

FY19-20 DWRC Undergraduate/Graduate Water Research Students

Undergraduate Intern	Advisor	Major	Research Topic
Sicily Bordick	Anastasia Chirnside	Environmental Engineering	Optimization of HPLC Analysis of Ergosterol to Quantify Fungal Biomass within Solid State Bioreactors utilizing Varying Support Materials
Zach Burcham	Anastasia Chirnside	Environmental Engineering	Optimization of HPLC Analysis of Ergosterol to Quantify Fungal Biomass within Solid State Bioreactors utilizing Varying Support Materials
Ji Zhendong	James Pizzuto	Environmental Science	Discriminating between Mill Dam and Flood Deposits along the White Clay Creek
Justin Leary	Gerald Kauffman	Environmental Engineering	Characterization and Monitoring of Headwater Streams in the White Clay Creek Watershed
Savanah Love	Stephanie Stotts	Wesley College Environ. Science	Interactive art exhibit focused on salinification of wetlands
Aaron Nolan	Gerald Kauffman	Environmental Engineering	Coastal Flood Planning and Response for Transportation Infrastructure
Polly Ni	Andrew Homsey	Environmental Engineering	Brandywine Piedmont Watershed Stream Monitoring and Habitat Assessment
Luke Stirparo	Gerald Kauffman	Environmental Engineering	Effects of Road Salt and Winter Deicing Agents on Delaware Stream Systems
Michaela Dougherty	Martha Narvaez	Energy and Environ. Policy	Energy Water Nexus and Water Supply Withdrawals in Delaware Watersheds
Undergraduate Student	Gerald Kauffman	Public Policy	Economics and Cost Effectiveness of Watershed Restoration in Delaware Coastal Plain Streams
Matt Kirchman	Andrew Homsey	M.S. Energy and Environ. Policy	White Clay Creek Water Quality Modeling
Kelly Jacobs	Martha Narvaez	M.S. Energy and Environ. Policy	Economic Value of the Nanticoke River Watershed in Delaware and Maryland

Optimization of Hydrogen Peroxide Analysis to Quantify Enzyme Activity within Bioreactors

Sicily Bordrick, Environmental Engineering, DWRC Intern
Dr. Anastasia E M Chirnside, Advisor
Sivaranjani Palani, Graduate student advisor

Abstract

White rot fungus can be used to kill harmful bacteria and pathogens that are found in manure waste. *Pleurotus ostreatus* and *Phanerochaete chrysosporium* can be used to remove *E. coli* in manure waste. The fungi produce hydrogen peroxide and ligninolytic enzymes such as lignin peroxidase and manganese peroxidase when degrading recalcitrant compounds and possibly *E. coli*. Using bioreactors that contained woodchips, fungi, and liquid manure waste spiked with *E. coli* and collecting liquid samples from the bioreactors over a ten-day period, I was able to test for hydrogen peroxide. Using spectrophotometry, I found that there was hydrogen peroxide in the liquid samples. The presence of hydrogen peroxide shows that the fungi was in ligninolytic activity and producing the enzymes.

Introduction

Certain white rot fungi are capable of killing bacteria that is present in manure waste. Animal manure is a biological soil amendment and can contain bacteria and pathogens such as *Salmonella*, *Escherichia coli*, *Listeria*, *Giardia*, *Cryptosporidium*, and *Campylobacter* (Meals and Braun, 2006). White rot fungi are wood decaying fungi that produce enzymes such as Lignin Peroxidase and Manganese Peroxidase and are capable of extensive degradation. White rot fungi are able to degrade recalcitrant contaminants such as antibiotics and their residues and have been used to remediate contaminated soils. The white rot fungus *Pleurotus ostreatus* can be grown in small bioreactors. It was able to reduce the number of *E. coli* naturally present in aqueous dairy manure. Another white rot fungus, *Phanerochaete chrysosporium*, grown in a non-sterile bioreactor was able to degrade antibiotics and other pharmaceuticals (Wen et al., 2009; Zhang and Geiben, 2012). Currently research is being done on bioreactors containing both *P. chrysosporium* and *P. ostreatus*. They are being evaluated for their ability to degrade *E. coli* and antibiotics within aqueous dairy manure. The predation and degradation behavior of the white rot fungi is also under investigation. The exact mechanism that the white rot fungi use to reduce the numbers of *E. coli* within the bioreactors is unknown. The reduction could be related to their secondary metabolism responsible for their ligninolytic activity. During lignin degradation, the white rot fungi produce non-specific, oxidative extracellular enzymes that degrade the lignin structure. The white rot fungi also produce hydrogen peroxide, which activates the enzymes during ligninolytic activity. These enzymes may be involved in *E. coli* degradation or the production of hydrogen peroxide (H_2O_2), which has antimicrobial properties, may be the mode of action for the reduction. The fungal mycelium may also act as a physical filtration mechanism to reduce the *E. coli* within the bioreactors. In a study working with the white rot fungi *Daedaleopsis confragosa*, *Pleurotus eryngii*, and *Piptoporus betulinus*, Umstead measured hydrogen peroxide production within bioreactors treating wastewater spiked with *E. coli*. All of the white rot fungi removed *E. coli* from the wastewater and significant concentrations of hydrogen peroxide was produced by all of the white rot fungi.

The objective of this research is to monitor the fungal bioreactors during treatment of dairy manure containing *E. coli* for both Lignin Peroxidase, Manganese Peroxidase, and hydrogen peroxide in order to ascertain the mode of action the fungi uses to degrade the *E. coli*. During measurement of H_2O_2 , the orange color produced by the hydrogen peroxide is measured and related to standard concentrations of hydrogen peroxide. The ligninolytic enzymes will also be monitored in the extracellular solution by standard enzyme assays.

Methods

10 bioreactors were set up and each one contained woodchips, live fungi, and manure spiked with *E. coli* (Figure 1). The first three were set up with Treatment 1, which contained live fungus and manure spiked with *E. coli*. The next three were set up with Treatment 2, which contained autoclave fungus on the support media and manure spiked with *E. coli*. The last three were set up with Treatment 3, which contained autoclaved support media and manure spiked with *E. coli*. The last bioreactor was used as the negative control and contained autoclaved support media and uninoculated manure. The experiment lasted 10 days. Liquid samples were collected from each bioreactor on day 0, 1, 3, 5, 7, and 10. The samples were then diluted with water 50:1 milliliter and stored for hydrogen peroxide and enzyme analysis.

Figure 1. Experimental set up with treatments 1 through 4 shown on the top from left to right.



For hydrogen peroxide analysis, a reagent solution was made consisting of 1 ml of ferrous ammonium sulfate in 0.25 M sulfuric acid and 99 ml of xylenol orange solution. Four milliliters of the reagent were added to a spectrophotometer tube containing two milliliters of diluted liquid sample. After a time period of thirty minutes for the reagent to react, the samples were read on a visible spectrophotometer at a wavelength of 580 nanometers and the absorbance was recorded. The results were compared to a standard curve of hydrogen peroxide concentration versus absorbance. Figure 2 is a standard curve used for the hydrogen peroxide measurement, where H₂O₂ concentration versus absorbance at 580 nm is plotted and the resulting regression curve is used to determine H₂O₂ concentration of the unknown samples. The regression equation is as follows: $y = 0.3265x - 0.0225$ where y is the absorbance measurement and x is the concentration of H₂O₂, and the R² value is 0.9899.

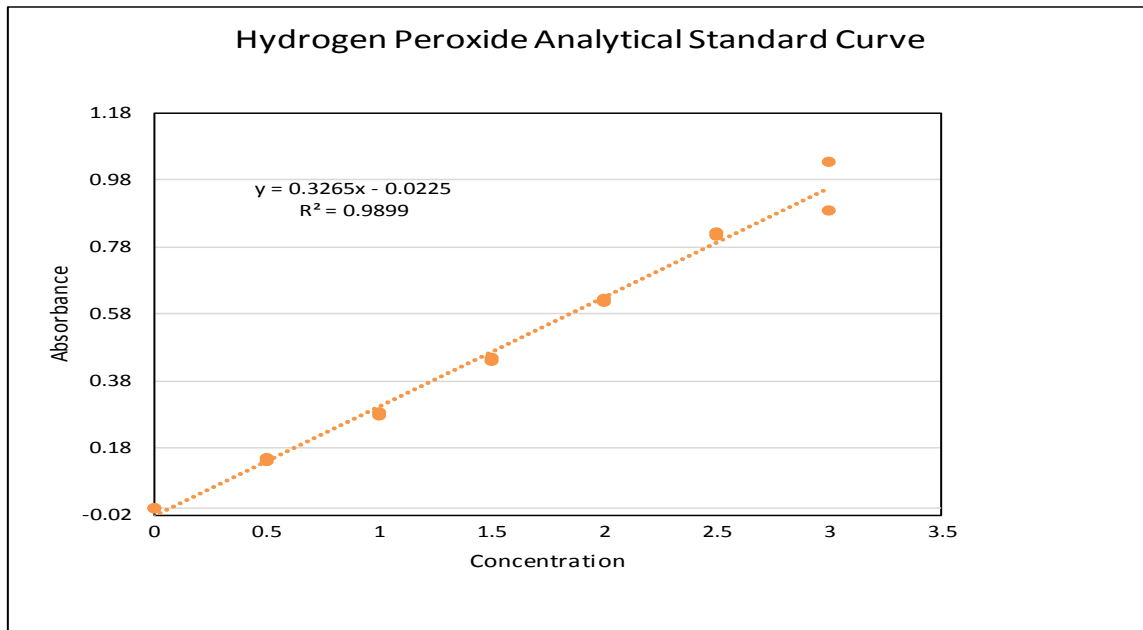


Figure 2. Standard curve for hydrogen peroxide colorimetric analysis.

Results and discussion

After measuring the absorbance, I found that over the ten-day period there was an increase of hydrogen peroxide in the samples for Treatment 3, which did not contain the fungus (Figure 3). The concentration of H₂O₂ remained constant in the inoculate and non-inoculated manure influents.

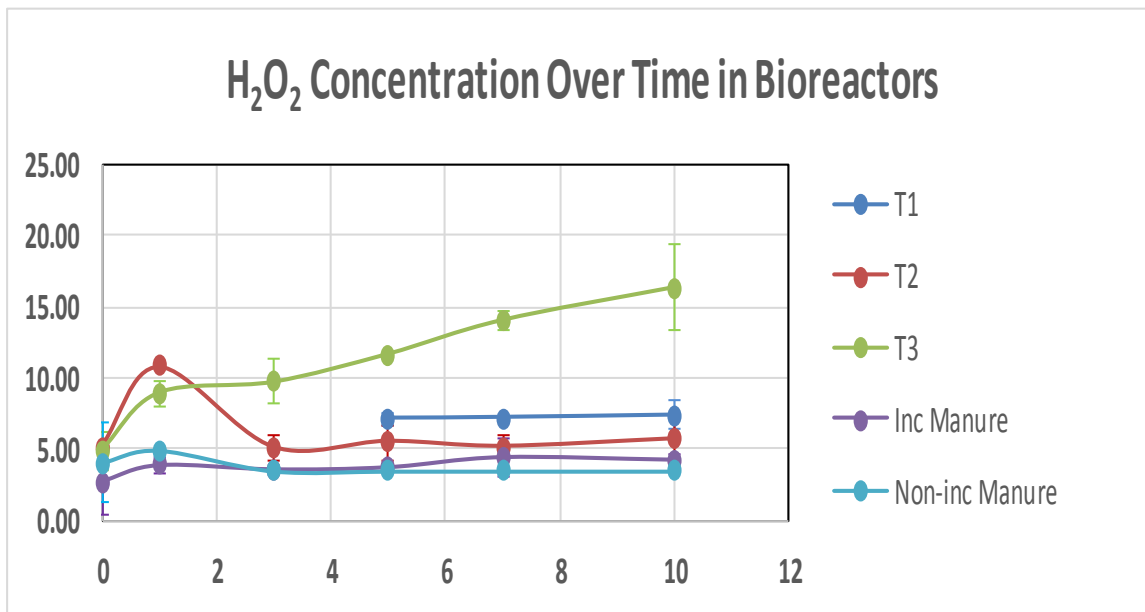


Figure 3. Production of Hydrogen Peroxide over time in bioreactors.

