Recommendations for Improving Fecal Coliform Pollution Control in Gwinnett County, Georgia

Upper Altamaha Practicum Course
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1.0 BACKGROUND and INTRODUCTION

The 1972 Amendments to the Federal Clean Water Act require the creation of a Total Maximum Daily Load (TMDL) for a body of water that is not achieving compliance with a water quality standard. The purpose of a TMDL is to assess the assimilative capacity of a waterway for a particular pollutant and allocate loads to different pollutant source categories so that the water quality standard may be met. A TMDL Implementation plan seeks to create a plan to allow a body of water to reach attainment of the water quality standard (such as drinkable, swimable, fishable, etc.) by establishing management measures that limit the amount of the pollutant of concern that can enter the water.

In order to ensure compliance with the TMDL requirement of the CWA, Gwinnett County, in suburban Atlanta, would like to investigate opportunities to enhance and expand their TMDL implementation plan for fecal coliform bacterial pollution. The purpose of this project is to identify and evaluate possible new management measures to reduce fecal coliform pollution load. This involved the following steps: surveying current measures used in Gwinnett County by reviewing TMDL implementation plans and other background research, looking at land uses in the county to identify potential sources of fecal coliform and appropriate new control measures, identifying and researching other management measures by reviewing TMDL implementation plans from other states, and then evaluating these management measures for efficiency, feasibility and cost.

Fecal coliform pollution comes from a variety of sources including urban runoff, pet waste, failing or leaking septic systems, livestock, wildlife, illicit connections, leaking sewer lines and NPDES permitted point sources. Current measures used to manage fecal coliform pollution in Gwinnett County include the National Pollutant Discharge Elimination System
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(NPDES) permit program, stormwater management ordinances, agricultural and land development best management practices (BMPs), and septic system programs such as using color infrared aerial photography to identify failing systems and septic-to-sewer transition.

Compared to other counties in Georgia and even other states, Gwinnett County has a strong, comprehensive implementation plan for addressing fecal coliform pollution. The broad-based, “toolbox” type of approach provides a variety of management measures to deal with the complex problem of fecal coliform pollution. There are some areas with room for improvement; our recommendations include the following:

- More detailed identification of pollution sources using the targeted sampling bacterial source tracking (BST) method and potentially DNA fingerprinting
- Creative financing options to help homeowners repair failing septic systems such as using Clean Water Act State Revolving Funds, tax incentives, or bonds
- Improvements to septic tank maintenance including a septic tank management ordinance
- Target and expand inspections of and educational outreach to high pet concentration areas, specifically focusing on places with high concentrations of animals such as kennels or boarding facilities, animal shelters, and breeders
- Ordinances or cost-share programs to keep livestock out of streams
- Programs to minimize attraction of wildlife to dumpsters and parking lots
- Organizational and structural improvements to current TMDL plans
- Improve septic-to-sewer transition program

2.0 CURRENT STATUS OF FECAL COLIFORM POLLUTION

According to the data provided by the Gwinnett County Department of Public Utilities...
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(DPU), 25 rivers in Gwinnett County are included in Georgia’s 2004 303(d) list of impaired waters. The impaired waterways are shown in Figure 1. The geometric mean fecal coliform levels in 16 rivers were monitored in 2004 and 2005. Among these rivers only six were below the geometric mean limit of fecal coliform (200 cfu/100 ml) when tested during the May to July quarter in 2005. The highest level was found in Sweetwater Creek, which is near 500 cfu/100 ml as shown in Figure 2. These data illustrate that further control efforts are needed to manage fecal coliform pollution in Gwinnett County.

3.0 SCIENTIFIC BACKGROUND, METHODS and ASSUMPTIONS

The term “coliform bacteria” refers to the bacterial species in the family Enterobacteriaceae that live in the intestines of warm-blooded vertebrates (mammals and birds). They are rod-shaped bacteria that are very closely related and therefore easily identified as a group with detection methods. Fecal coliform bacteria are a sub-set of the coliform bacteria and have little or no ability to persist for more than a few hours outside the intestine (Carroll, 2006). Unlike phosphorous and heavy metals, fecal coliform does not accumulate and persist in natural water bodies. There is debate about using fecal coliform as the indicator bacteria. Some states have adopted E.coli as the standard for fresh water and fecal enterococci for marine waters. Georgia (and therefore, Gwinnett County) use fecal coliform as the bacterial indicator for TMDL purposes. The research conducted for this paper assumes fecal coliform bacteria is the indicator bacteria and that the pollution control measures will reduce fecal coliform bacteria loads.

Establishing fecal coliform pollution source allocation loads is a complex, difficult process – especially when dealing with non-point sources. A large number of variables such as local rainfall, distance to a waterway, soil type and condition, ground slope, and vegetation
cover, among others, should be included in the calculation. We felt it was imperative to first roughly estimate source allocation loads in order to then discuss management measures.

Pollution control projects are subject to budget constraints and overview. Having a general idea of pollution source allocation load can allow an agency or organization to prioritize pollution control projects and more efficiently and effectively focus their limited financial resources.

