



Missouri Department of Natural Resources

Biological Assessment Report

Roark Creek Stone and Taney Counties

2003 - 2004

Prepared for:

Missouri Department of Natural Resources
Water Protection and Soil Conservation Division
Water Protection Program
Water Pollution Branch

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Table of Contents

Section	Page
1.0 Introduction.....	1
2.0 Study Areas.....	2
2.1 Land Cover.....	2
2.2 Beneficial Uses	2
2.3 Station Descriptions.....	3
3.0 Methods	6
3.1 Macroinvertebrate Collection and Analyses.....	6
3.2 Physicochemical Data Collection and Analyses.....	7
3.3 Physical Habitat	8
4.0 Data Results and Analyses.....	8
4.1 Biological Assessment.....	8
4.1.1 Missouri Stream Condition Index Scores	8
4.1.2 Ephemeroptera, Plecoptera, and Trichoptera Families	9
4.1.3 Macroinvertebrate Community Composition	10
4.2 Physicochemical Data.....	10
4.3 Habitat Assessment.....	11
5.0 Discussion.....	13
5.1 Biological Assessment.....	13
5.2 Physicochemical Data.....	14
5.3 Habitat Assessment.....	14
6.0 Conclusions.....	14
7.0 Summary.....	15
8.0 Recommendations.....	15
9.0 Literature Cited.....	15

Tables

Table 1	Percent Land Cover Within the Ozark/White EDU and Within a 500-Meter Radius of Each Sample Station	3
Table 2	Riffle/Pool Biological Criteria for Fall/Warm Water Streams in the Ozark/White EDU.....	7
Table 3	Riffle/Pool Biological Criteria for Spring/Warm Water Streams in the Ozark/White EDU.....	7
Table 4	Roark and Swan Creek Metric Values and Scores, Fall 2003, Ozark/White Ecological Drainage Unit.....	9
Table 5	Roark and Swan Creek Metric Values and Scores, Spring 2004, Ozark/White Ecological Drainage Unit.....	9

Table 6	Number of Ephemeroptera, Plecoptera, and Trichoptera Families, Tributaries of Roark Creek and Cane Creek.....	9
Table 7	Macroinvertebrate Composition per Sample Station, Fall 2003....	10
Table 8	Macroinvertebrate Composition per Sample Station, Spring 2004.....	11
Table 9	Physicochemical Data Collected per Station, Fall 2003	12
Table 10	Physicochemical Data Collected per Station, Spring 2004	12
Table 11	Stream Wetted Width All Stations (Feet).....	11
Table 12	SHAPP Scores	13

Figures

Figure 1	Roark Creek Sample Stations	5
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Attachments

Appendix A	Biological Assessment Study Plan, Roark Creek
Appendix B	Macroinvertebrate Taxonomic Bench Sheets for the 2003-2004 Roark Creek Biological Assessment
Appendix C	Family Level Macroinvertebrate Bench Sheets for 2003-2004 Roark Creek Biological Assessment

1.0 Introduction

At the request of the Water Protection Program (**WPP**), Water Pollution Branch (**WPB**), the Environmental Services Program (**ESP**), Water Quality Monitoring Section (**WQMS**) conducted a biological assessment of Roark Creek in southwest Missouri. This stream runs into Lake Taneycomo, a body of water listed as impaired on the 2002 303(d) list due to low dissolved oxygen. A loss of water quality and habitat for aquatic organisms in Roark Creek may have additive effects upon the stressed aquatic system of the lake.

The concern about lower water quality and habitat within Roark Creek is due to increasing development and urbanization of the watershed (MDNR 2002b). Urbanization of a watershed may have detrimental effects upon a stream such as alteration of the stream hydrology and increases in sedimentation, nutrients, toxic organic compounds, heavy metals, and road salts (Jones and Clark 1987). These effects may cause dramatic and significant changes in the aquatic communities of a stream (Gurie and McIntosh 1986, Pedersen and Perkins 1986). The biological, water quality, and habitat assessment data was collected from Roark Creek to assist the WPP in making a determination on whether urbanization has made an impact on the stream. Steve Humphrey, Randy Sarver, and Cecilia Campbell of the ESP collected samples in the fall of 2003 and the spring of 2004.

Water quality and macroinvertebrate samples were also collected in Swan Creek, located approximately three miles east of Chadwick, in Christian County, Missouri. This stream was used as a control site to compare to findings from the mainstem of Roark Creek. Samples were also taken from Cane Creek, located approximately three miles north of Hilda, in Taney County to compare to those collected at the Roark Creek tributaries West Fork Roark Creek and East Fork Roark Creek.

A study plan was submitted to the Water Protection Program in fall 2003 (see Appendix A). The study plan was later modified to include five null hypotheses to test in this study. Those null hypotheses were:

1. Macroinvertebrate communities are similar among mainstem Roark Creek, Swan Creek, and other biocriteria reference streams within the Ozark/White Ecological Drainage Unit.
2. Stream habitats are similar among mainstem Roark Creek, Swan Creek, and the Ozark/White Ecological Drainage Unit biocriteria reference streams.
3. Water quality is similar among mainstem Roark Creek, Swan Creek, and the Ozark/White Ecological Drainage Unit biocriteria reference streams.
4. Macroinvertebrate communities are similar among West Fork Roark Creek, East Fork Roark Creek, and Cane Creek.
5. Water quality is similar among West Fork Roark Creek, East Fork Roark Creek, and Cane Creek.

2.0 Study Areas

Roark Creek is formed in western Taney County by the confluence of two of its tributaries, East Fork Roark Creek and West Fork Roark Creek. East Fork Roark Creek flows approximately three miles through western Taney County and West Fork Roark flows southeast approximately seven miles through Stone and Taney counties before they meet to form the mainstem of Roark Creek. Roark Creek then flows through its 40-square mile watershed for seven miles until it runs into Lake Taneycomo. The Roark Creek watershed is located in an area of rapid development and urbanization; the population of the city of Branson almost doubled from 1990 to 2000, from 3,706 to 6,050 (Office of Social and Economic Trend Analysis 2004). The surrounding counties, Christian, Stone, and Taney, exhibited a 66.3%, 50.2%, and 55.3% increase, respectively, in their populations over that time period, reflecting a large migration of people into these counties (U.S. Census Bureau 2004). Along with this population influx, people have been moving away from farm-related jobs, increasing the potential for change to the rural landscape of the area. Rural Taney County has experienced a 148.6% decrease in private non-farm employment from 1990-1999, compared to a 16.8% decrease statewide (U.S. Census Bureau 2004).

2.1 Land Cover

Table 1 lists the land cover percentages from the Ozark/White Ecological Drainage Unit (EDU) and the land cover within a 500-meter radius of each sample station on Roark Creek and the two arms of Roark Creek. An EDU is a region in which biological communities and habitat conditions can be expected to be similar. The land cover information was retrieved through Geographic Information Systems land cover files provided by the Missouri Resource Assessment Partnership (MoRAP) and derived from 1991-1993 LANDSAT data.

Forest and grass cover the majority of the watershed of East and West Fork Roark Creek and the mainstem of Roark Creek. At station 1 on Roark Creek, urban land use was present, in an amount almost equal to that of grassland. With urban growth and sprawl expected to continue in the Branson area, the amounts of forest and grass within the watershed is expected to decrease dramatically and shift to urban land use.

2.2 Beneficial Uses

Roark Creek flows through approximately four miles of rural Taney County, then for three additional miles it skirts the city limits of Branson, flows through the city, and flows into Lake Taneycomo. The seven miles of mainstem Roark Creek are considered Class "C", a stream that ceases flow in dry periods, but maintains permanent pools that would support aquatic life.

Table 1
 Percent Land Cover Within the Ozark/White EDU and
 Within a 500-Meter Radius of Each Sample Station

Location	Urban	Crop	Grass	Forest	Other
EDU	0.9	0.4	46.4	48.8	3.5
Roark Creek 1	13.3	0	15.7	71	0
Roark Creek 2	0	0	47.8	45.1	7.1
West Fork Roark Creek 3	0	0	35.7	64.3	0
West Fork Roark Creek 4	0	0	43.6	56.4	0
East Fork Roark Creek 5	0	0	55.7	39.8	4.5
Swan Creek 6	0	0	46.3	50.4	3.3
Cane Creek 1	0	0	62.8	36.9	0.3

The upstream four miles on mainstem Roark Creek are listed for the beneficial uses of livestock and wildlife watering, protection of aquatic life (general warm-water fishery), whole body contact recreation, and boating and canoeing. The remaining classified three miles or downstream portion of Roark Creek were also listed for livestock and wildlife watering, protection of aquatic life, whole body contact recreation, and boating and canoeing. This segment of the creek differs from the upstream section because it is also listed as a cold-water fishery (MDNR 1998). The cold-water fishery designation was granted to Roark Creek because trout stocked in Lake Taneycomo have the ability to swim up into Roark Creek during periods of colder temperatures and greater flow. Because Roark Creek was unable to sustain the conditions necessary to support a cold-water fishery all year long, for the purposes of this invertebrate study it was assessed as a warm-water stream.

Swan Creek was used as a control stream for comparison to the sample stations on the mainstem of Roark Creek. Swan Creek originates in Douglas County and travels through Christian County and Taney County. It is a Class "P" stream with the beneficial uses of irrigation, livestock and wildlife watering, protection of aquatic life (general warm-water fishery), whole body contact recreation, boating and canoeing, and cool-water fishery.

