OFFICE OF RESOURCE CONSERVATION
State of Illinois
Grant

PROJECT NUMBER:

PROJECT TITLE: Demonstrating the benefits of Stream Restoration to Aquatic Communities in the Cache River Basin

PURPOSE: The Cache River watershed, located in the Cache River Conservation Opportunity Area, has been the site of numerous restoration efforts focused on reversing habitat loss and degraded water quality associated with human alterations of the watershed. Returning the stream hydrology to a more natural state by reconnecting the upper Cache River to the lower Cache River has been proposed, with the goal of benefiting in-stream communities. However, this is a controversial topic, as there are concerns about how re-connection will affect flooding and questions regarding the degree of biological benefits that will actually be realized (e.g., cost/benefit issues). There is evidence from other low gradient streams in Illinois, that small increases in stream discharge noticeably increase dissolved oxygen concentrations (Figure 1), without water rising above and leaving the stream channel (Figure 2). In response to this, we will perform an experimental manipulation that will allow us to assess and demonstrate the effects of increasing stream flow on oxygen dynamics and macroinvertebrate communities in the lower Cache River. We will do so by pumping water into the lower Cache River to simulate reconnection. Documenting in-stream responses will allow for informed decision making regarding costs and benefits of future restoration efforts.

NEED: Stream restoration projects have increased ten-fold since 1990, with nearly 10 billion dollars spent in the US to date (Bernhardt et al. 2005). Unfortunately, designs of many restoration projects often do not take into consideration basic ecological concepts (Palmer 2009). Others, although designed more prudently, have not been monitored for "ecological success" (Bernhardt et al. 2005, Palmer and Bernhardt 2006). Given the increasing demand for restoration projects, and the need for quantitative measures of their effects on communities and ecosystem functioning, studies of restoration projects are critical for justifying and guiding future efforts.

The Cache River watershed lies at the confluence of four major physiographic provinces and harbors high aquatic species diversity (McNab and Avers 1994). The Cache watershed is also recognized as one of the few regions in the US containing wetlands of international significance, which include critical breeding and overwintering grounds for migratory birds. The Cache supports 44% of the native fish species and 60% of native mussels species in Illinois, as well as 34 crustacean and >340 macroinvertebrate species (IDNR 1997). However, the Cache has experienced impaired water quality that threatens this biodiversity, and much of this is related to human modifications to the landscape and channel (IEPA 2008).

Several restoration projects have been carried out in the Cache River basin. These include construction of weirs to stabilize the channel. These weirs also act as "hotspots" of aquatic insect production (Walther and Whiles 2008), and potentially provide important food and habitat

for fish. Reconnecting the upper and lower Cache River channels, which were separated to facilitate drainage of agricultural lands, has been proposed as a restoration project to address water quality issues and ecological integrity in the lower Cache. Reconnection would increase flow in the Lower Cache River and influence oxygen dynamics (e.g., Garvey et al. 2007), presumably resulting in positive responses by aquatic communities, but the pros and cons of reconnection are difficult to assess without quantitative information on potential ecological responses.

OBJECTIVES:

1- Validate hydrologic models that predict the stream response (mean cross-sectional velocity) to the addition of water (increased flow) to the lower Cache River
2- Quantify oxygen dynamics in the lower Cache River before and after the addition of water.
3- Determine how increasing flow in the lower Cache channel will affect the production, abundance, and diversity of macroinvertebrate communities.

To assess and demonstrate potential benefits of increasing flow to water quality and stream communities in the lower Cache, we will simulate reconnection to the upper Cache by pumping water into the lower Cache. We will focus on responses of dissolved oxygen (increasing oxygen levels with increased flow; Garvey et al. 2007). We also predict that macroinvertebrate community structure will change, with increases in diversity, abundance, biomass, and production of important groups such as filter-feeding caddisflies, which represent major food sources for many stream fishes. This study is novel, as simulation of stream reconnection has not been attempted, and it will provide quantitative information on the ecological effects of reconnection prior to the implementation of a restoration project. Thus, the products of this effort will allow for informed decision-making regarding the potential reconnection of the Cache River.

Two years of data collection and analyses will be required to meet these objectives. Sampling monthly for 1 year before pumping and 1 year during the flow addition will allow us to accurately assess oxygen dynamics and calculate annual production of macroinvertebrates, while accounting for seasonal variability. Estimating secondary production, although time-intensive, will allow for an accurate, quantitative measure of potential changes in food availability to higher trophic levels such as fishes.

