AMERICAN WATER RESOURCES ASSOCIATION – WISCONSIN SECTION
41st ANNUAL MEETING

Wisconsin's One Water –

Breaking Boundaries

March 9 & 10, 2017
Osthoff Resort
Elkhart Lake, Wisconsin

Hosts:

American Water Resources Association – Wisconsin Section

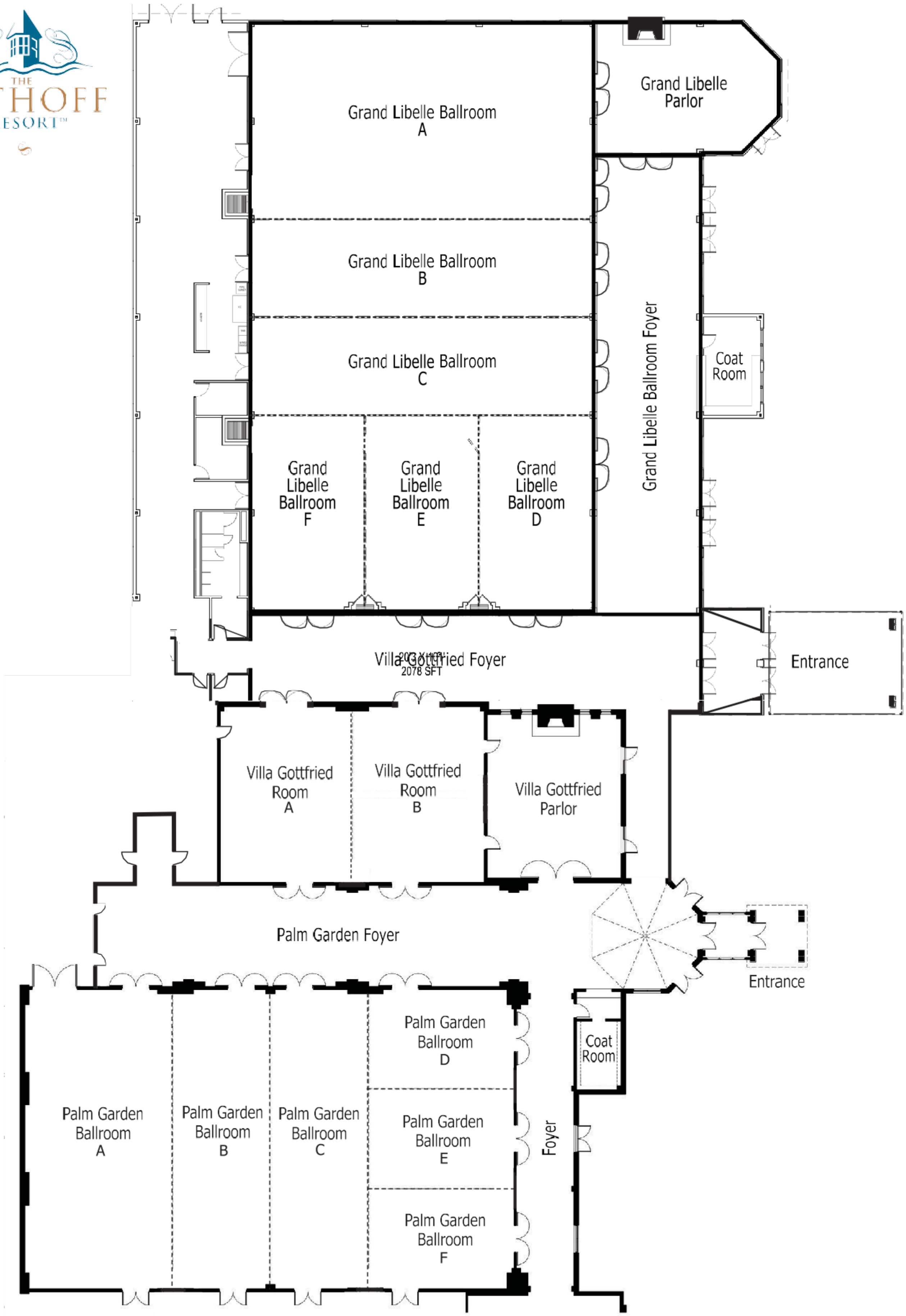
University of Wisconsin Water Resources Institute

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



Grand Libelle Ballroom A
Grand Libelle Parlor
Grand Libelle Ballroom B
Grand Libelle Ballroom C
Grand Libelle Ballroom Foyer
Coat Room
Grand Libelle Ballroom F
Grand Libelle Ballroom E
Grand Libelle Ballroom D
Villa Gottfried Foyer
Entrance
Villa Gottfried Room A
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Entrance
Coat Room
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Palm Garden Ballroom F

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

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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

Director-at-Large

Mitch Olds

Mitch received his Bachelor's Degree in Watershed Management and Hydrogeology from the University of Wisconsin-Stevens Point in 2012. While attending UWSP, Mitch was an active member of the student chapter of AWRA serving as Treasurer (2009-2010) and chapter president (2010-2012). Mitch is employed at the Milwaukee Metropolitan Sewerage District where he is involved in water quality monitoring in southeastern Wisconsin and is the captain of R/V Pelagos on Lake Michigan. Mitch is continuing his education by pursuing a Master's Degree in Freshwater Sciences and Technology at the University of Wisconsin-Milwaukee. He has continued to attend AWRA Wisconsin Section Annual Meetings, serving as a judge for student presentations, and plans to continue to be involved in AWRA throughout his career.

Secretary

Brent Brown

Brent Brown is a registered Professional Engineer for CH2M in their Milwaukee office. Mr. Brown practices water resources engineering and works on projects involving ecosystem protection and restoration, habitat and fluvial geomorphic assessments, watershed and stormwater management, low-impact development stormwater controls, sediment dredging and dewatering, and airport deicing fluid control. Mr. Brown has a Bachelor's Degree from the University of Wisconsin at Platteville in Civil/Environmental Engineering and a Master's Degree from the University of Illinois at Urbana-Champaign in Environmental Engineering. Mr. Brown has been employed with CH2M for 16 years.

Vice President

Andrew Leaf

Andrew Leaf is a hydrologist at the Wisconsin Water Science Center, where he works on hydrologic modeling studies throughout Wisconsin and the greater U.S. He received his bachelor's from Gustavus Adolphus College, and M.S. degrees in Hydrogeology and Water Resources Management from UW-Madison. He worked in the environmental consulting field in Seattle and has been with the USGS since 2012. He has attended the annual AWRA meeting since 2007, and looks forward to continued service on the board.

President-Elect

Mike Parsen

Mike Parsen is a hydrogeologist at the Wisconsin Geological and Natural History Survey (WGNHS). He received his Bachelor's Degree from the UW-Madison in Geology and Geological Engineering in 2003 and his Masters from the University of Neuchatel (Switzerland) in Hydrogeology and Water Resources Management. Mr. Parsen worked at URS (now AECOM) in Lyon, France as an environmental engineer and hydrogeologist for several years before returning to Wisconsin and joining the WGNHS in 2010. Mr. Parsen actively works on groundwater projects in Dane, Chippewa, Kewaunee and Trempealeau counties, helps manage the Wisconsin Groundwater-Level Monitoring Network in partnership with the DNR and USGS, and conducts research and educational outreach on industrial sand mining. He has attended and presented at AWRA Wisconsin Section meetings since 2011 and looks forward to continued service with this organization in 2017.

BIOGRAPHIES OF PLENARY AND EVENING SPEAKERS

George Kraft

George Kraft is a Professor of Water Resources and Director of the Center for Watershed Science and Education with the University of Wisconsin - Stevens Point College of Natural Resources and the University of Wisconsin - Extension. Dr. Kraft's position is largely dedicated to serving the citizens, communities, businesses, and governments of Wisconsin through outreach and research. He is passionate about the Wisconsin Idea tradition: "the boundaries of the University are the boundaries of the state."

Dr. Kraft's outreach involvement includes how lakes and streams have been dried by groundwater pumping, particularly in the Wisconsin central sands, modernizing Wisconsin's groundwater pumping management policy and laws, nitrate and pesticide pollution of groundwater, and assisting stewardship groups organize and manage their water resources.

Dr. Kraft's research interests revolve about questions of water resource sustainability, particularly about profitable agriculture and water impacts. He is actively involved in the local community, coaching high-school cross-country skiing and serving as an officer for the Tomorrow River Scholarship Foundation. He is perhaps best known for his cross-country skiing prowess, having completed 25 Birkebeiners and still finishing near the front of the pack despite his advanced age.

Kevin Shafer

Kevin Shafer is the Executive Director of the Milwaukee Metropolitan Sewerage District (MMSD) and is responsible for the overall management, administration, leadership and direction for MMSD in meeting short- and long-term goals and objectives; coordinates the establishment of strategic goals and objectives and their approval by the Commission; oversees the development of policies and operating plans; and represents MMSD to its customers, bond rating agencies, and the public. Prior to joining the District, Shafer spent 10 years in private industry with an international engineering firm in Chicago and Milwaukee, and six years with the U.S. Army Corps of Engineers in Fort Worth, Texas. He holds a bachelor's degree in science and civil engineering with a specialty in water resources from the University of Illinois and a master's in science and civil engineering from the University of Texas. He is a past president of the National Association of Clean Water Agencies and the Chair of the US Water Alliance's Urban Water Sustainability Leadership Council. He currently serves on the EPA's Local Government Advisory Committee and is the Chair of the Water Environment Research Foundation (WERF) Board of Directors.

Stacy Hron

Stacy is the Milwaukee Estuary Area of Concern Coordinator with the Wisconsin Dept. of Natural Resources Office of Great Waters. She received a B.S. in Conservation & Environmental Science and a M.S. in Biology from UW-Milwaukee. She was a part-time employee in the DNR fisheries and watershed management programs during her undergraduate years. After completing grad school she was an ecologist and project manager for a consulting firm. She came back to DNR in 2010 as the Sheboygan River Area of Concern Coordinator and followed by a stint in the Watershed Bureau as the Wetland Identification Specialist in eastern Wisconsin.

Huck Raddemann

Huck Raddemann received a B.S. in Natural Resource Management and Soil Science from UW Stevens Point and has been an Environmental Scientist and Project Manager with CH2M for nearly 14 years. Huck specializes in remedial investigations of contaminated sediment sites and has performed numerous sediment investigations within each of the Wisconsin AOCs. During the Sheboygan River Legacy Act Project Huck served as CH2M’s project scientist during each stage starting with investigation sampling and continuing through remedial action.

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PROGRAM SUMMARY

Wisconsin's One Water - Breaking Boundaries

41st Annual Meeting of the
American Water Resources Association—Wisconsin Section
Elkhart Lake, Wisconsin

THURSDAY, MARCH 9, 2017

9:00 – 11:00 a.m.	Registration Palm Garden Foyer
11:00 – 11:45 p.m.	Welcome and Lunch Palm Garden Ballroom
11:45 – 1:45 p.m.	**Plenary Session and Lightning Talks**
	Kevin Shafer Executive Director of the Milwaukee Metropolitan Sewerage District One Water, Infinite Possibilities
	George Kraft Professor of Water Resources and Director of the Center for Watershed Science and Education "50 Years of Central Sands Study Just Isn't Enough"
	Lightning Talks The Mindset to Advance Watershed Health Brent Brown, CH2M
	A Complete Solution to the Kewaunee County Water Crisis? John Luczaj, University of Wisconsin - Green Bay
	Teeny Trojans: New Zealand Mud Snails Amanda Bell, US Geological Survey
	Road Salt and Groundwater: Locally Sourced Salt Water Intrusion for the Land Locked John Jansen, Leggette, Brashears & Graham, Inc.
	Compiling an Irrigated Lands Coverage for Wisconsin Bob Smail, Bureau of Drinking Water and Groundwater, Wisconsin Department of Natural Resources
1:45 – 2:00 p.m.	**Break: Palm Garden Foyer**

2:00 - 3:20 p.m. **Concurrent Sessions 1A, 1B and 1C**

Session 1A **Groundwater Resources in Kewaunee County**
Villa Gottfried A
Moderator: Madeline Gotkowitz

2:00 Using Autosamplers to Determine the Timing of Enteric Pathogen Contamination of the Fractured Silurian Aquifer: Preliminary Results
Maureen Muldoon, University of Wisconsin Oshkosh

2:20 Pathogen Transport in Groundwater Systems – Contrasts with Traditional Solute Transport
Randall Hunt, US Geological Survey

2:40 Success and Limitations of Geophysical Survey Methods in the Town of Lincoln, Kewaunee County
Carolyn Streiff, Wisconsin Geological and Natural History Survey

3:00 Town of Lincoln groundwater study: A hydrogeologic characterization in Kewaunee County, WI
Michael Parsen, Wisconsin Geological and Natura History Survey - UW-Extension

Session 1B **Wisconsin's Water Quality**
Villa Gottfried B
Moderator: Laurel Braatz

2:00 Status and Trends of Water Quality in Wisconsin's Lakes, Streams, and Rivers
Timothy Asplund, Wisconsin Department of Natural Resources

2:20 Long-term water quality trends in Wisconsin rivers
Matthew Diebel, Wisconsin Department of Natural Resources

2:40 Water Quality Trends in Wisconsin's Wadeable Streams
Michael Shupryt, Wisconsin DNR

3:00 Long Term Water Quality Trends in Wisconsin Lakes
Katie Hein, Wisconsin Department of Natural Resources

Session 1C **Field Investigations**
Grand Libelle Ballroom D & E
Moderator: Steve Sellwood

2:00 A distributed temperature sensing investigation to inform lakebed pore-water sampling
Andrew Leaf, U.S. Geological Survey Wisconsin Water Science Center

2:20 Measuring diurnal signals in tree sway period as an indicator of water stress
Dominick Ciruzzi,* University of Wisconsin-Madison

2:40 — Investigation of the mound at the bottom of Lulu Lake
David Hart, Wisconsin Geological and Natural History Survey

3:00 — Climatology of Frozen Ground in Wisconsin
Brian Hahn-Service Hydrologist, NOAA/National Weather Service-Milwaukee/Sullivan, WI

3:20 – 3:40 — **Break: Palm Garden Foyer**

3:40 – 5:00 p.m. — Concurrent Sessions 2A, 2B and 2C

Session 2A
Surface Water
Villa Gottfried A
Moderator: Hayley Templar

3:40 — Application of Structure- and Function-Based Habitat Assessments for Evaluation of Rehabilitation Efforts in Urban Tributaries to Lake Michigan
Molly Breitmün, US Geological Survey, Wisconsin Water Science Center

4:00 — Managing Increasing Flood Risk on the Yahara Lakes, Dane County, WI
Kenneth Potter, University of Wisconsin

4:20 — Diurnal vertical Migration of Cyanobacteria and Chlorophyta in eutrophied shallow freshwater lakes
Hedda Sander, Ostfalia University

Session 2B
Central Sands
Villa Gottfried B
Moderator: Adam Friehoefer

3:40 — Engaging Stakeholders and Evaluating Water Management Scenarios to Improve the Use of Groundwater Flow Models for Decision Making
Maribeth Kniffin,* University of Wisconsin-Madison

[1]4:00 — Exploring groundwater forecasts to guide decision-making in Wisconsin's Central Sands
Colin McGuire,* University of Wisconsin - Madison,

4:20 — Steady-state versus transient analyses of high-capacity irrigation wells in central Wisconsin
Kenneth Bradbury, Wisconsin Geological and Natural History Survey

4:40 — High-resolution mapping of evapotranspiration and apparent electrical conductivity in the Wisconsin Central Sands: Could precision irrigation conserve groundwater?
Mallika Nocco,* University of Wisconsin-Madison

