

**38TH ANNUAL MEETING  
PROGRAM AND ABSTRACTS**

# **MINING AND WISCONSIN WATERS**



**MARCH 13 & 14, 2014 | CHULA VISTA RESORT | WISCONSIN DELLS, WISCONSIN**



**American Water Resources Association – Wisconsin Section**

The Wisconsin Section of the American Water Resources Association provides an interdisciplinary forum for people involved in all aspects of water resources research and management.

**AMERICAN WATER RESOURCES ASSOCIATION –  
WISCONSIN SECTION  
38<sup>th</sup> ANNUAL MEETING**

**Mining and Wisconsin Waters**

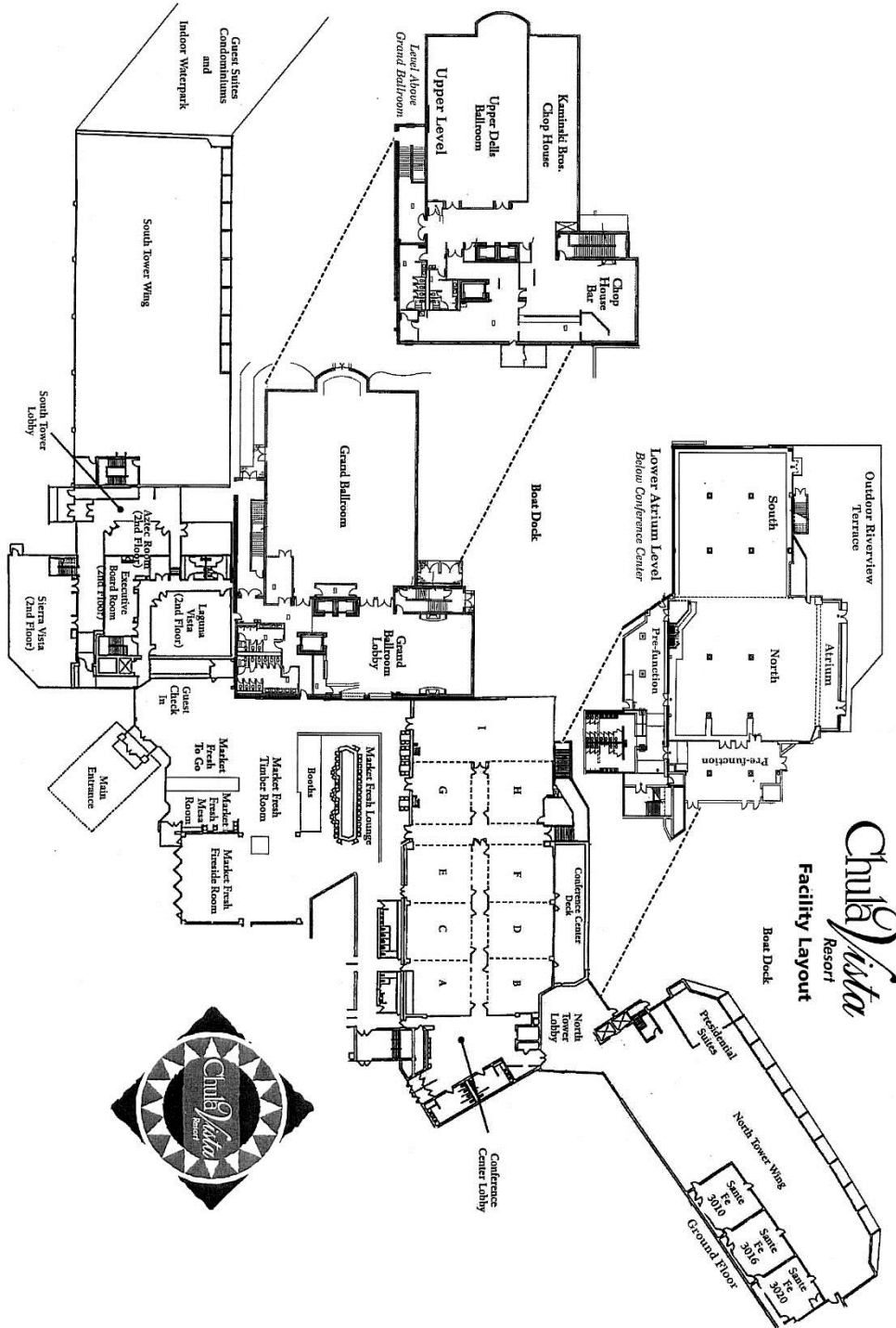
**March 13 & 14, 2014**

**Chula Vista Resort  
Wisconsin Dells, Wisconsin**

**Hosts:**

**American Water Resources—Wisconsin Section  
University of Wisconsin Water Resources Institute  
Wisconsin Department of Natural Resources  
Center for Watershed Science & Education, UW-Stevens Point  
Wisconsin Geological and Natural History Survey  
U.S. Geological Survey Wisconsin Water Science Center**

# Chula Vista Resort Facilities



*Chula Vista*  
Resort  
Facility Layout

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Michael Kvitrud, Wisconsin DNR, Madison	Web Coordinator

*The Wisconsin Section of the American Water Resources Association provides an interdisciplinary forum for people involved in all aspects of water resources research and management. The success of the section is due in part to the dedication of past and current members of our board of directors. We heartily acknowledge the following individuals for their service, and we invite others to consider volunteering to ensure an ongoing dialogue among those committed to water resources research and management in the state of Wisconsin.*

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Steve Gaffield	Chris Mechenich	Joan Underwood
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Susan Hill	Dale Patterson	Tom Wirth
Paulette Homant	Marie Peppler	Philip Younger
Peter Hughes	Mike Penn	

# **AWRA BOARD OF DIRECTORS POSITION DUTIES**

## **President (1-year term)**

Shall preside at meetings, shall, in consultation with the Board of Directors, appoint all committees, and shall perform all other duties incident to the office. The President shall prepare, in collaboration with the Secretary and Treasurer, an annual report of the Section's activities to be presented to the annual meeting of the Section and to be forwarded by the Secretary to the President of the American Water Resources Association.

## **President-Elect (1-year term)**

Shall perform the duties of the President when the latter is absent and shall succeed to the office of President in the following year. Historically has helped to recruit plenary and keynote speakers, has helped coordinate the nomination and election of officers, and performed other responsibilities related to the annual conference.

## **Vice-President (1-year term)**

Shall perform the duties of the President-Elect when the latter is absent. Some of the duties that the vice-president has helped with in the past include recruiting moderators for the general sessions, assisting with the technical program review, and performing other miscellaneous duties as assigned.

## **Secretary (2-year term, elected in odd years)**

Shall keep the minutes of the Section's meetings, shall issue notices of meetings, and shall perform all other duties incident to the office.

## **Treasurer (2-year term, elected in even years)**

Shall be responsible for all funds of the Section and the dues of the American Water Resources Association as agreed to between the Board of Directors and the American Water Resources Association. The Treasurer's accounts shall be audited at the close of each year as directed by the President. The Treasurer shall prepare an annual report and financial statement for presentation at the annual meeting.

## **Director-at-Large (2 positions, 2-year term, staggered appointments)**

Shall serve on the Board of Directors to help manage the affairs of the Section including administration, program development and supervision of financial affairs.

# **BIOGRAPHIES OF CANDIDATES FOR THE AWRA WISCONSIN SECTION BOARD**

## **Andrew Aslesen**

Andrew Aslesen has been a Source Water Specialist with the Wisconsin Rural Water Association since March 2010. Mr. Aslesen works with community water systems to solve groundwater quality and quantity issues, including the development and implementation of wellhead protection plans. Previously Mr. Aslesen worked as a project assistant with the Wisconsin Geological and Natural History Survey from 2008 to 2010. Mr. Aslesen has a M.S degree in Water Resources Management with an emphasis in Hydrogeology from UW-Madison's Nelson Institute of Environmental Studies and a B.S in Geography with a Geology emphasis from UW-Whitewater.

## **Eric Booth**

Dr. Eric Booth is an Assistant Research Scientist at UW-Madison in the Departments of Agronomy and Civil & Environmental Engineering. He also collaborates with the North Temperate Lakes Long-Term Ecological Research site, Center for Limnology, UW Arboretum, Great Lakes Bioenergy Research Center, and Wisconsin Energy Institute. He holds a BS in Environmental Engineering from UW-Madison (2004), MS in Hydrologic Science from UC-Davis (2006), and PhD in Limnology from UW-Madison (2011). His research interests cut across many disciplines with water as a centerpiece; these include hydroecology, impacts of climate and land-use change, urban stormwater management, wetland/stream restoration, water quality, groundwater hydrology, fluvial geomorphology, environmental history, agroecology, remote sensing, and numerical modeling.

## **Pat Jurcek**

Pat Jurcek is a senior hydrogeologist with Layne Christensen in their Pewaukee, Wisconsin office. He has a B.S. and M.S. in Geology and Hydrogeology, respectively from UW-Milwaukee. He has over 20 years of experience in water supply resource development with emphasis in aquifer test analysis, groundwater modeling, and geophysical surveys. He is a licensed professional geologist in Wisconsin, Illinois, Minnesota, and Texas.

## **John Panuska**

John Panuska is a Distinguished Faculty Associate in the Biological Systems Engineering Department and a Natural Resources Extension Specialist at UW – Madison where he teaches courses for the department, conducts outreach programming and applied research. He received his B.S. in Civil Engineering from SD School of Mines & Technology, his MS from the University of MN and Ph.D. from UW – Madison. Both his MS and Ph.D. are in Agricultural (Biosystems) Engineering. He's worked as an engineering consultant (4 years) and as the WDNR State Lake Management Program and TMDL modeling engineer for 12 years. His expertise includes: urban stormwater and agricultural runoff management, lake and reservoir nutrient modeling and water resources engineering design.

# **BIOGRAPHIES OF PLENARY AND EVENING SPEAKERS**

## **Bruce A. Brown**

Bruce Brown is Senior Exploration Geologist at Badger Mining Corp., a leading producer of industrial sand. He has a B.Sc. degree in geology from the University of Illinois, M.Sc. from the University of Oregon, and a Ph.D. from the University of Manitoba. He is a licensed Professional Geologist in the states of Wisconsin and Minnesota. In 2012 he retired from the Wisconsin Geological and Natural History Survey. In 34 years at the Wisconsin Survey he worked on a wide range of projects relating to the geology and the mineral and water resources of Wisconsin. He is a co-author of the Bedrock Geologic Map of Wisconsin, and has authored numerous maps and articles on Wisconsin geology. He specialized in nonmetallic and industrial minerals, and served as a member of the Wisconsin DNR Technical Advisory committee that wrote the nonmetallic reclamation rules (N.R.135). He was a member of the DNR Nonmetallic Mining Advisory Committee.

## **Seth Ebel**

Seth Ebel is a project engineer employed with Chippewa County Department Land Conservation & Forest Management for 8 years. His previous employment was with the Michigan Department of Transportation. He has an engineering degree from Michigan Technological University and he is a licensed Professional Engineer in the State of Wisconsin. He has diverse experience in conservation and environmental engineering; including mine site reclamation, erosion and sediment control, and waste management. He provides review of reclamation plans and on-site inspection of mines in Chippewa County.

## **Bradley A. Johnson**

Johnson graduated from UW-Stevens Point in 1992 with a B.S. in Resource Management. He began his career with the DNR in 1993 doing water quality appraisal monitoring, aquatic plant management and invasives work. In 1999, he was hired as a stormwater specialist to undertake all aspects of stormwater permitting and compliance in DNR's 19 county West Central Region. It was in that capacity that he began working with nonmetallic mines including industrial sand mining operations. Since then he has worked with 100's of mining operations. He is stationed out of the Wausau Service Center.

## **Steve Swenson**

Steve Swenson has spent his career advancing the relationship between people and land. As ecologist for the Aldo Leopold Foundation, he directs the Science and Stewardship Program at the Leopold Family Shack and Farm, a National Historic Landmark. This work serves as the basis for partnership and communication with private landowners and resource professionals throughout the Midwest. Steve coordinates the Leopold-Pine Island Important Bird Area partnership, comprised of Federal, State and private lands. This 15,000 acre partnership offers a great example of science, communication, and relationships delivering tangible conservation success. Steve has years of experience in land care including prairie restoration, prescribed burning, timber management, invasive species control, data collection, and management planning. Steve received his Bachelor's degree (1995) in environmental science and biology from the University of Wisconsin – Green Bay and a Master's degree (1999) in plant ecology from The Ohio State University.



