AMERICAN WATER RESOURCES ASSOCIATION –WISCONSIN SECTION
40th ANNUAL MEETING

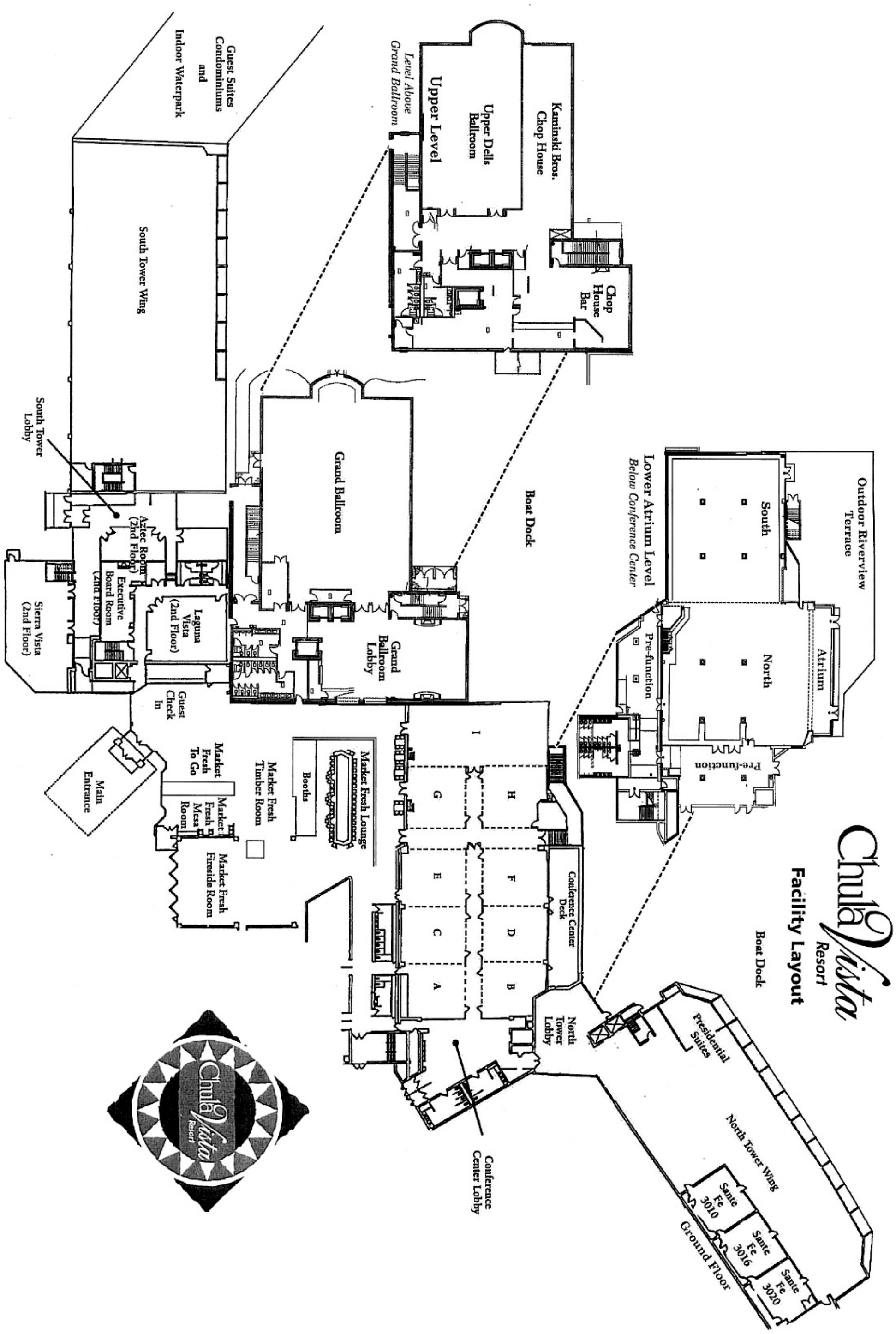
# 40 Years of Wisconsin Waters: Quantity, Quality, Technology

March 10 & 11, 2016
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



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| Austin Polebitski, UW-Platteville | Technical Co-Chair |
| Elizabeth White, UW-Madison Aquatic Sciences Center | WRI Representative |
| Michael Kvitrud , Wisconsin DNR, Madison | Web Coordinator |

*The Wisconsin Section of the American Water Resources Association provides an interdisci plinary 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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# 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

**Amanda Bell**

Amanda Bell has been with the U.S. Geological Survey since the spring of 2001, beginning as an undergraduate student intern for the Snake River NAWQA Basin in Idaho. She then transferred to the Wisconsin Water Science Center so she could complete her Bachelor's and Master's Degree from the University of Wisconsin-Stevens Point. Ms. Bell has been intensively involved in studies on the effects of urbanization on stream ecosystems and determination of temporal and nutrient trends in aquatic biological communities. She is currently the National Water-Quality Assessment Program's Ecological Sampling Coordinator overseeing the sampling of 200 streams annually across the US. She has served as the Vice President for the Wisconsin AWRA Chapter for the last year.

**Eric Booth**

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.

**Mike Parsen**

Mike Parsen is a Wisconsin native from Madison who received his B.S. in Geological Engineering, Geology, and History at the UW-Madison in 2003. Following graduation he moved to Switzerland to complete a Masters in hydrogeology and was subsequently hired by URS (acquired by AECOM in 2014) in Lyon, France as an environmental engineer and hydrogeologist. Projects took him to many countries in Europe as well as field sites in the Democratic Republic of the Congo and Turkey. In 2009, Mike returned home to Madison and has worked as a hydrogeologist at the Wisconsin Geological and Natural History Survey since 2010. At the Survey, Mr. Parsen actively works on groundwater projects in Dane, Chippewa, and Kewaunee counties, helps manage the Wisconsin Groundwater-Level Monitoring Network in partnership with the DNR and USGS, and conducts research and educational outreach regarding industrial sand mining. He has attended and presented at the AWRA Wisconsin Section annual meetings since 2011 and looks forward to having an opportunity to serve on the board beginning in 2016.

**Ted Powell**

Ted Powell is a Senior Hydrogeologist for Leggette, Brashears and Graham, Inc., located in Madison, WI. He has a BS in geology from Lake Superior State University and a MS in earth science, with an emphasis in hydrogeology, from Western Michigan University. He has 25 plus years of professional experience as a geoscientist involved in water resource and water supply investigations, as a hydrogeologist conducting remedial investigations, feasibility studies and remedial design aquifer pilot testing, and as a field geologist in the petroleum industry. For the past 15 years Mr. Powell has maintained his focus in water resource and supply investigations where he has managed wellhead protection and water supply projects that range from comprehensive well siting investigations to aquifer vulnerability studies. He has extensive experience with the design, performance and analysis of aquifer pumping tests. He has conducted numerous surface and borehole geophysical investigations to map aquifers, identify favorable drilling targets, characterize flow zones within formations, delineate potential recharge and storage formations, and map groundwater basin and aquifer boundary structures.

# BIOGRAPHIES OF PLENARY AND EVENING SPEAKERS

**Stephen Born**

Stephen Born was associated with the University of Wisconsin from 1969 until retirement in 2005 where he was a professor of Urban and Regional Planning and Environmental Studies. His interests are in the areas of environmental and natural resources planning and management, with emphasis on watersheds; recent research has focused on groundwater management and assessing watershed partnerships. Mr. Born has been a principal in the development of Wisconsin's laws for lake and watershed management, groundwater protection, land use planning and mineral development. He has served as chairman of the National Resources Board of Trout Unlimited USA; he has also served on the Boards of Directors of the River Alliance of Wisconsin, 1000 Friends of Wisconsin, Trout Unlimited Canada, Henry's Fork Foundation, and the Black Earth Creek Watershed Association. Mr. Born is coauthor of "Exploring Wisconsin Trout Streams" (UW Press), and writes occasionally for conservation/angling periodicals. He has fly fished all over the world for fresh and salt water species.

**Paul Kent**

Paul Kent is senior partner with Stafford Rosenbaum LLP in the Madison, Wisconsin. His practice focuses on environmental regulatory matters with a particular emphasis on water issues. He represents municipalities, businesses and individuals on wastewater, stormwater, wetlands and other environmental issues. He has co-taught the environmental law course at the University of Wisconsin Law School since 1989 and has authored several books and articles on environmental law including *Wisconsin Water Law in the 21st Century* which is available at www.WisconsinWaterLaw.com.

**J. Val Klump**

J. Val Klump is a Professor, Associate Dean of Research, and Senior Director of the School of Freshwater Sciences at UW-Milwaukee. His research focuses on how nutrients and carbon are cycled in lakes. This work has taken him from the deepest soundings in Lakes Superior and Michigan aboard a research submersible, to the largest and oldest lake in the world—Lake Baikal in eastern Siberia. His recent research highlights the presence and dynamics of "dead zones" in Green Bay including the impact climate change has on their extent and duration. Dr. Klump currently serves as a board member of several regional and national organizations including: the International Joint Commission's Science Advisory Board Research Coordination Council, the NOAA Integrated Ocean Observing System Federal Advisory Committee, the National Association of Marine Laboratories Executive Board, and Discovery World. He holds a degree in Law from Georgetown University and a PhD in Marine Science from the University of North Carolina at Chapel Hill.

**Bob Martini**

Bob Martini served 32 years at DNR leading the Wisconsin River cleanup, acid rain research, Central Sands groundwater work, and dam licensing/removal work statewide. He won the DNR's Brogan award in 1983 and was given the North American River Management Society Career Achievement award in 2014. In retirement he has served on about a dozen boards related to environmental protection and higher education. He makes a point to spend a couple hours in wild places almost every day to counteract the effects of the daily assault on the Wisconsin environment.

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# PROGRAM SUMMARY

## 40 Years of Wisconsin Waters: Quantity, Quality, Technology

## 40th Annual Meeting of the
## American Water Resources Association—Wisconsin Section
## Wisconsin Dells, Wisconsin

**THURSDAY, MARCH 10, 2016**

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| 9:00 – 11:00 a.m. | Registration<br>Riverview Prefunction Area |
| 11:00 – 1:45 p.m. | Welcome and Lunch<br>Riverview North |
| **11:45 – 1:45 p.m.** | **Plenary Session** |
| | Stephen Born<br>Emeritus Professor of Planning and Environmental Studies,<br>UW-Madison<br>“Four Decades of Water Resources Management in Wisconsin: One Viewpoint” |
| | J. Val Klump<br>Senior Director and Associate Dean of Research<br>UW-Milwaukee School of Freshwater Sciences<br>"The State and Future of the Great Lakes:  The Challenge for Science" |
| | Paul Kent<br>Attorney/Partner, Stafford Rosenbaump, LLP<br>“Evolution of Wisconsin’s Water Laws: Where have we been and where are we going” |
| 1:45 – 2:00 p.m. | **Break: Room E/F/G/H** |
| **2:00  - 3:20 p.m.** | **Concurrent Sessions 1A, 1B and 1C** |

**Session 1A** — **Urban Water Management**
**Room A/C**
**Moderator: Ken Potter**

2:00 — 40 Years of Urban Stream Restoration - A Look Back at Past Attempts, Current Design Philosophies, and Thoughts for the Future
Brent Brown, CH2M

2:20 — Hydroecologic outcomes of alternate residential development patterns: what's weather got to do with it?
Carolyn Voter,* University of Wisconsin – Madison

2:40 — Urbanization, Climate Change, and Stormwater Management in the Yahara Lakes Watershed
Kenneth Potter, University of Wisconsin – Madison

3:00 — Toxicity and source apportionment of PAHs in Milwaukee-area streambed sediment
Austin Baldwin, US Geological Survey

**Session 1B** — **Water Quality A**
**Room B/D**
**Moderator: Sam Zipper**

2:00 — Lower Wisconsin State Riverway Floodplain Lakes - Results of a Groundwater Study to Delineate Nutrient Contribution Areas
Kenneth Wade, Kenneth Wade Consulting

2:20 — Active channel loss, reed canary grass expansion, and nutrient-enriched groundwater in the Lower Chippewa River in west-central Wisconsin
Emily Moothart,* University of Wisconsin-Eau Claire

2:40 — Avian Influenza Virus RNA in Groundwater Wells Supplying Poultry Farms Affected by the 2015 Influenza Outbreak
Mark Borchardt, USDA Agricultural Research Service

3:00 — Identifying upland and channel sources of fine-grained sediment in an agricultural watershed using sediment fingerprinting, Otter Creek, WI
Leah Kammel, US Geological Survey

**Session 1C** — **Groundwater Modeling**
**Room I**
**Moderator: Mike Parsen**

2:00 — Modeling historical nitrate loading to groundwater in Dane County, Wisconsin
Cory McDonald, Wisconsin Department of Natural Resources

2:20 — Quantifying the Impact: Methodology for Evaluating High Capacity Well Applications
Ian Anderson, Wisconsin Department of Natural Resources

2:40 — High capacity wells and baseflow decline in the Wolf River Basin
Susan Borchardt,* University of Wisconsin – Milwaukee

3:00 — A new predictive model for understanding groundwater quality issues in west-central Wisconsin
Jay Zambito, Wisconsin Geological and Natural History Survey, UW-Extension

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| 3:20 – 3:40 | **Break: Room E/F/G/H** |

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| **3:40 – 5:00 p.m.** | **Concurrent Sessions 2A, 2B and 2C** |
| **Session 2A** | **Water Management**<br>**Room A/C**<br>**Moderator: Austin Baldwin** |
| 3:40 | Accessing Stormwater Control Practices through a Treatment Train in a Residential Low Impact Development Subdivision<br>Roger Bannerman, US Geological Survey |
| 4:00 | Hydrologic Performance of Biofiltration systems in Response to Drainage Area Size<br>Judy Horwatich, US Geological Survey |
| 4:20 | Evaluation of the Water-Quality Benefits of Permeable Pavement<br>Bill Selbig, US Geological Survey |
| 4:40 | Regenerative Stormwater Conveyance Applications for Wisconsin<br>Adrienne Cizek, Stormwater Solutions Engineering |
| **Session 2B** | **Water Resources**<br>**Room B/D**<br>**Moderator: Steve Gaffield** |
| 3:40 | Comparison of ET and recharge under Wisconsin Central Sands cropping systems using lysimetry and the FAO Penman-Monteith model<br>Mallika Nocco,* University of Wisconsin-Madison |
| 4:00 | Interpreting quantitative polymerase chain reaction (qPCR) data for water resource managers<br>Joel Stokdyk, US Geological Survey |
| 4:20 | Uncertainty in Driftless Area Cold-Water Fishery Decision Making<br>Zachary Schuster,* University of Wisconsin-Madison, Nelson Institute for Environmental Studies |
| 4:40 | Spatial and Temporal Variation in Wisconsin Water Levels<br>Robert Smail, Wisconsin Department of Natural Resources |
| **Session 2C** | **Water and Government**<br>**Room I**<br>**Moderator: Amanda Bell** |
| 3:40 | Advances in the USGS Wisconsin Water-Use Information Program<br>Cheryl Buchwald, US Geological Survey |
| 4:00 | The Role of Intergovernmental Deference in Water Quality Protection: Framework, Reality & Recommendations<br>Tressie Kamp, Midwest Environmental Advocates |
| 4:20 | Preventing Alien Invasions: Wisconsin's Invasive Species Law Updates<br>Dreux Watermolen, Wisconsin Department of Natural Resources |

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| 5:00 – 5:45 | Networking |
| **5:45 – 7:00 p.m.** | **Dinner and Evening Speaker**<br>**Riverview North**<br>**Bob Martini**<br>**“Environmental Regulation in the Upper Wisconsin River Basin: Nobody Won, Everyday Benefits”** |

**7:00 – 10:00 p.m.** **Poster Session and Social**
**Riverview South**

1. Overcoming Vertical Stratification in Open- and Closed-Channel Automated Water Quality Sampling
Nicolas Buer, US Geological Survey

2. Inactivation of Dairy Manure-Borne Pathogens by Anaerobic Digestion
Tucker Burch, USDA

3. Floating Bog Interceptor (FBI) Gardens for wetland erosion protection
Michael Busch,* University of Wisconsin - Madison

4. Promoting sustainable groundwater use and safeguarding calcareous fens in a perched groundwater setting, southeastern Minnesota
Jonathan Carter, Barr Engineering

5. Summary of Geochemical and Hydrologic Characteristics of the Albion Basin, Alta, Utah
Ryan Cascarano,* University of Wisconsin – Parkside

6. Investigating groundwater influenced trees during drought at different spatial scales in northern Wisconsin
Dominick Ciruzzi,* University of Wisconsin - Madison

7. Comparative Analysis of Lake Russo's Bathymetry and Chemistry: 1989 & 2015
Kayla Copeland,* University of Wisconsin – Parkside

8. Data and Models to Support Nutrient Management in the Winnebago-Fox-Green Bay System of Wisconsin
Kevin Fermanich, University of Wisconsin - Green Bay

9. Comparison of groundwater model predictions and construction observations for the Highway 14 utility dewatering, Cross Plains, Wisconsin
Stephen Gaffield, Montgomery Associates: Resource Solutions, LLC

10. Wonewoc Formation and Tunnel City Group Rocks: Potential Natural Sources of Groundwater Contaminants in Wisconsin?
Lisa Haas,* Wisconsin Geological and Natural History Survey, UW-Extension

11. Detection and Evaluation of an Inadvertent Cross-Connection of a Water Supply Pipeline to a Deep Well Using Time-Series Geochemical and Stable Isotopic Indicators
Amanda Hamby,* University of Wisconsin - Green Bay

12. Statewide lake level monitoring with citizen volunteers
Katie Hein, Wisconsin Department of Natural Resources

13. Predictions of harmful algal blooms in shallow freshwater lakes: Lake Russo
Matthias Jahn,* Ostfalia University of Applied Sciences

14. Coastal Bluff Evolution Adjacent to Shoreline Protection Structures
Nicholas Jordan,* University of Wisconsin - Madison

15. Using stable isotopes of well water to assess contamination vulnerability in a karst aquifer, Kewaunee County, Wisconsin, USA
Amber Konrad,* University of Wisconsin - Green Bay

16. Monitoring a Saline Tracer Experiment using Electrical Resistivity Imaging (ERI)
Jacob Krause,* University of Wisconsin - Madison , Dept. of Geoscience

17. Mapping stream alterations to enhance watershed scale water quality indicators
Brandon Lee,* University of Wisconsin - Stevens Point

18. Plant Roots, Soil, and Hydrology Relations of Prairie, Wetland, and Forest Vegetation Communities within the Yahara River Watershed, Wisconsin
Allison C. LoBue,* University of Wisconsin – Madison

19. Delineation of Tallent Hall Wetland, University of Wisconsin-Parkside, Kenosha, Wisconsin
Emma Macalister,* University of Wisconsin – Parkside

20. Fish kills and oxythermal stress under climate and land-use changes
Madeline Magee,* University of Wisconsin - Madison, Department of Civil and Environmental Engineering

21. Water Quality Assessment of the Root River in Racine, Wisconsin
Melissa Marra,* University of Wisconsin – Parkside

22. Investigating in-field variability of groundwater to quantify impact of agricultural management practices on quality
Kevin Masarik, University of Wisconsin - Extension & University of Wisconsin - Stevens Point

23. Impacts of Delineation Methods Curve Number Runoff on Watersheds Containing Internally Drainage
Katherine Miller,* University of Wisconsin - Stevens Point

24. Adapting stormwater ordinances to a changing climate: A case study in the Yahara River Watershed
Alexandra Norpel,* University of Wisconsin – Madison

25. Long-term Alterations in Groundwater Chemistry Induced by Municipal Well Pumping
Joshua Olson,* University of Wisconsin – Madison

26. Nitrate patterns, trends, and pathways in groundwater in south-central Wisconsin: A model-based evaluation
Michael Parsen, Wisconsin Geological and Natural History Survey - UW-Extension

27. Integrated Nowcast and Forecast Operation System (INFOS) for Yahara Lakes
John Reimer,* University of Wisconsin - Madison

28. Crop Type and Soil Texture Effects on Nitrogen Leaching from Irrigated Agroecosystems in the Wisconsin Central Sands
Amy Sandel,* University of Wisconsin - Stevens Point

