TMDL Implementation Plan: Rocky River-Wilson Creek

The City of Anderson, SC and Anderson County, SC, on behalf of the City of Belton, SC

December 2017

1 Background

The City of Anderson, City of Belton, and Anderson County are Phase II National Pollutant Discharge and Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) general permit holders. As such, their stormwater discharges are subject to regulation under the NPDES MS4 general permit issued by the South Carolina Department of Health and Environmental Control (DHEC). The City of Belton and Anderson County have agreed to be co-permittees, with Anderson County completing monitoring activities in shared Total Maximum Daily Load (TMDL) watersheds and reporting for the City of Belton. The City of Anderson and Anderson County have agreed to work together to address requirements for TMDLs that assign both a waste load allocation (WLA). Section 3 of the Phase II permit addresses stormwater discharges to sensitive waters, including waters with established TMDLs.

A TMDL was developed for fecal coliform bacteria in the Rocky River and Wilson Creek watersheds, which include portions of the City of Anderson, the City of Belton, and urbanized areas within Anderson County. The watershed location is shown in Figure 1. The TMDL became effective in September 2004 and includes WLA for non-point source runoff that thereby includes these urbanized areas. The TMDL covered Hydrologic Unit Codes (HUC) 03060103-070 and -080 and DHEC water quality monitoring station SV-031, SV-041, SV-043, SV-139, SV-140, SV-141, and SV-347. This TMDL is somewhat unique in that the entire named watershed is not impaired. Several stations were meeting water quality standards for fecal coliform at the time of the TMDL, so the impaired portions of the watershed are broken into several subwatersheds.

Since the time of the publication of this TMDL document, DHEC has changed their preferred indicator bacteria from fecal coliform to Escherichia coli (E. coli). This document will refer to E. coli as the indicator bacteria as a replacement for the originally-used fecal coliform bacteria. The conversion of the TMDL document from fecal coliform to E. coli is given by the equation:

$$E.coli = 10^{0.0491+0.9583*\log_{10}(Fecal\ Coliform)}$$

The statewide standard for E. coli bacteria is a monthly average of 126 MPN/100mL and a daily maximum of 349 MPN/100mL (SCDHEC, 2014). The NPDES MS4 permit defines steps necessary to reduce discharged loads of pollutants of concern to TMDL watersheds. This TMDL Implementation Plan (TIP) describes the actions the County and Cities have taken and will undertake to comply with these permit requirements to reduce bacteria loads discharged into receiving waters to the MEP.

