NC STATE UNIVERSITY

LESS RAIN DOWN THE DRAIN: DISCONNECTING STORMWATER SYSTEMS TO RESTORE BLACK CREEK

EPA319 grant Sponsored by NC Division of Water Resources
FY09 DWQ Contract Number 2853;
Contract Period: 1/01/2010- 03/31/2013
www.ncsu.edu/WECO/blackcreek
PIs: Christy Perrin, NC Cooperative Extension, Dept. ARE
Dr. Laura Taylor, Dept. ARE
Kris Bass, Dr. Jean Spooner; NC Cooperative Extension, Dept. BAE
Patrick Beggs, Dept. ARE

Acknowledgements:

This project was funded under an EPA319 grant. Thank you to our sponsors, NCDWQ and USEPA .

Thank you to our grant partners:

Dr. Dan Hitchcock, Clemson University

Charles Brown, Town of Cary

Doug McRainey, Town of Cary

Mitch Woodward, NC Cooperative Extension Wake County Center

Brantley Snipes, formerly with Department of Horticulture, NC State University

Thank you to all who participated during this project and offered advice and feedback:

Black Creek Watershed Association

Elena Horvath, BCWA (GIS analysis)

Amin Davis, BCWA (GIS analysis)

Susan Davenport (rain garden audits and design)

Anne Spafford, Department of Horticulture, NC State University (rain garden design)

Cary Rotary (sponsor of West Cary Middle School rain garden)

Wake County Public Schools

West Cary Middle School

Northwoods Elementary School

Alexandra Cousteau and Blue Legacy

Wessex Homeowners Association

Beechtree Homeowners Association

Buckhurst West Homeowners Association

Table of Contents

1. Executive Summary

The Black Creek Watershed Association (BCWA) is a partnership of citizens, neighborhoods, and local government organizations and agencies that was formed and has been coordinated by NC State University since 2006. They initially assessed the causes of Black Creek's impairment, and developed a watershed restoration and action plan (2009) to improve the stream system's health. The watershed is typical of a developed Piedmont watershed, highly urbanized and nearing build-out with a combination of high density residential, commercial, and institutional development. The Town's popular Black Creek Greenway runs adjacent to most of Black Creek, hence many people are familiar with the creek system.

The watershed assessment conducted as part of the Black Creek Watershed planning process (2009) identified excessive stormwater runoff volumes and velocity as the main impairing factors. Much of the stormflow during rain events arrives from culverts and pipes that drain straight into the creek or its tributaries bypassing the riparian buffers. Like many suburban Piedmont watersheds, most of it was built out before stormwater regulations such as the Neuse Rules and EPA Phase Two were in effect.

Restoring the biological health of the watershed requires broad scale implementation of stormwater retrofit practices that will disconnect the impervious cover from the creek system and allow stormwater to infiltrate and evaporate. This EPA319 project kicked off the efforts of NC State University, the Town of Cary, and the BCWA to begin the work of disconnecting impervious surfaces and restoring the creek back to health. The project sought to engage the community in identifying and implementing low impact development retrofits through a Disconnection Campaign (both residential scale and large scale public retrofits), and monitoring hydrologic changes that may be seen as a result.

The project reached out and engaged residents via presentations to homeowners association meetings, workshops, fact sheets, and email communications. Participants of workshops were invited to apply for "stormwater audits" of their residences to assess for opportunities to reduce runoff via retrofit projects which were called "Rainscapes" (including rain gardens, gutter disconnection, rain barrels, and conservation plantings). The project team provided participants with technical and financial assistance to implement projects. As a result, 18 residential rainscapes were installed, including rain gardens, rain barrels, a gutter disconnection, and a backyard wetland. Three large bioretention areas were installed at an elementary school and middle school, and a cistern was installed at a fire station.

Once targeted audiences were informed at workshops of the problems with Black Creek and how they could participate in the solutions, most wanted to participate. The level of interest in installing rain gardens in particular was quite high. Homeowners associations also expressed interest in participating in projects after hearing about the issues and opportunities. The retrofits installed on HOA right of way were also very well maintained by their landscaping contractors. Installing retrofits on HOA right of way seems like an ideal a way to capture greater amounts of runoff in larger projects, while ensuring better long-term maintenance.

While residents' interest and demand for rain gardens has increased as a result of the project, the local capacity for designing and installing rain gardens is not currently sufficient to meet this demand. According to the homeowners involved in the project, their landscape contractors had little knowledge about the practices, and were not an available resource for them to use. Turn-key services for evaluating properties for runoff reduction, rain garden design and installation are needed to meet this demand on a long term basis.

GIS analysis, stream flow monitoring, and hydrology modeling increased the knowledge base of the watershed. A GIS analysis of connected, or "effective", impervious cover revealed that in order to meet an impervious cover goal of 10%, which corresponds with known thresholds before seeing impacted stream quality, approximately 252 acres of impervious surface in the watershed needs to be disconnected from the stream system. This project disconnected nearly 2 acres.

Streamflow monitoring was conducted over the course of two years in both the 2,100-acre Black Creek watershed and the smaller 84-acre residential watershed (Wessex neighborhood) targeted for effective impervious cover reduction by the disconnection program. Monitoring results indicated that – on average - 30% of the rainfall was seen as stream flow, which is typical for highly urbanized watersheds. In contrast, monitoring results of the residential subwatershed showed that an average of 57% of the rainfall was discharged from the smaller watershed, a very high coefficient indicating not only that the neighborhood was a good target for the disconnection program, but also showing that unidentified areas outside of the delineated subwatershed may be contributing to stormwater flows and volumes.

