Missouri Department of Natural Resources

Biological Assessment of Gravel Mines

Swan Creek
Christian & Taney Counties

2003-2004

Prepared for:

Missouri Department of Natural Resources
Water Protection and Soil Conservation Division
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Prepared by:

Missouri Department of Natural Resources
Air and Land Protection Division
Environmental Services Program
Water Quality Monitoring Section

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1.0 Introduction

At the request of the Missouri Department of Natural Resources (**MDNR**) Water Protection Program (**WPP**), Water Pollution Branch (**WPB**), the Environmental Services Program (**ESP**) Water Quality Monitoring Section (**WQMS**) conducted a macroinvertebrate bioassessment and fine sediment study of Swan Creek in Christian and Taney counties.

The Swan Creek study area encompassed approximately 15 miles of Swan Creek north of Taneyville, Missouri. This reach of Swan Creek is considered in the 10 CSR 20-7 Rules of Department of Natural Resources, Clean Water Commission, Water Quality Standards as a class "P" stream. A class P stream maintains permanent flow even in draught 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."

1.1 Justification

Gravel mining is conducted at several sites on Swan Creek. Gravel mining has been shown to be detrimental to both macroinvertebrate and fish communities, mainly due to alteration of habitat. Fine sediment may significantly increase within the substrate at disturbed and downstream sites from gravel mines, affecting macroinvertebrates and fish assemblages (Brown and Lyttle 1992). Fines and silt clog the interstitial voids between the larger substrate 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).

It was our intention to determine if gravel mining was impairing Swan Creek. Biological, water quality, habitat, and sediment assessments were conducted and scores were compared upstream to downstream of four gravel mines and with biological reference streams within the Ozark/White Ecological Drainage Unit (**EDU**). Gravel mining operations on Swan Creek are often intermittent and were not in continuous operation during the time of this study.

In 2003, a study plan for a bioassessment and fine sediment study was submitted to the MDNR, WPCP (Appendix A). The WQMS was responsible for these proposed studies on Swan Creek.

1.2 Purpose

The purpose of the study was to determine if Swan Creek was impaired by gravel mining.

1.3 Objectives

1) Determine if the macroinvertebrate community of Swan Creek was impacted by gravel mining.

2) Ascertain the water quality of Swan Creek.

3) Determine if fine sediment was present in Swan Creek and determine its origin.

4) Define habitat influences on Swan Creek.

1.4 Tasks

1) Conduct a bioassessment, using macroinvertebrates, of Swan Creek.

2) Conduct a water quality study of Swan Creek.

3) Conduct a fine sediment assessment of Swan Creek.

4) Conduct a habitat assessment of Swan Creek.

1.5 Null Hypotheses

The macroinvertebrate communities are similar between the control (upstream) and test (downstream) stations on Swan Creek, Christian and Taney counties.

The macroinvertebrate communities of the Swan Creek stations and biological reference streams for the Ozark/White EDU are similar.

Water quality is similar between control and test stations.

There is no significant difference in the percentage of fine sediment between control and test stations.

Stream habitats are similar between control and test stations.

2.0 Methods

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

2.1 Study Timing

Sampling was conducted during the fall of 2003 and spring of 2004. Fall bioassessments, water quality sampling, fine sediment percentage estimation, and habitat assessments were conducted October 14-16, 2003. Spring bioassessments and water quality sampling were conducted March 16-18, 2004.

2.2 Station Descriptions

A total of four stations were sampled along the roughly 15-mile study reach on Swan Creek (Table 1, Figure 1). Stations are listed from upstream to downstream (e.g. #4, #3, #2, and #1). Four potential gravel mines within the segment were investigated. Three of the mines were within a five-mile stream reach in northern Taney County. Because of their small size and close proximity, these three gravel mines were treated as a combined potential impairment. One test station (station #1) was located downstream from the three mines and one control station (station #2) was sited upstream from the three mines (Figure 1). The fourth gravel mine was located approximately 10 miles upstream in southern Christian County south of Garrison, Missouri.

This gravel mine was bracketed with a test station (station #3) located downstream and a control station (station #4) located immediately upstream.

Table 1
Station Number, Legal, Geographic Coordinates, and Descriptions for Swan Creek

Station Number	County	Legal and Geographic Coordinates	Description
#4	Christian	SE ¼ sec. 28, T. 25 N., R. 19 W.	Upstream Control
		N. 36° 49' 38.6" W. 93° 00" 58.3"	
#3	Christian	NW ¼ sec. 34, T. 25 N., R. 19 W.	Downstream Test
		N. 36° 49' 28.8" W. 93° 00' 57.5"	
#2	Taney	S ½ sec. 1, T. 24 N., R. 20 W.	Upstream Control
		N. 36° 47' 14.7" W. 93° 03' 36.2"	
#1	Taney	SW ¼ sec. 10, T. 24 N., R. 20 W.	Downstream Test
		N. 36° 44' 27.5" W. 93° 05' 30.1"	

2.2.1 Ecological Drainage Unit (EDU)

An EDU is a region in which biological communities and habitat conditions are expected to be similar. Table 2 compares the land cover percentages from the Ozark/White EDU and the 14-digit Hydrologic Unit (**HU**), #11010003010005, which contains the Swan Creek Study Reach. Also listed are the land cover percentages for the Bull Creek reference station (HU #11010003010006) used for habitat assessment comparisons to Swan Creek. Percent land cover data were derived from Thematic Mapper satellite data collected between 1991 and 1993 and interpreted by the Missouri Resource Assessment Partnership (MoRAP). Swan Creek appears to be similar in percent land cover and can be compared with biological reference streams of the EDU for habitat assessments and biological assessments.

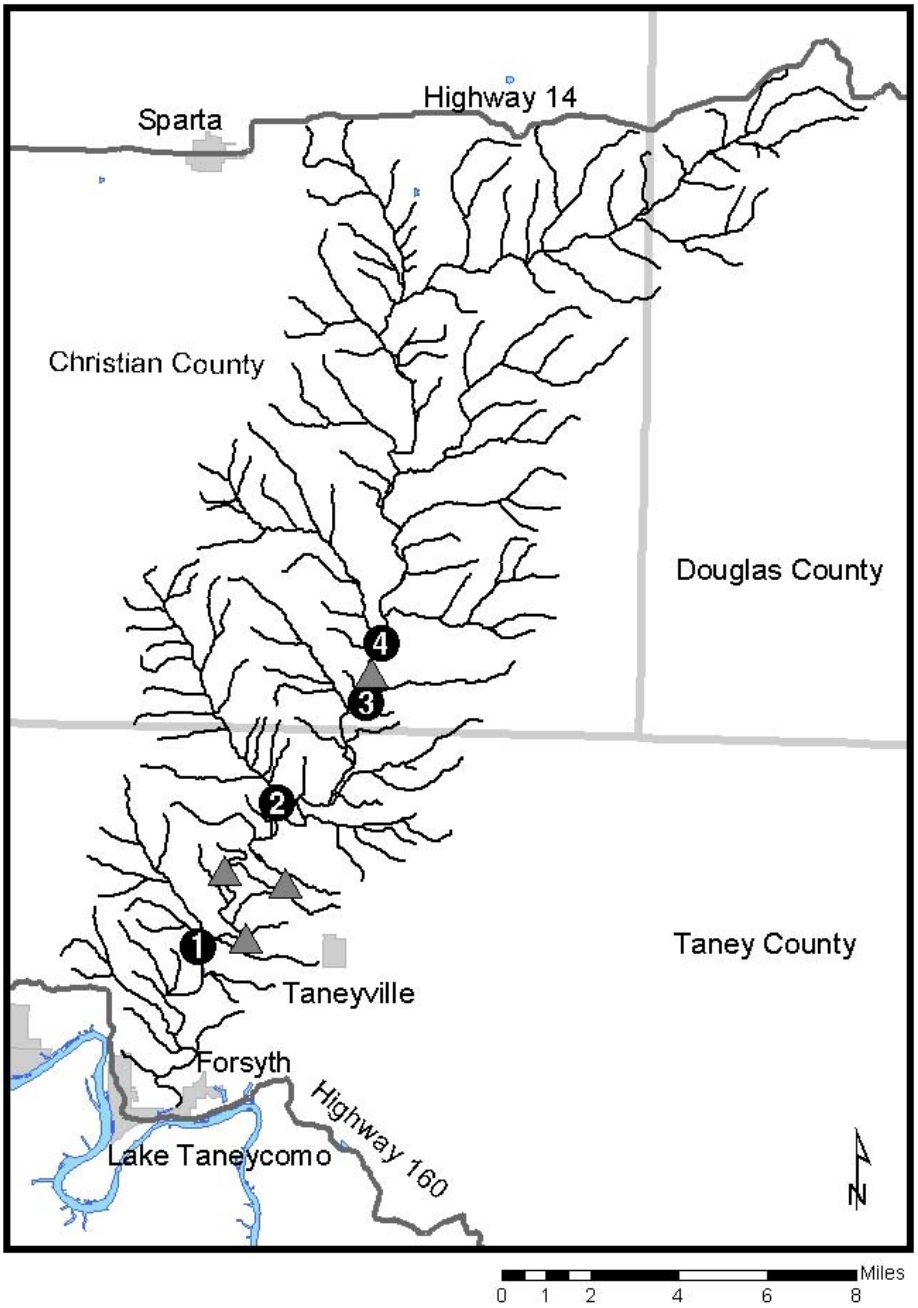
Table 2
Percent Land Cover. Percentages Based on 14-Digit Hydrologic Unit Codes for the Ozark/White EDU, Bull Creek, and Swan Creek

Land Cover (%)	Urban	Crops	Grassland	Forest	Swamp/Marsh
Ozark/White EDU	0.9	0.4	46.4	48.8	0.0
Bull Creek (BIOREF)	0.2	0.0	35.7	62.9	0.0
Swan Creek	0.1	0.1	34.8	63.3	0.0

2.3 Habitat Assessment

A standardized assessment procedure was followed as described for Riffle/Pool Habitat in the Stream Habitat Assessment Project Procedure (**SHAPP**) (MDNR 2003a). The habitat assessment was conducted in October 2003 and comparisons were made between scores from upstream to downstream of each gravel mining facility. Habitat scores for Swan Creek were also compared to the Bull Creek reference station within the Ozark/White EDU. The Bull Creek habitat assessment was conducted in mid-summer 2002 by Steve Humphrey and Kenneth B. Lister of the ESP.

