Missouri Department of Natural Resources

Biological Assessment and Fine Sediment Study: Effects of a Floodplain Pit Gravel Mine

Bull Creek
Christian and Taney Counties

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Table of Contents

Page

1.0 Introduction 1
- 1.1 Justification 1
- 1.2 Purpose 2
- 1.3 Objectives 2
- 1.4 Tasks 2
- 1.5 Null Hypotheses 2

2.0 Methods 3
- 2.1 Study Timing 3
- 2.2 Station Descriptions 3
  - 2.2.1 Ecological Drainage Unit 3
- 2.3 Habitat Assessment 4
- 2.4 Biological Assessment 4
  - 2.4.1 Macroinvertebrate Collection and Analyses 4
  - 2.4.2 Physicochemical Water Collection and Analyses 5
  - 2.4.3 Discharge 5
- 2.5 Fine Sediment 6
  - 2.5.1 Fine Sediment Percentage Estimation 6
  - 2.5.2 Fine Sediment Data Analyses 6
- 2.6 Quality Control 6

3.0 Results and Analyses 7
- 3.1 Habitat Assessments 7
- 3.2 Biological Assessment 7
  - 3.2.1 Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure 8
  - 3.2.2 EPT Taxa 9
  - 3.2.3 Dominant Macroinvertebrate Families 9
  - 3.2.4 Physicochemical Water 11
- 3.3 Fine Sediment Coverage Estimation 13

4.0 Discussion 14
- 4.1 Test Stations #2 and #1: Downstream of Tri-County Sand and Gravel 14
  - 4.1.1 Habitat Assessment 15
  - 4.1.2 Macroinvertebrate Analyses 15
  - 4.1.3 Physicochemical Water Variables 16
  - 4.1.4 Fine Sediment Percentages 17
- 4.2 Notable Concerns on Bull Creek 17
  - 4.2.1 Station #4: Upstream Control (Reference Reach) 17
  - 4.2.2 Stations #3 (Control) and #2 (Test): Dissolved Oxygen Fluctuation 18
  - 4.2.3 Other Gravel Impaired Sites 19

5.0 Conclusions 19

6.0 Recommendations 20

7.0 Literature Cited 20

TABLES

Page

Table 1 Station Number, Legal and Descriptive Information for Bull Creek.....3

Table 2 Percentages of Land Cover for EDU and the Local (Bull Creek) Area, Based on 14-Digit Hydrologic Unit Codes (HUC-14) 4

Table 3 Stream Habitat Assessment Scores (SHAPP, MDNR 2000) for Bull Creek, July 2002 7

Table 4 Metric Scores and Sustainability for Bull Creek and Biological Criteria (BIOREF) Stations, April 2002 8

Table 5 Metric Scores and Sustainability for Bull Creek and Biological Criteria (BIOREF) Stations, September 2002.....9

Table 6A and B Total Number of Individuals (all species), A) EPT Taxa and B) Dominant Macroinvertebrate Families (DMF) as a Percentage of the Total Number of Individuals per Station, April 2002 10

Table 7A and B Total Number of Individuals (all species), A) EPT Taxa and B) Dominant Macroinvertebrate Families (DMF) as a Percentage of the Total Number of Individuals per Station, September 2002.....11

Table 8 Physicochemical Water Variables per Station, Bull Creek, April 2002.....12

Table 9 Physicochemical Water Variables per Station, Bull Creek, September 2002 13

Table 10 Sediment Percent Values Observed per Station, Grid-Quadrat for Bull Creek, July 2002 14

FIGURES

Figure 1 Bull Creek Stations and Tri-County Sand and Gravel Company

Figure 2 Grid of Transects and Quadrats Used to Estimate the Relative Percentage of Fine Sediment

Figure 3 Fine Sediment Percentage per Station, Bull Creek, July 2002

ATTACHMENTS

Appendix A Missouri Department of Natural Resources Bioassessment and Sediment Study Plan, Bull Creek, Taney County

Appendix B Macroinvertebrate Bench Sheets for April 2002 and September 2002

Appendix C Kruskal-Wallis, ANOVA on Ranks: Mean Fine Sediment Percentage Comparison Between Stations on Bull Creek

1.0 Introduction

At the request of the Missouri Department of Natural Resources (**MDNR**) Water Pollution Control Program (**WPCP**), the Environmental Services Program (**ESP**) Water Quality Monitoring Section (**WQMS**) conducted a habitat assessment, biological assessment, and fine sediment study on Bull Creek in Christian and Taney counties.

This segment of Bull Creek is considered a class "P" stream, according to the 10 CSR 20-7 Rules of Department of Natural Resources, Clean Water Commission, Water Quality Standards (MDNR 2000b). A class "P" stream maintains permanent flow even in drought periods. Use designations are: "irrigation, livestock and wildlife watering, protection of warm water aquatic life and human health-fish consumption, cool water fishery, whole body contact recreation, and boating and canoeing." As such, it is considered a General Warm Water Fishery.

1.1 Justification

In-stream gravel mining can impair water quality and increase downstream sedimentation, which may reduce or eliminate aquatic communities (Roell 1999). This sedimentation affects the presence and composition of macroinvertebrates, as well as fish, in aquatic communities (Brown et al. 1992). Fines and silt clog the interstitial voids between the larger particles in the substrate (Smale et al. 1995; Berkman and Rabeni 1987; Murphy et al. 1981; Chutter 1969) and reduce available habitat during high flow periods (Lenat et al. 1981).

In 2002, a study plan for Bull Creek in Christian and Taney counties was submitted to the MDNR, WPCP (Appendix A). The study plan included an assessment of the fish community, which was conducted and reported (Beckman and Jones 2002) by Southwest Missouri State University and Drury University of Springfield in cooperation with the Missouri Department of Conservation. The WQMS was responsible for the proposed habitat assessments, biological assessments using macroinvertebrates, and fine sediment study.

This project differs from the study plan in that, one of the two gravel mine sites identified for study was excluded. Reconnaissance revealed that the gravel mine immediately downstream of Walnut Shade, Missouri (Table Rock Asphalt Construction) was not suitable for study using our methods. It did not fit into MDNR's wadeable streams methodology. It was also apparently off-stream and was not being mined. To more effectively examine gravel-mining effects, the four allotted stations were used to study a single gravel mine. Tri-County Sand and Gravel Company was the focus of this study. It was not an in-stream gravel mine, yet its effects on Bull Creek are of interest. Crunkilton (1982) noted that off-stream gravel mining was not as harmful to the stream environment as in-stream gravel mining. However, discharge from gravel washing may increase siltation, which is a source for environmental concern.

This study was conducted in order to determine if a floodplain pit (MDNR 2001a) gravel mine impaired Bull Creek. Habitat assessments, biological assessments, and the fine sediment assessments bracketed the sand and gravel mine.

1.2 Purpose

Determine if aquatic communities were impaired in Bull Creek, Christian and Taney counties, due to gravel mining.

1.3 Objectives

1) Define the habitat quality on Bull Creek, Christian and Taney counties, in the sample stations.

2) Determine if the macroinvertebrate community and water quality were affected by a gravel mining influence on Bull Creek.

3) Determine if fine sediment sized particles impaired Bull Creek due to the gravel mining.

1.4 Tasks

1) Conduct a habitat assessment of Bull Creek.

2) Conduct a biological assessment, which includes macroinvertebrate assessment and physicochemical water analyses, on Bull Creek, Taney County.

3) Conduct a fine sediment study, which includes percentage estimates per station on Bull Creek.

1.5 Null Hypotheses

Habitat assessment scores will be similar between control and test stations.

The macroinvertebrate analyses results at control stations will be similar to test stations on Bull Creek, Christian and Taney counties.

Physicochemical water quality at control stations will be similar to test stations.

Fine sediment estimations will not be significantly different ($p<0.05$) between the control and test stations.

2.0 Methods

This project was conducted by Kenneth B. Lister, Steve Humphrey, and the staff of the Water Quality Monitoring Section of the Missouri Department of Natural Resources, Air and Land Protection Division, Environmental Services Program.

2.1 Study Timing

The outlined tasks were conducted during three visits to the Bull Creek area. The spring biological assessments were conducted March 16, 2002 at stations #3 and #2. Stations #4 and #1 were assessed the next day on March 17, 2002. Fall biological assessments were conducted September 18, 2002 at stations #4 and #1 and September 19, 2002 at stations #3 and #2. Habitat and fine sediment assessments were conducted July 30-31, 2002.

2.2 Station Descriptions

A total of four stations were used to bracket a gravel mine on Bull Creek. Two were upstream and two were downstream of the Tri-County Sand and Gravel Company mine (Table 1; Figure 1). Stations #4 and #3 were located upstream of the gravel mine and were considered control stations. Stations #2 and #1 were located downstream from the gravel operation and were considered test stations. Stations throughout this project are listed from upstream to downstream (e.g. #4, #3, #2, and #1).

Table 1
Station Number, Legal and Descriptive Information for Bull Creek

Station No.	County	Location, Section, Township, Range	Description
4	Christian	SW ¼ sec. 31, T. 25 N., R. 20 W.	Upstream Control
3	Taney	N ½ sec. 11, T. 24 N., R. 21 W.	Upstream Control
2	Taney	S ½ sec. 11, T. 24 N., R. 21 W.	Downstream Tri-County Sand and Gravel
1	Taney	S ½ sec. 23, T. 24 N., R. 21 W.	Downstream approx. 2 miles Tri-County Sand and Gravel

(Also see Figure 1, map of study area)

2.2.1 Ecological Drainage Unit

An Ecological Drainage Unit (**EDU**) is a physiographic region where biological communities and habitat conditions should be similar. The Bull Creek, Christian and Taney counties study area was located in the Ozark/White EDU. A Hydrologic Unit (**HU**) is a subdivision of the EDU that contains the stream study area. The HU, identified by a 14-digit code (**HUC-14**), was 11010003010006 for all stations on Bull Creek.

Table 2 compared the percent land cover use from the Ozark/White EDU with the local Hydrologic Unit. Land cover within the EDU and HUC-14 were similarly dominated by forest. The local HU for Bull Creek had approximately 15 percent more forest habitat than the larger EDU. The percentage of grassland in the Bull Creek HU was approximately 10 percent lower than the entire EDU. Percent land cover data were derived from Thematic Mapper (**TM**) satellite data collected between 1991 and 1993 and interpreted by the Missouri Resource Assessment Partnership (**MoRAP**).

Table 2
Percentages of Land Cover for EDU and the Local (Bull Creek) Area, Based on 14-Digit Hydrologic Unit Codes (HUC-14)

Land Use (%)	Urban	Crops	Grassland	Forest	Swamp/Marsh
Ozark/White EDU	0.9	0.4	46.4	48.8	0
HUC-14, Bull Creek Stations	0.2	0	35.7	62.9	0

2.3 Habitat Assessment

A standardized assessment procedure was followed as described for Riffle/Pool Prevalence in the Stream Habitat Assessment Project Procedure (**SHAPP**; MDNR 2000a). The habitat assessments were conducted on the four Bull Creek stations in July 2002. Total score and percent score comparisons were made between control and test stations. Scores at each station should be at least 75 percent of the reference station in order to be considered "fully supportive" of an aquatic community.

2.4 Biological Assessment

Biological assessments consisted of macroinvertebrate and physicochemical collection and analyses. Complete biological assessments were conducted twice at the four stations on Bull Creek. These occurred in the spring and fall of 2002.

2.4.1 Macroinvertebrate Collection and Analyses

A standardized macroinvertebrate sample collection and analysis procedure was followed as described in the Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (**SMSBPP**; MDNR 2001b). The three standard habitats for Riffle/Pool Prevalence (e.g. flowing water over coarse substrates, depositional substrates in non-flowing water, and root-mat) were sampled at all locations. These macroinvertebrate data from Bull Creek were compared using Biological Criteria for Perennial/Wadeable Streams (**BIOREF**).

