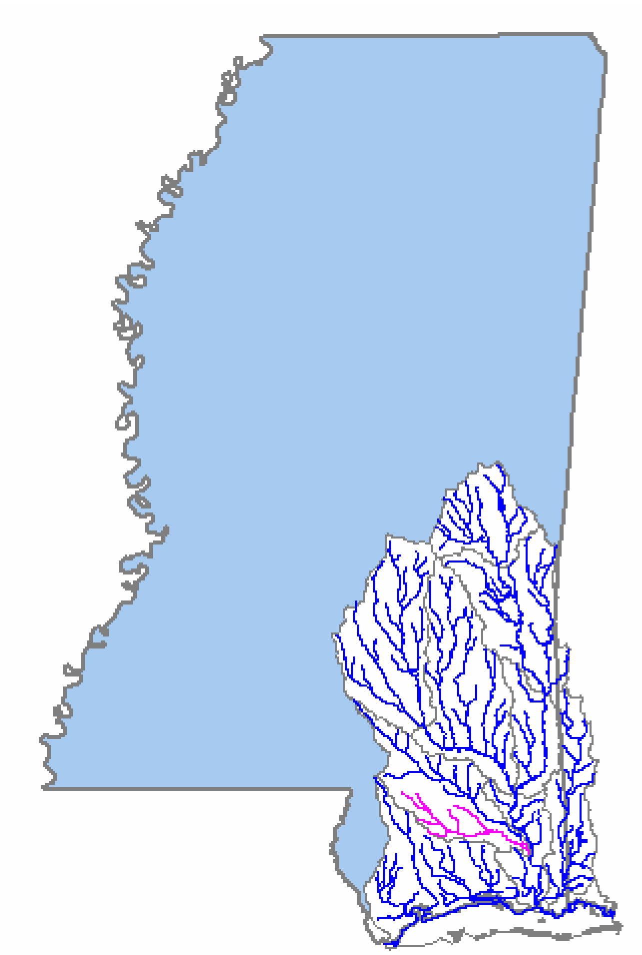
FINAL REPORT
December 1999
ID: 499121506

# Fecal Coliform TMDL for

# Red Creek

## Pascagoula River Basin
## George and Jackson Counties, Mississippi



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# CONTENTS

# ABBREVIATIONS

| | |
|---|---|
| 7Q10 | Seven-Day Average Low Stream Flow With a Ten-Year Occurrence Period |
| BASINS | Better Assessment Science Integrating Point and Nonpoint Sources |
| BMP | Best Management Practice |
| CWA | Clean Water Act |
| DMR | Discharge Monitoring Report |
| EPA | Environmental Protection Agency |
| GIS | Geographic Information System |
| HUC | Hydrologic Unit Code |
| LA | Load Allocation |
| MARIS | State of Mississippi Automated Information System |
| MDEQ | Mississippi Department of Environmental Quality |
| MOS | Margin of Safety |
| NRCS | National Resource Conservation Service |
| NPDES | National Pollution Discharge Elimination System |
| NPSM | Nonpoint Source Model |
| USGS | United States Geological Survey |
| WLA | Waste Load Allocation |

# DEFINITIONS

**Ambient stations:** a network of fixed monitoring stations established for systematic water quality sampling at regular intervals, and for uniform parametric coverage over a long-term period.

**Assimilative capacity**: the capacity of a body of water or soil-plant system to receive wastewater effluents or sludge without violating the provisions of the State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters and Water Quality regulations.

**Background**: the condition of waters in the absence of man-induced alterations based on the best scientific information available to MDEQ. The establishment of natural background for an altered waterbody may be based upon a similar, unaltered or least impaired, waterbody or on historical pre-alteration data.

**Calibrated model**: a model in which reaction rates and inputs are significantly based on actual measurements using data from surveys on the receiving waterbody.

**Critical Condition:** hydrologic and atmospheric conditions in which the pollutants causing impairment of a waterbody have their greatest potential for adverse effects.

**Daily discharge**: the "discharge of a pollutant" measured during a calendar day or any 24-hour period that reasonably represents the calendar day for purposes of sampling. For pollutants with limitations expressed in units of mass, the "daily discharge" is calculated as the total mass of the pollutant discharged over the day. For pollutants with limitations expressed in other units of measurement, the "daily average" is calculated as the average.

**Designated Use:** use specified in water quality standards for each waterbody or segment regardless of actual attainment.

**Discharge monitoring report:** report of effluent characteristics submitted by a NPDES Permitted facility.

**Effluent standards and limitations**: all State or Federal effluent standards and limitations on quantities, rates, and concentrations of chemical, physical, biological, and other constituents to which a waste or wastewater discharge may be subject under the Federal Act or the State law. This includes, but is not limited to, effluent limitations, standards of performance, toxic effluent standards and prohibitions, pretreatment standards, and schedules of compliance.

**Effluent**: treated wastewater flowing out of the treatment facilities.

**Fecal coliform bacteria:** a group of bacteria that normally live within the intestines of mammals, including humans. Fecal coliform bacteria are used as an indicator of the presence of pathogenic organisms in natural water.

**Geometric mean:** the *n*th root of the product of *n* numbers. A 30-day geometric mean is the $30^{th}$ root of the product of 30 numbers.

**Impaired Waterbody:** any waterbody that does not attain water quality standards due to an individual pollutant, multiple pollutants, pollution, or an unknown cause of impairment.

**Land Surface Runoff:** water that flows into the receiving stream after application by rainfall or irrigation. It is a transport method for nonpoint source pollution from the land surface to the receiving stream.

**Load allocation (LA)**: the portion of a receiving water's loading capacity attributed to or assigned to nonpoint sources (NPS) or background sources of a pollutant. The load allocation is the value assigned to the summation of all cattle and land applied fecal coliform that enter a receiving waterbody. It also contains a portion of the contribution from septic tanks.

**Loading**: the total amount of pollutants entering a stream from one or multiple sources.

**Nonpoint Source:** pollution that is runoff from the land. Rainfall, snowmelt, and other water that does not evaporate becomes surface runoff and either drains into surface waters or soaks into the soil and finds its way into groundwater. This surface water may contain pollutants that come from land use activities such as agriculture, construction, silviculture, surface mining, disposal of watewater, hydrologic modifications, and urban development.

**NPDES permit**: an individual or general permit issued by the Mississippi Environmental Quality Permit Board pursuant to regulations adopted by the Mississippi Commission on Environmental Quality under Mississippi Code Annotated (as amended) §§ 49-17-17 and 49-17-29 for discharges into State waters.

**Point Source:** pollution loads discharged at a specific location from pipes, outfalls, and conveyance channels from either wastewater treatment plants or industrial waste treatment facilities. Point sources can also include pollutant loads contributed by tributaries to the main receiving stream.

**Pollution**: contamination, or other alteration of the physical, chemical, or biological properties, of any waters of the State, including change in temperature, taste, color, turbidity, or odor of the waters, or such discharge of any liquid, gaseous, solid, radioactive, or other substance, or leak into any waters of the State, unless in compliance with a valid permit issued by the Permit Board.

**Publicly Owned Treatment Works (POTW)** : a waste treatment facility owned and/or operated by a public body or a privately owned treatment works which accepts discharges which would otherwise be subject to Federal Pretreatment Requirements.

**Regression Coefficient:** an expression of the functional relationship between two correlated variables that is often empirically determined from data, and is used to predict values of one variable when given values of the other variable.

**Scientific Notation (Exponential Notation)**: mathematical method in which very large numbers or very small numbers are expressed in a more concise form. The notation is based on powers of ten. Numbers in scientific notation are expressed as the following: *4.16 x 10^(+b)* and *4.16 x 10^(-b) [same as 4.16E4 or4.16E-4]*. In this case, *b* is always a positive, real number. The *10^(+b)* tells us that the decimal point is *b* places to the right of where it is shown. The *10^(-b)* tells us that the decimal point is *b* places to the left of where it is shown.
For example: $2.7X10^4 = 2.7E+4 = 27000$ and $2.7X10^{-4} = 2.7E-4 = 0.00027$.

**Sigma (Σ)**: shorthand way to express taking the sum of a series of numbers. For example, the sum or total of three amounts 24, 123, 16, ($\mathbf{d}_1$, $\mathbf{d}_2$, $\mathbf{d}_3$) respectively could be shown as:

$$\sum_{i=1}^{3} d_i = d_1+d_2+d_3 = 24 + 123 + 16 = 163$$

**Total Maximum Daily Load or TMDL**: the calculated maximum permissible pollutant loading to a waterbody at which water quality standards can be maintained.

**Waste**: sewage, industrial wastes, oil field wastes, and all other liquid, gaseous, solid, radioactive, or other substances which may pollute or tend to pollute any waters of the State.

**Wasteload allocation (WLA)**: the portion of a receiving water's loading capacity attributed to or assigned to point sources of a pollutant. It also contains a portion of the contribution from septic tanks.

**Water Quality Standards**: the criteria and requirements set forth in *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters*. Water quality standards are standards composed of designated present and future most beneficial uses (classification of waters), the numerical and narrative criteria applied to the specific water uses or classification, and the Mississippi antidegradation policy.

**Water quality criteria**: elements of State water quality standards, expressed as constituent concentrations, levels, or narrative statements, representing a quality of water that supports the present and future most beneficial uses.

**Waters of the State**: all waters within the jurisdiction of this State, including all streams, lakes, ponds, wetlands, impounding reservoirs, marshes, watercourses, waterways, wells, springs, irrigation systems, drainage systems, and all other bodies or accumulations of water, surface and underground, natural or artificial, situated wholly or partly within or bordering upon the State, and such coastal waters as are within the jurisdiction of the State, except lakes, ponds, or other surface waters which are wholly landlocked and privately owned, and which are not regulated under the Federal Clean Water Act (33 U.S.C.1251 et seq.).

