Iowa Water Center
Annual Technical Report
FY 2008

Introduction

The Iowa Water Center is a multi-campus and multi-organizational center focusing on research, teaching and outreach activities. The Center s goal is to encourage and promote interdisciplinary, inter-institutional water research that can improve Iowa s water quality and provide adequate water supplies to meet both current and future needs of the state. The Iowa Water Center continues to build statewide linkages between universities and public and private sectors and to promote education, research, and information transfer on water resources and water quality issues in Iowa. The Center also plays a vital role in identifying critical water research needs and providing the funding or impetus needed to initiate research that cannot or is not being conducted through other means.

Water quality remains a critical concern in Iowa. While our understanding of nutrient and sediment movement processes and how these materials affect Iowa's surface and ground water is improving, we do not fully understand a variety of issues linking land management and water quality at multiple scales. This is particularly important because Iowa is repeatedly identified as a major contributor of nutrients and sediment to the Gulf of Mexico where hypoxia research continues. There are numerous research questions that are critical to understanding Iowa's water quality issues and the state's contributions to regional problems. The Iowa Water Center plays a role in addressing these questions through administering the 104B program and garnering additional funds for other research projects.

Research Program Introduction

Introduction of Research Program

Sediment and nutrients are among the greatest water quality impairments facing the water bodies of the United States. Human activities have altered stream hydrology that affects water quality. Stream sinuosity, nutrient loads, habitat, biota, temperature, energy profile and hydrographs, and other physical, chemical, and biological characteristics have been influenced anthropogenically.

The focus of the 2009-2010 Iowa Water Center research program is on stream dynamics affecting water quality. We are interested in addressing related questions including, but not limited to:

How do natural vs channelized stream beds influence water quality and restoration potential?

How does stream channelization influence water quality?

How does impoundment alter stream dynamics and water quality?

We were able to fund one new project and continue funding for an existing two-year project.

Effects of managed riparian buffers on the integrity of stream systems: a biological assessment using fish and invertebrate communities

Basic Information

Title:	Effects of managed riparian buffers on the integrity of stream systems: a biological assessment using fish and invertebrate communities
Project Number:	2007IA117B
Start Date:	3/1/2007
End Date:	5/1/2008
Funding Source:	104B
Congressional District:	4
Research Category:	Water Quality
Focus Category:	Water Quality, Agriculture, Management and Planning
Descriptors:	
Principal Investigators:	Michael Carl Quist

Publication

IWC Annual Report

PIs: Michael Quist, Timothy Stewart, and Thomas Isenhart

June 2009 (for report period March 1, 2008—February 28, 2008)

Problem and Research Objectives

Large-scale changes in land use, stream channelization, and removal of riparian vegetation increase nutrient and sediment loading and solar irradiance that eliminate aquatic habitat, elevate water temperatures, and reduce dissolved oxygen concentrations. Pesticides and fertilizers may also threaten human health when they enter aquatic ecosystems (e.g., facilitation of toxic algae blooms). Despite the best efforts of government agencies and producers, significant reductions in sediment and chemical inputs are unlikely to be achieved through traditional, in-field management practices alone. Recognizing these limitations, public agencies are increasingly using conservation buffer practices such as riparian buffers, consisting of woody and nonwoody vegetation, to reduce nutrient, sediment, and pesticide inputs to streams. Nearly 2,000 km^2 of landscape buffers have been established in Iowa since the Continuous Open Enrollment of the Conservation Reserve Program was implemented in 1996, with most of these being riparian forest buffers or similar streamside buffers. In Iowa, benefits of re-establishing riparian forest buffers have been documented in recent studies by the Agroecology Issue Team at Iowa State University. Although work has documented significant reductions in nutrient and sediment loading to streams, critical knowledge gaps remain on the response of biological communities to management practices in Bear Creek. Because organisms are now acknowledged to be definitive indicators of water quality and ecosystem health, they are increasingly being used for regulatory assessments by the U.S. Environmental Protection Agency and are likewise essential tools for assessing riparian buffer effectiveness. Therefore, the objective of this project is to quantify the effects of riparian buffer systems on instream habitat and aquatic organisms. Relationships between riparian features (e.g., riparian conservation buffers), in-stream habitat characteristics (e.g., substrate composition), fish abundance, diversity, and growth, and aquatic invertebrate abundance and diversity are being used to assess effects of conservation practices on water quality and ecosystem integrity. Results of this research will be used to help guide management actions on small streams in central Iowa and will provide important insights that can be used when considering similar management practices across the Midwest.

Methodology

Fish assemblages and instream habitat features were characterized from 42 reaches (June-August 2007) in three stream systems, including Bear, Long Dick, and Kiegley Branch creeks. Bear Creek has received extensive riparian habitat enhancement. Land use in the Long Dick and Kiegley Branch creek watersheds is nearly identical to Bear Creek, but they have not yet been the focus of extensive streamside conservation practices. In addition to having similar land uses, soil types, and climate, the streams have similar connectivity to potential source populations (i.e., South Skunk River) of fishes and invertebrates. Twenty-one reaches were sampled from Bear Creek (13 buffered sites; 8 unbuffered sites), 11 reaches from Long Dick Creek (1 buffered site, 10 unbuffered sites), and 10 reaches from Kiegley Branch Creek (3 buffered sites, 7 unbufferd sites).

Fish were collected using standard sampling procedures developed by the Iowa Department of Natural Resources (IDNR) for biological assessment of wadeable streams. Specifically, fish were sampled using a backpack-mounted electrofishing unit, identified to species in the field, and measured (body length). Voucher specimens were preserved in 10% formalin. Scales and otoliths were removed from a sub-sample of central stonerollers and creek chubs for age and growth analysis. In addition to sampling fishes, aquatic invertebrates were sampled from one half of the reaches where fish were sampled. Similar to fish sampling, standard protocols developed by the IDNR for biological assessment were used for aquatic invertebrate sampling. Samples were preserved in 5% formalin and processed in the laboratory.

Physicochemical features in individual macrohabitats (i.e., pools, riffle, runs) were measured at each sampling reach. Percent cover of the streambed by different inorganic particle-size classes (e.g., cobble, silt) and instream cover (e.g., large wood debris) were measured using standard transect-based sampling techniques. In addition, mean and maximum depth, mean wetted width, streambed topographic complexity, and canopy cover were also estimated for each macrohabitat in the reach.

