Kickapoo Creek Restoration Project, Charleston, Illinois

IEPA 319 Grant

Final Report
Agreement Number 3190902

Prepared By:

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July 1, 2012

Prepared for:
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This report was prepared using U. S. Environmental Protection Agency funds under Section 319 of the Clean Water Act distributed through the Illinois Environmental Protection Agency. The findings and recommendations contained herein are not necessarily those of the funding agencies.

SUMMARY

PROJECT TITLE: Kickapoo Creek Restoration Project, Charleston, Illinois

GRANT NUMBER: 3190902 GRANT SOURCE: 319

INITIATION DATE: July 15, 2009 EXPIRATION DATE: July 15, 2012[1]

FUNDING:

Total Environmental Protection Agency Grant: $206,250
Illinois Department of Natural Resources Contribution: $137,500
TOTAL FUNDING: **$343,750**

EXPENDITURES:

Stream restoration: $225,273
Assessment and Monitoring: $107,500
Maintenance: $10,977
TOTAL EXPENDITURES: **$343,750**

SUMMARY OF ACCOMPLISHMENTS:

BMP: The Kickapoo creek instream restoration project included the construction of two rock riffles and bank protection/vanes within 2000 feet of stream. The project is benefiting stream habitat and stabilizing the streambanks, thereby increasing water quality and aquatic life within the project reach. 319 funds went towards project implementation as well as pre and post restoration monitoring (biological and geomorphological). Monitoring results are included herein. Continued monitoring efforts are being planned/proposed to determine long term effects of the project on the stream stability and aquatic life. IDNR fully supports such monitoring efforts.

Outreach: The project illustrates a great collaboration of various groups working together to implement a restoration project and monitoring the success of the project over time. IDNR has hosted multiple project tours. Pictures and a summary of the project have been uploaded to the NRDA program website and project information has been presented at technical meetings. An interview of the project team is being uploaded to EIU's website and EIU anticipates many scientific publications to come out of the monitoring effort. IDNR anticipates more project tours with agency staff, the public from the Charleston/Mattoon community, and local students.

Other Issues: The implemented project has met expectations to reduce severe bank erosion (sedimentation into the stream) and increase stream habitat for the stream fishery. IDNR anticipates submitting more project proposals for similar types of restoration projects to help increase water quality and wildlife habitat throughout the state of Illinois.

[1] After IDNR was awarded the 319 grant, IEPA allowed a one year extension for additional post monitoring data to be collected.

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LIST OF ACRONYMS AND ABBREVIATIONS

EIU	Eastern Illinois University
IDNR	Illinois Department of Natural Resources
IEPA	Illinois Environmental Protection Agency
NRDA	Natural Resource Damage Assessment
QAPP	Quality Assurance Project Plan
Trustees	Illinois Natural Resource co-Trustees
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

INTRODUCTION

Background

As a result of a June 2001 release of furfural by Vesuvius, Incorporated, into Cassell-Riley-Kickapoo Creeks, the Illinois Department of Natural Resources (IDNR) and Illinois Environmental Protection Agency (IEPA), acting as Illinois Natural Resource co-Trustees (Trustees) with legal representation from the Office of the Attorney General, conducted a Natural Resource Damage Assessment (NRDA). This release resulted in a fish kill that contributed to the partial-use and non support designations for segments of Cassell, Riley, and Kickapoo Creeks (Figure 1) between Mattoon and Charleston, Coles County, IL. Cassell Creek is rated as a "moderate aquatic resource", Riley Creek as a "unique aquatic resource", and Kickapoo Creek as a "highly valued aquatic resource" (Bertrand et al. 1996). All these streams are tributaries of the Embarras River which is a "moderate aquatic resource" (Bertrand et al. 1996). Riley Creek is also included on the Illinois Natural Areas Inventory for being a high quality stream. As a result of the NRDA, the State of Illinois and Vesuvius settled a claim which included $130,000 for instream restoration action and $7,500 for education outreach in the general vicinity of the incident.

The impacted waterbody is the Embarras/Middle Wabash River, Illinois EPA Basin 30, Hydrologic Unit Code 8 05120112 (Figure 2) (IEPA 2004 and 2008). Segments of this water body potentially benefitting from restoration practices described within, include: Kickapoo Creek (BEN 01, 02), Riley Creek (BENA01, BENA02, BENA03), and Cassell Creek (BENC01). BEN02 and BENA03 segments have been assessed and labeled as full-use support segments. All other segments have been impacted by non-point pollution sources, such as nonirrigated crop production, urban runoff/storm sewers, and spills. BEN01 and BENA02 are considered partial-use support segments. BENA01 and BENC01 are considered non support segments (IEPA 2004 and 2008).

As part of the NRDA restoration planning process, IDNR solicited many restoration alternatives in an effort to identify a project that would restore and enhance natural resources similar to and within the same watershed as those lost as a result of the furfural release. Through much planning, IDNR began a cooperative agreement with the United States Geological Survey (USGS) to assess the impacted stream system and provide guidance and oversight, developing the project outlined below.

Objective and purpose

Severe bank erosion and severe in-channel sediment deposition have led to the deposition of large amounts of sand and gravel in the Kickapoo Creek segment near Charleston, Illinois. Such impacts have been induced by a number of factors in the area. Some of the factors include, but are not limited to agricultural practices and urbanization (increased stormwater run-off). The deposition has left limited numbers of deep pools as in-stream habitat. Deep pool habitat is most critical as over-wintering habitat for several fish species distributed in mid-size streams, although such habitat is utilized year-round by many other species as well. Stabilizing the bank and the channel will decrease sand and gravel deposition in deeper water habitats leaving pools deep enough to support such habitat and aquatic species similar to those injured as a result of the release. Common stabilization measures also create riffles which in turn, provide habitat for a variety of other fish species and aquatic organisms.

DNR applied for additional funding thru Illinois Environmental Protection Agency (Section 319 grant funded by USEPA) in order to expand restoration activities in an effort to more fully address these problems and increase the overall benefits to the State's natural resources similar to those injured as a result of the release. IDNR was awarded a grant to implement the following project:

Project location and description

The restoration project site is located in Section 19 and 20, Township 12 N, Range 9 E of Coles County (Figure 3). With agreement from the landowners and township, more detailed stream-channel assessments were completed for the stream reach in order to complete hydraulic modeling to take a reach approach to summarizing existing conditions and possible restoration practices. The evaluation of the effectiveness of in-stream habitat and restoration alternatives upstream of the bridge was completed by using HEC-RAS modeling and USGS STREAMSTATS (see Appendix B, Interim stream restoration assessment, page 37). Part of the USGS guidance and oversight was in the form of a stream workshop. As a result of the workshop, plans were developed for the project site: This restoration effort included two Newbury riffles to simulate the scour pool hydraulics. The riffles are within approximately 1500 ft of stream bank stabilization. The 1500 ft of streambank is stabilized with riprap in a 2000 ft reach of stream. This restoration effort ultimately stabilized 1500 ft of streambank, reducing bank erosion and channel deposition, and created 2000 ft of favorable habitat for much of the aquatic life of Kickapoo Creek including the stream fishery. The township agreed to further stabilize the bridge downstream. IDNR entered into agreements with the township and the landowners to complete all aspects of the project.

Coordination with Eastern Illinois University (EIU) to monitor the completed restoration project complimented the monitoring component of the instream restoration effort. Such a monitoring effort involved the community by connecting local academia with the restoration effort and informing the students and the community about the benefits of instream restoration.

This effort has and will continue to benefit planners, regulators, scientists, and engineers on various stream restoration practices and contribute to the protection of Illinois natural resources.

Methods and timeframes

Approximately $1,548, 0.5% of the project funds, was used for the purpose of designing the instream project. The majority of the design was developed per a joint funding agreement between IDNR and USGS. The $1,548 covered costs associated with a Professional Engineer's review and sealing of the plans. The review and sealing occurred in September 2009 (Table 1).

Approximately $216, 650, 63% of the project funds, was used for materials and labor associated with the installation of rock riffles, stream barbs, and rock bank revetments along the 2000 feet of stream restoration, benefitting a broad spectrum of organisms. Materials consisted of Rip Rap of varying sizes (3, 4 and 5) and crest stone. Labor consisted of the manipulation and placement of rock using a dump truck, bulldozer, and trackhoe. Additional information, including photos, detailing the construction is included in Appendix B (Interim stream restoration assessment, pages 3-21). The time period for construction activities was August 2010-October 2010 (Table 1).

Approximately $7,075, 2% of the project funds, was used for material and labor associated with the replanting of the area after construction was complete. This initial planting was completed by MidStates Services. To stabilize the banks, a heavy cover crop was put down with a dormant permanent prairie matrix and covered with an erosion control blanket. A medium grade erosion control blanket (25 feet wide, 1500 feet long) was required along the reseeded area. Winter wheat was chosen for a heavy cover crop and was seeded on the upper and lower banks as well as throughout the filter strip. Big bluestem, switch grass, and Indian grass were seeded on the upper and lower banks. Annual rye, oats, big bluestem, switch grass, Indian grass, purple top, and June grass were seeded throughout the filter strip. The area was watered extensively after fall planting in an effort to establish cover before winter. On April 1st, 2011 MidStates Services planted the additional prairie grass seeds (same species as mentioned above) on the upper bank and the filter strip. After the spring 2012 maintenance activities, IDNR staff reseeded the area impacted by maintenance efforts. Approximately two acres were reseeded with oats, redtop, alsike clover, switch grass, and Virginia wild rye. To further protect the streambank, red osier dogwood bushes will be planted along the south bank upstream end of project, where additional bank stabilization was performed during the maintenance activities. Since part of the adjacent land is in a certified conservation practice all of the above mentioned seed mixes and plantings were approved by the Natural Resource Conservation Service and the landowner. The time period for replanting activities was September 2010, April 2011, & May 2012 (Table 1).

Approximately $107,500, 31% of the project funds, provided pre- and post-construction assessment and monitoring activities. The assessment and monitoring protocols consisted of:

- photographic documentation to be used for establishing the generalized geomorphic setting and restoration condition,
- evaluating the stability of channel forms,
- evaluating bedload transport and diversity of in-stream habitat including maintenance of pool depth,
- documenting riffle substrate characteristics,
- stream-channel surveying of channel and bed material sampling,
- collecting and comparing installed gage[2] discharges to original estimate of hydrologic flows determined from StreamStats for multi-year flows and continuing to examine and compare flow records from nearby gages,
- hydraulic and sediment modeling for the selected reach utilizing multiple methods to summarize velocity, stream power, shear stress, size of bed materials moved, and sediment continuity for various flood magnitudes throughout the stream reach for surveyed conditions.
- biological monitoring of fish and aquatic macroinvertebrates
- monitoring stream habitat and water quality parameters

Specific details of monitoring methodologies are included in Appendices B-C. The time period for pre- and post-construction assessment and monitoring activities was January 2009-July 2012 (Table 1).

Approximately $10,977, 3% of the project funds (contingency), was used for materials associated with the maintenance of the rock riffles, stream barbs, and rock bank revetments along the 2000 feet of stream restoration. An additional 220 feet of streambank was secured with rock directly upstream of the original project reach to further protect the streambank, extending the benefits to a broad spectrum of organisms further upstream. Materials consisted of Rip Rap of varying sizes (3, 4 and 5). IDNR provided in house labor and purchases (~$5,500) for the rock placement (including oversight) and reseeding/planting after the completion of the maintenance activities. Additional information, including photos, detailing the maintenance is included in Appendix D. The time period for maintenance activities was March 2012 - May 2012 (Table 1).

[2] In order to complete many of the tasks outlined above, a discharge-only gage was installed. The USGS purchased equipment for this discharge-only gage at no cost to IDNR.

RESULTS

Before/after pictures

Pre restoration, during construction, and post restoration pictures were documented of the project reach (see Appendix A).

Quality assurance project plan

Both the geomorphological and biological monitoring components were consistent with the project's Quality Assurance Project Plan (QAPP) approved by the IEPA QAPP Officer. The geomorphological component was executed to evaluate the effectiveness of the streambank and channel stability measures installed and to evaluate bedload transport and diversity of in-stream habitat including maintenance of pool depth. Photographic documentation, stream-channel surveying, bed material sampling, and in-stream habitat monitoring were conducted as described in the QAPP. The biological component was executed per IDNR and IEPA intensive basin survey procedures for fish and aquatic insects, the methods outlined in the QAPP were followed. The basic physical and chemical stream parameters were also measured, as described n the QAPP, to help explain the effects of the habitat restoration on the ecosystem. Overall, the below information (and information contained in Appendices B-C) should illustrate quality usable data for documenting the aquatic life and habitat improvements of the project reach.

Geomorphological monitoring

The results indicate channel pool depths have increased post restoration and are being maintained (continue to be scoured by the stream as a result of the riffle structures). Heavy spring 2011 floods did result in some rock shifting which indicated a few areas where additional stabilization of the structures would be beneficial, as well as increase bank stabilization upstream of the project reach to further secure the project stability (see Appendix D). As a result of the maintenance activities and further evaluation of the treatment reach, it is evident the restoration structures are stable and functioning as expected. The bed material samples indicate changes in channel substrate pre and post restoration, providing evidence of a decrease in bedload transport (decrease in bank erosion and sedimentation). For more details regarding the geomorphological results see Appendix B (Interim stream restoration assessment, pages 3-40; qualitative and quantitative assessments).

Biological monitoring

As indicated in the above section, it is clear the riffles have scoured and maintained deep pool habitat downstream of the riffle structures. As a result of the bank stabilization and riffle/pool habitat formation there has been a change in biological density and diversity within the treatment reach post restoration. For example, in post-restoration samples, the treatment reaches as compared to the control reaches had a higher number of species collected, illustrating some unique species not found in the control reaches (ex. fantail darter and redear sunfish). For more details regarding the biological sampling results see Appendix C (Restoration of Kickapoo Creek, pages 6-41; results, discussion, and associated figures/tables).

DISCUSSION

Achievements

The Kickapoo creek instream restoration project is benefiting 2000 feet of stream habitat and stabilizing the streambanks, thereby increasing water quality and aquatic life within the project reach. Monitoring of the project reach has taken place to assess the trend of various ecological parameters over time. The monitoring protocol is intended to generate practical information for evaluating project development in an effort to document success and/or provide the basis for the implementation of adaptive management.

The project illustrates a great collaboration of various groups working together to implement a restoration project and monitoring the success of the project over time. IDNR oversaw all project components including but not limited to: coordinating with USGS on a project location, concept, and design plans; receiving private landowner approval and appropriate permits; securing EPA 319 matching funds; working with Charleston Township to maintain a county bridge; coordinating with USGS and private contractors for project implementation; and coordinating with USGS and EIU for pre and post restoration monitoring.

In order to educate various groups and showcase the project IDNR has hosted multiple project tours to the site; pictures and a summary of the project have been uploaded to the NRDA program website; information has been presented at technical meetings; an interview of the project team is being uploaded to EIU's website; and EIU anticipates many scientific publications to come out of the monitoring (the EIU monitoring component used funds to finance graduate research at the site).

Lessons learned/suggestions for future projects

The primary lessons learned from this project are in regards to the construction/vegetation contracts for stream restoration work:

- Request that the construction crew place dirt on top of/between voids of rock in the bank protection.
- Request that the construction crew re-seed the entire disturbed area as a result of construction activities (staging areas, access points, traffic routes, etc).
- On the project construction design pages include areas for the construction crew to fill out rock quantity information (that way they will be able to better keep track of how much rock is delivered for each structure).
- Including a statement saying the vendor/contractor will be paid by the ton installed is important when doing these jobs.
- For the re-vegetation component, include a line item for the contractor to wet down the vegetation after putting on the blanket and continue to do so until the vegetation has established or frequent rainfall is occurring in the area.

Future activity recommendations

The implemented project has met expectation to reduce severe bank erosion (sedimentation into the stream) and increase stream habitat for the stream fishery. Therefore, IDNR anticipates submitting more project proposals for similar types of restoration projects to help increase water quality and wildlife habitat throughout the state of Illinois. For example, a project proposal IDNR Office of Realty and Environmental Planning will be submitting for the 2012 application period includes an instream restoration project similar to the Kickapoo Creek restoration effort. The project involves riffle/pool enhancements to Copper Slough near Champaign, Illinois. Similarly to the Kickapoo creek project the proposed riffle/pool enhancements will increase aquatic resource habitat as well as decrease sedimentation moving downstream.

In regards to the Kickapoo Creek site, in order to continue to educate various stakeholders IDNR anticipates more project tours with agency staff, public from the Charleston/Mattoon community, and local students.

Even though EIU and USGS will no longer receive funding through this 319 grant (expires July 2012), both groups are interested in continuing to monitor the project reach for years into the future in order to determine long term effects of the project on the stream stability and aquatic life. For example, EIU plans to decrease the biological sampling frequency (one time per year, in the fall) and increase the water quality parameters tested for (i.e., nitrates and phosphates). IDNR understands that EIU and USGS will be seeking additional grants to help fund this effort. IDNR fully supports their continued monitoring efforts, as long-term monitoring data are required in order to properly assess and evaluate changes in watersheds. The information they plan to collect will be very beneficial in understanding the long term functionality of these structures and their benefits to the aquatic system.

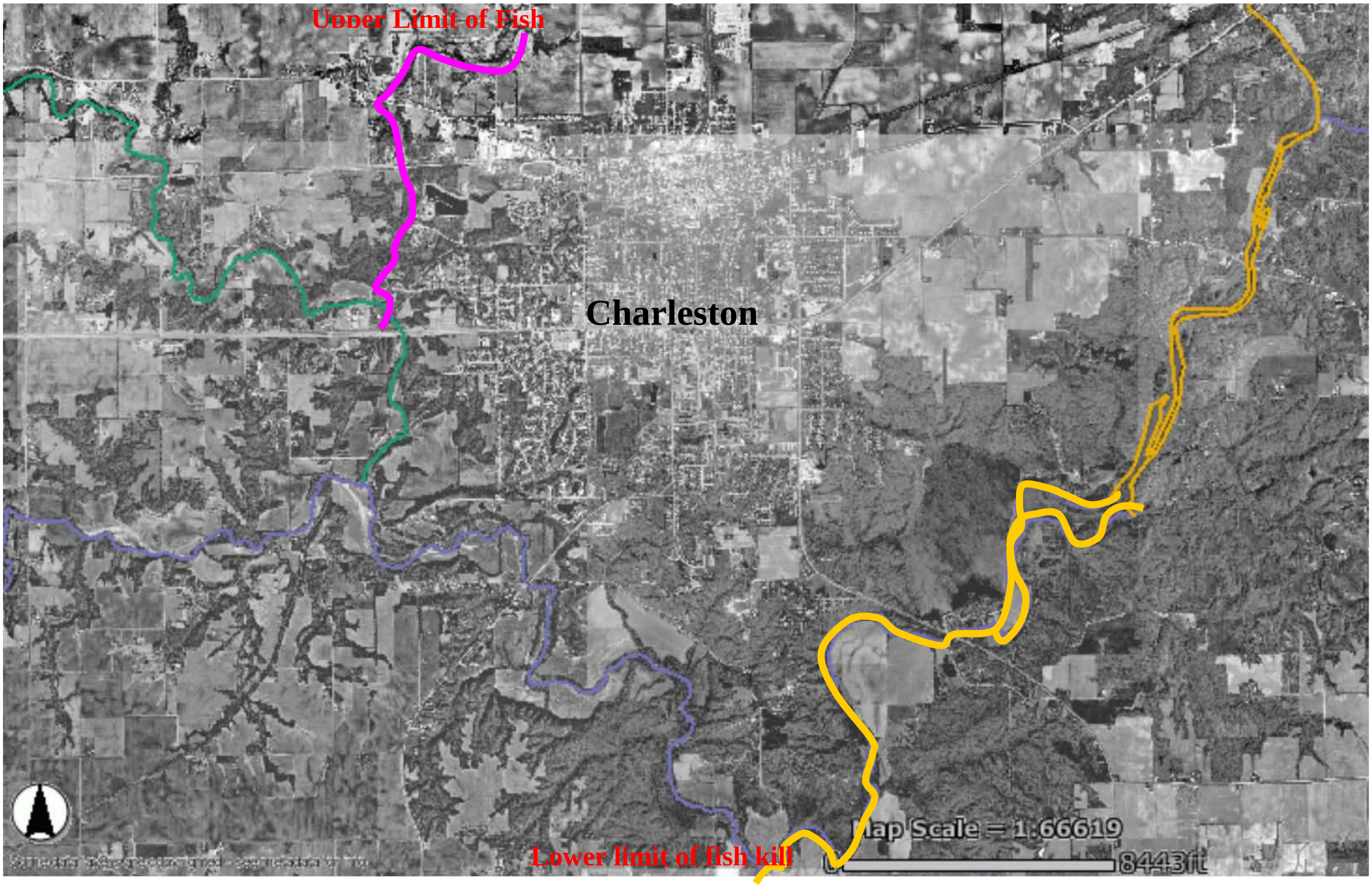
References

Bertrand, W.A., R.L. Hite, D.M. Day. 1996. Biological stream characterization: biological assessment of Illinois stream quality through 1993. Report No. IEPA/BOW/96-058. Illinois Environmental Protection Agency. 40 p.

Illinois Environmental Protection Agency. 2004. Illinois Water Quality Report.

Illinois Environmental Protection Agency. 2008. Illinois Integrated Water Quality Report and Section 303d list.

Figures



Cassel Creek

Riley Creek

Kickapoo Creek

Embarras River

Figure 1. Cassel/Riley/Kickapoo Creeks Natural Resource Damage Assessment area along Cassel, Riley, and Kickapoo Creeks, Coles County, Illinois. The map was obtained through the Wetland Impact Review Tool).

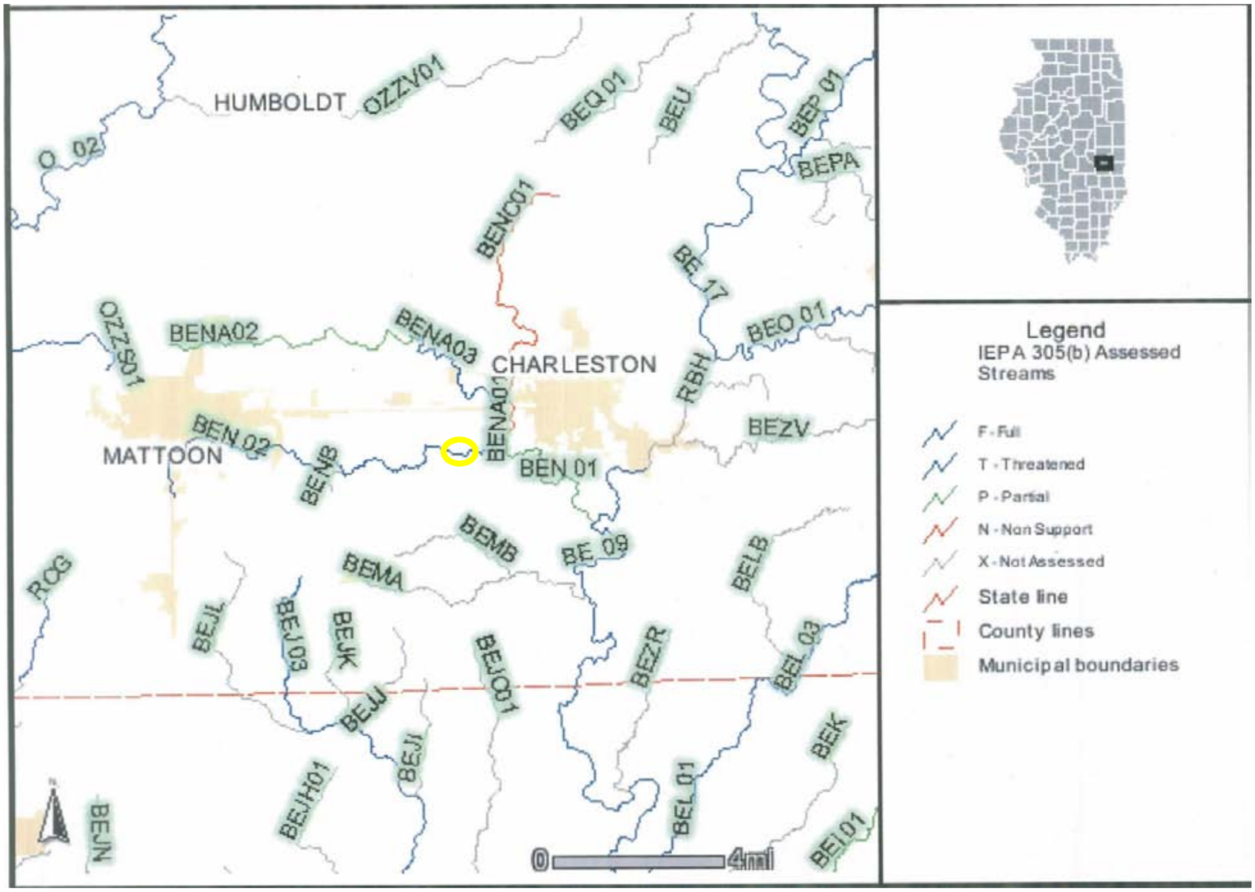


Figure 2. IEPA 305 (b) impaired Stream Segments in the vicinity of the proposed Kickapoo Creek restoration area near Charleston, Illinois. The approximate location of proposed restoration is highlighted with a yellow circle. The map and related information was obtained from http://maps.epa.state.il.us/website/wqinfo/

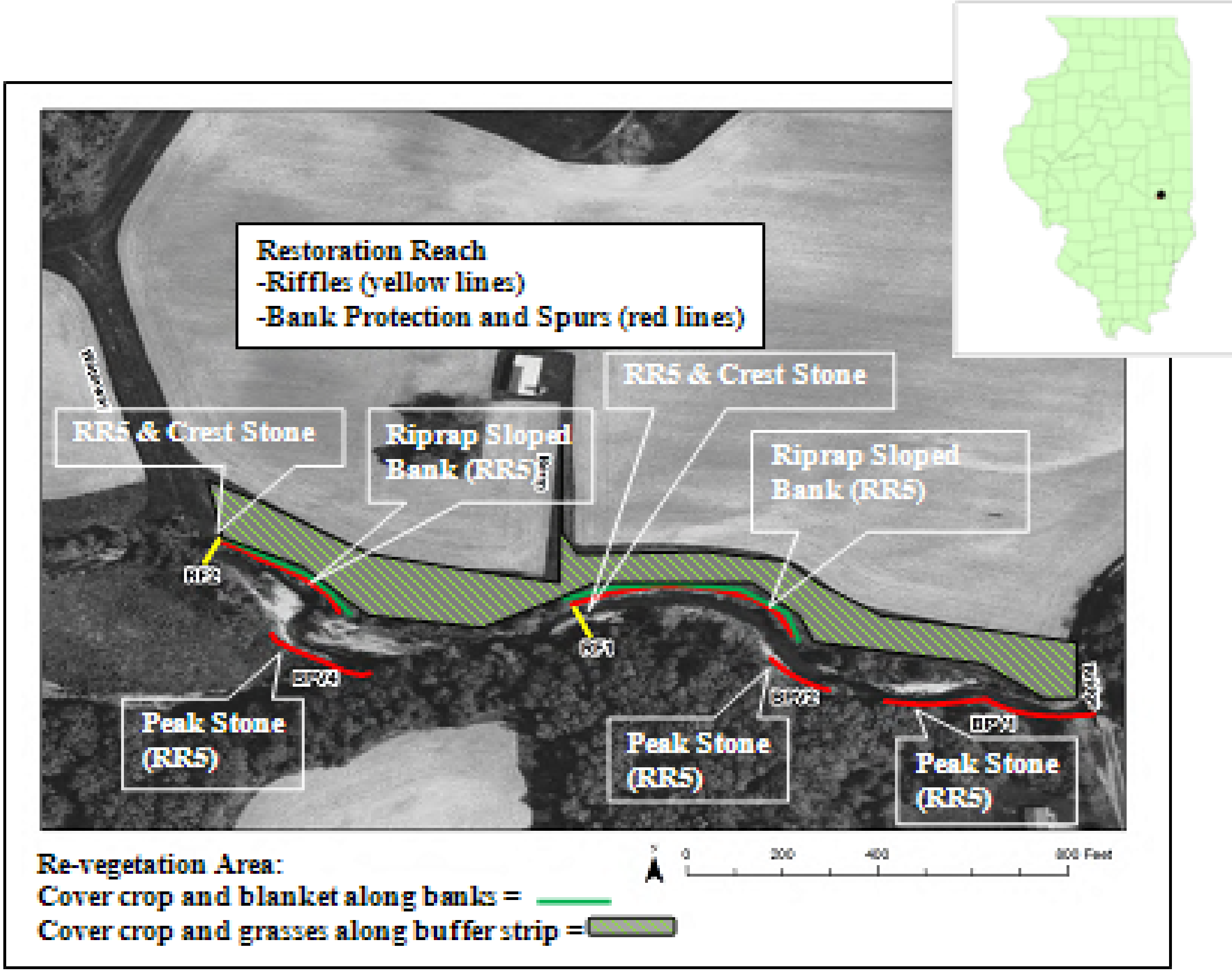


Figure 3. Map of project area, Coles Co IL. Township: 12N; Range: 9E; Section 19 &20. The map was obtained through Arc GIS.

