream bank are contributing to nutrient enrichment in Reach M01.

Reach M02

Reach M02 was divided into two segments based on the channel evolution stage and land use. The most downstream segment, M02-A is a 1,590 foot reach that has the downstream reach break about 500 feet upstream of Highland Street. Development is prevalent within the corridor of M02-A. The stream type is a gravel dominated "C" channel that has under major historic incision. The stream channel has been extensively straightened, and deviates from the reference riffle-pool bedform to planebed in some locations. Segment M02-B starts about 500 feet downstream of the Laconia/Gilford town line and extends upstream to the Hounsell Avenue crossing and the confluence of a major tributary to Jewett Brook (M02T1). In contract to M02-A, segment M02-B has no corridor encroachments with the exception of Hounsell Avenue, which crosses into the corridor near the upstream end of the reach.

The close proximity of Jewett Brook to development in segment M02-A has resulted in narrow buffers along the stream channel. Approximately ninety-five percent of the north bank and forty-five percent of the south bank have buffers less than 25 feet in width. There may be opportunity to increase the size of the buffer in some locations without compromising land use. One possible planting site is Tardiff Park where buffers are less than 25 feet along both banks (Figures 8.7 and 8.8). The public visibility of the Tardiff Park site would make a good demonstration project for improving riparian buffers along Jewett Brook (Project #1 on Page 2 of Appendix C). The pedestrian bridge at Tardiff Park is the only stream crossing within segment M02-A.

Figure 8.7. Narrow buffer on south bank at Tardiff Park

Figure 8.8. Lack of buffer on north bank at Tardiff Park

Upstream of Tardiff Park, grass clippings were in the channel and along the bank. A major algal bloom was observed (Figure 8.9). Similar to Reach M01, segment M02-A would benefit from a landowner education program that targets improving the water quality of Jewett Brook (Project #2 on Page 2 of Appendix C). Nutrient (phosphorus) loading to Jewett Brook could be reduced by disposing of grass clippings and pet waste properly. Grass clippings could be composted or left on the grass as a natural fertilizer. Pesticides and fertilizer should be used sparingly adjacent to the brook, and riparian buffers are recommended to filter stormwater, provide shade and stabilize the soil on the banks. In the vicinity of Brook Street and Paul Avenue, there is significant bank erosion and the rock riprap along the bank has deteriorated (Figure 8.10). Project #3 (Page 2 of Appendix C) has been recommended to evaluate solutions for addressing this erosion. There are a number of stormwater inputs in segment M02-A, and improved stormwater management is suggested as Project #4 (Page 4 of Appendix C).

Figure 8.9. Algal bloom upstream of Tardiff Park

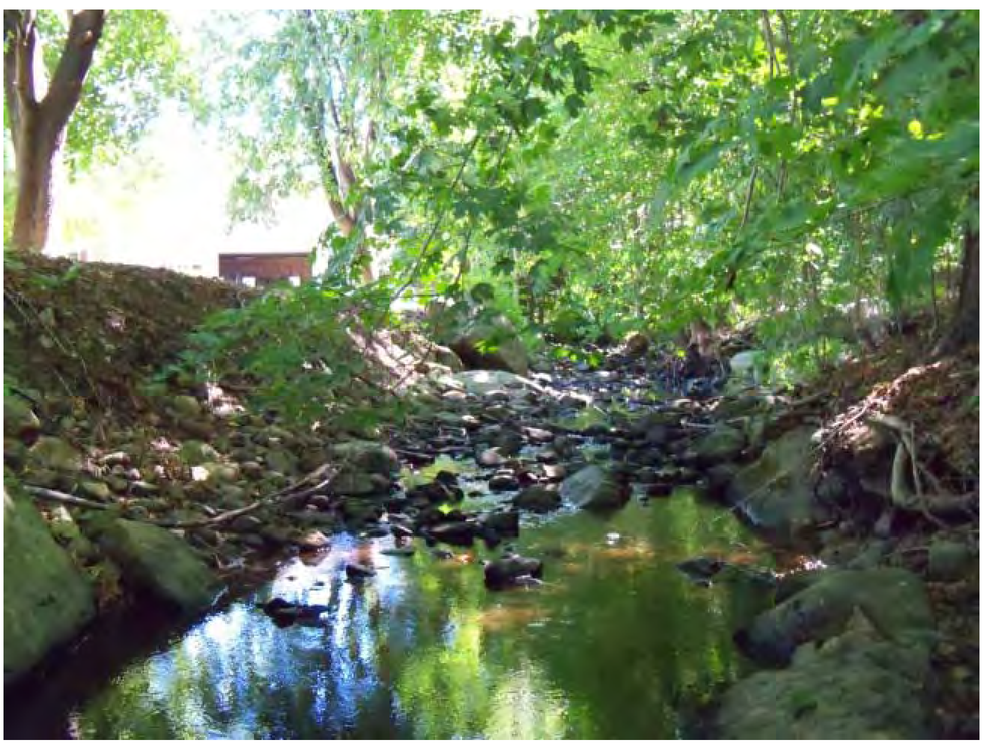

Figure 8.10. Bank erosion and failed riprap in the vicinity of Paul Avenue and Brook Street (see Project #3)