West Fork Roark Creek is classified as a Class "C" stream and listed for the beneficial uses of irrigation, livestock and wildlife watering, and aquatic life protection (general warm-water fishery). East Fork Roark Creek is an unclassified stream. The control stream that was selected to compare to West Fork and East Fork Roark Creek was Cane Creek. Cane Creek travels approximately ten miles through Taney County and is a Class "C" stream. The beneficial uses on this stream are livestock and wildlife watering, protection of aquatic life (general warm-water fishery), and cool-water fishery.

2.3 Station Descriptions

Roark Creek sample stations can be located on Figure 1.

Roark Creek Station 1 - [(E ½, sec. 32, T. 23 N., R. 21 W.)] was located on the mainstem of Roark Creek in Taney County, within the city of Branson's Stockstill Park. Water quality samples were collected upstream of two low-water crossings in the park (geographic coordinates, Lat. 36.65000251, Long. -93.23917923) and macroinvertebrates were sampled upstream and downstream of these crossings.

Roark Creek Station 2 - [(NW ¼, sec. 23, T. 23 N., R. 22 W.)] was located on the mainstem of Roark Creek, downstream of the low water bridge, in the Ruth and Paul Henning Conservation Area, northwest of Branson in Taney County. Water quality and macroinvertebrate samples were collected approximately 70 yards downstream of the bridge (geographic coordinates, Lat. 36.68135148, Long. -93.28637325).

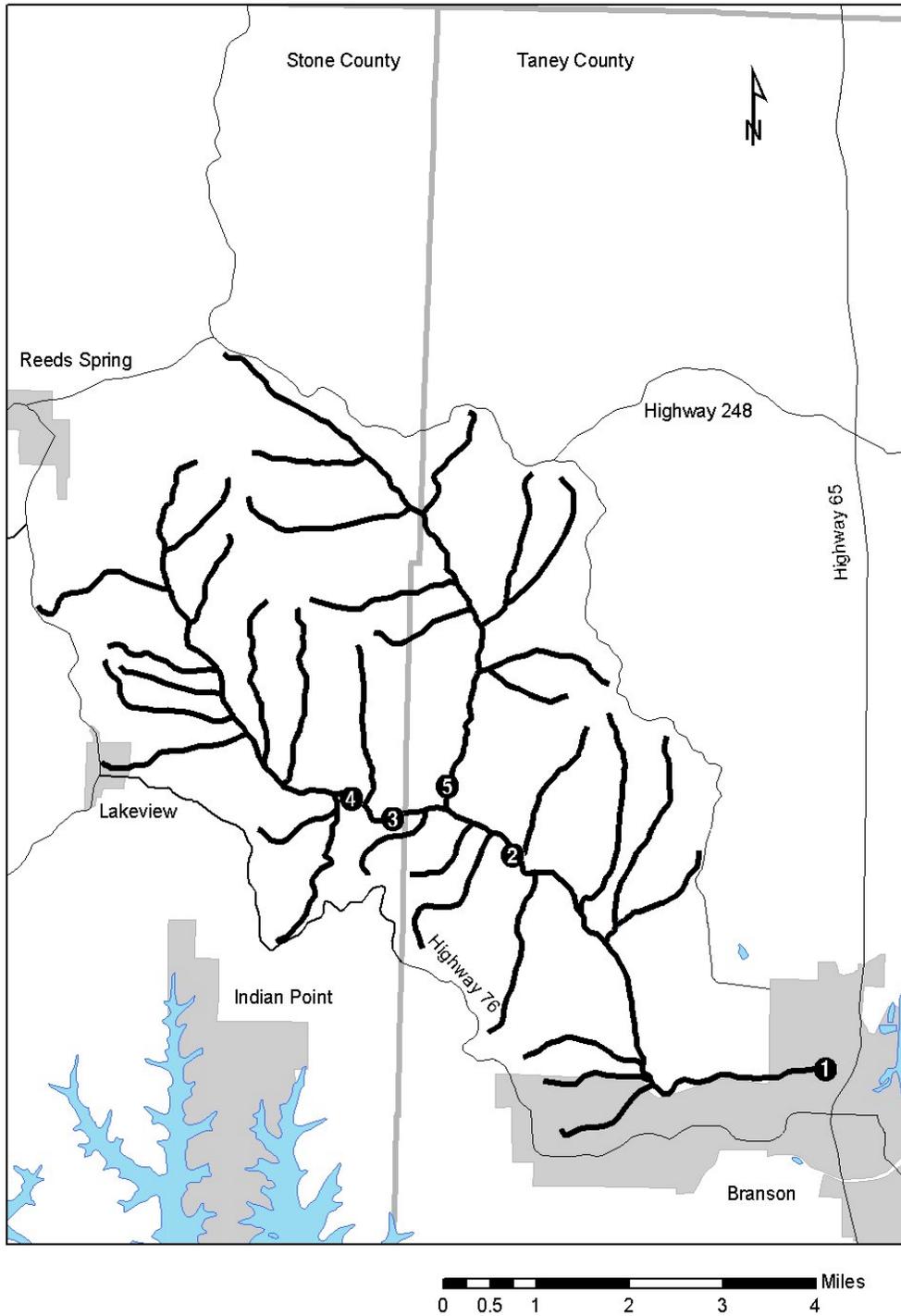
West Fork Roark Creek Station 3 - [(SE ¼, sec. 16, T. 23 N., R. 22 W.)] was located upstream approximately ten yards above the confluence of West Fork Roark Creek and East Fork Roark Creek in Taney County. This station is downstream of the Stonebridge Village development and is approximately 0.3 miles from their wastewater treatment facility (**WWTF**). The WWTF is an activated sludge wastewater treatment facility with a design flow of 0.1 million gallons/day. Macroinvertebrate and water quality samples were collected at the upstream limit of the sample reach (geographic coordinates, Lat. 36.69245359, Long. -93.30314714).

West Fork Roark Creek Station 4 - [(Center, sec. 16, T. 23 N., R. 22 W.)] was located upstream of the Stonebridge Village WWTF, off Highway 76 in Stone County, northwest of Branson. Stonebridge Village development includes housing and a golf course. Macroinvertebrate and water quality samples were collected from the stream as it flowed through the golf course (geographic coordinates, Lat. 36.69245359, Long. -93.31784795).

East Fork Roark Creek Station 5 - [(SW ¼, sec. 15, T. 23 N., R. 22 W.)] was located upstream approximately five yards from the confluence of West Fork Roark Creek and East Fork Roark Creek, in Taney County. In the fall, water was in isolated pools or short stretches of flowing water that disappeared, then reappeared several yards downstream. Water quality samples were collected from a large pool (geographic coordinates, Lat. 36.69252586, Long. -93.30205652). Macroinvertebrate samples were collected from pools where water was deep enough to collect a kicknet sample.

Cane Creek Station 1 - [(W ½, sec. 18, T. 23 N., R. 18 W.)] was located within the Hercules Glades Wilderness, approximately three miles north of Hilda in Taney County. Water samples were collected above the low water bridge and macroinvertebrates were collected above and below the low water bridge in the fall and above the low water bridge in the spring (geographic coordinates, Lat. 36.6829851, Long. -92.98230711).

Figure 1: Roark Creek Sample Stations



Swan Creek Station 6 - [(NE ¼, sec. 27, T. 26 N., R. 19 W.)] was located upstream of the Swan Cave Road Bridge, approximately three miles east of Chadwick in Christian County. Water quality samples were collected just above the bridge (geographic coordinates, Lat. 36.92210726, Long. -93.00205541) and macroinvertebrate samples were collected between the Swan Cave Road Bridge (downstream limit of the reach) and the Day Lane low water bridge (upstream limit of the reach).

3.0 Methods

There were two parts of the macroinvertebrate collection and analyses for the Roark Creek Study. A standardized sample collection procedure, the Semi-Quantitative Macroinvertebrate Stream Bioassessment Project Procedure (**SQMSBPP**), was used to collect and analyze macroinvertebrate samples on the mainstem reaches of Roark Creek and Swan Creek (MDNR 2003a). An Ephemeroptera, Plecoptera, Trichoptera family level screening method, which is in the process of development, was used for East Fork and West Fork of Roark Creek and Cane Creek.

3.1 Macroinvertebrate Collection and Analyses

All streams were sampled as riffle/pool streams. The SQMSBPP designates that each sample reach consist of a length of stream approximately 20 times the average stream width which usually contains at least two riffle/pool sequences with three standard habitats that are sampled. The standard habitats for a riffle/pool stream are flowing water over coarse substrate (**CS**), non-flowing water over depositional substrate (**NF**), and root-mat substrate (**RM**) along the banks. Macroinvertebrates are sampled from each habitat, preserved in the field, then processed and analyzed using the methods set out in the SQMSBPP and the Taxonomic Levels for Macroinvertebrate Identification Standard Operating Procedure MDNR-WQMS-209 (MDNR 2001a). The resulting macroinvertebrate counts from each sample were then used to calculate metrics for comparison between these sample stations. Macroinvertebrate bench sheets are attached as Appendix B.

