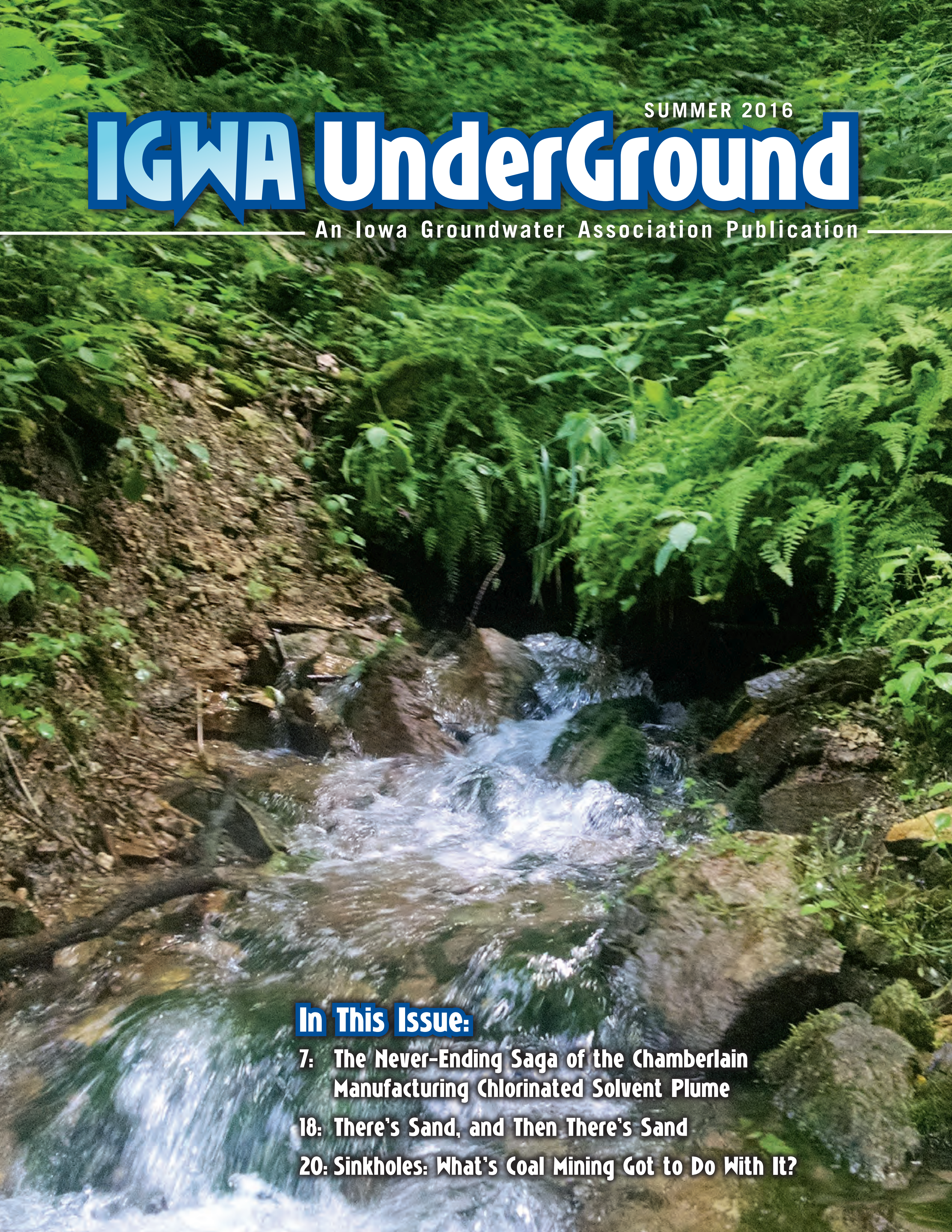
SUMMER 2016

IGWA UnderGround

An Iowa Groundwater Association Publication



In This Issue:

IGWA's 2016 Fall Conference

AT THE GRAND RIVER CENTER IN DUBUQUE, IOWA

Thursday October 6, 2016 – Presentations

Friday October 7, 2016 – Field Trip to Northeast Iowa – Karst, Frac-Sand Mine, and More!

Register online at www.igwa.org

CONFERENCE AGENDA

THURSDAY (OCTOBER 6TH)

8:00 am	**Registration and Breakfast**
8:20 am	**Welcome and Introduction to the 2016 Iowa Groundwater Association Fall Meeting** *Dr. Claire Hruby, IGWA President*
8:30 am	**Morning Panel Discussion – Iowa Source Water Protection and Watershed Management Authorities** *Ross Evelsizer, Northeast Iowa RC&D; Dean Mattoon (Catfish Creek WMA); Mary Beth Stevenson & Rebecca Ohrtman, Iowa Department of Natural Resources*
9:30 am	**Continuous Nitrate Monitoring at Big Spring and Manchester Hatcheries** *Dr. Chris Jones, University of Iowa, IIHR - Hydroscience & Engineering*
10:15 am	**Morning Break**
10:30 am	**Groundwater Forensics – Tools for Identifying Contaminant Sources** *Dr. Dan Snow, University of Nebraska*
11:15 am	**Application of Surface, Water-Borne, and Airborne Geophysical Surveys in Assessing the Hydrogeology of the Cedar River Aquifer, Cedar Rapids, Iowa** *Dr. Adel Haj, U.S. Geological Survey - Iowa Water Center*
12:00 pm	**Lunch provided to all conference attendees**
1:00 pm	**Afternoon Panel Discussion – Iowa's State Groundwater Programs: Recent News and Changes to Water Use, Private Wells, Iowa Geological Survey & Public Water Supply Programs** *Michael Anderson, Russell Tell, Robert Libra & Mark Moeller, Iowa Department of Natural Resources Water Supply Group*
2:00 pm	**Encouraging Local Participation in Groundwater Protection** *Jennifer Wemhoff, The Groundwater Foundation*
2:45 pm	**Afternoon Break**
3:00 pm	**Health Effects of Radionuclides** *Dr. James Jacobus, Minnesota Department of Public Health*
3:45 pm	**Craters in Iowa and Their Impacts on Groundwater** *Ryan Clark, Iowa Geological Survey , IIHR - Hydroscience & Engineering*
4:30 pm	**Post Conference Break, IGWA Board Meeting**
5:00 pm	**A delicious dinner is provided to all keynote attendees**

---------------------------------KEYNOTE SPEAKER---------------------------------

5:15 pm	**The River That Flows Uphill: Geologic Evolution of the Lower Wisconsin River Valley, Stream Piracy, and Reorganization of North American Mid-Continent Drainage Systems** *Dr. Eric Carson, Wisconsin Geological & Natural History Survey*

Reserve your hotel room at the Grand River Center no later than September 12, 2016 - Phone: (563) 690-4500

4.5 CEUs for Groundwater professionals, 6 CEUs for Well Contractors, and 6 CEUs for Water Treatment Operators

This Year's Conference Features a Field Trip to Northeast Iowa – Karst, Frac-Sand Mine, and More!

