



Mar 22nd, 8:00 AM

Proceedings of 2010 Kentucky Water Resources Annual Symposium

Digital Object Identifier: <https://doi.org/10.13023/kwrri.proceedings.2010>

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Kentucky Water Resources Annual Symposium

March 22, 2010



Marriott's Griffin Gate Resort
Lexington, Kentucky

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UNIVERSITY OF KENTUCKY
Kentucky Water Resources
Research Institute

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Kentucky Water Resources Research Institute
USGS Kentucky Water Science Center
Kentucky Geological Survey
Kentucky Division of Water

Kentucky Water Resources Annual Symposium

March 22, 2010

Marriott's Griffin Gate Resort
Lexington, Kentucky

This conference was planned and conducted as part of the state water resources research annual program with the support and collaboration of the Department of the Interior, U.S. Geological Survey and the University of Kentucky Research Foundation, under Grant Agreement Number 06HQGR0087.

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- Bill Barfield Award for Water Research
 - Sylvia Daunert (09)
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NOTES

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EVALUATING THE IMPACT OF HEMLOCK WOOLLY ADELGID INVASION ON HEADWATER STREAMS

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Invasions by non-native species are widely considered among the most important causes of the loss of native biota. A serious example of a devastating exotic forest pest recently established in Kentucky is the hemlock woolly adelgid (HWA: *Adelges tsugae*, Hemiptera: Adelgidae). HWA is a xylem feeding insect native to Asia that feeds on all ages, sizes, and species of hemlock (*Tsuga* spp). While certain hemlock species exhibit some measure of resistance, HWA infestations usually lead to mortality of eastern hemlock (*T. canadensis*). Furthermore, native predators appear unable to regulate HWA populations in eastern North America (Wallace and Hain 2000). HWA has the capacity to functionally eliminate eastern hemlock from the landscape.

Eastern hemlock is considered a foundation species that dictates microclimatic conditions and strongly influences ecological processes and interactions (Ellison et al. 2005). It is also an irreplaceable component of riparian zones, particularly within headwater streams. The loss of eastern hemlock may create a cascade of changes from stand to ecosystem level, including increased nutrient exports (Jenkins et al. 1999), altered transpiration rates (Ford and Vose 2007), changes in stream macroinvertebrate diversity (Snyder et al. 2002), loss of unique microclimates (Ellison et al. 2005), and community shifts to deciduous species (Spaulding and Rieske, in review). Benthic macroinvertebrate community composition is correlated with surrounding forest composition (Snyder et al. 2002) and many species are sensitive to slight changes in stream characteristics (Karr 1999). Thus the loss of eastern hemlock from riparian zones has the potential to significantly alter benthic community abundance and functional feeding guild composition (Snyder et al. 2002). This can have far reaching ecosystem-level consequences, since benthic macroinvertebrates form a vital part of the aquatic food chain as both immatures and adults (Merritt and Cummins 1996).

The overall goal of this project is to characterize the composition and structure of benthic macroinvertebrate communities associated with eastern hemlock dominated headwater streams, which will be compared with those from deciduous dominated headwater streams. We are also characterizing chemical and physical characteristics within these streams, which will enable us to correlate stream characteristics with the benthic macroinvertebrate community to evaluate the extent to which HWA-induced eastern hemlock mortality impacts stream health. Research sites are located in eastern Kentucky at Kentucky Ridge State Forest, Natural Bridge State Nature Preserve/Red River Gorge, and Robinson Forest. At each site three hemlock dominated headwater streams have been paired with three deciduous dominated streams with similar physical characteristics for a total of eighteen study streams. A 30 m segment ("reach") was established in each

study stream ~150 m above the confluence. Within each reach, transects were established across three riffles. Benthic macroinvertebrates are sampled from each riffle at 30 d intervals using a standard kick-net and a 0.1 m² Surber sampler. Artificial substrates (2.5 × 5 cm five plate Hester-Dendy samplers) provide a means of monitoring long-term colonization of benthic macroinvertebrates; one sampler is deployed at each end of the designated 30 m reach and monitored at 30 d intervals. Benthic macroinvertebrates are being identified to the highest resolution possible and categorized into functional feeding guilds (Merritt and Cummins 1996) in order to elucidate functional differences within the benthic communities of hemlock and non-hemlock headwater streams.

Stream chemistry is evaluated by collecting two 500 ml water samples concurrent with benthic macroinvertebrate sampling. These samples are taken ~2 m downstream from each 30 m reach, placed on ice and returned to the laboratory. Nitrate, ammonia, phosphorus, sulfate, and hardness are evaluated using colorimetric methods (Hach Corporation, Loveland, CO). Total carbon and total organic carbon are being measured using an automated total organic carbon analyzer (Shimadzu Scientific Instruments, Kyoto, Japan). Chlorophyll is measured using standard spectroscopic methods. Stream velocity is measured using a flow meter, and width and depth measurements are taken to calculate total flow. Dissolved oxygen, pH, temperature, and specific conductance are measured using a Multi-Probe System (YSI Inc., Yellow Springs, OH). Daily maximum, minimum, and mean water temperature is being monitored using waterproofed iButtons (Maxim Integrated Products, Sunnyvale, CA) anchored in-stream.

Preliminary results indicate significant differences between eastern hemlock-dominated and deciduous-dominated streams in water chemistry characteristics as well as benthic macroinvertebrate function feeding groups. On average, concentrations of sulfate, total carbon, total organic carbon, as well as conductivity are lower in streams draining eastern hemlock. Further, benthic macroinvertebrate shredders and collectors are more abundant in eastern hemlock dominated streams. These results suggest that loss of eastern hemlock from headwater riparian zones due to hemlock woolly adelgid-induced mortality will likely lead to functional changes in headwater stream communities.

Works Cited

- Ellison AM, et al. 2005. *Frontiers in Ecology and the Environment* 3: 479-486.
Ford CR and Vose JM. 2007. *Ecological Applications* 17: 1156-1167.
Jenkins JC, Aber JD, and Canham CD. 1999. *Canadian Journal of Forest Research* 29: 630-645.
Karr JR. 1999. *Freshwater Biology* 41: 221-234.
Merritt RW and Cummins KW. 1996. Kendall/Hunt Pub. Co., Dubuque, Iowa.
Snyder CD, Young JA, Lemarie DP, and Smith DR. 2002. *Canadian Journal of Fisheries and Aquatic Sciences* 59: 262-275.
Spaulding HL and Rieske LK. In review. *Biological Invasions* (subm April 2009).
Wallace MS and Hain FP. 2000. *Environmental Entomology* 29: 638-644.

EFFECTS OF ROUNDUP® EXPOSURE
ON BEHAVIOR AND REPRODUCTIVE FUNCTION
IN A POND-BREEDING SALAMANDER

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Project/Research Objectives

Contamination of water resources by pesticides can pose serious risks to humans and wildlife. More research is needed on sublethal and low-dose effects of exposure so that action can be taken before large-scale, irreversible damage occurs. Endocrinological effects are of particular interest, as hormones drive key processes related to development, reproduction, and relative fitness. In amphibians, biocide exposure may affect reproduction and behavior by interfering with production, delivery, and/or receptor binding of hormones relevant to these processes. We are utilizing a pond-breeding salamander as a model to examine the acute effects of a common herbicide, Roundup®, on courtship behavior, feeding response, and related plasma levels of sex steroids.

Methodology

Adult spotted salamanders (*Ambystoma maculatum*) were collected from two field sites in Calloway County and semi-randomly assigned to one of four nominal exposure concentrations: Negative Control (0.00 mg AI/L), Low (0.05 mg AI/L), Medium (0.50 mg AI/L), and High (5.00 mg AI/L). The Low and Medium treatments were below the maximum glyphosate concentration of 2.6 mg AI/L documented in natural habitats. All treatments were more dilute than the manufacturer's maximum recommended concentration for application. Stock solutions were prepared using Roundup® Ready-to-

¹ The views expressed are those of the authors and do not necessarily reflect the position of the U.S. Environmental Protection Agency.

Use Weed and Grass Killer and stored in airtight polypropylene containers in a dark room. Because of the proprietary nature of the surfactant in Roundup[®], no surfactant control was included.

Prior to exposure, specimens were maintained in well water and housed in individual containers in an environmental chamber (6°C ±2). At test initiation, treatment animals were individually submersed in solution for 72 hours. Control animals were newly submersed in untreated well water for an equivalent duration.

Snout-vent length, mass, and reproductive status were recorded for each specimen prior to exposure. Courtship behavior was videotaped for eight hours following treatment and was evaluated using methods from previous studies. Individual feeding response was documented as the number of mealworms eaten (maximum=10) in a 24-hour period immediately following the courtship trials. Plasma was obtained from individual blood samples at the conclusion of behavioral trials and was stored at -80°C ±3 prior to hormone extraction.

Preliminary Findings and Significance

Unexpectedly, 100% mortality was noted in the High treatment within 24 hours of application. An LC₅₀ could not be determined because no mortality was noted at either of the other treatment levels. However, the results suggest that the LC₅₀ for adult *Ambystoma maculatum* acutely exposed to Roundup[®] is considerably less than the LC₅₀ for amphibians exposed to the active ingredient, glyphosate, in other formulations (e.g., Rodeo[®]) and in non-formulated applications. This suggests that the surfactant and/or other “inert” ingredients in Roundup[®] (1) are directly toxic to the salamander and/or (2) enhance the toxicity of the active ingredient to the salamander. Alternatively, reproductive status may affect the vulnerability of adult salamanders to glyphosate exposure.

For the Low and Medium treatments, no significant differences in courtship behavior were noted. However, preliminary analysis of log transformed data suggests that Roundup[®] exposure significantly decreased feeding response in male salamanders ($F_{2,29}=12.15$, $p<0.001$), when controlling for mass. Both treatment levels were significantly different from the Control ($p<0.05$), but not from one another. Decreased foraging activity and/or effectiveness following Roundup[®] exposure may inhibit the salamander's ability to re-establish energy reserves that are depleted during the breeding season.

Ongoing Research

To determine whether endocrine endpoints related to courtship and feeding response are affected by Roundup[®] exposure, steroid hormone extraction and enzyme immunoassay (EIA) are being performed on plasma samples as the necessary antisera (C. Munro, U.C. Davis) become available.

THE WESTERN DEEPS—3D GRAPHIC MODELS OF DEEP AQUIFERS IN THE WESTERN COAL FIELD

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Existing mapping by several researchers has provided structure and isopach maps for deep aquifers in the western coal field region of Kentucky. McFarlan (1943) provided a general description of the coal field, while Kosanke, et al. (1960) discussed the classification of the Pennsylvanian strata within which the aquifers occur. Shawe and Guildersleeve (1969) described the unconformity at the base of the Pennsylvanian as the lower limit of fresh water within the western coal field. Davis, Plebuch, and Whitman (1974) completed extensive mapping and interpretation of certain deep aquifers in the western part of the field.

In this research, mapping by Davis, Plebuch, and Whitman (1974) was digitized for use in three dimensional (3D) modeling. Two questions were posed: (1) What routines and workflows expedite hard-copy-to-digital conversion? (2) What graphic techniques provide flexible and realistic 3D aquifer models?

To address the first question, maps of the pre-Pennsylvanian surface and the 600 foot (Vienna datum) aquifer were digitized using a CalComp digitizing table and Didger 3 software (Golden Software, 2001). Separate layers were created for faults, structural contours, isopachs, drillholes, and areas to be blanked. Digital data then were exported to Surfer (Golden Software, 2002) and gridded using the minimum curvature algorithm. Faulting was accommodated during gridding to ensure that contours did not cross fault locations, and data-free areas were blanked. To monitor data quality, a structural contour or isopach map (as appropriate) generated from gridded data was prepared and overlain on the source map. Where the two contour sets did not match, the grid was manually edited.

To address the second question, structure and isopachs of the 600 foot aquifer and isopachs of the pre-Pennsylvanian surface were modeled using (a) a contour (or isopach) map, (b) a wireframe model, and (c) a contour-draped surface model. Traditional *contour and isopach maps* prepared digitally retained a customary presentation method while enabling the drafter to edit map content and control information overload. *Wireframe* aquifer models employed a multi-chromatic color scheme on a black background. This provided a high-impact presentation tool, but the multi-chromatic color scheme did not correctly represent subsurface conditions. The contour draped *surface model* was effective with both aquifer isopach and structure models. Various rotations and tilts were employed, illumination was varied in both azimuth and altitude, and both orthometric and

perspective projections were employed. Natural colors were used to provide realistic aquifer models that would support interpretation.

In conclusion, digital modeling provides a means of viewing and manipulating subsurface data digitally. This extends the usefulness of the significant data analysis and interpretative effort in the original aquifer mapping effort. When defined workflows are used, data quality can be assured. Various graphic presentation techniques can be employed for presentation or interpretation, and the triaxial coordinate data developed for each aquifer are potentially useful in hydrologic modeling of aquifer flow, recharge, and storage, and volume determination.

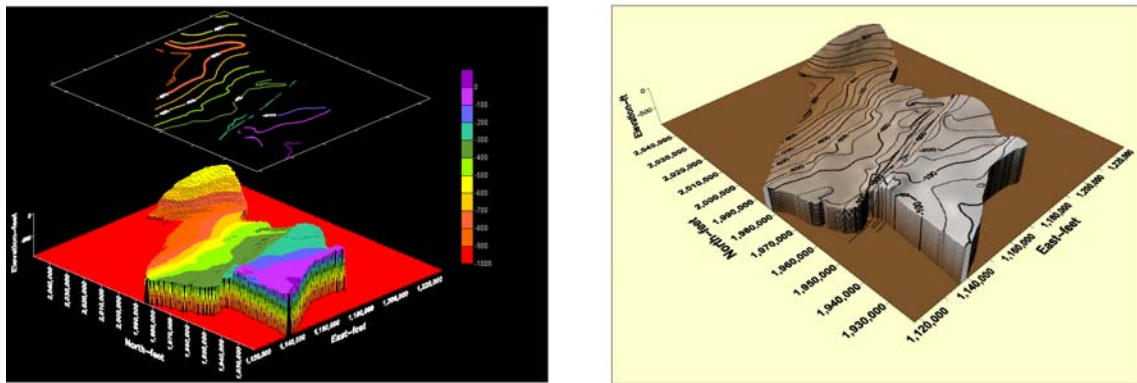


Figure 1. Wireframe (left) and structural model (right) of 600 foot aquifer from mapping by Davis, Plebuch, and Whitman (1974).

References cited

- Davis, R.W., Plebuch, R.O., & Whitman, H.M. (1974). Hydrology and geology of deep sandstone aquifers of Pennsylvanian age in part of the western coal field region, Kentucky. Kentucky Geological Survey, Series X, Report of Investigations, No. 15, Lexington, KY.
- Golden Software (2002). Surfer. (version 8). Golden, CO.
- Golden Software (2001). Didger. (version 3). Golden, CO.
- Kosanke, R.M., Simon, J.A., Wanless, H.R., & Willman, H.B. (1960). Classification of the Pennsylvanian strata of Illinois. Illinois Geological Survey, Report of Investigations 214.
- McFarlan, A.C. (1943). Geology of Kentucky. University of Kentucky Press, Lexington, KY.
- Shawe, F.R., & Gildersleeve, B. (1969). An anastomosing channel complex at the base of the Pennsylvanian System in western Kentucky. U.S. Geological Survey prof. paper 650-D, GPO, Washington, D.C.

LOCATING KARST CONDUITS IN CANE RUN WATERSHED OF CENTRAL KENTUCKY USING ELECTRICAL RESISTIVITY METHODS

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The Cane Run watershed and underlying karst aquifer in central Kentucky is the recharge area of Royal Spring, the primary source of drinking-water for the city of Georgetown, Kentucky. This watershed, including the associated karst aquifer, is degraded by pathogens, nutrients, siltation, and organic enrichment and is listed by the Kentucky Division of Water as one of four focus watersheds for clean-up under the State's nonpoint-source pollution program. The pollution sources include both municipal point sources and agricultural and nonagricultural nonpoint sources. The relative contribution of different parts of the watershed to the pollution is not well understood. The geology of Cane Run watershed consists of Ordovician thin-bedded limestone with sparse interbeds of shale. The landscape is dominated by karst features such as sinkholes and springs. Cane Run only flows on the surface during times of significant rainfall, usually in the spring of the year. The remainder of the year, most water is recharged to a karst conduit system that leads from Lexington to Royal Spring.

To help locate the actual source of contamination and to track progress of remediation efforts, it is important to monitor contaminants before they reach the point of groundwater use. Kentucky Geological Survey (KGS) is attempting to drill into the conduit to establish a water quantity (discharge) and quality (temperature, pH, conductivity, dissolved oxygen, turbidity, and sampling capability) monitoring station, just a few hundred meters up gradient from where the conduit diverges from the Can Run surface watershed. However, there is no known entrance into the Royal Spring Conduit. This study is using geophysics to assist in locating the karst conduit. We have applied electrical resistivity (ER) in four scenarios: (1) 2D surveys, (2) quasi 3D surveys, (3) synthetic time-lapse simulation, and (4) time-lapse survey with calcium chloride injection. A 2D survey conducted in 2008 showed some low resistivity anomalies and subsequent field drilling and tracer tests indicated these anomalies are mud-filled voids that are not located in the main conduit system. A quasi 3D survey consisting of twelve parallel survey lines was conducted to further investigate a prominent low resistivity anomaly identified by a 2D survey conducted in summer 2009. The quasi 3D survey shows the anomaly disappears approximately 40 meters northwest from the first parallel line Figure 1). The synthetic time-lapse simulation showed that, given our hypothesis of conduit depth and size, a time-lapse survey can potentially pick up the signal disturbed by calcium chloride injection. The field time-lapse survey conducted in October 2009

showed noticeable resistivity change for a low resistivity anomaly in the southwest portion of an ER line. This anomaly will be further studied through additional time-lapse surveys and microgravity measurements. This work is being carried out in cooperation with the University of Kentucky's College of Agriculture and Department of Earth and Environmental Sciences.

