

ANALYSIS

OF

AN UNNAMED TRIBUTARY OF CROW CREEK

MCNENNY STATE FISH HATCHERY

LAWRENCE COUNTY, SOUTH DAKOTA

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South Dakota
Department of Environment and Natural Resources
Division of Environmental Services
Pierre, South Dakota

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Executive Summary

Name of Waterbody: Unnamed tributary of Crow Creek

Location: Approximately 12 miles northwest of Spearfish in northwestern Lawrence County, South Dakota

Boundary of Waterbody under Assessment: An unnamed tributary from McNenny State Hatchery Outfall 002 in the Northwest $\frac{1}{4}$ of Section 21, Township 7 North, Range 1 East, to the confluence with Crow Creek in the Southwest $\frac{1}{4}$ of Section 16, Township 7 North, Range 1 East, Lawrence County.

Condition/Description of Creek Segment: The unnamed tributary originated as overflow from natural springs and McNenny Pond, a natural sinkhole supplied by artesian springs from the Madison aquifer. This spring water has been diverted and is now used in the fish hatchery process, but is later discharged to the unnamed tributary. Water also seeps from springs in the hillsides into the unnamed tributary. The stream flows about 0.2 miles to the confluence with Crow Creek. The area through which this segment of the stream flows is characterized by wide floodplains that grade into small knolls or flat topped ridges often capped by terrace gravels.

The creek bottom consists of sand, gravel, and rocks, with some areas of accumulated sediment and solids in the upper half of the unnamed tributary. The creek bed is well-defined and moderately incised into the land surface. The upper portion of the creek between Outfall 002 and Outfall 001 has slow moving, shallow water (over 1 cubic feet per second (cfs) and less than 1 foot in depth) which results in sometimes heavy algae and aquatic macrophyte growth. Downstream of Outfall 001 to the confluence with Crow Creek, the stream flow measures approximately 9 cfs and contains pooled areas measuring as much as three feet in depth. This section of the stream also contains areas of macrophyte plant growth which provides habitat and protection to aquatic fish life. Two species of fish, brown trout and rainbow trout, were collected in the unnamed tributary. Several age classes of fish, including mature adults and young of year, were observed for both species. Given the nutrient-rich environment and regular supply of cool water below the hatchery, the algal growth is expected to be persistent. DENR considers such aesthetic and shallow water conditions to be unappealing for public swimming.

Recommendation: It is recommended the assigned beneficial use for the unnamed tributary of Crow Creek from Outfall 002 in Section 21, Township 7 North, Range 1 East, to the confluence with Crow Creek in Section 16, Township 7 North, Range 1 East, Lawrence County, be upgraded to include (2) Coldwater permanent fish life propagation waters; (8) Limited contact recreation waters; (9) Fish and wildlife propagation, recreation, and stock watering waters; and (10) Irrigation waters.

Introduction

The South Dakota Department of Game, Fish, & Parks (GF&P) operates McNenny State Fish Hatchery northwest of Spearfish in Section 21, Township 7 North, Range 1 East, Lawrence County. The facility was constructed in 1951 by the US Fish and Wildlife Service (USFWS) and taken over by GF&P in 1983. McNenny State Fish Hatchery rears about 60,000 pounds of trout and salmon and incubates about 1 million eggs annually. These fish are stocked into coldwater fisheries throughout South Dakota. McNenny State Fish Hatchery meets criteria for being defined as a concentrated coldwater aquatic animal production facility by the Administrative Rules of South Dakota (ARSD), Section 74:52:02:35.

The fish hatchery consists of three production ponds, a display pond (McNenny Pond), eight covered outdoor raceways, two indoor raceways, and 35 indoor circular tanks. The two fish production ponds east of the raceways are supplied water by developed springs. Spring water is discharged from these two ponds at Outfall 002 at approximately 1 cfs. Water supply for the west production pond, the indoor and outdoor raceways, and the indoor circular tanks is supplied by well water. This water, plus spring water from McNenny Pond, is collected in the settling ponds before being discharged to Outfall 001 at a maximum flow of 7 cfs.

Under the operation of the USFWS, all fish production water was discharged directly to Outfall 002. This discharge had high levels of total suspended solids from the fish production process. This sediment is still present in the immediate vicinity surrounding Outfall 002 and in several locations downstream. The settling ponds were constructed by GF&P in 1993.