Due to the pandemic, I was not able to complete the analyses and some data is missing for Treatment 1, which is the treatment with the live fungus. The concentration of H₂O₂ remained steady from day 5 to 10 for Treatment 1, while the concentration increased over time for Treatment 3 containing no fungus. This may be due to interferences in the manure affecting the analysis. The live treatment showed a decrease in the concentration of organic compounds (data not shown) indicating that the fungus was degrading these materials and the H₂O₂ produced was utilized to activate the ligninolytic enzymes. Treatment 3 had the biggest increase in hydrogen peroxide over the time period of ten days. Due to COVID-19, I was not able to run more trials or test the collected effluent from the bioreactors for enzymes, therefore we can't correlate the H₂O₂ concentration to the enzyme activity.

Conclusion

The presence of hydrogen peroxide in treatments 1 and 2 indicates that the white rot fungi may have been producing the ligninolytic enzymes. The lack of data hinders our ability to make concrete conclusions on the work done. In the future I would want to run enzyme tests using kinetics to find out the amount of these enzymes in the samples. I also would repeat the experiment so that we have the full data set of the collected samples.

References

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Optimization of HPLC Analysis of Ergosterol to Quantify Fungal Biomass within Bioreactors

Zach Burcham
Advisor: Dr. Chirnside
Graduates: Siva Palani, Aubrey Inkster

Abstract & Goals

-Determine the relationship between fungal biomass and ergosterol concentration for two kinds of fungi

-Use HPLC analysis of standards to develop a standard curve.
(Methanol solvent, 282 nm)

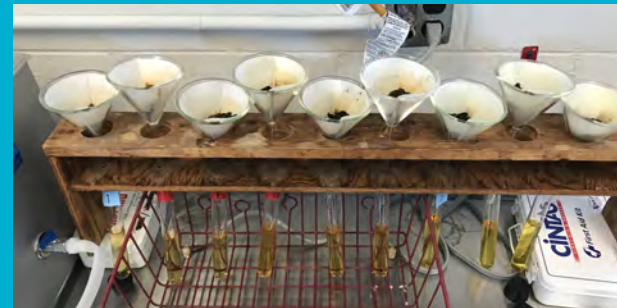
-Take samples from fungus over time (liquid media) for ergosterol extractions

-Analyze the ergosterol concentration over time using the curve, compare to overall biomass over time

Procedure

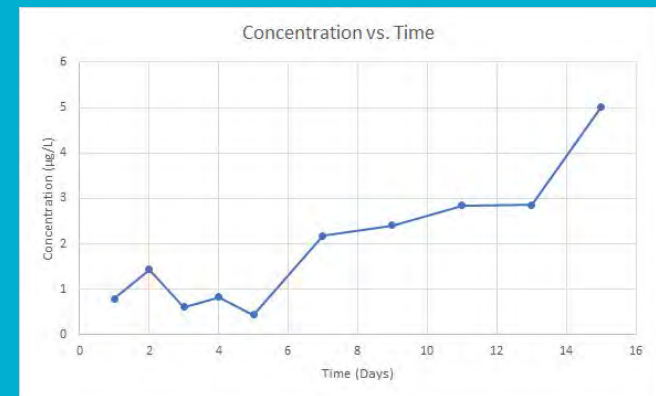
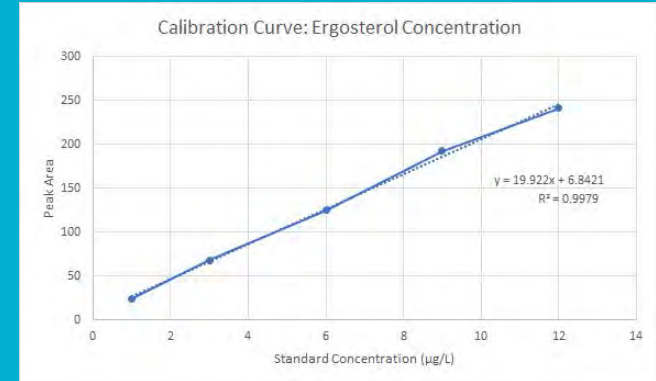


Pictured: Extraction process of P.C. from growth on an inert media



Pictured: Filtering process of samples for extraction

Data



Discriminating between Mill Dam and Flood Deposits
along the White Clay Creek
Research Advisor: James Pizzuto
Research Student: Zhendong Ji

Abstract

Before the European settlement of the mid-Atlantic region, river valleys consisted of wetlands (Walter and Merritts, 2008) and subaerially exposed floodplains (Jacobson and Coleman). These environments developed just a few tens of centimeters above channel the channel bed, so pre-settlement valleys exhibited much less relief than at present. As settlement progressed, the sediment deposits on floodplains and wetlands increased dramatically, creating a deposit to 2 meters thick of silt, clay and fine sand. Recent research has demonstrated that these processes continue today.

Erosion of these deposits has been cited as a water quality problem, as they are often cited as the primary source of fine-grained suspended sediment delivered to impaired water bodies, and they may also contain, and therefore supply when eroded, nutrients such as phosphorus and heavy metals such as mercury and zinc (Walter and Merritts, 2008).

Management schemes to address the erosion of these “legacy” deposits, however, is humped by an ongoing scientific controversy regarding their origin and spatial distribution. One hypothesis suggests that these deposits are solely caused by sedimentation in impoundments that developed behind colonial-age water-powered mill dams (Walter and Merritts, 2008), while Jacobson and Coleman (1986) suggest that the sediments were deposited on floodplains during overbank flow events. Neither of these authors consider that deposition by contemporary floods is important, but recent measurements suggest otherwise (Pizzuto et al., 2016). Resolving this issue is important, because understanding of the origin of these deposits and their ongoing evolution is key to mapping their occurrence and designing appropriate watershed management strategies (reference STAC report).

Location

There are several existing mill dams in the area of research, which is in the White Clay Creek Watershed. This study focused on the one that is located at the upstream of the town of Landenburg.

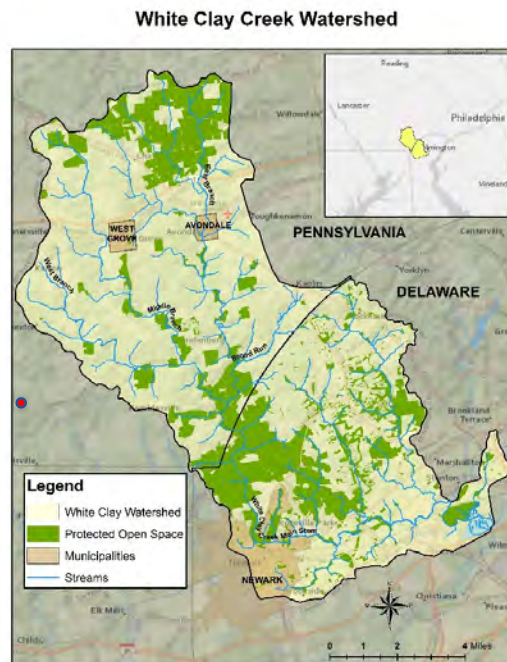


Figure 1: Red dot on the map shows the study area in Landenburg

White Clay Creek is considered as one of the most important resources for drinking water in the surrounding areas. It is crucial and helpful to understand what caused the buildup of deposition in this area and how does it affect the water quality.

In this study, total of six samples are taken along the stream where the mill dam is.

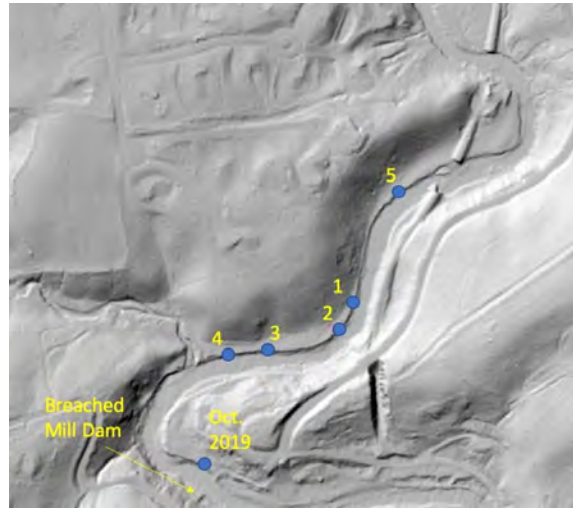


Figure 2: Six sample sites within the research location

Each sample have different distance from the mill dam. This helps to find out the change of deposit composition when it moves further from the mill dam.

Methods

Based on the measurement and observation at the river bank, it has a height around three meters. In order to observe the different layers of deposits, we dig out the surface of the river bank vertically. Then, a cross section of the river bank can be easily observed.



Figure 3: Cross section photo from one of the sites that has been sampled

When we look closely at the cross section, different layers of soil can be determined. From the bottom to the top, we take a small chunk of each layer. Color, soil type, what presents in the soil are recorded for the description. The distance of each layer and soil samples has been taken for measurement later in the lab. We repeat the same method for all six sites. The next step is to use lab equipment to find out what is the composition of those soil samples through more accurate measurement. These measurements will help to define those soils are either flooding deposits or mill dam deposits.

To understand the composition of the deposits, it is important to measure the percentage of both sand and silt and clay. The first step is to soaking the sample in H₂O₂. We place approximately 25 grams of sediment and cover with 25mL of distilled water in a 250mL or larger beaker. Then, carefully add a few drops of 30% Hydrogen Peroxide to remove organics and disaggregate the sample. Once they are removed, the clean sample are placed into the centrifuge machine. Centrifuging the sample makes the soil sticks together and we don't lose much of them for an accurate measurement. Liquids in the container also need to be removed after the centrifuging. After these steps, we are ready to separate the sand from the soil samples. At this point, dispersant is needed to make sure all particles are well separated. The first step is to know the weight of beakers that used for holding sand and mud. Adding dispersant into the bottles that contains clean soil samples, shaking it for more than ten minutes. Then, we are ready to filter the mud out. One beaker weighted earlier is used for collecting mud and the other if used for collecting sand left in the filter net. After separating them, large amount of liquids is still in the beakers. The measurement has to be taken after the liquids are evaporated by heating the beakers. Also, it is important to measure the amount of dispersant used. Those dispersants have to be subtracted from the weight of mud. By finishing all these measurements, we are able to get the fraction of mud and sand.

Table 1: This table shows the lab results of sand-mud ratio and other measurements of samples collected in Oct. 2019. Through the lab work, sand-mud ratio has been tested from the table above. The numbers help us to understand what type of deposits each layer contain and how does the layer changes.

Sample	Sand Beaker Weight (g)	Mud Beaker Weight (g)	Amt. of Water Used (mL)	Dry Weight Sand & Beaker (g)	Dry Weight Mud & Beaker + Dispersant (g)	Weight Dispersant (g)	Weight of Sand (g)	Weight of Mud	Fraction Mud
Mill Dam Core 1 20-25 cm	96.666	219.805	300	105.362	222.843	0.816	8.696	2.222	0.204
Mill Dam Core 1 60-65 cm	110.342	218.574	380	113.252	231.032	1.0336	2.91	11.4244	0.797
Mill Dam Core 1 80-85 cm	98.464	222.144	412	101.674	236.902	1.12064	3.21	13.63736	0.809
Mill Dam Core 1 275-280 cm	112.508	223.898	397	113.744	232.473	1.07984	1.236	7.49516	0.858
Mill Dam Core 1 40-45 cm	106.744	211.842	372	119.636	215.285	1.01184	12.892	2.43116	0.159
Mill Dam Core 1 160-165 cm	100.713	218.834	375	104.858	234.476	1.02	4.145	14.622	0.779
Mill Dam Core 1 100-105 cm	107.355	219.736	350	109.067	230.054	0.9275	1.712	9.3905	0.846
Mill Dam Core 1 205-210 cm	118.647	228.436	373	122.592	242.949	0.98845	3.945	13.52455	0.774

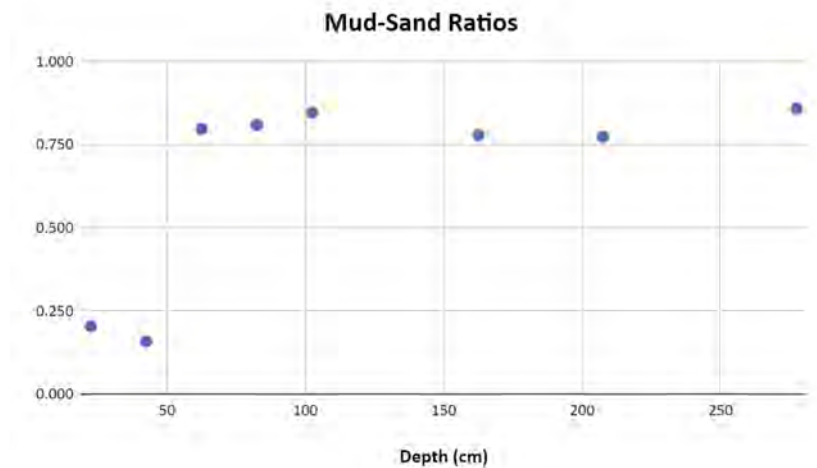


Figure 4: Mud-Sand ratio graph of samples collected in Oct. 2019

Results

Combining the lab results and the observation at the field will give us a better understanding on the layers of the river bank. The sample site which is collected on Oct. 2019 is the closest one to the mill dam. From the bottom to the top, we separate the entire river bank into three big layers. The first layer contains two small layers. One part is from 0 to 38 centimeters. In this part, the deposits are from medium sands to fine sands. Trace silt are also found in it. The color of the deposits is yellow. Then, from 38 centimeters to 48 centimeters is the second part. The grain size of this part is the same as the first part. But the color changed to dark yellowish brown. There is an abrupt contact in this part. We consider this layer as the basal deposits layer. Moving on to the next layer, it starts from 48 centimeters above the ground and ends at 218 centimeters. In this layer, the grain size is mud, and it is locally finely laminated. Also, one or two sand laminations are found in the layer. Other than those, root traces and orange mottles appear in this part. The color of the layer is pole brown. We consider this layer as the mill dam deposits. The last layer is from 218 centimeters to 292 centimeters which is the top of the river bank. In this layer, fine sand is the main type of deposits, but 10%-20% of mud are also included. Color of the layer changes from dark yellowish brown to weak red. Based on the observation and data results, this layer is the flood deposits layer.

