

Working towards environmental restoration through small scale engagement in coastal North Carolina

By Kirby Rootes-Murdy

Dr. William Kirby-Smith, Advisor

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Abstract

Nonpoint source (NPS) pollution is a pervasive problem throughout the United States. In coastal North Carolina, NPS most commonly takes the form of stormwater carrying large quantities of bacteria into neighboring estuarine waterways. Elevated levels of bacteria can have significant effects on water quality and result in area closures for commercial shellfish harvesting.

This masters project investigates stormwater retrofitting potential in a small coastal neighborhood located within the White Oak River watershed. Applying Geographical Information Systems (GIS) to estimate impervious surface and model stormwater runoff, a mixed method approach is used to better evaluate areas of concern within a subwatershed of the White Oak River. In analyzing both state-level stormwater management guidelines and interviewing local residents on their perceptions of water quality, a goal of this study is to determine what considerations are needed to guide current and future stormwater projects.

The results of this study indicate that the current stormwater regulatory framework operates on a temporal scale that hinders comprehensive funding, implementation, and monitoring of Best Management Practices (BMP) retrofitting projects. Modifications on the subwatershed level highlight impervious surface coverage from development may be significantly increasing sheet stormwater runoff. Qualitative findings demonstrate the educational outreach could be useful in gaining community support for future BMP projects. Further research in applying participatory mixed methods to study local stormwater may provide greater stakeholder engagement and successful implementation of low-cost BMPs in continuing efforts of water quality improvement.

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Introduction

Nonpoint source (NPS) pollution is a pervasive problem throughout the United States and is considered by many to be the largest source of water pollution in the country¹. In coastal North Carolina, NPS most commonly takes the form of stormwater, carrying large loads of bacteria into neighboring estuarine waterways. One such waterway is the White Oak River². Located on the border of the Carteret and Onslow County, the White Oak River provides commercial fishing, recreation, and economic revenue to the adjacent towns of Swansboro and Cedar Point. For this reason, efforts to improve stormwater management are important.

The purpose of this study is to aid the town of Cedar Point (NC) in a Best Management Practice (BMP) retrofit project of residential and commercial landowner. The Town of Cedar Point Stormwater Project is currently funded by a Federal EPA 319-grant that supports inexpensive retrofits of current stormwater management throughout the town. The 319 grant was received in 2006, in an effort to determine the sources causing the neighboring White Oak River to be listed on North Carolina state 303d list of Impaired Water Bodies. A stipulation of the grant was to study the White Oak River's water quality by conducting a Total Maximum Daily Load (TMDL)³. This study evaluated the presence of pollutants such as fecal coliform, a key indicator of water quality in coastal waters. This study was carried out over two years, with the study's findings linking elevated fecal coliform concentrations to natural sources entering the river through stormwater.

¹ Environmental Protection Agency, 'Nonpoint Source Pollution: The Nation's Largest Water Quality Problem', 24 November 2009, available from <http://water.epa.gov/polwaste/nps/outreach/point1.cfm>; Internet; accessed September 30 2010.

² N.C. DWQ et al., 'Southeast White Oak River Shellfish Restoration Project', White Oak Restoration Project Final Report, March 2009

³ Study concluded in 2009.

Stormwater within the White Oak River watershed has been attributed to alterations in the natural hydrology caused by increased development within the town of Cedar Point. The presence of fecal coliform in the water column has caused time area closures for harvesting commercial shellfish such as oysters and clams. Furthermore, in times of severe rain events, areas within the town of Cedar Point have experienced flooding.

To remedy the stormwater issue, the town of Cedar Point in partnership with The North Carolina Coastal Federation (NCCF) are moving to implement BMP retrofits throughout the White Oak River watershed. Current retrofitting practices include modifying roof top gutter systems by redirecting the flow of water during storm events from roof tops towards vegetated areas, constructing bio-retention areas (i.e. rain gardens), or using rainwater harvesting methods such rain barrels to decrease the overall sheet flow of stormwater by increasing infiltration and storage. Most recently the NCCF became interested in assessing the feasibility of retrofitting current stormwater conveyance ditches within residential subdivisions. All of the above methods are being considered as the town of Cedar Point moves forward with implementing a voluntary low-impact development ordinance and reduce stormwater runoff⁴. A major goal in this study will be developing a set of criteria for stormwater retrofitting that could be replicated in other areas. This would hopefully aid local towns and small-scale municipalities in the decision-making process for determining retrofit sites and feasibility.

Research Questions

In conducting research on stormwater within coastal North Carolina, the initial question addressed in this study is ‘what is the regulatory set up for stormwater management

⁴ ‘Low-Impact Development Ordinance’. Town of Cedar Point website. < <http://www.cedarpointnc.org/dev-ord.php>> 4/4/2011

at the federal, state, and local levels?’ Establishing a comprehensive framework of how institutions and statutory law guide stormwater management will help illuminate where specific responsibility lies at each of the three regulatory levels and what are areas of oversight for management. By examining these levels of governance vertically through the regulatory framework areas of improvement on the current setup will be assessed.

Another goal of this project is to determine some of the best avenues for improving stormwater management within the White Oak River watershed. To address this goal the second research goal is ‘where does stormwater management efforts need to be focused?’. In the 2009 White Oak River TMDL report, fecal coliform concentration were found to be highest in subwatersheds of the White Oak River basin, most notably the Boathouse Creek watershed. This sub-watershed is located within the town extra-territorial limits of Cedar Point, specifically abutting the Ocean Spray Mobile Home Estates. To aid in prioritizing areas for better management, assessing where high stormwater runoff and impervious surface coverage was modeled using Geographical Information Systems (GIS) tools. This technique was coupled with data collected from summer 2010 looking at stormwater volume assessed using the LID-EZ calculator. Analyzing these two components together an approximate storage capacity was estimated for potential retrofit sites.

While determining where spatially stormwater BMPs should be distributed is an important component in the equation of improving the White Oak River water quality, this study also seeks to assess the readiness of Cedar Point residents to adopt BMPs. Central to this goal is the third research question of ‘how do current residents perceive stormwater and their connection to the White Oak River?’. To assess this question, year-round residents within the Boathouse creek watershed were interviewed. Using qualitative methods to

analyze responses, these efforts also seek to illuminate stakeholder knowledge regarding the White Oak River and what possible concerns they may have for retrofitting projects.

Through evaluating the legal management framework of stormwater with qualitative and quantitative analysis on retrofitting sites and considerations using mixed methods (Creswell 2007), recommendations for stormwater retrofit site selection is put forth. These recommendations will be geared towards the NCCF and the Town of Cedar Point for determining future sites for retrofitting. While the objective is to make these recommendations useful to both the town of Cedar Point and NCCF, a secondary consideration will be offering tentative evaluation on its potential use in assessing stormwater BMP retrofitting projects in other coastal areas.

Stormwater Policy & Management: Federal to Local Level

Federal level

In addressing coastal NPS stormwater, it is important to establish which regulatory statutes and agencies are involved in management at the Federal level of government. The Clean Water Act (CWA)⁵ of 1972 sets forth the goals of improving the nations' waters through a variety of regulatory and non-regulatory tools. Pertaining to stormwater, there are three important considerations that the CWA stipulates in achieving its goals;

- 1) Reduce direct pollutant discharges into waterways,
- 2) Finance municipal wastewater treatment facilities
- 3) Manage polluted runoff.

Tasked with organizing the CWA's goals and objectives on the federal level, the Environmental Protection Agency (EPA) oversees and directs funding to aid the states in addressing water quality pollution. The EPA also sets forth water quality standards that states must adopt for the varying designated uses determined for each water body by the state⁶. As part of the objectives in meeting water quality standards, the National Pollutant Discharge Elimination System (NPDES) program is authorized to the EPA by the CWA⁷ to deal with pollution entering into the U.S. waters. Developed in 1990, the NPDES was initially implemented to address point source pollution discharging into any water body (Cicin-Sain & Knecht 2000). The NPDES required that the point source emitters had to obtain a discharge permit from the proper authority (usually a state, a tribe, or a territory)⁸.

These NPDES I permits were targeted at;

- industrial and municipal discharges,
- discharges from municipal storm sewer systems (MS4s) in larger cities,

⁵ 33 U.S.C. § 1251

⁶ 33 U.S.C. § 131.11

⁷ Section 402 of the Clean Water Act.

⁸ The EPA in some cases is authorizing body.

- storm water associated with numerous kinds of industrial activity,
- runoff from construction sites disturbing more than one acre,
- mining operations,
- animal feedlots and aquaculture facilities above certain thresholds.

The NPDES phase I program has largely been deemed a success by having significantly improved the water ways adjacent to or in close proximity to many of the large cities around the country. The second phase of the NPDES program is of particular importance to stormwater, and will be addressed later on in this section as it applies more to the local context.

The other important national level statute that addresses stormwater on the coast is the Coastal Zone Management Act (CZMA)⁹ enacted in 1972. This management statute sets forth the goals of maintaining the coastal environment, protecting important coastal areas, and guiding development along the U.S. coastlines. This statute gives management responsibility on a national level to the National Oceanographic and Atmospheric Administration (NOAA) in assisting states with funding and creating policy guidelines to achieve the national goals of stormwater mitigation. Specifically in regards to stormwater, the coastal nonpoint source pollution program initiated by NOAA through the CZMA in 1990¹⁰ is of importance because this management program's goal is to encourage better coordination between state coastal zone managers and water quality experts to reduce polluted runoff in the coastal zone.

In considering stormwater management & policy at the federal level, the important understanding at this point is that these statutes delineate power of implementation and enforcement to the state agencies, while specifying national consistency standards that states

⁹ 16 U.S.C. § 1452.

¹⁰ 16 U.S.C. § 1455b. Section 6217 of the Federal 1990 Coastal Zone Reauthorization Amendments.

can achieve through coordination with federal agencies and their programs. In shifting to the state level, it is important to keep attention on how state agencies strive to meet national standards on water quality, while balancing other federal environmental regulation.

State level

In the context of coastal North Carolina, The state level CZMA management statute¹¹ stipulates that all counties must have a land-use plans to guide current and future development in coastal counties. In order to develop areas along the coast they must meet state level standard for addressing potential pollution. These plans have the potential to play an important role in protecting resources such as estuaries and shorelines by limiting the type of development that can take place in close proximity to them.

In managing water quality at the state level, the State Water and Air Resources Act empowered by the CWA, gives the N.C. Division of Water Quality (DWQ)¹² the responsibility of issuing water quality permits and designating water types. Water type designations as alluded to earlier are important in determining the specific standards that these waters are required to be maintained at. For example, the White Oak River is classified as ‘SA’ waters which designate its use as Shellfish harvesting waters for market use¹³. With water quality impairment by stormwater, shellfish harvesting in the White Oak River negatively affected; shellfish such as oysters cannot be harvested for commercial use if there are elevated levels of fecal coliform in the water. Certain areas within the river are permanently closed off while others are subject to temporary closures based on storm events (appendix 1).

¹¹ § 113A-106. Coastal Area Management Act (CAMA)

¹² The NC DWQ is housed within the Department of Environment and Natural Resources (DENR).