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* Student presentation

Session 2C	**Water and Agriculture** **Grand Libelle Ballroom D & E** **Moderator: Maureen Muldoon**
3:40	Collaboration for Safe Drinking Water: The Nitrate Demonstration Project Brian Austin, Wisconsin Department of Natural Resources
4:00	Reducing winter phosphorus losses from dairy agroecosystems through tillage and manure application timing Melanie Stock,* University of Wisconsin - Madison
4:20	Imagining a maximum future irrigation footprint to evaluate water resources in a Wisconsin County Michael Fienen, USGS Wisconsin Water Science Center
4:40	Review of a Utility-Led Agricultural Based Adaptive Management Pilot Study in Silver Creek– Green Bay, WI Erin Houghton, NEW Water
5:00 – 5:45	**Networking**
5:45 – 7:00 p.m.	**Dinner and Evening Speaker** **Palm Garden Ballroom** **Stacy Hron** **Wisconsin Department of Natural Resources** **Huck Raddemann** **CH2M** **“A One Water Approach to Restoring Sheboygan River and Its Legacy”**

7:00 – 10:00 p.m. **Poster Session and Social**
Palm Garden Ballroom

1. Potential Leaching of Metals from Fly Ash Amended Asphalt
Chelsey Heiden,* University of Wisconsin-Platteville

2. Toxicity of Sediment to Benthic Communities in Two Wisconsin Areas of Concern
Barbara Scudder Eikenberry, U.S. Geological Survey, Wisconsin Water Science Center

3. Optical Approaches to the Detection of Heavy Metals in Water
Paul Henning, University of Wisconsin-Milwaukee

4. Sources and sinks for phosphorus in stormwater through a pond-prairie system
Elizabeth Buschert,* University of Wisconsin-Madison

5. Uranium Concentrations in Central Wisconsin Groundwater and Their Relationship to Groundwater Chemistry
Paul Mcginley,* University of Wisconsin- Stevens Point

6. Influence of freezing and thawing on soil aggregate dynamics and sediment detachment
Edward Boswell,* University of Wisconsin-Madison

7. Soil Moisture and Plant Root Distribution Influence on Root Water Uptake in Prairie, Forest, and Corn
Allison C. LoBue,* University of Wisconsin-Madison, Department of Biological Systems Engineering

8. An Overview of the 2016 Chippewa County Groundwater Quality Inventory
Kevin Masarik, UW-Extension & UW-Stevens Point

9. Summer Applied Hydrogeology Course at the University of Wisconsin-Parkside Campus, Kenosha, Wisconsin: A Positive Outcome of the UW-System Budget Cuts
John Skalbeck, University of Wisconsin-Parkside

10. Using Nitrate Source Analysis to Understand Groundwater Quality in Chippewa County
Amy Nitka, UW-Stevens Point Water and Environmental Analysis Lab

11. Hydrogeologic Characteristics of Surface Water and Groundwater Flow in the Albion Basin, Alta, Utah
Nicholas Potter,* University of Wisconsin Parkside

12. Spatial and Temporal Variation in Sediment and Phosphorus in Green Lake's Wetland Ecosystems
Sarah Fuller,* UW-Madison

13. Developing Restoration Concepts for the lower Kinnickinnic River, Milwaukee, WI
Nicholas Hayden, Montgomery Associates: Resource Solutions

14. Establishing background metals concentrations in surface water and groundwater in western Wisconsin
Carly Mueller,* University of Wisconsin - Eau Claire

15. Identifying nitrate retention and denitrification hot spots at the groundwater-surface water interface in streams of the Central Sands
Robert Stelzer, University of Wisconsin Oshkosh

16. Natural Groundwater Contamination Potential of Trace Metal-Bearing Sulfides in Tunnel City and Wonewoc Sandstones in Western and South-Central Wisconsin
Lisa Haas,* Wisconsin Geological and Natural History Survey, UW Extension

17. Remote measurement of nearshore waves using a single camera
Erin Zimmerman,* University of Wisconsin -- Madison

18. Assessment of Data Frequency Requirements for Continuous Water-Quality Monitoring Stations
Mitch Olds, Milwaukee Metropolitan Sewerage District (MMSD)

19. An Evaluation of the Zooplankton Community at the Sheboygan River Area of Concern
Hayley Templar, U.S. Geological Survey

20. Flood Forecasting by the National Weather Service
Sarah Marquardt, NOAA National Weather Service

21. Geochemical and Mineralogical Characterization of the Mount Simon Aquifer Sandstones in Trempealeau County, Wisconsin
Zambito Jay, Wisconsin Geological Survey, UW-Extension

22. Ra source characterization in the Cambrian-Ordovician aquifer through isotopic and geochemical study
Madeleine Mathews,* University of Wisconsin, Madison

23. Bioremediation of Heavy Metal Contamination using Inactivated Algal Biomass
Cora Rolfes,* Ostfalia University

FRIDAY, MARCH 10, 2017

7:00 – 8:30 a.m.	Board Breakfast Meeting Grand Libelle Ballroom D
8:30 – 9:50 a.m.	**Concurrent Sessions 3A and 3B**
Session 3A	**Water Quality** **Villa Gottfried A & B** **Moderator: Anna Fehling**
8:30	Predicting daily total phosphorus and suspended solids across Wisconsin stream reaches for impairment assessment Alexander Latzka, Wisconsin Department of Natural Resources
8:50	Interacting effect of soil phosphorus and extreme precipitation on surface water quality Melissa Motew,* University of Wisconsin-Madison
9:10	Evaluation of Leaf Removal as a Way to Reduce Nutrients in Urban Runoff Bill Selbig, USGS - Wisconsin Water Science Center
Session 3B	**Groundwater/Surface Water** **Palm Garden D, E & F** **Moderator: Tim Grundl**
8:30	Using a tracer approach to estimate nitrate loading to a shallow sandy aquifer beneath an agricultural field Jacob Krause,* University of Wisconsin - Madison
8:50	Potential change in groundwater recharge around the Madison Lakes under alternate residential development scenarios Carolyn Voter,* UW-Madison
9:10	Fish Farm Groundwater Pumping Impacts on Spring and Stream Flows to Blotz Branch and Dodge Branch Creeks, Dodgeville Wisconsin Kenneth Wade, Kenneth Wade Consulting LLC
9:30	Using artificial sweeteners to trace subsurface transport of wastewater to groundwater Madeline Gotkowitz, Wisconsin Geological Survey
9:50 – 10:10	**Break: Palm Garden Foyer**
10:10 – 11:30 p.m.	**Concurrent Sessions 4A and 4B**

Session 4A	**Groundwater** **Villa Gottfried A & B** **Moderator: Dave Hart**
10:30	Estimating Groundwater Availability at a Wisconsin State Fish Hatchery using Flow Models and an Aquifer Pumping Test Charles Dunning, USGS Wisconsin Water Science Center,
10:50	Review and Expansion of the Climate Response Network in Wisconsin Megan Haserodt, U.S. Geological Survey
11:10	Planning for the next statewide inventory of springs in 2075 Sue Swanson, Beloit College
11:30	Hydrogeology of Wisconsin's National Forests Anna Fehling, Wisconsin Geological and Natural History Survey

Session 4B	**Urban Stormwater Management** **Palm Garden D, E & F** **Moderator: Nick Hayden**
10:30	Evaluation of Bioswales for Reducing the Quantity of Highway Runoff in Menomonee Falls, WI Judy Horwatich, USGS
10:50	Evaluation of MS4 NPDES Compliance Measures in Southeast Wisconsin Walter McDonald, Marquette Univeristy
11:10	Stochastic dynamics of passive and controlled stormwater basins Anthony Parolari, Marquette University
11:30	New Average Annual Rainfall Files for the Source Loading and Management Model WinSLAMM Mari Danz, US Geological Survey (USGS),
11:30 – 11:50	**Student Awards and 2017 Meeting Announcements** **Villa Gottfried A & B**

Lightning Talks
Thursday, March 9, 2017
11:45-1:45

The Mindset to Advance Watershed Health

Brent Brown, CH2M, Brent.Brown@CH2M.com

Wisconsin is a leader in protecting water resources. In this highly charged political environment, this is not always obvious and it's easy to question if the path we're on has the right end points. For better or worse, Wisconsin lead their development of numeric nutrient water quality criteria, they have studied the aquatic biology like no other Midwestern state and take pride in a creek chub like the pacific northwestern states value salmon and trout, we are one of few states to have the regulatory ability to hold farms of all sizes accountable for protecting water quality, and we have developed creative regulatory options for fostering partnerships for achieving watershed-level protection. Yet with all these great strides, challenges still remain and the talk of water quality impairments is not too dissimilar than in other states that have not had this progressive movement. We are missing a few things, but luckily for us (and the fish), the missing pieces can be overcome with a change in mindset….

* * *

A Complete Solution to the Kewaunee County Water Crisis?

John Luczaj, University of Wisconsin - Green Bay, luczajj@uwgb.edu

Access to safe drinking water in parts of northeastern Wisconsin has been a long-standing challenge, especially in areas with karsted bedrock and thin soil cover. Parts of Door, Kewaunee, Brown, Manitowoc, and Calumet counties have seen the most significant water quality impacts in the Silurian dolostone aquifer. In some counties, about one-third of wells are considered unsafe due to detections of coliform bacteria or exceedances of nitrate in groundwater. Significant attention has been given to these areas in the past decade, but Kewaunee County has received state and national attention from citizens groups and regulatory agencies, some of which have referred to the problem as a "public health crisis". Emerging contaminants receiving added scrutiny (e.g., viruses, endocrine disrupting compounds) are likely to make this problem appear worse in the future.

Several solutions to the problem of access to safe drinking water could be considered for Kewaunee County. Further restrictions on agricultural practices, improvement of best management practices, and enforcement of existing regulations are unlikely to ever guarantee safe drinking water in this geologic environment. Alternative water supplies or water treatment options include individualized treatment systems, deep wells that access the confined sandstone aquifer, and rural water district supply lines. Each of these proposals has advantages and disadvantages, but rural water supply through distribution pipelines is the only solution that can to guarantee public health with a dependable, high quality water supply for the 21st century.

* * *

Teeny Trojans: New Zealand Mud Snails

Amanda Bell, US Geological Survey, ahbell@usgs.gov

New Zealand Mud Snails (NZMS) are, as the name implies, a snail native to New Zealand. Like many aquatic invasive species, they start out as undetected “hitchhikers” on the bottoms of boots and waders, boats, fish broods, and in ship ballast water, and once established are nearly impossible to eradicate. Juvenile NZMS are no larger than a poppy seed, and adults are only the size of the tip of a ball-point pen; therefore, it is extremely difficult to detect and identify. NZMS are already present in several of Wisconsin’s waterbodies, hence proper decontamination is vital to prevent the spread of these and other invasive species across the state.

* * *

Road Salt and Groundwater: Locally Sourced Salt Water Intrusion for the Land Locked

John Jansen, Leggette, Brashears & Graham, Inc.

Chloride and sodium levels in many aquifers in Wisconsin are rising. While the problem started in the 1970s, it has accelerated since the 1990s. In almost every case the main cause is road salt. Best management practices have been developed to limit salt use and have been adopted by most highway departments for over a decade. Most people think that salt use has been curtailed and the problem has been solved. In reality the annual application of road salt is still increasing and sodium and chloride levels are rising in most streams and many aquifers. High chloride is toxic to fish, gives drinking water an unpleasant flavor, and is toxic to plants. High sodium levels in drinking water are unhealthy for people with high blood pressure. Treating drinking water for chloride is possible, but expensive and often impractical. Left to current trends, chloride levels in many aquifers may rise above chronic toxicity levels rendering the aquifers unfit for potable use and making the groundwater base flow to streams toxic to most aquatic life.

* * *

Compiling an Irrigated Lands Coverage for Wisconsin:

Bob Smail, Bureau of Drinking Water and Groundwater, Wisconsin Department of Natural Resources

DNR staff integrated multiple datasets including reported water withdrawal data, land ownership records from DOA, and remote sensing data from USDA to compile a statewide irrigated lands coverage for Wisconsin. This dataset was then used to estimate the annual volume of irrigation water applied per crop type in Wisconsin. This presentation will highlight the process used to build the dataset as well as results of ongoing analysis showing where different crops are grown in Wisconsin and how much water is typically applied per crop type. This dataset will be useful for planning and modeling where fine grain knowledge of existing irrigation and prediction of future irrigation are important. This analysis has been updated from past efforts and is expected to improve as water use data and remote sensing resolution improves.

Session 1A:
Groundwater Resources in Kewaunee County
Thursday, March 9, 2017
2:00 – 3:20 p.m.

Using Autosamplers to Determine the Timing of Enteric Pathogen Contamination of the Fractured Silurian Aquifer: Preliminary Results

Maureen Muldoon, University of Wisconsin Oshkosh, muldoon@uwosh.edu
Mark Borchardt, USDA-ARS
Randy Hunt, USGS
David Owens, USGS
Aaron Firnstahl, USGS
Joel Stokdyk, USGS

The fractured Silurian aquifer is an important, but vulnerable, source of water supply in rural northeastern Wisconsin. Dairy farming and associated crop production in this area comprise the primary land use and manure is commonly applied to crop land. As a result, this area has had long-term water quality problems with elevated nitrate, bacteria levels, and instances of non-potable brown water impacting domestic wells. Sporadic outbreaks of water-borne disease in the area have focused attention on the presence of enteric pathogens in the aquifer. Currently there are no data available on the variability of pathogen loading or understanding f how pathogen transport relates to recharge events in this aquifer.

Our ongoing research project seeks to determine the timing of enteric pathogen contamination of the Silurian aquifer in relation to groundwater recharge and nearby meteorological variables collected by others. We have installed specialized autosamplers on domestic water systems in order to collect detailed time-series of the concentrations of enteric pathogens and fecal microbial markers. The first autosampler was in place for a brown-water contamination event that occurred in late October 2016. Sampling was initiated at the start of the rain event and multiple samples were collected continuously over a period of 8 days. Although the sampled household water never turned visibly brown, the eluent collected off the sampling filters was brown and appeared to be impacted by fecal matter. The results of the October sampling event will be presented in this talk.

* * *

Pathogen Transport in Groundwater Systems – Contrasts with Traditional Solute Transport

Randall Hunt, US Geological Survey, rjhunt@usgs.gov
William Johnson, University of Utah

Water quality affects many aspects of water availability, from precluding use to societal perceptions of fit-for-purpose. Pathogen source and transport processes are drivers of water quality because they have been responsible for numerous outbreaks resulting in large economic losses due to illness and, in some cases, loss of life. Outbreaks result from very small exposure (e.g., less than 20 viruses) from very strong sources (e.g., trillions of viruses shed by a single infected individual). Thus, unlike solute contaminants, an acute exposure to a very small amount of contaminated water can cause immediate adverse health effects.

Similarly, pathogens are larger than solutes. Thus, interactions with surfaces and settling become important even as processes important for solutes such as diffusion become less important. These differences are articulated in “Colloid Filtration Theory”, a separate branch of pore-scale transport. Consequently, understanding pathogen processes requires changes in how groundwater systems are typically characterized, where the focus is on the leading edges of plumes and preferential flow paths, even if such features move only a very small fraction of the aquifer flow. Moreover, the relatively short survival times of pathogens in the subsurface require greater attention to very fast (<10 year) flow paths. By better understanding the differences between pathogen and solute transport mechanisms, a more encompassing view of water quality and source water protection is attained. With this more holistic view and theoretical understanding, better evaluations can be made regarding drinking water vulnerability and the relation between groundwater and human health.

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Success and Limitations of Geophysical Survey Methods in the Town of Lincoln, Kewaunee County

Carolyn Streiff, Wisconsin Geological and Natural History Survey, streiff@wisc.edu
Michael Parsen, Wisconsin Geological and Natural History Survey

Geophysical measurements are a relatively fast and inexpensive way to supplement existing hydrogeological datasets that contain coverage gaps and/or have uncertain accuracy. These issues were initially present in the depth-to-bedrock dataset for a hydrogeological mapping project in the Town of Lincoln, Kewaunee County, Wisconsin. The goal of this study was to create a depth-to-bedrock map for use in regulatory decision making. In this study area, fractured dolomite bedrock lies beneath varying thicknesses of unlithified soil and glacially-deposited sediments. Several different geophysical survey methods were used to acquire depth-to-bedrock estimates for this study, with Horizontal-to-Vertical Spectral Ratio (HVSR) Passive Seismic and Electrical Resistivity Imaging (ERI) proving most useful.