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# PROGRAM SUMMARY

## Mining and Wisconsin Waters

### 38<sup>th</sup> Annual Meeting of the American Water Resources Association—Wisconsin Section Wisconsin Dells, Wisconsin

Thursday, March 13, 2014

9:00 – 11:00 Registration—Lower Level

11:00 – 11:45 p.m. Welcome and Lunch – Riverview North, lower level

11:45 – 1:45 p.m. **Plenary Session** – Riverview North, lower level

Bradley A. Johnson

Wausau Service Center, Wisconsin Dept. of Natural Resources  
Industrial Sand Mining in Wisconsin: An Overview

Seth Ebel

Project Engineer, Chippewa County Department Land  
Conservation and Forest Management  
County Experiences with Industrial Sand Mining

Bruce A. Brown

Senior Exploration Geologist, Badger Mining Corp.  
Wisconsin's Sand Industry: The Facts, the Fiction, and the Future

1:45 – 2:00 p.m. **Break**

2:00 – 3:40 p.m. **Concurrent Sessions 1A and 1B**

**Session 1A – Agriculture Hydrology and Management**  
Room A/C  
Moderator: Kevin Masarik

- 2:00 Integrating Agricultural Land Management into a Watershed Response Model, Adam Freihoefer
- 2:20 Prioritizing Water Quality Improvement Efforts on Agricultural Lands Using LiDAR Elevation Data, Theresa M. Nelson
- 2:40 Development of a Watershed Model to Assess Alternative Management Strategies in an Agricultural Watershed Vulnerable to High Sediment and P Runoff, Alexis Heim\*
- 3:00 Surface Runoff from Manured Cropping Systems Assessed by the Paired-Watershed Method, Part 1: P, N, and Sediment Transport, William E. Jokela
- 3:20 Surface Runoff from Manured Cropping Systems Assessed by the Paired-Watershed Method, Part 2: Pathogen Transport, Mark A. Borchardt

**Session 1B – Groundwater Modeling**

Room B/D

Moderator: Paul Juckem

- 2:00 Planned Methods to Quantify Denitrification and Lag-Time Scaling among Wells, Principal Aquifers, and River Systems in Central Wisconsin, Paul Juckem
- 2:20 Characterization of Physicochemical Groundwater Flow Processes in the Peatland of the Cedarburg Bog, Jack P. Graham\*
- 2:40 A Groundwater Flow Model for Columbia County, Wisconsin, Andrew Leaf
- 3:00 The Little Plover Basin Model: Applying State-of-the-Art Simulation Tools for Groundwater Management in Wisconsin's Central Sand Plain, Michael Fienen
- 3:20 Evaluating Aquifer Flow Conditions Using Heat as an In-Well Tracer, Stephen M. Sellwood\*

3:40 – 4:00 p.m. **Break**

4:00 – 5:40 p.m.     **Concurrent Sessions 2A and 2B**

**Session 2A –     Agriculture Watershed Modeling**

Room A/C

Moderator: Mac Naber

- 4:00     Soil Texture and Groundwater Availability as Drivers of Subfield-scale Yield Variability, Yahara Watershed, Wisconsin, Samuel C. Zipper\*
- 4:20     WISP 2012: A New Irrigation Soil Water Management Tool, John C. Panuska
- 4:40     Assessing Agricultural Vulnerability to Recent Climate Change and Variability in Wisconsin Using USDA Crop Insurance Indemnity Data, Eric Booth
- 5:00     Impacts of Root Distribution and Root Water Uptake on Maize Water Use in Shallow Groundwater Agroecosystems, M. Evren Soylu
- 5:20     Passive Stormwater Agricultural Runoff Sampling, Kyra Fitzgerald\*

**Session 2B –     Groundwater Quality**

Room B/D

Moderator: Andrew Leaf

- 4:00     Effects of Precipitation Events on Virus Presence in Groundwater, Madeline Gotkowitz
- 4:20     Comparison of *Escherichia coli* and *Bacteriodes fragilis* Transport within Saturated Quartz Sands, Jennifer Johanson\*
- 4:40     Developing and Testing a Method for the Analysis of Chemical Waste Markers in Groundwater and Identifying Sources of Nitrate Contamination, Amy L. Nitka

5:40 – 6:00 p.m.     **Social**

6:00 – 7:30 p.m.     **Dinner** – Riverview North, lower level

**Speaker:** Steve Swenson, Ecologist, the Aldo Leopold Foundation  
Title: Aldo Leopold and a Land Ethic in Our Time

7:30 – 10:00 p.m. **Posters** – Riverview South, lower level

1. Soil Hydraulic Properties are Strongly Related to Soil Organic Content and Can Affect Soil Moisture Availability for Plants, Kyle Ankenbauer\*
2. Evaluation of Benthos and Plankton Communities in Wisconsin's Lake Michigan Areas of Concern, Daniel J. Burns\*
3. Water Runoff and Sediment Losses from Biofuel Cropping Systems, Justin Cartier\*
4. Aquatic Invasive Species Monitoring Protocol, Shannon Davis-Foust\*
5. Simulating Recharge in Two Small Watersheds: The Effect of Sub Annual Precipitation Patterns, Alice M. Egan\*
6. Evaluating Nitrogen Removal of an Enhanced Wetland in an Agricultural Watershed, Stephen J. Gaffield
7. Applying Shared Vision Planning to Water Resources in the Central Sands Region of Wisconsin: Case Study on the Little Plover River, Maribeth L. Kniffin\*
8. Integrating Build-Out Scenarios with Lake Response Models to Guide Management Decisions, Ryan Haney
9. The Hydrogeology of Chamberlin Springs, Beloit, WI, Harry M. Kuttner \*
10. Evaluating Water Quality and Stratification in the Shallow Water Lake Environment, Brian J. Liesch\*
11. Investigating Temporal Trends in Groundwater Nitrate Concentrations, Kevin Masarik
12. Mapping compositional heterogeneity in the St. Peter Sandstone: improving prediction of potential frac sand and groundwater resources, Patrick McLaughlin
13. Hydrogeologic Data Viewer: Map-Based Access to Wisconsin's Hydrogeologic Information, Peter Schoephoester
14. How Does Map Design Influence Well Water Testing for Residents with Private Wells?, Dolores (Lori) Severtson
15. Understanding Factors Controlling Chromium Speciation in Wisconsin Groundwaters, Zana Sijan\*

16. Wetland Investigation of the Albion Basin, Little Cottonwood Canyon, Alta, Utah, John D. Skalbeck
17. Improving Sediment Delivery Process in a Semi-Physical Model, Harsh Vardhan Singh\*
18. Geologic Mapping of Columbia County: 3-D Subsurface Reconstruction Using an Integrated Geological Dataset, Esther Stewart
19. Passive Water Sampling for Agricultural Antibiotics on Three Rivers in Eastern Wisconsin, Samuel D. Thomas\*
20. Understanding Stream Phosphorus Concentrations: Contrasting the Role of External Inputs and Internal Reactions, Amy A. Timm
21. The Triemstra Drill Core from Northern Columbia County: New Insights into the Cambrian Stratigraphic Succession on the Wisconsin Arch, Jay Zambito
22. Comparison of Breakthrough and Downward Migration of Live and Irradiated *Cryptosporidium parvum* and Microspheres Under Simulated Rainfall, Zachariah P. Zopp

Friday, March 14, 2014

- 7:00 – 8:30 a.m.      AWRA – Wisconsin Section Board of Directors’ Breakfast Meeting (Laguna Vista)
- 8:30 – 10:10 a.m.    **Concurrent Sessions 3A and 3B**
- Session 3A –            Mining Impact on Groundwater and Surface Water**  
Room A/C  
Moderator: Earl Spangenberg
- 8:30                      Water Use in Wisconsin’s Non-Metallic Mining Industry, Robert Smail
- 8:50                      Evaluating Hydrogeologic Impacts of Frac Sand Mining and Irrigated Agriculture in Western Chippewa County, WI, Michael Parsen
- 9:10                      Simulating Flow for the Proposed Crandon Mine - What Did We Learn?, Ken Bradbury

9:30 The Largest Flowing Artesian Well in the State of Wisconsin Is (sometimes) an Abandoned Deep Quarry, John A. Luczaj

9:50 Improved Understanding of the Rountree Formation in Southwest Wisconsin Using Geophysics and Quarry Exposures, Carolyn Streiff

**Session 3B — Urban Water Quality**

Room B/D

Moderator: Austin Baldwin

8:30 Modeling the Hydrologic Effects of Parcel-Scale Changes in Lot Layout and Impervious Surface Connectivity, Carolyn B. Voter\*

8:50 Evaluation of Grass Swales - Reducing Volume and Pollutant Concentrations in Highway Runoff, Judy Horwathich

9:10 Influence of Different Methods for Estimating Impervious Surface Cover on Model-simulated Streamflow of the Milwaukee River Basin, Feng Pan\*

9:30 The Quest for Clean Lakes: Evaluation of a City-Wide Leaf Collection Program to Reduce Phosphorus, Nic Buer

9:50 From Streets to Streams: Assessing the Toxicity Potential of Urban Sediment by Particle Size, William Selbig

10:10 – 10:30 a.m. **Break**

10:30 – 12:10 p.m. **Concurrent Sessions 4A and 4B**

**Session 4A — Surface Water Quality**

Room A/C

Moderator: Bill Selbig

10:30 Apportionment of Stream Bed Sediment Sources in an Agricultural Watershed Using Sediment Fingerprinting Techniques, Jasmeet Lamba\*

10:50 Methylmercury Dynamics in Nearshore Quagga Mussel-Cladophora Communities of Lake Michigan, Ryan F. Lepak\*

11:10 Phosphorus and TSS Trends in Two Streams in Northeastern Wisconsin, Paul D. Baumgart

- 11:30 Harmful Algal Blooms in Wisconsin: Results of a Statewide Public Health Surveillance Program, Emelia Wollenburg
- 11:50 Trace Organic Compounds in Great Lakes Tributaries: How Does Wisconsin Compare?, Austin Baldwin
- Session 4B — Measuring, Monitoring, and Managing Water Resources**  
Room B/D  
Moderator: Eric Booth
- 10:30 Streamflow Trends in WI, Warren A. Gebert
- 10:50 Seasonal Streamflow Changes in Wisconsin Watersheds, Rabi Gyawali
- 11:10 Probabilistic Survey of National and WI Stream Resources, Camille Bruhn
- 11:30 Evaluation of a Geometric Sampling Design Used to Assess Stream Resources and Identify Environmental Stressors in Watersheds, Michael Miller
- 11:50 Beer, Brats, Cheese and Water Are Things Every Wisconsinite Needs Even during Drought, Martin Griffin
- 12:10 – 12:30 **Student Awards and 2015 Meeting Announcements**  
Room A/C
- 12:30 – 2:30 **Student Career Session Lunch**, Laguna Room

\* Student Presentation



**Session 1A:**  
**Agriculture Hydrology and Management**  
**Thursday, March 13, 2014**  
**2:00 – 3:40 p.m.**

**Integrating Agricultural Land Management into a Watershed Response Model**

Adam Freihoefer,<sup>1</sup> *adam.freihoefer@wi.gov*

Tom Beneke,<sup>1</sup> *thomas.beneke@wi.gov*

Aaron Ruesch,<sup>1</sup> *aaron.ruesch@wi.gov*

<sup>1</sup>Wisconsin Department of Natural Resources, Madison, WI

Landcover and land management are important components in the evaluation of hydrologic and water-quality response for pollutant allocations as part of a watershed-based Total Maximum Daily Load (TMDL). The evolution of geospatial products has improved how these factors can be defined. Datasets such as the gridded Cropland Data Layer, which classifies 133 different landcover types for each 30-meter pixel for the contiguous U.S., provides scientists with rich spatiotemporal information for analyzing landcover and landcover change. The resulting increase in heterogeneity and resolution of landscape data can improve precision when targeting areas of high sediment and nutrient export. Although gridded landcover data is easily accessible from remotely-sensed products, how the land is managed cannot be inferred from remote-sensing. Incorporating spatiotemporal land management information into an improved landcover classification provides further refinement when defining hydrologic and water-quality response variability.

The Wisconsin Department of Natural Resources Bureau of Water Quality modeling team has developed a methodology that incorporates geospatial data and analysis, county Land and Water Conservation staff knowledge, and field-collected data such as transect surveys to define agricultural management. The methodology was applied to agricultural landcover within the Wisconsin River Basin, extending from the headwaters to Lake Wisconsin (9,156 square miles). The result is a spatial layer that defines spatiotemporal variability of dominant landcover and land management, such as rotation, tillage, and nutrient application, for all 160-acre agricultural plots above Lake Wisconsin.

## **Prioritizing Water Quality Improvement Efforts on Agricultural Lands Using LiDAR Elevation Data**

Theresa M. Nelson,<sup>1</sup> *theresa.nelson@wisconsin.gov*

Aaron S. Ruesch,<sup>1</sup> *aaron.ruesch@wisconsin.gov*

<sup>1</sup>Wisconsin Department of Natural Resources, Madison, WI

With the recent development and approval of several large-scale total maximum daily load (TMDL) projects in Wisconsin, a need for implementation targeting has been identified by the Wisconsin Department of Natural Resources and county land conservation staff. During the development of the TMDL, subbasins that contribute higher pollutant loads are identified. In order to implement management practices to reduce the loading from those subbasins, targeting needs to be done at approximately the field scale - the scale at which projects can be practically implemented. Prioritizing allows local conservation staff and watershed partners to identify critical source areas to obtain the greatest water quality benefits for the least amount of money spent on best management practices. Currently, watershed managers rely on subjective targeting methods at the field scale and thus are limited in their ability to use resources most efficiently to improve water quality. Here, we present GIS-based tools, and results from several "pilot" studies, for prioritizing the implementation of agricultural best management practices. A discussion of the use and analysis of land management information will be included. Because phosphorus export is strongly linked to soil erosion, the tools use high-resolution LiDAR elevation grids to assess vulnerability to erosion while masking out areas that do not contribute directly to surface water (i.e., internally draining areas). The distribution of these tools will give watershed managers and county conservation staff a "bang-for-buck" framework for reducing agricultural contributions of sediment and phosphorus.

