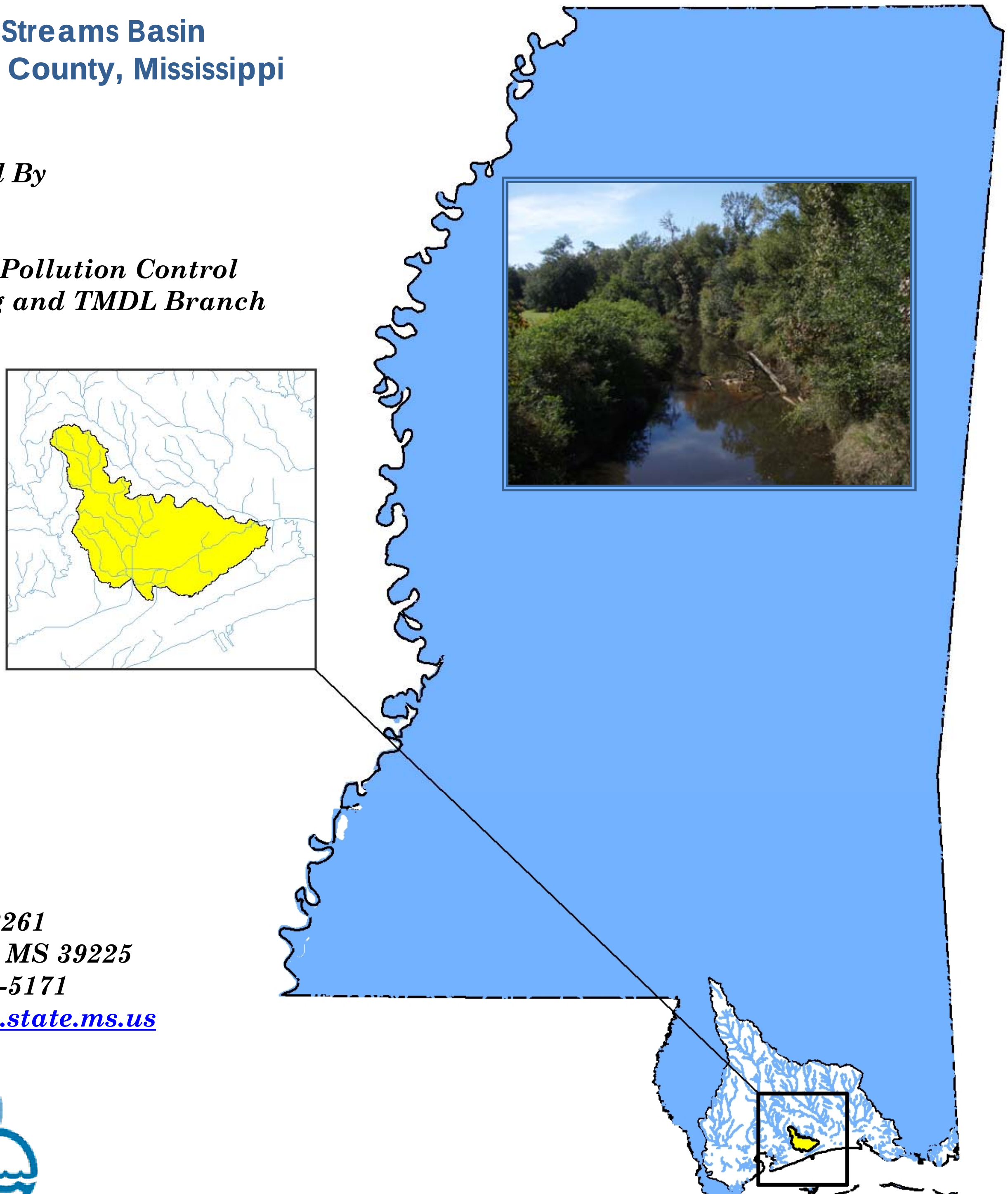
REVISED REPORT
JUNE 2016
FINAL

Fecal Coliform TMDL for Turkey Creek



Coastal Streams Basin
Harrison County, Mississippi

Prepared By

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FOREWORD

The report contains two Total Maximum Daily Load (TMDL) for a water body segment found on Mississippi's 1998 Section 303(d) List of Impaired Water Bodies. The implementation of the TMDL contained herein will be prioritized within Mississippi's rotating basin approach.

As additional information becomes available, the TMDL may be updated. Such additional information may include water quality and quantity data, changes in pollutant loadings, modifications to the water quality standards or criteria, or changes in landuse within the watershed. In some cases, additional water quality data may indicate that no impairment exists.

Prefixes for fractions and multiples of SI units

Fraction	Prefix	Symbol	Multiple	Prefix	Symbol
10^{-1}	deci	d	10	deka	da
10^{-2}	centi	c	10^{2}	hecto	h
10^{-3}	milli	m	10^{3}	kilo	k
10^{-6}	micro	µ	10^{6}	mega	M
10^{-9}	nano	n	10^{9}	giga	G
10^{-12}	pico	p	10^{12}	tera	T
10^{-15}	femto	f	10^{15}	peta	P
10^{-18}	atto	a	10^{18}	exa	E

Conversion Factors

To convert from	To	Multiply by	To Convert from	To	Multiply by
Acres	Sq. miles	0.00156	Days	Seconds	86400
Cubic feet	Cu. Meter	0.02832	Feet	Meters	0.3048
Cubic feet	Gallons	7.4805	Gallons	Cu feet	0.13368
Cubic feet	Liters	28.316	Hectares	Acres	2.4711
cfs	Gal/min	448.83	Miles	Meters	1609.34
cfs	MGD	0.64632	Mg/l	ppm	1
Cubic meters	Gallons	264.173	µg/l * cfs	Gm/day	2.45

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FIGURES

TABLES

TMDL INFORMATION PAGE

Listing Information

Name	ID	County	Cause
Turkey Creek	202211	Harrison	Fecal Coliform
Location– Near Gulfport: From confluence with Canal #2 to split with North Gulfport 8th Grade			
Turkey Creek	202214	Harrison	Fecal Coliform
Location– Near Gulfport: From split with North Gulfport 8th Grade to mouth at Bernard Bayou			

Water Quality Standard

Parameter	Beneficial use	Water Quality Criteria
Fecal Coliform	Secondary Contact Recreation	**May - October**: Fecal coliform colony counts are not to exceed a geometric mean of 200 per 100ml based on a minimum of 5 samples taken over a 30-day period with a minimum of 12 hours between individual samples, nor shall the samples examined during a 30-day period exceed 400 per 100ml more than 10% of the time. **November – April**: Fecal coliform colony counts shall not exceed a geometric mean of 2000 per 100 ml based on a minimum of 5 samples taken over a 30-day period with no less than 12 hours between individual samples, nor shall the samples examined during a 30-day period exceed 4000 per 100 ml more than 10% of the time.
Fecal Coliform	Contact Recreation	Annually- The fecal coliform colony counts shall not exceed a geometric mean of 200 per 100 ml, based on a minimum of 5 samples taken over a 30-day period with no less than 12 hours between individual samples, nor shall the samples examined during a 30-day period exceed 400 per 100 ml more than 10% of the time**.**

Total Maximum Daily Load for Segment 202211

WLA (counts per day)	LA (counts per day)	MOS (counts per day)	Total TMDL (counts per day)	TMDL Percent Reduction
1.48E+10	5.17E +12	5.76E+11	5.76E+12	80.3%

Total Maximum Daily Load for Segment 202214

WLA (counts per day)	LA (counts per day)	MOS (counts per day)	Total TMDL (counts per day)	TMDL Percent Reduction
1.48E+10	5.93E +12	6.60E+11	6.60E+12	77.4%

EXECUTIVE SUMMARY

A revised pathogen TMDL has been developed for Turkey Creek located in Harrison County. The original segment, MS118BBM1, was included in a TMDL report completed in 2003. Since then, recent monitoring data were collected and assessed for this segment based on water quality standards. MDEQ selected fecal coliform as an indicator organism for pathogenic bacteria. The revised TMDL report includes segment 202211, which is equivalent to MS118BBM1. This report also includes segment 202214 located below the original segment, which is shown in Figure 2.

Turkey Creek flows in a southeastern direction. The location for segment 202211 is from the confluence with Canal #2 to te split with orth Gulfport 8th Grade. The location for segment 202214 is from the split with North Gulfport 8th Grade to the mouth at Bernard Bayou. Due to data limitations, complex dynamic modeling was inappropriate for performing the TMDL allocations for this study. Therefore, a mass balance approach was used to develop the TMDL for the Turkey Creek segments. The watershed is shown in Figure 1 below.

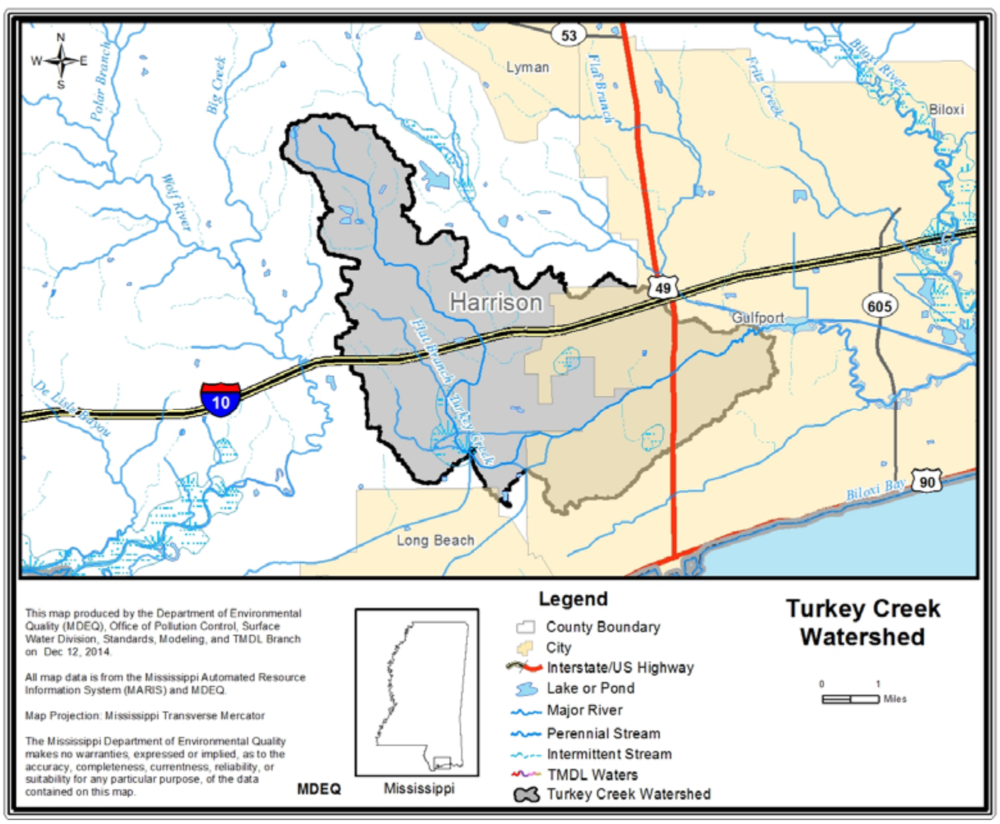


Figure 1. Location of the Turkey Creek Watershed

Although, fecal coliform loadings from point and nonpoint sources in the watershed were not explicitly represented with a model, a source assessment was conducted for the Turkey Creek Watershed. Nonpoint sources of fecal coliform may include wildlife, livestock, and urban/developed areas. Also, considered were the nonpoint sources such as failing septic systems and other direct inputs into Turkey Creek. There are 3 NPDES permitted dischargers included as sources in the wasteload allocation (WLA).

The seasonal variations in hydrology, climatic conditions, and watershed activities are represented through the use of a seasonal TMDL based on seasonal average flows and seasonal monitoring. An explicit 10% margin of safety (MOS) was used in the mass balance method to account for uncertainty.

Water quality data indicated violations of the fecal coliform standard in the water body segments during the summer and winter seasons, however the greatest reduction required for both segments occurred during the summer. Therefore, the summer will be used as the critical period for the TMDL calculations. The estimated reduction of fecal coliform bacteria for segment 202211 is 80.3%. The estimated reduction of fecal coliform bacteria for segment 202214 is 77.4%.

INTRODUCTION

1.1 Background

The identification of water bodies not meeting their designated use and the development of total maximum daily loads (TMDLs) for those water bodies is 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 water bodies through the establishment of pollutant specific allowable loads. The pollutant of concern for this TMDL is pathogens as indicated by fecal coliform. Fecal coliform bacteria are used as indicator organisms because they are readily identifiable and indicate the possible presence of other pathogenic organisms in the water body. The TMDL process can be used to establish water quality based controls to reduce pollution from nonpoint sources, maintain permit requirements for point sources, and restore and maintain the quality of water resources. A TMDL report was completed in 2003 for Turkey Creek. MDEQ collected more data within the last several years and believes a revision in the report is necessary based upon the data.

Turkey Creek is approximately 15 miles long from the headwaters to the mouth at Bernard Bayou. The location of the segments are shown in Figure 2.

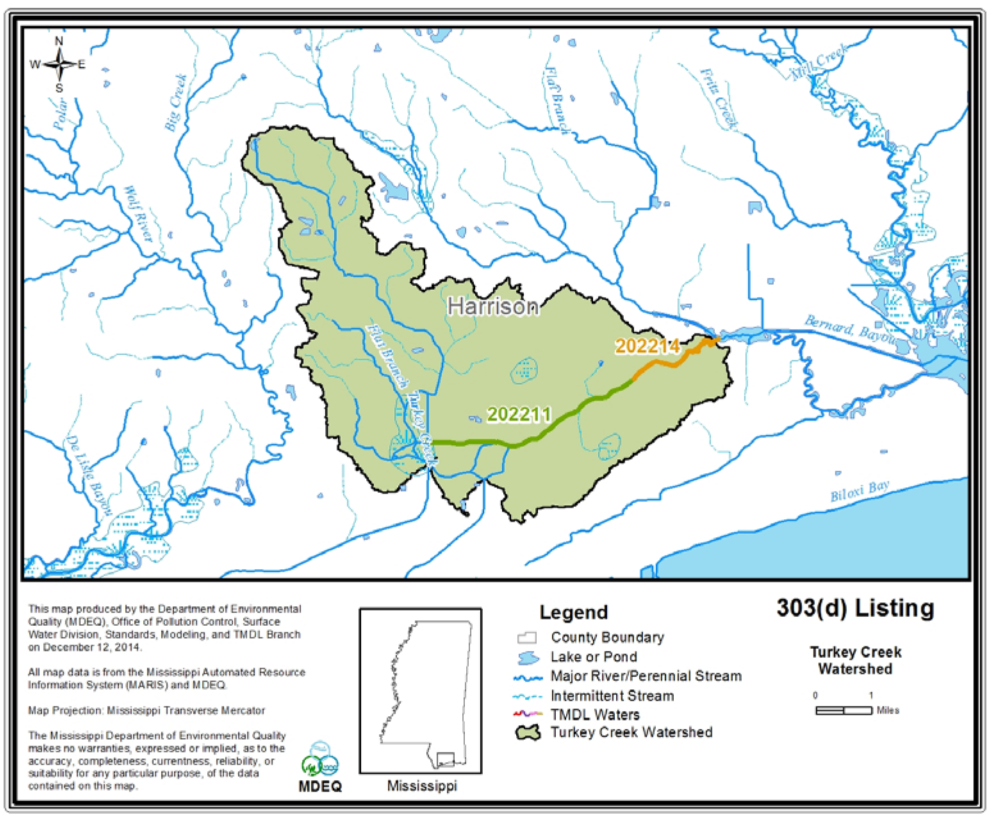


Figure 2. Turkey Creek 303(d) Segment

1.2 Applicable Water Body Segment Use

The water use classifications are established by the State of Mississippi in The Administrative Procedures Act Rules Title 11, Part 6, Chapter 2: Mississippi Commission on Environmental Quality Regulations for Water Quality Criteria For Intrastate, Interstate, And Coastal Waters Rules 2.2 and 2.4 (MDEQ, 2014). Source: Miss. Code Ann. §§ 49-2-1, et seq. and 49-17-1, et seq. The water use classification for segment 202211 is Fish and Wildlife which includes Secondary Contact Recreation. The water use classification for segment 202214 is Recreation.

1.3 Applicable Water Body Segment Standard

The water quality standard applicable to the use of the water body and the pollutant of concern is defined in The Administrative Procedures Act Rules Title 11, Part 6, Chapter 2: Mississippi Commission on Environmental Quality Regulations for Water Quality Criteria For Intrastate, Interstate, And Coastal Waters Rule 2.3 (MDEQ, 2014). Ibid.

The standard for fecal coliform is different for summer and winter for a secondary contact use, where summer is defined as the months of May through October, and winter is defined as the months of November through April. For the summer months, the fecal coliform colony counts shall not exceed a geometric mean of 200 per 100 ml, based on a minimum of 5 samples taken over a 30-day period with no less than 12 hours between individual samples, nor shall the samples examined during a 30-day period exceed 400 per 100 ml more than 10% of the time. For the winter months, the maximum allowable level of fecal coliform shall not exceed a geometric mean of 2000 colonies per 100 ml, based on a minimum of 5 samples taken over a 30-day period with no less than 12 hours between individual samples, nor shall the samples examined during a 30-day period exceed 4000 per 100 ml more than 10% of the time. This water quality standard was used to assess the data to determine impairment in the water body.

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 wasteload reductions specified in the TMDL. The endpoints allow for a comparison between observed instream conditions and conditions that are expected to restore designated uses. MDEQ's fecal coliform standard allows for a statistical review of any fecal coliform data set. There are two tests, the geometric mean test and the 10% test, that the data set must pass to indicate acceptable water quality.

The geometric mean test states that for secondary contact recreation, the summer fecal coliform colony count shall not exceed a geometric mean of 200 per 100 ml based on a minimum of 5 samples taken over a 30-day period with no less than 12 hours between individual samples and for the winter the fecal coliform colony count shall not exceed a geometric mean of 2000 per 100 ml based on a minimum of 5 samples taken over a 30-day period with no less than 12 hours between individual samples. The 10% test states that for the summer the samples examined during a 30-day period shall not exceed a count of 400 per 100 ml more than 10% of the time and for the winter the samples examined during a 30-day period shall not exceed a count of 4000 per 100 ml more than 10% of the time.

The geometric mean test states that for primary contact recreation, the annual fecal coliform colony count shall not exceed a geometric mean of 200 per 100 ml based on a minimum of 5 samples taken over a 30-day period with no less than 12 hours between individual samples. The 10% test states that for the annual fecal coliform colony, the samples examined during a 30-day period shall not exceed a count of 400 per 100 ml more than 10% of the time.

2.1.1 Discussion of the Geometric Mean Test

The level of fecal coliform found in a natural water body varies greatly depending on several independent factors such as temperature, flow, or distance from the source. This variability is accentuated by the standard laboratory analysis method used to measure fecal coliform levels in the water. The membrane filtration (MF) method uses a direct count of bacteria colonies on a nutrient medium to estimate the fecal level. The fecal coliform colony count per 100 ml is determined using an equation that incorporates the dilution and volume to the sample filtered.