**Watershed:** the area of land draining into a stream at a given location.

# MONITORED SEGMENT IDENTIFICATION

| | |
|---|---|
| Name: | Red Creek |
| Waterbody ID#: | MS103RM |
| Location: | At Vestry: From Confluence of Bluff Creek at Ruble to Watershed Boundary Near Mouth at Black Creek |
| County: | George and Jackson Counties, Mississippi |
| USGS HUC Code: | 03170007 |
| NRCS Watershed: | 050 |
| Length: | 21 miles |
| Use Impairment: | Contact Recreation |
| Cause Noted: | Fecal Coliform Bacteria, an Indicator for the Presence of Pathogenic Organisms |
| Priority Rank: | 35 |
| NPDES Permits: | 11 NPDES Permits Analyzed as Contributors in this TMDL |
| Pollutant Standard: | Fecal coliform colony counts shall not exceed a geometric mean of 200 per 100 ml, nor shall more than 10 percent of the samples examined during any month exceed a fecal coliform colony count of 400 per 100 ml |
| Waste Load Allocation: | 1.36E+12 counts/30 days for critical period<br>(all dischargers must meet water quality standards for disinfection) |
| Load Allocation: | 27.2E+12 counts/30 days |
| Margin of Safety: | Implicit in Conservative Modeling Assumptions |
| Total Maximum Daily Load (TMDL): | 28.6E+12 counts/30 days<br>Combination of point and nonpoint sources due to NPDES permits, cows with access to streams, failing septic tanks, and fecal coliform applied to the land available for surface runoff. |

# EVALUATED DRAINAGE AREA IDENTIFICATION

| | |
|---|---|
| Name: | Red Creek - DA |
| Waterbody ID#: | MS102RE |
| Location: | Near Perkinston |
| County: | Lamar, Stone, and Pearl River Counties, Mississippi |
| USGS HUC Code: | 03170007 |
| NRCS Watershed: | 080 |
| Area: | 114,724 acres |
| Use Impairment: | Secondary Contact Recreation |
| Cause Noted: | Fecal Coliform Bacteria, an Indicator for the Presence of Pathogenic Organisms |
| Priority Rank: | Low |
| NPDES Permits: | 1 NPDES Permit Issued in this Drainage Area |
| Pollutant Standard: | May through October - Geometric Mean of 200 per 100 ml, Less Than 10 percent of the Samples may exceed 400 per 100 ml<br>November through April - Geometric Mean of 2000 per 100 ml, Less Than 10 percent of the Samples may exceed 4000 per 100 ml |
| Waste Load Allocation: | 5.17E+11 counts/30 days for critical period<br>(all dischargers must meet water quality standards for disinfection) |
| Load Allocation: | 122.0E+11 counts/30 days |
| Margin of Safety: | Implicit in Conservative Modeling Assumptions |
| Total Maximum Daily Load (TMDL): | 127.0E+11 counts/30 days<br>Combination of point and nonpoint sources due to NPDES permits, cows with access to streams, failing septic tanks, and fecal coliform applied to the land available for surface runoff. |

# EXECUTIVE SUMMARY

A segment, MS103RM, of Red Creek has been placed on the Monitored Section of the Mississippi 1998 Section 303(d) List of Waterbodies as partially supporting its designated use of Contact Recreation due to impairment caused by fecal coliform bacteria. For Contact Recreation the applicable state standard specifies that the fecal coliform colony counts shall not exceed a geometric mean of 200 per 100 ml, nor shall more than 10 percent of the samples examined during any month exceed a colony count of 400 per 100 ml. A review of the available monitoring data for the watershed indicate that there is a violation of the standard.

Within the Red Creek Watershed there is a drainage area, MS102RE, which is on the Evaluated Section of the Mississippi 1998 Section 303(d) List of Waterbodies for the use of Secondary Contact Recreation due to fecal coliform bacteria. For Secondary Contact Recreation the applicable state standard specifies that for the months of May through October the maximum allowable level of fecal coliform shall not exceed a geometric mean of 200 per 100 ml, nor shall more than 10 percent of the samples examined during any month exceed a colony count of 400 per 100 ml and that for the months of November through April the maximum allowable level of fecal coliform shall not exceed a geometric mean of 2000 per 100 ml, nor shall more than 10 percent of the samples examined during any month exceed a colony count of 4000 per 100 ml.

Red Creek is a major waterbody in the Pascagoula Basin. It flows approximately 63 miles in a southeasterly direction from its headwaters in Lamar and Pearl River Counties to its confluence with the Black Creek in Jackson County. This TMDL has been developed to bring the monitored segment of Red Creek, which is 21 miles long, into compliance with the water quality standards. Even though the monitored segment begins in Stone County near Ruble at the confluence with Bluff Creek and ends at the mouth at Black Creek, the entire Red Creek Watershed was modeled. Therefore, the 114,724 acre evaluated drainage area, which is in the upper portion of the Red Creek Watershed, is also covered by this TMDL and its recommendations.

The BASINS Nonpoint Source Model (NPSM) was selected as the modeling framework for performing the TMDL allocations for this study. Daily flow values from the USGS gage on Red Creek near Vestry were used to analyze the hydrologic flow for the watershed. The weather data used for this model was collected at Saucier Experimental Forest Station. The representative hydrologic period used for this TMDL was January 1, 1985 through December 31, 1995.

Fecal coliform loadings from nonpoint sources in the watershed were calculated based upon wildlife populations; numbers of cattle, hogs, and chickens; information on livestock and manure management practices for the Pascagoula Basin; and urban development. The estimated fecal coliform production and accumulation rates due to nonpoint sources for the watershed were incorporated into the model. Also represented in the model were the nonpoint sources such as failing septic systems and cattle which have direct access to Red Creek or a tributary of Red Creek. There are permitted dischargers located in the watershed that are included as point sources in the model. Under existing conditions, output from the model indicates violation of the fecal coliform standard in the stream. After applying a load reduction scenario there were no violations of the standard according to the model.

The scenario used to reduce the fecal coliform load involves a cooperative effort between all fecal coliform contributors in the Red Creek Watershed. First, all NPDES facilities will be required to treat their discharge so that the fecal coliform concentrations do not exceed water quality standards. Monitoring of all permitted facilities in the Red Creek should be continued to ensure that compliance with permit limits is consistently attained. Second, cattle access to streams should be reduced by 60 percent. This could be accomplished by fencing streams in cattle pastures. Education on best management practices is a vital part of achieving this goal. Finally, a 50 percent reduction in the fecal coliform contribution from failing septic tanks is required. The model assumed there is a 40 percent failure rate of septic tanks in the Red Creek Watershed. A reduction could be accomplished by education on best management practices for septic tank owners. Additionally, users of individual onsite wastewater treatment plants could be educated on the importance of disinfection of the effluent from their treatment plant.

The model accounted for seasonal variations in hydrology, climatic conditions, and watershed activities. The use of the continuous simulation model allowed for consideration of the seasonal aspects of rainfall and temperature patterns within the watershed. Calculation of the fecal coliform accumulation parameters and source contributions on a monthly basis accounted for seasonal variations in watershed activities such as livestock grazing and land application of manure.

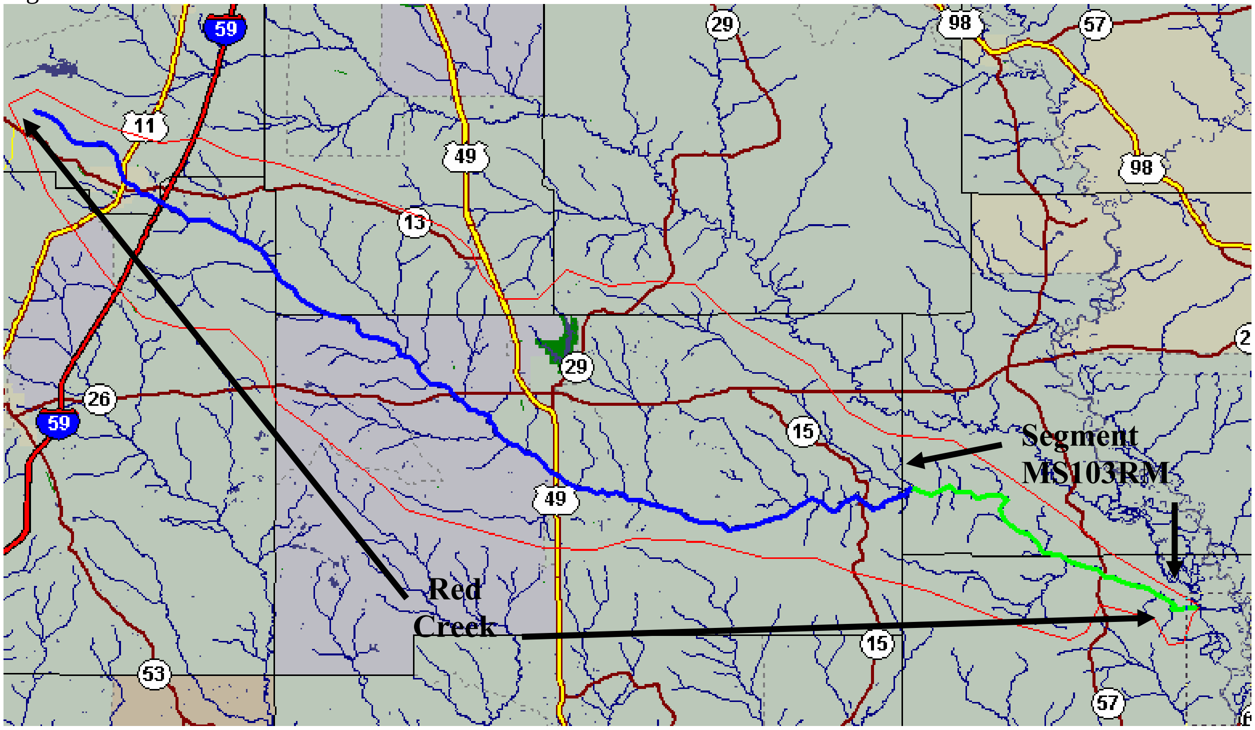
# 1.0 INTRODUCTION

## 1.1 Background

The identification of waterbodies not meeting their designated use and the development of total maximum daily loads (TMDLs) for those waterbodies are required by Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (40 CFR part 130). The TMDL process is designed to restore and maintain the quality of those impaired waterbodies through the establishment of pollutant specific allowable loads. The pollutant of concern for this TMDL is fecal coliform. Fecal coliform bacteria are used as indicator organisms. They are readily identifiable and indicate the possible presence of other pathogenic organisms in the waterbody. The TMDL process can be used to establish water quality based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of water resources.

The Mississippi Department of Environmental Quality (MDEQ) has determined through monitoring that segment MS103RM of Red Creek is impaired by fecal coliform bacteria for a length of 21 miles as reported in the 1998 Section 303(d) List of Waterbodies. The monitored segment begins near Ruble, at the confluence with Bluff Creek, and ends at the mouth of Red Creek at Black Creek. Red Creek is shown in Figure 1.1 with the monitored segment in green. The listing of the evaluated drainage area is not based on monitoring data.

Figure 1.1 Red Creek



The monitored segment of Red Creek, along with the evaluated drainage area and the entire Red Creek Watershed, lies within the Pascagoula River Basin Hydrologic Unit Code (HUC) 03170007 in southeastern Mississippi. The monitored segment is in NRCS Watershed 050, while the evaluated drainage area is in NRCS Watershed 080. The watershed of this segment, from the headwaters of Red Creek to the end of the monitored section, is approximately 311,855 acres. The watershed has been divided into 11 subwatersheds based on the major tributaries and topography. Figure 1.2 shows the subwatersheds. Table 1.1 provides the corresponding identification number, which is a combination of the eight digit HUC and the three digit Reach File 1 segment identification number, and areas of the subwatersheds. The monitored segment is the most downstream reach in the Red Creek Watershed. It is Reach 03170007021, which is also shown in green on Figure 1.2. The evaluated drainage area is approximately a 115,000 acre area in the upper portion of the Red Creek Watershed comprised of subwatersheds 03170007027, 03170007028, and 03170007029, which are all highlighted in green on Figure 1.2. The entire Red Creek Watershed lies within portions of Lamar, Pearl River, Forrest, Stone, Perry, George, and Jackson Counties. Figure 1.3 shows the general landuse distribution of the Red Creek Watershed. While forest is the dominant landuse within this watershed, there are several urban areas in the Red Creek Watershed. The City of Wiggins is the largest.

