Kentucky Water Resources Annual Symposium

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The Cane Run Watershed is an important water resource because it supplies the major source of drinking water for the city of Georgetown, KY. Segments of the watershed have been identified as having high levels of sedimentation/siltation, pathogens, and nutrient/organic enrichment resulting in the stream being placed on KY’s 303(d) list. Nonpoint sources of pollution for Cane Run Creek and the Royal Spring aquifer include both agricultural and non-agricultural sources. Efforts have been focused on the upper Cane Run watershed (15,000 acres), which is the recharge zone for the Royal Spring Aquifer and the city of Georgetown, KY. The watershed includes a portion of the city of Lexington and the Kentucky Horse Park, which is preparing to host the 2010 World Equestrian Games. A phased project was designed to take advantage of the enthusiasm for the watershed and expedite its cleanup. This phased project will take advantage of EPA 319(h) funds to complete a watershed based plan (WBP) and initial implementation. Phase I of the Cane Run Project is the development and approval of a watershed based plan with some initial implementation. Phase II of the Cane Run Project is the continued implementation of the watershed based plan. An educational and outreach strategy has been designed to increase awareness and educate residents, visitors, and businesses regarding their impact on the watershed and how they can participate in the restoration efforts.

Enthusiasm for the project is shown by the scale of cooperators that have been assembled from federal, state, and local governments and private landowners. These cooperators have a vested interest in the watershed and considering their influence on the stream, create a high probability of success.
The Center for Water Resource Studies (CWRS) at Western Kentucky University (WKU) has established the Kentucky Institute for Watershed Management Support (KIWMS) for the purpose of providing regional planning support to communities throughout the Commonwealth in order to maintain the natural and economic resources of their watersheds. The CWRS operates the WKU Technical Assistance Center for Water Quality, currently one of eight university-housed technical assistance centers for small drinking water systems, part of the US EPA's capacity development initiative, as well as the Kentucky Center for Wastewater Research, a similar capacity development initiative aimed at wastewater system support. The CWRS is also a founding partner of the Kentucky Collaborative for Combined Sewer Overflow Management, a public-private sector partnership aimed at providing technical assistance to small communities trying to address Combined Sewer Overflow problems in the Commonwealth of Kentucky.

The CWRS expanded its scope of services, leveraging on existing expertise as a water, wastewater, utility and municipal technical assistance provider, to assist communities with realizing the fundamental goal of holistic watershed management. The vision is for KIWMS to leverage synergy between local, state and other resource agencies at a watershed level by providing infrastructure and support for accountability and the technical basis to ensure measurable results.

Regulatory instruments exist for improving water quality on a watershed basis for redress and rehabilitation in the case of pathogen impaired streams. For streams impacted by runoff from agricultural operations, Kentucky’s Agricultural Water Quality Act provides operational standards and a means for enforcement to ensure the protection of the Commonwealth’s waters. Water quality impacts from failed septic systems can be mitigated by enforcement of performance standards by local public health departments. Kentucky’s Watershed Management Framework favors local engagement and implementation over regulatory enforcement for meeting water quality goals. Success of this approach is dependent on access and engagement of technical, financial and managerial capacity development programs in a similar fashion as those existing for drinking water and wastewater infrastructure. KIWMS will engage stakeholders at the local and regional level in a collaborative problem solving process to develop sustainable and technically sound solutions for pervasive failures in onsite wastewater systems that
potentially contribute to the pathogen impairment of local streams and limit economic growth.

KIWMS will connect local communities with regional planning entities to achieve local change that positively impacts watershed health. A key strategy in the community-specific implementation of the KIWMS is a public education campaign. KIWMS will promote strategies for wastewater minimization for both residential and commercial establishments. KIWMS will also provide *Technical, Financial and Managerial* assistance to develop and implement functional and extensible wastewater management alternatives for communities throughout Kentucky to improve watershed health and promote economic development. This assistance will be provided through detailed situation assessments, technology demonstrations, public education, and technical, managerial and financial alternatives. The techniques developed and resources accessed to further wastewater minimization strategies will be transferable to other project areas.

As an impartial entity, KIWMS will act at the interface between federal, state and local government, private sector organizations, funding agencies and local stakeholder groups with the ability to expend effort and resources on critical activities that do not fit neatly within the other organizations' missions. The proposed KIWMS will provide scientific expertise to local Area Development Districts and local stakeholder groups using CWRS resources and through coordination with universities and community/technical colleges serving the region.
In 2003, US EPA issued its *Nonpoint Source Program and Grants Guidelines for States and Territories*, which contained new requirements for projects funded under Section 319 of the Clean Water Act. Specifically, the agency directed that projects be based on watershed management plans that contained nine key elements, including several related to quantifying watershed problems and the management measures proposed for dealing with them.

The federal guidelines and the 2006 handbook for developing watershed plans issued by US EPA contained broad-based information for national audiences. The Kentucky Waterways Alliance, with support from the Kentucky Division of Water, University of Kentucky, and other partners, summarized and focused these materials for Kentucky watershed groups via the 2008 *Watershed Planning Guidebook for Kentucky Communities*. The Guidebook, which is now available in draft form, walks users through a step-by-step process for assessing and characterizing the watershed, identifying relevant water quality standards and other goals, defining stressors impacting water quality and their sources, developing management practices to deal with identified problems, and forging an implementation plan. As the planning process proceeds, completed parts are documented in the Kentucky Watershed Plan Outline in Appendix A.

The rationale for developing watershed plans goes back several decades. Historically, efforts to improve water quality have been implemented on a piecemeal basis and did not examine watersheds as a whole, often creating situations where funds were used without planning. Restoration of water quality was a priority while protection was neglected; certain pollutants were addressed without considering the overall health of the watershed. Since the late 1980s, community organizations, tribes, and federal and state agencies have moved toward managing water quality by using a watershed approach. A *watershed approach* is a flexible framework for managing water resource quality and quantity within specified drainage areas or *watersheds*. This approach involves stakeholders and emphasizes the use of management practices supported by science and technology. The watershed approach to planning uses a series of cooperative, iterative steps to characterize existing conditions, identify and prioritize problems, define objectives, develop protection or remediation strategies, and implement and adapt selected actions as necessary. The outcomes of this process are documented in a watershed plan. A *watershed plan* is a strategy that provides assessment and management information for a geographically defined watershed, including the analyses, actions, participants, and resources for developing and implementing the plan.
While watershed plans should use traditional Best Management Practices (BMPs) to address water quality issues, equally as important will be plans’ efforts to use creative planning to build on available programs and resources. These strategies could include ensuring that Agriculture Water Quality Plans have been developed and implemented, revising local ordinances, developing local programs and local capacity to address water pollution issues, understanding stream dynamics and the affects of stream sediments on

The Guidebook is organized into five chapters that represent phases in the watershed planning process. As a watershed group completes a chapter, the coordinator should document the results in the Kentucky Watershed Plan Outline.

The planning steps outlined in the document are: Chapter 1—Get organized—helps users identify who should be involved in the planning process and get them involved. As the group organizes itself, it will identify the community's concerns about the waterway and choose some preliminary goals for addressing them. Chapter 2—Look around—helps the group define the boundaries of the watershed as part of a larger system and to understand the information that is available about it. There will likely be gaps in knowledge about the existing water quality in the watershed, which is the basis for the watershed management plan and measuring its progress. This step may cause users to include strategies to get more information for the plan. Chapter 3—Analyze this—helps the group analyze and compare data about the waterway and watershed to help identify the waterway's problems through objective and scientific methods. Chapter 4—Get your act together—helps the group choose how best to achieve the watershed plan’s goals. Users identify effective best management practices and integrate them into the watershed plan. This chapter also discusses funding and outreach. Chapter 5—Check it out—helps the group track the plan as it unfolds through water quality monitoring, progress reports, and program evaluation.

The processes of watershed assessment, planning, and management are iterative; they develop over time based on the experience of implementation. Targeted actions might not result in complete success during the first or second cycle. It is expected, however, that through adjustments made during the management cycles, water quality improvements can be documented and continuous progress toward attaining water quality standards can be achieved.
COMMUNITY BASED SCIENCE
WATER QUALITY AND NONPOINT SOURCE POLLUTION

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Since 2003 the staff of the Tracy Farmer Center for the Environment (TFCE) has conducted year long community based science education projects. The staff works closely with teachers and students to enhance learning through content based education projects. This year students and their teachers in the Cane Run Watershed are investigating water quality issues. They are working alongside researchers from the University of Kentucky, the University of Louisville, KDFWR and their community. They are working to explore water issues and collect data while improving their science content knowledge, science process skills, and understanding of the nature of science. The focus is on understanding how activities within their watershed impact water quality.

Teachers, along with the TFCE staff develop an instructional plan (see following page) consisting of learning modules that allow students to study their essential question. The learning modules are designed to help students understand and research their essential question. Additionally, students take part in lessons and discussions on the Nature of Science and Science Communication. The focus is on uncovering the basics of science by breaking down stereotypes and misconceptions. Exercises illuminate the difference between inference and observation, allude to the accessibility of science, and stress the importance of asking/researching an essential question.

Students begin with an orientation of their watershed. Experts are brought in to speak with the students about different aspects of water quality and are guided in designing their research and conducting their investigation.

Their investigations are centered in their community. Field studies are then carried out by the students. They are taught how to conduct water quality assessments, habitat surveys, chemical tests (i.e. pH, dissolved oxygen), check water temperature, record conductivity,
and collect indicator species. Students also take part in researching the relationship of water quality and wastewater treatment plants in the field. Students make use of GPS technology and draw from information sources such as the Kentucky Waterwatch.

The students organize their findings and then present their research to various groups including the KSTA and UK.

**2007-08 Instructional Plan – Water Quality**

**Module 1**  The Nature of Science  
Classroom Activity: the whole picture

**Module 2**  Introduction to Watersheds  
Classroom/Field Activity: background research, understanding the project

**Module 3**  Introduction to Species/ Data Collection  
Classroom/Field Activity: species collection, water quality indicator species

**Module 4**  Data Analysis, Post Creek Discussion  
Classroom Activity: Bioindicators, data analysis

**Module 5**  Species-Species/Species-Environment Interdependency  
Classroom Activity: species interactions

**Module 6**  Community Water Quality Impact  
Classroom Activity: Guest Speaker

**Module 7**  Mapping Watersheds  
Classroom/Laboratory/Field Activity: GPS, GIS, mapping

**Module 8**  Watershed Connections  
Classroom Activity: Guest Speaker, water avenues

**Module 9**  Home Impacts on Water Quality  
Classroom Activity: Guest Speaker, Bluegrass Pride

**Module 10**  Implementation  
Classroom/Field Activity: present ideas for projects implementation
A STORMWATER EDUCATION PROGRAM TO ASSIST
KENTUCKY’S MS4 PHASE II COMMUNITIES

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The National Pollutant Discharge Elimination System (NPDES) small Municipal Separate Storm Sewer System (sMS4) Phase II stormwater quality permit program, established by the US EPA as part of the Clean Water Act, is administered in Kentucky by the KY Division of Water. The Phase I stormwater permit program regulates communities with a population of 100,000 or more. Communities within an urbanized area with a population of 10,000 -100,000 are regulated by the Phase II permit program.

The Kentucky Transportation Cabinet (KYTC), along with 100 communities throughout Kentucky, has been required to participate in the MS4 Phase II permit program since 2003. The requirements of the Phase II MS4 program include public education, public involvement, illicit discharge detection and elimination, construction site stormwater runoff control, post construction management, and pollution prevention/good housekeeping.

In 2007, the KYTC, in collaboration with the Kentucky Environmental Education Council (KEEC), designed and implemented a stormwater education program as a means to expand the public education and public involvement portions of the Phase II, MS4 program. As part of this project, two stormwater educators were hired to assist the Phase II communities with their public education and public involvement efforts.

After meeting with the Phase II communities to discuss their needs and priorities, the educators are developing educational toolkits and a website that contain effective stormwater education resources and strategies tailored to the needs of these communities. The toolkits and website include resources that are relevant to the EPA-identified audiences that the Phase II communities are responsible for addressing through their public education and public involvement program. These audiences include elected officials, city and county employees, business and industry, nongovernment organizations, schools, citizens, and volunteers and partners. In addition to providing the communities with resources, workshops are being designed to train the community MS4 operators to use the outreach resources and strategies effectively.

Examples of resources to be provided to the communities include school curriculum aligned with Kentucky Education Standards, samples of press releases, news articles,
public service announcements, slogans and storm drain stencils, educational videos and DVDs, and powerpoint training presentations. A telephone survey designed to measure public knowledge, attitudes and behavior (with respect to stormwater issues) among the general public in the Phase II MS4 communities will be conducted this spring, prior to the second 5-year permit cycle. The results of this survey will be used by the communities to set benchmarks and to monitor the ongoing effectiveness of resources and strategies they are using.