2016 IGWA Board Members

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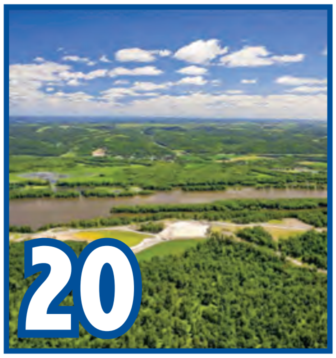

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Objectives

- 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.

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

Claire Hruby – President, Iowa Groundwater Association

Dear IGWA members and friends,

Do you ever think about why you ended up in this field? I do. I think about how important spending time outdoors was to me as a child. How a puddle could be a source of entertainment for hours, and a trip to the Boundary Waters in northern Minnesota was heaven! Now I am watching my daughter grow, and I am reminded daily of that state of wonder. Life gets busy. We rush to work, and we rush to the store, and we rush home, and time just flies right by. But for a three-year old, there are no deadlines, no bills to pay, and the past and the future are vague concepts at best, so the moment is NOW. Throwing rocks into the water is so satisfying, and a centipede on the bathroom floor is a story worth repeating for days!

So, it isn't too surprising when I find myself out sampling, exploring caves, or driving along a dirt road in central Iowa imagining the ice that moved piles of silt and sand and cobbles to form the hills holding up a row of windmills. These moments are perks of this job. But still, far too much of my time is spent in this cubicle in front of two screens measuring the impacts us busy people have on the resources that we need to sustain (and inspire!) ourselves, and wondering whether our children and our grandchildren will be able to survive and thrive, or whether they will suffer from our shortsighted obsession with getting more for less. All of this can be overwhelming, but there is an antidote. Try tapping into your inner three-year-old! Today I am giddy with anticipation about a new set of monitoring results. Later I will spend time with coworkers who dissect streams into pieces: riffles, pools, thalwegs. There is so much more to learn and explore!

As you flip through the pages of this magazine (hopefully while relaxing in one of your favorite outdoor spots!), I hope you find a little something to remind you of the passion and excitement of exploring the world around you. I look forward to exploring new ideas and old rocks with you at our fall meeting and field trip in October!

Until then, Happy trails!

Jordan Aquifer News and Updates

Chad L. Fields – Water Supply Engineering Section, IDNR

IMAGE 1: St. Peter Sandstone overlying the Prairie Du Chien Group rocks in a cliff face along the Mississippi River at the Pattison Sand Mine.

Jordan Aquifer Basics

The Jordan aquifer, also known as the Cambrian-Ordovician aquifer, is the most extensive and well-known bedrock aquifer in Iowa. The Jordan aquifer underlies over 80% of the state, and is absent only in mapped impact craters and in the extreme northeast and northwest regions. In northeast Iowa the Jordan aquifer is exposed at the land surface and visible along scenic road cuts and bluffs **(see IMAGE 1)**. The aquifer quickly deepens to over 1,000 feet in central, west, and south areas of the state. The shallowest Jordan aquifer water use wells are less than 200 feet deep in northeast Iowa, the deepest wells are over 3,000 feet deep in southwest Iowa.

Three distinct geologic units comprise the Jordan aquifer. From top to bottom these units are the St. Peter Sandstone, the Prairie du Chien Group and the Jordan Sandstone **(FIGURE 1)**. Although these geologic units can vary in thickness, all three formations are typically present throughout the extent of the aquifer. The cumulative thickness of the geologic units comprising the Jordan aquifer is normally between 400 and 500 feet. The majority of the Jordan aquifer thickness is derived from the dolomite of the Prairie du Chien Group, though in certain areas the St. Peter Sandstone has eroded deep into the Prairie du Chien Group.

Updates to the Jordan Rule

Iowa updated the water use regulations covering the Jordan aquifer in 2015. The rule update changed measurement requirements from a regional area 200-foot decline to a well-specific three-tiered system. The tier categories for the rule depend on pumping water level measurements matched to the 1978 Jordan potentiometric surface at the well location. Acceptable pumping water level measurements can be either an average from the calendar year, or a single instance measured during the year.

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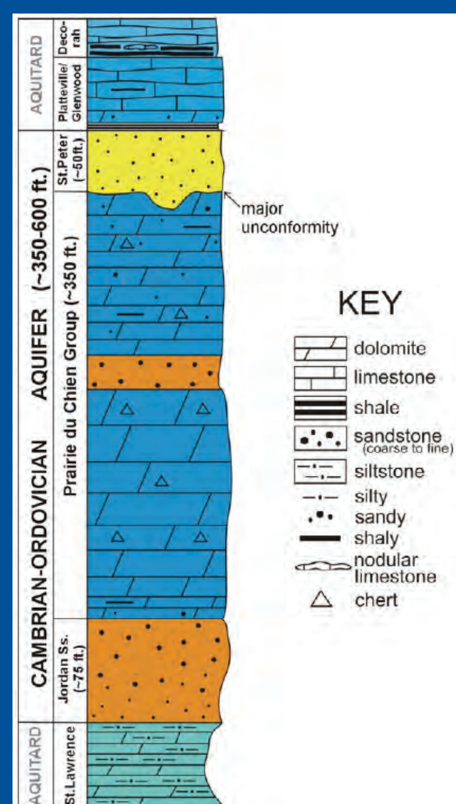

FIGURE 1: Generalized stratigraphy and thickness of geologic formations that comprise the Jordan (Cambrian-Ordovician) aquifer in Iowa. Included are the aquitards above and below the aquifer (from IDNR 2011).

