DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

July 2012

AWRC

Arkansas Water Resources Center Annual Technical Report FY 2011

104B funding provided by the U.S. Geological Survey through
the National Institutes of Water Resources
MSC Publication 102.2011| Arkansas Water Resources Center

Arkansas Water Resources Center Annual Technical Report FY 2011

L.B. Massey[1] and B.E. Haggard[2]

[1]Project Manager, Arkansas Water Resources Center
[2]Director and Professor, Arkansas Water Resources Center, 201 Engineering Hall, Fayetteville, Arkansas, 72701 Corresponding author: awrc@uark.edu

This publication serves as the annual report to the U.S. Geological Survey regarding the projects and activities of the Arkansas Water Resources Center for FY 2011. This document provides summary information for each of the 104B projects funded by the USGS: 1) Evaluation of septic system absorption field products with differing architectures in a profile-limited soil; 2) Increasing awareness for water quality protection: Stream restoration through temporary and permanent animal access restrictions; 3) Continued Investigation of Land Use and Best Management Practices on the Strawberry River Watershed; and 4) Assessment of the microbial population in Beaver Lake swim beach regions to determine origin of fecal pollution. This publication also summarizes the Arkansas Water Resources Center's information transfer program, student involvement, notable awards and achievements, and publications of previous 104B projects.

Keywords: Arkansas Water Resources Center, 104B Program Funding, Information Transfer, Water Quality

Introduction

The Arkansas Water Resources Center located at the University of Arkansas at Fayetteville, is part of the network of 54 water institutes established by the Water Resources Research Act of 1964. Since its formation, the Arkansas Water Resources Center (AWRC) program in cooperation with the US Geological Survey and the National Institute for Water Resources has focused on helping local, state and federal agencies understand, manage and protect water resources within Arkansas. AWRC has contributed substantially to the understanding and management of water resources through scientific research and training of students. Center projects have focused on topics concerned with water quality of surface water and groundwater, especially non-point source pollution and sensitive ecosystems. AWRC helps organize research to ensure good water quality for Arkansas today and in the future.

The AWRC focuses its research on providing local, state and federal agencies with scientific data and information necessary to understand, manage, and protect water resources within Arkansas. AWRC cooperates closely with colleges, university and other organization in Arkansas to address the state's water and land-related issues, promote the dissemination and application of research results, and provide for the training of scientists in water resources. Each year, several research faculty participate in AWRC projects with the help of students who gain valuable experience doing environmentally related work across the state. AWRC research projects have studied irrigation and runoff, innovative domestic wastewater disposal systems, ground water modeling and landuse mapping, erosion and pollution, water quality and ecosystem functions.

The Center provides support to the State's water research by acting as a liaison between funding groups and the scientists, and then coordinates and administers grants once they are funded. Accounting, reporting and water analyses are major areas of support offered to principal investigators. The AWRC has historically archived reports of water resource studies funded by the 104B program or through the Center on its website.

In addition, the AWRC sponsors an annual water conference held in Fayetteville, Arkansas each spring, drawing over 100 researchers, students, agency personnel and interested citizens to hear about results of current research and hot topics in water resources throughout the state. AWRC also co-sponsors short courses and other water-related conference in the state and region. In addition, AWRC maintains a technical library containing over 900 titles, many of which are online. This valuable resource is utilized by a variety of user groups including researchers, regulators, planners, lawyers and citizens.

The AWRC also maintains a modern water quality laboratory that provides water analyses for researchers, municipal facilities, and watershed stakeholders; farmers and other citizens submit samplers through the cooperative extension service. This laboratory is certified through the Arkansas Department of Environmental Quality for the analysis of surface and ground water samples.

The AWRC has a technical advisory committee made up of professionals from education institutions, environmental organizations, water supply districts, and government agencies throughout Arkansas. This committee has the opportunity to evaluate proposals submitted annually to the USGS 104B program, to recommend session topics included in the annual research conference, and to provide general advice to the AWRC Director and staff.

Research Program Introduction

Each year, several researchers participate in 104B projects funded through the Arkansas Water Resources Center (AWRC), and these projects are completed with the help of students in water and environmentally related fields. The research projects funded through the AWRC have studied a broad range of environmental and water issues facing Arkansas, including irrigation and rainfall-runoff, innovated domestic wastewater disposal, groundwater modeling and land use mapping, erosion and nonpoint source pollution, water quality and ecosystem function. The AWRC has given priority to solid scientific research proposals submitted by the faculty to the 104B program; the intent has been to provide seed data to researchers such that larger proposals can be developed and submitted to extramural funding sources. The AWRC has funded several projects using 104B funding that have resulted in the award of extramural grants to continue the base research.

To formulate a research program relevant to state water issues, the Center works closely with state and federal agencies, and academic institutions. An advisory committee, composed of representatives from state and federal agencies, industry and academia, provides guidance for the Center. The technical advisory committee plays an important role in insuring that the water institute program (section 104) funds address current and regional issues. The priority research areas of the AWRC base program directly relate to the program objectives of the Water Resources Act, including research that fosters improvements in water supply, explores new water quality issues, and expands the understanding of water resources and water related phenomena.

In FY2011, the AWRC under the guidance of the technical advisory committee funded the following research projects:

1)"Evaluation of Septic System Absorption Field Products with Differing Architectures in a Profile-limited Soil", Dr. Kristofor R. Brye, University of Arkansas, $15,389

2)"Increasing Awareness for Water Quality Protection: Stream Restoration through Temporary and Permanent Animal Access Restrictions", Drs. Dirk Philipp and Kelly J. Bryant, University of Arkansas and University of Arkansas at Monticello, respectively, $10,634.

3) "Continued Investigation of Land Use and Best Management Practices on the Strawberry Watershed", Drs. Jennifer L. Bouldin and Richard A.F. Warby, Arkansas State University, $14,000.

4)"Assessment of the Microbial Population in Beaver Lake Swim Beach Regions to Determine Origin of Fecal Pollution", Drs. Kristen E. Gibson and Steven Ricke, University of Arkansas, $21,003.