¹³ Chapter 6. N.C. Water Quality Classifications and Standards. White Oak River Basinwide Water Quality Plan. May 2007. http://h2o.enr.state.nc.us/basinwide/documents/Chapter6_012.pdf. viewed 11/29/2010

To address water quality in this local context, the CWA sets forth an order of operations that state agencies such as DWQ implement to demonstrate consistency with the national standards listed above (figure 1.). These task are usually done in the following sequence;



Figure 1. CWA procedural diagram for restoration

1) Monitoring of these water bodies is conducted to determine if the standards are being met. Responsibility for monitoring falls primarily on the state agencies (i.e. DWQ)

2) If monitoring and assessment indicate that a waterbody does not meeting water quality standards (WQS), then that waterbody is considered "impaired" and then is classified on the "303(d) list," named after the section of the CWA that calls upon states, approved tribes, and territories to create such lists.

3) From here a Total Maximum Daily Load (TMDL) is conducted to assess the potential sources of pollutants and how much their presence needs to be reduced by in order to meet state standards. TMDLs are tend to be conducted by state environmental/natural resource departments in partnership with local interest groups.

The driving goal in carrying out a TDML is to at least identify areas of concern and where pollution may be most concentrated. With this information, the next step is to offer prescriptive measures to mitigate the pathways (i.e. stormwater) that pollutants are entering into the water bodies. A TMDL also used in conjunction with the NPDES Phase II

regulations, which expands upon existing NPDES stormwater program (Phase I) to addressing stormwater discharges from small MS4s and construction sites that disturb 1 to 5 acres. To facilitate and finance stormwater projects addressing needs highlighted in a TMDL, local groups are able to apply for federal grants to help in implementing Best Management Practices (BMPs) to mitigate stormwater. For example, the town of Cedar Point has applied and received federal 319-grants to install demonstration BMPs as a measure to increase public awareness.

These two division of the North Carolina Department of Environment and Natural Resources (DENR) come together to address stormwater issues across the state, specific to regional differences regarding development and water quality. In the context of coastal North Carolina, stormwater permits are required for any new low density development that is 10,000 sq ft. Built upon area (BUA) or has greater >12%¹⁴ BUA for the property has located within ½ mile of SA waters. These permits stipulate that these areas must treat 1.5'' in. storm event for low density and a 1 year 24hr storm event (3.5 in.) for high density development projects. These permits are administered by the DWQ, and depending on the extent of the project, may involve a CAMA permit as well, which is administered by the DCM. What is most important in understanding at the state level is that state agencies housed within DENR are the designated water quality power. That being said, the mandate to address resources across biotas and ecosystems significantly reduces their capacity stringently enforce compliance and monitor water quality.

¹⁴ Rule change as of 2008. http://h2o.enr.state.nc.us/su/documents/CoastalStormwaterRule_11x17Pamphlet.pdf

Local Level

Within the White Oak River watershed there are a number of small towns that through the use of zoning and ordinances create the local setting for stormwater management. For the town of Cedar Point, there are two main ordinance mandates¹⁵ geared towards water quality protection of the White Oak River and stormwater runoff (Cedar Point 2010). The first targets parking lot design within the town, designating specific areas for vegetative buffering for commercial/industrial development. Vegetative buffering is required and considered separate from the design of stormwater retention component in any parking lot design project¹⁶ (Cedar Point 2010). The more comprehensive of the two ordinances though is the Soil Erosion and Drainage Control. This ordinance specifies general requirements for any land-disturbing activity from initial planning stages of a project through to inspections and penalties. Within the context of this ordinance, stormwater is specifically addressed in the basic control objectives of ‘control surface water’ and ‘manage stormwater runoff’. The first outlines any surface water *upgrade* of a development site must be controlled to reduce and prevent erosion. The second control objective is critical for understanding both the importance and attention stormwater is given in relation to erosion;

...When the increase in the velocity of stormwater runoff resulting from a land-disturbing activity is sufficient to cause accelerated erosion as well as excessive drainage onto adjacent properties, plans are to include measures to control the velocity at the point of discharge, so as to minimize negative secondary impacts. (Cedar Point 2010)

This control objective demonstrates that stormwater runoff is only considered an issue when there is an increase in its velocity attributed to the land-distributing activity that results in erosion. Furthermore, in this instance, stormwater is explained as a result of point source discharge. After a land distributing activity, developers are required to install soil erosion

¹⁵ Sections 15-257 (Parking Lot Buffering) & 258 (Soil Erosion and Drainage Control)

¹⁶ Unless deemed improbable by the Cedar Point Planning Board.

controls as specific to the stormwater that may cause erosion. In this light, other pollutants that might be carried into the White Oak River are currently not managed for in the existing local town ordinances.

Regulatory Gap

While there are measures in place to address future development within coastal areas with attention to stormwater management, much of the oversight begins with little coordination from state agencies to local ordinances. States implementing measures to bring 303d listed water bodies into compliance largely work within federal & state grant cycles and monitoring projects. Both of these can operate on different time scales, with feedback between the monitoring to funding in many cases taking years. While assessing the impact of BMP retrofit projects and continuing water quality monitoring are important to conduct, the time scale of being able to demonstrate qualitative improvement in the water quality there are limited factors in applying for more grant funding. Outside of federal and state grants there is limited funding sources to comprehensively address areas that are contributing to water quality degradation. To deal with this at the onset, land use planning as stated before has the capacity to address this in the planning stage. The issue that arises is that local towns and cities often fall under general county level land use plans. County level plans have to encompass land use practices across large areas on the N.C. coast, which tends to guide the use of general designations to as to not restrict development. Yet, this minimizes efforts to account for resource protection when developing, such in the case of development in close proximity to rivers. With much of water quality pollution in coastal areas resulting from impervious surface coverage such as roads, roofs, and parking lots

(Mallin et. al 2000), there is currently a need to retrofit many residential and commercial areas along coast.

In the case of Cedar Point, a small coastal town¹⁷, the White Oak River TMDL highlighted two water bodies (Boathouse Creek and White Oak River) that needed the have significant reductions in fecal coliform levels. Adjacent to these areas listed are urbanized residential and commercial areas that have increased the impervious surface coverage, thus increasing the potential for stormwater to transport fecal coliform (Tong & Chen 2002) into the tributaries of the White Oak River. What complicates efforts to address stormwater pollution entering into the White Oak River through the Boathouse Creek subwatershed is that neighborhoods abutting the Town of Cedar Point are technically outside the town's regulatory territory¹⁸. While nuisance and abatement ordinances apply to neighborhoods in these areas, such as the Ocean Spray Mobile Home Estates subdivision, stormwater does not fall under either of these and therefore cannot technically be enforced within the subdivision if adopted by the town of Cedar Point. This creates the need for coordination across two separate local governing organizations and state level agencies¹⁹. In the meantime, regional non-profit organizations such as the NCCF continue to operate as facilitators in engaging the local planning boards, homeowners associations, and state agencies to address stormwater pollution. With no legal mandate to require the town of Cedar Point to address commercial and residential sources of stormwater outside of the context of erosion control, or current

¹⁷ Based off of 2000 Census data. Listed population in 2000, 929 residents. <http://www.cedarpointnc.org/cedar-point-nc-facts.php>

¹⁸ Ocean Spray Mobile Home Estates is located outside of the town of Cedar Point proper. Its located within the extra-territory district of the town of Cedar Point.

¹⁹ The Ocean Spray Mobile Home Estates manages their neighborhood separate from the town of Cedar Point through a homeowners association. Highway 24 is maintained by the North Carolina Department of Transportation (NCDOT).

stormwater statutes regarding BUA, restoring the White Oak River is left to voluntary actions by concerned residents, local businesses, and institutions.

Policy Options

To mitigate current and future stormwater pollution in Cedar Point while effectively improving the water quality of the White Oak River, I propose three possible scenarios that could aid in achieving these goals;

1) The adoption of a mandatory Low-Impact Development Ordinance

Much of the issue associated with mitigating stormwater pollution is the barrier of getting residents & businesses to make adjust practices and/or structural changes on their property. The concern of residential and commercial property owners is that such changes will induce damage to the property and will be costly. Currently the town of Cedar Point is in the initial stages of adopting a voluntary Low-Impact Development Ordinance²⁰ with the neighboring town of Cape Carteret. But because this initiative is voluntary, only some developers will seek to utilize this model in development if they think it will be cost-effective. In making the ordinance mandatory, future developers within the Town of Cedar Point will have to follow guidelines on how best to build with less harmful impact techniques to White Oak River. It has also been demonstrated that some of these techniques can cost less than conventional methods of development in some instances. This initiative would also give legal power to the town in enforcing compliance through fines and fees.

²⁰ Low Impact Development Ordinance. Town of Cedar Point. <http://www.cedarpointnc.org/dev-ord.php>. viewed 12/6/2010

2) Creating more stringent rule for stormwater permits

In 2008 stormwater permit requirements became more stringent in coastal counties, with a drop in allowable BUA from > 25 % to >12%²¹. This rule change has increased the number of areas that now must alter residential and commercial areas to come within compliance of state regulation. There is mounting evidence though that any amount of development greater than 10% BUA may negatively affect water quality of neighboring water bodies. Dropping the allowable BUA to >10% for areas within ½ mile of SA waters would likely draw all current development in Cedar Point as well across the NC coastal counties into violation requiring BMP retrofitting.

3) Implementation of stormwater tax fund retrofit projects

While there is current federal funding for BMP retrofit projects, the process to apply for funding projects is tedious and rarely local towns and municipalities have the resources to do so. This is why the role of Non-governmental Organizations (NGO) such as the NCCF are critical for securing funding for BMP retrofit projects. If local municipalities and towns were able to generate their own funding through a stormwater tax, the process of developing BMP projects and implementing them may be much quicker. A stormwater tax for the town of Cedar Point could act as a form of property tax, with tax rates either constant for all residents or graduated based on property size. Such measures have been implemented on a small scale in other states such as Maryland²² with some success.

²¹ N.C. Code § 2008-21

²² City of Takoma Park. 'Stormwater'. <http://www.takomaparkmd.gov/publicworks/stormwater.html>. Viewed 12/2/2010.

Recommendation

Of the three options listed above, the adoption of a mandatory low impact development ordinance for future & current development projects would likely be the most effective. Implementing this ordinance would put the burden on future developers to comply with town regulation. Currently if and when stormwater problems arise on a residential property, that homeowner must address it through retrofitting the layout of the property (i.e. rain gardens) or with structural changes (i.e. downspout disconnects, rain barrels, etc.). Shifting the responsibility to the developer, and incorporating structural principles that reduce the volume of stormwater leaving the property when the home or subdivision is being constructed, will be less costly over the lifetime of the property.

While seeking to implement a lower threshold of BUA may be good intentioned for stormwater mitigation, there are many logistical concerns that would crop up do to a regional rule change. An overhaul on impervious surface threshold on this scale may induce more setbacks in implementing efforts to mitigate stormwater, mainly in competition for federal funding. While currently limited by governance resources as a small town, lowering the BUA threshold in Cedar Point may further impediment efforts to adequately address stormwater by making it an overwhelming task.

