

ANALYSIS OF
BIG SLOUGH CREEK
TOWN OF ROSHOLT
&
NORTH COUNTRY ETHANOL, LLC
ROBERTS COUNTY, SOUTH DAKOTA

SEPTEMBER 2006

SOUTH DAKOTA
DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL SERVICES
PIERRE, SD

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Executive Summary

Name of Waterbody: Big Slough Creek.

Location: Roberts County, South Dakota.

Boundary of Waterbody under Assessment:

Big Slough Creek from County Road 7, Section 13, Township 128 North, Range 49 West, Roberts County to the confluence with the Bois de Sioux River in Section 17, Township 128 North, Range 47 West, Roberts County.

Condition/Description of Creek Segment: Department of Environment and Natural Resources (DENR) personnel assessed Big Slough Creek on three separate occasions: November 6, 2001, May 4 and 5, 2005, and September 28 and 29, 2005.

Big Slough Creek had flow on all sampling occasions and fish were collected at each sampling site on at least one sampling occasion.

Recommendation:

It is recommended that the assigned beneficial use classification of Big Slough Creek from Section 13, Township 128 North, Range 49 West, Roberts County to the confluence with Bois de Sioux River in Section 17, Range 128 North, Range 47 West, Roberts County be upgraded to include (5) Warmwater semipermanent fish life propagation water; and (8) Limited contact recreation waters.

Introduction

Rosholt is a small community located in northeastern South Dakota. Based upon the 2000 census, its population is 419. Rosholt's wastewater treatment facility (WWTF) is located in the northwest ¼ Section 18, Township 128 North, Range 48 West, Roberts County, South Dakota. The facility receives wastewater from residential users and flows to a 5.5 acre two-cell stabilization pond system, followed by a 5.25 acre artificial wetland. The wetland has a retention time of 14 days and the entire system has a storage capacity of 150 days. The treated wastewater is discharged from the wetland and flows about 1/8 mile in an unnamed tributary of Big Slough Creek, then flows approximately eight miles through Big Slough Creek to the Bois de Sioux River.

North Country Ethanol Company, LLC owns and operates an ethanol production facility northeast of Rosholt in the northwest ¼ of Section 18, Township 128 North, Range 48 West, Roberts County, South Dakota. North Country Ethanol discharges non-process wastewater including reverse osmosis reject water and cooling tower blowdown water. The non-process wastewater is discharged through a pipe to a road ditch where it flows approximately ½ mile before entering Big Slough Creek, then flows approximately eight miles to the Bois de Sioux River.

General Waterbody/Drainage Area Description

Surface Water

Big Slough Creek originates north of the town of New Effington, South Dakota, and flows approximately four miles northeast, then flows another six miles southeast into a wetland. The wetland is about three miles in length running west to east. The wetland overflows about one mile west of Rosholt and Big Slough Creek continues to flow in an easterly direction until the confluence with the Bois de Sioux River.

The drainage basin area of the segment of Big Slough Creek that is under review includes approximately 45 square miles. Big Slough Creek drains into the Bois de Sioux River, which is a tributary of the Red River, and included in the Souris-Red-Rainy River Basin.

Current Assigned Beneficial Use

Big Slough Creek is assigned the beneficial use classification for (9) Fish and wildlife propagation, recreation, and stock watering waters; and (10) Irrigation waters, from its origin in Section 9, Township 128 North, Range 50 West, Roberts County through Section 17, Township 128 North, Range 47 West, Roberts County.

National Wetlands Inventory

Within the segment of creek under review, about 80 percent of Big Slough Creek is classified as containing wetland areas. Near Rosholt and extending about four miles east, Big Slough Creek is classified by the National Wetlands Inventory as palustrine wetlands that are mostly emergent, and are temporarily and semipermanently flooded.

From the Bois de Sioux River extending about two miles west, several types of wetlands dominate the area surrounding Big Slough Creek and are defined as palustrine systems of the emergent class. These wetland areas are defined as temporarily, seasonally, and semipermanently flooded. Other types of wetlands in the area include palustrine systems of the aquatic bed class that is intermittently exposed and semipermanently flooded.