Evaluation of septic system absorption field products with differing architectures in a profile-limited soil

Basic Information

Title:	Evaluation of septic system absorption field products with differing architectures in a profile-limited soil
Project Number:	2011AR289B
Start Date:	3/1/2011
End Date: Funding	2/29/2012
Source: Congressional	104B
District: Research	3rd Congressional District of Arkansas
Category: Focus	Non-point source pollution, Wastewater, Water Quality
Category: Descriptors:	None
Principal Investigators:	
	Kristofor R. Brye

Publications

1. Prater, N.J.M. 2012. Evaluating the Effects of Absorption Field Product Architecture Type on Effluent Dispersal in a Profile-Limited Soil, Department of Crop, Soil, and Environmental Sciences, University of Arkansas. (anticipated)

Arkansas Water Resources Center 104B Program Project – March 2011 through February 2012

Project Title: Evaluation of septic system absorption field products with differing architectures in a Profile-limited soil

Project Team: Dr. Kristofor Brye, Crop, Soil, and Environmental Science Dept., University of Arkansas
Nina Prater, Crop, Soil, and Environmental Science Dept., University of Arkansas

Interpretative Summary:
On-site wastewater treatment systems can be a source of non-point-source pollution, unless they are designed and function appropriately. Household wastewater can contain nutrients and other contaminants that must be treated before returning to the groundwater. Thirteen absorption field products were installed in a 3-year field study at the Bethel Heights Wastewater Treatment Facility in order to evaluate the effect of absorption field product architecture type on performance. Biomat formation and soil chemical properties were also analyzed. Architecture type did not affect performance, though individual products differed. Biomat thickness was affected by architecture type. Many soil chemical properties were affected by time, but not architecture type.

Introduction:
On-site wastewater treatment systems (OWTSs) are commonly used by households in areas of low population density to treat and dispose of household wastewater. The traditional absorption field product used in OWTSs is a pipe-and-gravel architecture type, which has been used for decades and is the basis for most design regulations. However, new products of differing architecture types including chambers, polystyrene-aggregate, pipe-and-tire-chip, and gravelless-pipe systems have recently become available. A three-year field study was conducted in Bethel Heights, AR to assess the performance of several newer products and to compare different architecture types to the traditional pipe-and-gravel design under wet and dry soil conditions.

Methods:
Thirteen products of four different architecture types were installed at the Bethel Heights Wastewater Treatment Facility (BHWTF) in a Captina silt-loam soil (fine-silty, siliceous, active, mesic Typic Fragiudult) with redoximorphic features indicating a seasonal water table (Table 1). Loading rates were determined using the maximum allowable rate under State of Arkansas regulations. Product performance was evaluated based on the height of in-trench solution storage, measured approximately weekly between January 2009 and January 2012. Between May 2010 and January 2012, the thickness of any biomat formation was also measured approximately weekly. Soil samples were taken at the depth of the infiltrative surface (45-55 cm) at the time of product installation in 2008 as well as after greater than two years of effluent dosing, in 2011, and samples were analyzed for pH, electrical conductivity (EC), and Mehlich-3 extractable nutrients.

Table 1. Summary of absorption field products included in the Bethel Heights Wastewater Treatment Facility (BHWTF) study.

Architecture Type	Product Name	Abbreviation	Trench Width	Product Length
			-- cm --	-- m --
Chamber	ADS Bio 3	ADS Bio 3	61	4.4
	ADS ARC 24	ADS Arc 24	61	4.4
	Infiltrator EQ 24	INFILEQ 24	41	5.4
	ADS Bio 2	ADSBio 2	46	4.4
	Infiltrator EQ 36	INFILEQ 36	61	5.4
Polystyrene-aggregate	EZ Flow 1201P-GEO	EZ 1201	30	6.1
	EZ Flow 1202H-GEO	EZ 1202	61	6.1
Gravel-less Pipe	ADS SB2 10 inch	SB2 25cm	46	6.1
	ADS SB2 8 inch	SB2 20cm	41	6.1
Pipe and Aggregate	Pipe and Gravel (30 cm)	P&G 30cm	30	6.1
	Pipe and Gravel (46 cm)	P&G 46cm	46	6.1
	Pipe and Tire Chip	P&TireChip	61	6.1
	Pipe and Gravel (61 cm)	P&G 61cm	61	6.1

Results:

No products exhibited signs of failure (i.e., surface ponding) throughout the duration of the study. Architecture type did not affect product performance. However, individual products' performance differed under wet and dry soil conditions. The pipe-and-tire-chip product had the greatest mean storage under both wet and dry conditions of the thirteen products, and the Infiltrator EQ 36 had the least mean storage under both wet and dry conditions (Table 2).

The presence of a biomat ranged from 0 to 97.5 % of the time among the 13 products. When present, biomat thickness differed significantly among all four architecture types, ranging from 1.4 to 6.2 cm on average in the pipe-and-aggregate and polystyrene aggregate types, respectively.

At the infiltrative surface, averaged across all products, the mean soil pH was lower after > 2 years of effluent dosing, with a pH of 5.3 in 2008, and a pH of 4.9 in 2011. The EC was approximately three times greater after dosing, with a mean of 0.042 dS m^{-1} in 2008 and 0.138 dS m^{-1} in 2011. Soil P concentration increased nearly two-fold after dosing from 3.1 mg kg^{-1} in 2008 to 5.5 mg kg^{-1} in 2011.

Of the Melich-3 extractable nutrients, architecture type only affected Cu levels in the soil over time. The Cu concentration in the soil surrounding products with chamber and polystyrene-aggregate architecture types decreased, changing from 1.2 mg kg^{-1} to 0.8 mg kg^{-1} in the chamber systems and from 1.3 mg kg^{-1} to 0.4 mg kg^{-1} in the polystyrene-aggregate systems. The concentration of Cu did not change in soils surrounding products of gravel-less pipe and pipe-and-aggregate architecture types. Other nutrients analyzed either did not change or were not significant in terms of water or soil quality.

Table 2. Mean height of stored solution of individual products and the mean of all products under wet and dry soil conditions.

