PHASE 1 STREAM GEOMORPHIC ASSESSMENT

Mill River, Rutland County Vermont

Final Report

February 1, 2007

RUTLAND REGIONAL PLANNING COMMISSION

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MAPS, FIGURES AND TABLES

SPECIAL THANKS to: Shannon Hill, Vermont DEC River Management Section , Ethan Swift, Vermont DEC Watershed Coordinator, for technical support and quality assurance on this project

INTRODUCTION

Fluvial geomorphology is the study of the interaction between streams and the landscape through which they travel. It is the science of understanding the physical interrelationships of the water, the sediments it carries and the lands it flows through. The phase 1 geomorphic assessment specifically looked at how changes on the landscape have translated to changes within the Mill River Basin stream channels. The Rutland Regional Planning Commission (RRPC) used a number of different tools such as maps, public records and files, ortho-and aerial photos and digital mapping programs to survey the Mill River in Vermont and seven of its tributaries. The major tributaries surveyed included Freeman Brook, Russell Brook, Fowler Brook, sometimes referred to as Feller Brook, and Meadow Brook, also known as Beaver Meadow Brook. Three minor tributaries, all unnamed, were also studied. These three lie predominantly in Mount Holly and run along the southern side of Route 103 with branches running generally North and South; Refer to *Map 1* for project location.

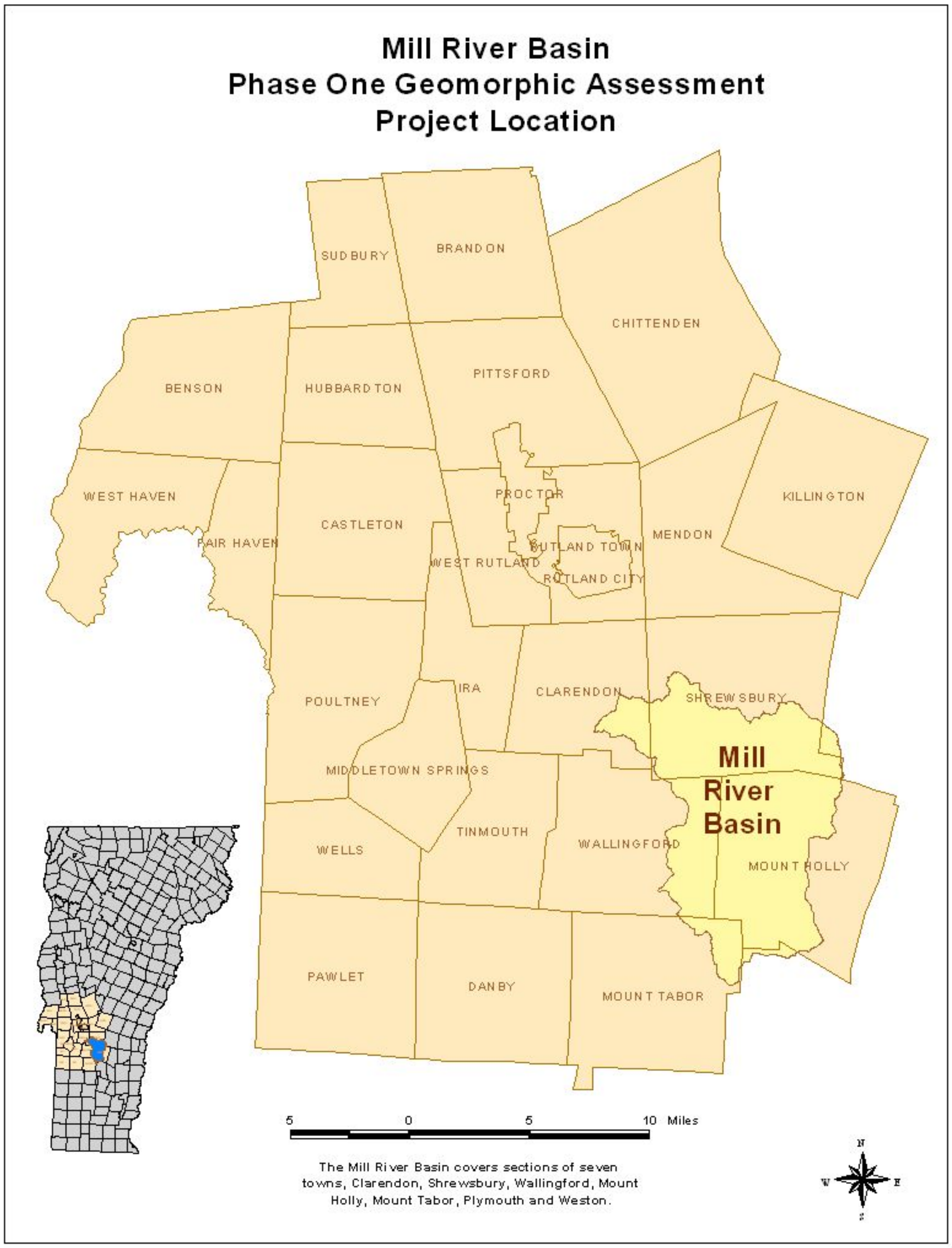
This study was conducted using the most current Vermont Geomorphic Assessment Protocols, which were designed to standardize geomorphic assessments conducted by different organizations around the state. Steps 1-4 of this study looked at deterministic watershed characteristics such as valley width, stream channel slope and prevailing soil types. Steps 5 and 6 looked at changes that have occurred on the landscape through human activities such as development, berms and roads and armoring placed along the river and creeks. Other information collected relates to the depositional characteristics of the river and its actual movement on the landscape. Step 7, a field survey of the Mill River and select tributaries from public access points, was only partially completed and will be looked at again when conditions permit. The purpose of the field survey is to verify the remote sensing and mapping information used in this assessment.