29. Inexpensive in -field manure solids tester
Joseph Sanford,* University of Wisconsin - Madison

30. Hydrologic impacts of Wisconsin's winter on surface water – groundwater interactions
Kimberly Scherber,* University of Wisconsin – Madison

31. Groundwater Quality at the University of Wisconsin - Platteville Pioneer Farm
Amber Slovik,* University of Wisconsin – Platteville

32. How Low Can We Go? Estimating Passive Conservation Rates Through In Home Surveys
Amber Slovik,* University of Wisconsin – Platteville

33. Modeling Cyanobacteria Abundance: Can Season-Ahead Statistical Forecasts Improve Beach Management?
Caitlin Soley,* University of Wisconsin – Madison

34. Comparing the contributions of springs and seeps to nitrate flux in a stream network in central Wisconsin
Robert Stelzer, University of Wisconsin Oshkosh

35. Evaluation of nutrient loading from three major Wisconsin tributaries to Lake St. Croix
Benjamin Torrison, US Geological Survey

36. Smartphone Prediction of Harmful Algae Blooms 2.0: Model refinement
Jonas Weusthoff,* Ostfalia University of Applied Sciences

37. A new coupled groundwater-vadose zone-agroecosystem model: AgroIBIS-MODFLOW (AIM)
Samuel Zipper, University of Wisconsin - Madison

## FRIDAY, MARCH 11, 2016

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| 7:00 – 8:30 a.m. | Board Breakfast Meeting<br>Executive Board Room |
| **8:30 – 10:10 a.m.** | **Concurrent Sessions 3A, 3B and 3C** |
| **Session 3A** | **Central Sands**<br>**Room A/C**<br>**Moderator: George Kraft** |
| 8:30 | Moving groundwater science out of the stovepipe through Integrated Groundwater Management<br>Randall Hunt, US Geological Survey |
| 8:50 | Groundwater Modeling to Support Balancing Stakeholder Interests in the Little Plover River Basin<br>Michael Fienen, US Geological Survey |
| 9:10 | Estimating recharge in the central sands using water-table fluctuations<br>David Hart, Wisconsin Geological and Natural History Survey |
| 9:30 | Using a groundwater flow model to support decision making for agriculture and the environment in central Wisconsin<br>Kenneth Bradbury, Wisconsin Geological and Natural History Survey, UW-Extension |
| 9:50 | Techniques for Quantifying Groundwater Recharge within Wisconsin's Central Sands<br>Adam Freihoefer, Wisconsin Department of Natural Resources |
| **Session 3B** | **High Tech**<br>**Room B/D**<br>**Moderator: Hayley Templar** |
| 8:30 | Innovative Flow Measurement Technology for Stream Discharge near Hydraulic Structures: WIde-angle Oblique Automated Streamflow Imaging System (WI-OASIS)<br>Yuli Liu,* University of Wisconsin-Madison |
| 8:50 | Wave Climatology of the Apostle Islands, Lake Superior<br>Joshua Anerson,* University of Wisconsin – Madison |
| 9:10 | Development of a Rip Current Forecasting System in Lake Michigan<br>Fnu Prashansa,* University of Wisconsin-Madison |
| 9:30 | Long-term Characterization and Real-time Forecasting of High-frequency Water Level Oscillations caused by Fast Moving Storms<br>Alvaro Linares,* University of Wisconsin – Madison |
| 9:50 | Prediction of HAB via Smartphone Application<br>Hedda Sander, Ostfalia University of Applied Sciences |

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| **Session 3C** | **Water Quality B**<br>**Room I**<br>**Moderator: Austin Polebitski** |
| 8:30 | Legacy Phosphorus in Stream Sediments within an Agricultural Dominated Watershed, Wisconsin<br>John Reimer,* University of Wisconsin Madison, Department of Civil and Environmental Engineering |
| 8:50 | Achieving agricultural runoff phosphorus reductions in a Driftless Area watershed<br>Laura Good, University of Wisconsin – Madison |
| 9:10 | Silver Creek Adaptive Management Pilot Study: Monitoring, design, and implementation updates<br>Erin Wilcox, NEW Water (GBMSD) |
| 9:30 | Developing Reference Conditions for Wisconsin Streams<br>Mike Miller, Wisconsin Department of Natural Resources |
| 9:50 | The Influence of Land Use on Nutrient Loads in Spring Brook, Beloit, WI<br>Emma Koeppel,* Beloit College |
| 10:10 – 10:30 | **Break: Room E/F/G/H** |
| **10:30 – 12:10 p.m.** | **Concurrent Sessions 4A and 4B** |
| **Session 4A** | **Agriculture**<br>**Room A/C**<br>**Moderator: Gretchen Bohnhoff** |
| 10:30 | The influence of restored prairie vegetation on freeze-thaw cycles and soil aggregate stability in an agricultural landscape<br>Edward Boswell,* University of Wisconsin-Madison |
| 10:50 | Determining the feasibility of using satellite-derived tillage practices to improve statewide erosion vulnerability estimates<br>Jyun-Yi Michelle Hu,* Wisconsin Department of Natural Resources |
| 11:10 | Evaluation of Filter Media for an In-Line Tile Drainage Nutrient Treatment System<br>Joseph Sanford,* UW-Madison BSE |
| 11:30 | Effect of Woody Biochar Amendment to Sand on Nutrient Leaching to Groundwater with Dairy Manure Application<br>Alysa Hinde,* UW-Madison, Biological Systems Engineering Department |
| | ~~The effects of a denitrifying bioreactor on nitrate and phosphorus discharge~~<br>~~John Nelson, The Nature Conservancy~~ |

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| **Session 4B** | **Groundwater-Surface Water**<br>**Room B/D**<br>**Moderator: Pat Jurcek** |
| 10:30 | Groundwater/Surface-Water Interactions in the Bad River Watershed<br>Andrew Leaf, US Geological Survey |
| 10:50 | Evaluating seepage lake drought resilience using stable isotopes of water and groundwater flow models<br>Hangjian Zhao,* University of Wisconsin – Madison |
| 11:10 | Measurements of infiltration at industrial sand mines<br>Madeline Gotkowitz, Wisconsin Geological Survey |
| 11:30 | Groundwater - surface water interactions caused by pumping from a riverbank inducement well field<br>Tim Grundl, University of Wisconsin – Milwaukee |
| 11:50 | A New Statewide Inventory of Springs in Wisconsin<br>Grace Graham, Wisconsin Geological and Natural History Survey |
| **12:10 – 12:30** | **Student Awards and 2016 Meeting Announcements**<br>**E/F/G/H** |
| 12:30 – 2:00 | Student Career Session Lunch |

**Session 1A:**
**Urban Water Management**
**Thursday, March 10, 2016**
**2:00 – 3:20 p.m.**

## 40 Years of Urban Stream Restoration - A Look Back at Past Attempts, Current Design Philosophies, and Thoughts for the Future

Brent Brown, CH2M, brent.brown@ch2m.com

Stream restoration in the United States has taken quite the journey. From "correcting" streams to increase conveyance for flood control through the use of concrete lining, to science-only attempts using "bio-engineering" and "natural channel" principles, to blending science and engineering to balance ecological needs, natural aesthetics, flood control, and the entirely un-natural conditions that accompany urban hydrology. Whether you call it stream restoration, stream rehabilitation, or naturalization, the last 40 years has been quite a journey for urban streams.

This presentation will provide an entertaining look back at good intentions of the past, lessons we learned over the years and current design and engineering philosophies. Three Midwestern U.S. design examples will be used as case studies to provide an illustrative review of how this profession has evolved. The case studies will include Rockefeller Park in Cleveland that is registered on the National Registry of Historic Places, a highly urban creek in Omaha, and an urban park in Milwaukee. Although the profession has evolved, it still has room to mature from design and construction techniques, to expectations of operations and maintenance. The presentation will conclude with thoughts about how to improve the success of urban stream restoration through design and construction techniques and contracting considerations that are unique for biological systems.

* * *

## Hydroecologic Outcomes of Alternate Residential Development Patterns: What's Weather Got To Do with It?

Carolyn Voter,* University of Wisconsin-Madison, cvoter@wisc.edu
Steve Loheide, University of Wisconsin-Madison

Fine-scale characteristics of urban areas, such as impervious connectivity and soil condition, have a notable effect on urban hydrology. It is well known that surface water runoff decreases when impervious connectivity is reduced or soil permeability and microtopography are increased. Under these conditions, locally enhanced infiltration increases other subsurface fluxes including localized recharge, root water uptake, and/or soil evaporation. The relationship among these subsurface processes can be quite complex depending on whether evapotranspiration is water-limited or energy-limited. In wetter conditions when water stress is rare, root water uptake and soil evaporation are unlikely to be affected by enhanced soil moisture and increases in infiltration more directly translate to increases in recharge. In drier conditions, more of this enhanced infiltration is used to relieve water stress and less becomes recharge. Understanding these tradeoffs in the context of Wisconsin's climate is relevant for predicting the hydroecologic outcomes of stormwater green infrastructure, which uniformly seek to reduce runoff and enhance infiltration.

We use ParFlow.CLM, a watershed model with variably-saturated subsurface flow and fully integrated overland flow and land-surface processes, to examine the extent to which seasonal weather conditions affect subsurface partitioning of enhanced infiltration due to alternate residential parcel development scenarios. Growing season hydrologic fluxes are compared for end member development scenarios – fully connected impervious surfaces with compacted soil vs. highly disconnected impervious surfaces with permeable soil – under different weather scenarios. We show that changes in subsurface fluxes due to alternate development patterns are non-linearly related to changes in infiltration and runoff.

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**Urbanization, Climate Change, and Stormwater Management in the Yahara Lakes Watershed**

Kenneth Potter, University of Wisconsin, kwpotter@wisc.edu

The risk of flooding from the Yahara Lakes has been increasing in recent years. This risk will likely increase in the future, for two reasons. First, most climate models project increases in the frequency of extreme rainfall events. Second, rainfall-runoff modeling using a transposed 2008 storm indicates that adherence to the current county stormwater ordinance will not prevent increases in runoff volume resulting from further urbanization. In particular, the percent of volume control needs to be increased and restrictions need to be placed on the drainage of presently closed watersheds. Institution of a fee-in-lieu system would be an efficient and perhaps more acceptable way to implement such changes.

* * *

**Toxicity and Source Apportionment of PAHs in Milwaukee-area Streambed Sediment**

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Steve Corsi, U.S. Geological Survey
Michelle Lutz, U.S. Geological Survey
Pete Lenaker, U.S. Geological Survey
Matt Magruder, Milwaukee Metropolitan Sewerage District
Chris Magruder, Milwaukee Metropolitan Sewerage District

Concentrations of polycyclic aromatic hydrocarbons (PAHs) have increased in many urban area sediments in recent decades. Because PAHs are potentially toxic to aquatic organisms, a priority of resource managers is to determine PAH concentrations in streambed sediments and identify the primary source(s) of PAHs to streams. To address those two priorities, streambed sediment and parking lot dust samples were collected from 40 and 6 sites in the Milwaukee area, respectively, and analyzed for 63 parent and alkyl PAHs. Total PAH16 concentrations (the sum of the U.S. Environmental Protection Agency 16 Priority Pollutant PAHs) in sediment samples ranged from 1.6 – 208 mg/kg, and in parking lot dust samples from 5.3 – 24,900 mg/kg. Probable Effect Concentrations and Equilibrium Partitioning Sediment Benchmarks were exceeded in 68% and 80% of sediment samples, respectively, indicating toxic effects to benthic organisms are likely at those sites. Laboratory toxicity tests on a 16-sample subset of the streambed sites using Hyalella azteca (28-day) and Chironomus dilutus (10-day) measured significant reductions in one or more biological endpoints, including survival, in 12 of 16 samples.

A multiple-lines-of-evidence approach was taken to identify the primary source(s) of the PAHs to streambed sediments. Diagnostic ratios, profile correlations, principle components analysis, source-receptor modelling, and mass fractions analysis were used to compare sediment samples to potential PAH sources from the literature, and basin land use analysis was used to relate sediment PAH concentrations to different urban-related land uses. Only one source, coal tar pavement sealant, was consistently identified as a likely source. The overlapping agreement of the numerous methods indicates that coal tar sealant was the primary source of PAHs in nearly all streambed-sediment samples, contributing an estimated 42 – 94 percent of total PAHs.

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**Session 1B:**
**Water Quality A**
**Thursday, March 10, 2016**
**2:00 – 3:20 p.m.**

**Lower Wisconsin State Riverway Floodplain Lakes - Results of a Groundwater Study to Delineate Nutrient Contribution Areas**

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Elisabeth Schlaudt,* University of Wisconsin-Madison

Jones Slough, Norton Slough, Bakken's Pond and Long Lake are four floodplain oxbow lakes within the Lower Wisconsin State Riverway in Sauk County Wisconsin. They represent an entire class of lakes that exist outside of mainstream lake research, monitoring and management in Wisconsin. They are the most environmentally sensitive water resources along the Riverway and are vital to main stem river ecology, biodiversity and water quality. The lakes lie adjacent to intensively managed agricultural fields located on sandy river terraces with high susceptibility to groundwater contamination from agricultural nutrient applications. Recent studies have documented elevated nitrate concentrations and excessive free floating plant growths in the lakes. Secondary effects of these eutrophic conditions include low dissolved oxygen concentrations and habitat degradation that threatens state endangered fish and other species.

A hydrologic study of the lakes and associated floodplain and river terrace areas utilized groundwater monitoring wells along with lake and river staff gages to determine groundwater hydraulic gradients and water quality variation. Lake biological and chemical surveys were also conducted. The results delineated groundwater flow paths, both horizontally and vertically in the lake areas, and describe the distribution of nutrients in groundwater discharge originating from recharge at adjacent agricultural areas. The results provide valuable land use planning information and aid in working with landowners to strategically target nutrient reduction practices in those areas with greatest impact on lake water quality. The study results will allow for the development of numerical groundwater models that will provide a more refined understanding of the flow system and target specific ways to address the current nutrient impacts to the lakes.

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**Active Channel Loss, Reed Canary Grass Expansion, and Nutrient-Enriched Groundwater in the Lower Chippewa River in West-Central Wisconsin**

Emily Moothart,* University of Wisconsin-Eau Claire, moothaea@uwec.edu
Scott Nesbit, University of Wisconsin-Eau Claire
Douglas Faulkner, University of Wisconsin-Eau Claire
Garry Running, University of Wisconsin-Eau Claire

Maps constructed from aerial photographs dating to 1938 along a 50-km section of the Lower Chippewa River (LCR) in western Wisconsin document a decline of active-channel area exceeding 25%. This loss in channel area has occurred despite no detectable change in stream hydrology. Much of the loss instead seems due to the stabilization of lateral bars by reed canary grass (RCG), a significant invasive wetland species in the Upper Midwest. GPS surveys of RCG patches along the river indicate that RCG-stabilized bars account for as much as 100% of the main channel loss that occurred during the main period of RCG invasion. Why RCG invaded the channel during this time period is unknown, but one hypothesis is that it is coincident with the expansion of center-pivot irrigation on nearby cropland, which led to groundwater discharge into the river enriched in plant-available nutrients. As a first step in testing this hypothesis, we collected water samples during the summer of 2015 at six different times from six locations along the river where extensive monocultures of RCG exist. At each location we collected a river sample from mid channel and a groundwater sample from a hand-excavated pit along the riverbank. Samples were then analyzed at the county health department lab for nitrate and phosphorus concentrations. Results indicate that groundwater flowing toward the river is generally enriched in nitrates and phosphorus compared to the river, consistent with the hypothesis that groundwater enriched with agricultural nutrients is promoting RCG growth along the LCR.

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**Avian Influenza Virus RNA in Groundwater Wells Supplying Poultry Farms Affected by the 2015 Influenza Outbreak**

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Laura Hubbard, U.S. Geological Survey, Wisconsin Water Science Center
Susan Spencer, U.S. Department of Agriculture, Agricultural Research Service
Aaron Firnstahl, U.S. Geological Survey, Wisconsin Water Science Center
Joel Stokdyk, U.S. Geological Survey, Wisconsin Water Science Center
Dana Kolpin, U.S. Geological Survey, Iowa Water Science Center

During the 2015 outbreak of highly pathogenic avian influenza virus (HPAI) on Midwest poultry farms it was noted that the potential for HPAI groundwater-borne transmission was unknown. Influenza virus is released in bird feces and re-infects new birds by ingestion. As the outbreak-affected poultry farms had high virus levels in large volumes of fecal material, and the outbreaks occurred during heavy spring rains and cool temperatures, conditions were favorable for HPAI transport to groundwater. Avian influenza virus (AI) has been detected in surface waters, but to our knowledge AI has not been documented in groundwater. We sampled 20 water supply wells, six waste-storage lagoons, and one pond on 13 outbreak-affected poultry farms in Iowa and Wisconsin. The time between outbreak onset and sampling date ranged from 8 to 79 days. Virus sampling was by standard methods, and AI was measured by qPCR and cell culture methods. Samples were also analyzed for a parvovirus specific to poultry feces. Three wells and one lagoon were positive for the matrix gene indicative of influenza A virus. We designed a semi-nested qPCR assay specific to the H5 HPAI outbreak strain using genetic sequence data for HPAI isolates from poultry infected during the outbreak. This test indicated one of the matrix gene-positive wells was also positive for the H5 gene unique to the outbreak HPAI strain. This positive sample was collected with the least elapsed time after outbreak onset (8 days), consistent with the prevailing view that AI survival in the environment is brief. All samples analyzed for AI by cell culture were negative. Seven wells (35%) were positive for the poultry-specific parvovirus thus providing corroborating evidence of virus transport pathways between poultry fecal waste and groundwater. To our knowledge this is the first report of AI RNA in groundwater, and it suggests that under some conditions groundwater may be an overlooked route for transmission of avian influenza virus.

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**Identifying Upland and Channel Sources of Fine-Grained Sediment in an Agricultural Watershed Using Sediment Fingerprinting, Otter Creek, WI**

Leah Kammel, U.S. Geological Survey, WI Water Science Center, lkammel@usgs.gov
Faith Fitzpatrick, U.S. Geological Survey, WI Water Science Center

Silt and clay-sized fine-grained sediment is a pollutant in many agricultural watersheds that causes reduced water clarity, high phosphorus loads, and negative impacts on aquatic habitat. Understanding the sources and loading patterns of sediment is essential to developing successful strategies for reducing sediment loads within the total maximum daily load (TMDL) management framework. A sediment fingerprinting approach was used to distinguish upland soil erosion from bank erosion in Otter Creek, a small tributary to the Sheboygan River. A suite of trace element concentrations from upland and eroding bank source samples were used to determine unique signatures or "fingerprints" that distinguish between each of the sources. These fingerprints were used to calculate the relative contribution from each source to a fine-grained streambed sediment sample collected at a watershed outlet. In this study, fine-grained soft sediment was collected at 15 sites in depositional areas along the streambed of Otter Creek in the spring of 2012. The source samples consisted of 15 eroding bank samples and 41 upland soil samples collected during the spring of 2012 and 2013, respectively. A Sediment Fingerprinting Model (SFM), developed by the U.S. Geological Survey Maryland Water Science Center, was used to quantify the relative contributions of sediment from eroding banks and upland soils eroded from cropland, grassland, and woodland areas. The results from this study indicate that both eroding banks and upland sources are significant contributors of sediment and nutrients to Otter Creek, and that the proportion of sediment contributed by each source varies spatially depending on location in the watershed. The automated statistical calculations in the SFM provided a powerful and time-saving tool for determining significant sources of sediment in a watershed.

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**Session 1C:**
**Groundwater Modeling**
**Thursday, March 10, 2016**
**2:00 – 3:20 p.m.**

## Modeling Historical Nitrate Loading to Groundwater in Dane County, Wisconsin

Cory McDonald, Wisconsin Department of Natural Resources, cory.mcdonald@wisconsin.gov
Michael Parsen, Wisconsin Geological and Natural History Survey
Richard Lathrop, University of Wisconsin-Madison
Kirsti Sorsa, Public Health Madison Dane County
Kenneth Bradbury, Wisconsin Geological and Natural History Survey
Michael Kakuska, Capital Area Regional Planning Commission

Private domestic wells are the source of drinking water for about one-quarter of Wisconsin residents. Statewide, approximately 12% of tested wells exceed the state and federal standard of 10 mg/L Nitrate-N; it has been estimated that the source of the majority (90%) of this contamination is agriculture. In highly-agricultural Dane County, the exceedance rate is approximately double the statewide average (25%). As one component of a multi-objective study examining spatial and temporal trends in nitrate concentrations in shallow groundwater in Dane County, output from the recently completed Dane County groundwater flow model (MODFLOW) was combined with nitrate measurements collected over several decades from thousands of wells in order to uncover historical trends in nitrate loading to groundwater. Comparing temporal trends in this extensive, but noisy, dataset with historical land use is complicated by the fact that there are essentially two time dimensions associated with each measurement: the point in time at which the well was sampled (which is known) and the point in time at which the water being sampled entered the groundwater system (which is not). We applied a novel, model based approach to estimate the second time dimension (average water age) for thousands of broadly-distributed wells, and then normalized the data to a single, common time scale. This analysis revealed a clear trend over the course of the past century that is strongly correlated with the record of nitrogen fertilizer application.