The RGA scored as "fair" in M02-A. Channel alteration (straightening) has led to major historic incision and minor aggradation, widening and planform adjustment. In many locations, the bank armoring (rock riprap and rock walls) are preventing the channel from widening. In other locations, the armoring is failing and the banks are eroding, causing some channel widening. The RHA also scored "fair" in segment M02-A. The channel lacks deep pools and a high quality riparian buffer. Japanese knotweed, an invasive, is present on the bank. Filamentous algae and silt coat the substrate. Minnows were present in the channel.

Segment M02-B is a gravel dominated channel that is not incised. Numerous side bars, diagonal bars, and steep riffles indicate aggradation is a major process in the segment (Figure 8.11). Bank erosion is moderate (about 40 percent of each bank is eroded) and the high width to depth ratio of 32 suggests the channel has widened. Multiple flood chutes provide evidence of major planform adjustment. Segment M02-B has high quality buffers and the good floodplain access makes M02-B a valuable section for attenuation of flood flows and sediment storage. Conservation easements are recommended to protect the corridor and this important attenuation asset (Project #5 on Page 2 of Appendix C).

The habitat scored at the high end of the "fair" category. Many of the habitat parameters including: woody debris cover, bed substrate cover, scour and deposition features, river banks and riparian area scored in the good range. The high width to depth ratio and the high percentage of exposed substrate contributed to lowering the habitat score. There were many pools within segment M02-B; however, most were less than two feet in depth. There were no areas with buffers less than 25 feet and the dominant buffers were 76-100 feet and >200 feet on the south and north sides, respectively. In general, river corridor development was absent. Purple loosestrife, an invasive plant, is present in the northern corridor.

Figure 8.11. Segment M02-B is an important attenuation reach. A large diagonal bar is shown upstream of a pool. This section of channel has a high quality wooded corridor and excellent floodplain access.

Reach M03

The Hounsell Avenue crossing is at the reach break between M02 and M03. Reach M03 was segmented to account for differences in channel dimensions and substrate. The lower segment, M03-A, is 1,377 feet in length and is bounded by Hounsell Avenue and Route 3 & 11. Segment M03-B starts above the Route 3 & 11 crossings and extends upstream 755 feet to about 200 feet below Country Club Road. The existing and reference stream type for both segments M03-A and M03-B is a Rosgen “C” channel with a “b” subslope. The upper segment is more entrenched and has dominant substrate that is cobble rather than gravel.

Segment M03-A has a riffle-pool bedform with sedimented (i.e., diagonal) riffles. A mass failure about 12 feet high and 50 feet long is located approximately 750 feet downstream of the outlet of the Route 3 & 11 culvert (Figure 8.12). Active planform adjustment, as evidenced by flood chutes, is occurring downstream of the Route 3 & 11 crossing (Figure 8.13). Bank erosion was noted to be moderate. The bank erosion and planform adjustment may be attributed to impacts from this significantly undersized structure. Although the structure is in good to fair condition, a culvert replacement project is recommended to provide improved sediment transport (Project #3 on page 3 of Appendix C). A significant iron seep is located in the vicinity of the Route 3 & 11 structure (Figure 8.14). If the culvert is replaced, consideration should be given to remediate this active iron seep, which enters from the north side of the channel (Project #2 on page 3 of Appendix C). Iron precipitate often occurs in areas where the soil has been disturbed. This can result in a decrease in available food and habitat for aquatic insects.

Figure 8.12. Mass failure 12 feet high by 50 feet long in M03-A

Figure 8.13. Typical channel with flood chutes in M03-A downstream of Route 3 & 11 culvert. Segment M03-A has relatively good floodplain access.

Figure 8.14. Swale entering below Route 3 & 11 crossing with iron precipitate

The RGA resulted in a "fair" score due to the minor historic incision, minor widening and major aggradation and planform adjustment. A significant human-caused change in valley width and historic channel straightening has occurred as a result of the installation of the Route 3 & 11 culvert. Multiple unvegetated bars (Figure 8.15) at the head of bendways are leading to steep riffles and flood chutes. High side bars were observed upstream of the arch at Hounsell Avenue. This abundant sediment deposition is a sign that major aggradation is occurring within segment M03-A. A conservation easement or the adoption of FEH zones to protect the flood and attenuation assets in M03-A is recommended (Project #1 on page 3 of Appendix C).