Comparing this sample site to the furthest site would help us to find the differences and changes on the deposits. Sample site 5 shows a very different result. From 0 to 50 centimeters, we find a similar basal deposit layer. The grain size in this layer is mostly sandy mud with scattered pebbles. Around 30% medium sand and little amount of coarse sand also appears in it. Then, a very different layer was found in this site. Between 50 centimeters to 63 centimeters, the deposit is mostly muddy sand with about 30% mud. And the color of it is dark olive brown. A very gradational change was found between this layer and the top layer. We consider this as the buried A horizon. The last layer is the flood deposits layer again. From 63 centimeters to the top which is 138 centimeters, the soil type becomes sandy mud. In this site, a buried A horizon was found and the mill dam deposits does not appear any more. To present this result more clearly, we made a cross section graph for all sample sites. In this graph, it is very easy to see that the amount of mill dam deposits starts to reduce when it moves further from the mill dam. For all six sites, flood deposits cover the top of the river bank. Both type of deposits has a fair amount of influence to the current river bank.

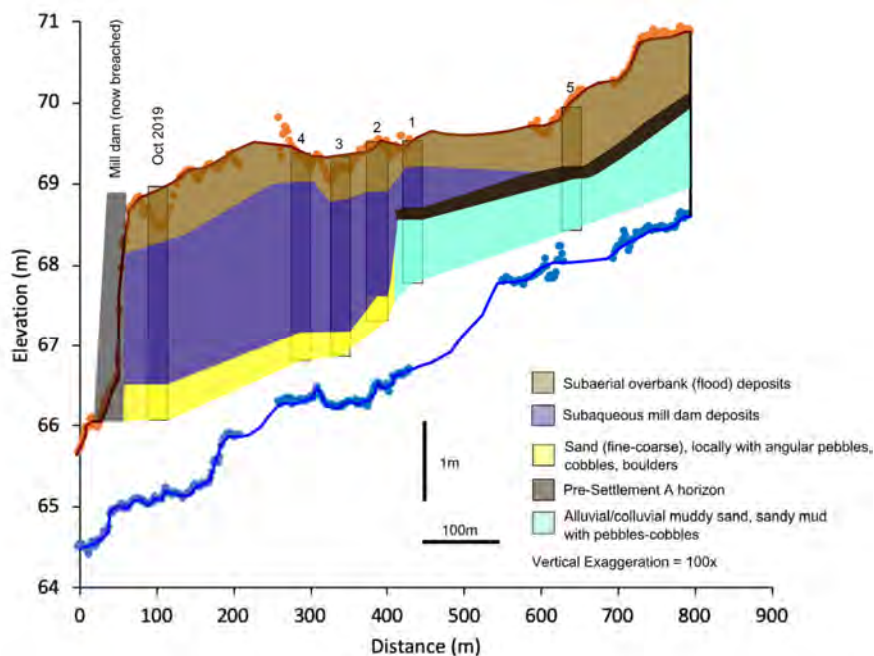


Figure 5: Cross section graph for all six sample sites.

Discussion

Mill dam deposit truly have influence to the existing river banks. But based on figure 5, the result is somehow different with Walter and Merritts concluded in their paper. The mill dam only has influences to a certain range. Closer to the mill dam,

the river bank is being more affected. When we move further downstream, the influence from mill dam starts to reduce and even disappear when reaching a certain distance. The results also suggest that the findings from Jacobson and Coleman is partially correct, not also not very accurate. Flood deposits appears in all six samples, but it is not the only factor of deposits accumulation. Mill dam deposits and flood deposits are both big elements for the buildup of thick river banks.

Conclusion

This research improves my understanding on analyzing soil layers and I learned how to measure the composition of soil samples. The lab part of this research is very helpful. Through all the processes, I understand what are the crucial steps for measuring and calculating the fraction of sand and mud. Properly use chemicals can helps to improve the accuracy for the data results. The observation that we took in the field is another important step for accomplish the study. I learned what are the factors that I need to look for. Colors, grain size, items presenting in the soils are all important materials. By putting all of them together, a conclusion will be formed. Then, arrange the findings on to a graph would provide a clear understanding to audience. This research is a unique experience to me. It does not only improve my skills on filed works, but also inspires my interest on future studies.

Work Cited

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Introduction

The American Shad (*Alosa sapidissima*) is a migratory fish found throughout the east coast. In the Spring time these fish try to swim up rivers along the coast to spawn, but dams block the spawning path that has existed for many generations of fish. In the Delaware section of the Brandywine river there are ten remaining dams that are stopping the fish from swimming up stream as the dams farthest down stream has been removed. Removing the dams or fitting bypass race on the dams would let the historic fish return to the Brandywine river.

Objective

The objective of this project was to create a steady flow model of the Brandywine river so that data can be used to make decisions on how to best let the American shad swim up the rivers by removing dams or creating raceways to bypass them.

Methodology

Analyze the Brandywine river dams by:

- Conducting field surveys
- Use stream gages to find average monthly exceedance flow rates during the American Shad's spawning season
- Survey stream banks
- Model Stream in HEC-RAS using FEMA data
- Send output data of proper cross sections to engineering consultant