Principal Findings and Significance

During the first year of the project, all field sampling was completed. All of the fish-related data have been processed and the aquatic invertebrate samples have been sorted. Although we are still analyzing the instream habitat and macroinvertebrate data, several interesting patterns have emerged from preliminary analysis of the fishery data. For instance, run habitats typically had the highest number of fish species (mean = 8.9 species) across all stream reaches followed by pools (8.6 species) and riffles (7.3 species). Interestingly, stream reaches in Long Dick and Kiegley Branch creeks (i.e., streams with few riparian buffers) typically had more species than stream reaches in Bear Creek. Species richness was highest in Kiegley Branch (mean =13.7 species), followed by Long Dick Creek (11.9 species) and Bear Creek (9.1 species). This result is likely due to the addition of a few species highly tolerant of environmental degradation. Creek chubs (frequency of occurrence = 29%), bluntnose minnows (21%), bigmouth shiners (8%), and white suckers (7%) were the most common species sampled across sites, but their dominance differed between reaches with and without riparian buffers. Sites with riparian buffers were dominated by creek chubs (27%), bluntnose minnows (16%), white suckers (8%), and common shiners (7%); whereas, the most common species in sites without riparian buffers were creek chubs (30%), bluntnose minnows (27%), bigmouth shiners (11%), and central stoneroller (7%). Creek chubs, bluntnose minnows, and Johnny darters were the most common species in run habitats, while creek chubs, bluntnose minnows, and white suckers were the most common species in pool habitats. Riffle habitats were dominated by bluntnose minnows, creek chubs, common shiners, and bigmouth shiners. Black bullheads, black crappie, blacknosed dace, common carp, largemouth bass, and shorthead redhorse were only sampled in pools and runs. Quillback carpsucker was the only species that was sampled in riffles but not in pool or run habitats.

All of the fish species sampled during the study are common in small streams across the Midwest. Most of the species are typically considered "generalists" by aquatic ecologists, and given the relatively harsh nature of prairie streams (i.e., temperature and flow fluctuations, low substrate diversity) and the long history of ecological degradation in the region, dominance by species tolerant of poor habitat quality is not surprising, particularly in areas lacking riparian buffers. In particular, we will be exploring relationships between fish and invertebrate communities and instream habitat using a number of univariate and multivariate statistical techniques (e.g., canonical correspondence analyses, cluster analysis). These analyses will better our understanding of the effects of riparian buffers on biotic communities and overall ecological health.

USGS Grant No. 07HQAG0163 Guidelines for Sampling and Averaging in Measurements of Discharge with Acoustic Doppler Current Profilers

Basic Information

Title:	USGS Grant No. 07HQAG0163 Guidelines for Sampling and Averaging in Measurements of Discharge with Acoustic Doppler Current Profilers
Project Number:	2007IA141S
Start Date:	9/1/2007
End Date:	12/15/2008
Funding Source:	Supplemental
Congressional District:	004
Research Category:	Engineering
Focus Category:	Surface Water, Hydrology, Methods
Descriptors:	
Principal Investigators:	Chris Robert Rehmann

Publication

1. Rehmann, C.R., D.S. Mueller, and K.A. Oberg, 2009. Measuring discharge with ADCPs: inferences from synthetic velocity profiles. In ASCE World Environmental and Water Resources Congress Proceedings, Kansas City, MO.

Iowa Water Center Final Report
Sampling requirements for discharge measurements with ADCPs
PI: Chris R. Rehmann
June 2009

Problem and Research Objectives

The U.S. Geological Survey (USGS) assesses water quantity in the United States by measuring river discharge at thousands of gaging stations. To verify the relations used to infer discharge from a measure of the water depth, the USGS regularly computes discharge from direct measurements of velocities at its stations. Recently the USGS has started using acoustic Doppler current profilers (ADCPs), which provide much more detail than traditional propeller meters, to measure velocity profiles across the river, and while the USGS has issued protocols for sampling with ADCPs, questions remain about the number of transects required, sampling time, the use of transects vs. profiles measured at fixed positions, etc. The objective of this project is to use synthetic velocity profiles to aid the USGS and others in determining protocols for measuring discharge with ADCPs.

Methods

Synthetic velocity profiles, for which the actual discharge is known exactly, are generated and used to test various methods of sampling. Two main types of sampling are simulated: section-by-section measurements, in which velocities are sampled at fixed points, and transects, in which velocities are measured while the instrument moves across the cross-section. In both cases, the simulated sampling follows typical USGS practice. Several effects are isolated and studied: the shape of the velocity profile, sampling at a fixed number of points, ADCP noise, and turbulence. For example, ADCP noise is specified as Gaussian noise, and turbulence is specified by imposing fluctuations that yield a given energy spectrum.

Principal Findings and Significance

Discharge measurements can have error even when the mean velocity profile is measured perfectly. Because the profile is measured at a finite number of points, error will result from the integration method even if ADCP noise and turbulence are not present. The mid-section method, which the USGS uses to compute discharge from velocity measured in several sections, is equivalent to the trapezoid rule, and it is slightly less accurate than Simpson's rule. For the section-by-section method applied to perfectly measured profiles, equal-width sections yield less error than equal-discharge sections for symmetric velocity profiles. For the range of parameters tested, when the number of profiles exceeds 15, the discharge error is less than 5% for equal-discharge sections and less than 2% for equal-width sections. Equal-width sections always underestimate the discharge, but equal-discharge sections overestimate for more peaked profiles.

Simulations of velocity measurements with ADCP noise yield insight into requirements for the number of samples to be acquired. With ADCP noise alone, the discharge error is a random variable whose mean converges to the value in the absence of noise—that is, the error caused by approximating the velocity profile with a discrete number of points. A theoretical expression for the variance can be derived that reproduces the results of the model within 3%. In particular, the variance in the discharge estimate is proportional to the noise variance and inversely proportional to the square root of the total number of samples.

The study of section-by-section measurements with ADCP noise and turbulence focused on the time required for the average error to converge to the value in the absence of noise and turbulence. Histograms of the averaging time are skewed toward high value; therefore, the required averaging time for any measurement can be much larger than the mean from many realizations. For the parameters considered, the averaging time required for a single profile measurement always exceeded the 40 s usually recommended for velocity measurements. The averaging time increases as the time scale of the large eddies, which is proportional to H/u_*, increases, and it also increases with sample interval. For a particular parameter range, the averaging time can be predicted with a simple expression. In general, section-by-section measurements must sample enough large eddies of the flow.

Simulations of transect measurements with noise and turbulence complement and extend the analysis of field data by Oberg and Mueller (2007). With appropriate choice of the boat speed and sample interval, one can measure the velocity profile at more points across the cross-section with transect measurements than with section-by-section measurements, but the averages to determine the mean velocity will have far fewer points in general. Simulations were run with the parameters from the data sets for modes 5, 11, and 12 in Oberg and Mueller (2007). Discharge error decreases with increasing number of transects and increasing total measurement duration. Calculations support the duration of 720 s recommended by Oberg and Mueller (2007). Also, the discharge error decreases as both the number of samples increases and as $u_* T_s/H$, which is related to the number of large eddies sampled, increases. For the cases simulated, errors remain less than 5% when the number of samples exceeds 7000 or $u_* T_s/H > 20$. Although the latter criterion requires more effort to apply, its key advantage is that it accounts for the physics of the flow being measured and therefore may be more general than a criterion based on measurement duration or number of samples.

These findings show that standard USGS approaches can be improved. The project has provided the USGS with a tool to guide discharge measurements. With improved sampling protocols and more accurate discharge measurements, estimates of water supply and water quantity across the United States will be more reliable.