		Condition	
Architecture Type	Product	Dry	Wet
		----- cm -----	----- cm -----
Chamber	ADS Arc 24	4.84	14.03
	ADS Bio 2	4.18	5.41
	ADS Bio 3	4.82	21.08
	INFILEQ 24	1.02	9.95
	INFILEQ 36	0.13	3.29
Gravel-less Pipe	SB2 25cm	3.76	8.16
	SB2 20cm	2.90	16.27
Pipe and Agg.	P&G 30cm	0.58	5.64
	P&G 46cm	1.95	11.93
	P&G 61cm	0.67	5.81
	P&TireChip	13.14	24.05
Polystyrene Agg.	EZ 1201	5.68	14.32
	EZ 1202	1.90	11.87
All Types	All Products	3.51	11.68

LSD to compare any pair of dry mean = 2.34
LSD to compare any pair of wet means = 4.65
LSD to compare a wet mean with a dry mean = 3.68

Conclusions:

Results showed that there are several currently approved alternative product that perform equally as well as or better than the traditional pipe-and-gravel system, but that there are also several alternative products that perform worse the traditional pipe-and-gravel system. Overall, no products exhibited failure (i.e., surface ponding of effluent), and all products mean storage was significantly below the soil surface (46-cm from the infiltrative surface). This suggests that the method of determining loading rates, by analysis of morphologic features in the soil profile, is a valid and effective method of sizing absorption fields.

Results suggest that architecture type does not affect most soil chemical properties (except Cu levels), but dosing for two years does affect soil chemical properties. Both the increase in acidity and the increase in EC can affect soil structure by dispersing clay particles and thereby breaking down soil peds. This could negatively affect the infiltration of solution from the product into and through the soil, which could impair the performance of the OWTS over time. The increase in P in the soil suggests that some of the P in the effluent is being retained by the soil, limiting leaching of this potentially problematic nutrient at least while the soil is able to adsorb P. Once the soil becomes saturated with P, there may be more of a risk of P contamination of groundwater resources.

References:

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Research Publications Stemming from this Project:

Prater, N.J.M. 2012. Evaluating the Effects of Absorption Field Product Architecture Type on Effluent Dispersal in a Profile-Limited Soil. Thesis, Mater of Science in Crop, Soil and Environmental Sciences, University of Arkansas, Fayetteville, Arkansas.

Increasing awareness for water quality protection: Stream restoration through temporary and permanent animal access restrictions

Basic Information

Title:	Increasing awareness for water quality protection: Stream restoration through temporary and permanent animal restrictions
Project Number:	2011AR294B
Start Date:	3/1/2011
End Date: Funding	2/29/2012
Source: Congressional	104B
District: Research	4th Congressional District of Arkansas
Category: Focus	Water Quality
Category: Descriptors:	Agriculture, Water Quality, Education
Principal Investigators:	
	Dirk Philip, Kelly Jay Bryant

Publications

There are no publications.

Arkansas Water Resources Center 104B Program Project – March 2011 through February 2012

Project Title: Increasing awareness for water quality protection: stream restoration through temporary and permanent animal access restrictions

Project Team: Dr. Dirk Philipp, Animal Science, University of Arkansas
Kelly Bryant, Hal Liechty, and Paul Francis

Interpretative Summary:
To demonstrate beef cattle management BMPs related to water quality, this project implemented four stream protection treatments that serve as demonstration sites for landowners, producers, UA Monticello students and other interested entities from southeast Arkansas. One-sided fence, two-sided fence, a tree buffer zone, and a control area were divided into four transects to measure changes in vegetation and soil patterns. Water quality samples were obtained from various locations along the stream project. A major part of the project was to involve undergraduate students in the project and utilize for fostering the understanding of soil and water conservation.

Introduction:
Increased awareness has resulted in various and diverse activities to address water quality impairments in urban and rural areas. Erosion of intermittent streams on pasture land remains one of the biggest challenges on beef farms for reducing nutrient and sediment loss. This project was initiated to address these challenges by implementing stream protection measures encompassing fencing options and a buffer tree zone, and give students, landowners, and producers' access to information resulting from this project.

Methods:
Three treatments besides a control were installed prior to project start. These include one- sided fence, two-sided fence, and a tree buffer zone. In each treatment including the control, four transects were installed as locations for vegetation assessment and soil sampling. In addition, water monitoring has occurred on six locations. For evaluation of student learning, surveys were administered in soil and conservation courses.

Results:
Student surveys:

- 15+ students in two courses (AGRO 2244, Soil Science; and AGEN 2263, Soil & Water Conservation)
- Scored from 1 (not familiar with topic) -4 (very familiar with it) regarding knowledge of concepts including BMP, CRP, RUSLE, TMDL, riparian buffer strip, conservation tillage, soil carbon sequestration, nutrient management plan (selected examples)
- Score increased from 2.27 to 2.86 post-course

Soil sampling and Transect Analysis:

- 64 composite soil samples taken along transects
- 16 stream profile transects taken (0.25-m increments)
- 16, 30-m long species index transects taken (0.50-m increments)
- Two laboratory field trips taken to the site where students collected soil samples, measured profiles, and toured all four treatment areas observing the treatments. Students also processed a few soil samples.

- Data analysis is underway.

Water quality measurements:

- 6 sets of low flow grab samples were collected
- 12 rain events were collected, but only 5 of the rain events produced adequate amounts of water samples from all three sets of samplers.
- Water sample analyses is underway.

Conclusions:

While much of the data analyses are still underway, the project has been a success already in terms of highlighting the issue of stream erosion on pastureland and its remediation in southeast Arkansas. The project was features several times in news outlets and a species field day for representatives of federal and state agencies was conducted early during the project term. Data analysis will be completed within the next few months.

Continued investigation of land use and best management practices on the Strawberry River Watershed

Basic Information

Title:	Continued investigation of land use and best management practices on the Strawberry River Watershed
Project Number:	2011AR313B
Start Date: End	3/1/2011
Date: Funding	2/29/2012
Source:	104B
Congressional District:	1st Congressional District of Arkansas
Research Category:	Water Quality
Focus Category:	Water Quality
Descriptors:	
Principal Investigators:	Jennifer L Bouldin, Richard AF Warby

Publications

1. Brueggen, T.R. Effects of Best Management Practices on the Upper Strawberry River Watershed, Fulton, CO, AR. Environmental Sciences, Arkansas State University. (anticipated).

Arkansas Water Resources Center 104B Program Project – March 2011 through February 2012

Project Title: Continued investigation of land use and best management practices on the Strawberry River Watershed

Project Team: Dr. Jennifer Bouldin, Environmental Biology, Arkansas State University
Teresa Brueggen, Environmental Sciences, Arkansas State University

Interpretative Summary:
Best Management Practices (BMPs) including exclusion of cattle from waterways, providing alternative watering facilities, and use of no-till planting methods have been put into place on three creeks in the upper watershed of the Strawberry River, AR. This study incorporates physical, biological and chemical analyses to determine the effects of the implemented BMPs on water and sediment quality of the three creeks. Protection of upper headwater streams will improve ecosystem integrity downstream in this Ecologically Sensitive Waterbody. This study has the potential to expand the knowledge base of improved water quality from stream-side agricultural BMPs.