Results from the phase 1 study will provide much needed data about the current conditions in the Mill River Basin. The data will be used to provide recommendations for future restoration project locations, planning and zoning decisions, tree planting sites and other types of restoration projects that may be successful. The data will also be used in future phase two geomorphic analyses.

Funding for the Mill River Phase I geomorphic assessment was provided by Vermont's Clean and Clear Initiative (Corridor Management Grants from Vermont's Department of Environmental Conservation (DEC), Rivers Management Program).

The study was conducted by the RRPC with support from the Vermont DEC and the Rivers Management Program.

Remote sensing data used in this study was obtained from the Vermont Center for Geographic Information (VCGI), Vermont DEC, and the Rutland Regional Planning Commission (RRPC). Information was also provided by officials and residents from the towns of Clarendon, Wallingford, Mount Holly and Shrewsbury.



MAP 1: *Project Location*

MILL RIVER BASIN: STUDY AREA BACKGROUND

The Mill River Basin is comprised of fifty-nine subwatersheds covering approximately seventy-one square miles. It is one of the major sub-basins comprising the Upper Otter Creek Watershed. It covers portions of seven towns: Clarendon, Wallingford, Shrewsbury, Mount Tabor, Plymouth, Weston and Mount Holly. It includes Spring Lake, and several other smaller ponds and several small wetlands.

There are numerous recent phase one and phase two fluvial geomorphic assessments for the surrounding basins within the Upper Otter Creek Watershed. These other studies provided background data to help in our assessment and the data from them will help to further develop fluvial erosion hazard zones for many towns in the region.

METHODOLOGY

This assessment was completed using the methodologies outlined in the Vermont Geomorphic Assessment Phase I Handbook, dated April 2004. Computer mapping functions were completed through the automated GIS extension/tool, Stream Geomorphic Assessment Tool (SGAT), version 4.53.using ESRI's ArcView 3.2 software. This software and extension were used to create the initial data used to run SGAT. This data includes the following GIS databases: Subwatersheds, reach points, meander center line(thalweg), and valley walls. All data resulting from this study has been entered into Vermont DEC's online Data Management System (DMS) and checked for quality and reproducibility by qualified Vermont DEC staff.

DATA INPUTS/STUDY RESULTS

The results of this study are derived from the following data inputs: watershed location; valley and channel characteristics; soils data; land use and riparian buffer data; post-settlement changes to the channel, floodplain, stream corridor and watershed and a comparison of the expected stream channel characteristics to the measured characteristics. All of the phase 1 data (drawn upon in the following summaries) can be found in the online DMS.

Reach Location

The Mill River Basin was divided into 59 reaches for the purposes of this study. Each reach is a like area studied as one geologic unit(*Figure 1*) The main stem of the Mill River was divided into twenty reaches, Freeman Brook into seven reaches, Russell Brook into four reaches, Fowler Brook into four reaches, Meadow Brook into seven reaches and the three unnamed tributaries have eight, five, and four reaches. Please refer to the online DMS for a complete list of the reaches and their locations within the basin. The following map details the location of each reach and a representation of it's' subwatershed area. See *Map 2*.