Figure 1.2 Red Creek Subwatersheds

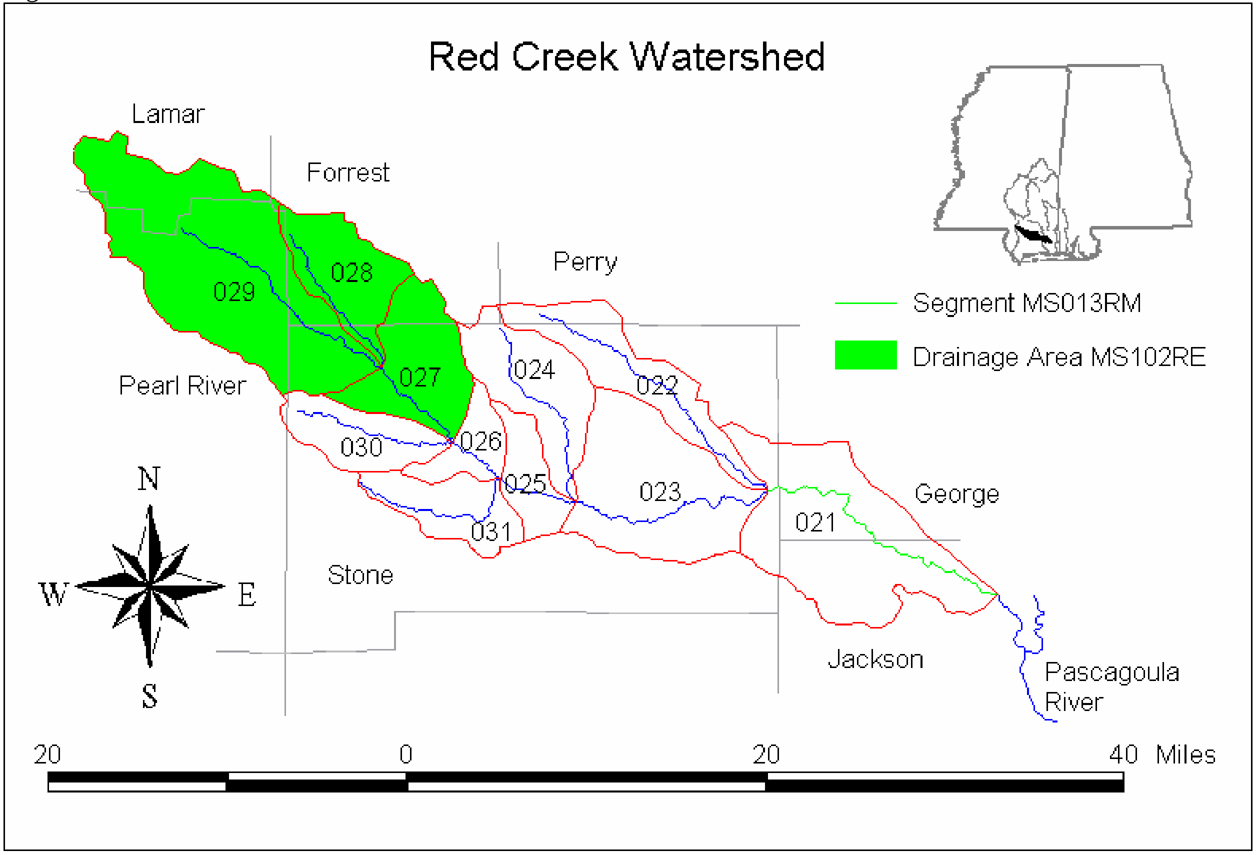
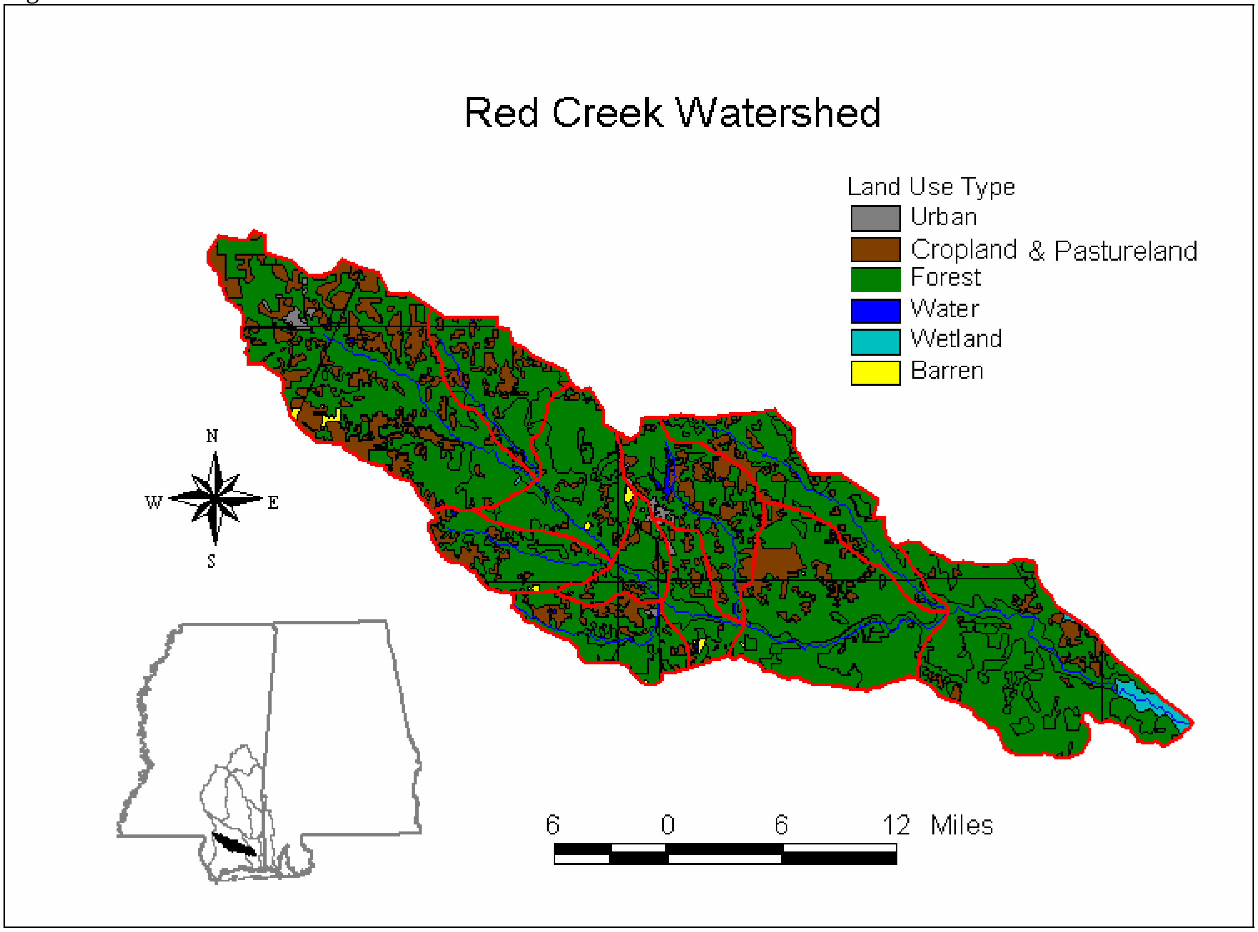


Table 1.1 Red Creek Subwatersheds

| Subwatershed | Stream Name | Area (acres) |
|---|---|---|
| 03170007-021 | Red Creek | 54,685 |
| 03170007-022 | Bluff Creek | 23,871 |
| 03170007-023 | Red Creek | 42,271 |
| 03170007-024 | Flint Creek | 24,014 |
| 03170007-025 | Red Creek | 10,822 |
| 03170007-026 | Red Creek | 9,453 |
| 03170007-027 | Red Creek | 24,216 |
| 03170007-028 | Red Creek Double | 20,079 |
| 03170007-029 | Red Creek | 70,429 |
| 03170007-030 | Kirby Creek | 16,129 |
| 03170007-031 | Tem Mile Creek | 15,884 |
| All | | 311,855 |

Figure 1.3 Red Creek Landuse Distribution



## 1.2 Applicable Waterbody Segment Use

Designated beneficial uses and water quality standards are established by the *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters*. The designated use for the monitored segment of Red Creek as defined by the regulations is Contact Recreation. Waters in this classification are intended to be suitable for such water contact activities as swimming and water skiing. Waters that meet the Contact Recreation Criteria shall also be suitable for uses for which waters of lower quality will be satisfactory. The designated use for the evaluated drainage area is Secondary Contact Recreation. Secondary contact recreation is defined as incidental contact with the water, including wading and occasional swimming.

## 1.3 Applicable Waterbody Segment Standard

The water quality standard applicable to the use of the monitored segment and the pollutant of concern is defined in the *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters*. The standard states that fecal coliform shall not exceed a geometric mean of 200 per 100 ml, nor shall more than 10 percent of the samples examined during any month exceed a colony count of 400 per 100 ml. This water quality standard will be used as targeted endpoints to evaluate impairments and establish this TMDL.

The water quality standard applicable to the evaluated drainage area states that from May through October the fecal coliform colony counts shall not exceed a geometric mean of 200 per 100 ml, nor shall more than 10 percent of the samples examined during any month exceed a colony count of 400 per 100 ml, and that from November through April the fecal coliform colony counts shall not exceed a geometric mean of 2000 per 100 ml, nor shall more than 10 percent of the samples examined during any month exceed a colony count of 4000 per 100 ml.

# 2.0 TMDL ENDPOINT AND WATER QUALITY ASSESSMENT

## 2.1 Selection of a TMDL Endpoint and Critical Condition

One of the major components of a TMDL is the establishment of instream numeric endpoints, which are used to evaluate the attainment of acceptable water quality. Instream numeric endpoints, therefore, represent the water quality goals that are to be achieved by implementing the load and waste load reductions specified in the TMDL. The endpoints allow for a comparison between observed instream conditions and conditions that are expected to restore designated uses. The instream fecal coliform target for this TMDL is a 30-day geometric mean of 200 colony counts per 100 ml.

Because fecal coliform may be attributed to both nonpoint and point sources, the critical condition used for the modeling and evaluation of stream response was represented by a multi-year period. Critical conditions for waters impaired by nonpoint sources generally occur during periods of wet-weather and high surface runoff. But, critical conditions for point source dominated systems generally occur during low-flow, low-dilution conditions. The 1985-1995 period represents both low-flow conditions as well as wet-weather conditions and encompasses a range of wet and dry seasons. Therefore, the 11 year period was selected as representing critical conditions associated with all potential sources within the watershed.

## 2.2 Discussion of Instream Water Quality

Water quality data available for Red Creek show that the stream is impaired by fecal coliform bacteria. There was one ambient station operated by MDEQ which collected fecal coliform monitoring data during the 11 year modeling period. At station 02479300, which is at Vestry in Reach 03170007021, fecal coliform samples are collected approximately bimonthly and stream flow is recorded daily. The data were analyzed from January 1993, the beginning of sampling, to September 1996, the end of the analysis period. The data indicate that instream fecal coliform violations occurred during periods of both high and low flow.

### 2.2.1 Inventory of Available Water Quality Monitoring Data

The State's 1998 Section 305(b) Water Quality Assessment Report was reviewed to assess water quality conditions and data available for segment MS103RM of Red Creek. According to the report, segment MS103RM Red Creek is not supporting the use of contact recreation. This conclusions was based on data collected at station 02479300, which is in the impaired reach.

