UDWRC Research Interns

FY19 Student Support

The University of Delaware Water Resources Center supported 11 undergraduate and graduate water research internships during FY19 through the annual base (104b) grants. The DWRC research students presented their research findings at the 55th annual meeting of the DWRC Advisory Panel on May 14, 2020 at the University of Delaware:

FY19 Delaware Water Resources Center Undergraduate/Graduate Internships

Last	School	Major	Research Advisor	Title of Proposed Research
Sicily Bordrick	UD	Environmental Engineering	Anastasia Chirnside	Optimization of HPLC Analysis of Ergosterol to Quantify Fungal Biomass within Bioreactors
Zach Burcham	UD	Environmental Engineering	Anastasia Chirnside	Optimization of HPLC Analysis of Ergosterol to Quantify Fungal Biomass within Bioreactors
Ji Zhendong	UD	Environmental Science	James Pizzuto	Discriminating between Mill Dam and Flood Deposits along White Clay Creek
Justin Leary	UD	Environmental Engineering	Jerry Kauffman	Hercules Red Clay Creek Watershed Monitoring Plan
Savanah Love	Wesley	Environmental Science	Stephanie Stotts	Interactive art exhibit focused on salinification of wetlands
Aaron Nolan	UD	Environmental Engineering	Jerry Kauffman	Duck Pond Creek Watershed Plan at Winterthur Gardens, Wilmington, Del.
Polly Ni	UD	Environmental Engineering	Jerry Kauffman	Brandywine Piedmont Field Monitoring Plan
Emily Symes	UD	Geological Sciences	James Pizzuto	Sediment Fingerprint Red Clay Creek Watershed
Mary Kegelman	UD	Environmental Engineering	Jerry Kauffman	Water Quality Trends in New Castle County (Delaware) Streams, 2000-2020
Matt Kirchman	UD	M.S. Energy & Environ. Policy	Andrew Homsey	White Clay Creek Water Quality Modeling
Kelly Jacobs	UD	M.S. Energy & Environ. Policy	Martha Narvaez	Effect of Marcellus Shale Gas Drilling on the Delaware River Watershed.

FY20 Student Support

Beginning in June 2020, the DWRC has supported 18 undergraduate and graduate water research internships during FY20 through the annual base (104b) grants. The DWRC research students are scheduled to present their research findings at the 56th annual meeting of the DWRC Advisory Panel on May 13, 2021 at the University of Delaware:

FY20 Delaware Water Resources Center Water Research Internships

Water Research Student	Major	Research
Hayley Rost	Master of Public Administration, Biden School	White Clay Creek Wild and Scenic River Water Quality Sampling Network.
Sophie Phillips	Master of Energy & Environ. Policy, Biden School	Environmental Justice and Water Use in Rural Delaware. Research
Sitlaly Avelino	Environmental Engineering	Watershed Characterization of First Order Tributaries along the Brandywine River in Delaware
Brendan Benson	Environmental Engineering	The Effect of Biochar on Infiltration Rate and Soil Aggregation in Both the Field and Lab
Brielle Bianchini	Environmental Engineering	Water Quality Trends in White Clay Creek Nat'l Wild & Scenic River, Delaware and Pennsylvania
Tommy Breedveld	Environmental Engineering	Stream Habitat Sampling along Tributaries of the Red Clay Creek in Delaware
Shannon Bushinsky	Environmental Engineering	Intergovernmental River Basin Management, the International Joint Commission Model
Alexis Cervantes	Environmental Science	Historic Significance of the Brandywine River as Drinking Water Supply in Wilmington, Delaware
Elizabeth DeSonier	Environmental Science	Stratigraphy of Valley Fill Deposits Upstream of a Small Colonial-Age Mill Dam, White Clay Creek, Pennsylvania
Delaney Doran	Environmental Engineering	Watershed Characterization of First Order Tributaries along the Brandywine River in Delaware
Grace Hussar	Environmental Studies	The Effects of Reforestation and Invasive Species Removal on Stormwater Flooding Events in Baltimore
Emily Jimenez	Environmental Engineering	Frequency of Peak Flood and High Tide Events in Delaware with Climate Change and Sea Level Rise
Bridgette Kegelman	Geography/Greek Roman Studies	Updating Land Use and Impervious Cover Change for the State of the Bays Report
Patrick McGay	Environmental Engineering	White Rot Fungi with Solid State Bioreactors to Reduce Pathogens in Dairy Manure Runoff
Karmyn Pasquariello	Environmental Engineering	Economic Value of Properties in the Coastal/Riverine Floodplain in Delaware with Sea Level Rise
Lily Peterson	Environmental Engineering	Stream Habitat Sampling along Tributaries of the Red Clay Creek in Delaware
Jady Perez	Environmental Engineering	Forest Hydrology and Stream Health in the Hickory Run Watershed at Mt. Cuba Center
Anna Singer	Environmental. Studies/ Public Policy	Water Quality Trends in White Clay Creek Nat'l Wild & Scenic River, Delaware and Pennsylvania

Watershed Characterization of 1st Order Tributaries along Brandywine River in Delaware

Sitlaly Avelino and Delaney Doran
Home Watersheds: Santa Ana; Brandywine River

By focusing on 14 first order tributaries that flow into the Brandywine River, the study aims to better understand and characterize the waters that constitute a major source of drinking water for the state of Delaware. Field studies conducted at reaches along the tributaries will be analyzed to assess variables such as the flow and velocity of the tributaries as well as nitrogen, turbidity, and conductivity. The overall goal of the study is to examine the data to assess the ecological health of each tributary that drains to the Brandywine River.

The Effect of Biochar on Infiltration Rate and Soil Aggregation in Both the Field and Lab

Brendan Benson
Home Watershed: Raritan River

The study seeks to simulate biweekly artificial storm events to evaluate the response of laboratory soil columns with and without the presence of biochar. The samples are examined in order to measure steady-state runoff and percolation rates that result from each storm event as well as the cracking and swelling of each soil column before and after each storm event. The overall goal of the project is to determine, based on these factors, what the differences are between soil samples where biochar is present and samples where there is no biochar present.

Watershed Characterization of 1st Order Tributaries along the Red Clay Creek in Delaware

Tommy Breedveld and Lily Peterson
Home Watershed: Passaic River Basin; White Clay Creek

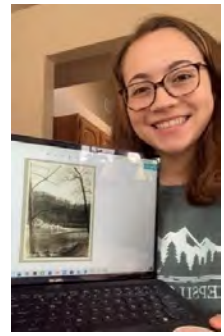
By assessing stream geomorphology, stream habitat, and water quality, this research seeks to characterize the watershed of first order tributaries of the Red Clay Creek in Delaware. The study will classify each stream reach according to the EPA rapid stream bioassessment technique and collect water samples along each tributary to be analyzed for changes in turbidity, nitrogen, and conductivity over time.

Intergovernmental River Basin Management: The International Joint Commission Model

Shannon Bushinsky
Home watershed: Lehigh River

Analysis of the International Joint Commission (IJC), including its structure and policies, will provide an overview of how a large international agency can oversee several extensive river basins. Examining the role of the organization in river basin protection and international treaties concerning water quality and aquatic ecosystem health between Canada and the United States gives insight into how Canada and the United States negotiate policies based upon different views and regulations of water quality and environmental health. The overall goal of the study is to determine whether the organizational structure of the IJC would be successful if applied in other river basins such as the Delaware River and Chesapeake Bay basins.

Historic Significance of the Brandywine River in Wilmington, Delaware
Alexis Cervantes
Home watershed: Manasquan River



The Brandywine River is the largest river and sole drinking water supply for the city of Wilmington, Delaware and as such it is the goal of this project to determine its historic significance in context. The 2020 Brandywine Shad Project has identified resources listed by the National Register of Historic Places (NRHP) and properties that might be considered eligible for listing, located within the geographic area of the potential effect (APE) relevant to identifying the River's historic significance. The study found that based on existing information Dam 2 and Dam 4, in particular, have contributed to the historical significance of the Brandywine River.

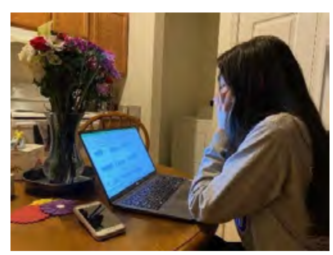
Milldam Deposits in White Clay Creek
Liz DeSonier
Home Watershed: Skippack Creek Watershed

By examining the sediments in White Clay Creek, the project works to identify how the soil profile of the area has changed since human settlement. The study looks to identify the presence of Milldam deposits, which are an indicator of the arrival of humans in the area. By noting the presence and location of Milldam deposits within soil layers, the study will be able to determine the characteristics of soil layers since the presence of Milldam deposits were detected and note the changes. These changes indicate how the soil has changed since humans entered the area and would provide insight for creek management going forward.

Environmental Justice & Stormwater Mitigation Through Reforestation in West Baltimore
Grace Hussar
Home Watershed: White Clay Creek

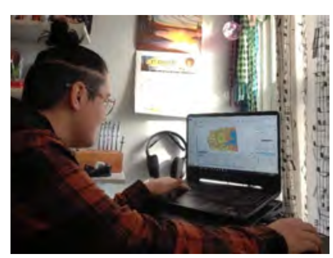
The purpose of this study is to utilize hands-on experience and a series of interviews to assess the positive impacts of forest restoration on a community in West Baltimore that has historically suffered the negative effects of stormwater. The study focuses on the 10-acre plot of land behind the West Baltimore Stillmeadow Community Fellowship Church. Hands-on experiences will include assisting in the establishment of a tree nursery and planting native species, clearing the plot of dead and fallen trees, invasive species, and litter. Interview subjects will include residents of the neighborhood, members of the Stillmeadow Church, and U.S. Forestry employees (the project is in partnership with the U.S. Forest Service).

The Relationship between the Severity of Peak Delaware Flood Events and Climate Change
Emily Jimenez
Home watershed: Chesapeake Bay



The goal of this project is to examine peak flood events and high tides and assess whether riverine and coastal flood conditions are increasing in severity, in terms of frequency and magnitude, over time in Delaware as a result of climate change. Utilizing data values collected from literature, as well as long-term precipitation data from three DEOS weather stations in New Castle, Kent, and Sussex counties, annual peak streamflow data from USGS stream gages, and annual peak high tide data from USGS and NOAA tide gages, the study will conduct statistical analysis to determine if peak streamflow and coastal high tides are changing with precipitation levels in Delaware watersheds.

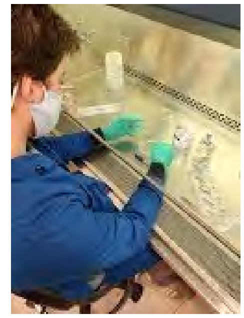
Updating Land Use and Impervious Cover Change for the 2016 State of the Bays Report
Bridgette Kegelman
Home watershed: Brandywine Creek



By collecting data and create updated graphs and charts, this study works to make updates to the 2016 State of the Bays Report. Based on the findings yielded from the latest available data, a decision will be made regarding which available data (collected from the National Oceanic and Atmospheric Administration (NOAA) or the state) would be the most appropriate. Utilizing various GIS tools, the report will generate buffers around bodies of water, agricultural areas, and developed areas to update the 2016 State of the Bays Report and datasets for variables such as bacteria levels, land use, nutrient concentration, dissolved oxygen levels, nutrient loads, and submerged aquatic vegetation (SAV).

Modification of Peroxidase Enzyme Analytical Methods for Solid State Bioreactors use to Reduce Pathogens in Dairy Manure

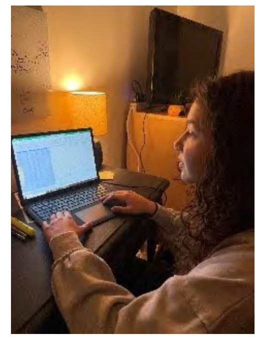
Patrick McGay
Home Watershed: White Clay Creek



The white rot fungi (WRF) Pleurotus ostreatus grown in small bench-scale bioreactors was able to reduce the number of E. coli naturally present in aqueous dairy manure. Currently, bioreactors containing both P. chrysosporium and P. ostreatus are being evaluated for their ability to degrade E. coli and antibiotics within aqueous dairy manure. The objective of this research is to monitor the fungal bioreactors during treatment of dairy manure containing E. coli for both Lignin Peroxidase and Manganese Peroxidase. Once the tests are confirmed successful, the assays will be performed on samples taken from the bioreactors during the E. coli degradation experiments.

Economic Value of Properties in Delaware Coastal/Riverine Floodplain with Sea Level Rise

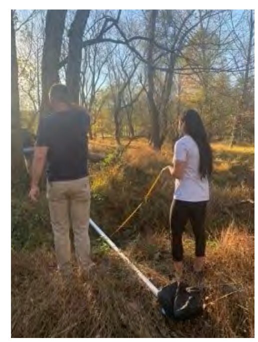
Karmyn Pasquariello
Home watershed: Pompton Lakes



By conducting research into the economic value of properties in the coastal/riverine floodplain in Delaware with sea level rise, this study assesses the real-estate value of properties in Delaware and how the value has changed since 1975 in relation to sea level rise and flooding. The study examines flood insurance premiums, claims, and coverage in Delaware to find high-flood risk areas and determine whether the flood insurance program is adequately funded or subsidized by FEMA. ArcGIS will be used to overlay FEMA and NOAA flood inundation maps with parcel/property value maps to estimate the value of real estate at risk for flooding, given that nearly 20% of Delaware rests in the 100-year floodplain.

Forest Hydrology and Stream Health in the Hickory Run Watershed at Mt. Cuba Center

Jady Perez
Home watershed: Panama Canal



In partnership with Mt. Cuba Center, this study works to conduct field studies, streamflow, and water quality monitoring along the Piedmont tributary of Barley Mill Run that flows east and joins Red Clay Creek near Hoopes Reservoir in Ashland, Delaware. The objective of the watershed-based research program is to quantify the benefits of reforestation at Mt. Cuba Center on the water quality and water quality of Barley Mill Run by analyzing field data collected at monitoring stations where the creek flows by roadway and railroad crossings. At the four water quality monitoring stations, water quality samples are tested for a base (low) flow and a storm (high) flow event.

Water Quality Trends in White Clay Creek National Wild & Scenic River, Delaware and Pennsylvania

Anna Singer
Home watershed: Lake Champlain

The goal of the project is to evaluate the benefits of reforestation and other land cover changes on the creek and also to design best management practices (BMPs) to restore the watershed and the stream. The study will conduct water quality monitoring and analyze trends along the White Clay Creek in Delaware and Pennsylvania by establishing stream flow and water quality monitoring stations at 6 locations. Once per week and during storms over a 6-month period, flow depth and velocity will be recorded to estimate streamflow.

Water Resources Graduate Research Assistant Research

Diversity in National Parks: How Understanding our Past Can Help Us Create an Inclusive Experience
Sophie Phillips
Home Watershed: Croton Watershed

Throughout the year, National Parks are busy with activity. From hiking and camping, to museum visits and ranger-led tours, there are options for everyone to enjoy. In 2019 alone there were 327,516,619 visitors to the National Parks (NPS, 2020). On the surface, it appears the National Parks are doing very well, but looking deeper, there are concerns about the demographics of visitors and employees. A survey by the National Park Service in 2016 showed only 7% of park visitors are African American, and only 20% of visitors are minorities, even though African Americans make up 13% of the U.S. population and minorities make up 40% (Rott 2016). The history of African American experiences with nature, forests, and national lands provides some insight as to why National Park engagement within this population is so low.

The history of segregation in the United States national lands, the lack of representation of African Americans in the National Parks workforce, and a system that pushes kids out of environmental fields leave us with a lot of work to do. Creating programs within the park system that invite youth to become part of that space is an important first step. The creation of an app and podcast series about black history can build understanding and help address the knowledge gap around the history of this nation, while the hiring of more African American employees in leadership positions will allow for the increase of that vital representation. We are far from solving this problem, but those in leadership positions of our national lands are ready to make the changes needed to truly show that we all have ownership in this land.

Critical Steps to Mitigating Climate Change and Addressing Climate Change Based Environmental Racism
Hayley Rost
Home Watershed: Perkiomen Creek

An analysis of the global average surface temperature conducted by the National Aeronautics and Space Administration (NASA) found that 2020 was the warmest year on record. Earth's average temperature has increased by more than 2°F since the 1880s as a result of human activity, in particular, actions that release greenhouse gasses (GHGs) such as carbon dioxide and methane into the atmosphere (NASA, 2021). States which border an ocean, such as Delaware, will be the first and most significantly impacted and many coastal communities have already been affected. It is critical that the Biden administration prioritizes the development of an effective and efficient plan to combat climate change by addressing GHG emissions in the United States. New environmental policies should focus on determining which industries and practices are the most significant sources of GHG pollution and creating regulations to ensure these sectors become environmentally sustainable in the near future. In the state of Delaware 27% of the state's emissions are produced by industry, 23% by electricity production, and 31% by the transportation industry (ICF International, 2020). By transitioning towards the use of renewable energy resources in these three areas in particular, the United States, and the state of Delaware, will be able to reduce the amount of GHG emissions on a large scale. While it is critical to establish policies to reduce GHGs and mitigate future climate change, it is also vital that communities already affected by climate change are addressed such as communities that have been displaced due to climate change and communities that are impacted by environmental racism. President Biden must ensure that the policies and regulations enacted by his administration guarantee that environmental protections are afforded to all citizens and that policy changes are made so that communities of color are no longer disproportionately affected by climate change.

Research with the UD Water Resources Center SY2020-2021

Hayley Rost

UD WRC Graduate Student

University of Delaware

Field Work

- Partnership with White Clay Wild & Scenic River Organization
  - 2000: White Clay Creek designated National Wild & Scenic River
  - Majority of streams are impaired with nutrients, sediment, and/or pathogens
  - Gather data to establish changes in ecosystem health
- Primary Responsibilities Associated
  - Gathering Data
  - Maintaining sampling sites
  - Water Sampling

Site Maintenance

Fig. 1. Debris by sensor

Fig. 2. Cleaning sensor

Fig. 3. Sensor battery

Gathering Data

Fig. 4. pH and EC Probe

Fig. 5. Staff gage

Fig. 6. Sensor box with SD card

Water Sampling

Fig. 7. Water sample collection bottles

Fig. 8. Water sample collection

Goals

- Long-term goals of monitoring
  - Improve knowledge of stream conditions
  - Community awareness
  - Share data with elected officials and watershed residents

Fig. 9. Sensor station in Hockessin, Delaware

Cost-Benefit Analysis of Improved Water Quality in the Delaware Estuary

- Develop a cost-benefit analysis to be presented to a Stakeholder Advisory Committee
  - Delaware River Basin Commission
  - Dischargers/Water Treatment Facilities from each state
  - State/local Government from each state
- Goals
  1. Assign costs to each of the major water treatment facilities in reducing ammonia and nitrogen
  2. Assign economic benefits due to improved water quality through increasing dissolved oxygen
  3. Assess the relationship between costs and benefits

University of Delaware

Assigning Costs

- Based on values from 2020 Kleinfelder Report
- Developed charts relating effluent ammonia output for each water treatment facility to the cost of reaching target effluent ammonia levels (NH3)
  - 10 mg/L
  - 5mg/L
  - 1.5 mg/L

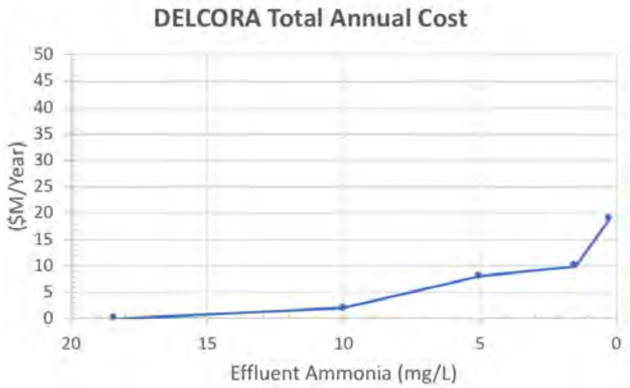


Fig. 10. Annual Cost DELCORA

Fig. 11. Marginal Cost DELCORA

Assigning Costs

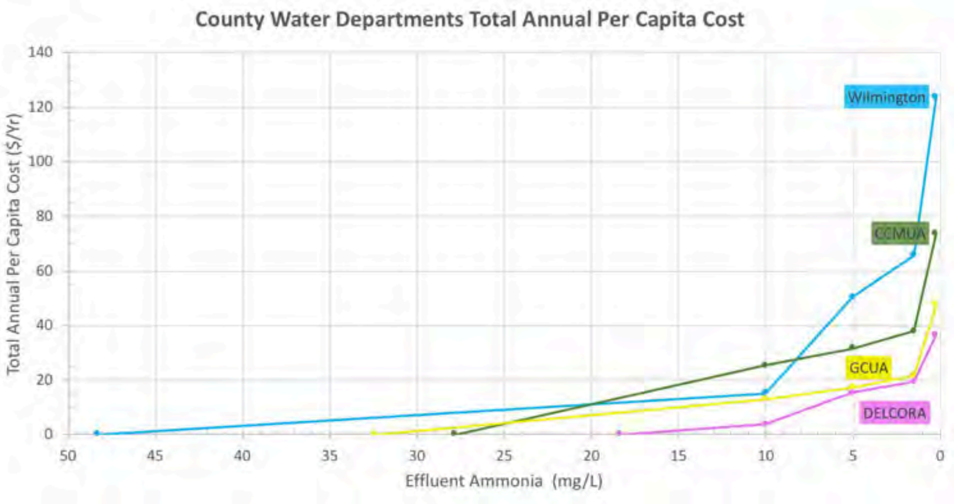


Fig. 12. *Total Annual Per Capita Cost of County Water Departments*

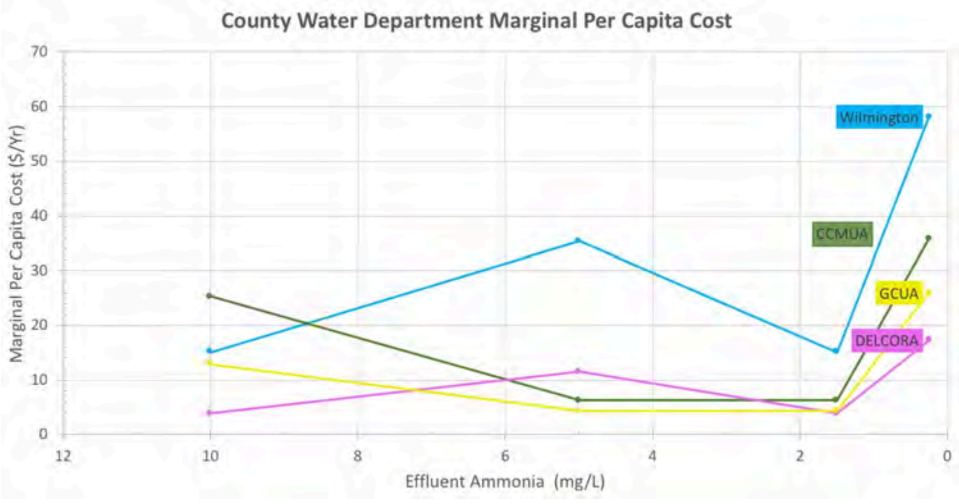


Fig. 13. Marginal Per Capita Cost of County Water Departments

UNIVERSITY OF DELAWARE

Assigning Benefits

- Report estimating economic benefits of improved water quality
  - Improving water quality based on dissolved oxygen levels
  - Current dissolved oxygen levels between Wilmington and Philadelphia 3.5 mg/l
- Waste Water Treatment Service Area (12 WTPs) vs. Delaware Estuary Watershed

Assigning Benefits

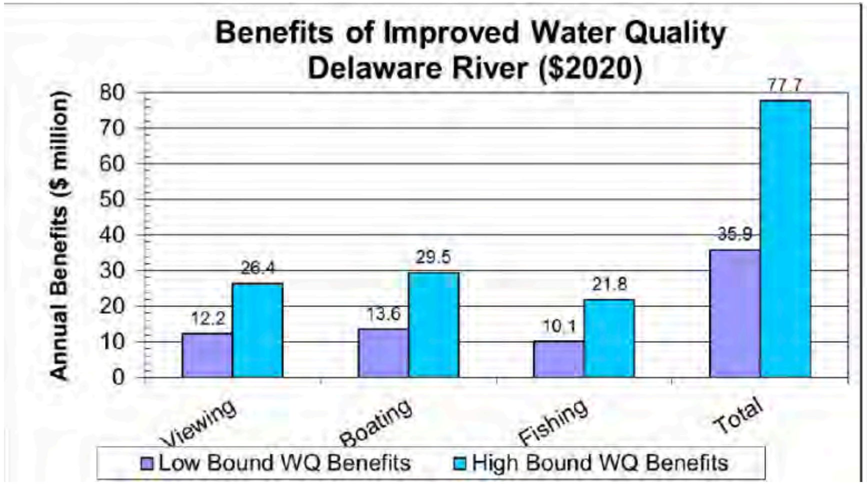


Fig. 14. Benefits of Improved Water Quality in the Delaware Estuary by Type of Activity

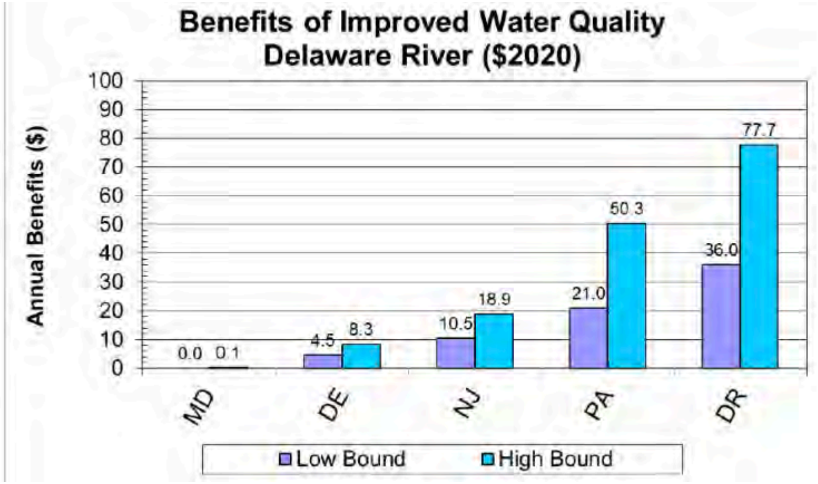


Fig. 15. Benefits of Improved Water Quality in the Delaware Estuary by State

Outcome

- Presentations to Stakeholder Advisory Committee
  - Costs Report
  - Benefits Report
  - Valuable feedback from stakeholders
- Reports conveying valuable information for future investment in improved water quality in the Delaware Estuary

Thank you! Are there any questions?

Thank you to my advisors Dr. Gerald Kauffman and Ms. Martha Narvaez for their support and guidance over the course of this year.

