Water Resources Center
University of Delaware

Annual Technical Report
2018

General Information

Products

Young, Jillian. Spring 2019. Analysis of the Watershed Resources Registry Using GIS to Evaluate Stormwater Restoration Practices in the Christina River Watershed. Master's Thesis. M.S. Water Science and Policy. Biden School of Public Policy & Administration. College of Arts and Sciences.

Kauffman, G. J., 2019. Economic Benefits of Improved Water Quality in the Delaware River (USA). River Research and Applications. 1-14. DOI: 10:1002/rra.3484

Kauffman, G. J. and C. Collier, 2018. The Great American Megabasin: Chesapeake and Delaware. Water Resources Impact. American Water Resources Association. 20(5):6-9.

Information Transfer Program

One of the major ongoing activities of the DWRC is to disseminate information on water resources to all interested individuals in Delaware and other states. The DWRC has a website to facilitate this and published the December 2018 annual newsletter (DWRC Water News) which is distributed to 1500 individuals and organizations and water-related faculty and staff at UD and many individuals in state/federal agencies, and local/regional water organizations. We have also established a formal link with the UD's undergraduate research program to distribute information to interested students about opportunities for water resources research. Students who participate in a research project will present their results during the undergraduate research poster session sponsored by the UD Office of Undergraduate Research. DWRC Director Dr. Gerald J. Kauffman represented the DWRC and presented at the following forums and seminars during FY18:

1. Brandywine and the Piedmont: Restoration and Revival of America's Most Historic Small Watershed. June 11, 2019. Universities Council on Water Resources (UCOWR)/National Institutes for Water Resources (NIWR) Annual Water Resources Conference. Snowbird, Utah.

2. Water Quality Trends in the Brandywine Christina Cluster along the Arc Boundary of Delaware. November 29, 2018. Delaware Watershed Research Conference. Academy of Natural Sciences. Philadelphia, PA.

3. Waters of the United States (WOTUS) and Supreme Court of the United States (SCOTUS). October 18, 2018. School of Public Policy & Administration (SPPA) Research Seminar. University of Delaware. Newark, DE.

4. River Basin Finance and Economics in a Mid-Atlantic Watershed. June 27 2018. Universities Council on Water Resources (UCOWR)/National Institutes for Water Resources (NIWR) Annual Water Resources Conference. Pittsburgh, PA.

Student Support

The University of Delaware Water Resources Center supported 14 undergraduate and graduate water research internships during FY18 through the annual base (104b) grants. The DWRC research students presented their research findings at the 54th annual meeting of the DWRC Advisory Panel on May 16, 2019 at the University of Delaware:

1. Michaella Becker (Environmental Engineering), Advisor: Paul Imhoff (Civil and Environmental Engineering). Impact of Biochar-Amended Roadway Soils on Runoff & Pollutant Loads.

2. Nicolette Bugher (Environmental Engineering), Advisor: Gerald Kauffman (Public Policy). Recommendations for

Addressing Perfluoroalkyl Chemical Contamination in Delaware.

3. Chelsea Caplinger (Political Science), Advisor: Gretchen Bauer (Political Science). Interstate Watershed Management:Expanding the Clean Water Act to Include Modern Pollutants.

4. Alyssa Cortese (Environmental Science), Advisor: Gerald Kauffman (Public Policy). Nitrate Sources in White Clay Creek.

5. Monica Crosby (Environmental Studies), Advisor: Paul Jackson (Geography). Status, Policies & Mitigation for Wetlands in Delaware.

6. Veronica Hill (Resource Economics), Advisor: Leah Palm Forster (Resource Economics). The Impact of Sea Level Rise on Seasonal Rental Properties in Delaware.

7. Allison Kaltenbach (Environmental Engineering), Advisor: Gerald Kauffman (Public Policy). Tidal Effects of Coastal Flood Inundation along the Atlantic Seaboard.

8. Rebecca Steiner (Public Policy), Advisor: Nina David (Public Policy). Land Use Change in the Delaware Inland Bays Watershed.

9. Mia Kane (Environmental Science), Advisor: Gerald Kauffman (Public Policy). Agriculture at Delaware Nature Society Coverdale Farm.

10. Liam Warren (Energy/Environmental Policy), Advisor: Phillip Barnes (Public Policy). Stormwater Utility Charge Policies in Delaware: A Sustainability Analysis.
11. Natalie Zimmerman (Geology), Advisor: Gerald Kauffman (Public Policy). Determining the Source of Sediment Pollution in White Clay Creek Wild & Scenic River.
12. Andrew Dorazio (Mechanical Engineering), Advisor: Gerald Kauffman (Public Policy). White Clay Creek's Potential for Hydroelectric Power Generation.

