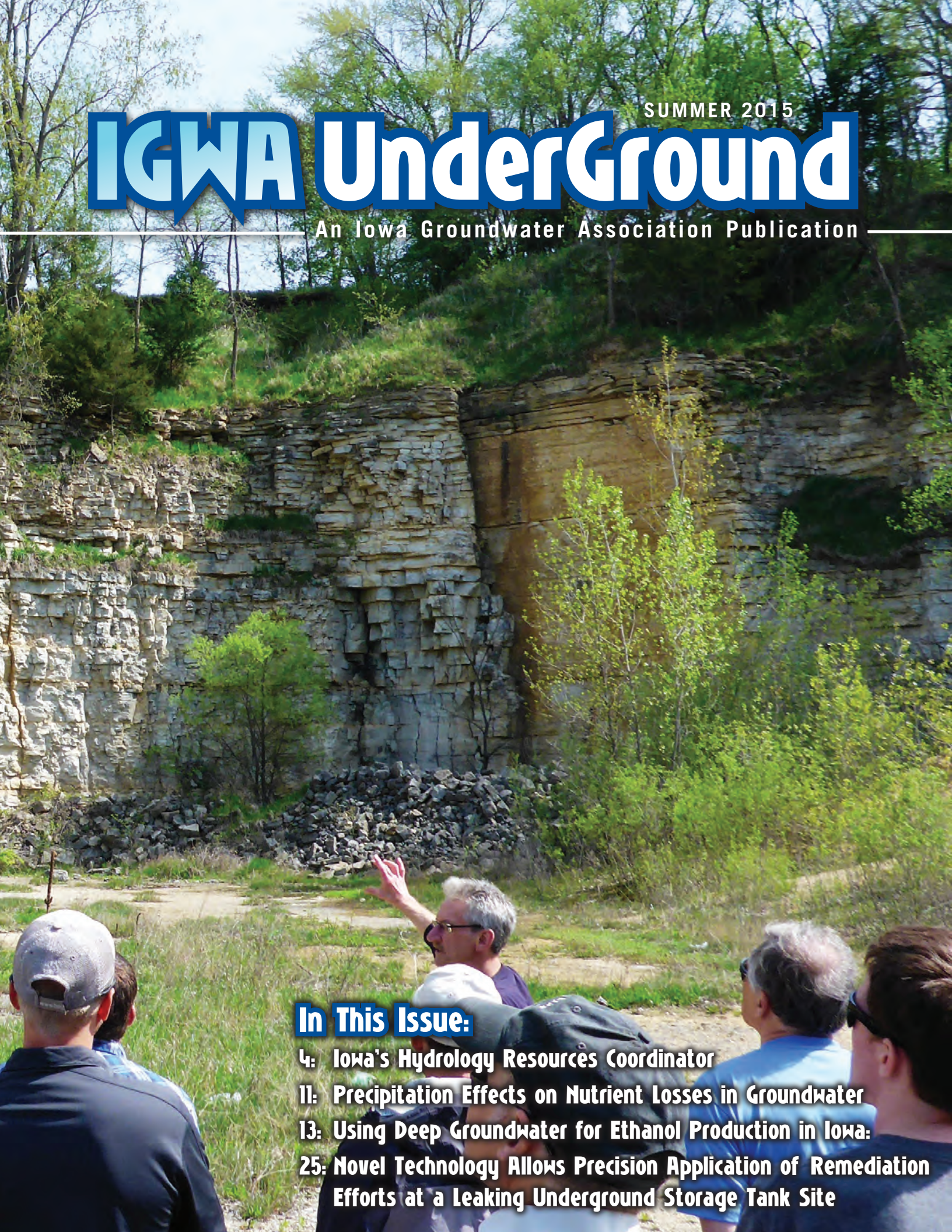
SUMMER 2015

IGWA UnderGround

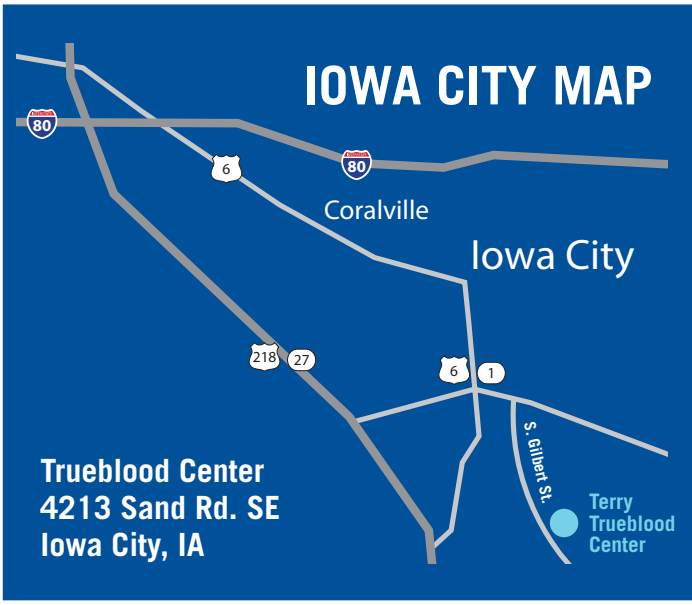
An Iowa Groundwater Association Publication



In This Issue:

IGWA's 2015 Fall Conference

October 21st Premeeting IIRR Stanley Hydraulics Lab
October 22nd at the Terry Trueblood Center in Iowa City
Register online at www.igwa.org



CONFERENCE AGENDA

WEDNESDAY (OCTOBER 21ST)

2:00 – 3:00 pm	Tour #1 – IIHR Maxwell Stanley Hydraulics Lab
3:15 – 4:15 pm	Tour #2 – University of Iowa water plant
5:00 – 8:00 pm	Informal dinner: The Mill

THURSDAY (OCTOBER 22ND) - Park Lodge at the Terry Trueblood Recreation Area

7:30 – 8:00 am	Registration and Continental breakfast
8:00 – 8:05 am	Welcome and Introduction to IGWA – Cindy Quast, IGWA President
8:05 – 9:00 am	PCE Contamination in Atlantic, Iowa – Susan Fisher, EPA Region 7
9:00 – 10:00 am	Factors Affecting Public-Supply-Well Vulnerability to Contamination: Understanding Observed Water Quality and Anticipating Future Water Quality- Sandra Eberts, USGS
10:00 – 10:15 am	Break
10:15 – 11:15 am	The Minnesota Experience: Creation of the Clean Water Fund and what it has meant – Gaylen Reetz, Minnesota Pollution Control Agency
11:15 am – 12:00 pm	Tank Fund Sunset – Jim Gastineau, AON Risk Solutions
12:00 – 1:00 pm	Lunch (provided for registered participants)
1:00 – 1:40 pm	Radionuclides Associated with Disposal of Unconsolidated Drilling Waste – Andrew Nelson, U of I
1:40 – 2:20 pm	Laser Induced Fluorescence – Dan Thompson & Ed Creaden, MATRIX
2:20 – 3:00 pm	Hydraulic Profiling Tool – Jonathan Sarich, Stanley Consultants

4.5 CEUs for Groundwater Professionals, 6 CEUs for Well Contractors, 0.4 CEUs for Water Treatment Operators

This year's conference features free pre-meeting tours of the U of I's Stanley Hydraulics Laboratory and the U of I's Water Treatment Plant, followed by an informal dinner at The Mill

2015 IGWA Board Members

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Table of Contents

Objectives

- Promote education and research on Iowa groundwater issues.
- Foster cooperation and information exchange throughout its membership.
- Improve communication among state regulatory officials, professionals, and technicians working with groundwater.
- Cooperate with the activities of various state and national associations organized in the interest of groundwater use, conservation, management, and protection.

IGWA
Iowa Groundwater Association

We are a not for profit organization.

Iowa Groundwater Association
P.O. Box 744 • Des Moines, IA 50303
www.igwa.org

the President's message

Cindy Quast - President, Iowa Groundwater Association

2015 has been a good year to be President of IGWA:

- The Jordan Aquifer rule was passed in June;
- Iowa finally has a nutrient management strategy that it's beginning to implement;
- and the percentage (93.7%) of our public water supplies that meet all health-based requirements continues its 10-year growing streak.

Iowa's institutional environmental stewardship is an important part of what makes Iowa a great place to live as we all know, however, government can't do everything. I'd like to use this message to encourage each IGWA member to use his or her special expertise to get involved at a local level in protecting, improving, and especially enjoying Iowa's groundwater and surface water.

Volunteering is a great way to put your professional knowledge and skills to work at the community level. (It's also a great way to meet like-minded people.) Many of you are already "volunteered to death." If there is already a water-related organization in your community, you can offer your services on an as-needed basis. If there is not a water-related organization in your community, perhaps an organization with which you already are involved could do a water-related project. An example might be an educational event for grade schoolers where they learn where their drinking water comes from.

Iowans are already busy volunteering for water quality. On the Iowa DNR website you can find that Project Aware "Volunteers Muscle 30 Tons Of Trash From Wapsipinicon River." There are similar Project Aware efforts each year on other streams in Iowa that offer volunteer opportunities. For information on Project Aware go to www.iowadnr.gov/Recreation/CanoeingKayaking/ProjectAWARE.aspx.

In my community a local business has invited its customers to a pork chop dinner and a soil profile demonstration showing how deep the roots go on various cover crops. They are also going to have a dump truck full of top soil so people can visualize the volume of 1-2" of lost topsoil.

Volunteer opportunities abound! Here are a couple of other opportunities that might interest you:

Join the Groundwater Foundation, www.groundwater.org, and form a Groundwater Guardian Team in your community.

> **Mission:** The Groundwater Foundation provides motivational and inspirational education and community-based action programs that creatively involve individuals, communities, public and private entities in groundwater conservation and protection.

Become a volunteer water quality monitor at IOWATER, www.iowadnr.gov/Environment/WaterQuality/WaterMonitoring/IOWATER.aspx.

> **Mission:** To protect and improve Iowa's water quality by raising citizen awareness about Iowa's watersheds, supporting and encouraging the growth and networking of Iowa's volunteer water monitoring communities, and promoting water monitoring activities as a means of assessing and understanding Iowa's aquatic resources.

However you decide to share your knowledge and skills, have fun also sharing your enjoyment of Iowa's abundant and quality water resources.

KARST & GROUNDWATER IN NORTHEAST IOWA

Robert Libra, State Geologist - Iowa Department of Natural Resources

The shallow rock landscape of northeast Iowa is dotted with karst features – sinkholes, springs, losing streams, caves, and fractured rock just below ground. This hydrogeologic setting, while containing incredibly productive aquifers, is inherently susceptible to groundwater contamination. Contamination impacts are derived via infiltration through the thin soil cover from nonpoint sources such as row-crop agriculture and all the typical point sources, such as leaking tanks, landfills, and waste storage structures.

The presence of sinkholes and losing streams adds an additional contamination threat in the area. Surface water runoff often carries contaminants that are removed to varying degrees when water infiltrates through soil and glacial materials. This contamination directly enters the groundwater and can move rapidly in ways that are hard to predict.

Wastewater treatment plant discharges in this part of the state are problematic because some locations cannot avoid discharging to losing streams. Sinkhole formation is also a threat to earthen basins and lagoons holding liquid waste. Seepage from lagoons promotes failure of the structures into underlying voids in the shallow bedrock.

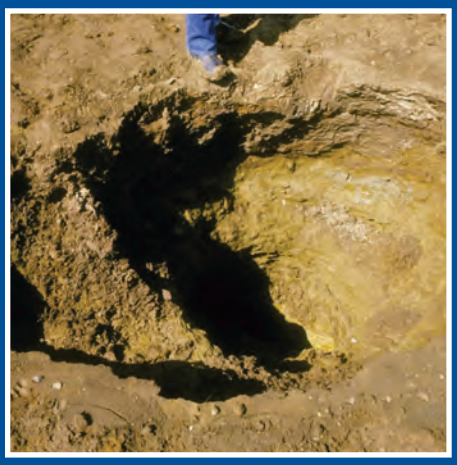
In response to the unique challenges karst provides for groundwater protection, DNR staff have led field trips to northeast Iowa, most recently for other DNR staff and local conservation agencies. The Iowa Groundwater Association (IGWA) is planning to run such a trip in conjunction with its 2016 fall meeting. We would look at sinkholes, losing streams, limestone outcrops, and quarries that let you "step into the aquifer". The trip would also include stops at Big Spring where water quality has been monitored for 35 years, and a visit to the site of a failed sewage lagoon. Stay tuned for more information!

A view of the Galena aquifer in a Clayton County quarry.

Barely buried fractured carbonate rocks.

A recently opened sinkhole.

Lagoon failure from a sinkhole.



What drained the lagoon.

Iowa's Hydrology Resources Coordinator

Tim Hall

"What is it you do at the DNR?" is a question that I get quite often. For more than a decade after joining the Iowa Department of Natural Resources (DNR) I served as Chief of the Iowa Geological and Water Survey Bureau (IGWSB), or a version of that group. During those years I was involved in managing staff working on projects ranging from brownfields to underground storage tanks (USTs) to geology to groundwater modeling. In 2013 the DNR began a process of organizational changes that resulted in the moving of geological functions from the DNR in Iowa City to the University of Iowa, and the moving of other sections of the Bureau to different locations within the DNR. As a result, my job duties have changed significantly but in a way that fits well with my background. I have an education in Civil Engineering and GeoHydrology. and 15 years of environmental consulting experience prior to working for the DNR.

The hydrologic coordination story began in 2012 when the question was raised by some stakeholders in Iowa about the need for a State Hydrologist. I was asked to research the issue, and to make recommendations. After exploring policies and practices in other states, it was concluded that Iowa had sufficient hydrological technical resources, but that additional coordination was needed. As a result of that discussion, the DNR was given the role of coordinating hydrologic expertise for the State, and I began providing some of that guidance. With the reorganization of the DNR, I found myself in a position to spend more of my time and energy on this coordination.

Then in 2014, I was hired into the newly created position of **Hydrology Resources Coordinator** for the DNR, working for Bill Ehm, the Division Administrator of the Environmental Services Division (ESD). As the job title implies, I am involved in a range of activities related to hydrology programs within the DNR, including both ESD and Conservation and Recreation Division (CRD) staff and activities. Since both my role and the position are relatively new to the DNR, my job responsibilities are evolving over time. In general, I provide technical interpretation for a wide range of DNR staff and programs, and look for ways to coordinate activities across the DNR that impact hydrology issues. I work regularly with staff from the DNR Director's office as well as staff from across the DNR.

Since starting in this role, I have worked in several areas, and for several programs in the DNR, including:

River Policy Coordination: The DNR is involved in organizations that represent interests in both of Iowa's bordering rivers, the Missouri and Mississippi. I serve as the state's representative on the Board of the Upper Mississippi River Basin Association (UMRBA) – participating in discussions related to policies on the Mississippi River. UMRBA has full-time staff based in St. Paul, MN, and the UMRBA Board

"The hydrologic coordination story began in 2012 when the question was raised by some stakeholders in Iowa about the need for a State Hydrologist. I was asked to research the issue, and to make recommendations."

is composed of my counterparts from Wisconsin, Minnesota, Illinois, and Missouri. UMRBA meets quarterly and is involved in policy issues that include navigation and transportation, invasive species, water quality, and recreation.

The DNR is also the lead agency for the State Interagency Missouri River Authority (SIMRA). SIMRA is comprised of a number of state agencies, and deals with some of the same issues on the Missouri River that UMRBA deals with on the Mississippi River – although there is a greater emphasis on habitat restoration and flood protection on the Missouri. My role with SIMRA is to assist in providing information to state agencies on a regular basis, and to work with the Corps of Engineers in the areas of hydrology and policy interpretation.

Water Summary Updates – Hydrology Information: During the 2012 drought the DNR initiated the production of bi-weekly Water Summary Updates (WSUs) to provide regular information on drought conditions. Since that time, I continue to work with other agency partners to prepare WSU information and basic hydrological information. In addition, I am often called upon to review and interpret technical hydrological data and information for the DNR and or other policy makers and legislators. As part of these duties I interact with the USGS, the Iowa Geological Survey, the National Weather Service, the State Climatologist, and other partners.

Source Water Protection: The DNR's Source Water Protection (SWP) Program was consolidated in Des Moines after the reorganization, and I have been called upon to work with internal and external SWP program professionals to continue to move this program forward. I work in areas including contracting with external service providers that help with SWP planning, review of SWP plans submitted to the DNR, interaction with EPA on funding and grant issues, and assisting other DNR staff on this program.

HydroGeo Investigation Team: Many DNR programs are involved with groundwater investigation and evaluation including Solid Waste, USTs, SWP, Contaminated Sites, and Drinking Water. Occasionally there are specific sites or projects that would benefit from additional internal technical review. I was asked to establish and coordinate an internal team of groundwater specialists that can meet regularly to review and discuss complicated hydrogeological issues, and provide feedback and recommendations to DNR staff. This group has been meeting every other month or so, and has looked at issues related to drinking water quality, landfill monitoring, and source water protection.

Stream Mitigation/River Restoration: The DNR has been involved in the development of a broad based stream mitigation/river restoration program over the last year. Our fisheries biologists and our geologists are working on stream assessment methodologies, and other staff are working on a wide range of river restoration issues. I am involved in the early stages of assisting in the development of a fee system that will provide a way for the State to collect damage fees for work that impacts streams, and then to use money collected by those fees to fund stream restoration and improvement in other locations (similar to wetland mitigation programs).

Other Issues: Since my role is new for the DNR, my responsibilities are evolving, and I expect that as other issues arise, I will be called on to step in and provide expertise, or find the needed expertise within the DNR or from other professionals around the state. Feel free to contact me at tim.hall@dnr.iowa.gov for more information on hydrology issues within the DNR.