### 2.2.2 Analysis of Instream Water Quality Monitoring Data

A statistical summary of the water quality data discussed above is presented in Table 2.1. Samples are compared to the instantaneous maximum standard of 400 counts per 100 ml. The percent exceedances was calculated by dividing the number of exceedances by the total number of samples and does not represent the amount of time that the water quality is in exceedance.

Table 2.1 Statistical Summary of Fecal Coliform Data

| Station | Standard | # of Samples | # of Exceedances | Percent Exceedances |
|---|---|---|---|---|
| 02479300 | 400 | 23 | 7 | 30 |

# 3.0 SOURCE ASSESSMENT

The TMDL evaluation summarized in this report examined all known potential fecal coliform sources in the Red Creek Watershed. The source assessment was used as the basis of development for the model and ultimate analysis of the TMDL allocation options. In evaluation of the sources, loads are characterized by the best available information, monitoring data, literature values, and local management activities. This section documents the available information and interpretation for the analysis. The representation of the following sources as model input is discussed in Section 4.

The sources were analyzed in the Red Creek Watershed according to the 11 separate subwatersheds. The monitored section is contained entirely within the lower subwatershed, 03170007021. Red Creek was generally divided into a new reach at the confluence of each major tributary. The watershed delineations were based primarily on an analysis of the Reach File 3 (RF3) stream network and the digital elevation model of the watershed.

## 3.1 Assessment of Point Sources

Point sources of fecal coliform bacteria have their greatest potential impact on water quality during periods of low flow because the dilution capacity of the stream is diminished during dry periods. Thus, an evaluation of all point sources was necessary in order to quantify the potential for impairment present during the low flow, critical condition period. The 11 wastewater dischargers in the Red Creek Watershed serve a variety of activities including municipalities, industries, residential subdivisions, schools, recreational areas, and other businesses.

A point source assessment was completed for each subwatershed in the Red Creek Watershed. Reference maps were used to determine the appropriate subwatershed location of each discharger. Figure 1.2 shows a map of the drainage area of the monitored section of Red Creek and its division into subwatersheds. The map also shows the Reach File 1 identification number for each of the subwatersheds. Table 3.1 lists all of the dischargers according to subwatershed, along with the NPDES permit number and receiving waterbody.

Once the permitted dischargers were located, the effluent from each source was characterized based on all available monitoring data including permit limits, discharge monitoring reports, and information on treatment types. Discharge monitoring reports were the best data source for characterizing effluent because they contain measurements of flow and fecal coliform present in effluent samples. Of the facilities for which they were available, the discharge monitoring reports for the past five years, 1993 through 1998, were analyzed. If the discharge monitoring data were inadequate, permit limits were used to represent fecal coliform concentrations in the model, unless there was a history of an insufficient or malfunctioning disinfection system. If evidence of insufficient treatment existed, best professional judgement was used to estimate a fecal coliform loading rate in the model. The fecal coliform permit limits for each facility included in the model are also displayed in Table 3.1.

Table 3.1 Inventory of Point Source Dischargers

| Facility Name | Subwatershed | NPDES | Permit Limit (counts/100ml) | Receiving Waterbody |
|---|---|---|---|---|
| Bluff Mobile Home Park | 03170007022 | MS0032115 | 200 | Bluff Creek |
| Vancleave High School | 03170007022 | MS0038326 | 200 | Bluff Creek |
| Vancleave Junior High School | 03170007022 | MS0028762 | 200 | Bluff Creek |
| Wiggins POTW - #1 | 03170007024 | MS0024964 | 2000 | Flint Creek |
| Hood Industries Incorporated | 03170007025 | MS0001546 | 200 | Church House Creek |
| Wiggins POTW - #2 | 03170007025 | MS0026905 | 200 / 7700 rec / non-rec | Four Mile Creek |
| Coastal Paper Company | 03170007026 | MS0033057 | 0 | Red Creek |
| Subway #16124 | 03170007026 | MS0043265 | 200 | Red Creek |
| Lumberton POTW | 03170007029 | MS0020206 | 200 / 7800 rec / non-rec | Red Creek |
| MS Gulf Coast Jr. College | 03170007031 | MS0022764 | 200 | Ten Mile Creek |
| Red Creek Market & Restaurant | 03170007031 | MS0022764 | 200 | Ten Mile Creek |

## 3.2 Assessment of Nonpoint Sources

There are many potential nonpoint sources of fecal coliform bacteria for Red Creek, including:

- Failing septic systems
- Wildlife
- Land application of hog and cattle manure
- Land application of poultry litter
- Cattle contributions directly deposited instream
- Grazing animals
- Urban development

The 311,855 acre drainage area of Red Creek contains many different landuse types, including urban, forest, cropland, pasture, barren, and wetlands. The landuse information is based on data collected by the State of Mississippi's Automated Information System (MARIS, 1997). This data set is based on Landsat Thematic Mapper digital images taken between 1992 and 1993. The MARIS data are classified on a modified Anderson level one and two system. However, for modeling purposes the landuse categories were grouped into the landuses of urban, forest, cropland, pasture, barren, and wetlands. The contributions of each of these land types to the fecal coliform loading of Red Creek was considered on a subwatershed basis. Table 3.2 shows the landuse distribution within each subwatershed in acres.

Table 3.2 Red Creek Watershed Landuse Distribution in Each Subwatershed in Acres

| Subwatershed | Urban | Forest | Cropland | Pasture | Barren | Wetlands | Total |
|---|---|---|---|---|---|---|---|
| 03170007021 | 0 | 45,667 | 272 | 4,074 | 27 | 4,646 | **54,686** |
| 03170007022 | 0 | 17,488 | 597 | 3,944 | 0 | 1,843 | **23,871** |
| 03170007023 | 0 | 34,096 | 818 | 5,783 | 55 | 1,519 | **42,271** |
| 03170007024 | 293 | 17,669 | 370 | 4,113 | 66 | 1,505 | **24,014** |
| 03170007025 | 57 | 8,708 | 148 | 616 | 266 | 1,026 | **10,822** |
| 03170007026 | 296 | 7,778 | 88 | 407 | 155 | 728 | **9,453** |
| 03170007027 | 208 | 20,799 | 194 | 1,419 | 25 | 1,571 | **24,216** |
| 03170007028 | 0 | 15,785 | 256 | 2,853 | 0 | 1,184 | **20,079** |
| 03170007029 | 1,300 | 46,192 | 1,705 | 16,006 | 171 | 5,054 | **70,429** |
| 03170007030 | 0 | 13,209 | 216 | 1,250 | 217 | 1,237 | **16,129** |
| 03170007031 | 317 | 13,941 | 60 | 622 | 24 | 921 | **15,884** |
| **All** | **2,471** | **241,331** | **4,723** | **41,087** | **1,007** | **21,235** | **311,855** |

The nonpoint fecal coliform contribution from each landuse was estimated using the latest information available. Population and agricultural census data were extracted from the MARIS landuse data for Mississippi. MDEQ contacted several agencies to refine the assumptions made in determining the fecal coliform loading. The Mississippi Department of Wildlife, Fisheries, and Parks provided information of wildlife density in the Red Creek Watershed. The Mississippi State Department of Health was contacted regarding the failure rate of septic tank systems in this portion of the state. Mississippi State University researchers provided information on manure application practices and loading rates for hog farms and cattle operations. The Natural Resources Conservation Service also gave MDEQ information on manure treatment practices and land application of manure.

### 3.2.1 Failing Septic Systems

Septic systems have a potential to deliver fecal coliform bacteria loads to surface waters due to malfunctions, failures, and direct pipe discharges. Properly operating septic systems treat wastewater and dispose of the water through a series of underground field lines. The water is applied through these lines into a rock substrate, thence into underground absorption. The systems can fail when the field lines are broken, or the underground substrate is clogged or flooded. A failing septic system’s discharge can reach the surface, where it becomes available for wash-off into the stream. Another potential problem is a direct bypass from the system to a stream, which can be represented as a point source.

Another consideration is the use of individual onsite wastewater treatment plants. These treatment systems are in wide use in Mississippi. They can adequately treat wastewater when properly maintained. However, these systems do not typically receive the maintenance needed for proper, long-term operation. These systems require some sort of disinfection to properly operate. When this expense is ignored, the water does not receive adequate disinfection prior to release.

The number of septic systems for each subwatershed in the Red Creek Watershed was estimated from population and septic information provided in the 1990 U.S. Census. It was then estimated that 40percent are currently failing. The 40percent failure rate also incorporates direct bypasses and estimates for failing onsite wastewater treatment systems in the watershed. Table 3.3 shows the estimated percentage of failing septic tanks in each subwatershed based on the estimated total number of failing septic tanks in the entire Red Creek Watershed.

Table 3.3 Estimated Percent of Failing Septic Tanks

| Subwatershed | Percent of Failing Septic Systems |
|---|---|
| 03170007021 | 18 |
| 03170007022 | 8 |
| 03170007023 | 14 |
| 03170007024 | 8 |
| 03170007025 | 4 |
| 03170007026 | 3 |
| 03170007027 | 8 |
| 03170007028 | 6 |
| 03170007029 | 23 |
| 03170007030 | 4 |
| 03170007031 | 4 |

### 3.2.2 Wildlife

Wildlife present in the Red Creek Watershed contribute to fecal coliform bacteria on the land surface. In the Red Creek model, all wildlife was accounted for by considering contributions from deer. The deer population is estimated to be 30 to 45 animals per square mile for this area. The upper limit of 45 deer per square mile has been chosen to account for deer and all of the other wildlife present in the area. It was assumed that the wildlife population remained constant throughout the year, and that wildlife were present on all land classified as pastureland, cropland, and forest. It was also assumed that the wildlife and the manure produced by the wildlife were evenly distributed throughout these land use types.

### 3.2.3 Land Application of Hog and Cattle Manure

In the Pascagoula Basin processed manure from confined hog and dairy cattle operations is collected in lagoons and routinely applied to pastureland during April through October. This manure is a potential contributor of bacteria to receiving waterbodies due to runoff produced during a rain event. Hog farms in the Pascagoula Basin operate by either keeping the animals confined by or allowing hogs to graze in a small pasture or pen. For this model, it was assumed that all of the hog manure produced by either farming method was applied evenly to the available pastureland. Application rates of hog manure to pastureland from confined operations varied monthly according to management practices currently used in this area.

The dairy farms that are currently operating in the Red Creek Watershed only confine the animals for a limited time during the day. A confinement time of four hours per day was assumed to represent the time the cattle are milked and fed. During all other times, dairy cattle are allowed to graze on pasturelands. The manure collected during confinement is applied to the available pastureland in the watershed. Like the hog farms, application rates of dairy cow manure to pastureland vary monthly according to management practices currently used in this area. The number of hog and cattle producing manure in each subwatershed was estimated based on the 1997 Census of Agriculture data.

### 3.2.4 Grazing Animals

Cattle, including beef and dairy, spend time grazing on pastureland, depositing manure containing fecal coliform bacteria on the land surface. In a rain event, a portion of this fecal matter is available for wash-off and delivery to receiving waterbodies. A proportion of hogs in the Red Creek Watershed also spend time on pastureland depositing manure onto the land surface.

