Kentucky Water Resources Research Institute
Annual Technical Report
FY 2005

Introduction

The 2005 Annual Technical Report for Kentucky consolidates reporting requirements of the Section 104(b) base grant award in a single technical report that includes: 1) a synopsis of each research project supported during the period, 2) related reports and publications, 3) a description of information transfer activities, 4) a summary of student support during the reporting period, and 5) notable achievements and awards during the year.

Research Program

The activities supported by Section 104(b) program funds and required matching are interwoven into the total program of the Kentucky Water Resources Research Institute. Additional elements of the program during FY2005 included the Environmental Protection Scholarship Program and other research, service, and technology transfer activities funded through a variety of sources. Memoranda of Agreement projects with the Kentucky Division of Water included TMDL development for several Kentucky streams and a water quality evaluation for the Upper Cumberland River (focused on pathogens). Other projects were funded by the Kentucky Cabinet for Health and Family Services (technical support for the Maxey Flats Nuclear Disposal Site and the Paducah Gaseous Diffusion Plant - Federal Facilities Agreement and Agreement in Principle), the Kentucky River Authority (Watershed Management Services), the National Institute of Environmental Health Sciences (Superfund Public Outreach Program), East Kentucky PRIDE (Water Quality Assessment), and Metropolitan Sewer District (Beargrass Creek Combined Sewer Overflow). In addition, the Kentucky Consortium for Energy and the Environment, headed by Lindell Ormsbee (Director of KWRRI), is a collaborative program involving faculty and staff at the University of Kentucky, the University of Louisville, and Murray State University. This consortium assisted with efforts supporting a variety of environmental assessment and cleanup activities at the Paducah Gaseous Diffusion Plant.

Four research projects received support through 104(b) FY2005 program funding. Investigators represented the University of Kentucky (Rowe 2005KY48B), Western Kentucky University (Kenworthy 2005KY50B), Eastern Kentucky University (LaSage 2005KY51B), and Murray State University (Fuller 2005KY52B). In addition, a no-cost extension was granted to one of the 2004 projects (Kenworthy 2004KY43B). Project synopses for the five investigations follow.

Reconstructing Late Quaternary Paleohydrology of the Lower Ohio Valley

Basic Information

Title:	Reconstructing Late Quaternary Paleohydrology of the Lower Ohio Valley
Project Number:	2005KY48B
Start Date:	3/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	KY 6th
Research Category:	Climate and Hydrologic Processes
Focus Category:	Sediments, Hydrogeochemistry, Climatological Processes
Descriptors:	speleothems, lacustrine sediments, stable isotopes
Principal Investigators:	Harry Rowe

Publication

1. Brown, D.A. and H.D. Rowe, 2005, Developing late Quaternary paleolacustrine climate records in the Salt River Basin, Kentucky, in Proceedings of the Fall 2005 American Institute for Professional Geologists Meeting.

Problem and Research Objectives

Kentucky possesses two very important Late Quaternary paleohydrological archives: lacustrine sediments and speleothems (cave deposits). Extensive glacial-age lacustrine and alluvial deposits along the northern border of the state indicate that Kentucky is geographically located in a unique region that yields important paleoclimatic information regarding atmospheric circulation patterns and geomorphic responses to climate change in an area proximal to continent-scale ice sheets, and Quaternary climate change and its impacts on the drainage patterns within the Ohio Valley have a commanding effect on the modern surface and near-surface hydrology of Kentucky. Previous investigations completed by the US Geological Survey and the Kentucky Geological Survey along the Ohio River in the vicinity of Owensboro and Paducah identified at least two large Wisconsin-age paleolakes within the glacial valley train. In addition, investigations in the Salt River basin revealed that the lower reaches of the Salt and its tributaries were occupied by a large, long-lived paleolake, perhaps during both the Illinoisan and Wisconsin glacial episodes. This study expands on previously existing paleolimnological work by 1) constructing coherent geochronologies for Wisconsin-age fluvio-lacustrine deposits in the lower Ohio Valley drainage, 2) characterizing regional variability in geomorphic/hydrological settings during the last glacial episode, and finally 3) developing a paleohydrology/paleoclimatology record from lacustrine facies preserved in the Salt River basin.

Methodology

Long sediment cores were collected in the vicinity of Owensboro and Paducah, Kentucky and studied with a focus on down-core grain-size variations. A core collected from the Salt River Basin (south of Shepherdsville, Kentucky) was also utilized in the investigation. Project funding also supported installation of cave environment monitoring equipment (temperature, humidity and drip plates) in Crystal Cave (Fayette County). Speleothems obtained from this cave will hopefully provide a record of hydrologic history in the central Bluegrass Region going back several thousand years through the utilization of U-Th techniques.

Principal Findings and Significance

Based upon analysis of the Salt River Basin core, variations in down-core gamma, magnetic susceptibility, bulk geochemistry, and bulk stable isotopes provide only limited information on paleoenvironment. The sediments were deposited very rapidly (60 feet in ~1500 years), so pollen succession is also limited in its ability to define shifts in paleoenvironment. Down-core grain-size changes are likely the most useful tool for understanding subtle shifts in environmental conditions. Acquisition of a laser-particle grain-size analyzer to define high-resolution (sub-decadal) changes in fluviolacustrine deposition archived in the sediment cores is planned through separate funding (July 2006). Speleothems collected from Crystal Cave are being dated using the U-Th technique to assess the hydrologic history of the central Bluegrass Region.

