

Phase 1 Geomorphic Assessment of the Walloomsac River Watershed in Southwestern Vermont

Conducted in 2005 by

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I. EXECUTIVE SUMMARY

In 2005, the Bennington County Conservation District and the Hoosic River Watershed Association conducted a Phase 1 Geomorphic Assessment of thirty-nine reaches in the Walloomsac River watershed in southwestern Vermont.

Much of the watershed has been highly altered by human activities, and this assessment quantifies many of those alterations. (Because they are what is consequential in terms of future management actions in the watershed, this report focuses on those human-induced impacts.)

- Twenty-nine reaches received a “high” impact rating due to urban land uses in the stream corridor.
- Three reaches were rated “high” impact due to bank armoring.
- Twenty-one reaches received a “high” impact rating due to straightening.
- One reach received a “high” impact rating due to a history of commercial dredging, and three other reaches rated “high” due to dredging in general (most often in response to flood events).
- Fourteen reaches were rated “high” impact due to restrictions of the floodplain caused by berms and roads.
- Ten reaches received a project reach condition score of “poor” and nineteen a project reach condition score of “fair.”

II: PROJECT OVERVIEW

Introduction

Physical features such as channel slope, width, depth and planform are essentially responses to the water and sediments a watercourse must transport. In natural systems, these geomorphic features are in a dynamic balance with sediment supply and water volume and velocity. Where systems have been disturbed, rivers are likely to be “in adjustment” – evolving toward a new, sustainable dynamic equilibrium between profile, dimension, and pattern on the one hand and watershed inputs of water and sediment on the other.

Empirical studies of rivers worldwide have enabled river scientists to characterize rivers in dynamic equilibrium according to their geomorphic features. We know, for example, that, in nature, a northeastern valley bottom stream typically occupies a wide, gently sloping valley; that the channel is a good deal wider than deep, and that sinuosity is moderate. In nature, a northeastern headwaters stream is usually steep, deeply entrenched, and often exhibits numerous cascades. For the river researcher, a red flag is raised where any feature of a stream departs in an important way from what would be typical of a watercourse in that landscape setting. Assessments of physical features of rivers are useful because, by uncovering and describing these departures, they can help us understand how and why a watercourse is changing, and guide us in managing for those changes.

Goals and objectives

In 2005, the Bennington County Conservation District and the Hoosic River Watershed Association conducted a geomorphic assessment of the Walloomsac River watershed in

Bennington County, Vermont. The purpose of the project was to lay a foundation for future targeted field investigation of the causes of instability in the watershed and, eventually, for the design and implementation of their “cures.” The long term objective was to reduce instability and its impacts on natural and cultural resources.

The results, summarized in this report, describe the sort of rivers typical of the watershed’s geologic setting, and red-flag departures from the typical reach by reach. The assessment made use of the April 2005 Vermont Agency of Natural Resources (ANR) Vermont Stream Geomorphic Assessment Phase 1 Handbook (ANR 2005 SGA Phase 1) and the Stream Geomorphic Assessment Tool software developed for the ANR. More information on the protocols and SGAT can be found at

http://www.anr.state.vt.us/dec/waterq/rivers/htm/rv_geoassesspro.htm Study findings were uploaded to the agency’s web-based Data Management System (DMS) and are available for public review at <https://anrnode.anr.state.vt.us/ssl/sga/security/frmLogin.cfm>.