For the purposes of this paper, which is the result of a semester-long class project, we used very gross estimation processes for establishing pollution source allocation loads. The calculations are based on equations found in current scientific literature but we did not manipulate them to incorporate the large number of variables referenced earlier (local rainfall, soil type and condition, etc.). It was not within the scope or focus of this project to delve into the in-depth analysis required for those types of calculations. *It is important to note that the numbers listed in this paper for pollution allocation loads from all the various point and non-point sources are very general, rough estimates and can not be used as a basis for further studies without more in-depth research and analysis.*
Figure 1: Fecal coliform bacteria impaired waters in Gwinnett County, GA
Source: Gwinnett County Department of Public Utilities
Map by: UGA River Basin Center
Figure 2: The fecal coliform geometric mean in a subset of Ocmulgee River Basin sample stations in Gwinnett County during the May-July Quarter, 2005
(1–Camp Creek, 2—Jackson Creek, 3—Sweetwater Creek, 4—Pew Creek, 5—Beaver Ruin Creek, 6—Bromolow Creek, 7—Shetley Creek, 8—Little Suwanee Creek, 9—Cedar Creek/Luke Edwards, 10—Shoal Creek, 11—Cedar Creek, 12—Hopkins Creek, 13—Yellow River, 14—Jacks Creek, 15—Watson Creek, 16—Turkey Creek)
Source: Gwinnett County Department of Public Utilities

4.0 POSSIBLE SOURCES OF FECAL COLIFORM POLLUTION

The sources of fecal coliform in Gwinnett County can be grouped into point source and non-point source categories. The point sources include the effluent from the Water Reclamation Facilities (WRF), which are NPDES permitted sources. The non-point sources include urban runoff, leaking or failing septic systems, and waste from pets, livestock, and wildlife. The land uses in Gwinnett County are illustrated in Figure 3.
4.1 Point Source

Approximately half of the population of Gwinnett County is served by the sanitary sewer system. The rest of the wastewater in the county is treated using decentralized wastewater
treatment methods such as onsite septic systems. The Water Reclamation Facilities (WRF) in Gwinnett County treat the wastewater collected by the sanitary sewer system and have a total capacity of approximately 64.1 mgd (http://www.co.gwinnett.ga.us). Advanced techniques are used in these facilities to remove solids and nutrients from wastewater. Chlorine and ultraviolet (UV) are used to disinfect the effluent. The geometric mean of the effluent from the facilities is below 5cfu/100 ml, which demonstrates that the coliform concentration of WRF effluent is much lower than that in the receiving rivers. The total fecal coliform discharged from each facility is listed in Table 1. As of March 2006, the Big Haynes, Sugar Hill, and No Business Facilities were retired and will be dismantled. If we assume the other sewer treatment plants have similar efficiency, the estimated annual amount of fecal coliform discharged from WRF and other sewer treatment facilities may be around 1,352 billion cfu. This is a very rough estimate.

Table 1: The total geometric mean of fecal coliform bacteria discharged from January 2004 through October 2005 from Gwinnett County Water Reclamation Facilities

<table>
<thead>
<tr>
<th>Site</th>
<th>Average geometric concentration of fecal coliform in effluent (cfu/100 ml)</th>
<th>Average flow (mgd)</th>
<th>Total geometric fecal coliform discharged (billion cfu/year)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beaver Ruin WRF</td>
<td>1.64</td>
<td>3.22</td>
<td>72.95</td>
</tr>
<tr>
<td>Jacks WRF</td>
<td>1.52</td>
<td>0.53</td>
<td>11.21</td>
</tr>
<tr>
<td>Jackson WRF</td>
<td>1.05</td>
<td>2.72</td>
<td>39.48</td>
</tr>
<tr>
<td>No Business Creek WRF</td>
<td>1.09</td>
<td>0.92</td>
<td>18.88</td>
</tr>
<tr>
<td>Yellow River WRF</td>
<td>1.72</td>
<td>8.44</td>
<td>200</td>
</tr>
<tr>
<td>Crooked Creek WRF</td>
<td>4.25</td>
<td>12.68</td>
<td>745</td>
</tr>
<tr>
<td>Hill WRC</td>
<td>1.10</td>
<td>17.38</td>
<td>264</td>
</tr>
<tr>
<td>Total</td>
<td>-</td>
<td>-</td>
<td>1,352</td>
</tr>
</tbody>
</table>

*Note: Fecal coliform bacteria have a short life span and will not persist long in natural waters. See section 3.0 for more information.
4.2 Non-Point Sources

Compared with the point sources, non-point sources are diffuse and difficult to estimate. Nevertheless, we attempted to provide a rough estimate of the possible loadings according to current data and relevant values in literature. See section 3.0 for more information.
4.2.1 Failing Septic Systems

Failing septic systems are potential sources of fecal coliform to water bodies. According to an aerial color infrared study conducted by the Gwinnett County DPU in spring of 2004 to detect failing septic systems, out of approximately 100,000 septic systems in the county there were about 128 surface failures, 520 seasonal failures, and 452 seasonal stress sites (Figures 5 and 6). It is important to note that seasonal stress sites can not be categorized as failures.