Figure 8.15. Debris jam and high depositional side bar in M03-A

M03-A was difficult to assess because flow conditions at the time of the assessment were low and very little water was in the channel (Figure 8.16). Consistent with the geomorphic condition rating, the habitat condition also scored "fair". Most of the habitat parameters scored in the good (minor) or fair (major) range. Hydrologic characteristics scored in the poor (severe) category because exposed substrate was greater than 60 percent and runoff characteristics are completely altered due to stormwater influence. The number of pools per mile fell in the good category; however, pool cover for fish was only fair. Most of the pools were shallow with the exception of the large scour pool located below the outlet of the Route 3 & 11 culvert.

Figure 8.16. High percentage of exposed substrate in Segment M03-A

M03-B was also difficult to assess because of the extreme low flow conditions. The RGA resulted in a segment condition of "good" for Segment M03-B. The channel is not incised and has good floodplain access in this location (Figure 8.17). Minor aggradation was observed in the form of steep riffles and diagonal bars. Many of the habitat parameters scored in the good category; however, the overall habitat condition is "fair". Hydrologic characteristics scored fair because of the high percentage of exposed substrate. The north riparian area and woody debris cover also scored in the fair category. The north riparian corridor has been cut adjacent to a landscaping business resulting in a narrow buffer in some locations.

Figure 8.17. Channel with good floodplain access in Segment M03-B.

M04

Reach M04 was divided into two segments to account for a change in slope. The most downstream segment, M04-A, begins about 200 feet west of the County Club Road crossing and extends upstream about 2,200 feet. M04-B is 1,400 feet in length and the upper end of the segment ends at the confluence with an unnamed tributary to Jewett Brook (M04T2). Both segments have existing and reference stream types that are Rosgen "C" channels with "b" subslopes. The lower segment, M04-A, is steeper than M04-B.

M04-A is gravel dominated and has a dominant bedform of step-pool. The bedform is planebed in areas where the slope is lower. The Country Club Road crossing is the only road crossing within segment M04-A. The twin culverts at Country Club Road are mostly incompatible in terms of geomorphic stability and were flagged as no aquatic organism passage including adult salmonids using the Vermont AOP screening tool. The structure is significantly undersized and is recommended for replacement (Project # 1 on Page 4 of Appendix C). An old rock wall, at the upstream end of M04-A is another channel constriction that is causing localized geomorphic incompatibility (Figure 8.18). The rock wall may be a remnant structure from a former mill, where streamflow was once diverted. An island has formed in this location and there are flood chutes downstream of the rock wall indicating major planform adjustment. An alternatives analysis is recommended to evaluate the planform issues at the former mill site and determine if it makes sense to remove the rock wall and a berm located downstream of the rock wall (Project #2 on Page 4 of Appendix C).

Figure 8.18. An old Rock wall has caused geomorphic instability within segment M04-A. The rock wall may be a remnant structure from an old mill site.

Other than the localized geomorphic instability caused by remnant structures from what may have been an old mill site, segment M04-A generally is in "good" geomorphic condition. The cross section measurement provides evidence that the channel is not incised. The rapid habitat condition was "fair". Similar to reach M03, reach M04 was difficult to assess because of the extreme low flows at the time of the assessment. Although the quality of the river banks and riparian area was good (e.g., wide buffers, minor bank erosion, and minimal corridor encroachments), M04-A had a high percentage of exposed substrate and lacked pools and undercut banks to support fish under low flow conditions. Three mass failures, which are contributing sediment to the channel, were mapped within the segment.

Monitoring wells were noted in segment M04-A adjacent to Jewett Brook. These wells are likely associated with monitoring of coal tar contamination in the vicinity of Lower Liberty Hill Road. Based on a media release dated October 8, 2010, the New Hampshire Department of Environmental Conservation has issued a preliminary decision to require EnergyNorth Natural Gas, Inc. d/b/a National Grid to complete removal of all coal tar impacted soils. The clean-up plan submitted by National Grid in 2007 proposed eighty percent removal of site contamination. A final decision will be issued by the DES following a public meeting and a 30-day public comment period (NHDES, 2010c).

Segment M04-B was also given a rating of "good" for geomorphic condition. The banks are generally stable and there is good floodplain access (Figure 8.19). Minor aggradation and planform adjustment are occurring within the segment. The overall physical habitat condition is also "good". River banks and riparian area scored in the good to reference range. Similar to M04-A, segment M04-B lacked deep pools and had a high percentage of exposed substrate under low flow conditions. There are a number of places adjacent to Liberty Hill Road where stormwater runoff is entering the channel. Project #3 (Page 4 of Appendix C) has been included to improve stormwater treatment within the segment.