Macroinvertebrate data were analyzed using two methods. The first method was a comparison of the Stream Condition Index (**SCI**) scores between control and test stations. The second was an examination of community composition at order and family levels between stations.

The SCI scores were calculated using the BIOREF data and offered a rating of sustainability of the macroinvertebrate community for each station. These ratings were full, partial, and non-sustainable. Four metrics were used to calculate the SCI score: 1) Total Taxa (**TT**); 2) Ephemeroptera/Plecoptera/Trichoptera Taxa (**EPTT**); 3) Biotic Index (**BI**); and 4) Shannon Diversity Index (**SDI**). A maximum score of five was possible for each of the four metrics. A total score of 16 to 20 considers the macroinvertebrate community to have full sustainability, 10-14 partial sustainability, and 4-8 non-sustainability.

The second method was an evaluation of the number and percentage of EPT taxa as well as the percentage of dominant macroinvertebrate families (**DMF**) in the sample. These were generally identified based on dominance from upstream to downstream or for other trends that may indicate a change in the community composition.

2.4.2 Physicochemical Water Collection and Analyses

Physicochemical water samples were handled according to MDNR, ESP, Standard Operating Procedures (**SOPs**) for sampling and analyzing physical and chemical water samples.

Physicochemical parameters measured in the field during April and September 2002 were temperature (C^0), pH, conductivity (uS/cm), dissolved oxygen (mg/L), and discharge (cubic feet per second). Water samples were returned to the ESP Laboratory in Jefferson City, Missouri for analyses that included turbidity (NTU), ammonia-nitrogen (mg/L), nitrate+nitrite-nitrogen (mg/L), total Kjeldahl nitrogen (**TKN**, mg/L), chloride (mg/L), and total phosphorus (mg/L). Samples were collected and transported on ice according to MDNR-FSS-001, Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations (MDNR 2002).

The ESP conducted all analyses on the returned water samples. The WQMS measured turbidity. The Chemical Analysis Section (CAS) analyzed remaining water samples.

Physicochemical variables were analyzed for trends between the two upstream (controls) and two downstream (test) stations. Results were also compared with acceptable limits according to the Missouri Water Quality Standards (MDNR 2000b).

2.4.3 Discharge

Stream flow was measured using a Marsh-McBirney flow meter at each station. Measurements were taken and discharge was interpreted according to the methods in MDNR-WQMS-113, Flow Measurement in Open Channels (MDNR 2003). Units were reported as cubic feet per second (**cfs**).

2.5 Fine Sediment

In-stream deposits of fine sediment (i.e. particle size ca. <2 mm) were estimated for percent coverage per area and data were analyzed for trends and differences between control and test stations.

2.5.1 Fine Sediment Percentage Estimation

The relative percentage of fine sediment (<2.0 mm) was estimated for each station. Each sampling station contained three sediment estimation areas (i.e. **grids**). In order to ensure sampling method uniformity, each grid was located between the lower margins of riffle/run habitats and the upper margin of pools (Figure 2). Depths of the stream did not exceed two (2.0) feet and the water velocity was not more than 0.5 feet per second within these grids. A Marsh-McBirney flow meter was used to ensure that water velocity of the sample area was within this range.

The relative percentage of fine sediment was estimated at each station by constructing a virtual grid of potential quadrats (Figure 2). A tape measure was anchored from bank to bank that comprised the downstream edge of each grid. Each grid consisted of six contiguous transects that traversed the stream. One sample quadrat (ca. 10" x 10") was randomly placed directly on the substrate within each of the six transects. Placement of the quadrat within each transect was determined by using a random number that equated to one foot increments from one bank edge. The trailing edge of the quadrat was placed on the downstream transect edge.

Two investigators then estimated the percentage of fine sediment observed on the stream bottom within each quadrat. The estimates were accepted if the two observations were within a ten percent margin of error. If estimates diverged more than ten percent, the investigators repeated the process until the estimates were within the acceptable margin of error. An average of these two estimates was recorded and used for analyses.

2.5.2 Fine Sediment Data Analyses

Statistical analyses of the relative percentage of fine sediment found in the substrate were conducted using Sigmastat Version 2.0 (1997). Kruskal-Wallis, One way Analysis of Variance on ranks (**ANOVA on Ranks**) determined similarity between stations. If significant differences ($p<0.05$) were detected between stations, an All Pairwise Multiple Comparison Procedure, such as the Tukey Test, was conducted to identify which stations were different. Data for each station (n=18 quadrats) were included in the comparison. Data from 72 quadrats were used to compare all four stations.

2.6 Quality Control

Quality control was used as stated in the applicable MDNR Project Procedures (**PP**s), SOPs, and Quality Assurance Project Plans (**QAPP**s).

3.0 Results and Analyses

Variables included in the results were found to have high values or exhibit interesting trends. Others not included here were not outstanding. Results are included for habitat assessments, biological assessments, including macroinvertebrate assessments and physicochemical water analyses, and fine sediment coverage estimation.

3.1 Habitat Assessments

Habitat assessments (SHAPP) were conducted at all four stations. Two comparisons were made using the scores based on the quality of habitat. The first comparison was of habitat scores between stations from upstream to downstream. The second comparison was as outlined in the SHAPP, whereby the habitat of a study stream must score greater than 75 percent of a reference stream reach in order to be considered to be able to fully support an aquatic community similar to reference communities.

The first habitat assessment comparison was of scores at stations from upstream to downstream (Table 3). Stream habitat assessment scores decreased slightly from 139 and 134 at the upstream control stations, #4 and #3, to 121 downstream of test station #2 below Tri-County Sand and Gravel. The habitat score increased to 171 at station #1.

All stream habitat assessment total scores were greater than 80 percent of the reference stream reach (#4; Table 3). Therefore, all stations scored greater than the 75 percent called for in the SHAPP, which suggests that they are capable of supporting an aquatic community similar to reference conditions. The habitat in station #2 scored 121, yet was still 87 percent of the reference station. The habitat assessment score at station #1 received the highest score (171), which was 123 percent of the reference station.

Table 3
Stream Habitat Assessment Scores (SHAPP, MDNR 2000) for Bull Creek, July 2002

Stations	4	3	2	1
SHAPP Total Score	139	134	121	171
Percent of Station #4 (Control/ Reference)	100	96	87	123

3.2 Biological Assessment

As outlined in the methods, a biological assessment consists of macroinvertebrate analyses as well as evaluation of the physicochemical water data. The macroinvertebrate analyses consisted of two methods. The first analysis was a multi-metric evaluation (Stream Condition Index) according to the SMSBPP. The second analysis was an examination of the numbers and percentage of EPT taxa, as well as examination of dominant macroinvertebrate families (**DMF**).

3.2.1 Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure

The SMSBPP metric calculations that determine Stream Condition Index (SCI) scores were calculated for each station using biological criteria. Total SCI scores and individual metric scores were examined for the April 2002 and September 2002 sample seasons.

Macroinvertebrate SCI scores in April 2002 indicated that all stations could fully sustain aquatic communities (Table 4). All had total scores of 16 with the exception of the farthest downstream test station (#1) which had the highest overall score of 18. Individual metrics scores were similar across the study area in April as well (Table 4). Station #2 scored slightly lower (88) in the total taxa, but was similar to upstream stations #4 and #3 totals (98 and 91 respectively). BI scores were similarly lower at stations #4, #3, and #2, which illustrated that community composition at these stations were less tolerant of organic pollution. A higher BI score at station #1 indicated that the aquatic community may be more tolerant to organic pollution. The SDI score followed a similar trend, in which these stations were not as rich in taxa and less evenly distributed than station #1.

Table 4
Metrics Scores and Sustainability for Bull Creek and Biological Criteria (BIOREF) Stations
n=9 stations (in gray), April 2002

Station	4	3	2	1	Score 5	Score 3	Score 1
Sample No.	0218039	0218038	0218037	0218040	--	--	--
Total Taxa	98	91	88	101	>96	96 - 48	<48
EPT Taxa	31	35	32	34	>31	31 - 16	<16
BI	2.89	3.42	3.87	5.12	<4.59	4.59-7.30	>7.30
SDI	2.71	3.19	3.21	3.38	>3.21	3.21-1.60	<1.60
SCI Scores	16	16	16	18	20 – 16	14 - 10	8 - 4
Sustainability	Full	Full	Full	Full	Full	Partial	Non

In September, macroinvertebrate total SCI scores were similar at stations #3 through #1 and were very similar in their capability to sustain aquatic communities (Table 5). Interestingly, the control (i.e. BIOREF reference stream) station #4 had a total SCI score that was slightly lower (14) than the downstream control and test stations (16, 18 and 16), which placed station #4 in the partial sustainability category.

Individual metric scores further illustrate the differences from upstream to downstream in September (Table 5). The upstream control station #4 had fewer total taxa (71) than downstream stations #3 (79), #2 (89), and #1 (83). The BI and SDI individual scores were lower for the control stations (#4 and #3), indicating that the community was less tolerant to pollution and less diverse than the test stations.

Table 5
Metrics Scores and Sustainability for Bull Creek and Biological Criteria (BIOREF) Stations
n=8 stations (in gray), September 2002

Station	4	3	2	1	Score 5	Score 3	Score 1
Sample No.	0218126	0218128	0218127	0218125	--	--	--
Total Taxa	71	79	89	83	>78	78-39	<39
EPT Taxa	25	30	29	24	>26	26-13	<13
BI	4.37	4.42	5.18	5.58	<4.70	4.70-7.35	>7.35
SDI	2.93	3.04	3.37	3.62	>3.15	3.15-1.57	<1.57
SCI Score	14	16	18	16	20 – 16	14 - 10	8 - 4
Sustainability	Partial	Full	Full	Full	Full	Partial	No

3.2.2 EPT Taxa

The number of EPT taxa was consistent from upstream to downstream in April 2002 (Table 6A). However, Ephemeroptera increased slightly at station #2 to 58 percent of the total number of individuals. The percentages of Plecoptera remained relatively constant, while Trichoptera dropped slightly from upstream to downstream.

The number of overall EPT taxa per station was relatively consistent from upstream to downstream in September 2002 (Table 7A). Again, there was a slight trend in the percentage of Ephemeroptera per station. The percentage of Ephemeroptera increased from 19 percent at station #3 to 30 percent of the total number of individuals at station #2.

3.2.3 Dominant Macroinvertebrate Families

At the family level, the community composition changed between controls and test stations in April 2002 (Table 6B). The dominant macroinvertebrate family was Heptageniidae at the control stations #4 and #3 and changed to Ephemerellidae at test station #2. Chironomidae increased to dominate the percentage of total number of individuals at station #1. Trends within families showed that heptageniids and pleurocerids decreased sharply at downstream stations from their highs at station #4. Chironomids increased three-fold at station #1 (35%) compared to station #2 (11%). Caenids increased four-fold from the control stations #4 and #3 to the test stations #2 and #1.