APPROACH:

We will simulate reconnection of the upper and lower Cache River channels by pumping water from either wells near the Lower Cache River or from the Upper Cache River into the Lower Cache River over the Karnak Levee. At this point, the most likely source of water is abandoned agricultural wells in the area (Figure 3). The stream surface gradient of the Lower Cache River may be altered by raising or lowering weirs to facilitate increasing the mean stream velocity (see Figure 4 for weirs potentially modified by this experiment). The design of the experiment (i.e. alterations to weirs, the source of water, and the point of water addition to the stream) is currently underway. As the details of the pumping are developed, documents will be submitted

supporting those details. All plans will be submitted prior to earth moving activities. All weirs that are altered in the watershed will be designed to fail in flood events so that drainage of private lands is not compromised. Further, water will be pumped only during baseflow conditions in summer months, when dissolved oxygen levels are at their lowest. During storm events, there are inputs from tributaries into the lower Cache River. During the summer, however, these inputs are minimal and the lower Cache River has no measurable flow, so the addition of water during these periods potentially has disproportionate effects on the stream ecosystem. By adding water during low flow periods, we intend to reestablish historical current velocities (although low) that maintained riverine characteristics of the stream (Figure 5). Although reconnection of the stream would have multiple benefits, including the transport of sediment, organisms and nutrients, the aim of this project is to experimentally increase water velocity to observe the effects on key physical and biological variables such as dissolved oxygen dynamics and invertebrate community structure. The results of this study will be used to guide the planned physical reconnection of the river. Long-term pumping of water into the lower Cache River is not a viable option, as it would be cost prohibitive. We have met with local drainage district personnel about this project and they are supportive of our efforts; they will be involved in all planning and implementation phases of this project.

Objective 1. As part of this effort, we will modify (for in-bank flow) and validate the accuracy of hydrologic models of reconnection previously published by the Illinois State Water Survey (DeMissie et al. 2008). The physical parameters in the ISWS model will be field verified, and altered if necessary, by surveying stream reaches and flow patterns included in the model during pumping.

Objective 2. We will quantify oxygen dynamics before and after pumping at 4 sites in the lower Cache River and 4 reference sites in the upper Cache River (Figures 6 and 7). Datalogging dissolved oxygen meters will be placed at sites in the upper and lower Cache to measure dissolved oxygen and temperature every 10 minutes for at least 24 continuous hours once a month. Dataloggers will be mounted to a fence post within a meter of the bottom of the stream. Oxygen concentrations will be used to estimate whole-stream metabolism using a one-station method (Owens 1974). Primary production will be assessed, using benthic chlorophyll-*a* concentrations as a proxy, at 4 stream reaches before and after pumping by scraping attached algae from snag habitat, filtering through a glass-fiber filter and extracting in 90% acetone. Water column chlorophyll-*a* will also be measured, as an estimate of primary production of phytoplankton. The concentrations of chlorophyll-*a* will be measured using fluorometry (Arar and Collins 1997). Turbidity and duckweed cover, both which limit light penetration in the water column, will be assessed monthly. Results will allow us to quantitatively assess changes in dissolved oxygen and stream metabolism to increased flows.

Objective 3. The effects of increased flows on stream communities will be assessed by monthly sampling of macroinvertebrates associated with snag habitats (submerged wood) and drifting in the channel. Three snags will be sampled at each of 4 stream reaches in the lower and upper (reference) Cache by placing a 250 µm mesh bag over a piece of submerged wood and removing it with a saw. Surface area of each snag sample will be determined by measuring length and circumference. Macroinvertebrates will be identified to the lowest feasible taxonomic level (usually genus), measured, and biomass will be calculated using length-mass regressions (Benke

et al. 1999). Snag surface area will be used to normalize biomass data to mg/m^2 and secondary production will be estimated using standard approaches (Benke and Huryn 2006). Stream reaches will be surveyed at least once each year to determine total amount of wood in the stream, which will be used to estimate a habitat-weighted estimate of secondary production (Wallace and Benke 1984).

Invertebrate biomass in drift will be measured by placing three drift nets (250 µm mesh) in the stream for 15 minutes at the four study sites in each reach (upper and lower) and samples will be processed as described above. Mean velocity during sampling will be determined for each drift net to normalize biomass of invertebrates per liter of water.