University of Delaware

Diversity in Parks

Sophie Phillips

Statistics

- 2019: 327,516,619 visitors
- 7% of visitors are African American
- 20% of visitors are minorities
- 7% of full-time workforce are African Americans
- 17.4% of full-time workforce are minorities

A historical connect/disconnect with land

- Forests were used in a number of positive ways
- The Ku Klux Klan turned forests into a negative place
  - African Americans lynched every 3.5 days (USDA)
  - Created disconnect
- 1910-1960: Great Migration
  - 1930: 25% of southern African Americans moved north
  - 90.9% of them lived in cities

National Park Service History

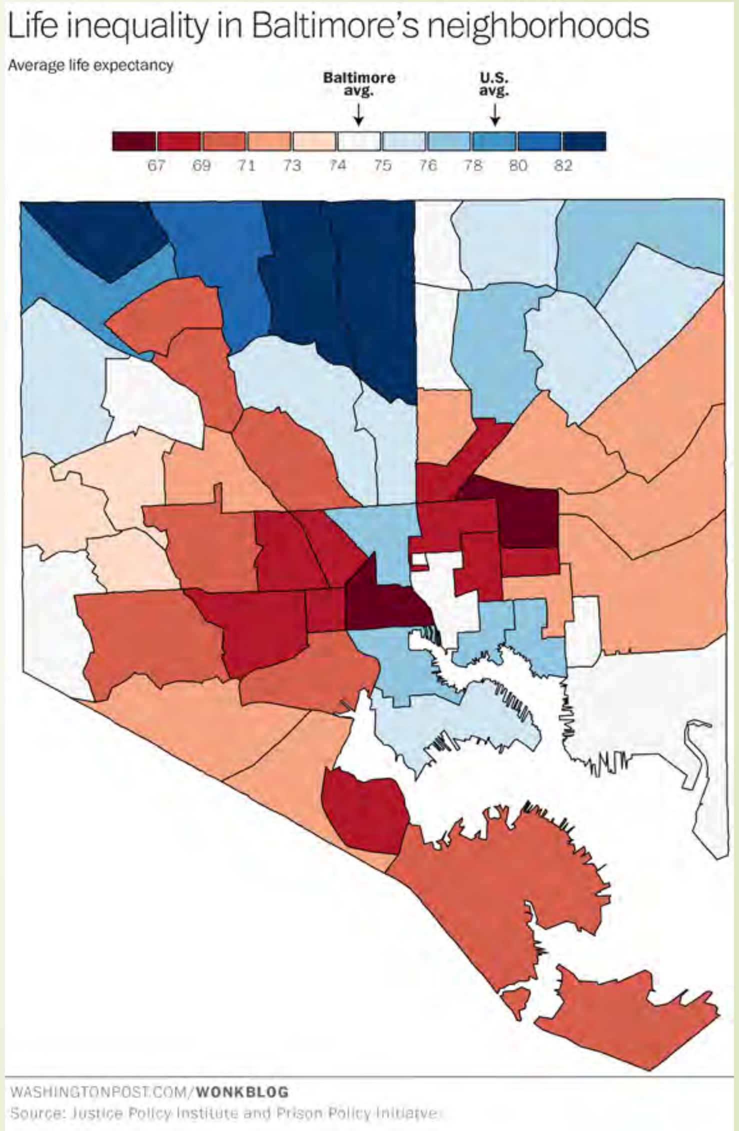
- Post WWII: visitation to public lands accelerated
- Segregation in parks
- 1922 National Park Service superintendents said, “we cannot openly discriminate against [African Americans], [but] they should be told that the parks have no facilities for taking care of them.”
- 1930: black codes
  - Ex: Shenandoah National Park gentleman’s agreement
- 1932: creation of separate facilities
  - Lewis Mountain

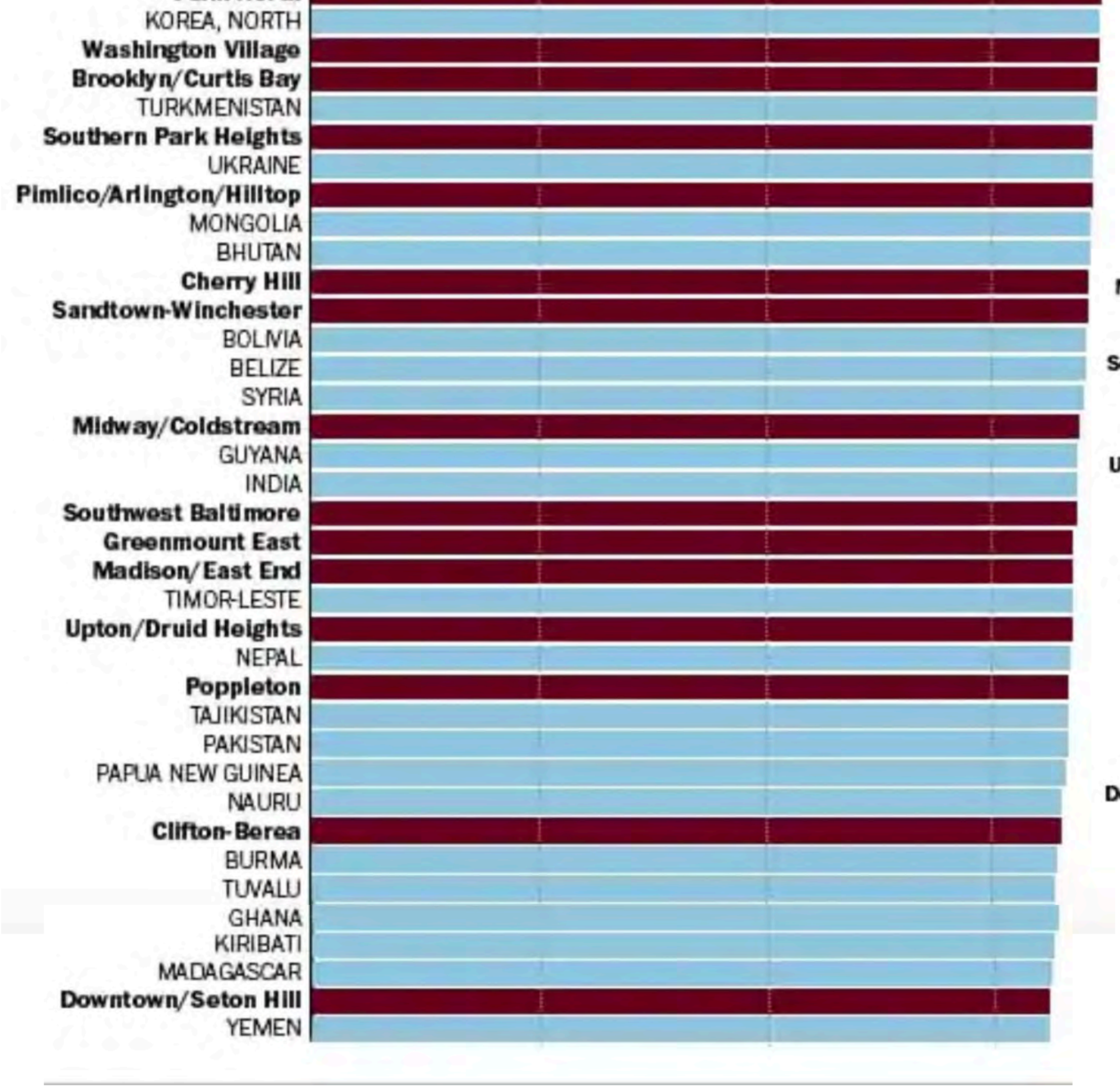
Baltimore History

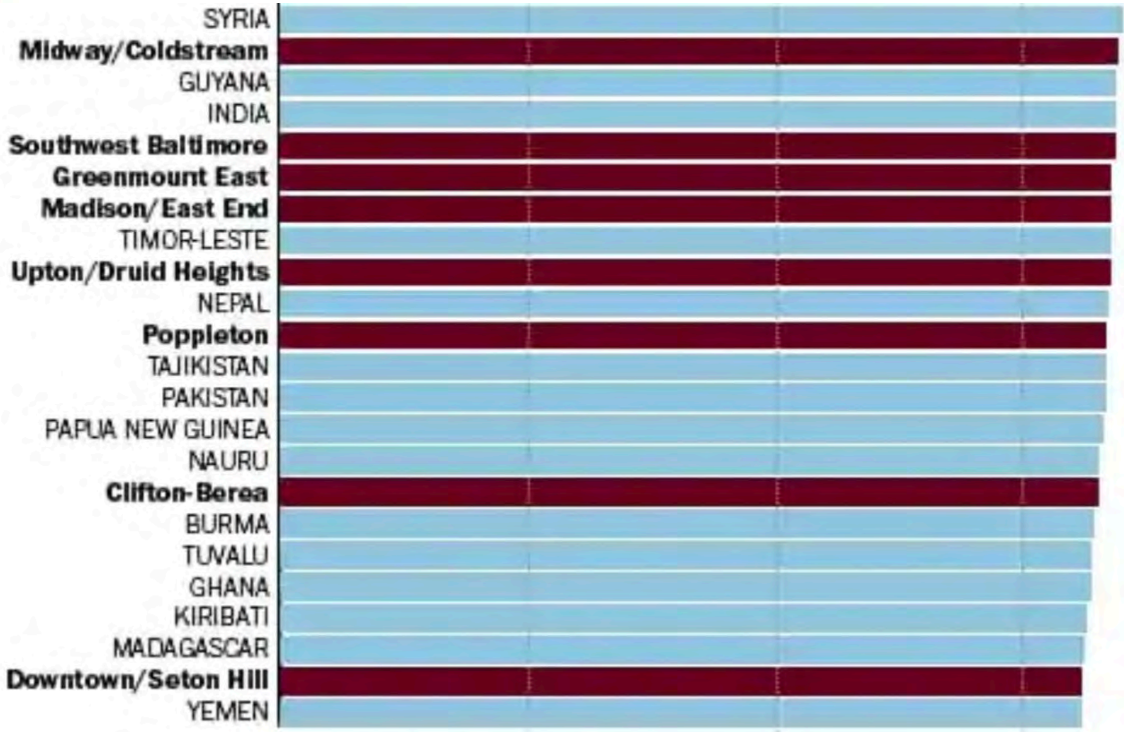
- Until 1970s: Africans Americans were 46.4% of Baltimore's population
  - Now: 63.7% African American
- Largest population of free black people half a century before the Emancipation Proclamation
- End of Civil War: heightened racial tensions as free black people flocked to the city
  - Lots of violence and militias formed
  - Police repression increased
- Segregated schools and neighborhoods

Baltimore in the Present Day

- African-American community: West Baltimore and East Baltimore
- Gentrification
- Life expectancy issues




KOREA, NORTH
Washington Village
Brooklyn/Curtis Bay
TURKMENISTAN
Southern Park Heights
UKRAINE
Pimlico/Arlington/Hilltop
MONGOLIA
BHUTAN
Cherry Hill
Sandtown-Winchester
BOLIVIA
BELIZE
SYRIA
Midway/Coldstream
GUYANA
INDIA
Southwest Baltimore
Greenmount East
Madison/East End
TIMOR-LESTE
Upton/Druid Heights
NEPAL
Poppleton
TAJIKISTAN
PAKISTAN
PAPUA NEW GUINEA
NAURU
Clifton-Berea
BURMA
TUVALU
GHANA
KIRIBATI
MADAGASCAR
Downtown/Seton Hill
YEMEN


SYRIA
Midway/Coldstream
GUYANA
INDIA
Southwest Baltimore
Greenmount East
Madison/East End
TIMOR-LESTE
Upton/Druid Heights
NEPAL
Poppleton
TAJIKISTAN
PAKISTAN
PAPUA NEW GUINEA
NAURU
Clifton-Berea
BURMA
TUVALU
GHANA
KIRIBATI
MADAGASCAR
Downtown/Seton Hill
YEMEN

Gwynns Falls/Leakin Park

- Gwynns Falls/Leakin Park: West Baltimore
- Established: 1948
- 1200 acres: largest woodland park in East Coast city
- Problems: Highway, pipeline, sewer, stigma, and awareness
- Ongoing: survey

Stillmeadow PeacePark

- Location: West Baltimore
- Pastor Michael Martin saw potential
- Gained partners in 2018 after flash flood
- Problems: Emerald Ash Borer, invasive plants
- Steps: remove invasive plants, cut down dead ash, clear planting locations, plant 3,000 fast-growing baby trees

Thesis Goals/Stillmeadow Goals

- Understand the history and communities around parks: surveys
- Create diversity and inclusion management plans
  - Increase visitation
  - Eventually: increase diversity in park staff and visitors
  - Eventually: open up new job opportunities to BIPOC
- Create an outdoor classroom and model community space
  - New experience for BIPOC community members

Watershed Characterization of 1st Order Tributaries along the Lower Brandywine River: 1 - 7

Sitlaly Avelino
Environmental Engineering Major
May 13, 2021

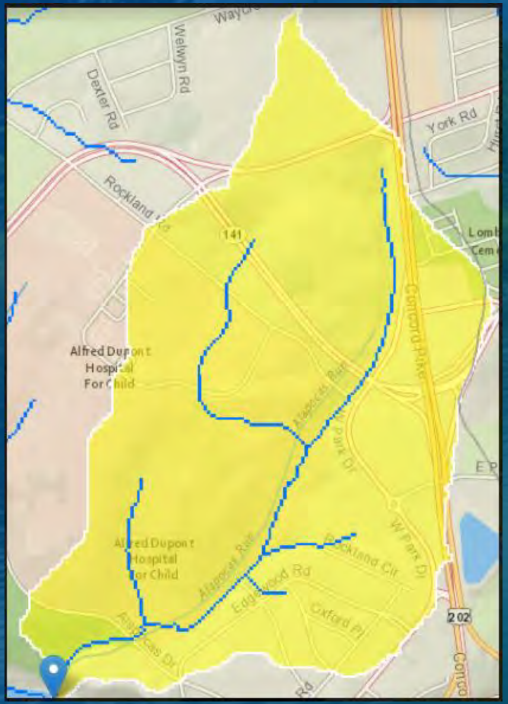
Research Approaches

- Hydrogeology
  - Streamstats
- Soils
  - Use USDA Natural Resources Conservation Service (NRCS) soil survey for New Castle County, Delaware County, and Pennsylvania
- Stream Habitat
  - EPA rapid stream bioassessment
- Stream Geomorphology
  - Rosgen Method
- Water quality
  - Nitrogen, turbidity, and conductivity

Photo of Me

StreamStats

Alopocas Run



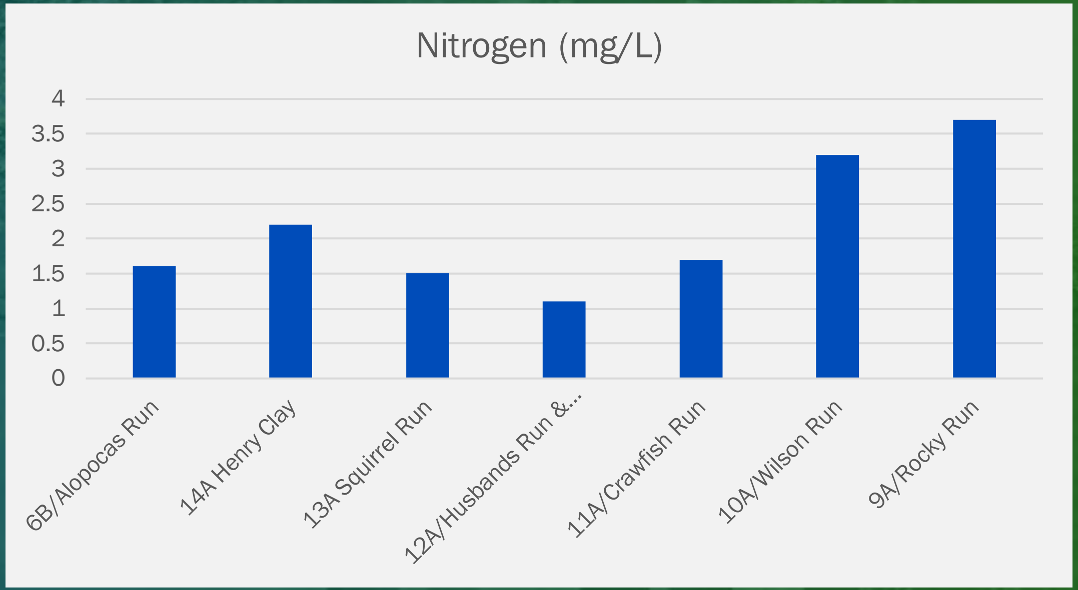
Basin Characteristics

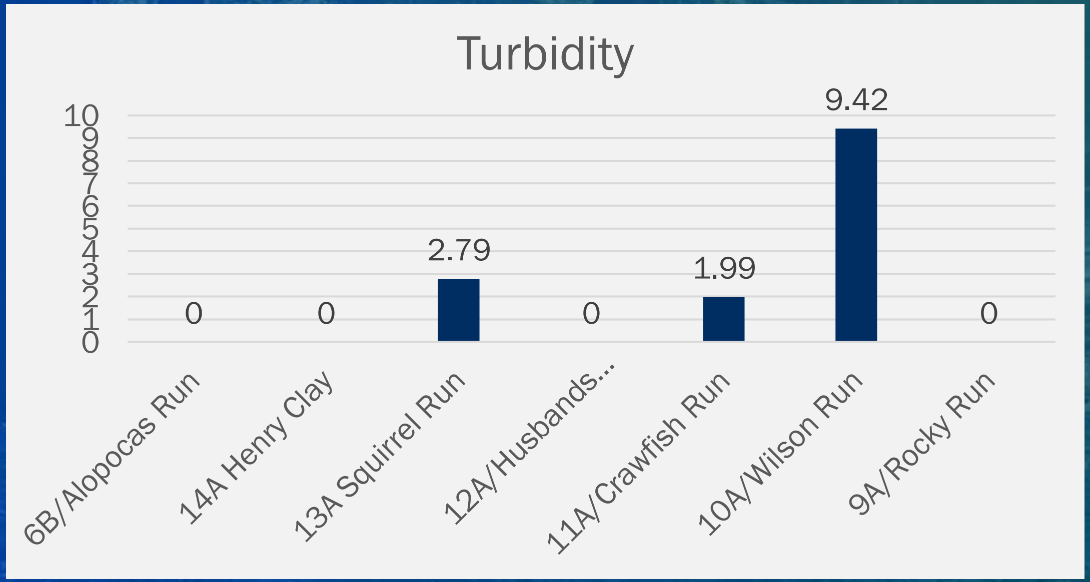
Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	0.77	square miles
FOREST	Percentage of area covered by forest	32.403	percent
SOILA	Percentage of area of Hydrologic Soil Type A	0	percent
IMPNLCD01	Percentage of impervious area determined from NLCD 2001 impervious dataset	13.2836	percent
STORNHD	Percent storage (wetlands and waterbodies) determined from 1:24K NHD	0.0899	percent

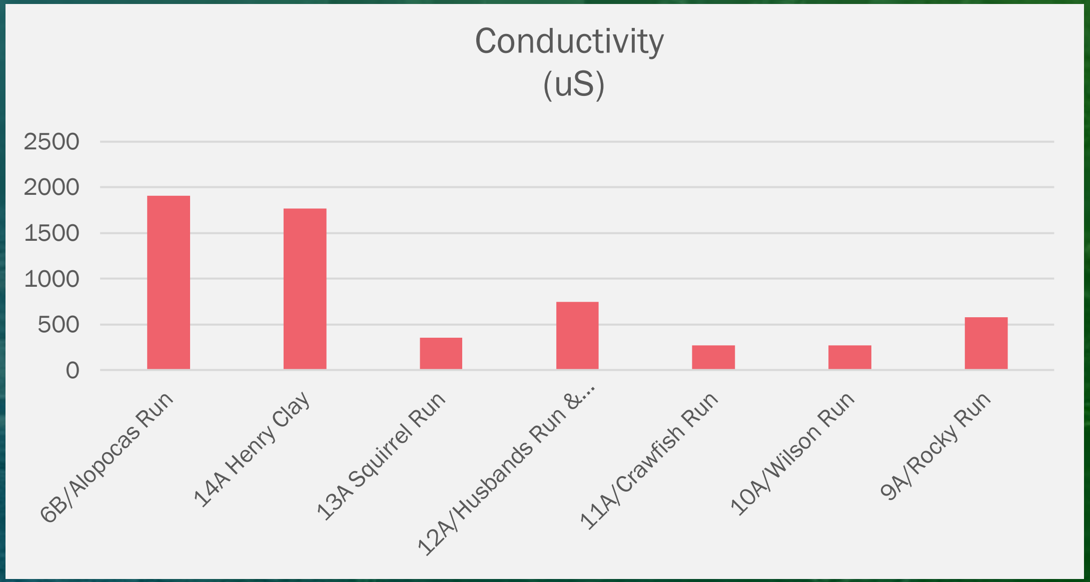
U.S. Geological Survey

Water Quality Data

Collector Number	Stream Name	Turbidity	Nitrogen (mg/L)	Conductivity (uS)
1	6B/Alopocas Run	0	1.6	1905
2	14A Henry Clay	0	2.2	1770
3	13A Squirrel Run	2.79	1.5	354
4	12A/Husbands Run & Willow Run	0	1.1	748
5	11A/Crawfish Run	1.99	1.7	270
6	10A/Wilson Run	9.42	3.2	270
7	9A/Rocky Run	0	3.7	578





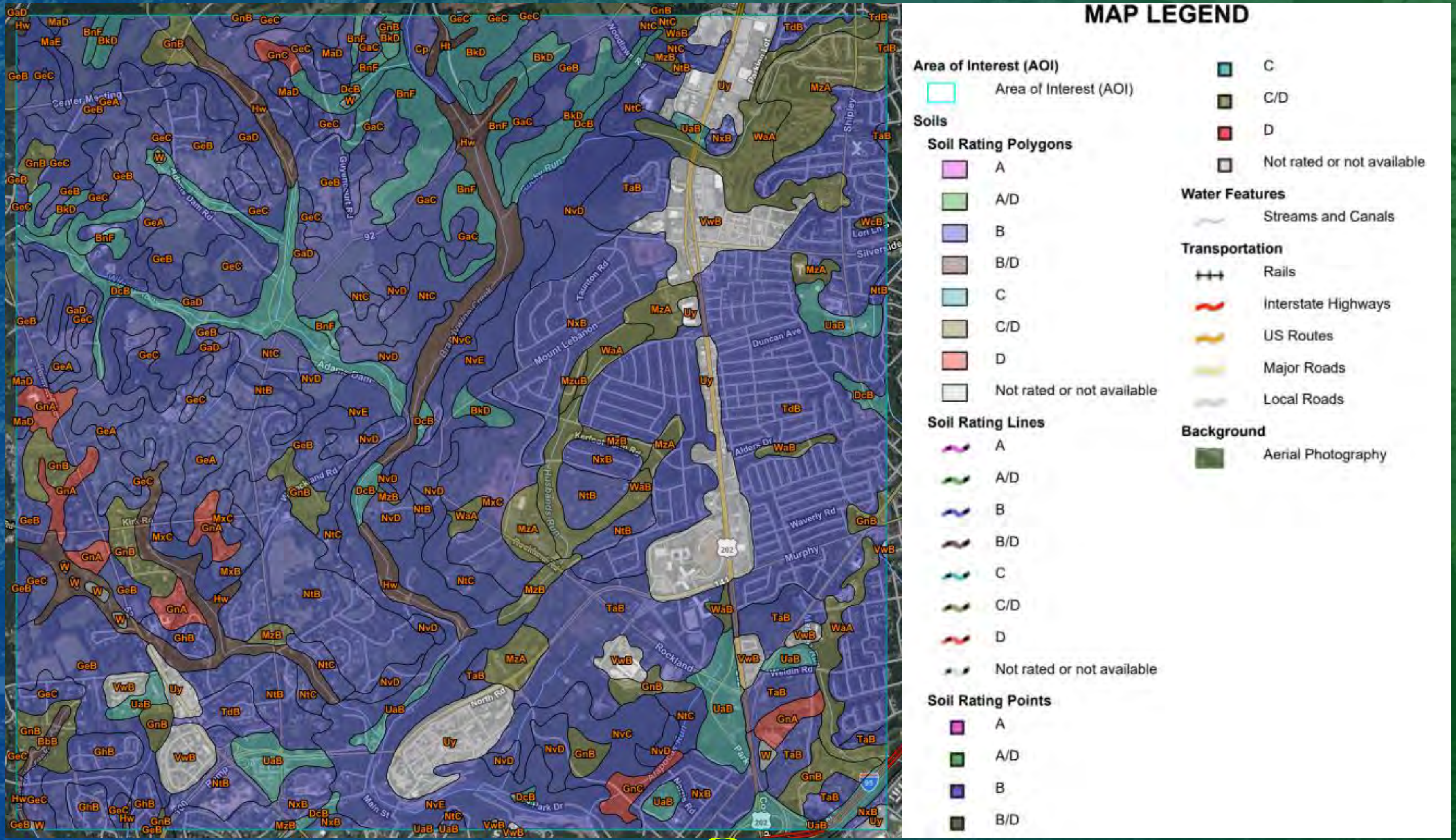


Water Quality Parameters

- Base (low) flow and storm (high) flow event for pH
- Dissolved oxygen
- Turbidity, and
- Conductivity
- Nutrients (nitrogen/phosphorus)
- Bacteria
- Sediment
- Metals
- Organics

Analyzed by City of Wilmington Water Quality Laboratory

Soils



USDA Soil Survey

EPA Rapid Stream Bioassessments

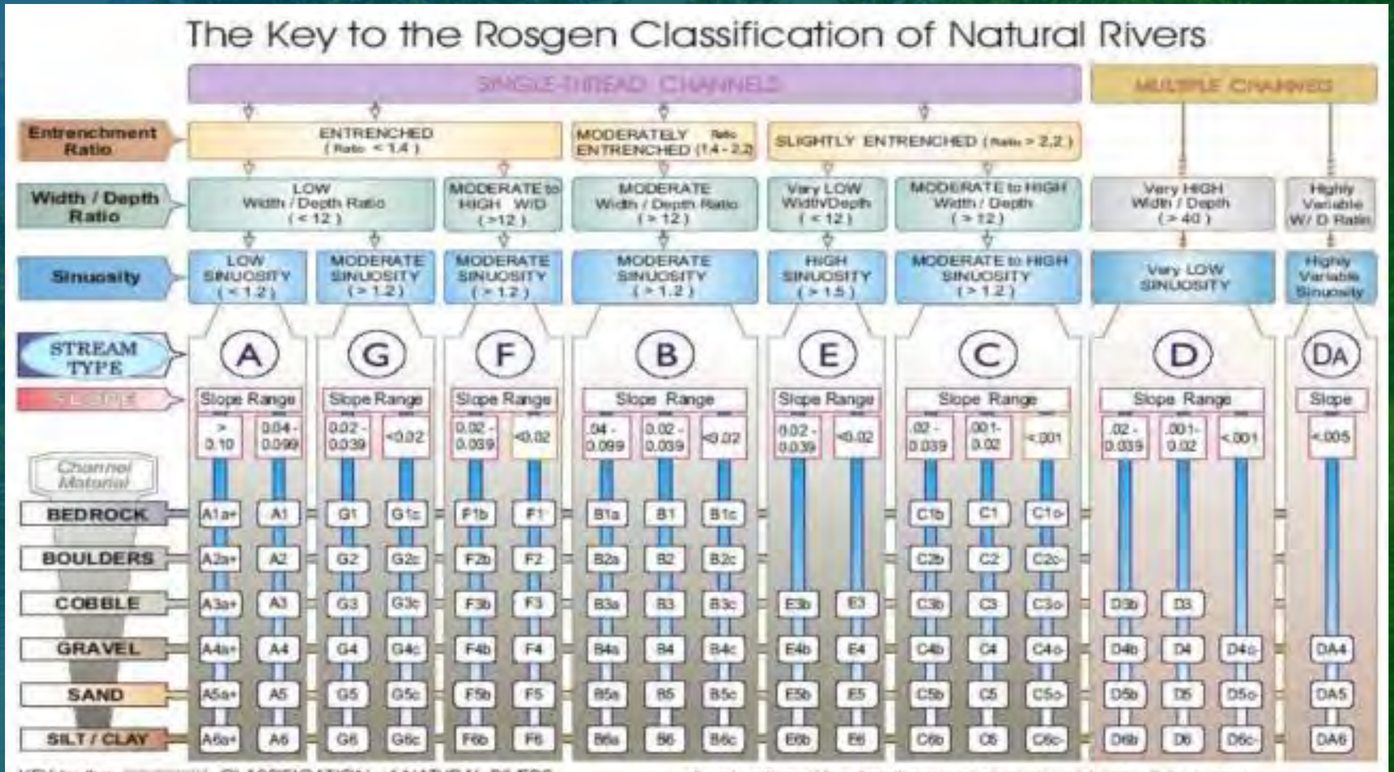
Epifaunal Substrate	Pool Substrate	Pool Variability	Sediment Deposition	Channel Flow Status	Channel Alteration	Channel Sinuousity	Bank Stability	Veget. Protection	Riparian Veget. Zone	Score	Rating	% DE Reference
16	16	12	16	16	19	16	6	5	1	**131**	**Suboptimal**	**69%**
19	18	18	15	13	19	20	8	9	10	**173**	**Optimal**	**91%**
18	17	15	16	16	19	17	6	9	2	**160**	**Optimal**	**84%**
19	17	19	17	17	18	18	8	8	3	**164**	**Optimal**	**86%**
18	19	19	18	18	18	17	5	8	6	**160**	**Optimal**	**84%**
16	17	16	14	15	18	16	6	9	10	**132**	**Suboptimal**	**70%**
18	17	18	16	16	17	17	7	8	7	**162**	**Optimal**	**85%**
14	17	10	15	17	15	11	7	8	1	**134**	**Suboptimal**	**71%**
17	17	18	15	16	19	15	6	7	9	**153**	**Optimal**	**81%**
18	17	13	14	14	18	16	7	7	9	**156**	**Optimal**	**82%**
18	17	16	14	15	19	15	6	7.5	9	**159**	**Optimal**	**84%**

EPA Biohabitat Score	Rating	% DE Ref. = 190
131	Suboptimal	69%
173	Optimal	91%
160	Optimal	84%
164	Optimal	86%
160	Optimal	84%
132	Suboptimal	70%
162	Optimal	85%
134	Suboptimal	71%
153	Optimal	81%
156	Optimal	82%
159	Optimal	84%

Example of EPA Bioassessments

Rosgen Method

- Classifies morphology of streams based on shape, geometry, slope, and substrate type.
- Parameters:
  - Entrenchment ratio
  - Channel width to depth ratio
  - Sinuosity
  - Slope



KEY to the ROSGEN CLASSIFICATION of NATURAL RIVERS. As a function of the "continuum of physical variables" within stream reaches, values of Entrenchment and Sinuosity ratios can vary by +/- 0.2 units; while values for Width / Depth ratios can vary by +/- 2.0 units.

Conclusions

- The percentage of forest ranged from 0% at Henry Clay to 32% at Alopocas Run.
- The turbidity ranges from 0 to 9.42.
- The nitrogen levels ranged from 1.1 mg/L at Wilson's Run to 3.7 mg/L at Rocky's Run with a median of 1.7 mg/L.
- The conductivity ranged from 270 uS at Wilson Run and Crawfish Run to 1905 at Alopocas Run with a median of 576 uS.
- The soil is mostly comprised of type B soil, with GeB accounting for about 13.3% of the overall area of interest.

THANK YOU!

Any Questions?

The Effect of Biochar Addition on Infiltration Rate and Soil Aggregation in the Lab

By: Brendan Benson

Background

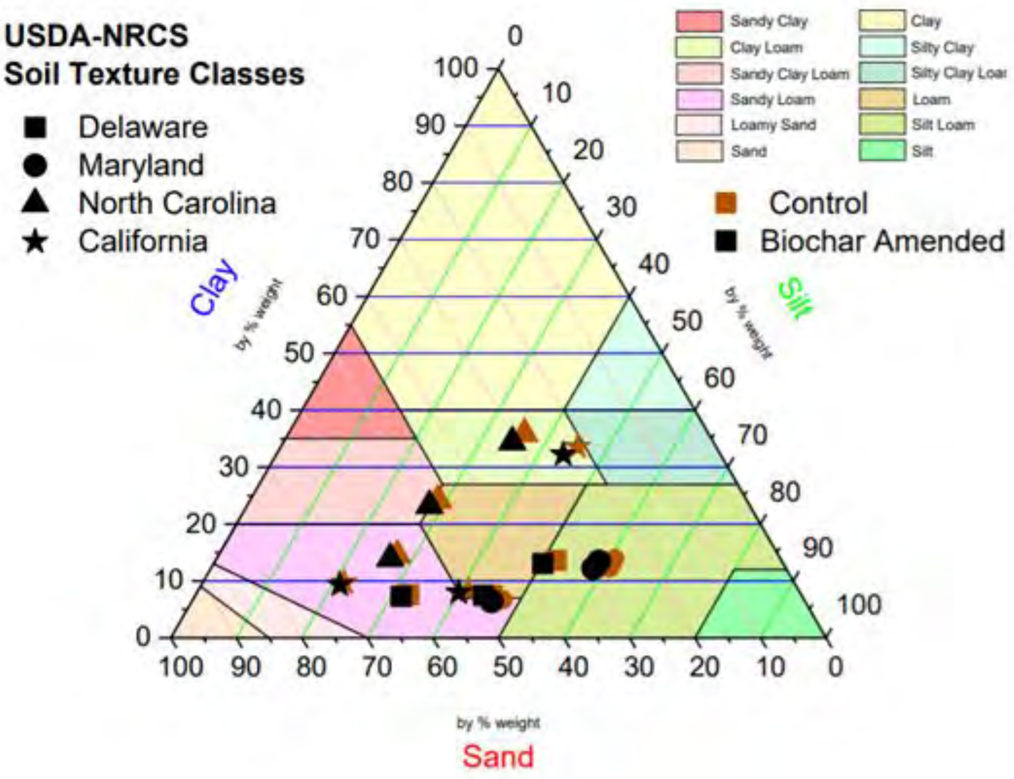


Figure 1: USDA soil texture classes of soils

Experimental Procedure

Figure 2: Infiltration test setup.

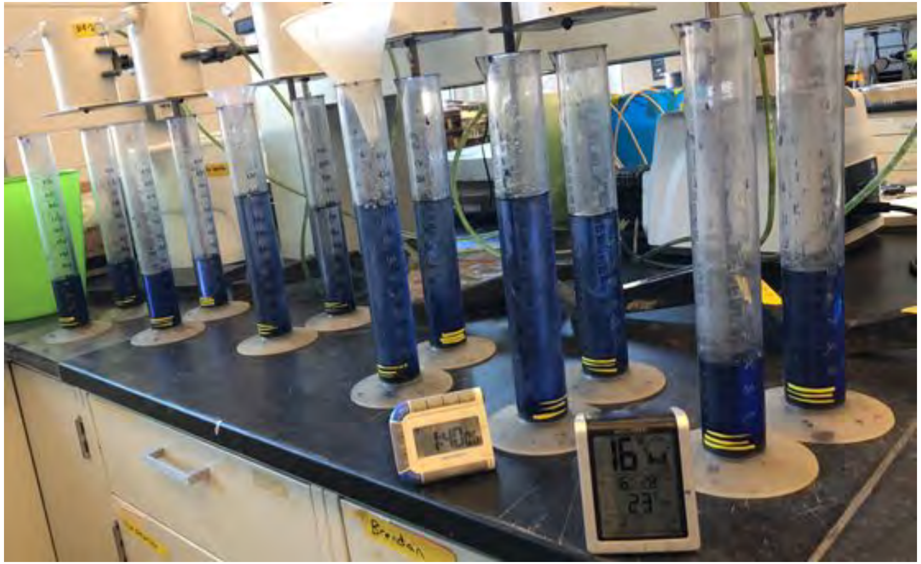


Figure 3: Infiltration test example.

