Indiana Water Resources Association

Twenty-Ninth Annual

Water Resources Conference

Featuring Symposia on:

Indiana Water Monitoring Council

and

Nutrient Enrichment in Streams and Lakes: Sources, Effects, and Management

Indiana Department of Environmental Management

Indiana Lakes Management Society

Radisson Hotel
Bloomington, Indiana
May 14-16, 2008

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Kathleen Fowler, U.S. Geological Survey
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2008 IWRA President

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Elizabeth Trybula, Indiana Association of Soil and Water Conservation Districts

1:40 **Existing Statewide Data Networks**
Art Garceau, IDEM and Jeff Frey, USGS

2:10 **Sharing Locations of Water Monitoring: A First Step in Integrating Water Information**
Laura Esman, Purdue University

2:40 **Technology for Integration: Kosciusko County Monitoring Database**
Eileen Boekestein, Grace College

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3:40 **Regional Application of Integrated Data Network: Upper White River Watershed**
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Conference Program

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6:30 **Banquet / Awards**
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Entertainment: "Lost Water Boys"

Thursday, May 15, 2008

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Sarah Roley, University of Notre Dame

3:40 **Conservation Practices and Nutrients**
Barry Fisher, NRCS

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Conference Program

Thursday, May 15, 2008 (Continued)

5:00 **Dinner** (On your own)

8:00 **IWRA Business Meeting and Hospitality Hour**
All members and friends are welcome

Friday, May 16, 2008

Ken Luther, Valparaiso University, Moderator

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Nathan Utt, Purdue University

9:00 **Fish and Invertebrate Communities in Agricultural Headwater Streams**
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9:30 **Conjunctive Flow in Wetlands and Underlying Aquifers**
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10:00 **Break**

10:30 **Contrasts and Similarities in Water Quality Issues Facing East Central China and Northwest Indiana: Issues, Perceptions, and Approaches for Resolution**
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11:00 **Long-Term Monitoring of Mercury in Indiana**
Marty Risch, USGS

11:30 **Incorporating Method Performance Information in Pesticide Trend Analysis**
Jeff Martin, USGS

12:00 **Meeting adjourned**

THE
CHARLES HAROLD BECHERT
AWARD

The Indiana Water Resources Association is pleased to announce the awarding of the Charles Harold Bechert Award this year. The award was first established in 1981 to honor a member of the water-resources community who has contributed significantly to water-resources activities in Indiana.

Charles Bechert was a major pioneer in Indiana's water-resources management programs. Following graduation with honors from Purdue University in 1929, he became the State's first sanitary engineer in the Department of Conservation. During his 36-year career with the Department, he served as Assistant Chief of the Division of Water, Department of Natural Resources, and served in that capacity until 1970.

Mr. Bechert was an officer and member of numerous water-related organizations during his distinguished career. He served as president of the American Society of Civil Engineers and of the Indiana Division of the American Water Works Association. His membership in other organizations included, Indiana Society of Professional Engineers, Scientech Club, Indiana Academy of Sciences, and Tau Kappa Epsilon and Chi Epsilon honorary fraternities.

His professional abilities were recognized in 1963 by Governor Matthew Welch when Mr. Bechert was appointed Sagamore of the Wabash. He was also presented the George Fuller Award in 1955 by the American Water Works Association and is listed in Who's Who in the Midwest (1967-68).

Past recipients of the Charles Harold Bechert Award are Oral Hert (1981), Daniel Wiersma (1982), William J. Andrews (1984), William J. Steen (1986), Dennis K. Stewart (1990), Jacques W. Delleur (1992), Jim Barnett (1996), John Simpson (1998), Thomas Bruns (2002), Mark Reshkin (2004), Charles G. Crawford (2006), and Judith E. Beaty (2007).

James A. Stewart

2008 Recipient of the Charles Harold Bechert Award

The Indiana Water Resources Association is pleased to present the thirteenth Charles Harold Bechert Award to James A. Stewart in recognition and appreciation of his many important contributions to the knowledge of water resources in Indiana.

Mr. Stewart received a Bachelor of Science degree in Geology from Indiana University at Indianapolis in 1976. Mr. Stewart joined the U.S. Geological Survey Indiana District as a hydrologic technician in 1976 and worked in the streamflow-gaging program with responsibilities for collecting and managing hydrologic data and conducting hydrologic investigations. In 1989 He was selected as Chief of the Hydrologic Data Section of the Indiana District and one of his first priorities was to improve the processes for computation, review, and publication of streamflow data. His revised procedures resulted in on-time publication of the Indiana District annual data report for 18 straight years. These procedures were successfully implemented by many other USGS Districts.

Jim Stewart was instrumental in developing one of the Nation's first statewide real-time streamflow data-reporting networks. Under his leadership, nearly all of Indiana's active streamflow gaging stations began reporting data via satellite to the internet. Jim and his staff designed and implemented automated methods for data collection, transmission, computer data entry, computations, and quality control. These advancements enabled provisional estimates of discharge to be quickly and reliably made from raw, river-stage data. Improvements in the timeliness of streamflow information greatly enhanced the value of the Indiana streamflow network to users, especially during flooding.

Jim Stewart is a visionary that recognized the immense accuracy, reliability, cost, and safety benefits of acoustic velocity technology for streamflow gaging programs. Efforts to measure streamflow in the Grand Calumet River and other streams tributary to Lake Michigan using conventional streamflow measurement technologies often produced unreliable results. Jim adapted and applied acoustic velocity technology to measure flow direction and velocity in these problematic streams, which greatly improved discharge estimates.

As a result of these early applications of acoustic technology, the Indiana District became the leader in research, applications, and training for acoustic streamflow measurement in the USGS. One innovation is particularly notable. Jim developed a tethered catamaran platform that allowed a acoustic current profiler to be towed across a stream from a hand line deployed from a bridge. This application allowed multiple discharge measurements to be made in much less time than that required for a single conventional current-meter measurement. The tethered boat current meter greatly improved the quality, safety, and cost of discharge measurements.

For his innovations and improvements to hydrologic data collection and dissemination in Indiana, Jim Stewart was awarded the U.S. Department of Interior's Meritorious Service Award in 2005.

Congratulations Jim and best wishes for the future.