	Feet or Percentage - Jordan Rule Criteria	
	600+ feet of pressure head between aquifer & 1978 potentiometric surface	Less than 600 feet of pressure head between aquifer & 1978 potentiometric surface
Tier 1	<300 feet	<50%
Tier 2	300-400 feet	50-75%
Tier 3	>400 feet	>75%

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The tiers are separated into the levels above:

If a Jordan well pumping water levels decline below the Tier 1 classification, the water use permittee is required to develop and implement an approved water use reduction plan for the Jordan well(s). These plans are specific to the water use permittee, and can involve many different management strategies.

There are additional, new considerations for Jordan aquifer water use permits, including defined protected water source areas and 5-year permit cycles. If you are interested in the rule specifics, please visit www.legis.iowa.gov/law/administrativeRules/rules?agency=567&chapter=52.

Jordan Water Use Permits and Wells

The Water Use Program currently has an active, catalogued total of 198 permits and 328 wells utilizing the Jordan aquifer in the state **(FIGURE 2)**. There are significantly less Jordan water use permits and wells noted today than in previous reports. This decline is due to an increased effort by the state to properly characterize potential Jordan wells in the program's databases. Characterization efforts included moving wells to proper locations, accurately defining source aquifers, and collecting well construction records.

The Iowa Water Use Program groups Jordan water use wells into four overall use categories: public, industrial, ethanol, and irrigation. In 2015, most water use Jordan wells (251 out of 328) were categorized as public. The remaining industrial, ethanol, and irrigation well categories all take less than 20% of the total. It should be noted that many of the wells categorized as "public" also serve industrial and ethanol uses, sometimes taking nearly 50% of the annual water allocation.

FIGURE 2 uses the most recent information to estimate water use totals by county from the Jordan aquifer. Five counties in Iowa use more than one billion gallons per year (bgy) from the Jordan aquifer in 2015. In order of increasing use, those counties were: Linn (1.9 bgy), Polk (1.9 bgy), Clinton (2.2 bgy), Cerro Gordo (2.8 bgy) and Webster (2.9 bgy). Webster County surpassed Cerro Gordo County as the leading county in water withdrawals from the Jordan aquifer for the first time last year in 2015.

Jordan Water Levels

The 1978 Horick and Steinhilber report established the baseline understanding of the Jordan aquifer in Iowa. The report catalogued all major producing wells, water withdrawals, and hydrologic characteristics of the Jordan aquifer. The report's potentiometric surface, measured from known Jordan wells during the mid-1970s, was utilized as the foundation for both current and historic rules. The report also included a pre-development potentiometric surface from the early 1900s and water use estimates from the mid-1970s.

To update the current understanding of the Jordan aquifer's water levels, Jordan water use permittees collected and submitted water level measurements in 2015 and early 2016 to the state via both paper and electronic forms. A total of 217 well water level readings were selected to create an updated potentiometric surface elevation map for 2015, most water measurements were single instance,

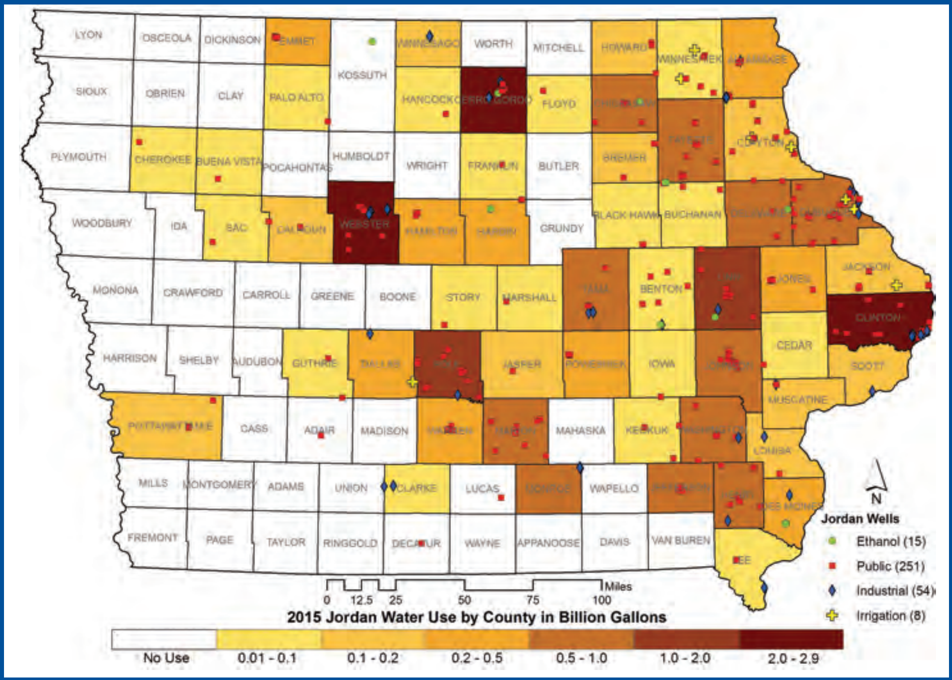

FIGURE 2: Water use total by county from the 2015 Water Use annual report dataset, in billion gallons per year. Included are use categories for each well.

but in certain areas average monthly measurements taken throughout the 2015 calendar year were used instead. **FIGURE 3** shows the 2015 Jordan potentiometric surface elevation map for Iowa. The highest Jordan water level elevation occurs in Emmet County in the northwest region of the state with a number of water level readings of 1,150 feet above sea level (asl). The lowest noted Jordan water level readings were in Clinton County, where a number of wells had water level measurements below 350 feet asl.

In areas with little known water level data, such as western Iowa, no potentiometric surface elevation was created. There are a number of areas with evident cones of depression on the map, including portions of Linn and Johnson Counties, Cerro Gordo County, Polk County, and Webster County.
In almost all of Iowa, with the exception of the northeast region of the state, the Jordan aquifer is categorized as a deep confined aquifer. Most water stored in the Jordan aquifer is very old (> 10,000 years) and not easily replenished. Over the past century increases in water withdrawals from the Jordan aquifer has coincided with considerable decreases in water levels, particularly where the aquifer is both confined and extensively used as a water source. Comparison of the 2015 potentiometric surface elevation to predevelopment water levels indicate extensive areas in the state where the Jordan potentiometric surface has declined over 200 feet, typically in the north and central region of Iowa **(FIGURE 4)**. Water levels have declined over 300 feet in Johnson, Linn and Benton Counties in east-central Iowa. The regions with over 300 feet of decline have had substantial increases in Jordan water use over the past few decades.