These methods had different success and limitations. The HVSR method was useful in areas where the depth-to-bedrock was shallow (65). At several locations, a sharp, high amplitude spectral peak was visible in the HVSR output; providing a reliable estimate of depth-to-bedrock. In contrast, compacted gravel layers can limit the success of the HVSR method. Based on confirmation Geoprobe borings, it was determined that a highly compacted, thin gravel layer mimicked the impedance of the underlying shallow dolomite, which generated a spectral peak that could be misinterpreted as the bedrock contact. Fortunately, ERI is able to image through this compacted gravel to create a reliable resistivity profile with depth of the subsurface. However, the bedrock must be within ~45 feet of land surface.

The collection of several geophysical surveys aided in depth-to-bedrock mapping by supplementing and providing confirmation of existing datasets. Utilizing several geophysical data acquisition methods is essential in regions where datasets lack coverage and accuracy confidence, and where there are significant variations in the character of the subsurface laterally and in depth.

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Town of Lincoln Groundwater Study: A Hydrogeologic Characterization in Kewaunee County, WI

Michael Parsen, Wisconsin Geological and Natura History Survey - UW-Extension, michael.parsen@wgnhs.uwex.edu
Carolyn Streiff, Wisconsin Geological and Natural History Survey - UW-Extension

Over the past decade, well water testing in Kewaunee County, Wisconsin has consistently shown that 30% of private wells fail to meet health standards for nitrates and total coliform. Kewaunee County is home to several Concentrated Animal Feeding Operations and numerous rural homes with septic systems. The county's carbonate bedrock, which contains numerous fractures and solution features, is particularly susceptible to groundwater contamination because it can rapidly transport groundwater and any associated contaminants. In response to ongoing groundwater quality concerns and a county-wide ordinance in 2015, prohibiting winter manure spreading in areas less than 20 feet to bedrock, the Town of Lincoln commissioned the Wisconsin Geological and Natural History Survey (WGNHS) to better characterize their groundwater resources.

The WGNHS, in cooperation with the Town of Lincoln, Kewaunee County Land and Water Conservation Department, and Kewaunee County Land Information Department, is conducting field work and preparing a series of maps to better characterize hydrogeologic conditions within the Town. Mapping depth to bedrock and depth to the water table incorporates existing data sets, such as well construction records, borings from wind turbines, USDA/NRCS soils data, farmer shallow bedrock data, and high-resolution LIDAR data. New datasets collected by the WGNHS for this project include subsurface borings, geophysical surveys, measurements of water levels in wells, and stream flows. A recharge map will approximate how much water infiltrates to groundwater in specific areas, and a closed depression map will identify areas where runoff collects on the landscape and may preferentially infiltrate.

The shallow Silurian dolomite aquifer in eastern Wisconsin stretches from Door County to the Illinois border and is extensively fractured as a result of the natural weathering processes of carbonate rock. Maps that identify depth to bedrock, depth to the water table, closed depressions, and the distribution of recharge are essential for areas like these with vulnerable groundwater resources. The final maps will provide town and county officials with improved tools for making informed land-use management decisions.

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Session 1B:
Wisconsin's Water Quality
Thursday, March 9, 2017
2:00 – 3:20 p.m.

Status and Trends of Water Quality in Wisconsin's Lakes, Streams, and Rivers

Timothy Asplund, Wisconsin Department of Natural Resources, tim.asplund@wisconsin.gov
Matt Diebel, Wisconsin DNR
Katie Hein, Wisconsin DNR
Mike Shupryt, Wisconsin DNR

Wisconsin DNR has been monitoring water quality at fixed stations on over 100 lakes and rivers since the mid-1980's, with some records extending back more than 50 years. In addition, citizens have been monitoring lakes for Secchi disk water clarity for 30+ years, and water quality in wadeable streams for 20+ years. Wisconsin DNR has also conducted various statewide surveys of lake and stream condition as part of national and regional monitoring studies, including the National Aquatic Resource Survey effort initiated in 2007. While we have been using this data for biennial reporting of water condition, and documenting trends and interannual variability for individual sites, we now have enough information and statistical power to be able to distinguish between localized and short term drivers of water quality and longer term patterns and trends that may be driven by regional factors such as land use and climate. A few major themes are emerging from our analysis. First, most lakes and streams exhibit interannual variations in water quality in response to climatic factors, but for the most part, water quality has been relatively stable on a statewide basis. However, some lakes and rivers show strong increasing trends, while others show decreasing trends in certain parameters, suggesting that local, watershed influences and in-lake processes may be a stronger driver of change than regional or landscape influences. For example, overall reductions in TP since the 1970s are apparent in historically eutrophic systems, likely due to point source controls, but at the same time we are seeing increases in more oligotrophic or nutrient poor systems, either due to non-point sources or climatic changes. Other parameters, such as lake water clarity, nitrate, and chloride are showing increasing trends in some parts of the state, or on certain types of waterbodies, but not on a statewide basis. These findings suggest that targeted management actions can make a difference and can counteract or dampen impact of larger-scale stressors. In this talk, I will briefly summarize key findings from various long term and statewide datasets, and provide case studies where local management actions appear to be making a difference in water quality conditions. This talk will complement more detailed talks being presented in this session.

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Long-term Water Quality Trends in Wisconsin Rivers

Matthew Diebel, Wisconsin Department of Natural Resources, matthew.diebel@wisconsin.gov

The Wisconsin Department of Natural Resources has been monitoring water quality at 38 stations on the state's major rivers for periods of 15 to 55 years. Summary reports have been published on approximately five year intervals, but until now, no analyses of trends over the entire periods of record have been conducted. I used the WRTDS statistical model to describe long-term trends in water quality in these rivers, and to explore how these trends have varied by season and discharge. River water quality trends were highly variable among parameters and regions of the state. Concentrations of total phosphorus and total

suspended solids have decreased in most rivers through the last several decades. In contrast, concentrations of chloride and nitrate have increased in most rivers over this period. The largest reductions in total phosphorus occurred in southern Wisconsin, and many of the rivers with large phosphorus reductions also had large suspended solids reductions. Nitrate concentrations increased in most rivers in agricultural basins in Wisconsin. Chloride concentrations increased in nearly all rivers in Wisconsin, even in mostly forested basins. There was little systematic variation in trends across season and discharge, except that in many rivers, phosphorus concentrations were highest during low flow in the 1970s and are now highest during high flow, indicating a transition from wastewater to non-point sources. The reasons for the observed trends in all parameters are likely a combination of changes in land management practices (including agricultural production systems, erosion control, and nutrient management), improvements in wastewater treatment, and increases in road salt use.

* * *

Water Quality Trends in Wisconsin's Wadeable Streams

Michael Shupryt, Wisconsin DNR, Michael.Shupryt@wisconsin.gov

Since the early 2000's the United States Environmental Protection Agency (USEPA) and States have been assessing the current condition of wadeable streams using probabilistic surveys. Probabilistic surveys involve sampling streams across a known area selected using a spatially-balanced, stratified random sampling design to statistically estimate the condition of all of the streams in the population. The WDNR participated in three USEPA led surveys (2003, 2009 and 2014) as well as initiating three WDNR led surveys (2007, 2012 and 2015). We combined all six probabilistic surveys conducted over the past 12 years to analyze trends in water quality among Wisconsin's wadeable streams. Initial results suggest that there is no significant trend in mean TP concentrations in Wisconsin's wadeable streams over the 12 years of the study. However, there is some evidence to suggest that the percentage streams with extremely low TP concentrations significantly decreased over the study period. We will share analysis of water quality trends from these studies for total nitrogen, dissolved inorganic nitrogen and total suspended solids.

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Long Term Water Quality Trends in Wisconsin Lakes

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

Anthropogenic nutrient loading is a major stressor of lakes worldwide. Although watershed management efforts have reduced nutrient loading, eutrophication may worsen as agriculture expands, land develops, and precipitation intensifies. The Wisconsin Department of Natural Resources (WDNR) has collected water quality data from 62 lakes for up to 45 years, and citizen volunteers have monitored total phosphorus (TP) and chlorophyll a on ~500 lakes for up to 24 years. I tested for linear trends in phosphorus, nitrogen, alkalinity, calcium, magnesium, and color. Most lakes have not changed significantly over time, but some have improved and others have degraded. For all parameters, the slope was much greater if examining trends with only 3-5 years of data. The lack of a spatial pattern across the state suggests that local watershed processes are responsible for changes observed over time. This analysis helps identify lakes that should be investigated for degrading water quality and lakes that can be celebrated for improving water quality. It also cautions drawing strong conclusions about trends over time with limited data. Although the National Aquatic Resource Surveys recently showed that phosphorus is rapidly increasing in minimally disturbed lakes and streams, only 2-3 surveys through time have been conducted to date.

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Session 1C:
Field Investigations
Thursday, March 9, 2017
2:00 – 3:20 p.m.

A Distributed Temperature Sensing Investigation to Inform Lakebed Pore-Water Sampling

Andrew Leaf, U.S. Geological Survey Wisconsin Water Science Center, aleaf@usgs.gov

Haskell Lake is a 90-acre drainage lake on the Lac du Flambeau Reservation in northern WI. Historically this lake was an important producer of wild rice for the Lac du Flambeau Tribe. Sediment cores and tribal records indicate the presence of wild rice dating back at least several centuries, but beginning in the late 1970s, the rice began to diminish and by the late 1990s, the lake had little or no rice. The cause of wild rice decline is unknown. Restoration of the resource is of great interest to the Tribe, as is understanding of the Lake's hydrology, which is characteristic of other lakes on the Reservation. A petroleum contamination plume in the shallow aquifer upgradient of the Lake poses an additional problem, with dissolved concentrations indicating the possible presence of residual non-aqueous phase contamination. The timing of the gasoline release is unclear, but probably occurred sometime before 1990. The downgradient extent and discharge of contamination to Haskell Lake remain undefined.

In July of 2016, the USGS conducted a fiber-optic distributed temperature sensing (DTS) survey in the nearshore areas of the lake downgradient of the plume, with the goal of delineating areas of increased groundwater discharge. Water temperatures along the lakebed were monitored with 1,400 feet of fiber optic cable in a double-ended configuration for 6 days. Challenges encountered in the investigation included data storage and power supply limitations, maintenance of calibration baths, accurate location of the cable in space, cable placement in weeds and soft sediment, the confounding effects of solar radiation, and contamination of the data by multiple sources of instrument noise. The latter problem was overcome by solving the DTS calibration equation for two parameters that describe temporal variation in both the source laser and the photon detectors that observe the backscatter. Early morning temperatures, when the influence solar radiation is minimized, were used to evaluate groundwater discharge, similar to other studies. The results show a persistent temperature gradient of up to 5.5 °C across the study area with areas of relatively cool and steady temperatures being interpreted as groundwater discharge. Results of the study are being used to inform sampling of the lakebed pore water to better define the contamination extent.

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Measuring Diurnal Signals in Tree Sway Period as an Indicator of Water Stress

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

Drought monitoring of tree water stress typically relies on discrete measurements both in space and in time. Indirect, but continuous measurements of water stress, such as from sap flux sensors or soil moisture sensors, are both invasive and expensive. We used a non-invasive and relatively inexpensive setup to continuously measure sub-daily signals of tree sway period as an indicator of water stress using accelerometers. Several models have been developed to relate the natural dominant sway period to the parameters of a tree, such as diameter, height, mass, and elasticity. We assumed diameter and height do not change on short timescales and that short-term changes in sway period are related to mass and elasticity. The model we used assumes that the sway period is inversely related to elasticity and directly related to tree mass. We hypothesized that the predominant signal in the tree sway data will be related to changes in water content (e.g. tree mass) over 24 hours with secondary influences from changes in trunk elasticity associated with changes in turgor pressure. To test this, we measured changes in tree deflection for different forces over 24 hours in trees to evaluate relative changes in tree elasticity. As an indicator of tree water content, we measured wet leaf mass during the same 24 hour period. We observed the trees had less mass and were less elastic during the day than at night. Preliminary data show diurnal variations in sway period occur in 2016 indicating variations in water stress, even during the 4th wettest summer in Wisconsin.

* * *

Investigation of the Mound at the Bottom of Lulu Lake

David Hart, Wisconsi Geological and Natural History Survey, dave.hart@wgnhs.uwex.edu
Carolyn Streiff, Wisconsin Geological and Natural History Survey
Sarah Gatzke, The Nature Conservancy
Jerry Ziegler, The Nature Conservancy

In Wisconsin steeply-walled mounds in lake bottoms are rare. When they do occur, the mounds are often thought to have anthropogenic origins. One such steeply-walled mound is found in the bottom of Lulu Lake, a 95-acre lake in southeastern Wisconsin. We are currently investigating the hydrogeology in and around Lulu Lake, and the origins of this submerged mound might provide insight into the lake's geologic history. The mound rises about 25 feet above the surrounding lake bottom and is about 40 feet in diameter. Apart from this mound, the lake bottom topography is what would be expected, a smoothly varying shallow bowl.

We formed two hypotheses for the mound formation: 1) as a refuse pile or 2) from tufa formed during carbonate precipitation from groundwater discharge. We used a sub-bottom acoustic profiler to image into the mound and surrounding lake sediments. We worked with a team of scuba divers to collect sediment and water samples from the mound top and side and from near the mound base in the lake sediment. We also collected underwater video of the mound. The sub-bottom profiler showed mound sediments with layering and possible slumping into the lake sediments. The core from the mound top and edge was grey colored while that from the lake bottom was black with what seemed to be more organic material. The in-situ coloration of the two sediments was confirmed by the video. The major ion chemistry of water collected from the inlet and outlet of Lulu Lake and from pore water from the mound sediment is similar. The mound sediment pore water was slightly enriched with regard to deuterium and O18 when compared to the lake sediment pore water, though the variation is likely too small to be significant. The divers also reported that the water was significantly colder over the mound.

Based on the data above, it seems likely that the mound is formed of tufa by carbonate precipitation. If this is the case, the mound likely contains a record of climate from the last several thousand years similar to other studied Wisconsin tufa mounds and so warrants further investigation so that we can confirm this hypothesis and better understand this lake and the basin it occupies.

* * *

Climatology of Frozen Ground in Wisconsin

Brian Hahn, NOAA/National Weather Service-Milwaukee/Sullivan, WI, brian.hahn@noaa.gov

The presentation will outline the observed trends in the way ground freezes versus temperature patterns, varying levels of snow cover and various types of soil. Favored areas for deep frost in Wisconsin will be shown as well as how frost depth is measured using simple, inexpensive manual gauges.

* * *

Session 2A:
Surface Water
Thursday, March 9, 2017
3:40- 5:00 p.m.

Application of Structure- and Function-Based Habitat Assessments for Evaluation of Rehabilitation Efforts in Urban Tributaries to Lake Michigan

Molly Breitmün, US Geological Survey, Wisconsin Water Science Center, mbreitmun@usgs.gov
James Blount, USGS
Michelle Lutz, USGS
Faith Fitzpatrick, USGS

The geomorphic and habitat characteristics of urban streams in the Milwaukee area were characterized for stream rehabilitation planning and evaluation by the U.S. Geological Survey (USGS), in cooperation with the Milwaukee Metropolitan Sewerage District (MMSD). The study focused on 27 stream reaches covering a continuum of channel alterations including unaltered, artificially stabilized, and rehabilitated. Field assessments were conducted from 2013-15 in the three major watersheds that drain into the Milwaukee Estuary – the Milwaukee, Menomonee, and Kinnickinnic Rivers. Transect and area–based measurements were collected based on an updated version of the USGS National Water-Quality Assessment habitat assessment protocol. Data collected included channel morphology, slope, bedform and substrate, habitat cover, riparian vegetation, stream velocity, bank erosion, and presence of artificial channel alterations. Fourteen reaches were established in 2004 to assess and routinely monitor water quality and biological integrity within the MMSD planning area. Nine additional reaches were chosen for their contrasting states of channel alteration within the same streams as the 14 original sites. Another four reaches were included in 2015 as analogs, due to their unique status as relatively urban sites with minimal channel alterations and historically good biological integrity. Sampled reach lengths were a function of channel width and ranged from 150 to 800 meters. Channel widths ranged from 1.95 to 98.6 meters. Slopes varied from 0.0 percent on a reach affected by Lake Michigan backwater to 1.12 percent a few miles further inland. Data analyses include calculations of habitat structure, diversity, and function based on the four statistical moments of mean, standard deviation, skew, and kurtosis value. The use of multiple moments describing central tendency, variability and distributional shape within the reaches helps to describe the diversity and possible resiliency of habitat conditions. Preliminary results will be presented that draw on both the diversity of statistical measures and site characteristics to assess the effectiveness of previous restoration efforts and to inform future activities.

