# TMDL Implementation Plan: Upper Savannah River

## Anderson County, SC

December 2017

# 1 Background

Anderson County is a Phase II National Pollutant Discharge and Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) general permit holder. As such, its stormwater discharges are subject to regulation under the NPDES MS4 general permit issued by the South Carolina Department of Health and Environmental Control (DHEC). 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 four subwatersheds of the Upper Savannah River basin, which includes urbanized portions of Anderson County. The watershed location is shown in Figure 1. The upper portion of the TMDL watershed includes the Eighteen Mile Creek and Three and Twenty Creek subwatersheds. The lower portion of the watershed includes the Little River and Long Cane Creek watersheds. The TMDL became effective in July 2005 and includes WLAs for non-point source runoff that thereby includes this urbanized area. The TMDL covered Hydrologic Unit Codes (HUC) 03060101 and 03060103 and DHEC water quality monitoring stations SV-017, SV-245, SV-135, SV-233, SV-268, SV-241, SV-111, SV-052, SV-164, SV-348, SV-192, RS-01049, SV-053B, SV-349, and SV-318.

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 has taken and will undertake to comply with these permit requirements to reduce bacteria loads discharged into receiving waters to the MEP.

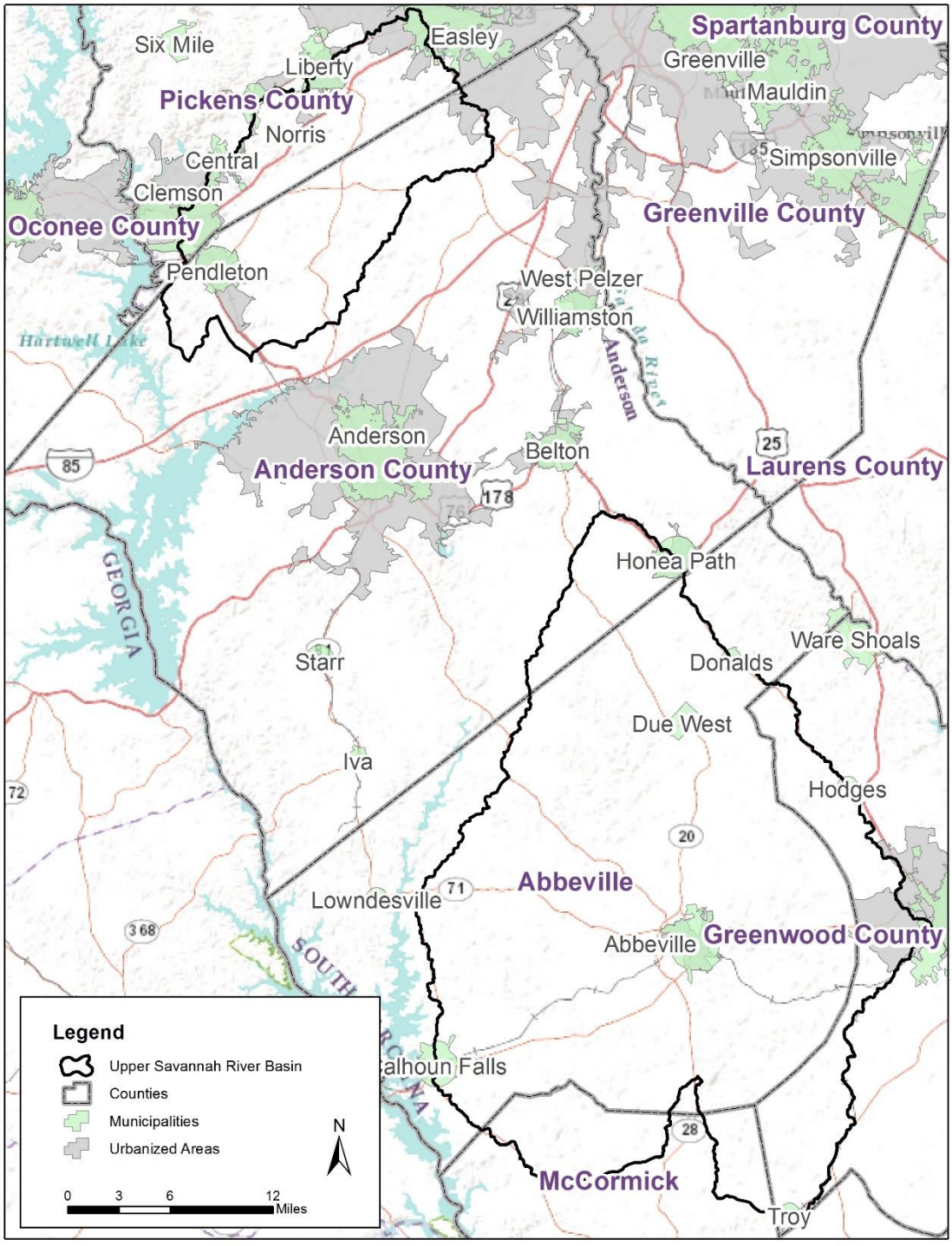



Figure 1: Location of Upper Savannah River Basin

In January 2015, Anderson County published a monitoring plan in compliance with its Phase II MS4 permit, and has been implementing that plan since then. The plan identified a location near Cely Road on Big Brushy Creek, a tributary to the Upper Saluda River as representative of MS4 contributions of runoff to the watershed and minimizing the contribution of other sources (see Figure 3). The plan describes that even though the sampling location is outside of the Savannah River basin, it can still be considered a location that is representative of the typical runoff from urbanized areas in Anderson County. 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

