Missouri Department of Natural Resources

Biological Assessment and Stressor Study Report

West Locust Creek
Putnam County, Missouri

Summer and Fall 2009 – Spring 2010

Prepared for:
Missouri Department of Natural Resources
Division of Environmental Quality
Water Protection Program
Water Pollution Control Branch

Prepared by:
Missouri Department of Natural Resources
Division of Environmental Quality
Environmental Services Program
Water Quality Monitoring Section

TABLE OF CONTENTS

TABLES

Page

FIGURES

ATTACHMENTS

Appendix A Biological Assessment and Stressor Study Proposal for West Locust Creek, Putnam County, July 13, 2009

Appendix B Macroinvertebrate Bench Sheet Report for West Locust Creek, Putnam County, Fall 2009 – Spring 2010

Appendix C Dissolved Oxygen Datalogger Information, Graphs, and Data West Locust Creek Stations #2 and #1, Putnam County

Appendix D Precipitation During Dissolved Oxygen Datalogger Deployment, August 11, 2009 to August 25, 2009.

1.0 Introduction

West Locust Creek (WBID 611), Putnam County, is a small stream not yet assigned a stream classification or designated beneficial use categories by the Missouri Department of Natural Resources (**MDNR**). The stream is approximately 20 miles long and is located in north-central Missouri in the Central Plains/Grand/Chariton Ecological Drainage Unit (Figure 1). West Locust Creek enters Missouri from Iowa in northwest Putnam County (Figure 2). The stream's headwaters are part of the watershed approximately five miles northeast of Powersville, Missouri. West Locust Creek reaches its confluence with Locust Creek approximately two miles southeast of Quinn, Missouri.

1.1 Justification

Since 1994, several biological assessments have been conducted on West Locust Creek, Putnam County, using Missouri Department of Natural Resources project and standard operating procedures. The MDNR conducted a study in the fall of 1994 and spring of 1995. A consulting firm conducted spring assessments from 1996 through 2000 as a result of a consent decree with Premium Standard Farms, Princeton, Missouri. Results of all assessments conducted from 1995 through 1998 indicated that West Locust Creek is partially supporting of the beneficial use "protection of aquatic life and human health-fish consumption (**AQL**)." Macroinvertebrate Stream Condition Index Scores identified the stream as fully supporting the AQL beneficial use only in the spring of 1999 and 2000. No comprehensive report was written by either the MDNR or the consulting firm. Past correspondence related to West Locust Creek is stored electronically on the Environmental Services Program's network in the Water Quality Monitoring "special studies" folder. Biological assessment data are housed in the aquatic macroinvertebrate database with the MDNR Environmental Services Program, Jefferson City, Missouri.

This study was conducted at the request of the Missouri Department of Natural Resources Water Protection Program (**WPP**), Water Pollution Control Branch (**WPCB**). A study proposal was written that included a biological assessment, stream habitat assessment, channel morphology assessment, and dissolved oxygen stressor study to be conducted in West Locust Creek, Putnam County in 2009-2010 (Appendix A). The study was coordinated and conducted by the Division of Environmental Quality (**DEQ**), Water Quality Monitoring Section (**WQMS**), Aquatic Bioassessment Unit (**ABU**) and the Chemical Analysis Section (**CAS**) of the Environmental Services Program (**ESP**).

1.2 Objectives

- Assess the stream habitat quality.
- Assess the aquatic life protection beneficial use status of the macroinvertebrate community.
- Measure channel morphology attributes.
- Assess the physicochemical water quality of the stream.
- Identify important diel dissolved oxygen concentrations during a stressful period.

1.3 Null Hypotheses

1) The stream habitat quality will be similar between reaches and comparable to control streams.

2) Macroinvertebrate communities are similar between reaches of West Locust Creek from upstream to downstream and to reference streams' biological criteria index scoring range.

2) Water quality is similar from upstream to downstream and within acceptable Missouri Water Quality Standards (**WQS**s; MDNR 2009b).

3) Daily (diel) dissolved oxygen concentrations will not fluctuate and will be within WQSs.

2.0 Methods

Kenneth B. Lister, Brandy Bergthold, and others of the ESP, WQMS staff conducted this study. Methods are described in this section. The study timing is outlined. The study area and stations, Ecological Drainage Units (**EDUs**), and land uses are identified and described. The stream habitat assessment procedures and channel morphology observation methods are outlined. Biological assessment procedures, which include macroinvertebrate community and physicochemical water collection and analyses, are discussed. The dissolved oxygen stressor study methods are outlined in this section.

2.1 Study Timing

All tasks in this project were conducted in the summer of 2009, fall of 2009, and spring of 2010. Stream habitat assessment project procedure (SHAPP) was conducted at West Locust Creek stations on September 29, 2009. Channel measurements also were recorded on that date for further description of channel morphology and riparian conditions.

Biological assessment samples were conducted at West Locust Creek stations in the fall of 2009 and the spring of 2010. Fall macroinvertebrate and water samples were collected at all stations on September 29, 2009. Spring macroinvertebrate and water samples were collected at all stations on April 1, 2010.

Dissolved oxygen dataloggers were deployed at stations #2 and #1 on August 11, 2009, and were retrieved August 25, 2009. However, accurate recording by the dataloggers was for a much shorter time. Both dataloggers were displaced and stopped recording early. The datalogger at station #2 was buried under 6 inches of sand and #1 was found buried in 18 inches of sand. The dataloggers at West Locust Creek #2 and #1 were deployed on August 11, 2009 and accurate or acceptable recording stopped on August 13, 2009 and August 16, 2009, respectively (Appendix C).

2.2 Study Area, Station Locations and Descriptions

The study area included West Locust Creek in the Central Plains/Grand/Chariton Ecological Drainage Unit (**EDU**; Figure 1). The study area is approximately 10 miles long from the Iowa and Missouri border to Highway EE. Two stations were allocated for this project (Table 1; Figure 2). Stations are numbered (high to low) from upstream to downstream. Station #2 was located downstream of Missouri Highway 136. Station #1 was downstream of Highway EE, approximately two miles upstream from the stream's confluence with Locust Creek. Distance between the stations was approximately five miles.

Table 1
Station Locations and Descriptive Information for West Locust Creek, Putnam County

Station	County	Location	Description; WBID	Purpose; Class
West Locust Creek #2	Putnam	SW sec. 32; T. 66 N., R.20 W. E0484829 N4480270	Downstream MO 136 bridge; 611	Test; U
West Locust Creek #1	Putnam	NW sec. 20; T. 65 N., R. 20 W. E0485674 N4474993	Downstream Hwy EE bridge; 611	Test; U

2.2.1 Ecological Drainage Unit

West Locust Creek is located within the Central Plains/Grand Chariton Ecological Drainage Unit (**EDU**; Figure 1). Ecological Drainage Units are units that are delineated and identified by their natural terrestrial physiographic division and major riverine watershed component. EDUs are further described in Sowa et al. (2007). Similar-size streams within an EDU are expected to contain similar aquatic communities and stream habitat conditions. Comparisons of habitat, biological communities, and physicochemical results between test and reference streams within the same EDU should then be appropriate.

2.2.2 Land Cover Description

Land cover was compared between West Locust Creek stations and the Central Plains/Grand/Chariton EDU using a 14-digit Hydrological Unit scale (**HUC-14**; Table 2). Percent land cover data were derived from Thematic Mapper satellite data collected between 2000 and 2004 and interpreted by the Missouri Resource Assessment Partnership (**MoRAP**). Land cover within the 14-digit HUC is generally similar between the test stations and the Central Plains/Grand/Chariton EDU. West Locust Creek #2 and #1 had less cropland and more grassland than the overall EDU. Differences in the land cover should not negatively affect results of the stream habitat assessment, biological assessment, or dissolved oxygen stressor study.

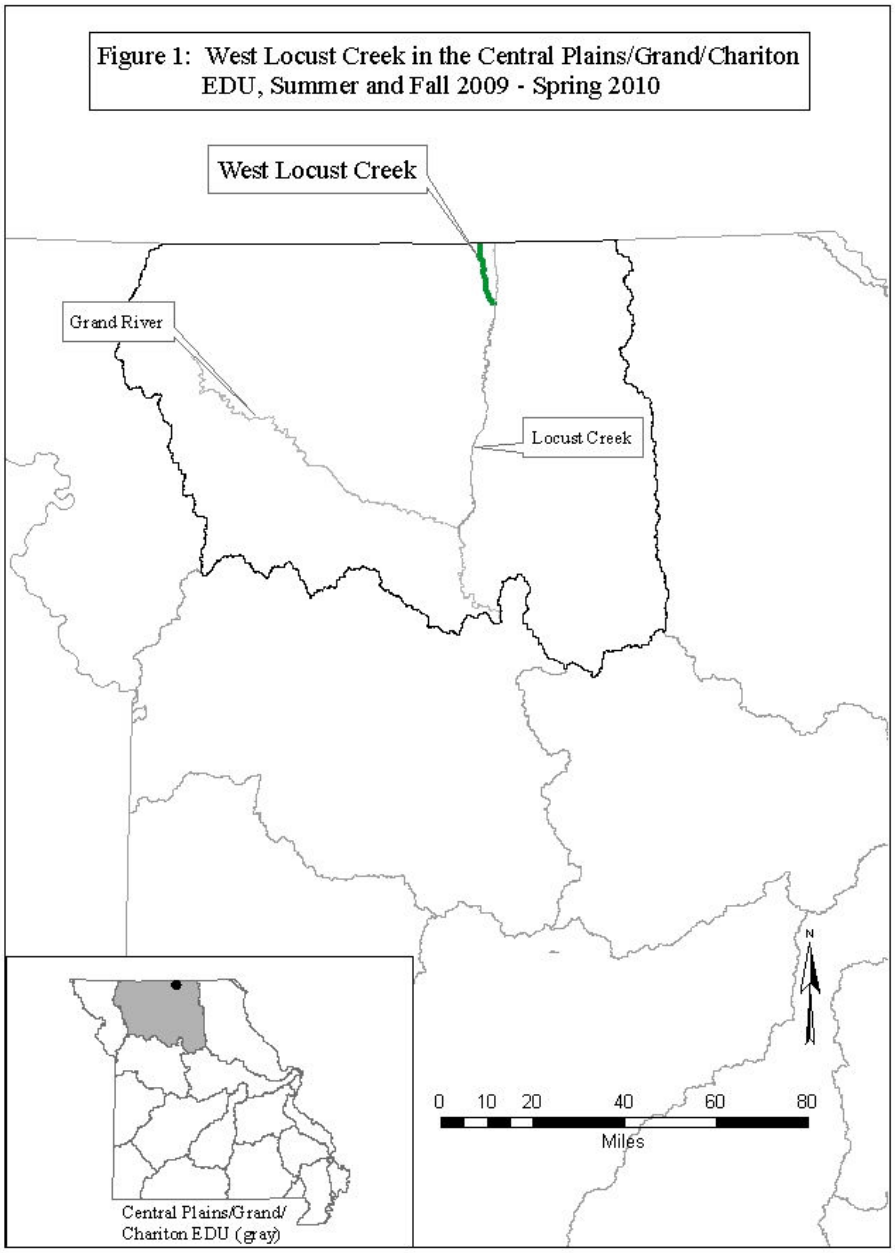


Figure 1: West Locust Creek in the Central Plains/Grand/Chariton EDU, Summer and Fall 2009 - Spring 2010

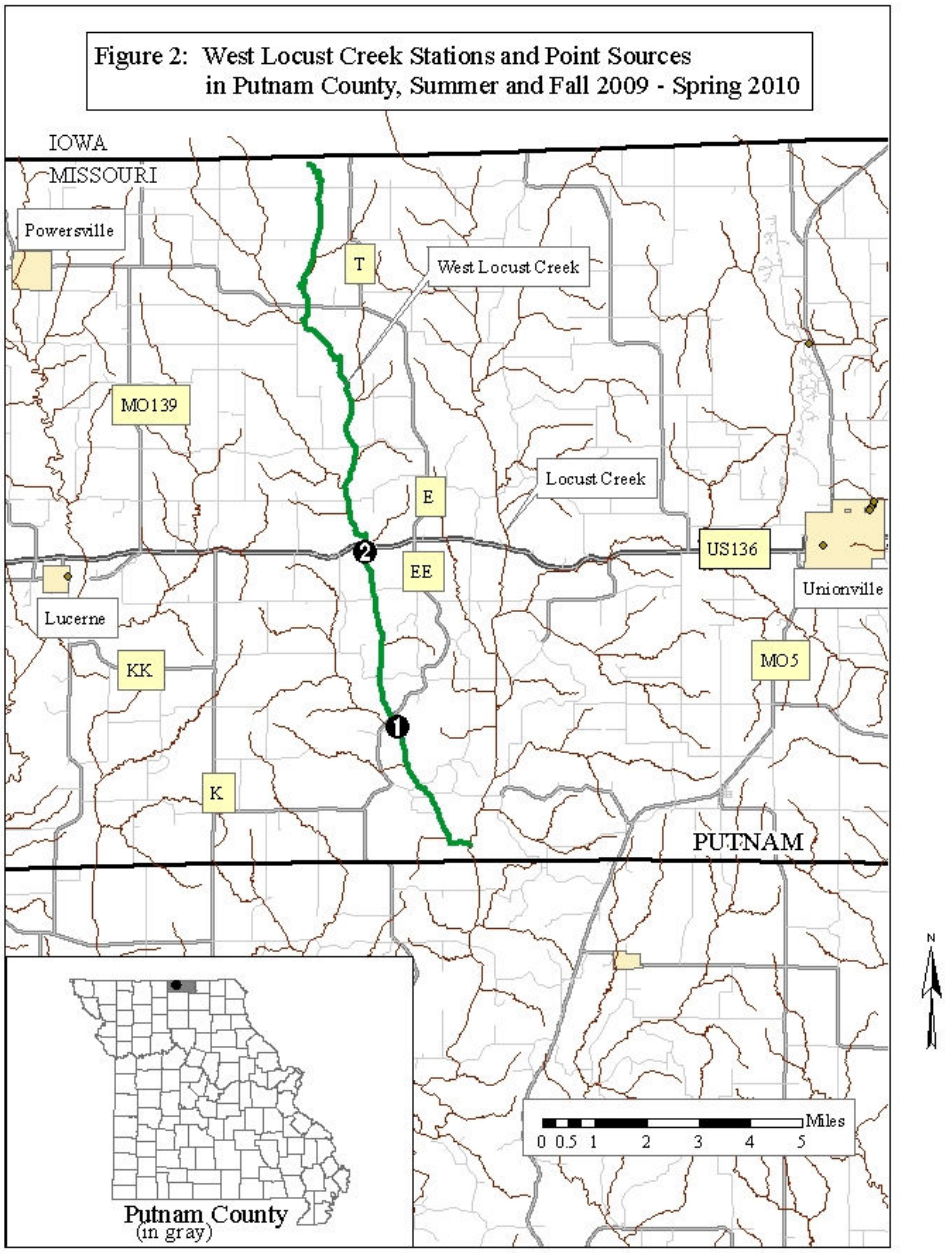


Figure 2: West Locust Creek Stations and Point Sources
in Putnam County, Summer and Fall 2009 - Spring 2010
IOWA
MISSOURI
Powersville
T
West Locust Creek
MO139
Locust Creek
E
2
EE
US136
Unionville
Lucerne
KK
MO5
1
K
PUTNAM
N
Miles
0 0.5 1 2 3 4 5
Putnam County
(in gray)

