Watershed Analysis of Little Turtle Basin to determine origin of daily Fluctuations in Main Station Hydrograph

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Introduction

The main gaging station at the base of the Little Turtle Basin displays daily fluctuations in gage height. The gage height rises slowly in the morning, peaks a little before noon, and then slowly declines. The most obvious source of the daily fluctuations would be the water pumped through the Sharon Wastewater Treatment Plant directly into the Little Turtle Creek. By analyzing the major tributaries separately, fluctuations may then be isolated to a particular region of the watershed to determine their origin.

Methods

The watershed was first separated into catchment areas surrounding each of the main tributaries. The watershed was examined to find possible effects on base flow, such as irrigation wells and water treatment plants. The Sharon Wastewater Treatment Plant was the only outstanding mechanism for fluctuations in stream flow.

Stilling wells were then installed at the base of the two largest tributaries, Ladd Creek and the Upper Little Turtle (ULT). Selection of a gaging site was determined by several stream characteristics. First the site must be located on a fairly straight stretch of stream with no unusual meanders. Second the site must be near a physical control, such as water flowing through a rapids area. (Carter, 1968) These controls should be downstream of the gaging site, and if possible upstream also. The Ladd Creek site had controls up and down stream. The ULT site only had a nearby control downstream.

Gage height recorders were mounted on steel cylinders, open at both ends, with several holes in the side so water could pass freely in and out. The substrate of these streams was very hard as the underlying bedrock depth was very shallow. Positioning stilling wells directly in streams is only acceptable for short term, temporary projects. One was located downstream of the railroad bridge, at the base of the Upper Little Turtle, called the Steir Station into which the Sharon Wastewater Treatment Plant flowed and the other was located at the base of Ladd Creek called the Gunnink Station.

Gage height was recorded at each station using Stevens recorders. Due to limited resources two different models were used each recording at a different scale. The Gunnink station recorder was a continuous strip-chart recorder which showed much less detail than the Steir Station, a horizontal-drum recorder. (Buchanan, 1968) Gage height was then digitized so the data could be analyzed in Kaleidagraph™ (Version 2.1, Abelbeck Software), an advanced graphing system. The Steir data was typed in manually, points were recorded for each hour. The Gunnink station, because of the lack of detail in the time verse gage height recording, was digitized using a Kurta Digitizer Tablet Model IS/ADB (Digitize™ Rock Ware Inc.). Then this data was also transferred into Kaleidagraph.

Discharge readings were taken a different levels of gage height at each site. To determine an