During the interpretation of the results, the County is 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 several of the monitoring stations in Anderson County used to develop this TMDL are still active. In the upper portion, SV-311, SV-268, and SV-233 are active (though SV-311 is not being sampled for E. coli), while RS-03506 was a Random Sampling location in 2003 and SV-135 is inactive. These sampling locations are shown below in Figure 3. There were no SCDHEC monitoring stations in Anderson County in the lower portion of the Savannah River TMDL watershed. The only station downstream of Anderson County, SV-164, is currently inactive. Statistics for E. coli samples collected between 2013 and 2017 (all that are on record) at DHEC stations SV-233 and SV-268 are shown below in Table 1. Figure 2 is a scatterplot of all the samples from 2013-17, showing that there is no significant trend over time.

Table 1: Statistics for DHEC Sampling Locations

| | SV-233 | SV-268 |
|---|---|---|
| Total No. Samples Analyzed | 31 | 32 |
| Samples Meeting Standards | 1 | 3 |
| Samples Over Daily Max Standard | 18 | 12 |
| Samples Over Monthly Avg. Standard | 12 | 17 |
| Minimum (MPN/100mL) | 93 | 99 |
| Maximum (MPN/100mL) | 1,733 | 2,420 |
| Median (MPN/100mL) | 387 | 292 |

| | | |
|---|---|---|
| Average (MPN/100mL) | 478 | 452 |

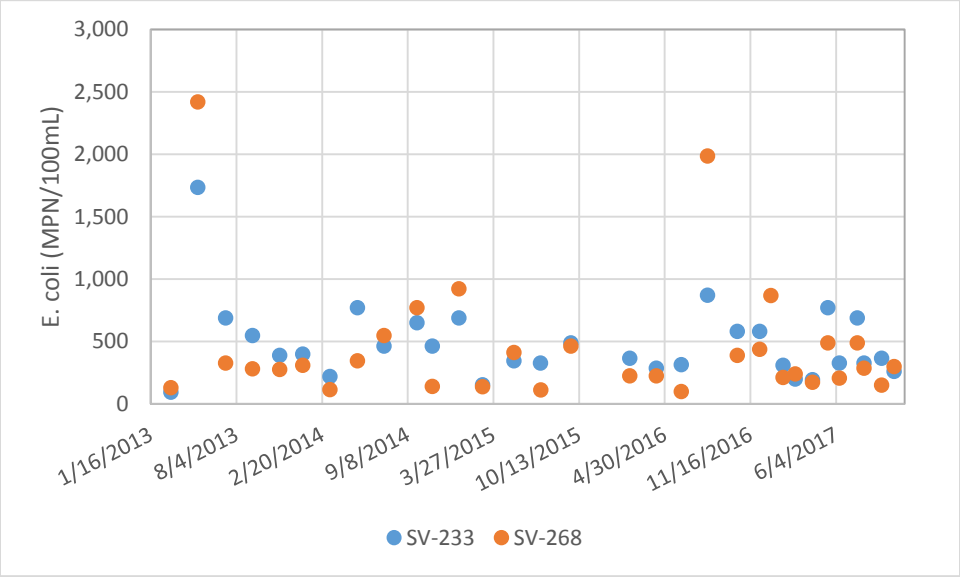



Figure 2: E. coli Concentrations for all DHEC Samples, 2013-17

DHEC also publishes a list of sanitary sewer overflows (SSOs) reported to them. Because the County did not sample within this watershed, the SSO list was not consulted for this Implementation Plan. Efforts to reduce SSOs are discussed in the BMP Implementation section below.