Four metrics comprised the biological criteria used for comparison between streams: Taxa Richness (**TR**); Ephemeroptera, Plecoptera, and Trichoptera Taxa (**EPTT**); the Biotic Index (**BI**), and the Shannon Diversity Index (**SDI**). The biological criteria calculated for the Ozark/White EDU are calculated according to criteria methods established in Biological Criteria for Wadeable Perennial Streams of Missouri (MDNR 2002a). The biological criteria are expressed as the Missouri Stream Condition Index (**MSCI**) score and are calculated from the TR, EPTT, BI, and SDI metrics. Reference stream metric values used in calculating the MSCI scores are listed in Table 2 for fall and Table 3 for spring. The MSCI scores are divided into three categories of impairment. Study stream reaches that scored from 16-20 were considered fully biologically sustaining, scores from 10-14 were considered partially biologically sustaining, and scores of 4-8 were considered non-biologically sustaining. These criteria were used as a

comparison for data collected at the two stations on Roark Creek to that collected on Swan Creek, an Ozark/White EDU control stream of similar size.

Table 2
 Riffle/Pool Biological Criteria for Fall/Warm Water Streams
 in the Ozark/White EDU

Metric	Score = 5	Score = 3	Score = 1
TR	>78	39-78	<39
EPTT	>26	13-26	<13
BI	<4.69	4.69-7.35	>7.35
SDI	>3.15	1.57-3.15	<1.57

Table 3
 Riffle/Pool Biological Criteria for Spring/Warm Water Streams
 in the Ozark/White EDU

Metric	Score = 5	Score = 3	Score = 1
TR	>96	48-96	<48
EPTT	>31	16-31	<16
BI	<4.59	4.59-7.30	>7.30
SDI	>3.21	1.60-3.21	<1.60

The second part of the macroinvertebrate collection and analyses was conducted on East Fork Roark Creek, two stations on the West Fork Roark Creek, and the control site on Cane Creek. Flow within these reaches decreased in late summer to a narrow, shallow channel that could not be measured with a flow meter. These conditions restricted the available habitat.

A less intensive method was used for this part of the study because of time and economic limitations. The method used to compare these smaller stream reaches is a method under development for use with Level IV volunteers and as a stream quality screening method for the ESP, WQMS. The Ephemeroptera, Plecoptera, and Trichoptera family (**EPTF**) level method involves collecting six kicknet samples from CS habitat as stated in the SQMSBPP. Instead of compositing the six subsamples, each net was field picked for fifteen minutes to remove family level representatives of the insect orders Ephemeroptera, Plecoptera, and Trichoptera. These representatives were preserved in a single vial of alcohol, labeled, and returned to the ESP for identification and recording. Family level macroinvertebrate bench sheets are attached as Appendix C.

3.2 Physicochemical Data Collection and Analyses

Physical and chemical water quality measurements were taken at each sample station. Field measurements included temperature (MDNR 1993), pH (MDNR 2001c), conductivity (MDNR 2000b), and dissolved oxygen concentrations (MDNR 2002d). Grab samples of stream water were collected from each station and preserved in

accordance with the Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations (MDNR 2002c). Water samples were collected and submitted for analysis using the Field Sheet and Chain of Custody Record (MDNR 2001b). The samples were submitted to the Environmental Services Program, Chemical Analysis Section for analyses of nitrate/nitrite-nitrogen (NO_2+NO_3), ammonia-nitrogen ($\text{NH}_3\text{-N}$), total phosphorus (**TP**), chloride (**Cl**), and total Kjeldahl nitrogen (**TKN**). Members of the ESP, WQMS analyzed samples collected for turbidity.

Stream velocity measurements were collected at each sample station using a Marsh-McBirney Flow-Mate Model 2000. Discharge at each sample station was later calculated using the methods set out in the Flow Measurements in Open Channels (MDNR 2001d).

The physicochemical data were compiled and presented in tabular form for comparison among the sample stations on Roark Creek to Swan Creek and the stations on the Roark Creek tributaries to Cane Creek.

3.3 Physical Habitat

Physical assessments of the in-stream and riparian habitat were conducted at each sample reach to determine the quality and availability of habitat for the biological community. The assessments were used to score the habitat at Roark Creek Stations 1 and 2 and compare it to the scores collected at Swan Creek Station 6, using the procedure applicable to Riffle/Pool habitat in the MDNR Stream Habitat Assessment Project Procedure (**SHAPP**) (MDNR 2000c). If the SHAPP habitat scores at Roark Creek and Swan Creek were 75% or greater in similarity, Roark Creek would be expected to support biological communities comparable to those at Swan Creek.

4.0 Data Results and Analyses

4.1 Biological Assessment

As outlined in the methods, macroinvertebrate data were evaluated using two different analyses. The first analysis of the biological data used biological criteria MSCI scores to compare the mainstem of Roark Creek with biological criteria and the control stream Swan Creek. The second analysis of the biological data used family level Ephemeroptera, Plecoptera, and Trichoptera taxa to compare the upper tributaries of Roark Creek to the control stream Cane Creek.

4.1.1 Missouri Stream Condition Index Scores

The Roark and Swan Creek metric results and MSCI scores for fall 2003 and spring 2004 are found in Table 4 and Table 5, respectively. MSCI scores are calculated by scoring station metrics against the appropriate biological criteria in Table 2 or Table 3. Once individual metrics are scored they are compiled into a multi-metric index, the MSCI.

Table 4
 Roark and Swan Creek Metric Values and Scores, Fall 2003,
 Ozark/White Ecological Drainage Unit

Sample Station	Roark Ck 1 Metrics	Metric Score	Roark Ck 2 Metrics	Metric Score	Swan Ck 6 Metrics	Metric Score
TR	78	3	80	5	96	5
EPTT	18	3	21	3	23	3
BI	5.78	3	6.00	3	5.46	3
SDI	3.35	5	3.17	5	3.74	5
MSCI Score	14		16		16	
Sustainability	Partial		Full		Full	

Table 5
 Roark and Swan Creek Metric Values and Scores, Spring 2004,
 Ozark/White Ecological Drainage Unit

Sample Station	Roark Ck 1 Metrics	Metric Score	Roark Ck 2 Metrics	Metric Score	Swan Ck 6 Metrics	Metric Score
TR	97	5	90	3	98	5
EPTT	28	3	29	3	33	5
BI	5.43	3	5.28	3	5.13	3
SDI	3.27	5	3.34	5	3.78	5
MSCI Score	16		14		18	
Sustainability	Full		Partial		Full	

4.1.2 Ephemeroptera, Plecoptera, and Trichoptera Families

The screening level EPTF samples were collected during both the fall and spring index period. The number of EPTF collected at all Roark tributaries and the control stream, Cane Creek, are located in Table 6.

Table 6
 Number of Ephemeroptera, Plecoptera, and Trichoptera Families,
 Tributaries of Roark Creek and Cane Creek

Station	No. of Families Collected-Fall	No. of Families Collected-Spring
West Fork Roark Creek 3	5	5
West Fork Roark Creek 4	3	4
East Fork Roark Creek 5	6	7
Cane Creek 1	9	8

4.1.3 Macroinvertebrate Community Composition

Analyses of the relative abundance of macroinvertebrate communities often reveals information not available in the standard MSCI multi-metric index. Table 7 and Table 8 list the relative abundance of the insect orders Ephemeroptera, Plecoptera, and Trichoptera and the dominant invertebrate families of mainstem Roark and Swan Creek sampling stations.

Table 7
 Macroinvertebrate Composition per Sample Station, Fall 2003

	Roark Ck 2	Roark Ck 1	Swan Ck 6
No. of Total Taxa	80	78	96
No. of EPT Taxa	21	18	23
% Ephemeroptera	35	37	26
%Plecoptera	<1	<1	<1
%Trichoptera	2	5	4
Dominant Families in Sample (% present in sample)			
Caenidae	19	17	9
Psephenidae	6	14	8
Chironomidae	13	13	20
Asellidae	12	2	-----
Baetidae	9	10	5
Heptageniidae	6	4	9
Elmidae	5	8	10
Coenagrionidae	3	4	4
Gomphidae	3	-----	5
Arachnoidea	2	4	2
Planorbidae	2	4	-----
Ancylidae	2	2	-----
Isonychiidae	-----	5	-----
Pleuroceridae	-----	4	6
Philopotamidae	-----	3	-----
Hyalellidae	-----	2	6

4.2 Physicochemical Data

Grab sample results of physical and chemical water analyses are listed in Table 9 for the fall index period and Table 10 for the spring index period. The flow was so low at East Fork Roark Creek 5 in fall of 2003 that it was in between rocks and could not be measured for discharge.

Table 8
 Macroinvertebrate Composition per Sample Station, Spring 2004

	Roark Ck 2	Roark Ck 1	Swan Ck 6
No. of Total Taxa	90	97	98
No. of EPT Taxa	29	28	33
% Ephemeroptera	34	20	28
%Plecoptera	17	2	7
%Trichoptera	4	2	5
Dominant Families in sample (% in sample)			
Chironomidae	26	60	40
Caenidae	17	14	5
Heptageniidae	12	2	6
Asellidae	11	-----	-----
Perlidae	8	-----	-----
Perlodidae	6	-----	-----
Nemouridae	3	-----	2
Leptophlebiidae	3	-----	2
Pleuroceridae	3	2	4
Elmidae	-----	5	2
Ephemerellidae	-----	-----	13
Hydroptilidae	-----	-----	3

4.3 Habitat Assessment

The stream wetted width measurements are listed below in Table 11. As would be expected, the spring wetted width measurements were consistently greater than the fall. Fall wetted widths and flow measurements are more useful for comparison of stream size. Seasonal rains affected the spring measurements, with control streams having the most dramatic increase between seasons.