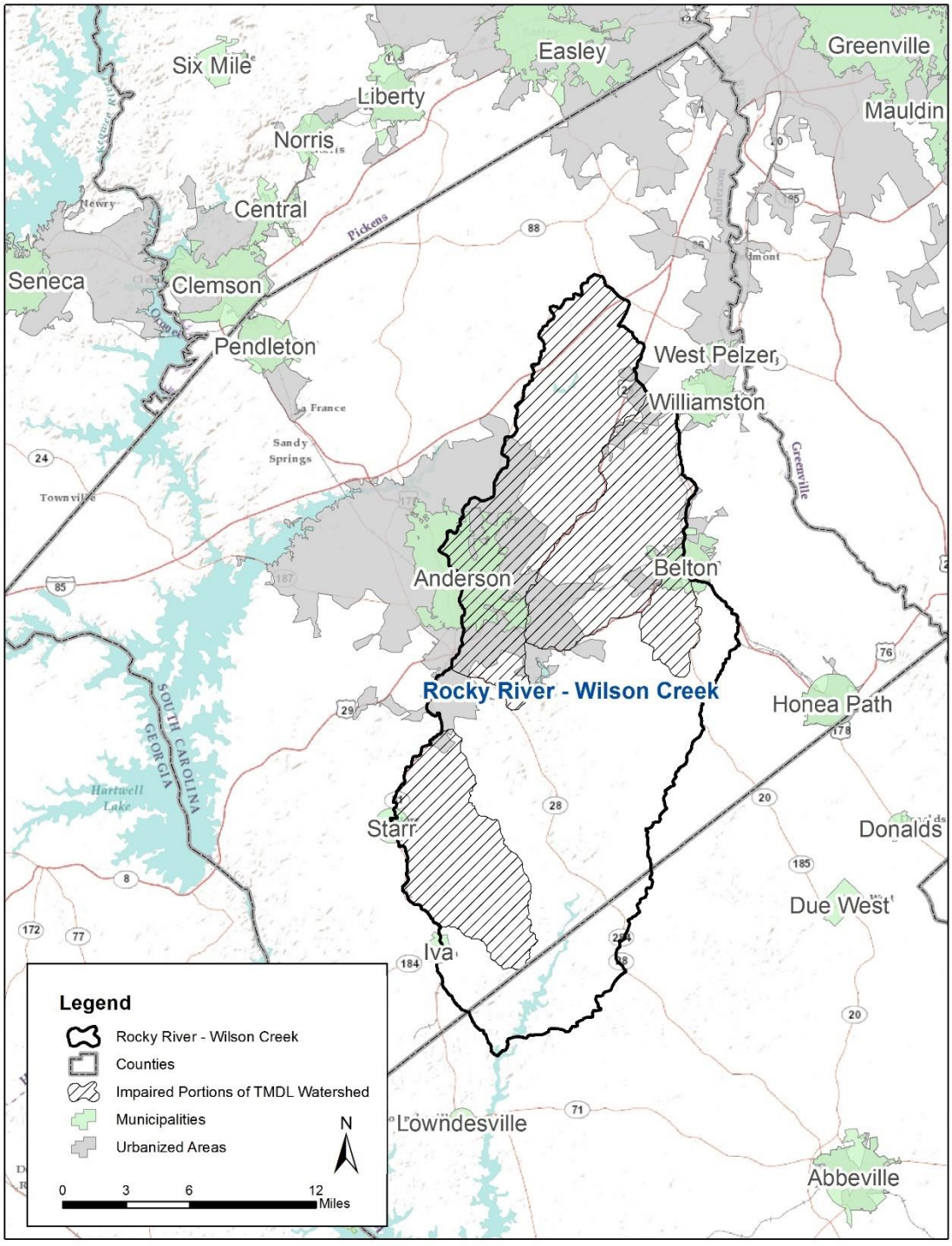


Figure 1: Location of Rocky River and Wilson Creek Watersheds

In January 2015, Anderson County and the City of Anderson published a monitoring plan in compliance with their Phase II MS4 permits, and have been implementing that plan since then. The plan identified a location on a tributary to the Rocky River as representative of MS4 contributions of runoff to the watershed and minimizing the contribution of other sources (see Figure 2). The plan specified that at least one storm event would be sampled in each of the four seasons, with multiple samples collected per storm event when feasible.

Monitoring has produced records of E. coli concentrations that each represent a "snapshot" in time. Because of the non-continuous nature of the grab samples, the analysis is limited to comparisons and correlations that could reasonably be expected to provide insight into the nature of E. coli in the stream. The analysis is also limited to those parameters which are deemed measurable and relatively consistent. For example, a correlation with rainfall is hypothesized because the rain may be measured with some degree of accuracy, but groundwater effects are not evaluated because of the lack of available data. Similarly, some potential sources, such as septic tank effluent and pet waste, are not quantifiable with the present analysis, but may still be sources worth reducing to the extent practicable.

2 Assessment of Monitoring Data

DHEC, the City of Anderson, and Anderson County have conducted various sampling programs in the Rocky River and Wilson Creek watersheds. During the interpretation of the results, the County and Cities are being careful to keep in mind that the use of fecal coliform, E. coli, or other bacterial indicator organisms can be an uncertain science. Unlike other pollutants, bacteria can multiply rapidly, even inside a stormwater system, BMP, wetlands, or in a receiving water. Therefore, the presence of bacteria in a receiving water may not indicate the presence of a "source" other than natural reproduction of bacteria. Correlating increased levels of bacteria in receiving waters with stormwater runoff may also be more tenuous than previously thought. The author of a 2017 article in *Stormwater* magazine found that increased bacteria loads in receiving waters can result from growth in wetlands being displaced by runoff from development, even when the runoff is relatively bacteria-free. The author's studies, which occurred in SC, demonstrate that correlation and causation can often differ in unexpected ways when dealing with a pollutant capable of increasing between storms (Ahern, 2017). Because of these uncertainties and the relatively few samples collected to this point, the analysis below was not able to draw extensive conclusions about the nature of the watershed or loading mechanisms. Any correlations (or lack of correlation) should be addressed again as a more robust dataset is collected.

2.1 DHEC Monitoring

DHEC records indicate that none of the water quality monitoring stations used in the TMDL are active today. However, DHEC is collecting grab samples at a station in the watershed that has been activated since the publication of the TMDL (SV-331 on Lake Secession at the lower end of the Rocky River watershed).

DHEC also publishes a list of sanitary sewer overflows (SSOs) reported to them. The City and County checked the SSO list for overflows that may have influenced bacteria counts in grab samples. Any SSOs that occurred upstream of the Cox monitoring site the day before, the day of, or the day after a grab sampling event were recorded. The range of dates was selected to account for the fact that SSOs may discharge a significant amount of bacteria into a receiving water that influences samples collected the next day, or may have already discharged bacteria into receiving waters if discovered the day after a sampling event. No SSOs were found within this timing window that occurred upstream of the sampling location.