## 2.2 Microbial Source Tracking

As part of the monitoring effort, some samples collected by the 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 (shown in Table 2), 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 and dogs. However, neither was 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 2: qCPR Results from Samples

| 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 | 406 |
| 11/29/2016 | Clemson University | 1.5 | Not Detected | Not Detected | Not Detected | Low Concentration | 390 |
| 11/29/2016 | Clemson University | 1.5 | Not Detected | NA | NA | Low Concentration | 1,446 |
| 11/30/2016 | Clemson University | 0.75 | Present | Not Detected | Not Detected | Not Detected | 1,108 |
| 12/21/2016 | Clemson University | 0 | Not Detected | Not Detected | Not Detected | Not Detected | 218 |
| 4/3/2017 | Source Molecular | 0.79 | Not Detected | Not Detected | Not Detected | Not Detected | 195 |
| 6/29/2017 | Source Molecular | 0 | Present | Not Detected | Not Detected | Not Detected | 20 |

## 2.3 Anderson County Monitoring

The County began sampling at the Cely Road location on Big Brushy Creek, a tributary to the Upper Saluda River, in 2015 to comply with their NPDES MS4 permit. Their sampling program was described in the document entitled "TMDL Monitoring and Assessment Plan: Upper Savannah River 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 County's urbanized area, but also includes non-urbanized area. The Monitoring Plan shows that the Upper Saluda River basin has similar characteristics to the Upper Savannah River basin. The location of the upper portion of the Savannah River watershed (HUC 03060101) and the County sampling location are shown on a map, along with DHEC monitoring locations, in Figure 3. Figure 4 shows the lower portion of the Savannah River basin (HUC 03060103). 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 different sampling programs also prevent direct comparisons to DHEC sampling results, which were collected predominately during dry weather.

The sampling program has resulted in 60 grab samples being collected and analyzed for E. coli as of the date of this publication. The County has analyzed the 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 Cely Road sampling site are presented in Table 3 below.

Table 3: E. coli Concentration Statistics at the Cely Road Monitoring Site

| | |
|---|---|
| Total No. Samples Analyzed | 60 |
| Samples Meeting Standards | 6 |
| Samples Over Daily Max Standard | 15 |
| Samples Over Monthly Avg. Standard | 54 |
| Minimum (MPN/100mL) | 20 |
| Maximum (MPN/100mL) | 5,974 |
| Median (MPN/100mL) | 566 |