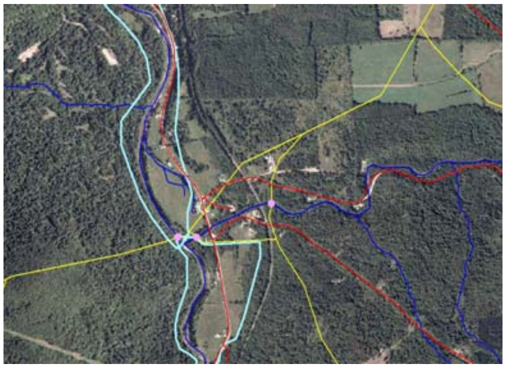
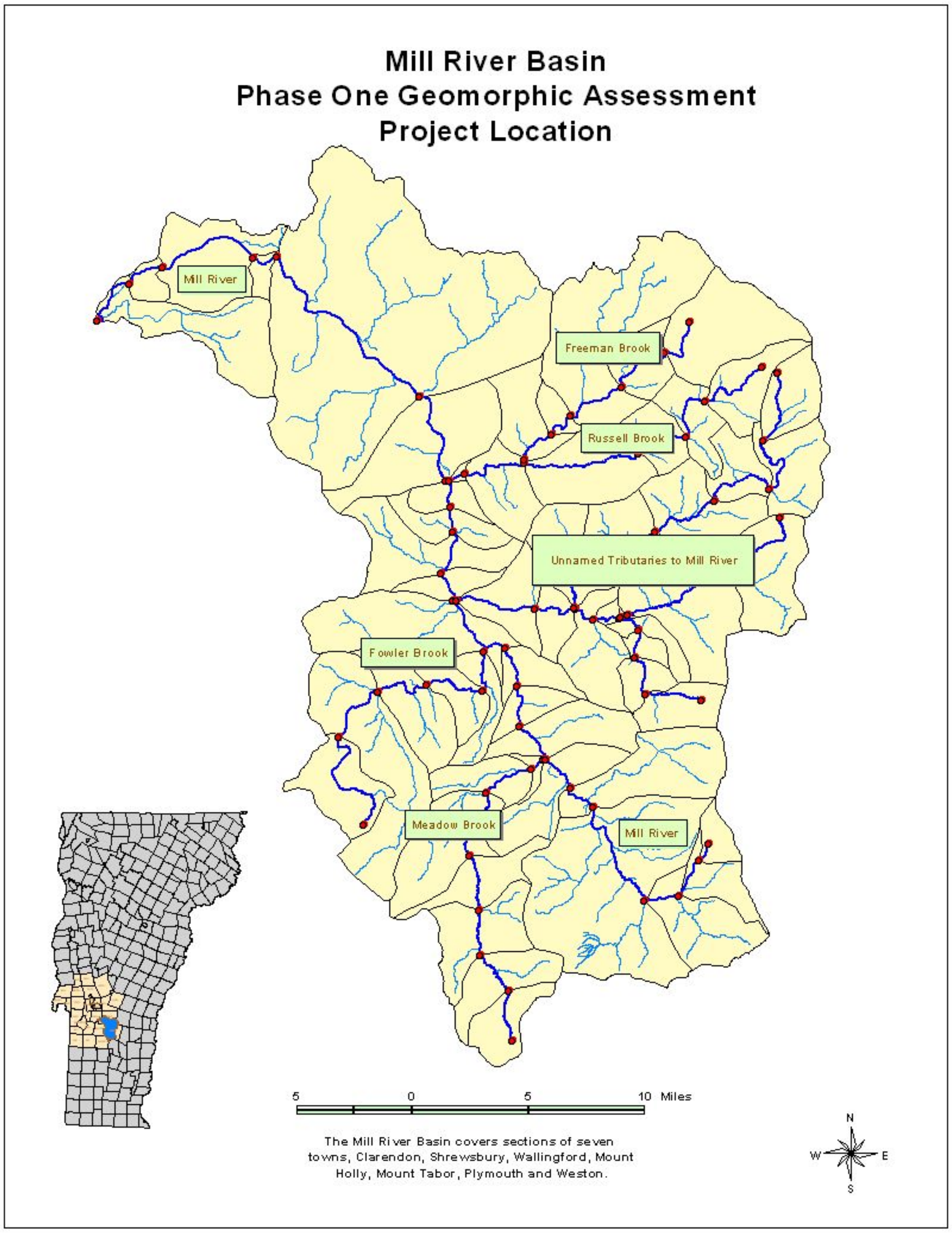


Figure 1: *Reach number M06 and parts of M07 and T1.01 depicting main stem of the river in royal blue, subwatersheds In yellow, valley walls in cyan, reach points as pink dots and roads as red lines.Location shown is of Mount Holly, Shrewsbury and Wallingford.*



MAP 2*:Reach breaks and subwatersheds*

<u>Stream Types</u>

All stream reaches in this study were classified as Rosgen (1996) and Montgomery Buffington (1996) stream types A, B, C, or E.

Stream type “A”-steep, cascading, headwater reaches. Stream type “B”- include moderately steep, step-pool streams. Stream type “C”- the most common stream type in the Mill River Basin, “C” streams include less-steep, pool-riffle streams with floodplain access. Stream type “E” – very similar to type “C” but used only when sinuosity values are greater than 1.5 and supported by windshield surveys. The “C” stream type predominated, especially in the valleys. See *Table 1*.