## **Development of a Watershed Model to Assess Alternative Management Strategies in an Agricultural Watershed Vulnerable to High Sediment and P Runoff**

Alexis Heim, Environmental Science and Policy Graduate Program, University of Wisconsin-Green Bay, Green Bay, WI, *heima@uwgb.edu*

Kevin Fermanich, University of Wisconsin-Green Bay, Green Bay, WI, *fermanik@uwgb.edu*

Paul Baumgart, University of Wisconsin-Green Bay, Green Bay, WI, *baumgarp@uwgb.edu*

Plum Creek is a predominately agricultural watershed which contributes substantial loads of phosphorus (P) and sediment to the Lower Fox River. Baseline modeling for the Lower Fox River and Lower Green Bay Total Maximum Daily Load (TMDL) indicated that sediment and P loading from Plum Creek needs to be reduced by greater than 70% to meet water quality goals. Understanding the impact of various land management activities in relationship to highly event driven loads is a critical aspect to reducing P and sediment loading to Plum Creek and meeting water quality goals for the Lower Fox River and Lower Green Bay. In this study we are using the Soil Water Assessment Tool (SWAT) model to assess water quality and hydrologic response under various climate and alternative land use/management conditions in the West Branch subwatershed (33.7 km<sup>2</sup>) of Plum Creek. SWAT is a daily time step model that operates based on inputs of soil type, hydrology, topography, land cover, management practices, and climate. Water quality data collected primarily at the Main Branch (58.6 km<sup>2</sup>) subwatershed monitoring station in Water Years 2011 and 2012 were used to calibrate the model (>400 total samples). WY 2013 data from the Main Branch and near-instantaneous loads from the West Branch station were used to validate the SWAT model. The West Branch loads were based on correlations between discrete constituent concentrations and continuous turbidity observations ( $R^2 > 0.97$ ,  $p < 0.0001$ ). This presentation focuses on model development, calibration and validation aspects of the overall study. Application of the model to development of effective and efficient alternative land management strategies for the West Plum watershed is planned.

\*Student Presentation

## **Surface Runoff from Manured Cropping Systems Assessed by the Paired-Watershed Method, Part 1: P, N, and Sediment Transport**

William E. Jokela, USDA-Agricultural Research Service, Marshfield, WI,  
*bill.jokela@ars.usda.gov*

Michael D. Casler, USDA-Agricultural Research Service, Madison, WI,  
*michael.casler@ars.usda.gov*

Michael G. Bertram, University of Wisconsin Research Station, Arlington, WI,  
*mbertram@wisc.edu*

Mark A. Borchardt, USDA-Agricultural Research Service, Marshfield, WI,  
*mark.borchardt@ars.usda.gov*

Transport of P, N, and sediment via runoff from crop fields can contribute to degradation of surface waters. We established a paired-watershed study in central Wisconsin to evaluate surface runoff losses of nutrients, sediment, and pathogens from different manure/crop/tillage management systems for silage corn production. During the 2-yr calibration period the four 1.6-ha “watersheds,” or fields, were treated identically with fall dairy manure application and chisel plowing. That management was maintained as a control in one watershed, while alternative management systems were carried out on the three treatment fields from Oct 2008 to Apr 2012: fall surface-applied manure with spring chisel plowing, fall-seeded rye cover crop with spring manure and chisel plowing, and fall manure and chisel plowing with grass-legume buffers.

Runoff and nutrient export varied by treatment; averaged across treatments, snowmelt-derived runoff was 39% of the total runoff and contributed 11 to 65% of the total and dissolved P and N export. Fall surface-applied manure left over winter increased concentration of dissolved P (DP) and total P (TP) and export of DP (>200%). Fall-seeded rye cover reduced concentrations of suspended sediment (SS), TP, and total N and export of SS; effectiveness was limited by minimal fall growth due to difficulty achieving timely seeding. The vegetative buffer treatment reduced both concentration and export of SS, TP (but not DP), and total N, making it the most effective system evaluated in this study.

## Surface Runoff from Manured Cropping Systems Assessed by the Paired-Watershed Method, Part 2: Pathogen Transport

Mark A. Borchardt,<sup>1</sup> [mark.borchardt@ars.usda.gov](mailto:mark.borchardt@ars.usda.gov)

Susan K. Spencer,<sup>1</sup> [susan.spencer2@ars.usda.gov](mailto:susan.spencer2@ars.usda.gov)

William E. Jokela,<sup>1</sup> [bill.jokela@ars.usda.gov](mailto:bill.jokela@ars.usda.gov)

<sup>1</sup> U.S. Department of Agriculture – Agricultural Research Service, Marshfield, WI,

Manure application to cultivated land is a sustainable approach for enhancing soil fertility and tilth. However, pathogens are common in manure and can be transported from application sites via runoff and potentially transmitted to livestock and humans. Our objective is to quantify a diverse group of bovine and zoonotic pathogens in surface runoff from field-scale sites, to which dairy manure is applied.

A 6.4 hectare field located in central Wisconsin was divided by drive-through berms into four 1.6 ha fields so that each has a single drainage point. The fields have 1-3% slope and are cropped annually in corn. Manure (56,000 L/ha) is applied once per year. Runoff stations are equipped with 60-cm H-flumes, flow meters, and automated samplers. Samples are analyzed for enteric pathogenic protozoa, bacteria, and viruses by qPCR and for indicator *E. coli* by chromogenic assay. Treatment effects (i.e., different manure/cropping systems) on pathogen runoff are being evaluated by the paired-watershed method.

Pathogen types and concentrations in the applied manure and subsequent runoff were highly variable by year. Runoff continued to contain pathogens many months after manure application. Indicator *E. coli* was not correlated with pathogen levels. Estimated pathogen export ranged from 0.001% to 7% of the pathogen load applied to the land surface via manure. These data are valuable for identifying best management practices for reducing pathogen transport from agricultural sites and for assessing health risk to livestock and humans.

**Session 1B:  
Groundwater Modeling  
Thursday, March 13, 2014  
2:00 – 3:40 p.m.**

**Planned Methods to Quantify Denitrification and Lag-Time Scaling among Wells, Principal Aquifers, and River Systems in Central Wisconsin**

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The National Water Quality Assessment (NAWQA) program of the U.S. Geological Survey recently began its third decade assessing water quality in surface water and groundwater resources of the United States. During this third decade, two major focuses of NAWQA's groundwater assessment are to quantify delays between land application of nutrients and discharge to streams, and to map groundwater quality at the depths of domestic and public supply wells in principal aquifers, such as the glacial aquifer in the northern U.S.

Tools and methods are needed for scaling multi-constituent concentration data from point locations at wells up to principal aquifers and rivers. Such scaling methods should account for geochemical processes and lag-times between loading at the surface and observations at depth. In Wisconsin, a single-layer Analytic Element (AE) model and a multi-layer MODFLOW model of the Tomorrow-Waupaca River watershed will be calibrated to age tracer and redox constituent concentrations. New tools for application of convolution-based particle tracking (CBPT) for regional transport simulation with AE models will be developed. The models will be used to enhance understanding of how geochemical processes and lag-times "scale-up" by comparing simulated results to the water chemistry measured in: 1) Nested wells sampled along a groundwater flowpath, 2) Hyporheic pore-water samples collected below a stream bottom, 3) Spatially distributed shallow monitoring wells adjacent to agricultural fields, and 4) Spatially distributed domestic and public supply wells. Finally, a quasi-2D groundwater stratigraphy tool, GWstrat, will be developed and evaluated against the MODFLOW and AE model results and measured data to assess its potential as a simple analytical tool for estimating groundwater ages in areas of the Glacial Aquifer System where numerical flow models are lacking.

## **Characterization of Physicochemical Groundwater Flow Processes in the Peatland of the Cedarburg Bog**

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The Cedarburg bog has long been identified as a groundwater recharge zone for Ozaukee and Washington counties. The purpose of this study is to characterize the subsurface geology of the bog as well as the surrounding area, using existing hydrogeologic and geophysical datasets, estimate spatiotemporal recharge, and characterize responses of the bog brought on by changes in temperature, precipitation, and other meteorological factors. The Wisconsin Initiative on Climate Change Impact has developed projections of climate change. We have replicated a series of variations of the future climate in the MODFLOW model. Integration of well-data and geophysical survey data from electromagnetic and resistivity tomography resulted in a 3-dimensional subsurface map for the development of a groundwater flow model in the bog area. Additionally, 20-year trends of the potentiometric map were analyzed to identify differences throughout previous years and determined hydraulic conductivity by conducting slug and infiltrometer tests at multiple locations. The 20-year dataset was used to calibrate the heads within the monitoring wells and private drinking-water wells outside the bog. Preliminary results produced from the MODFLOW model indicate the bog is acting as a recharge zone under current recharge conditions, approximately 5 inches per year. Finally, a series of long-term monitoring data of groundwater level, temperature, EC, pH, and dissolved oxygen at piezometers were analyzed to reveal the role of this peatland on the local groundwater flow system. Knowledge acquired from this investigation can be used to better inform local agencies, as well as predict future changes within this groundwater system.

\* Student presentation

## **A Groundwater Flow Model for Columbia County, Wisconsin**

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Groundwater is used to meet all potable water supply needs in Columbia County, with fourteen cities and villages managing municipal well systems and private wells supplying rural residents and farms. However, agricultural practices and land spreading of waste have resulted in water quality issues. Over 20 percent of almost 3,000 groundwater samples from the County exceed 10 parts per million nitrate. The Columbia County Land Conservation and Information Departments requested that scientists from the US Geological Survey and Wisconsin Geological and Natural History Survey develop a groundwater flow model in support of efforts to improve drinking water quality.

The model is three dimensional and steady-state, with six layers representing surficial and bedrock deposits. Unconfined and confined groundwater flow are simulated using the USGS MODFLOW-NWT finite-difference code, with streamflow routing representing groundwater-surface water interactions, and the multi-node well package representing flow to wells in multiple model layers. A soil water balance method was used to estimate relative recharge spatially throughout the model domain. The model was calibrated to raw and processed groundwater levels and stream baseflows using the PEST software suite. Vertical head profiles obtained from packer testing indicate the Tunnel City Group acts as an important aquitard in the eastern half of the County, where it overlies the Elk Mound aquifer. To the west, where the Tunnel City is not present, the Elk Mound aquifer is relatively more susceptible to contamination. The model and supporting data collection advance our understanding of groundwater resources in Columbia County and provide a quantitative tool for better management of the natural resources.



## **The Little Plover Basin Model: Applying State-of-the-Art Simulation Tools for Groundwater Management in Wisconsin's Central Sand Plain**

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In recent years, interest in the impacts of high-capacity water-supply wells on groundwater and surface-water resources has increased, especially in Wisconsin's Central Sand Plain, where thousands of irrigation wells serve agricultural industries. Under current Wisconsin law, the cumulative effects of multiple high-capacity wells are not considered in the permitting process for new wells. As concern grows over management of groundwater resources connected to surface water, the State of Wisconsin has commissioned a study exploring tools for basin-scale groundwater management, which explicitly consider groundwater use, connections to surface water, and interactions among multiple extraction sources. The Little Plover River basin in Portage County, which has a long history of groundwater/surface water interactions studies, was chosen as the study area for this effort.

A state-of-the-art groundwater flow model using the USGS MODFLOW code builds on existing work by including explicit representation of extraction wells, calibration to current conditions, and streamflow routing. Inherent trade-offs between competing groundwater uses will be illustrated by applying the optimization code GWM (groundwater management) to the MODFLOW model. GWM provides optimal solutions for groundwater withdrawal and land use subject to hydrologic constraints such as minimum flow rates in streams or water levels in or near lakes. Other constraints, including costs and benefits of various agricultural practices, can also be applied to the management scheme.

While the primary goal of this project is to provide a path forward for resolving water-management issues in central Wisconsin, our broader goal is to educate non-scientists in how groundwater systems operate, and to produce an example decision-making tool that can inform groundwater management decisions across Wisconsin.

## **Evaluating Aquifer Flow Conditions Using Heat as an In-Well Tracer**

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Understanding aquifer flow conditions, including the presence or absence of preferential flow paths or aquitards, is critical for developing accurate conceptual models and numerical simulations of groundwater supply and contaminant transport problems. Borehole flow measurements can be used to determine the variation of borehole flow magnitude and direction with depth. These variations are caused by changes in flow conditions in the aquifer. As a result, borehole flow measurements are a valuable tool for assessing aquifer flow conditions and identifying heterogeneities that can significantly affect groundwater flow.

We used heat as an in-well tracer to evaluate borehole flow characteristics in four bedrock wells in south-central Wisconsin. Heat tracer tests were initiated using an electric downhole heater and monitored using a distributed temperature sensing (DTS) system. DTS measurements of borehole fluid temperature provide a record of heat movement in the well with time.

Heat tracer tests revealed a number of distinct flow regimes in the tested wells. In some wells a single direction of vertical flow was observed while in others both upward and downward flow were detected. Vertical flow in some boreholes was dominated by a few fractures, while in others it appeared to reflect porous media flow. Finally, in one example, no vertical borehole flow was observed. These borehole flow characteristics provide valuable information about the flow regimes in the aquifers adjacent to the boreholes, including the presence or absence of hydraulically active fractures that serve as preferential flow paths.