Figure 1: Swan Creek Sample Stations



2.4 Biological Assessment

Biological assessments consisted of macroinvertebrate collections and community analyses. Complete bioassessments were conducted at the four Swan Creek stations in October 2003 and March 2004.

2.4.1 Macroinvertebrate Collection and Analyses

A standardized macroinvertebrate sample collection and analysis procedure was followed as described in ESP's Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (**SMSBPP**) (MDNR 2003b). Three standard habitats (e.g. coarse substrates covered by flowing water, depositional substrates in non-flowing water, and root-mat) were sampled at all locations. Macroinvertebrate data from Swan Creek were compared using ESP's Biological Criteria for Wadeable/Perennial Streams (**BIOREF**) (MDNR 2002a). Macroinvertebrate BIOREF data were from samples collected at three reference streams of the Ozark/White EDU. A total of nine spring samples and eight fall samples were used to calculate the numeric criteria.

Macroinvertebrate scores were analyzed each season using three methods. The first analysis was an upstream to downstream metric evaluation, per the SMSBPP, versus BIOREF score ranges. The SMSBPP provides details on the calculation of metrics and scoring of the multi-metric Stream Condition Index (**SCI**). The four primary metrics of the SCI are: Taxa Richness (**TR**); Ephemeroptera, Plecoptera, and Trichoptera Taxa (**EPTT**); Biotic Index (**BI**); and the Shannon Diversity Index (**SDI**). An SCI score of 16-20 is considered full biological sustainability, 10-14 is partial biological sustainability, and 4-8 is non-biological sustainability. Tables 3 and 4 provide scoring criteria for the fall and spring index periods, respectively.

Table 3
Biological Criteria for Riffle/Pool-Fall Index Period
Ozark/White EDU, n = 8 samples

Metric	Score = 1	Score = 3	Score = 5
TR	<39	39 –78	>78
EPTT	<13	13 - 26	>26
BI	>7.35	7.35 – 4.70	<4.70
SDI	<1.57	1.57 – 3.15	>3.15

Table 4
Biological Criteria for Riffle/Pool-Spring Index Period
Ozark/White EDU, n = 9 samples

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

The second analysis of the biological data was an evaluation of the dominant macroinvertebrate families (**DMF**) using relative abundance of predominant macroinvertebrate taxa. The

predominant families within each station were identified and compared between control and test stations.

A third biological data analysis was the Quantitative Similarity Index for Taxa (**QSI-T**), a secondary metric of the SMSBPP, developed by the state of Arkansas (Shackleford, 1988). The quantitative similarity index compares two communities in terms of presence or absence of taxa, also taking relative abundance (percent composition) into account. QSI-T values theoretically can range from zero percent for totally dissimilar communities to 100 percent for identical communities.

2.5 Physicochemical Water Collection and Analyses

Surface water grab samples were collected from all stations during both the fall and spring seasons. Parameters collected were nitrate + nitrite-nitrogen, ammonia-nitrogen, Total Kjeldahl Nitrogen, chloride, turbidity, temperature, conductivity, dissolved oxygen, pH, and discharge. WQMS personnel analyzed temperature, conductivity, dissolved oxygen, pH, and discharge in the field and turbidity in the biology laboratory. Samples for all other parameters were delivered to the ESP, Chemical Analyses Section for analyses. All samples were collected according to the standard operating procedure MDNR-FSS-001: Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations (MDNR 2002b) and were recorded on MDNR chain-of-custodies.

2.6 Fine Sediment Percentage

The relative percentage of fine sediment was estimated for each station. Each sampling station was composed of three sample areas (i.e. grids). In order to ensure sampling method uniformity, grids were located at the upper margins of pools and lower margins of riffle/run habitat. Depths of the sample areas did not exceed two (2.0) feet and water velocity was less than 0.5 feet per second (fps). A Marsh McBirney flow meter was used to ensure that water velocity of the sample area was within this range. Sediments were estimated during the fall sampling season.

A relative percentage of fine sediment on the substrate was estimated at each station by constructing a grid of potential quadrats. 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. Random placement of the quadrat within each transect was determined by using a random number (random number chart) that equated to one foot increments. The trailing edge of the quadrat was placed on the downstream transect border edge. Two investigators estimated the percentage of the stream bottom covered by fine sediment 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.

Analysis of the relative percentage of fine sediment was conducted using Sigmastat Version 2.0 (1997). Kruskal-Wallis One Way Analysis of Variance (ANOVA on Ranks) determined significant differences ($p<0.05$) between sample stations. If differences were detected ($p<0.05$)

between stations, an All Pairwise Multiple Comparison Procedure, Tukey Test, was conducted to identify where differences ($p<0.05$) were found. Each station's data (n=18 quadrats) was included in the comparison between stations.

3.0 Results and Analyses

Included in this section are habitat assessments, macroinvertebrate assessments, physicochemical water analyses, and fine sediment percentage estimations.

3.1 Habitat Assessment

Two comparisons were made to adequately assess the quality of Swan Creek habitat. First, in order to determine the percentage of similarity, the Swan Creek habitat scores were compared to the habitat score from the Bull Creek BIOREF station that was assessed for habitat quality in summer 2002. According to guidance in the SHAPP, a study stream that scores greater than 75 percent of reference stream conditions is considered to have habitat that fully supports a similar biological community. Secondly, comparisons were made of the habitat scores from upstream to downstream of each gravel mining area.

Habitat scores of all Swan Creek stations were comparable to the Bull Creek BIOREF station. Swan Creek #4 had the lowest score of 125, but this value was still within 90 percent of the BIOREF score (Table 5).

Downstream test stations #3 and #1 habitat scores were comparable or higher than the scores obtained from the upstream control stations #4 and #2. The relatively low score of 125 at station #4 was mostly due to lower scores than the other three stations for several habitat parameters, including embeddedness, channel flow status, and sediment deposition.

Table 5
Habitat Assessment Scores (SHAPP) for Swan Creek and Biological Criteria Reference (BIOREF) Station

Stations	Swan Creek #4	Swan Creek #3	Swan Creek #2	Swan Creek #1	Bull Creek (BIOREF)
Habitat Score	125	148	136	140	139
Percent of BIOREF	90	106	98	101	_

3.2 Biological Assessment

As outlined in the methods, macroinvertebrate data were evaluated by three methods. The first analysis was metric evaluation of Stream Condition Index (SCI) scores as per the Biological Criteria for Wadeable/Perennial Streams of Missouri (2002a). The second analysis of the biological data was an evaluation of dominant macroinvertebrate family (DMF) composition. Thirdly, Swan Creek macroinvertebrates were examined for similarities in taxa and relative abundance using the Quantitative Similarity Index for Taxa (QSI-T) metric.

3.2.1 Stream Condition Index Scores

The Swan Creek metric results and SCI scores for fall 2003 and spring 2004 are presented in Tables 6 and 7, respectively. The SCI scores were calculated by scoring station metrics against the appropriate criteria in Table 3 or Table 4.

Table 6
Biocriteria Metric Scores, Stream Condition Index Scores, and Sustainability for Swan Creek, October 2003

Sampling Station	Swan Creek #4	Swan Creek #3	Swan Creek #2	Swan Creek #1
Sample No.	0318761	0318762	0318760	0318759
Taxa Richness	75	90	86	80
EPT Taxa	24	30	26	24
Biotic Index	5.69	4.84	5.29	5.96
Shannon Diversity Index	3.23	3.58	3.42	2.76
SCI Score	14	18	16	14
Sustainability	Partial	Full	Full	Partial

Table 7
Biocriteria Metric Scores, Stream Condition Index Scores, and Sustainability for Swan Creek, March 2004

Sampling Station	Swan Creek #4	Swan Creek #3	Swan Creek #2	Swan Creek #1
Sample No.	0418681	0418680	0418679	0418678
Taxa Richness	105	99	104	104
EPT Taxa	35	38	39	39
Biotic Index	4.62	4.20	4.85	5.41
Shannon Diversity Index	3.65	3.50	3.64	3.51
SCI Score	18	20	18	18
Sustainability	Full	Full	Full	Full

During the fall 2003 sample season, two of the four Swan Creek stations had full sustainability and the other two stations were considered to have partial sustainability, according to biological criteria score ranges in Table 3. Swan Creek control station #4 had an SCI of 14 and partial sustainability while downstream test station #3 scored 18 and was judged fully sustainable (Table 6). This unexpected result occurred because three of the core metrics of the SCI, Taxa Richness, EPT Taxa, and Biotic Index, each scored only three points at control station #4; only the SDI scored 5 at this station. Probable causes for this anomaly will be explored in the Discussion section.

Test station #1 scored 14 and was considered partially sustainable, while upstream control station #2 scored 16 and was rated fully sustainable during the fall 2003 sampling period (Table 6). Substantially lower SDI values at station #1 resulted in a score of three instead of five for this metric and a total score of 14 instead of 16 and a rating of partial

sustainability. The remaining three metric values were more similar between the two stations and received the same score for each value.

Spring 2004 Swan Creek stations were all fully sustainable. Each of the four stations also had higher SCI scores in the spring compared to the fall scores at these stations. A possible reason for this seasonal difference in SCI scores is provided in the Discussion section. Control station #4 scored 18 compared to a score of 20 at test station #3. The BI score of 4.62 at station #4 was 0.03 higher than the cut-off value of 4.59 (Tables 4 and 7). This small difference caused station #4 to receive a total SCI score of 18 instead of 20. There were only slight differences in scores among the other three metrics at stations #4 and #3.