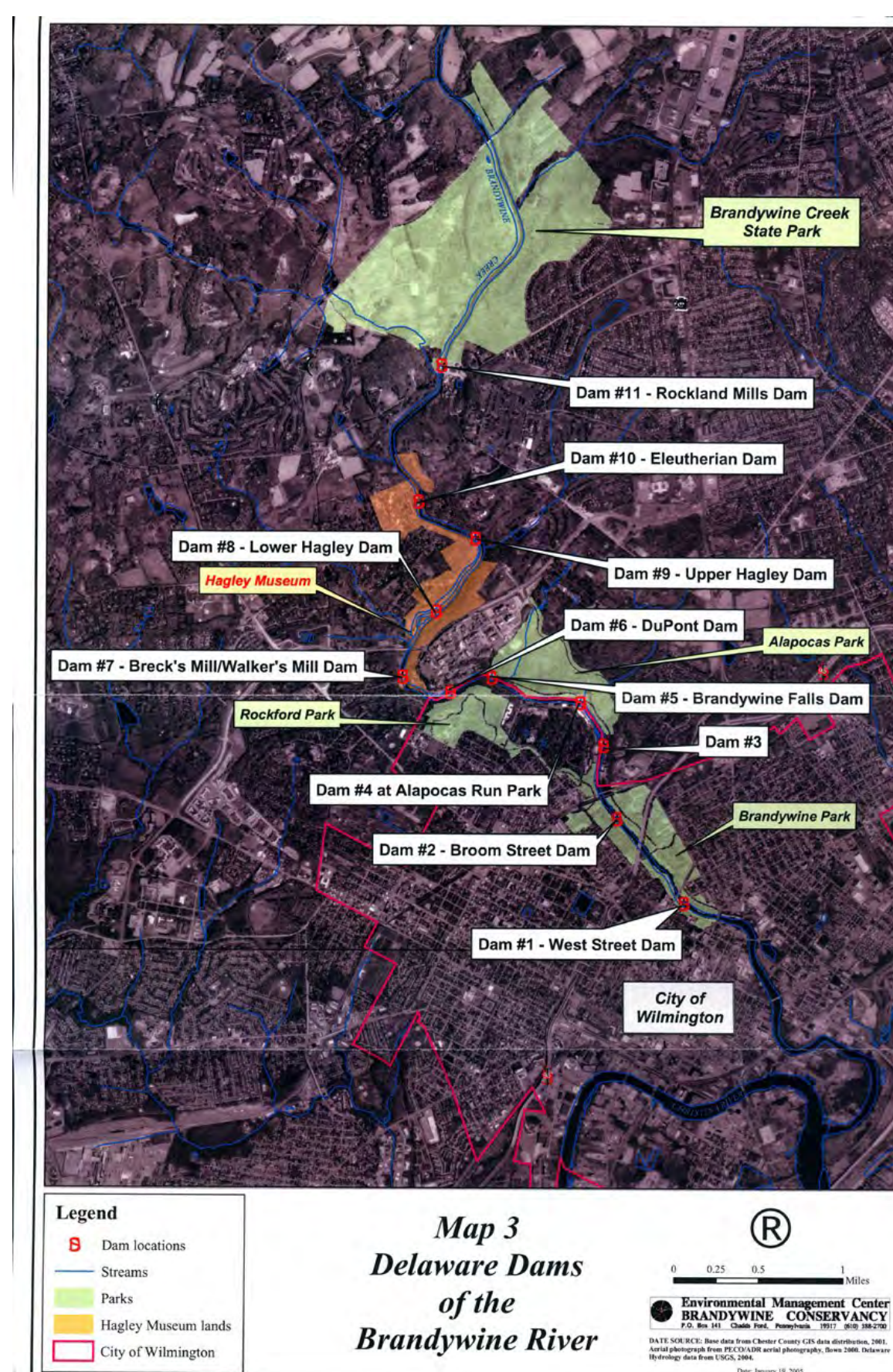


Figure 7. Map of Delaware Dams on the Brandywine including the removed Dam #1

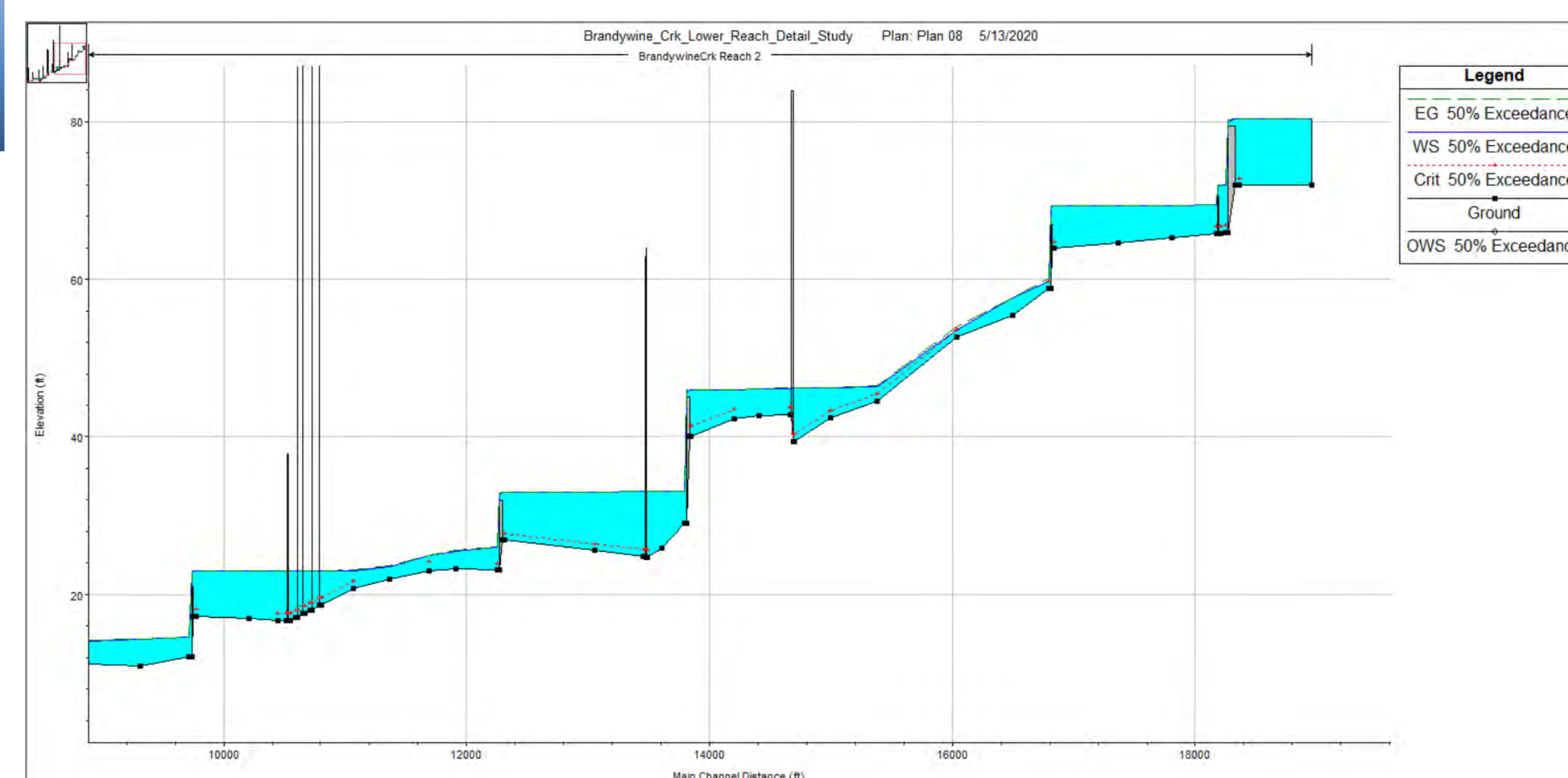


Figure 1. Profile of lower DE Dams

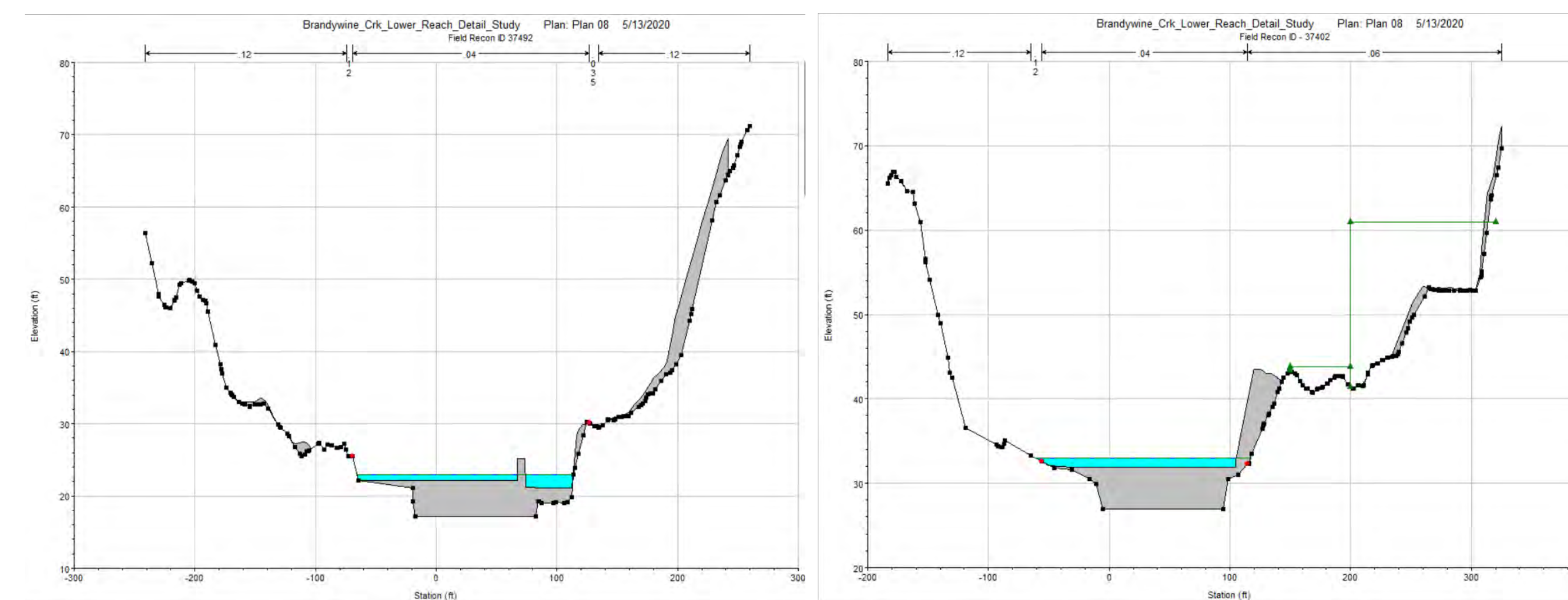


Figure 2. Cross Section Dam 2

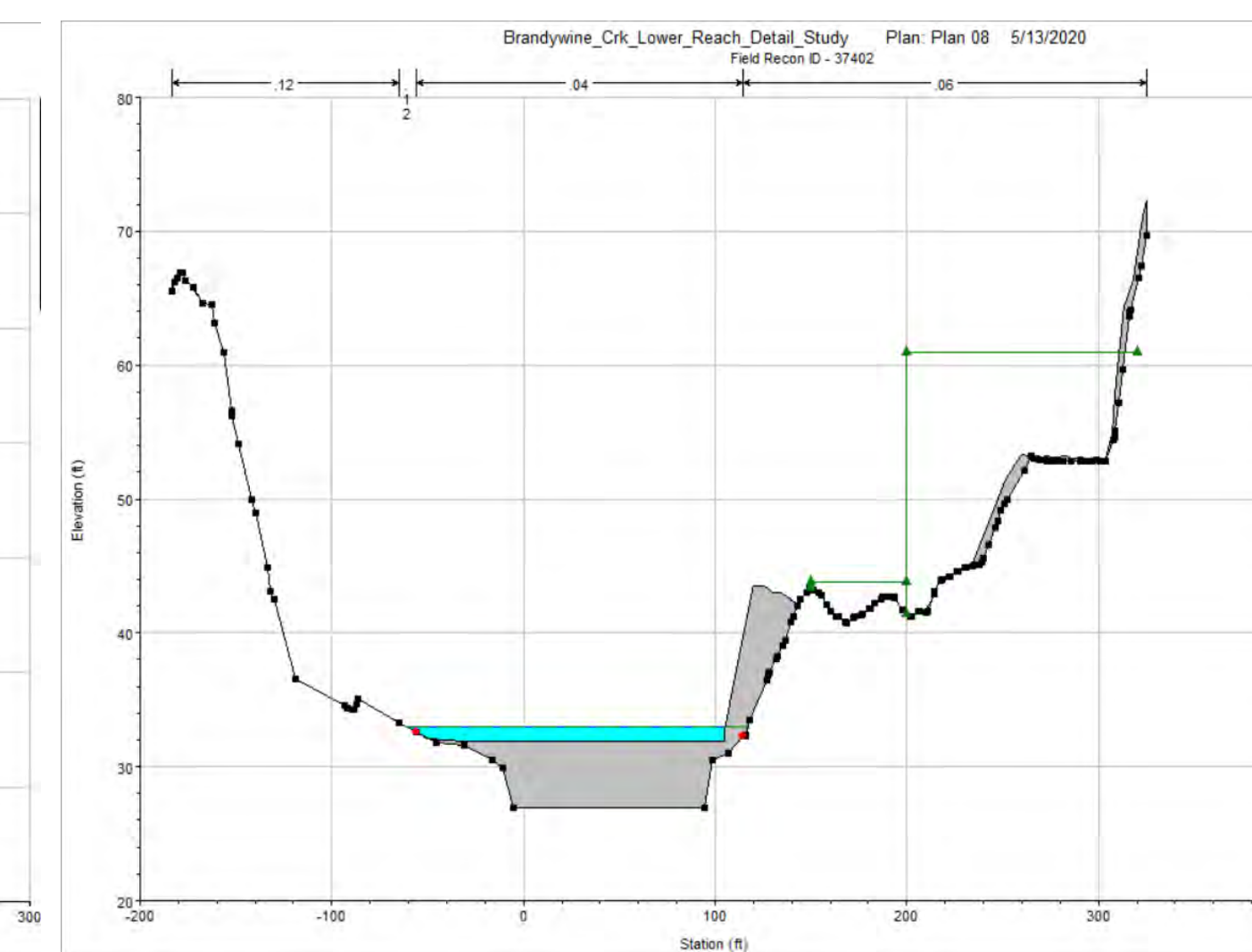


Figure 3. Cross Section Dam 3

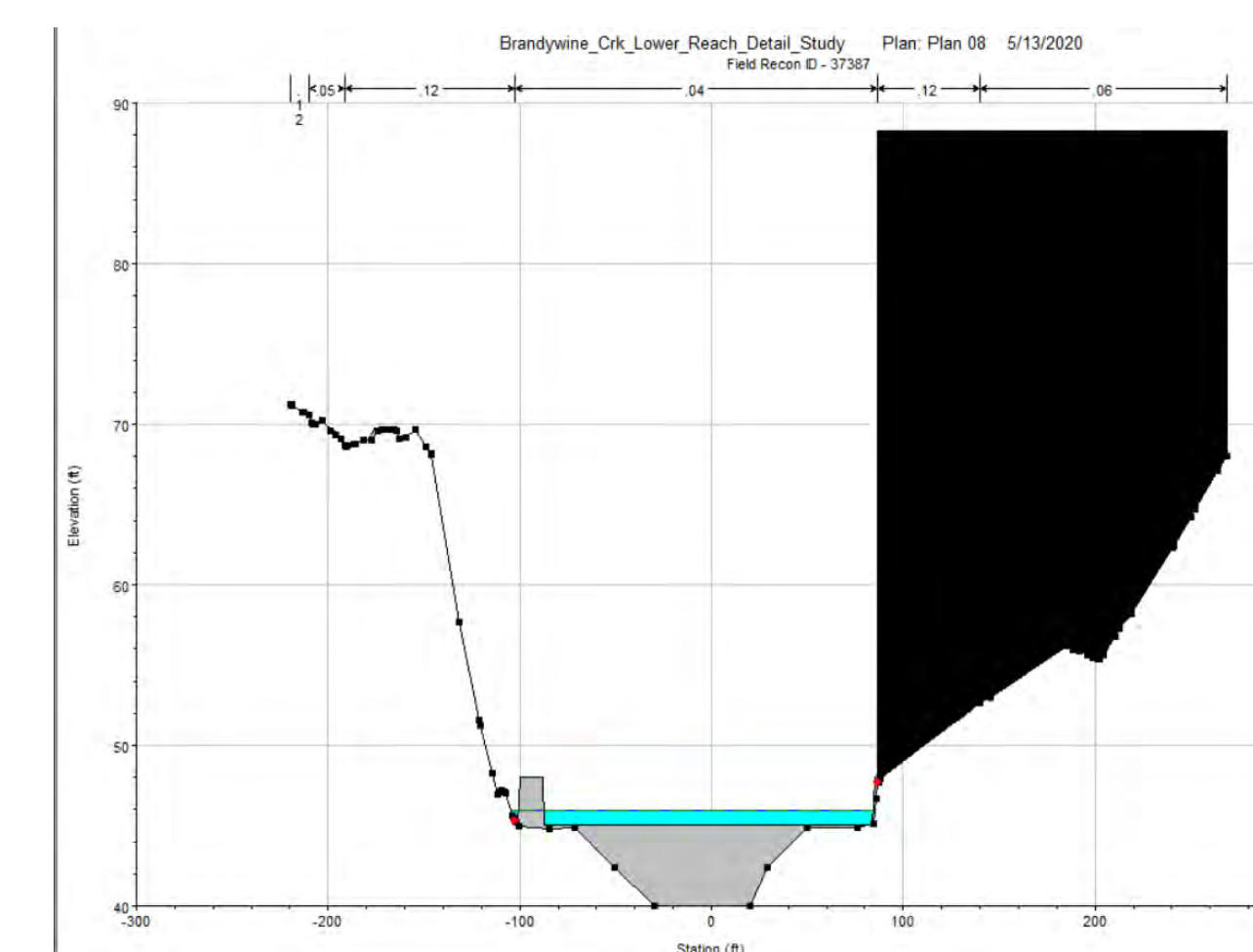


Figure 4. Cross Section Dam 4

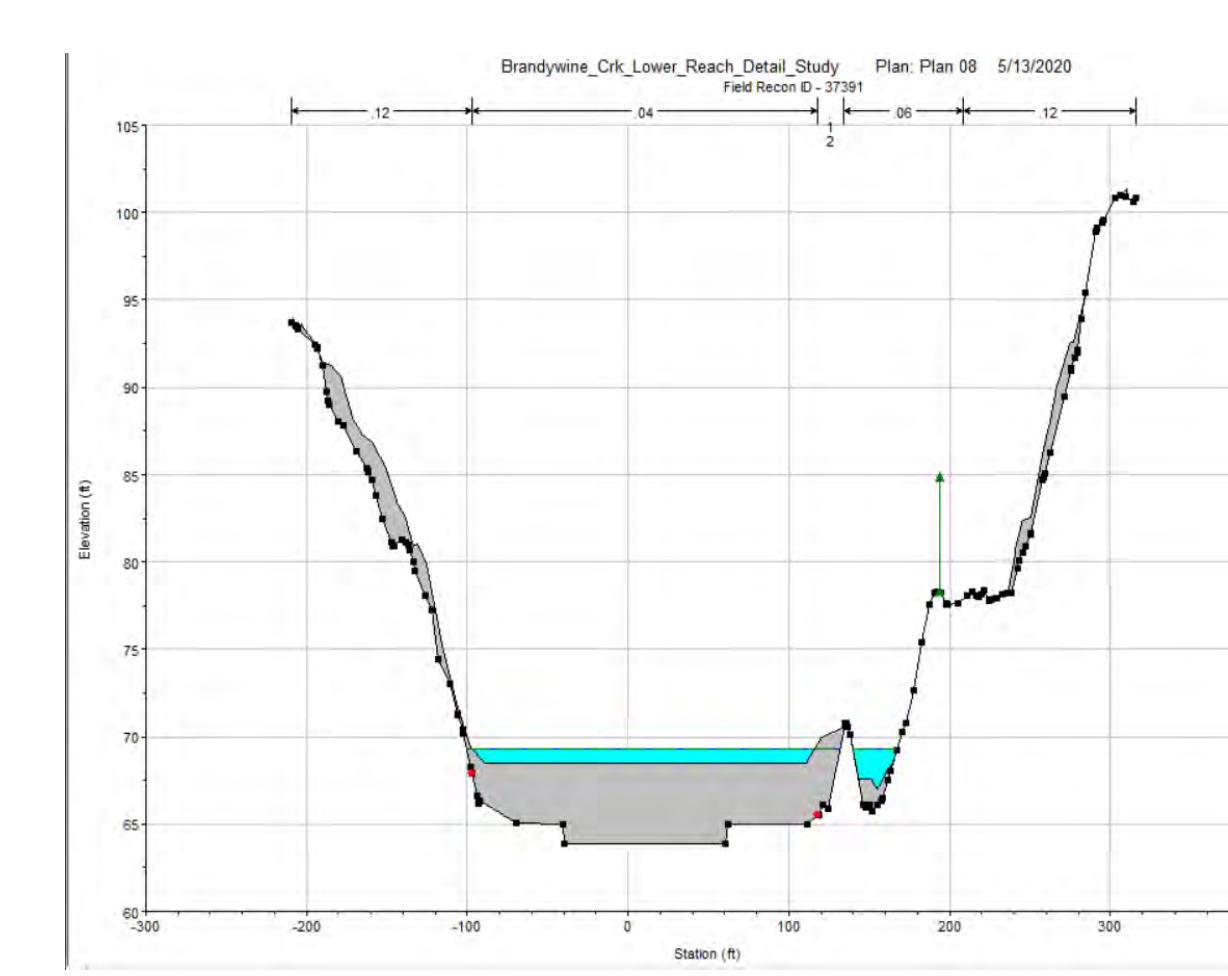


Figure 5. Cross Section Dam 5

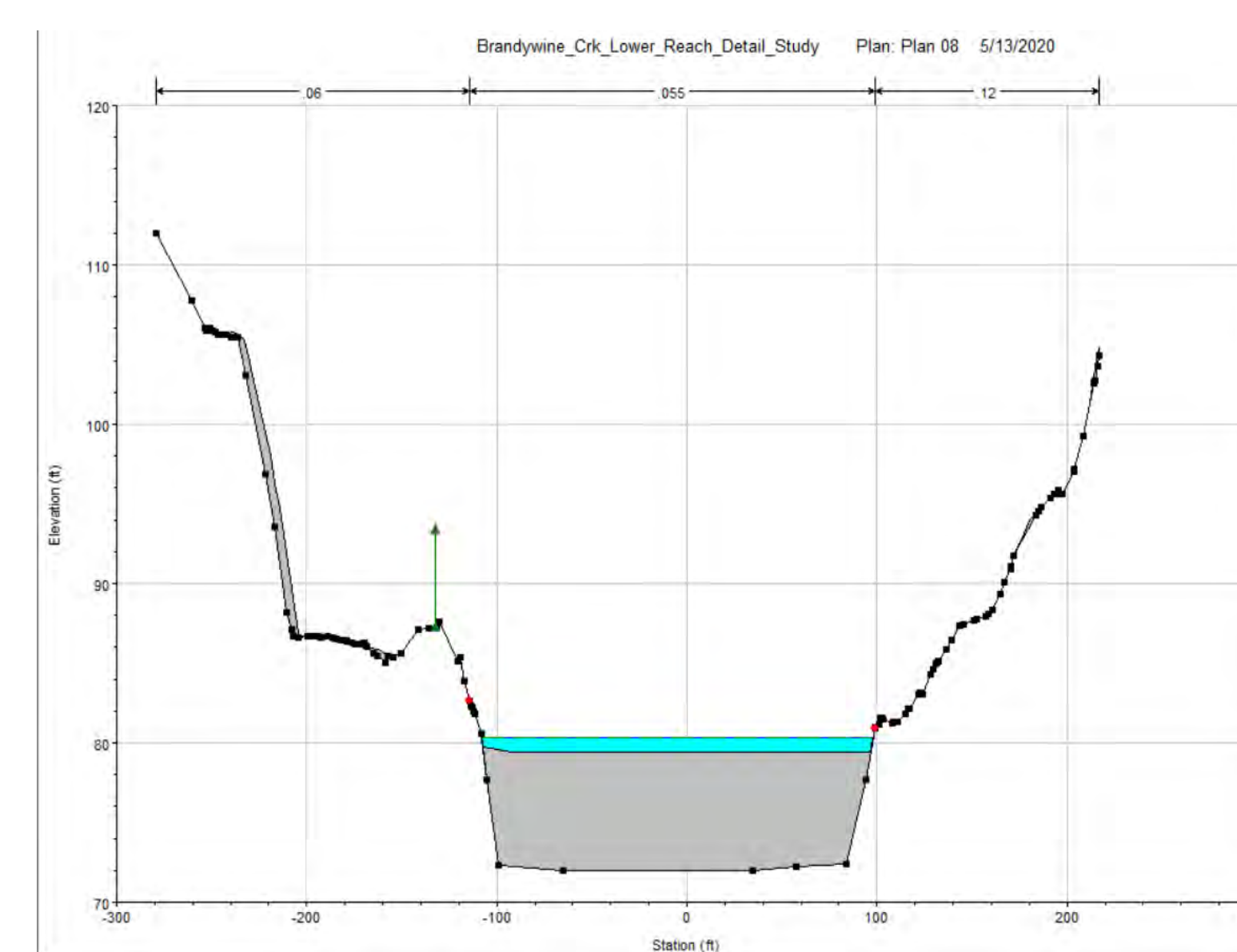


Figure 6. Cross Section Dam 6

Results

- Conducted a steady flow analysis of the lower six dams using 17 different flow rates including:
 - 10 year storm = 18088 cfs
 - 25 year storm = 24060 cfs
 - 50 year storm = 28947 cfs
 - 100 year storm = 34189 cfs
 - 500 year storm = 47928 cfs
 - Minimum April flow = 221 cfs
 - Mean April flow = 692 cfs
 - Max April flow = 1773 cfs
 - Minimum May flow = 282 cfs
 - Mean May flow = 568 cfs
 - Max May flow = 1528 cfs
 - Minimum June flow = 216 cfs
 - Mean June flow = 469 cfs
 - Max June flow = 1492 cfs
 - 5% Exceedance = 1418 cfs
 - 50% Exceedance = 478 cfs
 - 95% Exceedance = 246 cfs
- From cross sections adjacent to the each of the dams get values of:
 - Minimum channel elevation
 - Water surface elevation
 - Velocity of the channel
 - Top width
 - Flow area
 - Flow depth
- This data was sent to an engineering firm to aid in their decision on how to best deal with each dam.
- Dams 3, 4 and 6 are to be removed and by pass race ways will be added to dams 2 and 5

Future Research

- Similar analysis should be done of the upper reach dams as well as the Dams in PA so the American shad can take back their historic spawning route
- Use Lidar to supplement the FEMA data collected