In this region of the state there is no monthly variation in beef and dairy cattle access to the pastures. Therefore, it is assumed that their loading rates are equal throughout the year. Beef cattle spend all of their time in pasture, while dairy cattle are confined for a limited period each day, during which time they are being milked and fed. This is estimated to be four hours per day for each cow. The percentage of manure deposited during their grazing time is applied to the available pastureland in the watershed.

### 3.2.5 Land Application of Poultry Litter

There is a considerable number of chickens produced in the Red Creek Watershed as estimated by the 1997 Census of Agriculture. In this area, poultry farming operations use houses in which chickens are confined all of the time. The manure produced by the chickens is collected in litter on the floor of the chicken houses. This litter is routinely applied as a fertilizer to pastureland in the watershed. Application rates of the litter vary monthly.

Two kinds of chickens are raised on farms in the Pascagoula Basin, broilers and layers. For the broiler chickens, the amount of growth time from when the chicken is born to when it is sold off the farm is approximately 48 days. Layer chickens remain on farms for 10 months or longer.

More than 93 percent of the chickens raised in this area are broilers. For the model, a weighted average of growth time was determined to account for both types of chickens. An average growth time of 52 days, or one-seventh of a year, was used. To determine the number of chickens on farms on any given day, the yearly population of chickens sold was divided by seven.

### 3.2.6 Cattle Contributions Directly Deposited Instream

Cattle often have direct access to flowing and intermittent streams which run through fenced pastureland. These small streams are tributaries of larger streams. Fecal coliform bacteria deposited in these streams by grazing cattle are considered a direct input of bacteria to the stream. Due to the general topography in the Red Creek Watershed, it was assumed that all land slopes in the watershed are such that cattle are able to access the intermittent streams in all pastures. In order to determine the amount of bacteria introduced into streams from cattle, it was assumed that all grazing cattle spent five percent of their time standing in the streams. Thus, the model assumes that five percent of the manure produced by grazing beef and dairy cows is deposited directly in the stream.

### 3.2.7 Urban Development

Urban areas include land classified as urban and barren. Even though less than two percent of the Red Creek Watershed is urban and barren, the contribution of the urban areas to fecal coliform loading in Red Creek was considered. Municipalities within the Red Creek Watershed include Dantzler, Vestry, Beatrice, Ramsey Springs, Moore Crossing, Whites Crossing, Wiggins, Big Level, Ten Mile, Texas, Bond, Fruitland Park, Lumberton, Hickory Grove, and Young. Fecal coliform contributions from urban areas may come from storm water runoff through stormwater sewers (e.g. residential, commercial, industrial, road transportation), illicit discharges of sanitary wastes, and runoff contribution from improper disposal of waste materials.

# 4.0 MODELING PROCEDURE: LINKING THE SOURCES TO THE ENDPOINT

Establishing the relationship between the instream water quality target and the source loadings is a critical component of TMDL development. It allows for the evaluation of management options that will achieve the desired source load reductions. The link can be established though a range of techniques, from qualitative assumptions based on sound scientific principles to sophisticated modeling techniques. Ideally, the linkage will be supported by monitoring data that allow the TMDL developer to associate certain waterbody responses to flow and loading conditions. In this section, the selection of the modeling tools, setup, and model application are discussed.

## 4.1 Modeling Framework Selection

The BASINS model platform and the NPSM model were used to predict the significance of fecal coliform sources to fecal coliform levels in the Red Creek Watershed. BASINS is a multipurpose environmental analysis system for use in performing watershed and water quality-based studies. A geographic information system (GIS) provides the integrating framework for BASINS and allows for the display and analysis of a wide variety of landscape information such as landuses, monitoring stations, point source discharges, and stream descriptions. NPSM simulates nonpoint source runoff from selected watersheds, as well as the transport and flow of the pollutants through stream reaches. A key reason for using BASINS as the modeling framework is its ability to integrate both point and nonpoint sources in the simulation, as well as its ability to assess instream water quality response.

## 4.2 Model Setup

The Red Creek TMDL model includes the monitored section of the creek as well as the evaluated drainage area and the rest of the Red Creek Watershed. Thus, all upstream contributors of bacteria are accounted for in the model. To obtain a spatial variation of the concentration of bacteria along Red Creek, the watershed was divided into 11 subwatersheds in an effort to isolate the major stream reaches in the Red Creek Watershed. This allowed the relative contribution of point and nonpoint sources to be addressed within each subwatershed.

## 4.3 Source Representation

Both point and nonpoint sources were represented in the model. Due to die-off rates and overland transportation assumptions, the fecal coliform loadings from point and nonpoint sources must be addressed separately. A fecal coliform spreadsheet was developed for quantifying point and nonpoint sources of bacteria for the Red Creek model. This spreadsheet calculates the model inputs for fecal coliform loading due to point and nonpoint sources using assumptions about land management, septic systems, farming practices, and permitted point source contributions. Each of the potential bacteria sources is covered in the fecal coliform spreadsheet.

The discharge from point sources was added as a direct input into the appropriate reach of the waterbody. There are 11 NPDES permitted facilities in the watershed which discharge fecal coliform bacteria. Fecal coliform loading rates for point sources are input to the model as flow in cubic feet per second and fecal coliform contribution in counts per hour.

The nonpoint sources are represented in the model with two different methods. The first of these methods is a direct fecal coliform loading to Red Creek. Other sources are represented as an application rate to the land in the Red Creek Watershed. For these sources, fecal coliform accumulation rates in counts per acre per day were calculated for each subwatershed on a monthly basis and input to the model for each landuse. Fecal coliform contributions from forests and wetlands were considered to be equal. Urban and barren areas were also considered to produce equal loads. The fecal coliform accumulation rate for pastureland is the sum of accumulation rates due to litter application, wildlife, processed manure, and grazing animals. For cropland in this area it is only due to wildlife. Accumulation rates for pastureland are calculated on a monthly basis to account for seasonal variations in manure and litter application.

### 4.3.1 Failing Septic Systems

Discharges from failing septic systems were quantified based on several factors including the estimated population served by the septic systems, an average daily discharge of 100 gallons per person per day, and a septic system effluent fecal coliform concentration of 10,000 counts per 100 ml.

### 4.3.2 Wildlife

Deer are distributed throughout the Red Creek Watershed on forest, cropland and pasturelands based on a density of 45 deer per square mile, as discussed in Section 3.2.2. This is multiplied by the loading rate of manure for one deer and by the area for each applicable landuse category. The manure from the deer is evenly distributed in the model to the pasture, cropland, and forest. The per animal loading rate used in the model is 5.00E+08 counts/day/deer. The per acre loading rate applied to the landuses is 3.52E+07 counts/acre/day.

### 4.3.3 Land Application of Hog and Cattle Manure

The fecal coliform spreadsheet was used to estimate the amount of waste and the concentration of fecal coliform bacteria contained in hog and dairy cattle manure produced by confined animal feeding operations. Fecal coliform production rates of 1.08E+10 counts/day/hog and 5.40E+09 counts/day/cow were multiplied by the number of confined animals to quantify the amount of bacteria produced (ASAE, 1998 and Metcalf and Eddy, 1991). The manure produced by these operations is collected in lagoons and applied evenly to all pastureland. Manure application rates to pastureland vary on a monthly basis. This monthly variation is incorporated into the model by using monthly loading rates.

### 4.3.4 Grazing Animals

Manure produced by grazing beef and dairy cattle is evenly spread on pastureland throughout the year. The number of grazing cattle is calculated by subtracting the number of confined cattle from the total number of cattle. The fecal coliform content of manure produced by grazing cattle is estimated by multiplying the number of grazing cattle by a fecal coliform production of 5.40E+09 counts/day/cow (Metcalf and Eddy, 1991). The resulting fecal coliform loads are in the units of counts/acre/day. The fecal coliform loading rates due to grazing cattle are shown in the spreadsheet in Appendix A.

### 4.3.5 Land Application of Poultry Litter

The fecal coliform spreadsheet estimates the concentration of bacteria which accumulates in the dry litter where poultry waste is collected. This is done by multiplying the daily number of chickens on farms by a fecal coliform production rate of 6.75E+07 counts/day/chicken (ASAE, 1998). The model assumed a watershed area normalized chicken population. The chicken population was determined from the 1997 Census of Agriculture Data for the number of chickens sold from each county per year. Litter application to pastureland varies monthly, and is modeled with a monthly loading rate.

### 4.3.6 Cattle Contributions Deposited Directly Instream

The contribution of fecal coliform from cattle to a stream is represented as a direct input into the stream by the model. In order to estimate the point source loading produced by grazing beef and dairy cattle with access to streams, five percent of the number of grazing cattle in each subwatershed are assumed to be standing in a stream at any given time. When cattle are standing in a stream, their fecal coliform production is estimated as flow in cubic feet per second and a concentration in counts per hour. The fecal coliform concentration is calculated using the number of cows in the stream and a bacteria production rate of 5.40E+09 counts/day/cow (Metcalf and Eddy, 1991).

### 4.3.7 Urban Development

For the Red Creek Watershed, the urban and barren areas are combined and classified as high density, low density, or transportation. Fecal coliform buildup rates for each category were determined from literature values (Horner, 1992). The literature value accounts for all of the potential fecal coliform sources in each urban category. The literature values for each urban landuse category are given in Table 4.1. The urban landuse distribution within each subwatershed is shown in Table 4.2. Fecal coliform loading rates on urban land are input as counts per acre per day.

Table 4.1 Urban Loading Rates

| High Density Area | Low Density Area | Transportation Area |
|---|---|---|
| 1.54E+07 | 1.03E+07 | 2.00E+05 |

Table 4.2 Urban Landuse Distribution

| Subwatershed | High Density Area (acres) | Low Density Area (acres) | Transportation Area (acres) | Total |
|---|---|---|---|---|
| 03170007021 | 4 | 12 | 10 | **26** |
| 03170007022 | 0 | 0 | 0 | **0** |
| 03170007023 | 9 | 25 | 22 | **56** |
| 03170007024 | 57 | 161 | 140 | **358** |
| 03170007025 | 52 | 145 | 126 | **323** |
| 03170007026 | 72 | 203 | 176 | **451** |
| 03170007027 | 37 | 105 | 91 | **233** |
| 03170007028 | 0 | 0 | 0 | **0** |
| 03170007029 | 235 | 662 | 574 | **1471** |
| 03170007030 | 35 | 98 | 85 | **218** |
| 03170007031 | 55 | 153 | 133 | **341** |
| **Total** | **556** | **1564** | **1357** | **3477** |

## 4.4 Stream Characteristics

The stream characteristics given below describe the entire modeled section of Red Creek. This section begins at the headwaters and ends at the end of the impaired reach, with the confluence with the Leaf River. The stream characteristics for Red Creek are based on data available within the BASINS modeling system. The characteristics of the modeled section of Red Creek are as follows.

- Length 62.8 miles
- Average Depth 1.2 feet
- Average Width 76.7 feet
- Mean Flow 902.4 cubic feet per second
- Mean Velocity 2.0 feet per second
- 7Q10 Flow 121.1 cubic feet per second
- Slope 0.0005

## 4.5 Selection of Representative Modeling Period

The model was run for 12 years, from January 1, 1984 through December 31, 1995. The results from the first year were diregarded to allow for model stabilization. Results from the model were evaluated for the time period from January 1, 1985, until December 31, 1994. Because an 11 year time spans used a margin of safety (MOS) is implicitly applied. Seasonality and critical conditions are accounted for during the extended time frame of the simulation.