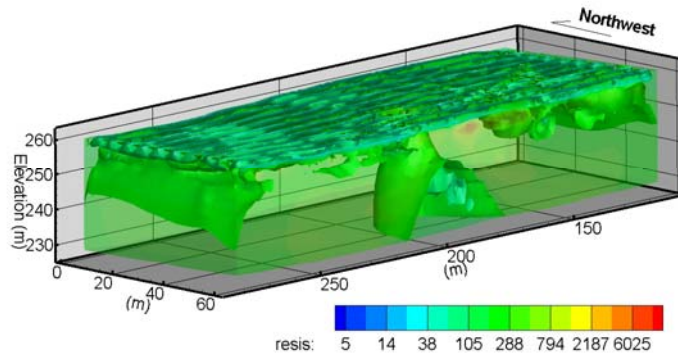


Fig 1. Inverted Electrical Resistivity for a Quasi 3D Survey

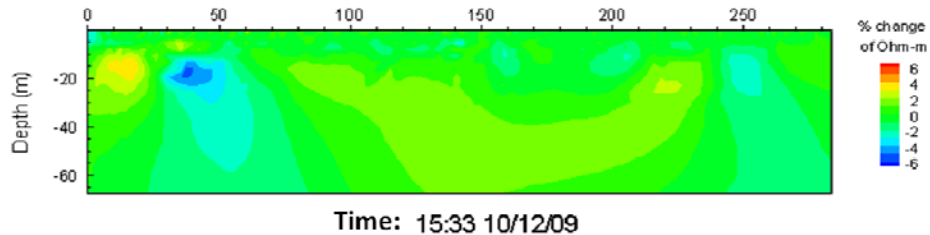


Fig.2 Resistivity Change During a Time-Lapse Survey

Reference:

R. Paylor and J. C. Currens, Royal Spring karst groundwater travel time investigation, prepared for Georgetown Municipal Water and Sewer Service, Kentucky Geological Survey, University of Kentucky, June 2004.

NEW GROUNDWATER RESOURCES MAP FOR KENTUCKY

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The USGS Hydrologic Atlas maps for Kentucky have been used extensively over the years to facilitate the search for groundwater. Each atlas included an “Availability of Groundwater” map, which indicated the most likely areas to obtain groundwater, as well as possible flow rates and general water-quality information. These maps were completed in the 1950’s and early 1960’s using extremely limited water-well and geologic mapping data, however.

KGS personnel recently used GIS techniques to overlay current digital geology and water-well data onto the groundwater availability maps. This process revealed that the older maps are occasionally inaccurate in locating groundwater resources. The availability of digital geology and up-to-date water-well information has made possible a new detailed groundwater resource map for Kentucky. The new map(s) will be created in three formats: statewide, physiographic region, and by county. An interactive Web site will also be created to allow users to view these maps. The maps will help users determine the likelihood of obtaining groundwater from any point in the State, and provide basic information on the probable quantity and quality of water available. This presentation will summarize the compilation process for the statewide groundwater resource map, and review possible end-products that could result from this project.

Figure 1 illustrates a section of the USGS Hydrologic Atlas 25 “Availability of groundwater” map showing actual water well locations in the eastern part of Bourbon County that are outside the primary producing zones (dark-colored areas).

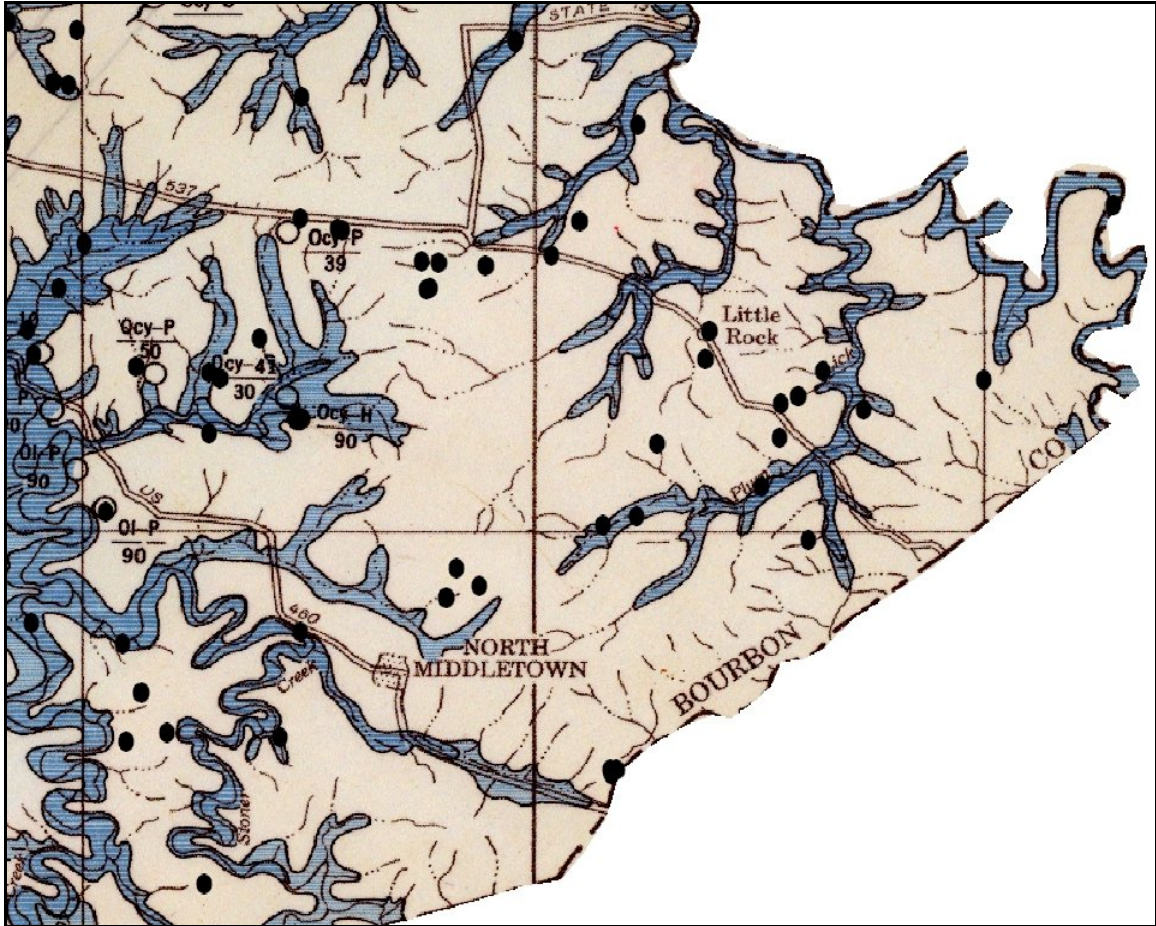


Figure 1. Section of USGS Hydrologic Atlas 25 “Availability of groundwater” map showing water well locations in the eastern part of Bourbon County that are outside the primary producing zones (dark-colored areas).

IMPACT OF RAINFALL AMOUNT, INTENSITY AND TIME LAG ON LEACHING BEHAVIOUR OF A SURFACE-APPLIED BROMIDE TRACER

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Introduction

Amount and intensity of rainfall are known as important characteristics that affect the leaching of surface-applied agri-chemicals. Besides these, the effect of the time interval between a fertilizer or tracer application and subsequent rainfall on solute leaching is not well understood. Moreover, little is known about the spatial representativity of the solute concentration based on a relatively small soil sample in field-scale transport studies.

The objectives of this study were to identify the impact of rainfall intensity and amount as well as the application time delay on solute transport in a well-drained Maury silt loam soil. Moreover, an experimental design and protocol had to be developed that exhibited spatial variability structure and representativity of bromide concentration. The spatial association between treatments imposed and pattern of solute leaching depth should be quantified using spatial statistics and frequency-domain techniques, such as spectral and cospectral analysis.

Materials and Methods

The study was conducted in a Maury silt loam soil at the University of Kentucky, College of Agriculture Experimental Farm Spindletop. Along a 64-m transect, 32 plots each 2-m long and 4-m wide were established. Two different rainfall amounts at four different rates were applied in a non-random cyclically repeating pattern (Figure 1). Application time

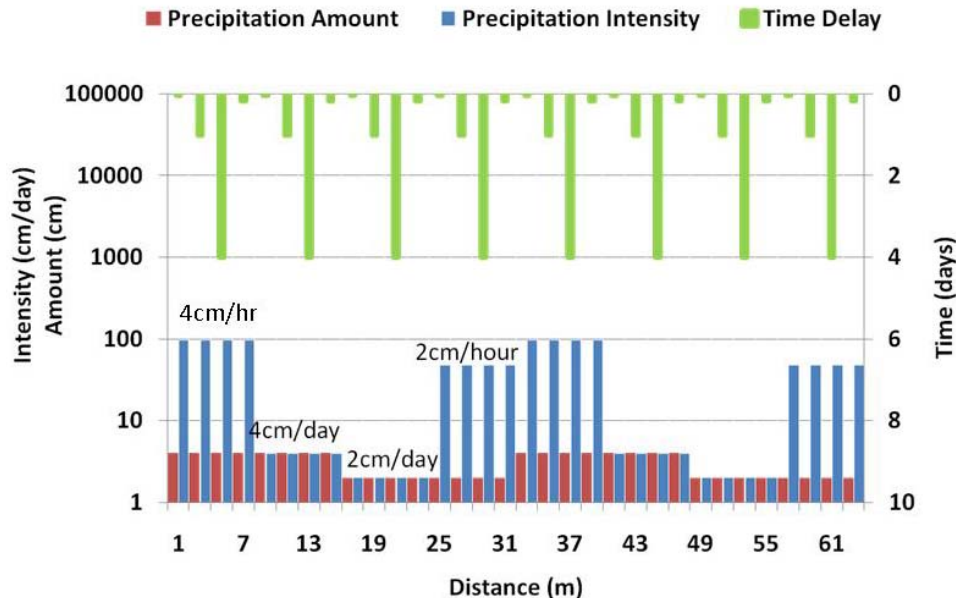


Figure 1. Upper boundary condition and its spatial distribution along the experimental field.

was also spatially arranged in a sinusoidal pattern. This design allows to base the statistical analysis on special frequency domain-based methods. Bromide leaching under different treatments was quantified with the spatial distribution of the center of mass.

Results and Discussion

Rainfall amount showed the largest effect on Bromide leaching. The effect of rainfall intensity of leaching became only obvious for the highest and lowest intensity. With increasing time delay between tracer application and subsequent rainfall, the shallower the leaching depth. Application of agri-chemicals should be delayed if there is a moderate or high chance of a rainfall event. Long and low-intensity rainfall events may cause deeper leaching than short and high-intensity rainfall events. The experimental design was efficient to study impact of transport-relevant rainfall characteristics of solute leaching.

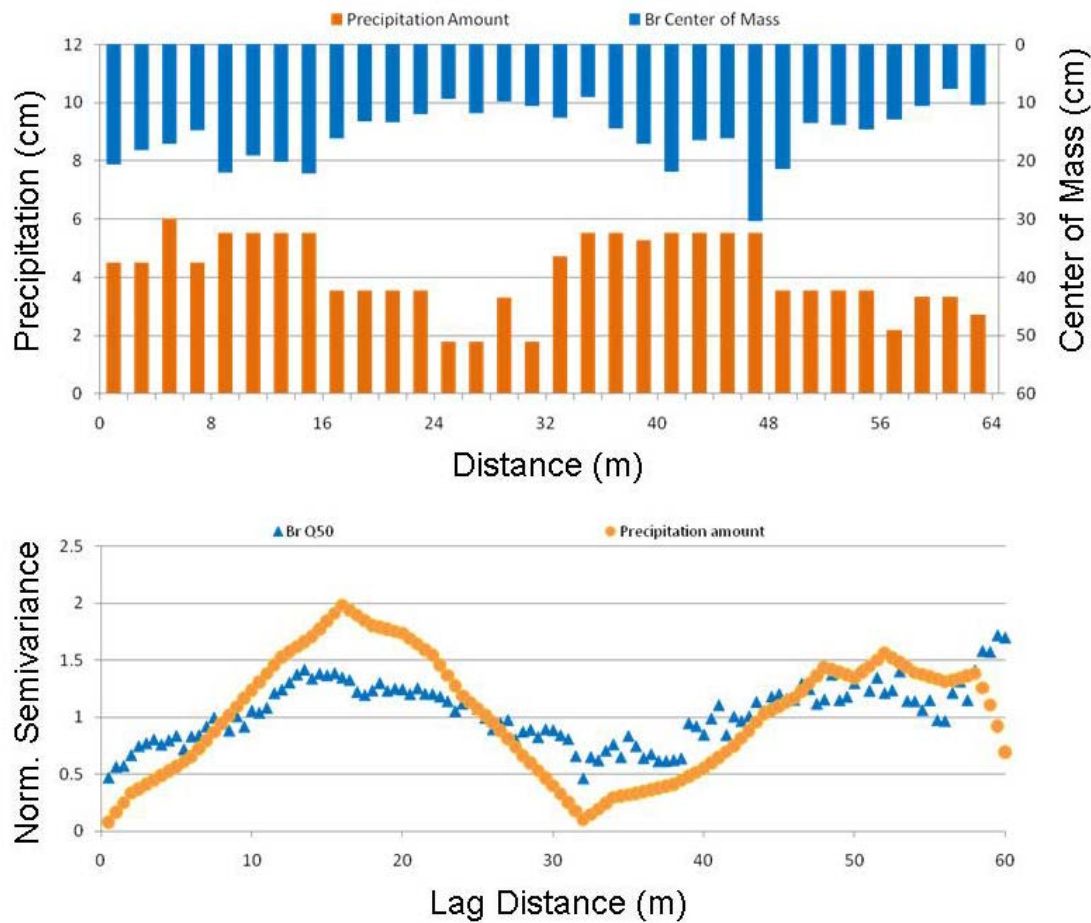


Figure 2. Spatial distribution of precipitation amount and center of mass of Bromide along the 64-m-transect (top) and normalized semivariograms for both variables (bottom).

Acknowledgement:

This work was funded by the SB-271 program.

A NUTRIENT MONITORING PROJECT
FOR THE PENNYROYAL ECOREGION OF KENTUCKY

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The Center for Water Resource Studies at Western Kentucky University is conducting a nutrient monitoring project for the Pennyroyal ecoregion of Kentucky. A gap in nutrient data exists for the Pennyroyal ecoregion in the Commonwealth of Kentucky. This ecoregion is characterized by karst topography with sink holes, sinking streams, springs and caverns. The goal of this project is to collect and analyze nutrient data to assist the Kentucky Division of Water (KDOW) in establishing nutrient criteria in the Pennyroyal ecoregion.

The first step of this project was to identify and finalize all sampling sites. KDOW contacted EPA-Corvallis to select 50 original sites and 50 overdraft sites based on a probabilistic design. Half of the sites are within sub-ecoregion 71e, the Western Pennyroyal Karst Plain, and half are within 71g, the Eastern Highland Rim. Site reconnaissance was conducted and sites were selected based on accessibility. If an original site was not accessible, a site from the overdraft pool was used to replace it and the rationale for the change was documented. A total of 50 sites, 25 from each of the two sub-ecoregions, have been determined. The locations of final sampling sites were recorded using Global Positioning System (GPS) technology.

After the sampling sites were established, the first sampling event was conducted by Center for Water Resource Studies (CWRS) field operations personnel. A total of three sampling events will be conducted; Fall 2009, Spring 2010, and Summer 2010. During each sampling event, grab samples will be taken at the 50 sites identified during project planning. Samples will be collected for the following parameters: nitrate, nitrite, ammonia nitrogen, total Kjeldahl nitrogen, and total phosphorus. Two of the sampling events will be conducted during ambient and low-flow conditions, and one will be conducted during wet-weather conditions.

During each sampling event, water quality parameters are also measured using a multi-probe instrument. Using the YSI 6920 V2 Sonde; pH, dissolved oxygen (DO), water temperature (Tw), and specific conductivity (SpC) are recorded.

After the sampling events, all water quality samples will be analyzed at the WATERS Laboratory at WKU for required parameters and reported to approved detection limits.

CWRS will contribute real time results at the symposium based on data accumulated in Fall 2009 campaign. Although no previous nutrient data exists for the Pennyroyal, this project will set numeric standards on nutrient criteria for this region of Kentucky.

Nutrients, such as nitrates and phosphates, are distinct from other pollutants in that they are not only naturally present in bodies of water, they are necessary to maintain healthy aquatic ecosystems. Run-off from agriculture, and discharges from certain industries, can cause imbalances in nutrient levels that disrupt local ecosystems. It is hoped that once numerical standards for nutrient criteria have been established it will be possible to measure the consistency of nutrients in our water systems. A plan will be implemented by the KDOW to monitor the waters regularly to ensure the waterways are within the numerical standard set by the state to appease the Clean Water Act of 1998. With this knowledge KDOW will be able to identify where the impairments are centralized and steps will be taken to restore the waterways accordingly.

FEATURE CORRECTION TOOLS DEVELOPED FOR RURAL WATER DISTRICT MAP CORRECTION

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In the course of developing an application under a grant from the Kentucky Science Technology Corporation (KSTC) to export Geographic Information Systems (GIS) features to an EPANET model, it was found that some rural water districts need slight corrections to GIS data. Tools were developed for GIS that include merging lines, adding missing junction points, estimating elevation of points, and more. This presentation will go over the issues that were found with data from rural water districts, the need for tools to correct features, and the tools that were developed for this project.

Additionally low or no cost tools currently available were utilized and documented for use in the system.

Issues found and tools developed:

- Mains not split at intersection with mains
Plainarize Lines within GIS was used to correct this issue in our case. Functions need developed to evaluate issues involving mains crossing as opposed to intersecting. Within the developed toolset this could be replaced with mains being split at junctions allowing for the event of crossing where no junction exists.
- Mains not split at junctions (meters, fittings, etc)
A tool was created to split the line segments at point features.
- Junctions missing
This tool will use line data to find locations where points for junctions are missing. If a line endpoint doesn't match a point from any of the map point layers and has only two lines attached, the two lines will be merged.
 - Merge Tool – In some cases these mains should not be joined.
A tool was also developed to join mains where two lines intersect or add a junction point if more than two lines are intersecting.
- Elevation data missing in many locations -
The tool developed uses a Raster coverage to fill in missing elevation data. A user entered field allows for correction of estimated value to allow for depth of feature.
- Missing main segments
The tool developed allows the user to select a segment and will select all connected lines using the select intersecting in an iteration. In a pipe network all the lines should be connected and any that are then not selected are disconnected pipes.

- Junctions not snapped to mains.
A tool from Hawth's was utilized to correct for this. This tool required the M and Z values to be removed from the feature layer. – A python script was used for this purpose
 - Future tools may include a utility to snap lines to points, as the points are likely to result from GPS measurements in the field.

Additional issues included:

- Meter Locations not matching address information in water usage file.
- Length Values missing

These tools have been developed using the ESRI ARCGIS SDK for .NET. For information about tool availability: email cwrs@wku.edu.

BRIDGING THE GAP INTO THE WATER INDUSTRY

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The looming 'brain drain' coupled with non-competitive wages, an increasing training burden, and the perception that water and wastewater operator and technician positions are professions of last resort, create a challenge acknowledged by both state regulatory agencies and the water resource professionals charged with maintaining capacity. The effects of the retiring Baby Boomer generation have been exacerbated in the water and wastewater industry. The large numbers of Baby Boomers working for water/wastewater utilities will result in a large wave of retirements in the next 10 years. The water/wastewater industry will lose a great deal of tacit (undocumented) knowledge. As much as 80% of useful operational knowledge is tacit. Certain skills that utilities need when replacing workers are in short supply and are forecasted to get worse. In addition, few utilities report that they have succession plans in place and many publically-owned utilities operate under personnel rules that limit the ability to implement succession planning. Where plans are in place, much attention has been placed on succession planning for leadership positions and less emphasis has been paid to mission critical professional level positions.