Introduction:
The Strawberry River Watershed is located in the Ozark Highland Ecoregion of Arkansas and defined as an Extraordinary Resource Water, Ecologically Sensitive Water Body, and Scenic Waterway (ADEQ, 2008). The waters of the Strawberry River support a diversity of species including the endogenous Strawberry River Darter, diverse communities of aquatic macroinvertebrates including several ranked or listed freshwater mussels (Harp and Robinson, 2006). The ADEQ (2008) defines the designated uses for the Strawberry River as Primary and Secondary Contact Recreation, Domestic, Industrial and Agricultural Water Supply. Seven reaches of the Strawberry River Watershed are included in the 303d list as not supporting aquatic life due to excess turbidity (ADEQ, 2008). Land use in the watershed is primarily forested (56.5%) and grassland (35.3%) (ADEQ, 2003), with livestock grazing and hay harvesting for livestock common among the grassland owners. Grazing practices often do not include fencing from the streambed leading to increased bank sloughing. Best Management Practice implementation is presently underway in the upper watershed and landowner participation is encouraged through an EPA 319 grant issued to the Fulton County Conservation District and Arkansas State University. Upstream and downstream monitoring sites are located on Little Strawberry, Greasy Creek and Sandy Creek.

Methods:
Erosion pins were used to assess bank stability and estimate sediment transport from bank erosion. Multiple pins were installed perpendicular into the stream bank. These pins have been installed at the active bank and above the active bank determined at each designated sampling location (Zaimes et al., 2005). A survey of each stream reach will quantify the extent of stream with bank instability. Benthic surveys will be performed with D-frame nets using the traveling kick method. Organisms will be keyed to species according to Merrit et al. (2008) whenever possible and 10% of samples will be referred to a benthic taxonomist for Quality Assurance of identification. Enumeration of *E. coli* and measures of chlorophyll *a* will be determined monthly. *Escherichia coli* and chlorophyll *a* concentrations will be determined using the filtration technique in accordance with the American Public Health Association (APHA, 2005).

Aqueous and sediment toxicity studies will be performed in the fall and spring. Bioassays will be used to measure the presence of toxicity. *Ceriodaphnia dubia* and *Pimphales promelas* will be used in whole effluent toxicity (WET) 7-d chronic tests, in accordance with the EPA guidelines (2002) to determine aqueous toxicity. Presence of sediment toxicity will be measured using *Chironomus dilutus* with a 10-d acute toxicity test in accordance with EPA guidelines (2000).

Results:
Approximately 5480 m of stream bank was assessed within the Little Strawberry Creek. It was determined that there 14 percent was severely or very severely eroded, up four percent from 2010. Approximately 6340 m of stream bank were assessed of Greasy Creek subwatershed. Nine percent was determined to be severe or very severely eroded, up one percent from 2010. Approximately 13260 m of stream bank was assessed of Sandy Creek subwatershed of which four percent was determined to be classified as severely or very severely eroded, same as the previous year. Four assessments have been made of stream bank stability through the use of erosion pins. Since the installation in 2010, the greatest recorded loss of stream bank has been 202.5 (mm) in the Sandy Creek subwatershed.

Benthic macroinvertebrate collections took place in spring and fall 2011. Sandy Creek upper site was not sampled fall 2010 and 2011 due to dry conditions. The following orders have been found: Coleoptera, Diptera, Ephemeroptera, Hemiptera, Lepidoptera, Megaloptera, Odonata, Plecoptera, Trichoptera, Decapoda, and Mollusca. Fifty percent of locations experienced a decrease in family diversity from those determined in 2010 (Fig 1). Fifty percent of locations experienced an increase in family diversity from those determined in 2010 (Fig 2). *E. coli* mean values ranged from 286-756 colony forming units (CFUs). There were multiple collection events, at every sampling location, where levels exceeded the single sample concentration allowable limits (APCEC, 2011). In spring 2011, significanlethal aqueous toxicity, using *P. promelas,* was detected in Sandy Creek upper site. Also in spring 2011 all sites, with the exception of Sandy Creek upper, experienced significant sublethal sediment toxicity. No toxicity was detected in fall 2011 samples.