Figure 8.19. High quality banks and riparian corridor in Segment M04-B

M05

The upper most reach on Jewett Brook to receive a full Phase 2 assessment is M05. Reach M05 starts at the confluence of an unnamed tributary to Jewett Brook (M04T2) and is 3,740 feet in length. The upper end of reach M05 is about 500 feet upstream of the Swain Road crossing in Gilford, and is adjacent to the wetland in reach M06. The channel at the top of the reach is sand dominated (Figure 8.20). The channel transitions to a gravel dominated, braided channel about 250 feet above Swain Road (Figure 8.21). Dense moss coats the substrate and the width to depth ratio of the bankfull channel is high. The channel appears to be fed by wetland seeps.

The Swain Road box culvert is a significant channel constriction within Reach M05. The reference channel width at that location is about 16 feet and the width of the box culvert is only 4 feet. The replacement of the box culvert has been identified as a possible project (Project #2 on Page 5 of Appendix C) to improve geomorphic stability and aquatic organism passage. A large scour pool has been created downstream of the box culvert. Numerous tadpoles were present in the channel below the crossing. Minnows, such as black nose dace, were also observed in this section of the brook.

Figure 8.20. Sand dominated channel at top of Reach M05

Figure 8.21. Gravel dominated channel with high width to depth ratio and dense moss above Swain Road crossing

Below the Swain Road crossing the stream type changes to a Rosgen "C" channel with a "b" subslope. At the time of the assessment on August 18, 2010, there was not much water in the channel. Flow picked up along the reach, yet riffles were shallow (less than 0.1 feet in depth) even at the downstream end. With the exception of the scour poor below Swain Road, pool depths were less than 2 feet.

As shown in Figure 8.22, an incised tributary (swale) enters Jewett Brook from the west side about 300 feet downstream of Swain Road. It is recommended that the source of this incision be investigated and possible remediation measures be developed to reduce sediment entering Jewett Brook (Project # 3 on Page 5 of Appendix C). Bank erosion mapped in the field indicates Reach M05 has moderate erosion (about 25 percent of the banks are eroded). This erosion may have been overestimated due to lack of water in the channel. Much of the mapped erosion was at the upper end of the reach below Swain Road. In some locations there was dense moss cover along the banks (Figure 8.23).

Figure 8.22. An incised tributary (swale) enters Jewett Brook from the west about 300 feet below Swain Road

Based on the Phase 2 assessment, the geomorphic condition of reach M05 is "good". Two cross sections were measured in M05 to confirm the existing stream type of "Cb". Both cross sections indicate the channel is slightly incised (incision ratios of 1.17 and 1.19). A representative cross section location is shown below in Figure 8.24. Reach M05 is undergoing minor widening, aggradation and planform change. The planform change was mostly attributed to debris jams that are blocking all or part of the channel. This large woody debris is also helping to form pools (Figure 8.25) that provide suitable water depths for fish and amphibians.

Figure 8.23. Dense moss cover on stable bank about 1100 feet below Swain Road

Figure 8.24. Typical channel in Reach M05

Figure 8.25. Root wad creating small pool

The habitat condition scored at the high end of the "fair" range. The lack of water in the channel greatly impacted the habitat condition. While pools per mile were frequent, very few pools provided deep habitat (over 2 feet in depth). There were few bank undercuts due to shallow water and exposed substrate was estimated to be ninety percent. The riparian area was close to reference condition, with wide buffers (greater than 150 feet), diverse native vegetation to provide canopy cover and the absence of river corridor development (Figure 8.26).

Figure 8.26. High quality buffer and riparian zone in reach M05

M06

Reach M06, the uppermost reach on Jewett Brook, did not receive a full Phase 2 assessment because it is a wetland. The wetland is included in the National Wetland Inventory GIS layer. A beaver dam (Figures 8.27 and 8.28) was at the reach break between M05 and M06 at the time of the Phase 2 assessment.

Figure 8.28. Upper extent of impact of beaver dam impoundment. Dominant tree species are white pine and maples

Figure 8.27. Beaver dam on reach break between M05 and M06

Major Tributary to Jewett Brook

Reach M02T1.01

Reach M02T1.01 begins at the confluence with Jewett Brook and was divided into five segments primarily based on channel dimensions and bank and buffer conditions. In stream culverts for road and development infrastructure are common within the reach. With the exception of the most downstream and upstream segments, the reach has been extensively altered and straightened. The middle segments (M02T1.01-B, M02T1.01-C and M02T1.01-D) were most likely wetlands which were filled, dredged and channelized. This alteration was for development and to route drainage along Gilford Avenue through numerous culvert crossings including Route 3 & 11. The river corridor is encroached by Gilford Avenue for ninety percent of its length. All assessed segments in M02T1.01 resulted in “fair” condition for both the RGA and RHA except for segment M02T1.01-B, which had a habitat condition of “poor”.