Palustrine systems include all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens. These wetlands are less than 20 acres in size, lack wave-formed or bedrock shoreline features, and at the deepest are less than 2 meters.

The emergent wetland class is characterized by erect, herbaceous hydrophytes (trees, shrubs, persistent emergents), excluding mosses and lichens. The aquatic bed class includes wetlands and deepwater habitats dominated by plants that grow on or below the surface of the water for most of the growing season in most years.

The temporarily flooded water regime can have surface water present for brief periods during the growing season, but the water table usually lies well below the soil surface. Seasonally flooded water regimes contain surface water for extended periods of time typically early in the growing season and are often absent by the end of the growing season. When surface water is absent, the

water table is typically near the land surface. Semipermanently flooded water regimes often contain surface water throughout most of the growing season in most years. When surface water is absent, the water table is often at or near the land surface. Intermittently exposed water regimes are areas that contain surface water throughout the year except in years of extreme drought.

Geology and Ground Water

The Rosholt aquifer is located in northeast Roberts County and underlies Big Slough Creek from its origin north of New Effington to the wetland areas west of the Bois de Sioux River. The aquifer is near land surface along the wetland area west of Rosholt. Available data suggest ground water may surface in the wetland west of Rosholt and contribute to the flow of Big Slough Creek. The Fairmount aquifer also underlies portions of Roberts County including Big Slough Creek; however, the depth from land surface to the top of the Fairmount aquifer is such that the aquifer does not contribute ground water to the wetland or Big Slough Creek.

The segment of Big Slough Creek under review flows through three soil associations: the Eckman-Poinsett-Heimdal association, the Fordville-Sioux-Renshaw association, and the Doran-Lindass-Hamerly association. Attachment 2 is a map that outlines the soil associations underlying the segment under review of Big Slough Creek.

The Eckman-Poinsett-Heimdal association is within the segment under review from the beginning of the segment at County Road 7 to approximately Site #2 on 475th Avenue. This association is characterized by well-drained, nearly level to sloping, silty to loamy soils formed in glacial drift and lacustrine silts. The association is a smooth ground moraine with large flats and sloughs interspersed within; the drainage pattern is poorly defined and often ends in sloughs, small lakes, potholes or depressions. Most soil types within this association are conducive to growing crops, however some soils in steeper areas or poorly drained areas may be used for grazing or hayland.

The Fordville-Sioux-Renshaw association extends from west of 475th Avenue nearly two miles east and is characterized by excessively to well-drained, nearly level to steep soils, underlain by sand and gravel. This association consists mainly of glacial outwash moraines and plains containing a few small lakes, sloughs, and potholes. About fifty percent is cultivated and well suited for small grain crops. Steeper areas and poorly drained areas are often used for grazing or hayland.

The Doran-Lindass-Hamerly association extends from about a quarter mile east of 476th Avenue until the confluence with the Bois de Sioux River. The Doran-Lindass-Hamerly association consists of deep, poorly drained, nearly level, loamy soils. The content of organic matter is high, fertility is medium to high, and water permeability and runoff is slow. Most areas of this soil association are cultivated and used for grains, corn, soybean, and alfalfa.

DENR Assessment Results

On November 6, 2001, May 4 and 5, 2005, and September 28 and 29, 2005, DENR personnel visited the Rosholt area to assess Big Slough Creek.

Site #1 is on Big Slough Creek and is located about ½ mile north of Rosholt on County Road 7.

Site #1 is located upstream from each of the separate tributaries into which North Country Ethanol and the town of Rosholt discharge wastewater. Attachments 3 and 4 are photographs taken September 28, 2005, showing the flowing creek channel. Attachment 1 is a site map.

Field water quality measurements were taken, and water samples were collected for laboratory analysis. Results indicate water quality meets standards assigned for the current and proposed beneficial uses. Attachments 16 through 21 are summaries of water quality data.

Site #1 was flowing on all three visits. On November 6, 2001, channel width measured 15 feet, maximum depth was 1.3 feet, and flow was approximately 3.17 cfs. On September 28, 2005, the channel width measured 12.5 feet, maximum depth measured 1.7 feet, and flow measured 12.74 cfs. The flow was not measured in May 2005. Attachments 22 and 25 contain flow data for Site #1.