This session will include an overview of the KYTC and KEEC MS4 Phase II stormwater education program, a demonstration of the website and a sample of toolkits, and recommendations for ways that community organizations can partner with the MS4 Phase II communities to educate the public about stormwater issues and involve the public in the resolution of stormwater issues.
WATER/WASTEWATER TECHNICIAN TRAINING INSTITUTE: 
A HOLISTIC APPROACH TO DEVELOPING A PROFESSIONAL WATER AND 
WASTEWATER WORKFORCE

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The Center for Water Resource Studies and the Bowling Green Community College of 
Western Kentucky University has formed a partnership to address a Water & Wastewater 
Operator/Technician shortage anticipated over the next few years as "Baby Boomers" 
retire. The Water and Wastewater Technician Training Institute (WTTI, pronounced 
"witty"), is a partnership with the employment sector (a growing number of water & 
wastewater utilities/municipalities/districts), state primacy agencies and technical 
assistance/trade associations to refine an industry needs driven curriculum that utilizes 
on-line course delivery to provide options for both traditional & non-traditional students.

The partnership is revitalizing an existing Associates Degree program entitled “Water 
Utilities Management" and integrating 4-year transitions through formal articulation 
agreements. WTTI takes a pedagogical approach to elevating and transforming the water 
and wastewater operator positions from trades of last resort, to professions of choice, and 
integrates practitioners into the recruitment, retention and educational process to achieve 
a coupled education, training and capacity development environment. A gradual and 
strategic elevation of the perception, both internal and external, of the trades, through a 
combination of increased capacity, mobility and accountability will attract high school 
students whose interests and scholarly record fall between the traditional trades/vocations 
and academically-based professions, and through inappropriate choices limit their career 
advancement potential, and elevate skill levels in the critical environmental and public 
health functions of the water and wastewater utility sector.

In order to limit the hurdles associated with integrating regulatory, trade association and 
academic principles into a single, functional, coherent framework, WTTI is initially 
focused on Kentucky and Tennessee. However, as a demonstrably functional framework 
is put in place, extrapolating to address other regional policy, academic discipline and 
industrial sector issues becomes a logistical rather than conceptual challenge. Partnering 
utilities and municipalities are developing internship and co-operative educational 
opportunities to ensure work-based experiences for students in the program, while the 
trade associations have committed to developing scholarship programs to lessen the 
financial disincentive for potential students.
Academic content is provided by core university faculty, while practitioner oriented content will be provided by qualified trade association and utility/municipality staff eligible for adjunct faculty status. Committed to the precept of open-knowledge, WTTI is extending and coupling an open-source hybrid practitioner cyber-collaboratory (based on Drupal) with an open-source course management system (Moodle) to integrate the learning environment with practitioners and enhance retention of both students and the retiring practitioner knowledge-base. All instructors (academic and practitioner) involved in the program will undergo collaborative professional development to ensure that they are receptive to the unique structure of the program. All aspects of the program will be available through this on-line environment, allowing current practitioners to participate both as mentors, and as students pursuing career advancement goals. Experiential components of the program include on-line virtual activities, as well as opportunities provided by partnering utilities and municipalities local to the student.
Continued rural residential and suburban growth across Kentucky may threaten the environment, resources, and natural beauty of an area. Well-planned development requires an understanding of the physical environment in which we live. Taxpayers and homeowners bear the cost of poor development decisions that result from inadequate technical input.

The Kentucky Geological Survey has developed a series of maps that show in a non-technical way how the rocks beneath our feet shape the land and affect our activities. The maps were designed for homeowners, developers, policy-makers, planners, educators, students, and the general public.

Generalized geologic maps for land-use planning at scales of 1:48,000 or 1:63,360 have been completed for each of Kentucky’s 120 counties. The maps highlight geologic limitations on excavation and foundations; suitability for on-site wastewater treatment systems; underground utilities; residential, commercial, industrial, and recreational developments; highway and street development; and pond and reservoir construction. Diagrams and photos of sites in the county are used to illustrate local issues: landslide hazards and slope stability, shrinking and swelling shales, radon, drainage and flooding problems, karst hazards, natural resources, and development pressures. Photos are used to illustrate the underlying rocks and their relationship to the terrain, land use, and economy of an area. Links to additional information for each county are given. The maps are available as PDF files at kgsweb.uky.edu/download/geology/landuse/lumaps.htm.

The Maps-to-Teachers initiative at KGS provides free, laminated county geologic maps to earth science educators across the state. In early 2008, 195 maps had been sent to teachers in 73 counties.

The “Geohazards in Kentucky” map summarizes the county map series with photos and diagrams illustrating the geologic hazards in different regions of Kentucky.

The “Kentucky Terrain” map uses photos to show the dominant underlying rocks in each of Kentucky’s physiographic regions, the terrain associated with those rocks, and how the rocks create scenic beauty and shape land use, economic and recreational activities.

All map products are available as PDF files on the KGS Web site: www.uky.edu/kgs.
A 3-D COMPUTATIONAL FLUID DYNAMICS CODE
FOR SIMULATION OF PUMP STATIONS WITH
VERTICAL PLUNGING JET AND AIR BUBBLE TRANSPORT

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Abstract

Pump stations with plunging jets are traditionally tested using scaled models. Scaled models are expensive to construct and time consuming to test. The use of computer aided modeling, better known as computational fluid dynamics (CFD) is another approach to study such problem. Commercial CFD packages can be used to solve for the hydrodynamics and turbulence in a pump station, but lack the capability to model air bubble transport from plunging jets. This work attempts to tie together the modeling of hydrodynamics and air bubble transport from a plunging jet.

This study was performed based on the use of CFD to model air bubble transport of a plunging jet, normally seen in pump stations. A finite volume numerical based solver was used along with the dynamic subgrid scale model to simulate the hydrodynamics and turbulence. Effects of the air bubbles drag force to the flow field due to its upward motion was integrated into the source terms of the Navier-Stokes equations. A modified transport equation was used to track the migration of air bubbles from the plunging jet. The modification involves coupling the rising velocity of the air bubbles with the local velocities in the flow field.

Preliminary results from this work will be presented and compared to published data. For applications such as pump station modeling, where microscopic details of the air bubbles are unnecessary, this approach may be a cheaper alternative for air entrainment modeling and associated applications.
CHEMICAL EVOLUTION OF GROUNDWATER IN THE WILCOX AQUIFER OF THE MISSISSIPPI EMBAYMENT

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We are integrating solute analyses and numerical modeling to evaluate groundwater residence time and chemical evolution within the confined Wilcox aquifer of the northern Gulf Coastal Plain. This study focuses on a broad regional flow path extending ~ 325 km from the subcrop of the Wilcox Group in southeastern Missouri to the farthest downgradient municipal wells in eastern Arkansas. We sampled 21 wells in the Wilcox aquifer, six wells in the overlying Claiborne aquifer, and one well in the underlying McNairy-Nacatoch aquifer, with depths ranging from 116 to 518 m. Along the regional flow path, we observed increases in temperature (consistent with increasing depth), pH, and CH₄; decreases in Mn and SO₄²⁻; a prevalence of Fe (18 wells > 0.3 mg/L); and a lack of O₂ (27 wells ≤ 1.0 mg/L) and NO₃⁻ (undetectable in 23 wells). Ca²⁺ concentrations gradually decreased as Na⁺ increased. We infer that upgradient calcite dissolution, downgradient cation exchange, redox reactions, and (possibly) cross-formational mixing control solute chemistry. Values of δ²H and δ¹⁸O (-42 to -28‰ and -6.8 to -5.1‰, respectively, relative to the V-SMOW standard) fall along a regional meteoric water line (MWL) for Paducah, Kentucky, and are slightly enriched with respect to the global MWL. There are two distinct, gradual enrichments in these stable isotopes along the flow path. One plausible explanation for the north-south increase in values is increasing proximity to the moisture source area (the Gulf of Mexico). A second, but not exclusive, explanation is depletion of the isotopic composition of recharge over time. Use of ³⁶Cl and temperature in numerical models of groundwater flow coupled to solute transport and heat flow will test the aforementioned explanations.
Non-point source sediment pollution of fine sediments (silt- and clay-sized particles or aggregates) threatens the continued health and vitality of surface waters in Kentucky. In order to address these concerns, sediment transport studies at the watershed scale aim to identify principal sediment sources for affected rivers and streams in order to develop watershed optimization techniques. Sediment fingerprinting is one such method to identify sediment source and estimate the contribution of each source to the total sediment loading.

In the past, sediment fingerprinting has utilized primarily inorganic tracers of sediment due to their conservative nature. More recently, sediment fingerprinting studies have explored using indicators of sediment organic matter (SOM) including total organic carbon (TOC) elemental percentage, total nitrogen (TN) elemental percentage, stable carbon and nitrogen isotopes ($\delta^{13}C$ and $\delta^{15}N$), and the carbon to nitrogen atomic ratio (C/N) as natural sediment tracers to study fine sediment transport processes. If well understood, these tracers can provide information regarding not only sediment source but also sediment erosion and transport processes. TOC, TN, C/N, $\delta^{13}C$, and $\delta^{15}N$ have been shown to be conservative in small watersheds over short periods of time. However, SOM stored in-stream can undergo degradation via biological processing of the organic matter due to the active microbial community thereby causing the tracers to be non-conservative over larger spatial and temporal scales. This degradation limits the use of organic tracers because SOM decay is not well understood due to the limited information available regarding the in-stream microbial pools. Ecological variables affecting microbial processing include water temperature, algal biomass, water chemistry (pH), oxygen and
nutrient concentrations, and turbidity. In the context of sediment transport studies, these variables are further complicated by varying watershed parameters (e.g. climate, geology, topography, and land-use) and multiple upland erosion sources.

The objective of this study was to investigate the microbial degradation of TOC, TN, C/N, $\delta^{13}$C, and $\delta^{15}$N in a large watershed with in-stream sediment storage by isolating ecological variables affecting microbial processing of organic matter in-stream. To accomplish this, a watershed was carefully selected that exhibits one primary sediment source and limits the impact of watershed parameters on sediment transport processes. The study site chosen is a headwater reach of the South Elkhorn Watershed near Lexington, Kentucky. The primary erosion source within the watershed is streambank erosion, and in-stream sediment storage is common. Suspended sediment samples and erosion source samples were collected at multiple sites over a nine-month sampling routine to represent the tracer distribution in the watershed both spatially and temporally. All samples were analyzed for TOC, TN, C/N, $\delta^{13}$C, and $\delta^{15}$N using an elemental analyzer and an isotope ratio mass spectrometer. In addition, microscopy techniques were utilized to study physical aggregate characteristics and the influence of algal biomass on tracer variation. Sediment load and flowrate were also measured.

Results of the study showed distinct seasonal variations for SOM reflective primarily of seasonal effects on microbial processing. TOC and TN values are lower in the warmer summer months as compared to the cooler spring months, and $\delta^{13}$C and $\delta^{15}$N are enriched for the summer as compared to the spring. Both of these trends indicate decomposition of SOM within sediment storage zones in-stream during the summer months when microbial activity is higher. Spatial and hydrologic trends are not as prominent, indicating a successful isolation of microbial processing of SOM as opposed to watershed parameters dictating SOM tracer signature.

In addition, a suspended sediment source and fate un-mixing model is being developed to further study organic decomposition of SOM within in-stream storage zones. The un-mixing model will estimate the erosion rates of streambank sediment and will be complemented with shear and settling parameters for sediment stored in-stream. A better understanding of the linkage between sediment residence time in stream and SOM degradation will improve watershed-scale sediment transport studies by providing a correction factor for organic degradation when utilizing SOM properties as tracers in sediment fingerprinting studies.
One of the primary concerns associated with timber harvesting is the production of sediments from stream crossings. While research has shown that using improved haul road crossings can mitigate sediment production in perennial streams compared to the use of unimproved crossings little research has been undertaken on temporary skidder crossings of headwater streams, a situation common to a significant percentage of ground skidding operations. This experiment consisted of a controlled replicated testing of the effectiveness of four types of temporary skidder stream crossings (unimproved ford, corrugated culvert, wood panel skidder bridge, and PVC pipe bundle) relative to bed load and suspended sediment production. Automated samplers were used to monitor sediment and bedload production during the construction, use, removal, and post-removal phases associated with the use of these temporary crossings. Results showed that improved crossings mitigated total sediment production compared to unimproved fords. Further, wood panel bridges yielded lower amounts of sediment than culverts but PVC pipe bundles show no difference between bridges or culverts. Sediment production varied by crossing type and use phase. While no differences were found among crossings types during construction, there was a difference between improved crossings and fords during use. Further, bridges and PVC pipe bundle crossings produced significantly less sediments than culverts during both their removal and during post-removal sampling and fords produced the largest amount of sediments during these phases.
The Appalachian Region of the United States has sometimes been termed, “...a third world country within the U.S.”. Mountaintop Mining (MTM) in Appalachia has been blamed for flooding and water quality problems and challenged in recent years by continuous reinterpretations of environmental regulations for this long accepted coal mining practice. Effective planning, permitting and reclamation for Mountaintop sites can result in a “Higher and Better Land Use”. MTM creates opportunities for development as a byproduct of the mining process and many consider it a value-added process. This analysis of MTM and Post Mining Land Uses attempts to set out a conceptual framework for establishing increased land and environmental values and presents a new way of representing mining to the public. MTM can epitomize the concept of Sustainable Development within the borders of the United States in a region that needs new development opportunities.
The Kentucky Landscape Census Project (KLC) is releasing the final version of the 2005, Kentucky update to the 2001 National Land Cover Dataset (NLCD01). This update product is derived from 2001 Landsat 7 ETM+ and 2005 Landsat 5 imagery, by calculating a change vector analysis mask based on the 2-date tasseled cap transformation (Lillesand et al., 2007). The presence or absence of change was captured with a success rate of 96%. While a deterministic result shows 58.8% classification accuracy, a representative fuzzy assessment of the classification shows a favorable overall classification accuracy of 79.9% (Congalton and Green, 1999; Congalton and Macleod, 1998; Ginevan, 1979). A total surface area of over 240,000 acres (approx. 98,000 Has) was mapped as experiencing change between Anderson Level II classes. The most frequent “source” class was forest with a loss of 153,000 acres (approx. 62,000 Has.), while scrub/shrub and grassland were the majority competing “target” classes, with gains of 91,000 acres (approx. 37,000 Has.) and 87,000 acres (approx. 35,000 Has.), respectively (Fig. 1). Spatial distribution metrics were calculated referenced to the 12-digit hydrologic unit dataset (http://kygeonet.ky.gov) including: percentage of total change, percent of 12-digit hydrologic units (HUC12), and Euclidean distance. Distinct spatial clustering of binary change was observed for groupings of HUC12s, corroborating the trends in type and direction of land cover change (Figs. 2a, 2b, and 2c).
Figure 2. Change relative to total land cover change area (a), HUC12 area (b); mean Euclidean distance (c).