| | |
|---|---|
| Average (MPN/100mL) | 1,017 |

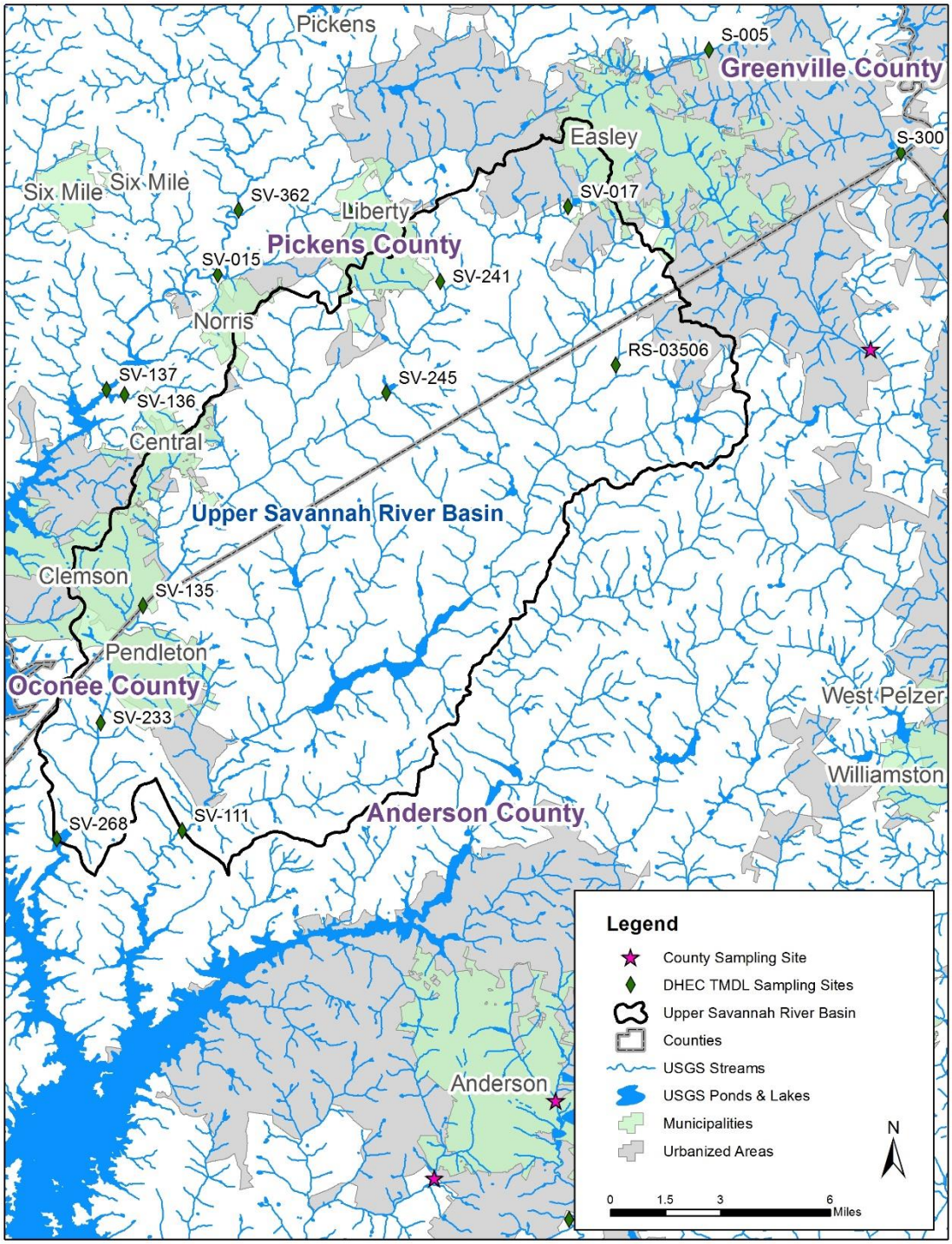



Figure 3: Anderson County and DHEC Sampling Locations in HUC 03060101

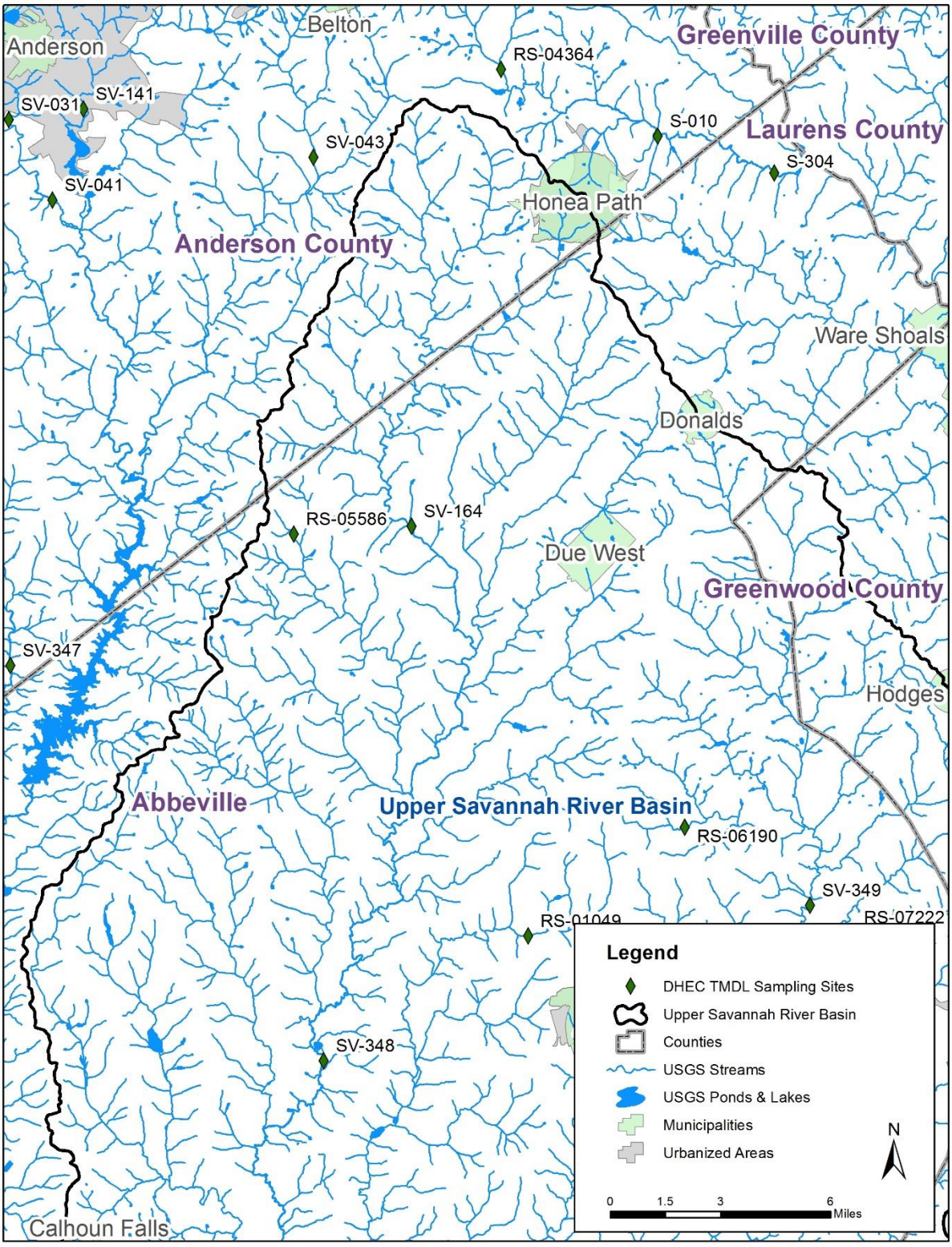



Figure 4: Anderson County and DHEC Sampling Locations in HUC 03060103

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 not the case during dry conditions, where the 3 samples taken during winter averaged 180 MPN/100mL, but the 5 samples taken during the summer months averaged 151 MPN/100mL. The samples taken during wet conditions showed an unexpected different pattern. The 7 samples taken during the winter averaged 2,259 