2.2 Microbial Source Tracking

As part of the monitoring effort, some samples collected by the City and County at the monitoring location were used for microbial source tracking (MST) analysis. Five samples were sent to a Clemson University lab and two samples were sent to the Source Molecular lab. The Clemson University lab was being set up at the time of these analyses and performed these quantitative polymerase chain reaction (qCPR) procedures as a way to test their new laboratory equipment and procedures. The results, therefore, will not be relied upon to make major

management decisions, but may be useful to draw tentative conclusions. The results showed that at various times, the watershed may experience bacterial loading from humans, swine, and dogs. However, there were no source types that were present for all of the samples. Nor did there appear to be a pattern related to prior 24-hour rainfall depth. With so few results, and the uncertainty of the results from the Clemson lab, it is impossible to make definitive conclusions about patterns or trends. However, it may be said that efforts undertaken to reduce the bacterial loadings from any of the researched sources could potentially provide valuable reductions in bacteria reaching receiving waters.

Table 1: qCPR Results from Samples in the Rocky River-Wilson Creek Watershed

Date	Laboratory	24-hr rainfall (in)	Human	Bovine	Swine	Dog	E.Coli (MPN/100mL)
11/2/2016	Clemson University	0	Present	Not Detected	Not Detected	Not Detected	170
11/29/2016	Clemson University	0.73	Present	Not Detected	Not Detected	Not Detected	3,446
11/29/2016	Clemson University	0.73	Not Detected	Not Detected	Not Detected	Not Detected	3,570
11/30/2016	Clemson University	0.47	Present	Not Detected	Present	Not Detected	584
12/21/2016	Clemson University	0	Present	Not Detected	Not Detected	Not Detected	104
4/3/2017	Source Molecular	0.73	Present	Not Detected	Low Concentration	Low Concentration	1,662
6/29/2017	Source Molecular	0	Low Concentration	NA	Not Detected	Low Concentration	292

2.3 Anderson County & City of Anderson Monitoring

The City and County began sampling at one location in Cox Creek, a tributary to Rocky River, in 2015 to comply with their NPDES MS4 permit. Their sampling program was described in the document entitled "TMDL Monitoring and Assessment Plan: Rocky River-Wilson Creek Watershed," (Monitoring Plan) which was finalized in January 2015. The location, on a tributary west of the main stem, was chosen for its representativeness of the City of Anderson and the County's urbanized area, but also includes a significant amount of non-urbanized area outside the City's limits. The location is shown on a map, along with DHEC monitoring locations, in Figure 2. The sampling program is intended to provide an accurate representation of the E. coli concentrations at the monitoring location over time. Individual samples, however, are not to be understood as representative; the whole data series must always be analyzed. Further, the data may be skewed by constraints on the sampling program, such as lab hours, personnel safety, and stream/weather conditions. These constraints may prevent the collection of samples during certain conditions. As the dataset increases in number of observations, these effects will diminish, but during the first several years these effects may be more noticeable.