* * *

## Quantifying the Impact: Methodology for Evaluating High Capacity Well Applications

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Adam Freihoefer, Wisconsin Department of Natural Resources
Rachel Greve, Wisconsin Department of Natural Resources
Jeff Helmuth, Wisconsin Department of Natural Resources
Jared Niewoehner, Wisconsin Department of Natural Resources

The Department of Natural Resources (DNR) is responsible for reviewing all new high capacity well applications. Due to a significant increase in the number of applications and the complexity of the required review, DNR faces challenges in completing high capacity well reviews. Currently, DNR screens each high capacity well application to assess potential impacts to waters of the state, including streams, lakes, wetlands, springs and water supply wells. Many high capacity wells are proposed in locations that are geologically and hydrologically complex, have a high density of existing high capacity wells, or are near sensitive resources such as headwater streams.

DNR has developed a technical approach that incorporates existing geologic and hydrologic data into commonly used analytic or numeric tools to improve our ability to assess significant impacts to water resources. Data sources include well construction reports, geologic maps, water resource inventories, and DNR's water use reporting database. Stream gage data and individual measurements of flow and

water elevation are used in combination with a statewide model of streamflow statistics and stream natural communities to quantify depletion and drawdown. Hydrogeologically complex applications or those in ecologically sensitive areas often involve increased site-specific investigation or groundwater flow modeling, either by DNR staff or by the applicant.

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**High Capacity Wells and Baseflow Decline in the Wolf River Basin**

Susan Borchardt,* University of Wisconsin-Milwaukee, borcha48@uwm.edu
Woonsup Choi, University of Wisconsin-Milwaukee
Weon Shik Han, University of Wisconsin-Milwaukee

The baseflow of the Wolf River (drainage area of 1200 km2) in northeastern Wisconsin has declined by over 30% during the last thirty years, whereas climatic, land cover, and soil characteristics of the basin have remain unchanged. Because groundwater basins do not always coincide with surface water basins, estimating groundwater discharge to streams using variables only pertinent to the surface water basin can be ineffective. The purpose of this study is to explain the decline in the baseflow of the Wolf River by developing a multiple regression model. To take into account variables pertaining to the groundwater basin, we included withdrawal rates from high capacity wells outside of, but close to the Wolf River basin to the regression model. The other explanatory variables include annual precipitation and growing degree-days. Groundwater discharge to the river was calculated using streamflow records with the computer program Groundwater Toolbox from the United States Geological Survey. Without the high capacity wells data, the model only explained 29.5% of the variability in the groundwater discharge ($r^2 = 0.295$). With the high capacity wells data, $^{r2}$ improved to 0.677. The study suggests the effect of human activity taking place outside of the basin on the streamflow.

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**A New Predictive Model For Understanding Groundwater Quality Issues In West-Central Wisconsin**

Jay Zambito, Wisconsin Geological and Natural History Survey, UW-Extension, jay.zambito@uwex.edu
Mike Parsen, Wisconsin Geological and Natural History Survey, UW-Extension
Lisa Haas,* Wisconsin Geological and Natural History Survey, UW-Extension

Over the past decade, west-central Wisconsin has undergone rapid land-use change related to suburban sprawl and increased industrial (frac) sand mining. As population rises and new homes are built in traditionally rural areas, new private drinking water wells are being constructed and their water quality tested. In the vicinity of La Crosse, WI, water from some private wells has been shown to contain enrichments of aluminum, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, vanadium, and zinc above advisory levels, as well as low pH. Furthermore, sandstones that are primary aquifers in the region are the same rocks mined for industrial (frac) sand where they outcrop on hillsides, and stormwater runoff ponds at these sites can have fluctuating pH and be enriched in arsenic, lead, manganese, and vanadium. Herein we present recently collected data suggesting that these water quality issues have the same cause. Our conceptual model predicts not only where sulfides and trace metals naturally occur, but also where and how they are oxidized within the aquifer-aquitard system. Our preliminary data suggests that sulfides and trace metals present are directly related to Cambrian depositional environments, and that these sulfides and metal-bearing minerals are weathered at three predictable oxidation fronts causing pH changes in groundwater and trace metals to go into solution. The hypothesized oxidation fronts responsible for a majority of water quality issues in west-central Wisconsin are 1) the Weathering Front, where rocks and minerals are oxidized at Earth's

surface; 2) the Water Table Front, a zone of oxidation that occurs when the water table fluctuates due to seasonal variations or well drawdown, exposing rocks to varying redox conditions; and, 3) the Groundwater Flow Front, which occurs at abrupt contrasts in lithology, such as formation boundaries or within-formation bedding-plane partings at which water flows laterally and oxygen is preferentially introduced. We will present preliminary data supporting this conceptual model as well as methods and plans for further testing.

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**Session 2A:**
**Water Management**
**Thursday, March 10, 2016**
**3:40 – 5:00 p.m.**

### Accessing Stormwater Control Practices through a Treatment Train in a Residential Low Impact Development Subdivision

Roger Bannerman, U.S. Geological Survey, rbannerman@usgs.gov
Judy Horwatich, U.S. Geological Survey

A 38-acre single family residential subdivision featured a low impact development (LID) design to reduce runoff through a series of stormwater control practices (SCPs). The subdivision's LID design included: 1) narrower streets from standard design (36 ft versus 40 ft); 2) a single sidewalk instead of two sidewalks, 3) required disconnection of all roof drains, 4) grass swale roadside drainage, 5) wet detention basin, and 6) an infiltration basin. The USGS established long term automated stormwater monitoring stations at the outlet of the 38 acre project site to determine the effectiveness of SCPs. A total of 309 rain events were monitored between 1999 – 2005, however only 91 rain events resulted in measureable discharge that left the project site. The urban stormwater quality model, Source Loading and Management Model for Windows (WinSLAMM) will be used to verify the benefits of LID designs. During the calibrated and verified procedures, the measured data will improve WinSLAMM. As a result, the measured data is transferred to other users of WinSLAMM when modeling LID residential sites. This presentation will compare the model results to the monitored events and will identify strengths and limitations of this stormwater modeling tool.

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### Hydrologic Performance of Biofiltration systems in Response to Drainage Area Size

Judy Horwatich, U.S. Geological Survey, jahorwat@usgs.gov
Roger Bannerman, U.S. Geological Survey

Few monitoring projects report the hydrologic performance of biofiltration cells relative to the size of their drainage areas. In Wisconsin, the technical standard (1004) advises engineers to have non-erosive flows entering the cells, but this does not address the hydrologic capacity of the cell before it overflows. A study by the USGS and WDNR assessed performance of three biofiltration cells of different depths with ratios of drainage area to cell size of greater than 30 to 1. More than 12 percent of 123 events monitored had significant overflow, caused by high rainfall intensity and rainfall depths greater than 0.5 inches. The overflows for larger events could represent an important portion of the annual water loads that go untreated. Results from these monitoring studies will be presented and are used to calibrate the urban runoff model WinSLAMM (Windows Source and Loading and Management Model). For biofiltration, the model is sensitive to runoff volumes, underdrain and overflow piping, soil media type, evaporation, evapotranspiration, cell depth, and infiltration rates of the native soil. Calibrated model runs using the study site attributes and the range of site characteristics expected for Wisconsin biofiltration systems were used to create plots describing how the ratio of drainage area size to cell size limits the amount of overflow.

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### Evaluation of the Water-Quality Benefits of Permeable Pavement

Bill Selbig, U.S. Geological Survey, wrselbig@usgs.gov

Urbanization of the landscape can increase the quantity and degrade the quality of stormwater entering our lakes and streams. Replacing natural vegetation with impervious surfaces, such as parking lots and streets, can promote the rapid transport of many urban pollutants such as nutrients and sediment. Permeable pavement is considered one of the stormwater control measures available to environmental managers as a way to mitigate the adverse impact of urban stormwater; however, few studies have quantified the water-quality benefits of different types of permeable pavements.

From August 2014 through October 2015, the U.S Geological Survey measured the infiltration rates and pollutant reduction capabilities of three variations of permeable pavement: pavers, concrete, and asphalt. Untreated stormwater runoff from an adjacent parking lot was directed towards and distributed equally between the three permeable surfaces by use of a flow splitter. Mean infiltration rates of the asphalt surface remained above 100 in/hr whereas the paver and concrete surfaces both dropped from >100 in/hr to <10 in/hr, a result of clogging by sediment retained in each surface. Twenty-eight precipitation events over the 14-month monitoring period were sampled and analyzed for water-quality. Cumulative suspended sediment load influent to each permeable surface was reduced by 66, 59, and 79 percent in the paver, concrete, and asphalt plots, respectively. Cumulative total phosphorus load was reduced by 19, 22, and 17 percent, respectively.

Both the permeable paver and concrete surfaces initially showed higher percentages of pollutant reduction than asphalt; however, a continued decline in the ability to infiltrate runoff resulted in more runoff flowing over, not through the surface. This led to a decline in overall treatment. Conversely, the asphalt surface continued to provide some level of treatment since it was capable of treating nearly all of the influent runoff volume. Results from this study will be used to amend the Wisconsin Department of Natural Resources conservation practice standard for installation of permeable pavement in Wisconsin.

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### Regenerative Stormwater Conveyance Applications for Wisconsin

Adrienne Cizek, Stormwater Solutions Engineering, adrienne@stormwater-solutions-engineering.com

Regenerative stormwater conveyance (RSC) uses design principles from natural headwater streams to manage, treat, and convey stormwater in one practive. RSCs are designed with a series of pools and riffles over a sand media bed. Runoff flow and velocities are reduced in each pool, allowing for infiltration into the sand media bed and important treatment processes to occur. Research from the east coast has shown greater than 95% reduction in TSS, TP, and TN loads, along with reduction of peak flow and surface volume outflow to that of pre-developed (undeveloped) conditions. Additionally, RSCs have demonstrated the ability to provide important auxiliary benefits beyond those observed in conventional stormwater practices, including soil formation, carbon sequestration, and educational and recreational benefits. RSCs are a credited BMP and watershed mitigation tool in the Chesapeake Bay region at tidal inlets, headwater streams, and storm pipe outfalls. RSCs have similar potential applications for protecting surface waters of the midwest, especially with the implementation of TMDL strategies. This presentation will provide an introduction to RSC design and application and review demonstrated RSC stormwater mitigation performance in NC. A case study of RSC design and implementation in Wisconsin will illustrate a use for RSCs as a tool for stormwater mitigation in the Midwest.

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**Session 2B:**
**Water Resources**
**Thursday, March 10, 2016**
**3:40 – 5:00 p.m.**

## Comparison of ET and Recharge under Wisconsin Central Sands Cropping Systems Using Lysimetry and the FAO Penman-Monteith model

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Christopher Kucharik, University of Wisconsin-Madison

Irrigated agricultural expansion and severe surface water stresses have facilitated a long-term management conflict over water quantity in the Wisconsin Central Sands (WCS). Because of the high groundwater-surface water connectivity in this region, reductions in net groundwater recharge from irrigated agricultural landscapes directly impact adjacent surface waters. Therefore, net groundwater recharge estimates from different irrigated crops is a critical input to groundwater models as well as an important measurable outcome of water management efforts in the WCS.

Net groundwater recharge from irrigated agroecosystems is conceptualized as the difference between precipitation and evapotranspiration (ET), which is often modeled using reference and crop-coefficient methods such as the FAO-56 Penman-Monteith model. Typically, reference ET is calculated using micrometeorological data and empirical crop-coefficients, which encapsulate crop differences in canopy growth and function into three constants for early, middle, and late stages of crop growth. Though the FAO-56 crop coefficient approach makes ET and net recharge approximation accessible to a variety of stakeholders and water managers, empirical crop coefficients may not be representative of WCS regional crop growth and physiology.

Our goal is to validate crop coefficients for the irrigated crops typically grown in the Wisconsin Central Sands-potato, field corn, sweet corn, and peas and better understand the relationship between crop cover, ET, and net groundwater recharge. To this end, we calculated actual crop ET, soil moisture storage, and net groundwater recharge using 25 passive-capillary wick lysimeters and 96 frequency domain reflectometry probes installed in six agroecosystems on Isherwood Farms in Plover, WI. Using an onsite meteorological station, we also approximated crop ET and net recharge using existing empirical crop coefficients and the FAO-56 Penman-Monteith model. We will present results comparing ET and net groundwater recharge estimated from each method and new, validated crop coefficients for WCS cropping systems.

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## Interpreting Quantitative Polymerase Chain Reaction (qPCR) Data for Water Resource Managers

Joel Stokdyk, U.S. Geological Survey, jstokdyk@usgs.gov
Aaron Firnstahl, U.S. Geological Survey
Sue Spencer, U.S. Department of Agriculture
Tucker Burch, U.S. Department of Agriculture
Mark Borchardt, U.S. Department of Agriculture

Powerful quantitative polymerase chain reaction (qPCR) methods are now commonly used to detect and quantify microorganisms in the environment, including groundwater, surface water, and drinking water. In terms of water-resource management, qPCR-based methods can be used to investigate pathogens as contaminants, assess recreational and drinking water quality, determine fecal contamination sources, and inform management or policy decisions regarding our water resources. Understanding how qPCR results can be used for water-resource management requires knowledge of basic concepts of qPCR microbial analysis and interpretation. We will present basics of qPCR, including method limitations and comparison to non-molecular methods, which provide background context for application to water-resource problems. Assay characteristics, like sensitivity and specificity, will be defined and explained because they describe the quality and potential application of a qPCR method. This information, along with knowledge of quality control and quality assurance practices, allows unambiguous assessment of the data and recognition/quantification of confounding inference. With a better understanding of this background, water-resource managers can better understand and apply the powerful insights provided by modern qPCR techniques.

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**Uncertainty in Driftless Area Cold-Water Fishery Decision Making**

Zachary Schuster,* University of Wisconsin-Madison, Nelson Institute for Environmental Studies, zschuster@wisc.edu

The paradigm of useful science is becoming more popular as researchers seek to make their scientific information more applicable to solving real-world problems. One of the key issues stakeholders face in adopting climate change information into their decision processes is how uncertainty is addressed and communicated. In this study, we conducted a series of semi-structured interviews with managers and scientists working on stream habitat restoration of cold-water fisheries in the Driftless Area that were focused on how they interpret and manage uncertainty and what types of information they need to make better decisions. These interviews provide insight about how managers from the Wisconsin DNR and other agencies decide to do stream restoration work and how organizations such as Trout Unlimited can contribute to the stream restoration process. They also provide a model for how other researchers can engage with practitioners to help produce scientific information that is useful in helping improve environmental decision making.

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**Spatial and Temporal Variation in Wisconsin Water Levels**

Robert Smail, Wisconsin Department of Natural Resources, robert.smail@wisconsin.gov

The Wisconsin Department of Natural Resources approves or limits human water withdrawals based on estimations of how significantly the withdrawal will affect water availability for other human and ecological needs. Estimating these impacts is complicated by weather and climate variation concurrently affecting water availability. To better understand baseline variation water quantity available, a dataset was assembled of 49 stream, lake and groundwater level observations dating back to 1948. Annual averages, multi-year averages, and Z-scores were calculated for all data points and were compared spatially and temporally. In addition, annual precipitation (P), potential evaporation (PET) and P-PET were mapped statewide from 1948 to 2014 and compared to local water level variation.

Results of this analysis showed a high level of synchronicity across many water level data points with many Pearson's r >.75 annually and r > .90 for 10-year averages. Surprisingly, many of the largest correlations were found between disparate gauge types located at considerable distance from each other. These similarities indicate the possibility that local water quantity variation may be significantly associated with weather and climatic variation at regional spatial and temporal scales. Of these, annual P most strongly correlated with annual changes in water level. However, longer term water level variation was more strongly correlated with variation in PET. Again, the strongest correlations between weather variables and water levels were not proximate for many points. This observation indicates that in some places, local water level variation may be more closely associated with regional hydrologic, climatic and weather variation.

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**Session 2C:**
**Water and Government**
**Thursday, March 10, 2016**
**3:40 – 5:00 p.m.**

### Advances in the USGS Wisconsin Water-Use Information Program

Cheryl Buchwald, U.S. Geological Survey, cabuchwa@usgs.gov

Each year government agencies, regional planning commissions, and water utilities spend millions of dollars to quantify water availability and use. These funds are used to identify trends or emerging problems, to design and implement resource-management and regulatory programs, and to determine the connection between water use and water quantity, flow, and quality. Water-use information is essential for characterizing water availability. With good water-use estimates, water budgets and ecological flows can be accurately determined, conservation (or lack thereof) can be tracked, and impacts associated with return flows to aquatic resources can be quantified. However, managers and researchers often rely on estimation methods to quantify water withdrawals, consumption, use relationships, and future demands.

For nearly 40 years, water-use information has been gathered and reported periodically by the United States Geological Survey (USGS) Wisconsin Water-Use Information Program (WIWUIP). The WIWUIP began in 1978 as a cooperative agreement with the Wisconsin Department of Natural Resources (WDNR) to inventory water use in Wisconsin as part of the USGS Regional Aquifer-System Analysis Program. During the following years, the types and magnitudes of water use in Wisconsin have changed, and methods for estimating those uses have evolved. Considerably more water-use data are currently available (2015) from the WDNR Water-Use Program as a result of recent legislation. In response, the WIWUIP is evolving its focus from data-collection and simple calculations to include statistical analyses and development of new methods to estimate missing or unreported water withdrawals and consumptive uses. Over the next few decades, it is anticipated that the program will offer new data-derived tools to support decision-making for managing competing water uses and limited water resources. Example advancements will include conveyance modeling from the Site-specific Water-Use Data System, mapping watershed-scale water-use data from the online Water Census Data Portal, and projecting irrigation water needs from a State energy balance model to compare against reported withdrawal data.

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### The Role of Intergovernmental Deference in Water Quality Protection: Framework, Reality & Recommendations

Tressie Kamp, Midwest Environmental Advocates, tkamp@midwestadvocates.org
Dave Marshall, Underwater Habitat Investigations LLC

Intergovernmental deference is an expected result of federalism in the United States, including keystone federal laws such as the Clean Water Act (CWA). Deference of the Environmental Protection Agency (EPA) to individual states stems both from the CWA, interpretive case law, and common sense principles. Federal and state regulatory agencies are meant tp partner to issue permits and enforce the CWA. The EPA may delegate permitting authority to states because it is assumed that states have the capacity and expertise to best control and prevent pollution. Delegated programs must comply with federal laws and regulations; the CWA allows the EPA to rescind permitting authority when such compliance is lacking. Wisconsin was delegated authority to issue permits in compliance with the CWA in 1974. In 2011, the Wisconsin Department of Natural Resources (DNR) received a letter from the EPA listing 75 deficiencies with the permitting program. The DNR has not comprehensively resolved these issues and as such the DNR is no longer entitled to the full deference or permitting authority that may have historically protected our state's water resources. Recently, 16 Petitioners living throughout Wisconsin submitted a Petition for Corrective Action (PCA) to the EPA. The PCA is intertwined with the balance of powers established to uphold the CWA. Petitioners' testimonials speak to issues such as permanent or extended non-compliance with federal regulations and standards, and the restricted ability of Wisconsinites to challenge and enforce water pollution permits. The PCA outlines numerous ways in which the EPA can begin to remedy unacceptable and unhealthy water quality degradation in Wisconsin. Finally, the PCA is an effort to advocate for broader public participation and compliance with minimum federal water protection requirements by restoring proper intergovernmental balance in the name of water quality.