Tables

Table 1. Schedule

Kickapoo Creek (Charleston) project tasks

TASK				AGENCY/CONTACT PERSON	PROJECTED COST / $ TYPE	internal deadline/task completed	319 DEADLINE DRAFT	319 DEADLINE approval	319 DEADLINE FINAL
pre-construction monitoring	streambank and channel stability measures			USGS via stream assessment and workshop	$10,000/JFA	5/7/2009	N/A	N/A	N/A
	bedload transport and diversity of instream habitat						N/A	N/A	N/A
	gage discharges vs. streamstats						N/A	N/A	N/A
	biological monitoring	fish		EIU	$10,000/monitoring	sampling by 9/11/2009; report by 12/31/09	N/A	N/A	included updates in quarterly reports
		macros							
design	science and modeling			USGS/Straub and Roseboom	$9,000/JFA	6/15/2009	10/7/2009	10/28/2009	10/28/2009 per Jan Carpenter's correspondence of 11/09/09
	pollutant removal efficiency calculation					9/1/2009			
	BMP application forms					9/1/2009			
	engineering			subcontractor #1	$1600/restoration	9/10/2009			
O and M Plan				IDNR	will track	8/21/2009	8/20/2009	8/21/2009	10/7/2009
permits				IDNR/Jessica Riney	will track	submitted permits to ACOE, OWR, IEPA on 10/07/09; OWR approval 10/21/09; ACOE approval 11/01/09	6/1/2011		
				USGS/Straub and Roseboom	$1000/JFA				
project implementation	construction			V3 Dan Cikauskas	$188,650.00/restoration	September 7-22, 2020	6/1/2011		
	vegetation stabilization and buffer strip reseeding			Midstates Scott Miller	$7,075.00/restoration	September 24 - 29, 2010			
	oversight and photo documentation			IDNR with assistance from USGS	$28,000/restoration	September 3 - 29, 2010			
	maintenance (rock/haul, placement, oversight, reseeding)			IDNR with assistance from USGS	$16,500/maintenance	April 25 - May 2, 2012	6/1/2012		
QAPP for post construction monitoring and assessment	streambank and channel stability measures			USGS	$1,000/monitoring	8/1/2010	10/26/2009	11/5/2009	11/16/2009
	bedload transport and diversity of instream habitat								
	gage discharges vs. streamstats								
	biological monitoring	fish		IDNR	will track	8/15/2009	8/19/2009	8/21/2009	10/28/2009
		macros							
progress reports				IDNR	will track	1st of July, October, January and April	Completed: 11 (July 2010 & 2011; October 2009, 2010, & 2011; January 2010, 2011, & 2012; April 2010, 2011, & 2012)		
all monitoring and assessments activities	complete all monitoring and asessments activities	streambank and channel stability measures		USGS	$86,500/monitoring	5/15/2012	6/1/2012		
		bedload transport and diversity of instream habitat							
		gage discharges vs. streamstats							
		biological monitoring	fish	EIU	$10,000/monitoring				
			macros						
	monitoring data submitted in electronic form			IDNR will compile and submit	will track		7/1/2012		
final report				IDNR	will track	6/1/2012	6/1/2012		7/1/2012

Table 2. Budget

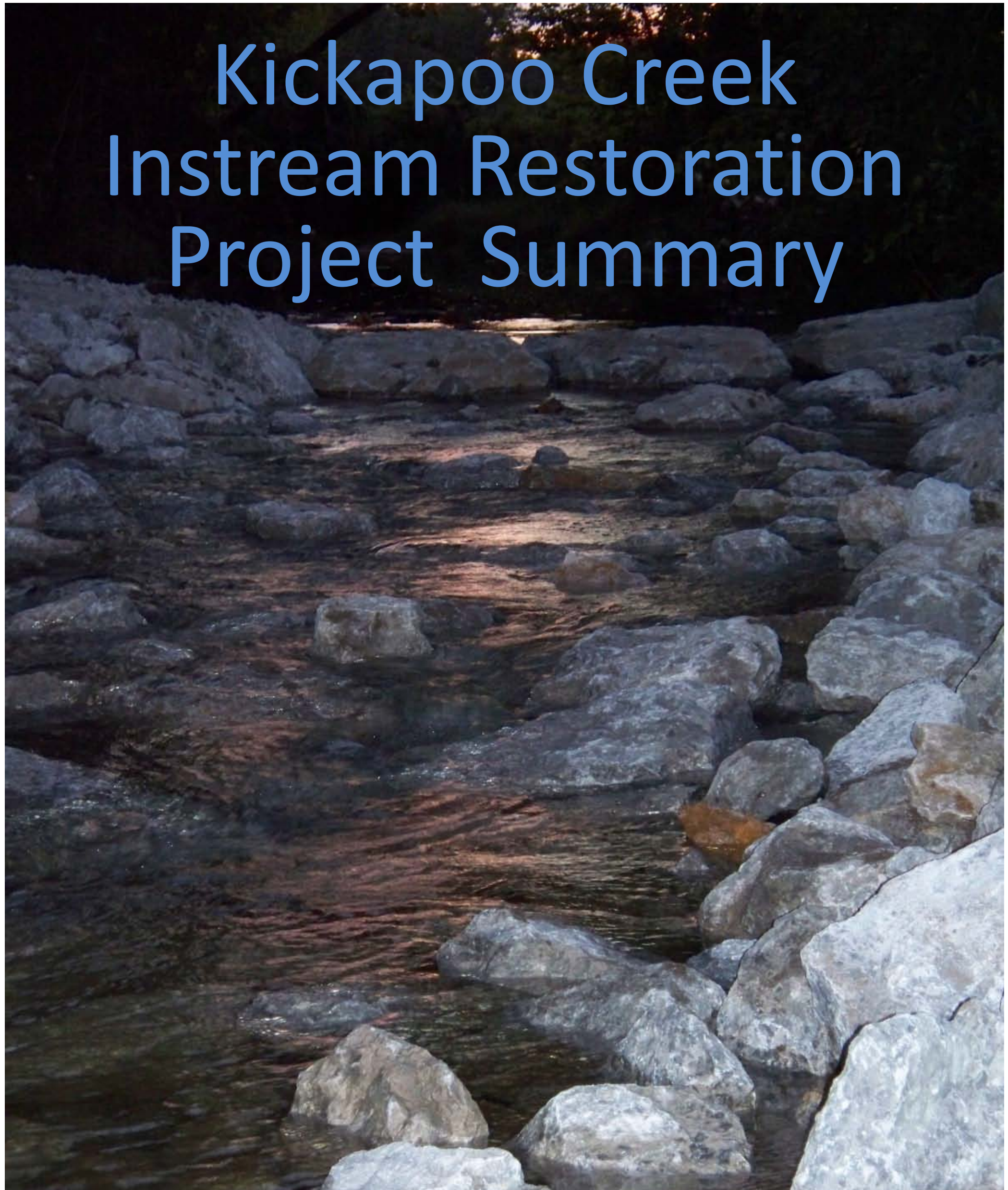
	319 Project Funds	IDNR Funds Only[1]
Stream Restoration		
Construction	$ 188,650.00	$ -
USGS Oversight	$ 28,000.00	$ -
Engineering Design Seal	$ 1,548.00	$ -
Vegetation Contract	$ 7,075.00	$ -
Assessment & Monitoring		
USGS Monitoring	$ 87,500.00	$ -
Eastern IL Univ.	$ 20,000.00	$ -
Maintenance		
Rock	$ 7,920.00	$ -
Hauling	$ 3,057.00	*$ 543.00*
Seed	$ -	*$ 148.62*
USGS Oversight	$ -	*$ 4,800.00*
Total Project Cost	$ 343,750.00	$ 5,491.62

Notes:

1: The Maintenance activities put us over our 319 budget therefore the remaining activities (part of the hauling costs, seed, and USGS oversight of the maintenance activities) were funded through IDNR funds only (we did not seek reimbursement from EPA for these activities)

Appendices

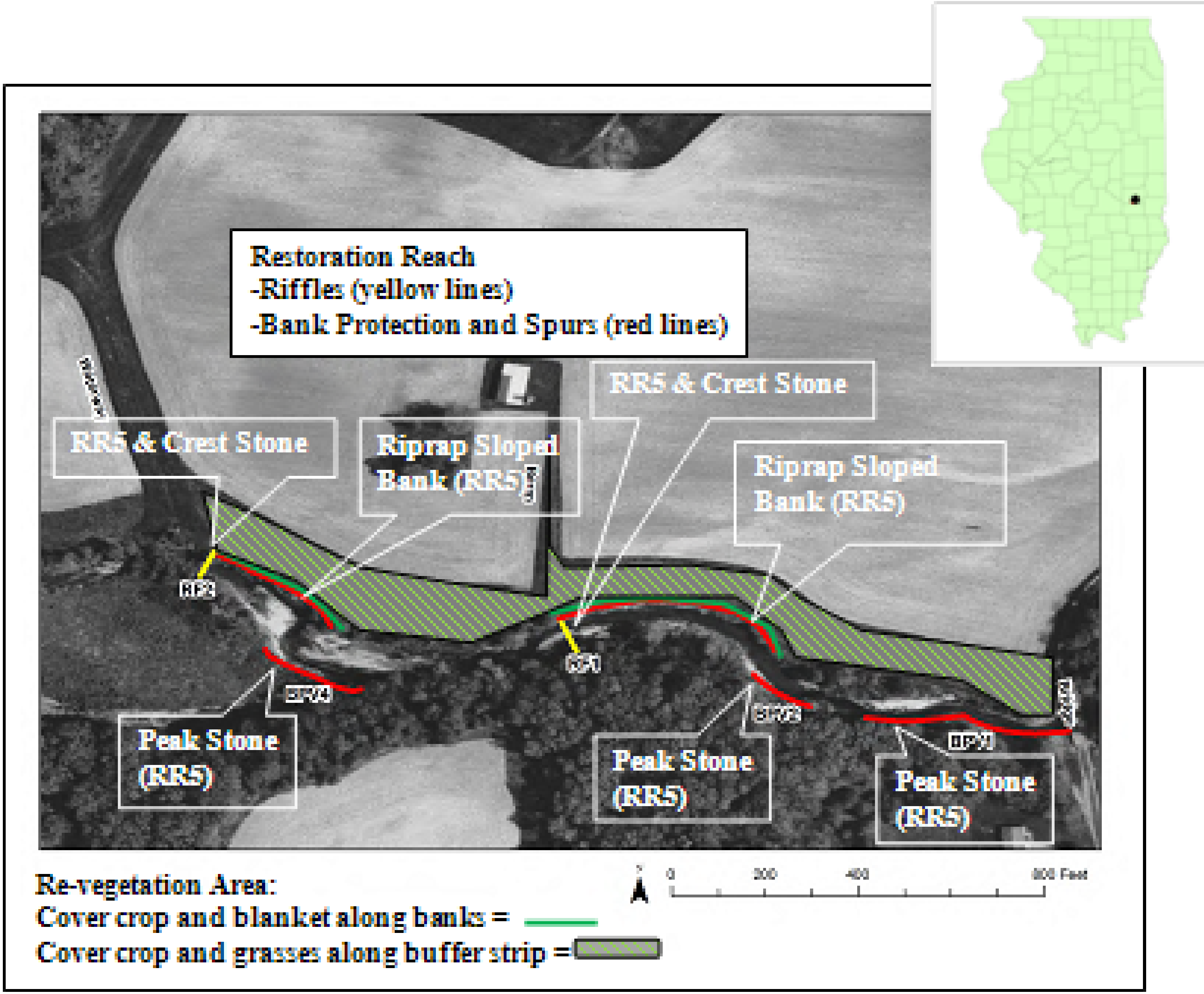
Appendix A
Project Title: Kickapoo Creek Restoration Project, Charleston, Illinois Pages 18-27
Grant Number: 3190902 Grant Source: 319



Project components: 2 constructed riffles and 5 Bank Protection Locations within 2,000 ft of a stream reach

Project location: Near Charleston and Mattoon in Coles County, Illinois

Constructed in: Sept 2010


Restoration Reach
-Riffles (yellow lines)
-Bank Protection and Spurs (red lines)
RR5 & Crest Stone
Riprap Sloped Bank (RR5)
RR5 & Crest Stone
Riprap Sloped Bank (RR5)
Peak Stone (RR5)
Peak Stone (RR5)
Peak Stone (RR5)
Re-vegetation Area:
Cover crop and blanket along banks =
Cover crop and grasses along buffer strip =

Bridge Stabilization Effort

Pre

Post

On top of bridge looking at South bank

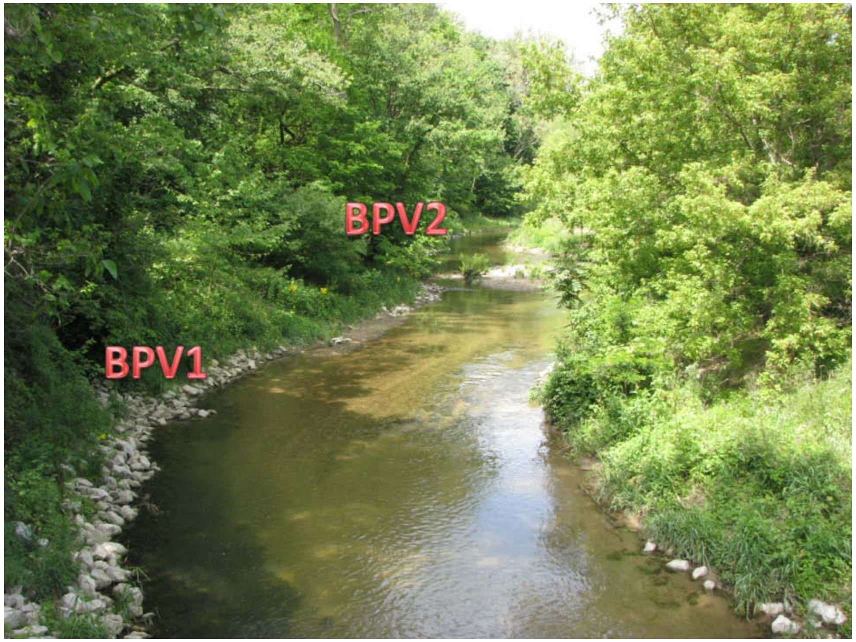
Under bridge looking at South bank

Bridge Stabilization Effort was completed by Charleston Township July 2010

Bank Protection (BPV1 and BPV2)

Pre

Post



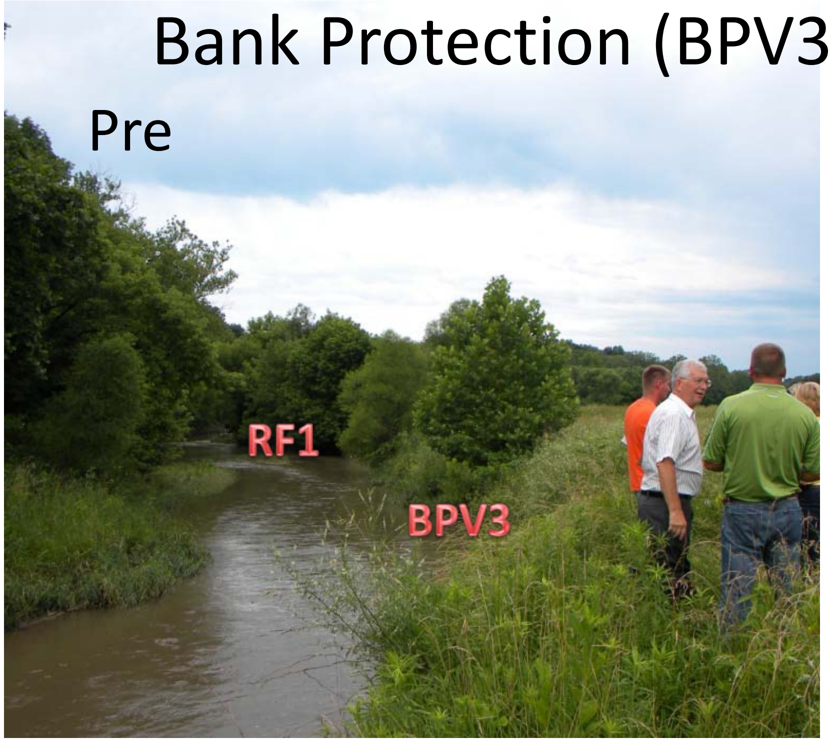
Natural Riffle and Bank Protection (BPV2)

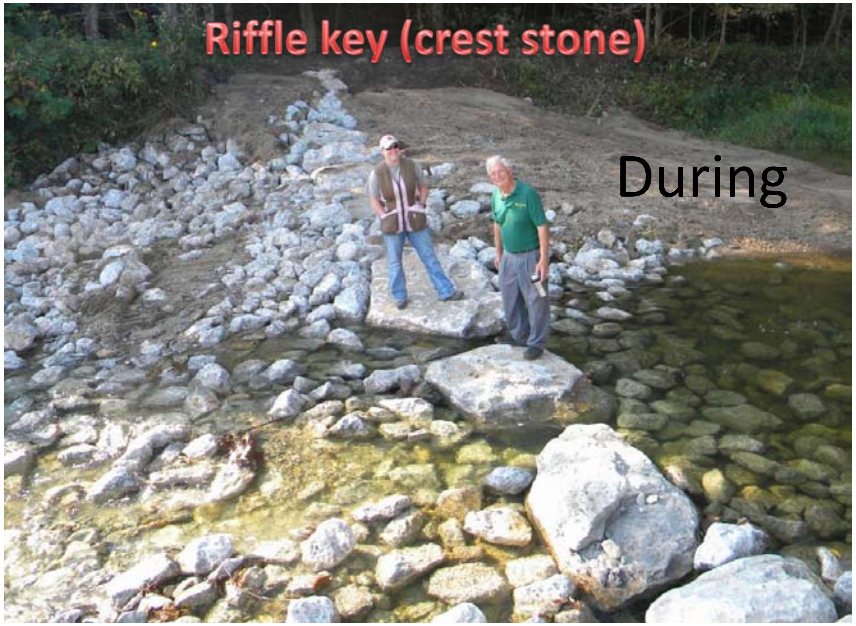
Pre

Post

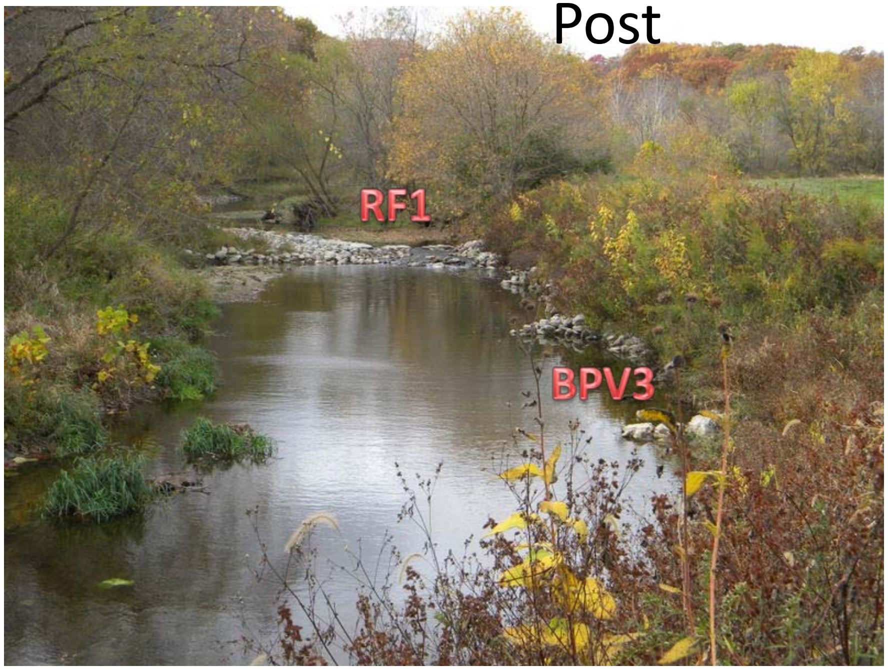
Efforts were made to ensure the natural riffle went unharmed throughout the project construction.

Bank Protection (BPV3) and Riffle One (RF1)



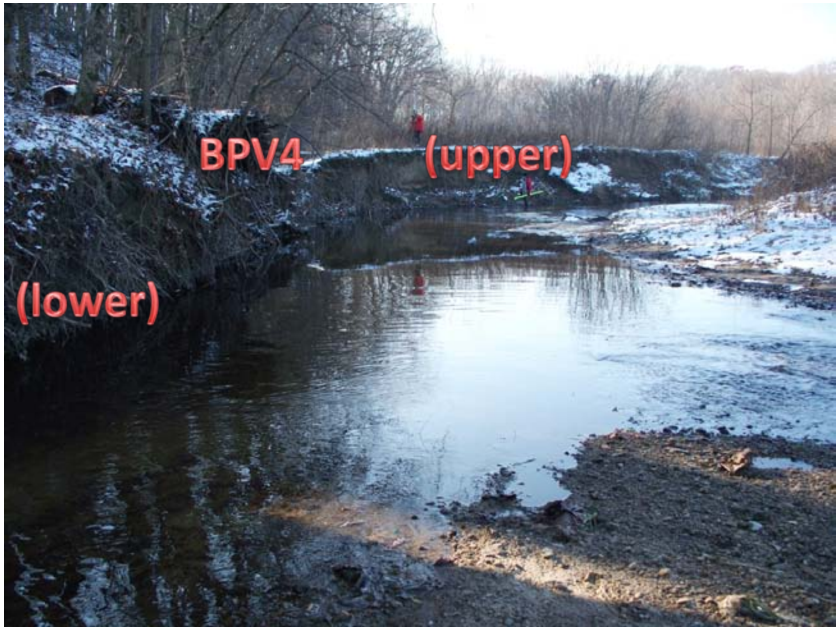


Post

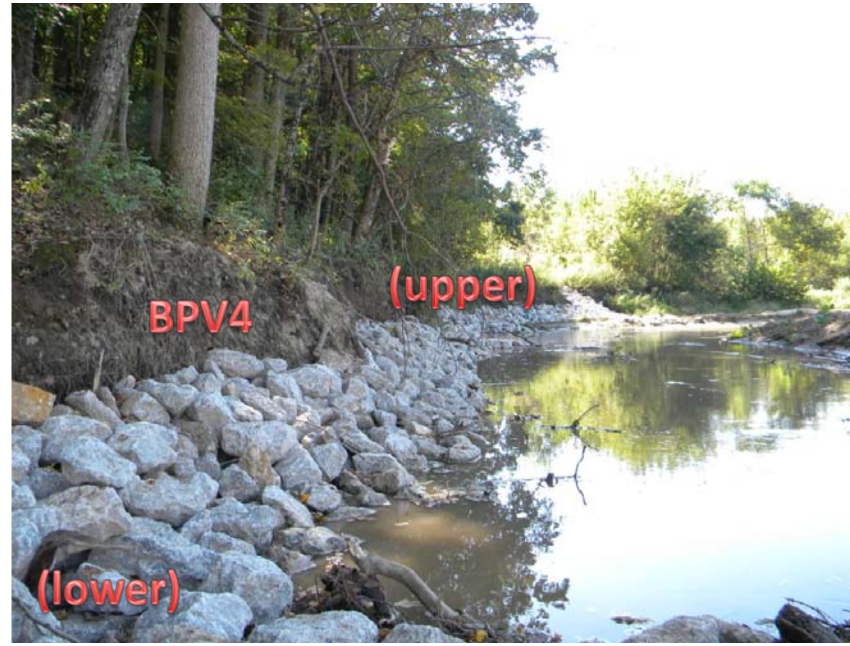


Bank Protection (BPV4 and BPV5)

Pre



Post

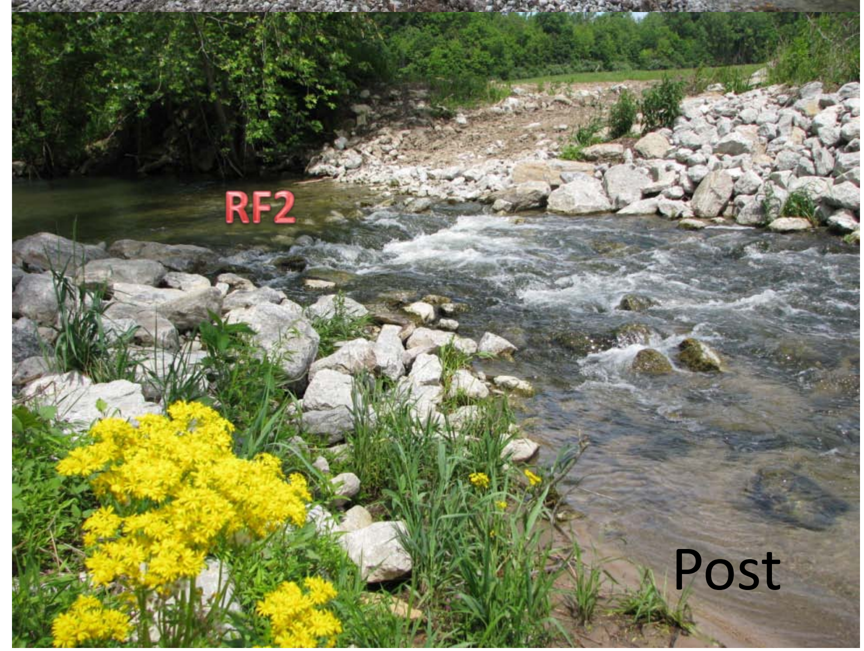


Pre

Bank Protection (BPV5) and Riffle Two (RF2)

Pre

During



Thanks to everyone who helped with the Kickapoo Creek Project implementation and monitoring!

USGS: Surveying, Oversight, & Monitoring

EIU: Biological, Habitat, and Water Quality Monitoring

A special thanks to the cooperative landowners willing to have the project implemented along their property

Funding Agencies: EPA 319 and IDNR

STREAM RESTORATION ASSESSMENT FOR KICKAPOO CREEK NEAR CHARLESTON, ILLINOIS

Prepared for

Illinois Department of Natural Resources, and

Illinois Environmental Protection Agency

June 18, 2012

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Background

A stream restoration project was completed on Kickapoo Creek near Charleston, Illinois in September 2010 by the Illinois Department of Natural Resources. The goals of the project were to enhance fish and biotic habitat, and reduce stream erosion and improve overall water quality. The construction of riffles enhances habitat for aquatic organisms and maintains deep pools that are critical over-wintering habitat for several fish species commonly found in mid-size streams. Stabilizing the stream banks and channel decreases sand and gravel deposition in deeper pool habitats.

Objective

The objective of this study is to assess the effects of the stream restoration on the physical characteristics of the stream. The changes to the geomorphology and habitat after the stream has been restored have not been well documented. Collecting and analyzing this post-restoration data will provide insights to the overall effectiveness of a restoration project in maintaining a quality habitat and stable channel morphology.

Approach

Assessment of three main measures of stream restoration effectiveness are being performed: 1) evaluation of the effectiveness of the streambank and channel stability measures installed; 2) evaluation of the transport of bed material and diversity of in-stream habitat including maintenance of pool depth; and 3) evaluation of the biological attributes of the stream. The focus of this summary will be on the qualitative and quantitative assessment of items 1 and 2. The components of the assessment include photographic, streamflow, geomorphic, and bed material monitoring for two years after restoration.

Qualitative Restoration Status

The restoration was completed within a 2000 ft reach of Kickapoo Creek in September 2010 in Section 19 and 20, Township 12 N, Range 9 E of Coles County near Charleston, Illinois. Riffles, riprap sloped banks, and peak stone were constructed as part of the restoration effort. Two Newbury riffles simulate scour pool hydraulics within approximately 1500 ft of streambank stabilization. The restoration effort reduces bank erosion and channel deposition and creates 2000 ft of favorable habitat for much of the aquatic life of Kickapoo Creek including the stream fishery. At the downstream end of the project, Charleston Township also installed riprap on the right bank under the bridge in coordination with the restoration effort. Photographic documentation is being used for establishing the geomorphic setting, restoration condition, and stability of channel forms. Selected images and photos of before and after restoration are presented in Figures 1-5 (Additional pre-restoration photos and maps are presented in Appendix A).

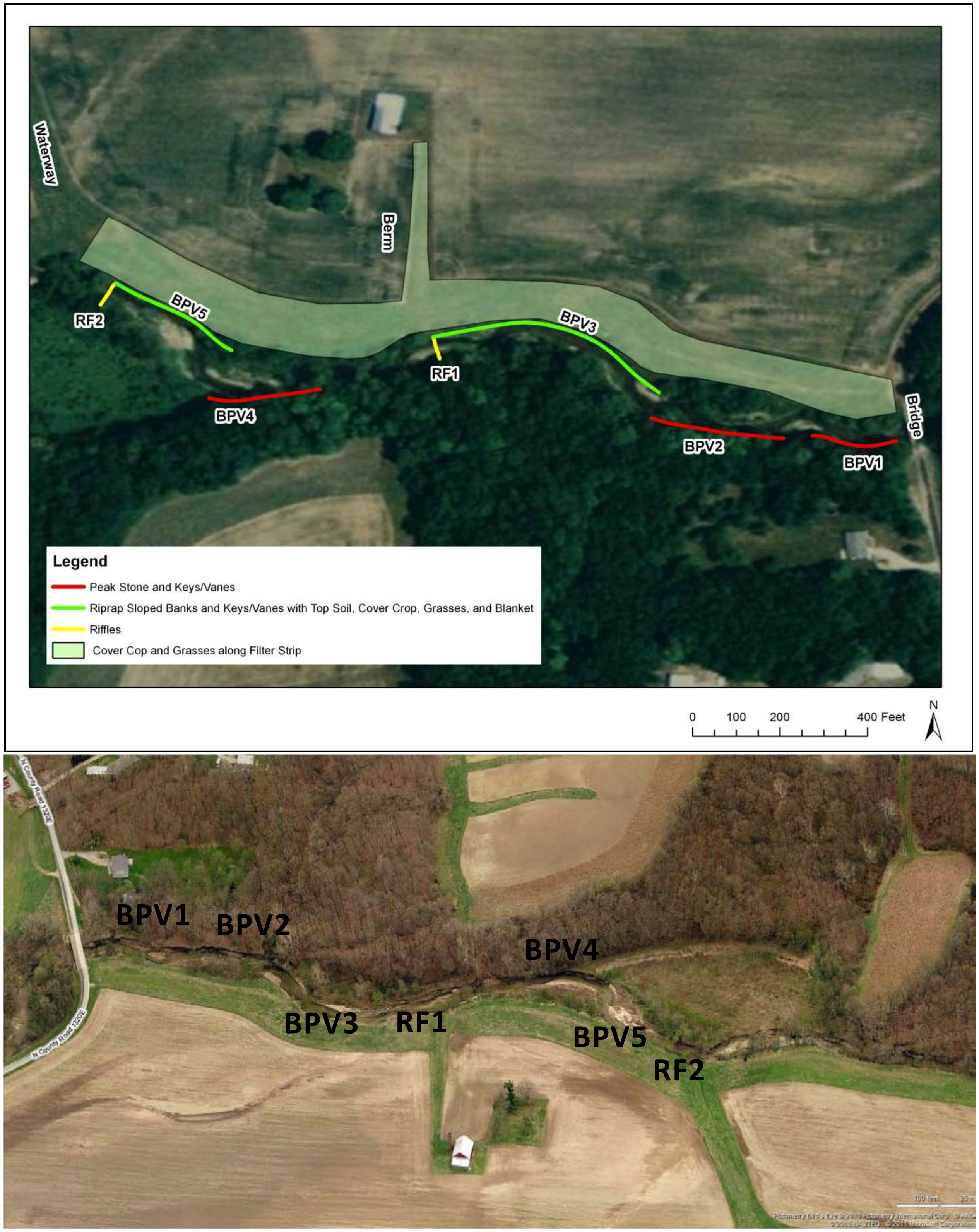


Figure 1. Locations of riffles (RF1 and RF2), riprap sloped banks (BPV3 and BPV5), and peak stone (BPV1, BPV2 and BPV4) constructed as part of the restoration effort (top – 2007 aerial image) (bottom – 2009 or 2010 oblique image looking south at restoration reach).