Attachment 1 is a photograph of McNenny State Fish Hatchery and the unnamed tributary to Crow Creek.

General Waterbody/Drainage Area Description

Current Assigned Beneficial Uses

Currently, the unnamed tributary of Crow Creek is assigned the beneficial uses for (9) Fish and wildlife propagation, recreation, and stock watering waters; and (10) Irrigation waters.

The unnamed tributary flows about 0.2 miles to Crow Creek. Crow Creek is assigned the beneficial uses of (2) Coldwater permanent fish life propagation waters; (8) Limited contact recreations waters; (9) Fish and wildlife propagation, recreation, and stock watering waters; and (10) Irrigation waters.

Surface Water

The unnamed tributary of Crow Creek originates at McNenny State Fishery Outfall 002, however, may have historically conveyed overflow spring water from McNenny Pond and natural springs before the construction of the facility. Approximately half way down the unnamed tributary, Outfall 001 discharges water from the settling ponds. In total, the stream measures approximately 0.2 miles before the confluence with Crow Creek. Water flow downstream of Outfall 001 (which would include flow from Outfall 002 and natural springs) measured approximately 9 cfs.

Wetlands

The area immediately surrounding the unnamed tributary to Crow Creek does not contain any wetlands identified by the National Wetlands Inventory (NWI). However, Mirror Lakes, McNenny Pond, and a natural spring east of the McNenny facility are classified as aquatic bed class, palustrine system. Wetland segments located near the confluence of the unnamed tributary and Crow Creek are defined as emergent class, palustrine system.

Palustrine systems are wetlands dominated by trees, shrubs, persistent emergents, and emergent mosses or lichens. Emergent class wetlands are characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens. Vegetation is predominantly perennial plants and is present for most of the growing season. Aquatic bed class wetlands are dominated by plants that grow principally on or below the surface of the water for most of the growing season in most years.

Soils/Ground Water

The unnamed tributary and most of Crow Creek lie within the Black Hills Foothills ecoregion. This ecoregion is characterized as an unglaciated ring of foothills surrounding the Black Hills' mountainous core. The geology consists of sandstone and shales, including red shales. Nevee-Tilford silty loam soils underlie the creek bed of the unnamed tributary.

The groundwater in the northern Black Hills has been extensively studied. Outcrops of the Minnelusa and Madison formations produce artesian springs that provide base flow to many streams, including Crow Creek and the unnamed tributary. Sinkholes, including Mirror Lakes, McNenny Pond, and Cox Lake, also have water flow from artesian springs originating from the Madison formation. Within McNenny State Fish Hatchery, water flow from artesian springs in McNenny Pond averages about 1 cfs. Water flow from springs feeding the east fish production ponds also average about 1 cfs. Along the unnamed tributary, springs seep through the red shale hillsides into the unnamed tributary. Attachments 1 and 2 are maps depicting the locations of springs and lakes influenced by groundwater connections. Attachment 3 is a photograph of trout swimming in McNenny Pond.

DENR Assessment Results

On June 20, 2006, May 1, 2007, and October 24, 2007, DENR personnel visited McNenny State Fish Hatchery and assessed 0.2 miles of the unnamed tributary from the origin near Outfall 002 to the confluence with Crow Creek. At the time of each visit, water was being discharged from each of the two outfalls (which includes overflow from spring-fed McNenny Pond and the east fish production ponds) and there was visual evidence of spring water seeping into the unnamed tributary along the red shale banks. Brown trout and rainbow trout were observed and/or collected during each visit. Water quality samples and field data were collected at each visit. All water quality data collected meet existing (9, 10) and proposed (2, 8, 9, 10) beneficial use water quality standards.

Unnamed tributary Site #1:

Site #1 is located on the unnamed tributary immediately downstream from Outfall 001. Attachments 7 and 8 are photographs of this site.

DENR personnel visited the site on June 20, 2006, May 1, 2007, and October 24, 2007. Site #1 had flow on all three visits. In May 2007, flow measured 7.92 cfs and in October 2007, flow measured 8.92 cfs using a Marsh McBirney Model-201E Flow Meter. Attachments 26 and 27 are water velocity measurements at this site. Water depth near Site #1 ranges from approximately one foot to as much as three feet in depth; channel width ranges from approximately 15 to 30 feet.

