Total Maximum Daily Loads
For Pathogen Indicators
Big Sioux River, Iowa and South Dakota

2007

USEPA Region 7

and

Iowa Department of Natural Resources

and

South Dakota Department of Environment and Natural Resources

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1. Summary

Table 1.1 Big Sioux River TMDL Summary

Waterbody Name:	Big Sioux River (BSR), see Table 1.2 and Table 1.3 for details for impaired segments
Use Designation Classes, all impaired segments:	Iowa: Class A, recreational Class B (WW), aquatic life 4 South Dakota: Immersion and limited contact recreation, warm water semi-permanent fish life, fish and wildlife propagation recreation and stock watering, and irrigation watering..
Major River Basin:	Big Sioux River Basin
Pollutants:	Pathogen indicator: *E. coli* bacteria (Iowa) Fecal Coliform (South Dakota)
Pollutant Sources:	Point, Nonpoint
Impaired Use:	Iowa: Recreational Primary Contact, March 15 to November 15 South Dakota: Immersion recreation, May 1 to September 30
Watershed Area: Total Iowa South Dakota Minnesota	 9,570 square miles 1,436 square miles 6,603 square miles 1,531 square miles
Stream Length: Iowa/Minnesota border to Missouri confluence	125 miles
Target: Pathogen Indicator Concentration for all five of the Big Sioux River segments:	Iowa: Water Quality Standard (WQS) numeric limits for *E. coli,* a geometric mean of 126 E. coli organisms/100 ml or a sample maximum of 235 *E. coli* organisms /100ml South Dakota: WQS numeric limits for fecal coliform bacteria, a sample maximum of 400 cfu/100 ml.
Wasteload Allocations (WLA)*:	The wasteload allocations for this report can be found in the following tables in Section 3. BSRTMDL**-1: 3.14 and 3.15 BSRTMDL-3: 3.47 BSRTMDL-4: 3.69 BSRTMDL-5: 3.81
Load allocations, existing loads, and load reductions needed to achieve target concentrations *:	The load allocations, existing loads, and load reductions for this report can be found in the following tables in section 3. BSRTMDL-1: 3.17 to 3.21

	BSRTMDL-2: 3.29 to 3.33 BSRTMDL-3: Rock River: 3.50 to 3.53 Minnesota border: 3.54 to 3.56 BSR direct: 3.57 to 3.61 BSRTMDL-4: 3.70 to 3.74 BSRTMDL-5: 3.82 to 3.86

*Note on tables. Bacteria counts tend to get very large very quickly. The values in the tables of loads and allocations for the TMDLs in this document as well as in the associated spreadsheets are in scientific notation for ease of use and legibility. As a guide: 10E+3 = one thousand, 10E+6 = one million, 10E+9 = one billion, 10E+12 = one trillion, and so on.

**The five Iowa impaired waterbody segments are identified by a label consisting of the prefix BSRTMDL (Big Sioux River TMDL) followed by the Iowa segment number (1-5).

1.1 Introduction

This report consists of a Total Maximum Daily Load (TMDL) for each of five contiguous segments of the Big Sioux River. These five segments include both the South Dakota (SD) and the Iowa pathogen indicator-impaired segments listed on the 303(d) list for the Big Sioux River. Table 1.2 shows these five segments in relation to the seven Iowa impaired segment and Table 1.3 shows the relationship of these five TMDL segments to the five South Dakota impaired segments and the associated mainstem river monitoring stations.

Table 1.2. Relationship of five TMDL segments and Iowa impaired segments

Big Sioux Impaired Segment	Segment description	Segment length	Iowa Counties
IA 06-BSR-0020-segments 2 and 3 (BSRTMDL-1)	Minnesota/Iowa border to Beaver Creek	29.23 miles	Lyon
IA 06-BSR-0020-segment 1 (BSRTMDL-2)	Beaver Creek to Rock River	25.26 miles	Lyon and Sioux
IA 06-BSR-0010-segment 4 (BSRTMDL-3)	Rock River to Indian Creek	21.35 miles	Sioux, Osceola, and Plymouth
IA 06-BSR-0010-segment 3 (BSRTMDL-4)	Indian Creek to Brule Creek	26.58 miles	Plymouth
IA 06-BSR-0010- segments 1 and 2 (BSRTMDL-5)	Brule Creek to Missouri River confluence	34.72 miles	Plymouth and Woodbury

Table 1.3. Relationship of five TMDL segments and South Dakota impaired segments and monitoring stations in the mainstem Big Sioux River

IA Impaired Segment	SD Impaired Segment	Monitoring Station ID	Monitoring Station Name
Minnesota/Iowa Border to Beaver Creek (BSRTMDL-1)	Lower Big Sioux River Above Brandon to Nine Mile Creek	LBSM01	Big Sioux at Recreation Area (Brandon)
	Lower Big Sioux River Nine Mile Creek to near Fairview	LBSM03	Klondike Dam
	Lower Big Sioux River Nine Mile Creek to near Fairview	LBSM05	Big Sioux at Canton, SD

IA Impaired Segment	SD Impaired Segment	Monitoring Station ID	Monitoring Station Name
Beaver Creek to Rock River (BSRTMDL-2)	Lower Big Sioux River Nine Mile Creek to near Fairview	LBSM08	Big Sioux at Fairview, SD
	Lower Big Sioux River Near Fairview to near Alcester	LBSM09	Big Sioux at Hudson, SD
Rock River to Indian Creek (BSRTMDL-3)	Lower Big Sioux River Near Alcester to Indian Creek	LBSM13	Big Sioux River at Hawarden, IA
Indian Creek to Brule Creek (BSRTMDL-4)	Lower Big Sioux River Indian Creek to mouth	LBSM17	USGS guage station Akron, IA
	Lower Big Sioux River Indian Creek to mouth	LBSM19	Lower Big Sioux near Richland, SD
Brule Creek to Missouri River Confluence (BSRTMDL-5)	Lower Big Sioux River Indian Creek to mouth	LBSM20	Lower Big Sioux near Broken Kettle Creek
	Lower Big Sioux River Indian Creek to mouth	LBSM21	Lower Big Sioux at North Sioux City, SD

The BSRTMDL-1 segment runs 29.23 miles from the Minnesota/Iowa border to Beaver Creek. The Iowa part includes eight directly draining HUC 12 sub-watersheds and four wastewater treatment plants. The larger Iowa tributaries draining to the Big Sioux are Blood Run and Klondike Creek. The South Dakota part includes 18 HUC 12 sub-watersheds and two wastewater treatment plants that drain into the BSRTMDL-1 segment. Slip-up Creek, Beaver Creek and Ninemile Creek are the major tributaries that drain the South Dakota part of this sub-watershed.

The BSRTMDL-2 segment runs 25.26 miles from Beaver Creek to the Rock River. The Iowa part includes a single directly draining HUC 12 sub-watershed and no wastewater treatment plants. Nelson Creek and two unnamed streams drain the Iowa part of this sub-watershed. The South Dakota part includes three HUC 12 sub-watersheds and no wastewater treatment plants. Little Beaver Creek and Pattee Creek drain the South Dakota part of this sub-watershed.

The BSRTMDL-3 segment runs 21.35 miles from the Rock River to Indian Creek. The entire Rock River watershed, consisting of 23 HUC 12 sub-watersheds in Iowa and a similarly sized area in Minnesota, drains to this Big Sioux River segment. In addition to the Rock River watershed, there are seven Iowa HUC 12 sub-watersheds that discharge directly to the Big Sioux River from this segment's watershed. The Minnesota part of the Rock River watershed is drained by three streams that cross the state border. From east to west, they are the Little Rock River, the mainstem of the Rock River, and Mud Creek. The Little Rock River and Mud Creek flow into the Rock River 26 miles and 27 miles upstream from the Big Sioux River, respectively. There are eleven wastewater treatment plants in the Iowa part of the Rock River watershed and one that discharges directly to the Big Sioux River. Besides the Rock River, there are two streams that flow into this segment of the Big Sioux, Dry Creek and Sixmile Creek. The South Dakota part includes two HUC 12 sub-watersheds and no wastewater treatment plants. Finnie Creek and Green Creek drain the South Dakota part of this sub-watershed.

The BSRTMDL-4 segment runs 27.58 miles from Indian Creek to Brule Creek. The Iowa part includes four HUC 12 sub-watersheds and three wastewater treatment plants. Indian and Westfield Creeks drain the Iowa part of this sub-watershed. The South Dakota part includes four HUC 12 sub-watersheds and no wastewater treatment plants. Union Creek and Sayles Creek are the main tributaries that drain the South Dakota part of this sub-watershed.

The BSRTMDL-5 segment runs 35.72 miles from Brule Creek to the confluence with the Missouri River. The Iowa part includes five HUC 12 sub-watersheds and no wastewater treatment plants. Broken Kettle and Rock Creeks drain this watershed. The South Dakota part includes eight HUC 12 sub-watersheds and two wastewater treatment plants. Big Ditch and Brule Creek are the main tributaries that drain the South Dakota part of this sub-watershed.

Background: The Federal Clean Water Act requires the Iowa Department of Natural Resources (IDNR) and the South Dakota Department of Environment and Natural Resources (SD DENR) to develop a TMDL for waters that have been identified on the state's 303(d) list as impaired by a pollutant. Five segments of the Big Sioux River have been identified as impaired by the pathogen indicator, *E. coli* for Iowa and fecal coliform for South Dakota (Table 1.2 and 1.3). The purpose of these Big Sioux River TMDL's is to estimate the maximum pathogen indicator "loads" that can be delivered from the watershed and still meet both the Iowa and South Dakota Water Quality Standards (WQS). Complying with the WQS limits for *E. coli* and fecal coliform will provide full support for the river's designated recreational uses.

TMDL development and implementation is often an iterative process that requires re-evaluation of existing information, analysis of new data as it becomes available, and the refinement of analytical procedures. This process is frequently referred to as phasing. Phasing TMDL's is an approach to managing water quality used when the origin, nature and sources of water quality impairments are not completely understood. In Phase 1, the waterbody load capacity, existing pollutant load in excess of this capacity, and the source load allocations are estimated based on the resources and information available.

The five TMDLs presented in this report represent Phase 1 in the development of a project to improve Big Sioux River water quality. The evaluation process will continue as more data and the resources to analyze it are made available, allowing for improved understanding of the specific problems that are causing the impairment. This will lead to stakeholder driven solutions and more effective management practices. Continued monitoring will help determine what management practices result in load reductions and the attainment of water quality standards. These monitoring activities are continuing components of the ambient monitoring programs of the states of Iowa and South Dakota and will:

- Assess the future beneficial use status;
- Determine if water quality is improving, getting worse, or staying the same;
- Evaluate the effectiveness of implemented best management practices.

The first phase of these TMDLs sets specific and quantified targets for pathogen indicator concentrations in the river and allocates allowable loads to all sources. Phase 2 will consist of implementing the follow-up monitoring plan, evaluating collected data, and readjusting the allocations and management practices, if needed.

Calculating Total Maximum Daily Load. There are three components to a TMDL: the wasteload allocation (WLA) for permitted point sources like wastewater treatment plants (wwtp); load allocations for non-point sources; and a margin of safety to account for uncertainty in the estimates for the wasteload and load allocations.

- Wasteload Allocations. The wwtp wasteload allocations for each of the four TMDL segments that include wastewater treatment plants in their watersheds are in the Section 3 Tables 3.14 and 3.15 (BSRTMDL-1), 3.47 (BSRTMDL-3), 3.69 (BSRTMDL-4), and 3.81 (BSRTMDL-5). The watersheds of segment BSRTMDL-2 do not include any permitted facilities requiring a WLA.

  The Iowa WLA's are for two stream design conditions, "low" and "very low" flow, described in Appendix B, Assumptions and Procedures. Continuous discharge facilities have WLA's at both design conditions while controlled discharge lagoons do not discharge at "very low" stream flow. The IWLA concentrations higher than the water quality standard (WQS) concentration are the result of calculating the bacterial die-off from the time the indicator bacteria transit from the plant discharge location to the impaired Big Sioux River segment.

  The BSRTMDL-3 segment includes the Rock River watershed as well as seven HUC 12 sub-watersheds that discharge directly into the Big Sioux River. WLA's for all of the Iowa permitted wastewater treatment plants in the Rock watershed are included in BSRTMDL-3. The City of Hawarden wastewater treatment plant discharges directly into the Big Sioux River and already has a bacteria WLA that requires it to disinfect plant effluent and comply with the WQS.

The South Dakota WLA's assumes no die-off and therefore each of these WLA's is calculated using the permitted discharge rate and effluent permit limit. Appendix C includes the assumptions and procedures used to calculate the South Dakota WLA's.

- Load Allocations. The *E. coli* and fecal coliform load allocations for all non-point sources are based on four percentile ranked design flow conditions. The percentile rank is how frequently the stream flow is as high or higher than a given flow value. The four percentile ranks used for Iowa tributaries are 1%, 10%, 50%, and 70%, which represent flows that are exceeded 1%, 10%, 50%, and 70% of the time, respectively. The four percentile ranks used for South Dakota tributaries are 5%, 25%, 55%, and 85%.

  The percentile rank or flow duration intervals are different for each type of waterbody (e.g. tributary vs. mainstem). Specific flow duration interval used for each waterbody was developed based on several factors. Because the flow and drainage areas were significantly larger for the mainstem when compared to most tributaries, a wider range of flow for the higher zone (0-25% flow frequency) was used for mainstem load duration curves. The wider range captured most of the storm events delivered from the tributaries. In contrast, a narrower flow range (e.g. 0-10% for the South Dakota tributaries) was used to capture most of the significant storm events. This was due to the smaller drainage areas, i.e. flashier flow behavior; and limited flow and concentration data for the tributaries (~2 years of data for the tributaries vs. 20+ years of data for the mainstem).

  Evaluation of Iowa monitoring data with load duration curves showed that the Iowa Big Sioux River tributaries had indicator bacteria concentrations that significantly exceeded the WQS throughout most flow conditions. The load allocations are based on all tributaries meeting the WQS at their confluences with the Big Sioux River. Evaluation of South Dakota monitoring data with load duration curves showed that exceedances were observed mostly during mid to high stream flows (0 to 50^{th} percentile) for the main stem Lower Big Sioux River segments. Exceedances for the South Dakota tributary segments generally occur throughout most flow conditions.

  There are 48 HUC 12 sub-watersheds in the Iowa Big Sioux River watershed. Of these, 23 are in the Rock River watershed and 25 directly drain into the Big Sioux River (BSR). The Iowa HUC 12 discharge locations have been identified and the total distance from the discharges to the impaired BSR segments has been measured. This information has been used to calculate bacteria *die-off* from the sub-watershed discharge location to the BSR and this is then incorporated into individual HUC 12 load allocations.

- Margin of Safety. The margin of safety (MOS) for these total maximum daily loads is implicit. The implicit MOS is the consequence of the frequent incorporation of conservative assumptions in the evaluations.

Required components. This TMDL has been prepared in compliance with the current regulations for TMDL development that were promulgated in 1992 as 40 CFR Part 130.7 in compliance with the Clean Water Act. These regulations and consequent TMDL development are summarized below:

1. **Name and geographic location of the impaired or threatened waterbody for which the TMDL is being established:** Five contiguous segments of the Big Sioux River are impaired. These segments include the entire Iowa Big Sioux River reach, from the Minnesota/Iowa Border to the confluence with the Missouri River.

2. **Identification of the pollutant and applicable water quality standards:** The pollutants causing the water quality impairments are pathogens that are measured by the bacterial indicators *E. coli* and fecal coliform. The designated uses for the Big Sioux River are Class A1, Primary Contact Recreation and Class B (WW), aquatic life for Iowa. The designated uses for these same Big Sioux River segments for South Dakota are immersion recreation, warm water semi-permanent fish life, fish and wildlife propagation recreation and stock watering, irrigation watering, and limited contact recreation.

3. **Quantification of the pollutant load that may be present in the waterbody and still allow attainment and maintenance of water quality standards:** The target for the Iowa part of this TMDL is a reduction of pathogen indicator loading to the Iowa water quality standard numeric limits for Class A1 waterbodies. These limits are for *E. coli* from March 15th to November 15th and are for a geometric mean concentration of 126 organisms/100ml and a sample maximum of 235 organisms/100ml. In practice, these limits are often translated by IDNR to a fecal coliform geometric mean of 200 org/100 ml and a sample maximum concentration of 400 org/100 ml. This translation is often done for NPDES permits since there is not an EPA approved method of *E. coli* measurement. Similarly, the target for the South Dakota part of this TMDL is a reduction of pathogen indicator loading to the South Dakota water quality standard numeric limits for fecal coliform from May 1st to September 30th. These limits are for a geometric mean concentration of 200 cfu/100ml and a sample maximum of 400 cfu/100ml.

4. **Quantification of the amount or degree by which the current pollutant load in the waterbody deviates from the pollutant load needed to attain and maintain water quality standards**: The Iowa water quality standard is for an *E. coli* geometric mean of 126 org/100 ml and a sample maximum of 235 org/100 ml. The South Dakota water quality standard is for a fecal coliform sample maximum of 400 cfu/100ml. Specifics of the monitoring data used in the assessment of the impairment can be found in *Section 3.1, Problem Identification*.

5. **Identification of pollution source categories**: Both point and non-point sources of pathogen indicators have been identified as the cause of the primary contact recreation use impairment for four of the five impaired segments of the Big Sioux River. The remaining segment, BSRTMDL-2 has no point sources within the watershed and non-point sources of pathogen indicators have been identified as the cause of the impairment.

6. **Wasteload allocations for pollutants from point sources**: The point source dischargers to the impaired segments of the Big Sioux River and the wasteload allocations to these point sources are listed in Tables 3.14 and 3.15 (BSRTMDL-1), 3.47 (BSRTMDL-3), 3.69 (BSRTMDL-4), and 3.81 (BSRTMDL-5).

7. **Load allocations for pollutants from nonpoint sources**: The load allocations for the Big Sioux River for the individual TMDLs can be found in the following tables:
   - BSRTMDL-1: 3.17 to 3.21
   - BSRTMDL-2: 3.29 to 3.33
   - BSRTMDL-3:
     - Rock River: 3.50 to 3.53
     - Minnesota border: 3.54 to 3.56
     - BSR direct: 3.57 to 3.61
   - BSRTMDL-4: 3.70 to 3.74
   - BSRTMDL-5: 3.82 to 3.86

8. **A margin of safety**: The Margins of Safety (MOS) for all of the TMDLs in this document are the same. The MOS has been incorporated through implicit conservative assumptions in the modeling and representation of point and non-point sources. For Iowa non-point sources, a conservative assumption is that die-off does not occur for bacteria originating in HUC 12's adjacent to the Big Sioux River or from the time of travel between the source within the sub-watershed and the HUC 12 discharge location. For Iowa non-point sources, a conservative assumption is that die-off do not occur. For both Iowa and South Dakota point sources, i.e., wastewater treatment

facilities, it is assumed that the facility will monitor discharges for compliance with the water quality standards and disinfect as needed.

9. **Consideration of seasonal variation**: These TMDLs were developed based on the Iowa water quality standards primary contact recreation season that runs from March 15 to November 15 and the South Dakota water quality standards that runs from May 1 to September 30. Seasonal variation in non-point source (NPS) livestock loading has been considered in the timing and distribution of manure in the BSR watershed. In addition, the TMDLs for the main stem Big Sioux River uses the Load Duration Curve method which incorporates all flow ranges and thus adequately represents seasonal variability.

10. **Allowance for reasonably foreseeable increases in pollutant loads**: No allowance for an increase in pathogen indicators has been included in these TMDLs because current watershed land uses are predominantly agricultural. The addition or deletion of animal feeding operations within the watershed could increase or decrease pathogen indicator loading. Because such events cannot be predicted or quantified at this time, a future allowance for their potential occurrence was not accounted for in these TMDLs.

11. **Implementation plan**: Although not required by the current regulations, an implementation plan is outlined in section 4 of this report.

2. Big Sioux River, Description and History

2.1 The Stream and its Hydrology

The Big Sioux River basin (Table 2.1) is located in far northwest Iowa, eastern South Dakota, and southwest Minnesota. The Big Sioux River forms the border between Iowa and South Dakota from the Iowa/Minnesota border to the Missouri River.

Table 2.1 Big Sioux River and its Basin Features

Waterbody Name:	Big Sioux River, seven and five impaired segments in Iowa and South Dakota, respectively
Hydrologic Unit Code:	Big Sioux River – 10170203 Rock River – 10170204
IDNR Waterbody ID:	IA 06-BSR
SD DENR Waterbody ID:	SD-BS-R-BIG_SIOUX_14-17
Location:	S33, T92N, R49W to S25, T100N, R49W
Water Quality Standards and Designated Uses:	See Table 3.1 and Section 3.1.1
Major Tributaries (Iowa):	Rock River, Indian Creek
Major Tributaries (South Dakota):	Beaver Creek, Brule Creek
Receiving Waterbody:	Missouri River
Stream Segment Length (Iowa):	125 miles
Stream Segment Length (South Dakota):	130 miles
Watershed Area: **Total** **Iowa** **South Dakota** **Minnesota**	 9,570 square miles 1,436 square miles 6,603 square miles 1,531 square miles

The Big Sioux River originates north of Watertown, South Dakota and flows generally south for 420 miles to its confluence with the Missouri River near Sioux City, Iowa. The Big Sioux River forms the boundary between South Dakota and Iowa from near Sioux Falls, SD to Sioux City, IA. Major tributaries to the Big Sioux in the Iowa reach include the Rock River, with a drainage area of 1,688 square miles, and Indian Creek with a drainage area of 63 square miles. Major tributaries to the Big Sioux in the South Dakota reach include Split Rock Creek, Brule Creek, Beaver Creek, Ninemile Creek, and Pattee Creek with a drainage area of 464, 214, 99, 53, and 41 square miles, respectively. The linear distance between Sioux City and Sioux Falls is 75 miles while the river distance is 125 miles. The meandering nature of the river creates a diversity of aquatic habitats. Most of the watershed is used for agriculture, specifically row crops and livestock feeding operations, including open feedlots.

2.2 The Watershed

The project area for this report is shown in Figure 1. The Lower Big Sioux River drains approximately 661,418 acres (1,033 miles^2) and 919,040 acres (1,436 miles^2) in South Dakota and Iowa, respectively. The Big Sioux River watershed is located in the Northern Glaciated Plains and Western Corn Belt Plains ecoregions. A flat to gently rolling landscape composed of glacial drift characterizes the Northern Glaciated Plains ecoregion. The Western Corn Belt Plains ecoregion is composed of level to gently rolling glacial till plains with areas of moraine hills and loess deposits. Wildlife species present in the area include whitetail deer, red fox, beavers, raccoons, ring-necked pheasants, mourning doves, and numerous other species of songbirds, waterfowl, reptiles and amphibians.

The Lower Big Sioux River is divided into five impaired segments in South Dakota extending from the City of Brandon to the mouth of the river. The average rainfall in the lower Big Sioux Watershed is approximately 25 inches per year with 78% falling during the growing season. The average annual snowfall is approximately 34 inches but varies widely from year to year. As shown on Figure 1, there are 10 South Dakota monitoring stations located along the main stem segments (LBSM). This same reach of river is divided into seven river segments under the Iowa 303(d) list. The relationship of the South Dakota and Iowa listed segments with the five TMDL assessment segments is summarized in Table 1.2 and Table 1.3. Table 2.2 shows the relationship between the Iowa listed segments with the South Dakota water quality monitoring stations.

Table 2.2 Big Sioux River Assessment Reach and Segment Designations.

Reach	Segment	Length, miles	Description	South Dakota Monitoring Stations for Mainstem River
0010	1	16.9	Mouth to Broken Kettle Creek, not assessed	LBSM21
0010	2	18.4	Broken Kettle Creek to Brule Creek, impaired	LBSM20
0010	3	22.8	Brule Creek to Indian Creek, impaired	LBSM17 and LBSM19
0010	4	23.7	Indian Creek to Rock River, impaired	LBSM13
0020	1	22.2	Rock River to Beaver Creek, impaired	LBSM08 and LBSM09
0020	2	22.5	Beaver Creek to Ninemile	LBSM05

Reach	Segment	Length, miles	Description	South Dakota Monitoring Stations for Mainstem River
			Creek, impaired	
0020	3	9.25	Ninemile Creek to the IA/MN border, not assessed	LBSM01 and LBSM03

2.2.1 Land Use

Land use/land cover characteristics are a determinant in identifying and quantifying sources of bacteria within the watershed. Table 2.3 to 2.5 summarize land use categories used for the Bacteria Indicator Tool (BIT) model for the Lower Big Sioux River and the Rock River drainage areas in Iowa, respectively. These tables list both the total acreage and the percent land uses within each HUC 12 drainage area, and the associated Iowa segment. The BIT modeled land use categories are derived by reassigning land use categories into the modeled categories showed in Table 2.3 to 2.5. Specifically, ungrazed pastureland/forest land use category includes ungrazed pasture and cropland, and forest lands. It is assumed that there is no manure application in these lands. Built-up land use category includes roads, commercial, industrial, and residential land uses.

Land uses in the various HUC 12 drainage areas within Iowa are generally similar. With the exception of a few drainage areas discharging into segment 0010-2 and 0010-1, where land uses are dominated by ungrazed pasture/forest land use, all of the remaining HUC 12 drainage areas within Iowa are dominated by cropland, follow by ungrazed pasture/forest land and pastureland. With the exception of two HUC-12s draining into 0010-4 and 0010-1, there are generally limited built-up land uses within the HUC 12s areas draining into both the LBS River and the Rock River.

Table 2.5 quantifies the general land use categories within the Lower Big Sioux River drainage area in South Dakota derived from the USGS Earth Resources Observation and Science database (USGS, 2005). Specifically, the table lists the percent land uses within each segment drainage area by twelve-digit HUC numbers (HUC 12s). The total acreage of each drainage area by HUC 12s is included as well.

Land uses in the various HUC 12 drainage areas in South Dakota are generally similar. The majority of these areas are dominated by a combination of grassland, hay, pasture, corn, and soybeans land uses, follow by high intensity commercial and industrial land uses. There is relatively limited residential area within these drainage areas and therefore impacts from these land uses are expected to be minimal.

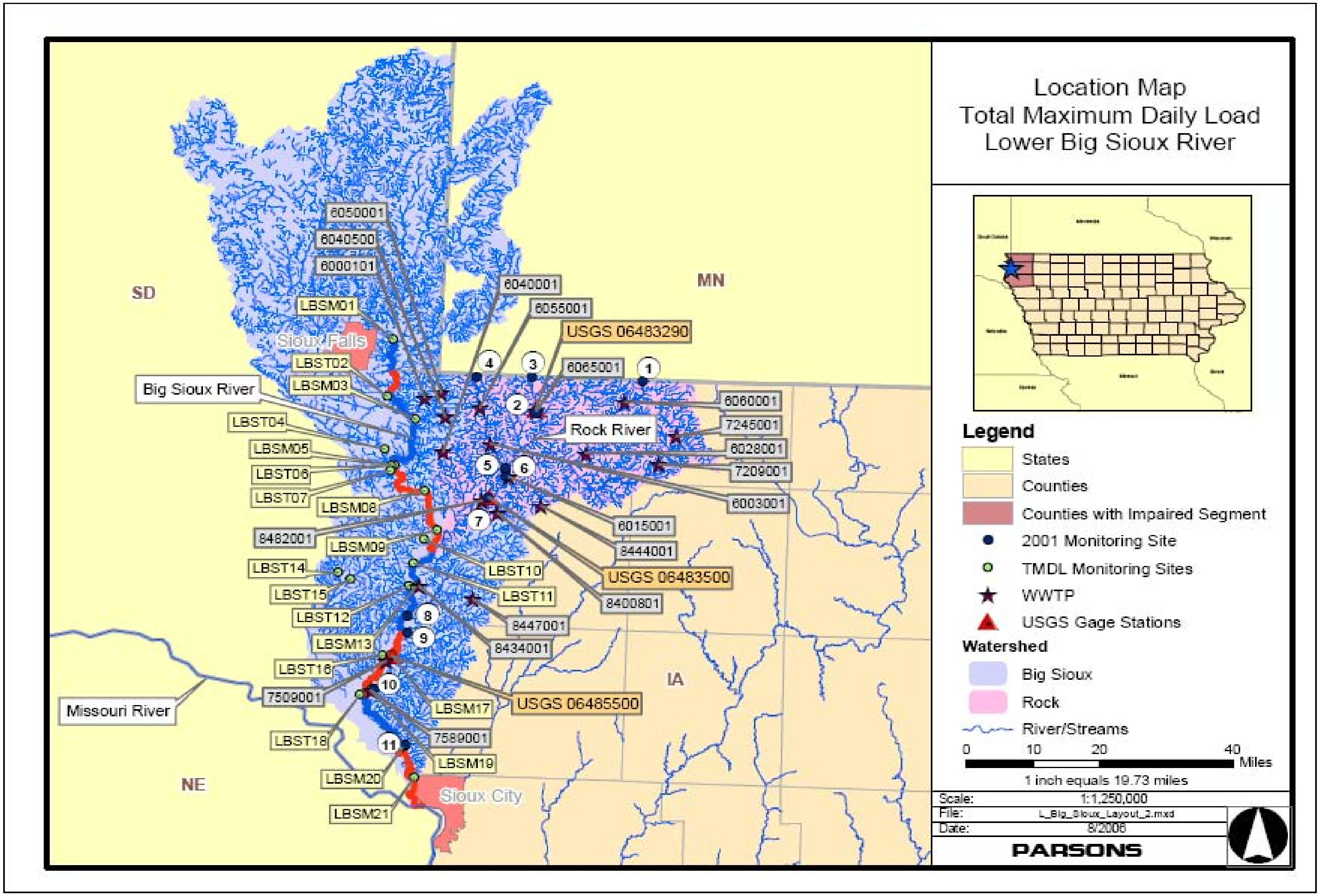


Figure 1. Big Sioux River Project Area

Table 2.3 Land Use Categories for Lower Big Sioux River by Iowa Listed Segments by Iowa HUC 12s.

Iowa Segment	HUC 12 Description	Area (acres)	Cropland	Pastureland	Ungrazed pasture/forest	Built-up
	Unnamed Creek-Rowena	1,028	61.0%	19.0%	18.8%	1.3%
	Big Sioux River	1,652	61.4%	11.6%	25.9%	1.2%
	Blood Run	13,541	73.6%	7.8%	17.9%	0.7%
0020-3	Big Sioux River	445	52.6%	7.8%	38.6%	1.1%
	Big Sioux River	10,934	66.4%	10.8%	22.0%	0.7%
	Klondike Creek	23,611	76.3%	6.8%	15.6%	1.3%
	Big Sioux River	13,498	60.1%	9.8%	29.5%	0.7%
0020-2	Inwood	11,581	65.4%	12.2%	20.7%	1.6%
0020-1	Big Sioux River	26,279	69.2%	5.9%	24.0%	0.9%
	Big Sioux River	4,637	49.3%	7.5%	33.0%	10.3%
	Dry Creek-Big Sioux River	32,076	87.8%	1.9%	9.4%	0.9%
	Big Sioux River	4,089	67.9%	8.4%	21.9%	1.9%
	Upper Sixmile Creek	22,909	86.8%	1.5%	9.1%	2.6%
	Middle Sixmile Creek	21,121	91.3%	1.4%	6.9%	0.3%
	Lower Sixmile Creek	24,991	86.5%	1.8%	11.3%	0.5%
0010-4	Big Sioux River	2,947	82.1%	2.5%	14.3%	1.2%
	Indian Creek-Dubois Creek	29,763	83.2%	2.6%	13.3%	0.9%
	Unnamed Creek-Indian Creek	10,209	90.6%	0.7%	8.3%	0.3%
	Big Sioux River	16,884	60.1%	5.8%	30.9%	3.2%
0010-3	Westfield Creek	18,747	78.0%	5.7%	15.3%	0.9%
0010-2	Big Sioux River	14,406	27.3%	13.8%	57.2%	1.7%
	Upper Broken Kettle Creek	23,462	83.4%	4.2%	12.0%	0.5%
	Bull Run	10,563	82.3%	3.4%	13.5%	0.8%
	Lower Broken Kettle Creek	29,189	37.5%	16.5%	44.8%	1.2%
0010-1	Big Sioux River	12,386	11.0%	12.7%	69.3%	7.1%

Table 2.4 Land Use Categories for Rock River by Iowa Listed Segments by Iowa HUC 12s.

Iowa Segment	HUC 12 Description	Area (acres)	Cropland	Pastureland	Ungrazed pasture/forest	Built-up
	Burr Oak Creek-Rock River	24,981	86.5%	1.8%	10.3%	1.3%
	Unnamed Creek-Dry Run Creek	13,022	90.4%	1.3%	7.6%	0.7%
	Dry Run Creek-Rock River	19,018	90.1%	1.4%	8.1%	0.4%
	Rock River-Burr Oak Creek	25,959	76.8%	2.9%	17.1%	3.1%
	Lower Rock River	20,710	79.4%	5.1%	14.9%	0.5%
	Otter Creek-Rat Creek	32,219	88.3%	1.8%	9.4%	0.5%
	Otter Creek-Schutte Creek	30,672	86.0%	1.0%	10.6%	2.4%
	Cloverdale Creek	12,974	90.5%	0.7%	8.3%	0.5%
	Otter Creek-Kappes Creek	34,412	86.1%	2.1%	10.7%	1.1%
	Rat Creek	20,060	91.0%	1.2%	7.4%	0.3%
	Rock River	8,711	80.0%	4.6%	14.6%	0.8%
	Kanaranzi Creek	6,450	81.5%	6.7%	11.1%	0.8%
	Lower Mud Creek	23,590	85.8%	2.6%	11.0%	0.6%
	Upper Mud Creek	10,632	88.3%	1.8%	9.4%	0.6%
	Middle Mud Creek	28,480	87.5%	1.5%	10.1%	0.9%
	Little Rock River	596	78.9%	8.4%	12.1%	0.5%
	Little Rock River-Snow Creek	28,633	82.8%	3.4%	12.9%	1.0%
	Emery Creek	11,096	91.3%	1.0%	7.5%	0.2%
	Little Rock River-Whitney Creek	33,221	86.0%	1.9%	11.1%	1.1%
	Tom Creek-Rock River	33,336	86.0%	3.0%	10.4%	0.5%
	Unnamed Creek-Rock River	10,366	89.2%	1.4%	9.1%	0.4%
	Rock River-Tom Creek	36,462	79.1%	5.5%	13.2%	2.2%
0010-4	Little Rock River-Emery Creek	25,816	84.9%	2.9%	11.4%	0.8%

Table 2.5 Land Use Categories for Lower Big Sioux River by Iowa Listed Segments by South Dakota HUC 12s.

Iowa Segment	HUC 12	HUC 12 Description	Area (acres)	Open Water	Low Intensity Residential	High Intensity Residential	High Intensity Commercial / Industrial	Bare Rock/ Sand/ Clay	Quarries/ Strip Mines/ Gravel Pits	Deciduous Forest	Evergreen Forest	Mixed Forest	Other Grasses	Woody Wetlands	Emergent Herb Wetlands	Grassland, Hay/ Pasture	Corn	Soybeans	Alfalfa	Spring Grains, Fallow	Other summer crops	Winter Wheat
0020-3	101702031503	Middle Pipestone Creek	18,435	0.0%	0.0%	0.0%	3.5%	0.0%	0.0%	1.2%	0.0%	0.0%	0.0%	0.1%	1.7%	13.7%	36.1%	42.5%	0.6%	0.4%	0.0%	0.0%
	101702031601	Upper-West Pipestone Creek	31,225	0.1%	0.0%	0.0%	3.8%	0.0%	0.0%	0.8%	0.1%	0.0%	0.0%	0.0%	1.0%	13.3%	39.5%	40.7%	0.4%	0.4%	0.0%	0.0%
	101702031504	Lower Pipestone Creek	25,606	0.7%	0.0%	0.0%	4.0%	0.0%	0.0%	0.4%	0.0%	0.0%	0.0%	0.1%	1.7%	12.0%	38.9%	40.6%	0.7%	0.1%	0.0%	0.8%
	101702031401	Upper Split Rock Creek	192	0.0%	0.0%	0.0%	1.9%	0.0%	0.0%	0.7%	0.0%	0.0%	0.0%	0.0%	0.5%	8.1%	0.0%	88.9%	0.0%	0.0%	0.0%	0.0%
	101702031602	Lower West Pipestone Creek	24,370	0.5%	0.0%	0.0%	3.9%	0.0%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.9%	18.9%	33.0%	40.6%	1.7%	0.1%	0.0%	0.1%
	101702031402	Middle Split Rock Creek	23,309	1.6%	0.5%	0.0%	4.4%	0.0%	0.0%	0.4%	0.0%	0.0%	0.5%	0.0%	0.2%	22.4%	30.5%	36.9%	2.5%	0.0%	0.0%	0.1%
	101702031702	Lower Beaver Creek- Split Rock Creek	20,593	0.4%	0.5%	0.0%	4.8%	0.0%	0.0%	0.6%	0.1%	0.0%	0.0%	0.0%	0.6%	22.3%	32.8%	33.6%	3.8%	0.5%	0.0%	0.0%
	101702031403	Lower Split Rock Creek	11,293	3.0%	1.5%	0.0%	6.8%	0.1%	0.0%	0.6%	0.1%	0.0%	1.0%	0.0%	0.5%	32.9%	27.6%	22.8%	2.5%	0.7%	0.0%	0.0%
	101702031703	Springwater Creek	262	0.2%	0.8%	0.0%	18.6%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.6%	47.2%	21.0%	0.3%	0.0%	0.0%	0.0%
	101702031704	Four Mile Creek	8,506	0.1%	0.0%	0.0%	3.8%	0.0%	0.0%	2.1%	0.0%	0.0%	0.0%	0.0%	0.3%	23.5%	30.3%	31.2%	8.8%	0.0%	0.0%	0.0%
	101702031303	Blood Run	1,717	0.0%	0.0%	0.0%	3.0%	0.0%	0.0%	1.0%	0.0%	0.0%	0.0%	0.0%	0.2%	9.5%	40.9%	43.9%	1.4%	0.0%	0.0%	0.0%
	101702031304	Spring Creek	9,198	0.2%	0.1%	0.0%	4.5%	0.0%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%	2.4%	20.5%	35.4%	32.7%	2.8%	0.0%	0.8%	0.0%
	101702031301	Big Sioux River- Slip-Up Creek	21,204	1.6%	2.3%	0.0%	7.2%	0.0%	0.0%	3.3%	0.1%	0.0%	0.8%	0.0%	0.8%	34.7%	21.2%	24.7%	2.7%	0.5%	0.0%	0.0%
0020-2	101702031901	Upper Beaver Creek	35,072	0.7%	0.1%	0.0%	4.7%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	3.7%	21.3%	30.4%	36.4%	1.4%	0.4%	0.6%	0.1%
	101702031305	Ninemile Creek	34,175	0.8%	0.3%	0.0%	5.4%	0.1%	0.0%	0.4%	0.1%	0.0%	0.1%	0.0%	2.3%	18.6%	31.2%	38.4%	1.3%	0.3%	0.5%	0.0%

Iowa Segment	HUC 12	HUC 12 Description	Area (acres)	Open Water	Low Intensity Residential	High Intensity Residential	High Intensity Commercial / Industrial	Bare Rock/ Sand/ Clay	Quarries/ Strip Mines/ Gravel Pits	Deciduous Forest	Evergreen Forest	Mixed Forest	Other Grasses	Woody Wetlands	Emergent Herb Wetlands	Grassland, Hay/ Pasture	Corn	Soybeans	Alfalfa	Spring Grains, Fallow	Other summer crops	Winter Wheat
	101702031801	Big Sioux River- Klondike Creek	7,623	1.8%	0.0%	0.0%	3.4%	0.0%	0.0%	3.1%	0.2%	0.0%	0.0%	0.0%	1.8%	22.2%	35.9%	29.3%	1.2%	0.3%	0.0%	0.6%
	101702031902	Lower Beaver Creek	28,261	0.7%	0.6%	0.0%	4.7%	0.0%	0.0%	1.1%	0.2%	0.0%	0.0%	0.0%	1.7%	14.7%	35.2%	39.0%	1.7%	0.1%	0.2%	0.1%
	101702031802	Big Sioux River Peterson Creek	16,371	1.2%	0.9%	0.0%	5.4%	0.0%	0.0%	0.6%	0.2%	0.0%	0.0%	0.0%	1.2%	12.9%	35.4%	39.8%	2.0%	0.3%	0.1%	0.0%
	101702031903	South Fork Beaver Creek	16,502	0.2%	0.0%	0.0%	4.2%	0.0%	0.0%	0.5%	0.0%	0.0%	0.0%	0.0%	3.3%	10.1%	40.1%	40.6%	0.9%	0.0%	0.0%	0.0%
0020-1	101702031803	Big Sioux River- Little Beaver Creek	13,267	1.4%	0.0%	0.0%	3.4%	0.0%	0.0%	13.3%	0.1%	0.0%	0.0%	0.0%	1.0%	21.7%	28.1%	28.2%	2.8%	0.0%	0.0%	0.0%
	101702031804	Big Sioux River- Pattee Creek	8,017	2.1%	0.7%	0.0%	4.2%	0.0%	0.0%	13.0%	0.7%	0.0%	0.0%	0.8%	0.8%	25.8%	26.6%	21.0%	3.7%	0.7%	0.0%	0.0%
	101702032002	Pattee Creek	25,919	0.5%	0.0%	0.0%	3.6%	0.0%	0.0%	1.2%	0.0%	0.0%	0.0%	0.0%	0.7%	15.6%	37.7%	37.5%	2.9%	0.1%	0.0%	0.3%
0010-4	101702032001	Big Sioux River- Dry Creek	30,209	0.8%	0.0%	0.0%	3.2%	0.0%	0.0%	1.5%	0.0%	0.0%	0.0%	0.1%	1.0%	18.0%	37.0%	34.3%	3.8%	0.2%	0.1%	0.0%
	101702032201	Big Sioux River- Indian Creek North	6,927	1.4%	0.0%	0.0%	3.3%	0.0%	0.0%	2.3%	0.3%	0.0%	0.0%	1.4%	3.6%	26.7%	27.0%	24.6%	7.7%	0.9%	0.0%	0.8%
0010-3	101702032202	Union Creek	23,219	0.2%	0.0%	0.0%	3.7%	0.0%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.2%	13.7%	37.5%	34.7%	9.0%	0.0%	0.2%	0.4%
	101702032203	Big Sioux River- Union Creek	14,213	1.4%	0.0%	0.0%	2.7%	0.0%	0.0%	5.0%	0.1%	0.0%	0.0%	1.6%	8.6%	25.2%	22.6%	24.0%	4.9%	1.2%	0.3%	2.2%
	101702032201	Big Sioux River- Indian Creek South	6,927	1.4%	0.0%	0.0%	3.3%	0.0%	0.0%	2.3%	0.3%	0.0%	0.0%	1.4%	3.6%	26.7%	27.0%	24.6%	7.7%	0.9%	0.0%	0.8%

Iowa Segment	HUC 12	HUC 12 Description	Area (acres)	Open Water	Low Intensity Residential	High Intensity Residential	High Intensity Commercial / Industrial	Bare Rock/ Sand/ Clay	Quarries/ Strip Mines/ Gravel Pits	Deciduous Forest	Evergreen Forest	Mixed Forest	Other Grasses	Woody Wetlands	Emergent Herb Wetlands	Grassland, Hay/ Pasture	Corn	Soybeans	Alfalfa	Spring Grains, Fallow	Other summer crops	Winter Wheat
	101702032205	Big Sioux River- Rock Creek North	2,135	1.7%	0.3%	0.0%	5.5%	0.0%	0.0%	0.9%	0.0%	0.0%	0.0%	0.5%	2.9%	9.4%	40.8%	37.2%	0.1%	0.6%	0.0%	0.0%
	101702032401	Upper East Brule Creek	21,893	0.1%	0.0%	0.0%	3.9%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.6%	11.0%	39.0%	42.7%	1.8%	0.2%	0.2%	0.5%
	101702032403	West Brule Creek	24,785	0.1%	0.0%	0.0%	3.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.2%	10.3%	41.1%	41.2%	2.3%	0.0%	0.0%	0.0%
	101702032402	Lower East Brule Creek	22,692	0.3%	0.5%	0.0%	4.3%	0.0%	0.0%	0.8%	0.1%	0.0%	0.0%	0.0%	1.8%	12.5%	34.2%	42.2%	3.0%	0.1%	0.1%	0.0%
	101702032404	Upper Brule Creek	34,104	0.3%	0.1%	0.0%	4.8%	0.0%	0.0%	0.6%	0.0%	0.0%	0.0%	0.0%	0.8%	15.0%	38.6%	34.9%	4.1%	0.2%	0.1%	0.6%
	101702032405	Lower Brule Creek	33,569	0.2%	0.0%	0.0%	3.5%	0.0%	0.0%	2.8%	0.1%	0.0%	0.0%	0.0%	0.6%	15.7%	36.0%	33.3%	5.9%	0.1%	0.2%	1.5%
	101702032206	Big Ditch	30,324	0.3%	0.1%	0.0%	5.6%	0.0%	0.0%	0.5%	0.1%	0.0%	0.0%	0.0%	1.8%	8.6%	43.4%	39.0%	0.5%	0.1%	0.0%	0.1%
0010-2	101702032205	Big Sioux River- Rock Creek South	19,211	1.7%	0.3%	0.0%	5.5%	0.0%	0.0%	0.9%	0.0%	0.0%	0.0%	0.5%	2.9%	9.4%	40.8%	37.2%	0.1%	0.6%	0.0%	0.0%
0010-1	101702032207	Mouth of the Big Sioux River	10,091	1.6%	1.6%	0.0%	9.8%	0.0%	0.0%	0.9%	0.0%	0.0%	1.4%	0.0%	1.8%	13.9%	32.1%	35.7%	0.7%	0.0%	0.0%	0.0%

2.2.2 Soils

In general, the soils in the Iowa part of the Lower Big Sioux River watershed are alluvium in the river valleys, deep loess when traveling further from the river, which then changes to shallow loess over glacial till. A regional soils map shows three soil regions in the Iowa watershed. These are:

- Semi arid area of loess over glacial till, Moody-Trent Association; most of Lyon County and northwest Sioux County.
- Loess over till, Galva-Primghar-Steinaur Association; eastern Lyon County and most of Sioux County.
- Thin loess over Tazewell till, Sac-Everly-Wilmonton Association; far eastern Lyon County into Osceola County.
- Loess over till, Ida-Galva Association, northwest Plymouth County; Ida-Hamburg southwest Plymouth County; Galva-Ida to Ida-Monona north central to south central Plymouth County.

The stream bottomland and bench soils are nearly level to gently sloping silty soils formed in loess and alluvium. County by county from south to north in the three counties along the LBS Iowa watershed the descriptions of the major soil groups are:

- Plymouth County – gently sloping to very steep well drained silt; level to strongly sloping well drained silt.
- Sioux County - gently sloping to strongly sloping well drained silty soils formed in loess; nearly level to moderately sloping well to somewhat poorly drained silt formed in loess and alluvium; nearly level to strongly sloping well drained silty soils formed in loess.
- Lyon County - nearly level to strongly sloping well drained silty soils formed in loess; nearly level to moderately sloping well drained to somewhat poorly drained moderately fine textured soil.

The soils within the watershed area located in South Dakota are formed from the four main categories: 1) those formed mostly in glacial drift and glacial till; on uplands, 2) soils formed mostly in loess; on uplands, 3) soils formed in alluvium; on bottomlands, and 4) soils formed in alluvium overlying gravelly sand; on stream terraces. Upland soils are relatively fine-grained, and have developed over glacial till or eolian (loess) deposits. Coarse-grained soils are found along present or former water courses, and are derived from glacial outwash or alluvial sediments.

2.2.3 Livestock Feeding Operations

A land use assessment based on aerial infrared photography completed in June 2005 by the IDNR also indicated the major land use in Iowa portion of the LBS River watershed is row crop, that pasture and forage crops are significant land uses, and there are large numbers of Confined Animal Feeding Operations (CAFOs) and active and inactive open feedlots within the Iowa watershed. Similarly, the SDDENR, in partnership with the South Dakota Association of Conservation Districts, also completed an inventory of all (large CAFO, medium animal feeding operation, and small open feedlot) active and inactive animal feeding operations within the Lower Big Sioux watershed.

In Iowa, CAFOs are defined as operations where animals are kept in totally roofed areas. Whereas in South Dakota, a CAFO is defined as a lot or facility that stables or confines and feeds or maintains animals for a total of 45 days or more in any 12-month period and meets the associated criteria for large, medium, or small concentrated animal feeding operations. In addition, existing large South Dakota CAFOs that include operations that feed at least 1,000 beef cattle, 700 dairy cows, or 2,500 head of hogs weighing 55 pounds or more had until September 30, 2005 to get permitted under the state's general water pollution control permit. Existing South Dakota CAFOs that signed a Notice of Intent and did not meet the 2005 deadline have compliance schedules to complete the permitting process.

CAFOs typically utilize earthen or concrete structures to contain and store manure prior to land application. Pathogen indicators, oxygen demanding substances, and nutrients from CAFOs are delivered via runoff from land-applied manure or from leaking/failing storage structures. IDNR's Division of Environmental Regulation responds to complaints regarding water pollution. If pollution from medium and small animal feeding operations is found, the operations are either required to work with the NRCS or a watershed project to remove the unacceptable conditions causing water pollution or get permitted under the general permit.

In Iowa, open feedlots are defined as unroofed or partially roofed animal feeding operations in which no crop, vegetation, or forage growth or residue cover is maintained during the period that animals are confined in the operation. Feedlots with more than one thousand head capacity are registered with IDNR and are required under an agreement with EPA to provide complete control over discharges from their operations or reduce capacity under 1000 head in 2006. These feedlots are considered point sources under EPA rules.

Runoff from open feedlots can deliver substantial quantities of pathogen indicators, nutrients and oxygen demanding materials. Waterbody proximity, livestock numbers and type affect delivery and impact of these constituents, whether or not water is diverted around the feedlot facility when it rains, the efficiency of controls on manure in runoff, and how well these are maintained.

3. Big Sioux River TMDLs for Pathogen Indicators

3.1 Problem Identification

Iowa. The 1998 Iowa Section 305b Assessment Report divided the part of the Big Sioux River that borders Iowa into two segments. The first segment was 82 miles long and extended from the Missouri River confluence to the Rock River confluence. The second segment was 54 miles long and ran from the Rock River to the Iowa/Minnesota border. Both segments had the same designated uses; Class A, Primary Contact Recreation, and Class B, Warm Water Aquatic Life.

The 2002 305b assessment for the Big Sioux River, which is the basis for these TMDLs, subdivides the same two reaches into 7 segments as shown in Figure 2 and Table 2.2.

The following paragraphs are the basis for the Iowa 2002 305b impaired assessment for the five contiguous impaired Big Sioux River segments. These five segments were included on the 2002 Iowa 303d list of impaired waters. The 2002 water quality assessment used fecal coliform as the pathogen indicator bacteria because at the time it was the pathogen indicator in the WQS. Since then the WQS pathogen indicator has been changed to *E. coli* and this new standard is used in Iowa sections of this report unless otherwise noted.

> *For purposes of Section 305(b) assessments, DNR uses the long-term average monthly flow plus one standard deviation of this average to identify river flows that are materially affected by surface runoff. According to the Iowa Water Quality Standards (IAC 1990:8), the water quality criterion for fecal coliform bacteria (200 orgs/100 ml) does not apply "when the waters are materially affected by surface runoff."*
>
> *<u>Reach 0010</u>: For the 2002 report, the previous waterbody segment for the Big Sioux River (IA 06-BSR-0010-0), which extended 82 miles from its mouth at Sioux City to confluence with the Rock River in Sioux County, was split into four sub segments: (1) mouth to Broken Kettle Creek in southwestern Plymouth County (IA 06-BSR-0010-1), (2) Broken Kettle Creek to Brule Creek near Richland, SD (and near Westfield, IA) (IA 06-BSR-0010-2), (3) Brule Creek to Indian Creek in northwestern Plymouth Co. (IA 06-BSR-0010-3), and (4) Indian Creek to the Rock River in Sioux Co. (IA 06-BSR-0010-4).*
>
> - *<u>Reach 0010, Segment 2</u>: See segment 3 for assessment information. Listed as impaired in 2002.*
>
> - *<u>Reach 0010, Segment 3</u>: The Class A (primary contact recreation) uses are assessed (monitored) as "not supported." The data for this assessment is monthly Big Sioux River monitoring done near Richland, SD, by the South Dakota Department of Environment and Natural Resources (DENR) from November 1999 through September 2001. The fecal coliform 10 sample geometric mean not materially affected by surface runoff during the recreational seasons of 2000 and 2001 at the Richland station exceeded the primary contact criterion. The fecal coliform geometric mean was 291-organisms/100 ml, with five samples (50%) exceeding the EPA-recommended single-sample maximum value of 400-organisms/100 ml. According to U.S. EPA guidelines, if the geometric mean level of*

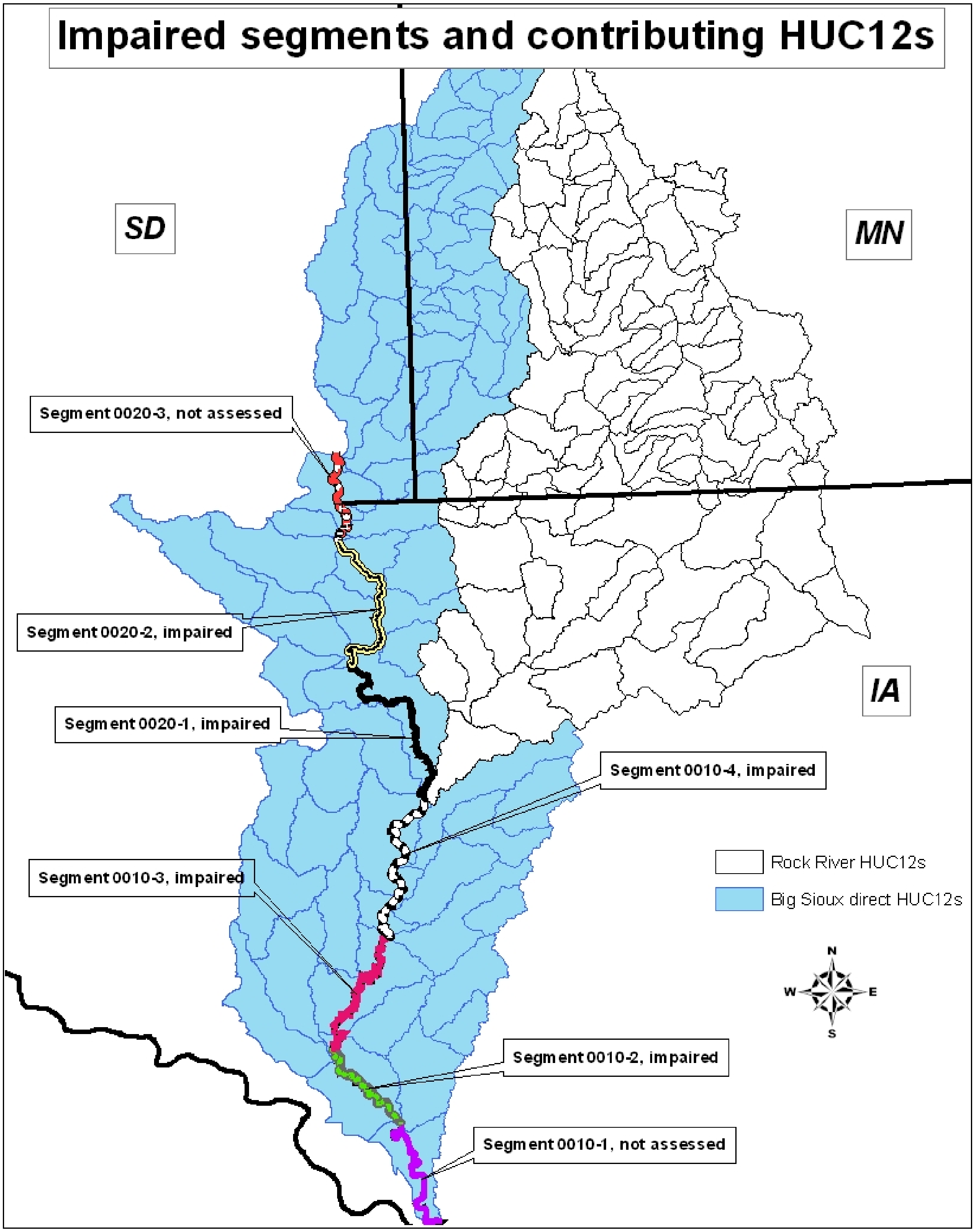


Figure 2. Iowa Impaired Segments and Contributing HUC 12 Sub-watersheds

fecal coliforms exceeds 200 orgs/100 ml, the primary contact recreation uses are "not supported".

