Escherichia coli BACTERIA TOTAL MAXIMUM DAILY LOAD EVALUATIONS FOR THE NORTH AND SOUTH FORKS OF THE YELLOWBANK RIVER-GRANT, CODINGTON AND DEUEL COUNTIES, SOUTH DAKOTA

South Dakota Department of
Environment and Natural Resources

Protecting South Dakota's Tomorrow ... Today

SOUTH DAKOTA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

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North Fork Yellow Bank River Total Maximum Daily Load

Entity ID's:	SD-MN-R-YELLOW_BANK_N_FORK_01
Location:	HUC Code: 07020001
Size of Watershed:	143,676 acres
Water body Type:	River/Stream
303(d) Listing Parameter:	*E. coli* Bacteria
Initial Listing date:	2012 IR
TMDL Priority Ranking:	1
Listed Stream Miles:	SD/MN border to S27,T120N, R48W
Designated Use of Concern:	Limited Contact Recreation
Analytical Approach:	Load Duration Curve Framework
Target:	Meet applicable water quality standards for South Dakota 74:51:01:51 and Minnesota-Class 2 waters.
Indicators:	*E. coli* Bacteria Counts
Threshold Value:	$\leq$ 126 *E. coli* counts/100 ml geometric mean concentration with maximum single sample concentrations of $\leq$ 1,178 E. coli counts/100 ml
High Flow Zone LA:	1.8×10^{12} *E. coli*/day
High Flow Zone WLA:	None
High Flow Zone MOS:	3.6×10^{11} *E. coli*/ day
High Flow Zone TMDL:	2.2×10^{12} *E. coli*/ day

Total Maximum Daily Load Summary Table

South Fork Yellow Bank River Total Maximum Daily Load

Entity ID's:	SD-MN-R-YELLOW_BANK_S_FORK_01
Location:	HUC Code: 07020001
Size of Watershed:	103,451 acres
Water body Type:	River/Stream
303(d) Listing Parameter:	*E. coli* Bacteria
Initial Listing date:	2012 IR
TMDL Priority Ranking:	1
Listed Stream Miles:	SD/MN border to S33, T118N,R49W
Designated Use of Concern:	Limited Contact Recreation
Analytical Approach:	Load Duration Curve Framework
Target:	Meet applicable water quality standards for South Dakota 74:51:01:51 and Minnesota-Class 2 waters.
Indicators:	*E. coli* Bacteria Counts
Threshold Value:	$\leq$ 126 *E. coli* counts/100 ml geometric mean concentration with maximum single sample concentrations of $\leq$ 1,178 *E. coli* counts/100 ml
High Flow Zone LA:	1.5×10^{12} *E. coli*/ Day
High Flow Zone WLA:	None
High Flow Zone MOS:	1.7×10^{11} *E. coli*/ Day
High Flow Zone TMDL:	1.7×10^{12} *E. coli*/ Day

1.0 Introduction

The intent of this document is to clearly identify the components of the TMDLs submitted to support adequate public participation and facilitate the United States Environmental Protection Agency (EPA) review and approval. These TMDLs were developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by EPA. This TMDL document addresses the *Escherichia coli* (*E. coli*) bacteria impairments of the classified segments of the North and South Forks of the Yellow Bank River. The impaired segments are identified as SD-MN-R-Yellow_Bank_N_Fork_01 and SD-MN-R-Yellow_Bank_S_Fork_01 in the 303(d) list of impaired waterbodies in South Dakota's 2012 Integrated Report (IR) for Surface Water Quality.

1.1 Watershed Characteristics

The North and South Forks of the Yellow Bank River drain the eastern flank of the Choteau des Prairies upland in Grant, Deuel and Codington Counties in northeastern South Dakota. Both systems flow into Minnesota where they merge to form the Yellow Bank River approximately 8 miles downstream of the South Dakota border. The Yellow Bank River, Whetstone River and outflow from Big Stone Lake constitute the headwaters of the Minnesota River.

The combined drainage area of the North and South Forks of the Yellow Bank River, in South Dakota, is approximately 274,000 acres. The individual North Fork and South Fork watersheds encompass approximately 143,676 acres and 103,451 acres, respectively. Land use in the combined watersheds is primarily agriculture. The headwaters of both systems originate along the Choteau des Prairies escarpment which is dominated by rangeland/pasture and grasslands with several wooded draws. The eastern portion of the watershed is a relatively flat valley dominated by row crops, in particular, corn and soy beans with some small grains and alfalfa. Numerous animal feeding areas are located within the watershed, although the trend is toward fewer operations with higher numbers of animals.

Hydrology of the North and South Fork can be variable due to the exceptional high relief along the Coteau des Prairies escarpment. Elevation changes in excess of 1,000 feet take place across the length of the watershed, much of which occurs within the initial third of the river system. The headwaters of most tributary streams begin at elevations over 2,000 feet above mean sea level, dropping to an elevation of roughly 960 feet where the rivers enter the Minnesota River. This elevation change takes place over as little as 30 miles.

The average annual precipitation in the study area is 22 inches, of which 75% typically falls April through September. Tornadoes and severe thunderstorms strike occasionally. These storms are often of local extent and duration, and occasionally produce heavy rainfall events. The average seasonal snowfall is 30 inches per year.

The surficial character of the watershed can be divided into four parts. The southwestern and northeastern edges of the watershed are dominated by poorly drained, depressions. These areas mark the location of ice-marginal deposits left behind during the last ice age. The northeast flank of the Coteau des Prairies is a well-drained area, with substantial relief. Many small tributary streams cross the area from the southwest to the northeast. The central part of the watershed is characterized by moderately well drained, low relief terrain sloping gently toward the northeast. In all three cases, the land surface is underlain by glacial till. Finally, the valleys of the Yellow Bank Rivers are deeply incised into the land surface. Glacial outwash is found along these valleys. Shallow wells in the saturated sand and gravel (aquifer) are the drinking water source for some private wells. Discharge from the aquifer may also help maintain river levels during dry periods.

Soils within the study area are derived from a variety of parent materials. Uplands soils are relatively fine-grained, and have developed over glacial till, often with a thin loess (wind-blown silt) cover. Coarse-grained soils are found around the valley bottoms of the river and major tributaries, and are derived from glacial outwash or alluvial sediments.

A few small communities reside within the North and South Fork Yellow Bank watersheds. The population density of these communities ranges anywhere from around 300 to 10 people. Figure 1 depicts the location of the North and South Fork Yellow Bank watersheds with respect to location in South Dakota. Figure 2 depicts the individual North and South Fork Yellow Bank River watersheds with defined, county boundaries, roads, towns, tributaries, impaired segments (red) and monitoring stations.

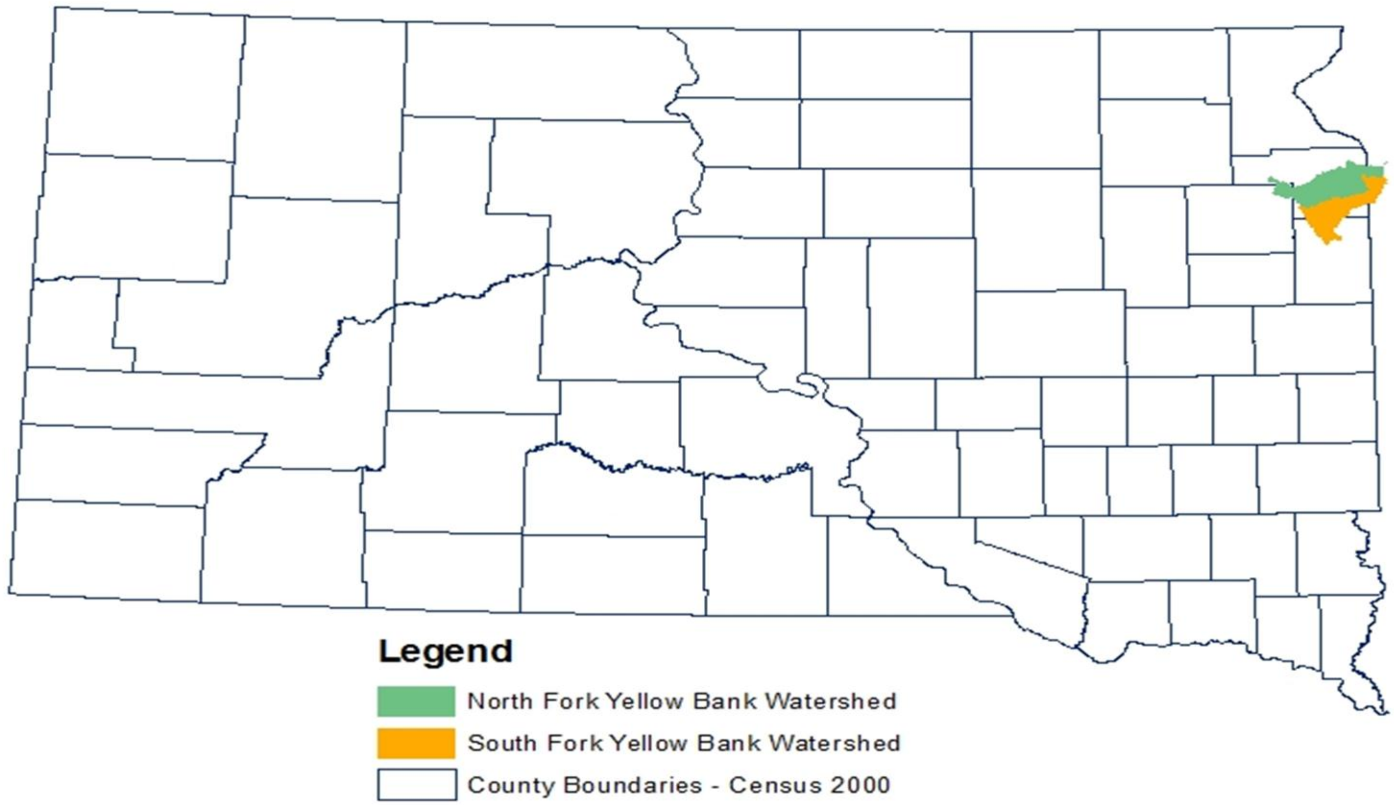

Figure 1. Location of the North and South Fork Yellow Bank River Watersheds in South Dakota.

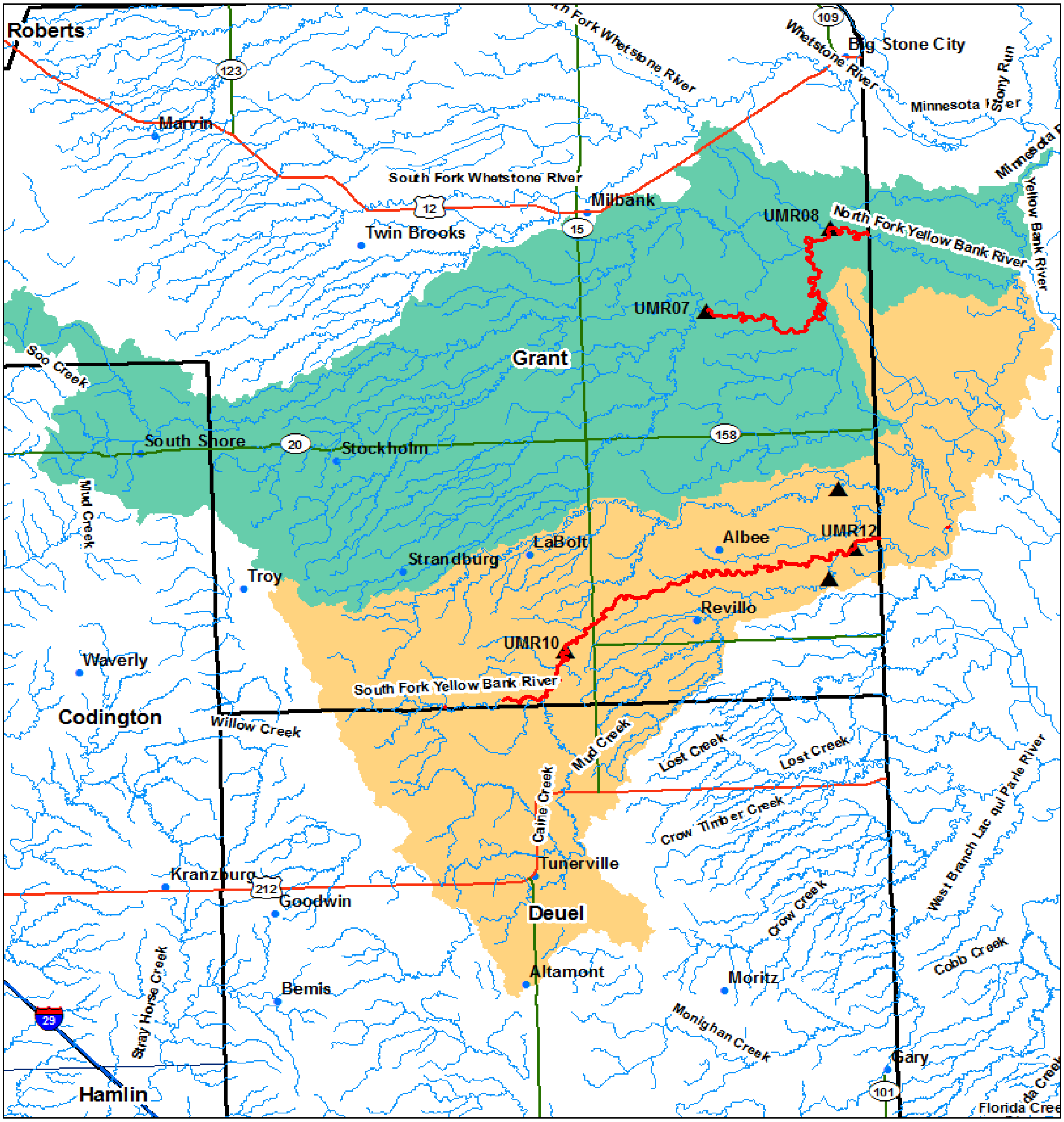

Figure 2. Watershed for the North and South Forks of the Yellow Bank River including locations of impaired segments (red) and monitoring stations.

