GEOMORPHIC ASSESSMENT OF BACHMAN RUN WITHIN THE LITTLE CONESTOGA CREEK WATERSHED

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INTRODUCTION

A recent study by the U. S. Geological Survey(USGS) found that the Conestoga River and its tributary subbasins contribute the highest nutrient yields to the Susquehanna River (Loper and Davis, 1998). As the largest river emptying into the Chesapeake Bay, the Susquehanna is the focal point of restoration efforts to improve the Chesapeake's water quality. Recent point source pollution regulations by the EPA are effectively controlling the amount of industrial waste that enters the Bay, but the water quality of the Chesapeake Bay Watershed remains poor. Although the next step in the process of restoring the Chesapeake Bay must be to improve the water quality of its tributaries, many of the streams and rivers that empty into the Bay, such as the Conestoga River, do not have significant point source pollution. These tributaries pick up contaminants as they flow through agricultural areas and receive runoff from city streets and highly fertilized backyards. Ordinarily, streams and rivers have mechanisms that help them reduce the amount of runoff and contaminants that enter the stream, but urbanization greatly reduces these capabilities.

One of the impacts urbanization has had on the watershed is the increase in the amount of impervious surfaces in the form of city streets, buildings, parking lots, and even residential lawns, which inhibit rainwater infiltration. Rather than soaking in, the water pours off streets, carrying pollutants picked up along the way and running into drainage pipes that often empty directly into a stream or river. Thus, impervious surfaces not only contribute to higher levels of contaminants, but they also are responsible for flash flood behavior and increased erosion (Simon and Downs, 1994).

Increased erosion is often a sign of an unstable stream, which develops when the scouring process leads to degradation or when sediment deposition leads to aggradation. Degradation results from a fall in base level, a decrease in sediment supply, or an increase in discharge. Aggradation occurs with a rise in base level, an increase in sediment supply, or a decrease in discharge (Knighton, 1998). To remain in its natural stable state, a stream needs to carry a consistent sediment load to prevent aggradation and degradation. A stream may remain in equilibrium, even as it laterally migrates, as long as the stream's bankfull width and width/depth ratio remain constant (Rosgen, 1996).

Stable streams are desirable because they exhibit low erosion rates and less flashy flood behavior. Bachman Run, a small subbasin of the Little Conestoga Creek Watershed, is experiencing rapid development that is affecting the stability of the stream and both erosion and more frequent flash floods have been observed (Figures 1 and 2).

PROJECT AREA

The headwaters of Bachman Run are located in the northeast corner of the Little Conestoga Creek Watershed in Manheim and Warwick townships. The stream's two branches drain an area of 9.9 km^2 with an average discharge of 0.15 m^3/sec. The area land use is primarily agricultural, but farmland is being converted to residential areas. A recent survey by the USGS using 1994 Landsat data, found the land use of Bachman Run Watershed to be 10% urban, 85% agricultural, and 4% forest land (Loper and Davis, 1998).

The underlying geology of the watershed includes the Cocalico Shale, Eplar Limestone and Dolomite, Stonehenge Limestone, Buffalo Springs Dolomite, Zooks Corner Dolomite, and Ledger Dolomite. The stream channel consists of cut banks, point bars, mid-channel bars, and gravel bars. The streambed is also characterized by multiple outcrops of bedrock and has been altered by human additions of dams and bridges. The channel banks and flood plains include sandy/silty loam deposits, and the

meanders range from gentle to tortuous and irregular. The confluence occurs in a recently developed neighborhood, providing an easily accessible study site to observe the morphological changes a stream undergoes in response to development.

METHODS

Cross-sections of various stream reaches were obtained using an automatic level. Longitudinal profiles of the confluence area of

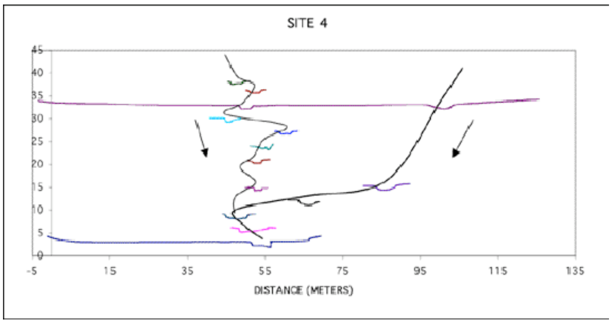

Figure 1 The sinuosity and low width-depth ratio of the west branch contrast with the straightened and more shallow channels of the east branch and main trunk.

the west and east branches were created by digitizing information from Lancaster County Geographic Information System (GIS) database (2001) and ArcView GIS. A detailed longitudinal profile showing thalweg depth, water level, channel bank, and flood plain locations was created by using a total station (TS). The depth to bedrock was found by driving a six-foot iron rod into the stream bottom sediments at the thalweg depth, and measuring the depth relative to the channel bottom and the water level. The location of the points where the bedrock was measured was established with Global Positioning System (GPS). This data was then added to the data collected with the total station to create a longitudinal profile that included bedrock depth. Aerial photographs from 1947 to 1988 and color infrared photographs from 2000 were studied to compare the morphologic changes of the stream that accompanied the land use transition from entirely agricultural to significantly urbanized.