Acknowledgements

I want to thank my fellow undergrad researchers for working with me on this project and Jerry Kauffman for all guidance and support he provided.

Abstract

Our purpose for this project was to draft up a watershed plan to preserve the Hercules Country Club Golf Course. In order to do so, several research assistants and I had to apply four different methods of research. From there, we were able to assess the watershed. Of the streams evaluated, we found that they were optimal and suboptimal. We were able to apply a probe analysis from the field research. Moreover, we are awaiting for the results of a water quality analysis. A preliminary draft of the watershed restoration plan was written on behalf of the community attempting to preserve the land. However, the completion of this project was halted due to COVID-19.

Objective

The objective of this project was to preserve the Hercules golf course in New Castle County by conducting field surveys and stream monitoring to prepare a watershed restoration plan.

Introduction

- Hercules was established in the 1930s as a golf course in the Red Clay watershed (Figure 1)
- By October 2010, the golf course was closed and abandoned
- Hercules golf course covers roughly 205 acres
- Land is broken up into three major categories: golf/open area, forest area, and wetlands
- Since the closure, the land has remained unoccupied but construction companies are interested in developing the land for future homes
- Local residents and conservation groups are rallying together to preserve the open land

Methodology

Characterized the the Hercules Golf Course through:

- GIS mapping
- Water quality analysis
- EPA Rapid Stream Bioassessment
- Rosgen Geomorphology