The sampling program has resulted in 60 grab samples being collected and analyzed for E. coli as of the date of this publication. Additionally, as a pilot effort, the City and County partnered to install and operate a continuous monitoring station at the Cox Creek site. The station collects a depth and turbidity reading every 15 minutes. This pilot effort is intended to serve as an indicator of whether a correlation may be made with depth or turbidity and other water quality parameters, including E. coli concentrations. The City and County will continue to monitor and will reevaluate the use of this station periodically based on an analysis of the results.

The City and County have analyzed the grab samples for trends and correlations in an attempt to characterize and understand E. coli responses to various environmental factors. The statements regarding the capabilities and

limitations of this data analysis presented at the beginning of Section 2 should be considered when interpreting these results. The basic statistics from the Cox Creek sampling site are presented in Table 2 below.

Table 2: E. coli Concentration Statistics at the Cox Creek Monitoring Site

Total No. Samples Analyzed	60
Samples Meeting Standards	4
Samples Over Daily Max Standard	10
Samples Over Monthly Avg. Standard	56
Minimum (MPN/100mL)	82
Maximum (MPN/100mL)	9,222
Median (MPN/100mL)	790
Average (MPN/100mL)	1,604

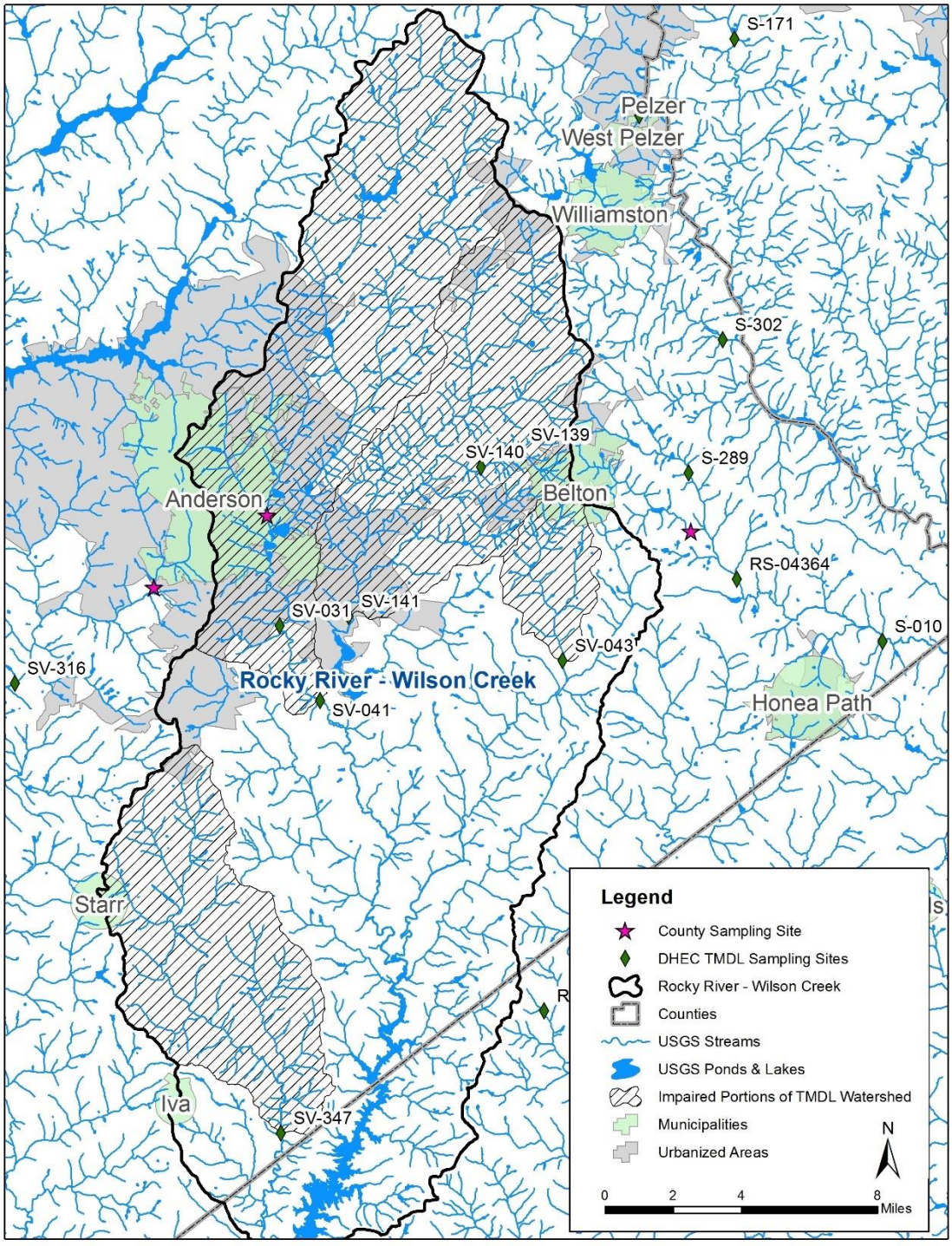


Figure 2: City of Anderson/Anderson County and DHEC Sampling Locations

As bacteria growth rates are known to be largely dependent on temperature, it was expected that the winter months would provide lower average concentrations than the summer months. This was the case during dry conditions, where the 3 samples taken during winter averaged just 134 MPN/100mL and the 6 samples taken during the summer months averaged 392 MPN/100mL. However, the samples taken during wet conditions showed a different pattern. The 7 samples taken during the winter averaged 1,633 MPN/100mL, while the 10 taken during the summer averaged just 856 MPN/100mL. While these findings are counterintuitive, the low numbers of samples taken during each precipitation and season-specific condition preclude the City and County from drawing definitive conclusions about the watershed. This analysis is complicated by the fact that some individual storm events have samples taken multiple times during the event to help characterize the pollutograph throughout the duration of the runoff event. There were different numbers of samples collected in different storm events because of the limitations on holding times, laboratory hours, and durations of rain events, preventing the collection of multiple samples for every event. Because multiple grab samples were collected during a small number of storms, those storms can be overrepresented in the data set. This overrepresentation weights the overall average toward the results from that single event. This effect may be demonstrated by the fact that removing the results of a single storm event leaves the average of the three remaining samples taken during wet, winter conditions at only 531 MPN/100mL, significantly less than the 1,633 MPN/100mL reported. The average concentrations by season and whether it was taken during a precipitation event (wet) or not (dry) are shown in Figure 3 below.

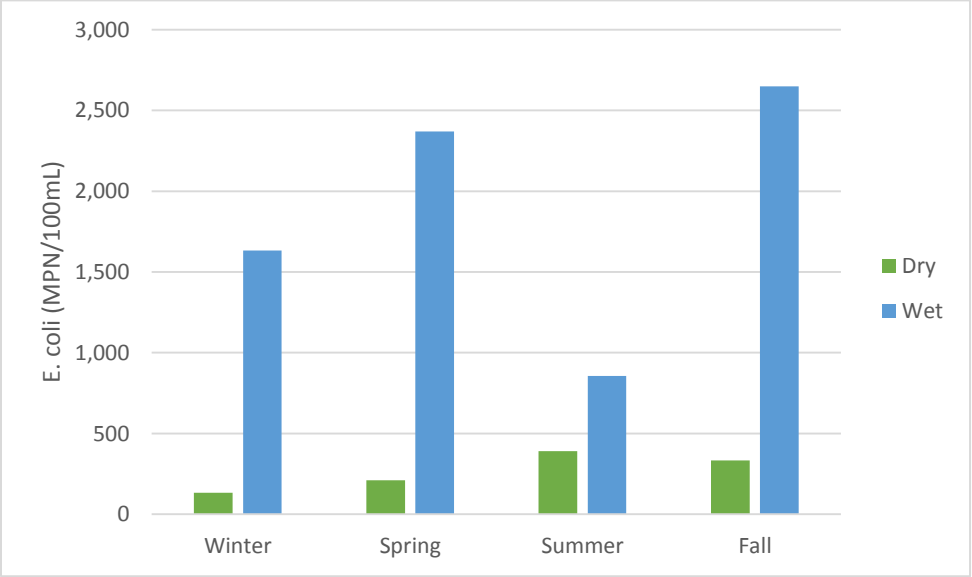


Figure 3: Average E. coli Concentrations by Season and Precipitation

Another way of viewing the influence of rainfall, and non-point sources (NPS) by extension, is to determine whether the creek is flowing at baseflow or some higher flow conditions at the time the sample is taken. As highlighted by the research presented above, this is not an entirely understood method of drawing conclusions about NPSs, but may provide some insight into any correlation between elevated creek flows and bacteria concentrations. Figure 4 shows the two variables plotted together, with flow represented by staff gauge height. This plot shows some degree of correlation. While more sampling may demonstrate a more decided relationship, it is not necessarily expected that this comparison would yield a high degree of correlation. The staff gauge reading is only able to provide a single measurement, which may be used as a surrogate for flow, but does not give information on whether the sample occurred during the rising or falling limb (or the peak) of a hydrograph. It also does not indicate whether the sample occurred during the "first flush" of a single event, several days after a major event, or any other potentially important considerations. Therefore, while it is likely that with the accumulation of a large sample set a positive correlation will emerge, it is not unreasonable to see only a weak correlation after 60 samples have been collected during a variety of conditions.