Table 11
 Stream Wetted Width All Stations (Feet)

Station	Fall 2003	Spring 2004
Roark Creek 1	17	45
Roark Creek 2	16.9	23.5
Swan Creek 6	9	65
West Fork Roark Creek 3	16.5	22
West Fork Roark Creek 4	17	26.5
East Fork Roark Creek 5	-----	21
Cane Creek 1	6.7	63

Table 9
 Physicochemical Data Collected per Station, Fall 2003

Sample Station	Temperature (°C)	pH	Conductivity (µmhos/cm)	D.O. (mg/L)	Flow (ft ³ /sec)	Turbidity (NTU)	Cl (mg/L)	TKN (mg/L)	NH ₃ -N (mg/L)	NO ₂ +NO ₃ (mg/L)	TP (mg/L)
Roark Creek 1	16.5	8.1	566	7.0	1.9	1.02	19.8	0.10	<0.03	0.09	0.02
Roark Creek 2	17.0	7.8	521	6.4	0.6	2.64	13.0	0.05	<0.03	0.11	0.01
Swan Creek 6	17.5	8.0	395	8.8	1.5	1.17	6.3	0.22	<0.03	0.15	0.01
West Fork Roark Creek 3	21.0	8.3	500	11.6	0.6	1.35	22.1	1.29	<0.03	0.45	0.01
West Fork Roark Creek 4	-----	7.7	493	6.6	0.1	2.64	13.7	0.05	<0.03	0.16	0.01
East Fork Roark Creek 5	-----	-----	-----	-----	-----	<1.00	5.7	0.07	<0.03	0.04	0.01
Cane Creek 1	19.0	8.1	452	10.2	0.4	<1.00	2.8	0.10	<0.03	0.02	<0.01

The symbol < indicates a value below detection limits.

Table 10
 Physicochemical Data Collected per Station, Spring 2004

Sample Station	Temperature (°C)	pH	Conductivity (µmhos/cm)	D.O. (mg/L)	Flow (ft ³ /sec)	Turbidity (NTU)	Cl (mg/L)	TKN (mg/L)	NH ₃ -N (mg/L)	NO ₂ +NO ₃ (mg/L)	TP (mg/L)
Roark Creek 1	6.5	8.0	457	12.8	19.8	1.25	8.1	0.16	<0.03	0.22	0.01
Roark Creek 2	9.0	8.1	365	11.0	15.6	<1.00	6.0	0.10	<0.03	0.20	<0.01
Swan Creek 6	8.0	8.0	329	13.0	39.4	1.09	5.2	<0.05	<0.03	0.24	<0.01
West Fork Roark Creek 3	12.5	7.8	362	11.4	6.4	<1.00	8.4	<0.05	<0.03	0.29	<0.01
West Fork Roark Creek 4	11.5	7.3	361	10.4	5.3	1.84	6.3	<0.05	<0.03	0.28	<0.01
East Fork Roark Creek 5	11.0	7.9	399	11.2	6.3	1.38	4.7	0.12	<0.03	0.14	0.02
Cane Creek 1	10.5	8.2	415	11.2	4.7	1.01	3.5	0.15	<0.03	0.11	<0.01

The symbol < indicates a value below detection limits.

SHAPP scores are listed in Table 12 and were calculated from the data collected in the fall of 2003. The control site, Swan Creek Station 1, was used as a comparison for the mainstem Roark Creek stations. The SHAPP document guidance states that test streams should be at least 75% similar to control or reference scores to consider the test stream capable of supporting a comparable aquatic community.

Table 12
 SHAPP Scores

Control Site	Test Sites	Test Habitat Scores	% of Control
Swan Creek Station 6	Roark Creek Station 1	136	89
Habitat Score = 153	Roark Creek Station 2	147	96

5.0 Discussion

5.1 Biological Assessment

The MSCI score (Tables 4 & 5) for the control station, Swan Creek Station 6, was considered fully biological supporting during both the fall and spring index period.

Roark Creek MSCI scores (Tables 4 & 5) were split at 50% fully biological supporting and 50% partially biological supporting. All metrics, except spring TR at Roark Creek Station 1, show trends toward a lower quality macroinvertebrate community as compared to the Swan Creek Station 1 control.

Table 7 lists community composition for the fall sampling period. Ephemeroptera in fall Roark Creek stations are approximately 10% higher than Swan Creek. This can largely be explained by an increase in the proportion of Caenid mayflies in Roark Creek. Caenid mayflies have BI values of 7.6 and would have a negative influence on the Roark Creek BI metric values in Tables 4 & 5.

Table 8 lists community composition for the spring sampling period. Relative abundance of Ephemeroptera, Plecoptera, and Trichoptera taxa are all significantly lower during the spring index period at Roark Creek Station 1. Inversely, Roark Creek Station 1 has higher relative abundance of the family Chironomidae, which is often more pollution tolerant. While the family Caenidae has the same pattern mentioned for the fall index period, the spring emergent mayfly family Ephemerellidae demonstrates a significant difference in mayfly fauna between the test stream Roark Creek and the control stream Swan Creek. The family Ephemerellidae is entirely absent from Roark Creek but makes up 13% of the community at Swan Creek. In addition, the BI tolerance value of 1.0 for Ephemerellidae is evidence of mayflies that are very intolerant to organic pollution.

A qualitative comparison of the data reveals trends toward lower numbers of EPTF taxa at the Roark Creek tributaries when compared to the Cane Creek Station 1 control. In

addition, East Fork Roark Creek Station 5 reveals higher trends in EPTF taxa than the West Fork Roark Creek sampling stations. West Fork Roark Creek stations were selected for monitoring because of potential effects from the Stonebridge Village development. The difference in fall EPTF taxa between East Fork and West Fork of Roark Creek is especially significant because East Fork Roark Creek, although having only a small amount of surface flow, had more taxa. Cane Creek and the Roark Creek tributaries were much smaller than biological criteria reference streams and were not expected to meet the EPTF screening criteria. However, for comparative purposes, the screening criteria for wadeable/perennial biological reference streams are provided. The Ozark/White Ecological Drainage Unit EPTF criteria is the 25th % of reference value, (lower limit for passing biological screening) which is 13 taxa in the fall and 15 taxa in the spring. The stream that ranked closest to these criteria was the control stream, Cane Creek.

5.2 Physicochemical Data

Although there are no extremely high values, Roark Creek Station 3, below the Stonebridge Village WWTF, had the highest results in the fall for Chloride, TKN, and NO₂+NO₃. Differences in water chemistry values were less obvious in the spring when stream discharge was higher.

5.3 Habitat Assessment

When compared to the Swan Creek control station, scores from both sample reaches on Roark Creek were within 75% of the score obtained from the Swan Creek data. Therefore, the assessment of in-stream and riparian habitat at all three stations inferred that the stream reaches at Roark Creek Station 1 and 2 should have supported a similar biological community to that found at Swan Creek 1.

6.0 Conclusions

Reject the null hypothesis that the macroinvertebrate communities are similar among mainstem Roark Creek, Swan Creek, and other biocriteria reference streams within the Ozark/White Ecological Drainage Unit.

Accept the null hypothesis that stream habitats and water quality are similar among mainstem Roark Creek, Swan Creek, and the Ozark/White Ecological Drainage Unit biocriteria reference streams.

Reject the null hypothesis that macroinvertebrate communities and water quality are similar among West Fork Roark Creek, East Fork Roark Creek, and Cane Creek.

7.0 Summary

The four MSCI scores for Roark Creek are split at 50% full biological support and 50% partial biological support. In comparison, individual stream samples for warm water riffle/pool biocriteria reference streams in the Ozark/White EDU have an MSCI score proportion of 88% at full biological support and 12% at partial biological support. Roark Creek MSCI scores from the sampling period covered by this report are well under the proportion that would be similar to the biocriteria reference streams.

Physical habitat and chemical samples indicated no extreme conditions to explain the condition of the biological community. However, screening level EPTF information collected of the East and West Fork tributaries to Roark Creek indicated that the biological community is of a lower quality in the West Fork, below Stonebridge Village. The highest nutrient levels were also found at the West Fork Roark sampling station below the Stonebridge Village WWTF.

8.0 Recommendations

- Further water quality assessment for the mainstem, West Fork, East Fork, and other tributaries of Roark Creek
- Repeat the biological assessment of Roark Creek at periodic intervals as the Branson area continues to develop.

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Appendix A

Biological Assessment Study Plan
Roark Creek

Missouri Department of Natural Resources
Bioassessment Study Plan
Roark Creek, Stone and Taney Counties

Objective

Determine if aquatic communities in Roark Creek, Stone and Taney Counties are impaired from urbanization.

Tasks

- 1) Conduct a bioassessment, including macroinvertebrates and water quality, of mainstem Roark Creek, Taney County, and upper Swan Creek, Christian County.
- 2) Conduct a habitat assessment of mainstem Roark Creek and upper Swan Creek.
- 3) Conduct a qualitative bioassessment, including macroinvertebrates and water quality, of West Fork Roark Creek, and East Fork Roark Creek, Stone and Taney Counties, and Long Creek, Taney County.
- 4) Conduct a reconnaissance type habitat assessment of West Fork Roark Creek, East Fork Roark Creek, and Long Creek.