Figure 2. Condition of banks before peak stone installation at BPV1 and BPV2 (top-looking south) and after installation (bottom left-looking upstream). The single natural riffle in the restoration reach is shown in the bottom right (looking upstream) (natural riffle was undisturbed during construction).

Figure 3. Conditions of banks BPV1 and BPV2 and natural riffle in September 2011.

Figure 4. Condition of banks and stream before riprap sloped bank and riffle installation at BPV3 and RF1 (center-looking east) and after installation (top left and bottom right-both looking upstream).

Figure 5. Photo looking upstream at BPV3 and RF1 in flood conditions spring 2011. Top right photo looking downstream from RF1 at BPV3.

Figure 6. Conditions of banks BPV3 (looking upstream in top and bottom photo) and RF1 (looking upstream in bottom photo) in September 2011.

Figure 7. Both photos looking downstream from RF1 at BPV3

Figure 8. Condition of bank before peak stone installation at BPV4 (top-looking south) and after installation (bottom right-looking upstream).

Figure 9. Both photos looking downstream from BPV4

Figure 10. Condition of banks and stream before riprap sloped bank and riffle installation at BPV5 and RF2 (top-looking east) and after installation (bottom right-looking downstream).

Figure 11. Top left photo looking at RF2 in flood conditions spring 2011. Middle photo looking upstream at RF2 and BPV5. Top right photo looking downstream at RF2 and BPV5.

Figure 12. Conditions of BPV5 and RF2 after spring floods in 2011 (top photo looking upstream and bottom photos looking downstream).

Figure 13. Photos and text discussing linkage of physical properties of riffles and fish habitat and passage (top). Fish survey results of deep pool below RF2 along the BPV5 bank in Sept of 2011(bottom photos).

Figure 14. Bed material downstream of RF2 in May 2011 after spring floods.

Only one natural riffle with a downstream pool was observed in the demonstration reach (Figure 2) (just downstream of BPV3 with a failed bank stabilization of concrete debris). On the steep cobble natural riffle, the cobble was not covered with sand or gravel and a deeper pool was maintained below the riffle.

The instream habitat enhancement from the construction of two Newbury rock riffles provides deep pools with large rock substrate during low streamflows to increase instream physical habitat diversity. The heavy bedload deposition had eliminated such habitat during low streamflows except at bank erosion sites with tree debris, or at landowner's bank stabilization efforts.

Much of the bed material deposition of instream habitat results from major bank erosion sites in the restoration reach and upstream. The bed materials in floodplain soils result from ravine erosion into the moraine deposits along the valley bluffs. Bed materials continue to move into the stream channel from bluff erosion in steep ravines.

Landowner attempts to stabilize the eroding banks with dumped concrete debris was partially successful when compared to large bank erosion site in stream reaches upstream and downstream of the instream habitat demonstration area. When flood flows undercut the concrete slabs over the last 10 years, concrete debris has deflected flood flow into stream banks on the opposite south bank below both eroding meanders in the demonstration reach.

In the current project, additional riprap was placed in peak stone revetments and rock keys on the opposite bank below each riffle and stream bank stabilization site (Figure 2 through 12). The peak stone revetment was extended below the downstream bridge along the south bank. Smaller peak stone sites were placed above each riffle site and above the downstream bridge on the north bank.

While the major stream fishery habitat enhancements were the two rock riffles, short spurs on the rock keys extended approximately four feet into the channel beyond riprap bank revetment (Figure 15). The short spurs increase turbulence in stream flow and create scour pools below each spur. Similar to the rock riffles, a series of floods are required to scour deeper pools below the spurs.

However, the wider channel along the sloped bank will decrease the rate of scour pool formation below the spurs until bedload deposition increases the point bar size and narrows the stream channel against the stabilized bank. As vegetation increases on the point bars, more of the flood flow will be deflected against the spurs to increase scour pool size and depth below the spurs. Note that vegetated point bar at the stream barbs narrows the channel and causes high velocity flood waters to scour deep pools below barbs (Figure 15).

Figure 15. Conditions before (top) and after (bottom) spring 2011 floods (photos taken looking upstream at BPV5 and RF2).

Quantitative Restoration Assessment

Streamflow, stream-channel surveying, bed material sampling, and instream habitat and fish monitoring are being used to quantitatively evaluate the transport of bed material and diversity of habitat including maintenance of pool depth. The focus of this summary is on the first three assessment techniques listed.

Operation and maintenance of a streamflow gaging station and computation of streamflow started in the summer of 2010. The gaging station is located at the bridge at the downstream extent of the restoration project (Figure 1), and the satellite and radar equipment can be seen in Figure 2. Streamflow measurements are ongoing to develop and maintain a streamflow and stage rating curve so that streamflow can be calculated and posted to the USGS NWIS website. The streamflow values of the various storms that occurred can then be compared to the estimate of hydrologic flows (2-yr, 5-yr, 10-yr, and 100-yr flows) determined from StreamStats (Appendix C).

In 2008 the thalweg and ten cross sections were surveyed to provide data for modeling of potential restoration scenarios (Figure 16 and Appendix D). The survey of the ten 2008 cross-sections was repeated in 2010 and the data are also presented in Appendix D. An additional 32 cross sections were surveyed in 2010 (Appendix D). From these 32 locations, bed material samples were taken at the 10 locations where the most changes were expected (Figure 17). The majority of the remaining 22 cross sections (out of the extra 32 cross sections in 2010) were taken at or near the natural and constructed riffles. Data for these cross sections are not presented in this summary, but are available for comparison with future surveys if changes occur at the riffles.

The results of the 2010, 2011, and 2012 thalweg, cross-section surveys, and bed material particle size analyses are presented in Figure 16-20. The results show deepening of the thalweg and cross sections downstream of the riffles (e.g. XS 2000 and 3200) indicating the development of pool habitat. In the pools downstream of riffles 1 and 2, the bed material has coarsened at BM5 and BM9.

In 2012 riprap was installed approximately 100 ft upstream of riffle 2 on the south bank. The pool just upstream of the riffle filled 1.5 ft in 2012, most likely the result of this construction and the lack of floods after construction. This construction may also have caused the increase in sands visually confirmed at BM9 (cobbles still present and visible), and at BM8 and BM6 (Figure 20). However, both deep pools below the riffles are deeper by approximately 0.5 ft (Figure 16).

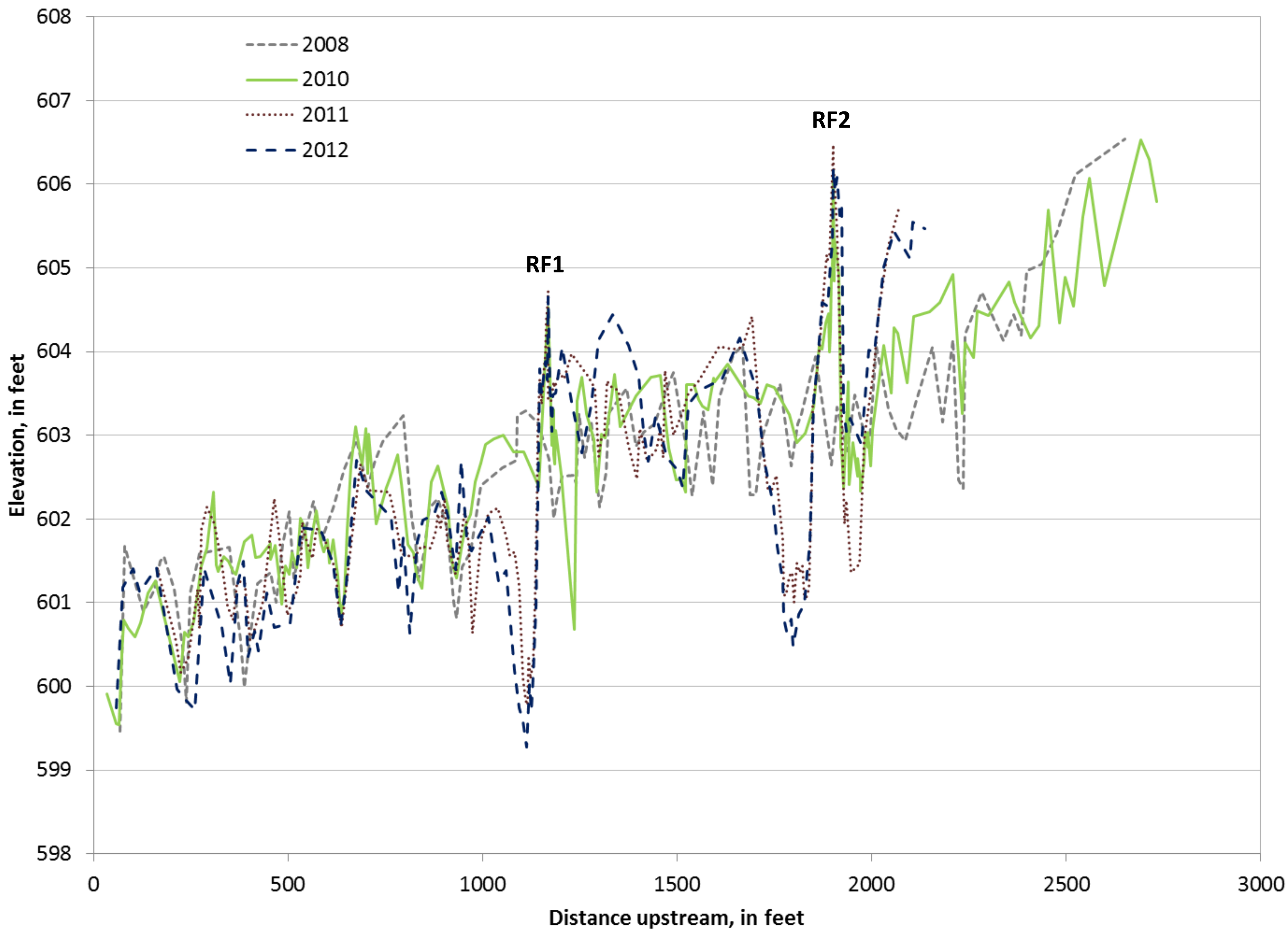


Figure 16. Thalweg profile and location of natural and constructed riffles on Kickapoo Creek near Charleston in 2008-2012.

Figure 17. Location of bed material samples and surveyed cross sections at bed material locations.

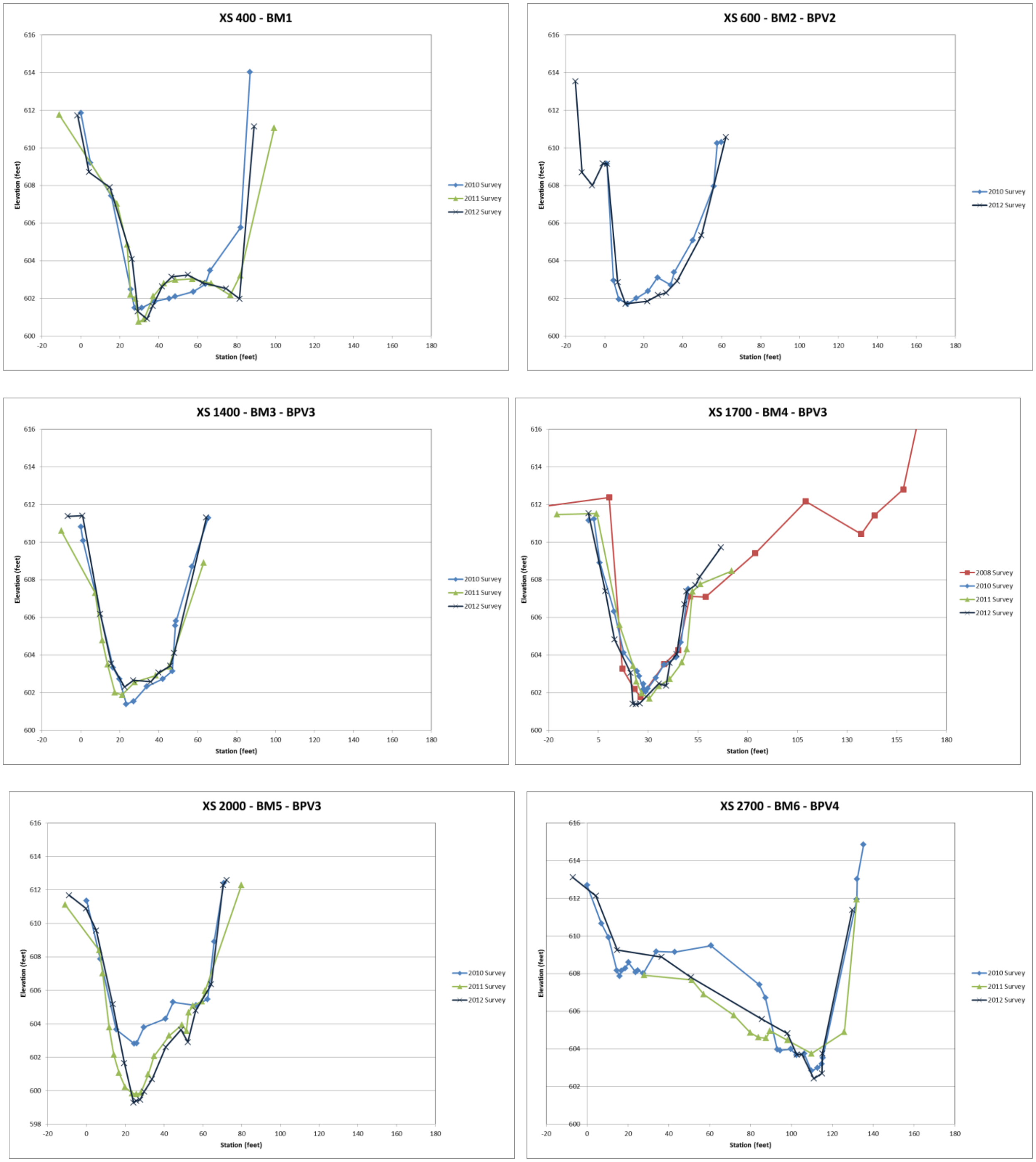


Figure 18. Graphs of 2010 through 2012 surveyed cross sections at bed material sample locations.

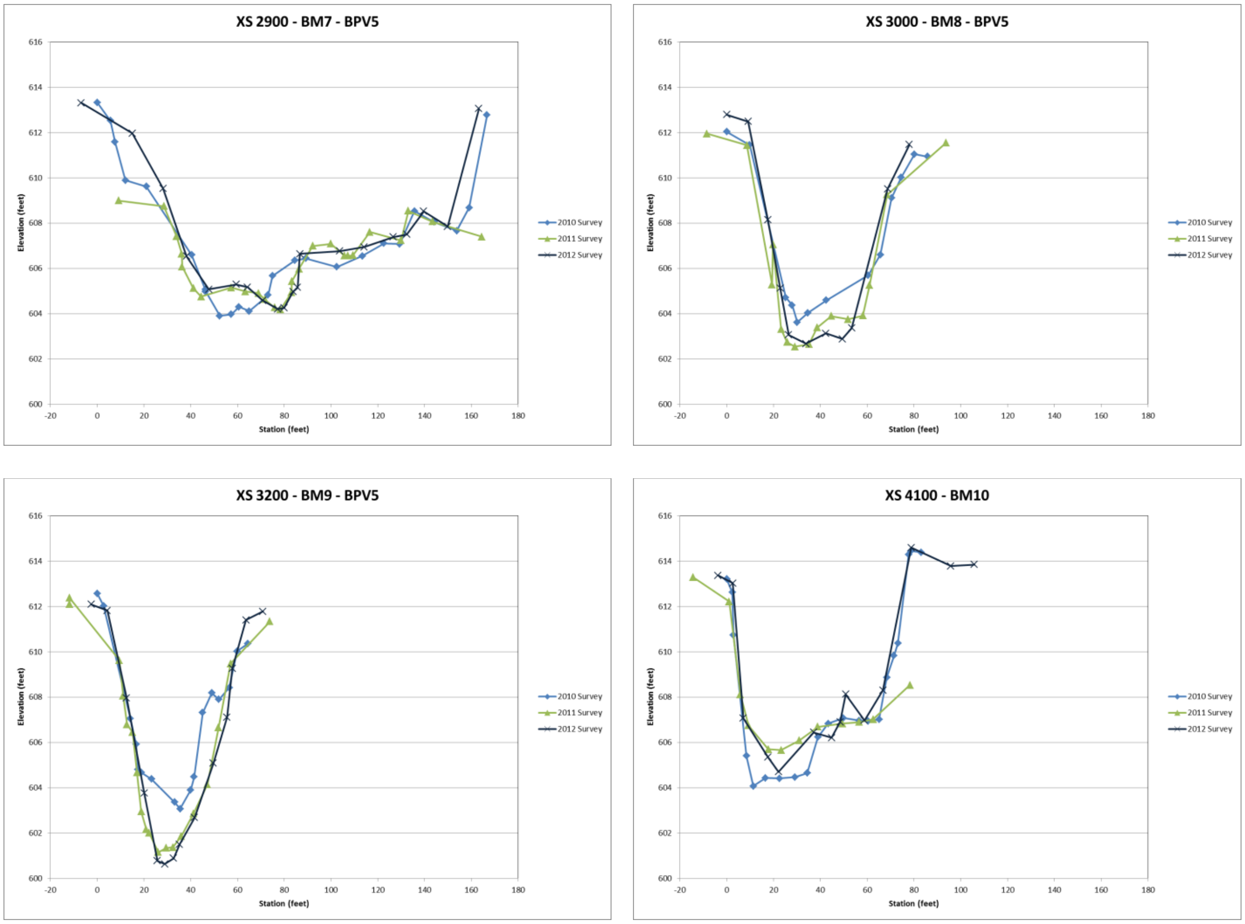


Figure 19. Graphs of 2010 through 2012 surveyed cross sections at bed material sample locations (continued).

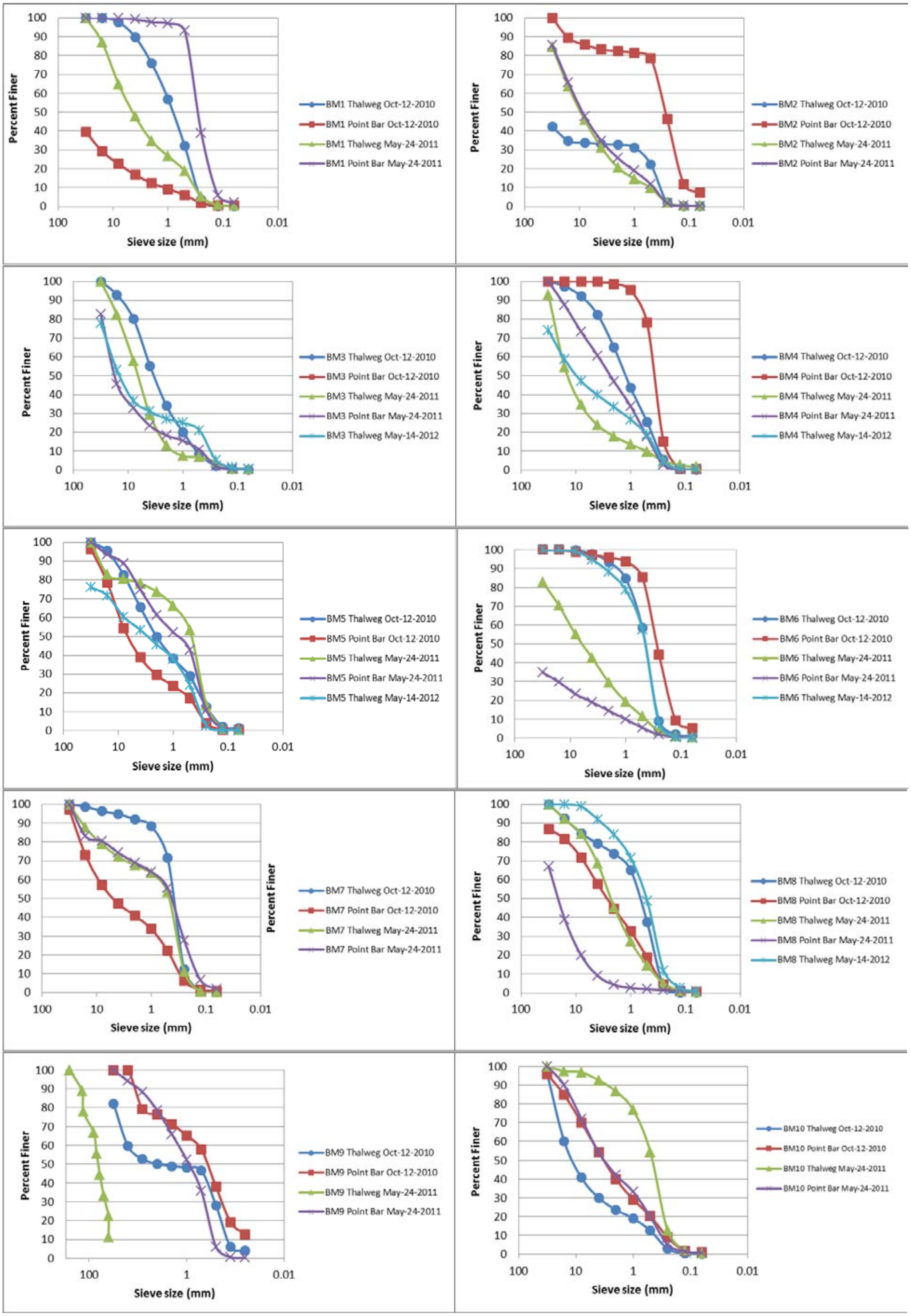


Figure 20. Bed material particle-size analysis from samples taken in 2010-2012.

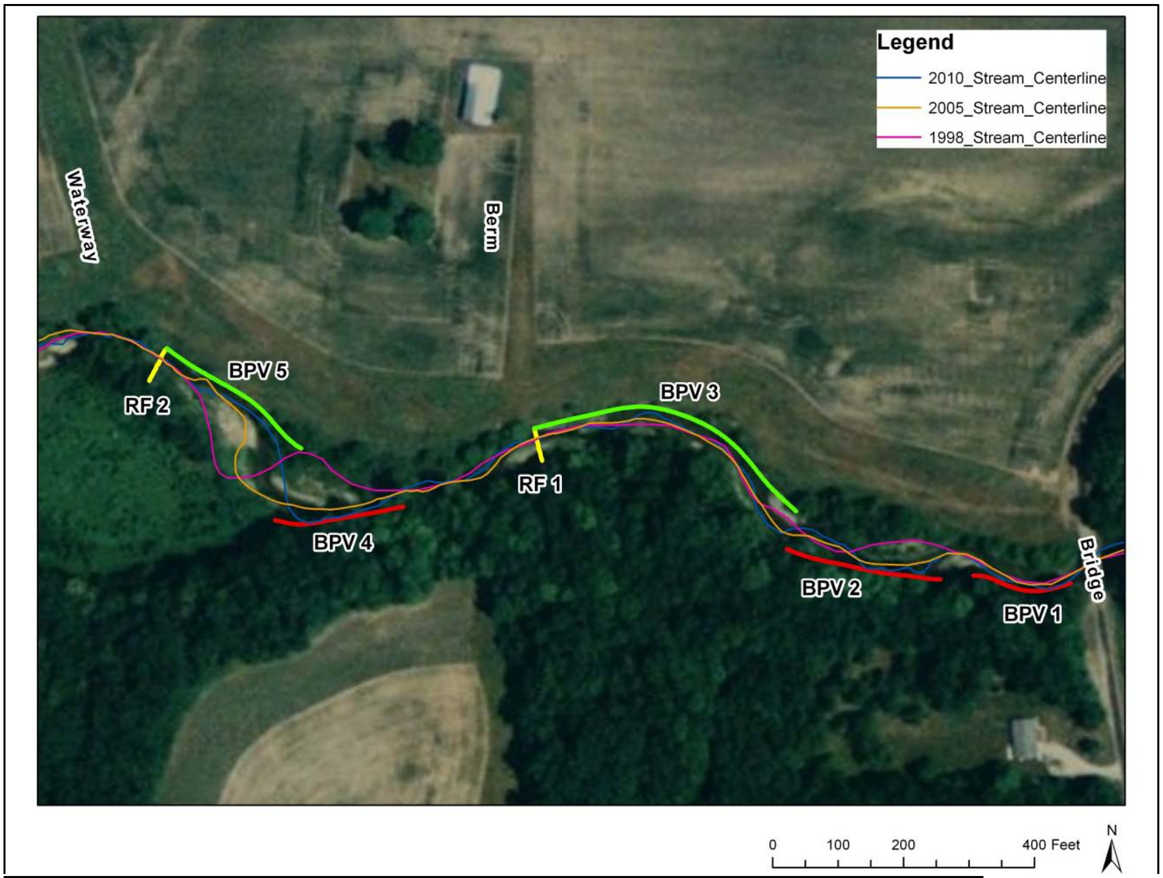
Appendix A – Pre-restoration Photos and Maps

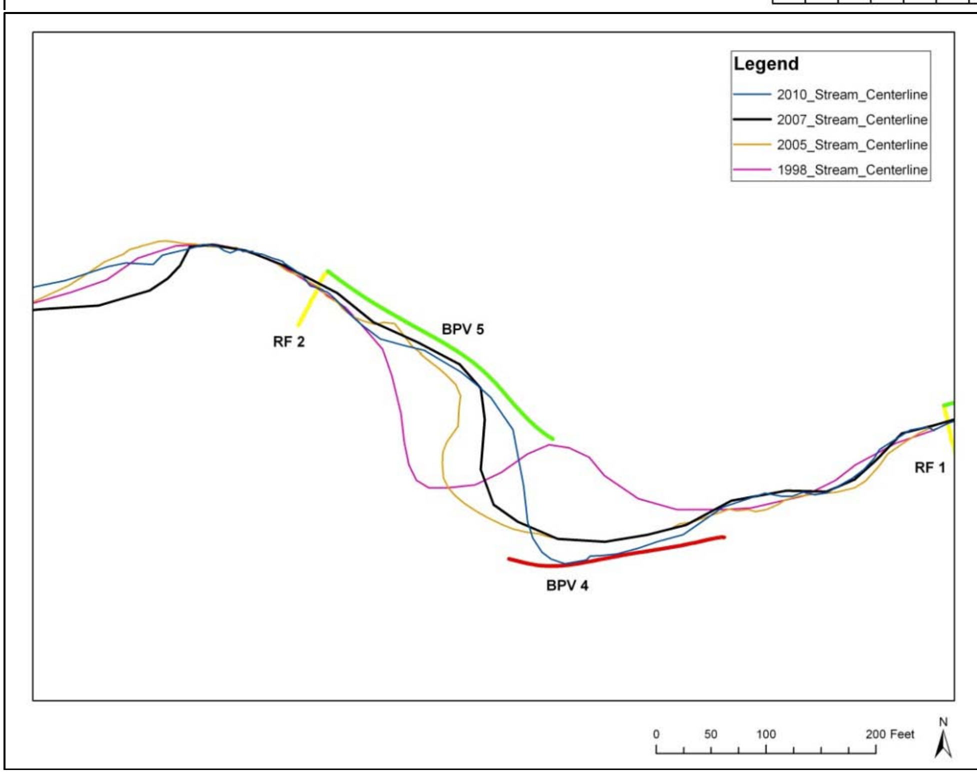

A
BPV3
B
A
RF1
B


BPV4
A
B
RF1
A
B


BPV5
A
B
C
RF2
A
B
C
© AND
Pictome


Bed material deposition on point bar adjacent to eroding bank (BPV5) below upper riffle (RF2) prior to restoration.