References


http://kygeonet.ky.gov: “The 8, 10, and 12 digit hydrologic unit boundaries for Kentucky (FGDC) / kyu12sz (ISO)”.

http://kygeonet.ky.gov/metadataexplorer/full_metadata.jsp?docId=%7BEB0F78B9-487E-40EE-8AAD-FDB35D830206%7D; last accessed on January 28, 2008, 10:00 p.m.
Cover collapse is the sudden and unpredictable collapse of the unconsolidated cover over karstic bedrock. Cover collapse damages buildings, roads, utility lines, and farm equipment. It has killed livestock, including some thoroughbred horses, and has injured people. Predicting the precise location and timing of collapse remains enigmatic. Measuring a rate or frequency of occurrence has been done in other study areas (Beck, 1991) and could provide actuarial data as a basis for insurance coverage of buildings. The development mechanism of voids in unconsolidated cover overlying karstic bedrock has been understood for many years (White and White, 1992). Cover-collapse formation is driven by a loss of cohesion and surcharge loading from a wetting front, which results in a loss of strength of the regolith arch (Tharp, 1999).

The project area is a 2 square mile quadrangle in east-central Christian County, Kentucky. The exposed geologic section, in ascending order, is Mississippian Ste. Genevieve Limestone, Renault Limestone, and Bethel Sandstone (Klemic, 1967). The limestones are oobiosparites and micrites, medium-to thick-bedded, and have a high carbonate content. Interbedded thin shale and argillaceous carbonates are a minor interruption to the otherwise very pure carbonate section. The topography within the study area is karst plain and a single low hill of 77 ft local relief formed by the basal 30 ft of the Bethel Sandstone. The Bethel is a calcite-cemented, argillaceous quartzarenite and weathers into a friable, porous, sandy soil that readily slumps into underlying sinkholes (Klemic, 1967). The Lost River Chert is exposed near the base of the Ste. Genevieve in local quarries, but is below the depth of karst development in the study area. The exposed Ste. Genevieve Limestone is over 170 ft thick. The cover-collapses inventoried were mostly in the outcrop area of the Renault Limestone, some 50 to 95 ft thick. Land use is largely pasture and cropped fields with scattered farmsteads, a retail agriculture supply, a cement plant, and a restaurant.

KGS staff examined enlargements of black and white, low-altitude, visible-light aerial photographs. The photographs were taken March 9, 1971, and January 31, 1991. Contact prints for the Tennessee River Valley, at an image scale of 1:12,000 (1 in. = 1,000 ft) were used in stereo pairs. The enlargements were 1:3000-scale (1 in.= 250 ft). We field-checked 49 features seen on the photographs and identified 15 as cover collapse developed within the 20-year time frame. KGS was told of several collapses that occurred after 1971 that had been filled and graded over prior to the 1991 picture. We found
conclusive field evidence that 3 reported cover collapses had been filled and they were counted. The inventory results are shown in Table 1.

In planning this study we anticipated some limitations on the accuracy of the rate of cover collapse. First, the size of the study area is too small to be strictly statistically valid (Beck, 1991). Second, artificial effects of the quarry operation on the rate of cover collapse was in question. The quarry activity is thought to be negligible because the quarry became inactive shortly after 1971. We did not find a pattern either in the field or on the photographs that suggests any clustering induced by the quarry. Finally, the method does not work in densely wooded areas, although woodlands can still be field checked, which we did.

<table>
<thead>
<tr>
<th>Study area, 1971 and 1991 photography</th>
<th>Number of cover-collapse</th>
<th>Inventory Area</th>
<th>Cover-Collapse Events per unit area</th>
<th>Cover-Collapse Events/Unit Area/Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area of quarry included</td>
<td>18</td>
<td>1.90 mi²</td>
<td>9.47 CC/mi²</td>
<td>0.47 CC/mi²/yr</td>
</tr>
<tr>
<td>Area of quarry excluded</td>
<td>18</td>
<td>1.56 mi²</td>
<td>11.53 CC/mi²</td>
<td>0.58 CC/mi²/yr</td>
</tr>
</tbody>
</table>

The field verification of suspected cover collapse identified on large scale aerial photographs proved practical and more accurate than analyzing case histories. The rate of cover-collapse events for Christian County is 0.58 CC/mi²/yr, which is higher than many previous studies (0.29 CC/mi²/yr, Beck, 1991). The probability of a house being affected was calculated with the method of (Wilson and Shock, 1996). We estimate that 438,000 single-family homes are on karst terrain in Kentucky, with an average living space of 1,902 ft² (U.S. Department of Energy, 2001). The rate from this study suggests that 14 to 17 houses are affected annually by cover collapse.

References Cited


KENTUCKY SPARROW MODEL
AND ITS APPLICATIONS TO UNDERSTANDING NUTRIENT LOADS

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SPARROW (SPAtially Referenced Regression on Watershed Attributes) uses monitoring data in a statistically based land-use and land-attribute model that incorporates source and delivery variables in order to estimate contaminant loads for non-monitored streams. In Kentucky, a statewide SPARROW model is available for mean annual nitrogen and phosphorus loads using 1992 data as a baseline. This model is based on a combination of spatial data, with resolutions varying from 100 m² to 25 km², and a stream network with a mean watershed size of 6.0 km². The resolution of the input data limits the applicability of the model to watersheds where the total drainage area is on the order of several hundred km². One such watershed is Floyds Fork (743 km²), east of Louisville. Current issues of concern in the watershed include phosphorus, nitrogen, pathogens, and sediment. The current SPARROW model only addresses relative nutrient contributions for the six largest stream segments within Floyds Fork. However, an improvement in the sampling data and spatial data resolution of the model would address nutrient contributions in the smaller tributaries, as well as hopefully enabling an understanding of sediment contributions. This talk will discuss the possible improvements in development of the model for smaller watersheds as well as how this local model relates to the national and regional SPARROW modeling efforts.
HOW CLOSE DO WE NEED TO SAMPLE FOR APPROPRIATE SOLUTE TRANSPORT CHARACTERIZATION THROUGH THE VADOSE ZONE?

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Soil hydraulic properties and solute transport characteristics in the soil profile strongly affect the transport velocity of chemicals through the vadose zone and to the ground water. Especially the soluble components of surface-applied mineral and organic fertilizers as well as pesticides can quickly be transported downward in the soil profile and leach to the ground water. Managing our soils with the focus on ground and surface water quality implies a thorough analysis of transport paths and transport behavior through soils while efficiently taking advantage of retention and transformation processes in soils. The objective of this study is to quantify solute transport coefficients for a conservative tracer in an agriculturally managed field soil based on time series of solute concentration and the upper boundary condition.

Quantification of transport behavior in field soils is a complex task especially due to the fact that residential concentration of solutes is spatially extremely variable, even over short spatial distances. For this reason, in many cases, only a field-average transport behavior is approximated. This average result is, however, unsatisfactory inasmuch as the local scale transport behavior is not addressed. The underlying long-term task is to quantify the impact of management, coincidence of timing and rainfall intensity on solute transport through the vadose zone.

In order to determine solute flux rates based on residential concentration at a given location, a time series of solute concentration needs to be derived for that location. For this purpose, the spatial autocovariance behavior is quantified, in other words, the spatial distance represented by an individual soil sample has to be derived. The sample volume, i.e., the size of the auger strongly affects this distance. The pilot study presented here is focused on a transect experiment. A 16-m-transect was divided into zones of varying initial soil water content by pre-wetting a distance of approximately 11 m. A bromide tracer was applied to the soil surface through sprinkler irrigation, followed by two 20-mm-rainfall events. At the 0-10 cm depth, solute concentration - presented here as total anions – proceeded randomly in space due to the large amount of soil organic matter and debris at the soil surface. At the following soil depths down to 50 cm, anion concentrations were spatially correlated over 4 to 5 lag distances, corresponding to a distance of 1 to 1.25 m. The sampling scheme derived in this pilot study will be used in the subsequent experiment where rainfall intensity and timing of pesticide application prior to rainfall is investigated.
Figure 1. Initial profile soil water storage and anion concentration after 45 mm of rainfall along the transect.

Figure 2. Spatial autocorrelation of anion concentration versus lag distance at the 10-20 cm soil depth, manifesting a covariance structure of 1 m.
EFFICIENTLY LOCATING AND REPAIRING DAMAGED SEWER LINES IN A
KARST TERRANE

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In early September 2007, raw sewage was reported to be contaminating a reach of Town Branch Creek in Lexington, Kentucky. The source of the pollution was found to be a spring on the south side of the creek located in a Mixed-Use Industrial area of town. Spring flow from the limestone bedrock was estimated at 0.5 cubic feet per second (cfs). Initial observations of the spring discharge showed high levels of fecal contamination and a strong sulfur smell. Low dissolved-oxygen values and stressed algal growth were observed downstream of the contaminated spring.

A “shotgun approach” of dye-testing, line cleaning, and televising were all started on nearby sewer trunk lines in an attempt to locate the leaking section of pipe. Geologists from the Kentucky Geological Survey were consulted for information on groundwater flow associated with the contaminated spring. After studying confirmed dye-trace data for the spring, our search was expanded to dye test the trunk lines that collect sewage from over 3000 acres of the Urban Service Area of Lexington. All dye traces were then coordinated by one section of the Division of Water and Air Quality (DWAQ) with a modified approach, similar to a karst investigation. DWAQ, with the assistance of the KY Division of Water, conducted coordinated tracing to identify one trunk line draining nearly 1300 acres as leaking into the spring recharge area. Systematic dye testing along the trunk line narrowed the leaking section down to a 2000 foot reach of Vitrified Clay Pipe (VCP), over 4000 feet south of the spring.

The contaminated spring rises in Town Branch were contained in Corps of Engineers approved dams and all discharges were pumped into a sanitary trunk line for treatment. The damaged 18” VCP trunk line was then cleaned and televised to locate the leaking sections of pipe. Point-repairs were made to replace the worst sections of pipe and smaller leaks were repaired using Cure-In-Place-Pipe (CIPP) sleeve linings.

Stream and spring conditions were continually monitored and tested for fecal coliform, conductivity, pH, ammonia content and dissolved oxygen, with all results being sent to
the Kentucky Division of Water. Subsequent dye-tracing has confirmed that this section of sewer line has been repaired and is no longer contaminating the spring.
HYDROGEOLOGIC INVESTIGATIONS OF PAVEMENT SUBSIDENCE IN THE
CUMBERLAND GAP TUNNEL

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On October 18, 1996, the portion U.S. Highway 25E from Middlesboro, Kentucky, to Harrogate, Tennessee, was relocated into a newly constructed tunnel beneath Cumberland Mountain to both improve transportation efficiency and safety, and to help restore Cumberland Gap to its appearance when Daniel Boone brought the first settlers to Kentucky in the mid 1770’s. The tunnel is approximately 4,150 ft. long and consists of two bores, one southbound and the other northbound, each having two lanes for traffic. Approximately 26,000 vehicles pass through the two bores each day. The stratigraphic section pierced by the tunnel consists of primarily carbonate rocks of upper Silurian age and Mississippian age, and clastic strata of lower Pennsylvanian age. Cumberland Mountain is on the southeastern margin on the structural wedge of the Pine Mountain thrust sheet. The strata are tilted approximately 40 degrees to the northwest, and there are no major faults. The tunnel transects the strata at almost 90 degrees.