Effects of Reservoir Releases on Riverbank Erosion

Basic Information

Title:	Effects of Reservoir Releases on Riverbank Erosion
Project Number:	2005KY50B
Start Date:	3/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	KY 2nd
Research Category:	Climate and Hydrologic Processes
Focus Category:	Geomorphological Processes, Floods, Sediments
Descriptors:	sediment supply, channel adjustment, streambank stability
Principal Investigators:	Stephen Kenworthy

Publication

Problem and Research Objectives

This project evaluated the influence of Green River Lake Dam located near Campbellsville, Kentucky on the hydrology and bank stability of the Upper Green River of Kentucky. Alteration of natural river flow regimes by dams can have negative impacts on river channel morphology and aquatic ecosystems. These environmental costs must be balanced against the water resource benefits provided by dams and reservoirs. Changes in riverbank stability and channel width are commonly observed downstream of dams. These geomorphic impacts can lead to degradation of habitat and impairment of riparian and aquatic biological communities.

The Upper Green River is of particular concern because of impacts on threatened and endangered species, and because of federal and state soil conservation programs aimed at improving water quality in the river. Several flood control reservoirs were built in the Green River Basin during the middle of the 20th century to regulate flows on the Green and Ohio Rivers. The geomorphic effects of Green River Lake Dam are undocumented and thus poorly understood. This project analyzed the historical impacts of the dam on bank stability and provided new information on the effects of hydrological modification by flood control reservoirs on channel dynamics in large alluvial river systems. These results will be valuable in planning flood control operations and land use practices that minimize the negative geomorphic and ecological effects of flow regulation.

The scientific objectives of this research were to document historical rates of channel migration, changes in channel width, and spatial patterns of recent bank instability on the upper Green River, and to relate these geomorphic changes to patterns of hydrologic modification by Green River Lake Dam.

Methodology

Hydrologic Modification: The hydrological impacts of Green River Lake were evaluated by analyzing available daily streamflow records from USGS gaging stations at Greensburg and Munfordville, Kentucky. Analysis entailed comparing flow regimes during pre-dam and post-dam periods of record, along with information on climatic variability during these periods.

Historical Pattern of Channel Change: Due to the time and effort involved in obtaining and analyzing aerial imagery, analysis of historical channel change was restricted to the tailwater reach of the Green River, defined as the reach between the dam and the confluence with Russell Creek. This part of the river is most likely to have had significant, dam-related hydrologic alteration (this geographic focus is a modification to the analysis described in the original proposal). Rates of channel migration and channel width changes were estimated from sequences of aerial photographs (USDA aerial photography field office). Imagery from 1955, 1964, 1983, 1991, and 2004 were used in this analysis. Digital scans of older aerial photos were georeferenced and orthorectified using 2004 NAIP (National Agricultural Information Program) imagery as the geographic reference. Series of images were analyzed by automated classification algorithms (*Erdas Imagine*) and by manual assessment of changes in channel width. Bank stability for periods before and after flow regulation by the dam was compared to the observed changes in hydrologic regime between pre- and post-dam periods.

Recent Streambank Instability: Locations of recent streambank instability were mapped, in part by using a previous survey of bank erosion locations provided by faculty in the Department of Biology at Western Kentucky University. This survey, and additional surveys of bank erosion locations were used to select sites for detailed study where erosion pins were inserted into steep, eroding banks, and bank planform geometry was mapped in order to monitor bank retreat in relation to flow fluctuations in the future.

Principal Findings and Significance

Hydrologic Modification: Analysis of daily streamflow records from the Greensburg and Munfordville gages revealed a pattern of hydrologic alteration consistent with the flood control objectives of the dam. Peak flows during the post dam period of record (after 1970) are lower and less frequent at both gage sites. Flow duration curves were altered at both Greensburg and Munfordville in a similar fashion, with the proportions of low and high flows reduced, and the proportions of intermediate level flow correspondingly increased (Tables 1 and 2). These changes reflect the retention of runoff for flood abatement objectives and the mandatory minimum release from the dam for water supply purposes. These changes correspond to increases in the duration and frequency of in-channel flows and thus could be expected to contribute to decreased bank stability during the post-dam period.

Table 1. Hydrologic Alteration at the Greensburg, KY gaging site

Summary of Mean Daily Flow Records, Green River @ Greensburg, KY	Pre-Dam (1940-1969)	Post-Dam (1970-1975)
N (days)	11050	2099
Low Flows, Q < 2 cms		
Average # days/yr	84	5
Proportion of days	0.23	0.014
In-Channel Flows, Q = 100 - 200 cms		
Average # days/yr	15	57
Proportion of days	0.04	0.155
High Flows, Q > 200 cms		
Average # days/yr	9	2
Proportion of days	0.025	0.005
Maximum Mean Daily Flow (cms)	1621	244

Table 2. Hydrologic Alteration at the Munfordville, KY gaging site

Summary of Mean Daily Flow Records, Green River @ Munfordville, KY	Pre-Dam (1915-1969)	Post-Dam (1970-2003)
N (days)	16194	11961
Low Flows, Q < 5 cms		
Average # days/yr	44.5	3.7
Proportion of days	0.12	0.01
Intermediate Flows, Q = 100 - 300 cms		
Average # days/yr	50.3	99.3
Proportion of days	0.14	0.27
High Flows, Q > 600 cms		
Average # days/yr	4.7	2.0
Proportion of days	0.013	0.005
Maximum Mean Daily Flow (cfs)	2086	1780