Stream Type	Description	Channel Slope	Channel Length(Sum in feet)	Number Reaches	Percent by channel length
A	Step-pool	Steep	12,516	2	4.5
B	Plane bed	Moderate	11,816	4	4.2
B	Riffle-pool	Gentle	40,285	7	14.3
B	Step-pool	Steep	29,119	8	10.4
C	Riffle-pool	Gentle	164,191	35	58.4
E	Dune-ripple	Gentle	8925	1	3.1
E	Riffle-pool	Gentle	14,257	2	5.1

Table 1: *Stream type and percent of total channel length*

Basin Characteristics: Geology and Soils

As stated in the Vermont DEC protocols, “A stream carries not only water but also sediment. Geology determines the source material that the river is carrying, the way that material is carried and the rate of channel adjustments.”

The dominant geological materials in the Mill River Basin are glacial till, ice-contact, and alluvial deposits. The characteristics of the dominant soil types in the watershed show infrequent flooding, but variable erosion rates across the basin, with some reaches having soil types throughout that show potential for very severe erosion. See *Table 2*

Dominant Material	Number of Reaches	Range(% of reach)	Percent(of reaches)
Alluvial	7	32.0 – 87.0	11.9
Glacial Till	27	36.0 – 99.0	45.8
Ice-Contact	17	43.0 – 100.0	28.7
Other	8	31.0- 70.0	13.6

Table 2: *Geologic Material*

Reaches M02, M03 and M04 cover a section of the river know as Clarendon Gorge. It is approximately 2.5 miles of natural beauty and actually consists of two gorges, an upper and a lower. The upper gorge is about one third of a mile long and consists of several pools connected by small drops. A small cascade exists on a genteler river section between the upper and lower gorges, The cascade drops about 20 feet in 3 steps, the last being the largest. The lower gorge is also a series of drops. The first drop, locally known as Devil's Gorge is beautiful. The lower gorge is extremely narrow (less than 10' in places), with higher, darker walls (80-100') and slightly bigger drops than the upper gorge. This scenic resource is an area used for all types of outdoor recreation. See *Figure 3*. The following quote attempts to describe the gorge area:

"The white marble at the gorge is heavily fractured, the river has done some water sculpture, and there is a huge purplish basaltic intrusion in the rocks just above the head of the lower gorge. The textures here are quite amazing. The Mill River as it approaches the gorge is wide, shallow, and bubbles over countless rounded marble rocks in the river. As it approaches the gorge, it narrows, slides over some contorted bedrock, then plunges about 10' into a narrow and deep gorge that is aligned more or less east-west."
From: Waterfalls of the Northeastern United States web site, http://www.northeastwaterfalls.com.

Figure 2: *Looking southeast down to Clarendon Gorge, Mill River reach M04***.**

Figure 3: *Various photos of the Clarendon Gorge area, both old and new, reaches M02,M03, and M04 of the Mill River, Clarendon, VT.*

Land Cover and Reach Hydrology

Landuse in the watershed is mainly forested, with forest cover in each subwatershed ranging from 78.0 percent on one reach to 95.0 percent on another. See *Figure 2*. Urban areas rank as the next highest land cover percentage in the watershed, ranging from 2.0 to 9.0 percent. Historically, a much higher percent of the watershed was cleared for pasture and croplands although much of it was still in forest land, today fields are a close third in land use percentage, 0.0 – 6.0 percent.

Dominant land cover in the stream corridor is forested land and or water coverage, in almost every reach; reach M10 is urban. Percent forested land ranges from 7.0 percent to 92.0 percent of the reach corridor with water covering from 7.0 to 52.0 percent. Urban areas comprise the next highest land cover percentages in the corridor, ranging from 0.0 to 60.0 percent. See *Figure4*.

Figure 4: *East Wallingford, the Mill River and tributaries reaches M10 and M11,a more settled section along the river, Wallingford, VT.*

Woody vegetative buffers vary throughout the basin. There are 10 reaches that have 0-25 feet, 22 reaches at 26 – 50 feet and 12 reaches at 51 -100 feet of buffer on one side of the river, no reaches have 0-25 feet buffer on both sides, 13 reaches have 26 – 50 feet of buffer on both sides and 5 reaches have from 51 – 100 feet of buffer on both sides. Conversely, 32 reaches have more than 100 feet of buffer on both sides and 10 reaches have 100 feet of buffer on one side.

Groundwater and wetland inputs are fairly evenly distributed by reach. Of the 59 reaches, 17 have no groundwater input, 17 have minimal groundwater input and 25 have abundant groundwater input. See *Figure 5*.