In June, 2002, it was observed during routine maintenance that short, discrete sections of the highway pavement were beginning to subside in both the southbound and northbound bores in the part of the tunnel bored through the Pennsylvanian age strata; no pavement subsidence has been noted in the southern third of the tunnel which is bored in carbonate rock. Ground penetrating radar surveys conducted by the Kentucky Transportation Center, University of Kentucky, indicated that the aggregate roadbase, commonly referred to as Number 57 limestone aggregate, had subsided away from the concrete pavement in at least 6, nearly juxtaposed locations in each bore. The proximity of the subsidence in the two parallel bores indicates involvement of discrete geologic strata or structure. Limited pavement core holes and lithologic core borings indicate subsidence in the aggregate roadbase of at least 2 feet from the pavement. Hydrogeotechnical documentation of conditions encountered in the initial pilot tunnel and during the construction of the two highway bores indicates the local presence of zones of high groundwater discharge, occurrence of mudstone strata, major joints and minor faults, or combinations thereof in the subsidence zones.

An initial hypothesis was that convergence of groundwater flow and resulting increased velocity in the subsidence zones, into and through the drainage field in the aggregate roadbase, might be physically eroding the aggregate or creating upwelling conditions into which aggregate was sinking. Either or both of these processes would undermine support for and lead to subsequent subsidence of the overlying pavement. However, observations at access portals for the groundwater drainage system did not reveal the movement of any large amounts of sediment, and the alkaline pH and electrical
conductivity measurements less than 250 uS of groundwater in the drainage system were not indicative of groundwater dissolution of rock material at a rate sufficient to cause the observed subsidence.

Intensified hydrogeologic and hydrogeochemical studies have been pursued in the southbound bore in the past three years. Dye tracing and particle tracing, using both Lycopodium spores and colored glass spheres (0.5 mm diameter), were employed to help define the groundwater flow within the roadbed aggregate. Dye recovery indicated that all the groundwater entering the tunnel aggregate is being transported through the designed drainage system; there is no extraneous groundwater flow out of the tunnel that could carry rock material from the tunnel unobserved. Dye tracing also indicated that groundwater velocity in the aggregate was approximately 0.02 ft/sec (0.49 cm/sec). The velocity needed to suspend and transport the 0.5 mm spheres is 0.12 to 0.22 ft/sec which explained why no glass sphere were recovered in plankton sampling nets installed in the drainage system. Likewise, no Lycopodium spores were recovered in the nets, for unknown reasons.

In the summer of 2006, five core borings were completed in the southbound bore in several subsidence zones to look at the stratigraphy of the underlying bedrock. A downhole video camera documented geologic conditions in the bore hole, and groundwater head was measured by straddled packers in discrete 7.12 ft intervals in two of the core borings. Cores and video logs show voids that range from a few inches to 2.5 ft. in bedrock, and the presence of highly weathered zones without noticeable distinction among bedrock lithologies which consist primarily of shales, siltstone, sandstone, and orthoquartzite. In a total of 210 ft. of core, no significant calcite-rich strata were observed. Perhaps the voids and highly weathered zones represent zones where calcite-rich strata have been dissolved since construction of the tunnel. Video logs indicated that in several void areas, groundwater velocity was great enough to move the camera, and carry rock particles horizontally across a void, and upward in the bore hole. Straddle-packer measurements indicated vertically upward groundwater movement in the bedrock.

In the spring of 2007, several monitoring wells were driven through the roadbase limestone aggregate to the top of bedrock. Water quality analyses and geochemical modeling indicated that the groundwater in these wells was aggressive with respect to calcite. In the summer of 2007, a 115 foot-long section of the highway pavement and limestone roadbase aggregate was excavated in a subsidence zone. Several high volume springs were observed on the bedrock floor, one having a pH of 6.0. The roadbase aggregate exhibited rounded and etched surfaces, and a particle size analysis indicated that there was a reduced percentage of fines in the aggregate and that the coarse-fraction particles were reduced in size by approximately 30 percent when compared to standards for Number 57 aggregate. These observations indicate limestone dissolution by groundwater. In September, 2007, 25 monitoring wells were driven through the aggregate to refusal at the bedrock surface in both the southbound and northbound bores to monitor groundwater levels and water quality up gradient, within, and down gradient of the six prominent pavement subsidence zones. Water-quality modeling of water samples collected in October and November indicate that although pH is predominantly above 7.0, most groundwater is still aggressive towards calcite dissolution (pH < 8.4) and, hence, limestone aggregate dissolution. Preliminary mass flux estimates indicate that the volume of subgrade loss is approximately 0.6 ft³/day/bore.
The Mud-Horse BMP demonstration project is related to environmental and water quality protection targeted to suburban and pleasure horse owners in Kentucky. Existing educational programs for horse owners are usually on a county level basis only. This project aims at reaching larger audiences. With nearly 200,000 horses in Kentucky, an interdisciplinary team has been assembled to provide the horse owner with the training and information needed to implement sound management decisions that enhance horse well-being and protect the environment. Little information is available to the horse owner demonstrating the proper use of, or more importantly, the effectiveness of BMP’s in suburban horse farms.

The goal of the BMP demonstration project was to transfer and promote the knowledge that will be essential to realistically protect water quality in suburban horse farms while enhancing horse well-being. We have tried to accomplish this by (i) accurately identifying baseline water quality and other environmental issues in suburban horse farms, (ii) implementing BMPs that have been proven to reduce water pollution elsewhere, and (iii) facilitating the transfer of this knowledge to horse farmers.

The project developed and distributed a survey to 4000 horse owners in the state of Kentucky. At present, we have received over 700 responses. The data are being analyzed for inclusion in a fact sheet about critical issues faced by the suburban horse owner. A project website has been created with information for the horse owner. Heavy use pads have been constructed at farm sites in Anderson, Fayette, Jessamine, Scott, and Woodford Counties. Fact sheets have been developed related to the heavy use pads, composting, and pasture management. A distribution strategy for the fact sheets is under development.
Experimental results of flow visualizations in turbulent open channel flows over smooth and rough beds reveal a universal pattern of coherent vortex formation that influences the spatial and time-average velocity distributions. These interactions are responsible for the generation of large eddies in rivers. The geometrical properties of the coherent vortices are shown to be related to the size of the roughness elements in gravel-beds. These structures are responsible for three-dimensional control of the turbulent core region and the location of the maximum velocity filament in the instantaneous and time-average velocity fields. The topological properties of the linked and knotted vortex interactions are used to constrain the derivation of the velocity distribution in straight, gravel-bed reaches and a simple model for velocity distribution based on the topological properties of the coherent vortex structure is presented and compared to measured velocity data in new experimental channels and to data from previous field studies.
Impervious surfaces such as roofs and pavement prevent stormwater from soaking into the ground. In developed areas, small tributaries and larger streams often experience eroded banks, incised channels, loss of habitat, increased flooding, and cause property damage because they are unable to handle the increased water volume and flow. Temporarily retaining as much stormwater as possible and letting it soak into the ground rather than letting it run off quickly can help manage harmful flows. Rain gardens are one way to reduce stormwater runoff.

A rain garden is a shallow depression that captures runoff before it enters the stormwater system. It filters pollutants and reduces the amount of runoff by encouraging infiltration of water into the soil where it can recharge groundwater. The increased soil moisture and added vegetation can help reduce the Urban Heat Island Effect that can cause temperatures to be up to 5 °F warmer in urban settings; attract birds, bees, and butterflies; and decrease drainage problems and localized flooding. Rain gardens are typically sized to capture water from a 1 inch rainfall event and allow it to soak into the ground within 1-2 days.

Deep roots of native plants typically help to enhance this process. Native plant species are recommended for rain gardens because of their extensive root systems and tolerance to local weather conditions. Their deep root structures break up the soil and help water infiltrate into the ground. Use of plants that bloom at different times can help create a long flowering season. A mix of heights, shapes, and textures also gives the gardens depth and dimension. Shredded hardwood mulch can help prevent weeds and adds nutrients to the rain garden.
A permit is required for projects that disturb one or more acres or is less than one acre but is part of a common plan of sale or development that disturbs one or more acres. Many projects are able to be covered under the Kentucky Storm Water General KPDES Permit (KYR10) when a properly executed application, or Notice of Intent (NOI), is submitted. KYR10 requires that Best Management Practices Plans (BMP Plans) be prepared and implemented for each project, and that inspections for proper implementation of the BMP Plans be conducted by qualified personnel. But KYR10 does not define what qualified personnel are.

Thus began the challenge for each community, agency, developer and contractor. What is a qualified inspector? The Municipal Separate Storm Sewer System (MS4) Workgroup, consisting of storm water professionals from across the Commonwealth, decided to develop a consistent approach across the Commonwealth instead of each community trying to define a qualified inspector (QI) on their own. The MS4 Workgroup established a Subcommittee to help develop the approach to define a QI.

The Qualified Inspector (QI) Subcommittee started working the first part of 2007 to develop a training course and exam to determine who is a QI. The Subcommittee titled
The training Kentucky Erosion Prevention and Sediment Control (KEPSC) – Qualified Inspector. The training course and exam rolled out in June 2007 and continues to be offered throughout the Commonwealth. The training course uses the information contained in KYR10 to address what a QI needs to know and what they need to do.

The main guidance for determining what constitutes a QI is KYR10; therefore, the QI needs to be knowledgeable of the KYR10 contents. KYR10 states what should be contained in a BMP Plan, what a QI should inspect and document, how often a QI should conduct an inspection, and who are the responsible parties of the permit.

Though the QI is not required to have the skill set to develop a BMP Plan, they need to be knowledgeable about BMP Plans to know what seems reasonable and to know when a modification is needed. The BMP Plan typically consists of a map and a written portion. KYR10 contains requirements for the contents of the written portion, including:

- Site description
- Sediment and erosion control measures
- Other control measures, such as good housekeeping
- Other state or local requirements
- Maintenance requirements for the BMPs
- Inspections: frequency, documentation
- Management of non-storm water discharges
- Names of Contractors and Subcontractors

The QI needs to be able to read the BMP Plan map to know what BMPs need to be installed and where they need to be installed. The QI should use the Kentucky Erosion Prevention and Sediment Control Field Guide and Kentucky Planning and Technical Specifications BMP Manual as references. To be able to determine the proper functioning of the BMPs, the QI needs to know the applicability, proper installation, and proper maintenance of each of the BMPs on the Plan.

As the name signifies, the QI conducts an inspection. The inspection is to assess the proper implementation of the BMP Plan. The training guides the QI in how to conduct an inspection and provides checklists for what to inspect.

The inspection does not serve much use unless it is documented and communicated with the appropriate personnel. The QI will be guided on how to document the inspection by completing a recommended inspection form. The inspection form is necessary to validate compliance with KYR10 and is an excellent tool for communicating BMP Plan deficiencies to appropriate personnel.
DETERMINATIONS OF BIOAVAILABLE FRACTIONS IN THE ASSESSMENT OF METALS IN BIG AND LITTLE BAYOU CREEKS DUE TO EFFLUENT DISCHARGES ORIGINATING FROM THE PADUCAH GASEOUS DIFFUSION PLANT, MCCracken COUNTY, KENTUCKY

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The hypothesis of this study was that even though metals may be present in the water column, not all of the metal concentration is available to aquatic organisms; therefore risk assessment based solely on total recoverable metals would overestimate environmental impacts. During 2000 through 2005, chemical characterizations and biomonitoring were conducted on Big and Little Bayou creeks, which were impacted by effluents from the Paducah Gaseous Diffusion Plant, McCracken County. Water, sediments, and sentinel fish samples were analyzed for nine metals (Ag, Be, Cd, total Cr, Cu, Fe, Ni, Pb, and Zn). Metal body burdens in stoneroller minnows (Campostoma anomalum) were used to develop multipliers to convert total recoverable water metal concentrations to bioavailable metal concentrations. Detections of Be, Cr, and Pb in waters from Big Bayou creek tended to be sporadic, while Ag, Cu, Ni, and Zn were consistently detected, indicating chronic contamination by these metals. Determinations of bioavailable fractions for stations in the effluent receiving zone (ERZ, stations BB4-BB7) indicated that for Cd, Cr, Fe, and Pb, less than half of the water column metal was bioavailable to stoneroller minnows. In contrast, 60 % of Ag, 73 % of Cu, and 64 % of Zn were bioavailable to stoneroller minnows in the ERZ. In Big Bayou creek, stoneroller minnow Cu body burden correlated with water column Cu, but poorly with sediment Cu, indicating that most of the copper uptake was from the water column. Unlike results from Big Bayou creek where only 3 metals were >59 % bioavailable, most metals found in Little Bayou creek water were >70 % bioavailable. In general, most of the sediment metals from both streams did not correlate with stoneroller minnow body burden, possibly due to high binding of the metals to the sediments. No seasonal changes were observed in metal concentrations. Results from this study support the hypothesis that total recoverable metal concentrations overestimated biologically available metal concentrations. Several developing models, such as the Windermere humic aqueous model (WHAM) and the biotic ligand model (BLM) being used for predicting bioavailable metals are limited by their focus of a single route of exposure, namely respiratory exposure. These models do not take into account other important routes, such as dietary exposure. The use of stoneroller minnows as in-situ sentinel monitors proved to be a valuable concept and allowed the study of metal behavior in stream systems under real-world conditions.
CREATION OF A CATALOG OF ENVIRONMENTAL MERCURY DATABASES IN KENTUCKY

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Mercury is a potent toxin to humans, with the nervous system of the developing fetus being the most susceptible to its effects. A primary route of exposure is ingestion of mercury through fish consumption. In Kentucky, mercury levels in fish tissue are consistently out of compliance with the Clean Water Act, resulting in fish consumption advisories. A better understanding of the relationship between environmental mercury sources and mercury levels in fish is necessary to plan strategies to reduce these levels in order to protect human health.