* * *

Managing Increasing Flood Risk on the Yahara Lakes, Dane County, WI

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

During the past two decades, flood risk has increased on the Yahara Lakes in Dane County, with major damage resulting from severe and persistent rainfalls in 1993, 2000, and 2008. The primary reasons are land development and an increase in the incidence of severe storms. These factors will likely persist, even further increasing the magnitude and frequency of damaging flood events. The most promising strategy for managing this risk is to strengthen existing stormwater ordinances. Dane County has initiated a technical

advisory committee to explore options for ordinance revisions, including the institution of a program for trading stormwater volumes, analogous to existing pollution trading programs. This talk will report on the recommendations of the technical advisory committee.

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Diurnal Vertical Migration of Cyanobacteria and Chlorophyta in Eutrophied Shallow Freshwater Lakes

Hedda Sander, Ostfalia University, h.sander@ostfalia.de
Cora Rolfes, Ostfalia University
Thomas Eckel, Ostfalia University
John Skalbeck, University of Wisconsin at Parkside
Derek Riley, Madison School of Engineering
Malin von Orgies Rutenberg, Ostfalia University

Circadian rhythms are thought of as means for adaptation helping survival fitness of a species. For species associated with harmful algal blooms (HAB) in eutrophied freshwater lakes usually light and nutrient availability, especially of phosphate, seem to drive patterns of diel vertical migration. As HAB present a health risk to the public they need to be monitored and predicted via simulation models, at best employing smartphone apps onsite. Those models have to take the vertical migration patterns of species associated with HAB in freshwater lakes (Cyanobacteria) into account, as input parameters needed for prediction may be influenced by those patterns.

Thus, two shallow freshwater lakes (eutrophic condition: Lake Stadtgraben, Northern Germany, oligotrophic condition: Lake Russo, Wisconsin, USA) were selected in temperate climates to serve as models for the vertical migration in different seasonal times under natural conditions. The lakes were monitored for phosphate concentrations, as well as light and temperature development over time in hourly increments at lake surface and bottom. In addition the vertical migration pattern of Cyanobacteria and Chlorophyta populations were followed over 24 hrs in spring (May) and fall (August) in order to derive a behavior assumption as input for a model predicting HAB from these patterns.

In Lake Stadtgraben the vertical migration pattern was influenced by light rather than by phosphate availability in spring, as phosphate was readily available at that time in all depths investigated, while temperatures difference top-bottom was high. The vertical migration pattern was dampened in fall season in both, the oligotrophic and the eutrophic lake, while temperature differences top-bottom were low. Thus, the vertical migration patterns observed may change slightly with season, which might have an impact on the outcome of simulation models dependent on the time of day and lake depth, at which input parameters such as Chlorophyll a are measured.

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Session 2B:
Central Sands
Thursday, March 9, 2017
3:40- 5:00 p.m.

Engaging Stakeholders and Evaluating Water Management Scenarios to Improve the Use of Groundwater Flow Models for Decision Making

Maribeth Kniffin,* University of Wisconsin-Madison, kniffin@wisc.edu
Ken Bradbury, Wisconsin Geological and Natural History Survey
Mike Fienen, US Geological Survey

Water resource management processes employing cross-sectoral planning, public participation, and collaborative modeling have shown promise in addressing complex water resource challenges in regions throughout the United States (Palmer et al., 2013). Such an integrated approach may help inform water management in Wisconsin where citizens are concerned about allocation of water between competing interests. Disagreement among stakeholders living near the Little Plover River (LPR), a groundwater-fed trout stream, has intensified since groundwater pumping from high-capacity wells has expanded to support nearby agricultural irrigation and since the flow rate in the river has decreased with stretches of the river periodically going dry. To address this issue, the Wisconsin Geological and Natural History Survey and U.S. Geological Survey constructed a transient groundwater flow model of the LPR basin to provide scientific support for water- and land-use management decisions (Bradbury et al., 2016). This study uses the model to evaluate seasonal impacts that potential management scenarios have on the flow rate in the river under different climate trends ("wet", "average" and "dry"). Potential alternative management scenarios were identified through collaboration with stakeholder workgroups and were simulated individually and cumulatively. Comparisons between management scenario simulations and baseline simulations quantify their level of impact on river flowrates and provide principles for seasonal and annual groundwater management. Results show the connection between human decisions and the environment, and the trade-offs necessary for meeting the legally-established Public Rights Flows in the Little Plover River.

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Exploring Groundwater Forecasts to Guide Decision-Making in Wisconsin's Central Sands

Colin McGuire,* University of Wisconsin - Madison, cfmcguire@wisc.edu
Paul Block, University of Wisconsin - Madison

Wisconsin's Central Sands is an important asset to the state from both recreational and agricultural perspectives. The region boasts more than 300 lakes and 800 miles of streams, which are valued by nature enthusiasts, recreationalists, and lakeshore properties. Agriculture is also burgeoning in the region, with 200,000 acres of cranberries, potatoes, and other high-value vegetables contributing an estimated economic impact of $6 billion and 35,000 jobs annually. This production is highly dependent on groundwater sources for supplemental irrigation. It has been widely hypothesized that increasing groundwater sourced irrigation is detrimentally affecting surface water lakes and streams, particularly during dry years. Presently, however, there is no formal groundwater mechanism to manage these competing demands. Season-ahead predictions of growing season precipitation and groundwater are explored as a potential benefit to demand and supply management. We apply local-scale and large-scale hydroclimatic

predictors to forecast precipitation and groundwater variability in the Central Sands, including both seasonal characterization and intra-seasonal events (e.g. high precipitation events.) Forecast value to farmers and potential adaptation strategies are also explored.

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Steady-State Versus Transient Analyses of High-Capacity Irrigation Wells in Central Wisconsin

Kenneth Bradbury, Wisconsin Geological and Natural History Survey, ken.bradbury@wgnhs.uwex.edu
Michael Fienen, U.S. Geological Survey

It is sometimes argued that irrigation using high-capacity wells has little impact on nearby groundwater and surface-water resources because the infiltrating irrigation water augments natural recharge and the net change in recharge is negligible or even positive relative to non-irrigated crops being grown. Comparing the consumptive water needs of irrigated and non-irrigated crops, calculated on an annual basis, can suggest that less water is consumed by irrigated crops. Furthermore, evaluations of the potential impacts of high-capacity wells in central Wisconsin often assume steady-state conditions, but these assumptions can lead to under-estimation of the seasonal effects of pumping. Analyses of the potential impacts of wells on nearby surface-water features commonly take one of two approaches: annual water budgets at the land surface or steady-state hydraulic analyses using analytic or numerical models. Evaluating the impacts of irrigation wells is fundamentally a transient problem because the wells operate only periodically during the growing season and are generally not operated during the fall, winter, and spring. Static annual water budgets, which balance total yearly inputs (precipitation, irrigation) against total yearly outputs (evapotranspiration, pumping, runoff) can give an incomplete picture of pumping impacts because they do not account for temporary water deficits during dry summers or temporary surpluses during wet periods. Steady-state groundwater flow models that average transient water use over longer simulation periods suffer from the same problem – they can underestimate impacts during times of maximum pumping, which usually coincide with periods of naturally low streamflow. Furthermore, there is a fundamental disconnect between spatially-averaged water budgets at the land surface and the focused hydraulic impacts (drawdown, changes in storage) that occur when a well operates. During transient pumping cycles an aquifer's hydraulic diffusivity (K/Sy) governs the rate of lateral propagation of pumping impacts, and for this reason maximum impacts on streamflow do not necessarily coincide with times of maximum pumping. Transient analyses show that even if irrigation water annually completely replenishes the total amount of water pumped (an improbable scenario because some water will be lost to evapotranspiration) there can still be substantial seasonal reductions in streamflow due to well operations.

* * *

High-Resolution Mapping of Evapotranspiration and Apparent Electrical Conductivity in the Wisconsin Central Sands: Could Precision Irrigation Conserve Groundwater?

Mallika Nocco,* University of Wisconsin-Madison, nocco@wisc.edu
Samuel Zipper, McGill University
Eric Booth, University of Wisconsin-Madison
Matthew Ruark, University of Wisconsin-Madison
Steven Loheide, University of Wisconsin-Madison
Christopher Kucharik, University of Wisconsin-Madison

The growth of irrigated agriculture and decline of surface waters has led to a community conflict over groundwater resources in the Wisconsin Central Sands (WCS). We estimate that an annual increase in evapotranspiration (ET) of 50 mm due to consumptive groundwater use is enough to explain observed

impacts on surface waters; however, ET is difficult to predict and control because of high spatiotemporal variability in these humid agroecosystems. WCS growers are experimenting with precision irrigation as a strategy to control ET at the subfield scale using mapped apparent electrical conductivity (ECa) as a proxy for soil water holding capacity. Though this strategy has been effective in arid agroecosystems, there are limited experimental data supporting these practices in the WCS, which makes it difficult to assess potential conservation benefits.

Our goal was to identify trends in the spatiotemporal variability and uncertainty of ET and ECa by partnering with a sixth-generation family farm growing irrigated vegetables in the WCS. First, we developed high-resolution maps of ECa and complementary point-based measurements of soil physical properties for six conventionally irrigated fields. Next, we collected thermal imagery via aircraft over the same six fields, which we used with the High-Resolution Mapping of Evapotranspiration (HRMET) energy balance model to map instantaneous ET several times during 2014-2016. Simultaneously with aircraft missions, we collected gas exchange measurements to make point-based estimates of instantaneous ET within the six fields. Finally, we made weekly ET estimates using 25 passive capillary lysimeters installed in the same six fields. Preliminary results suggest relationships between mapped ECa, ET, and soil physical properties that could be further optimized for precision irrigation in the WCS. Future work will use these relationships to quantify potential groundwater savings from precision irrigation at the regional scale.

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Session 2C:
Water and Agriculture
Thursday, March 9, 2017
3:40- 5:00 p.m.

Collaboration for Safe Drinking Water: The Nitrate Demonstration Project

Brian Austin, Wisconsin Department of Natural Resources, Brian.Austin@wi.gov
Elizabeth Finzer, Wisconsin Department of Natural Resources
Christina Anderson, Wisconsin Land and Water
Andrew Aslesen, Wisconsin Rural Water Association

Nitrate is the most prevalent groundwater contaminant causing exceedance of the Maximum Contaminant Level (MCL) for public water systems in Wisconsin. For mitigation options, communities presently choose between expensive infrastructure upgrades such as well replacement, blending or water treatment. A 2012 survey of Wisconsin municipal drinking water systems showed that respondents had collectively spent over $34M on nitrate remedies, up from $24 million in 2004. Communities need new tools to reliably structure partnerships for sustained source water protection. By working with a range of technical and community partners, the project seeks to demonstrate methods and develop decision support tools for communities to effectively manage nitrate contaminant loading from agricultural sources in wellhead protection areas.

Three project sites have been established in municipal wellhead protection areas in Wisconsin where the systems have been experiencing rising nitrate trends above 5 mg/L and approaching the MCL. These sites are serving as focus areas for partners to explore solutions to three primary problems: 1) characterization of specific wellhead vulnerability, including identification of the lands contributing the most recharge and nitrate loading to the well, 2) improving robustness of voluntary initiatives to reduce and quantify nitrate loading to groundwater from agricultural sources and 3) the structuring of cost sharing agreements for implementing nitrogen management following economic analysis and constraining the upper bounds of nitrate loading to groundwater through analysis of management practice and crop rotation scenario testing. In addition to the long term protection of groundwater sources of drinking water, successful implementation of methods to reduce nonpoint nitrogen losses to groundwater will prove more cost effective for many communities to achieve safe drinking water as compared to infrastructure or treatment based options.

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Reducing Winter Phosphorus Losses from Dairy Agroecosystems Through Tillage and Manure Application Timing

Melanie Stock,* University of Wisconsin - Madison, stock@wisc.edu
Francisco Arriaga, UW-Madison, Soil Science
K.G. Karthikeyan, UW-Madison, Biological Systems Engineering
Peter Vadas, USDA-ARS
Laura Ward-Good, UW-Madison, Soil Science

Wintertime land applications of manure are a longstanding practice for dairy producers, but frozen soils and snowpack increase the potential for nutrient transport through surface runoff processes. The goals of this study are to 1) test practical management techniques that may reduce runoff on fields receiving winter applications of liquid dairy manure, and 2) use a water-energy balance approach to quantify the underlying drivers of runoff on these frozen soils. 18 plots were installed on a 5 % slope at the UW Arlington Agricultural Research Station and will be monitored from 2015-2018. Within these plots, conventional versus no tillage with three manure application timing treatments are tested: unmanured controls, early winter, and mid-winter applications to frozen ground. Liquid dairy manure (2-3 % solids) is applied at a rate of 37.4 kL ha-1 (4000 gal ac-1). The plots are monitored for atmospheric (radiation, wind, temperature, vapor pressure), soil (temperature, potential, water content, frost), and hydrological parameters (precipitation, runoff volume); runoff is analyzed for TKP, DRP, TKN, NOX, TS, VS, and EC. During Winter 2015-2016, nine runoff events occurred, during which 84% of no till plots and 23% of conventionally tilled plots produced runoff in each event. Nutrient loads and concentrations were significantly greater in treatments with no tillage and mid-winter applications of manure compared to treatments with conventional tillage, unmanured controls, and early winter applications of manure. Tillage created surface depressional storage, which slowed surface water movement and aided infiltration into frozen soil, while mid-winter applications of manure decreased albedo and the freezing point of snow, which accelerated snowmelt, hence runoff losses. This field study expands frozen soil research to applied agricultural systems and provides a mechanistic context for management and regulatory decisions that balance environmental and economic viability.

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Imagining a Maximum Future Irrigation Footprint to Evaluate Water Resources in a Wisconsin County

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Seth Ebel, Chippewa County
Dan Masterpole, Chippewa County

For many groundwater modeling projects, forecasts of system responses to future conditions drive the analysis. A challenge can be to adequately represent such future conditions with a balance of specificity and the flexibility of an unknown future. An example solution to this challenge may be drawn from the atmospheric sciences, where ensembles of future climate forcings informed by global circulation models can be carried forward to provide a range of likely forecasts.

We took a similar approach for a county scale groundwater modeling project in Chippewa County, Wisconsin USA. Stakeholders want to understand base flow and water level impacts in the face of uncertain future land use pressures. Industrial sand mining for hydraulic fracturing and irrigated agriculture are key land use changes occurring now and into the future. In this presentation, we discuss how to determine a reasonable maximum impact case of base flow changes due to increasing irrigated agriculture. Distributed mapped datasets were examined incorporating stakeholder expertise in determining a footprint of potentially irrigable land based on soil, existing land use, slope, and other mappable characteristics. Stakeholders indicated that 80% of that footprint was likely to be irrigated, so a stochastic approach was adopted using 1,000 random samples of the 80% footprint, assigning recharge and pumping changes based on agriculture in other parts of Wisconsin, and maintaining the proportion of the three most common crops throughout the irrigated land. Each realization was run through the groundwater model resulting in an ensemble of base flow and water level changes including estimates of their uncertainty.