Steady State Percolation Rate

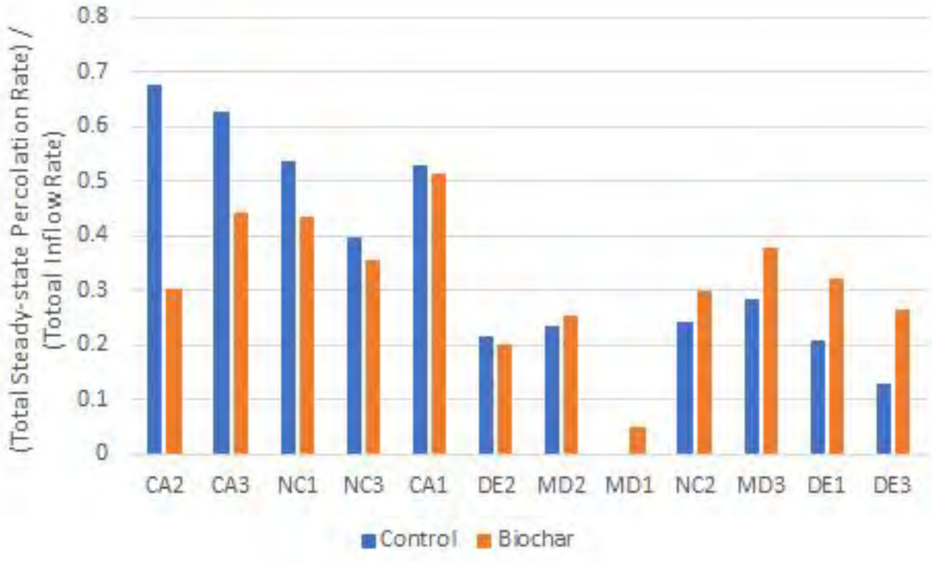


Figure 4

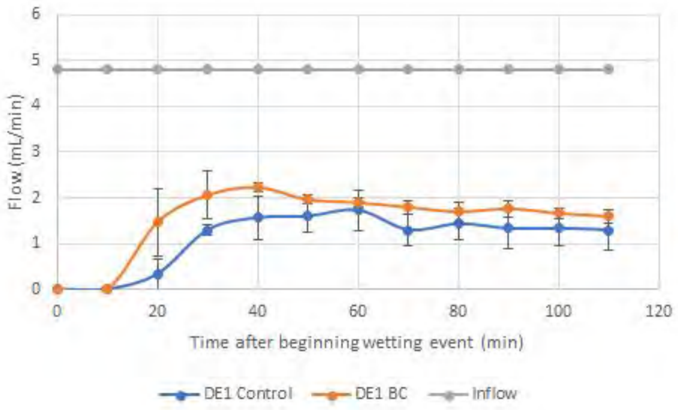


Figure 5

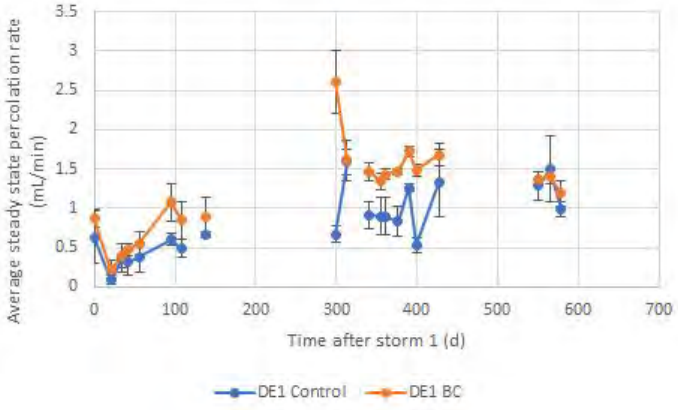


Figure 6

Soil Cracking & Swelling

Figure 7

Figure 9

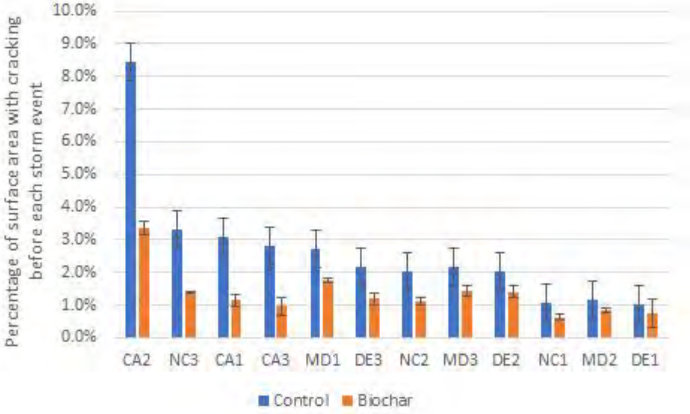


Figure 8

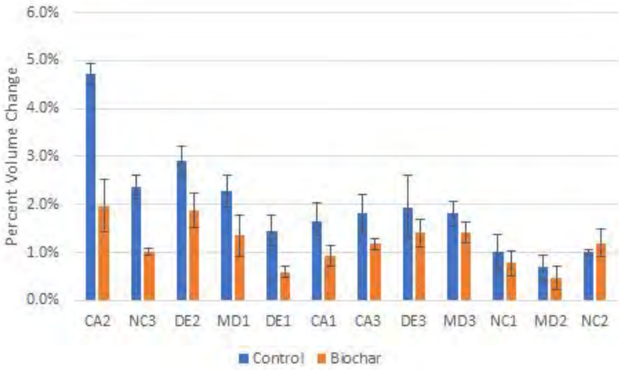


Figure 10

Conclusions

- Biochar reduces soil swelling.
- Biochar reduces soil cracking.
- Biochar increases percolation in roughly half of the tested soils.
    - Soils where biochar decreased percolation show significant reductions in swelling and cracking for biochar-amended replicates.
    - Large soil cracks inhibited the effect of biocha addition on percolation.

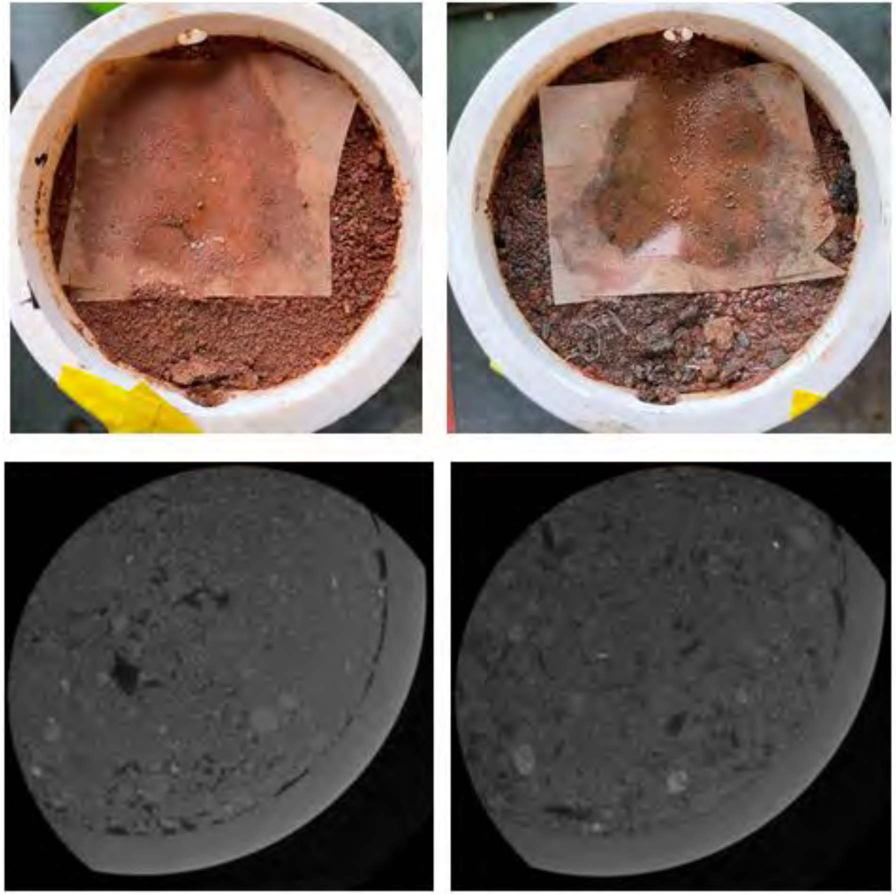


Figure 11

Forest Hydrology and Stream Health in the Barley Mill Run Watershed at Mt. Cuba Center

Delaware Water Resources Center (DWRC)

University of Delaware

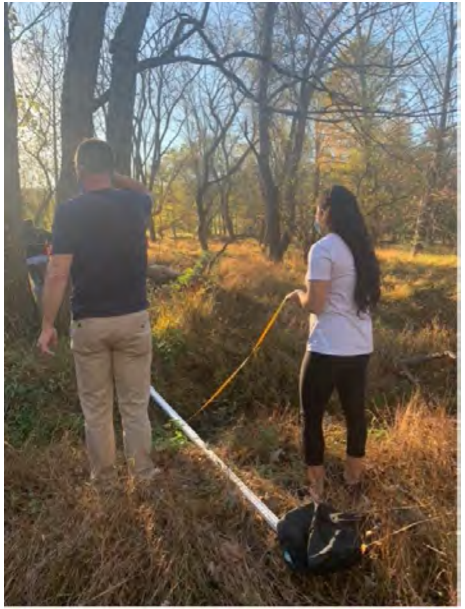
Project Description

- Goal: Quantify the benefits of reforestation at Mt. Cuba Center on the water quality and water quantity of the Barley Mill Run watershed. Field methods include water characterization, stream cross-sections, stream habitat, geomorphology, stream flow monitoring, water quality, soils, hydrogeology, and more.

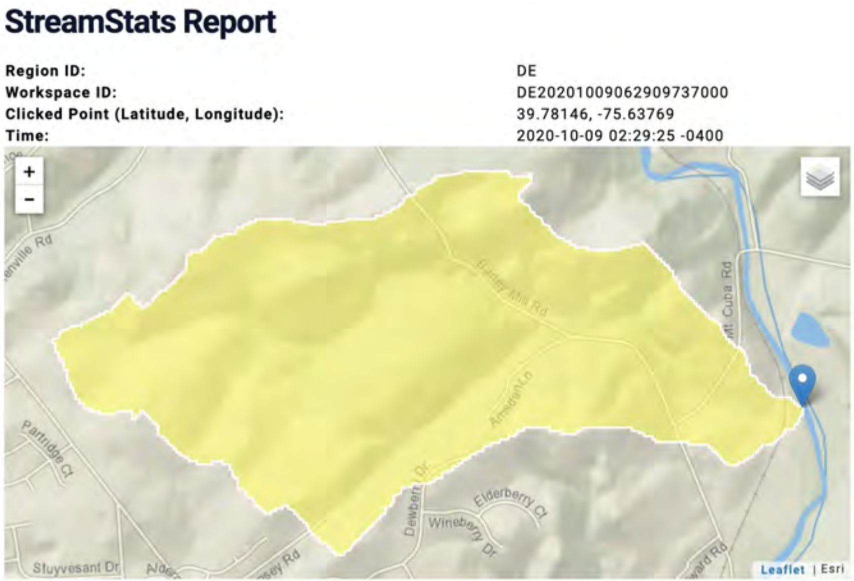
About Mt. Cuba Center

- Non-profit botanical garden dedicated to native plants and ecological gardening
- Top spot in USA Today’s Best Readers’ Choice Awards for best botanical garden in North America

Research — First Semester



Field Work



StreamStats Delineation and Report

Basin Characteristics

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
BSLDEM10M	Mean basin slope computed from 10 m DEM	13	percent
DRNAREA	Area that drains to a point on a stream	0.67	square miles
FOREST	Percentage of area covered by forest	52.8508	percent
IMPNLCD01	Percentage of impervious area determined from NLCD 2001 impervious dataset	0.2097	percent
LC11DEV	Percentage of developed (urban) land from NLCD 2011 classes 21-24	9.6	percent
LC11IMP	Average percentage of impervious area determined from NLCD 2011 impervious dataset	0.4	percent
SOILA	Percentage of area of Hydrologic Soil Type A	6	percent
STORNHD	Percent storage (wetlands and waterbodies) determined from 1:24K NHD	0.104	percent

Research — Second Semester

Nitrate reading — creek protected by Mt. Cuba

Nitrate reading — creek not protected by Mt. Cuba

Research — Future Plans

- Unfortunately, Jady will be leaving us, but Brielle hopes to continue the research throughout the summer
- Continue to go in the field to collect more data and come to a final conclusion on the impact of reforestation to the watershed at Mt. Cuba
- Excited to learn more hands on experience relevant to my future goals as an environmental engineer

Thank you!

C. aracterization of the Red Clay Creek Watershed

b:A

Tommy Breedveld, Lily Peterson

June 18, 2021

Department of Water Resources

University of Dela. are

Abstract

This report summarizes our field work and subsequent analysis on water quality data and measured physical parameters for 17 tributaries to the Red Clay Creek Watershed, supported by the Water Resources Center at the University of Delaware. Data was collected weekly for 7 consecutive weeks: physical parameters (flow rate and EPA Rapid Steam Bioassessment scores) being recorded once for each tributary, and water quality data (turbidity, conductivity, and nitrogen levels) being recorded for the months of April and May. Data analysis revealed a lot of variation in physical characteristics of each tributary; abnormally high nitrogen levels in many tributaries, due to the agrarian nature of land use in the watershed; and acceptable conductivity levels per EPA standards. Expected increases in water temperature were also observed between April and May. Our understanding of this data and its implications is key to our ability to protect and maintain Delaware's drinking water and aquatic ecosystems, therefore continuation of this research is highly recommended.

Table of Contents

List of Figures

Introduction

The Water Resources Center at the University of Delaware (DWRC), funded by the Water Resources Research Act of 1984 and administered by the U.S. Geological Survey (USGS), serves to train and educate future water quality and management professionals, as well as support related research and public outreach efforts. This research project was completed with respect to the mission of the DWRC. The watersheds of New Castle County, Delaware are vital to the wellbeing of the local population, making it crucial for us to monitor and report on the water quality and ecosystem health of waterways within these systems. Extensive data has been collected on key rivers in the county, such as Brandywine Creek and White Clay Creek, however little is known about the health of the tributaries that feed into these resources. To the benefit of local residents that use these waterways for recreation, drinking water, flood damage prevention, etc., we surveyed and characterized 17 tributaries of the Red Clay Creek Watershed for this project, then analyzed our findings in the context of existing stream health and water quality measures. [41]

Procedure

Our research began with delineation of each tributary to the Red Clay Creek Watershed within New Castle County via the USGS StreamStats tool. Our initial digital survey yielded 41 tributaries, later narrowed down to 17 streams on the basis of accessibility and significance. We then collected data every Friday for 7 consecutive weeks before completing the field component of our research and analyzing results. Once in April and once in May, we recorded the following water quality data: nitrogen concentrations in the water (mg/L), conductivity of the water, and turbidity of the water (FNU) for each of the 17 tributaries. On other days, we measured physical parameters of each tributary, namely the tributary flow rate (cfs) and EPA Rapid Stream Habitat Bioassessment scores. After collecting our data, we analyzed using Excel plots and our knowledge of the context in which we found each tributary while completing field work.

Results and Discussion

The EPA Rapid Stream Habitat Bioassessment test was performed on seventeen Red Clay Creek tributary streams. Figure 1 shows that the majority of the streams fell in the Suboptimal and Optimal range. To be exact, nine streams were Optimal, seven were Suboptimal, one was Marginal, and zero were Poor. The EPA Rapid Stream Habitat Bioassessment test ultimately just summarizes the overall quality and health of the stream. The dirtier the streams are, and the more erosion and blockages that are present, the lower the rating will be. These results represent the high stream quality of the Red Clay Creek tributaries.

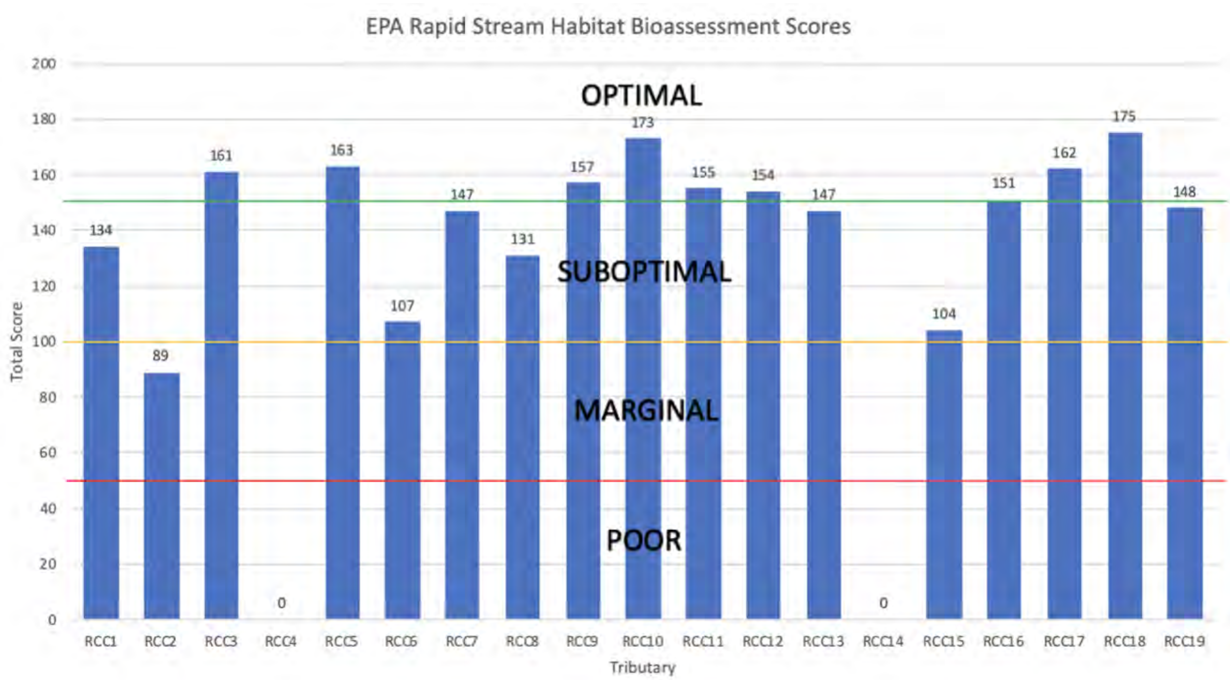


Figure 1. EPA Rapid Stream Habitat Bioassessment Scores

Physical measurements, like flow rates, were taken at each Red Clay Creek tributary. All of the streams ranged in size from about 70 to 4600 acres. Tributary #3 and #10 were the largest in size, and had the highest flow rates. Hyde Run is the name of #3, while Burrow's Run is the name of #10. The more established and well-known tributaries were bigger in size and had higher flow rates.

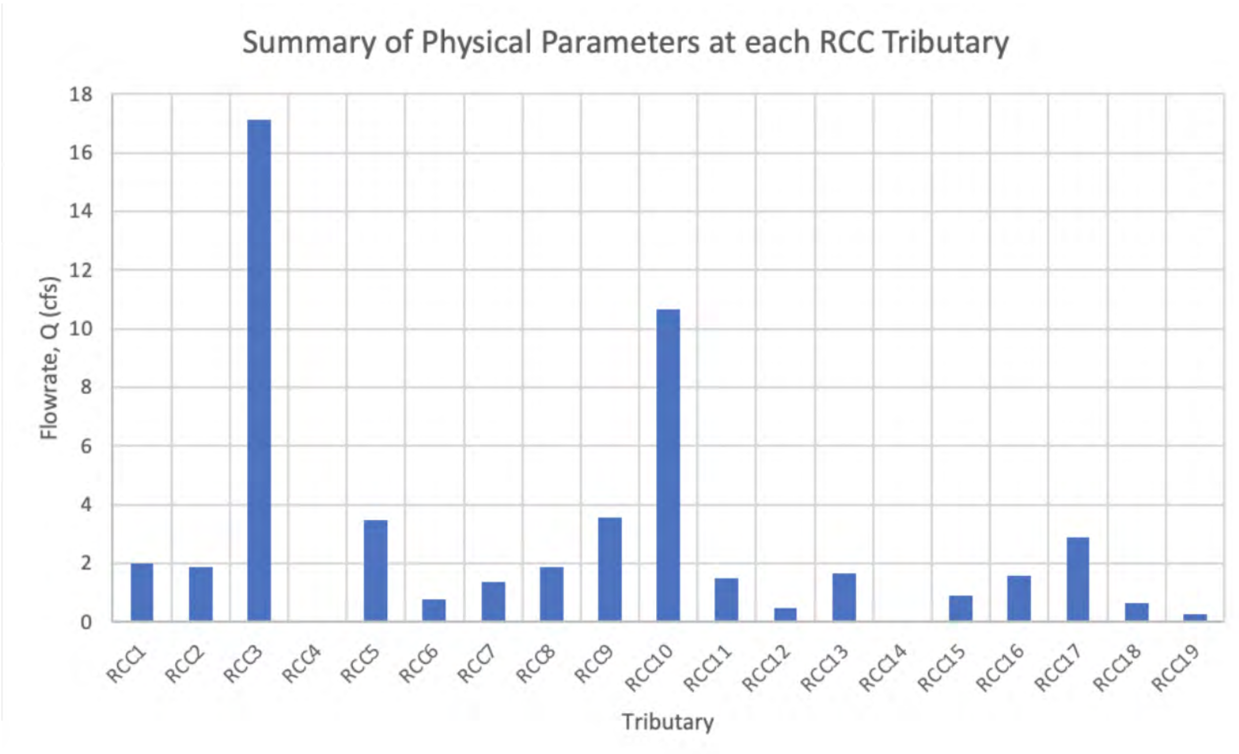


Figure 2. Flow Rates for Red Clay Creek Tributaries

Nitrogen levels were measured and recorded at every stream in units of milligrams per liter for months April and May. Most of the Red Clay Creek tributaries were found in rural areas, which means agriculture is more common in this area of Delaware. Typically, nitrogen and phosphorus levels in water systems are higher in rural areas because the fertilizer used while farming makes its way into the nearby streams due to runoff. The University of Delaware Department of Agriculture and Natural Resources stated that the Delaware threshold for nitrogen in freshwater streams is 3 mg/L. In Figure 3, it is shown that almost all of the nitrogen levels for the seventeen streams fall above 3 mg/L. This means that most of the Red Clay Creek tributaries have abnormally high levels of nitrogen, which was expected because of the rural community that Red Clay Creek is present in. However, it is not ideal for stream health. High nitrogen levels can lead to excessive algae growth, or algae bloom, which is not good for wildlife that may be living in these streams.

Figure 3 also compares nitrogen levels collected in April and May. It is clear that there seemed to be a slight increase in nitrogen levels from April to May. This may have been caused by an increase in farming activity due to the increase in temperature. However, it is difficult to draw a connection because there are only two months of data present. With a whole year of data, or more, more conclusions and connections could have been made.

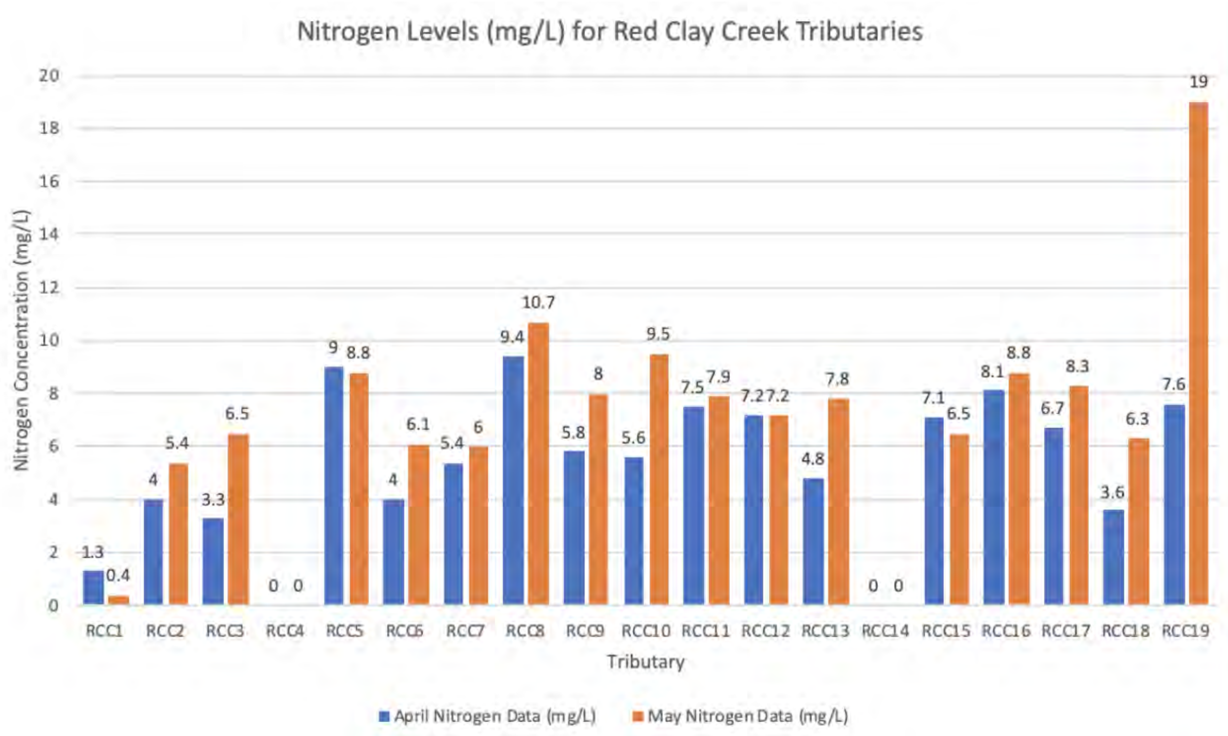


Figure 3. Nitrogen Levels for Red Clay Creek Tributaries

Turbidity levels, in units FNU (Formazin Turbidity Units), were recorded for the Red Clay Creek Tributaries for only the month of April. Turbidity is a measurement of how clear the water is. The foggier the water is, the higher the turbidity is. Sediment, clay, organic matter, and other minerals in the water are some substances that can cause water to be more turbid. Specifically, high turbidity levels due to sediment pollution is particularly bad because it can be harmful to aquatic wildlife. The cloudiness of the way can make it difficult for sunlight to go through the water and feed organisms that live off of photosynthesis. In addition, a lot of silt and sediment can result in the death of fish due to the tiny particles getting trapped in the gills of the fish.

The turbidity data for the month of April, shown in Figure 4, varied a good amount. A lot of the turbidity levels were pretty high, which is not the best outcome to see. However, this data could have been taken after a rainstorm, which would naturally cause higher turbidity levels for a few days after the storm. Due to the fact that there was only one month of data collected, no serious conclusions can be drawn in regards to turbidity.

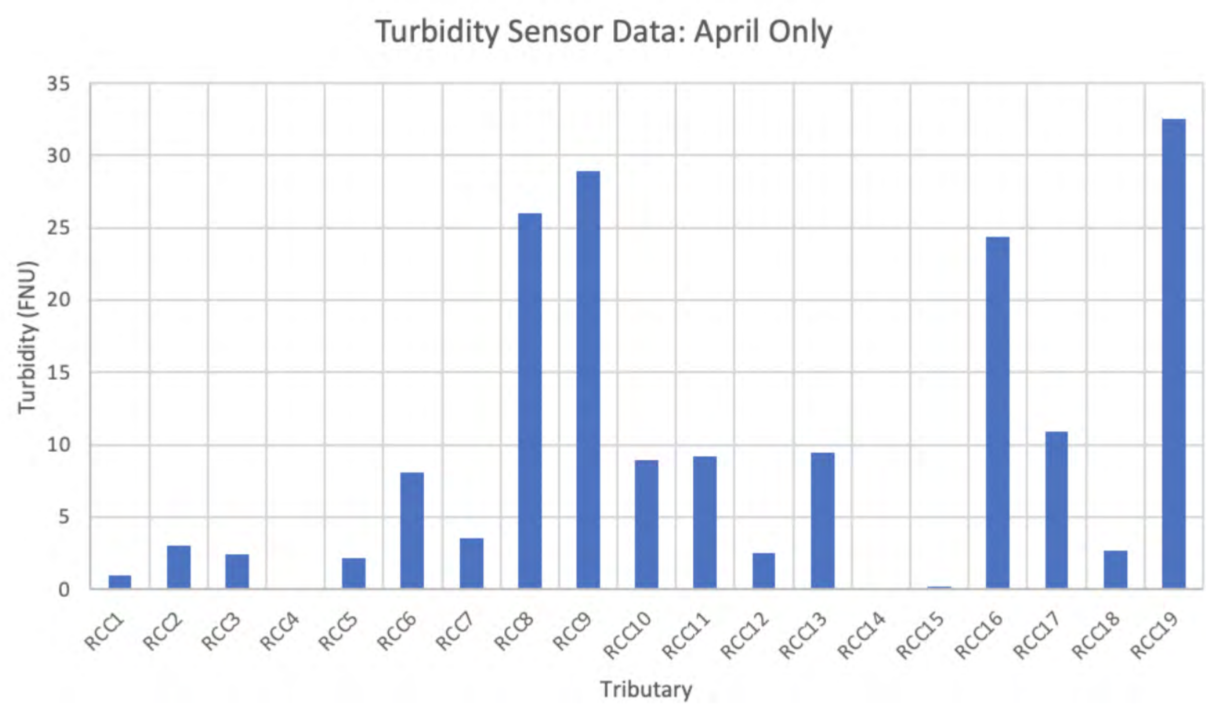


Figure 4. Turbidity Levels for Red Clay Creek Tributaries

Conductivity levels were also taken for both April and May for all Red Clay Creek Tributaries. Conductivity is the ability of water to pass an electrical current. The levels were recorded in units of microhms per centimeter. Conductivity is affected by the amount of ions that are found in the water. Some common ions that could have been present in the Red Clay Creek streams are sodium and chloride ions. More ions results in a higher conductivity, which then results in less pure water.

Figure 5 shows the comparison of conductivity levels for April and May. There is a good amount of variation in the data. The values range from about 160 to 460 microhms per centimeter. The EPA stated that U.S. rivers typically have a conductivity of 150 to 500 microhms per centimeter. Therefore, all of the Red Clay Creek tributaries had conductivity levels that fell within the EPA's range. This is a sign of good stream health and quality for Red Clay Creek and Delaware.