\* Student presentation

**Session 2A:**  
**Agricultural Watershed Modeling**  
**Thursday, March 13, 2014**  
**4:00 – 5:40 p.m.**

**Soil Texture and Groundwater Availability as Drivers of Subfield-Scale Yield Variability, Yahara Watershed, Wisconsin**

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Understanding the drivers of subfield-scale yield variability is critical for efficient agricultural management, which has the potential to increase yields. However, drivers of subfield-scale variability in yield are poorly understood and often covary. For example, coarse soil with poor water holding capacity and a deep water table can separately reduce plant available water and lead to water stress and yield loss; confoundingly, coarser soils are typically more erosion resistant and found at higher elevations with a deeper water table. Using a combination of field data from a study site near Deforest WI and biophysical modeling using AgrolBIS-VSF, we demonstrate that both soil texture and shallow groundwater availability can impact crop productivity, and the magnitude and direction of this influence depend on growing season meteorological conditions. In 2012, parts of the study site with coarse soils and a deep water table experienced significant yield losses due to drought conditions, which were somewhat alleviated where groundwater was closer to root zone. In contrast, an elevated early-season water table and flooding in 2013 caused yield losses in low-lying, fine-grained sections of the study site, while late-season drought also caused yield reductions in high-elevation, coarser soils. These results indicate that managers should consider both static (soil texture, topography) and dynamic (groundwater level, weather) drivers when making decisions and forecasts for their fields.

\* Student presentation

## **WISP 2012: A New Irrigation Soil Water Management Tool**

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Spatial variation in soil water retention and rainfall patterns across Wisconsin has resulted in the increased use of irrigation and an increase in new system installation. Concerns have been raised over adequate groundwater availability and the impacts of irrigation on groundwater quality, thus making optimal water use and soil water management a priority. Irrigation scheduling using the Checkbook Method is one approach to better match plant water needs to irrigation water supplied. A proper irrigation strategy strives to maintain optimal moisture in the root zone for plant growth, minimize drainage below the root zone and takes maximum advantage of natural rainfall. This is often done using a daily accounting of water inputs and outputs from the root zone accompanied by field soil moisture monitoring to verify model estimates. The **Wisconsin Irrigation Scheduling Program (WISP 2012)** is a new web-based tool recently developed by UW Madison Departments of Biological Systems Engineering and Soil Science that allows growers to track daily root zone soil moisture content. Inputs include canopy cover, rainfall, irrigation and evapotranspiration (plant water removal) or ET. Site-specific ET values are automatically imported from the UW Automated Weather Observation Network (AWON). Observed soil moisture values can be entered directly into WISP 2012 to adjust model estimates. Other features include seasonal summaries of rainfall, irrigation, ET and drainage passing through the root zone. Output can be exported in CSV format and is also displayed as a time series graph and table.

## **Assessing Agricultural Vulnerability to Recent Climate Change and Variability in Wisconsin Using USDA Crop Insurance Indemnity Data**

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Recent years in Wisconsin have shown dramatic swings in climatic conditions from excessive precipitation in 2007-2008 to widespread drought in 2012. These extremes have heavily impacted the agricultural industry as crops become stressed and yield is reduced with too much water (oxygen stress) and not enough water (water stress). One way in which this impact is manifested is in crop insurance indemnity payments from the US federal government. Records of these payments separated by cause of loss (e.g. excessive moisture, drought) are available through the USDA Risk Management Agency from 1948 to present and represent a potential dataset to assess trends and vulnerability of the agricultural sector to climate change and variability.

However, changes in federal crop insurance policy including large increases in enrolled acres make it challenging to analyze changes through time even if indemnity payments are adjusted for inflation. We present a method that normalizes this data so that a more reasonable analysis of changes in indemnity payments can be made. Data analysis from across all counties in the state shows substantial variability that can be partially explained by factors such as soil type, precipitation, and depth to the water table. As crop insurance continues to represent a substantial cost to the federal government and a potential strategy for adapting to climate change and variability, analyses such as these will help decision-makers effectively use limited financial resources.

## **Impacts of Root Distribution and Root Water Uptake on Maize Water Use in Shallow Groundwater Agroecosystems**

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Plant root water uptake (RWU) is a critical component of land surface processes controlling plant growth as well as water, energy, and carbon transfer within soil-plant-atmosphere systems. Plants adjust their RWU dynamically to escape water stresses during dry periods by enhancing their RWU in unstressed parts of the root zone to compensate for stress in other soil regions. However, simulating the dynamic response of RWU is challenging in ecosystem models because the distribution of RWU is commonly specified a priori. Moreover, these models simulate the plant root length density distributions (RLD) as a constant entity through time. Here, we investigate the potential impacts of RWU compensation and RLD distributions on transpiration and net primary productivity for maize in southern Wisconsin. An agroecosystem model was driven with 27 years of hourly weather observations for various maize RLD distributions across a continuum of groundwater depths. The results show that the strength of the relationship between groundwater depth and plant water use is controlled by the plant root structure, and RWU compensation. During drought periods, the amount of water that plants draw due to compensated RWU capabilities diminish as RLD becomes deeper. Moreover, shallow groundwater redistributes the soil moisture toward the land surface and the plants with shallow roots benefits the most from the additional redistributed soil water by increasing their transpiration by up to 230 mm/year.

## **Passive Stormwater Agricultural Runoff Sampling**

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Pollutant loading in stormwater runoff from agricultural fields is a growing issue for watershed management. The purpose of this research is to provide a less costly and less energy intensive method for monitoring agricultural runoff.

Programmed flow-weighted pumping samplers are often employed for agricultural runoff monitoring when sufficient financial resources are available. An alternative method is a passive sampler that does not require external energy input. The two types of passive samplers analyzed in this study are the multi-orifice passive sampler (MOPS) and the slit-weir passive sampler (SWPS).

In order to properly design the two samplers, coefficients of discharge for small orifices and narrow slits are needed. A hydraulic bench was used to maintain constant head within the apparatus where the MOPS and SWPS were mounted. Flow rates were determined by weighing a timed volume of water captured from the apparatus at each stage over multiple stages. The study results include:

- Orifice coefficients of discharge as a function of diameter and material thickness;
- Slit-weir coefficients of discharge for multiple slit widths and material thickness;
- Splitting accuracy of the MOPS;
- Evaluation of the ability of the MOPS to collect a representative sample of runoff for water quality evaluation purposes.

\*Student presentation.

**Session 2B:**  
**Groundwater Quality**  
**Thursday, March 13, 2014**  
**4:00 – 5:40 p.m.**

**Effects of Precipitation Events on Virus Presence in Groundwater**

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Previous studies by our group have demonstrated the presence of human enteric viruses in groundwater, and that leakage from sanitary sewers is a likely source of such contamination in urban areas. This work showed high rates of virus detection, and virus detection was positively correlated with precipitation events. In a recent study, we developed a network of 24 wells at seven field sites in Dane County, Wisconsin. A total of 455 groundwater samples were collected over a twelve month period and analyzed for viruses and coliform bacteria.

In contrast to our initial study, rates of virus detection in the more recent work were low. Viruses were detected in 13 of the 24 wells, but of the virus positive wells, 9 were positive only once and four were positive twice. The presence of viruses did not correlate to the presence of coliform bacteria. The over-all virus detection rate of 3.7 percent (17 of 455) was much lower than the 43 percent positive rate observed earlier at a subset of these wells.

Our data analysis focuses on causes of the low detection rate. Climatic conditions during the study varied from an extended period of drought to conditions favorable for spring recharge, which induced over six feet of water table rise in the study area. However, in contrast to previous studies, these data do not show an association between precipitation events and virus levels in wells. Understanding all factors, abiotic and biotic, contributing to well vulnerability to virus contamination is an ongoing research priority.



## Comparison of *Escherichia coli* and *Bacteriodes fragilis* Transport within Saturated Quartz Sands

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Groundwater is commonly analyzed for *Escherichia coli* to detect possible fecal contamination. However the effectiveness of *E. coli* as a fecal indicator has been questioned (AWWA, 2006; Bolster et al., 1999; Schinner et al., 2010). *E. coli* can display lower mobility than some pathogenic microorganisms in groundwater, and using *E. coli* to track the fecal contamination source has had limited success (Ahmad et al., 2009; Cimenti et al., 2005; Graves et al., 2007; Whitlock et al., 2002). Fecal anaerobes such as *Bacteriodes* are much more abundant than fecal coliforms. Surface water experiments have shown that host-specific markers in *Bacteriodes* have potential for microbial source tracking to identify the source of fecal contamination (Ahmad et al., 2009; Bower et al., 2005; Fiksdal et al., 1985; Gawler et al., 2007; Layton et al., 2006; Mieszkin et al., 2009). *Bacteriodes spp.* thus represent a promising groundwater fecal contamination indicator.

Laboratory column transport experiments were performed to compare the transport behavior of *Bacteriodes fragilis* and *E. coli* K12 within saturated sands under various ionic strength conditions. Cell surface properties were determined and the extended Derjaguin-Landau-Verwey-Overbeek (XDLVO) theory was applied to explain the retention difference. Results showed low attachment to the quartz sand (high mobility), at low ionic strength conditions for both *E. coli* and *B. fragilis*. Under higher ionic strength conditions attachment increased, but *B. fragilis* had significantly higher mobility (less attachment) than *E. coli*. The higher mobility further supports the potential for *B. fragilis* as a fecal source indicator.

\*Student presentation

## **Developing and Testing a Method for the Analysis of Chemical Waste Markers in Groundwater and Identifying Sources of Nitrate Contamination**

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Understanding the source of groundwater nitrate contamination is important to making appropriate land management decisions and treatment recommendations. Both fertilizers and domestic wastewater can contaminate groundwater with nitrate concentrations above the drinking water standard. When there are several possible sources of contamination, it may be difficult to remediate the condition unless the source can be identified. The objective of this study was to develop a method for the simultaneous analysis of a group of possible septic system contaminants, which could be used in tandem with traditional pesticide analysis to identify sources of nitrate contamination.

We are developing a rapid analytical procedure that quantifies a suite of pharmaceuticals, personal care products, and food additives. The method utilizes solid phase extraction for a 200-fold increase in detection for most analytes. Analysis is performed by ESI-LC/MS/MS. When the procedure is combined with an existing pesticide method, they span a range of chemicals useful for segregating human septic system impact from agricultural impacts.

The tracer method was tested with groundwater samples collected within a subdivision in Central Wisconsin. This area has a relatively high density of septic systems and has adjacent agricultural fields. Initial results show that in this subdivision, the water quality of the shallow wells is influenced by septic systems, while the source of nitrate in the deeper wells is agricultural. That is consistent with the flow paths expected in this relatively shallow sand and gravel aquifer.

**Poster Session**  
**Thursday, March 13, 2014**  
**7:30 – 10:00 p.m.**

**1. Soil Hydraulic Properties Are Strongly Related to Soil Organic Content and Can Affect Soil Moisture Availability for Plants**

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Organic matter in soil plays a significant role in determining the soil hydraulic properties, but it is uncertain how hydraulic properties respond when organic matter is lost or gained. For soils from a sub-alpine meadow in Yosemite National Park, CA, we found soil water retention is higher in organic rich soils by measuring the characteristic curves of mineral soils that differ widely in organic content. To isolate the effects of variable organic content on the soil characteristic curve, we tested soil samples with similar distributions of mineral content while varying in organic content by up to 20%.

This strong correlation between organic content and soil water retention implies that organic matter may play an important role in making soil moisture available to plants, however, the magnitude of this effect on the hydrologic budget was unquantified. We developed a numerical model of the vadose zone to determine how the changes in organic matter influence the spatiotemporal distribution of plant-available soil moisture. Our models indicate that soil moisture retained in organic rich soils can increase summer transpiration by more than 5 cm. Ultimately, this work will be used by the National Park Service to develop a watershed management plan for an area that includes most of Yosemite National Park and the source of the San Francisco Municipal Water Supply.

\* Student presentation

## **2. Evaluation of Benthos and Plankton Communities in Wisconsin's Lake Michigan Areas of Concern**

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The U.S. Geological Survey in cooperation with the Wisconsin Department of Natural Resources (WDNR) conducted a survey of benthos and plankton communities to support decision making for removal of Beneficial Use Impairments, as established by the International Joint Commission, in Wisconsin's Lake Michigan Areas of Concern (AOCs) during 2012. Three samples of benthos and plankton (spring, summer, and fall) were collected from four AOCs (Menominee River, Fox River/Lower Green Bay, Sheboygan River, and Milwaukee Estuary) and six non-AOCs (Escanaba, Oconto, Ahnapee, Kewaunee, Manitowoc, and Root Rivers) used as comparison sites with similar watershed areas, land use, and geology.

Evaluations of each community metric (diversity and benthos biotic integrity) were made at three levels, between an AOC and: (1) all non-AOCs as a group for each seasonal sample, 2) its two respective non-AOC comparison sites for each seasonal sample, and 3) its two respective non-AOC comparison sites across all seasons. If the metric was below the range or median of the non-AOCs for two or more levels, with 90% confidence, it was considered degraded. All of the AOCs had at least one seasonal metric deemed to be degraded at the second level. Only the spring Milwaukee River zooplankton were deemed degraded at more than one comparison level. Sampling will be repeated in 2014 and reports for this study will provide a basis for future comparisons within those AOCs.