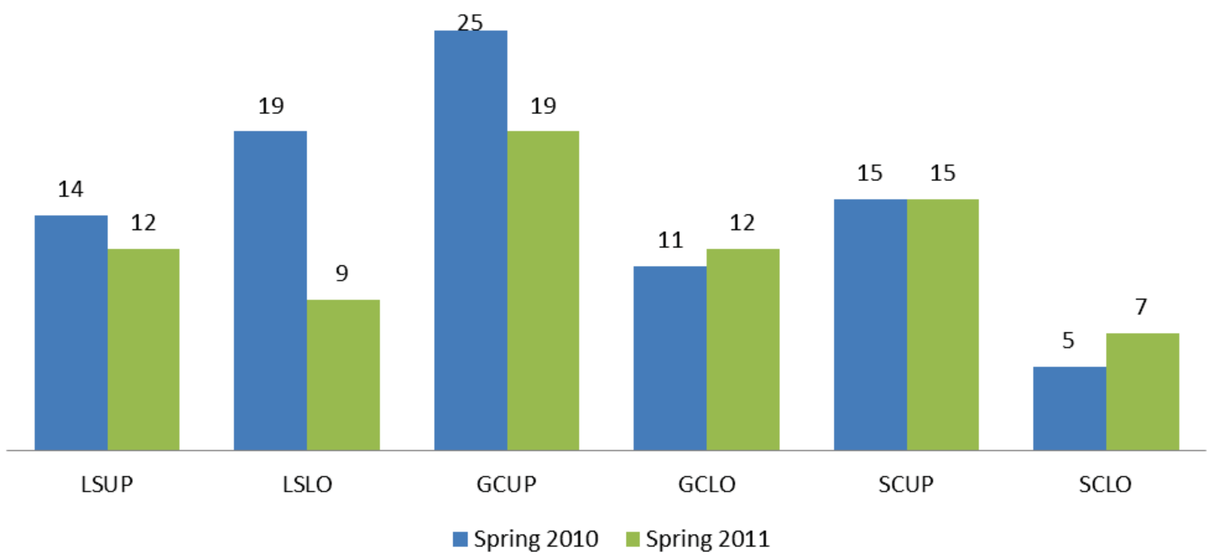

Figure 1: Comparison of 2010 and 2011 family diversity for spring collections

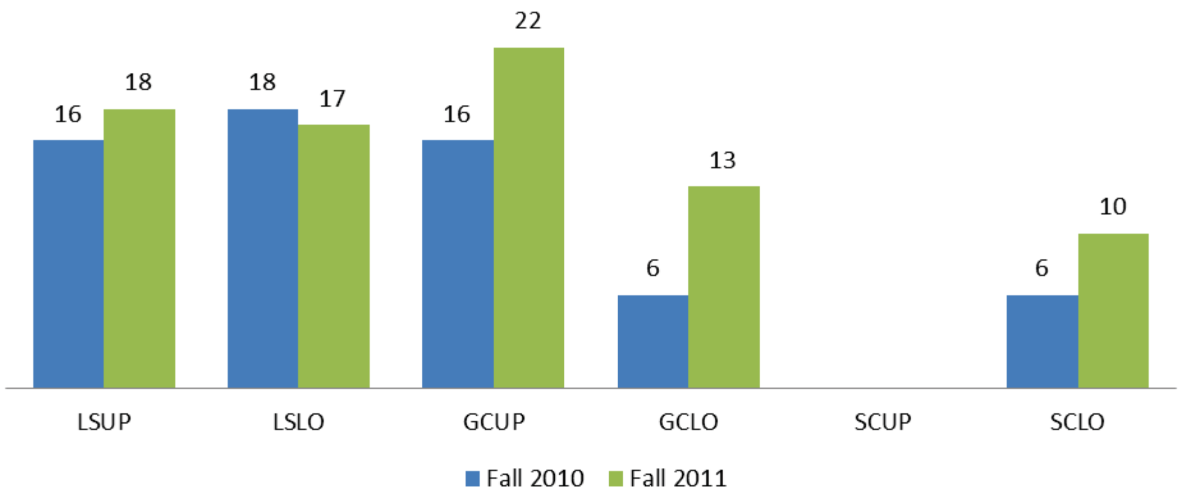

Figure 2: Comparison of 2010 and 2011 family diversity for fall collections. SCUP not sampled due to dry sampling location.

Conclusions:

This is an ongoing study; therefore, final conclusions are limited. It is evident that multiple years of analysis assessing physical, chemical and biological parameters are vital to evaluate the impact of implemented BMPs. Much variability can occur from year to year as environmental parameters outside of the researcher's control fluctuate (e.g. rainfall, temperature).

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Research Publications Stemming from this Project:

Brueggen, T.R. Effects of Best Management Practices on the Upper Strawberry River Watershed, Fulton CO, AR. Environmental Sciences, Arkansas State University. (anticipated)

Assessment of the microbial population in Beaver Lake swim beach regions to determine origin of fecal pollution

Basic Information

Title:	Assessment of the microbial population in Beaver Lake swim beach regions to determine origin of fecal pollution
Project Number:	2011AR317B
Start Date: End	3/1/2011
Date: Funding	2/29/2012
Source:	104B
Congressional District:	3rd Congressional District of Arkansas
Research Category:	Water Quality
Focus Category:	Non Point Pollution, Water Quality, Recreation
Descriptors:	
Principal Investigators:	Kristen Elizabeth Gibson, Steven Ricke

Publications

There are no publications.

Arkansas Water Resources Center 104B Program Project – March 2011 through February 2012

Project Title: Assessment of the microbial population in Beaver Lake swim beach regions to determine origin of fecal pollution

Project Team: Kristen E. Gibson, Department of Food Science, University of Arkansas
Steven C. Ricke, Department of Food Science, University of Arkansas

Interpretative Summary:
Recreational swim beach closures due to elevated levels of *Escherichia coli* occur each year in Beaver Lake located in Northwest Arkansas. *E. coli* may indicate presence of pathogens and thus pose a health risk. Here, an ultrafiltration method was applied for the recovery of microorganisms in 60L water samples collected from 4 swim beaches over a 12-month period. Eighty- four samples have been collected—21 from each site—with 3 more collection days planned until the end of June. Thus far, only one site has exceeded the limit for *E. coli* while each site has exceeded the limit for enterococci at least once. In addition, 32 samples have been analyzed by real time PCR for viruses with 50% (16 of 32) of samples positive for one or more of the virus targets.

Introduction:
In northwest Arkansas (NWA), Beaver Lake Reservoir serves as a drinking water supply for more than 250,000 people residing in the Beaver Water District and offers recreational opportunities for nearby residents and seasonal tourists. However, recreational swim beach closures due to elevated levels of *Escherichia coli* occur each year at Beaver Lake. High levels of *E. coli* may indicate presence of human pathogens and thus pose a health risk to those using the lake for recreational purposes. In addition, to help prevent these closures from happening, identification of the primary origins/sources of fecal pollution is needed. By identifying the source, potential mitigation strategies may be better informed and directed. Therefore, in this study, an optimized tangential flow ultrafiltration (TFU) method was applied for the concentration and recovery of each class of microorganism from large volume (60 L) water samples collected from 4 swim beach areas in Beaver Lake over a 12-month period.

Methods:
Water samples (60 L) were collected on a biweekly basis from 4 swim beach areas [War Eagle (WE), Rocky Branch (RB), Prairie Creek (PC), Horseshoe Bend (HB)] in Beaver Lake beginning in July 2011. Samples were collected from swim beaches by boat using a submersible pump and 20 L collapsible, polypropylene carboys. Large-volume samples were then stored at 4°C until processing by the TFU method. During the collection of large volume samples, 400 mL grab samples will be collected in sterile Nalgene bottles for the analysis total coliforms/*E. coli* and enterococci. The grab samples were transported to the lab in a cooler at 4°C and processed within 6 hours. Water quality parameters were collected at the time of sampling using a Hydrolab DS5X to measure temperature, conductivity, dissolved oxygen, pH, chlorophyll-a, and oxidation reduction potential. Additional reservoir information including daily precipitation and mean daily water inflow for the watershed will be obtained from the Little Rock USACE Reservoir Information Recording and Monthly reports available online. UV index will be obtained from local weather forecasts.