Surface and seasonal failures do not imply or provide a direct connection to a stream. It is difficult to accurately calculate the amount of fecal coliform pollution contributed by failing septic systems because many factors have to be considered including local rainfall, distance to a waterway, soil type and condition, ground slope, vegetation cover and more. Acknowledging these limitations, which are also discussed in section 3.0, we came up with the following estimations. If we assume the seasonal failures happen at a chance of one out of four or 25 percent (based on one rainy season, winter, out of four seasons), then the total number of failures is 258. 520x.25 = 130+128=258. According to the population and number of housing units (US Census Bureau, 2005), one septic tank serves 3 people. If average fecal coliform production of one person is $1.95 \times 10^9$ cfu/day (Yagow et al, 2001), and assuming that the fecal coliform bacterial load passes through the system to the point of failure within the system, then the total fecal coliform discharge from all failing septic systems is estimated as $1.95 \times 3 \times 258 \times 365 = 550,895$ billion cfu. Compared with a 3% national failure rate (Durand, 2002), the ratio in Gwinnett County (0.026%) is much lower.

This survey had an unknown false-negative or error rate due to some characteristics of the aerial color infrared (ACIR) survey method. The ACIR technique relies on the fluctuations in the color of vegetation (color signatures) to detect leaking septic tanks (Perrin, 2005). The
following factors may affect the accuracy of the results: (i) Season of photograph. The greatest differences between healthy and stressed vegetation are observed during the spring season. (ii) Planting distance. The spacing of trees has a considerable effect on ACIR photography as the space between trees forms shadows in ACIR photography. Besides these shadows, there are also shadows between the major branches (Warner et al, 2000), so the space between the trees will affect the differentiability between trees and spaces. (iii) Canopy density. The size and density of tree canopy can greatly affect the amount of light reflected by bare soil between trees. (iv) Soil type. Soil types vary greatly in color and consequently change the range of exposure settings. (v) Warm season grasses such as Centipede, Zoysia, and St. Augustine are commonly used on lawns in the area and are dormant (brown) until May in Gwinnett County and therefore will not provide a good color signature. (vi) Moisture. Moisture is another important variable affecting the reflection of background soil and vegetation (NASA, 1980). The error rate of the survey was also affected because 14 percent of the county was obscured by pine trees. If all of the failing septic systems were located, the ratio of failures might be higher and the efforts to maintain septic systems could be more justifiable.
Figure 5: Fecal coliform bacteria impaired waters and property parcels served by septic systems in Gwinnett County, GA

Source: Gwinnett County Department of Public Utilities
Map by: UGA River Basin Center
Figure 6: Fecal coliform bacteria impaired waters and property parcels with failing septic systems in Gwinnett County, GA
Source: Gwinnett County Department of Public Utilities Map by: UGA River Basin Center

4.2.2 Pets

Another important source of fecal coliform may be pet waste. Gwinnett County does not track its pet populations via an animal licensing program, so a formula from the American Veterinary Medical Association (AVMA, 2005) was used to estimate the number of pets in the
county. The potential pet residences identified in Figure 3 represent the residentially zoned parcels excluding multi-family zoning categories (Gwinnett County GIS digital data from photography based on 2005 flight data) and assume one medium-sized dog per household. The reasoning behind this is that the majority of multi-family housing does not usually have a yard. Parks are included in the map because people often take their dogs to parks and may not clean up pet waste.

Using the average fecal coliform production rate listed in literature (Mostaghimi et al, 2002), we estimated the amount of fecal coliform production of these pets, which is shown in Table 2. These results could indicate that the fecal coliform contribution from these pets may potentially be significant.

**Table 2: Estimated amount of fecal coliform in the wastes of pets in Gwinnett County**

<table>
<thead>
<tr>
<th>Pets</th>
<th>Estimated number</th>
<th>Fecal coliform produced (million cfu/head/day)</th>
<th>Total fecal coliform production (billion cfu/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dog</td>
<td>117,344</td>
<td>330</td>
<td>14,134,085</td>
</tr>
<tr>
<td>Cat</td>
<td>133,529</td>
<td>538</td>
<td>26,221,090</td>
</tr>
<tr>
<td>Bird</td>
<td>19,969</td>
<td>45</td>
<td>327,991</td>
</tr>
<tr>
<td>Horse</td>
<td>294</td>
<td>21,100</td>
<td>2,264,241</td>
</tr>
<tr>
<td>Total</td>
<td>271,136</td>
<td>-</td>
<td>42,947,407</td>
</tr>
</tbody>
</table>