Null Hypotheses

Macroinvertebrate communities are similar among mainstem Roark Creek, Taney County, upper Swan Creek, Christian County, and biocriteria reference streams within the Ozark/White Ecological Drainage Unit (EDU).

Stream habitats are similar among mainstem Roark Creek, upper Swan Creek, and the Ozark/White EDU biocriteria reference streams.

Water quality is similar among mainstem Roark Creek, upper Swan Creek, and the Ozark/White EDU biocriteria reference streams.

Macroinvertebrate communities are similar among West Fork Roark Creek, and East Fork Roark Creek, Stone and Taney Counties, and Long Creek, Taney County.

Stream habitats are similar among West Fork Roark Creek, East Fork Roark Creek, and Long Creek.

Water quality is similar among West Fork Roark Creek, East Fork Roark Creek, and Long Creek.

Background

The Roark Creek catchment (approx. 40 sq. mi.) in Stone and Taney Counties near Branson, Missouri is undergoing rapid development and urbanization. Numerous point and non-point pollution sources may impact Roark Creek and impair water quality and aquatic communities. There is also concern that an impaired Roark Creek may impact the water quality and fishery of Lake Taneycomo. Urbanization may have several detrimental effects upon a stream including alteration of stream hydrology and increases in sedimentation, nutrients, toxic organic compounds, heavy metals, and road salts (Jones and Clark 1987). These impacts may radically alter the aquatic communities of a stream (Gurie and Mc Intosh 1986; Pedersen and Perkins 1986). Using bioassessment and habitat assessment procedures, we intend to determine if Roark Creek is impaired from urbanization.

Study Methods

General: The study area encompasses approximately seven miles of mainstem Roark Creek and the tributaries West Fork Roark Creek and East Fork Roark Creek, northwest from Branson, Missouri. Five stations, two mainstem and three on the tributaries, will be established and sampled (Figure 1). Water quality samples will be collected and habitat assessments will be conducted at each of the five stations. At the two mainstem stations, complete bioassessments will be conducted as per the Environmental Services Program (ESP) Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (SMSBPP) (MDNR 2003a), and complete habitat assessments will be done as described in ESP's Stream Habitat Assessment Project Procedure (SHAPP) (MDNR 2003b). At the tributary stations, a general reconnaissance type of habitat assessment (Appendix D-SHAPP) and qualitative bioassessment will be employed. Limited assessments will be conducted at the tributaries because only the mainstem Roark Creek is a classified stream (Class "C"), according to the Missouri Department of Natural Resources Water Quality Standards (MDNR 2000). These tributaries are likely intermittent much of the time and invertebrate communities may not be comparable to the mainstem stream. All stations are potentially impacted; there is no upstream control station. Therefore, a station on upper Swan Creek, Christian County, of similar size to mainstem Roark Creek will be used as a control station for the mainstem Roark Creek stations. A full bioassessment and habitat assessment will be done at this station. A small unimpaired, unclassified stream, Long Creek in Taney County, will be used as a control station for the West Fork and East Fork Roark Creek stations. Assessments at Long Creek will be the same as for West and East Fork Roark Creek.

Station Locations: Station #1 (E ½ S32, T23N, R21W, Taney Co.) is the most downstream station and is located on Roark Creek within Stockstill Park in Branson, approximately 0.5 mile upstream from the creek's confluence with Lake Taneycomo. Station #2 (NW ¼ S23, T23N R22W, Taney Co.) is located on Roark Creek within the Ruth and Paul Henning State Forest. This station is about 5.0 miles upstream from Station #1. Station #3 (SE1/4 S16, T23N, R22W, Stone Co.) is located on West Fork

Roark Creek, about 1.5 miles upstream from Station #2 and approximately 0.5 mile upstream from the confluence with East Fork Roark Creek. Station #3 was chosen as a downstream monitoring station below Stonebridge Village Wastewater Treatment Facility. Station #4 (Center S16 T23N, R22W, Stone Co.) is located immediately upstream from the Stonebridge Village WWTF. Station #5 (Center S15, T23N, R22W, Taney Co.) is located on East Fork Roark Creek a short distance upstream from its confluence with West Fork Roark Creek. Station #6 (NE ¼ S27, T26N, R19W, Christian Co.), the control station for mainstem Roark Creek, is located on upper Swan Creek east of Chadwick, Missouri. Station #7 (S1/2 S7, T23N, R18W, Taney Co.), the control station for West Fork and East Fork Roark Creek, is located on Long Creek about four miles east of Kisse Mills, Missouri.

Each mainstem Roark Creek station and upper Swan Creek station will consist of a length of twenty-times the stream's average width, with at least two riffle reaches, as outlined in the ESP's SHAPP. West Fork and East Fork Roark Creek and Long Creek stream segments may be less than twenty-times the streams' average widths but will include two riffle reaches in each stream. Sampling will occur in the fall of 2003 and spring of 2004.

Bioassessment: Macroinvertebrates will be sampled according to the ESP's SMSBPP, at mainstem Roark Creek and upper Swan Creek. These creeks are considered "Riffle/Pool" predominant streams and habitats will be sampled accordingly. Macroinvertebrate habitats to be sampled at these stations will be coarse substrate, non-flow, and rootmat. Reconnaissance type qualitative macroinvertebrate sampling will be conducted at the three Roark Creek tributary stations and Long Creek. Because of their small size and likely intermittent flow, only coarse substrate will be sampled at these stations. Three coarse substrate kicknet samples, each of about one square meter, will be collected at each station and composited from a variety of depth, flow and substrate mixtures.

Habitat Sampling: Stream discharge will be measured at each station using a Marsh-McBirney flow meter (MDNR 2003c). Stream habitat assessments will also be conducted within the study area in accordance with ESP's SHAPP at mainstem Roark Creek and upper Swan Creek. Reconnaissance type habitat assessments (Appendix D-SHAPP) will be carried out at the Roark Creek tributaries and Long Creek.

Water Quality Sampling: Water quality samples will be collected at the five Roark Creek stations, upper Swan Creek, and Long Creek during the spring and fall seasons. Parameters will include Total Kjeldahl Nitrogen (TKN), ammonia-nitrogen, nitrite plus nitrate nitrogen, total phosphorus, and chloride. The nutrient samples will be preserved with sulfuric acid. All samples will be kept on ice until they are delivered to the ESP, Chemical and Analytical Section (CAS), in Jefferson City, Missouri. In addition, turbidity samples will be collected and analyzed by the ESP, Water Quality Monitoring Section. Field parameters, such as dissolved oxygen, pH, conductivity, and temperature will be measured *in situ* at each station on Roark Creek, West Fork and East Fork Roark Creek, upper Swan Creek, and Long Creek.

Laboratory Methods: Analyses of biological and chemical samples will be conducted at the MDNR Environmental Laboratory in Jefferson City, Missouri. Biological samples from mainstem Roark Creek and upper Swan Creek will be processed and identified according to MDNR-FSS-209 Taxonomic Levels for Macroinvertebrate Identifications (MDNR 2001). Upper Roark Creek and Long Creek invertebrate samples will be field-picked and identified to family level on site.

Data Analysis: Macroinvertebrate data from mainstem Roark Creek and upper Swan Creek will be entered in a Microsoft Access database according to the MDNR Standard Operating Procedure MDNR-WQMS-214, Quality Control Procedures for Data Processing (MDNR 2003d). Data analysis is automated within the Access database. Four standard metrics are calculated according to the Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (SMSBPP): Total Taxa (TT); Ephemeroptera, Plecoptera, Trichoptera Taxa (EPTT); Biotic Index; and the Shannon Index (SI) will be calculated for each station. Additional metrics such as Quantitative Similarity Index for Taxa (QSI-T) may be employed to discern differences in taxa between control and test stations. Macroinvertebrate data will be compared among the mainstem Roark Creek, upper Swan Creek, and the Ozark/White EDU biocriteria reference streams database. Macroinvertebrate data from the Ozark/White EDU will allow for the calculation of a 25th percentile for the four metrics in the SMSBPP, and thus compared to Roark Creek stations. Roark Creek will be scored against these calculations and a composite score of 16 or greater will determine non-impairment, according to the draft- Biological Criteria for Wadeable/Perennial Streams of Missouri (MDNR 2002).

Qualitative macroinvertebrate data from riffle habitats within West Fork and East Fork Roark Creek will be summarized as the total number of Ephemeroptera, Plecoptera and Trichoptera (EPT) families. The EPT family data will be compared to the expected EPT family taxa from the Ozark/White EDU reference streams database and to the EPT family taxa from the Long Creek control station.

Data Reporting: A report will be written for the Water Pollution Control Program (WPCP), which outlines and interprets the results of the study.

Quality Controls: As stated in the various MDNR Project Procedures and Standard Operating Procedures.