Historical Pattern of Channel Change: Analysis of imagery for the tailwater reach revealed surprisingly little evidence of significant channel migration or bank erosion since 1955. The most prominent changes occurring appear to be the modification and/or erosion of islands. The evidence of island erosion and modification does not appear to be correlated with hydrologic modification during the post-dam period. Identification of changes in bank position is limited by the resolution and geospatial accuracy of the imagery and by differences in shadow and image quality. Given these limits, observed changes in bank position, and thus evidence of bank erosion and channel migration, appear to be within the margin of error for the analytical techniques for most of the tailwater reach. For those locations where channel change is apparent, it appears that changes in riparian vegetation, often associated with agriculture, are a significant factor. Thus, the initial results of this work suggest that flow regulation by Green River Lake Dam has not significantly modified channel width, planform geometry, or channel migration rates within the study reach. It is possible that progressive change due to the dam is occurring, but is too slow to produce significant planform changes over 50 years.

Recent Streambank Instability: Field surveys of bank erosion suggest that the occurrence of local accelerated bank erosion is more frequent along the portion of the Upper Green River upstream of the confluence of Little Barren River. This pattern may reflect a combination of hydrologic and geomorphic factors, but the explanation remains uncertain. Enhanced bank erosion in river segments nearer to the dam is consistent with the hypothesis that hydrologic alteration has induced bank instability in the tailwater reach. However, the apparent stability of this river segment as revealed by the aerial imagery analysis suggests that other factors, such as riparian land use, may be just as important.

Pathogen and Sediment Transport in the Muddy Creek Subbasin, Kentucky River Watershed

Basic Information

Title:	Pathogen and Sediment Transport in the Muddy Creek Subbasin, Kentucky River Watershed
Project Number:	2005KY51B
Start Date:	3/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	Ky 6th
Research Category:	Water Quality
Focus Category:	Management and Planning, Water Quality, Non Point Pollution
Descriptors:	coliform bacteria, suspended sediments, land use, stormwater
Principal Investigators:	Danita Maynard LaSage, Thomas L. Edwards, Alice Jones

Publication

1. LaSage, Danita, Alice Jones, and Tom Edwards, 2006, The Muddy Creek project: evolution of a field-based research and learning collaborative, Journal of Geoscience Education, 54(2), p. 109-115.
2. Albright, Michael, Danita LaSage, and Alice Jones, 2006, Multi-scalar geomorphological characterization of the Muddy Creek watershed, Kentucky, in Proceedings of the Kentukcy Water Resources Annual Symposium, Kentucky Water Resources Research Institute, Lexington, Kentucky, p. 51-52.
3. Collins, Samuel, Michael Albright, and Danita LaSage, 2006, Pathogen and sediment transport in Muddy Creek, in Proceedings of the Kentucky Water Resources Annual Symposium, Kentucky Water Resources Research Institute, Lexington, Kentucky, p. 79-80.
4. LaSage, Danita, Alice Jones, and Tom Edwards, 2005, Muddy Creek: The evolution of a community-university watershed partnership, 8th Annual Southeast Watershed Roundtable and 3rd Annual Kentucky State Watershed Roundtable - Watershed strategies for a new era: Protecting the environment and the bottom line, Convened by the Southeast Watershed Forum (www.southeastwaterforum.org) and the Kentucky Waterways Alliance.

Problem and Research Objectives

This project focuses on Muddy Creek, a tributary of the Kentucky River that was included as a Priority 1 stream on the 2004 Kentucky 303(d) list of impaired waters. The Kentucky Chapter of the Nature Conservancy has identified the watershed as one of its five state-wide landscape-scale conservation targets because it contains examples of several pre-settlement habitats. One riparian species, running buffalo clover, is a federally protected endangered species. Threats to the health of the Muddy Creek Watershed include pathogen risk and cumulative downstream stormwater impacts from expanding suburban development. Building on a previous study (Jones, 2002KY7B), we sought to address several areas where information on Muddy Creek remained insufficient: (1) sources of fecal coliform in the upper reaches of the watershed; (2) stream hydrology and discharge information; (3) suspended sediment concentrations; and (4) the need to ground truth the accuracy of the Kentucky Gap Analysis Program ("GAP" or "Kentucky GAP") GIS land use layer.

Methodology

Water-quality data were collected approximately monthly at 7 stations, and samples for coliform analyses were collected at 15 locations. The scope of the project was changed through initiating collaboration with USGS to provide continuous water-quality monitoring at one stream station. Low flow conditions in Muddy Creek resulted in an adjustment to plans to collect quarterly discharge measurements for one year at several of the selected sites. Instead, our USGS collaboration will allow us to gather continuous discharge data at one site for three years.

We initiated a study of sediment transport in the watershed by doing cross-sectional surveys at three sites. Streambed materials were classified at each of the survey sites and GIS was utilized to construct a geomorphological model at landscape and site scales. Samples for suspended sediment analysis were collected and turbidity measurements were taken at several stations during both baseflow and stormflow conditions to establish turbidity as a surrogate for suspended sediment sampling. Finally, a multi-probe capable of collecting large amounts of turbidity data was installed at the USGS stream station.

The watershed was ground truthed by comparing the actual landscape in portions of the watershed against predicted vegetation based on currently available GIS layers. Differences in patterns of landscape type throughout the watershed were examined. Observation points were located and the vegetation types were recorded. The field observations are now being used to prepare new maps.