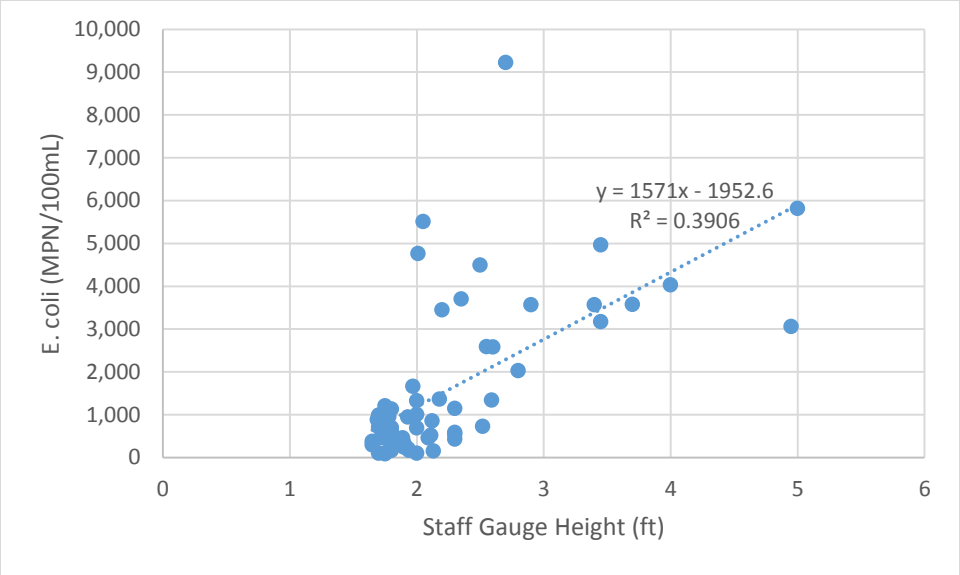


Figure 4: E. coli Concentrations vs. Staff Gauge Height

Perhaps the parameter most expected to correlate with E. coli concentrations was prior rainfall. Because bacteria grows in various conditions between storms, it tends to wash off and cause elevated concentrations during storm events. The exact mechanisms, however, are less well understood. The “first flush” theory is often seen in urban environments, but requires extensive sampling to be seen consistently. Because temperature can also have a large effect on bacteria concentrations, the correlation of bacteria concentration with rainfall can be skewed by an uneven distribution of sampled events across the range of temperatures.

The comparison of wet and dry samples by season shown in Figure 3 may be seen as a method of making the comparison with temperature. In all four seasons, the average E. coli concentration of samples taken in wet conditions was higher than the average of samples taken during dry conditions, but the low number of samples in each of those categories should temper the conclusiveness of that trend. In Figure 5 below, the actual rainfall depth that fell in the 24-hour period prior to the sampling event is plotted with the resulting E. coli concentration. There is a significant positive correlation, but the correlation is not precise, presumably due to the factors including those described above concerning collecting multiple samples during some storm events in addition to the potential for rain to be unevenly distributed throughout the drainage area, the antecedent moisture condition, and other factors.

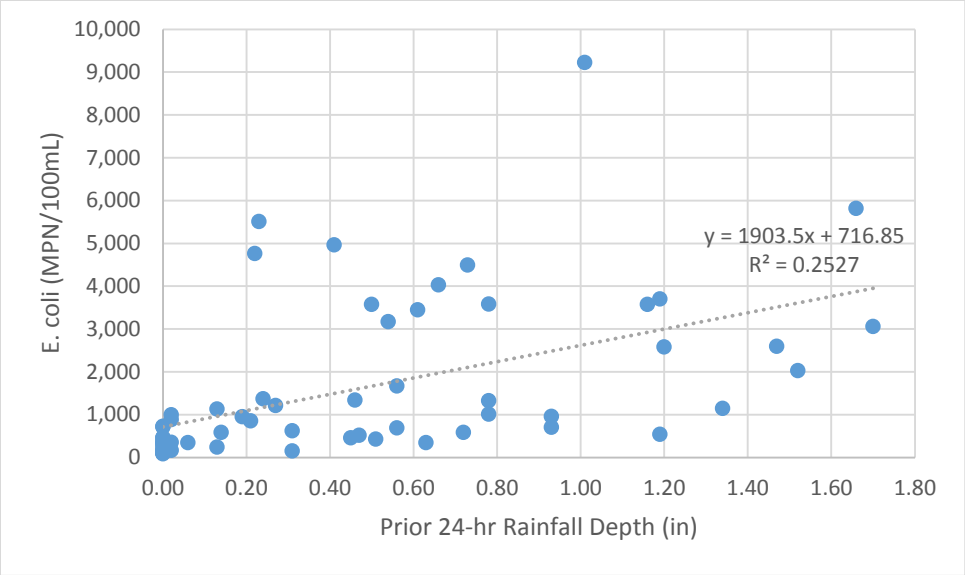


Figure 5: E. coli Concentration vs. Prior 24-hr Rainfall Depth

The turbidity and depth monitoring began in September 2016. 39 of the 60 grab samples were collected after this time, giving precise depth and turbidity readings to go with each. Figure 6 shows a comparison of E. coli concentrations with depth as measured by the continuous monitoring instrument. The correlation is much stronger than it was for the correlation with staff gauge reading, but that is due to the different sample set. If the comparison with staff gauge reading were limited to the same set of samples, its correlation would be nearly identical to the one below. This comparison confirms that these two variables are likely correlated and highlights the importance of a robust data set when making conclusions.

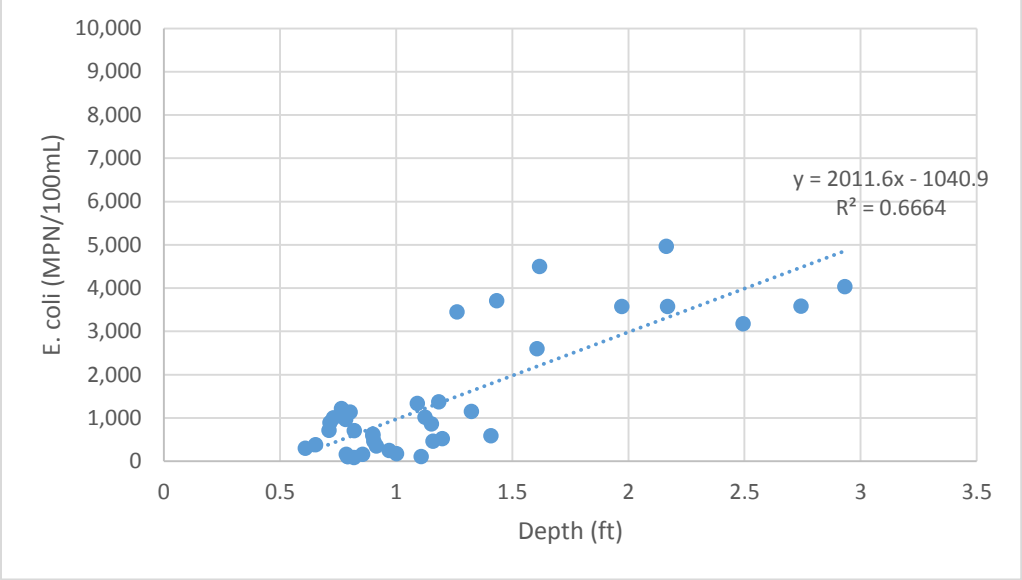


Figure 6: E. coli Concentrations vs. Depth

The City and County also explored whether E. coli concentrations were correlated with turbidity. With the exception of one outlier, the correlation appears strong (when the outlier is excluded, the R^2 value is 0.6). Turbidity is typically fairly well correlated with many pollutants during storm events, though each station location will

produce a different correlation equation. The City and County will continue collecting these continuous measurements in an attempt to improve on the correlations with more grab samples.