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Review of a Utility-Led Agricultural Based Adaptive Management Pilot Study in Silver Creek–Green Bay, WI

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Jeff Smudde, NEW Water
Bill Hafs, NEW Water
Brent Brown, CH2M

Silver Creek is in a subwatershed of Duck Creek, located one mile west of Green Bay, WI, where a suite of best management practices (BMPs) are addressing high levels of nutrient and sediment runoff. NEW Water, the brand of the Green Bay Metropolitan Sewerage District, is leading the project to evaluate if it is more cost effective to spend $200 million or more on wastewater treatment plant phosphorus improvements or to work with agriculture to reduce the amount of phosphorus and sediment reaching Green Bay. 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. NEW Water is partnering with the local community to effectively execute an agricultural- based Adaptive Management pilot project in the Green Bay area. Baseline data and inventory of the watershed is complete and being used to develop enhanced nutrient management plans and conservation plans that define management, operational, and structural measures to aid implementation of BMPs that reduce phosphorus and total suspended solids in Silver Creek. Implementation of several large and small practices have been completed in the last year. The pilot study is utilizing innovative tools to execute field-level assessments, gather soil and water data, work closely with landowners and growers, and leverage local agronomist experience to target the most effective practices. The pilot will evaluate the success of implemented practices and review potential frameworks for implementing a future full scale Adaptive Management program to achieve continued permit compliance for NEW Water.

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POSTER SESSION

Thursday, March 9, 2017

7:00 – 10:00 p.m.

1. Potential Leaching of Metals from Fly Ash Amended Asphalt

Chelsey Heiden,* University of Wisconsin-Platteville, heidenc@uwplatt.edu
Mike Penn
Chuck Cornett
Hannah Molitor

Fly ash is an abundant by-product of coal combustion. In order minimize waste disposal, options for reuse are being investigated. Incorporating fly ash into pavement materials is one such option, however, fly ash amended asphalts have the potential to release harmful contaminants into drinking water and surface water sources. The leaching potential of heavy metals from asphalt pavement amended with fly ash was measured on asphalt samples of varying fly ash composition by percent weight. Asphalt particles were leached in water adjusted to the pH of rainwater and mixed using an end-over-end rotary tumbler. Metals of environmental concern, such as cadmium, copper, mercury, and zinc, were quantified using the inductively coupled plasma optical emission spectrometer (ICP-OES). The resultant concentrations of metals in the simulated rain water after leaching were then compared to existing background concentrations in rainfall, and to standards established by regulatory agencies for groundwater safety.

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2. Toxicity of Sediment to Benthic Communities in Two Wisconsin Areas of Concern

Barbara Scudder Eikenberry, U.S. Geological Survey, Wisconsin Water Science Center, beikenberry@usgs.gov
John Besser, U.S. Geological Survey, Columbia Environmental Research Center
Hayley Templar, U.S. Geological Survey, Wisconsin Water Science Center
Daniel Burns, U.S. Geological Survey, Wisconsin Water Science Center

Benthic communities have been degraded due to human activities in a number of areas in the Great Lakes. The Beneficial Use Impairment (BUI) designation for the Degradation of Benthos is one of the most widespread BUIs in Great Lakes Areas of Concern (AOCs), areas where significant impairments of beneficial uses have occurred as a result of human activities at the local level. Although this impairment is most often caused by sediment contamination, other factors such as substrate type, inadequate food supply, water chemistry, and river flow may also be important. The Great Lakes Restoration Initiative has enabled accelerated restoration efforts as well as monitoring to evaluate their effectiveness. For benthos, recent sediment quality data are needed to evaluate whether remediation has been successful. In the fall of 2016, the U.S. Geological Survey sampled sediment at 15 sites, including sites in two AOCs and two non-AOC comparison sites along the western shoreline of Lake Michigan. The AOC sites were in the Sheboygan River and the Milwaukee Estuary and the non-AOC sites were in the Manitowoc River and the Root River. Sediment remediation was completed at the Sheboygan River AOC in 2013 and is ongoing in the Milwaukee Estuary AOC. Sediment from each site was collected for toxicity tests (amphipod, Hyalella azteca, and midge, Chironomus dilutus) and for chemical analyses (PCBs, PAHs, and selected trace elements) to evaluate whether the sediment at these sites was toxic and if chemical contaminants were present at toxic concentrations. The sediment was also characterized for particle size distribution (among 8 size fractions), total organic carbon, and acid-volatile sulfide. Results from this study will provide information about sediment toxicity and chemistry in the AOCs to inform management decisions regarding removal of the “Degradation of Benthos” BUI that is needed for delisting these two AOCs.

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3. Optical Approaches to the Detection of Heavy Metals in Water

Paul Henning, University of Wisconsin-Milwaukee, ehenning@uwm.edu
Joseph Labeots, University of Wisconsin-Milwaukee
Peter Geissinger, University of Wisconsin-MIlwaukee

The presence of heavy metals in environmental waters may pose a grave threat to public health. Many industries discharge process water into the environment after appropriate treatment. Yet, a technology capable of continuous real-time measurement of the concentrations of multiple metal ions in discharge water has not been available; current methods rely on sampling and subsequent analysis off-line in a laboratory.

Metals in water can be monitored optically if suitable sensor molecules are available. While at first glance an ideal optical sensor should be required to be specific and only respond to one target analyte, this property may restrict continuous measurement capabilities. Hence, we have taken two separate approaches that utilized “imperfect” sensors for measuring metal concentrations in water.

First, optical sensors that bind to multiple metal ions and generate a unique absorbance response can be combined into an array. A multivariate data-mining approach from chemometrics can be used to build a predictive model of the array response. This model can be subsequently used with the array to quantify simultaneously multiple metals in an aqueous sample.

The second approach examines the fluorescence lifetime of existing sensors. The fluorescence lifetime is an intensity-independent quantity and does not require periodic recalibration, which is a key benefit for optical sensing. We have found one sensor that exhibits steady-state fluorescence quenching by many metals, but also exhibits a “lifetime-based selectivity” for copper and cobalt.

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4. Sources and Sinks for Phosphorus in Stormwater Through a Pond-Prairie System

Elizabeth Buschert,* University of Wisconsin-Madison, buschert@wisc.edu
Anita Thompson, University of Wisconsin-Madison
Zach Zopp, University of Wisconsin-Madison

Phosphorus in stormwater is an ongoing management problem in urban areas. The University of Wisconsin-Madison Arboretum is dedicated to research and restoration, but by virtue of its location (downslope from urban developments and adjacent to Lake Wingra) it has had to manage the impact of increasing stormwater flows. Curtis Pond, a detention pond in the Arboretum, was designed to slow and treat stormwater discharge from several residential neighborhoods and a portion of highway. Effluent from the pond flows overland across portions of the restored Curtis Prairie before joining several other flow streams in an intermittent creek that flows into Lake Wingra. Previous monitoring through this system indicated that dissolved reactive phosphorus concentrations were sometimes higher in water leaving Curtis Prairie than concentrations leaving Curtis Pond. Since phosphorus sorption/desorption from soils and sediments can play a role in dissolved phosphorus levels, this study aims to quantify: (1) spatial and temporal variations in storm event phosphorus in the pond-prairie system and (2) the potential for pond sediments and prairie soil to affect phosphorus in stormwater. In 2016, concentrations of total phosphorus, dissolved reactive phosphorus, and total suspended solids were measured for eight storms at the inlet and outlet of the pond, and at the point where overland flow leaves the prairie. In addition, soil samples from three locations in the prairie and two locations in the pond were collected to be analyzed for equilibrium phosphorus concentrations (EPC0). Sediment and soil EPC0 will be compared to dissolved reactive phosphorus concentrations in stormwater to evaluate potential phosphorus sources and sinks in the system.

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5. Uranium Concentrations in Central Wisconsin Groundwater and Their Relationship to Groundwater Chemistry

Paul Mcginley,* University of Wisconsin- Stevens Point, awick597@uwsp.edu
Andrew Wick, University of Wisconsin- Stevens Point
Nick Salewski, University of Wisconsin- Stevens Point

Uranium is a naturally occurring element in the environment that can occur in groundwater at concentrations above the drinking water standard. Uranium has toxic effects when consumed by humans at concentrations above the MCL of 30 ppb. When ingested it attacks the kidneys causing acute kidney failure and possibly cancer. Very little is known about what controls uranium concentrations in groundwater.

The concentration of uranium in groundwater may be related to the overall chemistry of groundwater. Uranium is found in the granite rich bedrock throughout the state of Wisconsin. Past research has pointed to evidence of granite bedrock having higher concentrations compared to other types of bedrock. Excess amounts of nitrate from agricultural fertilizers and other sources can penetrate the soil and enter the groundwater, potentially increasing the amount of uranium that is released into the groundwater.

This study is examining uranium and nitrate concentrations from wells in Central Wisconsin in areas where uranium and/or elevated nitrate has been detected in groundwater. In addition to uranium and nitrate, samples will be analyzed for pH, conductivity, chloride, alkalinity, and metals to further characterize the water chemistry of these areas. We have received preliminary results that indicate high levels of nitrates and uranium in multiple tests sites. Further results will be used to evaluate the spatial and geochemical relationships between uranium and nitrate. The results of this study will address the implications for household water treatment, and will be used to develop information for homeowners, municipalities and well drilling contractors in these regions regarding uranium and other elements of emerging concern in private water wells.

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6. Influence of Freezing and Thawing on Soil Aggregate Dynamics and Sediment Detachment.

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

Rising atmospheric temperatures are predicted to reduce Northern Hemisphere snowfall and snowpack formation potentially increasing the severity and frequency of ground freezing events. This research investigates the effects that increased freeze-thaw cycles may have on soil aggregate stability, a property critical to erosion resistance. Laboratory studies indicate that freeze-thaw cycles generally cause aggregate disruption resulting in smaller and more easily detached particles, however, field studies investigating the mechanisms involved in over-winter aggregate dynamics are lacking. A three-year winter field study was designed to test the hypothesis that increased freeze-thaw cycles resulting from reduced snowpack formation will disrupt soil aggregates. Furthermore, aggregate disruption will leave the soil more susceptible to detachment during the erosion process. The experiment included 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. Soil wet-aggregate stability, dry mean weight diameter, and degree of aggregation using laser diffraction were measured throughout the experiment as well as soil temperature and volumetric moisture content. A cohesive strength meter was used to estimate in situ soil critical shear stress, a proxy for sediment detachment during erosion. Results of this study may help inform soil erosion models such as the Water Erosion Prediction Project (WEPP).

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7. Soil Moisture and Plant Root Distribution Influence on Root Water Uptake in Prairie, Forest, and Corn

Allison C. LoBue,* University of Wisconsin-Madison, Department of Biological Systems Engineering, alobue@wisc.edu
Eric G. Booth, University of Wisconsin-Madison, Department of Agronomy & Department of Civil and Environmental Engineering
Steven P. Loheide II, University of Wisconsin-Madison, Department of Civil and Environmental Engineering

The influence of plant root distribution and soil moisture on root water uptake in-situ is often poorly understood, resulting from difficulty in characterizing the precise plant root distributions and the effects of environmental properties, including soil characteristics and hydrologic relations. Traditional plant root analyses often disturb or impair the roots, leading to biased root growth monitoring and collocated soil moisture dynamics. The objective of this study is to design and implement a nondestructive technique to analyze plant root structure and simultaneously monitor soil moisture at four depths for a better understanding of root water uptake. Our procedure involved collecting images of the soil wall of augured holes and developing a computer program to estimate plant root density. This method was implemented at six sites within the Yahara River Watershed, comprising prairie and forest ecosystems and verified with the traditional method of hand examined soil cores. Continuous soil moisture data collected from prairie, forest, and corn field sites between the years 2012 and 2015 at depths 10cm, 35cm, 65cm, and 125cm were analyzed using a new computer program to identify periods of drawdown during the growing seasons. The correlation between periods of drawdown at multiple depths and root density in varying ecosystems allow for a more conclusive understanding of root water uptake.

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8. An Overview of the 2016 Chippewa County Groundwater Quality Inventory

Kevin Masarik, UW-Extension & UW-Stevens Point, kmasarik@uwsp.edu
Amy Nitka, UW-Stevens Point
Dan Masterpole, Chippewa County Land Conservation & Forest Management Department
Brewster Johnson, UW-Stevens Point
Sean Piette, UW-Stevens Point

Chippewa County has been a leader in well and groundwater monitoring. The county conducted extensive well water sampling in both 1985 (715 wells) and 2007 (800 wells) which established baseline data on nitrate-nitrogen, chloride, pH and total hardness. Chippewa Land Conservation and Forest Management Department worked with the UW-Stevens Point and UW-Extension to conduct another groundwater inventory in 2016. Recruitment mailings targeted homeowners that participated in the 2007 sampling event; 508 out of 800 submitted samples. Additional recruitment letters were sent to residences with Wisconsin Unique Well Numbers. In total 756 Chippewa households submitted samples for the 2016 inventory.

The most recent inventory included parameters such as nitrate-nitrogen, chloride, pH, and total hardness which were measured previously. In addition, alkalinity, arsenic, calcium, copper, iron, potassium, magnesium, manganese, sodium, total phosphorus, lead, sulfate, and zinc were also collected and allow for additional characterization of the groundwater in Chippewa County.

Current and previous data was used to characterize water quality of the county's three primary aquifer categories: sand/gravel, Cambrian era deposits or crystalline bedrock. The nitrate-nitrogen results were of particular interest for investigating relationships between land-use, geology and groundwater quality. Comparisons between 2016, 2007 and 1985 datasets were performed to understand whether groundwater quality has changed over time and where within the county changes were most pronounced.

The routine and systematic monitoring of well water quality by Chippewa County is unique amongst Wisconsin counties and serves as a template for others looking to establish baseline data and provide a framework for investigating changes over time.

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9. Summer Applied Hydrogeology Course at the University of Wisconsin-Parkside Campus, Kenosha, Wisconsin: A Positive Outcome of the UW-System Budget Cuts

John Skalbeck, University of Wisconsin-Parkside, skalbeck@uwp.edu

GEOS 465: Applied Hydrogeology was offered during Summer terms in 2014 and 2016 (previously offered during alternating Fall terms since 2002) in response to budget cuts at the University of Wisconsin-Parkside. The four week summer term, which met daily, allowed for more concentrated student engagement relative to the traditional 15 week semester term. Some interesting and surprising hydrologic characteristics were observed during this intensive hands-on learning experience.

A network of shallow monitoring wells on campus allows for hydrogeologic investigation of the 100-foot thick Holocene glacial moraine (Oak Creek and New Berlin Formations) overlaying Silurian dolomite of the Racine Formation. These two till formations consist primarily of clay separated by a sand lens forms a shallow confined aquifer. Clay separates the shallow confined aquifer from the deep confined aquifer consisting of a sand/gravel layer above the dolomite.

Standard hydrogeologic characterization activities included: water-level monitoring, preparation of cross-sections from borehole logs, and aquifer analysis using slug and pumping tests. The class prepared a consulting style report summarizing study results and each student participated in an oral presentation of the report.

Reverse drawdown (increasing water levels) in shallow wells observed during drawdown from pumping the deeper well documents the Noordbergum effect at this site. The Noordbergum effect is a response to the decrease in pressure in the layered aquifer system from the drawdown of the water level in the pumping well screened in the deeper aquifer. The pressure decline is transferred quickly to the shallow aquifer which squeezes the aquifer and results in an observable rise in water level in the shallow aquifer.

An elevated potentiometric surface beneath the campus buildings has been observed since the installation of the monitoring well network. Water-level monitoring for a two-week period using pressure transducers in a well near and a well away from the campus buildings along with stage height at the USGS Pike River gaging station (proxy for precipitation) provided data to assess the possibility of artificial recharge from the buildings. Students constructed a simple spreadsheet groundwater flow model to simulate the potential recharge from the buildings.