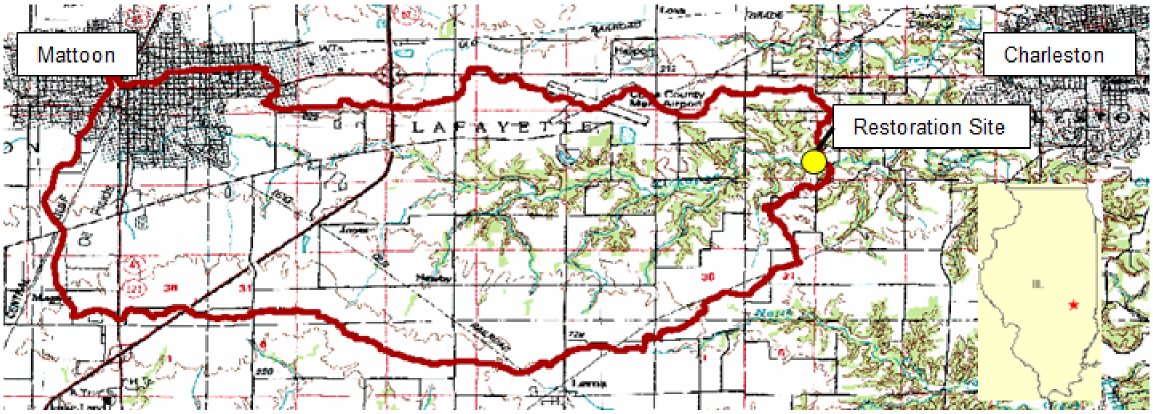




Historical bank erosion within the restored reach (also for perspective, the 1938 Aerial is presented in Appendix B).

Appendix B – 1938 Aerial Photo of the Demonstration Reach

Appendix C – StreamStats Results and Streamflow Stage and Measurements



Watershed delineated in StreamStats upstream of proposed restoration site.

Streamstats Ungaged Site Report

Date: Thu Apr 30 2009 20:55:40
Site Location: Illinois
Latitude (NAD83): 39.4652 (39 27 54)
Longitude (NAD83): -88.2302 (-88 13 48)
Drainage Area: 27.7434 mi2

Peak Flow Basin Characteristics

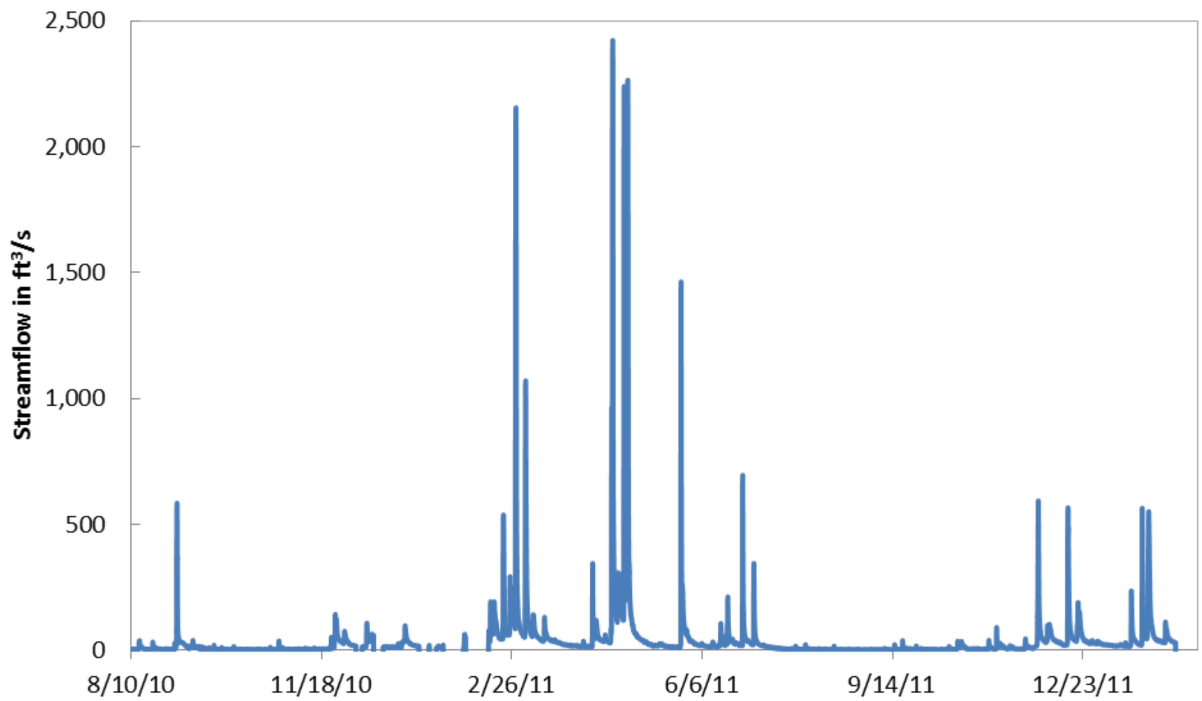
100% Regions 5 AMS (27.743 mi2)

Parameter	Value	Min	Max
Drainage Area (square miles)	27.743	0.03	9554
Stream Slope 10 and 85 Method (feet per mi)	9.184	0.81	317
Average Soil Permeability (inches per hour)	1.392	0.3	8
Region 5 Indicator (enter 1) (dimensionless)	1	0	1

Streamflow Statistics

Statistic	Flow (ft^3/s)	Prediction Error (percent)	Equivalent years of record	90-Percent Prediction Interval	
				Minimum	Maximum
Peak-Flow Statistics					
PK2	1290	40	2.7	693	2390
PK5	2330	40	3.2	1250	4350
PK10	3100	42	3.9	1620	5910
PK25	4130	44	4.7	2080	8190
PK50	4940	47	5.2	2410	10100
PK100	5760	49	5.6	2720	12200
PK500	7790	55	6.2	3400	17800

StreamStats determined watershed characteristics and streamflow statistics.



Streamflow data at Kickapoo Creek near Mattoon

Appendix D – Additional Surveyed Cross-Section Information

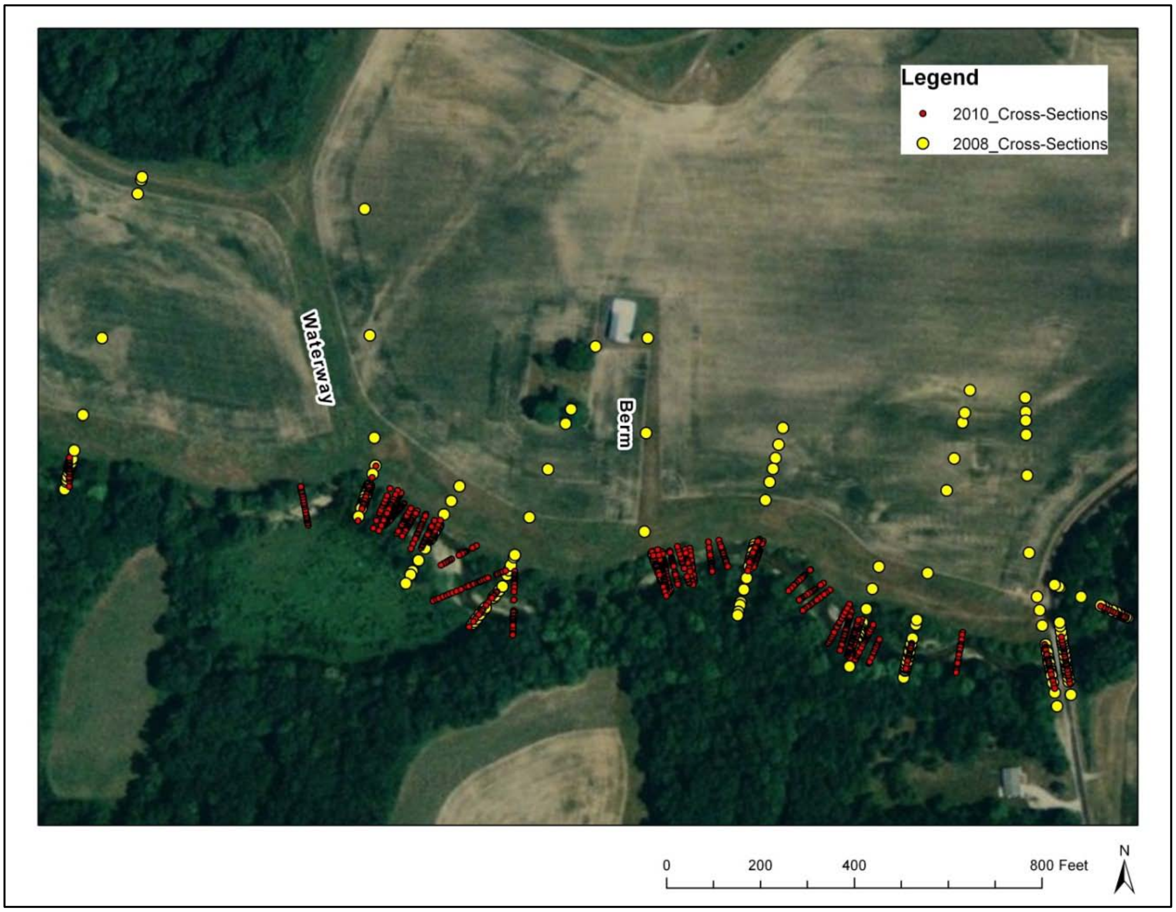


Figure D1. All 2008 and 2010 Survey Data

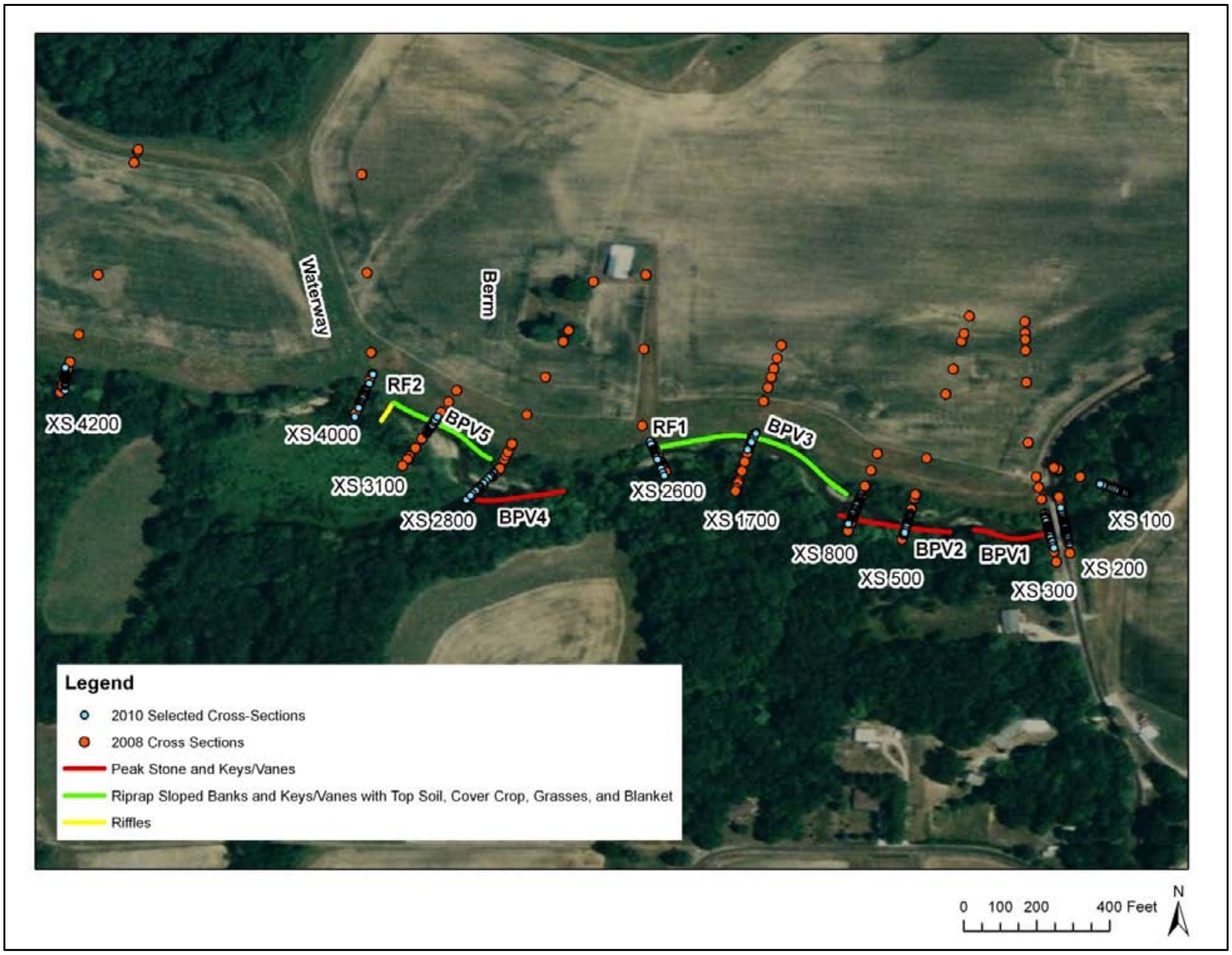


Figure D2. Location of repeated surveyed cross sections in 2008 and 2010

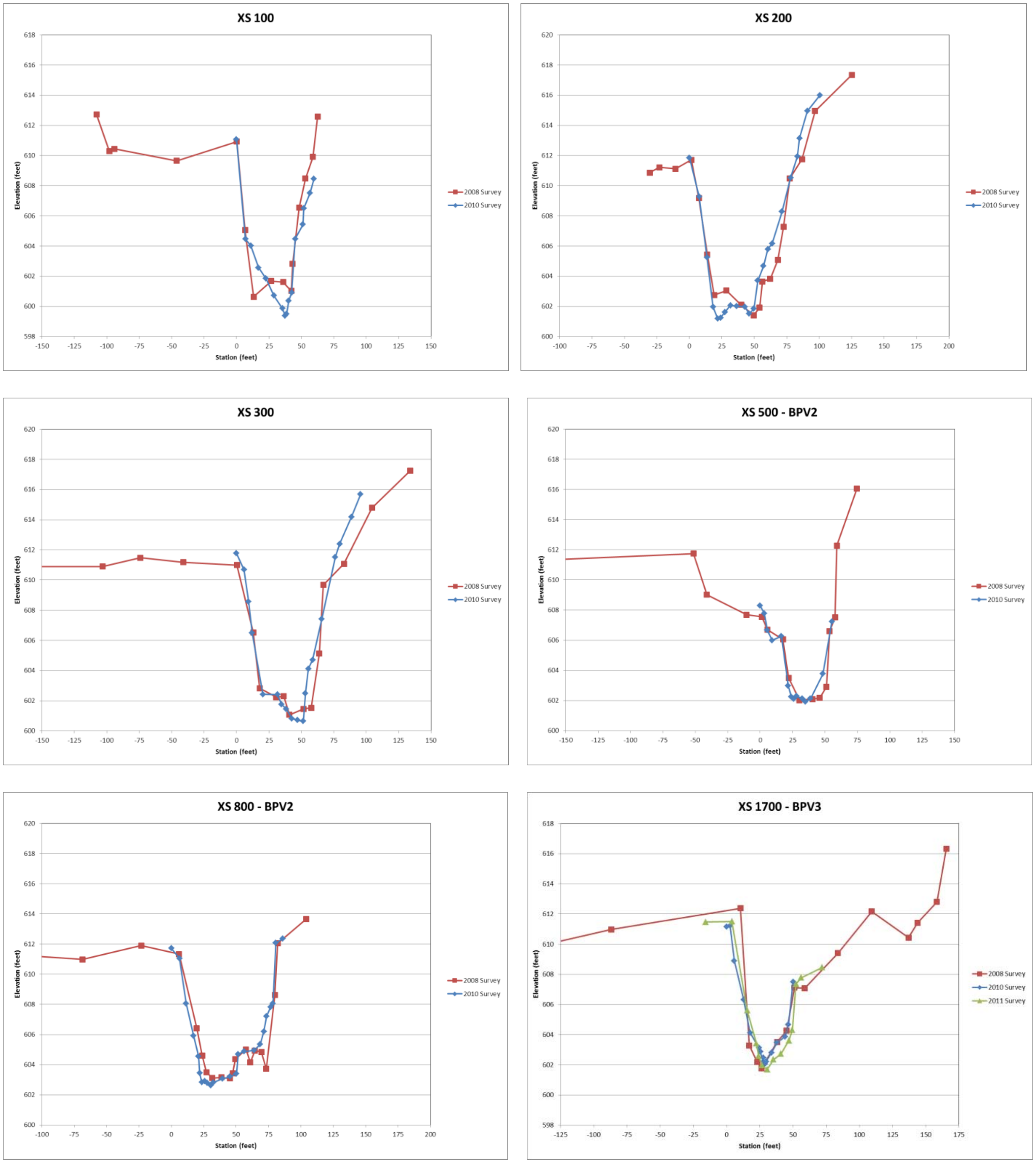


Figure D3. Graphs of repeated surveyed cross sections in 2008, 2010, and 2011.

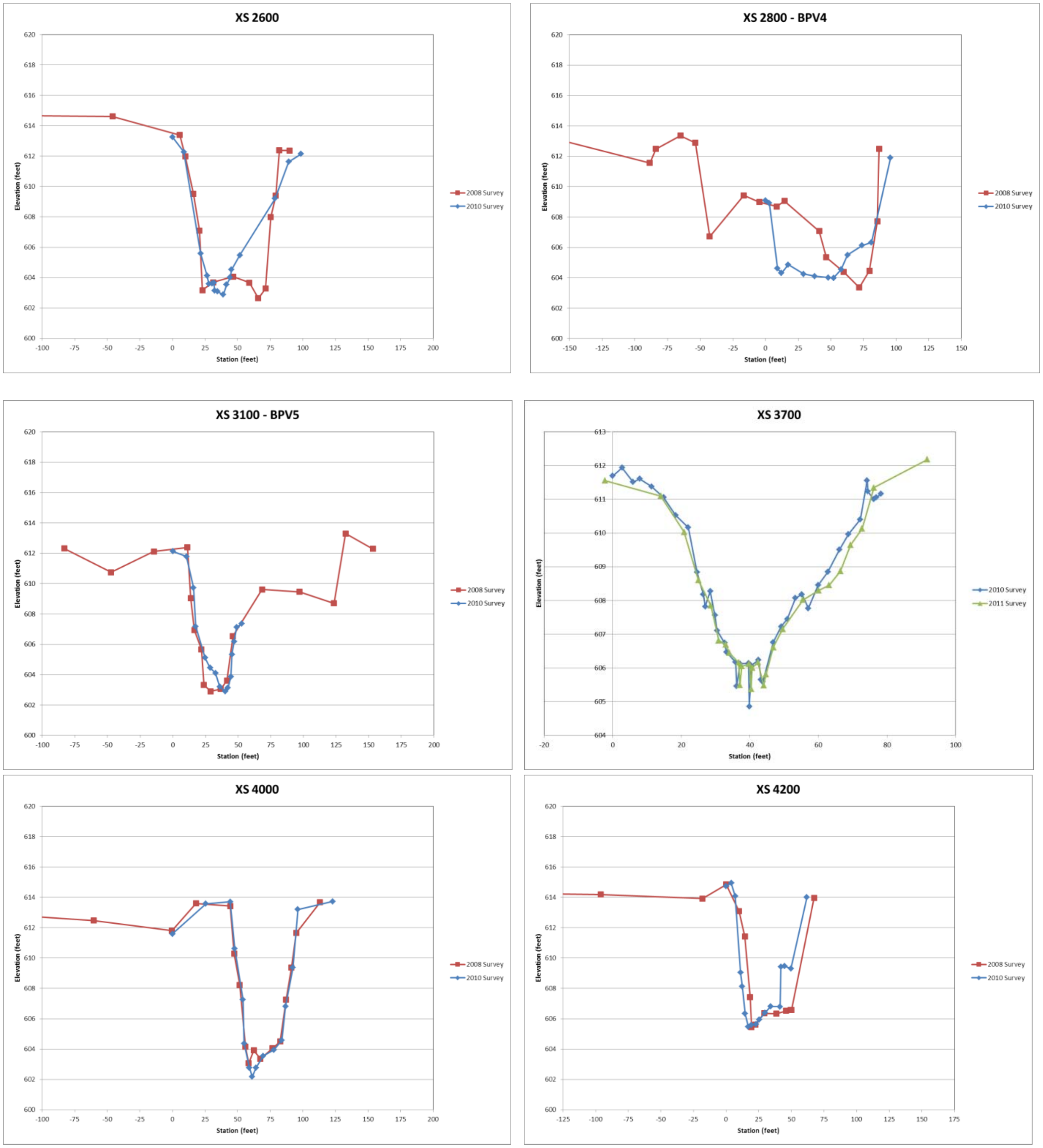


Figure D4. Graphs of repeated surveyed cross sections in 2008, 2010, and 2011 (continued).

The Impacts of Stream Restoration on the Fish and Macroinvertebrate Assemblages in Kickapoo Creek near Charleston Illinois

Final Report

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Fall 2009 through Fall 2011

Submitted June 2012

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INTRODUCTION

During June 2001, approximately 8000 gallons of the chemical solvent furfural were released into Kickapoo Creek near Charleston, Illinois. This chemical spill resulted in the loss of more than 200,000 fish and other aquatic fauna. The company Vesuvius was deemed responsible for the spill and thereby required to provide a monetary restitution to the Illinois Natural Resource Trustees, Illinois Department of Natural Resources (IDNR) and Illinois Environmental Protection Agency (IEPA) with legal representation by the Illinois Attorney General's Office. With the aid of the United States Geological Survey, IDNR attempted to determine a suitable restoration project for Kickapoo Creek. The group determined that massive bank erosion caused by agricultural and urbanization processes has increased sediment deposition in the stream limiting the deepwater pool habitats (essential overwintering habitats for stream fishes) and restoration measures to address such loss of habitat as a result of erosion and deposition would provide benefits to aquatic resources similar to those injured as a result of the subject release.

Agricultural and urbanization practices have caused massive degradation of freshwater ecosystems worldwide. In the Midwestern United States, agricultural practices have impacted as much as 85% of stream ecosystems (Morke and Lamberti 2003). Often, agricultural practices remove riparian (along shore) vegetation, causing increased bank erosion and sedimentation thereby reducing the diversity and productivity of aquatic fauna (Berkman and Rabeni 1987). Although millions of dollars are spent annually on stream restoration and enhancement projects (Roni et al. 2002), few studies have assessed the results of habitat enhancement on aquatic fauna (Berhardt et al. 2005, Baldigo et al. 2008).

Fishes provide reliable indicators of aquatic ecosystem health. They are easily collected and identified. Fish have complex life cycles that require multiple habitat types (Schlosser and Angermeir 1995). Fish community assemblages span multiple trophic levels and therefore have strong effects on ecosystem processes (Vanni 2010). Additionally, the environmental requirements of fishes are well understood. Finally, community indices for stream fishes have been elucidated at both the local and regional scales (Karr et al. 1986).

The benthic macroinvertebrate communities of streams also provide indicators of aquatic ecosystem health. Macroinvertebrates provide an assessment of local conditions due to their poor migration capabilities (Barbour et al. 1999). They have short complex life histories that have life stages that respond to environmental stress quickly (Barbour et al. 1999). Similar to fishes the benthic macroinvertebrate community spans various trophic levels and information on the tolerance values of different macroinvertebrate taxa has been described (Barbour et al. 1999). Additionally, the ease of collection of macroinvertebrates has led to their collection by various state and federal agencies for biotic assessments (Barbour et al. 1999).

Although, anthropogenic influences have led to altered instream physical habitat (Karr 1991), instream habitat quality is of paramount importance to both fish and macroinvertebrate communities. Since both the quality and quantity can have impacts on both the benthic macroinvertebrate and fish communities, it is important to estimate the habitat quality of stream reaches. Several different protocols have been used to assess the habitat quality of wadeable streams. The stream habitat assessment protocol (SHAP) and the qualitative habitat evaluation index (QHEI) (Rankin 1989) have been widely used to assess the quantity of habitats important to stream biota. Currently, the IEPA uses the QHEI to assess the quantity of different instream habitats and uses outputs from the QHEI to determine how much and what habitats will be sampled for macroinvertebrates. Another desirable trait of the QHEI is that it is correlated with both fish (Rankin 1989) and macroinvertebrate (Hammer and Linke 2003, Colombo et al. 2011) indices of biotic integrity.

This study will directly assess the results of stream habitat restoration on the aquatic fauna of a small Midwestern stream. In doing so, we will determine the responses of fish and macroinvertebrate populations to habitat enhancement. Additionally, we are incorporating both upstream and downstream “control” reaches, allowing us to evaluate both the local impacts of restoration (comparisons between the upstream control and restoration reach) and the downstream benefits resulting from upstream enhancement on downstream system function.

METHODS

We are assessing the impact of instream habitat enhancement measures on Kickapoo Creek near Charleston, Illinois. Sampling was conducted at four reaches: A downstream control reach (Site A: 232 m / 760 ft) two reaches that are within the enhancement stretch (Site B: 254 m / 832 ft; Site C: 192 m / 630 ft), one upstream control reach (Site D: 183 m / 600 ft) (Figure 1). During fall 2009 through spring 2012 each reach was sampled for both fish and macroinvertebrates. To assure the same sites are returned to annually, the lengths of the sites were measured and both upstream and downstream limits were marked using a hand held GPS.

Habitat and Water Quality:

A full habitat assessment based on IEPA protocols was completed in the spring of 2010, 2011 and 2012. To assess the habitat we used the qualitative habitat evaluation index (QHEI). The QHEI ranks habitat on a scale from 0 to 100 with higher scores signifying better habitat quality. The ranking is based on six metrics: substrate type, instream cover, channel morphology, riparian zone, pool/riffle quality, and gradient (Rankin 1989, Rankin 2006). We separated each treatment reach into eleven equidistant transects perpendicular to the flow. Along each transect we measured water depth and substrate every two feet encompassing the entire wetted width. Between each two transects we estimated percent habitat type and instream cover, and estimated the riparian zone and channel morphology character. The gradient of each treatment reach was estimated from a topographic map of Coles County. These data were inputted into a Microsoft Excel spreadsheet to estimate effort for the macroinvertebrate 20 jab samples. During fall samples we used an estimation technique based on IEPA protocols to estimate jab allocation. The estimation process included a full site inspection that was compared to the previous QHEI, any drastic changes were noted so that the jab allocation could be modified accordingly. For the water quality measurements a YSI multi-meter was used to assess temperature, dissolved oxygen, conductivity, at three locations within each site during each sampling trip.

Fish

Beginning summer 2009, we sampled fish six times (September 2009, June 2010, September 2010, June 2011, September 2011, and May 2012) at each of the four reaches using an electric seine. Upstream and downstream station limits were set using blocking seines using the methods described in *IDNR-fisheries stream sampling guidelines* (IDNR 2001). Seine operation, crew size, and sampling effort were conducted following guidelines set forth in the *IDNR-fisheries stream sampling guidelines* (IDNR 2001). As a result of the restoration efforts a deep pool formed in the upper treatment site (C) forcing us to use DC electrofishing in the upper 68 m of the site. When possible, fishes greater than 102 mm (4 inches) were weighed, measured, identified to species, and released unharmed. We euthanized all other fishes using a lethal dose of MS-222. We preserved all fishes in 10% Formalin and brought them to the Eastern Illinois University's (EIU) Fisheries Lab for species identification and enumeration. All euthanized fish were weighed, measured, and identified to species. Reference individuals for each species have been preserved and catalogued into the fish collection at EIU. We are currently identifying the fish from the spring 2012 sample; all other samples have been processed and analyzed.

Macroinvertebrates

Macroinvertebrates were sampled six times (fall 2009, 2010, 2011 and spring 2010, 2011, 2012) concurrently with the fish sampling. Macroinvertebrates were sampled using *IEPA's multihabitat 20- jab* method (IEPA 2007). We preserved all macroinvertebrates in 95% ethanol and brought them to the EIU Fisheries Lab for species identification and enumeration. Within one week of sampling, we exchanged the ethanol in the sample containers to ensure quality fixation. All macroinvertebrates were identified to the lowest taxonomic group possible, enumerated, and reference specimens were fixed and catalogued into the EIU invertebrate collection. We are currently identifying the macroinvertebrates from the spring 2012 sample; all other samples have been processed and analyzed.

Data Analysis

Habitat quality – Upon completion of this project we will assess changes to the habitat using ANOVA comparing differences in the QHEI scores among treatment reaches. Additionally, we will use correlation to assess if macroinvertebrate or fish IBI scores were correlated with QHEI scores.

Fish – We used a paired t-test to determine if the relative density as estimated by catch per unit effort and diversity as estimated by Simpson's D were different between the fall and spring samples. On completion of this project ANOVA will be used to determine if relative density (CPUE) differed among treatment reaches. Additionally, ANOVA will be used to assess differences in CPUE within the treatment reach based on before and after data. To assess changes in fish community structure we employed multidimensional scaling (MDS) based on Bray-Curtis Similarity. To assess these data community structure will be standardized based on largest values and square root transformed. To determine if clusters are significantly different we will us analysis of similarity. In all cases we will use a type 1 error rate of $\alpha = 0.05$.

Macroinvertebrates –We analyzed the macroinvertebrates based on Hilsenhoff's Macroinvertebrate Biotic Index (MBI) scores. This index gives a tolerance value between zero and eleven to each macroinvertebrate taxon. For the MBI index, lower values represent a better macroinvertebrate community. We also calculated the percentage of EPT taxa.

RESULTS

Fish Community Assemblage

We sampled a total of 48109 individuals from ten families and 45 species from all sites on Kickapoo creek during fall 2009 through fall 2011 (Table 1). We found Cyprinidae to be the most numerically abundant family comprising 90% of the individuals sampled (Table 1). Over all sites, the sand shiner was the most numerically abundant in terms of total number and average CPUE (Table 2-6). Initially, the silverjaw minnow was the second most dominant species; however, the spotfin shiner population increased substantially subsequent to restoration (Table 2-6). The increase in spotfin shiner was most pronounced in the restored reaches (Table 4 & 5). We found five other families to be prevalent throughout the sampling to date, in order of dominance they were Percidae (3.3%), Centrarchidae (2.8%), Catostomidae (2.1%), and Ictaluridae (1.6%) (Table 2-6).