This project is the first step in evaluating the problem of mercury levels in fish. A number of agencies collect information on mercury levels in the environment. However, there is no coordination between agencies for evaluating these data or a common platform for assessing the data. Databases were identified by contacting federal, regional, state, and local agencies, and a catalog was created. For each database, the catalog includes a review of the sampling strategy, collection method, form(s) of mercury, collection sites, date range, frequency of sampling, and data format. Quality assurance and quality control methods were reviewed to evaluate the reliability of the data and these processes are included in the catalog. The entries include who has access to the database, and how the database is accessed. The catalog also contains maps of mercury emission sources and sampling sites.

Information on airborne mercury is collected and maintained by three agencies or programs: the Toxics Release Inventory (TRI) is a regulatory database that includes estimates of mercury emissions from coal-fired power plants; the Kentucky Division for Air Quality (DAQ) samples for mercury by two different methods, wet deposition and continuous ambient air monitoring; and the Mercury Deposition Network (MDN) is a national collaborative effort that monitors wet deposition of mercury across the nation.

Mercury monitoring in water is done in several different media: the water column—both groundwater and surface waters, fish tissue, and sediment. In addition, the water column can be monitored for total mercury and dissolved mercury. Several agencies monitor for mercury in water in Kentucky. The Kentucky Division of Water (KDOH) is responsible for water quality in the state, and has the most comprehensive monitoring program. KDOH monitors for total mercury in the water column, fish tissue, and sediment. The Ohio River Valley Sanitation Commission (ORSANCO) is an interstate agency that monitors the Ohio River and its tributaries. ORSANCO monitors
the water column for both dissolved and total mercury. Fish tissue is monitored for methylmercury. The Metropolitan Sewer District (MSD) is responsible for the monitoring of surface waters in Jefferson County, Kentucky. MSD monitors for total mercury. Lexington Fayette Urban County Government (LFUCG) had limited water column, sediment, and fish tissue sampling from 1992 to 2003. The Kentucky Division of Waste Management (DWM) does some groundwater monitoring around landfills to determine if mercury has leached out of these sites. The Kentucky Geological Survey (KGS) has a more comprehensive groundwater monitoring program and maintains a searchable database on the internet that reports groundwater mercury data from a number of agencies.

This study found that data collected for regulatory purposes are not always collected in a manner that is practical for research or maintained in a platform that is readily accessible. In addition, a lack of uniformity across agencies in the species of mercury sampled, variation in quality control, and differences in ease of access were findings that make using these data for research more difficult. Quality control and quality assurance methods were reliable for state and regional agencies, but were inconsistent in local agencies. However, state and regional agencies often monitored for different species of mercury, resulting in data that are not comparable. For several databases, geographic information was kept in separate files, complicating the task of performing geographic analyses. The Kentucky Department of Environmental Protection (DEP) is transitioning to a new database platform, COMPASS, that will facilitate the access of data kept by all divisions within the department. This platform will improve the ability to analyze information between the various media and provide geographic information of sample sites instantly.

At this time there is no coordination of sampling strategies between the DEP divisions. The DAQ monitors for mercury based on emission sites, while also monitoring one background site. The KDOW monitors major rivers and waterways monthly, and samples each of its five major watershed regions more intensely on a five year rotating basis. Coordination of sampling strategies between the various media is necessary to perform meaningful analyses to evaluate the fate and transport of mercury in the environment. The DEP has begun to bring the DAQ, KDOW, and DWM together to discuss the issue of mercury and how to address this problem. This may result in a shared strategy for monitoring mercury which is a necessary first step in devising a strategy to reduce its impact in the environment.

Significant amounts of mercury sampling data are available from federal, regional, state, and local agencies which monitor for regulatory purposes. With attention to quality control and quality assurance, coordinated sampling strategies, and attention to the manner in which these data are maintained and stored, these data could be used to help devise strategies to reduce levels of mercury in fish. The DEP has begun to work toward this objective by beginning to transition to COMPASS as a database platform, and bringing the various divisions together to discuss a coordinated strategy for addressing the problem of mercury levels in fish.
Wilgreen Lake is a dammed lake that has been classified as nutrient-impaired (303d list) by the EPA and State of Kentucky. The lake is moderately-sized covering 169 acres (0.7 km$^2$), and drains a watershed with residential developments, cattle pasture, modified woodlands, and some industrial/urban usage in the city of Richmond. The principal tributaries are Taylor Fork and Old Town Branch that meet to form the trunk of the lake approximately one mile in length. The upper reaches of Taylor Fork are adjacent to a densely-packed (quarter-acre lots) housing development with septic systems. Old Town Branch drains cattle pasture and residential areas. Residences within these developments, while also served by septic systems, are more sparsely distributed than residences within developments adjacent to those of Taylor Fork. An ancillary tributary flowing into Pond Cove is intermittent, and drains cattle pasture and one small housing development. Recognizing and quantifying potential nutrient sources is critical to any remediation efforts in decreasing nutrient input to the lake. We hypothesize that significant nutrient input occurs from the septic systems adjacent to the shallow lake waters of Taylor Fork. We use stable nitrogen isotopes ($^{14}$N and $^{15}$N) as a tracer in characterizing organic sources of nitrogen entering lake waters, and in characterizing organic sinks of nitrogen residing in the lake system.

We measure the carbon-to-nitrogen ratio, carbon isotopic composition ($\delta^{13}$C), and nitrogen isotopic composition ($\delta^{15}$N) of organic matter held within potential nutrient sources and sinks within the Wilgreen Lake system. Potential sources include fertilizers, bovine fecal matter, human effluent from septic systems, and “natural” organic material. Sinks include plankton, macroalgae, macrophyta, and organic matter within sediments.

Our samples are being measured at press time. The fundamental assumption of the test of our hypothesis is that $\delta^{15}$N values of nitrogen sinks should reflect that of their source. With knowledge of the nitrogen isotopic composition of nitrogen sources, we may be able to recognize gradients within the nitrogen sinks of the system. Consequently, our samples of plankton, macroalgae, macrophyta, and sedimentary organic matter are taken over the entire expanse of lake.
Wilgreen Lake is a eutrophic lake that has been listed on the EPA’s 303d list as nutrient impaired. Potential sources of this impairment are likely from humans, cattle manure, and fertilizers. We suspect that the majority of nutrients originate from human sources, namely from septic tank effluent emanating from key housing developments ringing the lakeshore. We test our hypothesis using two independent methods: a combination of nitrogen isotopic analyses; and conventional microbial assays (Escherichia coli) and RT-PCR techniques (Bacteroides). This paper examines only our microbe data, principally during the 2007 field season.

For the microbial tracer study, we took water samples at 19 sampling locations on 4 occasions for both tests. Sampling occurred within three tributaries of the lake (Taylor Fork, Old Town Branch, and Pond Cove), as well as its trunk. Sampling spanned about 2 months from 26 June to 15 August with the last 3 sampling events occurring at roughly two-week intervals. We measured the abundance of Escherichia coli using IDEXX methods, which approximates the number of colony-forming units (CFU) per 100 mL in terms of most probable number (MPN). Corresponding sub-samples slated for potential PCR analysis were stored at -40°C until all microbial assays were completed. Then we chose PCR candidates on the basis of elevated E. coli levels, and the probability of differing source contributions.

E. coli levels are generally elevated (up to >2419 MPN) at sites adjacent to septic tank clusters at the upper reaches of Taylor Fork. The second main tributary, Old Town Branch produced E. coli levels consistently lower (3 - 410 MPN), and E. coli levels are also low (1 - 24 MPN) in the third lake tributary that dominantly drains cattle pasture. There is a decline in microbial abundance (1 - 20 MPN) distal to these populated areas, and as you approach the main trunk of the lake. This suggests that the principal source of microbial input is from septic systems; however, we cannot eliminate the possibility that fecal microbes are introduced into the lake via inflows. For example, a sewage pumping station exists immediately upstream of the septic tank clusters of Taylor Fork. Thus, high
microbial abundance often observed here may also be due to this alternative input, which
is likely to enter the lake system during periods of significant rainfall.

We used quantitative PCR analysis to measure *Bacteroides* abundance, and to
distinguish between human and cattle sources of this microbe. We measured 14 samples
with most samples (11) taken on 1 August 2007, and ancillary samples (3) taken on 15
August. Total fecal microbe concentrations in all samples targeting all *Bacteroides*
species ranged from 45 mg/L to 142 mg/L. Unlike other studies, there was no apparent
relationship between the concentration of all *Bacteroides* species and that of *E. coli*. The
reasons for this result are unclear.

We also attempted to quantitatively assay the proportion of *Bacteroides*
contributions from specific sources, namely human and bovine fecal matter. Although
fecal contamination was measured in all 14 samples, only 1 sample had significant
amounts of human fecal contamination (21%) as measured by the human-associated
*Bacteroides* assay. None of the samples had significant bovine fecal concentration as
measured by the bovine-associated *Bacteroides* assay. These inconclusive results suggest
that either there are other unidentified sources of fecal contamination by *Bacteroides*
and/or *E. coli*, or that the prevailing drought conditions skewed our results by not
capturing fecal transport effects due to lack of surface and/or groundwater flow.
As part of statewide efforts to characterize ambient groundwater and nonpoint source impacts, the Kentucky Division of Water sampled twenty-two springs in the South Elkhorn Creek watershed in central Kentucky. The project began in January 2004 and is funded with a Clean Water Act §319(h) Nonpoint Source Pollution grant.

Surface water in South Elkhorn Creek has been impacted by flow and habitat alterations, nutrient enrichment, heavy metals including lead and copper, low dissolved oxygen, pathogens, and organic compounds associated with agricultural and urban run-off. Portions of the watershed have been listed as impaired and do not support all or some of their designated uses (KDOW 305b report, 2000). The focus of this project was to assess groundwater quality and its contribution to surface water quality.

The South Elkhorn Creek watershed covers approximately 179 mi² in portions of Fayette, Jessamine, Woodford, Scott and Franklin Counties. The watershed lies completely within the Inner Bluegrass Physiographic Region of Kentucky. The area is underlain by Ordovician limestone and shale with moderately to well-developed karst. Land cover in the study area is predominantly agricultural (71%), forest (14%) and urban/residential (13%).

While some historical groundwater quality data are available this study has significantly increased our knowledge. A total of 168 samples were collected from 22 springs, including two springs that had been part of our Ambient Groundwater Monitoring Network since its inception in 1995. Groundwater quality in the study area is degraded by pathogens and nutrients. Specifically, Eschericia Coli (E. Coli) was detected in all study area springs and 98% of samples. Nutrients found to be problematic are Nitrate-N, Orthophosphate-P and Total Phosphorus. These data will be evaluated to determine whether these springs are meeting water quality standards.

Many of these karst groundwater basins ultimately draining to the South Fork of Elkhorn Creek have previously been mapped by dye-tracing; additional tracer tests were conducted for this study. Previous authors identified 90 unique subsurface flow paths and delineated a total of 18 karst groundwater basins interconnected with the South Elkhorn Creek watershed. Tracer tests conducted for this study revealed 12 new subsurface flow paths and allowed the delineation of two additional karst groundwater basins. Comparison of dye-trace data to the USGS 11- and 14-digit Hydrologic Unit Code (HUC) boundaries indicates that 43% of mapped karst groundwater basins deviate from boundaries based on topographic divides.
Karst groundwater mapping and water-quality sampling of 30 karst springs in the Beargrass Creek watershed has been conducted since 2004, funded primarily by a Clean Water Act §319(h) Nonpoint Source Pollution grant. This work increased the inventoried karst springs in the watershed from 9 to 48, several of which included attendant spring houses dating from the late 1700’s. Karst development mainly occurs in the Devonian Sellersburg & Jeffersonville Limestones and the Silurian Louisville Limestone. Although karst landforms are subdued and depth of development is relatively shallow, occasional cover-collapse sinkholes 3-5 m deep have occurred, usually triggered by stormwater erosion. This study has discovered significant inter-relationships between karst groundwater flow in this watershed with the sanitary, storm, and combined sewers, providing insight for Metropolitan Sewer District (MSD) in addressing Combined Sewer Overflows (CSO’s) and Sanitary Sewer Overflows (SSO’s).

Localized conduit flow can be efficient and rapid. Traced groundwater flow routes are generally less than 2 km in length, with the greatest flow velocity exceeding 1.4 km/d. These tests have helped map 16 spring basins, only one of which had been previously identified. As might be expected in this urban watershed, several karst springs have been channelized with concrete storm-drains or metal culverts, including five CSO’s.

Tracer tests in two basins demonstrated that dyes infiltrated the sanitary sewer, revealing that significant base flow was locally being diverted from Beargrass Creek. This abstraction occurs by infiltration of an aging leaky infrastructure as well as intentionally engineered diversion of groundwater runoff. This combined extraction may impact the stream’s water quality by limiting potential dilution of urban and agricultural pollutant load.