4.2.3 Livestock

The main livestock in Gwinnett County are cattle, chickens and hogs. These numbers were estimated according to Georgia county estimates (http://www.nass.usda.gov/ga/estpages/ctyest.htm) and the 2002 Census of Agriculture (http://www.ams.usda.gov/statesumaries/GA/County/County.pdf/Gwinnett.pdf). The estimated fecal coliform production is listed in Table 3. These results show that the fecal coliform from livestock waste might be another significant source of fecal coliform pollution in Gwinnett County.
Table 3: Estimated coliform production of livestock in Gwinnett County

<table>
<thead>
<tr>
<th>Livestock</th>
<th>Number</th>
<th>Fecal coliform produced (million cfu/head/day)</th>
<th>Total fecal coliform production (billion cfu/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>3,500</td>
<td>25,800</td>
<td>32,959,500</td>
</tr>
<tr>
<td>Layer</td>
<td>73</td>
<td>136</td>
<td>3,624</td>
</tr>
<tr>
<td>Broiler and Chicken</td>
<td>1,133,247</td>
<td>89</td>
<td>36,813,529</td>
</tr>
<tr>
<td>Hog</td>
<td>1,000</td>
<td>12,400</td>
<td>4,526,000</td>
</tr>
<tr>
<td>Total</td>
<td>1,137,820</td>
<td>-</td>
<td>74,302,653</td>
</tr>
</tbody>
</table>

4.2.4 Estimation of Load Contributions

In order to estimate the load contributions from different sources, we must first assess what portions of the potential waste sources are available to flow into streams through runoff or discharge. We used the following figures, per research conducted by the Minnesota Pollution Control Agency (2002). (i) all effluents from WRF and sewer treatment plants; (ii) 2.67 percent of effluents from failing septic systems; (iii) 0.33 percent of pet wastes; (iv) 0.1 percent of the cattle manure, 0.085 percent of poultry manure, and 0.035 percent of hog manure. The results are shown in Table 4. *It is important to note that the load allocations are very gross, rough estimates and can not be used as a basis for further studies without more in-depth research and analysis.*

*More efforts are needed to confirm the assumptions used here.* Nevertheless, these results show that the fecal coliform load produced by pets and livestock is greater in volume than the pollution load produced by humans. The livestock estimates are surprising considering that Gwinnett County is predominantly suburban and only a couple of the listed stream segments are near large farm operations. This suggests that further study is merited on the pollution contribution of livestock. As illustrated in Figures 3 through 6, almost all of the listed stream segments are near potential human sources of pollution such as WRF plants, failing septic systems, potential pet-
owning residences, and public parks. Wildlife is another source of fecal coliform but we did not include it in these calculations because it is very difficult to estimate the potential load contribution of wildlife populations of unknown numbers and locations. This leads us to the conclusion that further investigation is needed to determine the main sources of fecal coliform pollution in Gwinnett County.

Table 4: Estimated load contribution from different sources

<table>
<thead>
<tr>
<th>Source</th>
<th>Load contribution (billion cfu/year)</th>
<th>Percentage of total load</th>
</tr>
</thead>
<tbody>
<tr>
<td>WRF &amp; Sewer treatment plant</td>
<td>1,352</td>
<td>0.61</td>
</tr>
<tr>
<td>Failing septic systems</td>
<td>13,993</td>
<td>6.28</td>
</tr>
<tr>
<td>Pets</td>
<td>141,726</td>
<td>63.58</td>
</tr>
<tr>
<td>Livestock</td>
<td>65,838</td>
<td>29.53</td>
</tr>
<tr>
<td>Total</td>
<td>222,909</td>
<td>100</td>
</tr>
</tbody>
</table>

5.0 CURRENT MEASURES EMPLOYED IN GWINNETT COUNTY

Gwinnett County has an extensive array of management measures in place to address the various sources of fecal coliform pollution. These include both city-specific and county-wide policies and ordinances; several different state, county, and city agencies and departments are involved in creating, maintaining, and enforcing these ordinances and policies. These rules and regulations are designed not only to manage urban runoff and thereby reduce pollution, but also to protect floodplains, stream channels, and ultimately, water quality.

As the purpose of this paper is to focus on new management measures, this section only briefly discusses some of the current control measures to emphasize how thorough the list is rather than to provide an in-depth explanation of each control strategy. These management measures are more fully covered in the different TMDL implementation plans for the county; the “Yellow River Watershed (HUC10 #0307010304) TMDL Implementation Plan Narrative” for
Gwinnett and DeKalb Counties was used as a primary reference, see Appendix A. The county Stormwater Management department website has a wealth of information including descriptions of the dry weather screening and sampling program, links to documents such as the Stormwater Design Manual and the Soil Erosion and Sediment Control Ordinance, and information on septic system education and outreach programs. The website address is: www.gwinnettstormwater.com. The city websites for Duluth, Lawrenceville, Lilburn, Norcross, Snellville, and Suwanee also have information on city-specific ordinances and regulations.