Fish were collected on November 6, 2001, and May 4, 2005, using an Engineering Technical Services (ET) Model APB-3 electrofisher. Several species of fish were collected including: northern pike, black bullhead, two unidentified minnow species, fathead minnow, johnny darter, stickleback, creek chubs, and central stoneroller. Several age classes of bluntnose minnows were observed. Only bluntnose minnows were caught in an great number. Other species were represented by 1-3 individual fish. Fish collection was attempted at Site #1 on September 28, 2005, using a seine net but was unsuccessful. Attachments 10 and 11 contain fish collection data.

Site #BS-2 is on Big Slough Creek located about one mile northeast of Rosholt on 474th Avenue. Attachment 1 is a site map. Site #BS-2 was only visited November 6, 2001.

Field water quality measurements were taken, and water samples were collected for laboratory analysis. Results indicate water quality meets standards and proposed assigned for the current beneficial uses. Attachments 16 and 19 are summaries of water quality data.

On November 6, 2001, water flow measured 4.63 cfs; the channel measured 11 feet in width, and a maximum of 0.8 feet in depth. Attachment 23 is a summary of flow data at Site #BS-2.

Fish were collected from Site #BS-2 on November 6, 2001, using an Engineering Technical Services (ET) Model APB-3 electrofisher. Four fish representing three species

of fish were collected. These species were black bullhead, an unidentified minnow species, and johnny darter. Attachment 14 contains fish collection data.

Site #2 is located on Big Slough Creek about two miles northeast of Rosholt on 475th Avenue. Attachment 5 is a photograph of Site #2 and displays a well-defined channel and flowing water. Attachment 1 is a site map.

Field water quality measurements were taken, and water samples were collected for laboratory analysis. Results indicate water quality meets standards and proposed assigned for the current beneficial uses. Attachments 17, 18, 20, and 21 are summaries of water quality data.

On September 28, 2005, the channel width measured 5.5 feet, maximum depth measured 1.0 feet, and flow measured 8.77 cfs. Attachment 26 contains flow data for Site #2.

Fish were collected from Site #2 on May 4, 2005, using an Engineering Technical Services (ET) Model APB-3 electrofisher and on September 28, 2005, using a seine net. Several species of fish were collected including: johnny darter, bluntnose minnow, fathead minnow, two unidentified shiner species, and an unidentified darter. With the exception of the bluntnose minnows collected in May 2005, only few of the other fish species (1-4 individuals) were collected. Attachments 12 and 13 are a summary of the fish collection data. Attachments 6 and 7 are photographs of the fish collected at Site #2.

Site #BS-3 is located on Big Slough Creek about five miles east of Rosholt on Highway 127. Attachment 1 is a site map.

Field water quality measurements were taken, and water samples were collected for laboratory analysis. Results indicate water quality meets standards and proposed assigned for the current beneficial uses. Attachments 16 and 19 are summaries of water quality data.

On November 6, 2001, water flow measured 5.72 cfs. The stream channel measured 14 feet in width and a maximum depth of 2.3 feet. Attachment 24 is a summary of flow data at Site #BS-3.

Fish were collected from Site #BS-3 November 6, 2001, using an Engineering Technical Services (ET) Model APB-3 electrofisher. Only two fish were caught, a sucker and a creek chub.. Attachment 15 is a summary of fish collection data.

Site #4 is located upstream of the confluence of Big Slough Creek and the Bois de Sioux River near 105th Street. Attachment 8 is a photograph of Site #4 displaying a wide, well-defined, flowing channel. Attachment 1 is a site map.

Field water quality measurements were taken, and water samples were collected for

laboratory analysis. Results indicate water quality meets standards assigned for the current and proposed beneficial uses. Attachments 18 and 21 are summaries of water quality data.

Flow was not measured, and fish collection was not attempted at Site #4.