Biomass Harvest and Nutrient Management Systems Impacts on Water Quality.

Basic Information

Title:	Biomass Harvest and Nutrient Management Systems Impacts on Water Quality.
Project Number:	2008IA126B
Start Date:	3/1/2008
End Date:	2/28/2010
Funding Source:	104B
Congressional District:	3
Research Category:	Water Quality
Focus Category:	Water Quality, Non Point Pollution, Nutrients
Descriptors:	None
Principal Investigators:	Antonio P. P. Mallarino, Matthew J. Helmers

Publication

PROGRESS REPORT

Iowa Water Center Project
Biomass Harvest and Nutrient Management Systems Impacts on Water Quality.

May 2009

Prepared by Antonio P. Mallarino and Matt J. Helmers

This project is evaluating impacts of selected crop, biomass harvest, and nutrient management systems on loss of N and P from fields with surface runoff and subsurface tile drainage. The two main objectives stated in the proposal are the following.

1. Determine dissolved reactive P, total dissolved P, algal-available P, total P, and total N concentrations and loads in surface runoff from corn production systems harvested for grain using different tillage and fertilizer or manure P management systems and from continuous corn harvested for grain and cornstalks.

2. Determine loss of nitrate, dissolved reactive P, and total dissolved P through subsurface tile drainage from crops of selected bioenergy production systems managed with fertilizer or manure N-P management systems.

The study also involves analyzing soil and harvested crop biomass for nutrient concentration and relating these results to treatment effects on N and P loss.

<u>Progress for Objective 1</u>.

The work has been conducted as planned for the runoff P study located in the Northwest Research and Demonstration Farm, where semi-automatic monitoring devices measure and collect surface runoff. Corn and soybean crops were planted and all nutrient management systems were applied, although soybean seedlings have not emerged yet. We are continuing the evaluations for a second year as planned. The experiment consists of five replicated treatments that include an N-based liquid swine manure management system for continuous corn managed with chisel-plow tillage, P-based fertilizer management for corn-soybean rotations managed with no-till or chisel-plow tillage, and P-based liquid swine manure management for corn-soybean rotations managed with no-till or chisel-plow tillage. Because the two crops of the corn-soybean rotations are grown each year, there are a total of 27 plots. Only grain is harvested from the corn-soybean rotations while both grain and a portion of the cornstalks of the continuous corn system are harvested. Seed funding from other sources were used to apply crop and nutrient treatments for the first time in 2007, and to collect and analyze soil and surface runoff during the first year. Water Center funds have been used since spring 2008 mainly to collect and analyze new soil and runoff samples. Remaining IFLM funds have been used to establish crops, apply treatments, maintain surface runoff monitoring systems, and both sample and analyze crop biomass.

We completed analysis for P and other nutrients in profile soil samples that had been collected from all plots before the treatments were first applied (from depths 0-2, 2-6, 6-12, 12-24, and 24-36 inches), and also in surface samples collected in Fall 2007 and Fall 2008 from two soil depths (0-2 and 2-6 inches) of all plots. The samples were analyzed by three soil-test P methods in order to study treatments effects on soil P and to decide P application rates. These results will be useful to help interpret cropping and P fertilizer/manure management effects on P loss with surface runoff.

Concerning surface runoff, we have completed runoff P analyses of all samples collected in 2008 and from the single runoff event (from snowmelt, in mid February) for this year until the time this report is being written (first week of May). These analyses included dissolved reactive P (in samples filtered using a 0.45 μm filter), algal-available P (estimated by the iron oxide-impregnated paper test), and total P. Analyses for runoff for sediment and total N concentrations as well as analyses for nutrient concentration of harvested biomass continue at this time and available data have not been summarized.

No statistical analysis has been conducted for available runoff P data, so no strong conclusions can be drawn at this time. However, results indicate that, as expected, sediment loss has been greater for soybean residue and chisel-plow management than for corn residue and the no-till treatments but there were small and inconsistent differences among the nutrient management systems. Concerning runoff P loss, results indicate less loss with no-till than with tillage for soybean residue, but small and inconsistent tillage effects for corn residue and also inconsistent differences between the fertilizer and swine manure P management systems. Comparisons of analyses for dissolved reactive P and total dissolved P in runoff from selected treatments indicate that the differences between these two P fractions varied greatly across treatments and runoff events. Sometimes these two fractions were almost similar (most or all dissolved P was dissolved reactive P) but sometimes total dissolved P was as much as twice the concentration of dissolved reactive P. We continue studying results, but such a result is important because dissolved P that is not measured as dissolved reactive P can be readily available for algae growth.

Progress for Objective 2.

The work has been conducted as planned for the subsurface tile drainage study site in the Agronomy and Agricultural Engineering Research Farm in central Iowa. Corn and soybean crops were planted and all nutrient management systems were applied, although soybean seedlings have not emerged yet. We are continuing the evaluations for a second year as planned. Treatments include eight systems replicated three times that include three continuous corn systems with commercial fertilizer N-P management with corn harvested for grain, partial stover removal, and total aboveground biomass removal; two continuous corn systems with liquid swine manure N-based management with corn harvested for grain or total biomass; one corn-soybean rotation system with liquid swine manure N-based management with corn and soybeans harvested for grain, one for switchgrass harvested for biomass with N-P management to switchgrass removal rates, and one for switchgrass harvested for biomass to remove nutrients and reduce N and P loss from soil with a history of large and frequent manure applications. In-kind contributions from the ISU Research Farms and from the IFLM program of IDALS were used in Spring 2008 establish the crops and the drainage monitoring systems, to apply the nutrient management systems for the first time, to sample and analyze the tile drainage for dissolved reactive P and nitrate. Plots with corn were chisel-plowed and disked in spring, soybean residue was disked in spring, and both fertilizer and manure were applied in the spring and incorporated into the soil. Water Center funds were used to hire labor for the field work during the season, to sample and analyze surface soil samples, and to begin analyzing soil samples for routine fertility tests and tile drainage samples for total dissolved P.

Until late November we had collected about 700 water samples from about drainage 30 events which resulted in drainage from most plots. Laboratory analyses of the spring and early summer water samples have been completed. We continue analyses of samples form more recent events, and only nitrate data for the early spring water samples have been summarized at this time. The early results suggest larger nitrate loss for the fertilizer management systems than for the swine manure systems and lowest loss for the switchgrass systems. These results suggest that swine manure N was less available for leaching through the soil profile than the fertilizer N. There were small differences between the cropping and harvest systems that cannot be interpreted with certainty until more recent samples are analyzed and statistical analysis are completed. Analyses for dissolved reactive P and total dissolved P in tile drainage indicate that the differences between these two P fractions varied greatly across treatments and flow events. Usually these two fractions were similar but sometimes total dissolved P was as much as twice the concentration of dissolved reactive P. These early results must be interpreted with caution because no statistical analyses have been conducted and the treatment effects may change during late summer and fall or the next year.

Plans for the future.