In June 2006, fish collection was attempted using a seine due to equipment failure with the Technical Services (ET) Model APB-3 electrofisher. Although many brown trout and rainbow trout were visually observed, including young of year and adults, fish collection was unsuccessful. In May and October 2007, fish collection was performed using a Technical Services (ET) Model APB-3 electrofisher and blocking seine net. Fish collected at this site in 2007 include several age classes of brown trout and rainbow trout. In May 2007, a total of 53 trout were collected from a 50 meter stretch of stream. In October 2007, the same stretch of stream yielded 70 trout. Attachments 21 and 22 are a list of the fish species and corresponding fish length measurements collected at this site in 2007. Attachments 9 through 16 are photographs of trout collected at this site in 2007. Attachment 12 is a photograph of an adult female brown trout with a hook in her mouth. The hook was removed before she was released back into the water. Attachment 14 is a photograph taken in October 2007 of an adult male brown trout in spawning colors. GF&P personnel described that the adult trout are attracted to the fast moving water near Outfall 001 and likely come to the unnamed tributary in the fall to spawn. Attachment 16 is a photograph of a fish collection cage used while electroshocking. The cage contains several age classes of brown trout and rainbow trout.

Field water quality measurements were taken, and water samples were collected for laboratory analysis on June 20, 2006, May 1, 2007, and October 24, 2007. Water at Site #1 meets water quality criteria and appears to fully support the current beneficial use classification (9, 10) and the proposed beneficial use classification (2, 8, 9, 10). Attachments 23 through 25 are summaries of the field and laboratory analysis results.

Unnamed tributary Site #2:

Site #2 is located near Outfall 002 and the origin of the unnamed tributary. Attachments 4 through 6 are photographs of this site.

DENR personnel visited the site on June 20, 2006, May 1, 2007, and October 24, 2007. Site #2 had flow on all three visits. In October 2007, flow was measured at 1.21 using a Marsh McBirney Model-201E Flow Meter. Attachment 28 is a chart of water velocity measurements at this site. Flow at Site #2 is mostly discharged from Outfall 002; however, a small amount may be attributed to natural springs seeping into the stream. Water depth at Site #2 is less than one foot deep; channel width ranges from approximately 5 to 20 feet.

In June 2006, fish collection was attempted with a seine and blocking net. In October 2007, fish collection was attempted using a Technical Services (ET) Model APB-3 electrofisher. During both fish collection attempts, juvenile and young of year trout were observed, however, collection was unsuccessful.

Field water quality measurements were taken, and water samples were collected for laboratory analysis on June 20, 2006, and October 24, 2007. Water at Site #2 meets water quality criteria and appears to fully support the current beneficial use classification (9, 10) and the proposed beneficial use classification (2, 8, 9, 10). Attachments 23 and 25 are summaries of the field and laboratory analysis results.

Unnamed tributary Site #3:

Site #3 is located at the confluence of the unnamed tributary and Crow Creek. Attachments 17 through 20 are photographs of this site. Water sampling, fish collection, and flow data were not collected at this site.

Recreation Waters

The unnamed tributary originates and flows through state lands with public access. McNenny State Fish Hatchery provides the public with an educational experience. Part of this educational experience is a nature trail along the unnamed tributary complete with signs identifying aspects of nature including the natural springs, types of trees, and types of wildlife. Recreational fishing is allowed along the nature trail and occurs on occasion. The photograph of the adult female brown trout in Attachment 12 with a hook in her mouth is evidence that fishing may occur in the unnamed tributary or in the surrounding area. Due to the presence of recreational activities including the nature trail and fishing, DENR recommends the beneficial use classification for the unnamed tributary include (8) Limited contact recreation waters.

Immersion recreation activities, such as swimming, skiing, or boating are unlikely to occur on the unnamed tributary. The unnamed tributary does not have a swim beach or other accommodations that would facilitate physical access through thick vegetation and riparian wetlands. Further, the water temperature averages 52 degrees Fahrenheit due to its sources, an unfavorable temperature for swimming. In addition, immersion recreation activities do not appear to be supported due to natural and physical limitations of the stream, such as the presence of aquatic plants and the generally shallow water depth. DENR considers the aesthetically unappealing and shallow water conditions to be a strong deterrent to public swimming. Hence, in considerations of these multiple reasons, DENR does not recommend the beneficial use classification for the unnamed tributary include (7) Immersion recreation waters.