Existing Statewide Data Networks

Art Garceau[1] and Jeff Frey[2]

[1]Indiana Department of Environmental Management
[2]U.S. Geological Survey, Indiana Water Science Center

State water monitoring councils provide the opportunity to leverage agency resources for mutual benefit. Several agencies have the goal of monitoring trends or tracking new stressors in the environment. Using data from other agencies to meet program goals conserves funds for environmental programs while increasing the efficiency of monitoring programs. The Indiana Department of Environmental Management (IDEM) and the U.S. Geological Survey (USGS) each have two stream-monitoring networks that could be used to meet program goals related to monitoring trends or tracking stressors. IDEM operates the Fixed Station and the Probabilistic Watershed Monitoring Programs. USGS operates the National Water Quality Assessment Program (NAWQA) and the National Stream-Quality Accounting Network (NASQAN). Design and operational details of these programs including sampling frequency, parameters measured, and number of sites will be discussed.

Sharing Locations of Water Monitoring: A First Step in Integrating Water Information

Laura Esman[1,3], Jan Frankenberger[1], and Jae Sung Kim[2]

[1]Agricultural and Biological Engineering, Purdue University
[2]Civil Engineering, Purdue University
[3]lesman@purdue.edu

The Indiana Water Monitoring Inventory serves as a portal for locating water monitoring information in the state of Indiana. Monitoring has been conducted at many locations within Indiana's waters by a variety of government agencies and organizations, but information may be difficult to find. The Inventory provides an easily accessible, web-based Google™ Maps application that allows potential users of monitoring information to locate monitoring sites, determine what data have been collected, and contact the data holders or their web site for more information. The actual monitoring data is not stored at the web site -- only detailed information on the location of the monitoring site and what is being monitored or was monitored in the past. The Inventory is searchable by location, parameter type, or agency/organization who conducted the sampling. The Inventory provides environmental managers, regulators, local volunteers, citizen groups, and others with a tool to aid in improving Indiana's water quality, and is accessible at https://engineering.purdue.edu/~inwater/

Technology for Integration: Kosciusko County Monitoring Database

Eileen C. Boekestein

Kosciusko Lakes and Streams, A community water-quality program centered at Grace College, 200 Seminary Drive, Winona Lake, IN 46580, (574) 372-5100 ext. 6446, boekesec@grace.edu

Located in the midst of the lakes region of northern Indiana, Kosciusko County is graced with an abundance of natural lakes which are valuable environmental, economic, and social resources. General care and concern for the health of these lakes has been evidenced by a large number of lake associations, monitoring programs, and watershed groups working in the county. In early 2007, Grace College in Winona Lake launched a community-centered water quality program meant to pull existing programs together into collaborative efforts to improve water quality and education throughout the county. The program seeks to document historical, social and scientific data about the lakes; to establish a clearinghouse of data on county waters; to encourage local water monitoring efforts; to provide aquatic science curriculum and education to citizens of all ages; and to work with other groups to establish infrastructure for the sustainable management and stewardship of the water resources of Kosciusko County.

One program goal, the development of a clearinghouse of local water quality data, has been a major focus for the program thus far. Data has been compiled from volunteer monitoring programs, agencies, and individual lake and watershed groups to provide a detailed picture of water quality. The first segment of this clearinghouse focuses on lake data and was recently launched online at http://water.grace/edu. A segment compiling county stream data is currently under development and is scheduled to launch late summer 2008. It is hoped that, when completed, this clearinghouse will serve as a model for the centralization of local water quality data in other communities.

Nutrient Criteria Overview

Brian Thompson

U.S. Environmental Protection Agency

Excessive inputs of nutrients into streams have human-health and ecological consequences. Eutrophication, or excess amounts of the nutrients, primarily nitrogen (N) and phosphorus (P), in aquatic ecosystems have been linked to fish kills, shifts in species composition, taste and odor in drinking-water supplies, and harmful algal blooms.

The Clean Water Act (CWA) of 1972 established a national goal of achieving water-quality levels for the protection and propagation of aquatic organisms and wildlife and for human recreation in and on the water. In their water quality assessment reports under section 305(b) of the CWA, States and Tribes have consistently identified nutrient over-enrichment as a leading cause of impairment in rivers and streams across the United States. The excess amounts of nutrients found in many rivers and streams may be the cause in waters that are not meeting the goal of the CWA.

In 1998, the U.S. EPA put forth a strategy for States and Tribes to adopt criteria to address nutrient over-enrichment. The strategy includes the development of State plans to develop and adopt nutrient criteria, as well as technical guidance to assist States in the development of nutrient criteria. In 2000, U.S. EPA published nutrient criteria recommendations for stream/rivers and lakes reflecting eco-regional conditions and in 2001/2002, published technical guidance to assist States and Tribes in developing nutrient criteria that more closely address State and Tribal specific conditions. The guidance recommends that adopt of water-quality criteria for two causal parameters, total nitrogen (TN) and total phosphorus (TP), and two response parameters, chlorophyll a (CHL a) and turbidity. States have the option of using the recommended criteria or developing their own based on the technical guidance.

Occurrence and Distribution of Algal Biomass in Selected Indiana Streams, 2001-2005

B. Scott Lowe[1], Donald R. Leer, Jeffrey W. Frey, and Brian J. Caskey

U.S. Geological Survey, Indiana Water Science Center
5957 Lakeside Boulevard, Indianapolis, IN 46278
[1](317) 290-3333 ext. 131, bslowe@usgs.gov

The purpose of the study was to examine the relations between algal biomass and nutrients and to investigate other environmental factors that may influence algal biomass concentrations in Indiana streams. To aid in the development of nutrient water-quality criteria, algal biomass and nutrient data were gathered at 322 randomly selected sites on 261 streams in 8-major Indiana river basins during spring (May), summer (June –July) and fall (Aug-Oct) from 2001 through 2005. Stream size varied from headwater, wadable, to boatable streams. The relations of seasonal algal biomass parameters (periphyton chlorophyll a (CHLa), ash-free dry mass (AFDM), seston CHLa, and particulate organic carbon (POC) to seasonal nutrient concentrations (nitrate, total Kjeldahl nitrogen (TKN), total nitrogen (TN), and total phosphorus (TP)) were determined using Spearman's rho.