Table 2
Percent Land Cover for West Locust Creek Stations in the
Central Plains/Grand/Chariton EDU

Stations	HUC-14	Urban	Crops	Grass	Forest	Wet	Open water
West Locust Creek #2 and #1	10280103090003	1	10	67	15	2	1
Central Plains/ Grand/Chariton EDU	N/A	2	28	45	18	--	--

HUC-14 = 14-digit Hydrologic Unit Code; EDU = Ecological Drainage Unit

2.3 Stream Habitat Assessment Project Procedure

The standardized Stream Habitat Assessment Project Procedure (**SHAPP**) was followed as described for glide/pool prevalent streams (MDNR 2010d). According to the SHAPP, the quality of an aquatic community is based on the ability of the stream to support the aquatic community. If SHAPP scores at test stations are ≥75% of the mean control scores, the stream habitat at the test station is considered to be comparable to the control streams. East Fork Grand River and West Fork Big River were used as the SHAPP controls for the Central Plains/Grand/Chariton EDU (Table 3). Those scores were retrieved from the fall 2006 study of Hickory Creek, Grundy County (MDNR 2007). Stream habitat assessment scores were compared as a percentage of the mean of SHAPP control scores. Scoring factors may be included to explain differences if needed.

2.4 Channel Morphology

Further habitat examinations included observations of channel morphology, assessment of bank stability, and quality of the riparian corridor taken at multiple locations within each station. Ten transects were equally spaced within each station using SHAPP (MDNR 2010d) methodology. Channel-width and wetted-width were measured and recorded at each transect (n=10) to determine the mean channel-width and mean wetted-width. Channel depth was measured at 20, 40, 60, and 80 percent of the wetted-width within each transect (n=40) to determine the mean depth and standard deviation for each station. The substrate size class (i.e. clay, sand, gravel) was recorded for each of the four depth locations (n=40) and numbered to determine the dominant substrate size class per station. The flow regimes (i.e. riffle, run, pool) were recorded at each transect and likewise given numbers to determine a mean. Bank conditions were categorized using SHAPP methods and a mean was calculated for the left and right descending banks at each transect (n=10). Riparian corridor depth was estimated at each transect (n=10) for left and right descending banks, according the SHAPP methods, and a mean class was determined at each station. The means were used to describe the stream's morphology.

2.5 Biological Assessment

Sampling was conducted as described in the MDNR Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (**SMSBPP,** MDNR 2010c). The biological assessment consists of macroinvertebrate community and physicochemical water sampling and analyses.

2.5.1 Macroinvertebrate Sampling and Analyses

Macroinvertebrates were sampled from multiple habitats as described in the SMSBPP (MDNR 2010c). West Locust Creek is considered to be a glide/pool dominant stream. As such, non-flowing water over depositional substrate (**NF**), large woody debris (**SG**), and rootmat (**RM**) habitats were sampled. Macroinvertebrates were subsampled in the WQMS lab according to the SMSBPP and identified to specific taxonomic levels in order to standardize calculation of the metrics (MDNR 2010c; MDNR 2010e).

Macroinvertebrate community data were analyzed using three strategies. Macroinvertebrate Stream Condition Index (**MSCI**) scores, individual biological criteria metrics, and dominant macroinvertebrate families (**DMF**) were examined and compared from upstream to downstream.

A Macroinvertebrate Stream Condition Index score is a qualitative or rank measurement of a stream's aquatic biological integrity (Rabeni et al. 1997). The MSCI was further refined for reference streams within each EDU in Biological Criteria for Perennial/Wadeable Streams (**BIOREF,** MDNR 2002). Comparisons are made between test streams and a BIOREF scoring range that was generated from data collected from wadeable/perennial reference streams. A station's MSCI score ultimately identifies the ability of the stream to support the beneficial use for the protection of warm water aquatic life and human health-fish consumption (**AQL**).

A station's MSCI score is a compilation of rank scores that are assigned to individual biological criteria metrics as a measure of biological integrity. Four primary biological criteria metrics were used to calculate the MSCI per station: 1) Taxa Richness (**TR**); 2) Ephemeroptera/Plecoptera/Trichoptera Taxa (**EPTT**); 3) Biotic Index (**BI**); and 4) Shannon Diversity Index (**SDI**). Metric scores were compared to the BIOREF scoring range (MSCI Scoring Table, in light gray) and rank scores (5, 3, 1) were assigned to each metric (Tables 5 and 6). Rank scores from all four primary biological criteria metrics were compiled and the MSCI was completed. The MSCI scores are interpreted as follows: 20-16 = full biological support; 14-10 = partial biological support; and 8-4 = non-support of the beneficial use protection of aquatic life (AQL). MSCI scores were also grouped by season and compared between stations.

Secondly, the individual biological criteria metrics for each station were compared to the BIOREF scoring range to identify the level of integrity in the metrics that contributed to the MSCI score. Variations in the metrics may help to identify how a community is affected and, potentially, to identify a source of impairment.

The third biological analysis was an evaluation of the "dominant macroinvertebrate families" (**DMFs**) per station. The seven most abundant DMFs for each station are listed as a percentage of the total number of individuals in the sample. Dominance by certain families also may help identify the type and source of impairment. A complete taxa list, usually to the generic level, reported by season and station, is attached as Appendix B.

2.5.2 Physicochemical Water Sampling and Analyses

Water samples were handled according to the appropriate MDNR, ESP Standard Operating Procedures (**SOP**) for sampling and analyzing physicochemical water samples.

Fall 2009 and spring 2010 physicochemical water parameters consisted of field measurements and grab samples. Field measurements including temperature (^{o}C), pH, conductivity (µS/cm), dissolved oxygen (mg/L), and discharge (cubic feet per second-**cfs**) were measured *in situ*. Grab samples were collected according to the SOP MDNR-ESP-001 Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations (MDNR 2009a). Water grab samples were returned to the ESP environmental laboratory for analyses that were conducted by the ESP, Chemical Analysis Section in Jefferson City, Missouri. These included analyses for nitrogen - ammonia (**NH_3-N**; mg/L), nitrate+nitrite as nitrogen (**NO_3+NO_2-N;** mg/L), total nitrogen (**TN**; mg/L), chloride (**Cl;** mg/L), total phosphorus (**TP;** mg/L), and non-filterable residue (**NFR**; mg/L). Turbidity (**NTU**) was measured and recorded in the WQMS biology laboratory.

Physicochemical water parameters were compared between stations from upstream to downstream and also to MDNR's Missouri Water Quality Standards (**WQS**, MDNR 2009b). Interpretation of acceptable limits in the WQS may be dependent on a stream's classification and its beneficial use designation (MDNR 2009b). West Locust Creek has not been categorized and does not have designated beneficial uses. However, for purposes of this study, we will assume the beneficial use category of protection of aquatic life and human consumption (AQL) and livestock watering (LWW).

2.5.3 Discharge

Stream discharge was calculated for each station. Velocity and depth measurements were recorded at each station in accordance with SOP MDNR-WQMS-113 Flow Measurement in Open Channels (MDNR 2010b). Velocity was measured using a Marsh-McBirney Flowmate™ flow meter.

2.6 Dissolved Oxygen Stressor Study

A continuous dissolved oxygen stressor study was attempted in West Locust Creek, Putnam County on August 11-25, 2009. The Manta ™ Water Quality Multiprobe (Eureka Environmental Engineering, Austin, Texas) datalogger was used as outlined in MDNR-ESP-104 (MDNR 2010a). The datalogger was set to record dissolved oxygen, temperature, and conductivity at 15 minute intervals.

The dataloggers were retrieved on August 25, 2009 at which time they were discovered to be displaced and buried under a heavy sand bedload. The West Locust Creek #2 datalogger was found approximately 10 feet downstream from the deployment location and buried under 18 inches of sand. Similarly, the datalogger at Station #1 was found downstream and buried in a sand lens approximately 6 inches deep.

Both dataloggers stopped recording before the retrieval date. The datalogger at West Locust Creek #2 recorded measurements from August 11 to 13, 2009 before all parameters moved into the negative range. The West Locust Creek #1 datalogger recorded from August 11 to 16, 2009 before the conductivity dropped and all parameters became negative. Precipitation data show that over 5 inches of rain fell in the area on August 15 and 16, 2009 (Appendix D). This event probably displaced the datalogger at station #1. Accurate recording at station #2 stopped before the event, so removal may have been related to another source. Results are included only for those periods when accurate recording was likely.

3.0 Results

Results are presented separately by 1) stream habitat assessment; 2) channel morphology; 3) biological assessment, which includes macroinvertebrate community analyses and physicochemical water quality parameter analyses; and 4) diel dissolved oxygen stressor observations. Trends and exceptional results are highlighted.

3.1 Stream Habitat Assessment

Stream habitat of the test stations both scored >75 percent of the SHAPP controls (Table 3) and, therefore should support a comparable biological community. The score at West Locust Creek #2 (92) was 79 percent of the mean SHAPP controls. The West Locust Creek #1 score (93) was 80 percent of the mean SHAPP control score.

Table 3
Stream Habitat Assessment Project Procedure (SHAPP) Scores
and Comparisons with SHAPP Control Stations

Station	SHAPP Score	Percent of control average
West Locust Creek #2	92	79
West Locust Creek #1	93	80
East Fork Grand River (SHAPP control)	120	116 control average
West Fork Big River (SHAPP control)	112	

*SHAPP controls from fall 2006 Hickory Creek, Grundy County study (MDNR 2007)

3.2 Channel Morphology

West Locust Creek was further described by recording detailed channel measurements and adjacent conditions at 10 transects per station (Table 4). Descriptive statistics, such as mean and standard deviation, identified the dominant measurement for each parameter, and thus described what the stream and riparian corridor looked like. West Locust Creek

#2 was approximately 40 feet wide with a wetted-width of 33 feet. This difference between channel and wetted-width identified bars (sand) that were an average of 7 feet wide. The station was usually less than 8 inches deep and dominated by pools with sand-covered substrate. The left bank was slightly more unstable than the right and the riparian corridor was between 6 and 11.9 meters wide. West Locust Creek #1 was approximately 41 feet wide, with a wetted-width of 31 feet. This difference revealed sand bars that were an average of 10 feet wide. This station was usually less than 8 inches deep, dominated by pools, and had a sand-covered stream bed. Left bank conditions were slightly more unstable than the right. The riparian corridor was less than 6 meters on both the left and right banks of the stream.

Table 4
Channel Morphology Including Descriptions of Channel-Width, Wetted-Width, Depth, Dominant Substrate Size Class, Dominant Flow Regime, Bank Conditions - left and right, and Riparian Corridor Width - left and right

Station	Channel -Width (feet)	Wetted -Width (feet)	Depth Mean (inches)	Dominant Substrate Size Class	Dominant Flow Regime	Bank Condition L	Bank Condition R	Riparian Corridor L	Riparian Corridor R
West Locust Creek #2	40.1 ±8.8	33.1 ±6.2	7.8 ±6.2	Sand	Pool	Mod. unstable Cat. 3	Mod. stable Cat. 2	11.9-6.0 meters Cat. 3	11.9-6.0 meters Cat. 3
West Locust Creek #1	41.4 ±4.6	31.4 ±11.7	7.7 ±5.6	Sand	Pool	Mod. unstable Cat. 3	Mod. stable Cat. 2	<6.0 meters Cat. 4	<6.0 meters Cat. 4

Mod = moderately; Cat. = Category (SHAPP MDNR 2010d)

3.3 Biological Assessment

Biological assessments consist of macroinvertebrate community analyses and physicochemical water quality analyses. Results are grouped by season and station.

3.3.1 Macroinvertebrate Community Analyses

The macroinvertebrate community is examined in this section. The Macroinvertebrate Stream Condition Index (MSCI) scores and individual metric scores are examined for each test station for the fall and spring seasons. Dominant macroinvertebrate families also were examined. Results are grouped by season and station. A detailed taxa bench sheet list that is grouped by season and station can be found in Appendix B.

The fall MSCI scores, individual metrics, and biological support categories of the West Locust Creek stations are presented in Table 5. The West Locust Creek #2 station scored 18 and was fully supporting of the AQL designated use. The West Locust Creek #1 station had a score of 18 and was similarly fully supporting. The BI was slightly elevated at both stations, which contributed to the slightly lower than optimum MSCI score. The

BI suggests a community that was very slightly more tolerant to organic influences and disturbance than the reference range. Other individual metrics were well within the optimum BIOREF scoring range.