MPN/100mL, while the 11 taken during the summer averaged just 566 MPN/100mL. While these findings are counterintuitive, the low numbers of samples taken during each precipitation and season-specific condition preclude the 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. The average concentrations by season and whether it was taken during a precipitation event (wet) or not (dry) are shown in Figure 5 below.

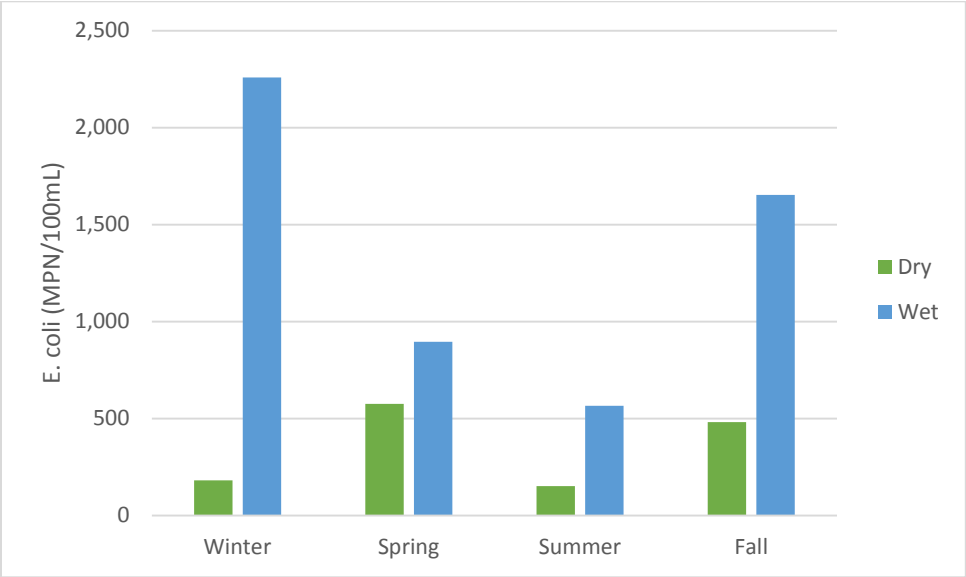



Figure 5: Average E. coli Concentrations by Season and Precipitation

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 6 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.

