Fecal Analysis of the Goose Creek Watershed in Mecklenburg County North Carolina

By
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Abstract

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The Goose Creek Watershed is located in Southeastern Mecklenburg County and is found almost entirely within the town limits or extraterritorial jurisdiction of Mint Hill. This specific watershed has been designated a habitat for the federally listed, critically endangered Carolina Heelsplitter Mussel. This designation has brought about the implementation of a Site Specific Management Plan and the municipalities in the watershed were also required to develop a Water Quality Recovery Program for Fecal Coliform, which was the result of a Fecal Coliform TMDL(Total Maximum Daily Load).

During the implementation of the local Water Quality Recovery Plan for Goose Creek, the level of Fecal Coliform Bacteria tapered off, resulting in Goose Creek being removed from a TMDL. The resulting drop in Fecal Bacteria also correlated directly with The Great Recession and stoppage of literally every construction project in the watershed. As the economy has improved, it has driven an increase in development once again. Sediment levels have started to increase in the watershed, and new septic systems are being installed on a dynamic subsurface that straddles two distinctly different underlying substrates. The possible combination of these factors has once again led to an increase in Fecal levels in the watershed. My investigation is focused on the sediments creating a Fecal Bacteria reservoir within the stream, allowing the bacteria to propagate within the waters, instead of actually being added by a non point source. The geological composition of the underlying soils may also be allowing for a short circuit of the septic system, allowing Fecal latent water to flow through rock fissures directly adding to water recharge of the stream.

Biography

Jason Klingler is a graduate of Ohio University located in Athens, Ohio. He completed his Bachelor of Science in Geography-Environmental Pre-law in the Spring of 2000. During his college tenure in 1998 and 1999 he interned with the Ohio Environmental Protection Agency's Southwest District Office in Dayton , Ohio. His major areas of responsibility included the implementation of the General NPDES permit for construction activities in a 7 county area in Southwest Ohio. His professional career began with the Pelham, NY based Sanborn Map Company, the oldest mapping company in the Unites States. His specializations were in environmental mapping and municipal map applications. Jason began his career with Mecklenburg County in July of 2006. His major areas of focus now are implementation of the Town of Mint Hill's municipal NPDES permit. This includes all facets of the NPDES permit, including sediment and erosion control. Having walked the entire Mecklenburg County portion of the Goose Creek watershed every year, he is knowledgeable in all areas of the watershed.

Acknowledgements

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INTRODUCTION

HISTORY

The preservation of Mecklenburg County's waterways has been an effort that started over 30 years ago. What has morphed from a simple plan to make the streams in the county smell better is now a plan to ensure that over 80 percent of the streams in the county are safe for human contact. As the program has progressed so have governmental requirements that must be met in order to achieve not only the program goal, but to be in compliance with both state and federal regulations. Requirements have morphed from simply monitoring the watershed, to implementation of undisturbed buffers and threshold limits in the amount of Fecal Bacteria found in the watershed. In Mecklenburg County the two greatest pollutants of concern in the streams are Fecal Coliform Bacteria and sediment. This study addresses these pollutants in the Goose Creek Watershed.

Fecal Bacteria are used to determine the possible presence of organisms that are pathogenic to humans. Fecal Bacteria originate in the gut of animals, and thus are found in the released feces, which also contain bacteria, viruses and protozoa that can cause a vast array of intestinal illness(Alm et Al, 2003). Currently, only surface water counts of these bacteria are measured by water quality agencies, as a measurement of Fecal Bacteria in the water column. However, studies have shown that, "The association of Fecal Bacteria with re-suspendable bottom sediments is not considered. Bacteria adherence and deposition to stream bottoms have revealed that sediment counts at base flow conditions are hundreds to thousands times greater than levels in the overlying water(Jolley et Al, 2008)". Therefore, Fecal Bacteria in stream bed sediments may play a major role in contributing Fecal Bacteria to stream Fecal assessments.

BACKGROUND

The Goose Creek watershed was chosen primarily for one reason. The watershed has the distinction of being home to one of the last few populations of the critically endangered Carolina Heelsplitter *(Lasmigona decorata)*. Appendix 1 shows the current and historical range of the Carolina Heelsplitter. The Carolina Heelsplitter was placed on the list of Federally Endangered Species by the United States Fish and Wildlife Service on June 30th, 1993(U.S.F.W.S. 1993). With its placement on the list of endangered species, a federal recovery plan was created to help the Carolina Heelsplitter survive and repopulate. Coupled with the federal program, the creation of a TMDL was submitted and approved by the U.S. EPA, in July of 2005. Soon thereafter, the North Carolina Department of Environment and Natural Resources required local municipalities to create a Watershed Recovery Program(NCDENR 2006).

The MCWQP(Mecklenburg County Water Quality Program) took the lead on implementing the Water Quality Recovery Program(WQRP) and the Goose Creek Site Specific Watershed Management Plan(GCSSWMP). Both of these plans were different in their requirements, but they ultimately had the same goals of pollutant reduction within the watershed. The WQRP's aim was to improve pollutant removal through the implementation of the Goose Creek watershed TMDL, and specific water quality pollutant targets. The State's GCSSWMP requirements were to implement laws passed as preventative measures to keep the watershed from being exposed to the pollutants through buffer implantations and development guidelines. The different approach of these two plans is invaluable in restoring clean water to the watershed.

The WQRP was an intensive, boots on the ground approach to pollutant reduction and water quality improvement in the watershed. The main goal is the sourcing and identification of Fecal Bacteria and its elimination. The level of reduction specified in the WQRP is a goal not to exceed a geometric mean of 200colonies/100 mL(membrane filter count method) based on five consecutive samples examined during any 30 day period or 400 colonies/100 mL not to exceed in 20 percent of the samples taken during such period (Mecklenburg County Water Quality Program, 2009). Table 1 shows the range of samples taken at the beginning of the WQRP.

Table 1: Base flow Fecal Coliform sample results-2006

Pollutant	Action Level	Sample Size	MIN	MAX	MEAN	MEDIAN	% Samples Over Action Level
Fecal Coliform	200cfu/100mL	63	1	58000	2398	500	82%

Implementation of the GCSSWMP required staff to conduct stream walks, outfall identification, ambient in-stream Fecal sampling, and pollutant source identification and elimination. In addition, septic system inspections were conducted by staff in another department. Although half the residences in the watershed are on septic systems, the results of these inspections found twelve failures among 1,422 systems(Mecklenburg County Groundwater Services, 2011). It is assumed that these have little to no impact on Fecal contribution to the streams.

The implementation of the WQRP improved water quality in the Mecklenburg County portion of Goose Creek, to levels that allowed this section to be suspended from the WQRP. Results from the WQRP, performed by the MCWQP showed results had dipped to below the threshold limits of 200 and 400 Fecal colonies per 100 mL/water. However, in additional sections in Union County the plan did not result in the same level of Fecal reduction. The levels of Fecal Coliform were found to be above the threshold, 44 percent of the time in the lower sections. Major progress in Fecal reduction had occurred and this area was also suspended from the program. **Table 2** shows the 53 percent reduction in Fecal Coliform Bacteria that led to the suspension of the WQRP.

Table 2: Base flow Fecal Coliform sample results-2010

Pollutant	**Action Level**	**Sample Size**	**MIN**	**MAX**	**MEAN**	**MEDIAN**	**% Samples Over Action Level**
Fecal Coliform	200cfu/100mL	36	120	900	526	485	44%

In late 2011 the Fecal numbers for this suspended section of Goose Creek had started to rise again. The mean samples collected had started to creep steadily up, consistently being over the thresholds that were established. Installation of post construction BMP's, enhanced erosion control measures and strict buffer guidelines were passed for implemented on all future development in 2009, but no new projects had occurred. These buffer rules created 200 foot undisturbed buffers on all FEMA regulated streams, and 100 foot buffers on all other perennial and intermittent streams. However, the results of the Fecal sampling from 2010-2011 have shown a sharp upward trend in Fecal loads in the stream. Furthermore, the correlation that one would expect of increased bacteria with increased flow is not apparent in the Mecklenburg reach of Goose Creek. Many of the higher concentrations sampled occurred when base flow conditions were not storm water impacted. The extensive nature of the WQRP was successful in removing land based pollutant sources. However, data indicates that the Fecal levels in the Goose Creek watershed tended to remain constant, and the land based sources do not contribute as much Fecal Bacteria to the streams as originally hypothesized. In-stream concentrations of Fecal Coliform tend to be lowest during periods of higher base flow. The increase may be due to existing sources of Fecal Bacteria being diluted by higher base flow(MCWQP, 2009).

STREAM CHARACTERISTICS

With land based sources of Fecal Coliform Bacteria revealed, additional study on the in-stream properties of Goose Creek are necessary. The levels of the Fecal Bacteria are highest at base flow levels, therefore analysis of the question, "Are in-stream sediments allowing the Fecal Bacteria to propagate, thereby causing the in-stream sediments to be the Fecal Bacteria non-point source?". Fecal Bacteria associated with bottom sediments can be re-suspended and transported with the sediments when the sediments are disturbed by rain events or a variety of other water related activities(Jolley et Al.). Simple water flow can agitate the bottom sediments and cause a spike in the Fecal Bacteria attached to the sediments. Aside from attaching to the sediment, sediments provide a hospitable incubation zone for the attached Fecal Bacteria. Fecal Bacteria have been demonstrated to live longer than other bacteria in overlying water(Howell, 1996). Even when the bacteria are not in the water column, Davies et al. showed that sediments provide a more nutrient rich environment to support growth of bacteria.

Recently, the construction in the Goose Creek Watershed has increased and associated levels of Fecal Bacteria have also risen. With the implementation success of the WQRP and its recent suspension, the source of the increased Fecal Bacteria needs to be found. Departmental attention was focused on finding land based non-point source Fecal pollutants. Repair of failing septic systems, reduction and elimination of sewer overflows, in-stream livestock input has been implemented. However, concentrations of Fecal Coliform are still high enough to warrant additional studies.

