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GEOG 3511

Lab 6 - Stream Gauging: Float and Velocity-Area Methods

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Abstract

The scientific study provided below is a statistical and methodical analysis of discharge measurements. A section of Boulder Creek in Boulder, CO is the hydrological feature to be analyzed. There are two main methods of data collection which are in comparison: the float method, and the velocity-area method. Using both methods, and comparing them directly to established scientific measurements, we can draw conclusions about which method can provide us with better approximations. Generally speaking, it was hypothesized that the velocity-area method would give us the most accurate measurements, and that these measurements would resemble the Mile-High Flood District's (MHFD) measurements. Additionally, a section of this lab report is dedicated to addressing certain aspects which may prohibit or convolute our measurements. Some of these aspects can be found in pollution, time of day, and season of the study. In regard to the results found, our hypothesis turned out to be correct in both aspects. The discharge data closer resembled the MHFD rates, and the velocity-area method served as the better method for study. These conclusions can lead us to more research questions to investigate, as well as provide us with a better understanding of the hydrological features located in Boulder, Colorado.

Introduction

This weeks' study was an analysis of discharge data and methods of measurement. Discharge data is important for multiple reasons, namely how it affects people downstream. In many areas around the world, people live in close proximity to rivers, and much of their life relies on it. By knowing the most appropriate methods for measuring discharge, as hydrologists we can potentially have positive impacts on lives around the world. Our measurements for this study were conducted in Boulder Colorado, on a small section of Boulder Creek. An important component of today's lab is comparing our measurements to those of established data centers, such as the United States Geological Survey (USGS) and the Mile High Flood District (MHFD). Based on certain aspects of these data centers, such as proximity and river composition, our data **should be closer to that of the MHFD**. This is mainly due to the fact that the MHFD center is very close to where we took our measurements, especially in reference to that of the USGS center. This close proximity essentially means that our section of the creek doesn't have any **additional tributaries** to that of the MHFD section and is practically the **same section** of the creek. The USGS center, however, has more tributaries and we would therefore expect it to record a higher discharge.

In regard to the methods which we used; I would expect the velocity-area method to be the most accurate for our section of Boulder Creek. This method provides a more in-depth analysis of almost every aspect of the study. The other method in practice, the float method, is better suited for low-velocity streams and shallow waters. Our section of the creek, while it may not be deep when compared to other major rivers, isn't shallow by any means and exhibits reasonably quick surface velocity.

Methods

This study was conducted at the corner of 17th and Athens Street in Boulder Colorado on Monday, October 14th, 2019. The stream itself is lined by trees on both sides, leading all the way up to the corner of Broadway Street and Arapahoe Avenue. The trees aren't densely packed, but all of them are leaf bearing and therefore shed those leaves in the Fall season. Some of these trees are in fact dying or already dead, which adds a component of obstruction and will be discussed later on in this lab report. The section of stream that we measured branches off from the rest of the creek at the corner of Arapahoe and Broadway. Two additional measurement stations are also addressed in this study: USGS and MHFD (see fig. 1.1).

Additionally, the surrounding area has multiple places which exhibit a high frequency of people on a day to day basis. Two prime examples of these places are **Boulder High School** and **the University of Colorado Boulder**. These two schools have high concentrations of students year-round, especially in the Fall and Spring semesters. A walkway leading away from the University's campus is very close in proximity to where we took our measurements. Another component of this high concentration of people is **downtown Boulder**, which is roughly 700 feet away (Google maps). Leading up to downtown Boulder is a very popular bike path which follows the creek for the majority of its length within the city. During our measurements, a completely intact bike was found in the stream, with both wheels attached. In regard to the weather and season of which our study was conducted, our measurements were taken under clear skies in the Fall season around 2 pm. The week before our study was conducted, Boulder CO received approximately 3.3 inches of snowfall on Thursday, October 10th. This aspect, however, most likely had little impact on the study, considering most if not all of the snowfall had already been runoff.

Figure 1.1: Pictured above is a map of discharge measurement centers: USGS (red), MHFD (black), and the location of our data collection (blue).