The critical condition for fecal coliform impairment from nonpoint source contributors occurs after a heavy rainfall which is preceded by several days of dry weather. The dry weather allows a build up of fecal coliform bacteria which is then washed off the ground by a heavy rainfall. By using the 11 year time period, the effects of many such occurrences are captured in the model results. Critical conditions for point sources, which occur during low flow and low dilution conditions, are simulated as well.

### 4.6 Model Calibration Process

First, the model was calibrated for hydrology on various gages in the Pascagoula Basin. A set of input values was established for the Pascagoula Basin through the hydrologic calibration. A continuous USGS gage was available for comparison in reach 03170007021 of Red Creek. Gage 02479300 is near Vestry in the impaired reach. A sample of these results is included in Appendix A. Graph A-1a shows modeled output and actual gage data for year 1986, while Graph A-1b shows the same for year 1989 and Graph A-1c for year 1993. Even though there is a good correlation between the simulated and observed data sets, the offset may be a result of the distance between the rain gage and the streamflow gage.

The water quality data available are such that water quality calibration was difficult. As described in Section 2.2 the water quality data available are instantaneous samples collected approximately every two months. The data available are not sufficient for calibration purposes. Instead, MDEQ contacted researchers and agricultural experts to quantify representative pathogen loads entering the stream.

### 4.7 Existing Loadings

Appendix A also includes two graphs of the model results showing the instream fecal coliform concentrations for the monitored reach of Red Creek, 03170007021. Graph A-2 shows the fecal coliform levels in the stream during the 11 year modeling period. The graph shows a 30-day geometric mean of the data. There have been 13 standards violations in 11 years according to the model. The straight line at 200 counts per 100 ml indicates the water quality standard for the stream.

Graph A-3 shows the 30-day geometric mean of the fecal coliform levels after the reduction scenario has been modeled. The scale matches the previous graph for comparison purposes. Again, the straight line at 200 counts per 100 ml indicates the water quality standard for the stream. The graph indicates that there are no violations of the water quality standard.

# 5.0 ALLOCATION

The allocation for this TMDL involves a wasteload allocation for point sources and a load allocation for nonpoint sources necessary for attainment of water quality standards in the monitored segment, MS013RM, and the evaluated drainage area, MS102RE. The allocated loads for the monitored segment are equal to the sum of the loads in all of the 11 subwatersheds because all of the subwatersheds drain to the monitored segment. The allocated loads for the evaluated drainage area are equal to the sum of the loads in subwatersheds 03170007027, 03170007028, and 03170007029.

Point source contributions enter the stream directly in the appropriate reach. Cows in the stream and failing septic tanks were also modeled as direct inputs to the stream. Cows in the stream are a nonpoint source, while failing septic tanks are both a point and nonpoint source. The other nonpoint source contributions were applied to land area on a counts per day per acre basis. The fecal coliform bacteria applied to land is subject to a die-off rate and an absorption rate before it enters the stream. The TMDL was calculated based on modeling estimates which are referenced in Appendix A.

## 5.1 Wasteload Allocations

Point sources within the watershed discharging at their current level are subject to some reduction from their current level of fecal coliform contribution. The contribution of point sources was considered on a subwatershed basis for the model. Within each subwatershed, the modeled contribution of each discharger was based on the facility's maximum permitted discharge, discharge monitoring data, and other records of past performance. In some cases, the fecal coliform contribution from a facility is much greater than the maximum permitted limit. As part of this TMDL, all permitted facilities which are not in compliance with their current NPDES permits should take steps to comply with their NPDES permit. It is also recommended that all permit limits, which allow end of pipe concentrations greater than the water quality standards for the receiving stream, be lowered so that effluent concentrations are equal to water quality standards upon reissuance. In the Red Creek Watershed only two facilities currently have limits which are higher than the water quality standard. These are the Wiggins #2 and the Lumberton Municipal Facilities. The reduction of their non-recreation season limits to 2000 counts per 100 ml accounts for the primary portion of the 62 percent wasteload allocation reduction for the non-recreation season. Table 5.1 lists the point source contributions from permitted dischargers for the recreation season, on a subwatershed basis, along with their existing load, allocated load, and percent reduction. A portion of failing septic tanks, which are direct bypasses and a point source of pollution, are also a component of the wasteload allocation (WLA).

Table 5.1 Component of WLA due to permitted dischargers

| Subwatershed | Existing Load (counts/hr) | Allocated Load (counts/hr) | Percent Load Reduction |
|---|---|---|---|
| 03170007021 | 0.0 | 0.0 | 0 |
| 03170007022 | 2.36E+07 | 2.36E+07 | 0 |
| 03170007023 | 0.0 | 0.0 | 0 |
| 03170007024 | 1.51E+08 | 1.51E+08 | 0 |
| 03170007025 | 5.01E+07 | 5.01E+07 | 0 |
| 03170007026 | 1.89E+05 | 1.89E+05 | 0 |
| 03170007027 | 0.0 | 0.0 | 0 |
| 03170007028 | 0.0 | 0.0 | 0 |
| 03170007029 | 1.57E+08 | 1.57E+08 | 0 |
| 03170007030 | 0.0 | 0.0 | 0 |
| 03170007031 | 3.51E+07 | 3.51E+07 | 0 |
| **Total** | **4.17E+08** | **4.17E+08** | **0** |

## 5.2 Load Allocations

Nonpoint sources which contribute to fecal coliform accumulation within the Red Creek Watershed are subject to reduction from their current level of contribution. Reductions in the load allocation for this TMDL involve two different types of nonpoint sources: cattle access to streams and septic tanks. Contributions from both of these sources are input into the model in a manner similar to point source input, with a flow and fecal coliform concentration in counts per hour. Table 5.2 lists the nonpoint source contributions due to cattle access to streams, on a subwatershed basis, along with their existing load, allocated load, and percent reduction. Table 5.3 gives the same for contributions due to septic tank failure, which are evenly distributed between point and nonpoint sources.

Table 5.2 Fecal Coliform Loading Rates from Cattle Access to Streams

| Subwatershed | Existing Flow (cfs) | Existing Load (counts/hr) | Allocated Flow (cfs) | Allocated Load (counts/hr) | Percent Reduction |
|---|---|---|---|---|---|
| 03170007021 | 3.39E-04 | 1.30E+10 | 1.36E-04 | 5.19E+09 | 60 |
| 03170007022 | 1.49E-04 | 5.68E+09 | 5.95E-05 | 2.27E+09 | 60 |
| 03170007023 | 2.88E-04 | 1.10E+10 | 1.15E-04 | 4.41E+09 | 60 |
| 03170007024 | 1.65E-04 | 6.29E+09 | 6.58E-05 | 2.52E+09 | 60 |
| 03170007025 | 7.53E-05 | 2.88E+09 | 3.01E-05 | 1.15E+09 | 60 |
| 03170007026 | 6.35E-05 | 2.43E+09 | 2.54E-05 | 9.71E+08 | 60 |
| 03170007027 | 1.57E-04 | 6.01E+09 | 6.29E-05 | 2.40E+09 | 60 |
| 03170007028 | 1.11E-04 | 4.24E+09 | 4.43E-05 | 1.69E+09 | 60 |
| 03170007029 | 8.06E-04 | 3.08E+10 | 3.22E-04 | 1.23E+10 | 60 |
| 03170007030 | 1.12E-04 | 4.29E+09 | 4.49E-05 | 1.72E+09 | 60 |
| 03170007031 | 1.08E-04 | 4.15E+09 | 4.34E-05 | 1.66E+09 | 60 |
| **Total** | **2.37E-03** | **9.08E+10** | **9.49E-04** | **3.63E+10** | **60** |

Table 5.3 Fecal Coliform Loading Rates from Failing Septic Tanks (50% WLA, 50% LA)

| Subwatershed | Existing Flow (cfs) | Existing Load (counts/hr) | Allocated Flow (cfs) | Allocated Load (counts/hr) | Percent Reduction |
|---|---|---|---|---|---|
| 03170007021 | 1.05E-01 | 1.07E+09 | 5.26E-02 | 5.35E+08 | 50 |
| 03170007022 | 4.59E-02 | 4.67E+08 | 2.30E-02 | 2.34E+08 | 50 |
| 03170007023 | 8.14E-02 | 8.28E+08 | 4.07E-02 | 4.14E+08 | 50 |
| 03170007024 | 4.62E-02 | 4.70E+08 | 2.31E-02 | 2.35E+08 | 50 |
| 03170007025 | 2.08E-02 | 2.12E+08 | 1.04E-02 | 1.06E+08 | 50 |
| 03170007026 | 1.82E-02 | 1.85E+08 | 9.10E-03 | 9.26E+07 | 50 |
| 03170007027 | 4.66E-02 | 4.74E+08 | 2.33E-02 | 2.37E+08 | 50 |
| 03170007028 | 3.86E-02 | 3.93E+08 | 1.93E-02 | 1.97E+08 | 50 |
| 03170007029 | 1.36E-01 | 1.38E+09 | 6.78E-02 | 6.90E+08 | 50 |
| 03170007030 | 2.14E-02 | 2.18E+08 | 1.07E-02 | 1.09E+08 | 50 |
| 03170007031 | 2.11E-02 | 2.15E+08 | 1.06E-02 | 1.07E+08 | 50 |
| **Total** | **5.81E-01** | **5.91E+09** | **2.91E-01** | **2.96E+09** | **50** |

Nonpoint fecal coliform loadings due to cattle grazing; land application of manure produced by confined dairy cattle, hogs, and poultry; wildlife; and urban development are also included in the load allocation. Currently, no reduction is required for these contributors in order for Red Creek to achieve water quality standards. Daily fecal coliform loading rates for each landuse are given in Table 5.4. The total accumulation for each landuse type was determined by combining the contributions from each subwatershed. The loading rates are constant throughout the year for forest, cropland, and urban land. However, the loading rates for pastureland vary monthly. In the Table 5.4 the rates given for pastureland are based on an average of the monthly accumulation rates. The estimated loads shown in Table 5.4 are those which accumulate on the land and are available for runoff, while the load allocation is the load as it enters the stream due to runoff.

Table 5.4 Fecal Coliform Loads Available for Runoff by Subwatershed and Landuse Type in counts per day

| Subwatershed | Urban & Barren | Forest & Wetland | Cropland | Pastureland | Total |
|---|---|---|---|---|---|
| 03170007021 | 1.94E+08 | 9.63E+12 | 9.56E+09 | 7.85E+12 | **9.63E+12** |
| 03170007022 | 0.0 | 4.79E+12 | 2.10E+10 | 4.09E+12 | **4.79E+12** |
| 03170007023 | 3.95E+08 | 9.09E+12 | 2.88E+10 | 7.80E+12 | **9.09E+12** |
| 03170007024 | 2.57E+09 | 5.18E+12 | 1.30E+10 | 4.49E+12 | **5.18E+12** |
| 03170007025 | 2.32E+09 | 2.35E+12 | 5.20E+09 | 2.00E+12 | **2.35E+12** |
| 03170007026 | 3.24E+09 | 1.99E+12 | 3.09E+09 | 1.69E+12 | **1.99E+12** |
| 03170007027 | 1.67E+09 | 5.00E+12 | 6.82E+09 | 4.21E+12 | **5.00E+12** |
| 03170007028 | 0.0 | 3.65E+12 | 9.00E+09 | 3.05E+12 | **3.65E+12** |
| 03170007029 | 1.06E+10 | 1.86E+13 | 5.99E+10 | 1.68E+13 | **1.86E+13** |
| 03170007030 | 1.56E+09 | 3.49E+12 | 7.59E+09 | 2.98E+12 | **3.49E+12** |
| 03170007031 | 2.45E+09 | 3.41E+12 | 2.11E+09 | 2.88E+12 | **3.41E+12** |
| **Total** | **2.50E+10** | **9.23E+12** | **1.66E+11** | **5.78E+13** | **6.72E+13** |

The scenario chosen for the load allocation in the Red Creek Watershed is a 60 percent reduction in contributions from cows in the stream, and a 50 percent reduction from failing septic tanks. This scenario could be achieved by supporting BMP projects that promote fencing around streams in pastures, and by supporting education projects that encourage homeowners to properly maintain their septic tanks by routinely pumping them out, repairing broken field lines, and disinfecting the effluent from individual onsite wastewater treatment plants.