Table 6A and B
Total Number of Individuals (all species), A) EPT Taxa and B) Dominant Macroinvertebrate Families (DMF) as a Percentage of the Total Number of Individuals per Station, April 2002

Station	4	3	2	1
Sample Number	0218039	0218038	0218037	0218040
A) Total Number of Individuals	1409	1170	1201	1012
Ephemeroptera, (%)	41	43	**58**	44
Plecoptera , (%)	4	6	9	5
Trichoptera, (%)	2	6	2	2
Number of EPT Taxa	31	35	32	34
B) Dominant Macroinvertebrate Families, (%)	Heptageniid	Heptageniid	Ephemerellid	Chironomid
Ephemerellidae	7	14	**23**	7
Heptageniidae	**28**	**18**	16	11
Caenidae	4	6	**15**	**21**
Chironomidae	11	10	11	**35**
Psephenidae	4	4	3	0
Class Arachnoidea	2	0	3	0
Perlidae	0	0	3	2
Nemouridae	0	0	3	0
Baetidae	0	4	0	2
Pleuroceridae	**28**	**16**	0	0
Elmidae	2	6	0	3
Simuliidae	0	0	0	2

A shift was identified at the family level in September 2002 (Table 7B). The dominant macroinvertebrate families (DMFs) changed from upstream to downstream. Psephenids were dominant at stations #4 and #3, while Chironomidae increased to dominate at stations #2 and #1. As a percentage of the total number of individuals, chironomids increased in stations #2 and #1. Caenid mayflies increased three-fold at stations #2 and #1 over the upstream controls. Heptageniid mayflies more than doubled from station #2 (7) to station #1 (15) as a percentage of the total number of individuals per station.

Table 7A and B
Total Number of Individuals (all species), A) EPT Taxa and B) Dominant Macroinvertebrate Families (DMF) as a Percentage of the Total Number of Individuals per Station, September 2002

Station	4	3	2	1
Sample Number	0218126	0218128	0218127	0218125
A) Total Number of Individuals	1321	1312	1752	1265
Ephemeroptera, (%)	14	19	**30**	**39**
Plecoptera , (%)	0	2	0	0
Trichoptera, (%)	9	6	5	4
Number of EPT Taxa	25	30	29	24
B) Dominant Macroinvertebrate Families, (%)	Psephenid	Psephenid	Chironomid	Chironomid
Psephenidae	**32**	**34**	19	5
Chironomidae	14	16	**20**	**21**
Hyalellidae	11	5	4	0
Heptageniidae	7	9	7	**15**
Gomphidae	5	0	5	0
Elimidae	4	5	4	7
Leptoceridae	4	4	0	0
Pleuroceridae	4	3	4	4
Caenidae	0	5	**16**	**15**
Coenagrionidae	0	0	0	7
Isonychiidae	0	0	0	5

Appendix B identifies the taxa found in Bull Creek stations for each season. Many are identified to the generic level. Sensitive species were found in all four stations for each season. Heptageniid mayflies and other sensitive taxa were found in relative abundance in the test stations.

3.2.4 Physicochemical Water

Results for physicochemical water analyses are arranged in chronological order for April and September 2002. Data was compared to the Water Quality Standards (MDNR 2000b), if necessary, and trends were identified from upstream and downstream.

The physicochemical data from stations on Bull Creek were not outstanding in April 2002 (Table 8). None of the values exceeded Water Quality Standards (MDNR 2000b). However, the discharge was in the 200 to 350 cfs range due to recent rains.

Table 8
Physicochemical Water Variables per Station, Bull Creek, April 2002
Units mg/L unless otherwise noted.

Variable-Station	Bull Creek #4, Reference Station-Upstream April 17, 2002	Bull Creek #3, Reference Station-Upstream April 16, 2002	Bull Creek #2, Test Station-Downstream Tri-County S&G April 16, 2002	Bull Creek #1/ 1B-QC, Test Station-Downstream Tri-County S&G April 17, 2002
Physicochemical Sample Number	0216480	0216479	0216478	0216481/ 0216482
pH (Units)	8.0	8.2	8.2	8.4
Temperature (C^0)	13	16	16	15
Conductivity (uS)	311	310	314	319
Dissolved O_2	9.2	9.4	10.3	10.4
Discharge (cfs)	227	239	239	343
Turbidity (NTUs)	<1.00	<1.00	<1.00	<1.00
Ammonia-N	<0.05	<0.05	<0.05	<0.05/ <0.05
Nitrate/Nitrite-N	0.47	0.41	0.40	0.34/ 0.35
TKN	<0.20	<0.20	0.70	0.21/ 0.22
Chloride	<5.00	<5.00	<5.00	<5.00/ <5.00
Total Phosphorus	<0.05	<0.05	<0.05	<0.05/ <0.05

The physicochemical variables results were not outstanding in September 2002, with one exception (Table 9). Dissolved oxygen was below MDNR (2000b) Water Quality Standards (5 mg/L) at stations #3 (4.0 mg/L) and #2 (3.5 mg/L). Station #3 is a control station located directly upstream of the gravel mine. Station #2 is directly downstream of the gravel mine.

Table 9
Physicochemical Water Variables per Station, Bull Creek, September 2002
Units mg/L unless otherwise noted.

Variable-Station	Bull Creek #4, Reference Station-Upstream September 18, 2002	Bull Creek #3, Reference Station-Upstream September 19, 2002	Bull Creek #2, Test Station-Downstream Tri-County S&G September 19, 2002	Bull Creek #1, Test Station-Downstream Tri-County S&G September 18, 2002
Physicochemical Sample Number	0230855	0230857	0230856	0230854
pH (Units)	8.0	7.9	7.7	8.2
Temperature (C^0)	25	23	22	24
Conductivity (uS)	397	406	404	366
Dissolved O_2	9.02	**4.0**	**3.5**	9.43
Discharge (cfs)	2.40	2.31	2.31	3.52
Turbidity (NTUs)	<1.00	<1.00	1.05	<1.00
Ammonia-N	<0.05	<0.05	<0.05	<0.05
Nitrate/Nitrite-N	0.28	0.17	0.10	<0.05
TKN	<0.2	<0.2	0.32	<0.2
Chloride	8.54	7.89	7.05	7.24
Total Phosphorus	<0.05	<0.05	0.81	<0.05

3.3 Fine Sediment Coverage Estimation

The fine sediment percentages increased slightly from upstream to downstream. The percentage of fine sediment ranged from zero to as much as 62 percent in quadrats between stations (Table 10). However, means only ranged from 1.3 to 8.9 percent (Table 10; Figure 2). Mean percentages of fine sediment were similar in the controls (2.0 $\pm$ 2.4; and 1.3 $\pm$ 1.8) as well as between control and test stations (6.6 $\pm$ 15; and 8.9 $\pm$ 16.7). Statistical analysis revealed that fine sediment did not significantly increase ($H = 2.485$, 3 d.f.; $p = 0.478$) between all stations on Bull Creek (Appendix C).

Table 10
Sediment Percent Values Observed per Station, Grid-Quadrat for Bull Creek, July 2002
(e.g. Six quadrats per grid, 18 per Station)

Grid-Quadrat	Bull Creek #4	Bull Creek #3	Bull Creek #2	Bull Creek #1
1-1	0	1	1	0
1-2	1	1	4	5
1-3	0	1	2	1
1-4	0	0	1	1
1-5	4	4	2	2
1-6	0	1	0	0
2-1	0	0	0	0
2-2	1	0	2	0
2-3	1	3	1	0
2-4	7	2	2	0
2-5	3	5	0	0
2-6	4	5	0	0
3-1	0	0	0	10
3-2	8	0	8	20
3-3	3	0	1	62
3-4	2	0	6	40
3-5	0	0	10	8
3-6	2	0	22	12
Mean	2	1.3	6.6	8.9
S.D.	±2.4	±1.8	±15.0	±16.7

4.0 Discussion

The purpose of this project was to determine if gravel mining was affecting aquatic communities on Bull Creek. If Tri-County Sand and Gravel Company was impairing Bull Creek, test stations (#2 and #1) should be different than the control stations (#4 and #3). Station #1, the second test station, was positioned to show the extent of impairment downstream, if it existed. Habitat, biological, water quality variables, and relative fine sediment measures were used to identify impairment between controls and test stations and subsequently if the gravel mine is affecting the quality of the stream.

4.1 Test Stations #2 and #1: Downstream of Tri-County Sand and Gravel

Variables that might identify impairment are found in the habitat assessments, macroinvertebrate assessments, water quality assessments, and fine sediment assessments. Station #2 could show impact and station #1 the extent of impairment downstream, if it exists.

4.1.1 Habitat Assessment

The habitat assessment at station #2 was not distinct from the controls, in that it was fully supportive of the aquatic community. However, a lower total score at station #2 suggested that it might be slightly more disturbed than the controls. This station looked disturbed between the mine and the Goodnight Hollow Road low-water bridge. The channel was slightly braided downstream of Tri-County, which indicated there might have been improper gravel mining practices in the past. No large-scale mining was being conducted during this project, which may have influenced the outcome. However, the difference between the control habitat scores and station #2 did not absolutely identify Tri-County Sand and Gravel Company as the cause. Nor was impairment indicated according to the SHAPP standards.

There were several other influences in the area that may have affected the score at station #2. The low-water bridge at Goodnight Hollow Road may be related to braiding of the stream. The downstream end of station #2 was approximately 100 yards upstream of the low water bridge and may act as a dam during high water events, which could impact the area. Secondly, the area is obviously used by the local population for water sports that may have affected the habitat scores. This is private land, yet used extensively by the public. The property owner is trying to curb traffic and was working with the MDNR (Dan Leyland, MDNR, SWRO and Land Reclamation, MDNR, Jefferson City, Missouri) to reclaim and properly manage the property. Future biological assessments and habitat assessments may score higher if he is successful.

The drop in score at station #2 was not apparent in station #1. In fact, station #1 scored the highest of all habitat assessments. Unlike station #2, station #1 is secluded. It is farther away from intensive traffic and the general habitat appeared to be of higher quality than all other stations, including the controls. In this case, accessibility may be key to quality.

Overall, the habitat scores indicated that all stations should support an aquatic macroinvertebrate community similar to reference conditions. A slight decline in the habitat score was apparent below the gravel mine, yet was not significantly different from controls or the other test stations.

4.1.2 Macroinvertebrate Analyses

Macroinvertebrate analyses were conducted on several levels at stations #2 and #1. Stream Condition Index (SCI) scores based on biological criteria metrics; EPT taxa abundance and percentage; and dominant macroinvertebrate families showed some changes from the controls to the test stations (i.e. upstream to downstream).

Macroinvertebrate SCI scores showed that test stations were fully sustainable of the aquatic communities and scores were similar to the control stations, with one exception (i.e. control station #4; see 4.2.2). Stations #2 and #1 SCI scores were as high as the controls, if not better, in both seasons. No impairment was identified by the SCI scores at either test station. However, individual metric scores (BI and SDI) suggested that the macroinvertebrate community shifted

from a less tolerant to a community more tolerant of organic pollution. The shift also increased the number of taxa and the evenness of taxa distribution.

EPT taxa abundance and percentages were not obviously different between the controls and test stations. Ephemeroptera increased in the test stations, probably due to increased percentage of caenid and heptageniid mayflies. Because of the abundance of tolerant and intolerant taxa present (Appendix B) in the test stations, it is not likely that impairment caused the shift. Rather, the shift may be a function of the stream size or other physical factors such as number of pools.

As indicated in the individual biological metric scores (i.e. BI and SDI), the dominant macroinvertebrate family composition changed between the control and the test stations during both seasons. In April, dominant macroinvertebrate families shifted from less tolerant heptageniid mayflies in the controls to more generally tolerant taxa caenid mayflies in the test stations. In September, the sediment intolerant psephenid beetles (Lenat et al. 1981) were dominant in the control stations while test stations were dominated by potentially more tolerant (Lenat 1983) chironomids. This suggests there was some shift in community structure downstream of the gravel mine. However, the number of taxa may vary with stream size (Lenat 1983) in an unstressed system and may have caused this shift. If the shift in stations #2 and #1 was not due to natural fluctuations, it may have been due to either physicochemical water variables or the amount of fine sediment on the substrate. Since no impairment to the macroinvertebrate communities in the test stations was found, the interest then becomes the cause of the community shift that took place in the test stations.