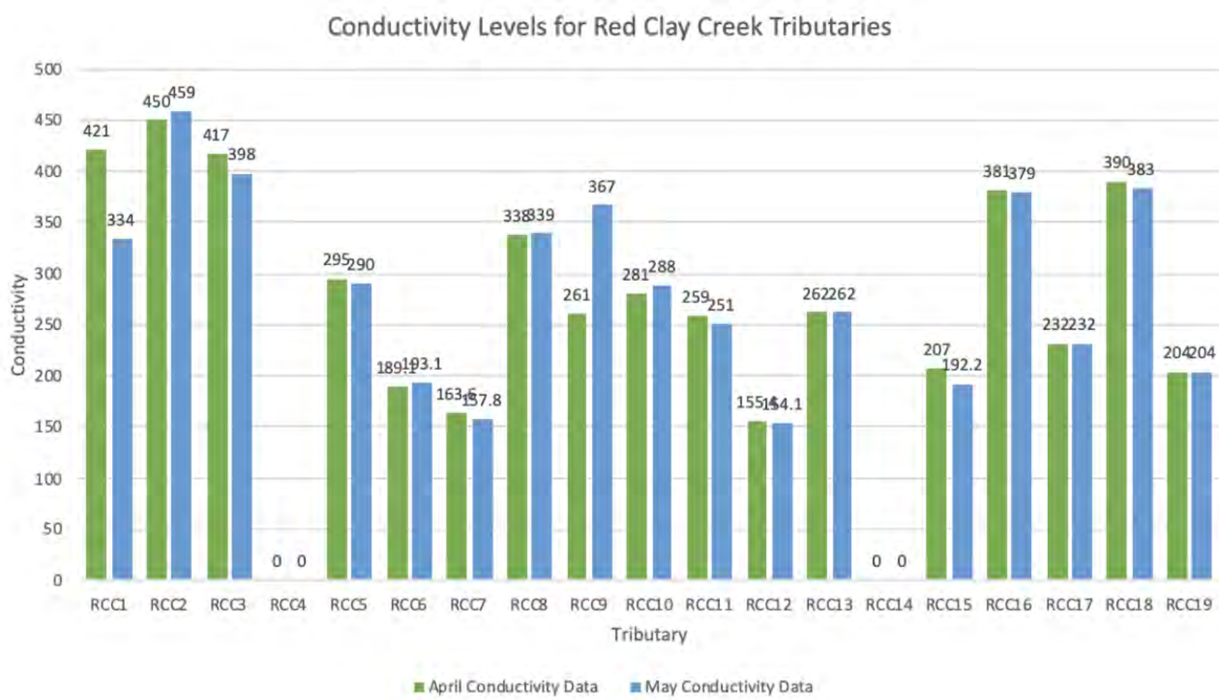


Figure 5. Conductivity Levels for Red Clay Creek Tributaries

Lastly, temperatures were taken at every tributary of Red Clay Creek for months April and May. Since the air temperature increased from April to May, an increase in water temperature was predicted. In Figure 6, it is clear that there was a slight increase in temperature after one month. Specifically, temperature increased by about 3.5 degrees Fahrenheit in about one month.

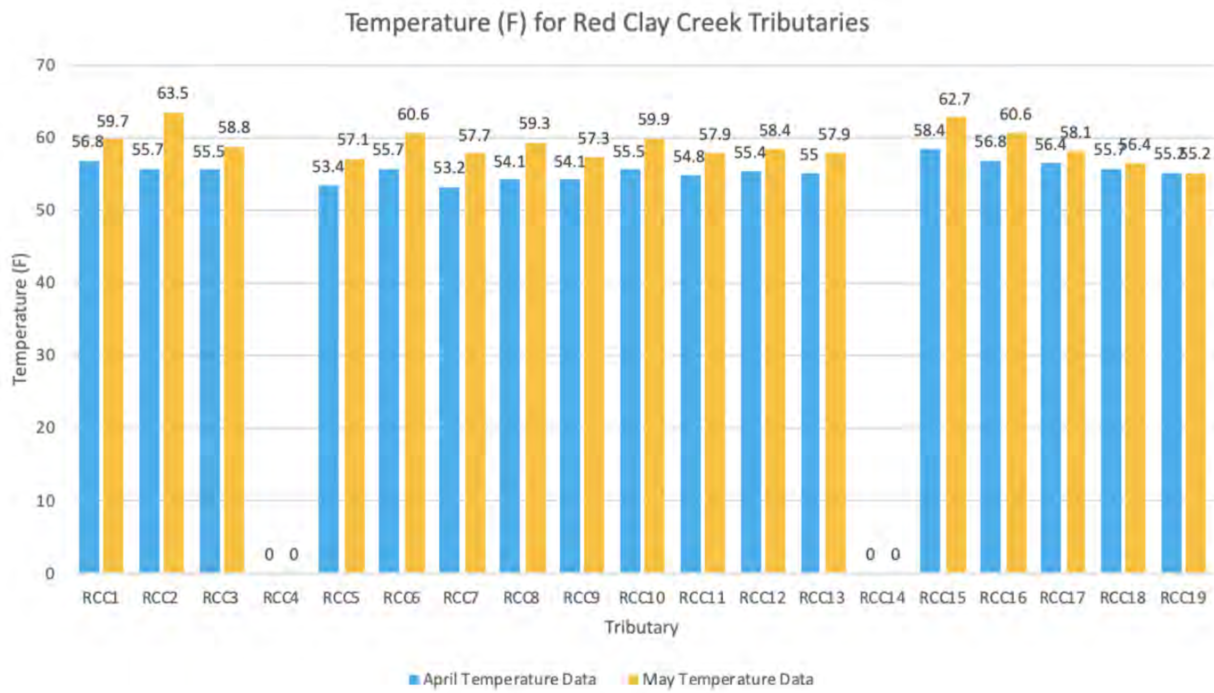


Figure 6. Temperature for Red Clay Creek Tributaries

Conclusions

This research characterized the Delaware tributaries of the Red Clay Creek watershed that were greater than forty acres in area. Data was collected for seventeen tributaries total for months April and May. The EPA Rapid Stream Habitat Bioassessment was performed once for all seventeen tributaries, and majority of them scored greater than one-hundred points and fell in the Suboptimal and Optimal range. All of the streams had flow rates greater than zero, and none were just stagnant water. Majority of the tributaries had nitrogen levels above the threshold of 3 mg/L, which is not ideal, but this discovery makes sense and was predicted due to the popular farming area most of Red Clay Creek and its tributaries are found in. There was some variation in the turbidity data, but this could have been caused by several different factors, one being a recent rainstorm. The conductivity levels all fell within the range of the EPA's recommended range. Most of the data collected points to the direction of good and healthy stream quality in Delaware. Nitrogen and turbidity levels were not ideal, but many different factors could have contributed to this. Due to the fact that data was only collected for a span of two months, major conclusions cannot be drawn. However, the majority of the data for the Red Clay Creek tributaries reflect good stream health, which is a great sign for Delaware's overall water quality. Ultimately, these findings should be used to encourage further research and data collection for the Red Clay Creek, so real and concrete conclusions can be drawn, and any issues, if present, can be addressed and resolved.

Literature Cited

"5.9 Conductivity." *EPA*, Environmental Protection Agency, 6 Mar. 2012, archive.epa.gov/water/archive/web/html/vms59.html.

"DWRC Mission." *Water Resources Center*, www.wrc.udel.edu/wrc-mission/.

"The Impacts of Nitrogen and Phosphorus from Agriculture on Delaware's Water Quality: University of Delaware." *The Impacts of Nitrogen and Phosphorus from Agriculture on Delaware's Water Qualit. | University of Delaware*, www.udel.edu/academics/colleges/canr/cooperative-extension/fact-sheets/the-impacts-of-nitrogen-and-phosphorus-from-agriculture-on-delawares-water-quality/.

Intergovernmental River Basin Management:
The International Joint Commission Model between the United States and Canada

Shannon Bushinsky
University of Delaware

Objective

To translate the International Joint Commission's (IJC) successful river basin strategies to the state of Delaware and its bordering states, this research:

- Analyzes the IJC's structure and policies
- Analyzes the intergovernmental water protection relations between Canada and the United States
- Examines actions of the IJC within the Great Lakes-St. Lawrence River basin
- Compares the IJC to two international transboundary river basin organizations

Overview: International Joint Commission

- Independent agency guided by the Boundary Waters Treaty of 1909 between Canada and the United States
- Settles disputes within transboundary river basins
- Structured with commissioners, region-specific boards, and committees

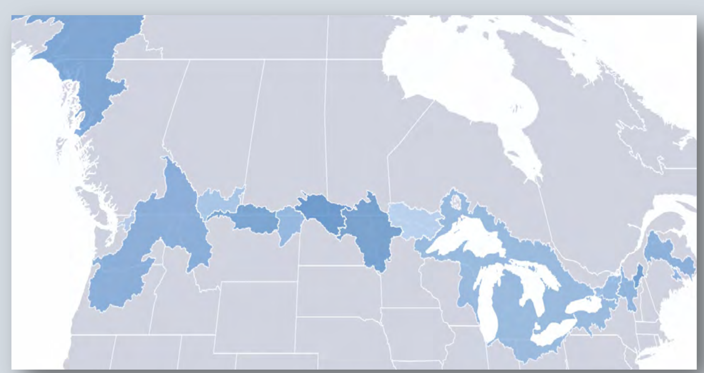
Great Lakes-St. Lawrence River Basin Case Study

- 2012 Great Lakes Water Quality Agreement
- IJC reinforces goals of the agreement through public assessment reports and stakeholder collaboration conferences
- Variations of water quality standards of Canada and United States
- IJC has no authority to bind parties to its recommendations or enact into law

Comparative Analysis

Comparative Analysis Metrics for International River Basin Management

Metric	Description
Staff structure	• Number of staff from each state, province, country, or area of the organization
Annual budget	• Yearly operating budget
River basin population	• Amount of people residing within the basin
Jurisdiction area	• Area over which the organization has authority
Coordinated decision making	• Coordination between and within basin organizations • Decision making consensus
Role of law	• Utilization of strong and flexible river basin management laws • Legislation specifies functions, structure, financial base
Information and research	• Utilization of a knowledge system and protocols to help make decisions and share information • Accessible to stakeholders with collaboration
Adaptive management	• Flexible and continuous improvement and adaptation of approaches • Incorporate social impact assessment and region-specific priorities
Engaging communities and Indigenous peoples	• Enable participation by local communities and Indigenous peoples who have a vital role in integrated watershed management due to their knowledge and practices
Diversity, inclusion, social equity, and social justice	• Promotes and ensures diversity, inclusion, social equity, and social justice that includes a variety of perspectives



International Joint Commission (IJC) Basins
Canada & United States

International Boundary and Water Commission (IBWC) Basins
Mexico & United States

Amazon Cooperation Treaty Organization (ACTO) Basin
Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname & Venezuela

Best Metrics and Practices of Analyzed International River Basin Management Organizations

International Joint Commission	International Boundary and Water Commission	Amazon Cooperation Treaty Organization
1. **Staff structure:** equal representation from all parties as well as binational boards and committees that oversee regional watershed issues 2. **Coordinated decision making:** International Watershed Initiative allows the IJC boards to manage water data without duplicating work or missing information and harmonizes data within the basins. 3. **Information and research:** ladder of information exchange organized by the structure of boards, advisory committees, and science/technical committees 4. **Adaptive management:** flexible decision making that is adjusted from outcomes of previous actions, recommendations, and stakeholder involvement 5. **Engaging communities and Indigenous peoples & Diversity, inclusion, social equity, and social justice:** Justice, Equity, Diversity and Inclusion process	1. **Information and research:** Public Affairs Office publishes information for the American public so that there is exchange of information and stakeholder engagement	1. **Engaging communities and Indigenous peoples:** Indigenous Affairs Agenda and highly values Indigenous knowledge to improve river basin management practices 2. **Diversity, inclusion, social equity, and social justice:** outlines social inclusion as a necessity for its Regional Plan of Action for Amazon Biodiversity

Interstate Commission Analysis & Suggestions

Conclusions

IJC best exemplifies the following metrics in comparison to the IBWC and ACTO: (1) staff structure, (2) coordinated decision making, (3) information and research, (4) adaptive management, (5) engaging communities and Indigenous peoples, and (6) diversity, inclusion, social equity, and social justice.

Recommendations

- **Staff structure:** equal representation of Commissioners for each state
- **Annual budget:** relative to area of state within basin
- **Coordinated decision making:** similar to IJC's interdisciplinary framework of structure and mandates
- **Role of law:** authority to bind parties to an agreement
- **Information and research:** similar to IJC's and IBWC's information exchange
- **Adaptive management:** social impact assessment and region-specific priorities for continuous adaptation and flexibility
- **Engaging communities and Indigenous peoples & Diversity, inclusion, social equity, and social justice:** similar to IJC's and ACTO's process of including diverse stakeholder groups

University of Delaware

Delaware Water Resources Center

Historic Significance of the Brandywine River in Wilmington, Delaware

Alexis Cervantes

Delaware Water Resources Center Internship

Dr. Gerald Kauffman

18 June 2021

Introduction:

The Brandywine River, called “Wawaset,” “Sittacunck,” and “Tankopanican” by the Lenape Indians, winds from Southeastern Pennsylvania into the state of Delaware. The River carves out some of the most beautiful rolling hills and valleys that are now the landmarks of the Brandywine Valley.

The original inhabitants of the Brandywine Valley were an Algonquin Indian tribe, who called themselves Lenape. The tribe were eventually displaced from the lands by early Swedish, Finnish, and Dutch settlers, who had acquired the land through treaties.

Since the arrival of its first European settlers in the early 17th century, the Brandywine Valley played a crucial role in the development of colonies and settlements. By the early 18th century, the Valley was America’s paper milling center. Along the Brandywine, many mills were constructed, including a black powder mill that is now the Hagley Museum today. In addition to the museum, some other major attractions include Winterthur and Longwood Gardens, as well as Nemours Mansion, which are all close to the Brandywine River.

The Brandywine River and the watershed look as they do today because of the protection and conservation work of the Brandywine Conservancy. Co-founder George Weymouth and a group of concerned citizens took action when the Valley was being threatened with massive industrial development. They were able to permanently protect and preserve more than 32,000 acres of land that is now the heart of the Brandywine.

Additionally, there are dams along the Brandywine River that play an important role in Delaware’s economy and industry. However, the dams also prevent the upstream passage of migratory fish, such as the American shad, which have their spawning grounds in the Pennsylvania section of the creek in the northern section of the River. Consequently, the Hagley

Dams and others along the Brandywine River are targets for removal or modification to allow shad and other marine species to reach their proper spawning locations for the first time in some 200 years.

https://www.delawarepublic.org/post/brandywine-creek-dam-removal-project-aiming-start-work-year

The Brandywine River is the largest river and sole drinking water supply for the city of Wilmington, Delaware. The once-abundant American shad population has been in peril along the Brandywine, primarily due to the dams that are constructed along the river.

Abstract:

This research seeks to assess the historic significance of the Brandywine River as the largest and sole drinking water supply for the City of Wilmington in the State of Delaware. Brandywine Shad 2020 has identified involved resources that are listed in the National Register of Historic Places (NRHP), and properties that might be considered eligible for listing that are

located within the geographic area of the potential effect (APE) of the proposed project. As a means to identify historic properties under 36 CFR 800.4, we have completed a preliminary review of available information on previously identified historic properties to determine if any are located within the APE of this undertaking. The review of existing information revealed that:Dam 2 is listed as a contributing element to the Brandywine Park Historic District listed on the National Register of Historic Places in 1976 (CRS# N01566.024). Dam 4 is listed as a contributing element to the Bancroft and Sons Cotton Mills Historic District listed on the National Register of Historic Places in 1984 (CRS# N03646.048).

Scope:

A cultural and historic survey of the Brandywine River must be conducted in order to determine the significance of the body of water. First, a deep dive into the digital photographs held by the Hagley Museum will shed light on the importance of the Brandywine River. This will then lead to collecting literature and documents that pertain to the history of the Brandywine.

Readings:

Over the course of my research, I was able to read many sources that allowed me to learn more about the Brandywine River, its history, and the role it will play in the future.

One of the most compelling pieces of information I read was an article by Maddy Lauria, "Dam removal along Brandywine one of 25 projects to restore the Delaware watershed." Lauria explains that by removing the dams that are constructed all along the Brandywine, fish, particularly shad, will be able to swim freely up into the northern Brandywine for the first time in nearly two centuries. The river is the healthiest it quite possibly has ever been, since there are currently no dead zones. If we remove human interference, like these dams, and restore the ecological integrity of the river, the Brandywine can continue to be a thriving habitat for many fish species and provide water for the nearby residents.

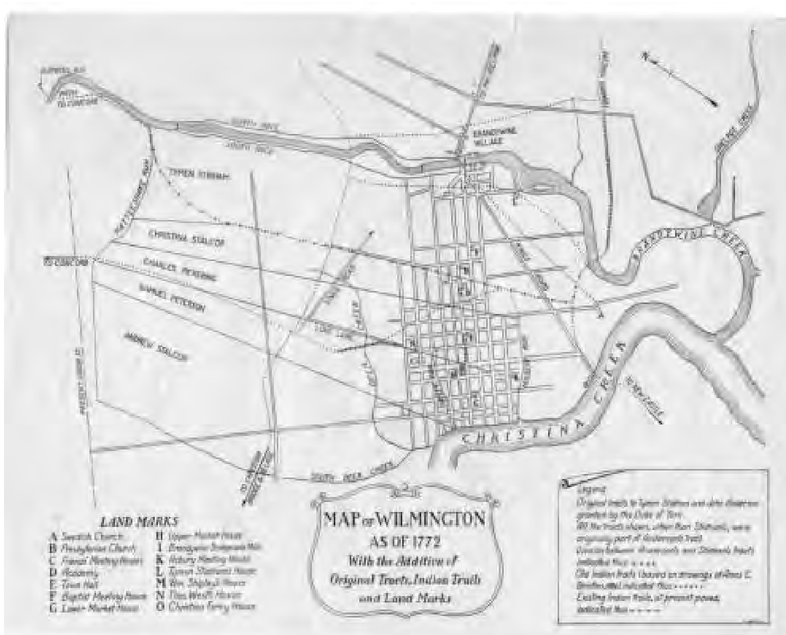
Demolition continues on the dam and replacement of a water main across the Brandywine in Wilmington. *WILLIAM BRETZGER, The News Journal*

Another important source I was able to find information from was “The Brandywine: An Intimate Portrait.” This text, written by W. Barksdale Maynard, explains the picturesque Brandywine river that winds among the rolling hills of Pennsylvania and Delaware. The book traces the history of the region, from European settlement to the current state of the banks. Maynard writes about legislative acts that called for all dams to be removed from the Brandywine. Fish should be allowed to swim freely without any barriers in their way, especially ones that are put there by humans. With these dams in place, fish are becoming extinct or facing extinction in upcoming generations.

To really show the significance of the Brandywine, and the success that is felt within communities along the River, “From Creek to Tap: The Brandywine and Wilmington’s Public Water System” explains Wilmington’s relationship with the River. The city could not exist or thrive without the adequate and readily accessible source of freshwater from the Brandywine. In 1909, when the River was heavily polluted by upstream creameries, slaughterhouses, and paper mills, Wilmington really felt the impacts. In fact, to increase the supply of filtered water, the city had to implement a rapid sand filter plant a few years later.

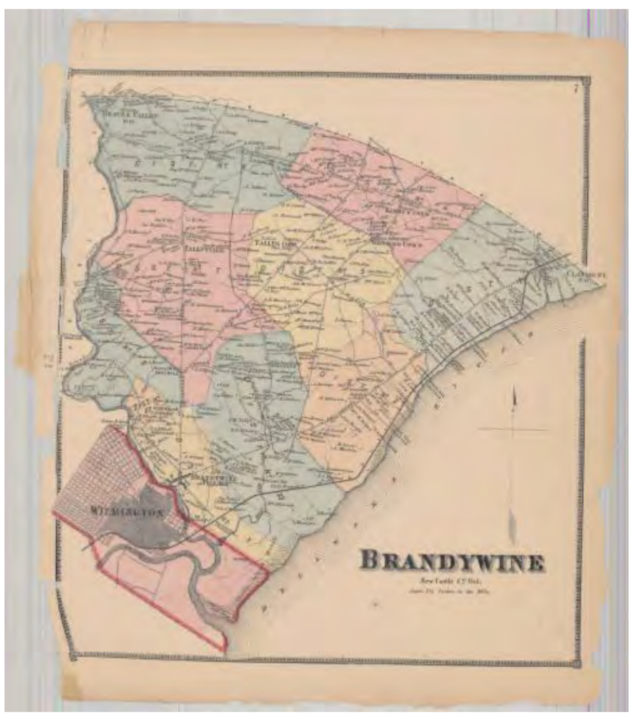
Maps:

All of the following maps are from the Delaware Public Archives.

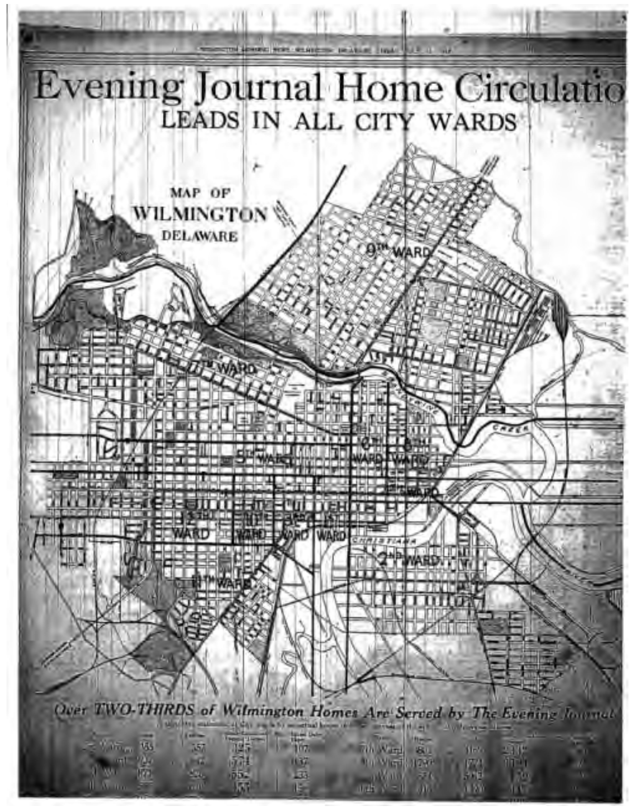


Map of Wilmington in 1772

Map of Wilmington in 1781



Map of Wilmington in 1868



Map of Wilmington in 1928

As seen above, the maps of Wilmington that vary over time also vary in specificity. Generally, as time goes on, the maps have been able to improve and become more accurate, allowing citizens to navigate the Brandywine and the surrounding areas.

Photographs:

Another aspect that allowed my research to show the importance of the Brandywine River was that of examining the photographs, mainly historical ones, of the River. All of the photographs below are from the Hagley Museum website.

Bancroft Mills Dam 4 in 1890

Bancroft Mills Dam in 1931

Bancroft Mills Dam in 1933

Bancroft Mills Dam in 1970

Bancroft Mills in a now abandoned mill complex along the Brandywine in Wilmington, Delaware. It has been the site of some of the earliest, and some of the most famous, mills near Wilmington.

Dupont Dam in 1927

Dupont Dam in 1929

Dupont Dam in 1931

Dupont Dam in 1950

Conclusion:

Dam 2 is listed as a contributing element to the Brandywine Park Historic District, as listed on the National Register of Historic Places in 1976. In Wilmington, where the river meets navigable tidewaters, milling operations are allowed to flourish. Historically, this allowed small ships to dock right at the mills and for trade to occur easily. Today, almost all of the mills have been preserved for visitors, as well as researchers. The first of the eight dams on the Brandywine River was removed in 2019. After this removal, the American shad was able to migrate further north in the River. With this trend on track with hopes, the removal of further dams is likely on the horizon. The Brandywine was clearly important to settlers and settlements, in addition to Wilmington throughout history. Today, the Brandywine continues to allow Wilmington to be a busy and thriving city, but we must also take into consideration the importance of the marine life living in this body of water.

Works Cited

http://www.thebrandywine.com/about/

https://www.delawarepublic.org/post/brandywine-creek-dam-removal-project-aiming-start-work-year

https://www.hagley.org/

https://archives.delaware.gov/

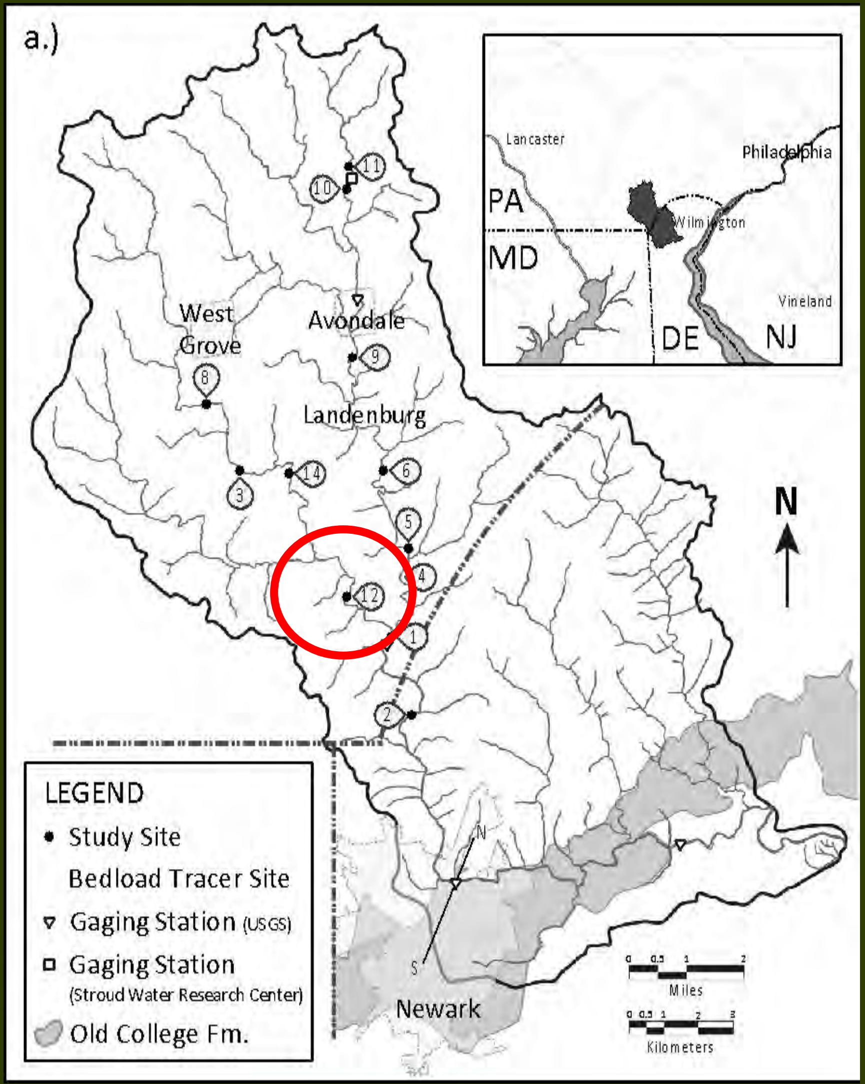
Research Question

How has a small colonial-aged mill dam in White Clay Creek State Park affected the sedimentation upstream?