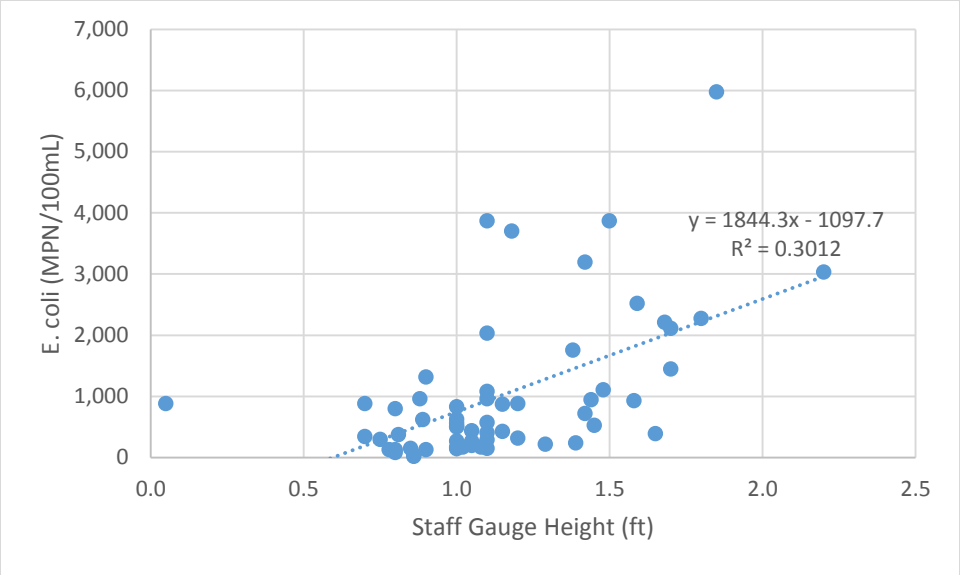



Figure 6: E. coli Concentrations vs. Staff Gauge Height

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 5 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 7 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.