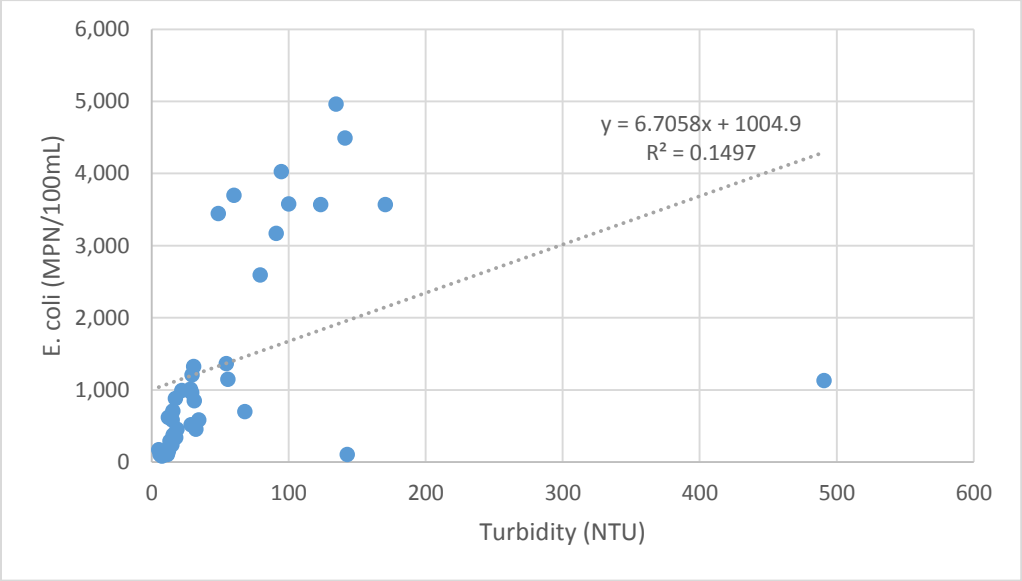


Figure 7: E. coli Concentration vs. Turbidity

The data analysis, when taken as a whole, indicates that further sampling and monitoring are needed to draw definitive conclusions about the level of correlation between E. coli concentrations and the researched factors. It can be seen, however, that only 7% of samples were below the monthly average standard and 83% were below the allowable daily maximum. These values alone make a case for the City and County's continued efforts to reduce bacteria loading to the MEP. The following sections describe the actions the City and County will take to do so.

3 Target Area Prioritization

Section 3.3.3.2 of the Phase II MS4 permit requires permittees to target specific areas for BMP implementation and report the rationale in this plan. The targeting should be based on known sources and data analysis. The analysis presented above show that more often than not, E. coli concentrations are higher when stormwater runoff is present than when conditions are dry. The MST analysis suggests that sources of E. coli include human, bovine, swine, and dog (no attempt was made to detect the presence of other sources). Therefore, efforts targeted at a single source would not be misplaced, but should be accompanied by broader efforts.

Because the sampling program implemented by the City and County have only one sampling location, it was not possible to determine "hot spots" or specific priority locations. However, the primary geographic focus will be the urbanized areas that fall under the jurisdiction of the respective NPDES MS4 permittees.

Swine and bovine sources are outside the jurisdiction of an MS4 to address, so no attempts will be made to reducing loading from these sources. It is expected that some of the other stakeholders named in the TMDL document will work towards addressing these and other agricultural sources. Anderson County, the City of Anderson, and the City of Belton will address loading from humans and pets (including, but not limited to dogs) to the MEP. Geographic and source-specific target areas for each BMP are presented in the next section in

Table 3.

4 BMP Implementation

Permittees are required to address the WLA through the use of structural and nonstructural BMPs. BMP selection and prioritization was based on the expected benefit of each BMP, feasibility of implementation, and cost of implementation. The TMDL document listed several methods of reducing bacteria loading, including:

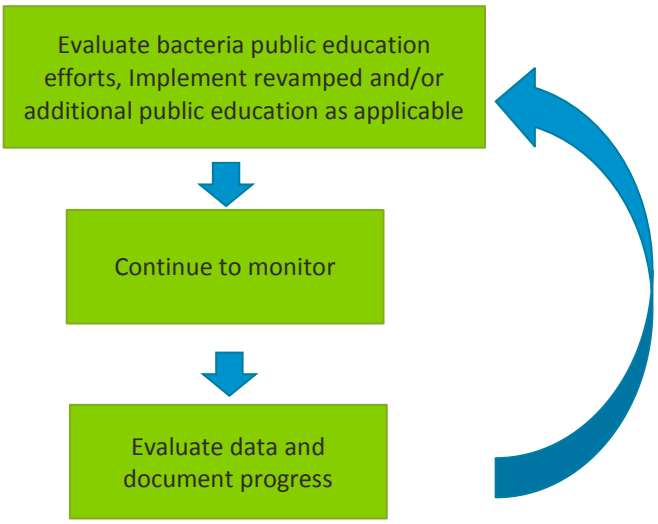
- DHEC's animal agriculture permitting program to address animal operations and land application of animal wastes
- Public and landowner education through the MS4, Clemson Extension Service, the Natural Resource Conservation Service (NRCS), the Anderson and Abbeville County Soil and Water Conservation Services, and the South Carolina Department of Natural Resources.
- Agricultural BMPs
- Discovery and removal of illicit storm drain cross connections