RESULTS AND DISCUSSION

Cross-sectional data from several reaches

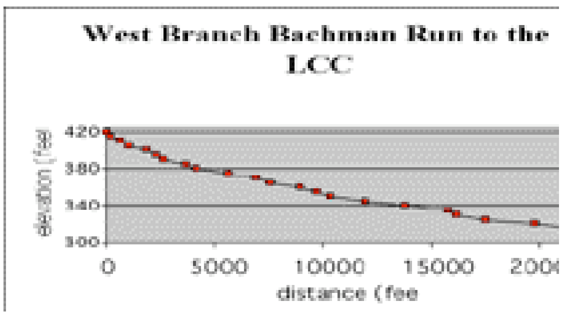

Figure 2 Longitudinal profile for the West Branch Bachman Run deviates from an expected exponential curve.

along Bachman Run show that channels in the west branch have a lower width/depth ratio than those located in either the east branch or the main trunk (Figure 1). Streams with low width/depth ratios generally tend to be less impacted and more sinuous. In addition to the lower width-to depth ratio, the west branch also had more meanders than the east branch or the main trunk, resulting in higher sinuosity values. When sinuosity was calculated using valley lengths and thalweg lengths measured in ArcView from the Lancaster County GIS database, the values for the west branch ranged from 1.18 at the headwaters to1.03 in the mid-valley to 1.29 at the confluence. The east branch sinuosity values ranged from 1.0 to 1.18 and the value for the main trunk was 1.05.

In the short duration of the project, active erosion was observed. Many residents owning property along the banks of Bachman Run mow their lawns to the edge of the stream, a practice that destabilizes the banks and limits the infiltration capacity for rainwater. Banks where riparian vegetation is allowed to remain tend to be more stable and resist erosion. A small rainfall event resulted in multiple slumps in which portions of residents' lawns fell into the stream. Large scale bank erosion and meander migration was observed from comparing old aerial photos and 35 mm snapshots taken by residents.

As erosion allows for sediment transport, it is expected that the longitudinal profiles will

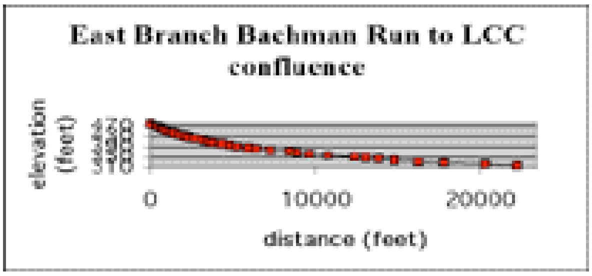

Figure 3 Longitudinal profile for the east branch of Bachman Run is closer to the expected exponential curve.

reveal a sediment wedge advancing through the watershed. Longitudinal profiles generated from the Lancaster GIS database did not provide enough detail to ascertain whether or not the wedge was present (Figures 2 and 3). However, the GIS profiles approximate an exponential curve, characteristic of a profile of a stream in its natural state. The closer the curve is to exponential, the closer that stream is to its stable state.

While constructing the cross sections, bedrock outcrops of Buffalo Springs Dolomite were observed in west branch of the stream. Core samples taken downstream of the confluence revealed bedrock of the same formation buried half a meter below the channel bed. This data combined with a longitudinal profile allowed us to compare the bedrock depth along the length of the stream, indicating the presence of a Colonial deforestation sediment wedge that is slowly being transported downstream (Figure 4).

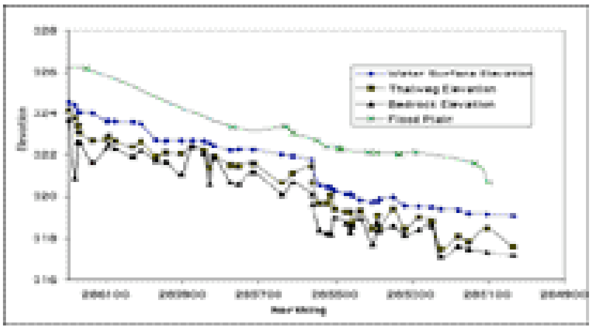

Figure 4 Longitudinal profile of the West Branch of Bachman

CONCLUSIONS

With increasing population pressures, suburban sprawl will continue as more land is converted from farms to housing developments. The amount of impervious surface in Bachman Run watershed will parallel the increase in development, resulting in larger volumes of runoff entering the stream. An increase in discharge causes several changes in stream dynamics that can already be observed in Bachman Run. One of these is flashier flood behavior due to the lower rainwater infiltration rates. Flash floods not only pose a problem for the residents who must deal with the high waters but also contribute large-scale erosion events.

Another change resulting from an increase in discharge is channel incision; incision is an indicator of a stream's instability, and a stream will continue to incise until it reaches a new state of equilibrium. Bachman Run is degrading, and is not in equilibrium. The depth to which the stream may incise is limited by the presence of bedrock near the surface. Once the post-Colonial sediment wedge overlying the bedrock is removed, the stream will most likely erode its banks and widen its channel. Although some bank erosion has already occurred, it will become much more severe once the bedrock base level is reached.

Bachman Run appears to be one of the least impacted streams in the Little Conestoga Creek Watershed, but the increase in development could easily change this. Any changes in the morphology and carrying capacity of Bachman Run directly impact the Little Conestoga Creek, Conestoga River, and the Chesapeake Bay. Thus, measures that can be implemented now in order to prevent further impact to Bachman Run should be considered so that this watershed does not become a future restoration project or contribute to the water quality problems plaguing the Chesapeake Bay.

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