Conclusion and Recommendation

The unnamed tributary at McNenny State Fish Hatchery flows year round based on discharge from the fish hatchery and natural springs along the creek. Spring water under artesian conditions from McNenny Pond and the east fish production ponds is discharged into the unnamed tributary and accounts for an approximate combined flow of 2 cfs. Discharge from the indoor and outdoor raceways, indoor circular tanks, and west production pond accounts for approximately 6 cfs. Natural springs along the creek bed account for less than 1 cfs. Downstream from Site #1, the combined flow from all sources in the unnamed tributary measured close to 9 cfs in October 2007. The abundance of clean, permanent water in the unnamed tributary provide suitable long-term habitat for aquatic fish life.

Two coldwater fish species are found in the unnamed tributary, including multiple age classes of brown trout and rainbow trout. The fast moving water near Outfall 001 likely attracts adult trout during spawning season and times of decreased flow in Crow Creek. In addition, the suitable habitat and protection in the unnamed tributary provide favorable conditions for young of year and juvenile trout.

Based upon the available information, it is recommended the assigned beneficial use of the unnamed tributary from its origin in Section 21, Township 7 North, Range 1 East, to the confluence with Crow Creek be amended to include (2) Coldwater permanent fish life propagation waters; (8) Limited contact recreation waters; (9) Fish and wildlife propagation, recreation, and stock watering waters; and (10) Irrigation waters.

REFERENCE DOCUMENTS

- 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. McNenny State Fish Hatchery Permit file.
- DeLorme, 2004. South Dakota Atlas and Gazetteer.
- South Dakota Department of Game, Fish, and Parks website. Power Point Presentation of McNenny State Fish Hatchery.
- South Dakota Geological Survey. 1962. Preliminary Report on the Artesian Water Supplies from the Minnelusa and Pahasapa Aquifers in the Spearfish – Belle Fourche Area.
- United States Department of the Interior, Geological Survey, 2007. Characterization of Ground-Water Flow and Water Quality for the Madison and Minnelusa Aquifers in Northern Lawrence County, South Dakota.
- South Dakota Bureau of Information and Telecommunications, GIS ArcMap.

ATTACHMENT 1



Site Map. This map shows McNenny State Fish Hatchery, sample site and outfall locations, the unnamed tributary, and Crow Creek.

ATTACHMENT 2



Site Map. This map portrays the locations of the spring-fed sinkholes Mirror Lakes, McNenny Pond, and Cox Lake.

ATTACHMENT 3



McNenny Pond. This is a photograph of McNenny Pond, a natural sinkhole that is supplied water by an artesian spring. Although the pond measures approximately 30 meters wide, it is also approximately 30 meters deep, with water that is a consistent 52 degrees Fahrenheit. The water from this pond overflows at a rate of over 1 cfs into the settling ponds before being discharged to Outfall 001. This pond is used for fish display purposes. As evident in the photo, mature trout reside in this pond and are on display to the public.

ATTACHMENT 4



Site #2. This photograph was taken on June 20, 2006. The photographer is standing downstream from Site #2 facing northeast. Spring water was observed seeping from the red cliff into the unnamed tributary.

ATTACHMENT 5



Site #2. This photograph was taken on October 24, 2007, facing northeast (downstream).

ATTACHMENT 6



Site #2. This photo depicts a natural spring seeping from the hillside into the unnamed tributary near Site #2. This photograph is facing east and was taken by GF&P. The creek bed is incised into the landscape and is located between the red shale bank and the sign.

ATTACHMENT 7



Site #1. This photograph was taken on May 1, 2007, facing north (downstream). The flow from the Outfall 002 enters the stream at the right of the photograph; while the flow from Outfall 001 enters the stream near the left of the photograph.

ATTACHMENT 8



Site #1. This photograph was taken on October 24, 2007, facing north (downstream).

ATTACHMENT 9



Site #1. This photograph was taken on May 1, 2007, of a female brown trout.

ATTACHMENT 10



Site #1. This photograph was taken on May 1, 2007, of a male brown trout.

ATTACHMENT 11



Site #1. This photograph was taken on May 1, 2007, of a rainbow trout.

ATTACHMENT 12



Site #1. This photograph was taken on May 1, 2007, of a female brown trout. The hook in the trout's mouth is evidence that fishing occurs in the area.

ATTACHMENT 13



Site #1. This photograph was taken on October 24, 2007, of a rainbow trout.

ATTACHMENT 14



Site #1. This photograph was taken on October 24, 2007, of a male brown trout in spawning colors.