Recreation Waters

Big Slough Creek meanders through private and public property and has public access at several road crossings and at White Rock Recreational area. At the confluence of Big Slough Creek and the Bois de Sioux River, White Rock Recreational area provides a fish cleaning station, public restrooms, and picnic area. The average water depth in the Big Slough channel is less than one foot; however, it contains areas with water measuring over two feet in depth. Due to the channel depth and flow, presence of fish, and available evidence that limited recreational activities may occur, the recommendation by DENR is to include (8) Limited contact recreation waters in the beneficial use classification of Big Slough Creek as appropriate. Attachment 9 is a photograph of a fish cleaning station at Site #4 and is evidence that fishing and other limited contact recreation activities are occurring along Big Slough Creek.

Most of Big Slough Creek is located on private property dominated by rangeland and cropland, and public access is not available. In locations where there is public access, the creek is not aesthetically pleasing nor a hospitable immersion recreation environment due to algae growth and an extremely muddy bottom. DENR does not recommend the classification include (7) Immersion recreation waters.

Conclusion and Recommendation

An inspection of Big Slough Creek was conducted November 6, 2001, May 4 and 5, 2005, and September 28 and 29, 2005 by DENR personnel.

On all three sampling events, the entire segment of Big Slough Creek under review had flowing water, adequate depth to support fish life propagation, and a defined channel. The Rosholt aquifer likely contributes ground water to the wetland west of Rosholt and results in perennial flow of Big Slough Creek. Water quality meets standards for its current beneficial uses and for the recommended beneficial. Collectively among the three sampling events, fish were collected at Sites #1, #2, BS-2, and BS-3. Site #4 was not sampled for fish. Species of fish collected include: fathead minnow, northern pike, sucker, multiple age classes of bluntnose minnow, multiple age classes of an unidentified darter, johnny darter, creek chubs, central stoneroller, brook stickleback, black bullhead, two unidentified shiner species, and two unidentified minnow species. Of the fish collected, only bluntnose minnows collect in May 2005 occurred in significant numbers that represented multiple age class. All other species were represented by 1-4 individuals at any of the sampling visits. Local landowners and citizens relate that while the stream may hold some game fish like walleye during warmer months, the creek completely freezes out during the winter. Additionally, area residents informed the DENR that the stream has been know to go completely dry, leaving large number of carp and other rough fish in the dry channels. While the creek appears to contain a wide variety of fish species, most species occur in

very low numbers, indicating that other factors such as lack of proper substrate, cover, or other habitat components are limiting the fish life propagation use in this stream. Based on the results of field and laboratory data, flow data, field reconnaissance, and fish data indicating limited warmwater fish life propagation, it is recommended this segment of Big Slough Creek be reclassified to include (5) Warmwater semipermanent fish life propagation waters; and (8) Limited contact recreation waters.

