Hydraulic Geometry of Various Sites in Thatcher Brook, Vermont, and the Relationship with Riparian Vegetation, 2011

Mariana Rivera Figueroa[1]; Maeve McBride, Ph D.[2]

[1]University of Puerto Rico; [2]University of Vermont

ABSTRACT

An evaluation of bankfull geometry measurements (width and depth) of a small stream in Vermont was made. These measurements were compared to the Vermont Regional Hydraulic Geometry Curve. The relationship between width and the presence or absence of riparian vegetation in the channel was also evaluated. To achieve that, aerial photographs of the streams were used to measure historical changes in the channel. Differences in width were found in the stream sites where the most riparian vegetation changes were present. No significant difference was found between the field data and the Vermont Regional Curve. Therefore this curve can be useful to estimate bankfull geometry in this stream.

INTRODUCTION

The study of the processes that influence and shape river systems is important for different purposes such as river engineering, river restoration, water resources planning and river ecosystem studies (Cassie, 2006). This study focused on some geomorphic characteristics of various sites in a Vermont stream called Thatcher Brook. Bankfull dimensions of the stream channel (width and depth) are the geomorphic features that were evaluated in terms of drainage area, land use and riparian vegetation.

Bankfull hydraulic geometry relationships or regional curves have been developed for various states, including Vermont, to predict bankfull characteristics in different drainage areas (River Management Program Vermont Department of Environmental Conservation, 2006). Nevertheless, these curves seem to be inaccurate when applied to highly disturbed watersheds (Ellison, 2010). In addition, Anderson and others (2004), draws attention to the importance of bank vegetation characteristics and land use as controlling factors of channel width, which are not normally considered in these regional curves.

Planting riparian buffers is a common river restoration practice, also known as a Best Management Practice (BMP), for improving water quality. However, some references indicate that reforesting riparian zones is related to channel widening, at least in smaller streams (Davies-Colley, 1997; McBride et.al, 2008; Hession, 2003). This effect seems to be related to stream banks erosion product of changes from grass vegetation (that generally hold deposited sediments) to forestry type vegetation until the channel adjusts to a more stable condition (Davies-Colley, 1997). The stabilization of natural river width after replanting is a long-term process and some models predict that it should take from 35 to 40 years (Parkyn et.al, 2005). However McBride (2008) shows that reforested reaches are still widening after 40 years.

OBJECTIVES

- Comparing bankfull dimensions between Thatcher Brook and the Vermont Regional Curve.
- Evaluating long term riparian vegetation and width changes in Thatcher Brook.

STUDY AREA

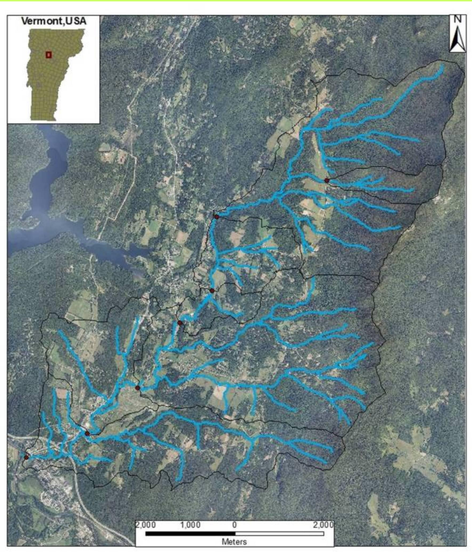

Figure 1. Thatcher Brook Study Sites (red points) and drainage area.

- Six sites at Thatcher Brook and a tributary of this stream were measured for bankfull dimensions.
- This stream drains to Winooski River in Waterbury, Vermont.
- Each site is identified with its elevation from headwaters to river mouth.
- Land use surrounding each site varies between forested, agricultural and urban.
- Each site has differences in the streamside or riparian vegetation. Some are covered with trees, grass or mixed vegetation.