Current training levels need to be upgraded and expanded. As regulations in the water and wastewater industry become more stringent, there is a lack of quality people entering the field and operators are being required to take on increasing responsibilities and to understand complex regulatory issues. Operators face increased expectations in both occupational and professional competencies. Increasing automation of utilities calls for more technically skilled workers. To complicate the matter, today's pool of non-degreed workers has fewer skills than candidates have displayed in the past. The available supply of desirable workers is thin and water/wastewater utilities have difficulty competing with other employers for the best hires. The achievement of a post-secondary education may be the key to acquiring the skills needed in today's water/wastewater workforce. Graduates of post-secondary programs tend to possess critical-thinking skills with the foresight to recognize potential problems and be more adaptable to change. However, competition for employees entering the workforce from colleges and trade schools is fierce. Potential entry-level employees are being lured away by higher-paying, higher-prestige jobs in consulting and other technical industries such as petroleum.

Federal regulations require that operators of water and wastewater treatment, distribution, and collection systems be certified/licensed and obtain continuing education to maintain this certification/licensure. Some college coursework (such as courses taught in the Water Resource Management Associate Degree program at Bowling Green Community College of Western Kentucky University) has been approved for continuing education credit for operators. In addition, for currently certified/licensed operators, college coursework can be substituted for years of experience, allowing them to advance at a faster pace in the industry. In an effort to have a broad reach, the aforementioned, Water Resource Studies program, is an on-line Associate Degree program. Accredited on-line courses and degree programs equal traditional face-to-face programs in meeting students needs, access to faculty, and interaction with other students. The on-line course environment offers students unparalleled flexibility with no set class schedule and no travel time. Academically, on-line courses are equally as rigorous as face-to-face classes. On-line courses also give students several advantages in their professional development: students are exposed to technology that they will use as tools in their current or future jobs, learn to manage deadlines, and play a key role in their own learning process.

DEPLOYMENT OF SENSOR NETWORKS FOR MONITORING WATER QUALITY USING RULE-BASED EXPERT SYSTEM IN GIS

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The Center for Water Resource Studies aims to help rural communities efficiently and cost-effectively complete the deployment of sensors and sensor networks for monitoring water supply systems in a user-friendly environment with the aid of a rule-based expert system embedded in a geographical information system (GIS) platform. The design-basis involves developing a customized sensor and control/response network, a rule-based expert system, and the analysis, display and response methods that enhance a unique spatial visualization to promote interactions between the designers, the operators, and the end-users. System costs will be minimized by using the expert system to design a sensor network that triggers response based on changes in overall system state, rather than the more expensive route of detecting specific intrusions with vector-specific sensors.

The EPANET toolkit was used to set up simulations of hydraulic and water quality scenarios. Outputs from EPANET were analyzed by engineers and experts for creating rules and assessment of sensor deployment. Types, amounts, and locations of sensors were assessed based on the historical water usage data and the simulation outcomes from EPANET. Spatial data of the water distribution network was converted and exported into the EPANET file format. Simulations were conducted based on multi-dimensional scenarios. EPANET offers various capabilities including hydraulic and water quality assessments. Spatial data is imported into EPANET software as .INP file format. The simulation was set to run for 72 hours. Once complete simulations of the network are assessed, the next step is to deploy sensors based on the needs. Determinations will be made on recommendation of the types, the number, and the locations of sensors needed.

A rule-based expert system is software that provides the knowledge of an expert in answering a problem for which a human expert would normally be consulted. This is accomplished by using a rule base, facts, and an inference engine. The rule base is the knowledge of an expert. The facts are the information about the real world problem or environment. The inference engine analyzes the rules and facts to produce a result to answer the problem.

Simple rules-based engines chain procedural logic together in an order that the user specifies. Most offer sophisticated matching algorithms like Rete to connect facts with rules, determine which rules should be run, and in what order. Rete builds a tree from the rules, like a state machine. Facts enter the tree at the top-level nodes as parameters to the rules, and work their way down the tree if they match the conditions until they reach the leaf nodes: rule consequences.

There are two types of chain procedural logic for a rule system: Forward Chaining and Backward Chaining. Forward chaining is "data-driven." It is reactionary with facts being searched against the inference rules until the desired result is found. Backward chaining is "goal-driven," meaning that it starts with a list of goals and works backwards to see if there are data which will allow it to conclude any of these goals.

The rule-based expert system was created by modifying a rule engine, jDREW and the extension OO (Object-Oriented) jDREW. jDREW is an easily configured, powerful deductive reasoning engine for clausal first-order logic (facts and rules) written in Java. jDREW uses Prolog and RuleML formats. It is both backward and forward reasoning.

OO jDREW contains a rule base, a place for facts, and an induction engine. Rules and facts are stored in the RuleML format. The rule base is initially created based on the knowledge of an expert. The facts are dynamically created with each project based on the spatial data provided by the user. The inference engine processes the data using forward chaining and/or backwards chaining to produce the result.

New tools were developed and integrated into the rule-based system to increase usability and cross functionality with many other existing programs. This was accomplished by adding conversion capabilities to the program. The conversion tool was created with the OGR Simple Features Library which is an open source library written in C++ programming language. This tool allows users to convert existing GIS data into many different formats.

The GML format was chosen to be the standard format used in this project. It was chosen because it is the open source standard used by the Open Geospatial Consortium (OGC) and is an XML schema. Many of the software already mentioned can use the GML format. Several popular open source software, including GRASS and MapWindow GIS, use the format as well.

The rule-based system converts GIS data to the GML format. A parser written in Java programming language was created. The parser takes the GIS data that is in the GML format and translates it into a RuleML file. The RuleML file is used in the rule engine OO jDREW to create a fact base. The parsing component dynamically locates each GIS data set and places them into separate relations within the RuleML file and associates the data sets attributes into relating variables. After OO jDREW creates results based on facts and rules then the RuleML is parsed into GML and added to the GIS as a new layer. The goal of using the GML format is to increase usability. The GML format is becoming an industry standard. The GML format helps make the rule-based system compatible with many of the most popular GIS software packages.

QUANTIFYING THE SOIL CARBON UPTAKE RATE IN RECLAIMED APPALACHIAN MINE SOIL

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While recent research has focused on the use of carbon capture and sequestration technology feasibility, less focus has been placed upon terrestrial carbon storage affected by coal mining in the context of the clean coal debate. Recent research has shown that the initial disturbance of soil and above-ground carbon pools caused by surface coal mining methods can produce a significant carbon loss from the terrestrial ecosystem, thus increasing the coal carbon footprint of coal. However there is a lack of information regarding the uptake of carbon on reclaimed mining sites during re-growth and re-establishment of the soil organic carbon profile.

This study was conducted in order to investigate carbon sequestration processes and rates in reclaimed surface coal mine lands in the Southern Appalachian forest region. Five reclaimed mining sites varying in age since reclamation (0, 2, 6, 8 and 10 years) were

sampled to a depth of 50 cm to determine the corresponding carbon densities. In addition, nearby undisturbed forest sites were sampled to determine baseline carbon data for the region. In undisturbed forest sites, the organic carbon content decreases gradually with depth while nearly all soil organic carbon was stored in the first 10 centimeters for the reclaimed soils. Estimates of the carbon density at each site were calculated by un-mixing soil organic carbon and geogenic organic carbon using carbon stable isotopes and a correction for rock fragments at the sites.

Carbon densities for the 0, 2, 6, 8 and 10 year sites were 0.73, 1.1, 8.0, 6.3 , and 7.0 $Mg\ C\ ha^{-1}$, respectively, as compared to 91 and 81 $Mg\ C\ ha^{-1}$ at the control sites. The temporal variation of soil carbon was modeled using a first order kinematic equation. Analysis of carbon elemental and isotopic data suggested that soil carbon turnover increases with the age of reclaimed mining site. Further analysis of short and long-term ecosystem carbon budgets is needed for reclaimed mining soils in order to better model their carbon sequestration potential. Understanding the long-term progression of carbon budgeting in reclaimed mine soil can lead to more effective reclamation guidelines and cleaner coal production.

MODELING OF CO₂-WATER-ROCK INTERACTIONS IN MISSISSIPPIAN SANDSTONE AND CARBONATE RESERVOIRS OF KENTUCKY

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Mitigating the input of carbon dioxide (CO₂) into the atmosphere is becoming increasingly critical as usage of fossil fuels continues. With the overwhelming majority of electricity coming from coal-fired power plants, Kentucky is a significant producer of CO₂. Pilot tests are underway in Kentucky to further understand the processes involved with sequestering captured carbon into geologic reservoirs including: oil and gas fields, and deep saline aquifers. This study focuses on modeling the subsurface water-rock-CO₂ interactions occurring during carbon sequestration into Mississippian oil and gas reservoirs of western and eastern Kentucky.

New samples (n= 62) and archived data, both collected from oil wells, were used to characterize the chemistry of formation waters from Sugar Creek field in Hopkins County, Euterpe field in Henderson County, and various fields in Leslie County. In addition, 20 core and 17 cuttings samples from the reservoir and overlying cap-rocks in or near these fields were analyzed for bulk and clay mineralogy using X-ray diffraction. Electric logs were used to select sample intervals within the overlying cap-rocks and in the center of the producing zones. Samples from the sandstones include the Cypress, Big Clifty Member (Jackson) of the Golconda Formation, Hardinsburg, and Tar Springs Formations in western Kentucky. The carbonate samples were taken from the Slade Formation/Newman Limestone (Big Lime) of eastern Kentucky.

The chemistry of formation waters directly influences the potential for dissolution of CO₂ into fluids (solubility trapping), as well as influencing mineral-forming reactions (mineral trapping). Using the water chemistry and mineralogic data as inputs, speciation and reaction path models were created using the Geochemist Workbench software to predict the distribution of aqueous species at equilibrium, evolution of fluid chemistry, and reservoir mineralogy as CO₂ is injected into the reservoir. Ongoing work involves comparison of fluid-mineral equilibria and reactions in the sandstone versus carbonate reservoirs to determine the feasibility of long-term carbon capture, as well as comparing model results against actual data collected from pilot sites.

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BRINE CHEMISTRY
IN THE ILLINOIS AND APPALACHIAN BASINS OF KENTUCKY
IMPLICATIONS FOR GEOLOGIC CARBON SEQUESTRATION

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Theoretical studies show the potential to dissolve up to 30% of injected CO₂ in formation water over a period of tens of years in sequestration projects. The dissolution, called solubility trapping, is important because it removes CO₂ as a separate buoyant phase that would migrate upward. Subsequently, the dissolved CO₂ may form HCO₃⁻, which can react with divalent cations, such as Mg, Ca, and Fe, to form carbonate minerals (mineral trapping). The extent of dissolution is influenced by temperature, pressure, and formation water chemistry. The relationship between formation water chemistry and CO₂ solubility provided the motivation for examining more than 900 analyses of formation waters collected mostly from oil and gas wells in Kentucky. The samples were distributed among 106 counties in the Appalachian and Illinois basins and Cincinnati arch areas. Specifically, we analyzed salinity distribution with depth and stratigraphy, and the influence of salinity on CO₂ solubility. The formation water samples come from carbonate, clastic, and igneous-metamorphic rocks ranging in age from Precambrian to Pennsylvanian, and span elevations of 1550 to -7765 ft (sea level reference). In both basins, two distinct salinity trends are observed, with Cambrian-Ordovician samples mostly from the Knox Group showing salinities significantly less than those predicted by trends in Silurian and younger Paleozoic reservoirs. Solubility calculations confirm that lower salinities along with higher pressures at depth result in more potential for solubility trapping in the Knox Group reservoirs. Moreover, the contrast in salinity trends suggests the presence of an aurally extensive seal in the upper Ordovician that hydrologically separates Silurian and younger reservoirs from deeper Knox reservoirs. The sealing interval, which likely corresponds to the Maquoketa Shale and its equivalents, is significant because it overlies Knox Group reservoirs, a potentially important sequestration target in Kentucky. The upper Ordovician seal is also important because it has been penetrated by far fewer well-bores, which are potential leak pathways, as compared to other seals, such as the Devonian shales.

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RECONNAISSANCE OF SELENIUM OCCURRENCE
AND BIOACCUMULATION
IN THE EASTERN KENTUCKY COAL FIELD

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The toxic effects of selenium in the aquatic environment are well recognized as a result of decades of research, but the fate and role of selenium in biological systems is highly variable and quite contentious. The observed variable nature of selenium toxicity and bioaccumulation has caused considerable debate with respect to establishment of an appropriate criterion protective of aquatic and other wildlife. The complexity of selenium bioavailability and toxicity is a result of food chain dynamics, the concentration and speciation of selenium in aqueous systems, hydrologic characteristics (lentic vs. lotic environments), and the ecological nature of aquatic systems.

Given the recent findings of elevated selenium concentrations in adjacent West Virginia coal fields, the Kentucky Division of Water contracted with the Kentucky Geological Survey to plan and implement a study in the Eastern Kentucky Coal Field (EKCF). This

study was designed to target geologic strata that had relatively high concentrations of selenium, under various land disturbances. Due to budget constraints, data collected in this project were meant to be a first look at the selenium conditions in the EKCF. The study design required collection of water-quality, sediment-quality, and fish tissue samples to determine if selenium concentrations in the water column were elevated compared to control watersheds, and if bioaccumulation of selenium was occurring. Water, sediment, and fish tissue samples were collected in September 2007, with a few samples collected in May, June, and July of 2008. Data were collected from active mining areas, reclaimed mines, abandoned mines, roadcuts, and undisturbed watersheds. Samples were collected just below the toe of valleyfills, below sediment ponds, and just above or within receiving streams.

Background values from the two undisturbed sites were as follows: aqueous total selenium concentrations were below the RMDL (reporting limit = 1.0 µg/L); sediment selenium concentrations averaged 0.48 mg/Kg; and fish tissue total selenium concentrations averaged 2.28 mg/Kg. These values are based on limited data and should be considered with caution, especially since they are one-time samples and do not reflect any temporal variability.

No viable relationships were observed between selenium in the water column and bioaccumulation in fish tissue. Weak relationships did exist between bioaccumulation and sediment selenium concentrations. These results correspond with findings from studies in West Virginia. However, the correlations were too weak to be considered useful. Also, no relationships could be observed between sediment selenium concentrations and aqueous selenium concentrations. No observable relationships existed between the various aqueous species of selenium and the general surface water-quality variables collected in this study.

Based on the limited data collected, the EKCF does have fish communities with elevated tissue selenium concentrations (4 fish tissue samples out of 31 exceeded the proposed 7.91 mg/Kg selenium total body residue criterion [during this study the proposed EPA criterion was withdrawn and additional data were considered to refine a forthcoming criterion expected in 2010]). The elevated concentrations tended to be associated with mining activities. However, the data were insufficient in number to determine if one landuse was statistically different from any of the others. It cannot be stated, based on these data, that active mining produced statistically different selenium levels than what was observed at the undisturbed sites, or that the undisturbed sites produced significantly less selenium than the mining areas. More data are needed before such conclusions can be drawn.

MILLCREEK ELEMENTARY STREAM & WELANDS RESTORATION
PROJECT & OUTDOOR CLASSROOM

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In 2008, there was a wonderful opportunity to develop a school-wide, interdisciplinary, water-focused education program at Millcreek Elementary School by restoring stream and wetland habitats around the free-flowing, meandering creek on the school grounds. This enhanced outdoor classroom would form the basis for environmental education in an urban setting. The outdoor classroom would help the environment by improving water quality and increasing aquatic and terrestrial habitats in and along the stream. Each habitat would be constructed using the latest technologies in partnership with the National Center of Excellence in Wetland and Stream Restoration, and would require a minimum of maintenance. Through the educational program, the creation of student Water Ambassadors, and the professional development of teachers and PTA volunteers, the entire community would benefit from the program.

In fall of 2008, this project began with hopes to restore approximately 625 feet of perennial stream riparian habitat using natural channel design techniques and to create of wetland habitat in the Millcreek watershed. This project assembled a team of over ten experienced conservation partners to insure the project was designed, implemented and measured effectively. The team had extensive experience in natural stream channel design concepts, wetland restoration and natural vegetation systems. Partners included the University of Louisville Stream Institute which is at the forefront in the development of natural channel design plans, parameters, and geomorphic regional curves for Kentucky, as well as Bluegrass Stream, a design/build stream restoration firm, who have restored over 30,000 feet of stream throughout Kentucky, Ohio, and Tennessee. Others included the Sheltowee Wetland Coalition who have implemented numerous education wetlands throughout Kentucky and aided in the establishment of educational classrooms.

Biologists with KDFWR and the USFWS Partners for Fish and Wildlife program assisted using their extensive knowledge of habitat restoration practices and fish and wildlife systems.

Over the past year, this project has continued to address the ecological need for restoring stream and wetland habitats, demonstrate natural channel design concepts, and facilitate the educational process related to those habitats. The original stream habitat of this project had been severely degraded over the past 200 years by agriculture and urbanization. Prior to this project, throughout this watershed, streams had been straightened and channelized and wetlands drained. This project demonstrates how streams and wetlands should function and has aided in the restoration of additional stream and wetland habitats.

Educational objectives of the program were to increase student, teacher and PTA volunteer content knowledge regarding biological and chemical indicators of water quality, physical features of streams, stream ecology, and GIS mapping. The targeted audience for this project was the Millcreek Elementary students, teachers, and PTA members at Millcreek Elementary School in Fayette County, Kentucky. One teacher representative from each grade level, K-5, along with a Family Resource Center teacher, special education teacher and the science resource teacher, continue to participate in the year-long investigations and maintain the stream and wetland at their school.

As this project continues through another year, it proves to be a beneficial step in educating the community of Mill Creek Elementary of their surrounding environment and it is helping them take a part in preserving it for future generations. Currently, this project is expanding to other schools in Fayette County so their communities may also be educated on the importance of streams and wetlands and the importance of maintaining their surroundings for the good of the environment.

SOUTHERN REGION 4-H₂O AMBASSADOR PROGRAM

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The Southern Region 4-H₂O Ambassador Program is part of an ongoing effort in the EPA Regions 4 and 6 to educate and empower youth to conserve and protect our water resources. The program includes four units, each of which focuses on a specific question related to watersheds and water quality. Each unit includes hands-on, investigative activities. Agents and volunteers trained on unit curriculum assist youth in these activities.

Once youth have completed all four units, they are considered 4-H₂O Ambassadors. As ambassadors, they are required to develop and implement a community-based service project. The service project must 1) educate community members on local watershed issues and 2) improve the water quality of a local watershed. After an ambassador has completed his or her service project, they will be recognized for their efforts locally, statewide, and regionally. In addition, as a 4-H₂O Ambassador, youth will be required to mentor new participants entering the program.