III. PROJECT AREA AND FLUVIAL GEOMORPHIC SETTING

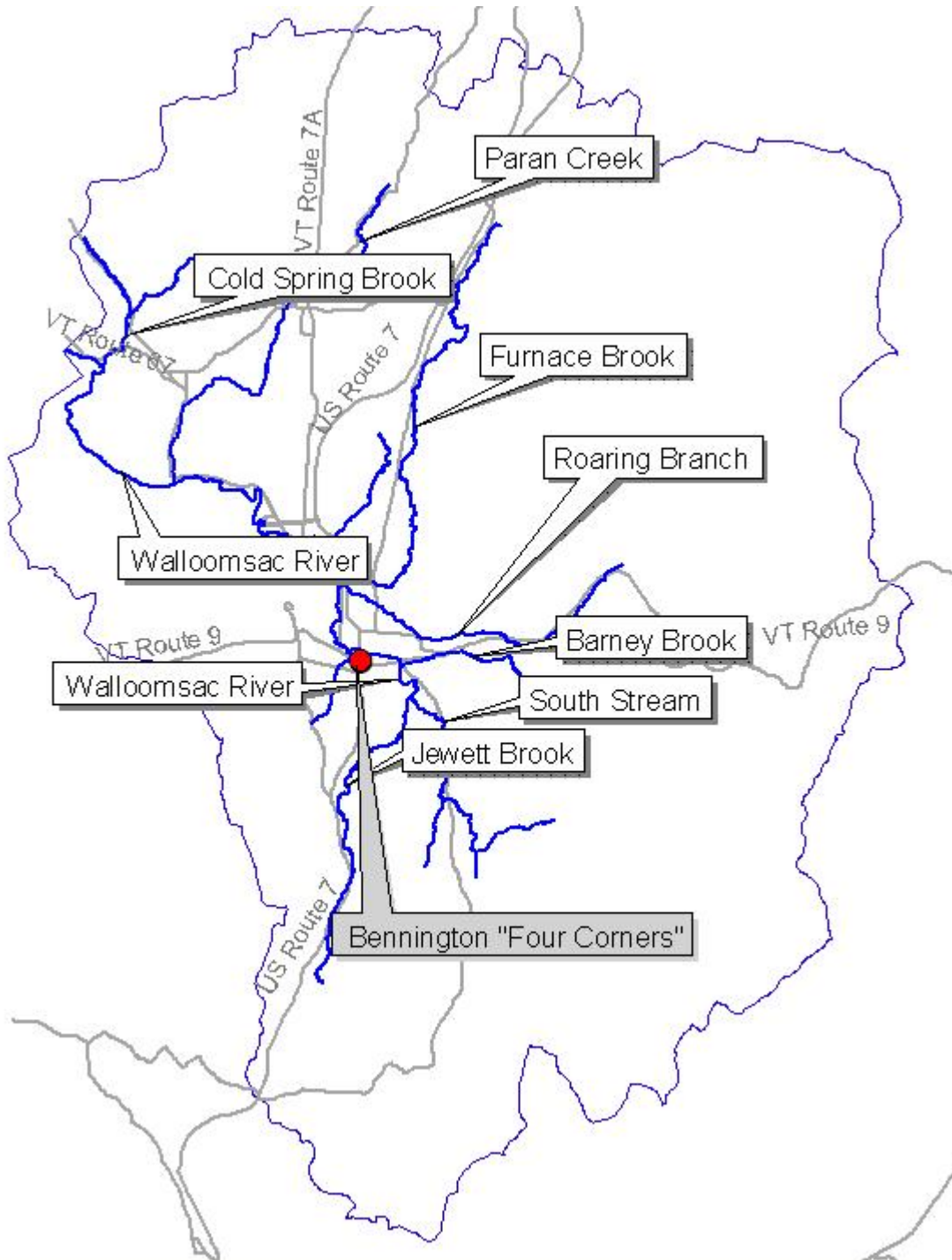
The Vermont portion of the Walloomsac watershed occupies an area of about 130 square miles in the towns of Pownal, Woodford, and Bennington, Vermont. The Walloomsac discharges to the Hoosic River in the town of Hoosick, NY. The Hoosic discharges to the Hudson River in Schaghticoke, NY. The Hoosic River and the Batten Kill watersheds are the only watersheds in Vermont which drain to the Hudson River.

Thirty-nine reaches on the Walloomsac River, the Roaring Branch, Barney Brook, Cold Spring Brook, Furnace Brook, Jewett Brook, Paran Creek, South Stream and five unnamed tributaries were assessed.

Much of the watershed in the town of Bennington occupies an alluvial fan. Alluvial fans form where a steep stream valley opens upon a flatter, broader landform. Watercourses flow upon alluvial fans in an incorrigibly random fashion, moving here and there as the somewhat unconsolidated sediments beneath them are also moved. As a result, braided streams are common hydrologic features of alluvial fans. Portions of Barney Brook, the Walloomsac River, Furnace Brook, and Roaring Branch lie on the alluvial fan and represent old braids or are today braided themselves.

Since at least the mid-1800s, these watercourses have at times of flood transported huge and devastating volumes of water and sediment to the urbanized village center. Again and again, the community acted in response. Parts of the Walloomsac were ripped or enclosed within walls. The Roaring Branch was bermed, walled, and as recently as the late 1980s, dredged. Despite and to some extent because of the activities of the Town of Bennington, the US Army Corps of Engineers, the US Soil Conservation Service, the Vermont Department of Environmental Conservation, and others over decades, the Roaring Branch particularly remains a threat to public safety and investment. In addition to clarifying the effects of a wide variety of human activities on the community’s watercourses, this Phase 1 assessment lays a foundation for a better understanding of that threat.

Map 1 illustrates the study area.