In looking at stormwater tax as way to generate funding for stormwater retrofit project and speed up there completion time table, the implementation of tax at this time seems political unfeasible. While instituting new taxes is never easy, residents of the town may feel burdened and animosity towards restoration efforts. Gaining support for water quality improvement measures is critical at local scale, and instituting a local tax may decrease support. With these things in mind, making the low-impact ordinance mandatory may offer Cedar Point the best may of mitigating future stormwater concerns.

Spatial Analysis of Stormwater Runoff in White Oak River watershed

As mentioned in the previous section, fecal coliform concentrations in the White Oak River have been attributed to stormwater runoff throughout the watershed (TMDL 2009). Stormwater runoff caused by increased development has been shown to influence the prevalence of fecal coliform in coastal rivers (Mallin et al 2001). Specifically within North Carolina coastal watersheds, stormwater can affect bacteria concentrations in commercial shellfishing waters (Mallin et al. 2000). Specifically, increases in impervious surface area from development have caused increases in stormwater runoff during storm events at the watershed scale (Zhou et al. 2010). Understanding how hydrologic changes from impervious surface at the watershed scale may offer insight in determining where to implement Best Management Practices (BMP) retrofits. To evaluate the potential sites for BMP retrofitting in the town of Cedar Point, NC this study aims to model the hydrology within a critical subwatershed of the White Oak River. This study will compare the use of Geographical Information System (GIS) spatial analysis to determine areas of high flow accumulation and impervious surface to stormwater volume calculated using the LID-EZ method. Of particular interest will be how these measures can be used to assess potentially retrofit sites based on the policy and water quality assessments already conducted²³. The goal of this study is threefold;

- 1. Determine the impervious surface coverage within the Boathouse creek subwatershed**
- 2. Identity potential stormwater retrofitting sites using LID-EZ calculator in the Ocean Spray Mobile Home Estates and soils data**
- 3. Model stormwater runoff accumulation within the Boathouse Creek Watershed**

²³ 2008 N.C. ruling on 12% impervious surface (section 1) and 2009 TMDL of Southeast White Oak River.

The LID-EZ method for assessing BMP potential sites is first discussed with regards to criteria used to assess general locations within the Boathouse creek watershed. The use of GIS modeling is then discussed regarding methodology in modeling percent cover of impervious surface area and flow accumulation within the Boathouse creek watershed. Comparing these two techniques with regard to areas of consideration for BMP retrofitting within the Ocean Spray subdivision will be discussed. To conclude the strengths and weakness of each method will be evaluated regarding their potential benefit in future studies.

LID-EZ Site Assessment

Methodology

The LID-EZ method for BMP siting assessment is an excel spreadsheet function currently employed by the City of Wilmington and New Hanover County. The spreadsheet uses soil variables and impervious surface area percent cover to calculate stormwater runoff volumes for first-flush and 1-year storm events (BCBC 2002). Used in conjunction with a Low Impact Development (LID) Manual created by Brunswick County, the spreadsheet model is available to planners, developers, and engineers to design stormwater storage capacity needed in various development projects²⁴.

For this section data was collected in summer 2010. Coupling LID-EZ method with soil maps and visual photo assessments was used to evaluate potential areas for retrofitting.

The main factors that were employed in the assessment were the following;

1. 2009 TMDL Report Sampling sites
2. Soil Type
3. Hydric Soil Grouping

²⁴ 'Storm Water: Low Impact Development'. Brunswick County, North Carolina Department of Engineering. <http://www.brunswickcountync.gov/Departments/Engineering/StormWater/tabid/173/Default.aspx>

4. Depth to Water Table
5. Visual assessment technique

These factors were organized spatially into maps (figures 5-8). Of the White Oak River tributaries listed on the 2009 TMDL Report, Boathouse Creek was cited as requiring the largest reduction in fecal coliform to meet state and standards for impaired SA waters (NCDWQ, 2010). Based on assessment, a 72% percent reduction of fecal coliform presence was need to meet load allocation (TMDL 2009). Located within the Boathouse Creek Watershed are the Ocean Spray Moblie Home Estates, Western Park, Marsh Harbor Estates development, and a section of the Croatan National Forest Camp Grounds. Of these four sites, two are them are currently slated to be retrofitted²⁵, with Marsh Harbor Estates still in the development stages. The Ocean Spray subdivision is currently the only one of these sites that isn't in active consideration for retrofit projects by government or non-government organizations. With this in mind the Ocean Spray residential subdivision was marked as a priority for potential retrofitting projects.

Another important consideration with the White Oak River subwatershed was soil. Soils were assessed within the watershed with specific attention to soil type, hydric soil grouping, and depth to water table. These soil variables are useful in assessing stormwater runoff infiltration (Corbett et al. 1997). Applying the metrics used by the National Soil Survey Handbook²⁶, soil types Wando Fine Sand (WaB), Kureb Sand (KuB), and Sandbrook Fine Sand (Se) classified as 'good' for infiltration for the following reasons: (1) The hydric soil grouping associated with these soils-which measures how well infiltration can occur- is also the best²⁷; and (2) The seasonal high water table line associated with these soils was

²⁵ 'Cedar Point Continues Stormwater Reduction Effort'. Press Release 3/14/2011

²⁶ NRCS. National Soil Survey Handbook. <http://soils.usda.gov/technical/handbook/>

²⁷ Hydric Soil Type 'A', on a scale of 'A', 'A/D', 'B', 'B/D', 'C', 'D'. Web Soil Surveys.

relatively low, approximately 5 ft, which can further facilitate infiltration²⁸. Considering both of these factors of soil, much of the Ocean Spray subdivision, Marsh Harbour development and Western Park all have comparatively ‘good’ soils for infiltration (figure 8).

Due to the combination of soil type, potential for retrofit, visual assessment, and importance with regards 2009 TMDL, the Ocean Spray Mobile Home Estates was chosen for calculating impervious surface and retrofit potential. With the potential of modifying current stormwater conveyance ditches as the method in question, areas where soil infiltration were poor and slope were high were excluded (Figure 7). For this study southern extent of the Ocean Spray Lane was examined on a property parcel basis in the LID-EZ spreadsheet to assess impervious surface and stormwater volumes. Impervious surface coverage was calculated for each property parcel, by measuring the square feet area and converting it to acreage through the Carteret GIS website. Volume and impervious surface percentage were calculated by soil and area coefficient functions in the LID-EZ spreadsheet. Based on the corresponding coefficients and the surface area, the spreadsheet calculated out impervious surface as a percentage of the entire parcel, and also calculated stormwater volumes for a 1.5 inch storm (first flush) and a 3.5 inch storm (1 year/24 hr storm event). A total of 38 parcels were calculated initially, as well as the impervious surface areas of three streets (Ocean Spray Ln, Star Fish Dr, Driftwood Ln).

Results

Calculating out volumes for sections of the Ocean Spray Mobile Home Estates, four property were selected as having the largest volume²⁹. In looking at the impervious surface,

²⁸ Depth to Water Table Soil Rating in Centimeters for ‘WaB’, 153. Web Soil Surveys.

²⁹ Greater than 200 cubic feet of stormwater volume calculated for 1 year/24 hr storm event (3.5 inches).

slightly half of the homes met or exceeded the threshold of >12% impervious surface area³⁰ (total of 12). This figure was calculated based on the property area and dimensions, which doesn't include a portion of many private driveways³¹. In calculating stormwater volumes for these properties using low coefficient estimates, the average volume generated per parcel for a 1 year/ 24 hr storm event was approximately 125 cubic ft. Factoring in the roads & driveways into the stormwater calculation for this section of the subdivision added an additional 1398 sq ft (.032 acres) to each property. Using the low end calculations of the LID-EZ³², this equates to an added 25 cu. ft. of stormwater per site during a one year/24 hr storm event. Totaling this with average estimates of runoff volume from properties, the adjusted total volume for each property parcel is approximately 150 cubic ft. This added acreage would increase the number of properties with impervious surface coverage >12% from 12 to 28- roughly 74% of the properties³³ in the studied area.

While not fully calculated, there remains an area between the end of each property parcel line and the beginning of the road throughout the subdivision that average a distance of 20 ft. This coupled with varying property boundaries of approximately 50 ft, initially seemed to offer the potential for stormwater to be temporarily stored in areas where current stormwater conveyances are in place. This assumption though did not take into account the accumulated flow that could build during a storm event as well as soil infiltration rates (IR) that fluctuate through seasonal temperature variation (Lin et al 2003). Furthermore, local residential testimonials also confirm that the neighborhood is prone to seasonal flooding

³⁰ Percentage is a computed using impervious surface/area of property parcel.

³¹ On average there is approximately 20 feet from the edge of a residents' property and the beginning of the road.

³² Disconnected impervious surface is considered 'low-end' due to it decreasing the potential volume of runoff.

³³ Properties with driveway& road added in that equated to 11.5% were rounded up.

(section 3) highlighting that efforts to retrofit stormwater drainage ditches to hold more water for longer periods of time might not gain support at the community level currently.

GIS Spatial Analysis

To compare findings calculated using the LID-EZ calculator regarding the viability of stormwater conveyance ditches, GIS spatial analysis was applied to model stormwater runoff and estimate impervious surface within the Boathouse creek. GIS has tools have increasingly become common as a method to assess impervious surface and model stormwater runoff over the last 20 years (Roy & Shuster 2009).

Methodology

Data layers were collected between July 2010- March 2011 for analysis in ArcMap 10. Of particular importance were pictometry³⁴ aerial imagery and elevation data, collected from Carteret County GIS website. A composite pictometry image was created using arc mosaic function. The mosaic function allows for combining multiple, separate images into one homogenous file. Using this mosaic image, light bands were reclassified based on value generated by adding light reflectivity bands together. In reclassifying bands based on numerical value of light reflected, lower value pixels were reclassified as general *forest*³⁵, lighter pixels were classified as general *dirt*, and pixels with the highest reflection were classified as *impervious surface*. From this data layer I was able to quantitative each of these reclassified categories with an impervious variable. *Forest* was assigned as value of 3, *dirt* a value of 8, and *impervious surface* a value of 10 on scale of increasing imperviousness. The

³⁴ Pictometry use oblique, geo-referenced aerial imagery. http://www.pictometry.com/about_us/overview.shtml

³⁵ Vegetation covered reflected less light compared to exposed soil & impervious surface.

area reclassified by this method was bounded within the Boathouse Creek watershed (Figure 9). To assess the percentage of impervious surface within the Boathouse Creek watershed, a count of raster cells for each classified layer was multiplied by the cell size to determine approximate area. A watershed polygon boundary was acquired from GIS files generated from the 2009 TMDL report. Below is a breakdown of the reclassified categories, areas, and percent cover within Boathouse Creek watershed;

Table 1

	Count	Area	Percent Coverage
Forest	433598	433597.53	40.19
Exposed Soil	459919	459918.50	42.63
ImperviousSurface	185354	185353.80	17.18
Total Area		1078869.83	100

Based on the reclassification method used, approximately 17 percent of the Boathouse Creek watershed consists of impervious surface. This is percentage understood within the context of North Carolina state legal requirements for built upon area (BUAs) discussed in section 1, demonstrates the potential for stormwater runoff from development. While the percent coverage doesn't correlate to spatial distribution of the fecal coliform from the methodology used, it does offer a partial picture as to what might be contributing to stormwater runoff.