Basis for this study is to determine if an increase in Fecal Bacteria can be attributed to bacteria propagating within the in-stream sediment. Do the in-stream sediments act as a reservoir for Fecal Bacteria? Sediments have several factors that attribute to longer survival and growth rates for Fecal Bacteria while attached. Sediment size, composition, temperature, nutrients and predatory protections offer ideal conditions for bacteria to grow(Sherer et al, 1992), allowing the sediment to be considered as a non-point source for the Fecal Bacteria. Part of this Goose Creek assessment will involve analyzing the stream catchments in Mecklenburg County, to determine composition of the stream channel substrate. Different types of underlying channels would provide different sediment types for the bacteria. The goal of this study will be to evaluate the concentration of Fecal Coliform Bacteria, and to determine if the stream channel substrate and quantity of sediments are contributing to the increase in elevated Fecal numbers in the stream. In addition, the study hopes to identify if the type of sediments impact the propagation of the Fecal Coliform Bacteria, therefore causing the numbers to increase without an actual introduction of Fecal Coliform Bacteria itself.

METHODS OF STUDY

STUDY AREA

The Goose Creek headwaters originate in Mecklenburg County. The headwaters comprise two sub-basins that include Goose and Duck Creeks in the Southeast Corner of Mecklenburg County, in the Town of Mint Hill**(Appendix 1).** The community of Mint Hill encompassing the Goose Creek Watershed is comprised of rural residential, vacant land, low density, medium density and transportation corridors, with the dominant land use of rural residential, as shown in **Table 3.**

Table 3: General Goose Creek Background

Estimated Goose Creek Watershed Population	5616	
Goose Creek Watershed Area	6975 acres	
Stream Miles (Draining > 50 acres)	28 miles	
	Rural Residential	34%
	Vacant	31%
	Low Density Residential	11%

Dominant Land Uses	Medium/Low Density Residential	9%
	Transportation	8%
Major Political Jurisdictions	Town of Mint Hill	
Major Streams in the Goose Creek Watershed	Goose Creek	
	Duck Creek	
	Stevens Creek	

*Table provided by MCWQP, 2009

This study will focus on a catchment of the Goose Creek Basin with mixed land uses that contain sediment laden water, non-impacted, riparian buffered water and residential runoff. Analyzing these water types will assist in the assessment of what role the sediments play in acting as a non-point source pollutant source for Fecal Bacteria.

The North Carolina Department of Environment and Natural Resources classify soils in this region as what shallow, moderately draining, clayey red to orange sub-soils, with an erodability K factor of .16 to .28(NCDENR, 2000). Although this soil type is the primary soil type in this region, pockets of sandy soils are found in the basin and underlying many of these area are outcroppings of slate. In some areas, the slate outcroppings break the surface and are barely covered.

STUDY DESIGN-STEP ONE

In order to narrow down the catchments to study, a baseline Fecal Bacteria assessment of the entire Mecklenburg County watershed of Goose Creek was performed. Non-impacted baseline flows provide Fecal Bacteria numbers that are present in the stream, without the possible impact of Fecal laden storm water. The survival of Fecal Bacteria once released in the aquatic environment, is determined by numerous environmental factors including temperature variation, salinity, oxygen levels, nutrient deficiencies, predation, and Ultraviolet

Irradiation(McFeters and Singh, 1991). The baseline watershed sample points can be found on **Appendix 2.** Across the entire Mecklenburg County Goose Creek watershed, Fecal Coliform ambient sampling ranged from a low of 56 to a high of 4200 colonies per 100/mL of water. The mean for all the samples collected was a 1042, well above the state establish threshold of 400.

Fecal Bacteria sampling protocols will be followed using field grab sampling methods as provided by the Mecklenburg County QAPP manual, which are based on the USEPA guidelines. Each sample will consist of a chain of custody(Appendix 5), one, 100 mL (sterile, $Na_2S_2O_3$ preservative) Fecal Coliform sample bottle, one waterproof pre-designed sample bottle label. . Samples of Fecal Coliform Bacteria will be collected at each location. Quality Assurance procedures will be followed to include field blanks.

Field blank collection will be used as the following Mecklenburg County procedure. A QC blank will be filled at the first site with a bottle of lab sterilized buffer blank solution (for bacteriological parameters) for each blank sample set sent to the lab that day. The buffer blank solution will be poured into a Fecal bottle as mentioned earlier and stored for a holding time of no more than 6 hours on a sterile iced environment(Mecklenburg County QAPP, 2007).

Once the blank has been collected at the first site the collection of the bacteriological samples may begin. The following procedure will be used. Carefully open the sterile sample collection bottle cap using your thumb and forefinger to grip the cap tab. Hands should be covered in Nitrile gloves to protect both you and the integrity of the sample from cross contamination. Be sure not to contact any inside surface of the bottle cap or the bottle during the opening procedure. Holding the bottle so that no contact is made with any inside surface of the bottle or cap, tilt the base of the bottle down at approximately 45° angle. Dip the bottle mouth, submerged, upstream from where you are standing. Submerge until the bottle is full to the indicated 100mL volume. Hold the filled bottle upright and replace the cap. Using the hand-held temperature probe, measure the water temperature directly from the surface water source, not from the sample collection bottle. Record the water temperature on the appropriate lab COC form. Place all sample collection bottles (and blanks) upright in the cooler. Do not submerge sample bottles in ice-melt water. Complete the COC. Deliver all sample bottles in the cooler on ice to the CMU Lab for analysis. Submit a copy of the completed COC form(Mecklenburg County QAPP, 2007).

Once the samples are at the lab, strict Fecal Bacteria sample guidelines will be employed. The USEPA has strict protocols for Fecal Bacteria sampling. The Charlotte Mecklenburg Utilities(CMU) lab employs theses USEPA Standards. The CMU method to test for the Fecal Bacteria will be the Membrane Filtration Method. As this method is lab based, this procedure method can be found in Attachment 1, Membrane Filtration Using membrane-Enterococcus-Esculin Iron Agar(USEPA, 2002).

To go along with the non-impacted baseline Fecal sampling, a thorough walking geomorphogical assessment was performed. This assessment provided locations of physical change in the streambed, bank characteristics, in stream sediment types and vegetation coverage in the Mecklenburg County Watershed portion of Goose Creek. The purpose of this assessment was to locate where the underlying rock metamorphosis occurs from traditional slate belt characteristics, to typical piedmont based stream channel. Identifying these characteristics, will allow us to see if Fecal Bacteria may be introduced through the short circuiting of septic system drain fields. Drain field identification close to the stream will be observed to check for any possible influx into the stream itself.

Each catchment of stream that falls in the Goose Creek watershed within Mecklenburg County was assessed. Identification of changes in streambed types are documented on a GPS and pictures are taken recording the type of change and variation identified. Specific soil types were not recorded, only changes in streambed geomorphology. The majority of the soils in the Goose Creek watershed are a Sandy Clay Loam surface, with a subsoil of Clay and Clay

Loam(NCDENR, 2000). Major changes in underlying substrate are identified in Appendix 6. A major change from a soils based stream channel, to one of underlying slate rock formations that jettison to the surface and make up the stream bed channel occur in some areas.

The stream was divided into 6 areas for classification and analysis. Area A was the first section of stream that was assessed. This section, starts at the southern border of Mecklenburg and Union Counties, and stretches northward. As Figure 1 shows the underlying streambed consisted of large slate rock. This pattern of rock was consistent up into the surrounding underlying soils. The topsoil created a 2-4 foot layer over the slate rock formations through the first 2/3 of the assessment. Figure1 depicts the initial rock formations based towards the southern edge of Mecklenburg County.

Figure 1 : Large Slate rock formations within streambed.

In the more northern southern portions of Mecklenburg County, a slow and steady conversion of a different type of stream bed was observed. The slate rock formations gave way to a more flat and wider based stream. The substrate was no longer underlined by a thick slate formation, but more compacted soils with sand and gravel on top.

Figure 2: Northern Section of Goose Creek

Area D had some of the most distinguishable changes in the stream bed substrate of any of the areas in the watershed. The substrate started out at the Mecklenburg/Union County line as a complete layer of slate, with fractured rock and cobble. The sides of the stream bed were stable and no large scale in stream channel erosion was occurring. This area was slightly developed, with a minimal influx of residential storm water runoff. Figure 3, below, show the hard pan slate stream bottom that was found in the Area D.

Figure 3: Streambed of hard rock

The stream bed substrate in area D, was consistent until approaching area a mile north of Stevens Mill Road in Mecklenburg County, when there were some major underlying streambed changes. In this Area of Goose Creek the substrate and channel changed to pebbles, gravel and sediment, without the underlying rock layer. The stream banks quickly became eroded and the channel became very narrow-fast. This area was also served by very little residential storm water runoff, that would impact the stream.

Figure 4: Stream Channel substrate change, Erosion and Narrowing.

STUDY DESIGN-STEP TWO

The next step is going to determine how much bacteria are filtered out of the water when using a 20 micron filter to remove the sediment from the water. This testing phase is a general test to give us a baseline starting point, establishing a percentage removal by the filtration process, to observe the amount of Fecal Bacteria introduced to the stream through sediment laden storm water. The sample point in this process that was used is MY9(Appendix 3). MY9 is Mecklenburg County's main sample point for Goose Creek. It is where the confluence of all tributaries of Goose Creek have come together and are leaving the county boundary. Our sample filtration sampling will be performed by a rain impacted event. Classification of a rain impacted event is a rainfall of 1/10th of an inch or greater, at any time over a 24 hour period. The hypothesis behind the filtration of the sediments are to see the percentage of bacteria attached to sediments coming into the stream from sediment storm water runoff. Bacteria already in the stream and not attached to sediments, will not be removed, giving us a baseline percentage of bacteria already established in the stream. As growth in Goose Creek is very minute at the present time, the influx of sediments is not high.

Our grab sample will be done using a one gallon sterile Nalgene bottle. Our sample will be grabbed from the thalweg of the stream, to get a uniform sample of water. The sample will be iced and taken to the Hal Marshall Lab for preparation. A blank will be run through the filtration process and used in the non filtration sample, following the procedures mentioned above. The one gallon Nalgene bottle will be agitated to ensure even distribution of bacteria and sediment. Once the grab sample has been agitated, 8 filtered and 8 unfiltered samples will be distributed from the grab. One hundred milliliters will be poured into the top of a Nalgene Easy Flow sample bottle, with a 20 micron filter, 100 mL collection bottle(**Figure 5**) .

A Nalgene PVC hand vacuum pump(**Figure 5**) will be attached and used to pull the water through. The sample will be sealed and put on ice. A non-filtration sample will also be collected and put on ice. The samples will be iced and taken to the CMU lab for Membrane Filtration Method to determine the number of Fecal Bacteria colonies per 100/mL of water.