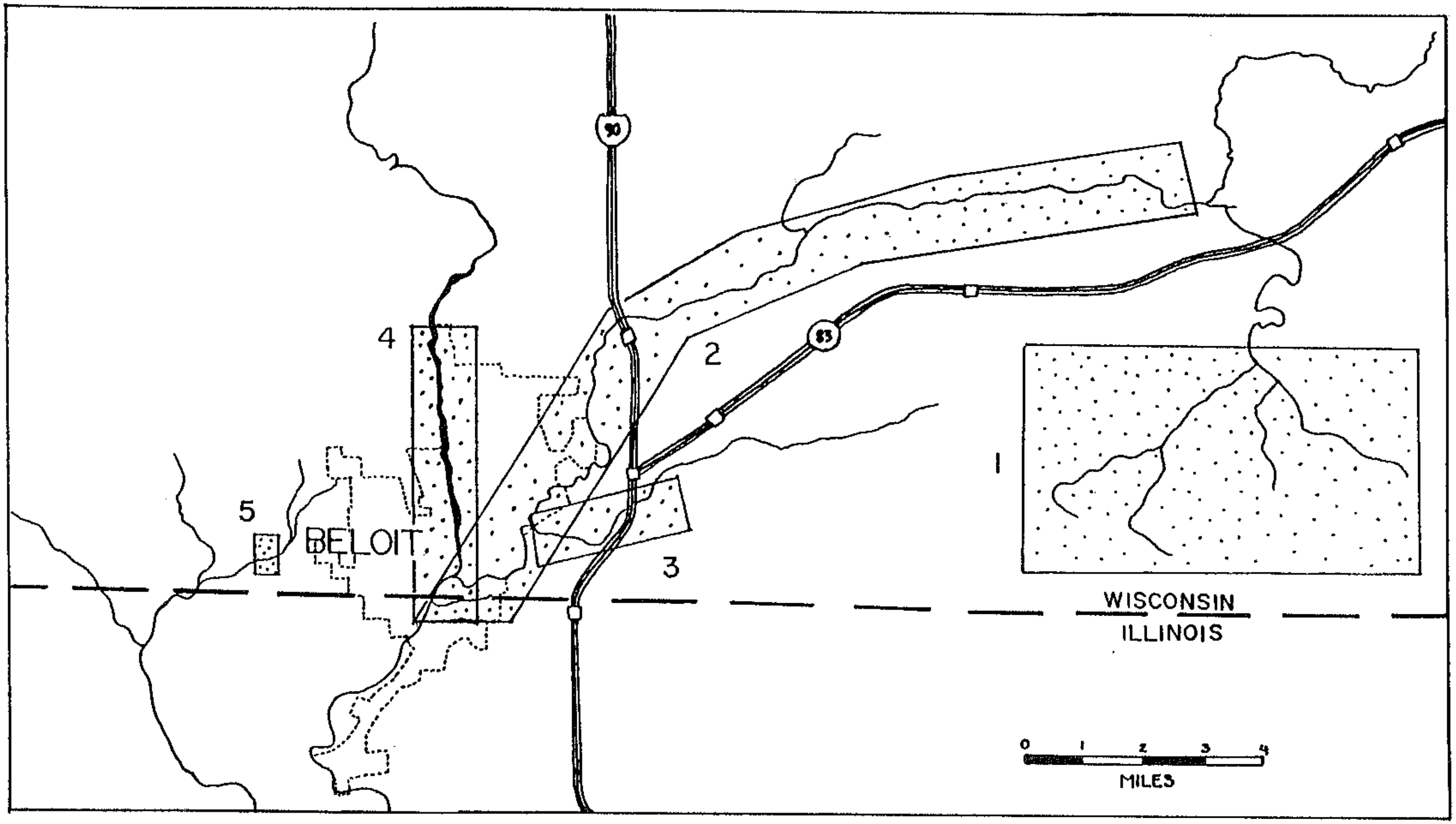

Figure 1. Hydrology research localities for the sophomore projects in south-central Wisconsin. Location numbers and research participants are: 1 - Little Turtle sub-basin, Christene Albanese; 2 - Turtle Creek, David Lund; 3 - Spring Brook, Debra Piette and Scott McMillin; 4 - Rock River, Seth Bacon; 5 - Chamberlin Springs and Raccoon Creek, LeAndra Archuleta, Veronica Diaz, Karyn Powers, and Tony Wilburn.

accurate discharge for the stream, the site of recording was divided up into 18 sections, each 20 cm in width across a profile of the stream. Velocity was recorded in each section and then multiplied by the area of the section, the product is the discharge for that section. Velocity for each individual section was found using a Price Pygmy Meter. The total discharge was found by adding up all of the discharges in each section. An example of a sectioned profile is seen in figure 1.