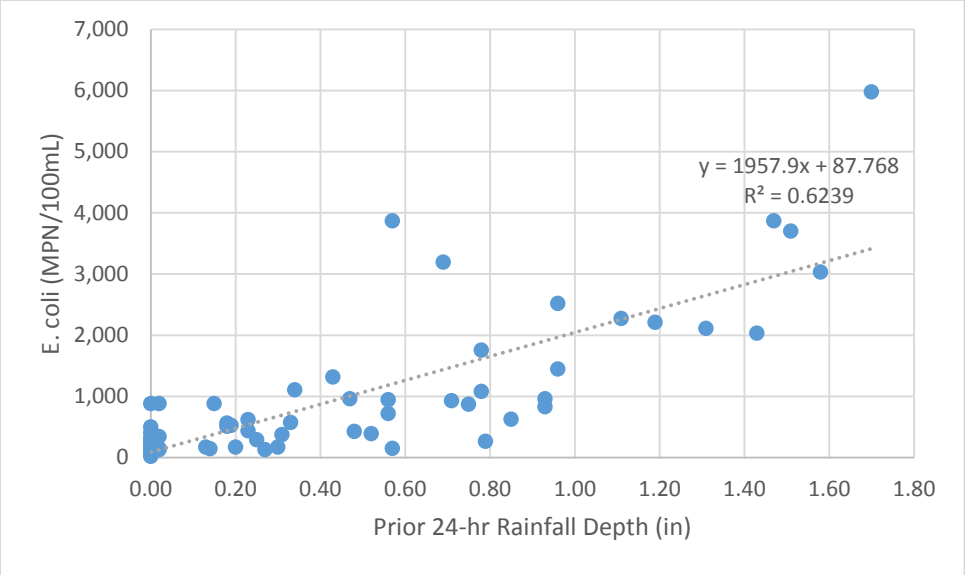



Figure 7: E. coli Concentration vs. Prior 24-hr Rainfall Depth

The data analysis, when taken as a whole, indicates that further sampling is 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 10% of samples were below the monthly average standard and 75% were below the allowable daily maximum. These values alone make a case for the County's continued efforts to reduce bacteria loading to the MEP. The following sections describe the actions the 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 and dog. 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 County has only one sampling location, and that location was outside of both parts of this specific watershed, it was not possible to determine "hot spots" or specific priority locations within the Upper Savannah watershed. However, the primary geographic focus will be the urbanized areas that fall under the jurisdiction of the County's MS4.

Swine and bovine sources are outside the jurisdiction of an MS4 to address, so no attempts will be made to reduce 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 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 **Error! Reference source not found.**.

# 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:

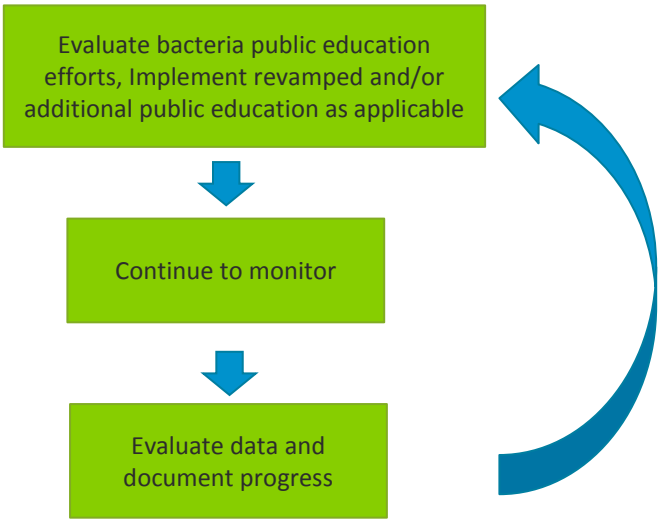
- DHEC's animal agriculture permitting program to address animal operations and land application of animal wastes
- Public and landowner education through the MS4, Clemson Extension Service, the Natural Resource Conservation Service (NRCS), the Anderson and Abbeville County Soil and Water Conservation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

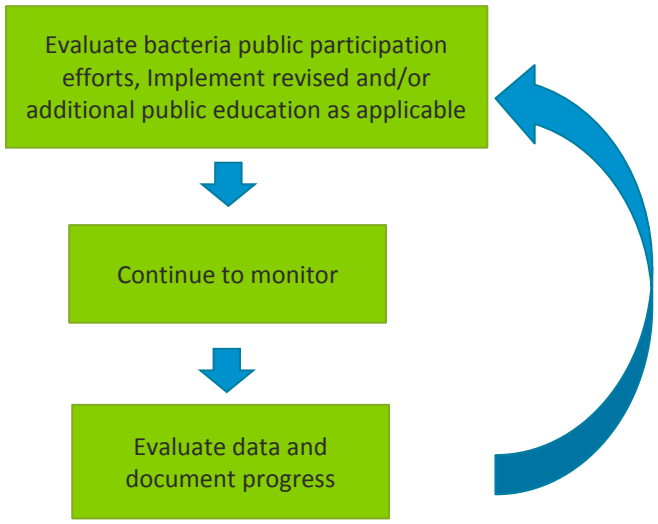
In addition to compliance with the NPDES MS4 permit, the County considered the following BMPs to reduce bacteria loading to its receiving waters:

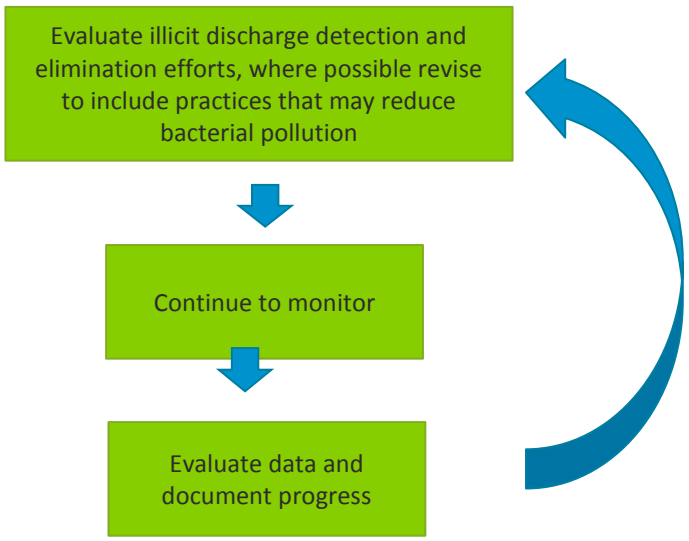
- Target bacteria with public education efforts
- Target bacteria during activities designed to draw public participation
- Address illicit discharges discovered during dry weather screening
- Inspect sanitary sewer lines located near streams
- Install pet waste stations in public locations
- Structural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