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**Preventing Alien Invasions: Wisconsin's Invasive Species Law Updates**

Dreux Watermolen, Wisconsin Department of Natural Resources, Dreux.Watermolen@Wisconsin.gov

The State of Wisconsin revised its invasive species identification, classification, and control rule (chapter NR 40, Wis. Admin. Code) in 2015, following a three-year effort that involved numerous stakeholders and affected industries. First enacted in 2009, the law seeks to prevent ecological and economic impacts associated with invasive species by prohibiting and restricting the introduction, possession, transfer, and transport of certain plants and animals. The intent is to provide a comprehensive, science-based system that prevents invasive species from becoming established in Wisconsin and prevents already-established species from spreading within the state. Significant changes to the law include: delisting two species, listing 49 new prohibited and 32 new restricted species, split-listing (prohibited/restricted) two species, changing the regulated status of five species, and creating a phase-out period for restricted plants to minimize impacts to the nursery industry and facilitate compliance. Other changes clarify rule language and streamline implementation. The state Department of Natural Resources can authorize transport, possession, and transfer of regulated species through permits in certain situations. A summary of permitting activity under the law will be provided. The law also requires certain preventative measures, including several related to working in lakes, streams, and wetlands. The water resources management community can help implement this law; what one needs to do varies depending on the type of work and activities. Resources for complying with ch. NR 40 will be provided.

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**POSTER SESSION**

**Thursday, March 10, 2016**

**7:00 – 10:00 p.m.**

## 1. Overcoming Vertical Stratification in Open- and Closed-Channel Automated Water Quality Sampling

Nicolas Buer, U.S. Geological Survey, Wisconsin Water Science Center, nbuer@usgs.gov
William Selbig, U.S. Geological Survey, Wisconsin Water Science Center

Fixed point auto sampling may misrepresent open- and closed-channel systems due to solids stratification in the flowing water column. The Depth-Integrated Sample Arm (DISA) was developed to overcome vertical stratification in sediment and sediment-associated pollutant concentrations in dynamic aqueous environments by sampling the entire water column rather than a single, fixed point. Use of the DISA has been shown to limit bias associated with oversampling due to vertical stratification and hyper concentration of sediments and associated nutrients during high discharge events.

When testing in a storm sewer under controlled laboratory conditions, suspended sediment concentrations (SSC) measured by the DISA slightly overestimated actual values by 7% compared to 96% when using a traditional fixed-point sampler. Examination of particle size distributions showed a bias towards coarse particles (>106 µm) in samples collected using fixed-point methods. The DISA was better able to reproduce the average distribution of particles over a range of hydraulic conditions.

In addition to storm sewers, the DISA has been successfully deployed in open channels and edge-of-field studies. Results thus far have been mixed, showing no significant differences in sediment concentrations from fixed point sampling methods. However, during high flow events, debris tend to accumulate over the fixed-point intake yet the self-cleaning nature of the DISA keeps the intake clear. Edge-of-field testing has also shown SSCs in DISA and fixed-point samples to be very similar up to concentrations of approximately 2,000 mg/L, after which concentration curves diverge with higher SSCs measured in the fixed-point sampler. This could be due to the water column becoming saturated with sediment resulting in a zone of hyper concentration near the base of the flume.

Use of the DISA may also better represent pollutants that have a high correlation with sediment such as total phosphorus. A reduction in bias and variability when using the DISA over fixed-point sampling methods could improve pollutant loading models thereby resulting in better assessment and understanding of BMPs and mitigation efforts used by watershed managers to meet environmental goals.

* * *

## 2. Inactivation of Dairy Manure-Borne Pathogens by Anaerobic Digestion

Tucker Burch, U.S. Department of Agriculture, Agricultureal Research Service
tucker.burch@ars.usda.gov
Susan Spencer, U.S.Department of Agriculture, Agricultureal Research Service
Spencer Borchardt, U.S. Geological Survey, Wisconsin Water Science Center
Rebecca Larson, University of Wisconsin-Madison Dept. of Biological Systems Engineering
Asli Alkan-Ozkaynak, University of Wisconsin-Madison Dept. of Biological Systems Engineering
Mark Borchardt, U.S.Department of Agriculture, Agricultureal Research Service

Land-application is a common disposal practice for livestock manure, and it can expose livestock and humans to enteric pathogens through contamination of surface water and groundwater. Anaerobic digestion is a waste treatment process that can inactivate these pathogens, thereby reducing the risk of exposure. However, the performance of anaerobic digestion for pathogen inactivation in livestock manure is not well-understood, particularly for full-scale systems. Our objective was to examine the inactivation of dairy manure-borne pathogens by anaerobic digestion in full-scale systems. We collected biweekly samples for 9 months from 7 mesophilic anaerobic digesters that treat dairy manure in Wisconsin, including both plug-flow (n = 5) and completely-mixed (n = 2) configurations. We measured protozoan (n = 2), bacterial (n = 7), and viral (n = 8) pathogen levels in feedstock inputs and digestate outputs using qPCR and calculated pathogen removal efficiencies. Measured pathogen removal varied over several orders of magnitude by date, but did not vary between plug-flow and completely-mixed systems. The digesters in this study are not optimized for pathogen removal. Rather, pathogen removal is a side-benefit to achieving unrelated treatment objectives. The variation in pathogen removal observed in this study is too great to determine a reliable "standard" pathogen removal efficiency for full-scale mesophilic anaerobic digestion. Thus, if pathogen removal is made an explicit treatment objective for these systems, then further optimization and/or monitoring will likely be required to ensure treatment effectiveness.

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## 3. Floating Bog Interceptor (FBI) Gardens for Wetland Erosion Protection

Michael Busch,* University of Wisconsin-Madison, mpbusch@wisc.edu
Brent Teske, University of Wisconsin-Madison
Chin Wu, University of Wisconsin-Madison

Important functions of wetlands include improving water quality, attenuating floods, and providing habitat for native plants and animals. Cherokee Marsh is Dane County's largest wetland, sitting upstream of Lake Mendota and downtown Madison. It has great potential to impact water quality in the Yahara chain of lakes. For the last century, the marsh has eroded considerably, including a significant portion that was dredged in the 1960's to create a man-made lake. Due to the increased fetch, wave energy was elevated, further accelerating marsh erosion. To address this concern, innovative ecological erosion control devices, Floating Bog Interceptor (FBI) Gardens, are created. FBI gardens act as detached breakwaters to dampen wave energy, induce wave-current interactions, and accumulate sediment behind the FBI Gardens, forming salients or tombolos. FBI Gardens are constructed from natural materials, which will gradually biodegrade and eventually provide additional material to the marsh. Native vegetation is also planted within the FBI Gardens, helping to re-establish vegetation lost to erosion. Over the course of four summers from 2012-2015, the results demonstrate that FBIs can be used as a wetland protection tool that can contribute ecological benefits with the physical protection and sediment accumulation of a detached "ecological" breakwater system.

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4. **Promoting Sustainable Groundwater Use and Safeguarding Calcareous Fens in a Perched Groundwater Setting, Southeastern Minnesota**

Jonathan Carter, Barr Engineering
John Greer, Barr Engineering
Evan Christianson, Barr Engineering
Todd Osweiler, Rochester Public Utilities

The hydrogeologic setting of southeastern Minnesota is characterized by extensive aquifers in shallow-dipping Paleozoic bedrock. These aquifers are the sole source of water for the City of Rochester. Rochester Public Utilities has recently undertaken an initiative to ensure the sustainability of the Rochester water supply. Preliminary simulations using a regional groundwater model indicated that proposed future pumping of supply wells in the Prairie du Chien and Jordan aquifers may cause several feet of drawdown in the vicinity of calcareous fens situated on the Decorah Edge. The Decorah Edge is the erosional edge of the Decorah Shale, Platteville Formation, and Glenwood Formation. Calcareous fens are explicitly protected by Minnesota statute, and any potential impacts to their source water quality or quality must be assessed and mitigated or avoided. A site investigation performed to assess the hydraulic connection between one of the fens and a nearby supply well revealed that pumping had no discernible impact on the fen, due in part to vertically extensive unsaturated conditions in the St. Peter Sandstone. The perched nature of the shallow groundwater system relative to the St. Peter Sandstone is a significant and not fully known aspect of the hydrogeologic setting that presents a challenge to accurate characterization of the hydrogeologic setting and its representation in the groundwater model. We will present the findings of hydrogeologic studies further investigating the extent of perched conditions, the approach to incorporating this aspect of the hydrogeologic setting into the regional groundwater model, and implications for similar hydrogeologic settings elsewhere.

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5. **Summary of Geochemical and Hydrologic Characteristics of the Albion Basin, Alta, Utah**

Ryan Cascarano,* University of Wisconsin-Parkside, casca001@rangers.uwp.edu
James Longo, University of Wisconsin-Parkside
Nate Duda, University of Wisconsin-Parkside
John Skalbeck, University of Wisconsin-Parkside

Beginning in 2005, a hydrologic investigation has taken place annually each summer in the Albion Basin, in the Little Cottonwood Canyon, in Alta, Utah. The study areas within the Albion Basin are Catherine's Pass, Collins/Sugarloaf, Albion Basin Fen, and Patsy Marley. The overall goal of this continuous long-term monitoring is to provide scientific information with the potential for use in watershed management decisions. Historically, annual monitoring has consisted of collecting: automated water levels using Levelogger pressure transducers, manual water levels using an electronic sounder, field water chemistry, and water samples for the purpose of chemical analysis in a laboratory setting. Water samples are collected from springs, surface water, and also from piezometers in the ground. Chemical analysis of water samples collected helps evaluate hydrologic characteristics of the wetlands. In 2013, an additional form of data collection in the form of spring characterization began being conducted. Through the categorization of spring inflow and outflow, a water balance can be created for a given study area. In 2013, a brief survey of springs was conducted in order to assess the general contribution of source water for each of the wetland areas being studied. In 2015, a more thorough study was conducted in order to accurately calculate flow within

these basins. These three primary forms of measurement—water levels, water chemistry, and spring characterization, provide useful data that can show whether or not each study area is groundwater or surface water dominated. Ultimately, this wetland study is important for describing hydrologic characteristics of the individual wetland basins present within the Albion Basin. It also helps to assess the implications of proposed water diversions from these sites, as any diversion has the potential to result in a permanent loss of water from the Albion Basin, which would also affect the natural environment within the study area.

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### 6. Investigating Groundwater Influenced Trees during Drought at Different Spatial Scales in Northern Wisconsin

Dominick Ciruzzi,* University of Wisconsin-Madison, ciruzzi@wisc.edu
Steven Loheide, University of Wisconsin-Madison

As drought variability increases in forests around the globe, it is critical to evaluate and understand ecosystem attributes that reduce drought vulnerability. It is generally accepted that shallow groundwater can sustain tree growth and transpiration in arid and semi-arid ecosystems during drought, yet the extent to which groundwater influences forest growth in temperate zones is essentially unknown. Northern Wisconsin forests experienced an intense drought from 2006-2012, which included decreased lake and groundwater levels and increased tree-stress and die-off. We hypothesize that trees in areas of shallow groundwater had higher and more consistent tree growth rates and healthier leaves during drought conditions. This hypothesis is tested at both the individual tree and watershed scale in the Northern Highland-American Legion State Forest in Vilas County, Wisconsin. At the tree scale, we examined tree growth response from tree cores across sites covering a 1-9 m depth to groundwater gradient over the past 30 years. At the watershed scale, we combined remotely sensed vegetation indices between a wet and dry year and an interpolated water table map across the entire watershed to identify areas of groundwater influence. Preliminary data indicate regions and individual trees influenced by groundwater depth. In general, temporal variability in vegetation indices and tree growth were lower in regions and years of shallower groundwater. Understanding and identifying regions of groundwater influence in a temperate forest can help guide sustainable water and forest management decisions during drought and non-drought conditions.

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### 7. Comparative Analysis of Lake Russo's Bathymetry and Chemistry: 1989 & 2015

Kayla Copeland,* University of Wisconsin-Parkside, copel002@rangers.uwp.edu
Scott Borchardt, University of Wisconsin-Parkside
McKenze Booth, University of Wisconsin-Parkside
Brian Sockness, University of Wisconsin-Parkside
John Skalbeck, University of Wisconsin-Parkside

Lake Russo is located in the southeastern Wisconsin town of Pleasant Prairie, and serves as both the River Oaks Community's recreation area as well as a tributary area for the Des Plaines River. Comprehensive studies of the lake were conducted in the years 1989-1999. Of these, the 1989 study provided a complete chemical, bathymetric, and general qualitative analysis of the lake. This study sought to use that information in conjunction with newly

collected data to assess the lake's evolution since 1989, with an emphasis on sediment accumulation and potentially harmful changes in water chemistry. Depth data was collected and used to generate an updated bathymetric map of the lake. In addition, water chemistry data was collected, which included dissolved oxygen content, pH, and electrical conductivity. The depth comparison shows that the average depth has decreased from 6'5" in 1989 to 5'8" in 2015, and the maximum depth has also decreased from 11'6" in 1989 to 11'1", indicating probable sediment accumulation. Preliminary findings indicate the lake is undergoing eutrophication, as the trophic value has increased between 1989 and 2015. It is recommended that continued monitoring of the lake depth and water chemistry be conducted in order to prevent potential degradation of the lake quality.

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## 8. Data and Models to Support Nutrient Management in the Winnebago-Fox-Green Bay System of Wisconsin

Kevin Fermanich, University of Wisconsin-Green Bay, fermanik@uwgb.edu
Paul Baumgart, University of Wisconsin-Green Bay
Michael Zorn, University of Wisconsin-Green Bay
J. Val Klump, University of Wisconsin-Milwaukee
Dale Robertson, U.S. Geological Survey, Wisconsin Water Science Center

Nutrient impairments of the Wisconsin waters that make up the Lake Winnebago-Lower Fox River-Green Bay system have been studied for more than 40 years. The health of these ecosystems is now largely a reflection of landscape sources of phosphorus and sediment. In recent years, point source P loads have equaled less than 20% of the total load at the mouth of the Fox River. Through the cooperative effort of many partners, we have collected and integrated critical data needed to understand and simulate biogeochemical dynamics of Green Bay and Lake Winnebago and the spatial and temporal nature of nutrient sources to these receiving waters. Recent development of eutrophication and hypoxia models of Green Bay and Lake Winnebago provides new tools to better understand the response of these systems to nutrient loading. We also have developed watershed simulation models for P and sediment across the basin that are useful for simulating P export response to varying management regimes. Because of the critical nature of the link between the Green Bay and Lake Winnebago systems, there still remains many questions about P sources, processing, and transport within the system. To better understand the event-driven nature of P export, we have begun to monitor P dynamics in the Lower Fox River with automated P and other sensors. The challenge ahead is to refine and improve our understanding of the linkages between the Lake Winnebago and Green Bay systems.

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## 9. Comparison of Groundwater Model Predictions and Construction Observations for the Highway 14 Utility Dewatering, Cross Plains, Wisconsin

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Warren Myers, Town & Country Engineering, Inc.
Jerry Gray, Village of Cross Plains, WI
Bill Casagranda, James Peterson Sons, Inc.

In 2015, the Village of Cross Plains replaced buried sewer and water mains along 6000 feet of Highway 14. These utilities were below the water table in most locations, requiring 5 feet or more of dewatering to excavate and replace them. The highway overlies a productive sand

and gravel aquifer that supplies baseflow to Black Earth Creek, a notable trout stream, and past projects indicated that very high pumping rates would be necessary. The project was further complicated by the presence of several sites with petroleum contamination of groundwater along the highway.

A groundwater model was constructed with the analytic element code GFLOW to plan the dewatering system and assist permitting by the Wisconsin Department of Natural Resources (DNR). A previous construction dewatering project provided data to estimate the sand and gravel hydraulic conductivity, and model recharge was then calibrated for existing conditions using available well and streamflow data. The model predicted dewatering rates of 4000 gpm to 6000 gpm. The dewatering was planned to be accomplished by an array of deep wells discharging to the creek, with shallow wells in contaminated areas discharging to the wastewater treatment plant. The pumping impact was predicted to extend farther upstream than the return flow to the creek, resulting local streamflow depletion and potential temperature impacts. The DNR therefore required mitigation pumping from an upstream gravel pit if streamflow dropped below specified limits.

The contractor, James Peterson and Sons, installed 55 dewatering wells, operating approximately 10 wells at a time at an aggregate rate of about 5000 gpm, consistent with the model predictions. Rather than using shallow wells in contaminated areas, deep wells were used with pumps set well below the water table to minimize intake of contaminated water. Petroleum compounds were not detected in the discharge, so no treatment was required and all water was discharged to the creek. Baseflow dropped near the low flow threshold during dewatering, consistent with model predictions, however no mitigation pumping was necessary. GFLOW proved to be a useful tool for anticipating the required dewatering system capacity, potential environmental impacts, and strategies for managing them.

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## 10. Wonewoc Formation and Tunnel City Group Rocks: Potential Natural Sources of Groundwater Contaminants in Wisconsin?

Lisa Haas,* Wisconsin Geological and Natural History Survey, UW-Extension, ldhaas@wisc.edu
Jay Zambito, Wisconsin Geological and Natural History Survey, UW-Extension
Mike Parsen, Wisconsin Geological and Natural History Survey, UW-Extension

Wisconsin faces a variety of groundwater quality issues that include both natural contaminants, such as arsenic from sulfide minerals, and human-induced contaminants, such as nitrate from agricultural land-use practices. Although some Cambrian-age sandstone-dominated rock units have been suggested to be potential natural sources of groundwater contaminants, little detailed rock geochemical data exists for these units. At the WGNHS, we are midway through a project to characterize the elemental composition of rocks of the Cambrian Wonewoc Formation and Tunnel City Group across western and south-central Wisconsin. Geochemical data has been collected using a handheld x-ray fluorescence (XRF) analyzer from drill cores, outcrops, and well cuttings. This dataset indicates that the elemental composition of rocks from the Wonewoc Formation and Tunnel City Group include a variety of elements for which groundwater quality standards and advisory levels exist, including aluminum, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, vanadium, and zinc. Furthermore, the presence and abundance of these elements varies spatially across the state, through stratigraphic successions, and even within individual rock beds at the centimeter-scale. Our preliminary data confirms that a regional geochemical and mineralogical dataset for the Wonewoc-Tunnel City interval is critical for determining the potential for these rock units to serve as natural source of groundwater contaminants.

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## 11. Detection and Evaluation of an Inadvertent Cross-Connection of a Water Supply Pipeline to a Deep Well Using Time-Series Geochemical and Stable Isotopic Indicators

Amanda Hamby,* University of Wisconsin-Green Bay, hambal29@uwgb.edu
John Luczaj, University of Wisconsin-Green Bay

Geochemical and stable isotopic data provide a regional context for predicting water quality in the Cambrian-Ordovician confined aquifer in northeastern Wisconsin. We present a case study illustrating the use of geochemical and stable isotopic indicators to explain water quality anomalies in a deep municipal well in central Brown County, Wisconsin.

Until 2007 when a regional water supply pipeline was put in service for the Central Brown County Water Authority, the Village of Bellevue well 4 was one of several regional deep aquifer wells supplying municipalities in the Northeast Groundwater Management Area of Wisconsin. Regional wells were placed on stand-by and remain connected to the water supply system for emergency use. Sampling in 2013 identified a discrepancy in the well's recent (2013-2015) and historical (1995-2008) major ion chemistry and its expected isotopic signature. Geochemical and stable isotopic comparisons showed a clear change from a high conductivity Ca-Na-Mg-$SO_4$-Cl water to a low conductivity Ca-Mg-$HCO_3$ water. The stable isotopic signature ($\delta^{18}O$ -5.8 to -6.0‰ and $\delta D$ -43 to -46‰) was consistent with Lake Michigan water, but significantly heavier than expected for the deep aquifer in the region ($\delta^{18}O$ -10.6 to -19‰ and $\delta D$ -71 to -135‰). The anomaly was of interest initially because of its location along the Green Bay Fault Zone, which might indicate preferred recharge occurring along the fault. In December 2014, the Village identified a faulty check valve that had allowed pipeline water to enter the well over time.