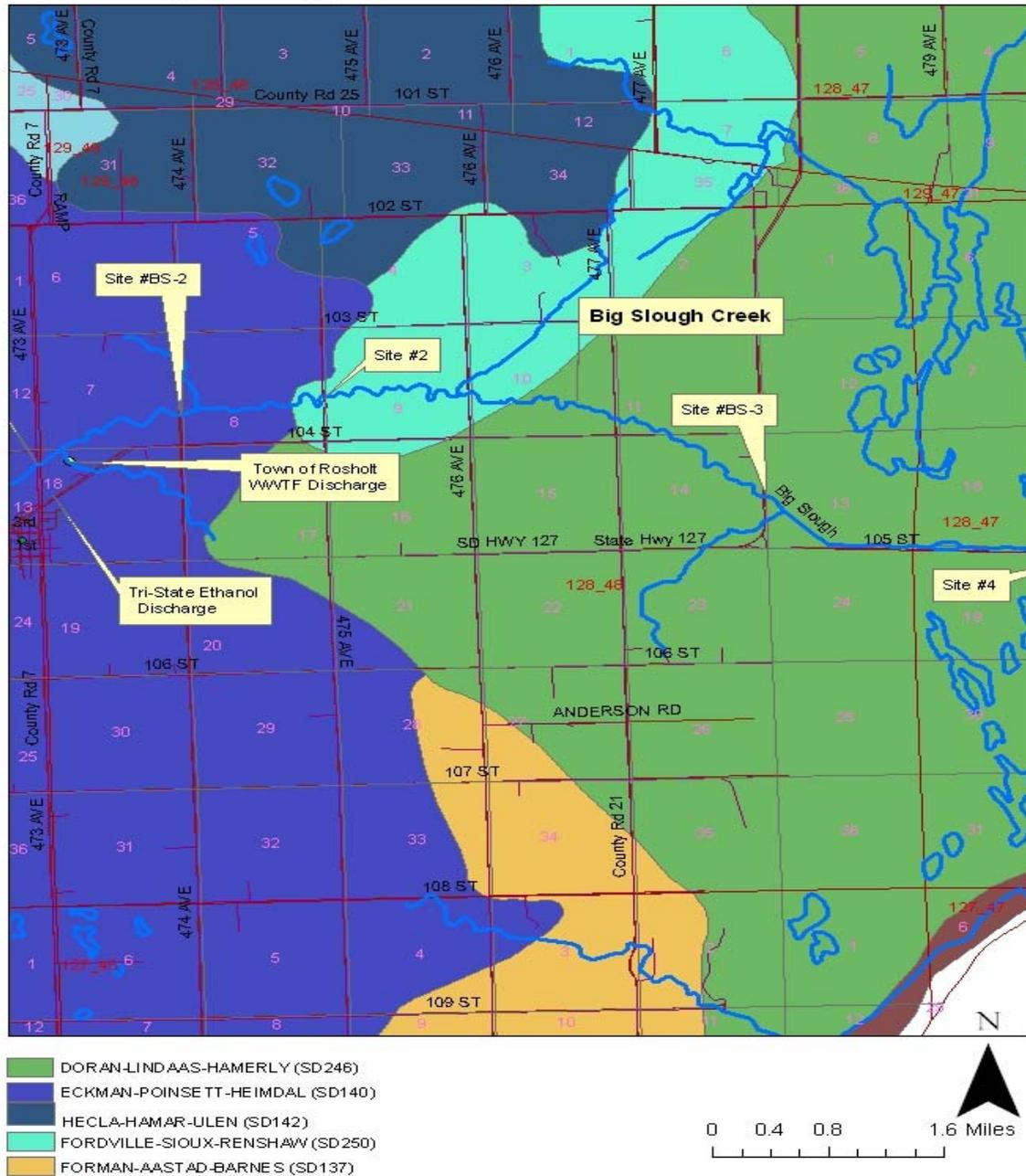
The normal, year-round water depth is less than 12 inches, and (7) Immersion recreation use is unlikely and is not recommended by DENR as a classification for this segment of Big Slough Creek.

References

- United States Environmental Protection Agency. 1983. Methods for Chemical Analysis of Water and Wastes. EPA 600/4-79-020. Cincinnati, Ohio.
- South Dakota Department of Environment and Natural Resources. 1999. Recommended Procedures for Reviewing Beneficial Use Designations, With Special Emphasis on Fishery and Recreational Uses.
- South Dakota Department of Environment and Natural Resources. Chapters 74:51:01 and 74:51:03, Surface Water Quality Standards.
- South Dakota Department of Environment and Natural Resources. Town of Rosholt, Statement of Basis.
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- South Dakota Department of Transportation, 1980. General Highway Map, Roberts County, South Dakota.
- DeLorme, 1997. South Dakota Atlas and Gazetteer.
- United States Department of the Interior, Fish and Wildlife Service. National Wetlands Inventory GIS Data Layer, South Dakota.
- United States Department of Agriculture, Soil Conservation Service, in cooperation with United States Department of the Interior, Bureau of Indian Affairs, and South Dakota Agricultural Experiment Station. Soil Survey of Roberts County, South Dakota. May 1977.
- United States Department of the Interior, United States Geological Survey, prepared in cooperation with the South Dakota Geological Survey, Sisseton-Wahpeton Sioux Tribe, and Roberts County. Water Resources of the Lake Traverse Reservation, South and North Dakota, and Roberts County, South Dakota. 2001.

ATTACHMENT 2

Big Slough Creek Soil Associations



ATTACHMENT 3



Site #1. Big Slough Creek facing east (downstream) on CR-7 bridge. Photograph taken September 28, 2005.

ATTACHMENT 4



Site #1. Big Slough Creek facing west (upstream) on CR-7 bridge. Photograph taken September 28, 2005.