**Sewer Infiltration:** An unnamed southern tributary of Middle Fork of Beargrass Creek, east of I-264, runs dry during low flow conditions, even though it is fed by at least three minor springs. Tracer dyes injected at stream swallets draining into bedrock along Hurstbourne Country Club were repeatedly lost until the sanitary sewer paralleling the tributary was monitored. The dye was quickly detected in the sewer, which apparently captures the entire base flow for this 6 km-long sub-basin. South of I-64, un-recovered dye injections at two losing points of Weicher Creek were explained when a replication was detected in less than two hours in a sewer main adjacent to the stream. The base flow of this 4.5 km-long sub-basin is likewise captured from the Middle Fork of Beargrass Creek. Two un-recovered dye injections into separate sinkholes in the City of St. Matthews may have also infiltrated the sanitary sewer at unknown locations.
Bowling Boulevard Spring, the second largest spring in the study area, with an estimated basin of 4.2 km\(^2\), fails to maintain flow during very dry periods. The most obvious explanation is loss of base flow into the sanitary sewer. Sewer abstraction of karst groundwater in the Beargrass is facilitated by shallow conduit flow routes and older sewer infrastructure. Likewise, intersection and diversion of natural flow routes into storm-water drains is suspected at Nunnlea Spring due to construction of Hurstbourne Parkway. Channelization of groundwater through two outfalls by construction of I-64 has been demonstrated over a path of at least 0.5 km. Although Brown Cemetery Spring appears to have been diminished by this storm-water channelization, the intercepted groundwater does discharge to Beargrass Creek.

Intentionally engineered diversion of karst groundwater into the sanitary sewer was verified along Brownsboro Road. Tracer dye injected into spring flow (1.5 L/s) entering a storm drain was not detected at the logical down-valley discharge point at CSO 154 along Mellwood Avenue. This non-recovery supported MSD maps which indicated that this storm drain contributed flow to the sewage treatment plant. Because of this single diversion, Edwards Pond Branch below CSO 154, which is contaminated by frequent sewer bypasses, fails to receive at least 130 m\(^3\)/d of flushing by groundwater discharge. Observations suggest that groundwater runoff from the entire 2.8 km\(^2\) watershed at the west end of Brownsboro Road may be diverted into the sewer system, depriving the surface stream of base flow (not to mention overloading of the treatment system).

**Sewer Leakage:** If groundwater leaks into a sanitary sewer, sewage may exit during peak flow. Sewer overflow into the groundwater system has been demonstrated north of the I-264/US 31-E interchange, near the historic Farmington Homestead Spring. During high-water conditions, dye introduced into the sanitary sewer near Bardstown Road was detected in the basement sump of a home 230 m to the east.

Also, Spring Station Spring west of St. Matthews appears to be impacted by an ongoing sewer leak at an unknown location. Evidence includes high background levels of fluorescent dyes common to sewage and occasional sewer gas at the spring conduit. During the summer of 2007, the spring was consistently high in bacteria. On May 15, Spring Station Spring exceeded 19 other springs sampled, at 24,196 and 9,804 colonies per 100 ml of total coliform and e-coli, respectively. The lowest of six samples collected at the spring were 7,850 and 1,100 colonies per 100 ml of total coliform and e-coli, respectively.

Dye-trace evidence from this study provides independent confirmation that the sanitary-sewer infrastructure in eastern Louisville requires repairs and re-engineering to limit diversion of groundwater and stream base flow, and to reduce sewer leakage and chronic by-passes. This study also demonstrates that karst development within the Beargrass Creek watershed is an integral component of its hydrology. These data further validate the high hydrogeologic sensitivity rating attributed to the Sellersburg & Jeffersonville Limestones and the Louisville Limestone by the Division of Water (1994).
In September 2007, a suspicious contaminant, believed to be untreated sewage, was detected in Town Branch Creek approximately 1,200 feet upstream of the Manchester Road stream crossing near Ferrell’s Car Care. The contaminant below the stream waterline was a gray color and contained a strong hydrogen sulfide odor. A few days after detection of the discharge, LFUCG, Tetra Tech, and the Kentucky Division of Water (KYDOW) Groundwater Branch collaborated to conduct a hydrogeologic documentation review and several dye trace studies. The hydrogeologic documentation revealed that the discharge point along Town Branch Creek was Mystery Spring, part of an extensive karst groundwater basin (see below).
lines could later be detected at the Mystery Spring discharge point. Any dye injected into pipelines on either side of the bounded area could later be detected at other discharge points, but could not be detected at Mystery Spring. Any pipeline rupture that discharged contaminant at the Mystery Spring location must therefore be contained within the Mystery Spring Basin. In this way, the hydrogeologic study proved extremely valuable in limiting the area of the possible locations of the source of the contaminant.

The dye traces revealed the location of the release to be between Chair Avenue and South Limestone. Dye traces further narrowed the field of possible locations to some point between TB2_28 and TB2_33A (see below).

While these investigative studies were being conducted, LFUCG took action to treat the illicit contaminant from the spring by capturing the water with a concrete structure and pumping it to the LFUCG collection system for treatment at the Town Branch wastewater treatment plant. A coffer dam was constructed around the spring to isolate the contaminated discharge and the spring water was pumped into the 36” line located near the spring’s discharge point.

Once the dye traces had narrowed the search, LFUCG mobilized to the area where the failure was believed to be and began investigation of this section of pipeline with television equipment. The leak in the sewer was found and rehabilitation of this section of line was accomplished using cured-in-place pipe (CIPP) technology that sealed the leak and stopped the migration of untreated sewage into the underlying karst aquifer.
This project consisted of analyzing existing water quality data for streams in the Upper Forks of Kentucky River Basin, with a particular focus on pathogen trends (Figure 1). According to the most recent 303(d) list of Kentucky waters, the majority of streams assessed in the Upper Forks of Kentucky River Basin are impaired for primary recreational contact as a result of pathogens. The state pathogen standard for primary contact recreation is expressed in a dual form which specifies that the 30-day geometric mean of fecal coliform counts not exceed 200 colonies per 100 mL (on a minimum of five samples) and not more than 20 percent of samples should exceed 400 colonies per 100 mL (KAR, 2002).

Historical monitoring data were utilized to assess fecal coliform concentrations and to evaluate the level of success of previous and ongoing projects in the basin. These projects are being funded and implemented through Section 319(h) of the EPA Clean Water Act, Eastern Kentucky PRIDE, the USCOE 531 wastewater program, and the Kentucky Wastewater Program to reduce the level of pathogens in the basin. The assessment utilized historic monitoring data obtained from four different sources: 1) the Kentucky Division of Water (KYDOW) ambient water quality network, 2) the KYDOW focused sampling network, 3) the Kentucky Watershed Watch network, and 4) the University of Kentucky monitoring network. The evaluation involved the analysis of the combined data sets using standard statistical measures to assess pathogen trends and project impacts. Land use patterns were documented to help identify likely pathogen sources, and areas of best management practices (BMP) implementation were examined for correlation with any water quality improvements. Statistical analysis was conducted using data sets to infer changes in the mean concentrations of fecal coliform over two monitoring periods. Standard statistical techniques F test, Student T test and Satterthwaite’s Two Sample T test were used for this analysis. Decreases in fecal coliform concentrations were noted for several individual sampling sites throughout the basin and for the aggregated data from the entire basin considered together (Figure 2).

References:

Figure 1. North Fork Watershed – Considered Sampling Station Locations

Figure 2. Cumulative Probability Distribution Plot indicating improvement in the System (Watershed based analysis)
Kentucky Water Awareness Month is an educational program of the University of Kentucky Cooperative Extension Service, Environmental and Natural Resource Issues Task Force. The program promotes overall water awareness for the citizens of Kentucky. Program materials are developed each year by a committee at the state level, and distributed to each of the 120 county Extension offices in the state. Individual county staffs are encouraged to tailor the program to fit their county's needs, and use the materials to enhance their program efforts. If you would like to receive an electronic copy of the Kentucky Water Awareness Month Packet please contact Ashley Osborne at ashley.osborne@uky.edu.
RECENT ENHANCEMENTS TO THE
KENTUCKY GROUNDWATER-QUALITY DATA SEARCH ENGINE

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In 2007, the Kentucky Geological Survey introduced a new online interactive search engine for Kentucky groundwater-quality data. Users can select one or more parameters of interest, view search results, and download the data for use in spreadsheet software or GIS software packages. A new feature allows the user to graphically compare concentrations between physiographic regions or major river watersheds.

The source of these data is the Kentucky Groundwater Data Repository, maintained by KGS. Thirty-eight parameters in five major categories (water properties, volatile organic compounds, nutrients, pesticides, and inorganic solutes) can be searched either as a group or individually. Each analyte has associated text files with descriptive information about the substance, possible health hazards, and EPA drinking-water standards. There are several search regions, including the entire state, one or more counties, or one or more 7.5-minute quadrangles, or a radius search can be made, in which the user specifies both the location and radius of the search.

This presentation will review procedures for searching, downloading, and displaying groundwater-quality data. Data searches can be formatted to include all sample data for every location for which records are available, or as a summary report that provides the median, maximum, and most recent result values. The number of samples below detection is also included in the summary report. Search results can be sorted by sampling date or by a range of dates. The groundwater-quality search engine can be accessed online at

kgsweb.uky.edu/DataSearching/Water/WaterQualSearch.asp.

Statistical plots for groundwater data can be generated for any analyte at

kgsmap.uky.edu/website/KGSWaterPlot/WaterQualityPlot.asp (Fig. 1).

For more information on groundwater-quality or water-well data, contact the Survey at 859-257-5500 x162 or 158.
Figure 1. Layout of new groundwater-quality data plotting page.
DIATOM COLONIZATION PATTERNS AND CARBON STABLE ISOTOPIC RATIOS IN DEVELOPING PERiphyTON AT SPRINGS OF DIFFERING GEOLOGIC ORIGIN IN LAND-BETWEEN-THE-LAKES (LBL)

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Previous studies have shown that physicochemical factors and nutrient concentrations of freshwater springs are influenced by the underlying geology and may influence species composition of periphyton colonizing stream substrates. The purpose of this study was to examine diatom assemblage composition, water chemistry, and changes in diatom community characteristics over time in four springs of different geological origins from November 2006 and July 2007. Changes in $^{13}$C composition of periphyton were examined over two seasons (every two weeks during spring and summer of 2007). Periphyton biomass was determined from ash-free dry mass and chlorophyll a measurements.

Using unglazed quarry tiles as artificial substrate, we found significant differences in diatom species composition in the different springs over time. *Planothidium lanceolata* and *Cocconeis placentula* were the dominant species in the carbonate streams with limestone geology (Mint and Panther springs) in the south of LBL; these taxa have been classified as calciphilous with a high optimal conductivity ($107-481 \mu$S cm $^{-1}$). *Eunotia intermedia*, *Achnanthidium minutissimum* and *Fragilariforma virescens* were most abundant in the streams with siliceous and argillaceous geology (Barnett and Brown springs) in the north of LBL; these taxa have been classified as acidophilous diatoms with low optimal conductivities ($48-163 \mu$S cm $^{-1}$). Average conductivity in the southern, calciphilous springs was 5X that of the northern, siliceous/argillaceous springs. Further, concentrations of SRP, SiO$_2$, Cl, and pH were significantly higher in the southern springs, while NO$_3$+NO$_2$ and SO$_4$ were significantly higher in the northern springs.

Changes in $^{13}$C composition of periphyton biomass over time were examined over two seasons (every two weeks during spring and summer) in 2007 as periphyton biomass accrued on the substrata. Hill and Middleton (2006) found that periphyton $\delta^{13}$C is correlated positively with the development of periphyton biomass over time. However, the results of this study showed that as periphyton biomass increased over time, $\delta^{13}$C became more negative (Fig. 1) at all sites, suggesting 1) some degree of internal C cycling during the course of periphyton community development, or 2) that the source of CO$_2$ to periphyton originated from CH$_4$ formed in groundwater prior to emergence in the springs. Future studies will require examination of $\delta^{13}$C in the spring water to determine the source of carbon being assimilated by the periphyton.

Literature cited:
Figure 1. Chl $a$ concentrations (solid line) and $\delta^{13}C$ isotopic composition (dotted line) in spring 2007. As periphyton biomass (Chl $a$) increased over time, the $\delta^{13}C$ became more negative.
SEASONAL CHANGES IN STRATIFICATION AND OXYGEN CONTENT OF A EUTROPHIC LAKE, WILGREEN LAKE, MADISON COUNTY, KENTUCKY

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Wilgreen Lake (Madison County, Kentucky) is listed by the Environmental Protection Agency as nutrient-impaired. The over abundance of nutrients is likely linked to the land-use practices in this area. Cattle pasture, residential developments served by septic systems, and urban/industrial areas lie in the lake’s watershed. We have studied the lake for two years to characterize its physical and chemical characteristics, and to identify nutrient sources.

The 2007 field season began in March and continued through October. We measured temperature and oxygen levels along with other parameters at 1-meter depth intervals at 19 stations distributed along the length of the lake and within its tributaries. Oxygen and temperature values were plotted on lake cross sections to show seasonal changes from March to October. The lake was essentially unstratified in March but was stratified by April. Stratification persisted to the end of the field season in October. The thermocline set up between 3 and 4 meters for the duration of summer with little variation. Peak anoxia occurred in July with anoxic waters spanning about 6 meters to bottom; disoxic waters (up to 2 mL/L oxygen) occurred from the thermocline downward to the anoxic boundary.