13. Jillian Young (M.S. Water Science and Policy), Advisor: Andrew Homsey (Public Policy and Administration). Analysis of the Watershed Resources Registry Using GIS to Evaluate Stormwater Restoration Practices in the Christina River Watershed.

14. Kelly Jacobs (M.S. Energy and Environmental Policy), Advisor: Martha Narvaez (Public Policy and Administration), Source Water Protection in the White Clay Creek Watershed.

Sec. 105 g Grant

Xuan Yu (Postdoctoral Researcher), Advisor: Dr. Holly A. Michael (Geology), Measurements and modeling to improve prediction of vulnerability of coastal water resources and ecosystems to salinization by storm surges and sea-level rise.

Notable Achievements and Awards

DWRC Director Dr. Gerald Kauffman was elected to the Board of the Universities Council on Water Resources (UCOWR) during FY18.

In November 2018, the University of Delaware student chapter of the American Water Resources Association was awarded the National Student Chapter of the Year Award at the AWRA annual conference in Baltimore, MD.

Projects

Alyssa Cortese (Environmental Science), Advisor: Gerald Kauffman (Public Policy). Nitrate Sources in White Clay Creek.

Project Type: Annual Base Grant **Project ID:** DE FY18 - 4

Project Impact: White Clay Creek Watershed covers area in both Delaware and Pennsylvania with its head waters in Pennsylvania. White Clay Creek consists of three branches flowing into the main stem; the west, east, and middle branches. White Clay Creek supplies the reservoir with water which is one of the main sources of drinking water for Newark, Delaware xcess nitrates has negative impacts on ecological health causing eutrophication and dead zones. Mitigation of nitrate inputs is important and this study hopes to illustrate that the east branch had the highest amount of nitrates with a median of 4.97 mg/ L during the 5 weeks, however surprisingly, the west branch came back with high nitrates as well at 4.76 mg/L. Land cover data suggests horse farms and mushroom farms could be a major cause for nitrogen inputs. There is a slight increase in the 2019 medians from the 2013- 2018 data, despite a declining trend in the 2013- 2018 data in nitrates suggesting a need for additional regulations in nitrate inputs. Future studies should set sampling sites farther up in the watershed to look further into nitrates sources.

Liam Warren (Energy/Environmental Policy), Advisor: Phillip Barnes (Public Policy). Stormwater Utility Charge Policies in Delaware: A Sustainability Analysis

Project Type: Annual Base Grant **Project ID:** DE FY18-10

Project Impact: What makes a stormwater utility policy sustainable? Urban areas are continuing to develop and expand, and more impervious surface area is being created. Impervious surface area prevents precipitation from naturally infiltrating into the ground. Stress is put on stormwater infrastructure from excessive runoff capacities. Municipalities implement stormwater utility charges (SWUs) to fund stormwater infrastructure. Sustainable SWU policies must fulfill certain sustainability criteria. A sustainable SWU policy: Generates enough revenue to cover the cost of stormwater infrastructure and no more burden of the charge is spread evenly across all who use the infrastructure, charges are structured on a fair ESU standard. Water quantity and quality is improved from implementing BMPs incentivized by the SWU provides incentives to property owners to reduce impervious surface coverage.

Measurements and Modeling to Improve Prediction of Vulnerability of Coastal Water Resources and Ecosystems to Salinization by Storm Surges and Sea-level Rise

Project Type: National Competitive Grant **Project ID:** DE18 - 1

Project Impact: We investigate the vulnerability of fresh groundwater resources and ecosystems in coastal zones to salinization due to storm-surge inundation and SLR. We will focus on three barrier-island field sites in New York, New Jersey, and Maryland/Virginia, and more broadly on the US Mid-Atlantic and Gulf Coastal Plain coastlines. The Mid-Atlantic region is among the most vulnerable in the US due to its low topography, frequency of intense storms, and high relative rate of SLR. Our objectives are to: 1) analyze data collected by recent and ongoing USGS studies as well as limited field data collected by this study from 1 or 2 storm events; 2) develop calibrated, transient, coupled groundwater-surface water models of three sites based on existing USGS steady-state groundwater models and water-level and salinity data; 3) vary model hydrologic conditions to assess impacts on groundwater salinization and flushing at those sites under current and future conditions, and develop vulnerability maps; 4) create generic models and vary hydrologic, geologic, and geomorphic properties to extend the analysis to include coastal zones typical of Coastal Plain coastlines, 5) develop vulnerability typologies, and 6) engage stakeholders. This work directly addresses the WRRI research priority to explore and advance understanding of changes in water quality in response to a changing climate.