The Southern Region 4-H₂O Ambassador Program is a collaboration between the University of Kentucky (UK), UK Tracy Farmer Institute for Sustainability and the Environment, Kentucky Water Resources Research Institute, University of Tennessee, Clemson University, University of Georgia, Georgia 4-H Foundation, and the Southern Regional Water Program. The program is funded by the Southern Regional Water Resource Project Grant.

The program is currently being piloted in Kentucky, Tennessee, and Georgia. Once results from the pilot programs are received, the curriculum will be revised and training sessions on the program will be offered.

NOTES

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OLDHAM COUNTY FISCAL COURT LEADS WATERSHED PLANNING EFFORT

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Oldham County continues to be one of the fastest growing areas in the State of Kentucky with residential, commercial, and light industrial developments planned for the near future. Curry's Fork of Floyds Fork runs through the heart of Oldham County and is listed as a 1st priority 303(d) stream by the Kentucky Division of Water (KDOW). In 2006, KDOW awarded Oldham County Fiscal Court a \$1.6 million grant through the 319(h) Non-point Source Implementation program to develop and implement a comprehensive Watershed Plan (WP).

This presentation addresses some of the most difficult challenges in the watershed planning process head-on and can serve as an example for other communities and groups to follow in developing innovative watershed planning documents:

1. Engaging and Building Support with Elected Officials

Oldham County Fiscal Court serving as the project lead creates instant program support and elected official buy-in of the process and project from the beginning. Many 319(h) grant funds are awarded to watershed groups or public agencies and thus most work to gain the critical support of elected officials. In this project, elected officials and their staff are leaders, active participants, and local supporters of the goals of the project.

2. Public Outreach and Participation

Oldham County is blessed with one of the best educated populations in Kentucky and its residents are active and engaged in their community. However, even in the most pro-active communities, engaging the general public, getting their input, and building support is a difficult endeavor. Multiple demands on time, overwhelming competition for attention, and other factors tend to drown out this vital voice. Oldham County Fiscal Court has been able to overcome these obstacles through a multi-layered outreach program that uses direct mail, targeted flyers, and strong word-of-mouth approaches to encourage participation. These efforts have proven successful through an active technical committee and most significantly in the public round-table that drew nearly 100 watershed residents. To maintain this high level of participation, Oldham County has created a system

of personal follow-ups on an individual basis to document that every voice is heard and recognized.

3. Early Implementation Projects to Generate Interest and Support

One of the most often heard criticisms of the watershed planning process is the emphasis on planning before action. While watershed professionals understand and value the need for proper planning, many stakeholders would prefer more ‘on-the-ground’ improvements. This project uses a stream restoration project on Oldham County School Board property for not just their required non-Federal match but to also demonstrate a commitment to action. The stream restoration project headed up by the University of Louisville’s Stream Institute is about to begin construction work and has been effectively leveraged to generate interest and encourage identification of additional projects.

This presentation will explain the history of this project, the obstacles that have been met and explain the processes that Oldham County Fiscal Court used to move forward successfully. These steps can be repeated anywhere and can serve as a blue-print for other communities wanting to engage in watershed planning.

UPDATE ON LEXINGTON'S CONSENT DECREE

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This presentation will give an update on Lexington's Consent Decree (CD). The CD is an agreement between the Lexington-Fayette Urban County Government, the U.S. EPA, and the KY Energy and Environment Cabinet regarding violations of the Clean Water Act. The CD was lodged in federal court on March 14, 2008 and is currently under review by the U.S. District Judge. LFUCG has proceeded to implement the CD requirements in accordance with the schedule in the CD. In addition, LFUCG received a new KPDES Municipal Separate Storm Sewer System (MS4) permit effective September 1, 2009, that addresses many of the same stormwater requirements in the CD.

The presentation will give a brief summary of the sanitary sewer and stormwater requirements of the CD and MS4 Permit, progress to date, and future direction of the program. Topics covered will include the following:

- Water quality management fee implemented in January 2010
- New ordinances that address private property maintenance, industrial and high risk commercial facilities, and enforcement
- MS4 Permit and the Stormwater Quality Management Program (SWQMP)
- Progress report on implementing the SWQMP, including: watershed management, legal authority, public education and involvement, illicit discharges, construction site runoff, residential and commercial development, municipal operations, industrial facilities, monitoring, and reporting
- Progress report on implementing the sanitary sewer requirements of the CD

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OUTER SCALING METHOD FOR VELOCITY PROFILE COLLAPSE IN GRAVEL-BED RIVERS

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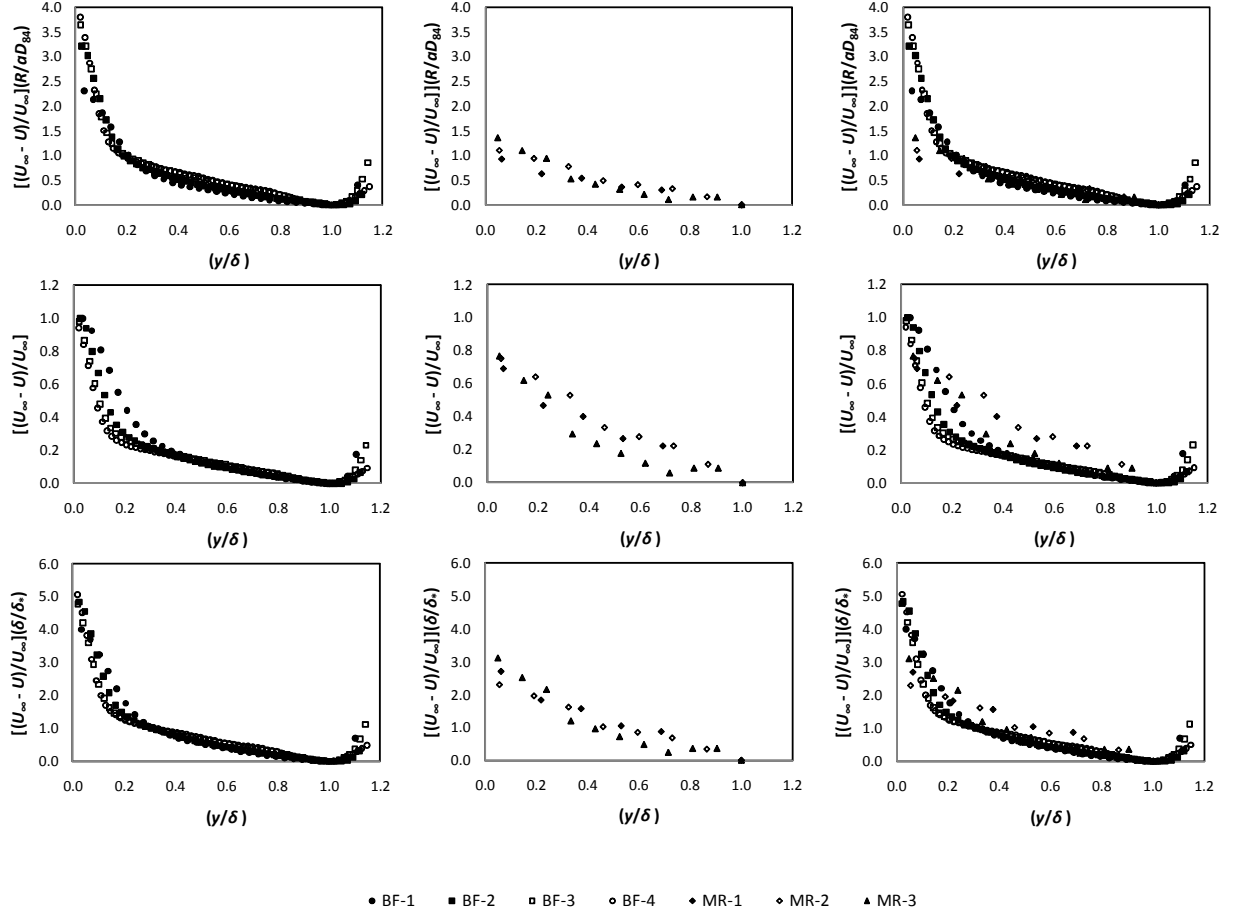
This paper provides a similarity analysis of the time-average velocity distribution in a hydraulically rough open channel flow over a gravel bed. The analysis is based on equilibrium turbulent boundary layer theory derived using the asymptotic invariance principle. The scaling parameter (R/aD_{84}) is included to account for the dominant upstream conditions, including vortex shedding responsible for boundary layer growth. Outer scaling based on the similarity theory shows agreement with velocity measurements from the laboratory and field, having Reynolds numbers on the order of 10^4 and 10^6 , respectively.

Flow parameters for the test conditions are listed in Table 1 and the similarity collapse for these data are shown in Figure 1. The outer scaling method using (R/aD_{84}) collapses these data across the water column and is an improvement over the two other outer scaling methods shown in Figure 1. The results are important for modeling the time-average velocity distribution under bankfull conditions in rivers with a gravel bed, which transport high fluid momentum responsible for driving environmental hydraulics phenomena.

Table 1. Flow parameters for the laboratory and field studies.

Test	D_{84}	U_{∞}	δ	R
	(mm)	(m s ⁻¹)	(m)	(m)
BF-1	5.6	0.62	0.034	0.035
BF-2	5.6	0.76	0.051	0.048
BF-3	5.6	0.83	0.060	0.056
BF-4	5.6	0.83	0.066	0.061
MR-1	190	2.25	0.64	0.64
MR-2	190	1.80	0.74	0.70
MR-3	190	1.70	1.05	0.85

Figure 1. Scaling using $U_\infty(aD_{84}/R)$ as well as outer scaling with U_∞ alone, and $U_\infty(\delta^*/\delta)$ that includes laboratory data (left column), field data (center column), combined plots (right column).



WATER AVAILABILITY TOOL
FOR ENVIRONMENTAL RESOURCES (WATER)

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To assist the State of Kentucky in the management of its water resources, the U.S. Geological Survey and the Kentucky Division of Water created the Water Availability Tool for Environmental Resources (WATER). WATER is a geospatially-referenced, deterministic hydrologic modeling tool recently developed and tested in the USGS Kentucky Water Science Center (Williamson and others, 2009). WATER is a flexible platform from which multiple extensions may be run; the first of these extensions is the TOPMODEL deterministic rainfall-runoff approach originally developed by Beven and Kirkby (1979). The TOPMODEL-based approach programmed into WATER uses historical climate data together with physiographic data that quantitatively describe watershed topography and soil-water storage to obtain a simulated record of daily streamflow within any user-defined watershed (surface catchment) area. The current version of the WATER application uses a custom map-based, point-and-click graphical user interface that provides for automated delineation of watershed (catchment) boundaries of any size, and is capable of simulating approximately 60 years of streamflow data (from 1948-2000 it uses climate data from Kentucky cooperative-weather stations and from 2000-2006 it uses available NEXRAD data). With these capabilities, WATER provides a variable field-scale hydrologic-modeling tool that generates streamflow hydrographs and other hydrologic analytical outputs such as flow duration curves for gaged or ungaged watersheds, and optimally functions in smaller, unregulated, upland watersheds where topographic gradients may be comparatively steep and precise channel-geometry data is not available or is unfeasible to collect.

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METHODS FOR ESTIMATING LOW-FLOW FREQUENCIES OF UNREGULATED STREAMS IN KENTUCKY

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Decisions related to waste-load allocations, discharge and withdrawal permits, water-supply planning, and in-stream flow requirements depend on estimates of low-flow frequencies. Low-flow frequencies are needed for effective management of Kentucky's water resources. Methods for estimating low-flow frequencies at ungaged stream sites are part of this need. The U. S. Geological Survey, in cooperation with the Kentucky Division of Water, made estimates of the unregulated streams in Kentucky for 7-day mean low flows for recurrence intervals of 5, 10, and 20 years ($7Q_2$, $7Q_{10}$, and $7Q_{20}$) and 30-day mean low flows for recurrence intervals of 2 and 5 years ($30Q_2$ and $30Q_5$) at 121 streamflow-gaging stations with data through the 2006 climate year and developed regional regression equations for estimating low-flow characteristics of unregulated streams in Kentucky. Data were screened to identify the periods of homogeneous, unregulated, natural flows by use of annual-low-flow time-series plots, trend tests, available information on permitted water discharges and withdrawals, and double-mass curves for comparing annual low flows at each gaging station to flows at a reference gaging station.

Logistic-regression equations were developed for estimating the probability of the annual 7- and 30-day low flows being zero. Weighted-least-squares regression equations were developed for estimating the magnitude of the nonzero $7Q_2$, $7Q_{10}$, $7Q_{20}$, $30Q_2$, and $30Q_5$ low flows. Three low-flow regions were defined and are used as location-indicator variables for estimating the nonzero 7-day low-flow frequencies.

In addition to the low-flow regions, the explanatory variables in the regression equations include the basin total drainage area and the mapped streamflow-variability index, which is determined from a revised statewide coverage of this characteristic. The percentage of the station low-flow frequencies correctly classified as zero or nonzero by use of the logistic-regression equations ranged from 87.5 to 93.8 percent. The average standard errors of prediction of the weighted-least-squares regression equations ranged from 108 to 226 percent. The regression equations are applicable only to stream sites with low flows unaffected by regulation from reservoirs and local diversions of flow and to drainage basins within specified ranges of basin characteristics. Caution is advised when applying the equations for basins with characteristics near the applicable limits and for basins with karst drainage features.

The estimating equations can be applied by (1) determining the basin characteristics required for the appropriate equation, (2) checking to ensure that the basin characteristics are within the range of values used to develop the equation, and (3) substituting the basin-characteristic values for the variables in the estimating equations. The user first determines the probability of the low-flow frequency having a value of zero by use of the logistic-regression equation, and if a nonzero value is likely, the low-flow frequency value is estimated by use of the weighted-least-squares regression equations as described in the example applications presented in this report.

INVESTIGATION OF THE SURFACE FINE GRAINED LAMINAE USING A WATERSHED SCALE SEDIMENT TRANSPORT MODEL

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Sediment transport at the watershed scale in the Bluegrass Region of Kentucky is dominated by surface fine grained laminae (SFGL), streambed, and streambank erosion; high in-stream sediment storage; and surface erosion processes. All these processes can be impacted by agricultural, urban, and suburban land-uses as well as hydrologic forcing. Understanding sediment transport processes at the watershed scale is a need for budgeting and controlling sediment pollution, and watershed modeling enables investigation of the cumulative effect of sediment processes and the parameters controlling these processes upon the entire sediment budget for a watershed.

An in-house conceptually based sediment transport model was created which models SFGL erosion, streambed erosion, streambank erosion, in-stream deposition, and in-stream storage at the watershed scale. The in-stream hydraulic and sediment transport model was set up with bathymetry measurements, bed sediment characteristics, and bank sediment characteristics for the South Elkhorn watershed located in Lexington Kentucky. This 61 km² watershed is partially urbanized, has gentle upland slopes, and is representative of semi developed watershed in the bluegrass region of Kentucky. The in-stream hydraulic and sediment transport model is driven by flow rate measurements at the outlet of the South Elkhorn watershed. The sediment model was then calibrated with sediment yield measurements at the outlet of the watershed. Outputs from the sediment transport model include total yield at the watershed outlet, the source fractions from surface fine grained lamina, streambed, and streambank sources; deposition; and biological generation within the streambed. Using this configuration, a sediment budget,

organic matter budget, stream bed storage pattern, and flow and sediment yield frequency analysis for the South Elkhorn watershed were predicted.

The SFGL shows a control on sediment transport in the watershed. The streambed is in quasi-equilibrium for the model runs. Small and moderate events are dominated by a net erosion from the streambed as the SFGL is downcut. Large events cause a deposition of sediment to the SFGL which is reflective of the transport limited condition of the lowland system. Results provide very good agreement with sediment yield analysis. A sediment budget is performed and it is seen that most sediment that comes into the stretch of stream is deposited to the SFGL, spends time there as intermittent sediment storage, and then erodes out of the watershed in a later event. The importance of the SFGL on protecting sediments deeper in the bed is seen as the bed has a low contribution to the sediment load in a cumulative sense. It is estimated that organic carbon generated in the SFGL makes up approximately 30% of the carbon loading for the watershed.

A FIELD PROTOCOL FOR MEASURING THE HYDROGEOMORPHIC EFFECTS OF LAND-USE CONVERSION IN NORTHERN KENTUCKY STREAMS

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Streamflow alteration associated with development in Kentucky has typically been regulated in terms of preventing flood level increases at specific return-intervals such as the 100-, 50-, 10-, or even 2-year peak flows. Such policies generally do not address channel stability in that they exclude two important components of the flow regime: 1) durations of the high-energy flow events, and 2) magnitudes and durations of potentially sediment-transporting flows below the minimum regulated flow (e.g. below the 2-year flow magnitude). Consistent with the rest of the nation, the altered delivery of water and sediment from a previously undeveloped watershed (i.e. 'hydromodification') has resulted in an imbalance between erosive forces and the channel's inherent resistance causing predictable, systematic responses in stream channel networks. The threshold of instability depends upon an interaction of hydrogeomorphic factors that vary regionally. Scientific literature documents that once the threshold is surpassed, the resulting system-wide instability may take periods of decades and even centuries for the degraded channel networks to return to some semblance of equilibrium and ecological function.

Field reconnaissance of 46 sites in northern Kentucky documented that 1) the threshold of instability has been crossed in many regional watersheds, and 2) the evolutionary trajectories of channel responses include both incision-driven and lateral adjustments, depending on the resistance of the bed materials relative to the banks. In order to better assess the effects of hydromodification, in conjunction with the water chemistry, biology,

and habitat monitoring protocols, 24 sites were selected for a multi-year monitoring program. Semi-permanent (rebar) benchmarks were set for repeated, spatially-integrated cross-section and profile surveys, along with 100-particle pebble counts. From the multi-year surveys, we populated a broad array of potentially-important measures of channel stability (e.g. change in ‘bankfull’ area, topwidth, and depth, rate of longitudinal headcut migration, change in average riffle length, pool length, and pool depth, change in the size of the median bed-material particle, etc.). Preliminary analyses indicate that the most developed watersheds tend to be associated with the most unstable channel reaches, which, in many cases, also correspond to streams with the most impacted biological communities.

SUBWATERSHED CLUSTERING BASED ON GEOMORPHIC AND HUMAN INDUCED LANDSCAPE MODIFICATIONS: THE LICKING RIVER BASIN

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Watershed boundaries rather than political boundaries are increasingly advocated to address a variety of water resource issues. Effective watershed assessment processes are needed that classify watersheds by geomorphic and human modified landscape scale characteristics. This platform presentation expands upon the presentations at the 2008 and 2009 KWRRI Symposiums. The research continues exploring the opportunities and constraints of an ongoing descriptive categorization approach. Watershed sample size has been increased to over 800 subwatersheds encompassing the entire Licking River Basin. Using a semi-automated process through ModelBuilder of ArcGIS and publically available data from the Kentucky Geography Network, over 50 landscape scale indicators are derived by Hydrologic Unit Code (HUC) 14 subwatersheds to describe land surface conditions. Example indicators include proportion and spatial configuration measures of human population, imperviousness, and agriculture/forest cover characteristics.