To assess the spatial distribution of stormwater runoff in relation to the impervious surface area, flow direction and flow accumulation tools were used. The ArcGIS flow direction tool is applied to define the direction of water flow by calculating cell-level values using elevation data (Bolston, 2008). Using raster data, a flow direction output highlights

integer raster layer with values that range from 1-255 (table 2). Cells lower than neighboring cells are assigned values that define flow towards the cell.³⁶

32	64	128
16		1
8	4	2

Figure 2

In using elevation data, a basic model of flow direction on the Boathouse creek watershed level is generated. This raster layer was then applied to determining flow accumulation. The ArcGIS flow accumulation tool uses a flow direction raster to calculate the accumulated flow for each raster cell³⁷. Cells with a high flow accumulation can be classified as stream channels. Within the context of this study, these stream channels may highlight potential pathways for transporting fecal coliform throughout the watershed. Using a flow direction tool, reclassify function and flow accumulation, initially a uniform flow accumulation layer was created to use a control (Figure 10). This map shows what flow direction may look like without any watershed alteration, and if land cover was homogenized throughout the watershed³⁸. Streams of varying hues of blue signify where flow accumulation is the highest; the darker the hue, the more cells contribute to the algorithm of value cells further down the streams of high accumulation based on elevation. To demonstrate land cover with heterogeneous perviousness³⁹, the flow accumulation model

³⁶ 'Flow Direction'. ArcGIS 9.2 Desktop Help.

<http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=Flow%20Direction>

³⁷ 'Flow Accumulation'. ArcGIS 9.2 Desktop Help.

<http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=Flow%20Direction>

³⁸ Holding variables of infiltration, vegetation, and precipitation volumes constant.

³⁹ Holding infiltration time rates constant over the three variables.

was run again using a weighted overlay raster⁴⁰. The reclassified layer used to determine impervious surface percent coverage in the watershed was applied as the weighted overlay (figure 11)⁴¹. This map shows using basic variables how modeled flow accumulation with levels of impervious surface may affect potential areas of high stormwater runoff. The order of operation for the methods is shown in figure 3.

Analysis

Comparing the LID-EZ calculated volumes to maps highlighting impervious surface percent cover, soil type, and elevation on initial viewing offers different types of data. Where the LID-EZ calculates stormwater runoff volumes for two storm events on a parcel level, the GIS hydrology models spatially show distribution of modeled stream directions and accumulation based largely on weighted elevation data. Neither of the two methods showed the spatial concentrations of fecal coliform throughout the watershed, nor how fecal coliform is transported throughout the watershed. What does emerge from these models is in applying the regulatory principles of BUA area thresholds for impervious surface to the subdivision of Ocean Spray does illustrates areas in the subdivision that have the highest impervious percentage cover to parcel level. In looking at the estimate of impervious surface within the subwatershed using land-use reclassification, the estimated impervious surface coverage of approximately 17% is important to consider within the context of regulatory framework for BUA. While regulation is held at the parcel level, the accumulated effect of a BUA greater than 12% at the watershed level is worth considering when managing to reduce runoff and improve water quality for the White Oak River. The last element of stormwater

⁴⁰ Weighted Overlay Raster is used to give raster cells differing weights to model various hydrologic scenarios.

⁴¹ Flow chart of steps is shown in Figure 2.

modeling was examined with attention to what a weighted flow accumulation could show in terms of potential areas of interest for retrofitting projects. While the flow direction and accumulation modeling shows where streams may emerge based on elevation and not sheet stormwater runoff, the weighted model does highlight that flow accumulation increases with increased impervious surface. This is demonstrated through the model that with other variables of infiltration and application, the flow regime of the altered watershed in this study increases nearly three times that of a natural⁴² watershed. Spatial these maps also demonstrate a more diffuse flow regime based on elevation data, which may be very different given the level of development in the Boathouse Creek watershed at this time.

Limitations and Considerations

While there are strengths in the modeling and algorithms used to assess potential areas of interest for stormwater retrofitting, it is also important to acknowledge the limitations of both. While the LID-EZ calculator is able to account for precipitation variations that offer volume amounts specific to parcel level size, it doesn't account for time variant factors of infiltration rates given in storm events or the variable of elevated water tables. The LID-EZ also doesn't explicitly highlight where on a given property BMP retrofit should occur. What the LID-EZ calculator is geared to do is evaluate how increased impervious surface affects the amount of stormwater volume generated, estimate a needed storage capacity, and offer BMP options for meeting storage needs.

In applying GIS to assess flow direction and accumulation, tools used in this research assumed both static flow rates outside of the subwatershed, and simplified land cover to three generalized categories of perviousness. More sophisticated models exist to

⁴² 'Natural' understood as unmodified, undeveloped watershed.

demonstrate nutrient transport and flow rate fluctuations as a function of precipitation and elevation (Zhou et al 2010). What both of these methods do highlight demonstrate is that flow regimes within the watershed have likely been altered significantly from pre-development, and as well as spatial where areas of high impervious surface are throughout the watershed as well for the entire Boathouse Creek Watershed. In the future, more research into the transportation rates of fecal coliform throughout the watershed using sampled data points will be useful in better illustrating how fecal coliform concentrations may vary given different storm events. This information will be most useful in continuing efforts to reduce the presence of fecal coliform in the White Oak River.

Case Study of Local Perceptions on the White Oak River & Stormwater Management

Stormwater retrofit projects tend to put the physical, hydrologic, and biological components of a project area as paramount in ensuring success. Often the social element- the opinion and support of the community- is a secondary concern in the planning process of stormwater projects yet are equally or more important. To better understand the obstacle of implementing stormwater BMP retrofits throughout the Ocean Spray community subdivision this study evaluates the current knowledge and concerns of residents using qualitative research methods. For the purposes of this research, residents were interviewed regarding the topics of White Oak River, stormwater, and BMP retrofitting projects. Interviews were centered around these topics to help in evaluating whether residents would be receptive to stormwater retrofitting projects and specifically to gain insight into whether a retrofitting program targeting current drainage ditches may be viable. Through qualitatively analyzing the responses of residents, recommendations are made for further evaluation of property owners in the study area and considerations in designing future stormwater retrofitting projects.

Positionality

When conducting qualitative research it is important to be upfront and transparent with the background, biases, and assumptions that a researcher brings to the research subject (Maxell 2005). Following this I briefly discuss how these factors framed my research design and methods.

As a former AmeriCorps Volunteer I've have been involved in environmental education initiatives focused on educating the general public and specific communities about water quality and stormwater. In these education efforts, I developed both perspective and opinions on the various methods of stormwater management through the use of BMPs from the standpoint of an educator. Having experienced firsthand that this form of public and community education can be successful in promoting pollution reduction and more engaged community members, I'm biased towards framing U.S. domestic water quality issues within this form of advocacy.

In summer 2010, I worked as an Intern for the North Carolina Coastal Federation (NCCF) on their coastal stormwater projects. My involvement in NCCF projects centered on determining areas within Cedar Point, NC that would be best suited for stormwater retrofitting. The goal of the stormwater retrofitting projects in and around the town of Cedar Point were focused on reducing the presence of fecal coliform in the White Oak River. As mentioned in previous sections, high concentrations of fecal coliform in the White Oak River have been attributed to stormwater (DWQ 2009). This form of pollution has an economic impact by closing commercial shellfishing waters while also indicating the presence of other pathogens that pose threats to recreational users in the watershed. Tasked with assessing stormwater runoff reductions, I calculated sheet runoff volumes for the Ocean Spray subdivision (section 2). The initial findings from this assessment led to the consideration of stormwater conveyance ditches modifications as a viable retrofitting technique to contain runoff on site.

As an intern, I attended a meeting with the Ocean Spray Homeowners Association in July 2010, where the current state of the White Oak River's water quality was presented by

an NCCF member. Community interest in adopting stormwater BMPs were gaged, and most appeared hesitant if not un-interest. From these experiences, the initial assumptions held by this research going in the research design were along these general themes;

- Property owners would have little knowledge of the White Oak River's water quality
- Property owners would not correlate stormwater within the Ocean Spray subdivision has having an effect on the White Oak River's water quality
- Most property owners would not be receptive to stormwater retrofitting projects due to concerns over cost and potential flooding

These assumptions of the participants were also viewed with the notion that there was significant potential benefits in physical modifications to current stormwater conveyance ditches for reducing stormwater entering into the White Oak River. Acknowledging these prejudices at the onset of my research design may begin to illuminate both the limitations of the research conducted and how data was collected and analyzed.

Theoretical Approach

In conducting research on the knowledge and perspectives of a distinct group of people, it is critical to move forward with a theoretical approach in creating and collecting data. From an ontological standpoint, researching the views of a people to get at the reality of the stormwater 'issue' in the White Oak River is very much relative to each of the residents in the community. In accounting for the need to accommodate the variety of 'realities' on the current state of the White Oak River, I adhered to a constructivist approach in analyzing the conducted interviews. The constructivist approach within qualitative research methods deals with this notion of relativity, as highlighted below;

Constructivists, on the other hand, tend toward the antifoundational. *Antifoundational* is the term used to denote a refusal to adopt any permanent, unvarying (or 'foundational') standards by which truth can be universally known...truth- and any agreement regarding

what is valid knowledge- arises from the relationship between members of some stakeholding community. (Lincoln & Guba, 2000)

In this light, truth of what the environmental issues are (or are not) can be relative to the stakeholders of a specific community. In the context of the Ocean Spray subdivision, residents may view water quality as 'good' or 'bad' equally.

While taking a constructivist approach accounts for contradictory elements in the views and opinions of participants interviewed, it is also important to account for heterogeneity in answers given. To give the analysis of the interviews both cohesion and greater clout, viewing the interviewee within the context of a *community* was important on epistemological and methodological grounds. By linking residents within Lincoln & Guba's sense of 'community', truth can be understood relative to what interview participants choose to say about themselves, or through their 'narrative',

This 'communitive and pragmatic concept of validity (Rorty, 1979) is never fixed or unvarying. Rather it is created by means of a *community narrative*⁴³, itself subject to the temporal and historical conditions that gave rise to the community. (Lincoln & Guba, 2000)

Along this definition of 'community', for this study the temporal bounds are confined to the time-frame in which the study was conducted. To account for historical and social conditions, interviewees were selected through spatial boundaries that include them within a local homeowner association⁴⁴. More specifics on the temporal bounds for the research are discussed in the methods section.

Methods

Collecting data on the perspectives of residents within the Ocean Spray Mobile Home Estates was done using a case study approach. Case studies are applied in conductive

⁴³ Formatted for emphasis.