RELATIONSHIP TO THE PLAN:

This project will contribute to attaining many of the goals of the state wildlife plan including (i) *increasing the knowledge of distribution and abundance of wildlife,* (ii) *describing stream habitat and conditions*, (iii) *describing problems in the stream* (i.e. filling in information gaps as described in Priority Actions Stream Campaign, page 64, IDNR 2005), and (iv) *describing effects of a proposed conservation project to guide a restoration effort* (Conservation Opportunity Area, Key Action, page 128, IDNR 2005). The Cache River watershed is home to 17 state listed species, including "species in greatest need of conservation". The stream reaches included in this study have populations of the state endangered Cypress minnow, *Hybognathus hayi* (Species in Greatest Need of Conservation, IDNR 2005, page 304), and the rare dragonfly, *Arigomphus maxwelli* (IDNR 1997). We will monitor macroinvertebrate communities in the river for two years, while documenting oxygen dynamics in the stream. Ultimately we will provide quantitative information on how the proposed reconnection of the Cache River would influence water quality and stream communities.

This project also addresses many of the stream-specific goals of the plan, including actions 7a and 7b, *increasing our understanding of baseline conditions and the effects of altered hydrology and water quality* (Priority Actions, Stream Campaign, page 64, IDNR 2005). By simulating stream reconnection, we will increase our understanding of how a future restoration effort, whose goal is to restore the natural hydrology in the lower Cache River, would influence in-stream habitat quality and stream ecosystem processes (secondary production of macroinvertebrates and stream metabolism). Because our study design would allow us to measure a gradient of influence from increased flow (the morphology of the channel is not uniform, so increasing discharge will have different effects on water velocity in each reach) we expect that responses of stream ecosystem processes will be correlated to the reach-specific change in flow. We would directly address the effects of low water velocity and dissolved oxygen on the stream, two parameters which placed the Cache River on the impaired waters (303(d)) list (IEPA 2008).

ANTICIPATED OUTCOMES AND BENEFITS:

The ultimate purpose of this project is to provide information that will allow for informed cost-benefit analyses of reconnecting the Cache River. Given the paucity of information on the

effects of restoration efforts on ecosystem processes in general, this study will also represent a strong contribution to the science of stream restoration that will undoubtedly resonate well beyond southern Illinois. The "simulated reconnection" of Cache River will guide the logistics and planning of the proposed future reconnection project. We will demonstrate how increasing water velocity will affect oxygen and macroinvertebrate communities, two foundations of aquatic ecosystem health.

This project will also strengthen one of the historically more active and successful groups associated with an Illinois Conservation Opportunity Area (COA). The Cache watershed group has been a model for other COAs to follow, and this project will further growing collaborations among researchers at SIU, agency personnel (IDNR and USFWS), private organizations (TNC), and private landowners, who all have a vested interest in generating information that will guide this and other proposed restoration efforts.

This effort will provide opportunities to train graduate and undergraduate students, as well as a post-doctoral fellow, in restoration ecology and conservation and will immerse them in important local decision making processes in southern Illinois. The project objectives will be accomplished in 2 years by two graduate students and a post-doctoral fellow at Southern Illinois University Carbondale. We will also provide important opportunities for undergraduate students at SIUC by hiring undergraduate students to assist with field and laboratory components of this study.

The end products of this project will be two Master's theses, one in Civil and Environmental Engineering, one in Zoology; at least four peer-reviewed scientific papers; and at least four presentations at scientific meetings by the graduate students and post-doc. We will also compile the information gathered, including papers published in scientific journals and detailed data, to be distributed to interested parties and presented at meetings of regional stakeholders.

LOCATION: This study will be conducted at four sites in the upper Cache River and four sites in the lower Cache River in Johnson County, Illinois. The sites in the upper Cache River are located near the town of Belknap, while the sites in the lower Cache River are located north of the town of Karnak (See Figures 6 and 7, Table 1).

PROJECT SCHEDULE:

Objectives	**Aug-Jun 10/11**	**Jul-Oct 11**	**Nov-Dec 11**	**Jan-Aug 12/13**
Insect Production	x	x	x	
Insect Drift	x	x	x	
Insect Sorting/analysis	x	x	x	x
Chlorophyll-a analysis	x	x	x	
Duckweed quantification	x	x	x	
24-hour oxygen measurements	x	x	x	
Pumping of water to lower Cache River		x		
Annual Report submission		x	x	x
Final report & manuscript submission				x

RELATED GRANTS: A part time (10/hr a week) undergraduate research assistant has been funded for this project through SIUC. This student will assist in both field and laboratory tasks.