2.0 Water Quality Standards

Waterbodies in South Dakota are assigned beneficial uses. All waters (lakes and streams) are designated the use of fish and wildlife propagation, recreation and stock watering (9). All streams are assigned the use of irrigation (10). Additional beneficial use designations may be assigned by the state based on a use attainability assessment of each waterbody. Water quality standard criteria have been defined in South Dakota state statutes in support of all beneficial uses. The standards consist of suites of numeric criteria that provide physical and chemical benchmarks from which support determinations and impairment decisions can be recognized.

The chronic standards are based on a minimum of 5 samples collected during separate 24-hour periods over a 30-day period. While not explicitly described within the state's water quality standards, chronic standards, including geometric means and 30-day averages, are applied to a calendar month. This method is documented in the listing methodology of South Dakota's most recent (2012) Integrated Report (IR) for Surface Water Quality and is used in permit development.

Additional "narrative" standards that may apply can be found in the "Administrative rules of South Dakota: Articles 74:51:01:05; 06; 08, 09; and 12". These standards contain language that generally prohibits the presence of materials causing pollutants to form, visible pollutants, nuisance aquatic life, and biological integrity.

The impaired segment of the North Fork Yellow Bank River has been assigned the following beneficial use designations: warmwater permanent fish life propagation (4), limited contact recreation (8), fish and wildlife propagation, recreation, and stock watering (9), and irrigation (10). The impaired segment of the South Fork Yellow Bank River has been assigned the following beneficial use designations: coldwater marginal fish life propagation (3), limited contact recreation (8), fish and wildlife propagation, recreation, and stock watering (9), and irrigation (10). Tables 1 and 2 display the water quality standard criteria assigned to protect the designated beneficial uses of the North Fork and South Fork Yellow Bank Rivers, respectively. When multiple criteria exist for a particular parameter, the most stringent criterion is used.

South Dakota adopted *E. coli* standards for the immersion and limited contact recreation uses in 2007. The *E. coli* standard will replace the fecal coliform standard once all the NPDES permits are updated. Therefore, assessment activities, impairment determinations and TMDL development were based primarily on *E. coli*. The acute and chronic *E. coli* criterion for waters designated the beneficial use of limited contact recreation requires that individual sample results and the geometric mean not exceed 1,178 counts/100ml and 630 counts/100ml, respectively. These criteria are exclusively applicable from May 1 through September 30. The chronic standards are based on the geometric mean of a minimum of 5 samples collected during separate 24-hour periods over a calendar month.

Table 1. Designated beneficial use and associated state water quality standards for the classified segment of the North Fork Yellow Bank River (SD-MN-R_Yellow_Bank_N_Fork_01).

Parameters	**Criteria**	**Unit of Measure**	**Beneficial Use Requiring this Standard**
Total ammonia nitrogen as N	Equal to or less than the result from Equation 3 in Appendix A of Surface Water Quality Standards	mg/L 30 average March 1 to October 31	Warmwater Permanent Fish Propagation
	Equal to or less than the result from Equation 4 in Appendix A of Surface Water Quality Standards	mg/L 30 average November 1 to February 29	
	Equal to or less than the result from Equation 2 in Appendix A of Surface Water Quality Standards	mg/L Daily Maximum	
Dissolved Oxygen	≥5.0	mg/L	Limited Contact Recreation (WPFP)
Total Suspended Solids	≤90 (30-day average) ≤158 (single sample)	mg/L	Warmwater Permanent Fish Propagation
Temperature	≤26.6	°C	Warmwater Permanent Fish Propagation
Fecal Coliform Bacteria (May 1- Sept 30)	≤1000 (geometric mean) ≤2000 (single sample)	count/100 mL	Limited Contact Recreation
Escherichia coli Bacteria (May 1- Sept 30)	≤630 (geometric mean) ≤1178 (single sample)	count/100 mL	Limited Contact Recreation
Alkalinity ($CaCO_3$)	≤750 (mean) ≤1,313 (single sample)	mg/L	Wildlife Propagation and Stock Watering
Conductivity	≤2,500 (mean) ≤4,375 (single sample)	µmhos/cm @ 25° C	Irrigation Waters
Nitrogen, nitrate as N	≤50 (mean) ≤88 (single sample)	mg/L	Wildlife Propagation and Stock Watering
pH (standard units)	≥6.5 to ≤9.0	units	Warmwater Permanent Fish Propagation
Solids, total dissolved	≤2,500 (mean) ≤4,375 (single sample)	mg/L	Wildlife Propagation and Stock Watering
Total Petroleum Hydrocarbon	≤10	mg/L	
Oil and Grease	≤10		Wildlife Propagation and Stock Watering
Sodium Adsorption Ratio	<10	ratio	Irrigation Waters

Table 2. Designated beneficial use and associated state water quality standards for the classified segment of the South Fork Yellow Bank River (SD-MN-R_Yellow_Bank_S_Fork_01).

Parameters	Criteria	Unit of Measure	Beneficial Use Requiring this Standard
Total ammonia nitrogen as N	Equal to or less than the result from Equation 3 in Appendix A of Surface Water Quality Standards	mg/L 30-day average	Coldwater Marginal Fish Propagation
	Equal to or less than the result from Equation 1 in Appendix A of Surface Water Quality Standards	mg/L Daily Maximum	
Dissolved Oxygen	≥5.0	mg/L	Limited Contact Recreation
Total Suspended Solids	≤90 (mean) ≤158 (single sample)	mg/L	Coldwater Marginal Fish Propagation
Temperature	≤23.9	°C	Coldwater Marginal Fish Propagation
Fecal Coliform Bacteria (May 1- Sept 30)	≤1000 (geometric mean) ≤2000 (single sample)	count/100 mL	Limited Contact Recreation
Escherichia coli Bacteria (May 1- Sept 30)	≤630 (geometric mean) ≤1178 (single sample)	count/100 mL	Limited Contact Recreation
Alkalinity ($CaCO_3$)	≤750 (mean) ≤1,313 (single sample)	mg/L	Wildlife Propagation and Stock Watering
Conductivity	≤2,500 (mean) ≤4,375 (single sample)	µmhos/cm @ 25° C	Irrigation Waters
Nitrogen, nitrate as N	≤50 (mean) ≤88 (single sample)	mg/L	Wildlife Propagation and Stock Watering
pH (standard units)	≥6.5 to ≤9.0	units	Coldwater Marginal Fish Propagation
Solids, total dissolved	≤2,500 (mean) ≤4,375 (single sample)	mg/L	Wildlife Propagation and Stock Watering
Total Petroleum Hydrocarbon	≤10	mg/L	Wildlife Propagation and Stock Watering
Oil and Grease	≤10		
Sodium Adsorption Ratio	<10	ratio	Irrigation Waters

Minnesota designates the North Fork and South Fork Yellow Bank Rivers as Class 2 waters. The acute *E. coli* water quality standard for Class 2 waters is 1,260 organisms/100ml and the chronic standard (geometric mean) is 126 organisms/100ml. To protect the downstream uses of the North Fork and South Fork Yellow Bank Rivers the TMDL targets for both impaired segments in South Dakota will be based on Minnesota's chronic *E. coli* threshold for Class 2 waters. The bacteria standards are applicable from April 1 through October 31. This approach will provide conservative protection and ensure compliance with both state standards.

3.0 Significant Sources

3.1 Point Sources

There are no direct point source dischargers within the drainage area of the impaired segments of the North Fork and South Fork Yellow Bank River. There are five permitted CAFO's in the North Fork and no permitted CAFO's in the South Fork watershed.

There are three small communities within the North Fork Yellow Bank River watershed (Figure 2). All communities in the North Fork watershed utilize retention pond systems as a mechanism to treat municipal wastewater. All facilities are regulated by NPDES/Surface Water Discharge permits (Table 3). All NPDES permits require no discharge unless in an emergency. All communities in the North Fork Yellow Bank are in the headwaters of the watershed ranging from 20 to 30 linear kilometers from the upstream end of the impaired segment. No Waste Load Allocation (WLA) is required in the TMDL for the impaired segment of the North Fork Yellow Bank River.

There are five small communities within the South Fork Yellow Bank River watershed (Figure 2). Three communities are not required to have NPDES discharge permits and two communities require NPDES permits (Table 3). The town of Labolt is the only community in the South Fork Yellow Bank watershed authorized to discharge wastewater.

Table 3. NPDES permit and waste load status of all communities in the North and South Fork Yellow Bank River watershed.

Watershed	Community	Population	NPDES permit status	WLA
North Fork Yellow Bank	South Shore	270	NPDES permit-no discharge	no
North Fork Yellow Bank	Stockholm	105	NPDES permit-no discharge	no
North Fork Yellow Bank	Strandburg	69	NPDES permit-no discharge	no
South Fork Yellow Bank	Altamont	34	No NPDES permit	no
South Fork Yellow Bank	Tunerville	0	No NPDES permit	no
South Fork Yellow Bank	Albee	10	No NPDES permit	no
South Fork Yellow Bank	Revillo	147	NPDES permit-no discharge	no
South Fork Yellow Bank	LaBolt	76	NPDES permit-discharge	yes

Wastewater discharge from the town of Labolt does not flow into the impaired segment of the South Fork Yellow Bank River in South Dakota. Rather, it flows to an unnamed (9,10) tributary of the South Fork Yellow Bank River approximately 21 kilometers (13 miles), upstream of the Minnesota border. The town of LaBolt's discharge is not impacting the impaired segment of the South Fork Yellow Bank River and was not given a WLA for the *E. coli* TMDL. Table 4 provides basic system information and permit numbers for the town of LaBolt wastewater discharge facility.

Table 4. Basic information for LaBolt's wastewater discharge system.

Permit Number	Facility Name	System comments	Pond 1 (acres)	Pond 2 (acres)	Pond 3 (acres)
SD0026662	LaBolt-Town of	Pond system-wetlands	0.65	0.25	0.25

Table 5 provides information used by SD DENR to calculate the maximum daily allowable discharge for the LaBolt facility. The WLA calculation is based on the effluent limits included in the surface water discharge permit, multiplied by the 80th percentile maximum flow rate. The normal operation of this system would typically result in only a portion of the calculated daily amounts actually being discharged. All discharges are required to meet the chronic water quality standards.

Table 5. Waste load allocation for Labolt's wastewater discharge system.

Facility Name	Flow (cfs) used in WLA	*E .coli* (cfu/100ml) permit limit	Fecal Coliform WLA (cfu/day)
LaBolt-Town of	0.176	1178	5.08×10^9

The NPDES discharge permit for the LaBolt facility has no monitoring requirements. The population of LaBolt is small (n=76) and while discharge is allowed twice annually, it is likely infrequent and at short durations of less than one week in most years. Discharge is most likely to occur early in the spring or late in the fall outside the peak recreation season. The LaBolt facilities pond structure provides a mechanism to reduce *E. coli* bacteria. Bacteria in the ponds are not likely viable for long periods due to extended retention time and resultant exposure to the sun's ultraviolet light. In addition, any potential minor bacterial discharge from LaBolt will be degraded before it reaches the Class 2 segment of the Yellow Bank River in Minnesota. Therefore, the relative assumption is that potential *E. coli* bacteria contributions from the LaBolt facility are minor and not impacting downstream waters in Minnesota.

3.2 Nonpoint Sources

Nonpoint sources of *E. coli* bacteria in the North and South Fork Yellow Bank River watersheds are attributed primarily to agricultural sources. Due to a lack of literature values for *E. coli* production of many livestock and wildlife species, source loading calculations were based on fecal coliform. The basis for using fecal coliform as a surrogate for *E. coli* is further described in Section 4.3. Data from the National Agricultural Statistic Survey and from the most recent South Dakota Game Fish and Parks County Wildlife Assessment were used to estimate livestock and wildlife densities, respectively (USDA, 2012, Huxoll, 2002). Animal density information was used to estimate relative source contributions of bacteria loads for the North and South Fork Yellow Bank River watersheds (Tables 6 and 7). Production of bacteria in the North and South Fork Yellow Bank River watersheds is estimated at 1.33E+10 and 1.62E+09 colony forming units/acre/day, respectively.