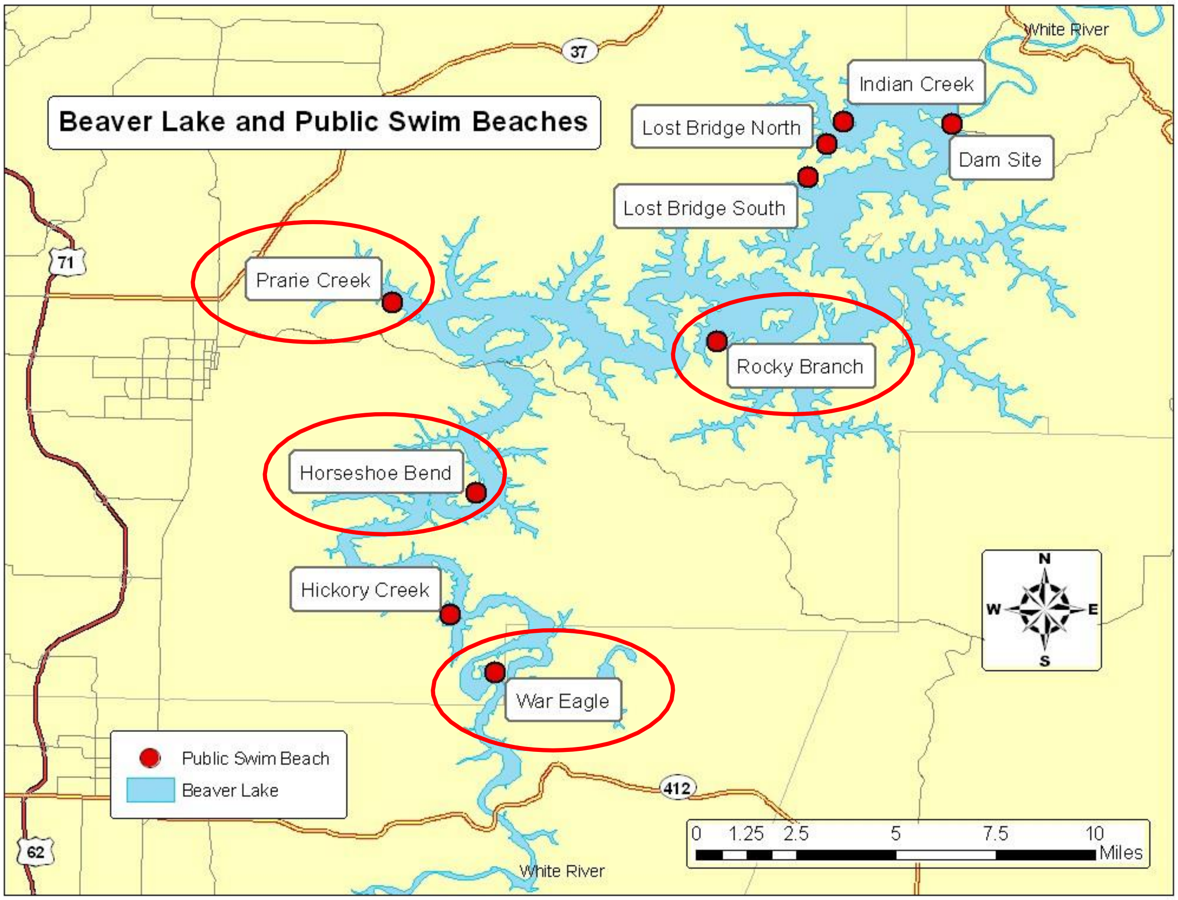

Figure 1. Map of Beaver Lake study area.

Each water sample (60 L) was transferred into a sterilized, 120 L polypropylene storage container. The chemical surfactant sodium polyphosphate (NaPP) (Sigma, St. Louis, MO) was added to each sample to achieve a final concentration of 0.01%. Each sample was allowed to equilibrate at room temperature for 30 min prior to TFU. The samples were processed using the method described in Gibson and Schwab (2010b). Filtration was performed until approximately 200 to 300 mL concentrated sample remains in the ultrafiltration system. The TFU concentrate was further processed by a secondary concentration step (Gibson and Schwab 2010b) and total nucleic acid (RNA and DNA) extraction as describe in Lambertini et al. (2008). For detection and enumeration of total coliforms and *E. coli*, Colilert™ Quanti-tray® system (IDEXX Laboratories, Westbrook, ME) was used to determine the Most Probable Number (MPN) in each sample before and after UF. Enterolert™ Quanti-tray® system was used to determine the MPN for enterococci in each sample before and after UF. A negative control containing 100 ml 0.1% peptone was analyzed by Colilert™ and Enterolert™ for each batch of samples. Microorganisms selected for use in fecal source tracking are listed in Table 1. Each target will be analyzed using real time PCR (qPCR) for DNA or real time reverse transcription PCR (qRT-PCR) for RNA. Sample inhibition analysis is being performed on the nucleic acid extract for each processed water sample as described in Gibson et al. (2010a).

Target microorganism and/or gene	Primary Origin
F-specific RNA coliphage GI and GIV	animal
F-specific RNA coliphage GII and GIII	human
human polyomavirus JC and BK	human
human norovirus GI and GII	human
human adenovirus	human
porcine adenovirus	porcine
bovine polyomavirus	bovine
bovine enterovirus	bovine
Bacteroidales (CGOF1-*Bac*, CGOF2-*Bac*, and CG-*Prev* f5)	geese
Brevibacterium avium	chicken

Table 1. Target microorganisms for determining source of fecal pollution in Beaver Lake.