Table 5
Biological Criteria (BIOREF) Metric Scores, Macroinvertebrate Stream Condition Index (MSCI) Scores, and Biological Support Category for West Locust Creek, Putnam County, Fall 2009

Stream and Station Number	Sample No.	TR	EPTT	BI	SDI	MSCI	Support
West Locust Creek #2	0918403	63	11	**7.3**	3.04	18	F
West Locust Creek #1	0918404	77	15	**7.5**	2.84	18	F
BIOREF Score=5	--	>53	>9	<7.2	>2.69	20-16	**F**ull
BIOREF Score=3	--	53-27	9-5	7.2-8.6	2.69-1.35	14-10	**P**artial
BIOREF Score=1	--	<27	<5	>8.6	<1.35	8-4	**N**on-

MSCI Scoring Table (gray) developed using BIOREF samples (n=18); TR=Taxa Richness; EPTT=Ephemeroptera, Plecoptera, Trichoptera Taxa; BI=Biotic Index; SDI=Shannon Diversity Index; **Bold**=metrics with less than optimum BIOREF scores.

The spring MSCI scores, individual metrics, and biological support categories for West Locust Creek stations are presented in Table 6. Station #2 and station #1 each had MSCI scores of 20 and were fully supporting of the AQL designated use. The individual metrics were well within the optimum range for all individual metrics at both stations. This indicated that the macroinvertebrate community at the test stations was similar to the reference selections.

The dominant macroinvertebrate families were generally similar between stations in the fall and spring (Table 7). Chironomidae (midges), Caenidae, and Heptageniidae (mayflies) were among the most dominant families at all stations in both seasons. Hyalellidae (amphipod) was among the dominant families at all but station #1 in the spring. Mayfly families such as Heptageniidae and Baetidae, that tend to be intolerant of organic pollutants, were among the dominant taxa in at least one station in both seasons.

Table 6
Biological Criteria (BIOREF) Metric Scores, Macroinvertebrate Stream Condition Index (MSCI) Scores, and Biological Support Category for West Locust Creek, Putnam County, Spring 2010

Stream and Station Number	Sample No.	TR	EPTT	BI	SDI	MSCI	Support
West Locust Creek #2	1004001	70	11	7.1	3.29	20	**F**
West Locust Creek #1	1004002	55	9	6.7	2.90	20	**F**
BIOREF Score=5	--	>51	>8	<7.3	>2.53	20-16	**F**ull
BIOREF Score=3	--	51-25	8-4	7.3-8.7	2.53-1.27	14-10	**P**artial
BIOREF Score=1	--	<25	<4	>8.7	<1.27	8-4	**N**on-

MSCI Scoring Table (gray) developed using BIOREF samples (n=23); TR=Taxa Richness; EPTT=Ephemeroptera, Plecoptera, Trichoptera Taxa; BI=Biotic Index; SDI=Shannon Diversity Index; **Bold**=metrics with less than optimum BIOREF score

Table 7
Dominant Macroinvertebrate Families (DMF) as a Percentage of the Total Number of Individuals per Station for West Locust Creek (WLC), Putnam County Stations, Fall 2009 and Spring 2010

Family	WLC #2 Fall 2009	WLC #1 Fall 2009	WLC #2 Spring 2010	WLC #1 Spring 2010
Chironomidae	57.0	50.1	62.9	58.6
Hyalellidae	15.6	33.8	6.7	-
Caenidae	13.2	3.2	6.3	8.5
Leptophlebiidae	3.1	-	-	-
Coenagrionidae	2.1	-	-	-
Heptageniidae	1.8	1.2	2.1	14.0
Baetidae	0.6	1.7	-	1.5
Ceratopogonidae	-	1.5	-	-
Physidae	-	1.2	-	-
Hydropsychidae	-	-	5.3	5.4
Enchytraeidae	-	-	4.9	-
Haliplidae	-	-	1.3	-
Simuliidae	-	-		5.3
Empididae	-	-		1.1

3.3.2 Physicochemical Water Quality Parameters

All physicochemical water parameters analyzed were unremarkable in both the fall and spring samples (Table 8). Nutrients (total nitrogen, ammonia, and total phosphorus) and chloride were detected in very low concentrations at West Locust Creek #2 and #1 during both seasons. Nutrients were slightly higher in the spring, possibly due to increased discharge.

Table 8
Physicochemical Water Quality Parameters for West Locust Creek Stations in Putnam County, Fall 2009 and Spring 2010

Station > Variable/Date	West Locust Creek #2 Fall 2009	West Locust Creek #1 Fall 2009	West Locust Creek #2 Spring 2010	West Locust Creek #1 Spring 2010
Sample Number	0912052	0912053	1000902	1000903
pH (Units)	8.0	8.6	8.0	8.3
Temperature (°C)	12.0	14.0	13.0	15.0
Conductivity (µS/cm)	480	451	370	355
Dissolved O_2	7.81	7.86	10.53	10.36
Discharge (cfs)	0.78	1.40	9.5	13.46
NFR	7.00	5.00	22.0	20.0
Turbidity (NTUs)	4.36	4.61	27.2	26.0
Total Nitrogen	0.40	0.37	0.56	0.63
Nitrate+Nitrite-N	<0.05	<0.01	0.12	0.19
Ammonia-N	0.07	0.09	0.11	0.13
Chloride	9.56	8.57	7.96	8.68
Total Phosphorus	0.05	0.05	0.08	0.08

(Units mg/L unless otherwise noted; **Bold**=Out of WQS acceptable range or trend)

3.4 Dissolved Oxygen Stressor Study

Although the long-term diel dissolved oxygen stressor study was shortened due to circumstances that resulted in datalogger failure, data were recorded, but for a shorter period of time (Appendix C).

The dissolved oxygen datalogger at West Locust Creek #2 recorded for two days before accurate recording stopped. It was buried under an estimated 18 inch deep sand lens, which presumably caused it to stop accurate recording. A total of 218 accurate measurements were recorded with an average dissolved oxygen concentration of 8.47 mg/L, average maximum of 11.24 mg/L, and an average minimum of 6.77 mg/L. The datalogger recorded no measurements below the MDNR WQS (2009b) of 5.0 mg/L.

The dissolved oxygen datalogger at West Locust Creek #1 was deployed for five days before it stopped accurate recording. A heavy rain and subsequent flood marked the end of accurate recording and the datalogger was buried in 6 inches of sand. A total of 494 total measurements were recorded with an average dissolved oxygen concentration of

7.89 mg/L, average maximum of 11.13 mg/L, and an average minimum of 6.07 mg/L. The datalogger recorded no measurements below the MDNR WQS (MDNR 2009b) of 5.0 mg/L.

The dataloggers also recorded temperature and conductivity in 15 minute intervals over the deployment (Appendix C). West Locust Creek #2 temperatures ranged from 20°C in the early morning to as much as 33°C in the mid-afternoon for a diel range of 13°C. Station #1 had a similar trend with low temperatures of 20°C and a high of 32°C with a diel range of 12°C. Conductivity ranged from mid 300 to mid 400 µS/cm at station #2. Conductivity ranged from high 300 to high 400 µS/cm at station #1.

4.0 Discussion

The results of the stream habitat assessment and channel morphology, biological assessment, and diel dissolved oxygen stressor study will be discussed in this section.

4.1 Stream Habitat and Channel Morphology

Stream habitat at both West Locust Creek stations scored >75 percent of the SHAPP controls. Despite both stations #2 and #1 having relatively low scores (79 and 80 percent, respectively), habitat was considered sufficiently comparable to control scores to support a similar biological community. Heavy sediment deposition and poor riparian corridor width contributed to the lower scores.

Detailed measurements of the channel and surroundings further described the appearance of West Locust Creek stations. The stream had large sand bars that filled about 20 percent of the channel width. Both stations were dominated by sand-filled shallow pools with moderately stable to moderately unstable banks and shallow riparian corridors.

General observation of the substrate revealed sand movement. A deep and unconsolidated sand layer was visibly moving during higher flow in the spring. The deposition of bars changed between visits. Other evidence of heavy movement was illustrated by the temporary loss of the dissolved oxygen dataloggers. Following their 14 day deployment, we found the dataloggers downstream from their original location and buried in 6 to 18 inches of loose sand.

This heavy sand deposition in West Locust Creek was observed earlier by researchers. In 1994 representatives of the Missouri Department of Conservation, while developing the Locust Creek Basin Management Plan, noted that fish habitat conditions were poor at most sample sites, including West Locust Creek. Excessive sand bedloads, probably from stream bank erosion, created unstable channels and adjacent agricultural land have filled in many pools, leaving very little stable substrate for spawning. Lack of instream woody debris also may be a factor limiting the standing crop of fish communities (MDC 1994). Fantz (1993) also determined that macroinvertebrate communities in the Locust Creek basin would benefit from an increase in snag habitat and a more diverse substrate. Oesch (1984) reported that no mussels occur in the Locust Creek basin and claimed that excessive inputs of animal waste and silt were responsible for the extirpation of mussels

from northwest and north-central Missouri streams. Fine sediment loads should be decreased to optimize macroinvertebrate and fish habitat in West Locust Creek. Best management practices in the stream banks, riparian corridor, and the primary floodplain may lessen the input of sand in the stream.

4.2 Biological Assessment

The biological assessment includes analyses of the macroinvertebrate community and comparison of the physicochemical water quality between stations and with water quality standards.

4.2.1 Macroinvertebrate Community Analyses

Based on macroinvertebrate community analyses, West Locust Creek, Putnam County was not impaired during the fall of 2009 or spring of 2010. Fall results showed that both stations #2 and #1 were fully supporting of the protection of aquatic life (AQL) beneficial use designation. The BI was slightly higher than the optimum reference range, which indicated that an upstream organic influence or disturbance may have slightly affected the community. Spring results showed that stations #2 and #1 again were fully supporting of the AQL designated use. Individual metrics were in the optimum range, which indicated that the community was similar to BIOREF streams in terms of taxa richness, organic pollutant tolerance, and diversity and evenness. The test stations were similar to the reference selections during both seasons.

Examination of dominant families and individual taxa suggested that the aquatic communities were comparable to the references. Heptageniid and baetid mayflies were among the dominant taxa in both seasons and in all stations but #1 in the spring, but in relatively low percentages. *Heptagenia* sp. was found in all seasons and is considered very intolerant to organic input. *Maccaffertium terminatum* or *M. pulchellum* are considered intolerant and were found in most stations, in either fall or spring. It appears that the useable habitat that is available in the stream is suitable to accommodate the sensitive taxa.

4.2.2 Water Quality

All parameters were relatively similar between stations during both seasons, and well within WQSs (MDNR 2009b) when applicable. Nutrients and chloride were detected in low levels at both stations during both seasons, which suggests a slight, yet continuous organic input upstream from both stations. This is consistent with runoff from sources such as land-applied fertilizer, animal use, or wastewater influence in the watershed upstream from both stations.

4.3 Dissolved Oxygen Stressor Study

The diel dissolved oxygen study using long-term datalogger deployment showed similar results between stations and concentrations were consistently above minimal WQSs. Temperatures ranged from low 20s to low 30s°C with a daily increase of 13°C at station #2 and 12°C at station #1. A wide range in temperatures and the presence of high temperatures illustrates the potential for a dissolved oxygen related stressor for the

aquatic community. Dissolved oxygen concentrations fluctuated from a low in early morning to a high in mid-afternoon, as would be expected with some photosynthetic effect. Dissolved oxygen concentrations averaged approximately 8.5 mg/L at station #2 and near 8.0 mg/L at station #1. Both are well above the WQS of 5.0 mg/L. The wide temperature range, high temperature, and high dissolved oxygen concentrations suggest that the aquatic communities were not overly stressed due to oxygen concentrations. Dissolved oxygen was not an obvious stressor during this abbreviated study. A full-term datalogger deployment during summer months may increase confidence in this conclusion.

5.0 Conclusion

The objectives were met. The stream habitat was assessed. The aquatic life protection beneficial use status of the macroinvertebrate community was assessed. The physicochemical water quality of the stream was assessed. The range of dissolved oxygen concentrations was identified during a period of temperature-related stress.

1) Stream habitat quality was similar between stations and supports an aquatic community similar to the SHAPP controls for the Central Plains/Grand/Chariton EDU.

2) Sand bedload was extremely heavy, which changed the morphology of the stream between visits.

3) An aquatic life protection beneficial use category has not been designated for the stream because it has not been classified by MDNR. However, Macroinvertebrate Stream Condition Index scores for the two test stations illustrated that the stream was fully supporting of the aquatic life protection beneficial use category during both seasons.

4) The stream physicochemical water quality parameters were similar between stations and within acceptable limits of Missouri's Water Quality Standards (MDNR 2009b).

5) Daily fluctuations in dissolved oxygen concentrations were within acceptable water quality standard limits for the entire abbreviated datalogger deployment.

6.0 Recommendations

- Fine sediment loads should be decreased to optimize macroinvertebrate and fish habitat in West Locust Creek.

- Best management practices in the stream banks, riparian corridor, and the primary floodplain within the watershed should be encouraged to lessen the amount of sand in the stream.

- A full-term datalogger deployment may be useful in the future.

7.0 Literature Cited

Fantz, J.R. 1993. The role of habitat in the distribution of macroinvertebrates in some central Missouri streams. Masters Thesis. University of Missouri-Columbia.

Missouri Department of Conservation. 1994. Locust Creek Basin Management Plan. Missouri Department of Conservation, Fisheries Division, P.O. Box 180, Jefferson City, Missouri. 96 pp.

Missouri Department of Natural Resources (MDNR). 2002. Biological criteria for wadeable/perennial streams of Missouri. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 32 pp.

MDNR. 2007. Biological assessment and channel evaluation, Hickory Creek and Hickory Creek Tributary, Grundy County, Fall 2006 – Spring 2007. Missouri Department of Natural Resources, Environmental Services Program. Jefferson City, Missouri. 26 pp. + Appendices.