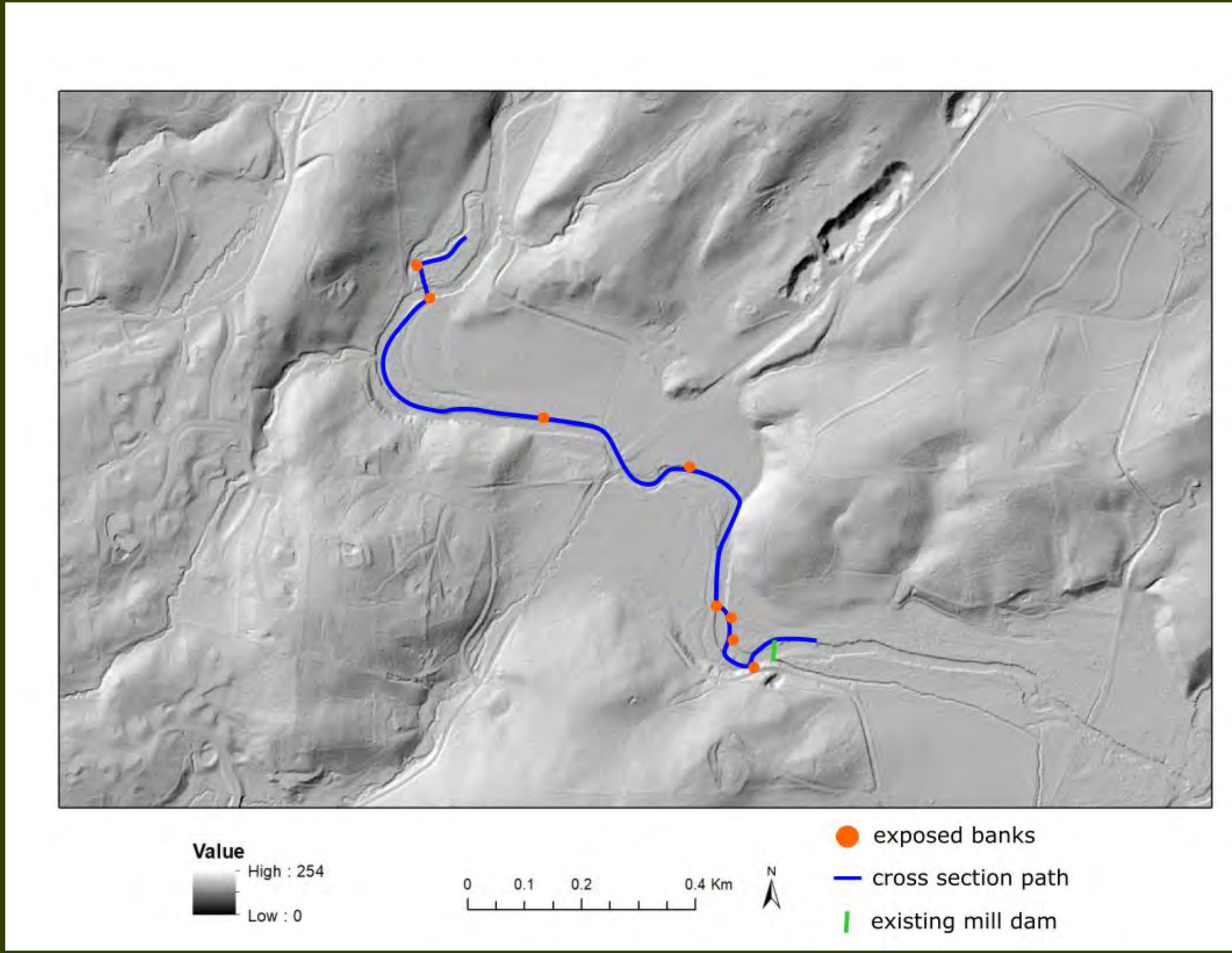
Work done by: Liz DeSonier, Jim Pizzuto and Max Huffman

Delaware Watershed Research Fund

Study Area



a.)
Lancaster
Philadelphia
PA
MD
Wilmington
Vineland
DE
NJ
West Grove
Avondale
Landenburg
N
LEGEND
Study Site
Bedload Tracer Site
Gaging Station (USGS)
Gaging Station (Stroud Water Research Center)
Old College Fm.
Newark
Miles
Kilometers



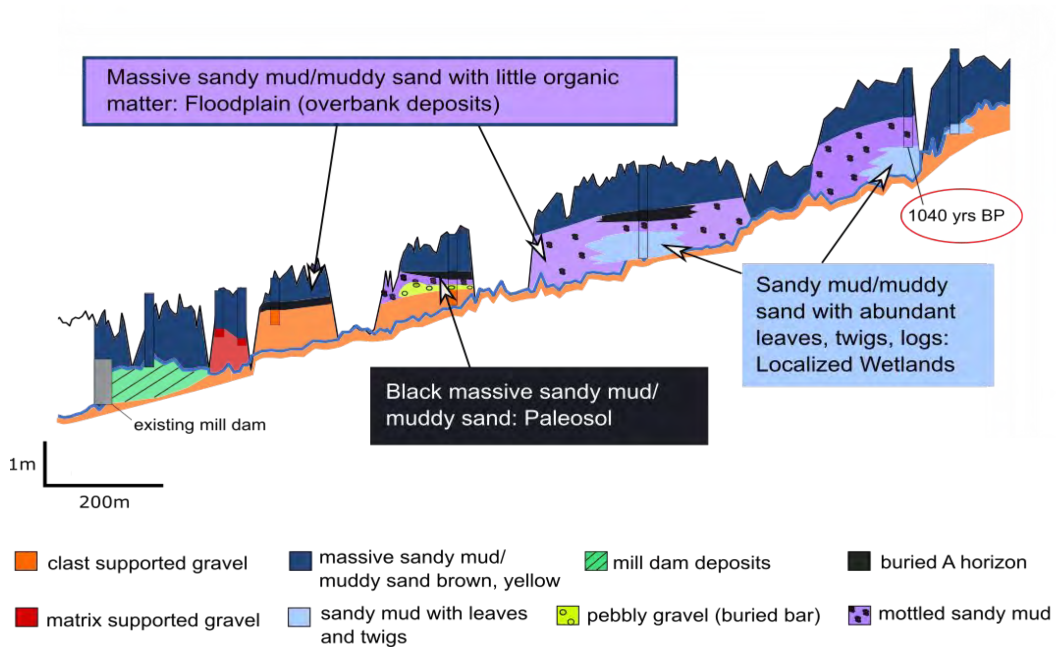
Value
High : 254
Low : 0
0 0.1 0.2 0.4 Km
N
exposed banks
cross section path
existing mill dam

Methods

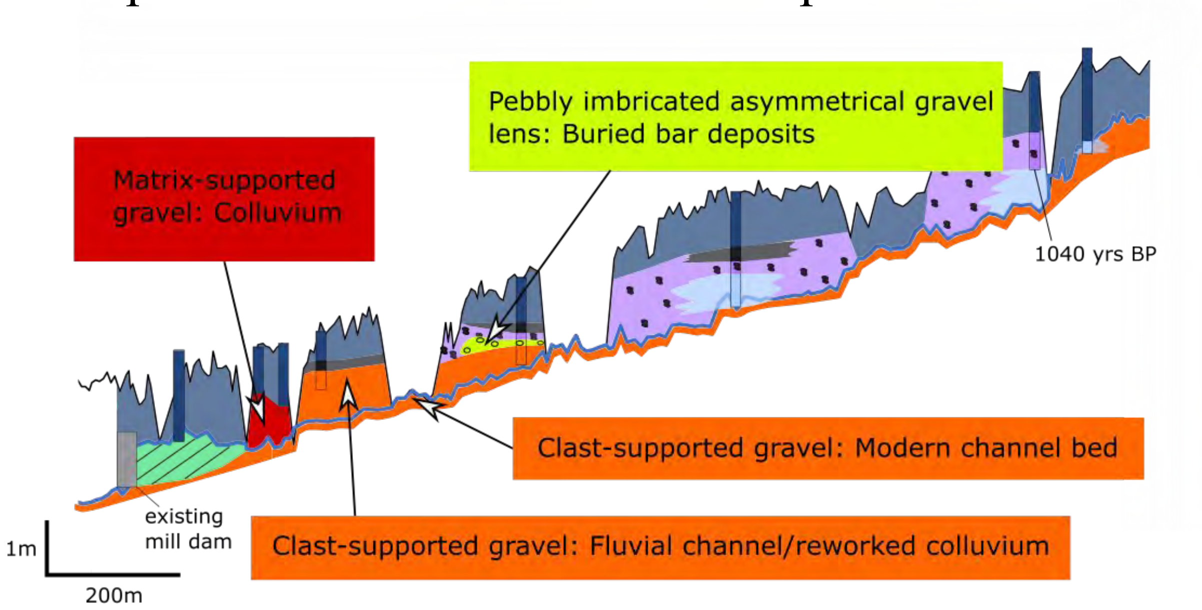
- Field observations of stratigraphy at exposed banks
- C14 dating
- Interpretation: comparison with modern environments, published literature

Results

Interpretation of Fine-Grained Deposits

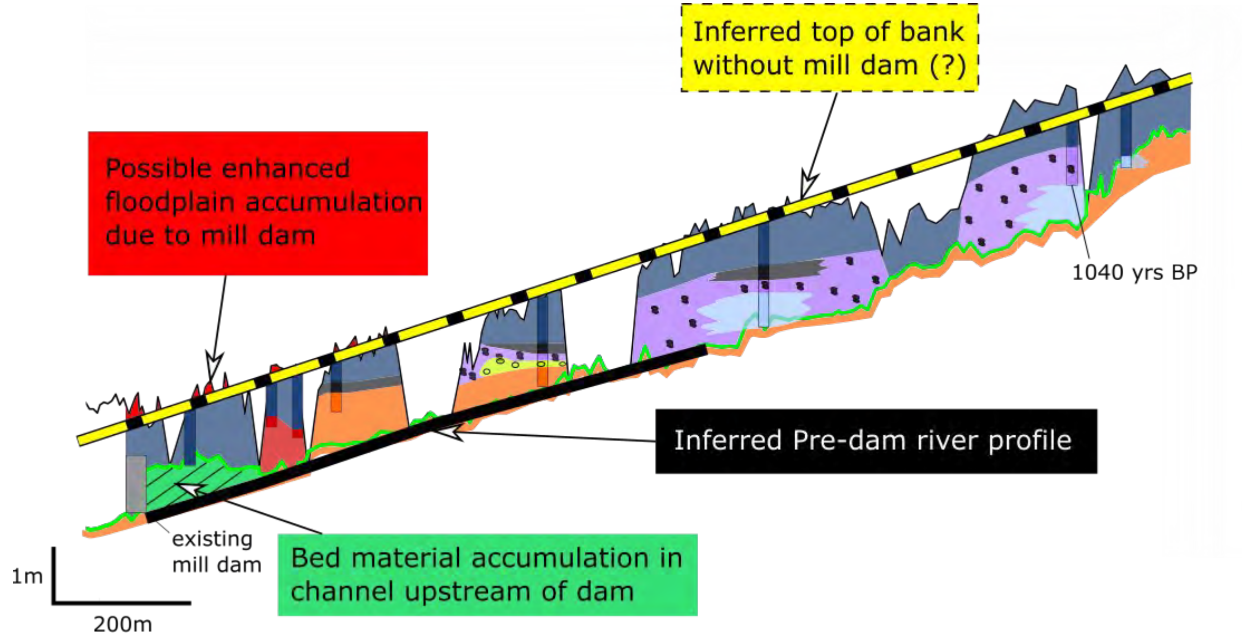


Interpretation of Coarse-Grained Deposits

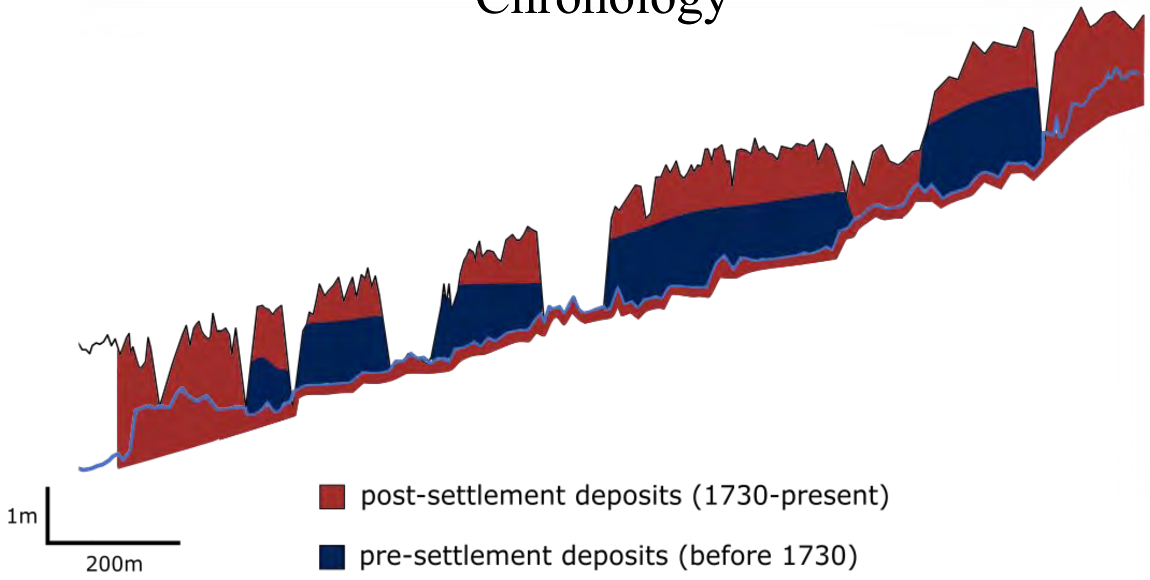


Results

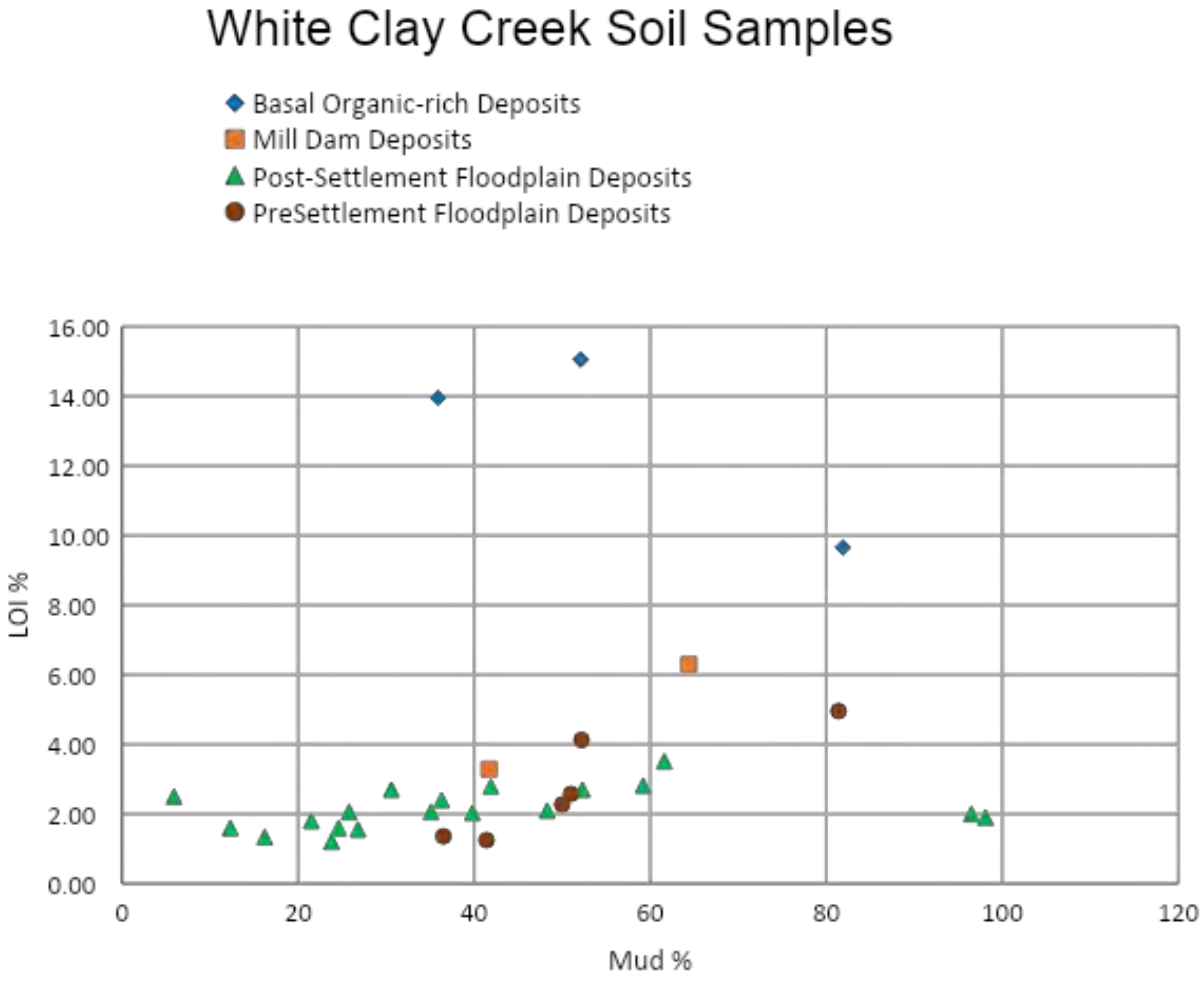
Colonial Mill Dam Influence



Interpretation of Pre-settlement/Post-settlement Chronology



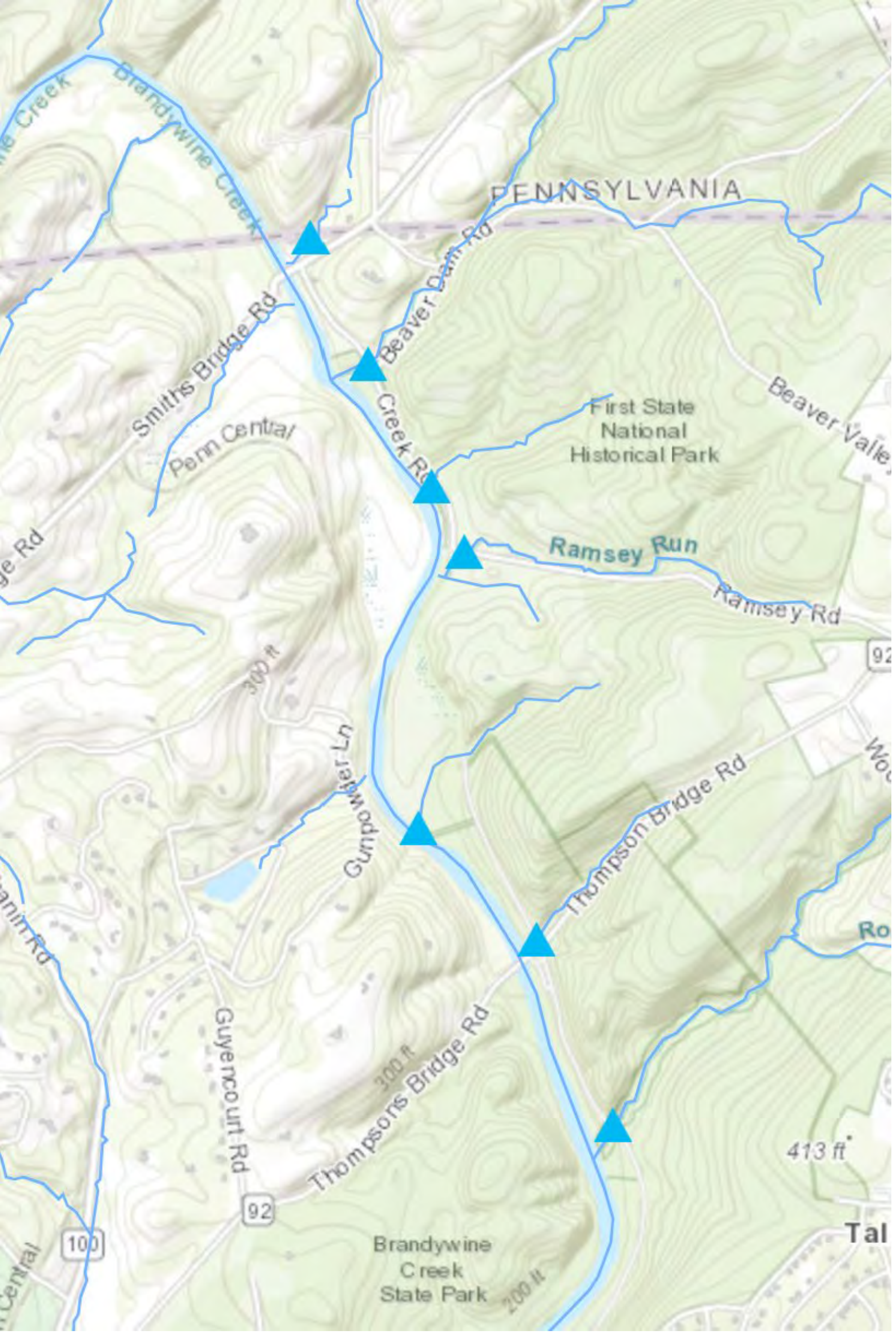
Results



- Older floodplain deposits are similar composition to newer
- Basal organic rich deposits represent another environment
- Mill dam deposits primarily identified by well-developed lamination

Conclusions

- Bank exposures along White Clay Creek include overbank deposits, colluvium, fluvially reworked colluvium, buried gravel bars and localized wetland deposits.
- Exposures are approx. equally divided between pre-settlement and post-settlement deposits
- Before European settlement, the White Clay Creek built gravel bars and carried gravel material similar to the modern stream channel
- A ~1 m colonial mill dam has influenced sedimentation within approximately 200 m upstream of the dam



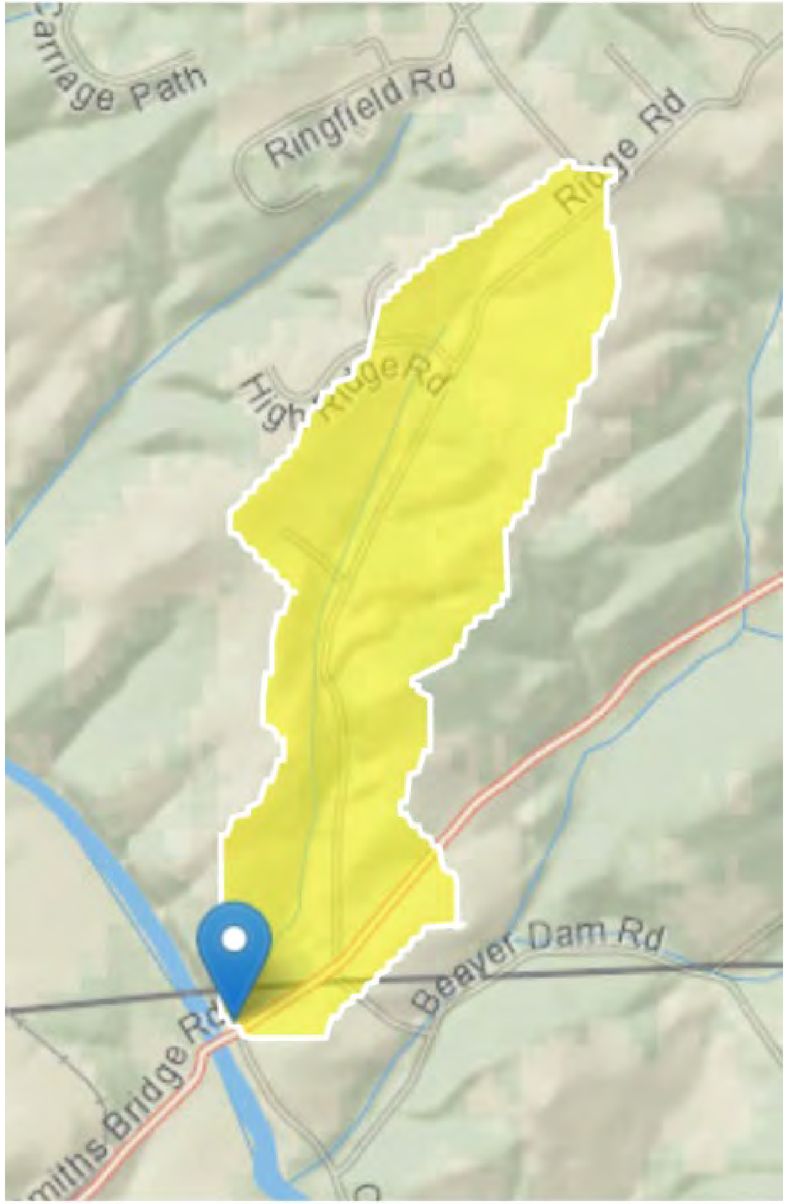
CHARACTERIZATION OF THE UPPER BRANDYWINE RIVER TRIBUTARIES

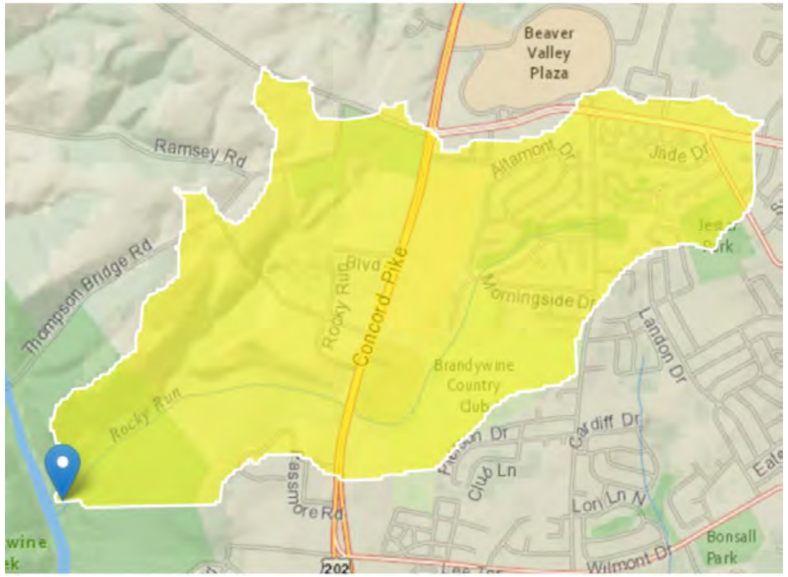
DELANEY DORAN

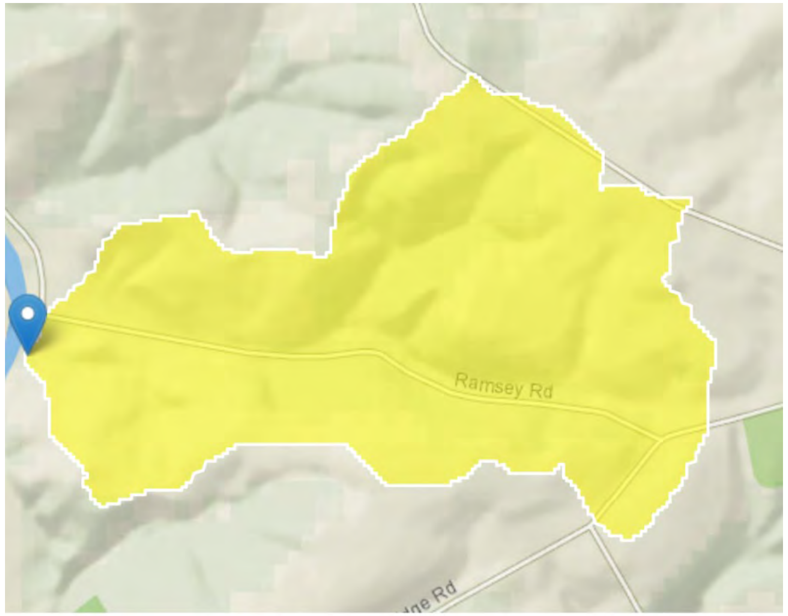
ENVIRONMENTAL ENGINEERING

STREAMSTATS DATA

- These pictures illustrate the StreamStats output for the Upper Brandywine tributaries
- Left- 2A, Top Right- Rocky Run, Bottom Left- Ramsey Run
- StreamStats provides a map of the watershed as well as drainage characteristics for that region

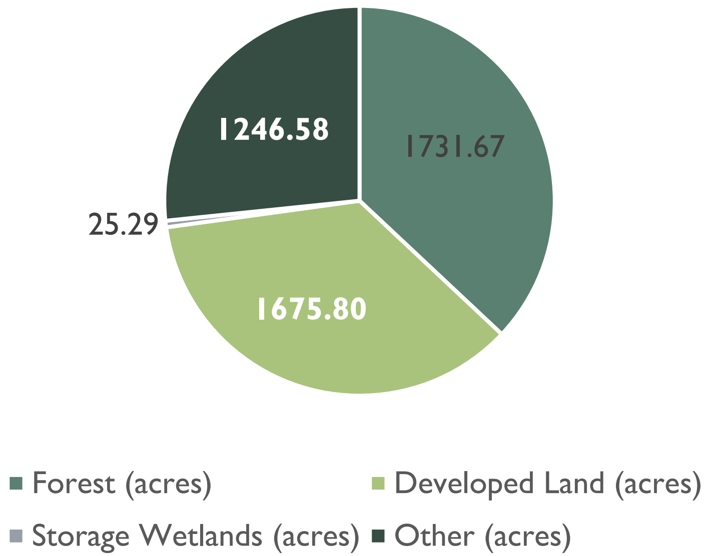






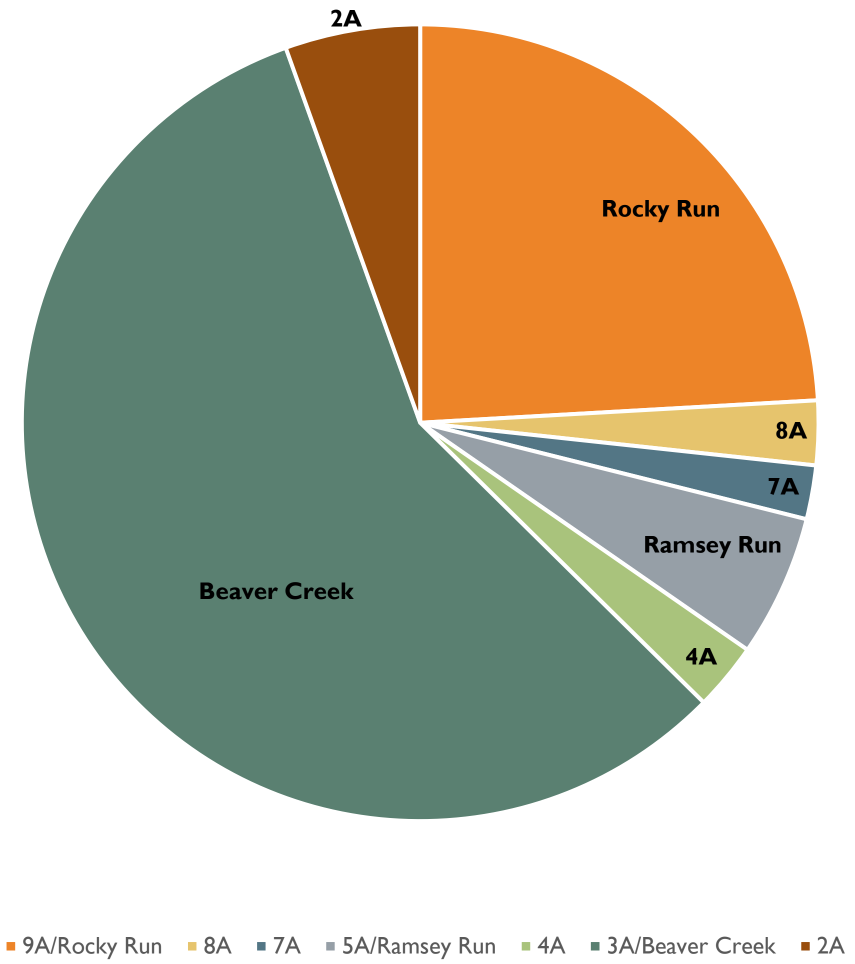
STREAMSTATS ANALYSIS

Distribution of Land Uses (in acres) of Tributary Watersheds in Upper Brandywine



Stream Name/Number	Total Drainage Area (acres)	Forest (acres)	Developed Land (acres)	Storage Wetlands (acres)	Other (acres)
9A/Rocky Run	1126	318.7	663.2	2.3	141.9
8A	122	74.7	16.6	0.0	30.7
7A	102	70.5	0.0	0.9	37.9
5A/Ramsey Run	269	97.9	22.9	0.0	148.2
4A	128	67.7	2.3	0.0	58.0
3A/Beaver Creek	2669	1056.9	942.2	21.4	648.6
2A	256	45.3	28.7	0.8	181.2
Total	4672	1731.7	1675.8	25.3	1246.6

Drainage Area of Upper Brandywine Tributaries (acres)



WATER QUALITY DATA

TOP: MARCH 6-7, 2021, BOTTOM: APRIL 18, 2021

Stream Name/Number	Depth (ft)	Width (ft)	Area (ft^2)	V (ft/sec)	Q (ft^3/sec)	Turbidity	Nitrogen (mg/L)	Conductivity (µS)
9A/Rocky Run	5.42	32.6	88.2	0.03	2.69	0.0	3.7	578
8A	0.50	4.8	1.2	0.05	0.05	0.0	1.4	30
7A	0.46	0.3	0.1	0.24	0.02	17.1	5.5	131
5A/Ramsey Run	0.25	4.1	0.5	0.08	0.04	0.3	4	132
4A	0.66	27.9	9.2	0.05	0.51	0.5	2.3	433
3A/Beaver Creek	0.53	0.4	0.1	0.07	0.01	0.7	5.2	232
2A	0.42	5.0	1.0	0.03	0.03	3.3	2.1	183

Stream Name/Number	Depth (ft)	Length (ft)	Area (ft^2)	V (ft/sec)	Q (ft^3/sec)	Turbidity	Nitrogen (mg/L)	Conductivity (µS)
9A/Rocky Run	5.50	32.8	90.2	0.06	15153.6-		7.8	388
8A	0.60	4.9	1.5-	-	-		5.4	232
7A	0.30	0.31	0.0	0.08	10.943-		5.4	127.8
5A/Ramsey Run	0.30	4.1	0.6	0.07	138.17-		5.4	220
4A	0.85	8.2	3.5-	-	-		0.3	140.4
3A/Beaver Creek	0.80	27.9	11.2	0.05	1361.52-		10.9	365
2A	0.53	4.75	1.3-	-	-		3.2	203