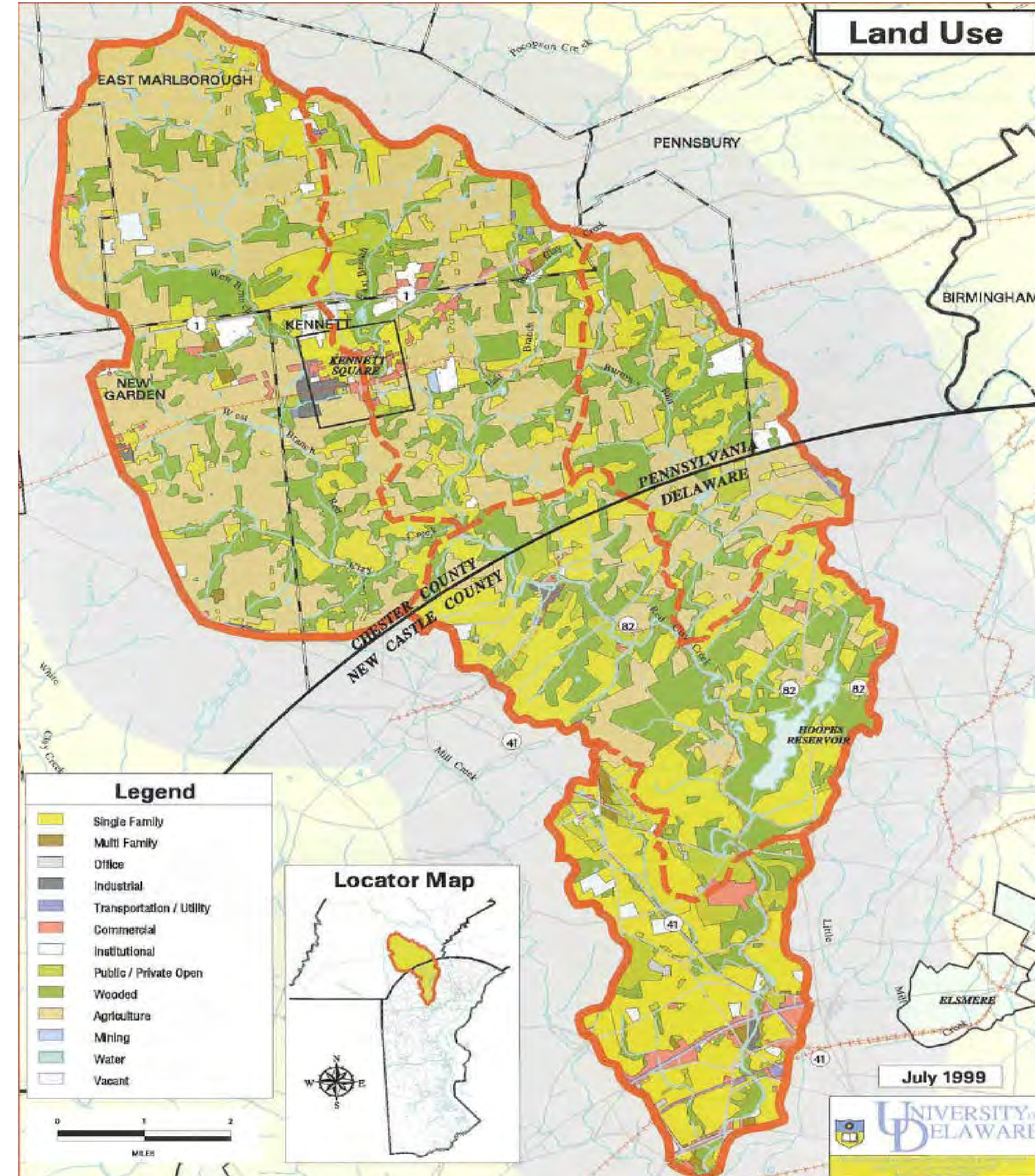


Figure 1. Red Clay Water Shed, characterized by land use

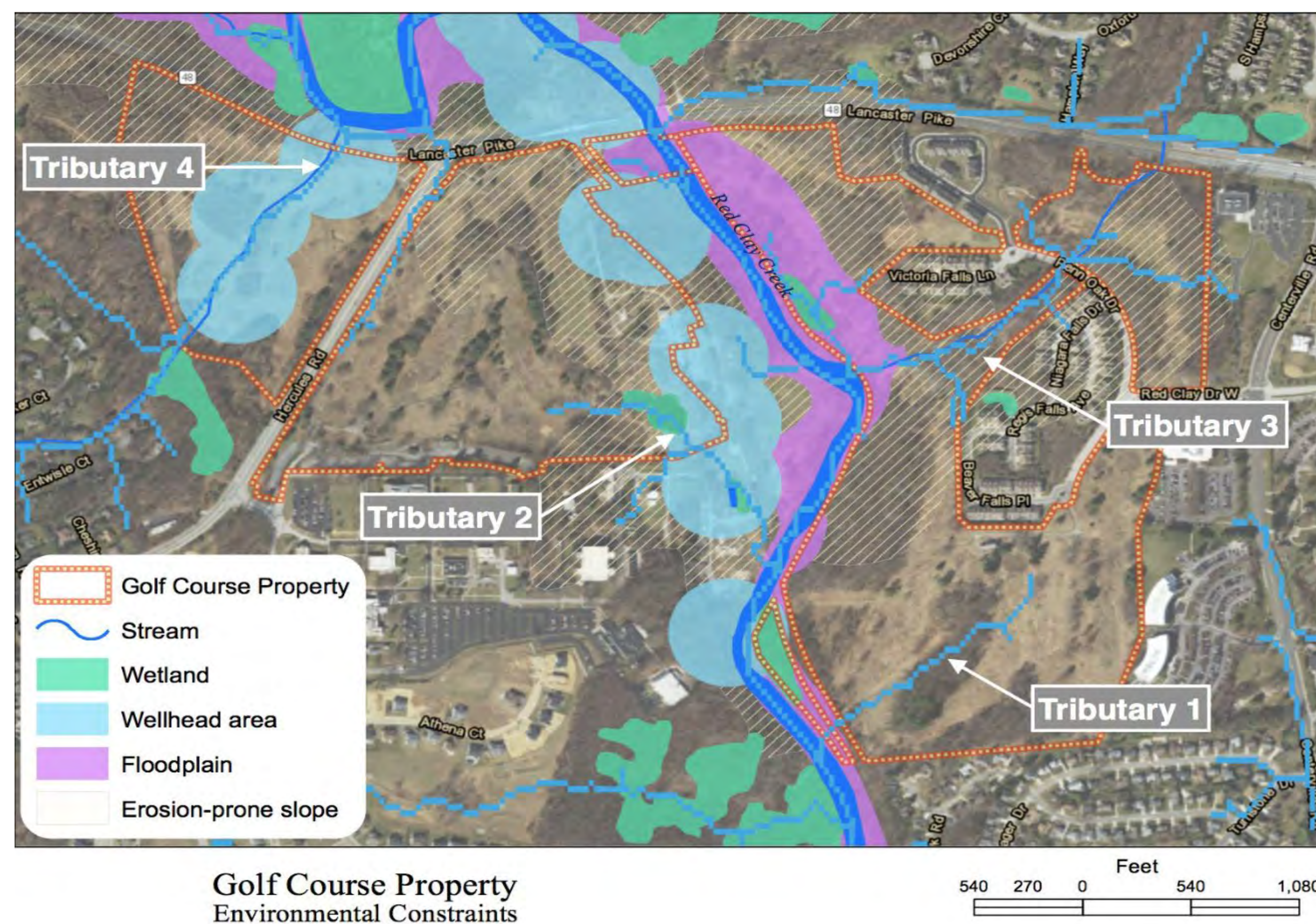


Figure 2. Hercules Golf Course characterized through GIS mapping

Results

- Conducted probe water analysis dealing with: pH, temperature, total dissolved solids (TDS), turbidity, and conductivity for six sample locations in November 2019
- Completed the EPA Rapid bioassessment, of Red Clay Creek and three Tributaries.
 - Ten different parameters measured were measured at five locations along each tributary (Figure 2)
 - Median scores reported for each parameter to calculate total scores
- Of the four tributaries and Red Clay creek, two were optimal and two were suboptimal
 - One tributary was not available to complete the assessment
- Rosgen method was not carried out during this past year
 - Rosgen classification is used to measure the morphology of streams based on shape, geometry, slope, and substrate type
- Obtained six water samples at each location labelled in Figure 2, including the Red Clay Creek upstream and downstream

Further Research

- (1) Gather the results from UD Soils Testing Lab
 - 18 different parameters are being measured includes: temperature, pH, turbidity, dissolved oxygen, electrical conductivity, enterococci bacteria, aluminum, boron, calcium, copper, iron, potassium, magnesium, manganese, sodium, phosphorus, sulfur, zinc, ammonia-nitrate, and nitrate
- (2) Complete Rosgen Geomorphology analysis of the tributaries and Red Clay Creek.
- (3) Continue to monitor the streams and mark any changes in the water quality and the physical features of the environment

Acknowledgements

- A special thank you to my advisor, Gerald Kauffman, for his help and guidance during this past year. Also, I would like to thank the University of Delaware Water Resource Center for their assistance and funding for the internship program.



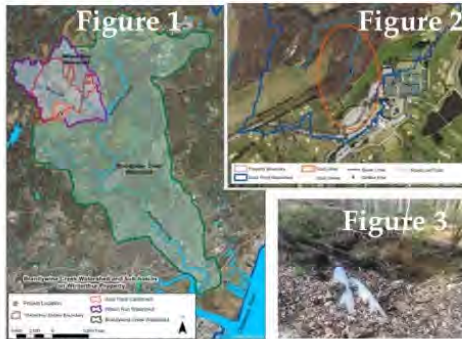


Wilson Run Watershed Field Surveying at Winterthur

University of Delaware Water Resources Center Undergraduate Internship

Research Assistant: Mary Kegelman, Advisor: Dr. Gerald Kauffman

Project Summary



Through collaboration with Winterthur's GIS specialist and other DWRC undergraduate research assistants, we have made progress with regards to the surveying of a portion of the Wilson Run Watershed (Figure 1). The objective of the surveying is to assess the stream circled in Figure 2 and located on the property of Winterthur Museum and Garden. The stream shows signs of extensive erosion which is seen in Figure 3. The results of our research may be used to take action to prevent further erosion damage.

Methods

Among many others, the impacts of erosion include loss of soil structure, nutrient degradation, and soil salinity. Thus, the continued erosion of the surveyed stream will cause declines in fish and other surrounding species populations. To combat these adversities, we used DWRC field surveying equipment to find accurate elevations of cross sections along the stream. We marked our 10 cross sections 100 feet apart, and proceeded to measure the elevations of each at 1-foot intervals. The disruption of research due to COVID-19 occurred when we had completed 80% of the cross sections. Further surveying will be conducted to complete the data set.

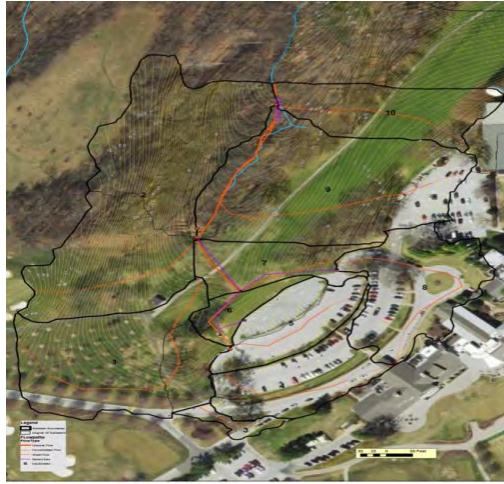
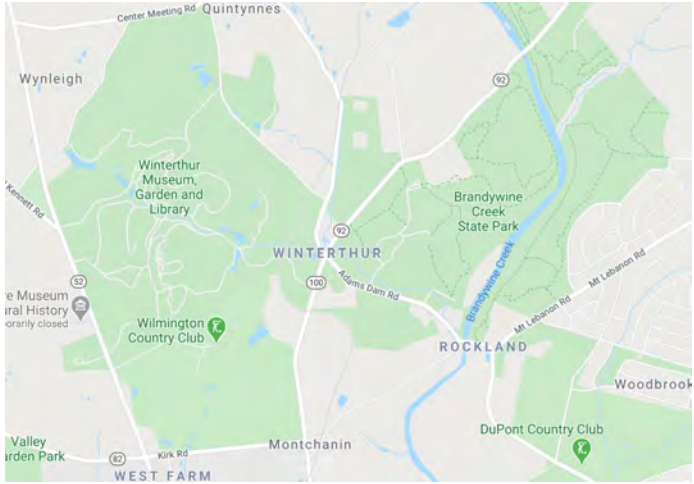


Future Outlook

As mentioned, the remaining 20% of cross sections await surveying after government social distancing orders lift. After the completion of all field work, we will gain substantial data with which a Technical Release 55 (TR-55) method can be finalized. This will allow for the calculation of storm runoff volume, hydrographs, peak rate of discharge, and storage volumes. These measurements will guide the potential implementation of preventative erosion buffers and other actions taken to reverse current and prevent future erosion damage.