Natalie Zimmerman (Geology), Advisor: Gerald Kauffman (Public Policy). Determining the Source of Sediment Pollution in White Clay Creek Wild & Scenic River

Project Type: Annual Base Grant **Project ID:** DE FY18 -11

Project Impact: Sediment pollution is the contamination of water sources with fine-grained, suspended sediments. It can lead to declines in fish populations, disruptions to the local food chain, algal blooms, alterations to the flow of water, and issues with drinking water supply. Fine-grained sediment polluting the White Clay Creek is currently effecting the availability of drinking water for the city of Newark, DE. After storm events and on high-pollution days the city's water treatment facility is often unable to process water from the White Clay Creek due to the excessive suspended sediment which clogs the water filters. As a result, the city must acquire potable water from a secondary source, inconveniencing the city. In an effort to identify the source of this fine-grained suspended sediment to develop a management plan, I am conducting a Sediment Fingerprinting analysis. Sediment Fingerprinting involves the determination of sediment sources on the basis of source material qualities. Currently, many people assume that the sediment polluting White Clay Creek comes from the many nearby agricultural farms. This theory does not account for streambank erosion, which may be a significant factor. I am comparing the sediment grain sizes and elemental tracers between water samples from five sites, streambanks at these sites, and nearby farms to attempt to identify the main source of suspended sediment.

1. Michaella Becker (Environmental Engineering), Advisor: Paul Imhoff (Civil and Environmental Engineering). Impact of Biochar-Amended Roadway Soils on Runoff & Pollutant Loads.

Project Type: Annual Base Grant **Project ID:** DE FY18-1

Project Impact: Biochar is an extremely porous charcoal (pyrolyzed biomass) with high specific surface area that when used as a soil amendment, it increases infiltration. Nutrients bind to the biochar as runoff filters through the soil, effectively reducing runoff quality and quantity. Biochar is mainly used in agriculture today due to its water and nutrient retaining properties which are great for growing crops, however, there is interest in using this soil amendment as a stormwater management BMP. This research originally focused on modeling the effect that biochar, used as a soil amendment to roadway filter strips located in New Castle County, had on the Chesapeake Bay watershed. However, I was advised to scale down to a more appropriately sized watershed so I could accurately model the reduction in runoff volume, and sediment, nitrogen and phosphorus loads. I delineated the watershed that contains the field site where a biochar filter strip intercepts runoff from 1-acre of impervious pavement. I chose this watershed because it lies within both New Castle County and the Chesapeake Bay Watershed, and because I could use existing data that correlates with this research site. From this research, they were able to conclude that biochar amendment reduced average surface runoff volume by 84%.

2. Nicolette Bugher (Environmental Engineering), Advisor: Gerald Kauffman (Public Policy). Recommendations for Addressing Perfluoroalkyl Chemical Contamination in Delaware.

Project Type: Annual Base Grant **Project ID:** DE FY18 - 2

Project Impact: Perfluoroalkyl chemicals, or PFAS, are a group of fluorinated organic chemicals used ubiquitously in manufacturing and industrial operations and to date have no federal regulations in response to public concerns of adverse health effects, large scope of contamination, and persistence in the environment. Although PFAS have been used since the 1940's, concern regarding the use and disposal of these chemicals has only recently been studied. Analytical methods created by the EPA only apply to a handful of the fluorinated compounds and were created in 2015. The contamination across the country, including the State of Delaware has not been comprehensively studied or had the proper data collection. In order to understand the scope of contamination in Delaware, remediation processes used, and the best management practices for future contamination within the state, it is imperative for Delaware to address standards for PFAS separate from the United States EPA. Using reported contamination, published journals, and EPA methodology, the scope of contamination in Delaware was determined to be limited, but likely to increase. The response from Delaware officials for remediation and prevention of further contamination is appropriate for the specific situations as compared to other successful remediation and treatment cases nationally. The prevalence and persistence of PFAS in the environment combined with the cases cited for PFAS contamination in Delaware provide sufficient motivation for the State of Delaware to investigate an individual state maximum

contaminant level.