- *Reach 0010, Segment 4: The Class A (primary contact recreation) uses are assessed (monitored) as "not supported." The data for this assessment is monthly Big Sioux River monitoring done near Alcester, SD, by the South Dakota Department of Environment and Natural Resources (DENR) from November 1999 through September 2001. The fecal coliform 8 sample geometric mean not materially affected by surface runoff during the recreational seasons of 2000 and 2001 at the Alcester station exceeded the primary contact criterion. The fecal coliform geometric mean was 448-organisms/100 ml, with three samples (38%) exceeding the EPA-recommended single-sample maximum value of 400-organisms/100 ml. According to U.S. EPA guidelines, if the geometric mean level of fecal coliform exceeds 200-organisms/100 ml, the primary contact recreation uses are "not supported".*

Reach 0020: For the 2002 report, the previous waterbody segment for the Big Sioux River (IA 06-BSR-0020-0), which extended 54 miles from its confluence with the Rock River in Sioux County to the Iowa/Minnesota state line, was split into three sub segments: (1) from Rock River to Beaver Creek near Canton, SD and Beloit, IA (IA 06-BSR-0020-1), (2) Beaver Creek to Ninemile Creek ENE of Harrisburg, SD and west of Larchwood, IA (IA 06-BSR-0020-2), and (3) Ninemile Creek to the Iowa Minnesota state line (IA 06-BSR-0020-3).

- *Reach 0020, Segment 1: The Class A uses are assessed (evaluated) as "partially supported." The data for this assessment is monthly Big Sioux River monitoring done near Hudson, SD, by the South Dakota Department of Environment and Natural Resources (DENR) from November 1999 through September 2001. The geometric mean of indicator bacteria (fecal coliforms) in the 7 samples not materially affected by surface runoff during the recreational seasons of 2000 and 2001 at the Canton monitoring station was below the Iowa water quality criterion (200 fecal coliform orgs/100ml) to protect primary contact recreation uses; the percentage of samples that exceeded the U.S. EPA-recommended single-sample maximum value, however, suggests "partial support" of the Class A uses. For purposes of Section 305(b) assessments, DNR uses the long-term average monthly flow plus one standard deviation of this average to identify river flows that are materially affected by surface runoff. According to the Iowa Water Quality Standards (IAC 1990:8), the water quality criterion for fecal coliform bacteria (200 orgs/100 ml) does not apply "when the waters are materially affected by surface runoff." The geometric mean of fecal coliform bacteria in the 7 non-runoff-affected samples was 111 orgs/100 ml, with two samples (29%) exceeding the EPA-recommended single-sample maximum value of 400 orgs/100 ml. According to U.S. EPA guidelines for Section 305(b) reporting, if more than 10% of the samples exceed the single-sample maximum value of 400 orgs/100 ml, the primary contact recreation uses are "partially supported" (see pgs 3-33 to 3-35of U.S. EPA 1997b). Because less than 10 non-flow affected samples were available for this assessment, the assessment type is considered "evaluated"; thus, this assessment is not of sufficient quality to support a Section 303(d) listing.*

Note: The 2004 305b assessment for this segment has determined that it is impaired, as did the 1998 assessment.

- *Reach 0020, Segment 2: The Class A uses were assessed (evaluated) as "partially supported." The geometric mean of indicator bacteria (fecal coliforms) in the 7 samples not materially affected by surface runoff during the recreational seasons of*

2000 and 2001 at the Canton monitoring station was below the Iowa water quality criterion (200 fecal coliform orgs/100ml) to protect primary contact recreation uses; the percentage of samples that exceeded the U.S. EPA-recommended single-sample maximum value, however, suggests "partial support" of the Class A uses. For purposes of Section 305(b) assessments, DNR uses the long-term average monthly flow plus one standard deviation of this average to identify river flows that are materially affected by surface runoff. According to the Iowa Water Quality Standards (IAC 1990:8), the water quality criterion for fecal coliform bacteria (200 orgs/100 ml) does not apply "when the waters are materially affected by surface runoff." The geometric mean of fecal coliform bacteria in the 7 non-runoff-affected samples was 111 orgs/100 ml, with two samples (29%) exceeding the EPA-recommended single-sample maximum value of 400 orgs/100 ml. According to U.S. EPA guidelines for Section 305(b) reporting, if more than 10% of the samples exceed the single-sample maximum value of 400 orgs/100 ml, the primary contact recreation uses are "partially supported" (see pgs 3-33 to 3-35of U.S. EPA 1997b). Because less than 10 non-flow affected samples were available for this assessment, the assessment type is considered "evaluated"; thus, this assessment is not of sufficient quality to support a Section 303(d) listing.

Note: The 2004 305b assessment for this segment has determined that it is impaired, as did the 1998 assessment.

Pathogen indicator bacteria sources can include runoff from fields where manure has been applied, pastures where livestock graze, open feedlots, wastewater treatment plant discharges, urban stormwater run-off, failed onsite systems (septic tanks), and wildlife. Non-point source pathogen problems are usually the consequence of runoff from rainfall. Material containing bacteria is transported by runoff to streams causing high bacteria counts when stream flows are high. There are some non-point sources, such as grazing cattle in streams and some wildlife, that act like point sources in that a pathogen load is delivered to the stream without a precipitation event for transport.

Sources that continuously discharge to a stream are point sources, such as wastewater treatment plants and failed septic tank systems. Wastewater treatment plants that discharge directly into waters designated Class A Primary Contact Recreational Use are required to meet the water quality criterion at their discharge and usually do this by disinfecting plant effluent.

South Dakota. Water quality data collected in the Lower Big Sioux River and its South Dakota tributaries between October 1, 1998 and September 30, 2003 (5 years) showed that the reach of the Lower Big Sioux River extending from the City of Brandon to the confluence with the Missouri River, along with some of its tributaries, contained elevated concentrations of fecal coliform bacteria. More than 10 percent of the water quality samples (mostly those with 20 or more samples) collected from each of the monitoring stations along these waterbodies have exceeded the South Dakota single sample maximum WQS of 400 cfu/100mL of fecal coliform, therefore these waterbodies are considered as impaired (IDNR 2004). Figures 3 to 23 compare fecal coliform concentrations measured during 2000 to 2004 at specific monitoring locations to both the geometric mean WQS and the maximum WQS for any single sample. In addition, Figures 3 to 23 include the median, 60th percentile, and 90th percentile concentrations at specific percentile flow duration interval.

Figures 3 through 23 also distinguish samples collected during May through September in which the WQS is applicable and samples that are collected on days where storm flow is greater than the 50th percentile (median value). In brief, most of the samples with greater than 50th percentile storm flow exceeded the WQS; these samples were mostly collected during May to September. Exceedances were observed mostly during mid to high stream flows (0 to 50th percentile) for the main stem segments and no apparent trends were observed for most tributary segments. Limited data was available for LBST02 and no sample was collected during storm events (i.e. greater than 50th percentile storm flow) as this monitoring station is located at the outlet of Lake Alvin, which is a 107-acre reservoir. Nine Mile Creek has a 28,013-acre watershed draining into Lake Alvin. The reservoir tempers the influence of the watershed on the Lower Big Sioux River therefore limited data was collected for the storm events. In addition, no exceedance was observed for this station and therefore it is not known whether the water quality is impaired at LBST02. There is an existing pathogen TMDL for Lake Alvin that was approved in March, 2001 (SDDENR, 2001), however.

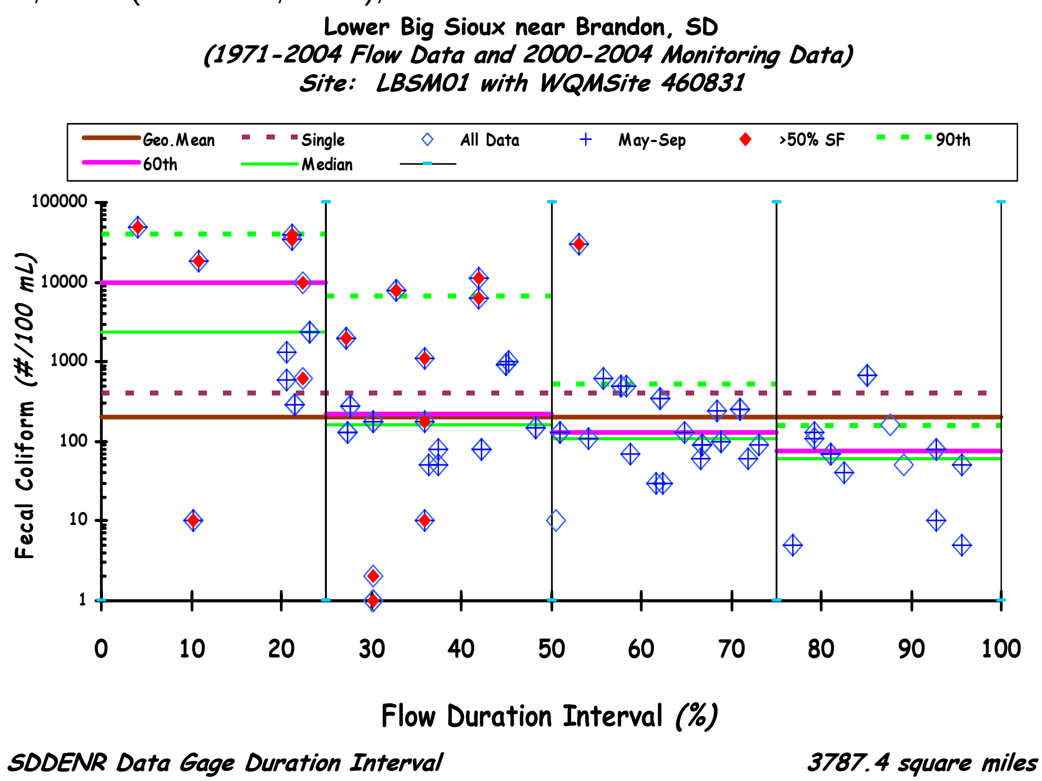


Figure 3. Comparison of Fecal Coliform Concentrations with WQS for LBSM01

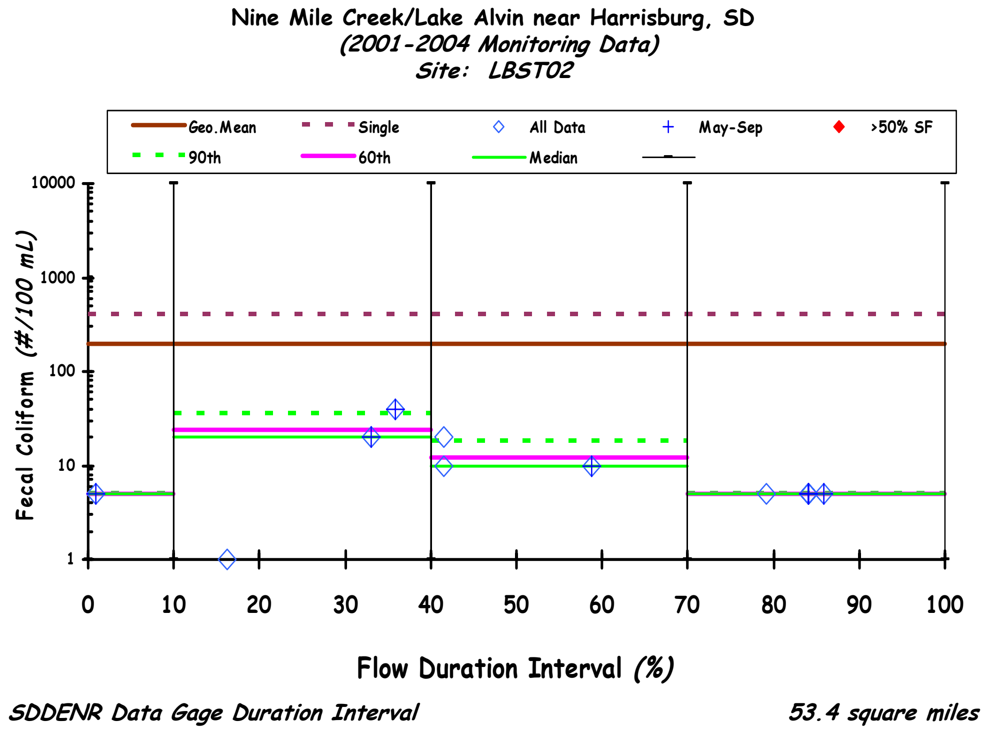


Figure 4. Comparison of Fecal Coliform Concentrations with WQS for LBST02

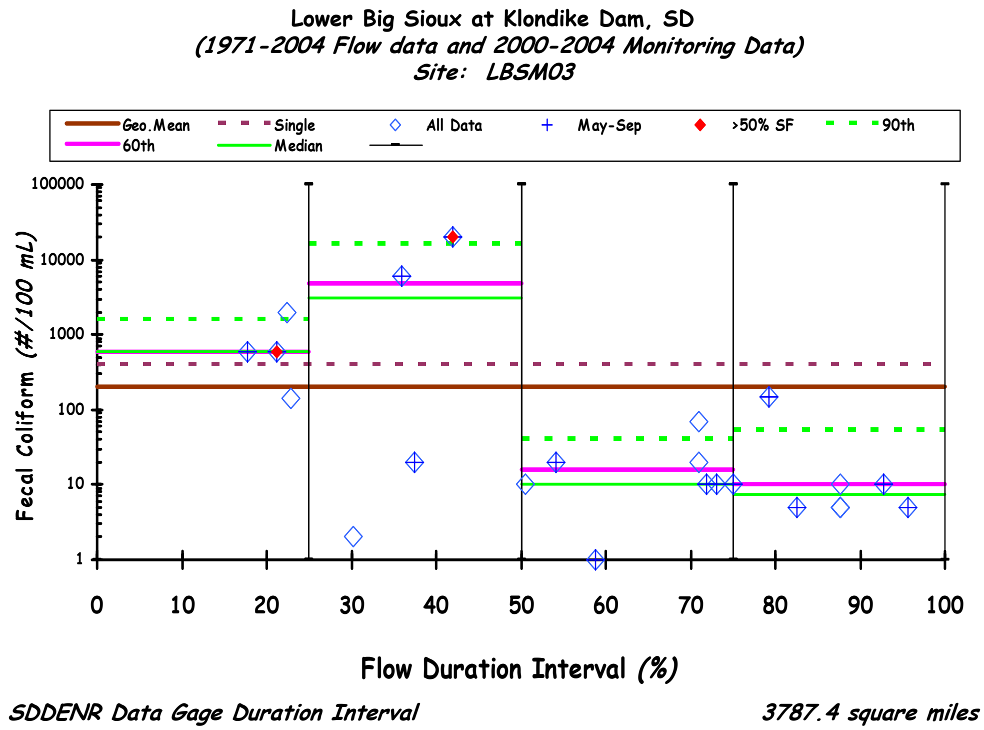


Figure 5. Comparison of Fecal Coliform Concentrations with WQS for LBSM03

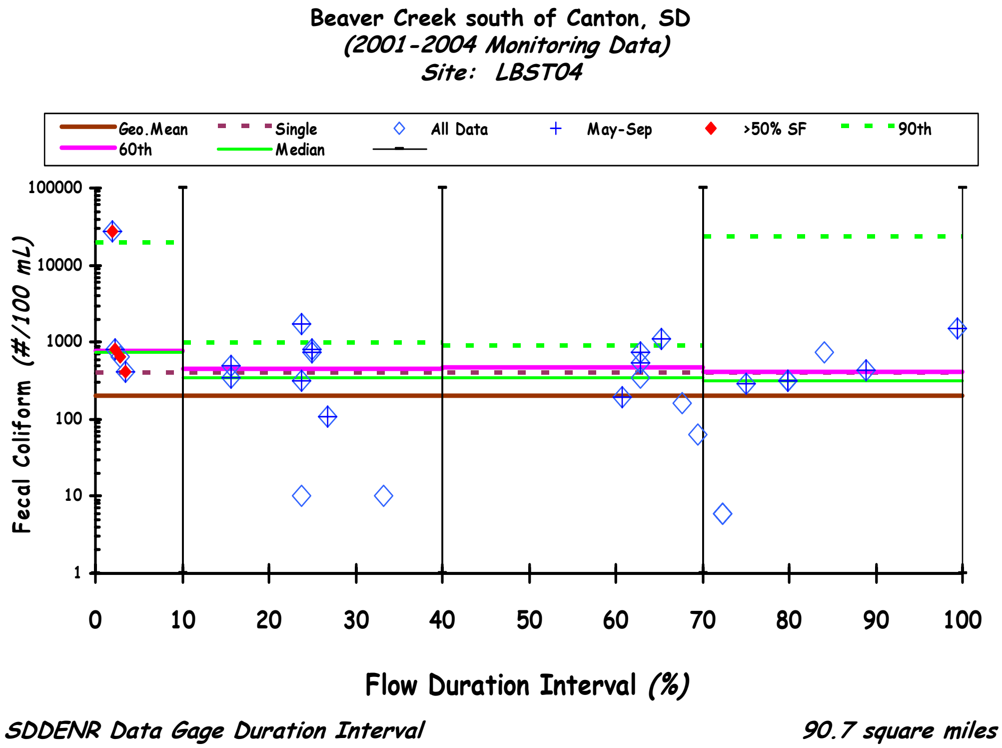


Figure 6. Comparison of Fecal Coliform Concentrations with WQS for LBST04

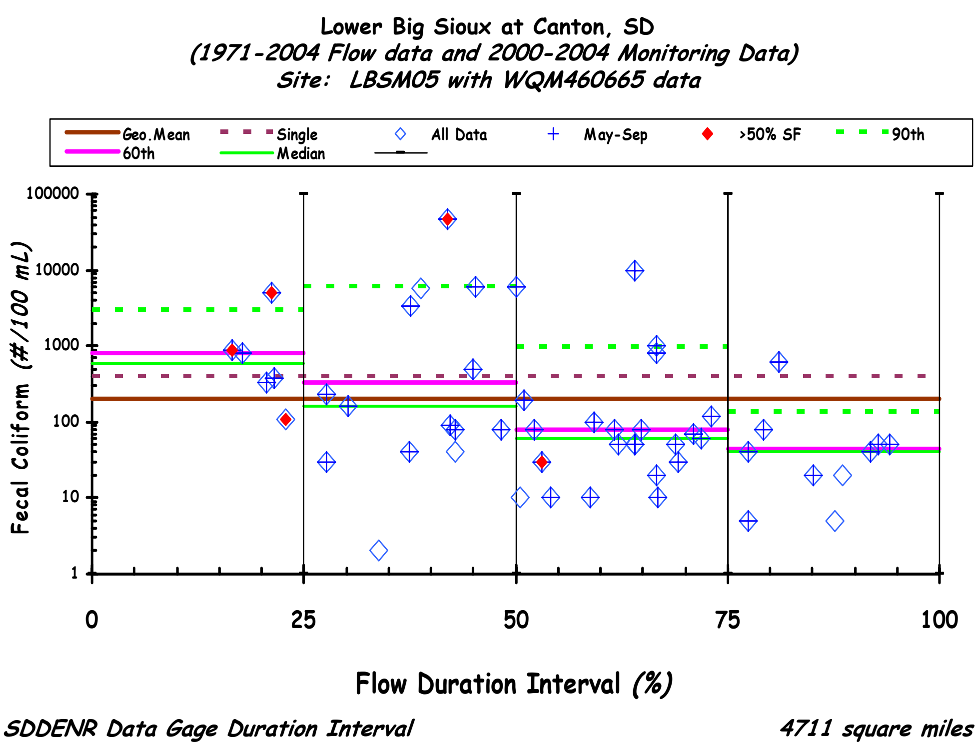


Figure 7. Comparison of Fecal Coliform Concentrations with WQS for BSM05

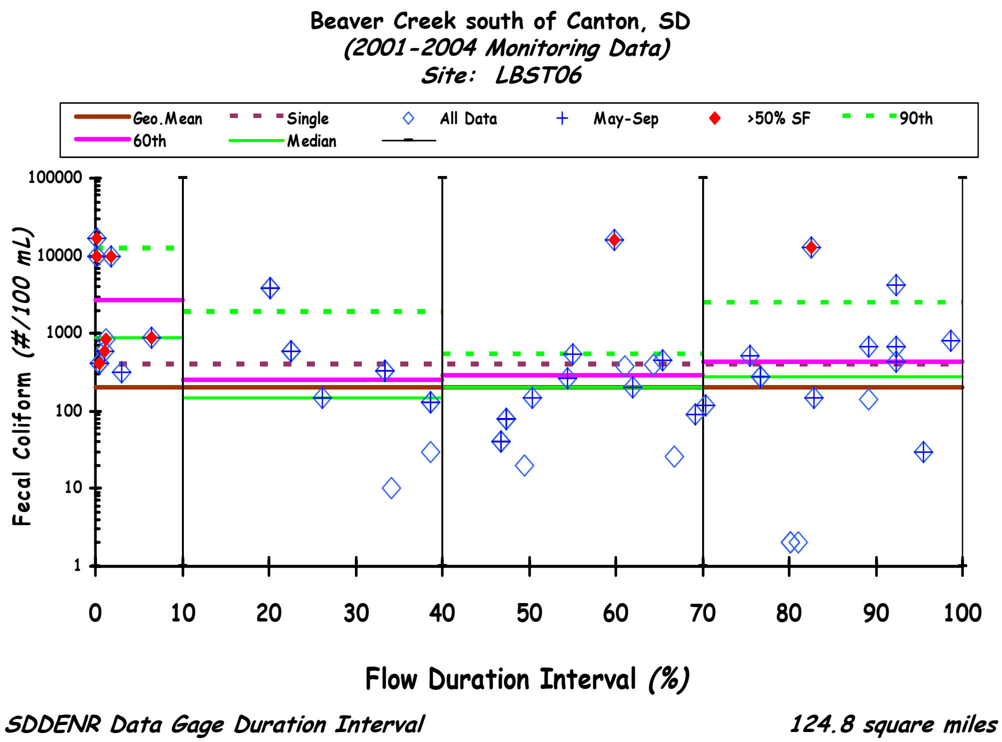


Figure 8. Comparison of Fecal Coliform Concentrations with WQS for LBST06

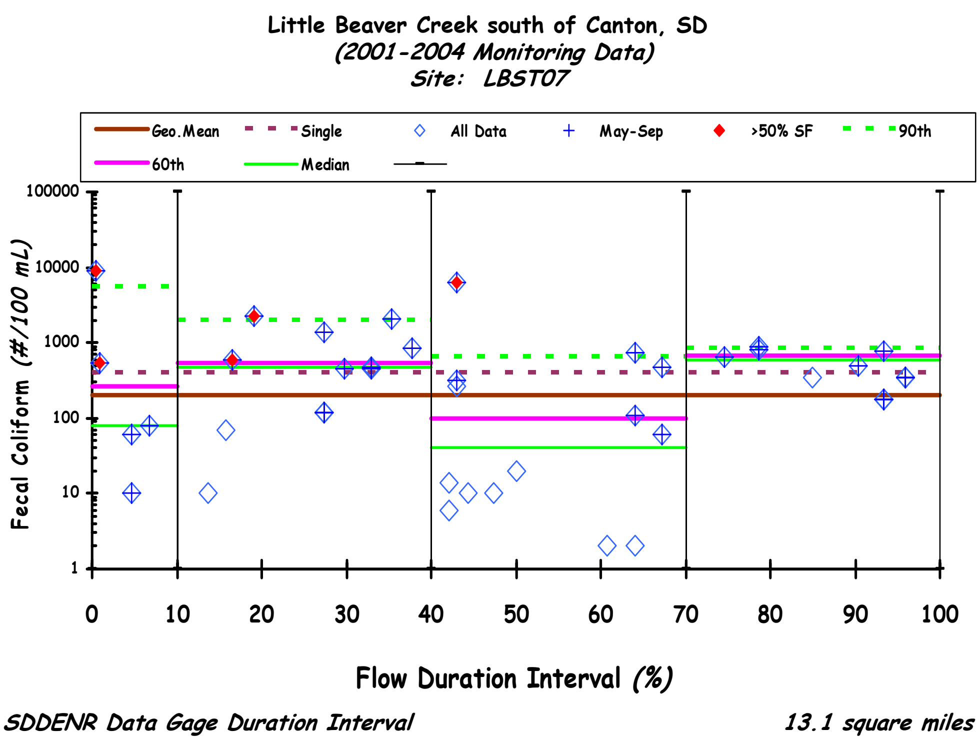


Figure 9. Comparison of Fecal Coliform Concentrations with WQS for LBST07

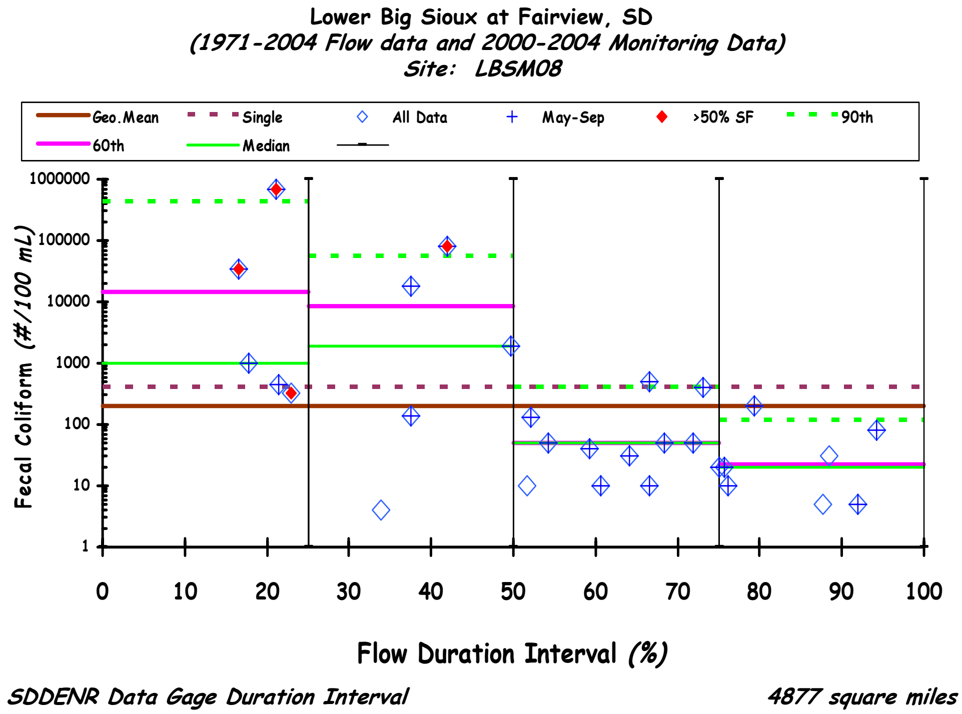


Figure 10. Comparison of Fecal Coliform Concentrations with WQS for LBSM08

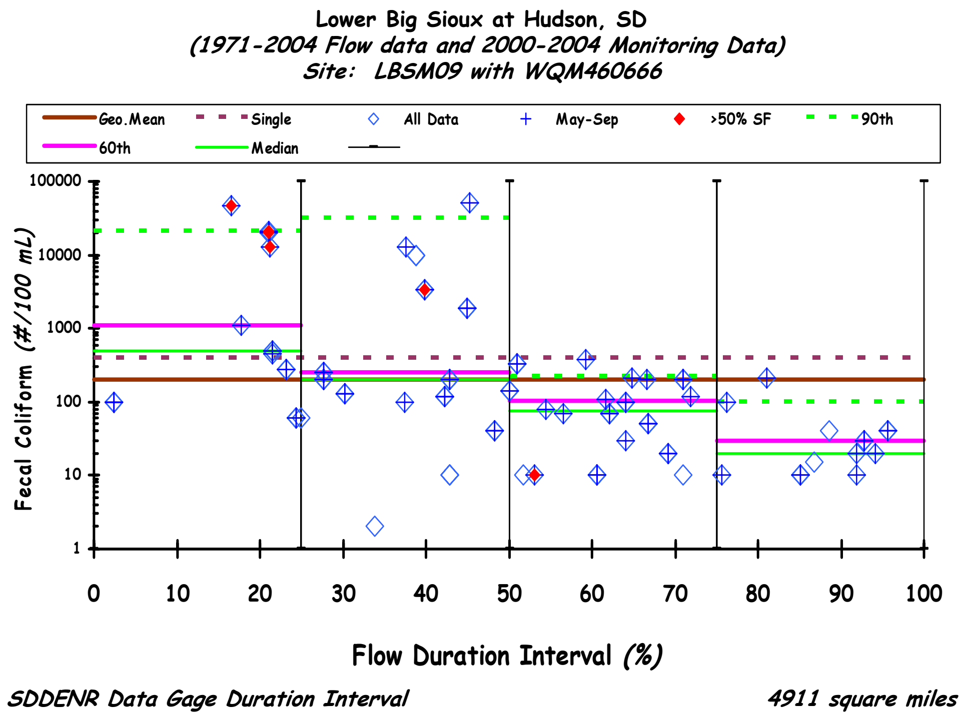


Figure 11. Comparison of Fecal Coliform Concentrations with WQS for LBSM09

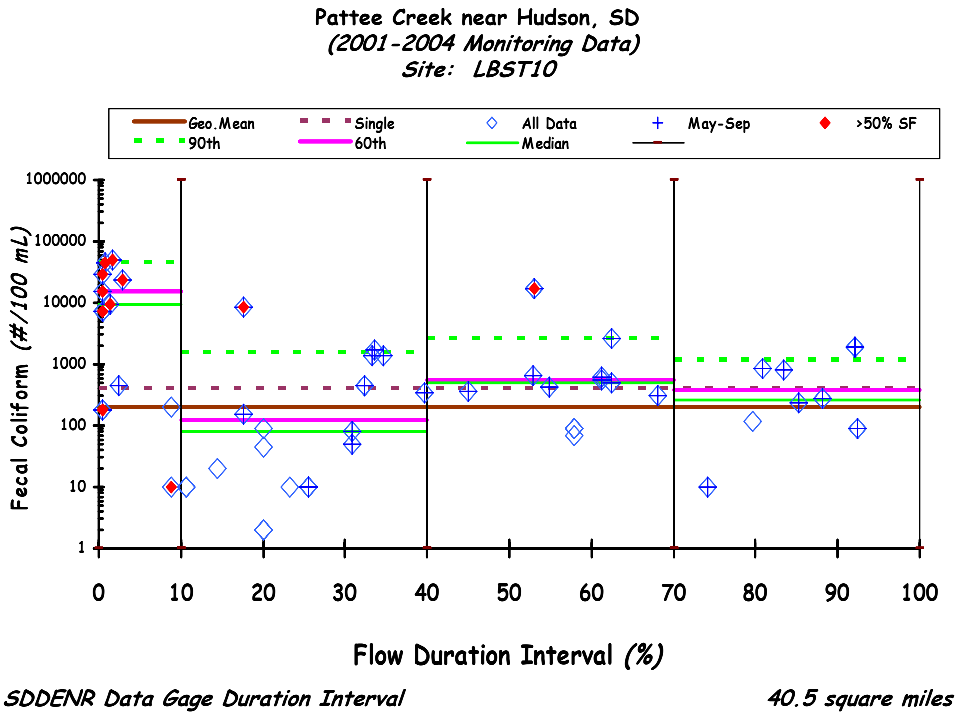


Figure 12. Comparison of Fecal Coliform Concentrations with WQS for LBST10

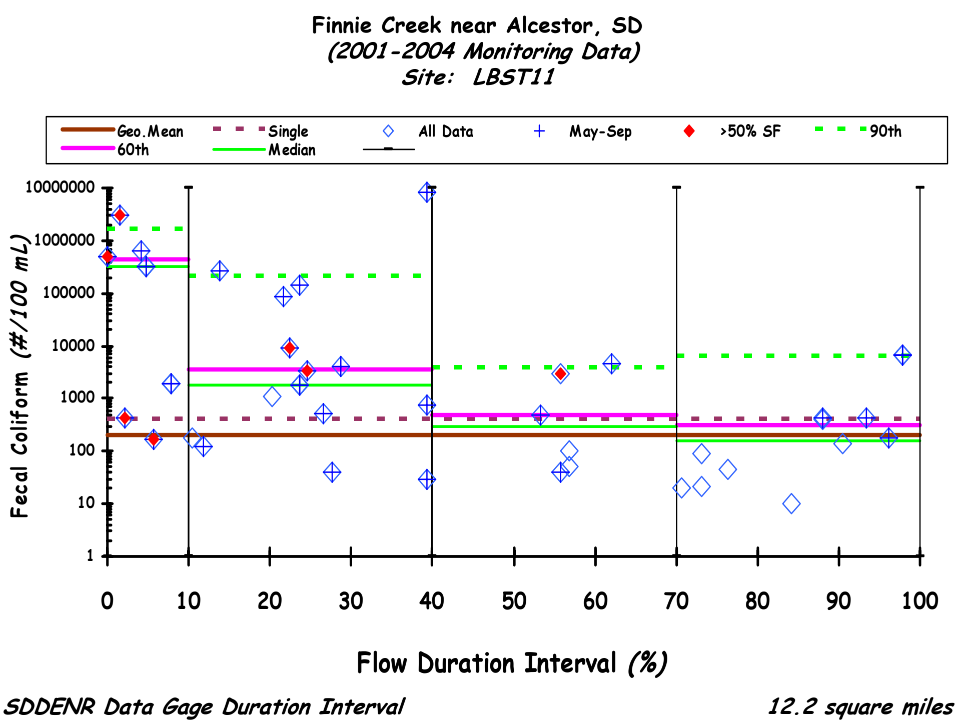


Figure 13. Comparison of Fecal Coliform Concentrations with WQS for LBST11

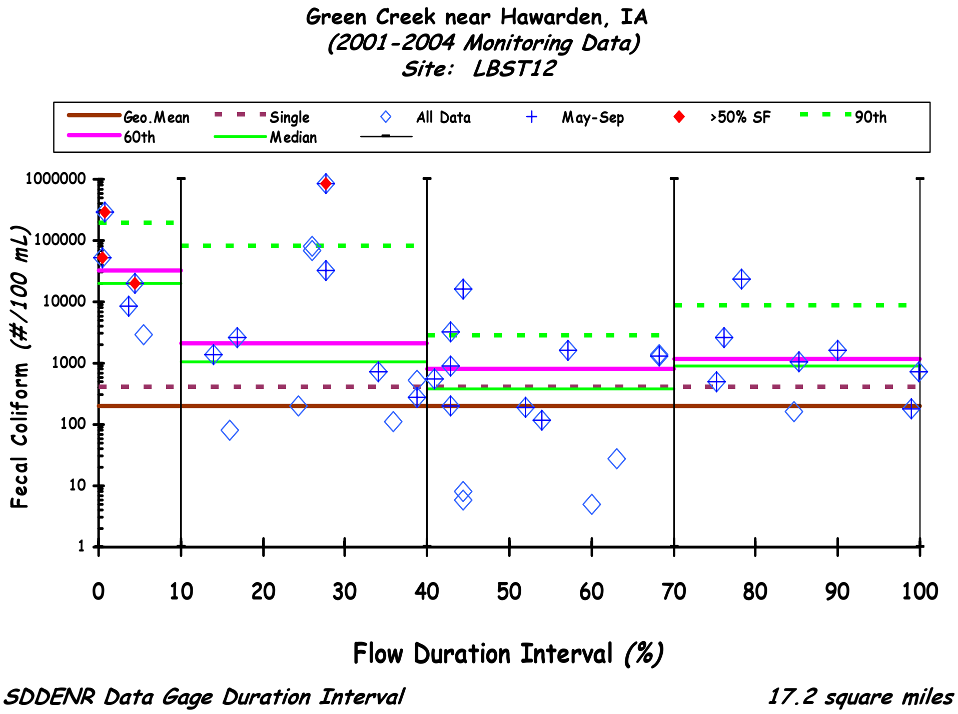


Figure 14. Comparison of Fecal Coliform Concentrations with WQS for LBST12

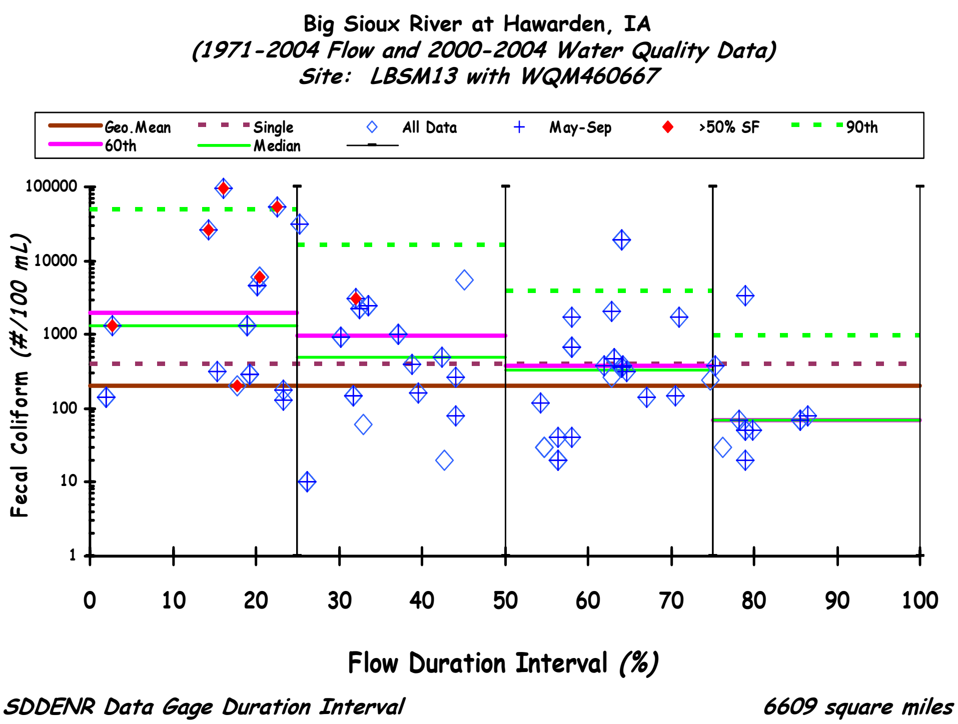


Figure 15. Comparison of Fecal Coliform Concentrations with WQS for LBSM13

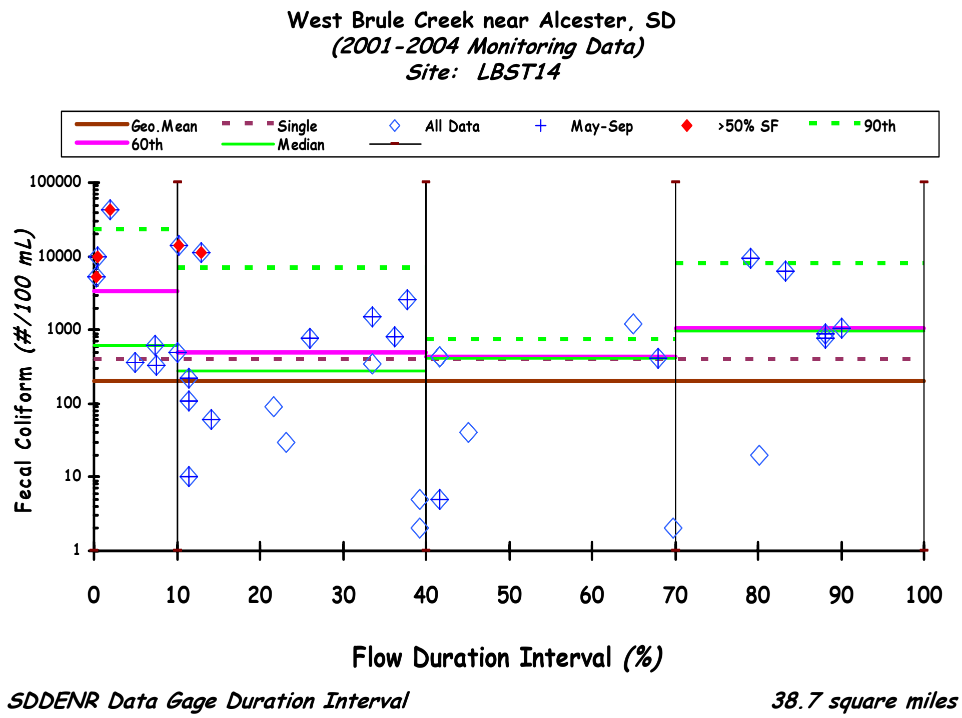


Figure 16. Comparison of Fecal Coliform Concentrations with WQS for LBST14

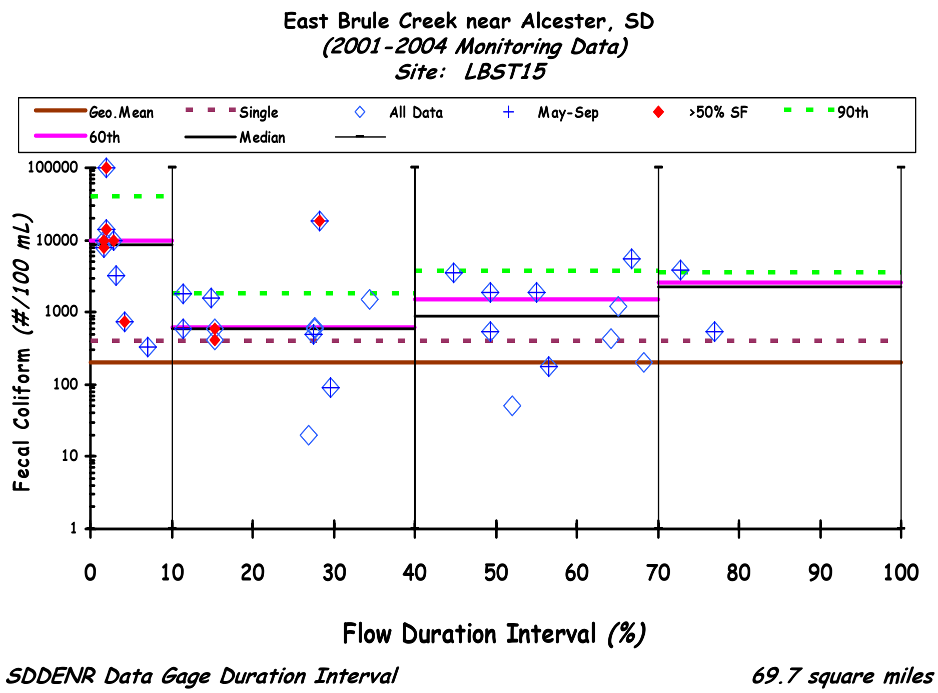
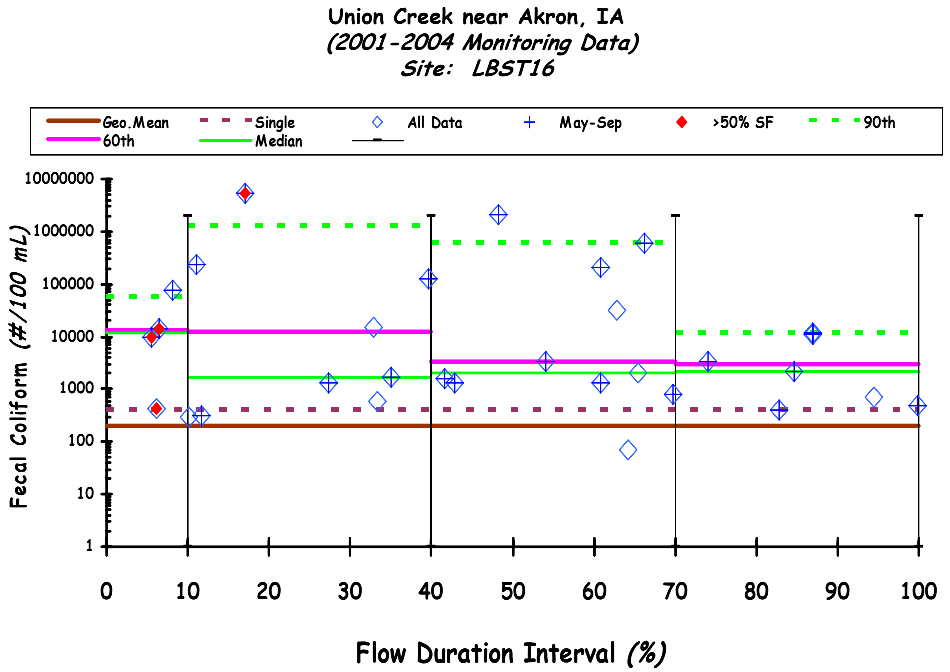
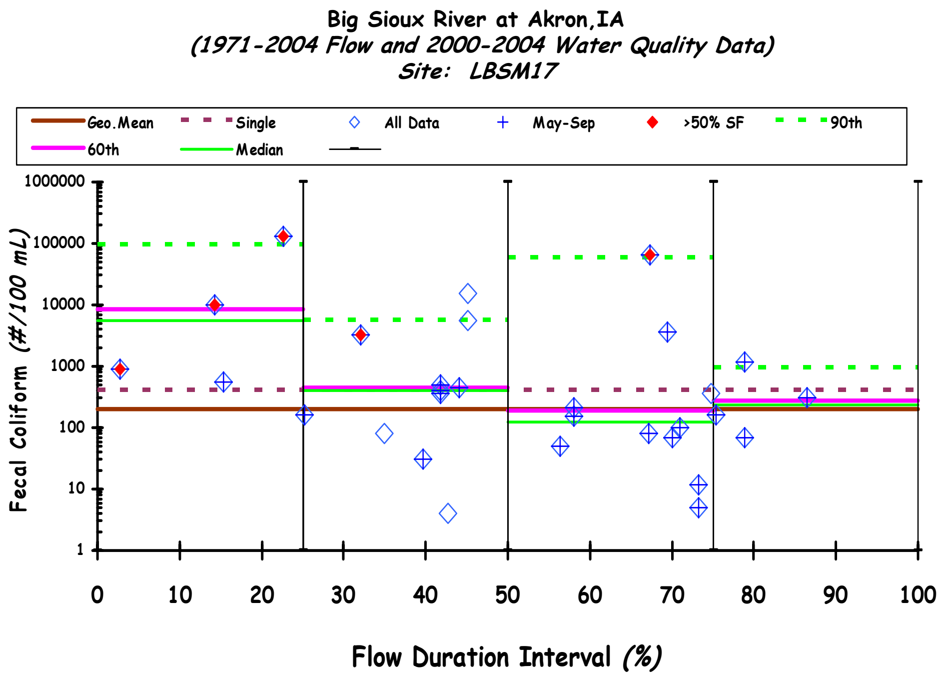


Figure 17. Comparison of Fecal Coliform Concentrations with WQS for LBST15



SDDENR Data Gage Duration Interval *36.3 square miles*

Figure 18. Comparison of Fecal Coliform Concentrations with WQS for LBST16



SDDENR WQData and USGS Gage Duration Interval *6937 square miles*

Figure 19. Comparison of Fecal Coliform Concentrations with WQS for LBSM17

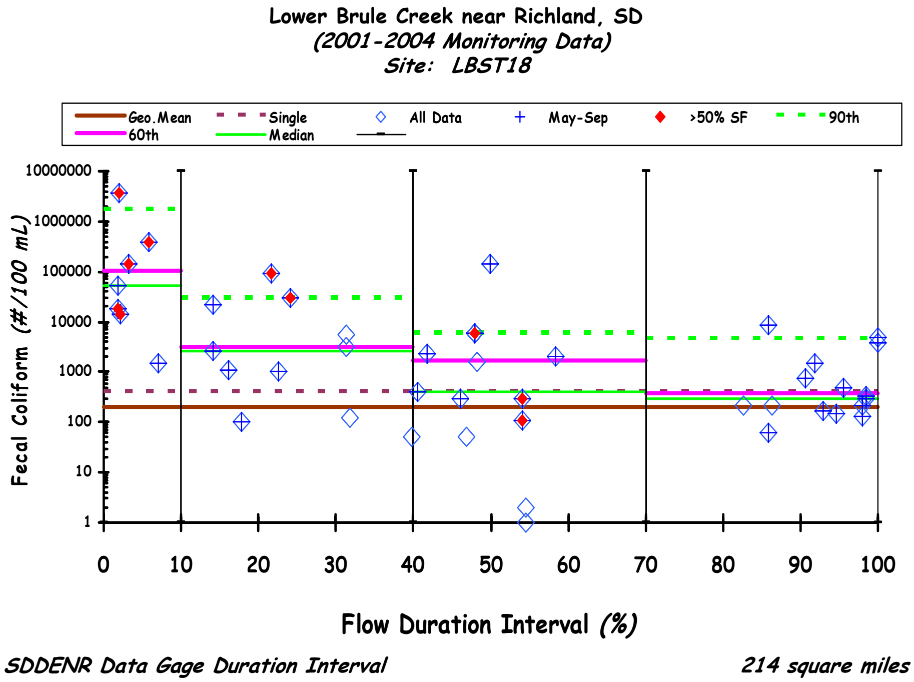


Figure 20. Comparison of Fecal Coliform Concentrations with WQS for LBST18

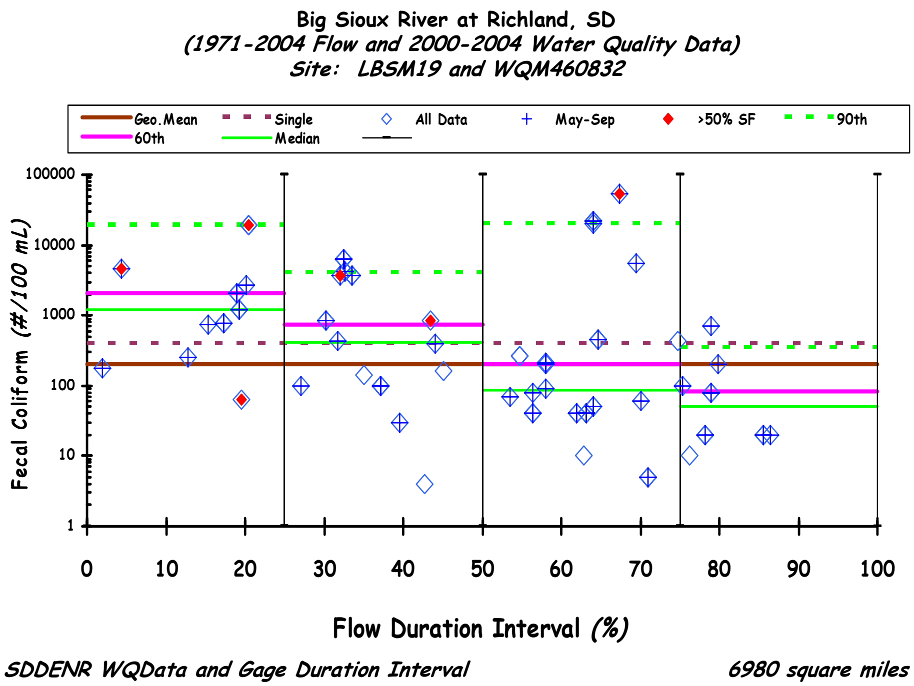


Figure 21. Comparison of Fecal Coliform Concentrations with WQS for LBSM19

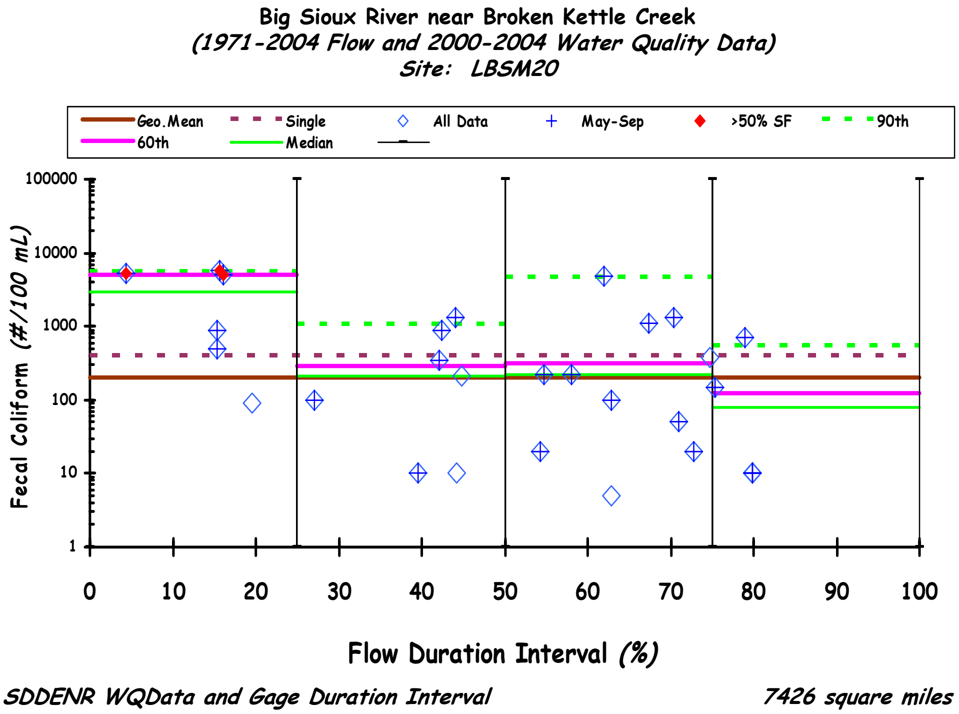


Figure 22. Comparison of Fecal Coliform Concentrations with WQS for LBSM20

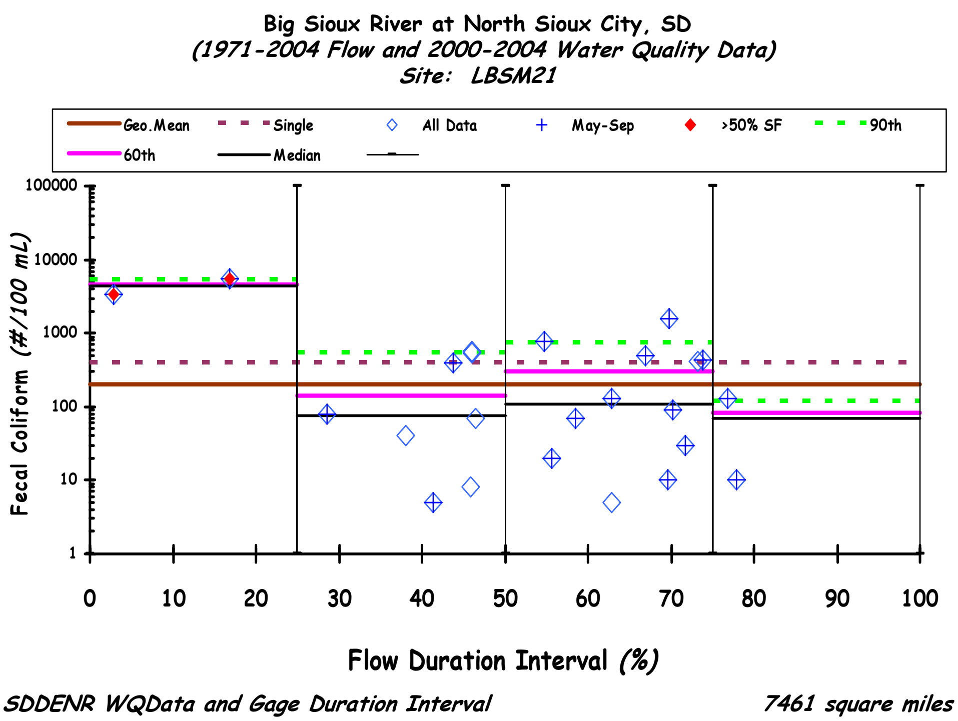


Figure 23. Comparison of Fecal Coliform Concentrations with WQS for LBSM21

3.1.1 Impaired Beneficial Uses and Applicable Water Quality Standards

Iowa. The applicable Iowa designated uses and water quality standards for pathogen indicators are found in *Iowa Administrative Code 567, Chapter 61, Water Quality Standards.*

> *61.3(3)a. Class "A" waters. Waters which are designated as Class "A1," "A2," or "A3" in subrule 61.3(5) are to be protected for primary contact, secondary contact, and children's recreational uses. The general criteria of subrule 61.3(2) and the following specific criteria apply to all Class "A" waters.*
>
> *(1) The Escherichia coli (E. coli) content shall not exceed the levels noted in the Bacteria Criteria Table when the Class "A1," "A2," or "A3" uses can reasonably be expected to occur.*

Table 3.1 E. coli Bacteria Criteria (organisms/100 ml of water)

Use	***Geometric Mean***	***Sample Maximum***
Class A1		
3/15 – 11/15	*126*	*235*
11/16 – 3/14	*Does not apply*	*Does not apply*
***Class A2** (Only)*		
3/15 – 11/15	*630*	*2880*
11/16 – 3/14	*Does not apply*	*Does not apply*
Class A2		
Year-Round	*630*	*2880*
Class A3		
3/15 - 11/15	*126*	*235*
11/16 - 3/14	*Does not apply*	*Does not apply*

Class A1 - Primary Contact Recreational Use.
Class A2 - Secondary Contact Recreational Use.
Class A3 - Children's Recreational Use.