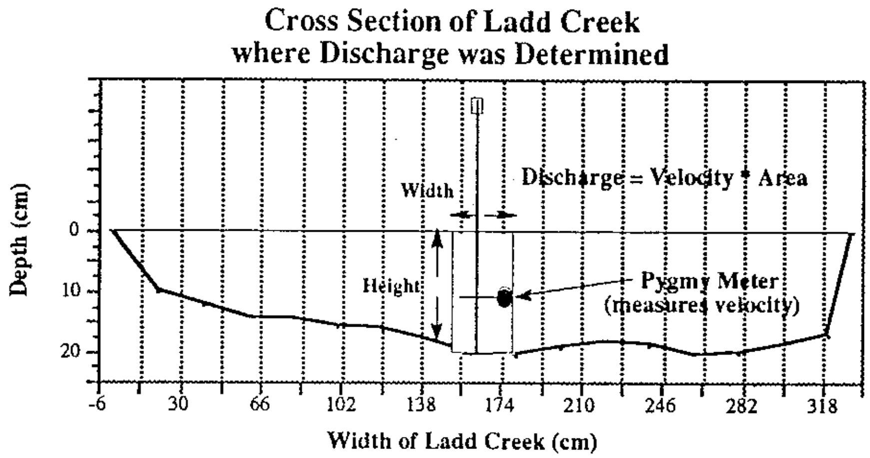

Figure 1.

The discharge readings were used to develop rating curves of gage height vs discharge. Rating curves were only based on a few points. Due to the summer dry season the streams remained at low flow rates. The Steir station was incredibly slow moving. One discharge point for each station was obtained at a high flow rate period, after a precipitation event. This lack of points made the rating curves questionable. They were only used to estimate discharge flow per gage height. The rating curves are polynomials, but since they represent only a small portion of the possible rating curve they look almost linear, they are shown in figure 2. The rating curves were then used to properly convert the gage height recordings into true hydrographs of discharge vs time. The Hydrographs were then ready for analysis.

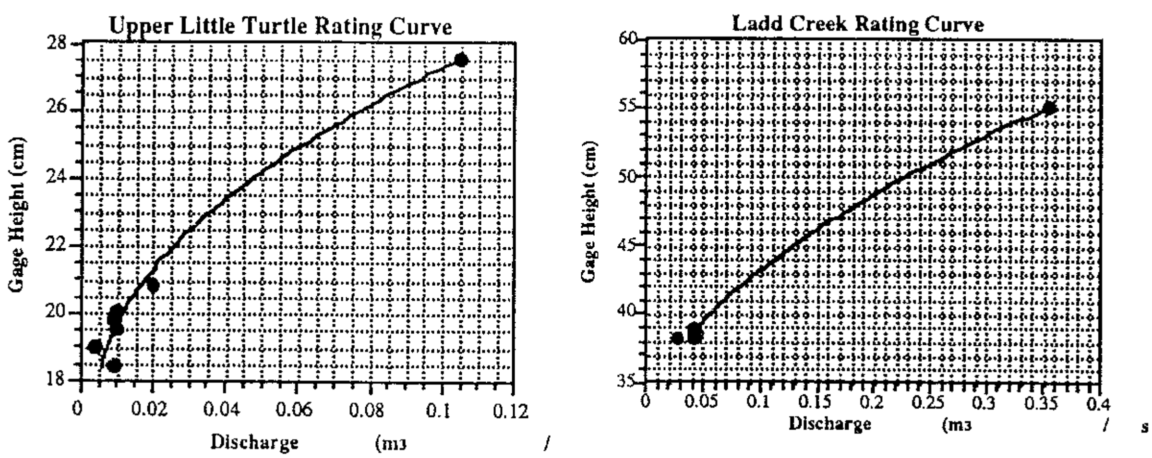

Figure 2.

The hydrographs have been analyzed up to one week after the precipitation event on July 21, 1991. For this watershed system, during the summer months, base flow is dominant. Rebound time after rain in this very dry season was very quick, less than a week. This return to "normalcy" is represented by the similar levels of base flow before and after the precipitation event. The hydrographs created for Ladd Creek and the Upper Little Turtle are shown in figure 3.