ATTACHMENT 5



Site #2. Big Slough Creek facing east (downstream) on 475th Avenue. Photograph taken May 5, 2005.

ATTACHMENT 6



Site #2. Unidentified shiner species #1 netted at Site #2. Photograph taken September 28, 2005.

ATTACHMENT 7



Site #2. Minnows in 5 gallon bucket netted at Site #2. Photograph taken May 5, 2005.

ATTACHMENT 8



Site #4. Big Slough Creek upstream of confluence with Bois de Sioux River. Photograph taken September 28, 2005.

ATTACHMENT 9



Site #4. Fish cleaning station at recreation area along Big Slough Creek. Photograph taken September 28, 2005.

ATTACHMENT 11

Site #1

FISH COLLECTION SUMMARY

Length in Millimeters

May 4, 2005

Electroshock 75 yards						
	<u>Creek Chubs</u>	<u>Central Stoneroller</u>	<u>Blunt nose Minnow</u>		<u>Johnny Darter</u>	<u>Stickleback</u>
	152	83	68	53	59	48
			54	52	42	42
			48	31		
			44	51		
			62	42		
			52	64		
			49	44		
			40	48		
			54	27		
			53	29		
			42	44		
			54			
			26			
			28			
			29			
			54			
			38			
			37			
			42			
Number of fish:	1	1	30		2	2
Maximum Length:	152	83	68		59	48
Minimum Length:	152	83	26		42	42
Average Length:	152	83	45		51	45
Comments:	+ 64 bluntnose minnows counted for but not measured. Multiple age classes present in bluntnose minnows.					

ATTACHMENT 14

Site #BS-2			
FISH COLLECTION SUMMARY			
Length in Millimeters			
November 6, 2001			
Electroshock 300 feet			
	<u>Black Bullhead</u>	<u>Minnow #2</u>	<u>Johnny Darter</u>
	105	54	40
			56
Number of fish:	1	1	2
Maximum Length:	105	54	56
Minimum Length:	105	54	40
Average Length:	105	54	48
Comments:			

ATTACHMENT 16

FIELD ANALYSIS PARAMETERS, INSTRUMENTS, AND RESULTS				
PARAMETER	INSTRUMENT / REFERENCE METHOD	RESULTS		
		<u>Site #1</u> 11/06/01	<u>Site #BS-2</u> 11/06/01	<u>Site #BS-3</u> 11/06/01
Temperature				
Air (°C)	Thermometer / EPA (170.1)	15	11	9
Water (°C)	Hanna 9025 portable pH meter / EPA (170.1)	9.9	10.9	8.5
Dissolved oxygen (mg/L)	Azide Modification of Winkler / EPA (360.2)	9.3	20.0	12.3
pH (su)	Jenko 6007 portable pH meter / EPA (360.2)	8.12	8.65	8.62

mg/L = *Milligrams per liter;*
 su = *Standard Unit; and*
 EPA = *Environmental Protection Agency .*

ATTACHMENT 17

FIELD ANALYSIS PARAMETERS, INSTRUMENTS, AND RESULTS			
PARAMETER	INSTRUMENT / REFERENCE METHOD	RESULTS	
		Site #1 5/05/05	Site #2 5/05/05
Temperature			
Air (°C)	Thermometer / EPA (170.1)	15	15
Water (°C)	Hanna 9025 portable pH meter / EPA (170.1)	14.3	14.6
Dissolved oxygen (mg/L)	Azide Modification of Winkler / EPA (360.2)	9.4	14.5
pH (su)	Jenko 6007 portable pH meter / EPA (360.2)	7.94	8.12
Conductivity (umhos/cm)	YSI 33 meter/EPA 120.1	908	957

umhos/cm = Microohms per centimeter;
 mg/L = *Milligrams per liter*;
 su = *Standard Unit*; and
 EPA = *Environmental Protection Agency*.