\* Student presentation

### 3. Water Runoff and Sediment Losses from Biofuel Cropping Systems

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As the global demand for energy rises, the need for alternative energy sources becomes more important due to the limited nature of fossil fuels. Biofuels offer this alternative but the environmental impact is still largely unknown. Currently, many plant species are being studied to determine the impact that they have on cellulosic ethanol production and the impact that harvesting the plant biomass has on the environment. In the Midwest, corn stover (*Zea mays*) and switchgrass (*Panicum virgatum*) have great potential as feedstock for cellulosic biofuel production. The objectives of this study are to, 1) determine the impact of corn stover harvest on water runoff and soil sediment losses, and 2) compare the environmental impact of corn stover as a biofuel feedstock to switchgrass. Preliminary results indicate a similar risk for water runoff and sediment losses for corn and switchgrass production systems in the first year of switchgrass establishment. However, less runoff and sediment losses were observed the second year after switchgrass was established. Similarly, using narrow row spacing and increasing the seeding rate of corn has a tendency to reduce water runoff and sediment losses. These preliminary data provide evidence that management practices can be adopted that would reduce runoff risks from cropping systems tailored towards biomass production.

\* Student Presentation

#### **4. Aquatic Invasive Species Monitoring Protocol**

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Lake Winnebago waters are a significant location for transfer of aquatic invasive species to inland water bodies. Presently there are no citizen-based AIS monitoring programs on the Winnebago system shorelines as well as no consistent, statewide standard for this type of monitoring. The Clean Boats Clean Waters interns and citizen volunteers sometimes have idle time at boat launches based on weather conditions, time of day, and location. As a secondary job duty, inspectors who have extra time and are already working on a boat launch can follow a simple shoreline monitoring procedure for early detection and rapid response for new invasive species.

We modified the shoreline monitoring protocol written by Paul Skawinski, and 15 UW-Oshkosh interns tried out the new protocol during two sampling events, once in July and August. Based on our trials and feedback from local DNR we have created a protocol fit for statewide use of monitoring. We have included step by step instructions on how to assemble and effective aquatic invasive species monitoring kit, as well as included a list of species to know, and species to watch out for. This protocol has been writing to be user friendly and with the ability to tailor based on region.

\* Student presentation

## **5. Simulating Recharge in Two Small Watersheds: The Effect of Sub Annual Precipitation Patterns**

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Two small watersheds, the Prairie River in North Central Wisconsin and the Coosawhatchie River in Southwestern South Carolina were used to study the effect of precipitation patterns on recharge, determine why the same annual precipitation produces different mean annual recharge and determine recharge using future climate scenarios. SWB, a USGS computer model was used to determine annual recharge. The mean annual precipitation for the Prairie River watershed is 31.6 inches with an annual recharge of 9.9 inches and a mean annual temperature of 41.8°F. For the Coosawhatchie River watershed, the mean annual precipitation is 48.3 inches with 8.81 inches of recharge and a 65.5°F mean annual temperature. Classifying similar annual precipitations gave a moderate Pearson correlation coefficient of .52 between annual recharge and mean days between rain events and a strong Pearson correlation coefficient of .79 between non-growing season recharge and non-growing season precipitation for the Prairie River watershed. For the Coosawhatchie River Watershed, there is also a strong Pearson correlation coefficient of .76 between non-growing season recharge and non-growing season precipitation. Different climate scenarios show differing trends. Some show an increasing trend in non-growing season precipitation while others show a decreasing trend in non-growing season precipitation.

\*Student Presentation

## 6. Evaluating Nitrogen Removal of an Enhanced Wetland in an Agricultural Watershed

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The sandy terrain of the Leopold Memorial Reserve (LMR) along the Wisconsin River near Baraboo, WI has been the site of previous water resources studies, including groundwater flow and quality and floodplain nitrogen cycling. More recently, Sand County Foundation has developed a demonstration project at the LMR to evaluate the effectiveness of an enhanced wetland as an agricultural nutrient management practice.

The wetland is located on an active farm and is drained by a ditch that flows into the Wisconsin River approximately 1000 ft downstream. Due to the sandy soils and proximity to the Wisconsin River, the wetland experiences wet/dry cycles due to water table fluctuations and river flooding. The wetland enhancement entailed two shallow scrapes covering four acres adjacent to the ditch, designed to capture overbank flow and slowly release it back to the ditch or to groundwater via infiltration.

For two years following construction, hydrologic and water quality monitoring of surface water and groundwater has been conducted using automated and manual sampling to characterize the nutrient load from the upstream watershed and nutrient removal performance of the wetland scrapes. Preliminary results indicate that denitrification of water ponded in the scrapes after high flows recede reduces nitrate to non-detectable levels within days or even hours. This occurs at a rate much faster than infiltration into the wetland soil, indicating that nitrogen transfer to the groundwater is minimal and that the nitrogen is removed from the watershed.



## **7. Applying Shared Vision Planning to Water Resources in the Central Sands Region of Wisconsin: Case Study on the Little Plover River**

Maribeth L. Kniffin, University of Wisconsin-Madison, Madison, WI, *kniffin@wisc.edu*

Computer-based models are integral for understanding and managing water resources and recent studies have investigated how models can best facilitate decision-making processes. Shared vision planning is a well-tested framework for water resources management that extends beyond traditional planning by incorporating structured participation and collaborative modeling into the model development process. The United States Geological Survey, the Wisconsin Geological and Natural History Survey and the University of Wisconsin-Madison are collaborating to develop a transient groundwater flow model of the Little Plover River and surrounding area in effort to support water resource management decision-making processes in an area where surface water declines have been of increasing concern. Shared vision planning is applied as a framework for the Little Plover River model development process in effort to build stakeholder trust and confidence in the model, educate stakeholders about local hydrogeological processes, and solicit stakeholder feedback for constructing management scenarios and constraints for model optimization. Key aspects of the model development process include stakeholder engagement meetings, individual interviews with stakeholders and technical advisors, stakeholder-informed scenario building and ongoing surveys for process evaluation and feedback.

\* Student presentation

## **8. Integrating Build-Out Scenarios with Lake Response Models to Guide Management Decisions**

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Lake management strategies should ideally be identified and implemented prior to the degradation of the lake. This could result in lower inputs of cost, time, and effort associated with the restoration of a degraded hydrologic system. However, preemptive land management decisions are often difficult for communities, primarily due to challenges in forecasting changes in land uses and perceiving how these changes may affect lakes and streams. The combination of a build-out scenario, based on zoning regulations, and lake response models can help predict water quality challenges that may result from increased development within a watershed and provide insight about strategies that would help avoid undesired degradation. Build-out and water quality scenarios were developed for a group of 70 lakes in central Wisconsin. The numbers of developable parcels identified in the build-out were translated to acreage using a coefficient of average disturbance per parcel. Corresponding changes in water quality were predicted using phosphorus export calibrated to the current phosphorus concentrations and hydrologic budgets developed from groundwater flow modeling. Phosphorus concentrations predicted with the model were used to estimate the chlorophyll a concentrations in the lakes at various levels of development.

## **9. The Hydrogeology of Chamberlin Springs, Beloit, WI**

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Chamberlin Springs, which is a 50-acre wooded area, was gifted to Beloit College in 1946 by the family of geologist T.C. Chamberlin. In summer 2012, Beloit College partnered with the U.S. Fish and Wildlife Service to restore the property to an oak savanna ecosystem. This natural area contains rheocrene springs that flow into Spring Creek, a tributary of the Sugar River. In July 2013, an assessment of the hydrogeologic controls on the groundwater-surface water system began in order to provide proper protection of the hydrologic and biotic resources. The main goal of this study is to develop a site-specific hydrogeologic conceptual model for Chamberlin Springs.

To help define base level conditions, four monitoring wells were installed, and hydraulic head, stage, and stream flow measurements are being recorded. Using well constructor reports in the vicinity of Chamberlin Springs, a water table map and four geologic cross-sections have been generated. Preliminary results indicate that groundwater flows to the springs through relatively shallow bedrock. Geochemical analysis of spring and stream water is also being used to understand the source of water to the springs. A refined conceptual model, the final output of this project, will aid in the development of a restoration plan for the Chamberlin Springs ecosystem.

\* Student Presentation

## **10. Evaluating Water Quality and Stratification in the Shallow Water Lake Environment**

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This study investigated the effects of air temperatures and wind speed on thermal stratification in Lake Russo, a shallow water lake in Pleasant Prairie, WI. A combined total of 17 locations were sampled over two sampling dates: September 18, 2013 and November 15, 2013. Water temperature was measured from surface to bottom in 1-foot intervals for each of the sampling locations. At each location, temperature profiles were produced at one foot depth intervals, starting one foot below the surface. Total depth measurements were taken using a Secchi disk. Mean air temperature data and mean wind speed velocity was collected from September 10, 2013 and November 15, 2013.

Differences in the temperature profile were observed between the two sampling dates. A thermocline was observed in a zone between 1 to 6 feet below the water surface during the first sampling date. The second sampling date had uniform temperatures and no stratification. The change in lake water correlates with the trend of decreasing air temperatures. There was an upward trend in wind speed velocities during the same time period. However, the difference between the two dates was relatively small. From this data, decrease in air temperatures played a larger role in the turning of the lake than wind speed. More water temperature data taken year round is suggested for further research.

\* Student presentation

## 11. Investigating Temporal Trends in Groundwater Nitrate Concentrations

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Nitrate is a concern for many Wisconsin communities and rural residents that rely on groundwater as their primary water supply. It is widely recognized as the most pervasive contaminant in Wisconsin groundwater by both the WI Department of Natural Resources and the Department of Agricultural Trade and Consumer Protection. Concentrations of nitrate in groundwater above 1 mg/L provide strong evidence of anthropogenic influence. Understanding whether groundwater nitrate concentrations are increasing or decreasing is of interest to water utility managers, private well owners, conservation professionals and those that enforce water quality standards.

Because nitrate has a health based drinking water standard, it is a required test for public water systems. The large number of Transient Non-Community (TNC) water systems (bars, restaurants, churches, etc.) and the frequency of nitrate sampling make them well suited for investigating temporal trends in shallow groundwater aquifers. We utilized the large amount of existing data on TNC water systems accessed through the WI Groundwater Retrieval Network to investigate changes in groundwater nitrate.

Linear regression analysis was applied to nitrate concentrations sampled over time for close to 9,000 individual TNC well water systems statewide. The estimated slope of the regression gives the direction and rate of change in nitrate concentration and its significance was evaluated at the 5% level. The majority of wells did not result in a regression with a significant time trend. Of those that were significant, the majority show increasing nitrate concentrations over the sample period of record. Results have been mapped and will be displayed spatially to show the location and magnitude of changes in nitrate concentrations of these systems.

## **12. Mapping compositional heterogeneity in the St. Peter Sandstone: improving prediction of potential frac sand and groundwater resources**

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The St. Peter Sandstone forms one of the primary aquifers in Wisconsin and is now the target of frac sand mining in several areas. However, the heterogeneity in the thickness and composition of the St. Peter poses significant difficulties for mining and groundwater management. Geologic mapping and case studies provide new data to refine our understanding of the St. Peter Sandstone across the state.

Newly-acquired field data demonstrate the heterogeneity of the St Peter and complex relationships with adjacent geologic units. Coupled sedimentological and XRF elemental analysis of new cores (and others in the WGNHS archive) show that the lower St. Peter (Readstown) is complex, dominated by four muddy lithofacies representing terrestrial to marginal marine environments. This interval also contains abundant large (>10'x30') inclined masses of Prairie du Chien dolostone, interpreted as blocks shed from adjacent tower karst pinnacles. The contact with the upper St. Peter (Tonti) is sharp and locally channel-form. The upper unit makes up a separate depositional sequence with three facies representing sandy marginal to offshore marine environments.

These new data change our view of the St. Peter in subtle but substantial ways. Sandstones of the upper St. Peter representing shallow marine environments and coastal dunes are the only deposits suitable for frac sand mining and are only widespread in western Wisconsin. The lower St. Peter is thickest along a NE-SW trend in eastern Wisconsin, the area of Prairie du Chien fossil tower karst, providing new insights into the difficulties of water well drilling in that area and observations of rapid compositional change. These results reveal a more chaotic distribution of St. Peter deposits in eastern Wisconsin than was indicated by previous studies, providing a caution to hydrogeologists and sand mine developers in that region.

### **13. Hydrogeologic Data Viewer: Map-Based Access to Wisconsin's Hydrogeologic Information**

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Quantitative analysis and modeling in aid of water management is standard practice in the hydrologic sciences, and in Wisconsin, such analyses benefit from a wealth of geologic and hydrogeologic data from across the State. The Wisconsin Geological & Natural History Survey (WGNHS) and the Wisconsin Department of Natural Resources (DNR) cooperatively developed a map-based catalog to improve the organization and access to this information.