Wilgreen Lake is a typical eutrophic lake. Heating in the spring leads to stratification. Phytoplankton growth in the lake’s upper layers yields organic matter to the lake’s lower layer and sediments. Here oxygen demand created by decomposition in both the water column and sediments of the lake causes disoxia and anoxia. Over the past two field seasons we have seen no increase in the amount of anoxic or disoxic waters. One of our aims in measuring the temperature and oxygenation of the lake so thoroughly is to detect any changes in the future. Continued nutrient loading may alter the characteristics of the lake and our study offers an effective comparison point.
In 1991, the University of Kentucky, Board of Trustees approved a plan that set aside coal royalties from a 5,000-acre section of the Robinson Forest to support economic development efforts. In 1996, the Board allocated a significant portion of those funds to provide scholarships to students in 29 eastern Kentucky counties with historically low rates of college attendance. The Robinson Scholars Program serves first generation college-bound and college students who have demonstrated the potential to succeed but who might encounter economic, cultural, or institutional impediments to their completion of four-year college degrees. Not only does the Scholars Program aim to provide opportunities for these students, but through a collateral effect, the Program also seeks to increase the college-going rates in their communities.

Upon successful completion of high school, Scholars who have fully participated in program activities receive annual scholarships. At the college level, Scholars must maintain an acceptable academic record and fully participate in programming. If Scholars meet program requirements, their awards are renewable for up to four years of undergraduate study at the University of Kentucky or up to two years at a KCTCS institution with the remainder at UK.

The Water Pioneers Water Quality Initiative is a program for rising high school sophomores in the Robinson Scholars Program at the University of Kentucky. First, students participate in an in-depth study of an Appalachian watershed during a week-long summer program. Students then take this knowledge and partner with educators, volunteers, and other interested local groups to increase awareness of Best Management Practices for water quality in their respective counties through a community service/outreach project of their own design.

During the summer program, students were introduced to watershed concepts and discovered how people impact a watershed. Robinson Scholars developed ideas, communicated their knowledge, and compared and contrasted watersheds in the area. The students’ hands-on activities included stream sampling, tree and insect identification, cave exploration, watershed management, sustainability analysis, team building, leadership study, and reflective writing.

The conclusion of the program required that Scholars partner with local groups, educators, and volunteers to create a community project to addresses water quality
problems in their community. As future University of Kentucky students, the Scholars will ensure high visibility for their projects within their communities. The Scholars must present the projects and findings at a culminating event or local summit with parents, local officials, decision makers, school administrators, teachers, Division of Water employees, and others.
IMPACTS OF DISTURBANCE ON STREAMFLOW AND SEDIMENT YIELD IN THE LICKING RIVER BASIN

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Natural and human-induced disturbances have been shown to modify streamflow and sedimentation regimes in forested watersheds. These issues are particularly problematic in forested mountain watersheds, e.g., in eastern Kentucky, where flash flooding is a persistent danger and natural and human-induced land cover/land use changes (e.g., due to storms or timber harvesting) on steep slopes often increase sediment input to streams.

The catastrophic ice storm that occurred in central and eastern Kentucky in mid-February, 2003 lasted over 30 hours, nearly five times the average storm length. Up to two inches of ice was deposited on tree limbs across the region, damaging tree stems and branches and uprooting some trees completely. A plan for removing severely damaged trees from portions of the Daniel Boone National Forest (DBNF) has received final approval, and it is anticipated that commercial logging operations will commence in the near future (lasting up to six years). The goal of this study was to begin developing an understanding of the impacts of the 2003 ice storm on streamflow and sediment yield in forested sub-basins of the Licking River Basin within the DBNF near Morehead, Kentucky – an area which experienced particularly heavy ice storm damage.

A paired-basin approach is being utilized to study the effects of the ice storm on streamflow and sediment yield for a ‘disturbed’ sub-basin (i.e., one that experienced severe ice storm damage and will eventually undergo logging) compared with an ‘undisturbed’ sub-basin. The undisturbed, or control, sub-basin was selected to: a) contain minimal development (roads, buildings, etc.) or prior disturbance and b) comprise similar vegetation, morphologic, geologic and climatic characteristics as the disturbed, or treatment, sub-basin. Selection of the control sub-basin was made using a combination of
local expertise and an analysis of relevant digital spatial data layers (e.g., a digital elevation model, soil type, land cover/use, geology, and climate) within a Geographic Information Systems (GIS) database. Field sampling equipment (including Hydrolab multi-parameter water quality instruments and ISCO Autosamplers) was set up and maintained over the study period at the outlet of each sub-basin. Streamflow and sediment measurements are being used to help understand the effects of the ice storm on flow and sediment yields, and to establish pre-logging baseline conditions in these sub-basins as a first step towards monitoring the impacts of future logging activities.
Environmental planning based on watershed boundaries rather than political boundaries is increasingly advocated to address water pollution. Effective watershed assessment processes are needed that classify watersheds according to ecological landscape scale characteristics. This poster explores the opportunities and constraints of an ongoing descriptive pilot categorization approach for watersheds near Lexington-Fayette County, Kentucky. Using a semi-automated process through ModelBuilder of ArcGIS and publicly available data from the Kentucky Geography Network, more than a dozen landscape indicators are comparatively assessed by Hydrologic Unit Code (HUC) 14 watersheds within minutes. Example indicators include proportion and spatial configuration measures of human population, imperviousness, and agriculture/forest cover characteristics. Watersheds are ranked by the values for each indicator, from highest to lowest, and then divided into five groups (quintile). Thus, watersheds can be visualized geographically with a color ramp indicating conditions for each indicator. A quantitative matrix can be made to allow for comparisons by indicator across the study area. The analysis provides a guide to relative watershed health 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 watershed scale land use decision-making. These landscape indicators are expected to lead to a better understanding of watershed categorization through future cluster analysis.
Ohio River Run is an annual collaborative effort among Marshall University, Thomas More College, University of Cincinnati, and Northern Kentucky University. Marshall University researchers studied antibiotic resistant signatures of *E. coli* and total coliforms in the Ohio River basin but concluded that the occurrence of antibiotic resistant bacteria has no obvious pattern specific to either human or domestic livestock origin. Some research suggests that trace metals from such sources as industrial effluents can influence antibiotic resistance and make identifying sources of fecal contamination difficult. Industrial effluents are released to the Ohio River near major cities such as Pittsburgh, Cincinnati and Louisville. To better understand the impact of industrial land use on antibiotic resistant bacteria in the Ohio River we analyzed water samples collected every 25 miles along the mainstem and in navigable tributaries for Al, Cd, Cr, Cu, Ni, Zn and Se using a graphite furnace.

Cd and Cr concentrations were non-detectable whereas Zn concentrations were too high for accurate analysis with the graphite furnace. Al, Cu, Ni, and Se concentrations were compared with antibiotic resistant coliform data. The highest concentrations of these metals occurred most often in tributaries near industrial areas and became more dilute in the mainstem. These results indicate that trace metals in the Ohio River are influencing antibiotic resistance. We suggest further studies that include bacteria cultures to select for and identify trace metal resistance in order to clarify the impact of trace metals on antibiotic resistance in the Ohio River.
It is of vital importance to understand the dynamics of sediment transport in watersheds for the health of aquatic habitats and riparian plants and pollutant fate in-stream. Sediment phenomenon is complex and transient in nature based on the watershed terrains, seasonal conditions, in-stream turbulence, and the heterogeneous distribution of vegetation. Due to this complexity, both field and laboratory research are needed to investigate sediment transport in watersheds. In the field, state-of-the-art sensing equipment and sediment tracers are needed to monitor sediment transport. In the laboratory, research requires that experiments are conducted in a controlled setting that allows study of individual processes in isolation as well as the interaction of two or more processes. Also in the laboratory, it is possible to perform physical modeling of restoration technologies that work to control sediment transport in a watershed.

We are currently developing a laboratory flume for study of sediment transport in watersheds. In this oral presentation, we present the design of our flume which has the following specific objectives: (1) To calibrate new environmental sensors and sediment tracers for application in field-based research; (2) To investigate fine sediment processes associated with sediment detachment mechanisms from streambank and streambed sources and sediment shearing in-stream during transport; and (3) To physically model hydraulic structures and riparian remediation strategies under a range of hydraulic conditions representative of a river that have the purpose of controlling sediment transport in a watershed.
It is expected that the watershed sediment transport flume will be used to investigate multi-disciplinary research by environmental scientists across the Commonwealth of Kentucky. Specific details of the flume include the following. The flume is designed to study the turbulence-sediment interaction in watersheds for a variety of field components such as straight rough beds, hillslope soils, tributaries and stream-banks. The proposed flume will have an adjustable cross-section to prototype various river channels. A hydraulic lift will be used to change the slope of the flume to study hillslope disaggregation and sediment shearing. A part of the flume will be branched to simulate the tributary component. Sediment hopper will be used to create sediment suspension to study sediment laden flow over straight rough beds. Sensor nodes will be installed to analyze interaction of turbulence upon the incipient motion of fine sediments in-stream. Stream bank erosion caused by turbulence will be investigated by making a set-up in the flume.

A series of initial experiments will be conducted to gather data that can be useful to further analyze the relationship of watershed sediment transport on water quality. These experiments will also be presented and discussed during the oral presentation. This data will be of immense value for creating models to estimate the change in characteristics of watershed over a period of time.
RIGHT FORK BEAVER CREEK MONITORING PROJECT: UNDERGRADUATE RESEARCH EXPERIENCES IN AN APPLIED SETTING

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The Eastern Kentucky Environmental Research Institute is conducting a year-long assessment of the Right Fork of Beaver Creek in Floyd and Knott Counties under contract with the Kentucky Division of Water. The year-long study began in March 2007 and consists of one- to two days of monthly water sampling at 33 sites throughout the watershed. Beaver Creek and its tributaries are on the state’s 2006 303(d) List of Impaired Waters for not meeting the designated-use standard for primary contact recreation (swimming) and/or warm water aquatic habitat for conditions including: nutrients, organic enrichment (sewage), pathogens, pH, and sedimentation/siltation. Data from this study will help the Kentucky Division of Water develop a “total maximum daily load” or TMDL report for the watershed that will incorporate details of the impairment(s), watershed characteristics and a general implementation plan to address the impairments and improve conditions in the watershed.

To date, 20+ undergraduates from various disciplines including environmental health sciences, agriculture, geography, mathematics, anthropology, sociology and biology have been trained and employed as field research assistants. We will overview the Institute’s efforts to provide a diversity of students with real-world experience in proper scientific practices, methods in watershed assessment and evaluation, as well as a genuine understanding of the changing ecosystem in the Appalachian area. We will summarize the preliminary findings of the project, and highlight the experiences of undergraduate participants and how the project has influenced their academic and professional plans.
DIFFERING WATER QUALITY CHARACTERISTICS BETWEEN THREE REGIONS OF APPALACHIA, USA, AS INDICATORS OF COAL MINING IMPACT ON WELL WATER.

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The effects of coal extraction, especially mountain top coal removal (MTR), and the disposal of the wastes generated by mining, especially deep mine injection, on ground and surface water have been of increasing concern to residents of Appalachia, USA. Previous study has indicated that concerns about water quality are higher than many other topics, including occupational injury and terrorism. Concern has recently grown about the possible human health and ecological effects of deep mine injection practices and “black water” events. In an effort to assess the relative impact of MTR and coal waste disposal, water samples were taken from wells in Martin and Pike Counties in Kentucky and Mingo County, West Virginia. Martin and Mingo Counties face concerns about coal waste injected into deep coal mines and accidental releases from coal slurry impoundments. A suite of metals was analyzed using inductively couple plasma optical emission spectroscopy and several anions, including sulfate and chloride, were analyzed using ion chromatography in each water sample. Some of these metals were chosen for their human health effects (e.g. As, Cd, Cr, Pb) while others (e.g. Fe, Mn) and sulfate were chosen because they can act as indicators of contamination from acid mine drainage. Results indicate that there are several differences between the water qualities measured in each county. Iron levels in both Martin and Mingo Counties exceeded U.S. EPA standards more than 70% of the time. Sampling locations in both Martin and Pike Counties had Pb levels greater than U.S. EPA standards 25%, or more, of the time. All three counties had greater than 60% of locations with Mn levels above U.S. EPA standards. One Pike County site had extremely poor water with As levels at 1.34 mg/L and Pb levels at 0.35 mg/L. ANOVA reveals that mean values for chloride are different between counties (p<0.05) while values for sulfate are not different (p>0.05).
THE USE OF SINGLE INDICATOR TEST KITS AND INTER-METALS CORRELATIONS TO ASSESS WATER QUALITY IN COAL PRODUCING AREAS OF APPALACHIA, USA

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Local communities in Appalachia have become more concerned about water quality in recent years. Mountain top coal removal (MTR), coal slurry impoundments, and deep mine coal slurry injections are all suspected by local residents of altering hydrology and impairing water quality. To provide a tool by which a local community might assess its own water quality, including individuals using private wells, at reasonable cost, the effectiveness of a sampling plan using single indicator test kits was evaluated. Water samples were taken from private wells in Martin and Pike Counties in Kentucky and Mingo County, West Virginia. Water samples were taken and analyzed using single indicator test kits for As, Cu, Fe, and Mn. These metals were chosen because in previous research, it was found that concentrations of some metals correlate with each other. This indicated that analysis for certain metals may give clues about the presence of other metals. Simultaneously gathered samples were analyzed using inductively couple plasma optical emission spectroscopy (ICP-OES) to confirm test kit results. Additionally, a suite of 30 metals was analyzed to test for additional inter-metal correlations. Correlations between test kit results and ICP-OES analysis were generally significant for As, Fe, and Mn, but not for Cu, perhaps because of uncertainly caused by relatively low levels of Cu in the well water. Significant correlations between test kits and ICP-OES metal values ranged from r= 0.445 to 0.984 (p<0.05). The concentrations of all metals except Zn were correlated with two or more other metals. Ag, Ba, K, Li, Sb, Si, Sr, and V had seven or more positive correlations each. Boron had nine negative correlations. These correlations ranged from r= 0.333 to 0.945, or r = -0.346 to -0.975 (p<0.05). There were correlations between As, Cu, Fe, and Pb and several other metals, illustrating the usefulness of the test kits to indicate the presence of additional metals beyond those directly measured.
Sediment loss is a major problem in Kentucky watersheds. Sediment is a pollutant that can kill fish and other aquatic life, and other potentially hazardous substances, such as fertilizers or pesticides, attach themselves onto the soil particles and eventually end up in the stream. Sediment transport at the watershed scale in the Bluegrass Region of Kentucky is dominated by streambank erosion, high in-stream sediment storage, and to a lesser degree 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. 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.