Over 90% of the North Fork Yellow Bank Watershed resides in Grant County. Therefore, animal density estimates were based exclusively on the NASS estimates from Grant County. The total numbers of animals in Grant County were divided proportiona1 to the number of acres in the watershed. The same procedure was also used for human and wildlife.

Table 6. North Fork Yellow Bank watershed *E. coli* sources.

Species	#/acre	Bacteria /Animal/Day	Bacteria/Acre	Percent
Dairy cow3	2.05E-02	1.01E+11	2.07E+09	15.7%
Beef3	1.04E-01	2.08E+11	1.09E+10	82.2%
Hog3	7.14E-03	1.08E+10	7.71E+07	0.6%
Sheep3	6.09E-03	1.20E+10	7.30E+07	0.6%
Horse3	1.11E-03	4.20E+08	4.66E+05	0.004%
All Wildlife	**Sum of all wildlife**		9.89E+07	0.7%
Human3	1.68E-02	2.00E+09	3.37E+07	0.3%
Turkey (Wild)2	1.83E-03	9.30E+07	1.70E+05	
Goose3	1.60E-03	4.90E+10	7.85E+07	
Deer3	6.18E-03	5.00E+08	3.09E+06	
Beaver3	9.16E-04	2.50E+08	2.29E+05	
Raccoon3	9.16E-03	1.25E+08	1.14E+06	
Coyote/Fox4	1.60E-03	4.09E+09	6.55E+06	
Muskrat2	2.29E-02	1.25E+08	2.86E+06	
Opossom5	1.83E-04	1.25E+08	2.29E+04	
Mink5	1.14E-03	1.25E+08	1.43E+05	
Skunk5	3.66E-03	1.25E+08	4.58E+05	
Badger5	7.78E-04	1.25E+08	9.73E+04	
Jackrabbit5	3.43E-03	1.25E+08	4.29E+05	
Cottontail5	2.06E-02	1.25E+08	2.58E+06	
Squirrel5	2.06E-02	1.25E+08	2.58E+06	
2 USEPA 2001				
3 Bacteria Indicator Tool Worksheet				
4 Best Professional Judgment based off of Dogs				
5 FC/Animal/Day copied from Raccoon to provide a more conservative estimate of background effects of wildlife				

Approximately 60% and 40% of the South Fork Yellow Bank Watershed resides in Grant and Deuel counties. Therefore, animal density estimates were based exclusively on the NASS estimates for these counties. The total numbers of animals in each county were divided proportiona1 to the number of acres in the watershed. The same procedures were also used for human and wildlife.

Table 7. South Fork Yellow Bank watershed *E. coli* sources.

Species	#/acre	Bacteria/Animal/Day	Bacteria/Acre	Percent
Dairy cow3	2.19E-03	1.01E+11	2.21E+08	13.8%
Beef3	1.29E-02	1.04E+11	1.34E+09	83.6%
Hog3	4.47E-04	1.08E+10	4.83E+06	0.3%
Sheep3	9.47E-04	1.20E+10	1.14E+07	0.7%
Horse3	1.65E-04	4.20E+08	6.92E+04	0.004%
All Wildlife	**Sum of all wildlife**		2.18E+07	1.4%
Human3	1.682E-03	2.00E+09	3.36E+06	0.2%
Turkey (Wild)2	1.36E-04	9.30E+07	1.27E+04	
Goose3	3.88E-04	4.90E+10	1.90E+07	
Deer3	8.47E-04	5.00E+08	4.23E+05	
Beaver3	8.61E-05	2.50E+08	2.15E+04	
Raccoon3	9.33E-04	1.25E+08	1.17E+05	
Coyote/Fox4	3.09E-04	4.09E+09	1.26E+06	
Muskrat2	1.61E-03	1.25E+08	2.01E+05	
Opossom5	1.87E-05	1.25E+08	2.33E+03	
Mink5	1.44E-04	1.25E+08	1.79E+04	
Skunk5	5.74E-04	1.25E+08	7.18E+04	
Badger5	9.19E-05	1.25E+08	1.15E+04	
Jackrabbit5	3.59E-04	1.25E+08	4.49E+04	
Cottontail5	2.30E-03	1.25E+08	2.87E+05	
Squirrel5	2.44E-03	1.25E+08	3.05E+05	
2 USEPA 2001				
3 Bacteria Indicator Tool Worksheet				
4 Best Professional Judgment based off of Dogs				
5 FC/Animal/Day copied from Raccoon to provide a more conservative estimate of background effects of wildlife				

3.2.1 Agriculture

Manure from livestock is a potential source of *E. coli* bacteria to the North and South Fork Yellow Bank watersheds. Livestock in theses basins are predominantly beef and dairy cattle. Livestock can contribute bacteria directly to the stream by defecating while wading in the stream. They can also contribute by defecating while grazing on rangelands that get washed off during precipitation events. Table 8 allocates sources of bacteria production in both watersheds into three primary categories. The summary is based on several assumptions. Feedlot numbers were calculated as the sum of all dairy, hog, and the NASS estimate of beef in feeding areas. All remaining livestock were assumed to be on grass.

Table 8. Bacteria source allocation for the North and South Fork Yellow Bank watersheds.

	Percentage	
Source	**North Fork**	**South Fork**
Feedlots	32%	29%
Livestock on Grass	67%	70%
Wildlife	1%	1%

The main source of *E. coli* bacteria in the North and South Fork Yellow Bank watersheds is livestock grazing. Bacteria migration from small feeding areas and upland grazing is most likely occurring during major run-off events. Direct use of the stream by livestock is the most likely source of bacteria at lower flows. Evidence of this is available in the load duration curves which indicate that elevated counts of *E. coli* occur throughout different flow regimes. Beef and dairy cattle were found to contribute the most significant amount of bacteria to the North and South Fork Yellow Bank watersheds (Tables 6 and 7).

3.2.2 Human

Several communities are located in the North and South Fork Yellow Bank River watersheds. Wastewater treatment systems serve 444 of the approximate 3000 people in the North Fork Yellow Bank watershed. Wastewater treatment systems serve 267 of the approximate 1600 people in the South Fork Yellow Bank watershed. Septic systems are assumed to be the primary human source for the rural population in both watersheds. When included in the total load, this population produces less than 0.5% of all fecal coliform produced in both watersheds. Human fecal production may be estimated at 1.95E+9 (Yagow et al., 2001). These bacteria should all be delivered to a septic system, which if functioning correctly would result in no bacteria entering the river systems. Septic system failure was not identified as a source of concern during the field investigation conducted in the North and South Fork Yellow Bank River watersheds.

3.2.3 Natural background/wildlife

Wildlife within the watershed is a natural background source of *E. coli* bacteria. Wildlife population density estimates were obtained from the South Dakota Department of Game, Fish, and Parks (Huxoll, 2002). The estimated wildlife contribution of bacteria in the North and South Fork Yellow Bank watersheds (0.7% and 1.4%) was considered insignificant in comparison to livestock sources.

4.0 Technical Analysis

4.1 Data Collection Method

Data used to develop the *E. coli* TMDLs for the impaired segments of the North and South Fork Yellow Bank River were based on two primary sources. First, *E. coli* samples were collected during the Upper Minnesota River (UMR) Water Quality Assessment project in 2010 and 2011. Second, historic *E. coli* and fecal coliform data were obtained from SD DENR's ambient Water Quality Monitoring (WQM) network. Monitoring stations were established at the downstream end of the classified segments (limited contact recreation) of the North Fork (UMR08-WQM 460688) and South Fork (UMR12-WQM 460687) at pre-existing WQM sites near the Minnesota border. In addition, monitoring stations were established at the upstream end of both classified segments on the North Fork (UMR07) and South Fork (UMR10) during the UMR project. The upstream sites were established to better characterize bacteria variation in each segment and aid in determining potential upstream issues that may be contributing to the impaired segments. Additional monitoring sites were established on major tributaries in the South Fork watershed to provide Minnesota with a means to determine cumulative loading at the border and to help focus implementation efforts. Figure 2 depicts the monitoring station locations established during the UMR project in the North and South Fork Yellow Bank watersheds.

Continuous stage recorders were installed at the WQM sites on the classified segments of the North and South Forks during the UMR project. Periodic flows measurements were collected to establish stage-discharge relationships. This flow information was modeled against long-term USGS flow records to construct a flow frequency curve for the impaired segments. Unless otherwise noted, analysis was completed with modeling programs according to the most recent version of the Water Quality Modeling in South Dakota document (SDDENR, 2009).

4.2 Flow Analysis

The hydrologic modeling program Aquarius (version 3.00) was used to construct a long-term flow record for the impaired segments of the North Fork and South Fork Yellow Bank River. Stream stage and discharge information collected during the UMR project at the North Fork Yellow Bank site UMR08 (WQM460688) was related to the flow records from USGS 05292704 near Odessa, MN. This USGS gage station was in closest proximity (5 km) and offered the longest flow record. Daily flows from 1991-2011 were used to generate the load duration curve which accurately represents the flow frequencies for the impaired segment.

Stream stage and discharge information collected during the UMR project at the South Fork Yellow Bank site UMR12 (WQM460687) was related to the flow records from USGS 0529300 near Odessa, MN. This USGS station is located approximately 15 km upstream at the confluence of the North and South Forks of the Yellow Bank River. This USGS station offered the longest flow record as all other sites associated with the South Fork were inactive or presented limited flow record. Daily flows from 1939-2011 were used to generate the load duration curve which accurately represents the flow frequencies for the impaired segment.

4.3 Sample Data

A total of 202 *E. coli* samples were collected during the UMR project at sites UMR08 (n=103) and UMR07 (n=99) for the impaired segment of the North Fork Yellow Bank. For the impaired segment of the South Fork Yellow Bank a total of 202 *E. coli* samples were collected from sites UMR12 (n=100) and UMR 10 (n=102). The acute exceedance rate was evaluated based on South Dakota's *E. coli* standard (1178/100ml) for limited contact recreation waters as it is more stringent then the Minnesota acute standard for Class 2 waters (1260/100ml). The acute exceedance rate for the impaired segments of the North Fork and South Fork Yellow Bank was 8.9% and 15.3%, respectively. All *E. coli* data collected during the UMR project is available in Appendix A.

Distribution of the *E. coli* concentrations between the upstream (UMR07) and downstream (UMR08) sites of the North Fork Yellow Bank were relatively similar (Figure 3). The downstream site displays a slightly higher median, quartile range and maximum value in comparison to the upstream site. This is likely due more to the increased drainage area then local controls. The relative similarity between the two sites suggests *E. coli* concentrations are representative of the entire segment.

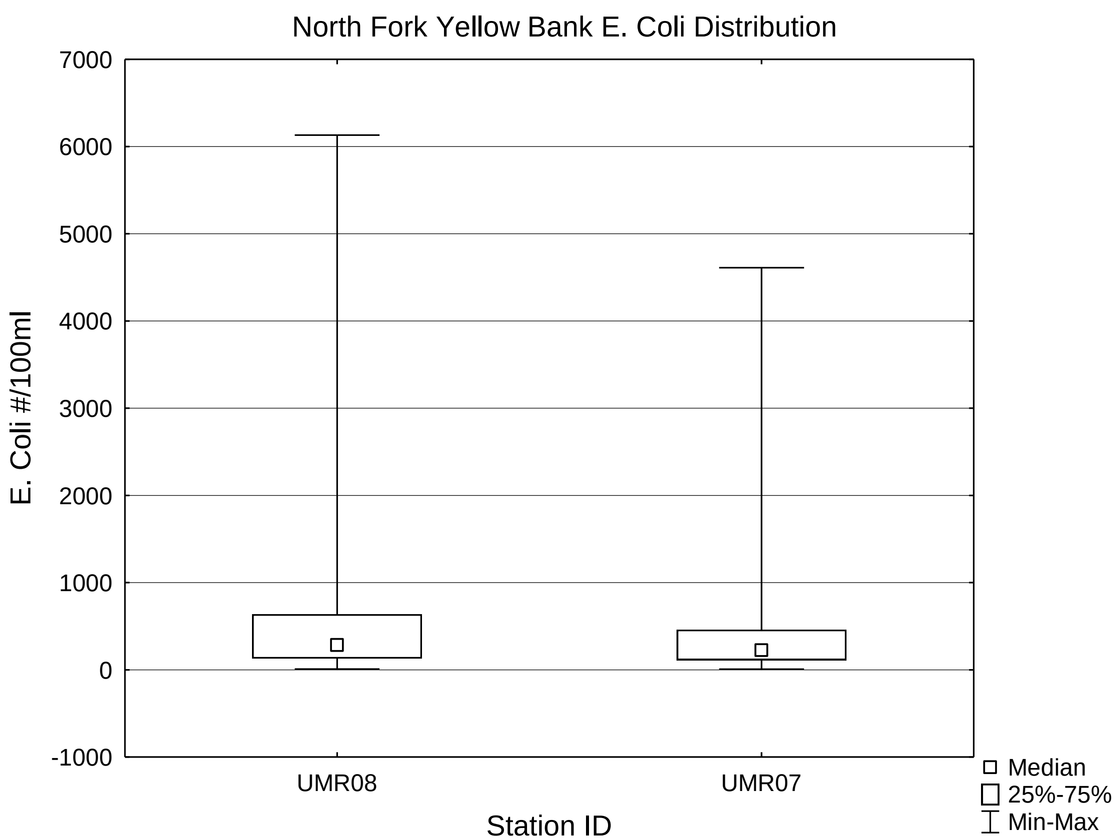

Figure 3. Distribution of *E. coli* between the two North Fork Yellow Bank sites.