ESTIMATED COSTS:

Category	Federal Request	SIUC Match	IDNR Match	LRRD Match	TNC Match	Total
Personnel						
Dr. Matt Whiles		$ 57,125				$ 57,125
Dr Greg Wilkerson		$ 46,440				$ 46,440
Heidi Rantala	$ 97,676					$ 97,676
Jim Garvey		$ 11,000				$ 11,000
IDNR personnel			$ 15,294			$ 15,294
LRRD personnel				$ 45,000		$ 45,000
Graduate student (2)	$ 59,344					$ 59,344
Student hourly (1)	$ 9,000				$ 15,000	$ 24,000
Primary care fee	$ 885					$ 885
Fringe	$ 31,256	$ 36,661				$ 67,917
Total Personnel and Benefits	**$ 198,161**	**$ 151,226**	**$ 15,294**	**$ 45,000**	**$ 15,000**	**$ 424,681**
Domestic travel	$ 16,500					$ 16,500
Commodities	$ 11,000					$ 11,000
Contractual						
Weir construction	$ 45,000					$ 45,000
Water pumping	$ 20,000					$ 20,000
Pump rental	$ 12,000					$ 12,000
Beaver dam removal	$ 4,000					$ 4,000
Permitting	$ 1,000					$ 1,000
Total Direct Costs	**$ 307,661**	**$ 151,226**	**$ 15,294**	**$ 45,000**	**$ 15,000**	**$ 534,181**
Indirect Costs (20%)	$ 61,532					$ 61,532
Facilities & Adm. 44.5% - SIU		$ 67,296				$ 67,296
Unrecovered F&A SIU (20% vs. 44.5%)		$ 75,377				$ 75,377
Total Project Costs	**$ 369,193**	**$ 293,899**	**$ 15,294**	**$ 45,000**	**$ 15,000**	**$ 738,386**
Percentages	50%	40%	2%	6%	2%	100%

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COMPLIANCE:

The IDNR will use its CERP (Comprehensive Environmental Review Process) as a tool to aid the Department in meeting NEPA compliance for the projects outlined under this grant proposal. It is the Department's policy to require CERP applications for all land disturbing activities unless those activities are covered by CERP exemptions (see the enclosed Comprehensive Environmental Review Process documents).

This proposal addresses NEPA via a categorical exclusion in 1.4B1, Appendix 1. Actions described in this proposal will not affect environmental quality and will not promote conflict over alternative resource uses. The USFWS categorical exclusion 1.6 allows for "nondestructive data collection, inventory, research and monitoring activities."

All planned activities will also be in compliance with the Endangered Species Act. All determinations and documentation will in accordance with the current established U. S. Fish and Wildlife Service protocols for Section 7.

All planned activities will be in compliance with the National Historic Preservation Act and the Council on Historic Preservation Act. All determinations and documentation will be in accordance with the terms of the Programmatic Agreement, as amended, effective September 23, 2002.

When applicable, those planned activities which involve a floodplain and/or jurisdiction wetlands will be done in accordance with Presidential Executive Orders 11988 and 11990.

BUDGET JUSTIFICATION:

Personnel: This project will include labor-intensive field and laboratory work, so the majority of the requested funds and matching funds (SIUC, IDNR, and Little River Research & Design) are related to personnel. USFWS funds will be used to support a post-doctoral researcher in the

Department of Zoology at SIUC at the rate of $42,000 for year 1 and $44,100 for year 2. Fringe and benefit rates through SIUC are 32% for retirement and medical and life insurance ($13,440 and $14,112 for years 1 and 2, respectively). Two M.S. students, one in each the Department of Zoology and the Department of Civil and Environmental Engineering, will be supported with Federal funds. Graduate stipends at SIUC are $18,825 a year, which includes a tuition waiver and health insurance. Federal funds are also requested to pay one undergraduate technician to help with field sampling and laboratory sampling process. The undergraduate will be paid at the rate of $9.00-$10.00 per hour, depending on experience. The master's students will be advised by the project leader, either Whiles or Wilkerson, in their field of study. As part of the SIUC match, Whiles and Wilkerson will dedicated 1.5 months time during year 1 and 2 months during years 2 and 3. Garvey will dedicate 1 month of time in year 1. The SIUC match of fringe and benefits associated with the matches of Whiles ($9,841 per month salary and assuming 5% annual raises), Wilkerson ($8,000 per month salary and assuming 5% annual raises), and Garvey ($11,000 per month salary and assuming 5% annual raises) are 32% for retirement and medical and life insurance (i.e., year 1, with a total of 3 person months for the PIs = $12, 084; years 2 and 3 with an annual total of 4 person months for the PIs = $11,989). Personnel from IDNR will match $10,000 in salary during each year 1 and 2. Personnel from LRRD will match $15,000 in salary during years 1-3.

Equipment: The equipment needed for the successful completion of this project is already in place at SIUC.

Travel: Funds are requested to lease a vehicle through SIUC travel services that will be dedicated to the project for 5 months of each year, given the frequency of travel that will be associated with field sampling. Funds are also requested to present the results of this study at professional meetings by the post-doctoral fellow and the two graduate students . Vehicle lease ($400 per month for 6 months), fuel and maintenance costs (estimated at $100-250 per month for 12 months), and travel related to presentation of project results ($500 per person per regional meeting, $1200 per person per national meeting) are estimated at $16,500 for the three-year duration of the project.