The work will continue this spring and beyond at both study sites mainly by monitoring and collecting runoff and drainage water and by continuing analyses of already collected runoff samples, drainage samples, and crop biomass samples collected last fall.

Development of Explicit Margin of Safety Methodology for Sediment TMDLs

Basic Information

Title:	Development of Explicit Margin of Safety Methodology for Sediment TMDLs
Project Number:	2008IA132B
Start Date:	3/1/2008
End Date:	2/28/2009
Funding Source:	104B
Congressional District:	4
Research Category:	Not Applicable
Focus Category:	Methods, Models, Sediments
Descriptors:	None
Principal Investigators:	Amy Kaleita, James K. Newman

Publication

1. Newman, J.K, and A. Kaleita. 2009. Quantifying uncertainty of sediment TMDLs using GeoWEPP. Presented at the 2009 Annual International Meeting of the American Society of Agricultural and Biological Engineers, June 22-24, Reno NV. ASABE Paper No. 096650. St. Joseph, MI.

IWC Final Report
Title: Development of Explicit Margin of Safety Methodology for Sediment TMDLs
PI - Dr. Amy Kaleita
May 2009

Problem and Research Objectives

The Total Maximum Daily Load (TMDL) development process for non-point sources is complex, with many decision points at which uncertainties exist. As a result, the margin of safety (MOS) concept is interpreted differently from state to state, and even within states. Recently approved sediment TMDLs in Iowa use conservative input to the Modified Universal Soil Loss Equation (MUSLE) for the 2 year-24 hour storm event to assess the sediment source. MUSLE does not consider the probability of this storm event occurring during the time of the cropping year most susceptible to soil erosion. The probability of the 2 year-24 hour storm event occurring at any time in any given year is 50%. EPA suggests a MOS of no more than 10%.

The objective of this project is to develop methodology that will permit simple yet statistically valid calculation of an explicit sediment TMDL margin of safety. The intent is to develop and document a methodology that can be repeated by IDNR technical staff for future sediment TMDL proposals and revisions. The methodology quantifies the uncertainty associated with sediment TMDLs by applying the daily time-step, process-based, geo-interfaced Water Erosion Prediction Project model (GeoWEPP) and stochastically generated climate data input.

Methodology

The methodology proposed here assumes that a target daily load for a stream segment has been determined and is a function of the daily flow discharge. The assessment of the sediment source and quantification of its uncertainty is developed through the application of the Water Erosion Prediction Project model (WEPP).

As an alternative to MUSLE for estimating sediment loads in Iowa watersheds, we proposed the use of stochastically generated climate data from CLIGEN for input into WEPP through Monte Carlo simulation. The daily output generated by WEPP permits mathematical quantification of the variability of sediment yield predictions and a probability for achieving the TMDL target. The integration of GIS tools through the GeoWEPP interface adds a spatial dimension for identifying areas of concern and treatment.

The GeoWEPP model was selected because of its daily time-step computation process and daily (single event) output. The process-based computations of GeoWEPP permit spatial and temporal estimates of both sediment detachment and deposition. The model uses stochastically generated climate data suitable for multiple simulations required for building a Monte Carlo distribution.

The model parameter input was obtained from the best available digitized data. Permanent land feature data for the study watershed is maintained constant while the stochastically generated climate parameters vary with each simulation. The accepted stochastic climate generator CLIGEN was used. Climatic parameter distribution data needed for CLIGEN are readily available for many regions of the globe. For this project, five thousand random climate sets of 20-years were generated.

Climate was chosen as the variable input for the Monte Carlo simulation because sediment delivery is most sensitive to attributes of the storm event, particularly rainfall depth. Precipitation is the single most important source of uncertainty contributing to physical simulation model output variance.

Two land management scenarios evaluated for demonstration are corn-soybean rotations under universal no-till and chisel plow. Several assumptions were required for this analysis. First, the daily precipitation event is assumed to occur uniformly over the watershed and individual storm events should affect sediment delivery independently. WEPP does not estimate stream bank erosion which is assumed not to contribute significantly to the sediment delivery. These assumptions limit the application of the WEPP model to a spatial scale of approximately one square mile, a fraction of the total area typical of TMDL watersheds in Iowa. Therefore, compliance by sub-watersheds is assumed to translate into compliance of the entire TMDL watershed. The target TMDL must first be defined by policy and/or science in order to determine the frequency of exceedance.

Principal Findings and Significance

This research develops a method for quantifying a level of confidence for stakeholders to make well-informed decisions for watershed management. The procedure developed follows below:

1. Define sub-watersheds such that WEPP criteria are met (Area<= ~ 640 acres or 1 square mile).
2. Set existing land management conditions within the sub-watershed.
3. Simulate sediment delivery for of each sub-watershed using stochastically different CLIGEN generated climate data in 20 year sets (automate with batch program).
4. Determine the probability of exceeding the target load criteria from the Monte Carlo distribution.
5. Adjust land management (with stakeholder participation) within the sub-watershed such that the probability of exceeding the target sediment load within a given time period is acceptable.
6. Apply procedure to each sub-watershed.

The code written for generation of the climate input and sediment delivery output can easily be modified for other watershed locations and land management scenarios. Computational efficiency, however, is an obstacle for Monte Carlo simulations using GeoWEPP on larger watersheds. The example watershed of296 ha (~1.4 square miles) used for development of this procedure required more than three days of computation time to complete 5,000 simulations. However, adequate statistical rigor may be achieved with less iteration. The mean and standard deviation of the Monte Carlo distribution stabilize after about 500 simulations in our example. Still, the analysis of multiple management scenarios in a timeframe conducive to stakeholder decision-making would require additional computational efficiency improvements.

Knowledge of uncertainty (spatially and temporally) is important for stakeholders to make informed decisions regarding sediment load mitigation that will be perceived as sensible and fair. GeoWEPP is particularly useful for identifying specific locations of high sediment yield. The sample 296 ha watershed used for development of this methodology is located in Tama County, Iowa. Corn-soybean rotations, first under chisel plow and then under no-till, were universally applied to all agricultural lands within the watershed. The target TMDL was exceeded more than once per year on average in all 5000 chisel plow scenario simulations. By contrast, only 10.44% of the no-till scenario simulations exceeded the target TMDL more than once per year on average. This information helps us better understand the soil erosion risk associated with these contrasting management scenarios and may be useful during the decision-making process and negotiating allocation of sediment loads.

Details of this project were presented in a poster at the 2009 Iowa Water Center Conference in Ames, Iowa. A paper has been approved for presentation at the 2009 International Conference of the American Society of Agricultural and Biological Engineers (ASABE) in Reno, Nevada. Finally, a full manuscript is under development for submission to a refereed journal.

Information Transfer Project

Basic Information

Title:	Information Transfer Project
Project Number:	2008IA135B
Start Date:	3/1/2008
End Date:	2/28/2009
Funding Source:	104B
Congressional District:	4
Research Category:	Not Applicable
Focus Category:	Education, None, None
Descriptors:	None
Principal Investigators:	Richard Cruse, Hillary Ann Olson

Publication

Iowa Water Center Information Transfer Project
March 1, 2008 – Feb 28, 2009

While the Iowa Water Center maintains a strong research component, disseminating information to water resource professionals, policy-makers and the public is a priority. With a renewed emphasis on information-transfer and outreach, the Center is developing itself as a clearinghouse for research information.