Hydrogeologic Data Viewer is an interactive web map developed on the Esri ArcGIS Javascript programming interface. The Viewer provides timely and efficient access to a variety of data types. Users can search for data by area of interest, address, or public land survey system description. Searches may be limited to a category of information, such as well construction reports, geologic logs, geophysical logs, published reports, graduate student theses, maps, or models. The Data Viewer includes access to a database of Wisconsin's springs, and links to the State's long-term groundwater monitoring network. Much of this information can be accessed and downloaded through the web tool. A goal of the project is to provide this web-based catalog to other state and local agencies and the general public in 2014.

## **14. How Does Map Design Influence Well Water Testing for Residents with Private Wells?**

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The purpose of this mixed methods study (interviews and experiment) was to assess how maps illustrating arsenic in private water wells influenced residents' (a) intentions to test their private well water for arsenic and, (b) beliefs that predict well water testing. The influences of four map variables were assessed: (1) map color (red, brown), (2) a symbol denoting areas with no data (with, without), (3) a table to supplement map information (with, without), and (4) participants' proximity to mapped hazard. A table-only control was also included. The sample was homeowners with private wells in Fond du Lac county; 7 were interviewed and 1224 were randomly assigned to 1 of the 9 map conditions mailed with a survey. Survey questions measured outcomes at the time of viewing and 3 weeks later; 733 (60%) completed both surveys.

Interviews illustrated: (a) how prior knowledge shaped peoples' interpretations of the maps and table, (b) preferences for red maps, and (c) why the table mitigated concern generated by maps. Survey results indicated 40% intended to test for arsenic at time 1, and 30% at time 2 (4% had tested). The map generated stronger intentions to test than the table. Proximity to mapped arsenic had the largest influence on beliefs and intentions. For maps with a table, personal safety thresholds for arsenic (highest arsenic level considered safe) were lower for red than brown maps. Stronger township-level beliefs influenced testing intentions. Multiple interaction effects among map variables and with participant characteristics resulted in complex patterns of map influences on outcomes. Main themes for these results will be shared in the presentation.



## 15. Understanding Factors Controlling Chromium Speciation in Wisconsin Groundwaters

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Chromium is a naturally occurring metal found in both surface and ground water. It occurs in two common oxidation states; Cr(III), and Cr(VI), the later a known carcinogen and comparatively geochemically mobile. The goal of this project is to characterize the aquifers within mineralized edges of three major geological basins (Forest City, Illinois and Michigan) and Wisconsin Arch in southern WI, as to their natural background concentrations and release rates of total Cr and Cr(VI). Fresh well cuttings of aquifer material were collected from new wells drilled in Tomah, La Crosse, the Fox Valley and Dane County, WI. Preliminary batch reactor experiments were conducted under anoxic conditions with a well cutting suspension density of 2 g/L in groundwater obtained from a deep well in Madison (Well #19). Anoxic conditions (< 1 mg/L dissolved oxygen) were maintained using a glovebox for the duration of the experiment (11 days). A slight increase in both total Cr (0.72µg/L to 1.05µg/L) and Cr(VI) (0.01µg/L to 0.32µg/L) were observed at pH 9.5. An increase in total iron and manganese concentrations were observed in several reactors. To determine the role of pH on concentrations and release rates of total Cr and Cr(VI), we plan to run reactor studies for 21 days while varying the pH (6.0, 7.5, 8.0) using appropriate non-reactive buffers. Bulk chemistry, chromium, iron and manganese oxidation state speciation, soluble organic carbon and soluble ions will be determined at several time points over the reactor/incubation period.

\*Student presentation

## **16. Wetland Investigation of the Albion Basin, Little Cottonwood Canyon, Alta, Utah**

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This wetland investigation of the Albion Basin was initiated in August 2005 with the goal to evaluate watershed characteristics of the Albion Basin and provide scientific information that can be used in watershed management decisions. The August 2013 field season represents the 8<sup>th</sup> annual monitoring consists of collecting: (1) automated water levels using pressure transducers, (2) manual water levels using an electronic sounder, (3) field water parameters (temperature, pH, electrical conductivity), and (4) water samples for laboratory chemical analysis of major cations and anions. A reconnaissance springs survey was performed during the August 2013 to assess the contribution of source water for each of the wetland areas and to identify water source areas and flow paths within the basin.

In general the water sample results represent calcium, magnesium bicarbonate fresh water. These results combined with the water level signatures indicate three distinct characteristics for these wetland areas. The Catherine's Pass wetland is groundwater dominant while the Albion Basin Fen area is precipitation (surface water) dominant. The wetland area at Collins/Sugarloaf is a mixture of groundwater and surface water and the wetland may persist due to perched water.

This study is instrumental for describing the uniqueness of the Albion Basin, discussing the hydrologic connections of the wetland areas, and assessing effects on the basin from proposed water diversions which may result in a permanent loss of water from basin and may affect the natural stream and wetland environment.

## 17. Improving Sediment Delivery Process in a Semi-Physical Model

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Precise estimation of sediment delivery from upland contributing areas through channels and rills is important for accurate prediction of sediment yield and associated attached pollutants delivered to receiving waters. The semi-physical model, Water Erosion Prediction Project (WEPP) is often used by land management agencies, like the United States Department of Agriculture (USDA), to estimate sediment delivery from agricultural areas. This study focuses on improving the sediment delivery predictions from WEPP. For this study, we used WEPP to estimate sediment yield from a 5.7 ha agricultural watershed at the University of Wisconsin-Platteville Pioneer Farm in south central Wisconsin. Flow and water quality (sediment) data for a 5 year period (2003 - 2007) were used to calibrate and validate WEPP for this watershed. While WEPP accurately predicted runoff and sediment yield for events separated by  $\geq$  one day, it over-predicted runoff and sediment yield for storms on consecutive days. Work by others suggests that as the soil surface dries, more loose fine particles become available which are more susceptible to erosion. In this study we measured changes in critical shear stress and soil erodibility with soil moisture content. These dynamics will be incorporated into the WEPP model to improve the prediction of runoff and sediment yield during consecutive storms.

\* Student poster

## **18. Geologic Mapping of Columbia County: 3-D Subsurface Reconstruction Using an Integrated Geological Dataset**

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The Wisconsin Geological and Natural History Survey (WGNHS) is dedicated to creating geologic maps for the residents of Wisconsin that support informed decision-making regarding land-use and natural resource issues. Bedrock mapping of Columbia County is an ongoing project funded by the state component of the National Geologic Mapping Program (STATEMAP) that will provide key geological data for addressing two important resource issues: groundwater protection and industrial sand mining.

Characterization of the extent and physical properties of regional aquitards is an ongoing groundwater protection issue, significant for wellhead protection. The recent rapid growth of industrial sand mining in western Wisconsin, and the initiation of frac sand mining in Columbia County, presents this region with new challenges and opportunities related to resource management. Compilation of a bedrock geologic map and subsurface cross-sections will provide a 3D reconstruction of the spatial distribution of geologic units. Geologic mapping thus aids identification of regional hydrostratigraphic units. Furthermore, mapping will improve the county's ability to predict the nature and potential scope of industrial sand mining.

Bedrock mapping in Wisconsin is complicated by limited exposure. WGNHS addresses this challenge by integrating data from existing outcrops with subsurface data extracted from drill core, well cuttings, and geophysical logs. Recently acquired tools, including a handheld X-ray fluorescence analyzer and the software package *Petrel*, allow exciting new opportunities for WGNHS to collect, integrate, and interpret data for geologic maps and cross sections, thereby improving our ability to address key resource issues.

## 19. Passive Water Sampling for Agricultural Antibiotics on Three Rivers in Eastern Wisconsin

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There is growing concern over antibiotic resistance resulting from the heavy use of antibiotics for animal production and in human medicine. Antibiotic resistance has been linked to illness and death. Therapeutic and subtherapeutic antibiotic use has been correlated with antibiotic resistance on dairy farms. The presence of antibiotics in streams may be a way to track their release into the environment. Traditional sampling methods are insufficient for these trace-level analytes in dynamic surface water systems. Passive integrative samplers that accumulate pharmaceuticals in-situ allow detection of very low concentrations as a time-weighted average.

This study investigated the occurrence of veterinary antibiotics in the Manitowoc, Sheboygan, and Milwaukee Rivers in eastern Wisconsin over a short period in fall 2013. Antibiotic analytes were accumulated on pharmaceutical-optimized sorbent, eluted, and analyzed by LC/MS/MS. Sulfonamide antibiotics were found at all three sites. Time-weighted average concentrations ranged from 0.5 to 4.5 ng L<sup>-1</sup>. The toxicological impacts of low-level chronic exposures to mixtures of antibiotics are not well-understood and these types of studies will be useful for understanding the importance of offsite transport.

\*Student presentation

## **20. Understanding Stream Phosphorus Concentrations: Contrasting the Role of External Inputs and Internal Reactions**

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Meeting stream phosphorus goals that include concentration criteria requires understanding how wastewater discharges and land management influence stream phosphorus concentrations. This is challenging. Stream phosphorus concentrations are not only impacted by the timing and magnitude of external inputs, but by in-stream routing, transient storage within the stream, and a variety of only partially understood and temporally variable abiotic and biotic reactions. In this study, we developed and applied a stream model to help assess the sensitivity of stream phosphorus concentrations to these factors in different hydrologic conditions.

Our stream phosphorus concentration model combines hydraulic routing and in-stream reaction by linking two models, CE-QUAL-RIV1 and OTIS. The linked model was used to explore the role of external inputs, routing and reaction on the temporal duration of stream phosphorus concentrations. We evaluate the impact of watershed size and baseflow index on stream phosphorus concentrations, and then compare the results to phosphorus concentrations measured in streams with different hydrologic characteristics. Our findings help characterize the complexity of stream phosphorus concentrations and identify the potential of management actions to influence those concentrations.

## 21. The Triemstra Drill Core from Northern Columbia County: New Insights into the Cambrian Stratigraphic Succession on the Wisconsin Arch

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As part of the National Cooperative Geologic Mapping Program (STATEMAP), the Wisconsin Geological and Natural History Survey is drilling core throughout Columbia County in order to better understand the subsurface bedrock geology. This project is currently in year 2 of 4, progressing westward across the county. During the 2013 field season, a core was drilled on the Triemstra farm located ~8 km north of Pardeeville, Wisconsin. This almost continuous (~92% recovery) ~605 foot-long core provides a unique window into the stratigraphic succession of deeper Cambrian strata in this part of the county and enhances our knowledge of the local hydrostratigraphy and sand resources.

The Triemstra Core starts in the basal portion of the Ordovician Oneota Formation (Prairie du Chien Group) and ends in the crystalline Precambrian basement. Our preliminary interpretation of the Cambrian succession consists of a ~37 foot-thick Jordan Formation (at 14' to 51' depth), an ~118 foot-thick Tunnel City Group (51' to 169'), and a ~433 foot-thick Elk Mound Group (169' to 602'). Carbonate rock typical of the St. Lawrence and shale indicative of the Eau Claire formations are not present in the Triemstra Core. Cementation in the Elk Mound Group is dominantly silica. The Cambrian succession, with a ~2.5 foot-thick conglomerate of rounded granitic gravel-size clasts at its base, sits unconformably on granitic basement. This core provides important new insights into the Cambrian sandstone units that comprise the primary aquifer in Columbia County. Furthermore, this core increases our understanding of the potential of these strata for industrial sand mining in the western part of the county where they occur closer to the surface. Cores such as this provide critical benchmarks for developing modern geologic and hydrogeologic models for resource management.

## **22. Comparison of Breakthrough and Downward Migration of Live and Irradiated *Cryptosporidium parvum* and Microspheres Under Simulated Rainfall**

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*Cryptosporidium parvum* oocysts (*C. parvum*), commonly found in manure, cause acute and chronic diarrhea in humans (cryptosporidiosis) and may be fatal for immunocompromised individuals. *C. parvum*'s primary means of transmission in humans is through ground or surface drinking water contamination. As part of a larger study, "Investigating the Subsurface Fate and Transport of *Cryptosporidium* in Soils of Wisconsin's Carbonate Aquifer Region," we are evaluating whether irradiated *C. parvum* and carboxylated microspheres are effective surrogate soil surface-to-groundwater tracers for field studies of *C. parvum* transport.

The comparison of live and irradiated *C. parvum* and microspheres is being conducted on undisturbed soil columns (15 cm diameter by 50 cm length) in our laboratory. A liquid manure solution inoculated with equal quantities of either live or irradiated *C. parvum* or microspheres will be applied to the soil surface. After application of inoculated liquid manure, the soil column will be subjected to a simulated rain fall event. After completion of the rainfall event, leachate and soil samples (taken at incremental depths) will be collected and analyzed for the presence of the inoculant.

The results of this study will be used determine if the soil transport and migration of *C. parvum* can be analyzed using surrogates. As live *C. parvum* is a pathogen, few in situ soil transport field studies have been conducted to our knowledge. The results provided from this study will indicate the potential for new *C. parvum* field studies to be conducted using non-pathogenic surrogates.



**Session 3A:**  
**Mining Impact on Groundwater and Surface Water**  
**Friday, March 14, 2014**  
**8:30 – 10:10 a.m.**

**Water Use in Wisconsin's Non-Metallic Mining Industry**

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Whether it is groundwater withdrawn for material processing or the dewatering of quarries, water management is an integral component of non-metallic mining in Wisconsin. In 2012, non-metallic mining operations withdrew over 13 billion gallons from nearly 400 sources. This made non-metallic mining as a use sector the 5<sup>th</sup> largest withdrawer of surface water and the 10<sup>th</sup> largest withdrawer of groundwater in the state. Additionally, industrial sand (frac sand) mining has emerged in the state as a rapidly growing water user.