4.1.3 Physicochemical Water Variables

Physicochemical water variables at stations #2 and #1 were relatively stable, with two exceptions. Discharge and dissolved oxygen levels may have contributed to the apparent shift in community composition at station #2 (and #3 control).

Discharge was 100 times greater in April than was found in September, which may have influenced the findings. Discharge was very different from one season to the next, so it was apparently not a consistent contributor to the shift in community composition. Conversely, its similarity from upstream to downstream within each season again suggests that it is not the cause for the shift in the test stations. The macroinvertebrate shift due to discharge was not directly obvious.

The low discharge in September may have affected the dissolved oxygen levels at test station #2 (and control #3; see 4.2.2). It is possible that low flow increased pooling and decreased the aeration in this station. Physical variables such as depth and number of pools may play a role in the shift from upstream to downstream, as suggested by Lenat (1983). In this case, past disturbances such as gravel mining may have played a role by altering habitat. However, many sensitive taxa occur in this station and were not obviously affected by either of these variables.

4.1.4 Fine Sediment Percentages

An increase in the mean fine sediment percentage from control to test stations was apparent (e.g. from 1.3 to 8.9), but not significant ($p>0.05$). While a slight increase in fine sediment could increase the abundance of certain species (Lenat 1983), inconsistencies were found that would suggest fine sediment is not the sole reason for a shift in community composition, if at all. According to Zweig and Rabeni (2001), *Caenis latipennis* is intolerant of increases in fine sediment. The relative abundance of *C. latipennis* was much higher at the test stations. Heptageniid mayflies, generally considered intolerant of fine sediment, increased as a proportion of the sample at the test stations (#2 and #1). *Stenonema pulchellum* and *S. femoratum* were found in relatively large numbers in the test stations (#2 and #1) and are also considered intolerant of fine sediment. The presence of these taxa suggests that fine sediment may not be a sole contributor to the slight change in community composition.

Given inconsistencies in the community composition and limited fine sediment indices, the EPT taxa may be a reliable indicator of sediment impairment. The numbers of EPT remained relatively stable and relatively high (ca. 30 taxa) compared to reference streams in the past. This again suggests that if an effect from increased sediment or other variable is present, differences were not very great. However, more work needs to be done to describe fine sediment effects on the macroinvertebrate communities through development of fine sediment indices.

4.2 Notable Concerns on Bull Creek

As mentioned earlier, there were exceptions in the macroinvertebrate and water quality results that suggested there were other notable concerns on Bull Creek. First, the control station #4 had an SCI score during one season that was lower than all other streams. Secondly, dissolved oxygen levels were very low at stations #3 and #2 in September 2002.

4.2.1 Station #4: Upstream Control (Reference Reach)

The macroinvertebrate total Stream Condition Index (SCI) score at station #4, which is within the biocriteria reference reach, was lower than all remaining stations in September 2002. This station only reached “Partial Sustainability”, as compared to the “Full Sustainability” at all other stations. It was lower than the control station #3 and the test stations #2 and #1. As an upstream control, it should have had a score similar to the control and test stations given the null hypothesis. This suggested that it was a poor control station or something occurred to cause it to be impaired. It is important to note that the upstream control (#4) performed well during the April sample season, so it was likely to be a good station overall.

Individual metric scores for total taxa (TT), EPT taxa, and the SDI differentiated station #4 as having partial sustainability. These scores were relatively close to the cutoff point between partial and full sustainability. An increase in any of the three metrics would raise the total SCI score to fully sustainable. For example, two EPT taxa or eight more total taxa would have increased the score at station #4 from 14 to 16. This would increase its status to fully sustainable. The score was close to the cutoff point and a slight increase would have made this a

non-issue. However, the low score may be an indicator of some unidentified upstream disturbance.

Some disturbance may have occurred after the April sample season and before the September sample season, which caused the slightly lower score at control station #4. There were no obvious causes for the lower SCI score at station #4 in September. Physicochemical variables were similar at all stations and well within Water Quality Standards (MDNR 2000b) at station #4. It is possible that low discharge may be the cause for fewer taxa. However, discharge was only one cfs lower at this upstream station than it was at the test station farthest downstream. So, it is unlikely that the difference from upstream to downstream is discharge related. Fine sediment percentages were low at station #4, so it is not a likely cause. A biological and habitat assessment should be conducted upstream and downstream of station #4 to determine if the impairment continues.

The potential for impairment is high at Bull Creek station #4. A major subdivision (Saddlebrookemo.com) was being developed during this project. This 2300-acre development includes all of station #4 and approximately 0.25 mile downstream. Development and occupation of this subdivision has the potential to impair Bull Creek and cause it to be excluded from being used as a BIOREF station. This station's status as a regional reference stream should be reviewed after upstream and downstream studies are conducted. It is a valuable reference (i.e. BIOREF) stream for this EDU.

4.2.2 Stations #3 (Control) and #2 (Test): Dissolved Oxygen Fluctuation

As mentioned earlier, the physicochemical data from Bull Creek stations were similar and not outstanding between seasons with one exception in September 2002 (Table 9). Dissolved oxygen levels at stations #3 and #2 (4.0 mg/L and 3.5 mg/L) were less than half of what was found the previous day at stations #4 and #1 (9.02 mg/L and 9.43 mg/L). The high readings at stations #4 and #1 were collected in the afternoon, while the low readings were collected from #3 and #2 in the morning of the following day. It is possible that the readings were consistent with natural diurnal fluctuations, in which oxygen levels would be lowest in the morning. Comparisons should not be made between readings from different days because it is possible that all stations had low readings early that morning. However, the low readings were below limits set by MDNR's Water Quality Standards (5 mg/L; MDNR 2000b). With that in mind, it is necessary to investigate potential error, effects, and sources for the fluctuation.

To determine if the readings were accurate, the meter was checked several times. The calibration procedure was conducted three times. Results were the same or similar to the original. The meter was checked for quality control upon our return to the laboratory and was found to be in good working order. It appears that the meter was functioning properly and the results were not erroneous.

During that visit, biology students from the School of the Ozarks were seen sampling in the stream down from #2 at the time of our sampling in September. They offered information about their recent dissolved oxygen readings at the same location. The students said that dissolved oxygen levels were "very low " when they sampled several weeks prior.

The dissolved oxygen levels were below acceptable limits, suggesting there may be effects on the biota. According to the MDNR (2000b) Water Quality Standards, minimum levels in a cool water fishery for the protection of aquatic life is 5 mg/L. Measurements were between 3-4 mg/L at stations #3 and #2 on the morning of September 19, 2002. Macroinvertebrate scores were similar and fully capable of sustaining the aquatic community in September 2002, which suggests that it had no effect. Furthermore, the water column near the collection point contained numerous fish. A fisherman caught a four-pound smallmouth bass (*Micropterus dolomieu*) and several other sunfish during that sampling period. The fish and others observed in the water were active. The dissolved oxygen levels did not deter the biota from feeding, which suggests that it is not continuous. It may be part of a daily fluctuation.

The frequency and extent of the low oxygen levels could be determined by monitoring for dissolved oxygen levels using continuous remote sampling devices, such as dissolved oxygen dataloggers. Periodic diurnal monitoring of dissolved oxygen at stations #3 and #2 may determine if this is a reoccurring condition. If it is, placement of the datalogger in various areas of the stream may help identify the source.

4.2.3 Other Gravel Impaired Sites

One previously unmentioned gravel mine was identified subsequent to this study (in Beckman and Jones 2002). Beckman and Jones conducted a fish Index of Biological Integrity (IBI) on Bull Creek, among others. A site (in Beckman and Jones, site 1, page 38) in Bull Creek, upstream from the Bear Creek confluence, was identified as impaired by gravel mining (Taney County; SW sec. 22, NE sec. 27, T. 24 N., R. 21 W.). More stations should be allocated for conducting a habitat assessment, biological assessment, and fine sediment study at this location.

5.0 Conclusions

The purpose of this study was to determine if gravel mining impaired Bull Creek. As mentioned by Beckman and Jones (2002), care should be taken in making assumptions about the entire watershed based on one or a few observations. There was no obvious impairment due to Tri-County Sand and Gravel Company gravel mine on Bull Creek. However, the mine was not consistently in operation during the time of sampling. Results may be different if the mine was being heavily used. This study should be duplicated in order to account for active gravel mine impairment.

The objectives of this study were met. The habitat quality was defined and was similar between control and test stations on Bull Creek, in Christian and Taney Counties. Secondly, no evidence was found that suggested that the macroinvertebrate community was impaired or affected by

gravel mining influences. Water quality was good and similar in control and test stations, with one exception (low dissolved oxygen at control station #3 and test station #2 in September). Fine sediment was found in relatively low mean percentages and was not significantly different from controls to test stations. Thus, all null hypotheses were supported.

6.0 Recommendations

1) Periodically monitor Bull Creek using biological, habitat, and fine sediment assessments.

2) Periodically monitor stations #3 and #2 for dissolved oxygen using continuous physicochemical water sampling devices (e.g. dataloggers) to determine a cause or source.

3) Conduct biological and habitat assessments upstream and downstream of station #4 to determine if it is impaired and identify sources, if possible.

4) Continue to monitor and document changes, as development may affect the stations' status as a biological criteria reference station.

5) Review the reference status of Bull Creek station #4 (BIOREF) after conducting habitat and biological assessment upstream.

6) Duplicate this project in the future during active gravel mine operation.

7) Develop fine sediment indices for macroinvertebrates.

8) Conduct habitat, biological, and fine sediment assessments on a gravel mine in Taney County; SW sec. 22, NE sec. 27, T. 24 N., R. 21 W. (Beckman and Jones 2002).