The number of permanent sampling sites along the farm meander was reduced from 5 to 3. We originally planned to do temperature probing along the meander as part of a hyporheic flow study to be accomplished for a master's thesis. However, the flow study proved impractical, and the temperature probing was not done.

Principal Findings and Significance

Muddy Creek remains at risk for aquatic and stream health. A particular concern is the occurrence of relatively high concentrations of coliform bacteria in the stream. Atypical Coliform/Total Coliform ratios, which indicate the age of coliform populations in streams, have been useful in larger watersheds to target point-source sewage inputs. However, AC/TC ratios were not a reliable indicator of coliform source in the Muddy Creek watershed, possibly due to the small size of the watershed and the preponderance of small, dispersed nonpoint sources of contamination (individual septic systems) rather than large point sources (such as municipal wastewater treatment plants).

Erosion and sediment loading from watershed-scale geology and local land use issues are also a source of concern. The baseline geomorphological and suspended sediment data collected during this project will be useful for future studies of sediment and erosion in the watershed. Turbidity data from large storm events or prolonged periods of rain are needed to evaluate sediment loading under bankfull conditions, the conditions under which most geomorphological work is performed.

The use of a readily available land use/land cover dataset (GAP) as an aid in identifying stressors related to human influences in a small watershed such as Muddy Creek was examined. While the GAP resolution is acceptable for understanding statewide landscape patterns, the GAP is insufficient at the watershed scale to characterize land use and therefore, not adequate for use in local water quality management programs. A methodology for rapid ground truthing ("Rapid Roadway Reconnaissance") involving delineation along publicly available corridors (roadways) with extrapolation of the results was field tested. The "Rapid Roadway Reconnaissance" methodology shows promise for application in ground truthing remotely sensed data in a cost-effective and time-efficient way, and merits further study. Future work will determine whether certain GAP land use types are more likely than others to be incorrectly classified.

Development and Immunity in Dragonfly (Odonata: Anisoptera): Indicators of Water Quality

Basic Information

Title:	Development and Immunity in Dragonfly (Odonata: Anisoptera): Indicators of Water Quality
Project Number:	2005KY52B
Start Date:	3/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	KY 1st
Research Category:	Biological Sciences
Focus Category:	Ecology, Non Point Pollution, Water Quality
Descriptors:	immunity, development, fluctuating astmmetry
Principal Investigators:	Claire A. Fuller, Howard H. Whiteman

Publication

1. Harris, Shawna, Claire Fuller, and Howard Whiteman, 2006, Environmental factors affecting dragonfly immunity, in Proceedings of Annual Meeting of the American Society of Biologists, Gatlinburg, Tennessee.

Problem and Research Objectives

Historically, one of the most widely-used indicators of water quality has been the presence or absence of certain organisms, particularly fish and aquatic insects. Such assays have proven very useful for monitoring, yet may fail if the environmental perturbation reducing diversity in these systems cannot be removed by natural or anthropogenic restoration, thus allowing natural recolonization. Scientists thus need an early-warning system that could identify environmentally-stressed animals before the stressor causes population and/or regional harm, i.e., one which is more sensitive than presence-absence data. Such an indicator should be able to measure stress-induced effects before drastic changes take place that would subsequently decrease the organism's survival and reproductive abilities. We proposed to correlate biological indicators (development and immunity) with important water chemistry and habitat variables known or hypothesized to cause negative consequences in an anisopteran odonate (dragonfly), *Plathemus lydia*. Developmental anomalies may indicate exposure to stress in the past; immunity may indicate the likelihood that organisms can withstand future stress. We related water chemistry variables and our bioindicators across forested, agricultural, and industrial landscapes to understand how current land-use practices are influencing odonate populations. The results of this study provide initial data necessary to evaluate the use of odonates as an early-warning indicator of water quality and environmental degradation. Development of these methods will provide researchers with a sensitive biological indicator of environmental health, which can potentially be used to monitor areas that are susceptible to ecological disturbance or where there are human health concerns.

Specifically our objectives were to:

1) Adapt two immunological techniques for use with dragonfly nymphs to add to techniques already in use in our laboratory.
2) Measure developmental and immune parameters in nymphs from 20 ponds across a N-S transect in Western KY. This transect represents a predicted gradient of water pollution due to wind-borne contaminants from Murray, Mayfield, Paducah, and Calvert City, Kentucky). Measurements were planned for a spring and late summer collection.
3) Measure water quality parameters in the same 20 ponds during each collection period.

This research is important to both species conservation and environmental monitoring. The data we collected using USGS funds will allow us to write a larger proposal at the national level (in progress). Such data are necessary since federal funding for ecological research is limited and extremely competitive.

Methodology

Changes to methodology from our initial proposal are indicated in **bold**.

Ponds. We identified over 40 ponds along a N-S gradient in Western KY. Twenty of these ponds were initially selected as potentially useful for our study. **However, six ponds dried during the summer, leaving only 14 for sampling during the fall.**

Time of year for collections. We proposed to collect in spring and late summer, during cool and hot temperatures, respectively (to test the hypothesis that temperature affects development and immunity). **Because of the grant start date, we were unable to begin sampling until the early fall, in 14 ponds. We have identified an additional seven ponds to use in the spring 2006 survey.**

Collections. We proposed to collect ten animals from each pond by scooping leaf litter and sediment into a net. The contents of the net are examined and nymphs gently transferred to a minnow bucket supplied with water and leafy debris from their pond. Animals are transported to the lab for measurement of Fluctuating Asymmetry (FA), immunity assays, and preservation (see below). **We increased the sample size by collecting 10 to 25 animals. Up to 20 of these animals were used for 3 of the immunity assays and FA measurements. Five were used in two additional immunity assays (encapsulation and post-challenge PO activity).**