Figure 6: Nalgene Easy Flow Sample Bottle and Hand Vacuum Pump

STUDY DESIGN-STEP THREE

Goose Creek presents itself as an interesting case study since part of the watershed is developed, other parts are not developed and heavily wooded, and other parts are in a transition, undergoing small amounts of active development. The objective is to close in with a more detailed sampling to isolate a small area of Goose Creek that has all of the above mentioned characteristics. To achieve this, 17 points(Appendix 2) were selected in the watershed that were fed by several tributaries of varying land uses. We will be looking for catchments of Goose Creek which have elevated counts of Fecal Bacteria and focus intensive filtration studies on that catchment, These 17 points were collected during storm water impacted events throughout the watershed.

The samples were collected using the standard grab method mentioned above. Each sample was collected in a 100 mL sterile Nalgene nylon bottle, preserved with $Na_2S_2O_3$. The samples were then cooled on ice and taken to the CMU lab within a period of six hours, where Membrane Filtration was used to determine the number of Fecal Bacteria colonies per 100/mL of water. This storm water impacted event testing was performed 3 times to determine the catchment that had the unique characteristics to study.

STUDY DESIGN-STEP FOUR

The Catchment that was selected is unique in that it provided all of the characteristics that Goose Creek possesses-heavily buffered, residential, pasture, livestock pasture and active construction. (**Appendix 4**). The sampling was performed between February 2013 until August 2013. Daily air temperatures ranged from 41 degrees to 88 degrees Fahrenheit.

The first step in the process is to get a baseline set of Fecal Bacteria counts within this catchment. This baseline set of samples will be non-impacted by storm water events. These will be used in a comparison to the storm water collected samples. At each of the five sample points in the catchment(A,B,C,D,E), samples will be non-storm water impacted samples. The sample points can be found in the Appendix 4 map. There is no prescribed EPA protocol, nor does MCWQP have a protocol set up for this type of sampling. A mix of MCWQP grab sampling protocol, including blanks and the use of EPA Fecal Bacteria Membrane Filtration will be used to determine results. At each sample point, two, sterile, 200 mL unpreserved bottles will be used for grab samples. The samples will then be placed on ice and brought back to the Hal Marshall MCWQP Lab. A total of 10 samples will be collected from the 5 sample points. At the lab, 6 Nalgene Easy Flow filtration bottles were set up. A blank will be run through the filtration process and used in the non filtration sample. The non-filtration sample will be poured directly into the sterile 100 mL, $Na_2S_2O_3$ preserved bottle. Each of the 5 grab samples were agitated and then 100 mL will be poured into the top of a Nalgene Easy Flow sample bottle, with a 20 micron filter, and 100 mL collection bottle(**Figure 5**) . A Nalgene PVC hand vacuum pump will be attached and used to pull the water through. The sample will be sealed and put on ice. A non-filtration sample will poured from the remaining water into a preserved 100mL Fecal sample bottle and put on ice. Each sample site will be labeled as Filtered A or Unfiltered A, corresponding to the sample site. The samples will be iced and taken to the CMU lab for Membrane Filtration. A method used to determine Fecal Bacteria colonies per 100/ mL of water.

A repeat process will be done for the same sample points in the catchment except they will be storm water impacted samples. On the Appendix 4 map, each sample point will have two samples collected at the same spot. One will be a filtered and one will be unfiltered. A mix of MCWQP grab sampling protocol and EPA Fecal Bacteria Membrane Filtration will be used to determine results. At each sample point, one, sterile, 200 mL unpreserved bottle will be used for grab samples. The samples will then be placed on ice and brought back to the Hal Marshall MCWQP lab. A total of 10 samples will be collected.

At the lab, 6 Nalgene Easy Flow filtration bottles were set up. A blank will be run through the filtration process and used in the non filtration sample. The non-filtration blank will be poured directly into the sterile 100 mL, $Na_2S_2O_3$ preserved bottle. Each of the 5 grab samples were agitated and then 100 mL will be poured in to the top of a Nalgene Easy Flow sample bottle, with a 10 micron filter, 100 mL collection bottle(**Picture 6**) . A Nalgene PVC hand vacuum pump will be attached and used to pull the water through. The sample will be sealed and put on ice. A non-filtration sample will also be collected and put on ice. The non-filtration sample will be poured directly into Fecal bottle and placed on ice. The samples will be iced and taken to the CMU lab where they will undergo the Membrane Filtration, a method to determine Fecal Bacteria colonies.

DATA COLLECTION

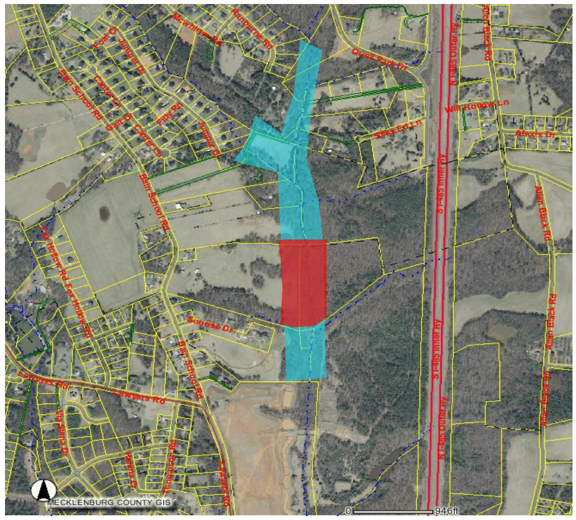
The overall application of this study applies to the entire Mecklenburg County portion of the Goose Creek Watershed. However, with the focus on a very specific catchment, this microcosm can be used as a model of what is happening throughout the watershed. As Fish and Pettibone state, "Micorcosms are a very useful tool to understand the complex influence of biotic and abiotic factors on Fecal Indicator Bacteria persistence". Application of the findings to the catchment under scrutiny will be applied to the entire watershed as the land use patterns for the Goose Creek are very similar. Data, once collected, will be displayed in an ARCMAP GIS geodatabase layer. Each sample point has the results tied to it so it may be accessed by the MCWQP staff. For every sample that was collected, date, time, conditions, temperature and results were recorded for that specific point. CMU labs have a data repository where all Fecal samples collected in this study will be stored. Once the results have been determined in the lab, the data is uploaded to the repository and the results are sent to a specified party. Data from this study and prior studies is accessible through the Charlotte-Mecklenburg Utilities Data Repository.

RESULTS

STREAM ASSESSMENT FINDINGS

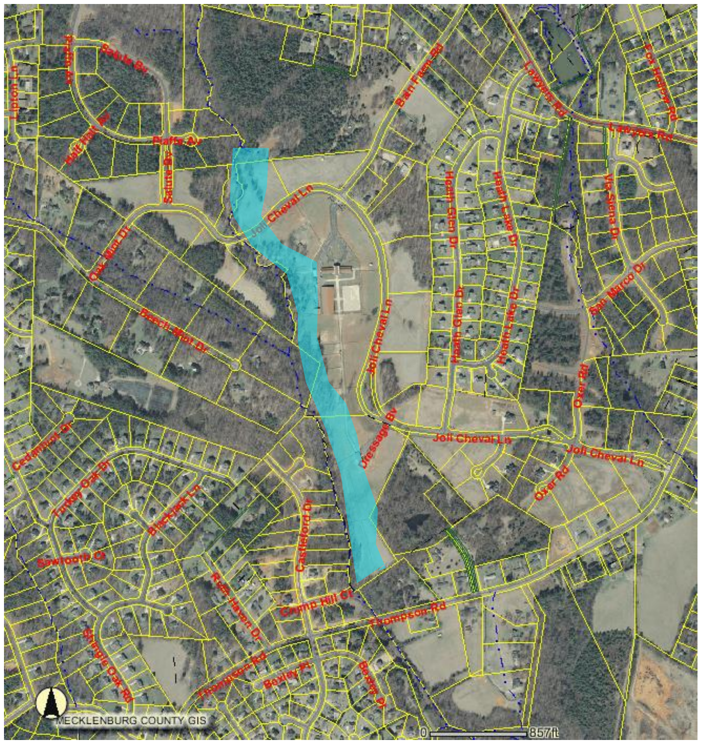
The results of the Goose Creek assessment can be broken down into categories. First being, the streambed composition and the land assessment of the watershed. The goal in doing a visual assessment is to establish any direct Fecal links in the land and streambed types to a direct source for Fecal Bacteria. Two areas of the watershed that encompass roughly 2% of the stream length in Mecklenburg County had a livestock agricultural use. The first area can be seen in Figure 6.

Figure 6-Agricultural Livestock Areas



Within this section of livestock agricultural use, the predominant animal is cows. Roughly 40 head of cattle are found in the red colored area. Other animals in this are 3-4 horses and 12 goats. The horses and goats do not have access to the stream, and are over 200 feet away. However, the cattle, up until 2012 had access to the stream and used it as a watering hole and wallow in the summer. Fecal Bacteria counts have been consistently high in this area up until last year. As part of a cost share program to help comply with the State Mandated TMDL, a fence was constructed 200 feet from the stream to provide an adequate buffer. The cows are now at a minimum of 200 feet from the stream and may not have access to the stream to use as a wallow anymore. Sampling in this area was done during the walking stream assessment, below the entire livestock impacted section. The result average was a Fecal count of 320 colonies per 100/mL. Samples before the installation of the fencing resulted in a range from a high of 13000 to a low of 340 colonies per 100/mL. The average during the course of study when the livestock had access to the stream was 3337 Fecal colonies per 100/mL.

Figure 7-Joli Cheval Horse Complex



The other area of Goose Creek that has a heavy livestock use is found in Figure 7. The section of Goose Creek is bordered on the East side by the Joli Cheval Horse Complex. The horse complex has inlets in the pastures that are susceptible to Fecal Bacteria runoff. The outlets then discharge directly to the 200 foot buffer of Goose Creek, as seen in Figure 8 and 9.

Figure 8-Joli Cheval Outlet

Figure 9-Joli Cheval Outlet

However the mean sample average for the catchment below the outfalls was 210 Fecal colonies per 100/mL. The horse complex implements two BMP's that help reduce the amount of bacteria entering the stream. First they use the buffers as a natural barriers to keep the bacteria and fences to keep the horses out of the stream. Natural buffers have never been fully tested to effectively see their removal efficiency characteristics. However, their effectiveness lies in the ability of the buffer to have zero discharge of surface runoff to the stream. The effectiveness is greatly dependent on the amount of infiltration of sheet flow(Shuler, 2000). Essentially the longer the buffer, the more time for infiltration. Secondly, they implement a waste reduction program within the pastures. Daily the pastures are vacuumed to remove the horse waste. It is then composted at a location well away from potential stream impacts.