MDNR. 2009a. Required/recommended containers, volumes, preservatives, holding times, and special sampling considerations. MDNR-ESP-001. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 25 pp.

MDNR. 2009b. Title 10. Rules of Department of Natural Resources Division 20-Clean Water Commission, Chapter 7-Water Quality. 10 CSR 20-7.031 Water Quality Standards. September 30, 2009. 150 pp.

MDNR. 2010a. Continuous or long-term monitoring of water quality using a dissolved oxygen, specific conductivity, and temperature data logger. MDNR-ESP-104. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 174, Jefferson City, Missouri. 9 pp.

MDNR. 2010b. Flow measurements in open channels. MDNR-ESP-113. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 25 pp.

MDNR. 2010c. Semi-quantitative macroinvertebrate stream bioassessment project procedure. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 26 pp.

MDNR. 2010d. Stream habitat assessment project procedure. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 40 pp.

MDNR. 2010e. Taxonomic levels for macroinvertebrate identifications. MDNR-ESP-209. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 32 pp.

Oesch, R.D. 1984. Missouri naiades: A guide to the mussels of Missouri. Missouri Department of Conservation. 343 pp.

Rabeni, C.F., R.J. Sarver, N. Wang, G.S. Wallace, M. Weiland, and J.T. Peterson. 1997. Biological criteria for streams of Missouri. Missouri Cooperative Fish and Wildlife Research Unit, University of Missouri-Columbia, Columbia, Missouri. 261 pp.

Sowa, S.C., G. Annis, M.E. Morey, and D.D. Diamond. 2007. A GAP analysis and comprehensive conservation strategy for riverine ecosystems of Missouri. Ecol. Mono. 77(3), pp. 301-334.

Submitted by: _____

Kenneth B. Lister
Water Quality Biologist
Environmental Specialist III
Water Quality Monitoring Section
Environmental Services Program

Date: _____

Approved by: _____

Alan Reinkemeyer
Director
Environmental Services Program

AR:klt

c: John Ford, Water Protection Program
Irene Crawford, Northeast Regional Office

Appendix A

Biological Assessment and Stressor Study Proposal
West Locust Creek
Putnam County
July 13, 2009

Missouri Department of Natural Resources
Field Services Division
Environmental Services Program
Water Quality Monitoring Section

Biological Assessment and Stressor Study Proposal for West Locust Creek, Putnam County July 13, 2009

1.0 Background

West Locust Creek (WBID 611), Putnam County, (**WLC**) is a small stream not yet assigned a designated stream classification by the Missouri Department of Natural Resources (**MDNR**). The stream is approximately 20 miles long, reaching from near the Iowa border to approximately the Sullivan County line. Its headwaters are in northwest Putnam County approximately five miles northeast of Powersville, Missouri. West Locust Creek extends to approximately two miles southeast of Quinn, Missouri where it reaches its confluence with Locust Creek.

Several biological assessments have been conducted on the stream since 1994 to 2000 with interesting results. The MDNR conducted a study in the fall of 1994 and spring of 1995. A consulting firm conducted spring assessments from 1996 through 2000. All assessments conducted from 1995 through 1998 resulted in partial support of the beneficial use "the protection of aquatic life and human health-fish consumption (**AQL**)". Scores identified full support for AQL in the spring of 1999 and 2000. No comprehensive report was written by either the consulting firm or MDNR. Biological assessment data are housed in the aquatic macroinvertebrate database with the MDNR/ESP.

It is our intention to conduct a biological assessment, stream habitat assessment, and stressor study on West Locust Creek, Putnam County, Missouri. The stressor study will include frequent dissolved oxygen monitoring within the stream for an extended period of time. The goal is to determine if West Locust Creek is impaired.

This study was requested by the Water Pollution Protection (**WPP**), of the Division of Environmental Quality (**DEQ**), in the MDNR. The study will be conducted by the Field Services Division (**FSD**), Environmental Services Program (**ESP**), Water Quality Monitoring Section (**WQMS**), and Chemical Analysis Section (**CAS**).

2.0 Objectives

1. Assess the biological (macroinvertebrate) integrity and water quality of West Locust Creek.

2. Determine the quality of the stream habitat.

3. Identify the diel dissolved oxygen range.

2.1 Tasks

1. Conduct a biological assessment on West Locust Creek.

2. Conduct a stream habitat assessment.

3. Conduct dissolved oxygen studies at each station.

2.2 Null Hypotheses

Biological metrics and MSCI scores will be similar between stations and to wadeable/perennial stream biological criteria.

Physicochemical water quality will be similar at all stations, and parameters will meet the Water Quality Standards (**WQS**) of Missouri (MDNR 2005c).

Dissolved oxygen concentrations will be similar between stations and within acceptable WQS levels throughout the day and night.

3.0 Study Design

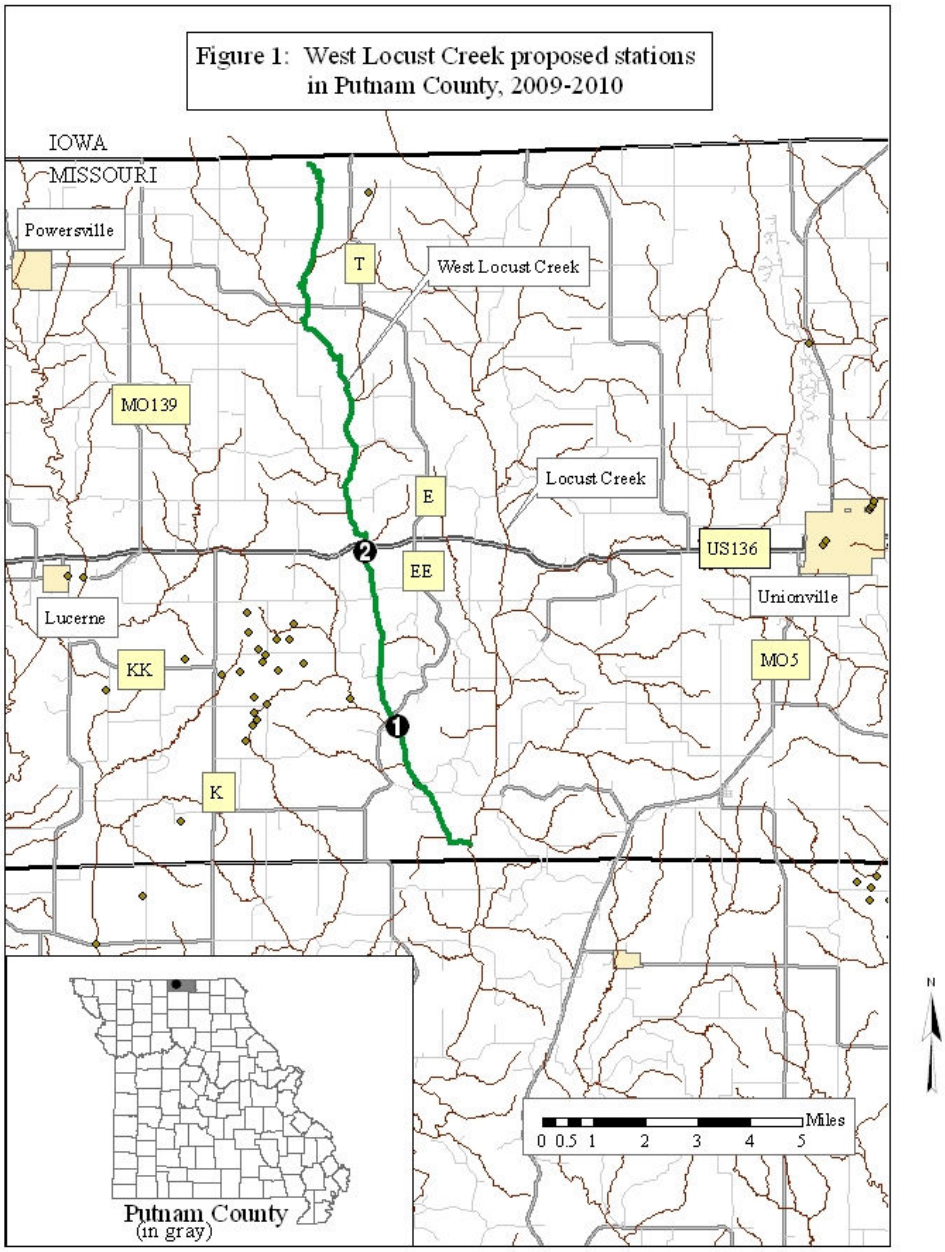
The study area, biological assessment, stream habitat assessment, and dissolved oxygen studies are described below.

3.1 Study Area

The study area and station locations for the 2009-2010 West Locust Creek, Putnam County (WBID 611) project are shown in Figure 1. Two stations were allocated for this project. Stations were positioned approximately five miles apart. Stations are identified and described in Table 1. Stations are identified by number downstream to upstream. West Locust Creek is located in the Central Plains/Grand/Chariton, Ecological Drainage Unit (**EDU**).

Table 1
West Locust Creek, Putnam County Station Locations and Descriptions

Station	County	TRS; Location	Description
West Locust Creek #2	Putnam	SW ¼ sec. 32, T. 66 N., R. 20 W. UTM 0484936E 4480336N	Downstream MO Hwy 136 bridge
West Locust Creek #1	Putnam	NW ¼ sec. 20, T. 65 N., R. 20 W. UTM 0485653E 4475032N	Downstream Hwy EE bridge



Diamond = Outfall

3.2 Biological Assessment

A biological assessment consists of macroinvertebrate community and physicochemical water evaluation.

3.2.1 Macroinvertebrate Sampling and Analyses

As specified in the Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (**SMSBPP,** MDNR 2003c), macroinvertebrates will be sampled from three specific habitats. These target habitats are based on stream type. West Locust Creek is considered a "glide/pool" dominant stream, in which non-flowing water over depositional substrate; large woody debris; and rootmat habitats will be sampled. Macroinvertebrates will be subsampled according to the SMSBPP, and identified to specific taxonomic levels (MDNR 2005a) in order to calculate metrics in a standardized fashion (MDNR 2002; MDNR 2003c).

Macroinvertebrate community data will be analyzed using three strategies. Macroinvertebrate Stream Condition Index scores, individual biological criteria metrics, and dominant macroinvertebrate families will be examined and compared between test and reference streams.

Macroinvertebrate data will be entered in a Microsoft Access database in accordance with Quality Control Procedures for Data Processing, MDNR-WQMS-214 (MDNR 2003b). Data analysis is automated within the Access database. According to the SMSBPP, a total of four standard metrics will be calculated for each station: Taxa Richness (TR); Ephemeroptera, Plecoptera, Trichoptera Taxa (EPTT); Biotic Index (BI); and the Shannon Diversity Index (SDI).

3.2.2 Physicochemical Water Sampling and Analyses

Physicochemical water samples will be handled according to the appropriate MDNR, Standard Operating Procedure (**SOP**) and/or Project Procedure (**PP**) for sampling and analyzing physicochemical water samples. Results for physicochemical water parameters will be examined by season and station.

Fall 2009 and spring 2010 physicochemical water samples will either be measured *in-situ* or collected as grab samples and analyzed at the Environmental Services Program laboratory. Temperature (C^o), pH, conductivity (µS), dissolved oxygen (mg/L), and discharge in cubic feet per second (**cfs**) will be measured *in situ*. Grab samples will be collected and handled according to the SOP MDNR-FSS-001 Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations (MDNR 2009). All samples will be kept on ice during transport to ESP. Turbidity samples (NTU) will be measured and recorded in the WQMS biology laboratory. The ESP, Chemical Analysis Section (**CAS**) will conduct analyses for non-filterable residue (NFR = TSS), ammonia-nitrogen (mg/L), nitrate+nitrite-nitrogen (mg/L), total nitrogen (mg/L), chloride (mg/L), and total phosphorus (mg/L).

Physicochemical results will be compared between stations from upstream to downstream, as well as with Missouri's WQS (MDNR 2005b). Interpretation of acceptable limits in the WQS may be dependent on a stream's classification and its beneficial-use designation (MDNR 2005b). West Locust Creek is not classified at this time, and has no designated beneficial uses.

Stream flow will be measured at each station using a Marsh-McBirney Flowmate™ flow meter. Velocity and depth measurements will be recorded at each station according to SOP MDNR-WQMS-113 Flow Measurement in Open Channels (MDNR 2003a).

Water quality data will be entered in the ESP Laboratory Information Management System (LIMS) database. Results of the study will be summarized and interpreted in report format.

3.3 Stream Habitat Assessment

Stream habitat will be assessed as outlined in the Stream Habitat Assessment Project Procedure (**SHAPP**) for Glide/Pool prevalent streams (MDNR 2003d). The SHAPP assesses the quality of the stream habitat and the potential influence habitat might have on the aquatic biological community. Stream habitat quality is scored for each station and the test scores are compared with mean SHAPP reference station scores.

As another indicator of stream condition, channel measurements and observations will be recorded at ten transects within each station. Channel-width, wetted-width, depth measurements, bank conditions, type of flow, and riparian corridor condition will be recorded at each transect. Channel-width includes the distance (feet) between the lower banks, including bars. The wetted-width includes only the wetted portion of the stream. Water depth (inches) will be measured, perpendicular to flow, at three locations (¼, ½, and ¾ of wetted-width) on each transect to identify morphology. The bank stability, type of flow, and riparian corridor observations will be recorded at each transect. Data will be compiled, and potentially tested between stations.

3.4 Dissolved Oxygen Study

Dissolved oxygen will be monitored at the four stations using dissolved oxygen dataloggers. Four Manta™ Water Quality Multiprobes, (Eureka Environmental Engineering, Austin, Texas) using standard procedures describing deployment, recovery, and download procedures, along with quality control procedures (WQMS draft).
The dataloggers will be in place for two weeks in late July or August to identify dissolved oxygen concentrations throughout the day and night. Time of deployment will illustrate dissolved oxygen levels during extreme conditions of low flow and high water temperature. Data will be graphed to illustrate fluctuations in diel concentration, and to identify conformity with the WQS.