M02T1.01-A is a 1,025 foot long gravel dominated “E” channel that has undergone major historic incision which has led to major widening, aggradation, and planform adjustment. Steep riffles and diagonal bars are common showing evidence of major aggradation. The aggradation (Figure 8.29) is primarily due to sediment transport from altered segments upstream. Bank erosion of about 30 percent on the south bank and 50 percent on the north bank indicates major widening, High quality buffers are present on both sides, e.g., greater than 200 feet on the south side and greater than 150 feet on the north side. A conservation easement and/or the adoption of fluvial erosion hazard zones is recommended to provide continued flood and sediment attenuation within M02T1.01-A (Project # 1 on Page 6 of Appendix C). Flood and sediment attenuation is important to prevent further transport of sediment to Jewett Brook. The only stream crossing is a culvert at Hounsell Avenue which has been given a high priority for replacement. The RHA score of “fair” in segment M02T1.01-A was primarily due to reduced quality of hydrologic characteristics and major bank erosion.

Segment M02T1.01-B begins at the Route 3 & 11 western bypass and continues 1,512 feet to upstream of Sawmill Road where the banks and buffers become vegetated with shrubs/saplings. The culvert lengths make up forty percent of the segment length (Figure 8.30). The culvert crossings include: Western Bypass for Route 3& 11, Route 3 & 11, Eastern Bypass for Route 3 & 11, and Sawmill Road. All of these culverts are recommended for replacement (Project #s 2 through 5 on Page 6 of Appendix C). Due to the culverts and channel alteration, the natural channel conditions have been considerably altered from a sediment attenuation system to a transport system.

Figure 8.29. Large depositional feature in M02T1.01-A caused by upstream sediment transport

Figure 8.30. Long culvert in M02T1.01-B

Historic incision is extreme in M02T1.01-B with an incision ratio of 4.0 and a stream type departure from a “C” to an “E”. The extensive channel alteration has led to a planebed channel bedform and has contributed to the “poor” habitat condition. Except for bed substrate cover, all habitat parameters scored in the “poor” category for segment M02T1.01-B leading to its “poor” condition. Buffers are less than 25 feet on both sides for approximately seventy percent of the segment. Bank armoring is also prevalent within segment B. The channel evolution stage remains in Stage F-II reflecting the channel has incised, but has not yet widened. Boundary resistance from the culverts and bank armoring is preventing the channel from widening and progressing to Stage F-III.

Segment M02T1.01-C is 673 feet long and begins upstream of Sawmill Road where banks and buffers become vegetated with shrubs and saplings (Figure 8.31). Due to the channel alteration, the stream has undergone extreme historic incision resulting in a stream type departure from a “C” to a “B” stream and the bedform is primarily plane bed. Numerous stormwater inputs from Gilford Avenue have created depositional features within segment M02T1.01-C. It is recommended that stormwater improvements be made along Gilford Avenue to reduce sediment and stormwater input to M02T1.01-C (Project #6 on Page 6 of Appendix C). Segment M02T1.01-C’s “fair” habitat condition was a result of a lack of large woody debris, channel incision and alteration, and degraded riparian area.

The last assessed segment in reach M02T1.01, M02T1.01-D, is 1,163 feet long and less incised (ratio of 1.4) than its downstream segments. All geomorphic processes are minor in segment M02T1.01-D. The stream type is a gravel dominated “E” channel that was previously a wetland which has since been filled in (Figure 8.32). There are two in stream culverts located at Maple Street and Wesley Road crossings, which have been given a high priority for replacement (Projects #7 and #8 on Page 6 of Appendix C). The lack of woody debris, poor substrate cover, and the altered riparian area has led to the “fair” habitat condition in segment M02T1.01-D. The most upstream segment, M02T1.01-E, is a 333 foot long wetland segment that could not be assessed using the Phase 2 protocol (Figure 8.33).

Figure 8.31. Typical channel of Segment M02T1.01-C

Figure 8.32. Channelized stream in previous wetland of M02T1.01-D

Figure 8.33. Wetland in Segment M02T1.01-E

Reach M02T1.02

Reach M02T1.02 is 653 feet long and is a wetland channel that primarily contains herbaceous vegetation in both its buffers and near its banks (Figure 8.34). In contrast to the downstream reach, it has not been straightened and is not incised. The stream type is a gravel dominated "E" channel. Channel aggradation and planform adjustment are minor and incision and widening were scored in the reference range. Therefore, the RGA was scored as "good". The RHA was also scored as "good" due to the high quality habitat conditions especially substrate cover and channel morphology. Since M02T1.02 has not incised, it is in Stage F-I of the channel evolution model.