Simulation results from a watershed model (HEC HMS) indicated that by the removal of approximately 2 acres (1.72 acres or 75,000 sq. ft.) of effective impervious cover in the residential neighborhood, peak flow would be reduced from 13.3 cfs to 12.0 cfs, and 45,236 gallons of stormwater would be managed prior to entering Black Creek. However, if a more aggressive campaign were to reduce the effective impervious cover to 10% (or 8.4 acres total remaining effective impervious cover in the subwatershed), then the peak flow under the same one-inch rain event would decrease from 13.3 cfs to 5.9 cfs – a very significant reduction - and a total of 226,180 gallons of water would be kept from entering Black Creek. In short, simulation results revealed how much impervious cover area reduction would be required to achieve effective downspout disconnection for water quantity management based on rainfall and subsequent discharge at the residential/neighborhood subwatershed scale. Results also indicated the target volumes for which stormwater control measures should be designed within the neighborhood subwatershed given a one-inch rainfall event.

Further work must be conducted to determine any hydrographic benefits from impervious cover disconnection at the larger Black Creek watershed scale, including efforts to expand monitoring and modeling to other subwatersheds with different land uses, stormwater infrastructure, and impervious cover percentages in the Black Creek watershed. Further research is also needed to explore the connection between stormwater peak flow and volume reduction, water quality, and aquatic habitat improvements. The ability to scale between the smaller subwatersheds and the larger Black Creek watershed allows for identification of future impervious cover reduction target areas based on citizen

willingness to participate, availability of retrofit opportunities within the landscape, and the overall capacity for stormwater reduction.

2. List of figures and abbreviations

Abbreviations:

Black Creek Watershed Association (BCWA)

North Carolina Division of Water Quality (NCDWQ)

North Carolina Ecosystem Enhancement Program (EEP)

NC State University (NCSU) Department of Agricultural and Resource Economics (ARE

NC State University (NCSU) Department of Biological and Agricultural Engineering (BAE)

Total Maximum Daily Load (TMDL)

Watershed Education for Communities and Officials (WECO)

3. Introduction/Background

The Black Creek Watershed Association (BCWA) is a partnership of citizens, neighborhoods, and local government organizations and agencies that was formed and has been coordinated by NC State University since 2006. They initially assessed the causes of Black Creek's impairment, and developed a watershed restoration and action plan (2009) to improve the stream system's health that was accepted by EPA as an alternative to a Total Maximum Daily Load (TMDL) if critical milestones are met by 2014. The Black Creek watershed, about 3.3 mi2 in area, is in the northern section of the Town of Cary. The creek discharges to Lake Crabtree, in the Crabtree Creek subwatershed of the Neuse River Basin. The

watershed is typical of a developed Piedmont watershed with hilly terrain, low-high density residential subdivisions, three schools, two town parks, and supporting commercial and office properties including shopping centers and gas stations. The Town's popular Black Creek Greenway runs adjacent to most of Black Creek. The Greenway connects to Umstead State Park, Crabtree County Park, and City of Raleigh greenways, and experiences heavy use. Hence many people are familiar with the creek system.

Highly urbanized, the watershed is nearing build-out with a combination of high density residential, commercial, and institutional development. Classified C, NSW, Black Creek has been on the NC 303d list since 1998 with impairment for aquatic life and potential sources listed as urban runoff/storm sewer. Like many suburban Piedmont watersheds, most of it was built out before stormwater regulations such as the Neuse Rules and EPA Phase Two were in effect.

The watershed assessment conducted as part of the Black Creek Watershed planning process (2009) identified excessive stormwater runoff volumes and velocity as the main impairing factors. Much of the stormflow during rain events arrives from culverts and pipes that drain straight into the creek or its tributaries bypassing the riparian buffers. Stormflow from impervious cover to piped systems results in reduced groundwater recharge, increased pollutants, and increased erosion. The stream is essentially scoured clean during high rainfall events. The assessment also found high levels of fecal coliform bacteria. High turbidity and nutrients were found during targeted stormflow monitoring (outside of timed collections). While the riparian buffers in this watershed are mainly intact, many stormwater conveyances connect directly from downspouts and parking lots to the tributaries and creek, bypassing opportunities to infiltrate stormwater before reaching the creek. A GIS study recently conducted by a BCWA member characterized 23% of the watershed land as impervious cover that is untreated by stormwater management practices (though overall impervious cover is closer to 30%). Restoring the biological health of the watershed requires broad scale implementation of stormwater retrofit practices that will disconnect this impervious cover from the creek system and allow stormwater to infiltrate and evaporate. This EPA319 project kicked off the efforts of NC State University, the Town of Cary, and the BCWA to begin the work of disconnecting impervious cover and restoring the creek back to health.

4. Purpose and Goals

The purpose was to implement several of the top priority strategies in the Black Creek Watershed Plan, by engaging the community in identifying and implementing low impact development retrofits through a Disconnection Campaign (tentatively titled Less Rain Down the Drain), and monitoring hydrologic changes.