Another way to look at water level changes is by observing the decline in feet per year. Annualizing the

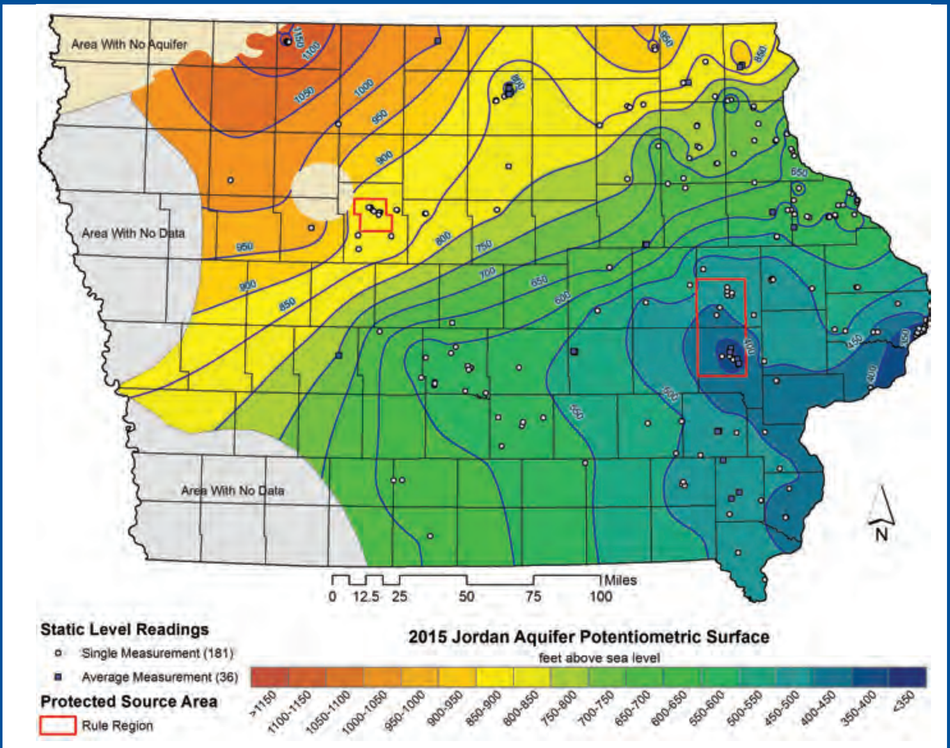

FIGURE 3: Potentiometric surface elevation of the Jordan aquifer derived from selected observed static water level information from Jordan water users. Areas with insufficient data or where the aquifer is absent have been removed from the map.

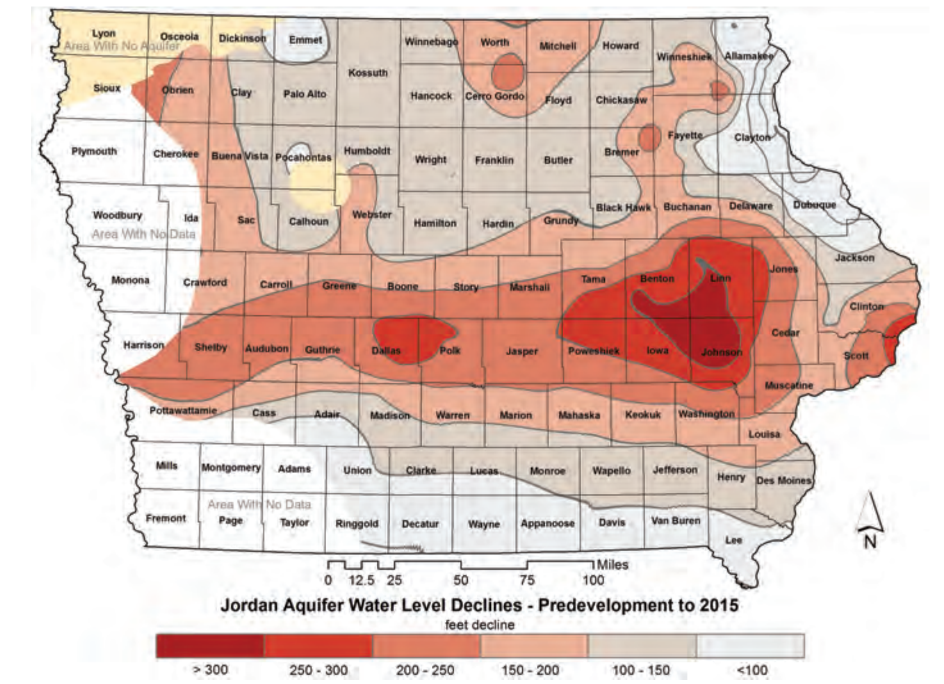

FIGURE 4: Water level declines in the Jordan aquifer in Iowa, predevelopment to 2015.

water level declines from the two potentiometric surfaces (115 years) indicate a yearly minimum of roughly 1-1.5 feet per year in areas of the state with little to no pumping, to a maximum of over three feet per year in areas with substantial pumping. Recent data from 2005-2015 indicates zones in Linn, Johnson, and Webster Counties experiencing water level declines of nearly five feet per year. It is anticipated that with improved annual measurements and analysis,

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yearly water level trends will become a vital asset in determining which areas have the highest levels of decline, and which reduction strategies have noticeable impacts on declining trends in the aquifer.

Jordan Water Use

During the last three years the Water Use Program has made the effort to improve use information by source aquifer. This endeavor has led to increased resolution of water use information, including more detailed estimates of water use by source. In Iowa, there are 74 water use wells that utilize the Jordan aquifer in conjunction with other aquifer sources, commonly the Silurian and Mt. Simon aquifers. In such instances, use estimates for these wells and systems were derived from available total production data, well construction characteristics, and known aquifer characteristics. Aggregating the results from the recent updated information indicates that water use from the Jordan aquifer in 2015 totaled 24.5 billion gallons. Recent trends from 2013-2015 indicate that water use from the Jordan aquifer has increased by roughly 200-300 million gallons per year **(FIGURE 5)**. This trend follows a linear increase that goes back to the 1970s.