Distribution of the *E. coli* concentrations between the upstream (UMR10) and downstream (UMR12) sites of the South Fork Yellow Bank are significantly different ($p<0.05$) (Figure 3). The upstream site displays a higher median, quartile range and maximum value in comparison to the downstream site. This is likely due to local controls in the upper portion of the watershed. The *E. coli* concentrations between the upstream site and downstream site characterize the variation of the impaired segment. The upper portion of the segment appears to be receiving elevated bacteria and is a prime target for implementation efforts focused on riparian and grazing management.

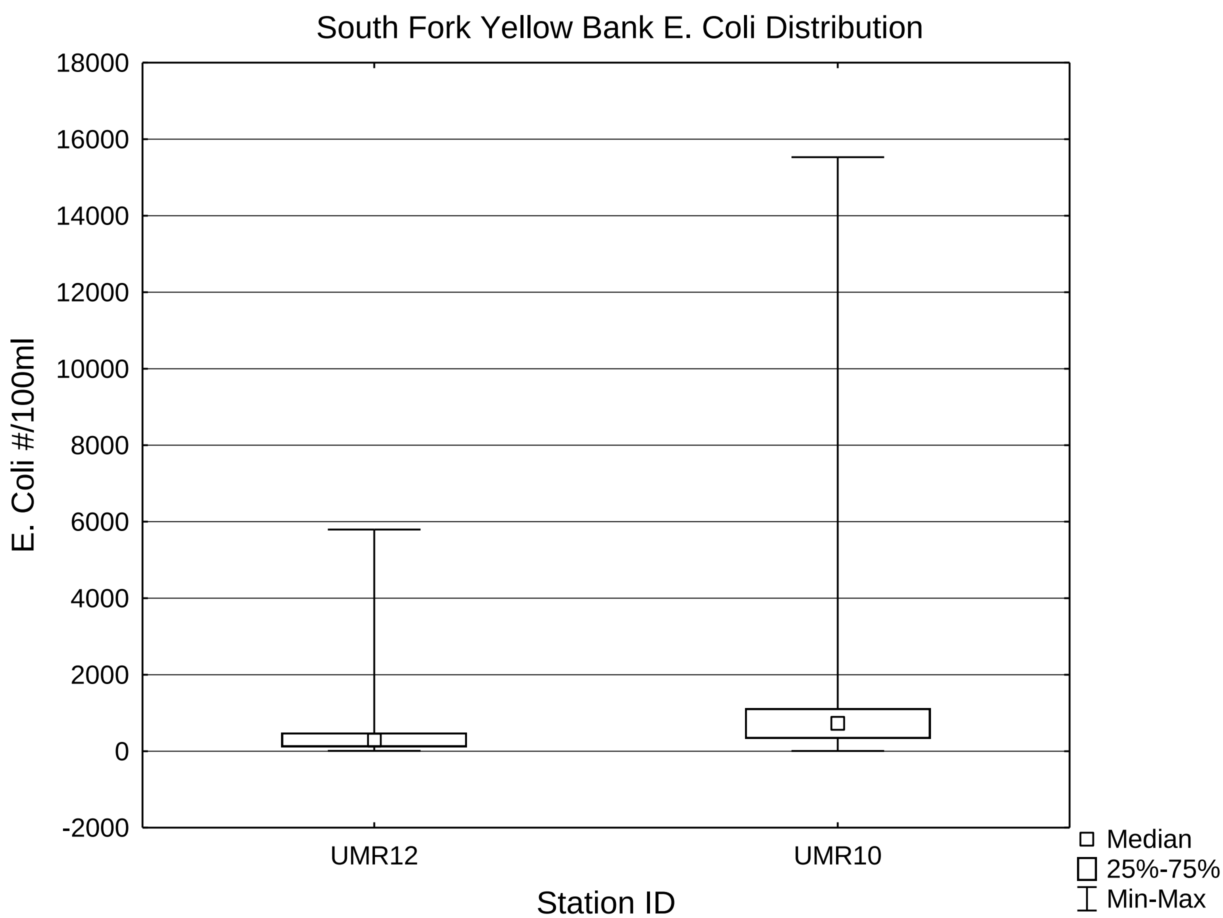

Figure 4. Distribution of *E. coli* between the two South Fork Yellow Bank sites.

During the UMR project an attempt was made to collect the minimum monthly number (n=5) of *E. coli* samples required to calculate a geometric mean. The geometric means calculated at both sites on the impaired segments of the North Fork and South Fork Yellow Bank demonstrate high exceedance rates in comparison to Minnesota's *E. coli* standard of 126 organisms/100ml for Class 2 waters (Table 9). The exceedance rate for the North and South Fork Yellow Bank was calculated at 90% (19 out of 21) and 81% (18 out of 22) when compared to the Minnesota chronic standard, respectively. The exceedance rate was 10% (2 out of 21) and 36% (8 out of 22) for the North and South Fork Yellow Bank sites when compared to the South Dakota chronic standard (630/100ml) for limited contact recreation waters. These exceedance rates demonstrate impairment in accordance with each states standards and 303(d) listing methodologies.

Table 9. Monthly *E. coli* geometric means for the impaired segments of the North and South Yellow Bank.

North Fork Yellow Bank

Site	Month/Year	Geometric Mean (MPN/100ml)		Site
UMR08	May-10	220	Na	UMR07
UMR08	Jun-10	174	242	UMR07
UMR08	Jul-10	431	257	UMR07
UMR08	Aug-10	181	147	UMR07
UMR08	Sep-10	596	613	UMR07
UMR08	Apr-11	31	31	UMR07
UMR08	May-11	107	130	UMR07
UMR08	Jun-11	383	374	UMR07
UMR08	Jul-11	813	733	UMR07
UMR08	Aug-11	270	167	UMR07
UMR08	Sep-11	544	374	UMR07

South Fork Yellow Bank

Site	Month/Year	Geometric Mean (MPN/100ml)		Site
UMR12	May-10	78	395	UMR10
UMR12	Jun-10	342	922	UMR10
UMR12	Jul-10	439	1088	UMR10
UMR12	Aug-10	451	739	UMR10
UMR12	Sep-10	694	1527	UMR10
UMR12	Apr-11	21	16	UMR10
UMR12	May-11	81	128	UMR10
UMR12	Jun-11	310	1321	UMR10
UMR12	Jul-11	470	1003	UMR10
UMR12	Aug-11	198	448	UMR10
UMR12	Sep-11	298	1036	UMR10

Monthly geometric means for *E. coli* appear to be relatively similar between the upstream (UMR8) and downstream (UMR7) sites on the impaired segment of the North Fork Yellow Bank. The geometric means appear to deviate significantly higher on the upstream site (UMR10) then the downstream site (UMR12) of impaired segment of the South Fork Yellow Bank. As described above this is likely due to local controls in the upper portion of the watershed.

A preliminary analysis was performed to evaluate the distribution of geometric mean values plotted against the average monthly load frequency curve for the impaired segment of the North and South Fork Yellow Bank based on the Class 2 waters standard of 126 organisms/100mL. The North Fork contained 21 geometric mean values poorly distributed over the curve. Most values were clustered at 20%, 30-50% and at 80% of the flow frequency. There were no values to represent low flows and one value in the high flow range well below the chronic threshold. The South Fork contained 22 geometric mean values all distributed from 0% to 46% of the flow frequency. There were no *E. coli* geometric mean values to represent over half of the monthly flow frequency curve.

A conservative approach was used to develop the load duration curve and *E. coli* TMDLs for the impaired segments of the North and South Forks of the Yellow Bank River. The individual bacteria loadings were plotted against the daily load frequency curve based on Minnesota's chronic threshold (126 organisms/100ml) for Class 2 waters. This approach was considered acceptable to avoid confusion, facilitate interpretation and assure compliance with the acute and chronic standards in South Dakota and Minnesota.

Fecal coliform bacteria can provide a useful surrogate for *E. coli* in TMDL development. *E. coli* is a fecal coliform bacterium and both indicators originate from common sources in relatively consistent proportions. A relational analysis was performed on paired fecal coliform and *E. coli* concentrations collected from streams in the North Glaciated Plains ecoregion (ecoregion 46) which includes the North and South Fork Yellow Bank River watersheds. Fecal coliform and *E. coli* concentrations from over 2,200 paired samples were logarithmically transformed and plotted. *E. coli* (Y-axis) was plotted as a function of fecal coliform (X-axis) and the result was a best fit linear relationship yielding an r^2 value of 0.64 (Figure 5). The slope equation yields nearly a 1:1 relationship suggesting that fecal coliform data may be directly substituted in an absence of adequate *E. coli* data in ecoregion 46. This relationship also justifies the use of fecal coliform based literature values for determining bacteria source allocations in Section 3.2

All available fecal coliform data collected within the applicable timeframe (April 1 to October 31) for Class 2 waters was used to supplement the *E. coli* data in the load duration curve framework. This approach allowed for a better distribution of bacteria loading across the entire flow frequency curve for both impaired segments. Historic fecal coliform data collected at WQM 460688 (UMR8) was used for the North Fork Yellow Bank and fecal coliform data from WQM 460687 (UMR12) was used for the South Fork Yellow Bank analysis.

Fecal coliform data for the impaired segment of the North Fork Yellow Bank comprised 5% (n=12) of the total bacteria dataset. Fecal coliform data consisted mostly of April and October samples collected from 1991-2003. All fecal coliform data was well within the range of the *E. coli* dataset. Fecal coliform data used for the impaired segment of the South Fork Yellow Bank comprised 18% (n=44) of the total bacteria dataset. Fecal coliform data was available for several months within the applicable timeframe from 1978 to 2008. Again, all fecal coliform data was well within the range of the *E. coli* dataset. All bacteria data used in the TMDL analysis are presented in Appendix A.

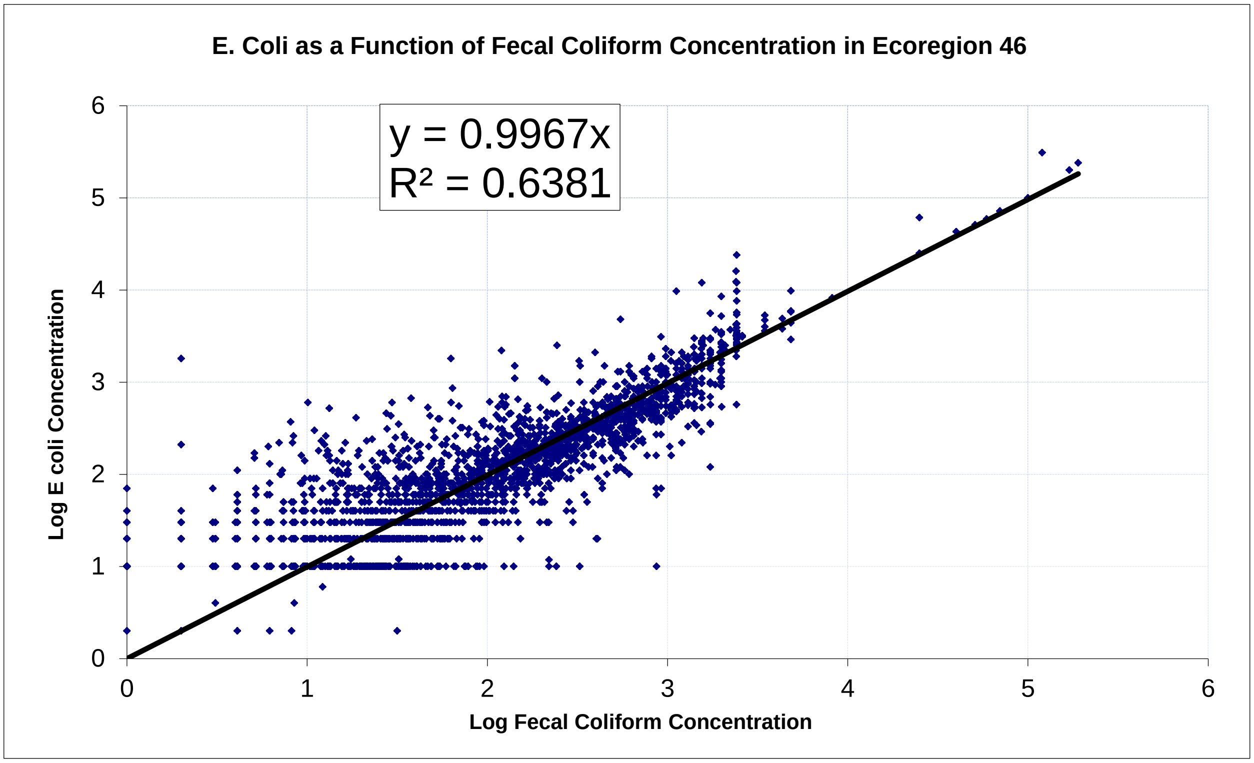

Figure 5. Linear relationship between paired *E. coli* and fecal coliform concentrations in ecoregion 46.