Specific goals included:

- **an increase in knowledge and awareness**, and commitments to adopt behaviors that contribute to improved stewardship of the watershed, among neighborhood workshop participants and residents of a target subwatershed

- **residents and homeowners associations disconnecting their stormwater conveyances** from the town stormwater infrastructure through draining rooftop and driveway runoff overland, installing raingardens and/or rainbarrels, pocket wetlands
- **stormwater BMP retrofits installed on three Town of Cary properties and/or school properties**
- **Increased understanding of the watershed hydrology**

5. Deliverables

Periodic meetings of the BCWA to plan outreach and education activities, provide guidance on site selections, and BMP designs

The Black Creek Watershed Association was actively involved throughout the project period. Their involvement took multiple forms:

Meetings: The BCWA met six times over the course of the grant to provide guidance on all aspects of the grant. They also were engaged electronically in between meetings via a listserve and a through attempts at a blog. The listserve was very active with contributions and discussion, the blog did not appear to be the preferred way to interact.

Individual assistance on products: One BCWA member was trained in residential rain garden design, and subsequently provided assistance with evaluating residential properties for rain gardens, and with designing rain gardens. Another BCWA member conducted her masters theses using the Black Creek watershed as her subject (Horvath). The results of her work provided innovative new ways of measuring potential improvements in Black Creek, and provided a new goal for disconnecting impervious cover that may correspond with improvements in the creek.

Community involvement/advocacy: BCWA members served on both the Town of Cary Greenway Committee and the Environmental Advisory Board, and on their HOA boards. As such they were able to provide links from the BCWA to the town and their neighborhoods. Some members also were active in providing feedback to the Town regarding proposed rezonings in the watershed. The listserve helped to facilitate communication about these issues.

Periodic newsletters to inform community of efforts and recruit participants

Five newsletters called “the Black Creek Watershed Wire” were published and distributed to members of the Black Creek Watershed database. More frequent informal email updates were provided in lieu of the newsletters as the project progressed and staff became busier in implementing retrofits. The Black Creek watershed audience is extremely comfortable with electronic communications, so this turned out

to be a successful method of communication. Invitations to workshops continued to be sent by email and postal mail however.

BCWA website updated regularly, with access to maps, reports and educational materials

The website was updated as needed, including with a new report with an updated GIS analysis , a new page on Rainscaping, which included a residential application for homeowners to apply for "Rainscapes" (our homeowner-friendly term for retrofit BMPs), and detailed fact sheets on recommended Rainscapes. A new online map of the Black Creek watershed was created and posted as well. This new version is more accessible than the previous GoogleEarth KMZ files, and contains updated GIS layers such as BMPs in the watershed. The previous mapping product required the user to have GoogleEarth downloaded on their computer, which prevented some people from accessing the product based on computer limitations. The new map is on ArcGIS online (in the cloud), requires no downloading of software, or membership to the site.

At least 3 community workshops, including a mapping charette to identify potential retro-fit opportunities in the targeted drainage area (s).

Figure 1 Mapping charette at a workshop

Six community workshops were held, including a mapping charette to identify potential retrofit opportunities, and workshops that educated targeted neighborhoods about issues affecting Black Creek, and how to participate in solutions through Rainscapes and behavioral changes. Attendance ran between 12-20 participants at each workshop. The workshop process included:

- Inviting target audiences to workshops
- Direct presentations to HOA boards ahead of time to "prime" the audience, which led to buy-in from Boards to help advertise
- Emails to HOA lists, BCWA list, mailing to initial target subwatershed, flyers on doors of another targeted subwatershed
- Workshops provided introductions to issues and solutions, interactive exercises, and invited participants to join the project.
- Fact sheets and Rainscape applications were provided for those who were interested in possibly installing rainscapes on their property
- Following up with stormwater "audits", where NCSU staff and a BCWA volunteer visited the residential property with the homeowner, looked for areas where stormwater was being conveyed directly to a ditch, creek, or stormdrain, and worked with the homeowner to identify appropriate landscaping techniques to reduce runoff

- When high value projects were identified and the landowner requested assistance, we assisted with designing and/or installing rain gardens and rain barrels.

Educational materials published to increase awareness of the Disconnect Campaign

This grant was used to fund and create the following educational outreach products:

- Rainscapes overview fact sheet
- Application for homeowners to apply for stormwater audit/rain scape evaluation
- Powerpoint presentations were also developed and delivered at the public workshops and at homeowners' association annual meetings (Wessex, Beechtree HOAs).
- Signage for West Cary Middle school's bioretention

One-two annual stream clean-ups

The "Big Sweep for Black Creek" event, hosted every October in conjuction with the NC and Wake County Big Sweep cleanup, as well as the Town of Cary "Spruce" clean up, was a popular event for volunteers. Participation ranged from 14 – 35 at this event. Some groups who participated included BCWA members, Panther Creek High School, Enloe High School Key Club, Cary Presbyterian Youth Group, Cary Page Rotary, and Cary Rotary. We held a springtime clean up event during the first year of the grant, but found turn-out to be less than optimal, and also found the amount of trash to be small. The amount of trash taken from the creek and tributaries has declined since the first clean-up was held back in 2006.