Map 1. Walloomsac River Watershed Study Area

IV. METHODOLOGY

The Phase 1 assessment of the Walloomsac watershed used the November 2003 version

of the SGAT Arcview extension, which helps automate much of the data collection and creation, the NHD Reach Indexing Tool, and the April 2005 version of the Vermont Stream Geomorphic Assessment Phase 1 Handbook. Orthophotography was flown in 2001. Study findings were uploaded to the agency’s web-based Data Management System (DMS) and are available for public review at <https://anrnode.anr.state.vt.us/ssl/sga/security/frmLogin.cfm>.

V. ASSESSMENT RESULTS

A. Pre-intervention: the reference condition

Phase 1 stream geomorphic assessments begin by describing a watercourse’s reference condition, that is, the kind of stream it most likely would have been absent human intervention. The following table illustrates the stream typing scheme used by the VT ANR (ANR 2005 SGA Phase 1, p. 28).

Table 1. Stream Typing Chart

Reference stream type	Confinement (Valley type)	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 2.0-4.0%	Step-pool
B	Confined, semi-confined, or narrow	Mod. – Steep 2.0-3.0%	Plane Bed
C or E	Unconfined	Mod. –Gentle <2.0%	Riffle-pool or Dune-ripple
D	Unconfined	Mod.-Gentle <4.0%	Braided Channel

The thirty-nine reaches were found to have the following stream types.

Table 2. Study Area Reach Types

Reach number	Watercourse name	Stream type
MO1S1.01	Cold Spring Brook	C Riffle-pool
MO1S1.01S1.01	Cold Spring Brook trib	C Riffle-pool
MO1S1.02	Cold Spring Brook	C Riffle-pool
M02	Walloomsac River	C Riffle-pool
MO2T1.01	Paran Ck.	C Riffle-pool
MO2T1.03	Paran Ck.	C Riffle-pool
MO2T1.04	Paran Ck.	C Riffle-pool
MO2T1.05	Paran Ck.	C Riffle-pool
MO3	Walloomsac River	C Riffle-pool
MO4	Walloomsac River	C Riffle-pool
M05	Walloomsac River	E Riffle-pool
M05T2.01	Furnace Creek	C Riffle-pool
M05T2.01S1.01	Furnace Creek trib	C Riffle-pool
M05T2.02	Furnace Creek	D Braided
M05T2.03	Furnace Creek	C Riffle-pool
M05T2.04	Furnace Creek	C Riffle-pool
M05T2.05	Furnace Creek	C Riffle-pool

M06	Walloomsac River	D Braided
M06T3.01	Roaring Branch	D Braided
M06T3.02	Roaring Branch	D Braided
M06T3.03	Roaring Branch	C Riffle-pool
M06T3.04	Roaring Branch	C Riffle-pool
M07	Walloomsac River	D Braided
M07S2.01	Walloomsac trib	C Riffle-pool
M08	Walloomsac River	D Braided
M08S1.01	Barney Brook	C Riffle-pool
M09	Walloomsac River	C Riffle-pool
M09T4.01	Jewett Brook	C Riffle-pool
M09T4.02	Jewett Brook	C Riffle-pool
M09T4.03	Jewett Brook	C Riffle-pool
M09T4.04	Jewett Brook	C Riffle-pool
M09T5.01	South Stream	C Riffle-pool
M09T5.02	South Stream	C Riffle-pool
M09T5.03	South Stream	C Riffle-pool
M09T5.03S1.01	South Stream trib	C Riffle-pool
M09T5.03S1.02	South Stream trib	C Riffle-pool
M09T5.04	South Stream	C Riffle-pool
M09T5.05	South Stream	C Riffle-pool
M09T5.05S1.01	South Stream trib	A

Table 2 continued

B. Post-intervention: human-induced impacts – in the watershed or stream corridor, and in the stream

The concept of dynamic equilibrium acknowledges the primacy of change in watercourses over time. Streams free of human intervention erode their banks, cut off bends, move laterally in response to new obstructions, grow deeper in one location and shallower in others, and otherwise move up and down and from side to side within their valley walls.