## 5.3 Incorporation of a Margin of Safety

The two types of MOS development are to implicitly incorporate the MOS using conservative model assumptions or to explicitly specify a portion of the total TMDL as the MOS. The MOS selected for this model is implicit. The primary component of the MOS is provided by running the model for 11 years with no violations of the water quality standard. Ensuring compliance with the standard throughout all of the critical condition periods represented during the 11 years is a conservative practice. Another component of the MOS is the conservative assumption that in the model all of the fecal coliform bacteria discharged from failing septic tanks reaches the stream, while it is likely that only a portion of the bacteria will reach the stream due to filtration and die off during transport.

## 5.4 Seasonality

For many streams in the state, fecal coliform limits vary according to the seasons. The monitored segment of Red Creek, however, is designated for the use of contact recreation. For this use, the pollutant standard is constant throughout the year.

Because the model was established for an 11-year time span, it took into account all of the seasons within the calendar years from 1985 to 1995. The extended time period allowed the simulation of many different atmospheric conditions such as rainy and dry periods and high and low temperatures. It also allowed seasonal critical conditions to be simulated.

# 6.0 IMPLEMENTATION

Implementation of the TMDL has been considered for both point and nonpoint source contributors in all 11 subwatersheds in order to improve water quality in segment MS103RM and drainage area MS012RE. The fecal coliform reduction scenario used in this TMDL for point sources includes requiring all NPDES permitted dischargers of fecal coliform to disinfect to meet water quality standards. For nonpoint sources the TMDL recommends a 60 percent reduction of the cattle access to streams and a 50 percent reduction of the failing septic tanks in the watershed. The TMDL will not impact future NPDES permits as long as the effluent is disinfected to meet water quality standards for fecal coliform bacteria. Also, this TMDL should not affect the growth of animal operations or the continued installation of septic tanks in the Red Creek Watershed as long as they are both properly managed. Education projects which teach best management practices to land and home owners should be used as a tool for reducing nonpoint source contributions. These projects may be funded by CWA Section 319 Nonpoint Source (NPS) Grants.

## 6.1 Follow-Up Monitoring

MDEQ has adopted the Basin Approach to Water Quality Management. The approach will provide for continued monitoring of the watershed in future cycles. During the next monitoring phase in the Pascagoula Basin, Red Creek may receive follow-up monitoring to identify the improvement in water quality from the implementation of the strategies in this TMDL.

## 6.2 Reasonable Assurance

Point sources will be regulated through their NPDES permits as described in Section 5.1. Permits for constructing wastewater treatment plants without the proper disinfection equipment, are not recommended for approval by this TMDL. At this time there are no statutes to force implementation of the best management practices for nonpoint sources. However, MDEQ is working within the Basin Approach to Water Quality Management to educate the public on the importance of nonpoint source pollution management and encourage the use of nonpoint source best management practices. Public education efforts will be targeted to teaching stakeholders within the Pascagoula Basin about the proper use of best management practices.

## 6.3 Public Participation

This TMDL will be published for a 30-day public notice. During this time, the public will be notified by publication in the statewide newspaper and a newspaper in the area of the watershed. The public will be given an opportunity to review the TMDL and submit comments. At the end of the 30-day period, MDEQ will determine the level of interest in the TMDL and make a decision on the necessity of holding a public hearing.

If a public hearing is deemed appropriate, the public will be given a 30-day notice of the hearing to be held at a location near the watershed. That public hearing would be an official hearing of the Mississippi Commission on Environmental Quality, and would be transcribed.

All comments received during the public notice period and at any public hearings become a part of the record of this TMDL. All comments will be considered in the ultimate approval of this TMDL by the Commission on Environmental Quality and for submission of this TMDL to EPA Region Four for final approval.

# 7.0 REFERENCES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MDEQ. 1994. *Wastewater Regulations for National Pollutant Discharge Elimination System (NPDES) Permits, Underground Injection Control (UIC) Permits, State Permits, Water Quality Based Effluent Limitations and Water Quality Certification*. Office of pollution Control.

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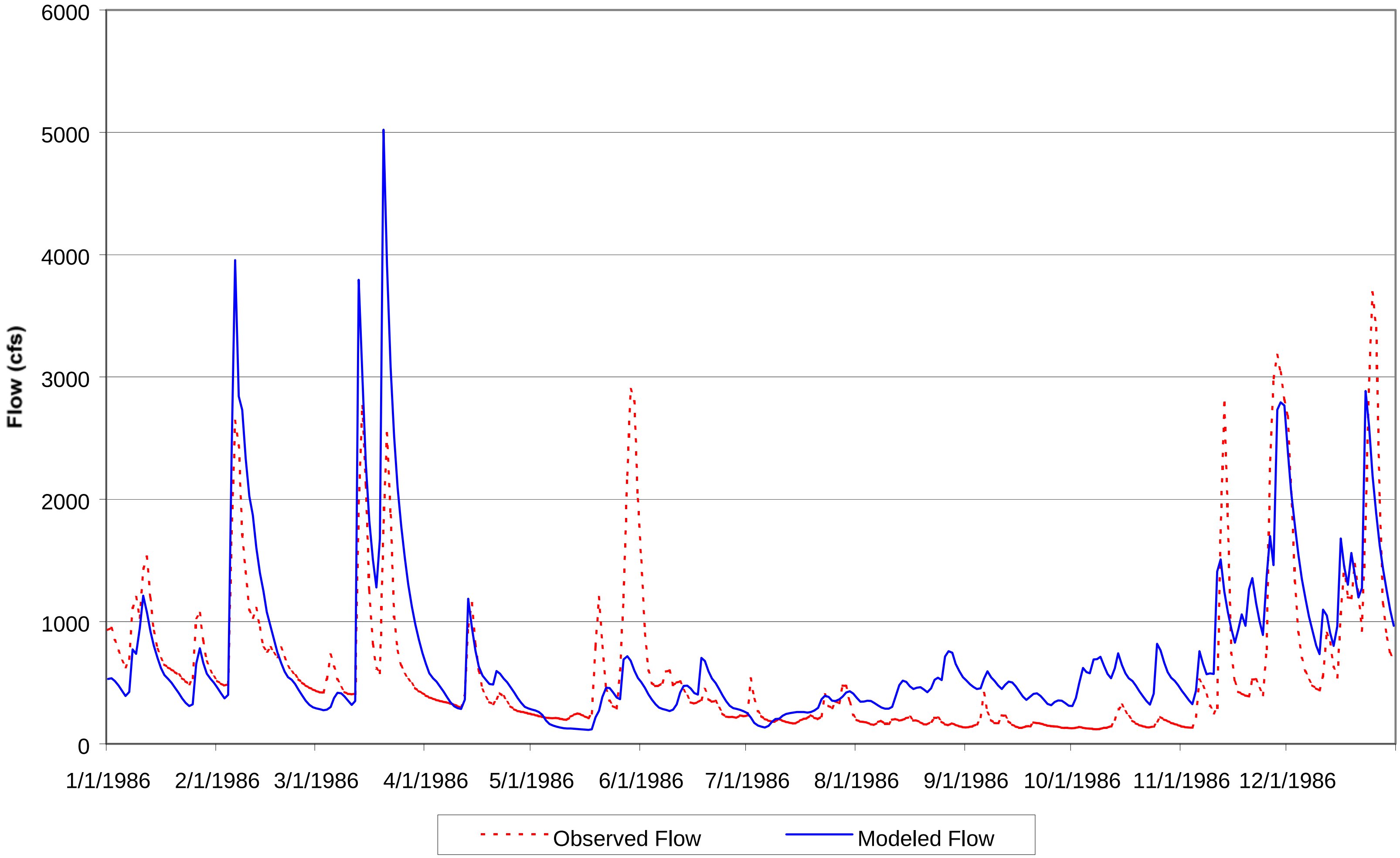
# 8.0 APPENDIX A

This appendix contains printouts of the various model run results. An 11 year time period, from January 1, 1985 to December 31, 1995, was modeled. However, Graph A-1a, Graph A-1b, and Graph A-1c show the modeled flow, in cfs, through reach 03170007021 compared to the actual USGS gage readings from Red Creek at Vestry for years 1986, 1989, and 1993, respectively. The second set of graphs show the 30-day geometric mean for fecal coliform concentrations in counts per 100 ml in the impaired section of Red Creek, reach 03170007021. The graphs contain a reference line at 200 counts per 100 ml. Graph A-2 represents the existing conditions in Red Creek. There are 13 violations of the fecal coliform standard on this graph. Graph A-3 represents the conditions in Red Creek after the reduction scenario has been applied. Graphs A-2 and A-3 are shown with the same scale for comparison purposes.