Fluctuating asymmetry. After capture, individuals were transported in buckets back to Murray State University for digital imaging. Each individual was initially to be anesthetized by chilling on ice for 5 minutes and then photographed with a Pixera Professional digital camera connected to a PC. **However, animals were first used for immunological analyses (except encapsulation because that assay can damage traits measured for FA), then preserved in 95% ETOH, and subsequently photographed.** Digital imagery reduces measurement error considerably when compared to other techniques (Whiteman et al. in prep). In addition, digital imagery allows us to easily take multiple measurements at a later time, rather than immediately while the animal is in the laboratory. Measurements of FA concentrate on major morphological structures associated with the head, mouth, legs, and torso. Each individual was measured three separate times in order to statistically analyze measurement error (Palmer 1994).

Immunological Assays. We originally proposed to conduct the following immunological assays: encapsulation, phenoloxidase (PO) in unchallenged animals, hemolymph protein levels and lytic activity. **We were unable to measure lytic activity. However, we added prophenoloxidase (PPO) as another assay. We also measured PO in animals that were immunologically challenged prior to assessment. To do this, we inserted an inert object (monofilament line) into the hemocoel and measured PO activity 24 hrs later. (Note: the monofilament line also serves as the object for encapsulation in the encapsulation assay).**

Principal Findings and Significance

All water quality measurements (except for organics) for the fall samples have been made and entered into a data base. Organic samples have been prepared for analysis. We photographed and measured all animals captured during the fall and data analysis has begun. We have finished all of the immunological assays (PO, PPO and protein levels) for the fall sampling period except for the measurements of encapsulation (all encapsulation immunological assays have been conducted, however, the animals with their encapsulated monofilmament have been preserved in ETOH and are awaiting measurement). We have conducted preliminary analyses to determine the relationship between these parameters and the following water quality indicators: temperature, pH, conductivity, dissolved oxygen, ORP, and turbidity. We have arranged a meeting with a statistician for help conducting additional statistical analyses. Preliminary

analyses show a number of statistically significant relationships (Table 1). Overall, PPO activity was related to temperature, but this relationship was not significant (Backward stepwise ANCOVA, N = 92, $R^2 = 0.356$). However, a number of environmental variables were significantly related to PO activity (Table 1; Backward stepwise ANCOVA, N = 79, $R^2 = 0.935$). Protein levels were significantly related to one environmental variable, turbidity (Table 1; Backward stepwise ANCOVA, N = 63, $R^2 = 0.547$)

These preliminary analyses of immunity and water quality suggest a number of strong relationships, particularly between PPO and temperature, conductivity, pH and ORP. In addition, we found a significant relationship between hemolymph protein levels and temperature. Thus, we have found at least one potential easy-to-measure early indicator of animal health (PPO). Our next step is to determine experimentally, which of these environmental parameters have the most impact on immunity. In addition, we will experimentally examine susceptibility to disease by exposing odonates to pathogens.

Table 1. The results of ANCOVA analyses examining the relationship between measures of immunity (PO, PPO and protein) and environmental parameters. Only significant or nearly significant values are included in the table.

Dependent Variable	**Independent Environmental Variable**	**df**	**F**	**P**
Phenoloxidase (PO)	Temperature	13, 75	1.550	0.120
ProPhenoloxidase (PPO)	Temperature	4, 63	138.4	< 0.001
	Conductivity	2, 63	13.5	< 0.001
	Ph	2, 63	21.7	< 0.001
	ORP	3, 63	16.9	< 0.001
Hemolymph protein	Turbidity	7, 52	9.74	< 0.001

Fine sediment source areas and in-channel sediment storage in the Upper Green River Basin, KY

Basic Information

Title:	Fine sediment source areas and in-channel sediment storage in the Upper Green River Basin, KY
Project Number:	2004KY43B
Start Date:	3/1/2004
End Date:	8/31/2005
Funding Source:	104B
Congressional District:	KY 2nd
Research Category:	Water Quality
Focus Category:	Non Point Pollution, Sediments, Water Quality
Descriptors:	soil erosion, aquatic habitat, sediment supply
Principal Investigators:	Stephen Kenworthy

Publication

1. Kenworthy, Stephen, 2005, Landscape Attributes Affecting Sediment Production and Sediment Delivery in the Upper Green River Basin, in Proceedings Kentucky Water Resources Annual Symposium, March 3, 2005, Kentucky Water Resources Research Institute, Lexington, Kentucky, p. 23.
2. Kenworthy, Stephen T., 2006, Sediment Monitoring Efforts in the Upper Green River Basin in Support of the Kentucky Conservation Reserve Enhancement Program, in Proceedings Kentucky Water Resources Annual Symposium, March 2, 2006, Kentucky Water Resources Research Institute, Lexington, Kentucky, p. 47.
3. Kenworthy, Stephen, 2006, Fine Sediment Source Areas and In-Channel Sediment Storage in the Upper Green River Basin, Kentucky, Kentucky Water Resources Research Institute, University of Kentucky, Lexington, Kentucky, 12 p.