As in the past decades, much of the water use from the Jordan is for public water systems, but recent increases in Jordan water withdrawals have been exclusively for industrial use **(FIGURE 5)**. At roughly 16 billion gallons annually, or 65%, the largest user of water from the Jordan aquifer has been for public use. Water use from public water systems has been fairly steady in recent history, with no definitive upward or downward trend. Industrial use is the second highest at 6 bgy in 2015. Industrial use is also the category experiencing the strongest growth, increasing nearly 20% or a billion gallons from 2013 to 2015. Jordan water used in making ethanol is the latest designated use category in the state datasets. However, Jordan withdrawals for ethanol production have held steady at 2.6-2.8 bgy over the past few years, showing no increase in the trend. Due to a restriction on Jordan water used for irrigation purposes in the original rule, there is very little irrigation use from the Jordan aquifer (less than 0.1 bgy), and no increasing trend in that use category.

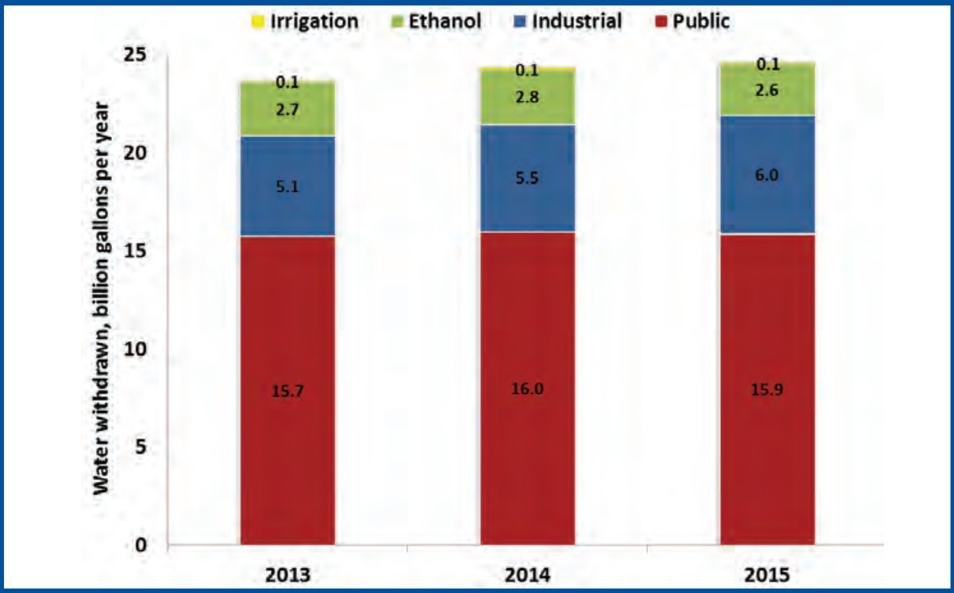

FIGURE 5: Iowa water use program permitted withdrawals from the Jordan aquifer from 2013-2015.

Water Use Program Updates

There were a total of two new Jordan aquifer water use wells constructed in 2015: one for the city of Calmar and one for the city of Pella. Both of these wells were permitted prior to the updates to the Jordan aquifer rule. Both wells are located outside of the protected water source areas and outside of areas with substantial water level declines.

A total of 37 permits were modified, renewed, or updated under the new rule protocols during this past year. All updates and modifications to Jordan water use permits now include information on water levels and tier categories, as well as allocation caps and reporting requirements. Using results from the annual report forms, two water use permits were classified as Tier 2 for 2015: Coralville and Big River United Energy near Dyersville.

The Water Use Program is working with both systems to develop and implement a water use reduction plan that removes both permits from the Tier 2 listing in the future. The Water Use Program's annual report forms and web application have been updated to allow for more specific water level information, including measurement dates, type of measurement, and pumping water levels. Links to the form and web application are available on the water use website at: www.iowadnr.gov/wateruse/

References & Additional Resources

Horick, P.J., and Steinhilber, W.L., 1978, Jordan aquifer of Iowa: Iowa City, Iowa Geological Survey Miscellaneous Map Series 6, 3 sheets, scale 1:1,000,000.

Iowa Department of Natural Resources, 2011, Water Quality of the Cambrian Ordovician Aquifer in Iowa: Iowa Geological and Water Survey Resource Information Fact

The Never-Ending Saga of the Chamberlain Manufacturing Chlorinated Solvent Plume

Cynthia Quast – Stanley Consultants

In the mid-2000s, at the urging of a contingency of local residents, the City of Waterloo purchased the Chamberlain Manufacturing site located at 550 Esther Street in Waterloo, Iowa. Located in a low-income, high minority residential area, with homes to the west and north of the site and a city park to the east and south and Virden Creek running through the park adjacent to the site on the east and south, the City thought this would be a good location for residential expansion. Little did the City know, this would not be a quick process.

The property has a long manufacturing history. Andrew Chamberlain, a prominent butter maker, started the company in the early 1900s to service the butter separation industry. The company eventually evolved into the Waterloo Rope Belt Company, producing components associated with the large separators in creameries. In 1913 the company changed to Chamberlain Machine Works. Over the years items were added to the suite of products manufactured at that location including metal wringers for washing machines, aluminum awnings, refrigerator shelves and projectile metal parts including artillery shells for the World War I war effort. From 1978 through 1996 the site was owned by Duchossois Industries, Inc and among other things was a location where Patriot missiles used in the Persian Gulf War (1990-1991) were assembled.