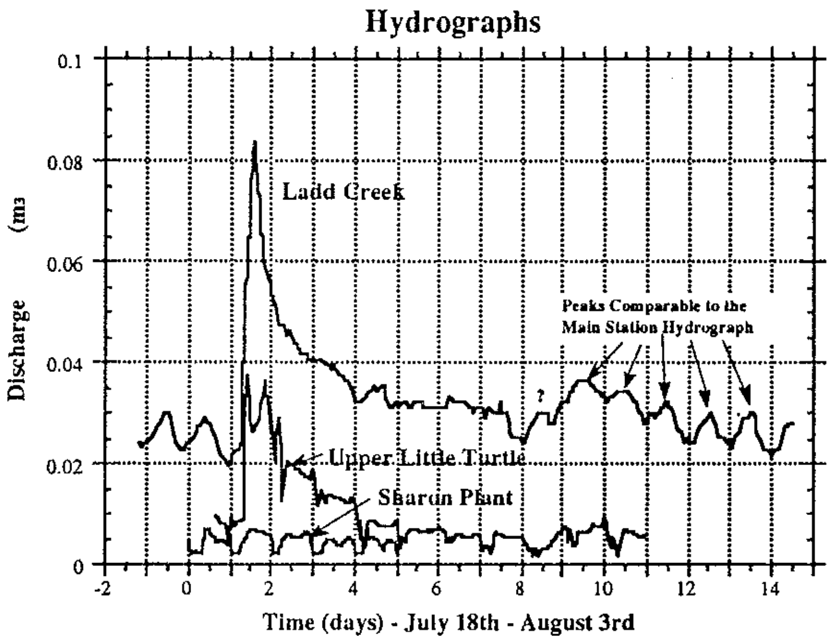

Figure 3.

The Sharon Waste Water Treatment Plant records its daily discharge into the Upper Little Turtle on circle graphs. Conversion of these circle graphs into similar hydrographs was needed to compare flow rates from the Plant with the base flow downstream in the Upper Little Turtle. The conversion was done manually, points were taken every half hour. Only a few days were converted to give a general idea of what part of the base flow was made up of water from the town of Sharon. This "hydrograph" is seen compared to its downstream gaging station in figure 3.

Discussion

There seems to be some similarities in the patterns of flow from the Sharon Wastewater Treatment Plant and through the stretch of stream past the Steir Station. There are definite dips in the flow rates in the early morning which are also recorded in the Steir hydrograph about a 4.5 miles downstream a few hours later. There are many aspects of the upper Little Turtle Creek which may effect the patterns of flow through the Steir Station.

The upper Little Turtle is made up of many areas of ponded water, areas of running water, and at least one large area which holds water as a small reservoir by a beaver dam. The Creek is by no means consistent in its flow. All of these effects may in some way contribute to the "agitated" hydrograph recorded at the Steir Station.

Ladd Creek fluctuates daily which is especially well seen on the two days before the precipitation event, July 19 and 20 and the last six days of recording, July 29 - August 3 . These fluctuations were unexpected observations only found upon careful analysis of the small scale gage height recording. There is no agricultural irrigation system in this region and also no pubic or industrial wells were observed in the Ladd Creek watershed.

Conclusions

Because of the summer season the watershed was flowing at minimum flow rates. The lack of precipitation events allowed the observation of base flow conditions and of the watersheds reaction to a singular event. It is shown that the Sharon Wastewater Treatment Plant makes up only a very small part of the total hydrograph recorded at the main station as seen in figure 3.

It has been shown that fluctuations are occuring in both of the major tributaries, not just in one of them, as a result of the Sharon Plant. The fluctuations in Ladd Creek are far more comparable to the main station fluctuations than the Upper Little Turtle fluctuations. They are similar in pattern and consistency. It is also peculiar that the Ladd Creek hydrograph peaks at noon and is low at midnight because it rules out the simple explanation of daily evapotranspiration, especially in a dry hot summer. Therefore, the daily fluctuations in the main station hydrograph of the Little Turtle Basin are coming from the Ladd Creek tributary, exact cause unknown.