Once the data are derived for each subwatershed, they can be visualized geographically with a color ramp indicating conditions for each indicator independently or in combination. A quantitative matrix can also be made to allow for comparisons by indicator across the study area. The process provides a guide to relative watershed condition both in relation to a specific indicator and amongst all indicators. This enables

indicator recombination as needed for particular issues under consideration by planners, policy makers and interested stakeholders for more informed subwatershed scale land use decision-making. In particular, statistical cluster analysis based on 17 geomorphic and human influenced variables was utilized to identify similar subwatersheds. The statistical clustering using complete linkages identified 11 clusters in total with eight clusters comprising the majority of the subwatersheds. These data and the statistical clustering approach are anticipated to lead to a better understanding of subwatershed categorization as well as implementation and management opportunities and constraints.

Acknowledgement: This material is based upon work supported by the Cooperative State Research, Education and Extension Service, U.S. Department of Agriculture, under Agreement No. 2008-34628-19532. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U. S. Department of Agriculture.

UPDATING THE NHD IN A DYNAMIC LAND COVER CHANGE ENVIRONMENT: THE CASE OF THE ELUSIVE WATER BODIES IN KENTUCKY'S EASTERN COAL FIELD REGION

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Constant maintenance and update of the spatial and attribute information contained in the National Hydrography Dataset (NHD) is of critical importance to water resource managers. Water bodies in Kentucky – such as ponds and reservoirs, provide essential and diverse services to fish and wildlife, livestock, crops, industry, commerce and humans, including flood and sediment control. Inventorying these water bodies is often challenging due to the patterns of land use and ownership in the Commonwealth. Both the USGS National Land Cover Dataset (NLCD) 1992/2001 Retrofit Land Cover Change Product (LCC9201) (<http://www.mrlc.gov/multizone.php>); and the 2001-2005 land cover change product (LCC0105) created by the Kentucky Landscape Census Project (KLC) (<http://kygeonet.ky.gov>) document significant changes in number and extent of water bodies in Kentucky. Due to the dynamic nature of the changes and to access issues, inventorying of new water bodies and deletion of no longer extant features is often accomplished by delineations utilizing high resolution (e.g. aerial) imagery as photobase.

For several years now, the Landsat mission archives have been available to the public at no cost (<http://landsat.usgs.gov/>). The continued operation of the Landsat 5 and 7 missions counteracts the low resolution of the multispectral imagery. On the other hand, while aerial imagery acquisitions are typically carried out at much higher spatial resolution, their episodic nature poses a problem for periodic monitoring of resource change. The third band resulting from applying a tasseled-cap transformation – a spectral enhancement method to visible and infrared bands in Thematic Mapper (TM) Landsat 5 data, is known as the “wetness” band (Crist et al., 1986). Landsat 5 TM scenes, 2009 epoch (green up) and high resolution aerial imagery (leaf-on, 2008) were used to detect and photo-verify both pre-existing, and new but unmapped bodies of water in counties from the Eastern Coal Fields physiographic region (Frazier and Page, 2000). Water bodies and area features contained in the Kentucky portion of the NHD (<http://nhd.usgs.gov>) (downloaded January 2010) were used as a mask to calculate pixel-based statistical measures for the wetness values. By using a threshold wetness band value as an indicator of open water (i.e. water bodies), a preliminary analysis yielded features not present in the NHD, with areas between slightly less than 1 Ha to almost 17 Ha, distributed in eight counties (Table 1). This method, however, failed to detect smaller features and also yielded some false positives due to snow ground cover, water ponding,

clouds and cloud shadows. Based on preliminary evidence, it seems a technique including spectral enhancements of low resolution – but current – imagery from Landsat 5 or 7 could guide the discovery and inventorying of features, concomitantly assisting with the update of the NHD.

Feature	County	Latitude			Longitude			Area (Ha)	No. Pixels (30 m)
		Degrees	Minutes	Seconds	Degrees	Minutes	Seconds		
1	Johnson	37	45	42.7	-82	51	45.1	1	11
2	Knox	36	57	55.9	-84	3	44.5	0.8	9
3	Laurel	36	58	20.2	-84	8	52.1	0.8	9
4	Lawrence	37	57	33.4	-82	35	17.9	5.7	63
5	Martin	37	48	12.1	-82	24	22.5	6.9	77
6	Martin	37	45	21.9	-82	31	50.6	3.1	34
7	Martin	37	45	10.1	-82	31	31.7	1.3	14
8	Martin	37	44	35.3	-82	31	54.7	1.2	13
9	Martin	37	44	45.4	-82	32	0.8	1.6	18
10	Perry	37	3	29.3	-83	9	16.9	7.7	86
11	Perry/Knott	37	23	36.5	-83	7	26.3	15.1	168
12	Pike	37	37	56.6	-82	22	6.5	11.4	127
13	Pike	37	37	39.1	-82	20	35.4	16.8	187

Table 1. Water body features detected from Landsat 5 TM scenes (acquired February and March 2009; paths 19 and 18, row 34, respectively; geographic coordinates are for approximate feature centroids, captured at an approximate scale of 1:40,000; North American Datum of 1983).

References

- Crist, E. P., R. Laurin, and R. C. Cicone. 1986. Vegetation and soils information contained in transformed Thematic Mapper data. In *Proceedings of IGARSS 86 Symposium*, 1465-70. Ref. ESA SP-254. Paris: European Space Agency.
- Frazier, P.S., and K.J. Page. 2000. Water body detection and delineation with Landsat TM Data. *Photogrammetric Engineering and Remote Sensing*. 66(12): 1461-1467.

RELATIONSHIPS ASSOCIATED WITH LAND COVER
AND THE MACROINVERTEBRATE COMMUNITY OF
NORTHERN KENTUCKY WATERSHEDS

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As adaptive watershed management becomes an increasingly more prevalent means of managing water quality in streams, it is vital to understand the role that surrounding land covers play within the biological communities of streams. This is especially true in highly developing watersheds, such as many of those located in the Northern Kentucky counties of Boone, Kenton and Campbell. Sanitation District No. 1 (SD1) is charged with the regional management of both sanitary wastewater and storm water systems, evaluation of current and potential impacts, planning for future regional needs and the implementation of sanitary and storm water systems projects in Northern Kentucky. One of the first steps in understanding the various roles and influences within a watershed is the characterization of the watershed itself (i.e. biological, physical and chemical aspects). In order to accomplish this, SD1 launched a monitoring program to initiate the characterization process in Northern Kentucky streams. The objective of this project is to present the preliminary findings of the biological portion of this monitoring program. Specifically, this study focuses on the relationship of the macroinvertebrate communities and the surrounding land covers within these streams, and will also begin to examine the relationship of stream hydromodification and the macroinvertebrate community. Macroinvertebrate samples were collected using protocols developed by the Kentucky Division of Water (KDOW 2008). Community data were analyzed using various multivariate techniques and the Kentucky Macroinvertebrate Index (MBI) (KDOW 2003, 2008). Habitat assessments developed by USEPA and adapted by KDOW were performed at each sampling location, and primary land cover was determined by visual interpretation of GIS coverage. Preliminary results indicate both positive and negative relationships between macroinvertebrate community structure, the MBI, the degree of development (i.e. percent impervious), and the degree of stream stability/instability of a given watershed.

NOTES

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RIVER BASINS OF KENTUCKY

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The Kentucky Geological Survey recently published a series of maps of the major river basins of Kentucky: Green/Tradewater, Kentucky, Licking, Salt, Upper Cumberland (in Kentucky), Big Sandy/Little Sandy and Tygarts Creek, and Four Rivers (Cumberland, Tennessee, Ohio, Mississippi).

The maps were designed to put each major river basin in context and help people visualize the basin for its extent, the communities it affects, and the resources associated with each basin. The maps were created for use by planners, environmentalists, fishermen, students, and anyone who lives in or has an interest in a particular basin.

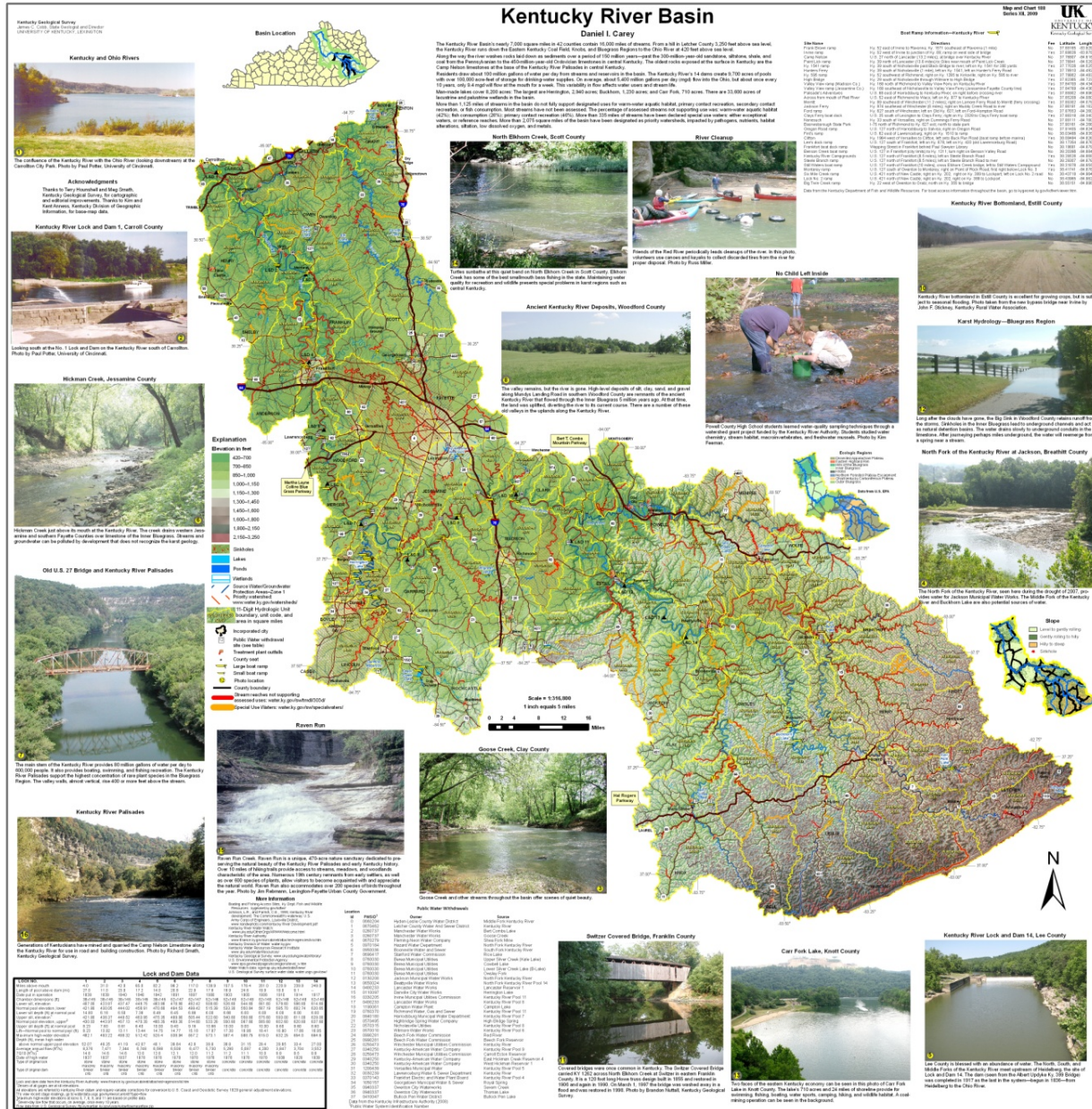
The shaded topographic relief maps used as a base show streams and water bodies, source/groundwater protection areas, priority watersheds, 11-digit hydrologic unit boundaries, water withdrawal points, wastewater discharge points, boat ramps, locks, stream reaches not supporting designated uses, special-use waters, cities, roads, and county boundaries. Tables include information on boat ramps, locks and dams, and water withdrawal. Photos and diagrams illustrate features of the basin. Basin slopes and ecologic regions are illustrated with inset maps.

Map sizes range from 36 x 36 inches to 36 x 48 inches, and map scales range from 1 inch = 3 miles to 1 inch = 5 miles.

Information for the maps was taken from River Basin Coordinating Committees, the Kentucky Division of Water, the Department of Fish and Wildlife Resources, the Kentucky Infrastructure Authority, the Kentucky Department of Transportation, the U.S. Geological Survey, the U.S. Army Corps of Engineers, and the Kentucky Division of Geographic Information.

Since the maps are print-on-demand, they can be custom-tailored to meet the needs of organizations that provide information related to their own missions.

POSTER PRESENTATION



Actual size: 36" x 36", scale, 1 inch equals 5 miles

AN INITIAL PRIORITIZATION APPROACH FOR POTENTIAL AGRICULTURAL
BEST MANAGEMENT PRACTICE IMPLEMENTATION BASED ON
SUBWATERSHED INDICATORS AND EXPERT KNOWLEDGE

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This poster describes a flexible approach that relies on expert knowledge and landscape conditions for making preliminary decisions on where to focus efforts to reduce agriculturally sourced nitrogen and phosphorus through voluntary use of best management practices (BMPs). Using geospatial technology and data describing landscape conditions offers an opportunity for decision-making support across an entire river basin while not relying on complete temporal and spatial water quality data. For demonstration purposes, this approach targets a subset of subwatersheds in the Licking River Basin. The 828 Hydrologic Unit Code 14 subwatersheds are used to provide the basis for a practical demonstration using only data from the Kentucky Geography Network. Subwatersheds were characterized on ten landscape indicators that have been determined to influence water quality based on literature review. A Z-score was calculated for each indicator, and the ten indicator Z-scores were weighted and then added together for each subwatershed. This results in a total Z-score for each subwatershed.

A subwatershed approach utilizing several indicators and weighting them differently can quickly generate a variety of options that can be visually evaluated by experts. For example, one weighting scheme might focus water quality BMPs towards higher densities of permitted animal feeding operations based on animal equivalent units. A second weighting scheme might focus on subwatersheds with conditions that are characterized with relatively high riparian agriculture land cover, road/stream intersection density, stream density, and steeper riparian zone slope. Very often resources are dedicated towards locations that have the worst existing conditions and are often the most expensive and/or complicated to improve. An alternative approach could be to identify subwatersheds with good riparian indicator conditions and thus likely better water quality, and further improve conditions in those subwatersheds. Such targeting might be helpful if it is determined that it is more effective to improve an area with relatively good conditions rather than completely establish riparian zone BMPs in new areas. As an additional consideration, landowners/managers in subwatersheds with intact riparian zone BMPs might be more willing to maintain and expand existing riparian zone BMPs than landowners/managers where few riparian BMPs are in existence. An advantage of this

approach is that it helps decision makers combine expert knowledge of on the ground conditions and past efforts with the ability to visualize landscape conditions for the purpose of establishing or continuing landowner/manager discussion.

Acknowledgement: The poster uses data from work that was supported by the Cooperative State Research, Education and Extension Service, U.S. Department of Agriculture, under Agreement No. 2008-34628-19532. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U. S. Department of Agriculture.

LOCATING KARST CONDUITS IN CANE RUN WATERSHED OF CENTRAL KENTUCKY USING ELECTRICAL RESISTIVITY METHODS

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The Cane Run watershed and underlying karst aquifer in central Kentucky is the recharge area of Royal Spring, the primary source of drinking-water for the city of Georgetown, Kentucky. This watershed, including the associated karst aquifer, is degraded by pathogens, nutrients, siltation, and organic enrichment and is listed by the Kentucky Division of Water as one of four focus watersheds for clean-up under the State's nonpoint-source pollution program. The pollution sources include both municipal point sources and agricultural and nonagricultural nonpoint sources. The relative contribution of different parts of the watershed to the pollution is not well understood. The geology of Cane Run watershed consists of Ordovician thin-bedded limestone with sparse interbeds of shale. The landscape is dominated by karst features such as sinkholes and springs. Cane Run only flows on the surface during times of significant rainfall, usually in the spring of the year. The remainder of the year, most water is recharged to a karst conduit system that leads from Lexington to Royal Spring.

To help locate the actual source of contamination and to track progress of remediation efforts, it is important to monitor contaminants before they reach the point of groundwater use. Kentucky Geological Survey (KGS) is attempting to drill into the conduit to establish a water quantity (discharge) and quality (temperature, pH, conductivity, dissolved oxygen, turbidity, and sampling capability) monitoring station, just a few hundred meters up gradient from where the conduit diverges from the Can Run surface watershed. However, there is no known entrance into the Royal Spring Conduit. This study is using geophysics to assist in locating the karst conduit. We have applied electrical resistivity (ER) in four scenarios: (1) 2D surveys, (2) quasi 3D surveys, (3) synthetic time-lapse simulation, and (4) time-lapse survey with calcium chloride injection. A 2D survey conducted in 2008 showed some low resistivity anomalies and subsequent field drilling and tracer tests indicated these anomalies are mud-filled voids that are not located in the main conduit system. A quasi 3D survey consisting of twelve parallel survey lines was conducted to further investigate a prominent low resistivity anomaly identified by a 2D survey conducted in summer 2009. The quasi 3D survey shows the anomaly disappears approximately 40 meters northwest from the first parallel line Figure 1). The synthetic time-lapse simulation showed that, given our hypothesis of conduit depth and size, a time-lapse survey can potentially pick up the signal disturbed by calcium chloride injection. The field time-lapse survey conducted in October 2009

showed noticeable resistivity change for a low resistivity anomaly in the southwest portion of an ER line. This anomaly will be further studied through additional time-lapse surveys and microgravity measurements. This work is being carried out in cooperation with the University of Kentucky's College of Agriculture and Department of Earth and Environmental Sciences.

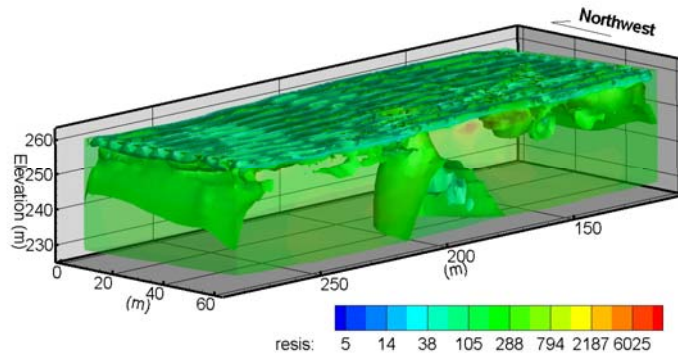


Fig 1. Inverted Electrical Resistivity for a Quasi 3D Survey

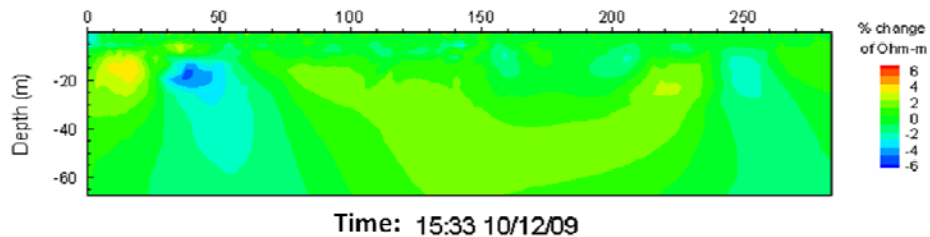


Fig.2 Resistivity Change During a Time-Lapse Survey

Reference:

R. Paylor and J. C. Currens, Royal Spring karst groundwater travel time investigation, prepared for Georgetown Municipal Water and Sewer Service, Kentucky Geological Survey, University of Kentucky, June 2004.