Problem and Research Objectives

Fine sediment pollution is an important water quality concern in the Commonwealth of Kentucky. Fine sediment accumulation can lead to degradation of aquatic ecosystems as a result of habitat alteration or because of contaminants and nutrients bound to sediments. As part of the US Department of Agriculture Conservation Reserve Enhancement Program (CREP), state and federal funds have been committed to reduce the amount of sediment, pesticides, and nutrients entering the Upper Green River between Green River Lake and Mammoth Cave National Park by 10%. These funds are targeted to support the implementation of soil conservation practices in the Upper Green River Basin, and emphasize the environmental and ecological importance of fluxes of sediment and sediment-bound contaminants into riparian zones and channels. In order to monitor and evaluate the effectiveness of these conservation efforts, management agencies require information on the spatial pattern of potential agricultural and non-agricultural sediment sources and on the quantity and distribution of fine sediment stored in the stream channel network.

The scientific objectives of this research were to identify potential sources of fine sediment in the Upper Green River Basin CREP area and to explain the distribution of fine sediment storage in terms of the spatial pattern of source areas and the geomorphic controls on in-channel and riparian sediment deposition. The work provides an assessment of the potential supply of fine sediment from agricultural and non-agricultural portions of the CREP area, based on the integration of digital landscape data with field surveys of sediment storage. Field surveys of fine sediment storage within the main channel of Green River and major tributary valleys were used to identify portions of the landscape that may be fine sediment sources. This information will be valuable to the CREP partner agencies and to individual program participants in assessing the effectiveness of conservation practices in specific locations, and will serve as critical habitat data for resource management agencies charged with protecting aquatic biota in the Green River and Mammoth Cave system.

Methodology

Large samples (50-100 kg) of bed material were collected from wadeable sections of a sample of channel reaches on the mainstem of the Green River and along selected tributaries. One or more samples were collected at each field site. Data for some sample locations are reported as aggregated samples in this report. Gravel fractions coarser than 8 mm were wet-sieved and weighed in the field. The total wet mass of material finer than 8 mm for each sample was determined in the field, and a sample (500-1000 g) was retained for determination of a wet-to dry conversion factor and laboratory sieving of fine sediments. Owing to the sampling technique used, non-wadeable channel sections were not sampled, introducing a potential bias toward larger grain sizes in the population of sediments sampled. Although this effect may overestimate the reach-scale percentiles of the bed material size distributions, it should still be possible to identify basin-scale variations in the sampled proportion of relatively fine sediment, and to link these patterns to land use and geomorphic factors.

Landscape analysis included characterization of surface geology, topography, and land use. Geologic and topographic data were obtained from the Kentucky Office of Geographic Information website. Land use data were derived from the Kentucky Landcover Dataset (KLCD). Observed patterns of the fine sediment content of bed material samples were compared to spatial patterns in the landscape attributes of the upstream contributing areas, and interpreted in terms of these patterns and local hydrological and geomorphic controls on fine sediment deposition.

Principal Findings and Significance

Within the area between Green River Lake and Mammoth Cave National Park, median grain size ($\mathbf{D_{50}}$) varied by a factor of six. For bed material samples from the Green River mainstem, there was a weak trend of decreasing $\mathbf{D_{50}}$ with increasing drainage area. This pattern appears mainly related to higher proportions of fine sediment (D > 2 mm) at sampled locations in the downstream portion of the study area, rather than systematic downstream fining of the coarse portion of the bed material. The mean grain size $\mathbf{D_g}$ of the coarse portion of the bed material (gravel, D > 2 mm) shows little or no trend with increasing drainage area, including samples taken from tributary streams. Slightly coarser gravel fractions at some sites appear to be related to local hydraulic conditions at these sites that also result in reduced fine sediment content.

Relative depletion or enrichment of bed material with fine sediment appears to be a function of local hydraulic factors and fine sediment supply from tributary streams. Despite the likelihood of a local sediment deficit (reduction in fine sediment supply relative to transport capacity) within the section of the Green River closest to Green River Lake Dam, most bed material samples in this portion of the river contain appreciable proportions (> 10%) of fine sediment, suggesting that the supply of fines from small tributaries entering along this reach is significant.

A general downstream increase in fine sediment content reflects tributary inputs, modified by local hydraulic conditions. In particular, the fine sediment present at the Mammoth Cave sites is related to backwater conditions in the navigation pool of Green River Lock and Dam #6, near Brownsville. These sites were sampled during extreme low flow conditions during August 2005 that exposed many streambed areas that are normally submerged even at low water.

Sampled tributary sites (Pitman Creek, Little Barren River, and Lynn Camp Creek) showed bed material characteristics broadly similar to the sampled Green River sites. Among these sites, samples with higher fine sediment content values are related to local hydraulic conditions that favor fine sediment deposition, such as backwater environments near tributary confluences.

Patterns of bed material characteristics along the Green River are not related to geographic patterns in geology, topography or land use in a simple correlative manner, although these factors obviously may influence sediment loads originating in different subcatchments. This result is in part related to the limited number of sites sampled in

combination with the relatively even proportional distribution of land uses among the catchments contributing to the sampled sites. There is a weak downstream trend of decreasing agricultural land use and increasing proportional forest cover over the study region, and this spatial distribution of land use is consistent with the general patterns in bed material characteristics documented. However, the overall downstream increase in the fine sediment content of Green River bed material is most simply explained in terms of the basic longitudinal pattern of tributary sediment inputs and local hydraulic factors.