Results:

Currently, 84 samples have been collected—21 from each site—with 3 more collection days planned from now until the end of June. Each sample was analyzed for *E. coli* and enterococci before and after TFU. Results for *E. coli* and enterococci levels at each swim beach across sampling dates are shown in Figures 2A and 2B, respectively. Thus far, only one sample site [WE] has exceeded the recreational water quality limit (126 CFU/100mL) for *E. coli* while each site has exceeded the limit for enterococci (33 CFU/100mL) at least once. Data indicate that the sample site influenced more by inflow of the White River [site WE] has on average higher levels of *E. coli* (31.3 MPN/100mL) and enterococci (29.5 MPN/100mL) compared to levels at swim beaches influenced primarily by recreational use [HB, RB] and/or urban drainage [PC] with 4.5 and 6 MPN/100mL for *E. coli* and enterococci, respectively. In addition, levels of *E. coli* at one sample site [WE] were significantly different ($p = 0.03$) between Summer (4.5 MPN/100mL) and Fall (33 MPN/100mL) and remained elevated through early Spring. In addition to fecal indicator bacteria (FIB), real time PCR and reverse transcription (RT) PCR analysis of the following human and animal viruses, bacteriophage, and bacterial 16S gene markers are ongoing: human norovirus [HuNoV; GI and GII], polyomavirus [HPyV] and adenovirus [HAdV]; bovine enterovirus [BEV]; porcine adenovirus; F+ RNA bacteriophage [GI – GIV]; *Brevibacterium* poultry marker; and *Bacteroides* goose marker. Thus far, 32 samples have been analyzed by real time PCR for HuNoV [GI and GII], HPyV, HAdV, and BEV with 50% (16 of 32) of samples positive for one or more of the virus targets. Six of the positive samples are from PC while there are four positive samples each from WE and HB and 2 positive samples from RB. Upon completion of all analyses, PCR results for human viruses will be compared to FIB levels to determine if there is any correlation between indicators and pathogens. PCR data will also being used to help determine primary sources of fecal pollution at each swim beach. Water quality parameters collected at each site during sampling will also be analyzed for correlation with both FIB levels and presence of viruses. Additionally, rainfall data will also be included in analyses.

A.

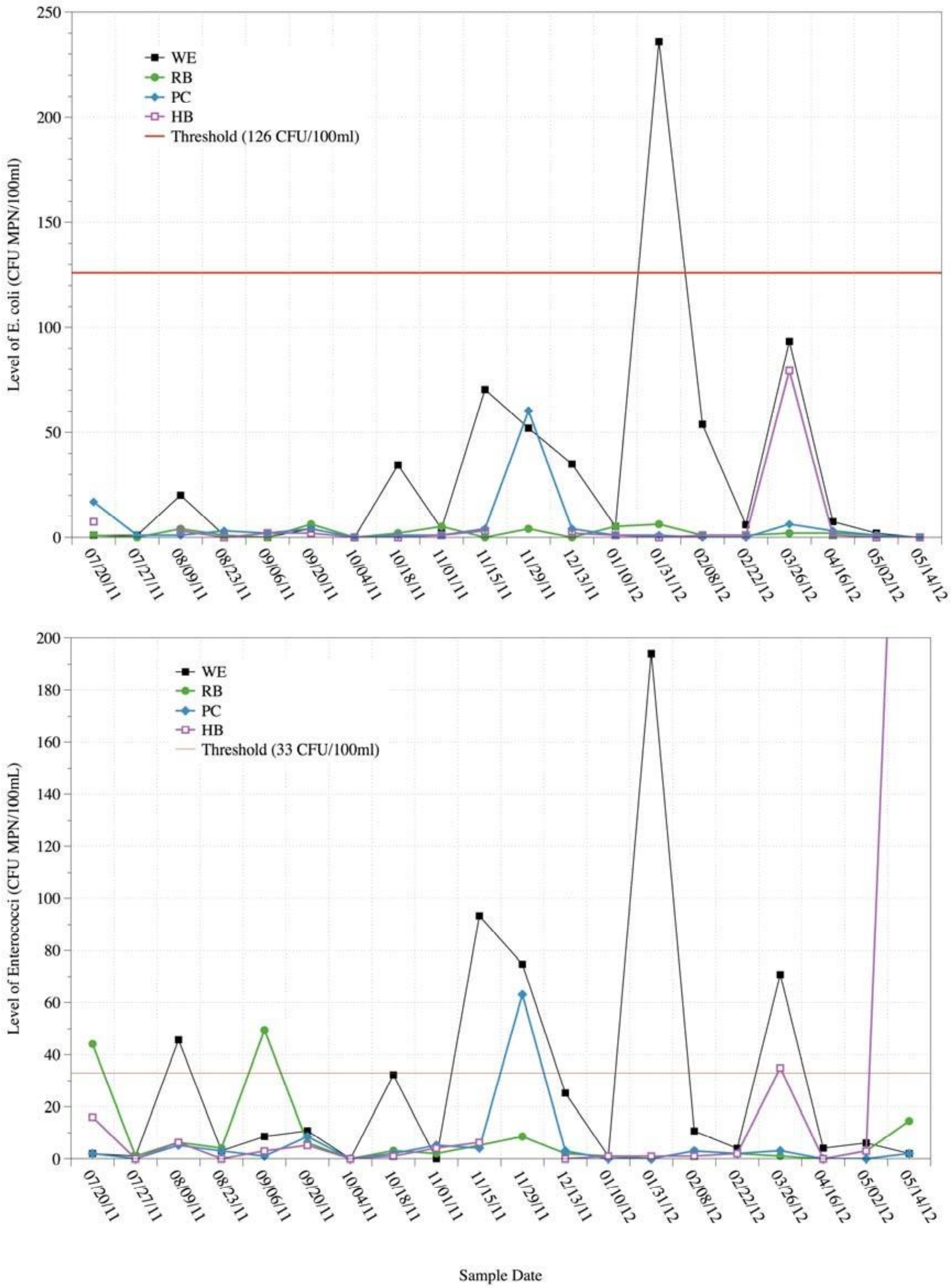

Figure 2. Levels of fecal indicator bacteria at four Beaver Lake swim beaches over time. A) *E. coli*, B) Enterococcus. WE = War Eagle, RB = Rocky Branch, PC = Prairie Creek, HB = Horseshoe Bend; CFU = colony forming unit; MPN = most probable number.

Conclusions: Beaver Lake reservoir is both a critical water supply and an economic asset for NWA and this research will assist in the formation of effective control measures for reducing swim beach closures as well as provide a better understanding of the actual health risk posed by elevated levels of FIB. Future research should involve 1) long-term, comprehensive sampling at all swim beach areas in Beaver Lake and 2) development of microbial risk assessment models for each swim beach.

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Information Transfer Program Introduction

Dissemination of information is one of the main objectives of the Arkansas Water Resources Center (AWRC). AWRC sponsors an annual water conference held in Fayetteville, AR. The 2011 conference focused on "The Illinois River and the Statement of Joint Principles and Actions--What's Next?" The conference drew approximately 125 researchers, students, agency personnel, and interested citizens from Arkansas and Oklahoma to hear about this hot topic and other research in water resources throughout the state. AWRC also co-sponsors workshops and other water related conferences in the state and region.