One other area of concern within the watershed is the installation and maintenance of septic systems. The watershed lies in the Yadkin River Basin, and Charlotte-Mecklenburg Utilities gets its water from the Catawba River Basin. Antiquated laws in North Carolina prevent the transfer of water from one watershed to the other, unless legislative action is taken. In the case of the Goose Creek watershed, a court ordered moratorium was put in place in 2009, that prevented intrabasin water transfer to the Yadkin River watershed, where Goose Creek is a tributary. Tradtionally, Mint Hill has been one of the more rural communities within Mecklenburg County, and as such, the primary mode of waste water disposal has been septic systems. With the implementation of this moratorium, the proliferation of septic systems will continue to be the dominate wastewater treatment system.

Septic system failure could provide a direct link to increased Fecal Bacteria in the Goose Creek Watershed. Research and septic system evaluation throughout the entire watershed was performed by a different agency. Mecklenburg County Ground Water services performed over 1,422 septic system inspections and found only 12 failures. Of the 12 failures, only three were considered possible high risk for Fecal Bacteria contamination to Goose Creek tributaries. High risk means that the failure was found within 400 feet of the tributary(Mecklenburg County Ground Water Services, 2011). A direct correlation to septic system failure and Fecal Bacteria increases cannot be correlated with such a small number of Septic System failures within the watershed(Mecklenburg County Ground Water Services, 2011).

Direct source control of Fecal Bacteria is one of the easiest to identify. However, actually reducing the impact once it has been found can be a matter of lifestyle changes, economic conditions and education of the public. Schueler states that, "effective source control seeks to reduce or eliminate sources of bacteria before they come into contact with storm water. Common sources include septic systems and pet waste. The effectiveness on bacteria removal is contingent on how often to the sources happen, how effective is enforcement, what methods have reduced the source of the pollutant and what are realistic expectations of Fecal Bacteria reduction." In the Goose Creek Watershed Schuelers comment that, "if untreated wastewater is a documented source of bacteria, basic repairs can produce impressive results in bacteria reduction".

The walking stream channel assessment performed in the Goose Creek watershed, did not find any direct source Fecal Bacteria sources. Inspection efforts were detailed , looking for any type of failing septic system that may contribute to the increased Fecal Bacteria within the watershed. As mentioned earlier, the underlying soil types change dramatically as you move to the Southeast end of Mecklenburg County. Moving into the southern area with more of a rock based sub-layer, inspections were looking for fractures or short circuits of septic systems. None were found. One area that had the potential was isolated and investigated, but this area was determined to be a spring, due to the low Fecal numbers and the presence of iron bacteria-a ground water indicator.

FECAL BACTERIA FINDINGS

Multiple studies have proven that Fecal Bacteria do adhere to sediment particles in storm water conditions. One estimate by Schillinger and Gannon, is that 15-30 percent of all Fecal Bacteria in storm water are adsorbed to suspended particles greater than 30 microns in diameter.

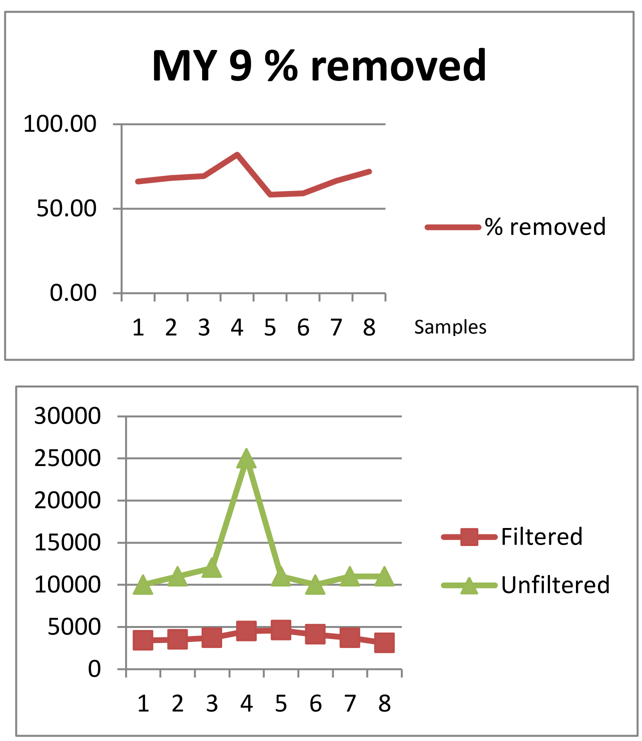
Bacteria that are not attached are much harder to settle out. Settling periods for these bacteria can take days or weeks(Schueler, 2000).

Our study catchment involved five sample Points-A through E. Within this study section several types of stream conditions are represented. Catchment A is mix of a buffered stream area with a small amount of residential runoff from houses that are within a 200 foot buffer. Catchment B is all wooded with no development. Catchment C is actively undergoing construction and has heavy sediment laden storm water runoff. Catchment D is wooded with low density housing. Catchment E is the headwaters with agriculture, pastures for livestock and low density homes.

BASELINE FILTRATION RESULTS

The initial filtration testing performed at MY9 showed that roughly 67 percent of the in stream bacteria where attached to sediments during rain impacted events. When the storm water was filtered, a large percentage of the bacteria were removed from the water. Results of the samples are found in Figure 10.

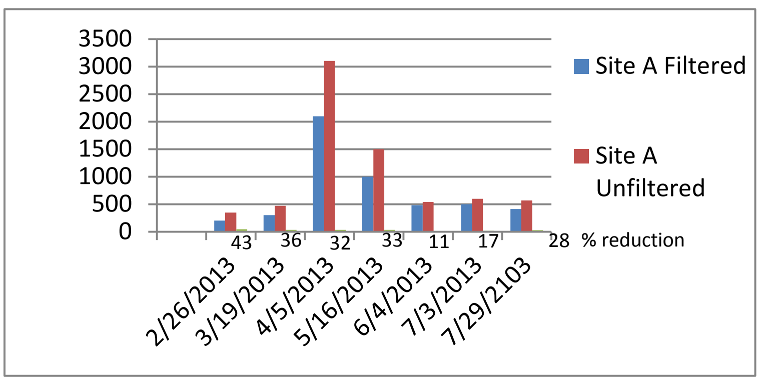
Figure 10-MY9 Filtration Results



CATCHMENT A

Catchment A presents a study area that most typically represents the development in the Goose Creek Watershed. The catchment is 3516 feet in length and receives both point and non-point source storm water impacts from neighborhood outlets and sheet flow. The residential areas provide the bulk of the outfalls with direct storm water discharge. There are horse pastures that drain to this catchment as well, but the farm practices good BMP's, as mentioned earlier so the impacts should be negligible. There are no areas under active construction where sediments could be discharged into the corridor. This is the most densely populated catchment of the study area.

Figure 11-Catchment A results

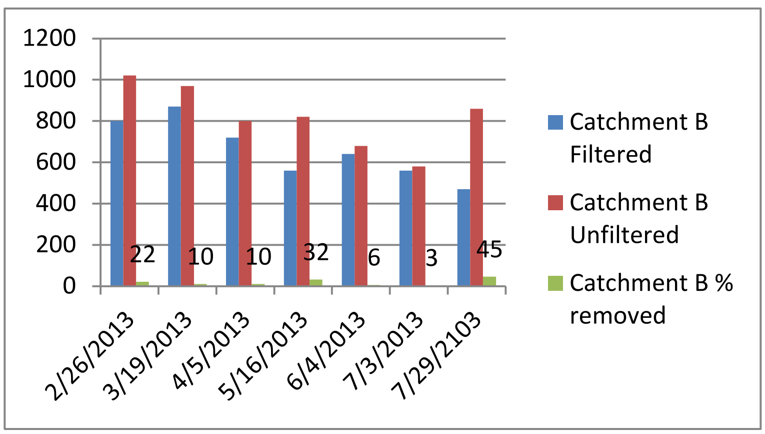


Catchment A has unfiltered storm water Fecal levels that range from 350 to 3100 colonies per 100/mL. The 350 is below the 400 colony threshold, used to help determine the TMDL status of the Goose Creek Watershed. The average unfiltered storm water Fecal count for Catchment A was 1018 colonies per 100/mL. This level would show a large scale of impairment from impacted storm water. The filtered samples ranged from 200 to 2100 colonies per 100/mL, with an average of 712 colonies per 100/mL. Still above the 400 threshold limit, but close to a 30 percent reduction in Fecal Bacteria on average. This is well below the 67 percent average of Fecal reduction that was observed at MY9. With no active construction in the catchment, the introduction of soil sediments, is low. Sill close to 30 percent of Fecal Bacteria were adsorbed to suspended sediment particles. Twenty percent lower than Schiller and Gannon stated that should be adsorbed to suspended sediments.

CATCHMENT B

This catchment does not have any type of influence on its receiving waters other than what is naturally occurring. This is a tributary that is heavily wooded and buffered on each side. Fecal influences would be from sheet flow runoff interactions with wild animal scat or in stream Fecal sources that are already present. This catchment is the shortest at just 1000 feet, but due to the nature of the stream it provides a microcosm of an undisturbed section of the Goose Creek Watershed.