The geometric mean test is used to dampen the impact of the large numbers when there are smaller numbers in the data set. The geometric mean is calculated by multiplying all of the data values together and taking the root of that number based on the number of samples in the data set.

$$G = \sqrt[n]{s1*s2*s3*s4*s5*sn}$$

The water quality standard requires a minimum of 5 samples be used to determine the geometric mean. MDEQ routinely gathers 6 samples within a 30-day period in case there is a problem with one of the samples. It is conceivable that there would be more samples available in an intensive survey, but typically each data set will contain 6 samples therefore, n would equal 6. For the data set to indicate no impairment, the result must be less than or equal to 200 counts per 100 ml annually for primary contact recreation and less than or equal to 200 counts per 100 ml in the summer and 2000 counts per 100 ml in winter for secondary contact recreation.

2.1.2 Discussion of the 10% Test

The 10% test looks at the data set as representing the 30 days for 100% of the time. The data points are sorted from the lowest to the highest and each value then represents a point on the curve from 0% to 100% or from day 1 to day 30. The lowest value becomes the 1st data point and the highest data point becomes the nth data point. The water quality standard requires that 90% of the time, the counts of fecal coliform in the stream be less than or equal to 400 counts per 100 ml annually for primary contact recreation and 400 counts per 100 ml in summer and 4000 counts per 100 ml in winter for secondary contact recreation.

By calculating a concentration of fecal coliform for every percentile point based on the data set, it is possible to determine a curve that represents the percentile ranking of the data set. Once the 90th percentile of the data set has been determined, it may be compared to the standard of 400 counts per 100 ml. If the 90th percentile of the data is greater than 400, then the data violates the criteria and the stream will be considered impaired. This can be used not only to assess actual water quality data, but also computer generated daily average model results. Actual water quality data will typically have 5 or 6 values in the data set, and computer generated model results would have 30 daily values.

2.1.3 Discussion of Combining the Tests

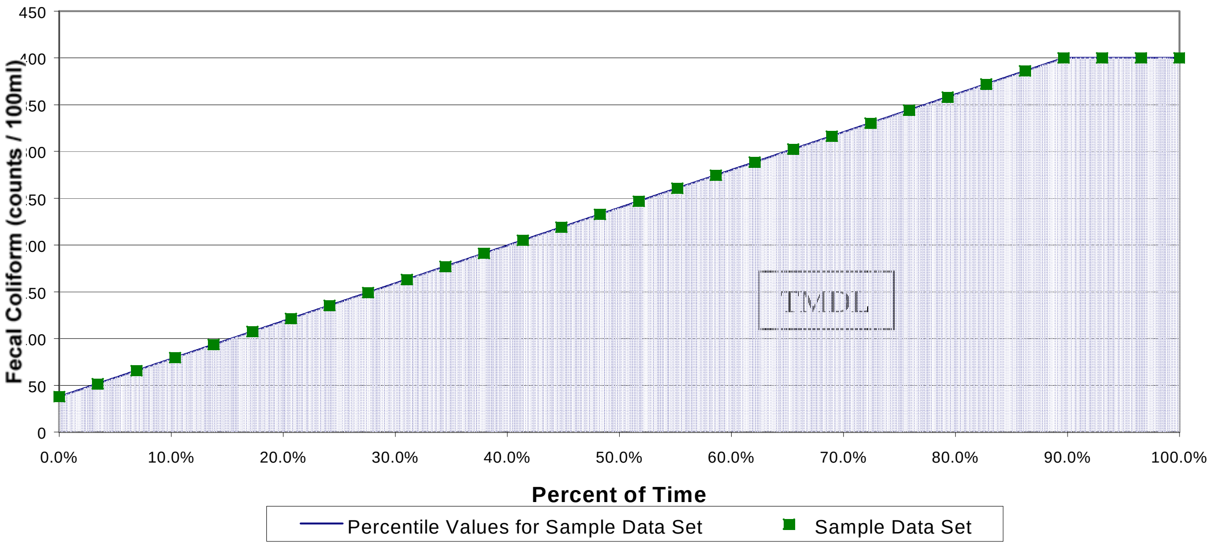
MDEQ determined a theoretical capacity data set that meets both portions of the water quality standard and is indicative of possible water quality conditions. This theoretical capacity data set is shown in Table 1. The theoretical capacity data set was constructed to represent the maximum amount of fecal coliform per day that will still meet both portions of the water quality standard. The theoretical capacity data set was then plotted, generating a theoretical capacity curve. This curve can be seen in Figure 4. The integral of the theoretical capacity curve is used for mass balance TMDL calculations. By multiplying the integral of the theoretical capacity curve by the flow in a given water body, the mass balance TMDL can be calculated.

When actual data violate both portions of the standard, and the data are plotted in a similar way, the resulting curve can be compared to the theoretical capacity curve to determine the percent reduction of fecal coliform necessary for the water body to meet both portions of the water quality standard, the geometric mean test and the 10% test.

Table 1. Theoretical Capacity Data Set

Fecal Coliform (counts/100ml)	Percentile Madisong
37.82	0.0%
52.75	3.4%
65.68	6.9%
79.61	10.3%
93.54	13.8%
107.47	17.2%
121.4	20.7%
135.33	24.1%
149.26	27.6%
163.19	31.0%
177.12	34.5%
191.05	37.9%
204.98	41.4%
218.91	44.8%
232.84	48.3%
246.77	52.7%
260.7	55.2%
274.63	58.6%
288.56	62.1%
302.49	65.5%
316.42	69.0%
330.35	72.4%
344.28	75.9%
358.21	79.3%
372.14	82.8%
386.07	86.2%
400	89.7%
400	93.1%
400	96.6%
400	100.0%

Figure 3. Theoretical Capacity Curve



2.1.4 Discussion of the Targeted Endpoint

While the endpoint of a TMDL calculation is similar to a standard for a pollutant, the endpoint is not the standard. For a mass balance TMDL, the endpoint selected is both portions of the standard, that is the geometric mean test and the 10% test. Meeting the geometric mean test and applying the 10% test to the data sets applies both parts of the standard to an actual data set or to a considered computer generated data set. It is therefore appropriate to select both portions of the standard as the targeted endpoint for the mass balance TMDL.

2.1.5 Discussion of the Critical Condition for Fecal Coliform

Critical conditions for waters impaired by nonpoint sources generally occur during periods of wet weather and high surface runoff. However, critical conditions for point source dominated systems generally occur during periods of low flow, low dilution conditions. Therefore, an examination of the data is needed to determine the critical 30-day period to be used for the TMDL.

2.2 Discussion of Instream Water Quality

Monitoring was performed in a manner consistent with the water quality standards. At least 5 samples were collected in a 30-day period, at stations 02481240, 02481252, and CS221 during summer and winter seasons from 2008 through 2014. The monitoring stations are shown in Figure 4.

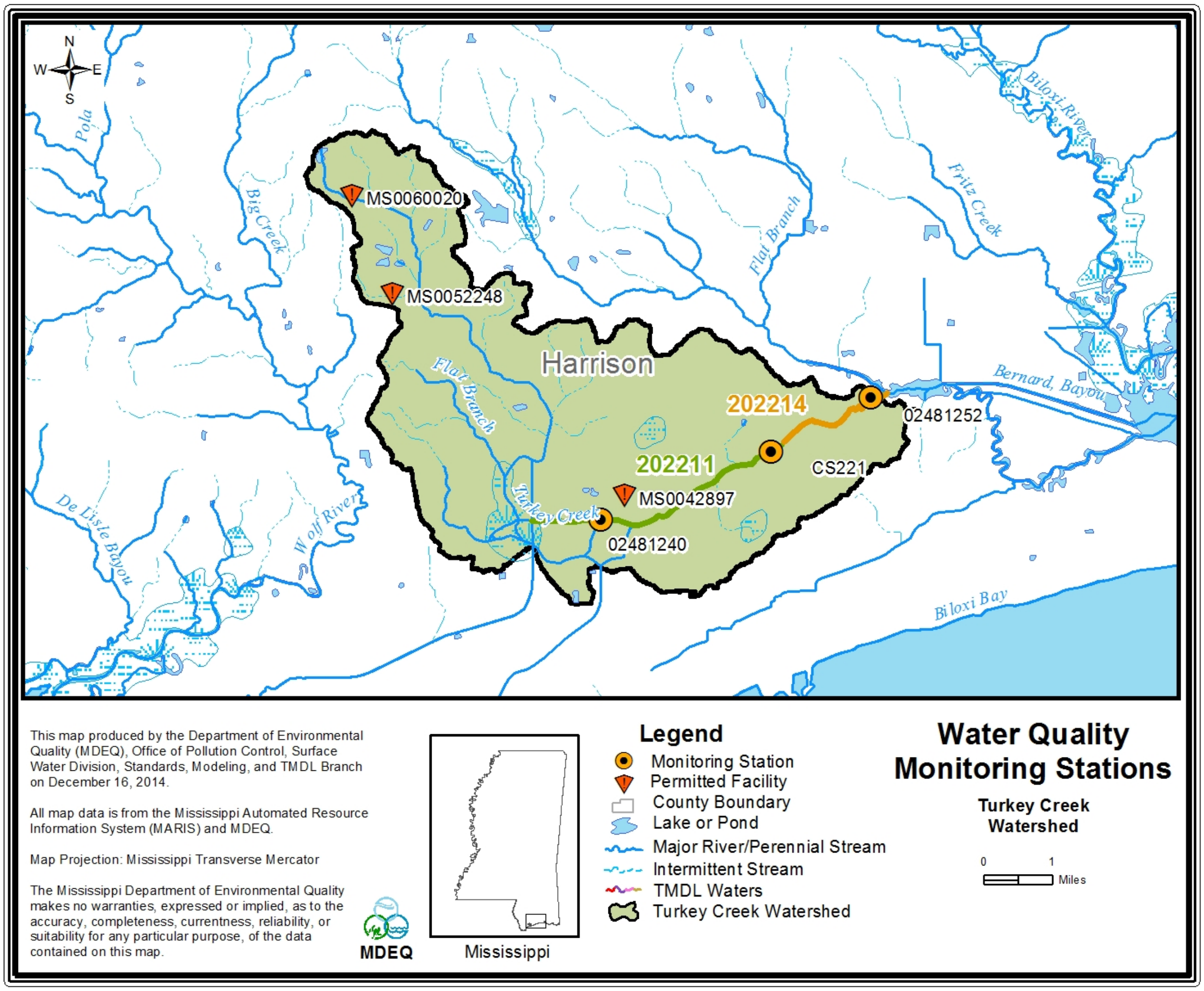


Figure 4. Turkey Creek Water Quality Stations

2.2.1 Inventory of Available Water Quality Monitoring Data

The data collected at station 02481240 (Canal Rd) are provided in Tables 2 through 14. The data collected at station CS221 (Arkansas Rd) are provided in Tables 15 through 25. The data collected at station 02481252 (Creosote Rd) are provided in Tables 26 through 38.

Table 2. Fecal Coliform Data reported in Turkey Creek, Station 02481240 Summer 2008

Date	Time	Fecal Coliform (counts/100ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
8/28/08	11:20	49	95.4	No, geometric mean is >200	473	Yes, 90th percentile is >400
9/9/08	11:10	51				
9/16/08	10:55	867				
9/18/08	10:55	63				
9/23/08	10:50	70				
9/25/08	10:05	79				

Table 3. Fecal Coliform Data reported in Turkey Creek, Station 02481240 Winter 2009

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
2/24/09	10:10	73	213	No, geometric mean is <2000	1050	No, 90th percentile is <4000
2/26/09	10:00	93				
3/3/09	13:00	49				
3/5/09	10:30	35				
3/9/09	10:05	56				
3/11/09	12:45	330				

Table 4. Fecal Coliform Data reported in Turkey Creek, Station 02481240 Summer 2009

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
7/16/09	11:30	183	186.6	No, geometric mean is >200	325	No, 90th percentile is >400
7/21/09	10:15	270				
7/23/09	11:05	280				
7/28/09	9:00	370				
7/30/09	9:35	107				
8/3/09	10:00	77				

Table 5. Fecal Coliform Data reported in Turkey Creek, Station 02481240 Winter 2010

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
2/3/10	9:30	12	26.2	No, geometric mean is <2000	196.5	No, 90th percentile is <4000
2/10/10	9:55	310				
2/17/10	9:55	33				
2/19/10	9:45	83				
2/22/10	10:05	16				
2/24/10	9:40	2				

Table 6. Fecal Coliform Data reported in Turkey Creek, Station 02481240 Summer 2010

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
9/16/10	11:25	73	129.1	No, geometric mean is <200	1055	Yes, 90th percentile is >400
9/20/10	9:30	40				
9/22/10	9:15	103				
9/24/10	11:50	110				
9/28/10	9:30	2000				
9/30/10	11:00	70				

Table 7. Fecal Coliform Data reported in Turkey Creek, Station 02481240
Winter 2011

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
2/1/11	10:25	1500	166.5	No, geometric mean is <2000	1000	No, 90th percentile is <4000
2/3/11	9:25	500				
2/8/11	10:00	56				
2/15/11	10:45	33				
2/17/11	11:05	70				
2/23/11	10:40	220				

Table 8. Fecal Coliform Data reported in Turkey Creek, Station 02481240
Summer 2011

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
7/20/11	10:30	157	146.4	No, geometric mean is <200	378	No, 90th percentile is <400
7/27/11	11:30	110				
8/8/11	11:10	600				
8/10/11	11:35	120				
8/15/11	9:27	103				
8/17/11	10:50	77				

Table 9. Fecal Coliform Data reported in Turkey Creek, Station 02481240
Winter 2012

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
2/3/12	10:40	390	85.5	No, geometric mean is <2000	290	No, 90th percentile is <4000
2/7/12	10:35	40				
2/9/12	10:20	40				
2/21/12	9:55	190				
2/23/12	9:55	65				
3/1/12	11:00	51				

Table 10. Fecal Coliform Data reported in Turkey Creek, Station 02481240
Summer 2012

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
7/24/12	9:15	67	200.4	Yes, geometric mean is >200	1053	Yes, 90th percentile is >400
7/31/12	10:25	113				
8/2/12	9:45	1633				
8/14/12	10:15	143				
8/22/12	6:50	183				
8/24/12	8:05	2000				

Table 11. Fecal Coliform Data reported in Turkey Creek, Station 02481240
Winter 2013

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
01/24/2013	10:55	16	58	No, geometric mean is <2000	157	No, 90th percentile is <4000
01/29/2013	09:50	23				
02/06/2013	08:25	173				
02/15/2013	08:15	80				
02/20/2013	07:40	133				

Table 12. Fecal Coliform Data reported in Turkey Creek, Station 02481240
Summer 2013

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
07/29/2013	10:40	183	256	Yes, geometric mean is >200	1070	Yes, 90th percentile is >400
08/01/2013	10:30	93				
08/07/2013	10:45	177				
08/12/2013	09:50	1700				
08/15/2013	10:55	440				
08/22/2013	12:35	127				

Table 13. Fecal Coliform Data reported in Turkey Creek, Station 02481240
Winter 2014

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
02/04/2014	09:25	140	122.2	No, geometric mean is <2000	996	No, 90th percentile is <4000
02/06/2014	10:20	1567				
02/10/2014	12:00	63				
02/18/2014	12:45	47				
02/20/2014	11:50	42				

Table 14. Fecal Coliform Data reported in Turkey Creek, Station 02481240
Summer 2014

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
09/22/2014	09:56	30	79	No, geometric mean is <200	188	No, 90th percentile is <400
09/24/2014	10:20	30				
09/30/2014	10:15	83				
10/02/2014	10:50	97				
10/06/2014	11:00	187				

Table 15. Fecal Coliform Data reported in Turkey Creek, Station CS221 Winter 2008

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
1/15/08	13:45	127	238.2	Yes, geometric mean is >200	833.5	Yes, 90th percentile is >400
1/22/08	13:30	137				
1/29/08	13:25	130				
2/5/08	9:40	300				
2/7/08	14:05	197				
2/14/08	14:45	1367				

Table 16. Fecal Coliform Data reported in Turkey Creek, Station CS221 Summer 2008

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
8/28/08	12:15	70	132.9	No, geometric mean is >200	265	No, 90th percentile is >400
9/9/08	12:20	290				
9/16/08	12:00	200				
9/18/08	12:05	107				
9/23/08	12:00	240				
9/25/08	11:00	53				

Table 17. Fecal Coliform Data reported in Turkey Creek, Station CS221 Summer 2010

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
9/16/10	12:00	2000	4018	Yes, geometric mean is >200	19000	Yes, 90th percentile is >400
9/20/10	10:00	2000				
9/22/10	9:40	11000				
9/24/10	12:10	17000				
9/28/10	9:50	21,000				
9/30/10	11:15	268				

Table 18. Fecal Coliform Data reported in Turkey Creek, Station CS221 Winter 2011

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
02/01/2011	10:05	2000	402.89	Yes, geometric mean is >200	1516.5	Yes, 90th percentile is >200
02/03/2011	09:50	1033				
02/08/2011	09:35	130				
02/15/2011	10:20	117				
02/17/2011	10:40	157				
02/23/2011	10:20	867				

Table 19. Fecal Coliform Data reported in Turkey Creek, Station CS221 Summer 2011

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
07/20/2011	10:55	117	132.3	No, geometric mean is >200	425	Yes, 90th percentile is >400
07/27/2011	11:05	130				
08/08/2011	10:55	700				
08/10/2011	11:15	150				
08/15/2011	09:45	80				
08/17/2011	11:15	42				

Table 20. Fecal Coliform Data reported in Turkey Creek, Station CS221 Winter 2012

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
02/03/2012	10:15	1033	207.3	Yes, geometric mean is >200	706.5	Yes, 90th percentile is >400
02/07/2012	10:15	80				
02/09/2012	09:55	150				
02/21/2012	10:20	380				
02/23/2012	09:35	137				
03/01/2012	10:40	123				

Table 21. Fecal Coliform Data reported in Turkey Creek, Station CS221 Summer 2012

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
7/24/12	9:15	967	475	Yes, geometric mean is >200	1050	Yes, 90th percentile is >400
7/31/12	10:25	107				
8/2/12	9:45	600				
8/14/12	10:15	1133				
8/22/12	6:50	567				
8/24/12	8:05	290				

Table 22. Fecal Coliform Data reported in Turkey Creek, Station CS221 Winter 2013

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
2/15/2013	8:35	450	495.5	Yes, geometric mean is >200	2000	Yes, 90th percentile is >400
02/20/2013	08:00	2000				
03/07/2013	10:55	93				
03/05/2013	09:50	65				
03/14/2013	10:45	1367				
03/12/2013	10:25	2000				

Table 23. Fecal Coliform Data reported in Turkey Creek, Station CS221 Summer 2013

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
07/29/2013	11:15	467	670.9	Yes, geometric mean is >200	1450	Yes, 90th percentile is >400
08/01/2013	10:55	490				
08/07/2013	11:00	900				
08/12/2013	10:10	633				
08/15/2013	11:15	2000				
08/22/2013	12:50	350				

Table 24. Fecal Coliform Data reported in Turkey Creek, Station CS221 Winter 2014

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
02/04/2014	09:05	350	297	Yes, geometric mean is >200	550	Yes, 90th percentile is >400
02/06/2014	10:05	550				
02/10/2014	12:20	73				
02/18/2014	13:05	300				
02/20/2014	11:35	550				
02/04/2014	09:05	350				