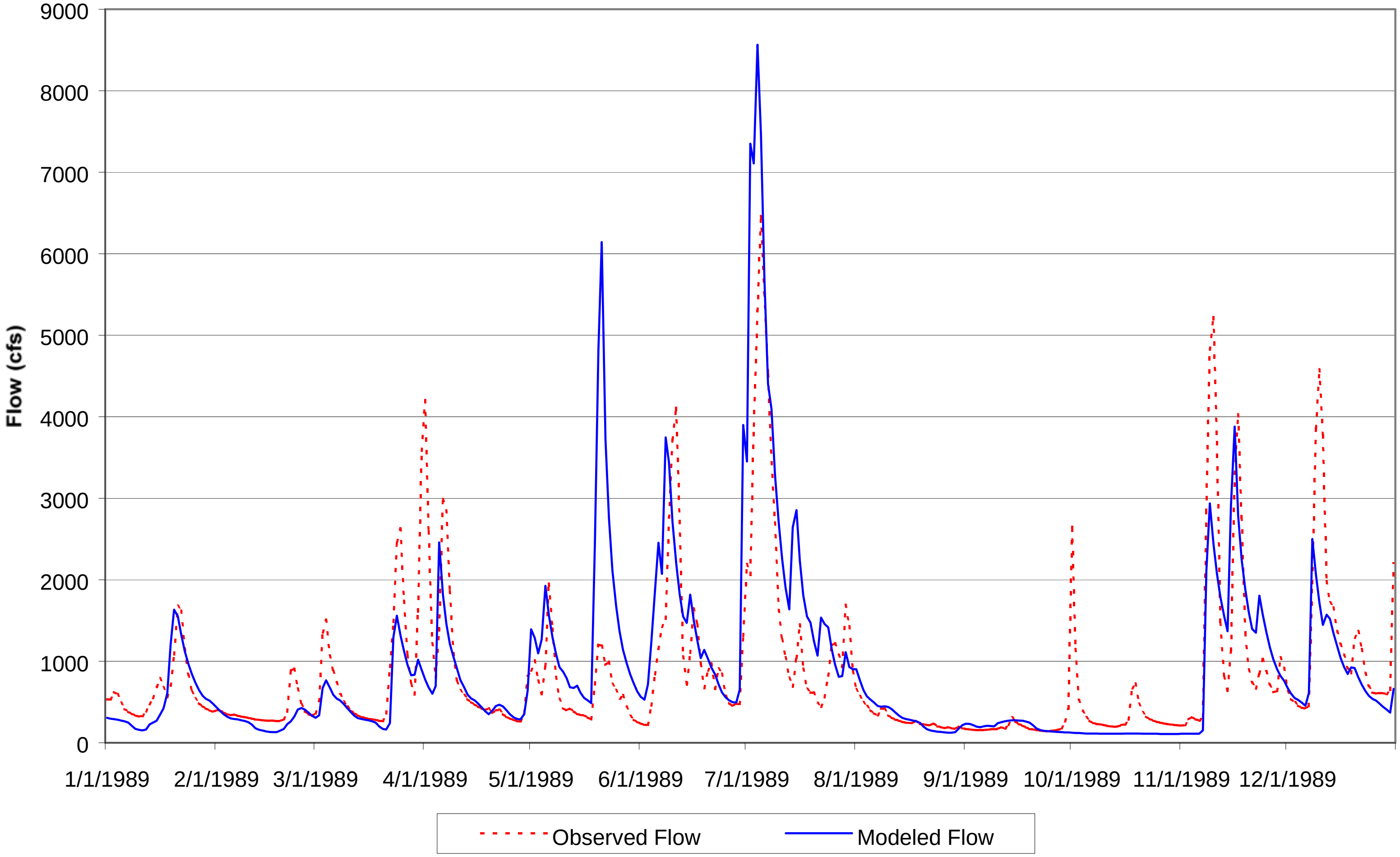
The TMDL calculated in this report represents the maximum fecal coliform load that can be assimilated by the waterbody segment during the critical 30-day period that will maintain water quality standards. The calculation of this TMDL is based on the critical hydrologic flow condition that occurred during the modeled time span. Graph A-3, which shows the 30-day geometric mean of instream fecal coliform concentrations representing the allocated loading scenario, was used to identify the critical condition. The TMDL calculation includes the sum of the loads from all identified point and nonpoint sources applied or discharged within the modeled watershed.

An individual TMDL calculation was prepared for each waterbody segment and drainage area included in this report. The numerical values for the wasteload allocation (point sources) and load allocation (nonpoint sources) for each waterbody segment or drainage area can be found on the waterbody segment identification pages at the beginning of this report.

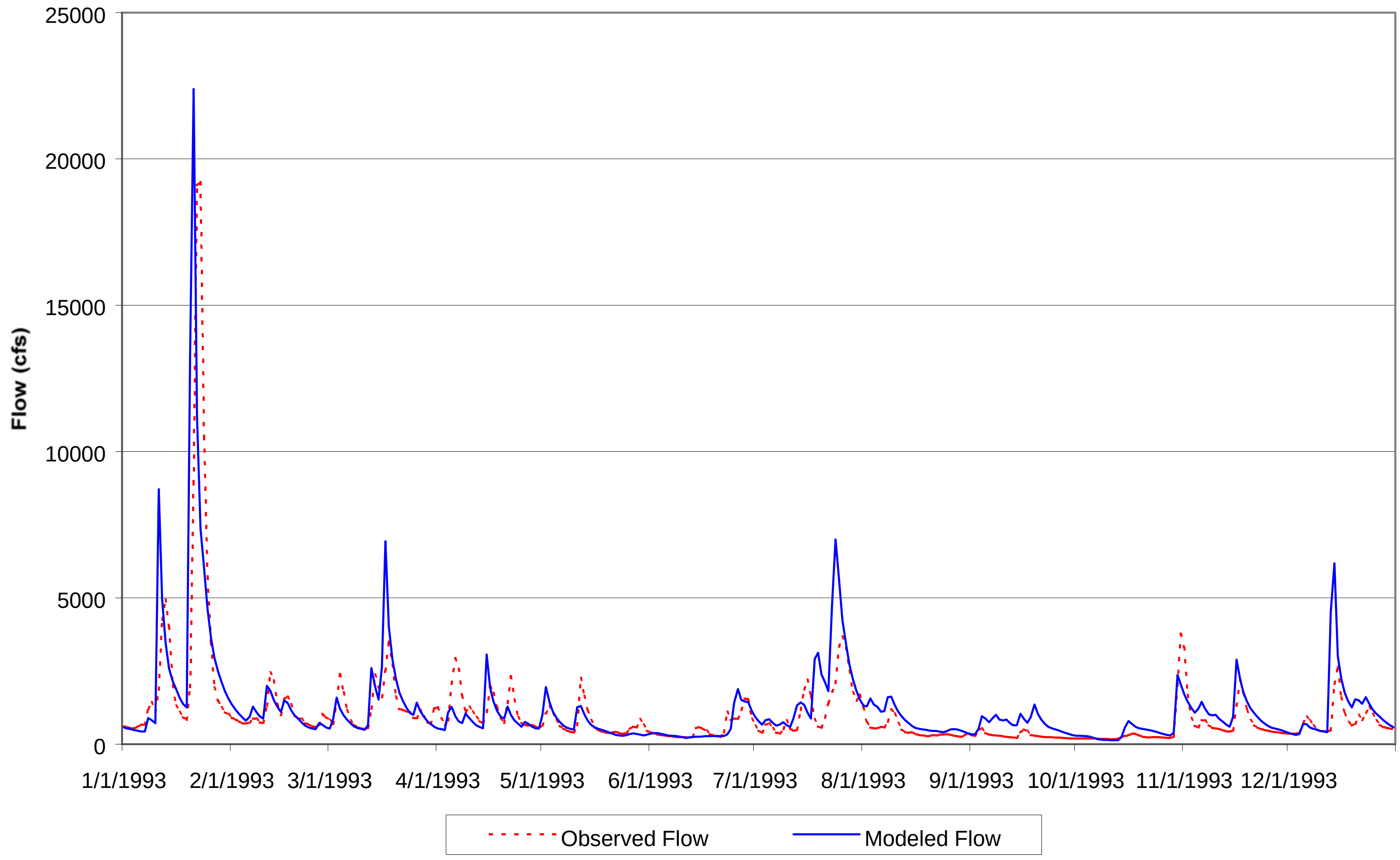
**Graph A-1a Daily Flow Comparison between USGS Gage 02479300 and Reach 03170007021 for 01/01/86 - 12/31/86**



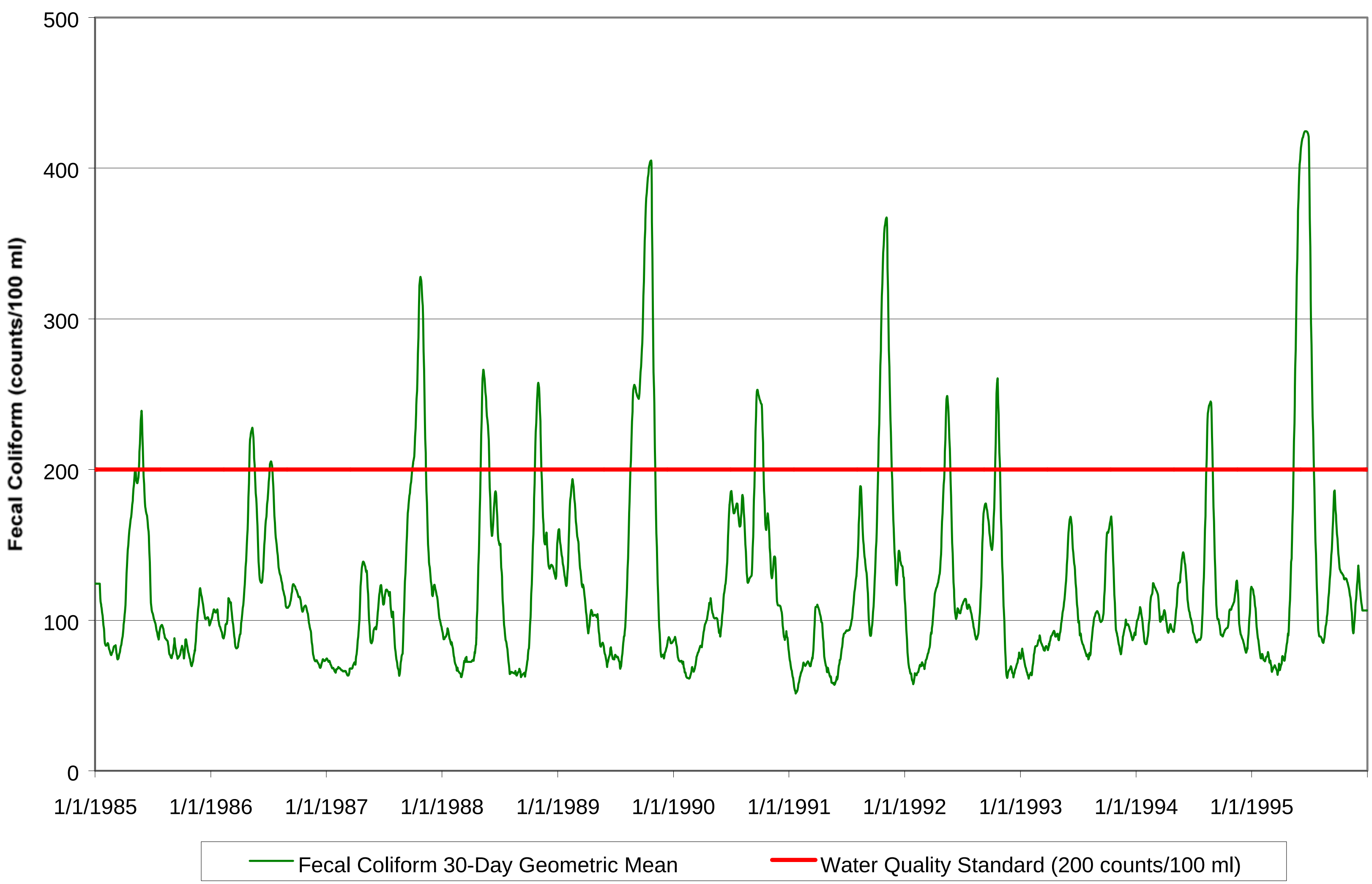
**Graph A-1b Daily Flow Comparison between USGS Gage 02479300 and Reach 03170007021 for 01/01/89 - 12/31/89**



**Graph A-1c Daily Flow Comparison between USGS Gage 02479300 and Reach 03170007021 for 01/01/93 - 12/31/93**



**Graph A-2 Modeled Fecal Coliform Concentrations Under Existing Conditions**



**Graph A-3 Modeled Fecal Coliform Concentrations After Application of Reduction Scenario**