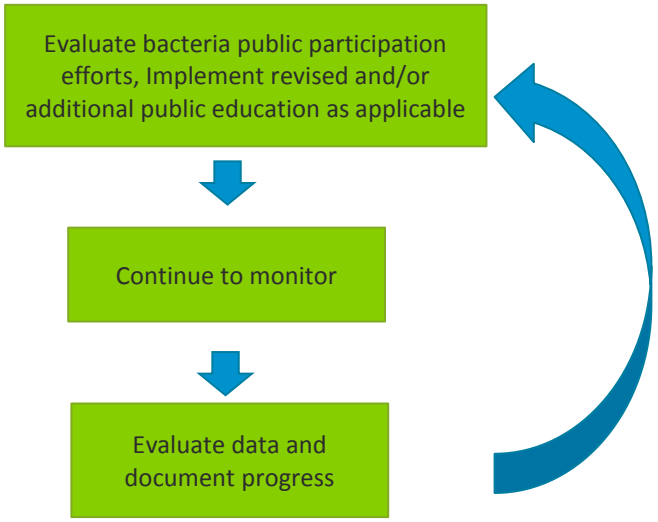
In addition to compliance with the NPDES MS4 permit, the City and County considered the following BMPs to reduce bacteria loading to its receiving waters:

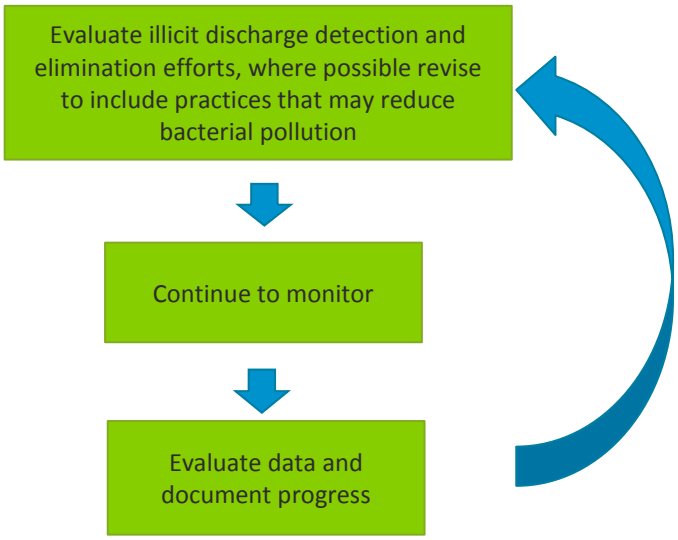
- Target bacteria with public education efforts
- Target bacteria during activities designed to draw public participation
- Address illicit discharges discovered during dry weather screening
- Inspect sanitary sewer lines located near streams
- Install pet waste stations in public locations
- Structural BMPs

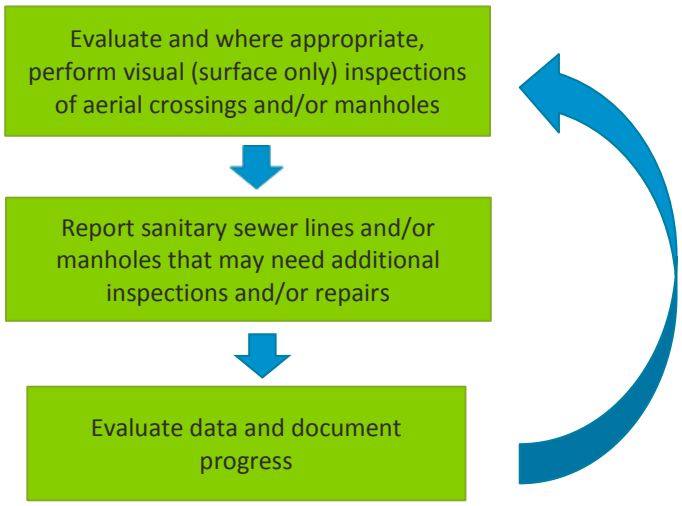
The following table presents the City and County's selection of BMPs for implementation with explanations to demonstrate why they were chosen and the areas to which they will apply.

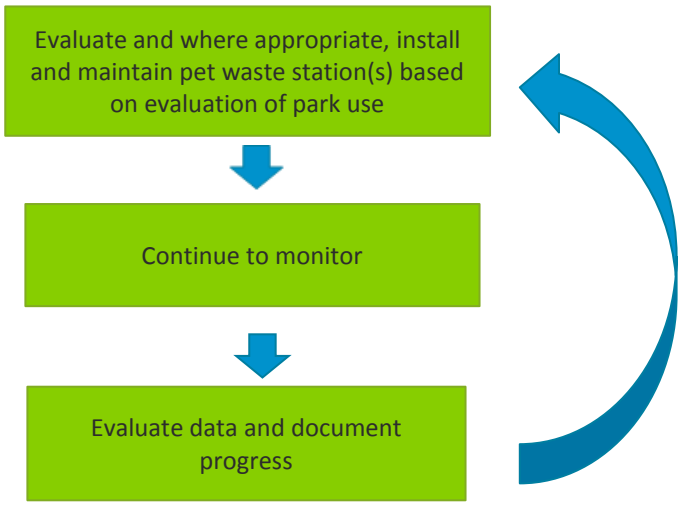
Table 3: BMP Implementation Rationale and Schedule

BEST MANAGEMENT PRACTICES FOR IMPLEMENTATION	
Proposed BMP:	Target bacteria with public education efforts
Prioritized Area:	This BMP will be implemented throughout the urbanized areas of the watershed.
Underlying Rationale:	The County and City currently have public education programs operated throughout their MS4s in accordance with Section 4.2.1 of the NPDES SMS4 permit, but this will be evaluated and as appropriate revamped to include further focus on sources of bacteria such as pet waste, septic tanks, and sanitary sewer overflows (including Fats Oils and Grease [FOG] education).
Implementation Schedule:	
Monitoring for Compliance:	The City and County will continue to monitor their public education campaign by tracking or estimating the total number of impressions (or other metric as appropriate for the means of communication). In-stream grab samples will also continue to be collected according to the Monitoring Plan and evaluated for progress.