When a water body is designated for more than one of the recreational uses, the most stringent criteria for the appropriate season shall apply.

South Dakota. The applicable South Dakota designated uses are Immersion recreation, warm water semi-permanent fish life, fish and wildlife propagation recreation and stock watering, irrigation watering, and limited contact recreation. Administrative Rules of South Dakota Article 74:51 contains numeric and narrative standards to be applied to the surface waters (i.e. streams, rivers) of the state. The Water quality standard for fecal coliform bacteria is applicable from May 1st to September 30th. The geometric mean standard for fecal coliform bacteria is 200 cfu/100 ml, in which exceedance may not occur in more than 20 percent of the samples examined in any 30-day period (based on a minimum of five samples obtained during separate 24-hour periods for this 30-day period). The sample maximum standard for fecal coliform is 400 cfu/100 ml, i.e. any one sample may not exceed this concentration. Although some of the South Dakota tributary sites have WQS different from the mainstem river (400 cfu/100 mL vs. 2000 cfu/100 mL daily maximum WQS), the 400 cfu/100 mL was used in the South Dakota sections of this

TMDL as a result of South Dakota Administrative Rule 74:51:01:04. Application of criterion to contiguous water. "If pollutants are discharged into a segment and the criteria for that segment's designated beneficial use are not exceeded, but the waters flow into another segment whose designated beneficial use requires a more stringent parameter criterion, the pollutants may not cause the more stringent criterion to be exceeded." The instantaneous fecal coliform WQS of 400 cfu/100 mL was targeted as a conservative approach and should be protective of both the instantaneous and 30-day geometric mean fecal coliform bacteria standards.

3.1.2 Data Sources

Most of the water quality monitoring data used in the development of this TMDL project originates from four different but related monitoring programs and activities managed by the Iowa DNR and South Dakota DENR. These are:

Iowa ambient monitoring program. The Iowa ambient water quality monitoring program is a statewide network of monitoring sites intended to provide data for the assessment of the state's streams and lakes. There is only one ambient monitoring site in the Big Sioux River Iowa watershed and that is on the Rock River near Hawarden. Iowa does not do any ambient monitoring on the Big Sioux River itself.

South Dakota ambient monitoring program. The South Dakota DENR ambient water quality monitoring program also is a program providing statewide water quality monitoring data for assessment purposes. This program operates, four monitoring sites located on the Iowa reach of the Big Sioux River at Canton, Hudson, Alcester and Richland, all on the South Dakota side. Data collected at these four sites has been used by the IDNR for its biannual water quality assessments of the Big Sioux River.

Iowa TMDL targeted water-monitoring program. IDNR began targeted monitoring of the Iowa Big Sioux River tributaries including the Rock River and its major tributaries, in the early spring of 2002 through November of 2003. This monitoring plan consisted of monthly sampling at all of the eleven monitoring sites and the installation of seven autosamplers at seven tributary sites to collect data during precipitation events and to provide continuous water surface elevations that are used to estimate continuous flow rates.

Figure 24 shows the detailed locations of all monitoring sites in relationship to the tributaries. The Iowa autosamplers were installed at sites 5, 6, 7, 8, 9, 10, and 11. Monthly Sites 1, 3, and 4 are located where the Rock River and its two major tributaries, Mud Creek and Little Rock River, cross the border from Minnesota. Monthly Site 2 is located downstream of the City of Rock Rapids at the USGS gage. There is also a USGS gage at autosampler Site 7 in the City of Rock Valley. Hydrographs and data from these Iowa sites can be found in the Data and Model Development E-folder. An index of this folder can be found in Appendix A. The estimated flows for each of the South Dakota monitoring stations are listed in Appendix D.

Figure 24. Iowa Targeted TMDL Monitoring Sites

The South Dakota targeted water-monitoring program. The SDDENR conducted monitoring in the Lower Big Sioux River and its watershed at the same time as the Iowa TMDL targeted monitoring beginning in 2002. This monitoring program includes 21 monitoring sites, 10 sites on the mainstem Big Sioux River and 11 sites on tributaries in the South Dakota portion of the watershed. The USGS completed the water quality and flow monitoring on the 10 mainstem sites during the 2003-2004 period. Flow and load information provided by this monitoring data were used to develop the South Dakota load allocations. The locations of South Daktoa files with the monitoring site listing and a map of their locations can be found in Appendix C.

U.S. Geological Survey (USGS) Gage Stations. There are two USGS flow gages on the Rock River and one on the Big Sioux River. These are located at Rock Rapids and Rock Valley on the Rock and at Akron on the Big Sioux. There are also two relevant gages on the Big Sioux in South Dakota, one in Sioux Falls at North Cliff Ave. and one on Split Rock Creek, a major tributary to the Big Sioux draining parts of South Dakota and Minnesota.

3.1.3 Interpreting Big Sioux River Water Quality Data

Load duration curves and statistical analysis have been used to establish the flow conditions where water quality standards violations occur. Load duration curves are derived from flow plotted as a percentage of their recurrence and pollutant loads calculated from pollutant concentrations and flow volume. Load duration methods have been applied to Iowa flow and water quality data for the four tributaries downstream of the Rock River: Sixmile Creek, Indian Creek, Westfield Creek, and Broken Kettle Creek. SDDENR have also applied the load duration curves to the South Dakota mainstem and tributary flow and concentration data.

3.1.4 Big Sioux River Water Quality Evaluation Plan and Organization

This document consists of five total maximum daily loads for the impaired segments (seven for Iowa and five for South Dakota) of the Big Sioux River. These TMDLs are, in order from the Iowa/Minnesota border to the Missouri:

BSRTMDL-1: From the Iowa/Minnesota border to Beaver Creek, south of Canton, South Dakota, a distance of 47.04 km (29.23 miles). This includes two Iowa assessment segments.

BSRTMDL-2: From Beaver Creek to the Rock River, a distance of 40.65 km (25.26 miles).

BSRTMDL-3: From the Rock River to Indian Creek, a distance of 34.36 km (21.35 miles).

BSRTMDL-4: From Indian Creek to Brule Creek (on the South Dakota side), a distance of 42.78 km (26.58 miles).

BSRTMDL-5: From Brule Creek to the Missouri River confluence, a distance of 55.87 km (34.72 miles). This includes two Iowa assessment segments.

Since the waterbodies are contiguous the TMDL's for the Big Sioux River were developed jointly but calculated separately. The target for each is the same, an organism count that meets the pathogen indicator water quality standards, i.e. for Iowa: Class A designated uses; a geometric mean of 126 *E. coli* organisms/100 ml and a sample maximum of 235 *E. coli* organisms/100 ml and for South Dakota: a sample maximum of 400 fecal coliform/100 ml.

On the Iowa side of the Big Sioux River, the segment into which each of the HUC 12's discharges and the discharge location are identified in Table 3.2. For calculation purposes it is assumed that there is a single discharge point for all loads from each HUC 12 sub-watershed.

On the South Dakota side of the Big Sioux River, the relationship of each Iowa segment with the HUC 12's subwatersheds in South Dakota are summarized in Table 3.3.

For computational and practical reasons it has been assumed that *E. coli* and fecal coliform monitored and calculated values represent the concentration of organisms throughout the waterbody. Estimated numbers of organisms are diluted in the volume of water in the stream. Based on this, the bacteria delivery from the watershed is the ratio of *E. coli* bacteria indicators available for "washoff" to the number of number of organisms monitored and counted in a given volume of the stream expressed as a percentage.

Table 3.2 Iowa Big Sioux River HUC 12 sub-watershed and Rock River discharge locations and associated assessment segments

model #	HUC 12 Name	BSR discharge location, river km	Iowa assessment segment
25	Big Sioux River	202.00	0010-1
23	Lower Broken Kettle Creek	192.82	0010-1
22	Bull Run	192.82	0010-1
20	Upper Broken Kettle Creek	192.82	0010-1
24	Big Sioux River	176.00	0010-2
21	Westfield Creek	159.61	0010-3
19	Big Sioux River	141.00	0010-3
17	Unnamed Creek-Indian Creek	122.00	0010-3
16	Indian Creek-Dubois Creek	122.00	0010-3
18	Big Sioux River	117.00	0010-4

model #	HUC 12 Name	BSR discharge location, river km	Iowa assessment segment
14	Lower Sixmile Creek	113.42	0010-4
12	Middle Sixmile Creek	113.42	0010-4
11	Upper Sixmile Creek	113.42	0010-4
15	Big Sioux River	108.00	0010-4
10	Dry Creek-Big Sioux River	102.63	0010-4
13	Big Sioux River	95.00	0010-4
RR	**Rock River**	87.69	0010-4
9	Big Sioux River	67.00	0020-1
8	Inwood	35.43	0020-2
7	Big Sioux River	29.00	0020-2
5	Klondike Creek	23.28	0020-2
6	Big Sioux River	16.70	0020-2
4	Big Sioux River	8.00	0020-3
3	Blood Run	6.12	0020-3
1	Big Sioux River	2.00	0020-3
2	Unnamed Creek-Rowena	0.00	0020-3

Table 3.3 South Dakota Big Sioux River HUC 12 sub-watershed and associated Iowa assessment segments

TMDL assessment segment	Iowa assessment segment*	HUC 12	HUC 12 Description
Minnesota/Iowa Border to Beaver Creek (BSRTMDL-1)	0020-3	101702031503	Middle Pipestone Creek
		101702031601	Upper-West Pipestone Creek
		101702031504	Lower Pipestone Creek
		101702031602	Lower West Pipestone Creek
		101702031402	Middle Split Rock Creek
		101702031702	Lower Beaver Creek- Split Rock Creek
		101702031403	Lower Split Rock Creek
		101702031703	Springwater Creek
		101702031704	Four Mile Creek
		101702031303	Blood Run
		101702031304	Spring Creek
		101702031301	Big Sioux River- Slip-Up Creek
	0020-2	101702031901	Upper Beaver Creek
		101702031305	Ninemile Creek
		101702031801	Big Sioux River- Klondike Creek
		101702031902	Lower Beaver Creek
		101702031802	Big Sioux River Peterson Creek
		101702031903	South Fork Beaver Creek
Beaver Creek to	0020-1	101702031803	Big Sioux River- Little Beaver Creek

TMDL assessment segment	Iowa assessment segment*	HUC 12	HUC 12 Description
Rock River (BSRTMDL-2)		101702031804	Big Sioux River- Pattee Creek
		101702032002	Patte Creek
Rock River to Indian Creek (BSRTMDL-3)	0010-4	101702032001	Big Sioux River- Dry Creek
		101702032201	Big Sioux River- Indian Creek
Indian Creek to Brule Creek (BSRTMDL-4)	0010-3	101702032202	Union Creek
		101702032203	Big Sioux River- Union Creek
		101702032201	Big Sioux River- Indian Creek
		101702032205	Big Sioux River- Rock Creek
Brule Creek to Missouri River Confluence (BSRTMDL-5)	0010-2	101702032401	Upper East Brule Creek
		101702032403	West Brule Creek
		101702032402	Lower East Brule Creek
		101702032404	Upper Brule Creek
		101702032405	Lower Brule Creek
		101702032206	Big Ditch
		101702032205	Big Sioux River- Rock Creek
	0010-1	101702032207	Mouth of the Big Sioux River

Note: * description indicates reach designation-segment designation

3.1.5 Potential Pollution Sources

There are two types of point sources that could potentially discharge fecal coliform bacteria and *E.coli* into Lower Big Sioux River; they are continuous point sources and Municipal Separate Storm Sewer Systems (MS4). Stormwater runoff from MS4 areas, which is now regulated under the USEPA NPDES Stormwater Program, can also contain high fecal coliform bacteria and *E.coli* concentrations. There are currently no MS4 areas within the Lower Big Sioux River watershed and therefore this TMDL only includes continuous point sources.

Continuous point source discharges such as wastewater treatment plants (WWTP) and animal feeding operation facilities, could result in discharge of elevated concentrations of fecal coliform bacteria and *E. coli* if the disinfection unit is not properly maintained, is of poor design, or if flow rates are above the disinfection capacity.

Non-point sources originate from many diffuse, often unidentified sources rather than from a single location. Because fecal coliform and *E.coli* are associated with warm-blooded animals, non-point sources of fecal coliform and *E.coli* may originate from both rural and urbanized areas. The following sections include a summary of point and non-point sources from Iowa and South Dakota.

<u>Iowa Point Sources</u>

There are 19 permitted point sources in the Big Sioux River Iowa watershed that are potential sources of pathogen indicators. Most are wastewater treatment plants (wwtp) for small municipalities. Tables 3.4 and 3.5 list the NPDES permitted facilities in the Iowa Rock River watershed and the directly draining part of the Iowa Big Sioux River watershed, respectively. For each facility the tables list the treatment process used, design population equivalent, distance to the Big Sioux River, and whether or not the facility is currently disinfecting its effluent. In addition, there are currently 17 NPDES permitted animal feeding operation facilities in Iowa that drains to the Lower Big Sioux River.

Table 3.4 Wastewater treatment plants in the Iowa Rock River watershed

Facility name	Treatment process	Design PE*	Distance to the Big Sioux River, miles	Disinfecting?
Alvord wwtp	Controlled discharge lagoon	269	36.4	No
Ashton wwtp	Controlled discharge lagoon	629	68.5	No
Doon wwtp	Controlled discharge lagoon	454	27.3	No
George wwtp	Controlled discharge lagoon	1257	49.3	No
Hull wwtp	Trickling filter	2994	35.9	No
Lester wwtp	Controlled discharge lagoon	251	45.3	No
Little Rock wwtp	Controlled discharge lagoon	527	68.6	No
Niessink Home	Primary treatment	20	25.6	No
Rock Rapids wwtp	Trickling filter	2934	44.3	No
Rock Valley of wwtp	Aerated lagoon	3174	18.9	No
Sibley wwtp	Aerated lagoon	10922	78.6	No

*population equivalent

Table 3.5 Wastewater treatment plants in the direct Iowa BSR watershed

Facility name	Treatment process	Design PE*	Distance to Big Sioux River, miles	Disinfecting?
Akron, City of wwtp	Controlled discharge lagoon	2216	0	No
Novartis Animal Vaccines	Controlled discharge lagoon	464	5.1	No
Hawarden, City of wwtp	Activated Sludge	21467	0	yes
Inwood, City of wwtp	Aerated lagoon	1006	6.3	No
Ireton, City of wwtp	Trickling filter	754	18.2	No
Larchwood, City of wwtp	Controlled discharge lagoon	675	9.6	No
West Lyon Comm. School	Controlled discharge lagoon	240	8.3	No
Westfield, City of wwtp	Controlled discharge lagoon	234	0	No

*population equivalent

<u>South Dakota Point Sources</u>

There are currently four actively discharging permitted point source dischargers on the South Dakota side of the Lower Big Sioux River. A list of these point sources is summarized in Table 3.6. This table also includes facility type, treatment system used, design flow, and daily maximum permit limit concentration for fecal coliform. There is a difference in the length of the disinfection season for South Dakota and Iowa. The contact recreation season in Iowa is between March 15 and November 15 while in South Dakota it is between May 1 and September 30. This means that from March 15 to May 1 and from September 30 to November 15, even South Dakota plants that are currently disinfecting for the South Dakota recreation season are potential sources. The loads from these point sources are included in the load allocations where flows from the South Dakota part of the watershed enter the Big Sioux River.

Table 3.6 Wastewater treatment plants in the direct South Dakota BSR watershed

Facility name	Facility Type	Treatment process	Disinfecting?	Design Flow (mgd)	Daily Maximum Permit Limit (colonies/100 ml)
City of Brandon	Pond	Aeration/pond system	No	2.56	400
City of Canton	Pond	Pond system	No	3.356	400
City of Alcester	Mechanical	Continuous Discharger	Yes	0.3	2000
Coffee Cup Fuel Stop	Pond	2 cells	No	0.358	2000

Iowa Nonpoint Sources

The non-point pathogen indicator sources in the Iowa part of the Big Sioux River watershed are livestock, wildlife, and failed onsite septic tank systems. The non-point source (NPS) pollutant source components are livestock and wildlife fecal material that is transported periodically during precipitation events and those that are continuous such as discharges from leaking septic tank treatment systems and manure from cattle in and near streams.

South Dakota Nonpoint Sources

The non-point pathogen indicator sources in the South Dakota part of the Big Sioux River watershed may include wildlife, agricultural activities and domesticated animals, land application fields, urban runoff, failing onsite septic tank systems, and pets.

Minnesota Point and Non-point Sources

For the purposes of this TMDL it is assumed that sources originating in Minnesota are the waterways themselves and specific point and non-point sources are not identified. In addition, the Minnesota drainage area in the Lower Big Sioux River watershed is relatively small and therefore this TMDL report assumes that the in-stream monitoring information would also represent all loadings (both point and non-point) from Minnesota. There are two sources of pollutants from the parts of the larger Big Sioux River watershed that originate in Minnesota. One of these is the part of the Rock River watershed that is north of the border. There are three major tributaries from the Minnesota Rock River watershed: Mud Creek, the Rock River, and the Little Rock River. The second source is from the Big Sioux River itself as it crosses the Iowa/Minnesota border into the BSRTMDL-1 segment that runs from the border to Indian Creek.

3.1.6 Natural Background Conditions

Natural background conditions are assumed to be the *E. coli* or fecal coliform load associated with wildlife. This loading has been included in the non-point source load from the watershed.

3.2 TMDL Target

The Iowa target for each of the five Big Sioux River TMDLs is the water quality standard for Class A1, Primary Contact Recreational Use which is a geometric mean of 126 *E. coli* orgs./100ml and a single sample maximum of 235 *E. coli* orgs/100ml. The South Dakota target for the same five TMDLs is the single sample maximum standard of 400 fecal coliform/100 ml. The "loads" associated with these concentrations vary with flow conditions.

3.2.1 Criteria for Assessing Water Quality Standards Attainment

The criteria used to determine attainment of the water quality standards is explained in the 305b report assessment protocol described in the preceding *Section 3.1, Problem Identification*.

3.2.2 Selection of Environmental Conditions

There are two ways that are used to describe flow conditions in this report. The first method is stratification or lumping of measured flow into high and low flow categories. In general, the high flow data are from event automatic samplers and the low flow and very low flow data are from samples taken at regular intervals, usually monthly. The second way is to organize the flow by percent occurrence in flow duration and load duration curves. Both of these methods are described in Appendix B, Procedures and Assumptions and the second method specific to South Dakota is summarized in Appendix C.

<u>High Flow</u>: High flow carries the pollutants in the watershed that are transported during rainfall events. In the Big Sioux River watershed this includes the fecal material available for wash-off from livestock and wildlife. The pollutant loads monitored during high flow are assumed to be associated with this condition. The data indicate that high flows are accompanied by very high *E. coli* or fecal coliform counts. The combination of high flow and high concentrations mean that total *E. coli* or fecal coliform counts are very elevated compared to low flow periods.

<u>Low and Very Low Flow</u>: These flow conditions occur when there is little or no runoff occurring and the stream flow consists mostly of groundwater and continuous discharges from sources like wastewater treatment plants, failed septic systems, and cattle in streams. During periods of low flow, relatively small numbers of fecal coliform can cause water quality standard violations. Design of wastewater treatment plant discharge permits is based on defined low flow conditions, usually the 7-day average low flow with a 10-year recurrence (7Q10).

3.3 Linkage of Sources and Targets: Load Representation, Transportation, and Fate Procedures

Several analytical tools have been used to estimate loads from point and non-point sources, to link the sources to the impaired waterbodies, and to evaluate the impact of the source loads on the ability of a Big Sioux River segment to meet the water quality criteria. Appendix A: E-file Index lists the Iowa data, data analysis, modeling, and allocation and ArcView GIS procedures available in digital format.

Appendix B: Procedures and Assumptions describe the key spreadsheets and assumptions of used to develop the Iowa portion of this TMDL. Similarly, Appendix C describes the data analysis and modeling procedures and Appendix E includes description of the key spreadsheets for the South Dakota analyses and modeling.

Geographical Information System and IDNR Data Coverages: IDNR maintains databases and ARCMAP GIS coverages of landuse, livestock numbers and distribution, locations of wastewater treatment facilities, various hydrologic units, stream locations, recent infrared photography with one meter resolution, USGS 7.5 minute contour maps, etc. These tools were used to estimate stream length and width, locations of pollutant load inputs, changes in stream slope, distribution of rural population on failed septic systems, and wildlife numbers and distribution. Coverages and maps used to develop the Big Sioux River TMDLs can be found in the ARCMAP GIS E-folder. An index of this folder can be found in Appendix A.

Geographical Information System and SD DENR Data Coverages: ARCMAP GIS coverages for the project, bacterial indicator tool (BIT) setup for the HUC12s, and the load duration curve spreadsheets, as well as other water quality and landuse related data can be found in the SDDENR E-folder. A description of the data can be found in Appendix B-E.

Iowa Livestock Census and Distribution Estimates: Livestock have been estimated using the Confined Animal Feeding Operation (CAFO) databases, county livestock census data, land uses and GIS aerial infrared photography. Data from these sources has been evaluated and livestock numbers for each 12 digit hydrologic unit have been estimated and used as input for the modified EPA Bacteria Indicator Tool described below. The Iowa portions of the Rock River watershed and the direct draining Big Sioux River watershed HUC 12's have been evaluated separately. There are 23 HUC 12's in the Rock River watershed that have been evaluated and that discharge through the Rock River to the BSRTMDL-3 segment that runs from the Rock River to Indian Creek. There are 25 HUC 12's that discharge directly to the Big Sioux or to a stream that discharges directly to the Big Sioux River.

South Dakota Cattle Estimates: Loading from cattle standing directly in the stream varies depending on the percent time grazing and percent time standing in the stream. The BIT model assumes only beef cattle are grazing and therefore have access to streams. Loading from cattle in streams from animal feeding operations rated greater than 50 on the Agricultural Non-point Source (AGNPS) rating scale is calculated similar to that for cattle standing directly in streams. It was important to distinguish this source from general loading from cattle in streams because SD DENR protocol for implementation projects dictates that priority for funding will be given to animal feeding operations (AFOs) rated greater than 50 on the AGNPS rating scale. In brief, an inventory of all AFOs located within Lincoln and Union Counties was completed for the Lower Big Sioux Watershed Assessment in 2002 (SDDENR, 2002). The type and number of livestock present in each lot was documented. Digital Orthophoto Quads (DOQs) in GIS were used to determine size of the lot, and subwatershed above the lot that, during a storm event, could provide water potentially draining through the lot. This information, along with slope and soils information, were used with the AGNPS Feedlot Model. This model calculates a pollutant severity rating for the AFO on a scale of zero (no pollution potential) to 100 (severe). The SD DENR standard protocol for the feedlot model is to use a 25 year, 24 hour storm event to evaluate pollution potential.

Modified EPA Bacteria Indicator Tool: The Bacteria Indicator Tool (BIT) is a spreadsheet that was developed by the EPA to provide input for the Hydrological Simulation Program FORTRAN (HSPF). HSPF has not been used to develop these TMDLs but the spreadsheet has been restructured and modified by IDNR to provide daily fecal coliform loads available for wash-off during precipitation events in pasture and cropland from livestock, and in forest, cropland and pasture from wildlife sources, measured as total organism counts. The tool estimates the monthly accumulation rate and uses estimated asymptotic limits of 1.5 (summer) and 1.8 (spring and fall) times the maximum daily accumulation if no wash-off occurs. The input and output are based on monthly assumptions about manure applications and grazing practices. Fecal coliform loads are translated to E. coli values as final worksheet calculations prior to being entered into the Iowa sections of the TMDL document tables as discussed in Appendix B Procedures and Assumptions.

The modified BIT also estimates continuous and direct inputs from cattle in streams and failed septic tanks. Assumptions about when and how many cattle are direct stream inputs vary by the month of the year. It is assumed that the failed onsite septic systems are a direct and continuous input to the stream. The number of failed septic systems in the Iowa side of the Lower Big Sioux River was estimated from the population that does not reside in towns with municipal treatment and the 2002 census block data clipped by HUC 12 using GIS methods. Loadings from septics within each South Dakota HUC 12 subwatershed were estimated based on the number of failing septic tanks reported in the 2002 census data for each county (Minnehaha, Lincoln, and Union). The Iowa model assumes the rural population is equal to the difference between the total population and the population of the cities. In addition, the Iowa model assumes 2.5 persons per housing unit and one septic tank per each housing unit.

The rationale for most of the Iowa assumptions and procedures used in the BIT are explained in Appendix B Procedures and Assumptions and are embedded in the relevant spreadsheets. Additional development information and calculations can be found in the electronic files listed in Appendix A. Similarly, South Dakota assumptions and procedures used in the BIT are explained in Appendix C and are embedded in the relevant spreadsheets listed in Appendix E.

Load Duration Curves: Load duration curves are being used in this report to compare monitored bacteria concentrations and flow data to the water quality standard values at the range of flow conditions. The flow is represented as a percentage of the time a flow rate occurs. The lower the percentile rank, the higher the flow. The highest percentile ranks are for the lowest flows.

Monitoring data that exceeds the water quality standard values at high flow (low percentage) indicates sources that are problems during precipitation events when pollutants available for wash off in the watershed are transported to the stream in runoff. Violations at low flow are from direct and continuous discharges. Examples of runoff driven sources are manure applied to crop and pasture lands, built-up urban areas, and areas inhabited by large numbers of wildlife. Examples of direct and continuous discharges are wastewater treatment plants, cattle in streams, and failed septic systems. Investigating duration curve hydrological conditions can often separate point and non-point sources and their impacts.

Pollutant Fate: Estimating Stream Velocity and Pathogen Die-off: The fate of pathogen indicators from the sources to the particular HUC 12 discharge locations to the discharge locations on the particular impaired Big Sioux River segment have been evaluated using estimated time of travel and a bacteria indicator die off factor. To get the time of travel, the velocity was estimated using the Manning's equation; stream length was estimated by digitizing GIS measurements from aerial photography (one meter resolution). The slope for use in Manning's equation was estimated by measuring the distance between the contours crossing the streams on USGS 7.5 minute topo maps that are available in the Iowa GIS system, and then assuming a linear relationship of the vertical fall to the horizontal distance. Cross-sectional area was estimated using measured width, monitored flow, and field data. Roughness was taken from tables of typical values for natural streams. The critical design flow conditions used in time of travel estimates were those determined from flow and load duration curves. Unlike Iowa, South Dakota assumes no die-off for the fecal coliform bacteria and therefore calculation of time of travel and die off factors were not necessary. This was used as part of the margin of safety.

3.4 Existing Loads on the Big Sioux River

The existing loads on the five TMDL segments along the Big Sioux River have been evaluated using the load duration curve approach using fecal coliform data from the associated SD DENR targeted TMDL monitoring stations (LBSM05, LBSM09, LBSM13, LBSM19, and LBSM21). These load duration curves and the estimated existing loads are summarized in the associated TMDL segment sections in this document.

In addition, IDNR also evaluated the existing loads on the Big Sioux River at the Akron, Iowa USGS gage station using monitoring data from the SD DENR targeted TMDL monitoring done in 2002, 2003, and 2004. The daily flows from the USGS gage have been matched with the monitored E. coli concentrations (translated from fecal coliform values, see Appendix B) and plotted on a load duration curve. The USGS flow data from 1980 to 2004 was used to make the flow duration curve that generated the load duration curve. The target curves are for the Water Quality

Standard targets of 126 E. coli organisms per 100 milliliters for the geometric mean and a sample maximum of 235 E. coli organisms per 100 milliliters converted to daily loads.

Figure 25 shows the monitored data plotted against the Iowa target loading curves. The data on the load duration curve represents the existing overall Lower Big Sioux River condition. This is further developed in subsequent sections for the specific TMDLs. As can be seen, the values that exceed the two target curves occur throughout the flow range. Whether or not the concentration exceeds the target at the two ends, the very high and low flow conditions, is not clear since no samples were collected for these flow conditions. This is due to the fact that flow data was measured daily for 25 years, while the water quality samples were taken much less frequently and for only three years. This means that the more extreme conditions that would be encountered in the longer flow measurement period are less likely to occur during a relatively shorter monitoring period. The first section in Appendix B, Procedures and Assumptions called 'Ecoli and Fecal Coliform Pathogen Indicator Bacteria' describes the issues and treatment of the pathogen indicator bacteria used in the development of this load duration curve and throughout the development of the Iowa part of this TMDL report.

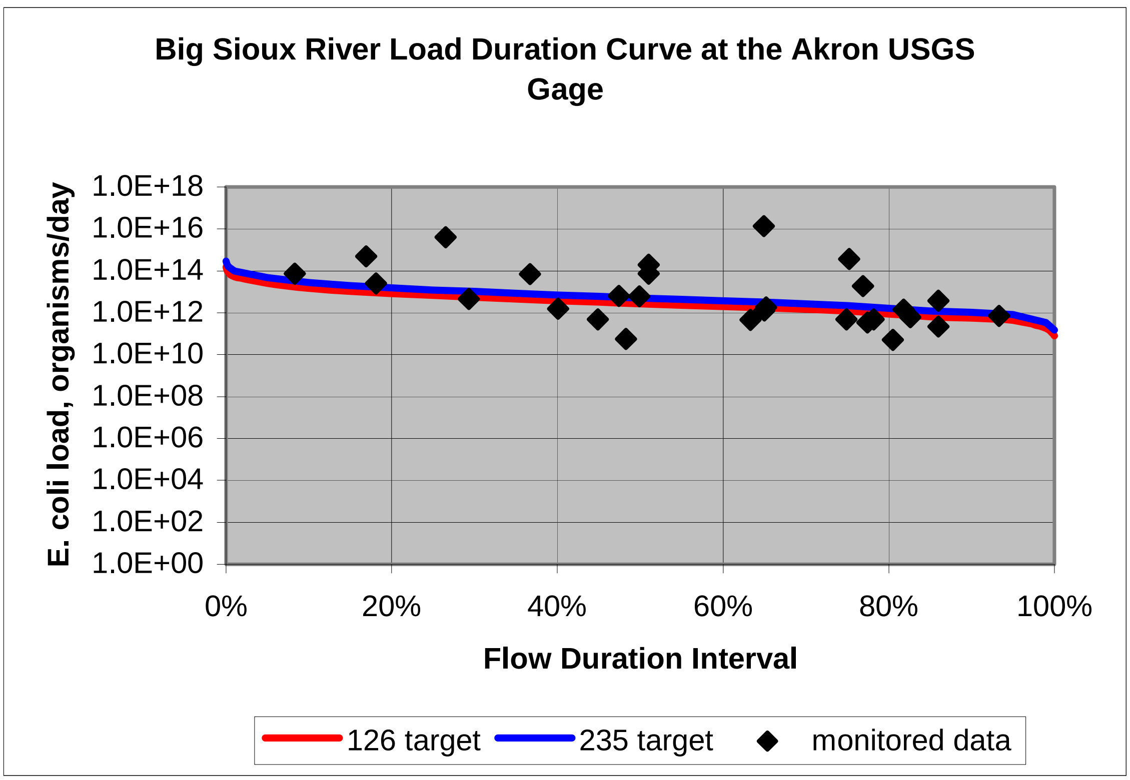


Figure 25. Big Sioux River Load Duration Curve at the Akron USGS gage.

3.5 BSRTMDL-1: The Big Sioux River from the Iowa/Minnesota Border to Beaver Creek

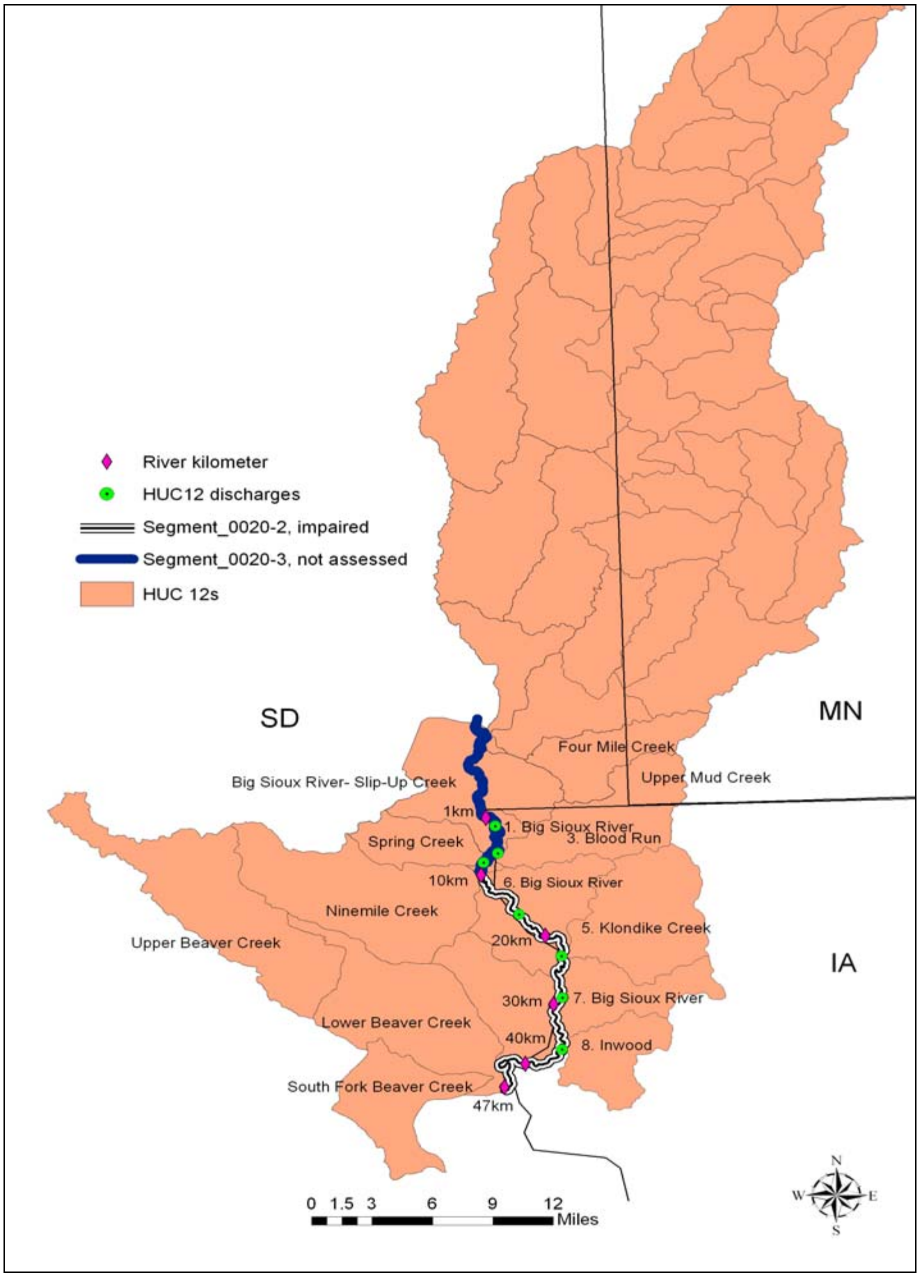


Figure 26. BSRTMDL-1, Iowa/Minnesota Border to Beaver Creek

3.5.1 Pollution Source Assessment

As shown in Figure 26, the BSRTMDL-1 segment is 29.2 miles long and drains eight and 18 HUC 12's in the Iowa and South Dakota portion of the Big Sioux River watershed, respectively. For the Iowa portion, the drainage area is 76,690 acres and there are four wastewater treatment plants in the segment's sub-watershed.

The drainage area is 350,883 acres for the South Dakota portion of this segment's sub-watershed and there are two South Dakota wastewater treatment plants.

Existing Load

The existing load was estimated using the procedures described in Appendix C. In brief, the 60th percentile loading value estimated from the SD DENR water quality data at each flow percentile represents the existing load at the associated flow percentile. A summary of the existing loads reported as both fecal coliform bacteria and *E.coli* for this segment is shown in Table 3.7. Since the water quality data was reported as fecal coliform, the *E.coli* loads were estimated by multiplying the fecal coliform concentration by a conversion factor derived from the single maximum standards for these pathogen indicators (i.e. 235 E.coli/400 fecal coliform = 0.5875).

Table 3.7 BSRTMDL-1, Existing Load Calculated using data from LBSM05

Flow Percentile	Existing Load (cfu/day)	
	Fecal Coliform	*E. coli*
12.5	3.22E+13	1.89E+13
37.5	3.32E+12	1.95E+12
62.5	3.12E+11	1.83E+11
87.5	1.24E+11	7.30E+10

Departure from Load Capacity

The load capacity for this segment of the Big Sioux River is that which meets the water quality standard sample maximum of concentration of 235 *E. coli* organisms/100 ml or 400 fecal coliform/100 ml converted to a daily load. The load capacity varies with the water volume and follows the load duration curve for each monitoring site. The departure from load capacity is the difference between the sample maximum concentration and the monitored concentration for a given stream volume or flow rate. Appendix C includes a description of the procedure in calculating the load capacity and the load reduction. Tables 3.8 shows the maximum allowable load and the percent reduction required to meet the water quality standards. Figure 27 shows the load duration curve for fecal coliform bacteria for LBSM05. The curve represents the TMDL at each percentile flow duration interval. This figure also includes the median, 60th percentile (used to calculate TMDL load reduction), and 90th percentile load at specific percentile flow duration interval. Figure 27 also distinguishes samples collected during the recreational season in which the WQS is applicable. In addition, samples that are collected on days where storm flow is greater than the 50th percentile is also identified.

Table 3.8 BSRTMDL-1, Departure from Load Capacity and Load Reductions Required

Flow Percentile	TMDL (cfu/day)		Load Reductions Required (%)
	Fecal Coliform	*E. coli*	
12.5	2.34E+13	1.37+13	27.5
37.5	5.96E+12	3.5+12	No reduction
62.5	2.45E+12	1.44+12	No reduction
87.5	1.10E+12	6.49+11	No reduction

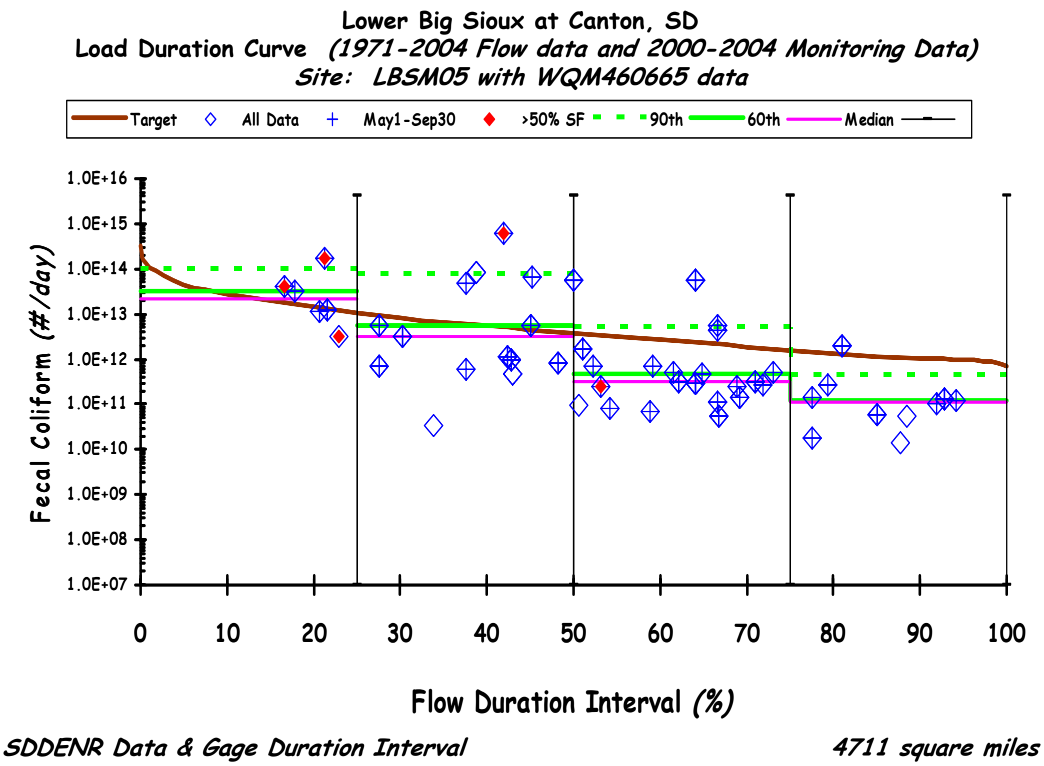


Figure 27. BSRTMDL-1 Load Duration Curve for LBSM05

Identification of Pollutant Sources

The pollutant sources for the BSRTMDL-1 segment are located in both Iowa and South Dakota. The Iowa and South Dakota loads are considered separately. The South Dakota pollutant sources have been identified and evaluated using different procedures than those used in Iowa. South Dakota pollutant sources were identified using various data sources such as 2002 census data and digital Orthophoto Quads in GIS. Detail procedure and model assumptions are described in Appendix C. Iowa pollutant sources were identified used county ag statistics, aerial photography, livestock registration databases, and GIS methods described in Appendix B, Procedures and Assumptions.

Iowa Pollutant Sources:

The pollutant sources on the Iowa part of this impaired segment consist of the upstream loads from South Dakota and Minnesota, loads from four wastewater treatment plants, and non-point sources discharging from this segment's eight HUC 12 sub-watersheds.

Iowa Point Sources: There are four wastewater treatment plants in the BSRTMDL-1 watershed. The distance of each of these from the Big Sioux River has been measured and the delivered load calculated using time of travel and an assumed bacteria die-off coefficient of 0.96 per day during low flow conditions when continuous sources have their greatest impact. Appendix B, Procedures and Assumptions explains the evaluation spreadsheets and the assumptions, modeling equations, and rationale for plant treatment reductions. Table 3.9 shows the delivered loads assuming no effluent disinfection.

Table 3.9 BSRTMDL-1, Wastewater treatment plant *E. coli* loads at BSR

NAME	distance to BSR, km	Low flow time of travel, days	WWTP effluent load *	Load at the BSR *
Novartis Animal Vaccines	8.12	0.43	5.85E+10	3.87E+10
Inwood wwtp	10.16	0.71	1.04E+11	5.25E+10
Larchwood wwtp	15.40	0.95	9.31E+10	3.73E+10
West Lyon School wwtp	13.34	0.71	3.02E+10	1.53E+10

*Units for these loads are *E. coli* organisms/day.

Three of these facilities are controlled discharge lagoons and one is a continuous discharge aerated lagoon. Table 3.5 includes a summary of plant characteristics. In general, controlled discharge lagoons are designed to discharge infrequently, perhaps twice a year, for two or three weeks during higher stream flows. Discharges are usually in the spring and fall.

Iowa Non-point Sources: There are three categories of non-point source loads; manure from livestock and wildlife distributed over the different landuses, cattle in streams, and failing septic tank systems.

The livestock and wildlife manure non-point sources and the built-up land use for this segment have been evaluated for the months of April, June, and October. (The built-up land use consists of commercial, residential and transportation land uses.) These were selected as design conditions because more manure is applied to cropland and pasture in April and October than in other months. These loads require a precipitation event for delivery to the Big Sioux River. The design event has an assumed 1% recurrence (event that occurs every 100 days), i.e., there is enough precipitation to significantly increase runoff and bacteria transport. The bacteria delivery ratio is the *E. coli* organisms delivered divided by the number available for washoff. A delivery ratio of 0.35 has been estimated for flows with a 1% recurrence.

Cattle in streams is a non-point source category that accounts for livestock bacteria loads that are directly delivered to the stream without a significant precipitation event to provide transport. These loads are assumed to be continuous and unvarying through the month. The cattle in streams load is obtained by estimating the number of grazing cattle there are in the HUC 12's and the amount of time they spend in streams. In June the warmer weather is assumed to increase the number of grazing cattle in the stream and the associated loads. Based on county ag statistics, livestock registration databases, and local field assessments, the fraction of grazing beef cattle (versus confined) is 7% of the total in each HUC 12. The cattle in the stream percentage is based on what research is available is 12% in the cooler months and 24% in the warmer months, June, July, and August. This is shown in the Table 3.10 loading values.

Failed septic tanks are assumed to be continuous throughout the year and do not need an event for bacteria transport. Tables 3.10 to 3.12 show the delivered loads for the various non-point sources for the eight HUC 12's on the Iowa side that discharge into the BSRTMDL-1 segment.

Table 3.10 BSRTMDL-1, Iowa Livestock, wildlife and built-up area event NPS loads

No.	HUC 12 name	Dist. to BSR, km	April load * at BSR **	June load * at BSR **	Oct. load * at BSR **
1	Big Sioux River	0.00	6.10E+11	4.69E+11	3.83E+12
2	Unnamed Cr. Rowena	0.00	1.09E+09	1.09E+09	1.30E+09
3	Blood Run	0.00	3.39E+13	2.46E+13	2.19E+14
4	Big Sioux River	0.00	3.79E+08	3.79E+08	4.48E+08
5	Klondike Creek	0.00	6.35E+13	4.51E+13	4.10E+14
6	Big Sioux River	0.00	3.45E+13	2.62E+13	2.25E+14
7	Big Sioux River	0.00	1.58E+13	1.11E+13	1.01E+14
8	Inwood	0.00	7.98E+13	5.90E+13	5.18E+14

*Units for these loads are *E. coli* organisms/day.
** The 1% event bacteria delivery ratio (load delivered divided by available for washoff) is 0.35.

Table 3.11 BSRTMDL-1, Iowa Cattle in streams NPS loads

No.	HUC 12 name	# grazing beef cattle	Dist. to BSR, km	April load, 12% in streams *	June load, 24% in streams *	Oct. load, 12% in streams *
1	Big Sioux River	3	0	2.35E+10	4.70E+10	2.35E+10
2	Unnamed Cr-Rowena	0	0	0.00E+00	0.00E+00	0.00E+00
3	Blood Run	119	0	9.26E+11	1.85E+12	9.26E+11
4	Big Sioux River	0	0	0.00E+00	0.00E+00	0.00E+00
5	Klondike Creek	203	0	1.58E+12	3.16E+12	1.58E+12
6	Big Sioux River	128	0	9.96E+11	1.99E+12	9.96E+11
7	Big Sioux River	53	0	4.14E+11	8.29E+11	4.14E+11
8	Inwood	283	0	2.20E+12	4.41E+12	2.20E+12

*Units for these loads are *E. coli* organisms/day. Percentages are the fraction of grazing cattle that are assumed to be in the stream.

Table 3.12 BSRTMDL-1, Iowa Failing Septic systems NPS loads

No.	HUC 12 name	No. of failed septics	Distance to BSR, km	Load at BSR *
1	Big Sioux River	14	0.00	6.15E+08
2	Unnamed Cr.-Rowena	8	0.00	3.75E+08
3	Blood Run	111	0.00	4.94E+09
4	Big Sioux River	4	0.00	1.73E+08
5	Klondike Creek	194	0.00	8.63E+09
6	Big Sioux River	90	0.00	4.01E+09
7	Big Sioux River	111	0.00	4.95E+09
8	Inwood	95	0.00	4.22E+09

*Units for these loads are *E. coli* organisms/day.

South Dakota Pollutant Sources

The pollutant sources on the South Dakota part of this impaired segment consist of loads from two wastewater treatment plants, and non-point sources discharging from this segment's 18 HUC 12 sub-watersheds.

South Dakota Point Sources: There are two wastewater treatment plants in the BSRTMDL-1 watershed. Appendix C explains the evaluation spreadsheets and the assumptions associated with the waste load allocations. In brief, this TMDL assumes no exceedance in point source discharge from South Dakota, and therefore the maximum loadings from these dischargers are expected to be the same as the Waste Load Allocation (WLA).

South Dakota Non-point Sources: Land uses in the various HUC 12 drainage areas in South Dakota are generally similar (See Table 2.5). The majority of these areas are dominated by a combination of grassland, hay, pasture, corn, and soybeans land uses, follow by high intensity commercial and industrial land uses. There is relatively limited residential area within these drainage areas and therefore impacts from these land uses are expected to be minimal. Assumptions used to model the non-point load estimates are described in Appendix C. Table 3.13 shows the estimated delivered loads for the various non-point sources for the 18 HUC 12's on the South Dakota side that discharge into the BSRTMDL-1 segment during June.