FY2015 AMBIENT GROUNDWATER QUALITY MONITORING SUMMARY

Claire Hruby, Ambient Groundwater Quality Monitoring Coordinator - Iowa Department of Natural Resources

Iowa DNR's Ambient Groundwater Quality Monitoring program was suspended in 2006 due to the high costs of outsourcing the program. Since then, efforts to collect groundwater quality data have been sporadic. In 2012, reassessment of the program began. Lessons learned from the 2013 survey of emerging contaminants in Iowa's groundwater[1], review of past data, and input from stakeholders, pointed towards a need to further assess groundwater contaminants that are not regularly monitored by public or private water supplies, such as herbicides and pharmaceuticals. In Iowa, occurrence of herbicides is significantly greater in wells with little or no protection from confining materials[1], and it is reasonable to expect pharmaceuticals originating from human waste and other sources near the ground surface are also more likely to occur in these wells. Thus, the primary objective of FY2015's ambient groundwater monitoring was to evaluate the occurrence and distribution of selected herbicide and pharmaceutical compounds in Iowa's vulnerable aquifers.

Fifty vulnerable municipal water supply wells were selected to be sampled in the Fall/Winter of 2014-2015. Forty-five municipal water operators submitted raw (untreated) groundwater samples, while the other five were unable to sample due to cold conditions and other operational limitations. Of the wells sampled, 30 tapped alluvial aquifers, 11 drew water from Silurian-Devonian aquifers, 1 from the Dakota aquifer, 1 from the Mississippian aquifer, and 2 from the Cambrian-Ordovician aquifer in northeastern Iowa **(FIGURE 1)**. All samples were analyzed by the State Hygienic Laboratory (SHL) for basic water quality parameters, nutrients, atrazine and two of its breakdown products, chloroacetanilide herbicides and their ethanesulfonic acid (ESA) and oxanilic acid (OXA) degradates, along with a suite of 16 pharmaceuticals.

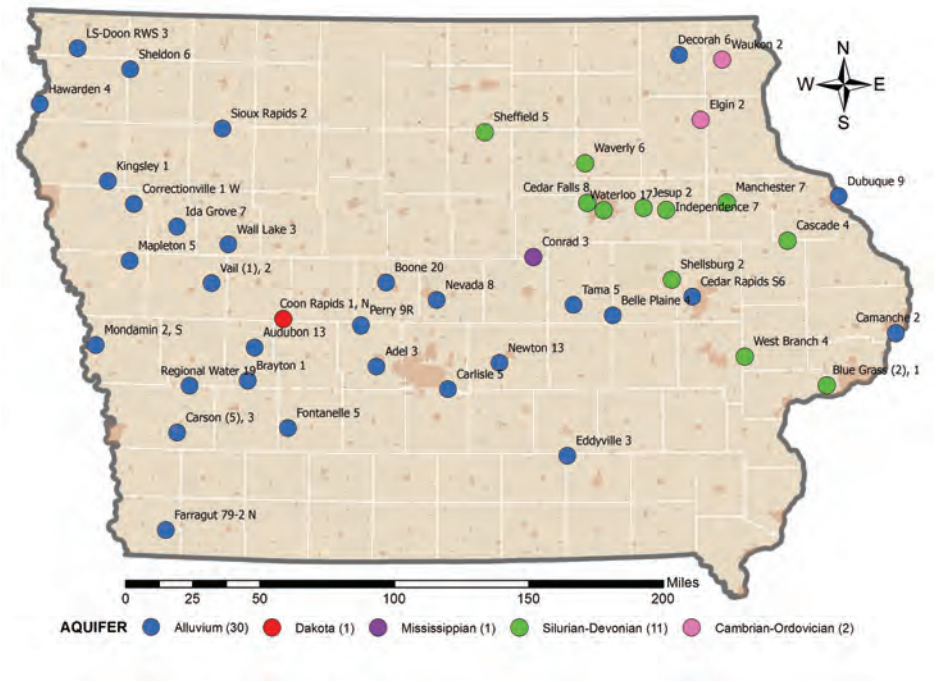


FIGURE 1: Locations of ambient groundwater samples for FY2015 colored by aquifer.

A basic summary of the results of nutrient, herbicide, and pharmaceutical analyses are presented in **TABLE 1**. All results will be entered into the Iowa DNR's EQUIS database and made available in GIS format via the Groundwater Quality geodatabase.

Nitrate + nitrite as nitrogen (N) was detected in 73 percent of the vulnerable wells with a mean concentration of the detections at 4.8 mg/L, and a maximum concentration of 17 mg/L. Conversion of ammonia to nitrate only occurs when oxygen is present in soils, and denitrification often occurs in low-oxygen conditions. Thus, the lack of nitrate does not necessarily indicate a lack of nitrogen sources. In fact, all 12 samples that did not contain nitrate, contained detectable levels of ammonia nitrogen, ranging from 0.07 – 1.6 mg/L as N. The highest nitrate concentrations were found in alluvial aquifers in western Iowa **(FIGURE 2)**.

In past years the reporting limit for atrazine in ambient groundwater samples was 0.1 µg/L. Improvements to the method by

SHL in 2014 lowered the detection limit to 0.02 µg/L. While only one sample exceeded the pre-2014 reporting limit, 12 (27%) of the samples collected had detectable levels of atrazine at the lower detection limit. This improvement allows us to see the distribution of low levels of atrazine in vulnerable aquifers. Atrazine detections occurred more frequently in the eastern portion of the state, while samples from alluvial aquifers in western Iowa showed no atrazine detections with the exception of the far northwest corner of the state **(FIGURE 3)**.

The occurrence of pesticides (including herbicides) have been widely studied[2,3,] but drinking-water standards have not been established for many of these compounds. All measured concentrations of atrazine and alachlor in FY2015 samples were below the maximum contaminant levels of 3 µg/L and 2 µg/L, respectively. For many other pesticide compounds, potential health risks from drinking-water exposures are a concern, but more data on health effects are needed to determine appropriate standards. Acetochlor and its ESA and OXA degradates, alachlor ESA and OXA, and metolachlor and its ESA and OXA degradates are listed on the Environmental Protection Agency's Contaminant Candidate List 3.[4]

As with past groundwater studies in Iowa[5-7], results of FY2015 analyses showed that chloroacetanilide herbicide degradates were more prevalent than their parent compounds (metolachlor, alachlor, acetochlor, and dimethanamid). The most common herbicide compound was metolachlor ESA, with a maximum concentration of 1.9 µg/L. Although more widespread than atrazine, the distribution of metolachlor ESA in groundwater is

Continued on page 8

Group	Analyte	Limit of Detection	N	Number of Detections	Percent Detections	Mean of Detections	Median of all values	Maximum
Nutrients	Nitrate + Nitrite nitrogen as N	0.1 mg/L	45	33	73	4.8	2	17
	Ammonia Nitrogen as N	0.05 mg/L	45	21	47	0.38	ND	1.60
	Total Kjeldahl Nitrogen as N	0.1 mg/L	45	19	42	0.4	ND	1.6
	Total Phosphorus as P	0.02 mg/L	45	45	100	0.14	0.10	0.81
	Ortho-Phosphate as P	0.02 mg/L	45	25	56	0.067	0.027	0.140
Herbicides and Degradates	Atrazine	0.020 µg/L	44	12	27	0.065	ND	0.240
	Desethyl Atrazine	0.020 µg/L	44	16	36	0.061	ND	0.200
	Desisopropyl Atrazine	0.020 µg/L	44	2	5	0.022	ND	0.023
	Acetochlor	0.025 µg/L	44	0	0	ND	ND	ND
	Acetochlor ESA	0.025 µg/L	44	24	55	0.211	0.030	0.770
	Acetochlor OXA	0.025 µg/L	44	13	30	0.271	ND	1.300
	Alachlor	0.025 µg/L	44	0	0	ND	ND	ND
	Alachlor ESA	0.025 µg/L	44	25	57	0.284	0.058	0.750
	Alachlor OXA	0.025 µg/L	44	8	18	0.395	ND	1.600
	Dimethenamid	0.025 µg/L	44	0	0	ND	ND	ND
	Dimethenamid ESA	0.025 µg/L	44	3	7	0.048	ND	0.057
	Dimethenamid OXA	0.025 µg/L	44	3	7	0.049	ND	0.092
	Metolachlor	0.025 µg/L	44	5	11	0.275	ND	0.600
	Metolachlor ESA	0.025 µg/L	44	38	86	0.483	0.310	1.900
	Metolachlor OXA	0.025 µg/L	44	21	48	0.247	ND	1.600
Pharmaceuticals	Acetaminophen	0.025 µg/L	45	0	0	ND	ND	ND
	Caffeine	0.025 µg/L	45	8	18	0.077	ND	0.200
	Carbamazepine	0.01 µg/L	45	0	0	ND	ND	ND
	Cotinine	0.01 µg/L	45	0	0	ND	ND	ND
	DEET	0.025 µg/L	45	0	0	ND	ND	ND
	Diclofenac	0.025 µg/L	45	0	0	ND	ND	ND
	Gemfibrozil	0.025 µg/L	45	1	2	0.057	ND	0.057
	Ibuprofen	0.010 µg/L	45	0	0	ND	ND	ND
	Lincomycin	0.010 µg/L	45	0	0	ND	ND	ND
	Metoprolol	0.010 µg/L	45	0	0	ND	ND	ND
	Sulfadimethoxine	0.010 µg/L	45	0	0	ND	ND	ND
	Sulfamethazine	0.010 µg/L	45	1	2	0.020	ND	0.020
	Sulfamethoxazole	0.010 µg/L	45	3	7	0.029	ND	0.036
	Sulfathiazole	0.010 µg/L	45	0	0	ND	ND	ND
	Triclosan	0.025 µg/L	45	0	0	ND	ND	ND
	Trimethoprim	0.025 µg/L	45	0	0	ND	ND	ND

TABLE 1: Summary of results for nutrients, herbicide compounds, and pharmaceuticals. Values below the limit of detection are denoted by ND.

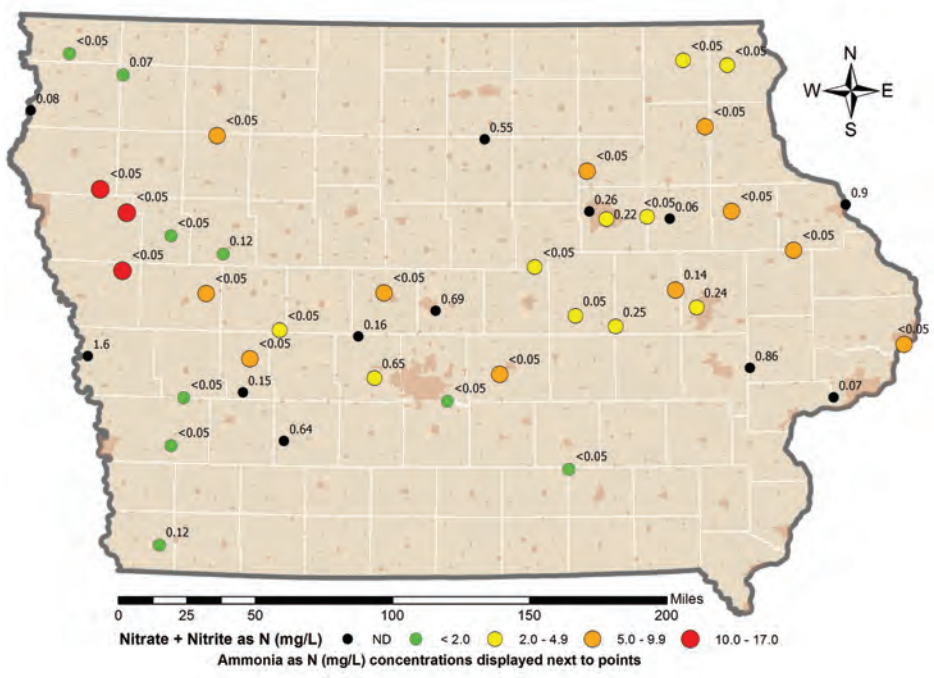


FIGURE 2: Nitrate + nitrite as nitrogen (N) concentrations in ambient groundwater samples from FY2015. Measured concentrations of ammonia nitrogen as N are shown next to the symbol.

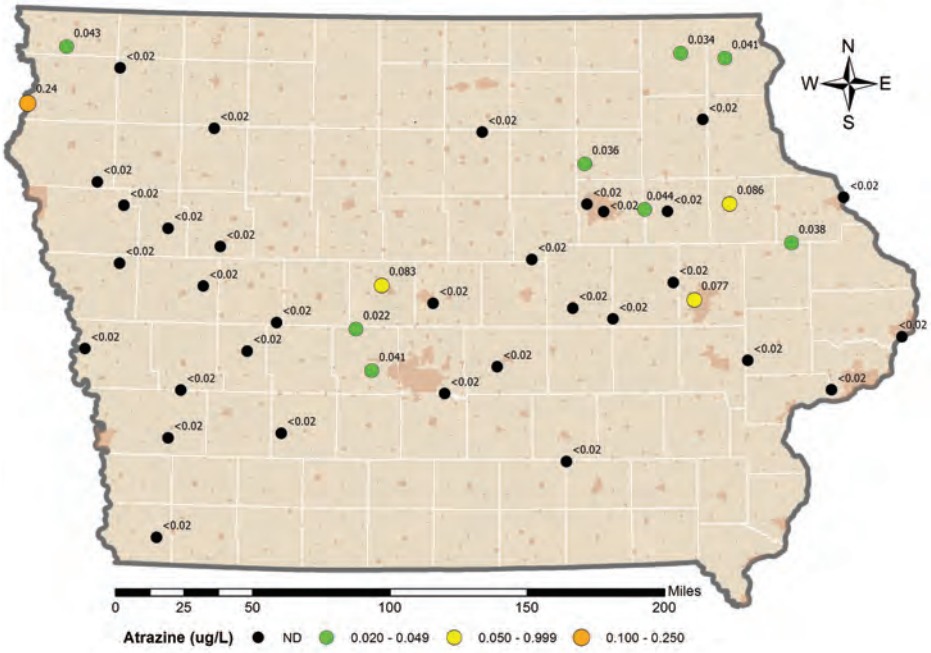


FIGURE 3: Map of atrazine results for FY2015. Numbers above locations indicate measured concentrations.

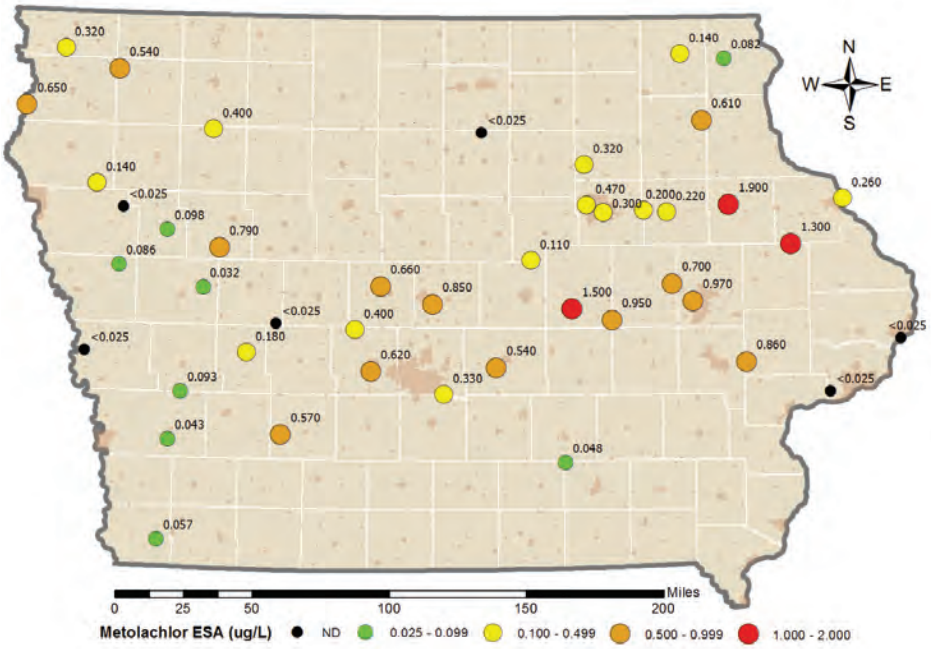


FIGURE 4: Map of metolachlor ESA results from FY2015. Numbers above locations indicate measured concentrations.

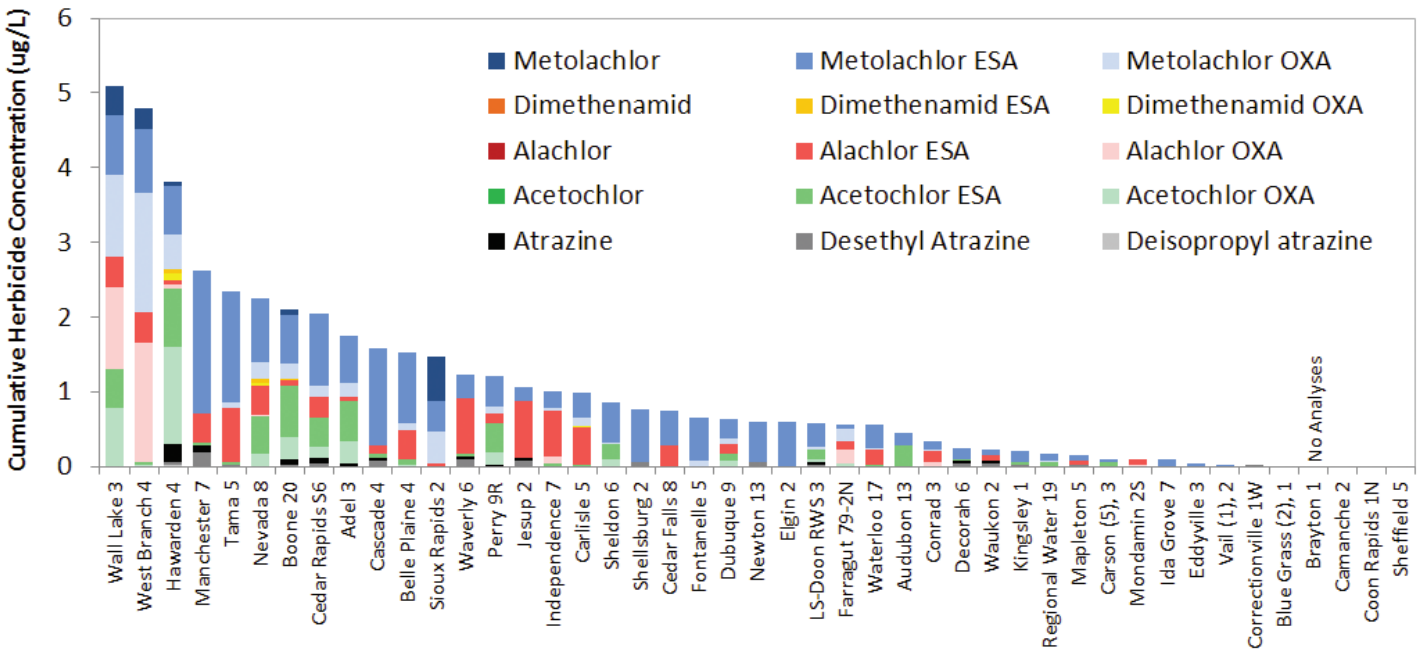
Continued from page 7

similar to atrazine, with the lowest concentrations generally occurring in western Iowa's alluvial aquifer systems **(FIGURE 4)**. Mixtures of up to 12 different herbicides compounds were found in individual wells samples, with a maximum cumulative herbicide concentration of 5.090 µg/L **(FIGURE 5)**.