Approximately 32 percent of the periphyton CHLa and 6 percent of the seston CHLa samples were eutrophic (nutrient enriched) when compared to the Dodd's nutrient boundaries which determined eutrophic levels of 70 mg/m3 for pheriphyton CHLa and 30 mg/L for seston CHLa. The highest seasonal median concentration of periphyton CHLa was in spring, while the highest median concentrations of AFDM, seston CHLa, and POC were in the summer Statistical correlation analysis indicted that there was no significant relations between nutrients and algal biomass. The only statistically significant seasonal relations among algal biomass and nutrient parameters were between seasons (1) spring POC to spring TP, and (2) summer POC to summer TKN and summer TP. These significant relations suggest that as nutrient concentrations increase within a stream, POC concentrations increase, mostly likely related to phosphorus associated with seston and attached to sediment. There were no significant relations among periphyton CHLa and any nutrients.

The median concentrations of all seasonal nutrient and algal biomass samples, collected on a sample stream were compared to published United States Environmental Protection Agency (USEPA) concentrations for their respective ecoregions. Algal biomass concentrations were greater than the 25th percentile published USEPA concentrations and expanded the range of algal biomass and nutrient data. As basin size increased, seston CHLa and POC concentrations increased while periphyton CHLa and AFDM concentrations decreased. United States Geological Survey gaging-station data indicated that streamflow varied greatly throughout the 5-years, and likely influenced algal biomass concentrations through scour and algal drift.

Factors Affecting Nutrient Losses from Agricultural Watersheds in the St. Joseph River Watershed, Northeast Indiana

D.R. Smith[1], S.J. Livingston, G.C. Heathman, and C. Huang

USDA – Agricultural Research Service, National Soil Erosion Research Laboratory, West Lafayette, IN 47906
[1](765) 494-0330, Douglas.R.Smith@ars.usda.gov

Nutrient losses from agricultural watersheds in Indiana have been implicated in the hypoxic zone in the Gulf of Mexico as well as algal blooms in Lake Erie. We monitored water quality from fields and drainage ditches in the St. Joseph River Watershed, Northeast Indiana. Agricultural production records were obtained from producers in the monitored watersheds. Satellite imagery was used to classify land-use/land cover and to create DEM's for the watersheds. The complex 'pot-hole' topography and associated hydrology have a tremendous impact on nutrient losses from these watersheds. The amount of land that directly drains into agricultural ditches and the amount of land classified as 'pot-holes' are significantly and positively correlated with nutrient concentrations and loads, while the proportion of land that has no direct drainage to the agricultural ditches are significantly and negatively correlated to nutrient concentrations and loads. Land use is also an important factor in nutrient transport from watersheds, as the proportion of land in corn significantly affected NH_4-N, NO_3-N, and TKN loads and land classified as urban was positively correlated with TKN and TP concentrations. Management of drainage ditches is also an important factor influencing nutrient losses. During our monitoring period, one of the ditches was dredged. The immediate impact of dredging was shown to be an increase in the N and P transport in the water column. The longer-term (up to one year) impacts were quite different, as this ditch resulted in a net loss of 12 kg of soluble P and 5 kg of TP (i.e. greater mass loss of P upstream of dredging than downstream of dredging) during the monitored year after dredging occurred. Data from this work may be used to focus future water quality protection efforts to critical source areas for nutrients within the landscape.

Transport of Nutrients in a Tiled Watershed

Nancy T. Baker[1], Wesley W. Stone, John T. Wilson, and Jeffrey W. Frey

U.S. Geological Survey, Indiana Water Science Center
5957 Lakeside Boulevard, Indianapolis, IN 46278
[1](317) 290-3333 ext. 185, ntbaker@usgs.gov

Leary Weber Ditch in Hancock County, Indiana is one of seven watersheds across the nation selected by the U.S. Geological Survey National Water Quality Assessment Program for inclusion in its Agricultural Chemical Transport study. The watershed was selected to represent the tile-drained, corn-soybean agricultural areas of the Midwest. Leary Weber Ditch is a 2.73-mi^2, intensively-farmed, watershed dominated by poorly drained soils and a nearly flat land surface. Corn and soybeans are grown on 87 percent of the watershed. Growing crops on this land requires lowering the water table and removing ponded water by draining the fields through tiles.

Nutrients primarily enter the watershed through application of fertilizers to crops. The greatest loss of nitrogen applied to crops leaves the watershed through plant uptake and harvest; most of the phosphorus applied to crops attaches to soil particles and remains in the soil. Much of the nitrogen that is not taken up by plants moves through soils (as nitrate) to tile drains which flow to the ditch. Runoff is not the major pathway for the movement of nitrate to Leary Weber Ditch; tile drains decrease surface runoff losses of nitrate while increasing losses through tile-drain water. Also, because nitrogen fertilizer may be injected into the soil, the direct runoff of nitrate to streams is small and the potential for nitrate movement to tile drains is further increased.

The highest nitrate concentrations in the watershed were measured in samples collected from water in the soils. While some nitrate moves directly to tile drains, excess nitrate also may accumulate in the soil over a period of months to a few years before moving into tile drains and streams after rainfall. The potential for nitrate movement is greatest during and immediately after rainfall, regardless of when the nitrate was applied. Very low nitrate concentrations were found in ground-water samples in the watershed. This is because the small amount of nitrate that moves below tile drains converts to gaseous forms of nitrogen (undergoes denitrification) in the saturated soils below the water table.

Most of the phosphorus that does not accumulate in soils or is not taken up by plants moves in runoff to the ditch. Phosphorus concentrations increase in tile drains in response to increased rainfall; however, concentrations are only one tenth as large in the tile drain as in runoff. Phosphorus concentrations are low in tile drains between storms, indicating that phosphorus moving in matrix flow attaches to soils before reaching tile drains. For the same reason, negligible amounts of phosphorus move into ground water.