Table 3.13 BSRTMDL-1, South Dakota NPS Load during June

Iowa Assessment Segment	HUC_12	HU_12_NAME	Non-point Source Load (fecal coliform/day)							
			Cropland	Pastureland	Forest	Built up	Storm Sewers	Septics	Cattle in Streams	AFOs
0020-3	101702031503	Middle Pipestone Creek	6.60E+13	1.17E+13	2.31E+03	6.08E+06	0.00E+00	1.00E+09	3.92E+12	0.00E+00
	101702031601	Upper-West Pipestone Creek	1.10E+14	2.12E+13	2.64E+03	6.08E+06	0.00E+00	3.68E+09	6.20E+12	0.00E+00
	101702031504	Lower Pipestone Creek	9.05E+13	1.59E+13	1.35E+03	6.09E+06	0.00E+00	3.67E+09	5.08E+12	0.00E+00
	101702031602	Lower West Pipestone Creek	7.38E+13	2.16E+13	1.06E+03	6.08E+06	0.00E+00	4.23E+09	4.61E+12	0.00E+00
	101702031402	Middle Split Rock Creek	6.37E+13	2.39E+13	1.15E+03	6.08E+06	5.12E+11	3.66E+09	4.41E+12	7.80E+13
	101702031702	Lower Beaver Creek- Split Rock Creek	5.69E+13	2.02E+13	1.56E+03	6.09E+06	3.24E+11	6.81E+09	3.89E+12	0.00E+00
	101702031403	Lower Split Rock Creek	2.16E+13	1.39E+13	8.97E+02	6.11E+06	1.16E+12	5.05E+09	2.13E+12	0.00E+00
	101702031703	Springwater Creek	5.92E+11	4.91E+10	0.00E+00	6.11E+06	0.00E+00	2.92E+08	4.00E+10	0.00E+00
	101702031704	Four Mile Creek	2.32E+13	6.56E+12	1.94E+03	6.08E+06	0.00E+00	3.11E+09	1.61E+12	0.00E+00
	101702031303	Blood Run	6.49E+12	3.31E+11	1.92E+02	6.07E+06	0.00E+00	7.34E+08	3.25E+11	0.00E+00
	101702031304	Spring Creek	1.97E+13	4.86E+12	8.03E+02	6.09E+06	0.00E+00	2.23E+10	1.40E+12	1.34E+14
	101702031301	Big Sioux River- Slip-Up Creek	3.92E+13	2.81E+13	3.96E+03	6.15E+06	0.00E+00	7.72E+10	3.69E+12	0.00E+00
0020-2	101702031901	Upper Beaver Creek	9.02E+13	4.07E+13	3.40E+02	6.09E+06	0.00E+00	1.64E+10	6.38E+12	1.05E+14
	101702031305	Ninemile Creek	7.45E+13	2.48E+13	3.33E+03	6.09E+06	1.10E+12	1.49E+10	5.22E+12	1.76E+14
	101702031801	Big Sioux River- Klondike Creek	1.52E+13	3.93E+12	4.52E+03	6.08E+06	0.00E+00	1.17E+09	1.16E+12	3.12E+12
	101702031902	Lower Beaver Creek	6.81E+13	1.53E+13	6.61E+03	6.09E+06	7.55E+11	1.10E+10	4.32E+12	2.01E+14
	101702031802	Big Sioux River Peterson Creek	4.08E+13	6.55E+12	2.34E+03	6.09E+06	6.35E+11	5.42E+08	2.50E+12	5.41E+13
	101702031903	South Fork Beaver Creek	4.36E+13	6.27E+12	1.56E+03	6.09E+06	0.00E+00	2.72E+09	2.52E+12	0.00E+00

3.5.2 Pollutant Allocations

Wasteload Allocations

Wastewater Treatment Plant Wasteload Allocations: The wasteload allocations (WLA) for the Iowa wastewater treatment plants in the BSRTMDL-1 segment sub-watershed are based on the standard assumption that effluent concentration must meet the water quality standard at the point where it enters a stream that has the Class A1 Primary Contact Recreational Use designation. Therefore, the WLA for a plant discharging directly into a classified stream would be the same as the numeric *E. coli* water quality standard. The wastewater treatment plant *E. coli* loads delivered to the BSRTMDL-1 segment and the distance of the plant discharge from the BSR is shown in Table 3.9 in Section 3.5.1 Pollution Source Assessment.

Wasteload allocations for Iowa discharges some distance from the designated use waterbody (BSR) are calculated using the estimated time of travel between the discharge location and the Big Sioux River and a bacteria die-off factor. The time of travel estimates for the four BSRTMDL-1 wastewater treatment plants used time of travel calculations for segments of Mud Creek similar to the streams receiving the plant effluent. (See the spreadsheets *Mud Time of Travel.xls* and *BSR direct wwtp.xls* listed in Appendix A.) The Mud Creek time of travel estimates were calculated from flow monitoring data stratified into three categories; high flow, low flow, and very low flow.

Wasteload allocations for Iowa dischargers were calculated for the most stringent condition, which is low flow. At high flow, the load from these small facilities is not over the E. coli standard and is also dwarfed by the surface run-off loads. At very low flow, the reduced stream velocity allows for greater die-off so the allocation concentration at the discharge location is higher (less stringent) than for low flow.

For the indirect discharges, the time of travel has been estimated at low flow and die-off has been back calculated from the Big Sioux River upstream to the discharge location. The calculations and assumptions used in the development of Iowa wasteload allocations are in the time of travel and bacteria die-off sections of Appendix B, Procedures and Assumptions.

These WLA's apply from March 15 through November 15 and are intended to provide *E. coli* and fecal coliform concentrations at the confluence with the Big Sioux River that complies with the *E. coli* Water Quality Standards (WQS). The WQS values for *E. coli* are a geometric mean of 126-organisms/100 ml and a sample maximum of 235-organisms/100 ml. The WLA's for the BSRTMDL-1 wastewater treatment plants are in Table 3.14.

Table 3.14 BSRTMDL-1 Iowa WWTP Wasteload Allocations

Name	WQS load at BSR, *E. coli* org/day *	WLA at wwtp location, *E. coli* org./day **	WLA geometric mean, *E. coli* org/100 ml ***	WLA sample max. *E. coli* org/100 ml ***
Novartis Animal Vaccines wwtp	7.39E+08	1.12E+09	**191**	**356**
Inwood wwtp	1.57E+09	3.11E+09	**249**	**466**
Larchwood wwtp	3.77E+08	9.40E+08	**314**	**588**
West Lyon School wwtp.	1.14E+09	2.26E+09	**249**	**466**

*This is the allowable total daily load for the wwtp in *E. coli* organisms per day for the design plant flow at the WQS concentration of 126 E. coli organisms/100ml.
**This is the allowable total daily load at the effluent discharge location after die-off has been calculated at low flow time of travel.
***Concentration WLA's are based on the E. coli numeric WQS values of 126-organisms/100 ml for geometric mean and 235-organisms/100 ml for the sample maximum and accounting for die-off between the discharge and the BSR. Standard applies from March 15 to November 15.

WLA's for South Dakota are calculated using the permit effluent limit and the design flow. Detailed procedure for these calculations is described in Appendix C. These WLA's are apply from May 1st to September 30th. The South Dakota WLA's for the BSRTMDL-1 point source discharges are summarize in Table 3.15. This table also includes information on the permit limit (i.e. the maximum wasteload allocation concentration) and design flow.

Table 3.15 BSRTMDL-1 South Dakota WWTP Wasteload Allocations

Facility Name	Permit Number	Design Flow (mgd)	Wasteload allocation concentration, maximum (colonies/100 ml)	WLA (colonies/day)
City of Brandon, SD	SD0022535	2.56	400	3.88E+10
City of Canton, SD	SD0022489	3.356	400	5.08E+10

<u>BSR Direct Watershed Permitted Animal Feeding Operation Facilities Wasteload Allocations</u>: Some animal feeding operations require National Pollutant Discharge Elimination System (NPDES) permits. These permits set limits on the pollutants that can be discharged to waterbodies based on a wasteload allocation. The thresholds for needing a permit are based on animal units (AU) - one beef cow equals one animal unit; one dairy cow equals 1.4 animal units. All of the permitted facilities in the Big Sioux watershed are beef cattle feedlots or dairy operations. For feedlots the threshold is 1000 beef cattle and for dairies it is 700 dairy cows.

There is one Iowa NPDES permitted animal feeding operation facility in the BSR direct watershed that drains to the BSRTMDL-1 impaired segment. The wasteload allocation for this facility follows state (IAC 567- Ch.65) and federal rules (40 CFR

125.30 through 125.32) requirements for open feedlots. The relevant state rule, IAC 567 – 65.101(2)a(1), requires that there be no discharge of manure, process wastewater, settled open feedlot effluent, settleable solids or open feedlot effluent resulting from precipitation events less than or equal to the 25 year, 24 hour precipitation event. The permitted facility, its location, HUC 12, and WLA, is shown in Table 3.16.

Table 3.16 BSRTMDL-1 BSR Direct Watershed NPDES Permitted Animal Feeding Operation Facility Wasteload Allocation

Facility Name	Facility ID	NPDES permit #	EPA #	Township and range	Sec	1/4 Sec	HUC 12	WLA
Hoogendoorn Feedlot	56506	60-00-0-07	IA0079502	T98N R48W	35	SE	BSR #8*	No discharge**

*This refers to the HUC 12 sub-watershed in the BSR direct watershed and corresponds to the HUC 12 number in column one of Table 3.17.
**No discharge resulting from precipitation events less than or equal to the 25 year, 24 hour precipitation event.

Load Allocations and Pollutant Load Reductions Needed
The load allocations for this TMDL are based on the discharges from the Iowa and South Dakota HUC 12s sub-watersheds that discharge to the BSRTMDL-1 segment and the loads from the Big Sioux River itself where it crosses into Iowa. The load allocations are based on the assumption that all discharges into the Big Sioux River from all sources must meet the single sample water quality standard of 235 *E. coli* organisms/100 ml or 400 fecal coliform/100 ml converted to a daily load.

A review of the Iowa load duration curves (spreadsheet *stream data analysis.xls*) for the Big Sioux and the tributaries that have been monitored shows that the bacteria targets are exceeded at most flow conditions, although by different sources with different delivery mechanisms. Four representative flow conditions have been selected for the derivation of Iowa load allocations and needed pollutant reductions. These are the 1%, 10%, 50%, and 70% load duration curve flow ranks (Tables 3.17 through 3.20). June load estimates for non-point sources that are event driven and for cattle in the stream sources have been selected as sufficiently representative. June is also the month when most monitored tributary events occurred. See Appendix B, Procedures and Assumptions for an explanation of load allocation development.

A review of the South Dakota load duration curves for the Big Sioux and the tributaries that have been monitored shows that the bacteria targets are exceeded at mid to high flow conditions. Four representative flow conditions have been selected for the derivation of South Dakota load allocations and needed pollutant reductions. These are the 0-10%, 10-40%, 40-70%, and 70-100%, see load duration curve range (Tables 3.21). See Appendix C for explanation on the load allocation calculations.

Table 3.17 BSRTMDL-1 Iowa Allocations and Reductions for 1% rank flow

No.	HUC 12 name	Load Allocation*	Existing Load *	Reduction needed
1	Big Sioux River	3.14E+10	5.16E+11	93.9%
2	Unnamed Cr.-Rowena	1.91E+10	1.47E+09	none
3	Blood Run	2.52E+11	2.65E+13	99.0%
4	Big Sioux River	8.80E+09	5.52E+08	none
5	Klondike Creek	4.40E+11	4.83E+13	99.1%
6	Big Sioux River	2.05E+11	2.82E+13	99.3%
7	Big Sioux River	2.53E+11	1.19E+13	97.9%
8	Inwood	2.15E+11	6.34E+13	99.7%

*Units for these loads are *E. coli* organisms/day.

Table 3.18 BSRTMDL-1 Iowa Allocations and Reductions for 10% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
1	Big Sioux River	6.35E+09	6.10E+10	89.6%
2	Unnamed Cr.-Rowena	3.87E+09	4.06E+08	none
3	Blood Run	5.10E+10	2.56E+12	98.0%
4	Big Sioux River	1.78E+09	1.83E+08	none
5	Klondike Creek	8.92E+10	4.46E+12	98.0%
6	Big Sioux River	4.14E+10	2.75E+12	98.5%
7	Big Sioux River	5.12E+10	1.15E+12	95.6%
8	Inwood	4.36E+10	6.10E+12	99.3%

*Units for these loads are *E. coli* organisms/day.

Table 3.19 BSRTMDL-1 Iowa Allocations and Reductions for 50% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
1	Big Sioux River	2.38E+09	4.89E+10	95.1%
2	Unnamed Cr.-Rowena	1.45E+09	3.78E+08	none
3	Blood Run	1.91E+10	1.93E+12	99.0%
4	Big Sioux River	6.68E+08	1.74E+08	none
5	Klondike Creek	3.34E+10	3.30E+12	99.0%
6	Big Sioux River	1.55E+10	2.07E+12	99.3%
7	Big Sioux River	1.92E+10	8.66E+11	97.8%
8	Inwood	1.63E+10	4.58E+12	99.6%

*Units for these loads are *E. coli* organisms/day.

Table 3.20 BSRTMDL-1 Iowa Allocations and Reductions for 70% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
1	Big Sioux River	1.59E+09	4.77E+10	96.7%
2	Unnamed Cr.-Rowena	9.68E+08	3.75E+08	none
3	Blood Run	1.27E+10	1.86E+12	99.3%
4	Big Sioux River	4.46E+08	1.73E+08	none
5	Klondike Creek	2.23E+10	3.19E+12	99.3%
6	Big Sioux River	1.04E+10	2.00E+12	99.5%
7	Big Sioux River	1.28E+10	8.37E+11	98.5%
8	Inwood	1.09E+10	4.43E+12	99.8%

*Units for these loads are *E. coli* organisms/day.

Table 3.21 BSRTMDL-1 South Dakota Allocations and Reductions for Various Flow Percentile Range

		Load Allocation (fecal coliform/day)				Existing Load (fecal coliform/day)				Percent Load Reduction			
HUC_12	**HU_12_NAME**	**0-10%**	**10-40%**	**40-70%**	**70-100%**	**0-10%**	**10-40%**	**40-70%**	**70-100%**	**0-10%**	**10-40%**	**40-70%**	**70-100%**
101702031503	Middle Pipestone Creek	8.22E+11	1.05E+11	2.57E+10	1.49E+10	1.04E+13	1.88E+12	8.42E+10	3.50E+10	92.1%	94.4%	69.5%	57.5%
101702031601	Upper-West Pipestone Creek	2.33E+12	5.46E+11	1.92E+10	3.53E+09	1.64E+12	2.08E+13	4.72E+10	8.10E+10	0.0%	97.4%	59.4%	95.6%
101702031504	Lower Pipestone Creek	1.33E+12	1.53E+11	8.25E+10	7.49E+10	1.43E+13	2.59E+12	1.16E+11	4.81E+10	90.7%	94.1%	28.6%	0.0%
101702031602	Lower West Pipestone Creek	1.16E+12	1.48E+11	6.42E+10	2.60E+10	1.28E+13	2.32E+12	1.04E+11	4.31E+10	90.9%	93.6%	38.1%	39.7%
101702031402	Middle Split Rock Creek	8.09E+11	1.18E+11	5.76E+10	1.81E+10	2.28E+13	4.13E+12	1.85E+11	7.68E+10	96.4%	97.1%	68.8%	76.4%
101702031702	Lower Beaver Creek- Split Rock Creek	1.13E+12	2.43E+11	3.51E+10	9.93E+09	6.10E+13	4.19E+12	5.54E+11	8.76E+10	98.2%	94.2%	93.7%	88.7%
101702031403	Lower Split Rock Creek	1.86E+11	2.68E+10	7.82E+09	2.31E+09	4.87E+12	8.81E+11	3.94E+10	1.64E+10	96.2%	97.0%	80.2%	85.9%
101702031703	Springwater Creek	7.51E+09	2.94E+09	6.95E+08	1.50E+08	8.48E+10	1.53E+10	6.86E+08	2.86E+08	91.1%	80.8%	0.0%	47.6%
101702031704	Four Mile Creek	4.65E+11	1.00E+11	1.45E+10	4.10E+09	3.97E+12	7.19E+11	3.21E+10	1.34E+10	88.3%	86.0%	54.9%	69.3%
101702031303	Blood Run	See Iowa Load Values											
101702031304	Spring Creek	2.68E+11	5.96E+10	1.17E+10	4.08E+09	2.21E+13	4.00E+12	1.79E+11	7.45E+10	98.8%	98.5%	93.5%	94.5%
101702031301	Big Sioux River- Slip-Up Creek	1.12E+12	2.48E+11	4.86E+10	1.70E+10	8.96E+12	1.62E+12	7.25E+10	3.02E+10	87.5%	84.7%	33.0%	43.6%
101702031901	Upper Beaver Creek	1.25E+11	3.96E+10	2.92E+10	1.42E+10	3.24E+13	5.87E+12	2.63E+11	1.09E+11	99.6%	99.3%	88.9%	87.0%
101702031305	Ninemile Creek	2.83E+11	7.93E+10	2.05E+10	9.56E+09	1.19E+10	2.54E+09	6.20E+08	1.21E+08	0.0%	0.0%	0.0%	0.0%
101702031801	Big Sioux River- Klondike Creek	2.82E+10	1.03E+10	7.64E+09	2.77E+09	2.98E+12	5.38E+11	2.41E+10	1.00E+10	99.1%	98.1%	68.3%	72.3%
101702031902	Lower Beaver Creek	1.09E+11	4.48E+10	3.31E+10	9.14E+09	2.50E+12	4.66E+10	4.33E+10	2.73E+10	95.7%	3.8%	23.5%	66.5%
101702031802	Big Sioux River Peterson Creek	6.06E+10	2.22E+10	1.64E+10	5.96E+09	1.40E+13	2.54E+12	1.14E+11	4.73E+10	99.6%	99.1%	85.6%	87.4%
101702031903	South Fork Beaver Creek	6.11E+10	2.24E+10	1.65E+10	6.01E+09	6.68E+12	1.21E+12	5.41E+10	2.25E+10	99.1%	98.1%	69.4%	73.3%

3.6 BSRTMDL-2: The Big Sioux River from Beaver Creek to the Rock River.

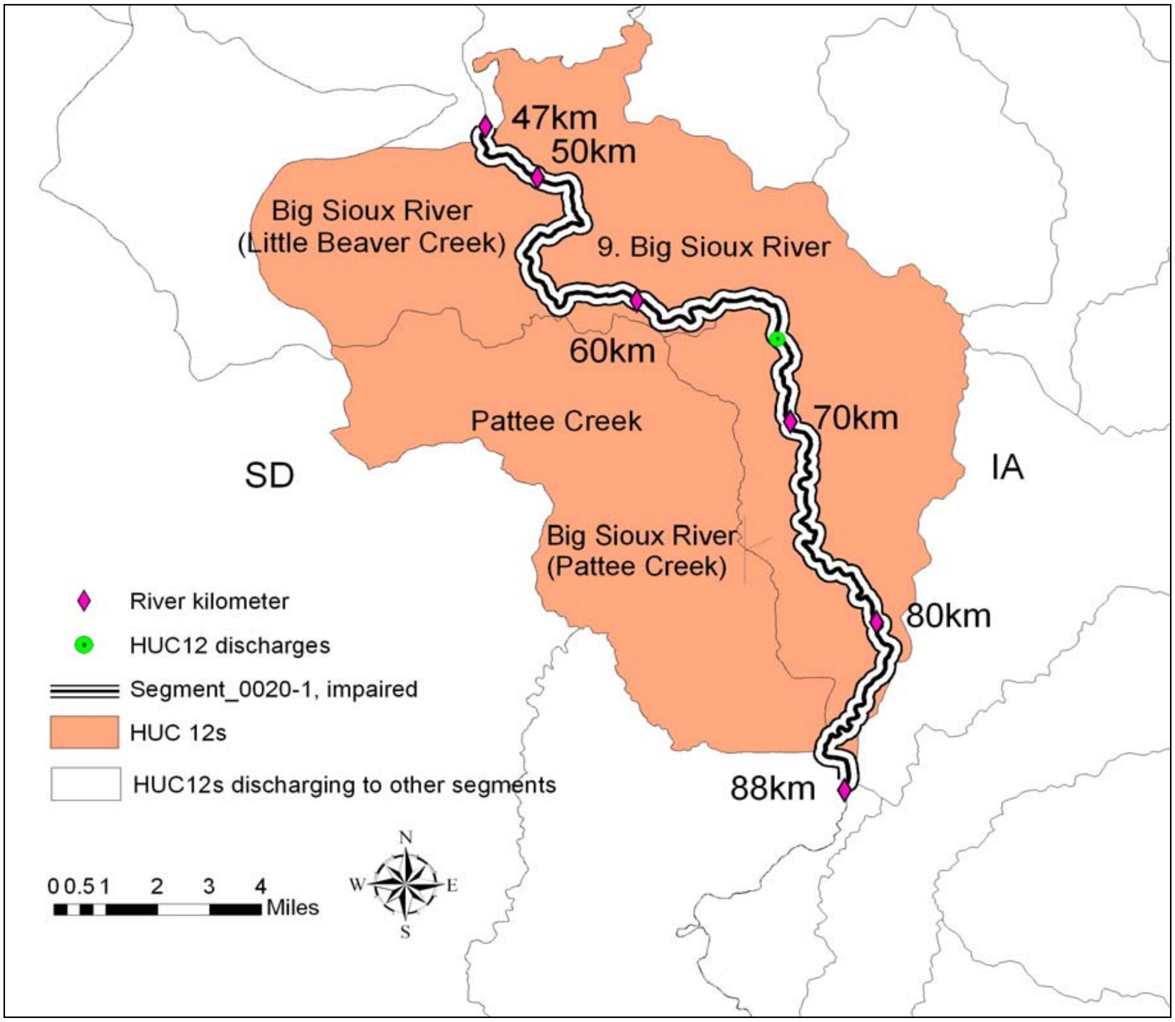


Figure 28. BSRTMDL-2, Beaver Creek to the Rock River

3.6.1 Pollution Source Assessment

As shown in Figure 28, the BSRTMDL-2 segment is 25.3 miles long and drains one and three HUC 12's in the Iowa and South Dakota portion of the Big Sioux River watershed, respectively. For the Iowa portion, the drainage area is 26,670 acres and there are not any wastewater treatment plants in the segment's sub-watershed. The drainage area is 47,206 acres for the South Dakota portion of this segment's sub-watershed and there are no South Dakota wastewater treatment plants.

Existing Load

The existing load was estimated using the procedures described in Appendix C. In brief, the 60th percentile loading value estimated from the SD DENR water quality data at each flow percentile represents the existing load at the associated flow percentile. A summary of the existing loads reported as both fecal coliform bacteria and *E.coli* for this segment is shown in Table 3.22.   Since the water quality data was reported as fecal coliform, the *E.coli* loads were estimated by multiplying the fecal coliform concentration by a conversion factor derived from the single maximum standards for these pathogen indicators (i.e. 235 E.coli/400 fecal coliform = 0.5875).

Table 3.22 BSRTMDL-2 Existing Load Calculated using data from LBSM09

Flow Percentile	Existing Load (cfu/day)	
	Fecal Coliform	***E. coli***
12.5	5.40E+13	3.17E+13
37.5	2.62E+14	1.54E+14
62.5	9.01E+11	5.29E+11
87.5	9.68E+10	5.69E+10

Departure from Load Capacity

The load capacity for this segment of the Big Sioux River is that which meets the water quality standard sample maximum concentration of 235 *E. coli* organisms/100 ml or 400 fecal coliform/100 ml converted to a daily load. The load capacity varies with the water volume and follows the load duration curve for each monitoring site. The departure from load capacity is the difference between the sample maximum concentration and the monitored concentration for a given stream volume or flow rate. Appendix C includes a description of the procedure in calculating the load capacity and the load reduction. Tables 3.23 shows the maximum allowable load and the percent reduction required to meet the water quality standards. Figure 29 shows the load duration curve for fecal coliform bacteria for LBSM09. The curve represents the TMDL at each percentile flow duration interval. This figure also includes the median, 60th percentile (used to calculate TMDL load reduction), and 90th percentile load at specific percentile flow duration interval. Figure 29 also distinguishes samples collected during the recreational season in which the WQS is applicable. Samples collected on days where storm flow is greater than the 50th percentile are also identified.

Table 3.23 BSRTMDL-2 Departure from Load Capacity and Load Reductions Required

Flow Percentile	TMDL (cfu/day)		Load Reductions Required (%)
	Fecal Coliform	***E. coli***	
12.5	2.79E+13	1.64E+13	48.3
37.5	7.33E+12	4.31E+12	No reduction
62.5	3.07E+12	1.80E+12	No reduction
87.5	1.41E+12	8.26E+11	No reduction

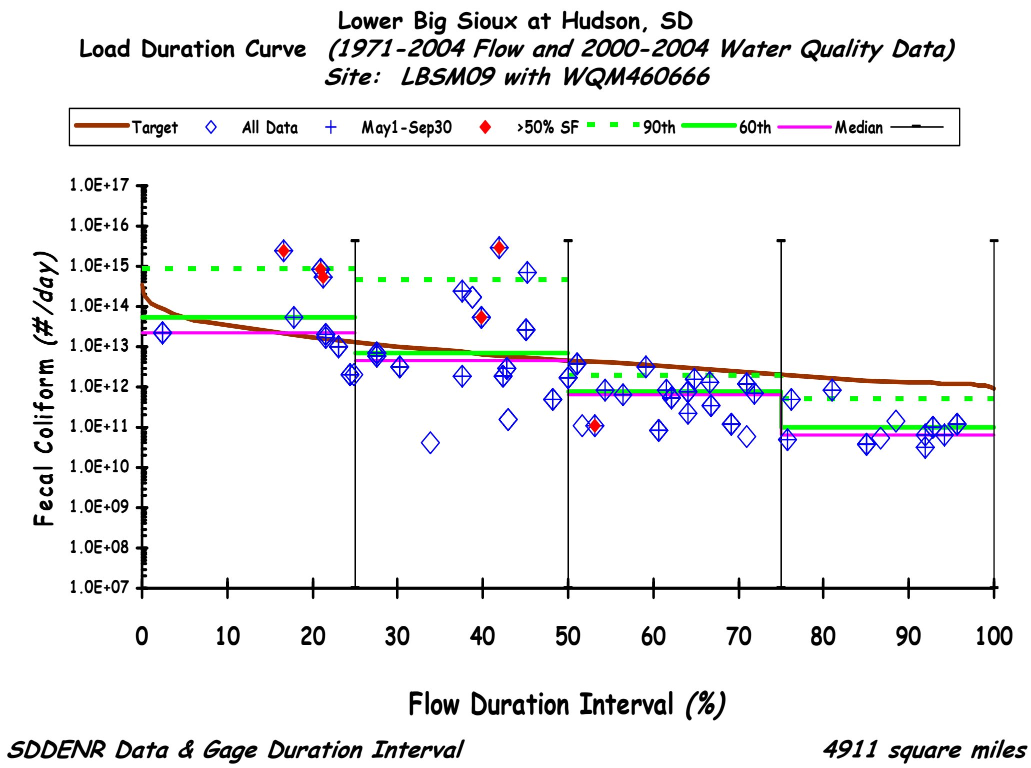


Figure 29. BSRTMDL-2 Load Duration Curve for LBSM09

Identification of Pollutant Sources

The pollutant sources for the BSRTMDL-2 segment are located in both Iowa and South Dakota. The Iowa and South Dakota loads are considered separately. The South Dakota pollutant sources have been identified and evaluated using different procedures than those used in Iowa. South Dakota pollutant sources were identified using various data sources such as 2002 census data and digital Orthophoto Quads in GIS. Detail procedure and model assumptions are described in Appendix C. Iowa pollutant sources were identified used county ag statistics, aerial photography, livestock registration databases, and GIS methods described in Appendix B, Procedures and Assumptions.

Iowa Pollutant Sources:

The pollutant sources on the Iowa part of this impaired segment consist of the upstream loads from BSRTMDL-2, and non-point sources from the one HUC 12 that drains directly to this river segment.

Iowa Point Sources: There are not any permitted wastewater treatment plants and there are three permitted Animal feeding operations in the BSRTMDL-2 sub-watershed.

Iowa Non-point Sources: There are three categories of non-point source loads; manure from livestock and wildlife distributed over the different landuses, cattle in streams, and failing septic tank systems.

The livestock and wildlife manure non-point sources and the built-up land use for this segment have been evaluated for the months of April, June, and October. (The built-up land use consists of commercial, residential and transportation land uses.) These were selected as design conditions because more manure is applied to cropland and pasture in April and October than in other months. These loads require a precipitation event for delivery to the Big Sioux River. The design event has an assumed 1% recurrence (event that occurs every 100 days), i.e., there is enough precipitation to significantly increase runoff and bacteria transport. The bacteria delivery ratio is the *E. coli* organisms delivered divided by the number available for washoff. A delivery ratio of 0.35 has been estimated for flows with a 1% recurrence.

Cattle in streams is a non-point source category that accounts for livestock bacteria loads that are directly delivered to the stream without a significant precipitation event to provide transport. These loads are assumed to be continuous and unvarying through the month. The cattle in streams load is obtained by estimating the number of grazing cattle there are in the HUC 12's and the amount of time they spend in streams. In June the warmer weather is assumed to increase the number of grazing cattle in the stream and the associated loads. Based on county ag statistics, livestock registration databases, and local field assessments, the fraction of grazing beef cattle (versus confined) is 7% of the total in each HUC 12. The cattle in the stream percentage is based on what research is available is 12% in the cooler months and 24% in the warmer months, June, July, and August. This is shown in the Table 3.23 loading values.

Failed septic tanks are assumed to be continuous throughout the year and do not need an event for bacteria transport. Tables 3.24 to 3.26 show the delivered loads for the various non-point sources for the one HUC 12 on the Iowa side that discharges into the BSRTMDL-2 segment.

Table 3.24 BSRTMDL-2, Iowa Livestock, wildlife, built-up area event NPS loads

No.	HUC 12 name	Dist. to BSR, km	April load * at BSR **	June load* at BSR **	Oct. load * at BSR**
9	Big Sioux River	0.0	3.62E+14	2.72E+14	2.42E+15

*Units for these loads are *E. coli* organisms/day.
** The 1% event bacteria delivery ratio (load delivered divided by available for washoff) is 0.35.

Table 3.25 BSRTMDL-2, Iowa Cattle in streams NPS loads

No.	HUC 12 name	# grazing beef cattle	Dist. to BSR, km	April load, 12% in streams *	June load, 24% in streams *	Oct. load, 12% in streams, *
9	Big Sioux River	974	0.0	7.60E+12	1.52E+13	7.60E+12

*Units for these loads are *E. coli* organisms/day. Percentages are the fraction of grazing cattle assumed to be in the stream.

Table 3.26 BSRTMDL-2, Iowa Failing Septic systems NPS loads

No.	HUC 12 name	No. of Failed septics	distance to BSR, km	load at BSR *
9	Big Sioux River	218	0.0	9.71E+09

*Units for these loads are *E. coli* organisms/day.

South Dakota Pollutant Sources

The pollutant sources on the South Dakota part of this impaired segment consist of loads from non-point sources only discharging from this segment's three HUC 12 sub-watersheds. This segment does not have any point source discharges from the South Dakota portion of the waterbody.

South Dakota Point Sources: There are no wastewater treatment plants in the BSRTMDL-1 watershed and therefore point sources are not expected to be a contributing factor for the South Dakota loadings.

South Dakota Non-point Sources: Land uses in the various HUC 12 drainage areas in South Dakota are generally similar (See Table 2.5). The majority of these areas are dominated by a combination of grassland, hay, pasture, corn, and soybeans land uses, follow by high intensity commercial and industrial land uses. There is relatively limited residential area within these drainage areas and therefore impacts from these land uses are expected to be minimal. Assumptions used to model the non-point load estimates are described in Appendix C. Table 3.27 show the estimated delivered loads for the various non-point sources for the three HUC 12's on the South Dakota side that discharge into the BSRTMDL-2 segment during June.

Table 3.27 BSRTMDL-2, South Dakota NPS Load during June

Iowa Assessment Segment	HUC_12	HU_12_NAME	Non-point Source Load (fecal coliform/day)							
			Cropland	Pastureland	Forest	Built up	Storm Sewers	Septics	Cattle in Streams	AFOs
0020-1	101702031803	Big Sioux River- Little Beaver Creek	2.35E+13	7.92E+12	3.09E+04	6.08E+06	0.00E+00	1.86E+09	2.03E+12	5.72E+13
	101702031804	Big Sioux River- Pattee Creek	1.21E+13	4.66E+12	2.03E+04	6.09E+06	2.03E+11	1.13E+09	1.22E+12	6.55E+13
	101702032002	Patte Creek	6.43E+13	1.37E+13	5.41E+03	6.08E+06	0.00E+00	3.36E+09	3.96E+12	8.48E+13

3.6.2 Pollutant Allocations

Wasteload Allocation

Wastewater Treatment Plant Wasteload Allocations: There are no wastewater treatment plants in the BSRTMDL-2 sub-watershed on either the Iowa or South Dakota side of the Big Sioux River. Therefore, there are no wwtp wasteload allocations for this TMDL.

BSR Direct Watershed Permitted Animal Feeding Operation Facilities Wasteload Allocations: Some animal feeding operations require National Pollutant Discharge Elimination System (NPDES) permits. These permits set limits on the pollutants that can be discharged to waterbodies based on a wasteload allocation. The thresholds for needing a permit are based on animal units (AU) - one beef cow equals one animal unit; one dairy cow equals 1.4 animal units. All of the permitted facilities in the Big Sioux watershed are beef cattle feedlots or dairy operations. For feedlots the threshold is 1000 beef cattle and for dairies it is 700 dairy cows.

There are three Iowa NPDES permitted animal feeding operation facilities in the BSR direct watershed that drain to the BSRTMDL-2 impaired segment. The wasteload allocation for these facilities follows state (IAC 567- Ch.65) and federal rules (40 CFR 125.30 through 125.32) for open feedlots. The relevant state rule, IAC 567 – 65.101(2)a(1), requires that there be no discharge of manure, process wastewater, settled open feedlot effluent, settleable solids or open feedlot effluent resulting from precipitation events less than or equal to the 25 year, 24 hour precipitation event. The permitted facilities, their locations and HUC 12, and WLA's are shown in Table 3.28.

Table 3.28 BSRTMDL-2 BSR Direct Watershed NPDES Permitted Animal Feeding Operation Facilities Wasteload Allocations

Facility Name	Facility ID	NPDES #	EPA #	Township and range	Sec	1/4 Sec	HUC 12 *	WLA **
Ysseltein Dairy, Inc. North	62015	84-00-3-02	77844	T97N R47W	18	SE	BSR #9	No discharge
Ysseltein Dairy, Inc. South	61393	84-00-3-11	77852	T97N R47W	19	SW	BSR #9	No discharge
Bar K Farms- Inwood	56567	84-00-0-32	77518	T97N R48W	4	NE	BSR #9	No discharge

*This refers to the HUC 12 sub-watershed in the BSR direct watershed and corresponds to the HUC 12 number in column one of Table 3.17.

**No discharge resulting from precipitation events less than or equal to the 25 year, 24 hour precipitation event.

Load Allocations and Pollutant Load Reductions Needed

The load allocations for this TMDL are based on the discharges from the Iowa and South Dakota HUC 12s sub-watersheds that discharge to the BSRTMDL-2 segment and the BSRTMDL-1 segment of the Big Sioux River where it flows into the BSRTMDL-2 segment. The load allocations are based on the assumption that all discharges into the Big Sioux River from all sources must meet the water quality standard sample maximum criteria of 235 *E. coli* organisms/100 ml or 400 fecal coliform/100 ml converted to a daily load.

A review of the Iowa load duration curves (spreadsheet *stream data analysis.xls*) for the Big Sioux and the tributaries that have been monitored shows that the bacteria targets are exceeded at most flow conditions, although by different sources with different delivery mechanisms. Four representative flow conditions have been selected for the derivation of load allocations and needed pollutant reductions. These are the 1%, 10%, 50%, and 70% load duration curve flow ranks (Tables 3.29 through 3.32). June load estimates for non-point sources that are event driven and for cattle in the stream sources have been selected as sufficiently representative. June is also the month when most monitored tributary events occurred. See Appendix B, Procedures and Assumptions for an explanation of load allocation development.

Table 3.29 BSRTMDL-2 Allocations and Reductions for 1% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
9	Big Sioux River	4.95E+11	2.87E+14	99.8%

*Units for these loads are *E. coli* organisms/day.

Table 3.30 BSRTMDL-2 Allocations and Reductions for 10% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
9	Big Sioux River	1.00E+11	2.30E+13	99.6%

*Units for these loads are *E. coli* organisms/day.

Table 3.31 BSRTMDL-2 Allocations and Reductions for 50% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
9	Big Sioux River	3.76E+10	1.60E+13	99.8%

*Units for these loads are *E. coli* organisms/day.

Table 3.32 BSRTMDL-2 Allocations and Reductions for 70% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
9	Big Sioux River	2.51E+10	1.53E+13	99.8%

*Units for these loads are *E. coli* organisms/day.

A review of the South Dakota load duration curves for the Big Sioux River and the tributaries that have been monitored shows that the bacteria targets are exceeded at mid to high flow conditions in the mainstem river and at high and low flows in the tributaries. Four representative flow conditions have been selected for the derivation of South Dakota load allocations and needed pollutant reductions. These are the 0-10%, 10-40%, 40-70%, and 70-100%,, see load duration curve range (Tables 3.21). See Appendix C for explanation on the load allocation calculations.

Table 3.33 BSRTMDL-2 South Dakota Allocations and Reductions for Various Flow Percentile Range

Iowa Assessment Segment	HUC_12	HU_12_NAME	Load Allocation (fecal coliform/day)				Existing Load (fecal coliform/day)				Percent Load Reduction			
			0-10%	10-40%	40-70%	70-100%	0-10%	10-40%	40-70%	70-100%	0-10%	10-40%	40-70%	70-100%
0020-1	101702031803	Big Sioux River Little Beaver Creek	1.05E+12	7.88E+10	3.21E+10	1.64E+10	1.09E+11	4.27E+10	1.83E+09	1.37E+10	0.0%	0.0%	0.0%	0.0%
	101702031804	Big Sioux River Pattee Creek	3.31E+10	2.38E+10	1.61E+10	1.25E+10	1.15E+13	2.07E+12	9.28E+10	3.86E+10	99.7%	98.9%	82.6%	67.5%
	101702032002	Patte Creek	1.07E+11	7.71E+10	5.21E+10	4.05E+10	6.20E+12	1.43E+10	6.27E+10	2.43E+10	98.3%	0.0%	16.9%	0.0%

3.7 BSRTMDL-3: The Big Sioux River from the Rock River to Indian Creek.

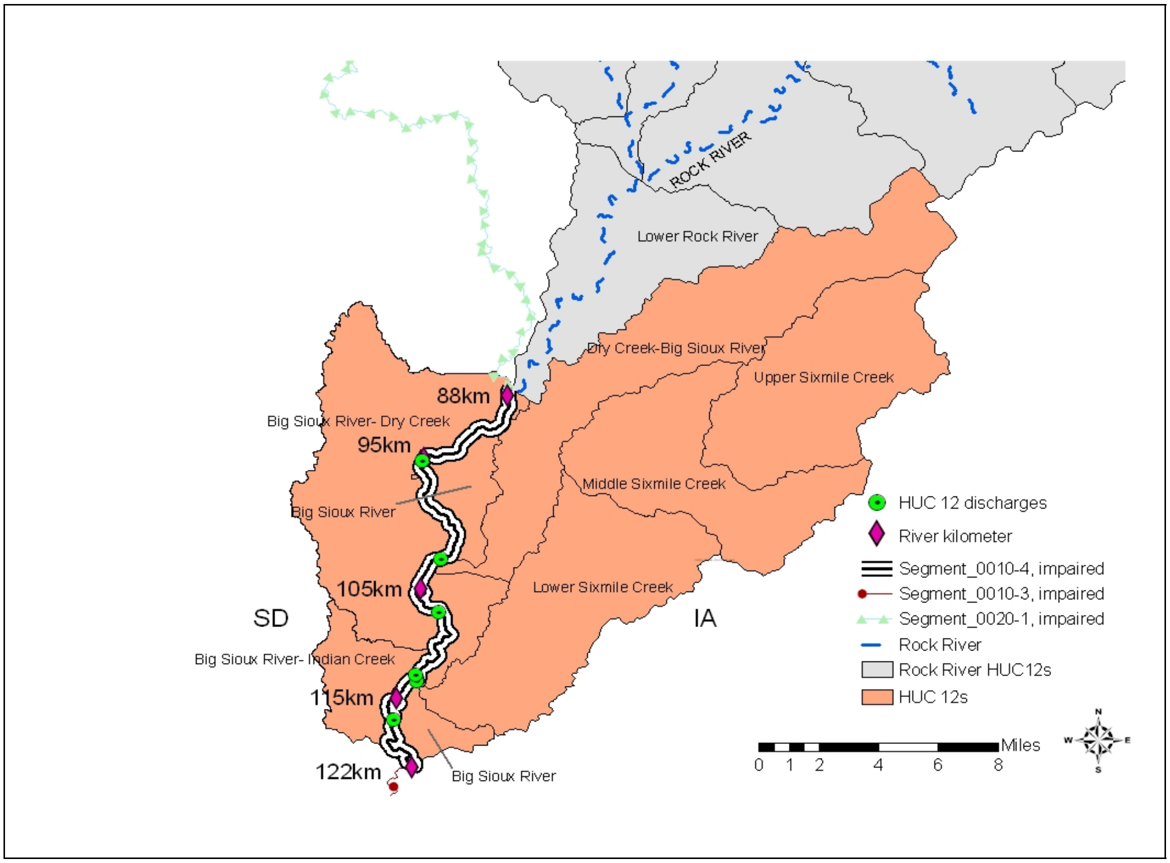


Figure 30. BSRTMDL-3, Rock River to Indian Creek

BSRTMDL-3 Organization. The BSRTMDL-3 segment watershed includes Iowa and Minnesota parts of the Rock River watershed as well as seven Iowa HUC 12's and two South Dakota HUC 12's that drain directly to the Big Sioux River as shown in Figures 30 and 31. The first part of BSRTMDL-3 is an evaluation of the Rock River *E. coli* point and non-point sources and loads from both Iowa and Minnesota. The second part is an evaluation of the existing *E. coli* and fecal coliform loads in the BSRTMDL-3 segment and an estimate of the departure from load capacity and an evaluation of the *E. coli* and fecal coliform point and non-point sources and loads from the nine directly draining HUC 12's (seven Iowa HUC 12's and two South Dakota HUC 12's). The last part includes the wasteload allocations and reductions from the Rock River watershed and the load allocations from the Rock River watershed, including the Minnesota load allocations, and the load allocations and reductions from the nine directly draining HUC 12's.

3.7.1 Pollution Source Assessment - Rock River watershed

The Iowa part of the Rock River includes 23 HUC 12 sub-watersheds. As noted in the section on Data Sources, data was collected in 2002 and 2003 for the Rock River at the Hawarden ambient site, at the Rock Valley gage, at the confluence of Mud Creek and the Rock River, at the confluence of the Little Rock and Rock Rivers, at the USGS gage site downstream of Rock Rapids, and where Mud Creek, the Rock River, and the Little Rock River cross into Iowa from Minnesota. The 23 HUC 12 sub-watersheds that comprise the Iowa part of the Rock River watershed were evaluated separately from the 25 HUC 12 sub-watersheds that drain directly into the Big Sioux River.

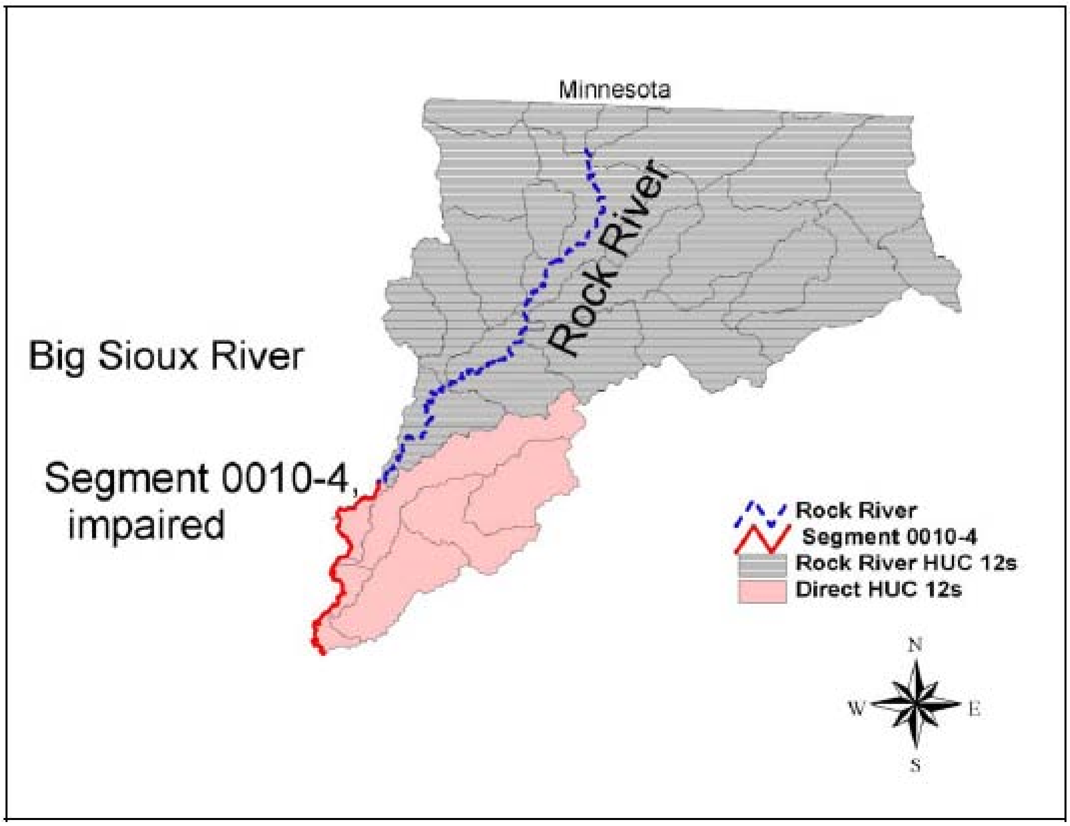


Figure 31. BSRTMDL-3, Entire Iowa Watershed Including Rock River

Rock River, Identification of Pollutant Sources

The pollutant sources for the Rock River watershed are located in both Iowa and Minnesota. The Iowa and Minnesota loads are considered together as loads delivered at the Big Sioux River confluence. The Minnesota loads have been estimated based on the monthly monitoring data at the Mud Creek, Rock River, and Little Rock River sites where they cross the border.

Iowa Pollutant Sources:
The pollutant sources in the Iowa part of the Rock River watershed consist of point source loads from eleven wastewater treatment plants and non-point sources discharging from the 23 Rock River HUC 12's.

Iowa Point Sources: There are eleven wastewater treatment plants in the BSRTMDL-3 Iowa Rock River watershed. The distance of each of these from the Rock River and the Big Sioux River has been measured and the delivered load calculated using time of travel and an assumed bacteria die-off coefficient of 0.96 per day during low flow conditions when continuous sources have their greatest impact. Appendix B, Procedures and Assumptions explains the evaluation spreadsheets and the assumptions, modeling equations, and rationale for plant treatment reductions. Table 3.34 shows the delivered loads assuming no effluent disinfection.

Seven of these facilities are controlled discharge lagoons, two are continuous discharge aerated lagoons, and two are continuous discharge trickling filters (See Table 3.4 for wwtp characteristics). In general, controlled discharge lagoons are designed to discharge infrequently, perhaps twice a year, for two or three weeks during higher flows. Discharges are usually in the spring and fall.

Table 3.34 BSRTMDL-3 Rock River Wastewater treatment plant *E. coli* loads at BSR confluence

NAME	Distance to BSR, km	Low flow time of travel, days	WWTP effluent load *	Load at the BSR *
Alvord wwtp	58.51	2.18	2.55E+10	3.15E+09
Ashton wwtp	110.23	3.58	5.78E+10	1.86E+09
Doon wwtp	43.85	1.20	5.95E+10	1.88E+10
George wwtp	79.29	2.48	1.33E+11	1.23E+10
Hull wwtp	57.71	1.56	2.16E+11	4.84E+10
Lester wwtp	72.97	2.52	3.21E+10	2.86E+09
Little Rock wwtp	110.42	3.77	6.16E+10	1.66E+09
Niessink Home wwtp	41.26	1.01	2.50E+09	9.50E+08
Rock Rapids wwtp	71.32	1.91	3.25E+11	5.20E+10
Rock Valley wwtp	30.39	0.87	3.18E+11	1.37E+11
Sibley wwtp	126.56	4.39	3.52E+11	5.20E+09

*Units for these loads are *E. coli* organisms/day.

Iowa Non-point Sources: There are three categories of non-point source loads; manure from livestock and wildlife distributed over the different landuses, cattle in streams, and failing septic tank systems.

The livestock and wildlife manure non-point sources and the built-up land use for this segment have been evaluated for the months of April, June, and October. (The built-up land use consists of commercial, residential and transportation land uses.) These were selected as design conditions because more manure is applied to cropland and pasture in April and October than in other months. These loads require a precipitation event for delivery to the Big Sioux River. The design event has an assumed 1% recurrence (event that occurs every 100 days), i.e., there is enough precipitation to significantly increase runoff and bacteria transport. The bacteria delivery ratio is the *E. coli* organisms delivered divided by the number available for washoff. A delivery ratio of 0.35 has been estimated for flows with a 1% recurrence.

Cattle in streams is a non-point source category that accounts for livestock bacteria loads that are directly delivered to the stream without a significant precipitation event to provide transport. These loads are assumed to be continuous and unvarying through the month. The cattle in streams load is obtained by estimating the number of grazing cattle there are in the HUC 12's and the amount of time they spend in streams. In June the warmer weather is assumed to increase the number of grazing cattle in the stream and the associated loads. Based on county ag statistics, livestock registration databases, and local field assessments, the fraction of grazing beef cattle (versus confined) is 7% of the total in each HUC 12. The cattle in the stream percentage is based on what research is available is 12% in the cooler months and 24% in the warmer months, June, July, and August. This is shown in the Table 3.35 loading values.

Failed septic tanks are assumed to be continuous throughout the year and do not need an event for bacteria transport. Tables 3.35 to 3.37 show the delivered loads for the various non-point sources for the 23 HUC 12's in the Iowa Rock River watershed that discharge into the BSRTMDL-3 segment.

Table 3.35 Rock River livestock, wildlife and built-up area event NPS loads

No.	HUC 12 name	Dist. to BSR, km	April load at BSR *	June load at BSR *	Oct. load at BSR *
1	Burr Oak Creek-Rock River	39.4	7.90E+13	5.46E+13	4.89E+14
2	Unnamed Cr. Dry Run Creek	27.98	8.85E+13	6.64E+13	5.56E+14
3	Dry Run Creek-Rock River	23.03	2.66E+13	9.94E+13	5.03E+14
4	Rock River-Burr Oak Creek	23.03	1.54E+14	1.11E+14	5.73E+14
5	Lower Rock River	0	1.58E+14	1.15E+14	9.82E+14
6	Otter Creek-Rat Creek	42.5	2.19E+13	1.46E+13	1.35E+14
7	Otter Creek-Schutte Creek	42.5	5.83E+12	4.02E+12	3.59E+13
8	Cloverdale Creek	42.5	9.16E+11	4.10E+11	5.19E+12
9	Otter Creek-Kappes Creek	42.5	1.61E+13	1.08E+13	9.88E+13
10	Rat Creek	42.5	4.64E+12	2.56E+12	2.74E+13
11	Rock River	76.5	4.90E+12	3.65E+12	3.05E+13

No.	HUC 12 name	Dist. to BSR, km	April load at BSR *	June load at BSR *	Oct. load at BSR *
12	Kanaranzi Creek	76.5	1.80E+12	1.21E+12	1.09E+13
13	Lower Mud Creek	44.58	8.46E+13	6.09E+13	5.25E+14
14	Upper Mud Creek	44.58	1.84E+13	1.36E+13	1.15E+14
15	Middle Mud Creek	44.58	5.91E+13	4.27E+13	3.73E+14
16	Little Rock River	42.5	5.94E+07	5.94E+07	7.11E+07
17	Little Rock River-Snow Creek	42.5	6.92E+12	3.80E+12	4.08E+13
18	Emery Creek	42.5	7.64E+12	5.11E+12	4.81E+13
19	Little Rock River-Whitney Cr.	42.5	1.89E+13	1.30E+13	1.16E+14
20	Tom Creek-Rock River	73.62	2.03E+13	1.20E+13	1.27E+14
21	Unnamed Creek-Rock River	55.02	1.10E+13	7.82E+12	6.81E+13
22	Rock River-Tom Creek	42.19	1.22E+14	8.93E+13	7.61E+14
23	Little Rock River-Emery Creek	42.5	5.76E+13	4.19E+13	3.63E+14

*Units for these loads are *E. coli* organisms/day.
** The 1% event bacteria delivery ratio (load delivered divided by available for washoff) is 0.35.

Table 3.36 Rock River - Cattle in streams NPS loads

No.	HUC 12 name	# grazing beef cattle	Dist. to BSR, km	April load, 12% in streams*	June load, 24% in streams *	Oct. load, 12% in streams*
1	Burr Oak Cr.-Rock River	612	39.4	1.14E+12	2.28E+12	1.14E+12
2	Unnamed Cr.-Dry Run Cr.	725	27.98	1.63E+12	3.27E+12	1.63E+12
3	Dry Run Creek-Rock River	910	23.03	3.08E+12	6.15E+12	3.08E+12
4	Rock River-Burr Oak Cr.	1000	23.03	3.38E+12	6.76E+12	3.38E+12
5	Lower Rock River	755	0	5.89E+12	1.18E+13	5.89E+12
6	Otter Creek-Rat Creek	315	42.5	1.47E+11	2.95E+11	1.47E+11
7	Otter Creek-Schutte Cr.	307	42.5	1.25E+10	2.51E+10	1.25E+10
8	Cloverdale Creek	31	42.5	1.28E+09	2.56E+09	1.28E+09
9	Otter Creek-Kappes Cr.	389	42.5	6.72E+10	1.34E+11	6.72E+10
10	Rat Creek	92	42.5	1.59E+10	3.17E+10	1.59E+10
11	Rock River	76	76.5	3.69E+10	7.38E+10	3.69E+10
12	Kanaranzi Creek	26	76.5	1.24E+10	2.49E+10	1.24E+10
13	Lower Mud Creek	768	44.58	1.19E+12	2.37E+12	1.19E+12
14	Upper Mud Creek	396	44.58	1.12E+11	2.24E+11	1.12E+11
15	Middle Mud Creek	767	44.58	4.58E+11	9.15E+11	4.58E+11
16	Little Rock River	0	42.5	0.00E+00	0.00E+00	0.00E+00
17	Little Rock River-Snow Cr.	155	42.5	2.07E+10	4.14E+10	2.07E+10
18	Emery Creek	75	42.5	5.13E+10	1.03E+11	5.13E+10
19	Little Rock R.-Whitney Cr.	296	42.5	1.38E+11	2.77E+11	1.38E+11
20	Tom Creek-Rock River	134	73.62	7.20E+10	1.44E+11	7.20E+10
21	Unnamed Cr.-Rock River	116	55.02	1.22E+11	2.45E+11	1.22E+11
22	Rock River-Tom Creek	1067	42.19	1.80E+12	3.60E+12	1.80E+12
23	Little Rock R.-Emery Cr.	472	42.5	7.87E+11	1.57E+12	7.87E+11

*Units for these loads are *E. coli* organisms/day. Percentages are the fraction of grazing cattle that are assumed to be in the stream.