Figure 12-Catchment B results

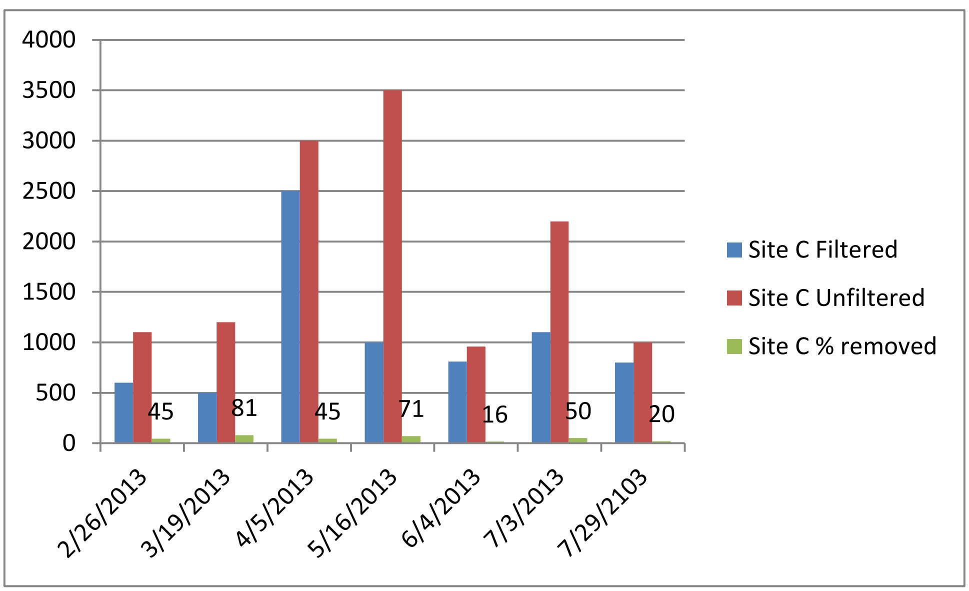


The unfiltered levels ranged from 580 to 1020 colonies per 100/mL. The average for all unfiltered samples collected was 818 colonies per 100/mL. Filtered samples ranged from 470 to 870 colonies per 100/mL, with an average of 660 colonies per 100/mL. The overall percent reduced by the filtering all of the samples is 18 percent. Given that this is an undisturbed section, very little Fecal Bacteria have adsorbed to suspended sediment particles. With Fecal counts elevated, Fecal Bacteria may already be in the stream and storm water agitation, along with natural flow, disperses them from the stream bed sediments. Prolonged survival of bacteria poses a potential risk for recontamination of a water column through bacterial re-suspension before die-off(Sherer et Al, 1992). Re-suspension may be caused by the increased velocities that storm water causes in the stream channel. The introduction of Fecal Bacteria from the drainage area through adsorption to sediment particles seems to be negligible due to the lack of exposed incoming sediments, available for Fecal Bacteria absorption.

CATCHMENT C

This catchment provides the most dynamic area of our study catchments. Within this area there is active construction occurring on a 30 acre development. Direct storm water discharges go through construction BMP's, consisting of silt fence. Once the sediment laden water has run through the silt fence it then has roughly a 30-70 foot area to sheet flow thorough woods before entering the catchment. In addition to the sediment coming from the site, deposits on the road enter the storm drain system for an expedited route to the creek. Measures in place on the inlets include silt sacks, but their holding capacity is limited and sediment laden water can easily spill over and bypass them. The stream catchment consistently has turbid water, hovering in the 100-200 NTU range. The distance of this catchment is approximately 1900 feet in length.

Figure 13-Catchment C results



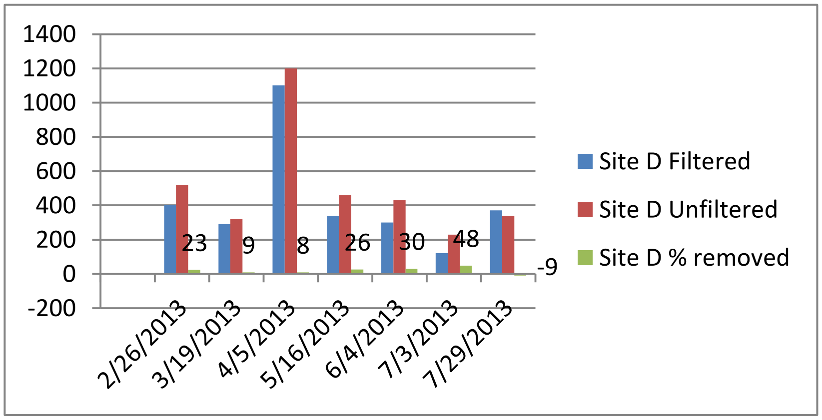
In catchment C the unfiltered samples ranged from 960 to 3500 colonies per 100/mL. Averaging a high 1851 colonies per 100/mL. The filtered samples range still had a high level of colonies, ranging from 500 to 2500 colonies per 100/mL, while averaging 1044 colonies per

100/mL. On average, the filtering removed 47 percent of the bacteria. It is clear the flow of sediment laden water through a watershed allows for adsorption of Fecal Bacteria to the sediments. These sediment are also deposited within this catchment as well. As the sediment are deposited with the Fecal Bacteria attached, it provides an already hospitable breeding ground. Sherer et Al, states, "Bacteria that have settled to bottom sediment may experience a more favorable chemical and biological microenvironment, which can prolong bacterial survival". As these Fecal Bacteria absorb to sediments and suspended particles, they may then undergo sedimentation, from the water column and leads to accumulation in sediment(Bloesch, 1995). This sedimentation can allow for re-suspension and prolonged life for Fecal Bacteria, causing extended high Fecal counts, even in ambient conditions.

CATCHMENT D

Within the Goose Creek Watershed, one area had greater than normal sediment discharge- Sample point C. This drainage area is undergoing active construction and discharged a higher amount of sediment than the other areas. Catchments D and C join together and provide a contrast in drainage areas. Catchment D provides a drainage area that is flowing through a lightly wooded area. The flow of the catchment is through open fields and some small wooded sections. The length of the catchment is roughly 2000 feet long. This catchment was not influenced by human development. There are adequate buffers that help to shield the catchment from any human storm water influences. Houses being well away from the stream with a minimum of a 200 foot vegetated buffer in some places. Storm water impacts come in the form of sheet flow versus direct outlet flow. The unfiltered samples ranged from a low of 230 to 1200 colonies per 100 mL/water. The overall average of this catchment is 500 colonies per 100/mL water. The filtered results provided a closer to threshold range of 120 to 1100 colonies per 100/mL water. While the overall average at 417 colonies per 100/mL water was close to the 400 colonies per 100/mL of water mean average the state requires not to be impaired by Fecal Coliform Bacteria.

Figure 14-Catchment D results



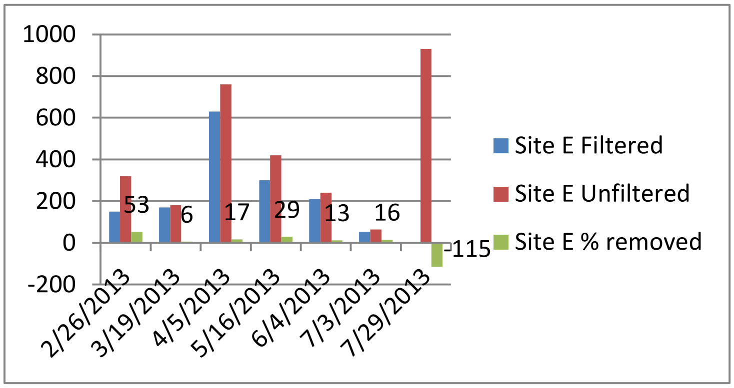
The results were as expected with the exception of the last sample which resulted in higher Fecal concentrations from the filtered sample versus the unfiltered sample. However due to such slight variances with bacterial logical samples, the results are considered negligible.

CATCHMENT E

The final catchment that was studied examines the headwaters of the Goose Creek Watershed. Here the stream begins from the discharge of a twenty acre deepwater pond. The headwaters in this section have varied from free flowing this year, to sporadic and stagnant, over the last 4 years. This section, 1540 feet long, flows through a lightly wooded section with a foot path next to it. It also traverses a 200 foot section of old pasture. There are some houses in this catchment that are on septic, but they are well over 200 feet away. Based on data provided by Mecklenburg County Groundwater services, all of the septic systems in this area are functional.

The range for the unfiltered samples was from 64 to 930 colonies per 100/mL of water. While the overall average comes in at 502 colonies. The filtered sections ranged from 54 to 2000 colonies per 100/mL of water. The final average is at 416 colonies. The sample of 2000 colonies per 100/mL of water on 7/29/2013 skewed the data, which otherwise would have been under the 400 colony threshold. In addition, the percent removal was also skewed by this sample. The sampling in this catchment did not vary much from the filtered to the unfiltered sample, with the exception of the final sample.

Figure 15-Catchment E results

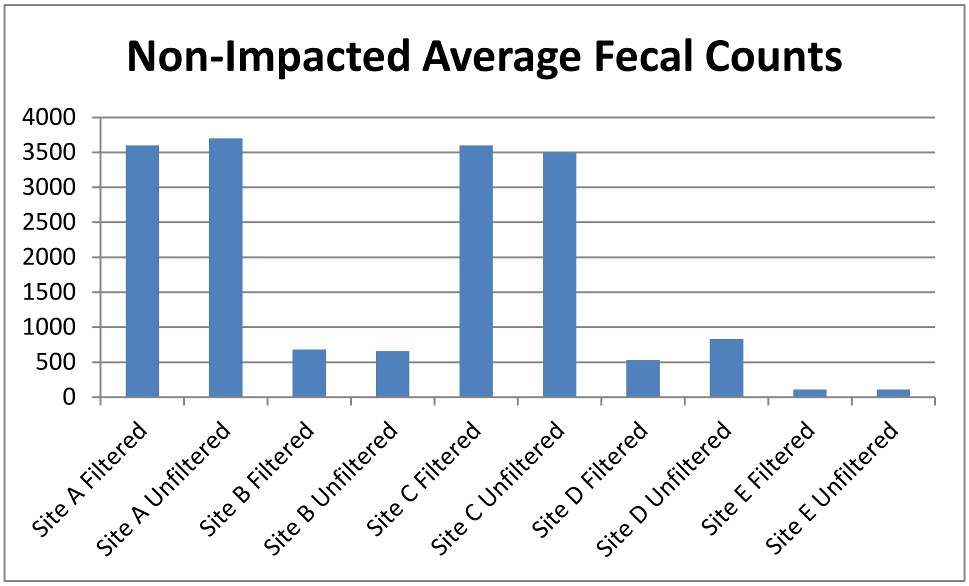


NON-STORM IMPACTED RESULTS

The storm water impacted events were the bulk of the study data. Comparable storm water studies would indicate that storm water levels would be much higher in Fecal Bacteria concentration. In our efforts to establish a baseline for filtration removal we found that the confluence of all the Goose Creek streams in Mecklenburg County had on average 12625 colonies per 100/mL of water. This was from the entire county portion of the watershed, which included many other catchments that were not studied. In addition, the filtered sample had on average 3825 colonies per 100/mL of water. This presents, a close to 67 percent removal rate of bacteria that have adsorbed to particles of sediment.