This presentation will provide background on how water is used in non-metallic mining and how these uses are regulated by the Wisconsin Department of Natural Resources. In addition, results from 2011, 2012, and 2013 withdrawal reporting will be presented to quantify the locations, number, sizes and changes of water withdrawals by non-metallic mining operations. Finally, the magnitude of these withdrawals will be compared to other water use categories in the state.

## **Evaluating Hydrogeologic Impacts of Frac Sand Mining and Irrigated Agriculture in Western Chippewa County, WI**

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Recent growth in frac sand mining and irrigated agriculture in west central Wisconsin represents significant new demands on Chippewa County's groundwater resources. This is a region with high-quality, groundwater-fed trout streams and relatively low historic water use. In 2012, the Chippewa County Department of Land Conservation and Forest Management commissioned a 5-year study of the potential hydrologic impacts of increases in groundwater use. The study, carried out by the Wisconsin Geological and Natural History Survey and the U.S. Geological Survey, seeks to quantify the effects of pumping on the water table and baseflow to streams, both under current and potential future water use scenarios.

High-quality data collected from several new high-capacity wells provides a framework for developing a regional hydrogeologic model. High-capacity wells at sand mines and farms penetrate several hundred feet into sandstone aquifers within the Eau Claire and Mount Simon Formations. Within these sandstone units, interbedded siltstone and shale, up to tens of feet thick, are common, resulting in a complex layered system of locally important aquitards within the groundwater system.

This study includes development of a three-dimensional MODFLOW model that will incorporate information on the regional hydrogeology. A soil-water-balance model will estimate groundwater recharge within the study area. Stream flow will be continuously gauged at three locations within the study area to provide high-quality estimates of baseflow for model calibration. The model will provide decision makers with a tool for managing groundwater resources during active frac sand mining and following mine reclamation.

## Simulating Groundwater Flow for the Proposed Crandon Mine – What Did We Learn?

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Plans for a proposed underground massive sulfide mine near Crandon, WI were abandoned in 2003 after nearly two decades of environmental investigation and technical review. A state review team composed of DNR, WGNHS, USGS, UW scientists, and private consultants collectively spent several years evaluating voluminous data and reports submitted by the mining company. Much of the review focused on groundwater issues, including drawdown, water consumption, water quality, groundwater-surface water interactions, waste management, and contaminant transport. A retrospective look at groundwater issues raised during the Crandon review is appropriate now, as new bedrock mines are being proposed in or near Wisconsin.

The site was located in a region of Precambrian igneous and metasedimentary rocks in the Wolf River basin, an area characterized by a shallow water table and numerous lakes, streams, and wetlands. The mine itself was to be underground and extend down to approximately 2000 feet below the ground surface.

Groundwater flow and transport simulation was an essential part of the technical review. Based on this experience we can say that:

1. All models were limited by shortcomings in the field data, and modeling would have been more informative, and the overall review more rapid, had it followed a true stepwise approach to guide the investigation process and focus subsequent field work. In particular, establishment of reliable records for baseline conditions (streamflow, groundwater levels, lake levels) was essential for the development of appropriate calibration targets.
2. Flow simulation was generally successful in representing the overall site hydrogeology and the potential impacts associated with mine dewatering.
3. Transport simulations associated with contaminant migration from tailings and waste rock disposal were less satisfying because the underlying model was not calibrated. While this effort relied on evaluating a range of hypothetical, future conditions it was the most practical means available for decision makers to determine possible long-term permit requirements.

## **The Largest Flowing Artesian Well in the State of Wisconsin Is (Sometimes) an Abandoned Deep Quarry**

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The Cambrian-Ordovician sandstone aquifer in the Northeast Groundwater Management Area (GMA) experienced a dramatic water level recovery in central Brown County after 2007. Between 2006 and 2007, eight communities stopped pumping groundwater for their municipal supplies and began using surface water, reducing daily withdrawals from the deep aquifer by ~12.25 million gallons. As a result, the potentiometric surface increased by as much as 150 feet in parts of the GMA. The villages of Howard and Suamico northwest of Green Bay have seen a large part of the deep aquifer recovery. Howard's Well #3 near Duck Creek Quarry is essentially a giant diameter flowing artesian well, indicating that the potentiometric surface exceeds ground surface nearby.

Quarry water levels appear to mimic both the major and minor water level fluctuations in the confined sandstone aquifer. This is due the fact that it is the largest and deepest (170 feet) quarry in the area, which intersects the top of St. Peter Sandstone at its deepest point. Before the switch from groundwater to surface water, the potentiometric surface in the aquifer was below the quarry floor. Water levels exhibited a rapid rise in the quarry during 2007-2011, as a result of the cessation of deep aquifer pumping by the municipalities surrounding Green Bay.

Water in the quarry reached the top of the bedrock in June 2011 on the east side of the quarry and in late October 2011 in the northwest part of the quarry and is in contact with unconsolidated sediment berms at those locations. The data suggest that the quarry's water level finally caught up with the deep aquifer's potentiometric surface during 2011. Although the signal is damped, more than two years of frequent water level monitoring in the quarry since 2011 show that water levels in the quarry continue to rise and fall in concert with the seasonal signal observed in the deep aquifer. The seasonal signal is piggybacked on a long-term rising potentiometric surface.

An engineered outfall was installed at 579.5 feet in the event that water levels in the quarry would rise that far. At times of highest water levels in the deep aquifer, the quarry discharged water at this location at rates as high as 140,000 gallons per day for about two months. During this period, the quarry represented a small, but significant percentage of the total known deep aquifer discharge in the Northeast GMA. The discharge rate and seasonal flow period are expected to increase each year until the deep aquifer recovery reaches equilibrium.

## **Improved Understanding of the Rountree Formation in Southwest Wisconsin Using Geophysics and Quarry Exposures.**

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An important part of the landscape and geology in southwestern Wisconsin is the Rountree Formation, a layer of clay-rich materials that is widely distributed across upland landscapes, varying in thickness from 1 - 2 feet to more than 16 feet. Mapping the thickness, distribution and variation of the Rountree Formation on the landscape will be important for understanding recharge and contamination susceptibility through this potentially widespread, continuous, low permeability formation.

We used geophysics and quarry exposures to improve our understanding of the Rountree Formation. Multiple lines of electrical resistivity tomography were collected in seven quarries in southwestern Wisconsin where the Rountree Formation overlies the Oneota Formation of the Prairie du Chien Group. The data were inverted to provide resistivity profiles that were compared to photographs and descriptions of the Rountree Formation seen in the quarry walls. The contrast between the lower resistivity clays of the Rountree Formation and the higher resistivity dolomites of the Oneota Formation was readily apparent in both the geophysics and quarry walls.

Good agreement between the geophysics and quarry walls provides us with a tool to map depth and thickness the Rountree in those areas without exposures. Variations within both the Rountree and the Oneota dolomite are also apparent using geophysics. This information is expected to be used for better land use planning in southwestern Wisconsin.

**Session 3B:**  
**Urban Water Quality**  
**Friday, March 14, 2014**  
**8:30 – 10:10 a.m.**

**Modeling the Hydrologic Effects of Parcel-Scale Changes in Lot Layout and Impervious Surface Connectivity**

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The introduction of impervious surfaces is recognized as a major driver of hydrologic change in urban areas, but little has been done to explore the effect of nuanced differences in impervious patterns at a small, parcel scale, particularly as these differences impact soil moisture regimes and groundwater recharge. While impervious areas generally increase surface water runoff and decrease groundwater recharge, it is possible that certain arrangements may actually increase local soil moisture availability or promote local recharge by directing runoff from impervious areas to pervious areas.

A physically-based, fully-coupled 2D surface water-3D subsurface water model was created to explore the extent to which the amount, arrangement, and connectivity of impervious area in residential lots impact the hydrologic regime at the urban parcel scale. Simulated lot layouts represent both single family detached (urban and suburban) and single family attached (townhouse) dwellings over a range of total percent impervious cover. Characteristics of interest for each lot configuration include sidewalk disconnect, downspout disconnect, slope from building, direction of driveway/sidewalk slope, and soil type. Preliminary results demonstrate significant changes in moisture regimes at the outlets of impervious features.

\* Student presentation

## **Evaluation of Grass Swales - Reducing Volume and Pollutant Concentrations in Highway Runoff**

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Grass swales offer some degree of water-quality benefit by promoting infiltration, decreasing runoff velocities (thus increasing time of concentration), filtering pollutants through the grass media, and promoting uptake of pollutants by plant roots. The Wisconsin Department of Transportation (WisDOT) needs to control at least 40 percent of total suspended solids (TSS) from existing highways; newly constructed highways will require control of at least 80 percent TSS as well as 60 percent control of the pre-constructed infiltration volume. These prescribed conditions are to be implemented to meet federal and state requirements, including U.S. Environmental Protection Agency's National Pollution Discharge Elimination Standard, Wisconsin Department of Natural Resources NR216 and NR151, and WisDOT's TRANS 401. Since the WisDOT already incorporates grass swales along most highways, they could potentially meet their permit requirement through simple maintenance of existing systems. This study is evaluating the infiltrative capacity of grass swales and their potential to reduce pollutants by monitoring a section of grass swale separated into two contributing components: a vegetated side slope and a grassed channel. Results from monitoring these two components show how length of the slope and channel length of the swale affects water volume and pollutants through infiltration.

## **Influence of Different Methods for Estimating Impervious Surface Cover on Model-simulated Streamflow of the Milwaukee River Basin**

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Fraction of impervious surface covers is an important parameter for hydrologic modeling, especially in urbanized basins, because imperviousness can strongly affect the amount and intensity of streamflow. Our study evaluated the influence of three different methods for estimating impervious surface cover on model-simulated streamflow. The methods tested are (1) homogeneous distribution of impervious surfaces for the entire urban area, (2) homogeneous distribution of impervious surfaces for commercial and residential land uses, respectively, and (3) different imperviousness for each urban land use of each subbasin. Streamflow of the Milwaukee River basin was modeled using a semi-distributed hydrologic model HSPF for this project. The results show that the three methods resulted in substantially different streamflow. The simulated streamflow with the second method produced the largest streamflow, and that from the first one was a little larger than that from the third one. It was also found that these differences in simulated streamflow are highly correlated with percentage of urban land use types. It suggests that future research with urbanized basins should pay attention to the accuracy of percent imperviousness.

\* Student presentation



## **The Quest for Clean Lakes: Evaluation of a City-Wide Leaf Collection Program to Reduce Phosphorus**

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Organic detritus and particulate matter can act as a major source of phosphorus (P) and nitrogen (N) in the urban environment, especially in areas with dense overhead tree canopy. In order to meet impending regulation to reduce P loads, Wisconsin cities will require information on structural and non-structural Best Management Practices (BMPs) that target organic detritus and particulate matter. Although data on sources of P and N is extensive, few studies have quantified the water-quality benefits of their removal. For example, implementing city-wide leaf collection, terracing or bagging of leaves, in addition to a street cleaning program can remove organic detritus and particulate matter before it becomes entrained in runoff. This may be preferable to structural BMPs because most cities already conduct some level of leaf collection and street sweeping program and may receive the benefit of phosphorus removal requirements with minor changes to existing practices.

The U.S Geological Survey is quantifying the potential reduction in nutrient load as a result of existing and improved leaf collection practices compared to no practices. Phase I of the study, completed in 2013, characterized P and N concentrations and loads without a leaf collection program. Phase II (2014) will measure the change in concentrations as a result of existing city-wide leaf collection while Phase III (2015) will enhance the effort through bagging of leaves.

## **From Streets to Streams: Assessing the Toxicity Potential of Urban Sediment by Particle Size**

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Urban sediment can act as a transport mechanism for a variety of pollutants to move towards a receiving water body. The concentrations of these pollutants oftentimes exceed levels that are toxic to aquatic organisms. Many treatment structures are designed to capture coarse sediment but do not work well to similarly capture the fines. This study measured concentrations of select trace metals and PAHs in both the silt and sand fraction of urban sediment from four sources: stormwater bed, stormwater suspended, street dirt, and streambed. Concentrations were used to assess the toxic potential of sediment based on published sediment quality guidelines. All sources of sediment showed some level of toxic potential with stormwater bed sediment the highest followed by stormwater suspended, street dirt, and streambed. Both metals and PAH concentration distributions were highly correlated between the four sampling locations suggesting the presence of one or perhaps only a few sources of these pollutants which remain persistent as sediment is transported from street to stream. Comparison to other forms of combustion- and vehicle-related sources of PAHs revealed coal tar sealants to have the strongest correlation, in both the silt and sand fraction, at all four sampling sites. This information is important for environmental managers when selecting the most appropriate Best Management Practice (BMP) as a way to mitigate pollution conveyed in urban stormwater from source to sink.