Table 3.37 Rock River, Failing Septic Systems NPS loads

No.	HUC 12 name	No. of failed septics	Distance to BSR, km	Load at BSR *
1	Burr Oak Creek-Rock River	151	39.4	1.49E+09
2	Unnamed Creek-Dry Run Creek	79	27.98	9.42E+08
3	Dry Run Creek-Rock River	115	23.03	2.06E+09
4	Rock River-Burr Oak Creek	157	23.03	2.81E+09
5	Lower Rock River	125	0	5.18E+09
6	Otter Creek-Rat Creek	195	42.5	4.83E+08
7	Otter Creek-Schutte Creek	185	42.5	4.02E+07
8	Cloverdale Creek	78	42.5	1.70E+07
9	Otter Creek-Kappes Creek	208	42.5	1.90E+08
10	Rat Creek	121	42.5	1.11E+08
11	Rock River	53	76.5	1.35E+08
12	Kanaranzi Creek	39	76.5	1.00E+08
13	Lower Mud Creek	143	44.58	1.17E+09
14	Upper Mud Creek	64	44.58	9.64E+07
15	Middle Mud Creek	172	44.58	5.45E+08
16	Little Rock River	4	42.5	8.44E+05
17	Little Rock River-Snow Creek	173	42.5	1.23E+08
18	Emery Creek	67	42.5	2.43E+08
19	Little Rock River-Whitney Creek	201	42.5	4.98E+08
20	Tom Creek-Rock River	201	73.62	5.76E+08
21	Unnamed Creek-Rock River	63	55.02	3.52E+08
22	Rock River-Tom Creek	220	42.19	1.97E+09
23	Little Rock River-Emery Creek	156	42.5	1.38E+09

*Units for these loads are *E. coli* organisms/day.

Minnesota Pollutant Sources

A large part of the Rock River watershed is in Minnesota and there are three major streams that drain this area; Mud Creek, the mainstem Rock River, and the Little Rock River. These three streams were monitored monthly where they cross the border. The loads from Minnesota are combined point and non-point pollutants at the spot where the streams cross into Iowa. Tables 3.38 to 3.40 show the bacteria die-off over the distance to the Big Sioux River.

Table 3.38 Minnesota High Flow *E. coli* loads at the BSR

Stream	Time of Travel to BSR, days	Measured load at the border	Load at BSR *
Mud Creek	1.792	6.26E+13	1.12E+13
Rock River, mainstem	1.419	2.02E+14	5.16E+13
Little Rock RIver	3.034	1.39E+13	3.71E+11

*Units for these loads are *E. coli* organisms/day.

Table 3.39 Minnesota Low Flow *E. coli* loads at the BSR

Stream	Time of Travel to BSR, days	Measured load at the border *	Load at BSR *
Mud Creek	3.471	1.37E+11	4.89E+09
Rock River, mainstem	2.422	1.14E+12	1.11E+11
Little Rock RIver	4.763	2.04E+11	2.11E+09

*Units for these loads are *E. coli* organisms/day.

Table 3.40 Minnesota Very Low Flow *E. coli* loads at the BSR

Stream	Time of Travel to BSR, days	Measured load at the border *	Load at BSR *
Mud Creek	5.845	2.14E+10	7.83E+07
Rock River, mainstem	3.346	2.45E+11	9.85E+09
Little Rock RIver	4.443	1.36E+11	1.91E+09

*Units for these loads are *E. coli* organisms/day.

3.7.2 Pollution Source Assessment - Direct BSR and Rock River Watershed Loads

The BSRTMDL-3 segment is 21.4 miles long and drains the 23 HUC 12's of the Rock River watershed, 7 Iowa HUC 12's and two South Dakota HUC 12's that drain directly to the Big Sioux (See Figures 30 and 31). This drainage area is a significant part of the Big Sioux River watershed and only a small portion of this drainage area is located in South Dakota. There are eleven Iowa wastewater treatment plants in the Iowa Rock River watershed and one in the direct draining HUC12's. No wastewater treatment plants were located in the South Dakota portion of the watershed.

Existing Load

Existing load was estimated using the procedures described in Appendix C. In brief, the 60th percentile loading value estimated from the SD DENR water quality data at each flow percentile represents the existing load at the associated flow percentile. A summary of the existing loads reported as both fecal coliform bacteria and *E.coli* for this segment is shown in Table 3.41. Since the water quality data was reported as fecal coliform, the *E.coli* loads were estimated by multiplying the fecal coliform concentration by a conversion factor derived from the single maximum standards for these pathogen indicators (i.e. 235 E.coli/400 fecal coliform = 0.5875).

Table 3.41 BSRTMDL-3, Existing Load Calculated using data from LBSM013

Flow Percentile	Existing Load (cfu/day)	
	Fecal Coliform	*E. coli*
12.5	2.48E+14	1.46E+14
37.5	4.92E+14	2.89E+14
62.5	1.02E+14	6.00E+13
87.5	2.35E+11	1.38E+11

Departure from Load Capacity

The load capacity for this segment of the Big Sioux River is that which meets the water quality standard sample maximum concentration of 235 *E. coli* organisms/100 ml or 400 fecal coliform/100 ml converted to a daily load. The load capacity varies with the water volume and follows the load duration curve for each monitoring site. The departure from load capacity is the difference between the sample maximum concentration and the monitored concentration for a given stream volume or flow rate. Appendix C includes a description of the procedure in calculating the load capacity and the load reduction. Tables 3.42 shows the maximum allowable load and the percent reduction required to meet the water quality standards. Figure 32 shows the load duration curve for fecal coliform bacteria for LBSM13. The curve represents the TMDL at each percentile flow duration interval. This figure also includes the median, 60th percentile (used to calculate TMDL load reduction), and 90th percentile load at specific percentile flow duration interval. Figure 32 also distinguishes samples collected during the recreational season in which the WQS is applicable. In addition, samples that are collected on days where storm flow is greater than the 50th percentile is also identified.

Table 3.42 BSRTMDL-3, Departure from Load Capacity and Load Reductions Required

Flow Percentile	TMDL (cfu/day)		Load Reductions Required (%)
	Fecal Coliform	*E. coli*	
12.5	3.07+13	1.81+13	87.6
37.5	9.91+12	5.82+12	66
62.5	4.05+12	2.38+12	No reduction
87.5	1.13+12	6.66+11	No reduction

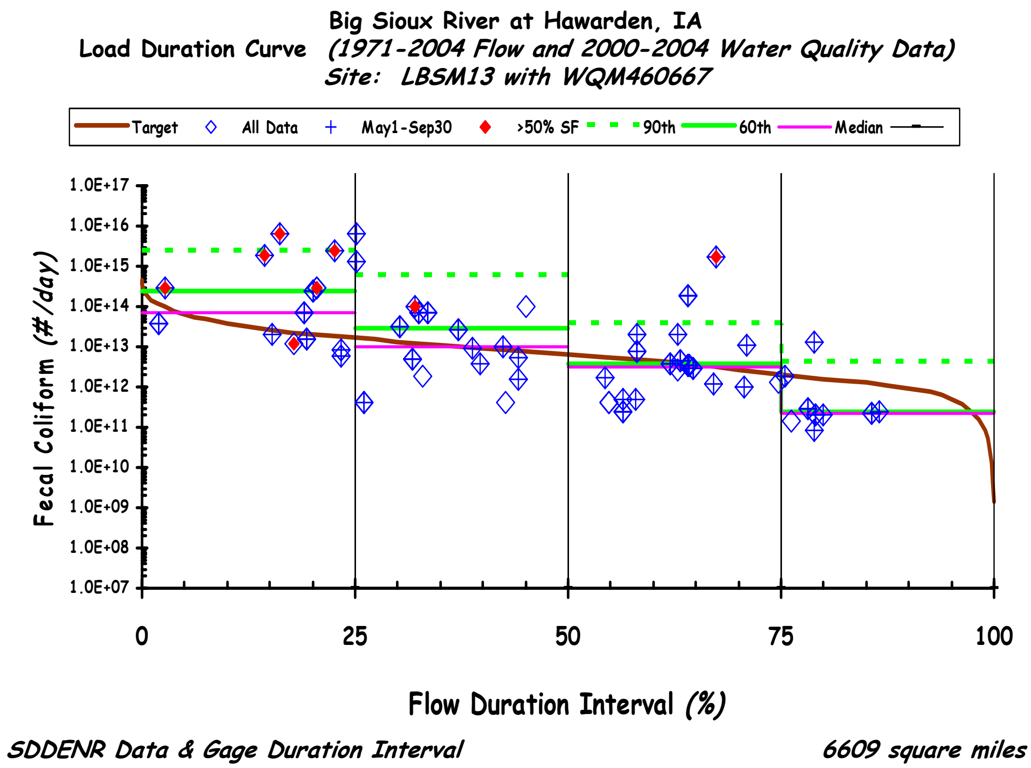


Figure 32. BSRTMDL-3 Load Duration Curve for LBSM13

Identification of Pollutant Sources

The pollutant sources for the BSRTMDL-3 segment are located in Iowa, South Dakota, and Minnesota. The Minnesota loads have been calculated independently and are included as part of the Rock River load at the Big Sioux confluence. The Iowa and South Dakota loads are considered separately. South Dakota pollutant sources were identified using various data sources such as 2002 census data and digital Orthophoto Quads in GIS. Detail procedure and model assumptions are described in Appendix C. Iowa pollutant sources were identified used county ag statistics, aerial photography, livestock registration databases, and GIS methods described in Appendix B, Procedures and Assumptions.

Iowa Pollutant Sources:

The Iowa pollutant sources on this impaired segment consist of the loads from the Big Sioux River upstream of the Rock River as measured at the Hudson monitoring site, the estimated loads from the Rock River watershed, and loads from the nine direct HUC 12 sub-watersheds draining into this segment.

Iowa Point Sources: There is one wastewater treatment plant in the BSRTMDL-3 watershed that discharges directly into the Big Sioux River from the City of Hawarden. The Hawarden wastewater treatment plant continuously discharges and is required by its NPDES permit to meet the pathogen indicator WQS limits. The plant disinfects its effluent to meet the water quality standards. There are eleven wastewater treatment facilities in the Rock River Iowa watershed that are discussed in more detail in Section 3.7.1.

Iowa Non-point Sources: There are three categories of non-point source loads; manure from livestock and wildlife distributed over the different landuses, cattle in streams, and failing septic tank systems.

The livestock and wildlife manure non-point sources and the built-up land use for this segment have been evaluated for the months of April, June, and October. (The built-up land use consists of commercial, residential and transportation land uses.) These were selected as design conditions because more manure is applied to cropland and pasture in April and October than in other months. These loads require a precipitation event for delivery to the Big Sioux River. The design event has an assumed 1% recurrence (event that occurs every 100 days), i.e., there is enough precipitation to significantly increase runoff and bacteria transport. The bacteria delivery ratio is the *E. coli* organisms delivered divided by the number available for washoff. A delivery ratio of 0.35 has been estimated for flows with a 1% recurrence.

Cattle in streams is a non-point source category that accounts for livestock bacteria loads that are directly delivered to the stream without a significant precipitation event to provide transport. These loads are assumed to be continuous and unvarying through the month. The cattle in streams load is obtained by estimating the number of grazing cattle there are in the HUC 12's and the amount of time they spend in streams. In June the warmer weather is assumed to increase the number of grazing cattle in the stream and the associated loads. Based on county ag statistics, livestock registration databases, and local field assessments, the fraction of grazing beef cattle (versus confined) is 7% of the total in each HUC 12. The cattle in the stream percentage is based on what research is available is 12% in the cooler months and 24% in the warmer months, June, July, and August. This is shown in the Table 3.44 loading values.

Failed septic tanks are assumed to be continuous throughout the year and do not need an event for bacteria transport. The NPS loads for the 23 HUC 12's in the Rock River watershed were presented in Tables 3.35 to 3.37. Tables 3.43 to 3.45 show the delivered loads for the various non-point sources for the seven direct HUC 12's on the Iowa side that discharge into the BSRTMDL-3 segment.

Table 3.43 BSRTMDL-3, Livestock, wildlife, built-up area event NPS loads

No.	HUC 12 name	Dist. to BSR, km	April load * at BSR **	June load * at BSR **	Oct. load * at BSR **
10	Dry Cr.Big Sioux River	0.00	3.27E+14	2.40E+14	2.12E+15
11	Upper Sixmile Creek	41.58	2.13E+14	1.29E+14	1.30E+15
12	Middle Sixmile Creek	27.71	1.46E+14	1.07E+14	9.30E+14
13	Big Sioux River	0.00	3.15E+12	2.41E+12	2.01E+13
14	Lower Sixmile Creek	0.00	1.29E+14	9.13E+13	8.20E+14
15	Big Sioux River	0.00	3.42E+13	2.58E+13	2.18E+14
18	Big Sioux River	0.00	2.73E+12	1.90E+12	1.92E+13

*Units for these loads are *E. coli* organisms/day.
** The 1% event bacteria delivery ratio (load delivered divided by available for washoff) is 0.35.

Table 3.44 BSRTMDL-3, Cattle in streams NPS loads

No.	HUC 12 name	# grazing beef cattle	Dist. to BSR, km	April load, 12% in streams *	June load, 24% in streams *	Oct. load, 12% in streams *
10	Dry Cr. Big Sioux R.	1124	0.00	8.77E+12	1.75E+13	8.77E+12
11	Upper Sixmile Creek	1749	41.58	2.07E+12	4.14E+12	2.07E+12
12	Middle Sixmile Creek	1098	27.71	2.44E+12	4.87E+12	2.44E+12
13	Big Sioux River	14	0.00	1.10E+11	2.21E+11	1.10E+11
14	Lower Sixmile Creek	478	0.00	3.73E+12	7.46E+12	3.73E+12
15	Big Sioux River	150	0.00	1.17E+12	2.33E+12	1.17E+12
18	Big Sioux River	0	0.00	0.00E+00	0.00E+00	0.00E+00

*Units for these loads are *E. coli* organisms/day. Percentages are the fraction of grazing cattle that are assumed to be in the stream.

Table 3.45 BSRTMDL-3, Failing Septic systems NPS loads

No.	HUC 12 name	No. of failed septics	Distance to BSR, km	Load at BSR *
10	Dry Creek-Big Sioux River	263	0.00	1.17E+10
11	Upper Sixmile Creek	187	41.58	1.27E+09
12	Middle Sixmile Creek	173	27.71	2.19E+09
13	Big Sioux River	43	0.00	1.91E+09
14	Lower Sixmile Creek	204	0.00	9.10E+09
15	Big Sioux River	34	0.00	1.53E+09
18	Big Sioux River	25	0.00	1.12E+09

*Units for these loads are *E. coli* organisms/day.

South Dakota Pollutant Sources

The pollutant sources on the South Dakota part of this impaired segment consist of loads from non-point sources only discharging from this segment's two HUC 12 sub-watersheds.

South Dakota Point Sources: There are no wastewater treatment plants in the BSRTMDL-3 watershed and therefore point sources are not expected to be a contributor to the impairment in this segment.

South Dakota Non-point Sources: South Dakota flows and loads for this segment consist of the loads measured at Finnie Creek and at Green Creek near their confluences with the Big Sioux River and the direct HUC 12 loads. Land uses in the various HUC 12 drainage areas in South Dakota are generally similar (See Table 2.5). The majority of these areas are dominated by a combination of grassland, hay, pasture, corn, and soybeans land uses, follow by high intensity commercial and industrial land uses. There is relatively limited residential area within these drainage areas and therefore impacts from these land uses are expected to be minimal.   Assumptions used to model the non-point load estimates are described in Appendix C. Table 3.46 show the estimated delivered loads for the various non-point sources for the two HUC 12's on the South Dakota side that discharge into the BSRTMDL-3 segment during June.

Table 3.46 BSRTMDL-3, South Dakota NPS Load during June

Iowa Assessment Segment	HUC_12	HU_12_NAME	Non-point Source Load (fecal coliform/day)							
			Cropland	Pastureland	Forest	Built up	Storm Sewers	Septics	Cattle in Streams	AFOs
0010-4	101702032001	Big Sioux River- Dry Creek	6.74E+13	1.85E+13	7.93E+03	6.08E+06	0.00E+00	2.96E+09	4.41E+12	3.16E+14
	101702032201	Big Sioux River- Indian Creek	9.57E+12	9.32E+12	4.31E+03	6.08E+06	0.00E+00	6.41E+08	9.57E+11	5.17E+13

3.7.3 Pollutant Allocations

Wasteload Allocations, Rock River Watershed

Rock River Watershed Wastewater Treatment Plant Load Allocations: The wasteload allocations (WLA) for the eleven Iowa wastewater treatment plants in the Rock River sub-watershed contributing loads to the BSRTMDL-3 segment are based on the standard assumption that effluent concentration must meet the water quality standard at the point where it enters a stream that has the Class A1 Primary Contact Recreational Use designation. Therefore, the WLA for a plant discharging directly into a classified stream would be the same as the numeric E. coli water quality standard. The wastewater treatment plant E. coli loads delivered to the BSRTMDL-3 segment and the distance of the plant discharge from the BSR is shown in Table 3.34 in Section 3.7.1 Pollution Source Assessment, Rock River Watershed.

Wasteload allocations for discharges some distance from the designated use waterbody (BSR) are calculated using the estimated time of travel between the discharge location and the Big Sioux River and a bacteria die-off factor. The time of travel estimates for the eleven BSRTMDL-3 wastewater treatment plants in the Rock River watershed used time of travel calculations for the relevant segments of Mud Creek, the Rock River, and the Little Rock River. (See the spreadsheets *Mud Time of Travel.xls, Rock Time of Travel.xls, Little Rock Time of Travel.xls,* and *Rock wwtp.xls* listed in Appendix A.) The time of travel estimates for the three streams were calculated from flow monitoring data stratified into three categories; high flow, low flow, and very low flow.

Wasteload allocations were calculated for the most stringent condition, which is low flow. At high flow, the load from these small facilities is not over the E. coli standard and is also dwarfed by the surface run-off loads. At very low flow, the reduced stream velocity allows for greater die-off so the allocation concentration at the discharge location is higher (less stringent) than for low flow.

All of the wwtp discharges in the Rock River watershed to the Big Sioux River are indirect. For indirect discharges, the time of travel has been estimated at low flow and die-off has been back calculated from the Big Sioux River upstream to the discharge location. The calculations and assumptions used in the development of wasteload allocations are in the time of travel and bacteria die-off sections of Appendix B, Procedures and Assumptions.

These WLA's apply from March 15 through November 15 and are intended to provide *E. coli* and fecal coliform concentrations at the confluence with the Big Sioux River that complies with the *E. coli* Water Quality Standards (WQS). The WQS values for *E. coli* are a geometric mean of 126-organisms/100 ml and a sample maximum of 235-organisms/100 ml. The WLA's for the Rock River watershed BSRTMDL-3 wastewater treatment plants are in Table 3.43.

Table 3.47 BSRTMDL-3, Rock River Low Flow Wasteload Allocations

Name	WQS load at BSR, *E. coli* org/day *	WLA at wwtp location, *E. coli* org./day **	WLA geometric mean, *E. coli* org/100 ml ***	WLA sample max. *E. coli* org/100 ml ***
Alvord wwtp	1.19E+09	9.67E+09	**1022**	**1910**
Ashton wwtp	2.14E+09	6.64E+10	**none**	**none**
Doon wwtp	2.10E+09	6.65E+09	**399**	**747**
George wwtp	6.00E+09	6.48E+10	**1361**	**2545**
Hull wwtp	2.10E+09	9.35E+09	**561**	**1049**
Lester wwtp	1.43E+09	1.61E+10	**1416**	**2647**
Little Rock wwtp	2.67E+09	9.93E+10	**none**	**none**
Niessink wwtp	9.54E+07	2.51E+08	**332**	**620**
Rock Rapids wwtp	2.39E+09	1.50E+10	**788**	**1474**
Rock Valley wwtp	3.42E+09	7.91E+09	**291**	**544**
Sibley wwtp	3.20E+09	2.16E+11	**8524**	**15940**

*This is the allowable total daily load for the wwtp in *E. coli* organisms per day for the design plant flow at the WQS concentration of 126 E. coli organisms/100ml.
**This is the allowable total daily load at the effluent discharge location after die-off has been calculated at low flow time of travel.
***Concentration WLA are based on the E. coli numeric WQS values of 126-organisms/100 ml for geometric mean and 235-organisms/100 ml for the sample maximum and accounting for die-off between the discharge and the BSR. Apply from March 15 to November 15.

<u>Rock River Watershed Permitted Animal Feeding Operation Facilities Wasteload Allocations</u>: Some animal feeding operations require National Pollutant Discharge Elimination System (NPDES) permits. These permits set limits on the pollutants that can be discharged to waterbodies based on a wasteload allocation. The thresholds for needing a permit are based on animal units (AU) - one beef cow equals one animal unit; one dairy cow equals 1.4 animal units. All of the permitted facilities in the Big Sioux watershed are beef cattle feedlots or dairy operations. For feedlots the threshold is 1000 beef cattle and for dairies it is 700 dairy cows.

There are seven NPDES permitted animal feeding operation facilities in the Rock River watershed that drains to the BSRTMDL-3 impaired segment. The wasteload allocations for these facilities follow state (IAC 567- Ch.65) and federal (40 CFR 125.30 through 125.32) rules for open feedlots. The relevant state rule, IAC 567 – 65.101(2) a(1), requires that there be no discharge of manure, process wastewater, settled open feedlot effluent, settleable solids or open feedlot effluent resulting from precipitation events less than or equal to the 25 year, 24 hour precipitation event. The permitted facilities, their locations and HUC 12, and WLA's are shown in Table 3.44.

Table 3.48 BSRTMDL-3 Rock River Watershed NPDES Permitted Animal Feeding Operation Facilities

Facility Name	Facility ID	NPDES #	EPA #	Township and range	Sec	1/4 Sec	HUC 12*	WLA **
Jansma Cattle Co.	61304	60-00-0-04	77640	T99N R45W	7&6	SW-NE	RR #22	No discharge
Rock River Feedyards	56382	60-00-0-06	79022	T99N R46W	10	NE	RR #15	No discharge
John Fluit, Jr. Feedlot	56833	60-00-0-08(2)	79685	T98N R47W	16	SW	RR #3	No discharge
East Valley Farm, Inc	56490	84-00-0-27	78107	T96N R46W	2	NE	RR #4	No discharge
Fairview Feeders	62532	84-00-0-30	78379	T97N R47W	16	NW	RR #2	No discharge
Sunrise Feedlots, Inc	56715	84-00-0-35	79103	T97N R45W	17,18	NW, NE	RR #1	No discharge
Performance Beef	61089	84-00-0-26	77704	T97N R47W	14	NE	RR #3	No discharge

*This refers to the HUC 12 sub-watershed in the Rock River watershed and corresponds to the HUC 12 number in column one of Table 3.50.
**No discharge resulting from precipitation events less than or equal to the 25 year, 24 hour precipitation event.

Wasteload Allocations, BSR Direct Watershed

Wastewater Treatment Plant Wasteload Allocations: The Hawarden wastewater treatment plant is the only one on the BSRTMDL-3 segment that discharges directly to the Big Sioux River. This plant already has a wasteload allocation and NPDES permit limit that limits effluent *E. coli* to the water quality standard values during the primary contact recreational season from March 15 to November 15. Therefore a new wasteload allocation is not necessary for this facility.

BSR Direct Watershed Permitted Animal Feeding Operation Facilities Wasteload Allocations: Some animal feeding operations require National Pollutant Discharge Elimination System (NPDES) permits. These permits set limits on the pollutants that can be discharged to waterbodies based on a wasteload allocation. The thresholds for needing a permit are based on animal units (AU) - one beef cow equals one animal unit; one dairy cow equals 1.4 animal units. All of the permitted facilities in the Big Sioux watershed are beef cattle feedlots or dairy operations. For feedlots the threshold is 1000 beef cattle and for dairies it is 700 dairy cows.

There are six NPDES permitted animal feeding operation facilities in the BSR direct watershed that drains to the BSRTMDL-3 impaired segment. The wasteload allocations for these facilities follow state (IAC 567- Ch.65) and federal (40 CFR 125.30 through 125.32) rules for open feedlots. The relevant state rule, IAC 567 – 65.101(2) a(1), requires that there be no discharge of manure, process wastewater, settled open feedlot effluent, settleable solids or open feedlot effluent resulting from precipitation events less than or equal to the 25 year, 24 hour precipitation event. The permitted facilities, their locations and HUC 12, and WLA's are shown in Table 3.45.

Table 3.49 BSRTMDL-3 BSR direct Watershed NPDES Permitted Animal Feeding Operation Facilities Wasteload Allocations

Facility Name	Facility ID	NPDES #	EPA #	Township and range	Sec	1/4 Sec	HUC 12*	WLA**
Farmer's Coop Society	60404	84-00-0-12	77577	T96N R46W	36	NW	BSR #11	No discharge
Remmerde Farms	56481	84-00-0-29	78387	T96N R46W	10	NE	BSR #10	No discharge
Jeff Eilts Feedlot	56276	84-00-0-37	79189	T95N, R46W	33	SW	BSR #12	No discharge
Van Berkel Farms	56294	84-00-0-40	79464	T96N R46W	31	NE	BSR #10	No discharge
Halverhals Feedlot	59740	84-00-0-42	79499	T95N R46W	6	SW	BSR #12	No discharge
Rolling Hills Feedlot	56731	84-00-0-39	79341	T94N R47W	4	NW	BSR #14	No discharge

*This refers to the HUC 12 sub-watershed in the BSR direct watershed and corresponds to the HUC 12 number in column one of Table 3.57.
**No discharge resulting from precipitation events less than or equal to the 25 year, 24 hour precipitation event.

Load Allocations and Pollutant Load Reductions Needed

The load allocations for TMDL 3 have been calculated and distributed to the loads from the Rock River tributary watershed and the HUC 12 sub-watersheds that discharge directly to the Big Sioux River.

Rock River Load Allocations

The load allocations for the Rock River at its confluence with the Big Sioux are based on the discharges from the 23 Iowa HUC 12s and the two South Dakota HUC 12s that discharge to the Rock River and then to the Big Sioux BSRTMDL-3 segment. The load allocations are based on the assumption that all discharges into the Big Sioux River from all sources must meet the single sample water quality standard of 235 *E. coli* organisms/100 ml or 400 fecal coliform/100 ml converted to a daily load.

A review of the Iowa load duration curves (spreadsheet *stream data analysis.xls*) for the Big Sioux and the tributaries that have been monitored shows that the bacteria targets are exceeded at most flow conditions, although by different sources with different delivery mechanisms. Four representative flow conditions have been selected for the derivation of load allocations and needed pollutant reductions. These are the 1%, 10%, 50%, and 70% load duration curve flow ranks (Tables 3.50 through 3.53). June load estimates for non-point sources that are event driven and for cattle in the stream sources have been selected as sufficiently representative. June is also the month when most monitored tributary events occurred. See Appendix B, Procedures and Assumptions for an explanation of load allocation development.

Table 3.50 BSRTMDL-3 – Rock R. Allocations and Reductions for 1% flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
1	Burr Oak Creek-Rock River	4.64E+11	5.69E+13	99.2%
2	Unnamed Creek-Dry Run Creek	2.42E+11	6.97E+13	99.8%
3	Dry Run Creek-Rock River	3.53E+11	1.06E+14	99.7%
4	Rock River-Burr Oak Creek	4.82E+11	1.18E+14	99.6%
5	Lower Rock River	3.85E+11	1.27E+14	99.7%
6	Otter Creek-Rat Creek	5.98E+11	1.49E+13	96.0%
7	Otter Creek-Schutte Creek	5.69E+11	4.05E+12	86.0%
8	Cloverdale Creek	2.41E+11	4.13E+11	41.6%
9	Otter Creek-Kappes Creek	6.39E+11	1.09E+13	94.2%
10	Rat Creek	3.72E+11	2.59E+12	85.6%
11	Rock River	1.62E+11	3.73E+12	95.7%
12	Kanaranzi Creek	1.20E+11	1.23E+12	90.3%
13	Lower Mud Creek	4.38E+11	6.33E+13	99.3%
14	Upper Mud Creek	1.97E+11	1.38E+13	98.6%
15	Middle Mud Creek	5.29E+11	4.36E+13	98.8%
16	Little Rock River	1.10E+10	6.02E+07	none
17	Little Rock River-Snow Creek	5.32E+11	3.84E+12	86.2%
18	Emery Creek	2.06E+11	5.21E+12	96.0%
19	Little Rock River-Whitney Creek	6.17E+11	1.33E+13	95.4%
20	Tom Creek-Rock River	6.19E+11	1.21E+13	94.9%
21	Unnamed Creek-Rock River	1.92E+11	8.07E+12	97.6%
22	Rock River-Tom Creek	6.79E+11	9.29E+13	99.3%
23	Little Rock River-Emery Creek	4.79E+11	4.35E+13	98.9%

*Units for these loads are *E. coli* organisms/day.

Table 3.51 BSRTMDL-3 – Rock R. Allocations and Reductions for 10% flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
1	Burr Oak Creek-Rock River	9.39E+10	3.85E+12	97.6%
2	Unnamed Creek-Dry Run Creek	4.90E+10	5.17E+12	99.1%
3	Dry Run Creek-Rock River	7.15E+10	9.00E+12	99.2%
4	Rock River-Burr Oak Creek	9.77E+10	9.94E+12	99.0%
5	Lower Rock River	7.80E+10	1.51E+13	99.5%
6	Otter Creek-Rat Creek	1.21E+11	7.12E+11	83.0%
7	Otter Creek-Schutte Creek	1.15E+11	1.40E+11	17.7%
8	Cloverdale Creek	4.88E+10	1.43E+10	none
9	Otter Creek-Kappes Creek	1.29E+11	4.43E+11	70.8%
10	Rat Creek	7.54E+10	1.05E+11	28.1%
11	Rock River	3.28E+10	1.78E+11	81.6%
12	Kanaranzi Creek	2.43E+10	5.95E+10	59.2%
13	Lower Mud Creek	8.87E+10	4.12E+12	97.8%
14	Upper Mud Creek	3.99E+10	6.13E+11	93.5%
15	Middle Mud Creek	1.07E+11	2.14E+12	95.0%
16	Little Rock River	2.22E+09	2.54E+06	none

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
17	Little Rock River-Snow Creek	1.08E+11	1.50E+11	28.2%
18	Emery Creek	4.17E+10	2.49E+11	83.2%
19	Little Rock River-Whitney Creek	1.25E+11	6.49E+11	80.7%
20	Tom Creek-Rock River	1.25E+11	4.86E+11	74.2%
21	Unnamed Creek-Rock River	3.90E+10	4.69E+11	91.7%
22	Rock River-Tom Creek	1.37E+11	6.15E+12	97.8%
23	Little Rock River-Emery Creek	9.71E+10	2.77E+12	96.5%

*Units for these loads are *E. coli* organisms/day.

Table 3.52 BSRTMDL-3 – Rock R. Allocations and Reductions for 50% flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
1	Burr Oak Creek-Rock River	3.52E+10	2.44E+12	98.6%
2	Unnamed Creek-Dry Run Creek	1.84E+10	3.46E+12	99.5%
3	Dry Run Creek-Rock River	2.68E+10	6.44E+12	99.6%
4	Rock River-Burr Oak Creek	3.66E+10	7.08E+12	99.5%
5	Lower Rock River	2.93E+10	1.21E+13	99.8%
6	Otter Creek-Rat Creek	4.54E+10	3.37E+11	86.5%
7	Otter Creek-Schutte Creek	4.32E+10	3.66E+10	none
8	Cloverdale Creek	1.83E+10	3.75E+09	none
9	Otter Creek-Kappes Creek	4.86E+10	1.65E+11	70.6%
10	Rat Creek	2.83E+10	3.91E+10	27.7%
11	Rock River	1.23E+10	8.44E+10	85.4%
12	Kanaranzi Creek	9.10E+09	2.84E+10	68.0%
13	Lower Mud Creek	3.33E+10	2.55E+12	98.7%
14	Upper Mud Creek	1.50E+10	2.63E+11	94.3%
15	Middle Mud Creek	4.02E+10	1.04E+12	96.1%
16	Little Rock River	8.34E+08	1.01E+06	none
17	Little Rock River-Snow Creek	4.04E+10	5.24E+10	22.9%
18	Emery Creek	1.56E+10	1.17E+11	86.7%
19	Little Rock River-Whitney Creek	4.68E+10	3.14E+11	85.1%
20	Tom Creek-Rock River	4.70E+10	1.79E+11	73.7%
21	Unnamed Creek-Rock River	1.46E+10	2.68E+11	94.5%
22	Rock River-Tom Creek	5.15E+10	3.85E+12	98.7%
23	Little Rock River-Emery Creek	3.64E+10	1.69E+12	97.9%

*Units for these loads are *E. coli* organisms/day.

Table 3.53 BSRTMDL-3 – Rock R. Allocations and Reductions for 70% flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
1	Burr Oak Creek-Rock River	2.35E+10	2.30E+12	99.0%
2	Unnamed Creek-Dry Run Creek	1.22E+10	3.29E+12	99.6%
3	Dry Run Creek-Rock River	1.79E+10	6.18E+12	99.7%
4	Rock River-Burr Oak Creek	2.44E+10	6.79E+12	99.6%
5	Lower Rock River	1.95E+10	1.18E+13	99.8%

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
6	Otter Creek-Rat Creek	3.03E+10	2.99E+11	89.9%
7	Otter Creek-Schutte Creek	2.88E+10	2.63E+10	none
8	Cloverdale Creek	1.22E+10	2.70E+09	none
9	Otter Creek-Kappes Creek	3.24E+10	1.38E+11	76.5%
10	Rat Creek	1.89E+10	3.25E+10	42.1%
11	Rock River	8.19E+09	7.50E+10	89.1%
12	Kanaranzi Creek	6.07E+09	2.53E+10	76.0%
13	Lower Mud Creek	2.22E+10	2.39E+12	99.1%
14	Upper Mud Creek	9.98E+09	2.28E+11	95.6%
15	Middle Mud Creek	2.68E+10	9.28E+11	97.1%
16	Little Rock River	5.56E+08	8.61E+05	none
17	Little Rock River-Snow Creek	2.69E+10	4.26E+10	36.9%
18	Emery Creek	1.04E+10	1.04E+11	90.0%
19	Little Rock River-Whitney Creek	3.12E+10	2.81E+11	88.9%
20	Tom Creek-Rock River	3.13E+10	1.48E+11	78.8%
21	Unnamed Creek-Rock River	9.74E+09	2.48E+11	96.1%
22	Rock River-Tom Creek	3.44E+10	3.62E+12	99.1%
23	Little Rock River-Emery Creek	2.43E+10	1.59E+12	98.5%

*Units for these loads are *E. coli* organisms/day.

Minnesota load allocations:

The Minnesota calculations for high, low and very low flow loads were based on monitored high flow event data and monthly measurements near where the three streams cross the border into Iowa. Time of travel was estimated and a bacteria die-off function was used to derive an allocation at the border from the water quality standard target sample maximum 235 *E. coli* organisms/100 ml at the Big Sioux River. These flow conditions and time of travel derivations can be found in Appendix B, Procedures and Assumptions. The Minnesota load allocations are shown in Tables 3.54 to 3.56.

Table 3.54 High flow - Minnesota Load Allocations

Stream	Load allocation at BSR *	Load allocation at MN border *	Load reduction needed
Mud Creek	3.80E+11	2.12E+12	96.6
Rock River, mainstem	3.30E+12	1.29E+13	93.6
Little Rock RIver	1.61E+11	6.04E+12	56.6

*Units for these loads are *E. coli* organisms/day.

Table 3.55 Low flow - Minnesota Load Allocations

Stream	Load allocation at BSR *	Load allocation at MN border*	Load reduction needed
Mud Creek	3.68E+10	1.03E+12	none
Rock River, mainstem	6.68E+11	6.83E+12	none
Little Rock RIver	8.63E+10	8.35E+12	none

*Units for these loads are *E. coli* organisms/day.

Table 3.56 Very Low flow - Minnesota Load Allocations

Stream	Load allocation at BSR *	Load allocation at MN border *	Load reduction needed
Mud Creek	5.75E+09	1.57E+12	none
Rock River, mainstem	1.44E+11	3.57E+12	none
Little Rock RIver	5.75E+10	4.09E+12	none

*Units for these loads are *E. coli* organisms/day.

Direct Discharging HUC 12 Sub-watershed Load Allocations

The load allocations for the seven Iowa HUC 12 sub-watersheds that discharge directly to the Big Sioux River BSRTMDL-3 segment are in Tables 3.57 to 3.60. The load allocations are based on the assumption that all discharges into the Big Sioux River from all sources must meet the single sample water quality standard of 235 *E. coli* organisms/100 ml converted to a daily load.

A review of the load duration curves for the Big Sioux and the tributaries that have been monitored shows that the bacteria targets are exceeded at most flow conditions, although by different sources with different delivery mechanisms. Four representative flow conditions have been selected for the derivation of load allocations and needed pollutant reductions. These are the 1%, 10%, 50%, and 70% load duration curve flow ranks (Tables 3.57 through 3.60). June load estimates for non-point sources that are event driven and for cattle in the stream sources have been selected as sufficiently representative. June is also the month when most monitored tributary events occurred. See Appendix B, Procedures and Assumptions for an explanation of load allocation development.

Table 3.57 BSRTMDL-3 BSR Direct Allocations and Reductions for 1% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
10	Dry Creek-Big Sioux River	5.98E+11	2.58E+14	99.8%
11	Upper Sixmile Creek	4.26E+11	1.33E+14	99.7%
12	Middle Sixmile Creek	3.92E+11	1.12E+14	99.6%
13	Big Sioux River	9.72E+10	2.63E+12	96.3%
14	Lower Sixmile Creek	4.64E+11	9.87E+13	99.5%
15	Big Sioux River	7.79E+10	2.81E+13	99.7%
18	Big Sioux River	5.69E+10	1.90E+12	97.0%

*Units for these loads are *E. coli* organisms/day.

Table 3.58 BSRTMDL-3 BSR Direct Allocations and Reductions for 10% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
10	Dry Creek-Big Sioux River	1.21E+11	2.44E+13	99.5%
11	Upper Sixmile Creek	8.62E+10	7.82E+12	98.9%
12	Middle Sixmile Creek	7.94E+10	7.92E+12	99.0%
13	Big Sioux River	1.97E+10	2.91E+11	93.2%
14	Lower Sixmile Creek	9.40E+10	1.01E+13	99.1%
15	Big Sioux River	1.58E+10	3.07E+12	99.5%
18	Big Sioux River	1.15E+10	5.53E+10	79.2%

*Units for these loads are *E. coli* organisms/day.

Table 3.59 BSRTMDL-3 BSR Direct Allocations and Reductions for 50% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
10	Dry Creek-Big Sioux River	4.54E+10	1.82E+13	99.8%
11	Upper Sixmile Creek	3.23E+10	4.51E+12	99.3%
12	Middle Sixmile Creek	2.98E+10	5.18E+12	99.4%
13	Big Sioux River	7.39E+09	2.29E+11	96.8%
14	Lower Sixmile Creek	3.52E+10	7.73E+12	99.5%
15	Big Sioux River	5.91E+09	2.41E+12	99.8%
18	Big Sioux River	4.32E+09	6.54E+09	33.9%

*Units for these loads are *E. coli* organisms/day.

Table 3.60 BSRTMDL-3 BSR Direct Allocations and Reductions for 70% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
10	Dry Creek-Big Sioux River	3.03E+10	1.76E+13	99.8%
11	Upper Sixmile Creek	2.16E+10	4.18E+12	99.5%
12	Middle Sixmile Creek	1.99E+10	4.91E+12	99.6%
13	Big Sioux River	4.92E+09	2.23E+11	97.8%
14	Lower Sixmile Creek	2.35E+10	7.49E+12	99.7%
15	Big Sioux River	3.94E+09	2.34E+12	99.8%
18	Big Sioux River	2.88E+09	1.66E+09	none

*Units for these loads are *E. coli* organisms/day.

A review of the South Dakota load duration curves for the Big Sioux River and the tributaries that have been monitored shows that the bacteria targets are exceeded at mid to high flow conditions. Four representative flow conditions have been selected for the derivation of South Dakota load allocations and needed pollutant reductions. These are the 0-10%, 10-40%, 40-70%, and 70-100%, load duration curve ranges (Tables 3.61). See Appendix C for explanation on the load allocation calculations.

Table 3.61 BSRTMDL-3 South Dakota Allocations and Reductions for Various Flow Percentile Range

Iowa Assessment Segment	HUC_12	HU_12_NAME	Load Allocation (fecal coliform/day)				Existing Load (fecal coliform/day)				Percent Load Reduction			
			0-10%	**10-40%**	**40-70%**	**70-100%**	**0-10%**	**10-40%**	**40-70%**	**70-100%**	**0-10%**	**10-40%**	**40-70%**	**70-100%**
0010-4	101702032001	Big Sioux River Dry Creek	4.63E+11	2.18E+11	1.48E+11	7.91E+10	5.61E+13	1.01E+13	4.54E+11	1.89E+11	99.2%	97.8%	67.3%	58.1%
	101702032201	Big Sioux River Indian Creek	2.38E+11	8.02E+10	4.63E+10	2.08E+10	9.82E+12	1.78E+12	7.95E+10	3.31E+10	97.6%	95.5%	41.7%	37.2%

3.8 BSRTMDL-4: The Big Sioux River from Indian Creek to Brule Creek.

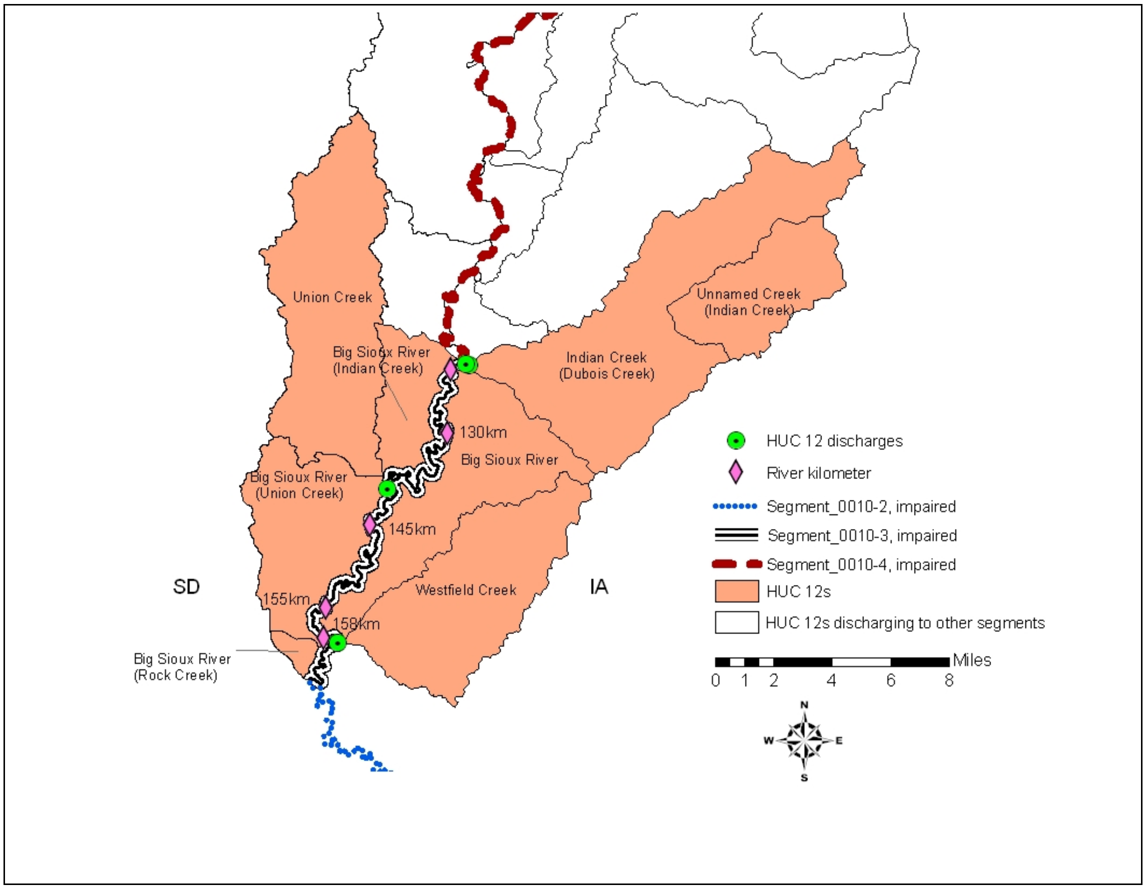


Figure 33. BSRTMDL-4. Indian Creek to Brule Creek

3.8.1 Pollution Source Assessment

The BSRTMDL-4 segment is 25.6 miles long and drains four HUC 12's in each of the Iowa and South Dakota portion of the Big Sioux River Iowa watershed as shown in Figure 30. For the Iowa portion, the drainage area is 76,300 acres and there are three wastewater treatment plants in the segment's sub-watershed. The drainage area is 72,641 acres for the South Dakota portion of this segment's sub-watershed and there are no South Dakota wastewater treatment plants.

Existing Load

Existing load was estimated using the procedures described in Appendix C. In brief, the 60th percentile loading value estimated from the SD DENR water quality data at each flow percentile represents the existing load at the associated flow percentile. A summary of the existing loads reported as both fecal coliform bacteria and *E.coli* for this segment is shown in Table 3.62. Since the water quality data was reported as fecal coliform, the *E.coli* loads were estimated by multiplying the fecal coliform concentration by a conversion factor derived from the single maximum standards for these pathogen indicators (i.e. 235 E.coli/400 fecal coliform = 0.5875).

Table 3.62 BSRTMDL-4, Existing Load Calculated using data from LBSM19

Flow Percentile	Existing Load (cfu/day)	
	Fecal Coliform	*E. coli*
12.5	2.24E+14	7.28E+13
37.5	4.93E+13	2.90E+13
62.5	5.23E+13	3.07E+13
87.5	4.59E+11	2.70E+11

Departure from Load Capacity

The load capacity for this segment of the Big Sioux River is that which meets the water quality standard sample maximum concentration of 235 *E. coli* organisms/100 ml or 400 fecal coliform/100 ml converted to a daily load. The load capacity varies with the water volume and follows the load duration curve for each monitoring site. The departure from load capacity is the difference between the sample maximum concentration and the monitored concentration for a given stream volume or flow rate. Appendix C includes a description of the procedure in calculating the load capacity and the load reduction. Tables 3.63 shows the maximum allowable load and the percent reduction required to meet the water quality standards. Figure 34 shows the load duration curve for fecal coliform bacteria for LBSM19. The curve represents the TMDL at each percentile flow duration interval. This figure also includes the median, 60th percentile (used to calculate TMDL load reduction), and 90th percentile load at specific percentile flow duration interval. Figure 34 also distinguishes samples collected during the recreational season in which the WQS is applicable. Samples that are collected on days where storm flow is greater than the 50th percentile are also identified.

Table 3.63 BSRTMDL-4, Departure from Load Capacity and Load Reductions Required

Flow Percentile	TMDL (cfu/day)		Load Reductions Required (%)
	Fecal Coliform	*E. coli*	
12.5	3.34E+13	1.97E+13	73.0
37.5	1.10E+13	6.48E+12	38.7
62.5	2.70E+12	2.76E+12	No reduction
87.5	1.57E+12	9.20E+11	No reduction

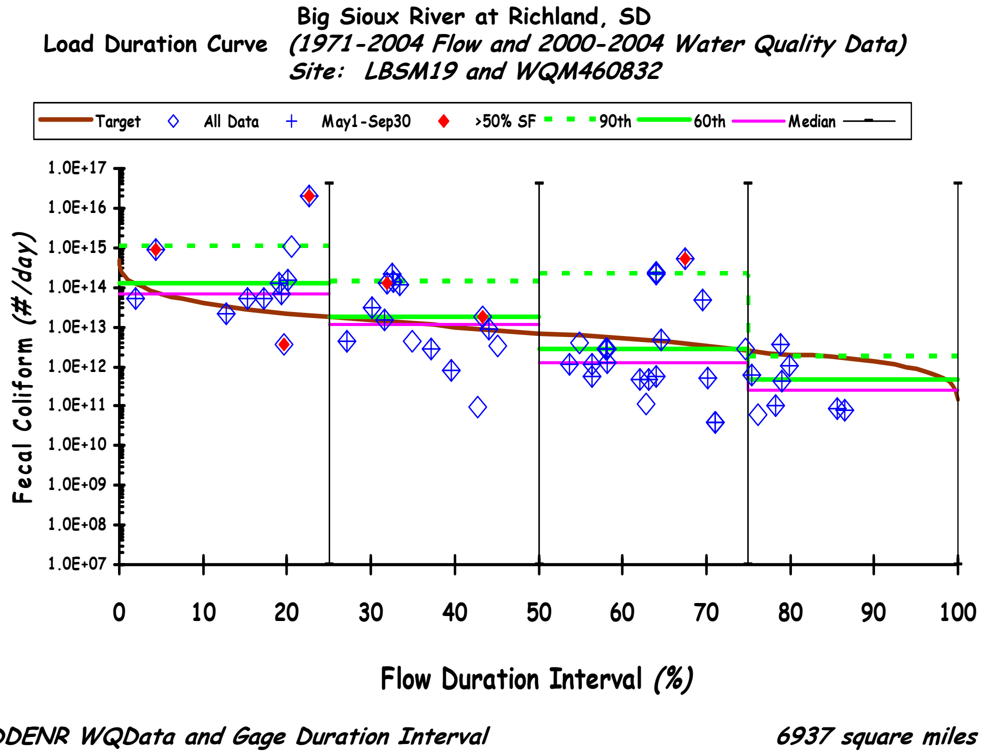


Figure 34. BSRTMDL-4 Load Duration Curve for LBSM19

Identification of Pollutant Sources

The pollutant sources for the BSRTMDL-4 segment are located in both Iowa and South Dakota. The Iowa and South Dakota loads are considered separately. The South Dakota pollutant sources have been identified and evaluated using different procedures than those used in Iowa. South Dakota pollutant sources were identified using various data sources such as 2002 census data and digital Orthophoto Quads in GIS. Detail procedure and model assumptions are described in Appendix C. Iowa pollutant sources were identified used county ag statistics, aerial photography, livestock registration databases, and GIS methods described in Appendix B, Procedures and Assumptions.

Iowa Pollutant Sources:

The pollutant sources on the Iowa part of this impaired segment consist of the upstream loads from the BSTTMDL 3 segment, loads from three wastewater treatment plants, and non-point sources discharging from this segment's four HUC 12 sub-watersheds.

Iowa Point Sources: There are three wastewater treatment plants in the BSRTMDL-4 watershed. The distance of each of these from the Big Sioux River has been measured and the delivered load calculated using time of travel and an assumed die-off coefficient of 0.96 per day during low flow conditions when continuous sources have their greatest impact. Appendix B, Procedures and Assumptions explains the evaluation spreadsheets and the assumptions, modeling equations, and rationale for plant treatment reductions. Table 3.64 shows the delivered loads assuming no effluent disinfection.

Table 3.64 BSRTMDL-4, Wastewater treatment plant *E. coli* loads at BSR

NAME	distance to BSR, km	Low flow time of travel, days	Wwtp effluent load	Load at the BSR
Akron wwtp	0.00	0.00	1.83E+11	1.83E+11
Ireton wwtp	29.24	1.914	7.52E+10	1.20E+10
Westfield wwtp	0.00	0.00	2.02E+10	2.02E+10

Two of these facilities are controlled discharge lagoons and one is a continuous discharge trickling filters (See Table 3.5 for wwtp characteristics). In general, controlled discharge lagoons are designed to discharge infrequently, perhaps twice a year, for two or three weeks during higher flows. Discharges are usually in the spring and fall. None of these facilities disinfects its effluent.

Iowa Non-point Sources: There are three categories of non-point source loads; manure from livestock and wildlife distributed over the different landuses, cattle in streams, and failing septic tank systems.

The livestock and wildlife manure non-point sources and the built-up land use for this segment have been evaluated for the months of April, June, and October. (The built-up land use consists of commercial, residential and transportation land uses.) These were selected as design conditions because more manure is applied to cropland and pasture in April and October than in other months. These loads require a precipitation event for delivery to the Big Sioux River. The design event has an assumed 1% recurrence (event that occurs every 100 days), i.e., there is enough precipitation to significantly increase runoff and bacteria transport. The bacteria delivery ratio is the *E. coli* organisms delivered divided by the number available for washoff. A delivery ratio of 0.35 has been estimated for flows with a 1% recurrence.

Cattle in streams is a non-point source category that accounts for livestock bacteria loads that are directly delivered to the stream without a significant precipitation event to provide transport. These loads are assumed to be continuous and unvarying through the month. The cattle in streams load is obtained by estimating the number of grazing cattle there are in the HUC 12's and the amount of time they spend in streams. In June the warmer weather is assumed to increase the number of grazing cattle in the stream and the associated loads. Based on county ag statistics, livestock registration databases, and local field assessments, the fraction of grazing beef cattle (versus confined) is 7% of the total in each HUC 12. The cattle in the stream percentage is based on what research is available is 12% in the cooler months and 24% in the warmer months, June, July, and August. This is shown in the Table 3.65 loading values.

Failed septic tanks are assumed to be continuous throughout the year and do not need an event for bacteria transport. Tables 3.65 to 3.67 show the delivered loads for the various non-point sources for the four HUC 12's on the Iowa side that discharge into the BSRTMDL-4 segment.

Table 3.65 BSRTMDL-4, Livestock, wildlife, built-up area event NPS loads

No.	HUC 12 name	Dist. to BSR, km	April load* at BSR**,	June load*at BSR**	Oct. load* at BSR**
16	Indian Cr.-Dubois Cr.	0	4.71E+13	3.33E+13	3.02E+14
17	Unnamed Cr.-Indian Cr.	19.16	6.19E+12	3.50E+12	3.68E+13
19	Big Sioux River	0	6.52E+12	3.16E+12	3.84E+13
21	Westfield Creek	0	3.46E+12	1.12E+12	1.90E+13

*Units for these loads are *E. coli* organisms/day.
** The 1% event bacteria delivery ratio (load delivered divided by available for washoff) is 0.35.

Table 3.66 BSRTMDL-4, Cattle in streams NPS loads

No.	HUC name	# grazing beef cattle	Dist. to BSR, km	April load, 12% in streams *	June load, 24% in streams *	Oct. load, 12% in streams *
16	Indian Cr.-Dubois Cr.	161	0	1.26E+12	2.52E+12	1.26E+12
17	Unnamed Cr.-Indian Cr	33	19.16	1.08E+11	2.17E+11	1.08E+11
19	Big Sioux River	15	0	1.19E+11	2.38E+11	1.19E+11
21	Westfield Creek	5	0	4.04E+10	8.08E+10	4.04E+10

*Units for these loads are *E. coli* organisms/day. The percentage is the fraction of grazing cattle that are in the stream.