Of the 34 species that we sampled in the downstream control site (A) two unique species were found (dusky darter and tadpole madtom) (Table 3). In the lower treatment site (B) we sampled a total of 36 species with two species unique to the site (fantail darter and chestnut lamprey) (Table 4). In the upper treatment site (C) we sampled a total of 37 species with four species unique to the site (redear sunfish, highfin carpsucker, shorthead redhorse, and fathead minnow) (Table 5). In the upstream control site (D) we sampled a total of 29 species none of which were unique (Table 6). We found a total of 40 species during fall sampling with eleven unique species (Table 7). During spring, we found a total of 35 species of which five were unique (Table 7)

Based on Bray-Curtis similarity, we found significant changes in community similarity between and within sampling periods. We found that the restored reaches had a different community assemblage than did the control reach (Figure 2, ANOSIM, $p < 0.05$). This difference can be attributed to the increase in proportion of suckermouth minnow, redfin shiner, striped shiner and golden redhorse, centrarchids, and spotfin shiner in the restored reaches that was not as pronounced in the control reaches (Table 2-6). There was a significant difference in fish community assemblages among samples in the restoration reach (Figure 2, ANOSIM, $p < 0.03$). In the restoration reach the post-restoration (spring 2011 & fall 2011) fish community assemblages were significantly different than pre-restoration sampling (fall 2009 & spring 2010) (ANOSIM, $p < 0.004$); These differences can be attributed to both an increase in the overall density of fishes in the restoration and changes in density of the gizzard shad, suckermouth minnow, redfin shiner, spotfin shiner, and golden shiner. There was no difference in the fish community assemblage in the restored reaches between the pre and during samples nor the during and post samples (Figure 4, ANOSIM, $p > 0.05$). We found no significant difference among samples in the control reaches (ANOSIM $p > 0.05$). Although the relative density of fishes in these sites did increase the differences the proportions of each taxa remained relatively similar.

We found a difference in fish community assemblage among seasons over all sites (Figure 5, ANOSIM, $p < 0.003$). Fall samples had significantly higher densities and changes in the community most impacted by changes in suckermouth minnow, central stoneroller, largemouth bass, and johnny darter.

Fish Density

Overall, density of fishes was higher in the fall compared to the spring (Figure 6, t-test $p < 0.05$). Additionally the species diversity (D), relative density (CPUE), and evenness (E) were significantly higher in the fall compared to the spring (Table 8, $p < 0.05$). Overall the relative density was higher in the restored sites compared to the control sites (Table 8); however, this difference was not significant (ANOVA $p < 0.05$). Additionally, diversity and evenness was similar between control and restored sites Table 8).

Immediately following restoration we saw a large increase in the overall CPUE in both the restored and control reaches (Figure 7-8). The increase in the relative density remained high during the spring 2010 and fall 2011 (post-restoration) samples (Figure 7-8). This large increase in CPUE was largely influenced by an increase in Cyprinidae (Figure 8); however, there was also a large spike in the abundance of Catostomidae subsequent to restoration (Figure 11). The Percidae seemed to be a seasonal variation in catch with higher catches in the fall compared to the spring samples (Figure 10). We also saw a general decrease in the percids through the entire project (Figure 10); the differences in relative abundance were not significant (ANOVA, $p < 0.05$). Relative density of Centrarchidae showed an initial decrease in the treatment reach directly subsequent to restoration (Figure 12); however, there was a large increase of centrarchids in the treatment reaches during the post-restoration samples (Figure 12). Both the bluegill and the longear sunfish relative density increased dramatically in the restored reaches in the spring 2011 and fall 2011 samples (Figure 13). This increase in Lepomis was not seen in the control reaches during the same time period (Figure 13). The Ictaluridae showed an initial decrease in the treatment reaches subsequent to restoration (Figure 14); however, there was a large increase in their relative density in the in the fall 2011 post restoration sample (Figure 14).

Our sampling revealed a large increase in the relative density and total number of the genus Cyprinella subsequent to restoration. The spotfin and steelcolor shiner numbers per sample and CPUE increased by an order of magnitude in the fall 2010 sample and remained high in the spring 2011 and fall 2011 samples (Table 2, Figure 13). We found that the central stoneroller along with the Percidae showed strong seasonality in relative density. Both the stonerollers (Figure 14) and darters (Figure 10) had higher relative density during fall sampling. Subsequent to restoration there were spikes relative to density of intolerant and tolerant fish species (Figures 17 & 18); however, these increases did not continue as the relative density was similar to pre restoration samples in the fall 2011 sample (Figure 17 & 18)

Habitat

As estimated by the QHEI, pre-restoration habitat quality ranged from a low of 64 in the lower treatment reach to a high of 73.5 in the downstream control reach (Table 9-12, Figure 15). There was an increase in the QHEI scores in the treatment reaches in the post-restoration sample (Tables 13-16, Figure 15). Based on these scores all of the sites would be designated as good quality (Rankin 2006).

Macroinvertebrates

We identified 5698 different macroinvertebrates from 12 invertebrate orders (Table 17). The most numerically abundant taxa was diptera comprising 61% of the individuals. We identified three families of diptera with chironomidae being by far the most abundant family. Both mayflies and caddisflies were also fairly abundant comprising 28% of the individuals. The mayflies and caddisflies were the dominant group in the fall 2011(post restoration) sample comprising 64% of the individuals identified (Table 17).

There were large differences in the macroinvertebrate communities between seasons. The MBI scores of the spring samples averaged 7.8 pre restoration and 7.4 post restoration (Figure 20). The MBI of the fall samples averaged 5.9 during restoration and 4.88 post restoration (Figure 20). The fall 2011 MBI score in the restored reach (4.39) was the lowest recorded in the study. Additionally, we saw a large increase in the %EPT taxa in the fall 2011 sample in both the control and restored reaches (Figure 21).

Water Quality

All water quality parameters were within acceptable ranges for the support of fish and macroinvertebrate communities (Table 18)

DISCUSSION

The results of the first five sampling runs have produced some interesting trends. There is an apparent difference in seasonal density and diversity. There are several species that show large changes in relative density seasonally (central stoneroller, steelcolor shiner, and many percids) all of which tended to have higher density in the fall sampling compared to the spring. Seasonal difference in diversity, community structure, and density suggests that a standardized sampling protocol for fish community structure include season as a variable.

We saw a large increase in relative density of fishes one week subsequent to restoration. This increase was largely due to an increase in the cyprinids in the treatment reaches. We did see an apparent decrease in centrarchids directly subsequent to restoration; however, the spring 2011 and fall 2011 sample had an increase in this family that was most pronounced in the restored reaches. The initial increase in cyprinids and decrease in centrarchids may be an effect of differential dispersal between the groups. The cyprinids often have large shoals that can reestablish quickly, while the centrarchids are often territorial and solitary leading to a slower dispersal rate.

We saw a change in fish community structure subsequent to restoration. The MDS suggested the post-restoration sample community structure was different than both the pre-restoration and the during restoration sample. In the spring 2011 and fall 2011, post-restoration sample, we found two species that are not often associated with small streams, but are common in the mainstem Embarras. The brook silverside and the gizzard shad were both found in the newly formed deep pools in the treatment reaches. Gizzard shad were still found in the treatment reaches during the fall 2011 sample. Additionally, in the fall 2011 sample we saw a large increase in the number of centrarchids in the restored reaches. Bluegill and longear sunfish densities were high in the rocky habitats that were formed by the restoration. Anecdotally, this trend continued in the spring 2012 sample along with a large increase in the relative density of Ictalurids.

Restoration did cause a change in the available habitats in the treatment reaches. There was a large increase in the deep pools in the treatment reaches. This increase in the amount of the deep pools may have contributed to the increase in QHEI in the treatment reaches.

Similar to the results of the fish assessment the macroinvertebrate assemblages changed seasonally. This can be attributed to the lack of Ephemeroptera sampled in the spring. Mayflies are often in early instars during spring that are not effectively sampled by the 20 jab sampling. These data suggest that season should be considered when designing a project dealing with macroinvertebrates.

Restoration did seem to positively impact the assemblage of macroinvertebrates. There was a large decrease in the in Hilsenhoff's MBI in the fall 2011 sample attributed to a large increase in the mayfly and caddisfly abundance in the restoration reach. The increase in mayfly abundance could be attributed to the increase in riffle habitat in the restored reach. Because of the small sample size and large seasonality differences in the MBI there is little statistical power to assess the impacts of restoration on the MBI; therefore we were forced to look at trends in the data.

We did take additional samples of fishes, macroinvertebrates, and habitats during the spring of 2012 we are continuing to process these samples and an amended final report will be made available once these samples are completely processed.

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Tables and Figures

Table 1: Summary of all fishes sampled from all sites in Kickapoo Creek during fall 2009, 2010, 2011 and spring 2010, 2011. A total of 46 species from ten families have been sampled.

Family	Common Name	Scientific Name	Number
Cyprinidae	Sand shiner	*Notropis stramineus*	13219
Cyprinidae	Spotfin shiner	*Cyprinella spiloptera*	9517
Cyprinidae	Silverjaw minnow	*Ericymba buccatus*	8183
Cyprinidae	Bluntnose minnow	*Pimephales notatus*	5102
Cyprinidae	Central stoneroller	*Campostoma anomalum*	4048
Cyprinidae	Creek chub	*Semotilus atromaculatus*	1346
Cyprinidae	Steelcolor shiner	*Cyprinella whipplei*	1211
Ictaluridae	Brindled madtom	*Noturus miurus*	678
Catostomidae	Northern hogsucker	*Hypentelium nigricans*	602
Percidae	Orangethroat darter	*Etheostoma spectabile*	597
Centrarchidae	Bluegill	*Lepomis macrochirus*	494
Percidae	Johnny darter	*Etheostoma nigrum*	464
Centrarchidae	Green sunfish	*Lepomis cyanellus*	392
Centrarchidae	Longear sunfish	*Lepomis megalotis*	380
Catostomidae	White sucker	*Catostomus commersonii*	347
Cyprinidae	Suckermouth minnow	*Phenacobius mirabilis*	274
Percidae	Greenside darter	*Etheostoma blennioides*	265
Percidae	Rainbow darter	*Etheostoma caeruleum*	262
Fundulidae	Blackstriped	*Fundulus notatus*	129
Cyprinidae	Redfin shiner	*Lythrurus umbratilis*	120
Centrarchidae	Largemouth bass	*Micropterus salmoides*	85
Ictaluridae	Yellow bullhead	*Ameiurus natalis*	68
Catostomidae	Golden redhorse	*Moxostoma erythrurum*	67
Clupeidae	Gizzard shad	*Dorosoma cepedianum*	62
Cyprinidae	Bullhead minnow	*Pimephales vigilax*	59
Cyprinidae	Striped shiner	*Luxilus chrysocephalus*	55
Catostomidae	Quillback	*Carpiodes cyprinus*	22
Atherinidae	Brook silverside	*Labidesthes sicculus*	14
Catostomidae	Creek chubsucker	*Erimyzon oblongus*	7
Cyprinidae	Golden shiner	*Notemigonus crysoleucas*	6
Poeciliidae	Mosquitofish	*Gambusia affinis*	6
Centrarchidae	Spotted bass	*Micropterus punctulatus*	4
Lepisosteidae	Longnose gar	*Lepisosteus osseus*	4
Cyprinidae	Mississippi Silvery	*Hybognathus Nuchalis*	3
Percidae	Logperch	*Percina caprodes*	3
Ictaluridae	Channel catfish	*Ictalurus punctatus*	3
Centrarchidae	Redear sunfish	*Lepomis microlophus*	2
Ictaluridae	Black Bullhead	*Ameiurus melas*	2
Cyprinidae	Fathead minnow	*Pimephales promelas*	1
Percidae	Dusky darter	*Percina sciera*	1
Percidae	Fantail darter	*Etheostoma flabellare*	1
Catostomidae	Highfin carpsucker	*Carpiodes velifer*	1
Catostomidae	Shorthead redhorse	*Moxostoma macrolepidotum*	1
Ictaluridae	Tadpole madtom	*Noturus gyrinus*	1
Petromyzontidae	Chestnut lamprey	*Ichthyomyzon castaneus*	1
Total			48109

Table 2: Summary of CPUE (Fish/Hr) for individual species sampled from all sites of Kickapoo Creek during fall 2009, 2010, 2011 and spring 2010, 2011.

	Sample					
Common Name	Fall ‘09	Spring ‘10	Fall ‘10	Spring ‘11	Fall ‘11	Mean
Sand shiner	315.28	242.32	589.02	582.66	751.85	496.23
Spotfin shiner	42.69	48.12	429.47	329.70	840.56	338.11
Silverjaw minnow	370.61	297.10	440.15	190.04	321.11	323.80
Bluntnose minnow	133.14	70.43	213.68	168.08	370.37	191.14
Central stoneroller	190.74	56.23	222.56	84.87	214.63	153.81
Creek chub	57.60	31.59	106.32	26.01	29.81	50.27
Steelcolor shiner	15.16	1.45	70.08	35.79	90.00	42.50
Brindled madtom	25.52	15.65	22.26	27.12	42.22	26.55
Northern hogsucker	13.64	7.54	58.95	11.25	12.78	20.83
Orangethroat darter	40.93	13.04	30.23	8.30	26.67	23.83
Bluegill	22.23	0.87	9.02	31.55	31.85	19.11
Johnny darter	16.67	2.32	35.94	6.09	21.85	16.57
Green sunfish	17.94	11.30	13.83	16.05	19.07	15.64
Longear sunfish	21.73	6.38	4.96	13.65	30.56	15.45
White sucker	17.43	3.77	24.21	11.07	8.15	12.93
Suckermouth minnow	34.11	1.74	8.72	3.32	10.56	11.69
Greenside darter	27.03	12.46	8.42	7.75	3.15	11.76
Rainbow darter	18.44	9.86	12.48	7.75	5.56	10.82
Blackstripe topminnow	4.55	4.93	2.26	1.11	13.52	5.27
Redfin shiner	6.06	3.48	9.47	1.11	2.78	4.58
Largemouth bass	9.09	0.00	1.20	0.74	6.85	3.58
Yellow bullhead	4.29	0.58	1.50	4.06	3.15	2.72
Golden redhorse	9.85	4.35	0.60	0.18	1.48	3.29
Gizzard shad	0.00	0.00	0.00	8.30	3.15	2.29
Bullhead minnow	0.00	0.00	0.00	0.00	10.93	2.19
Striped shiner	8.84	3.48	0.45	0.37	0.56	2.74
Quillback	0.00	2.90	0.00	0.00	2.22	1.02
Brook silverside	0.00	0.00	2.11	0.00	0.00	0.42
Creek chubsucker	0.76	1.16	0.00	0.00	0.00	0.38
Golden shiner	0.00	0.00	0.00	1.11	0.00	0.22
Mosquitofish	0.00	0.00	0.00	0.00	1.11	0.22
Spotted bass	0.51	0.00	0.30	0.00	0.00	0.16
Longnose gar	0.00	0.29	0.00	0.55	0.00	0.17
Silvery minnow	0.00	0.00	0.00	0.00	0.56	0.11
Logperch	0.00	0.58	0.00	0.00	0.19	0.15
Channel catfish	0.25	0.00	0.15	0.00	0.19	0.12
Redear sunfish	0.00	0.00	0.00	0.00	0.37	0.07
Black bullhead	0.00	0.00	0.15	0.18	0.00	0.07
Fathead minnow	0.00	0.00	0.15	0.00	0.00	0.03
Dusky darter	0.00	0.29	0.00	0.00	0.00	0.06
Fantail darter	0.00	0.00	0.15	0.00	0.00	0.03
Highfin carpsucker	0.00	0.29	0.00	0.00	0.00	0.06
Shorthead redhorse	0.00	0.00	0.15	0.00	0.00	0.03
Tadpole madtom	0.00	0.00	0.15	0.00	0.00	0.03
Chestnut lamprey	0.00	0.00	0.00	0.18	0.00	0.04

Table 3. Summary of all fishes sampled from the downstream control site (downstream coordinates: N 39.46689, W 088.22843; upstream coordinates: N 39.46557, W 088.22964) during fall 2009, 2010, 2011 and spring 2010, 2011. A total of 34 species was sampled from the downstream control site.

	Sample					
Common Name	Fall '09	Spring '10	Fall '10	Spring '11	Fall '11	Total
Sand shiner	279	239	600	234	1066	2418
Silverjaw minnow	435	234	358	188	327	1542
Spotfin shiner	51	30	380	326	651	1438
Bluntnose minnow	101	65	66	187	248	667
Central stoneroller	106	6	108	10	80	310
Creek chub	73	32	144	41	15	305
Steelcolor shiner	25	0	50	36	145	256
Brindled madtom	43	13	52	23	46	177
Northern hogsucker	8	5	78	4	8	103
Orangethroat darter	25	18	38	3	8	92
Green sunfish	18	2	31	15	16	82
Johnny darter	17	0	43	7	7	74
Longear sunfish	19	1	12	14	8	54
White sucker	23	2	21	4	2	52
Bluegill	11	0	19	9	8	47
Greenside darter	18	7	11	4	1	41
Rainbow darter	10	6	19	1	2	38
Blackstripe topminnow	5	3	0	1	25	34
Redfin shiner	8	1	13	0	0	22
Suckermouth minnow	12	0	7	0	1	20
Yellow bullhead	4	0	6	7	2	19
Bullhead minnow	0	0	0	0	16	16
Largemouth bass	8	0	1	0	1	10
Striped shiner	5	0	2	0	0	7
Golden redhorse	4	0	0	1	0	5
Channel catfish	0	0	1	0	1	2
Creek chubsucker	2	0	0	0	0	2
Mosquitofish	0	0	0	0	2	2
Tadpole madtom	0	0	1	0	0	1
Quillback	0	0	0	0	1	1
Longnose gar	0	1	0	0	0	1
Dusky darter	0	1	0	0	0	1
Gizzard shad	0	0	0	1	0	1
Golden shiner	0	0	0	1	0	1
Total	1310	666	2061	1117	2687	5154

Table 4. Summary of all fishes sampled from the lower treatment site (downstream coordinates: N 39.46509, W 088.23048; upstream coordinates: N 39.46572, W 088.23318) during fall 2009, 2010, 2011 and spring 2010, 2011. A total of 36 species was sampled from the lower treatment reach.

	Sample					
Common Name	Fall ‘09	Spring ‘10	Fall ‘10	Spring ‘11	Fall ‘11	Total
Sand shiner	311	399	1427	851	1627	4615
Spotfin shiner	13	81	834	625	2042	3595
Silverjaw minnow	580	594	1066	357	601	3198
Bluntnose minnow	231	121	711	354	1344	2761
Central stoneroller	146	158	465	369	460	1598
Creek chub	41	48	205	27	48	369
Steelcolor shiner	8	2	138	65	147	360
Orangethroat darter	50	15	85	20	67	237
Brindled madtom	13	18	41	39	118	229
Northern hogsucker	27	14	100	33	42	216
Longear sunfish	32	10	13	17	112	184
Bluegill	57	1	6	49	57	170
Johnny darter	8	7	73	12	62	162
Green sunfish	29	14	23	41	40	147
White sucker	25	7	60	22	12	126
Rainbow darter	18	24	28	21	10	101
Greenside darter	23	28	8	18	7	84
Blackstripe topminnow	8	13	5	3	42	71
Redfin shiner	13	6	39	1	6	65
Suckermouth minnow	8	4	18	2	13	45
Golden redhorse	29	8	2	0	2	41
Largemouth bass	16	0	2	0	15	33
Gizzard shad	0	0	0	25	4	29
Striped shiner	8	5	0	1	3	17
Bullhead minnow	0	0	0	0	15	15
Yellow bullhead	8	2	0	2	2	14
Brook silverside	0	0	13	0	0	13
Quillback	0	0	0	0	7	7
Mosquitofish	0	0	0	0	4	4
Golden shiner	0	0	0	3	0	3
Spotted bass	2	0	1	0	0	3
Silvery minnow	0	0	0	0	2	2
Fantail darter	0	0	1	0	0	1
Creek chubsucker	0	1	0	0	0	1
Chestnut lamprey	0	0	0	1	0	1
Logperch	0	1	0	0	0	1
Total	1647	1581	5364	2958	6911	18518

Table 5. Summary of all fishes sampled from the upper treatment site (downstream coordinates N 39.46573 W 088.23320; upstream coordinates N 39.46617 W 088.23545) during fall 2009, 2010, 2011 and spring 2010, 2011. A total of 37 species was sampled from the upper treatment reach.

	Sample					
Common Name	Fall '09	Spring '10	Fall '10	Spring '11	Fall '11	Total
Sand shiner	362	156	1340	1385	847	4090
Spotfin shiner	51	48	996	448	1461	3004
Silverjaw minnow	281	194	1077	303	347	2202
Bluntnose minnow	136	54	521	266	297	1274
Central stoneroller	267	24	673	34	166	1164
Steelcolor shiner	21	1	216	47	94	379
Creek chub	32	23	195	42	24	316
Bluegill	16	2	18	98	103	237
Northern hogsucker	8	6	112	17	10	153
White sucker	16	4	61	34	28	143
Longear sunfish	31	11	7	41	40	130
Green sunfish	17	23	24	24	40	128
Johnny darter	26	1	53	7	28	115
Orangethroat darter	21	10	44	5	27	107
Brindled madtom	18	12	15	33	29	107
Largemouth bass	9	0	4	4	21	38
Redfin shiner	3	5	11	5	9	33
Gizzard shad	0	0	0	19	13	32
Rainbow darter	7	1	11	9	3	31
Bullhead minnow	0	0	0	0	27	27
Striped shiner	21	2	0	0	0	23
Blackstripe topminnow	5	1	8	1	5	20
Greenside darter	4	1	1	9	2	17
Golden redhorse	6	7	0	0	4	17
Suckermouth minnow	0	0	14	0	1	15
Quillback	0	10	0	0	4	14
Yellow bullhead	1	0	0	4	7	12
Creek chubsucker	1	3	0	0	0	4
Longnose gar	0	0	0	3	0	3
Logperch	0	1	0	0	1	2
Redear sunfish	0	0	0	0	2	2
Black bullhead	0	0	0	1	0	1
Brook silverside	0	0	1	0	0	1
Shorthead redhorse	0	0	1	0	0	1
Highfin carpsucker	0	1	0	0	0	1
Total	1360	601	5404	2839	3640	13845

Table 6. Summary of all fishes sampled from the upstream control site (downstream coordinates: N 39.46897 W 088.24810; upstream coordinates: N 39.46922 W 088.24988 during fall 2009, 2010, 2011 and spring 2010, 2011. A total of 27 species was sampled from the upstream control reach during fall 2009, 2010, 2011 and spring 2010, 2011

	Sample					
Common Name	Fall '09	Spring '10	Fall '10	Spring '11	Fall '11	Total
Sand shiner	296	42	550	688	520	2096
Spotfin shiner	54	7	646	388	385	1480
Silverjaw minnow	171	3	426	182	459	1241
Central stoneroller	236	6	234	47	453	976
Bluntnose minnow	59	3	123	104	111	400
Creek chub	82	6	163	31	74	356
Steelcolor shiner	6	2	62	46	100	216
Suckermouth minnow	115	2	19	16	42	194
Brindled madtom	27	11	40	52	35	165
Orangethroat darter	66	2	34	17	42	161
Northern hogsucker	11	1	102	7	9	130
Greenside darter	62	7	36	11	7	123
Johnny darter	15	0	70	7	21	113
Rainbow darter	38	3	25	11	15	92
Bluegill	4	0	17	15	4	40
Green sunfish	7	0	14	7	7	35
White sucker	5	0	19	0	2	26
Yellow bullhead	4	0	4	9	6	23
Longear sunfish	4	0	1	2	5	12
Striped shiner	1	5	1	1	0	8
Golden redhorse	0	0	2	0	2	4
Blackstripe topminnow	0	0	2	1	1	4
Largemouth bass	3	0	1	0	0	4
Channel catfish	1	0	0	0	0	1
Golden shiner	0	0	0	1	0	1
Silvery minnow	0	0	0	0	1	1
Black bullhead	0	0	1	0	0	1
Spotted bass	0	0	0	0	0	1
Bullhead minnow	0	0	0	0	0	1
Total	1265	100	2593	1643	2302	7905

Table 7: Summary of all fishes sampled by season from all site of Kickapoo Creek during fall 2009, 2010, 2011 and spring 2010, 2011. There were 11 unique species captured in the fall and 5 unique species captured in the spring.

	Season	
Common Name	Fall	Spring
Sand shiner	9225	3994
Spotfin shiner	7564	1953
Silverjaw minnow	6128	2055
Bluntnose minnow	3948	1154
Central stoneroller	3394	654
Creek chub	1096	250
Steelcolor shiner	1012	199
Northern hogsucker	515	87
Orangethroat darter	507	90
Brindled madtom	477	201
Johnny darter	423	41
Bluegill	320	174
Longear sunfish	284	96
White sucker	274	73
Green sunfish	266	126
Suckermouth minnow	250	24
Rainbow darter	186	76
Greenside darter	180	85
Blackstripe topminnow	106	23
Redfin shiner	102	18
Largemouth bass	81	4
Bullhead minnow	59	0
Golden redhorse	51	16
Yellow bullhead	44	24
Striped shiner	41	14
Gizzard shad	17	45
Brook silverside	14	0
Quillback	12	10
Mosquitofish	6	0
Spotted bass	4	0
Creek chubsucker	3	4
Silvery minnow	3	0
Channel catfish	3	0
Redear sunfish	2	0
Logperch	1	2
Black bullhead	1	1
Tadpole madtom	1	0
Shorthead redhorse	1	0
Fantail darter	1	0
Fathead minnow	1	0
Golden shiner	0	6
Longnose gar	0	4
Highfin carpsucker	0	1
Dusky darter	0	1
Chestnut lamprey	0	1
Total	36603	11505

Table 8. Summary statistics for the fish community sampled from Kickapoo Creek during fall 2009 through fall 2011.

Sample	Richness	CPUE (Fish/hr)	CPUE (Fish/m)	Simpson's D	Simpson's E
Treatment Reaches	42	2148.2	13.65	6.00	0.14
Fall 2009	26	1414.5	6.80	5.92	0.23
Spring 2010	27	1103.0	4.38	4.67	0.17
Fall 2010	27	2544.6	22.82	6.17	0.23
Spring 2011	28	1979.1	14.00	4.47	0.16
Fall 2011	31	3897.3	24.97	4.94	0.16
Control Reaches*	37	1604.5	7.60	6.13	0.17
Fall 2009	26	1474.7	6.29	7.24	0.28
Spring 2010	21	451.6	1.71	4.09	0.19
Fall 2010	28	1986.8	11.73	6.54	0.23
Spring 2011	24	1386.5	6.90	4.75	0.20
Fall 2011	27	2320.5	12.04	5.30	0.19
Seasons	42	1542.6	9.33	6.13	0.14
Fall*	40	1855.2	11.90	6.36	0.16
Spring	34	1230.0	6.75	5.10	0.15

Table 9. QHEI Scoring summary for the downstream control reach pre-restoration (downstream coordinates: N 39.46689 W 088.22843; upstream coordinates: N 39.46557 W 088.22964) of Kickapoo Creek Near Charleston, IL.

				Stream:	Kickapoo Creek
				Station:	BEN-02A
	QHEI SCORING SUMMARY (Maximum = 100)			Date:	7/1/10
QHEI METRICS			Metric Component	Scoring Range	Scores
1	Substrate		a) Type	0 to 21	21
			b) Quality	-5 to 3	1.5
			Total Substrate Score (max = 20):		20
2	Instream Cover		a) Type	0 to 10	10
			b) Amount	1 to 11	2
			Total Instream Cover Score (max = 20):		12
3	Channel Morphology		a) Sinuosity	1 to 4	3
			b) Development	1 to 7	5
			c) Channelization	1 to 6	6
			d) Stability	1 to 3	2
			Total Channel Morphology Score (max = 20):		16
4	Riparian Zone & Bank Erosion		a) Width	0 to 4	2.5
			b) Quality	0 to 3	1.5
			c) Bank Erosion	1 to 3	2
			Total Riparian Zone & Bank Erosion Score (max = 10):		6
5	Pool/Glide & Riffle/Run Quality				
	5 A) Pool Quality:		a) Max. Depth	0 to 6	4
			b) Current	-2 to 4	3
			c) Morphology	0 to 2	2
			Total Pool/Currrent Score (max = 12):		9
	5 B) Riffle Quality:		a) Riffle Depth	0 to 2	2
			b) Run Depth	0 to 2	2
			c) Substr. Stab.	0 to 2	0
			d) Substr. Embd.	-1 to 2	0
			Total Riffle/Run Score (max = 8):		4
6	Gradient			2 to 10	6
			Total QHEI Score (max = 100):		73
			Subjective Rating (1-10):		7
			Aesthetic Rating (1-10):		7

Table 10. QHEI Scoring summary for the lower treatment reach pre-restoration (downstream coordinates: N 39.46509 W 088.23048; upstream coordinates: N 39.46572 W 088.23318) of Kickapoo Creek near Charleston, IL.