The 2013 study of groundwater quality in 66 wells representing all of Iowa's major aquifers reported very low levels of one or more pharmaceuticals in 35% of wells using analytical methods developed by the USGS for 112 compounds1. Of the 14 pharmaceuticals detected in 2013, the most common was caffeine (25% of samples), followed by a breakdown product of caffeine. Similarly, caffeine was the most commonly detected pharmaceutical in FY2015 (18% of samples). Of the 16 pharmaceuticals analyzed in FY2015, only sulfamethoxazole, sulfamethazine, and gemfibrozil were detected in addition to caffeine. Sulfamethoxazole is an antibiotic used to treat infections in humans, and sulfamethazine is an antibiotic commonly used to treat livestock. Gemfibrozil is a drug used to treat high cholesterol.

Results presented for FY2015 represent groundwater that is highly vulnerable to contamination from surface activities due to a lack of protective confining material. These wells were not specifically selected to represent urban or rural land use, and analysis of the relationship between land use in the capture zones of these wells and contaminant concentrations has not yet been completed. All of the samples were collected during the late fall and winter in order to avoid short-term variations in concentrations driven by precipitation events or land application of chemicals. Concentrations reported here are

FIGURE 5: Mixtures of herbicide compounds by well.



thought to be baseline levels; however, more frequent monitoring would be necessary to determine whether these concentrations are sustained year-round, and the SWRL2 study of private wells showed higher percentages of detections during the dry (Oct – March) period than during the wet (April – Sept) season[7]. Further comparisons to herbicide data collected in previous years are planned.

Finally, it is very important to point out that concentrations of these contaminants in untreated water are not necessarily representative of the quality of water that reaches drinking-water users. Many communities that depend on vulnerable aquifers mix from multiple wells within the aquifer, or multiple aquifers, and some treatment methods are effective at removing organic compounds. Because private wells are less likely to be tested or treated for organic contaminants, efforts to assess and mitigate risks of organic contaminant exposures for private well users, like the 2006-2008 SWRL2 study[7] and the Grants-to-Counties Program8, should be continued.

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[2] Toccalino, P.T., Norman, J.E., and K.J. Hitt, 2010. Quality of Source Water from Public-Supply Wells in the United States, 1993-2007. National Water-Quality Assessment Program, Scientific Investigations Report 2010-5024, url: http://pubs.usgs.gov/sir/2010/5024/pdf/sir20105024.pdf, 126 p.

[3] Kolpin, D.W., Barbash, J.E., and R.J. Gilliom, 2001. Major herbicides in ground water: results from the National Water-Quality Assessment, Journal of Environmental Quality, V. 28, n. 3, p. 103-112.

[4] Environmental Protection Agency, 2009. Contaminant Candidate List 3, url: http://www2.epa.gov/ccl/contaminant-candidate-list-3-ccl-3, accessed August 24, 2015.

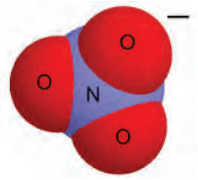
[5] Kolpin, D.A., Hallberg, G.R., and Libra, R.D. 1997, Temporal Trends of Selected Agricultural Chemicals in Iowa's Groundwater, 1982-1995: Are things getting better?: Journal of Environmental Quality, v. 26, n. 4, p. 1007-1017.

[6] Kolpin, D.W., Kalkhoff, S.J., Goolsby, D.A., Sneck-Fahrer, D.A., and Thurman, E.M. 1997, Occurrence of Selected Herbicides and Herbicide Degradation Products in Iowa's Ground Water, 1995: Ground Water, v. 35, n. 4, p. 679-688.

[7] Center for Health Effects of Environmental Contamination, 2009. Iowa Statewide Rural Well Water Survey Phase 2 (SWRL2) Results and Analyses, report submitted to the Iowa Department of Natural Resources, url: http://www.cheec.uiowa.edu/research/SWRL2%20results.pdf, 27 p.

[8] Iowa Department of Public Health, 2015. Grants to Counties Water Well Program website, url: https://www.idph.state.ia.us/eh/grants.asp.

NITRATE AND NITRITE Fact Sheet



Michael Anderson, Iowa Department of Natural Resources, Water Supply Engineering

This is a brief fact sheet about the drinking water contaminants nitrate and nitrite, which have been the focus of considerable discussion in Iowa over the past year. It is intended to be a synopsis of the facts surrounding this issue. The administrative rules for nitrate and nitrite are found at 567 Iowa Administrative Code (IA), Rule 41.3.

Nitrate and nitrite contamination can arise from several places: (1) the natural decay of organic materials such as leaves and crop residue, (2) the use of commercial fertilizers, (3) contamination by human sewage and wastes from farm animals, and (4) the nitrification of ammonia in the water treatment and water distribution system.

The Maximum Contaminant Level (MCL) for nitrate (set as a Federal and as a State standard) is 10 mg/L as N, and the MCL for nitrite is 1.0 mg/L as N. A water system gets a violation when the MCL is exceeded in any 1 compliance period, assigned either as a monthly, quarterly, or annual (monitoring) requirement. Violation of the nitrate or nitrite MCL is classed as an acute violation. The water system returns to compliance after 2 consecutive months in which all required samples are collected as directed and all analytical results are below the MCL.

In 2014, the number of nitrate MCL violations in Iowa and the number of drinking water systems with violations were very similar to 2013. For example, there were 16 nitrate nitrogen violations in 2013, and 13 in 2014. Violations can occur for various reasons, so the data should be treated with caution. The State of Iowa Public Drinking Water Program 2014 Annual Compliance Report discusses these compliance issues in considerable more detail. The document can be found at http://www.iowadnr.gov/InsideDNR/RegulatoryWater/DrinkingWaterCompliance/AnnualComplianceReport.aspx.

The reason nitrate and nitrite is set as an acute violation is the nature of human response to this contaminant. Excessive levels of nitrate and nitrite in drinking water can cause serious illness, and sometimes death, in infants less than six months of age. Nitrate converts to nitrite, which interferes with the oxygen-carrying capacity in the child's blood (methemoglobinemia or blue-baby syndrome). This is an acute disease, because symptoms can quickly develop. Health deteriorates usually over a timeframe of days. Indicators include shortness of breath and blueness of the skin. Medical advice should be sought at one if these symptoms occur. Elevated nitrate and nitrite levels can also cause undesirable health effects in pregnant women through the risk of miscarriage, and in people with particular metabolic diseases that increase methemoglobinemia risk.

Boiling the water should not be done as some might think, since it will only concentrate the nitrates and nitrites. Other sources of water should be used to drink, such as Federal Food and Drug Administration (FDA)-approved bottled drinking water, with (specified) low levels of nitrate clearly listed on the label.

Nitrate is relatively unaffected by conventional water treatment processes. Water systems have to use either ion exchange or some type of demineralization process to specifically reduce nitrate concentrations. Most ion exchange media now in use are synthetically produced. Alternative membrane processes (typically reverse osmosis or electrodialysis) can also be effectively used for nitrate removal. All of these treatments work quite well to remove nitrate, but they are expensive to design and to install. All require retention of a licensed professional engineer in the State of Iowa to install and implement.

Precipitation Effects on Nutrient Losses in Groundwater

Christopher Jones, Research Engineer, IIHR Hydroscience and Engineering, University of Iowa

"Everybody complains about the weather, but nobody does anything about it." Mark Twain? No. It was his friend and fellow writer Charles Dudley Warner who first used the phrase in 1884.

A hydrologist might question the accuracy of that quote, especially in Iowa. The productive Iowa we see today is the result of thousands of years of soil formation and 150 years of brute-force and fine-tuned landscape engineering. Much of this engineering removes water from the landscape—rainfall in excess of what our crops can use in a normal year. Field tiles, tile mains, and drainage ditches move the water through and off the land much more rapidly than the native prairie. Our ancestors may not have changed the weather but they certainly acted in response to it. More than half of Iowa land is now artificially drained.

The ecosystem that resulted from all this engineering, composed of both natural and man-made elements, is complex. The underlying biogeochemical processes like nutrient cycling are dynamic and weather dependent. Year-to-year variations are amplified by markets, land use change, and technology development.

Nutrient transport (loss of nitrogen and phosphorous) from our farmed landscape and degraded water quality are negative consequences of our engineering efforts. We know that production in the corn-soybean system is maximized when the landscape is essentially saturated with nitrogen (N). Because the most common form of N in the environment, nitrate (NO_3), is very soluble in water, the system is vulnerable to loss of N. If we liken the Iowa landscape to a glass filled to the brim with nitrogen, it's easy to imagine perturbations or upsets causing the N to slosh out of the glass, escaping the farm into the stream network.

To learn about N loss, we need to "follow the water". If a large rainfall follows a period of dry weather, there may be adequate water storage capacity in the soil and N may not move to the stream. On the other hand, even a moderate rain falling on wet soils can initiate or increase water flow through the soil profile and into our constructed drainage system, causing large N delivery to streams.

In recent years, agriculturists have focused on fertilizer management to try to reduce N loss. The 4R strategy of right rate, right timing, right place, and right form of fertilizer is a common-sense way to increase farm profits and improve water quality.

But Iowa's unpredictable weather doesn't always cooperate with 4R approaches. Repressed crop yields during drought leave unused fertilizer and soil nitrate behind on the landscape. A wet May and June can move nitrate down through the soil profile, beyond the reach of crop roots but poised to move into the tile and stream network. A look at 2014 Des Moines and Raccoon River nitrate is instructive.

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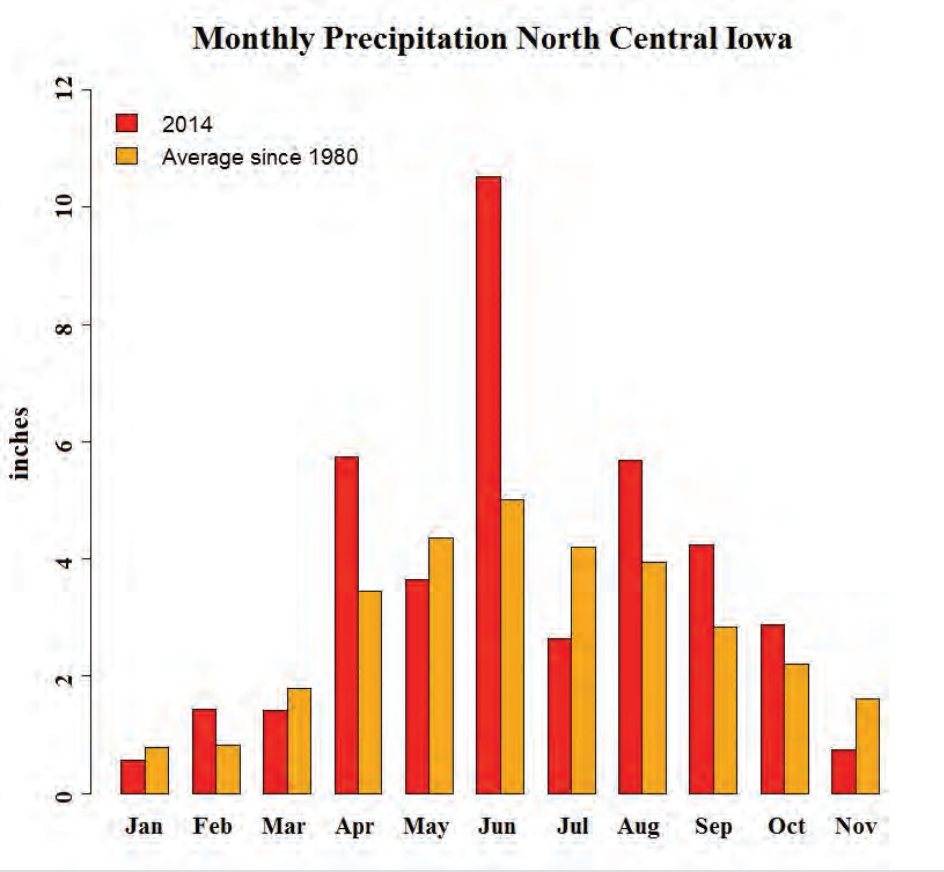

FIGURE 1: Average and 2014 precipitation for North Central Iowa.

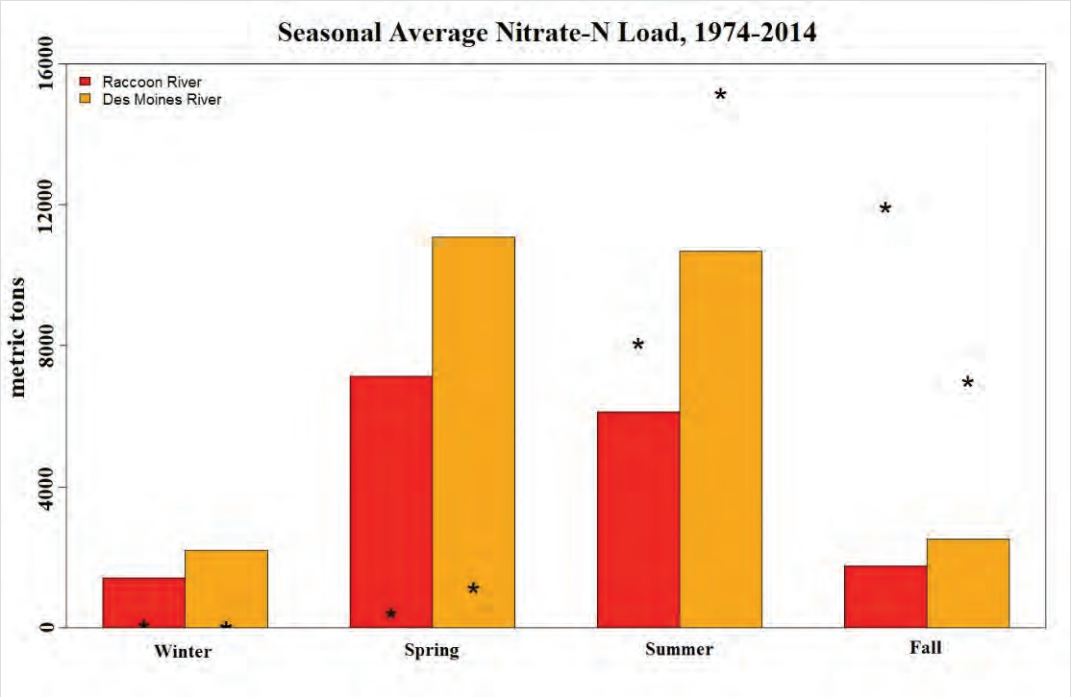

FIGURE 2: Average seasonal nitrate loads, with 2014 levels indicated by stars.

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These watersheds drain about 5 million acres in north central Iowa, extending from the Raccoon-Des Moines River confluence in Des Moines northwest into Minnesota. Precipitation and groundwater from the recently-glaciated Des Moines Lobe Landform feeds into both rivers. The landscape is part of the prairie pothole eco-region, and is extensively drained to enable row crop cultivation.

Soil conditions were dry going into 2014 as the second half of 2013 saw much below normal precipitation. April 2014 was wet and was followed by a normal May, a very wet June, a dry July, and then a very wet period from August through October **(FIGURE 1)**.

Because the April rains fell on dry soils, not much nitrate was transported to the drainage network. Spring nitrate loads (total mass of N moved by the rivers) were low **(FIGURE 2)**. June rains moved nitrate down through the soil profile, and then abundant late summer and fall rains mobilized abnormally large amounts of nitrate. Managing fertilizer inputs for improved water quality is nearly impossible in this type of scenario, where unexpected or extreme weather can overcome farmers' best efforts to avoid N loss through input management. Researchers and many farmers have realized that we cannot achieve our water quality goals solely through better methods of fertilization.

So what are the answers? We can try to restore or mimic prairie-like ground covers by planting deep-rooted cover crops, which can bring nitrogen back up to where crops can get it. We also can trap N after it has been lost to the tiles using edge-of-field treatment. This includes constructed wetlands, saturated buffer strips, and woodchip bioreactors, all of which serve as mini-treatment plants that scrub the tile water before it enters the stream. Many of our mitigation strategies, however, are expensive and not easily managed on every landscape.

These changes will only become more difficult if trends toward more precipitation continue. About 2/3 of the N loss in Iowa occurs during only 1/3 of the year: April through July. We get about half of our annual precipitation during this period. If this four month period gets wetter relative to the rest of the year, all things being equal, N loss will increase. Looking at historical nitrate data for these rivers, it appears the nitrate load is being increasingly concentrated into the months of May and June. This may be an indicator of more rain during those two months, and/or improvements in the drainage infrastructure moving more water off the landscape during the rainy season.

Farmers, policy-makers and the public need to understand that the unpredictability of Iowa rainfall is not going to change. The physics and chemistry of soil nitrogen are not going to change. So if we want to reduce N loss and improve water quality, we have to modify our production systems. We must get smarter and adapt. This means constructing systems and developing strategies robust enough to endure the weather extremes characteristic of Iowa's mid-continent location.