Table 3.67 BSRTMDL-4, Failing Septic systems NPS loads

No.	HUC name	# of failed septics	distance to BSR, km	load at BSR *
16	Indian Creek-Dubois Creek	243	0	1.08E+10
17	Unnamed Creek-Indian Creek	83	19.16	1.56E+09
19	Big Sioux River	143	0	6.39E+09
21	Westfield Creek	153	0	6.83E+09

*Units for these loads are *E. coli* organisms/day.

South Dakota Pollutant Sources

The pollutant sources on the South Dakota part of this impaired segment consist of loads from non-point sources only discharging from this segment's four HUC 12 sub-watersheds.

South Dakota Point Sources: There are no wastewater treatment plants in the BSRTMDL-4 watershed and therefore point sources are not likely to be a contributor of the impairment in the South Dakota part of the watershed.

South Dakota Non-point Sources: Land uses in the various HUC 12 drainage areas in South Dakota are generally similar (See Table 2.5). The majority of these areas are dominated by a combination of grassland, hay, pasture, corn, and soybeans land uses, follow by high intensity commercial and industrial land uses. There is relatively limited residential area within these drainage areas and therefore impacts from these land uses are expected to be minimal. Assumptions used to model the non-point load estimates are described in Appendix C. Table 3.68 show the estimated delivered loads for the various non-point sources for the four HUC 12's on the South Dakota side that discharge into the BSRTMDL-4 segment during June.

Table 3.68 BSRTMDL-4, South Dakota NPS Load during June

Iowa Assessment Segment	HUC_12	HU_12_NAME	Non-point Source Load (fecal coliform/day)							
			Cropland	Pastureland	Forest	Built up	Storm Sewers	Septics	Cattle in Streams	AFOs
0010-3	101702032202	Union Creek	5.54E+13	9.42E+12	1.69E+03	6.08E+06	0.00E+00	3.14E+09	3.21E+12	4.77E+14
	101702032203	Big Sioux River- Union Creek	2.13E+13	1.70E+13	1.51E+04	6.07E+06	0.00E+00	1.72E+09	1.96E+12	1.16E+14
	101702032201	Big Sioux River- Indian Creek	9.57E+12	9.32E+12	4.31E+03	6.08E+06	0.00E+00	6.41E+08	9.57E+11	5.17E+13
	101702032205	Big Sioux River- Rock Creek	4.31E+13	7.48E+12	4.38E+03	6.09E+06	2.31E+11	1.50E+09	2.65E+12	0.00E+00

3.8.2 Pollutant Allocations

Wasteload Allocations

Wastewater Treatment Plant Wasteload Allocations: The wasteload allocations (WLA) for the three Iowa wastewater treatment plants in the BSRTMDL-4 segment sub-watershed are based on the standard assumption that effluent concentration must meet the water quality standard at the point where it enters a stream that has the Class A1 Primary Contact Recreational Use designation. Therefore, the WLA for a plant discharging directly into a classified stream would be the same as the numeric E. coli water quality standard. Two of the three wastewater treatment plants discharge directly to the Big Sioux River. These are the Akron and Westfield facilities. The Ireton wwtp is 29 km from the BSR. *E. coli* loads delivered to the BSRTMDL-4 segment are shown in Table 3.64 in Section 3.8.1 Pollution Source Assessment.

Wasteload allocations for the Ireton plant are calculated using the estimated time of travel between the discharge location and the Big Sioux River and a bacteria die-off factor. The time of travel estimates for the wastewater treatment plant used time of travel calculations for segments of Mud Creek similar to the stream receiving the plant effluent. (See the spreadsheets *Mud Time of Travel.xls* and *BSR direct wwtp.xls* listed in Appendix A.) The Mud Creek time of travel estimate was calculated from flow monitoring data stratified into three categories; high flow, low flow, and very low flow.

Wasteload allocations were calculated for the most stringent condition, which is low flow. At high flow, the load from small facilities is not over the E. coli standard and is also dwarfed by the surface run-off loads. At very low flow, the reduced stream velocity allows for greater die-off so the allocation concentration at the discharge location is higher (less stringent) than for low flow.

For the indirect discharge, the time of travel has been estimated at low flow and die-off has been back calculated from the Big Sioux River upstream to the discharge location. The calculations and assumptions used in the development of wasteload allocations are in the time of travel and bacteria die-off sections of Appendix B, Procedures and Assumptions.

These WLA's apply from March 15 through November 15 and are intended to provide *E. coli* and fecal coliform concentrations at the BSR confluence that complies with the *E. coli* Water Quality Standards (WQS). The WQS values for *E. coli* are a geometric mean of 126-organisms/100 ml and a sample maximum of 235-organisms/100 ml. The WLA's for the BSRTMDL-4 wastewater treatment plants are in Table 3.69.

Table 3.69 BSRTMDL-4 Low Flow Wasteload Allocations

Name	WQS load at BSR, *E. coli* org/day *	WLA at wwtp location, *E. coli* org./day **	WLA geometric mean, *E. coli* org/100 ml ***	WLA sample max. *E. coli* org/100 ml ***
Akron wwtp	1.03E+10	1.03E+10	**126**	**235**
Ireton wwtp	6.34E+08	3.97E+09	**788**	**1474**
Westfield wwtpTP	8.39E+08	8.39E+08	**126**	**235**

*This is the allowable total daily load for the wwtp in *E. coli* organisms per day for the design plant flow at the WQS concentration of 126 E. coli organisms/100ml.
**This is the allowable total daily load at the effluent discharge location after die-off has been calculated at low flow time of travel.
***Concentration WLA are based on the E. coli numeric WQS values of 126-organisms/100 ml for geometric mean and 235-organisms/100 ml for the sample maximum and accounting for die-off between the discharge and the BSR. Apply from March 15 to November 15.

Load Allocations and Pollutant Load Reductions Needed

The load allocations for this TMDL are based on the discharges from the eight Iowa HUC 12s that discharge to the BSRTMDL-4 segment and the loads from the South Dakota hydrologic units, tributary streams, and the BSRTMDL-3 segment of the Big Sioux River itself where it crosses into the BSRTMDL-4 segment. The load allocations are based on the assumption that all discharges into the Big Sioux River from all sources must meet the single sample water quality standard of 235 *E. coli* organisms/100 ml or 400 fecal coliform/100 ml converted to a daily load.

A review of the load duration curves for the Big Sioux and the tributaries that have been monitored shows that the bacteria targets are exceeded at most flow conditions, although by different sources with different delivery mechanisms. Four representative flow conditions have been selected for the derivation of load allocations and needed pollutant reductions. These are the 1%, 10%, 50%, and 70% load duration curve flow ranks (Tables 3.70 through 3.73). June load estimates for non-point sources that are event driven and for cattle in the stream sources have been selected as sufficiently representative. June is also the month when most monitored tributary events occurred. See Appendix B, Procedures and Assumptions for an explanation of load allocation development.

Table 3.70 BSRTMDL-4 Allocations and Reductions for 1% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
16	Indian Creek-Dubois Creek	5.53E+11	3.59E+13	98.5%
17	Unnamed Creek-Indian Creek	1.90E+11	3.72E+12	94.9%
19	Big Sioux River	3.26E+11	3.40E+12	90.4%
21	Westfield Creek	3.48E+11	1.20E+12	71.1%

*Units for these loads are *E. coli* organisms/day.

Table 3.71 BSRTMDL-4 Allocations and Reductions for 10% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
16	Indian Creek-Dubois Creek	1.12E+11	3.48E+12	96.8%
17	Unnamed Creek-Indian Creek	3.84E+10	3.18E+11	87.9%
19	Big Sioux River	6.60E+10	3.35E+11	80.3%
21	Westfield Creek	7.05E+10	1.20E+11	41.0%

*Units for these loads are *E. coli* organisms/day.

Table 3.72 BSRTMDL-4 Allocations and Reductions for 50% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
16	Indian Creek-Dubois Creek	4.20E+10	2.62E+12	98.4%
17	Unnamed Creek-Indian Creek	1.44E+10	2.28E+11	93.7%
19	Big Sioux River	2.47E+10	2.53E+11	90.2%
21	Westfield Creek	2.65E+10	9.08E+10	70.9%

*Units for these loads are *E. coli* organisms/day.

Table 3.73 BSRTMDL-4 Allocations and Reductions for 70% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction needed
16	Indian Creek-Dubois Creek	2.80E+10	2.54E+12	98.9%
17	Unnamed Creek-Indian Creek	9.60E+09	2.19E+11	95.6%
19	Big Sioux River	1.65E+10	2.45E+11	93.3%
21	Westfield Creek	1.76E+10	8.80E+10	79.9%

*Units for these loads are *E. coli* organisms/day.

A review of the South Dakota load duration curves for the Big Sioux River and the tributaries that have been monitored shows that the bacteria targets are exceeded at mid to high flow conditions. Four representative flow conditions have been selected for the derivation of South Dakota load allocations and needed pollutant reductions. These are the 0-10%, 10-40%, 40-70%, and 70-100%, see load duration curve range (Tables 3.74). See Appendix C for explanation on the load allocation calculations.

Table 3.74 BSRTMDL-4 South Dakota Allocations and Reductions for Various Flow Percentile Range

Iowa Assessment Segment	HUC_12	HU_12_NAME	Load Allocation (fecal coliform/day)				Existing Load (fecal coliform/day)				Percent Load Reduction			
			0-10%	10-40%	40-70%	70-100%	0-10%	10-40%	40-70%	70-100%	0-10%	10-40%	40-70%	70-100%
0010-3	101702032202	Union Creek	5.90E+11	1.64E+11	8.51E+10	4.31E+10	7.59E+13	1.37E+13	6.15E+11	2.56E+11	99.2%	98.8%	86.2%	83.1%
	101702032203	Big Sioux River Union Creek	2.51E+11	7.81E+10	3.80E+10	2.14E+10	2.15E+13	3.89E+12	1.74E+11	7.23E+10	98.8%	98.0%	78.1%	70.4%
	101702032201	Big Sioux River Indian Creek	2.38E+11	8.02E+10	4.63E+10	2.08E+10	9.82E+12	1.78E+12	7.95E+10	3.31E+10	97.6%	95.5%	41.7%	37.2%
	101702032205	Big Sioux River Rock Creek	2.98E+11	9.73E+10	4.48E+10	2.37E+10	6.79E+12	1.23E+12	5.49E+10	2.29E+10	95.6%	92.1%	18.5%	0.0%

3.9 BSRTMDL-5: The Big Sioux River from Brule Creek to the Missouri River

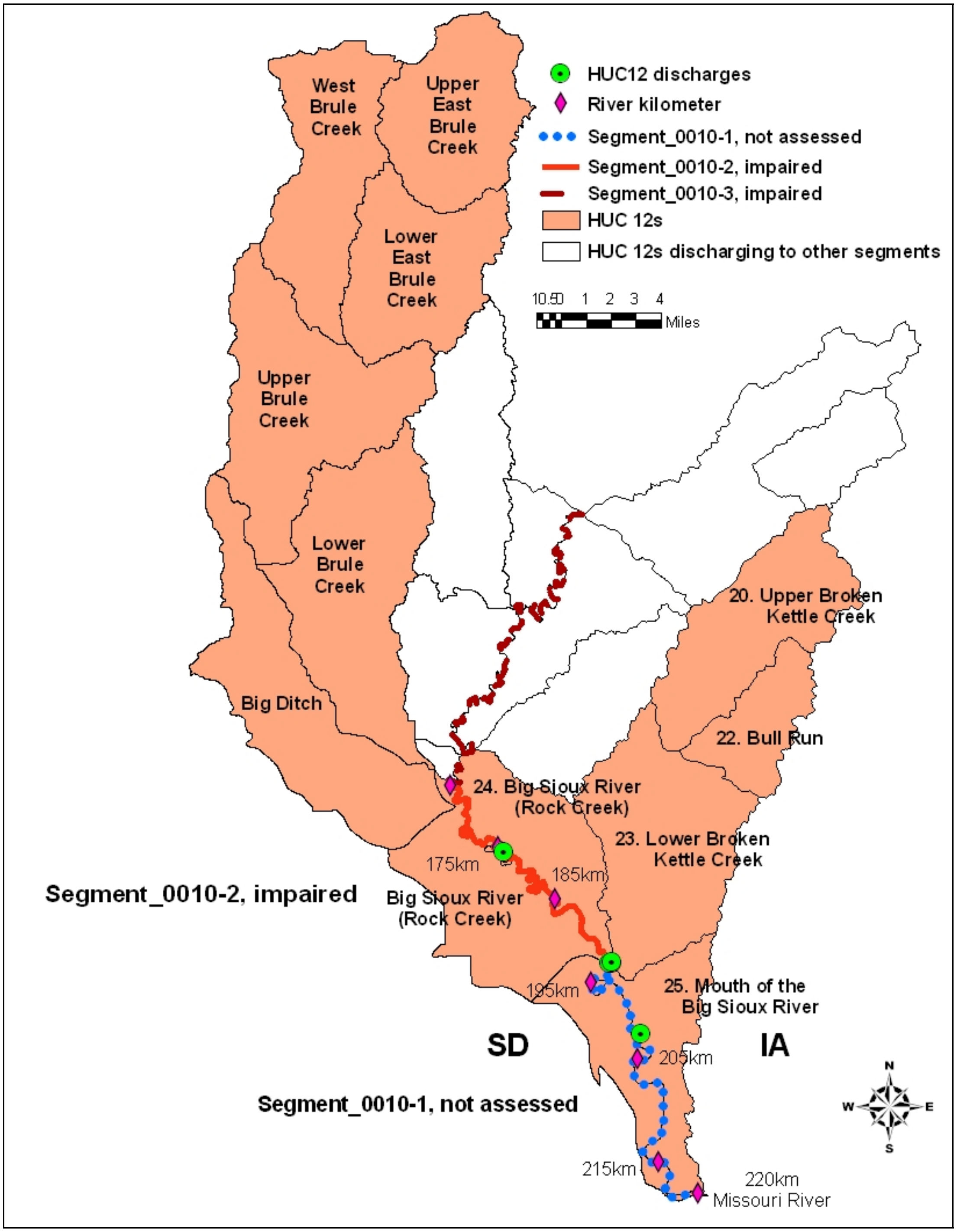


Figure 35. BSRTMDL-5, Brule Creek to the Missouri River Confluence

3.9.1 Pollution Source Assessment

The BSRTMDL-5 segment is 34.7 miles long and drains five and five HUC 12's in the Iowa and South Dakota portion of the Big Sioux River Iowa watershed as shown in Figure 31. For the Iowa portion, the drainage area is 90,640 acres (142 square miles) and there are no NPDES permitted wastewater treatment plants in the segment's sub-watershed. The draining area is 198,802 acres for the South Dakota portion of this segment's sub-watershed and there are two South Dakota wastewater treatment plants.

Existing Load

Existing load was estimated using the procedures described in Appendix C. In brief, the 60th percentile loading value estimated from the SD DENR water quality data at each flow percentile represents the existing load at the associated flow percentile. A summary of the existing loads reported as both fecal coliform bacteria and *E.coli* for this segment is shown in Table 3.75. Since the water quality data was reported as fecal coliform, the *E.coli* loads were estimated by multiplying the fecal coliform concentration by a conversion factor derived from the single maximum standards for these pathogen indicators (i.e. 235 E.coli/400 fecal coliform = 0.5875).

Table 3.75 BSRTMDL-1, Existing Load Calculated using data from LBSM21

Flow Percentile	Existing Load (cfu/day)	
	Fecal Coliform	*E. coli*
12.5	7.87E+14	4.62E+14
37.5	7.38E+12	4.33E+12
62.5	6.42E+12	3.77E+12
87.5	1.12E+12	6.58E+11

Departure from Load Capacity

The load capacity for this segment of the Big Sioux River is that which meets the water quality standard sample maximum concentration of 235 *E. coli* organisms/100 ml or 400 fecal coliform/100 ml converted to a daily load. The load capacity varies with the water volume and follows the load duration curve for each monitoring site. The departure from load capacity is the difference between the sample maximum concentration and the monitored concentration for a given stream volume or flow rate. Appendix C includes a description of the procedure in calculating the load capacity and the load reduction. Tables 3.76 shows the maximum allowable load and the percent reduction required to meet the water quality standards. Figure 36 shows the load duration curve for fecal coliform bacteria for LBSM21. The curve represents the TMDL at each percentile flow duration interval. This figure also includes the median, 60th percentile (used to calculate TMDL load reduction), and 90th percentile load at specific percentile flow duration interval. Figure 36 also distinguishes samples collected during the recreational season in which the WQS is applicable. In addition, samples that are collected on days where storm flow is greater than the 50th percentile is also identified.

Table 3.76 BSRTMDL-5, Departure from Load Capacity and Load Reductions Required

Flow Percentile	TMDL (cfu/day)		Load Reductions Required (%)
	Fecal Coliform	*E. coli*	
12.5	4.22E+13	2.48E+13	94.6
37.5	1.59E+13	9.36E+12	No reduction
62.5	8.53E+12	5.01E+12	No reduction
87.5	4.85E+12	2.85E+12	No reduction

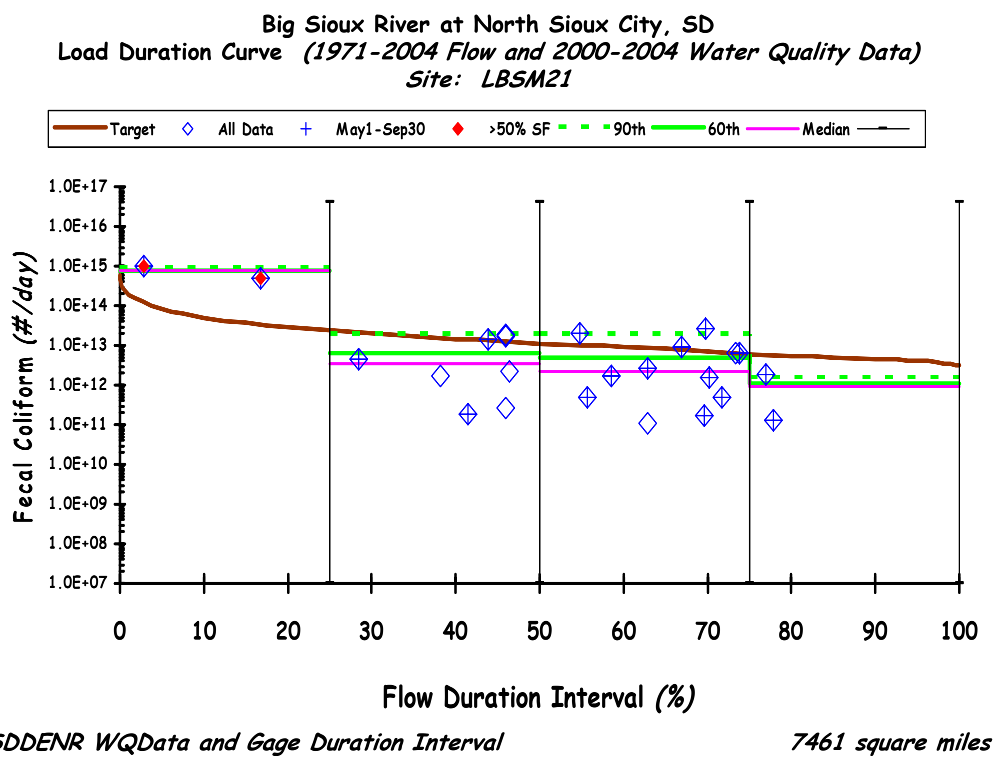


Figure 36. BSRTMDL-5 Load Duration Curve for LBSM21

Identification of Pollutant Sources

The pollutant sources for the BSRTMDL-5 segment are located in both Iowa and South Dakota. The Iowa and South Dakota loads are considered separately. The South Dakota pollutant sources have been identified and evaluated using different procedures than those used in Iowa. South Dakota pollutant sources were identified using various data sources such as 2002 census data and digital Orthophoto Quads in GIS. Detail procedure and model assumptions are described in Appendix C. Iowa pollutant sources were identified used county ag statistics, aerial photography, livestock registration databases, and GIS methods described in Appendix B, Procedures and Assumptions.

Iowa Pollutant Sources:
The pollutant sources on the Iowa part of this impaired segment consist of the upstream loads from BSRTMDL-4, and non-point sources from the five HUC 12's that drain directly to this river segment.

Iowa Point Sources: There are no permitted wastewater treatment plants or animal feeding operation facilities in the BSRTMDL-5 sub-watershed.

Iowa Non-point Sources: There are three categories of non-point source loads; manure from livestock and wildlife distributed over the different landuses, cattle in streams, and failing septic tank systems.

The livestock and wildlife manure non-point sources and the built-up land use for this segment have been evaluated for the months of April, June, and October. (The built-up land use consists of commercial, residential and transportation land uses.) These were selected as design conditions because more manure is applied to cropland and pasture in April and October than in other months. These loads require a precipitation event for delivery to the Big Sioux River. The design event has an assumed 1% recurrence (event that occurs every 100 days), i.e., there is enough precipitation to significantly increase runoff and bacteria transport. The bacteria delivery ratio is the *E. coli* organisms delivered divided by the number available for washoff. A delivery ratio of 0.35 has been estimated for flows with a 1% recurrence.

Cattle in streams is a non-point source category that accounts for livestock bacteria loads that are directly delivered to the stream without a significant precipitation event to provide transport. These loads are assumed to be continuous and unvarying through the month. The cattle in streams load is obtained by estimating the number of grazing cattle there are in the HUC 12's and the amount of time they spend in streams. In June the warmer weather is assumed to increase the number of grazing cattle in the stream and the associated loads. Based on county ag statistics, livestock registration databases, and local field assessments, the fraction of grazing beef cattle (versus confined) is 7% of the total in each HUC 12. The cattle in the stream percentage is based on what research is available is 12% in the cooler months and 24% in the warmer months, June, July, and August. This is shown in the Table 3.77 loading values.

Failed septic tanks are assumed to be continuous throughout the year and do not need an event for bacteria transport. Tables 3.77 to 3.79 show the delivered loads for the various non-point sources for the five HUC 12's on the Iowa side that discharge into the BSRTMDL-5 segment.

Table 3.77 BSRTMDL-5, Livestock, wildlife and built-up area event NPS loads

No.	HUC 12 name	Dist. to BSR, km	April load * at BSR**	June load* at BSR **	Oct. load * at BSR **
20	Upper Broken Kettle Cr.	19.71	4.74E+13	3.42E+13	3.06E+14
22	Bull Run	19.71	1.83E+13	1.33E+13	1.16E+14
23	Lower Broken Kettle Cr.	0	1.24E+13	6.40E+12	7.65E+13
24	Big Sioux River	0	2.40E+10	2.40E+10	2.81E+10
25	Big Sioux River	0	2.07E+13	1.57E+13	1.38E+14

*Units for these loads are *E. coli* organisms/day.
** The 1% event bacteria delivery ratio (load delivered divided by available for washoff) is 0.35.

Table 3.78 BSRTMDL-5, Cattle in streams NPS loads

No.	HUC name	# grazing beef cattle	Dist. to BSR, km	April load, 12% in streams *	June load, 24% in streams *	Oct. load, 12% in streams *
20	Upper Broken Kettle Cr	252	19.71	8.05E+11	1.61E+12	8.05E+11
22	Bull Run	114	19.71	3.62E+11	7.25E+11	3.62E+11
23	Lower Broken Kettle Cr	17	0	1.32E+11	2.64E+11	1.32E+11
24	Big Sioux River	0	0	0.00E+00	0.00E+00	0.00E+00
25	Big Sioux River	20	0	1.53E+11	3.07E+11	1.53E+11

*Units for these loads are *E. coli* organisms/day. The percentages are the fraction of time that grazing cattle spend in the stream.

Table 3.79 BSRTMDL-5, Failing Septic systems NPS loads

No.	HUC 12 name	Failed septics	Distance to BSR, km	Load at BSR *
20	Upper Broken Kettle Creek	192	19.71	3.50E+09
22	Bull Run	86	19.71	1.57E+09
23	Lower Broken Kettle Creek	239	0	1.07E+10
24	Big Sioux River	120	0	5.36E+09
25	Big Sioux River	103	0	4.58E+09

*Units for these loads are *E. coli* organisms/day.

<u>South Dakota Pollutant Sources</u>

The pollutant sources on the South Dakota part of this impaired segment consist of loads from two wastewater treatment plants, and non-point sources discharging from this segment's four HUC 12 sub-watersheds.

South Dakota Point Sources: There are two wastewater treatment plants in the BSRTMDL-5 watershed. Appendix C explains the evaluation spreadsheets and the assumptions associated with the waste load allocations. In brief, this TMDL assumes no exceedance in point source discharge from South Dakota, and therefore the maximum loadings from these dischargers are expected to be the same as the WLA.

South Dakota Non-point Sources: Land uses in the various HUC 12 drainage areas in South Dakota are generally similar (See Table 2.5). The majority of these areas are dominated by a combination of grassland, hay, pasture, corn, and soybeans land uses, follow by high intensity commercial and industrial land uses. There is relatively limited residential area within these drainage areas and therefore impacts from these land uses are expected to be minimal. Assumptions used to model the non-point load estimates are described in Appendix C. Table 3.80 show the estimated delivered loads for the various non-point sources for the four HUC 12's on the South Dakota side that discharge into the BSRTMDL-5 segment during June.

Table 3.80 BSRTMDL-5, South Dakota NPS Load during June

Iowa Assessment Segment	HUC_12	HU_12_NAME	Non-point Source Load (fecal coliform/day)							
			Cropland	Pastureland	Forest	Built up	Storm Sewers	Septics	Cattle in Streams	AFOs
0010-2	101702032401	Upper East Brule Creek	5.83E+13	7.49E+12	1.68E+02	6.09E+06	0.00E+00	2.64E+09	3.20E+12	0.00E+00
	101702032403	West Brule Creek	6.62E+13	8.69E+12	1.83E+02	6.08E+06	0.00E+00	3.04E+09	3.62E+12	1.03E+14
	101702032402	Lower East Brule Creek	5.56E+13	9.72E+12	3.27E+03	6.08E+06	3.60E+11	2.99E+09	3.32E+12	8.58E+13
	101702032404	Upper Brule Creek	8.14E+13	1.32E+13	3.37E+03	6.09E+06	0.00E+00	3.61E+09	4.71E+12	7.64E+14
	101702032405	Lower Brule Creek	7.86E+13	1.36E+13	1.50E+04	6.08E+06	0.00E+00	4.16E+09	4.64E+12	3.10E+14
	101702032206	Big Ditch	6.47E+13	8.35E+12	4.27E+03	6.09E+06	0.00E+00	2.79E+09	3.56E+12	1.30E+13
	101702032205	Big Sioux River- Rock Creek	4.31E+13	7.48E+12	4.38E+03	6.09E+06	2.31E+11	1.50E+09	2.65E+12	0.00E+00
0010-1	101702032207	Mouth of the Big Sioux River	1.74E+13	6.91E+12	1.60E+03	6.12E+06	1.11E+12	8.55E+07	1.39E+12	0.00E+00

3.9.2 Pollutant Allocations

Wasteload Allocation

There are no wastewater treatment plants or NPDES permitted animal feeding operations in the BSRTMDL-5 sub-watershed on the Iowa side of the River. Therefore, there are no wasteload allocations for the Iowa portion of this TMDL. WLA's for South Dakota are calculated using the permit effluent limit and the design flow. Detailed procedure for these calculations is described in Appendix C. These WLA's apply from May 1st to September 30th. The South Dakota WLA's for the BSRTMDL-5 point source discharges are summarized in Table 3.81. This table also includes information on the permit limit (i.e. the maximum wasteload allocation concentration) and design flow.

Table 3.81 BSRTMDL-5 South Dakota WWTP Wasteload Allocations

Facility Name	Permit Number	Design Flow (mgd)	Wasteload allocation concentration, maximum (colonies/100 ml)	WLA (colonies/day)
City of Alcester, SD	SD0021695	0.3	2000	2.27E+10
Coffee Cup Fuel Stop, SD	SD0027456	0.358	2000	2.71E+10

Load Allocations and Pollutant Load Reductions Needed

The load allocations for this TMDL are based on the discharges from the Iowa and South Dakota HUC 12's that discharge to the BSRTMDL-5 segment, the loads from the South Dakota hydrologic units, tributary streams, and the BSRTMDL-4 segment of the Big Sioux River itself where it flows into the BSRTMDL-5 segment. The load allocations are based on the assumption that all discharges into the Big Sioux River from all sources must meet the sample maximum water quality standard of 235 *E. coli* organisms/100 ml or 400 fecal coliform/100 ml converted to a daily load.

A review of the load duration curves for the Big Sioux and the tributaries that have been monitored shows that the bacteria targets are exceeded at most flow conditions, although by different sources with different delivery mechanisms. Four representative flow conditions have been selected for the derivation of load allocations and needed pollutant reductions. These are the 1%, 10%, 50%, and 70% load duration curve flow ranks (Tables 3.82 through 3.85). June load estimates for non-point sources that are event driven and for cattle in the stream sources have been selected as sufficiently representative. June is also the month when most monitored tributary events occurred. See Appendix B, Procedures and Assumptions for an explanation of load allocation development.

Table 3.82 BSRTMDL-5 Allocations and Reductions for 1% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction %
20	Upper Broken Kettle Creek	4.36E+11	3.58E+13	98.8%
22	Bull Run	1.96E+11	1.41E+13	98.6%
23	Lower Broken Kettle Creek	5.44E+11	6.68E+12	91.9%
24	Big Sioux River	2.73E+11	2.94E+10	none
25	Big Sioux River	2.33E+11	1.61E+13	98.5%

*Units for these loads are *E. coli* organisms/day.

Table 3.83 BSRTMDL-5 Allocations and Reductions for 10% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction %
20	Upper Broken Kettle Creek	8.83E+10	2.59E+12	96.6%
22	Bull Run	3.97E+10	1.11E+12	96.4%
23	Lower Broken Kettle Creek	1.10E+11	4.58E+11	75.9%
24	Big Sioux River	5.54E+10	6.05E+09	none
25	Big Sioux River	4.73E+10	7.61E+11	93.8%

*Units for these loads are *E. coli* organisms/day.

Table 3.84 BSRTMDL-5 Allocations and Reductions for 50% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction %
20	Upper Broken Kettle Creek	3.31E+10	1.71E+12	98.1%
22	Bull Run	1.49E+10	7.64E+11	98.1%
23	Lower Broken Kettle Creek	4.13E+10	2.93E+11	85.9%
24	Big Sioux River	2.08E+10	5.43E+09	none
25	Big Sioux River	1.77E+10	3.56E+11	95.0%

*Units for these loads are *E. coli* organisms/day.

Table 3.85 BSRTMDL-5 Allocations and Reductions for 70% rank flow

No.	HUC 12 name	Load Allocation *	Existing Load *	Reduction %
20	Upper Broken Kettle Creek	2.21E+10	1.62E+12	98.6%
22	Bull Run	9.93E+09	7.30E+11	98.6%
23	Lower Broken Kettle Creek	2.75E+10	2.77E+11	90.0%
24	Big Sioux River	1.38E+10	5.37E+09	none
25	Big Sioux River	1.18E+10	3.16E+11	96.3%

*Units for these loads are *E. coli* organisms/day.

A review of the South Dakota load duration curves for the Big Sioux River and the tributaries that have been monitored shows that the bacteria targets are exceeded at high flow conditions. Four representative flow conditions have been selected for the derivation of South Dakota load allocations and needed pollutant reductions. These are the 0-10%, 10-40%, 40-70%, and 70-100%, see load duration curve range (Tables 3.86). See Appendix C for explanation on the load allocation calculations.

Table 3.86 BSRTMDL-5 South Dakota Allocations and Reductions for Various Flow Percentile Range

Iowa Assessment Segment	HUC_12	HU_12_NAME	Load Allocation (fecal coliform/day)				Existing Load (fecal coliform/day)				Percent Load Reduction			
			0-10%	10-40%	40-70%	70-100%	0-10%	10-40%	40-70%	70-100%	0-10%	10-40%	40-70%	70-100%
0010-2	101702032401	Upper East Brule Creek	2.26E+11	7.94E+10	3.32E+10	1.55E+10	8.82E+12	1.60E+12	7.14E+10	2.97E+10	97.4%	95.0%	53.5%	47.7%
	101702032403	West Brule Creek	1.88E+11	4.56E+10	2.56E+10	1.45E+10	1.93E+11	3.04E+10	2.62E+10	2.82E+10	2.9%	0.0%	2.4%	48.7%
	101702032402	Lower East Brule Creek	2.97E+11	1.23E+11	4.54E+10	1.90E+10	2.15E+13	3.23E+11	1.32E+11	3.02E+11	98.6%	62.0%	65.7%	93.7%
	101702032404	Upper Brule Creek	3.47E+11	1.27E+11	5.37E+10	2.93E+10	1.20E+14	2.18E+13	9.75E+11	4.06E+11	99.7%	99.4%	94.5%	92.8%
	101702032405	Lower Brule Creek	3.31E+11	1.31E+11	5.65E+10	3.88E+10	4.33E+14	4.07E+12	3.90E+11	6.39E+10	99.9%	96.8%	85.5%	39.3%
	101702032206	Big Ditch	3.08E+11	1.13E+11	4.77E+10	2.60E+10	1.16E+13	2.10E+12	9.41E+10	3.92E+10	97.3%	94.6%	49.3%	33.6%
	101702032205	Big Sioux River Rock Creek	2.98E+11	9.73E+10	4.48E+10	2.37E+10	6.79E+12	1.23E+12	5.49E+10	2.29E+10	95.6%	92.1%	18.5%	0.0%
0010-1	101702032207	Mouth of the Big Sioux River	1.41E+11	4.60E+10	2.11E+10	1.12E+10	3.39E+12	6.14E+11	2.75E+10	1.14E+10	95.8%	92.5%	23.0%	2.2%

3.10 Margin of Safety for All Five TMDLs

The Margin of Safety (MOS) for all five of the Big Sioux River TMDLs in this document is the same. The MOS is intended to provide a buffer for uncertainty in the load evaluations. The MOS consists of conservative assumptions implicit in the representation and modeling of non-point sources. The following are assumptions that apply to all TMDLs:

- Upstream/downstream effect is not accounted for. This implicit MOS is especially protective of the downstream stations since it assumes load reduction from the upstream stations would not affect in-stream water quality of downstream stations.
- There is no die-off of bacteria originating in HUC 12's adjacent to the Big Sioux River or from the time of travel between the source within the sub-watershed and the HUC 12 discharge location.
- The water quality standard of a sample maximum of 235 E. coli org/100 ml or 400 fecal coliform/100 ml is used to evaluate all discharges to the Big Sioux River and that these criteria must be met without considering dilution.
- The maximum non-point source load as estimated by the Bacteria Indicator Tool spreadsheet is always available for washoff.
- Bacteria die-off in manure storage tanks and lagoons is not included in the load available for washoff calculations.
- TMDL load reduction in the mainstem segments are calculated using the 60th percentile of the measured load instead of the median load.

For point sources, i.e., wastewater treatment facilities, it is assumed that the facility will monitor discharges for compliance with the water quality standards and disinfect as needed. A margin of safety has not been applied to the wasteload allocations for the municipal wastewater treatment plants since they are required to meet the water quality standards at their discharge and to demonstrate this by monitoring, making the uncertainty of compliance very low.

3.11 Total Maximum Daily Load Calculation

The total maximum daily load for each of the five impaired Big Sioux River segments are the water quality standard sample maximum of 235 *E. coli* organisms/100 ml or 400 fecal coliform/100 ml. The total maximum daily load equation is:

TMDL (allowable load) = WLA (point source loads) + LA (non-point source loads) - MOS (implicit reduction in the allocations to provide for uncertainty)

As noted in the margin of safety section, there is little uncertainty in the wasteload allocation calculations for the wastewater treatment plants in the watershed. The margin of safety reduction is implicitly applied to the non-point source load allocations. The TMDL equation then becomes:

TMDL = WLA + LA

For example, using a Load Allocation criteria of 235 *E. coli* org./100 ml at a given design flow the allocation is:

Load allocation = (design flow, liters/second)*(235 *E. coli* org./100ml)*
(10 deciliters/liter, conversion)

This method of calculating the Load Allocations for all non-point source loads in the 48 Iowa HUC 12 sub-watersheds includes all event driven non-point source, cattle in the stream, and failed septic tank loads. Event driven loads are runoff from livestock, wildlife, and built-up areas.

4. Implementation Plan

An implementation plan is not a required component of a TMDL document but is a useful and logical extension of TMDL development. Implementation plans provide IDNR and SD DENR staff, partners, and watershed stakeholders with insight into water quality problems and can point towards a strategy for improvement.

This strategy should guide the stakeholders and the IDNR and SD DENR in the development of a priority based watershed plan that will implement best management practices with the goal of improving the water quality of the Big Sioux River and meeting the TMDL targets.

Iowa. The analysis and modeling of the Big Sioux River watershed shows that controlling livestock manure runoff and cattle in streams would need to be a large part of a plan to reduce bacteria. Best management practices include feedlot runoff control; fencing off livestock from streams; alternative livestock watering supply; and buffer strips along the river and tributary corridors to slow and divert runoff. In addition to these sources, failed septic tank systems need to be repaired. The regulation and enforcement of these requirements is delegated to the individual counties. In addition, wastewater treatment plants need to control the bacteria in their effluent.

As noted in Section 2, open feedlots for cattle with a capacity of 1000 head or more are registered with IDNR. As part of an agreement with EPA, called the Iowa Plan for Open Feed Lots, these operations will be required to have complete runoff controls (to the 25 year, 24 hour storm) or reduce their operations to under 1000 head in 2006. There are currently 38 registered open feedlots in the Iowa part of the Big Sioux and Rock River watersheds. As part of an implementation plan the department can see how many of these plan on implementing run-off controls and how many will be reducing below 1000 head. This is a high level of control and it should be possible, with adequate monitoring, to see improvements in water quality downstream of these feedlots. Since feedlots can have major impacts these changes may provide significant pollutant reductions.

It would be useful to create a local watershed advisory committee that could identify high priority areas within the Big Sioux River watershed where resources can be concentrated for the greatest effect. The areas with greatest impact on the river are adjacent to streams. In addition, priority best management practices should be identified for implementation. Since the impairment problem occurs at almost all flow conditions, solutions will need to be implemented for non-point sources with event driven transport, non-point sources that behave like continuous sources such as cattle in streams and failed septic tank systems, and continuous point sources such as wastewater treatment plants.

South Dakota. The South Dakota data analysis and modeling shows similar issues as those outlined for Iowa. With only a few small municipalities located in the project area on the SD side of the Big Sioux River, implementation needs to focus on controlling livestock manure runoff and cattle in streams in order to restore the recreational uses of the river. Best management practices will include animal waste management systems; fencing off livestock from streams; alternative livestock watering supply; and buffer strips along the river and tributary corridors to slow and divert runoff allowing filtration and bacterial decay to occur.

The SDDENR, in partnership with the South Dakota Association of Conservation Districts, completed an inventory of all (large CAFO, medium animal feeding operation, and small open feedlot) active and inactive animal feeding operations within the Lower Big Sioux watershed.

A CAFO as defined in South Dakota is a lot or facility that stables or confines and feeds or maintains animals for a total of 45 days or more in any 12-month period and meets the associated criteria for large, medium, or small concentrated animal feeding operations. Existing large South Dakota CAFOs that include operations that feed at least 1,000 beef cattle, 700 dairy cows, or 2,500 head of hogs weighing 55 pounds or more had until September 30, 2005, to be permitted under the state's general water pollution control permit. Existing South Dakota CAFOs that signed a Notice of Intent and did not meet the 2005 deadline have compliance schedules to complete the permitting process.

The Agricultural Nonpoint Source (AGNPS) feedlot-rating model was used to assess all the smaller and medium sized AFOs identified in the inventory. Those livestock facilities with a rating of 50 or above will be targeted for implementation. This feedlot analysis, in conjunction with tributary monitoring data and landuse analysis will be used to target individual 12-digit HUCs for implementation as well.

Typically, the SDDENR works with the local county conservation districts in setting up implementation projects. Because of the large project area for the Lower Big Sioux River however, a multi-county agency or non-governmental organization may serve as the local sponsor. The local conservation districts will need to be intimately involved to ensure local buy-in during the implementation phase.

Currently wastewater treatment facilities that discharge to the Big Sioux River have fecal coliform limits in effect from May 1 through September 30 as required by the South Dakota Water Quality Standards. Iowa's fecal coliform and E. coli water quality standards are in effect from March 15 through November 15. The fecal coliform limits for the dischargers that discharge directly to the Big Sioux River in these segments, will be extended within the Surface Water Discharge Permit reissuance to ensure Iowa's water quality standards will be protected.

5. Monitoring

Monitoring of the Big Sioux River mainstem will continue to be done by SDDENR at their four historical ambient sites. This program operates four monitoring sites on the Iowa reach of the Big Sioux River, at Canton, Hudson, Alcester and Richland, South Dakota. Data collected at these four sites is used by the IDNR for its biannual water quality assessments (305b report) of the Big Sioux River. IDNR will continue monthly Rock River ambient monitoring at the site near Hawarden.

Due to resource limitations, there are not any plans to continue targeted TMDL monitoring of the mainstem BSR, Rock River, or other tributaries. The existing ambient monitoring being done by South Dakota and Iowa provides only minimal information for water quality assessment and evaluation of the effectiveness of watershed best management practices. To really understand the Big Sioux River pollutant problems and effectively manage their impact through improvements to controls, additional targeted monitoring is needed.

Phasing TMDLs is an iterative approach to managing water quality that is used when the origin, nature and sources of water quality impairments are not completely understood. In Phase 1, the waterbody load capacity, existing pollutant load in excess of this capacity, and the source load allocations are estimated based on the resources and information available.

These five TMDLs represent Phase 1 in the development of a project to improve Big Sioux River water quality. The value of these evaluations and the effectiveness of their follow-ups are dependent on local activities to improve conditions in the watershed. Without the efforts of watershed citizens, implementation of practices that will remedy the Big Sioux River impairment may not occur. What is needed in a second phase are stakeholder driven solutions and more effective management practices. Continuing targeted monitoring will determine what management practices result in load reductions and the attainment of water quality standards. Summarizing, renewed targeted monitoring will:

- Assess the future beneficial use status;
- Determine if water quality is improving, getting worse, or staying the same;
- Evaluate the effectiveness of implemented best management practices.

The first phase of the Big Sioux River watershed improvement plan is contained in these five TMDLs that set specific and quantified targets for pathogen indicator concentrations in the river and allocate allowable loads to all sources. An effective Phase 2 will require the participation of the watershed stakeholders in the implementation of pollutant controls and continued water quality evaluation. This will require continued targeted monitoring, thorough appraisal of the collected data, the readjustment of allocations, and the modification of management practices as shown to be necessary.

6. Public Participation

Iowa. The department has put together and implemented a plan to inform the public and stakeholders and get input and response for Big Sioux watershed TMDL project reports and activities. The plan has included three public meetings held in June 2005 at three locations in the Big Sioux River watershed. Two other meetings that included discussion of the Big Sioux TMDL took place at meetings of the Plymouth and Lyon County Soil and Water Conservation Districts (SWCD).

The dates and locations of the public meetings were:

June 17, 2005 West Lyon Comm. School, City of Inwood, Lyon County. (8 attendees)
June 21, 2005 City of Hawarden, Plymouth County (8 attendees)
June 21, 2005 City of Sioux Center, Sioux County (13 attendees)

The public and stakeholders attending these meetings included farmers, livestock producers, county conservation staff, municipal staff, engineering consultants, bankers, Natural Resource and Conservation Service (NRCS) staff, reporters, county public health staff, and university students. Comments received at these public meetings were noted, summarized, and have been and continue to be reviewed and considered.

The dates and locations of the other two stakeholder meetings were:

June 23, 2005 Plymouth County SWCD Focus Meeting, Le Mars (9 participants)
June 28, 2005 Lyon County SWCD Focus Meeting, Rock Rapids (11 participants)

The Plymouth County meeting included SWCD commissioners, representatives of the Pork Producers, the Plymouth County Cattlemen's Association, rural water associations, and NRCS. The Lyon County meeting included SWCD commissioners, representatives of the Cattlemen's Association, rural water associations, landowners and livestock operators. The water quality problems in the watershed were discussed at length in these meetings and comments made have been considered during the development of this document.

A second series of public and stakeholder meetings were held in the watershed with the release of the draft TMDL. The purpose of these meetings was to provide information related to the draft TMDL and to obtain public and stakeholder input and comment on TMDL development and conclusions. Comments received were reviewed and given consideration and, where appropriate, incorporated into the TMDL.

The dates and locations of the second series of stakeholder meetings were:

March 9, 2006 Rock Rapids Community Center (34 attendees)
March 9, 2006 Hawarden Community Center (27 attendees)

South Dakota. Presentations regarding the progress of the TMDL Assessment Project were made during monthly meetings of the Lincoln County Conservation District (Canton, SD) and the Union County Conservation District (Elk Point, SD).

A series of public and stakeholder meetings will be held in the watershed with the release of this draft TMDL. The purpose of these meetings is to provide information related to the draft TMDL and to obtain public and stakeholder input and comment on TMDL development and conclusions. Comments received will be reviewed and given consideration and, where appropriate, incorporated into the TMDL.

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Appendix A – List of Available E-files for Iowa

The first part of this list of electronic spreadsheets, maps, and GIS coverages consists of fourteen spreadsheets that include most of the key data and analysis used in the development of this TMDL report. These spreadsheets and the procedures and assumptions in them are documented and described in detail in Appendix B, Procedures and Assumptions. They are accessible using widely available spreadsheet software and can usually be distributed by email.

The second part of the list includes spreadsheets that are not as well documented and explained and which are more peripheral to TMDL analysis and development; maps of the watershed and streams including monitoring sites; information such as duration curves and monitoring data in less accessible formats such as the hydrograph software used in the project autosamplers; and ArcView GIS coverages (Other Development E-files section).

Key Data and Analysis Spreadsheets

1. BSR direct BIT.xls – This spreadsheet distributes non-point source bacteria loads by the 25 BSR directly draining HUC 12's and by the month of the year.

2. Rock BIT.xls - This spreadsheet distributes non-point source bacteria loads by the 23 Rock River HUC 12's and by the month of the year.

3. BSR direct delivery.xls – Non-point source load delivery estimates for the BSR directly draining HUC 12's. Includes bacteria die off calculations.

4. Rock delivery.xls - Non-point source load delivery estimates for the Rock River HUC 12's. Includes bacteria die off calculations.

5. Mud Creek Time of Travel.xls – Estimated time of travel for design flows from the Iowa/Minnesota border to the BSR.

6. Rock River Time of Travel.xls - Estimated time of travel for design flows from the Iowa/Minnesota border to the BSR.

7. Little Rock River Time of Travel.xls - Estimated time of travel for design flows from the Iowa/Minnesota border to the BSR.

8. Rock River data.xls – Rock River monitoring data and tributary design flow estimates.

9. BSR direct wwtp.xls – This spreadsheet includes the calculations for the development of the WLA's for the wastewater treatment facilities in the BSR directly draining watershed.

10. Rock wwtp.xls - This spreadsheet includes the calculations for the development of the WLA's for the wastewater treatment facilities in the Rock River watershed.

11. MN allocations.xls – Calculations of the load allocations for the Minnesota part of the Rock River watershed.

12. Stream data analysis.xls – This spreadsheet includes the data and analysis of the four streams monitored streams used to develop delivery ratios and design flow conditions for bacteria loads.

13. BSR direct allocations and reductions.xls – Calculation of the BSR directly draining HUC 12 allocations, existing loads, and reductions needed.

14. Rock allocations and reductions.xls - Calculation of the Rock River HUC 12 allocations, existing loads, and reductions needed.

Other Development E-files

- BSMaps *folder*- Contains maps of the entire BSR watershed, the Iowa targeted TMDL monitoring sites, and the SD DENR mainstem and tributary monitoring sites.

- Hydrographs *folder* – Contains hydrographs from the 7 autosamplers for 2002 and 2003 as well as concentration data and charts of measured concentration vs. flow.

- Loading Rates *folder* – Contains event data and flow estimates, both daily and hourly for each auto-sampler site.

- Source inventory *folder* – Estimates of source locations and load quantification.
    - BSR direct livestock distribution by huc 12.xls – This is where the distribution of livestock by type and HUC 12 is made.
    - County deer population est2004.xls – Deer population estimates by county.
    - lyonpop.xls – Census blocks for Lyon County. Used to estimate septic tank numbers.

- plymouthpop.xls – Census blocks for Plymouth County. Used to estimate septic tank numbers.
- siouxpop.xls – Census blocks for Sioux County. Used to estimate septic tank numbers.

- RV gage characteristics.xls – USGS gage data used to calibrate and check estimates.

ArcView GIS *folder* – This folder contains ArcView project and theme files showing the digitized streams, elevation changes, HUC 12's, HUC 12 discharge locations, wastewater treatment plants, impaired river segments, and tables of distances. ArcView 3.2 is required to view these folders.

Big Sioux River Model Project – There are three Views in this Arcview project and several layout maps. The three views are BSR model, Rock model, and NPS loads. The BSR model includes the Big Sioux River layout and themes and the direct discharge HUC 12's, SD DENR mainstem monitoring sites, stream elevations, model kilometer markers, land uses, clipped census blocks by county for septic tank evaluation, wastewater treatment plant locations, and river and tributary lengths. The Rock River model includes all of the same types of coverages that the BSR model has only for the Rock River. The Rock River model also includes distances, elevations and slope, model kilometer markers, and locations of HUC 12 discharges for the two main tributaries from Minnesota, Mud Creek and the Little Rock River. The NPS load view includes both the Rock River and BSR direct discharging HUC 12's and the locations of registered animal feeding operations.

TMDL 1 Project – Contains spatial information and tables showing the impaired TMDL 1 segment, associated HUC 12's, HUC 12 discharge locations, and model kilometer measurements.

TMDL 2 Project – Contains spatial information and tables showing the impaired TMDL 2 segment, associated HUC 12's, HUC 12 discharge locations, and model kilometer measurements.

TMDL 3 Project – Contains spatial information and tables showing the impaired TMDL 3 segment, associated HUC 12's, HUC 12 discharge locations, and model kilometer measurements.

TMDL 4 Project – Contains spatial information and tables showing the impaired TMDL 4 segment, associated HUC 12's, HUC 12 discharge locations, and model kilometer measurements.

TMDL 5 Project- Contains spatial information and tables showing the impaired TMDL 5 segment, associated HUC 12's, HUC 12 discharge locations, and model kilometer measurements.

Appendix B, Procedures and Assumptions for Iowa TMDL Calculations

This appendix consists of a sequential guide to the spreadsheets and procedures used in the development of the Big Sioux River bacteria TMDLs. It begins with an evaluation of the bacteria sources and ends with load allocations and reductions needed.

E. coli and Fecal Coliform Pathogen Indicator Bacteria

The 2002 305(b) water quality assessment, the basis for the impaired listing of the Big Sioux River segments, used fecal coliform as pathogen indicator bacteria since this was the water quality standard at the time. Then, effective July 17, 2003, another pathogen indicator bacteria, E. coli, replaced fecal coliform in the Iowa water quality standards. *E. coli* are a subset of fecal coliform bacteria and research has indicated that *E. coli* are a better indicator of fecal contamination by warm-blooded animals.

This TMDL report has been developed during the period of transition from one standard to the other. Since there is currently no EPA approved analytical method for measuring *E. coli*, an equivalent *E. coli* to fecal coliform conversion has been used that is based on comparable risk of illness for primary recreational contact rather than an organism-to-organism ratio. The equivalent fecal coliform values are calculated based on an *E. coli* to fecal coliform comparable risk ratio of 1 to 1.6.

Table B.1 *E. coli* to fecal coliform risk ratio

E. coli **(organisms/100ml)**	**Fecal Coliform (organisms/100ml)**
126	202
235	376
630	1008
2880	4608

The effects that this transition has had on the development and writing of this document are:

- References for fecal coliform loads from various sources are more available and tested than those for *E. coli.*
- Die-off calculations have been performed using fecal coliform since many of the equations were developed for them.
- The maximum E. coli value that is available in the SDENR data is 2,420-organisms/100 ml, in bacterial terms a fairly small number. During events the fecal coliform counts go into the millions. This means that a relationship between flow and E. coli cannot be established and the more reliable fecal coliform measure needs to be used for this purpose.

- For consistency, to avoid confusion, and because the new water quality standards use E. coli, nearly all pathogen indicator values in the TMDL document itself are expressed as E. coli organisms/100 ml although this has required the frequent translation of fecal coliform to E. coli.
- Most of the spreadsheets used in the development of the TMDLs use fecal coliform that is translated to E. coli as a last step before being incorporated into the main document.

The Modified EPA Bacteria Indicator Tool (BIT); Inventorying and Estimating Non-point Source Bacteria Loads

There are two spreadsheets used to develop the non-point source loads to the Big Sioux River, *BSRdirectBIT.xls* and *RockBIT.xls* that are based on the EPA Bacteria Indicator Tool. This tool was designed to provide input to the Hydrological Simulation Program FORTRAN (HSPF) for non-point source bacteria loads. For this report, it has been modified by the IDNR in two separate spreadsheets to estimate fecal coliform loads available for washoff from each of the 23 twelve digit HUCs in the Iowa Rock River watershed and the 25 twelve digit HUCs in Iowa that directly drain to the Big Sioux River (BSR). The loads are input to a straightforward hydrologic model based on the Manning equation and HSPF is not used.

The animal numbers have been spatially distributed to the 23 Rock River and 25 BSR direct HUC 12's using GIS methods developed by IDNR. This method incorporates CAFO and AFO registration and permitting data bases, surveys of buildings and feedlots using aerial infrared photography done in 2002, and livestock statistics and numbers from county by county counts.

The landuse information comes from 2002 IDNR coverages that have been consolidated into the four landuses found in this spreadsheet. A number of modifications have been made to the original EPA worksheets and some additional worksheets have been added to accommodate the needs of the project. The assumptions about the distribution and timing of manure application have been made based on advice from Iowa Department of Agriculture and Land Stewardship (IDALS) staff, IDNR field and central office staff, and locally based field assessments. These assumptions will be reviewed and adjustments made as better information becomes available for follow-up phases of this project. Notes on assumptions and references can also be found in the individual worksheets.

There are three worksheets in each of the BIT spreadsheets that provide loading input for evaluation of non-point source loads. These worksheets are named 'cattle in stream', 'septics', and 'total loads'.

The first two, 'cattle in streams' and 'septics', are used to estimate loads from sources that are assumed to be constant through the times that they are significant. For cattle in streams, this includes the grazing season, from April to November, and adjusts by the month, i.e., cattle spend more time in the stream during the warmer months. For failed septic tank systems, the loads are assumed to be continual and steady. In both the ‘cattle in streams’ and ‘septics’ worksheets the bacteria load die-off has been estimated from the time of travel and die-off rate for each of the 23 Rock River HUC 12s and 25 Big Sioux River direct HUC 12’s.