The nature of this work is modeling sediment transport processes, including streambank erosion and in-stream storage, at the watershed scale in the South Elkhorn Watershed located in the Bluegrass Region of Kentucky. The objectives of the research include: (1) To modify an existing sediment transport watershed model to include improved equations for streambank erosion and in-stream storage, (2) To use sediment tracer data to calibrate the in-stream processes occurring, and (3) To use the model to investigate how land-use and hydrologic forcing scenarios impact sediment processes and the cumulative sediment budget. The South Elkhorn Watershed was chosen for this research because (i) the in-stream erosion, storage, and deposition processes are significant contributors to the sediment load, (ii) it is representative of Kentucky
watersheds in the Bluegrass Region, (iii) the watershed is closely accessible to the
University of Kentucky, (iv) and data has been previously collected in this watershed.

Sediment transport is being modeled using a modified Hydrologic Simulations
Program-FORTRAN (HSPF). By breaking down a watershed into small sub-basins of
similar properties and defining the geometry of the tributary that drains each area, an
estimate of sediment leaving the sub basins is being determined. Small sub basins of
similar characteristics allows spatial parameters to be lumped together for the whole of
the sub basin. Physically and empirically based equations can then be used on the sub
basin to estimate sediment loss without the complexity of following the fate of
individual sediment particles. The total suspended solids at the outlet of the modeled
watershed are being calibrated with the measured load at the outlet of the South Elkhorn
watershed, and watershed parameters that are immeasurable, such as the rate of water
absorption from the uplands, are being adjusted.

In-stream sediment sources are the largest contributors to sediment load, and these
sources are being modeled in the HSPF model using a new subroutine that reproduces
the erosion processes from streambanks, slump banks, and streambeds. The subroutine
estimates the load from these sources and this subroutine is being calibrated using a
watershed fingerprinting study that was previously completed on the South Elkhorn
watershed. Modeling the in-stream erosion processes in this way isolates specific in-
stream sources that greatly contribute to the sediment yield.

A number of different scenarios can then be run on a properly calibrated model. Flood
response, land retirement, and control structures are potential scenarios for modeling
and estimations of the expected flow and effluent are being obtained. A sensitivity
analysis is being run by varying global watershed parameters to discover too which
properties the South Elkhorn watershed is most sensitive, and to isolate sources of
sediment albeit from in stream or upland sources. A proper working model of the South
Elkhorn watershed will greatly aid in the analysis of the watershed to pinpoint sources
of sediment, determine worthwhile control techniques, predict future problem with ever
increasing urban development, and determine to what extent a sediment erosion
problem already exists.
The Dry Creek watershed in Rowan County, Kentucky, has been listed on Kentucky’s second priority 303d list as impaired. Recently, funding was secured from the Kentucky Waterways Alliance to develop a watershed-shed based plan for Dry Creek. During a 30-day period in the Fall of 2007, the students of Principles of Microbiology at Morehead State University engaged in a project to assess eight sites in the Dry Creek watershed for fecal coliform (FC), fecal enterococci (FE), and *Escherichia coli* (Ec) bacterial densities by the membrane filtration method. Additionally, the students assessed selected *E. coli* isolates for antibiotic resistance against a panel of 12 antibiotics (amikacin, amoxicillin with clavulanate, ampicillin with sulbactam, cefotaxime, ceftazidime, cephalothin, ciprofloxacin, gentamycin, minocycline, piperacillin, tetracycline, and trimethoprim) by the Kirby-Bauer method. FC counts ranged from 0 to 1,600/100 mL across the sampling sites during the 30-day sampling period. Geometric means of FC counts from five sampling events per site ranged from 3/100 mL to 52/100 mL, all below the state limit of 200 FC/100 mL for primary contact recreational waters. Ec counts ranged from 0 to 2,260/100 mL across the sampling sites. Geometric means of Ec counts from five sampling events per site ranged from 2/100 mL to 312/100 mL, with only one site exceeding the state limit of 130 Ec/100 mL. FE counts ranged from 0 to 1,170/100 mL across the sampling sites. Geometric means of FE counts from five sampling events per site ranged from 19/100 mL to 291/100 mL, with five sites above the federal limit of 33 FE/100 mL. FC:FE ratios indicate that the source of fecal contamination is animal (FC:FE < 0.7) or a mix of animal and human (FC:FE = 0.7 – 4.0). Eighty eight watershed bacterial isolates positively identified as *E. coli* were tested for antibiotic resistance. 65.9% of the isolates evaluated exhibited resistance to two or more antibiotics. 89.8% of the isolates tested exhibited resistance to cephalothin; 40.9% to piperacillin; 30.7% to tetracycline; 23.9% to amoxicillin plus clavulanate; and 21.6% to ampicillin plus sulbactam. These data demonstrate the continued fecal contamination of the Dry Creek watershed, and the significant occurrence of antibiotic resistant bacteria. In the context of developing a watershed-based plan, these data will be used to further define sampling sites in the watershed, begin to determine the host and point sources of fecal contamination, and to provide a baseline database for gauging the effectiveness of future remediation efforts.
This research study presents use of Kohonen neural network for clustering and identifying meteorological droughts in a region. Drought analysis is very essential in re-defining water resources management strategies and agricultural management. Periodically, the National Drought Mitigation Center (NDMC) provides the details of drought indices to help different state and federal agencies for better preparedness. Standardized Precipitation Index (SPI) (McKee et al 1995) and Palmer Drought Severity Index (PDSI) are the most popular indices used in the field to define meteorological and hydrological droughts. Other indices such as Crop Moisture Index (CMI), Surface Water Supply Index (SWSI) and Reclamation Drought Index (RDI) are also very useful in defining the characteristics of the prevailing drought. This research study is an attempt to use modern techniques in analyzing regional drought.

During spring and summer 2007, Kentucky and several other states faced meteorological drought. Daily observations from eleven raingauge stations were considered (Figure 1). For the regional analysis, monthly Standard Precipitation Index (SPI) values for all stations were derived using SPI software (Figure 2a and 2b). In May 2007, extremely dry conditions prevailed in Lexington. SPI data were used as the basis for evaluating the performance of a Kohonen Neural Network (KNN) model. KNN are self-organizing maps (ASCE 2000a). Popular feed forward artificial neural network models (ANNs) are trained by a supervised training approach, whereas KNNs are usually trained by an unsupervised approach. They are successfully used as clustering algorithms in several research studies. The developed KNN model had 12 neurons in its architecture. The model was trained using monthly rainfall data from the 11 stations. During the training process, the weight of the neuron with closest Euclidean distance to the considered dataset was readjusted by the algorithm based on the input data. In that way, each dataset clustered with one neuron. After training, each neuron could be classified as extreme, severe, mild drought or normal conditions. Trained KNNs are very useful to identify prevailing regional drought severities and can be very effectively used for different managerial models.

References:
Figure 1. Raingauge Stations located in Kentucky

Figure 2a. SPI Index for Lexington Stations

Figure 2b. SPI Index during May 2007 at Different Stations
RAIN GARDENS: RESTORING A WASTE WATER TO A PRICELESS RESOURCE

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Impervious surfaces such as roofs and pavement prevent stormwater from soaking into the ground. In developed areas, small tributaries and larger streams often experience eroded banks, incised channels, loss of habitat, increased flooding, and cause property damage because they are unable to handle the increased water volume and flow. Temporarily retaining as much stormwater as possible and letting it soak into the ground rather than letting it run off quickly can help manage harmful flows. Rain gardens are one way to reduce stormwater runoff.

A rain garden is a shallow depression that captures runoff before it enters the stormwater system. It filters pollutants and reduces the amount of runoff by encouraging infiltration of water into the soil where it can recharge groundwater. The increased soil moisture and added vegetation can help reduce the Urban Heat Island Effect that can cause temperatures to be up to 5 °F warmer in urban settings; attract birds, bees, and butterflies; and decrease drainage problems and localized flooding. Rain gardens are typically sized to capture water from a 1 inch rainfall event and allow it to soak into the ground within 1-2 days.

Deep roots of native plants typically help to enhance this process. Native plant species are recommended for rain gardens because of their extensive root systems and tolerance to local weather conditions. Their deep root structures break up the soil and help water infiltrate into the ground. Use of plants that bloom at different times can help create a long flowering season. A mix of heights, shapes, and textures also gives the gardens depth and dimension. Shredded hardwood mulch can help prevent weeds and adds nutrients to the rain garden.
To facilitate the efficient and timely translation of research to application, the University of Kentucky Superfund Basic Research Program Research Translation Core coordinated the 2007 Kentucky Research Consortium for Energy and the Environment (KRCEE) Scientific and Technical Symposium. Held October 30-31, this event brought together representatives from state and federal government, industry, and academia to discuss projects underway at the Paducah Gaseous Diffusion Plant Superfund site in western Kentucky. Sessions covered new technologies, data management issues, seismic activities, surface water issues, and groundwater modeling.

UK-SBRP RT Core Leader Dr. Lindell Ormsbee hosted the event, while UK-SBRP project leaders Dr. Dibakar Bhattacharrya and Dr. Sylvia Daunert presented research related to chloro-organic degradation and whole cell sensing, respectively. Their audience included representatives of the US Department of Energy, the US Environmental Protection Agency, the Kentucky Environmental and Public Protection Cabinet, and regional colleges and universities, as well as technology corporations and consultants.

Opportunities were provided for graduate student and post-doctoral participation. UK-SBRP supported scholars Scott Lewis and David Meyer assisted Dr. Bhattacharrya with his presentation. Posters also were submitted by a number of UK-SBRP students and post-doctoral scholars, including biomedical researchers Elizabeth Oesterling and Xabier Arzuaga, chemistry researcher Kendrick Turner, chemical engineering researcher Karthik Ventakatachalam, and the Community Outreach Core’s Carolyn Hofe and Megan Finnie.
The Georgetown-Scott County Planning Commission, working with CDP Engineers, Inc., is conducting a pilot project combining watershed and land use planning that encompasses properties within the city limits of Georgetown and land in Scott County. This plan was approved by the Kentucky Division of Water – Non-Point Source Section, as a Section 319(h) Grant for FFY 2004 and is in its fourth year. The study area is defined as the “Dry Run Watershed Basin” which incorporates approximately 8,000 acres (12.5 square miles) and is generally located north of downtown Georgetown. Approximately one-third of the proposed study area is located within the current Urban Service Boundary (USB) with the potential growth area, per the Comprehensive Plan process, to increase to over one-half of the study area within a minimum of ten years. The purpose of this study is the development of a proactive land use and watershed plan focused on stream protection and water quality. Some goals of the study are: to mimic pre-development hydrology rather than just peak flow rates in future development, to attempt small area planning with environmental protection steering the land use planning initiative, and to educate local, regional and national groups on what we learn about combined watershed and land use planning.

Based on development projections, the Dry Run Basin is identified for future growth and urban development within the community. This area has been identified as a growth corridor since the 1991 Comprehensive Plan. Infrastructure which will support the future urban development, including roads, schools and utilities are currently being planned and constructed in the lower elevations of the basin. Once completed, this watershed plan would provide a long range plan for development in this area by guiding designers in planning for storm water and establishing water quality features (BMP’s) including open space, riparian areas, trail linkages, etc. This plan will also provide the baseline elements for an overall drainage study that would be used by the design and development community as they propose various developments within the basin area.

The intent of this poster presentation is to demonstrate the progression of work on this study to date. Material will include watershed mapping and delineation, field collection of existing conditions and stream classification, existing watershed modeling, how land use growth scenarios have been analyzed and selected, and the selection of BMP’s for pollutant modeling.