IDENTIFICATION OF DNA BIOMARKERS FOR DETERMINING SOURCES OF FECAL POLLUTION IN WATER

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Fecal contamination of water sources is a serious problem worldwide. Most of Kentucky and a quarter of the world's population draw drinking water from highly porous underground karst aquifers formed in the underlying limestone. Kentucky and the Mammoth Cave region are recognized as part of the most extensive and vulnerable karst terrain on the globe. From GenBank we compiled extensive 16S rDNA sequence data of the fecal-specific bacterial group *Bacteroides* obtained from a variety of host animals. Sequences of *Bacteroides* 16S genes were trimmed to match the sequence flanked by standard PCR primers for this group and then analyzed for fragment sizes generated from a number of restriction enzymes. The fragment sizes for each enzyme were compared between animal groups using discriminant analysis methods and multiple enzymes along with the GC content were selected as assessment markers to maximize the ability to differentiate between animal groups. The results predict that different animal hosts and human activities contributing to fecal pollution can be discriminated based upon easily measured DNA sequence features including restriction sites and GC content.

NOTES

[illegible]

INTEGRATING PARTICIPATORY COMMUNICATION AND STRUCTURED
PUBLIC INVOLVEMENT PROCESSES TO BETTER ADDRESS
SUPERFUND ISSUES: THE PADUCAH GASEOUS DIFFUSION PLANT
FUTURE STATE VISION PROJECT

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Through the auspices of the Kentucky Research Consortium for Energy and the Environment (KRCEE), members of the University of Kentucky Superfund Research Program Research Translation Core have joined experts in participatory rural communication appraisal and structured public involvement to develop an innovative approach for community involvement in determining the future of Superfund sites. The KRCEE team has been charged by Kentucky's Congressional delegation and the United States Department of Energy with integrating public, regulatory, and technical community visions to produce a publicly approved Future State Vision Report for the Paducah Gaseous Diffusion Plant (PGDP) National Priority List Superfund site. The three-step methodology being implemented includes personal interviews, focus groups, and large community meetings, with individuals from disparate stakeholder groups engaged at each stage. The information gathered during the interview and focus group stages will be utilized to create sample scenario visualizations that will be discussed and scored during the community meeting stage. Ultimately, the project will result in a "PGDP Future State Vision Document" that, while not decisional, will be available to inform future US Department of Energy decisions related to the disposition of the PGDP after decommissioning. In addition, CAsewise Visual Evaluation (CAVE) technology will utilize community preferences for sampled scenarios to predict preferences for additional, non-sampled model scenarios. A community consultation panel with representatives from sixteen unique stakeholder groups will advise the team throughout about potential process improvements.

NOTES

[illegible]

INVERTEBRATE PRODUCTION IN RESTORED AND REFERENCE STREAMS

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The restoration of stream ecosystems has recently received substantial attention. In this study, we assess invertebrate secondary production in a restored stream channel and an un-restored reference stream. Wilson Creek (restored stream) and Hart's Run (reference stream) are located in the Bernheim Research Forest (BRF) in Bullitt County, KY. Like many streams in Kentucky, Wilson Creek was historically relocated into a straight channel against its valley wall, presumably to increase arable land in the stream valley. In October 2003, a 965-meter reach of Wilson Creek was relocated into its original stream channel using natural channel design techniques. Hart's Run, which flows adjacent to Wilson Creek, lies entirely within the BRF. Approximately five years have passed since the Wilson Creek restoration was completed allowing the restored reach to recover from the channel relocation and restoration process.

Monthly benthic invertebrate samples ($n=5$) were collected from riffles of each reach using a Surber sampler (250 μm mesh size) for one calendar year. Invertebrate production was estimated for each taxa using one of three methods. Non-tanypodinae Chironomidae production was estimated using the instantaneous growth method. For all other taxa with sufficient abundance in the study streams, the size-frequency method corrected for the cohort production interval was used for production calculations. Production of rare taxa in each stream was estimated using an assumed P/B ratio of 5 for univoltine taxa and 10 for bivoltine taxa.

Total invertebrate abundance, biomass, and secondary production were similar between the two study streams. Total EPT production was also similar between the two study streams. However, invertebrate richness was higher in the restored stream (67 taxa) than the reference stream (62 taxa). Also, differences were observed in the production of functional feeding groups in each stream. Specifically, the restored stream had higher scraper production than the reference stream. Increased scraper production coincided with the availability of epilithic periphyton as a food resource in the restored stream. This is most likely because the canopy of the restored stream has not fully developed since the restoration project was completed, which has increased sunlight availability in the restored stream.

The results of this study indicate that, based on invertebrate production, the restored stream is very similar to the reference stream after five years of recovery from the channel relocation. Additionally, as the canopy matures on the restored reach, it is believed that the production of functional feeding groups in the reference and restored streams will also converge. Additional work in these streams will use these secondary production estimates to create quantitative energy flow food webs for the invertebrate assemblages of these two streams.

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MICROSCOPIC POPULATION DYNAMICS AND THEIR RELATIONSHIPS TO
THE ACTIVATED SLUDGE PROCESS IN A 30 MGD WASTEWATER
TREATMENT PLANT

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Population dynamics of protozoa and higher-life forms in the activated sludge can provide useful information in monitoring and optimizing operations, and for toxicity assessments of wastewater treatment facilities. Monitoring of protozoan abundance in mixed liquor (ML) from the Town Branch Wastewater Treatment Plant (TBWWTP), Lexington, KY was initiated by the Town Branch Lab in July 2009. The TBWWTP is classified as a single-stage conventional activated sludge system with an average design flow of 30 MGD, which can hydraulically treat a maximum flow of 64 MGD. Protozoan counts were grouped into four categories: amoebae/flagellates; free-swimming/crawling ciliates; stalked ciliates; and rotifers/nematodes. Trends in protozoan numbers (No./mg MLVSS) were compared with several parameters, including ML temperature, pH, alkalinity and TSS; F/M ratios; and sludge age. Although trend analyses were preliminary at press time, protozoan dominance was observed to be cyclical over time. As expected, dominance by amoebae/flagellates corresponded with decreases in abundance of both free-swimming/crawling ciliates and stalked ciliates, with converse results observed over time. Even though rotifers/nematodes tended to be less abundant, trends of their numbers over time were similar to those of the amoebae/flagellates. Protozoan's growth phases correlated with nutrient availability (F/M ratios), settleable solids, and sludge density indices (SDI). Along with protozoan enumerations, the Town Branch Lab is currently conducting filamentous bacteria identification. Data generated will be compared to the metrics above providing a comprehensive view of the activated sludge treatment processes. In addition, similar studies are being conducted at the West Hickman Creek WWTP (WHCWWTP), Nicholasville, KY. The WHC plant is classified as a two-stage activated sludge nitrification system with an average flow of 22.3 MGD, but can hydraulically treat 52 MGD.

NOTES

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BREAKPOINT ANALYSIS AND ASSESSMENT
OF NUTRIENT CONCENTRATIONS AND TURBIDITY
TO DIATOM AND MACROINVERTEBRATE INTEGRITY
IN THE PENNYROYAL BIOREGION OF KENTUCKY, 2007-08

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To assist the State of Kentucky in the development of numeric nutrient criteria for the Pennyroyal Bioregion, the U.S. Geological Survey and the Kentucky Division of Water collected water chemistry, turbidity, and biological-community data from 22 streams throughout the Pennyroyal Bioregion from September 2007 to May 2008. The goals of this study were to: (1) determine statistically significant and ecologically relevant relations among stressor [total nitrogen (TN) and total phosphorus (TP)] and response (biological community) variables; and (2) determine the breakpoint values of biological-community attributes and metrics in response to changes in stressor variables. Six of 11 diatom and 13 of 18 macroinvertebrate attributes and metrics were significantly and ecologically correlated (p -value < 0.10) with at least one nutrient measure. The diatom measures with the strongest correlations to nutrients were the Siltation Index, Diatom Pollution-Tolerant Index, percentage of *Cymbella* and *Achnanthes*, and *Cymbella* group richness. The macroinvertebrate measures with the strongest correlations to nutrients were total number of individuals, *Ephemeroptera-Plecoptera-Trichoptera* richness, and average tolerance value.

Trophic-state is a classification system designed to “rate” rivers and streams based on the amount of biological productivity occurring in the water. To assess the trophic level of each stream, the median stressor concentrations for TP and TN were compared to Dodds’ trophic classification. Based on Dodd’s trophic-state classifications, streams in this study were most often classified as eutrophic based on the distribution of median TP concentrations (44 percent of values), and the distribution of median TN concentrations (56 percent). The biological breakpoints for the median concentrations of TP in this study

were similar to the U.S. Environmental Protection Agency's proposed numeric TP criteria (0.037 mg/L), but the median concentration of TN were about 1.5 times higher than the proposed numeric TN criteria (0.69 mg/L). No sites were impacted adversely using median turbidity values for diatoms based on a 25 Formazin Nephelometric Units (FNU) biological threshold. The turbidity results for the macroinvertebrates were similar to the turbidity results for the diatoms. The breakpoints determined in this study, in addition to Dodds' trophic classifications, were used as multiple lines of evidence to show changes in diatom and macroinvertebrate community and attributes based on exposure to nutrients.

The goal of the study was not to develop numeric nutrient criteria, but to demonstrate the breakpoint analysis approach between nutrient concentrations and some aspects of diatom and macroinvertebrate attributes and metrics. Although the sample size was small, this study found meaningful relations between nutrient concentrations and changes in diatom and macroinvertebrate attributes and metrics in the Pennyroyal Bioregion. With additional biological data (such as chlorophyll *a* and fish), the biological assessment of diatom- and macroinvertebrate communities has a greater potential for success in developing and refining numeric nutrient criteria in the Pennyroyal Bioregion.

GENE EXPRESSION IN ZEBRAFISH (*DANIO RERIO*)
FOLLOWING EXPOSURE TO GASEOUS DIFFUSION PLANT EFFLEUNT
AND EFFLUENT RECEIVING STREAM WATER

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The expression of six genes known to serve as bioindicators of environmental stress were examined using real-time quantitative PCR in liver tissue extracted from zebrafish (*Danio rerio*) exposed to effluent and effluent containing stream water associated with the Paducah Gaseous Diffusion Plant. The PGDP, the only active uranium enrichment facility in the U.S., is located in western Kentucky and discharges treated effluents into several surrounding streams. Environmentally relevant concentrations of several heavy metals and polychlorinated biphenyls (PCBs) can be found in effluents emerging from the plant as well as in receiving streams. Fish were exposed in the laboratory to water from both effluents and downstream areas as well as to water from an upstream reference site. Expression of six genes known to be altered by metal and/or PCB exposure were quantified at both 7 and 14 day time points. Transcription of the biomarker enzyme cytochrome P4501A1 (CYP1A1) was significantly elevated in fish exposed to one plant effluent at both the 7 (16 fold) and 14 (10 fold) day time points. Sediment PCB levels from this site were the highest observed in the study, indicating PCBs may be contributing to the elevated CYP1A1

mRNA. Additionally, catalase, an enzyme responsible for hydrogen peroxide detoxification and known to be impacted by metal contamination, demonstrated significant alterations in expression in the effluent containing the highest concentrations of most metals observed in the study. Interestingly, despite the presence of metal levels consistent with the induction of metallothionein (MT) in other studies, no MT induction was observed. All other stress biomarker encoding genes were likewise unimpacted by effluent water exposure. These results strongly suggest that contaminants observed in this study altered transcription of catalase and CYP1A1 and provide an important link between pollutant levels and physiological effects.

RESTRUCTURING THE KENTUCKY GROUNDWATER DATA REPOSITORY DATABASE

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The Kentucky Groundwater Data Repository maintains groundwater information from over 15 sources, including State and federal agencies and other organizations. The principal contributor, however, continues to be the Kentucky Division of Water. Data uploads from DOW have been provided on a biannual basis since 2005. Each year, a major effort was required to input these data into the totally different framework of the Kentucky Geological Survey database. Recent improvements to the DOW database structure prompted KGS to completely redesign the Repository database to closely resemble that of DOW. This redesign will enable future data uploads to be seamlessly added to the Repository database with minimal interruption to users.

The search engine for the new database allows users to perform a geographical search for water wells and springs by county, 7.5-minute quadrangle, or by using a radius from a specified latitude and longitude. The resulting well or spring data can be viewed on a map or in tabular form, or downloaded to a text file or spreadsheet for use in GIS software. A link is also provided to run a water-quality search on the selected data set. The data vintage is currently through 2008, but an upload is being processed that will include all data for 2009.

The groundwater-quality database, part of the water-well and spring database, has also been restructured. The new water-quality data search engine includes the ability to search for any analyte in the database using a drop-down list. Previously the online search was limited to 38 parameters in five major categories: water properties, volatile organic compounds, inorganic solutes, nutrients and pesticides.

This poster uses Web screen captures to show procedures for searching, downloading, and displaying groundwater-well and spring data on the new search engine: kgs.uky.edu/kgsweb/DataSearching/Water/WaterWellSearch.asp (Fig. 1). For more information on water-well or spring data, contact the Survey at (859) 323-0524.

KGS Kentucky Geological Survey
University Of Kentucky

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[KGS Home](#) > [Search the Spring & Water Well Records Database](#)

Spring & Water Well Records Database

KY Groundwater Data Repository

[send us feedback](#)

Select A Search Method: Search by Quadrangle
Search by County
ADVANCED: Radius Search (lat/long coordinates)
ADVANCED: Radius Search (decimal degree coordinates)
ADVANCED: AKGWA Number Search

Select One or More COUNTIES to search:

ADAIR
ALLEN
ANDERSON
BALLARD
BARREN

hold the "ctrl" key to make multiple selections
clear all selections

use an [INDEX MAP](#) to make selections

☐ Return only wells/springs with water-quality data available.
● [HELP: About Water Quality Analyses Reports](#)
● [Water Quality Standards \(pdf file\)](#)

Search Limit for Water Wells Only:

Driller Last Name: _____ First Name: _____
Driller Certification Number: _____

Owner Last Name: _____ First Name: _____
Owner Business: _____

tip: use a * (asterix) as a wildcard character

☐ ONLY wells constructed within the PAST YEAR of Today (1/12/2010)
☐ Construction Date (enter in mth/day/year format: 06/09/1972): _____

SEARCH FOR WATER DATA (wells or springs):

WATER WELLS SPRINGS RESET

Figure 1. Layout of new water-well and spring search page.

FEASIBILITY OF USING ^{15}N -ENRICHED *E. COLI* AS A BACTERIAL TRACER IN THE CANE RUN/ROYAL SPRING BASIN

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Karst aquifers are an important source of groundwater in Kentucky, supplying water in both rural and urban areas and supplementing surface water in streams. The nature of karst aquifers and the ease with which unfiltered contaminants can enter them make them particularly vulnerable to contamination. A novel tracer method has used ^{15}N to label *Escherichia coli* and closely track the transport of bacteria, a common contaminant, through karst aquifers (J.W. Ward, 2008, PhD dissertation, University of Kentucky). Information on the fate of the ^{15}N label over the lifespan of the bacteria can extend the applicability of the tracing method.

A wild strain of *E. coli* was isolated from the Cane Run basin in the Inner Bluegrass region of Kentucky. Serotyping and virulence testing were performed to identify if the isolated strain had any of the characteristics of commonly pathogenic *E. coli*. Five karst microcosms were filled with sterilized water collected from Royal Spring in Georgetown and incubated at 14°C for 130 days. The wild-type *E. coli* was enriched in ^{15}N and used to inoculate each of the microcosms on day 0. The microcosms were sampled for *E. coli* concentration at days 0, 1, 3, 8, 15, 28, 60, and 130 and the $\delta^{15}\text{N}$ value of *E. coli* cells on days 1, 28, 60, and 130.

The wild-type *E. coli* was serotyped O:H⁻ and was negative for all of the tested virulence factors, indicating that the strain is likely commensal to either humans or animals. The *E. coli* survived for 130 days in sterilized Royal Spring water under simulated karst conditions. The concentration at day 0 was within the standard error of the concentration at day 130 and vice versa. The *E. coli* had a mean starting concentration of 5.62×10^{10} (standard error 4.12×10^9) and a mean ending concentration of 5.88×10^{10} (standard error 7.53×10^9). Statistical modeling showed no significant difference in $\delta^{15}\text{N}$ values from day 1 and day 130. The mean $\delta^{15}\text{N}$ value from day 1 was 834.6 ‰ with a standard error of 17.9 ‰ and the mean $\delta^{15}\text{N}$ value from day 130 was 1023.9 ‰ with a standard error of 55.5 ‰. This strain is therefore recommended for traces in the Cane Run watershed and Royal Spring groundwater basin. Use of this method could provide valuable insight into the movement of bacterial contaminants in the already-contaminated system, which would help improve remediation methods and strategies.

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THE USE OF STABLE ISOTOPE ANALYSIS TO IDENTIFY SOURCES OF
SEDIMENT TRANSPORTED FROM FOUR APPALACHIAN WATERSHEDS IN
SOUTHEASTERN KENTUCKY

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Stable isotope analysis was used to identify sources of soil particulate organic matter (SPOM) spatially in four watersheds with high gradients in the Appalachian region of southeastern Kentucky over a two-month sampling period. The four watersheds varied in the time since coal mining occurred with one watershed having reclamation about 20 years ago, one having reclamation about 5 years ago, one having active coal mining in progress, and one with old growth forest (no mining activities). Sediment sources were characterized and sampled in the four watersheds as the upland surface soils, the streambanks, and the streambed. Weekly samples of transported sediments were collected from the four watershed using *in situ* sediment trap samplers from April 2009 to May 2009 at outlet of each watershed. Streambank, streambed, and surface soil samples were also collected during this period. Bulk sediment-water samples collected from the traps and end-members were prepared in the laboratory to isolate the fine fraction of sediment with particle diameter less than 53 μm and then further prepared and analyzed for their carbon and nitrogen isotopic signatures on the stable isotope ratio mass spectrometer. The stable carbon and nitrogen isotope signatures of the surface soils and

streambanks bracketed the signatures of the streambed and transported sediments, which suggests that the streambed and transported sediments are a mixture of the uplands surface soils and the streambanks. It has been hypothesized that the streambed signature does not solely consist of a mixture upland surface soils and streambank samples, but also includes an enrichment of the signatures due to the benthic growth occurring in-stream. Research is ongoing to quantify the instream benthic processes associated with fine sediment deposition. The methods under further investigation are placing trap samplers to quantify the amount of enrichment over time and gathering bed samples at different points in the deposition's profile. A mass balance un-mixing model was used to calculate the contributions from each source to the transported sediments from each of the four watersheds.