In 2004 and 2005, during an environmental protection agency (EPA) Brownfields-funded Phase II Environmental Site Assessment (ESA)[1] of the former Chamberlain Manufacturing site, a few interesting discoveries were made; besides localized soil and groundwater contamination from metals and petroleum hydrocarbons, approximately 200, 55-gallon drums of unidentified contents, some bulging and in disrepair, were found. A ground-penetrating radar (GPR) survey identified 12 anomalies in an area of the site where there were purported to be buried drums and the subject of this article, a site-wide groundwater plume of chlorinated solvents, mostly trichloroethylene (TCE) was discovered in the shallow aquifer (10 to 20 feet below ground surface). The maximum concentration of TCE identified in groundwater was 607 ug/L. (The Iowa Protected and non-Protected Groundwater Standards are 5 and 76 ug/L, respectively.) A Supplemental Phase II ESA[2] conducted later in 2005, found that the TCE plume had migrated off-site to the south (OSMW-4) and west (OSMW-5) toward local residences. The highest off-site concentration of TCE was 49.2 ug/L in OSMW-4. **(FIGURE 1 on page 9)**

In 2006, EPA assumed control of the investigation because of the potential risks to off-site populations from vapor intrusion. EPA contacted three previous site owners, Chamberlain, Duchossois and Vose, requesting their assistance with the investigation. Chamberlain, now owned by Duchossois, retained a consultant that performed additional soil and groundwater investigation and started quarterly monitoring in 2007[3]. By this time, the concentration of TCE in OSMW-4 had increased to 3,650 ug/L.

At a public meeting in Waterloo in 2008, a representative from the Waterloo School District told EPA that residents in the area complain of odors in their homes after the houses have been closed up for a period of time. EPA told the representative that preliminary models showed an unacceptable health risk for indoor air in the vicinity of the site and that additional soil vapor and indoor air sampling would be conducted. In the first Quarter of 2009, EPA sampled soil vapors beneath several house foundations in the immediate vicinity of the Chamberlain site and in November of 2009 notified 10 property owners that soil gas concentrations of chlorinated solvents beneath the slabs of their homes could present a cancer risk if the vapors enter the homes.

In April of 2010, EPA released a Risk Assessment[4] it had prepared on the former Chamberlain Manufacturing site. The Risk Assessment found unacceptable cancer and non-cancer health risks for site workers, construction workers, and adult and child residents. Less than two weeks later EPA issued a Unilateral Administrative Order to Chamberlain to address the contamination at the site.

In July of 2011, Chamberlain submitted a Vapor Intrusion Characterization Report[5] to EPA which found 1) the concentration of tetrachloroethylene (PCE) in sub-slab air exceeded EPA screening values in 12 residences; 2) the concentration of TCE in sub-slab air exceeded EPA screening values in

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9 residences; 3) the concentration of PCE in indoor air exceeded EPA screening values in 3 residences 4) the concentration of TCE in indoor air exceeded EPA screening values in 1 residence and 5) volatile organic chemicals (VOCs) were not detected above EPA screening levels for ambient air in all samples. In February 2012, at the request of EPA, the Iowa Department of Public Health (IDPH) prepared a risk assessment report[6] recommending that future structures built on the site be equipped with vapor mitigation systems as a precaution against vapor intrusion of volatile chemicals.

A Chamberlain Status Update[7] dated November 20, 2012 stated that a Vapor Intrusion Characterization had been completed: Vapor sampling was performed at 32 homes, 8 homes had mitigation systems installed but 3 were subsequently turned off after screening levels were revised, all at-risk homes have been offered vapor sampling and Chamberlain will continue to conduct periodic inspections of mitigation systems. It also stated that EPA agreed that the groundwater plume had been adequately delineated.

By early February 2013 all buildings at the Chamberlain site had been razed and, with the buildings out of the way, EPA required additional soil investigation. Chromium contamination was identified in the soil in exceedance of the statewide standard for hexavalent chromium. In January 2015, EPA sent a letter to Chamberlain requiring additional soil and groundwater characterization at the northeast corner of the site and to the east of the site. The additional investigation was approved in September 2015 and EPA requested that Chamberlain evaluate remedial alternatives.

Because the City of Waterloo indicated that it wanted the site to be used for residential purposes in the future, EPA required that after the final remedy, only restriction of groundwater use should be necessary. In a 2016 Corrective Actions Alternatives Study[8], Chamberlain recommended the following:

- In-situ oxidation for VOC-impacted soil;
- Excavation and off-site disposal for soil impacted by semi-volatile organic compounds (SVOCs) and metals;
- In-situ enhanced reductive dechlorination for VOC-impacted perched groundwater;
- In-situ enhanced reductive dechlorination with recirculation in combination with monitoring natural attenuation (MNA) and institutional controls for VOC-impacted groundwater (non-perched); and
- Vapor barriers for VOC-impacted soil vapor.

As of the date of this writing, EPA and Iowa DNR had not yet approved the recommended corrective actions on the Chamberlain site. All the facts of this story (as well as the future ending) can be followed on the Iowa DNR Contaminated Sites Database, https://programs.iowadnr.gov/contaminatedsites/Site/Detail/133.

[1] Howard R Green Company. Phase II Environmental Site Assessment, Former Chamberlain Manufacturing Property, 550 Esther Street, Waterloo, Iowa, January 2005.

[2] Howard R Green Company. Supplemental Phase II Environmental Site Assessment, Former Chamberlain Manufacturing Property, 550 Esther Street, Waterloo, Iowa, September 2005.

[3] Terracon. Soil and Groundwater Assessment Report, Former Industrial Property, 550 Esther Street, Waterloo, Iowa, April, 2007.

[4] U.S. Environmental Protection Agency. Former Chamberlain Manufacturing Company Risk Assessment, Waterloo Iowa, April 2010.

[5] Terracon. Vapor Intrusion Characterization Report—Former Chamberlain Manufacturing Corporation, July 5, 2011.

[6] Iowa Department of Public Health. Health Consultation—Former Chamberlain Manufacturing Site, February 27, 2012.

[7] Iowa Department of Natural Resources. Meeting Notes: Current Status of Former Chamberlain Facility Work-November 20, 2012.

[8] Ramboll Environ. Corrective Measure Study Report, Former Chamberlain Manufacturing Corporation, January 2016.

FIGURE 1: Supplemental Phase II ESA Sampling Locations.