Table 25. Fecal Coliform Data reported in Turkey Creek, Station CS221 Summer 2014

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
09/22/2014	11:50	37	82.9	No, geometric mean is <200	138	No, 90th percentile is <400
09/24/2014	10:30	107				
09/30/2014	10:30	133				
10/02/2014	11:05	56				
10/06/2014	11:20	143				
10/08/2014	11:10	77				

Table 26. Fecal Coliform Data reported in Turkey Creek, Station 02481252 Summer 2008

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
8/28/2008	11:45	130	105.2	No, geometric mean is >200	198.5	No, 90th percentile is >400
9/9/2008	11:40	130				
9/16/2008	11:25	197				
9/18/2008	11:35	40				
9/23/2008	11:30	200				
9/25/2008	10:35	51				

Table 27. Fecal Coliform Data reported in Turkey Creek, Station 02481252 Winter 2009

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
2/24/2009	10:45	160	114.7	No, geometric mean is >200	265	No, 90th percentile is >400
2/26/2009	10:35	230				
3/3/2009	12:00	70				
3/5/2009	10:55	300				
3/9/2009	10:30	67				
3/11/2009	11:45	44				

Table 28. Fecal Coliform Data reported in Turkey Creek, Station 02481252 Summer 2009

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
7/16/2009	12:20	80	57.3	No, geometric mean is >200	135	No, 90th percentile is >400
7/21/2009	11:10	42				
7/23/2009	11:55	44				
7/28/2009	9:30	14				
7/30/2009	10:15	103				
8/3/2009	10:50	167				

Table 29. Fecal Coliform Data reported in Turkey Creek, Station 02481252 Winter 2010

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
2/3/2010	10:20	51	41.1	No, geometric mean is >200	119	No, 90th percentile is >400
2/10/2010	10:40	187				
2/17/2010	10:35	19				
2/19/2010	10:25	16				
2/22/2010	10:50	40				
2/24/2010	10:25	42				

Table 30. Fecal Coliform Data reported in Turkey Creek, Station 02481252 Summer 2010

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
9/16/2010	12:20	123	247.8	Yes, geometric mean is >200	1000	Yes, 90th percentile is >400
9/20/2010	10:15	330				
9/22/2010	9:55	70				
9/24/2010	12:20	83				
9/28/2010	10:05	867				
9/30/2010	11:30	1133				

Table 31. Fecal Coliform Data reported in Turkey Creek, Station 02481252 Winter 2011

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
2/1/2011	9:37	2000	226.3	Yes, geometric mean is >200	1333.5	Yes, 90th percentile is >400
2/3/2011	10:15	667				
2/8/2011	9:20	90				
2/15/2011	9:55	70				
2/17/2011	10:20	193				
2/23/2011	10:00	83				

Table 32. Fecal Coliform Data reported in Turkey Creek, Station 02481252 Summer 2011

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
7/20/2011	11:20	140	154.8	No, geometric mean is >200	420	Yes, 90th percentile is >400
7/27/2011	10:50	170				
8/8/2011	10:45	390				
8/10/2011	10:55	450				
8/15/2011	10:20	157				
8/17/2011	11:40	21				

Table 33. Fecal Coliform Data reported in Turkey Creek, Station 02481252 Winter 2012

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
2/3/2012	9:55	1000	145.3	No, geometric mean is >200	740	Yes, 90th percentile is >400
2/7/2012	9:45	35				
2/9/2012	12:40	37				
2/21/2012	10:35	480				
2/23/2012	9:15	103				
3/1/2012	10:15	147				

Table 34. Fecal Coliform Data reported in Turkey Creek, Station 02481252 Summer 2012

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
7/24/2012	9:55	400	356.6	Yes, geometric mean is >200	1360	Yes, 90th percentile is >400
7/31/2012	11:15	200				
8/2/2012	10:30	103				
8/14/2012	10:50	2000				
8/22/2012	7:30	350				
8/24/2012	8:40	230				

Table 35. Fecal Coliform Data reported in Turkey Creek, Station 02481252 Winter 2013

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
02/06/2013	08:55	867	175	No, geometric mean is <200	643	Yes, 90th percentile is >400
02/15/2013	08:50	420				
03/07/2013	11:05	44				
03/05/2013	10:05	67				
03/14/2013	11:00	100				
03/12/2013	10:40	270				

Table 36. Fecal Coliform Data reported in Turkey Creek, Station 02481252 Summer 2013

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
07/29/2013	11:30	160	68.7	No, geometric mean is <200	160	No, 90th percentile is <400
08/12/2013	10:20	26				
08/01/2013	11:10	70				
08/07/2013	11:10	33				
08/15/2013	11:30	160				
08/22/2013	13:00	400				

Table 37. Fecal Coliform Data reported in Turkey Creek, Station 02481252 Winter 2014

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
02/04/2014	08:55	180	145.2	No, geometric mean is <200	472.2	Yes, 90th percentile is >400
02/06/2014	09:45	667				
02/10/2014	12:30	80				
02/18/2014	13:20	56				
02/20/2014	11:15	120				

Table 38. Fecal Coliform Data reported in Turkey Creek, Station 02481252 Summer 2014

Date	Time	Fecal Coliform (counts/100 ml)	Geometric Mean	Geometric Mean Test Violation	90th Percentile	10% Test Violation
09/22/2014	12:05	63	62	No, geometric mean is <200	115	No, 90th percentile is >400
09/24/2014	10:40	30				
09/30/2014	10:40	113				
10/02/2014	11:15	93				
10/06/2014	11:30	117				
10/08/2014	11:30	26				

2.2.2 Analysis of Instream Water Quality Monitoring Data

Data collected during the summer and winter violate the standard for segment 202211 and 202214. Figures 5 through 23 display the 10% test curves for station 02481240, CS221, and 02481252 for the monitoring periods where a violation occurs. A line has been added to the graph representing 400 counts/100 ml and showing that this occurs less than 90% of the time, meaning that the counts of fecal coliform in the stream are greater than 400 more than 10% of the time. Figures 24-25 display the geometric mean versus the season at these stations. Because station 02481240, located at Canal Street, is on a segment of Turkey Creek that is secondary contact recreation, its' geometric mean data for the winter are graphed separately to show data comparison to the winter standard of 2000 colonies per 100 ml. All other data have been graphed in Figure 25 to show data comparison to the standard of 200 colonies per 100 ml. Though there are violations during both seasons, the summer was selected as the critical period for Turkey Creek. The greatest reduction was needed during the summer for both segments.

After reviewing the data, it was determined that Turkey Creek is severely impaired in its' lower segment. Significant violations were not observed at the monitoring site located at Canal Street. However, several violations occurred at the Arkansas and Cresote locations. MDEQ believes the the violations at the Arkansas site may be due to malfunctioning sewer lines within the city limits and faulty infrastructure (lift stations). MDEQ believes the violations at Cresote may be as a result of backwater tides at the confluence of Turkey Creek and Bernard Bayou.