References

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SEDIMENTARY BEDFORMS OF RACCOON CREEK-BELOIT, WISCONSIN

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INTRODUCTION

The purpose of this study is to determine factors governing the development of ripples on the bed of Raccoon Creek in the Chamberlin Springs area of southern Wisconsin, latitude 42°, 31' North, longitude 89°, 6' West. The height and wavelength of the ripples were measured, and compared to the water depth, velocity, and discharge. Five sampling locations were chosen and a map constructed to show their relative positions. General sediment samples were collected on three occasions at each site, along with specific samples from the crests and troughs of the ripples, and were subsequently subjected to grain size analysis.

MATERIALS AND METHODS

Velocity and depth measurements were taken at each of the five sites with the use of a Pygmy meter. Spacing of the readings was between 30 and 50 centimeters at each cross section. Each of the five sites were mapped along Raccoon Creek and were within a distance of 34 to 65 meters of one other. Wavelength and height measurements of ripples were carefully taken by using standard metric rulers.

Sediment samples were taken by using a piston-type bed-material sediment sampler, US BMH-53 (for the general site), and a pipette for the specific sediment samples (i.e. samples from the troughs and crests of the ripples). Grain size analysis for each sample was completed by first drying each sample at 110° centigrade and then by using a RoTap to sieve the samples.

The following references were used generally for my research: Folk, R.L., 1974, Tucker, M.E., 1981, 1982.

DISCUSSION

Ripples are formed in fluvial environments by transportation of sediment and they are especially useful when studying sedimentation and stratigraphy. Rippled layers of sediments are commonly preserved in the geologic record and provide excellent bed form geometry that is easier to examine than that of larger scale cross stratification. The layer directly below a rippled surface possesses stratification that can commonly be interpreted as the result of the moving bed forms. In addition, ripples and their related stratification may provide a very detailed record for studying hydrodynamics.

Ripple formation results from mainly two factors: velocity of the stream and grain size of the sediment. If for example, there is a slight increase in wavelength with increasing flow velocity, the main control on ripple size is the grain size of the sediment. Coarser sand gives way to larger ripples (i.e. larger wavelength). The ripples studied here, which are formed by the current of the water, are formed in sediments which for the most part, are not coarser than 0.6mm (coarse sand). Ripples which are formed in sediments finer than 0.6mm in diameter, form asymmetrical ripples almost immediately (Collinson and Thompson, 1982, p.59-68). The average grain size of the sediment forming the ripples being studied here is between 3.0 phi and 1.0 phi (0.125mm to 0.50mm). This means that most of sediments are of fine to medium sand.

There is no significant difference between the sediments in the trough of the ripple and the crest. However, it seems as though there are coarser sediments caught in the trough. Perhaps this is because the grains in the troughs are closer packed, while the packing is looser in the crests. The grain size analyses show no distinct increase of coarser sediment within the troughs. The mean grain size, represented by cumulative curves (although not shown here), is still fine to medium sand (3.0 phi to 1.0 phi (0.125mm to 0.50mm)).

Ripples with highly sinuous crests such as these, usually have asymmetrical profiles. They have steeper concave-upward lee faces and more gently sloping convex-upwards stoss sides. This is the result of the currents flowing in one direction only (Collinson and Thompson, 1982, p.59-68). Research done on similar environments has shown that as the velocity increases, ripples become more rounded and flatter, and the wavelength increases somewhat. However, an increase in wavelength only reflects the measurements of the third day of data gathering (07/30/91)-seven days after a rainfall. It has also been shown that the height of ripples formed at low velocities appears to be smaller (lesser). The data here suggest that both the height and the wavelength tend to increase at lower velocities. These parameters may be controlled by sediment size and seem especially true for the first day of data (07/17/91). The grain size at the lower velocities is coarser than 1.0 phi (0.50mm), and as stated before, coarser sediment forms larger ripples.