METHODS

Field Methods:

- At each site, widths and depths were measured within a representative reach at bankfull elevation by hand with a measuring tape and a meter stick.
- Five widths and depths were measured in each stream reach.
- For depth, the Streams Project protocol was used.

Analytical Methods:

- Simple linear regressions were made for the comparison of the Vermont Regional Curve data and the Thatcher Brook data.
- Two additional datasets of previous studies were included in the regression.
- A t test was done to compare the two simple linear regression equations.

GIS Analysis:

- Vermont aerial photographs from 1962 were examined for changes in width and riparian vegetation along the channel.
- National Agriculture Imagery Program (NAIP) 2009 images were used to compare it with 1962 state of Vermont' aerial photographs.

RESULTS AND DISCUSION

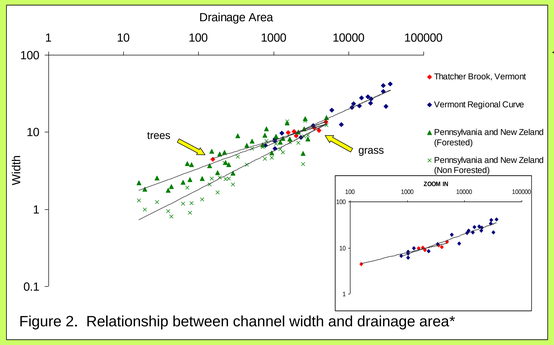

Figure 2. Relationship between channel width and drainage area*

- The arrows in figure 2 represent the more obvious outliers in the field data and their corresponding riparian vegetation. The one with the more trees better correspond with the forested data set and the one with the more grass with the non forested data set.
- The t-test of the regression lines in figures 2 and 3 between field data and the Vermont regional curve showed no significant difference.

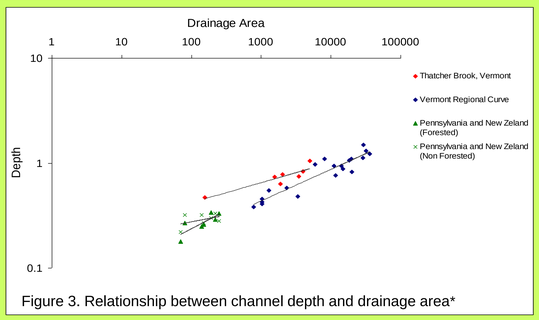

Figure 3. Relationship between channel depth and drainage area*

* Comparison between the field data in Thatcher Brook, the Vermont Regional Curve and two previous studies' datasets from Pennsylvania (Hession, et al., 2003) and New Zeland (Davies-Colley, 1997).

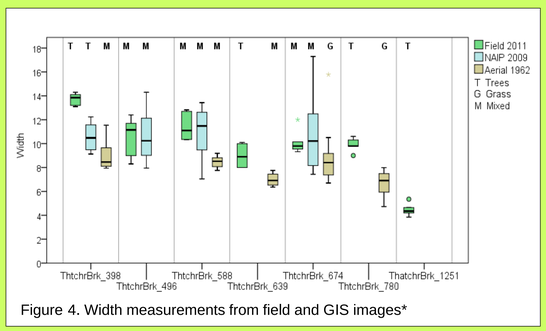

Figure 4. Width measurements from field and GIS images*

- In figure 4 more riparian vegetation associated with trees is found in the NAIP 2009 and 2011 field measurements than in 1962 aerial photographs.
- In those sites where more trees and mixed vegetation is recently found, there is also, a wider channel.

* In some sites' images, the presence of riparian vegetation covering the channel inhibited width measurements from aerial photographs.