The well was pumped twice for 4-5 hours during 2015 to detect "breakthrough" of normal aquifer water, because the leakage volume was unknown. Although some indication of increasing conductivity occurred between the two events, continued pumping showed limited change from a Lake Michigan water signature, indicating that a minimum volume of 400,000 gallons entered the well before the valve was repaired. Arsenic and nickel concentrations increased with pumping, reaching 2.8 µg/L for As and 32.5 µg/L for Ni. This is an expected result of sulfide oxidation of aquifer materials in response to injection of chlorinated surface water. This study illustrates the successful application of geochemical and stable isotopic time-series data to identify artificial well recharge and estimate rates and volumes.

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## 12. Statewide Lake Level Monitoring with Citizen Volunteers

Katie Hein, Wisconsin Department of Natural Resources, catherine.hein@wisconsin.gov

The Wisconsin Department of Natural Resources initiated a statewide lake-level monitoring program to address growing concern for surface waters due to drought, changing climate, and groundwater withdrawals. As water levels decline, critical littoral habitat for fish and aquatic life is stranded above water and, in some cases, piers are left hundreds of feet from shore. Thus, this water quantity issue also becomes a water quality and designated use issue. Although long-term water level records exist, current monitoring efforts are disjointed and do not cover all areas of the state. Two citizen-based lake level monitoring efforts already exist: volunteers monitor groundwater wells adjacent to 44 lakes in the Central Sands region and North Lakeland Discovery Center coordinates monitoring on 30 lakes in Vilas County. In 2015, WDNR established protocols, database capacity, and training workshops to support a network of volunteers monitoring lake levels statewide. Partnerships were made with local professionals (county surveyors and university professors) to install and survey staff gages in seven counties: Ashland, Bayfield, Polk, Sawyer, Chippewa, Langlade, and Oconto. Volunteer trainings were conducted one-on-one, and citizens monitored lake levels from July – November 2015 on 17 lakes. This partnership between professionals and volunteers is proving to be successful, and the program will continue to expand in 2016.

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## 13. Predictions of Harmful Algal Blooms in Shallow Freshwater Lakes: Lake Russo

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Yannick Brandes, Ostfalia Wolfenbüttel
Glenn Margraff, University of Wisconsin-Parkside
Hedda Sander, Ostfalia Wolfenbüttel
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Harmful algae blooms (HABs) can be hazardous to the life of humans, organisms that live in or near aquatic environments, and to the environments themselves. A smart phone app was created for the prediction of HABs during summer 2014 for private users. The app uses different data including dissolved oxygen, total chlorophyll a and phosphate as the prime value having a prominent influence on the prediction outcome.

The aim of the study in 2015 was to verify app prediction outcomes in the field and therefore to collect data from a shallow freshwater lake (Lake Russo, Kenosha, WI). Water transparency was measured with Secchi disc, further samples were collected to gather the required data.

The measured data showed constant temperature (24°C), and little variation in dissolved oxygen (6-8 mg/L) and pH (7-8) in all water depths (0-1-2 m) in six locations throughout the lake. The amount of ammonia, nitrate and nitrite were low (<0.5 mg/L) in all depths except at the bottom, where the amount of nitrate in some probe locations was higher (up to 10 mg/L). Phosphate values showed were below detection limit in all depths and locations (<0.026 mg/L). Thus, the data set showed an oligotrophic lake not endangered by algal blooms. Cell count showed an average of 170.000 cells/mL indicating a low cell density as normally found in the absence of algal blooms.

Simulation using the app model based on the data collected did not predict HAB accordingly, this was confirmed similar by low chlorophyll a values in all locations of the lake measured two weeks later. In summary, the app gave correct prediction in case of the absence of HAB under oligotrophic conditions. Additional tests are required for a more eutrophic environment in order to further validate the app.

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**14. Coastal Bluff Evolution Adjacent to Shoreline Protection Structures**

Nicholas Jordan,* University of Wisconsin-Madison, nbjordan@wisc.edu
Chin Wu, University of Wisconsin-Madison

Shoreline protection structures such as groins and revetments are commonly employed in the Great Lakes to protect coastal infrastructure and property against bluff erosion. Nevertheless, structures are also known to interrupt longshore sediment transport and disrupt sediment budgets on regional scales. Protection structures also can elevate wave climate locally, creating steeper nearshore slopes adjacent to the structure. As a result, beaches and bluffs experience accelerated erosion. To date, both regional and local impacts of shoreline protection structures on beach and bluff systems have not yet been clearly addressed. This study investigates processes and feedbacks of coastal bluff evolution adjacent to coastal structures on local to regional scales. We use remote sensing techniques, integrated bluff, beach, and nearshore wave and sediment modeling, and field measurements of coastal morphology to unravel those interactions. It is found that headland bay beaches are created down-coast of most structures, though the shape and stability of the headland bay beach is determined by degree of sediment interruption and wave height amplification by the structure. Bluff recession in headland bay beaches is most sensitive to the local cumulative wave impact height, which is dependent on local wave conditions and sediment supply. The findings have significant implications for public and private stakeholders on the coast who must make regional management decisions regarding setback requirements, further shoreline protection, and coastal ecosystem health. Finally, we investigate the regional and local effects of bluff erosion mitigation management decision in the Great Lakes.

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**15. Using Stable Isotopes of Well Water to Assess Contamination Vulnerability in a Karst Aquifer, Kewaunee County, Wisconsin, USA**

Amber Konrad,* University of Wisconsin-Green Bay, Department of Natural & Applied Sciences, konram05@uwgb.edu
John Luczaj, University of Wisconsin-Green Bay, Department of Natural & Applied Sciences
Andrew Schauer, University of Washington, Department of Earth & Space Sciences

Ground water contamination has been a long-standing problem in rural northeastern Wisconsin, especially in areas with thin soils over karsted Silurian dolostone bedrock. In some counties, 20-35% of the wells exceed health standards for nitrates and/or coliform bacteria presence. One limitation of testing for bacteria and viruses is their episodic presence in well water. Here we present the results of a high-resolution time series technique using stable isotopes of oxygen and hydrogen in well water to assess well vulnerability to surface contamination from rapid recharge.

Homeowners self collected water samples from four private wells between March and October of 2015. Sampling occurred at least once per week, with more frequent sampling after large recharge events. Three wells had prior histories of contamination and vary in total depth from 74 to 240 feet, with depth to bedrock ranging from 5 feet to 42 feet. A control well with no prior record of contamination had a total depth of 364 feet, with a depth to bedrock of 79 feet. Preliminary results show average $\delta$D values ranging from -68.15‰ to -74.55‰, with average $\delta^{18}$O values ranged from -10.06‰ to -10.80‰. Average deuterium excess (d) values ranged from 11.8 to 12.6, with the shallowest well containing the lowest d value.

Well depth and average isotopic composition were strongly correlated ($R^2 \geq 0.88$), but a geographic influence was not ruled out. Deuterium excess did not show a strong correlation

with well depth. The shallowest well had a higher standard deviation for $\delta D$ and $\delta^{18}O$ than the deeper wells ($\sigma$ = 1.39 vs. $\sigma$ = 0.31 to 0.42). All wells showed some isotopic variation during the sampling period, but the shallowest well showed the largest responses to recharge events. A negative isotopic response occurred during the first spring melt of a thin snowpack during early March 2015 and smaller positive isotopic responses occurred after heavy rain events during summer months. As expected, the largest isotopic response occurred when the isotopic composition of recharge water was farthest from that of the average groundwater (i.e., snow melt). The shallowest well, with the shortest casing and thinnest soils showed the largest water isotope variation, suggesting the shortest travel time from surface to well. This lends support to the utility of this technique in identifying potentially vulnerable wells in karst systems

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## 16. Monitoring a Saline Tracer Experiment using Electrical Resistivity Imaging (ERI)

Jacob Krause,* University of Wisconsin-Madison, Dept. of Geoscience, jjkrause2@wisc.edu

Tracer tests are commonly used by hydrogeologists to determine site specific solute transport properties. The goal of this small-scale tracer test was to determine representative local solute transport parameters for a sandy unconsolidated aquifer using fluid electrical conductivity as the tracer. We used a limited number of traditional groundwater sampling points combined with two Electrical Resistivity Imaging (ERI) survey lines to monitor the migration of the highly conductive tracer plume. ERI is a geophysical technique that images the electrical resistivity distribution of the subsurface using an array of electrodes deployed on the surface. Because the electrical resistivity of the subsurface is sensitive to changes in fluid conductivity, this non-invasive technique can be used to image the location of the highly conductive plume. For this experiment, two ERI lines were surveyed repeatedly before and after tracer injection. One ERI line was parallel to the expected groundwater flow direction and intersected the location of the injection well. The other ERI line was located down-gradient of the injection well, and was oriented perpendicular to the first line, acting as a 'fence' that the saline plume would pass through. ERI profiles and groundwater fluid conductivity measurements were collected prior to injection, as well as every 4-5 days following injection. By comparing electrical resistivity profiles before tracer injection and after, we can gain information about the location of the saline tracer plume. Use of this technique to monitor tracer tests is not without its pitfalls – the resolution of ERI can be limited by site geometry, regularization during inverse modeling provides an overly smooth picture of the subsurface, and other natural factors influencing subsurface electrical resistivity can confound results. However, ERI data is simple to collect, which saves time compared to an exhaustive field sampling campaign typically required during tracer tests.

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**17. Mapping Stream Alterations to Enhance Watershed Scale Water Quality Indicators**

Brandon Lee,* University of Wisconsin-Stevens Point, Brandon.M.Lee@uwsp.edu
Mason Johnson, University of Wisconsin-Stevens Point
Katherine Clancy, University of Wisconsin-Stevens Point

Land use is a strong predictor of runoff, sediment, and nutrient loading in streams. This degree of correlation between water quality and land use allows planners to rapidly estimate how land cover changes might impact at the watershed scale. Models developed for the watershed scale are often expected to provide information for smaller sub scale riverine habitat such riparian zones and micro-habitat, but study results are conflicting. The problem in comparison of scales is associated with smaller scale habitats requiring a spatial relation to a disturbance or land use factors. In addition to land use factors, riparian and smaller scales are impacted directly by human alterations to streams. In this study, we evaluated ten Wisconsin watersheds at the HUC 12 scale and mapped the location and type of alteration using hillshade, 1936-present orthophotos, land cover and crop land data. We found that higher percentages of altered stream miles were found in crop land agriculture and forest having the least altered stream miles.

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**18. Plant Roots, Soil, and Hydrology Relations of Prairie, Wetland, and Forest Vegetation Communities within the Yahara River Watershed, Wisconsin**

Allison C. LoBue,* Universtiy of Wisconsin-Madison, alobue@wisc.edu
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The relation between plant roots, soil, and hydrology in natural ecosystems is poorly understood, due in part to lacking knowledge of accurate plant root structures and their association with environmental attributes, such as soil properties and root water uptake. Traditional invasive and destructive methods used to analyze plant roots frequently disturb or damage the roots, making it difficult to simultaneously monitor root growth and collocated soil moisture dynamics. Therefore, our objective is to design and test a method that is neither destructive nor invasive to analyze the root structure. Our approach consisted of collecting images from a borescope camera of a mirror setup reflecting the soil wall of augured holes. A computer program was developed to analyze the images to estimate the root density. This system was deployed at nine sites within the Yahara Watershed, comprising prairie, wetland, and forest biomes, and verified with traditional methods of plant root analysis, including soil cores and hand examination, at the three Arboretum locations. A better understanding of root configuration in the Yahara River Watershed will allow for improved plant, soil, and hydrologic analyses.

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**19. Delineation of Tallent Hall Wetland, University of Wisconsin-Parkside, Kenosha, Wisconsin**

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Wetlands in Wisconsin perform a crucial role in the hydrologic cycle and the environment. The wetland areas maintain water quality, control runoff, recharge groundwater, and also provide an area rich in aquatic life. Since wetlands play such a pivotal part in enhancing the environment, it is important that these areas are protected. The objective of this study was to reexamine a nationally recognized wetland site on the campus of the University of Wisconsin-Parkside and determine whether the site still met wetland classification criteria. To do this, background data was gathered and quantitative field research was completed, in accordance with standard procedures, which investigated the vegetation, soil, and hydrology. The field work completed at the Tallent Wetland site determined the presence of hydrophytic plants, hydric soils, and the presence of groundwater throughout the growing season. This study revealed discrepancies in the National Wetlands Inventory delineation, which outlined an area that was moderately smaller than what the data obtained in this study suggested. The results of this study reaffirmed the status of the Tallent Wetland, which will aid in ensuring future conservation within the University of Wisconsin-Parkside campus.

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**20. Fish Kills and Oxythermal Stress under Climate and Land-Use Changes**

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Survival and growth of fish in lakes is strongly affected by water temperature and dissolved oxygen. Recent studies show that changing climate has altered temperature and dissolved oxygen characteristics in lakes. Further, land use changes alter nutrient loading, leading to decreased water quality and increased hypolimnetic anoxia. Both drivers (e.g. changing climate and land-use changes) are prone to reduce habitat for cold- and cool-water fish within lakes and change the distribution of species throughout the state. Evaluating how fish habitat vulnerability and species distribution will changes under future climate and land use is of utmost importance to managing this critical ecological resource. Here we develop a novel metric, cumulative oxythermal stress dosage (COSD), to investigate historical changes in cisco populations in Lake Mendota, Madison, WI, in response to climate and land-use changes. Occurrences of oxythermal stress under future climate and land-use changes are then predicted and likelihood of fish kills is determined. Furthermore, a three-dimensional model will be employed for the first time to identify spatial changes in refuge habitat within the lake. At last the newly developed dosage approach will be incorporated into the INFOS-Yahara (http://www.infosyahara.org/) to determine oxythermal stress in real-time and forecast imminent critical stress conditions.

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## 21. Water Quality Assessment of the Root River in Racine, Wisconsin

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A study was conducted on the Root River in Racine, Wisconsin. The data was collected on October 22, 2015 and November 17, 2015 with different weather conditions along a 10,300ft section of the river starting at the Root River Environmental Educational Community Center (REC) and ending by Lake Michigan. On each day, water quality measurements were obtained. Also, past research and historical geology of the river was acquired to further understand the current data. The purpose of this study of the Root River is to assess the water quality of the river under multiple conditions.

The Root River is in Southeastern Wisconsin and starts in the city of New Berlin in Waukesha County. The Root River watershed is mostly from rural areas. However, there are large cities that accompany the watershed including places in Milwaukee and Waukesha Counties and also the city of Racine.

When the data was brought back to the lab to be analyzed, there was a clear relationship between certain variables. In order to assess the Root River properly and fully comprehend the relationship between these important variables, the river had to be monitored and more data would be taken on another day of field work. Three students returned to the REC on the 17th of November 2015 to measure electrical conductivity, pH, temperature, Secci depth, and GPS coordinates.

It was found with a higher electrical conductivity, there is a lower recorded Secci depth. Also, pH and temperature have a direct relationship to each other. The discharge of the river is also important along with the gradient, which was found using a topographic map. The results of this study contain general water quality measurements, but could potentially influence the sources that are feeding the river. Waukesha is looking to treat wastewater and return it to the Root River. Discharge rates will increase, but water quality is estimated to stay the same and/or improve the Root River.

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## 22. Investigating in-Field Variability of Groundwater to Quantify Impact of Agricultural Management Practices on Quality

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The soil profile and vadose zone are complex environments which make studying the impacts of agricultural practices on groundwater challenging. Cost effective field scale methods for quantifying effects of management practices are needed, particularly on working farms. The objective of this project was to characterize spatial variability of groundwater nitrate below agricultural fields in an effort to evaluate the extent of sampling needed to quantify differences between nitrogen management practices.

The study farm was located in the Central Sands region south of Plover, WI. Two fields selected for evaluation were in different years of a potato-field corn-sweet corn-peas/millet rotation. A geoprobe® was used for two sampling events and a hand auger was utilized for the third. Samples were collected from the top of the water table in: Dec. 2014, April 2015, Nov. 2015. Nitrate and chloride was obtained for all samples; more extensive testing of anions and cations was performed on select samples.

Variability in nitrate concentrations at the water table was less than expected compared to leachate studies on the site. Clear differences in groundwater chemistry between fields persisted through all three sample events suggesting factors beyond rotation effects. Seasonal differences within individual fields was less noticeable; however fertilizer application rates provide context to changes.

Understanding initial starting groundwater chemistry and variability is important prior to designing experiments, particularly where treatment effects are likely to be subtle. This project provides some insight into sampling numbers and experimental design. At least on sandy soils this approach may be useful for conducting on-farm research for the purpose of evaluating nitrogen reduction strategies.

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### 23. Impacts of Delineation Methods Curve Number Runoff on Watersheds Containing Internally Drainage

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We evaluated three watershed delineation methods: fill, cut, and potential contributing source area (PCSA) using ArcMap 10.1 for twenty watersheds in Wisconsin and Minnesota with sizes ranging from 40-100 km2. In addition to watershed area, we determined the internal drainage, wetland and agricultural land use, and relief of the watershed. We compared runoff generated using the curve number method to USGS discharge. Results from twenty watersheds, using 8-10 independent storm events, indicate that models perform similarly for all delineations despite differences in watershed sizes and land use for small storms (< 50 mm). For large storms (p> 50 mm) the fill delineation method had a slightly higher error, especially in watersheds with high agriculture. Additionally, for large storms in predominantly agriculture watershed, we found that PCSA was the most accurate.

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### 24. Adapting Stormwater Ordinances to a Changing Climate: A Case Study in the Yahara River Watershed

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When assessing the effectiveness of stormwater ordinances, it is important to consider an inevitable future involving both landuse change and climate change. As open spaces are developed, the expansion of impervious surfaces will cause higher rates and volumes of stormwater runoff reaching our surface waters. Also, it is predicted that climate change will cause an increase in the frequency and magnitude of large rainfall events in the Great Lakes region of North America. The current stormwater ordinances pertaining to volume control are not sufficient to mitigate flooding in the Yahara chain of lakes around Madison.

The Yahara River watershed in South Central Wisconsin presents a complex issue in which the upper portion of the watershed extends into both Dane and Columbia Counties. In addition, the Yahara River watershed contains many subwatersheds that are “closed”. These

closed watersheds do not drain into the Yahara River during small storm events, but large storm events, like those predicted to occur with climate change, can cause closed watersheds to overflow and drain into the Yahara Rive, eventually reaching Lake Mendota. Improving infiltration practices in closed watersheds could prevent them from contributing and significantly reduce the flood risk downstream.

It has been found by previous research that improving stormwater ordinances to require 100% volume control will significantly reduce the amount of runoff flowing to the Yahara River. If landowners cannot meet this 100% requirement, they should have the opportunity to pay a fee in lieu of compliance. The money collected would be used to fund future city projects that intend to protect water resources. It is necessary that the entire Yahara River watershed, including both Dane and Columbia Counties, cooperate in efforts to reduce the flooding risk in the City of Madison. Madison and many adjacent areas remain vulnerable if nothing is done.

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## 25. Long-term Alterations in Groundwater Chemistry Induced by Municipal Well Pumping

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Madeline Gotkowitz, Wisconsin Geological and Natural History Survey

Dane County, Wisconsin, hosts a number of high-capacity, multi-aquifer wells that were drilled through the regional Eau Claire aquitard and draw from both the confined and unconfined aquifers. These wells are excellent study sites in which to test hypotheses related to pumping-induced changes in redox conditions and mobilization of trace elements, as the wells create a direct connection between the oxic, shallow waters and the anoxic, confined aquifer. In addition, drawdown generated by decades of pumping may be inducing accelerated downward movement of contaminants from near surface sources. Mixing groundwater of different age and chemistry creates new geochemical environments, potentially resulting in mobilization of trace elements. The recently released Dane County groundwater flow model developed by the WGNHS and USGS is being utilized to run MODFLOW simulations of the groundwater system under current, historic, and potential future pumping scenarios to identify how long-term pumping has changed, and may continue to change, hydraulic gradients and flow directions. Initial simulations, focused on wells located on the isthmus between Lakes Mendota and Monona, indicate that under current conditions the confined aquifer receives recharge from Lake Mendota, where there is no confining unit underlying the lake basin. Additionally, the simulations show downward flow across the confining unit where it is present and a shift in the direction of flow in the confined aquifer. These flow directions are in contrast to dominantly upwards flow towards the lakes before pumping development.