4.0 Quality Control

Quality control will be used as stated in the MDNR Standard Operating Procedures and Project Procedures.

5.0 Literature Cited

Missouri Department of Natural Resources (MDNR). 2002. Biological Criteria for Wadeable/Perennial Streams of Missouri. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 32 pp.

MDNR. 2003a. Flow Measurements in Open Channels. MDNR-WQMS-113. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 9 pp.

MDNR. 2003b. Quality Control Procedures for Data Processing. MDNR-WQMS-214. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 6 pp.

MDNR. 2003c. Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 24 pp.

MDNR. 2003d. Stream Habitat Assessment Project Procedure. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 40 pp.

MDNR. 2005a. Taxonomic Levels for Macroinvertebrate Identifications. MDNR-WQMS-209. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 30 pp.

MDNR. 2005b. Title 10. Rules of Department of Natural Resources Division 20-Clean Water Commission, Chapter 7-Water Quality. 10 CSR 20-7.031 Water Quality Standards. pp. 10-136.

MDNR. 2009. Required/recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations. MDNR-ESP-001. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 25 pp.

Appendix B

Macroinvertebrate Bench Sheet Report for West Locust Creek
Putnam County
Fall 2009 – Spring 2010

(Grouped by season and station; upstream to downstream)

Aquid Invertebrate Database Bench Sheet Report
West Locust Cr [0918403], Station #2, Sample Date: 9/29/2009 12:00:00 PM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
"HYDRACARINA"			
Acarina		1	
AMPHIPODA			
Hyalella azteca		116	27
COLEOPTERA			
Berosus		1	
Dubiraphia			1
Dytiscidae	1	2	
Helichus lithophilus		2	
Peltodytes		2	
Tropisternus		-99	1
DIPTERA			
Ablabesmyia	9	2	4
Anopheles		6	
Chironomidae	3	1	7
Chironomus	19		2
Cladotanytarsus	7		1
Cricotopus bicinctus	8	1	5
Cricotopus/Orthocladius	2	2	1
Cryptochironomus	13		2
Dicrotendipes	16		54
Endochironomus		1	3
Forcipomyiinae			6
Glyptotendipes	5	3	17
Hemerodromia			2
Nanocladius		6	2
Paralauterborniella	1		
Paratanytarsus	14	10	3
Phaenopsectra	4		3
Polypedilum fallax grp			7
Polypedilum halterale grp	19		1
Polypedilum illinoense grp	6	4	21
Polypedilum scalaenum grp			3
Procladius	1		1
Rheotanytarsus		1	
Saetheria	2		
Stempellinella	13		
Stenochironomus			40
Tanypus			1
Tanytarsus	122	3	31
Thienemanniella	1	2	

Aquid Invertebrate Database Bench Sheet Report
West Locust Cr [0918403], Station #2, Sample Date: 9/29/2009 12:00:00 PM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
Thienemannimyia grp.		3	7
EPHEMEROPTERA			
Caenis latipennis	42	61	18
Callibaetis		4	
Centroptilum	2		
Heptagenia			2
Leptophlebiidae		28	1
Maccaffertium terminatum	5		1
Stenacron		2	7
Tricorythodes			1
HEMIPTERA			
Corixidae	6		
Microvelia		2	
Neoplea		1	
LIMNOPHILA			
Helisoma			1
Physella	1	2	1
ODONATA			
Argia		4	
Calopteryx			1
Enallagma	1	10	1
Erythemis		1	
Ischnura		4	
Progomphus obscurus	1		
RHYNCHOBDELLIDA			
Piscicolidae	1		
TRICHOPTERA			
Nectopsyche	1	2	
Oecetis	1	1	
Ptilostomis		1	
TUBIFICIDA			
Enchytraeidae		1	
Tubificidae	3		1

Aquid Invertebrate Database Bench Sheet Report
West Locust Cr [0918404], Station #1, Sample Date: 9/29/2009 2:00:00 PM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
AMPHIPODA			
Hyalella azteca	2	199	152
BRANCHIOBDELLIDA			
Branchiobdellida		1	
COLEOPTERA			
Berosus		2	-99
Dytiscidae		1	
Neoporus		1	
DECAPODA			
Orconectes virilis		-99	
DIPTERA			
Ablabesmyia	3	2	
Anopheles		4	
Ceratopogoninae	7		
Chironomidae	3	3	3
Chironomus	72	3	6
Chrysops		1	
Cladotanytarsus	10		
Corynoneura		1	
Cricotopus bicinctus	6	3	2
Cricotopus/Orthocladius	1	1	
Cryptochironomus	13	1	
Cryptotendipes	2		
Dicrotendipes	9	5	21
Endochironomus	3	3	1
Forcipomyiinae			9
Glyptotendipes		19	22
Gonomyia	3		
Hemerodromia			7
Labrundinia		1	2
Nanocladius	4	8	1
Parachironomus		3	
Paracladopelma	2		
Paralauterborniella		1	
Paratanytarsus	4	12	6
Phaenopsectra		2	3
Polypedilum convictum	1		2
Polypedilum fallax grp		1	3
Polypedilum halterale grp	40		1
Polypedilum illinoense grp	5	9	3

Aquid Invertebrate Database Bench Sheet Report
West Locust Cr [0918404], Station #1, Sample Date: 9/29/2009 2:00:00 PM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
Procladius	1		1
Rheotanytarsus	2		2
Simuliidae	1		
Stempellinella	14		
Stenochironomus		1	8
Stictochironomus	1		
Tanytarsus	99	7	30
Thienemanniella	2	1	2
Thienemannimyia grp.		6	14
Tipula	4		
EPHEMEROPTERA			
Baetis		2	2
Brachycercus	1		
Caenis latipennis	18	14	1
Callibaetis		5	
Centroptilum	2		
Heptagenia		2	8
Leptophlebiidae	1	8	
Maccaffertium terminatum			1
Paracloeodes	1		1
Pseudocloeon		5	
Stenacron		2	
Tricorythodes	1		1
HEMIPTERA			
Belostoma		-99	
Corixidae	1		1
Microvelia			1
Neoplea		2	
Ranatra nigra		-99	
Trichocorixa	1	1	
LIMNOPHILA			
Menetus			1
Physella		13	
ODONATA			
Argia		1	
Boyeria		-99	
Calopteryx		-99	
Enallagma		3	
Gomphidae		1	
Ischnura	1	7	
Libellulidae		1	

Aquid Invertebrate Database Bench Sheet Report
West Locust Cr [0918404], Station #1, Sample Date: 9/29/2009 2:00:00 PM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
Progomphus obscurus	1		
TRICHOPTERA			
Cheumatopsyche			6
Nectopsyche	1	1	
Oecetis	1	1	
TUBIFICIDA			
Tubificidae		2	1

Aquid Invertebrate Database Bench Sheet Report
West Locust Cr [1004001], Station #2, Sample Date: 4/1/2010 10:30:00 AM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
AMPHIPODA			
Crangonyx		1	
Hyalella azteca		32	2
ARHYNCHOBDELLIDA			
Erpobdellidae		-99	
BRANCHIOBDELLIDA			
Branchiobdellida		1	
COLEOPTERA			
Agabus		1	
Dubiraphia		1	
Helichus basalis		1	
Helichus lithophilus		3	
Paracymus			1
Peltodytes		7	
Tropisternus		1	
DECAPODA			
Orconectes virilis		-99	
DIPTERA			
Ceratopogoninae	1	1	
Chaoborus	1	1	
Chironomidae		4	
Chironomus		1	
Chrysops		-99	
Corynoneura	1	3	
Cricotopus bicinctus	1	1	4
Cricotopus/Orthocladius	8	28	18
Cryptochironomus	4		
Dicrotendipes		1	1
Diplocladius	1	1	2
Diptera	2	1	
Glyptotendipes		1	
Hydrobaenus	1		1
Micropsectra		5	2
Nanocladius		3	
Natarsia		1	
Parametriocnemus		1	
Paraphaenocladius			3
Paratanytarsus		24	5
Phaenopsectra		12	1
Pilaria	1		

Aquid Invertebrate Database Bench Sheet Report
West Locust Cr [1004001], Station #2, Sample Date: 4/1/2010 10:30:00 AM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
Polypedilum convictum			2
Polypedilum halterale grp	69	1	
Polypedilum illinoense grp		3	
Polypedilum scalaenum grp	1	2	
Polypedilum tritum		7	
Prosimulium			1
Pseudorthocladius		1	
Rheotanytarsus		3	
Saetheria	10	2	
Simulium	1		2
Smittia	1		
Tanytarsus		6	1
Thienemanniella	1		4
Thienemannimyia grp.		39	6
Tipula		5	
Zavrelimyia		20	
EPHEMEROPTERA			
Acerpenna		1	
Baetis		1	1
Caenis latipennis	2	27	3
Heptagenia		9	
Leptophlebia		1	
Stenacron			2
ISOPODA			
Caecidotea		1	
LIMNOPHILA			
Lymnaeidae	2	1	
ODONATA			
Boyeria		-99	
Calopteryx		3	
Progomphus obscurus		-99	
PLECOPTERA			
Perlidae	1	1	
RHYNCHOBDELLIDA			
Glossiphoniidae		1	
TRICHOPTERA			
Cheumatopsyche		21	6
Hydropsyche			-99
Nectopsyche		1	
Pycnopsyche	1	2	

Aquid Invertebrate Database Bench Sheet Report
West Locust Cr [1004001], Station #2, Sample Date: 4/1/2010 10:30:00 AM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
TUBIFICIDA			
Enchytraeidae	1	24	
Tubificidae	2	2	
VENEROIDA			
Pisidiidae		2	

Aquid Invertebrate Database Bench Sheet Report
West Locust Cr [1004002], Station #1, Sample Date: 4/1/2010 11:54:00 AM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
AMPHIPODA			
Hyalella azteca		6	1
ARHYNCHOBDELLIDA			
Erpobdellidae	1		
COLEOPTERA			
Helichus lithophilus		1	
Tropisternus		-99	
DIPTERA			
Ablabesmyia	1		
Chironomidae	1	1	1
Chrysops		-99	
Corynoneura	2		
Cricotopus bicinctus	6	5	8
Cricotopus/Orthocladius	19	32	115
Cryptochironomus	1		
Dicrotendipes	2	3	18
Diplocladius		3	9
Diptera			1
Eukiefferiella		1	1
Glyptotendipes			5
Hemerodromia		2	6
Hydrobaenus		1	4
Micropsectra		1	3
Nanocladius			1
Paracladopelma	3		6
Parametriocnemus	1		3
Paratanytarsus	6	16	10
Paratendipes	1		
Phaenopsectra		1	
Polypedilum convictum	2	8	7
Polypedilum halterale grp	2		
Polypedilum illinoense grp		4	
Polypedilum scalaenum grp	1		
Pseudolimnophila		-99	
Rheosmittia	1		
Rheotanytarsus		2	2
Simulium	4	20	13
Stenochironomus			9
Stictochironomus		1	
Tanytarsus	2	12	8

Aquid Invertebrate Database Bench Sheet Report
West Locust Cr [1004002], Station #1, Sample Date: 4/1/2010 11:54:00 AM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
Thienemanniella	3	15	6
Thienemannimyia grp.	8	14	7
Tipula		-99	
Zavrelimyia		1	
EPHEMEROPTERA			
Acerpenna	1	8	2
Caenis latipennis	4	51	4
Heptagenia	29	48	16
Leptophlebia		-99	
Maccaffertium pulchellum		3	1
LIMNOPHILA			
Physella	2	1	
ODONATA			
Calopteryx		1	
Progomphus obscurus	4		
PLECOPTERA			
Perlesta		4	
TRICHOPTERA			
Cheumatopsyche	3	13	22
Helicopsyche		1	
Lepidostoma			1
TUBIFICIDA			
Enchytraeidae			6
Limnodrilus hoffmeisteri	1		
Tubificidae	4		1

Appendix C

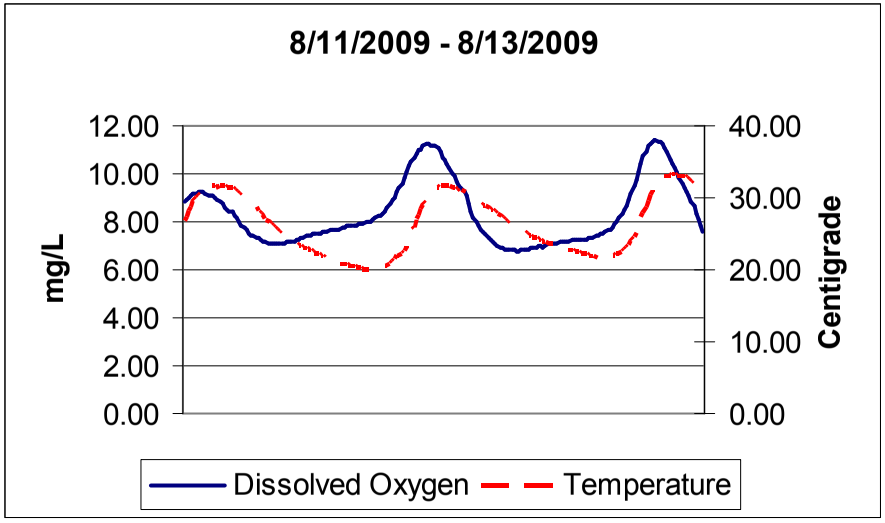
Dissolved Oxygen Datalogger Information, Graphs, and Data
West Locust Creek Stations #2 and #1
Putnam County

(#2 = August 11, 2009 to August 13, 2009 and #1 = August 11, 2009 to August 16, 2009)
(Heavy rain shortened working deployment period; buried dataloggers)

Stream	**West Locust Creek**	**Station**	**#2**	**County**	**PUTNAM**
Survey Start Date	08/11/09	**UTM Easting**	484829		
Survey End Date	08/13/09	**UTM Northing**	4480270		