Test station #2 and control station #1 each had SCI scores of 18 in March 2004. Both stations also had a taxa richness of 104 and an EPT taxa richness of 39. Both scores were well above the 25th percentile of reference conditions of 96 total taxa and 31 EPT taxa needed to score five for each metric. The SDI score of each station was also above the 25th percentile. However, the BI scores of 4.85 for station #2 and 5.41 for station #1 were above the 75th percentile of reference conditions of this metric (inverse metric), and thus each scored three, adding to a total SCI score of 18 for each station.

3.2.2 Dominant Macroinvertebrate Families

October 2003 macroinvertebrate samples from Swan Creek comprised 75 to 90 total taxa (Table 8). EPT taxa made up almost one-third of the total taxa and ranged from 24 EPT taxa at stations #4 and #1 to 30 EPT taxa at station #3. The majority of EPT taxa at each station were composed of many mayfly species, followed by several caddisfly taxa, and a few stonefly taxa. Stoneflies are more prevalent in the spring than in the fall and were represented by five or fewer taxa at each station in fall samples (Appendix C).

The overall pattern of percent dominant macroinvertebrate families in October 2003 was one of fairly even distribution. Chironomidae (midges), as expected, was one of the five dominant families at each station. At station #4, Chironomidae was co-dominant with the crustacean amphipod family Hyalellidae and each family comprised 16 percent of the composite of three habitats. Psephenidae (water pennies), Heptageniidae (flat-headed mayflies), and Gomphidae (club-tailed dragonfly larvae) each comprised 11 percent of the sample. Baetidae, or small minnow mayflies, Elmidae (riffle beetles), and Caenidae (small square-gilled mayflies) were the remaining dominant families of macroinvertebrates at control station #4 (Table 8).

At test station #3, the top five dominant families were mostly the same dominant groups of organisms, and in similar proportions, as were found at control station #4. Chironomidae and Heptageniidae accounted for, respectively, 16 percent and 15 percent of the macroinvertebrates. These were followed by Psephenidae (13 percent), Elmidae (10 percent), and Hyalellidae (8 percent).

Swan Creek control station #2 dominant macroinvertebrate families were Caenidae (19 percent) and Chironomidae (18 percent). These were followed by Heptageniidae (13 percent), Isonychiidae (brush-legged mayflies) and Tricorythidae (little stout crawler mayflies) each at 9 percent, and Elmidae (6 percent).

At test station #1, four of five macroinvertebrate families that were dominant at control station #2 were also the most abundant families in samples from this station. The main differences in composition between the two stations were that Caenidae made up approximately twice the proportion (37 percent) of the macroinvertebrates at station #1. Another difference between the two stations was that Chironomidae and Heptageniidae comprised a smaller proportion of the dominant families at station #1. The remaining dominant families at station #1 were Elmidae (14 percent) and Pleuroceridae (gilled snails, 11 percent).

March 2004 macroinvertebrate samples from Swan Creek contained more than 100 total taxa at most stations (Table 9). EPT taxa comprised one-third or more of the total taxa and ranged from 35 to 39 taxa among the four stations. The majority of EPTT were mayflies, however, stonefly and caddisfly taxa were also well represented at each station (Appendix C). Mayflies were numerically dominant among the EPTT and comprised 34 to 47 percent of the macroinvertebrates among the stations. Although taxonomically diverse, numbers of stoneflies and caddisflies constituted a small proportion of each sample and collectively made up only six to 13 percent of the organisms at each station.

Chironomidae, as expected, was the dominant macroinvertebrate family at each of the four stations in spring samples. Percent occurrence of Chironomidae ranged from 23 percent at station #3 to 44 percent at station #1(Table 9). Averages of 25 chironomid taxa, mostly genera, were distributed among the four stations (Appendix C). Although Chironomidae was the most abundant family, the proportion of the samples comprised of these organisms was not excessive. Disturbed and polluted habitats often contain much higher proportions of chironomids than were found at any Swan Creek station.

Control station #4 contained an average of 40 percent Chironomidae among the three macroinvertebrate habitats. Next in dominance were Heptageniidae and Ephemerellidae (spiny crawler mayflies), each comprising 13 percent of the macroinvertebrates. Caenidae, Pleuroceridae, and Hyalellidae were the remaining dominant families at this station.

Test station #3 samples contained most of the same dominant families as control station #4. Chironomidae made up 23 percent of station #3 organisms followed by Ephemerellidae (20 percent), Heptageniidae (14 percent), and Caenidae (6 percent). Leptophlebiidae (prong-gill mayflies) were the fifth most dominant family at this station.

Chironomidae comprised 34 percent of control station #2 samples. The next most abundant macroinvertebrates were roughly equal proportions of the mayfly families Caenidae (13 percent), Ephemerellidae (12 percent), and Heptageniidae (11 percent).

These were followed by Isonychiidae, Elmidae, and Nemouridae (nemourid broadbacked stoneflies, Table 9). Each of these families made up four percent of station #2 macroinvertebrates.

Test station #1 contained 44 percent Chironomidae, the highest percentage of the four stations. Caenidae was the next most abundant family and made up 20 percent of the composite from the three habitats. Heptageniid mayflies constituted the third dominant family at this station and made up 10 percent of the organisms. Elmidae, Ephemerellidae, and Isonychiidae were the remaining dominant families.

Table 8
Swan Creek Macroinvertebrate Composition and Dominant Macroinvertebrate Families (DMF) per Station, October 2003

Variable-Station	4	3	2	1
Sample Number	03-18761	03-18762	03-18760	03-18759
Taxa Richness	75	90	86	80
Number EPT Taxa	24	30	26	24
% Ephemeroptera	27	29	55	50
% Plecoptera	<1	1	<1	1
% Trichoptera	2	5	8	1
% Dominant Macroinvertebrate Families (DMF; below in bold)				
Chironomidae	**16**	**16**	**18**	**7**
Hyalellidae	**16**	**8**	1	<1
Psephenidae	**11**	**13**	1	1
Heptageniidae	**11**	**15**	**13**	**8**
Gomphidae	**11**	3	1	<1
Baetidae	**8**	3	2	1
Elmidae	**7**	**10**	**6**	**14**
Caenidae	**3**	3	**19**	**37**
Isonychiidae	<1	2	**9**	1
Tricorythidae	1	<1	**9**	1
Pleuroceridae	2	5	3	**11**

3.2.3 Quantitative Similarity Index for Taxa

The macroinvertebrate communities of control and test stations were quite similar, based on the relative abundance of shared taxa. October 2003 values of the QSI-T between control station #4 and test station #3 were 70 percent and between control station #2 and test station #1 the values were 53 percent. In March 2004 the QSI-T between the same set of stations was 64 percent (#4 vs. #3) and 65 percent (#2 vs. #1). For comparison, the average QSI-T computed from the ESP's biocriteria database of same stream duplicate macroinvertebrate samples is 77 percent. Thus, three of the four QSI-T values approached the duplicate sample value, and the lowest QSI-T of 53 percent was 69 percent of this value.

Table 9
Swan Creek Macroinvertebrate Composition and Dominant Macroinvertebrate Families (DMF) per Station, March 2004

Variable-Station	4	3	2	1
Sample Number	04-18681	04-18680	04-18679	04-18678
Taxa Richness	105	99	104	104
Number EPT Taxa	35	38	39	39
% Ephemeroptera	34	47	45	38
% Plecoptera	6	10	8	3
% Trichoptera	2	3	3	3
% Dominant Macroinvertebrate Families (DMF; below in bold)				
Chironomidae	**40**	**23**	**34**	**44**
Heptageniidae	**13**	**14**	**11**	**10**
Ephemerellidae	**13**	**20**	**12**	**3**
Caenidae	**6**	**6**	**13**	**20**
Pleuroceridae	**4**	3	1	1
Hyalellidae	**3**	1	<1	0
Leptophlebiidae	2	**4**	<1	1
Isonychiidae	<1	<1	**4**	**3**
Elmidae	1	2	**4**	**6**
Nemouridae	<1	2	**4**	<1

3.3 Physicochemical Water

Physicochemical analyses of surface water grab samples are presented in Tables 10 and 11. October 2003 samples were collected during a period of low stream flow. Discharge at the upper set of stations was 4.4 cubic feet per second (cfs) at station #4 and 4.6 cfs at station #3. Discharge at the lower two stations was 12.8 cfs at station #2 and 13.9 cfs at station #1. These stations were located downstream from several small tributaries and Blue Creek, a major Swan Creek tributary. Although flow was not measured in Blue Creek, it likely contributed significantly to the much higher discharge determined at stations #2 and #1. Nutrient levels were at or below detection limits for all parameters except nitrate + nitrite - nitrogen. Maximum values of this parameter were 0.24 mg/L at station #4.

March 2004 samples were collected following a period of rainfall and stream flows were considerably greater during this sampling period. Discharge ranged from 69 cfs at station #1 to 35 cfs at stations #2 and #1. All nutrient levels except nitrate + nitrite - nitrogen were at or below detection limits. The highest values of this nutrient were recorded from station #2 and measured 0.24 mg/L.

Table 10
Physicochemical Water Variables per Station, Swan Creek, October 2003
Units mg/L unless otherwise noted.

Variable-Station	4	3	2	1
Sample Number	03-37325	03-37326	03-37324	03-37323
pH (Units)	7.9	7.8	7.9	8.0
Temperature (C°)	19.0	16.5	14.0	17.0
Conductivity (uS)	427	445	451	411
Dissolved O_2	9.0	6.8	7.7	8.2
Discharge (cfs)	4.4	4.6	12.8	13.9
Turbidity (NTUs)	<1.0	<1.0	1.4	<1.0
Ammonia-N	<0.03	<0.03	<0.03	<0.03
Nitrate + Nitrite-N	0.21	**0.24**	0.12	0.05*
TKN	<0.05	<0.05	0.06*	0.14*
Chloride	4.31*	4.23*	3.96*	4.24*
Total Phosphorus	0.03*	0.01*	0.01*	0.01*

*Estimated value, detected below practical quantitation limit.