Using Deep Groundwater for Ethanol Production in Iowa: Are We Mining One Fossil Resource to Preserve Another?

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INTRODUCTION

Although ethanol plants use a variety of aquifer sources for production water, including shallow alluvial aquifers, Paleozoic carbonate aquifers and deep regional systems, most of the growth of water use for ethanol production in the last decade has been in the use of deep confined aquifers such as the Cambrian-Ordovician (C-O) aquifer that underlies much of the state. From 2004 to 2013, annual use of the C-O aquifer for ethanol production increased approximately 7.4 billion liters per year, an increase nearly double that of additional water use from shallower aquifers. In 2013, the annual use of C-O water for ethanol production represented approximately 15% of the water pumped from the aquifer, compared to 73% for public use and 12% for other industrial non-ethanol use. However, the increase in ethanol water use from the C-O aquifer from 2008 to 2013 (2.8 billion liters) was seven-times greater than the increase of C-O water for public water consumption (0.4 billion liters), and other industrial non-ethanol uses actually declined (decrease of 0.08 billion liters) (Iowa DNR, unpublished data).

The use of deep confined water for ethanol production raises questions about how best to sustain the beneficial use of the water resource for future generations. When significant amounts of water are withdrawn from an aquifer without adequate replenishment from precipitation and induced recharge, groundwater depletion will inevitably occur. In deep regional aquifers that contain old water isolated from modern recharge, this groundwater depletion represents water that is essentially "mined" from the aquifer. We used a groundwater flow model and isotopic age dating to assess the degree to which water withdrawal from the C-O aquifer for ethanol production is mining old groundwater from the aquifer. We address the question, are we essentially mining one fossil resource (groundwater) for ethanol production in order to preserve another (fossil fuels)?

BACKGROUND

The C-O aquifer, commonly referred to as the "Jordan aquifer," is comprised of three separate water-bearing units. The uppermost unit is the St. Peter Formation comprised of fine to coarse grained, poorly-cemented sandstone. Beneath this unit lies the Prairie du Chien Group, which consists of the Shakopee Formation (dolomite and sandstone), and the Oneota Formation (primarily dolomite). The base of the aquifer is the Jordan Sandstone, which consists of fine to medium grained, well-sorted sandstone and dolomite. The C-O aquifer is confined above by a series of laterally extensive shales, shaley-dolomite, and dolomite units, and includes the Maquoketa Formation. The low permeability of these upper units controls the downward leakage of groundwater entering the aquifer. Siltstone, dolomite, and glauconitic sandstone of the St. Lawrence and Lone Rock Formations confine the Cambrian-Ordovician aquifer from below. The C-O aquifer is present at the land surface in northeast Iowa but reaches depths of more than 900 m in southwest Iowa. Groundwater in the aquifer generally flows southeast towards Missouri and Illinois.

GROUNDWATER FLOW MODEL

A three-dimensional numerical model of the C-O aquifer was developed to evaluate groundwater availability and sustainability using historical and current water use, and several future usage scenarios (Gannon et al., 2009). The model consisted of a grid of 400 columns and 300 rows (1600m by 1600m cell size) superimposed on three model layers: layer 1 consisted of aggregated regional confining beds above the C-O aquifer, layer 2 was the aquifer itself and layer 3 consisted of lower confining beds. Model calibration was achieved by adjusting hydraulic properties and recharge rates to minimize errors in hydraulic head against measured head values and pumping tests.

Hydraulic heads in the C-O aquifer indicate groundwater flow across Iowa from the north to the southeast. Recharge to the aquifer occurs in southern Minnesota where the aquifer is exposed at the ground surface and along the groundwater flow path via leakage through overlying confining units. Leakage from upper units is particularly important to the aquifer water budget with model estimated leakage accounting for 15.9 billion liters of water, or equivalently 50% of the water flux into the aquifer. Discharge from the Iowa portion of the aquifer consists of outflow into neighboring states of Illinois and Missouri and groundwater withdrawal from pumping.

Relative to pre-development conditions, groundwater pumping

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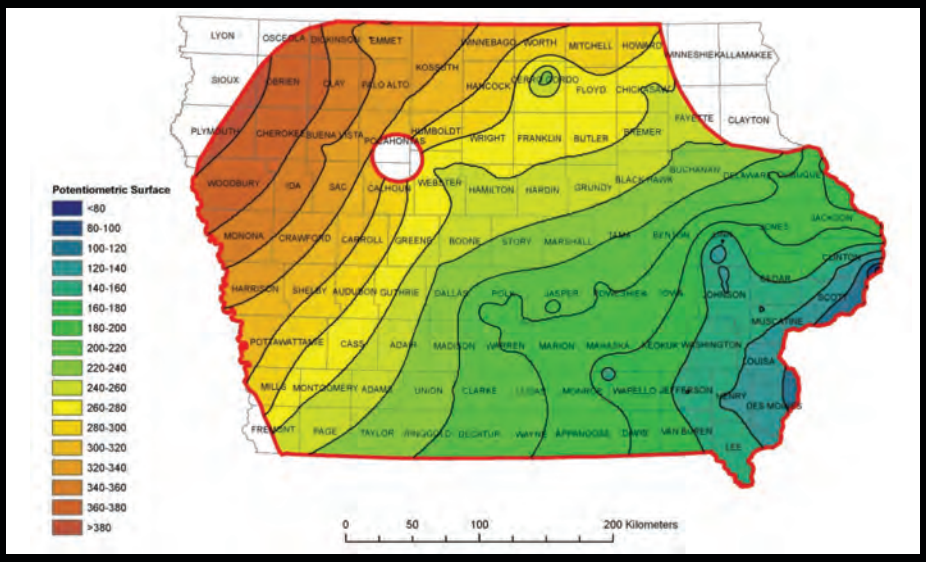

FIGURE 1: Hydraulic heads (m) in C-O aquifer (2007) prior to increase in C-O aquifer use for ethanol production.

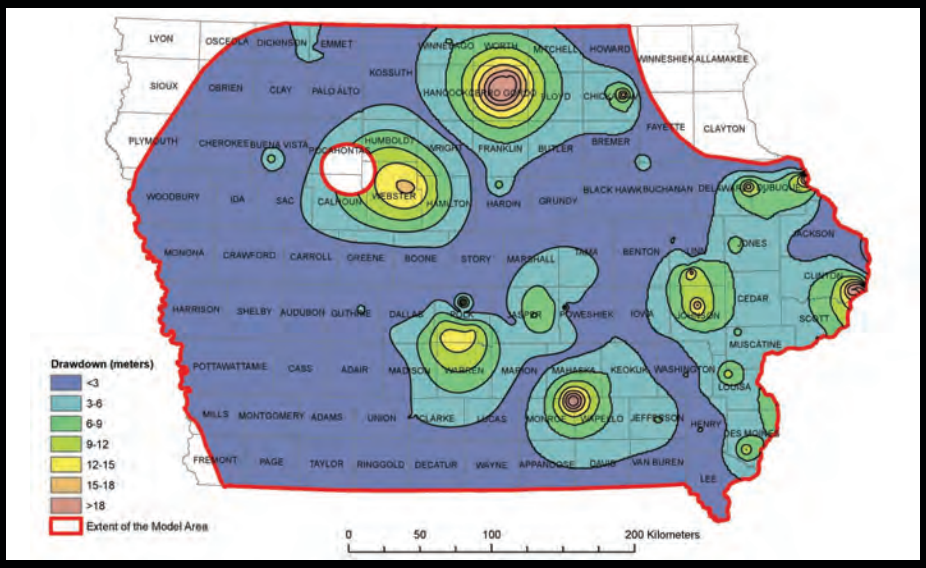

FIGURE 2: Increase in drawdown in the C-O aquifer from 2004 to 2013 due to ethanol production.

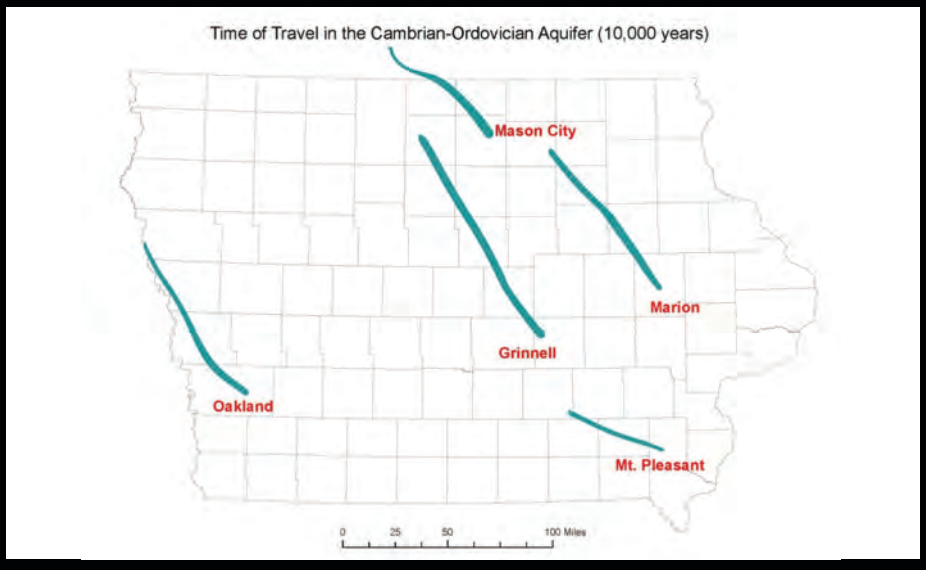

FIGURE 3: Backward particle tracking for 10,000 years in the C-O aquifer from selected municipal wells sampled in this study.

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over the last century of use has depleted the aquifer near major pumping centers **(FIGURE 1)**. Cones of depression have formed around these sites with hydraulic heads declining more than 60 m in some areas due to long-term pumping for public and industrial use. Superimposed on this head decrease over the last decade, groundwater withdrawals for ethanol production have accelerated aquifer depletion **(FIGURE 2)**. Since 2004, additional annual water use of nearly 7.6 billion liters per year for ethanol production has lowered hydraulic heads by nearly 20 m. In some areas, groundwater extraction for ethanol production accounts for nearly one-third of the total head decline.

Due to low hydraulic gradients in the aquifer, groundwater travel times in the C-O aquifer are very long, with groundwater flowing approximately 80 to 160 km in 10,000 years **(FIGURE 3)**. Hence, groundwater pumped from a municipal well in southeast Iowa at Mt. Pleasant may be on the order of 50,000 years old based on advective travel velocities in the C-O aquifer.

GROUNDWATER AGE

To assess the age of groundwater in the C-O aquifer, we sampled eight municipal wells located across the extent of the aquifer in Iowa **(FIGURE 4)** for major and minor ions, $\delta^{18}O$ and δD isotopes, trace elements and ^{36}Cl. Chlorine-36 analyses were completed by the PRIME laboratory at Purdue University using accelerator mass spectrometry (http://science.purdue.edu/primelab/user-information/quality-control.php). With a half-life of 301,000 years, ^{36}Cl has been used in a variety of aquifer studies to date old water (e.g., Plummer et al., 2012; Hendry and Wassenaar, 2011).

The $\delta^{18}O$ and δD values of C-O groundwater ranged from -8.8 to -17.4 ‰ and -57.8 to -131.5 ‰, respectively, and plotted as a straight line on a meteoric water line indicating that no substantial evaporative enrichment or other reactions with aquifer rock have

occurred since recharge. The ^{36}Cl concentration (reported as $^{36}Cl/Cl \times 10^{-15}$) declined from north to south in the C-O aquifer, ranging from 324 in northern Iowa at Mason City to 36-37 at Oakland and Mt. Pleasant **(FIGURE 4)**. Assuming the groundwater system has remained closed to chlorine inputs and a surface recharge $^{36}Cl/Cl$ value can be estimated, groundwater ages can be assessed. The ^{36}Cl values measured in central and southern Iowa (<100) suggest groundwater age may exceed 600,000 years in the C-O aquifer, assuming a modern, pre-anthropogenic $^{36}Cl/Cl$ value for the Iowa area to be ~500 x 10^{-15} (Davis et al., 2003). With an assumption of no additional Cl inputs into the groundwater system, age estimates could exceed 1,000,000 years in southern Iowa.

ARE WE MINING OLD WATER?

Multiple lines of evidence from this study suggest that groundwater in the C-O aquifer is old, and quite possibly exceptionally old. From the groundwater flow model, the residence time of water along a flow path from northern to southeast Iowa may be tens of thousands of years. A long water residence time is consistent with patterns of higher TDS and elemental concentrations in the C-O aquifer at downgradient locations. In another study, the ^{14}C content in the C-O aquifer was found to be below detection limits, implying a groundwater age of more than 35,000 years (Siegel, 1991). In this study, we used ^{36}Cl values to suggest an even older groundwater age in the aquifer, potentially on the order of 500,000 to 1,000,000 years old in central and southern Iowa, provided the aquifer system remained closed to Cl inputs.

A clear disparity exists in our estimates of groundwater residence time in the C-O aquifer based on model-calibrated advective flow rates (tens of thousands of years) and ^{36}Cl measurements (hundreds of thousands of years). The difference likely reflects the effects of leakage from overlying confining beds into the aquifer. The groundwater flow model was calibrated with substantial leakage occurring from strata above and below the aquifer, but flux of leakage water into the aquifer means that the isotope values (^{36}Cl) actually represent a mixture of water of different ages. While the true groundwater age of water extracted from the C-O aquifer cannot be fully understood without more sophisticated reactive transport modeling, the policy implications of our study are clear: groundwater withdrawn from the C-O aquifer will not be recharged in human timeframes and thus the pumping represents the mining of a fossil resource.

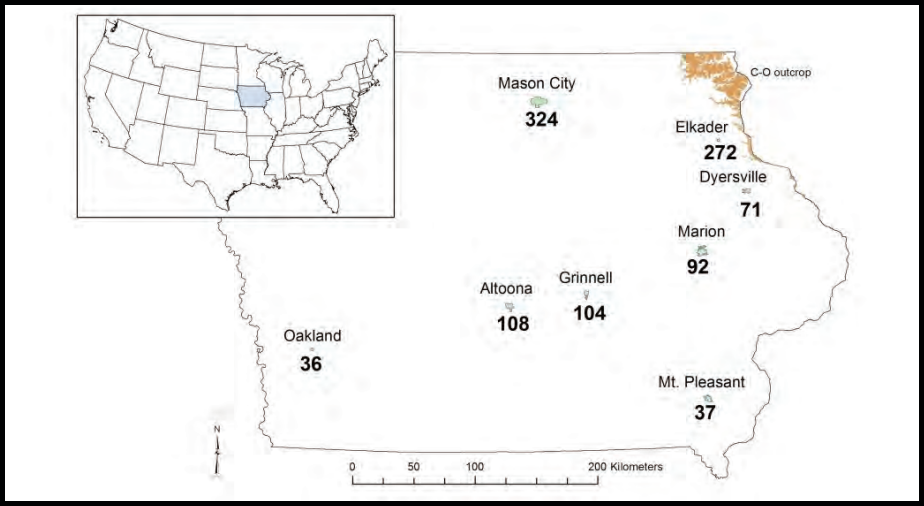

FIGURE 4: Location of municipal well sampling sites and measured ^{36}Cl concentrations (reported as $^{36}Cl/Cl \times 10^{-15}$).

Pumping water from the C-O aquifer for ethanol production is lowering hydraulic heads for public water systems, making it more expensive to extract water and undermining the aquifer's long-term sustainability. Accordingly, we urge restraint for using groundwater from the C-O aquifer for ethanol production since it represents the mining of a fossil resource, and a resource that is the most important state-wide source for municipal water supplies. We thus recommend that expansion of new ethanol production should be based on accessibility of sustainable groundwater resources rather than siting facilities near corn acres or rail access and subsequently relying on deep groundwater reserves for production.

Finally, we believe there are broader lessons from this study for all C-O aquifer users. There is an urgent need for public awareness regarding the long-term risks of reliance on a fossil water resource. Knowing that the water coming out of a tap is potentially hundreds of thousands of years old should ultimately affect water use decisions across the C-O aquifer. It is thus important that society broadly assess what uses are appropriate for the fossil waters of the C-O aquifer, and whether all current uses of this common resource genuinely serve the long-term public good.

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Taking Another Look at Radionuclides in Iowa

Claire Hruby, Ambient Groundwater Quality Monitoring Coordinator, Iowa Department of Natural Resources

Shallow versus deep? A common conundrum for Iowa communities is the choice between obtaining water from shallow aquifer systems which are more likely to contain contaminants associated with human activities, or protected bedrock aquifers which are more likely to contain high levels of naturally-derived contaminants. The solution for many of these communities is to blend. Mixing two water sources dilutes both groups of contaminants, and allows communities to meet drinking water standards. Radionuclides are a group of naturally-derived contaminants that many people assume are only a problem for deep wells in the Jordan aquifer, and sometimes in the Dakota. But this isn't always the case as radionuclides can be found in all of Iowa's aquifers, even alluvial aquifers. Although a substantial amount of research has been done by U.S. and Iowa Geological Survey staff and others over the years, and thousands of water samples have been collected and analyzed, many questions remain unanswered. In order to help communities assess risks from radionuclides in groundwater, it is worth taking the time to understand what the available data can tell us.

What are radionuclides, where do they come from, and why do we care? Radionuclides are atoms that emit radiation as they decay. This radiation, in the form of alpha and beta particles, or gamma rays, can cause damage to cells and tissues. An accumulation of damage to the nucleus of cells, can cause genetic mutations and potentially cancer. There are about 2000 known radionuclides, which include naturally occurring radionuclides formed by the decay of elements incorporated into the Earth's crust or by interactions with cosmic rays, and man-made radionuclides produced through the use of nuclear fuels, nuclear weapons, or radiopharmaceuticals[1].