The third worksheet (‘total loads’) sums up the maximum fecal coliform load available for “wash-off” during a precipitation event for each month of the year. This represents the potential for non-point source loads. There are four land use categories in the BIT spreadsheets that are consolidations of the 16-landuse types in the IDNR GIS coverages. The land use categories are:

- Cropland – includes the alfalfa, corn, soybean, and “other rowcrop” land use types.
- Grazed pastureland – includes only grazed grassland landuse. It is assumed that all grazing cattle manure except that from cattle in streams is deposited on this type.
- Forest and ungrazed pastureland – Includes three types of forest; bottomland, coniferous, and deciduous; and two types of pasture, ungrazed grasslands and CRP grasslands. It is assumed that the only fecal coliform loads to this category are from wildlife.
- Built-up areas – Includes roads, commercial/industrial, and residential categories. These three types are used in the Built-up worksheet to estimate loads.

In the worksheets for the four land use categories the total bacteria accumulation from wildlife and the different livestock types is estimated month by month. The maximum number of fecal coliform organisms that is available for washoff is 1.5 times the maximum daily accumulation in the warm months (April to September) and 1.8 in the colder months (October to March). The total loads by landuse and HUC 12 are calculated in the worksheet ‘HUC 12 monthly total loads’. The maximum loads from the four landuses are summed in the ‘total loads’ worksheet by HUC 12 and then by month of the year.

All of the HUC 12 total fecal coliform daily loads from the BIT spreadsheets for the months of April, June, and October are input into the spreadsheets *Rock delivery.xls* and *BSR direct delivery.xls*. In these spreadsheets the delivered load, accounting for time of travel die-off and the delivery ratio, is calculated. The resulting delivered loads from each HUC 12 for April, June, and October are found in the report tables for each TMDL labeled *Livestock, wildlife and built-up area event NPS loads*. April and October are months when manure application is usually at its maximum and June is a month when there are high manure application rates, maximum numbers of cattle in the stream, and the month when most precipitation events were monitored. Only the highest delivery ratio, 35%, is used for the months of April and October in these worksheets. For the month of June, all four of the delivery ratios, 35%, 1%, 0.1%, and 0.01%, were used because June is the design period for load allocations and reductions.

Time of travel, bacteria die-off, delivery ratios, and load allocations and reductions are described in the following sections.

Estimating Time of Travel

The time of travel from the bacteria sources to the Big Sioux River is an important value in the calculation of bacteria die-off. It is used to estimate bacteria die-off that occurs from each of the wastewater treatment plants, HUC 12 discharge locations, and loads from the three Minnesota streams contributing to the Rock River watershed.

The length of the streams tributary to the Big Sioux River has been measured and digitized using IDNR one meter resolution infrared aerial photography and USGS 7.5 minute topographic map GIS coverages. A system of kilometer markers has been laid over the digitized streams, as have the 10-foot contour elevations from the USGS 7.5 minute maps. The length of the segments between contours and the change in elevation has been used to calculate the average slope between contour lines. Figure B.1 shows an example of the way the Rock River watershed streams have been laid out where Mud Creek and the Little Rock River flow into the mainstem Rock River.

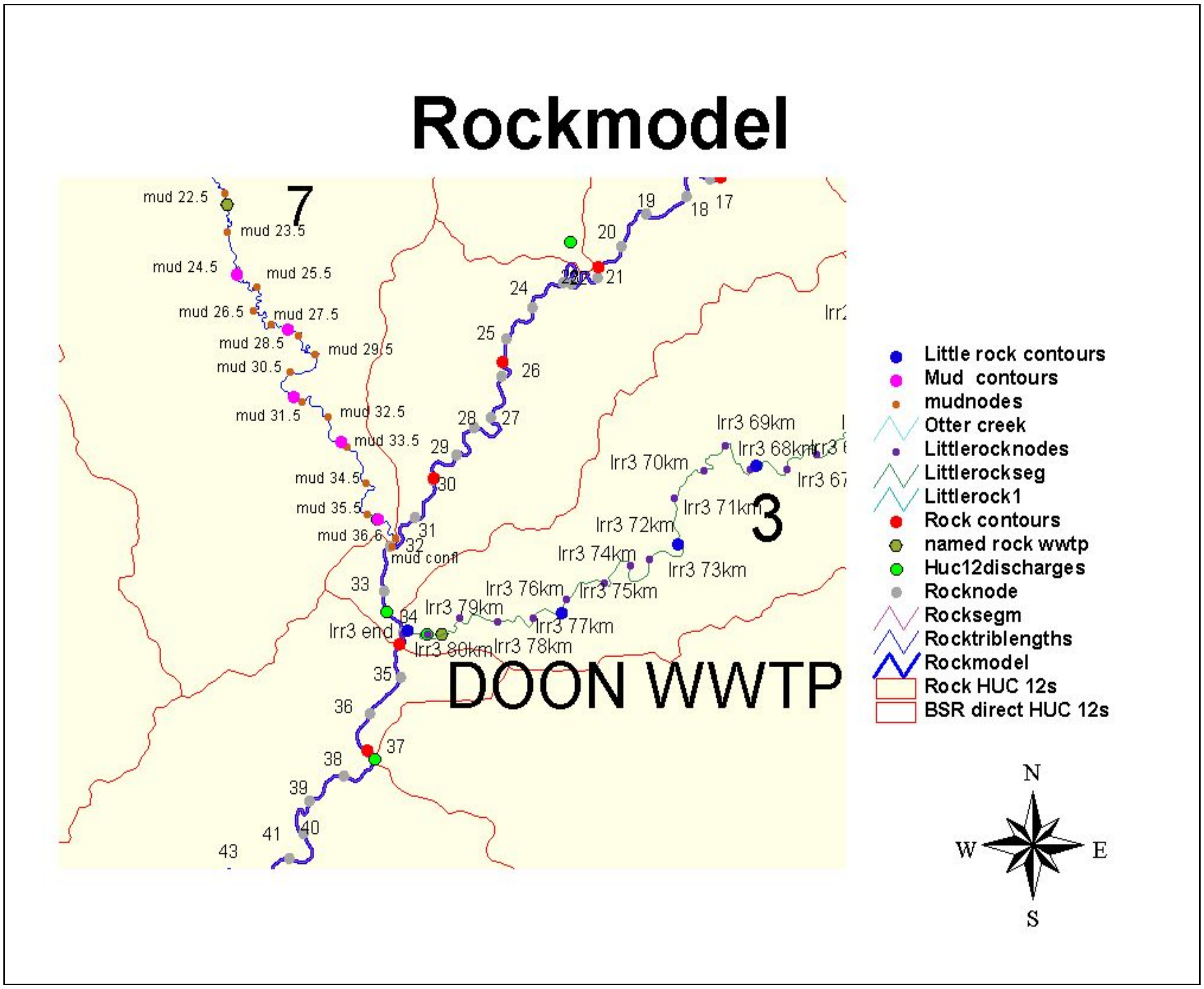


Figure B.1 Layout example

For each segment between contours the Manning equation is applied to estimate the time of travel as shown here.

Solve for:
d = mean depth = hydraulic radius, meters
A= x-section area, m^2
v = stream velocity, meters/second
ToT = time of travel, seconds or hours or days

$$Q = \left(\sqrt{S/n}\right)(w)\left(d^{5/3}\right)$$
$$d = \left[Q\left(n/\sqrt{S}\right)(1/w)\right]^{(3/5)}$$
$$A = w * d$$
$$v = Q/A$$
$$ToT = v/L$$

<u>Known</u>
Q = flow, m^3/s
S = slope, meter/meter
n, roughness, unitless
W = channel width, meter
L = segment length, km

The bank-to-bank width for each slope segment has been estimated by taking several measurements from the aerial photography coverage taking care to avoid sand bars, cut banks, and tree covered areas. These measurements are then averaged for each segment (see the 'width' worksheets in the Mud creek, Rock River, and Little Rock River time of travel spreadsheets). The channel roughness is obtained from standard tables and adjusted upwards as the calculations move upstream, i.e., the smaller a stream gets the higher the roughness factor. The range used is from 0.035 to 0.045 depending on the stream size.

The stream flow for Mud Creek, Rock River, and the Little Rock River have been estimated for three design conditions based on data collected during and after precipitation events and at regular monthly intervals in 2002 and 2003. The monitoring sites for Mud Creek and the Little Rock River were where the streams crossed from Minnesota into Iowa and where they flowed into the Rock River. Auto-samplers with continuous flow estimating were used at the confluences of Mud Creek and the Little Rock River with the Rock River. The Rock River was monitored where it crossed into Iowa, at the Rock Rapids USGS gage, and at the Rock Valley USGS gage.

Event flows and concentrations were used to estimate the high flow conditions. These events were infrequent but the measured flows were significantly higher than the typical monthly measurements. The high flows at the border for each stream were matched against the high flows at the confluence with the Rock, or, in the case of the Rock River itself, the flows at the border were matched against the Rock Rapids and Rock Valley USGS gages. The flow estimates for the three design conditions can found in the *Rock River Data.xls* spreadsheet. The monitoring site numbers in the spreadsheet match those on the Figure 3 site map.

The difference between the upstream flow at the border of each stream and the larger flow at the downstream sampling site is added equally to each kilometer of stream length between the two sites. The flow added to each slope segment is added based on its length. A segment 2.5 km long and with an incremental flow increase of 2 cfs per km would have a flow equal to the segment upstream of it plus 5 cfs (2 cfs/km*2.5 km). This segment flow then becomes the upstream flow to the next slope segment and the incremental flow is then added to it and so on down stream.

For the Little Rock River, a large tributary, Otter Creek, was not monitored. The flow for this stream was estimated by land area proportional to the land area of the watershed that was monitored. This flow was introduced into the Little Rock River slope segment at its confluence with Otter Creek. The flow calculations for the individual stream slope segments are in the 'high flow', 'low flow' and 'very low flow' worksheets in the Time of Travel spreadsheets for each of the streams. These worksheets also contain specific references to the data used from the *Rock River Data.xls* spreadsheet.

There is another worksheet in *Rock River Data.xls* called ‘hydrocheck’ that has been used to do a water balance between the flows measured in Mud Creek, mainstem Rock River, and the Little Rock River and the flows measured at the Rock Valley USGS gage. The total of the three upstream flows should equal the flow at the Rock Valley gage for the same time period. Twelve sets of data for the three-stream total and the Rock Valley gage were regressed and the r-squared was 0.992, a very good correlation. Some of the data was not included in the regression because there was missing flow data for one of the three streams or field notes indicated that there had been a problem with the ISCO samplers on the day of interest.

Making the assumption that the hydraulic radius is the same as the average depth for channels that are much wider than they are deep, enough information is available to solve the Manning equation for mean depth (d). From this the cross-sectional area (A), velocity (v), and time of travel (ToT) can be estimated for each individual slope segment. Adding the individual slope segments’ time of travel together gives the total time of travel for the entire stream reach.

Direct time of travel estimates as described above were made for the entire length of the Iowa reaches of the Rock River, the Little Rock River, and Mud Creek at each of the three flow conditions; high, low, and very low all the way to the confluence with the Big Sioux River. The Rock River watershed wasteload allocations for wastewater treatment plants and the load allocations for Minnesota used these times of travel to estimate die-off from the discharge location to the Big Sioux River.

For the Rock River HUC 12 discharges, including non-point source event run-off and for the continuous non-point sources - cattle in stream and failed septic tank systems - time of travel estimates were made using velocity averages for the lengths of Mud Creek (high = 0.495 m/s, low = 0.245 m/s, very low = 0.127 m/s) and the Rock River (high = 0.747 m/s, low = 0.438 m/s, very low = 0.315 m/s) at the three flow conditions.

For the wastewater treatment plants and the non-point sources in the HUC 12s that discharge directly to the Big Sioux River, the Mud Creek time of travel and velocity averages were used since Mud Creek was most like the streams draining these sub-watersheds.

Estimating Bacteria Die-off

Fecal coliform bacteria die-off between the source and the Big Sioux River was estimated using the time of travel as calculated above and a decay coefficient in the standard exponential equation used for this purpose. The equation is:

$$C_x = C_o / e^{kt}$$

Where: **Co** = Initial bacteria count, as a concentration of organisms per 100 milliliters or liters or as a daily load, organisms per day immediately below the discharge.

C_x = Concentration or daily load at a point distance "x" downstream of the discharge.

k = first order decay coefficient, 1/day

t = time of travel, days

This form of the equation is used to estimate the fecal coliform loads delivered to the Big Sioux River. To estimate the allocations to a source that is some distance from the impaired river segment the following equation form is used:

$$C_o = C_x e^{k*t}$$

Where: **C_o** is the allocation at the discharge location taking into account the decay that will take place before the load gets to the impaired stream.

The first order decay coefficient used throughout the die-off calculations used for the Big Sioux TMDLs is 0.96 per day. This is the median coliform disappearance rate from 30 in-situ studies described in the EPA document *Rates, Constants, and Kinetics Formulations in Surface Water Quality Modeling* (2^{nd} edition) EPA/600/3-85/040.

Time of travel and bacteria decay is incorporated in the two loading spreadsheets, *Rock BIT.xls* and *BSR direct BIT.xls*, in the cattle in streams and septic tank worksheets; in the two delivery spreadsheets associated with the loading spreadsheets, *Rock delivery.xls* and *BSR direct delivery.xls*; the wastewater treatment plant wasteload allocations spreadsheets, *Rock wwtp.xls* and *BSR direct wwtp.xls*; and the Minnesota loads and allocations spreadsheet called *MN allocations.xls*.

Bacteria die-off can be a big factor for sources that are a good distance from the Big Sioux River, especially in low flow conditions when velocity decreases and time of travel increases. The load allocations for the three streams that cross from Minnesota show this in that there are load allocations at high flow but none at low or very low flows.

Estimating Delivery Ratios and Design Flow Conditions

Delivery ratios as used in these load and allocation calculations are the ratio of the load measured in the stream by monitoring and the load at the sources as estimated with the modified EPA Bacteria Indicator Tool spreadsheets. Four streams draining nine HUC 12's were monitored for two years by auto-samplers located near their confluences with the Big Sioux River. The data collected included event samples, monthly samples, and continuous flow. These streams were Sixmile Creek, draining three HUC 12's, Indian Creek draining two HUC 12's, Westfield Creek draining one HUC 12, and Broken Kettle Creek draining three HUC 12's.

The delivery ratios are affected by assumptions made in the loading worksheets for the nine HUC 12's in the watersheds of these streams as well as the relatively short time (two years) that targeted monitoring was done. The delivery ratios are used only to estimate the fraction of the non-point source loads that need a precipitation event to have an impact. The ratio is the percentage of the maximum load that is estimated to be available based on livestock and wildlife manure in croplands, pasture, and forest and runoff from built-up areas. It is assumed that some fraction (the delivery ratio) of the entire load from each HUC 12 is delivered to the HUC 12 discharge location.

There are two spreadsheets that include calculations for approximating a delivery ratio and estimating the design flow conditions. These are the *stream data analysis.xls* and the *BSR direct allocations and reductions.xls* spreadsheets. The *stream data analysis.xls* spreadsheet contains three worksheets for each of the four monitored streams:

- '(stream name) data' - These worksheets consist of the monitored flow and concentration data from the autosamplers sited near to where the streams flow into the Big Sioux River. The samplers were installed in 2002 and 2003 to collect continuous flow data and concentration data during precipitation events when the stream flows increased significantly. The data has required analysis and review to match the event concentration data with the correct flow. It was found that daily average flow did not represent the flow for a given event sample's concentration. By going back to the hydrograph and matching the time sample bottles used in the composite event sampling were taken to the hourly flow, it was found that the correlation between flow and concentration was greatly improved. This was especially true for event data.

The r-squared for a regression of the Sixmile Creek 2002 event data when hourly values are used is 0.833. There are three flow values for the event data that were evaluated,

1. The instantaneous flow and grab sample concentration taken when the samples were collected. This may or may not represent event related conditions depending on how elevated the stream flow is at the time.

2. The average daily flow of the stream calculated from the auto-sampler hydrograph. This flow value often does not accurately portray the real flow conditions when an event sample is taken by the auto-sampler, particularly for the four rather flashy small streams monitored.

3. The hourly flow from the auto-sampler hydrograph that could be matched to the time that specific sampler bottles were filled. As noted above, using this flow much improved the correlation between flow and concentration.

The evaluated data from these worksheets is used in the flow worksheets to provide data for flow and load duration curves and for the regression equations relating flow and concentration.

- '(stream name) flow' – The flow worksheets include all of the 2002 and 2003 average daily flow data for each of the four monitored streams as well as the evaluated flow and concentration data from the data worksheet. The flow data approximates the recreational use season when the auto-samplers were installed, April through November.

  The daily flow data is used to generate the flow and load duration curves found in these worksheets. The flow and concentration data from the data worksheet is plotted against the TMDL target load on the load duration curve. Multiplying the daily flow values times the target concentration of 235 E. coli org/100 ml converted to a daily load and plotting it as a percent load recurrence generates the curve representing the target load as shown in Figure B.2. By examining the load duration curve the hydrological conditions where the water quality problem occurs can often be determined. If the problem occurs at higher flows then it is likely caused by non-point source run-off and if it is occurring at lower flows then the problem is related to continuous point sources such as wastewater treatment plants. The load duration curves for the four streams tributary show that the target concentration (converted to a daily load) is exceeded through almost all flow conditions.

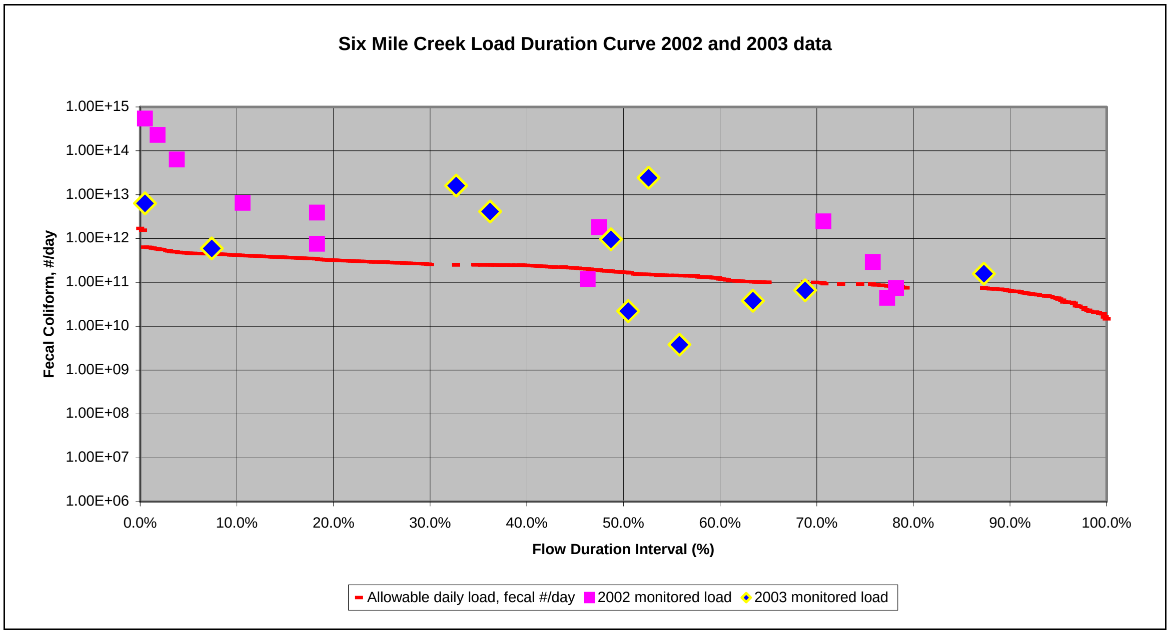


Figure B.2 Sixmile Creek Load Duration Curve

Often what is done to evaluate a load duration curve is to divide it into flow conditions. For example, EPA's Bruce Cleland, who has studied the use of load duration curves and their application to TMDL's, divides them in to five flow regions, 0-10% = high flows, 10-40% = moist conditions, 40-60% = mid-range flow, 60-90% = dry conditions, and 90-100% = low flows. The median of the monitoring data for each of these flow zones is then plotted along with the data points themselves.

Typically the flow duration curve, from which the load duration curve is derived, is based on data from a USGS gage and there are several years of daily flow data available. The flow duration curves for these four streams are based on flow data from only two years. This means that there is a chance that the ends of the flow duration curve, the highest and lowest flows, are not included.

For these TMDL's, where the bacteria water quality problems occur across most of the flow ranges, four flow duration rank conditions have been used. These are the 1%, 10%, 50%, and 70% flows. The 1% rank captures the impacts of significant run-off events and the 10%, 50%, and 70% ranks describe the continuum of decreasing concentrations from run-off and the increasing impacts from continuous sources such as cattle in the streams, failed septic tank systems, and wastewater treatment plants.

The evaluated flow and concentration data is also used in this worksheet to define the relationship between flow and concentration. This relationship is estimated using a non-linear power regression equation. Bacteria data from a mix of event and monthly monitoring typically does not show a linear relationship between flow and concentration and the Big Sioux monitoring data is no exception. At lower flows when the loads are from continuous sources and there are not any loads from run-off, the concentration and flow remain in a constant relationship. At higher flows when run-off from livestock and wildlife manure is the biggest factor, the bacteria concentrations rise very rapidly, usually more rapidly than the hydrograph. This is why power equations are used here to describe the relationship between flow and concentration.

Finally, the flow at the four flow percentile ranks, 1%, 10%, 50%, and 70% has been calculated for each of the four monitored streams. The regression equation is then used to estimate the bacteria concentration for the flow at the four ranks. A chart of the data and the flow/concentration regression equation for the Sixmile Creek monitoring is shown in Figure B.3. Table B.1 shows the flow for the design percentile flow ranks and the bacteria concentration calculated for each flow using the regression equation.

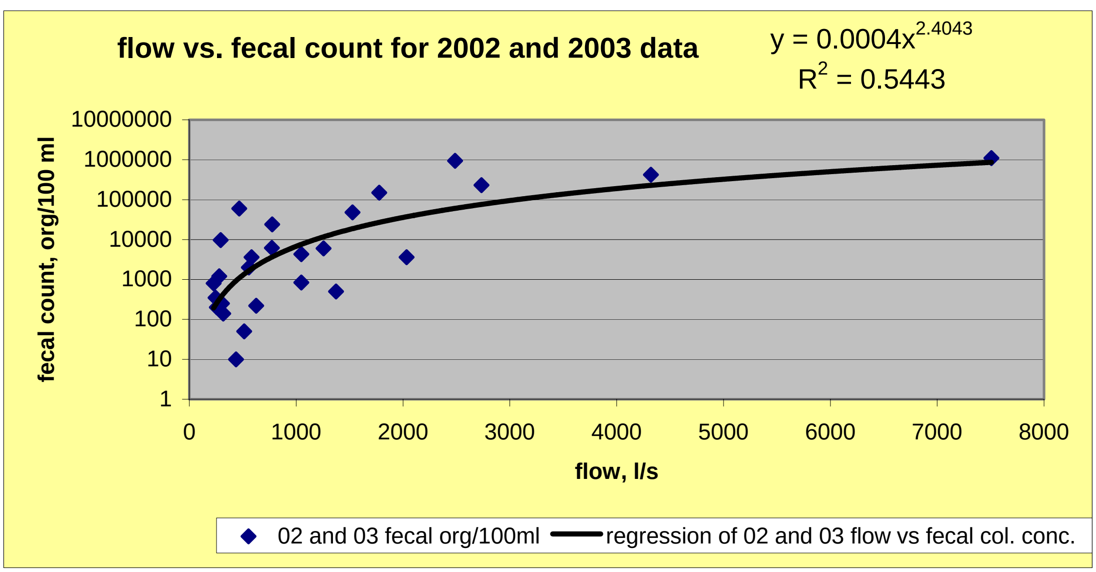


Figure B.3 Sixmile Creek data regression, flow vs. concentration

Table B.2 Application of the regression equation to the Sixmile Creek flow percentile ranks

flow duration percentile	design flow, l/s	fecal col. org./100 ml
0.1 percentile	5020	316010
1 percentile	1916	31193
10th percentile	1285	11943
50th percentile	521	1359
70th percentile	304	373
80th percentile	228	187

The flows at the percentile ranks and the associated bacteria concentrations are used in the loading worksheet to calculate the non-point source delivery ratio.

- '(stream name) loads' – This worksheet estimates the delivery ratio for each of the four monitored streams at each of the four design flow condition ranks (1%, 10%, 50%, and 70%). This involves converting the design flows from liters per second to liters per day and the associated fecal coliform concentrations from organisms per 100 milliliters to organisms per day based on the daily flow. The non-point loads for the HUC 12's in the watersheds of the monitored streams were added together for each and this became the available run-off load for the whole stream watershed from these sources.

  For the purposes of figuring the delivery at the decreasing flow rank discharge values, it has been assumed that the entire load for the concentration associated with the discharge is from non-point source run-off. This means that the fraction of the watershed load delivered drops a lot as the flow and concentration of bacteria in that flow decreases. This makes sense because runoff should hardly be a factor when the precipitation transport mechanism is no longer available. Table B.2 shows the delivery ratio estimate for the four flow ranks for Sixmile Creek where the total fecal coliform load for the three HUC 12's in this watershed has been estimated to be 2.90 E+15 org/day.

Table B.3 Sixmile Creek NPS delivery ratio estimate

Design flow duration, %	Design flow at interval, l/d	Existing load estimate at design flow, fecal col. org/day	Existing NPS load est. for the watershed, fecal col. org/day	Delivery ratio, June loading estimate, %
0.1 percentile	4.34E+08	1.37E+15	2.90 E+15	29.5%
1 percentile	1.66E+08	5.16E+13	2.90 E+15	1.1%
10th percentile	1.11E+08	1.33E+13	2.90 E+15	0.3%
50th percentile	4.50E+07	6.11E+11	2.90 E+15	0.01%
70th percentile	2.63E+07	9.81E+10	2.90 E+15	0.002%

The delivery ratios for the watersheds were variable at the design flow conditions. Westfield Creek is an anomaly because its watershed is a large HUC 12 whose landuse is mostly cropland but which received a fairly small number of cattle and other livestock in the distribution. The monitoring data shows a large run-off event bacteria load but the BIT spreadsheet estimates a small load available for washoff because there are few animals. What is going on here is that manure from other HUC 12's is being applied to the cropland in the Westfield Creek watershed or the livestock distribution is not accurate for this HUC 12.

The estimated delivery ratios and flows at the design percentile rank are used in the nonpoint source load allocations and reductions spreadsheet.

Estimating Load Allocations and Reductions

There are two spreadsheets that include the calculations for the load allocations and the load reductions needed for the Iowa parts of the Rock and Big Sioux River watersheds. These spreadsheets are called *BSR direct allocations and reductions.xls* and *Rock allocations and reductions.xls*. The delivery ratio for the Iowa part of the Big Sioux and Rock HUC 12 sub-watersheds is derived in the worksheet called 'delivery ratios'. The areal flow for each of the design flow conditions based on the HUC 12 area is also derived on this worksheet.

The delivery ratios for the four design flow rank conditions, 1%, 10%, 50%, and 70%, are the average of the estimated delivery ratios for the monitored streams excluding Westfield Creek. Westfield Creek is anomalous because the small number of animals assigned to its watershed in the livestock distribution does not reflect the high percentage of cropland that has manure applied to it from outside the Westfield Creek HUC 12. This means that the load estimate from the event monitoring greatly exceeds the load predicted in the *BSR direct BIT.xls* spreadsheet where the loads are the result of animal numbers in the HUC 12.

The approximated delivery ratios for the design flow conditions are 0.35 for the 1% flow rank, 0.01 for the 10% flow rank, 0.001 for the 50% flow rank, and 0.0001 for the 70% flow rank. These values make sense in that one hundred percent delivery to the Big Sioux River doesn't happen during a precipitation event and because the delivery of the load available for washoff should rapidly decrease with the disappearance of the event transport mechanism.

The other values calculated in the ‘delivery ratios’ worksheet are the average flows based on area for the design flow ranks in the monitored watersheds. These average flows for the design flow rank conditions are 7900 liters/day/acre for the 1% flow rank, 1600 liters/day/acre for the 10% flow rank, 600 liters/day/acre for the 50% flow rank, and 400 liters/day/acre for the 70% flow rank. Again, these values make sense physically; the 1% flow rank represents precipitation events when the flow in smaller streams would be expected to increase dramatically. The 50% and 70% flow ranks represent a base flow that should be more consistent and even within the flow ranks.

There are four other worksheets in each of the spreadsheets *BSR direct allocations and reductions.xls* and *Rock allocations and reductions.xls*. Each of these worksheets calculates the load allocations and the percent load reductions needed for one of the four flow ranks and the associated areal flow estimate by HUC 12.

The stream flow from each HUC 12 is estimated based on discharge per acre times the HUC 12 area. This daily flow rate (liters/day) is multiplied by the water quality standard target of a sample maximum concentration 235 E. coli organisms per 100 milliliters to determine the load allocation for each HUC 12 sub-watershed.

The non-point source loading from the modified BIT spreadsheets has three components that are entered into these worksheets separately:

1. The totalized non-point source daily loads from the event run-off of the four land use categories; cropland, pasture, ungrazed pasture/forest, and built-up. These are the non-point source loads that the delivery ratios are applied to at the different flow ranks. As the flow decreases these loads decrease rapidly.

2. Cattle in the stream loads are generally from grazing cattle that spend some percentage of their grazing time directly in streams where their manure becomes a direct deposit. Cattle in the stream includes any loads from livestock or wildlife that get into the stream when there are not run-off conditions.

   This category changes by the month with the assumptions that no cattle graze December through March and seven percent of the total beef cattle graze April through November (estimate from evaluation of county ag statistics and field assessments in Lyon County). The fraction of the grazing cattle that deposit manure is assumed to be at least 12% from April to

October and twice as high (24%) in the summer months of June, July, and August (estimates from IDALS staff).

3. Failed septic tanks are rural household onsite wastewater treatment systems that generally consist of a septic tank that discharges directly to a ditch or tile. The total number of households was determined from the 2002 census blocks for each county and the number of households in cities with wastewater treatment facilities was subtracted from the total to get the number of rural households.

The 'septics' worksheet in the two BIT spreadsheets, *BSR direct BIT.xls* and *Rock BIT.xls* describe the assumptions and calculations used to estimate the failed septic tank loads. It is assumed that failed septics are distributed evenly across the watershed based on land area. The density for the Rock River watershed is estimated to be 0.006 failed septics/acre and for the Big Sioux direct it is estimated to be 0.008 failed septics/acre. Discussions with IDNR staff responsible for the onsite wastewater treatment systems program suggest that the failure rate for septic tank systems in northwest Iowa is over 90%. This assessment is supported by a survey that was done in nearby Clay County showing that 92% of the onsite septic tanks discharge directly to a ditch or a tile. The fraction of failed septic systems for both Iowa watersheds used for this report is 90%.

The direct contributions of bacteria from failed septics to the Big Sioux River are represented as a point source located at the discharge of each HUC 12 sub-watershed and the die-off is calculated from the HUC 12 discharge to the Big Sioux River as previously described. It is assumed that the load from failed septics is continuous throughout the year and in all flow conditions. The failed septic load from each HUC 12 is translated from fecal coliform to *E. coli* and then put in the 'allocation and reduction' worksheets for the four flow ranks.

The loads from the three categories of non-point sources are totaled and the load allocation is subtracted from this total. This difference is the load reduction needed and it is calculated for each HUC 12 at each of the design flow ranks, 1%, 10%, 50%, and 70%. The percent load reduction needed is also calculated.

The load allocations have been calculated for the month of June because it is representative of some of the highest loadings from the two non-point sources that have seasonal fluctuations. The June non-point source daily loads from event run-off of the four land use categories, while not always as high as in the spring and fall, are still substantial. The estimated fraction of grazing cattle in the streams is as high as it is assumed to get. Together, these loads approach the worst case expected in the Big Sioux watershed at all four of the design flow ranks. There is another reason to use the month of June for the design conditions and that is because almost all of the monitored events occurred then. The data from these events has been important in the calculations used to estimate delivery ratios and areal flow from the HUC 12's at the design flow ranks.

Appendix C, Procedures and Assumptions for South Dakota TMDL Calculations

This appendix provides a summary of the steps involved in the calculation of the key components of the TMDLs for the mainstem Lower Big Sioux River. In addition, it summarizes the procedures and assumptions used to estimate the non-point load allocations and load reductions for the South Dakota HUC 12's sub-watersheds.

Step 1: Develop load duration curve (TMDL). A LDC depicts the percent of time in which a given fecal coliform load is equaled or exceeded. When using the fecal coliform WQS to calculate the LDC, the resulting curve also represents the TMDL. In brief, the LDC is developed by multiplying the stream flows in Appendix D by the WQS and by a unit conversion factor, as summarized in the following equation:

Load duration curve (TMDL; (cfu/day)) = streamflow (cfs) * 400 (cfu/ 100 ml) * 24465888

The *E.coli* TMDL was developed by multiplying the fecal coliform TMDL by the fecal coliform to *E.coli* conversion factor of 0.5875. The conversion factor represents the ratio of the *E.coli* to fecal coliform single maximum standard, i.e. 235/400.

Step 2: Calculate WLA. The Waste Load Allocation (WLA) for each discharger is an in-stream, cfu per day pollutant (fecal coliform) or *E.coli* load allocation used to calculate permit limits for point source dischargers. In South Dakota, the WLA expressed as daily fecal coliform loading for each discharge would be calculated using the following equation:

WLA (cfu/day) = design flow (mgd) * 10^6 * {[effluent permit limit (cfu/100mL) * 10] / 0.2641721}

The WLA for each South Dakota discharger is calculated using the permitted discharge rate and effluent permit limit.

Step 3: Calculate LA. The LA is also an in-stream pollutant allocation expressed in cfu/day, similar to the WLA. It is used to calculate watershed loadings for non-point source pollutants only, which are not subject to permitting requirements. LA for each of the South Dakota HUC12's sub-watersheds was calculated by multiplying the water quality criteria by the estimated flow for the associated HUC 12 sub-basin by a unit conversion factor, as summarized in the following equation:

LA (cfu/day) = 400 (cfu/100 ml) * streamflow (cfs) * (28317/100) * 60 * 60 * 24

Step 4: Estimate Non-point Load Using the BIT Model. The sources included in the South Dakota BIT modeling are cropland, pastureland, forestland, built-up from landuse types, cattle in streams, septics, animal feeding operations rated greater than 50 on the Agricultural Non-point Source (AGNPS) rating scale, and storm sewers. The model was conducted based on the following assumptions and data sources for each of the modeled sources of fecal coliform bacteria for South Dakota.

Cropland. This source includes both livestock and wildlife contribution on the cropland. Fecal coliform loading from croplands varies depending on the type of animal and manure application rates.

Pastureland. Loading from pastureland is calculated based on similar assumptions to those used for croplands.

Forestland. Loading from forestland is also calculated based on similar assumptions to those used for croplands and pastureland except only wildlife contribution is considered. The wildlife species modeled in these TMDLs is deer.

Built-up from landuse types. This includes loading from roads, urban, low, and high intensity residential, and industrial landuses.

Cattle in streams. This estimates the loading from cattle standing directly in the stream. Loading varies depending on the percent time grazing and percent time standing in the stream. The model assumes only beef cattle are grazing and therefore have access to streams.

Animal Feeding Operations rated greater than 50 on the AGNPS rating scale. Loading from this source is calculated similar to that for cattle in streams. It was important to distinguish this source from general loading from cattle in streams because SD DENR protocol for implementation projects dictates that priority for funding will be given to animal feeding operations (AFOs) rated greater than 50 on the AGNPS rating scale. In brief, an inventory of all AFO located within Lincoln and Union Counties was completed for the Lower Big Sioux Watershed Assessment in 2002 (SDDENR, 2002). The type and number of livestock present in each lot was documented. Digital Orthophoto Quads (DOQs) in GIS were used to determine size of the lot, and subwatershed above the lot that, during a storm event, could provide water potentially draining through the lot. This information, along with slope and soils information, were used with the AGNPS Feedlot Model. This model calculates a pollutant severity rating for the AFO on a scale of zero (no pollution potential) to 100 (severe). The SD DENR standard protocol for the feedlot model is to use a 25 year, 24 hour storm event to evaluate pollution potential.

Septics. Loadings from septics within each HUC 12 subwatershed were estimated based on the number of failing septic tanks reported in the 2002 census data for each county (Minnehaha, Lincoln, and Union). The model assumes the rural population is equal to the difference between the total population and the population of the cities. In addition, the model assumes 2.5 persons per housing unit and one septic tank per each housing unit.

Storm sewers. Loading from storm sewers were estimated based on the identified cities, their population and potential bacterial loads associated with the population. A total of 14 cities were modeled in these TMDLs.

Step 5: Estimate Existing Load for South Dakota HUC 12's Sub-watersheds. Existing fecal coliform load for each South Dakota HUC 12 sub-watershed was calculated by multiplying the total non-point source load by the average delivery coefficient for each percentile flow range as shown in the following equation:

Existing load (cfu/day) = total non-point load (cfu/day) * average delivery coefficient

The total non-point load was estimated using the BIT model. See Step 4 for specific BIT model assumption used by South Dakota. The average delivery coefficient represents the geometric mean of all delivery coefficients for each monitoring station at a particular flow percentile. Each individual delivery coefficient was calculated by dividing the median load by the total non-point load. The median load was calculated using measured data from each monitoring station multiplied by the associated flows.

Step 6: Estimate TMDL Load Reduction for Mainstem River Segments. TMDL load reduction was calculated by subtracting the TMDL (Step 1) from the existing loading (calculated from in-stream data) loading at specific percentile flow duration interval (e.g. 0-25%, 25-50%, 50-75%, and 75-100% for mainstem LBS River). Current non-point loading is assumed to be equal to the 60th percentile loading value for the associated percentile flow duration interval. And the individual in-stream loading at the individual percentile flow (0-100) is calculated by multiplying the measured in-stream concentration by the associated flow.

The percent load reduction at any given percentile flow duration interval is then calculated using the following equation:

Percent TMDL load reduction for the mainstem segment = [Existing load for mainstem segment(cfu/day) – TMDL (cfu/day)] / Existing load for mainstem segment (cfu/day) * 100

Step 7: Estimate Non-point Load Reduction for Each South Dakota HUC12's Sub-watershed. Non-point load reduction for each South Dakota HUC 12's sub-watershed was calculated by subtracting the LA (Step 3) from the existing loading for the sub-watersheds (Step 5) at specific percentile flow duration interval (e.g. 0-10%, 10-40%, 40-70%, and 70-100% for the South Dakota HUC 12's sub-watersheds). The percent load reduction at any given percentile flow duration interval is then calculated using the following equation:

Percent TMDL load reduction for the sub-watershed	**= [Existing load for sub-watershed(cfu/day) – LA (cfu/day)] / Existing load for sub-watershed (cfu/day) * 100**

Appendix D, Flow Data Used to Generate the Load Duration Curves for the Lower Big Sioux River

Flow Percentile	Flow (cfs)																				
	LBSM01	LBST02	LBSM03	LBST04	LBSM05	LBST06	LBST07	LBSM08	LBSM09	LBST10	LBST11	LBST12	LBSM13	LBST14	LBST15	LBST16	LBSM17	LBST18	LBSM19	LBSM20	LBSM21
0.008%	24272	138	32022	415	32477	262	253	35278	36822	44	119	1157	46772	165	428	292	50600	871	50421	59753	59393
0.100%	16999	132	22437	388	22762	244	234	24826	25995	43	87	1010	29751	154	403	215	32195	767	32085	38125	37906
0.274%	12200	124	16112	342	16351	230	210	17902	18800	38	50	364	23003	139	207	151	24898	542	24815	29551	29387
1%	8144	79	10766	148	10932	130	101	12025	12674	24	40	83	14447	54	130	150	15647	400	15599	18680	18587
5%	3398	29	4512	21	4594	31	68	5103	5420	11	17	10	6466	19	60	60	7017	138	7001	8539	8512
10%	2097	17	2798	11	2856	24	23	3190	3403	10	14	9	3723	11	43	25	4050	87	4045	5053	5048
15%	1441	15	1933	8	1979	18	16	2220	2376	9	13	7	2742	8	33	19	2990	70	2989	3807	3811
20%	1053	12	1422	7	1461	15	9	1644	1765	9	10	5	2095	6	29	18	2290	62	2292	2985	2994
25%	778	8	1058	7	1093	13	5	1234	1328	8	8	5	1697	5	25	17	1860	55	1864	2479	2492
30%	597	7	821	6	852	13	3	965	1040	7	7	5	1383	4	17	15	1520	52	1525	2080	2095
35%	464	4	645	6	674	12	3	765	827	7	7	4	1115	4	15	14	1230	47	1236	1739	1756
40%	375	3	527	5	554	12	3	631	683	6	6	4	920	3	12	13	1020	40	1027	1492	1511
45%	301	2	430	5	456	11	2	520	564	6	6	4	762	3	10	10	849	34	856	1291	1311
50%	248	2	360	5	384	11	2	439	477	6	6	4	634	3	10	10	710	28	718	1128	1149
55%	204	2	302	5	326	10	2	373	406	5	5	3	538	3	9	9	607	24	615	1007	1029
60%	164	2	249	5	273	9	2	313	341	5	5	3	457	3	8	8	519	20	528	904	926
65%	134	2	211	4	233	8	2	268	293	5	5	3	373	3	8	7	428	17	437	797	820
70%	105	2	172	4	194	8	2	224	245	5	4	3	281	2	7	5	329	17	338	680	704
75%	82	1	141	3	163	7	1	188	206	5	4	3	208	2	5	5	250	17	260	587	612
80%	59	1	112	2	133	6	1	154	169	4	4	2	158	2	4	5	196	17	206	524	549
85%	49	1	98	2	119	3	1	138	151	4	3	1	132	1	4	4	168	16	178	491	516
90%	41	0	87	2	108	2	1	125	138	2	3	1	92	1	2	4	124	13	134	439	465
95%	32	0	76	2	97	2	1	113	124	1	3	1	49	1	2	4	78	11	88	385	411
99%	23	0	64	2	85	2	0	98	108	1	2	1	9	1	1	4	34	8	44	334	360
100%	12	0	50	2	70	1	0	82	90	1	0	1	0	1	1	4	4	0	15	298	325

Appendix E, Outline and Description of the Available E-files for South Dakota

The State of South Dakota followed the premise used by Iowa in their development of the TMDL using the 12 digit hydrologic units (HUC12s). The United States Geological Survey (USGS) has not certified the Minnesota or South Dakota HUC12s so these are not the finalized version for what may be available late this year or early next year. South Dakota is assuming that there will be only insignificant changes to these watershed or HUC boundary lines. To develop loadings from all landuses within each HUC12, SD used a modified version of the Bacterial Indicator Tool (BIT), which can be found at the EPA website (http://www.epa.gov/ost/ftp/basins/system/BASINS3/bit.htm)

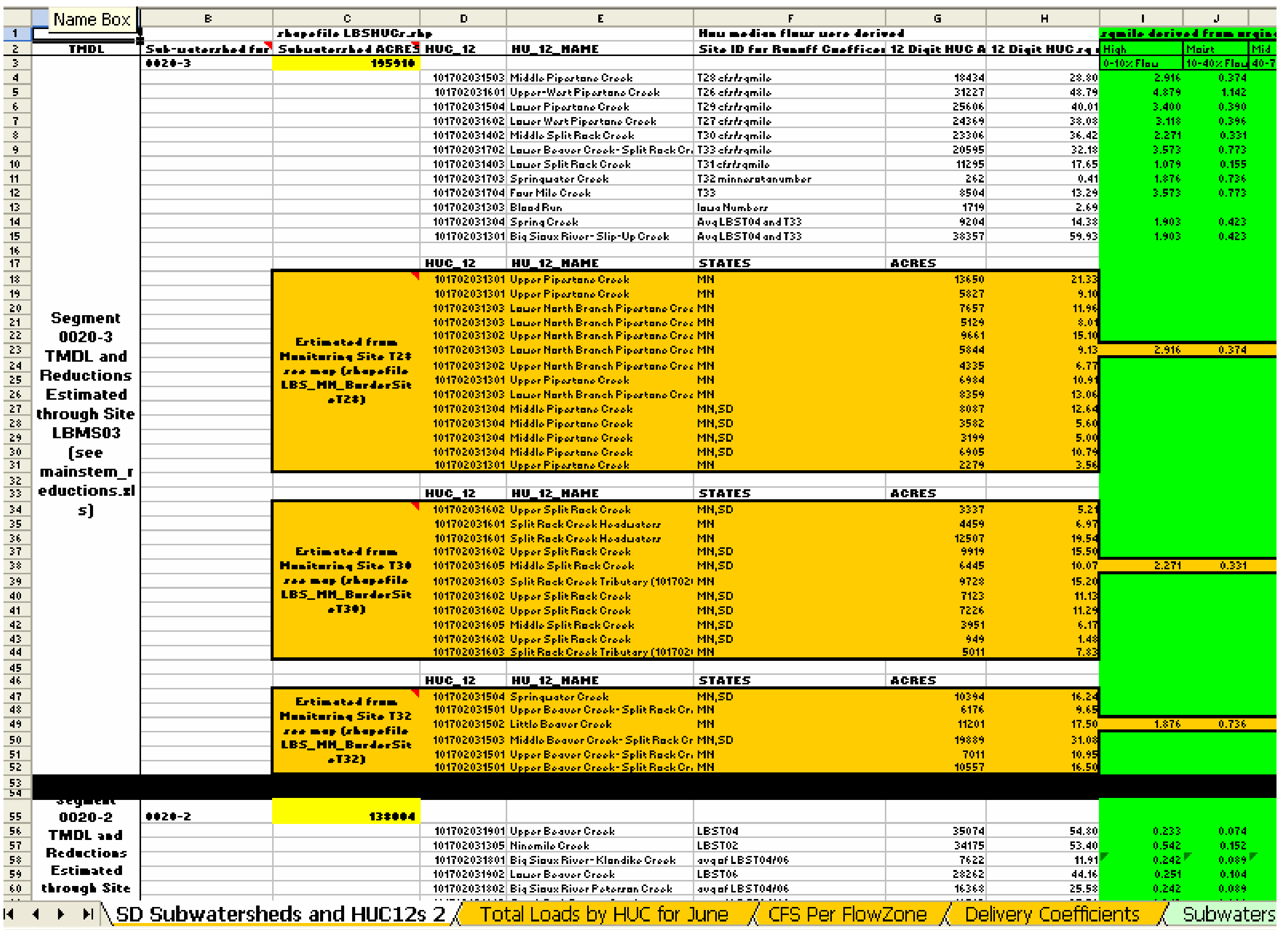
Workbook "SD BSR Direct (by segment).xls"

The main TMDL EXCEL workbook is "SD BSR Direct (by segment).xls" which is located in the LBS_Fecal_Tool. When this workbook is opened the first worksheet "SD Subwatersheds and HUC12s 2" should look like Figure 1. This worksheet contains the following information:

- Column **A** – Shows which segment each row belongs to. There are total of seven segments. Please review the shapefiles located in the "LBS_Giswork" subdirectory. Also, please note several comments in various cells within the worksheet identified by the red triangles in upper right corner of said cells.
- Column **B** – contains the segment number from IDNR.
- Column **C** – contains the subwatershed acres (yellow cells) for each segment for the South Dakota side only. Does not include Iowa or Minnesota acres. Still in column C, rows 18-52 contain information for the HUC12s draining from Minnesota. No landuse information for the BIT tool was gathered for these Minnesota acres. Fecal coliform contributions from these HUC12s were calculated through load duration curves (see "Reductions.xls" and "T28_T30_T32 Load Duration Intervals.xls" in the subdirectory Load Curves and Reductions\Tributary)
- Column D – HUC12 numbers which are found in the attribute table for the shapefile LBSHUCs (Projection NAD83, Zone14).
- Column E - HUC12 names which are found in the attribute table for the shapefile LBSHUCs (Projection NAD83, Zone14).
- Column F – shows which monitoring site or information was used to derive the runoff, target loads, and existing loads for each HUC.
- Column G – acres for each 12 digit HUC.
- Column H – square miles for each 12 digit HUC.
- Columns I-L – contain cfs/sq mile for each HUC calculated from Q rating tables and equations for monitoring sites identified in Column F. Exceptions

are the Minnesota border sites (rows 23, 38, 49) which used actual load duration curves (LDCs).

- Columns M-P – Median flow for each flowzone within each HUC12.
- Columns Q-T – Target loads using the 400 (cfu/100ml) daily max for each flowzone.
- Columns U-X – Existing loads calculated using the delivery coefficients derived from the 2001-2004 monitoring data and described in the worksheet “Delivery Coefficients”.
- Columns Y-AB – Reductions for each flowzone for each HUC12 using columns Q-T and U-X (target loads vs. existing loads).
- Columns AC-AX- Source allocations for each HUC12 (actual sources and percentages). Note that AFOs >50 are the animal feeding operations rated greater than 50 using the AGNPS Feedlot Rating Program. This program rates AFOs on a pollution severity scale of 0-100 with 100 being the worst.



	A	B	C	D	E	F	G	H	I	J
1			shapefile LBSHUCs.shp			How median flows were derived			sqmile derived from origin	
2	TMDL	Sub-watershed for	Subwatershed ACRES	HUC_12	HU_12_NAME	Site ID for Runoff Coefficien	12 Digit HUC A	12 Digit HUC sq	High	Moist
3		0020-3	195910						0-10% Flow	10-40% Flow
4				101702031503	Middle Pipestone Creek	T28 cfs/sqmile	18434	28.80	2.916	0.374
5				101702031601	Upper-West Pipestone Creek	T26 cfs/sqmile	31227	48.79	4.879	1.142
6				101702031504	Lower Pipestone Creek	T29 cfs/sqmile	25606	40.01	3.400	0.390
7				101702031602	Lower West Pipestone Creek	T27 cfs/sqmile	24369	38.08	3.118	0.396
8				101702031402	Middle Split Rock Creek	T30 cfs/sqmile	23306	36.42	2.271	0.331
9				101702031702	Lower Beaver Creek-Split Rock Cr	T33 cfs/sqmile	20595	32.18	3.573	0.773
10				101702031403	Lower Split Rock Creek	T31 cfs/sqmile	11295	17.65	1.079	0.155
11				101702031703	Springwater Creek	T32 minnesotanumber	262	0.41	1.876	0.736
12				101702031704	Four Mile Creek	T33	8504	13.29	3.573	0.773
13				101702031303	Blood Run	Iowa Numbers	1719	2.69		
14				101702031304	Spring Creek	Avg LBST04 and T33	9204	14.38	1.903	0.423
15				101702031301	Big Sioux River-Slip-Up Creek	Avg LBST04 and T33	38357	59.93	1.903	0.423
16										
17				HUC_12	HU_12_NAME	STATES	ACRES			
18				101702031301	Upper Pipestone Creek	MN	13650	21.33		
19				101702031301	Upper Pipestone Creek	MN	5827	9.10		
20				101702031303	Lower North Branch Pipestone Cree	MN	7657	11.96		
21	Segment 0020-3 TMDL and Reductions Estimated through Site LBMS03 (see mainstem_reductions.xls)			101702031303	Lower North Branch Pipestone Cree	MN	5129	8.01		
22				101702031302	Upper North Branch Pipestone Cree	MN	9661	15.10		
23			Estimated from Monitoring Site T28 see map (shapefile LBS_MN_BorderSite T28)	101702031303	Lower North Branch Pipestone Cree	MN	5844	9.13	2.916	0.374
24				101702031302	Upper North Branch Pipestone Cree	MN	4335	6.77		
25				101702031301	Upper Pipestone Creek	MN	6984	10.91		
26				101702031303	Lower North Branch Pipestone Cree	MN	8359	13.06		
27				101702031304	Middle Pipestone Creek	MN,SD	8087	12.64		
28				101702031304	Middle Pipestone Creek	MN,SD	3582	5.60		
29				101702031304	Middle Pipestone Creek	MN,SD	3199	5.00		
30				101702031304	Middle Pipestone Creek	MN,SD	6905	10.79		
31				101702031301	Upper Pipestone Creek	MN	2279	3.56		
32										
33				HUC_12	HU_12_NAME	STATES	ACRES			
34				101702031602	Upper Split Rock Creek	MN,SD	3337	5.21		
35				101702031601	Split Rock Creek Headwaters	MN	4459	6.97		
36				101702031601	Split Rock Creek Headwaters	MN	12507	19.54		
37				101702031602	Upper Split Rock Creek	MN,SD	9919	15.50		
38			Estimated from Monitoring Site T30 see map (shapefile LBS_MN_BorderSite T30)	101702031605	Middle Split Rock Creek	MN,SD	6445	10.07	2.271	0.331
39				101702031603	Split Rock Creek Tributary (101702	MN	9728	15.20		
40				101702031602	Upper Split Rock Creek	MN,SD	7123	11.13		
41				101702031602	Upper Split Rock Creek	MN,SD	7226	11.29		
42				101702031605	Middle Split Rock Creek	MN,SD	3951	6.17		
43				101702031602	Upper Split Rock Creek	MN,SD	949	1.48		
44				101702031603	Split Rock Creek Tributary (101702	MN	5011	7.83		
45										
46				HUC_12	HU_12_NAME	STATES	ACRES			
47				101702031504	Springwater Creek	MN,SD	10394	16.24		
48				101702031501	Upper Beaver Creek-Split Rock Cr	MN	6176	9.65		
49			Estimated from Monitoring Site T32 see map (shapefile LBS_MN_BorderSite T32)	101702031502	Little Beaver Creek	MN	11201	17.50	1.876	0.736
50				101702031503	Middle Beaver Creek-Split Rock Cr	MN,SD	19889	31.08		
51				101702031501	Upper Beaver Creek-Split Rock Cr	MN	7011	10.95		
52				101702031501	Upper Beaver Creek-Split Rock Cr	MN	10557	16.50		
53										
54										
55	Segment 0020-2 TMDL and Reductions Estimated through Site	0020-2	138004							
56				101702031901	Upper Beaver Creek	LBST04	35074	54.80	0.233	0.074
57				101702031305	Ninemile Creek	LBST02	34175	53.40	0.542	0.152
58				101702031801	Big Sioux River-Klondike Creek	avg of LBST04/06	7622	11.91	0.242	0.089
59				101702031902	Lower Beaver Creek	LBST06	28262	44.16	0.251	0.104
60				101702031802	Big Sioux River Peterson Creek	avg of LBST04/06	16368	25.58	0.242	0.089

SD Subwatersheds and HUC12s 2 / Total Loads by HUC for June / CFS Per FlowZone / Delivery Coefficients / Subwaters

Figure 1. SD Subwatersheds and HUC12s 2 in workbook SD BSR Direct (by Segment).xls.