**Session 4A:  
Surface Water Quality  
Friday, March 14, 2014  
10:30 – 12:10 p.m.**

**Apportionment of Stream Bed Sediment Sources in an Agricultural Watershed Using Sediment Fingerprinting Techniques**

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Agricultural activities play an important role in accelerating the offsite transport of productive soil from fields that can lead to significant water quality impairment. The eroded sediments are effective carriers of sediment-bound nutrients, such as phosphorus (P), from landscape to downstream water bodies. Identification of the nature and relative contribution of different sources to in-stream sediments is important to effectively target management practices. Sediment fingerprinting techniques through the use of tracers are commonly used to identify the provenance of in-stream sediments. Research was conducted in the Pleasant Valley watershed in South Central Wisconsin (USA) to identify provenance of stream bed sediments using inorganic tracers and evaluate the impact of land use on the relative contributions to stream bed sediment sources. The potential contributing sources considered for this study were croplands, pasture, woodlands, and stream banks.

Results show that both agriculture (croplands and pastures) and stream banks are important sources to stream bed fine sediments. The increase in area under agricultural land use within a subwatershed results in greater contribution from agriculture. Contributions from stream banks to stream bed sediments increased with increasing area under grasslands and woodlands within a subwatershed. Results from this study indicate that the conservation practices in this watershed should be targeted to stream banks and agricultural lands. The changes in magnitude and type of stream bed sediment sources among different sites in this watershed indicate the complexities involved in sediment transport dynamics.

\* Student presentation

## **Methylmercury Dynamics in Nearshore Quagga Mussel-Cladophora Communities of Lake Michigan**

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The recent proliferation of invasive quagga mussels (*Dreissena bugensis*) in Lake Michigan has resulted in a profound shift in carbon dynamics of the nearshore zone. Our group hypothesizes that this shift in carbon flow in the nearshore zone will have significant impacts on mercury (Hg) cycling. We are particularly interested in dynamics of the filamentous green alga *Cladophora*, which co-occur in quagga mussel beds, and in *Cladophora* mats that accumulate and decay on the shore.

Our initial observations of onshore processes on the western shore of Lake Michigan indicate that methyl mercury (MeHg) cycling is enhanced in zones with thick deposits of *Cladophora*. Samples of growing *Cladophora* attached to rocks and hard surfaces in the Sheboygan area showed that MeHg content represented 4-21% of HgT, suggesting either efficient uptake of watershed-derived MeHg or in situ methylation within the growing mat. Solid phase deposits of decaying plant material on beaches were further elevated in MeHg, with 20-26% of HgT as MeHg. Additionally, pore water collected under the mats and advectively transported to Lake Michigan, was 64-76% MeHg of the HgT during summer and fall. Lake Michigan surface water samples taken from nearshore regions suggest a decreasing gradient of MeHg away from the beach regions suggesting a local source of MeHg production. Nearshore MeHg concentrations exceed offshore concentrations collected by USGS in 2011-12 about tenfold. This study suggests the recent shift in productivity in Lake Michigan has affected whole-lake MeHg cycling.

\* Student presentation

## **Phosphorus and TSS Trends in Two Streams in Northeastern Wisconsin**

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Land management changes have been implemented within the Duck and Baird creek watersheds to improve water quality. Phosphorus and TSS water concentrations were examined to determine if commensurate temporal changes have occurred. Statistical procedures were applied to the Duck Creek dataset (1989-2008) to test for changes in total and dissolved phosphorus concentrations. A 20-year multiple linear regression trend analysis found that phosphorus declined in a non-linear fashion, primarily during the first period. Therefore, regression was conducted separately on Period 1 (1989-1995) and Period 3 (2004-2008). Phosphorus concentrations decreased 10% per year in Period 1. Unusual climate or sampling problems in 2008 were associated with Period 3, so results were inconclusive. A Wilcoxon Rank sum test was applied to phosphorus concentrations between Periods 1 and 3 under data censoring and flow scenarios. In all cases, phosphorus concentrations were significantly lower in Period 3 than in Period 1 ( $p < 0.05$ ), even for subsets of data based on one sample per month or week. Multiple regression analysis was performed on monthly and weekly sub-sampled data sets. Time was not a significant explanatory variable. However, the weight of evidence was sufficient to conclude that phosphorus concentrations in Duck Creek have likely decreased during the 20-year record. Additional sampling was conducted during 2010-2013: initial results indicate a downward trend in TSS and TP concentrations (2004-2013). Results of statistical procedures applied to over 800 samples collected from Baird Creek (2004-2013) will be presented; however, conclusions will be tempered because landuse hasn't been consistent.

## **Harmful Algal Blooms in Wisconsin: Results of a Statewide Public Health Surveillance Program**

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The presence of freshwater harmful algal blooms (HABs) and the toxins they may produce are of increasing concern in recreational and drinking waters due to their potential public health risk. The Wisconsin Department of Health Services, the Wisconsin Department of Natural Resources and the Wisconsin State Laboratory of Hygiene conducted a multi-year surveillance study to measure the public health burden of HABs and to better characterize environmental conditions during these blooms.

Between 2009 and 2013, the Wisconsin Department of Health Services received 144 complaints of human and animal illness associated with exposure to HABs. The most common HAB-related illnesses reported were gastrointestinal distress, dermal rash, respiratory irritation and cold-like symptoms. Cyanotoxins were detected in over 56% (26 of 46) of the environmental samples analyzed, with microcystin-LR, -LA and -RR the most common toxins in Wisconsin surface waters. In addition to collecting health and water quality data, this surveillance program also expanded outreach to health-care professionals, veterinarians, local lakes associations and the general public in order to: 1. increase reporting of HAB-related illnesses and 2. increase awareness of the potential hazard associated with algal blooms. The information gathered in this surveillance study will enhance our understanding of the public health burden of HABs and facilitate the development of prevention measures aimed at reducing exposures to harmful algal blooms.

## Trace Organic Compounds in Great Lakes Tributaries: How Does Wisconsin Compare?

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Concentrations of trace organic compounds in some Great Lakes tributaries indicated potential for adverse impacts on aquatic organisms. Compounds used in agriculture, industry, and households make their way into surface waters through runoff, leaking septic-conveyance systems, regulated and unregulated discharges, and combined sewage overflows, among other sources.

During 2011-13, as part of the Great Lakes Restoration Initiative, 706 water samples were collected from 60 tributaries in MN, WI, MI, OH, IN, and NY, representing a range of land uses, from forested to agricultural to urban. Samples were collected during high and low-flow conditions and analyzed for 69 compounds, including herbicides, insecticides, PAHs, plasticizers, detergent metabolites, fire retardants, non-prescription drugs, and flavors/fragrances.

Aquatic-toxicity benchmarks were exceeded for a number of compounds with known benchmarks. The compounds with the most benchmark exceedances were the PAHs, and the herbicide atrazine. Herbicides showed a clear seasonal pattern, with concentrations exceeding benchmarks for long periods during summer months at some sites. Urban basins showed higher concentrations than other land use types for many of the compounds, including PAHs, fire retardants, and non-prescription drugs. Of the 10 Wisconsin tributaries sampled, the Milwaukee River at Milwaukee had the most frequent detections, with a median of 7 detected compounds per sample.

**Session 4B:**  
**Measuring, Monitoring, and Managing Water Resources**  
**Friday, March 14, 2014**  
**10:30 – 12:10 p.m.**

**Streamflow Trends in Wisconsin**

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Streamflow characteristics were determined for fifteen streamflow gaging stations for three periods, 1915-2008, 1915-1968 and 1969-2008 to identify trends. The stations represent flow characteristics for the twelve major river basins in Wisconsin. Trends in streamflow were found statistically significant at some stations for various streamflow characteristics for the 1915-2008 period. The most prominent trend was the increase in low flow at ten of the fifteen stations, with most of the stations being in agricultural areas. The average annual low flow increased 58 percent for the ten streams in agricultural areas compared to 14 percent for five forested area streams. The largest increase in low flow was 117 percent with an average increase of 42 percent. The average annual flows had statistically significant increases at seven of the ten stations for agriculture- dominated streams. The average increase in annual flow was 16 percent. The annual flood peaks decreased 11 percent and the decrease in flood –peak magnitude was statistically significant for five stations: the dominant land use was agricultural for four of these stations. Annual precipitation increased 6.8 percent when comparing 1915-1968 to the 1969-2008 periods. The increases in low flow in agricultural areas were likely the result of improved agricultural practices, land use changes and increased precipitation. The decrease in flood peaks with increased precipitation can possibly be attributed to increased infiltration due to agricultural practices changes.



## **Seasonal Streamflow Changes in Wisconsin Watersheds**

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Changes in seasonal and annual streamflow in Wisconsin watersheds affected and least affected by anthropogenic influence are analyzed using a) regime change analysis; b) comparison of runoff statistics; c) standardized departures of runoff; d) trend analysis; e) flow duration curves and f) relative and absolute changes in streamflow. Considerable temporal and regional variability was found in streamflow changes between two historic periods 1951-1980 and 1981-2010 considered in the study. For example, in the recent historic period, the northern basins showed increased streamflow volume ranging from -6.0% and 4.2% while the southern basins showed increase ranging from 13.1% to 18.2%. A method based on potential evapotranspiration (PET) changes in the recent and earlier historic periods is demonstrated to apportion streamflow changes to climate and non-climatic factors. Results show that non-climatic factors account for more than 60% of changes in annual runoff in Wisconsin watersheds considered in the study.

## **Probabilistic Survey of National and Wisconsin Stream Resources**

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The National Rivers and Streams Assessment is a study sponsored by the U.S. Environmental Protection Agency that uses a random sample survey to assess the overall quality of the nation's rivers and streams every 5 years. In 2013, a total of 900 wadeable stream sites were sampled in 9 ecoregions across the U.S. The survey can accurately describe stream resources at broad ecoregional scales, but more sampling sites are beneficial to adequately characterize individual states. A total of 25 randomly selected sites in Wisconsin were chosen for the national sample and an additional 25 sites were added to provide a statistically robust assessment of the State's wadeable streams. Physical habitat, streambed sediment, water chemistry, and biological aspects of streams were measured at each site. Physical habitat was characterized using a Qualitative Habitat Evaluation Index, which assessed in stream and riparian features of each stream. Streambed sediment was analyzed for nutrients, metals, polycyclic aromatic hydrocarbons, and various pesticides. Water quality data included: dissolved oxygen, temperature, pH, conductivity, total phosphorus, total nitrogen, basic anions and cations, alkalinity, dissolved organic carbon, total organic carbon, total suspended solids, conductivity, chlorophyll a, microcystin, and a fecal indicator (enterococci). Periphyton (soft algae and diatoms) and biological indices of macroinvertebrates and fish characterized the biological component of streams.

The results of this survey will be used to summarize the health of rivers and streams both across the U.S. and in Wisconsin using a wide breadth of environmental parameters.

## **Evaluation of a Geometric Sampling Design Used to Assess Stream Resources and Identify Environmental Stressors in Watersheds**

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A goal of the Wisconsin Department of Natural Resources is to refine its stream monitoring strategy to gain sampling efficiencies and generate more robust information. WDNR partnered with USEPA Region 5 and the Midwest Biodiversity Institute to evaluate the use of a “geometric” watershed sampling design. Two pilot study watersheds, each approximately 220 sq. mi. in size, were sampled at their pour points. Additional upstream sampling sites within each watershed were systematically chosen based on the drainage area of each stream sampling site. A geometric progression of catchment sizes were selected 110 sq. mi., 55 sq. mi., 27 sq. mi. and so forth until the pour points for the smallest (approximately 2 sq. mi.) drainage areas were identified. Physical, chemical, and biological data collected at each sampling site were used to assess stream quality. A battery of statistical tests were used to investigate which land use, stream habitat, or water quality factors were most responsible for biological degradation, and to determine if stressor thresholds resulting in biological decline were evident. Bray-Curtis analyses identified biologically-distinct groups of stream sites based on fish or invertebrates. Non-metric multidimensional scaling, canonical correspondence analysis, classification and regression trees, and structural equation modeling were used to identify key physical and chemical factors influencing the integrity of stream biota and to determine their relative importance. Quantile regression analyses helped identify thresholds for the concentrations of some pollutants or physical stressors that once exceeded resulted in declines in stream biological integrity.

## **Beer, Brats, Cheese and Water Are Things Every Wisconsinite Needs Even During Drought**

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Are using the words water withdrawals and drought in the same sentence an oxymoron? Water withdrawals from our lakes and streams can have an adverse effect on aquatic communities and on downstream beneficial users. In times of drought, that effect can be even greater. So how do we balance the needs of users vs. the needs of the resource?

Laws have been created to preserve the public interest in waterways as well as the interest of any downstream users. These laws allow the state do perform a balancing act when evaluating the public's interest in the waterway by requiring a state authorization to divert surface water from any water of the state for: 1) agricultural or irrigation purposes, 2) to maintain the normal flow of any navigable stream, or 3) to bring back or maintain the normal level of any navigable lake. The law also requires permits for diversions from any lake or stream if the diversion will result in a water loss averaging 2 million gallons per day (3.09 cfs) in any 30-day period. Are these laws enough to protect the resource?

This presentation will examine and the impetus in Wisconsin for surface water withdrawals and the state's authority to regulate these withdrawals. In addition, we will compare the different approaches the State takes when making decisions to authorize withdrawals when the state is experiencing low water conditions (drought) vs. 'normal' water conditions.

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