⁴⁴ The Ocean Spray Homeowners Association (OSHA).

qualitative work when the intent is to study a subject in the context of clear spatial and/or temporal boundaries (Creswell, 2007). This case study as mentioned before was bounded spatial (Ocean Spray neighborhood) and temporally (interviews conducted in February 2011). To further specify the type of case study, topics of interest were largely exploratory. This was chosen as a means to better understand questions of ‘what’ (i.e. what does water quality mean to you?) pertaining to local knowledge of environment and water quality (Yin 1994). To gather interview data for this research, I solicited property owners to interview by telephone. A research protocol and interview guide was developed and approved by Duke University’s Institutional Review Board (IRB) in August 2010 (Appendix A). 11 semi-structured phone interviews were conducted throughout February 2011 using a land-line telephone at the Duke University Marine Lab.

The subdivision of Ocean Spray Mobile Homes Estate near Cedar Point, NC was used as the study site to spatially bound the area for selecting interview subjects from. Ocean Spray Home Estates subdivision consists of both part-time and year round residents⁴⁵. Interview subjects were contacted based on evidence of year-round residence. Year-round residents were selected because they were more likely to have witnessed a variety of fluctuations in storm events both throughout the year and over a longer period of time. It was also assumed that year round residents would be most impacted by stormwater retrofitting projects. A year-round residency criterion was determined based on property owner and parcel information obtained through an online county GIS website⁴⁶. Key information for distinguishing year round resident from part-time residents was listed mailing address; if listed mailing address matched with the parcel property address, the

⁴⁵ ‘Ocean Sray MH Estates- Home Page’. <http://oceanspraymhstates.com/Home_Page.html>

⁴⁶ Carteret County. <<http://carteret.connectgis.com>>

homeowner was considered a year-round resident in this study. Based on this selection method, total year round resident households was estimated to be approximately 55⁴⁷. These households were then assigned a number in alphabetical order from 1-55. Telephone numbers were found by address through local white page phonebook available online. In contacting households, a random number generator was used to ensure that participants were selected randomly. When calling potential interviewees, if there was no answer a voice message was left indicating a request for interview & contact information was included. All 55 listed telephone numbers were initially called in the first round. After assessing the telephone numbers where a voice message was left, a second round of calls were place. The same selection process for telephone numbers called and voice message was repeated a second time to conduct a third round of interviews. The entire interviewing process lasted approximately two weeks.

Analysis

In evaluating both the quantitative and qualitative components of the interviews, a grounded theory approach (Gray & Campell 2007) was taken to comprehensively evaluate themes that emerged from the data. Following this theory, interviews were recorded over the phone and then transcribed, and data from the interviews was noted first through analyzing each interview individually (both transcript & audio) and then through comparative analysis using NVivo software. This method allowed for themes to emerge through inductive

⁴⁷ Total households within the subdivision was estimated at 171.

observation (qualitative themes), while also deductively examining how the structure imposed on the conversation affected the responses (quantitative findings). This approach was used to categorize the main findings and themes, with the complete list of questions referenced in appendix A.

Quantitative Findings

Of the 171 household properties in the Ocean Spray MH Estates, 55 households were considered to be year-round residents. Of the 55, 49 households had listed land-line telephone numbers. All 49 households were contacted. Interviews were conducted over three separate attempts that varied in each effort both in day during week and time of day. Collectively 11 households were interviewed (table 1). A total of 14 listed numbers were found to be ‘disconnected numbers’, while 10 households contacted declined to interviewed (table 2).

Table 2.

	Interviewed	Disconnected Number	Declined to be interviewed	Voicemail
1st effort	6	13	6	21
2nd effort	4	1	4	11
3rd effort	1	0	0	0*

*Called but did not leave voice mail

63% of respondents recreate in some capacity on the White Oak River. 45% of respondents thought that the water quality was in good shape. 54% of respondents understood pollution in relation to water quality as attributed to fertilizer and trash⁴⁸. 54% demonstrated some understanding of stormwater runoff concepts. 36 % of respondents discussed their observation of flooding issues within other areas the subdivision. 63% stated

⁴⁸ In attributing pollution as fertilizer & trash as the main form of pollution.

that they do not have an issue with stormwater on their property. 36% of respondents mentioned included the local government has having responsibility in maintaining water quality⁴⁹.

Themes

Water quality is not an issue in the White Oak River

When asked ‘What do you think the water quality of the White Oak River is currently?’, most respondents stated that the White Oak River was either in ‘fair’ to ‘good’ condition. The defining characteristics of what constituted ‘good’ or ‘bad’ water quality generally focused on the river’s appearance;

‘Well, I would say that its passable...it doesn’t look filthy to me.’

‘I would say, if you want a scale of 1 to 10...It would be between a 5-10, up 7 or 8...as good conditions, excellent conditions, and 1 as being very bad’

‘Yeah, I would say that to me, yes , my personal opinion, yes it is in good condition, now what the town thought of all of the water that I don’t know, but to me it always looks good’

These quotes highlight that the Ocean Spray residents’ perception of water quality in the White Oak River was judged largely on physical appearance. When asked what respondents thought pollution was in their opinion and what were the types of pollution that could be entering into the White Oak River, the most cited forms of pollution by respondents were garbage, trash and fertilizers. Interviewees were not asked what factors informed them of water quality in the White Oak River, rather how they understood the notion of ‘water quality’ followed by what they thought the water quality of the White Oak River was currently. Only two referenced the water quality as being ‘poor’ from personal experience and another from information they had obtained through education. With the

⁴⁹ Does not preclude other institutions or citizens from having responsibility.

exception of these interviewees, the rest of the respondents appeared to base their understanding of water quality in the White Oak River water on what they saw.

Everyone is responsible for water quality of the White Oak River

Nearly all of the respondents shared a view at some point in the interview that water quality was *everyone's* responsibility. Many of the answers that echoed this idea came in response to the question 'Who's responsible for the White Oak River's water quality?' If no initial answer was given, follow up questions began by listing government institutions starting at the local level up to the Federal government. Though respondents varied in voicing the full extent of responsibility that residents, local, state, and federal government had in water quality management, most respondents ascribed responsibility to both users and non-users of the White Oak River as shown below;

"Well it's up to every individual to keep paper and cans and bottles and so forth out of the water, keep their trash on the boat with them, and not throw it out, yeah"

"My thing is don't be dumping your toilets overboard, don't be dumping your you know, your this or that, that's what I'm talking..... I feel that all of us have a responsibility to keep it [water quality] from being an issue"

The ethos of individual responsibility that many residents spoke of is very interesting because it highlights a sense of personal stewardship that appears to be less formal in the general governance structure of the community. None of the residents interviewed attributed this responsibility to written law, statute or ordinance, but rather discussed the idea more in the context of a personal belief. Further inquiry regarding what may inform this belief (local ordinances, societal values, etc.) would be useful in trying to understand the basis of this sense of personal responsibility and its prevalence.

‘Stormwater & Drainage are in issue in the neighborhood...but not on my property’

‘I don’t have any flooding’ was a common comment when residents described their property and how they understand stormwater to either collect or drain from it. Many respondents held that drainage for their particular property was ‘adequate’ and effective;

“I would say yes if that was necessary with my property, but like I say my property drains very well so I’m saying it does not collect, it runs/ drains very well”

But, nearly all respondents alluded to or directly spoke of other areas within the Ocean Spray subdivision as has having drainage issues or flooding issues;

“ Not in my yard particularly because the only time I have seen any water at all that stood for any length of time is between my house and my sisters’.....now there are some lots in here [Ocean Spray] off of 58 [highway] that their backyard floods just about any time it rains very much”

These observations seemed to draw primarily on first-hand knowledge and experience. No respondents though linked these observations of other areas in the subdivision has being connected, affected, or effecting drainage within the subdivision. Lastly, areas within the subdivision that did experience flooding or drainage issues were often spoken of as a ‘problem’, opposite to the effective drainage that many sited on their own property.

Confusion over ownership/responsibility of ditches

In relating to the previous theme on drainage, there appeared to be differing opinions regarding whether or not the stormwater conveyance ditches located in front of or behind many of the residents’ homes were the property owner’s responsibility or the responsibility of the Ocean Spray Homeowner Association (OSHA). According to the listed OSHA website, OSHA board members are responsible;

...for the fresh water treatment system and two wells (contracted out), street lighting, **mowing common areas**, perimeter split rail fencing, maintaining the streets, **stormwater runoff**, the entrance including entry/exit gates, as well as collecting annual dues and insuring compliance with the covenants. (OSHA 2009-2011)

This seems to imply that the maintenance of the ditches- which are considered by some to be common areas and conveyances for stormwater- rests in the hands of the OSHA board members. As referenced by one interviewee:

“Well the association [OSHA] use to be on you more, they’d send you a note saying ‘can you clean out the ditch’ this and that....like I said four years later I got trees in that ditch”

When specifically asked about the ditches located adjacent to or in front of residents households, few attributed personal ownership in describing their function. Yet when asked if they would have any concerns regarding modification to the ditches, those that stated they would be receptive to a program, did voice concern over cost that they would incur from modifications. This seemed to imply that by proximity, those that were receptive to retrofitting the ditches did seem to think they would have some financial responsibility to a modification project. Thus further demonstrates the lack of clarity over responsibility and ownership of ditches in the Ocean Spray subdivision.

Influence of education outreach

Two of the interviewees explicitly referenced experiences with the North Carolina Coastal Federation (NCCF) that shaped their opinions and understanding of the water quality in the White Oak River as distinctively different from other respondents. At one interviewee was able to reference the meeting that a member of the NCCF conducted with the homeowner’s association in summer 2010. The other respondent took part in water quality sampling conducted by NCCF for the 2009 TMDL. Both interviewees cited fecal coliform as a pollutant contributing to poor water quality in the White Oak River.

Conclusions that may be drawn from these responses are limited because it is not known whether other interviewees had been participated in similar activities or not. What these responses do demonstrate is that outreach efforts by NCCF have influenced at least some residents in the Ocean Spray subdivision. Further surveying to targeted attendance of NCCF events & programs as well as retention of material would is needed to fully evaluate the impact of these outreach efforts.

Limitations of Methodology and Analysis

In examining the social perceptions of stormwater & water quality from a neighborhood level interview process, there are many limitations to establishing conclusions on consensus and accurate representation of the local population. In using this approach, the information and suggest results were bounded spatial and temporal to the coastal community of Cedar Point over the course one month. This inherently limits both the analysis and findings reached to a small group of people within in a relatively small amount of time. While there were some quantitative findings that could be grasped from the data, these figures are limited by the small sample size; none of the figures are statistical significantly in this regard. There are also limitations to the questions asked in interview sessions as well. Its important to acknowledge that the questions posed, the structure of the interview, and its form all contributed to forming the responses received. For example, with a focus on how residents understood the concept water quality currently, little attention to how other elements of local politics may be indirectly contributing to stormwater management.

In designing the methodology for contacting residents, an element not considered in the outset but observed often was the prevalence of disconnected land-line telephone numbers. This was finding that was not initially considered when creating the research

design and significantly limited the ability to contact residents from the selected population size. This may be attributed to the prevalence of cellular phones or potentially the disconnecting of landline phones seasonally when not in use.