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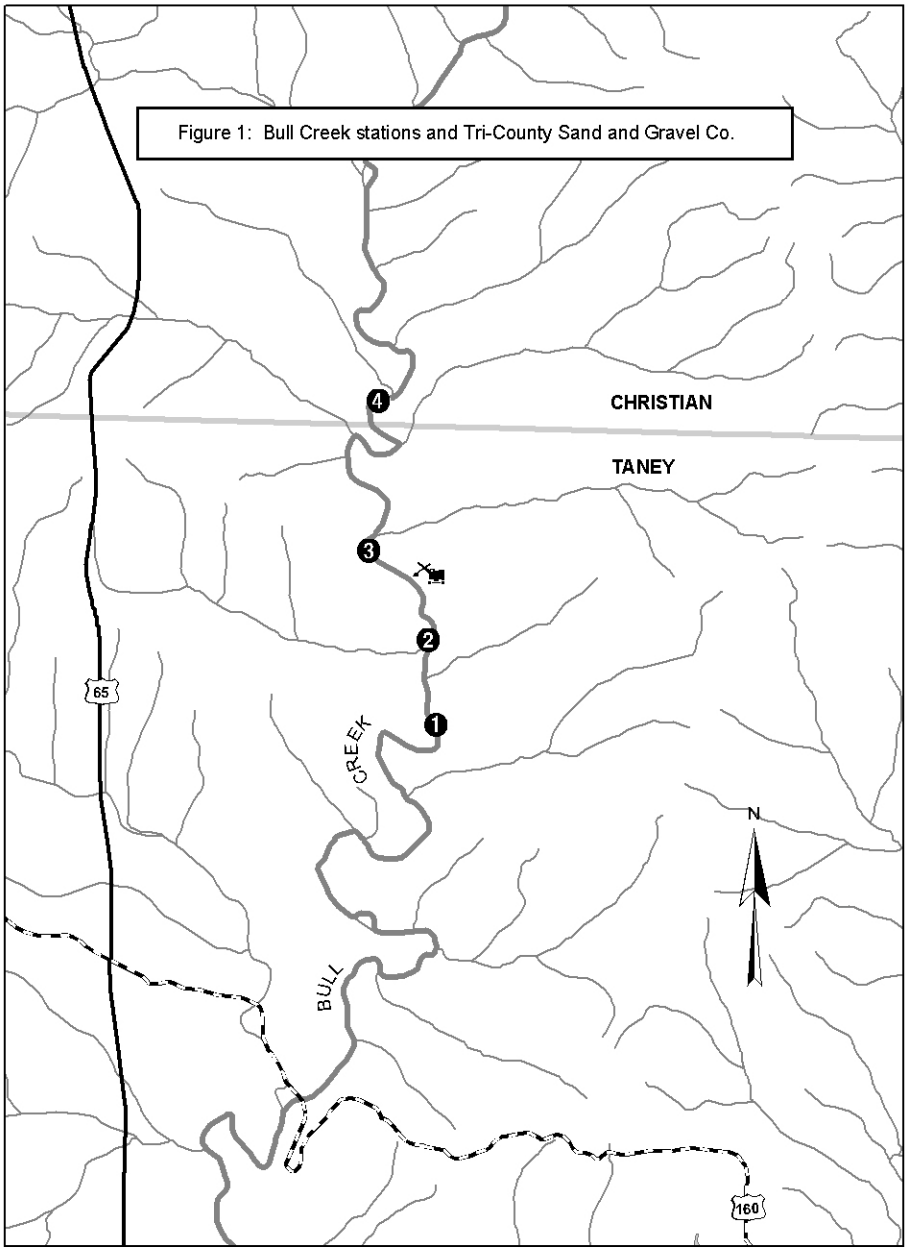
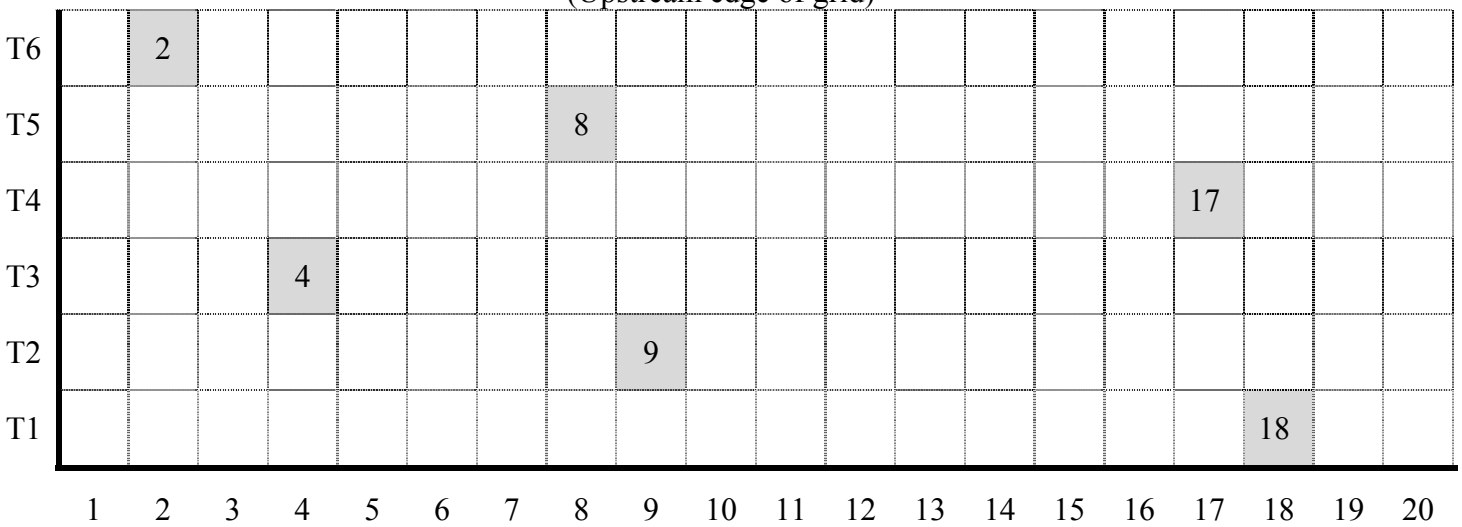


Figure 1: Bull Creek stations and Tri-County Sand and Gravel Co.

Figure 2: Grid of Transects (T) and Quadrats (open and gray squares) Used to Estimate the Relative Percentage of Fine Sediment. Location of grid: velocity <0.5 fps and depth<2.0 feet. Example: stream 20' wide; quadrat placement based on random numbers (e.g. in gray 18, 9, 4, 17, 8, 2).

RIFFLE

(Upstream edge of grid)

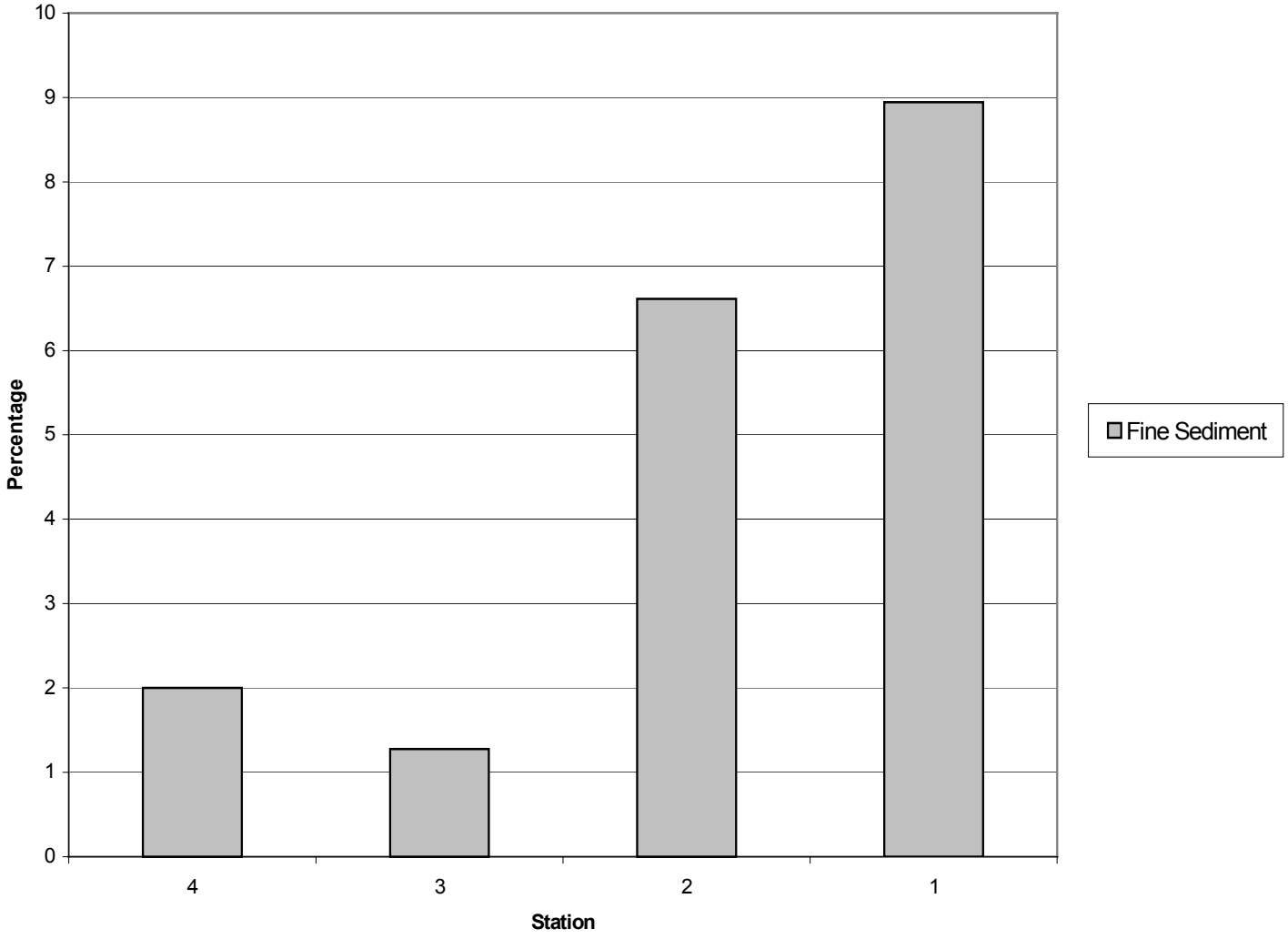


(Downstream edge of grid = Dark line)

Tape Measure Reading (feet; L to R)

POOL

Figure 3: Fine sediment percentage per station, Bull Creek, July 2002



Appendix A

Missouri Department of Natural Resources
Bioassessment and Sediment Study Plan
Bull Creek, Taney County

Missouri Department of Natural Resources
Bioassessment and Sediment Study Plan
Bull Creek, Taney County

Objective

Determine if aquatic communities are impaired in Bull Creek, Christian and Taney Counties, due to gravel mining.

Tasks

1) Conduct a bioassessment, including macroinvertebrates and fish, on Bull Creek, Taney County.

2) Conduct a habitat assessment of Bull Creek

3) Conduct a fine sediment percentage assessment on Bull Creek.

Null Hypotheses

Macroinvertebrate metrics will be similar between control and test stations on Bull Creek, Christian and Taney Counties.

Fish assemblages will be similar between control and test stations.

Water quality is similar between control and test stations.

Habitat assessments will indicate similarities between upstream and downstream stations from gravel mining facilities.

No significant difference ($p > 0.05$) in the fine sediment percentage between control and test stations.

Background

Bull Creek, Christian and Taney Counties, has three known gravel mines. Gravel mining has been shown to be detrimental to both macroinvertebrate and fish assemblages, mainly due to alteration of habitat. Sedimentation of fine particle sizes significantly increases at disturbed and downstream sites from gravel mines affecting macroinvertebrates and fish communities (Brown et al. 1992). Fines and silt clog the interstitial voids between the larger particles and can have destructive effects on invertebrates and fish communities (Smale et al. 1995; Berkman and Rabeni 1987; Murphy et al. 1981; Chutter 1969). Using

bioassessment procedures, habitat, and sediment assessment procedures, we intend to determine if gravel mining is a concern for aquatic life in Bull Creek.

Study Methods

General: The upstream boundary for this Bull Creek Study is approximately 1.0 mile north of the Christian/Taney county line, while the downstream boundary is approximately 2.0 miles downstream from the Missouri State Highway 160 bridge at Walnut Shade, Taney County, Missouri. The area is approximately 10 miles long and includes two of the three gravel mines. Within that area are two smaller study areas that are approximately 2.0 miles long, each of which encompass a single gravel mine. Each study area will contain two sample stations for a total of four stations. Stations upstream from each gravel mine will be considered control stations, while downstream stations will be considered test stations. There will be two controls and two test stations because of the distance (ca. 6 miles) between mines (Figure 1). Each station consists of a length of twenty-times the stream's average width, with at least two riffle reaches, as outlined in the Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (SMSBPP). The third gravel mine cannot be included in this study because it is located farther into the Lake Taneycomo basin and does not meet specifics of the project procedure. Sampling will occur in the spring and fall of 2002.

Bioassessment: Macroinvertebrates will be sampled according to the Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (MDNR). Bull Creek, Christian/Taney Counties, is considered a "Riffle/Pool" predominant stream and habitats will be sampled accordingly. Habitats included in these streams are coarse-substrate, non-flow, and root-mat.

Fish will be sampled by the Missouri Department of Conservation during the summer of 2002. Species composition and abundance will be recorded and compared between reference and test stations.