Proposed BMP:	Target bacteria during activities designed to draw public participation
Prioritized Area:	This BMP will be implemented throughout the urbanized areas of the watershed.
Underlying Rationale:	The City and County currently have public participation programs operated throughout their MS4s in accordance with Section 4.2.2 of the NPDES SMS4 permit. Existing programs will be evaluated and, where possible and applicable, revised to include participation in activities that reduce bacterial pollution.
Implementation Schedule:	
Monitoring for Compliance:	The City and County will continue to monitor their public participation activities by tracking or estimating the total number of participants (or other metric as appropriate for the type of activity). In-stream grab samples will also continue to be collected according to the Monitoring Plan and evaluated for progress.

Proposed BMP:	Address illicit discharges discovered during dry weather screening
Prioritized Area:	This BMP will be implemented throughout the urbanized areas of the watershed.
Underlying Rationale:	The City and County currently have illicit discharge detection and elimination (IDDE) programs operated throughout their MS4s in accordance with Section 4.2.3 of the NPDES SMS4 permit. Existing programs will be evaluated and, where possible, revised to include practices that are expected to reduce bacterial pollution.
Implementation Schedule:	
Monitoring for Compliance:	The City and County will continue to track and report the number of illicit discharges and the results of each investigation. In-stream grab samples will also continue to be collected according to the Monitoring Plan and evaluated for progress.

Proposed BMP:	Visually (surface only) inspect sanitary sewer lines located near streams
Prioritized Area:	Sanitary sewer lines in easements located near streams.
Underlying Rationale:	While relatively infrequent, and most often minor, sanitary sewer overflows allow high concentrations of human waste to enter directly into a stream. More importantly, if not discovered, the causes of these overflows can remain in place and cause recurring overflows. Areas with a history of SSOs or known potential issues will be evaluated and where appropriate visual inspections of aerial crossings and/or manholes will take place (surface only).
Implementation Schedule:	
Monitoring for Compliance:	The City and County will report the number of sanitary sewer overflows discovered as part of their IDDE program statistics. In-stream grab samples will also continue to be collected according to the Monitoring Plan and evaluated for progress.

Proposed BMP:	Install pet waste bag stations in key locations
Prioritized Area:	Parks and other public property locations within urbanized areas where dogs are frequently present. Locations will be evaluated and selected based on presence of dogs and/or suggestions from park staff.
Underlying Rationale:	The MST results showed the presence of bacteria from dogs in this watershed. Installing pet waste stations will have a double-effect on reducing bacteria loads: they will increase the public's awareness of the problems associated with not bagging pet waste and they will provide pet owners an easy way to pick up after their pets.
Implementation Schedule:	
Monitoring for Compliance:	Monitoring of pet waste stations will be performed through maintenance activities. These stations must be maintained by stocking with bags and checking their proper function and signage. Progress can be measured by estimating the number of pet waste bags used.

Proposed BMP:	Comply with NPDES SMS4 permit.
Prioritized Area:	Applicable area varies by BMP.
Underlying Rationale:	The SMS4 permit provides minimum control measures (MCMs) and other requirements intended to reduce the amount of pollutants (including bacterial pollutants) that reach receiving waters. While many of the BMPs and MCMs specified in the permit are general, or do not contain bacteria-specific language, they may still be effective at reducing bacterial pollution to some degree. Therefore, the County will continue to comply with the entire permit with the expectation that bacteria pollution will be minimized to the maximum extent practicable.
Implementation Schedule:	The City and County will continue to comply with their NPDES MS4 permit for the remainder of the current permit term and during the next permit term.
Monitoring for Compliance:	Compliance with the permit will be monitored through the MS4 Annual Reports. In-stream grab samples will also continue to be collected according to the Monitoring Plan and evaluated for progress.

Structural BMPs (other than pet waste stations) were considered, but will not be implemented at this time. The benefits of structural BMPs to reduce bacterial loadings in receiving waters are small compared to the cost to design, construct, and maintain those BMPs. There is evidence of the effectiveness of structural BMPs at reducing E. coli loads under certain conditions, but the ability of E. coli to reproduce and increase exponentially downstream of the treated runoff reduces the efficacy when evaluated at an in-stream monitoring station. The expense of large-scale implementation of structural BMPs is prohibitive at this time.

5 Revisions and Reporting

The monitoring methods described in

Table 3 above will be implemented and used to track the effectiveness of the BMPs at reducing bacteria loads in receiving waters. No matter the results of the grab sampling program (whether it shows decreases, increases, or no change in bacteria concentrations), the City of Anderson, Anderson County, and the City of Belton will reevaluate their BMPs and target areas annually. However, the BMPs above represent the MEP, and are not expected to increase in scope or effectiveness without a change in the circumstances of the County or Cities. Changes to the program may be made based on measures of effectiveness according to the monitoring methods listed in

Table 3, changes in circumstances (including budgetary, population trends, shifts in media usage preferences, etc.), or attempts to increase effectiveness through new or modified means.

Section 3.3.5 of the Phase II NPDES MS4 permit states that permittees are required to report their most up-to-date TMDL Implementation Plans and schedules as part of the permit re-application package. Further, Section 3.3.6 requires documentation of progress with TMDL implementation and analysis in each Annual Report. The City and County will therefore provide a section in each subsequent Annual Report to note changes in this TMDL Implementation Plan and analysis results.