5.0 North Fork Yellow Bank TMDL and Allocations

The load duration curve generated for the impaired segment of the North Fork Yellow Bank was separated into five flow zones (Figure 6). Flow zones were defined according to the flow regime structure and distribution of the observed data following guidance recommended by EPA (USEPA, 2001). Five distinct flow zones were established to facilitate interpretation of the hydrologic conditions and patterns associated with the impairment. The zones were segmented by high flows (0-10 percent), moist conditions (10-40 percent), mid-range flows (40-60 percent), dry conditions (60-90 percent) and low flows (90-100 percent).

The bacteria data represents individual loadings calculated based on the flows constructed from the respective USGS gauge. Bacteria loads are plotted against the load frequency curve based on the Minnesota threshold for Class 2 waters of 126 organisms/100mL (Figure 6). Sample data is well distributed across the flow regimes with the exception of the low flow zone. Lower flows (<1.9 cfs) can occur during the recreation season. Two samples have been collected which provides representation of these conditions.

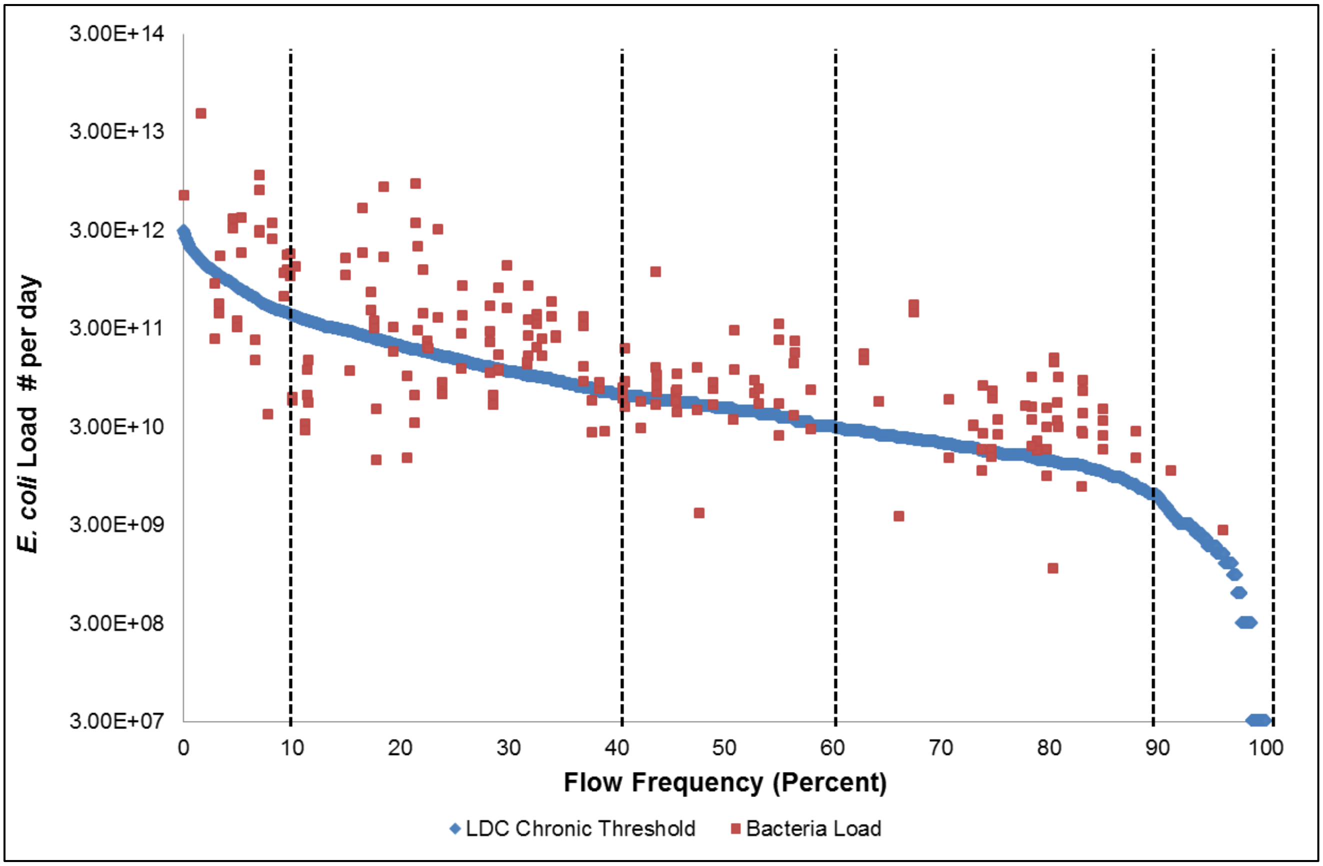

Figure 6. Load Duration Curve for the North Fork Yellow Bank impaired segment.

All TMDL components including numeric calculations for each flow zone associated with the impaired segment of the North Fork Yellow Bank are presented in Table 10. The current loads for all flow zones except the low flow zone were calculated by multiplying the 95th percentile flow and concentration. The current load for the low flow zone was calculated by multiplying the 95th percentile flow and maximum concentration. The max concentration was used due to the low density of samples available to represent this infrequent flow occurrence during the recreation season. Reduction calculations were based on reducing a single sample to the chronic threshold (126 organisms/100ml) to assure compliance with the Minnesota acute and chronic standards for Class 2 waters. Meeting this threshold will also assure compliance with South Dakota standards for limited contact recreation waters. No point sources discharges contribute to the impaired segment so the WLA was zero for all flow zones. As a result, all reductions are required from nonpoint sources (LA).

Table 10. *E. coli* TMDL and flow zone allocations for the North Fork Yellow Bank impaired segment.

TMDL Component	North Fork Yellow Bank Flow Zones Expressed as (# organisms/100ml)				
	High Flows	Moist Conditions	Mid-range Flows	Dry Conditions	Low Flows
	>131.6 cfs	>21 cfs	>9.8 cfs	>1.9 cfs	<1.9 cfs
LA	**1.8E+12**	**2.7E+11**	**4.6E+10**	**1.7E+10**	**3.1E+09**
WLA	**0**	**0**	**0**	**0**	**0**
MOS	**3.6E+11**	**8.3E+10**	**1.6E+10**	**1.0E+10**	**1.8E+09**
TMDL @ 126 CFU/ 100 mL	**2.2E+12**	**3.6E+11**	**6.2E+10**	**2.8E+10**	**4.9E+09**
Current Load*	**3.7E+13**	**6.6E+12**	**5.0E+11**	**3.0E+11**	**1.3E+10**
Load Reduction	**94%**	**95%**	**88%**	**91%**	**63%**

5.0.1 High Flows (<10% flow frequency)

The high flow zone represents the high flows in the North Fork Yellow Bank. The flow rate for this zone was widely variable ranging from 962 cfs to 131.6 cfs. Flows represented in this zone occur on an infrequent basis and are characteristic of significant run-off events typically during spring and early summer. High flows are commonly the product of spring snowmelt events but may be generated by intense rain events. Bacteria sources across the watershed have the potential to be conveyed to the stream channel during high flow conditions. The 95th percentile bacteria concentration was calculated at 2,179 organisms/100ml. An *E. coli* load reduction of 94% is required to achieve compliance with the acute and chronic thresholds.

5.0.2 Moist Conditions (10% to 40% flow frequency)

Moist conditions represent the portion of the flow regime that occurs following moderate storm events. Flows in this zone vary from 131.5 cfs to 21 cfs. The flows in this zone occur in early to mid-summer near the peak of the recreation season providing for optimal recreational opportunity. Sources of bacteria may be expected to be closer to the channel and somewhat easier to mitigate than those impacting the high flows. The 95th percentile bacteria concentration was calculated at 2,331 organisms/100ml. An *E. coli* load reduction of 95% is required to achieve compliance with the acute and chronic thresholds.

5.0.3 Mid-range Flows (40% to 60% flow frequency)

Mid-range flow conditions represent flow rates between 21 cfs and 9.8 cfs. This portion of the flow regime likely occurs in mid to late summer. Run-off from storm events is likely minimized by mature vegetative growth present during the peak of the growing season. Flows in this zone may also represent conditions that occur in the fall during recovery periods of dryness. Mid-range flows represent the transition from run-off based flow to base flows. Bacteria sources in this flow zone likely originated near the channel or within the riparian zone. The 95th percentile bacteria concentration was calculated at 1,029 organisms/100ml. An *E. coli* load reduction of 88% is required to achieve compliance with the acute and chronic thresholds.

5.0.3 Dry Conditions (60% to 90% flow frequency)

Dry conditions represent flow rates between 9.8 cfs and 1.9 cfs. Dry condition flows are best characterized as base flow conditions influenced by ground water sources. Bacteria sources likely originate in the stream channel during dry flow conditions. The 95th percentile bacteria concentration was calculated at 1,357 organisms/100ml. An *E. coli* load reduction of 91% is required to achieve compliance with the acute and chronic thresholds.

5.0.3 Low Flows (90% to 100% flow frequency)

The Low flow zone represents minimal to no flow conditions of less than 1.9 cfs. Recreation uses and associated standards are applicable to all flow conditions. However, lower flows result in reduced recreational opportunities. Bacteria sources likely originate in the stream channel during low flow conditions. Limited data availability (n=2) for the lowest flow zone is a product of reduced frequency of these flows during the recreational season. Nonetheless, the maximum concentration of 340 organisms/100ml was used to derive the current load at the standard resulting in an *E. coli* load reduction of 63% required to achieve compliance with the acute and chronic thresholds. Mitigation efforts affecting preceding flow zones are expected to result in reductions in the low zone to achieve compliance with acute and chronic standards.

5.1 South Fork Yellow Bank TMDL and Allocations

The load duration curve generated for the impaired segment of the South Fork Yellow Bank was separated into five flow zones (Figure 7). Flow zones were defined according to the flow regime structure and distribution of the observed data following guidance recommended by EPA (USEPA, 2001). Five distinct flow zones were established to facilitate interpretation of the hydrologic conditions and patterns associated with the impairment. The zones were segmented by high flows (0-10 percent), moist conditions (10-40 percent), mid-range flows (40-60 percent), dry conditions (60-90 percent) and low flows (90-100 percent).

The bacteria data represents individual loadings calculated based on the long-term daily flows records from the respective USGS gauge. Bacteria loads are plotted against the load frequency curve based on the Minnesota threshold for Class 2 waters of 126 organisms/100mL (Figure 7). Bacteria data is relatively dense and well distributed across the high and moist (0% to 40%) flow zones of the flow frequency curve. Bacteria data was more sparsely distributed across the remaining flow regimes. Low flow (<1.9 cfs) conditions are relatively infrequent, but can occur during the recreation season. One sample was available to represent the bacteria loading for the low flow zone condition.