ATTACHMENT 18

FIELD ANALYSIS PARAMETERS, INSTRUMENTS, AND RESULTS				
PARAMETER	INSTRUMENT / REFERENCE METHOD	RESULTS		
		Site #1 9/29/05	Site #2 9/29/05	Site #4 9/29/05
Temperature				
Air (°C)	Thermometer / EPA (170.1)	6	3	4
Water (°C)	Hanna 9025 portable pH meter / EPA (170.1)	8.8	8.2	9.4
Dissolved oxygen (mg/L)	Azide Modification of Winkler / EPA (360.2)	7.8	<7	9.4
pH (su)	Jenko 6007 portable pH meter / EPA (360.2)	7.67	7.74	8.12

mg/L = *Milligrams per liter;*
 su = *Standard Unit; and*
 EPA = *Environmental Protection Agency.*

ATTACHMENT 19

LABORATORY ANALYSIS PARAMETERS, METHODS, AND RESULTS				
PARAMETER	METHOD / REFERENCE	RESULTS		
		<u>Site #1</u> 11/06/01	<u>Site #BS-2</u> 11/06/01	<u>Site #BS-3</u> 11/06/01
Fecal Coliform Bacteria (organisms/100 ml)	SM 9222 B EC	60	40	1300
Alkalinity-M (mg/L)	SM 2320 B	351	363	383
Ammonia (mg/L)	SM 4500 NH3 H	<0.02	<0.02	<0.02
Nitrate (mg/L)	SM 4500 NO3 F	0.2	0.1	0.2
Biochemical Oxygen Demand (mg/L)	5 day incubation, 20°C / EPA Method (405.1)	<2	<2	<2
Conductivity (umho/cm)	EPA 120.1	1090	1080	1130
Total Suspended Solids (mg/L)	SM 2540 D	5	10	21
Total Dissolved Solids (mg/L)	SM 2540 C	814	800	821

umhos/cm = *Micromhos per centimeter;*
 < = *Not detected, followed by a number documenting the detection limit;*
 ml = *Milliliter;*
 * = *Calculated - not directly determined by laboratory analysis;*
 SM = *Standard Method;*
 EPA = *Environmental Protection Agency; and*
 mg/L = *Milligrams per liter.*

ATTACHMENT 20

LABORATORY ANALYSIS PARAMETERS, METHODS, AND RESULTS			
PARAMETER	METHOD / REFERENCE	RESULTS	
		<u>Site #1</u> 5/05/05	<u>Site #2</u> 5/05/05
Fecal Coliform Bacteria (organisms/100 ml)	SM 9222 B EC	40	30
Alkalinity-M (mg/L)	SM 2320 B	358	395
Ammonia (mg/L)	SM 4500 NH3 H	<0.02	<0.02
Nitrate (mg/L)	SM 4500 NO3 F	<0.1	<0.1
Biochemical Oxygen Demand (mg/L)	5 day incubation, 20°C / EPA Method (405.1)	<2	<2
Total Suspended Solids (mg/L)	SM 2540 D	19	68

- < = *Not detected, followed by a number documenting the detection limit;*
- ml = *Milliliter;*
- * = *Calculated - not directly determined by laboratory analysis;*
- SM = *Standard Method;*
- EPA = *Environmental Protection Agency; and*
- mg/L = *Milligrams per liter.*

ATTACHMENT 21

LABORATORY ANALYSIS PARAMETERS, METHODS, AND RESULTS				
PARAMETER	METHOD / REFERENCE	RESULTS		
		<u>Site #1</u> 9/29/05	<u>Site #2</u> 9/29/05	<u>Site #4</u> 9/29/05
Fecal Coliform Bacteria (organisms/100 ml)	SM 9222 B EC	130	200	400
Ammonia (mg/L)	SM 4500 NH3 H	<0.02	<0.02	<0.02
Nitrate (mg/L)	SM 4500 NO3 F	0.2	0.2	0.3
Biochemical Oxygen Demand (mg/L)	5 day incubation, 20°C / EPA Method (405.1)	<2	<2	<2
Conductivity (umho/cm)	EPA 120.1	1300	1290	1260
Total Suspended Solids (mg/L)	SM 2540 D	5	3	32
Total Dissolved Solids (mg/L)	SM 2540 C	964	968	660

- umhos/cm = *Micromhos per centimeter;*
- < = *Not detected, followed by a number documenting the detection limit;*
- ml = *Milliliter;*
- * = *Calculated - not directly determined by laboratory analysis;*
- SM = *Standard Method;*
- EPA = *Environmental Protection Agency; and*
- mg/L = *Milligrams per liter.*