Lastly, sampling only targeted property owners considered year round residents both limited the data collected and analyzed to those deemed 'year-round'. This population of residents estimated by the methodology referenced earlier accounts for less than a third of the households in the subdivision. More census data for this neighborhood is needed to determine if this finding is accurate. Calling residents by land-line telephone exclusively may have excluded some year round residents either with cellphones or not at home during the time of the call. Evaluating the selected properties in light of other census data such as voter registration might be able to verify whether those in the selected sample were year round residents. Another potentially better method may be to combine door to door surveys with telephone interviews in future research.

Educational Outreach Recommendations

Much of water quality education throughout the country has focused efforts on reducing litter, debris, and fertilizers from entering into waterways. These types of pollution are commonly viewed as being anthropogenic and preventable. Drawing from the responses given by the interviewees, education efforts that focus attention on more nuanced forms of pollution, such as how fecal coliform from native fauna *conveyed* by stormwater into the river and tributaries is an important concept that needs to be addressed in order to better communicate the current status of the White Oak River. That being said, this is a difficult public education point to convey because it is not visibly apparent to users & non-users of

the river without water quality testing. If small scale BMP retrofitting projects within the Ocean Spray Mobile Home Estates are to be supported on the community level, building a consensus view that water quality needs to be addressed with specific attention to fecal coliform is a critical first step.

An important component in moving forward on educational outreach concepts will be changing the perception of current stormwater management within the Ocean Spray Mobile Home Estates. Efforts involving retrofitting conveyance ditches in the subdivision as a method to improve water in the White Oak River will most likely prove the most difficult because of concerns over standing water. As demonstrated earlier in the emerging themes, many residents interviewed did not perceive an issue on their property or that stormwater that drains from their property as affecting other areas. This poses a cognitive obstacle of conveying how managing stormwater on the parcel-subdivision level may affect water quality on the watershed scale. Furthermore, proving that modifications of this system *will result* in improved water quality in White Oak River will remain a quantitative challenge on a policy front. The question of causality- that ditch modification would reduce fecal coliform concentration in the White Oak river- would be difficult to directly prove. A potential more effective approach would be continuing discussions with residents over concerns of various stormwater detention techniques. With continued participation and dialogue, the ability to conduct BMP experiment projects with some resident's permission may be possible if cost and potential harm are clearly defined and understood.

Lastly, a clear delineation of private property boundaries and common property rules regarding maintenance needs to be clarified by both residents and the homeowners association. With disconnecting impervious surfaces and detaining stormwater at the parcel

level as important principles in reducing sheet stormwater runoff, these common areas will play a prominent role in future retrofitting projects.

Conclusions

Interviewing residents of Ocean Spray subdivision confirmed some initial assumptions of local knowledge on stormwater, and water quality while also revealing unforeseen notions of individual-collective responsibility/stewardship. Combining the latter finding to education initiatives emphasizing the types of pollutants stormwater can increase in waterbodies (fecal coliform and turbidity) may prove to be more effective in promoting house-keeping BMPs than previously expected. Specifically relating these types of pollutants to negative impacts on recreation⁵⁰ or seafood consumption⁵¹ may prove to be useful in connecting the need to address stormwater management with local interests. If there is a largely part-time population in the Ocean Spray subdivision as shown by the response rate of interviews, this is important information that will need to be addressed in future stormwater retrofit projects. Lastly, promotion of low-effort BMP modifications (rain barrel use, downspout disconnect) coupled with educational workshops may increase the prominence of these measures⁵² throughout the Ocean Spray subdivision. These recommendations will be discussed in greater detail in the next section.

⁵⁰ Increased turbidity reducing DO and fish habit, reducing local fish populations

⁵¹ Lose of commercially viable oyster beds for harvest due to elevated levels of fecal coliform

⁵² This suggests continuing current efforts of community outreach being initiated by the NCCF

Conclusions and Recommendations

As mentioned before, stormwater retrofitting tends to be geared towards the physical, hydrologic, and the engineering elements of such projects. This study employed a mixed method approach to more fully explain the considerations needed when implementing such projects. In this regard, this study should at the very least offer more information in the decision-making process of future projects.

In each section there were conclusions reached that largely sought to examine the questions of where to implement retrofitting projects within the town of Cedar Point. Within the regulatory framework, the combination of generalized county level land-use planning and BUA threshold continues to hinder the need of addressing water quality protection in the initial planning stages of coastal development. This study proposes a mandatory low-impact development ordinance that what would at least account for current and future development projects. This option seemed to offer the better chance of addressing future issues of stormwater management from a regulatory standpoint. Attempting to lower the current BUA threshold to 10% would most likely be too costly will also potentially confuse what the priority areas within the White Oak River watershed are. That being said, this approach does not adequately deal with the current development that is contributing to stormwater entering the White Oak River.

In applying GIS modeling and LID-EZ tools to identify the best areas to retrofit within the Boathouse Creek watershed, the estimation of impervious surface at the watershed scale demonstrated that addressing stormwater from a BUA standpoint would be insufficient considering the current percentage coverage. While the coupling of these techniques did not fully illustrate areas best suited for retrofitting, they did highlight that through modeling an

altered watershed, there is clear indication that more sheet flow may be occurring within the watershed during storm events compared to a more natural watershed. At the very least, these techniques show that there is more research needed on how fecal coliform is physically transported throughout the watershed with attention to the biological elements that influence its survival and in turn, impact on water quality.

While the previous sections offer part of the components needed to address stormwater retrofitting from a regulatory & quantitative approach, the more holistic endeavor is to better understand the social obstacles of implementing small scale BMPs within residential communities. Because the low-cost caveat with current and future projects guides their current viability, a structural overhaul of current stormwater management is not financially or political feasible. Through conducting interviews with year round residents some themes emerged that may inform how to make education outreach more effective. Exercises that focus on building consensus on water quality, understanding best management practices on the parcel level, and encouraging community level engagement with retrofitting projects may ultimately gain more public buy-in and agreement on future retrofitting projects.

Across these three fields of inquiry, the findings from this study suggest the potential for further research and the capacity for change within both the local social and regulatory systems examined. However, how these two systems may effect water quality change at the tributary or watershed levels is not entirely clear. It is important to emphasis along with this, is that the efforts of BMP retrofitting within the White Oak River may not reduce fecal coliform concentrations nor be solely responsible if reductions are achieved. Given the

uncertain and limitations of the modeling, interviewing techniques, and findings, recommendations offered from this study are tentative at best.

In moving forward from the findings of this study, more research is needed to assess the transport of fecal coliform throughout the subwatersheds of the White Oak River. Information gained from this research may further highlight areas where attention should be focused for retrofitting projects. At the same time, more data is needed on understanding the current stormwater management from local resident on the parcel to subdivision level. More understanding of where sheet stormwater runoff is occurring at different times of year and condition will significantly add to research conducted in modeling. To best utilize these two approaches, organizations such as the NCCF should continue efforts that maximize the participatory elements of this research form. Including residents, Homeowner Association board member, local town administrators and other stakeholders in the process of collecting and creating data may significantly aid in implementing stormwater BMP retrofits with community support. Because of the localized and small-scale nature of current and future BMP retrofit projects within White Oak River subwatersheds, stakeholder participation and investment in these projects will be critical. To better ensure retrofitting projects' success, involving stakeholders from the siting of projects through to implementation and monitoring may be vital in maintaining projects' effectiveness.

At this point it seems that trying to incorporate these methods into BMP retrofitting projects in other coastal areas, while potential having a positive impact, are hard to demonstrate as always being successful or necessary. The specifics of where the areas of most concern regarding water quality within the context of watersheds are not always residential or low impact development. Rather, in many cases high density development

may be contributing to stormwater runoff, which would necessitate engaging different stakeholders than those addressed in this study. Still, the use of participatory methods in other fields of study, specifically using GIS mapping techniques has shown the potential for facilitating more stakeholder engagement and unifying a sense of community (St. Martin 2008). Trying to account for the varying types and number of communities within the bounds of a watershed will continue to make this a difficult approach to apply across different watershed scales. Further research incorporating the mixed methods approach of GIS tools and qualitative interviews & surveys in the case of Cedar Point, NC will hopefully highlight what elements may aid in successes of water quality improvement, as well what considerations may be critical in addressing stormwater management in other places.

Stormwater on the coast will most likely remain a continuing issue for small towns so long as development and infrastructure remain to support and provide for their residents. This is an unavoidable fact. The Town of Cedar Point is moving in the right direction to protect a valuable neighboring resource in the White Oak River. In taking the considerations made by this study in partnership with organizations like the North Carolina Coastal Federation, the town of Cedar Point may effectively make strides in water quality improvements and community engagement on future stormwater retrofitting projects.

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Town of Cedar Point Soils Map