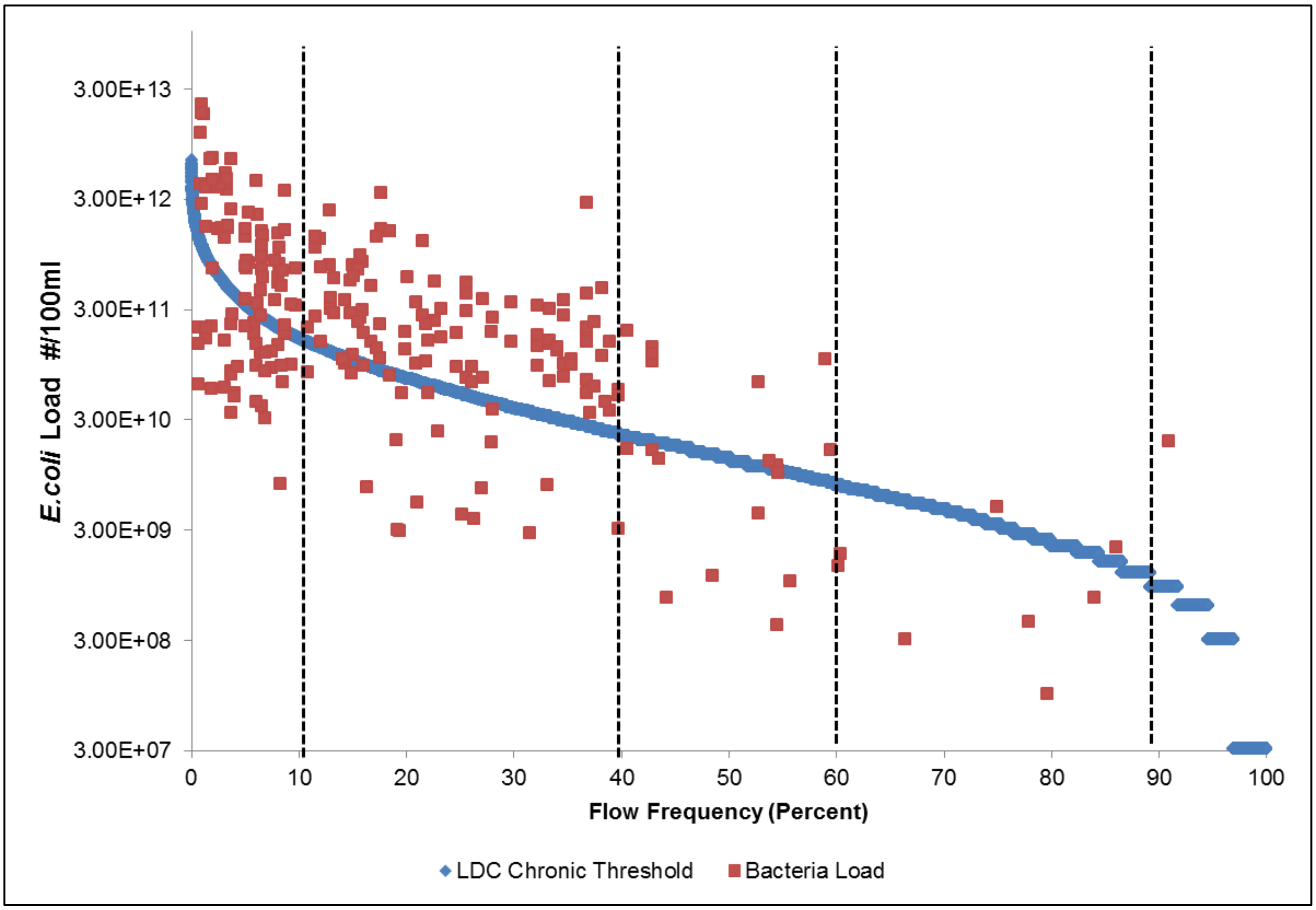

Figure 7. Load Duration Curve for the South Fork Yellow Bank impaired segment.

All TMDL components including numeric calculations for each flow zone associated with the impaired segment of the South Fork Yellow Bank are presented in Table 11. The current loads for all flow zones except the dry and low flow zone were calculated by multiplying the 95th percentile flow and concentration. The current load for the dry and low flow zones were calculated by multiplying the 95th percentile flow and maximum concentration. The maximum concentration was used due to the low density of samples available to represent these infrequent flow occurrences during the recreation season. Reduction calculations were based on reducing a single sample to the chronic threshold (126 organisms/100ml) to assure compliance with the Minnesota acute and chronic standards for Class 2 waters. Meeting this threshold will also assure compliance with South Dakota standards for limited contact recreation waters. No point sources discharges contribute to the impaired segment so the WLA was zero for all flow zones. As a result, all reductions are required from nonpoint sources (LA).

Table 11. *E. coli* TMDL and flow zone allocations for the South Fork Yellow Bank impaired segment.

TMDL Component	South Fork Yellow Bank Flow Zones Expressed as (organisms/100ml)				
	High Flows	Moist Conditions	Mid-range Flows	Dry Conditions	Low Flows
	>53.3 cfs	>7 cfs	>2.5 cfs	>0.3 cfs	<0.3 cfs
LA	**1.5E+12**	**1.1E+11**	**1.6E+10**	**4.9E+09**	**6.2E+08**
WLA	**0**	**0**	**0**	**0**	**0**
MOS	**1.7E+11**	**2.8E+10**	**4.6E+09**	**2.2E+09**	**3.1E+08**
TMDL @ 126 CFU/ 100 mL	**1.7E+12**	**1.4E+11**	**2.1E+10**	**7.1E+09**	**9.2E+08**
Current Load*	**2.9E+13**	**2.7E+12**	**2.0E+11**	**1.0E+10**	**1.9E+10**
Load Reduction	**94%**	**95%**	**89%**	**30%**	**95%**

5.1.1 High Flows (<10% flow frequency)

The high flow zone represents the high flows in the South Fork Yellow Bank. The flow rate for this zone was widely variable ranging from 2,224 cfs to 53.3 cfs. Flows represented in this zone occur on an infrequent basis and are characteristic of significant run-off events typically during spring and early summer. High flows are commonly the product of spring snowmelt events but may be generated by intense rain events. Bacteria sources across the watershed have the potential to be conveyed to the stream channel during high flow conditions. The 95th percentile bacteria concentration was calculated at 2,134 organisms/100ml. An *E. coli* load reduction of 94% is required to achieve compliance with the acute and chronic thresholds.

5.1.2 Moist Conditions (10% to 40% flow frequency)

Moist conditions represent the portion of the flow regime that occurs following moderate storm events. Flows in this zone vary from 53.3 cfs to 7 cfs. The flows in this zone occur in early to mid-summer near the peak of the recreation season providing for optimal recreational opportunity. Sources of bacteria may be expected to be closer to the channel and somewhat easier to mitigate than those impacting the high flows. The 95th percentile bacteria concentration was calculated at 2,419 organisms/100ml. An *E. coli* load reduction of 95% is required to achieve compliance with the acute and chronic thresholds.

5.1.3 Mid-range Flows (40% to 60% flow frequency)

Mid-range flow conditions represent flow rates between 7 cfs and 2.5 cfs. This portion of the flow regime likely occurs in mid to late summer. Run-off from storm events is likely minimized by mature vegetative growth present during the peak of the growing season. Flows in this zone may also represent conditions that occur in the fall during periods of recovery from dryness. Mid-range flows represent the transition from run-off based flow to base flows. Bacteria sources in this flow zone likely originated near the channel or within the riparian zone. The 95th percentile bacteria concentration was calculated at 1,192 organisms/100ml. An *E. coli* load reduction of 89% is required to achieve compliance with the acute and chronic thresholds.

5.1.3 Dry Conditions (60% to 90% flow frequency)

Dry conditions represent flow rates between 9.8 cfs and 1.9 cfs. Dry condition flows are best characterized as base flow conditions influenced by ground water sources. Bacteria sources likely originate in the stream channel during dry flow conditions. The maximum bacteria concentration was 180 organisms/100ml. An *E. coli* load reduction of 30% is required to achieve compliance with the acute and chronic thresholds. The current load and reduction is based on a limited (n=8) dataset. Reducing bacteria sources within the stream channel is warranted to assure compliance with acute and chronic standards for the dry flow condition.

5.1.3 Low Flows (90% to 100% flow frequency)

The Low flow zone represents minimal to no flow conditions of less than 0.3 cfs. Recreation uses and associated standards are applicable to all flow conditions. However, lower flows result in reduced recreational opportunities. Bacteria sources likely originate in the stream channel during low flow conditions. Limited data availability (n=1) for the lowest flow zone is a product of reduced frequency of these flows during the recreational season. Nonetheless, the maximum concentration of 2,600 organisms/100ml was used to derive the current load at the standard resulting in an *E. coli* load reduction of 95% required to achieve compliance with the acute and chronic thresholds. Mitigation efforts directed towards preceding flow zones are expected to result in reductions in the low zone to achieve compliance with acute and chronic standards.

5.2 Load Allocations (LAs)

The *E. coli* load capacity for the impaired segments of the North and South Forks of the Yellow Bank River is exclusively attributed to nonpoint source load allocation. The majority of bacteria production in the North Fork (99%) and South Fork (98%) Yellow Bank River watersheds originate from livestock sources. Human and wildlife bacteria production in both watersheds was considered negligible. The majority of the bacteria produced by livestock can be attributed to beef and dairy cattle. Approximately 70% of the livestock in both watersheds were estimated to be on grass or rangeland/pasture. Approximately 30% of the livestock were estimated to be in feedlots. Restoration efforts focused on grazing management and manure management in feedlots may yield the greatest bacteria reduction benefits.

The impaired segments of the North and South Forks of the Yellow Bank River flow directly into Minnesota and form the Yellow Bank River. To protect the downstream uses, bacteria load reductions were based on the single sample maximum chronic threshold to assure compliance with acute and chronic standards for Minnesota Class 2 waters. This conservative approach will also assure attainment of acute and chronic standards for the limited contact recreation use assigned to both impaired segments in South Dakota. The impaired segment of the North Fork Yellow Bank requires a 94% reduction in *E. coli* bacteria from anthropogenic sources (livestock) in the high flow zone. A 95% reduction in *E. coli* bacteria is required in the moist conditions flow zone. An 88% reduction in *E. coli* bacteria is required in the mid-range flow zone. A 91% and 63% reduction in *E. coli* bacteria is required in the dry and low flow zones, respectively. Reducing bacteria concentrations below the chronic threshold in each flow zone provides assurance that both acute and chronic standards will be met. To achieve the specified reductions, primary focus should be placed on reducing bacteria inputs from livestock grazing and feeding areas.

The impaired segment of the South Fork Yellow Bank requires a 94% in *E. coli* bacteria from anthropogenic sources (livestock) in the high flow zone. A 95% reduction in *E. coli* bacteria is required in the moist conditions flow zone. An 89% reduction in *E. coli* bacteria is required in the mid-range flow zone. A 30% and 95% reduction in *E. coli* bacteria is required in the dry and low flow zones, respectively. Reducing bacteria concentrations below the chronic threshold in each flow provides assurance that both acute and chronic standards will be met. To achieve the specified reductions, primary focus should be placed on reducing bacteria inputs from livestock grazing and feeding areas.

5.3 Waste Load Allocations (WLAs)

No point source discharges contribute directly to the impaired segments of the North and South Forks of the Yellow Bank River. As a result, the WLA for both TMDLs were assigned a zero value.

6.0 Margin of Safety (MOS) and Seasonality

6.1 Margin of Safety

An explicit MOS using a duration curve framework is basically unallocated assimilative capacity intended to account for uncertainty (e.g., loads from tributary streams, effectiveness of controls, etc). An explicit MOS was calculated as the difference between the loading capacity at the mid-point of each of the flow zones and the loading capacity at the minimum flow in each zone. A substantial MOS is provided using this method as the loading capacity is typically much less at the minimum flow of a zone as compared to the mid-point. Because the allocations are a direct function of flow, accounting for potential flow variability is an appropriate way to address the MOS.

6.2 Seasonality

Seasonality is an important factor when considering patterns associated with bacteria contamination. Bacteria samples used in the TMDL analysis were collected from April to

October to cover seasonal differences and satisfy the criterion associated with the standards for Minnesota Class 2 waters. Seasonal variation is also a component of the load duration curve framework through the establishment of individual flow zones and associated TMDL load allocations. Daily bacteria loads exceed the chronic TMDL threshold consistently throughout the flow regimes of both the impaired segments of the North Fork and South Fork Yellow Bank. The implications of this pattern suggest bacteria contamination in both systems is continual. Bacteria conveyance in the spring and early summer is likely to occur watershed wide during high, moist and mid-range flows. Bacteria contamination is more likely to be localized to the riparian zone and direct stream channels in the summer and fall during dry and low flow conditions. Focusing restoration efforts to account for these seasonal patterns is warranted to achieve attainment goals.

7.0 Public Participation

STATE AGENCIES

The South Dakota Department of Environment and Natural Resources (SD DENR) formed a partnership with the Minnesota Pollution Control Agency (MPCA) to provide technical support for project activities and coordination of the Upper Minnesota River Watershed Water Quality Assessment (i.e. UMR project). SD DENR also provided financial support for the UMR project and was the primary agency involved in the completion of this TMDL document. Bacteria data collected during the UMR project was supplemented with bacteria data available from SD DENR’s ambient water quality monitoring stations in the Yellow Bank watershed.

FEDERAL AGENCIES

The Environmental Protection Agency (EPA) provided a significant portion of the funding for the UMR project. Long-term daily stream flow data was obtained from United States Geologic Survey (USGS) gauge sites. This data was used in conjunction with flow data collected during the UMR project to construct long-term flow frequency curves for the impaired segments.

LOCAL GOVERNMENT, INDUSTRY, ENVIRONMENTAL, AND OTHER GROUPS AND PUBLIC AT LARGE

East Dakota Water Development District (EDWDD) was the primary South Dakota local sponsor for the UMR project. The district provided significant funding, field support and administrative processing during the UMR project. Two local watershed districts in Minnesota also provided support for the UMR project. The Upper Minnesota River Watershed District provided in-kind services and technical support to the local project coordinator responsible for sample collection. The Lac qui Parle-Yellow Bank River Watershed District also provided field support, funding and other in-kind services.