Summary of days with minimum of 22 hours of measurements:

Average DO (mg/L):	8.47	Average Maximum DO (mg/L)	11.24	Average Minimum DO (mg/L):	6.77
% Below 5.0	0.0%	Total count of measurements:	96		
Entire Survey:					
% Below 5.0	0.0%	Total count of measurements:	218		



Date	Time	Temp (°C)	Specific Cond (µS/cm)	DO (mg/L)
8/11/2009	11:30	26.64	342	8.86
8/11/2009	11:45	27.34	342	8.94
8/11/2009	12:00	28.08	343	9.03
8/11/2009	12:15	28.71	343	9.07
8/11/2009	12:30	29.34	344	9.14
8/11/2009	12:45	29.89	345	9.17
8/11/2009	13:00	30.39	345	9.22
8/11/2009	13:15	30.78	346	9.22
8/11/2009	13:30	31.10	347	9.22
8/11/2009	13:45	31.31	347	9.19
8/11/2009	14:00	31.25	348	9.11
8/11/2009	14:15	31.54	348	9.10
8/11/2009	14:30	31.72	349	9.06
8/11/2009	14:45	31.60	350	8.99
8/11/2009	15:00	31.52	350	8.89
8/11/2009	15:15	31.76	351	8.85
8/11/2009	15:30	31.68	352	8.74
8/11/2009	15:45	31.54	352	8.58
8/11/2009	16:00	31.52	353	8.51
8/11/2009	16:15	31.39	354	8.43
8/11/2009	16:30	31.31	354	8.38
8/11/2009	16:45	31.21	355	8.23
8/11/2009	17:00	30.89	356	8.13
8/11/2009	17:15	30.66	357	7.99
8/11/2009	17:30	30.33	357	7.85
8/11/2009	17:45	29.99	358	7.73
8/11/2009	18:00	29.71	359	7.63
8/11/2009	18:15	29.38	360	7.53
8/11/2009	18:30	29.08	361	7.45
8/11/2009	18:45	28.79	362	7.39

Date	Time	Temp (°C)	Specific Cond (µS/cm)	DO (mg/L)
8/11/2009	19:00	28.48	363	7.34
8/11/2009	19:15	28.14	360	7.30
8/11/2009	19:30	27.80	365	7.25
8/11/2009	19:45	27.43	366	7.19
8/11/2009	20:00	27.07	367	7.14
8/11/2009	20:15	26.71	368	7.11
8/11/2009	20:30	26.37	368	7.09
8/11/2009	20:45	26.06	369	7.06
8/11/2009	21:00	25.75	369	7.05
8/11/2009	21:15	25.45	371	7.05
8/11/2009	21:30	25.20	371	7.05
8/11/2009	21:45	24.94	372	7.10
8/11/2009	22:00	24.70	373	7.10
8/11/2009	22:15	24.46	374	7.13
8/11/2009	22:30	24.25	375	7.15
8/11/2009	22:45	24.06	375	7.16
8/11/2009	23:00	23.85	376	7.20
8/11/2009	23:15	23.65	377	7.22
8/11/2009	23:30	23.47	378	7.27
8/11/2009	23:45	23.30	378	7.30
8/12/2009	0:00	23.11	379	7.33
8/12/2009	0:15	22.94	379	7.38
8/12/2009	0:30	22.78	380	7.41
8/12/2009	0:45	22.64	380	7.43
8/12/2009	1:00	22.47	381	7.46
8/12/2009	1:15	22.35	381	7.49
8/12/2009	1:30	22.20	382	7.48
8/12/2009	1:45	22.06	383	7.52
8/12/2009	2:00	21.91	384	7.57
8/12/2009	2:15	21.79	383	7.60

Date	Time	Temp (°C)	Specific Cond (µS/cm)	DO (mg/L)
8/12/2009	2:30	21.66	382	7.61
8/12/2009	2:45	21.54	385	7.63
8/12/2009	3:00	21.43	385	7.67
8/12/2009	3:15	21.29	386	7.66
8/12/2009	3:30	21.18	386	7.66
8/12/2009	3:45	21.06	387	7.69
8/12/2009	4:00	20.95	387	7.74
8/12/2009	4:15	20.84	388	7.77
8/12/2009	4:30	20.72	388	7.81
8/12/2009	4:45	20.64	389	7.80
8/12/2009	5:00	20.56	389	7.84
8/12/2009	5:15	20.45	390	7.86
8/12/2009	5:30	20.36	390	7.87
8/12/2009	5:45	20.27	391	7.90
8/12/2009	6:00	20.18	391	7.92
8/12/2009	6:15	20.10	391	7.94
8/12/2009	6:30	20.02	389	7.98
8/12/2009	6:45	19.97	391	7.99
8/12/2009	7:00	19.96	391	8.02
8/12/2009	7:15	19.94	392	8.07
8/12/2009	7:30	19.98	393	8.14
8/12/2009	7:45	20.11	392	8.21
8/12/2009	8:00	20.14	392	8.26
8/12/2009	8:15	20.22	392	8.34
8/12/2009	8:30	20.43	391	8.43
8/12/2009	8:45	20.61	392	8.58
8/12/2009	9:00	20.88	392	8.77
8/12/2009	9:15	21.05	392	8.89
8/12/2009	9:30	21.31	392	9.01
8/12/2009	9:45	21.83	393	9.22
8/12/2009	10:00	21.98	393	9.44
8/12/2009	10:15	22.16	393	9.62
8/12/2009	10:30	22.43	393	9.83
8/12/2009	10:45	23.12	392	10.07
8/12/2009	11:00	23.94	392	10.33
8/12/2009	11:15	25.03	393	10.49
8/12/2009	11:30	25.95	393	10.70
8/12/2009	11:45	26.83	392	10.87
8/12/2009	12:00	27.57	391	10.97
8/12/2009	12:15	28.27	390	11.04
8/12/2009	12:30	28.92	390	11.13
8/12/2009	12:45	29.55	388	11.21
8/12/2009	13:00	30.09	388	11.24
8/12/2009	13:15	30.57	386	11.19
8/12/2009	13:30	30.97	386	11.14
8/12/2009	13:45	31.32	385	11.13
8/12/2009	14:00	31.41	384	11.05
8/12/2009	14:15	31.59	383	10.88
8/12/2009	14:30	31.71	384	10.70
8/12/2009	14:45	31.73	383	10.55
8/12/2009	15:00	31.73	383	10.44
8/12/2009	15:15	31.72	383	10.28
8/12/2009	15:30	31.50	384	10.04
8/12/2009	15:45	31.47	384	9.91
8/12/2009	16:00	31.09	385	9.64
8/12/2009	16:15	30.95	384	9.53
8/12/2009	16:30	30.99	384	9.39
8/12/2009	16:45	30.89	385	9.26
8/12/2009	17:00	30.75	385	9.06
8/12/2009	17:15	30.53	386	8.74

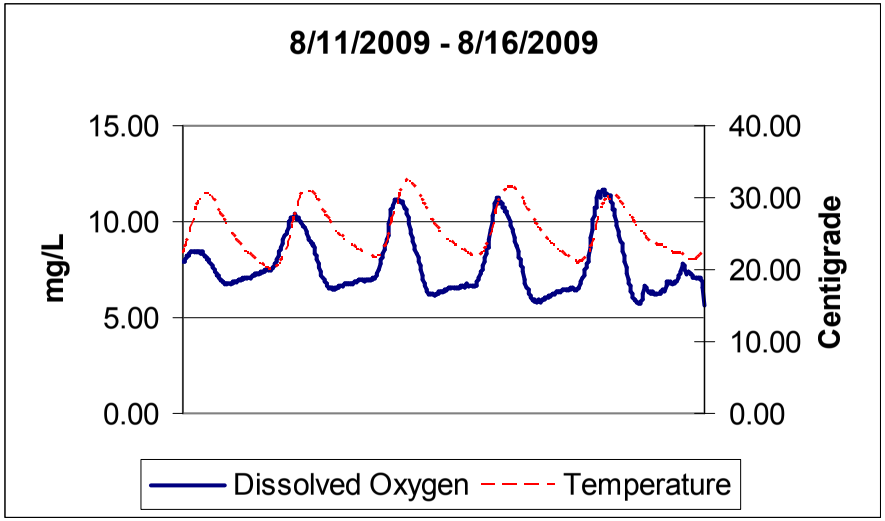
Date	Time	Temp (°C)	Specific Cond (µS/cm)	DO (mg/L)
8/12/2009	17:30	30.15	387	8.41
8/12/2009	17:45	29.93	388	8.18
8/12/2009	18:00	29.66	391	7.98
8/12/2009	18:15	29.44	391	7.83
8/12/2009	18:30	29.20	392	7.69
8/12/2009	18:45	29.00	393	7.57
8/12/2009	19:00	28.81	393	7.49
8/12/2009	19:15	28.62	393	7.37
8/12/2009	19:30	28.45	394	7.29
8/12/2009	19:45	28.26	396	7.17
8/12/2009	20:00	28.03	398	7.10
8/12/2009	20:15	27.78	399	7.01
8/12/2009	20:30	27.50	400	6.93
8/12/2009	20:45	27.23	401	6.88
8/12/2009	21:00	26.96	402	6.83
8/12/2009	21:15	26.69	403	6.81
8/12/2009	21:30	26.43	405	6.80
8/12/2009	21:45	26.18	406	6.81
8/12/2009	22:00	25.95	407	6.80
8/12/2009	22:15	25.74	408	6.77
8/12/2009	22:30	25.53	408	6.79
8/12/2009	22:45	25.30	410	6.82
8/12/2009	23:00	25.14	410	6.82
8/12/2009	23:15	24.99	411	6.85
8/12/2009	23:30	24.86	411	6.86
8/12/2009	23:45	24.69	412	6.89
8/13/2009	0:00	24.52	413	6.91
8/13/2009	0:15	24.36	414	6.95
8/13/2009	0:30	24.22	414	6.96
8/13/2009	0:45	24.05	415	6.98

Date	Time	Temp (°C)	Specific Cond (µS/cm)	DO (mg/L)
8/13/2009	1:00	23.93	416	6.95
8/13/2009	1:15	23.81	416	7.04
8/13/2009	1:30	23.70	417	7.05
8/13/2009	1:45	23.61	417	7.07
8/13/2009	2:00	23.52	418	7.10
8/13/2009	2:15	23.42	418	7.09
8/13/2009	2:30	23.32	419	7.11
8/13/2009	2:45	23.22	420	7.15
8/13/2009	3:00	23.10	421	7.16
8/13/2009	3:15	22.99	422	7.18
8/13/2009	3:30	22.89	422	7.17
8/13/2009	3:45	22.79	423	7.19
8/13/2009	4:00	22.70	423	7.22
8/13/2009	4:15	22.61	423	7.24
8/13/2009	4:30	22.51	424	7.24
8/13/2009	4:45	22.42	425	7.25
8/13/2009	5:00	22.34	425	7.22
8/13/2009	5:15	22.24	425	7.25
8/13/2009	5:30	22.14	425	7.27
8/13/2009	5:45	22.02	425	7.30
8/13/2009	6:00	21.92	426	7.34
8/13/2009	6:15	21.83	427	7.35
8/13/2009	6:30	21.72	428	7.41
8/13/2009	6:45	21.65	428	7.44
8/13/2009	7:00	21.61	428	7.49
8/13/2009	7:15	21.59	429	7.54
8/13/2009	7:30	21.63	429	7.57
8/13/2009	7:45	21.69	428	7.65
8/13/2009	8:00	21.78	428	7.68
8/13/2009	8:15	21.87	428	7.77

Date	Time	Temp (°C)	Specific Cond (µS/cm)	DO (mg/L)
8/13/2009	8:30	21.99	429	7.89
8/13/2009	8:45	22.15	429	8.01
8/13/2009	9:00	22.35	430	8.17
8/13/2009	9:15	22.59	430	8.33
8/13/2009	9:30	22.87	430	8.51
8/13/2009	9:45	23.14	431	8.68
8/13/2009	10:00	23.47	431	8.90
8/13/2009	10:15	23.89	430	9.14
8/13/2009	10:30	24.50	430	9.46
8/13/2009	10:45	25.25	430	9.77
8/13/2009	11:00	26.12	429	10.10
8/13/2009	11:15	26.94	429	10.43
8/13/2009	11:30	27.83	428	10.72
8/13/2009	11:45	28.67	427	10.93
8/13/2009	12:00	29.50	424	11.13
8/13/2009	12:15	30.23	423	11.27
8/13/2009	12:30	30.96	421	11.34
8/13/2009	12:45	31.55	419	11.42
8/13/2009	13:00	32.05	418	11.37
8/13/2009	13:15	32.45	416	11.37
8/13/2009	13:30	32.85	415	11.26
8/13/2009	13:45	33.05	414	11.08
8/13/2009	14:00	33.09	413	10.88
8/13/2009	14:15	33.13	413	10.62
8/13/2009	14:30	33.21	412	10.43
8/13/2009	14:45	33.24	412	10.21
8/13/2009	15:00	33.18	412	10.06
8/13/2009	15:15	33.10	412	9.83
8/13/2009	15:30	33.02	413	9.60
8/13/2009	15:45	32.95	414	9.45
8/13/2009	16:00	32.79	414	9.24
8/13/2009	16:15	32.52	414	9.08
8/13/2009	16:30	32.34	415	8.83
8/13/2009	16:45	32.06	414	8.65
8/13/2009	17:00	31.77	415	8.37
8/13/2009	17:15	31.42	416	8.10
8/13/2009	17:30	31.07	417	7.82
8/13/2009	17:45	30.76	417	7.58

Stream	**West Locust Creek**	**Station**	**#1**	**County**	**PUTNAM**
Survey Start Date	08/11/09	**UTM Easting**	485674		
Survey End Date	08/16/09	**UTM Northing**	4474993		