Kirby Rootes-Murdy
North Carolina Coastal Federation
6/30/2010

Figure 5

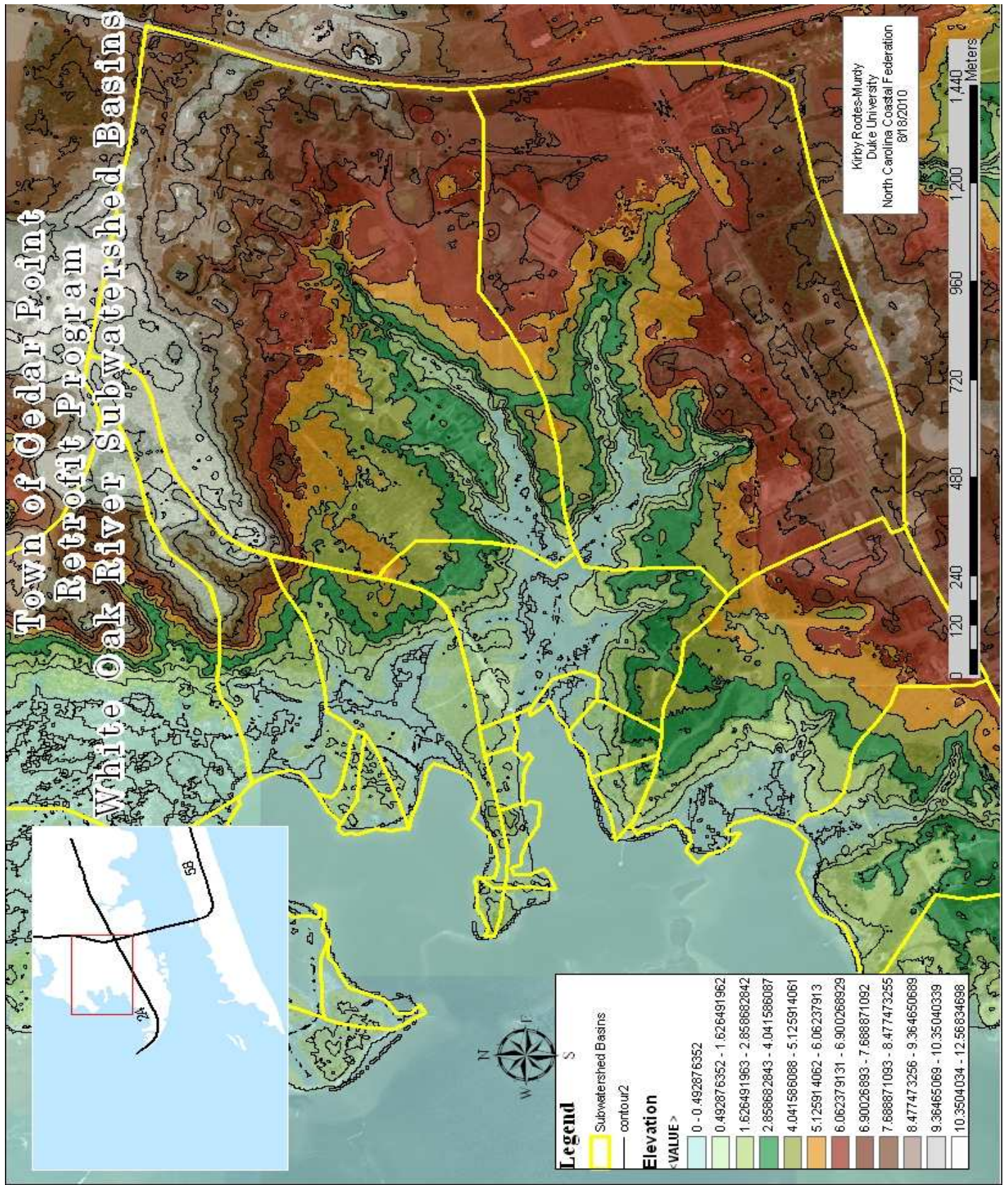


Figure 6

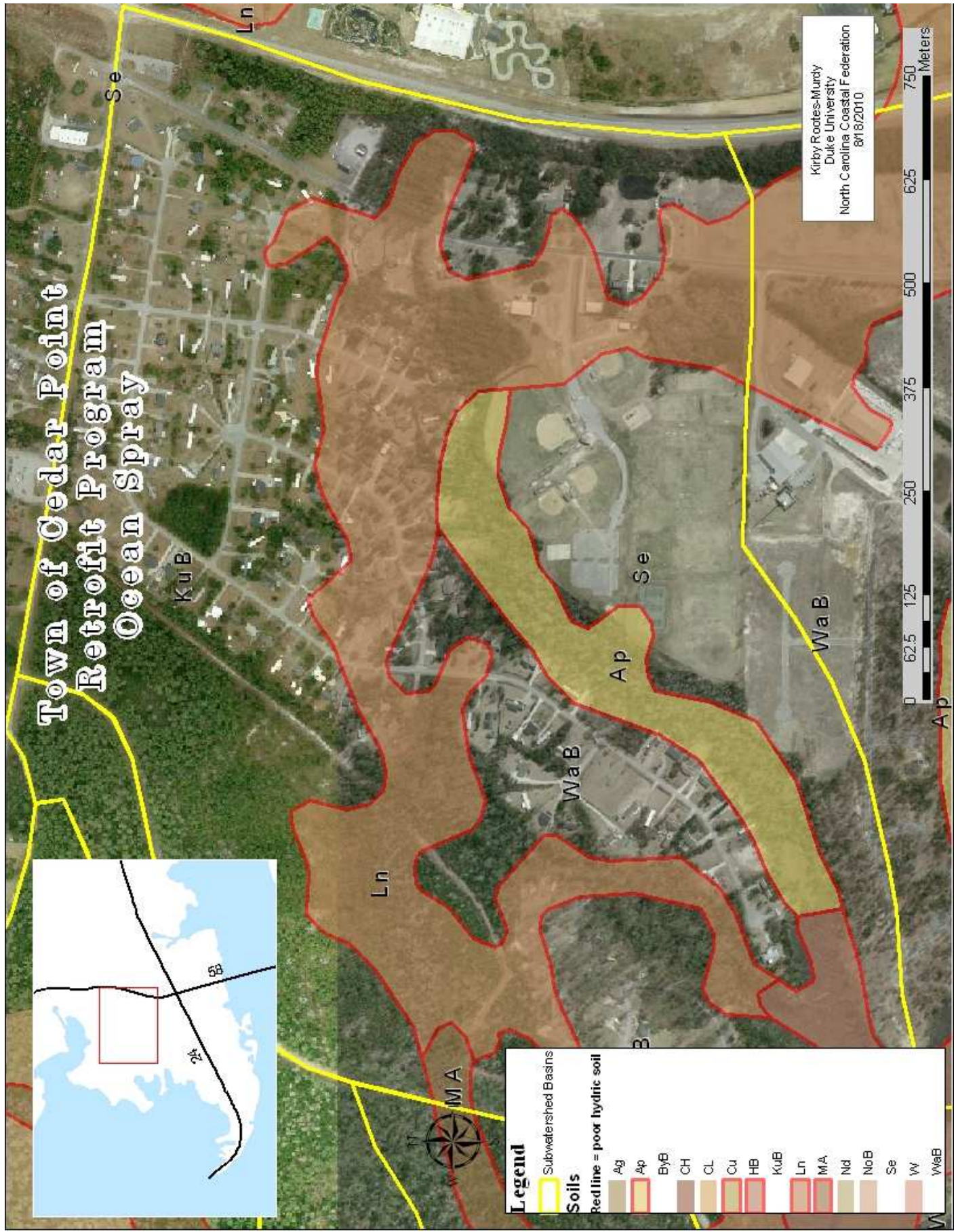


Figure 7

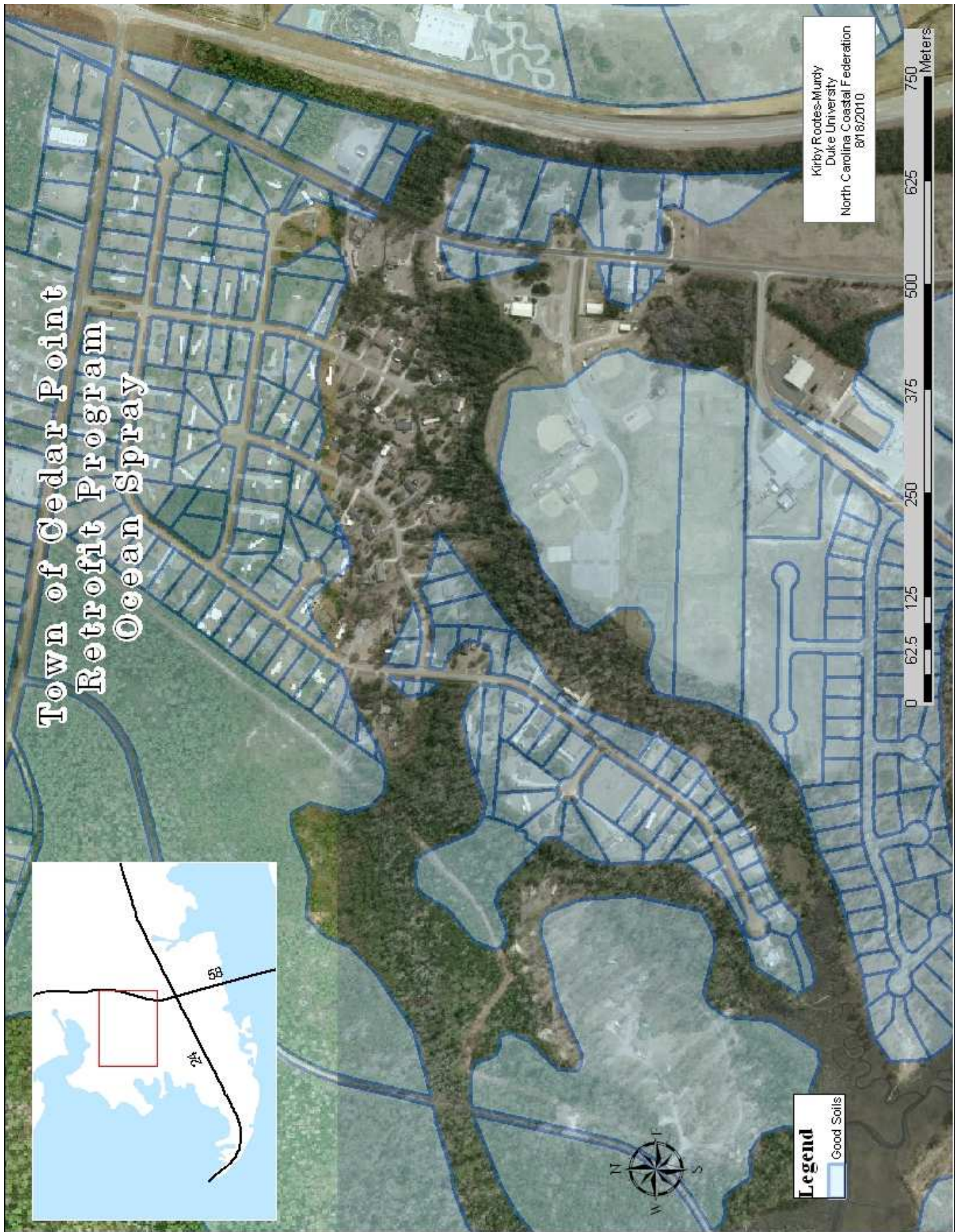


Figure 8

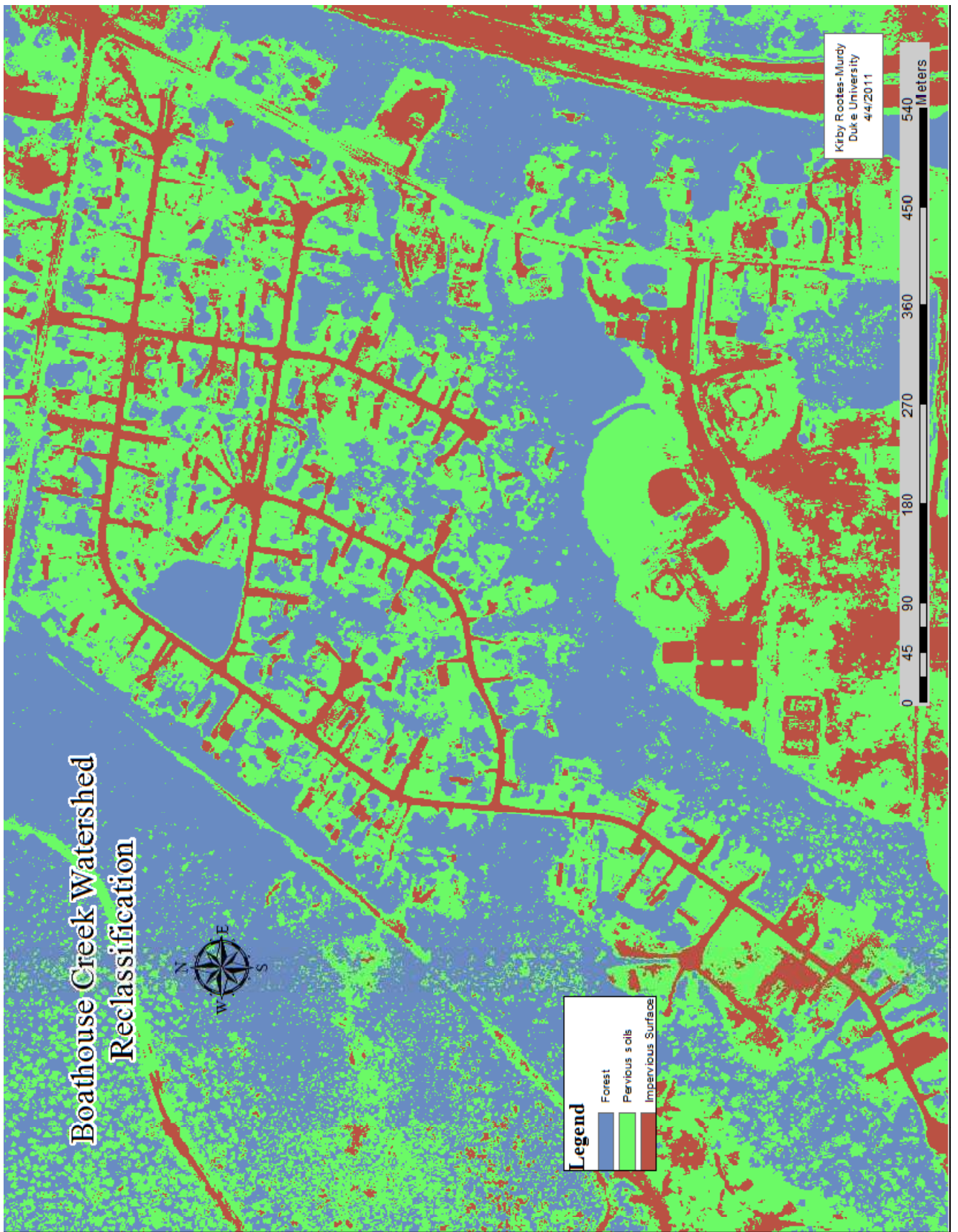


Figure 9

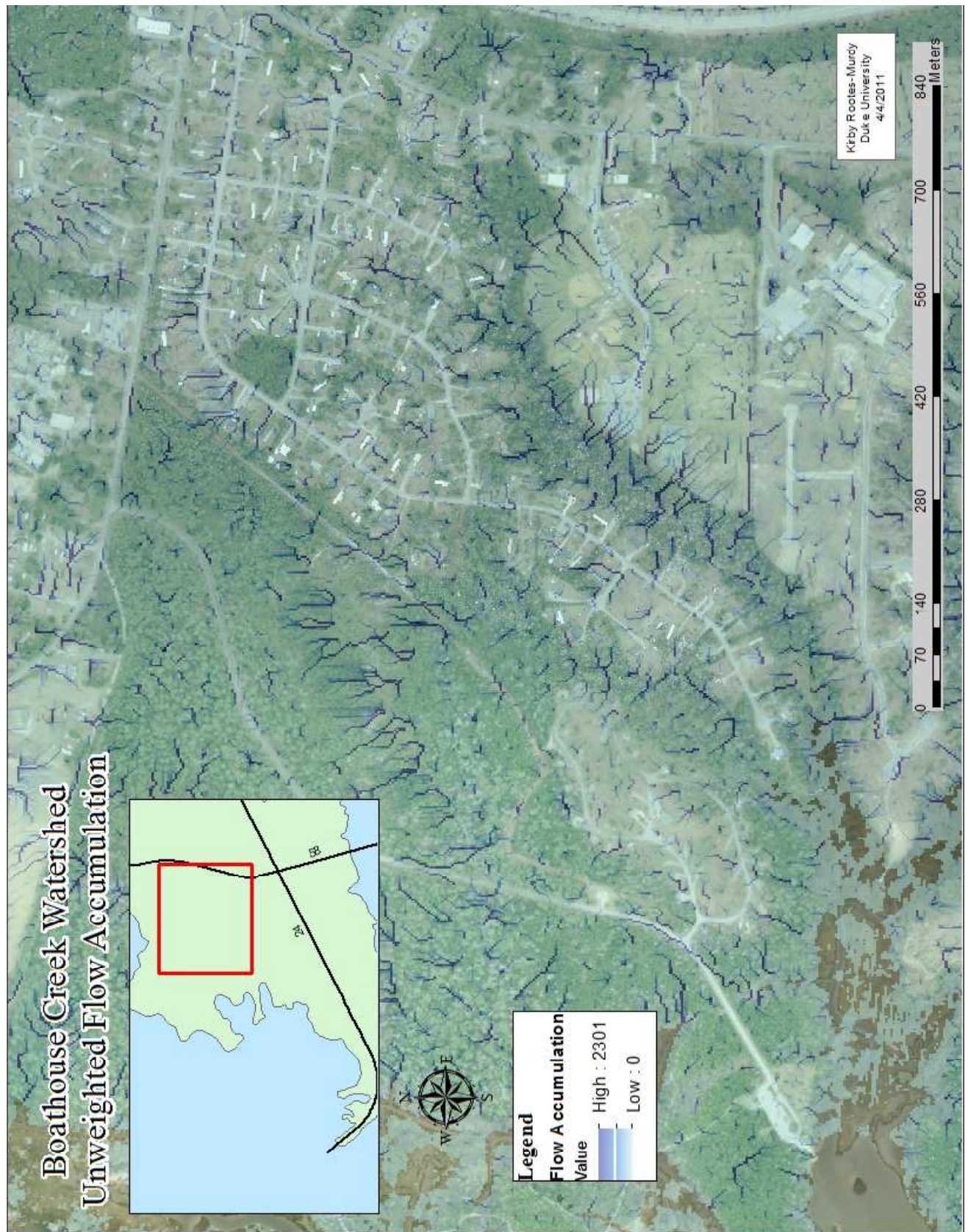
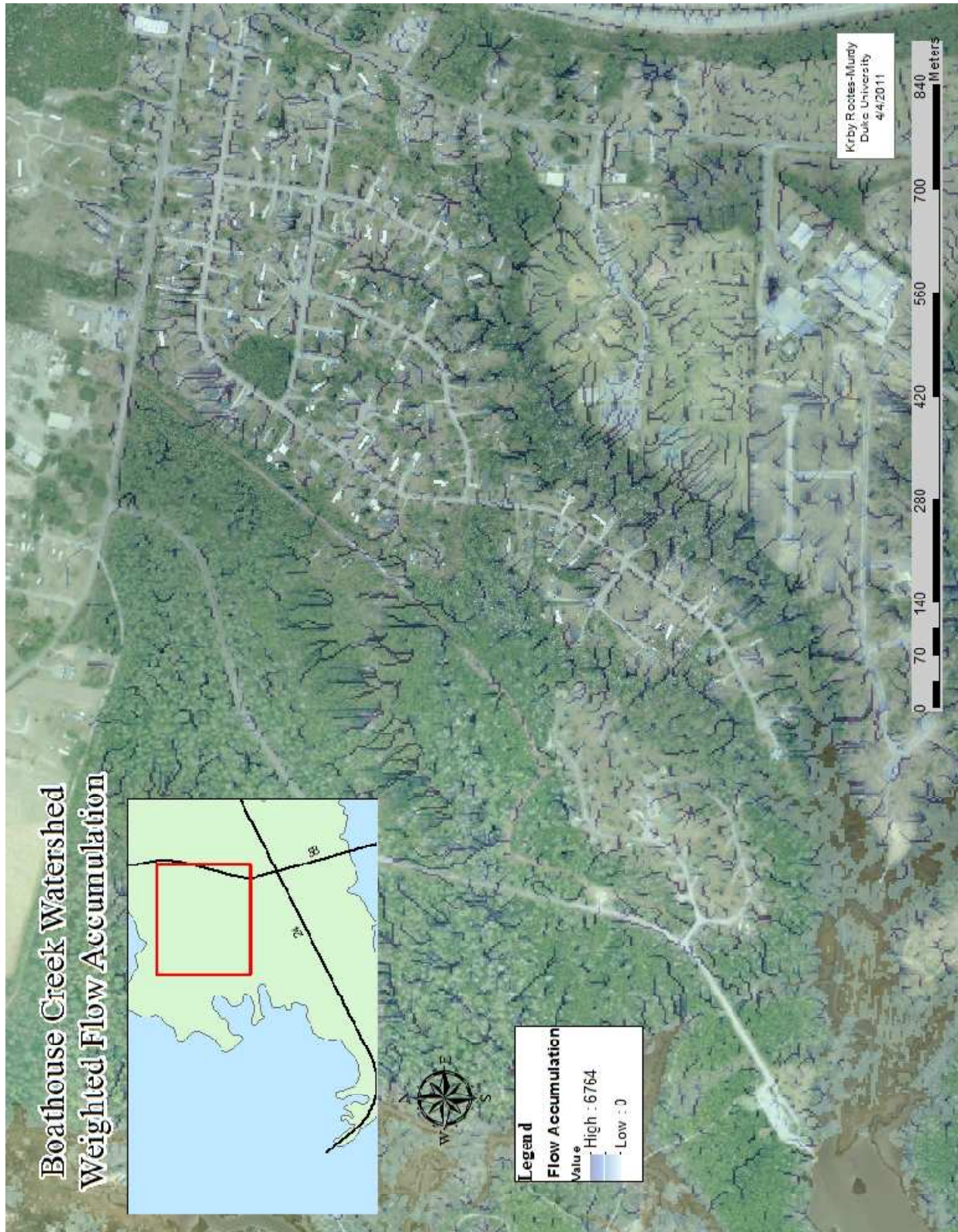


Figure 10

Figure 11



Appendix A.

Interview Guide 2-2011

Hi my name is Kirby Rootes-Murdy and I'm a graduate student at Duke University. I'm conducting interviews for my Master's Project, which focuses on understanding homeowners perception of stormwater issues and how these homeowners interact with the White Oak River.

Can I ask you few questions today?

No personal identification information will be asked, such as gender, name or address

Would you mind if I record the interview?

(Identify the date, and state the time into the recorder);

General Background

Do you live in Ocean Spray?

How long have you lived in Ocean Spray?

Do you live here year round?

Do you use the White Oak River for recreation (fishing, boating, swimming, etc.)?

*If so, what do you do?

Water Quality

What is water quality to you? What does water quality mean to you?

What do you think the water quality of the White Oak River is currently? Do you think it changes throughout the year? If so, what might cause it to change?

Who's responsible for the White Oak River's water quality? The local government? State government? Federal government? Individual homeowners?

How do you understand water quality in regards to pollution? What is pollution in your opinion?

Is pollution a problem in the White Oak River?

*If so, what pollutants might be getting into the White Oak River? How might they affect the water quality?

What are measures people can take to prevent pollution from entering into the White Oak River?

Are there things individual residents can do prevent pollution?

Stormwater

What is stormwater in your own words?

During a storm event, can you describe how water moves throughout your property? For example is there flooding or areas of concern in your yard during a storm event?

BMP Retrofit

If there was something that could be done on your property to potentially limit stormwater from coming from your property, would you be willing to? For example, if there was a program in place to adjust your downspout and direct it towards an area in your yard?

- If no, what are your concerns?
- If yes, do you have any concerns?

Would you be willing to plant a rain garden in your yard to help capture stormwater?

- If no, what are your concerns?
- If yes, do you have any concerns?

Do you have ditches in the front of your home?

Would you be willing to have your ditches modified to better handle stormwater?

- If no, what are your concerns?
- If yes, do you have any concerns?

This marks the end of the interview, thank you for your time.