Non impacted analysis in the study catchment is used strictly for comparison to our results. The goal with non-impacted samples was to get an average Fecal count, but not for in depth analysis. Catchment E consistently came in with the lowest totals at 110 colonies per 100/mL of water for both filtered and unfiltered. While as expected, Catchment C, was the highest with a 3600 for filtered and 3500 colonies per 100/mL for unfiltered. The 100 colony difference is considered a non-factor due to the amount of colonies. This was higher than the storm water impacted results.Figure 16 outlines the results.

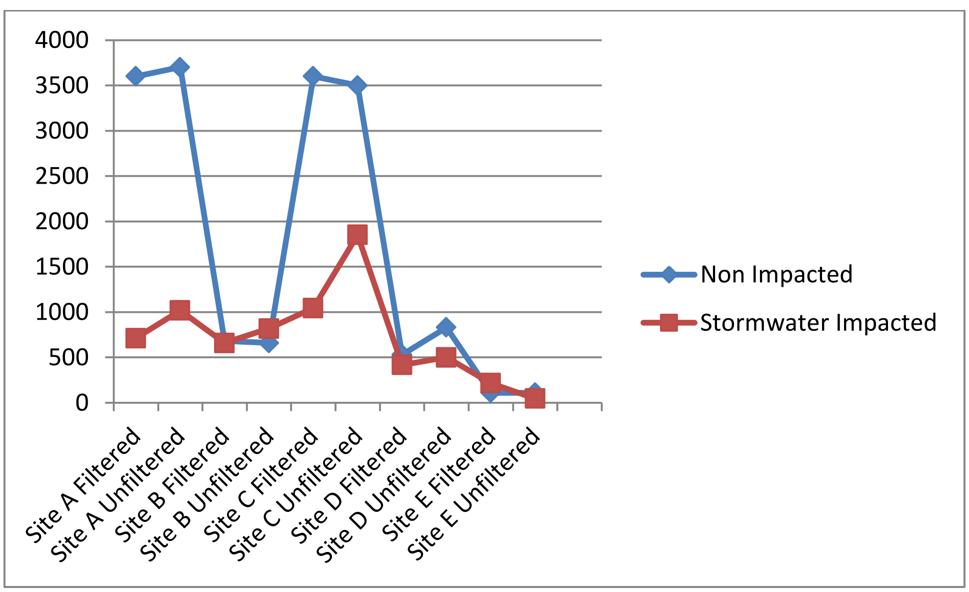
Figure 16-Non Impacted Sampling Averages



RESULTS COMPARISON

Based on the findings of MY9, the confluence of all of Goose Creek waters in Mecklenburg County, the expected results would be that storm water impacted samples would be higher. However, that does not appear to be the case. Figure 17 illustrates the opposite findings from the samples.

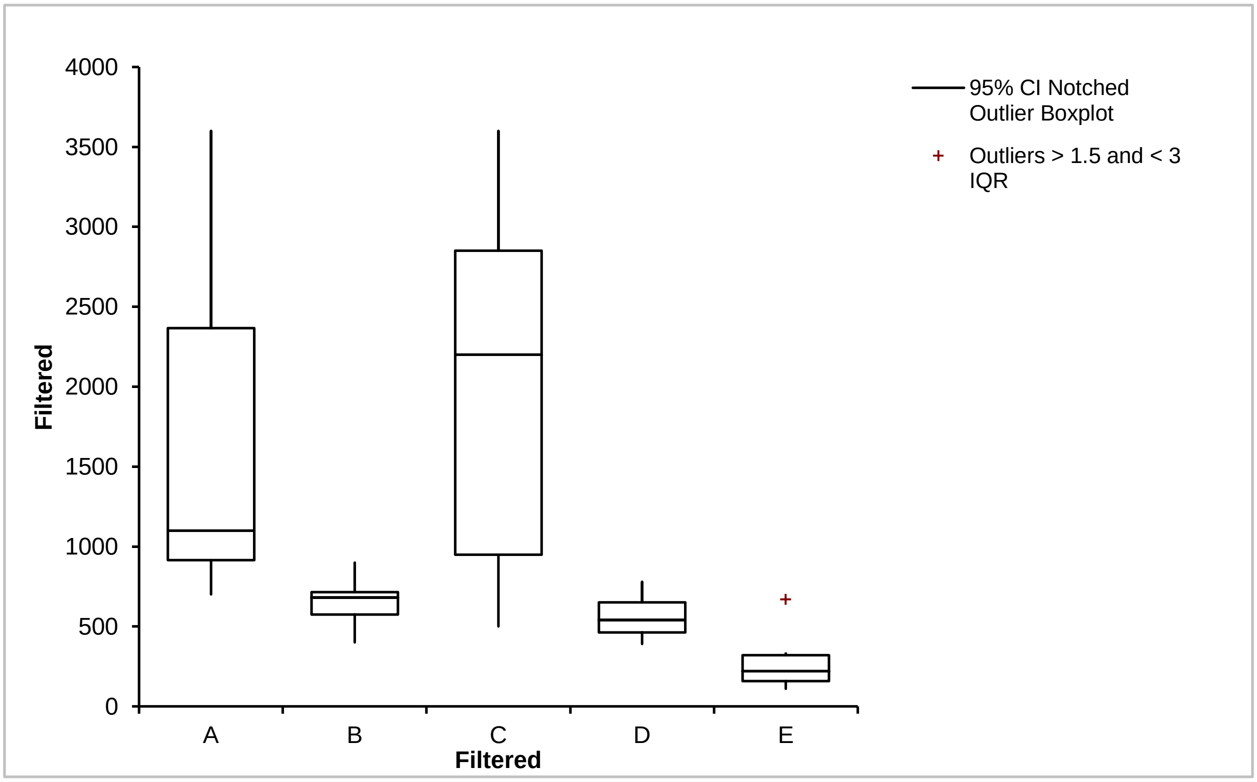
Figure 17-Overall Fecal Sampling Comparison



Higher up in the watershed, stormwater impacts are less apparent than they are at the confluence of many tributaries. As you move farther down in the watershed the development has increased, thus making impacts from pollutants, such as Fecal Bacteria, more abundant. As the USEPA states, "The impacts on receiving streams due to high storm water flow rates or volumes can be significant". The USEPA, goes onto say that, "The quantity of these pollutants per unit area delivered to receiving waters tends to increase with the degree of development in urban areas". The resulting EPA conclusions can be applied to the confluence leaving the County, but it does not explain the results for the study catchments, specifically catchment C.

The sampling events found variations and statistical differences in the different land uses. A non-parametric statistical whisker plot analysis was used to determine if there was any statistical significance in the filtered versus unfiltered samples in the Catchments. Figure 18 outlines the findings of the filtered samples. Based on the P value of the statistics at .0001, the confidence of the data is close to 99%. The statistical comparison between the filtered samples show that there is significance in the findings when comparing the different land uses. Based on the statistical results when all filtered samples are compared against each other, 50% of the results show statistical significance. A P value of less than .02 indicates statistical significance in the findings.

Figure 18-Statistical Significance Analysis



Bonferroni Contrast	Difference	p
A v B	10.4286	0.0240
A v C	0.0000	1.0000
A v D	14.3571	0.0008
A v E	22.0000	<0.0001
B v C	-10.4286	0.0240
B v D	3.9286	1.0000
B v E	11.5714	0.0092
C v D	14.3571	0.0008
C v E	22.0000	<0.0001
D v E	7.6429	0.2130

Based on the comparisons it can be concluded that the main difference in the filtered samples comes from the different land use types of the sample catchments. Catchment C has the most statistical variations when compared to the other Catchments. Catchment C also had the largest influx of sediment into the watershed. Active land uses and contribution of sediments to the watershed, not only increase the amount of Fecal Bacteria in the water, but contributes to an elevated Fecal count of bacteria, after storm water events. When you compare impacted and non-impacted events for Catchment C, versus the other Catchments, the influx of sediment keeps the Fecal Bacteria counts elevated by providing hospitable conditions to reproduce after they have settled.

SUMMARY AND CONCLUSION

Fieldwork assessment and catchment sampling took place from November 2012 through August 8, 2013 within the Goose Creek Watershed in Mint Hill, North Carolina. Sampling occurred in five catchments for storm water impacted, sediment laden water. The sampling was to determine the number of colonies per 100/mL of water of Fecal Coliform Bacteria. Samples were unfiltered and filtered with a 30 micron filter to remove bacteria attached to sediments. The Goose Creek Watershed has presented interesting past results of continual higher than state threshold counts of Fecal Bacteria in non-storm water impacted events. Thirteen of thirty five samples of the filtered storm water were below the state threshold. Two were from Catchment A, six from Catchment D and five from Catchment E. Catchment B and Catchment C had no filtered results below 400 colonies per 100/mL of water. Catchment B came from a highly wooded area with no exposed soils, so incoming sediment from sources were unattached for the most part. Catchment B also was not exposed to much light and had a very thick vegetative buffer to keep sunlight off the creek. This in turn can play a role in allowing the bacteria to propagate, since UV lights can help to reduce Fecal Bacteria. Exposure to sunlight is one of the most important factors causing bacteria die off(Scheuler, 1992). Lack of UV light, organic matter and lower flashy flow allow the Fecal Bacteria to remain suspended for long periods of time, including periods well after rain events have occurred.

Catchment C had significant impacts by sediment. The channel already had a well established substrate of deposited sediments from ongoing construction upstream. All of the filtered samples of Catchment C were 960 colonies or above. However, the percent removal of the sediments was 47 percent. Significantly higher than Catchment A, at 28 percent. Looking closer at Catchment C, a 30 micron filter was able to remove on average 47 percent of the Fecal Bacteria present in the water. Based on estimates in other studies, most Fecal Bacteria like to adhere to sediments 30 microns and larger. Thus, most of the attached sediment should have been filtered out, giving an accurate estimate of the non-absorbed Fecal Bacteria levels. With 47 percent, a combined average, of the bacteria being removed through filtration, 53 percent can be said to have not been absorbed to suspended particles. In our study, these high Fecal removal rates establish a source for incoming bacteria as having attached to the incoming sediment. In addition to the incoming sediments, there appears to be a well established in stream population as well. This in stream population is provided optimum growth conditions on the sediment in the stream bed. Suspended sediments also help to culture the in stream bacteria. Without clear water, coupled with turbidity from sediment, sand, and organic matter, maximum die off cannot occur, because of the interference of the natural sunlight(Bank et al, 1990).