Habitat Assessments: Stream habitat assessments will also be conducted within the study area in accordance with the Habitat Assessment Project Procedure (MDNR). Habitat assessments will include measurements of physical environmental variables. Stream flow and discharge will be measured using a Marsh-McBirney flow meter at each station. Width and depth will be estimated and later compared between control and test stations.

Water Quality Sampling: Three water samples will be collected during both the spring and fall sample seasons in 2002. A water sample (1L) will be collected at each sampling station for Total Kjeldahl Nitrogen (TKN), ammonia-nitrogen, nitrite plus nitrate nitrogen, and total phosphorus and preserved with sulfuric acid. Another sample (1L) will be collected for analysis of chloride concentration. All samples will be kept on ice until they are delivered to the MDNR, Air and Land Protection Division (ALPD), Environmental Services Program (ESP), Chemical and Analytical Section (CAS) in

Jefferson City, Missouri. In addition, two (2) 20-ml samples will be collected to measure turbidity. The Biology/Toxicity laboratory at MDNR-ESP laboratory will conduct this analysis.

Dissolved oxygen, pH, conductivity, and temperature will be measured once at all four stations on Bull Creek in the field using appropriate meters.

Sediment Percentage and Characterization: To ensure sampling method uniformity, depositional areas sampled will be in-stream at the upper margins of pools and lower margins of riffle/run habitat. Depths of the sample areas will not exceed two (2.0) feet and water velocity will be less than 0.5 feet per second (fps). A Marsh-McBirney flow meter will be used to ensure that water velocity of the sample area is within this range.

In-stream deposits of fine sediment (i.e. less than particle size ca. 2mm= coarse sand) will be estimated for percent coverage.

A visual method will be used to estimate the percentage of fine sediment. Each sampling station shall be composed of three sample areas (i.e. grids) each consisting of six contiguous transects across the stream. A tape measure will be stretched from bank to bank at each transect. One sample quadrat (ca. 10 x 10 inches) will be placed directly on the substrate within each of the six transects using a random number that equates to one foot increments. The trailing edge of the quadrat will be placed on the random foot increment. Two investigators will estimate the percentage of the stream bottom covered by fine sediment within each quadrat. If the estimated percentages are within ten percent between investigators it will be accepted. If estimates diverge more than ten percent, the investigators will repeat the process until the estimates are within the acceptable margin of error. An average of these two estimates will be recorded and used for analysis.

Laboratory Methods: Analyses of biological and chemical samples will be conducted at the MDNR environmental laboratory (ESP) in Jefferson City, Missouri. Biological samples will be processed and identified according to MDNR-FSS-209 Taxonomic Levels for Macroinvertebrate Identifications.

Data Analysis: Macroinvertebrate data will be entered in a Microsoft Access database according to the MDNR Standard Operating Procedure MDNR-WQMS-214, Quality Control Procedures for Data Processing. 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 percent Similarity of Taxa, may be employed to discern differences in taxa between control and test stations. Macroinvertebrate data will be compared between reference and test stations on Bull Creek. Macroinvertebrate data from reference streams within the Ozark/White EDU will allow for the calculation of a 25th percentile for the four metrics in the SMSBPP, and thus compared to Bull Creek stations. Bull Creek will be scored

against these calculations and a composite score of 16 or greater will determine non-impairment.

The percentage of sediment deposition may be compared between stations, sites, or grids. This will be done by parametric comparisons of means, correlation, or non-parametric methods at a significant probability level ($p < 0.05$).

Ordination of communities with multiple linear regression may be used in conjunction with habitat assessment, water quality values, sediment percentages, as well as character of sediments in order to correlate with environmental variables.

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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Attachments: Figure 1: Study area control, test stations, and locations of gravel mines on Bull Creek, Christian and Taney Counties.

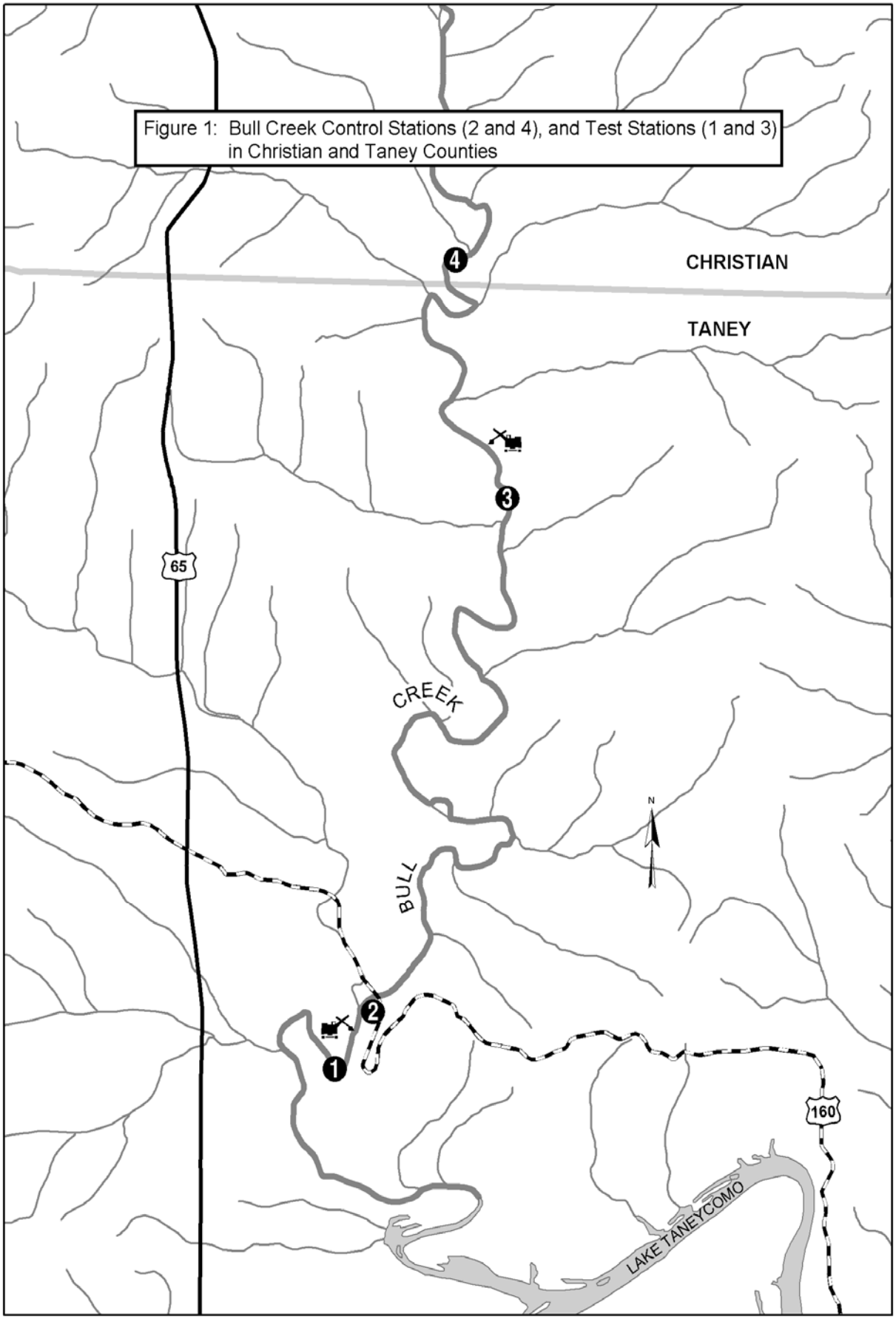

Figure 1: Bull Creek Control Stations (2 and 4), and Test Stations (1 and 3) in Christian and Taney Counties

Appendix B

Macroinvertebrate Bench Sheets for April 2002 and September 2002
In order from upstream (#4) to downstream (#1) by station and habitat
Habitats were: CS=Course substrate, NF=Non-Flow (pool),
SG=Snag (not sampled), RM=Root-mat
-99=taxa present in large/rare sample

Aquatic Invertebrate Database Bench Sheet Report
April 17, 2002 - Bull Ck [0218039], Station #4

ORDER (Taxa)	CS	RM	SG	NF
"HYDRACARINA"				
Acarina	17	1		9
AMPHIPODA				
Hyalella azteca	2			4
Stygobromus	1			3
COLEOPTERA				
Oreodytes				1
Hydroporus				1
Psephenus herricki	33	4		12
Ectopria nervosa	1			1
Helichus basalis				1
Ancyronyx variegatus				1
Dubiraphia	6	1		15
Optioservus sandersoni	1			
Stenelmis	3			7
Lutrochus		1		1
DECAPODA				
Orconectes	1			
Orconectes neglectus		3		
Orconectes virilis				1
DIPTERA				
Ceratopogoninae	2			3
Simulium		1		
Ablabesmyia				24
Larsia				2
Procladius				2
Corynoneura		1		2
Cricotopus/Orthocladius	11	8		7
Eukiefferiella brevicalcar grp	3			1
Parametriocnemus	1			
Rheocricotopus		1		
Thienemanniella	1			1
Cryptochironomus				1
Dicrotendipes		1		4
Paratendipes				1
Phaenopsectra				1
Polypedilum halterale grp				2
Polypedilum convictum grp	4			
Polypedilum fallax grp				1
Polypedilum illinoense grp	1			
Constempellina				1
Cladotanytarsus				1
Paratanytarsus	1			2
Rheotanytarsus		1		1
Stempellinella				2
Tanytarsus				2
Clinocera	4	1		1
Zavrelimyia	2			2
Potthastia	2	1		2

ORDER (Taxa)	CS	RM	SG	NF
Sympotthastia		1		1
Thienemannimyia grp.	34	1		15
EPHEMEROPTERA				
Acentrella	2	1		
Baetis	1			
Centroptilum		3		
Leucrocuta	377			8
Stenacron	2			2
Stenonema femoratum	2			1
Stenonema mediopunctatum	4			
Stenonema pulchellum	4	1		
Ephemerellidae	6			2
Ephemerella invaria	16	3		2
Eurylophella bicolor	30	11		32
Eurylophella enoensis		1		
Caenis anceps				1
Caenis latipennis	13	2		42
Leptophlebia		-99		
Paraleptophlebia	12			3
HEMIPTERA				
Microvelia		2		
ISOPODA				
Lirceus	5	1		2
Caecidotea (Blind & Unpigmented)	1			
LIMNOPHILA				
Ferrissia	1			
LUMBRICINA				
Lumbricidae	5			1
LUMBRICULIDA				
Lumbriculidae		1		
MESOGASTROPODA				
Elimia	17	265		111
ODONATA				
Calopteryx		1		
Argia	4			
Basiaeschna janata		-99		
Boyeria		1		
Gomphus		-99		
Hagenius brevistylus	-99			1
Stylogomphus albistylus	11			2
Macromia		1		
PLECOPTERA				
Leuctridae	7			2
Amphinemura	2	9		
Acroneuria	5			1
Neoperla	3			
Perlesta	5	3		4
Perlinella ephyre	1			
Isoperla	7	3		2
Pteronarcys pictetii	8	1		
RHYNCHOBDELLIDA				

ORDER (Taxa)	CS	RM	SG	NF
Piscicolidae		1		
TRICHOPTERA				
Polycentropus	4			
Agapetus	1			
Hydroptila	1			
Ochrotrichia	3			
Pycnopsyche		2		
Marilia	3			
Helicopsyche	5	4		1
TRICLADIDA				
Planariidae				1
TUBIFICIDA				
Tubificidae				3
Limnodrilus hoffmeisteri				1
Enchytraeidae	1			
VENEROIDEA				
Sphaerium	1			

Aquatic Invertebrate Database Bench Sheet Report
April 16, 2002 - Bull Ck [0218038], Station #3