ATTACHMENT 15



Site #1. This photograph was taken October 24, 2007, of a female brown trout.

ATTACHMENT 16



Site #1. This photograph was taken on October 24, 2007, of the fish in the wire collection basket.

ATTACHMENT 17



Site #3. This photograph was taken May 1, 2007, facing south (upstream). As evident in the photograph, beavers have created dams in the stream resulting in pools of deeper water.

ATTACHMENT 18



Site #3. This photograph was taken on October 24, 2007, facing south (upstream).

ATTACHMENT 19



Site #3. This photograph was taken on October 24, 2007, facing northeast at confluence of the unnamed tributary and Crow Creek. The unnamed tributary enters Crow Creek on the right side of the photograph.

ATTACHMENT 20



Site #3. This photograph was taken on May 1, 2007. The unnamed tributary is on the right of the photograph and is entering Crow Creek (left of photograph).

ATTACHMENT 21

**SITE # 1
FISH COLLECTION SUMMARY
Length in Millimeters
May 1, 2007**

Electroshocked 50 m	<u>Brown Trout</u>		<u>Rainbow Trout</u>	
		575	156	331
	574	135	278	120
	547	115	268	120
	365	105	234	120
	343	105	224	115
	292	95	221	110
	237	60	221	100
	230	56	216	90
	207	56	190	67
	205	55	185	58
	200	55	181	57
	200		175	55
	185		150	
	181		145	
	170		134	
Number of fish:	26		27	
Maximum Length:	575		331	
Minimum Length:	55		55	
Average Length:	212		159	

Comments: Both species of trout collected contained multiple age classes, including breeding males and females, and young of year.

ATTACHMENT 22

**SITE # 1
FISH COLLECTION SUMMARY
Length in Millimeters
October 24, 2007**

Electroshocked 50 m	<u>Brown Trout</u>			<u>Rainbow Trout</u>	
		585	285	120	385
	545	280	120	320	180
	525	270	120	250	180
	515	200	120	245	180
	502	200	120	240	176
	475	195	120	240	175
	460	180	112	225	172
	420	180	112	220	165
	370	140	110	205	165
	320	140	110	200	162
	310	140	110	200	150
	305	140	110	200	145
	295	140	110	188	130
	295	140	110	185	115
	290	130	110	182	110
Number of fish:	45			30	
Maximum Length:	585			385	
Minimum Length:	110			110	
Average Length:	237			196	

Comments: Both species of trout collected contained multiple age classes, including breeding males and females, and young of year.

ATTACHMENT 23

FIELD ANALYSIS PARAMETERS, INSTRUMENTS, AND RESULTS				
PARAMETER	INSTRUMENT / REFERENCE METHOD	RESULTS SITE #1		
		June 20, 2006	May 1, 2007	Oct. 24, 2007
Temperature	Thermometer / EPA (170.1)	28	21	34
Air (°C)				
Water (°C)	YSI 556 Multimeter / EPA (170.1)	13	13	11
Specific Conductance (umhos/cm)	YSI 556 Multimeter / EPA (120.1)	597	801	--
Dissolved oxygen (mg/L)	YSI 556 Multimeter / EPA (360.1)	10.5	15.1	8.9
pH (su)	YSI 556 Multimeter / EPA (150.1)	7.7	7.7	7.6

FIELD ANALYSIS PARAMETERS, INSTRUMENTS, AND RESULTS			
PARAMETER	INSTRUMENT / REFERENCE METHOD	RESULTS SITE #2	
		June 20, 2006	Oct. 24, 2007
Temperature	Thermometer / EPA (170.1)	28	32
Air (°C)			
Water (°C)	YSI 556 Multimeter / EPA (170.1)	15	11
Specific Conductance (umhos/cm)	YSI 556 Multimeter / EPA (120.1)	499	--
Dissolved oxygen (mg/L)	YSI 556 Multimeter / EPA (360.1)	9.7	8.8
pH (su)	YSI 556 Multimeter / EPA (150.1)	7.8	7.2