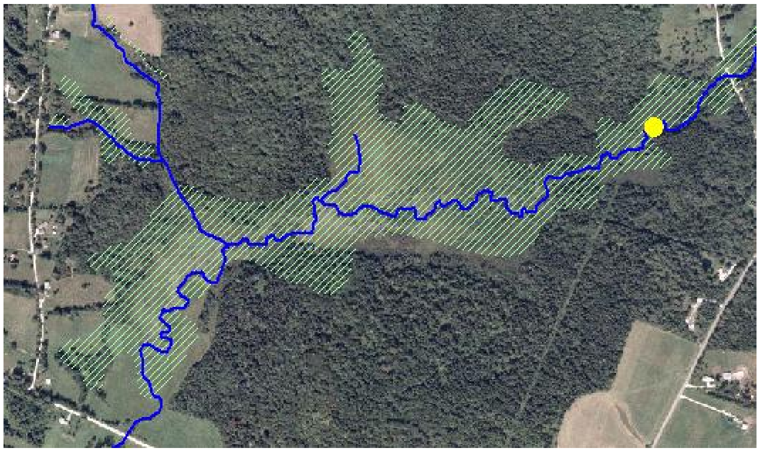


Figure 5: *A large wetland complex along an unnamed tributary to the Mill River, Mount Holly, VT., reach T2.04.*

Instream Channel Modifications

Instream channel modifications include the impact or frequency of bridges and culverts, bank armoring, channel straightening and dredging on the river.

Bridges and culverts seem to be the modifications effecting the river most. 25 reaches have no bridges or culverts, leaving 34 reaches with bridges and or culverts ranging from 1 to 4 per reach. Only six reaches, about ten percent, have a high impact rating from culverts and bridges. Of special interest is Kingsley Bridge, an historic covered bridge built in 1836, it carries Congdon Road, also known as the East Street Extension across the river. It is an often photographed historic marker found on the National Register of Historic Places. See *Figure 6.*

Figure 6: *Looking downstream at Kingsley Bridge, Clarendon, VT. Mill River, reach M03.*

Bank armoring is present in 21 reaches with approximately 7.3 % of the total river length armored. Rock rip rap is found on a few reaches on the outside of bends in the channel, usually protecting public infrastructure or private property. Bank armoring is a high impact for three reaches, M08, M10, T1.01.

Impacts from channel straightening effect 13 reaches, with approximately 7.4% of the total river length straightened and one reach, M14, having approximately 77.5% of its length straightened.
See *Figure 7*.

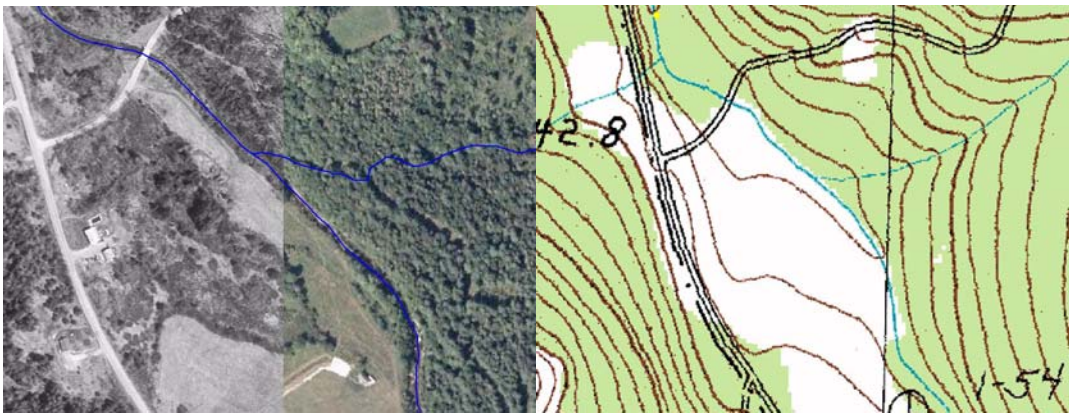


Figure 7: *Channel straightening on the Mill River, reach M14. This reach has been modified to run along the toe of the valley ,and the edge of a field. The photo on the left shows two orthophoto views, one from 1994(black and white) and the color image from 2003.The image on the right is from a USGS topographic map. The same area is depicted in both orthophotos and USGS map.*

Gravel mining has occurred throughout history in numerous reaches along the main stem of the Mill River. Today, gravel extraction is primarily performed by farmers abutting the river and town and state workers.

Floodplain Modifications

Changes in the floodplain can also affect the river and its natural processes. Development in the floodplain alters the ability of the river to react to changes in the overall system. Houses, roads, rail and berms are the predominant floodplain modifications found in the Mill River Basin. The majority of development is found along the main stem of the Mill River. 10 reaches have a high impact score relating to roads and berms while 5 reaches scored high due to development.