Figure 2: A Big Sweep for Black Creek volunteer

Three LID retro-fits on public properties, could include Town of Cary facilities, Wake County Schools, fire stations, or private schools

Parking lot bioretention, West Cary Middle School:

This was the first of two large bioretention areas to be installed at West Cary Middle School. Designs were completed by our project engineer and a landscape architect, then shared with Wake County Schools Facilities staff, West Cary Middle School staff, and the project team. Feedback from school staff resulted in replacing some bee-attracting plants that posed a liability to the school with others, and

leaving space for raised-bed edible gardens to be incorporated into the courtyard site. Both sites were bid through an NCSU bidding process, which included a pre-bid meeting. The award for ~$29,000 total was granted to Mellot Trucking and Supply out of Chapel Hill, NC. This included excavating, curb cuts, infrastructure, soils, mulch, and stabilizing areas where excavated soil was placed.

The parking lot bioretention area is located in the front parking lot area of the school. The rain garden was installed in an existing raised parking lot median, and collects runoff from an adjacent parking lot that is nearly one acre in size. The final configuration of the rain garden has approximately 2,000 square feet of surface area and a media depth between 2.5-3.5 feet. Two different types of fill media were used, including standard bioretention mix and a mix incorporating 50% leaf compost. Cary Rotary applied for and received a Rotary District grant to pay for $2,000 worth of plants for the sites. Ms. Spafford, our landscape architect partner, was able to get $900 worth of grasses and sedges donated from a nursery, and to get whole sale prices on the rest of the plants. A volunteer planting day was held on a Saturday with 20 members from Cary Rotary and Black Creek Watershed Association participating. Cary Fire Department watered the new plants over the weekend. The site was allowed to settle and stabilize and curb cuts were installed to open the site to runoff.

Location: Latitude 35°48'3.86"N" North, Longitude 78°47'40.40"W

Size of treatment area: 40,000 square feet of parking lot

Size of raingardens: 2,000 square feet (~1,250 gallons of water storage volume for 1 inch storm)

Pollutant removal: 192.84 lbs nitrogen over 30 years

Figure 3 West Cary Middle School parking lot: before

Figure 4 West Cary Middle schoole parking lot with bioretention

Courtyard bioretention, West Cary Middle School:

The second BMP is a courtyard area rain garden that collects rooftop and sidewalk runoff. It also collects a small amount of air conditioning condensate from surrounding classrooms. The courtyard rain garden has 3 separate treatment cells that are connected by piping and eventually to an underdrain system to the storm sewer. The final configuration for this area includes over 1,000 square feet of treatment area and captures runoff from approximately 10,000 square feet of rooftops. The two initial treatment cells are 18 inches deep and composed entirely of bioretention mix with 50% leaf compost. The main treatment cell is 3 feet deep and composed of standard bioretention media.

After all the planting was complete at both sites, the school began a watering program to help plant establishment. The school watered plants at a minimum of 3 times per week for several weeks until it rained the first time. The School installed raised edible beds in the bare areas left for that purpose. NCSU arranged a volunteer work day with PTA to weed the gardens a year after planting.

Location: Latitude 35°48'8.64"N, Longitude 78°47'36.72"W

Size of treatment area: 10,000 square feet of rooftop

Size of raingardens: 1,000 square feet (~625 gallons of water storage volume)

Pollutant removal: 48.21 lbs nitrogen over 30 years

Figure 5 West Cary Middle courtyard before

Figure 6 West Cary Middle courtyard with bioretention cells and gardens

Courtyard bioretention, Northwoods Elementary School:

A third bioretention retrofit was installed at Northwoods Elementary school following approval by Wake County Schools Facilities. The basic engineering design was provided to Anne Spafford, Professor of

Horticulture, who engaged her planting design class in developing planting designs. The student designs were presented to the PI and a PTA parent. The class took their feedback and incorporated it into a final design. Anne ordered the plants, including a donation of grasses. A volunteer planting event was held in November 2012. Participants included Green Hope High School students, NCSU students, Northwoods PTA parents, and BCWA members. The bioretention cell involved disconnecting rooftop drains that collected runoff from 5,500 ft2 from the stormwater system and redirecting them to the bioretention cell.

A problem was encountered when the contractor cut the pipes of a geothermal system that heated two adjacent classrooms. Although the school facilities staff reviewed and approved the engineering design, and the contractor had the utilities marked before excavation, the geothermal pipes were not identified before the construction. The School system employed their own HVAC contractors to repair the system with help of our contractor, and then they passed the bill along to NCSU. The NCSU project engineer was able to negotiate the invoice downward, but it was still an unexpected expense. Wake County Schools made it clear that they are not taking on any liability for problems encountered when doing stormwater retrofits on their properties, as they said their budget could not support it.

Location: Latitude 35°47'45.08"N , Longitude 78°47'25.06"W

Size of treatment area: 5,500 square feet of rooftop

Size of raingardens: 900 square feet (~563 gallons of water storage volume)

Pollutant removal: 26.52 lbs nitrogen over 30 years

Figure 7 Northwoods Elementary courtyard before

Figure 8 Northwoods Elementary courtyard bioretention after

500 gallon rainwater harvesting system, Cary Firehouse #1

A 500 gallon cistern was installed in the watershed at Cary Firehouse #1 in October 2012 as part of a class on rainwater harvesting, at no cost to this grant. This additional leveraging was provided by our partners, Mitch Woodward, Wake County Extension, and the Town of Cary.