WATER QUALITY TESTING

PARAMETERS TESTED FOR SAMPLES FROM APRIL 18, 2021

Parameter	Unit	Water Quality Standard
Temperature	°C	No more than 27.7°C
pH	pH unit	6.5-8.5
Turbidity	NTU	Cannot exceed 10 NTUs
Dissolved Oxygen (DO)	mg/L	Cannot be <5.5 average
Electrical Conductivity (EC)	µS	Should be between 150-500µS
Enterococci Bacteria	#/100mL	925/100mL
Aluminum (Al)	mg/L	0.75 mg/L acute 0.087 mg/L chronic
Boron (B)	mg/L	0.75 mg/L
Calcium (Ca)	mg/L	*
Copper (Cu)	mg/L	0.0134 mg/L
Iron (Fe)	mg/L	1 mg/L
Potassium (K)	mg/L	*
Magnesium (Mg)	mg/L	*
Manganese (Mn)	mg/L	0.5 mg/L
Sodium (Na)	mg/L	*
Phosphorus (P)	mg/L	0.2 mg/L
Sulfur (S)	mg/L	250 mg/L
Zinc (Zn)	mg/L	0.117 mg/L acute 0.118 mg/L chronic
NH4-N (Ammonia-Nitrate)	mg/L	Usually does not exceed 0.2 mg/L
NO3 (Nitrate)	mg/L	10 mg/L

EPA BIOASSESSMENT METHODOLOGY

- These charts display the characteristics used to assess the habitat of each of the Upper Brandywine Tributaries

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (FRONT)

STREAM NAME	LOCATION	
STATION # ________ RIVERMILE ________	STREAM CLASS	
LAT ____________ LONG ____________	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY	DATE ______ TIME ______ AM PM	REASON FOR SURVEY

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/Depth Regime	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m.)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

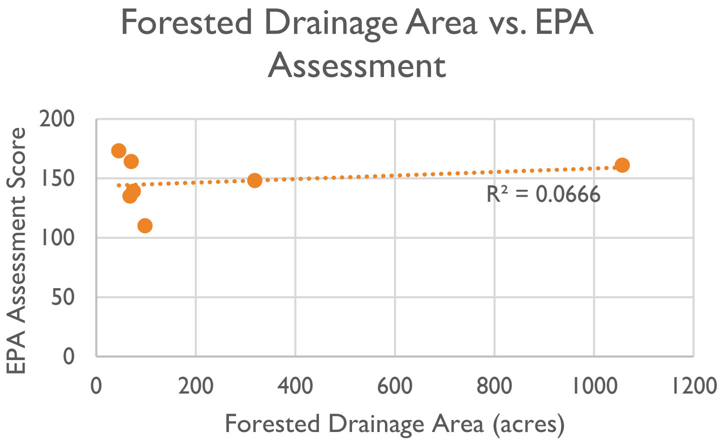
EPA ASSESSMENT RESULTS

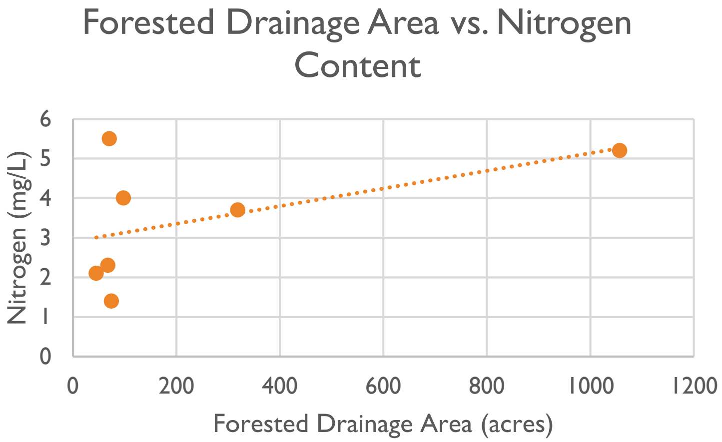
Stream Name/Number	Epifaunal Substrate/Available Cover	Embeddedness	Velocity/Depth Regime	Sediment Deposition	Channel Flow Status	Channel Alteration	Frequency of Riffles (or Bends)	Bank Stability (LB)	Bank Stability (RB)	Vegetative Protection (LB)	Vegetative Protection (RB)	Riparian Vegetative Zone Width (LB)	Riparian Vegetative Zone Width (RB)	Score	Condition
9A/Rocky Run	13	20	20	17	18	15	12	3	3	7	4	8	8	148	Suboptimal
8A	11	19	9	13	8	20	18	10	4	10	10	4	3	139	Suboptimal
7A	20	14	10	20	17	20	20	8	8	8	8	3	8	164	Optimal
5A/Ramsey Run	11	3	9	20	15	7	15	4	3	7	4	10	2	110	Suboptimal
4A	12	8	6	14	16	13	17	6	4	10	9	10	10	135	Suboptimal
3A/Beaver Creek	13	20	18	19	14	18	17	10	1	8	6	10	7	161	Optimal
2A	16	20	15	18	19	20	18	10	10	10	5	10	2	173	Optimal

Stream Name/Number	Score	Condition
9A/Rocky Run	148	Suboptimal
8A	139	Suboptimal
7A	164	Optimal
5A/Ramsey Run	110	Suboptimal
4A	135	Suboptimal
3A/Beaver Creek	161	Optimal
2A	173	Optimal

SUMMARY AND ANALYSIS

Stream Name/Number	Total Drainage Area (acres)	Forest (acres)	Developed Land (acres)	Storage Wetlands (acres)	Other (acres)	Q (ft3/sec)	Turbidity	Nitrogen (mg/L)	Conductivity (µS)	Score	Condition
9A/Rocky Run	1126	318.7	663.21	2.25	141.88	2.69	0.0	3.7	578	148	Suboptimal
8A	122	74.7	16.59	0.00	30.74	0.05	0.0	1.4	30	139	Suboptimal
7A	102	70.5	0.00	0.92	37.94	0.02	17.1	5.5	130.9	164	Optimal
5A/Ramsey Run	269	97.9	22.87	0.00	148.22	0.04	0.3	4	131.9	110	Suboptimal
4A	128	67.7	2.30	0.00	57.98	0.51	0.5	2.3	433	135	Suboptimal
3A/Beaver Creek	2669	1056.9	942.16	21.35	648.57	0.01	0.7	5.2	232	161	Optimal
2A	256	45.3	28.67	0.77	181.25	0.03	3.3	2.1	183.3	173	Optimal





Multiple analyses were done to consider the relationship between forested area, considered healthier for streams and very present in the Upper Brandywine tributaries, and other parameters of stream health. The scatter plots to the right show minimal correlation, however there are some limitations in the data set that would affect this.

CONCLUSIONS

StreamStats: the % forested area of the Upper Brandywine tributaries ranges from 17.7-61.9% with the average being 42.6%, the drainage area of the watersheds ranges from 102-2669 acres, with the average being 667 acres

Velocity and Discharge: the velocity (in ft/sec) ranges from 0.03-0.24, and the discharge ranges from 0.01-2.69 cubic feet/second

Water Quality: measures of conductivity range from 30 to 578 µS, nitrogen ranges from 1.4-5.5 mg/L, and turbidity ranges from 0-17.1 NTU

- **Conductivity-** be between 150-500 µS; at the time of collection, streams 8A, 7A, and Ramsey run were below this range while Rocky Run exceeded it
- **Nitrogen-** should be less than 1 mg/L; at the time of collection, all streams exceeded this metric
- **Turbidity-** should not exceed 10 NTU; at the time of collection, stream 7A had 17.1 NTU

EPA Assessment: 4 streams were in suboptimal condition while 3 streams were in optimal condition

Analysis: the data suggest that there is some relationship between land use and stream health; further analysis should be done to consider the presence of agricultural lands in tributary watersheds and how this relates to stream health and water quality parameters

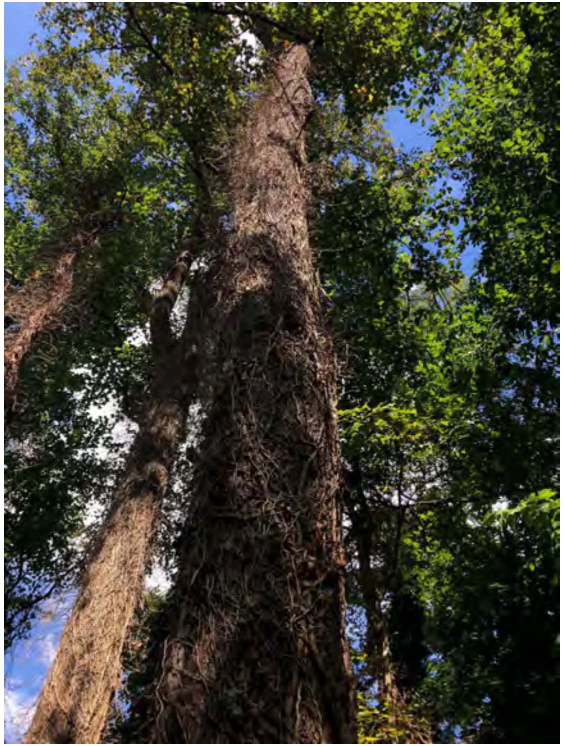
Generally: the health of the tributaries of the Upper Brandywine River is between suboptimal-optimal range; the nitrogen measurements are high in all tributaries, while conductivity and turbidity are generally within accepted values

Stormwater Mitigation in West Baltimore: Effects of Restoration

By Grace Hussar

Issues:

- Invasive species
  - Porcelain berry
  - English ivy
  - Japanese honeysuckle
  - Emerald Ash Borer
- Parking lot
  - Flooding
  - Water quality
- Lots of litter
- Overgrown



Solutions:

- Establish tree nurseries (3 total)
- Clear dead Ash trees and plant native tree species in their place
    - Southern Magnolia
    - Poppy
    - Black gum
    - Oak
    - Sweet gums
    - Pawpaw
- Remove invasive species, mulch areas to suppress invasive growth
- Get the community involved
- **Main goal**: get the forest to the point where it is self-sustaining

Tour of the Grounds and Our Work

https://youtu.be/3mVTeevPqKI

Thank you!

Frequency and Intensity of Peak Flood Events and Sea Levels in Delaware with Climate Change

Emily Jimenez, Gerald Kauffman, and Andrew Homsey

Objective

My objective was to obtain peak annual streamflow data, peak annual high tide data, precipitation data, and temperature data in order to conduct an analysis and determine if streamflow and costal tides are changing with precipitation and temperature spatially and temporally.

Streamflow Data

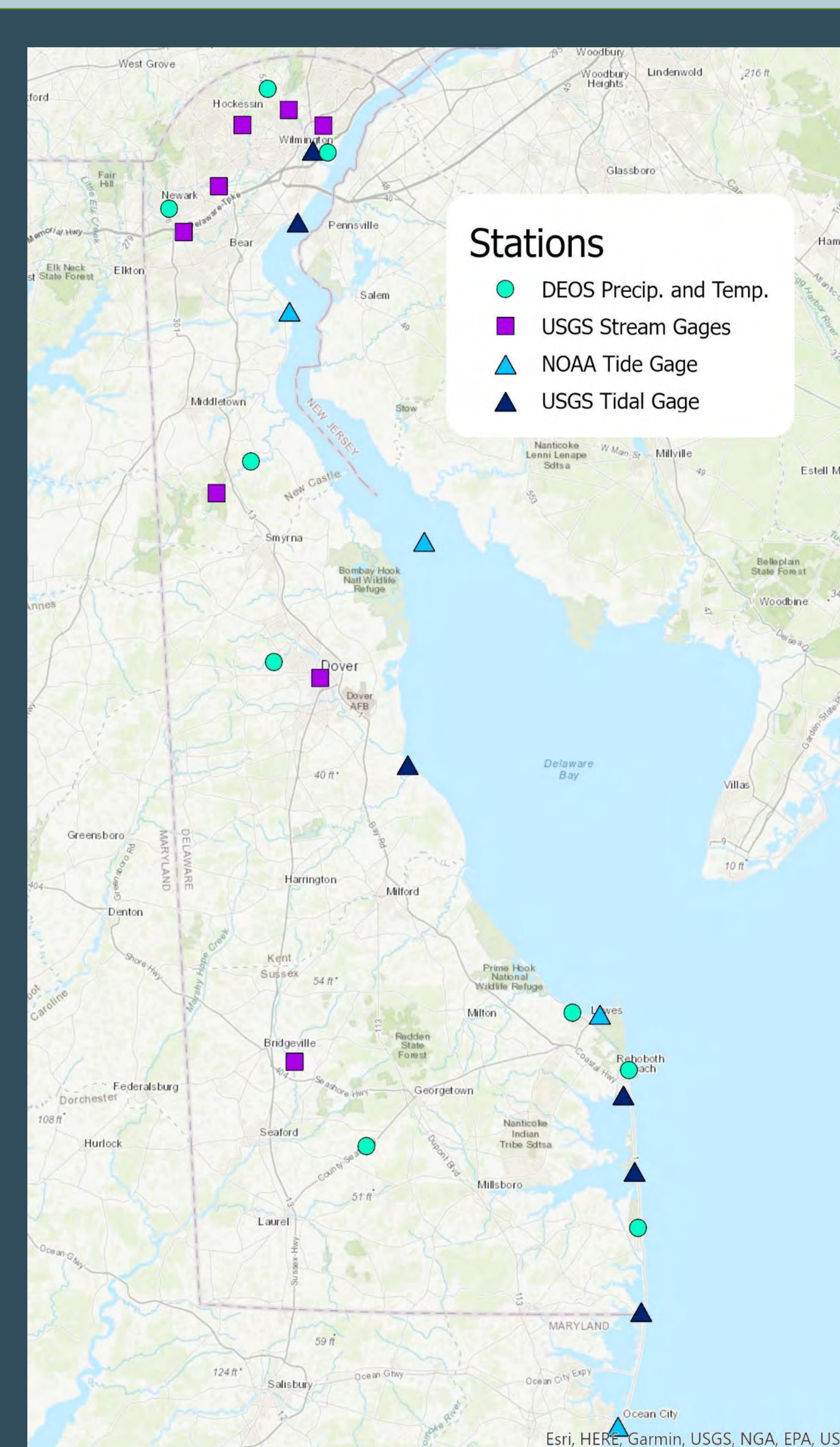
The table below is data collected from the 8 USGS streamflow gages. We found that 6 of the 8 gages have increased, and 2 were unchanged.

Gage	Period of Record	Peak Streamflow and Year		Minimum Streamflow and Year		Trend (+/- 0.01)	Slope (cfs/year)
Shellpot Creek	1945-2020	8040 cfs	1989	560 cfs	1963	▲	0.02
Cooches Bridge	1943-2020	7780 cfs	2011	629 cfs	2002	▲	0.02
White Clay Creek	1932-2020	19500 cfs	1999	1270 cfs	2002	▲	0.08
Red Clay Creek	1943-2020	15600 cfs	2003	638 cfs	1920	▲	0.07
Brandywine Creek	1947-2020	29000 cfs	1972	2000 cfs	2002	▲	0.1
Blackbird Creek	1952-2020	789 cfs	1999	40 cfs	2002	●	0.0
St. Jones River	1958-2020	2390 cfs	2011	93 cfs	1966	●	0.0
Nanticoke River	1943-2020	3020 cfs	1979	201 cfs	2011	▲	0.01

Tidal Data

The table below is data from the 10 high tide gages. From these 10 gages, 8 increased and 2 decreased. We noticed that the tide stations that decreased were in the Delaware Bay, and this could be due to the Coriolis affect.

Gage	Data Record	Period of Record	Max Tide Height and Year		Min Tide Height and Year		Trend (+/- 0.001)	Slope (ft/year)
Christiana River	USGS	2006-2020	5.66 ft	2007	1.86 ft	2010	▲	0.010
Delaware River	USGS	2012-2020	7.2 ft	2012	4.74 ft	2013, 2014	▼	-0.017
Reedy Point	NOAA	1970-2020	6.319 ft	2011	2.671 ft	1980	▲	0.007
Ship John Shoal	NOAA	2003-2020	6.381 ft	2012	3.921 ft	2009	▲	0.011
Murderkill River	USGS	1997-2020	8.6 ft	2008	3.79 ft	1997	▼	-0.004
Lewes	NOAA	1970-2020	7.024 ft	2016	3.386 ft	1974	▲	0.005
Rehoboth Beach	USGS	1985-2020	5.34 ft	2012	2.13 ft	2001	▲	0.014
Indian River Bay	USGS	1998-2020	6.5 ft	2012	2.5 ft	1988	▲	0.007
Little Assawoman	USGS	2005-2020	4.82 ft	2012	2.16 ft	2014	●	0.001
Ocean City, MD	NOAA	1997-2020	4.783 ft	1998	2.09 ft	1999	●	0.000



Above is a map of all the stations that data was collected from.

Precipitation Data

The table below contain the data from the 9 DEOS stations for precipitation. The "Normal" column is the normal precipitation value from 1980-2010. We graphed the normal value and found how many years were above the line (surplus) and how many were below (deficit). Precipitation increased at 8 of the 9 gages while 1 remained unchanged.

MET. Station	Period of Record	Normal (1980-2010)	Number of Surplus Precipitation (n)	Deficit Precipitation (n)	No change Precipitation (n)	Trend (+/- 0.01)	Slope (in/year)
Bethany Beach	2005- 2020	46.23 in	7	8	0	▲	1.36
Blackbird	2005-2020	46.05 in	3	11	1	▲	1.56
Dover	2005-2020	46.05 in	6	9	1	●	0.00
Georgetown	2005-2020	45.93 in	6	10	0	▲	0.29
Greenville	2010-2020	49.32 in	5	5	1	▲	1.31
Lewes	2015-2020	46.23 in	2	4	0	▲	3.00
Newark	2005-2020	46.23 in	8	8	0	▲	0.96
Rehoboth	2009-2020	46.23 in	4	7	1	▲	0.99
Wilmington	2005-2020	43.08 in	11	5	0	▲	0.44

Temperature Data

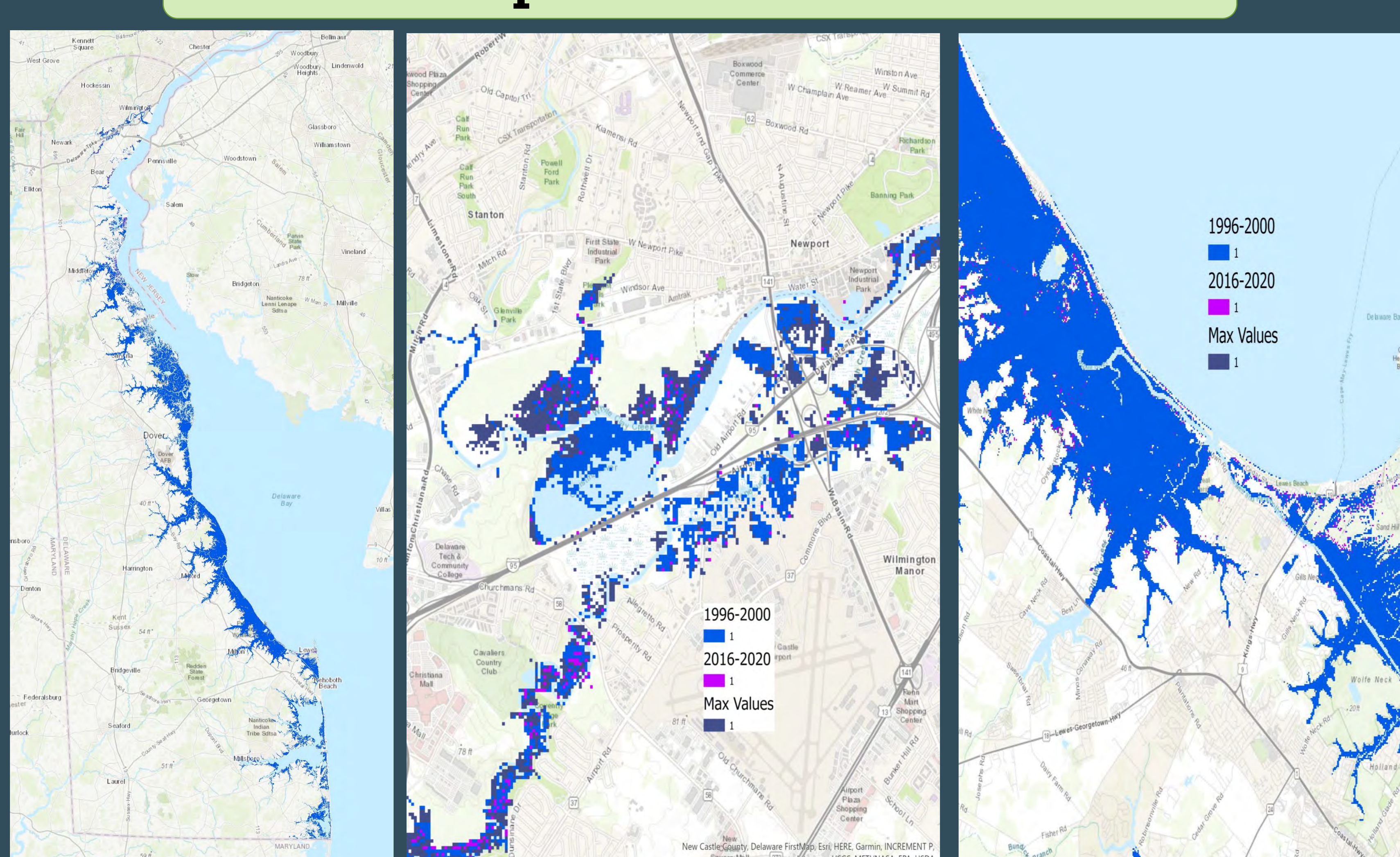
The table below represents data from the 9 DEOS stations for temperature. The "Normal" column is the average temperature from 1980-2010 at each station. om the 9 DEOS stations, temperature has increased but it has been very small it's negligible.

MET. Station	Period of Record	Normal	Trend	Slope (Temp/ month)
Bethany Beach	2004-2020	57.69	●	0.0003
Blackbird	2004-2020	55.84	●	0.0005
Dover	2005-2020	55.9125	●	0.0005
Georgetown	2005-2020	56.90	●	0.00007
Greenville	2010-2020	54.90	●	0.0004
Lewes	2014-2020	57.03	●	0.0027
Newark	2004-2020	54.98	●	0.0005
Rehoboth	2008-2020	55.88	●	0.0002
Wilmington	2004-2020	55.84	●	0.0001

Conclusion

In conclusion, it seems peak flood events have been increasing slightly due to climate change. The majority of stream and tidal gages have increased, and most precipitation stations also have an increasing trend. The temperature data has not changed, but this could be because the temperature rose before 2004 and has plateaued since then. In the data from the tides, the decreasing gages were in the Delaware Bay. This may be due to the Coriolis affect, but more research can be done to understand more.

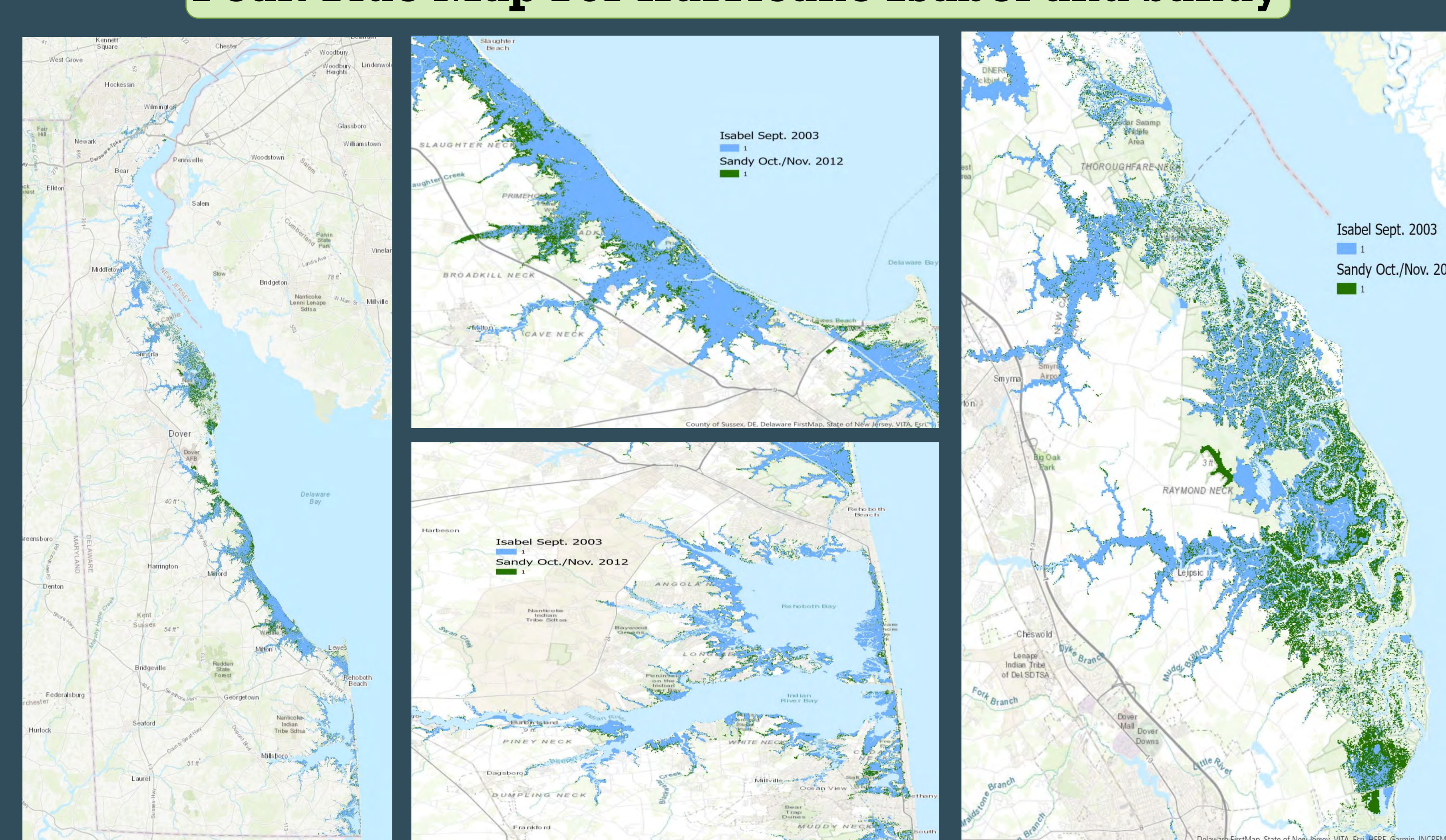
Peak Tide Map for 1996-2000 and 2016-2020



Maps Description

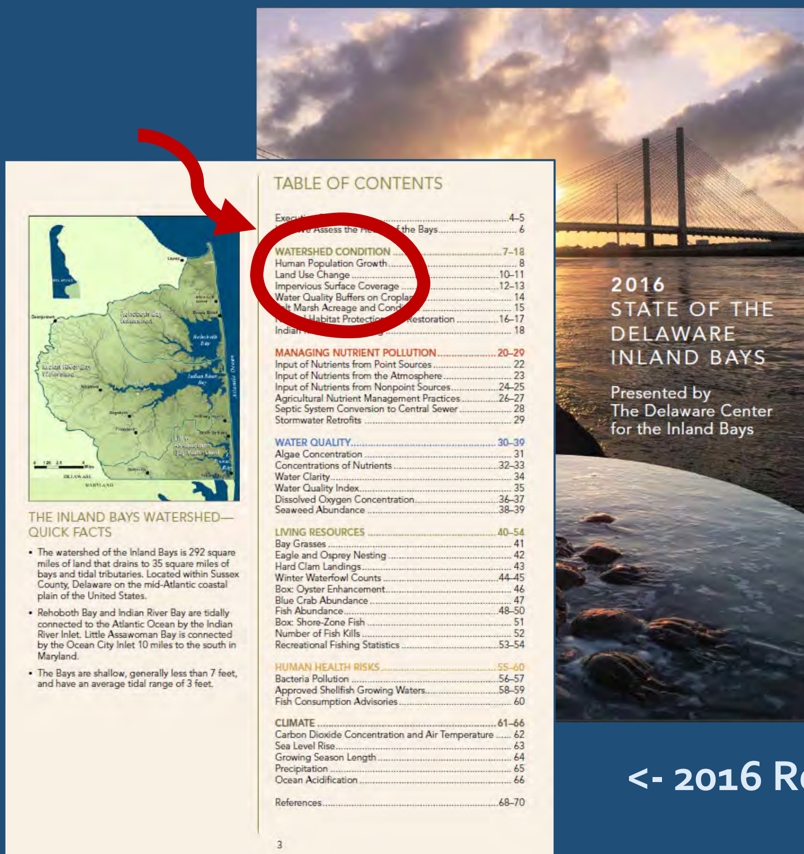
The maps on the left and right represent the peak tide levels for certain years and storms. For example, from 1996 to 2000 we found the peak tide for each station and extrapolated for the area between stations. The max values on the left maps is the worst-case scenario and takes the peak values of all stations no matter the year or storm. For both maps the most recent years are on the bottom, showing that overtime the peaks have increased in area since the color can still be seen.

Peak Tide Map For Hurricane Isabel and Sandy

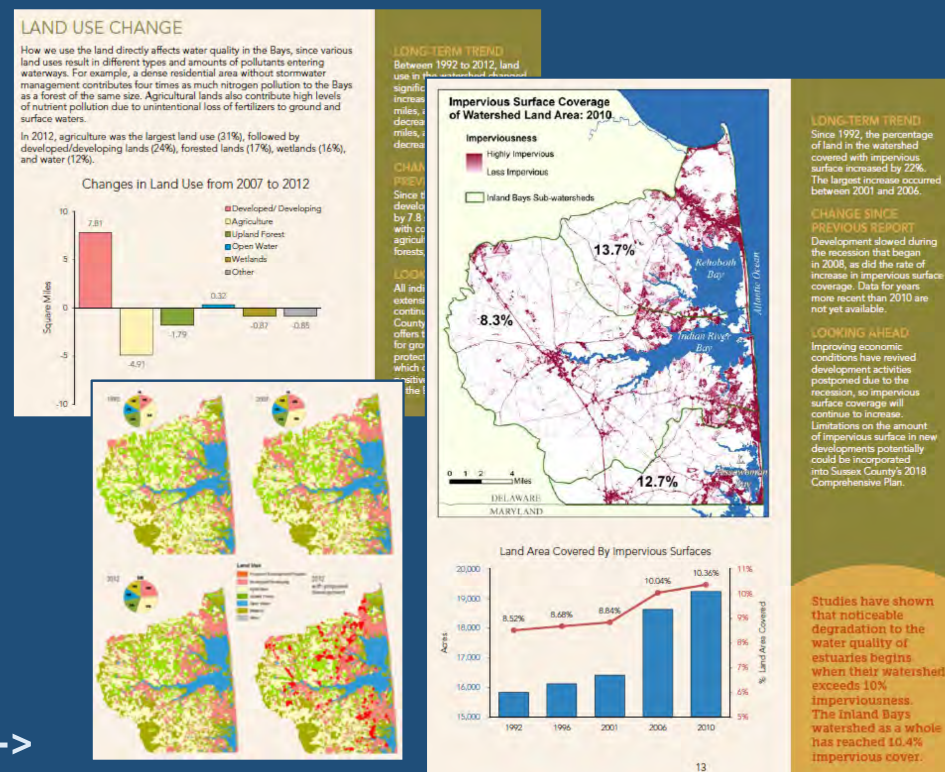


Updating Land Use and Impervious Cover Change for the Center of Inland Bays State of the Bays Report

By: Bridgette Kegelman, working under Andrew Homsey

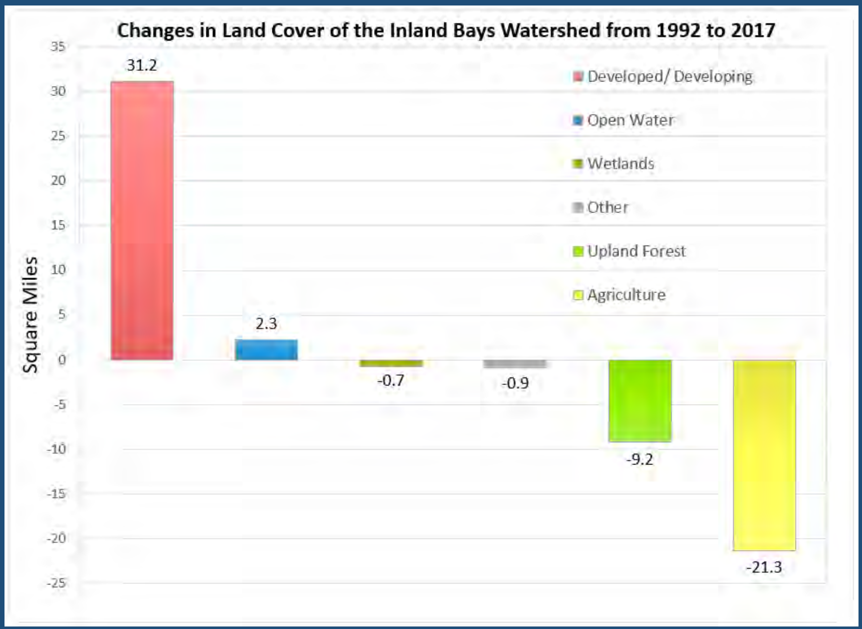


<- 2016 Report ->



https://www.inlandbays.org/about-the-bays/state-of-the-inland-bays-2016/

Updating Land Use



Problem:

2007 land use contained errors with misclassified developed land, and in the 2012 and 2017 data there were significant classification differences in which areas were classed as rangeland/upland forest/wetlands compared to all previous datasets (1992-2007).