Table 11
Physicochemical Water Variables per Station, March 2004
Units mg/L unless otherwise noted

Variable-Station	4	3	2	1
Sample Number	04-11710	04-11709	04-11708	04-11707
pH (Units)	8.1	8.1	8.3	8.3
Temperature (C°)	11.0	10.0	14.0	12.0
Conductivity (uS)	345	362	379	375
Dissolved O_2	10.9	11.2	10.8	10.6
Discharge (cfs)	35.1	35.1	55.3	69.3
Turbidity (NTUs)	<1.0	1.31	<1.0	<1.0
Ammonia-N	<0.03	<0.03	<0.03	<0.03
Nitrate + Nitrite-N	0.19	0.20	**0.24**	0.20
TKN	<0.05	0.07*	<0.05	0.12*
Chloride	4.82*	4.82*	4.86*	5.07
Total Phosphorus	<0.01	<0.01	<0.01	<0.01

*Estimated value, detected below practical quantitation limit.

3.4 Fine Sediment Estimations

Visual estimations of percent fine sediment are presented in Table 12. The mean of percent fine sediment at upstream control station #4 was 5.8 percent. At downstream test station #3 a mean of only 0.5 percent fine sediment was observed. The downstream set of Swan Creek stations had much higher percentages of fine sediment. The mean percent fine sediment at control station #2 was 70.2 percent, while test station #1 was 66.4 percent fine sediment. Kruskal Wallis ANOVA showed significant differences

(H=54.255, d.f. = 3, P<0.001) among stations (Appendix C). However, the Tukey test showed no significant differences between test and control stations.

Table 12
Percentage Fine Sediment per Grid and Quadrat for Swan Creek Stations, October 2003
(e.g. Six Quadrats per grid, 18 per Station)

Station Grid-Quadrat	4	3	2	1
1-1	0	2	22	96
1-2	0	2	18	80
1-3	4	0	25	95
1-4	1	1	52	90
1-5	8	1	4	98
1-6	0	0	8	98
2-1	22	0	98	75
2-2	18	0	98	78
2-3	10	0	100	35
2-4	12	1	98	85
2-5	1	0	92	48
2-6	10	0	92	30
3-1	2	0	88	48
3-2	5	2	90	12
3-3	8	0	100	72
3-4	1	0	96	52
3-5	2	0	88	32
3-6	1	0	95	72
Mean	5.8	0.5	70.2	66.4
S.D.	6.5	0.8	36.8	27.0

4.0 Discussion

This section is arranged under five main headings. These are habitat assessment, biological assessment, physicochemical data, percentage fine sediment, and problems in assessing macroinvertebrate assessment from gravel mining.

4.1 Habitat Assessment

Habitat scores did not show any impacts from gravel mining. The two test stations' habitat scores were similar to or higher than the two control stations' habitat scores. Significant impacts from recent gravel operations would have impaired Swan Creek macroinvertebrate habitat and lowered habitat scores. During this study, from reconnaissance in August 2003 through fall sampling in October 2004 there had been no apparent gravel removal conducted at the study sites. It could not be accurately determined when gravel mining occurred prior to the study. Shoals that had been mined had only partially revegetated. This indicated that mining had been recently conducted. However, the two observed mining operations were small and limited to shoal scraping

and shallow pit mines. There was no indication of instream mining or stream capture of pit mines. Since gravel mining apparently was not conducted during the study, and gravel operations were small and limited to shoals or floodplain, there were no significant impacts on macroinvertebrate habitat.

4.2 Biological Assessment

This discussion of biological assessment is organized under four headings. The first section examines differences in Macroinvertebrate Stream Condition Index (SCI) scores among Swan Creek stations. The second part of the discussion analyzes Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa and relative abundance. This is followed by a discussion of Dominant Macroinvertebrate Families (DMF). The fourth segment discusses Quantitative Similarity Index-Taxa (QSI-T) scores.

4.2.1 Stream Conditions Index Scores

Swan Creek SCI scores were lower than expected in October 2003 at control station #4 and test station #1 (Table 6). Both stations scored 14 and were considered partially sustainable. The macroinvertebrate habitat score of 125 at station #4 probably was partly responsible for the partial sustainability rating at this station. However, an examination of the macroinvertebrate bench sheet for station #4 (Appendix C) indicates another possible cause for the low SCI score at this station. The root-mat habitat sample contained an unusually high number of the amphipod, *Hyalella azteca*. Of the 309 organisms identified from this habitat, *H. azteca* accounted for 214 or 69 percent. There were only 26 total taxa and 4 EPT taxa in station #4 root-mat, compared to 40 total taxa and 11 EPT taxa in station #3 root-mat (Appendix C). *H. azteca* is unusual in that it is considered a fairly tolerant organism (tolerance value of 7.9) that is sometimes naturally found in a clumped distribution or in large numbers in root-mat habitat. This likely resulted in a fairly high Biotic Index (BI) value (this metric is inverted; i.e., high values indicate greater tolerance to pollution) for the station and contributed to the partial sustainability rating. In summary, a large proportion of rather tolerant *H. azteca*, combined with less suitable habitat than the other stations, likely lowered the total taxa and EPT taxa and raised the BI value for the entire composite data set of three habitats. This probably caused the score of 14 and partial sustainability at control station #4.

Station #1 was also rated partially sustainable in October 2003. The SCI score of 14 at this station may have been due in part to an exceptionally large proportion of one taxon. At station #1 in the fall, high numbers of the tolerant mayfly, *Caenis latipennis*, (BI tolerance value of 7.6) were found in samples from coarse substrate (riffle and run habitats) and from non-flow (pool) habitats. *Caenis latipennis* comprised 35 percent of the coarse substrate and 68 percent of the non-flow habitat (Appendix C). In addition to high BI tolerance values, *C. latipennis* also show a positive increase in relative abundance with increases in fine sediment measurements. The large proportion of *C. latipennis* within the station #1 coarse and non-flow habitats likely resulted in lowered SDI, higher BI values, and a lower SCI score.

All spring SCI scores were higher than the corresponding fall values. Higher stream flows, without flooding, in the spring likely provided more suitable habitat for macroinvertebrates. The better spring habitat conditions probably caused most metrics to exceed the 25th percentile of reference conditions and resulted in a higher SCI score at each station.

4.2.2 Ephemeroptera, Plecoptera, and Trichoptera Taxa and Relative Abundance

There was no indication of any impairment of the macroinvertebrate community from gravel mining or other sources in either sampling period based on comparisons of the number of EPT taxa and the percent occurrence of EPT taxa between control and test stations. In October 2003, the upstream control station #4 had 24 EPT taxa and downstream test station #3 samples contained 30 EPT taxa (Table 8). Further downstream on Swan Creek, control station #2 contained 26 EPT taxa, while 24 EPT taxa constituted test station #1. At the upstream control station #4, EPT constituted about 30 percent of the organisms, while at test station #3, EPT abundance made up about 35 percent of samples. At the lower pair of stations, EPT comprised the majority of organisms at each station and made up about 63 percent and 52 percent, respectively, of control station #2 and test station #1 macroinvertebrates.

March 2004 EPT taxa and relative abundances were similar among all control and test stations. There was no indication of impairment from gravel mining or other activities. In fact the EPT data from control and test stations were typical of a minimally impaired or reference quality Ozark stream. The average number of EPT taxa ranged from 35 at station #4 to 39 at stations #2 and #1 (Table 9). These values exceeded the 25th percentile of reference conditions of >31 taxa needed to score five for the SCI from reference streams within the Ozark/White EDU during the spring index period (Table 4).

The combined percent occurrence of EPT in March 2004 samples was 42 percent at control station #4, 60 percent at test station #3, 56 percent at control station #2, and 44 percent at test station #1 (Table 9). EPT organisms therefore comprised a large proportion of the macroinvertebrate fauna at each station. In combination with the large number of EPT taxa identified at each station, the high relative abundance of EPT organisms indicated an unimpaired and unpolluted Ozark stream.

4.2.3 Dominant Macroinvertebrate Families

There were no differences in percent dominant macroinvertebrate families between control and test stations, either sampling period, that indicated any impact from gravel mining (Tables 8 and 9). Most of the families that were dominant in upstream control stations were also dominant, and usually in similar proportions, at the corresponding downstream test stations. There were eight dominant or co-dominant families at control station #4 in October 2003. Five of these were DMFs at test station #3. Of the six DMFs at control station #2, four also were dominant at test station #1. Similarly, in March 2004, four of the six DMFs at station #4 comprised the majority of organisms at station #3. And at station #2, where seven families were dominant, six of these were also dominant at station #1. The general pattern, therefore, was similar dominant

macroinvertebrate families between corresponding test and control stations during each sampling period.

4.2.4 Quantitative Similarity Index-Taxa Values

Quantitative similarity index values for taxa, as reported in Section 3.2.3, showed that three of four control versus test station QSI-Ts were similar. Also, the three QSI-Ts approached the average QSI-T of 77 percent for duplicate biocriteria samples, and the lowest control versus test value was 69 percent of the duplicate value.

Rabeni et al. (1999) evaluated the adequacy of stream reach sampling using ESP's Macroinvertebrate Stream Bioassessment Project Procedure (SMSBPP), which was used for this study of Swan Creek. The authors found a mean similarity for within stream reach QSI-Ts of 54 percent. In addition, the authors found a mean similarity among a set of duplicate samples to be 77 percent, which is the same value subsequently derived from a later analysis of the biocriteria database. Based on our study QSI-T results, the biocriteria database, and the results of Rabeni et al., Swan Creek macroinvertebrate communities were very similar upstream and downstream from the gravel mining operations.

4.3 Physicochemical Data

Surface water grab sample analyses showed no impairment of Swan Creek from gravel mining or other impacts. There were two notable findings. First, all values were characteristic of an unimpaired Ozark stream. Missouri Water Quality Standards criteria were not exceeded. Dissolved oxygen was ample in the fall and near saturation levels in the spring. All nutrients, with the exception of small quantities of nitrate + nitrite - nitrogen, were below detection limits both sampling periods. Secondly, results were similar between each set of control and test stations. This was expected, since Swan Creek gravel mines were small operations and gravel removal was conducted infrequently.