Winterthur Duck Pond AJ Nolan May 2020



Watershed	Duck Pond Watersheds LandUse					Subtotal
	Golf Course	Impervious Cover	Woodland	Tennis Courts	Grassland	
1	2.14	0.19				2.33
2	1.13		2.82		0.12	4.07
3		0.17				0.17
4		1.07				1.07
5		0.93				0.93
6	0.33	0.02				0.35
7	0.58	0.05	0.16			0.79
8		1.56	0.01			1.57
9	0.87	0.48	1.86			3.21
10	0.41	0.05	0.81			1.27
Total	5.46	4.52	5.66	0	0.12	15.76

File Options ProjectData GlobalData Run Help

WinTR-55 Small Watershed Hydrology

Project Identification Data

User: 67K State: Delaware

Project: Winterthur County:

Subtitle: Duck Pond A Execution Date: 1/28/2020

Sub-areas are expressed in: Acres Square Miles

Dimensionless Unit Hydrograph: standard

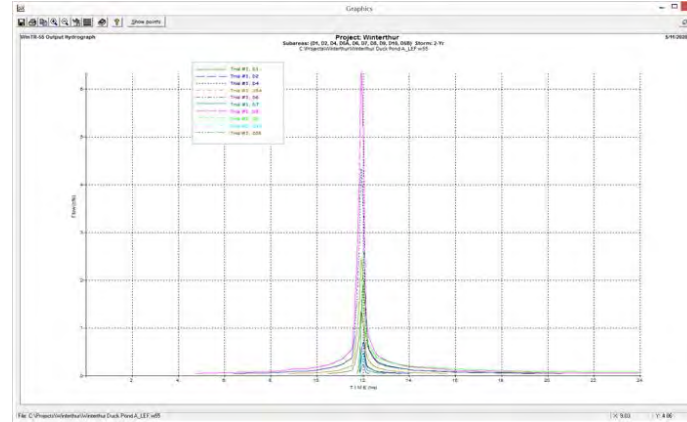
Storm Data Source: User-provided custom storm data

Rainfall Distribution Identifier: Type II

Sub-area Name	Sub-area Description	Sub-area Flows to Reach/Outlet	Area (ac)	Weighted CN	Tc (hr)
b1		Reach 1	2.33	64	0.168
b2		Reach 2	4.07	57	0.100
b3		Reach 3	0.17	98	0.245
b4		Reach 4	1.07	98	0.100
b5		Reach 5	0.93	98	0.100
b6		Reach 6	0.35	63	0.100
b7		Reach 7	0.79	62	0.100
b8		Reach 3	1.57	98	0.100
b9		Reach 4	3.21	63	0.100
b10		Outlet	1.27	59	0.121

Project Area: 15.76 (ac)

Subarea	DA (ac)	2-yr (cfs)	10-yr (cfs)	100-yr (cfs)	2-yr (cfs/ac)	10-yr (cfs/ac)	100-yr (cfs/ac)
1	2.33	1.54	4.53	12.19	0.66	1.94	5.23
2	4.07	1.31	5.5	18.47	0.32	1.35	4.54
3	0.17	0.57	0.86	1.44	3.35	5.06	8.47
4	1.07	4.33	6.55	10.95	4.05	6.12	10.23
5	0.93	3.76	5.69	9.5	4.04	6.12	10.22
6	0.35	0.24	0.71	1.99	0.69	2.03	5.69
7	0.79	0.48	1.49	4.3	0.61	1.89	5.44
8	1.57	6.36	9.61	16.06	4.05	6.12	10.23
9	3.21	2.15	6.45	18.12	0.67	2.01	5.64
10	1.27	0.52	1.92	5.98	0.41	1.51	4.71
Total	15.76	21.26	43.31	99.00			



Background

Biochar is a charcoal product that, due to its high porosity and surface area, has the potential to change the properties of soil. Biochar is known to be able to increase or decrease the hydraulic conductivity of the soil, however it is a complex process dependent on many variables. In this experiment, soil column experiments were taken place to understand exactly how biochar affects Ksat. The following variables that were inspected are:



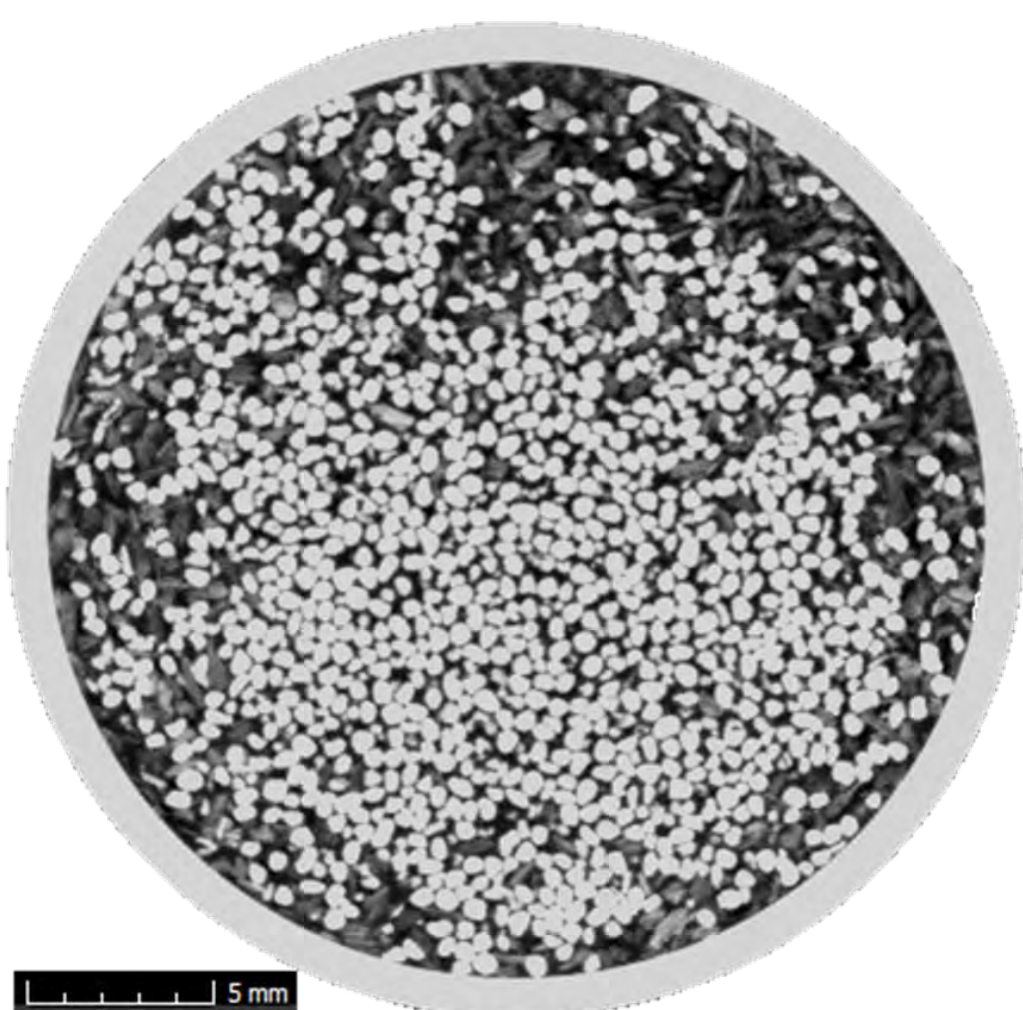
Biochar Particles

- **Biochar Particle Size:** The larger the Biochar particles are, the larger the porosity of the soil will be, thus having an affect on the flow of water through the medium.
- **Biochar Elongation:** Testing the effect of the shape of the Biochar on the Ksat. Longer particles may have different properties than more spherical particles.
- **Biochar Segregation:** Generally, in the field the biochar tends to clump together and segregate. How much does this affect the Ksat of the soil?

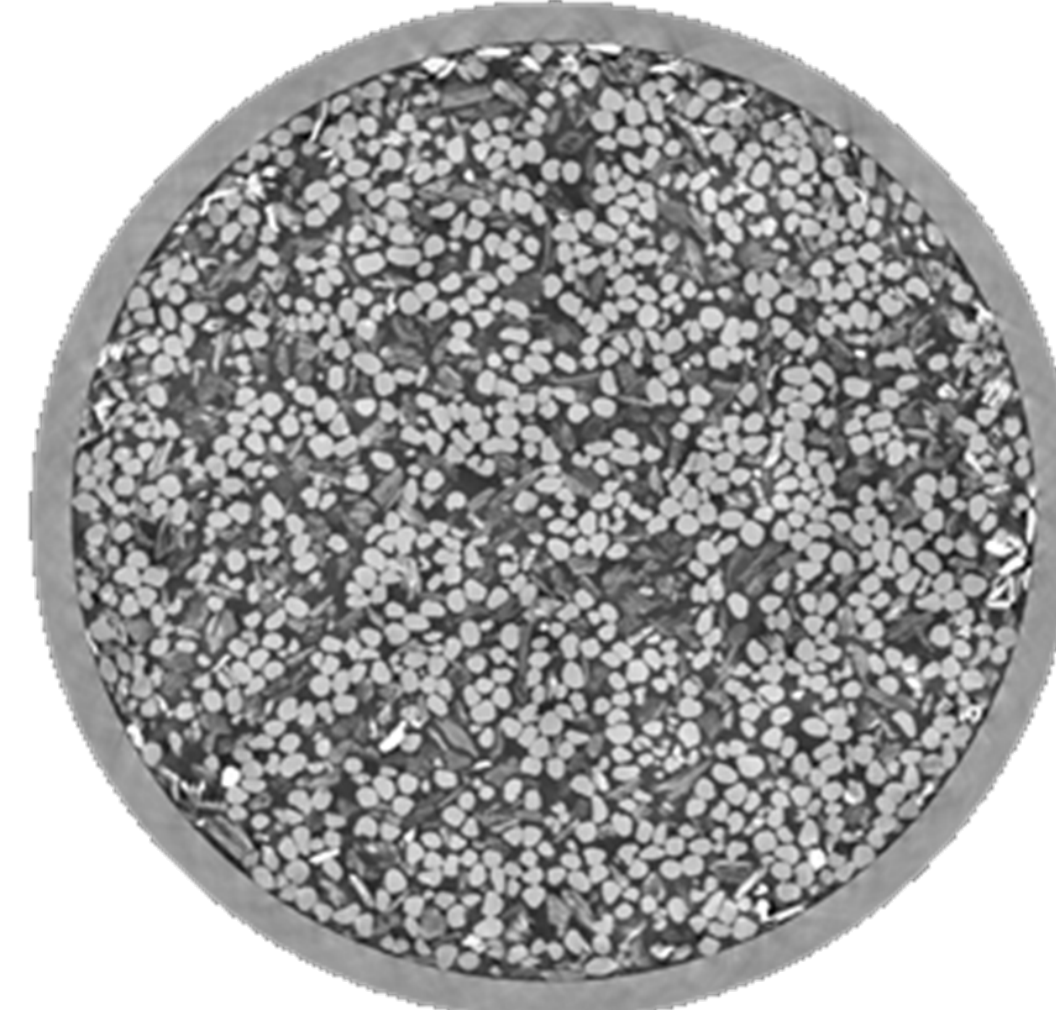
Objectives

- Quantify how the size of the added biochar particles affects the difference in hydraulic conductivity of the soil
- Quantify how the shape, or elongation, of the added biochar particles affects the difference in hydraulic conductivity of the soil
- Quantify how the segregation of the added biochar particles and the soil particles affects the difference in hydraulic conductivity of the soil