The Relation of Algae, Invertebrate, and Fish Communities to Nutrients and Other Natural Factors in Small Agricultural Streams of Indiana and Ohio, 2004

Brian J. Caskey[1] and Jeffrey W. Frey

U.S. Geological Survey, Indiana Water Science Center
5957 Lakeside Boulevard, Indianapolis, IN 46278
[1] (317) 290-3333 ext. 199, bcaskey@usgs.gov

The response of biological communities – algae (one from depositional and one from riffle habitats), invertebrate, and fish communities – to natural and anthropogenic factors was assessed at sites sampled along a nutrient concentration range. Sites were selected to focus on the nutrient gradient and minimize other influences by selecting sites in small wadeable agricultural basins within one ecoregion and when possible with similar substrate and canopy cover. Although this is a nutrient enriched area, the nutrients collected during the seasonal low August period were used to provide a low nutrient gradient. The study was conducted in 30 agricultural watersheds within the Corn Belt and Great Plains Ecoregion 55 as part of a National Water-Quality Assessment Program study. Canonical correspondence analysis (CCA) was used to determine which nutrient and physical factors influenced each biological community. Two nutrient and two habitat factors most influenced the biological communities along the first CCA axis. Nutrients were the most influential factors in the depositional habitat algae (total phosphorus) and invertebrate (phosphorus loading) communities, and habitat factors influenced the riffle habitat algae (pool to riffle ratio) and the fish (average bankfull depth) communities. The biological communities were similar at all sites along the nutrient gradient as shown by the low eigenvalues for all communities. The biological communities at all sites were dominated by organisms indicative of nutrient enriched waters. This suggests that (1) single sampling of nutrients during summer low flow may not adequately reflect the nutrient enrichment of the streams, and (2) biological communities in streams in this region tend to be limited more by habitat then nutrients.

Streams Around Indiana: A Look at the Influence of Land Use and Watershed Processes on Stream Water Quality

Sara Peel

JFNew, 708 Roosevelt Road, Walkerton, IN 46574
(574) 586-3400, speel@jfnew.com

Issue
It is a generally accepted precept that alteration of natural habitat negatively effects water quality and aquatic biota. In fact, nearly 40 percent of Indiana's streams do not support their designated aquatic life usage or safely allow for recreational contact (boating or swimming). At least a portion of these limitations are due to the loss of stream characteristics, such as morphology and riparian canopy; however, watershed land use often is a greater influence on stream health than stream morphology. Research suggests land use factors account for more than 60 percent of the impact on water quality within streams. Agricultural and urban watersheds typically possess poorer water quality than their natural watershed counterparts – those dominated by forested, wetland or prairie land uses.

Methods
To discern the relative impact of both urban and agricultural land use, multiple sites within streams were assessed throughout northern and central Indiana during low flow (base) and high flow (storm) conditions. These sites included:

- agricultural-dominated watersheds
- forested/wetland-dominated watersheds
- urban land use-dominated watersheds

Results/Implications
Sampling occurred during both minimal (drought) and regular precipitation conditions. The overall findings of the sampling showed that stream systems contained relatively poor water quality (high phosphorus, nitrogen, and E. coli concentrations and loads), and biotic communities dominated by pollution tolerant species. Data collected from these watersheds suggest water quality limitations present within the streams are due to land use factors. However, poor instream habitat and stream alterations also likely impact water quality within the representative streams.

Conclusions
Data from streams and their watersheds throughout Indiana will be presented. Additionally, the need for further assessment and management of instream factors and watershed processes (to define the relationship between watershed land use and instream water quality within these streams) will be detailed.

Fate of Nutrients in the Prairie Creek Watershed and Their Effects on the Trophic Status of the Reservoir

Jarka Popovicova[1] and Diana Fiallos Celi

Ball State University, NREM Department
West Quad 107, Muncie, IN 47306
[1](765) 285-5790, jpopovicova@bsu.edu

Water quality assessment of the Prairie Creek watershed and the reservoir was performed to assess the reservoir trophic status and to evaluate contribution of nutrient loading from five of its tributaries. Two reservoir locations and five of its tributaries were monitored for nutrients; Secchi disk transparency and chlorophyll a were also monitored at the reservoir. Sampling was performed bi-weekly from May through October 2007. The results characterized the reservoir as a eutrophic based on Secchi disk transparency, total nitrogen and chlorophyll a concentrations. However, concentrations of total phosphorus categorized the reservoir as hypereutrophic. Dissolved oxygen concentrations varied vertically and anoxic conditions frequently reached the 50% of the total reservoir depth. Concentration of ammonia and soluble reactive phosphorus exceeded the recommended water quality guidelines and standards. High concentrations of phosphorus have possibly resulted in nitrogen limitation in the reservoir, as determined by TN:TP ratio of 6.

Assessment of the five reservoir tributaries showed that the highest percent exceedance of the recommended water quality guidelines was for total phosphorus and total reactive phosphorus (orthophosphate) followed by E.coli, ammonia-N, pH, dissolved oxygen and nitrate-N. The results indicated that there were no significant differences among the tributaries in mass loading of ammonia-N, nitrate-N, total nitrogen, orthophoshates, total phosphorus and E.coli, making planning for future management more complicated. The reservoir restoration and watershed protection program needs to mainly address the internal loading of phosphorus and nitrogen limitation in the reservoir to prevent development of toxic algal blooms in the future.

Towards the Development of Nutrient Standards: Relationships Among Nutrients, Algal Biomass, and Dissolved Oxygen

Todd Royer

Indiana University, School of Public and Environmental Affairs

Development of nutrient criteria leading to standards for flowing waters is currently a major effort across the U.S., yet the efficacy of such criteria has not been fully assessed, particularly regarding effects on dissolved O_2 concentrations. We examined relationships among nutrients, algal biomass, and dissolved O_2 in 53 stream and river sites across Illinois. Dissolved O_2 concentrations were monitored continuously for 72 hours at each site and a series of metrics calculated. No occurrences of hypoxia were observed and overall the data did not indicate a strong link between nutrient concentrations and dissolved O_2 metrics. Cluster analysis was used to identify variables which explained differences among similar groups of sites. Results indicated that streams and rivers in Illinois could be placed into one of three groups with regard to the efficacy of nutrient standards to improve biotic integrity of flowing water ecosystems. The first two groups differed in size, supported different forms of algal biomass (sestonic vs. benthic), and might be responsive to nutrient standards. The third group included 56 % of the sites and biotic integrity in these sites likely would be non-responsive to nutrient standards without concurrent improvements in physical habitat quality.