					Stream:	Kickapoo Creek
					Station:	BEN-02B
	QHEI SCORING SUMMARY (Maximum = 100)				**Date:**	6/4/10
QHEI METRICS			**Metric Component**		**Scoring Range**	**Scores**
1	**Substrate**		**a) Type**		**0 to 21**	15
			b) Quality		**-5 to 3**	0.5
			Total Substrate Score (max = 20):			**15.5**
2	**Instream Cover**		**a) Type**		**0 to 10**	6
			b) Amount		**1 to 11**	3
			Total Instream Cover Score (max = 20):			**9**
3	**Channel Morphology**		**a) Sinuosity**		**1 to 4**	3
			b) Development		**1 to 7**	5
			c) Channelization		**1 to 6**	6
			d) Stability		**1 to 3**	2
		Total Channel Morphology Score (max = 20):				**16**
4	**Riparian Zone & Bank Erosion**		**a) Width**		**0 to 4**	3
			b) Quality		**0 to 3**	1.5
			c) Bank Erosion		**1 to 3**	2
		Total Riparian Zone & Bank Erosion Score (max = 10):				**6.5**
5	**Pool/Glide & Riffle/Run Quality**					
	5 A) Pool Quality:		**a) Max. Depth**		**0 to 6**	4
			b) Current		**-2 to 4**	3
			c) Morphology		**0 to 2**	0
			Total Pool/Currrent Score (max = 12):			**7**
	5 B) Riffle Quality:		**a) Riffle Depth**		**0 to 2**	2
			b) Run Depth		**0 to 2**	1
			c) Substr. Stab.		**0 to 2**	0
			d) Substr. Embd.		**-1 to 2**	1
			Total Riffle/Run Score (max = 8):			**4**
6	**Gradient**				**2 to 10**	**6**
			Total QHEI Score (max = 100):			**64**
			Subjective Rating (1-10):			**6**
			Aesthetic Rating (1-10):			**7**

Table 11. QHEI Scoring summary for the upper treatment reach pre-restoration (downstream coordinates N 39.46573 W 088.23320; upstream coordinates N 39.46617 W 088.23545) of Kickapoo Creek near Charleston, IL.

					Stream:	Kickapoo Creek
					Station:	BEN-02C
	QHEI SCORING SUMMARY (Maximum = 100)				**Date:**	7/5/10
QHEI METRICS			**Metric Component**		**Scoring Range**	**Scores**
1	**Substrate**		**a) Type**		**0 to 21**	15
			b) Quality		**-5 to 3**	1.5
					Total Substrate Score (max = 20):	**16.5**
2	**Instream Cover**		**a) Type**		**0 to 10**	10
			b) Amount		**1 to 11**	3
					Total Instream Cover Score (max = 20):	**13**
3	**Channel Morphology**		**a) Sinuosity**		**1 to 4**	3
			b) Development		**1 to 7**	5
			c) Channelization		**1 to 6**	6
			d) Stability		**1 to 3**	1
					Total Channel Morphology Score (max = 20):	**15**
4	**Riparian Zone & Bank Erosion**		**a) Width**		**0 to 4**	2.5
			b) Quality		**0 to 3**	1.5
			c) Bank Erosion		**1 to 3**	1.5
					Total Riparian Zone & Bank Erosion Score (max = 10):	**5.5**
5	**Pool/Glide & Riffle/Run Quality**					
	5 A) Pool Quality:		**a) Max. Depth**		**0 to 6**	6
			b) Current		**-2 to 4**	2
			c) Morphology		**0 to 2**	2
					Total Pool/Currrent Score (max = 12):	**10**
	5 B) Riffle Quality:		**a) Riffle Depth**		**0 to 2**	1
			b) Run Depth		**0 to 2**	1
			c) Substr. Stab.		**0 to 2**	0.5
			d) Substr. Embd.		**-1 to 2**	1
					Total Riffle/Run Score (max = 8):	**3.5**
6	**Gradient**				**2 to 10**	**6**
					Total QHEI Score (max = 100):	**69.5**
					Subjective Rating (1-10):	**7**
					Aesthetic Rating (1-10):	**6**

Table 12. QHEI Scoring summary for the upstream control reach pre-restoration (downstream coordinates: N 39.46897 W 088.24810; upstream coordinates: N 39.46922 W 088.24988) of Kickapoo Creek near Charleston, IL.

			Stream:	Kickapoo Creek
			Station:	BEN-02D
QHEI SCORING SUMMARY (Maximum = 100)			Date:	7/5/10
QHEI METRICS		**Metric Component**	**Scoring Range**	**Scores**
1	**Substrate**	a) Type	0 to 21	21
		b) Quality	-5 to 3	1.5
		Total Substrate Score (max = 20):		**20**
2	**Instream Cover**	a) Type	0 to 10	9
		b) Amount	1 to 11	3
		Total Instream Cover Score (max = 20):		**12**
3	**Channel Morphology**	a) Sinuosity	1 to 4	3
		b) Development	1 to 7	5
		c) Channelization	1 to 6	6
		d) Stability	1 to 3	2
		Total Channel Morphology Score (max = 20):		**16**
4	**Riparian Zone & Bank Erosion**	a) Width	0 to 4	2.5
		b) Quality	0 to 3	0.5
		c) Bank Erosion	1 to 3	1.5
		Total Riparian Zone & Bank Erosion Score (max = 10):		**4.5**
5	**Pool/Glide & Riffle/Run Quality**			
	5 A) Pool Quality:	a) Max. Depth	0 to 6	6
		b) Current	-2 to 4	2
		c) Morphology	0 to 2	2
		Total Pool/Currrent Score (max = 12):		**10**
	5 B) Riffle Quality:	a) Riffle Depth	0 to 2	2
		b) Run Depth	0 to 2	1
		c) Substr. Stab.	0 to 2	0
		d) Substr. Embd.	-1 to 2	0
		Total Riffle/Run Score (max = 8):		**3**
6	**Gradient**		2 to 10	**6**
		Total QHEI Score (max = 100):		**71.5**
		Subjective Rating (1-10):		**7**
		Aesthetic Rating (1-10):		**8**

Table 13. QHEI Scoring summary for the downstream control reach post-restoration (downstream coordinates: N 39.46689 W 088.22843; upstream coordinates: N 39.46557 W 088.22964) of Kickapoo Creek Near Charleston, IL.

				Stream:	Kickapoo Creek
				Station:	BEN-02A
	QHEI SCORING SUMMARY (Maximum = 100)			Date:	6/1/11
QHEI METRICS			Metric Component	Scoring Range	Scores
1	Substrate		a) Type	0 to 21	15
			b) Quality	-5 to 3	1
			Total Substrate Score (max = 20):		16
2	Instream Cover		a) Type	0 to 10	6
			b) Amount	1 to 11	5
			Total Instream Cover Score (max = 20):		11
3	Channel Morphology		a) Sinuosity	1 to 4	3
			b) Development	1 to 7	3
			c) Channelization	1 to 6	6
			d) Stability	1 to 3	1
			Total Channel Morphology Score (max = 20):		13
4	Riparian Zone & Bank Erosion		a) Width	0 to 4	3.5
			b) Quality	0 to 3	1.5
			c) Bank Erosion	1 to 3	2
			Total Riparian Zone & Bank Erosion Score (max = 10):		7
5	Pool/Glide & Riffle/Run Quality				
	5 A) Pool Quality:		a) Max. Depth	0 to 6	4
			b) Current	-2 to 4	1
			c) Morphology	0 to 2	2
			Total Pool/Currrent Score (max = 12):		7
	5 B) Riffle Quality:		a) Riffle Depth	0 to 2	1
			b) Run Depth	0 to 2	2
			c) Substr. Stab.	0 to 2	0
			d) Substr. Embd.	-1 to 2	0
			Total Riffle/Run Score (max = 8):		3
6	Gradient			2 to 10	6
			Total QHEI Score (max = 100):		63
			Subjective Rating (1-10):		7
			Aesthetic Rating (1-10):		7

Table 14. QHEI Scoring summary for the lower treatment reach post-restoration (downstream coordinates: N 39.46509 W 088.23048; upstream coordinates: N 39.46572 W 088.23318) of Kickapoo Creek near Charleston, IL.

					Stream:	Kickapoo Creek
					Station:	BEN-02B
	QHEI SCORING SUMMARY (Maximum = 100)				**Date:**	6/3/11
QHEI METRICS			**Metric Component**		**Scoring Range**	**Scores**
1	**Substrate**		**a) Type**		**0 to 21**	15
			b) Quality		**-5 to 3**	1
			Total Substrate Score (max = 20):			**16**
2	**Instream Cover**		**a) Type**		**0 to 10**	8
			b) Amount		**1 to 11**	7
			Total Instream Cover Score (max = 20):			**15**
3	**Channel Morphology**		**a) Sinuosity**		**1 to 4**	3
			b) Development		**1 to 7**	3
			c) Channelization		**1 to 6**	6
			d) Stability		**1 to 3**	2
		Total Channel Morphology Score (max = 20):				**14**
4	**Riparian Zone & Bank Erosion**		**a) Width**		**0 to 4**	3
			b) Quality		**0 to 3**	1.5
			c) Bank Erosion		**1 to 3**	3
		Total Riparian Zone & Bank Erosion Score (max = 10):				**7.5**
5	**Pool/Glide & Riffle/Run Quality**					
	5 A) Pool Quality:		**a) Max. Depth**		**0 to 6**	6
			b) Current		**-2 to 4**	1
			c) Morphology		**0 to 2**	2
			Total Pool/Currrent Score (max = 12):			**9**
	5 B) Riffle Quality:		**a) Riffle Depth**		**0 to 2**	2
			b) Run Depth		**0 to 2**	2
			c) Substr. Stab.		**0 to 2**	2
			d) Substr. Embd.		**-1 to 2**	1
			Total Riffle/Run Score (max = 8):			**7**
6	**Gradient**				**2 to 10**	**6**
			Total QHEI Score (max = 100):			**74.5**
			Subjective Rating (1-10):			**7**
			Aesthetic Rating (1-10):			**7**

Table 15. QHEI Scoring summary for the upper treatment reach post-restoration (downstream coordinates N 39.46573 W 088.23320; upstream coordinates N 39.46617 W 088.23545) of Kickapoo Creek near Charleston, IL.

					Stream:	Kickapoo Creek
					Station:	BEN-02C
	QHEI SCORING SUMMARY (Maximum = 100)				**Date:**	6/3/11
QHEI METRICS			**Metric Component**		**Scoring Range**	**Scores**
1	**Substrate**		**a) Type**		**0 to 21**	15
			b) Quality		**-5 to 3**	1
			Total Substrate Score (max = 20):			**16**
2	**Instream Cover**		**a) Type**		**0 to 10**	6
			b) Amount		**1 to 11**	7
			Total Instream Cover Score (max = 20):			**13**
3	**Channel Morphology**		**a) Sinuosity**		**1 to 4**	2
			b) Development		**1 to 7**	3
			c) Channelization		**1 to 6**	6
			d) Stability		**1 to 3**	3
		Total Channel Morphology Score (max = 20):				**14**
4	**Riparian Zone & Bank Erosion**		**a) Width**		**0 to 4**	3
			b) Quality		**0 to 3**	1.5
			c) Bank Erosion		**1 to 3**	3
	Total Riparian Zone & Bank Erosion Score (max = 10):					**7.5**
5	**Pool/Glide & Riffle/Run Quality**					
	5 A) Pool Quality:		**a) Max. Depth**		**0 to 6**	6
			b) Current		**-2 to 4**	1
			c) Morphology		**0 to 2**	2
			Total Pool/Currrent Score (max = 12):			**9**
	5 B) Riffle Quality:		**a) Riffle Depth**		**0 to 2**	2
			b) Run Depth		**0 to 2**	2
			c) Substr. Stab.		**0 to 2**	2
			d) Substr. Embd.		**-1 to 2**	1
			Total Riffle/Run Score (max = 8):			**7**
6	**Gradient**				**2 to 10**	**6**
			Total QHEI Score (max = 100):			**72.5**
			Subjective Rating (1-10):			**7**
			Aesthetic Rating (1-10):			**7**

Table 16. QHEI Scoring summary for the upstream control reach post-restoration (downstream coordinates: N 39.46897 W 088.24810; upstream coordinates: N 39.46922 W 088.24988) of Kickapoo Creek near Charleston, IL.

				Stream:	Kickapoo Creek
				Station:	BEN-02D
	QHEI SCORING SUMMARY (Maximum = 100)			Date:	6/2/11
QHEI METRICS			Metric Component	Scoring Range	Scores
1	Substrate		a) Type	0 to 21	15
			b) Quality	-5 to 3	1
			Total Substrate Score (max = 20):		16
2	Instream Cover		a) Type	0 to 10	8
			b) Amount	1 to 11	7
			Total Instream Cover Score (max = 20):		15
3	Channel Morphology		a) Sinuosity	1 to 4	2
			b) Development	1 to 7	3
			c) Channelization	1 to 6	6
			d) Stability	1 to 3	2
			Total Channel Morphology Score (max = 20):		13
4	Riparian Zone & Bank Erosion		a) Width	0 to 4	3
			b) Quality	0 to 3	0.5
			c) Bank Erosion	1 to 3	2
			Total Riparian Zone & Bank Erosion Score (max = 10):		5.5
5	Pool/Glide & Riffle/Run Quality				
	5 A) Pool Quality:		a) Max. Depth	0 to 6	4
			b) Current	-2 to 4	1
			c) Morphology	0 to 2	2
			Total Pool/Currrent Score (max = 12):		7
	5 B) Riffle Quality:		a) Riffle Depth	0 to 2	1
			b) Run Depth	0 to 2	1
			c) Substr. Stab.	0 to 2	2
			d) Substr. Embd.	-1 to 2	0
			Total Riffle/Run Score (max = 8):		4
6	Gradient			2 to 10	6
			Total QHEI Score (max = 100):		66.5
			Subjective Rating (1-10):		7
			Aesthetic Rating (1-10):		7

Table 17. Summary of macroinvertebrates sampled from Kickapoo Creek during fall 2009 through fall 2011.

PHYLUM	CLASS	ORDER	FAMILY	FALL 2009	SPRING 2010	FALL 2010	SPRING 2011	FALL 2011	TOTAL
ANNELIDA		HIRUDINEA		0	0	0	0	3	3
ANNELIDA		OLIGOCHAETA		2	5	29	2	54	92
ARTHROPODA	ARACHNIDA	HYDRACARINA		1	0	0	0	0	1
ARTHROPODA	ENTOGNATHA	COLLEMBOLA		0	0	0	0	2	2
ARTHROPODA	INSECTA	COLEOPTERA	DYTISCIDAE	3	0	2	1	1	7
ARTHROPODA	INSECTA	COLEOPTERA	ELMIDAE	8	0	12	13	8	41
ARTHROPODA	INSECTA	COLEOPTERA	HALIPLIDAE	0	0	2	1	1	4
ARTHROPODA	INSECTA	COLEOPTERA	HYDROPHILOIDAE	0	0	1	0	0	1
ARTHROPODA	INSECTA	COLLEMBOLA		0	1	0	0	0	1
ARTHROPODA	INSECTA	DIPTERA	CHIRONOMIDAE	112	476	1286	291	722	2887
ARTHROPODA	INSECTA	DIPTERA	SIMULIDAE	0	48	34	1	87	170
ARTHROPODA	INSECTA	DIPTERA	TIPULIDAE	0	0	4	2	0	6
ARTHROPODA	INSECTA	DIPTERA	PUPA	12	43	63	21	46	185
ARTHROPODA	INSECTA	EPHEMEROPTERA	BAETIDAE	17	2	5	16	13	53
ARTHROPODA	INSECTA	EPHEMEROPTERA	CAENIDAE	13	82	9	506	12	622
ARTHROPODA	INSECTA	EPHEMEROPTERA	HEPTAGENIIDAE	16	14	10	5	1	46
ARTHROPODA	INSECTA	EPHEMEROPTERA	TRICORYTHIDAE	6	1	0	20	0	27
ARTHROPODA	INSECTA	EPHEMEROPTERA	UNKOWN	10	6	2	10	6	34
ARTHROPODA	INSECTA	ODONATA	AESHNIDAE	1	2	3	0	0	6

Table 17. Summary of macroinvertebrates sampled from Kickapoo Creek during fall 2009 through fall 2011.

ARTHROPODA	INSECTA	ODONATA	ANISOPTERA	0	0	0	1	0	1
ARTHROPODA	INSECTA	ODONATA	CALOPTERYGIDAE	80	27	0	31	1	139
ARTHROPODA	INSECTA	ODONATA	COENAGRIONIDAE	16	30	12	43	0	101
ARTHROPODA	INSECTA	ODONATA	GOMPHIDAE	0	2	2	0	1	5
ARTHROPODA	INSECTA	ODONATA	LIBELLULIDAE	0	0	0	1	0	1
ARTHROPODA	INSECTA	ODONATA	UNKOWN	0	6	0	2	0	8
ARTHROPODA	INSECTA	TRICHOPTERA	HYDROPSYCHIDAE	10	171	157	171	181	690
ARTHROPODA	INSECTA	TRICHOPTERA	HYDROPTILIDAE	0	3	6	4	2	15
ARTHROPODA	INSECTA	TRICHOPTERA	LEPTOCERIDAE	0	0	0	2	0	2
ARTHROPODA	INSECTA	TRICHOPTERA	UNKOWN	0	6	11	2	8	27
ARTHROPODA	MALACOSTRA	AMPHIPODA		0	8	6	0	5	19
ARTHROPODA	MALACOSTRA	AMPHIPODA		0	5	0	0	0	5
ARTHROPODA	MALACOSTRA	AMPHIPODA		0	5	0	0	0	5
ARTHROPODA	MALACOSTRA	DECAPODA	CAMBARIDAE	0	3	6	0	4	13
ARTHROPODA	MALACOSTRA		ISOPODA	0	0	0	0	1	1
MOLLUSCA	BIVALVIA	VENEROIDA	CORBICULIDAE	2	12	5	0	0	19
MOLLUSCA	BIVALVIA	VENEROIDA	SPHAERIIDAE	1	0	3	8	4	16
MOLLUSCA	BIVALVIA	VENEROIDA	UNKOWN	0	0	0	6	4	10
MOLLUSCA	GASTROPODA			4	14	92	91	14	215
MOLLUSCA	GASTROPODA		ANCYLIDAE	4	0	0	7	0	11
MOLLUSCA	GASTROPODA		PHYSIDAE	0	8	81	84	14	187

Table 17. Summary of macroinvertebrates sampled from Kickapoo Creek during fall 2009 through fall 2011.

MOLLUSCA	GASTROPODA	PLANORBIDAE	0	6	11	0	0	17
NEMATOMORPHA			0	0	0	0	1	1
PLATYHELMINTHES	TUBELLARIA		0	0	0	2	0	2
		TOTAL	318	986	1854	1344	1196	5698

Table 18. Summary of water quality sampled in the two different treatments of Kickapoo Creek during fall 2009 through fall 2011. Values represent mean values.

Reach	DO (mg/L)	Conductivity (mS/L)	Temperature (°C)
Fall 2009			
Control	9.02	689	20.92
Restored	8.78	692	22
Spring 2010			
Control	9.45	593	17.24
Restored	13.33	592	17.75
Fall 2010			
Control	9.16	xx	16.7
Restored	9.02	569	17.2
Spring 2011			
Control	11.32	467	13
Restored	10.38	527	12.9
Fall 2011			
Control	8.89	414.6	16.6
Restored	7.56	399	18.6

Kickapoo Creek EIU Monitoring Stations

Figure 1. Aerial photograph of the restoration reach in Kickapoo Creek near Charleston IL. Green bars indicate expanse of the four sampling sites sampled for fish, macroinvertebrates, habitat (QHEI), and water quality.

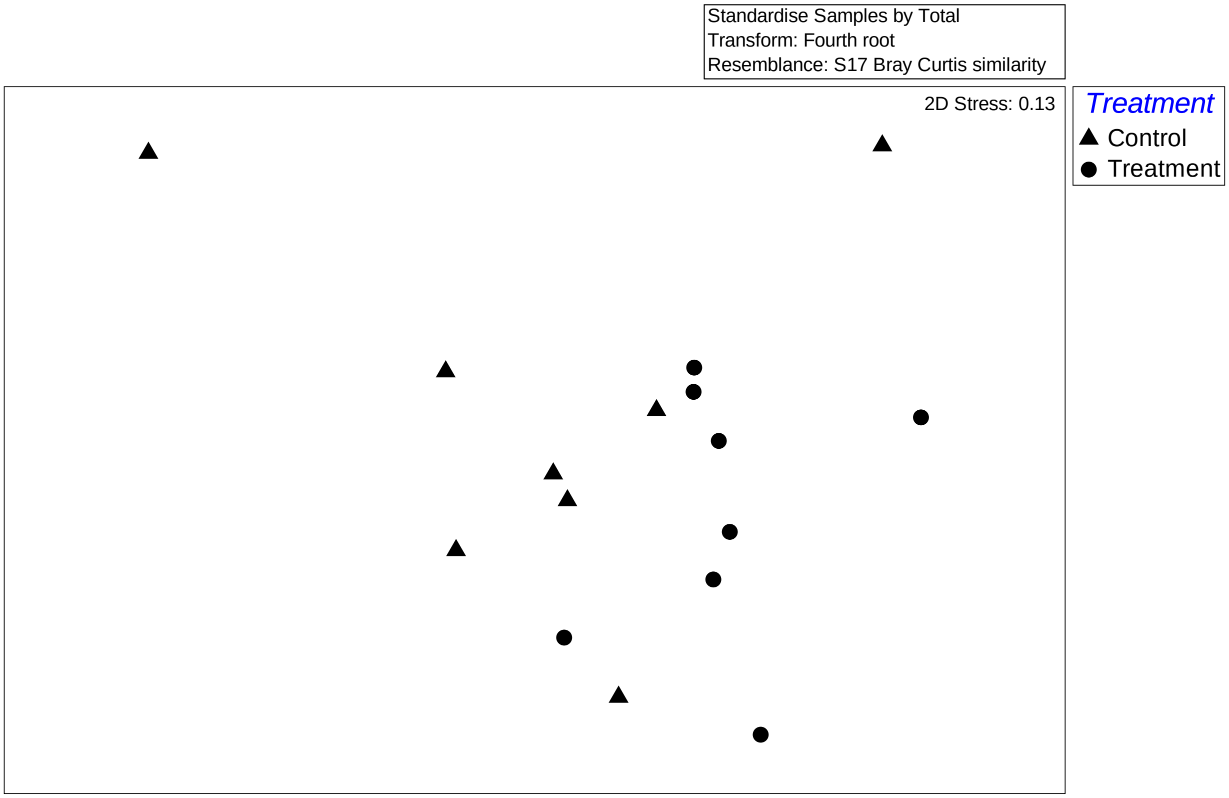

Figure 2. Multidimensional scaling plot of fish communities sampled from the four reaches of Kickapoo Creek during fall 2009 through fall 2011. Triangles represent fish community assemblages sampled in the downstream and upstream control reaches and circles represent fish community assemblages sampled from the lower and upper treatment reaches. Control reaches assemblages were significantly different than those in the treatment reaches (ANOSIM, $p < 0.05$)

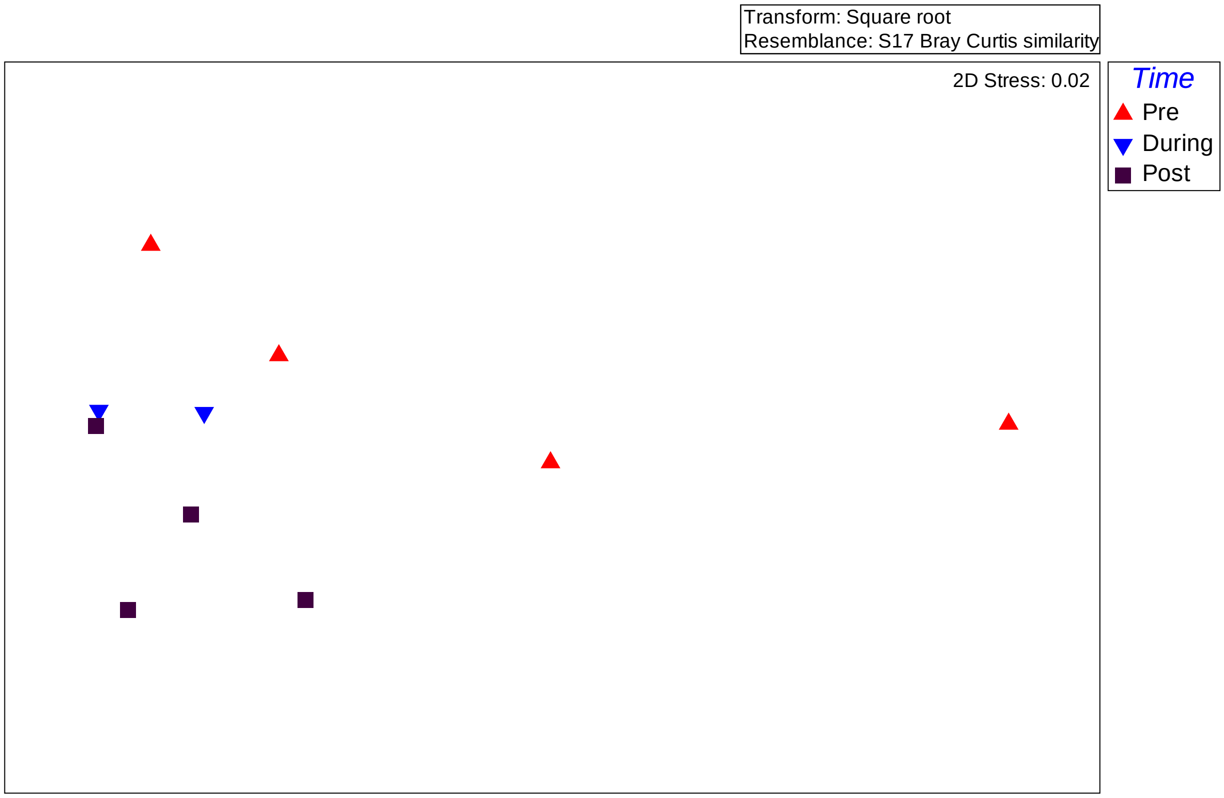

Figure 3. MDS plot of fish communities sampled from the two control reaches of Kickapoo Creek during fall 2009 through fall 2011. Symbols represent sampling time with triangles = pre-restoration (fall 2009 and spring 2010), upside down triangles = during restoration (fall 2010), and squares = post restoration (spring 2011 and fall 2011). There was no difference among sampling time (ANOSIM, $p > 0.05$)

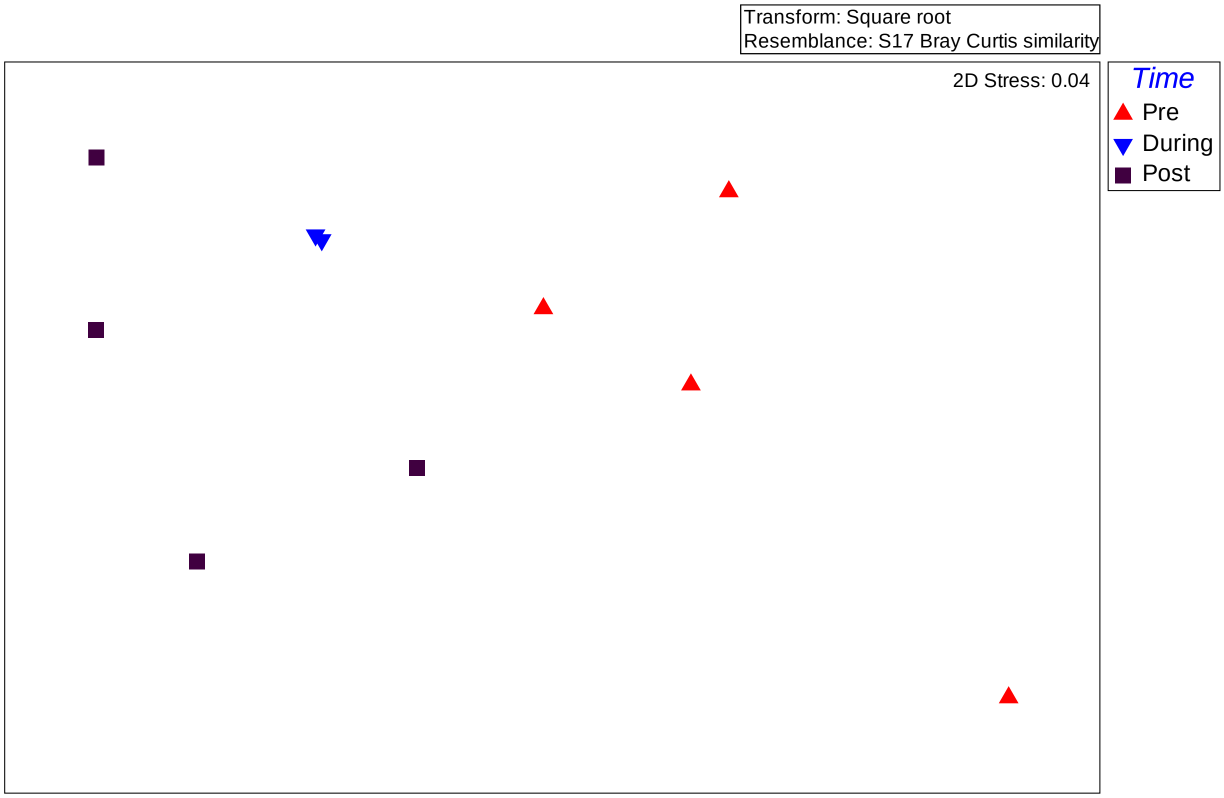

Figure 4. MDS plot of fish communities sampled from the two restored reaches of Kickapoo Creek during fall 2009 through spring 2011. Symbols represent sampling time with triangles = pre-restoration (fall 2009 and spring 2010), upside down triangles = during restoration (fall 2010), and squares = post restoration (spring 2011 and fall 2011). There was no difference between pre and during nor during and post sampling times (ANOSIM, $p > 0.05$). There was a significant difference between pre and post sampling time (ANOSIM, $p < 0.005$)

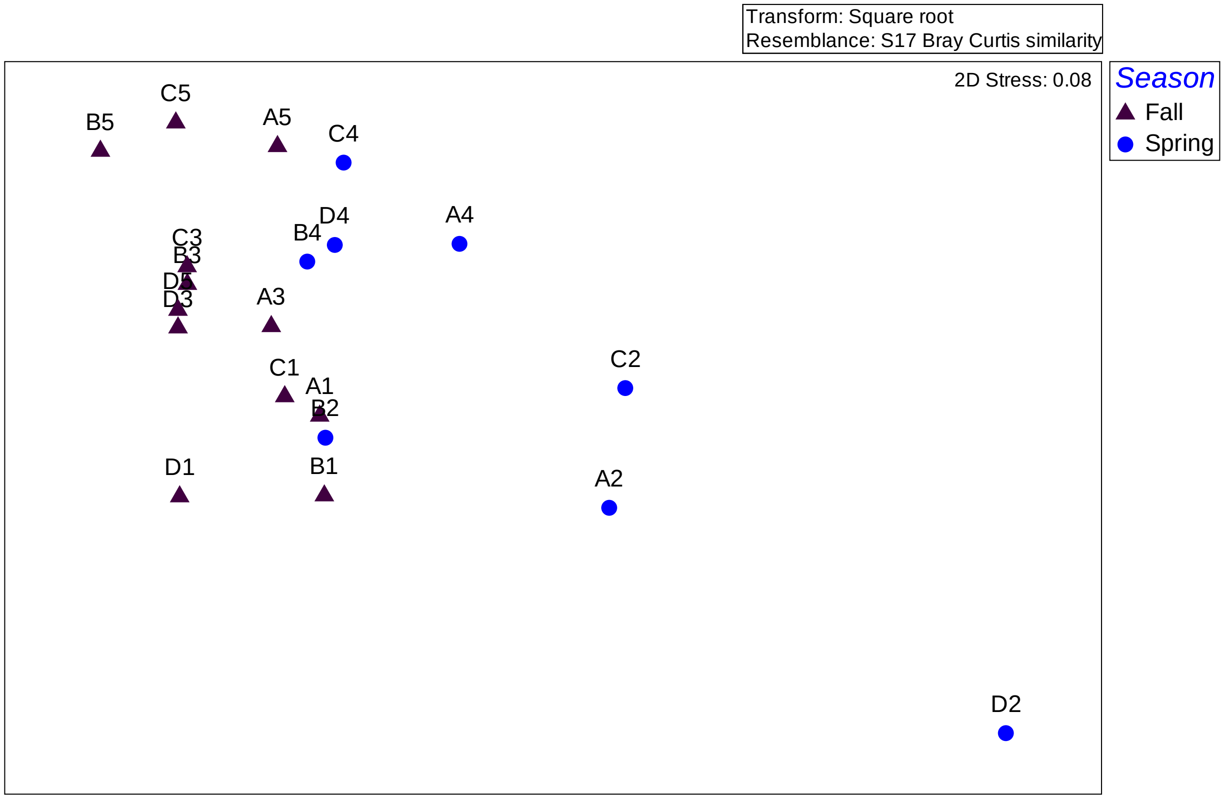

Figure 5. MDS plot of fish communities sampled from the four reaches of Kickapoo Creek during fall 2009 through Fall 2011. Triangles represent sample taken during fall and circles represent samples taken during spring. Fish community assemblages taken during fall were significantly different than those taken in spring (ANOSIM, $p < 0.003$).