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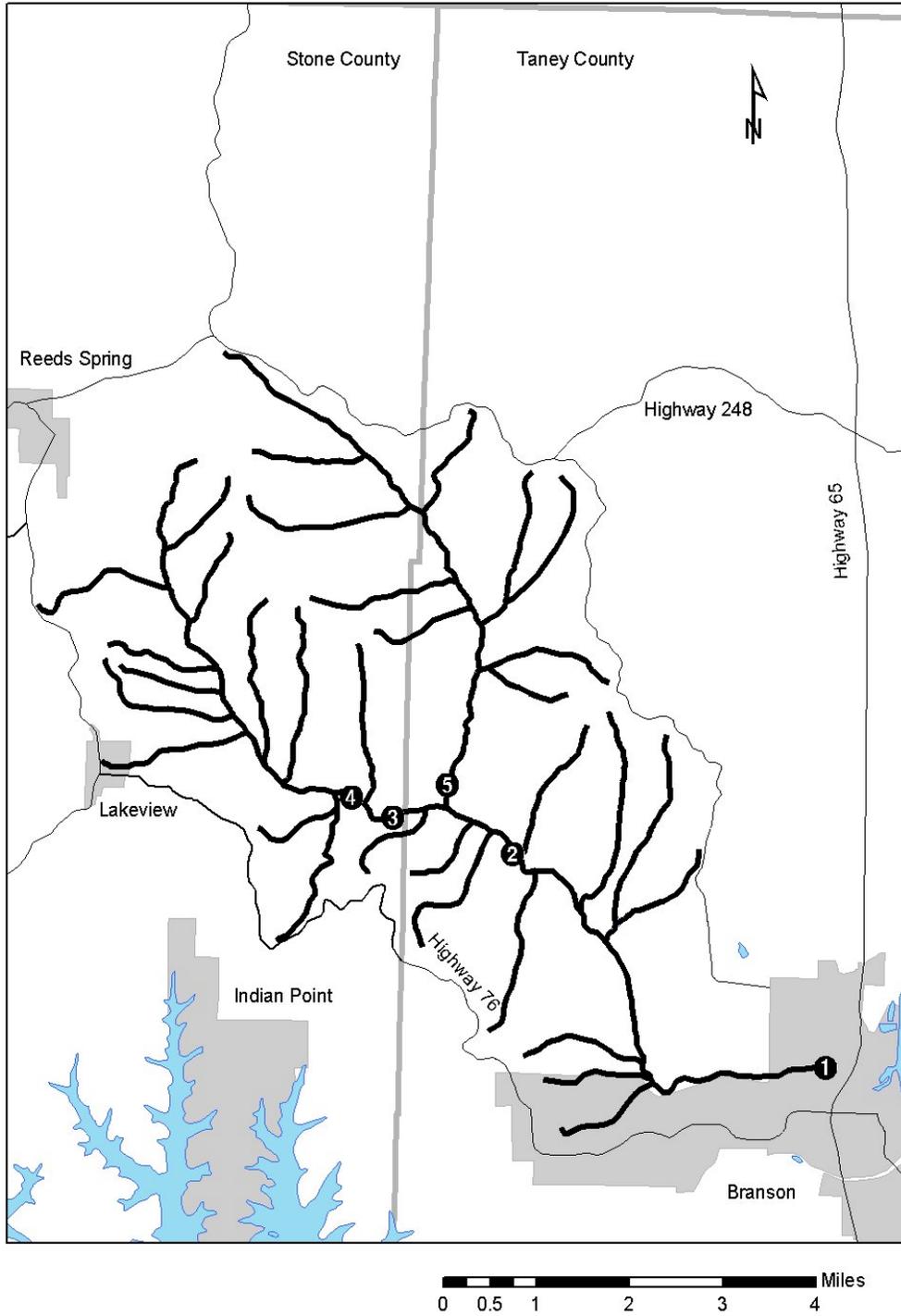
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Attachments: Figure 1: Roark Creek sample stations.

Figure 1: Roark Creek Sample Stations



Appendix B

Macroinvertebrate Taxonomic Bench Sheets for the
2003-2004 Roark Creek Biological Assessment
(-99 signifies presence of the taxa)

Aquid Invertebrate Database Bench Sheet Report

Roark Ck [0318754], Station #1, Sample Date: 10/8/2003 9:20:00 AM

ORDER: TAXA	CS	NF	SG	RM
"HYDRACARINA"				
Acarina	5	4		46
AMPHIPODA				
Hyalella azteca	1	1		17
ARHYNCHOBDELLIDA				
Erpobdellidae		-99		
COLEOPTERA				
Dubiraphia	2	2		4
Ectopria nervosa	1	1		
Lutrochus	4			
Microcylloepus pusillus	19			20
Psephenus herricki	73	1		1
Stenelmis	11	2		39
DECAPODA				
Orconectes ozarkae	-99	-99		
Orconectes virilis		-99		2
DIPTERA				
Ablabesmyia		8		1
Ceratopogoninae	1	2		
Corynoneura	3			
Cricotopus/Orthocladius	6			1
Cryptochironomus		1		
Dicrotendipes		4		
Hemerodromia	4			3
Labrundinia		1		1
Microtendipes		7		
Nanocladius	1			
Nilothauma		1		
Paralauterborniella		5		
Paratanytarsus	1			
Paratendipes		2		
Polypedilum convictum grp	19			2
Polypedilum illinoense grp	1			
Procladius		1		
Rheocricotopus	2			5
Rheotanytarsus	18			5
Simulium	28			1
Stempellinella		7		1
Stictochironomus		1		
Tanytarsus	3	14		1
Thienemanniella	24	1		4
Thienemannimyia grp.	4			

ORDER: TAXA	CS	NF	SG	RM
Tribelos		11		
Zavreliella		1		
EPHEMEROPTERA				
Baetis	101			28
Caenis anceps	14	3		1
Caenis latipennis	31	149		20
Isonychia	54			5
Leptophlebiidae	1			
Paracloeodes		1		
Stenonema femoratum		1		
Stenonema pulchellum	40	5		1
Tricorythodes	5	1		1
ISOPODA				
Lirceus	24			6
LEPIDOPTERA				
Petrophila	9			
LIMNOPHILA				
Ancylidae	9	21		1
Helisoma	-99			
Menetus	1	5		46
Physella				9
LUMBRICINA				
Lumbricidae	4			
MESOGASTROPODA				
Elimia	33	6		16
ODONATA				
Argia	31	2		3
Boyeria				1
Enallagma				18
Gomphidae	2			
Gomphus		-99		
Hetaerina	1			7
Libellula		-99		
Macromia		-99		
Stylogomphus albistylus		-99		
PLECOPTERA				
Acroneuria	-99			
TRICHOPTERA				
Cheumatopsyche	17			4
Chimarra	31			4
Helicopsyche		1		
Hydroptila				1
Mystacides		1		

ORDER: TAXA	CS	NF	SG	RM
Nectopsyche		1		
Oecetis	1			
Triaenodes				1
TRICLADIDA				
Planariidae	2			1
TUBIFICIDA				
Aulodrilus		2		
Branchiura sowerbyi		1		
Tubificidae		3		
VENEROIDEA				
Sphaerium		4		1

Aquid Invertebrate Database Bench Sheet Report

Roark Ck [0318755], Station #2, Sample Date: 10/8/2003 3:00:00 PM

ORDER: TAXA	CS	NF	SG	RM
"HYDRACARINA"				
Acarina	4			32
AMPHIPODA				
Allocrangonyx		1		
Hyalella azteca				3
Stygobromus	3			
COLEOPTERA				
Berosus		2		1
Dubiraphia		2		41
Ectopria nervosa				5
Optioservus sandersoni	13			
Psephenus herricki	182	1		2
Stenelmis	10	3		7
DECAPODA				
Orconectes neglectus	1			
Orconectes ozarkae	1	1		
Orconectes williamsi	-99			
DIPTERA				
Ablabesmyia		12		2
Ceratopogoninae		1		
Clinotanypus				1
Corynoneura		1		1
Cricotopus/Orthocladius	9			
Dicrotendipes		1		4
Forcipomyiinae				1
Labrundinia	2			2
Microtendipes	1	11		25
Natarsia		1		
Parametrioconemus	1			
Paratanytarsus				1
Polypedilum convictum grp	25			
Polypedilum halterale grp		1		
Polypedilum illinoense grp				1
Rheotanytarsus	9			
Simulium	4			
Stempellinella	1	3		4
Stenochironomus				3
Tanytarsus	1	7		12
Thienemanniella	1			
Thienemannimyia grp.	18			7
Tipulidae		1		
Tribelos		12		3

ORDER: TAXA	CS	NF	SG	RM
EPHEMEROPTERA				
Acentrella	1			
Baetis	116			1
Caenis anceps	18			
Caenis latipennis	6	207		41
Centroptilum		3		2
Heptageniidae	37			
Isonychia bicolor	6			
Leptophlebiidae	1	5		1
Leucrocuta	1			
Stenonema femoratum	6	18		3
Stenonema pulchellum	22			
ISOPODA				
Caecidotea (Blind & Unpigmented)	4			
Lirceus	166			1
LEPIDOPTERA				
Pyrilidae	2			
LIMNOPHILA				
Ancylidae	2	4		16
Gyraulus		2		1
Menetus		2		25
LUMBRICINA				
Lumbricidae	3	5		
LUMBRICULIDA				
Lumbriculidae	7			
MEGALOPTERA				
Corydalus	2			
Nigronia serricornis	2			
Sialis		1		
MESOGASTROPODA				
Elimia	1	5		9
ODONATA				
Argia	7	5		2
Basiaeschna janata		-99		
Enallagma				33
Hagenius brevistylus		-99		
Macromia				1
Stylogomphus albistylus	42	1		1
PLECOPTERA				
Acroneuria	2			
Leuctridae	1	1		
TRICHOPTERA				