The 2008 Iowa Water Conference encouraged communication between the Iowa Department of Natural Resources and Iowa Department of Agriculture and Land Stewardship to promote increased collaboration between water quality monitoring volunteers, agriculture and natural resources staff and academia.

The first "Science Café" at Iowa State University (ISU) was held on September $3^{rd,}$ 2008. The Science Café' is sponsored by the local chapter of Sigma Xi, the Iowa Water Center, and the Institute of Science and Society. It is designed to make science accessible to the public. Four ISU faculty members discussed the theme, "Extreme Water and Weather in Iowa."

A team building symposium was held at the University of Northern Iowa on September 11, 2008. The symposium provided participants the opportunity to interact with other faculty working with water from across the state and explore possible future collaborations. Twenty posters from Iowa State University, University of Northern Iowa, University of Iowa, and the National Soil Tilth Laboratory were displayed. A field tour of the Dry Run Creek watershed was also held that day as part of the Poster Symposium activities. Urban conservation efforts and research sites were observed.

The Iowa Water Center was involved in the 2009 Iowa Conservation Partnership Day on January 28. A groundwater flow model that illustrates how ground and surface water are connected was presented. We also spoke to legislators about the importance of funding conservation programs.

Students from the Iowa State University Chapter of the Soil and Water Conservation Club and the Center published a 30 page booklet titled, "Getting Into Soil and Water." It addresses issues facing Iowa's soil and water resources. The articles were written by a wide variety of authors from across the state. The publication has been distributed to Iowa High Schools, selected administrative offices on campus, Iowa USDA-Natural Resources Conservation Service offices, the National Council for Science and the Environment, and the Sustainable Agriculture and Research Education.

The Center will again be participating in Project AWARE (A Watershed Awareness River Expedition), which is a weeklong canoe program that promotes conservation and water quality awareness while volunteers remove garbage from Iowa rivers and streambanks.

We are currently developing a one-day networking opportunity for complimentary research programs within the three state universities to identify current research needs and emerging issues. Our goal is to identify collaboration opportunities among program leaders and between universities, and enhance competitiveness for external funding. We hope to hold this event in September 2009.

Award No. 08HQGR0147 Development of Techniques for Measuring and Mapping Flow Velocities in Rivers Using ADCPs

Basic Information

Title:	Award No. 08HQGR0147 Development of Techniques for Measuring and Mapping Flow Velocities in Rivers Using ADCPs
Project Number:	2008IA148S
Start Date:	9/1/2008
End Date:	5/31/2009
Funding Source:	Supplemental
Congressional District:	
Research Category:	Not Applicable
Focus Category:	None, None, None
Descriptors:	
Principal Investigators:	Marian V.I. Muste

Publication

IWC Final Report
Development of Techniques for Measuring and Mapping Flow Velocities in Rivers using ADCPs

PI: Marian Muste

June 2009 (for report period December 1 2008—June 1, 2009)

Problem and Research Objectives

The overall goal of USGS-IIHR collaborative development is to systematically review, evaluate, and develop methods and practical processing tools capable of measuring and mapping flow velocities in rivers using ADCPs. A set of operation guidelines for acquiring mean velocities using fixed and moving vessel procedures and map velocity fields and the reach scale will be formulated. This information is critical for a wide range of river-related investigations, from purely hydrologic to ecological. Currently there is not a software program that uses raw data files collected in the field and provide tools to quality assurance and mapping of data in project drawings. The research objective is to develop an efficient process for quality assuring and mapping prototype velocity vectors for display and comparison with physical and numerical model results

Methodology

Ancillary software is developed and used to ease post-processing by incorporating the best found algorithms and procedures are also delivered for processing ADCP data for velocity mapping and model verification project. The software should allow all files being processed to be selected as a group and then provide a means for statistical graphical quality assurance on the files and a group and/or individually as appropriate. The software is built using Object Oriented Programming (OOP) techniques in conjunction with Borland C++ Builder (version 6). The analysis results are displayed in numerical and graphical formats. In this initial stage, VMS handles ASCII file format provided by Teledyne RD Instruments Acoustic Doppler Current Profilers (ADCP).

Principal Findings and Significance

We finished development of the software named 'VMS' for the given period of time. During the user workshop jointly held with USGS and US Army Corps, where about 20 participants tested the software, the VMS was proved to successfully provide efficient and smooth work flows for processing groups of ADCP transects especially focusing on quality assurance and spatial averaging of velocity. Many of existing algorithms regarding the postprocessing of ADCP data, which have been separately developed and used in diverse user environments, were integrated into the VMS. It means that the VMS will be able to take a role of a centralized software platform for additional implementations required by the ADCP communities. Moreover, the VMS supports reading existing vector-based GIS file as a background of ADCP files and exporting the processed ADCP files into GIS files. Any vector formats of shape file (point, line, and polygon) are applicable. Integrating ADCP information in conjunction with GIS data is expected to extend potential applicability of ADCP data with the well established GIS functionalities.

The software is a first bold step in extending the capabilities of ADCP – the most capable non-intrusive river instrumentation for river hydrodynamic characteristics – from its traditional use, which is the estimation of discharge, to other quantities relevant to other water sciences and monitoring goals. Among them is the characterization of ecohabitat regions in the streams, the potential for scour and deposition in rivers, investigation of the bank stability, the long-term monitoring of the hydraulic structures. The software development is in its initial stage, and it is expected to lead to new requests for both intensive (new features) as well extensive (other ADCP manufacturers) developments.

The basic change brought by this research is that the high-resolution velocity data, that is currently a by-product of standard stream-gaging practice, will become main focus for the ADCP measurement campaigns. Use of such obtained velocity fields in conjunction with data from other instruments will collectively change the field of river science and engineering by enabling rapid acquisition of high resolution accurate data related to river morphology and hydrodynamics. Besides providing data that were available through conventional methods, these new datasets are providing fine scale datasets critically important for calibration and validation of numerical simulations and for investigating research issues that were only possible through laboratory experiments in the past. It is expected that the developed software will enable improved understanding of river dynamics and processes over a wide range of scales.

Information Transfer Program Introduction

None.