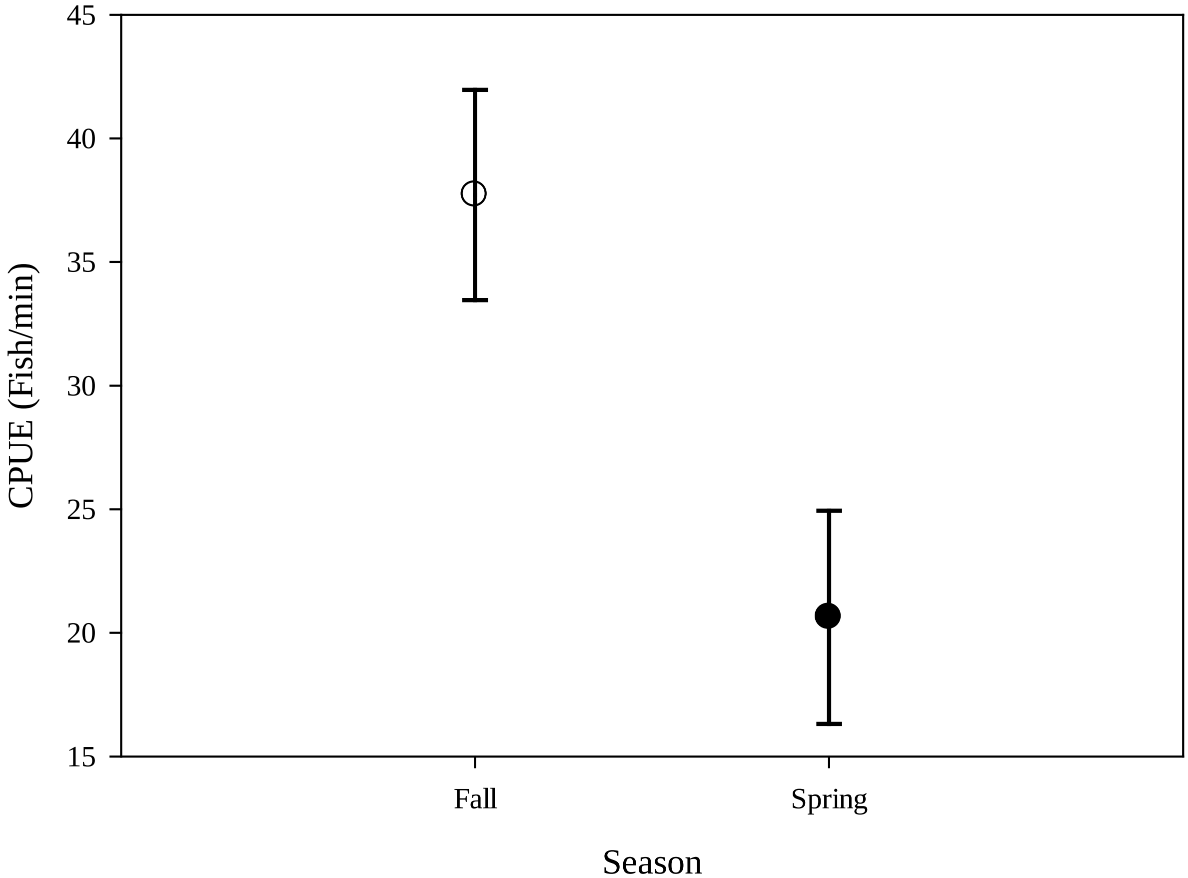

Figure 6. Seasonal mean CPUE (+/- S.E.) for fishes sampled from all sites in Kickapoo Creek during fall 2009 through fall 2011.

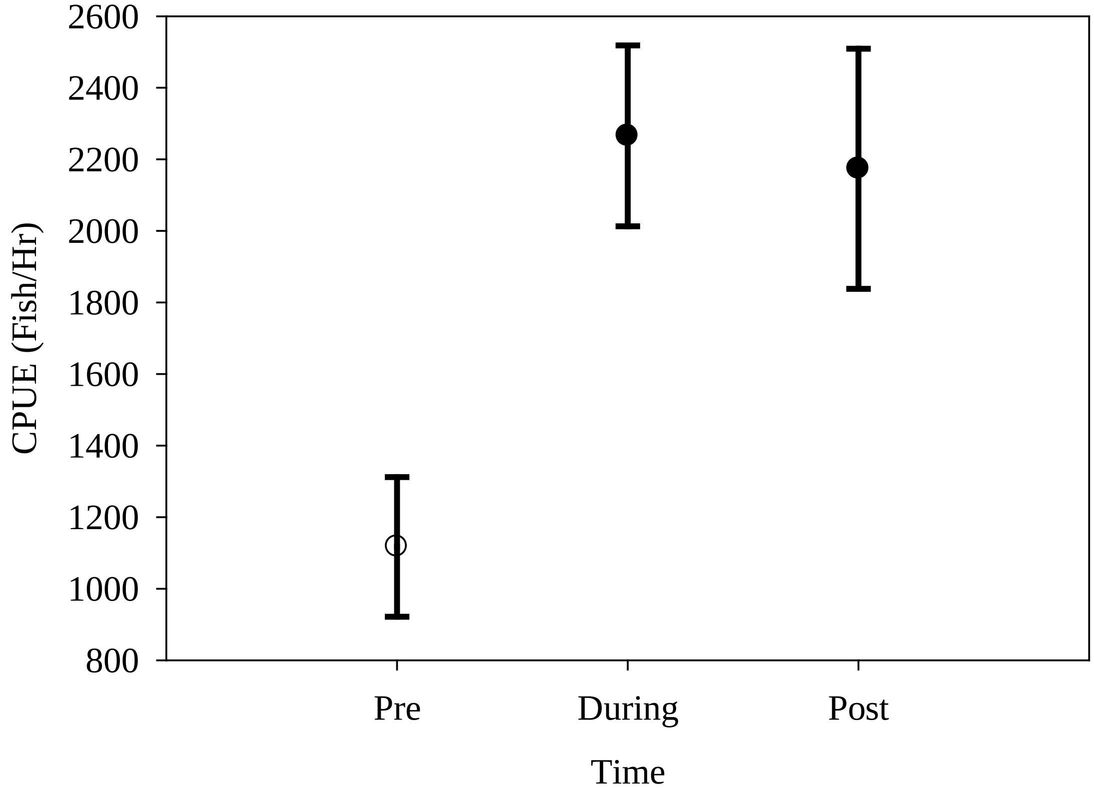

Figure 7. Impact of restoration on mean CPUE (+/- S.E.) for fishes sampled from all sites on Kickapoo Creek during fall 2009 through fall 2011. Pre includes fall 2009 and spring 2010, During includes fall 2010, and Post includes spring and fall 2011.

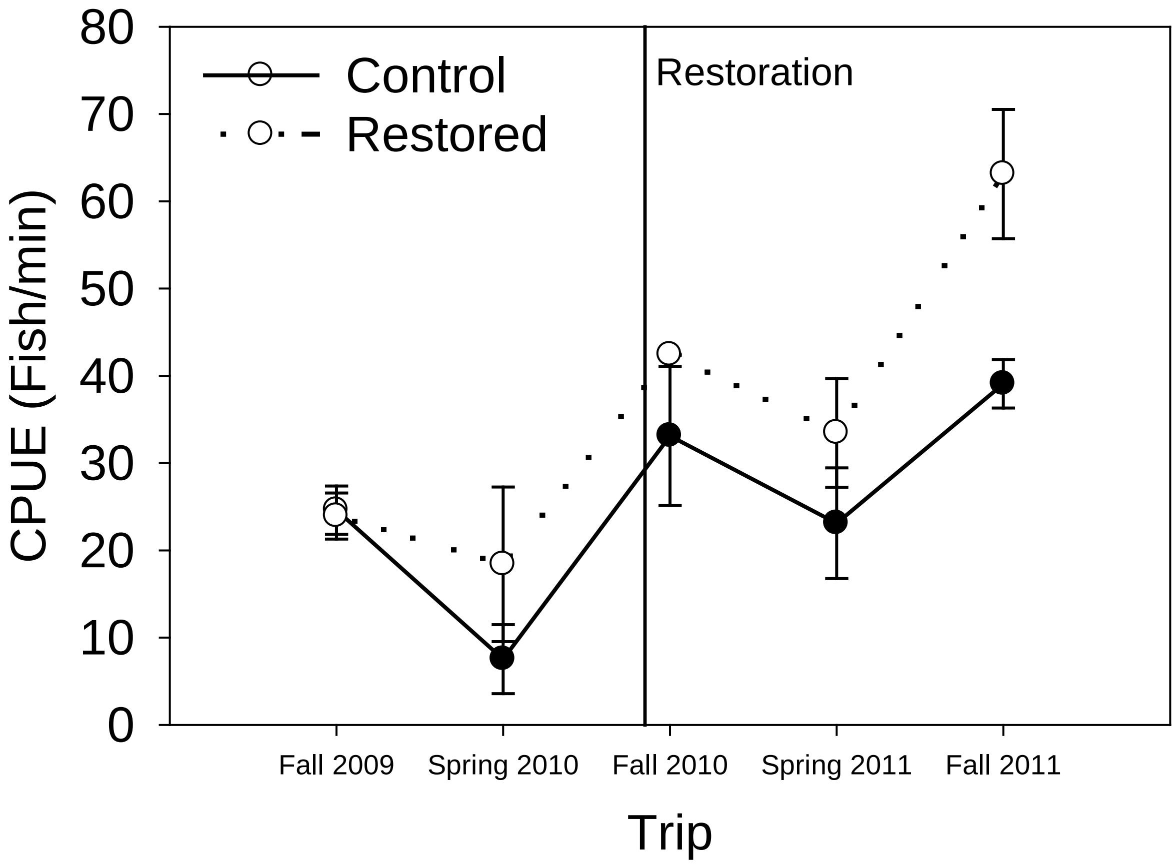

Figure 8. Seasonal CPUE (+/- S.E.) by treatment for all fishes sampled from Kickapoo Creek during fall 2009 through fall 2011. Control includes both upstream and downstream control sites (A & D), treatment includes the restored sites (B & C). Vertical dotted line represents approximate time of restoration.

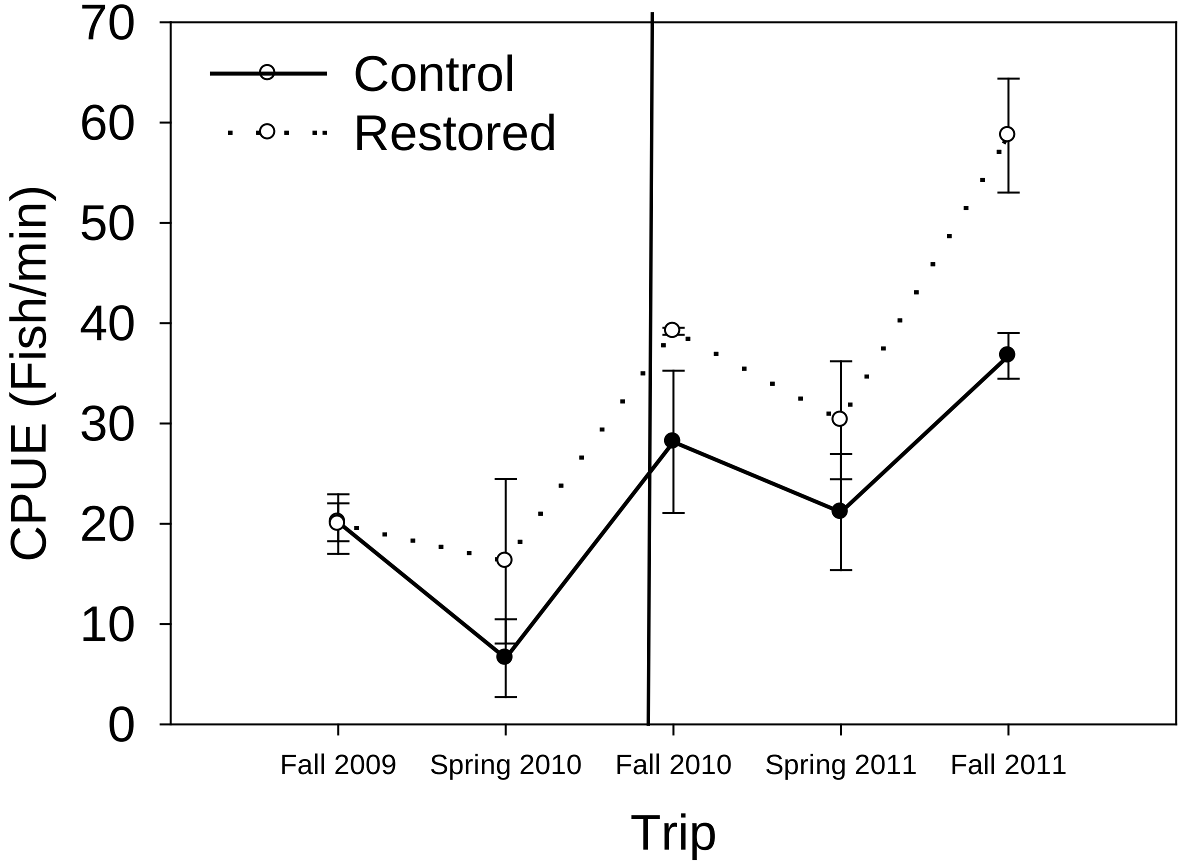

Figure 9. Seasonal CPUE (+/- S.E.) by treatment for Cyprinidae sampled from Kickapoo Creek during fall 2009 through fall 2011. Control includes both upstream and downstream control sites (A & D), treatment includes the restored sites (B & C). Vertical dotted line represents approximate time of restoration.

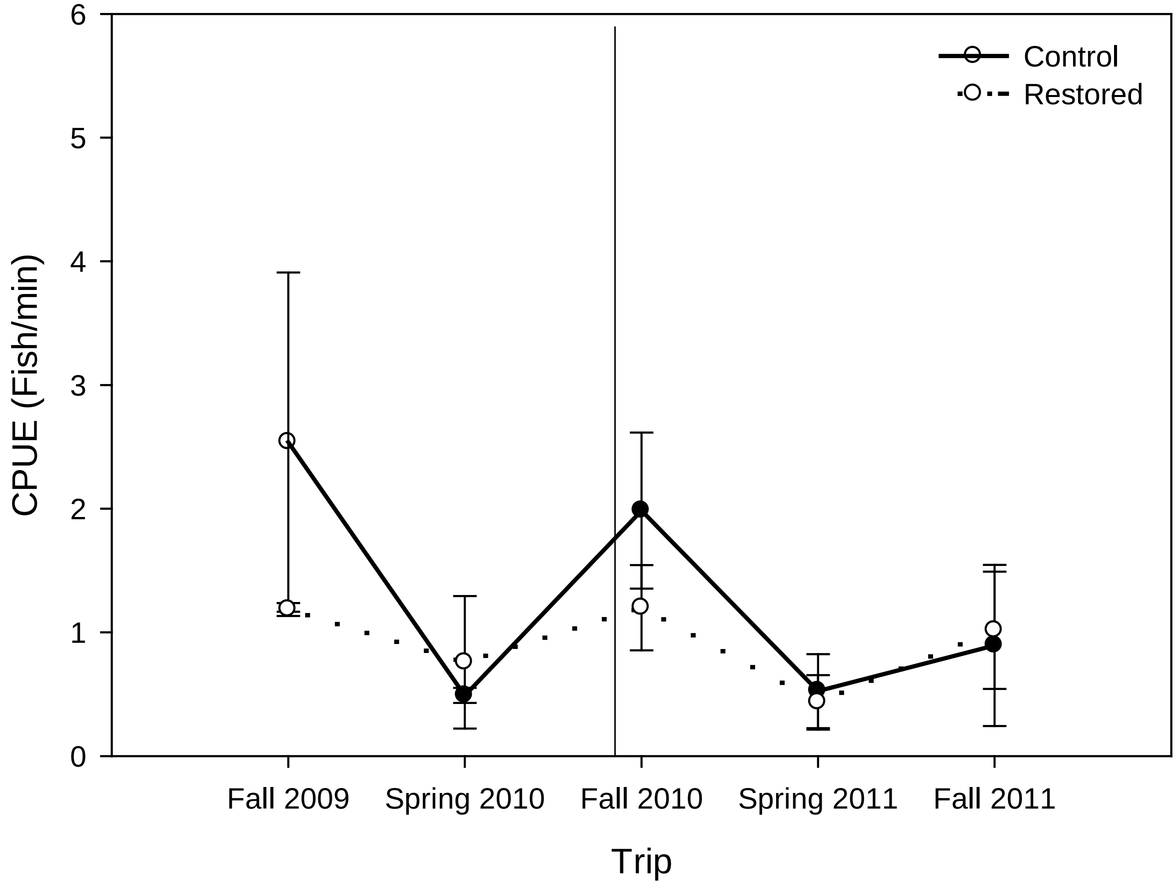

Figure 10. Seasonal CPUE (+/- S.E.) by treatment for Percidae sampled from Kickapoo Creek during fall 2009 through fall 2011. Control includes both upstream and downstream control sites (A & D), treatment includes the restored sites (B & C). Vertical dotted line represents approximate time of restoration.

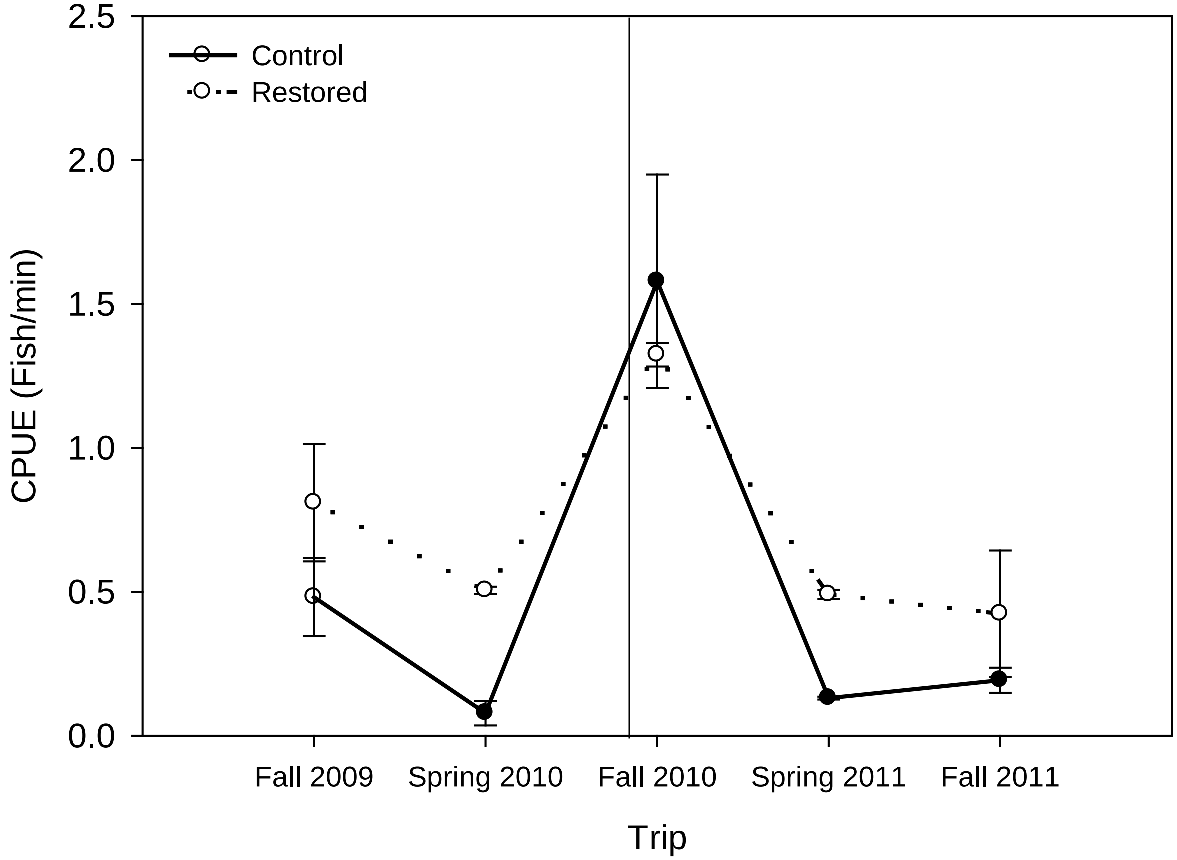

Figure 11. Seasonal CPUE (+/- S.E.) by treatment for Catostomidae sampled from Kickapoo Creek during fall 2009 through fall 2011. Control includes both upstream and downstream control sites (A & D), treatment includes the restored sites (B & C). Vertical dotted line represents approximate time of restoration.

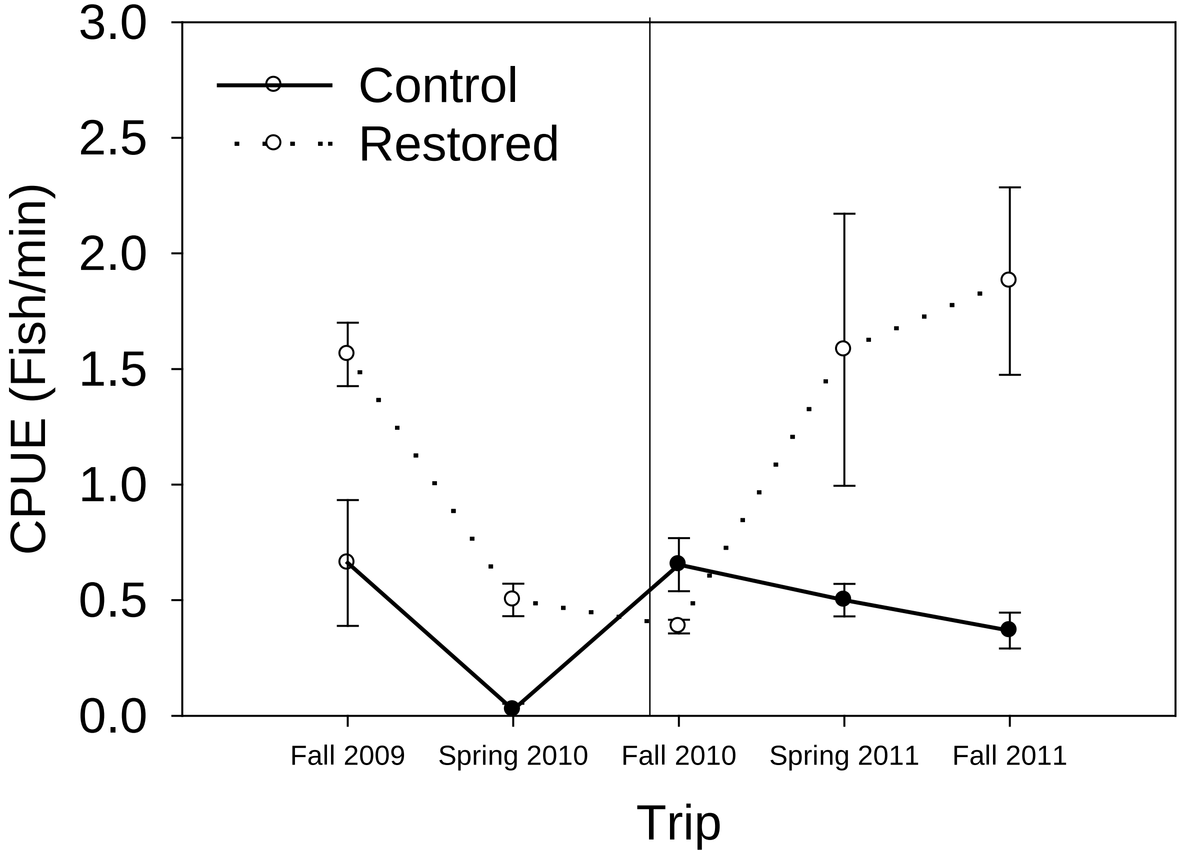

Figure 12. Seasonal CPUE (+/- S.E.) by treatment for Centrarchidae sampled from Kickapoo Creek during fall 2009 through fall 2011. Control includes both upstream and downstream control sites (A & D), treatment includes the restored sites (B & C). Vertical dotted line represents approximate time of restoration.

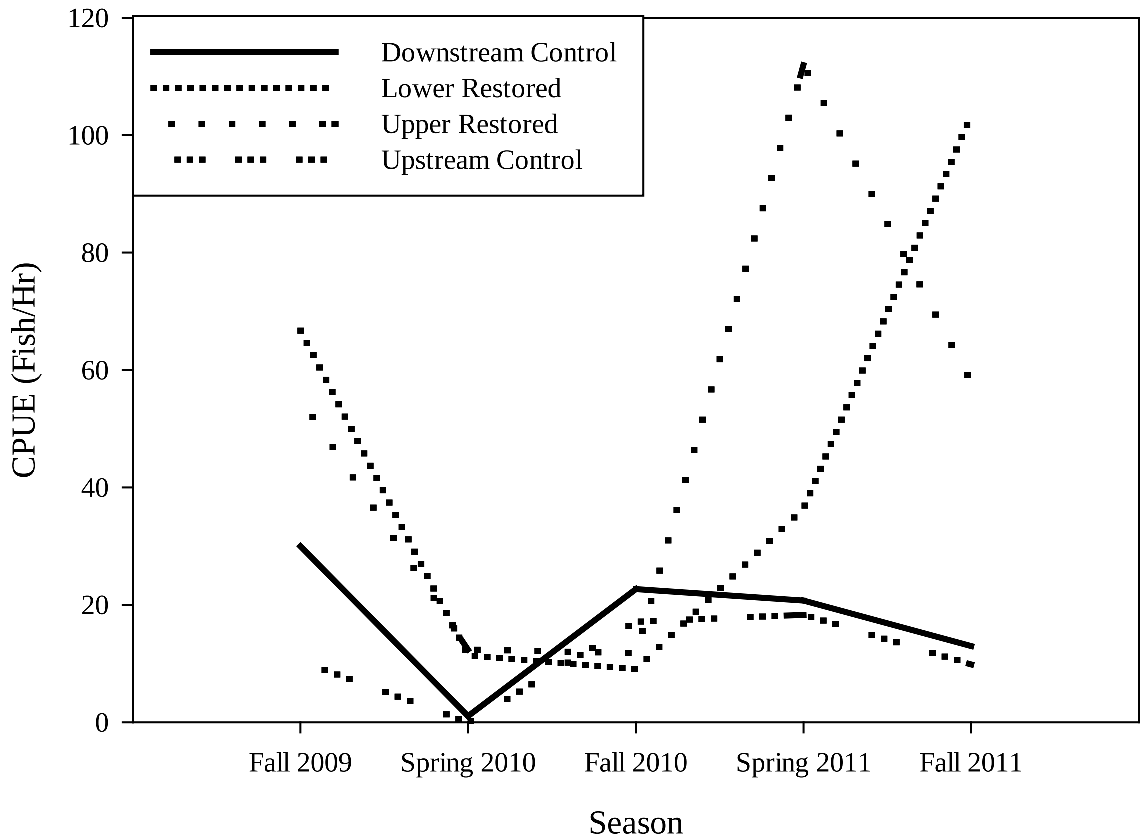

Figure 13. Seasonal CPUE of bluegill plus longear sunfish sampled from the four treatment reaches of Kickapoo Creek. Solid = Downstream control, Dotted = Lower treatment (restored), Dashed = Upper treatment (restored), and Dashed and dotted = Upstream Control.