ORDER: TAXA	CS	NF	SG	RM
Cheumatopsyche	5			
Chimarra	2			
Helicopsyche	1			
Leptoceridae		1		
Mystacides		2		
Polycentropodidae				3
Polycentropus	4			
Triaenodes		1		11
TRICLADIDA				
Planariidae		1		8
TUBIFICIDA				
Branchiura sowerbyi		2		
Tubificidae		2		
VENEROIDEA				
Sphaeriidae		1		

Aquid Invertebrate Database Bench Sheet Report

Roark Ck [0418672], Station #1, Sample Date: 3/17/2004 8:45:00 AM

ORDER: TAXA	CS	NF	SG	RM
N/A				
Gordiidae		-99		
"HYDRACARINA"				
Acarina	3	2		4
AMPHIPODA				
Hyaella azteca		1		5
COLEOPTERA				
Dubiraphia		1		
Ectopria nervosa				-99
Hydroporus		2		
Lutrochus	2	4		
Microcylloepus pusillus	1			
Psephenus herricki	4	6		
Stenelmis	42	2		8
DECAPODA				
Orconectes ozarkae	-99	-99		1
DIPTERA				
Ablabesmyia		24		2
Cardiocladius	1			
Chironomus		1		
Chrysops	2			
Clinocera	3	2		2
Corynoneura	6	14		10
Cricotopus bicinctus	2			2
Cricotopus/Orthocladius	9	11		17
Cryptochironomus	1	3		
Dicrotendipes	1	30		8
Eukiefferiella	152	23		106
Hemerodromia	3			
Hydrobaenus				1
Labrundinia		2		5
Micropsectra		2		3
Microtendipes	1	4		
Nanocladius	1			
Nilotanypus				1
Paracladopelma	1	5		
Parametrioctenemus	1			
Paratanytarsus		1		
Paratendipes		2		
Phaenopsectra		3		
Polypedilum convictum grp	27	3		7
Prosimulium		1		

ORDER: TAXA	CS	NF	SG	RM
Pseudochironomus		1		
Pseudosmittia		1		
Rheocricotopus	7			
Rheotanytarsus	27			13
Sciomyzidae		1		
Simulium	4			4
Stempellinella	5	17		6
Stictochironomus		1		
Sympothastia	1	1		2
Tanytarsus	5	10		6
Thienemanniella	5	1		14
Thienemannimyia grp.	6	25		8
Tipula	-99			-99
Tribelos		1		
Tvetenia	2			
EPHEMEROPTERA				
Acentrella	13	1		8
Acerpenna		2		
Baetidae				2
Baetis	1			
Caenis anceps	25	21		8
Caenis latipennis	41	18		44
Centroptilum		1		1
Eurylophella enoensis				1
Heptageniidae	5	1		
Isonychia bicolor	13			
Leptophlebia		4		
Leucrocuta	1	2		
Paraleptophlebia	1			1
Stenonema femoratum		3		1
Stenonema pulchellum	2	1		-99
HEMIPTERA				
Microvelia				1
ISOPODA				
Lirceus	6			4
LEPIDOPTERA				
Petrophila	3			
LIMNOPHILA				
Ferrissia		2		
Menetus	1			1
LUMBRICULIDA				
Lumbriculidae	4			
MEGALOPTERA				

ORDER: TAXA	CS	NF	SG	RM
Corydalus	-99			
MESOGASTROPODA				
Elimia	8	8		6
ODONATA				
Argia	3			1
Boyeria				-99
Calopteryx				1
Enallagma		2		6
Libellula		-99		
Stylogomphus albistylus		2		-99
PLECOPTERA				
Acroneuria				-99
Amphinemura	9	1		1
Clioperla clio				-99
Isoperla	1	1		1
Perlesta	2	3		7
TRICHOPTERA				
Agapetus	1			
Cheumatopsyche	1			-99
Chimarra	6			
Helicopsyche	2			
Hydroptila	5			
Ironoquia				1
Mystacides		3		
Pycnopsyche				-99
TRICLADIDA				
Planariidae	1			
TUBIFICIDA				
Branchiura sowerbyi	1			
Tubificidae	3	1		
VENEROIDEA				
Sphaeriidae	1			1

Aquid Invertebrate Database Bench Sheet Report

Roark Ck [0418673], Station #2, Sample Date: 3/17/2004 11:30:00 AM

ORDER: TAXA	CS	NF	SG	RM
"HYDRACARINA"				
Acarina	1	2		1
AMPHIPODA				
Hyalella azteca				1
ARHYNCHOBDELLIDA				
Erpobdellidae		-99		
COLEOPTERA				
Dubiraphia		1		2
Hydroporus		1		1
Psephenus herricki	1	2		1
Stenelmis	1	2		
DECAPODA				
Orconectes neglectus		1		
Orconectes ozarkae	1			1
Orconectes punctimanus				-99
Orconectes virilis	-99			
Orconectes williamsi	-99			
DIPTERA				
Ablabesmyia		23		5
Ceratopogoninae		2		1
Chelifera	1			
Clinocera	3	2		1
Clinotanypus		1		
Constempellina		1		
Corynoneura	1	8		4
Cricotopus bicinctus				1
Cricotopus/Orthocladius	18			24
Cryptochironomus		2		2
Dicrotendipes	1	11		13
Eukiefferiella	8	2		5
Glyptotendipes		1		
Hemerodromia	1			
Labrundinia		1		1
Micropsectra	2			
Microtendipes		7		2
Nanocladius	1			
Nilotanypus	3			
Paratanytarsus				5
Polypedilum				1
Polypedilum convictum grp	58			1
Polypedilum halterale grp		2		
Polypedilum illinoense grp	2			

ORDER: TAXA	CS	NF	SG	RM
Potthastia	1			
Rheocricotopus	5			4
Rheotanytarsus	11	1		2
Stempellinella	2	3		3
Stictochironomus		1		
Sympotthastia				10
Tanytarsus		3		
Thienemanniella	2			5
Thienemannimyia grp.	14	7		4
EPHEMEROPTERA				
Acentrella				3
Ameletus				1
Caenis latipennis	16	127		49
Centroptilum		3		9
Dipheter	3			
Eurylophella bicolor	1			2
Fallceon	1			
Heptageniidae	23	3		1
Isonychia bicolor	5			
Leptophlebia				3
Leucrocuta	15			
Paraleptophlebia	7	8		13
Stenonema femoratum	12	15		11
Stenonema pulchellum	51			
ISOPODA				
Caecidotea (Blind & Unpigmented)		5		
Lirceus	114			6
LIMNOPHILA				
Ancylidae	1			
Menetus		1		1
MEGALOPTERA				
Sialis	-99			
MESOGASTROPODA				
Elimia		-99		31
ODONATA				
Argia	1			2
Basiaeschna janata				-99
Calopteryx				-99
Enallagma				2
Macromia		-99		
Stylogomphus albistylus	2	2		2
PLECOPTERA				
Amphinemura	20	1		15

ORDER: TAXA	CS	NF	SG	RM
Chloroperlidae	1	2		
Clioperla clio				-99
Isoperla	42	8		14
Leuctridae		1		
Perlesta	47			37
Perlinella ephyre		1		
TRICHOPTERA				
Agapetus	1			
Cheumatopsyche	22	1		6
Chimarra	1	1		
Hydroptila	1			1
Mystacides		1		
Polycentropus	4	1		
Pycnopsyche		1		-99
Rhyacophila				-99
TUBIFICIDA				
Branchiura sowerbyi		5		
Enchytraeidae		1		1
Tubificidae		2		4
VENEROIDEA				
Pisidium		2		1

Aquid Invertebrate Database Bench Sheet Report

Swan Ck [0318752], Station #6, Sample Date: 10/7/2003 12:00:00 PM

ORDER: TAXA	CS	NF	SG	RM
N/A				
Branchiobdellida	1			
"HYDRACARINA "				
Acarina	26			
AMPHIPODA				
Hyaella azteca				87
COLEOPTERA				
Ancyronyx variegatus	1			
Dubiraphia		13		46
Ectopria nervosa	1	8		
Lutrochus	4			
Optioservus sandersoni	18	1		
Paracymus	1			
Psephenus herricki	41	58		
Scirtes				1
Stenelmis	34	29		
DECAPODA				
Orconectes neglectus	-99			
Orconectes ozarkae	1			
DIPTERA				
Ablabesmyia		5		4
Atherix	-99			
Ceratopogoninae	2	3		4
Chrysops		-99		
Clinotanypus		1		
Corynoneura	9	2		6
Cricotopus/Orthocladus	20	3		27
Dicrotendipes		1		3
Diptera	1	1		
Ephydriidae	1			
Hemerodromia	-99			
Labrundinia	1			44
Microtendipes		1		
Nanocladius	1			2
Parakiefferiella	1			4
Paratanytarsus				7
Polypedilum convictum grp	5			
Polypedilum halterale grp		5		
Polypedilum illinoense grp				3
Rheocricotopus	1			
Rheotanytarsus	8			12
Simulium	18			