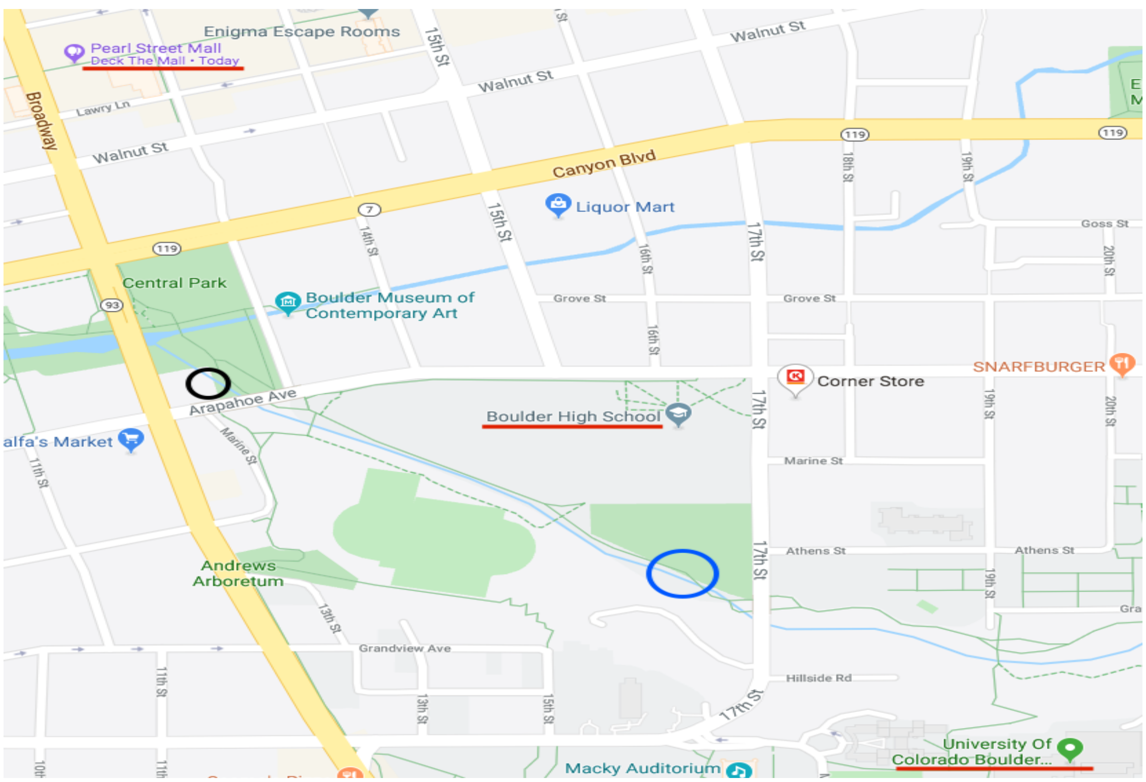

Figure 1.2: Pictured above is a close-up map of where our measurements were taken (blue). Additionally, Boulder High School, Pearl St. Mall (downtown Boulder), and CU Boulder are marked (red underline).

In regard to the statistics of the study, there were two main methods to calculate discharge: the **float method** and the **velocity-area method**. The main principle of both methods is very similar, but the execution is slightly different. For the float method, the first step was to find the depth (m) at each point using marks on our current meter, and length (m) of the stream using a tape measurer. The product of the **length (l)** and **average depth** (d) will give us a fairly accurate estimate of the cross-sectional area (A): $A(m^2) = l(m) * d(m)$ To find the velocity using the float method, a buoyant object is placed in the water a known distance away (around 10 meters). We then measured how long it took the object to travel down the known length. The velocity for an individual trial is simply the distance divided by the time it took to travel that distance (m/s): $V\left(\frac{m}{s}\right) = \frac{10(m)}{t(s)}$

Once the average velocity for 10 trials was found, we multiplied it by the approximate stream area to get the average discharge (Q): $Q\left(\frac{m^3}{s}\right) = V\left(\frac{m}{s}\right) * A(m^2)$

The velocity-area method is very similar to the float method, with a few minor alterations. In this method, both depth *as well as* the width were measured multiple times across the stream. Following these measurements, the velocity was measured for each subsection using a **pygmy** meter. A pygmy meter utilizes a wheel of sorts at the bottom of a long pole. The wheel is connected to a pair of headphones, and outputs an audible clicking sound every time the wheel completes a full rotation. Using the following equation, clicks per second (R) can be converted to velocity in meters per second: $V\left(\frac{m}{s}\right) = \left((0.9604 * R) + 0.0312\right) * 0.3048$ Once the velocity for each subsection was found, the average of the summation of these values resulted in the class average discharge (using the velocity-area method).

Results and Figures

The only measurements which we found that are not displayed in figures and tables below are the following: the average surface velocity for the entire class using the **float method** is $23.64\frac{ft^3}{s}$, and is $6.543\frac{ft^3}{s}$ using the velocity-area method.

Float Method

Table 1.1: The float method measurements for group 1. **Note:** our group only had time to complete 5 out of the 10 trials.

Velocity:			
Trial*	**Distance (m)**	**Time (s)**	**Velocity (m/s)**
1	10	14.57	0.6863
2	10	15.66	0.6386
3	10	15.04	0.6649
4	10	14.63	0.6835
5	10	16.23	0.6161
		Average Surface Velocity:	0.6579

Table 1.2: The average velocity for each group (float method) along with the differences between group 1 and the rest of the groups. Pictured in green is group 1's data (my group).