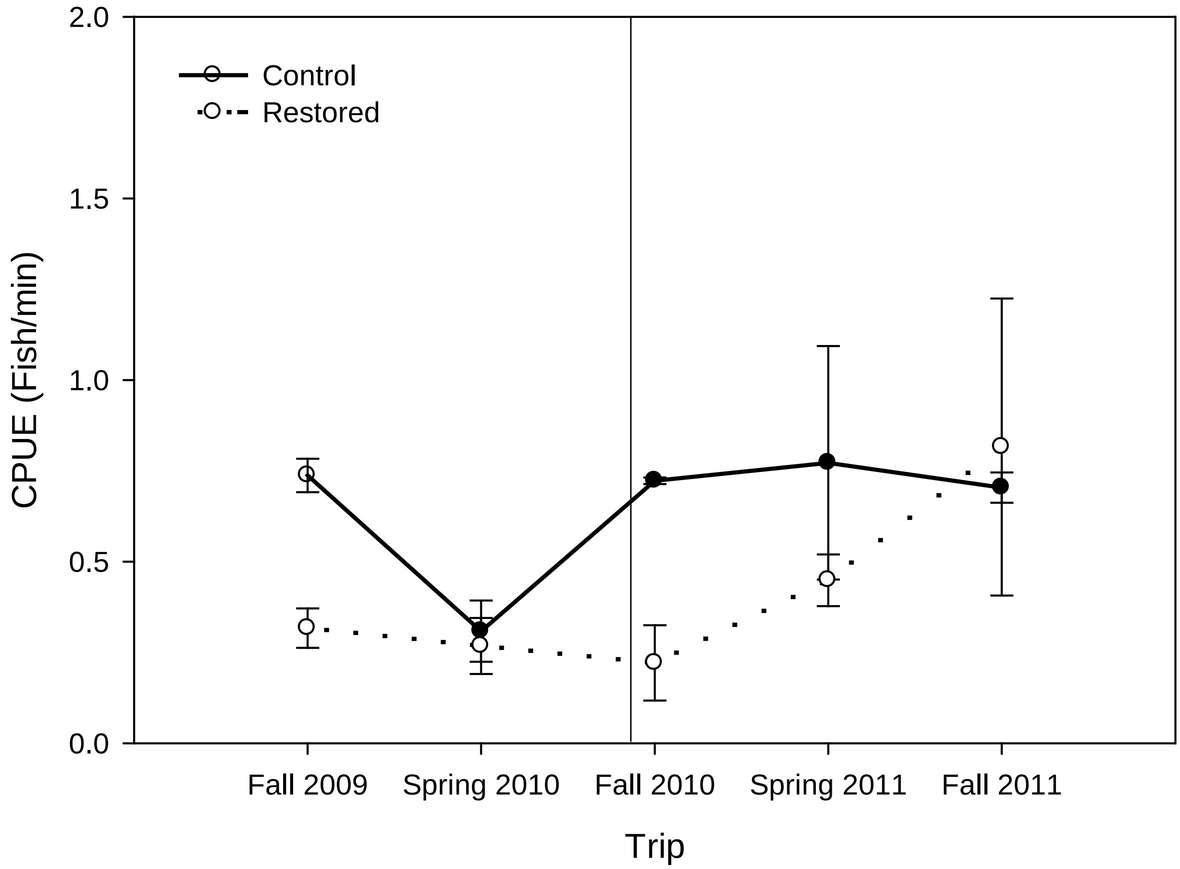

Figure 14. Seasonal CPUE (+/- S.E.) by treatment for Ictaluridae sampled from Kickapoo Creek during fall 2009 through fall 2011. Control includes both upstream and downstream control sites (A & D), treatment includes the restored sites (B & C). Vertical dotted line represents approximate time of restoration.

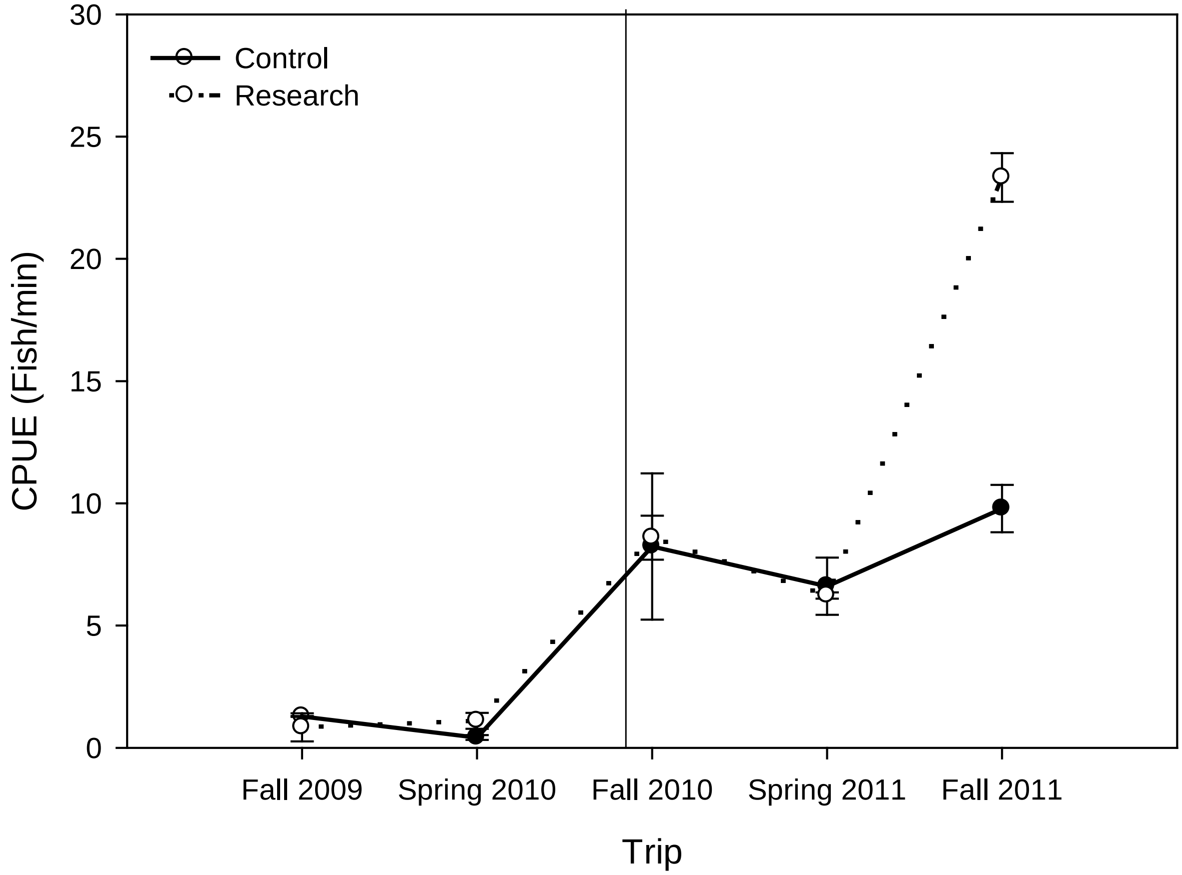

Figure 15. Mean CPUE (+/- S.E.) for spotfin shiner sampled from all reaches of Kickapoo Creek during fall 2009 through fall 2011.

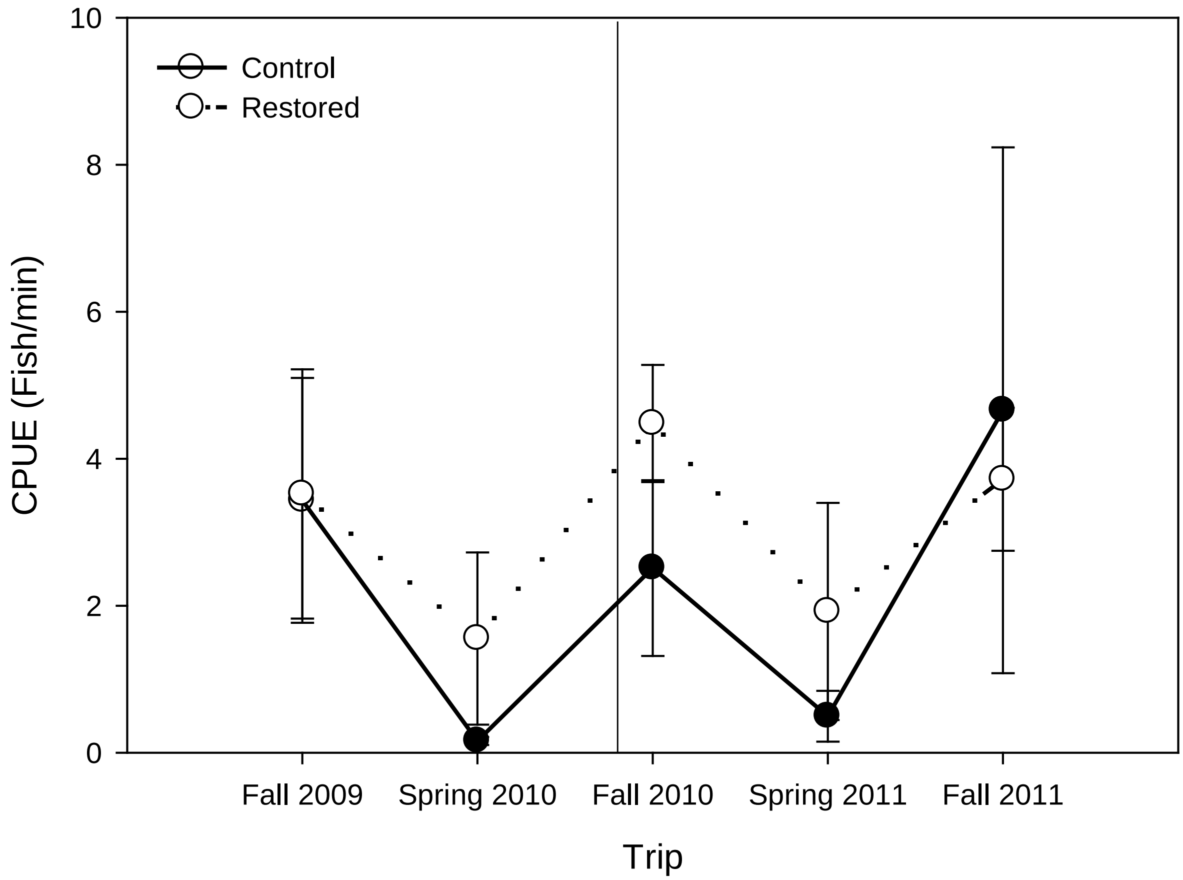

Figure 16. Mean CPUE (+/- S.E.) for central stoneroller sampled from all treatment reaches of Kickapoo Creek during fall 2009 through fall 2011.

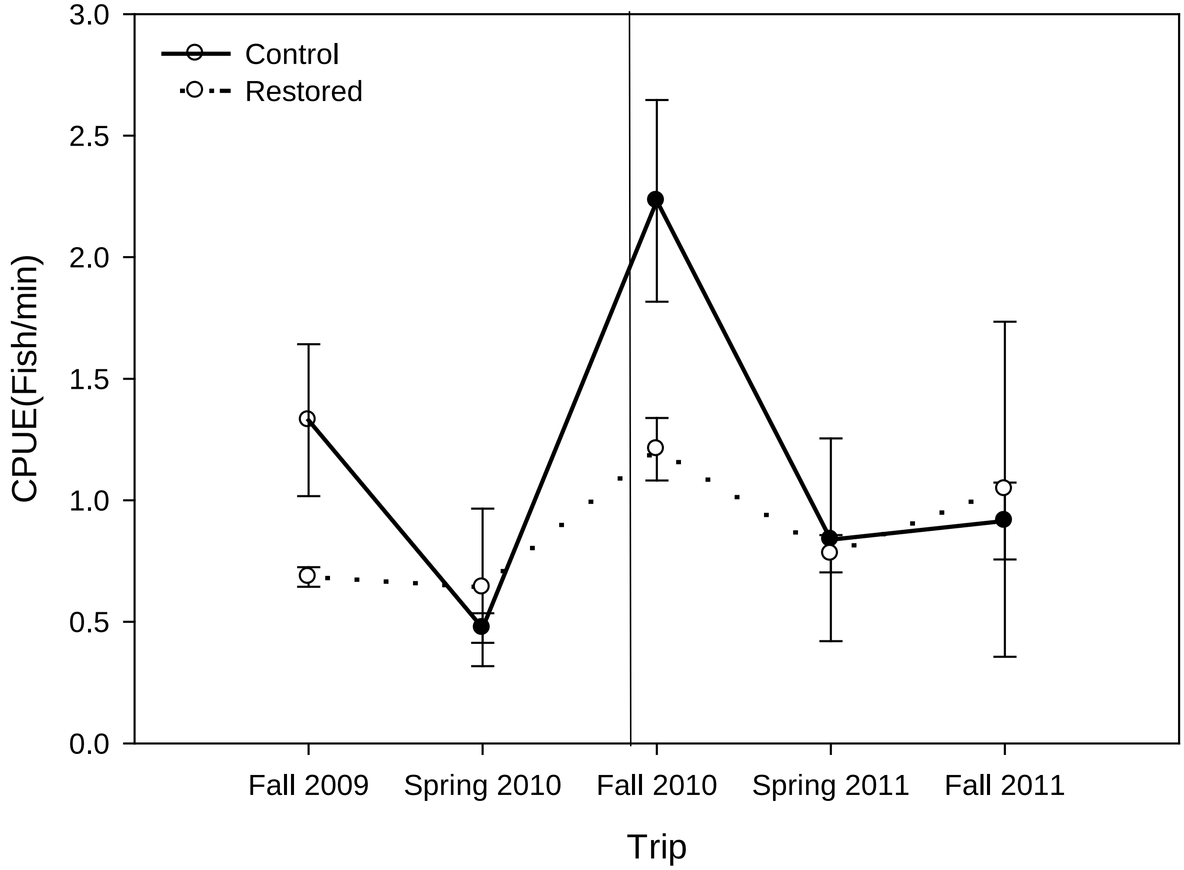

Figure 17. Mean CPUE (+/- S.E.) for intolerant fish species sampled from all treatment reaches of Kickapoo Creek during fall 2009 through fall 2011

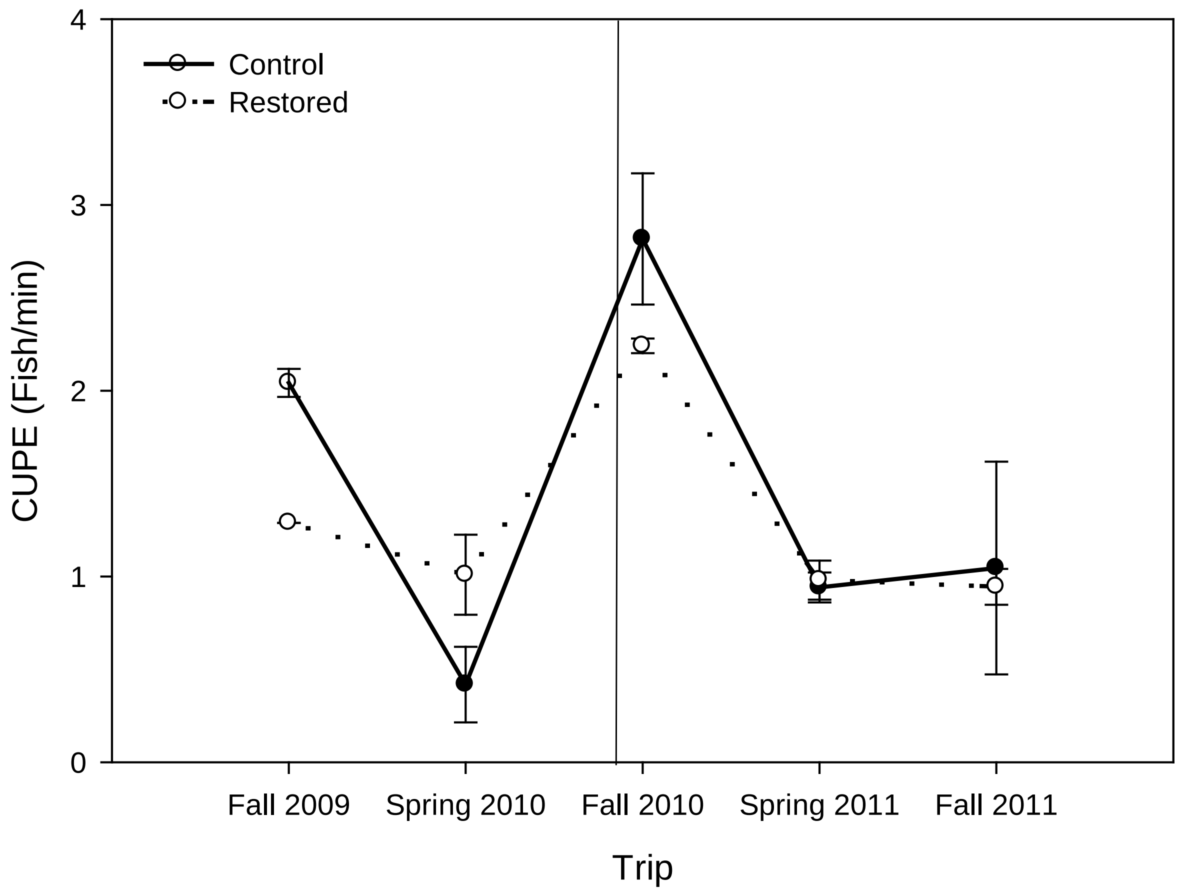

Figure 18.Mean CPUE (+/- S.E.) for tolerant fish species sampled from all treatment reaches of Kickapoo Creek during fall 2009 through fall 2011

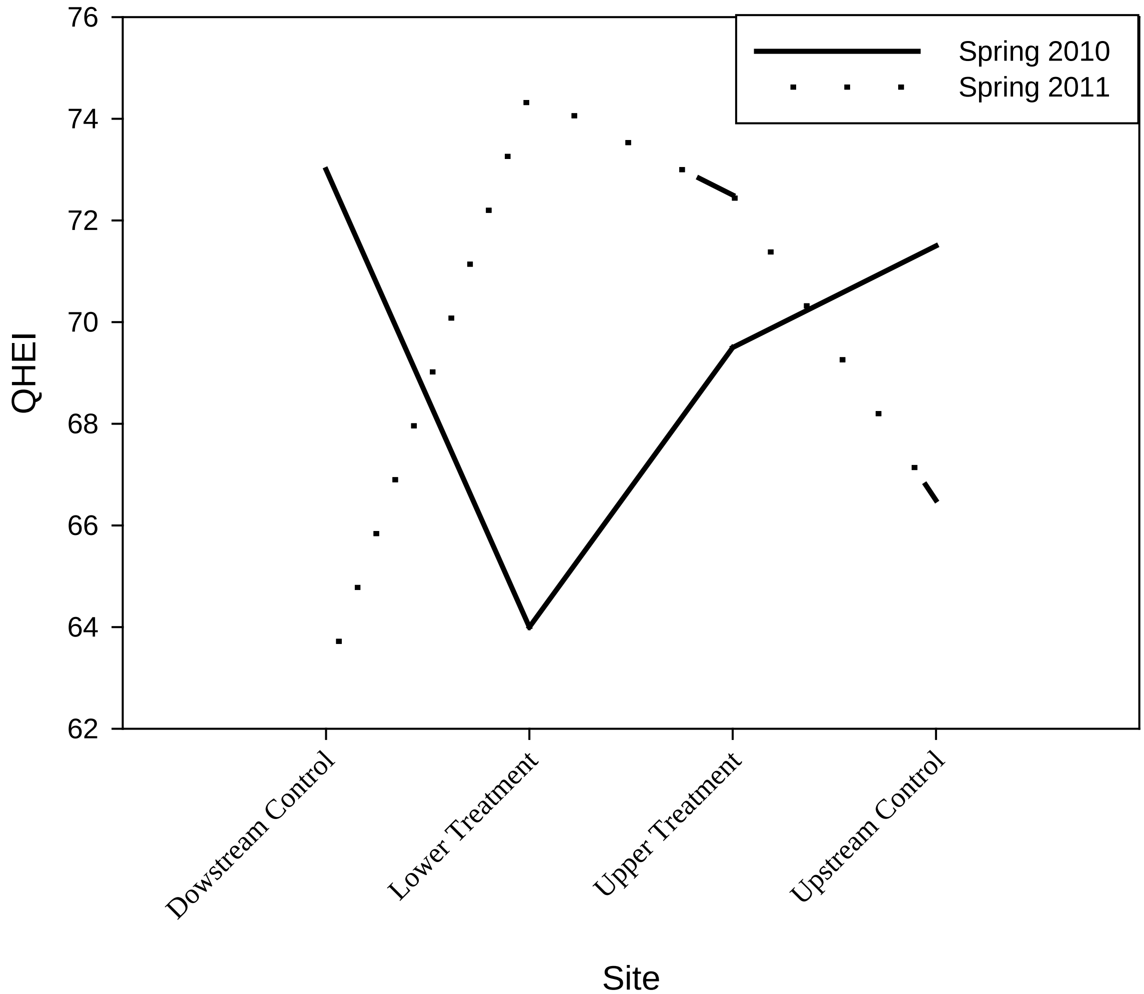

Figure 19. QHEI by site for Kickapoo Creek for spring 2010 solid line and spring 2011 dashed line.

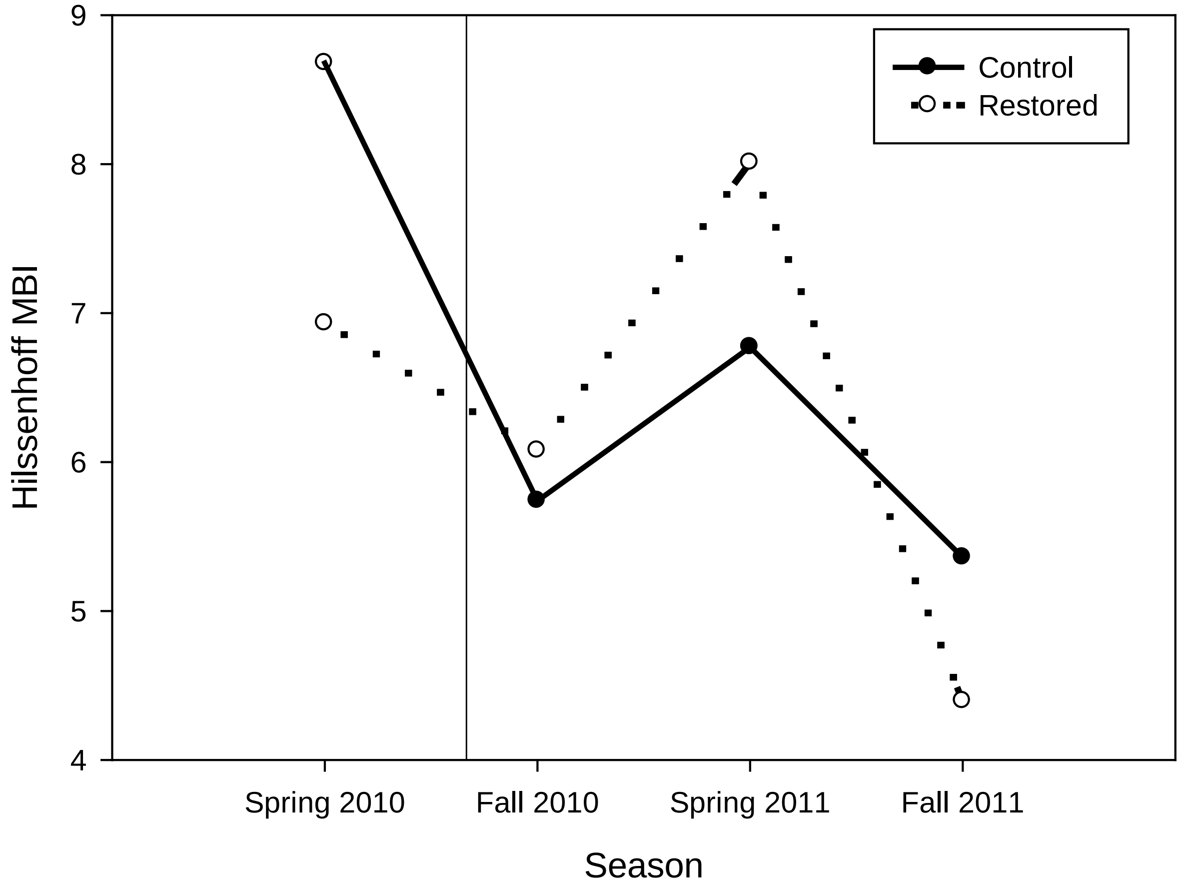

Figure 20. Hilsenhoff's Macroinvertebrate Biotic Index scores for macroinvertebrates sampled from Kickapoo Creek during spring 2010 through fall 2011. Solid = Control reaches (A,D), Dashed = Restored reaches (B,C)

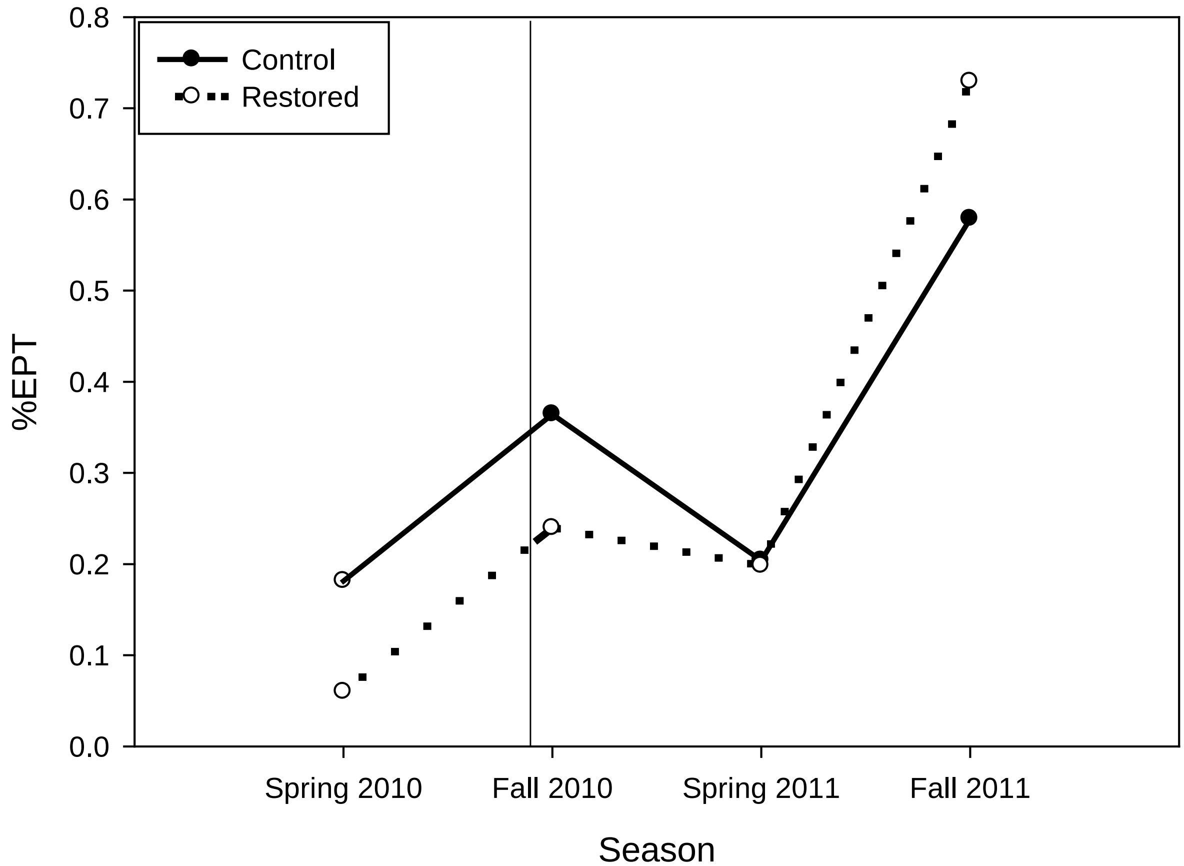

Figure 21. Percent Ephemeroptera, Plecotera, and Trichoptera (%EPT) sampled from the two treatment reaches of Kickapoo Creek during spring 2010 through fall 2011. Solid = Control reaches (A,D), Dashed = Restored reaches (B,C)

Kickapoo Cr Instream Restoration Project Maintenance Summary

Maintenance components:

- **Rock was added to the streambank and riffles to further secure the structures in preparation for flood events.**

- **Approximately 220 feet of additional bank protection was constructed upstream of the project reach to further secure the stream.**

Conducted in: **April 2012**

Below Riffle One, Two, & Upstream of Project Reach: the streambank was further protected with rock and vegetated soils

A special thanks to the Heavy Equipment Crew and DNR's wildlife staff for reseeding assistance.