Worksheet – "Total Loads by HUC for June"
These loads come from the "SD BSR Direct BIT (by HUC).xls" workbook (see formulas for exact locations of data).

Worksheet – "CFS Per Flowzone"
This worksheet contains the median flow (cfs) for each flowzone for each monitoring site within the Lower Big Sioux River project area. The square miles drained by each monitoring are also included. These numbers were used to develop the runoff and delivery coefficients for each flow zone so they could be applied to the HUC12s.

Worksheet – "Delivery Coefficients"
Contains how the final loadings for each flowzone for all 34 HUC12s were calculated. Also contains which runoff and delivery coefficient was used with each HUC12.

Worksheet – "Subwatershed Areas D"
The subwatersheds for the seven segments outlined in the Iowa report for the Lower Big Sioux River were delineated using 30 meter DEMs for the SD side of the River. The surface areas (acres) was calculated and the pre-certified HUC12 shapefile, provided by the USGS, was overlaid in GIS to determine which HUC drained into which segment of the river.

The remaining worksheets in the "SD BSR Direct BIT (by Segment).xls" really only pertain to the breakdown of the landuse, animals, cities, etc. of each segment with no reference to HUC12s. The fecal coliform numbers used in the TMDL for each HUC12 were derived from the workbook "SD BSR Direct BIT (by HUC).xls".

Workbook "SD BSR Direct (by HUC).xls"

The main TMDL EXCEL workbook is "SD BSR Direct (by HUC).xls" which is located in the LBS_Fecal_Tool. When this workbook is opened the first worksheet "SD_HUC12s D" should look like Figure 2. This workbook contains landuse and potential fecal coliform buildup and loadings for each of the 34 HUC12s draining into the Lower Big Sioux from the South Dakota.

Worksheet – "SD_HUC12s D"
This worksheet gives the 12-digit HUC number and the HUC12 name used in the TMDL analysis. It also shows which segment of the Big Sioux River that each HUC is located. The area of each HUC is listed with a breakdown of the various landuse categories (acres). The surface area of each landuse category were derived from infrared imagery provided by the EROS datacenter. Each type of landuse (Table 1) was given a specific code and was identified in the attribute table of the raster dataset. In ARCMAP ver9.0, the raster data collected for SD in 2001 was clipped using HUC12 shapefile. The smaller raster dataset containing the landuse for each

HUC12 were converted into individual polygons using the Raster to Polygon tool found in Arctoolbox. Using Xtools in ARCMAP the area was calculated for each polygon. The individual crop or landuse type was then queried out and the total area calculated for that landuse type in each HUC12.

Table 1

Open Water	**Other Grasses**
Low Intensity Residential	**Woody Wetlands**
High Intensity Residential	**Emergent Herb Wetlands**
High Intensity Commercial / Industrial	**Grassland, Hay/Pasture**
Bare Rock/Sand/Clay	**Corn**
Quarries/Strip Mines/Gravel Pits	**Soybeans**
Transitional	**Alfalfa**
Deciduous Forest	**Spring Grains, Fallow**
Evergreen Forest	**Other summer crops**
Mixed Forest	**Winter Wheat**

E37 Big Sioux River- Rock Creek North

	C	D	E	F	G	H	I	
1	**HU12**	**HUC_12**	**HU_12_NAME**	**Segment**	**Area**	**Open Wat**	**Low Intensity Residential**	**High Inte**
2	1.01702E+11	101702031503	Middle Pipestone Creek	0020-3	18434.54	9.117865	0	
3	1.01702E+11	101702031601	Upper-West Pipestone Creek	0020-3	31225.35	25.79689	0	
4	1.01702E+11	101702031504	Lower Pipestone Creek	0020-3	25605.63	185.9155	0.222386953	
5	1.01702E+11	101702031401	Upper Split Rock Creek	0020-3	191.9199	0	0	
6	1.01702E+11	101702031602	Lower West Pipestone Creek	0020-3	24369.61	128.762	0.444773907	
7	1.01702E+11	101702031402	Middle Split Rock Creek	0020-3	23309.04	364.7146	119.4217939	
8	1.01702E+11	101702031702	Lower Beaver Creek- Split Rock Creek	0020-3	20593.25	80.72646	109.636768	
9	1.01702E+11	101702031403	Lower Split Rock Creek	0020-3	11293.48	340.9192	166.3454411	
10	1.01702E+11	101702031703	Springwater Creek	0020-3	262.1942	0.444774	2.223869533	
11	1.01702E+11	101702031704	Four Mile Creek	0020-3	8505.634	5.559674	0	
12	1.01702E+11	101702031303	Blood Run	0020-3	1717.494	0.222387	0	
13	1.01702E+11	101702031901	Upper Beaver Creek	0020-2	35071.53	252.854	21.57153447	
14	1.01702E+11	101702031304	Spring Creek	0020-3	9198.369	18.01334	11.56412157	
15	1.01702E+11	101702031305	Ninemile Creek	0020-2	34175.32	275.0927	113.6397331	
16	1.01702E+11	101702031801	Big Sioux River- Klondike Creek	0020-2	7623.202	138.7695	0	
17	1.01702E+11	101702031902	Lower Beaver Creek	0020-2	28260.71	185.4707	167.4573758	
18	1.01702E+11	101702031802	Big Sioux River Peterson Creek	0020-2	16371.46	203.4841	141.2157153	
19	1.01702E+11	101702031903	South Fork Beaver Creek	0020-2	16501.56	40.69681	0	
20	1.01702E+11	101702031803	Big Sioux River- Little Beaver Creek	0020-1	13267.38	185.6931	0	
21	1.01702E+11	101702031804	Big Sioux River- Pattee Creek	0020-1	8017.05	166.5678	56.93106004	
22	1.01702E+11	101702032002	Pattee Creek	0020-1	25919.2	121.8681	0	
23	1.01702E+11	101702032401	Upper East Brule Creek	0010-2	21892.66	18.01334	0	
24	1.01702E+11	101702032403	West Brule Creek	0010-2	24785.47	34.46998	0	
25	1.01702E+11	101702032001	Big Sioux River- Dry Creek	0010-4	30209.27	256.1898	0	
26	1.01702E+11	101702032402	Lower East Brule Creek	0010-2	22692.14	72.94292	123.869533	
27	1.01702E+11	101702032404	Upper Brule Creek	0010-2	34104.37	101.4085	17.79095626	
28	1.01702E+11	101702032202	Union Creek	0010-3	23218.75	37.36101	2.446256486	
29	1.01702E+11	101702032405	Lower Brule Creek	0010-2	33569.31	64.93699	4.225352113	
30	1.01702E+11	101702032206	Big Ditch	0010-2	30323.57	78.94737	29.13269088	
31	1.01702E+11	101702032203	Big Sioux River- Union Creek	0010-3	14213.42	204.3736	6.449221646	
32	1.01702E+11	101702032207	Mouth of the Big Sioux River	0010-1	10091.25	162.1201	166.3454411	

SD_HUC12s D / landusereduced / Land Use D / Animals D / Manure Application D / Grazing D / References D / Wildlife D / Cropland D / Pastur

Figure 2. Lower Big Sioux HUC12 worksheet in SD BSR Direct (by HUC).xls.

Worksheet – “landusereduced”
The landusereduced worksheet shows the 16 different landuse types identified in the Lower Big Sioux watershed. The 16 were combined to form seven different landuses (Table 2).

Table 2

VALUE	COUNT	LANDUSE	ACRES	REDUCED_LA	SIMPLE_LAN
1	52263	water	11623	0	water
2	21741	wetland	4835	0	wetland
3	8422	bottomland forest	1873	3	forest
4	3014	coniferous forest	670	3	forest
5	269442	deciduous forest	59922	3	forest
6	1923644	ungrazed grassland	427806	1	pastureland
7	647027	grazed grassland	143895	1	pastureland
8	230645	CRP grassland	51294	1	pastureland
9	307180	alfalfa	68315	2	cropland
10	5567702	corn	1238221	2	cropland
11	6389840	soybeans	1421060	2	cropland
12	156041	other rowcrop	34703	2	cropland
13	85882	roads	19100	4	built-up
14	34297	commercial industrial	7627	4	built-up
15	70567	residential	15694	4	built-up
16	9256	barren	2058	0	barren

Worksheet – “Land Use D”
This worksheet includes the acres for each landuse type in each HUC12.

Worksheet – “Animals D”
The total number of livestock were calculated using the 2002 Ag Census Data from the National Agricultural Statistics Service (NASS). Estimates for beef cattle, swine, dairy cattle, poultry, horses, sheep were determined for each county based on statistical surveys conducted by NASS. An equal distribution (# of livestock per acre) was assumed for each livestock type. The number of livestock per HUC12 was determined by multiplying the percent of each HUC in each county by the total number of livestock within the county.

Wildlife were estimated by using deer as the surrogate for all wildlife types. The number of deer per square mile was taken from South Dakota Game Report No. 2003-11, 2002 Annual Report, County Wildlife Assessments by Corey Huxoll. Deer survey estimates per square mile for Lincoln, Minnehaha, and Union County were doubled. The percent of each landuse type within each HUC12 for each county was multiplied by the doubled deer density estimate.

Worksheet – “Manure Application D”
This worksheet contains information relevant to land application of waste produced by agricultural animals in each HUC12. Manure application rates for each month were estimated for each HUC12 for each of the four livestock types.

Worksheet – “Grazing D”
Calculates the percent time cattle are grazing during each month. It also calculates the percent time cattle spend in the streams versus grazing. During the summer months the amount of time a cow spends in the stream was estimated to be as high as 24% versus 0% during the winter months.

Worksheet – “References D”
The default value for estimated fecal coliform counts per animal type per day is used in calculations in other worksheets in the “by HUC.xls” workbook. Various literature values were available. There were also literature estimates (median counts/hectare/day) for various types of landuses, i.e. roads, single family low density, residential, etc.

Worksheet – “Wildlife D”
Calculates the total fecal coliform bacteria produced by wildlife each day per acre of cropland, pastureland and forest. This worksheet refers back to the “Animals D” worksheet which calculated the number of deer per HUC12 and multiplies that times the number coliform produced by deer (worksheet “References D”).

Worksheet – “Cropland D”
Calculates the total fecal coliform accumulated per month for cropland based on each animal type and the manure application rates (“Manure Application D” worksheet) for each livestock type. Also includes the wildlife amount accumulated on the cropland acres for each HUC12.

Worksheet – “Pastureland D”
Calculates total fecal coliform accumulated per month for pastureland similar to “Cropland D” worksheet.

Worksheet – “Forestland D”
Same as above except forest acres are considered. It was assumed that only wildlife significantly contributed to coliform buildup for this landuse type.

Worksheet – “Built-up D”
Calculates total fecal coliform accumulated per month for built-up landuse type. Built-up is comprised of roads, urban, low and high intensity residential, and industrial landuses which were bundled together for the Lower Big Sioux TMDL.

Worksheet – "Cattle in Streams D"
Estimates the number of cattle in each HUC12 ("Animals D" worksheet) standing directly in the stream. The number of beef cattle standing in the stream is based on the percent time grazing and percent time standing in the stream which are taken from the "Grazing D" worksheet. It is assumed that only beef cattle are grazing and therefore have access to streams. They have access to streams based on information in the Grazing worksheet. Literature values from "References D" worksheet estimated fecal coliform counts/day produced by an average beef cow.

Worksheet – "AFOs D" and "Cattle in Streams AFOs D"
In 2002 an inventory of all animal feeding operations (AFO) located within Lincoln and Union Counties was completed for the Lower Big Sioux Watershed Assessment. The type and number of livestock present in each lot was documented. Digital Orthophoto Quads (DOQ's) in GIS were used to determine size of the lot, subwatershed above the lot that, during a storm event, could provide water potentially draining through the lot. This information, along with slope and soils information, were used with the Agricultural Nonpoint Source (AGNPS) Feedlot Model. This model calculates a pollutant severity rating for the AFO on a scale of zero (no pollution potential) to 100 (severe). SD Dept. of Environment and Natural Resources (SDDENR) standard protocol for the feedlot model is to use a 25 year, 24 hour storm event to evaluate pollution potential.

AGNPS ratings for all AFOs were used in GIS with the number and type of livestock, to determine how many AFOs fell within each HUC12s. SDDENR protocol for implementation projects dictates that priority for funding will be given to AFOs rated greater than 50 on the AGNPS rating scale. Using this cutoff, each AFO rated greater than 50 was treated as a separate potential point source similar to cattle in streams. The number of livestock within the AFOs rated greater than 50 within the corresponding HUC12 were put into a separate worksheet "Cattle in Streams AFOs D". .

Worksheet – "Septics D"
The number failing septic tanks were estimated by using the 2002 census blocks from each county, Minnehaha, Lincoln, and Union clipped to the HUC12 watersheds. The population of the cities was subtracted from the total population and the remainder was assumed to be rural. Housing unit numbers from the census data has been used to estimate the numbers of persons per housing unit (2.5) and each housing unit was counted as one septic tank. This worksheet calculates the direct contribution of fecal coliform from septics to the Big Sioux River and are represented as a point source within the corresponding HUC12. The units used are total counts per day. The concentration in the stream would vary with flow rate.

Worksheet – "Storm Sewers D"
Potential fecal coliform contributions from municipal storm sewers was calculated for each HUC12 and segment of the Big Sioux River. This worksheet identifies all cities, their population, and potential bacterial loads.

Worksheet – "Accumulation by landuse D"
This worksheet calculates the per acre total buildup of fecal coliform for cropland, pastureland, forest, and built-up landuses for each month within each HUC12. Estimates for manure application rates, wildlife, grazing rates were taken from the "Cropland D", "Pastureland D", "Forest D", and "Built-up D" worksheets. This worksheet also assumes a buildup limit of 1.8 x daily buildup rate based literature values identified in the spreadsheet (see worksheet for exact formulas and reference cells).

Worksheet – "HUC12 monthly total loads D"
Calculates the total load for each landuse type for each HUC12 for each month. Simply mulitplies the number of acres of landuse type found within each HUC12 by the total coliform load per acre from that landuse type (fecal count per acre X acres of landuse).

Worksheet – "Delivery Coe"
To determine loadings from HUC12s a delivery coefficient was calculated for those HUC12s which were monitored during the course of 2002-2004. Discharge and fecal coliform concentrations were monitored for approximately three years. From the BIT tool the total possible coliform load was calculated for the field monitored HUC12s. This possible load was compared to the calculated or observed load. The observed load was based on a load duration curve calculated for each of the eleven monitoring sites (see load duration curves PowerPoint presentation LBS-Flow and WQ Analysis (tributary).ppt and Figure 3). Four flowzones were used for each monitoring site resulting in four delivery coefficients. Delivery coefficients were calculated on a per acre basis per flowzone. The surface area of each HUC12 was calculated and this area was multiplied by the individual flowzone delivery coefficient.

Worksheet – "total loads Apr-June-Oct"
The total loads for each HUC12 from all of the previously described worksheets are summed just for the months of April, June, and October to determine seasonality as well specifically for the recreational season for South Dakota Water Quality Standards (May 1-September 30).

Worksheet – "total loads"
Another worksheet showing the HUC12 total loads for each possible source for each month.

Worksheet – "WLA" and "WLA1"
These two worksheets were used to calculate the daily loadings from each NPDES facility within the Lower Big Sioux Watershed for South Dakota only.

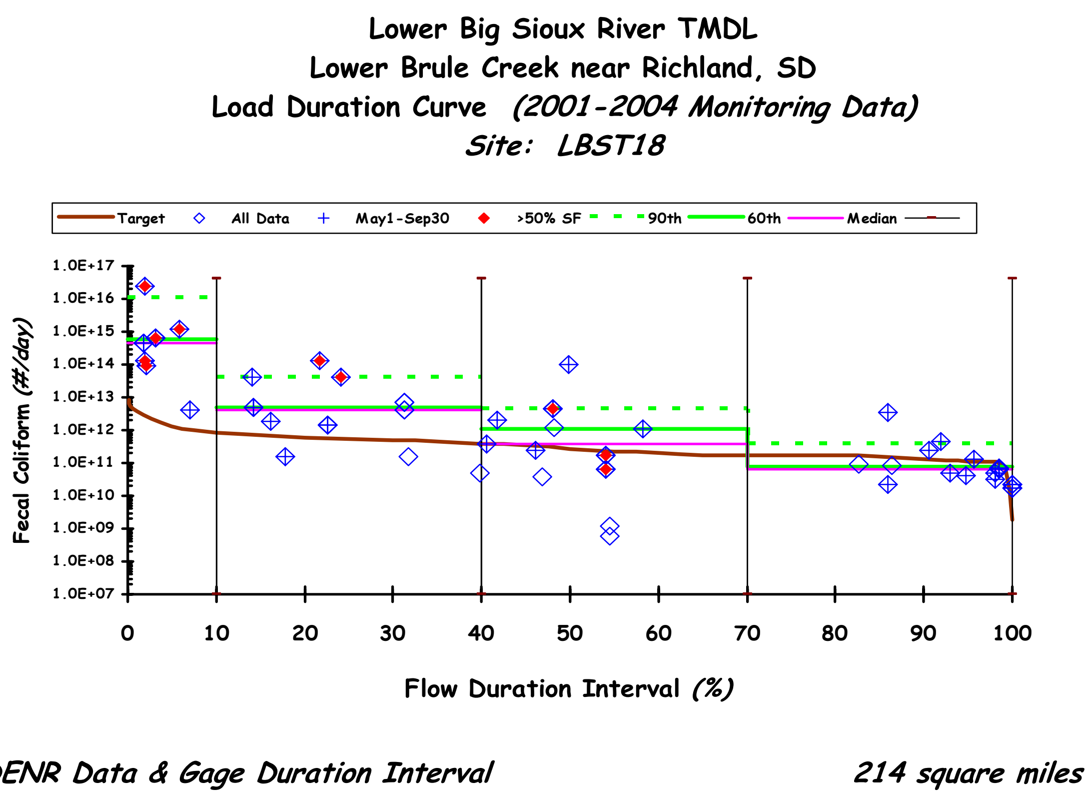


Figure 3

Load Duration Curves (Tributaries and Mainstems)

The two directories outlined below (Mainstem and Tributaries) show the individual load duration curves (LDC) for each of the 21 sites located in the Lower Big Sioux Watershed. There also three load duration curves for three sites monitoring part of the Central Big Sioux Watershed (see T28, T30, and T32) (Figure 4). These three sites were used to monitor streams draining directly from southwestern Minnesota and were used to document the total loads entering the Big Sioux from Minnesota HUC12s (see files “T28_T30_T32 Load Duration Intervals.xls”, and “Reductions for border sites.xls”).

In both the Tributary and Mainstem directories (Figure 4 and 5) there are PowerPoint presentations showing the individual load duration curves for each monitoring site. The 400 cfu/100ml daily maximum, which is the water quality standard for the immersion recreation beneficial use in South Dakota, was used to calculate the target load for all flow zones. A modified template originally based on Dr. Bruce Cleland’s series of spreadsheets he presented in training seminar for South Dakota, was used to calculate the load duration curves.

For both the tributaries and the mainstem there are four flow intervals. However, the mainstem flow and loading data resulted in 0-25%, 25-50%, 50-75%, 75-100% flow intervals whereas the tributaries resulted in 0-10%, 10-40%, 40-60%, 60-100% flow intervals. These breakouts of the flow data were based on the individual site analysis and seemed to assess the flow and sample distribution the best.

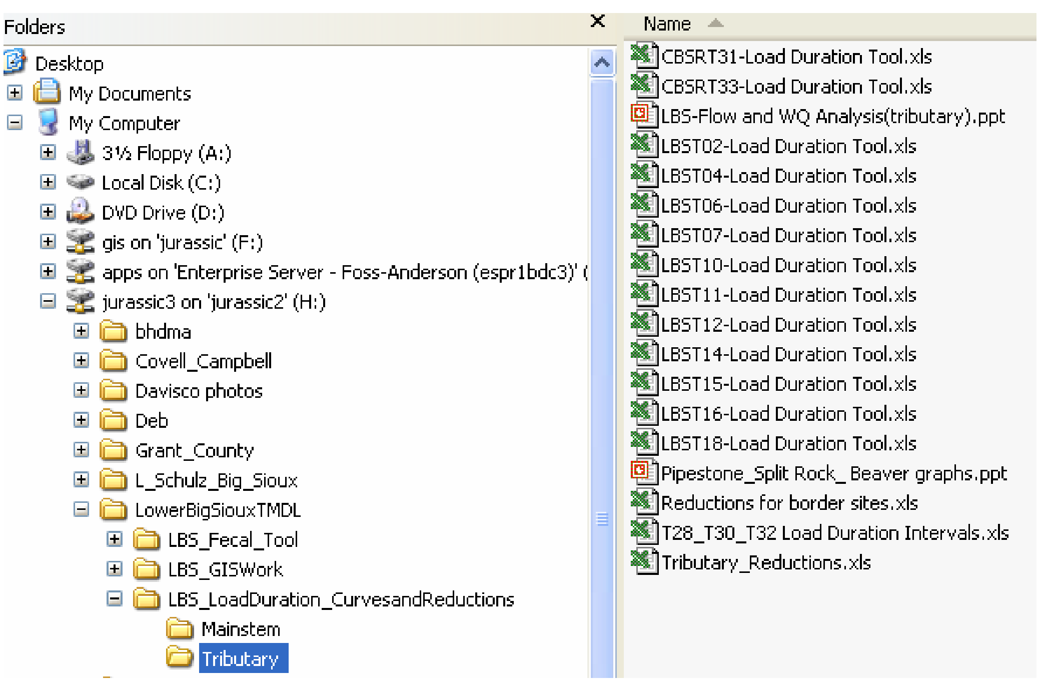


Figure 4. Files in Tributary Subdirectory.

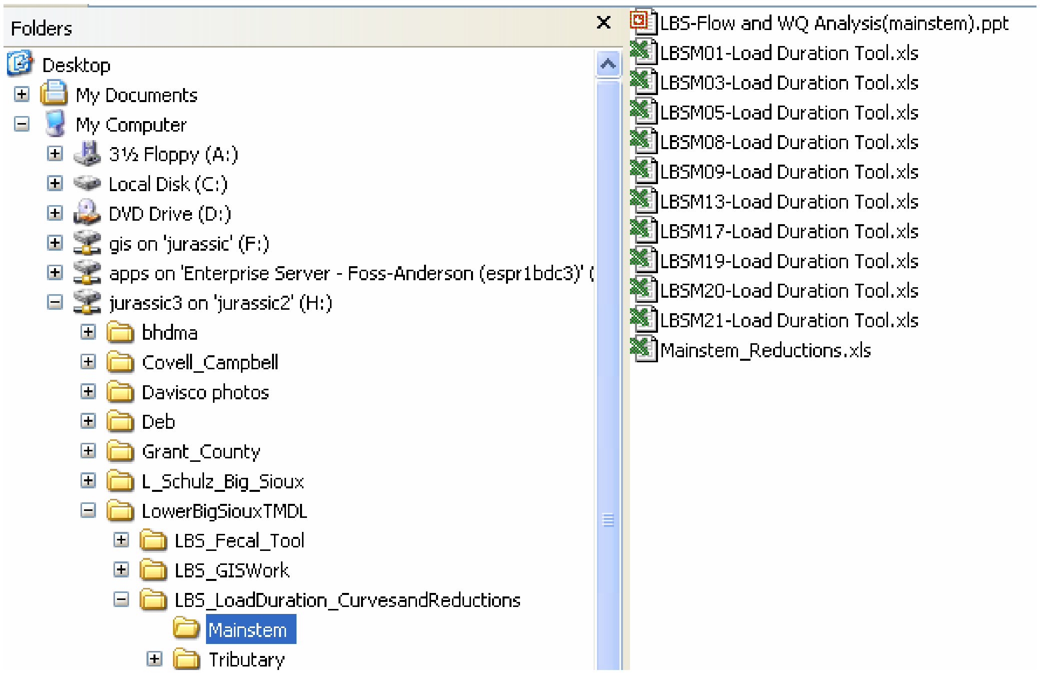


Figure 5. Files in Mainstem Subdirectory.

The load duration template developed in EXCEL and shown below was used for all the monitoring sites.

<u>Workbook – "LBSM01-Load Duration Tool.xls" (example)</u>

<u>Worksheet - "Reductions"</u>
When opening an individual site file workbook "LBS###-Load Duration Tool.xls", the first worksheet will be the "Reductions" worksheet which shows all of the reductions using the median concentration within each flowzone.

<u>Worksheet – "Siteinfo – Rawdata"</u>
The long term flows were ranked highest to lowest and percentiles were developed. The median flow and the corresponding load (median flow X 400 daily max concentration) for each flowzone can also be located in the worksheet (Cells I8-L12).

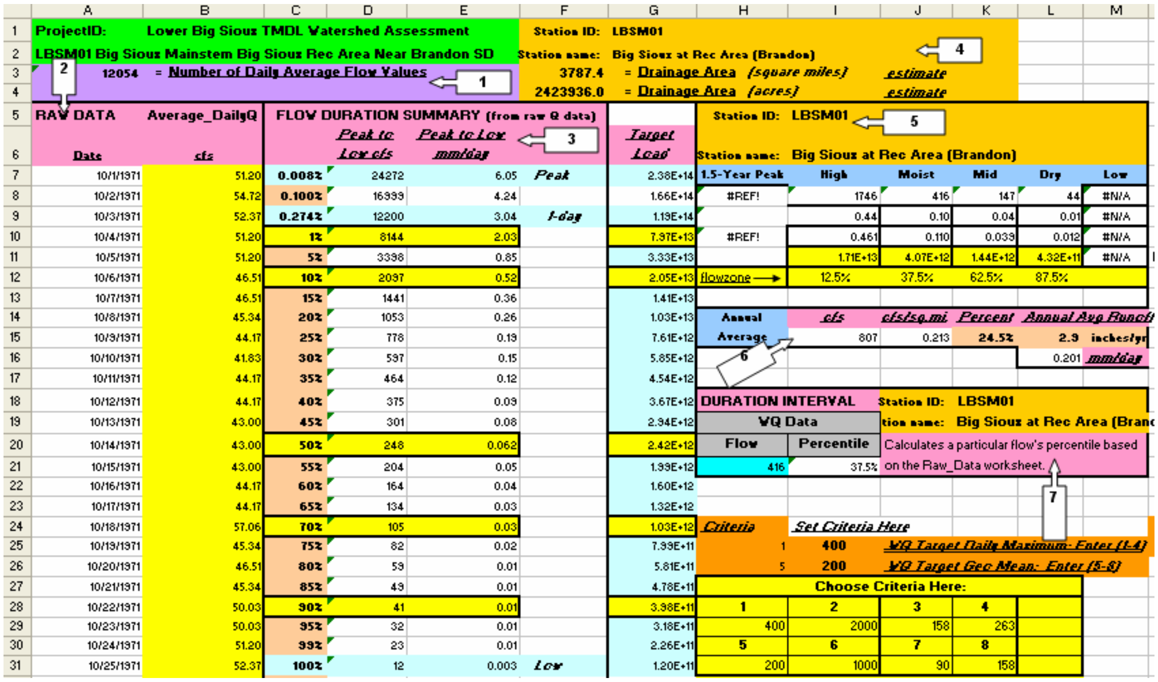


Figure 6. SiteInfo-Rawdata Worksheet.

Worksheet – "RawWQData"

The raw water quality data (fecal coliform, solids, and nutrients) are all shown in this particular worksheet (Figure 7).

	A	B	C	D	E	F	G	H
1	ActivityID	StationID	WQMID	Sample Da	Sample Tin	TSS (mg/L)	Fecal Coliform (CFU/100ml	NO2+NO3 (mg/L)
2	E02EC004071	LBSM01		7/3/2002	12:00:00 PM		290	
3	E02EC004173	LBSM01		7/9/2002	3:00:00 PM		240	
4	E02EC006395	LBSM01		9/10/2002	12:30:00 PM		90	
5	E02EC006941	LBSM01		9/23/2002	3:30:00 PM		5	
6	E03EC001559	LBSM01		3/24/2003	1:10:00 PM		1	
7	E03EC001560	LBSM01		3/24/2003	1:25:00 PM		2	
8	E03EC001561	LBSM01		3/24/2003	1:15:00 PM		1	
9	E03WB004274	LBSM01		4/21/2003	2:05:00 PM		630	
10	E03WB004275	LBSM01		4/21/2003	2:15:00 PM		9920	
11	E03EC003852	LBSM01		6/3/2003	10:00:00 AM		110	
12	E03EC004435	LBSM01		6/19/2003	2:00:00 PM		130	
13	E03WB007486	LBSM01		6/24/2003	12:20:00 PM		620	
14	E03WB006091	LBSM01		6/30/2003	8:00:00 AM		50	

Figure 7. Raw Water Quality Data worksheet in the "LBSM01-Load Duration Tool.xls" workbook used to develop the Load Duration Curves. Site LBSM01 is shown.

Worksheet – "GetflowVBTool"
This worksheet uses flowdata (Siteinfo-RawData) from each day a water quality sample was collected. A Visual Basic macro designed by Dr. Bruce Cleland is then used to calculate the one day change in flow (column C) and the %Stormflow (column D) based on methods described in the USGS computer program "HYSEP" (http://water.usgs.gov/cgi-bin/man_wrdapp?hysep).

	A	B	C	D	E
1	Date	Flow	Change	% Storm	
2	7/15/1974	48.85789	0.0000	12.0%	
3	8/4/1974	33.62202	-0.0009	0.0%	
4	9/17/1974	37.13799	0.0000	12.6%	
5	11/6/1974	40.65396	0.0000	14.4%	
6	12/9/1974	40.65396	0.0006	5.8%	
7	1/15/1975	38.30998	0.0003	15.3%	
8	2/10/1975	37.13799	0.0009	9.5%	
9	3/18/1975	53.54585	0.0000	19.7%	
10	4/15/1975	671.1846	0.0377	50.8%	
11	5/6/1975	426.2387	-0.0079	22.0%	
12	6/11/1975	126.2092	0.0015	16.7%	

Figure 8. GetFlowVBTool Worksheet.

Worksheet – "WQ_Data_loadgraphinPPT"
Each fecal coliform sample and its corresponding daily average flow is shown in this worksheet along with the calculated flowrank (column G). The %Stormflow and 1-day change in flow calculated in the previous spreadsheet are also used in this worksheet. Each sample load (column P) is then identified or "flagged" with a "***" in relation to the sample date (column S) and exceeding the %Stormflow threshold of 50% (column T). The remaining columns in this worksheet are setup so that they are directly copied over to the "PPTCOPY for Load Duration Graph".

	B	D	E	F	G	I	L	M	N	P	S	T	U	V	W
1				Stream Name	Big Sioux at Rec Area (Brand										1.36E+14
2				Site ID	LBSM01										7.26E+12
3				USGS Gage	XXXXX						Season:	Stormflow:	Year:		1.66E+14
4				8-Digit HUC	10170102						M	Threshhold	Jan-56		6.76E+11
5				Drainage Area	3787.4			Stormflow			to	50%	to		62
6								Indicators			S	0.10	Dec-65		
7	StationID	Sample Date	Sample Time	Flow (cfs)	Flow Rank	Fecal Coliform (CFU/100mL)	1-day Change in Flow (mm)	Stormflow (%)	1-day Change in Flow (cfs)	Fecal Coliform Load	Flag	Flag	Flag	Flow Rank (%)	Value
8	LBSM01	7/3/2002	12:00:00 PM	149.65	62.4%	29.1	-0.002	25.8%		1.07E+11	---		---	62.4	1.07E+11
9	LBSM01	7/9/2002	3:00:00 PM	114.49	68.4%	240	0.001	7.2%	3.5	6.72E+11	---		---	68.4	6.72E+11
10	LBSM01	9/10/2002	12:30:00 PM	89.88	73.1%	90	-0.001	9.1%		1.98E+11	---		---	73.1	1.98E+11
11	LBSM01	9/23/2002	3:30:00 PM	74.64	76.8%	5	0.000	4.7%		9.13E+09	---		---	76.8	9.13E+09
12	LBSM01	3/24/2003	1:10:00 PM	587.97	30.3%	1	-0.036	50.6%		1.44E+10		---	---	30.3	1.44E+10
13	LBSM01	3/24/2003	1:25:00 PM	587.97	30.3%	2	-0.036	50.6%		2.88E+10		---	---	30.3	2.88E+10
14	LBSM01	3/24/2003	1:15:00 PM	587.97	30.3%	1	-0.036	50.6%		1.44E+10		---	---	30.3	1.44E+10
15	LBSM01	4/21/2003	2:05:00 PM	904.41	22.4%	630	-0.017	70.4%		**1.39E+13**		---	---	**22.4**	1.39E+13
16	LBSM01	4/21/2003	2:15:00 PM	904.41	22.4%	9920	-0.017	70.4%		2.20E+14		---	---	22.4	2.20E+14
17	LBSM01	6/3/2003	10:00:00 AM	209.42	54.2%	110	-0.003	0.6%		5.64E+11	---		---	54.2	5.64E+11
18	LBSM01	6/19/2003	2:00:00 PM	135.59	64.8%	130	-0.004	4.3%		4.31E+11	---		---	64.8	4.31E+11

Figure 9. Worksheet “WQ_Data_loadgraphinPPT”

<u>Worksheet – “WQ_Data_concentrationgraphinPPT”</u>
This worksheet is setup in the same manner as the previous one. However, it uses concentration rather than bacterial load. The results from this worksheet are automatically copied to the “PPTCOPY for WQDuration Graph” worksheet.

<u>Worksheet – “PPTCOPY for Load Duration Graph” and “PPTCOPY for WQ Duration Graph”</u>
Both of these worksheets were copied directly into the datasheets behind each graph found in the “LBS-Flow and WQ Analysis(mainstem).ppt” and “LBS-Flow and WQ Analysis(tributary).ppt” files (Figure 10).

	A	B	C	D	E	F	G	H	I
1	% > Load	Target	All Data	May1-Sep3(	>50% SF	90th	60th	Median	
2	0.008	2.38E+14							
3	0.100	1.66E+14							
4	0.274	1.19E+14							
5	1	7.97E+13							
6	5	3.33E+13							
7	10	2.05E+13							
8	15	1.41E+13							
9	20	1.03E+13							
10	25	7.61E+12							
11	30	5.85E+12							
12	35	4.54E+12							
13	40	3.67E+12							
14	45	2.94E+12							
15	50	2.42E+12							
16	55	1.99E+12							
17	60	1.60E+12							
18	65	1.32E+12							
19	70	1.03E+12							
20	75	7.99E+11							
21	80	5.81E+11							
22	85	4.78E+11							
23	90	3.98E+11							
24	95	3.18E+11							
25	99	2.26E+11							
26	100	1.20E+11							
27									
28	0					9.24E+14	2.20E+14	5.10E+13	

Figure 10. Worksheet – "PPTCOPY for Load Duration Graph"

Appendix F, Public Notice Comments and Response to Comments for South Dakota

These are the comments received during the public notice period from South Dakota Stakeholders.

-----Original Message-----
From: Berry.Vern@epamail.epa.gov [mailto:Berry.Vern@epamail.epa.gov]
Sent: Thursday, September 06, 2007 12:13 PM
To: Stueven, Gene
Cc: Ruppel.James@epamail.epa.gov
Subject: EPA Comments on LBS TMDLs

Gene,

Thank-you for the opportunity to review the Lower Big Sioux TMDLs for pathogens during the public notice period. We recognize that it has been a long and difficult process to get to this point and we commend SD DENR for their hard work in gathering the data and information needed to go into this document. Many of the previous issues that we have discussed have been addressed. Although this document may not completely meet the needs for each state, it does contain the required elements of a TMDL. We have one remaining concern related to this TMDL document that is related to this transboundary water body.

As a transboundary water body, the TMDLs for the Lower Big Sioux River need to ensure compliance with the applicable water quality standards (WQS) for both SD and IA. If the WQS for one of the states is more stringent than the other state, then that standard must be met on both sides of the river and should be the basis of the TMDL targets. The draft LBS TMDL document lists the WQS for both IA and SD as the TMDL targets, but does not mention which one is more stringent and how the TMDL loads will meet the most stringent standards. Based on the information in the document it appears that although IA's WQS are currently expressed as E. coli values, they typically translate them to fecal coliform for purposes of implementation. IA's translated fecal coliform values are very similar to SD's fecal coliform WQS except for the length of the season. IA's primary contact recreation season runs from March 15 to November 15, whereas SD's immersion recreation season runs from May 1 - September 30. In this sense, IA's WQS are more stringent (i.e., longer recreation season). This needs to be highlighted in the final TMDL document and it needs to be made clear that the TMDL loads (i.e., WLAs, LAs, MOS) will meet the more stringent standards.

Further, the draft TMDL document says that SD's NPDES permits for discharges that drain to the Lower Big Sioux river are currently written to comply with the SD WQS. That is they have permit limits for fecal coliform that are in effect from May 1 - September 30. The final TMDL document needs to include some explanation, perhaps in the Implementation Plan section, of how the discharges from these permitted facilities are complying with the more stringent IA recreation season, or include a plan to modify the permits to ensure compliance with IA's longer recreational season.

Please contact me if you have any questions about these comments.

Vern Berry
Environmental Engineer
US EPA Region 8
Denver, CO
303-312-6234

Response to Comments:
It is noted that Iowa's recreational season is longer, and, therefore, the TMDL loads must meet this more stringent standard.

The load allocations are based on the assumption that all discharges into the Big Sioux River from all sources must meet the single sample water quality standard of 235 *E. coli* organisms/100 ml or 400 fecal coliform/100 ml converted to a daily load. As is outlined in the comments above IA's translated fecal coliform values are very similar to SD's fecal coliform WQS except for the length of the season. The implementation of the TMDL will result in the installation of the BMPs with the longer recreational season in mind, i.e. year round treatment.

Since the water quality data was reported as fecal coliform, the *E.coli* loads were estimated by multiplying the fecal coliform concentration by a conversion factor derived from the single maximum standards for these pathogen indicators (i.e. 235 E.coli/400 fecal coliform = 0.5875).

Language has been added to the South Dakota Section of the Implementation Plan (pages 117-118) regarding the longer recreational season.and the NPDES permits.

Appendix G, Public Notice Comments and Response to Comments for Iowa

September 7, 2007

Mr. William Graham
Technical Development
Watershed Quality Improvement Section
Iowa Department of Natural Resources
502 E. 9th Street, Des Moines, IA 50319-0034

RE: Big Sioux River Total maximum Daily Load

Dear Mr. Graham:

The Iowa Farm Bureau Federation (IFBF), the state's largest general farm organization with more than 154,000 members, would like to provide these comments regarding the draft Total Maximum Daily Load for the Big Sioux River bacteria impairments.

The draft plan indicates that controlling livestock manure runoff and cattle in streams will need to be a large part of a plan to reduce bacteria. Best management practices identified in the Implementation Plan include feedlot runoff control, fencing off livestock from streams, alternative livestock watering supplies, and installing buffer strips along the river and tributary corridors to slow and divert runoff. In addition, failed septic tanks need to be repaired and wastewater treatment plants need to control the bacteria in their effluent.

The impaired segments in Iowa are 1,436 square miles and include 125 miles of stream length from the Iowa-Minnesota border to the Missouri River confluence. The pollutant sources on the Iowa part of this impaired segment consist of the upstream loads from South Dakota and Minnesota, loads from four wastewater treatment plants, and non-point sources discharging from this segment's eight HUC 12 sub-watersheds.

This is clearly the most complex, technically challenging TMDL drafted by the department to date. Removing the impairment will take extensive resources and cooperation by multiple stakeholders in three states. A combination of strategic management actions may, with time and resources, begin to help restore the Big Sioux to its water quality standards. The DNR should state in the TMDL, however, that realistically, it may take years to begin to address this impairment, let alone remove the impairment.

Limited Monitoring

However, the department acknowledges in the Monitoring section on page 118 that the proposed monitoring plan for the Big Sioux basin will provide only minimal information for water quality assessment and evaluation of the effectiveness of watershed best management practices. Farm

Bureau policy supports all stakeholders in the watershed taking responsible and proactive approaches to optimize best management practices, but the lack of comprehensive watershed planning, assessment and monitoring will limit the TMDL's second phase of stakeholder driven solutions and attainment of water quality standards. In other words, in its current form, the information provided so far will be of limited value to a local group when trying to decide where to begin.

Modeling Procedures & Assumptions

Models and spreadsheets such as The Modified Bacteria Indicator Tool (BIT) permit users to separate the watershed spatially, and bacteria loads spatially and temporally, although this capacity is limited. The models are also limited in their ability to simulate bacterial life cycles, interaction with potential nutrient (food) sources and bacteria concentrations during extreme climatic conditions seen in Iowa. These limitations need to be discussed in the body of the TMDL so citizens begin to understand the potential variability of the load and waste load allocations and necessary reductions. This may also be compounded by the conversion of E. Coil to fecal coliform ratios.

This discussion should also include what can be found in the published scientific literature with respect to model strengths and weaknesses. Citizens should understand that these models can be useful for educational opportunities for both stakeholders.

While the load duration method used by these models may be a good representation of overall water quality and needed water quality improvement, the intra-watershed bacteria contributions must be determined through supplemental sampling or through subsequent hydrologic and water quality modeling. Published identified research needs for these models to make them more reliable for TMDLs include improved bacteria source characterization procedures (it is difficult to distinguish between human and animal sources) and supporting monitoring data. The lack of a comprehensive monitoring plan has already been discussed, but this limitation in amplified when considering the model limitations.

To limit this weakness in the future, the department should contract for an independent model analysis under existing Iowa conditions. This will help improve model accuracy, increase stakeholder support and limit inefficient allocation of scarce resources implementation activities.

Wildlife, Septic Tanks and Wastewater Bypasses

One of the sources of impairments mentioned in the draft TMDL is bacteria from wildlife. The DNR clearly recognizes their contribution to the impairment. However, the Implementation Plan fails to suggest any action the DNR will take that will help address this source. The DNR needs to identify the possible steps it will take to control this source, as it does for other nonpoint sources, in its final TMDL.

In the Implementation Plan section, there is no mention of a suggested approach to private septic tanks. This needs to be further developed to provide balance to possible solutions.

Wastewater bypasses are also not mentioned. How will these high-flow conditions impact the estimated loading and implementation plan? This needs to be discussed.

Also, this TMDL lacks the General Report Summary at the beginning that was included in the Milford Creek TMDL. Including this type of summary would be a good addition that may aid citizens in their understanding of the main issues, load sources and reduction targets. This would also be complementary to the summary table on page 1. In addition, this would be a good place to start the discussion about this being a staged TMDL and that it will be a long period of time before goals are reached.

Local Watershed Advisory Committee

The IFBF does, however, support creation of a local watershed advisory committee, as described in the Implementation Plan, which could help identify high priority areas within the Big Sioux River watershed where very limited resources can result in the most benefit. Should adequate monitoring someday become available, this will help ensure that solutions identified will not place crop and livestock farmers are treated equitably and not place them at a competitive disadvantage.

In addition, such a committee can help prioritize the best management practices and funding sources for implementation. In addition, these committees may need to coordinate with other sub-watersheds/impaired segments in Iowa, South Dakota and Minnesota.

For the urban point source needs, the IFBF would support expanded use of a variety of urban storm water best management practices that are being used in the region, but with limited monitoring data, it will be difficult to target where to begin. The IFBF commits to working with the county Farm Bureaus in the basin and their partners in any way we can to secure the funding and expertise necessary to expand the voluntary use and adoption of these BMPs. The IFBF has grants that can be used to support voluntary watershed education and demonstration efforts. We would also support application to other funding sources if a plan can be developed that is consistent with IFBF voluntary watershed education and demonstration policy.

Farm Bureau Policy & Related Issues

Farm Bureau emphasizes our support for the funding of incentive programs that assist farmers in achieving water quality goals. Farm Bureau policy supports voluntary incentive-based approaches based on sound scientific information, technical assistance to landowners and site-specific flexibility. We support a TMDL program that would require:

- The use of monitoring data (not just evaluated data) in determining impairments and sources of impairment;

- The determination, allocation and inclusion of background, natural and/or legacy levels in impairments;
- Use attainability analysis on all waters before initial listing and/or implementation of TMDLs;
- Complete agricultural participation in the listing, assessment, development and implementation of a TMDL;
- Good general public participation;
- Quantitative long-term data to evaluate success;
- A comprehensive watershed and source water monitoring program;
- Acknowledgement of previously adopted conservation measures; and
- Implementation strategies targeted at all sources.

Also, other IFBF programs may be useful in this effort. The IFBF supports the work of Trees Forever, a private nonprofit based in Marion, Iowa. Part of what they do is work with rural and urban partners to demonstrate and place trees, grasses and shrubs in locations that can benefit conditions and needs of the Big Sioux basin.

Another program that may be useful to promote is the availability of Farm*A*Syst. This is a farmstead and rural resident assessment system developed to protect water resources. Each of the 12 units available free online gives you a brief background on the subject, such as on-farm septic tanks and private well conditions, and an assessment worksheet to evaluate their affect on local water quality. Also included are references to Iowa environmental laws and contact information for technical advice. In the past, the IFBF has also sponsored local training session for those local professionals who may want to use these or promote their use to others. More information on this program can be found at Iowafarmasyst.com.

Longer-term, the IFBF is working at the state level to secure additional funding for voluntary conservation programs that may need to be used here. The IFBF is also a member of the Watershed Quality Planning Task Force that will make recommendations to the Iowa Legislature in January regarding ways to improve watershed efforts like the one needed here at the Big Sioux Basin. One of those recommendations may deal with pollution credit trading, a way that nonpoint sources may one day be able to help reduce the cost of reductions that permitted point sources may have to make in these federally required watershed plans.

We continue to have concerns about general issues that may have serious long-term impacts on draft TMDLs, the IDNR's TMDL program and the ability of agriculture to successfully deal with these issues in a voluntary fashion. Our overall concerns continue to remain that there is not a clear plan for initial field assessment, long-term monitoring, and model calibration with TMDLs in Iowa. These are critical questions that need to be considered and resolved.

Other concerns have been documented in detail in our previous recent comments, including: Use of the trophic state index in lieu of approved state water quality standards and approved numeric criteria; establishment of arbitrary endpoints that result in defacto water quality standards; a lack of a comprehensive cost-benefit analysis for each TMDL; and no apparent consideration of the useful life of the waterbody and other physical features of impaired waters.

In addition, the nonpoint source TMDLs we have previously commented on need to include more specific assurances in the Implementation Plan sections that load allocations will be achieved using incentive-based, non-regulatory approaches. As stated in other previous TMDLs with NPS contributions, these sections should also include specific assurances from DNR that TMDL implementation is dependent on application of available technology as much as is practicable by landowners and farmers in the watersheds, and availability of financial resources from the Clean Water Act Section 319 Nonpoint Source Management Program, Iowa Department of Agriculture and Land Stewardship cost-share programs, and USDA-NRCS cost-share programs.

The Implementation Plan sections should also explicitly state that load allocations should be recognized as planning and implementation guides and are not subject to EPA approval.

The IFBF again thanks you for the opportunity to comment and asks for your serious consideration of these issues so that long-term success is ensured for the citizens of Iowa and the agricultural nonpoint source community. If you have any questions, please contact me at 225-5432.

Sincerely,

Rick Robinson
Environmental Policy Advisor

Cc: Allen Bonini

September 21, 2007

Rick Robinson
Iowa Farm Bureau Federation
5400 University Ave
West Des Moines, IA 50266

Dear Mr. Robinson:

Thank you for your interest and comments on the Draft TMDL for the Big Sioux River. Below are IDNR responses to your comment letter dated September 7, 2007.

First, we feel it is necessary to clarify two facts cited in your letter. Your letter states that there are four wastewater treatment plants on the Iowa side, and nonpoint source drainage from eight HUC 12 sub-watersheds. There are actually nineteen (19) NPDES permitted wastewater treatment facilities in the Iowa portion of the Big Sioux River watershed (Tables 3.4 and 3.5). In addition, the Big Sioux River drains forty-eight (48) HUC 12 sub-watersheds in Iowa, not eight, representing 1,436 square miles.

We recognize, as Iowa Farm Bureau does, that removing the impairment will take extensive resources and interstate cooperation among stakeholders. IDNR also recognizes that this impairment did not occur overnight, and will likely require years to begin to address and eventually remove.

IDNR also agrees with IFBF that the limited water quality data and information available for the Big Sioux basin does not provide the type of detailed information that a local group would require to accurately prioritize areas and practices. However, the TMDL does identify that livestock and manure application are the primary sources of the bacteria impairment in the River. In addition, future water quality projects and development grants funded with CWA Section 319 funds will be required to have a water monitoring component to them, which will hopefully help to fill in some of the data gaps. Local watershed groups are encouraged to work with the DNR and its funding partners to pursue development grant funds to further assess targeted subwatersheds. These efforts can help identify potential strategies to begin addressing this impairment.

Under the heading of "Modeling Procedures and Assumptions" in your letter, you indicate that the model limitations should be discussed in the body of the TMDL, and that confusion may also occur due to the conversion of fecal coliform to *E. Coli*. Appendix B, *Procedures and Assumptions for Iowa TMDL Calculations*, describes the assumptions taken into consideration and the procedures followed in utilizing the Bacteria Indicator Tool. The Appendix also summarizes the change in water quality standards from fecal coliform to *E. Coli*, and the process and assumptions used in converting data.

IFBF also suggests that the department should contract for an independent model analysis under existing Iowa conditions. In 2005, IDNR contracted with the Agriculture and Biosystems Engineering Department at Iowa State University to conduct this type of analysis in a report titled "*Assessment, Calibration, and Evaluation of Water Quality Models for Estimating Urban and Agricultural Pollutant Discharge from Iowa Watersheds*". This analysis reviewed the strengths and weaknesses of over 100 models for use in TMDL development. The report also verified the need for more real-world data for use in calibration of the models. To this end, the TMDL program and Water Monitoring Section annually design monitoring strategies to provide the necessary data for accurate model use. This process is continually being enhanced, resulting in higher level confidence modeling as the TMDL program matures.

In the Section titled *Wildlife, Septic Tanks, and Wastewater Bypasses*, you indicate that the Implementation Plan does not address the possible steps to minimize the bacteria contribution from wildlife. The contribution from wildlife is representative of background contributions, and at its highest levels, accounts for approximately 0.02% of the bacteria load. Concentrating resources and effort on addressing the wildlife sources will result in negligible changes in the bacteria levels in the Big Sioux River.

Your letter also indicates that the TMDL needs to suggest an approach to dealing with the upgrade of private septic systems. The enforcement of the construction and maintenance of septic systems is delegated to the individual counties. A sentence has been added to the Implementation section to clarify this issue.

Wastewater bypasses are not specifically mentioned in the TMDL because the facilities are NPDES permitted and loads from these facilities were included in the point source calculations.

Your comments on the General Report Summary are acknowledged and appreciated. The TMDL program has been revising the TMDL documents to make them easier to read and understand. However, the Big Sioux River Draft TMDL was completed prior to these recent formatting changes and did not include the General Report Summary. Future TMDL documents will continue to include the General Report Summary and other formatting changes designed to make the documents more accessible.

Your letter also indicates that IFBF continues to have concerns over initial field assessments, long term monitoring, and model calibration. As a general rule, the TMDL program obtains field level data for each watershed that is being addressed. Clearly this has not occurred on the much larger scale of the Big Sioux River, but this type of data is collected for smaller watersheds. Data that is collected includes land use, management practices, conservation structures, condition of pasture, and livestock access to streams. This past year the NPS 319 Program and DSC have begun to accept development grant applications on a continual basis. These grants are often used for field and stream assessments and identification of priority areas and needed practices prior to submitting grant applications. With the EPA Consent Decree ending in the near future, the TMDL program has been able to align more with areas of local support and interest and with the priorities of other agency programs.

Your concern over long-term monitoring is shared by the DNR. There simply are not the resources available to conduct the needed ambient monitoring, targeted monitoring for TMDL development, and follow-up monitoring upon the completion of the TMDLs. Section 5 of the TMDL tries to highlight this issue and present a comprehensive monitoring plan should resources become available. Model calibration is, of course, based on the available data. Obviously the more data available, the better the modeling effort will be. Our annual monitoring plans take into account the data needed for modeling so that we can collect the data most valuable to the model. This is a continually improving process, but one we feel is the right direction and has been making progress over the past several years.

The IFBF comment letters continue to raise such issues as the use of the trophic state index (which was not used in this TMDL), the need for a cost-benefit analysis for each TMDL, and the belief that there is a need to consider the useful life of a waterbody. IDNR believes that these issues have been adequately addressed in previous replies, and refer you to those previous responses for further clarification.

In closing, we feel it is important to again address one comment that is near the end of your letter and which has appeared in many of your previous comment letters related to TMDLs with nonpoint source components. In your letter you request that the implementation section should state that the load allocations are not subject to EPA approval. EPA's regulations for total maximum daily loads and individual water quality-based effluent limitations are found in 40 CFR §130.7. This regulation states that "All TMDLs established under paragraph [130.7](c) for water quality limited segments shall continue to be submitted to EPA for review and approval".[1] WLAs and LAs are part of TMDLs, therefore including a statement as you have suggested would be inaccurate and violate federal regulations. (See 57 FR 33040-01)

Thank you again for taking the time to comment on the draft TMDL for the Big Sioux River. Your comments and this response will be included with the finalized TMDL submitted to the EPA Region VII office in Kansas City for approval. If you have any questions please contact Chris Van Gorp at 515-281-4791.

Sincerely,

Allen P. Bonini, Supervisor
Watershed Improvement Section

[1] In 57 FR 33040-01, EPA made it clear that the deletion of WLAs and LAs from 40 CFR 130,7(d) was a non-substantive change. The relevant portion of that Federal Register reads as follows:

> EPA is today making *non-substantive clarifying corrections* to its regulations in part 130 to amend repeated references to 'WLAs/LAs and TMDLs' to read 'TMDLs.' EPA had clearly stated in its definition of WLAs, LAs and TMDLs, and in the preamble to the 1985 final rule establishing part 130, that WLAs and LAs are part of a TMDL. See 50 FR 1775. Accordingly, the references to WLAs and LAs in these passages are not necessary. Since these changes are not substantive, and serve only to clarify existing requirements, EPA finds that notice and comment proceedings regarding these changes are unnecessary. Furthermore, the changes are in the nature of interpretive amendments to EPA rules, which are exempt from notice and comment requirements.

57 FR 33040-01 (emphasis added).