Commodities: Funds are requested to purchase supplies including chemicals for chlorophyll-*a* analyses, filters, sample containers and vials, slides and mounting medium, preservatives, field notebooks, and related materials that are essential of the field and laboratory components of this project.

Contractual: This project includes the pumping of water to increase the mean velocity of the water in the lower Cache River. This involves the construction of temporary weirs, the rental of a pump, the fuel or electricity to run the pump, and the removal of physical barriers (beaver dams and log jams) in the stream. Funds are requested to address those needs. The construction of weirs and other structures is estimated at $45,000 for year 1. In year 2, the estimated cost of rental of the pump ($3000 a month for 4 months) and the energy to operate the pump ($5000 per month for 4 months) and remove obstructions to stream flow ($1000 a month for 4 months). In addition, $1000 in year 1 is requested to draw up the proper permits required for the implementation of this project.

Indirect Costs: SIUC indirect costs are normally 44.5%. The federally-allowed 20% of total direct costs is included in the budget. The remaining unrecovered indirect costs constitute the remainder of the SIUC match on his project.

DOCUMENTS SUPPORTING THE GRANT PROPOSAL:

The following documents are attached in support of this grant proposal:

Application for federal assistance (Form 424)

Comprehensive Environmental Review Process

Federal Aid Section 7 Evaluation Form

Grant proposal budget

Illinois Clearinghouse response per Federal Executive Order 12372

NEPA Compliance Checklist

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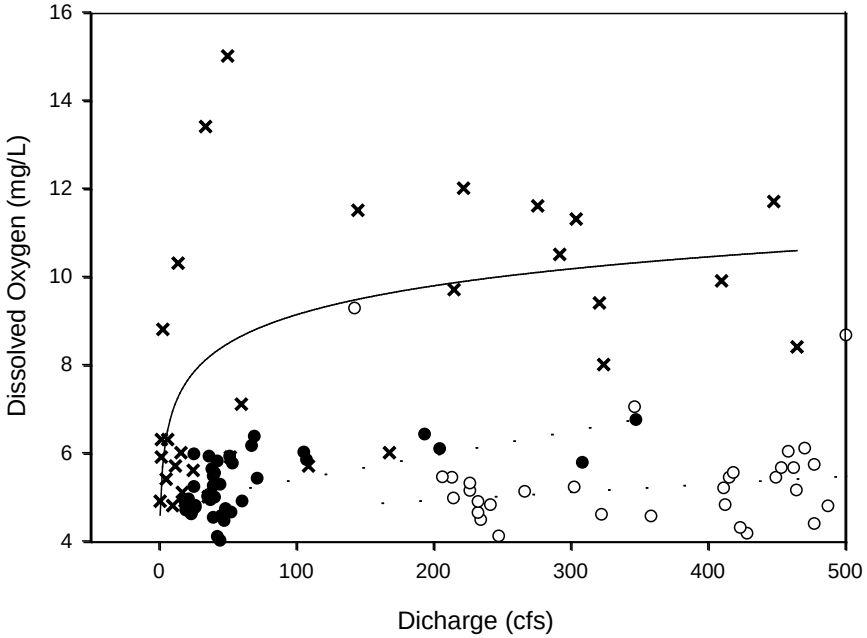

Figure 1: Graph showing the relationship between stream discharge and dissolved oxygen concentrations in three low gradient Illinois streams. Note: X = Cache River, Forman (IEPA, unpublished data), circles represent data from Garvey et al. (2007).