For the 2016 report, some areas from the 2012 data were reverted to what they were in 2007, before the classification method changed.

The 2016 Report stated that between 1992 to 2012.

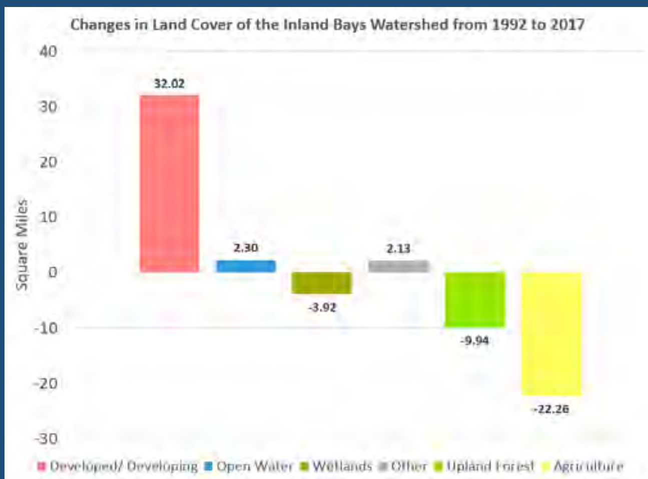
- Developed lands increased by 33.9 square miles
- Agricultural lands decreased by 18.2 square miles
- Upland forests decreased by 14 square miles

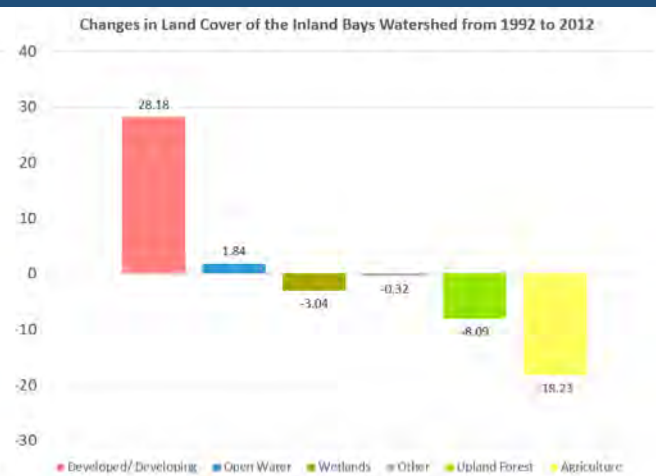
Solution:

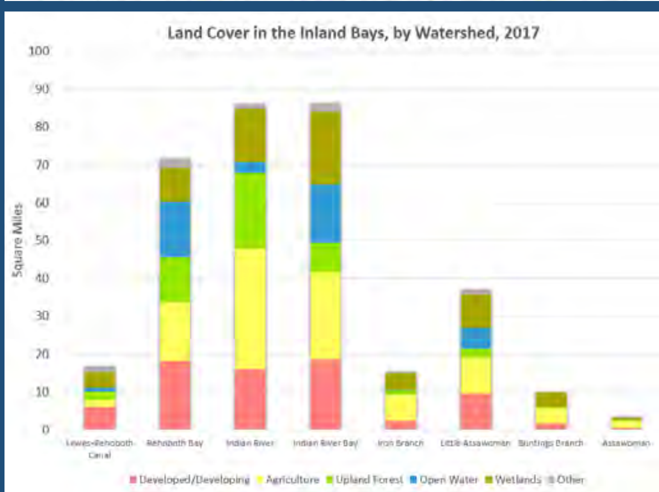
To decrease accumulating errors into the future, Andrew reclassified the data from 2007 and earlier to be consistent with the classification methods present in the 2012 and 2017 data.

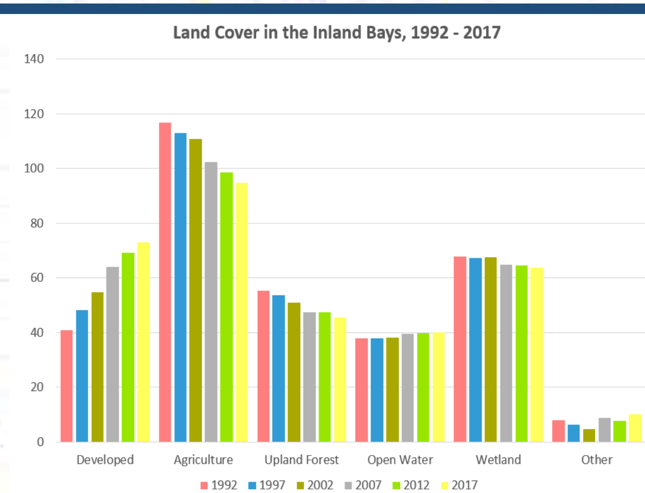
- This was done by allocating types of rangeland to either Agriculture, Upland Forest, or Other, depending on the year.

Updating Land Use









This method fixed the discrepancies between data sets and will hopes to make future updates more comparable.

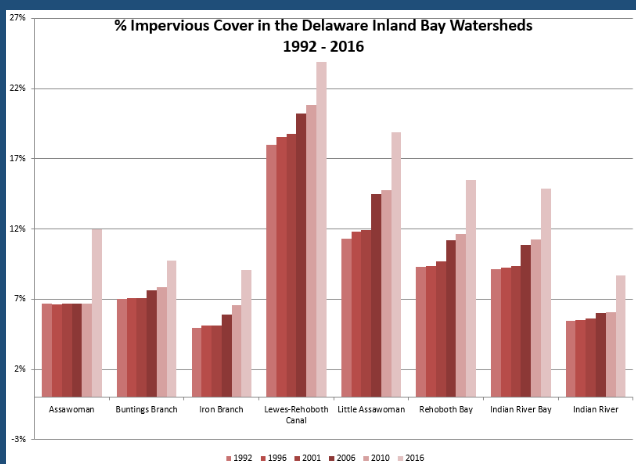
With data values from 1992-2017 adjusted to be comparable, the overall trends and land cover across the Inland Bays can be more accurately expressed.

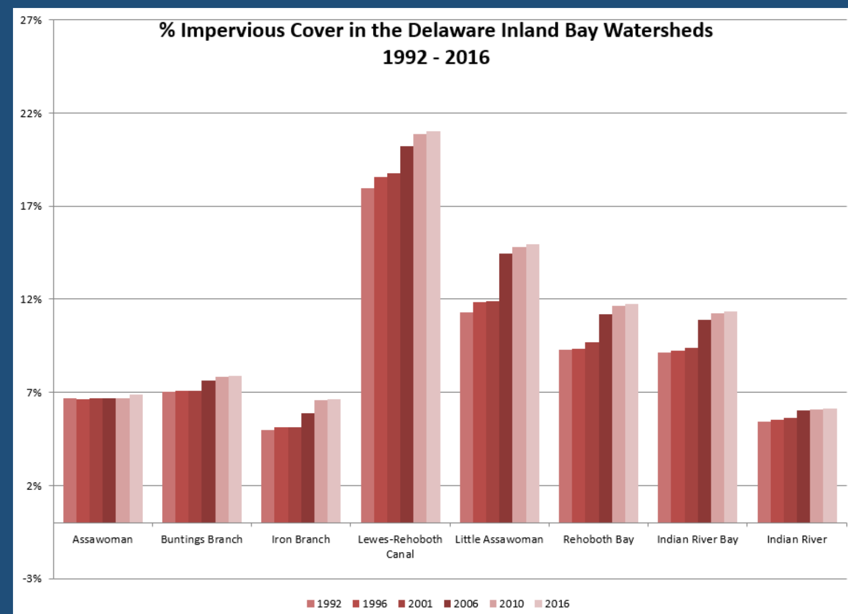
Updating Impervious Cover

For Impervious Cover in the previous report, data from NOAA and from the USGS National Land Cover Database were used.

In updating to the most recent data, we found inconsistencies with the NOAA data compared to previous years. Areas that had not changed between 2010 and 2016 were showing up as impervious in the most recent data when they hadn't before. This caused a unprecedented increase in impervious cover.

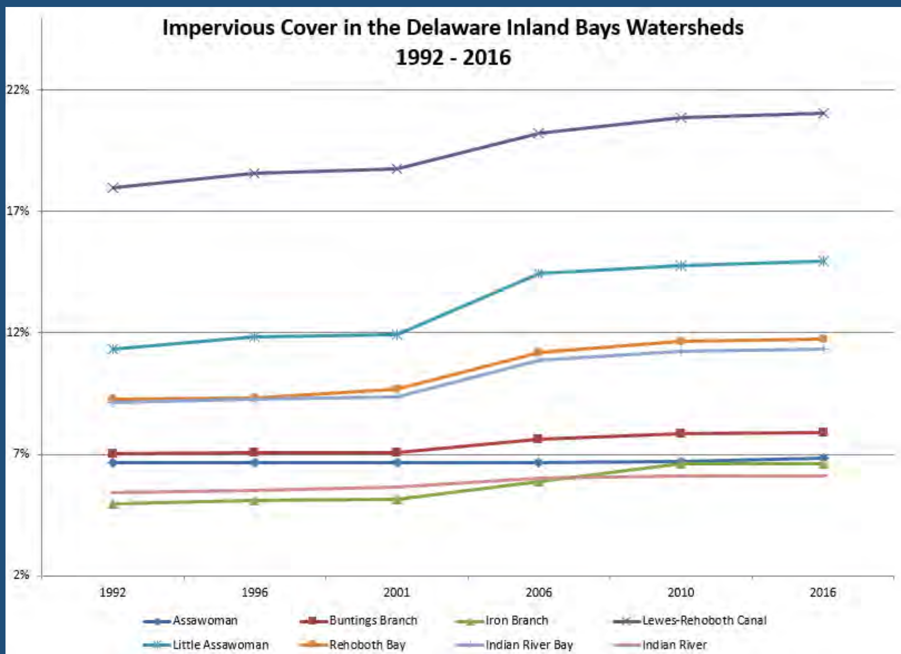
Attempts to mask out the major road changes did not fix the problem.

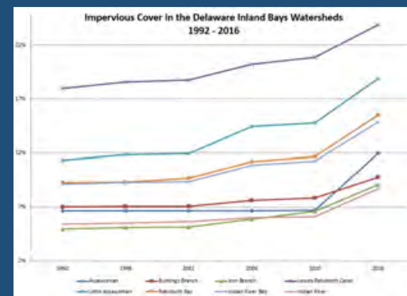




The work around ultimately implemented was to calculate and apply the % increase of impervious from our other impervious data source that did not have these inconsistencies (the USGS data), to the 2010 NOAA data.

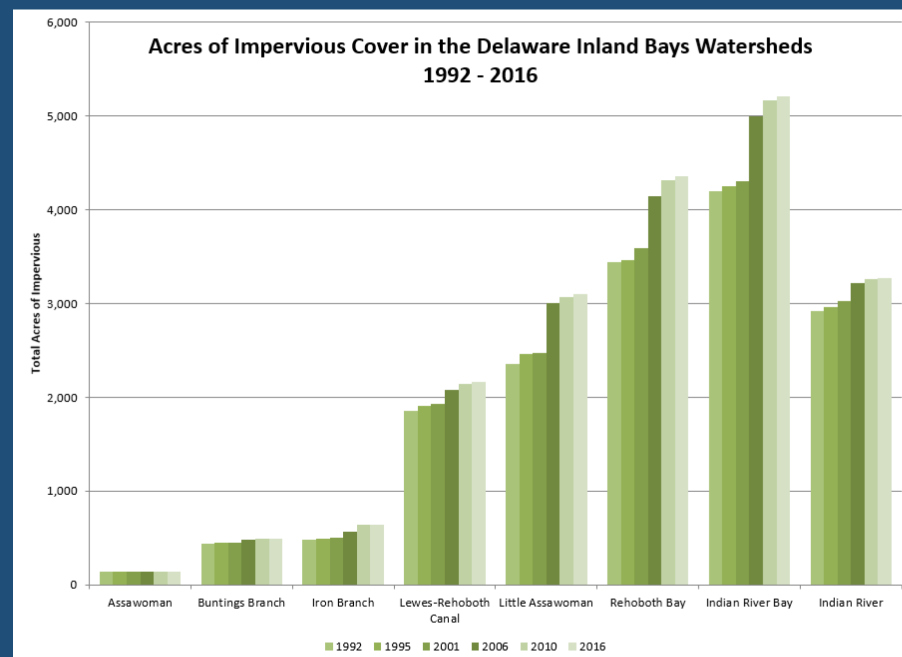
Updating Impervious Cover





Implementing this method created quality results that will be used in the next State of the Bays report.

Comparing Results:



Modification of Peroxidase Enzyme Analytical Methods for Complex Media from Solid State Bioreactors use to Reduce Pathogens in Dairy Manure

Patrick McGay

Dr. Anastasia E. M. Chirnside, Entomology & Wildlife Ecology; Civil & Environmental Eng.

University of Delaware

Background

- Certain white rot fungi (WRF) are capable of killing bacteria present in manure waste streams (Chirnside, 2016).
- During lignin degradation, the WRF produce non-specific, oxidative extracellular enzymes that degrade the lignin structure.
- This will happen when the fungi are nitrogen or carbon deficient.

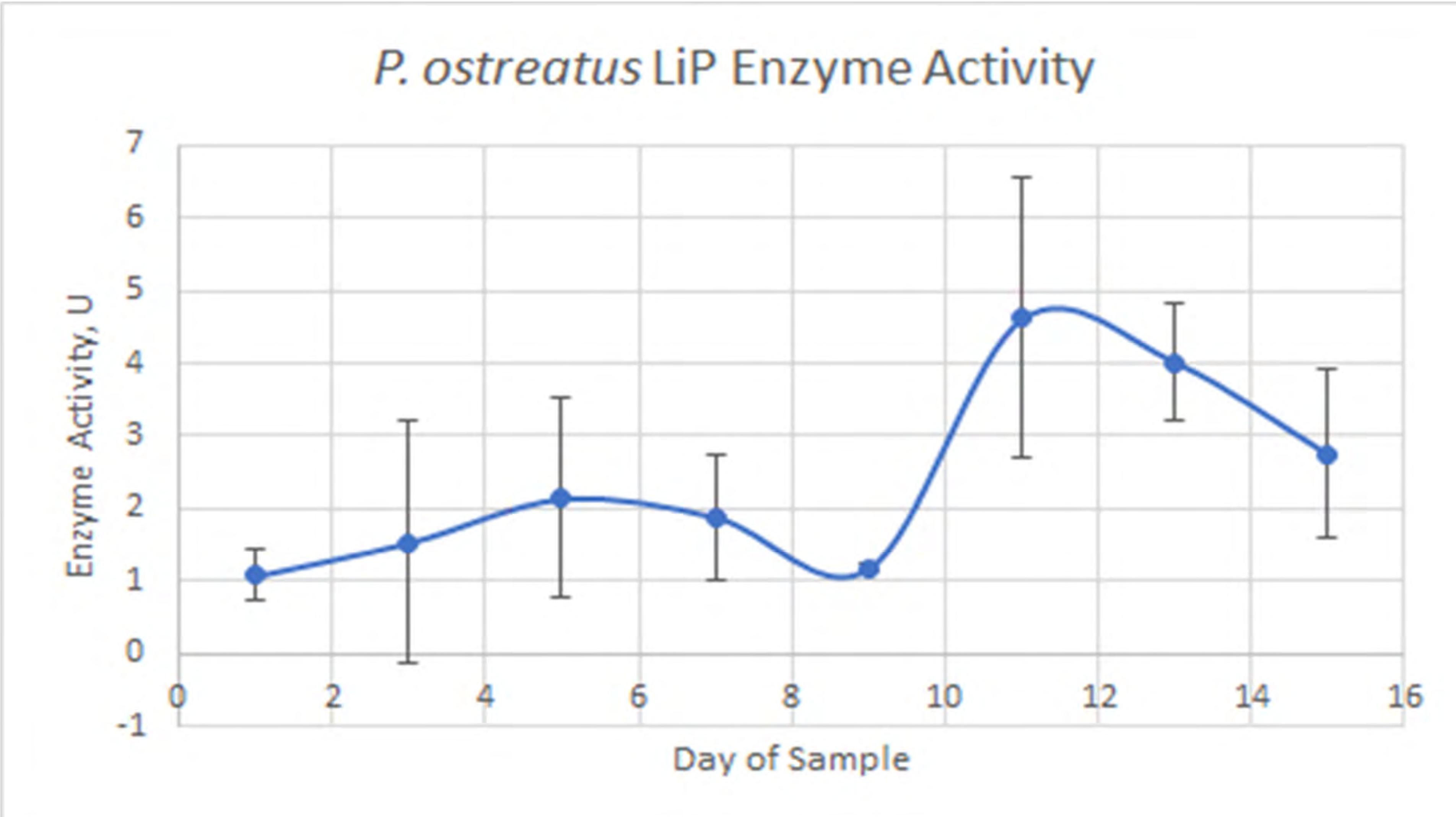
Background cont.

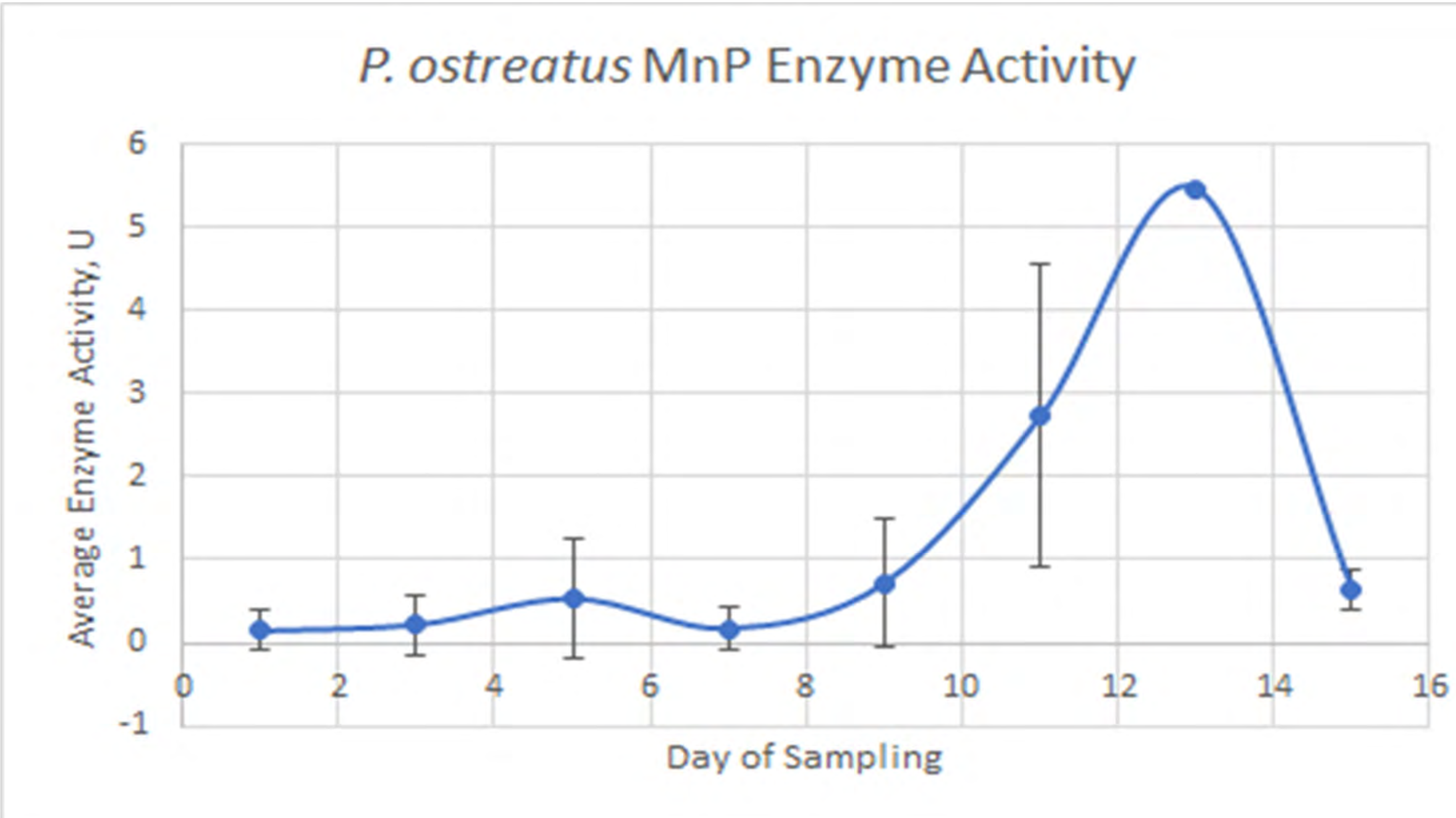
- The complex media from the bioreactors interferes with the standard enzyme assays.
- A review of the literature was done to modify the methods so the assays and procedures will be effective for the dark-colored media from the bioreactors.
- The fungi was grown in a liquid growth solution and moved to a nutrient deficient solution. The tests will be done on both *Pleurotus ostreatus* and *Phanerochaete chrysosporium* and sampled on days 1, 3, 5, 7, 9, 11, 13, and 15.

Scope of Research

- The production of Lignin Peroxidase (LiP) was tested using a reaction solution with Azure B to simulate dark media (Arora, 2000).

- The production of Manganese Peroxidase (MnP) was tested using a reaction solution with phenol red (Silva, 2014).


P. ostreatus LiP Enzyme Activity
Enzyme Activity, U
Day of Sample
7
6
5
4
3
2
1
0
-1
0
2
4
6
8
10
12
14
16


P. ostreatus MnP Enzyme Activity
Average Enzyme Activity, U
6
5
4
3
2
1
0
-1
0
2
4
6
8
10
12
14
16
Day of Sampling

Conclusion

- Timing of degradation activity in packed bed reactors can be estimated for *P. ostreatus* in order for full ligninolytic enzyme activity to take place.
- Currently at day 15 of sampling for *P. chrysosporium*, so those final results will be put in the paper once they are run on the spectrophotometer.
- Slight adjustments will be made in the testing procedure for the next round of samples.

Economic Value of Properties in the DE Coastal & Riverine Floodplain with Sea Level Rise

Karmyn Pasquariello, Gerald Kauffman, and Andrew Homsey

University of Delaware

Abstract

- The Research seeks to assess the economic and real estate value of properties in the Delaware riverine and coastal floodplain with/without sea level rise.

- Using GIS, we will overlay FEMA and NOAA flood inundation maps with parcel/property value maps to estimate the value of real estate risk for flooding given that nearly 1/5 of Delaware sits in the 100-yr floodplain.

County	Land Area (mi^2)	100-year Floodplain (mi^2)	% Floodplain
New Castle	432	67	16%
Kent	599	94	16%
Sussex	976	170	18%
Total	**2,007**	**331**	**17%**

Introduction

- Global warming and sea level rise over the past hundred years have caused risk of flooding, hurricanes, and natural disasters to spike in the U.S..
- Flood insurance is one-way residents and business owners protect against these risks, in theory a very symbiotic relationship between homeowners and insurance companies.
- Our research seeks to evaluate the truth behind this relationship, in areas such as Delaware's three counties where homes are at risk to storm damage and insurance corporations are filled with liabilities due to low flood insurance costs & high risk.
- First Street is a non-profit organization dedicated to assessing these factors on a larger scale per state, and found that of all 50 states Delaware has the highest average expected annual loss per property with risk in 2021.

Purpose & Research Question

- The purpose of our research project is to assess the economic value of properties in the coastal/riverine floodplain in Delaware on a smaller level that has not been analyzed before, per zip-code, by separating the spatial data we may recognize where the real disparity in flood insurance claims, coverage, and premiums lie.

Methods & Analysis

Methodology

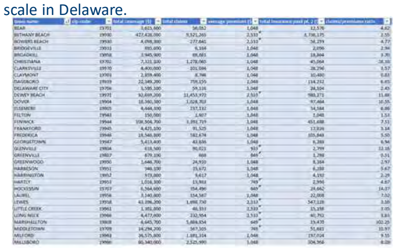
- Flood Mapping – prepare flood inundation mapping for DE from FEMA/DNREC data
- Parcel Mapping – using ArcGIS our insurance claims, coverage, and premiums data is analyzed
- Economic Analysis – joining insurance data per parcel we observe the trends using Excel

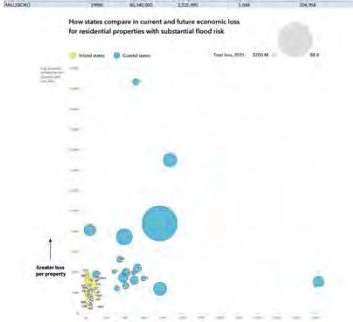
Spatial Analysis

- The map shown to the right represents the streamlines and areas where the most water will travel through. Although the coast a large cause of flood damage, the streamline map can reveal riverine flood prone areas.

Data Analysis

- The data analysis portion consisted of manipulating FEMA flood insurance data as well as extrapolating insurance premium data using First Street Organization data for different land types in Delaware.
- By separating the insurance claims, coverage, and average premium data we can better grasp the relationship between what is getting paid into this system and what is being taken out, on a town-wide scale in Delaware.

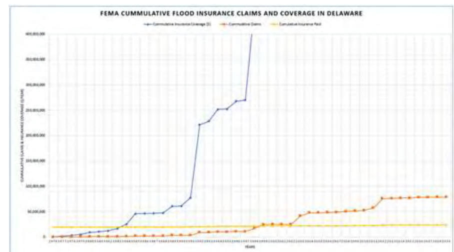




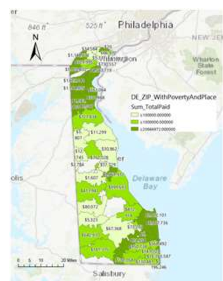
The Cost of Climate: America's Growing Flood Risk I © First Street Foundation 2021

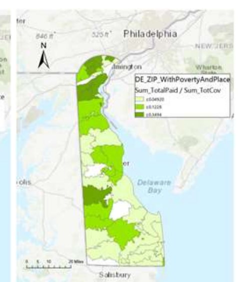
Results

•One of the largest concerns once the data analysis was completed was the disparity between premiums paid, and claims, as well as coverage.
•Claims are a more pressing issue, representative of what the current Delaware residents are experiencing in flood damage. Coverage is a value that blankets what insurance companies could pay out in the event of a major natural disaster, and if there is already underlying disparities this can be a major red flag or liability.



•The FEMA Cumulative Flood Insurance Claims and Coverage chart above shows this disparity distinctly. The coverage line reaches all the way to about $1.5 billion, this is certainly a concern for insurance companies.

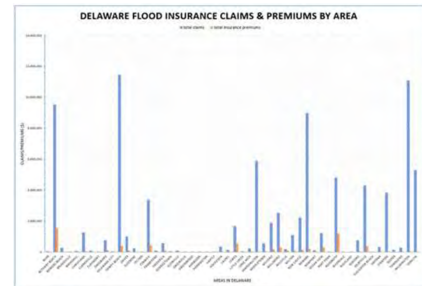




•The maps above represent the total insurance premiums paid per zip-code as well as the total premiums per coverage ratio in Delaware. Trends show that Sussex County coastal regions have higher premiums, due to coastal flood risk, and New Castle County urban/suburban regions have a higher total premiums paid due to its high density population.

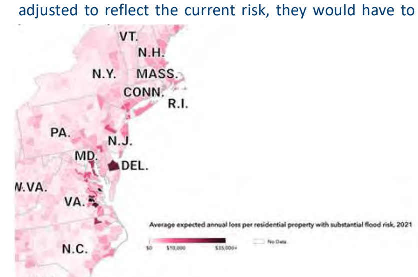
Conclusions

- Of the 51 zones analyzed in Delaware only 2 had a higher amount of total premiums paid than total claims. The largest disparities exist in New Castle County, although the largest risk lies in Sussex county.
- The value of claims/premiums ratio is telling of the current state of the insurance industry, and begs the question is a third party subsiding these claims.



Directions for Future Research

- The NFIP average insurance premium for properties with substantial flood risk is $2,380, if premiums were adjusted to reflect the current risk, they would have to



- The current state of insured property in the Delaware floodplain is unsustainable. In the case of a storm there is a significant liability for the insurance industry due to the inequity of coverage and premiums paid.
- For future research it may be beneficial to understand the plan insurance companies have to handle this inequity and if the NFIP has information on how claims are being paid out of a theoretically empty fund.