Non-Point Versus Point Source Streams: Implications for Nutrient Criteria

Harry D. Leland[1] and Jeffrey W. Frey[2]

[1] U.S. Geological Survey, National Research Program, Retired
[2]U.S. Geological Survey, Indiana Water Science Center
5957 Lakeside Boulevard, Indianapolis, IN, 46278
(317) 290-3333 ext. 151, jwfrey@usgs.gov

One of the assumptions in nutrient criteria development is that a reduction in nutrient concentrations will improve water quality. Environmental managers need to know what can be expected from proposed reductions in nutrient concentrations. Results from a nutrient study conducted by the USGS National Water-Quality Assessment Program on the East Fork White River and White River from 1993 though 1995 gives insight into possible algal biomass and phytoplankton species composition if nutrient reductions are made.

The White River and East Fork White River Basins during 1993 through 1995 provides a good setting to contrast two large, similar sized, agricultural basins with similar flow and annual loadings of total N. The major differences between the two basins are a greater loading of reactive P to the White River, and the seasonal variability in nutrient concentrations. Commercial fertilizer is the primary source of nutrients in both rivers. Only 3% of the nitrogen is from municipal and industrial sources. However, loadings of total N and total P from municipal wastewater are 4- to 10-fold greater in the White River than in the East Fork White River, and municipal wastewater from Indianapolis, Muncie, and Anderson is the primary source of reactive P and ammonia.

Although annual loadings of total N are similar for the basins, concentrations of total N and total P during the critical late-summer low-flow period are greater in the White River than in the East Fork White River. Consequently, the algal biomass concentrations in the White River were about 4-5 times greater than the East Fork White River during peak algal growth in July-September. In the more productive White River, phytoplankton species were controlled by centric diatoms and chlorophytes whereas in the less productive East Fork White River centric diatoms were never abundant. Additionally, there appeared to be silica limitation associated with diatom uptake in the White River whereas there was no limitation in the East Fork White River. The management implication is that even if there are reductions in non-point sources of nutrients, point source reductions in nutrients need to be made to control the seasonal inputs during the critical low flow periods of July through September.

Two-Stage Ditch Restoration as a Potential Nitrogen Removal Strategy in Agricultural Streams

Sarah S. Roley[1,3], Kent Wamsley[2], Jennifer L. Tank[1], Laura T. Johnson[1], Jake J. Beaulieu[1], and Mia L. Stephen[1]

[1]University of Notre Dame, Department of Biological Sciences
[2]The Nature Conservancy
[3](574) 631-3638, sroley@nd.edu

Intensely farmed landscapes export excess nutrients and sediments to streams, which leads to downstream turbidity and eutrophication problems, as well as potential community shifts to toxic species of algae, reduced fish and crustacean populations, human health risks, and aesthetic problems. Agricultural runoff in Indiana not only influences local lakes and rivers, but also contributes anthropogenic nitrogen to the Gulf of Mexico, where excess nutrients fuel a seasonal hypoxic zone.

Traditional agricultural stream management involves continued channelization, designed to efficiently move water off the landscape and downstream. The resulting geomorphology, however, results in unstable high flows and a minimal capacity for nutrient processing or sediment retention. Two-stage ditch construction is a restoration technique developed to improve channel stability and reduce maintenance costs, but recent studies have suggested that this novel technique may also reduce the export of nutrients. In a two-stage ditch, the stream banks are excavated to create benches (i.e. small floodplains) that will convey peak stream flows without overtopping stream banks. This reduces erosion during high flows, and also increases water-benthos contact time, which may result in increased biological processing of nutrients, ultimately decreasing stream nutrient export.

We are testing the efficacy of the two-stage ditch for nutrient and sediment removal in an agricultural stream in northern Indiana. Our study stream is located in the Tippecanoe River Basin, where the primary land use is row crop agriculture. Historically, the channel shape was maintained through periodic excavation, but bank slumping and sediment deposition had created a few, small, naturally formed benches. Using a before-after control-impact (BACI) experimental design, the restoration was completed on the manipulated reach (620 m) in November 2007 after more than one year of pre-treatment data collection. The control reach has been left unaltered as a comparison.

Restored bench height was based on the height of naturally formed benches and ranged from 30 – 60 cm above base flow water level, increasing longitudinally downstream. Benches were created on both stream banks, and each bench was approximately the same width as the stream channel (3 – 4 m), effectively tripling the stream width during storms.

To examine changes in ecosystem function associated with the two-stage ditch, we have been quantifying sediment denitrification, which is the microbially-mediated transformation of nitrate (NO_3^-) to dinitrogen gas (N_2), a process that permanently removes nitrogen from the system. We measured both in-stream and bench denitrification rates every two months using the chloramphenicol-amended acetylene block method. Additionally, to quantify physicochemical changes resulting from two-stage construction, we deployed sondes that continuously recorded temperature, dissolved oxygen, pH, conductivity, and turbidity. We also sampled for a suite of water chemistry metrics, including ammonium, nitrate, total phosphorus, soluble reactive phosphorus, and total suspended solids during storm and base flow.

Pre-restoration, in-stream denitrification rates ranged from 5.0 µgN/gAFDM/h in October to 32.8 µgN/gAFDM/h in August and could be explained by variation in stream water nitrate concentration. Mean pre-restoration bench denitrification rates averaged 2.5 gN/m^2/day, resulting in the removal of 1,870 gN/day in the 620 m reach. After restoration, the floodplain area increased from 756 m^2 to 3,780 m^2, increasing the average daily reach-scale nitrogen removal rate to 9,360 gN/day. In-stream benthic area did not change as a result of restoration, and average in-stream N removal accounted for 1,932 g N/day. Bench denitrification rates were significantly higher when inundated, indicating that denitrification rates are maximized when the benches are saturated (e.g. during storms). Our results thus far indicate that restored floodplains created using two-stage restoration have the potential to decrease N export from agricultural streams.

Putting the Pieces Together to Improve Water Quality: 303d List/305b Report, Total Maximum Daily Loads, Section 319 Nonpoint Source Grants, and the Watershed Specialists

Ernest Johnson III

Indiana Department of Environmental Management

The Indiana Department of Environmental Management's Office of Water Quality combined three program areas to more focus efforts on improving water quality. The integration of the 303(d) List, Total Maximum Daily Load, and Section 319 Grant Non Point Source Pollution Program areas has increased communication, teamwork, and transparency between the programs. The benefit of these program areas, in conjunction with the Watershed Specialists, is disseminating as much information to locally driven efforts, which are implementing watershed management plans to improve water quality. What are these programs? What do they do? How do they work together? What have theses program areas accomplished? What does all this mean to me, the interested individual in improving water quality in my backyard? These are some of the questions that will be answered during this presentation.