4.4 Percentage Fine Sediment

Fine sediment estimations did not indicate gravel mining impacts. The mean fine sediment percentages decreased, rather than increased, from each upstream control to the corresponding downstream test station (Table 12). The results illustrated a much higher percentage of fine sediment at the downstream pair of stations (#2 and #1) than was found at the upstream pair of stations (#4 and #3). The mean percentage coverage within the downstream stations was roughly ten times greater than was found upstream. These differences might be because of the larger size of downstream Swan Creek, tributary inputs of fine sediment, gradient differences, or other undetermined sources of fine sediment.

4.5 Problems in Assessing Macroinvertebrate Impairment from Gravel Mining

Our recent report titled *Biological Assessment of Gravel Mines* (MDNR 2003c) conducted on Beaver Creek, Taney County, contains a discussion section of gravel mine assessment problems. Several factors that made assessment of gravel mining impacts difficult to achieve in Beaver Creek also apply to this study of nearby Swan Creek. These factors were rapid colonization of disturbed habitats by macroinvertebrates, how the different types of gravel mining affect stream impacts, and how the timing and duration of gravel mining affect impact assessments. Refer to the document above for an examination of these assessment problems.

5.0 Conclusions

The purpose of the study was to determine if gravel mining impaired Swan Creek. Following are the conclusions regarding our findings of Swan Creek biological assessment, habitat assessment, water quality, and fine sediment percentage estimations.

All null hypotheses were supported. Macroinvertebrate communities were similar upstream and downstream from gravel mining operations. Swan Creek macroinvertebrate communities and reference macroinvertebrate communities of the Ozark/White EDU were similar. Macroinvertebrate habitat, water quality, and fine sediment were similar between control and test stations.

Swan Creek Stream Condition Index (SCI) scores generally supported Ozark/White EDU reference values. However, in the fall of 2003, two stations, control station #4 and test station #1,were considered partially sustainable based on SCI scores. An unusual clumping or concentration of a few macroinvertebrate taxa, combined with somewhat less suitable habitat at one station, likely caused the rating of partial sustainability.

A comparison of the number of Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa and relative abundance's indicated no impairment of the macroinvertebrate community from gravel mining.

Dominant Macroinvertebrate Families (DMF) were similar between corresponding control and test stations.

The macroinvertebrate metric, Quantitative Similarity Index for Taxa (QSI-T), found a high similarity of macroinvertebrate communities based on three of four comparisons upstream and downstream from the gravel mining operations.

Analyses of surface water grab samples indicated that Swan Creek was an unimpaired Ozark stream. Missouri Water Quality Standards criteria were not exceeded. Most nutrient parameters were below analysis detection limits.

Percentage estimations of fine sediment in Swan Creek showed no significant differences in fine sediment percentages between corresponding control and test stations. The lower pair of stations had an order of magnitude greater fine sediment percentage than the upper

pair of stations. The cause of greater sediment percentages at the downstream stations was unknown. It was hypothesized that larger stream order, difference in stream gradient, or tributary inputs may have been responsible.

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Submitted by: _____

Steve Humphrey
Environmental Specialist
Environmental Services Program
Water Quality Monitoring Section

Date: _____

Approved by: _____

Earl W. Pabst
Director
Environmental Services Program

EP:sht

c: John Ford, WPP
Bruce Martin, SWRO

Appendix A

Missouri Department of Natural Resources Bioassessment and Sediment Study Plan,
Swan Creek, Christian and Taney Counties

Missouri Department of Natural Resources
Bioassessment and Sediment Study Plan
Swan Creek, Christian and Taney Counties

Objective

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

Tasks

1) Conduct a bioassessment, including macroinvertebrates and water quality, of Swan Creek.

2) Conduct a habitat assessment of Swan Creek.

3) Conduct a fine sediment assessment of Swan Creek.

Null Hypotheses

Macroinvertebrate communities are similar between control and test stations on Swan Creek, Christian and Taney counties.

Habitat assessments will be similar upstream and downstream from gravel mining facilities.

Water quality is similar between control and test stations.

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

Background

Swan Creek, in Christian and Taney counties has several small 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 may significantly increase at disturbed and downstream sites from gravel mines, affecting macroinvertebrate 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, habitat assessment and sediment assessment procedures, we intend to determine if gravel mining is a concern for aquatic life in Swan Creek.

Study Methods

General: The study area encompasses approximately 15 miles of Swan Creek north of Taneyville, Missouri. Four potential gravel mines within the stream segment will be investigated. Three of the mines are within a five mile stream reach in northern Taney County. Because of their small size and close proximity, these gravel mines will be treated as a combined potential impairment. One test station (station #1) will be located downstream from the three mines and one control station (station #2) will be sited upstream from them (Figure 1). The fourth gravel mine is located approximately 10 miles upstream in southern Christian County south of Garrison, Missouri. This gravel mine will be bracketed with a test station (station #3) located downstream and a control station (station #4) located immediately upstream. Each station will consist of a length of twenty-times the stream's average width, with at least two riffle reaches, as outlined in the MDNR Stream Habitat Assessment Project Procedure (SHAPP) (MDNR 2003a). Sampling will occur in the fall of 2003 and spring of 2004.

Station Locations: Test station #1 (SW ¼ S10,T24N, R20W, Taney Co.) is located downstream of the lower three gravel mining sites at the Hulls Ford low water crossing southwest of Taneyville. Control station #2 (S1/2 S1, T24N, R20W, Taney Co.) is located upstream from the third gravel mine at the Highway AA road crossing. Test station #3 (NW ¼ S34, T25N, R19W, Christian Co.) is located about eight miles upstream from station #2, downstream from the gravel mine at a low water crossing off Highway 25 south of Garrison, Missouri. Control station #4 (SE1/4 S28, T25N, R19W, Christian Co.) is located upstream from station #3, above the low water crossing, off Highway 25 south of Garrison.

Bioassessment: Macroinvertebrates will be sampled according to the MDNR Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (SMSBPP) (MDNR 2003b). Swan Creek is considered a "Riffle/Pool" predominant stream and habitats will be sampled accordingly. Habitats included in these streams are coarse substrate, non-flow, and rootmat.

Habitat Sampling: Stream discharge will be measured at each station using a Marsh-McBirney flow meter. Stream habitat assessments will also be conducted within the study area in accordance with SHAPP. Width and depth will be compared between control and test stations.

Water Quality Sampling: Water quality samples will be collected at each Swan Creek sampling station 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, samples will be collected to measure turbidity. The biology/toxicity laboratory at MDNR-ESP will conduct analyses.

Field parameters, such as dissolved oxygen, pH, conductivity, and temperature will be measured *in situ* at each station on Swan Creek.

Sediment Percentage Estimation: 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 (MDNR 2001).

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 (MDNR 2003c). 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 between reference and test stations on Swan 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 Swan Creek stations. Swan Creek will be scored against these calculations and a composite score of 16 or greater will determine non-impairment (MDNR 2002).

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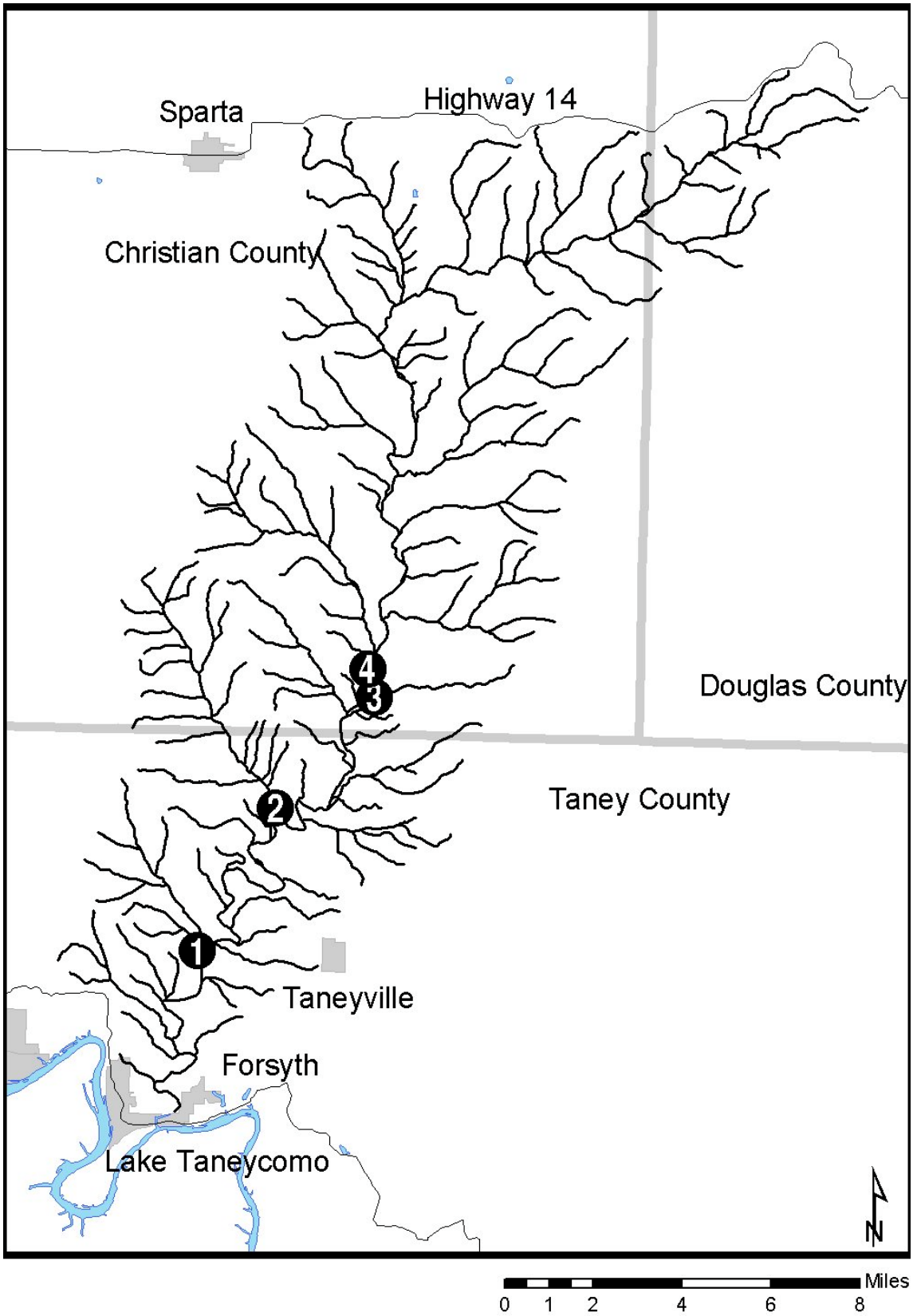
Attachments: Figure 1: Study area control, test stations, and locations of gravel mines on Swan Creek, Christian and Taney counties.