Thatcher Brook 780

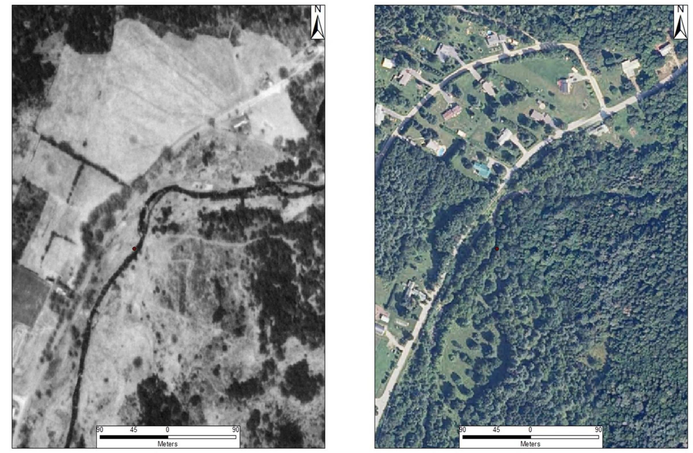

Figure 5. Example of changes in the channel's riparian vegetation. In the left is 1962 aerial photograph and in the right is 2009 NAIP image of the site.

CONCLUSION

- The bankfull geometry of Thatcher Brook can be estimated from drainage area following the Vermont Regional Curve. Outliers reveal the importance of land use and riparian vegetation.
- Thatcher Brook 398 is the most urban of all the stream sites in this study, and Thatcher Brook 1251 is the most forested. The widths and depths of the study site seem to correspond with the expected relationship between land use and channel geometry. In urban areas there is often an increase of width and depth of the stream because of erosion caused by increased and more frequent flow events (Booth, 1991).
- Widening of the channel has occurred in most of the stream sites since 1962.
- If the increment of the channel width when riparian zones have more trees is happening because of erosion, the water quality of the site could be impacted by excess of nutrients or soiled adhered pollutants.

ACKNOLEDGMENTS

- Maeve McBride, Ph.D. – Mentor, University of Vermont
- Jorge Ortíz – University of Puerto Rico
- Miranda Lescaze and the Streams Project staff
- Lexie Haselton – GIS Analyst, Streams Project
- Catherine Duck – Water Quality Laboratory, Streams Project
- W.Q. Lab Partners

REFERENCES

Anderson, R.J., Bledsoe, B.P. and Cully-Hession, W. (2004) "Width of Streams and Rivers in Response to Vegetation, Bank Material, and Other Factors". *Journal of the American Water Resources Association*. [Electronic version]

Booth, D.B. (1991) "Urbanization and the Natural Drainage System- Impacts, Solutions, and Prognoses". *The Northwest Environmental Journal, 7(1)*. [Electronic Version]

Cassie, D. (2006) "River Discharge and Channel Width Relationships for New Brunswick Riveras". Canadian Technical Report of Fisheries and Aquatic Sciences. [Electronic Version]

Davies-Colley, R.J. (1997) " Stream Channels are Narrower in Pasture than in Forest". *New Zealand Journal of Marine and Freshwater Research, 31(5)*. [Electronic Version]

Ellison, E. (2010) "Land Use Affects on Modern Bankfull Hydraulic Geometry in Southwest Ohio and its Implications for Stream Restoration". Miami University Thesis. [Electronic Version]

Hession, C.W., Pizzuto, J.E., Johnson, T.E., Horwitz, R.J.(2003) Influence of bank vegetation on channel morphology in rural and urban watersheds. *Geology, 31(2), 147-150.*

McBride, M., Cully-Heisson, W. and Rizzo, D.M. (2008) "Riparian Reforestation and Channel Change; A Case Study of Two Small Tributaries to Sleepers River, Northeastern Vermont, USA". *Geomorphology*, *102.* [Electronic Version]

Parkyn, S.M., Davis-Colley, R.J., Bryce-Cooper, A. and Stroud, M.J. (2005) "Predictions of Stream Nutrient and Sediment Yield Changes Following Restoration of Forested Riparian Buffers". *Ecological Engineering, 24*. [Electronic Version]

River Management Program VT DEC. (2006) "Vermont Regional Hydraulic Geometry Curves". [Electronic Version]