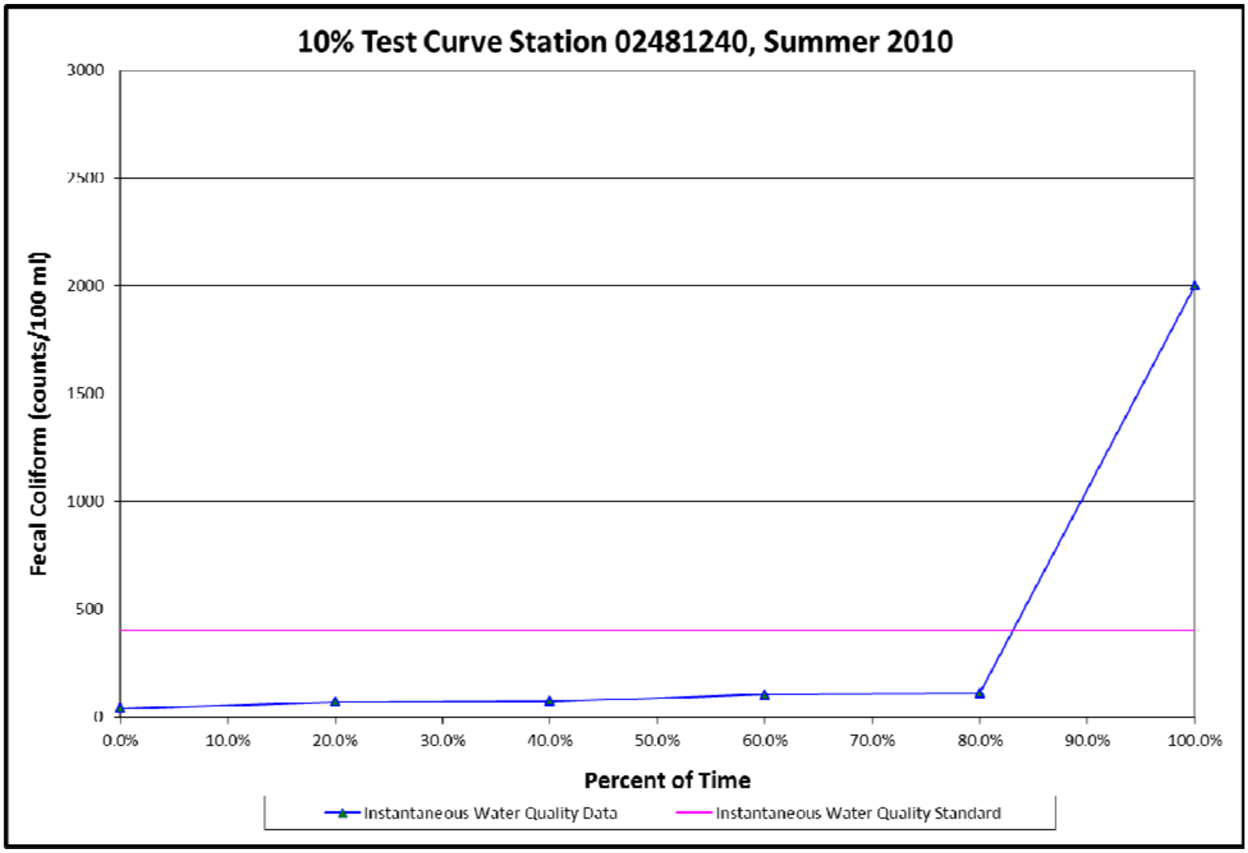


Figure 5. 10% Test Curve for Station 02481240, Summer 2010

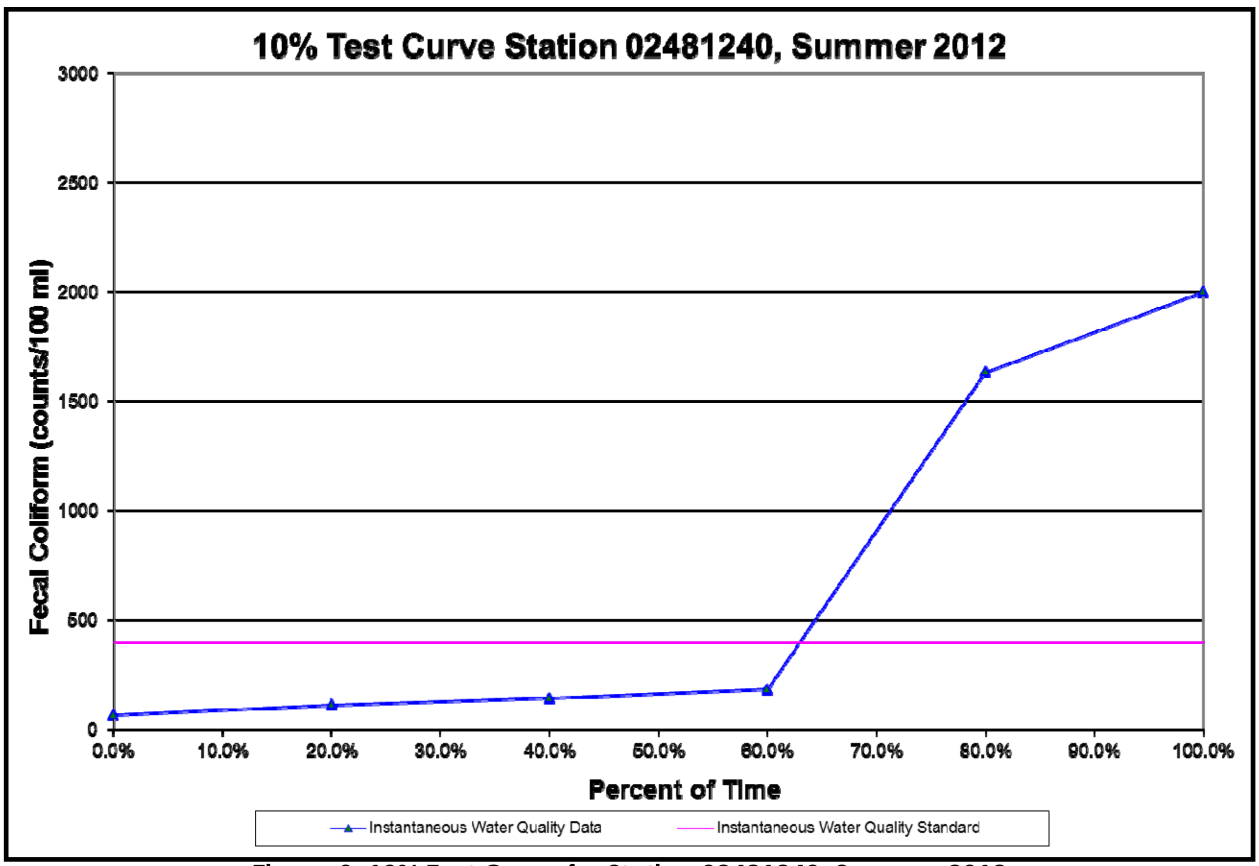


Figure 6. 10% Test Curve for Station 02481240, Summer 2012

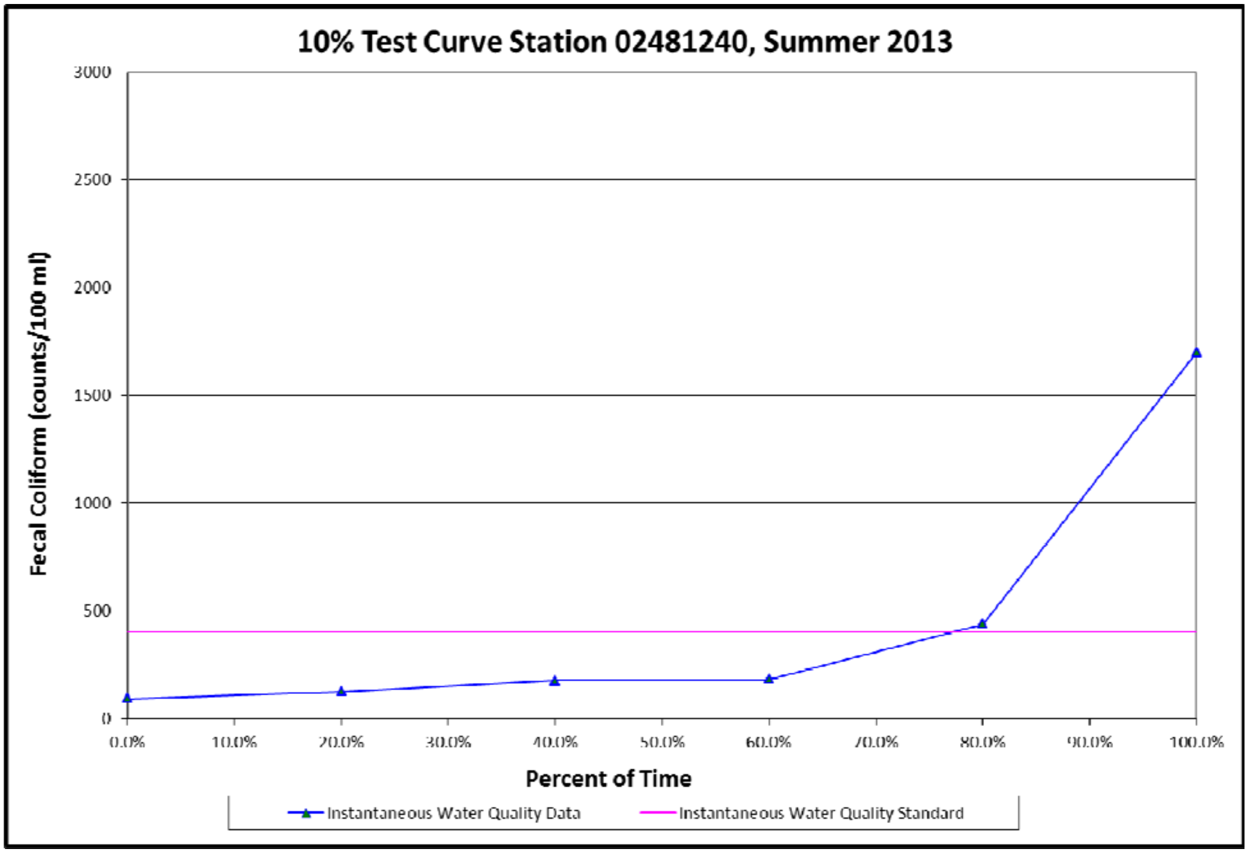


Figure 7. 10% Test Curve for Station 02481240, Summer 2013

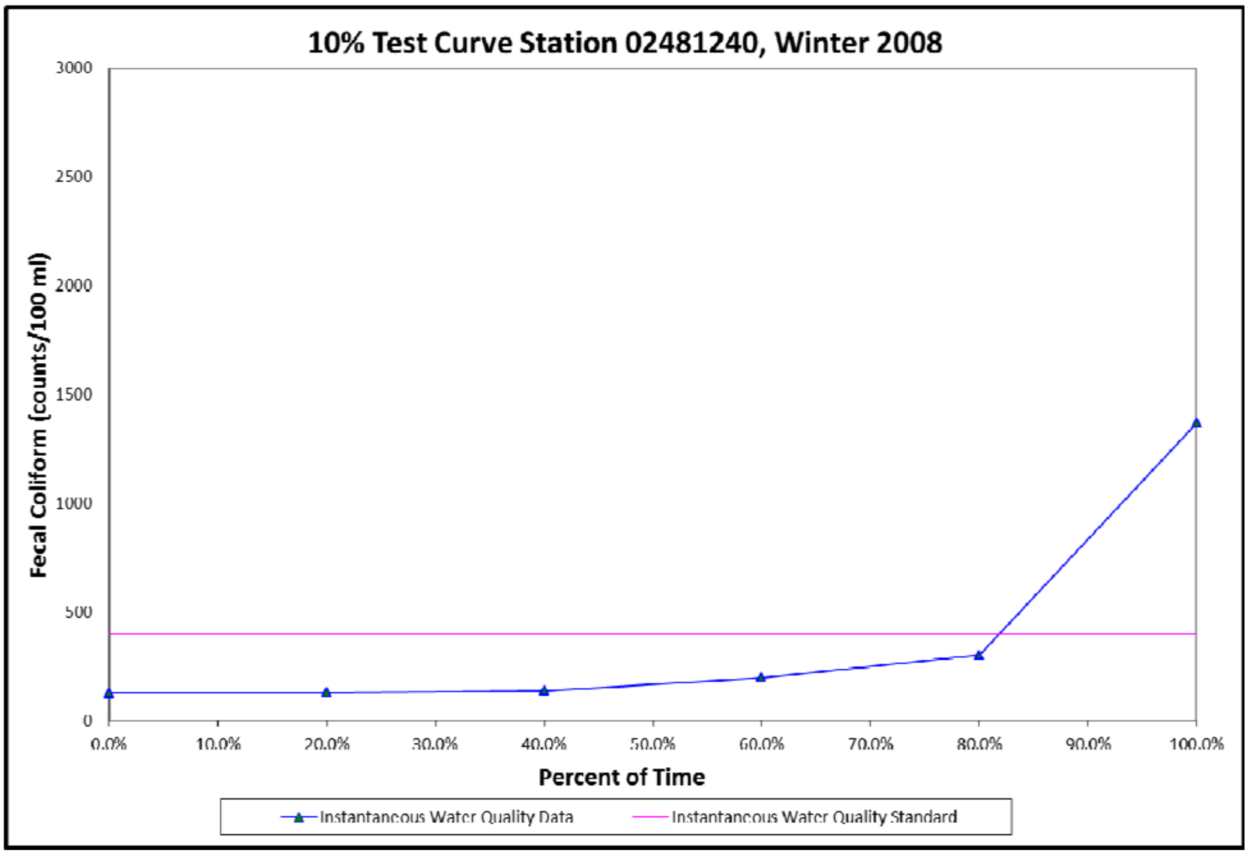


Figure 8. 10% Test Curve for Station CS221, Winter 2008

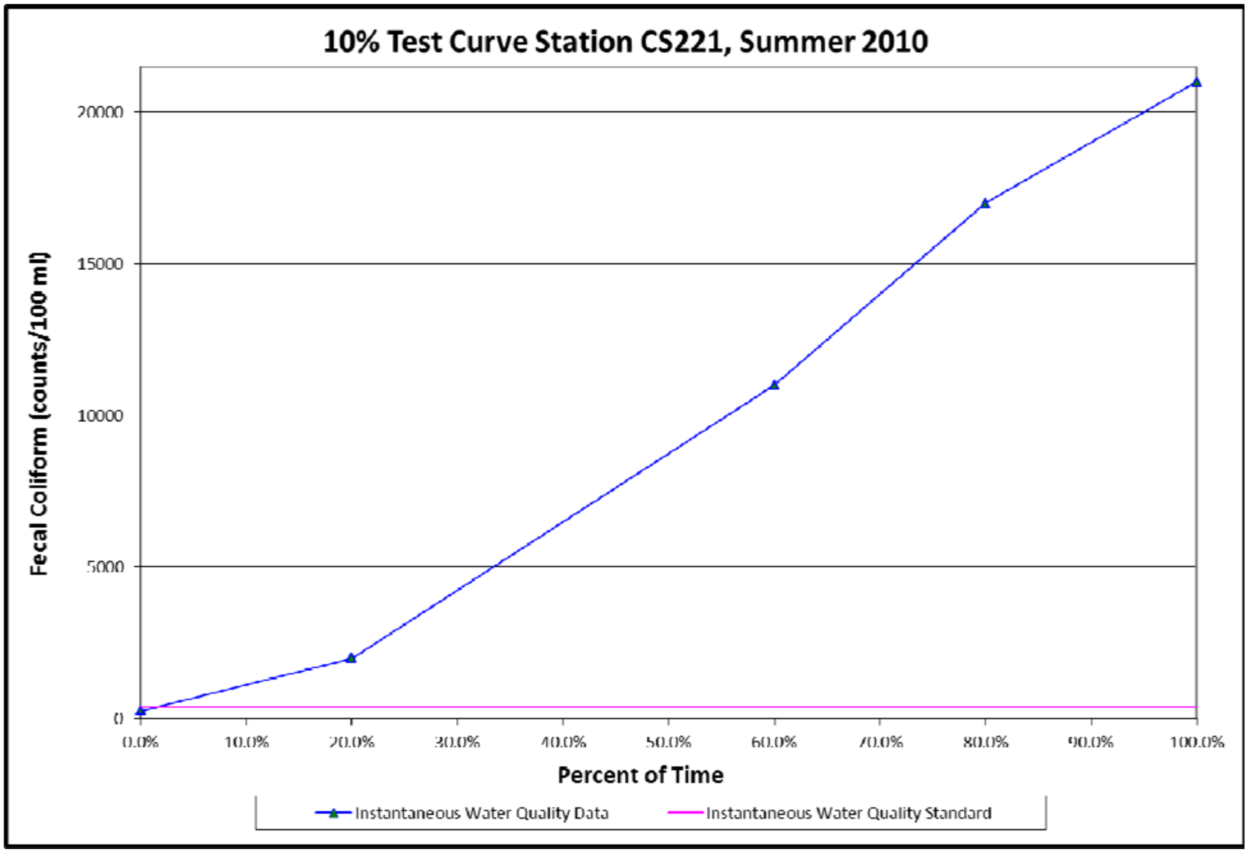


Figure 9. 10% Test Curve for Station CS221, Summer 2010

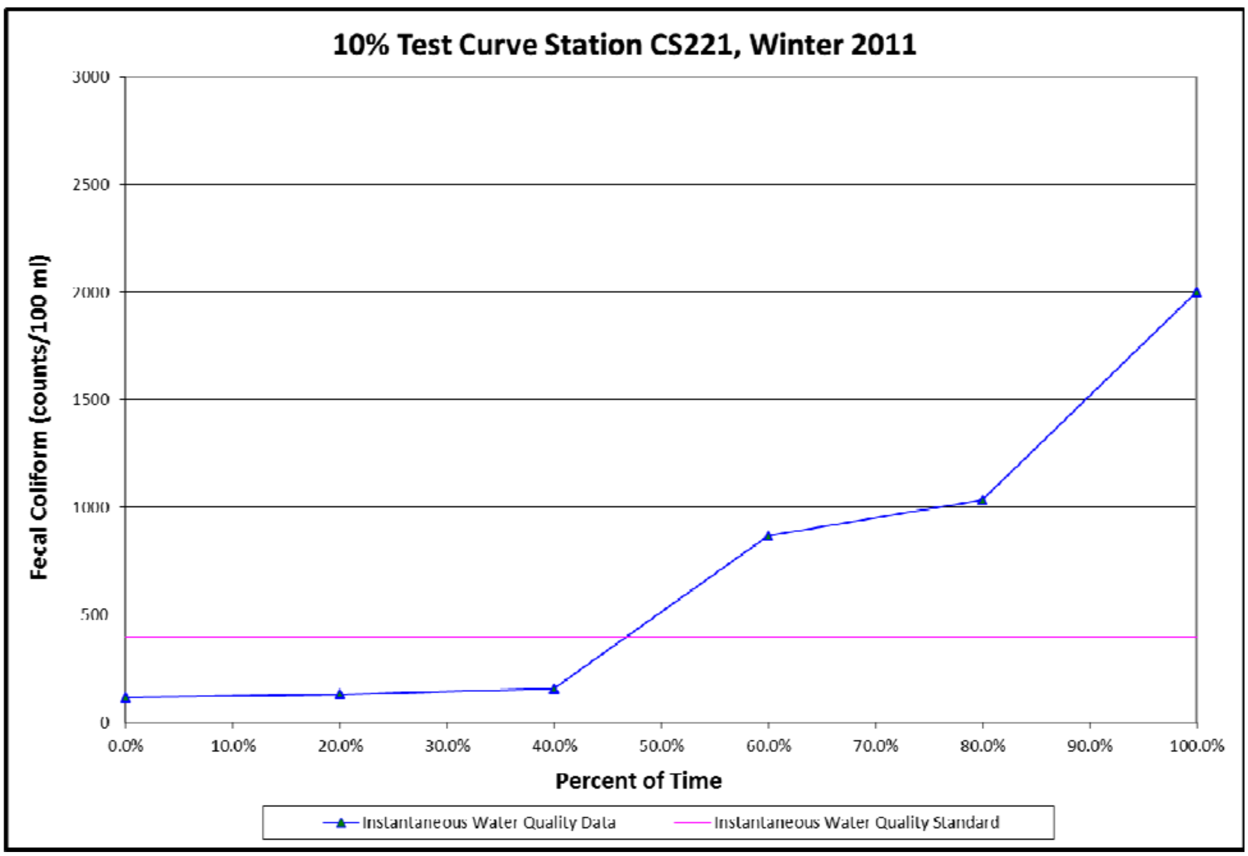


Figure 10. 10% Test Curve for Station CS221, Winter 2011

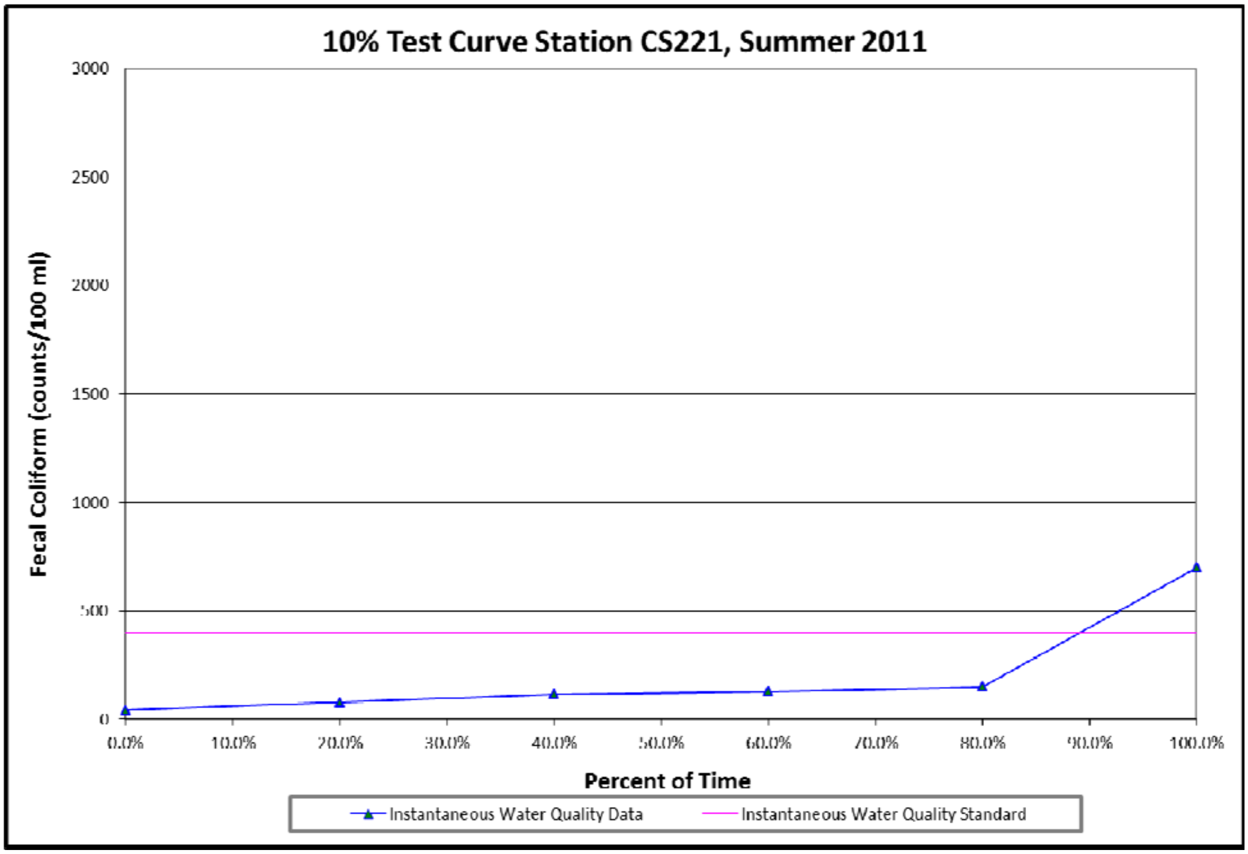


Figure 11. 10% Test Curve for Station CS221, Summer 2011