5.1 Gwinnett County Regulations, Ordinances, and Management Measures for fecal coliform pollution control

- Stormwater Design Manual which details recommended and required land development best management practices (BMPs) such as design and location criteria, easement requirements, and maintenance of stormwater detention facilities.
- Floodplain management ordinance
- Development regulations which were modified to include water quality and quantity requirements in response to the county’s Watershed Protection Plan
- Soil erosion and sediment control ordinance
- Zoning regulations
- Buffer, landscape, and tree ordinance which specifies stream buffer requirements
- As part of its Municipal Separate Storm Sewer System (MS4) permit, Gwinnett County conducts public education and outreach, illicit discharge detection and elimination, source identification activities, and water sampling and reporting. The source identification activities include stream walks, dry weather screenings, aerial investigations, and industrial and municipal facility inspections.
- Inspection program to evaluate the condition of manholes and pipes, and walk along easements to look for signs of leaks or sanitary sewer system overflows (SSOs). SSOs are a common problem caused by aging infrastructure, increased demand due to population growth, and the introduction of rainwater and ground water through leaks and breaks throughout the collection system. These overflows often cause pollution of nearby water bodies.

- Septic-to-sewer transition program which transfers communities with septic tanks to the sewer system. Suggested improvements to this program are discussed in section 6.8.

- Watershed Protection Plan, which establishes strategies to protect the county’s watersheds

- Watershed Master Planning (a.k.a. Watershed Improvement Planning) to assess stream bank restoration, water quality best management practice (BMP) installation, retrofit opportunities and to develop Capital Improvement Plans (CIPs) for these identified projects

- Grease trap inspection program. Grease traps are used in restaurants as a way to keep grease from entering the sewer system where it can buildup and lead to sanitary sewer system overflows (SSOs). Ensuring that grease traps are working properly can reduce the likelihood of SSOs.

- Wellhead protection ordinance to regulate the use of septic systems and drainfields in the wellhead protection zones

- Water supply watershed ordinances to protect drinking water supply watersheds through the establishment of stream buffers and prohibition of septic systems in those stream buffers
- NPDES permits for the WRF facilities are being modified by the Georgia Environmental Protection Division (EPD) to include TMDL limits.
- Health and sanitation or public nuisance ordinances that require homeowners to clean up pet waste so it will not accumulate.
- Tree and landscape ordinances to protect the tree canopy which should reduce runoff by increasing absorption
- Wetlands protection and Floodplain ordinances
- Color infrared aerial photography project to identify failing septic systems
- Board of Health rules to regulate the installation and repair of septic systems
- Pet sign/post requirement: All new public recreation areas are required to have pet posts.
  Gwinnett County recently installed pet posts at all Gwinnett County Pedestrian Parks.
  These include all parks that have wide open areas and walking trails likely to be frequented by dog owners, but does not include other parks such as historic parks, museums, and educational centers.

6.0 POSSIBLE FUTURE CONTROL MEASURES

Although significant measures have been taken to reduce fecal coliform pollution in Gwinnett County, there is a need for further improvement. After closely analyzing Gwinnett County’s and several other states’ TMDL implementation plans, we developed the following list of recommendations. Several of the recommendations would be suggested additions to Gwinnett County’s TMDL implementation plan management measures while others are improvements or enhancements to current control strategies. The approaches range in cost and complexity but would all be useful additions to Gwinnett County’s fecal coliform TMDL implementation plans.
6.1 Bacteria Source Tracking

While many known sources of fecal coliform pollution have been identified, it can be difficult to pinpoint the exact sources for a specific stream segment. If the sources are identified, then a community can more effectively focus their control strategies. Bacterial Source Tracking (BST) is a method that can be used to identify the fecal coliform pollution sources. In this section we will discuss the different types of BST along with the associated costs and benefits.

Bacterial Source Tracking (BST) is a relatively new methodology used to determine the source of fecal pathogen contamination in an environmental sample (in this case, water). BST can be used to differentiate between potential sources of fecal contamination. BST can be grouped into molecular and non-molecular methods. The molecular method can also be called “DNA finger-printing” and relies on genetic variation to identify the source of coliform. The molecular method includes ribotyping (RT), polymerase chain reaction (PCR), and pulsed-field gel electrophoresis (PFGE).

The non-molecular methods use non-genetic characteristics to differentiate the sources of coliform and can be grouped into biochemical and chemical methods. The biochemical methods use the type and quantity of biochemical substances produced by the bacteria to identify their source. The most commonly used biochemical method is Antibiotic Resistance Analysis (ARA). Other biochemical methods include cell wall analysis of fatty acid methyl ester (FAME), F-specific coliphage typing, and carbon source utilization (BIOLOG system). Chemical methods rely on the identification of compounds that co-occur with fecal pollution, and can only determine whether the source is human or not. Chemical methods include caffeine detection and optical brightener detection (US EPA, 2002).
The general process for all of the types of BST involves selecting a differential characteristic, such as optical brighteners or DNA, to identify various strains of bacteria. Next, a library of bacterial strains must be generated from the human and animal sources that might impact the water body. Then the indicator bacteria fingerprints from the polluted water body are compared with those in the library to assign its source according to fingerprint similarity. BST techniques have been successfully used for source identification in Virginia (multiple projects), Florida, New Hampshire, Washington, and Idaho (US EPA, 2002).