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10. Using Nitrate Source Analysis to Understand Groundwater Quality in Chippewa County

Amy Nitka, UW-Stevens Point Water and Environmental Analysis Lab, anitka@uwsp.edu
Kevin Masarik, UW-Stevens Point & UW-Extension
Dan Masterpole, Chippewa County Land Conservation & Forest Management
Brewster Johnson, UW-Stevens Point
Sean Piette, UW-Stevens Point

Chippewa County has a unique historical set of groundwater quality data. The county conducted extensive groundwater sampling of private wells in 1985 (715 wells) and 2007 (800 wells). In 2016, they collaborated with UW-Extension and UW-Stevens Point to evaluate the current status of groundwater quality of Chippewa County by sampling of as many of the previously studied wells as possible. Nitrate was a primary focus of this groundwater quality inventory. Of the 750 samples collected, 60 were further analyzed for chemical indicators of agricultural and septic waste, two major sources of nitrate contamination. Wells for nitrate source analysis were selected from the current 2016 participants based upon certain criteria. Only wells with a Wisconsin Unique Well Number were considered. Next, an Inverse Distance Weighting tool in ESRI ArcMap was used to assign density values. Two-thirds of the wells were selected in higher density areas and one-third in lower density areas. Equally prioritized was an even distribution of nitrate – N concentrations, with half of the wells having nitrate – N concentrations higher than 10 mg/L and about half with concentrations between 2 and 10 mg/L. All wells with WUWN and nitrate – N concentrations greater than 20 mg/L were selected. The results of the nitrate source analyses will aid in determining temporal changes and spatial relationships of groundwater quality to soils, geology and land-use in Chippewa County.

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11. Hydrogeologic Characteristics of Surface Water and Groundwater Flow in the Albion Basin, Alta, Utah

Nicholas Potter,* University of Wisconsin Parkside, potte016@rangers.uwp.edu
John Skalbeck, University of Wisconsin Parkside

The University of Wisconsin Parkside has partnered with the Friends of Alta on a hydrologic investigation of Albion Basin since 2005. This long-term annual study is conducted to gain a further understanding of an alpine wetland system and provide data to utilize in the future planning and management of this watershed. Albion Basin contains several alpine wetlands and is located at the headwaters of Little Cottonwood Creek in the Wasatch Mountains approximately 20 miles southeast of Salt Lake City. Four wetland study areas have been established to characterize the hydrologic setting of the Albion Basin. These wetland study areas include: Catherine's Pass, Collins/Sugarloaf, Albion Basin Fen, and Patsy Marley. Monitoring data collected includes: automated water levels from Levelogger pressure transducers, manual water levels from an electronic sounder, field water quality parameters (temperature, pH, EC), and water chemistry from a certified laboratory. Water samples are collected from springs, surface water, and piezometers. Water chemistry analysis has been useful in characterizing the source of water for each wetland study area.

In 2013 a spring study was initiated to map source water location and access the water balance at each wetland study area. Spring mapping was conducted using a survey caliber Trimble GPS and ArcMap GIS software. Spring flow measurements were collected from temporary earthen weirs to then fill a container of known volume and timed with a stopwatch. Within each wetland study area, the inflow and outflow rates were evaluated to access groundwater baseflow and recharge. The summation of inflow springs compared to the outflow spring provides an estimate of the water balance at each wetland study area. Positive water balance is attributed to baseflow and negative water balance is considered groundwater recharge. Understanding this groundwater element allows for greater deductions of the subsurface geology and

understanding of alpine wetlands. This alpine wetland study provides insight into a vital drinking water resource for Salt Lake City. Long-term monitoring also allows for better understanding of alpine wetlands like Albion Basin and helps inform educated decisions for protecting, developing, or restoring sensitive environments like the beautiful recreation area of the Albion Basin.

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12. Spatial and Temporal Variation in Sediment and Phosphorus in Green Lake's Wetland Ecosystems

Sarah Fuller,* UW-Madison, sfuller3@wisc.edu
Anita Thompson, UW-Madison

Green Lake, Wisconsin's deepest natural inland lake, is located in the center of the state within a predominately agricultural watershed. The lake and its major tributaries are listed as impaired under the Clean Water Act because of high phosphorus and sediment loads. Two wetland systems, Silver Creek Estuary and County K Marsh, are the primary inputs to the lake and differ in their biological communities. County K Marsh is algae dominated with little vegetation because of high carp density, while Silver Creek Estuary has become macrophyte dominated since carp were excluded over a decade ago. However, carp removal and macrophyte restoration are beginning in County K Marsh. The goal of this research is to use existing USGS and WDNR monitoring data combined with additional water quality measurements to: (1) characterize sediment and phosphorus variation within and between these two wetland systems and (2) evaluate whether they serve as phosphorus sinks or sources. Water samples were collected monthly (July – October) in 2016 at 7 locations in County K Marsh and at 5 locations in Silver Creek Estuary and analyzed for TSS, TP, DP, and TN. Results from 2016 along with historic data will be presented and discussed. Monthly water sampling and analysis will continue in 2017 (April – October). These data will also be used to evaluate the effect of initial restoration efforts in County K Marsh. Results will lead to a better understanding of how sediment and phosphorus enter Green Lake and will enable informed management decisions.

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13. Developing Restoration Concepts for the lower Kinnickinnic River, Milwaukee, WI

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The lower Kinnickinnic River in Milwaukee, WI, has been identified by the Milwaukee Metropolitan Sewerage District (MMSD) as a priority site for restoration. The project reach, between I-94 and Chase Ave., is severely impaired and acts as a barrier to ecological connectivity between the Milwaukee Estuary and restored portions of the Kinnickinnic River upstream due to extremely low summertime dissolved oxygen levels (below 2 mg/L). Low oxygen levels are not atypical of the geomorphic setting (drowned river mouth), but the problem has been intensified by historic dredging, loss of baseflow, and high oxygen demand of incoming flow. Additionally, residence times within the lower Kinnickinnic River are consistently prolonged due to cyclical seiche effects that propagate upriver from Lake Michigan and the Milwaukee Estuary.

Working for MMSD, Montgomery Associates: Resource Solutions (MARS) and a diverse team of project partners developed restoration design alternatives to address impairment within the lower Kinnickinnic River. These designs sought to reduce the dissolved oxygen impairment to an acceptable level while promoting more diverse and resilient habitat within the reach. The creation and evaluation of three different designs will be presented, and will be accompanied by a discussion on the challenges of working in a system that is both highly-constrained (regulatory floodplains, legacy pollutants, urban hydrology and infrastructure) and unpredictable (fluctuating Lake Michigan levels).

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14. Establishing Background Metals Concentrations in Surface Water and Groundwater in Western Wisconsin

Carly Mueller,* University of Wisconsin - Eau Claire, muelleca4376@uwec.edu
Samantha Bartnik, UWEC
Melissa Hackenmueller, UWEC
Adam Wiest, UWEC
J. Brian Mahoney, UWEC
Stephen Sellwood, UWEC

The primary objective of this investigation is to conduct the first comprehensive analysis of surface water and groundwater chemistry throughout western Wisconsin. This analysis will establish an environmental baseline that documents background variations in dissolved metal concentrations in surface water and groundwater throughout the region. The study area encompasses a large portion of western Wisconsin in the northeastern upper Mississippi River watershed. This geographic area closely aligns with the distribution of silica sand mines in western Wisconsin. Establishment of baseline water chemistry in this region is needed to assess the potential impacts of silica sand mining.

Surface water samples have been collected from streams throughout the study region. Groundwater samples have been collected from municipal water supply wells in the region tapping a variety of aquifers. Surface water and groundwater sampling locations are distributed to assess the spatial variability of water chemistry within the study area as well as the variability of groundwater chemistry in multiple aquifers. All samples are analyzed by high-resolution inductively-coupled mass spectrometry (HR-ICPMS) for a list of approximately 20 metals.

Preliminary results indicate surface water and groundwater in western Wisconsin contain relatively low values of most trace metals, commonly 1-2 orders of magnitude below EPA drinking water standards. Major element chemistry indicates that the bedrock geology is a first order control on water composition, with higher levels of Fe, Ti, and V proximal to Proterozoic bedrock, and higher levels of Ca, Mg, and Ba adjacent to Paleozoic carbonates.

Future work will include surface water and groundwater sampling at additional locations to further assess the geographic distribution of dissolved metals. In addition, we plan to complete repeat sampling at all sampling locations to begin to assess temporal variation of dissolved metal concentrations. Whole-rock geochemistry is being assessed in samples of bedrock form the region to further understand the geologic controls on metals in groundwater and surface water. Finally, sequential extraction geochemistry is necessary to evaluate the mobility of metals from geologic formations into surface water and groundwater.

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15. Identifying Nitrate Retention and Denitrification Hot Spots at the Groundwater-Surface Water Interface in Streams of the Central Sands.

Robert Stelzer, University of Wisconsin Oshkosh, stelzer@uwosh.edu
Thad Scott, Baylor University

Groundwater nitrate concentrations are elevated in many regions of the world, including central Wisconsin, which can cause human health problems and deleterious ecological impacts. Groundwater-surface water ecotones present opportunities for nitrate removal and retention because changes in organic carbon availability, redox potential and nitrate demand often occur at these locations.

We sought to identify spatial variation in nitrate retention and denitrification in shallow groundwater associated with streams in the Central Sands of Wisconsin, towards the ultimate goal of predicting the locations of nitrate removal hot spots. We were particularly interested in the role of groundwater discharge rate on nitrate transformation capacity at the patch scale. We predicted that groundwater nitrate removal will be optimized at intermediate rates of groundwater discharge, where microbes are exposed to suitable redox conditions for nitrate reduction and where groundwater delivers a moderate supply of nitrate to reaction sites. Three study sites were chosen that spanned an order of magnitude in groundwater nitrate concentration (2 to 20 mg NO3-N/L) and multiple counties in Central Wisconsin. About 25 piezometers were installed at each site. Groundwater discharge was estimated by applying Darcy's Law to measurements of vertical hydraulic gradient and hydraulic conductivity at each piezometer location. Nitrate and N2 concentrations were measured at discrete points along 60 cm groundwater flow paths in shallow sediments at the piezometer locations. Nitrate retention and denitrification rates were quantified by determining how nitrate and N2 fluxes changed along the flow paths. Nitrate retention occurred at about 30-50% of the piezometer locations and was related to groundwater nitrate and dissolved oxygen concentrations. Unexpectedly, denitrification did not always track nitrate retention. Preliminary results suggest that the influence of groundwater discharge rate on nitrogen transformation was site specific.

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16. Natural Groundwater Contamination Potential of Trace Metal-Bearing Sulfides in Tunnel City and Wonewoc Sandstones in Western and South-Central Wisconsin

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Mike Parsen, Wisconsin Geological and Natural History Survey, UW Extension

Degradation of groundwater quality by naturally-occurring trace metal contaminants is an ongoing concern for municipalities and private well owners in Wisconsin. A recent study by the Wisconsin Geological and Natural History Survey (WGNHS) examined the potential of the sandstone-dominated Cambrian Wonewoc Formation and Tunnel City Group to be sources for natural groundwater contaminants in west-central, southwestern, and south-central Wisconsin (WC, SW, and SC WI, respectively).

The WGNHS study identified the presence of oxygen sensitive trace metal-bearing sulfides, such as pyrite, in both units across the western portion of the state. Pyrite oxidation can occur at places where the water table fluctuates across the sulfide interval, and any trace metals present could therefore become mobilized and impact groundwater quality. To characterize this potential source of groundwater contamination, we have compiled a data set of over 100 wells from the WGNHS subsurface database to examine the relationship between the Tunnel City-Wonewoc contact and the water table across WC, SW, and SC Wisconsin.

While our results suggest that pyrite oxidation is generally not of concern in SW WI, where the geologic units of interest are typically 400 feet or more below the water table, it is of concern in WC and areas of SC WI where the contact interval is within 200 feet or less of the water table and contain trace metal-bearing sulfides. In general, the potential for poor water quality resulting from the oxidation of these rocks is greatest in WC WI, for example near La Crosse, where the Tunnel City-Wonewoc interval is close to the water table and hosts metal-bearing sulfides. However, parts of SC WI are of lesser concern, such as Dane and Columbia counties, where the Tunnel City-Wonewoc interval is close to the water table but hosts few metal-bearing sulfides. The results from this study will be useful for identifying regions in western and south-central WI where the Tunnel City-Wonewoc interval may be a source for naturally-occurring trace metal contaminants in the groundwater.

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17. Remote Measurement of Nearshore Waves Using a Single Camera

Erin Zimmerman,* University of Wisconsin -- Madison, emzimmerman2@wisc.edu

Nearshore wave measurements offer a number of potential uses for engineers, small vessels, and the public. Understanding the conditions near the coast is crucial for coastal construction, ship navigation, and safety concerning recreational water activities. Currently, wave wire gauges and subsurface pressure transducers are commonly used for wave measurements. While these methods provide accurate measurements, they require labor effort in deployment and maintenance. Hence, remote wave measurements using imaging is a promising tool. There are several studies on the use of imaging for wave heights; however, most techniques involve stereo-photogrammetry which requires at least two different perspectives. These two perspectives need to be precisely synchronized, requiring extra efforts in calibration and intensive image processing. In this study, a single camera monitoring a buoy is used to determine nearshore wave heights. A single camera and buoy is advantageous to previous techniques because it lacks the maintenance required for in-situ sensors and eliminates some of the issues that accompany stereo-imaging techniques, such as mismatch between images. This method is achieved using photogrammetry and additional information from the buoy. The ring of the buoy is equipped with three equally spaced balls, forming the shape of an equilateral triangle. The distance between the three balls is known, therefore offering three constraints. With the direct linear transformation (DLT) equations from photogrammetry and three constraints, there is sufficient information to obtain a true position from an image point. The success of this method allows wave heights to be measured off the shore of McKinley Beach in Milwaukee, a site of potential rip currents. Monitoring wave heights at this location offers an advantageous method to obtain wave measurements and provides observation data for rip current studies.

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18. Assessment of Data Frequency Requirements for Continuous Water-Quality Monitoring Stations

Mitch Olds, Milwaukee Metropolitan Sewerage District (MMSD), molds@mmsd.com
Beth Sauer, MMSD
Matt Maccoux, MMSD

The Milwaukee Metropolitan Sewerage District (MMSD) maintains 16 permanent continuous water quality monitoring stations on the Milwaukee River, Menomonee River, Kinnickinnic River, Root River, Underwood Creek, Cedar Creek and Honey Creek. Starting in the late 1990's, these stations were built to monitor ambient water quality as well as the influence of MMSD operations and projects on the waterways. Continuous water-quality monitoring stations capture dissolved oxygen, turbidity, temperature, and specific conductance measurements on 5-minute intervals 24/7.

The MMSD continuous water quality monitoring stations reside in a complicated urban environment with high susceptibility to biofouling, vandalism, reverse estuary flows, and multiple sewer influences. The data can be noisy, require significant data editing, and hard to interpret. MMSD now faces the challenge of maintaining multiple massive databases and housing them on dedicated servers. One method of reducing the overwhelming number of data points is to alter the data collection frequency while continuing to collect a comprehensive data set. After investigating the probable impacts from changing the data frequency, it was ultimately decided that the stations would switch from a 5-minute interval to an hourly interval. One concern is the inadvertent censoring of the data. The hope is that hourly intervals would lead to a cleaner looking data set knowing that it would also lead to a longer blind spot between data points. Ultimately, we are exploring what frequency of data collection is needed and how to evaluate that with a wide range of needs at MMSD including research, modeling, public viewing, and internal decision making.