The results of this field study suggest that patterns of fine sediment content in bed material samples are interpretable in terms of broad patterns of sediment supply and geomorphic/hydraulic controls on deposition. However the link between spatial patterns of land use and spatial patterns of bed material composition is not sufficiently strong for use in identifying source areas at fine spatial resolution, at least given the range of variation in proportional land use coverage in the study area. It is possible that a higher density of sample sites than was used in this study would reveal relationships to finer scale patterns of landscape attributes, and this possibility should be explored in future work in the Green River CREP region.

Information Transfer Program

The Information Transfer Program of KWRRI has numerous components including lectures, meetings, workshops, seminars, a symposium, publications, and a web site. Efforts during FY2005 included:

03/10/05 GSA Hydrogeology Division Birdsall-Dreiss Lecture. William Woessner, University of Montana, The occurrence, transport and fate of viruses and pharmaceuticals in groundwater impacted by septic system effluents: The hydrogeologists and human health (co-sponsored with the Department of Geological Sciences at the University of Kentucky).

May is designated as Kentucky Water Awareness Month. This observance is an educational outreach of the University of Kentucky Cooperative Extension Service through the Environmental and Natural Resource Issues Task Force (Associate Director of KWRRI serves on this committee). The program promotes overall water awareness for citizens. Program materials are assembled each year and packets are distributed to each of the 120 county extension offices. The materials remain available throughout the year for use by classroom teachers, 4-H volunteers, and others interested in water issues through the ENRI internet site: http://www.ca.uky.edu/enri/

05/12/2005 Muddy Creek Field Day. A field day was held at the Eastern Kentucky University Meadowbrook Farm for an overview of activities associated with the Muddy Creek Watershed Project (2005KY51B). The program addressed stream stabilization efforts undertaken jointly by a partnership including the Kentucky Department of Fish and Wildlife Resources, Eastern Kentucky University, Blue Grass Army Depot, Berea College, Madison County Conservation District, NRCS, and Kentucky Water Watch. The stabilization project included restriction of livestock access to the stream (through completion of stream fencing and installation of alternative water sources) and the planting of 8,000 tree seedlings in the riparian zone to improve wildlife habitat and reduce erosion. A similar field day was offered again later in the year during the Southern Region Water Quality Conference held in Lexington from 10/23-26/05 (for county extension agents and state specialists from the 13 states in the southern region of cooperative extension).

The Kentucky Research Consortium for Energy and the Environment (KRCEE) was created to support Department of Energy efforts to complete the expeditious and economically viable environmental restoration of the Paducah Gaseous Diffusion Plant and surrounding areas. KRCEE activities are administered through the Kentucky Water Resources Research Institute. Long-term and short-term tasks are addressed through the development of problem-specific project teams composed of faculty and professional staff drawn from the University of Kentucky, the University of Louisville, and Murray State University. A new website debuted during 2005 at http://www.uky.edu/krcee. The project website provides KRCEE history, its mission statement, and individual project summaries, as well as links to related regulatory agencies.

09/08/05 National Ground Water Association Darcy Lecture. Kip Solomon, University of Utah, Inert gas tracers in groundwater (co-sponsored with the Department of Geological Sciences at the University of Kentucky).

10/12/05 Earth Science Week. An open house was held on Wednesday evening in conjunction with the Kentucky Geological Survey. KWRRI provided and staffed a groundwater flow model for students and parents who attended.

10/02-04/05 The third annual Kentucky Watershed Roundtable was held in conjunction with the Southeast Watershed Forum in Bowling Green, Kentucky. The meeting united a diverse group of stakeholders including representatives from government, conservancy groups, research, business, industry, and agriculture to address current water issues and develop effective, cooperative solutions. The theme of the meeting was Watershed Strategies for a New Era: Protecting the Environment and the Bottom Line. The roundtable was sponsored by the Kentucky Waterways Alliance, Southeast Watershed Forum, and the Kentucky Division of Water in conjunction with Bluegrass PRIDE, Eastern Kentucky PRIDE, Tennessee Valley Authority, US Geological Survey, and the Kentucky Water Resources Research Institute.

11/15/05 The Kentucky Division of Water and the Kentucky Water Resources Research Institute jointly hosted the Upper Cumberland River Pathogen Summit at Pine Mountain State Park in Pineville. The Summit brought together representatives of state and local governments, volunteer groups, and the media to discuss water quality improvements in the Upper Cumberland River watershed. KWRRI staff presented the results of pathogen sampling conducted over the past several years. The meeting closed with a panel discussion addressing future steps needed to continue improvement of water quality in the region.

11/18/05 KWRRI staff members involved in the University of Kentuckys Superfund Basic Research Program (SBRP) Research Translation Core organized and conducted a Nutrition and Superfund Chemical Toxicity Workshop. Experts in the fields of nutritional sciences, medicine, and environmental toxicology presented evidence indicating that nutrition and diet can modulate toxicological insults associated with disease states. The SBRP at the University of Kentucky focuses on the environmental health impacts of chlorinated organics and Technetium. The workshop was supported in part by funds from NIEHS/NIH and by numerous university partners including the KWRRI.

12/02/05 Kentucky River Watershed Watch (KRWW) volunteers were invited to an annual celebration to recognize their efforts in monitoring and improving waterways within the Kentucky River Basin. KWRRI Director and KRWW Scientific Advisor Lindell Ormsbee presented a summary of the 2005 water quality sampling results. During 2005, volunteers conducted water quality sampling at 190 separate sites throughout the basin. The annual data analysis summarized the results of four sampling events held during the year: 1) herbicides in the spring, 2) pathogens in the summer (initial synoptic), 3) later follow-up focused pathogen testing at selected sites, and 4) chemical indicators, nutrients, and metals in the fall. Ten sampling sites of greatest concern were identified by KWRR based upon the analysis of the sampling results to help focus future efforts toward improving water quality in the basin.