Allison Kaltenbach (Environmental Engineering), Advisor: Gerald Kauffman (Public Policy). Tidal Effects of Coastal Flood Inundation along the Atlantic Seaboard

Project Type: Annual Base Grant **Project ID:** DE FY18-7

Project Impact: Sea levels along the Atlantic Seaboard are increasing at a level 3 to 4 times faster than the global average. In the next century alone, scientists have estimated the sea level will continue to rise anywhere from 0.5-1.5 meters along the Atlantic coast as sea temperatures rise and polar ice melts. Using USGS gages, the three most severe storms were used to recreate Delaware's three most severe storms from 2000-2019. Resulting analysis can provide insight into when storms peak, how they move, and their effects on coastal flood inundation along the coast.

Andrew Dorazio (Mechanical Engineering), Advisor: Gerald Kauffman (Public Policy). White Clay Creek's Potential for Hydroelectric Power Generation.

Project Type: Annual Base Grant **Project ID:** DE FY18-12

Project Impact: This project aims to propose a design, budget, and plan of action to implement hydroelectric turbines into White Clay Creek. The goal is to create an environmentally friendly design quoting specific manufacturers that could create the highest power generation at the lowest overall cost. Five designs were proposed, and after multiple selection matrices it was evident that this concept had the greatest potential with the lowest negative impact. This design is a very practical and viable option. There is a grid connection very close in proximity, and I am confident a permit could be quickly obtained. The only potential downfall is the possibility of local waders purposely tampering with or harming the machine, but if caution signs were implemented there should be no problem. Overall this project went well and hopefully will be seriously considered for implementation.

Chelsea Caplinger (Political Science), Advisor: Gretchen Bauer (Political Science). Interstate Watershed Management: Expanding the Clean Water Act to Include Modern Pollutants.

Project Type: Annual Base Grant **Project ID:** DE FY18-3

Project Impact: Watershed management is an essential aspect of environmental policy in order to establish a basis for healthy drinking water and appropriate access to water. Based off of the current research, the best way to improve the water quality in Delaware is to expand on the Clean Water Act to include modern pollutants. There is a lack of communication on the interstate watershed level, and there needs to be intervention on the federal level. These are suggestions on implementation strategies specifically for the Chesapeake Bay and the Delaware River Basin. Update the information systems across the entire watershed, not just on a state by state basis. In Delaware, Wilmington needs to incorporate permeable pavements, bio swales, and planter boxes to reduce flooding and improve infiltration. Water filtration systems need to be updated across the entire watershed to have a final filtration targeting micropollutants.

Jillian Young (M.S. Water Science and Policy), Advisor: Andrew Homsey (Public Policy and Administration). Analysis of the Watershed Resources Registry Using GIS to Evaluate Stormwater Restoration Practices in the Christina River Watershed.

Project Type: Annual Base Grant **Project ID:** DE FY18-13

Project Impact: The Watershed Resources Registry is a new interactive online mapping tool, created by federal, state, and local partners. The tool prioritizes areas for preservation and restoration practices in different landscapes across an entire state by using a variety of absolute and relative criteria to rank areas from 1 (least) to 5-stars (most suitable). The State of Delaware launched its Watershed Resources Registry in 2016. Potential applications of the Watershed Resources Registry are promising; however, few studies have been completed to assess the validity of

the Watershed Resources Registry in Delaware. The Municipal Separate Storm Sewer System Permit Program, under the United States Environmental Protection Agency's Clean Water Act, requires New Castle County, Delaware Department of Transportation, and other permittees to develop Water Quality Improvement Plans for two watersheds over the next year. The purpose of this research is to determine if the Watershed Resources Registry is suitable to predict sites for water quality improvement projects. If the Watershed Resources Registry is a suitable predictive tool it can be used to develop Water Quality Improvement Plans for New Castle County and Delaware Department of Transportation. To determine suitability, a relationship was examined between Watershed Resources Registry ranks and pre-treated pollutant loads and then a spatial resolution threshold was defined for the Watershed Resources Registry's site selection. This study used a completed Water Quality Improvement Plan for the Christina River Watershed that provided 26 proposed best management practice sites. The Watershed Resources Registry ranks were obtained from the stormwater compromised infrastructure restoration layer and pre-treated pollutant loads of total nitrogen, total phosphorus, and total suspended solids in pounds per acre per year were calculated by the Delaware Urban Runoff Management Model.

Kelly Jacobs (M.S. Energy and Environmental Policy), Advisor: Martha Narvaez (Public Policy and Administration), Source Water Protection in the White Clay Creek Watershed.