Although such change sometimes can be dramatic and nearly instantaneous, human intervention usually leads to comparatively greater instability (that is, more change) and generally more violent change within a watercourse. Degraded natural resources and drained public coffers can result. Vermont ANR’s Phase 1 assessments collect information on anthropogenic alterations in the watershed and in or along the stream itself which might cause atypical instability in stream profile, dimension, or pattern. Such human-induced changes uncovered in the Walloomsac watershed assessment include:

Land uses (Step 4 of the Phase 1 SGA)

- Intensive agriculture or urban development in the watershed or stream corridor
- Reduction in the width of the naturally occurring riparian buffer

Instream modifications (Step 5 of the Phase 1 SGA)

- Bridges and culverts
- Bank armoring
- Channel straightening
- Channel dredging or gravel mining

Floodplain modifications (Step 6 of the Phase 1 SGA)

- Berms and roads
- Intensive agriculture or urban development in the stream corridor

B1: Riparian land uses: forests, agricultural lands, urban areas

Land use and land cover in the stream corridor and in the riparian zone are indicators of watercourse stability and resiliency for a number of reasons. Forested corridors and buffer zones are more likely than urbanized or agricultural lands to capture precipitation. Storm-induced flows in forested streams are smaller in volume and slower in velocity – and therefore less powerful – than non-forested watercourses. Water that doesn’t quickly infiltrate the soil moves more slowly over the ground in forested landscapes compared to non-forested ground because of the friction provided by downed logs and limbs, leaf litter and other large and small organic particles. And stream banks on which trees and shrubs are growing are secured by plant roots; they are less likely to erode than unvegetated banks.

Using land use/land cover data derived from LANDSAT imagery created in the early 1990s, the Walloomsac watershed Phase 1 study looked at land uses within each reach’s stream corridor – that area inside the valley walls needed by a particular watercourse of a certain type to secure dynamic equilibrium. (In the land use/land cover GIS layer, lands of at least two acres in size as pictured in the satellite images are classified as wetland, forest, shrub, field, crop, residential, commercial, industrial or several other more specific classes.) Watercourses in forested corridors are at minimum risk of land use-induced instability. Residential, commercial, and other urban uses pose the greatest risk to stream stability – a risk so significant that the Phase 1 study considers urban land uses of 10% or more of the corridor to have a high impact. The following table summarizes land use impacts within corridors on the study reaches according to this 10% threshold.

Table 3. Urbanization in reach corridors

Total number reaches	39
Number of reaches with predominantly urban land uses	11
Number of reaches with at least 10% or “high” impact: urban land uses	29

The Phase 1 study also looked more closely at the riparian zone itself. Using orthophotography from April 2001, the study determined the width of the vegetated buffer along each reach. Table 4 summarizes predominant vegetated buffer widths on each bank..

Table 4. Buffer Widths

Stream Name	Predominant buffer width, left and right bank	
	Left bank	Right bank
Cold Spring Brook	>100	>100
Trib to Cold Spring Brook	>100	>100
Paran Creek	>100	>100
Furnace Creek	>100	>100
Trib to Furnace Creek	>100	>100

Roaring Branch	>100	51-100
Trib to Walloomsac River	0-25	0-25
Barney Brook	0-25	>100
Jewett Brook	>100	>100
South Stream	>100	>100
Downstream trib to South Stream	>100	>100
Upstream trib to South Stream	>100	>100
Walloomsac River	>100	0-25

Table 4 continued

B2: Channel Modifications

Phase 1 assessments of instream channel modifications look at five elements: flow regulation; the number and length of bridges and culverts; bank armoring, channel straightening; and dredging history.

a) Flow regulation

Five study reaches retain evidence of earlier industrial uses of the river in dams and weirs. Though most of the dams on Paran Creek and the dam on the Walloomsac at Paper Mill Village are substantial, the Phase 1 study couldn't gather information on defunct water intake structures, nor on sediment deposition behind the dams. (These are the factors the Phase 1 protocols use to gauge impacts created by dams.) Impacts due to these flow regulations are therefore, at this time, designated "unknown."

b) Bridges and culverts

Twenty-nine of the 39 reaches are clearly bridged and/or culverted. The lengths of such modifications as recorded by the study team are short enough, however, to be ranked as "low impact." This data might benefit from revisiting: team members learned in subsequent studies that they had been underestimating the length of areas affected by bridge crossings.

c) Bank armoring

Like many other Vermont communities, Bennington has suffered repeatedly from floods. In response, in the late 19th century and first half of the 20th century, the town erected flood walls and berms in some locations. Some of these features were rebuilt or expanded in the second half of the last century by the US Army Corps of Engineers, or by other federal and state agencies. Those reaches – much of the Roaring Branch and the Walloomsac in the heart of Bennington – are ranked "high impact" because of bank armoring.