Catchment C also provided the majority of supporting data during the non impacted sample periods as well. The average unfiltered Fecal colonies per 100/mL was at 1845 colonies, while filtering the count was at 1716 colonies. Without an active influx of sediments bacteria were still present in an unattached form. But as mentioned earlier, with slightly turbid water, and a well established stream bottom sediment layer the Fecal Bacteria have prime conditions to reproduce and thrive.

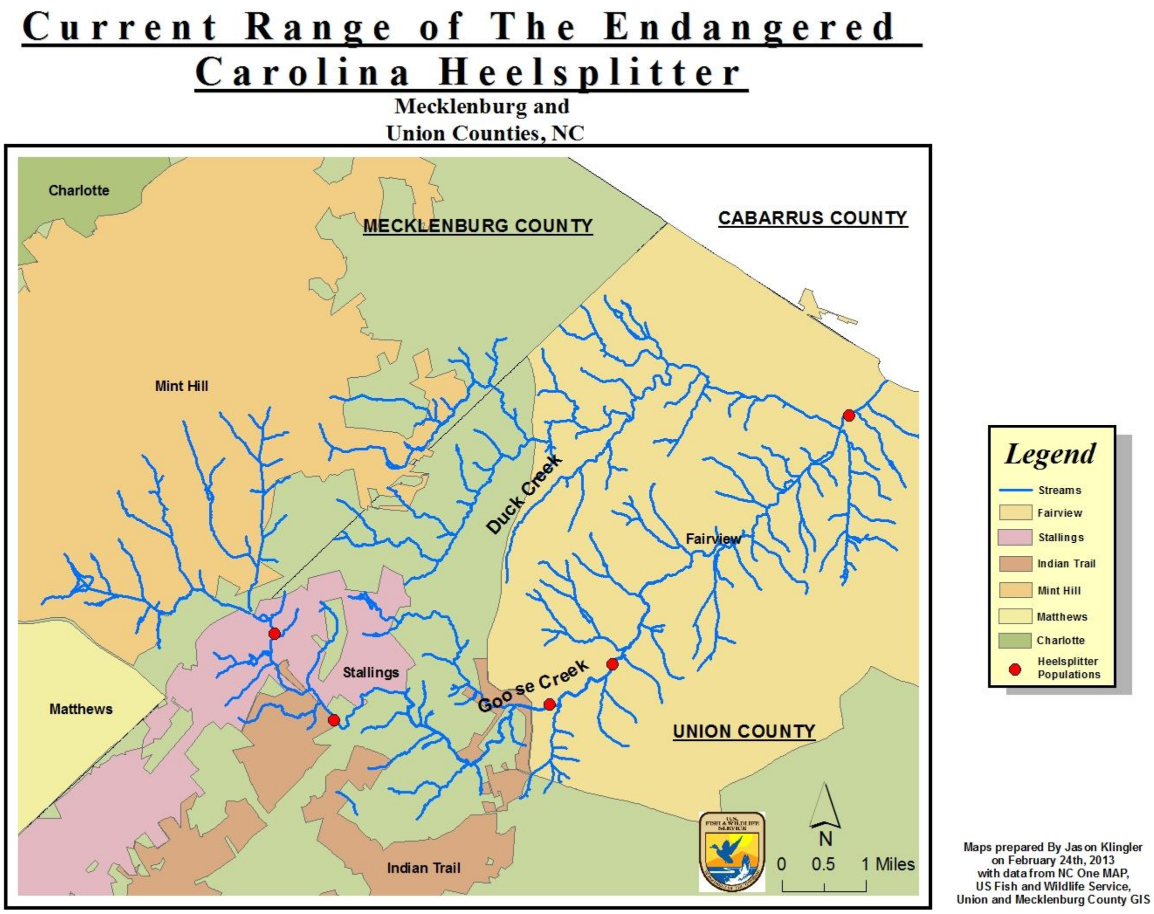
The other Catchments did not provide as much as a definitive data to helping prove if the in stream conditions would allow for sediments to be classified as a non point source for Fecal Bacteria, with the exception of Catchment A. All of the other catchments were very similar in the Fecal colony numbers that were sampled when comparing storm water impacted to non-impacted. Catchment A, however acted a little different in the data the was collected. The non impacted results average of 3600 filtered and 3700 unfiltered, were a stark increase from the storm water impacted numbers average of 712 colonies and 1018 colonies, respectively. In the case of these results, storm water acted almost as a dilutant to the Fecal Bacteria counts. Catchment A is the largest flow catchment. With little Fecal impacts from direct urban discharges into the storm water, it can be concluded that the Fecal Bacteria present during non storm water events are already present in the streambed substrate.

With the exception of Catchments A and C, storm water impacted events versus non storm water impacted events were relatively close in Fecal counts. Catchment A and C had the larger influx of impacted storm water, yet, storm water Fecal levels were lower. Active discharges of sediment do increase the Fecal counts of bacteria in the stream. As well, incoming sediments provide a hospitable streambed substrate to reproduce in once they settle out.

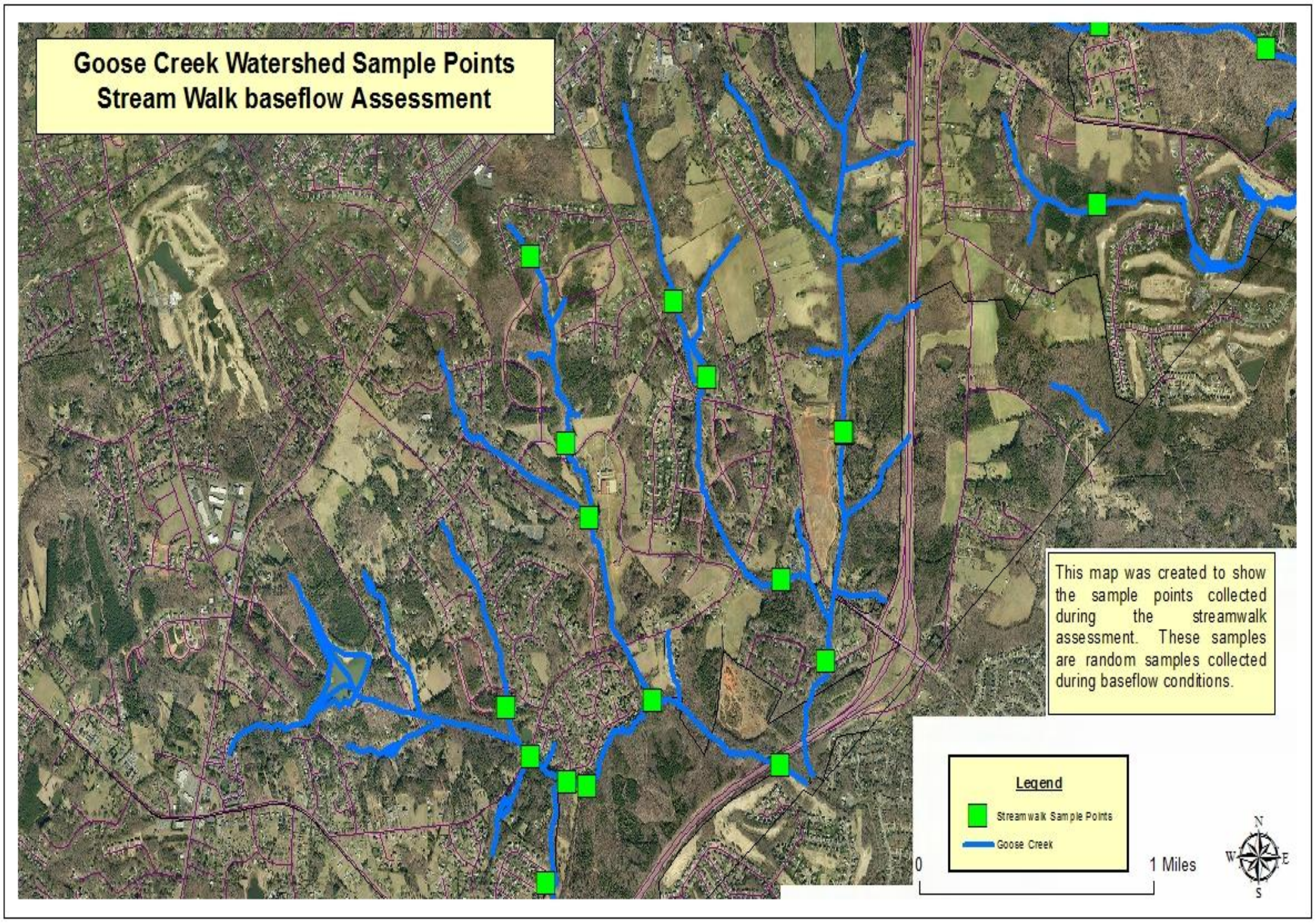
Exhaustive efforts have been put in place in the Goose Creek watershed. Onsite septic systems have been inspected, livestock have been removed from streams, enhanced stream buffers have been enacted and still Fecal counts remain high in the streams. There is no significant proof that any of the above items contribute Fecal Bacteria to the Goose Creek Watershed after an exhaustive Fecal Bacteria assessment. The majority of the high Fecal counts result from sediment influx, and sections of stream impacted by sediment deposition. The land variations in the watershed are an important variable in contributing Fecal Bacteria to Goose Creek. In areas with significant active construction, efforts need to be made to control as much sediment as possible from entering the stream. The other areas where construction activity is limited would benefit from stabilizing the watershed itself, through stream restoration and bank stabilization. Any pattern of stream hydraulics that contribute or cause sediments to be stirred up or added to the stream will cause elevated Fecal counts.

The next step in the process would be to sample and measure the Fecal counts of the incoming suspended sediments and the streambed sediment substrate itself. Further in depth septic system studies could be performed by sampling water discharge and sediments at the outlet of their drain fields. Studying the sediments and Fecal counts of the groundwater recharge to the Goose Creek Watershed could provide details to the effectiveness of septic systems in the soil types of the watershed. As the Goose Creek Watershed continues to be developed enhanced erosion control measures should be implemented to help remove Fecal Bacteria. The use of enhanced erosion control measures, including the use of floculants, will help to retain the sediment on site, instead of allowing permissable amounts to pass into the stream. The data has clearly shown that these areas impacted by past, current and future sediments provide a very hospitable area for the bacteria to reproduce within the stream. It can be concluded that these incoming sediments act as a Fecal Bacteria source once they are part of the streambed substrate.