Radionuclides in groundwater are most often naturally derived from the surrounding rock or sediments. The most common sources of radioactivity in groundwater are isotopes of radium. Radium-226 (^{226}Ra), a decay product of uranium-238 (^{238}U), is the most abundant isotope in groundwater because of its long half-life (1,622 years). ^{226}Ra emits alpha particles when it decays. Alpha particles cannot pass through the skin, but potential health effects can occur once this type of radiation is ingested. Radium-228 (^{228}Ra), which decays directly from thorium-232 (^{232}Th), is slightly less common, and has a half-life of 5.75 years. Decay of ^{228}Ra emits beta particles, but a product of its decay is radium-224 (^{224}Ra), an alpha emitter. Within the decay series of ^{238}U, actinium (^{235}U), and ^{232}Th, there are a total of 14 alpha-particle emitting radionuclides that have half-lives greater than 1 hour. All of these radionuclides could contribute to gross alpha measurements, depending on sample holding-times and analytical procedures. Man-made radionuclides are primarily beta-particle and photon emitters, including strontium-90 and tritium. A good source for information on the occurrence of radionuclides in groundwater nationwide can be found in the U.S. Geological Survey publication, "Occurrence of Selected Radionuclides in Ground Water Used for Drinking Water in the Unites States: A Reconnaissance Survey, 1998."[1] Iowa, and surrounding Midwestern states, are known to have higher levels of ^{226}Ra and ^{228}Ra in groundwater than the nationwide average, while levels of uranium are generally higher in western states and areas with large phosphate deposits, like Florida.

The U.S. Environmental Protection Agency set drinking-water standards for radionuclides in 1976, and an additional standard for uranium, which can cause kidney disease, was added in 2000. A separate standard was proposed for radon-222 (^{222}Rn), but was never approved. The current federal standards are as follows:

Current science suggests that there is some risk of developing cancer from any exposure to radioactivity. EPA's drinking-

Contaminant	Maximum Contaminant Level
Combined Radium-226/-228	5 picocuries per liter (pCi/L)
Gross Alpha Radioactivity (excluding radon and uranium)	15 pCi/L
Beta Particle and Photon Radioactivity	4 millirems/year
Uranium	30 micrograms per liter (µg/L)

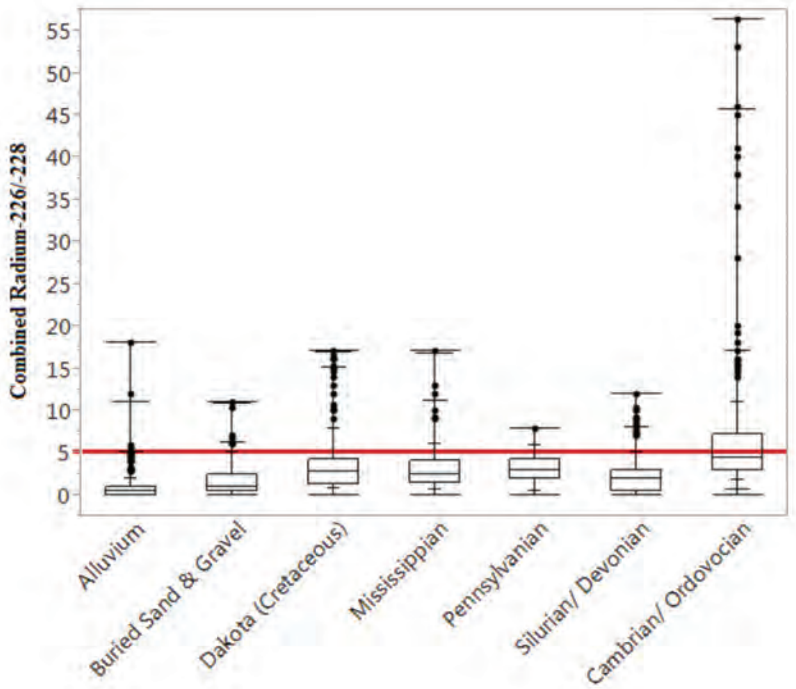
TABLE 1: Drinking water standards for radionuclides (EPA, 2000).

Aquifer Group	N	Mean*	Std Dev*	Median*	Maximum	% > 15 pCi/L
Alluvium	1039	3.07	5.44	1.7	88	1.4 %
Buried Sands and Gravels	496	2.56	2.84	1.7	24	0.8 %
Dakota (Cretaceous)	213	5.52	5.71	3.9	44	5.6 %
Mississippian	277	3.88	4.38	2.4	36	2.9 %
Pennsylvanian	27	3.19	1.85	2.8	6.9	0.0 %
Silurian/Devonian	550	2.30	2.99	1.3	24	1.3 %
Cambrian/Ordovician	416	8.23	9.98	4.8	105	15.1 %
Statewide	**3195**	**3.84**	**5.90**	**2.1**	**105**	**3.7 %**

TABLE 2: Gross alpha radioactivity (including uranium) by major aquifer.

water standards were developed for chronic exposure, assuming an individual consumes 2 liters of water per day for 70 years. MCLs were set to levels that do not exceed a lifetime cancer or kidney toxicity risk greater than 1 in 10,000. Exposures to higher doses or longer time periods increase health risks; however, exposures to radioactivity via food and water are less than 10% of the total amount of radioactivity the average person is exposed to in a lifetime.

Iowa Administrative Code 567 – Chapter 41 lists the monitoring requirements for public water supplies[3]. Community water supplies are evaluated using the average of 4 quarterly samples (or a single composite sample) of finished water from the point of entry into the distribution system. Systems may choose not to have samples analyzed for uranium if the gross alpha particle radioactivity is below 15 pCi/L. Only communities that have been determined to be at risk for contamination by man-made radionuclides are required to monitor for beta particle and photon radioactivity.



* For the purpose of statistical analyses reported here, results below the detection level were assigned values equal to half the detection level.

FIGURE 1: Quantile boxplots showing distributions of combined 226Ra/228Ra concentrations by major aquifer. The 5 pCi/L maximum contaminant level for drinking-water is shown in red. The number of data points available are displayed by aquifer.

Where are radionuclides found in Iowa? A "quick-and-dirty" analysis of all available data in the IDNR groundwater quality geodatabase4 allows us to get an idea of relative risk of exposure to radionuclides between aquifers, as seen in **TABLE 2** and **FIGURE 1**. However, the numbers presented here should be interpreted with caution for several reasons. This dataset contains multiple records from some wells. Wells with high concentrations of radionuclides may have been resampled more often, skewing average concentrations higher and exaggerating the percentage of wells with high levels of radioactivity. Alternatively, some results may have been reported for gross alpha radioactivity excluding uranium, biasing the numbers lower. Additionally, holding times can significantly impact results of gross alpha analyses. Depending on the nuclides contained in the original sample, gross alpha concentrations could increase or decrease over time. Results from USGS electronic files contain more samples above 15 pCi/L than other sources of data. One possible explanation is that sample holding times and analytical procedures were not consistent between data sets: holding samples for several months, or allowing more than three days between sample preparation and analysis can drastically alter gross alpha measurements. Timing of the samples may also be important. The highest gross alpha concentrations were reported in the 1980s. It is possible that the longer the drinking-water

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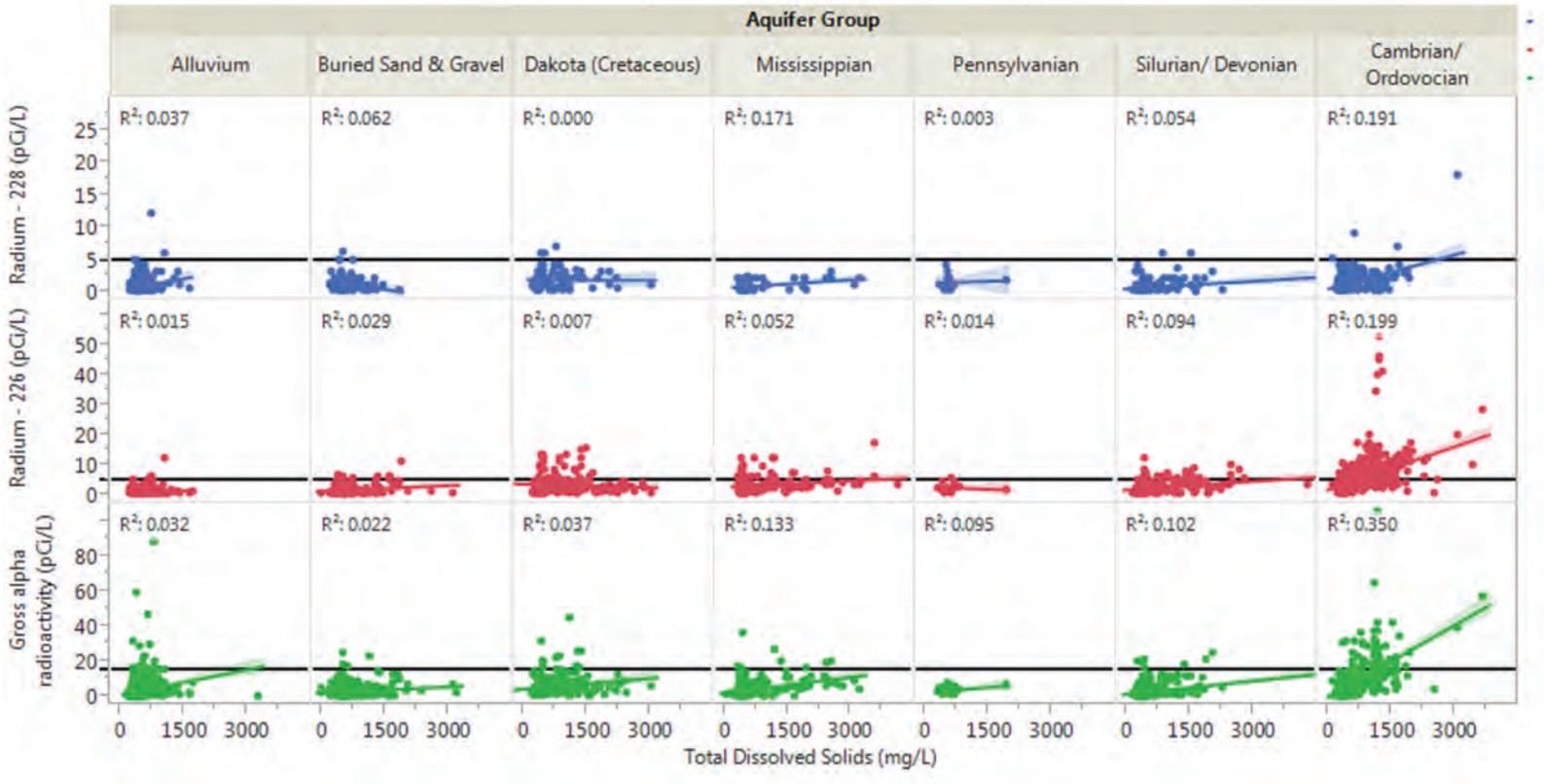
standards have been in place, the fewer public wells with high levels of radioactivity are available for sampling. A more rigorous analysis would be necessary to remove sources of bias, but one can safely conclude that the greatest risk from gross alpha radioactivity exists in the Cambrian/Ordovician aquifers (primarily the Jordan aquifer), followed by the Dakota (Cretaceous) aquifer. Risks from exposure to combined $^{226}Ra/^{228}Ra$ are highest from Cambrian/Ordovician wells, but exceedances of the standard are found in all major aquifers.

In general, radioactivity in the Cambrian/Ordovician aquifer system increases to the southwest, coinciding with waters that have been in contact with their host rocks for increasing lengths of time. This trend was first mapped for ^{226}Ra by P.J. Horick and W. Steinhilber in their summary of the Jordan aquifer published in 1978[5]. The Jordan aquifer also gets deeper to the southwest, and higher temperatures are known to enhance the leaching of radionuclides. In general, radionuclide concentrations increase as total dissolved solids concentrations increase in Cambrian/Ordovician samples as seen in **FIGURE 2**; however, this relationship is not perfect, and several high radionuclide concentrations have been observed at relatively low TDS concentrations. Luckily for communities with both problems, water softening can remove radioactivity and some of the anions that contribute to TDS (calcium, magnesium, and iron).

For other aquifers in Iowa, the distribution of radionuclides is less predictable. The groundwater quality of the Dakota aquifer in the 16 counties in far northwest Iowa was summarized by Rowden et al. in 2008[6]. This report contains a useful review of the natural processes that effect radionuclide concentrations in groundwater. This report also contains a contoured map of results from 48 Dakota wells showing two areas of high (>15 pCi/L) gross alpha particle concentrations centered around the towns of Ireton and Holstein. Gross alpha measurements above 15 pCi/L have also been recorded in samples from the West Bend, Laurens, and Pocahontas. There are no obvious correlations between observed concentrations of radionuclides and other water quality parameters in the Dakota aquifer. Additional monitoring may be necessary to more accurately predict radionuclide concentrations in the Dakota.

FIGURE 2: Concentrations of total dissolved solids vs. radionuclides by major aquifer. R^2 values of linear correlations (colored lines) are presented. Black lines represent drinking-water standards.



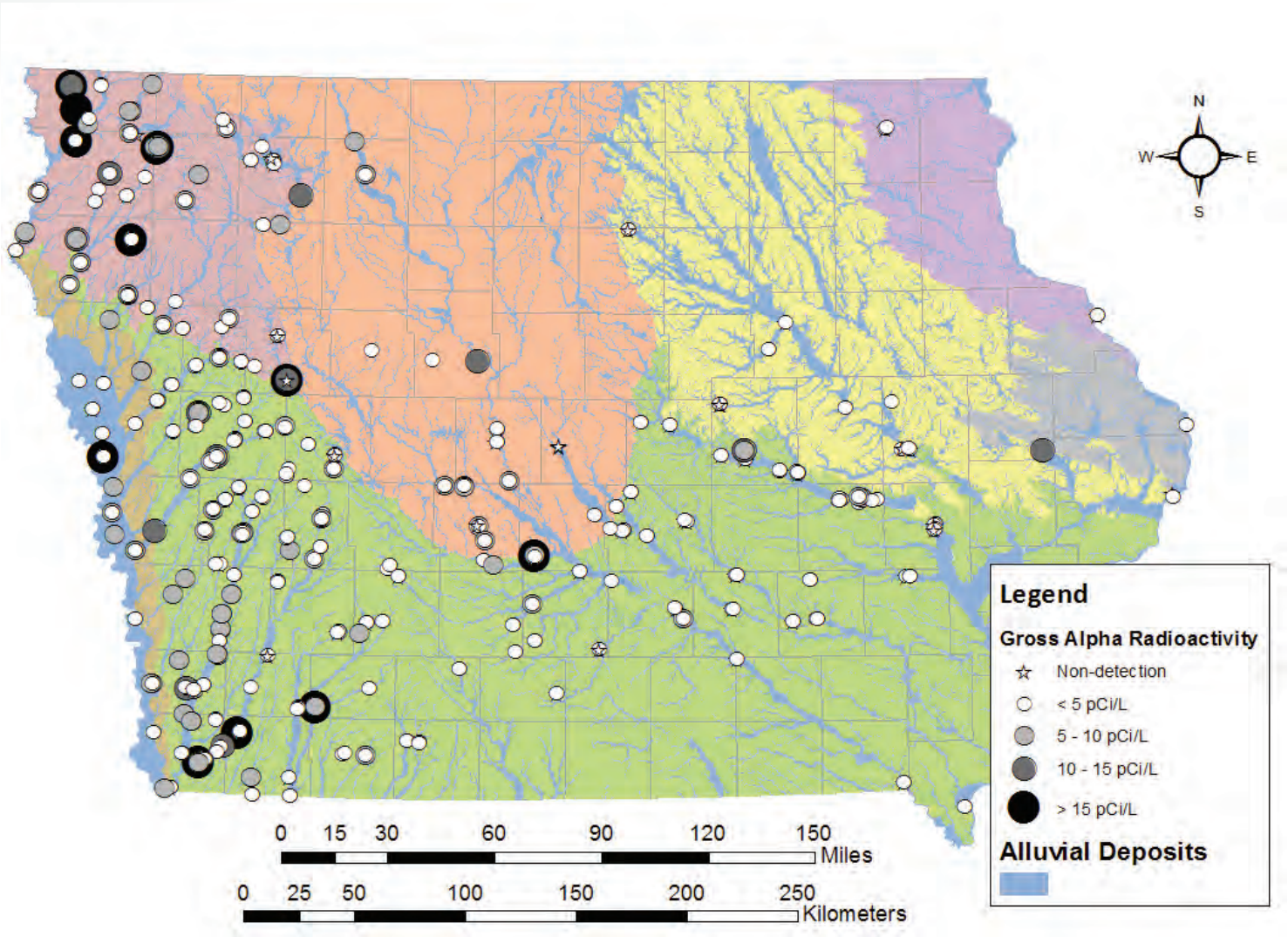


FIGURE 3: Concentrations of gross alpha radioactivity (in picocuries per liter) in alluvial wells from records included in the DNR's Groundwater Quality Geodatabase.

Communities in southern and western Iowa rely more heavily on alluvial aquifers than those in the north-central and north-eastern regions. While most samples from alluvial systems in these regions show gross alpha radioactivity concentrations below 10 pCi/L, concentrations up to 88 pCi/L have been measured in some alluvial systems **(FIGURE 3)**. Although ^{226}Ra is a common source of alpha radioactivity, the highest concentrations of ^{226}Ra in samples from alluvial aquifers do not coincide with the areas of highest observed gross alpha radioactivity. In fact, of the 11 alluvial samples with gross alpha radioactivity greater than 15 pCi/L that have corresponding ^{226}Ra analyses, seven had non-detectable levels of ^{226}Ra, three had measured concentrations at or below 1 pCi/L, and the remaining sample contained 2 pCi/L. If a simple mass balance approach is applied to these numbers, one might conclude that additional alpha-particle emitting radionuclides were present in these samples, but it is also possible that ^{228}Ra was present in the original sample. ^{228}Ra is a beta-emitter, but it decays into a series of 6 different alpha emitters, thus, if samples are held for 3-6 months, the contributions from these radionuclides could substantially increase the gross alpha concentrations[7]. Nothing about radionuclides is simple!