Figure 8.34. Wetland channel in Segment M02T1.02

8.3 Site Level Opportunities

Site specific projects were identified using the criteria outlined by the VANR in Chapter 6 – Preliminary Identification and Prioritization (Vermont Agency of Natural Resources 2010). This planning guide is intended to aid in the development of projects that protect and restore river equilibrium. Project maps (Appendix C) have been developed for the Jewett Brook watershed. These maps were created using indexed data from the Phase 1 and Phase 2 Stream Geomorphic Assessments along with existing data available from the New Hampshire Geographically Referenced Analysis and Information Transfer System (GRANIT). A total of three projects were identified to promote the restoration or protection of channel stability and aquatic habitat in the Jewett Brook watershed. The projects are broken down by category as follows: 3 conservation easements, 4 passive restoration (streamside plantings, river corridor protection, landowner education and outreach, i.e. yard waste input reduction, streamside planting, and buffer improvement projects); 4 stormwater improvement projects; 19 active restoration (12 bridge or culvert replacement or retrofit projects, one floodplain and sediment transport improvement project, two armoring deterioration projects, one gully remediation project, one iron seep remediation project, one berm removal/planform restoration project, and one project to investigate and remediate an incised tributary). Information from the Phase 2 stream geomorphic assessment and bridge and culvert assessments could be used to inform the Towns of Gilford and Laconia of which stream crossings are contributing to localized instability. The projects include:

Reach M01 – Jewett Brook Mainstem

- **Active Restoration** by replacing undersized bridge at Davis Street & Mill Building (Project #1 - Page 1 of Appendix C);
- **Active Restoration** by improving floodplain and sediment transport at Mill Building (Project #2);
- **Active Restoration** by managing stormwater coming off of adjacent parking lots and roads (Project #3);
- **Active Restoration** by evaluating solutions for deterioration of rock wall along stream banks (Project #4);
- **Passive Restoration** with landowner education and outreach to promote streamside plantings and reduction of yard waste disposal on banks such as grass clippings (Project #5);
- **Active Restoration** by remediation of incised gully (Project #6);
- **Passive Restoration** through river corridor protection to improve flood and sediment attenuation (Project #7).

Reach M02 – Jewett Brook Mainstem

- **Passive Restoration** with streamside plantings at Tardiff Park (Project #1 – Page 2 of Appendix C);

- **Passive Restoration** with landowner education and outreach to promote streamside plantings and reduction of yard waste disposal on banks such as grass clippings (Project #2);
- **Active Restoration** by evaluating and implementing solutions for deterioration of riprap armoring and erosion along stream banks (Project #3);
- **Active Restoration** by managing stormwater runoff from nearby roads (Project #4);
- **Conservation** easement to prevent further development that would reduce flood and sediment attenuation capacity (Project #5).

Reach M03 – Jewett Brook Mainstem

- **Conservation** easement to prevent further development that would reduce flood and sediment attenuation capacity (Project #1 – Page 3 of Appendix C);
- **Active Restoration** by remediation of iron seep entering stream through stormwater input (Project #2);
- **Active Restoration** by replacing undersized and perched culvert at Route 3 & 11 (Project #3);

Reach M04 – Jewett Brook Mainstem

- **Active Restoration** by replacing significantly undersized culvert at Country Club Road (Project #1 - Page 4 of Appendix C);
- **Active Restoration** through addressing planform adjustment issues caused by old mill site and possible berm removal (Project #2);
- **Active Restoration** by managing stormwater runoff from Liberty Hill Road (Project #3);

M04T2.01 (Unnamed tributary to Jewett Brook)

- **Active Restoration** by replacing significantly undersized culvert at Liberty Hill Road (Project #1 – Page 5 of Appendix C);

Reach M05 – Jewett Brook Mainstem

- **Active Restoration** by replacing significantly undersized culvert at Swain Road (Project #2 – Page 5 of Appendix C);
- **Active Restoration** by investigating incised tributary (swale) and determining remediation measures to arrest incision (Project #3).