Depositional features appear in 18 reaches with 4 having a high impact rating and 11 having a low impact with the remaining rated as not significant.. The most common deposits are point bars and mid-channel bars. See *Figure8.* The fact that almost one third of the reaches have some type of deposition is a good indicator that something is happening upstream.

Figure 8: *Point bars along reach M05 of the Mill River, Shrewsbury, VT.*

<u>Windshield Survey</u>

The windshield survey provides a means of limited field verification of the phase 1 data. Brief observations are taken at points of vehicular and/or public access along the rivers and creeks in the study. The windshield survey is in no way a comprehensive field verification and the results of the phase 1 study should be considered preliminary. The primary modification made to the data as a result of the windshield survey are changes in the reference stream type .In addition, ice jam potential, bank height and erosion can also be recorded in the windshield assessment. Most ice jam potential is from undersized culverts and/or low bridges, although some potential for jams exists at sharp bends and tight constrictions in the river. A more on depth windshield survey will be performed in the Spring of 2007. Please refer to the online DMS for updated information after that time.

DATA ANALYSIS

Impact Ratings

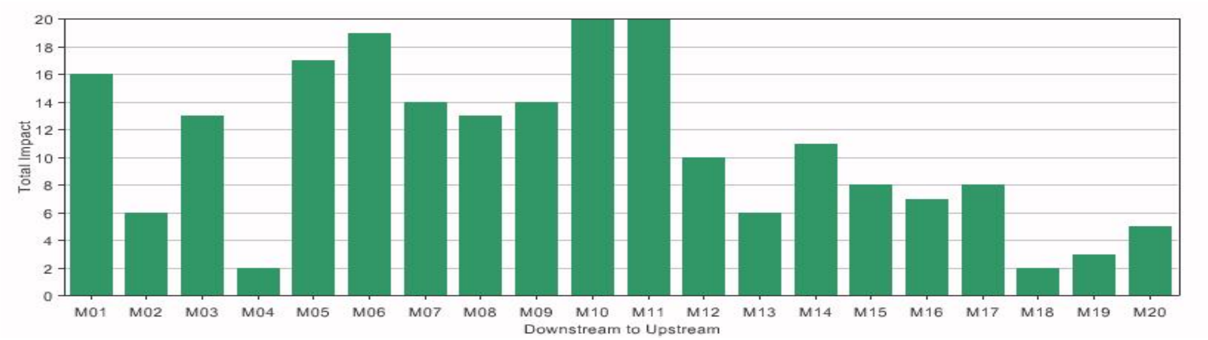


Figure 9: *Final impact ratings for the main stem of the Mill River*

Stream and Watershed Provisional Impact Rankings

Reach ID	Stream Name	Total Impact Score	Reach Condition (Project)
M01	Mill River	16	Fair
M02	Mill River	6	Reference
M03	Mill River	13	Fair
M04	Mill River	2	Reference
M05	Mill River	17	Fair
M06	Mill River	19	Fair
M07	Mill River	14	Fair
M08	Mill River	13	Fair
M09	Mill River	14	Fair
M10	Mill River	20	Poor
M11	Mill River	20	Poor
M12	Mill River	10	Good
M13	Mill River	6	Reference
M14	Mill River	11	Good
M15	Mill River	8	Good
M16	Mill River	7	Good
M17	Mill River	8	Good
M18	Mill River	2	Reference
M19	Mill River	3	Reference
M20	Mill River	5	Good
T1.01	Freeman Brook	17	Fair
T1.02	Freeman Brook	9	Good
T1.03	Freeman Brook	6	Reference
T1.04	Freeman Brook	2	Reference

T1.05	Freeman Brook	9	Good
T1.06	Freeman Brook	7	Reference
T1.08	Freeman Brook	3	Reference
T1-S1.01	Russell Brook	4	Reference
T1-S1.02	Russell Brook	4	Reference
T1-S1.03	Russell Brook	4	Reference
T1-S1.04	Russell Brook	4	Reference
T2.01	Unnamed Tributary 1	13	Fair
T2.02	Unnamed Tributary 1	9	Good
T2.03	Unnamed Tributary 1	5	Reference
T2.04	Unnamed Tributary 1	5	Reference
T2.05	Unnamed Tributary 1	6	Reference
T2.06	Unnamed Tributary 1	5	Reference
T2.07	Unnamed Tributary 1	2	Reference
T2.08	Unnamed Tributary 1	1	Reference
T2-S1.01	Unnamed Tributary 2	7	Good
T2-S1.02	Unnamed Tributary 2	6	Reference
T2-S1.03	Unnamed Tributary 2	13	Fair
T2-S1.04	Unnamed Tributary 2	9	Fair
T2-S1.05	Unnamed Tributary 2	8	Fair
T2-S1.02-S1.01	Unnamed Tributary 3	6	Reference
T2-S1.02-S1.02	Unnamed Tributary 3	3	Reference
T2-S1.02-S1.03	Unnamed Tributary 3	3	Reference
T2-S1.02-S1.04	Unnamed Tributary 3	2	Reference
T3.01	Fowler Brook	2	Reference
T3.02	Fowler Brook	6	Reference
T3.03	Fowler Brook	7	Reference
T3.04	Fowler Brook	2	Reference
T4.01	Meadow Brook	8	Fair
T4.02	Meadow Brook	3	Reference
T4.03	Meadow Brook	1	Reference
T4.04	Meadow Brook	1	Reference
T4.05	Meadow Brook	3	Reference
T4.06	Meadow Brook	1	Reference
T4.07	Meadow Brook	0	Reference