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## 26. Nitrate Patterns, Trends, and Pathways in Groundwater in South-Central Wisconsin: A Model-Based Evaluation

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Richard Lathrop, University of Wisconsin-Madison Center for Limnology
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Nitrate, a critical agricultural nutrient, is a common groundwater contaminant across Wisconsin. Analyses conducted over the past decades in Dane County, Wisconsin, indicate that roughly 25 percent of private domestic wells contained nitrate in excess of the state and federal drinking water standard of 10 mg/L NO3-N — well above Wisconsin's statewide exceedance level of 12 percent. While nitrate contamination is widespread, it is often challenging to quantify its spatial and temporal distribution, as well as track the fate and transport of such non-point source groundwater contaminants.

Our research seeks to improve understanding of the spatial and temporal distributions of nitrate in groundwater by combining GIS mapping, groundwater modeling, and statistical analysis. Using historical databases, we compiled approximately 61,000 individual nitrate analyses from wells within Dane County and evaluated them spatially using ArcGIS. The distribution of all groundwater nitrate concentrations was evaluated based on sampling date and location, and, for a subset of 23,000 records, included well and casing depth, well construction date, and aquifer type. A groundwater flow model (MODFLOW), recently developed for the county, was then used to generate particle traces (MODPATH) to estimate the travel time and source of groundwater. These results provided a basis for determining historical dates of nitrate loading to the groundwater system. Statistical analysis of this historical nitrate loading suggests a strong temporal correlation between nitrate concentrations and the application of nitrogen fertilizer for agricultural production.

The improved spatial and temporal understanding of nitrate concentrations across the county gives local and state decision makers an additional tool for managing groundwater resources within Dane County and for ensuring the sustainability of these resources for farmers, citizens, industry, and the environment.

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## 27. Integrated Nowcast and Forecast Operation System (INFOS) for Yahara Lakes

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Chin Wu, University of Wisconsin-Madison

Over the past 40 years, there has been significant advances in technology. We are taking advantage of the new technology to develop a state-of-the-art water cyberinfrastructure, an Integrated Nowcast and Forecast Operation System (INFOS) for the Yahara River Chain of Lakes (RCL) in Dane County, Wisconsin. The system infrastructure comprises a web portal to retrieve and display observations that are used to drive models under a high performance computing server. Water level and flow information are obtained from a suite of models featuring a hydrologic rainfall-runoff simulation for stream and storm sewer inflow to lakes; a hydrodynamic simulation for lake circulation to reveal the spatial movements of substance like sediment or algal migration; and a hydraulic river routing simulation for reverse flows due to sustained wind forcings or seiches, flow choking due to channel constriction, and flow

conveyance affected by aquatic plants. Applications of the developed system are illustrated. Specifically water level planning scenarios provide a quantitative measure for lake management to reduce floods under extreme rainfall events. A series of discharge delivery curves under various water level conditions are used for planning appropriate discharge release from the upstream lakes. Alternative management philosophies to minimize exceeding the water level orders can be thereby evaluated. Overall, reliable and timely reliably water information for the RCL for water planning and management demonstrated through this new cyberinfrastructure INFOS-Yahara.

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### 28. Crop Type and Soil Texture Effects on Nitrogen Leaching from Irrigated Agroecosystems in the Wisconsin Central Sands

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George Kraft, University of Wisconsin-Stevens Point
Christopher Kucharik, University of Wisconsin-Madison

Nitrogen (N) leaching and its effect on groundwater quality is a prevailing concern in the Wisconsin Central Sands (WCS) because of the region's distinctly sandy soils, large N fertilizer inputs, humid climate, and relatively high water table. Estimating N leaching is vital for groundwater quality management in the WCS, however it is difficult to quantify deep drainage of N from agricultural fields. The variety of crop types grown in the WCS can leach differing amounts of N because of varied fertilizer inputs needed for growth, root depth disparities (deeper root systems filter N), and crop residue differences. Soil texture can play a prominent role in N leaching as well; fine-textured soils can inhibit N leaching, while coarse soils may promote higher N levels in groundwater.

We have been conducting an ongoing experiment to better understand the drivers of N leaching from irrigated agricultural fields in the WCS. In 2014 and 2015, we collected weekly deep drainage and N fluxes (N leached at 1.4 m depth) from 24 passive capillary wick lysimeters installed in 6 irrigated fields typical of a WCS rotation (sweet corn, field corn, peas-pearl millet, and potatoes). Sampling began the spring of 2014 and has continued throughout 2015.

After significant spatiotemporal variability was observed in drainage and N leaching during 2014, we determined that crop type could not be the only driver of N leaching from WCS irrigated cropping systems. Therefore, we quantified soil texture at 0-30 cm and 45-60 cm depths adjacent to each lysimeter in 2015. We will present results from 2014 and 2015 exploring the relationship between crop type, soil texture, and nitrate leaching.

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**29. Inexpensive In-Field Manure Solids Tester**

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John Panuska, University of Wisconsin-Madison, Biological Systems Engineering
Christian Burnson, University of Wisconsin-Madison, Biological Systems Engineering

Manure losses from crop fields via surface and subsurface pathways following land application can lead to eutrophication and habitat destruction in surface waters. High solids manure has less susceptibility to runoff and leaching, which is particularly important in high risk fields with increased loss potential. Unfortunately the determination of manure solids content is typically conducted by laboratory analysis where results are provided after field application has occurred. An inexpensive solids tester (less than $40 to construct) was developed out of readily available materials for manure applicators to determine the solids content of liquid dairy manure in-field and in real time prior to application. As manure samples are passed through the screen, solids are captured on the screen while more dilute manure passes through. In order to evaluate the solids tester 33 manure samples were collected from 6 separate dairies with a variety of bedding types (3 farms used sand and 3 farms used recycled digested solids for bedding) and manure handling and processing systems. Results indicated that the manure volume that is retained on the screen can be related to the solids content of dairy manure from 3-9%. An equation was produced to relate manure solids to the volume retained on the screen, TS=1.7953e0.0046Vr, with an r-squared value of 0.82. Manure samples with less than 3% solids were shown to pass through the screen completely, therefore results were inaccurate as low TS content. The results did not vary significantly for dairies which used sand bedding and those that used recycled manure solids. This quick in-field measurement of total solids content allows for application to appropriate fields, thus reducing the risk of manure losses to nearby waterways.

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**30. Hydrologic Impacts of Wisconsin's Winter on Surface Water – Groundwater Interactions**

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Since the mid-1800's citizen scientists have recognized the importance of ice formation and ice breakup in lakes across Wisconsin. These records have been critical in documenting changes in climate over this time. However, Wisconsin's other dominant surface waters – rivers – have largely been neglected in relation to its hydrological importance during freezing conditions. When rivers freeze, the ice layer that forms creates friction between the ice-water interface, causing velocity in the river to decrease. As velocity decreases, stage increases as required to discharge the same volume of water. This produces a consequent "backwater" effect in the groundwater system that may be responsible for important biogeochemical and ecosystem processing such as nutrient processing, contaminant attenuation, and thermal buffering. Therefore, in order to categorize ice formation events in a river, abrupt increases in stage and groundwater levels can be identified and verified when surface water temperature reaches 0 C. To better understand surface water-groundwater interactions during freeze events across watersheds of different sizes, surface water-groundwater monitoring sites were installed in 5 rivers across southern Wisconsin. The rivers included in this study were the East Branch Pecatonica, Black Earth Creek, the Fox River, the Sugar River, and the Wisconsin River. At each of these sites, hydraulic head was continuously observed in monitoring wells spaced 0 meters, 2 meters, 10 meters, and at the edge of the floodplain from the river bank,

perpendicular to the river. A stream transducer was also installed to measure stage and temperature as well as a field camera mounted to capture photos to verify ice formation events in the river. With this data, it was determined how far the ice formation signal propagates into the floodplain, subsequent gradient changes, and the type of ice formation regime commonly experienced at each river in relation to its size and soil type. Future work will include developing several archetype models to better understand surface water-groundwater interactions in a multitude of different ice cover regimes, soil types, and groundwater inflow rates.

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## 31. Groundwater Quality at the University of Wisconsin - Platteville Pioneer Farm

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Stephanie Baribeau, University of Wisconsin-Platteville
Gretchen Bohnhoff, University of Wisconsin-Platteville

Groundwater quality research at the University of Wisconsin-Platteville Pioneer Farm has been conducted for almost a decade. The Pioneer Farm is one site among others around the nation associated with the Long-Term Agro-Ecosystem Research (LTAR) through the US Department of Agriculture (USDA) Agricultural Research Service (ARS). The LTAR program has recently established a national network of sites dedicated to long-term coordinated research. Pioneer Farm is one of four sites in the Upper Mississippi River Basin Experimental Watersheds LTAR node, which is one of ten LTAR nodes nationwide. The LTAR sites will engage in research to address questions related to the condition, trends, and sustainability of agricultural systems and resources across the United States. As part of this work, eleven wells are monitored at the Pioneer Farm each with multiple piezometers. Field measurements of temperature, pH, and conductivity are obtained in addition to laboratory analysis of chloride and nitrate-N. The data collected since the start of this project (2006) are summarized. Groundwater levels indicate a decrease in fluctuations and an overall decline in the water table at most locations since 2010. One well has gone dry with the last recordable measurement in November 2011. Comparisons between precipitation and water levels do not fully describe the downward trend in water levels and additional investigation into the contributing factors is warranted. In general, lower concentrations of nitrate-N were found in the downgradient and deeper piezometers whereas higher concentrations were noticed in the shallower, upland piezometers. The higher concentrations are more evident towards the top of the aquifer and are not as prevalent deep into the aquifer indicating that near-surface sources are the primary source of nitrate-N to the aquifer. The median nitrate-N concentration of all water samples is 10.2 mg/L with a range of <0.1 mg/L to 74.4 mg/L. Chloride concentrations averaged 19.0 mg/L for all measurements. The range of chloride concentration was from below detection limits (0.1 mg/L) to 82.5 mg/L. The Maximum Contaminant Level (MCL) for chloride is 250 mg/L, and with a maximum chloride concentration of 82.5 mg/L, there is no sample from any piezometer that exceeds this MCL. The distribution of chloride was similar to nitrate-N.

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**32. How Low Can We Go? Estimating Passive Conservation Rates Through In Home Surveys**

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Austin Polebitski, University of Wisconsin-Platteville

This research aims to develop a fixture replacement model using home improvement and plumbing replacement rates based on collected survey data. New construction and remodeling of residential units represent the majority of fixtures replaced in a given year. To understand how aging households, socioeconomics, and construction and remodeling impact passive conservation, this research examines a distribution of water fixtures for the study area (Platteville, WI) using in-home survey information.

The in-home surveys and fixture analysis was conducted during the summer of 2015-winter 2016 using willing participants. The homes visited needed to be older than 1995 due to U.S. Energy Policy Act of 1992 which set minimum efficiency standards on toilets (1.6 gal per flush (gpf)), and showers that were manufactured after 1994. The data collected includes information on household characteristics, fixture types, and field measurements of fixture flow rates. A total of 50 homes were surveyed. While the sample was not selected based on a randomization, the sample itself is still random. Samples were acquired based on verbal communication from both the project conductors and previous participants, meaning that each home in Platteville had a chance to be selected for fixture analysis assuming they had at least one connection within the City of Platteville. In addition to summary statistics and an increasing of general knowledge of the fixtures present, s statistical model is developed that estimates fixture replacement rates based on variables such as building age, income, and unit size.

This study is unique because no other data set like this one exists. This is due to many factors: the time consuming nature of the survey, water demand modeling is not an active area of research, and not many people will let someone into their home to look at their toilets. This study will hopefully lead to larger studies that become helpful in characterizing the decrease many utilities nationally are seeing in per capita demands, which is likely correlated with more efficient fixtures. Fixture technology has progressed greatly over the last 40 plus years and is continuing to change, understanding the rate of replacement is key to our understanding of future water demands. This project doesn't just fall into the theme of "40 Years of Wisconsin Waters: Quantity, Quality, Technology" – it encompasses everything about it!

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**33. Modeling Cyanobacteria Abundance: Can Season-Ahead Statistical Forecasts Improve Beach Management?**

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Cyanobacteria, commonly referred to as blue-green algae, are photosynthetic bacteria that thrive in culturally eutrophied waterbodies, characterized by large anthropogenic influxes of nutrients from watershed development. Although there are many negative ecological, aesthetic, and socioeconomic impacts associated with the presence of cyanobacteria, these bacteria are of particular concern to health officials due to their ability to produce dangerous hepatotoxins and neurotoxins, which can threaten the usability of the waterbody for recreational and drinking water purposes. Cyanobacteria have long been recorded as polluting Lake Mendota, prompting extensive research and interest. Presently, however, there is no long-term cyanobacteria outlook that can provide governing bodies and users with advance warning of a potential threat in the upcoming season. Season-ahead cyanobacteria forecasts could allow for the advance of management techniques and improved public awareness. A direct statistical based model is developed utilizing probabilistic modeling to evaluate the potential for informative cyanobacteria forecasts across the June-August season. Results from this model are in turn used to inform forecasts of beach closings. Preliminary results of management applications and forecast value are assessed according to stakeholder input.

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### 34. Comparing the Contributions of Springs and Seeps to Nitrate Flux in a Stream Network in Central Wisconsin

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Streams and rivers are the primary conduits that deliver nitrate and other forms of nitrogen from land to freshwater and marine coastal regions. Because nitrate is readily processed by microbes and plants healthy ecosystems provide opportunities for nitrate to be removed or retained before reaching streams. However, opportunities for nitrate removal differ among pathways by which nitrate travels to streams. My main objective was to compare the influence of two major routing pathways, springs and seeps, on the flux of nitrate in a 1400-m reach in the Emmons Creek network in Central Wisconsin. I predicted that spring outflows would contribute disproportionately to nitrate flux than expected based on their discharge because of anticipated lower nitrate uptake in springs and spring outflows than in seeps. Nitrate flux in spring outflows and in the main channel of Emmons Creek were measured directly and nitrate flux in seeps was measured by modeling (Darcy's Law) and by a whole-reach Rhodamine WT injection. Preliminary results suggest that spring and seeps contributed similarly to downstream nitrate flux in the stream network and proportionately to their discharge rates. Contributions to nitrate flux in the main channel varied among spring outflows and among locations where seepage was measured.

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### 35. Evaluation of Nutrient Loading from Three Major Wisconsin Tributaries to Lake St. Croix

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In 2006, the Wisconsin Department of Natural Resources and the Minnesota Pollution Control Agency agreed to reduce phosphorus loading to Lake St. Croix by 20% by 2020. These agencies developed a total maximum daily load plan in 2012 to address phosphorus reduction, which identified the Kinnickinnic, Apple, and Willow Rivers as among the largest phosphorus contributors to Lake St. Croix. This poster will describe nutrient and sediment loading from these tributaries during the 2013-2015 water years. Loads were computed using stream discharge coupled with automated water-quality sampling during baseflow and event conditions. Total phosphorus was the only water quality parameter sampled in 2013, while dissolved phosphorus, nitrogen, and suspended sediment were added for the following water years. All sites had above average annual stream flow during the study.

Results from 2013 and 2014 indicate that total phosphorus loads were highest in the Willow River (37,600 lbs in 2013 and 67,900 lbs in 2014), with Kinnickinnic and Apple River loads consistently 13 percent and 18 percent less than the Willow River, respectively. The Kinnickinnic River has the smallest watershed, but total phosphorus yields were 33 percent greater than from the Willow River watershed and 70 percent greater than the Apple River watershed. The 2014 total nitrogen load was highest at the Kinnickinnic River (1,710,000 lbs) with 12 percent and 38 percent smaller loads from the Willow and Apple Rivers, respectively. The total nitrogen yield from the Kinnickinnic River watershed was 50 and 82 percent greater than from the Willow and Apple River watersheds, respectively. The 2014 suspended sediment load was greatest at the Kinnickinnic River (13,700 tons), and 81 percent higher than both the Willow and Apple Rivers. The Kinnickinnic River watershed suspended sediment yield was 89 percent greater than from the Willow River watershed and 95 percent greater than from the Apple River watershed. Current work includes calculating 2015 loads for all parameters. Future work will use these data to evaluate trade-offs between reduced sampling frequencies and increased annual load uncertainties so that resource management agencies can track progress toward reduction goals for 2020 and beyond in a cost effective manner.

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## 36. Smartphone Prediction of Harmful Algae Blooms 2.0: Model refinement

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A massive algal bloom in Lake Erie (2011) caused the shutdown of fresh water supply for 0.5 Mill. citizens in the area and hence compromised everyday life for weeks. To minimize consequences, a smartphone app was developed for the prediction of harmful algal blooms (HAB) in 2014. A Version 2.0 of the app was tested on a data set gained from Lake Russo, Kenosha, WI.

Version 1.0 of the app “Algae Estimator” showed some flaws, like overestimated chlorophyll a starting values and growth rates overrating algal growth under oligotrophic conditions. Additionally, the equation used in version 1.0 did not simulate a lag-Phase, as often found in algal development.  Also the die-off phase, as it is typical for a population at the end of its life cycle, was not included in the model.

Adjustments were introduced into the growth algorithm (modified Verhulst equation) underlying the app, leading to version 2.0. The chlorophyll a starting value indicating algal density was adjusted to the time response curve in order to allow for a more closely fitting prediction curve, thus preventing an overestimation from the start. Also the growth rate was adapted, providing a more realistic slope in the growth equation.

App predictions were then tested for both versions on a dataset of Lake Russo, Kenosha, WI. In most of the 6 measurement locations throughout the lake the app did not predict HAB, which was proven correct by chlorophyll data obtained 2 weeks later. HAB were predicted as likely in 2 locations: Here Version 2.0 showed a more realistic growth curve including die-off phase as compared to version 1.0.

For further improvement of app performance local weather data should be included, since seasonal changes can have huge impact on development of algal populations. They change the contribution of nutrients from outside into the lake, like fertilizer runoff, and as a result prevent or accelerate the development of HAB.

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### 37. A New Coupled Groundwater-Vadose Zone-Agroecosystem Model: AgroIBIS-MODFLOW (AIM)

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Shallow groundwater is within or near the root zone in 22-32% of global land area, yet current critical zone models struggle to represent the ecohydrological processes occurring across the groundwater-vadose zone-vegetation spectrum. Existing hydrological models (e.g. HYDRUS, MODFLOW, COMSOL) are able to simulate the saturated/unsaturated zones accurately, but oversimplify vegetation. In contrast, existing ecosystem models (e.g. LPJmL, DSSAT, AgroIBIS) simulate vegetation dynamics well, but oversimplify the movement of water through the subsurface. In this study, we present an overview of a new critical zone model, AgroIBIS-MODFLOW (AIM). AIM is a fully coupled agroecosystem model (AgroIBIS), variably saturated flow model (HYDRUS-1D), and groundwater flow model (MODFLOW). By coupling these three models, we are able to accurately model ecohydrological processes across the complete critical zone, including lateral exchange of water between AgroIBIS cells via groundwater flow. We validate the model via comparison with saturated and unsaturated flow experiments as well as results from other models. We then present a sample application of AIM demonstrating the indirect impacts of land use change on agricultural productivity via altered groundwater recharge and water table depth in order to demonstrate its potential for simulating ecohydrological processes and feedbacks occurring at field- to watershed-scales.

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**Session 3A:**
**Central Sands**
**Friday, March 11, 2016**
**8:30 – 10:10 a.m.**

## Moving Groundwater Science out of the Stovepipe through Integrated Groundwater Management

Randall Hunt, U.S. Geological Survey, rjhunt@usgs.gov
Anthony Jakeman, Australian National University

In the past groundwater science was typically performed in a “silo” or “stovepipe,” removed from questions being posed and from stakeholders affected by the results. However, today groundwater science is increasingly addressing high-profile water resources questions where competing needs preclude simple translation of science to action. Moreover, the speed of decision making is more rapid, where the typical research cycle of report publication is not relevant. In recognition of these critical new forcing factors, groundwater science is now being directly informed and honed by social, economic, legal, and other drivers. This more holistic consideration of the wide range of elements affecting groundwater is termed “Integrated Groundwater Management”, or IGM. As described in an open-access, first-of-its-kind book by Jakeman et al. (2016), groundwater science provides the bounding box for possible actions, but the actions themselves involve a range of stakeholder and environmental considerations, as well as legal frameworks and economic options. This more holistic approach to management complicates groundwater science design and communication of results, but makes the science itself more societally relevant and effective. Knowledge of IGM concepts and examples provides critical context for water scientists, whether working with groundwater systems in the field or abstracted in Decision Support Systems.