Location: Latitude 35°47'45.08"N , Longitude 78°47'25.06"W

Size of treatment area: unknown

Pollutant removal: 388 lbs nitrogen over 30 years

Figure 9 Cary Fire Station #1 Cistern

12 residential LID retro-fits, could include rain gardens, native plantings to replace lawn or dirt areas, rainbarrels, pocket wetlands (could include larger but fewer LID retro-fits on HOA right of way)

Results: Eight rain gardens , 1 backyard wetland, 1 downspout disconnection, and five rainbarrels were installed at residences, and one rain garden design and one conservation planting list was provided for the homeowners to install themselves in spring 2013. Some residents did not need intensive retrofits to infiltrate stormwater, and instead were provided advice on how to better disperse the runoff from existing corrugated pipes into riparian areas (they are not counted in the official final retrofit count). A separate funding source paid for residential-sized demonstration retrofits at the Wessex Clubhouse (rain barrel and rain garden) and on the Beechtree neighborhood greenway in Town of Cary sewer easement right-of-way (2 rain gardens), resulting in a total of 18 residential retrofits installed during the grant period in Black Creek watershed (and likely 20 by summer 2013).

Rain barrels and cisterns: A rain barrel sale was advertised to the BCWA listserve- Rain Water Solutions offered rain barrels to us at cost, then we offered a reduced price to homeowners. Four homeowners responded. NCSU staff and a teen volunteer installed one of those for an elderly homeowner, while the others were installed by the homeowners themselves. One residence was identified as a good location for a cistern. We worked with the homeowner to try to get a 450 gallon cistern approved by the Homeowners Association, but it was rejected due to concerns about aesthetics since it may have been visible from the road. Given the amount of time the project team spent working with neighbors and the HOA to try to design the cistern in an aesthetically pleasing way, and the time spent meeting with the HOA board, the project team decided that the potential benefits from installing residential cisterns were

not worth the time and expense. The cistern had already been purchased by an NCSU professor as part of a class, so it is available for installation at another site. Northwoods Elementary School has expressed interest, so it may be installed there as part of future efforts.

Location: throughout the watershed

Metric	Residential rain gardens	Residential AND school rain gardens
Impervious Surface treated (square feet)	16,070	73,570
Rain garden installed (square feet)	2,060	6,360
Stormwater Gallons Potentially Captured in 1" rain (0.625 gallons per square foot)	1,288	3,975
Annual Stormwater Gallons Captured (annual rainfall 42 ")	54,075	166,950
Cost of projects (not incl design or oversight costs)	$4,532	$33,210
Cost per square foot	$2.41	$3.55
Volunteer hours	138	216
Value of volunteer time (2010 = $21.36/hr)	$2,948	$4,614

Source: BMP Calculations Spreadsheet developed by Dr. Bill Hunt and Wendi Hartup for NC Cooperative Extension Agents. Note that not every storm is 1 inch storm, variables like soil type are not included.

Watershed resident & greenway user preliminary draft survey plan

Dr. Laura Taylor and Dr. Sanja Lutzeyer provided this draft survey plan as cost sharing to this project. The work on the survey was funded by a NC Clean Water Management Trust Fund grant. A choice experiment survey was designed to elicit homeowner willingness to pay (WTP) for environmental improvements in the Black Creek watershed. The survey also elicited their experience and understanding of the watershed, educated about the creek's current conditions and how the conditions can improve through installation of best management practices (BMPs). The survey was mailed to 750 randomly selected single family homeowners with an accompanying self addressed and stamped envelope for returning the completed survey. The survey enjoyed a respectable response rate of 49%.

A brief overview of major findings is included here. Greenway use was high, with 65% of respondents using the greenway 2 or more times per month. While only 29% responded that they were aware of environmental problems associated with the creek and 22% were unsure of problems, most respondents (93%) said they were either somewhat or very interested in environmental issues (49% and 44% respectively).

The crux of the willingness to pay survey involved choice scenarios. In each survey, the respondent was asked to answer 8 "choice questions" consisting of 3 scenarios that respondents were to rank with a 1, 2, or 3 for their most preferred to least preferred scenario, respectively. In each choice question, the

first two scenarios moved away from the current, or "status-quo," condition of the watershed through installation of public or private BMPs that cost the homeowner a randomly assigned amount. These two scenarios are referred to as "designed", and the third scenario reflected the current condition of the Black Creek watershed and is referred to as the "status quo".

Only 11% of respondents always chose the status quo as their most preferred option, showing a strong willingness of respondents to take action to improve the watershed. Half of the respondents always chose a designed scenario, meaning they were always willing to pay something to help improve the creek. Respondents were willing to pay an average $3.56 per month to see an improvement from current condition to partial restoration, and $4.64 per month to see an improvement from current to full restoration. This shows respondents were on average willing to pay an extra $1.09 per month if they thought it would move the watershed from partial to full restoration. This shows support for a stormwater utility fee of that amount from the majority of respondents within the watershed.

Regarding private BMPs, respondents expressed willingness to install BMPs including rain gardens, conservation plantings, and rain barrels, but at highly subsidized rates. The average price respondents were willing to pay for rain gardens and conservation plantings was ~$200, while the average price they were willing to pay for three 55 gallon rain barrels was ~$50 (figures have been rounded).