Fish and Invertebrate Communities in Agricultural Headwater Streams

Jay Beugly[1] and Mark Pyron

Ball State University
[1]jsbeugly@bsu.edu

Agricultural practices may influence stream biological communities by removing riparian vegetation and modifying stream channel morphology, both which may reduce water retention time and increase the frequency of scouring events. I collected benthic invertebrates and fishes in seven headwater agriculturally-influenced streams in central Indiana, to quantify controls on macroinvertebrate and fish community assemblage variation. Invertebrates were collected at 14 sites and fish were collected at 12 sites in seven headwater streams in Buck Creek watershed, a tributary of the White River. The abundances of invertebrates and fishes were analyzed in separate Detrended Correspondence Analyses (DCA) ordinations in PC-ORD software and correlated with abiotic and biotic factors. The sites located in close proximity to Buck Creek have increased stability of biotic (fish assemblages) and abiotic (flow and water depth) factors. Abundances of invertebrates of headwater streams in east-central Indiana agricultural landscapes are impacted by environmental variables, distance between sites, distance to Buck Creek, and presence of fish species. Abundances of fishes were correlated with environmental variables and distance to Buck Creek.

Conjunctive Flow in Wetlands and Underlying Aquifers

M.A. Gusyev[1] and H.M. Haitjema

School of Public and Environmental Affairs, Indiana University
1315 East Tenth Street, Bloomington, IN 47405
[1](812) 855-1606, mgusyev@indiana.edu

Hydrology plays a critical role in all aspects of wetland dynamics. Complex interactions of surface water flow and flow in underlying aquifers support wetland ecosystem and drive transport and redistribution of materials and nutrients across the landscape. A quantitative understanding of wetland hydrology is essential to protect and restore natural wetlands. Our research focuses on modeling of surface water (sheet flow) and groundwater flow conjunctively by expressing the governing differential equation in terms of a comprehensive discharge potential for constant wetland bottom/aquifer top and pseudo potential for sloping wetland bottom/aquifer top. The discharge potential formulations were tested on a few one- and two-dimensional cases and appear robust and stable. We are currently applying this modeling approach to improve our understanding of wetland hydrology and material transport on a local scale, specifically in and around tree islands in the Florida Everglades.

Contrasts and Similarities in Water Quality Issues Facing East Central China and Northwest Indiana: Issues, Perceptions, and Approaches for Resolution

Jeffrey S. Field and Jonathon Schoer[1]

Department of Chemistry, Valparaiso University, Valparaiso, IN 46383
[1](219) 464-5374, Jon.Schoer@valpo.edu

Through collaboration with Zhejiang University, twenty sites were chosen in the surrounding Hangzhou region to study multiple water quality parameters. The parameters studied included dissolved oxygen, nitrates, phosphates, temperature, conductivity, heavy metals and then 30 different pesticides in eight major organophosphates classes. High nutrient levels in many sites led to increased plant growth, higher dissolved oxygen levels and algal blooms (i.e. Taihu Lake). Copper, mercury and cadmium levels were also elevated. The Hangzhou region was chosen to compare these results with a continuing study in the Valparaiso Chain of Lakes watershed as the land use and physical geography are similar. Both regions have significant impacts from heavy industry and fertilizers from agriculture/residential application. Along with the quantitative data, interviews with local academia, Chinese water quality experts and government officials provided an evaluation of land use impacts and management practices currently in Zhejiang Province. Overall, nonpoint source pollution from domestic waste and agricultural runoff remain the largest threats to water quality. Future work is recommended to gain more data on the region to make better predictions for the source(s) of pollution. The project also included interviews with local citizens, students, and professors which were helpful to determine the awareness of environmental degradation from all classes of society. Furthermore these interviews helped decipher the importance of growth, tradition and an international image in working with China into the future.

Long-Term Monitoring of Mercury in Indiana

Martin Risch

U.S. Geological Survey, Indiana Water Science Center
5957 Lakeside Boulevard, Indianapolis, IN 46278
(317) 290-3333, mrrisch@usgs.gov

Long-term monitoring of mercury in Indiana includes data for atmospheric deposition of mercury since 2001 and data for mercury in streams since 2002. Analysis of these data reveals changes over time, along with geographic differences. Some factors have been identified that help explain these changes and differences in mercury throughout the state. These findings have implications for planning and implementation of mercury policy and mercury regulation in Indiana.

The U.S. Geological Survey (USGS), in cooperation with the Indiana Department of Environmental Management, operates a statewide network of 25 monitoring sites at USGS streamflow-gaging stations where representative samples are collected on a seasonal schedule for analysis of mercury and related constituents. In addition, USGS operates a statewide network of five monitoring sites where weekly precipitation samples are collected for analysis of mercury and related meteorological measurements are made. Data from these two networks were examined with statistical and graphical techniques.

Mercury concentrations in precipitation and mercury wet deposition exhibit seasonality and episodes of high mercury deposition that contribute to temporal and geographic variability. Trends in mercury wet deposition and mercury concentrations in precipitation appear to be related, in part, to changes in mercury emissions over time. In some locations, high mercury deposition and high mercury concentrations appears to be related, in part, to local and regional mercury emissions.

Mercury concentrations in streams exhibit seasonality and episodes of high mercury concentrations and loads that contribute to temporal and geographic variability. Transport of particulate mercury is related to streamflow. Mercury concentrations in Indiana streams are highest and exceed the statewide water-quality standard the most often at locations downstream from urban areas. Estimated mercury loads in watersheds include a watershed load from mercury in precipitation, plus mercury from other sources.

Incorporating Method Performance Information in Pesticide Trend Analysis

Jeffrey D. Martin[1,3], Wesley W. Stone[1], and Duane S. Wydoski[2]

[1]U.S. Geological Survey, Indiana Water Science Center
[2]U.S. Geological Survey, National Water Quality Laboratory
[3]5957 Lakeside Boulevard, Indianapolis, IN 46278
(317) 290-3333 ext. 148, jdmartin@usgs.gov

Temporal changes in the recovery of pesticides measured in laboratory- and field-submitted quality-control samples indicate that changes in recovery during 1992-2006 have the potential to identify trends in environmental concentrations that are caused solely by trends in recovery in the analytical method. Changes in recovery through time were modeled using a LOWESS smooth and pesticide concentrations in environmental samples were adjusted to 100 percent recovery to compensate for temporal changes in recovery. A comparison of trend results using unadjusted and recovery-adjusted concentrations is planned but not completed.