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## Groundwater Modeling to Support Balancing Stakeholder Interests in the Little Plover River Basin

Michael Fienen, U.S. Geological Survey, Wisconsin Water Science Center, mnfienen@usgs.gov
Kenneth Bradbury, Wisconsin Geological and Natural History Survey, UW--Extension
Maribeth Kniffin, Wisconsin Geological and Natural History Survey, UW--Extension
Paul Barlow, U.S. Geological Survey, Office of Groundwater
Jacob Krause,* Wisconsin Geological and Natural History Survey, UW--Extension
Steve Westenbroek, U.S. Geological Survey, Wisconsin Water Science Center
Andrew Leaf, U.S. Geological Survey, Wisconsin Water Science Center

The well-drained sandy soil in the Wisconsin Central Sands is ideal for growing potatoes, corn, and other vegetables. A shallow sand and gravel aquifer provides abundant water for agricultural irrigation but also supplies critical base flow to cold-water trout streams. These needs compete with one another, and stakeholders from various perspectives are collaborating to seek solutions. Stakeholders were engaged in providing and verifying data to guide construction of a groundwater flow model which was used with linear and sequential linear programming to evaluate optimal tradeoffs between agricultural pumping and ecologically based minimum base flow values. The connection between individual irrigation wells as well as industrial and municipal supply and streamflow depletion can be evaluated using the model. Rather than addressing 1000s of wells individually, a variety of well management groups were established through k-means clustering. These groups are based on location, potential impact, water-use categories, depletion potential, and other factors. Through optimization, pumping rates were reduced to attain mandated minimum base flows. This formalization enables exploration of possible solutions for the stakeholders, and provides a tool which is transparent and forms a basis for discussion and negotiation.

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**Estimating Recharge in the Central Sands Using Water-Table Fluctuations**

David Hart, Wisconsin Geological and Natural History Survey, dave.hart@wgnhs.uwex.edu
Carolyn Streiff, Wisconsin Geological and Natural History Survey
Maribeth Kniffin, University of Wisconsin-Madison

Recharge estimates are essential for understanding and properly characterizing groundwater flow systems. Recharge is often estimated using soil-water-balance methods, calibration of groundwater flow models, or base-flow measurements. An alternative method uses monitored changes in the elevation of the water table and knowledge of the specific yield of the aquifer. We used this method to estimate recharge in an irrigated cropland and a prairie setting in the Central Sands of Wisconsin.

With this method, the water table is continuously monitored. The amount of recharge is calculated by multiplying the rise in the water table by the specific yield of the sediment. An advantage of this method is that we can observe individual recharge events at multiple sites, which allows us to investigate variation in recharge over time and across changes in land-use practices. Some uncertainty could be introduced into this method through changes in antecedent soil moisture levels, which changes the specific yield over time. In the Central Sands, we monitored water table fluctuations using wells in an irrigated cropland and prairie, which were approximately 700 feet apart. Water table rise, referred to here as recharge, occurred only following a precipitation event of 1 inch or more. Summing water table rise events over a year yields recharge estimates of 11.9 inches/year in irrigated cropland and 9.7 inches/year in the prairie. Although recharge might have occurred during smaller precipitation events, there was little-to-no change in the water table elevation. For example, the water table didn't respond during irrigation events, which suggests that the low irrigation rate, or high uptake rate by plants, precluded recharge from irrigation.

This method is relatively easy to implement and analyze. The necessary long-term monitoring required, as well as localized measurement readings, are limiting parameters of this technique. Therefore, this method is useful as a way to build confidence in broader methods of basin-streamflow measurements and soil water balance modeling. This method should be included in our toolbox of recharge measurement techniques, because it is grounded in measurements of the physical system, including specific yield of sediments and water table response to precipitation.

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**Using a Groundwater Flow Model to Support Decision Making for Agriculture and the Environment in Central Wisconsin**

Kenneth Bradbury, Wisconsin Geological and Natural History Survey/UW-Extension, ken.bradbury@wgnhs.uwex.edu
Michael Fienen, U.S. Geological Survey
Maribeth Kniffin, Wisconsin Geological and Natural History Survey
Jacob Krause, Wisconsin Geological and Natural History Survey

Balancing the water needs of the environment with those of an important agricultural industry is critical for the environmental and economic sustainability of central Wisconsin. Concerns about increasing use of groundwater for irrigation and declines in streamflows and lake levels in Wisconsin's central sand plain have motivated the development of modeling tools to help inform local water-management decisions. The Little Plover River is surrounded by irrigated fields and has a long history of groundwater/surface water interaction studies, making it ideal for an updated study using modern techniques. Declines in the river flow and subsequent establishment of public rights flows motivated the Wisconsin Department of Natural Resources to commission a modeling project using state-of-the-practice groundwater science to explore water management and sustainability options for the Little

Plover River watershed. The resulting models and analyses might serve as a prototype for addressing similar issues in wider areas of the state.

A soil-water balance (SWB) model and transient groundwater flow model (MODFLOW) simulate pumping, groundwater levels, and streamflows in the region. These models incorporate current hydrogeologic observations, monthly water-use records, and temporally and spatially variable estimates of evapotranspiration and recharge based on cropping and irrigation practices. We are using these models to investigate alternative management scenarios and as educational tools for stakeholders. It is critical that stakeholders gain trust that the science is unbiased and that the modeling tools used provide a means for fairly evaluating the various viewpoints and opinions of how groundwater and surface water (and, thus, water use and environmental stream flow conditions) are connected. Accordingly, our team has participated in numerous public meetings and outreach events with local stakeholders and regulatory officials. The overall project goal represents not only the interface between groundwater and surface water, but also the interface between society, science, and policy.

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**Techniques for Quantifying Groundwater Recharge within Wisconsin's Central Sands**

Adam Freihoefer, Wisconsin Department of Natural Resources, adam.freihoefer@wisconsin.gov
Robert Smail, Wisconsin Department of Natural Resources

In areas with unconfined aquifer systems such as Wisconsin's Central Sands, groundwater recharge rates are a major driver of surface water hydrology. Recharge rates are controlled by several factors that are spatially and temporally variable: precipitation, evapotranspiration, and land cover. Wisconsin's Central Sands region, covering a six-county area, is characterized by sandy soils with high infiltration rates and little overland flow. The region has many groundwater-dependent surface water features such as coldwater streams, seepage lakes, and wetlands. Many of these surface water resources have been identified as at risk due to long-term or seasonal declines in groundwater inputs. The declines have been attributed to climatic factors, changes in land use and the effect of withdrawals from high capacity wells. Numeric flow models are continually relied on to evaluate the groundwater-surface water interaction and the recharge parameter is a key model input supporting model calibration and management scenarios.

To assist with the review of high capacity well applications in the Central Sands, the Wisconsin Department of Natural Resources evaluated remote sensing data and a process-based model as methods for quantifying annual and monthly recharge distribution within a 2,600 km2 area of the sand plain. Results showed differences between the methods of calculating parameters such as evapotranspiration. Review of input datasets also sheds light on the importance of acknowledging the spatiotemporal variability of the parameters used to calculate recharge. For example, in 2007, annual precipitation within the study area ranged from 615 to 922 mm, a variability of 307 mm for a gridded dataset, versus a value of 668 mm measured at a single station. The spatiotemporal variability in datasets and the differences between various evapotranspiration calculation methods suggest that considering the uncertainity of recharge through a range of values may be more appropriate than using a single recharge value or distribution.

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**Session 3B:**
**High Tech**
**Friday, March 11, 2016**
**8:30 – 10:10 a.m.**

### Innovative Flow Measurement Technology for Stream Discharge near Hydraulic Structures: WIde-angle Oblique Automated Streamflow Imaging System (WI-OASIS)

Yuli Liu,* University of Wisconsin-Madison, yliu99@wisc.edu
John Reimer,* University of Wisconsin-Madison
Chin Wu, University of Wisconsin-Madison

Stream flow discharge is essential for many important uses like aquatic habitat, water supply, recreation, flood forecasting, and management water level of lake-river systems. In Wisconsin, continuous stream discharge is recorded over 200 stream gages. Most of measurements are made based upon mechanical current meters, which are slow and unreliable. In the last ten years, the application of acoustic Doppler current profilers (ADCPs) has greatly improved the efficiency and accuracy of measurements. Nevertheless, many gages are located near hydraulic structures, where stream flow cannot be obtained from ADCP due to the transient reversal eddies. In this study, an innovative technology, a wide-angle oblique automated streamflow imaging system (WI-OASIS), is developed for measuring discharge near hydraulic structures. WI-OASIS hardware consists of a single state-of-art wide-angle camera, which is capable to capture high resolution images of the entire river transect from an oblique angle. For WI-OASIS software, we develop oblique digital particle imaging velocimetry processing algorithms to remove image distortion and calculate transient reversal eddies based on the entropy relations of current velocities. The computing architecture of WI-OASIS is developed to operate continuously with no labor involvement. The technology has been deployed for Yahara River flow measurement near the Lafollette Lock at the outlet of Lake Kegonsa. The accuracy was validated with an average error less than 10%. Currently, WI-OASIS is incorporated into to the Integrated Nowcast/Forecast Operation System (INFOS) for Yahara Lakes to provide real-time discharge measurement to the public.

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### Wave Climatology of the Apostle Islands, Lake Superior

Joshua Anderson,* University of Wisconsin-Madison, janderson1@wisc.edu
Chin Wu, University of Wisconsin-Madison
David Schwab, University of Michigan Water Center

The Apostle Islands National Lakeshore in Lake Superior is a world-class destination for sea kayaking, luring paddlers with scenic wilderness, ancient geology and a rich cultural history. The wave environment in the Apostle Islands is undoubtedly complex and dynamic due to the interactions with the islands and rapidly changing weather conditions over Lake Superior. In this talk, we will present the wave climate of the Apostle Islands obtained from a 35 year (1979–2013) hindcast by a third-generation spectral wave model. Wave measurements within the Apostle Islands and offshore NOAA buoys were used to validate the model. Statistics of the significant wave height, peak wave period, and mean wave direction were computed to reveal the spatial variability of wave properties within the archipelago for average and extreme events. Extreme value analysis was performed to estimate the significant wave height at the 1, 10, and 100 year return periods. Significant wave heights in the interior areas of the islands vary spatially but are approximately half those immediately offshore of the islands. Due to reduced winter ice cover and a clockwise shift in wind direction over the hindcast period, long-term trend analysis indicates an increasing trend of significant wave height statistics by as much as 2% per year, which is approximately an order of magnitude greater than similar analysis performed in the

global ocean for areas unaffected by ice. Two scientific questions related to wave climate are addressed. First, the wave climate change due to the relative role of changing wind fields or ice covers over the past 35 years was revealed. Second, potential bluff erosion affected by the change of wave climate and the trend of lower water levels in the Apostle Islands, Lake Superior was examined.

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**Development of a Rip Current Forecasting System in Lake Michigan**

Fnu Prashansa,* University of Wisconsin-Madison, prashansa@wisc.edu
Chin Wu, University of Wisconsin-Madison
Yuli Liu, University of Wisconsin-Madison

Rip currents are responsible for about hundred drowning fatalities per year in the United States. Approximately 80 percent of rescues in the U.S. are due to people getting caught in rip currents. In the Great Lakes, there were 26 fatalities related to rip currents occurring in southern Lake Michigan alone between 2002 and 2007. Traditional approaches to mitigate rip current hazards are to provide information on escape procedures for beachgoers caught in a rip current. Signage and brochures have been also used as awareness and warning strategies. Life Guards on beaches rescue people caught in rip currents. While these methods are all important, the lack of a reliable, consistent, and cost-effective warning system for rip currents remains on the wishful list. Through the support of the NOAA Coastal Storm Program, we have developed a state-of-the-art cyberinfrastructure that consists of nested grid models and nearshore wave observations for rip current warning and forecasting in Lake Michigan. Specifically, a novel two-way nesting approach linking grids between Lake Michigan and nearshore beach is developed and validated. First, a low resolution Lake Michigan model is used as input to the high resolution nearshore beach model. Afterwards, the information from the nearshore beach model is returned back to re-adjust the uncertainty of the whole Lake Michigan model. This two-way nesting technique enables us to capture fine-scale rip currents while keeping the computational cost of real-time and forecasting rip currents feasible and cost-effective. For nearshore wave observations, a Wide Angle Imaging Tracking System for Rip Currents (WAITS-RC) is developed to detect rip currents at areas of interest which adds to the consistency and reliability of the system. Both modeling and observations will help rip-current communication and reduce the risk of beach hazards, leading to safer beaches in Wisconsin.

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**Long-term Characterization and Real-time Forecasting of High-frequency Water Level Oscillations Caused by Fast Moving Storms**

Alvaro Linares,* University of Wisconsin-Madison, alvaro.linares@wisc.edu
Chin Wu, University of Wisconsin-Madison

High-frequency water level oscillations (HFWLO, also called meteotsunamis), caused by fast moving storms, are continuously observed in Lake Michigan. HFWLO can cause extensive damages like coastal flooding, navigation hazard, bluff erosion, and contaminated sediment resuspension. In addition, HFWLO with large amplitudes have caused a great deal of fatalities and property losses. In this talk, we will examine the characteristics of HWFLO events in Lake Michigan including Port Inland, Ludington, Calumet Harbor, and Milwaukee during the past 20 years. Radar reflectivity images and high resolution (1 min sampling frequency) weather data from a network of stations surrounding Lake Michigan are used to associate the causes of fast moving storms. The role of different types of fast-moving storms with either pressure or wind induced HFWLO are examined. Statistical methods are employed to explore the relationships between the atmospheric parameters of each storm type and magnitudes and occurrences of HFWLO. We use the knowledge gained from this long-term characterization to construct an artificial neural network combined with heuristic prediction algorithms to

detect the atmospheric “anomalies” that are likely to cause hazardous HFWLO along Lake Michigan coasts. Overall, a state-of-the-art effective forecasting model that can provide real-time HFWLO warning in Lake Michigan is developed to reduce the risk posed by these coastal meteotsunami hazards.

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## Prediction of HAB via Smartphone Application

Hedda Sander, Ostfalia University of Applied Sciences, h.sander@ostfalia.de
Derek Riley, University of Wisconsin-Parkside
John Skalbeck, University of Wisconsin-Parkside
Vedant Nighojkar, University of Wisconsin-Parkside
Abhishek Deshmukh, University of Wisconsin-Parkside

Harmful algal blooms (HAB) mainly caused by cyanobacteria in freshwater ecosystems present a health risk to the public w ithin eutrophied shallow lakes due to algal toxins released into the w ater. Thus, algal grow th should be monitored during summer seasons, especially in recreational areas. Traditionally, w ater samples are sent to a lab to analyze for algal blooms, costing time and money. Models predicting HAB f rom easily measurable parameters on a smartphone could help individuals to take precautionary measures in order to prevent health risks f rom drinking and bathing in w ater and raise public awareness. We present an Android mobile application for a HAB prediction based on a modif ied Verhulst equation (Nt=N0+(k-N0)*exp(-r0*t)) f rom a variety of easy to measure input parameters, such as lake temperature, Secci depth, dissolved Oxygen (DO), light (lux) and Chlorophyll-fluorescence (Chl a). As Chlorophyll values are not normally easy to access for the user w e used equations for Chlorophyll a estimation using partial least square analysis (total Chl a (µg/l) = -6,4775 + 21,6396 * inverse Secci depth (m) + 0,0006 * square (DO surface (%); r2=0.69; Cyanobacterial Chl a (µg/L) = 0.409 – 0.7486 * surface temperature(°C) + 17.6979 * inverse Secci depth (m)); r2=0.76) from a data set obtained f rom a shallow lake (Stadtgraben, Germany, 2013). Data w ere collected by seasonal w eekly sampling of eutrophication parameters (temperature, conductivity, DO, Phosphate, Ammonia, Nitrite, Nitrate, Chl a, Secci depth). Temperature dif ferences w ithin w ater depth layers diminished tow ards late summer w ith full circulation stage reached in August. This coincided w ith full development of algal bloom (def ined as cyanobacterial Chl a = 40 µg/L and a sharp drop in Phosphate and Ammonia levels at the bottom. The model developed from there does show a maximum 16% between estimated and real values in bioreacter experiments and is now under validation in different freshwater lakes.

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**Session 3C:**
**Water Quality B**
**Friday, March 11, 2016**
**8:30 – 10:10 a.m.**

## Legacy Phosphorus in Stream Sediments within an Agricultural Dominated Watershed, Wisconsin

John Reimer,* University of Wisconsin-Madison, Department of Civil and Environmental Engineering, jrreimer@wisc.edu
Chin Wu, University of Wisconsin-Madison, Department of Civil and Environmental Engineering

Legacy phosphorus can delay the outcome of intended water quality benefits, thus undermining current conservation practices or calling for stricter land and nutrient management strategies. Regulations such as the Total Maximum Daily Loads (TMDL) are established to set pollution limits from current nonpoint and point sources. Nevertheless, phosphorus loads measured at the watershed outlet, based upon TMDL definition, reflect both current and remobilized legacy phosphorus sources from watersheds. As a result, watershed projects may be viewed as unsuccessful. To address this concern, we explore the mobility of the P legacy in the streambed sediments that can mask or buffer the impacts of conservation practices at the study site of Dorn Creek, Madison, Wisconsin. Specifically, we evaluate the contributions of retained and remobilized P in streams that may be considered an additional P source for TMDL allocations in the watersheds. Stream sediment cores are used to investigate the P release from the bottom sediments to the overlaying water column. The results reveal that at times stream sediments themselves produce concentrations above the allocated TMDL criterion. Age dating using radioisotopes are performed to reveal the mobility of stream sediments and the lasting impacts to water quality. The findings have important implications to develop effective watershed management strategies, where remediation is apportioned among point and non-point P contributors. We also address the time lag that might delay the water quality response of Dorn Creek due to legacy P sources. Finally we explore management options that specifically target the treatment of legacy phosphorus sources.

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## Achieving Agricultural Runoff Phosphorus Reductions in a Driftless Area Watershed

Laura Good, University of Wisconsin-Madison, lwgood@wisc.edu
Rebecca Carvin, U.S. Geological Survey

A project in southwestern Wisconsin demonstrates that producers' changes in management can lead to improvements in stream water quality. Two watersheds, both approximately 19 mi2, with a similar mix of agriculture, grasslands and woods and similar soils and topography, were selected for the project. The streams at the outlets of the two watersheds have been monitored for flow, phosphorus and sediment since September 2006. One of the watersheds was picked for targeted conservation efforts, while the other was used as a reference. Having a nearby reference watershed without any special conservation efforts allowed us to determine how the project itself affected water quality without having the results obscured by variations in weather and regional land management trends. The project watershed was inventoried to locate areas that were contributing comparatively high amounts of sediment and nutrients to the stream. The tools used for identifying high loss areas were the Revised Universal Soil Loss Equation 2 (RUSLE2) and the Wisconsin Phosphorus Index in the SnapPlus nutrient management. Dane County Land Conservation staff also used a barnyard model to rank barnyards by their potential phosphorus runoff. Using these inventories, the project identified ten operations estimated to be contributing the most total phosphorus in surface runoff to the streams. Eight of the ten focus operations began working with the project in 2010, and one joined in later. They

implemented a combination of in-field and off-field practices to reduce runoff phosphorus and sediment losses with cost-share funding from the NRCS and The Nature Conservancy. The main field management changes were no-till/reduced tillage and pasture/lot systems, and participating farmers cut their operations' estimated erosion and phosphorus delivery by half. In 2013 and 2014, the first two years after full implementation, there were statistically significant ($\alpha = 0.05$) reductions in phosphorus and sediment runoff event loads in the project stream compared to the reference stream. This project showed that it is possible to achieve water quality improvements in a relatively short time frame by focusing conservation efforts.