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19. An Evaluation of the Zooplankton Community at the Sheboygan River Area of Concern

Hayley Templar, U.S. Geological Survey, htemplar@usgs.gov
Barbara Scudder Eikenberry, U.S. Geological Survey
Daniel Burns, U.S. Geological Survey

The Great Lakes Areas of Concern (AOCs) are considered to be the most severely degraded areas within the Great Lakes basin, as defined in the Great Lakes Water Quality Agreement of 1972 and amendments. There are 43 designated AOCs, four of which are Lake Michigan AOCs in the state of Wisconsin. The smallest of these watersheds is the Sheboygan River AOC, which was designated as an AOC due to sediment contamination from PCBs, PAHs, VOCs, and heavy metals. The Sheboygan River AOC has nine of 14 possible Beneficial Use Impairments (BUIs), which must be addressed to improve overall water quality, and to ultimately de-list the AOC. One of the BUIs associated with this AOC is the degradation of phytoplankton and zooplankton populations, which can be removed from the list of impairments when it has been determined that the plankton communities at the AOC do not differ significantly from communities at non-AOC comparison sites (non-AOCs). In 2012 and 2014, the U.S. Geological Survey collected plankton community samples at the Sheboygan River AOC as part of a larger Great Lakes Restoration Initiative study evaluating both the benthos and plankton communities in all four of Wisconsin's Lake Michigan AOCs. Although neither phytoplankton nor zooplankton were found to be significantly degraded in the Sheboygan River in 2012, preliminary results from the 2014 data indicate that zooplankton diversity was degraded in 2014 compared to the Manitowoc and Kewaunee Rivers, two non-AOCs of similar size and land use. As a follow-up to the 2014 results, zooplankton samples were collected at the same locations in the AOC and non-AOCs during three sampling trips in the spring, summer, and fall of 2016. Relative abundance, taxa richness, and diversity were compared between the AOC and non-AOCs to determine if the zooplankton community in the Sheboygan River AOC is significantly different than those in the non-AOCs. The results from this study will be used by the Wisconsin DNR and the EPA to monitor future progress, as well as determine if restoration efforts have been effective to remove the plankton BUI.

* * *

20. Flood Forecasting by the National Weather Service

Sarah Marquardt, NOAA National Weather Service, sarah.marquardt@noaa.gov

The National Weather Service uses a variety of data and forecast tools to monitor flooding and flash flooding. We partner with other organizations to monitor river levels for input to our river forecast model, which then takes forecast precipitation to make river stage forecasts. We have a flash flood monitoring program that takes into account soil moisture, observed and forecast precipitation. This allows us to monitor basins that are susceptible to flash flooding.

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21. Geochemical and Mineralogical Characterization of the Mount Simon Aquifer Sandstones in Trempealeau County, Wisconsin

Jay Zambito, Wisconsin Geological Survey, UW-Extension, jay.zambito@uwex.edu
Lisa Haas, Wisconsin Geological Survey
Erin Niemisto, UW-Madison
Ethan Heyrman, UW-Madison
Mike Parsen, Wisconsin Geological Survey

Understanding baseline water quality in areas of land-use change is essential for evaluating environmental impacts. As a result, the Wisconsin Geological and Natural History Survey (WGNHS) receives numerous requests for historical information about surface and groundwater quality in areas near industrial sand mines and related facilities. In Trempealeau County, the geographic center of industrial (frac) sand mining in Wisconsin, an extensive baseline water quality dataset collected prior to the onset of mining does not exist. However, the WGNHS maintains well cutting samples from a majority of municipal and other high-capacity wells in the county. These wells are typically located in valleys floored by the Eau Claire Formation and draw water from the underlying Mount Simon Formation sandstone aquifer. Water quality tests detecting metals or other contaminants which are not naturally present in the aquifer (as determined from analysis of well cuttings), might suggest groundwater contamination from nearby mining, agricultural, or other human activity. Therefore, geologic characterization of well cuttings can serve as a proxy for baseline water quality.

In this study, we present preliminary data on the lithology, geochemistry, and mineralogy of rock cuttings collected during drilling of ~40 municipal and high-capacity wells through the Eau Claire and Mount Simon from across Trempealeau County. Elemental analysis using pXRF on all samples, and hi-resolution ICP-MS on select samples, provides the composition of metals present in the aquifer rocks. Mineralogical analysis using XRD provides an understanding of the mineral phases within which these elements are incorporated, and their susceptibility to be mobilized into groundwater. Minerals that are relatively inert under oxidizing conditions are less concerning for water quality than minerals like trace metal-bearing sulfides. Our data suggests that in general, low concentrations of trace metals and rare sulfides are characteristic of the Mount Simon sandstone. However, some samples have high concentrations of trace metals, on the order of ~100ppm, and should be investigated further both geochemically and mineralogically.

* * *

22. Ra Source Characterization in the Cambrian-Ordovician Aquifer Through Isotopic and Geochemical Study

Madeleine Mathews,* University of Wisconsin, Madison, mmathews2@wisc.edu
Madeline Gotkowitz, Wisconsin Geological and Natural History Survey
Matthew Ginder-Vogel, University of Wisconsin, Madison

The objective of this study is to determine geologic sources of radium in the Midwestern, Cambrian-Ordovician sandstone aquifer through analysis of aquifer solids and groundwater chemistry. The United States Environmental Protection Agency (EPA) has set a maximum contaminant level of 5 pCi/L for combined 226Ra and 228Ra in public water supplies, due to an increased risk of cancer associated with long-term exposure to radium. Potential sources of 226Ra and 228Ra, and their parent elements uranium and thorium, include coatings on sand grains, minerals within interbedded, fine-grained siltstone and shale, or deep brines originating from the Michigan basin. To evaluate these sources and subsequent transport of dissolved radium to wells, we sampled twenty-two monitoring wells completed in various hydrostratigraphic units within the Cambrian-Ordovician aquifer. The wells are located near municipal wells which provide drinking water to the city of Madison, WI. Each sample was analyzed for radium isotopes, as well as major anions and cations by ICP-OES and IC. Additional phases of this project will include analysis of well cuttings or core by x-ray spectroscopic techniques to characterize solid-phase geochemistry. These aqueous and solid-phase data will be used to develop a geochemical model of radium release from aquifer solids under the prevalent pH and redox conditions in the sandstone aquifer. If successful, insights from this study will be useful for remediating wells with elevated radium and optimizing design of new municipal wells to avoid radium-enriched groundwater.

* * *

23. Bioremediation of Heavy Metal Contamination Using Inactivated Algal Biomass

Cora Rolfes,* Ostfalia University, c.rolfes@ostfalia.de
Carmen Genning, Ostfalia University
Hedda Sander, Ostfalia University

Environmental pollution with heavy metals can cause health problems for humans and animals by its toxic impact. The concentration of heavy metals can enrich through the steps of the food chain, leads to discoloration in plants and bone diseases, like osteoporosis, but also has a narcotic effect on the central nervous system up to death. Since conventional decontamination methods, like dragging the sludge out of the lake and treating it with strong acid, for aquatic systems contaminated by former mining activities, are mostly expensive and challenge the environment by changing the composition of the soil and lake water, bioremediation using microalgae emerges as a cost efficient alternative option.

Studies with endemic Chlorophyta species present evidence, that microalgae like Chlorella vulgaris can uptake heavy metals from contaminated liquid media. The algal cells were cultivated over a time of 15 days in a light incubator and under controlled conditions (8000 lux, 28°C, 14/10 L/D rhythm and aeration of 10 L/h, initial pH 5) and in ES media contaminated with Arsenic, Cadmium, Mercury (30 µg/L each) and Lead (300 µg/L). The selected concentrations were close to maximum values found in the river Oker in Germany, with contamination derived from former mining activities and accumulating in sludge and lake sites.

The microalgal cultures can remediate heavy metal contamination by solved cation uptake and storage within the cell vacuoles where the heavy metals are innoxious for the algal cells. Uptake of Chlorella vulgaris cultures after 15 days was Cd (65 %) > Hg (37 %) > Pb (18,8 %) > As (9 %). Biosorption by inactivated algal biomass is even faster (within 10 minutes of contact) than the uptake into living cells. Experiments with Chlorella vulgaris powder show that the uptake rates are comparable to those of activated carbon. Heavy metal uptake after 20 hours contact time and a mixing of 200 rpm the heavy metal uptake is depicted below in table 1 (HM= Heavy MEtal, U= Uptake, p5=ph%, p7 = pH7, AC= Activated Carbon, CV=Chlorella vulgaris).

	HM Start Conc.[µg/l]	UCV-P5 [µg/l]	UAC5[µg/l]	UCV-P7[µg/l]	UAC7[µg/l]
Lead	300	236	247	175	198
Arsenic	30	14	15	0,2	10
Cadmium	30	23	10	19	14
Mercury	30	4,4	6,3	0,2	1,2

Thus the experiments will aim to create a filter module consisting of algal biomass that can be used in contaminated waterbodies, industrial and mining wastewaters. Five species (Arthrospira platensis, Chlorella vulgaris, Desmodesmus armatus, Tetraerdon minimum, Volvox globator) endemic to temperate climates are investigated at present in order to find an ideal mix for bioremediation purposes.

Session 3A:
Water Quality
Friday, March 10, 2017
8:30- 9:50 a.m.

Predicting Daily Total Phosphorus and Suspended Solids Across Wisconsin Stream Reaches for Impairment Assessment

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Matthew Diebel, Wisconsin Department of Natural Resources

Two critical drivers of poor water quality in Wisconsin streams are total phosphorus (TP) and total suspended solids (TSS), yet measurements of TP and TSS are spatially and temporally biased, creating difficulties in assessing stream condition and evaluating TP and TSS's impacts on stream biota. Recent advances in high-resolution stream and weather data enable modeling of daily TP and TSS across Wisconsin stream reaches. We used the WDNR Hydro24K stream database (>160,000 stream reaches, catchments, and contributing areas) to characterize land use, slope, soil, and daily temperature and precipitation for each stream reach, where precipitation is a function of upstream antecedent precipitation and a reach-specific lag effect. We used mixed effects models to predict daily TP and TSS, and extracted several summary statistics from the distributions of predicted values to characterize TP and TSS regimes. We will demonstrate how these summary statistics can be used to complement measured data in assessing the effects of TSS on macroinvertebrate and fish communities, and highlight findings that may inform stream impairment assessments.

* * *

Interacting Effect of Soil Phosphorus and Extreme Precipitation on Surface Water Quality

Melissa Motew,* University of Wisconsin-Madison, motew@wisc.edu
Eric Booth, UW-Madison
Stephen Carpenter, UW-Madison
Xi Chen, Univ. of Cincinnati
Chris Kucharik, UW-Madison

Phosphorus lost from terrestrial soils is a critical source of P to surface waters, where it causes substantial environmental harm. In Wisconsin, climate change is expected, and has begun, to bring an increase in the frequency of extreme precipitation events. Such events may serve as a primary mechanism of P transport within watersheds. As part of a water sustainability project focused on the Yahara Watershed (Yahara2070.org), a set of model simulations was conducted to examine outcomes of water quality in the year 2070. Preliminary analyses of those model runs indicated a synergistic effect between surface soil P concentration and extreme precipitation events on water quality. Here, we investigated this effect more directly by conducting a 2x2 factorial experiment to test the effects of (low/high) average cropland soil P concentration and (low/high) precipitation extremes on lake water quality. Sixty-year simulations were conducted for each of the four runs, and annual results obtained for average P yield from the landscape,

P load to Lake Mendota, and summertime total P concentration in Lake Mendota. Analysis of the factorial experiment is underway. If a synergistic effect between the two factors is confirmed in the factorial, this will imply that the effects of heavy precipitation on water quality are amplified when soil P is high, i.e. that further accumulation of soil P within the watershed will exacerbate water quality problems in the future as extreme events become more common. A synergy would also imply that lowering soil P could help protect water quality in the face of extreme events. The results of the 2x2 factorial experiment and our conclusions about a possible synergy will be presented during this talk.

* * *

Evaluation of Leaf Removal as a Way to Reduce Nutrients in Urban Runoff

Bill Selbig, USGS - Wisconsin Water Science Center, wrselbig@usgs.gov

The U.S Geological Survey measured the water-quality benefits of a municipal leaf collection and street cleaning program in Madison, WI during the months of April through November of 2014 and 2015. The calibration phase of the study characterized nutrient concentrations and loads from two paired basins without leaf collection or street cleaning. During the treatment phase, street cleaning was done in the test basin by city personnel on a weekly basis from April through September with leaf collection added in October and November. Additionally, prior to each precipitation event, USGS personnel removed as much organic debris from the street surface as reasonably possible. The control remained without street cleaning or leaf collection for the entire monitoring period.

During summer months, street cleaning alone did not significantly decrease the load of nutrients in runoff. Street cleaning in spring and leaf collection in fall was able to remove the increased amount of organic debris from the curb and street surface which resulted in statistically significant reductions in loads of phosphorus (P) and nitrogen (N). Total and dissolved P loads were reduced by 45 and 51 percent in the spring and 84 and 83 percent in the fall, respectively. Similarly, total and dissolved N was reduced by 52 and 44 percent in the spring and 74 and 71 percent in the fall, respectively. In the control basin, 56 percent of the annual P load occurred in fall (winter excluded), the majority of which was dissolved as orthophosphate, compared to only 16 percent in the test basin.

This study suggests a significant reduction of nutrient loads in urban stormwater is feasible when leaves and other organic detritus are removed from streets prior to precipitation events.

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Session 3B:
Groundwater/Surface Water
Friday, March 10, 2017
8:30- 9:50 a.m.

Using a Tracer Approach to Estimate Nitrate Loading to a Shallow Sandy Aquifer Beneath an Agricultural Field.

Jacob Krause,* University of Wisconsin - Madison, jjkrause2@wisc.edu
Madeline Gotkowitz, Wisconsin Geological and Natural History Survey
Michael Cardiff, University of Wisconsin – Madison
Brian Austin, WIsconsin Department of Natural Resources

Nitrate leaching to groundwater beneath fertilized agricultural operations contributes to elevated nitrate concentrations in many of Wisconsin's surficial aquifers. The annual nitrate loading rate depends on many factors including soil properties, weather, plant growth and uptake, nutrient delivery methods, and the timing of nutrient application. Understanding the magnitude of nitrate loading in an area can inform efforts to improve water quality in aquifers used for drinking water supply and can inform efforts to minimize nitrate loss. Quantifying nitrate loading to the water table is technically challenging, and no standard method exists. We are testing the use of a conservative solute tracer for a field-based estimate of the annual nitrate load from a intensively-managed agricultural field.

In order to properly account for a given year's annual nitrate load, we employ a novel tracer approach to differentiate water recharged during the most recent growing season from older groundwater. The method relies on collecting vertical profiles of both tracer and nitrate concentration throughout the upper section of the aquifer. Following the first nutrient application of the 2016 growing season, a bromide tracer solution was injected at the water table, approximately one year's groundwater travel distance up-gradient of a field edge monitoring system. The system includes two multilevel sampling wells with 21 sample ports spaced at 1.5 foot-intervals from just above the water table (~6ft) to 36 ft below ground surface. We assume that more recent groundwater recharge will push the tracer downward so that groundwater flowing above the elevation of the bromide tracer's breakthrough at the multilevels recharged after tracer injection, and groundwater flowing below the tracer recharged prior to tracer injection. This simple conceptual model of flow is appropriate in this case due to the relatively homogeneous aquifer materials present. We use estimates of hydraulic conductivity and monthly measurement of nitrate concentration at the field edge multilevel wells to calculate the nitrate mass that discharged through each monitoring zone. Using the bromide tracer to define the lower bound of recharge from a given year and the water table to define the upper bound, we can account for nitrate discharging across a control plane, summing the monthly estimates to determine the annual loading rate to groundwater. Many commonly accepted agricultural best practices to limit nitrate loss are used at this field, allowing us to evaluate the impact of these practices under the given crop rotation. This presentation will focus on the methodology and early monitoring results and observations from the tracer experiment.

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Potential Change in Groundwater Recharge Around the Madison Lakes Under Alternate Residential Development Scenarios

Carolyn Voter,* UW-Madison, cvoter@wisc.edu
Steven P. Loheide,

It is widely understood that the introduction of impervious surfaces in urban areas generally increases surface runoff and reduces groundwater recharge. It is also now commonly accepted that the amount of effective impervious area (directly connected to the storm sewer system) is a better predictor of surface runoff than total impervious area. However, less is known about the degree to which impervious surface connectivity affects subsurface hydrologic fluxes such as recharge, particularly at regional scales.