Another interesting pattern is apparent in data from alluvial systems: of the available records, all of the exceedances of 15 pCi/L gross alpha radioactivity occur in samples with less than 10 mg/L nitrate + nitrite, as nitrogen. One possible explanation for this relationship is that recharge events bring a pulse of relatively young water into the system. This water is often high in nitrates, but has not had time to interact with sediments carrying radioactivity. Although some might expect changes in oxidation to impact radionuclide concentrations, this theory is not supported by the available data. Differences in source materials, travel-times, temperature, pH, salinity, and ion-exchange capacity, may also influence the concentrations of radioactive contaminants. Unlike patterns in the Jordan aquifer, higher TDS does not correlate significantly to radioactivity in alluvial systems **(FIGURE 2)**.

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Because groundwater samples with less than 15 pCi/L gross alpha radioactivity are typically not analyzed for uranium, there is very little information on uranium concentrations in Iowa's groundwater. Looking at the numbers that are available only adds to the confusion. For example, there is one sample with no detectable gross alpha radioactivity that has a reported uranium concentration of 31 µg/L. This individual result suggests that doing more uranium analyses regardless of the gross alpha radioactivity is necessary to better describe the risk of uranium exposure.

The Groundwater Quality geodatabase contains results of ^{222}Rn analyses from 345 samples. While the highest median concentration of ^{222}Rn occurs in Cambrian/Ordovician samples (42.75 pCi/L), the highest maximum concentration (1750 pCi/L) occurs in an alluvial sample.

Can radionuclide concentrations change over time? While the source of rock-derived radioactive contamination should not change over time, the available data shows that concentrations of radionuclides can be highly variable. For example, there is a 115 foot-deep well drawing water from the Dakota aquifer in West Bend, Iowa, that has been sampled six times from 2001 to 2012. The results show gross alpha radioactivity concentrations ranging from <1.1 to 31 pCi/L. It is not clear what causes these variations. Changes in concentration over time could occur in response to recharge and/or pumping rates, especially in unconfined systems. It is also possible that differences in the holding-times of samples could play a role. To add to the difficulties in interpreting data, reported uncertainty for gross alpha radioactivity can be as much as 100% of the reported value. Sample preparation for measuring gross alpha radioactivity involves extraction of solids from the sample via evaporation or precipitation. For both methods, radon is readily volatilized and removed, but when the sample hardens, the concentration of radon and other alpha-emitters could be increased via the decay ^{224}Ra, ^{226}Ra, or ^{228}Ra.

Where do we go from here? Given the available data, we can do a reasonable job predicting the risk of radionuclide contamination in Cambrian/Ordovician (Jordan) wells. While we know that radioactivity in the Dakota can be high, we need more densely spaced samples to determine whether there is a pattern to radionuclide content of this aquifer. Although the risks appear to be lower in other aquifers, the potential for radionuclide contamination is present in all aquifers. Given the observed variability, we may never be able to collect enough data to do a good job predicting the concentrations of radionuclides in alluvial aquifers. So for now, communities drilling new wells will need to continue to test multiple times to evaluate potential risks. If we want to do a better job of predicting radionuclide concentrations, we would need to identify the relative importance of individual isotopes and determine the causes of spatial and temporal variability. To do this, the traditional tiered approach to analyses, where uranium, radon, and other less common radionuclides are only analyzed in cases of high gross alpha radioactivity is likely to be insufficient. In addition, we will need to be cognizant of the effect of variations in holding times and analytical procedures and do our best to improve consistency in order to get meaningful results

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ASSESSING WATERSHED-SCALE HYDROLOGIC RESPONSE TIMES WITH HIGH-RESOLUTION SENSOR DATA

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The different components of the hydrologic cycle are typically deeply interwoven with the degree of interconnectedness among them being affected by factors such as land cover, topography, and soil type. A quantitative understanding of the relation and timing between different hydrologic processes is important when conducting studies related to flood and drought mitigation and nutrient transport.

Advances in hydrologic data collection, storage, and transmission enable researchers to gain insight into the interplay among hydrologic processes from analyzing real-time high-resolution time series. Literature reports numerous studies that have used high-resolution data to perform studies on seasonal variability in runoff generation processes, baseflow estimations, the influence of soil moisture on runoff generation processes, recharge, evapotranspiration, and fast shallow groundwater responses (e.g., Penna et al. 2015, Radatz et al. 2013, Meyles et al. 2003).

In the last seven years, the Iowa Flood Center (IFC) and IIHR—Hydroscience & Engineering (IIHR) at the University of Iowa have deployed sensors located throughout Iowa. These sensors are being used for calibrating hydrologic models, issuing flood warning alerts, and studying watershed nutrient dynamics among many other uses. Sensor data includes stream stage, rainfall, soil moisture, shallow groundwater levels, in-stream nitrate+nitrite (nitrate) concentrations, specific conductance and other water quality parameters. Data is publicly available and can be viewed online on: http://ifis.iowafloodcenter.org/ifis/en/ and http://ifis.iowafloodcenter.org/ifis/sc/wqis/

This article focuses on data collected in Otter Creek, a HUC 12 watershed in Northeast Iowa **(FIGURE 1)** and analyzes the differences in response time to rainfall events captured by the sensor network. Otter Creek drains an area of

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Typical precipitation and soil moisture monitoring platform installed by IIHR

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approximately 47.1 mi^2 and is a tributary of the Turkey River. Agricultural activity is concentrated in the west part of the watershed where slopes are mild. In the East part forest and grassland are the predominant land cover and there is more topographic relief. Approximately 70% of the entire watershed's top soil is silt loam and only the southwest part is dominated by loam soil texture.

Data on rainfall amount, rainfall intensity, and soil-water content at 2, 4, 8, and 20 inches below ground were collected at five different locations in the watershed (see rgs stations in **FIGURE 1a**) and streamflow was obtained from a USGS station located approximately 1 mile upstream from the confluence between Otter Creek and the Turkey River. Shallow groundwater data were recorded at two observation wells. One located outside of the watershed (see USGS well in **FIGURE 1a**) and the other well was collocated in the watershed with the station rgs46. Hydrologic data were collected every 15 minutes at all locations.

In this article we focus on two selected rainfall events recorded in 2014. The first event analyzed a time window that included a high-intensity, short-duration summer precipitation event (total rain 1.4"). The second event occurred in the fall (what type of event?) (total rain 2.8"). It was assumed that the arithmetic average of the water content and rainfall data collected at the five stations was representative of the entire watershed. To quantify the response of the hydrologic component to a rainfall event, an analysis of time series slopes was performed. The hydrologic response to an event was defined as the first time, after the first rainfall was recorded, when the slope exceeded the 98th percentile value of the entire record available.

EVENTS

The initial conditions for the soil water content during the summer event (e1) were considerably wetter than those of the fall event (e2) **(FIGURES 2 and 3)**. The combined effect of initial wetter watershed

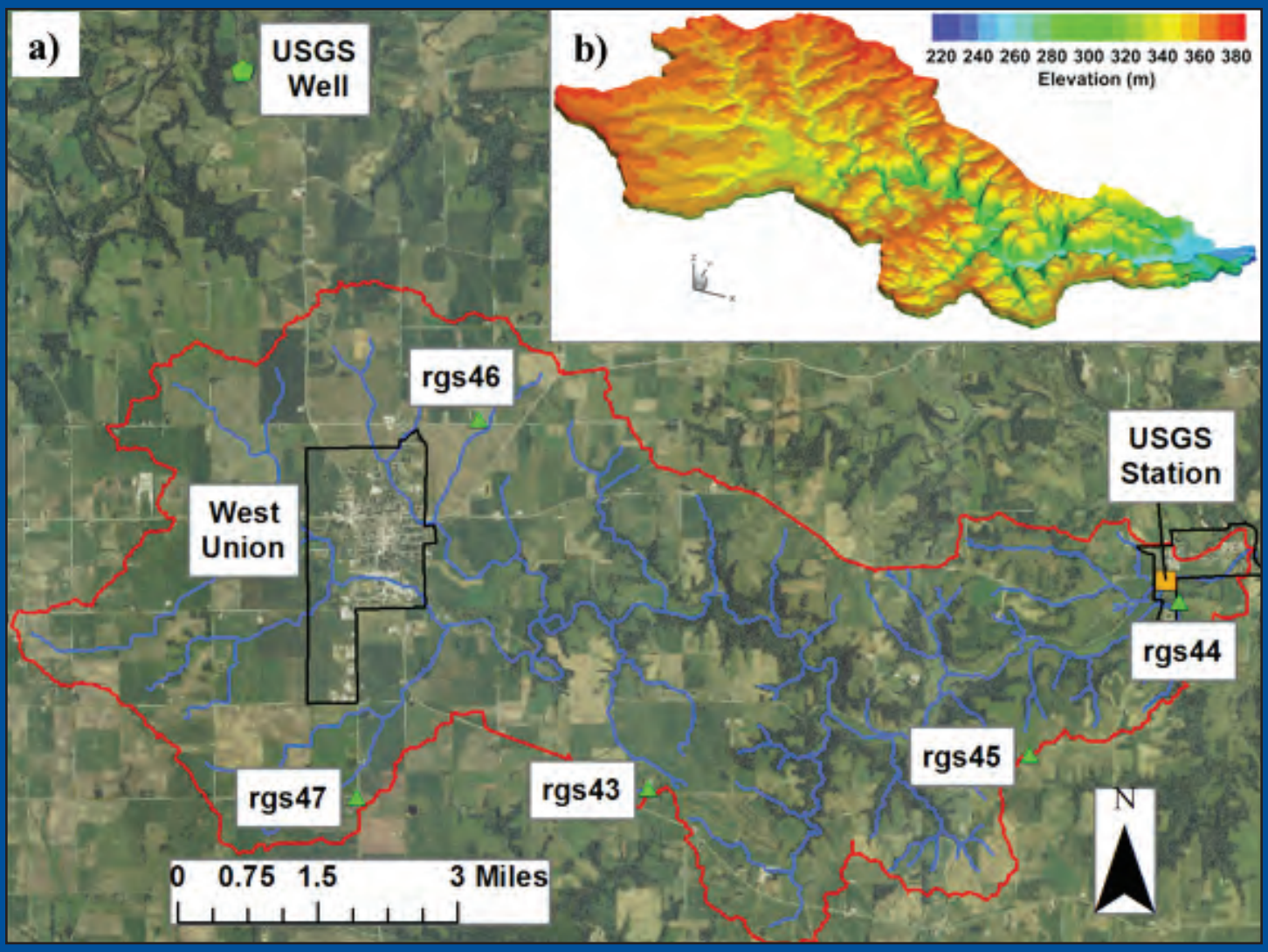

FIGURE 1: Otter Creek. a) Aerial photo and sensor locations. b) Topography.

conditions and higher rainfall intensities in event e1 generated maximum streamflow values of approximately 50 m^3/s whereas the maximum streamflow recorded in event e2 was approximately 12 times smaller. Furthermore, times between time series response and peak streamflow were considerably shorter for event e1 than for event e2 **(FIGURE 4)**.

It is interesting that all the time series responded prior to the peak in streamflow. This behavior was expected for the top water content sensors (2", 4", and 8") but it was also recorded by the sensors located 20" from the ground surface and in the shallow groundwater data. It is worth noting that even in event e2 when the water table was located approximately 7 m below the ground surface a rapid response to rainfall was observed (see DWT(rgs0046) in **FIGURE 3**). **FIGURE 3** also shows a similar water table rise captured by the two wells despite the fact that the well locations were approximately 2.5 mi apart.

Final remarks and future work

High frequency hydrologic data collection allows users to identify time series characteristics that have the potential to be integrated into a flood early warning system. Several communities across the State of Iowa have very short lead times to prepare for floods and therefore can benefit from a system of sensors similar to those installed in Otter Creek.

Considering average silt loam hydraulic properties, the time between the first recorded rainfall and the time series response at water content sensors can be explained by water movement through a porous medium with some preferential flow paths. However, the timing and magnitude of the

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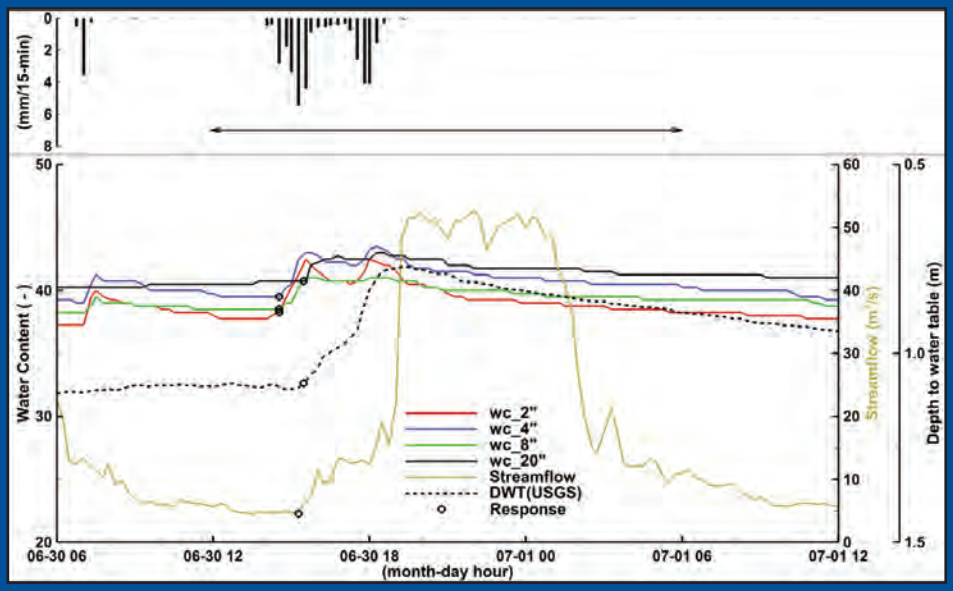

FIGURE 2: Event 1 (e1). Hydrologic time series. The horizontal arrow in the top panel shows the analyzed time window. DWT and wc stand for depth to water table and water content.

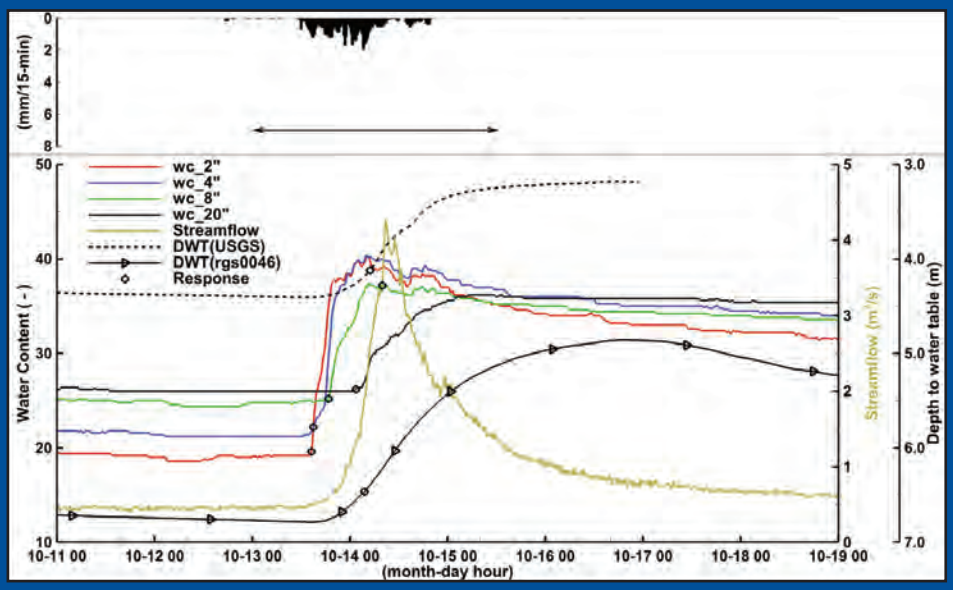

FIGURE 3: Event 2 (e2). Hydrologic time series. The horizontal arrow in the top panel shows the analyzed time window. DWT and wc stand for depth to water table and water content.

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response of the shallow groundwater data time series suggest that mechanisms other than infiltration, percolation, and preferential flow paths are present (e.g. capillary fringe).

In addition to the sensors displayed in **FIGURE 1**, at Otter Creek there are three water quality stations collecting in-stream nitrate concentrations, specific conductance, and other water quality parameters. Researches at IIHR and the Iowa Geological Survey are currently analyzing the water quality data to estimate groundwater and tile contribution to streamflow.

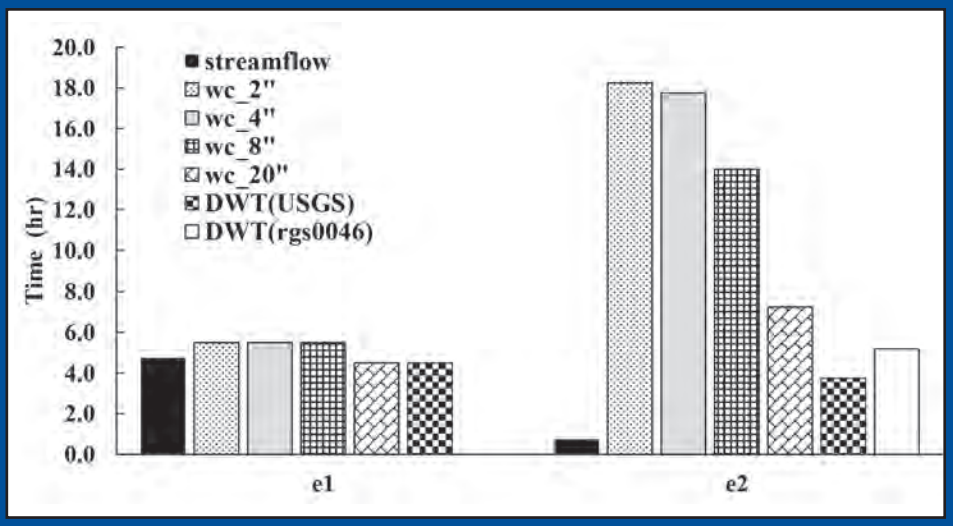

FIGURE 4: Time between time series response and peak streamflow. DWT and wc stand for depth to water table and water content.