Pesticide recovery is the primary measure of method performance and is measured by analysis of spiked quality-control samples. Spikes are samples where a known amount of pesticide is added to a sample. Recovery is the measured concentration of pesticide divided by the expected concentration and is expressed as a percentage. Both bias in recovery and variability of recovery are characteristics of method performance. Bias is the systematic error in a measurement process and results in measurements that differ from the true (or expected) value in the same direction. Variability is the random error in a measurement process. Changes in the bias of recovery were considered more important for trend analysis than changes in the variability of recovery and efforts to model changes in method performance focused solely on modeling bias in recovery.

Temporal patterns in recovery were similar among laboratory reagent spikes, stream-water field spikes, and ground-water field spikes, but for several pesticides, the magnitude of recovery was 10-30 percent greater in stream-water spikes than in the other spike types. Because stream-water field spikes are expected to more closely match the matrix of stream-water samples to be analyzed for trends, only stream-water field spikes were used to model bias in recovery.

Stream Ecosystem Effects of Nonprescription Pharmaceuticals

Aubrey R. Bunch[1] and Melody J. Bernot

Ball State University Biology Department
[1](812) 371-5979, arklare@bsu.edu

Contamination of freshwater ecosystems with nonprescription pharmaceuticals is an emerging concern. Pharmaceuticals consumed by humans are excreted into wastewater and can enter aquatic ecosystems after passing through water treatment facilities, as most systems are designed to remove only nutrients and pathogens. To quantify stream ecosystem response to these compounds, we measured the influence of four commonly used nonprescription pharmaceuticals (ibuprofen, acetaminophen, caffeine, and nicotine) on stream sediment respiration and nutrient uptake. Pharmaceuticals were added to stream sediment cultures with subsequent measurements of dissolved oxygen and nutrient concentrations. Four treatments for each pharmaceutical were assessed and treatments were based on published mean and maximum concentrations detected in US streams. Preliminary data show sediment respiration is reduced by acetaminophen, with concentrations as low as 5.1 µg/L, and ibuprofen, with concentrations as low as 0.1 µg/L (ANOVA, $p<0.05$). Nicotine and caffeine treatments both increased dissolved oxygen concentrations (ANOVA, $p<0.05$), suggesting stimulation of sediment macroinvertebrates. Phosphate uptake did not change with pharmaceutical treatment or increased respiration. In contrast, we measured variable nitrate uptake among treatments. Our data show nonprescription pharmaceuticals may influence stream ecosystem function even at low concentrations.

Effects of Ultraviolet Light on Sediment Respiration

Emily Cross and Melody Bernot

Ball State University

Ultraviolet (UV) radiation can be genotoxic to bacteria and cause distortions of DNA that may influence microbial activity. We measured biological response to UV exposure as bacterial respiration. Sediment inoculum was collected from a eutrophic duck pond in Muncie, IN for use in respiration assays. Room temperature homogenized sediment and pond water were used to make 16 sediment cultures with 50 cm^3 of sediment and 60 ml of pond water in 120 ml plastic specimen cups. Sediment cultures were exposed to four light treatments: UVA, UVB, fluorescent, and no light, each with 4 replicates. Cultures were exposed to light treatment for 48 h. Bacterial respiration rates were measured as change in oxygen concentration over time expressed per unit inorganic or organic substrate. We compared treatment means using an ANOVA and Tukey test. UVA, UVB, and fluorescent treatments yielded higher oxygen production than the no light treatment ($p < 0.001$). No significant differences were found among UVA, UVB, and fluorescent treatments, although UV exposure generally increased oxygen concentrations. Increased oxygen production may be due to either inhibited microbial respiration, stimulated photosynthesis, or a combination of these processes. Differences among light treatments were similar when respiration was expressed per unit organic substrate or per unit inorganic substrate indicating sediment was not being used as a source of carbon for respiration. Sediment was primarily clay (99%) and thus, physiochemical degradation of sediment by UV was likely minimal. These data indicate UV exposure may alter biological community structure and function by altering microbial activity, even when sediment organic content is low.

Effects of Urbanization and Road Salt on Chloride Concentrations in a Central Indiana Watershed

Kristin Gardiner and Todd Royer

Indiana University, School of Public and Environmental Affairs

Elevated chloride concentrations in streams can affect aquatic life and recent studies suggest salinization of freshwaters due to long-term road salt use. Yet, relationships between urbanization and chloride concentrations are not clear. Here we report on chloride concentrations from three sites within the Jack's Defeat Creek watershed in central Indiana and a small, adjacent reference watershed. Chloride concentrations were measured routinely beginning in September 2007. The sites vary in size and land use. Site 1 (4.8 km^2) drains a residential area and had significantly lower baseflow chloride concentration (mean = 14.3 mg/L) than Site 2 (17.4 km^2) or Site 3 (27.2 km^2), both of which contain urban and commercial areas (baseflow means of 22.2 and 25.4 mg/L, respectively). Intensive sampling during fall and winter storms in 2007 revealed chloride concentrations > 500 mg/L except at the reference site which never exceeded 25 mg/L. Run-off of road salt fluctuated daily in relation to air temperature, and stream chloride concentrations often varied 10-fold or more in a 24-hour period. During storm run-off, chloride increased at all stream sites regardless of land use, except for the reference site. Elevated baseflow concentrations suggest salinization of groundwater may be occurring in the more developed areas of the watershed.