ORDER (Taxa)	CS	RM	SG	NF
"HYDRACARINA"				
Acarina	3			12
AMPHIPODA				
Hyalella azteca		2		
COLEOPTERA				
Hydroporus				1
Psephenus herricki	30	3		18
Ectopria nervosa				2
Helichus lithophilus		1		
Dubiraphia	1	2		3
Optioservus sandersoni		1		
Stenelmis	42			24
Lutrochus	1			2
DECAPODA				
Orconectes	1			
Orconectes neglectus		4		1
Orconectes ozarkae	-99			
DIPTERA				
Tipula	1			
Ceratopogoninae				3
Ablabesmyia				3
Corynoneura		3		
Cricotopus/Orthocladius	1	7		7
Eukiefferiella brevicalcar grp	7	4		6
Parametriocnemus	2			1
Rheocricotopus		1		
Thienemanniella	1	1		
Cryptochironomus				1
Dicrotendipes				1
Paralauterborniella				1
Paratendipes				1
Polypedilum convictum grp	3			
Polypedilum fallax grp				1
Polypedilum scalaenum grp	1			1
Constempellina				3
Rheotanytarsus		1		2
Tabanus				-99
Hemerodromia				2
Clinocera	1			
Zavrelimyia				1
Potthastia	6	2		
Thienemannimyia grp.	20	13		15
Labrundinia		5		
EPHEMEROPTERA				
Baetidae	2	2		
Acentrella	3	21		
Centroptilum		13		1
Isonychia	-99			
Leucrocuta	185	1		7

ORDER (Taxa)	CS	RM	SG	NF
Stenacron				1
Stenonema femoratum		2		3
Stenonema mediopunctatum	9			1
Stenonema pulchellum		1		
Ephemerella invaria	59	5		2
Eurylophella bicolor	41	26		34
Tricorythodes	1			
Caenis latipennis	10	5		52
Leptophlebia		7		3
Paraleptophlebia	1	6		2
Anthopotamus				1
ISOPODA				
Lirceus	1	1		
LUMBRICINA				
Lumbricidae	7			-99
MESOGASTROPODA				
Elimia	24	136		27
ODONATA				
Calopteryx		4		
Argia		1		-99
Enallagma		1		
Basiaeschna janata		3		
Gomphidae	12			10
Hagenius brevistylus				3
Stylogomphus albistylus				-99
Libellulidae				1
PLECOPTERA				
Leuctridae				1
Amphinemura	3	2		
Alloperla	3	12		1
Acroneuria	5			
Neoperla	4			3
Perlesta	3			
Isoperla	27			
Pteronarcys pictetii	7			
TRICHOPTERA				
Wormaldia	1			
Chimarra	3			
Polycentropus	2			
Agapetus	15			
Ochrotrichia				1
Pycnopsyche		1		
Lepidostoma		1		1
Marilia	3			
Helicopsyche	29	1		4
Mystacides				2
Oecetis		1		
TRICLADIDA				
Planariidae		1		
TUBIFICIDA				
Tubificidae				5

ORDER (Taxa)	CS	RM	SG	NF
Branchiura sowerbyi				1
Limnodrilus hoffmeisteri				2
Limnodrilus angustipenis				1
Enchytraeidae		1		1
VENEROIDEA				
Sphaerium				1

April 16, 2002 - Bull Ck [0218037], Station #2

ORDER (Taxa)	CS	RM	SG	NF
"HYDRACARINA"				
Acarina	13			27
AMPHIPODA				
Hyalella azteca		1		
Stygobromus				2
COLEOPTERA				
Paracymus				1
Psephenus herricki	35			6
Ectopria nervosa				1
Ancyronyx variegatus		1		
Dubiraphia	4	1		7
Microcylloepus pusillus	1			
Optioservus sandersoni	1			
Stenelmis	1			9
Lutrochus		1		
DECAPODA				
Orconectes ozarkae	1			
Orconectes virilis		-99		
DIPTERA				
Tipula	2			-99
Dasyheleinae				1
Ceratopogoninae				10
Simulium	6	10		
Ablabesmyia	1	1		8
Larsia				1
Cricotopus/Orthocladius	3	8		1
Eukiefferiella	9	6		1
Orthocladius (Euorthocladius)		1		
Parakiefferiella				3
Parametriocnemus	1			2
Thienemanniella		4		1
Dicrotendipes				1
Demicryptochironomus				1
Paratendipes				1
Polypedilum convictum grp	4	3		
Polypedilum illinoense grp		1		
Constempellina	2			2
Cladotanytarsus	1			16
Rheotanytarsus	1			
Stempellinella	1			2
Tanytarsus				4
Stratiomys				1
Hemerodromia		1		1
Clinocera	2			
Potthastia	5	2		1
Thienemannimyia grp.	11	6		18
Diptera				1
EPHEMEROPTERA				
Acentrella		15		1

ORDER (Taxa)	CS	RM	SG	NF
Baetis	3	2		
Centroptilum		6		1
Leucrocuta	159	1		5
Stenacron	1			
Stenonema femoratum				3
Stenonema mediopunctatum	18			
Stenonema pulchellum	3	1		
Ephemerella invaria	119	62		8
Eurylophella		7		
Eurylophella bicolor	26	36		19
Caenis latipennis	63	15		104
Baetisca lacustris				1
Leptophlebia		8		
Paraleptophlebia	2	5		1
Anthopotamus	4			1
ISOPODA				
Lirceus	17	3		7
Caecidotea				1
LIMNOPHILA				
Menetus	1			1
LUMBRICINA				
Lumbricidae	1			4
LUMBRICULIDA				
Lumbriculidae				1
MEGALOPTERA				
Sialis				-99
MESOGASTROPODA				
Elimia	6	19		
ODONATA				
Calopteryx		1		
Argia				2
Gomphidae	6			5
Hagenius brevistylus		1		2
Stylogomphus albistylus	2			2
PLECOPTERA				
Leuctridae	1			1
Amphinemura	6	26		
Acroneuria	7	1		
Perlesta	12	16		1
Isoperla	6	17		
Pteronarcys pictetii	9	3		-99
TRICHOPTERA				
Chimarra	4			
Polycentropus	1			
Rhyacophila		-99		
Agapetus	7			
Pycnopsyche				-99
Lepidostoma		1		
Marilia	2			
Helicopsyche	10			1
Mystacides				1

ORDER (Taxa)	CS	RM	SG	NF
Triaenodes		1		
TUBIFICIDA				
Tubificidae				1
Enchytraeidae				2

Aquatic Invertebrate Database Bench Sheet Report
April 17, 2002 - Bull Ck [0218040], Station #1

ORDER (Taxa)	CS	RM	SG	NF
"HYDRACARINA"				
Acarina	2			3
AMPHIPODA				
Stygobromus				1
COLEOPTERA				
Psephenus herricki	7	2		-99
Ancyronyx variegatus		1		
Dubiraphia	2	1		11
Macronychus glabratus		5		
Stenelmis	5			2
Lutrochus	4			
DECAPODA				
Orconectes ozarkae	-99			
DIPTERA				
Tipulidae	1			
Tipula	-99			
Ceratopogoninae	1			
Simulium	24			
Prosimulium	1			
Ablabesmyia		3		12
Larsia		1		
Procladius				7
Cricotopus/Orthocladius	47	27		29
Eukiefferiella brevicalcar grp	48	6		1
Orthocladius (Euorthocladius)	4			
Parakiefferiella				2
Parametriocnemus	2			
Rheocricotopus	1	1		
Thienemanniella	2	1		1
Cryptochironomus		1		
Dicrotendipes		4		3
Cryptotendipes				10
Paralauterborniella				1
Paratendipes	3			
Polypedilum halterale grp				3
Polypedilum convictum grp	47			1
Pseudochironomus				1
Constempellina	1	2		
Cladotanytarsus				7
Paratanytarsus		2		
Rheotanytarsus	1	1		
Stempellinella	2	2		4
Stempellina	1	1		2
Tanytarsus	2	9		19
Tabanus	-99			
Atherix	1			
Hemerodromia	1			
Clinocera	1	1		
Zavrelimyia				1

ORDER (Taxa)	CS	RM	SG	NF
Potthastia	4	1		5
Thienemannimyia grp.	9	5		1
Labrundinia		4		
Cardiocladius	1			
EPHEMEROPTERA				
Acentrella	6	9		
Baetis	1			
Centroptilum		4		1
Isonychia bicolor	15			
Heptageniidae	1			
Leucrocuta	66			
Stenonema femoratum	9			12
Stenonema mediopunctatum	9			
Stenonema pulchellum	9	5		1
Ephemerella invaria	54	3		1
Eurylophella bicolor	3	6		6
Tricorythodes	6	1		
Caenis latipennis	75	25		116
Leptophlebia	1	2		
Paraleptophlebia	1	2		
Anthopotamus				-99
Ephemera				-99
Hexagenia limbata				1
ISOPODA				
Lirceus		1		1
Caecidotea (Blind & Unpigmented)				1
LIMNOPHILA				
Ferrissia	1			
LUMBRICINA				
Lumbricidae	10			
MEGALOPTERA				
Corydalus	-99			
MESOGASTROPODA				
Elimia	7			9
ODONATA				
Hetaerina		1		
Argia	2			1
Enallagma		5		1
Basiaeschna janata		-99		
Gomphidae				1
Stylogomphus albistylus	6			1
PLECOPTERA				
Leuctridae	3			
Amphinemura	15	2		
Acroneuria	-99			
Perlesta	15	8		
Isoperla	3	1		1
RHYNCHOBDELLIDA				
Piscicolidae	-99			
TRICHOPTERA				
Chimarra	-99			

ORDER (Taxa)	CS	RM	SG	NF
Lype diversa				1
Polycentropus		1		
Cheumatopsyche	2			
Rhyacophila	-99			
Agapetus	2			
Hydroptila		1		
Lepidostoma		1		2
Helicopsyche	5			
Mystacides		1		1
Oecetis		1		
TRICLADIDA				
Planariidae	5			
TUBIFICIDA				
Tubificidae	1			3
Branchiura sowerbyi				2
Limnodrilus hoffmeisteri				1
Limnodrilus angustipenis				1
Enchytraeidae		1		

Aquatic Invertebrate Database Bench Sheet Report
September 18, 2002 - Bull Ck [0218126], Station #4

ORDER (Taxa)	CS	RM	SG	NF
"HYDRACARINA"				
Acarina	14			4
AMPHIPODA				
Hyalella azteca		148		
COLEOPTERA				
Psephenus herricki	318	3		86
Ectopria nervosa		6		4
Scirtes		3		
Ancyronyx variegatus		1		
Dubiraphia		21		2
Macronychus glabratus		2		
Microcylloepus pusillus		4		
Stenelmis	2	4		21
DECAPODA				
Orconectes				-99
Orconectes neglectus		-99		
Orconectes virilis	1			
DIPTERA				
Ablabesmyia				1
Nilotanypus	1			
Cricotopus bicinctus				1
Corynoneura				1
Cricotopus/Orthocladius	11	18		7
Parametriocnemus	1			
Thienemanniella	4			1
Chironomus				1
Dicrotendipes		15		
Microtendipes		2		3
Phaenopsectra		1		1
Polypedilum convictum grp	54	1		
Stenochironomus		1		
Polypedilum illinoense grp		1		
Paratanytarsus		4		1
Rheotanytarsus	5			
Stempellinella	1	1		8
Tanytarsus	8	11		10
Thienemannimyia grp.	7	2		4
Labrundinia				1
EPHEMEROPTERA				
Centroptilum		1		1
Isonychia bicolor	7			
Heptageniidae	28			9
Leucrocuta	8			
Stenonema femoratum		4		26
Stenonema mediopunctatum	23			-99
Stenonema pulchellum	1			
Eurylophella				6
Tricorythodes	2	1		3
Caenis anceps	11			