Major Tributary to Jewett Brook (M02T1)

- **Active Restoration** by replacing significantly undersized culvert at Hounsell Avenue (Project #1 – Page 6 of Appendix C);
- **Conservation** easement to prevent further development that would reduce flood and sediment attenuation capacity (Project #2);

- **Active Restoration** by replacing undersized culvert at western Bypass for Route 3 & 11 (Project #3);
- **Active Restoration** by replacing undersized culvert at Route 3 & 11 (Project #4);
- **Active Restoration** by replacing undersized culvert at eastern Bypass for Route 3 & 11 (Project #5);
- **Active Restoration** by replacing undersized culvert at Sawmill Road (Project #6);
- **Active Restoration** by managing stormwater coming off of Gilford Avenue (Project #7);
- **Active Restoration** by replacing significantly undersized culvert at Maple Street (Project #8);
- **Active Restoration** by replacing significantly undersized culvert at Wesley Road (Project #9).

9.0 Next Steps

There are many opportunities to restore Jewett Brook and its tributaries to a stable condition. Preliminary reach level and site level projects have been identified in this plan and will form the bases for the development of a watershed plan. These preliminary projects include: river corridor protection, conservation easements, streamside plantings, retrofit and/or replacement of stream crossings, berm (rock wall removal), iron seep remediation, and improved stormwater treatment, and homeowner education and outreach. On the watershed level, the development and implementation of fluvial erosion hazard zones is recommended to avoid conflicts regarding land use and to save money spent on flood damage and river maintenance. The Towns of Laconia and Gilford could pursue the opportunity to work with the New Hampshire Department of Environmental Services to develop fluvial erosion hazard zones for the land surrounding the Jewett Brook mainstem and tributaries.

10.0 LIST OF ACRONYMS AND GLOSSARY OF TERMS

List of Acronyms

AOP – aquatic organism passage
BCE – Bear Creek Environmental, LLC
FEH – Fluvial Erosion Hazard Zone
GIS – Geographic Information System
GRANIT- New Hampshire Geographically Referenced Analysis and Information Transfer System
NHDES - New Hampshire Department of Environmental Services
NWI – National Wetlands Inventory
QA/QC – quality assurance/quality control
RHA- Rapid Habitat Assessment
RGA-Rapid Geomorphic Assessment
SGA – Stream Geomorphic Assessment
SGAT – Stream Geomorphic Assessment Tool
USGS – United States Geological Survey
VTDEC – Vermont Department of Environmental Conservation

Glossary of Terms

Adapted from:
Restoration Terms, by Craig Fischenich, February, 2000, USAE Research and Development Center, Environmental Laboratory, 3909 Halls Ferry Rd., Vicksburg, MS 39180
And
Vermont Stream Geomorphic Assessment Handbook, Appendix Q, 2009, VT Agency of Natural Resources, Waterbury, VT. http://www.vtwaterquality.org/rivers/docs/assessmenthandbooks/rv_apxqglossary.pdf

Adjustment process – type of change that is underway due to natural causes or human activity that has or will result in a change to the valley, floodplain, and/or channel condition (e.g., vertical, lateral, or channel plan form adjustment processes).

Aggradation - A progressive buildup or raising of the channel bed and floodplain due to sediment deposition. The geologic process by which streambeds are raised in elevation and floodplains are formed. Aggradation indicates that the stream discharge and/or bed load characteristics are changing. Opposite of degradation.

Alluvial fan – A fan-shaped accumulation of alluvium (alluvial soils) deposited at the mouth of a ravine or at the juncture of a tributary stream with the main stem where there is an abrupt change in slope.

Alluvial soils – Soil deposits from rivers.

Alluvium – A general term for detrital deposits made by streams on riverbeds, floodplains, and alluvial fans.

Avulsion – A change in channel course that occurs when a stream suddenly breaks through its banks, typically bisecting an overextended meander arc.

Bank Stability – The ability of a streambank to counteract erosion or gravity forces.

Bankfull channel depth - The maximum depth of a channel within a riffle segment when flowing at a bankfull discharge.

Bankfull channel width - The top surface width of a stream channel when flowing at a bankfull discharge.

Bankfull discharge - The stream discharge corresponding to the water stage that overtops the natural banks. This flow occurs, on average, about once every 1 to 2 years and given its frequency and magnitude is responsible for the shaping of most stream or river channels.

Bar – An accumulation of alluvium (usually gravel or sand) caused by a decrease in sediment transport capacity on the inside of meander bends or in the center of an over wide channel.

Berms – Mounds of dirt, earth, gravel or other fill built parallel to the stream banks designed to keep flood flows from entering the adjacent floodplain.

Cascade – River bed form where the channel is very steep with narrow confinement. There are often large boulders and bedrock with waterfalls.

Channelization – The process of changing (usually straightening) the natural path of a waterway.

Culvert – A buried pipe that allows flows to pass under a road.

Degradation – (1) A progressive lowering of the channel bed due to scour. Degradation is an indicator that the stream's discharge and/or sediment load is changing. The opposite of aggradation. (2) A decrease in value for a designated use.