IDNR Ground-Water Updates: Digital Aquifer Systems Map Status and the New Water Well Web Viewer

R. Tony Scott, et al.

Indiana Department of Natural Resources, Division of Water
(317) 234-1102, tscott@dnr.IN.gov, http://www.in.gov/dnr/water/

In 2003 the Resource Assessment Section within the Department of Natural Resources, Division of Water (IDNR/DOW) started production of a new series of aquifer systems maps for the purpose of assessing Indiana's ground-water resources. Bedrock and unconsolidated aquifer systems are defined and mapped within individual counties in Indiana. The maps describe characteristics such as geologic materials, range in thickness of the aquifer materials, thickness of confining units, typical well depths, depth to the aquifer resource, static water levels, and well yield. To date, 43 of 68 counties not previously mapped as part of the IDNR/DOW Basin Study series have been completed. The digital maps (with accompanying text and tables) are available online as digital images and ArcGIS shapefiles.

In June of 2007, the DOW enhanced web services by providing GIS capability to the Division of Water web site. The DNR Water Well Web Viewer was developed using ArcIMS version 9.2 with posting of data and imagery using ArcSDE version 9.1 and ArcGIS Image Server version 9.2. The Water Well Web Viewer provides access to approximately 142,000 located water well records and a variety of layers including USGS topographic maps, 2005 aerial photos, Public Land Survey Sections (PLSS) and more. Unique program tools allow users to identify layer features and query select water well data including depth, aquifer elevation, bedrock elevation, static water level, and pump capacity.

Indiana Water Resources Association Symposia and Field Trips

Water Resources and Land Use Management in Indiana, symposium at Turkey Run State Park, Marshall, *William Wilber, U.S. Geological Survey* (1980)

Lake and Wetland Hydrology, symposium at McCormick's Creek State Park, Spencer, *William Wilber, U.S. Geological Survey* (1981)

Water: Indiana's Abundant Resource, symposium at Century Center, South Bend, *Darrell Leap, Purdue University* (1982)

Topics in Hydrology: Theory and Applications, short courses at Turkey Run State Park, Marshall, *Charles Crawford, U.S. Geological Survey* (1983)

Acid Rain and Water Management, symposium at Shawnee Bluffs, Bloomington, *Noel Krothe, Indiana University* (1984)

Karst Hydrology, field trips from Spring Mill State Park to Lost River, French Lick, and other sites, *Paul van der Heijde, Holcomb Research Institute* (1985)

Managing the Great Lakes, symposium at Pokagon State Park, Angola, *Thomas Bruns, Indiana Department of Natural Resources* (1986)

Water Resources and Environmental Issues in Northwest Indiana, field trips from Michigan City to Pinhook Bog, Mt. Baldy, and Lake Michigan, *Robert Aten, Geosciences Research Associates, Inc.* (1987)

Water Resources: From Science to Regulation, symposium at DePauw University, Greencastle, *Konrad Banaszak, U.S. Geological Survey* (1988)

Effects of Coal Mining on Water Resources, field trips from Vincennes to active and reclaimed mine sites, *Judith Beaty, Indiana Department of Natural Resources* (1989)

Conjunctive Surface Water and Ground Water Studies, symposium at Seasons Lodge, Nashville, *Henk Haitjema, Indiana University* (1990)

Hydrology of South-Central Indiana, field trips from Clarksville to Harrison Spring, Indian Sinks, Falls of the Ohio, and other sites, *Richard Powell, WW Engineering and Science* (1991)

Water Quality and Its Effects on Human and Biological Health, symposium at Turkey Run State Park, Marshall, *Jeff Martin, U.S. Geological Survey* (1992)

Northwest Indiana Water Quality Opportunities and Concerns, field trips from Hammond to Superfund sites, LTV Steel, Amoco Refinery, Lake Michigan marinas, Wolf Lake, and other sites, *Mark Reshkin, Indiana University-Purdue University Northwest* (1993)

Understanding, Managing, and Protecting Indiana's Watersheds, symposium at Spring Mill State Park, Mitchell, *Rosemarie Hansell, Marion County Health Department* (1994)

Agriculture and Water Quality, field trips from Lafayette to farms and forested and agricultural watersheds, *Marty Risch, U.S. Geological Survey* (1995)

Environmental Restoration, symposium at Clifty Falls State Park, Madison, *Ronald Turco, Purdue University* (1996)

Flood Damage Reduction Strategies for the 21st Century, field trips from Pokagon State Park to Fort Wayne, Fox Island, Sylvan Lake Dam, and other sites, *Siavash Beik, Christopher B. Burke Engineering, Ltd.* (1997)

Source Water Protection and Assessment Programs, symposium at McCormick's Creek State Park, Spencer, *Gregory Nethery, Engineering and Testing Services* (1998)

Water Resource Issues of Northwestern Indiana, field trips from West Lafayette to the Kankakee Sands Restoration Project, Prophetstown State Park, Kentland Quarry, and Prudential Farms, *Mark Basch, Indiana Department of Natural Resources* (1999)

Improving and Protecting Water Quality: Assessment, Regulation, and Policy, symposium at Spring Mill State Park, Mitchell, *Cynthia Wagner, Indiana Department of Environmental Management* (2000)

Indiana's Water: In History, Today, and Tomorrow, field trips from French Lick to reclaimed coal mine sites, Augusta Lake, and Patoka National Wildlife Refuge, *Don Arvin, U.S. Geological Survey* (2001)

Water Quality and Water Rights in the Midwest: Converging Regulation, Technology, and Demand, symposium at Pokagon State Park, Angola, *Jack Wittman, Wittman Hydro Planning Associates, Inc.* (2002)

Exploring the Whitewater River Basin: Past and Present, field trips from Richmond to the Whitewater Canal, Metamora, Brookville Reservoir and the Whitewater River Gorge, *Tracy Branam, Indiana Geological Survey* (2003)

Watershed Science, Management, and Education on All Scales, symposium at Strongbow Inn, Valparaiso, *Ken Luther, Valparaiso University* (2004)

Brine Injection from Oil and Gas Production, and Other Water Resource Issues for Southwest Indiana, field trips from New Harmony to Nobel Energy's Griffin Oil Field, Harmonie State Park, and historic New Harmony, *Phil Ward, Groundwater & Environmental Services, Inc.* (2005)

Energizing Indiana's Water Community, symposium at Purdue University, West Lafayette, *Jane Frankenberger, Purdue University* (2006)

Environmental Issues in the Lake Michigan Basin, field trips from Merrillville to Thornton Quarry and Flood Control Project, ECI dredging containment site, Little Calumet Flood Control Project, and the U.S. National Park Service wetland restoration project, *Tim Kroeker, V3 Companies, Ltd.* (2007)