Segregation Images – Using X-ray Tomography



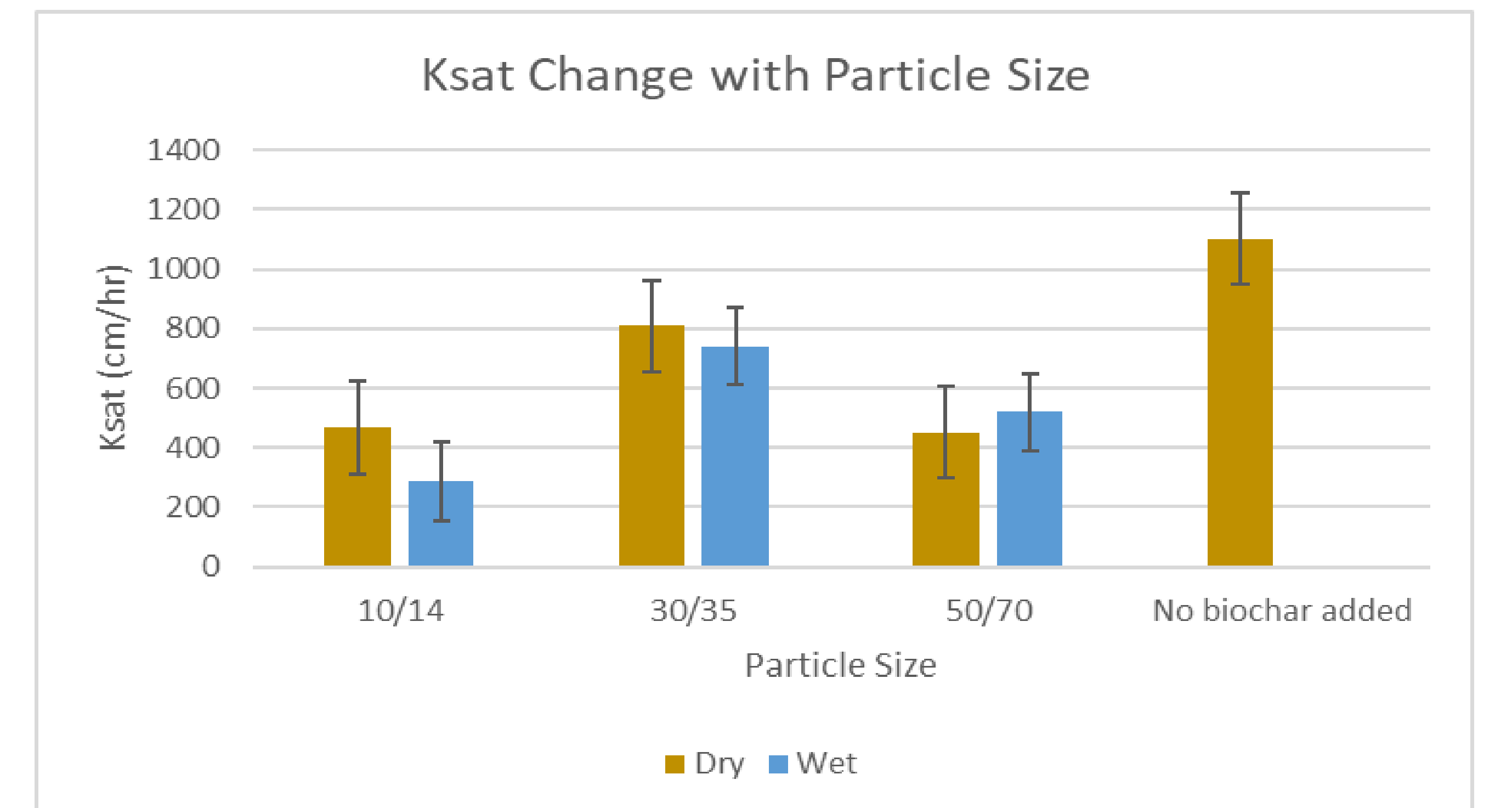
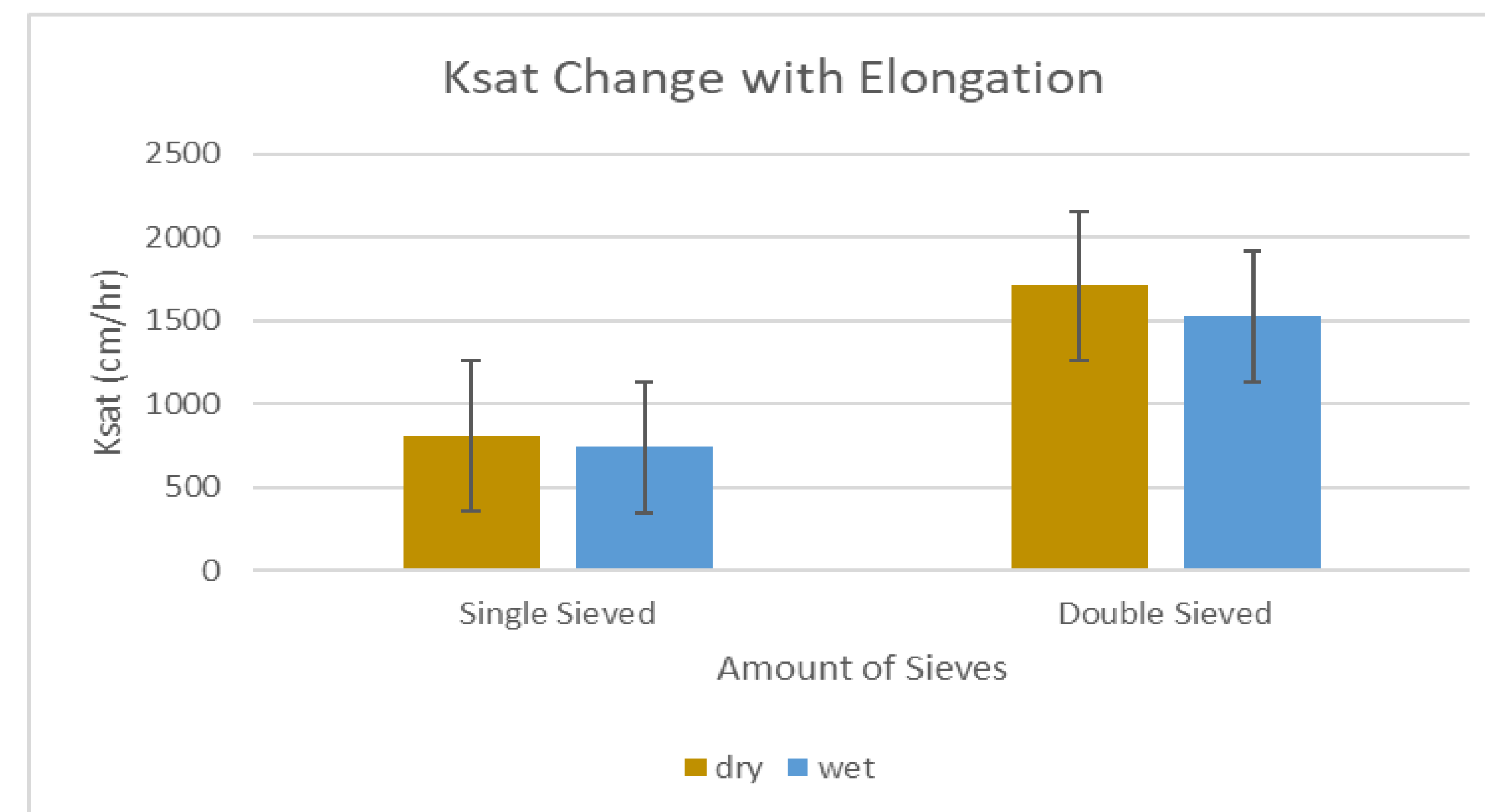
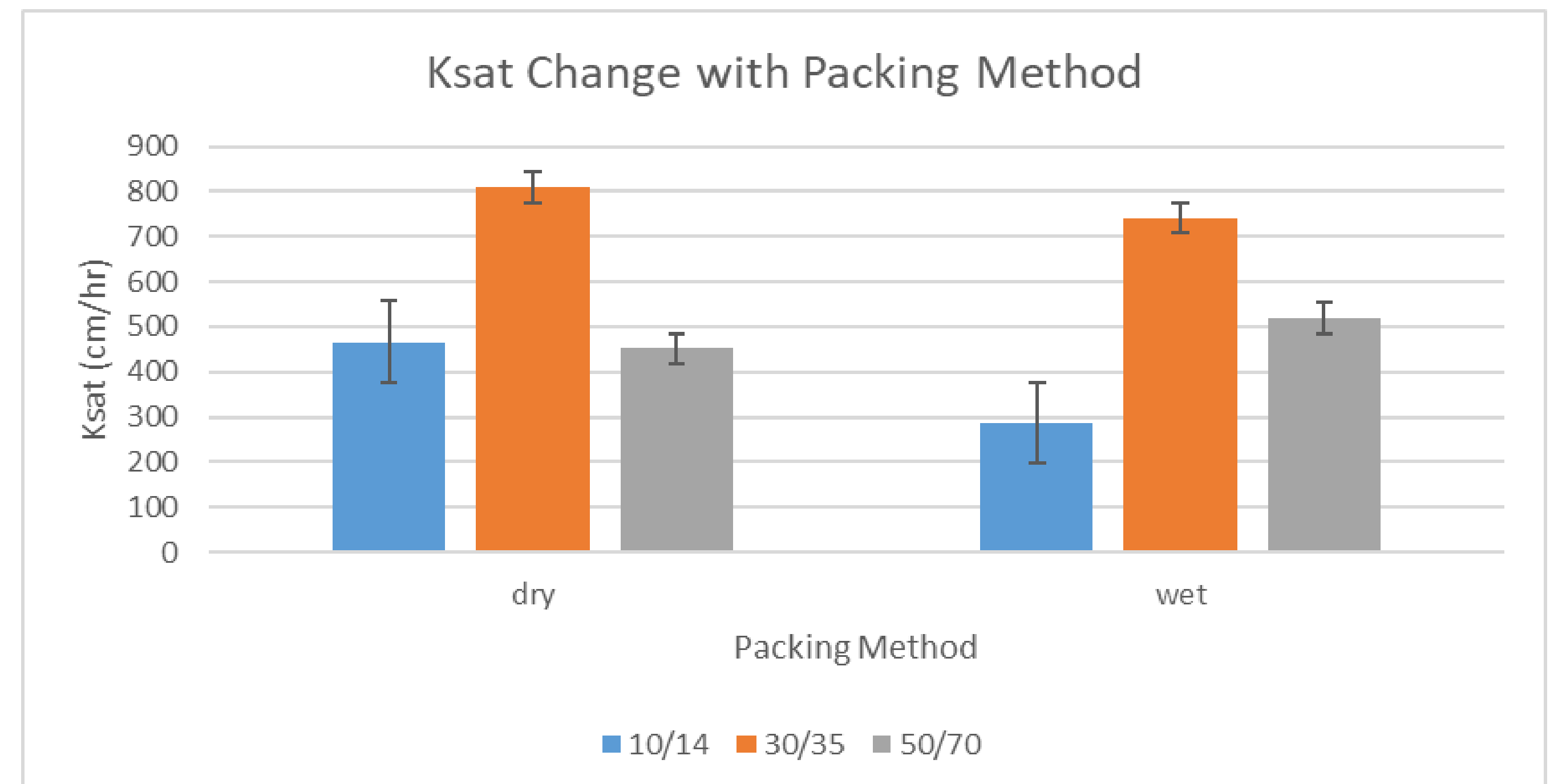
Microstructural Images for Dry Packed Biochar-Soil Mixture by Kalehiwot Nega Manahiloh



Microstructural Images for Wet Packed Biochar-Soil Mixture by Kalehiwot Nega Manahiloh

RESULTS

Type	Pure Sand (30/35)	Sand with Large Biochar (10/14)	Sand with Medium Biochar (30/35)	Sand with Small Biochar (50/70)	Sand with Double Sieved Medium Biochar
Sand Size (mm)	0.0197 - 0.0234	0.0197 - 0.0234	0.0197 - 0.0234	0.0197 - 0.0234	0.0197 - 0.0234
Biochar Size (mm)	-	0.0555 - 0.0787	0.0197 - 0.0234	0.0083 - 0.1170	0.0197 - 0.0234
Bulk Density (g/cm ³)	1.646	1.250	1.210	1.330	1.085
Total Porosity	0.378	0.504	0.520	0.473	0.570
Inter Porosity	0.378	0.449	0.467	0.414	0.522



Methods



Dry packing

Wet Packing

Sieving

- Unsieved biochar is placed in a three-sieve configuration. A standard shaker time of 8 minutes was used.
- Elongated particles were sieved once, then collected on the 30 sieve in a over a smaller 1 minute run.

Column Packing

- Wet: To prevent soil segregation, water is added before the mixture is put into the columns. The mixing with water creates a virtually unsegregated mixture.
- Dry: To mimic the real world, no water is added in the mixing stage. The particles are still put together and mixed, however they do not stick together, and the particles tend to stay next to their own type. So, the soil is mostly segregated.

Measuring Ksat

- To reliably measure the Ksat of the columns, water was pumped through the columns to achieve full saturation, meaning all voids are filled with water.
- To measure the Ksat, the volumetric flow of water out of the column was measured and then Darcy's law was used to find the Ksat. Containers filled with water are suspended at a know height h₂, the h₁ is the height where the water drips out of the column, L is vertical length of the column, and A is the cross-sectional area of the column.

Note: All Results in the graphs above are the mean value from triplicate data, and all error bars represent standard error.

Conclusion

- The total porosity of the medium size biochar is the largest, due to the properties of biochar
- The larger porosity of the medium biochar causes it to have the highest Ksat compared to small and large.
- The particle Elongation had the greatest effect out of any variable, nearly doubling the Ksat compared to single sieved.
- The elongated particles were the only biochar particles to increase Ksat
- The fully segregated particles only slightly decreased the Ksat, with the Ksat of the smaller particles actually increasing.

References and Acknowledgments

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Nanticoke Economic Report

- Goal – estimate the overall value of the Nanticoke watershed
- 3 separate methods of evaluation
 - Economic activity – \$2.6 billion
 - Natural capital/ecosystem services – \$3.7 billion
 - Jobs and wages – \$440 million
- Current project: Inland Bays report