Figure 1: Swan Creek Sample Stations



Appendix B

Macroinvertebrate Bench Sheets for Swan Creek Stations, Fall 2003-Spring 2004

Key: CS = Coarse substrate habitat, (i.e. riffle), NF = Non-flow habitat (i.e. pools), RM = Root-mat habitat, -99 = Large/Rare presence

Aquid Invertebrate Database Bench Sheet Report

Swan Ck [0318761], Station #4

ORDER: TAXA	CS	NF	SG	RM
"HYDRACARINA"				
Acarina	17			1
AMPHIPODA				
Hyalella azteca				214
Stygobromus	1	-99		
COLEOPTERA				
Dubiraphia	2	1		13
Ectopria nervosa	2	1		
Psephenus herricki	97	53		
Stenelmis	42	37		2
DECAPODA				
Orconectes neglectus				-99
Orconectes ozarkae	1			
DIPTERA				
Ablabesmyia		5		1
Ceratopogoninae		1		
Chironomus		2		
Cladotanytarsus	1			
Corynoneura		6		1
Cricotopus bicinctus	6	1		
Cricotopus/Orthocladius	37	6		2
Dicrotendipes	1	6		11
Eukiefferiella	3			
Hemerodromia	1			
Nanocladius	1			
Parakiefferiella	5	19		1
Paratanytarsus	1			
Polypedilum convictum grp	3			
Polypedilum illinoense grp				6
Potthastia	1			1
Rheocricotopus	1			
Rheotanytarsus	5			
Simulium	3			
Stempellinella		4		
Stenochironomus				2
Tabanus		-99		
Tanytarsus	4	2		2
Thienemanniella	22	1		
Thienemannimyia grp.	14	6		3
Tipula	-99			
Tribelos		30		
EPHEMEROPTERA				
Acentrella	21			
Baetis	78			
Caenis anceps	1			
Caenis latipennis	12	29		2
Eurylophella	9	3		1
Heptageniidae	23			
Isonychia	5			
Leptophlebiidae		40		

ORDER: TAXA	CS	NF	SG	RM
Procloeon		3		
Stenacron		1		
Stenonema femoratum	2	41		
Stenonema mediopunctatum	62			
Stenonema pulchellum	17			
Tricorythodes	15			
ISOPODA				
Lirceus				2
LIMNOPHILA				
Menetus				1
LUMBRICINA				
Lumbricidae	2			
MEGALOPTERA				
Corydalus	1	-99		
Nigronia serricornis	1			
Sialis		-99		
MESOGASTROPODA				
Elimia	14	1		7
ODONATA				
Argia	4	7		2
Enallagma				13
Gomphidae	137	1		
Hagenius brevistylus		1		
Macromia				-99
Stylogomphus albistylus		5		
PLECOPTERA				
Acroneuria	1	-99		
Pteronarcys pictetii		1		
Zealeuctra	1			
TRICHOPTERA				
Cheumatopsyche	9	1		
Chimarra	2			
Helicopsyche	8	1		
Marilia		1		
Nectopsyche	2			
Neureclipsis				1
Triaenodes				1
TRICLADIDA				
Planariidae	22	3		19
TUBIFICIDA				
Tubificidae		2		

Aquid Invertebrate Database Bench Sheet Report
Swan Ck [0318762], Station #3

ORDER: TAXA	CS	NF	SG	RM
"HYDRACARINA"				
Acarina	4	3		
AMPHIPODA				
Hyalella azteca		7		89
Stygobromus	1			
COLEOPTERA				
Ancyronyx variegatus				3
Dubiraphia		12		14
Ectopria nervosa	3	7		3
Helichus lithophilus				1
Hydroporus				1
Macronychus glabratus				1
Microcylloepus pusillus				1
Psephenus herricki	79	58		4
Stenelmis	29	51		3
DECAPODA				
Orconectes neglectus	-99			-99
Orconectes ozarkae	-99	1		1
DIPTERA				
Ablabesmyia		3		2
Atherix	9			
Ceratopogoninae		2		
Clinotanypus		1		
Corynoneura	2	5		12
Cricotopus bicinctus	2			
Cricotopus/Orthocladius	32	2		7
Cryptochironomus		1		
Dicrotendipes		1		1
Eukiefferiella	2			
Hemerodromia	1			
Hexatoma	1			
Labrundinia				7
Parakiefferiella	2	8		4
Phaenopsectra				1
Polypedilum convictum grp	1			
Rheocricotopus	1			
Rheotanytarsus	12			5
Simulium	2			1
Stempellinella	7	2		
Stenochironomus				1
Stictochironomus		1		
Synorthocladius	1			
Tanytarsus	10	3		4
Thienemanniella	23	1		1
Thienemannimyia grp.	9	5		3
Tribelos		6		
EPHEMEROPTERA				
Acentrella	9			
Baetis	25			1
Caenis anceps	10			

ORDER: TAXA	CS	NF	SG	RM
Caenis latipennis	5	12		10
Eurylophella	6	10		4
Heptageniidae	20	8		
Isonychia bicolor	26			
Leptophlebiidae	2	30		7
Leucrocuta	2			
Stenacron	8			
Stenonema bednariki	4			
Stenonema femoratum		26		2
Stenonema mediopunctatum	76			
Stenonema pulchellum	28			1
Tricorythodes	2			
HEMIPTERA				
Belostoma				-99
ISOPODA				
Caecidotea (Blind & Unpigmented)	1			
LEPIDOPTERA				
Petrophila	1			
LIMNOPHILA				
Menetus		1		
Physella	1			
LUMBRICINA				
Lumbricidae	2			
MEGALOPTERA				
Corydalus	1			
Nigronia serricornis	-99			
Sialis		-99		
MESOGASTROPODA				
Elimia	13	7		41
ODONATA				
Argia	11	9		
Enallagma		1		3
Gomphidae	20	8		1
Hagenius brevistylus				-99
Hetaerina		1		
Stylogomphus albistylus		5		3
PLECOPTERA				
Acroneuria	2			
Neoperla	3	2		
Perlidae	4			
Perlinella ephyre		1		
Pteronarcys pictetii	-99			
TRICHOPTERA				
Cernotina		1		2
Cheumatopsyche	6			
Chimarra	7			
Helicopsyche	9	3		3
Limnephilidae				6
Marilia	4			
Nectopsyche		1		
Oecetis				2
Polycentropus	4	2		

ORDER: TAXA	CS	NF	SG	RM
Triaenodes				5
TRICLADIDA				
Planariidae	21	10		6
TUBIFICIDA				
Ilyodrilus templetoni				1
Tubificidae		7		

Aquid Invertebrate Database Bench Sheet Report
Swan Ck [0318760], Station #2

ORDER: TAXA	CS	NF	SG	RM
"HYDRACARINA"				
Acarina	4	3		3
AMPHIPODA				
Hyalella azteca		1		6
COLEOPTERA				
Ancyronyx variegatus				1
Dubiraphia	1	25		13
Ectopria nervosa				1
Lutrochus	3			
Macronychus glabratus				4
Microcylloepus pusillus				7
Psephenus herricki	9			
Stenelmis	14	3		
DECAPODA				
Orconectes longidigitus				-99
Orconectes ozarkae	-99			
Orconectes virilis				-99
DIPTERA				
Ablabesmyia	1	8		4
Chironomus		4		
Cladotanytarsus		1		
Corynoneura		1		1
Cricotopus/Orthocladius	5	1		11
Cryptochironomus		6		
Dicrotendipes				1
Hemerodromia	1			
Labrundinia				12
Microtendipes		11		4
Nanocladius	2			1
Parakiefferiella				1
Paratanytarsus		1		2
Polypedilum convictum grp	2	1		
Polypedilum fallax grp	1			
Polypedilum halterale grp		1		
Polypedilum illinoense grp				2
Rheotanytarsus	14			4
Simulium	3			
Stempellinella	8	5		4
Tabanus	-99			
Tanytarsus	1	11		6
Thienemanniella	6			7
Thienemannimyia grp.	8	1		5
Tribelos		28		
EPHEMEROPTERA				
Acentrella				1
Baetis	20			2
Caenis anceps	8			2
Caenis latipennis	72	77		49
Centroptilum		1		1
Ephemera	2			

ORDER: TAXA	CS	NF	SG	RM
Ephemerella	1			1
Eurylophella	19			5
Heptageniidae	51			12
Isonychia bicolor	92			3
Leptophlebiidae	2	1		1
Stenacron	1			
Stenonema bednariki	1			
Stenonema femoratum		4		
Stenonema mediopunctatum	30			1
Stenonema pulchellum	33			5
Tricorythodes	61			34
HEMIPTERA				
Belostoma				-99
LEPIDOPTERA				
Petrophila	1			
LIMNOPHILA				
Ancylidae	3	1		
Menetus				2
LUMBRICINA				
Lumbricidae	2	3		
MEGALOPTERA				
Corydalus	1			-99
MESOGASTROPODA				
Elimia	8	2		20
Pleurocera		2		2
ODONATA				
Argia	5			7
Dromogomphus		1		
Enallagma		2		9
Gomphidae		3		
Hagenius brevistylus		1		-99
Hetaerina				1
Macromia				-99
Stylogomphus albistylus	5			
PLECOPTERA				
Perlidae				1
TRICHOPTERA				
Cheumatopsyche	13			3
Chimarra	37			10
Helicopsyche	6			
Limnephilidae		2		
Marilia	1			
Oecetis	1			3
Polycentropus		1		6
Triaenodes				9
TRICLADIDA				
Planariidae	1	4		
TUBIFICIDA				
Branchiura sowerbyi	1	6		
Limnodrilus hoffmeisteri		1		
Tubificidae		6		
UNIONIDA				