REAL TIME SEDIMENT DISCHARGE ESTIMATES USING A TURBIDITY AND VELOCITY BEND SENSOR NETWORK

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Sediment is one of the major causes of impaired streams in the United States and threatens the ecology of watersheds. Total suspended solids have been difficult to quantify and sensor networks that provide real time data at a frequency high enough to measure sediment discharge have not been practical to implement. New technologies and monitoring techniques need to be developed that are easy to implement and operate. The objective of this study is to develop a sensor network so that a real time monitoring system for velocity and sediment discharge of any watershed can be implemented quickly and in remote locations.

New, real time inexpensive turbidity and velocity bend sensors will be applied. Turbidity sensors measure turbidity and a relationship between turbidity and concentration of total suspended solids (TSS) will be derived for the stream. Turbidity curves must be calibrated for each watershed as different sediment types will yield a different TSS turbidity curve. Velocity bend sensors measure velocity with a variable resistance strip;

the water causes the strip to bend and the resistance to electrical conductivity varies as the strip bends, and a relationship between velocity and resistance is found.

Salamanders are sensor networks designed by Prof. Harnett that are used to perform the research. Each Salamander is made up of a turbidity and velocity bend sensor placed on opposite sides of a pole but at the same height. This paired sensor configuration exists at three height locations on the pole with a pressure transducer at the base to measure depth of flow. This will allow the researcher to obtain vertical velocity and sediment profiles. To accurately represent a cross section's sediment and velocity profiles, many salamanders need to be placed in the cross section. Five Salamanders will be placed in a cross section perpendicular to the flow. One will be in the thalweg and two others will be placed closer to the banks. These three will be used to monitor base flow and also the center of larger events. Two additional salamanders will be placed (one on either bank) to ensure that large flows are adequately measured. The cross section location of salamanders may vary depending on the stream (in the stream which these are to be placed, the width varies significantly with discharge).

The sensor network operates so that each Salamander in the cross section transmits its data via radio signal to a device which will simultaneously log the data for back up and also relay the information to a cell phone located nearby. The cell phone receives data and sends this data to another phone which is linked to a computer in the office. The computer converts the data from binary into velocity, concentration, and depth using the relationships developed for the stream. This information is passed into a program that will use the known channel geometry in conjunction with the height, velocity, and concentrations given by the Salamanders to calculate the sediment discharge. The computer will store the intermediate and end results as well as provide the interface in which the real time data can be viewed.

So far, results of this new technology include relationships developed for new, inexpensive velocity and turbidity sensors. Full implementation of the project is ongoing at this time and includes collaboration between Civil Engineers at UK and Electrical Engineers at U of L. Results are expected to provide accurate data of suspended sediment load derived from the watershed that can be used to calibrate hydrologic and suspended sediment transport models. The sediment monitoring network will be set up at a location where sediment fingerprinting is occurring which will help provide insight into the source of the sediment. By the end of the research period, new techniques will have been developed so that instrumentation can be quickly set up in any watershed to capture the hydrologic and sediment fluxes in real time.

ESTIMATES OF PARTICULATE ORGANIC CARBON FLUX IN VARIOUS LEVELS OF THE WATERSHED SYSTEM

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Substantial levels of carbon are deposited and stored in oceanic sediments through means of organic carbon flux. Particulate organic carbon (POC) is the carbon associated with fine sediments and is differentiated from dissolved organic carbon by the size of the carbon particles. The fate and transport of POC in river systems is an important component of the carbon cycle because on the order of half of the POC transported is buried or mineralized in-stream. POC fate in streams and rivers has proven difficult to quantify at varying watershed scales. Source contributions of organic carbon vary from watershed to watershed. In streams, POC can accumulate from numerous sources such as runoff from fields and forest floors, gully erosion and growth of algae in the river bed. Smaller basins with steep slopes have little to no storage and are heavily impacted by events such as landslides; whereas large watersheds have relatively low slopes in which storage plays a substantial role. The objective of this study was to tie in existing POC flux estimates, obtained from the literature, to new estimates of POC flux from a small watershed in the lowland region of central Kentucky. In addition, a geospatial analysis of the United States was conducted in order to provide approximations for the country's POC flux.

A table summarizing POC flux from different watersheds was developed through review of existing literature. Flux was given for some studies however others needed to be

calculated, with values being reported in $\text{t km}^{-2} \text{ yr}^{-1}$. We found that values typically ranged from 0.5 to $3 \text{ t km}^{-2} \text{ yr}^{-1}$, in agriculture/forested watersheds with mild gradients. Steep gradient, mountainous areas had significantly larger fluxes with values reaching $222 \text{ t km}^{-2} \text{ yr}^{-1}$. POC flux from the lowland region in central Kentucky was modeled using inputs of TOC content found through analysis of *in situ* sediment trap samples, and an in house sediment transport model. The annual POC flux from the watershed was found to be $0.825 \text{ t km}^{-2} \text{ yr}^{-1}$, which was comparable to the watersheds with mild gradients found in the literature. Though flux values from lowland regions are significantly lower than reaches with steep gradients, it is essential to determine their contribution to the carbon cycle because the areas are more abundant. Calculations can be integrated over large areas which in turn determine the POC flux contribution of basins with mild gradients. POC flux was found to vary primarily due to the hydrologic forcing, rather than seasonally, which agrees with research performed in agricultural areas in the Midwest. The sediments are derived from a number of sources including banks, surface erosion, and in-stream storage deposits. An initial estimate of POC generated in storage zones showed that 29% of the carbon is newly generated—showing the importance of benthic processes to the POC load.

Geospatial approximations were conducted using ArcGIS software to estimate POC flux throughout the United States. A sediment concentration map provided by the USGS, and STATSGO soils data provided by the NRCS were used to approximate POC flux. Source to sink values were approximated by the following equation; $POC_{Flux} = (\%SOC) * (ER) * (Sed.Flux)$, where ER is the enrichment ratio, sed flux is the sediment flux for each catchment, and % SOC is the percent of soil organic carbon for the area. This study assumes that soil organic carbon is an adequate representation of eroded material in stream but accounts for SOC derived from different sources, namely, variability is considered should sediment be derived from subsurface or surface erosion. Enrichment ratios were also varied between 1 and 1.3 to account for benthic processes that occur in the streambeds. Results show high variability in POC flux results based on inclusion, or lack thereof, of source and fate processes.

Although the preceding results show high variability when quantifying POC flux from watersheds of different magnitudes, it is important to push this research forward to create a framework that can allow us to estimate POC flux and its contributions from different levels of the watershed system, i.e., from a small sub basin in central Kentucky, to the Mississippi River Basin. Looking forward, the longterm goal is to develop uniformity with respect to calculations of POC flux that incorporate source and fate processes.

STUDY OF PERFORMANCE OF VELOCITY BEND SENSORS IN FLOW OVER GRAVEL BED FLUMES AND RIVERS

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In past research, velocity sensor technology has gained importance for measuring and understanding the mean and turbulent characteristics of river flows. Inexpensive sensors which are reliable and accurate and which can be left in the field to monitor watersheds and understand the spatial variability of flow with time are needed.

The objective of this study was to test the inexpensive Velocity Bend Sensor (VBS) for performance under both field and lab conditions. In order to meet this objective, we determined the following specific goals: (a) Mean velocity was compared for different sensors and different velocity conditions. Comparison was performed between VBS measurements and “modeled” velocity measurements. (b) Turbulence quantities were compared for the lab conditions. Comparison was performed between VBS measurements and acoustic Doppler velocimeter (ADV) measurements at a point in the flow for the same conditions. (c) Mean and turbulence quantities were measured at the same time in the field with VBS, ADV and a propellometer to test the sensors in the field.

Statistical analysis, correlations, spectrum and moving average values of data obtained from both VBS and ADV were compared to identify the ability and accuracy of the VBS in collecting mean and turbulent characteristics of flow. Basic statistical analysis was helpful in identifying the range of error exhibited by the VBS in collecting the data while correlations were useful to compare the time scales and length scales of turbulence as calculated from both VBS and ADV. While the VBS measures only 10% of the turbulence intensity, it was able to capture macroturbulence length scales fairly reliably. Spectrum was useful to identify different amplitudes of velocity, i.e., small scale versus large scale turbulence, present in turbulence flow structure. The values found from both ADV and VBS compared well. The macroturbulent time-scale found from the measurements collected from both the ADV and VBS were calculated and compared using moving average technique. This study showed that the sensors were able to measure the mean and turbulent characteristics of flow reliably. This study thus helps to understand the performance and variability of the VBS to identify and measure mean and turbulent characteristics of flow.

SPATIAL PATTERNS OF NUTRIENT LEACHING IN A CENTRAL KENTUCKY PASTURE UNDERGOING FORAGE RENOVATION

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Endophyte-infected tall fescue (*Festuca arundinaceae*) is a dominant forage grass in the southeastern United States. Efforts are being made to find replacement forages for animal production, but knowledge about such renovation effects on soil structure, associated soil hydraulic characteristics, chemical transport, and pollution potential are limited. This study focused on the potential effect of forage renovation on nutrient leaching. Two tall fescue cultivars differing in endophyte infection status (KY 31 and novel endophyte-free KYFA9301) were planted in 3 m x 160 m-long strips spanning a sinkhole, which represents a typical topographic feature in central Kentucky pastures. A similar strip of the original undisturbed native pasture (a mixture of tall fescue, bluegrass [*Poa pratensis*], and mixed forbs) was also utilized. We analyzed and compared nutrient leaching patterns under each forage type by means of anion and cation exchange resins buried in each strip. Ion exchange resin lysimeters were installed at 50 cm depth along each 160 m transect with a 5 m lag distance between lysimeters to capture nutrient leaching. The resin lysimeters were installed on July 1, 2009 and recovered five months later. The net nutrient fluxes were analyzed in terms of forage variety, spatial structure, and spatial auto correlation. Spatial cross correlations between nutrient fluxes and related soil hydraulic properties such as pore size distribution, saturated hydraulic conductivity, bulk density and mean weighted diameters of soil aggregate were also evaluated.

NOTES

[illegible]

THE EFFECTS OF INVASIVE AMUR HONEYSUCKLE LEAF CONSUMPTION ON GREEN FROG TADPOLES

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Amur Honeysuckle (*Lonicera maackii*) is an invasive Asian shrub that thrives along the edges of aquatic ecosystems in Eastern North America. This shrub is one of the first to leaf out in the spring and one of the last to drop its leaves in the fall. Our previous investigations suggest that allochthonous litter of *L. maackii* decompose faster than native riparian leaf litter, changing the water chemistry and having negative external effects on frog tadpole growth and digestion, survival to metamorphosis, and froglet fitness (Fig 1 and Fig. 2). This raises the question of digestive effects in tadpoles when *L. maackii*

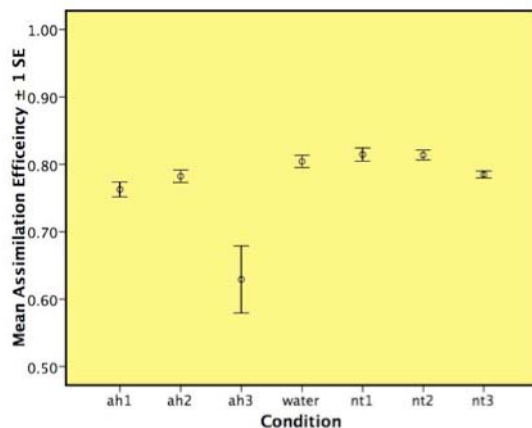


Fig. 1. Energy assimilation by tadpoles raised in Amur honeysuckle (AH) or native (NT) tea under various concentrations (1 – 3 [strongest]).

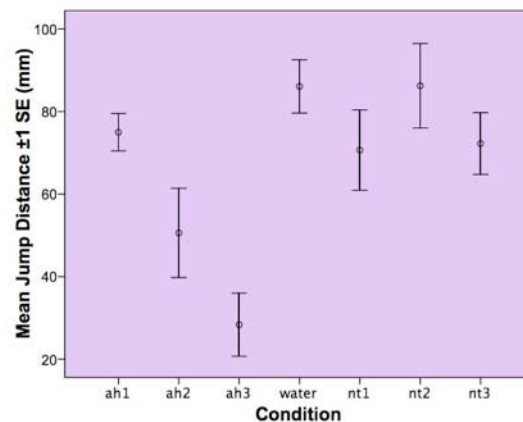


Fig. 2. Fitness (jumping performance) of frog metamorphs raised in Amur honeysuckle (AH) or native (NT) tea under various concentrations (1 – 3 [strongest]).

leaves are a food source. This study investigates the impact on green frog (*Lithobates clamitans*) tadpole digestion of an algae diet mixed with different concentrations of *L. maackii* leaves or native riparian leaves throughout the experiment. The results of each replicate are compared to set of control tadpole replicates that were fed only algae. Feeding experiments were carried out over four weeks, and dried food and fecal output material were used in nutritional analyses. Fig. 3 suggests that energetically, tadpoles consumed significantly more food when it did not contain leaf material and food containing honeysuckle was consumed the least. Assimilation efficiencies were calculated from a variety of laboratory based tests including: caloric content, percent

nitrogen (crude protein) analyses, organic content from ash-free dry mass, and spectroscopic analyses of mineral (Ca^{+2} , Mg^{+2} , Na^{+1} , etc.) depletion. Fig. 4 indicates that the tadpoles extracted the greatest amount of energy from the control diet, and that more of the honeysuckle diet was assimilated than that from native plant leaves. Total and lignated fiber analyses were carried out with the Van Soest method.

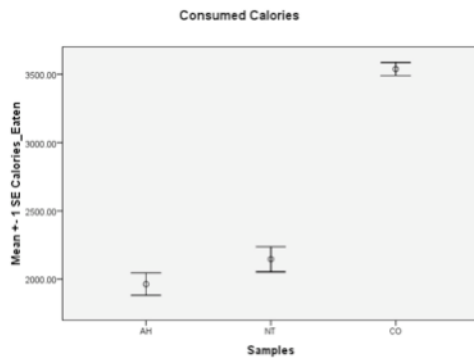


Fig. 3. Caloric content of algae food containing either leaf matter of Amur honeysuckle (AH) or native (NT by tadpoles) plants or lacking leaf matter (control) consumed by tadpoles.

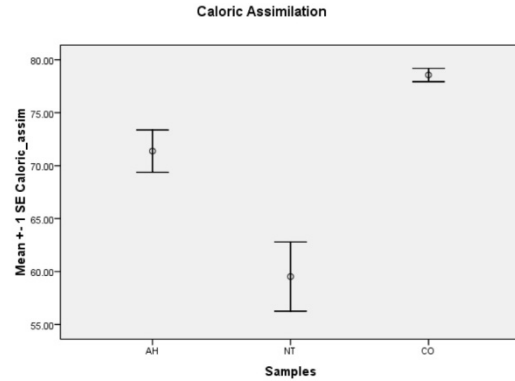


Fig. 4. Calories assimilated by tadpoles that consumed either algae food containing leaf matter of Amur honeysuckle (AH), of native (NT) plants or lacking leaf matter (control).

IMPACT OF THE INVASIVE AMUR HONEYSUCKLE (*LONICERA MAACKII*) ON STAND TRANSPIRATION IN A WETLAND FOREST

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The effect of Amur honeysuckle (*Lonicera maackii*) on water use by a wetland forest near the Ohio River was determined during the summer of 2009. An old-growth stand was compared with a second-growth stand on the St. Anne Wetlands Research and Educational Center in Melbourne, KY. While the old-growth stand had a very sparse shrub canopy, the second-growth stand had a dense cover of Amur honeysuckle. Shrub basal area was more than 5 times greater on the second-growth stand, and >85% was honeysuckle (Table 1).

Basal Area (m ² ha ⁻¹)	Old-Growth	Second-Growth
Trees	20.3	38.7
Shrubs	0.45	2.05
<i>L. maackii</i> (% shrub total)	0.34 (75.5%)	1.76 (85.9%)

Table 1. Tree, shrub and Amur honeysuckle basal area at the old-growth and second growth stands.

Sapflow rates in trees and large shrubs were measured with Granier sapflow probes, while rates in small shrubs were determined with heat balance sensors. Sapwood areas were then used to calculate transpiration rates. Transpiration rates from trees were similar in the two stands (Fig. 1). Shrub transpiration from the old-growth stand was only 1.4% of the tree transpiration (0.9% from honeysuckle), but 6.7% (5.5% from honeysuckle) from the second-growth stand (Fig. 1-2). Shrub transpiration was dominated by *L. maackii* in the second-growth stand (Fig. 2-3). Because of its extended leaf-out period, *L. maackii* continued to transpire late in the fall, when tree and native shrub transpiration has ceased (Fig. 3). Amur honeysuckle transpired the equivalent of ~7 mm of rainfall in the second-growth site over the monitored period, whereas it transpired the equivalent of ~ 1.3 mm in the old-growth site, a greater than 5-fold increase. The additional transpiration caused by *L. maackii* may shorten the lives of ephemeral ponds and streams in wetlands, with adverse impacts on organisms, such as amphibian larvae, that require them.

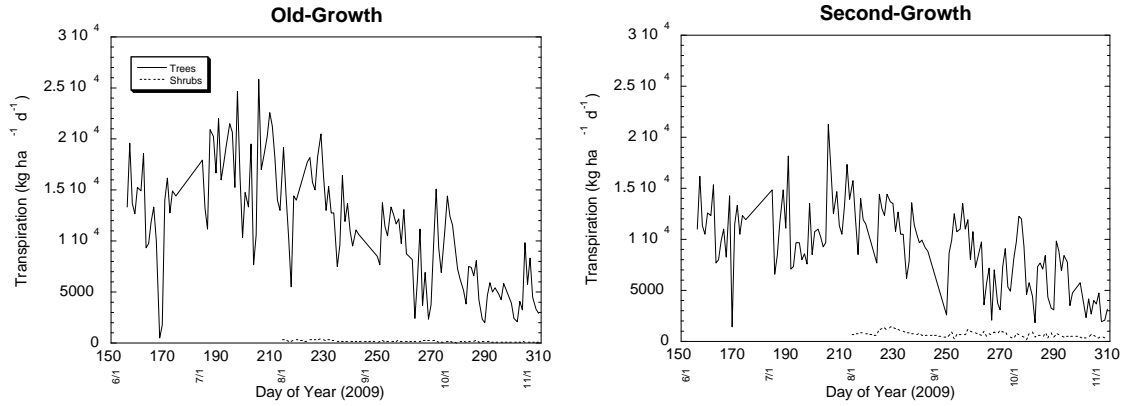


Fig. 1. Transpiration rates for trees and shrubs in each of the two stands. Both day of year and date are shown on the x-axes.