Table 3: *Final Impact Ratings*

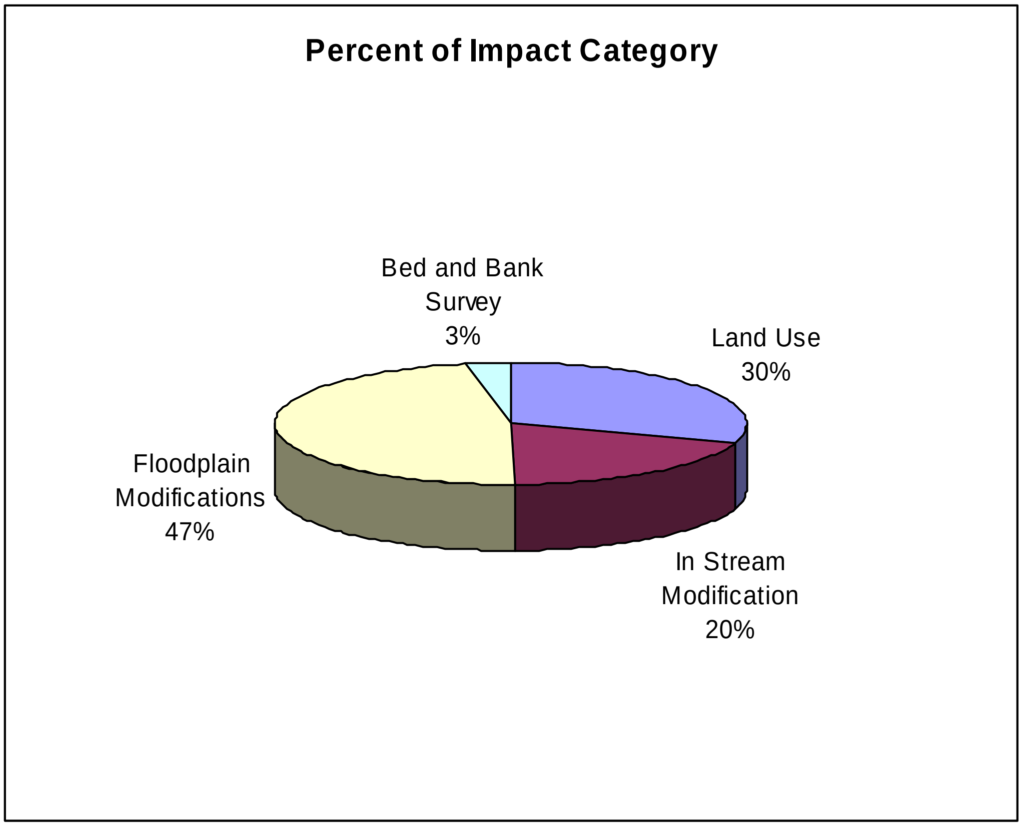


Figure 10 : *Percent of each impact category of the total impact score*

Adjustment Processes

SGAT predicted adjustment scores for each reach, it rated: degradation, aggradation, widening, and planform characteristics. Degradation, the scouring of the river channel and Aggradation, the storage of sediments, can be looked at together. In the Mill River Basin, on the main stem,17reaches exhibit more degradation, no reaches showed more aggradation. Equal amounts of aggradation changes and degradation occur in 3 reaches, M18, M19 and M20, indicating that both processes are occurring at the same time on different sections of the reach. Basin wide, 51 reaches ranked degradation highest or tied for the highest rank, and 17 ranked aggradation highest or tied for the highest rank.