Public interest in the UMR project was a result of communications between EDWDD, local South Dakota conservation districts (Grant and Roberts), local Minnesota watershed districts, Citizens for Big Stone Lake and other stakeholder groups concerned with water quality in the Whetstone and Yellow Bank watersheds. Public involvement was encouraged through several multi-media networks during the UMR project.

This TMDL document was placed on public notice in June 2012. Several participating entities in South Dakota and Minnesota were notified and the notice was published in several local newspapers from both states in close proximity to the Yellow Bank watershed. The TMDL document was made available for review on the SD DENR website home page. All comments received are taken into consideration in the final document

8.0 Monitoring Strategy

The Department may adjust the load and/or waste load allocations in this TMDL to account for new information or circumstances that are developed or come to light during the implementation of the TMDL and a review of the new information or circumstances indicate that such adjustments are appropriate. Adjustment of the load and waste load allocation will only be made following an opportunity for public participation. New information generated during TMDL implementation may include, among other things, monitoring data, BMP effectiveness information and land use information. The Department will propose adjustments only in the event that any adjusted LA or WLA will not result in a change to the loading capacity; the adjusted TMDL, including its WLAs and LAs, will be set at a level necessary to implement the applicable water quality standards; and any adjusted WLA will be supported by a demonstration that load allocations are practicable. The Department will notify EPA of any adjustments to this TMDL within 30 days of their adoption. Bacteria monitoring will continue for both impaired segments through the states Ambient Water Quality Monitoring Program. This data will provide a means for future evaluation to determine compliance of both impaired segments.

9.0 Restoration Strategy

The TMDLs for the North Fork (SD-MN-R-Yellow_Bank_N_Fork_01) and South Forks (SD-MN-R-Yellow_Bank_S_Fork_01) of the Yellow Bank River correspond exclusively to the 303(d) listed segments identified in South Dakota’s 2012 Integrated Report for Surface Water Quality. During the planning process for the Upper Minnesota River Watershed Water Quality Assessment project (UMR project) monitoring sites were established to determine potential impairment of beneficial uses in South Dakota and to allow quantification of loadings at the South Dakota/Minnesota border for use in potential future TMDL development in Minnesota.

A significant portion of the Yellow Bank watershed resides in South Dakota. Therefore, future implementation efforts will be directed to the entire Yellow Bank River watershed in South Dakota with priority to the sub-watersheds of the impaired segments. In June 2012, South Dakota received EPA 319 funding to incorporate the North Fork and South Fork watersheds into the Northeast Glacial Lakes Implementation Project boundary. The project coordinator is planning to target grazing management in the first phase of this multiple phase project. The coordinator will also establish relationships with federal, state and local entities as well as stakeholders in the watershed to increase project awareness and seek additional sources of funding to assure long-term project success. Bacteria data from monitoring efforts and a digital feedlot layer will be used as tools to identify potential target areas. The long-term goal of this implementation effort is to achieve the TMDL reductions derived in this document on both impaired segments and ultimately reduce bacteria inputs to the Yellow Bank River drainages to protect the upstream and downstream uses.

10.0 Literature Cited

Huxoll, Cory. 2002. South Dakota Game Fish and Parks; South Dakota Game Report No. 2003-11; 2002 Annual Report County Wildlife Assessments with a summary of the 1991-2002 Assessments.

SDDENR (South Dakota Department of Environment and Natural Resources). 2012. The 2012 South Dakota Integrated Report for Surface Water Quality Assessment Pierre, SD.

SDDENR (South Dakota Department of Environment and Natural Resources). 2009. Water Quality Modeling in South Dakota, May, 2009 Revision; Pierre, SD.

USEPA (United States Environmental Protection Agency). 2001. Protocol for Developing Pathogen TMDLs. EPA 841-R-00-002. Office of Water, United States Environmental Protection Agency, Washington D.C.

USDA (United States Department of Agriculture); National Agricultural Statistics Service. 2011. *South Dakota Agriculture 2011*, June 2011. Sioux Falls, SD.

Yagow, G., Dillaha, T., Mostaghimi, S., Brannan, K., Heatwole, C., and Wolfe, M.L. 2001. *TMDL modeling of fecal coliform bacteria with* HSPF. ASAE meeting paper No.01-2006. St. Joseph, Mich.

Appendix A

Bacteria data used in the TMDL analysis for the impaired segments of the North and South Forks of the Yellow Bank River

Site	Date	*E. coli* (#/100ml)	Flow (cfs)	Site	Date	*E. coli* (#/100ml)	Flow (cfs)
UMR07	05/19/2010	65.7	61.1	UMR10	06/08/2010	687	29.1
UMR07	05/24/2010	238.2	45.8	UMR10	06/10/2010	1203	31.8
UMR07	05/26/2010	125.9	37.2	UMR10	06/15/2010	1986	144.1
UMR07	06/01/2010	145	20.9	UMR10	06/17/2010	326	104.2
UMR07	06/02/2010	111.9	19.7	UMR10	06/22/2010	1203	46.2
UMR07	06/07/2010	95.9	20.3	UMR10	06/24/2010	1203	44.2
UMR07	06/09/2010	261.3	18.8	UMR10	06/29/2010	649	34.5
UMR07	06/14/2010	1410	58.6	UMR10	07/01/2010	1986	28.1
UMR07	06/16/2010	461.1	92.8	UMR10	07/06/2010	770	82.7
UMR07	06/21/2010	435.2	31.3	UMR10	07/08/2010	1986	371.9
UMR07	06/23/2010	365.4	28.3	UMR10	07/13/2010	326	66
UMR07	06/28/2010	172.3	32.1	UMR10	07/15/2010	1203	46.2
UMR07	06/30/2010	95.9	23.8	UMR10	07/20/2010	2420	25.8
UMR07	07/06/2010	123.6	17.9	UMR10	07/22/2010	1046	23.1
UMR07	07/07/2010	2419.6	18.8	UMR10	07/27/2010	1300	16.4
UMR07	07/12/2010	365.4	45.8	UMR10	07/29/2010	548	14.1
UMR07	07/14/2010	248.9	31.3	UMR10	08/03/2010	649	11.1
UMR07	07/19/2010	228.2	15.3	UMR10	08/05/2010	411	9.4
UMR07	07/21/2010	325.5	14.2	UMR10	08/10/2010	727	8.7
UMR07	07/26/2010	81.6	12.2	UMR10	08/12/2010	613	10.4
UMR07	07/28/2010	113.7	10.1	UMR10	08/17/2010	276	7.4
UMR07	08/02/2010	275.5	8.1	UMR10	08/19/2010	1120	12.7
UMR07	08/04/2010	90.6	6.5	UMR10	08/24/2010	727	8.7
UMR07	08/09/2010	77.6	5.6	UMR10	08/26/2010	866	6.4
UMR07	08/11/2010	110.6	5.5	UMR10	08/31/2010	2420	8
UMR07	08/16/2010	190	4.6	UMR10	09/02/2010	12997	8.7
UMR07	08/19/2010	76.7	3.9	UMR10	09/08/2010	1120	19.8
UMR07	08/23/2010	517.2	5.5	UMR10	09/09/2010	2420	21.1
UMR07	08/25/2010	85.7	4.5	UMR10	09/14/2010	1046	16.4
UMR07	08/30/2010	235.9	2.5	UMR10	09/15/2010	5172	27.1
UMR07	09/01/2010	275.5	5.3	UMR10	09/21/2010	291	38.9
UMR07	09/08/2010	770.1	12.2	UMR10	09/23/2010	2420	40.5
UMR07	09/09/2010	816.4	11.2	UMR10	09/28/2010	387	40.2
UMR07	09/14/2010	676.7	8.7	UMR10	09/30/2010	866	32.5
UMR07	09/15/2010	2914.6	7.3	UMR10	10/05/2010	649	22.1
UMR07	09/21/2010	770.1	29.8	UMR10	10/07/2010	313	20.4
UMR07	09/23/2010	517.2	24.8	UMR10	10/11/2010	435	17.4
UMR07	09/28/2010	290.9	39.7	UMR10	10/14/2010	236	15.7
UMR07	09/30/2010	307.6	30.9	UMR10	04/06/2011	5	489.1

Site	Date	*E. coli* (#/100ml)	Flow (cfs)	Site	Date	*E. coli* (#/100ml)	Flow (cfs)
UMR07	10/07/2010	167	17.6	UMR10	04/12/2011	27	308.2
UMR07	10/11/2010	133.3	15.3	UMR10	04/14/2011	10	245.9
UMR07	10/14/2010	191.8	14	UMR10	04/18/2011	14	169.8
UMR07	04/06/2011	96	366.2	UMR10	04/21/2011	22	144.7
UMR07	04/07/2011	51.2	339.2	UMR10	04/25/2011	63	144.4
UMR07	04/11/2011	49.6	253.9	UMR10	04/28/2011	15	134.7
UMR07	04/13/2011	29.2	199.4	UMR10	05/03/2011	20	89.8
UMR07	04/18/2011	18.7	131.6	UMR10	05/05/2011	43	78.4
UMR07	04/20/2011	18.5	115.5	UMR10	05/09/2011	99	92.8
UMR07	04/25/2011	9.6	118.2	UMR10	05/11/2011	131	83.4
UMR07	04/27/2011	39.9	116.8	UMR10	05/17/2011	71	72
UMR07	05/02/2011	7.5	75.1	UMR10	05/19/2011	314	64
UMR07	05/04/2011	22.6	59.6	UMR10	05/23/2011	1046	162.8
UMR07	05/09/2011	2419.6	51.8	UMR10	05/26/2011	285	107.2
UMR07	05/11/2011	146.7	55.1	UMR10	06/01/2011	1120	255.6
UMR07	05/16/2011	52	50.8	UMR10	06/02/2011	770	204.4
UMR07	05/18/2011	67	38.4	UMR10	06/06/2011	1983	90.5
UMR07	05/23/2011	2419.6	83.7	UMR10	06/09/2011	914	66
UMR07	05/25/2011	160	76.2	UMR10	06/13/2011	2420	61.3
UMR07	06/01/2011	1732.9	181.5	UMR10	06/15/2011	1046	62
UMR07	06/02/2011	488.4	139.7	UMR10	06/20/2011	687	65.7
UMR07	06/06/2011	185	67.4	UMR10	06/23/2011	12997	1276.4
UMR07	06/08/2011	226	39.3	UMR10	06/28/2011	520	303.5
UMR07	06/13/2011	471	32.1	UMR10	06/30/2011	882	188.9
UMR07	06/15/2011	1046	32.1	UMR10	07/05/2011	15531	338.4
UMR07	06/20/2011	155	22.2	UMR10	07/07/2011	1281	388.6
UMR07	06/28/2011	298	239.5	UMR10	07/12/2011	318	171.9
UMR07	06/29/2011	179	143.4	UMR10	07/13/2011	448	157.5
UMR07	07/05/2011	2419.6	59.1	UMR10	07/19/2011	1017	87.4
UMR07	07/07/2011	457	275.7	UMR10	07/21/2011	496	69
UMR07	07/12/2011	676	181.5	UMR10	07/25/2011	1153	162.1
UMR07	07/13/2011	520	133.8	UMR10	07/28/2011	620	106.9
UMR07	07/19/2011	238	78.5	UMR10	08/01/2011	712	80.7
UMR07	07/20/2011	309	56.1	UMR10	08/04/2011	909	101.2
UMR07	07/25/2011	630	156.5	UMR10	08/08/2011	520	55.3
UMR07	07/27/2011	4611	72.3	UMR10	08/11/2011	670	43.9
UMR07	08/01/2011	175	37.6	UMR10	08/15/2011	408	36.2
UMR07	08/04/2011	563	35.2	UMR10	08/18/2011	243	31.2
UMR07	08/08/2011	145	24.5	UMR10	08/22/2011	327	27.5
UMR07	08/10/2011	171	20.6	UMR10	08/25/2011	228	23.5