Project Type: Annual Base Grant **Project ID:** DE FY18-14

Project Impact: The White Clay Creek watershed supplies drinking water to 200,000 people or 1/5 of Delaware's population. The watershed originates in Pennsylvania where agricultural loads of sediment and nitrogen are impairing drinking water downstream in Delaware. This research uses GIS technology to identify the nature and types of farm activity in the watershed to prioritize source water protection programs. The research indicates that best management practices should be focused on the East Branch of the White Clay Creek where horse farms and mushroom farms are prevalent

Mia Kane (Environmental Science), Advisor: Gerald Kauffman (Public Policy). Agriculture at Delaware Nature Society Coverdale Farm.

Project Type: Annual Base Grant **Project ID:** DE FY18-9

Project Impact: In cooperation with the Delaware Nature Society, through the University of Delaware Water Resources Center Undergraduate Internship, the overall project goal is to assess the feasibility of implementing regenerative agriculture at the Coverdale Farm Preserve. This project consisted of working with the Delaware Nature Society to collect field data as well as synthesize data and content from prior reports on the water chemistry and quality at the Coverdale Farm Preserve. The culmination of this project may be used for the implementation of regenerative agriculture at this site. In the upcoming months, the Delaware Nature Society can use the information and data in this report to identify and quantify the health and quality of their streams and land at the Coverdale Farm and in the surrounding watershed. With this report, the Delaware Nature Society will have the data and resources necessary to pursue implementations of regenerative agriculture at the Coverdale Farm Preserve. The final recommendation for this project is to continue at add information to this report as new data is collecting and identified and becomes available.

Monica Crosby (Environmental Studies), Advisor: Paul Jackson (Geography). Status, Policies & Mitigation for Wetlands in Delaware.

Project Type: Annual Base Grant **Project ID:** DE FY18 - 5

Project Impact: Taking up 25% of Delaware and serving as one of the most productive ecosystems found on Earth, Wetlands are a critical resource across many scopes. Wetlands not only serve as a habitat for a vast array of terrestrial and marine species, but they also serve as a vital migration and spawning site for various species as well. Wetlands are also proven to be extremely crucial in the water filtration process. As agriculture and development contribute extra nutrients, pesticides, and silt to local rivers, wetlands help to trap and filter these toxins maintaining healthy water systems. Additionally, wetlands are an important resource in terms of combating climate change. Acting as a natural sponge, wetlands help sequester carbon and protect against sea level rise and increased flooding.

These natural barriers protect valuable ecosystems and can lower overall flood heights, protecting people, infrastructure, and agriculture from devastating flood damages (NOAA). Aside from their environmental benefit, wetlands are also a vital economic resource. They serve as a popular recreation spot for fishing, bird watch, etc. Studies have found for Delaware, sport fishing generates approximately $110 million/year in Delaware Inland Bays alone. With that said, the loss of wetlands could be devastating to Delaware's economy.

Rebecca Steiner (Public Policy), Advisor: Nina David (Public Policy). Land Use Change in the Delaware Inland Bays Watershed

Project Type: Annual Base Grant **Project ID:** DE FY18-8

Project Impact: Sussex County is experiencing extreme growth and is expected to continue to see large population shifts. This report aims to evaluate whether this area is prepared to accommodate this growth and protect water quality in the Delaware Inland Bays. By evaluating the Sussex County Comprehensive Plan, Sussex County's growth management is analyzed and quantified to determine whether growth management techniques are being implemented. By targeting the geographic area bounded by US-9, US-113, and State Route 244 and looking at the Delaware State PLUS Projects in that area, this study will determine how past and present development decisions impact water quality.

Veronica Hill (Resource Economics), Advisor: Leah Palm Forster (Resource Economics). The Impact of Sea Level Rise on Seasonal Rental Properties in Delaware.

Project Type: Annual Base Grant **Project ID:** DE FY18-6

Project Impact: How will 0.5m and 1.5m sea lev-el rise damage the economy of Delaware's seasonal recreational use that contributes to tourism around the inland bays and beaches? With no sales tax, great shoreline beaches, and industry, tourism has won its position as being the 4th largest private industry sector in Delaware. People may be less willing to purchase vacation homes due to the risk of flooding. With many people retiring, vacationing, and residing near Delaware's coast, action on sea level rise has become extremely prevalent. Although sea level rise is a world-wide crisis, Delaware can still do a lot. In terms of policy, the state should encourage construction to avoid building or buying within the perimeters of the discussed flooding events. Stilted houses are another key adaptation device to use against sea level rise. This technique can save some houses and rentals on the shore or around the bays from permanent flood damages. A combination of high-rise houses and moving out of the floodplain will save the seasonal rental market from injury and losing millions.