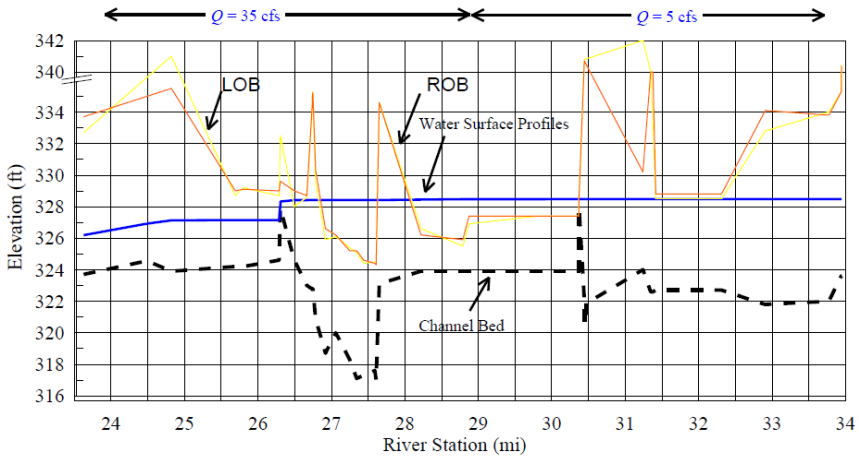

Figure 2: Plot of HEC-RAS model results for the lower Cache River with the addition of 5 cfs of water. In this scenario, water would be added at the Tunnel Hill State Trail crossing. The plot is a longitudinal representation of the stream bed (black dashed line), water surface elevation (solid blue line), and the right and left bank elevations (orange and yellow lines, respectively). The model assumes that Cypress Creek will input an additional 30 cfs, that flow is from east to west, and that the weir near the Tunnel Hill State Trail is raised to at least 329 feet above sea level. This plot indicates that the water surface elevation will be greater than the bank elevation only in two places between miles 31.5 and 27.5, which is the location of Buttonland swamp, where the river naturally moves laterally into the swamp. Source: Cameron Bencini and Greg Wilkerson, unpublished data.

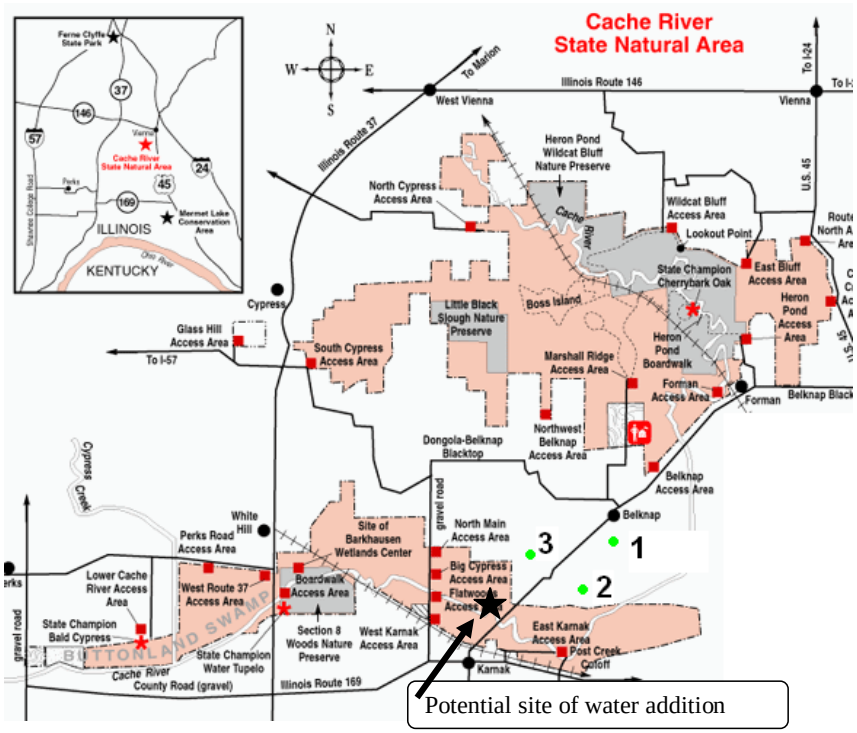

Figure 3: Location of abandoned agricultural wells in the vicinity of the lower Cache River. Well 2 is currently the best candidate for this study, as it has a turbine and is close to the proposed site of water addition. Well 3 is the other possible source of well water for this experiment. The capacity of well 2 is estimated at about 3.5 cubic feet per second (cfs).