Cyberseminars provided through the Consortium for the Advancement of Hydrologic Sciences, Inc. (CUAHSI) were made available by the KWRRI on the University of Kentucky campus for interested faculty, staff, students, and local professionals through financial support for membership in that organization.

The Kentucky Water Resources Annual Symposium was held March 2, 2006. Although the date of the symposium fell outside of FY2005, most of the planning and preparation occurred during the fiscal year. Two concurrent sessions included 34 platform presentations. A special session for projects funded by U.S. Environmental Protection Agency, Clean Water Act, Section 319(h) grant money was provided through support channeled though the Kentucky Division of Water and the Kentucky Waterways Alliance. A poster session break-out featuring 13 presentations was also provided as a separate component of the program. There were 160 registrants for the conference. Abstracts were printed as a proceedings volume and distributed to all participants: Proceedings Kentucky Water Resources Annual Symposium, 2006,

Kentucky Water Resources Research Institute, March 2, 2006, Kentucky Water Resources Research Institute, Lexington, Kentucky, 94 p. The full proceedings document is available electronically online at http://www.uky.edu/WaterResources/2006Proceedings.pdf.

Publication of the institutes newsletter WATERWORKS continued in 2005. Three issues were prepared, printed and distributed (fall and winter quarters were combined). The KWRRI Web site was also maintained: http://www.uky.edu/WaterResources/

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	5	0	0	0	5
Masters	6	0	0	0	6
Ph.D.	0	0	0	0	0
Post-Doc.	0	0	0	0	0
Total	11	0	0	0	11

Notable Awards and Achievements

Work begun in the Muddy Creek Watershed by investigators at Eastern Kentucky University (initially Jones, 2002KY7B and subsequently LaSage, 2005KY51B) convinced them of the need for an institutionalized environmental research presence at the university. They developed a proposal for funding to create such a unit and ultimately received $800,000 from NSF EPSCoR to establish the Eastern Kentucky Environmental Research Institute in July 2005. The institute continues to support the work begun in the Muddy Creek watershed and has provided funding (about $100,000) for a USGS stream gaging and water-quality monitoring station on Muddy Creek. The partnership developed through these efforts now includes federal, state, and local government agencies, multiple academic departments and disciplines within the university, private industry, and local citizens who participate in volunteer sampling.

The Kentucky Environmental Quality Commission (EQC), a seven member citizen advisory board, works to strengthen the role of the public in addressing environmental issues in the Commonwealth. KWRRI Director Lindell Ormsbee continues to serve as chair of the committee. The EQC conducts numerous meetings and public forums each year. Issues considered during the 2005-2006 period included high hazard surface water impoundments (at coal mines and other facilities), air quality (open burning/Air Toxics and Mercury Task Forces), solid waste management (collector and recycler registration), citizen water sampling, oil and gas regulatory programs (petroleum spills), underground storage tanks, Total Maximum Daily Loads, water withdrawal permitting, mountaintop removal mining, and a review of the activities of the Clean Water Task Force. The Commission issued numerous recommendations and resolutions related to these topics.

University of Kentucky President Lee T. Todd, Jr. has funded 23 projects aimed at addressing and solving the "Kentucky Uglies" (his term for long-entrenched problems that are holding back the state’s economic and cultural progress) to help improve Kentuckys schools, business climate, environment, health care, and lifestyles. One of the projects, the Water Pioneers Water Quality Outreach Initiative, will assist in educating eastern Kentucky youth about water resources and actively engage them in water issues in their local communities. Headed by the Kentucky Water Resources Research Institute at UK, this project unites the College of Agriculture’s Cooperative Extension Service, the UK Robinson Scholars Program and a variety of external agencies in an effort to encourage youth activism on behalf of local watersheds. The

youth, participants in the Robinson Scholars Program (a scholarship and leadership development program that seeks to improve college attendance in a twenty-nine county region of Eastern Kentucky with a traditionally low college-enrollment rate) will develop ideas and subsequently compare and contrast information about watersheds with students in diverse partnering regions around the country.

Publications from Prior Projects

1. 2004KY41B ("Linking chemical tolerance to reproductive resilience: CYP1A as a metric for predicting fish species distributions in chemically impacted habitats") - Dissertations - Brammell, Benjamin Frederick, 2005, Characterization of Pollutant Response in Teleosts with Varying Degrees of Pollutant Sensitivity, PhD. Dissertation, Department of Biological Sciences, College of Arts and Sciences, University of Kentucky, Lexington, Kentucky, 197 p.
2. 2001KY2801B ("Does waste amendment affect abiotic N cycling in soil by naturally occurring Fe(II)") - Articles in Refereed Scientific Journals - Matocha, Chris J., A. D. Karathanasis, S. Rakshit, and K.M. Wagner, 2005, Reduction of Copper (II) by Iron (II), Journal of Environmental Quality, 34:1539-1546.
3. 2000KYB-06 ("Defining perenmial, intermittent, and ephemeral channels in Eastern Kentucky: Application to forestry best management practices") - Articles in Refereed Scientific Journals - Svec, J.R., R. K. Kolka, and J.W. Stringer, 2005, Defining perennial, intermittent, and ephemeral channels in Eastern Kentucky: Application to forestry best managment practices, Forest Ecology and Management 214 (2005) 170-182.