ORDER: TAXA	CS	NF	SG	RM
Stempellinella	1	1		2
Stenochironomus				1
Sympothastia	1			
Synorthocladius		1		
Tabanus	2			
Tanytarsus	8	4		1
Thienemanniella	23			4
Thienemannimyia grp.	8	2		4
Tribelos		27		4
undescribed Empididae	2			
EPHEMEROPTERA				
Acentrella	16			
Baetis	43			
Caenis anceps	33			
Caenis latipennis	10	74		6
Ephemerella	1			
Eurylophella	23			
Heptageniidae	37	4		
Isonychia bicolor	16			
Leptophlebiidae		10		1
Leucrocuta	1			
Procloeon		7		
Stenacron	10			
Stenonema femoratum		26		
Stenonema mediopunctatum	41			
Tricorythodes	1			2
ISOPODA				
Caecidotea (Blind & Unpigmented)	3	5		
LEPIDOPTERA				
Petrophila	2	1		
LIMNOPHILA				
Ancylidae	1	2		2
Fossaria				1
Menetus		1		3
Physella	4			2
LUMBRICINA				
Lumbricidae	2	1		
LUMBRICULIDA				
Lumbriculidae				1
MEGALOPTERA				
Corydalus	1			
Nigronia serricornis	2			
MESOGASTROPODA				

ORDER: TAXA	CS	NF	SG	RM
Elimia	12	10		58
Hydrobiidae	1			
ODONATA				
Argia	16	17		
Basiaeschna janata				1
Enallagma		2		14
Erpetogomphus		-99		
Gomphidae		1		
Hagenius brevistylus		5		-99
Hetaerina				1
Stylogomphus albistylus	60	2		
PLECOPTERA				
Acroneuria	-99			
RHYNCHOBDELLIDA				
Glossiphoniidae	1			
TRICHOPTERA				
Cheumatopsyche	4			
Chimarra	9			
Helicopsyche	3	3		1
Hydroptila				1
Oecetis				6
Polycentropus	3	1		7
Triaenodes				23
TRICLADIDA				
Planariidae	23	3		1
TUBIFICIDA				
Aulodrilus		1		
Limnodrilus hoffmeisteri		1		
Tubificidae		8		2
VENEROIDEA				
Pisidium				1
Sphaerium		1		1

Aquid Invertebrate Database Bench Sheet Report

Swan Ck [0418671], Station #6, Sample Date: 3/16/2004 12:15:00 PM

ORDER: TAXA	CS	NF	SG	RM
"HYDRACARINA"				
Acarina	8	1		
AMPHIPODA				
Hyalella azteca	1			21
COLEOPTERA				
Dubiraphia	3	7		13
Ectopria nervosa	2	-99		
Psephenus herricki	6	12		1
Stenelmis	2	3		
DECAPODA				
Orconectes neglectus		-99		
Orconectes ozarkae	2	-99		
Orconectes virilis				-99
DIPTERA				
Ablabesmyia	1	14		14
Ceratopogoninae	1	2		3
Cladotanytarsus		1		
Clinocera	4	1		
Clinotanypus				3
Corynoneura	7	9		7
Cricotopus bicinctus	1			2
Cricotopus/Orthocladius	45	11		8
Cryptochironomus		3		
Dicrotendipes		8		8
Diptera				1
Eukiefferiella	46	4		2
Labrundinia		2		14
Micropsectra	4	8		6
Microtendipes		3		2
Nanocladius		2		
Parakiefferiella		11		15
Parametrioconemus	2			
Paraphaenocladius	1			
Paratanytarsus	3	1		13
Paratendipes	1			2
Polypedilum convictum grp	7			2
Potthastia	10			
Rheocricotopus	6			
Rheotanytarsus	8	1		2
Stempellinella	12	8		4
Sympotthastia	8	1		
Synorthocladius	3	4		

ORDER: TAXA	CS	NF	SG	RM
Tabanus	-99			
Tanytarsus	14	27		9
Thienemanniella	6	2		4
Thienemannimyia grp.	50	20		10
Tribelos		1		2
Zavrelimyia		3		1
EPHEMEROPTERA				
Acentrella	5			
Caenis latipennis	28	34		7
Centroptilum				4
Ephemera simulans		-99		
Ephemerella invaria	110	24		4
Eurylophella				1
Eurylophella bicolor	10	16		2
Heptageniidae	14	2		
Isonychia bicolor	4			
Leptophlebia	2	6		12
Paraleptophlebia	4	2		4
Stenacron	2			
Stenonema femoratum	10	40		5
Stenonema mediopunctatum	7	1		
Stenonema pulchellum	2			
HEMIPTERA				
Microvelia				6
LEPIDOPTERA				
Petrophila	1			
LIMNOPHILA				
Ancylidae	1			2
Menetus	1	1		1
Physella				1
LUMBRICINA				
Lumbricidae	-99	-99		-99
LUMBRICULIDA				
Lumbriculidae		1		4
MEGALOPTERA				
Nigronia serricornis	-99			
Sialis		-99		
MESOGASTROPODA				
Elimia	21	1		34
ODONATA				
Argia	7	8		3
Basiaeschna janata				-99
Dromogomphus				-99

ORDER: TAXA	CS	NF	SG	RM
Enallagma		1		13
Hagenius brevistylus	1			-99
Stylogomphus albistylus	10	2		-99
PLECOPTERA				
Acroneuria	-99			
Amphinemura	12			10
Chloroperlidae	3			
Clioperla clio				-99
Isoperla	14			1
Leuctridae	10	10		2
Perlesta	17	2		1
Prostoia				1
Pteronarcys pictetii	10			
TRICHOPTERA				
Ceraclea	1			
Chimarra	1			
Glossosoma	1			
Helicopsyche	3	1		
Hydroptila	36	3		1
Mystacides				1
Ochrotrichia	1			
Polycentropus	4	3		4
Triaenodes		1		3
TRICLADIDA				
Planariidae	3	1		1
TUBIFICIDA				
Aulodrilus		1		
Enchytraeidae	3	1		4
Tubificidae	1	3		3
VENEROIDEA				
Pisidium				7
Sphaerium	1	1		

Appendix C

Family Level Macroinvertebrate Bench Sheets
for 2003-2004 Roark Creek Biological Assessment
(-99 signifies presence of the taxa)

Aquid Invertebrate Database Bench Sheet Report

Cane Ck [0318753], Station #1, Sample Date: 10/7/2003 5:30:00 PM

ORDER: TAXA	CS	NF	SG	RM
EPHEMEROPTERA				
Baetidae	-99			
Caenidae	-99			
Heptageniidae	-99			
Isonychiidae	-99			
Tricorythidae	-99			
PLECOPTERA				
Leuctridae	-99			
TRICHOPTERA				
Hydropsychidae	-99			
Philopotamidae	-99			
Polycentropodidae	-99			

Aquid Invertebrate Database Bench Sheet Report

East Fk Roark Ck [0318756], Station #5, Sample Date: 10/8/2003 4:15:00 PM

ORDER: TAXA	CS	NF	SG	RM
EPHEMEROPTERA				
Baetidae	-99			
Heptageniidae	-99			
PLECOPTERA				
Leuctridae	-99			
Perlidae	-99			
TRICHOPTERA				
Philopotamidae	-99			
Polycentropodidae	-99			

Aquid Invertebrate Database Bench Sheet Report

West Fk Roark Ck [0318757], Station #3, Sample Date: 10/8/2003 4:45:00 PM

ORDER: TAXA	CS	NF	SG	RM
EPHEMEROPTERA				
Baetidae	-99			
Caenidae	-99			
Heptageniidae	-99			
Isonychiidae	-99			
TRICHOPTERA				
Hydropsychidae	-99			

Aquid Invertebrate Database Bench Sheet Report

West Fk Roark Ck [0318758], Station #4, Sample Date: 10/8/2003 6:10:00 PM

ORDER: TAXA	CS	NF	SG	RM
EPHEMEROPTERA				
Baetidae	-99			
Heptageniidae	-99			
PLECOPTERA				
Leuctridae	-99			

Aquid Invertebrate Database Bench Sheet Report

Cane Ck [0418677], Station #1, Sample Date: 3/18/2004 11:00:00 AM

ORDER: TAXA	CS	NF	SG	RM
EPHEMEROPTERA				
Baetidae	-99			
Heptageniidae	-99			
Isonychiidae	-99			
Leptophlebiidae	-99			
PLECOPTERA				
Leuctridae	-99			
Nemouridae	-99			
Perlidae	-99			
Perlodidae	-99			

Aquid Invertebrate Database Bench Sheet Report

East Fk Roark Ck [0418674], Station #5, Sample Date: 3/17/2004 1:30:00 PM

ORDER: TAXA	CS	NF	SG	RM
EPHEMEROPTERA				
Baetidae	-99			
Heptageniidae	-99			
Leptophlebiidae	-99			
PLECOPTERA				
Nemouridae	-99			
Perlidae	-99			
Perlodidae	-99			
TRICHOPTERA				
Rhyacophilidae	-99			

Aquid Invertebrate Database Bench Sheet Report

West Fk Roark Ck [0418675], Station #3, Sample Date: 3/17/2004 2:15:00 PM

ORDER: TAXA	CS	NF	SG	RM
EPHEMEROPTERA				
Baetidae	-99			
Heptageniidae	-99			
Isonychiidae	-99			
PLECOPTERA				
Perlodidae	-99			
TRICHOPTERA				
Hydropsychidae	-99			

Aquid Invertebrate Database Bench Sheet Report

West Fk Roark Ck [0418676], Station #4, Sample Date: 3/17/2004 3:45:00 PM

ORDER: TAXA	CS	NF	SG	RM
EPHEMEROPTERA				
Baetidae	-99			
Heptageniidae	-99			
PLECOPTERA				
Leuctridae	-99			
Perlodidae	-99			