Urban resident education integrating investigations of non-point source pollution in groundwater and public perceptions/technical understanding

Basic Information

Title:	Urban resident education integrating investigations of non-point source pollution in groundwater and public perceptions/technical understanding
Project Number:	2008IA128B
Start Date:	3/1/2008
End Date:	2/28/2009
Funding Source:	104B
Congressional District:	4
Research Category:	Water Quality
Focus Category:	Education, Groundwater, Non Point Pollution
Descriptors:	None
Principal Investigators:	Mimi Wagner, William Simpkins, Mimi Wagner

Publication

IWC Final Project Report

Urban resident education integrating investigations of non-point source pollution in groundwater and public perceptions/technical understanding

Iowa Water Center 2008 104(B) Research Grants Program

PI: M. M. Wagner, W. W. Simpkins

May, 2009 (for report period March 1, 2008 to February 28, 2009)

Problem and Research Objectives

The quality and quantity of groundwater resources in Iowa are a growing concern because of increased pressures on quantity and concerns about contamination. Interactions between land management, groundwater, and surface water are conceptually well understood by scientists but site specific data on groundwater levels and movement patterns are frequently not documented. Groundwater and streamwater quality are of particular concern in cities such as Ames because of their reliance on groundwater as a water supply. Recent monitoring near College Creek in Ames identified nitrate in groundwater at two of four transects and significant total P and SRP concentrations present in all 12 wells and in streamwater. Recent groundwater modeling of the Ames aquifer suggests direct interaction between surface water transported through tributaries running through the city and the Ames aquifer. Because most streams that enter the alluvium of Squaw Creek and South Skunk River becoming losing streams at that point, contaminants in the streams will impact the city's water supply. Thus, efforts to prevent contaminants from getting to streams in headwater areas are necessary to protect groundwater quality downstream. Those responsible for the contaminant loading become as important as the presence of the contaminants themselves.

This research focused on learning more about the presence of nutrients as a form of nonpoint source pollution in urban groundwater and stream water in a residential neighborhood. This research was folded into a larger urban stream non-point source pollution research and implementation project, College Creek Restoration. Our research included three specific objectives: (1) Monitor water levels and water quality in groundwater in an urban neighborhood setting adjacent to College Creek where various stormwater best management practices (BMPs) and stream stabilization practices are being constructed (with matching funding); (2) Monitor soil water for nutrients at locations in the riparian zone concurrent with various land management practices; and (3) Develop and implement targeted public groundwater-streamwater education utilizing monitoring and social assessment data (collected with matching funding).

Methods

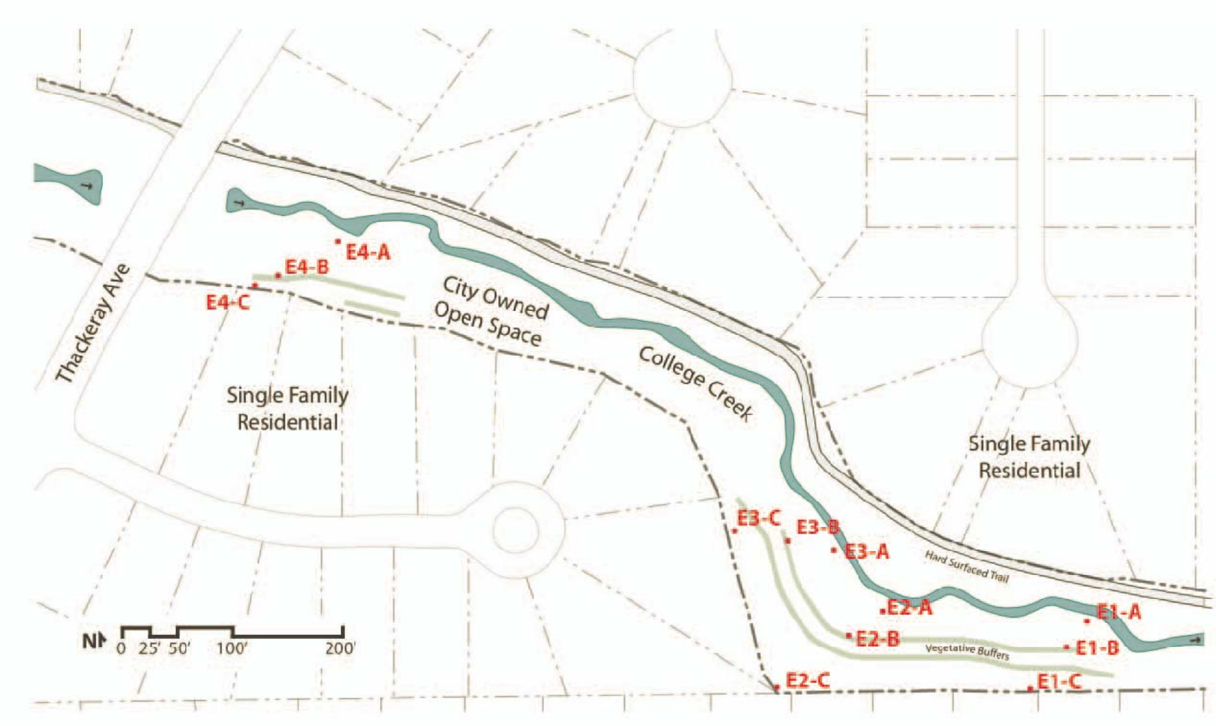
<u>Description of Water Sampling</u>

Shallow Groundwater

In November 2007, twelve monitoring wells were installed on public property along College Creek in west Ames. The site is a part of a public green belt system owned and maintained by the City of Ames Parks Department. Soils in this area are in the Coland-Terril complex consisting of poorly to moderately well drained, moderately permeable soils formed from local alluvium and in loamy alluvial sediments (DeWitt 1984).

Monitoring wells were organized in transects of four wells, at approximately a 45 degree angle to the stream (Figure 1). Wells were installed using a Giddings hydraulic soil coring rig and are between 5 and 11 feet deep. Groundwater was sampled monthly and analyzed for nitrate-N, total dissolved phosphorus (TDP), and dissolved O_2 in order to assess nutrient concentrations. Total phosphorus (TP) and soluble reactive phosphorus (SRP) were determined early in the study, but were abandoned in favor of TDP for the study period. Samples for TDP were filtered in the field through a 0.45 µm disposable-capsule filter and placed in pre-cleaned glass bottles. Dissolved O_2 was analyzed in the field monthly using a CHEMetrics photometric analysis. Total dissolved carbon and organic carbon was analyzed quarterly. Two days prior to sampling, hydraulic head measurements were taken and wells were purged of water equivalent to $1^1/_2$ of the casing volume.

Figure 1. Location of monitoring wells in the study area.



All samples were analyzed in the Limnology Laboratory in the Department of Ecology, Evolution, and Organismal Biology (EEOB) at Iowa State University. Total P, TDP and SRP were analyzed following the Murphy-Riley method (SM 4500-P, E) in Standard Methods (American Public Health Association, 1998). Total nitrogen and nitrite plus nitrate-N were analyzed using the second derivative ultraviolet spectroscopy method (Crumpton, et. al, 1992). Dissolved organic carbon and total dissolved carbon were analyzed using a Shimadzu TOC Analyzer. This automated method is equivalent to the total organic carbon method (SM 5310 B) in Standard Methods (American Public Health Association, 1998).