Delta bar – A deposit of sediment where a tributary enters the mainstem of a river.

Depositional features – Types of sediment deposition and storage areas in a channel (e.g. mid-channel bars, point bars, side bars, diagonal bars, delta bars, and islands).

Diagonal Bar – Type of depositional feature perpendicular to the bank that is formed from excess sedimentation and within the channel and from the development of steep riffles.

Drainage Basin – The total area of land from which water drains into a specific river.

Dredging – Removing material (usually sediments) from wetlands or waterways, usually to make them deeper or wider.

Erosion – Wearing away of rock or soil by the gradual detachment of soil or rock fragments by water, wind, ice, and other mechanical, chemical, or biological forces.

Floodplain – Land built of sediment that is regularly covered with water as a result of the flooding of a nearby stream.

Gaging Station – A particular site in a stream, lake, reservoir, etc., where hydrologic data are obtained.

Grade control - A fixed feature on the streambed that controls the bed elevation at that point, effectively fixing the bed elevation from potential incision; typically bedrock, dams or culverts.

Gradient – Vertical drop per unit of horizontal distance.

Habitat – The local environment in which organisms normally grow and live.

Headwater – Referring to the source of a stream or river.

Head cut – Sudden change in elevation or knickpoint at the leading edge of a gully

Incised River – A river that erodes its channel by the process of degradation to a lower base level than existed previously or is consistent with the current hydrology.

Islands – Mid-channel bars that are above the average water level and have established woody vegetation.

Lacustrine soils- Soil deposits from lakes.

Meander - The winding of a stream channel, usually in an erodible alluvial valley. A series of sine-generated curves characterized by curved flow and alternating banks and shoals.

Meander migration – The change of course or movement of a channel. The movement of a channel over time is natural in most alluvial systems. The rate of movement may be increased if the stream is out of balance with its watershed inputs.

Meander belt width – The horizontal distance between the opposite outside banks of fully developed meanders determined by extending two lines (one on each side of the channel) parallel to the valley from the lateral extent of each meander bend along both sides of the channel.

Meander wavelength - The lineal distance downvalley between two corresponding points of successive meanders of the same phase.

Meander wavelength ratio – The meander wavelength divided by the bankfull channel width.

Meander width ratio – The meander belt width divided by the bankfull channel width.

Mid-channel bar – Sediment deposits (bar) located in the channel away from the banks, generally found in areas where the channel runs straight. Mid-channel bars caused by recent channel instability are unvegetated.

Planform - The channel shape as if observed from the air. Changes in planform often involve shifts in large amount of sediment, bank erosion, or the migration of the channel.

Plane bed – Channel lacks discrete bed features (such as pools, riffles, and point bars) and may have long stretches of featureless bed.

Point bar –The convex side of a meander bend that is built up due to sediment deposition.

Pool -- A habitat feature (section of stream) that is characterized by deep, low-velocity water and a smooth surface.

Reach - Section of river with similar characteristics such as slope, confinement (valley width), and tributary influence.

Restoration – The return of an ecosystem to a close approximation of its condition prior to disturbance.

Riffle - A habitat feature (section of stream) that is characterized by shallow, fast-moving water broken by the presence of rocks and boulders.

Riffle-pool - Channel has undulating bed that defines a sequence of riffles, runs, pools, and point bars. Occurs in moderate to low gradient and moderately sinuous channels, generally in unconfined valleys with well-established floodplains.

Riparian Buffer – The width of naturally vegetated land adjacent to the stream between the top of the bank and the edge of other land uses. A buffer is largely undisturbed and consists of the trees, shrubs, groundcover plants, duff layer, and naturally uneven ground surface.

Riparian Corridor – Lands defined by the lateral extent of a stream's meanders necessary to maintain a stable stream dimension, pattern, profile and sediment regime.

Segment – A relatively homogeneous section of stream contained within a reach that has the same reference stream characteristics but is distinct from other segments in the reach.

Sensitivity – The valley, floodplain and/or channel condition's likelihood to change due to natural causes and/or anticipated human activity.

Side bar – Unvegetated sediment deposits located along the margins or the channel in locations other than the inside of channel meander bends.

Step-pool – Characterized by longitudinal steps formed by large particles (boulder/cobbles) organized into discrete channel-spanning accumulations that separate pools, which contain smaller sized materials. Often associated with steep channels in confined valleys.

Steep riflle – Associated with aggradation where sediment has dropped out to form a steep face of sediment on the downstream side.

Surficial sediment/geology – Sediment that lies on top of bedrock.

Tributary – A stream that flows into another stream, river, or lake.

Urban runoff – Storm water from city streets and gutters that usually carries a great deal of litter and organic and bacterial wastes into the receiving waters.

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