ORDER (Taxa)	CS	RM	SG	NF
Caenis latipennis		13		2
Baetiscidae				3
Leptophlebiidae	4	4		32
Choroterpes				1
Ephemera	1			
HEMIPTERA				
Neoplea		1		
LUMBRICINA				
Lumbricidae	2			3
MEGALOPTERA				
Corydalus	-99			
Nigronia serricornis	1			
MESOGASTROPODA				
Elimia	36	9		6
ODONATA				
Calopteryx		1		
Argia	9			16
Enallagma		7		
Basiaeschna janata		-99		
Hagenius brevistylus		-99		2
Stylogomphus albistylus	60			10
Macromia		-99		
PLECOPTERA				
Zealeuctra	2			
Acroneuria	-99			
Agnetina flavescens	5			1
Pteronarcys pictetii				-99
TRICHOPTERA				
Chimarra	4			
Polycentropus	2	4		3
Marilia	18			
Helicopsyche	21			19
Triaenodes		49		1
Oecetis		3		
TRICLADIDA				
Planariidae	1	1		

Aquatic Invertebrate Database Bench Sheet Report
September 19, 2002 - Bull Ck [0218128], Station #3

ORDER (Taxa)	CS	RM	SG	NF
"HYDRACARINA"				
Acarina	3	2		1
AMPHIPODA				
Hyalella azteca		61		3
ARHYNCHOBDELLIDA				
Erpobdellidae				2
COLEOPTERA				
Psephenus herricki	285	3		148
Ectopria nervosa	2	3		
Scirtes		19		
Dubiraphia		24		2
Optioservus sandersoni	3			
Stenelmis	7	1		34
DECAPODA				
Orconectes		-99		-99
Orconectes neglectus	-99			
Orconectes ozarkae	-99			
DIPTERA				
Hexatoma	2			
Anopheles		1		
Ablabesmyia	3	9		9
Paramerina				1
Corynoneura		2		
Cricotopus/Orthocladius	23	21		3
Nanocladius	1			
Thienemanniella	6			
Dicrotendipes		5		3
Paratendipes				1
Phaenopsectra		1		
Polypedilum	2			
Polypedilum convictum grp	43			
Stenochironomus		1		2
Polypedilum illinoense grp	2	2		
Polypedilum scalaenum grp	1			2
Paratanytarsus		28		
Rheotanytarsus	11			
Stempellinella	1			1
Tanytarsus	3	7		2
Hemerodromia	1			
Thienemannimyia grp.	14			
Labrundinia	2	3		
EPHEMEROPTERA				
Acerpenna	1			
Baetis	9			
Centroptilum		1		
Isonychia bicolor	12			
Heptageniidae	46			2
Leucrocuta	1			
Stenacron	1			

ORDER (Taxa)	CS	RM	SG	NF
Stenonema femoratum				28
Stenonema mediopunctatum	36			
Tricorythodes	1	4		
Caenis anceps	22			1
Caenis latipennis		18		27
Baetiscidae				3
Leptophlebiidae	9	1		28
Anthopotamus				1
ISOPODA				
Lirceus	1			
LEPIDOPTERA				
Petrophila	2			
LIMNOPHILA				
Menetus		2		1
Ancylidae	1	6		2
Ferrissia		4		1
MEGALOPTERA				
Corydalus	3			
MESOGASTROPODA				
Hydrobiidae	2	1		
Elimia	29	9		2
ODONATA				
Argia	14			6
Enallagma		10		
Boyeria		-99		
Hagenius brevistylus		-99		
Stylogomphus albistylus	33	1		
PLECOPTERA				
Zealeuctra				2
Acroneuria	3			-99
Agnetina flavescens	4			
Neoperla	7			1
Perlesta	2			
Perlinella ephyre				1
Pteronarcys pictetii	-99			
TRICHOPTERA				
Chimarra	1			
Lype diversa		1		
Cernotina		1		
Cheumatopsyche	8			
Marilia	8			1
Helicopsyche	12			
Triaenodes		52		1
Oecetis		1		
TRICLADIDA				
Planariidae		1		
TUBIFICIDA				
Tubificidae				1

Aquatic Invertebrate Database Bench Sheet Report
September 19, 2002 - Bull Ck [0218127], Station #2

ORDER (Taxa)	CS	RM	SG	NF
Branchiobdellida		1		
"HYDRACARINA"				
Acarina	19	6		1
AMPHIPODA				
Hyalella azteca	1	76		
Stygobromus	1			
COLEOPTERA				
Psephenus herricki	207	4		116
Ectopria nervosa				2
Scirtes		11		
Dubiraphia		21		16
Macronychus glabratus		5		
Microcylloepus pusillus		10		
Optioservus sandersoni	2	4		1
Stenelmis	9			3
Lutrochus	1			
DECAPODA				
Orconectes neglectus	-99	-99		1
DIPTERA				
Anopheles		4		
Ceratopogoninae		1		
Ablabesmyia	2	10		6
Corynoneura	1	1		
Cricotopus/Orthocladius	17	12		6
Parametriocnemus	1			
Thienemanniella	2			
Chironomus	23	1		2
Cryptochironomus				1
Dicrotendipes	5	16		12
Microtendipes		1		
Paratendipes				3
Phaenopsectra	2	1		2
Polypedilum convictum grp	73	1		
Polypedilum fallax grp	1			
Polypedilum illinoense grp	1	3		
Pseudochironomus		1		
Paratanytarsus		7		
Rheotanytarsus	22	4		
Stempellinella		8		1
Tanytarsus	15	38		7
Tabanus	1			
Atherix	1			
Hemerodromia	2			
Zavrelimyia	2			
Thienemannimyia grp.	29	5		1
Labrundinia		7		
EPHEMEROPTERA				
Acentrella	4			

ORDER (Taxa)	CS	RM	SG	NF
Acerpenna	1			
Baetis	24			
Centroptilum		1		
Isonychia bicolor	19			
Heptageniidae	32	2		1
Leucrocuta	4			
Stenonema femoratum				36
Stenonema mediopunctatum	47			1
Stenonema pulchellum	2	1		
Tricorythodes	11	4		1
Caenis anceps	106			
Caenis latipennis	51	77		50
Baetiscidae				1
Leptophlebiidae	28	3		17
Choroterpes				1
Anthopotamus				1
HEMIPTERA				
Rheumatobates		1		
Trepobates		2		
ISOPODA				
Lirceus				1
Caecidotea (Blind & Unpigmented)				1
LIMNOPHILA				
Planorbidae				1
Ancylidae	2	3		4
LUMBRICINA				
Lumbricidae	2			-99
MEGALOPTERA				
Corydalus	3			
Nigronia serricornis	1			
MESOGASTROPODA				
Elimia	36	15		13
ODONATA				
Calopteryx		2		
Argia	19	11		11
Enallagma		7		1
Hagenius brevistylus				2
Stylogomphus albistylus	79			4
PLECOPTERA				
Leuctra	1			
Acroneuria	1			
Agnetina flavescens	5			-99
Pteronarcys pictetii				-99
RHYNCHOBDELLIDA				
Glossiphoniidae	1			
TRICHOPTERA				
Chimarra	1			
Cernotina				1
Polycentropus		6		
Cheumatopsyche	5			
Marilia	11			

ORDER (Taxa)	CS	RM	SG	NF
Helicopsyche	27	1		7
Triaenodes		30		
Oecetis		5		
TRICLADIDA				
Planariidae	9			2
TUBIFICIDA				
Tubificidae				6
Branchiura sowerbyi				6

Aquatic Invertebrate Database Bench Sheet Report
September 18, 2002 - Bull Ck [0218125], Station #1

ORDER (Taxa)	CS	RM	SG	NF
"HYDRACARINA"				
Acarina	2	8		3
AMPHIPODA				
Hyalella azteca		13		
COLEOPTERA				
Psephenus herricki	52			7
Ectopria nervosa		4		
Scirtes		17		
Dubiraphia	1	38		14
Macronychus glabratus		7		3
Stenelmis	11			10
Lutrochus	7			
DECAPODA				
Orconectes neglectus		-99		
Orconectes ozarkae	-99			1
Orconectes virilis	1			
DIPTERA				
Forcipomyiinae	1			
Ceratopogoninae				7
Simulium	6			
Ablabesmyia		10		4
Nilotanypus	1			
Cricotopus/Orthocladius	15	8		1
Thienemanniella	4			
Dicrotendipes		1		
Paralauterborniella				1
Microtendipes		2		1
Parachironomus		1		
Phaenopsectra	1			
Polypedilum halterale grp				2
Polypedilum	1	2		
Polypedilum convictum grp	40			
Stenochironomus		1		5
Polypedilum illinoense grp	2	4		3
Tribelos				1
Pseudochironomus				1
Cladotanytarsus		10		3
Paratanytarsus		27		7
Rheotanytarsus	13			
Stempellinella		1		11
Tanytarsus	2	39		11
Dixella		5		
Tabanus		1		
Hemerodromia	1			
Clinotanypus				1
Thienemannimyia grp.	7	4		5
Labrundinia		10		
EPHEMEROPTERA				
Acentrella	5			

ORDER (Taxa)	CS	RM	SG	NF
Baetis	9			
Centroptilum		2		1
Isonychia bicolor	59			
Heptageniidae	42			13
Stenacron	5			11
Stenonema femoratum		2		42
Stenonema mediopunctatum	50			
Stenonema pulchellum	26			
Tricorythodes	32	1		1
Caenis anceps	114			59
Caenis latipennis	7	9		
Leptophlebiidae	2			5
Choroterpes				2
Ephemera simulans				-99
HEMIPTERA				
Rhagovelia	1			
LEPIDOPTERA				
Petrophila				1
LIMNOPHILA				
Menetus		5		1
Ancylidae	5			16
LUMBRICINA				
Lumbricidae	4			
MEGALOPTERA				
Corydalus	4			
MESOGASTROPODA				
Elimia	45	5		1
Leptoxis	7			
ODONATA				
Argia	35	3		17
Enallagma		35		2
Gomphidae		1		6
Stylogomphus albistylus	23			3
Macromia		2		
PLECOPTERA				
Perlidae				1
Acroneuria	2			1
RHYNCHOBDELLIDA				
Glossiphoniidae				1
TRICHOPTERA				
Chimarra	4			
Cheumatopsyche	5			
Helicopsyche	3			1
Leptoceridae				1
Nectopsyche				2
Triaenodes		35		
Oecetis		1		
TRICLADIDA				
Planariidae		2		
TUBIFICIDA				
Tubificidae				1

ORDER (Taxa)	CS	RM	SG	NF
Branchiura sowerbyi				1

Appendix C

Kruskal-Wallis, ANOVA on Ranks:
Mean Fine Sediment Percentage Comparison Between Stations on Bull Creek

Kruskal-Wallis ANOVA on Ranks for fine sediment per station,
Bull Creek, Taney County, 2002. (Sigmastat Version 2.0, 1997)

One Way Analysis of Variance Monday, March 03, 2003, 14:05:28
Data source: Bull Creek Fine Sediment per Station

Normality Test: Failed (P = <0.001)

Test execution ended by user request, ANOVA on Ranks begun
Kruskal-Wallis One Way Analysis of Variance on Ranks
Monday, March 03, 2003, 14:05:28
Data source: Data 1 in Notebook

Station	N	Missing	Median	25%	75%
4.000	18	0	1.000	0.000	3.000
3.000	18	0	0.500	0.000	2.000
2.000	18	0	1.500	0.000	4.000
1.000	18	0	1.000	0.000	10.000

H = 2.485 with 3 degrees of freedom. (P = 0.478)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.478)