Reach	Degradation	Aggradation	Widening	Planform Changes
M01	6	7	5	**10**
M02	**4**	3	0	0
M03	**6**	5	5	**6**
M04	**2**	**2**	0	0
M05	7	5	5	**8**
M06	**11**	7	3	10
M07	6	5	3	**7**
M08	8	7	3	**10**
M09	**6**	5	3	**6**
M10	**13**	8	3	10
M11	**12**	7	5	10
M12	**5**	4	2	2
M13	**2**	**2**	0	0
M14	**5**	4	2	**5**
M15	**4**	2	0	2
M16	**5**	4	2	3
M17	**6**	4	2	4
M18	**1**	**1**	0	0
M19	**3**	2	0	0
M20	4	**5**	2	0

Table 4 : *Adjustment process ranking by reach, main stem of Mill River only!*

The Mill River and its tributaries do not appear to be over widened. Most of the reaches on the main stem of the Mill River exhibit some type of widening but it is not the current adjustment process taking place in any reach.

Throughout the entire basin, only five reaches exhibit a high planform rating, M01, M06, M08,M10 and M11. This means in that reach the river is actively trying to change its path. Reach M14 ranks degradation and planform changes as the active processes. See *Table 4*.

Comparing reaches within the Mill River Basin system showed: 6 reaches were identified as ‘Good”, 13 reaches as ‘Fair”, 34 reaches as “Reference” and 2 reaches ranked “Poor”. See *Figure 11*.

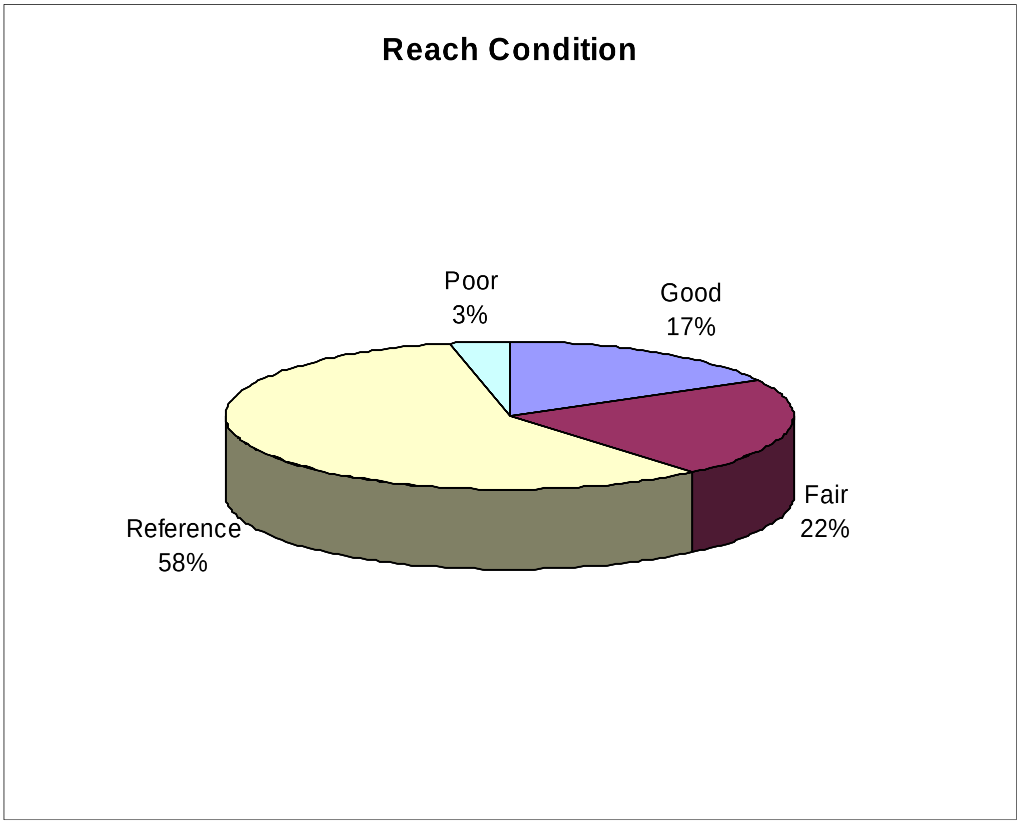


Figure 11: *Reach condition, percent of all reaches Mill River Basin only!.*

CONCLUSIONS

Much of the watershed is forested and urban with the river corridor exhibiting the same characteristics. Most of the reaches in the forested area have riparian buffers of 100 or more feet on both sides of the river. More of the urban areas have little to no riparian buffers, less than 25 feet on one or both sides.

With degradation being the active process taking place in so many reaches , it is somewhat surprising that aggradation is not the active process in more reaches. This imbalance may be due to past management practices including straightening of the river channel.

Based on the preliminary results of the phase 1 geomorphic assessment, system wide the Mill River is fairly stable, however there are areas of localized instability on the main stem and the tributaries. The RRPC recommends phase 2 studies to further investigate these potential unstable reaches.