Summary of days with minimum of 22 hours of measurements:					
Average DO (mg/L):	7.89	Average Maximum DO (mg/L)	11.13	Average Minimum DO (mg/L):	6.07
% Below 5.0	0.0%	Total count of measurements:	384		
Entire Survey:					
% Below 5.0	0.0%	Total count of measurements:	494		



Date	Time	Temp (°C)	Specific Cond (µS/cm)	DO (mg/L)
8/11/2009	10:15	22.18	330	7.90
8/11/2009	10:30	22.51	331	7.93
8/11/2009	10:45	22.98	332	8.01
8/11/2009	11:00	23.44	334	8.13
8/11/2009	11:15	24.02	335	8.22
8/11/2009	11:30	24.36	337	8.28
8/11/2009	11:45	24.83	338	8.29
8/11/2009	12:00	25.51	339	8.40
8/11/2009	12:15	25.95	340	8.44
8/11/2009	12:30	26.45	341	8.46
8/11/2009	12:45	27.00	342	8.44
8/11/2009	13:00	27.58	343	8.47
8/11/2009	13:15	28.32	344	8.45
8/11/2009	13:30	28.84	345	8.47
8/11/2009	13:45	29.18	346	8.46
8/11/2009	14:00	29.72	347	8.45
8/11/2009	14:15	29.85	348	8.37
8/11/2009	14:30	30.54	347	8.46
8/11/2009	14:45	30.59	349	8.39
8/11/2009	15:00	30.50	350	8.36
8/11/2009	15:15	30.63	350	8.26
8/11/2009	15:30	30.54	351	8.23
8/11/2009	15:45	30.54	352	8.12
8/11/2009	16:00	30.47	352	8.03
8/11/2009	16:15	30.46	353	8.01
8/11/2009	16:30	30.28	353	7.89
8/11/2009	16:45	30.15	354	7.80
8/11/2009	17:00	29.84	355	7.71
8/11/2009	17:15	29.63	356	7.60
8/11/2009	17:30	29.33	357	7.54

Date	Time	Temp (°C)	Specific Cond (µS/cm)	DO (mg/L)
8/11/2009	17:45	28.98	358	7.41
8/11/2009	18:00	28.72	358	7.31
8/11/2009	18:15	28.45	359	7.21
8/11/2009	18:30	28.13	360	7.15
8/11/2009	18:45	27.80	361	7.05
8/11/2009	19:00	27.59	362	6.96
8/11/2009	19:15	27.38	363	6.94
8/11/2009	19:30	27.13	364	6.88
8/11/2009	19:45	26.88	365	6.84
8/11/2009	20:00	26.61	366	6.82
8/11/2009	20:15	26.32	367	6.79
8/11/2009	20:30	26.06	368	6.78
8/11/2009	20:45	25.77	369	6.76
8/11/2009	21:00	25.49	370	6.77
8/11/2009	21:15	25.26	371	6.79
8/11/2009	21:30	25.03	373	6.76
8/11/2009	21:45	24.81	374	6.81
8/11/2009	22:00	24.59	375	6.84
8/11/2009	22:15	24.41	375	6.87
8/11/2009	22:30	24.21	376	6.85
8/11/2009	22:45	24.02	378	6.89
8/11/2009	23:00	23.83	378	6.91
8/11/2009	23:15	23.65	379	6.94
8/11/2009	23:30	23.48	380	6.99
8/11/2009	23:45	23.32	381	7.00
8/12/2009	0:00	23.17	381	7.01
8/12/2009	0:15	23.01	382	7.05
8/12/2009	0:30	22.89	383	7.03
8/12/2009	0:45	22.72	384	7.07
8/12/2009	1:00	22.57	385	7.07

Date	Time	Temp (°C)	Specific Cond (µS/cm)	DO (mg/L)
8/12/2009	1:15	22.43	386	7.08
8/12/2009	1:30	22.30	388	7.09
8/12/2009	1:45	22.17	387	7.10
8/12/2009	2:00	22.03	388	7.10
8/12/2009	2:15	21.91	389	7.13
8/12/2009	2:30	21.76	390	7.19
8/12/2009	2:45	21.61	391	7.22
8/12/2009	3:00	21.50	392	7.22
8/12/2009	3:15	21.40	391	7.27
8/12/2009	3:30	21.30	393	7.28
8/12/2009	3:45	21.17	393	7.33
8/12/2009	4:00	21.09	393	7.33
8/12/2009	4:15	20.97	393	7.34
8/12/2009	4:30	20.85	394	7.32
8/12/2009	4:45	20.76	394	7.37
8/12/2009	5:00	20.65	395	7.40
8/12/2009	5:15	20.57	395	7.40
8/12/2009	5:30	20.47	396	7.44
8/12/2009	5:45	20.36	396	7.45
8/12/2009	6:00	20.29	396	7.48
8/12/2009	6:15	20.21	397	7.45
8/12/2009	6:30	20.11	398	7.49
8/12/2009	6:45	20.04	399	7.51
8/12/2009	7:00	20.00	399	7.52
8/12/2009	7:15	19.98	401	7.56
8/12/2009	7:30	19.96	401	7.59
8/12/2009	7:45	20.00	401	7.69
8/12/2009	8:00	20.07	402	7.82
8/12/2009	8:15	20.14	401	7.88
8/12/2009	8:30	20.30	403	8.01
8/12/2009	8:45	20.58	403	8.26
8/12/2009	9:00	20.78	404	8.44
8/12/2009	9:15	20.97	404	8.57
8/12/2009	9:30	21.11	405	8.69
8/12/2009	9:45	21.44	405	8.83
8/12/2009	10:00	21.91	406	9.06
8/12/2009	10:15	22.06	406	9.28
8/12/2009	10:30	22.34	406	9.33
8/12/2009	10:45	22.61	406	9.49
8/12/2009	11:00	23.24	407	9.73
8/12/2009	11:15	23.82	407	9.95
8/12/2009	11:30	24.44	407	10.09
8/12/2009	11:45	25.12	407	10.25
8/12/2009	12:00	25.65	407	10.22
8/12/2009	12:15	26.29	407	10.22
8/12/2009	12:30	26.89	407	10.32
8/12/2009	12:45	27.42	407	10.37
8/12/2009	13:00	27.95	407	10.20
8/12/2009	13:15	28.42	406	10.10
8/12/2009	13:30	28.94	406	10.20
8/12/2009	13:45	29.49	406	10.14
8/12/2009	14:00	29.94	406	10.00
8/12/2009	14:15	30.28	405	9.95
8/12/2009	14:30	30.64	405	9.81
8/12/2009	14:45	30.98	405	9.76
8/12/2009	15:00	31.12	405	9.72
8/12/2009	15:15	31.16	405	9.51
8/12/2009	15:30	31.15	405	9.37
8/12/2009	15:45	30.95	405	9.18
8/12/2009	16:00	30.87	405	9.02

Date	Time	Temp (°C)	Specific Cond (µS/cm)	DO (mg/L)
8/12/2009	16:15	30.78	405	8.95
8/12/2009	16:30	30.88	405	8.94
8/12/2009	16:45	30.61	406	8.79
8/12/2009	17:00	30.66	406	8.83
8/12/2009	17:15	30.34	406	8.65
8/12/2009	17:30	30.12	407	8.34
8/12/2009	17:45	29.93	408	8.19
8/12/2009	18:00	29.71	408	8.01
8/12/2009	18:15	29.41	409	7.81
8/12/2009	18:30	28.99	410	7.57
8/12/2009	18:45	28.65	411	7.41
8/12/2009	19:00	28.36	412	7.21
8/12/2009	19:15	28.04	413	7.06
8/12/2009	19:30	27.80	413	6.95
8/12/2009	19:45	27.56	414	6.86
8/12/2009	20:00	27.31	414	6.77
8/12/2009	20:15	27.09	415	6.70
8/12/2009	20:30	26.83	416	6.61
8/12/2009	20:45	26.58	416	6.58
8/12/2009	21:00	26.37	417	6.53
8/12/2009	21:15	26.14	418	6.52
8/12/2009	21:30	25.93	418	6.52
8/12/2009	21:45	25.71	418	6.49
8/12/2009	22:00	25.53	419	6.49
8/12/2009	22:15	25.34	420	6.56
8/12/2009	22:30	25.16	420	6.61
8/12/2009	22:45	24.99	421	6.56
8/12/2009	23:00	24.84	422	6.59
8/12/2009	23:15	24.75	423	6.64
8/12/2009	23:30	24.59	423	6.66
8/12/2009	23:45	24.42	424	6.66
8/13/2009	0:00	24.28	424	6.70
8/13/2009	0:15	24.17	425	6.73
8/13/2009	0:30	24.06	424	6.72
8/13/2009	0:45	23.92	426	6.76
8/13/2009	1:00	23.80	427	6.77
8/13/2009	1:15	23.72	427	6.76
8/13/2009	1:30	23.61	428	6.78
8/13/2009	1:45	23.49	428	6.79
8/13/2009	2:00	23.40	429	6.76
8/13/2009	2:15	23.34	429	6.81
8/13/2009	2:30	23.23	430	6.76
8/13/2009	2:45	23.14	430	6.89
8/13/2009	3:00	23.06	431	6.92
8/13/2009	3:15	22.97	431	6.90
8/13/2009	3:30	22.89	431	6.89
8/13/2009	3:45	22.80	431	6.93
8/13/2009	4:00	22.70	431	6.94
8/13/2009	4:15	22.59	432	6.95
8/13/2009	4:30	22.53	423	6.93
8/13/2009	4:45	22.45	433	6.96
8/13/2009	5:00	22.35	435	6.92
8/13/2009	5:15	22.27	434	6.96
8/13/2009	5:30	22.22	435	6.97
8/13/2009	5:45	22.14	436	6.98
8/13/2009	6:00	22.01	436	6.99
8/13/2009	6:15	21.95	432	6.97
8/13/2009	6:30	21.88	438	6.94
8/13/2009	6:45	21.81	438	6.99
8/13/2009	7:00	21.75	438	6.98

Date	Time	Temp (°C)	Specific Cond (µS/cm)	DO (mg/L)
8/13/2009	7:15	21.72	439	7.04
8/13/2009	7:30	21.74	439	7.10
8/13/2009	7:45	21.77	439	7.08
8/13/2009	8:00	21.79	440	7.19
8/13/2009	8:15	21.85	440	7.32
8/13/2009	8:30	21.93	440	7.48
8/13/2009	8:45	22.08	441	7.78
8/13/2009	9:00	22.25	441	7.97
8/13/2009	9:15	22.47	441	8.16
8/13/2009	9:30	22.64	441	8.34
8/13/2009	9:45	22.88	441	8.57
8/13/2009	10:00	23.10	442	8.74
8/13/2009	10:15	23.33	442	8.95
8/13/2009	10:30	23.69	442	9.10
8/13/2009	10:45	24.18	442	9.27
8/13/2009	11:00	24.60	442	9.88
8/13/2009	11:15	25.31	441	10.24
8/13/2009	11:30	25.92	440	10.59
8/13/2009	11:45	26.63	440	10.76
8/13/2009	12:00	27.31	439	10.79
8/13/2009	12:15	27.88	438	11.01
8/13/2009	12:30	28.49	437	11.18
8/13/2009	12:45	28.97	437	11.19
8/13/2009	13:00	29.54	436	11.16
8/13/2009	13:15	29.84	435	11.12
8/13/2009	13:30	30.29	434	11.01
8/13/2009	13:45	30.82	433	11.04
8/13/2009	14:00	31.23	432	11.01
8/13/2009	14:15	31.71	430	10.95
8/13/2009	14:30	31.89	429	10.77
8/13/2009	14:45	32.15	429	10.73
8/13/2009	15:00	32.31	428	10.65
8/13/2009	15:15	32.35	427	10.42
8/13/2009	15:30	32.50	426	10.17
8/13/2009	15:45	32.31	427	9.88
8/13/2009	16:00	32.13	427	9.61
8/13/2009	16:15	31.98	426	9.33
8/13/2009	16:30	31.80	427	9.18
8/13/2009	16:45	31.60	428	8.91
8/13/2009	17:00	31.39	428	8.70
8/13/2009	17:15	31.24	428	8.55
8/13/2009	17:30	30.78	430	8.29
8/13/2009	17:45	30.60	430	8.09
8/13/2009	18:00	30.32	431	7.88
8/13/2009	18:15	30.01	433	7.71
8/13/2009	18:30	29.68	434	7.48
8/13/2009	18:45	29.37	436	7.20
8/13/2009	19:00	29.08	437	7.03
8/13/2009	19:15	28.81	439	6.81
8/13/2009	19:30	28.51	440	6.64
8/13/2009	19:45	28.24	442	6.49
8/13/2009	20:00	27.98	443	6.38
8/13/2009	20:15	27.70	444	6.28
8/13/2009	20:30	27.41	446	6.27
8/13/2009	20:45	27.14	446	6.20
8/13/2009	21:00	26.90	436	6.23
8/13/2009	21:15	26.66	444	6.21
8/13/2009	21:30	26.40	449	6.23
8/13/2009	21:45	26.19	449	6.18
8/13/2009	22:00	25.96	450	6.23