A project in the Eastern Shore of Virginia employed DNA fingerprinting (PFGE method) to determine the primary source of fecal coliform pollution. An oyster farmer was facing closure of his shellfish beds due to high levels of \textit{E.coli}. Originally, failing septic tanks were assumed to be the main pollution source. A survey of septic systems along with water samples indicating that the pollution levels were higher upstream of the septic systems shifted focus to non-human sources. Fecal samples from raccoon, waterfowl, otter, muskrat, deer and humans were collected and analyzed using DNA fingerprinting. The comparison of \textit{E.coli} from the shellfish bed against the known strains in the DNA library indicated that the main sources of \textit{E.coli} were raccoon and deer. Several hundred animals, including 180 raccoon, were removed and \textit{E.coli} levels declined by 1 to 2 orders of magnitude throughout the watershed (US EPA, 2002). This example shows how BST can play an important role in fecal coliform pollution control.

While the precise identification of specific pollution sources is a major advantage for using molecular BST methods, several serious disadvantages exist. The main disadvantage is the considerable time and expense involved with gathering a large number of isolates for the host origin library database in order to accommodate for the bacterial subspecies change with
geography and time (Kuntz, et al, 2003). The non-molecular (biochemical and chemical) BST methods provide appealing alternatives to the costly and time-consuming molecular BST process.

Targeted sampling is a chemical BST method that can be used either as a prelude to molecular BST methods or as the sole method (Kuntz, et al, 2003). The targeted sampling method uses an iterative monitoring process to isolate the areas with the highest levels of pollution and then chemical testing in those areas to differentiate between human and animal sources. A typical targeted sampling project involves first sampling fecal coliform bacteria levels in a broad area in one day. The sites or stream segments with the highest levels of bacteria are selected and a second round of sampling is conducted focusing on these sites. This process can narrow down a potentially large geographic area to a few very specific sites to focus on. Once the locations with persistent high fecal contamination have been identified (see Figure 4) chemical testing (for example, to detect caffeine or optical brighteners found in laundry detergent) can be conducted to determine whether the pollution source is human or animal. If the source is determined to be human, emphasis can be focused on management measures to control human sources such as illicit connections or failing septic systems.

The main advantage for using the targeted sampling method is that it limits temporal and spatial variations in a cost-effective way to identify the most egregious pollution sources. The main disadvantage is that it does not phenotypically or genotypically confirm the fecal coliform bacteria host origin. So if there are multiple sources contributing high pollution loads to the same stream segment, targeted sampling would not be the most effective method to use.

Rainfall and local knowledge are two important factors to carefully consider when using targeted sampling. Precipitation can greatly affect both the amount and the subspecies of bacteria so the sampling should be performed under dry weather and storm weather conditions.
respectively. Local knowledge is a necessity for conducting a successful sampling project. For example, if a sampling area includes a popular weekend recreation destination such as a park or area with vacation homes, it would be important to note that weekend sampling could yield very different results from weekday sampling. This illustrates how crucial local knowledge is to the success of source tracking; it should be seriously considered in any targeted sampling project plan. (Hartel, 2006)

![Flow chart of targeted sampling (modified from Kuntz et al, 2003)](image)

**Figure 7: Flow chart of targeted sampling (modified from Kuntz et al, 2003)**

If targeted sampling and other BST methods are applied in Gwinnett County, the main sources of the fecal coliform pollution could be confirmed on a scientific basis. The cost of BST tests ranges from $25 to $100 per sample for molecular methods and $10 to $30 per sample for non-molecular method (U.S. EPA, 2002). An example simple cost analysis for Gwinnett County is as follows: 10 samples for the targeted sampling non-molecular chemical BST method and 3 samples for the molecular BST method in each of the 25 listed streams under each weather
pattern (dry and storm) would result in a total of 1000 samples for the targeted sampling non-molecular chemical BST method and 150 samples for the molecular BST method. The total cost for the sampling would be around $13,750 to $45,000. When you consider that this expenditure to accurately identify the pollution source would allow the county to more effectively focus their pollution control measures these costs seem worthwhile.

6.2 Creative Financing Options to Fund Septic System Repairs

Currently there are limited options for financial assistance to help Gwinnett County homeowners pay for repairs to failing septic systems, especially for individuals who can not obtain financing from traditional sources. Several funding approaches have been used successfully in other states and jurisdictions including Clean Water Act state revolving loan funds, other loans and grants, bonds, user or service fees, cost sharing programs, and tax incentives. (Draft Handbook for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems. U.S. EPA, 2003)

Through the Clean Water Act State Revolving Fund (CWSRF) program, states maintain revolving loan funds to provide sources of low-cost financing for water quality infrastructure projects. One potential implementation of this program that might be practical for Gwinnett County is a linked deposit lending system. A linked deposit lending program involves a state or municipality partnering with a bank to process the loan applications to access CWSRF financing. Specifically, per the U.S. EPA “Funding Nonpoint Source Activities with the Clean Water State Revolving Fund” (CWSRF Nonpoint Source Funding) report:

“The state agrees to accept a reduced rate of return on an investment (e.g., a certificate of deposit) and the lending institution agrees to provide a loan to a borrower at a similarly reduced interest rate. For example, if the
typical earnings rate for a certificate of deposit (CD) is five percent, a state might agree to purchase a CD that earns two percent interest, and in exchange, the lending institution agrees to provide a loan to a borrower at an interest rate that is three percentage points lower than the market rate for the borrower. In this program, the CWSRF investment (deposit) is linked to a low-interest loan, thereby earning the description “linked deposit loan.”