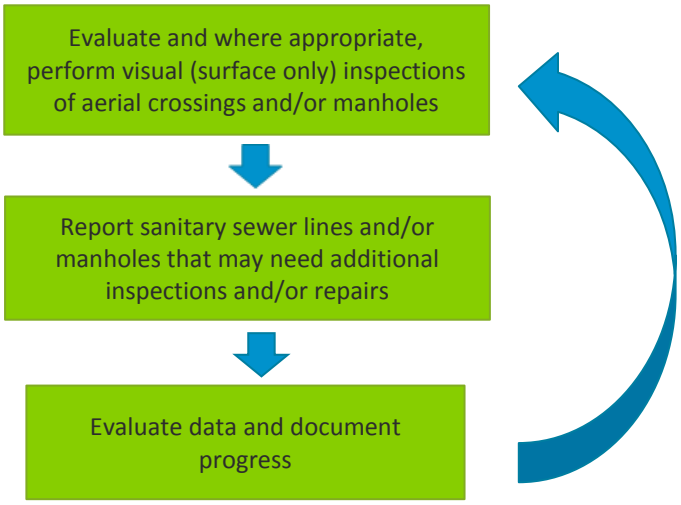
The following table presents the County's selection of BMPs for implementation with explanations to demonstrate why they were chosen and the areas to which they will apply.

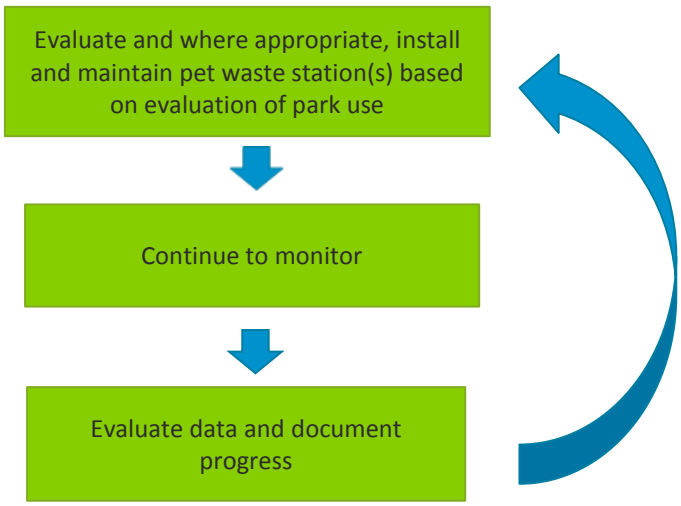
Table 4: BMP Implementation Rationale and Schedule

| 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 currently has a public education program operated throughout its MS4 in accordance with Section 4.2.1 of the NPDES SMS4 permit, but this will be evaluated and as appropriate revamped and/or enhanced 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 County will continue to monitor it 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 County currently has public participation programs operated throughout its MS4 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 could potentially reduce bacterial pollution. |
| Implementation Schedule: |  |
| Monitoring for Compliance: | The County will continue to monitor its 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 County currently has an illicit discharge detection and elimination (IDDE) program operated throughout its MS4 in accordance with Section 4.2.3 of the NPDES SMS4 permit. The existing program will be evaluated and, where possible, revised to include practices that are expected to reduce bacterial pollution. |
| Implementation Schedule: |  |
| Monitoring for Compliance: | The 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 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 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 4 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), Anderson County 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. Changes to the program may be made based on measures of effectiveness according to the monitoring methods listed in Table 4, 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 County will therefore provide a section in each subsequent Annual Report to note changes in this TMDL Implementation Plan and analysis results.