Date	Time	Temp (°C)	Specific Cond (µS/cm)	DO (mg/L)
8/13/2009	22:15	25.74	446	6.27
8/13/2009	22:30	25.54	451	6.29
8/13/2009	22:45	25.35	451	6.33
8/13/2009	23:00	25.13	451	6.31
8/13/2009	23:15	24.99	450	6.40
8/13/2009	23:30	24.86	450	6.39
8/13/2009	23:45	24.71	452	6.39
8/14/2009	0:00	24.56	450	6.40
8/14/2009	0:15	24.43	453	6.44
8/14/2009	0:30	24.31	453	6.44
8/14/2009	0:45	24.21	454	6.46
8/14/2009	1:00	24.12	452	6.53
8/14/2009	1:15	24.00	454	6.54
8/14/2009	1:30	23.87	455	6.57
8/14/2009	1:45	23.76	455	6.57
8/14/2009	2:00	23.64	455	6.58
8/14/2009	2:15	23.54	455	6.57
8/14/2009	2:30	23.44	454	6.58
8/14/2009	2:45	23.34	453	6.60
8/14/2009	3:00	23.24	455	6.59
8/14/2009	3:15	23.14	450	6.58
8/14/2009	3:30	23.03	456	6.60
8/14/2009	3:45	22.95	456	6.59
8/14/2009	4:00	22.87	457	6.62
8/14/2009	4:15	22.77	446	6.65
8/14/2009	4:30	22.67	452	6.62
8/14/2009	4:45	22.62	457	6.61
8/14/2009	5:00	22.51	457	6.66
8/14/2009	5:15	22.44	457	6.72
8/14/2009	5:30	22.32	456	6.70

Date	Time	Temp (°C)	Specific Cond (µS/cm)	DO (mg/L)
8/14/2009	5:45	22.25	458	6.70
8/14/2009	6:00	22.16	459	6.69
8/14/2009	6:15	22.05	460	6.66
8/14/2009	6:30	22.00	460	6.65
8/14/2009	6:45	21.91	460	6.66
8/14/2009	7:00	21.88	460	6.63
8/14/2009	7:15	21.85	461	6.70
8/14/2009	7:30	21.85	461	6.70
8/14/2009	7:45	21.84	459	6.85
8/14/2009	8:00	21.87	460	6.93
8/14/2009	8:15	21.92	460	7.10
8/14/2009	8:30	21.98	461	7.27
8/14/2009	8:45	22.08	461	7.44
8/14/2009	9:00	22.21	461	7.52
8/14/2009	9:15	22.39	462	7.70
8/14/2009	9:30	22.60	462	7.95
8/14/2009	9:45	22.80	462	8.15
8/14/2009	10:00	23.10	463	8.35
8/14/2009	10:15	23.38	462	8.62
8/14/2009	10:30	23.70	465	8.66
8/14/2009	10:45	24.02	465	9.08
8/14/2009	11:00	24.58	464	9.54
8/14/2009	11:15	25.14	462	10.01
8/14/2009	11:30	25.69	463	10.32
8/14/2009	11:45	26.50	464	10.60
8/14/2009	12:00	27.17	462	10.92
8/14/2009	12:15	27.84	462	11.15
8/14/2009	12:30	28.45	462	11.21
8/14/2009	12:45	29.05	462	11.27
8/14/2009	13:00	29.51	462	10.98

Date	Time	Temp (°C)	Specific Cond (µS/cm)	DO (mg/L)
8/14/2009	13:15	30.07	461	10.99
8/14/2009	13:30	30.25	459	10.98
8/14/2009	13:45	30.61	460	10.95
8/14/2009	14:00	30.52	460	10.76
8/14/2009	14:15	30.81	459	10.72
8/14/2009	14:30	30.90	458	10.47
8/14/2009	14:45	31.13	458	10.54
8/14/2009	15:00	31.36	457	10.42
8/14/2009	15:15	31.50	456	10.23
8/14/2009	15:30	31.29	457	9.96
8/14/2009	15:45	31.32	456	9.75
8/14/2009	16:00	31.35	456	9.63
8/14/2009	16:15	31.38	455	9.50
8/14/2009	16:30	31.23	456	9.17
8/14/2009	16:45	31.13	456	8.97
8/14/2009	17:00	31.08	455	8.77
8/14/2009	17:15	30.72	456	8.71
8/14/2009	17:30	30.47	457	8.47
8/14/2009	17:45	30.30	458	8.10
8/14/2009	18:00	30.03	458	7.99
8/14/2009	18:15	29.87	459	7.75
8/14/2009	18:30	29.63	459	7.65
8/14/2009	18:45	29.30	460	7.36
8/14/2009	19:00	28.99	462	6.98
8/14/2009	19:15	28.76	462	6.81
8/14/2009	19:30	28.46	464	6.58
8/14/2009	19:45	28.17	465	6.45
8/14/2009	20:00	27.90	466	6.29
8/14/2009	20:15	27.63	468	6.14
8/14/2009	20:30	27.39	469	6.04
8/14/2009	20:45	27.10	470	5.95
8/14/2009	21:00	26.84	470	5.92
8/14/2009	21:15	26.58	472	5.88
8/14/2009	21:30	26.32	473	5.90
8/14/2009	21:45	26.12	473	5.87
8/14/2009	22:00	25.94	475	5.86
8/14/2009	22:15	25.71	476	5.88
8/14/2009	22:30	25.53	476	5.92
8/14/2009	22:45	25.35	477	5.88
8/14/2009	23:00	25.15	478	5.86
8/14/2009	23:15	24.98	478	5.92
8/14/2009	23:30	24.77	478	5.94
8/14/2009	23:45	24.61	479	5.96
8/15/2009	0:00	24.42	479	5.99
8/15/2009	0:15	24.27	479	6.01
8/15/2009	0:30	24.11	479	6.09
8/15/2009	0:45	23.97	480	6.12
8/15/2009	1:00	23.82	479	6.14
8/15/2009	1:15	23.72	480	6.15
8/15/2009	1:30	23.58	480	6.21
8/15/2009	1:45	23.46	480	6.21
8/15/2009	2:00	23.28	480	6.26
8/15/2009	2:15	23.18	480	6.22
8/15/2009	2:30	23.04	478	6.31
8/15/2009	2:45	22.90	481	6.31
8/15/2009	3:00	22.80	481	6.32
8/15/2009	3:15	22.63	480	6.34
8/15/2009	3:30	22.50	480	6.34
8/15/2009	3:45	22.40	481	6.36
8/15/2009	4:00	22.25	479	6.41

Date	Time	Temp (°C)	Specific Cond (µS/cm)	DO (mg/L)
8/15/2009	4:15	22.15	480	6.44
8/15/2009	4:30	22.04	481	6.44
8/15/2009	4:45	21.91	481	6.48
8/15/2009	5:00	21.81	429	6.48
8/15/2009	5:15	21.73	478	6.46
8/15/2009	5:30	21.63	477	6.49
8/15/2009	5:45	21.49	479	6.54
8/15/2009	6:00	21.44	479	6.44
8/15/2009	6:15	21.31	479	6.55
8/15/2009	6:30	21.23	480	6.52
8/15/2009	6:45	21.13	480	6.49
8/15/2009	7:00	21.05	480	6.49
8/15/2009	7:15	21.03	480	6.50
8/15/2009	7:30	20.99	481	6.51
8/15/2009	7:45	20.96	482	6.56
8/15/2009	8:00	20.98	481	6.60
8/15/2009	8:15	21.03	481	6.75
8/15/2009	8:30	21.09	482	6.92
8/15/2009	8:45	21.20	482	7.05
8/15/2009	9:00	21.33	482	7.23
8/15/2009	9:15	21.45	482	7.47
8/15/2009	9:30	21.53	482	7.57
8/15/2009	9:45	21.55	482	7.78
8/15/2009	10:00	21.67	482	7.92
8/15/2009	10:15	22.22	483	8.26
8/15/2009	10:30	22.52	483	8.60
8/15/2009	10:45	22.97	483	9.12
8/15/2009	11:00	23.46	483	9.61
8/15/2009	11:15	23.73	482	10.11
8/15/2009	11:30	24.27	483	10.28
8/15/2009	11:45	24.85	482	10.72
8/15/2009	12:00	25.58	480	10.71
8/15/2009	12:15	26.23	480	11.21
8/15/2009	12:30	26.92	481	11.54
8/15/2009	12:45	27.39	480	11.48
8/15/2009	13:00	28.00	479	11.23
8/15/2009	13:15	28.37	477	11.45
8/15/2009	13:30	28.84	475	11.64
8/15/2009	13:45	29.17	475	11.67
8/15/2009	14:00	29.46	474	11.37
8/15/2009	14:15	29.72	474	11.44
8/15/2009	14:30	29.89	469	11.43
8/15/2009	14:45	29.92	471	11.31
8/15/2009	15:00	29.86	469	11.31
8/15/2009	15:15	29.91	468	11.31
8/15/2009	15:30	29.88	467	11.08
8/15/2009	15:45	30.06	466	10.90
8/15/2009	16:00	30.21	466	10.60
8/15/2009	16:15	30.24	465	10.58
8/15/2009	16:30	30.22	465	10.29
8/15/2009	16:45	30.04	466	10.02
8/15/2009	17:00	29.93	465	9.79
8/15/2009	17:15	29.65	465	9.49
8/15/2009	17:30	29.39	464	9.26
8/15/2009	17:45	29.11	466	8.95
8/15/2009	18:00	28.96	467	8.82
8/15/2009	18:15	28.74	468	8.45
8/15/2009	18:30	28.59	469	8.23
8/15/2009	18:45	28.40	471	7.88
8/15/2009	19:00	28.23	471	7.61

Date	Time	Temp (°C)	Specific Cond (µS/cm)	DO (mg/L)
8/15/2009	19:15	28.06	474	7.27
8/15/2009	19:30	27.85	476	7.01
8/15/2009	19:45	27.61	478	6.79
8/15/2009	20:00	27.38	479	6.67
8/15/2009	20:15	27.13	481	6.36
8/15/2009	20:30	26.88	482	6.22
8/15/2009	20:45	26.67	484	6.06
8/15/2009	21:00	26.45	485	5.94
8/15/2009	21:15	26.18	485	5.94
8/15/2009	21:30	25.99	487	5.84
8/15/2009	21:45	25.83	488	5.83
8/15/2009	22:00	25.72	488	5.74
8/15/2009	22:15	25.55	487	5.75
8/15/2009	22:30	25.40	485	5.83
8/15/2009	22:45	25.23	483	5.92
8/15/2009	23:00	24.94	472	6.28
8/15/2009	23:15	24.65	458	6.52
8/15/2009	23:30	24.46	440	6.70
8/15/2009	23:45	24.25	438	6.56
8/16/2009	0:00	24.11	432	6.43
8/16/2009	0:15	23.96	424	6.37
8/16/2009	0:30	23.87	421	6.33
8/16/2009	0:45	23.76	413	6.28
8/16/2009	1:00	23.70	418	6.32
8/16/2009	1:15	23.70	420	6.29
8/16/2009	1:30	23.60	415	6.35
8/16/2009	1:45	23.56	420	6.30
8/16/2009	2:00	23.49	424	6.22
8/16/2009	2:15	23.44	426	6.23
8/16/2009	2:30	23.41	433	6.22
8/16/2009	2:45	23.32	431	6.24
8/16/2009	3:00	23.30	435	6.26
8/16/2009	3:15	23.24	429	6.37
8/16/2009	3:30	23.22	431	6.40
8/16/2009	3:45	23.15	428	6.44
8/16/2009	4:00	23.10	429	6.44
8/16/2009	4:15	23.08	430	6.39
8/16/2009	4:30	22.95	419	6.64
8/16/2009	4:45	22.85	412	6.83
8/16/2009	5:00	22.75	405	6.86
8/16/2009	5:15	22.63	396	6.79
8/16/2009	5:30	22.54	390	6.85
8/16/2009	5:45	22.47	387	6.81
8/16/2009	6:00	22.45	388	6.74
8/16/2009	6:15	22.36	378	6.75
8/16/2009	6:30	22.31	371	6.79
8/16/2009	6:45	22.28	363	6.85
8/16/2009	7:00	22.25	364	6.89
8/16/2009	7:15	22.22	354	7.05
8/16/2009	7:30	22.17	338	7.20
8/16/2009	7:45	22.18	328	7.25
8/16/2009	8:00	22.09	310	7.41
8/16/2009	8:15	21.81	268	7.76
8/16/2009	8:30	21.57	224	7.80
8/16/2009	8:45	21.52	214	7.67
8/16/2009	9:00	21.44	200	7.54
8/16/2009	9:15	21.31	177	7.31
8/16/2009	9:30	21.31	192	7.32
8/16/2009	9:45	21.34	205	7.36
8/16/2009	10:00	21.27	207	7.38

Date	Time	Temp (°C)	Specific Cond (µS/cm)	DO (mg/L)
8/16/2009	10:15	21.26	229	7.31
8/16/2009	10:30	21.33	246	7.24
8/16/2009	10:45	21.31	244	7.19
8/16/2009	11:00	21.33	239	7.13
8/16/2009	11:15	21.31	231	7.05
8/16/2009	11:30	21.35	229	7.12
8/16/2009	11:45	21.44	235	7.13
8/16/2009	12:00	21.53	240	7.12
8/16/2009	12:15	21.65	246	7.11
8/16/2009	12:30	21.81	246	7.06
8/16/2009	12:45	21.98	236	7.01
8/16/2009	13:00	22.15	232	6.89
8/16/2009	13:15	22.24	231	6.57
8/16/2009	13:30	22.23	215	5.64

Appendix D

Precipitation During Dissolved Oxygen Datalogger Deployment
August 11, 2009 to August 25, 2009

(Courtesy of University Missouri Extension Service, Missouri Historical Weather Database for the agriculture weather station at the Forage Systems Research Center, Linneus, Missouri)

Missouri Historical Agricultural Weather Database

Weather Station: Linneus, Linn County, MO

Weather Description: Forage Systems Research Center (Linneus)

Starting Period: August 11, 2009

Ending Period: August 25, 2009

MONTH	DAY	YEAR	TOTAL PRECIP INCHES
8	11	2009	0.00
8	12	2009	0.00
8	13	2009	0.00
8	14	2009	0.00
8	15	2009	0.09
8	16	2009	2.15
8	17	2009	3.10
8	18	2009	0.00
8	19	2009	0.75
8	20	2009	0.03
8	21	2009	0.00
8	22	2009	0.00
8	23	2009	0.00
8	24	2009	0.00
8	25	2009	0.00
		Total:	6.12
		Avg:	

This report was generated by the MU Commercial Ag Weather System at 12/8/2010 7:56:00 AM.