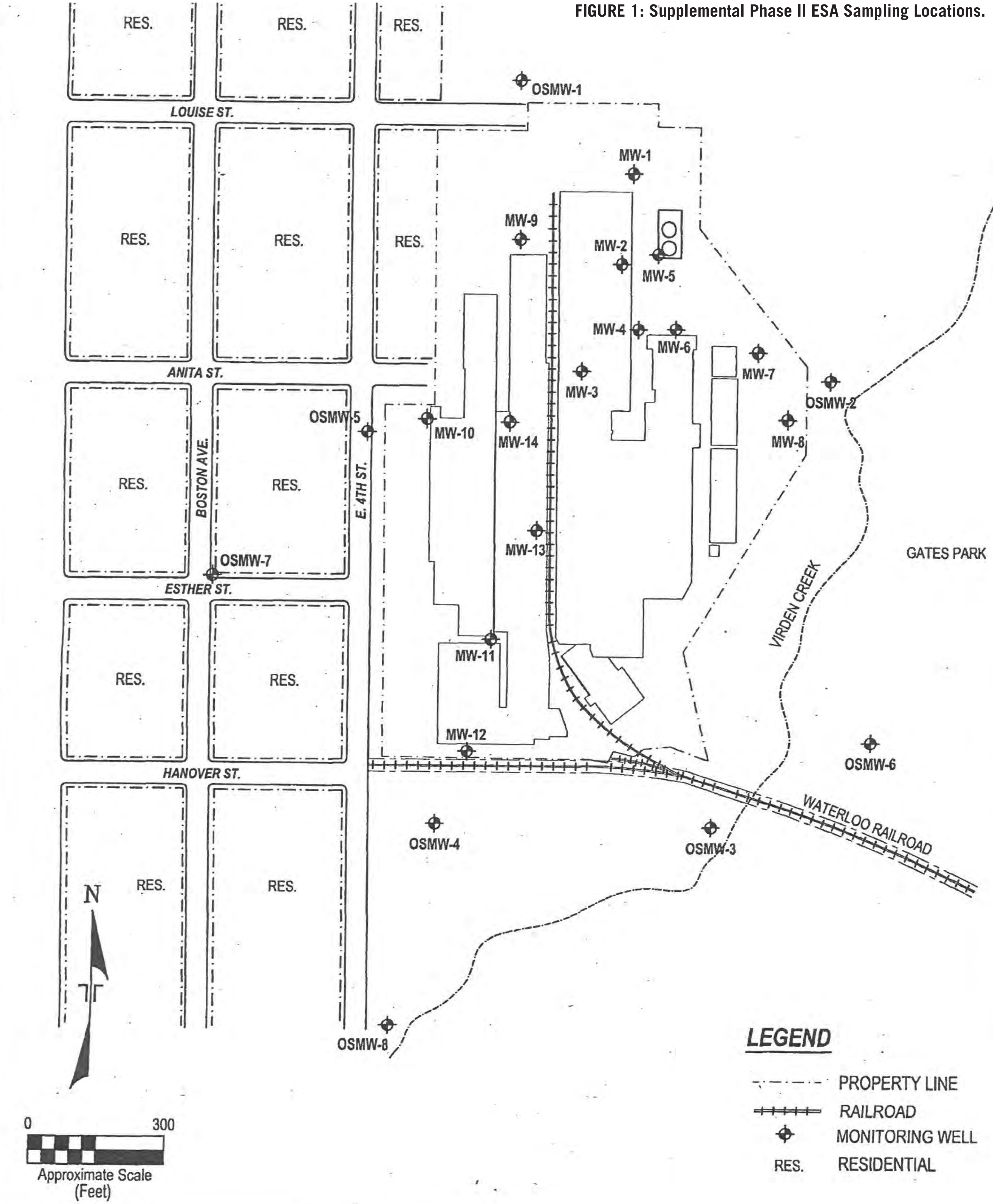

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Photo by Mitchel Schulz

Photo by Mitchel Schulz

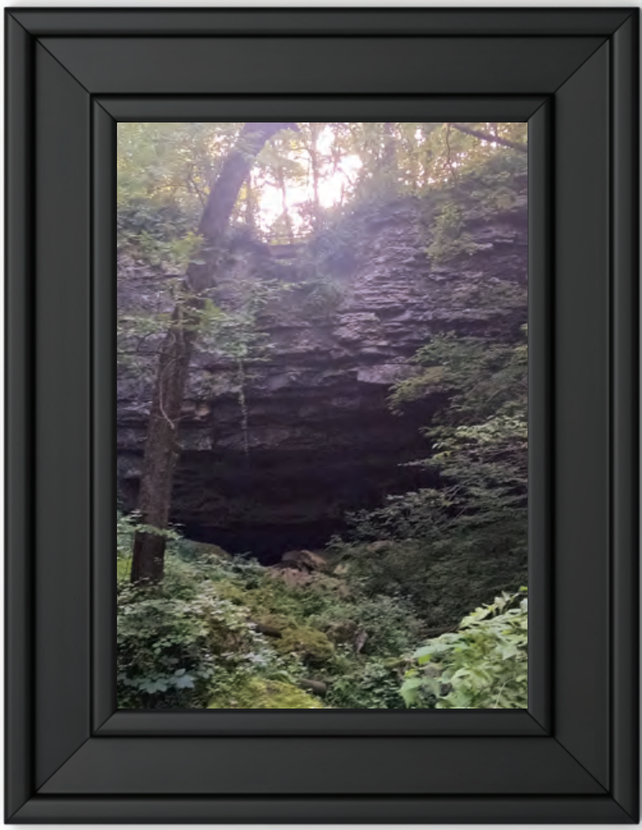

Photo by Chad Fields

Photo by Alana Peterson

Ambient Groundwater Quality Monitoring Report for Fiscal Year 2016

Claire Hruby, Ph.D – Geologist for the Iowa Department of Natural Resources

Annual collection of groundwater monitoring data is important for assessing the quality of water in Iowa's major aquifers, which may be used for a wide variety of purposes including drinking-water for humans and livestock, irrigation, and industrial activities. Groundwater discharges to surface-water can also contribute significantly to surface-water quality, especially during periods of low rainfall. While public drinking water supplies are required to test for contaminants in finished water, the Iowa Department of Natural Resources' (IDNR) ambient groundwater quality monitoring program focuses on raw (untreated) water, most of which is collected from individual public water supply wells. Results of these analyses help us to understand what contaminants are present and how their concentrations change over time. The ambient groundwater quality monitoring efforts in fiscal years (FY) 2015 and 2016 targeted wells considered to be vulnerable to surface activities.

A summary of FY 2015's monitoring can be found in the 2015 issue of IGWA UnderGround. The following is a summary of results from FY 2016.