ORDER: TAXA	CS	NF	SG	RM
Unionidae				-99
VENEROIDEA				
Sphaerium	2			1

Aquid Invertebrate Database Bench Sheet Report
Swan Ck [0318759], Station #1

ORDER: TAXA	CS	NF	SG	RM
"HYDRACARINA"				
Acarina	1	2		61
AMPHIPODA				
Hyalella azteca				2
ARHYNCHOBDELLIDA				
Erpobdellidae	-99			
COLEOPTERA				
Dubiraphia	4	11		45
Ectopria nervosa	1	2		1
Lutrochus	14			
Microcylloepus pusillus	7			2
Psephenus herricki	5	4		1
Stenelmis	99	10		2
DECAPODA				
Orconectes ozarkae		-99		
DIPTERA				
Ablabesmyia	2	3		
Atherix	1			
Corynoneura	2			3
Cricotopus/Orthocladius	2			1
Cryptochironomus	4	9		
Forcipomyiinae	1			
Hemerodromia	1			
Microtendipes	6			
Nanocladius	2			1
Parakiefferiella				1
Paratanytarsus		1		
Paratendipes		1		
Polypedilum convictum grp	1			
Polypedilum halterale grp		1		
Polypedilum illinoense grp				2
Polypedilum scalaenum grp	3	2		
Pseudochironomus		1		
Rheotanytarsus	4			
Simulium	1			
Stempellinella	9	13		
Stenochironomus	1			
Stictochironomus		1		
Tabanus	-99			
Tanytarsus	1	1		
Thienemanniella	2			
Thienemannimyia grp.	8	2		
Tribelos	2	2		
EPHEMEROPTERA				
Anthopotamus	2			
Baetis	15			
Baetiscidae		1		
Caenis anceps	16			
Caenis latipennis	223	231		14
Ephemera	1			

ORDER: TAXA	CS	NF	SG	RM
Eurylophella	3			
Heptageniidae	9	3		
Isonychia bicolor	13			
Leptophlebiidae	11	3		1
Stenacron	2	1		
Stenonema bednariki	2			
Stenonema femoratum		5		
Stenonema mediopunctatum	24			
Stenonema pulchellum	52			2
Tricorythodes	10			
HEMIPTERA				
Rhagovelia	2			
Rheumatobates				1
LEPIDOPTERA				
Petrophila	1			
LIMNOPHILA				
Ancylidae	3			1
Menetus				6
LUMBRICINA				
Lumbricidae	7			
MEGALOPTERA				
Corydalus	-99			
MESOGASTROPODA				
Elimia	2	4		125
Pleurocera				10
ODONATA				
Argia	31	8		6
Enallagma				20
Gomphidae		1		
Hagenius brevistylus		-99		
Hetaerina	1			
Macromia		-99		1
Stylogomphus albistylus	4			
PLECOPTERA				
Neoperla	2			
Perlidae	5			
Perlinella ephyre	1			
TRICHOPTERA				
Cheumatopsyche	2			
Chimarra	1			
Helicopsyche	3			2
Oecetis		1		1
Triaenodes				6
TUBIFICIDA				
Branchiura sowerbyi	5	5		
Tubificidae	2	11		
VENEROIDEA				
Sphaerium	1			

Aquid Invertebrate Database Bench Sheet Report
Swan Ck [0418681], Station #4

ORDER: TAXA	CS	NF	SG	RM
"HYDRACARINA"				
Acarina	16	4		
AMPHIPODA				
Hyalella azteca		2		29
Stygobromus	1	1		-99
COLEOPTERA				
Dubiraphia		5		4
Helichus lithophilus				2
Hydroporus		1		
Optioservus sandersoni		1		
Psephenus herricki	8			1
Scirtes				2
Stenelmis	4	2		
DECAPODA				
Orconectes longidigitus				1
Orconectes neglectus				-99
Orconectes ozarkae	-99			-99
DIPTERA				
Ablabesmyia		13		8
Ceratopogoninae		6		
Chironomus		2		
Cladotanytarsus		6		
Clinocera	2			
Corynoneura				4
Cricotopus bicinctus	11			1
Cricotopus/Orthocladius	54	10		10
Cryptochironomus		3		
Dicrotendipes		3		
Eukiefferiella	45	3		
Hemerodromia	2	1		
Labrundinia		2		26
Micropsectra	1	1		
Microtendipes		1		
Parakiefferiella	2	83		4
Paralauterborniella		1		
Paratanytarsus				22
Paratendipes		7		
Phaenopsectra		1		
Polypedilum convictum grp	12	1		
Polypedilum illinoense grp	1	1		2
Polypedilum scalaenum grp		1		
Potthastia	15	1		
Rheocricotopus	3			
Rheotanytarsus	3			2
Stempellinella	2	3		1
Stenochironomus				1
Sympotthastia	2			
Synorthocladius				5
Tabanus	-99			
Tanytarsus	2	21		6

ORDER: TAXA	CS	NF	SG	RM
Thienemanniella	3	1		
Thienemannimyia grp.	19	14		10
Tipula	1	-99		
Tribelos		3		
EPHEMEROPTERA				
Acentrella	4			1
Baetisca lacustris	1			
Caenis latipennis	20	29		17
Centroptilum				1
Ephemera simulans		-99		
Ephemerella invaria	110	2		15
Eurylophella bicolor	6	5		11
Heptageniidae	41			
Isonychia bicolor	3			
Leptophlebia		-99		6
Leucrocuta	81			2
Paraleptophlebia	1	4		11
Stenonema femoratum	1	9		12
Stenonema mediopunctatum	4			
Stenonema pulchellum				1
HEMIPTERA				
Microvelia				1
LIMNOPHILA				
Menetus		1		
Physella	1			2
LUMBRICINA				
Lumbricidae		-99		
LUMBRICULIDA				
Lumbriculidae				1
MEGALOPTERA				
Nigronia serricornis	-99			
MESOGASTROPODA				
Elimia	-99	1		44
ODONATA				
Argia	1	1		
Basiaeschna janata		-99		
Boyeria				-99
Calopteryx				-99
Enallagma				3
Gomphidae				1
Hagenius brevistylus		4		7
Perithemis		-99		
Stylogomphus albistylus	11	2		1
PLECOPTERA				
Acroneuria	2			
Amphinemura	3			2
Chloroperlidae	2			
Isoperla	18			
Leuctra	20			1
Neoperla	1			
Perlesta	10			2
Pteronarcys pictetii	3			

ORDER: TAXA	CS	NF	SG	RM
Zealeuctra		2		1
TRICHOPTERA				
Agapetus	2			
Chimarra	1			
Helicopsyche	4			3
Hydroptila		1		2
Lepidostoma				4
Leptoceridae				1
Marilia	1			
Mystacides				1
Polycentropus		1		3
Pycnopsyche	-99			-99
Rhyacophila	1			
TRICLADIDA				
Planariidae	1			3
TUBIFICIDA				
Enchytraeidae		3		
Limnodrilus hoffmeisteri		2		
Tubificidae		8		1
VENEROIDEA				
Sphaerium		4		2

Aquid Invertebrate Database Bench Sheet Report
Swan Ck [0418680], Station #3

ORDER: TAXA	CS	NF	SG	RM
"HYDRACARINA"				
Acarina	9	9		
AMPHIPODA				
Hyalella azteca		2		13
Stygobromus		-99		
COLEOPTERA				
Dubiraphia		2		8
Ectopria nervosa		1		
Hydroporus		8		
Optioservus sandersoni	1	3		
Psephenus herricki	6	21		3
Stenelmis	7	4		2
DECAPODA				
Orconectes neglectus		-99		
Orconectes ozarkae		-99		
DIPTERA				
Ablabesmyia		11		
Atherix	1	1		1
Ceratopogoninae		1		1
Clinocera	6	2		
Corynoneura		1		2
Cricotopus bicinctus	4	1		3
Cricotopus/Orthocladius	17	5		5
Dicrotendipes		4		1
Eukiefferiella	25			5
Fittkauimyia		1		
Labrundinia				12
Microtendipes				1
Nemotelus		1		
Parakiefferiella		16		2
Parametriocnemus				2
Paratanytarsus				6
Paratendipes		3		1
Polypedilum convictum grp	21			4
Potthastia	3			
Procladius		2		
Rheocricotopus	1			1
Rheotanytarsus	4	2		16
Simulium	2			
Stempellinella		2		
Stenochironomus				2
Stictochironomus		1		
Sympotthastia	2			1
Synorthocladius	1	1		1
Tabanus	1			
Tanytarsus	4	7		3
Thienemanniella		3		1
Thienemannimyia grp.	18	31		14
Tipula	-99			
Tribelos		2		

ORDER: TAXA	CS	NF	SG	RM
EPHEMEROPTERA				
Acentrella	25			1
Baetidae		1		
Caenis latipennis	7	29		36
Ephemera simulans		-99		
Ephemerella invaria	145	30		39
Eurylophella bicolor	4	10		13
Heptageniidae	107	11		2
Isonychia bicolor	2			2
Leptophlebia		-99		2
Leucrocuta	7	1		
Paraleptophlebia		5		36
Siphlonurus		1		
Stenacron	1	1		
Stenonema bednariki	1			
Stenonema femoratum	1	18		
Stenonema mediopunctatum	3	7		3
ISOPODA				
Lirceus		1		
LUMBRICINA				
Lumbricidae	-99			
LUMBRICULIDA				
Lumbriculidae	2			
MEGALOPTERA				
Corydalus		-99		
Nigronia serricornis				-99
MESOGASTROPODA				
Elimia		3		31
ODONATA				
Argia		4		
Calopteryx				1
Enallagma				1
Hagenius brevistylus		2		-99
Ophiogomphus		-99		
Stylogomphus albistylus	3	11		4
PLECOPTERA				
Acroneuria				-99
Amphinemura	15			13
Chloroperlidae	8			
Helopicus nalatus	-99			
Isoperla	26			2
Leuctra	15	2		4
Neoperla	2			
Perlesta	7	2		17
Pteronarcys pictetii	1			4
TRICHOPTERA				
Agapetus	3			
Cheumatopsyche	2	1		
Chimarra	3			1
Helicopsyche	1	1		2
Hydroptila		2		
Lepidostoma	1	1		