d) Channel straightening

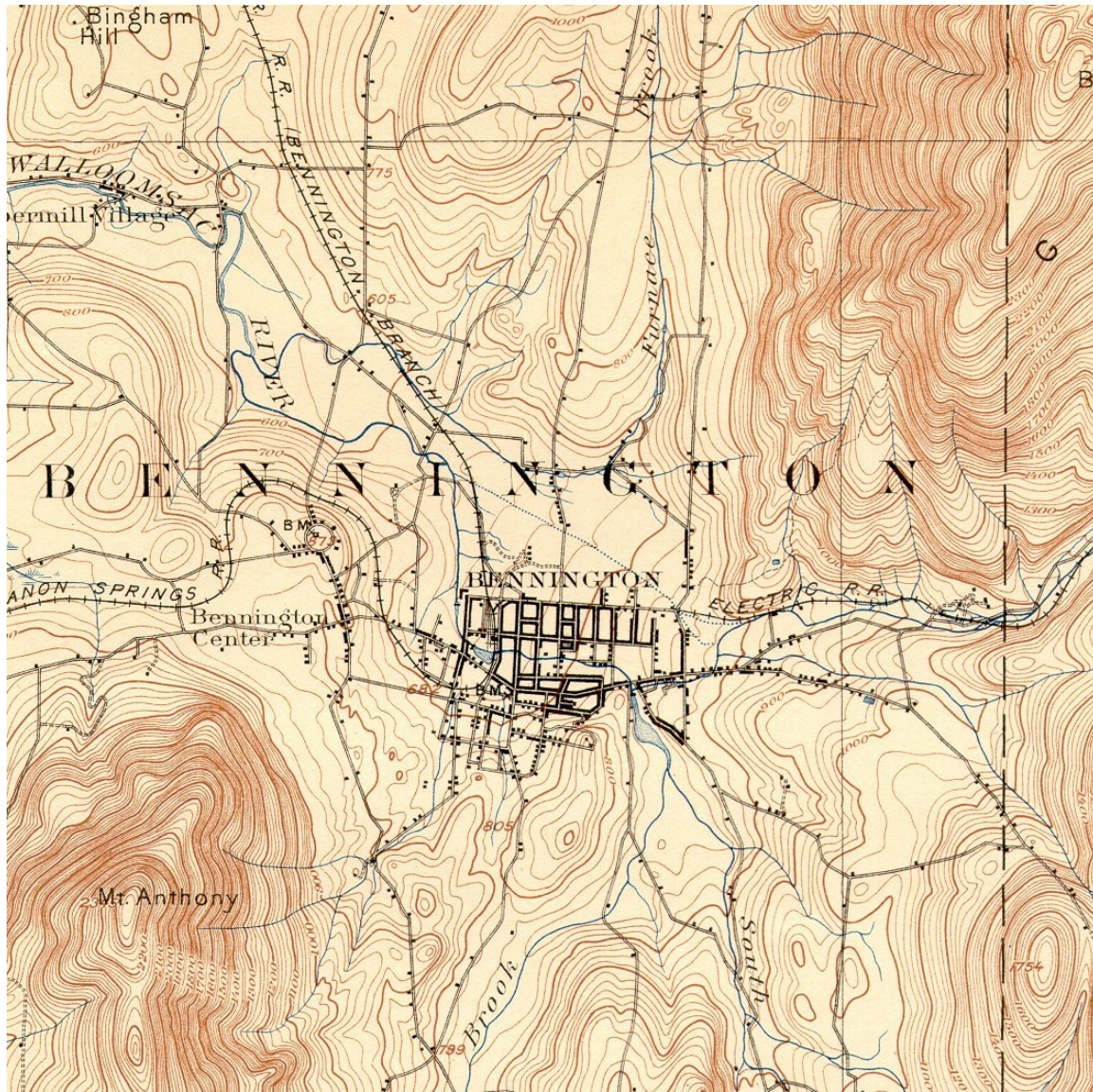
Relatively poor resolution on the orthophotographs used in the assessment or inaccessibility by road made evaluation of straightening in several small tributaries and headwaters reaches problematic. Fifteen reaches posed this problem and were not assessed for this feature. It is clear, however, that in the other reaches, straightening has been the rule rather than the exception. Four reaches have been straightened over more than ninety-percent of their length; an additional six reaches have been straightened over more than eighty-percent of their length. Altogether, twenty-one of the evaluated reaches were ranked as "high impact" due to straightening.

The Roaring Branch is worth particular note. On average, Roaring Branch reaches have been straightened over ninety-four percent of their length. This feature may date to the 19th century, as indicated on Map 2, a historic topographic map of Bennington dating to 1898. The map portrays the Roaring Branch as a straight-line, possibly artificial channel. Citizens of the time may have manipulated the watercourse in such a way as to divert flood waters into it and away from the main stem Walloomsac River running through the populated and industrialized town center. (BCCD was unable to learn from the USGS what the symbol used to represent the Roaring Branch means. USGS historians couldn't find the symbol in their legends files.)