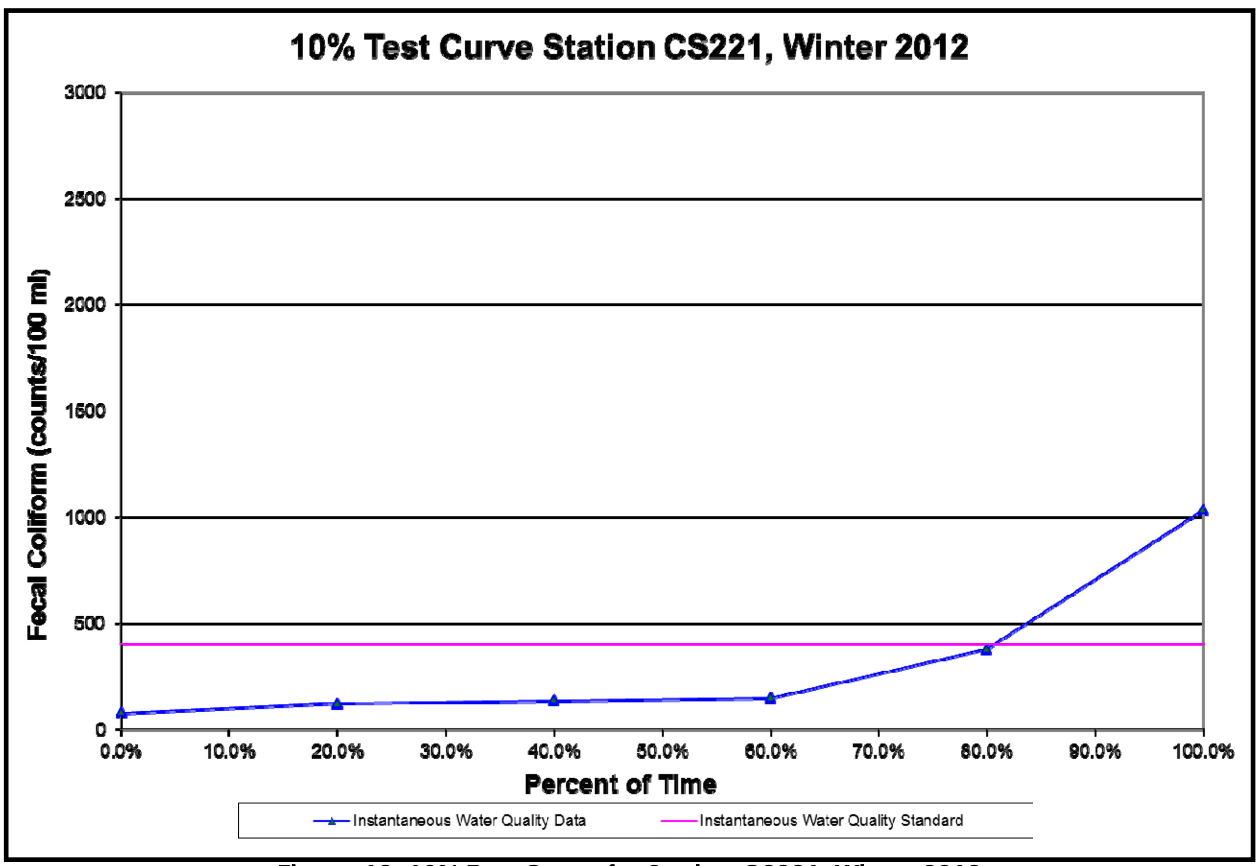


Figure 12. 10% Test Curve for Station CS221, Winter 2012

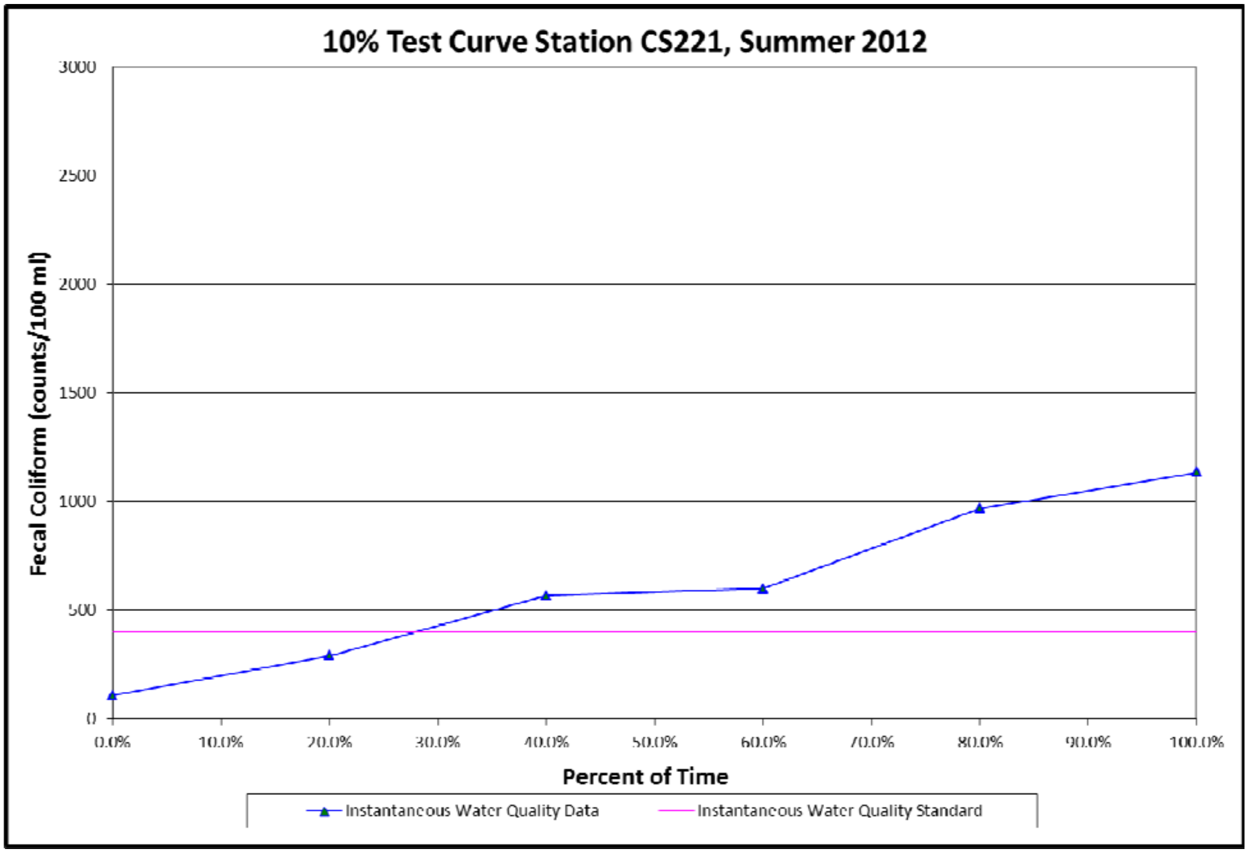


Figure 13. 10% Test Curve for Station CS221, Summer 2012

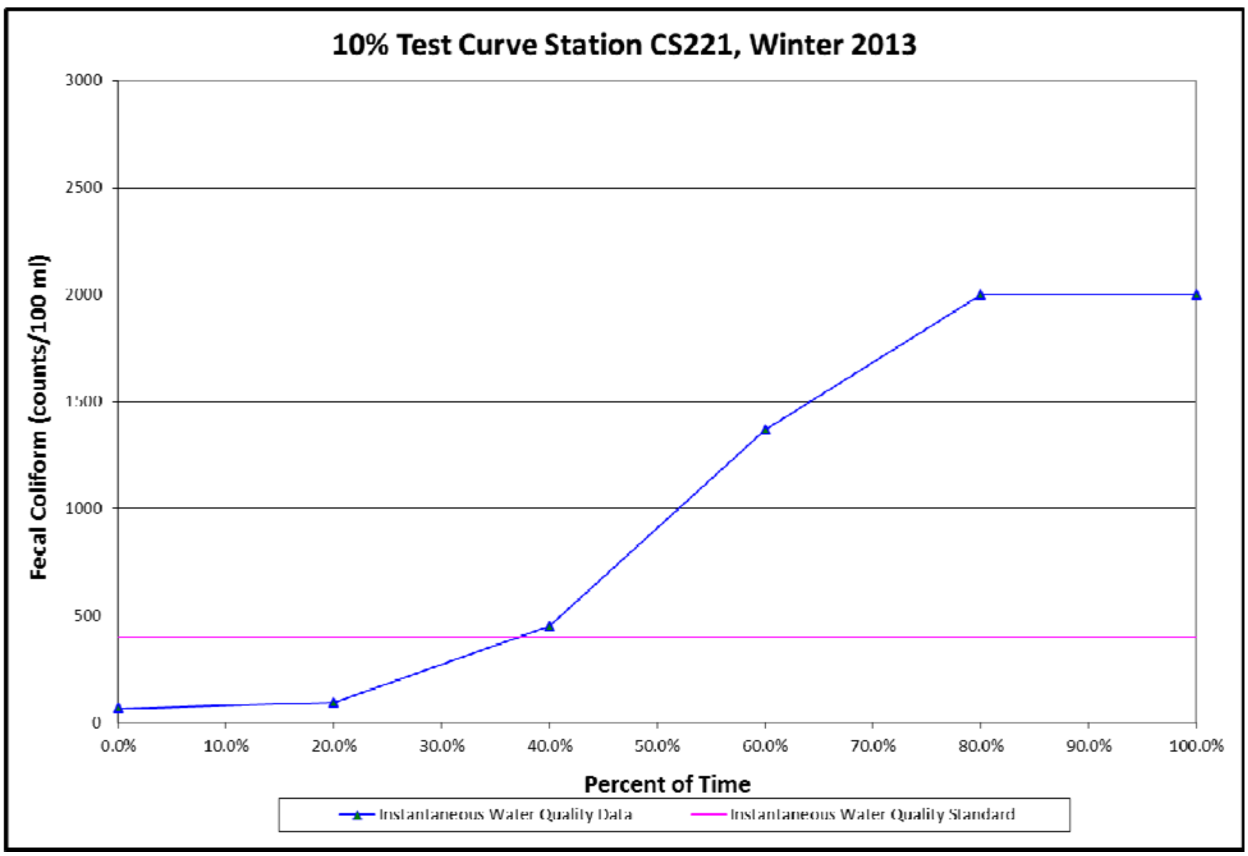


Figure 14. 10% Test Curve for Station CS221, Winter 2013

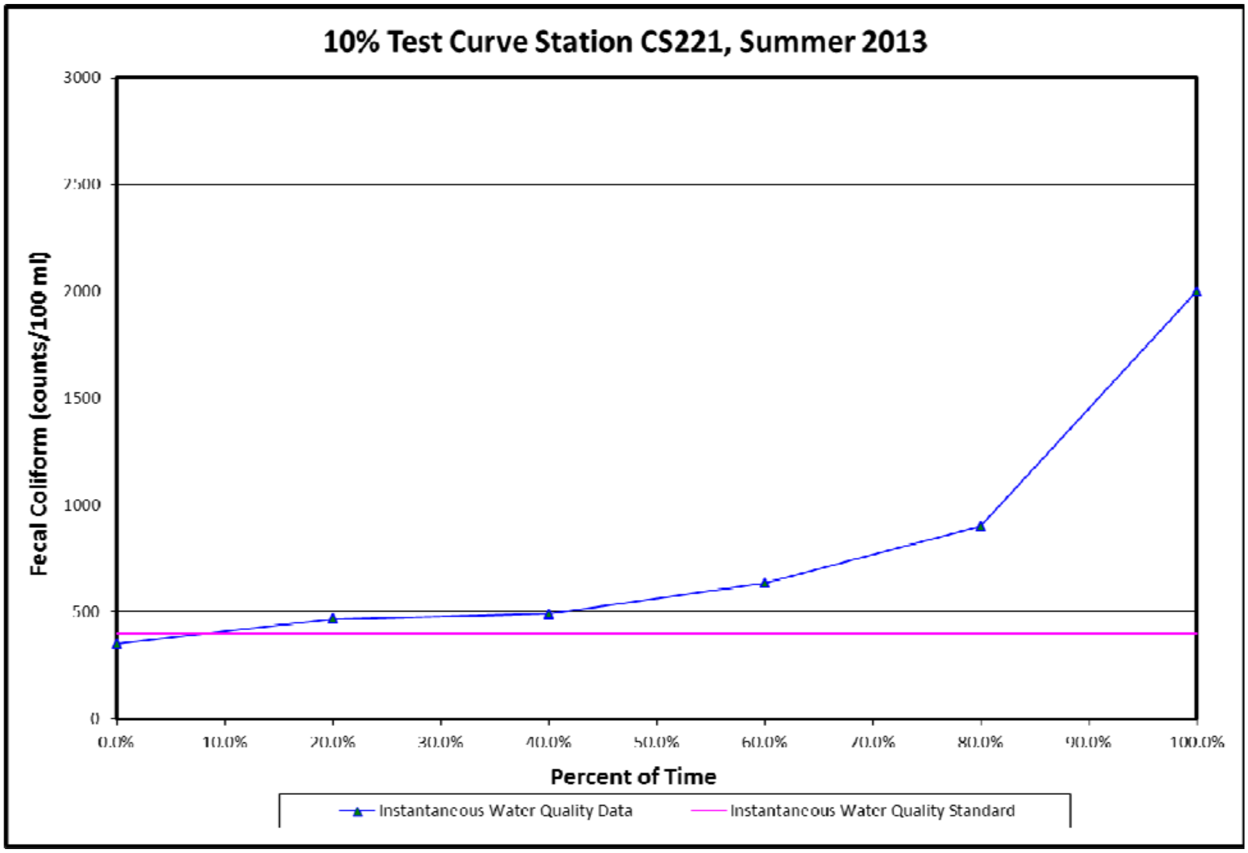


Figure 15. 10% Test Curve for Station CS221, Summer 2013

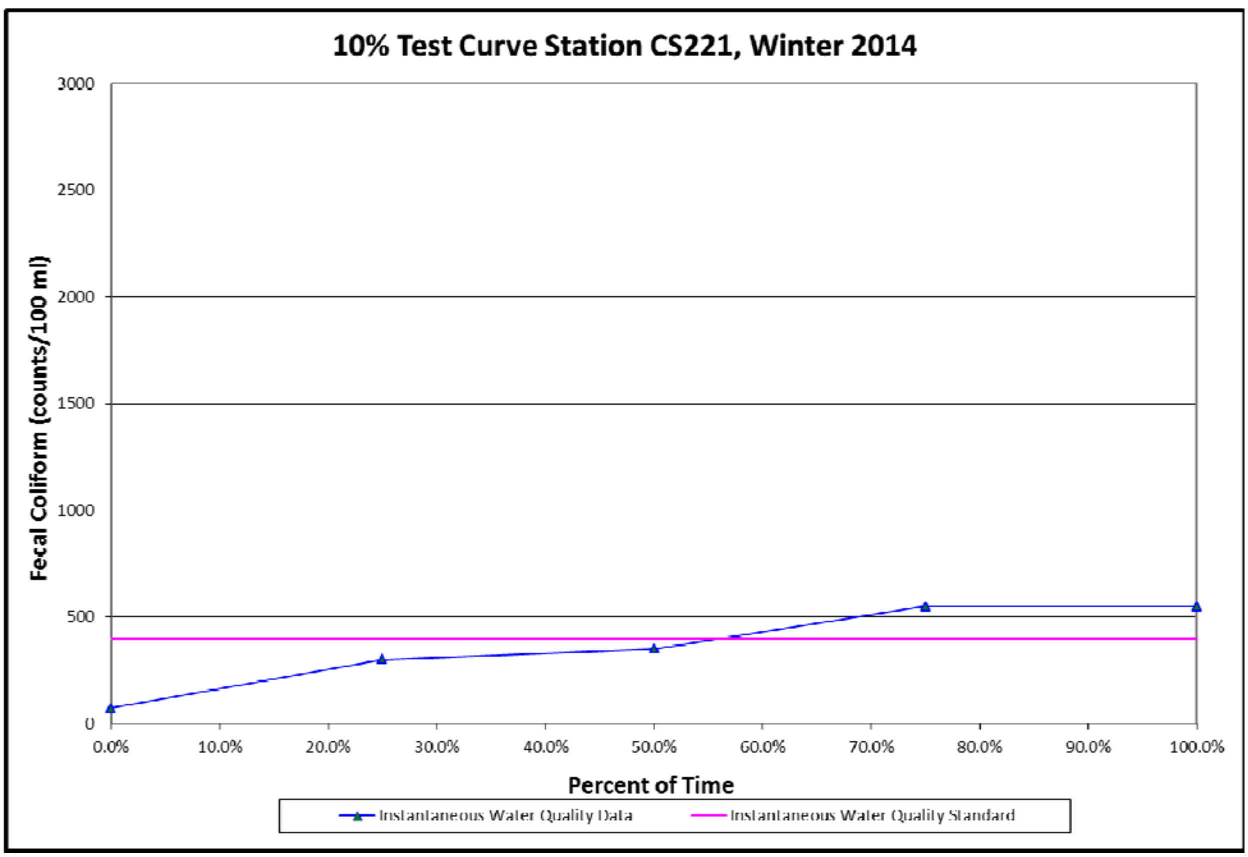


Figure 16. 10% Test Curve for Station CS221, Winter 2014

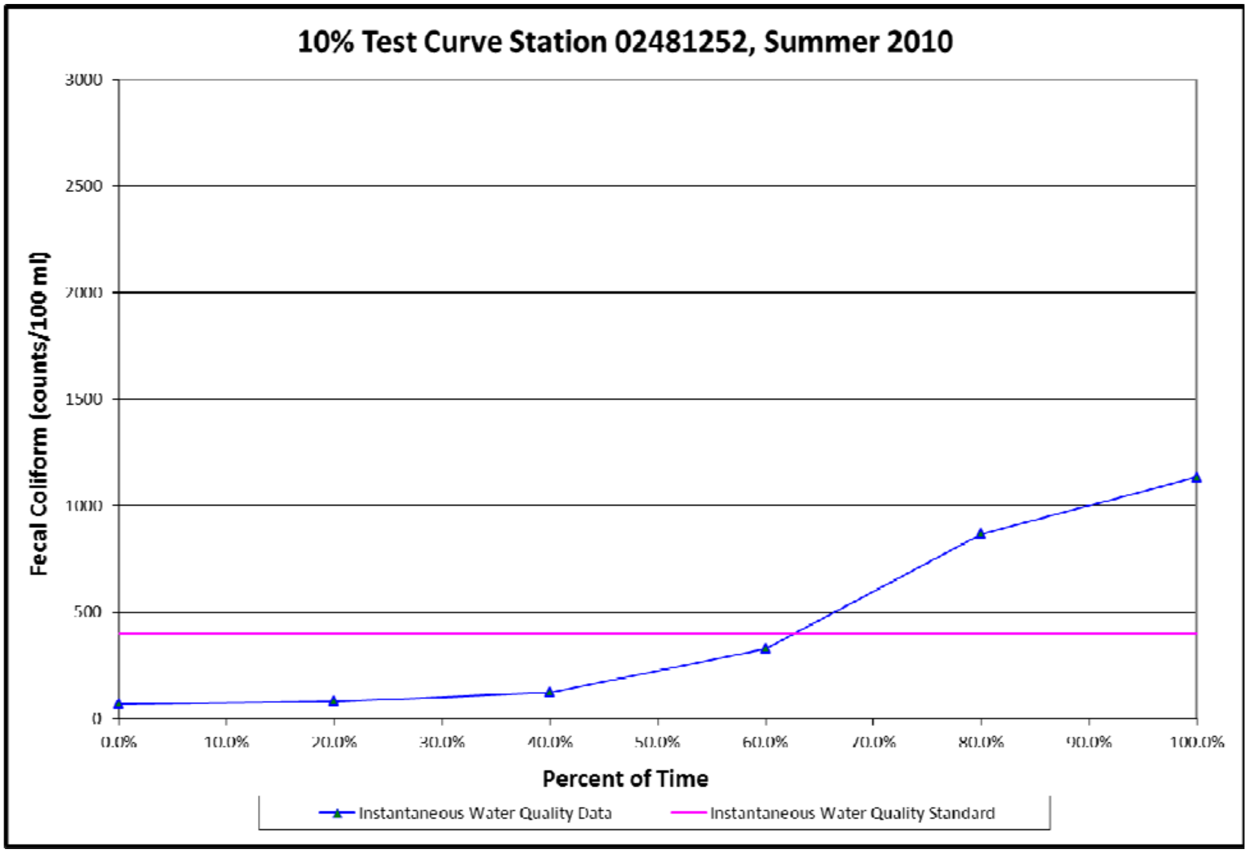


Figure 17. 10% Test Curve for Station 02481252, Summer 2010

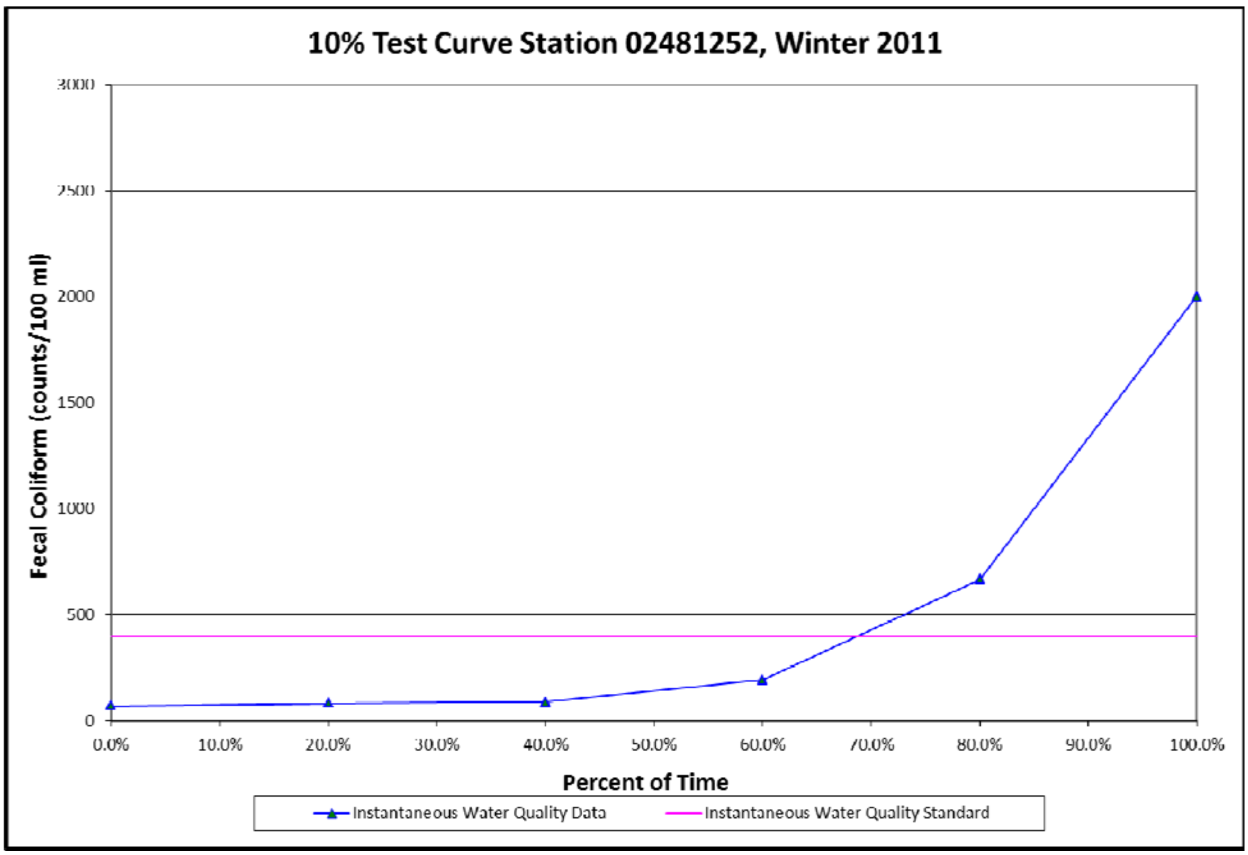