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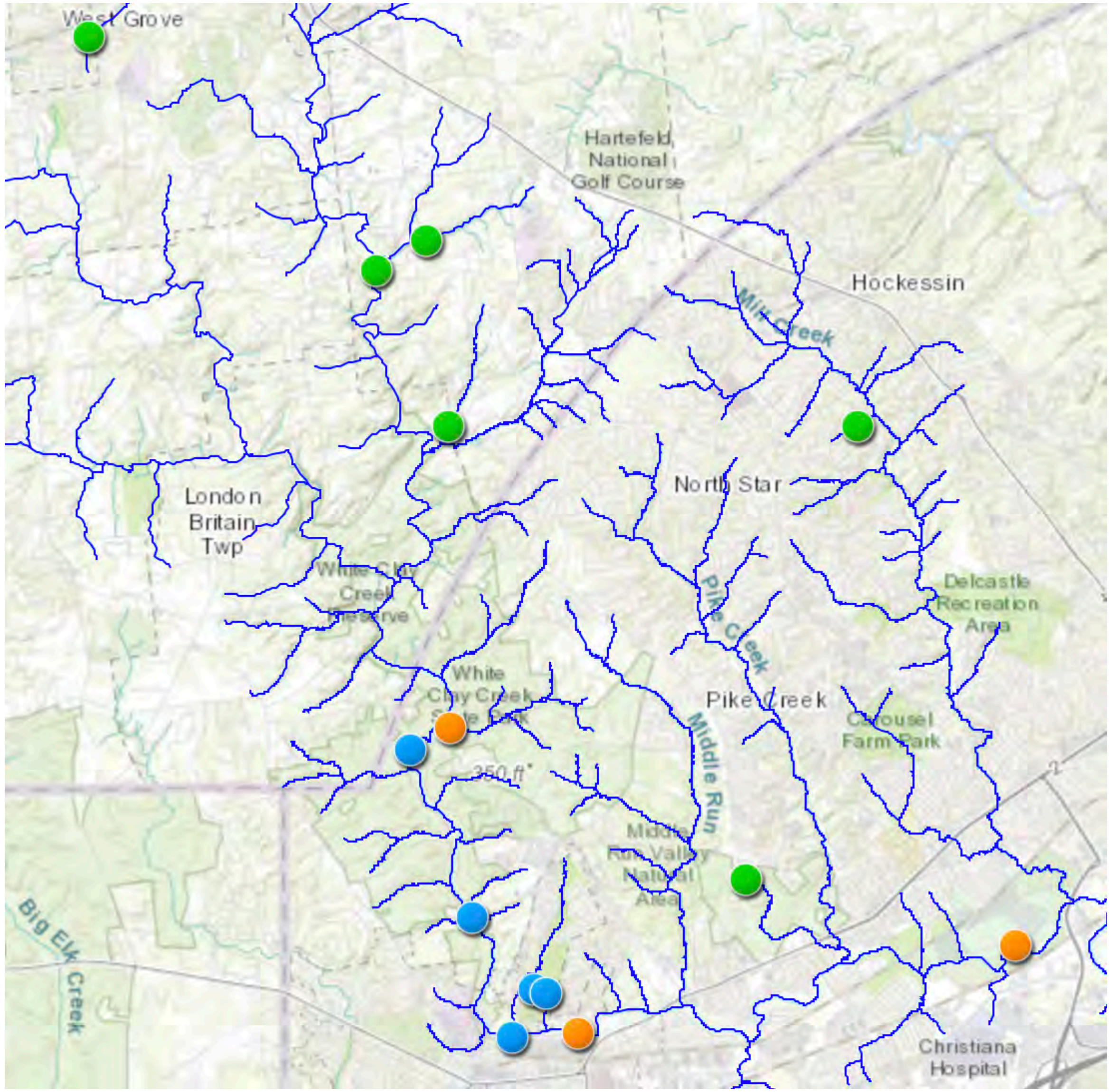
Watershed Characterization of White Clay Creek National & Scenic River in Delaware and Pennsylvania

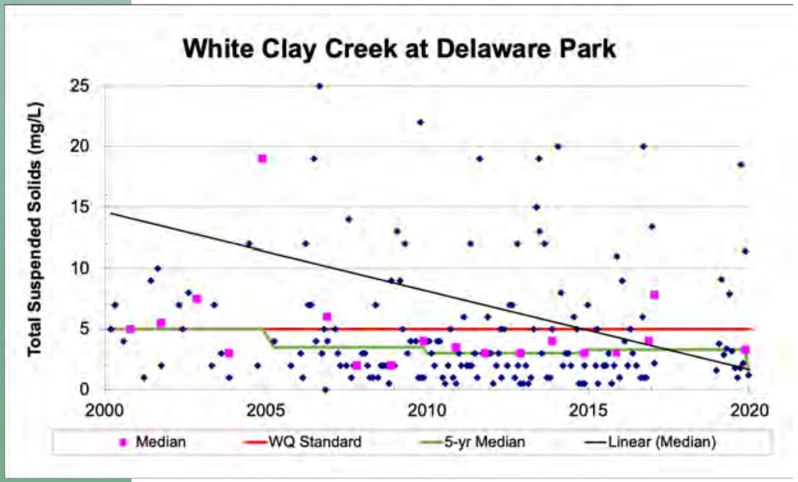
Anna Singer
Environmental Studies/Public Policy
May 13, 2021

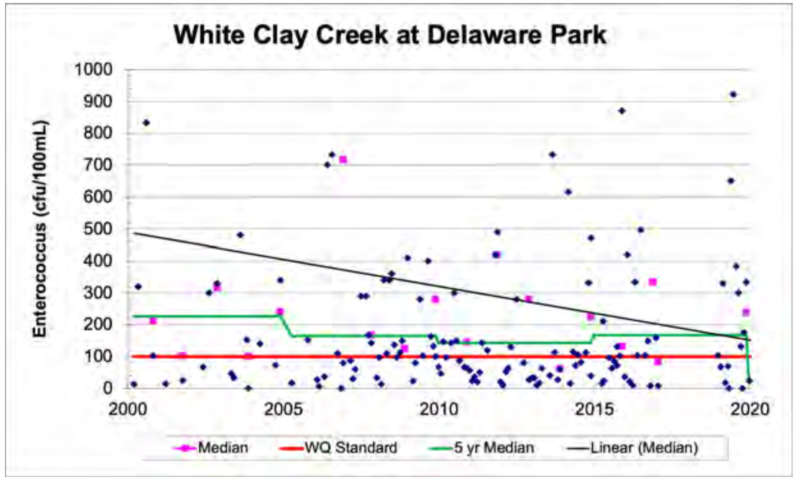


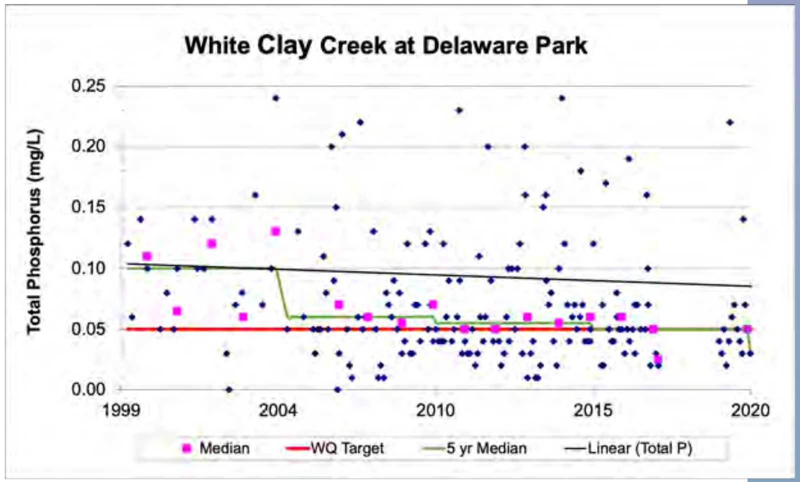
Areas of Research

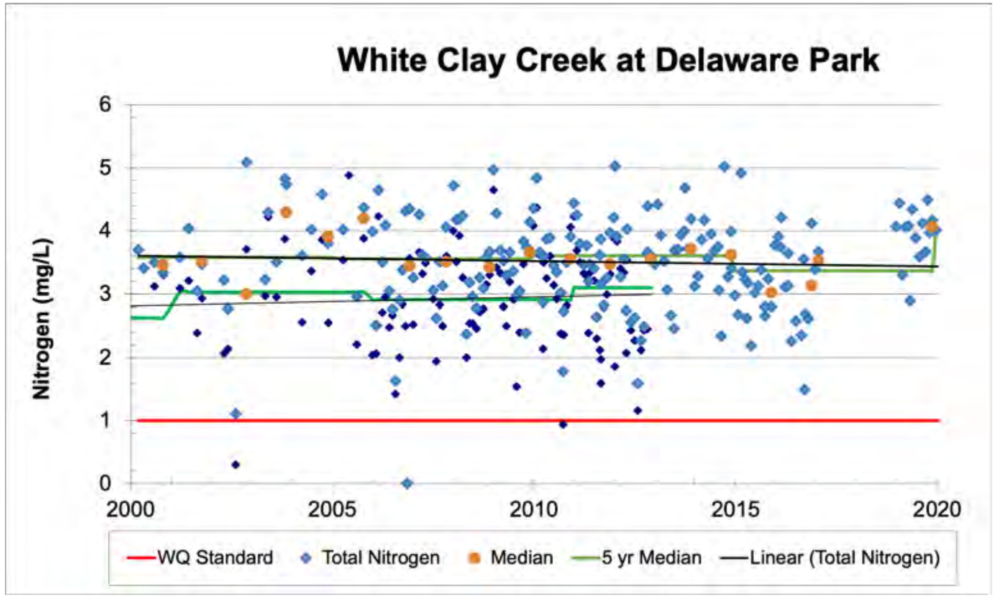
1. **Delaware State Sampling (Orange)**
   - Chambers Rock Rd
   - McKees Lane
   - Delaware Park
2. **White Clay Wild and Scenic River Sites (Green)**
   - Watsons Mill
   - Hickory Hill
   - Middle Run
   - West Grove
   - Egypt Run
3. **Nitrogen Sampling Newark Water Supply (Blue)**
   - Hop. Bridge
   - Dam 5
   - Dam 4
   - Res L
   - Res R

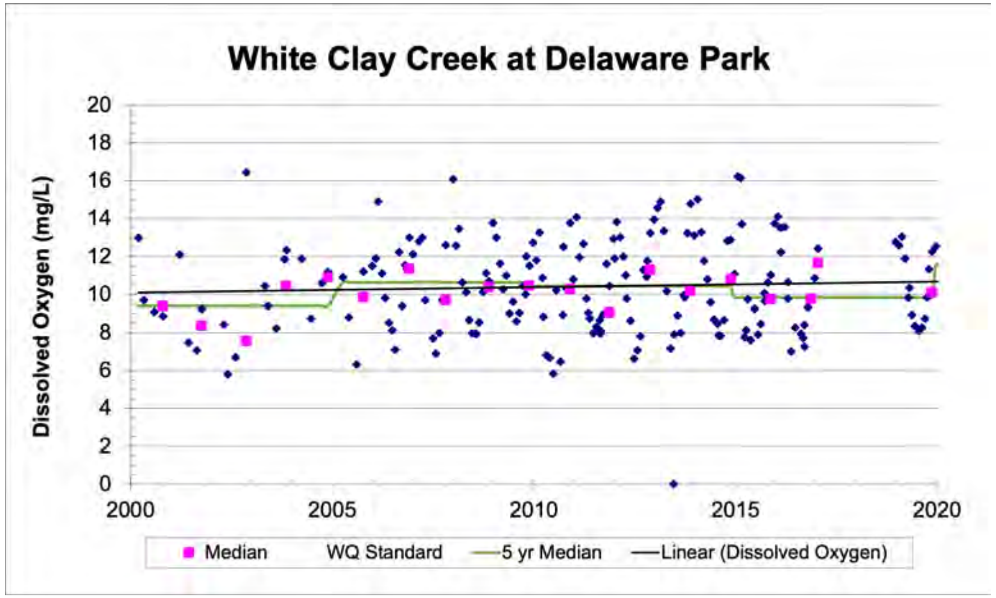
Delaware State Testing Site – Delaware Park





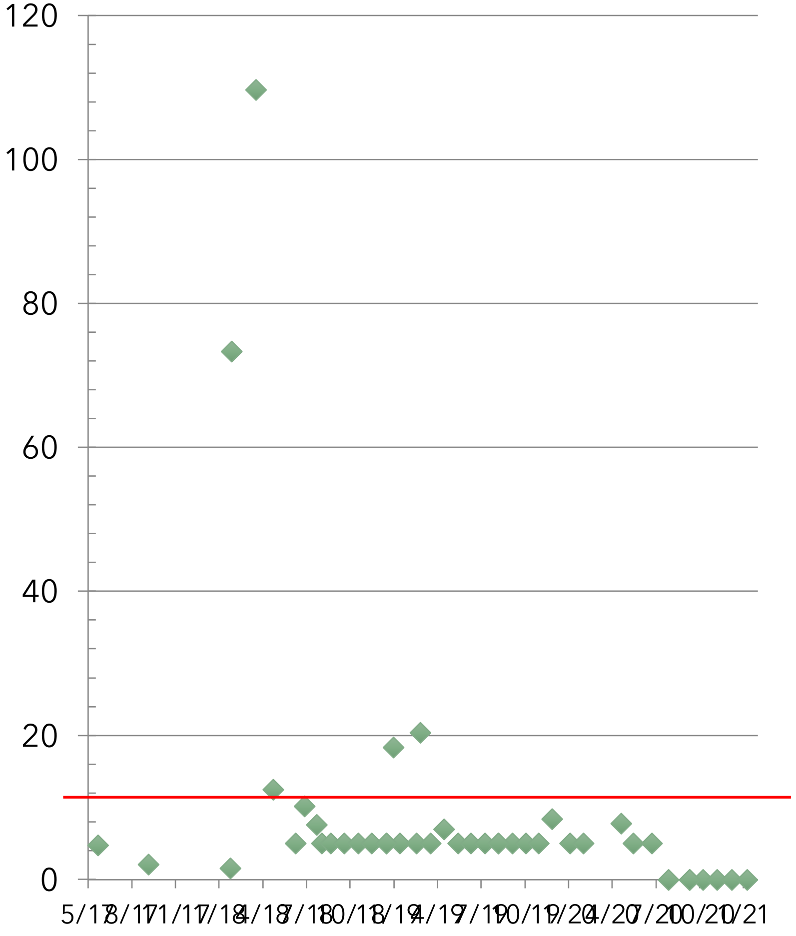




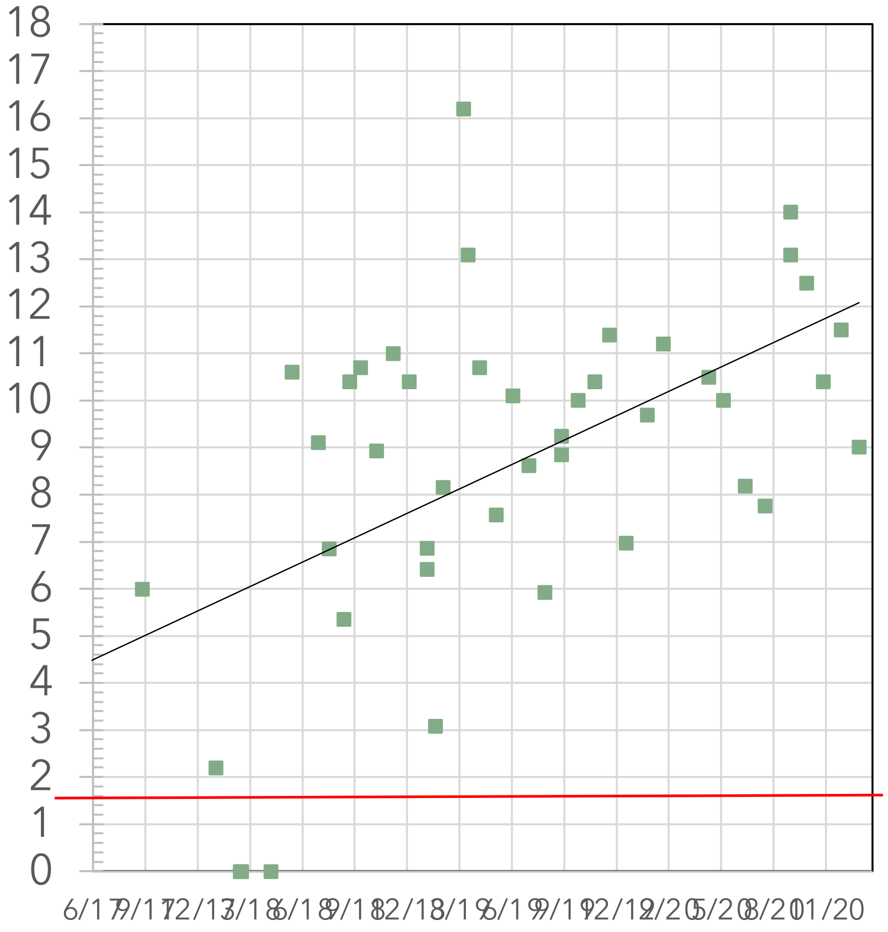


White Clay Creek above Newark

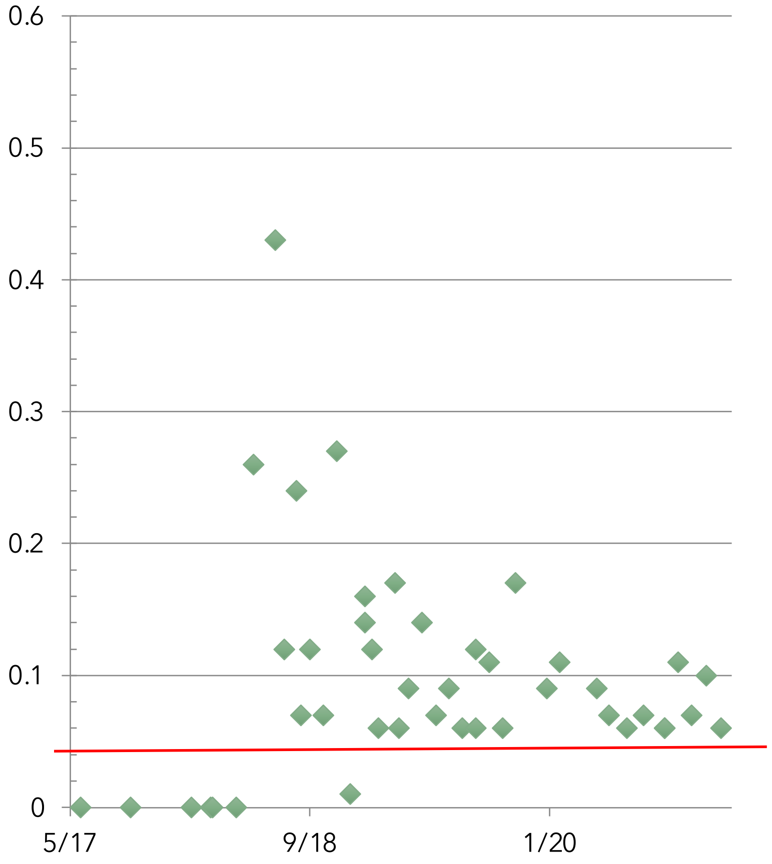
TSS (mg/l) Egypt Run



Nitrate Nitrogen (mg/l) Egypt Run



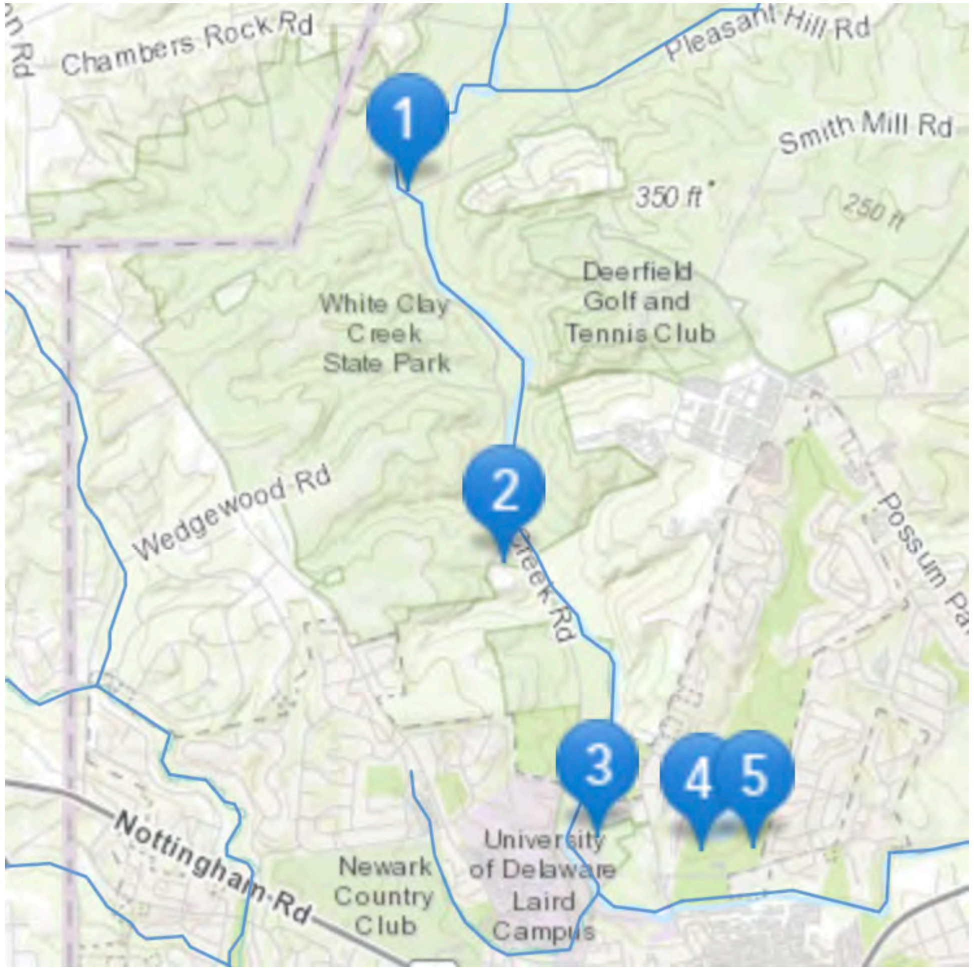
Phosphorous (mg/l) Egypt Run



White Clay Creek above Newark - Nitrogen

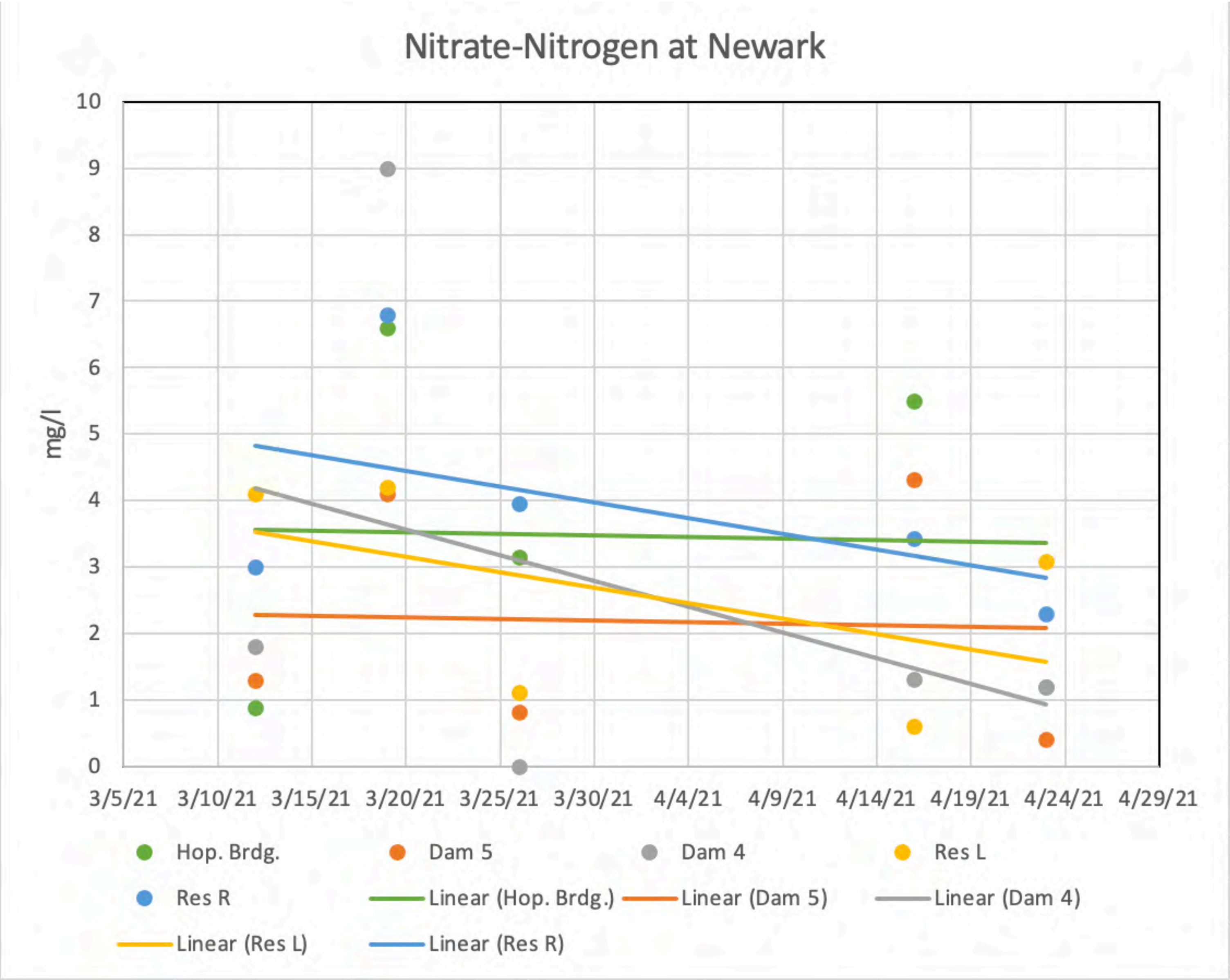
Site	Water Quality Indicator	Period of Record	Max recorded	Min Recorded	Median	Trend
Watsons Mill	Nitrogen	5/2017 - 1/2021	10.4	1.4	4.9	
Egypt Run	Nitrogen	9/2017 – 1/2021	16.2	2.2	9.7	
Hickory Hill Run	Nitrogen	10/2017 – 1/2021	7.3	0.8	4.4	
Middle Run	Nitrogen	5/2018 – 1/2021	4.5	1.8	3.3	
West Grove	Nitrogen	8/2019 – 1/2021	8.5	4.1	6.4	

White Clay Creek at Newark – Nitrogen (Mg/L)



	12-Mar	19-Mar	26-Mar	16-Apr	23-Apr	Median
1. Hop. Brdg.	0.9	6.6	3.1	5.5	1.2	3.1
2. Dam 5	1.3	4.1	0.8	4.3	0.4	1.3
3. Dam 4	1.8	9	N/A	1.3	1.2	1.6
4. Res L	4.1	4.2	1.1	0.6	3.08	3.1
5. Res R	3	6.8	4	3.4	2.3	3.4

White Clay Creek at Newark Results

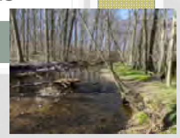


Thank You

Questions?

EUROPEAN SETTLEMENT AND THE EFFECTS ON WHITE CLAY CREEK DEPOSITIONAL ENVIRONMENTS

EMILY SYMES



BACKGROUND

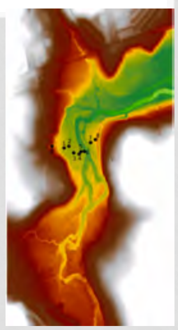
Hypothesis:

White Clay Creek was a vegetated wetland with small channels that was transformed into a modern river valley during European settlement.

- Based on research from Walter & Merritts, suggesting the above statement to be true for mid-Atlantic, piedmont streams.
- Walter & Merritts identified a wetland soil underlying piedmont river valleys and channel deposits.
  - Main piece of evidence

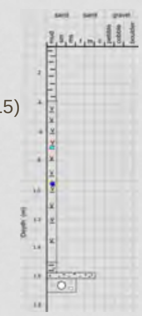
METHODS- CORE SAMPLES

- Core samples
  - Taken from 9 locations across the field Site.
  - Used to produce a cross section of the different depositional environments
  - The image to the right is a heat map showing the core locations.



METHODS -RADIOCARBON DATING

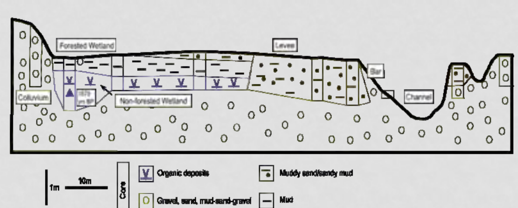
- A radiocarbon date was taken from a piece of wood
- Used to recreate the environment before European settlement (see slide 15)
  - Found in core 1
    - The location is illustrated by the blue star in the image to the right.
    - The wood came back to be 1870 years old



METHODS – LOSS OF IGNITION

- Gives percentage of organic material
- How is it calculated?
  1. Sediment samples were weighed
  2. Samples are dried over night in an oven at 100 degrees Celsius
  3. Samples are placed in a desiccator to cool
  4. Samples are weighed a second time
  5. Samples are then heated in a furnace at 425 degrees Celsius overnight
  6. Samples are placed in desiccator again
  7. Samples are weighed again
  8. The final value is then divided by the initial weight and multiplied by 100.

MODERN CROSS SECTION



Loss of ignition values
Non-forested – 69.8%
Forested – 3.2%
Levee -3.4%, 1.5%

HILL SLOPE/COLLUVIUM

Poorly sorted mud, sand and gravel with about 50% mud, 20% sand and 30% gravel. The gravel consists of angular to sub-angular pebbles with some cobble. Boulders are present on the hill slope.

Only exposed within a gully along the hill slope, on the hill slope, and Within the river channel

FORESTED SEASONAL WETLAND

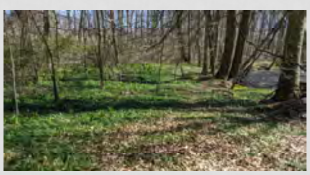
Mud deposits with 5% sand or less

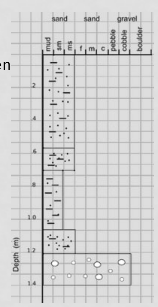
Roots and organic material present

Dark Brown – Grey in color

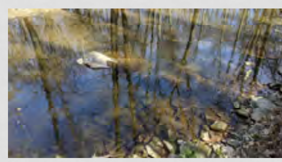
LEVEE

Contains a combination of muddy sand and sandy mud deposits. In general, the muddy sand deposits contain fine grained sand with 10-20% silt with root traces present. Sandy mud deposits contain between 15-30% fine grained sand with no distinguishable features.



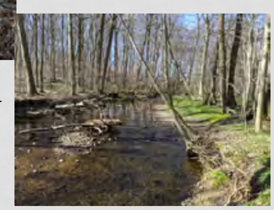


RIVER CHANNEL



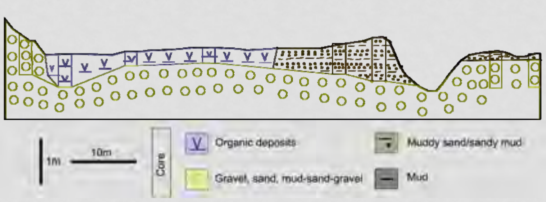
The river channel is about 10 m wide.

Pebbles, cobbles and boulders cover the bottom.



RECONSTRUCTION OF PREVIOUS SEDIMENTARY ENVIRONMENTS

- Cross section of 1800 years ago



CONCLUSIONS

- Prior to European settlement, a swampy Perennial Wetland covered half of the field site but did not extend across the river valley. This conclusion opposes that of other scientists.
- The pre-settlement channel was likely much smaller than today.
- Increased agriculture and land use during European settlement could have contributed to the increased size of the river channel.(Jacobson & Coleman)