The AWRC maintains a technical library containing over 900 titles, many of which are available online. This valuable resource is utlized by a variety of user groups including researchers, students, regulators, planners, lawyers and citizens. Many of the AWRC library holdings have been converted to electronic PDF format which can be accessed via the AWRC website at http://www.uark.edu/depts/awrc/pubs_ar.html. AWRC is continuing to add archived documents from the library to this electronic data set, and all new titles are added when received.

AWRC maintains an active website which is updated at least quarterly (www.uark.edu/depts/awrc). The website announces AWRC-related activities including conference announcements. The website is also home to the AWRC library listings and the AWRC Water Quality lab webpage. AWRC is also on facebook at http://www.facebook.com/pages/Arkansas-Water-Resources-Center/206554789388630.

Arkansas Water Resources Center Information Transfer Program

Basic Information

Title:	Arkansas Water Resources Center Information Transfer Program
Project Number:	2011AR320B
Start Date: End	3/1/2011
Date: Funding	2/29/2012
Source:	104B
Congressional District:	3rd Congressional District of Arkansas
Research Category:	Not Applicable
Focus Category:	Surface Water, Water Quality, Water Use
Descriptors:	None
Principal Investigators:	Brian E. Haggard

Publications

1. Haggard, BE and JT Scott. 2011. Phosphorus Release from Bottom Sediments at Lake Wister, Oklahoma, Summer 2010. Arkansas Water Resources Center, Fayetteville, Arkansas. MSC Publication 364. 13 pp.
2. Brion, G., K.R. Brye, B.E. Haggard, C. West, and V. Brahana. 2011. Land-use effects on water quality of a first-order stream in the Ozark Highlands, Mid-Southern United States. River Research and Applications 27(6): 772-790
3. David, M.M., and B.E. Haggard. 2011. Development of regression-based models to predict fecal bacteria numbers at select sites within the Illinois River Watershed, Arkansas and Oklahoma, USA. Water, Air and Soil Pollution 215: 525-547
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5. Giovanetti, J., L.B. Massey, B.E. Haggard, and R.A. Morgan. 2011. Land use effects on stream nutrients at Beaver Lake Watershed. Journal of the American Water Works Association [Revised, Submitted]
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7. Huffhines, B., K.R. Brye, B.E. Haggard, and R.A. Morgan. 2011. Net nutrient uptake in the White River, Northwest Arkansas, downstream of a municipal wastewater treatment plant. Journal of Environmental Protection 2: 255-270.
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11. Rogers, C.W., A.N. Sharpley, B.E. Haggard, J.T. Scott, and B.M. Drake. 2011. Physicochemical characterization of sediment in northwest Arkansas streams. Journal of Environmental Protection 2:629-638.
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13. Toland, D.C., Haggard, B.E., and Boyer, M.E. 2011. Evaluation of nutrient concentration in runoff water from green roofs, conventional roofs and urban streams. Transactions of the American Society of Agricultural and Biological Engineers [Accepted]
14. Cotton, C. and B. Haggard. 2011. Factors that contribute to turbidity on the West Fork of the White River in Arkansas. Discovery – The Student Journal of Dale Bumpers College of Agricultural, Food and Life Sciences 12:3-13
15. Anderson, J., B. Haggard, R. Kolka, D. Meals, and M. Tomer (authors in alphabetical order). 2011. External Pioneer Farm Review, Final Report, University of Wisconsin–Platteville, Pioneer Farms, Platteville, Wisconsin.
16. Bailey, B., L. Massey, and B. Haggard. 2011. Water Quality Trends across Select 319 Monitoring Sites in Northwest Arkansas. Final Report Project #09-400, Arkansas Natural Resources Commission, Little Rock, Arkansas.
17. Haggard, B., T. Scott and M. Evans-White. 2011. Database Analysis to Support Nutrient Criteria Development, Final Report, Texas Commission on Environmental Quality, Austin, Texas, 181 pages.
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21. Busch, D., P. Parker, B. Haggard, and B. Barnet. Alternative Methods for Monitoring Surface Water Runoff from Agricultural Fields. ASA – CSSA – SSSA, San Antonio, Texas – October 2011
22. Haggard, B., T. Scott, A. Sharpley, and J. Romeis. Stream Phosphorus and Nitrogen Trends in a Watershed under a Court Mandated Index. ASA – CSSA – SSSA, San Antonio, Texas – October 2011
23. Sharpley, A., M. Cochran, M. Daniels, B. Haggard, M. Matlock, T. Riley, and D. Saraswat (authors are alphabetical order after the first author). 2011. The Role of Nonpoint Source Models in Watershed Management. UA Division of Agriculture, Policy Center Fact Sheet FSPPC112.

Student Support

Category	Section 104B Grant	Section 104 NCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate	26	0	0	0	26
Masters	8	0	0	0	8
Ph.D.	3	0	0	0	3
Post-Doctoral	1	0	0	0	1
Total	38	0	0	0	38

Notable Awards and Achievements

2011 Biological and Agricultural Engineering Department – Research Award, Dr. Brian Haggard, Director, Arkansas Water Resources Center.

Dr. Kristen Gibson's work on presence of fecal indicator bacteria and pathogenic microorganisms at recreational beaches in Beaver Lake in Northwest Arkansas was featured on KUAF Ozarks at Large and on two news stations, KTHV-TV in Little Rock and KOLR-TV in Springfield, MO.

Teresa Brueggen won 2nd place student award for platform presentation – MidSouth Society of Environmental Toxicology and Chemistry, Jonesboro, AR, 19-20 May 2011 for her work on the project "Continued Investigation of Land Use and Best Management Practices on the Strawberry River".

Dr. Thad Scott, Assistant Professor of Environmental Water Science at the University of Arkansas, was awarded the 2011 NIWR IMPACT Award for his project "Denitrifictation, Internal Nitrogen Cycling, and Nitrogen Retention in River Impoundment Reservoirs" (2010AR252B). This study examined the role of sediment denitrification in N retention in reservoirs and resulted in recommendations for reservoir management that could enhance permanent N removal from reservoir waters through denitrification. These recommendations should be incorporated into reservoir management plans in order to maximize N retention and thereby decrease N export to downstream coastal environments. Dr. Scott represented the Great Plains Region in the competition.