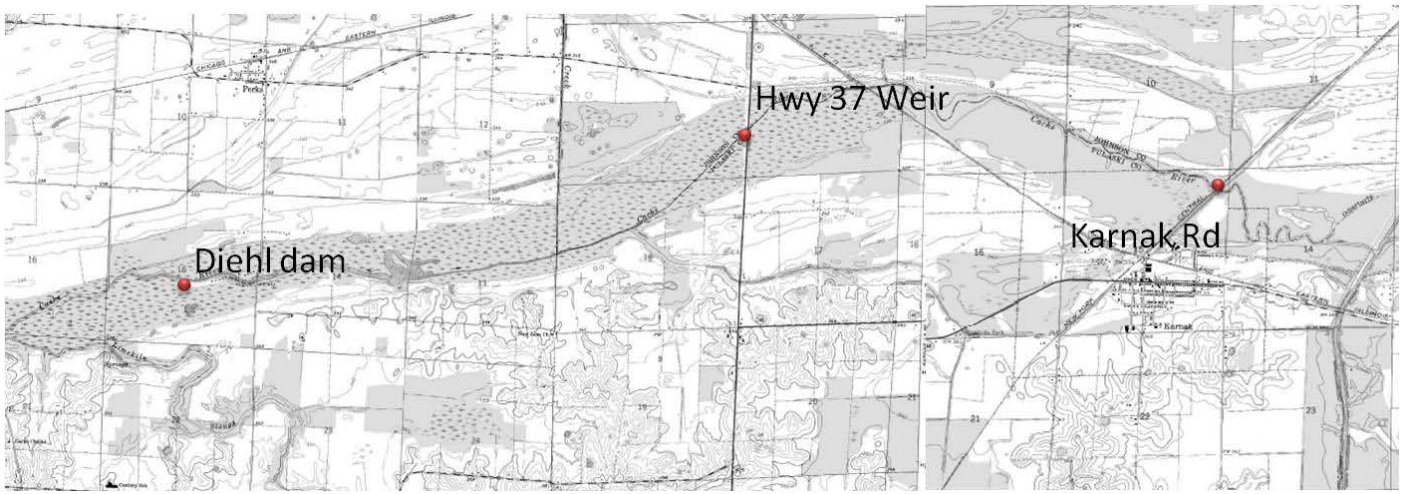

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Figure 4: Location of current weirs that may be affected by modifications in this study. The basemap for this figure was a combination of the Cypress and Karnak Quadrangles (USGS 1966, 1976, respectively).

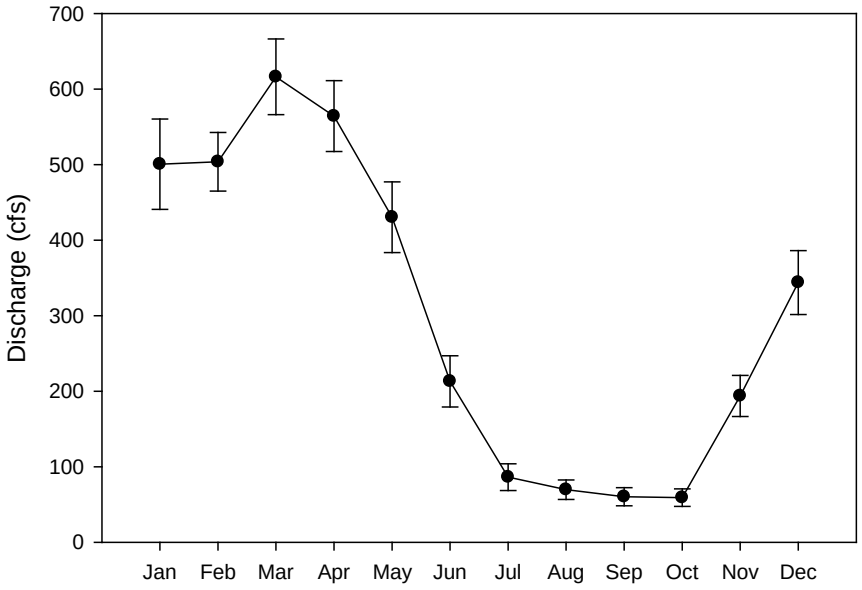

Figure 5: Mean monthly discharges (±1 s.e.) for the Cache River at the USGS gage station in Forman, IL. This plot is based on an 86 year record. Note that water levels are historically lowest from July through October. Source: http://waterdata.usgs.gov/nwis/uv?03612000, accessed June 15, 2010.

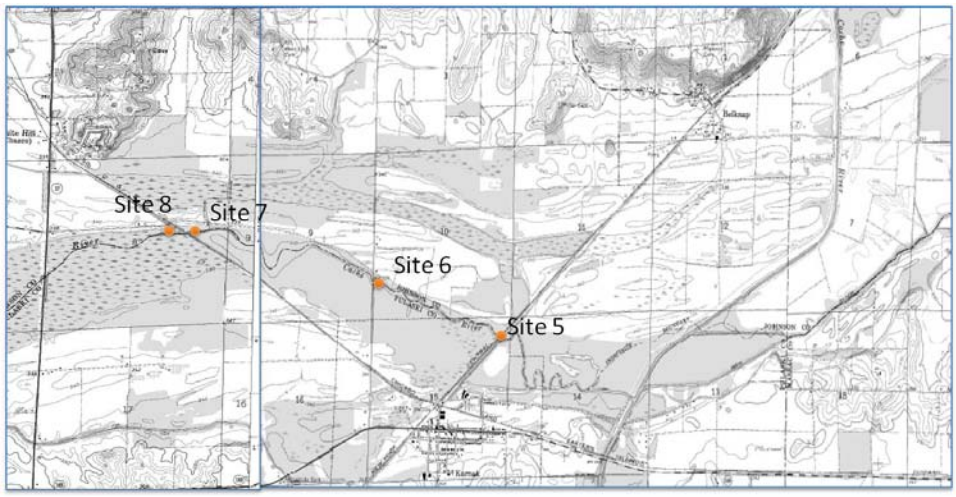

Figure 6: Location of stream sites in the lower Cache River, labeled from 5-8 (upstream to downstream). For a legal description of sites, see Table 1.