Table 5. Straightening

Reach	Percent straightened	Impact
M02	80.5	High
M02t1.01	87.8	High
M02t1.04	36.4	High
M03	84.2	High
M04	87.0	High
M05	29.3	High
M05t2.01	57.6	High
M05t2.02	37.8	High
M06	81.9	High
M06T3.01	95.7	High
M06T3.02	93.2	High
M06T3.03	92.9	High
M06T3.04	95.1	High
M08	89.4	High
M08S1.01	29.1	High
M09	39	High
M09T4.01	38.4	High
M09T4.03	41.2	High
M09T5.01	31.7	High
M09T5.02	68.5	High
M09T5.03	26.8	High
M02T1.05	17.1	Low
M07	16.3	Low
None of the other reaches were evaluated.		

Map 2, Historic topographic map, Bennington, shows how the Roaring Branch might have been engineered to capture main stem flood waters. Note its straight-line form.



Map 2. Historic Topographic Map, Bennington

e) *Dredging history*

As recently as the late 1980s, the Roaring Branch throughout much of its length in Bennington was dredged, and a series of historic berms on both banks of the Branch are evidence that this activity was a common one in earlier years. That the dredging resulted in large deposits of stone and gravel downstream in Walloomsac reach M06 can't be proven, but, nonetheless, M06 was the site of commercial gravel mining for decades. (Even some parts of Bennington not on the native alluvial fan can still be said to have been built on it!) Dredging in other reaches in the watershed may have been intended as flood protection, or were the means of straightening a reach. Table 6 summarizes dredging histories for impacted reaches. Table 7 summarizes instream channel modifications generally in the study area.

Table 6. Dredging History

Reach	Reach Name	Dredging History	Impact
MO6	Walloodsac	Commercial mining	High
M06T3.01	Roaring Branch	Dredging	High
M06T3.02	Roaring Branch	Dredging	High
M06T3.03	Roaring Branch	Dredging	High
M02	Walloodsac	Dredging	Low
M02T1.01	Paran Creek	Dredging	Low
M02T1.04	Paran Creek	Dredging	Low
M02T1.05	Paran Creek	Dredging	Low
M03	Walloodsac	Dredging	Low
M04	Walloodsac	Dredging	Low
M05	Walloodsac	Dredging	Low
M05T2.01	Furnace Creek	Dredging	Low
M05T2.02	Furnace Creek	Dredging	Low
M07	Walloodsac	Dredging	Low
For all other reaches, there was no dredging or it was not significant.			

Table 7. Instream channel modifications

Bridges-Culverts: Impacts (# of reaches) NS=not significant NE=not evaluated			Bank Armoring: Impacts (# of reaches) NS=not significant NE=not evaluated			Channel Straightening: Impacts (# of reaches) NS=not significant NE=not evaluated			Dredging History: Impacts (# of reaches) NS=not significant NE=not evaluated		
High	Low	NS/NE	High	Low	NS/NE	High	Low	NS/NE	High	Low	NS/NE
0	29	10	3		36	21	2	16	5	10	24
Flow regulation impacts were all either unknown or not significant.											

B3: Floodplain Modifications

A floodplain is essentially the land the stream made, primarily through accretion of alluvial deposits during times of bankfull flows or flood, or through lateral movement back and forth as the watercourse struggled to balance inputs from upstream. Valley walls limit the maximum width of a floodplain naturally; in the human-impacted setting, berms and roads along watercourses further restrict the area a watercourse might work while in bankfull stage or in flood.

As might be expected, many of the reaches in the developed portion of the watershed are impacted by berms or roads. Twenty such reaches in the study area are affected, over from eight percent to 163 percent of their length. (Totals of greater than one hundred percent can result where restrictions are present on both sides of the watercourse.) Table 8, Berm and Road Restrictions, summarizes this feature.

Table 8. Berm and Road Restrictions

Berm & Road Impacts (# of reaches)		
High	Low	None
14	6	19

Most of the other floodplain modification features analyzed in the Phase 1 assessment are results of modifications to the floodplain. They include depositional features, meander width ratios, and wavelength ratios. These impacts can be viewed at <https://anrnode.anr.state.vt.us/ssl/sga/security/frmLogin.cfm> in the Step 6 Report.

C: Impact Summary

The Phase 1 assessment of the Walloomsac River watershed first collected information on human-induced changes in the study area – on corridor land cover, riparian buffer widths, flow regulation, bridges and culverts, bank armoring, channel straightening, dredging history, berms and roads, corridor development, depositional features, meander migration, meander width ratio for C and E streams, wavelength ratio for C and E streams, bank erosion, and debris or ice jam potential. When entered into the River Management Program’s web-based Data Management System (DMS), those changes were each assigned a score of “2” or “high,” “1” or “low,” or “0” “not significant.” Those scores were then combined for a total impact score of from 0 (representing the least impact) to 32 (the most impact).