Previous modeling work by our group has shown that parcel-scale surface runoff and deep drainage are sensitive to sub-parcel differences in the arrangement and connectivity of impervious surfaces. Using zoning maps and property assessor data, we now map our findings to the Madison Lakes region and explore the degree to which development decisions may affect regional groundwater recharge. These explorations are helpful for framing realistic expectations of what future development may accomplish.

* * *

Fish Farm Groundwater Pumping Impacts On Spring and Stream Flows to Blotz Branch and Dodge Branch Creeks, Dodgeville Wisconsin

Kenneth Wade, Kenneth Wade Consulting LLC, kenneth.wade@tds.net
Larry Larson

The expansion of a commercial fish farming operation in the Dodgeville, Wisconsin area in 2015 was accompanied by an increase in pumping of the facility's six high capacity water supply wells completed within the Cambrian-Ordovician aquifier. Long term residents noted a reduction of stream flows and drying of springs in the vicinity of the facility that appeared to correspond to the seasonal farm groundwater withdrawals. A citizen hydrologic monitoring program was established in 2016 that included intensive measurements of spring and stream flows within the fish farm vicinity. Rainfall measurements and notations of fish farm pumping amounts were also made. The monitoring clearly showed the fish farm groundwater withdrawals resulted in very severe impacts to stream and spring flows in the vicinity of the fish farm operations with complete cessation of spring flow during the periods of greatest pumping. The fish farm's redirection of the locus of greatest pumping farther from the impacted spring area reduced the magnitude of the observed impacts. Rainfall during the monitoring period was much greater than average indicating the pumping impacts would have been much greater during normal or dryer rainfall periods.

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Using Artificial Sweeteners to Trace Subsurface Transport of Wastewater to Groundwater

Madeline Gotkowitz, Wisconsin Geological Survey, mbgotkow@wisc.edu
Curtis Hedman, Wisconsin Sate Lab of Hygiene

Various chemical constituents present in residential and commercial wastewater streams show promise for identifying underlying groundwater systems that have been affected by leaky sanitary sewers or onsite wastewater treatment systems. Transport of sewage within the subsurface environment is of particular interest where groundwater is used for water supply. We evaluated a variety of potential tracers, including artificial sweeteners, pharmaceutical and personal care compounds, and several steroidal hormones, in a heavily-pumped urban groundwater system in Dane County, Wisconsin.

We sampled groundwater from 15 monitoring wells completed at depths ranging from 9.5 to 80.2 m below ground surface and collected a sample of untreated sewage to characterize the presence of compounds of interest in wastewater. Samples were analyzed for 46 pharmaceuticals and personal care products, and four artificial sweeteners. Six of these samples were also analyzed for a suite of steroidal hormones. Laboratory techniques included use of high-performance liquid chromatography-tandem mass spectrometry (HPLC-MS/MS), which provided detection limits for some organic compounds as low as 10-9 g/L. All wells tested were positive for at least one organic compound. Steroidal hormones were present in wastewater but not in groundwater samples. Two artificial sweeteners, acesulfame and cyclamate, were detected in 14 of the 15 monitoring wells, including the deepest of the wells. Carbamazepine and sulfamethoxazole, both prescription medications, were detected frequently but primarily in shallow wells. Overall, the data show the widespread presence of wastewater constituents at significant depths within the groundwater system and suggest that these artificial sweeteners are conservative wastewater tracers in this setting. The public health implications of these findings are not clear, because the concentrations detected were orders of magnitude lower than those in medication and processed foods.

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Session 4A:
Groundwater
Friday, March 10, 2017
10:10- 11:30 a.m.

Estimating Groundwater Availability at a Wisconsin State Fish Hatchery using Flow Models and an Aquifer Pumping Test

Charles Dunning, USGS Wisconsin Water Science Center, cdunning@usgs.gov
Daniel Feinstein, USGS Wisconsin Water Science Center
Anna Grava, University of Milano-Bicocca

The Kettle Moraine Springs State Fish Hatchery, a supplier of critical Lake Michigan fish stock, was the focus of a recent groundwater availability assessment conducted jointly by Wisconsin Department of Natural Resource (WDNR) and the U.S. Geological Survey (USGS). Three MODFLOW groundwater-flow models were used to estimate the water resources available to the hatchery from bedrock aquifers.

Model one was an inset of the published regional USGS Lake Michigan Basin model and was constructed to simulate groundwater pumping from the semi-confined Silurian bedrock aquifer. The groundwater management package of MODFLOW was used to determine withdrawal locations and pumping rates from the Silurian aquifer that best met the specified management objective (maximize withdrawal) and a series of constraints (limited drawdown and stream flow reductions).

Model two was an irregular grid model constructed to represent the confined Cambrian-Ordovician aquifer system and was calibrated to transmissivity and storage values derived from an aquifer pumping test conducted as part of this project. Model two was then used to simulate the local effects of 20 years of groundwater pumping from this deep bedrock aquifer at rates corresponding to potential future hatchery operations.

Model three was a version of the published Lake Michigan Basin model that was modified by refining aquifer parameter values in a 5-mile radius corresponding to the area around the hatchery stressed by the aquifer pumping test. Model three was used to evaluate regional effects of pumping from the confined Cambrian-Ordovician aquifer system, and specifically to test if the effect of deep pumping at the hatchery would be cause for concern at the nearest known well completed in the aquifer.

The WDNR is using the results of these models to plan the future size of hatchery operations as a function of available groundwater.

* * *

Review and Expansion of the Climate Response Network in Wisconsin

Megan Haserodt, U.S. Geological Survey, mhaserodt@usgs.gov
Jason Smith, U.S. Geological Survey
Pete Chase, University of Wisconsin-Extension – Wisconsin Geological and Natural History Survey
Jeff Helmuth, Wisconsin Department of Natural Resources

The U.S. Geological Survey (USGS) and collaborators (Wisconsin collaborators include the Wisconsin Geological and Natural History Survey and the Wisconsin Department of Natural Resources) maintain a network of wells across the country for monitoring the effects of weather and climate on groundwater levels. The Climate Response Network (CRN) is composed of over 600 wells that are a subset of the USGS National Groundwater Monitoring Network, and provides a trusted source of timely, long-term, shallow groundwater conditions across the Nation. Wells selected for the CRN network are completed in unconsolidated deposits or shallow bedrock aquifers, and are located a sufficient distance away from known pumping or artificial recharge influences.

Upgrades were recently made to the eleven existing CRN wells in Wisconsin. These upgrades included well integrity testing, updated elevation surveys, and better online documentation of lithology and well construction details. The existing CRN network only covers eight of the nine climate divisions in Wisconsin. A twelfth well is being considered to provide monitoring coverage in the missing climate division.

Data generated by the network are either real-time or monthly readings, with the goal of eventually having at least one real-time site in all nine climate divisions. The USGS provides data checking and review and serves the data to a publically available database. Network data have been shown to be useful for climate studies, groundwater modeling, drought science, and local environmental projects. The CRN dataset is used by both the public and private sectors and may provide a long-term context of aquifer conditions for shorter term projects. This talk will discuss how to access well data and provide an overview of recent improvements to and expansion of the CRN in Wisconsin.

* * *

Planning for the Next Statewide Inventory of Springs in 2075

Sue Swanson, Beloit College, swansons@beloit.edu
Grace Graham, WGNHS, UW-Extension
Ken Bradbury, WGNHS, UW-Extension
Dave Hart, WGNHS, UW-Extension

The Wisconsin Conservation Department conducted surveys of springs across Wisconsin from 1956 to 1962. Nearly sixty years later, the Wisconsin Geological and Natural History Survey, University of Wisconsin-Extension embarked on a similar effort. If these two inventories are indicative of a recurrence interval for statewide efforts to collect baseline information on discrete points of groundwater discharge, then we shouldn't expect another inventory until around 2075. In the late 1950s, a desire to utilize springs to establish fisheries warranted the statewide effort. As a result, the historical surveys include spring substrate characteristics and ratings of development potential. However, they do not always include spring flow measurements, and spring positions are imprecise. Wisconsin's high capacity well application review process prompted the current inventory. The state now aims to avoid significant adverse environmental impacts to springs with flows of 1 cfs or more. Therefore, information on spring flow and position has become highly desirable. How might data needs shift in the future, and what types of data frameworks will serve the broadest range of possible needs? Without knowing what might prompt another inventory in sixty years, the current one aims to provide comprehensive descriptions of springs including information on location, flow rate, geologic setting, geomorphic setting, and water quality. At the close of the second field season, over 1000 features have been evaluated for potential field visits. Noting that only springs with flows thought to approach 0.25 cfs were surveyed, detailed field descriptions of 364 springs in 48 counties have been recorded. The descriptions allow for summary statistics of properties for all surveyed springs at the time of the inventory, such as mean spring flow (0.98 cfs) and range in flow (0.14 - 18.3 cfs). More importantly, spatial patterns of geologic origin, topographic position, spring morphology, and spring water chemistry are emerging as the inventory progresses. These patterns should help develop or refine questions that are most relevant to certain classes of springs in the state. Prioritization of questions could result in more focused, less expensive, and potentially more frequent surveys. Such an approach may even diminish the need for another comprehensive and costly statewide inventory in sixty years.

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Hydrogeology of Wisconsin's National Forests

Anna Fehling, Wisconsin Geological and Natural History Survey, afehling@wisc.edu
Kenneth Bradbury, WGNHS
Peter Schoephoester, WGNHS
Stephen Mauel, WGNHS
Randall Hunt, USGS
Paul Juckem, USGS

The Chequamegon-Nicolet National Forest (CNNF) in northern Wisconsin contains numerous groundwater-dependent water resources such as streams, lakes, springs, and wetlands. We recently completed a comprehensive analysis of groundwater systems in the Forest, motivated by growing concerns about the potential hydrologic impacts of climate change, new high-capacity wells, mining, and land development. These issues prompted a review and analysis of groundwater in the CNNF in order to improve management of forest resources. This study is the first comprehensive analysis of groundwater ever undertaken in Wisconsin's National Forests.

The project included inventories of all available data and development of regional groundwater flow models to improve the understanding of aquifer characteristics and the groundwater flow regime. Studying the hydrogeology of the CCNF is challenging because much of the area is undeveloped with sparse datasets. Well construction reports and other data were compiled to estimate aquifer thickness and properties. A survey of surface water and groundwater quality across the forest was completed using basic chemistry and stable isotopes. For each of the four contiguous National Forest units in Wisconsin, average annual recharge was estimated using a soil-water balance model and a regional groundwater flow model was constructed using the analytic element model code GFLOW. Model results illustrate the patterns of groundwater flow and, supported by water chemistry analyses, help quantify groundwater contributions to surface-water features. The CNNF supports a wide range of groundwater flow regimes, from shallow flow paths in fractured crystalline rock, to flow paths in heterogeneous glacial deposits with abundant springs, to long flow paths in thick unconsolidated sand and gravel. The results of this study can be used to target areas for restoration, identify areas where more data are needed, and evaluate the effects of future stresses on the groundwater system. The data and tools developed for this project also provide a platform from which to develop site-specific studies in the forest.

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Session 4B:
Urban Stormwater Management
Friday, March 10, 2017
10:10- 11:30 a.m.

Evaluation of Bioswales for Reducing the Quantity of Highway Runoff in Menomonee Falls, WI

Judy Horwatich, USGS, jahorwat@usgs.gov

The Wisconsin Department of Transportation (WisDOT) is increasing the use of a combination of conservation practices and management techniques in order to meet stormwater requirements for runoff volume, peak flow, and sediment load. Documents such as WisDOT's Facilities Development Manual (FDM) and Wisconsin Department of Natural Resources (WDNR) Stormwater Technical standards provide guidance to mitigate runoff when designing a stormwater control measure. These state documents prescribe site assessment evaluation, design recommendations, construction considerations, and maintenance criteria. Bioswales are linear bioretention cells designed with a mixture of sand/compost mix and planted with native vegetation. As part of 5.5 miles of capacity expansion, bioswales were constructed in the median of Highway VV near Menomonee Falls, WI. WisDOT, WDNR, and the U.S. Geological Survey evaluated the water-quantity benefits of treating stormwater runoff in two bioswales along this stretch of highway. Hydrologic monitoring results from these bioswales will be presented.

* * *

Evaluation of MS4 NPDES Compliance Measures in Southeast Wisconsin

Walter McDonald, Marquette Univeristy, walter.mcdonald@marquette.edu

Municipal Separate Storm Sewer Systems (MS4s) are conveyance systems owned by a city, town, village, or other public entity that discharge runoff to waters of the US, and as such are regulated under National Pollutant Discharge Elimination System (NPDES). As part of the NPDES regulatory requirements in the State of Wisconsin, MS4s have to submit an annual permit to the Wisconsin Department of Natural Resources (WDNR) documenting how they have reduced polluted stormwater runoff to the "maximum extent practicable" with best management practices (BMPs). These practices usually contain public education and outreach, public involvement and participation, illicit discharge detection and elimination, construction site pollutant control, and post-construction stormwater management, among others. While all MS4s seek to reduce pollutants to the "maximum extent practicable", in practice this looks different for each municipality and may be dependent upon a number of environmental, social, and economic factors. This study seeks to understand this variation in regulatory compliance measures by evaluating 84 MS4 permits submitted to the WDNR in the Southeast Wisconsin region. The objectives are to (1) quantify the BMPs and resources each MS4 employs to meet regulatory requirements, (2) determine what, if any, environmental, social, or economic variables explain the variance in BMP adoption across MS4s, and (3) use the results from 1 & 2 to identify underutilized BMPs and barriers to their adoption. The outcomes of this study are relevant to MS4 operators who are developing stormwater management programs, regulatory agencies that seek to draft relevant and effective stormwater management policies, and the public who benefit from effective stormwater management. The results also have implications for the impact that the MS4 remand rule, requiring greater regulatory oversight of Phase II MS4s, will have on MS4s in Southeast Wisconsin.

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Stochastic Dynamics of Passive and Controlled Stormwater Basins

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Stormwater control basins are often sized for a single design storm with a passive outflow control structure. However, given changes in the intensity and timing of rainfall with climate change, there is a need to develop design methods that account for hydro-climatic variability to evaluate long-term function and resilience of stormwater control infrastructure. Further, real-time control of stormwater basin outflows can be used to reduce peak outflows and increase pollutant removal efficiency. To address these emerging issues, we develop a stochastic-dynamic water balance model for stormwater basins that accounts for random variability of rainfall and real-time outflow control. This framework is used to derive the probability distribution of the water level and flow-duration curves as a function of land use, climate, and basin parameters. The model can be applied to characterize uncertainty in forecasts of the basin state and the likelihood of extreme overflow events.

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New Average Annual Rainfall Files for the Source Loading and Management Model WinSLAMM

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Wisconsin municipalities use urban-runoff models to help them prepare stormwater management plans. These models assist planners in designing practices that can achieve specified water quality standards. WinSLAMM, a Windows version of the Source Loading and Management Model (SLAMM), is a model recommended for stormwater planning by the Wisconsin Department of Natural Resources. One of the inputs required to perform computations in WinSLAMM is rainfall. In 2001, the US Geological Survey created WinSLAMM rainfall files for five regions in Wisconsin using National Weather Service rainfall data from 1949 to 1992. These rainfall files are currently being used throughout the state. In 2010, the dataset was expanded to include data through 2008. Expanding the dataset resulted in some changes to the rainfall files, but the effects on model output were determined to be too insignificant to recommend replacing the rainfall files currently in use. In 2016, datasets have been developed that include only the past 30 years of data (1986 to 2015). This was done in order to use rainfall data that are more representative of current conditions. This new analysis resulted in changes to rainfall files for all five regions. It was found that the event maximum and total precipitation increased for four of the regions and number of events decreased for four of the regions. This new evaluation may significantly alter model outputs when using WinSLAMM for assessment and design of stormwater practices. This presentation will include the results from the three evaluations (2001, 2010, and 2015) and discuss the possible implications of replacing the rainfall files on model output parameters.

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