Linked deposit loan programs provide benefits for CWSRF programs, local financial institutions, and borrowers. CWSRF programs can support high priority nonpoint source projects and place risk and management responsibilities with local lenders. Financial institutions earn profits from the linked deposit agreements and offer an additional service for their customers. Borrowers save money with low-interest loans and can comfortably work with their local bank or credit union.”

This model has been used successfully in Ohio, Maine, Delaware, Pennsylvania and several other states. Ohio’s CWSRF linked deposit loan program has been in place since 1993 and is used to fund projects supporting county watershed management plans, including repairs of onsite wastewater treatment system (CWSRF Nonpoint Source Funding). Ohio has been a leader in financing non-traditional CWSRF projects and would be a good source for further information. Maine has implemented some innovative lending practices—the Maine Department of Environmental Protection and the Maine Municipal Bond Bank have partnered with various state agencies to increase access to financing for individuals and businesses that usually are not eligible for CWSRF programs (Funding Decentralized Wastewater Systems Using the Clean
Water State Revolving Fund, US EPA January 2003). Delaware and Pennsylvania are two other states that have used CWSRF loans for the rehabilitation of failing septic systems and in fact have won CWSRF Pisces Awards which are granted for performance and innovation in the SRF (CWSRF Pisces Awards 2005 report). Pass-through loans are another type of CWSRF lending option where the municipality manages the loan process and does not partner with a bank or credit union.

Other types of financing for septic system repairs are available such as public-private partnerships where a management entity can negotiate special terms such as lower interest rates or longer payback periods. This might become a more practical option if more septic management ordinances are adopted. Other funding sources for septic system repair projects include the U.S. Department of Housing and Urban Development (HUD), U.S. Department of Agriculture, Community Development Block Grants, Sustainable Development Challenge Grants, EPA Nonpoint Source Section 319 Grant Program, and the National Decentralized Water Resources Capacity Development Project. There are two types of bonds available for environmental improvement: general obligation and revenue bonds. User or service fees are an option if there is a management entity in place to collect and manage the funds. Cost-sharing programs are available through grants or local revolving funds (Handbook for Managing Onsite and Clustered (Decentralized) Wastewater Treatment Systems, U.S. EPA, 2005). For example, the Limestone Valley RC&D Council in North Georgia is using EPA 319 funds to assist homeowners with septic repairs and pump-outs. Grant cost-share ratios: 60% grant to 40% homeowner with a $75 sign-up incentive. Tax incentives are another way communities can encourage homeowners to properly operate and maintain septic systems. Creating a tax credit to recover a portion of the maintenance costs helps to create an incentive for homeowners to
maintain their septic systems. For example, Massachusetts has a credit that can be applied to a homeowner’s state income tax return (Coastal Georgia On-site Disposal System Management Report, Borden 2005).

6.3 Septic System Management Ordinance

Gwinnett County has approximately 100,000 septic tanks (Steve Leo, 2006). The vast majority of these systems are non-mechanical gravity flow systems and no requirement exists to compel the owners of these systems to have them pumped out or otherwise maintained on a regular basis. A septic system management ordinance would provide a framework to help communities manage and perhaps share costs for septic system maintenance. Emily Poe and Shana Smith wrote the following paper on this subject “Community Septic System Management: A Maintenance-Model Ordinance” for the Fall 2005 Upper Altamaha Practicum course. More information on this paper is available at the following website:

http://www.rivercenter.uga.edu/education/upper_altamaha/fall2005/septic.htm

6.4 Expand Pet Waste Control Measures

Pet waste can be a major source of fecal coliform pollution loading. Currently, Duluth and Lilburn have city-specific ordinances requiring owners to clean-up pet waste but there are no county-wide regulations to control this source. Gwinnett County has a pet waste signage program (the ‘Pick it Up: It’s Your Duty’ program) in their parks; see section 5.1 for more details on the program. Other states have addressed this pollution source by targeting and expanding inspections of and educational outreach to high pet concentration areas. Specifically, this outreach focuses on places with high concentrations of animals such as kennels or boarding facilities, animal shelters, breeders, groomers, veterinary clinics, pet shops and high density neighborhoods with pet-owning residences.
A county-wide regulation requiring proper disposal of pet waste (mainly dogs) would help. Another option is to create programs to educate the inspectors of kennels and shelters to check for waste disposal practices. Targeted outreach measures would include signs in neighborhoods, public trash cans, and disposal bags for dog owners to use. Increasing general public awareness about pet waste as a pollution source could be a cost-effective way to help reduce fecal coliform pollution (Little Bear Creek Fecal Coliform Bacteria Total Maximum Daily Load (Water Cleanup Plan), May 2005, Washington State Department of Ecology).