Because the DMS assigns parameters not assessed a score of 0, lack of information on a certain kind of impact can skew an impact score lower than might be warranted. In this study, flow regulation wasn’t assessed on many reaches; meander migration wasn’t assessed at all; bed material information was lacking for most of the reaches; and bank erosion/bank height were not evaluated. (It is hard to accurately gather this information via a windshield survey.) Had it been possible to assess those parameters, total impact scores might have been higher.

The DMS also makes use of parameter impact values to suggest which of four adjustment processes – degradation, aggradation, widening, and planform change – are most at work in any reach. A cut-off score of 4 was established to distinguish (very broadly) between streams in equilibrium and those in adjustment. In general, the two highest scores indicate the adjustment processes most active in the reach.

Finally, these scores are used to generate a reach condition score for each reach in two different contexts – within the project area (the reaches are compared to one another), and statewide (in which the study reaches are compared to adjustment statewide). In each context, “reference” (a score of 0.85-1.0) means the reach has suffered no significant channel or floodplain modifications and is well-buffered; “good” (a score of 0.65-0.84) means a stream is undergoing only minor adjustments or has adjusted to previous modifications and is nearly in balance again; “fair” (a score of 0.35-0.64) means a reach is already experiencing major or rapid changes or that those changes are imminent; and “poor” (a score of 0.00- 0.34) refers to a reach that is severely out of regime.

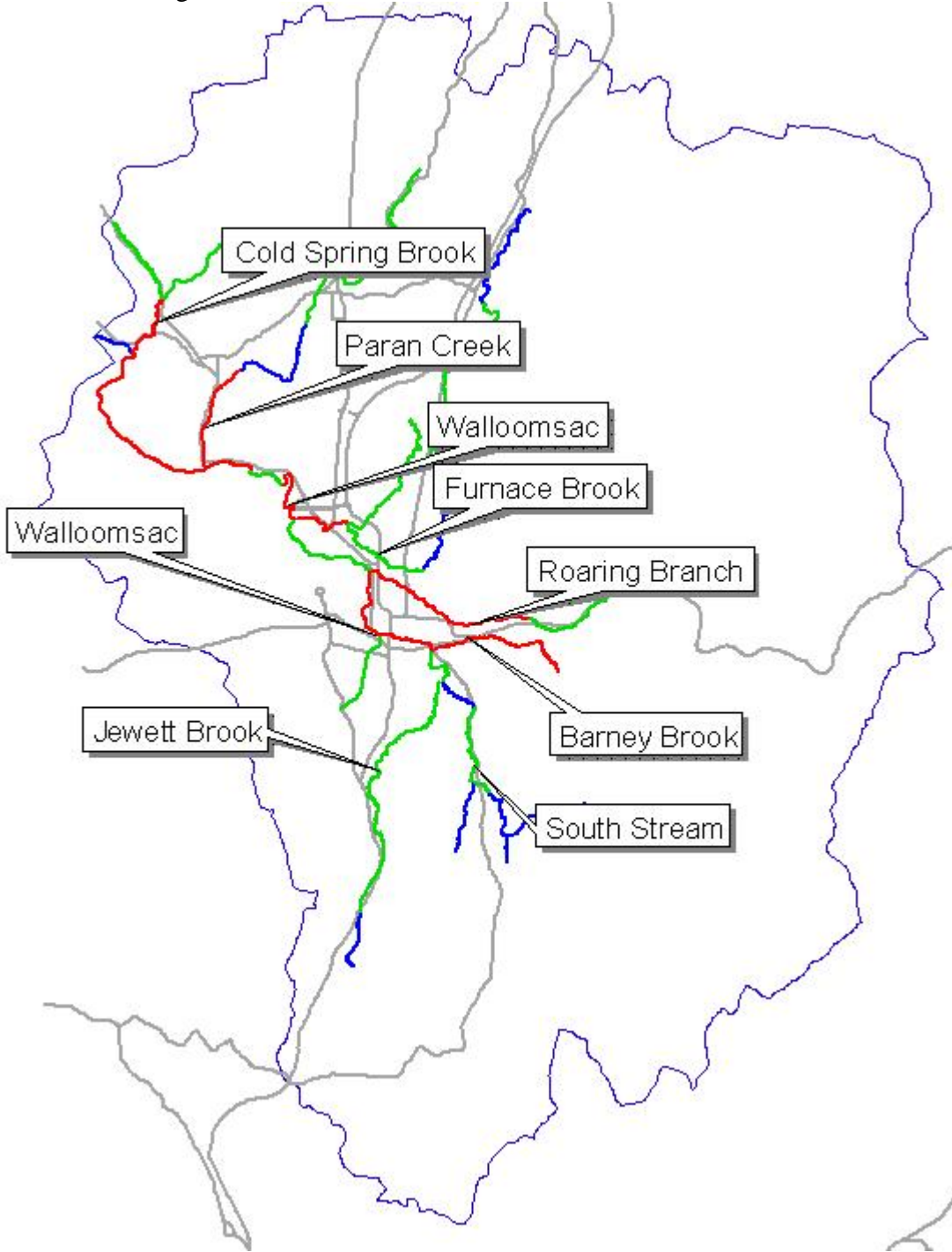
Page B-13 in Appendix B of the Phase 1 Handbook explains the process by which adjustment processes are assessed. (Because the processes are interrelated – one process entrains another – the adjustment process scores aren’t simply additive but are also weighted so as to capture that interplay phenomenon.) Page 75 in the April 2005 Phase 1 Handbook explains how reaches are assigned a reach condition.