In summary, most respondents were willing to pay something to see Black Creek watershed partially or fully restored. Another key finding is the high value of education in prompting respondents' willingness to take action. Though almost 50% of respondents were not aware Black Creek had any environmental problems at the outset of the survey, once educated about the problems facing Black Creek and the available solutions, most of these respondents expressed willingness to take action to improve Black Creek's condition in at least some of their choices. The survey was not intended as an educational outreach vehicle, but the result of the survey has been a more educated watershed population, with expressed willingness to participate in solutions.

The results of this study are intended to be published in refereed journals and in a format for watershed professionals (such as a NC Cooperative Extension fact sheet).

Amended Black Creek Watershed Management Plan

Hydrology monitoring and modeling were undertaken with the intention of honing runoff reduction goals for the watershed plan. In addition, a GIS study was undertaken by a BCWA member that explored new potential benchmarks for measuring improvements in the watershed.

Hydrologic Monitoring and Modeling:

Streamflow monitoring was conducted over the course of two years in both the 2,100-acre Black Creek watershed and the smaller 84-acre residential watershed (Wessex neighborhood) targeted for effective impervious cover reduction. For the residential watershed, event-based stormwater flows and volumes

were simulated using HEC-HMS to determine stormwater reductions under given effective impervious cover scenarios (see Appendix 1).

Monitoring results provided a watershed characterization of streamflows given certain rainfall events while also allowing for the calibration of the watershed model under existing impervious cover conditions. Using measurements of rainfall and streamflow data, runoff coefficients – or the percentage of rainfall that becomes runoff – were determined for Although highly variable due to storm event characteristics, seasonality, and antecedent moisture conditions (e.g number of days since prior rainfall), the average runoff coefficient over two years (March 2010 to February 2012) for Black Creek was 0.30 (or 30% of the rainfall was seen as stream flow), which is typical for highly urbanized watersheds. In contrast, the average runoff coefficient over one-and-a-half years (November 2010 to February 2012) for the residential subwatershed was 0.57 (or 57% of the rainfall was seen as discharge), a very high coefficient indicating that the neighborhood was a good target for the disconnection program.

Simulation results from watershed models indicated that if the proposed downspout disconnection campaign led to a removal of 1.72 acres (75,000 sq. ft.) of effective impervious cover in the residential neighborhood, resulting in 17 acres of total effective impervious cover (reduced from 22.3% to 20.2% of the 84-acre watershed area), and based on a one-inch rain event, peak flow would be reduced from 13.3 cfs to 12.0 cfs, and 45,236 gallons of stormwater from one storm would be managed prior to entering Black Creek. However, if a more aggressive campaign were to reduce the effective impervious cover to 10% (or 8.4 acres total remaining effective impervious cover in the subwatershed), then the peak flow for the same one-inch rainfall scenario would decrease from 13.3 cfs to 5.9 cfs – a very significant reduction - and a total of 226,180 gallons of water would be kept from entering Black Creek. The watershed modeling exercise provided estimates based on the simulated conversion of effective impervious cover to forested and/or grassed landscapes based on expected hydrologic processes, thus possibly over-predicting volume reduction. As a result, stormwater reduction could be further limited by the actual design and as-built capacities of individual stormwater control measures within the watershed.

While the 84-acre Wessex subwatershed only encompasses approximately 4% of the total 2,100-acre land area of the Black Creek watershed land area, HEC-HMS simulation results based on existing topography, soils, and land use/land cover along with scenarios of reduced effective impervious cover provided guidance as to how much stormwater flow and volume may be reduced from a given storm event before entering Black Creek. The results do not give direct indication of water quality benefits; however, it is expected that the significant reduction of overall peak flows would reduce potential bank erosion, water quality impairment including sediment loading, and degradation of aquatic habitat. Furthermore, simulations were not conducted for highly impervious areas such commercial or major roadway land uses. Simulation results do reveal how much impervious cover area reduction would be required to achieve effective downspout disconnection for water quantity management based on rainfall and subsequent discharge at the residential/neighborhood subwatershed scale.

Further work must be conducted to determine any hydrographic benefits from impervious cover disconnection at the larger Black Creek watershed scale, including efforts to expand monitoring and

modeling to other subwatersheds with different land uses, stormwater infrastructure, and impervious cover percentages in the Black Creek watershed. Further research is also needed to explore the connection between stormwater peak flow and volume reduction, water quality, and aquatic habitat improvements. The ability to scale between the smaller subwatersheds and the larger Black Creek watershed allows for identification of future impervious cover reduction target areas not only based on citizen willingness to participate and the availability of retrofit opportunities within the landscape, but also the overall capacity for stormwater reduction in Black Creek.

GIS Study:

A GIS analysis prioritized subwatersheds for restoration, and developed a potential stormwater retrofit goal. Six subwatersheds of Black Creek were prioritized based on impervious cover, state of riparian corridor (percent forested), and stormwater outfalls located within the riparian buffer. Not surprisingly, the 2 headwater drainage areas, located in downtown Cary, ranked highest priority, with East upper subwatershed as the highest. The analysis determined the amount of of connected, or "effective", impervious cover in each of the subwatersheds. Effective impervious cover (also called "legacy" impervious cover) was the impervious cover created (developed) before the Neuse Stormwater Rules were implemented in the watershed. The analysis revealed that in order to meet an impervious cover goal of 10%, which corresponds with known thresholds for unimpacted stream quality, approximately 252 acres of impervious surface in the watershed needs to be disconnected from the stream system. This is a new potential goal for the Black Creek watershed restoration efforts.