Other Groups Average Velocity		
Group #	Velocity (m/s)	Difference
1	0.6579	0
2	0.2741	0.3838
3	0.6338	0.0241
4	0.2349	0.4230
Class Avg.	0.4502	0.2077

Table 1.3: The standard deviations for each group (float method) along with the standard deviation for the entire class. Pictured in green is group 1's data (my group).

Standard Deviations	
Group #	St. Dev.
1	0.0301
2	0.0499
3	0.0900
4	0.0244
Entire Class	0.2029

Velocity- Area method

Table 2.1: Group 2's data for velocity-area method. Pictured in blue is the sum discharge measured in cubic feet per second (ft^3/s), and in orange is the sum discharge measured in cubic meters per second.

Cross-section 1:	Group 2		
Width (m)	**Depth (m)**	**Velocity (m/s)**	**Discharge (m^3/s)**
0.4267	0.2	0.1266	0.0108
1.0973	0.2	0.2876	0.0631
0.4267	0.2	0.1705	0.0146
0.7925	0.14	0.1339	0.0149
0.7925	0.14	0.2144	0.0238
0.7315	0.12	0.2071	0.0182
		Sum Discharge (**m^3/s**):	0.1453
		Sum Discharge (ft^3/s):	5.1312

Table 2.2: Group 3's data for velocity-area method. Pictured in blue is the sum discharge measured in cubic feet per second (ft^3/s), and in orange is the sum discharge measured in cubic meters per second. Additionally, the class average discharge (velocity-area method) is pictured at the bottom of the table in green in cubic feet per second.

Cross-section 2:	Group 3		
Width (m)	**Depth (m)**	**Velocity (m/s)**	**Discharge (m^3/s)**
0.8	0.21	0.1925	0.0323
0.3	0.2	0.4632	0.0278
0.5	0.18	0.3681	0.0331
0.2	0.19	0.6096	0.0232
0.2	0.195	0.5145	0.0201
0.5	0.2	0.6096	0.0610
0.3	0.2	0.4632	0.0278
	Sum Discharge (**m^3/s**):		0.2252
	Sum Discharge (ft^3/s):		7.954
	Class Average Discharge (ft^3/s):		6.5428