Soil Water

Four soil water samplers were installed in May, 2008 to evaluate the nitrate and phosphorous characteristics a grass clippings pile contributes to soil water. Two samplers (L2 and L3) were installed within a pile of grass clippings along the bank of college creek. This pile has been around for several years and is continually added to by a nearby resident as their yard is mown. The other two lysimeters (L1 and L4) were placed on both sides of the pile, one up stream and one down stream, to act as controls. During installation, boreholes were excavated to a depth of 17 inches using a hand auger with a 3 inch diameter barrel. To facilitate a good hydraulic connection with the soil, on-site geologic material was mixed with deionized water to create a slurry surrounding the porous cup to approximately 1 inch above the cup. One inch of bentonite was added directly on top of the slurry and on site material was used to backfill the remainder of the borehole (Figure _). After installation and sampling, a vacuum of 17.5 in Hg (60 centibars) is set to draw in soil water. Samplers were purged a week after instillation to remove deionized water leftover from instillation.

Samples from the lysimeters were extracted into a 1-liter glass vacuum flask through 1/16 inch (inside diameter) polyethylene tube inserted through the lysimeters neoprene tubing. Samples were transferred into sample containers, and filtered in the field through a 0.45μm disposable-capsule filter and collected in pre-cleaned glass bottles. Tension was applied to the lysimeters after each sample was taken to maintain tension until the next sampling period.

Water samples were taken twice monthly from all four samplers during the summer months and analyzed at the ISU Limnology Lab. Nitrate-N and TDP analysis were conducted on the samples and compared with one another.

<u>Social Assessment (funded by others)</u>
The objectives of the social assessment included characterizing riparian and near-riparian resident technical beliefs and understanding of groundwater systems, including interactions between groundwater and stream water and nutrient cycling. We also asked participants to document landscape management practices impacting water quality on their property including fertilization, mowing, irrigation, and pet waste removal. We used semi-structured focus groups (*qualitative reference here*) to develop and refine questions for a mailed survey. The mail survey utilized Dillman (2000) methods. All social assessment methods were approved by Iowa State University Institutional Review Board.

Survey Sample
The survey was administered to all single-family residential parcels less than five acres in size that were owner occupied within the city of Ames and its urban fringe limits meeting criteria we developed for riparian and near-riparian homeowners (n=934) in April 2008. This survey sample was selected because it corresponded to the landscape position of monitoring wells utilized in this research. Riparian homeowners (Tier 1) included those with property backing onto a stream or public greenbelt land containing a stream. Near-riparian homeowners (Tier 2) included those living directly across the street from all riparian homeowners. Figure 2 illustrates this selection and

Figure 2. Riparian and Near Riparian Survey Participant Example

stratification method. The final sample included 644 respondents (69% return rate) suggesting a well-written survey and managed administration. Respondent data were analyzed with SPSS survey statistical software and mapped spatially in ArcGIS. Assessed property values were also collected using spatial data and integrated with respondent data.

Public Groundwater – Stream Water Education
Two public educational events were developed and conducted at the groundwater monitoring site for local families in September 2008. These sessions, called the Ames Clean Water Festival, centered on active learning experiences for participants based on three learning outcomes. One hundred residents participated in one or both sessions. Outcomes included (a) understand depth of shallow groundwater currently at the site; (b) understand nutrient leaching from lawn clipping piles and fertilizer application into soil water; and (c) understand groundwater-surface water interactions and the extent of the Ames Aquifer.

Multiple agencies participated in the education sessions. Representatives from the City of Ames Water and Pollution Control Department presented information regarding the municipal water supply. Representatives from the City of Ames Public Works Department promoted P-free fertilizer and city objectives for reducing stormwater volume. We measured participants' learning outcomes using questionnaires distributed to attendees. Iowa Water Center staff and ISU Soil and Water Conservation club student members participated in the interactive groundwater modeling display.

Principal Findings and Significance

Groundwater Results**.** This grant funded the lab monitoring costs for seventy-three percent of the project; twenty-seven percent of the funding was secured for the remainder of the year from ISU Department of Landscape Architecture.

The water table map indicates that groundwater flows from the adjacent neighborhood towards the stream (Figure 3) and that College Creek is a gaining stream. Seasonal fluctuations produce a generally a higher water table in the spring and a lower water table in the later summer and early fall.

Water Quality. Throughout the study period, several wells contained nutrient concentrations above ecological threshold limits. TDP concentrations ranged from 631.1 to 0.9 μg/L while mean TDP concentrations for individual wells ranged from 7.1 to 108.4 μg/L. TDP concentrations above 50 μg/L were found in four of the twelve wells over various time periods during the sampling period. After one year of data, the samples register a mean of 35 μg/L (n=143) and a median of 13 μg/L, higher than a median TDP value of 15 μg/L reported in urban settings (see Burkart et. al. 2004). Nitrate-N concentrations (above 10 mg/L) were found in 3 of the 12 wells over various time periods after one year of sampling. Furthermore, one well had a mean nitrate-N concentration of 14 mg/L during the entire sampling period, which is significantly greater (significance < 0.05) than the US EPA drinking water regulation of 10 mg/L. Larger TDP concentrations during the spring. suggest impacts of of residential fertilization. Denitrification of nitrate-N may be occurring as groundwater flows toward College Creek in two of the four transects (Table 1). The evidence for this is the decrease in nitrate-N and dissolved O_2 concentrations as groundwater flows towards College Creek in transects E1 and E2 and the presence of dissolved organic carbon that could drive the reaction.

Figure 3 Water-table map. Arrows indicate the direction of groundwater flow.

Water table – highest recorded (3/16/08)

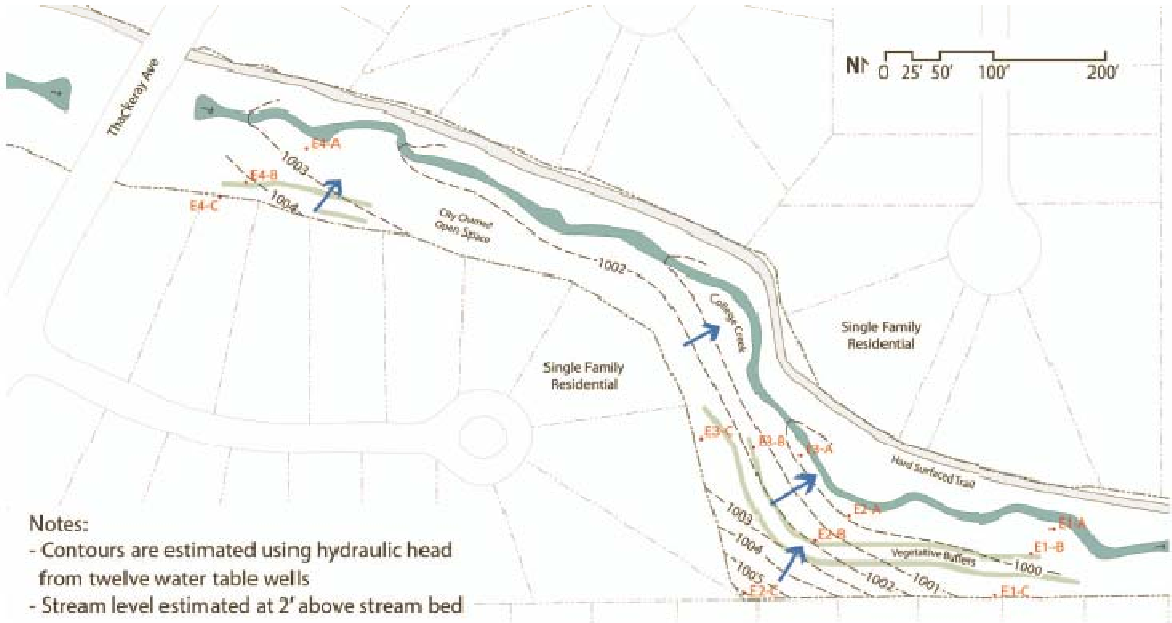


Table 1

Mean parameters determined from monthly sampling.