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**Silver Creek Adaptive Management Pilot Study: Monitoring, Design, and Implementation Updates**

Erin Wilcox, NEW Water (Green Bay Metropolitan Sewerage District), ewilcox@newwater.us
Jeff Smudde, NEW Water
Bill Hafs, NEW Water
Brent Brown, CH2M Hill

NEW Water, the brand of Green Bay Metropolitan Sewerage District, is completing its second year of work on a pilot study designed to test if phosphorus and sediment reductions in the watershed can be achieved through collaboration with the agricultural community. These reductions in the watershed are likely to improve local water quality far beyond what improved wastewater treatment plant effluent could, at a much lower cost. Silver Creek is a small stream located one mile west of the Green Bay Austin Straubel Airport and flows into Duck Creek which flows into the bay of Green Bay. The watershed is about 7.5 square miles (4,800 acres). Silver Creek water quality monitoring has shown levels of total phosphorus (TP) and total suspended solids (TSS), which contribute to algae growth, low oxygen and loss of habitat for fish and aquatic life, above water quality standard for tributaries. NEW Water has hired a team lead by CH2M HILL to design and implement the pilot project. The project includes 124 agricultural fields, 26 landowners, 15 growers and has collected numerous soil sample tests and in-stream biological and water chemistry data. Soil and water samples have been collected and analyzed for suites of nutrients and other physical parameters. Field soil samples show 26% of soil tests are above the state standard of 50ppm TP. These results along with detailed field walks have helped to identify and prioritize five to seven improved practices to each field surveyed in the Silver Creek watershed. Through our collaborations with agricultural landowners and operators, Outagamie and Brown County Land Conservation, Natural Resources Conservation Service, the Oneida Nation, local agronomists, and many others, our next steps will be implementation of improved field practices, edge of field management, rotational grazing, construction of wetlands, and continued monitoring efforts.

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**Developing Reference Conditions for Wisconsin Streams**

Mike Miller, Wisconsin Department of Natural Resources, michaela.miller@wisconsin.gov
Jonathan Kult, Wisconsin Department of Natural Resources
Dale Robertson, U.S. Geological Survey

Various physical, chemical, and biological parameters are used to assess stream quality. Reference condition criteria can provide numeric benchmarks to objectively determine whether stream resources are meeting their ecological potential. The primary goals of our study were to assess the utility of various classification methods and data sources commonly used to establish stream reference conditions, and evaluate the use of Random Forests modeling to develop reach - specific reference condition criteria based on continuously varying landscape – level and stream channel physical characteristics. We evaluated both geographic (grouping streams by Omernik Level III ecoregions) and several typologic (stream flow volume, thermal, and WI Department of Natural Resource's "Natural Community") classification schemes. Study results showed statistically significant differences in stream chemical and biological characteristics among ecoregions but these differences appear to be driven more by varying levels of agricultural and urban land use intensities than natural environmental factors. Typologic classification schemes showed mixed success in identifying statistically different stream populations. Overall, concentrations of various water chemistry constituents were not significantly different among stream thermal classes, or flow volume or Natural Community classes. These three stream typologies were slightly better at distinguishing distinct groupings for various macroinvertebrate and fish metrics. Using recent stream sites (n = 5,002) sampling data, Random Forests modeling allowed us to predict current statewide reach - specific conditions, and by mathematically dampening the effects agricultural and urban land use on the sample sites' data, we were able to develop reach - specific stream reference conditions.

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**The Influence of Land Use on Nutrient Loads in Spring Brook, Beloit, WI**

Emma Koeppel,* Beloit College, koeppele@beloit.edu
Carol Mankiewicz, Beloit College

Excessive levels of nutrients such as nitrogen (N) and phosphorus (P) can cause fish kills, algal blooms, and loss of biodiversity in streams. Anthropogenic activities such as row-crop agriculture, animal production, urbanization, industry, and wastewater treatment practices are major contributors of excessive nutrients to streams. Spring Brook, a second-order stream beginning in Clinton, WI and flowing toward Beloit, WI, is influenced by non-point-source pollution from agricultural land use, and by point-source pollution from a wastewater treatment facility and industry, making it an ideal study system for investigating the relative effects of different land uses. On 4 days in May, July, August, and September of 2015, temperature, discharge, and concentrations of nitrate (mg/L NO3-N) and reactive phosphorus (mg/L P) were measured at 6 sampling sites. Concentrations of N and reactive P decreased downstream during all months, with the exception of P in September; for example, N decreased from 16.9 mg/L NO3-N to 6.3 mg/L NO3-N in August. Conversely, the cumulative load values (mg/s) for N and P increased downstream during all months (e.g., from 151 mg/s NO3-N to 927 mg/s NO3-N in August). To better understand the influence of land-use on nutrient loading, ArcGIS Hydrology Tools were used to delineate sub-watersheds upstream of each sampling point and areas corresponding to specific reaches of the stream. After quantifying the area of different land-use types within these catchments, published export coefficients were used to calculate cumulative and incremental predicted loads. These predicted values were compared to the measured values to determine if agricultural land within the study system was the likely contributor of nutrients to the stream. Preliminary results suggest that while measured and predicted cumulative trends are similar in direction and magnitude, incremental trends show distinct, consistent differences.

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**Session 4A:**
**Agriculture**
**Friday, Mach 11, 2016**
**10:30 – 12:10 p.m.**

### The Influence of Restored Prairie Vegetation on Freeze-Thaw Cycles and Soil Aggregate Stability in an Agricultural Landscape

Edward Boswell,* University of Wisconsin-Madison, epboswell@wisc.edu
Anita Thompson, University of Wisconsin-Madison
Nick Balster, University of Wisconsin-Madison

The number of freeze-thaw cycles and intensity of precipitation events are predicted to increase in the Midwestern US. Although freeze-thaw cycles are known to disrupt soil aggregates, little quantitative understanding exists regarding how vegetation restoration influences wintertime processes affecting springtime erosion. In this presentation, a field study in which we are testing hypotheses related to the manipulation of wintertime processes on soil aggregate stability and resistance to detachment in both an agricultural field and a restored prairie will be described. The study design includes replicated treatments of natural snow accumulation, insulated plots to simulate a thick, sustained snow pack, and snow exclusion in an agricultural field and an adjacent restored prairie. Changes in soil temperature, moisture, and freeze depth were observed between treatments allowing comparison of the response variables. Aggregate stability and fractionation, as well as soil erodibility using a cohesive strength meter (CSM), a novel approach to estimate in situ critical shear stress will be reported from the 2014-15 and 2015-16 winter seasons.

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### Determining the Feasibility of Using Satellite-Derived Tillage Practices to Improve Statewide Erosion Vulnerability Estimates

Jyun-Yi Michelle Hu,* Wisconsin Department of Natural Resources, Jyunyi.Hu@wisconsin.gov
Theresa Nelson, Wisconsin Department of Natural Resources
Aaron Ruesch, Wisconsin Department of Natural Resources

The Wisconsin Department of Natural Resources' Erosion Vulnerability Assessment for Agricultural Lands (EVAAL) model shows how readily available data can be used to prioritize sediment and nutrient related water quality improvement efforts within a watershed at the field scale. Currently, one major limitation of the model is the assumption of uniform tillage practices across a watershed. Since tillage type can significantly affect sediment and nutrient export, accurate tillage information could greatly improve the prioritization of highly vulnerable fields while also reducing time spent by local watershed managers and county conservation staff. As previous studies have shown, reliable estimates of tillage practices can be found by determining crop residue cover percentages from satellite imagery using NDTI (Normalized Difference Tillage Index) values. This work endeavors to further those studies by developing an efficient methodology for determining tillage types on a statewide basis, by identifying limitations associated with the scale of application, and by ultimately demonstrating the feasibility of using this analysis to inform decisions related to water quality improvements. Results will be presented from the analysis of data from three Wisconsin counties spanning multiple years. Recommendations will be made regarding the use of NDTI-derived tillage estimates for improving erosion vulnerability assessments for EVAAL and other water quality related analyses.

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### Evaluation of Filter Media for an In-Line Tile Drainage Nutrient Treatment System

Joseph Sanford,* University of Wisconsin-Madison Biological Systems Engineering, jrsanford@wisc.edu
Rebecca Larson, University of Wisconsin-Madison Biological Systems Engineering

The enrichment of phosphorus in local and regional watersheds is leading to increases in water quality issues such as eutrophication. Subsurface drainage has been linked as a contributing factor of both nitrogen and phosphorus from agricultural lands into surface waters leading to these environmental issues. While a lot of research has been conducted into reducing the amount of nitrate leaving subsurface drainage, little has been done to address phosphorus treatment. This study evaluated different media (expanded shale, expanded clay, furnace slag, and natural soil) as a possible option to reduce phosphorus in an in-line treatment system. Using both batch and column studies the research found that furnace slag had the highest ability to bind phosphorus in a flow through system. Using the Langmuir model furnace slag was found to have a sorption capacity of 10.5 g P kg-1, and column studies found an average removal of 40% phosphorus from phosphorus enriched solution. In addition to phosphorus media, different treatments off biochar were carried out in an attempt at reducing nitrogen species as well in tile effluent. The data from this study will provide crucial information in developing and sizing an in-line treatment system to be placed in a tile outlet in south central Wisconsin.

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### Effect of Woody Biochar Amendment to Sand on Nutrient Leaching to Groundwater with Dairy Manure Application

Alysa Hinde,* University of Wisconsin-Madison, Biological Systems Engineering Department, alysa.bradley@wisc.edu
Rebecca Larson, University of Wisconsin-Madison, Biological Systems Engineering Department
Troy Runge, University of Wisconsin-Madison, Biological Systems Engineering Department

Fertilizer application to agricultural fields can increase yields making land use more efficient. However, nutrient losses through runoff and leaching cause problems in nearby waterways, including eutrophication, loss of aquatic life and human health issues related to drinking water. In Wisconsin, manure from dairy cattle is a prevalent agricultural fertilizer. Biochar is produced by the anoxic thermal degradation of organic matter and has been shown to improve soil quality, including retardation and reduction of the leaching of some nutrients in soils. The application of biochar to agricultural fields could retain nutrients in topsoil, preventing excess nutrient leaching and runoff.

In a soil column study, biochar from poplar chips at 450°C was added to sand at 0%, 1%, 2% and 5% by weight. Dairy manure was applied at 14 week intervals and columns were leached with deionized water every other week for a year. Leachate was measured and analyzed for pH, Biological Oxygen Demand (BOD), Nitrite ($NO_2$), Nitrate ($NO_3$), Ammonium ($NH_4$), Total Nitrogen (TN) and Total Phosphorus (TP). After the leaching trial, material in the columns was tested for pH, $NO_3$, $NH_4$, TN and TP. An estimate of nitrogen emissions was calculated by mass balance.

The study showed an increase in leachate pH and decreased peak values of BOD, an indicator of water quality, with increasing levels of biochar. $NO_3$, $NH_4$, and TN in leachate all decreased with increasing levels of biochar application, though TP increased. Higher levels of $NO_3$ and TN were retained in treatments with increasing levels of biochar and nitrogen emissions were reduced in biochar amended columns. The results from this study indicate that poplar biochar amendments could be effective to reduce nitrogen leaching from soils, though further study is needed to determine whether or not biochar amendment can be recommended as a nutrient management strategy.

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**John Nelson could not make this presentation due to an unavoidable schedule change.**

**The Effects of a Denitrifying Bioreactor on Nitrate and Phosphorus Discharge**

John Nelson, The Nature Conservancy, jnelson@tnc.org
Christopher Ertman, Sheboygan County Planning & Conservation Department

A denitrifying bioreactor was constructed on a field tile outlet to an unnamed tributary of the Sheboygan River, Sheboygan County, Wisconsin in October, 2013. The bioreactor was the first known such structure constructed in Wisconsin. The practice was previously used in other Midwestern States to reduce nitrate discharges to surface waters. A limited number of water samples were collected from above and below the structure in 2013 and 2014 to measure nitrates. Samples were collected for dissolved phosphorus in 2013, 2014, and 2015. Nitrate concentrations were reduced by 70.6% in 2013 and 40.5% in 2014. Dissolved phosphorus concentrations increased substantially from the inlet to the outlet in 2013 (1024%) as phosphorus was presumably released by the bioreactor wood chips. The increase dropped to 10% in 2014. Dissolved phosphorus levels decreased in 2015 by 44%, suggesting that the bioreactor was now absorbing some level of phosphorus as water flowed through the structure.

* * *

**Session 4B:**
**Groundwater-Surface Water**
**Friday, Mach 11, 2016**
**10:30 – 12:10 p.m.**

## Groundwater/Surface-Water Interactions in the Bad River Watershed

Andrew Leaf, U.S. Geological Survey, Wisconsin Water Science Center, aleaf@usgs.gov
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Randall J. Hunt, U.S. Geological Survey, Wisconsin Water Science Center
Cheryl A. Buchwald, U.S. Geological Survey, Wisconsin Water Science Center

The Bad River Watershed drains 1,000 square miles of northwestern Wisconsin, extending from forested uplands along the continental divide to Lake Superior's southern shore. The watershed encompasses the Bad River Reservation and coastal sloughs that contain the largest remaining wild rice beds in the Great Lakes Basin. Understanding of the watershed is important to the Bad River Band as they seek to manage their water resources against concerns of potential future iron mining, industrial agriculture, and climate change impacts.

A USGS study investigated the groundwater-flow system and groundwater/surface-water interactions. Average annual recharge, steady-state groundwater flow and average baseflow in streams were simulated using the SWB soil-water-balance recharge model and a MODFLOW-NWT groundwater model with streamflow routing using the SFR2 package. Model results and supporting stable isotope data illustrate differences in the nature of groundwater flow across the watershed, encompassing both shallow flow systems in upland areas and a deep flow system in the sandstone aquifer, where some δ18O values indicate recharge water from the last glacial period (at least 9,500 years before present). The model was used to delineate groundwater contributing areas, and a new data worth analysis evaluated the relative worth of new piezometer locations for reducing model prediction uncertainty. A report and interactive companion mapper are available online at http://pubs.er.usgs.gov/publication/sir20155162.

A second phase of the study includes expansion of the MODFLOW model to a transient, fully integrated watershed model (using GSFLOW) including the White River subbasin, and a synoptic water quality survey of the Kakagon and Bad River sloughs using a suite of integrated sensors. Results from the second phase will improve understanding of the hydrologic inputs to the sloughs and provide a powerful tool for assessing the water quantity and quality impacts of future land use and climate change.

*** * ***

## Evaluating Seepage Lake Drought Resilience Using Stable Isotopes of Water and Groundwater Flow Models

Hangjian Zhao,* University of Wisconsin-Madison, hzhao56@wisc.edu
Jean Bahr, University of Wisconsin-Madison
Randall Hunt, U.S. Geological Survey, Wisconsin

The resilience of seepage lakes to drought conditions is largely affected by their dynamic interaction with the groundwater system. Therefore, understanding of groundwater contribution to seepage lake water budgets is critical to predict their responses to drought conditions. Stable isotopes of water are a conservative tracer that can facilitate the unique estimation of lake water-budget components. Isotope fractionation processes allow different water-budget components to be distinguished based on their isotopic compositions. Fractionation during evaporation, which preferentially removes the lighter isotopes, results in heavier oxygen-18 ($^{18}O$) and deuterium (D) signatures in lakes compared with groundwater recharged by snow and rainfall. Conventional water budget methods can be coupled with an $^{18}O$ mass balance model to quantify groundwater and surface-water interactions in such lakes. A combined approach using an $^{18}O$ mass balance model and groundwater-flow model is a powerful way to understand lake response to drought.

Individual $^{18}O$ mass balance models are developed for 18 seepage lakes in Chequamegon-Nicolet National Forest, Northern Wisconsin. The hydrological and $^{18}O$ components of the isotope budgets come from different sources and methods. An average lake water-isotopic composition is obtained by analyzing $^{18}O$ and D compositions from samples collected when the lake was well mixed. $^{18}O$ in the water vapor is calculated from Craig-Gordon multilayer model based on fractionation from the evaporation process and evaluated using previous work in the area. Regional evaporation rate is estimated from National Oceanic and Atmospheric Administration (NOAA) gridded climate data using the Penman equation. Regional monthly average precipitation is interpolated based on NOAA ground station data though Kriging interpolation. Additionally, the results from 18O mass balance models will be combined with the results of a GFLOW analytic element groundwater model.

*** * ***

### Measurements of Infiltration at Industrial Sand Mines

Madeline Gotkowitz, Wisconsin Geological and Natural History Survey, mbgotkow@wisc.edu
Paul Juckem, U.S. Geological Survey
Zachary Vande Slundt, U.S. Geological Survey

Industrial sand mines can potentially affect the hydrologic cycle if the proportion of precipitation that recharges groundwater changes under this land use and associated alteration of soil structure. The 2,900 acres in Chippewa County, Wisconsin that are currently permitted for industrial sand mining are clustered within a relatively small region. Public concern about potential reductions in baseflow to nearby streams resulted in our recent investigation in infiltration of water into surficial materials as mines progress through phases of development, operations, and reclamation.

We conducted double-ring infiltrometer tests at 43 locations spanning six types of land use: forest, prairie and grassland, agriculture, active mine floor, mine staging areas, and reclaimed areas. This method involves driving two open rings into the ground and filling both with water. The head in each ring is maintained by adding water, and the rate of head decline in the inner ring is timed and converted to an infiltration rate. Results within the prairie and grassland setting were highly variable, ranging from 5 x 10-4 to 5x10-2 cm/sec. Infiltration rates measured at other sites ranged from a low of 2 x 10-5 cm/sec in the mine staging areas, to a high of about 7 x 10-3 cm/sec at locations in forested and actively mined areas.

Infiltration rates were lower at mine staging areas compared to the floor of the active mine pit. This could be caused by cessation of mining at the contact of the target sandstone formation with an underlying shale horizon, or by compaction from mining equipment. Results in reclaimed areas indicate that surface infiltration may increase over a period of years, likely due to formation of macropores in the soil structure. These observations have implications for best management practices at sand mines, and they will inform estimates of recharge applied to a regional groundwater flow model used to simulate potential effects of mining and irrigated agriculture on baseflow to streams.

*** * ***

**Groundwater - Surface Water Interactions Caused by Pumping from a Riverbank Inducement Well Field**

Tim Grundl, University of Wisconsin-Milwaukee, grundl@uwm.edu
Laura Fields-Sommers, University of Wisconsin-Milwaukee
Jack Graham, University of Wisconsin-Milwaukee

A well field consisting of 3 wells completed in the sand and gravel aquifer in southeast Wisconsin has been monitored since December 2006. Two of the wells are immediately adjacent to a river and behave as riverbank inducement (RBI) wells. The third well is distal from the river and pumps pristine groundwater. Analytes include major ions, boron, bromide, lithium, gadolinium, δ18O, δD, emerging contaminants and bacterial RNA. This data, in conjunction with numeric modelling of the site performed by the USGS, has yielded a clear picture of the interaction between river and well field. Key findings include presence of ~40% river water in the RBI wells, induced river water is a function of the relative pumping between RBI and pristine wells, an apparent lack of bacterial transport from river to well and retarded movement of the sweetener sucralose. The study is a good example of the coordinated use of geochemical data and numeric modelling.

* * *

**A New Statewide Inventory of Springs in Wisconsin**

Grace Graham, Wisconsin Geological and Natural History Survey, grace.graham@wgnhs.uwex.edu
Susan Swanson, Beloit College
Kenneth Bradbury, Wisconsin Geological and Natural History Survey
David Hart, Wisconsin Geological and Natural History Survey

The Wisconsin Geological and Natural History Survey, University of Wisconsin-Extension, is conducting a new statewide inventory of springs. Although historical records of springs were compiled into a single database in 2007, this project is the first field effort to comprehensively document spring resources at the statewide level since the Wisconsin Conservation Department conducted surveys over 50 years ago. The new inventory consists of county-level surveys of springs with flow rates of 0.25 cfs and higher, and semi-annual surveys of six reference springs selected from representative geological, hydrological, and ecological regions of Wisconsin. Progress for the first year was focused in southern, central, and western Wisconsin, where there is the greatest demand for new high-capacity wells. As of December 2015, detailed descriptions of 151 springs in 26 counties have been recorded.

The new spring database, which will be available as a downloadable database at the conclusion of the project, contains information on location, flow rate, geologic setting, geomorphic setting, and water quality. The mean flow rate of surveyed springs is 0.96cfs; values range from 0.17cfs to 8.69cfs. Spring sites vary in levels of disturbance. Over 50% of the highly disturbed springs are located in areas of residential or agricultural land use, and over 90% of undisturbed to lightly disturbed springs are located in forests and wetlands. As regions of the state are surveyed, patterns in spring distribution and type are emerging. Studying these patterns should be helpful in understanding the geologic conditions influencing preferential groundwater flow. The spring inventory will aid in evaluating the potential impacts of groundwater withdrawals on Wisconsin's water resources and provide a snapshot in time of the state of Wisconsin's springs.

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