Figure 18. 10% Test Curve for Station 02481252, Winter 2011

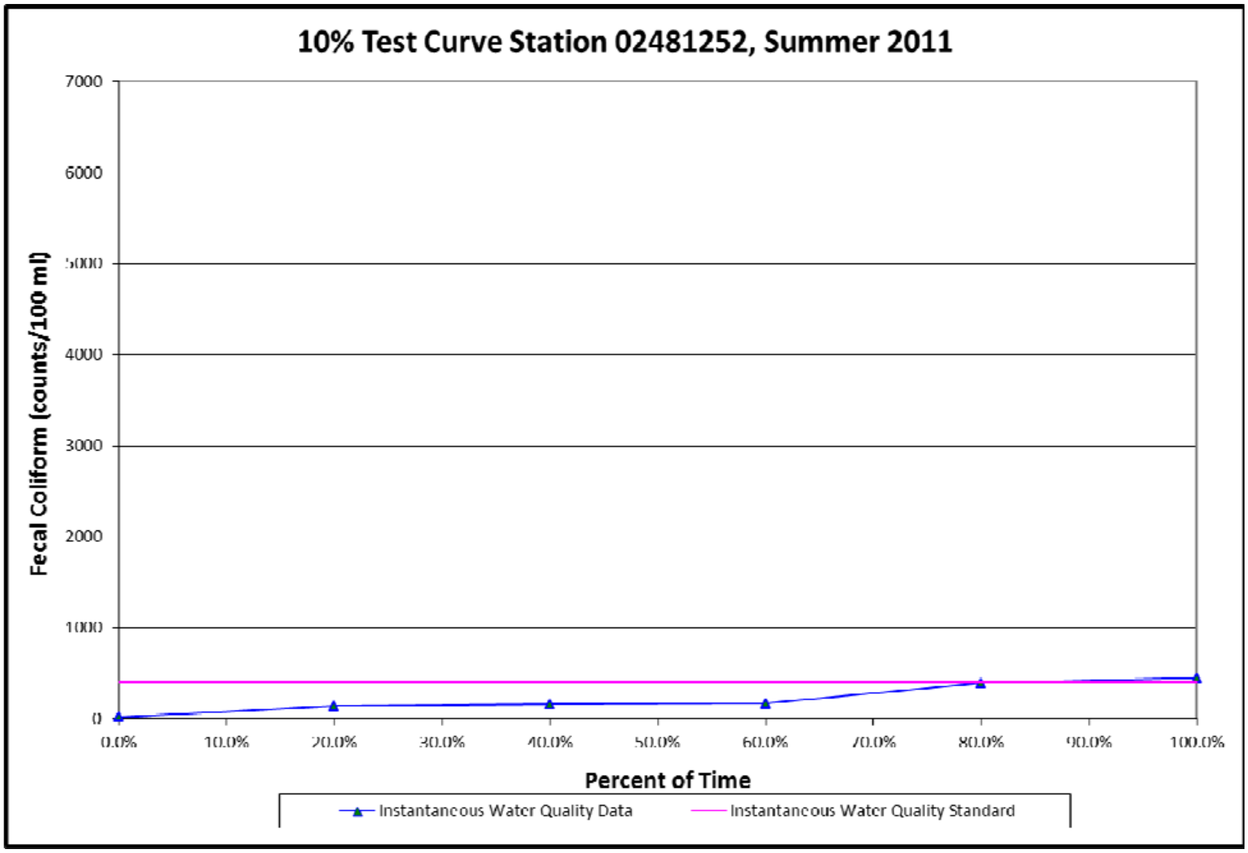


Figure 19. 10% Test Curve for Station 02481252, Summer 2011

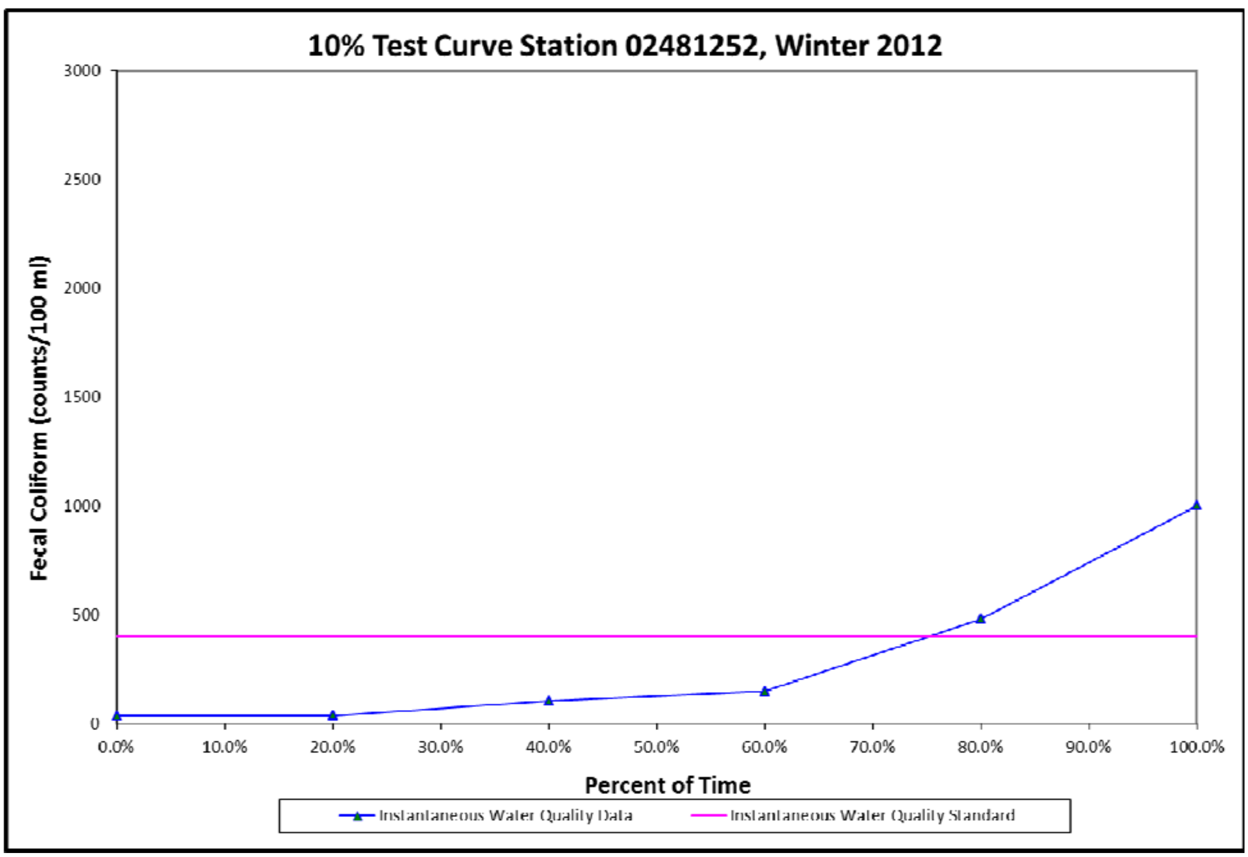


Figure 20. 10% Test Curve for Station 02481252, Winter 2012

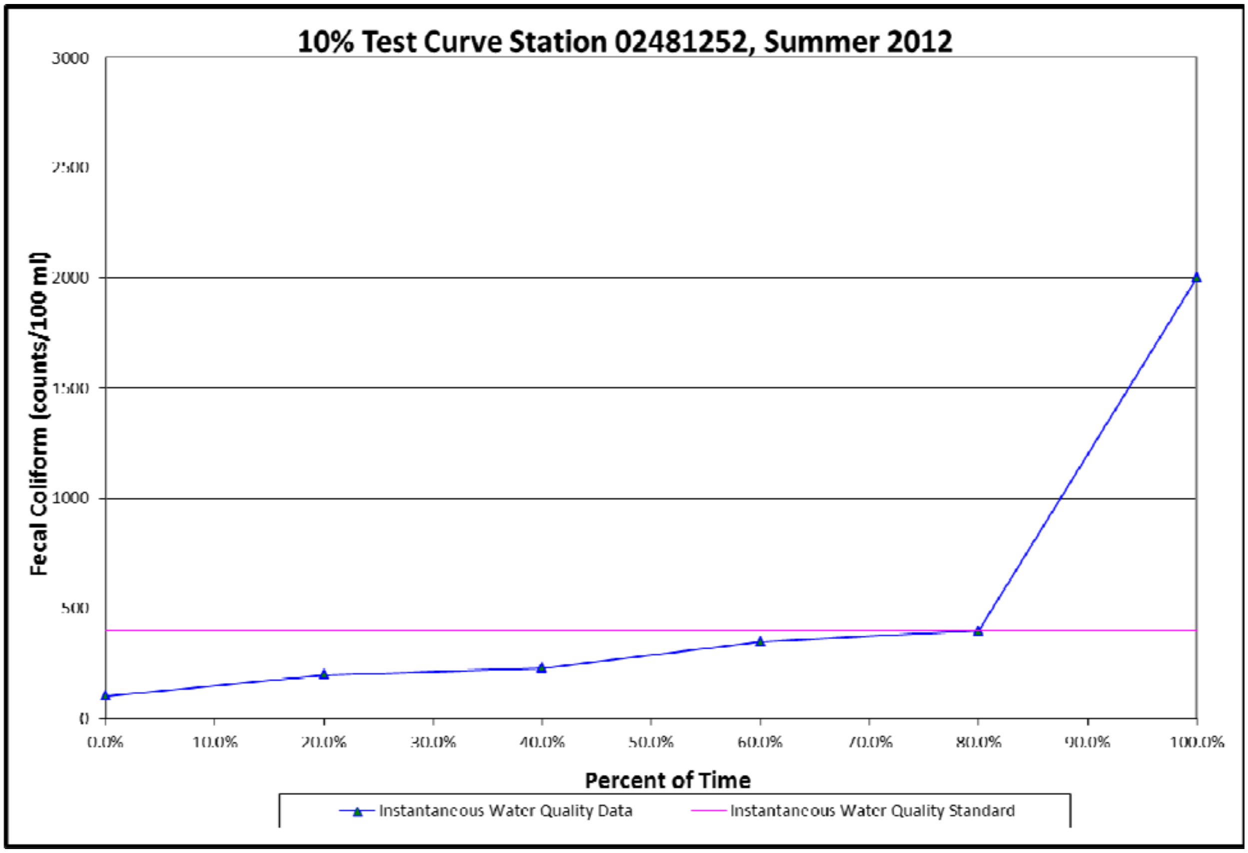


Figure 21. 10% Test Curve for Station 02481252, Summer 2012

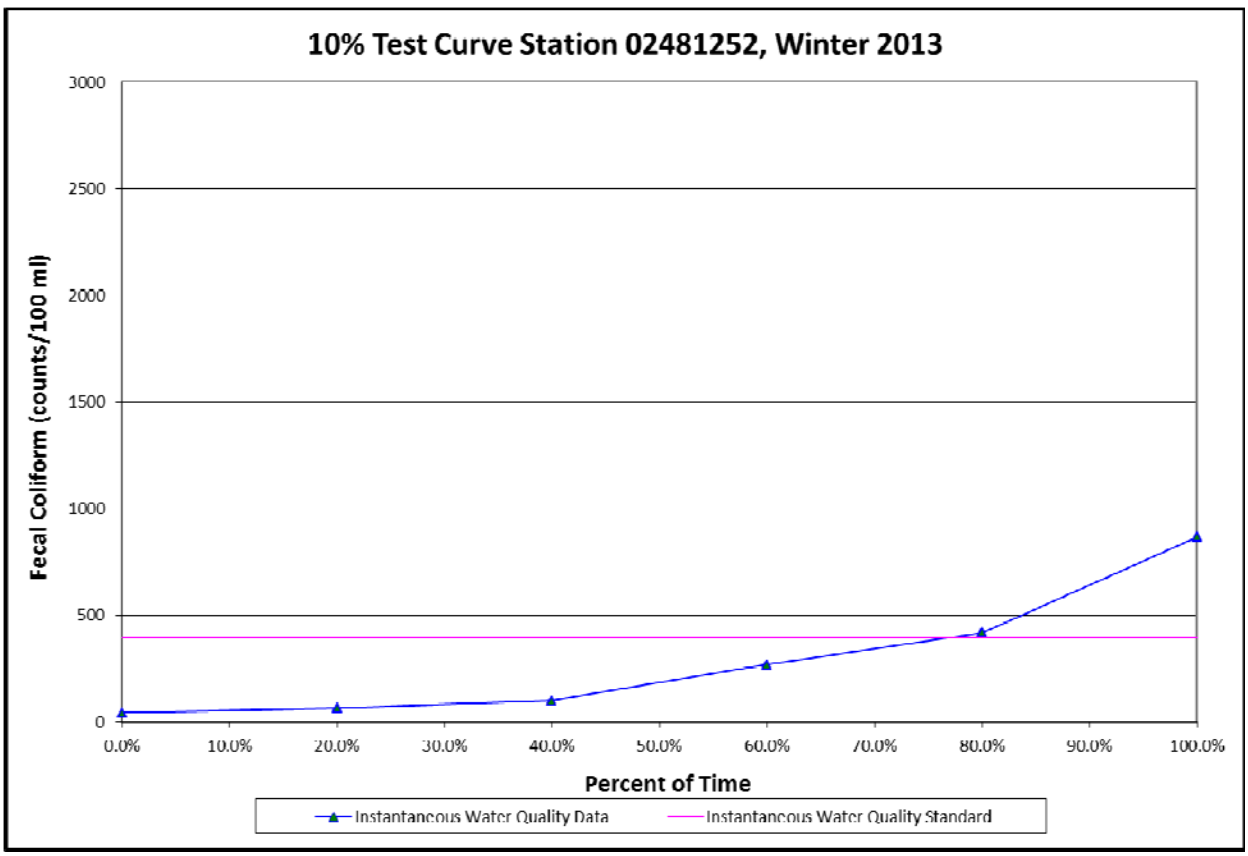


Figure 22. 10% Test Curve for Station 02481252, Winter 2013

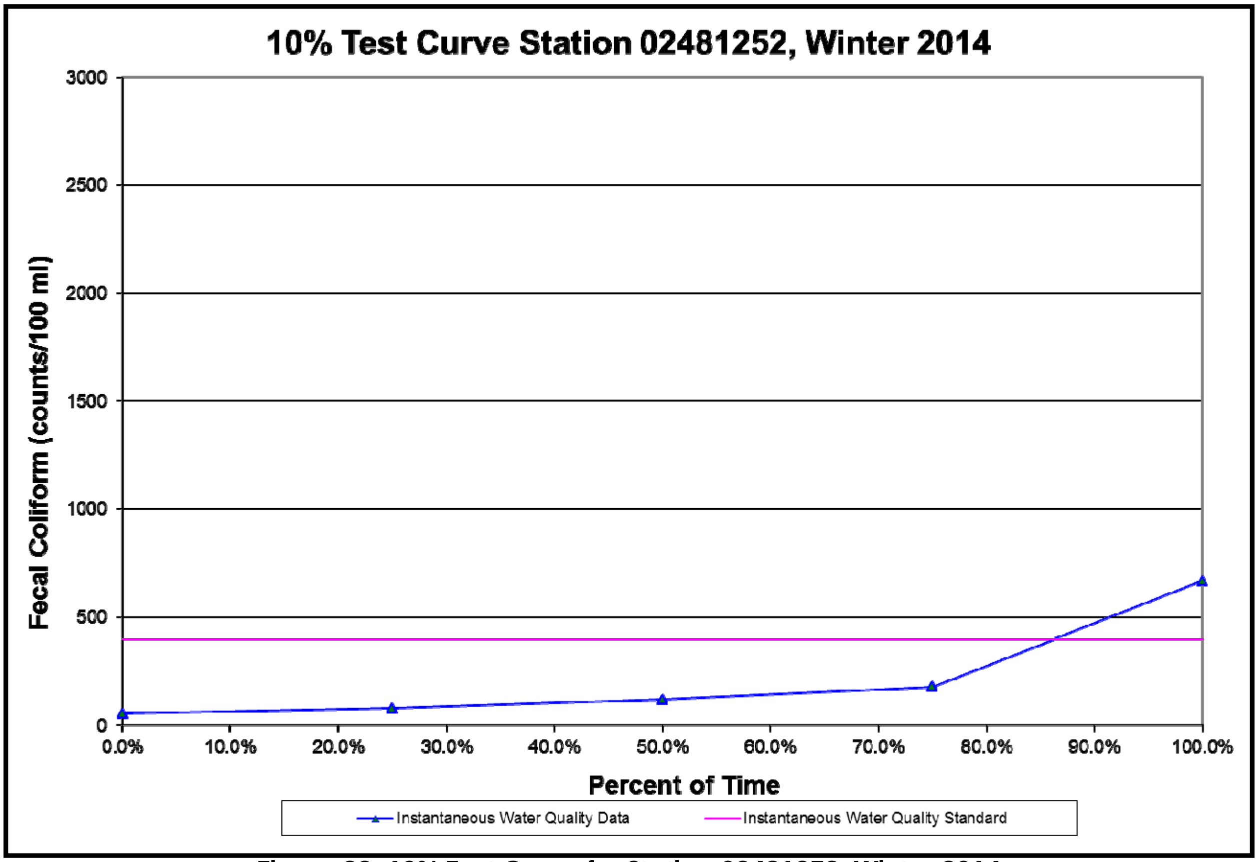


Figure 23. 10% Test Curve for Station 02481252, Winter 2014

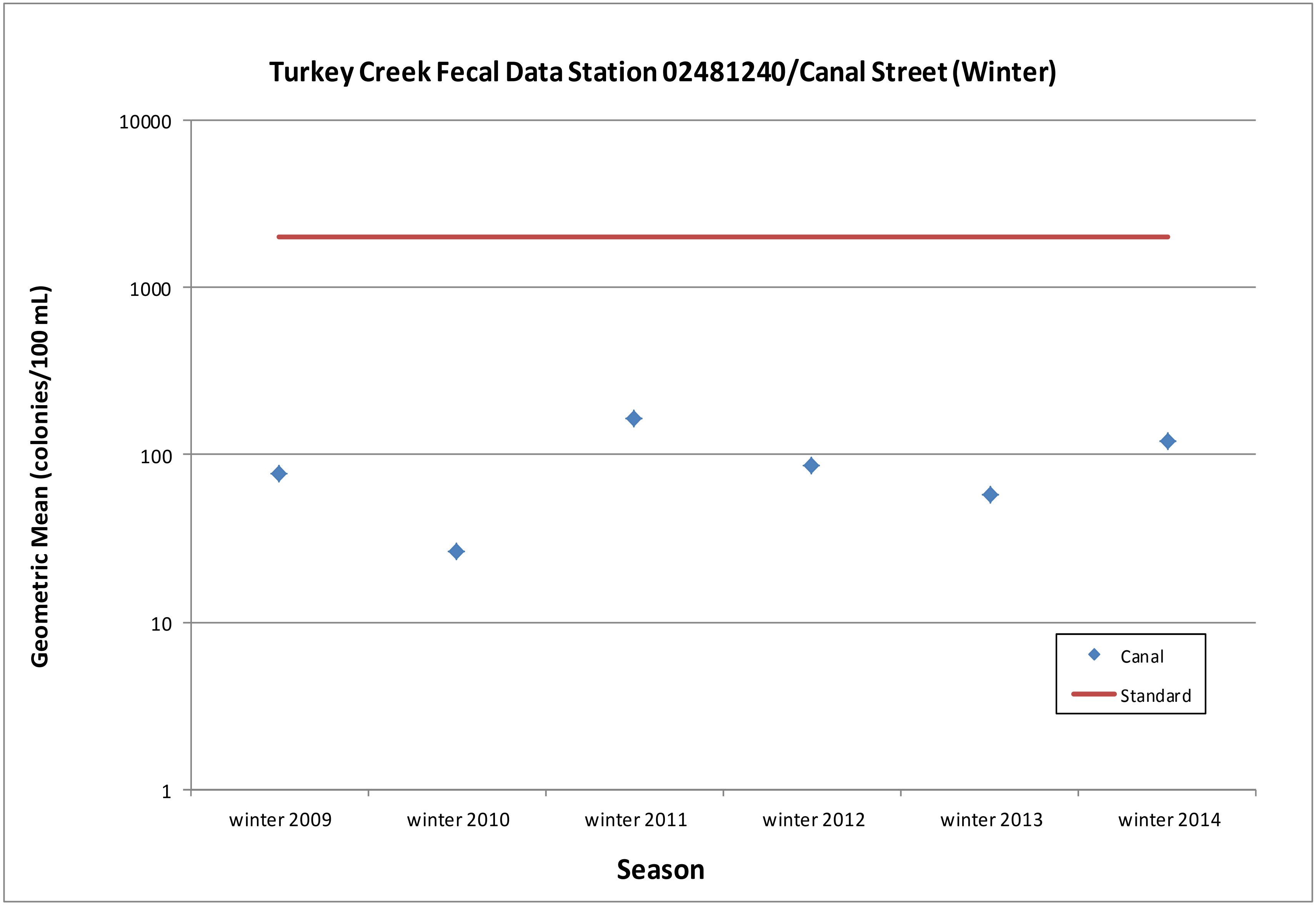


Figure 24. Geometric Mean for Station 02481240/Canal Street (winter)