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

ATTACHMENT 24

LABORATORY ANALYSIS PARAMETERS, METHODS, AND RESULTS				
PARAMETER	METHOD / REFERENCE	RESULTS SITE #1		
		June 20, 2006	May 1, 2007	Oct. 24, 2007
Fecal Coliform Bacteria (organisms/100 ml)	SM 9222 B EC	4	<10	<10
Alkalinity (mg/L)	EPA (160.2)	--	214	214
Ammonia (mg/L)	SM 4500 NH3 H	<0.02	<0.02	0.08
Nitrate (mg/L)	SM 4500 NO3 F	0.4	0.4	0.4
Biochemical Oxygen Demand (mg/L)	5 day incubation, 20°C / EPA Method (405.1)	<2	<2	<2
Total Suspended Solids (mg/L)	SM 2540 D	2	4	<3
Total Dissolved Solids (mg/L)	SM 2540 B	583	560	510
Specific Conductance (umhos/cm)	EPA 120.1	--	--	736

- umhos/cm = *Micro mhos per centimeter;*
- < = *Not detected, followed by a number documenting the detection limit;*
- ml = *Milliliter;*
- SM = *Standard Method;*
- EPA = *Environmental Protection Agency;*
- = *Not measured; and*
- mg/L = *Milligrams per liter.*

ATTACHMENT 25

LABORATORY ANALYSIS PARAMETERS, METHODS, AND RESULTS

PARAMETER	METHOD / REFERENCE	RESULTS SITE #2	
		June 20, 2006	Oct. 24, 2007
Fecal Coliform Bacteria (organisms/100 ml)	SM 9222 B EC	2	40
Alkalinity (mg/L)	EPA (160.2)	--	217
Ammonia (mg/L)	SM 4500 NH3 H	<0.02	0.13
Nitrate (mg/L)	SM 4500 NO3 F	0.3	<0.5
Biochemical Oxygen Demand (mg/L)	5 day incubation, 20°C / EPA Method (405.1)	<2	<2
Total Suspended Solids (mg/L)	SM 2540 D	1	<3
Total Dissolved Solids (mg/L)	SM 2540 B	446	426
Specific Conductance (umhos/cm)	EPA 120.1	--	649

- umhos/cm = *Micro mhos per centimeter;*
- < = *Not detected, followed by a number documenting the detection limit;*
- ml = *Milliliter;*
- SM = *Standard Method;*
- EPA = *Environmental Protection Agency;*
- = *Not measured; and*
- mg/L = *Milligrams per liter.*

ATTACHMENT 26

SITE # 1 VELOCITY MEASUREMENTS AND CALCULATED FLOW RATE* 16 FOOT CHANNEL WIDTH JUNE 20, 2006			
LOCATION (FEET FROM BANK)	WATER DEPTH (FEET)	VELOCITY (FEET/SECOND)	CALCULATED FLOW RATE (CUBIC FEET/SECOND)
1	0.8	0.03	0.048
3	1.0	0.6	1.2
5	1.0	0.03	0.06
7	1.0	0.56	1.12
9	1.0	1.10	2.2
11	0.9	1.42	2.556
13	0.6	0.6	0.72
15	0.6	0.03	0.036
Flow Rate:			7.94

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

ATTACHMENT 27

<p align="center">SITE # 1 VELOCITY MEASUREMENTS AND CALCULATED FLOW RATE* 20 FOOT CHANNEL WIDTH OCTOBER 24, 2007</p>			
LOCATION (FEET FROM BANK)	WATER DEPTH (FEET)	VELOCITY (FEET/SECOND)	CALCULATED FLOW RATE (CUBIC FEET/SECOND)
1	0.7	0.13	0.182
3	1.0	0.71	1.42
5	0.9	0.43	0.774
7	1.0	0.77	1.54
9	0.9	1.01	1.818
11	1.2	1.14	2.736
13	1.2	0.13	0.312
15	1.0	0.03	0.06
17	0.8	0.03	0.048
19	0.5	0.03	0.03
Flow Rate:			8.92

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

ATTACHMENT 28

SITE # 2 VELOCITY MEASUREMENTS AND CALCULATED FLOW RATE* 20 FOOT CHANNEL WIDTH OCTOBER 24, 2007			
LOCATION (FEET FROM BANK)	WATER DEPTH (FEET)	VELOCITY (FEET/SECOND)	CALCULATED FLOW RATE (CUBIC FEET/SECOND)
2	0.2	0.08	0.048
4	0.3	0.11	0.066
6	0.5	0.26	0.26
8	0.5	0.04	0.04
10	0.5	0.08	0.08
12	0.4	0.25	0.20
14	0.4	0.4	0.32
16	0.4	0.25	0.20
18	0.2	0.0	0.00
Flow Rate:			1.21

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