Table 9 displays these DMS-generated findings for reaches with total impact scores equal to or greater than “9.” (It’s near this point in the descending-order impact list that project reach conditions become “good” or “reference.” No reaches rated in “poor” project reach condition are omitted from the table.) “D” signifies degradation; “A,” aggradation; “W,” widening; and “P,” planform change.

Table 9. Impact Summary, Adjustment Processes, Reach Conditions

Reach #	Stream name	Highest adjustment processes	Total Impact Score	Project Reach Condition	Statewide Reach Condition
M05T2.01	Furnace Creek	D 12; P 12	20	Poor	Fair
M02	Walloodsac	D 12; P 10	19	Poor	Fair
M02T1.01	Paran Creek	D 12; P 10	19	Poor	Fair
M03	Walloodsac	D 12; P 10	19	Poor	Fair
M06T3.03	Roaring Branch	D 11; P 11	19	Fair	Fair
M06T3.01	Roaring Branch	D 13; P 13	18	Poor	Fair
M06	Walloodsac	P 11; D 9	17	Fair	Fair
M06T3.04	Roaring Branch	D 9; P 9	17	Fair	Fair
M05	Walloodsac	A 10; P 12	16	Poor	Fair
M05T2.02	Furnace Creek	D 11; P10	16	Fair	Fair
M09T5.02	South Stream	D 9; P8	16	Fair	Good
M06T3.02	Roaring Branch	D 10; P 12	15	Poor	Fair
M07S2.01	Walloodsac trib	A 9; D 7; P 7	15	Fair	Good
M02T1.04	Paran Creek	D 10; P 10	14	Fair	Fair
M04	Walloodsac	D 9; P 9	14	Fair	Fair
M08	Walloodsac	D 11; P 11	14	Poor	Fair
M08S1.01	Walloodsac trib	D 11; P 9	14	Poor	Fair
M09T4.03	Jewett Brook	D 11; P 9	14	Fair	Fair
M01S1.01	Cold Spring Brook	D 9; P 7	13	Fair	Good
M07	Walloodsac	P 11; A 10	13	Poor	Fair
M09T4.01	Jewett Brook	D 7; A 7; P 7	13	Fair	Good
M09T5.03	Jewett Brook	D 9; P 8	13	Fair	Good
M02T1.05	Paran Creek	D 9; P 7	12	Fair	Good
M05T2.01S1.01	Furnace Creek trib	D 7; P 7	12	Fair	Good
M09T5.04	South Stream	D5; P 6	12	Fair	Good
M01S1.01S1.01	Cold Spring trib	D8; P 7	11	Fair	Good
M09T5.01	South Stream	D 4; A 4	11	Good	Reference
M05T2.04	Furnace Creek	A 6; P 6	10	Fair	Good
M09	Walloodsac	D 8; P 8	10	Fair	Good
M09T4.02	Jewett Brook	A 7; all others 5	9	Fair	Good

Map 3, Project Reach Condition, codes “poor: project reach condition reaches red, “fair” reach condition reaches green, and all others blue.



Map 3. Project Reach Condition

Legend

Reach Condition Poor

Reach Condition Fair

Reach Condition Good or Reference

VI. CONCLUSIONS

This assessment of the Walloomsac River watershed in southwestern Vermont describes a system highly altered by human activities and one, in many locations, still adjusting to the impacts of those activities. Future field studies focusing particularly on high total impact, poor project reach condition reaches can help area residents and municipal officials craft short-term and long-term management plans.