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Novel Technology Allows Precision Application of Remediation Efforts at a Leaking Underground Storage Tank Site

Matthew Graesch (Iowa Department of Natural Resources), Linda J. Watts (GeoTek Engineering & Testing Services)

Traditional methods of site investigation at leaking underground storage tank (LUST) sites include advancing soil borings to collect soil samples and installing monitoring wells to collect groundwater samples. These methods deliver accurate information for specific locations; however, when attempting to locate light non-aqueous phase liquid (LNAPL or free product) source areas, resolution is limited due to the cost and time associated with installing enough monitoring wells to gain a clear picture of LNAPL vertical and horizontal distribution in the subsurface. Without a more complete picture of LNAPL locations in the subsurface, the decision of where to concentrate remediation efforts aimed at reducing source mass will be subject to chance or uncertainty.

Reduction of source mass is often the only way to truly have a positive impact on down-gradient, dissolved-phase contamination in groundwater. Quite commonly, groundwater contamination concentrations at LUST sites remain relatively constant over periods of many years or decades, indicating that leaching is ongoing from an LNAPL source. Remediation of these sources might consist of excavation, vapor extraction, various forms of liquid extraction, multi-phase extraction, chemical injection, carbon injection, as well as a multitude of other less-common methods. Each of these methods has proven effective at one site or another, depending upon subsurface conditions. Despite the wide variety of technologies that might be recommended to remove LNAPL, one characteristic unifies them; efficacy and efficiency are vastly improved by an accurate, three dimensional, up-to-date conceptual site model.

ENTER LASER-INDUCED FLUORESCENCE

Laser-induced fluorescence (LIF) is a novel method of site investigation that has been utilized at multiple LUST sites in Iowa. LIF is performed by sending ultra-violet light down a fiber optic cable strung through the rods of a direct-push rig and out a window **(FIGURES 1 and 2)**. When polynuclear aromatic hydrocarbons (PAHs) are present outside the window, they will absorb the UV light and in turn emit light of longer wavelengths that is collected and sent back above ground for analysis. LIF is only sensitive to NAPL and will not react to dissolved or vapor phase contamination. Additionally, LIF signals are four-channel in nature, meaning that it is possible to quantify to some extent the type of NAPL that has produced the return signal (gasoline, diesel, oils, kerosene, etc. as shown in **FIGURE 3**). Generally, LIF is conducted in a grid pattern across a site. At each borehole location LIF response relative to LNAPL depth, intensity and type, electrical conductivity, and the rate of probe penetration plotted against depth are recorded on a boring log **(FIGURE 4)**.

When LIF is conducted in a pattern with appropriate density, the logs can be integrated into a single three-dimensional model, resulting in a much more accurate picture of the subsurface. This model provides information on LNAPL mass, LNAPL vertical and horizontal extent/location, and LNAPL type, thus answering questions such as: "Is excavation feasible and if so what is the possible excavation extent?", "Is injection technology a good strategy and, if so, where and how much do I inject?", and "At what depth is the LNAPL and does is extend below static water level?". Answers to questions like these, in combination with logs of electrical conductivity and penetration rate, can be powerfully integrated with existing stratigraphic information into an accurate picture of the subsurface.

FIGURE 1: Laser induced fluorescence being conducted using a direct push rig and support vehicle.

FIGURE 2: Probe tip for LIF showing sapphire window and fiber optic/electrical connections.

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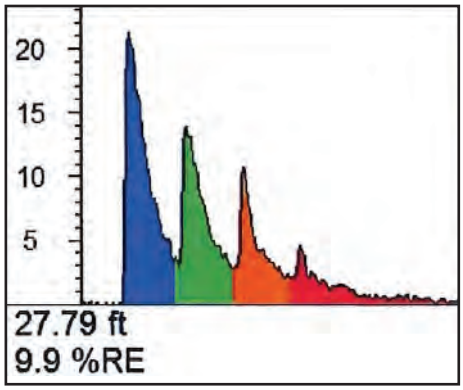

FIGURE 3A: Typical four-channel response for gasoline (note the dominance of blue wavelengths).

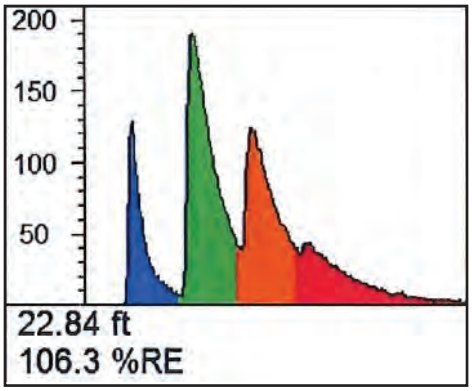

FIGURE 3B: Typical four-channel response for diesel fuel (note significantly elevated response and overall green color).

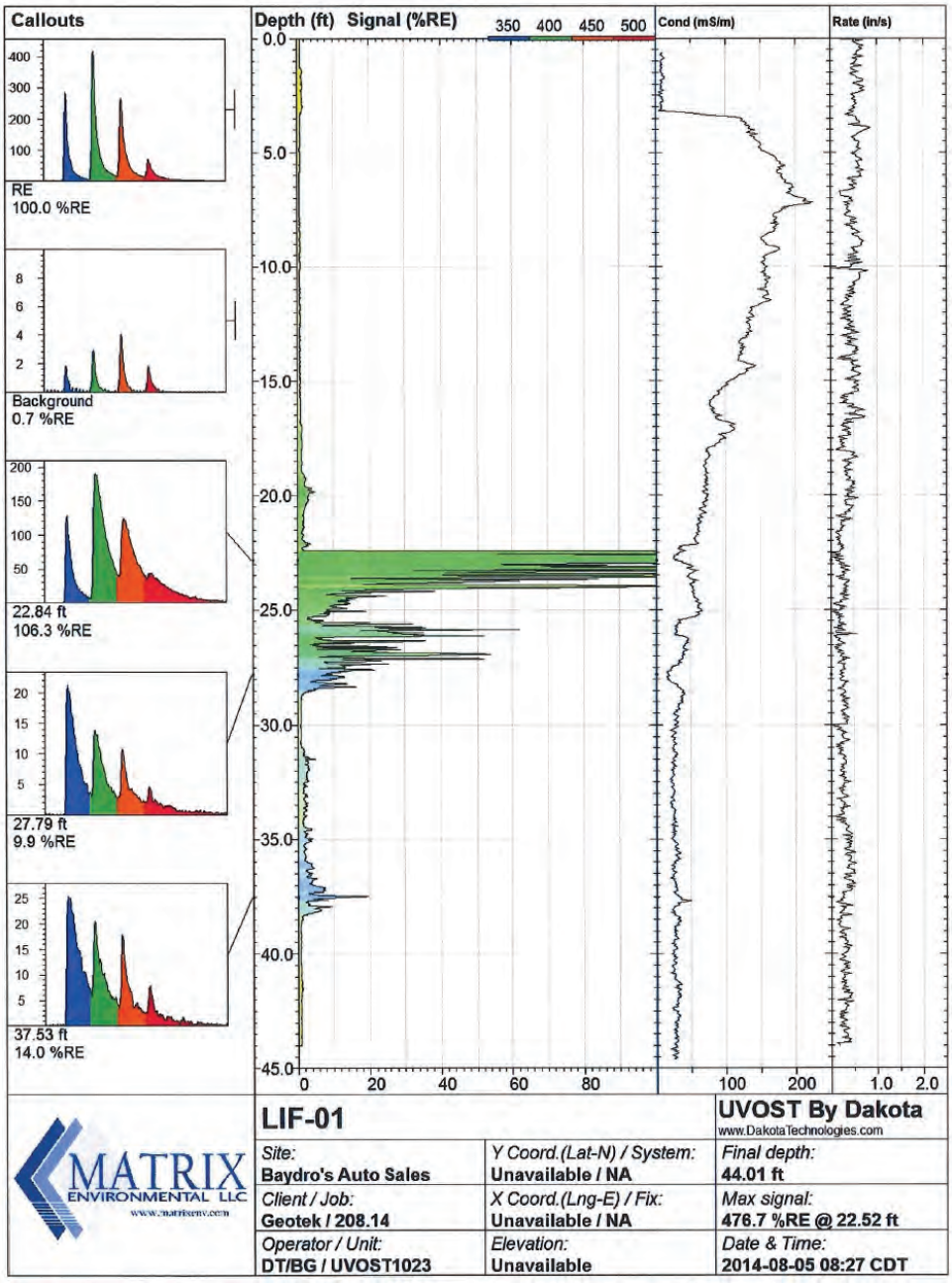

FIGURE 4: Typical LIF log showing depth, four-channel LIF response, electrical conductivity, and rate of probe advancement (note that both diesel and gasoline are present in this log).

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THE SITE

A good example of what can be gleaned from LIF has recently unfolded at The Former Battery Shack (LUST 8LTK79) in Sioux City. This typical gas station sold fuel (diesel and gasoline) from 1969 until 1994. Contamination was discovered, as with many Iowa LUST sites, in 1990 during an insurance audit. In 1995 the site was determined to be high risk for several receptors and remains high risk today. Additionally, recovery of free product via hand bailing commenced in 1991 and continues on a monthly basis. At various times since 1991, free product has been recovered from eleven monitoring wells stretching from near the tank pit to the dispenser island.

Monitoring well MW1A has been the "source" well at 8LTK79 for the purposes of risk-based corrective action (RBCA) and has traditionally had the highest concentration of dissolved petroleum chemicals of all site monitoring plan wells. **FIGURE 5** shows benzene, toluene, ethylbenzene, and xylene (BTEX) concentrations at the source well from 1997 (when regularly scheduled monitoring began) until the most recent sampling event in 2015. Note that BTEX is relatively stable throughout the first nine years indicating a balance has been reached between BTEX leaching from a source area and degradation by microorganisms and natural attenuation by groundwater. Sampling at similar sites elsewhere indicates that this balancing act can go on for decades, resulting in groundwater BTEX concentrations above action limits for an indefinite time period.

A multi-phase extraction (MPE) system with four extraction wells operated at 8LTK79 from February, 2006 until June, 2008. As can be

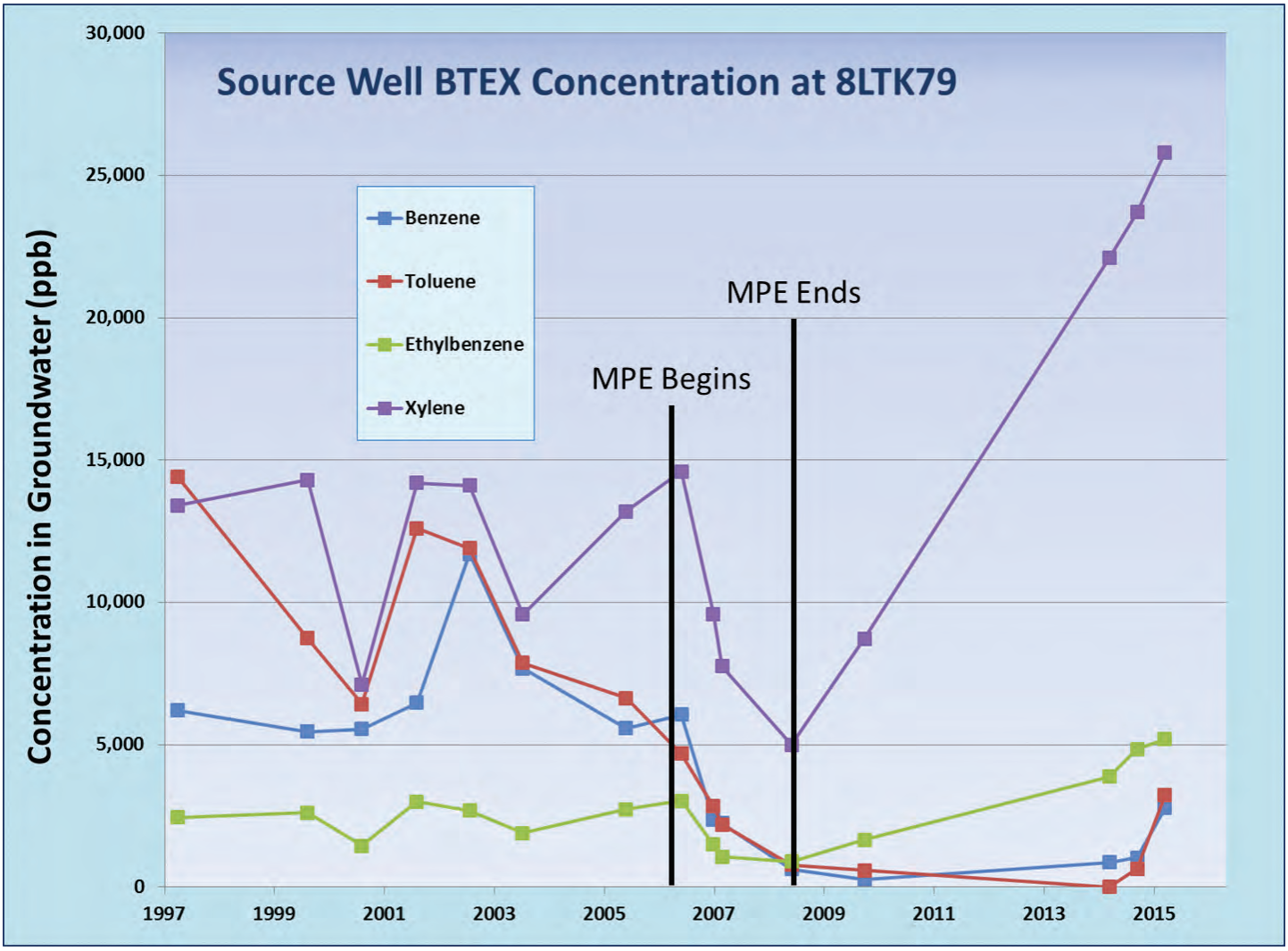

FIGURE 5: Graph showing concentration of benzene, toluene, ethylbenzene, and xylene at the source well for LUST site 8LTK79 from the beginning of regular monitoring through 2015. Also shown is the interval in which active remediation was attempted using multi-phase extraction.

seen from **FIGURE 5**, groundwater contamination at MW1A responded quickly and positively to operation of the MPE system. Once the MPE system ceased operation, contamination rebound (leaching from an LNAPL source) occurred, resulting in three consecutive sampling events with increasing BTEX concentration; back above regulatory limits.

FINDING THE SOURCE -- LIF AT 8LTK79

In an effort to locate and quantify LNAPL source areas at the site, an LIF survey was conducted at 8LTK79 in August, 2014. Matrix Environmental conducted the LIF survey and used a GeoProbe to advance 22 borings during three field days. Examination of the LIF logs **(FIGURE 4)**, three-dimensional plume maps **(FIGURE 6)**, and a cross section **(FIGURE 7)** leads to four conclusions:

1. Two plumes likely representing two separate release locations are present at 8LTK79. This detail was heretofore unknown. It appears that diesel fuel leaked at a pump island while gasoline contamination originated either at the tanks or from piping near the tanks. Previous groundwater sampling at the site had concentrated on gasoline-range organics and diesel range, low volatility compounds had not been tested. Subsequent sampling has revealed diesel in groundwater above state action limits.

2. Shallow soil contamination is limited in lateral extent, as the leaking fuel generally traveled vertically downward, adsorbing to soil and leaving a "pipe" of adsorbed soil contamination that may contribute petroleum vapors and leach to groundwater.

3. The leak(s) had sufficient head to displace and penetrate groundwater significantly. The bulk of LNAPL mass at 8LTK79 is held below the water table,

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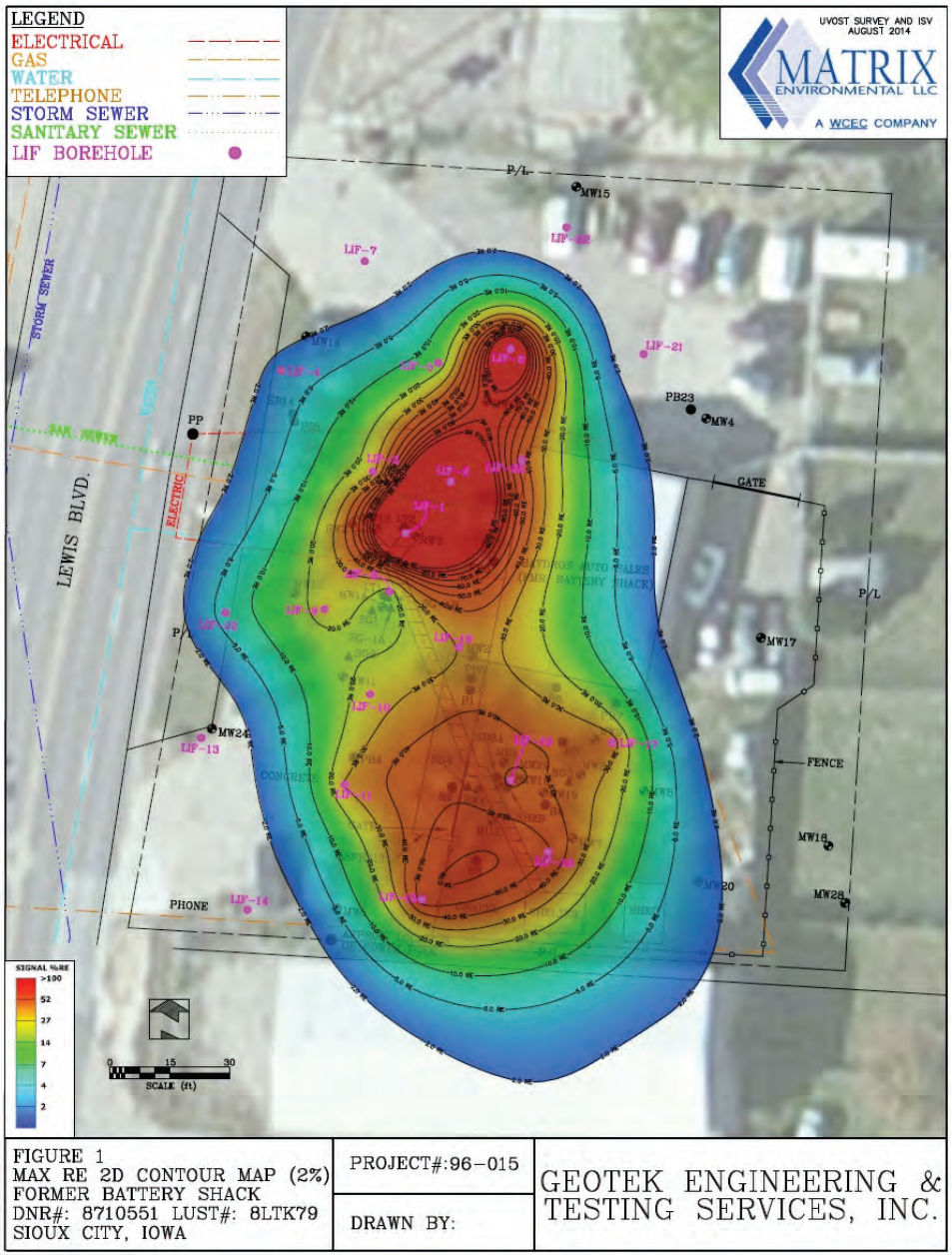


FIGURE 6: Graph showing concentration of benzene, toluene, ethylbenzene, and xylene at the source well for LUST site 8LTK79 from the beginning of regular monitoring through 2015. Also shown is the interval in which active remediation was attempted using multi-phase extraction.