ORDER: TAXA	CS	NF	SG	RM
Marilia	7			
Nectopsyche				1
Oecetis				1
Polycentropus	1			3
Pycnopsyche				-99
Rhyacophila	1			
Triaenodes				2
TRICLADIDA				
Planariidae	7	2		1
TUBIFICIDA				
Limnodrilus hoffmeisteri	2			
Tubificidae		3		1
VENEROIDEA				
Sphaerium		1		

Aquid Invertebrate Database Bench Sheet Report
Swan Ck [0418679], Station #2

ORDER: TAXA	CS	NF	SG	RM
"HYDRACARINA"				
Acarina	9	8		2
AMPHIPODA				
Hyalella azteca		1		2
Stygobromus	1			
COLEOPTERA				
Dubiraphia		1		10
Lutrochus		1		
Microcylloepus pusillus				5
Psephenus herricki	2	5		
Stenelmis	13	16		
DECAPODA				
Orconectes neglectus		-99		1
Orconectes ozarkae				-99
DIPTERA				
Ablabesmyia		29		6
Ceratopogoninae		1		
Cladotanytarsus	1	6		
Clinocera	1			
Corynoneura		1		
Cricotopus bicinctus	1	3		6
Cricotopus/Orthocladius	14	2		23
Cryptochironomus		2		1
Dicrotendipes		4		2
Eukiefferiella	43	3		25
Hemerodromia	2	1		2
Labrundinia		3		1
Nanocladius	1			1
Parakiefferiella	9	15		1
Paralauterborniella		1		
Parametriocnemus	2	1		
Paratanytarsus		1		3
Paratendipes		2		1
Polypedilum convictum grp	37			5
Polypedilum illinoense grp	1			
Polypedilum scalaenum grp		1		
Potthastia				1
Prosimulium	4			
Pseudochironomus		1		
Rheocricotopus	3			4
Rheotanytarsus	21	4		42
Silvius	-99			
Simulium				1
Stempellinella	4	26		
Sympotthastia	2			
Synorthocladius				1
Tanytarsus	7	10		2
Thienemanniella	3			
Thienemannimyia grp.	13	13		7
Tipula	-99			

ORDER: TAXA	CS	NF	SG	RM
Tribelos		3		
EPHEMEROPTERA				
Acentrella	12			7
Anthopotamus	3			
Baetisca lacustris	3			
Caenis anceps	19	28	1	
Caenis latipennis	37	48		37
Ephemerella invaria	95	3		32
Eurylophella bicolor	2	16		11
Heptageniidae	41	4		5
Hexagenia limbata		-99		
Isonychia bicolor	47			3
Leptophlebia		1		
Leptophlebiidae	6			
Leucrocuta	1			
Rhithrogena	1			
Stenacron	3	2		
Stenonema bednariki	5			
Stenonema femoratum		21		2
Stenonema mediopunctatum	27	1		1
Stenonema pulchellum	18	2		9
Tricorythodes	7	1		3
LEPIDOPTERA				
Petrophila	1			
LIMNOPHILA				
Ancylidae	1	2		2
Menetus		1		
LUMBRICINA				
Lumbricidae	-99	1		
MEGALOPTERA				
Corydalus	3			-99
MESOGASTROPODA				
Elimia	2			12
Pleurocera				-99
ODONATA				
Argia	1	2		
Basiaeschna janata				-99
Boyeria				-99
Enallagma		1		2
Gomphidae	1	1		1
Gomphus		-99		
Hagenius brevistylus		-99		
Macromia		1		
Stylogomphus albistylus	-99	-99		-99
PLECOPTERA				
Amphinemura	29			20
Clioperla clio				-99
Isoperla	4			
Leuctra	12			4
Perlesta	18			8
Perlinella drymo				-99
TRICHOPTERA				

ORDER: TAXA	CS	NF	SG	RM
Cheumatopsyche	8	2		1
Chimarra	7			1
Helicopsyche	1			2
Hydroptila	1	1		3
Lepidostoma		1		
Marilia	1			
Mystacides		1		
Oecetis	1			1
Oxyethira				7
Psychomyia	1			
Pycnopsyche				1
Rhyacophila	1			-99
Triaenodes				2
TRICLADIDA				
Planariidae	1	1		1
TUBIFICIDA				
Enchytraeidae		1		
Tubificidae		7		

Aquid Invertebrate Database Bench Sheet Report
Swan Ck [0418678], Station #1

ORDER: TAXA	CS	NF	SG	RM
N/A				
Branchiobdellida				3
"HYDRACARINA"				
Acarina	5	4		1
AMPHIPODA				
Crangonyx	1			
COLEOPTERA				
Agabus				1
Dubiraphia	1	1		
Ectopria nervosa		1		
Helichus lithophilus				1
Lutrochus	4	1		2
Microcylloepus pusillus	4	1		2
Psephenus herricki	1	4		1
Stenelmis	47	11		
Stenelmis lateralis	2			1
DECAPODA				
Orconectes longidigitus				-99
Orconectes neglectus		-99		-99
Orconectes ozarkae		-99		-99
DIPTERA				
Ablabesmyia		7		
Ceratopogoninae				1
Cladotanytarsus		1		
Clinocera	5			
Constempellina	1			
Corynoneura	6			8
Cricotopus bicinctus				9
Cricotopus/Orthocladius	20	2		53
Cryptochironomus		4		
Dicrotendipes	1			1
Eukiefferiella	37	2		75
Labrundinia		5		46
Micropsectra				3
Microtendipes	2	2		
Nanocladius				1
Ormosia	2			
Paracladopelma		1		
Parakiefferiella	1	1		
Paramerina				1
Paratanytarsus		1		10
Phaenopsectra		3		
Polypedilum convictum grp	69	1		
Polypedilum illinoense grp	1			7
Polypedilum scalaenum grp		2		
Rheotanytarsus	31	1		20
Stempellinella	8	10		5
Stictochironomus		4		
Tabanus	-99			
Tanytarsus	9	10		7

ORDER: TAXA	CS	NF	SG	RM
Thienemanniella	1	1		3
Thienemannimyia grp.	19	9		13
Tipula	-99	-99		
Zavreliella		1		
EPHEMEROPTERA				
Acentrella	1			
Acerpenna	1			
Ameletus lineatus				-99
Anthopotamus	1	1		
Baetisca lacustris		-99		
Caenis anceps	30	76		9
Caenis latipennis	32	64		33
Caenis punctata		1		
Ephemerella invaria	11	-99		1
Eurylophella bicolor		14		6
Eurylophella enoensis				3
Heptageniidae	11	6		3
Isonychia bicolor	34			
Leptophlebia		2		
Leucrocuta	6			
Paraleptophlebia		2		11
Stenacron	1	3		1
Stenonema bednariki	3			
Stenonema femoratum	1	19		4
Stenonema mediopunctatum	27	2		
Stenonema pulchellum	24	3		3
Tricorythodes	7	1		2
ISOPODA				
Lirceus	1	1		
LIMNOPHILA				
Fossaria		1		
LUMBRICINA				
Lumbricidae	1	-99		
MEGALOPTERA				
Corydalus		1		
MESOGASTROPODA				
Elimia	10	3		5
Pleurocera		-99		-99
ODONATA				
Argia		1		2
Basiaeschna janata		-99		1
Gomphus		1		
Hagenius brevistylus				1
Neurocordulia		-99		
Stylogomphus albistylus	-99	-99		
PLECOPTERA				
Acroneuria		-99		
Amphinemura	6			1
Clioperla clio		-99		
Helopicus nalatus	1			
Neoperla	5			
Perlesta	12	4		4

ORDER: TAXA	CS	NF	SG	RM
Perlinella drymo				-99
Pteronarcys pictetii	1			
TRICHOPTERA				
Cheumatopsyche	3			
Chimarra	10			
Helicopsyche	3			
Hydroptila		1		1
Nectopsyche		2		1
Oecetis	3	1		
Oxyethira	1	1		3
Pycnopsyche		-99		-99
Triaenodes		2		2
TRICLADIDA				
Planariidae	2			
TUBIFICIDA				
Branchiura sowerbyi		-99		
Enchytraeidae		2		
Tubificidae	1	3		
VENEROIDEA				
Sphaerium		1		

Appendix C

Fine Sediment Percentage: Kruskal-Wallis ANOVA on Ranks and Dunn's Comparisons, Swan Creek, Fall 2003

Kruskal-Wallis One Way Analysis of Variance on Ranks
Tuesday, November 16, 2004, 10:55:02

Data source: Data 1 in Notebook

Normality Test: Failed (P = <0.001)

Group	N	Missing	Median	25%	75%
4.000	18	0	3.000	1.000	10.000
3.000	18	0	0.000	0.000	1.000
2.000	18	0	91.000	25.000	98.000
1.000	18	0	73.500	48.000	90.000

H = 54.255 with 3 degrees of freedom. (P = <0.001)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Dunn's Method) :

Comparison	Diff of Ranks	Q	P<0.01
2 vs 3	42.694	6.120	Yes
2 vs 4	29.972	4.296	Yes
2 vs 1	2.778	0.398	No
1 vs 3	39.917	5.722	Yes
1 vs 4	27.194	3.898	Yes
4 vs 3	12.722	1.824	No

Note: The multiple comparisons on ranks do not include an adjustment for ties.