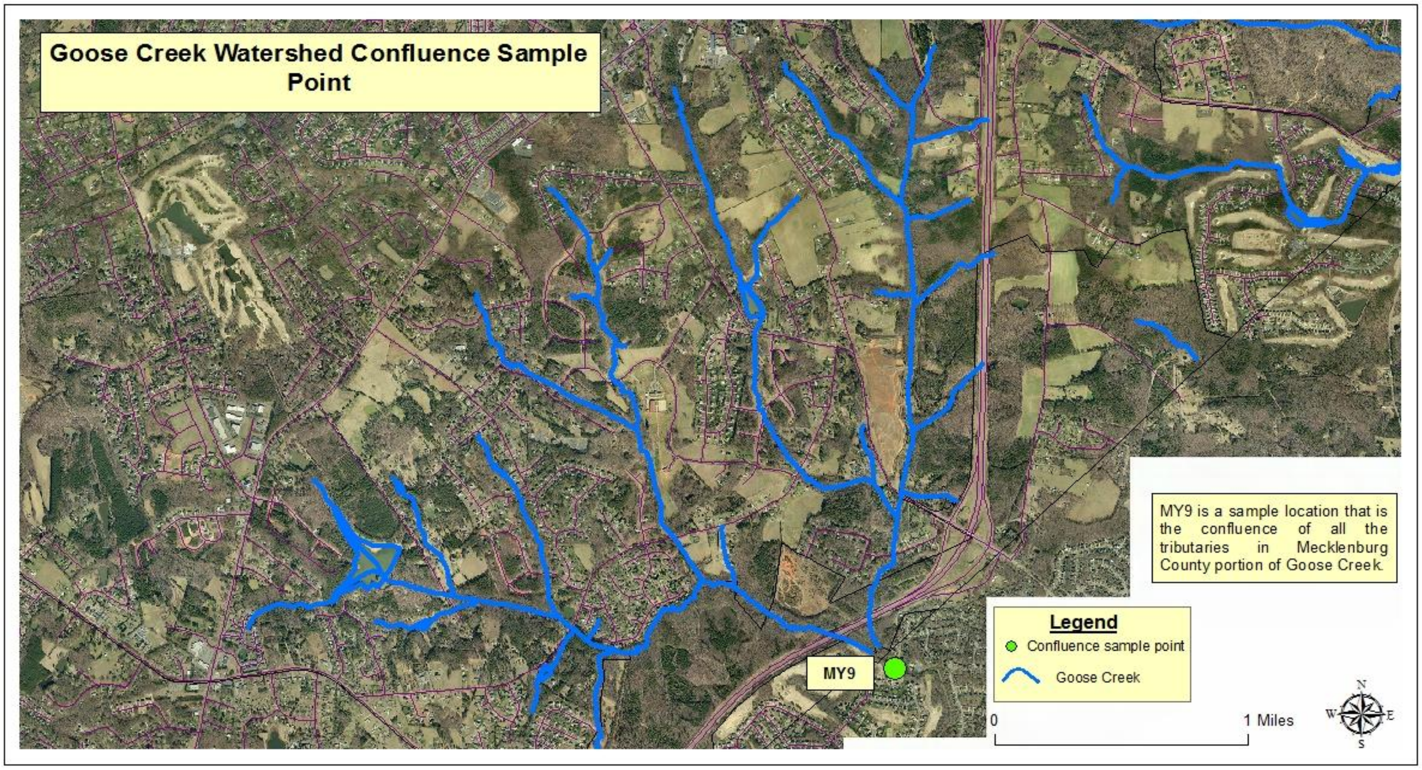
Appendix 1-Goose Creek and the Carolina Heelsplitter Current Range



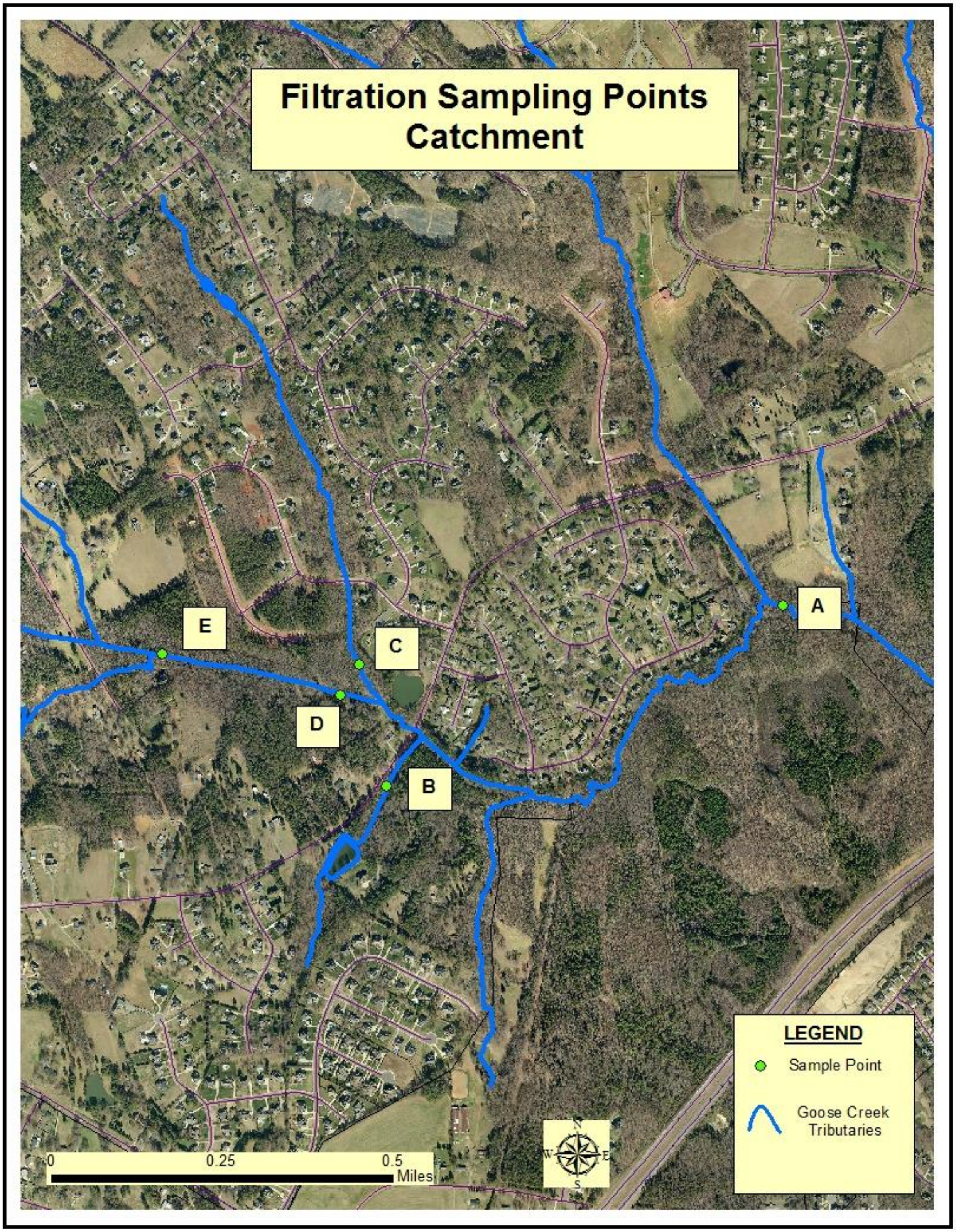
Appendix 2-Baseline Fecal sampling locations.



Appendix 3-MY9 Confluence sampling Point



Appendix 4-Intensive Filtration Sampling Catchment



Appendix 6-Lab Chain of Custody

CHARLOTTE-MECKLENBURG UTILITIES - LABORATORY SERVICES DIVISION

CMU ESF Laboratory, 422 Westmont Dr., Charlotte NC, 28217 (704) 336-2854 / (704) 622-7280

CHAIN OF CUSTODY RECORD			
PAGE	1	OF	1
COC#: Sampled By (Print Name)			

CLIENT:	MECKLENBURG COUNTY, LUESA - WATER QUALITY PROGRAI
FACILITY:	NA
PROJECT:	Goose Creek Stormwater
LAB CODE:	Monit Goose

Report To:	Jason Klingler
	Jeff Price
	700N Tryon St. Ste. 205

		Sample Collection				Sample Temp		Sample Type				Sample Containers			Chemical / Preservative							Analyses Requested				
Location Code		Staff ID	Date	Time	Chlorinated	Coll Temp	Rcpt Temp	Depth Comp	Auto Comp	Hand Comp	Grab	Plastic	Glass	# Containers	None	HNO3	H2SO4	NaOH	HCl	Na2S2O3	pH Correct	Fecal Coliform	E Coli	Turbidity		
W-	Blank	JTK			N						X	100 m		1						X		X				
W-	Goose A	JTK			N						X	100 m		1						X		X				
W-	Goose B	JTK			N						X	100 m		1						X		X				
W-	Goose C	JTK			N						X	100 m		1						X		X				
W-	Goose D	JTK			N						X	100 m		1						X		X				
W-	Goose E	JTK			N						X	100 m		1						X		X				
W-	Goose F	JTK			N						X	100 m		1						X		X				
W-	Goose G	JTK			N						X	100 m		1						X		X				
W-	Goose H	JTK			N						X	100 m		1						X		X				
W-	Goose I	JTK			N						X	100 m		1						X		X				
W-	Goose J	JTK			N						X	100 m		1						X		X				
W-	Goose K	JTK			N						X	100 m		1						X		X				
W-	Goose L	JTK			N						X	100 m		1						X		X				
W-	Goose M	JTK			N						X	100 m		1						X		X				
W-	Goose N	JTK			N						X	100 m		1						X		X				
W-	Goose O	JTK			N						X	100 m		1						X		X				
W-	Goose P	JTK			N						X	100 m		1						X		X				

NOTES:	Relinquished By: (Signature)	Received By: (Signature)	Date	Time
Form 5; effective 11/12/2012	Relinquished By: (Signature)	Received By: (Signature)	Date	Time

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