Changes to the watershed plan:

The only change to the watershed plan that resulted from this project was to incorporate and test the new potential goal of disconnecting enough effective impervious cover to reach the threshold of 10% impervious cover. While this would require the ambitious goal of disconnecting 252 acres throughout the watershed, the project team recommends approaching this target incrementally. Ideally, future work would attempt to target retrofits in one subcatchment, and to monitor hydrologic changes and potential resulting improvements in the benthic macro-invertebrate populations that may occur as a result. A return to pristine conditions may not be feasible or possible in this highly developed watershed. Future work could identify a more realistic restoration goal, which could possibly be achieved at a level higher than 10% effective impervious cover.

6. Methodology and Execution

Residential "Less Rain Down the Drain" campaign

The team intended to target one small subcatchment (called the Wessex tributary) for installing residential retro-fits, for the purpose of concentrating the stormwater reductions there and attempting to monitor actual changes in the tributary as a result of retrofits.

The methods of the campaign included the following:

- Held a campaign "kick-off" event in conjunction with a ribbon cutting for the first public bioretention installation at West Cary Middle School. NCSU staff asked the Neuse River Keeper to invite Alexandra Cousteau to speak at the ribbon cutting when it was learned she would be in town. Local elected officials also attended and spoke at the event. National Geographic Society featured the event on their Freshwater website as Alexandra Cousteau's "Blue Shot of the Day" blog post.
- Provided presentations about Black Creek, its issues, and solutions to annual Homeowner Association meetings in the targeted area of the watershed
- Mailed and emailed invitations to community workshops (with assistance from Homeowner Associations – several BCWA members are also on their HOA Boards and have access to listserves)
- Held community workshops to educate participants about Black Creek, its issues, and solutions
- Conducted a mapping "charette" exercise at one workshop to identify locations for potential retrofits on participants' and their neighbors' properties
- Provided workshop participants a fact sheet describing a series of actions that could be taken on their property to reduce runoff, which we called "Rainscapes"
- Provided Rainscape applications to residents who wanted to have "stormwater audits"
- Trained a BCWA member to help conduct stormwater audits
- Conducted 20 stormwater audits of residential properties to assess for opportunities to install Rainscapes
- Designed rain gardens for residents who were willing to install them
- Provided residents with varying levels of assistance in rain garden installation based on their individual needs
- Some rain gardenswere installed by the NCSU team, BCWA members, volunteers, and/or a contractor
- Some rain gardens were installed by homeowners themselves after being provided a design, advice, and planting lists.
- All participating residents received guidance on how to maintain the rain gardens
- Advertised a rain barrel sale online for highly subsidized rain barrels. Four rain barrels were sold and installed (1 installed by NCSU staff with a teen volunteer, the rest by the homeowners).

Public retrofits

The NCSU project team worked with the BCWA to identify potential public retrofits. A project atlas of potential projects was developed, and included ideas for BMPs at Town of Cary properties (Town Hall campus, North Cary Park, Godbold Park), schools (West Cary Middle School, Northwoods Elementary School, Kingswood Elementary School), and a fire station. A high priority site was Town Hall's campus, as large parking lots drain directly into a tributary with no stormwater treatment. However, a new road slated for construction in the area left too much uncertainty around that project. The BCWA also strongly preferred to work on a school campus in order to meet multiple benefits of runoff reduction, schoolchildren and parent education, and publicity.

We worked closely with Wake County Schools Public Facilities and campus staff at West Cary Middle School and Northwoods Elementary School to address concerns regarding safety and maintenance. For example, WCPSS preferred not to use flowering bushes that were likely to attract bees. NCSU Department of Horticulture Professor Anne Spafford donated her time and engaged her students (not officially counted as match for this project) to create attractive planting designs for the school bioretention areas. NCSU students gained valuable experience in designing rain gardens and working with "clients" to meet their interests. Two bioretention areas were installed at West Cary Middle School, and the ribbon cutting event for the school was used as an opportunity to raise public awareness of the Black Creek project.

Figure 10 Alexandra Cousteau drew a large crowd for the ribbon-cuting event (shown with West Cary Middle students and vice principal)

The third bioretention at Northwoods Elementary enjoyed strong involvement from the PTA. They helped review the designs, and recruited parents to help plant the bioretention area. The support for this bioretention area appears to be quite strong among parents, so it is believed that maintenance may go more smoothly at this site. Support was high among teachers and staff at West Cary Middle School, but there was very little parent involvement. It's more likely that parents will be taking time to maintain as volunteers rather than teachers, so engaging the PTA is model that may make sense to follow in the future.

Hydrology Monitoring and modeling

See appendix with Final Report for methods, execution, and results of the hydrology monitoring and modeling effort.

7. Outputs and results

See section 4 “Deliverables” for a complete and detailed explanation of all results, Deliverables are listed here also. Any changes in the expected results are listed here.

1.Periodic meetings of the BCWA to plan outreach and education activities, provide guidance on site selections, and BMP designs

2.Periodic newsletters to inform community of efforts and recruit participants

3.BCWA website updated regularly, with access to maps, reports and educational materials

4.At least 3 community workshops, including a mapping charette to identify potential retro-fit opportunities in the targeted drainage area (s). Six community workshops were held.