Site	Date	*E. coli* (#/100ml)	Flow (cfs)	Site	Date	*E. coli* (#/100ml)	Flow (cfs)
UMR07	08/17/2011	97	17.9	UMR10	09/01/2011	650	19.1
UMR07	08/22/2011	109	16.4	UMR10	09/06/2011	1050	14.7
UMR07	08/24/2011	98	14.8	UMR10	09/08/2011	728	14.1
UMR07	08/29/2011	228	13.2	UMR10	09/12/2011	1203	11.1
UMR07	09/01/2011	457	11.9	UMR10	09/14/2011	1120	9.7
UMR07	09/06/2011	160	4.8	UMR10	09/19/2011	1203	10.4
UMR07	09/07/2011	161	4.5	UMR10	09/21/2011	1553	9.7
UMR07	09/12/2011	435	3.9	UMR10	09/27/2011	980	8.7
UMR07	09/14/2011	547.5	3.4	UMR10	09/28/2011	1120	8.4
UMR07	09/19/2011	410.6	4.8	UMR10	10/03/2011	1120	7
UMR07	09/20/2011	1299.7	4.3	UMR10	10/05/2011	770	6.4
UMR07	09/27/2011	336	4.2	UMR10	10/10/2011	816	7.7
UMR07	09/28/2011	288	4.2	UMR10	10/11/2011	548	10.1
UMR07	10/03/2011	269	3.9	UMR12	05/13/2010	770	241.2
UMR07	10/05/2011	211	3.4	UMR12	05/18/2010	20	82.7
UMR07	10/10/2011	213	6	UMR12	05/20/2010	42	63.7
UMR07	10/11/2011	185	5.6	UMR12	05/25/2010	68	57.6
UMR08	05/19/2010	9.7	61.1	UMR12	05/27/2010	67	49.2
UMR08	05/24/2010	104.6	45.8	UMR12	06/01/2010	140	33.8
UMR08	05/26/2010	122.3	37.2	UMR12	06/03/2010	387	31.5
UMR08	06/01/2010	114.5	20.9	UMR12	06/08/2010	214	29.1
UMR08	06/02/2010	60.2	19.7	UMR12	06/10/2010	326	31.8
UMR08	06/07/2010	172.3	20.3	UMR12	06/15/2010	687	144.1
UMR08	06/09/2010	108.1	18.8	UMR12	06/17/2010	276	104.2
UMR08	06/14/2010	201	58.6	UMR12	06/22/2010	228	46.2
UMR08	06/16/2010	686.7	92.8	UMR12	06/24/2010	1203	44.2
UMR08	06/21/2010	547.5	31.3	UMR12	06/29/2010	328	34.5
UMR08	06/23/2010	344.8	28.3	UMR12	07/01/2010	194	28.1
UMR08	06/28/2010	166.4	32.1	UMR12	07/06/2010	345	82.7
UMR08	06/30/2010	45.2	23.8	UMR12	07/08/2010	2420	371.9
UMR08	07/06/2010	155.3	17.9	UMR12	07/13/2010	365	66
UMR08	07/07/2010	2419.6	18.8	UMR12	07/15/2010	977	46.2
UMR08	07/12/2010	727	45.8	UMR12	07/20/2010	2420	25.8
UMR08	07/14/2010	488.4	31.3	UMR12	07/27/2010	181	16.4
UMR08	07/19/2010	218.7	15.3	UMR12	07/29/2010	55	14.1
UMR08	07/21/2010	816.4	14.2	UMR12	08/03/2010	517	11.1
UMR08	07/26/2010	172	12.2	UMR12	08/05/2010	461	9.4
UMR08	07/28/2010	290.6	10.1	UMR12	08/10/2010	246	8.7
UMR08	08/02/2010	275.5	8.1	UMR12	08/12/2010	265	10.4
UMR08	08/04/2010	357.8	6.5	UMR12	08/17/2010	313	7.4

Site	Date	*E. coli* (#/100ml)	Flow (cfs)	Site	Date	*E. coli* (#/100ml)	Flow (cfs)
UMR08	08/11/2010	129.6	5.5	UMR12	08/24/2010	866	8.7
UMR08	08/16/2010	152	4.6	UMR12	08/26/2010	649	6.4
UMR08	08/19/2010	285.1	3.9	UMR12	08/31/2010	579	8
UMR08	08/23/2010	435.2	5.5	UMR12	09/02/2010	1986	8.7
UMR08	08/25/2010	272.3	4.5	UMR12	09/08/2010	488	19.8
UMR08	08/30/2010	435.2	2.5	UMR12	09/09/2010	517	21.1
UMR08	09/01/2010	193.5	5.3	UMR12	09/14/2010	727	16.4
UMR08	09/08/2010	1119.9	12.2	UMR12	09/15/2010	2420	27.1
UMR08	09/09/2010	613.1	11.2	UMR12	09/21/2010	613	38.9
UMR08	09/14/2010	770.1	8.7	UMR12	09/23/2010	770	40.5
UMR08	09/15/2010	2419.6	7.3	UMR12	09/28/2010	308	40.2
UMR08	09/21/2010	547.5	29.8	UMR12	09/30/2010	291	32.5
UMR08	09/23/2010	648.8	24.8	UMR12	10/05/2010	178	22.1
UMR08	09/28/2010	517.2	39.7	UMR12	10/07/2010	105	20.4
UMR08	09/30/2010	209.8	30.9	UMR12	10/11/2010	214	17.4
UMR08	10/05/2010	218.7	18.5	UMR12	10/14/2010	173	15.7
UMR08	10/07/2010	166.4	17.6	UMR12	04/06/2011	17	489.1
UMR08	10/11/2010	195.6	15.3	UMR12	04/07/2011	19	445.6
UMR08	10/14/2010	261.3	14	UMR12	04/12/2011	22	308.2
UMR08	04/06/2011	25.9	366.2	UMR12	04/14/2011	35	245.9
UMR08	04/07/2011	64	339.2	UMR12	04/18/2011	38	169.8
UMR08	04/12/2011	57.1	253.9	UMR12	04/21/2011	23	144.7
UMR08	04/14/2011	47.1	199.4	UMR12	04/25/2011	10	144.4
UMR08	04/18/2011	17.3	131.6	UMR12	04/28/2011	16	134.7
UMR08	04/21/2011	50.4	115.5	UMR12	05/03/2011	42	89.8
UMR08	04/25/2011	11	118.2	UMR12	05/05/2011	16	78.4
UMR08	04/28/2011	21.8	116.8	UMR12	05/09/2011	79	92.8
UMR08	05/03/2011	24.6	75.1	UMR12	05/11/2011	59	83.4
UMR08	05/05/2011	42.8	59.6	UMR12	05/17/2011	50	72
UMR08	05/09/2011	307.6	51.8	UMR12	05/19/2011	59	64
UMR08	05/11/2011	167	55.1	UMR12	05/23/2011	1300	162.8
UMR08	05/17/2011	67.7	50.8	UMR12	05/26/2011	144	107.2
UMR08	05/19/2011	53.6	38.4	UMR12	06/01/2011	1120	255.6
UMR08	05/23/2011	866.4	83.7	UMR12	06/02/2011	326	204.4
UMR08	05/26/2011	193.5	76.2	UMR12	06/06/2011	66	90.5
UMR08	06/01/2011	2419.6	181.5	UMR12	06/09/2011	88	66
UMR08	06/02/2011	344.8	139.7	UMR12	06/13/2011	120	61.3
UMR08	06/06/2011	104.3	67.4	UMR12	06/15/2011	142	62
UMR08	06/09/2011	110	39.3	UMR12	06/20/2011	488	65.7
UMR08	06/13/2011	199	32.1	UMR12	06/23/2011	5794	1276.4

Site	Date	*E. coli* (#/100ml)	Flow (cfs)	Site	Date	*E. coli* (#/100ml)	Flow (cfs)
UMR08	06/20/2011	134	22.2	UMR12	06/30/2011	359	188.9
UMR08	06/23/2011	3873	481.2	UMR12	07/05/2011	2142	338.4
UMR08	06/28/2011	683	239.5	UMR12	07/07/2011	435	388.6
UMR08	06/30/2011	313	143.4	UMR12	07/12/2011	355	171.9
UMR08	07/05/2011	6131	59.1	UMR12	07/13/2011	428	157.5
UMR08	07/07/2011	583	275.7	UMR12	07/19/2011	161	87.4
UMR08	07/12/2011	638	181.5	UMR12	07/21/2011	216	69
UMR08	07/13/2011	313	133.8	UMR12	07/25/2011	932	162.1
UMR08	07/19/2011	364	78.5	UMR12	07/28/2011	520	106.9
UMR08	07/21/2011	862	56.1	UMR12	08/01/2011	301	80.7
UMR08	07/25/2011	934	156.5	UMR12	08/04/2011	318	101.2
UMR08	07/28/2011	908	72.3	UMR12	08/08/2011	241	55.3
UMR08	08/01/2011	833	37.6	UMR12	08/11/2011	144	43.9
UMR08	08/04/2011	1529	35.2	UMR12	08/15/2011	110	36.2
UMR08	08/08/2011	203	24.5	UMR12	08/18/2011	121	31.2
UMR08	08/11/2011	368	20.6	UMR12	08/22/2011	161	27.5
UMR08	08/15/2011	148	18.5	UMR12	08/25/2011	331	23.5
UMR08	08/18/2011	295	16.4	UMR12	08/29/2011	199	20.8
UMR08	08/22/2011	98	14.8	UMR12	09/01/2011	359	19.1
UMR08	08/25/2011	161	13.2	UMR12	09/06/2011	199	14.7
UMR08	08/29/2011	134	11.9	UMR12	09/08/2011	108	14.1
UMR08	09/06/2011	305	4.8	UMR12	09/12/2011	345	11.1
UMR08	09/08/2011	420	4.5	UMR12	09/14/2011	411	9.7
UMR08	09/12/2011	920.8	3.9	UMR12	09/19/2011	579	10.4
UMR08	09/14/2011	410.6	3.4	UMR12	09/21/2011	308	9.7
UMR08	09/19/2011	816.4	4.8	UMR12	09/27/2011	326	8.7
UMR08	09/21/2011	1413.6	4.3	UMR12	09/28/2011	291	8.4
UMR08	09/27/2011	517.2	4.2	UMR12	10/03/2011	96	7
UMR08	09/28/2011	920.8	4.2	UMR12	10/05/2011	102	6.4
UMR08	10/03/2011	727	3.9	UMR12	10/10/2011	192	7.7
UMR08	10/05/2011	290.9	3.4	UMR12	10/11/2011	517	10.1
UMR08	10/10/2011	206.4	6	WQM87	05/12/2009	32	24.8
UMR08	10/11/2011	579.4	5.6	WQM87	08/17/2009	141	3.7
UMR10	05/13/2010	1203	241.2	WQM87	05/13/2010	770	241.2
UMR10	05/18/2010	453	82.7	WQM87	08/17/2010	17	7.4
UMR10	05/20/2010	435	63.7	WQM87	05/12/2011	64	78.7
UMR10	05/25/2010	236	57.6	WQM87	08/16/2011	93	34.2
UMR10	05/27/2010	173	49.2	WQM88	08/17/2010	10.4	4.3
UMR10	06/01/2010	921	33.8	WQM88	05/12/2011	54.6	50.4
UMR10	06/03/2010	1046	31.5	WQM88	08/16/2011	238	17.9

Site	Date	FC (#/100ml)	Flow(cfs)	Site	Date	FC (#/100ml)	Flow(cfs)
WQM87	10/17/1978	23	2.5	WQM87	04/12/1988	10	11.4
WQM87	04/24/1979	30	123.3	WQM87	04/18/1989	10	16.8
WQM87	10/10/1979	47	3.7	WQM87	04/10/1990	5	3.4
WQM87	05/15/1979	10	30.2	WQM87	04/09/1991	10	4.7
WQM87	06/12/1979	230	7.7	WQM87	10/17/1991	140	3.4
WQM87	07/10/1979	170	8.4	WQM87	04/15/1992	10	15.4
WQM87	08/14/1979	730	33.5	WQM87	10/08/1992	120	3.4
WQM87	09/11/1979	730	3.7	WQM87	04/14/1993	120	239.9
WQM87	04/23/1980	30	10.4	WQM87	10/06/1993	50	19.4
WQM87	05/15/1980	7	1.8	WQM87	04/18/1994	5	64.7
WQM87	06/10/1980	570	82.1	WQM87	10/18/1994	120	25.8
WQM87	07/15/1980	1600	2.7	WQM87	04/17/1995	300	371.9
WQM87	08/13/1980	180	1.1	WQM87	10/16/1995	220	83.8
WQM87	09/11/1980	2600	0.3	WQM87	04/16/1996	80	140
WQM87	04/09/1981	13	3.2	WQM87	With flow	30	2.5
WQM87	05/12/1981	20	0.9	WQM87	10/15/2008	5	6
WQM87	06/09/1981	170	0.5	WQM88	10/17/1991	20	7.5
WQM87	04/15/1982	5	24.1	WQM88	04/15/1992	10	16
WQM87	05/13/1982	90	6	WQM88	10/08/1992	410	4.9
WQM87	06/17/1982	250	2.6	WQM88	04/14/1993	200	331
WQM87	04/19/1983	5	24.5	WQM88	10/06/1993	50	22
WQM87	04/11/1984	80	106.9	WQM88	04/18/1994	50	90
WQM87	10/10/1984	50	0.6	WQM88	10/18/1994	140	55
WQM87	04/15/1985	10	21.8	WQM88	04/17/1995	290	949
WQM87	10/16/1985	120	36.5	WQM88	10/16/1995	400	129
WQM87	10/15/1986	20	14.7	WQM88	04/16/1996	10	163
WQM87	04/13/1987	90	23.8	WQM88	07/15/2002	340	1.3
WQM87	10/20/1987	5	0.8	WQM88	07/16/2003	220	0.5

WQM87=WQM460687 (UMR12)
WQM88=WQM460688 (UMR08)
FC=Fecal Coliform

Appendix B

Public Comments