6.5 Livestock Management Methods

Livestock, particularly when they have access to streams, can be a major contributor to fecal coliform pollution loads. While Gwinnett County does not have a significant number of large livestock operations, it is still important to address this issue. There are several possible regulatory and incentive approaches for keeping livestock out of streams such as management ordinances and cost-share programs. Jill Schonenberg, a student in the School of Law at the University of Georgia, prepared a paper, “Keeping Livestock out of Streams in Georgia” on these options as a project for the Fall 2005 Land Use Clinic class. Her paper on this subject has been presented and submitted separately to Gwinnett County. Please refer to the paper for more information: [http://www.law.uga.edu/landuseclinic/research/cattle.htm](http://www.law.uga.edu/landuseclinic/research/cattle.htm).

6.6 Minimize Attraction of Wildlife to Dumpsters and Parking Lots

Wildlife contributes bacteria to surface waters. Generally, bacteria loading from wildlife is considered natural and is not managed. However, land use practices such as unkempt dumpster areas or littered parking lots can attract wildlife including birds, raccoons, and even feral cats onto paved areas which are directly connected to waterways by storm sewer systems. This deposition of fecal matter onto an impervious surface, as compared to a similar deposition onto a
pervious surface, could result in an increased amount of fecal matter and fecal coliform migration into receiving waters. (Little Bear Creek Fecal Coliform Bacteria TMDL, May 2005, Washington State Department of Ecology). This pollution source can be better controlled through targeted outreach programs to businesses or organizations generating food waste (restaurants, grocery stores, etc.) regarding proper maintenance of dumpster areas. Another option would be to add inspections of dumpster areas to the Health Department restaurant inspection program.

6.7 Organizational and Structural Improvements to Current TMDL Plans

While Gwinnett County’s current TMDL implementation plans are quite thorough, they could benefit from some organizational and structural improvements. Specifically, we recommend the following improvements: add a component of accountability or reasonable assurance that each plan will succeed; provide more detailed timelines for monitoring progress – many of the measures have only an “ongoing” timeline; perhaps add an efficiency table for the BMPs as used in the Guidance Manual for Total Maximum Daily Load Implementation Plans developed by The Commonwealth of Virginia; reformat plan to provide more details on pollution sources and management measures; add the respective associated responsibilities to the list of stakeholders; and add a table of potential funding sources. The Little Bear Creek Fecal Coliform Bacteria TMDL from Washington, the Willamette Basin TMDL from Oregon, and the Fecal Coliform TMDL Development Plan for Cedar, Hall, Byers, and Hutton Creeks in Virginia are good reference plans for these suggested organizational improvements.

6.8 Improved Septic-to-Sewer Transition (Sewer Petition) Program

If failing septic systems are confirmed to be a significant source of fecal coliform pollution, one option is to transfer septic systems onto the sanitary sewer system. The sewer
system in Gwinnett County is shown in Figure 4 and septic systems are illustrated in Figures 5 and 6. Gwinnett County has a septic-to-sewer transition (sewer petition) program in place and there have been a few successful projects – three in the last four years. This number could possibly be increased if the program requirements were changed. Currently a minimum of 70 percent of a community must agree to transfer to the sanitary sewer system regardless of the estimated cost per lot to transfer. The county will contribute to two-thirds of the cost for the transfer but homeowners still bear significant costs and oftentimes it is difficult to get the necessary buy-in, especially from homeowners who either do not have problems with their septic system or who have recently made repairs to their system. Another potential barrier to this program is sanitary sewer system capacity. In order to transfer a large number of the approximately 100,000 county septic systems to the sanitary sewer system, the water reclamation facilities (WRF) would probably need to be expanded, most likely at significant cost. Another point to consider when analyzing this option is that laying new sewer lines often spurs growth and can lead to sprawling development patterns.

7.0 SUMMARY

In conclusion, while Gwinnett County has taken significant strides to address the serious problem of fecal coliform pollution, it could make even further progress by pursuing some of the recommended measures discussed in this paper. The comprehensive approach Gwinnett County uses is a smart strategy, however, the county’s pollution control measures could be even more effective if the exact sources of fecal coliform pollution were identified. Targeted sampling is a potential solution as it is a cost-efficient method to identify specific pollution sources. Improving measures to manage and repair septic systems could have a large impact as well as expanding pet
waste control ordinances and regulations. Another option is using constructed wetlands as part of the wastewater treatment process; this approach was not discussed in this paper because it is more related to WRF point-source activities. By pursuing some of the suggested measures, Gwinnett County can continue to improve its bacteria-impaired waterways and make progress toward its water quality goals.

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APPENDIX A
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(NOTE: Attached as hard copy document.)

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