	Hydraulic Head (feet above sea level) *(n=12)*	Total Disolved P (ug/L) *(n=12)*	Nitrate-N (mg/L) *(n=12)*	Dissolved O_2 (mg/L) *(n=6)*	Nonpurgable Organic C (mg/L) *(n=3)*
E1-A	996.57	7.57	1.22	1.75	3.11
E1-B	996.83	94.66	3.53	3.12	3.58
E1-C	997.14	11.00	14.11	5.47	7.06
E2-A	997.22	12.98	0.36	1.85	3.11
E2-B	997.95	9.96	2.72	1.77	1.86
E2-C	1003.21	12.12	5.57	6.27	1.26
E3-A	997.23	26.33	3.77	1.58	3.02
E3-B	998.43	108.37	6.95	3.17	4.11
E3-C	999.10	40.77	2.83	3.15	2.69
E4-A	1000.23	13.69	1.17	2.40	3.63
E4-B	1001.01	74.02	1.35	4.97	1.44
E4-C	1001.73	7.09	0.48	3.73	1.54
Mean	998.89	34.88	3.67	3.27	3.03
Median	998.19	13.34	2.77	3.13	3.06
Stream	-	86.50	7.07	-	-

<u>Social Assessment Results</u>

We identified widespread homeowner respondent confusion about groundwater-surface water. Our results suggest respondents lack critical understanding relative to nonpoint source pollution of groundwater and stream water. Groundwater extent and flow is one area of confusion among survey respondents. A majority of respondents (59%) acknowledged they did not know if groundwater is present near their home or how deep it is. As an example, of the twenty-two percent (n=95) who reported hearing their sump pump running more than 14 days in a typical year, 57% indicated they were unsure if groundwater was present near their home.

Respondents also acknowledged less understanding for questions pertaining to pollution of groundwater when compared to understanding of surface water pollution. A majority (78%) believed fertilizers applied to lawns can reach adjacent stream water. Fifty-eight percent also believed fertilizers can reach shallow groundwater, while only 39% believed they have the ability to reach deeper aquifers where drinking water supplies are located. More than two-thirds of respondents reported fertilizing in the last year despite the high rate of understanding that fertilizers applied to lawns can be transported to stream water.

We identified a similar lack of understanding concerning groundwater and stream water connectivity. Forty-two percent (n=254) of respondents acknowledged they don't know if groundwater and stream water are connected and three percent (n=21) believed there is no physical connection. Of the remaining fifty-five percent (n=334) who believe there is a connection, twenty-eight percent (n=96) indicated that streams are both gaining and losing.

<u>Public Groundwater – Stream Water Education Results</u>
Ninety-four percent of participants demonstrated they learned new information after participating in the outreach program. More than half (52%) of these included technical understanding about groundwater, including information on the "water table," groundwater depth and seasonal fluctuations of the water table; the concept of gaining streams and that groundwater flows toward the stream; and the impacts of agricultural drain tile systems on groundwater. Thirty-nine percent of participants demonstrated new understanding of how lawn management practices impact groundwater quality. Specifically this included the role of grass clipping piles in increasing N and P in soil water beneath them, and the likely movement of these nutrients into stream water when placed at stream's edge. Fifty-two percent documented new knowledge of N and P impacts on stream water and groundwater from lawn clipping piles and /or fertilizers.

Interconnectivity between stormwater runoff, groundwater, and stream water represented the most challenging concept we attempted to teach at the sessions. Thirty-two percent of participants documented this understanding including this comment, "We learned how important it is to protect groundwater and how easily it is contaminated."

Groundwater-surface water and related riparian research data and information were also shared with the public at ten interactive discussion sessions titled, *Creek Chats*. Each *Chat* focused on a specific topic of interest. University or other experts led each session. Approximately 120 residents attended one or more *Chat*.

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DeWitt, T.A. 1984. Soil Survey of Story County, Iowa. U.S. Dept of AG Soil Conservation Service, Washington, D.C.

Dillman, D.A. 2000. Mail and Internet Surveys: The Tailored Design Method 2nd ed. New York: John Wiley and Sons, Inc.

Images

Ames Clean Water Festival Interactive Learning—Measuring & Recording Water Table Depth, September 2008.

Ames Clean Water Festival Interactive Learning—Groundwater Model, September 2008

Ames Clean Water Festival--Iowa Water Center Staff, City of Ames Water and Pollution Control Staff and Professor Bill Simpkins (ISU) discuss extent of Ames Aquifer, September 2008

USGS Summer Intern Program

None.

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	13	0	0	0	13
Masters	3	0	0	1	4
Ph.D.	1	0	0	0	1
Post-Doc.	1	0	0	1	2
Total	18	0	0	2	20

Notable Awards and Achievements

Michael Quist was awarded "Best Professional Paper" at the Annual Meeting of the Iowa Chapter of the American Fisheries Society for his 104b research project, "Effects of riparian buffers on fish assemblages in central Iowa streams."

Mimi Wagner held eight public meetings to discuss water quality issues, stormwater and urban conservation measures in the City of Ames. These topics were related to her 104b project.

Publications from Prior Years

1. 2006IA94B ("Impact of Swine Manure Application on Phosphorus, NO3-N, Bacteria, and Antibiotics Concentrations in Surface Runoff and Subsurface Drainage Water") - Conference Proceedings - Kanwar, R.S. 2009. Best agricultural management practices for reducing water pollution and hypoxia in water bodies. In: Proceedings of the Dahlia Greidinger International Symposium on Global Climate Change, Environmental Risks and Water Scarcity held at Technion, Haifa, Israel, March 2-5.
2. 2006IA94B ("Impact of Swine Manure Application on Phosphorus, NO3-N, Bacteria, and Antibiotics Concentrations in Surface Runoff and Subsurface Drainage Water") - Articles in Refereed Scientific Journals - Pappas, E.A., R.S. Kanwar, J.L. Baker, J.C. Lorimor, and S. Mickelson. 2008. Fecal indicator bacteria in subsurface drain water following swine manure application. TRANSACTIONS of the American Society of Agricultural and Biological Engineers 51(5):1567-1573.