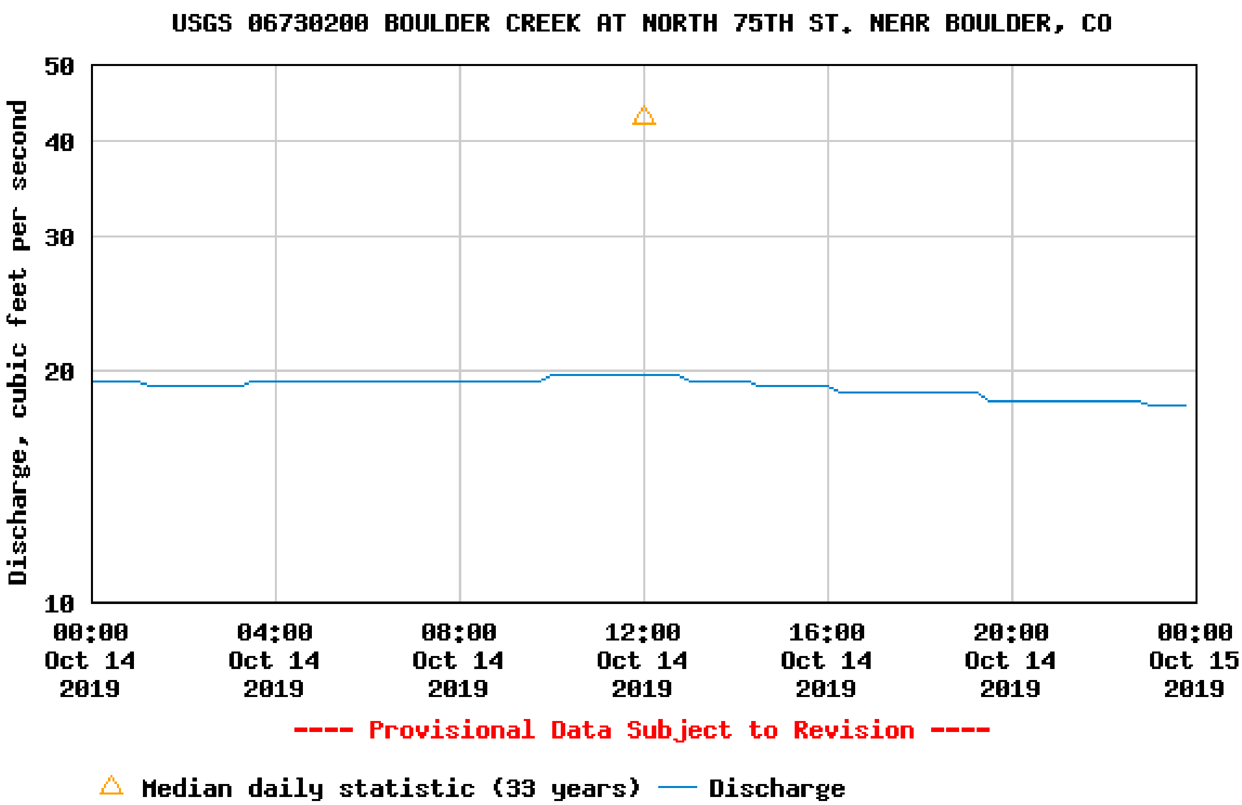

Figure 2.1: USGS discharge measurements (ft^3/s) recorded on October 14th, 2019 at a similar time to which we were making our measurements. Data collection center is located at N. 75th Street. The x-axis is time, pictured in military time.

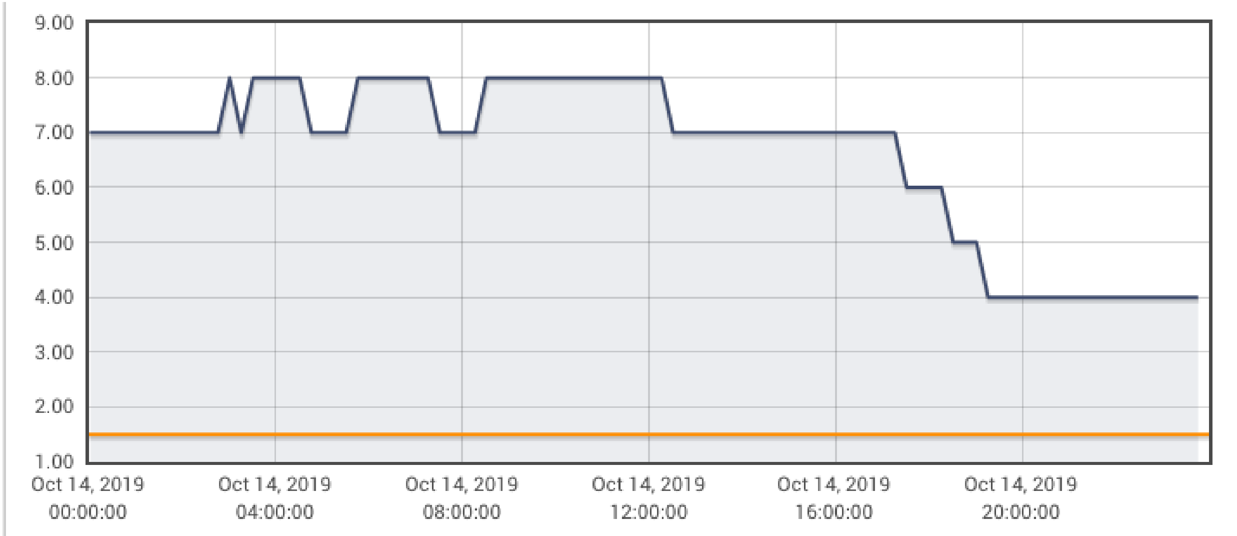

Figure 2.2: MHFD discharge measurements (ft^3/s) recorded on October 14th, 2019 at a similar time to which we were making our measurements. Data collection center is located near the junction of Broadway and Arapahoe Ave. The x-axis is time, pictured in military time.

Discussion

In conjunction with the data provided above, it was found that the aforementioned hypothesis was correct. Our class discharge value for the velocity-area method (6.543 cfs) was very close to that of the MHFD (about 7 cfs) and differed greatly from the USGS data which was noticeably higher (23.64 cfs). The float method, while it serves a good purpose for estimations, was not very accurate in determining surface velocity and therefore discharge. Our data sets for this method were much higher than those of the velocity area method. This viewpoint is mainly due to the nature of both methods. The float method is generally an estimate, and a fairly large amount of uncertainty accompanies it. This uncertainty comes in the form of many things, such as stream convergence causing a higher surface velocity, and certain objects floating downstream faster than others. While the float method doesn't require an extensive amount of equipment, it is easily implemented compared to the velocity area method. The latter, however, is much more in-depth and provided a more accurate measurement of our creek. There are still many uses for the float method, such as situations where an estimate may be encouraged. Closely following a flooding event, a general estimation can help city hydrologists make general conclusions about the impact the flooding may have.

Additionally, the setting of discharge study is very important. In our study, the section of Boulder Creek which we analyzed was in an area of high concentration of people. This aspect may cause a slowing of velocity and therefore discharge mainly based off pollution. A prime example of this pollution can be found in the bike which we found in the stream. While it didn't stop the stream entirely, it definitely had an impact. In regard to this aspect of pollution, it is beneficial for hydrologists to also get an analysis outside of the city, where pollution is less common, and discharge should be higher.