ATTACHMENT 22

Velocity Measurements and Flow Calculations			
Site #1 Big Slough Creek			
November 6, 2001			
Location (feet from shore)	Depth	Velocity (feet per second)	Calculated Flow (cubic feet per second)
2	0.40	0.07	0.07
3	0.40	0.09	0.04
4	0.30	0.00	0.00
5	0.50	0.14	0.07
6	0.20	0.00	0.00
7	0.60	0.01	0.01
8	0.90	0.43	0.39
9	1.30	0.70	0.91
10	0.60	0.15	0.09
11	0.40	0.60	0.24
12	0.70	0.04	0.03
13	0.70	0.52	0.364
14	0.70	0.90	0.95
Total Width: 15 feet		Calculated flow rate at Site #1:	3.17

*As Determined Using A Marsh McBirney Model-201E Flow Meter.

ATTACHMENT 23

Velocity Measurements and Flow Calculations Site #BS-2 Big Slough Creek November 6, 2001			
Location (feet from shore)	Depth	Velocity (feet per second)	Calculated Flow (cubic feet per second)
2	0.30	0.35	0.26
3	0.70	0.88	0.62
4	0.70	1.29	0.90
5	0.80	1.08	0.86
6	0.50	1.06	0.53
7	0.60	1.11	0.67
8	0.40	1.00	0.40
9	0.30	0.95	0.29
10	0.20	0.34	0.10
Total Width: 11 feet		Calculated flow rate at Site #BS-2:	4.63

*As Determined Using A Marsh McBirney Model-201E Flow Meter.

ATTACHMENT 24

Velocity Measurements and Flow Calculations Site #BS-3 Big Slough Creek November 6, 2001			
Location (feet from shore)	Depth	Velocity (feet per second)	Calculated Flow (cubic feet per second)
1	1.10	0.04	0.07
2	1.20	0.04	0.05
3	1.40	0.07	0.10
4	2.00	0.15	0.30
5	2.20	0.25	0.55
6	2.30	0.33	0.76
7	2.20	0.38	0.84
8	2.10	0.42	0.88
9	1.70	0.43	0.73
10	2.00	0.38	0.76
11	1.80	0.33	0.59
12	0.90	0.10	0.09
13	0.30	0.00	0.00
Total Width: 14 feet		Calculated flow rate at Site #BS-3:	5.72

*As Determined Using A Marsh McBirney Model-201E Flow Meter.

ATTACHMENT 25

Velocity Measurements and Flow Calculations Site # 1 Big Slough Creek September 28, 2005			
Location (feet from shore)	Depth	Velocity (feet per second)	Calculated Flow (cubic feet per second)
0.5	0.80	0.16	0.13
1.5	1.00	0.02	0.02
2.5	1.20	0.56	0.67
3.5	1.40	1.72	2.41
4.5	1.50	1.21	1.82
5.5	1.40	1.17	1.64
6.5	1.70	1.25	2.12
7.5	1.25	1.14	1.42
8.5	1.00	1.45	1.45
9.5	1.00	1.06	1.06
10.5	0.50	0.00	0.00
11.5	0.30	0.00	0.00
Total Width: 12.5 feet		Calculated flow rate at Site #1:	12.74

*As Determined Using A Marsh McBirney Model-201E Flow Meter.

ATTACHMENT 26

Velocity Measurements and Flow Calculations Site # 2 Big Slough Creek September 28, 2005			
Location (feet from shore)	Depth	Velocity (feet per second)	Calculated Flow (cubic feet per second)
0.5	0.80	1.40	0.84
1.0	0.90	1.61	0.72
1.5	0.90	3.66	1.65
2.0	0.90	3.79	1.71
2.5	0.80	2.82	1.13
3.0	1.00	3.67	1.84
3.5	0.90	0.24	0.11
4.0	0.30	0.80	0.12
4.5	0.40	1.63	0.33
5.0	0.30	1.42	0.32
Total Width: 5.5 feet	Calculated flow rate at Site #2:		8.76

*As Determined Using A Marsh McBirney Model-201E Flow Meter.