Continued from page 27

making remediation efforts relying on vapor extraction ineffective. Sandy sediment at depth and a productive aquifer render dewatering unfeasible.

4. Excavation is a viable option for dealing with shallow contaminated soils. The boundaries for such an excavation can now be well defined making time and cost estimation more accurate.

A corrective action conference was held in 2015 between Iowa DNR staff and certified groundwater professional (CGP) Linda Watts from GeoTek Engineering and Testing Services, representing the responsible party, to map a route toward closure. It was decided that a two-pronged approach to remediation was justified based on LIF information indicating both shallow/vadose and deeper submerged soil contamination. To address the shallow/vadose soil contamination, two small limited-extent excavations have been planned. Contaminated soil excavation in these two areas will effectively eliminate shallow LNAPL concerns at the site.

Remaining LNAPL mass is primarily detected at depth, in tighter materials, or submerged below the water table. It was decided that chemical injection using Trap & Treat BOS 200® was an appropriate strategy for dealing with deeper LNAPL that had not been effectively treated by the previous MPE system.

Chemicals, mobilization fees, and sub-contractor labor associated with injections are inherently expensive. The single most effective way to limit cost and increase the likelihood of success is to have a good understanding of LNAPL whereabouts and mass so that an injection strategy can be planned which integrates LNAPL location, depth, and concentrations. Using an integrated plan, injections can be located more precisely in those areas where they will do the most good and at the most cost-effective chemical concentrations and depths. Resources are not used to emplace chemicals in areas that do not require remediation.

SUMMARY, LIMITATIONS, AND POSSIBLE FUTURE APPLICATIONS

Though the number of sites in Iowa where LIF has been used is not large, it is ever-increasing because all interested persons (responsible parties, consultants, regulators, funding authorities) have found the technology to be well worth the cost. LIF has been effective at both enabling remediation at sites where previous efforts had failed and streamlining monitoring and remediation at new sites.

Is LIF a good option at all sites where petroleum contamination exists in the subsurface? Unfortunately, there are limitations to the technology and it may not be a good choice for some sites. Sites that lack significant amounts of NAPL are not good candidates as dissolved phase petroleum contaminants do not fluoresce and are not indicated on LIF logs. Also, sites with deep contamination or shallow bedrock may pose challenges for direct push technologies. An additional complication involves attempting to quantify LNAPL concentration at sites with complex geology. At a given LNAPL saturation, coarse material (such as sand) will fluoresce brighter (a stronger "response") than fine-grained material (such as clay). This does not limit the usefulness of LIF for finding the LNAPL, only the quality of relative quantity determinations.

LIF is most often employed in Iowa prior to selection of a remediation technology to ensure that the selected strategy best suits an individual site. Knowing the three-dimensional location of LNAPL enables consultants and regulators to select the best technology for a site while improving efficacy. Additionally, LIF data can be used to improve pilot tests by confirming that they are located in key areas and are chosen appropriately for a given lithologic or hydrogeologic setting.

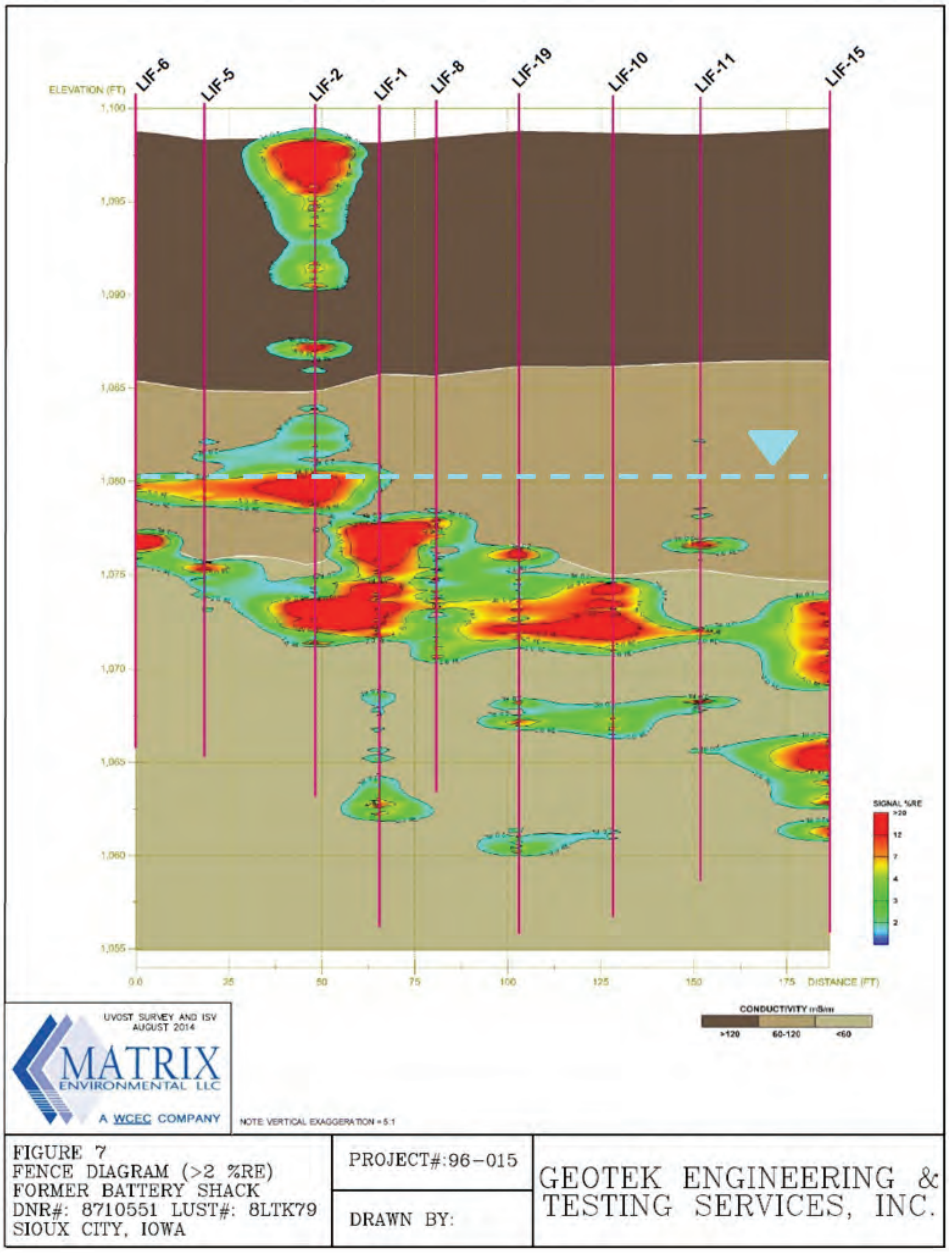


FIGURE 7: LIF cross section (north to south) through LUST site 8LTK79 (note that LIF-2 is at the location of a former dispenser). Average static water level is noted by the dashed blue line.

The initial phases of site investigation at LUST sites in Iowa have not involved LIF. Some states have found that an LIF survey immediately after a known release or discovery of contamination can be even more beneficial than using LIF only before remedial efforts. Significant savings could be realized by using an LIF survey to plan soil boring locations and a monitoring well network; the number and location of borings and wells can be custom tailored to avoid extraneous drilling, equipment, man-hours, sampling, and monitoring costs.

While LIF may not be ideal for all LUST sites, for complex or difficult sites such as 8LTK79, it can prove extremely useful. Empowered by an advanced understanding of subsurface geology and LNAPL location in three dimensions, a precision two-part strategy has been selected to reduce or eliminate the source of contamination at 8LTK79.

For more information:

http://www.wcec.com/page/what-we-do/direct-sensing-drilling/uvost/
Stock, Paul, 2011, Where's the LNAPL?: LUST Line Bulletin 68, p. 13-18

COE COLLEGE

Marty St. Clair teaches chemistry and environmental studies at Coe College in Cedar Rapids, Iowa. The Coe Water Quality Lab includes ion chromatography, flow injection analysis, and inductively coupled plasma, which allows the lab to run a variety of nutrient analyses. Professor St. Clair and his students have studied the interaction between nutrient concentrations and land use in eastern Iowa surface waters for the last 15 years. They have worked with agencies including the Cedar Rapids Utility Department, Iowa Department of Natural Resources (IDNR), (Iowa Department of Agriculture and Land Stewardship) IDALS, and Iowa Department of Transportation (IDOT) as well as with a variety of watershed groups. Recent projects included a National Science Foundation-Rapid Response Research (NSF-RAPID) funded study to look at the impacts of the 2012 drought on nutrient movement and an ongoing examination of the impact of management practices on nutrients in tile drainage at the field scale.

GRINNELL COLLEGE

Peter Jacobson is an ecosystem ecologist teaching at Grinnell College - a four-year liberal arts undergraduate institution in Iowa. His research interests focus primarily on the biogeochemical responses of prairies, floodplains and drylands to changes in land use, and associated shifts in nutrient and water availability. He is currently working with students and colleagues on several projects in Iowa, as well as in Namibia's Namib Desert in southwest Africa. Much of their work over the past decade has focused on groundwater-dependent ecosystems, including springs, fens and floodplain forests. Their work in Iowa has focused on the Lower Cedar River corridor in southeastern Iowa, where a network of preserves managed by The Nature Conservancy provides a dynamic natural laboratory for examining floodplain processes. In particular, they have sought to understand how the region's floodplain and fen ecosystems respond to variations in surface and groundwater hydrology, affecting the dynamics of key elements such as carbon, nitrogen and phosphorus. They have also been working at the Neal Smith National Wildlife Refuge in central Iowa, site of the largest reconstruction of the tallgrass prairie ecosystem in North America, examining carbon and nitrogen dynamics in soil and groundwater across a chronosequence of prairie reconstructions. Grinnell College and the National Science Foundation have supported the acquisition of an extensive suite of analytical instruments for analyses of organic and inorganic constituents of soil, water and vegetation samples, facilitating hands-on student experiences at all levels of the College's science curriculum.

Grinnell College students sampling groundwater under reconstructed tallgrass prairie at the Neal Smith National Wildlife Refuge.

GROUNDWATER HERO

Diane Moles

DENNIS ALT

Dennis began his life as a child in Lincoln, NE, eventually moving with his parents and siblings to Cedar Rapids. He graduated from the University of Iowa in engineering and has had a life-long love of the Hawkeyes ever since. He began working with the Environmental Engineering Service of the Iowa State Department of Health in May 1970, mere days after graduating.

By happenstance, The Environmental Protection Agency was formed in 1970, therefore Dennis has been involved with environmental protection from the ground floor. The Safe Drinking Water Act was passed in December 1974, and was the focus of Dennis' long career. He also had the water use and allocation program, public water supply supervision program, operator certification of water and wastewater operators, environmental laboratory certification, and private water well program.

In 2006, Dennis provided remarks on the changes he'd seen during his career:

"When I started working, our primary concern in the drinking water program was to ensure that public water supplies provided adequate amounts of "bacterially-safe, low-turbidity" water. There is no doubt that potable water is much safer to drink today than it was in 1970. The public water supplies in Iowa have achieved this even though the quality of their water sources has deteriorated in many cases during the same period.

Today we look at over 100 potential contaminants that impact public heath, including microorganisms, physical characteristics, inorganic and organic chemicals, and radionuclides. Sampling requirements are far more complex and are based on a better scientific approach. Some contaminants are now regulated by treatment requirements rather than the traditional laboratory analysis of the contaminant.

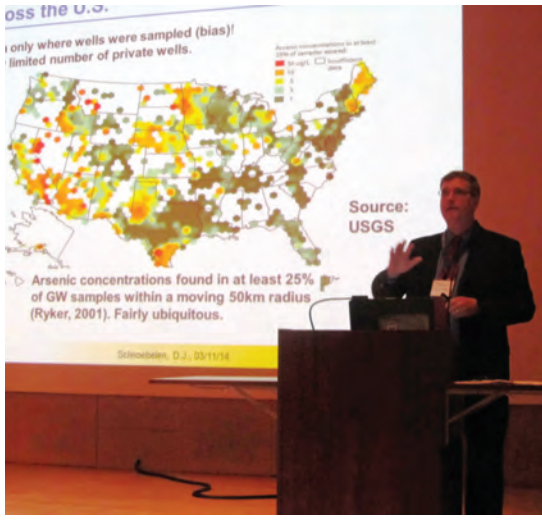
In the early years, the focus was on maintaining infrastructure and on retention of qualified system operators. While those two primary mechanisms to ensure the water remained safe to drink have been a great success, they fall short of achieving the higher standards that we expect today. We now realize that in order to achieve those higher expectations, public water supplies also need to protect their sources from contamination to maintain the technical, managerial and financial capacity of their system, and to keep the consumer informed about their water."

Dennis was very active during his entire career in professional organizations at a state and national level, including president of the Iowa Section of the American Water Works Association and a Fuller award recipient, along with an executive board member of the Association of State Drinking Water Administrators, representing our four-state region for many terms. As a boss, Dennis has always encouraged his staff to participate in professional organizations, attend and make presentations at professional conferences, and to keep abreast of the new technologies and advances in the water industry.

Anyone who knows Dennis knows that he and his wife Dian have four grandchildren whom they adore. Dennis and Dian love to travel, especially with their family. Dennis retired on December 18th, 2014, and on December 26th, he and Dian headed out for a two-month trip to Florida, Cayman Islands, New Orleans, and Arizona.

The best tribute that can be given to Dennis, as with anyone, is that he makes a positive difference in the world due to his actions, his work, and the way he's lived his life.

IGWA Member News



MEMBERSHIP RECOGNITION

New Members

• Aaron Anderson • Catherine Bazylinski • Laura Brandt
• Ryan Budke • Brad Bunn • Daniel Cook • Craig Erickson
• Matthew Graesch • Claire Hruby • Lyle Johnson
• Eric Mueggenberg • Sherry Storjohann • Hollis Weber
• Todd Whipple

5-Year Members

• Brent Beste • Bryan Bross • Bill Christensen • Susan Irving
• Sherri Marine • Michael McGee • Justin Meade
• Matthew Oedekoven

10-Year Members

• Dennis Clark • Michael Conzett • Fred Lawrence
• Paul Pietsch • Jill Soenen

15-Year Members

• Michael Wichman

20-Year Members

• Daryl Enfield

25-Year Members

• Michael Hart • Randy Kroneman • Moll Arp Newell
• Jon Olander • Jeff Vansteenberg

Corporate Members

• Apex Companies LLC • Downhole Well Services, LLC
• HR Green Inc. • Shawver Well Company, Inc.

DID YOU KNOW

that IGWA accepts government groups, such as Iowa DNR sections or county public health departments, as corporate members?

Contact an IGWA Board member for details.

IGWA
Iowa Groundwater Association

Upcoming Events

Minnesota Ground Water Association: The Sinkhole Conference October 5-9, 2015
Rochester, Minnesota • *www.mgwa.org/meetings.php*

2015 Iowa Section AWWA Annual Conference October 6-8, 2015
Cedar Rapids, Iowa • *www.ia-awwa.org/conferencesandtraining/annualconference.html*

2015 NEHA Region 4 Iowa Environmental Health Conference October 7-8, 2015
Waterloo, Iowa • *www.ieha.net/page-1825119*

60th Annual Midwest Groundwater Conference October 14-15, 2015
Bentonville, Arkansas • *www.irwp.org/education-and-outreach/60th-midwest-groundwater-conference*

IRWA Dubuque Fall Conference October 20-21, 2015
Dubuque, Iowa • *www.iowaruralwater.org/events_fall_conference.html*

2016 Groundwater Foundation National Conference October 20-22, 2015
Lincoln, Nebraska • *www.nebraskawelldrillers.org/*

Iowa Groundwater Association Fall Meeting October 21-22, 2015
Iowa City, Iowa • *www.igwa.org*

Aquifer Testing for Improved Hydrogeologic Site Characterization October 27-28, 2015
Ft Collins, Colorado • *www.midwestgeo.com/upcomingcourses.php*

IAMU 2015 Water/Wastewater Operator's Workshop November 17-19, 2015
Ankeny, Iowa • *www.members.iamu.org/events/event_list.asp*

2015 EPI Fall Symposium
Details unavailable, check website. • *www.epiowa.org*

NGWA Groundwater Expo 15 December 15-17, 2015
Las Vegas, Nevada • *www.groundwaterexpo.com/*

IWWA 87th Annual Convention & Trade Show January 28-29, 2016
Coralville, Iowa • *www.iwwa.org/calendar.htm*

IRWA 41st Annual Conference February 22-24, 2016
Des Moines, Iowa • *http://www.iowaruralwater.org/events_annual_conference.html*

Iowa Water Conference March 23-24, 2016
Ames, Iowa • *www.water.iastate.edu/content/iowa-water-center-events*

Iowa Groundwater Association
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COVER PHOTOS: Outcroppings in karst areas of northeastern Iowa. Front cover photo by Ryan Clark, IGS. Back cover photo by Satya Chennupati, IDNR.