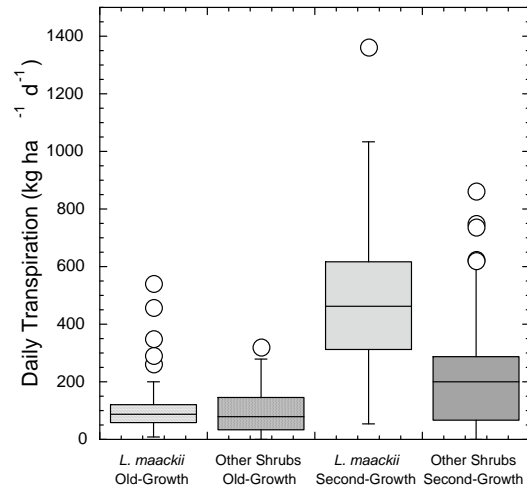


Fig. 2. Boxplots, showing medians and ranges, of daily transpiration rates for *L. maackii* and other shrubs in each of the two stands.

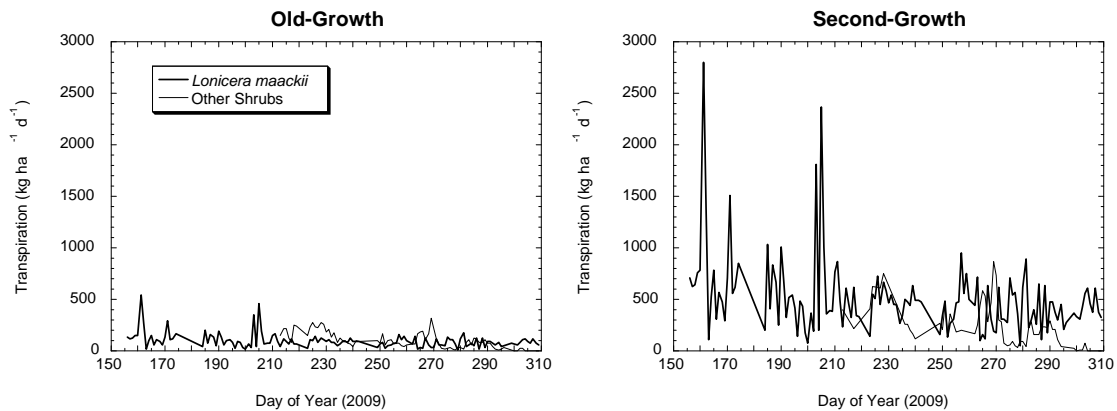


Fig. 3. Transpiration rates for *L. maackii* and other shrubs in each of the two stands.

RELATIONSHIP BETWEEN FECAL COLIFORM AND E COLI VALUES WITHIN THE KENTUCKY RIVER BASIN

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Fecal coliform criteria for primary and secondary contact recreation were first proposed by the federal government by the National Technical Advisory Committee in 1968. Potential deficiencies of using fecal coliform as a pathogen indicator organism were later identified by a National Academy of Science Report in 1972. Despite, these deficiencies, EPA standardized the adoption of fecal coliform for use as an indicator organism in 1976. Finally, in 1986, EPA published recommendations for a shift from using fecal coliform to a more specific coliform species (i.e. E coli) in 1986. In subsequent years, various states have begun the process of transitioning from using fecal coliform to E coli. Kentucky is one of those states. Currently, water quality criteria for primary and secondary recreation include both species. However, a significant amount of the legacy bacteriological data collected in the state have been fecal coliforms. Indeed, in some cases, fecal coliforms continued to be used. Given that fact, it would be beneficial to have some way to relate fecal counts to “equivalent” E coli counts. Several states, including Ohio, Virginia, and Oregon have attempted to develop such relationships. One thing that has come out of these efforts is the realization that such relationships tend to be regionally or even locally dependent. This poster will summarize efforts to develop such a relationship for the Kentucky River Basin using water quality samples collected over the last ten years by Kentucky River Watershed Watch. The resulting relationship may be used to estimate possible equivalent values for the purposes of extending existing fecal coliform data sets, or extrapolating backward to obtain extended series of E coli values.

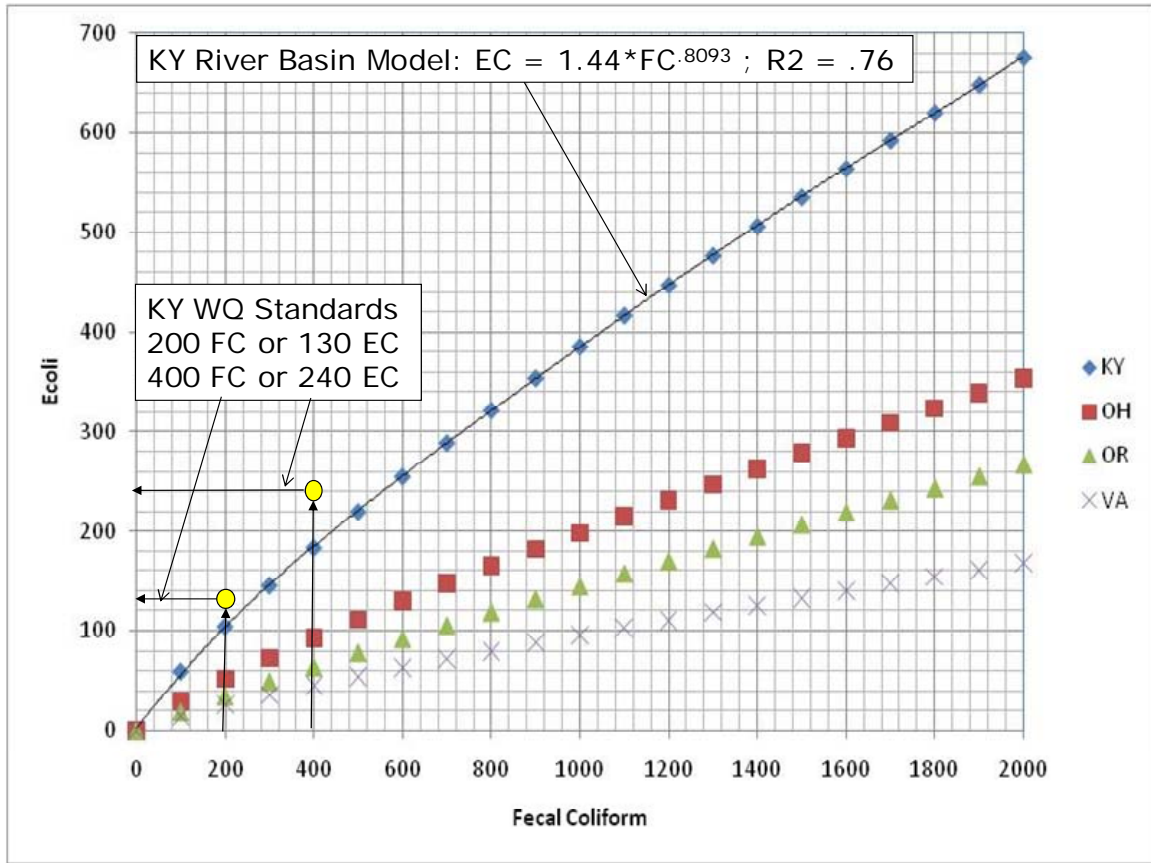


Figure 1. Relationship Between Fecal Coliform and E coli in the Kentucky River Basin

TEN MILE CREEK WATERSHED BASED PLAN

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This project addresses illegal point source issues (i.e. straight pipes and failing septic systems) within the Ten Mile Creek subwatershed of Eagle Creek, the majority of which is located within Grant County. Ten Mile Creek is a fifth order stream that joins with Eagle Creek near the town of Folsom. Arnolds Creek is a major tributary of Ten Mile Creek that enters near the stream mouth. Independent sampling results from the TMDL development process and from Kentucky River Watershed Watch volunteer sampling suggest that these tributaries are contributing to the overall pathogen contamination of Eagle Creek.

This poster will provide an overview of water quality sampling, watershed plan development, and best management practice (BMP) development and implementation associated with 319 funded activities in the watershed from 2004-2009. Specific activities conducted in the watershed have included: a grant incentive program to upgrade problem onsite wastewater systems (including straight pipes); public education encouraging agricultural and construction of BMPs; water quality education efforts in communities and local schools; and community efforts to increase the appreciation of the recreational and aesthetic value of the Eagle Creek Basin. Onsite wastewater system upgrades were begun in May 2006 and concluded in August 2008, with 85% of the work being done by the end of 2007.

A split sample statistical analysis of pre and post sampling (2004-2006 versus 2007-2009) reveals improvement of water quality conditions at all monitored stations, with the majority of stations showing a statistical level of confidence in excess of 90%.

Table 1. Water Quality Regarding Fecal Coliform Bacteria.

Sampling station	Total number of samples (2004-2006)	Number of samples with fecal coliform counts > 400 cfu/100 ml (2004-2006)	Percent violations (2004 - 2006)	Total number of samples (2007-2009)	Number of samples with fecal coliform counts > 400 cfu/100 ml (2007-2009)	Percent violations (2007 - 2009)
K318	34	7	21%	35	3	9%
K319	35	8	23%	36	5	14%
K321	34	8	24%	36	7	19%
K327	35	8	23%	36	6	17%
K328	32	8	25%	36	5	14%

Table 2. Probability of Improvement Fecal Coliform Values for Sampling Stations.

Sampling station	Mean of ln transformed data		t test results at a 95% Confidence Level	Actual Confidence Level
	(2004-2006)	(2007-2009)		
K318	4.717	4.034	Barely Fails 95% ($t < 1.67$)	94.1%
K319	4.930	4.658	Fails 95% ($t < 1.67$)	71.3%
K321	4.968	4.434	Fails 95% ($t < 1.67$)	86.5%
K327	5.102	4.231	Meets 97.5% ($t > 2.00$)	97.5%
K328	5.121	4.330	Meets 95% ($t > 1.67$)	95.8%

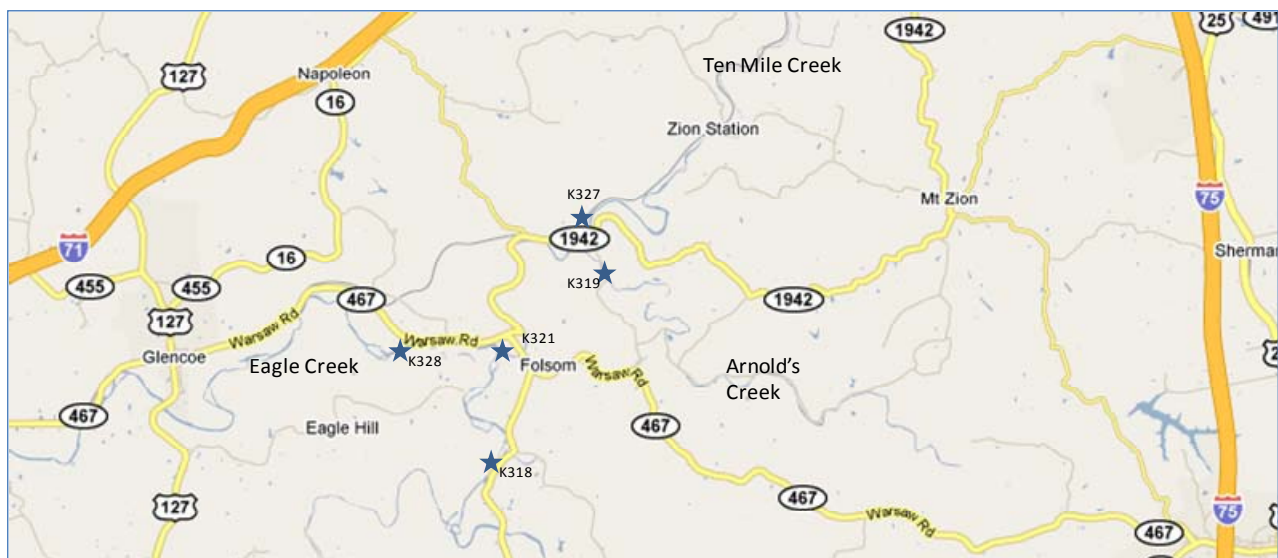


Figure 1. Location of Sampling Sites

PATHOGEN TMDL FOR SOUTH ELKHORN WATERSHED

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This poster summarizes activities associated with the development of a fecal coliform Total Maximum Daily Load (TMDL) for South Elkhorn Creek. The South Elkhorn Creek watershed is contained within Fayette, Franklin, Jessamine, Scott, and Woodford Counties, in central Kentucky. The watershed receives drainage from the Town Branch subwatershed, the Wolf Run subwatershed, and the Steeles Run subwatershed, all of which drain highly urbanized areas of Lexington, Kentucky, in Fayette County. The watershed also contains the city of Midway in the Lee Branch subwatershed located in the northeast corner of Woodford County.

The Kentucky Division of Water's 2008 303(d) list of waters for Kentucky indicates that the South Elkhorn Creek watershed does not support Primary Contact Recreation use due to fecal coliforms. The streams include South Elkhorn Creek (river mile (RM) 16.6 to 34.5), Town Branch (RM 0.0 to 9.2, and RM 9.2 to 10.6), and Wolf Run (RM 0.0 to 4.1). Additional sampling as part of the development of this TMDL has documented impairment with additional stream miles within the larger South Elkhorn watershed (see Figure 1).

In order to assess the sources and associated fecal coliform loadings in the South Elkhorn Creek watershed, an HSPF computer model of the watershed was developed subdividing the watershed into 45 catchments. The US EPA Bacterial Indicator Tool (BIT) was used to determine the initial loading conditions in the watershed. Loads were allocated between both permitted and non-permitted sources. Permitted sources included KPDES point sources (e.g. wastewater treatment plants) and municipal separate storm sewer system (MS4) nonpoint sources (e.g. stormwater runoff). Non-permitted sources included non-MS4 nonpoint sources and illegal point sources (e.g. straight pipes, sanitary sewer overflows, and failing onsite wastewater treatment systems). Once the initial loads were developed and the model calibrated, HSPF was used to simulate the effect of incremental load reductions on water quality until all water quality criteria were satisfied.

Loads were divided between a wasteload allocation, a load allocation, and a margin of safety. The wasteload allocation included KPDES point sources and MS4 sources from developed lands. The load allocation included MS4 sources from non-developed lands, and non-MS4 sources (including both developed and non-developed sources). All illegal sources were assumed to be eliminated. A margin of safety was enforced through the adoption of conservative modeling assumptions. The difference between the allowable load and the initial conditions is the reduction required. Wastewater Treatment Plants receive no percent reduction in this TMDL report, as their permit limits are already set at the water quality criterion.

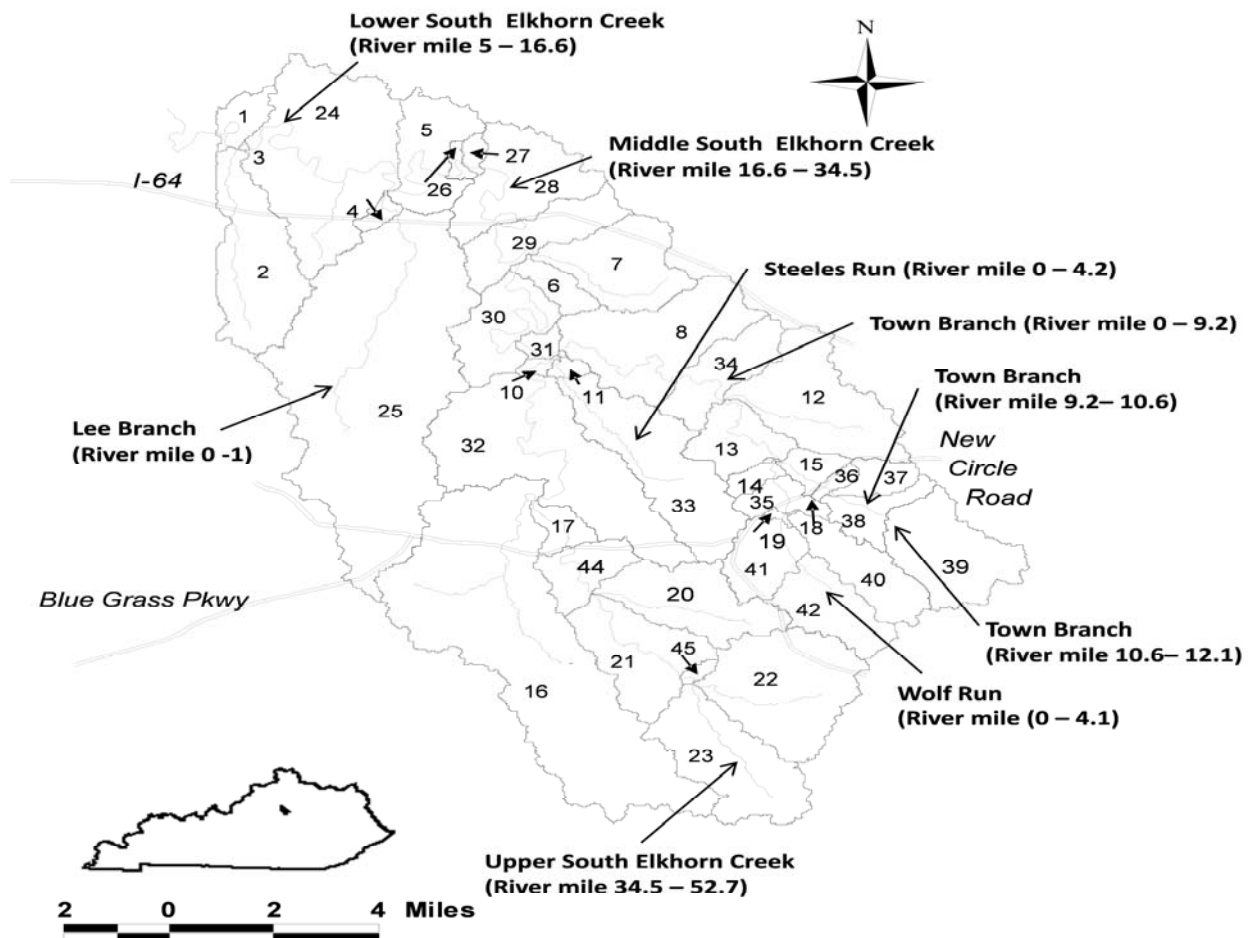


Figure 1. Map of South Elkhorn Watershed with Subbasins and Impaired Stream Segments