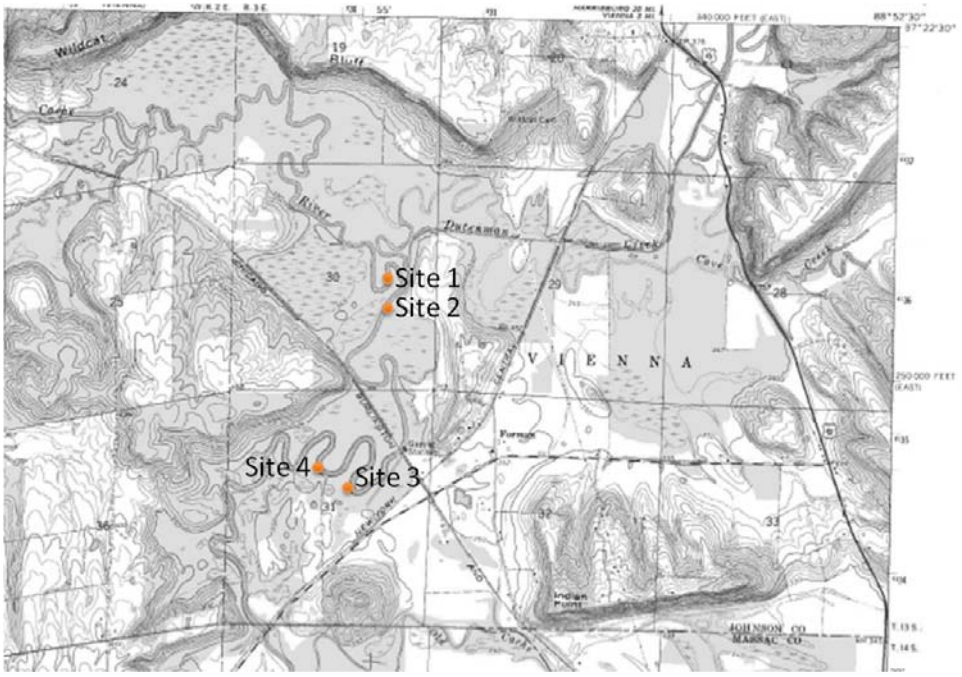

Figure 7: Location of stream sites in the upper Cache River, labeled from 1-4 (upstream to downstream). For a legal description of sites, see Table 1.

Table 1: Coordinates and descriptions of study reaches in the upper and lower Cache River watershed. Note: coordinates were obtained from Karnak Quadrangle (USGS 1976) and Cypress Quadrangle (USGS 1967). The datum used was NAD27. The descriptions of sites were based on those same maps.

Site	Watershed	Coordinates	Description
1	Upper Cache	88.9160 N, 37.3582 W	North of footbridge on western bank of river, NE1/4, SE1/4, Section 30, T13S, R3E
2	Upper Cache	88.9158 N, 37.3567 W	First pool/run downstream of footbridge, NE1/4, SE1/4, Section 30, T13S, R3E
3	Upper Cache	88.9185 N, 37.3445 W	First bend on western bank of river, accessible from trail, SW1/4, NE1/4, Section 31, T13S, R3E
4	Upper Cache	88.9214 N, 37.3459 W	Second bend on western bank of river, accessible from trail, SW1/4, NE1/4, Section 31, T13S, R3E
5	Lower Cache	88.9679 N, 37.3024 W	West side of river crossing on Karnak Rd, approx. 0.5 miles NE of Karnak, NE1/4, NE1/4, Section 15, T14S, R2E
6	Lower Cache	88.9838 N, 37.3070 W	East side of river crossing on Porthouse Rd, SW1/4, SW1/4, Section 10, T14S, R2E
7	Lower Cache	88.9007 N, 37.3109 W	East side of river crossing on Bike Trail, SW1/4, NE1/4, Section 8, T14S, R2E
8	Lower Cache	88.9008 N, 37.3107 W	West side of river crossing on Bike Trail, SW1/4, NE1/4, Section 8, T14S, R2E