5.Educational materials published to increase awareness of the Disconnect Campaign

6.1-2 annual stream clean-ups

7.Three LID retro-fits on public properties, could include Town of Cary facilities, Wake County Schools, fire stations, or private schools. Four LID retro-fits were actually installed, including two large bioretention projects at West Cary Middle School, one large bioretention project at Northwoods Elementary School, and a cistern at Cary Fire Station #1 .

8.12 residential LID retro-fits, could include rain gardens, native plantings to replace lawn or dirt areas, rainbarrels, pocket wetlands (could include larger but fewer LID retro-fits on HOA right of way). The final count of residential retro-fits was 18 retro-fits.

9.Watershed resident & greenway user preliminary draft survey plan.

10.Amended Black Creek Watershed Management Plan.

Mandatory DWQ/EPA reporting requirements

9. Outcomes and Conclusions

The methods used were successful in raising awareness and interest in residential retrofits, and installing residential and public retrofits. Each workshop had between 12-20 participants and resulted in several asking for stormwater audits. Participants expressed interest in changing their landscaping practices to reduce runoff, and many of them worked with us to implement those changes. Some who did not ask for stormwater audits indicated that they intended to make changes on their own. The project did increase demand for rain gardens in particular, and resulted in several residential rain gardens being installed (as well as rain barrels and a backyard wetland). Homeowners required varying levels of assistance in designing and installing rain gardens. All needed help of some kind- in particular design and plant selections, and some needed installation services. This project revealed a need for turn-key rain garden design and installation services to meet this growing demand, and to make the

installation of rain gardens an easy activity. It became apparent throughout the project that there is a lack of local capacity of landscaping professionals to provide this service. Continued progress in watershed restoration will require these professionals to offer these types of services to their clientele in the watershed.

The project originally intended to target our residential retrofits in one subcatchment to try to concentrate the impacts of these retrofits on one tributary, and possibly monitor changes as a result. We targeted our outreach efforts to two neighborhoods that are both partially located in the subcatchment- Wessex and Beechtree neighborhoods. Both HOA Boards were receptive to working on the issues. However, while the first community workshop did bring out a handful of people who lived in the subcatchment, three subsequently decided not to participate. Hence, a wider net was cast for participants. Many people were interested in the two target *neighborhoods*, but few of them actually lived in the target *subcatchment*. So as a results, measuring actual changes in the hydrology based on retrofits in the ground was not possible. Instead, we measured stream flow in that subcatchment to accurately validate a hydrology model, and then modeled the potential impact of installing all of our projects in that subcatchment, as well as other scenarios. GIS analysis undertaken by a BCWA member also identified a new potential goal of removing 252 acres of effective (connected directly to the stream system) impervious cover in order to reach an unimpacted watershed state.

Regarding public stormwater retrofits, the team found that administrators and teachers at local schools were enthusiastic about participating in retrofits to meet interests of aesthetic improvements and opportunities for outdoor classrooms. The Wake County Public School System served as a willing, but cautious partner. It was necessary to work closely with the WCPSS facilities administrators to complete the design and acquire official approvals for projects. WCPSS made it clear that they are not taking on any liability for problems encountered when doing stormwater retrofits on their properties, or increased maintenance costs, as they indicated that their budget could not support it. As a result, when an unexpected obstacle was encountered (geothermal pipes under a site that were not identified during the planning or design review), the unexpected repair expense fell to this grant. Having learned from this experience, the project team requested to the PTA that they submit the future request for a desired cistern, so that any unexpected expenses for that project (to be installed in 2013) would not default to NC State University.

In conclusion, the efforts undertaken during this grant period to educate and engage the residential and school communities in stormwater retrofits was highly successful in prompting participation and action. The only limitations on how many projects could be installed were the resources available. A residential survey and the project team's direct experience revealed that once watershed residents were educated about Black Creek's issues and how they could be involved in potential solutions, most were willing to participate if provided with the technical (and sometimes financial) assistance to do so. The resources needed to continue the installation of residential retrofits include an increased local capacity for landscaping companies to provide turn-key rain garden design and installation, financial resources to subsidize those services, and staff time and resources for educating homeowners about opportunities to help improve Black Creek.

10. Budget

	Federal request	Matching funds
Budgeted in contract	$195,985	$135,861
Actual expenditures	$195,256.08	$166,544.75
Difference	$728.92	($30,683.75)

11. References

Center for Watershed Protection. 2010. Impervious Cover TMDL Field Survey & Analysis Report. University of Connecticut

Horvath, Elena. 2011. Using GIS for Prioritization in Subwatershed Restoration. Submitted to The Pennsylvania State University for Master in Geographic Information System. November 28, 2011

NC Division of Water Quality. Basinwide Planning Program: Neuse River Basinwide Water Quality Plan – Chapter Two. 2009.

NC State University. Black Creek Watershed Assessment, Monitoring, & Planning. EPA319 Grant Final Report & Watershed Plan. June 2009

Watershed Education for Communities and Officials (WECO) website contains all reports, meeting summaries, technical presentations of the Black Creek Watershed Association: www.ncsu.edu/WECO/blackcreek

12. Appendices

Hydrology monitoring and modeling report
Notice of West Cary Middle School Ribbon Cutting
Rainscapes fact sheet
Rainscapes Application
Rainscape Audit Form
Black Creek Watershed Wires