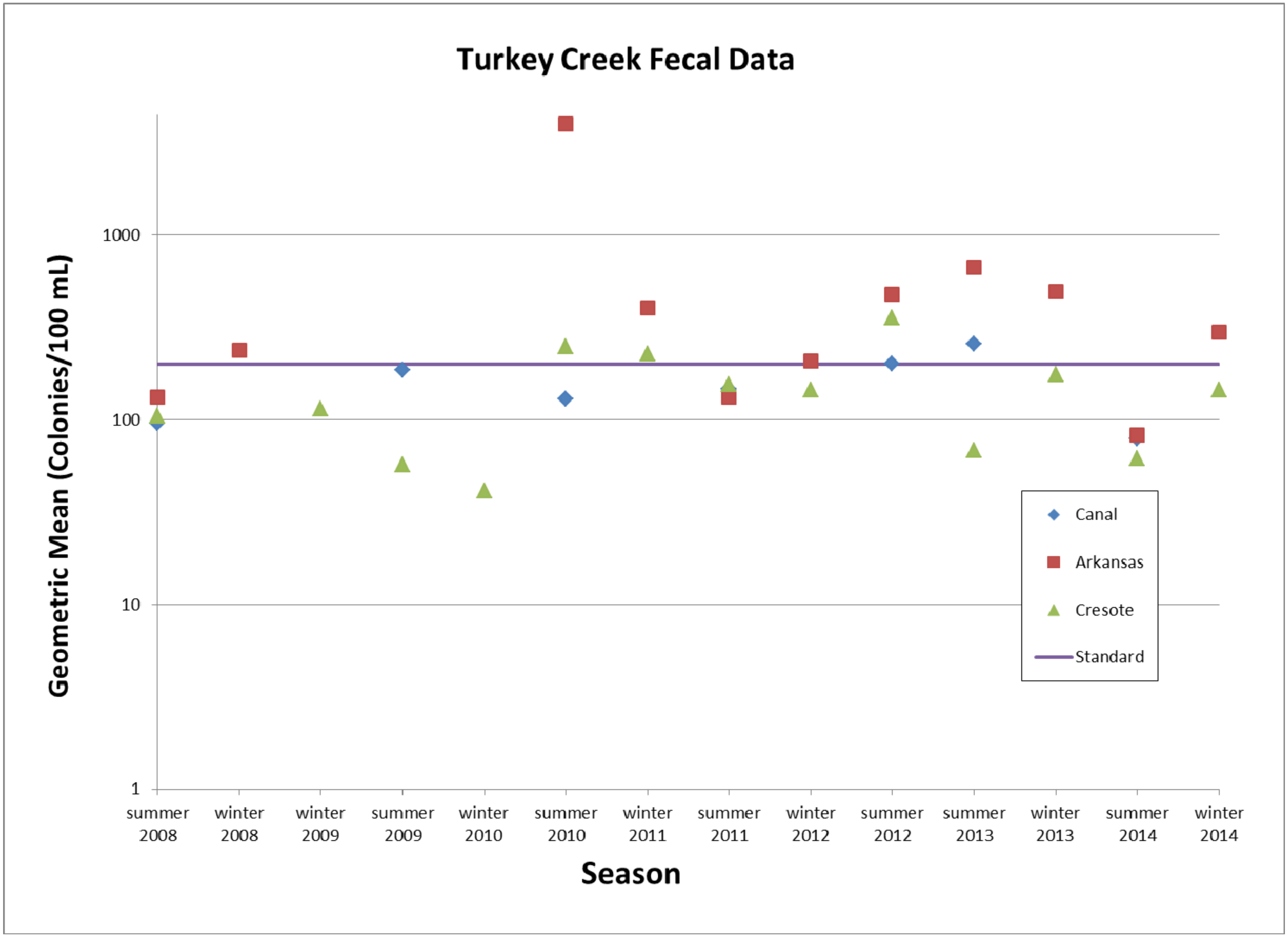


Figure 25. Geometric Mean for Station (All Stations)

SOURCE ASSESSMENT

The TMDL evaluation summarized in this report examined all known potential fecal coliform sources in the Turkey Creek Watershed. In evaluation of the sources, loads were 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.

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. Thus, a careful evaluation of point sources that discharge fecal coliform bacteria was necessary in order to quantify the degree of impairment present during the low-flow, critical condition period. There are 3 point sources located in the watershed, shown in Figure 26. The 3 wastewater facilites serve small residential areas.

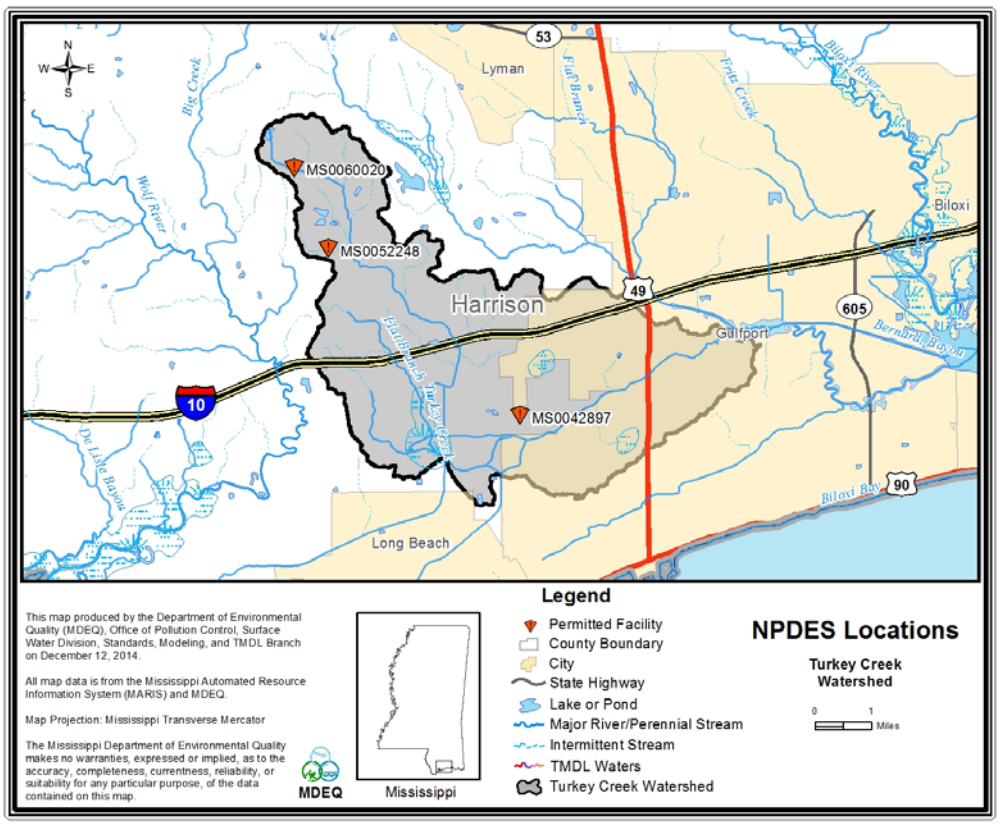


Figure 26. Point Sources in the Turkey Creek Watershed

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 (DMRs) were the best data source for characterizing effluent because they report measurements of flow and fecal coliform present in effluent samples. The facilities included are listed in Table 39. The DMR fecal coliform data for each facility are listed in Tables 40-42. After reviewing the current DMR data for the facilities, no violations of the standard were observed with the excepton of one data point for Gulfhaven subdivision. The facility's DMR reports indicate the datapoint was an outlier and that 3 measurements were taken to confirm the value. The additional measurements were 5 and 8 colonies/100 mL, respectively. It is noted that Dolans Trailer Park will be coming offline and connecting to North Gulfport WWTP. They are projected to have an interception date of late November 2016. This connection will help alleviate fecal coliform effects that may have been caused by this facility in previous years.

Table 39. Point Source Inventory in Turkey Creek Watershed

Facility Name	NPDES	Flow (MGD)	Permitted Concentation (#colonies/100 mL)
Gulfhaven Subdivison	MS0060020	0.047	200
Ridgecrest Estates	MS0052248	0.028	200
Dolan's Trailer Park	MS0042897	0.040	200

Table 40. DMR Data for Gulfhaven Subdivision

Monitoring Period	Annual Average Fecal Coliform (#colonies/100 mL)
1/1/08-12/31/08	No discharge
1/1/09-12/31/09	99
1/1/10-12-31/10	353*
1/1/11-12/31/11	5.75
1/1/12-12/31/12	53
1/1/13-12/31/13	33

*outlier- DMR report indicates 3 measurements taken. Other two measurements were 5 and 8.

Table 41. DMR Data for Ridgecrest Estates

Monitoring Period	Annual Average Fecal Coliform (#colonies/100 mL)
1/1/08-12/31/08	0
1/1/09-12/31/09	0
1/1/10-12-31/10	0
1/1/11-12/31/11	0
1/1/12-12/31/12	0
1/1/13-12/31/13	34

Table 42. DMR Data for Dolan's MHP

Monitoring Period	Annual Average Fecal Coliform (#colonies/100 mL)
1 Qtr 2008	20
2 Qtr 2008	<20
3 Qtr 2008	103
4 Qtr 2008	<20
1 Qtr 2009	57
2 Qtr 2009	20
3 Qtr 2009	13
4 Qtr 2009	13
1 Qtr 2010	87
2 Qtr 2010	20
3 Qtr 2010	33
4Qtr 2010	13
1 Qtr 2011	16
2 Qtr 2011	7.6
3 Qtr 2011	No value given
4 Qtr 2011	No value given
1 Qtr 2012	43
2 Qtr 2012	No discharge
3 Qtr 2012	54
4 Qtr 2012	43
1 Qtr 2013	104
2 Qtr 2013	140
3 Qtr 2013	No discharge
4 Qtr 2013	141
1 Qtr 2014	13
2 Qtr 2014	5

3.2 Assessment of Nonpoint Sources

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

- Failing septic systems
- Urban/ developed areas
- Stormwater
- Wildlife
- Other direct inputs

The nearly 17,500 acre drainage area of Turkey Creek contains several land use types, including water, urban, forest, scrub/barren, pasture, cropland, and wetlands. The area directly surrounding the impaired segments is comprised of mostly forest and wetland. The land use distribution for the watershed is provided in Table 43 and displayed in Figure 27. The land use for the Turkey Creek Watershed is gathered from the National Land Cover Database 2011 (NLCD). The land use categories were grouped into the following uses: urban, forest, cropland, pasture, scrub/ barren, water, and wetlands.

Table 43. Land Use Distribution (acres)

	Water	Urban	Forest	Scrub/Barren	Pasture	Cropland	Wetland	Total
Area (acres)	72.5	4890.9	993.2	998.5	2084.3	34.7	8334.3	17408
% Area	0.4	28.1	5.7	5.7	12.0	0.2	47.9	100

The mass balance method is an applicable method for TMDL development when the water quality data are collected in a manner consistent with the water quality standards, (5 samples collected within a 30 day period). The mass balance method requires water quality data and flow data. There are no gages located on Turkey Creek. The best stream with known flow to compare with Turkey Creek is Wolf Creek in the adjacent watershed. The Wolf Creek watershed is 308 sq miles. The average summer flow in Wolf Creek is 428 cfs. The TMDLs for segments 202211 and 202214 were developed using the mass balance method with this average flow. Using the drainage area ratio, the estimated flows for Turkey Creek segments 202211 and 202214, are shown below in Table 44.

Table 44. Flow Calculations for Turkey Creek Segments

Segment	DA (sq. miles)	Avg. Summer Flow (cfs)
202211	23.8	33
202214	27.2	37.8

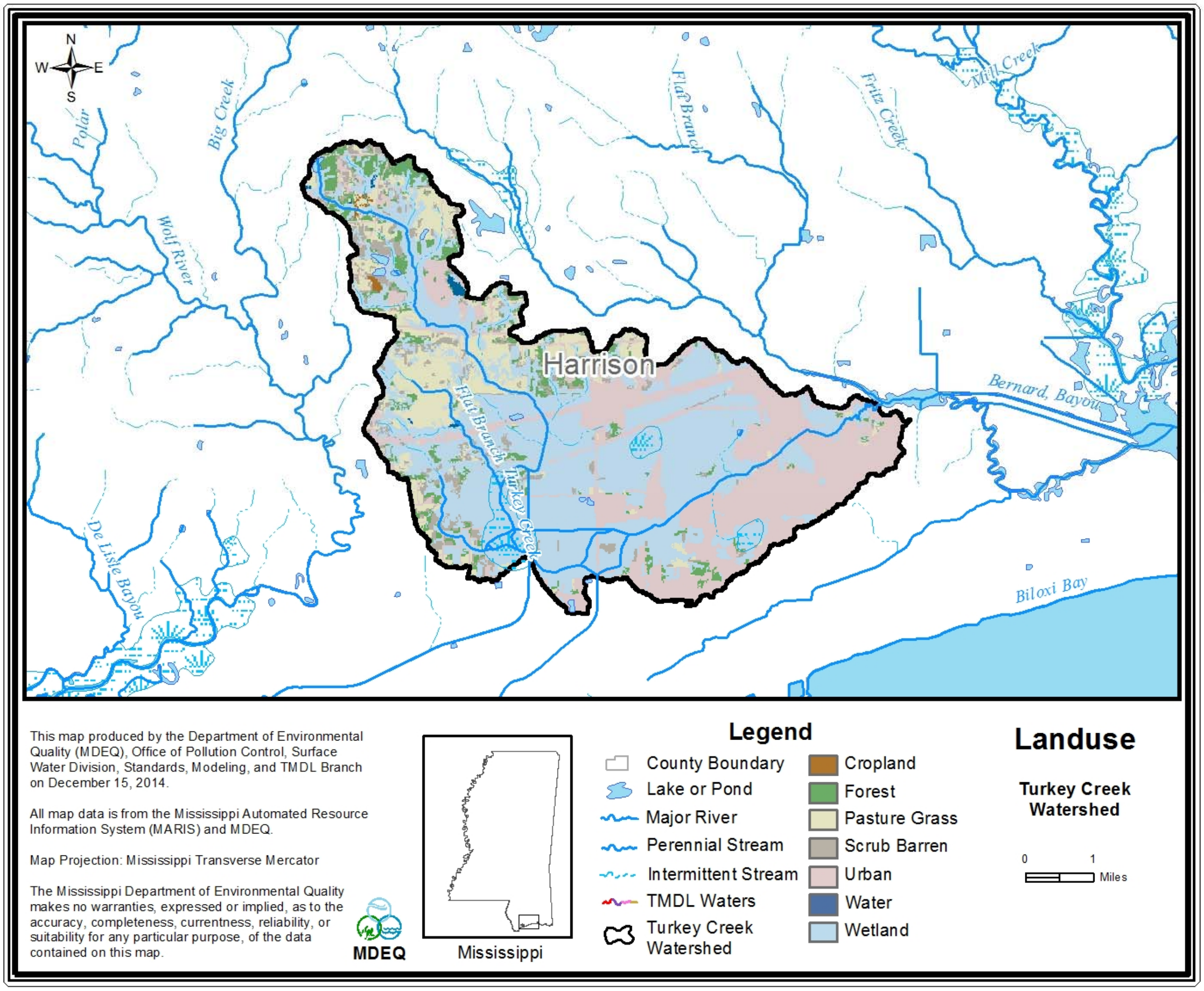


Figure 27. Land Use Distribution Map for the Turkey Creek Watershed

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 and dispose of wastewater 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 when 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. In an effort to keep the water off the land, pipes are occasionally placed from the septic tank or the field lines directly to the creek.

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 may not 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.

Septic systems have an impact on nonpoint source fecal coliform impairment in the Coastal Basin. The best management practices needed to reduce this pollutant load need to prioritize eliminating septic tank failures and improving maintenance and proper use of individual onsite treatment systems.

3.2.2 Urban / Developed Areas

Land classified as urban in the Turkey Creek Watershed is primarily representative of transportation corridors and does not represent land use activities associated with urban / developed areas that would contribute fecal coliform. In the past, it has been reported that the sewer system serving this area is susceptible to overflows and failures. This raw sewage overflow would impair the water quality in Turkey Creek. Figure 28 shows the certified sewered communities retrieved from MARIS for the Turkey Creek Watershed.

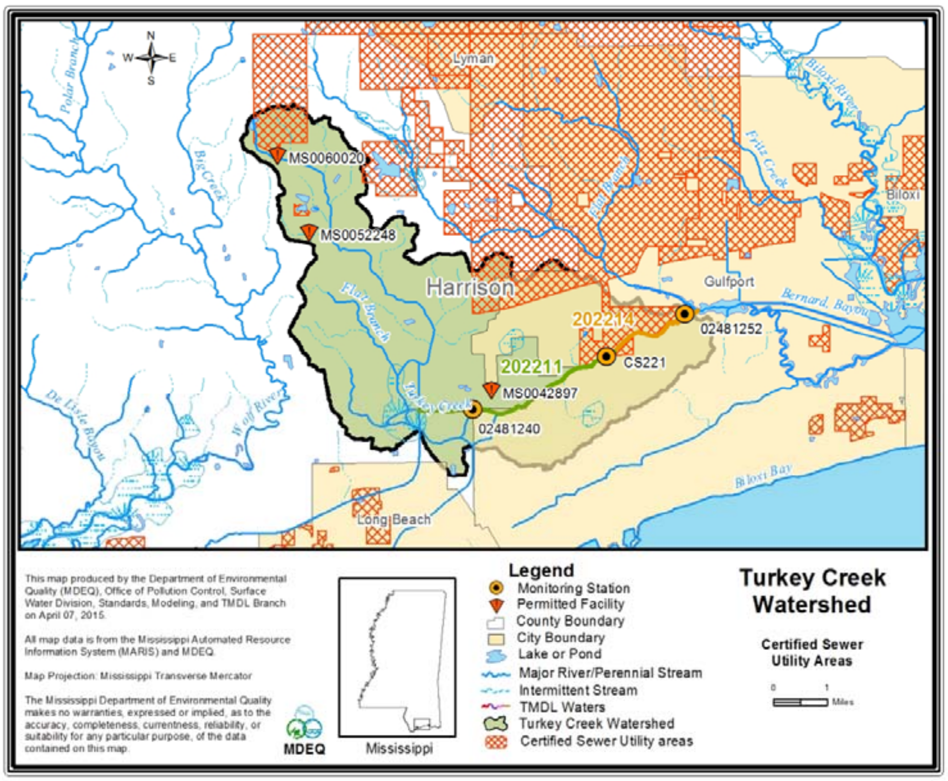


Figure 28. Certified Sewer Utiliities for the Turkey Creek Watershed

3.2.3 Stormwater

Stormwater is water that originates during precipitation events and snow/ice melt. Stormwater can soak into the soil (infiltrate), be held on the surface and evaporate, or runoff and end up in nearby streams, rivers, or other water bodies . Storm water is not clean and can pollute streams and lakes. Contaminated storm water is the largest contributor of pollutants to urban waters today. According to a 2009 Pathogens Study completed by CDM (Camp Dresser & McKee, Inc.), "The city of Gulfport confirmed that there are stormwater outfalls along Turkey Creek, although they could not confirm locations. The city also ackwledged Turkey Creek as a water quality sensitive watershed and that an ordinance has been enacted that requires any new development in the watershed with 20,000 square feet or more of impervious area to include stormwater detention and best management practices (BMPs) to capture and infiltrate a 25-year storm event. Additionally, cross-connections of sanitary and storm sewer systems may potentially be occurring. Because there is no available storm sewer data, the possibility and/or extent of this existing within the watershed is unknown. Future monitoring of the storm system could confirm or exclude cross-connections as a source of fecal coliform in Turkey Creek."

Polluted stormwater runoff is commonly transported through municipal separate storm sewer systems (MS4s), and then often discharged, untreated, into local water bodies. To prevent harmful pollutants from being washed or dumped into specific types of MS4s, EPA's Phase II Stormwater Rule requires all small municipal storm water systems (MS4s) located within an urbanized area to be covered under a NPDES stormwater permit. Figure 29 shows the locations of MS4 locations within the Turkey Creek Watershed.

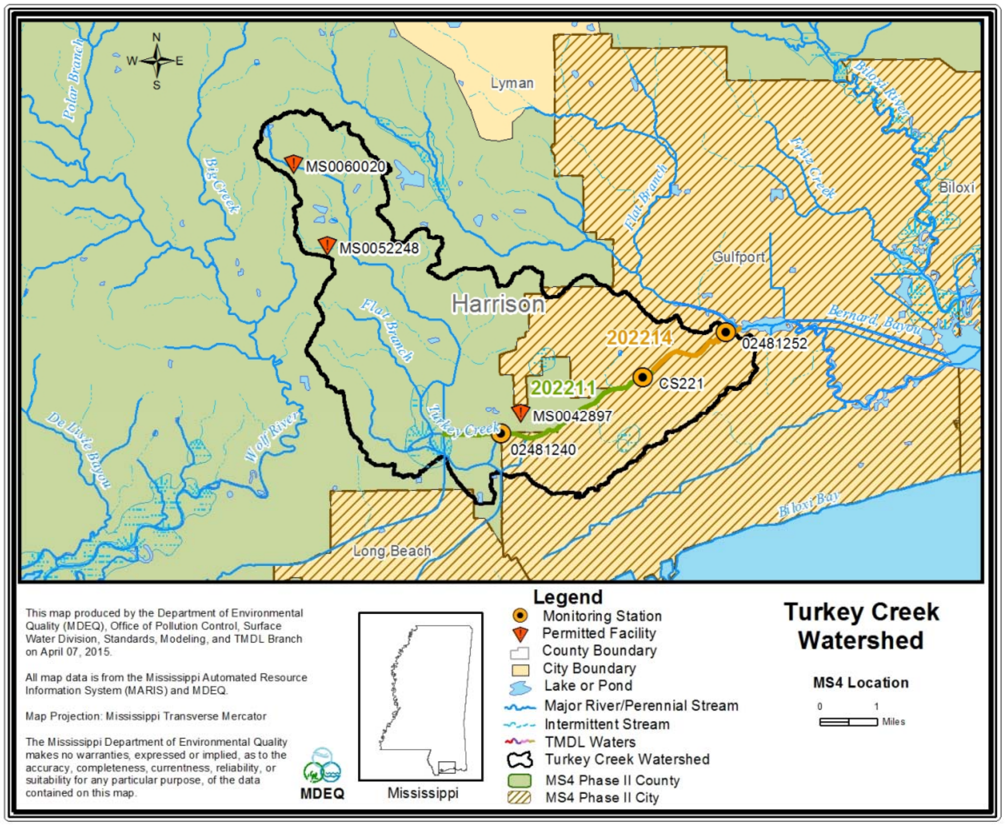


Figure 29. MS4 Stormwater Locations for Turkey Creek Watershed

3.2.4 Wildlife

Wildlife present in the Turkey Creek Watershed contributes to fecal coliform bacteria on the land surface which is then available for wash-off and delivery to receiving water bodies. Some form of wildlife may be present on all land uses within the watershed. Also, wildlife is present throughout the year.

3.2.5 Other Direct Inputs

Other direct inputs of fecal coliform bacteria to water bodies in the Turkey Creek Watershed could include illicit discharges, human recreation, access of both domestic and wild animals to the stream. The landuse report for the Turkey Creek Watershed indicates that pasture is 11.9% of the total land in the watershed. However in contacting the NRCS official for Harrison County, it was confirmed that there are no grazing animals in the immediate subwatersheds of the impaired segments. Grazing animals were identified in the upper part of the Turkey Creek watershed, but it is very unlikely that they contribute to fecal coliform violations for the lower segments.

MASS BALANCE PROCEDURE

Establishing the relationship between the instream water quality target and the source loading is a critical component of TMDL development. It allows for the evaluation of management options that will achieve the desired source load reductions. Ideally, the linkage will be supported by monitoring data that allow the TMDL developer to associate certain water body 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

A mass balance approach was used to calculate the TMDL for segments 202211 and 202214. This method of analysis was selected because data limitations precluded the use of more complex methods. The mass balance approach is suitable for this TMDL.

4.2 Calculation of the Allowable Load

The mass balance approach utilizes the conservation of mass principle. Loads can be calculated by multiplying the fecal coliform concentration in the water body by the flow. The principle of the conservation of mass allows for the addition and subtraction of those loads to determine the appropriate numbers necessary for the TMDL. The loads can be calculated using the following relationship:

$$\text{Load (counts per day)} = \text{Average Daily Capacity}\left(\frac{\text{day}\cdot\text{counts}}{100\,\text{ml}}\right)\times\text{Flow (cfs)} * \text{Conversion Factor}$$

$$\text{when Conversion Factor} = \left(\frac{28316.8\text{ml}}{\text{ft}^3}\right)\times\left(\frac{100\text{ml}}{100\text{ml}}\right)\times\left(\frac{60\text{s}}{1\text{min}}\right)\times\left(\frac{60\text{min}}{1\text{hr}}\right)\times\left(\frac{24\text{hr}}{1\text{day}}\right)$$

$$= 2.45\text{E}+07\left(\frac{100\,\text{ml}\cdot\text{s}}{\text{ft}^3\cdot\text{day}}\right)$$

The first step in calculating the average daily capacity is to calculate the theoretical 30 day capacity, as shown in the equation below, by taking the integral of the theoretical capacity curve shown in Figure 4.

$$\int_0^{26.91}\left[13.47x + 37.82\right]\text{dx} + \int_{26.91}^{30} 400\,\text{dx} = \mathbf{7129.4}\ (\text{day} * \text{counts}/100\,\text{ml})$$

The average daily capacity is then computed by dividing the theoretical 30 day capacity by 30.

$$\text{Average Daily Capacity} = \left(\frac{\mathbf{7129.4}\ (\text{day} * \text{counts}/100\ \text{ml})}{30}\right) = 237.65\ (\text{day} * \text{counts}/100\ \text{ml})$$

4.3 Calculation of the Percent Reduction

For the calculation of the percent reduction, the area under the 10% Test Curve for each season that violates both portions of the standard (Section 2.2.2) is computed and then compared to the area under the Theoretical Capacity Curve, Figure 4. The necessary percent reduction based on the observed data for each season is then calculated using the equation below. This method of calculating the percent reduction allows the data set to be compared to both portions of the water quality standard at the same time. Thus, the calculated percent reduction represents the reduction needed in order for the data set to meet both portions of the water quality standard.

$$\text{Percent Reduction} = \left(1 - \frac{\text{Theoretical Capacity Curve Area}}{\text{10\% Test Curve Area}}\right) * 100$$

For a season which only violates one portion of the standard, the percent reduction will only be based on the violating portion. The percent reduction calculation for a data set that violates the geometric mean portion of the standard follows.

$$\text{Percent Reduction} = \left(1 - \frac{\text{Geometric Mean of 200 mg/L}}{\text{Actual Greometric Mean of Violating Data Set}}\right) * 100$$

ALLOCATION

The allocation for this TMDL includes a wasteload allocation (WLA) for point sources, a load allocation (LA) for nonpoint sources, and a margin of safety (MOS).

5.1 Wasteload Allocations

There are currently 3 NPDES point source in the Turkey Creek Watershed. Dolans Trailer Park will be coming offline and connecting to North Gulfport's WWTP. Only 2 point sources will remain which are located in the upper watershed. These NPDES dischargers have disinfection. Future permits will be considered in accordance with Mississippi's *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* and will be required to disinfect as well.

WLA = Flow (cfs)* Fecal coliform concentration (#/100mL)*2.45E+07

5.2 Load Allocations

The load allocation for segment 202211 is calculated using the water quality criteria and the average summer flow of 33.0 cfs. The load allocation is assumed to represent nonpoint sources as described in Section 3.2. In calculating the LA component, the total TMDL for the water body is reduced by a 10% MOS and the WLA component. For segment 202211, the load is based on the average daily capacity and the average summer flow of 33.0 cfs. The resulting LA is estimated to be 5.17E +12 counts per day.

LA = 0.9*237.65(day*counts/100ml)* 33.0(cfs) * 2.45E+07[(100ml*s)/(ft^3*day)]-
1.48E+10 WLA

LA = 5.17E+12 (counts per day)

The load allocation for segment 202214 is calculated using the water quality criteria and the average summer flow of 37.8 cfs. For segment 202214, the load is based on the average daily capacity and the average summer flow of 37.8 cfs. The resulting LA is estimated to be 5.93E+12 counts per day.

LA = 0.9*237.65(day*counts/100ml)* 37.8 (cfs) * 2.45E+07[(100ml*s)/(ft^3*day)]-
1.48E+10 WLA

LA = 5.93E+12 (counts per day)

5.3 Incorporation of a Margin of Safety (MOS)

The two types of MOS development are to implicitly incorporate the MOS using conservative assumptions or to explicitly specify a portion of the total TMDL as the MOS. For segment 202211, reducing the TMDL by 10% explicitly specifies the MOS. Assuming the average flow of 33.0 cfs for this segment, the resulting load attributed to the MOS is 5.76E+11 counts per day.

MOS = 0.1*237.65(day*counts/100ml)* 33.0 (cfs) * 2.45E+07[(100ml*s)/(ft^3*day)]

MOS = 5.76E+11 (counts per day)

For segment 202214, reducing the TMDL by 10% explicitly specifies the MOS. Assuming the average flow of 37.8 cfs for this segment, the resulting load attributed to the MOS is 6.60E+11 counts per day.

5.4 Calculation of the TMDL

The TMDL is calculated based on the following equation:

TMDL = WLA + LA + MOS

where WLA is the Wasteload Allocation, LA is the Load Allocation, and MOS is the Margin of Safety.

WLA = NPDES Permitted Facilities

LA = Surface Runoff + Other Direct Inputs

MOS = 10% explicit

The TMDL for segments 202211 and 202214 was calculated based on the average flows of 33 cfs and 37.8 cfs, respectively, and the average daily capacity. The necessary percent reduction of fecal coliform to segment 202211 is a maximum of 80.3%. The necessary percent reduction of fecal coliform to segment 202214 is a maximum of 77.4%. These reductions are based on the more critical of the seasonal data sets for each water body segment.

The TMDL for segment 202211 is as follows:

TMDL = 237.65(day*counts/100ml)* 33.0(cfs) * 2.45E+07[(100ml*s)/(ft^3*day)]

TMDL = 5.76E+12 (counts per day)

Table 45. TMDL Summary for Segment 202211(counts per day)

WLA	1.48E+10
LA	5.17E+12
MOS	5.76E+11
TMDL = WLA + LA +MOS	5.76E+12

The TMDL for segment 202214 is as follows:

TMDL = 237.65(day*counts/100ml)* 37.8(cfs) * 2.45E+07[(100ml*s)/(ft^3*day)]

TMDL = 6.60E+12 (counts per day)

Table 46. TMDL Summary for Segment 202214 (counts per day)

WLA	1.48E+10
LA	5.93E+12
MOS	6.60E+11
TMDL = WLA + LA +MOS	6.60E+12

5.5 Seasonality

For many streams in the state, fecal coliform limits vary according to the seasons. Segment 202214 is designated for the use of secondary contact recreation which has a summer and winter standard. However, fecal monitoring was conducted during the summer and winter seasons for both segments to account for seasonal variations.

5.6 Reasonable Assurance

This component of TMDL development does not apply to this TMDL Report. There is no WLA reduction request based on promised LA components and reductions.

CONCLUSION

The TMDL reports a 77.4% reduction in fecal coliform for segment 202214 and an 80.3% reduction in fecal coliform in segment 202211 to meet water quality standards. MDEQ believes that these violations may be attributed to faulty infrastructure (lift stations)and malfunctioning sewer lines within the city limits and backwater tides at the confluence of Turkey Creek and Bernard Bayou further down stream. It is recommended that additional monitoring be performed at these two sites. As long as the effluent is disinfected to meet water quality standards for fecal coliform, the TMDL will not impact future NPDES Permits. MDEQ will not approve any NPDES Permit application that does not plan to meet water quality standards for pathogens. Education projects that teach best management practices 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 Future Monitoring

MDEQ's Ambient Recreational Monitoring Program will continue.

6.2 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. The public will be given an opportunity to review the TMDLs and submit comments. MDEQ also distributes all TMDLs at the beginning of the public notice to those members of the public who have requested to be included on a TMDL mailing list. Anyone wishing to become a member of the TMDL mailing list should contact Greg Jackson at gjackson@deq.state.ms.us.

All comments should be directed to Greg Jackson at gjackson@deq.state.ms.us or Greg Jackson, MDEQ, PO Box 2261, Jackson, MS 39225. All comments received during the public notice period and at any public hearings become a part of the record of this TMDL and will be considered in the submission of this TMDL to EPA Region 4 for final approval.

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 natural body of water to receive wastewaters or toxic materials without deleterious effects and without damage to aquatic life or humans who use the water.

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 water body may be based upon a similar, unaltered or least impaired, water body 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 water body.

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

Daily discharge: the discharge of a pollutant measured during a 24-hour period that reasonably represents the 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 discharge is calculated as the average measurement of the pollutant over the day.

Designated Uses: (1) those uses specified in the water quality standards for each water body or segment whether or not they are being attained. (2) those water uses identified in state water quality standards which must be achieved and maintained as required under the Clean Water Act. Uses can include public water supply, recreation, etc.

Discharge monitoring report (DMR): the EPA uniform national form, including any subsequent additions, revisions, or modifications for the reporting of self-monitoring results by permittees.

Effluent: wastewater – treated or untreated – that flows out of a treatment plant or industrial outfall. Generally refers to wastes discharged into surface waters.

Effluent limitation: (1) any restriction established by a State or the Administrator on quantities, rates, and concentrations of chemical, physical, biological, and other constituents which are discharged from point sources into navigable waters, the waters of the contiguous zone, or the ocean, including schedules of compliance. (2) restrictions established by a State or EPA on quantities, rates, and concentrations in wastewater discharges.

Effluent standard: any effluent standard or limitation, which may include a prohibition of any discharge, established or proposed to be established for any toxic pollutant under section 307(a) of the Act.

Fecal Coliform Bacteria: (1) those organisms associated with the intestines of warm-blooded animals that are commonly used to indicate the presence of fecal material and the potential presence of organisms capable of causing human disease. (2) bacteria found in the intestinal tracts of mammals. Their presence in water or sludge is an indicator of pollution and possible contamination by pathogens.

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

Impaired Water Body: any water body 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 that is attributed either to one of its existing or future nonpoint sources of pollution or to natural background sources. Load allocations are best estimates of the loading, which may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading. Wherever possible, natural and nonpoint source loads should be distinguished.

Loading: the introduction of waste into a waste management unit but not necessarily to complete capacity.

Mass Balance: a concept based on a fundamental law of physical science (conservation of mass) which says that matter can not be created or destroyed. It is used to calculate all input and output streams of a given substance in a system.

Model: a quantitative or mathematical representation or computer simulation which attempts to describe the characteristics or relationships of physical events.

National pollutant discharge elimination system (NPDES): the national program for issuing, modifying, revoking and reissuing, terminating, monitoring and enforcing permits, and imposing and enforcing pretreatment requirements, under section 307, 402, 318, and 405 of the Clean Water Act.

Nonpoint Source: the pollution sources which generally are not controlled by establishing effluent limitations under section 301, 302, and 402 of the Clean Water Act. Nonpoint source pollutants are not traceable to a discrete identifiable origin, but generally result from land runoff, precipitation, drainage, or seepage.

Outfall: the point where an effluent is discharges into receiving waters

Point Source: a stationery location or fixed facility from which pollutants are discharges or emitted. Also, any single identifiable source of pollution, e.g., a pipe, ditch, ship, ore pit, factory smokestack.

Pollution: generally, the presence of matter or energy whose nature, location or quantity produces undesired environmental effects. Under the Clean Water Act, for example, the term is defined as the man-made or man-induced alteration of the physical, biological, and radiological integrity of water.

Publicly Owned Treatment Works (POTW): the treatment works treating domestic sewage that is owned by a municipality or State.

Regression: a relationship of y and x in a function of y = f(x), where: y is the expected value of an independent random variable x. The parameters in the function f(x) are determined by the method of least squares. When f(x) is a linear function of x, the term linear regression is used.

Regression Coefficient: a quantity that describes the slope and intercept of a regression line.

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, ($\mathbf{d_l}$, $\mathbf{d_2}$, $\mathbf{d_3}$) 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: (1) the calculated maximum permissible pollutant loading introduced to a water body such that any additional loading will produce a violation of water quality standards. (2) the sum of the individual wasteload allocations and load allocations. A margin of safety is included with the two types of allocations so that any additional loading, regardless of source, would not produce a violation of water quality standards.

Waste: (1) useless, unwanted or discarded material resulting form (agricultural, commercial, community and industrial) activities. Wastes include solids, liquids, and gases. (2) any liquid resulting from industrial, commercial, mining, or agricultural operations, or from community activities that is discarded or is being accumulated, stored, or physically, chemically, or biologically treated prior to being discarded or recycled.

Wasteload allocation (WLA): (1) the portion of a receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution. WLAs constitute a type of water quality based effluent limitation. (2) the portion of a receiving water's total maximum daily load that is allocated to one of its existing or future point source of pollution. (3) the maximum load of pollutants each discharger of waste is allowed to release into a particular waterway. Discharge limits are usually required for each specific water quality criterion being, or expected to be, violated. The portion of a stream's total assimilative capacity assigned to an individual discharge.

Water Quality Standards: State-adopted and EPA-approved regulations mandated by the Clean Water Act and specified in 40 CFR 131 that describe the designated uses of a water body, the numeric and narrative water quality criteria designed to protect those uses, and an antidegredation statement to protect existing levels of water quality. Standards are designed to safeguard the public health and welfare, enhance the quality of water and serve the purposes of the Clean Water Act.

Water quality criteria: numeric water quality values and narrative statements which are derived to protect designated uses. Numeric criteria are scientifically-derived ambient concentrations developed by EPA or States for various pollutants of concern to protect human health and aquatic life. Narrative criteria are statements that describe the desired water quality goal. Ambient waters that meet applicable water quality criteria are considered to support their designated 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.1252 et seq.).

Watershed: (1) the land area that drains (contributes runoff) into a stream. (2) the land area that drains into a stream; the watershed for a major river may encompass a number of smaller watersheds that ultimately combine at a common delivery point.

ABBREVIATIONS

BMP .... Best Management Practice

CWA .... Clean Water Act

DMR .... Discharge Monitoring Report

EPA .... Environmental Protection Agency

GIS .... Geographic Information System

LA .... Load Allocation

MARIS .... Mississippi Automated Resource Information System

MDEQ .... Mississippi Department of Environmental Quality

MOS .... Margin of Safety

NRCS .... National Resource Conservation Service

NPDES .... National Pollution Discharge Elimination System

UNT .... Unnamed Tributary

USGS .... United States Geological Survey

WLA .... Wasteload Allocation

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