From October 2015 to March 2016, untreated groundwater samples were collected from 68 public water supply wells in Iowa **(FIGURE 1)**. Half (34) of the sampled wells are located in alluvial aquifers with less than 40 feet of confining materials. The other 34 wells represent buried sand-and-gravel and bedrock aquifers with less than 130 feet of confining materials. Most of the wells (76%) were sampled in the fall (October – December), 21% of samples were collected in winter (January – March), and 2 samples (3%) were collected in early April. Water samples were analyzed for basic water quality parameters (total suspended solids, total dissolved solids, carbonate and bicarbonate alkalinity), chloride, nutrients (total Kjeldahl nitrogen, ammonia as nitrogen, nitrate + nitrite as nitrogen, total phosphorus, and orthophosphate as phosphorus), atrazine and its degradates (desethyl atrazine, deisopropyl atrazine, and desethyl-deisopropyl atrazine), and chloroacetanilide herbicides (alachlor, acetochlor, dimethenamid, metolachlor) and their ethanesulfonic acid (ESA) and oxanilic acid (OXA) degradates). In addition, a subset of these samples were analyzed for radionuclides as part of a graduate student research project.

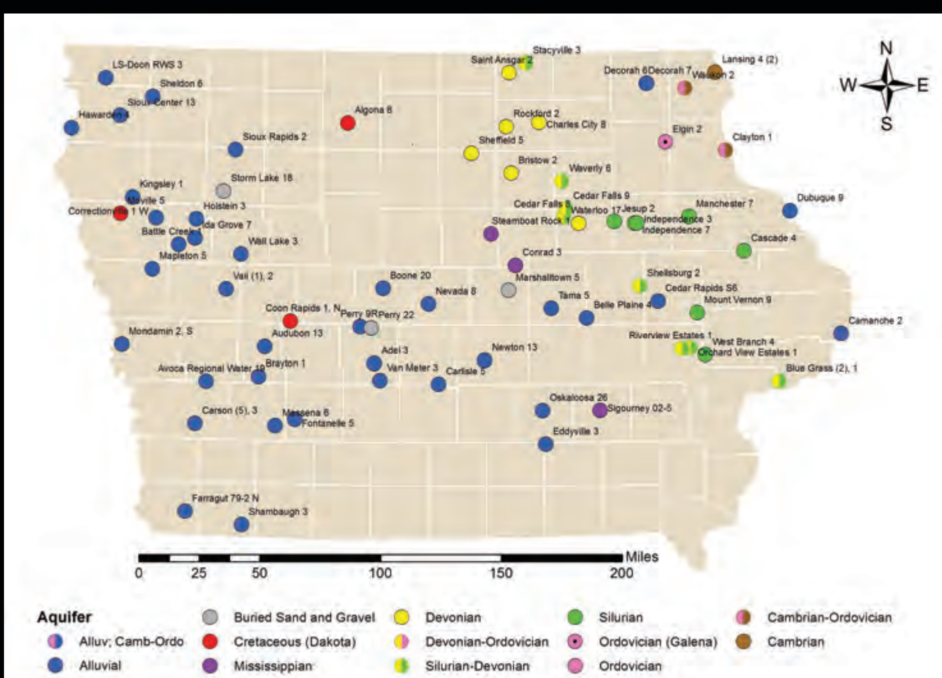

FIGURE 1: Ambient groundwater quality monitoring sites for FY2016 by aquifer.

Results of general water quality, nutrient, and herbicide analyses for FY2016 are summarized in **TABLE 1**. Overall, results from the FY2016 monitoring season were very similar to FY2015, which represented a similar set of wells considered vulnerable to surface contamination based on confining layer thickness.

Nitrate and nitrite contamination of groundwater supplies has been an ongoing concern for over 30 years. While the primary concerns are related to acute toxicity for babies under 6-months of age and for pregnant woman with certain metabolic diseases, recent studies have also shown that chronic exposures to elevated nitrate in drinking-water and diet is a potential risk-factor for certain types of cancers. One recently published study looked at 34,708 post-menopausal women in Iowa and found that women who consumed drinking water with greater than 5 mg/L nitrate as N for four or more years had significantly greater incidence of bladder cancer than those with no comparable nitrate exposure.[1] In FY2016, nitrate + nitrite as nitrogen (N) was detected in 60% of the wells, with a median concentration of 1.8 mg/L, and a maximum concentration of 24 mg/L. Six wells had nitrate + nitrite as N concentrations above the Environmental Protection Agency's (EPA's) maximum contaminant level

2015-2016 Monitoring Season

Group	Analyte	Limit of Detection	Method	N	Number of Detections	Percent Detections	Mean of Detections	Median of all values*	Maximum
General Water Quality	Total Dissolved Solids	1 mg/L	SM2540 C	68	68	100%	440	410	760
	Total Suspended Solids	1 mg/L	USGS I-3765-85	68	25	37%	6	ND	30
	Bicarbonate Alkalinity	1 mg/L	SM 2320 B	68	68	100%	281	270	500
	Carbonate Alkalinity	1 mg/L	SM 2320 B	68	0	0%	ND	ND	ND
	Chloride	1 mg/L	EPA 300.0	68	64.0	94%	29	20	150
Nutrients	Nitrate + Nitrite nitrogen as N	0.1 mg/L	LAC 10-107-04-1J	68	41	60%	5.9	1.8	24
	Ammonia Nitrogen as N	0.05 mg/L	LAC 10-107-06-1J	68	25	37%	0.50	ND	2.00
	Total Kjeldahl Nitrogen as N	0.1 mg/L	LAC 10-107-06-2E	68	24	35%	0.5	ND	1.7
	Total Phosphorus as P	0.02 mg/L	LAC 10-115-01-1D	68	66	97%	0.11	0.07	0.68
	Ortho-Phosphate as P	0.02 mg/L	LAC 10-115-01-1A	68	29	43%	0.06	ND	0.14
Herbicides and Degradates	Atrazine	0.020 µg/L	EPA 536	68	18	26%	0.060	ND	0.290
	Desethyl Atz.	0.020 µg/L	EPA 536	68	19	28%	0.059	ND	0.170
	Desisopropyl Atz.	0.020 µg/L	EPA 536	68	0	0%	ND	ND	ND
	Desethyl-Deisopropyl Atz.	0.020 µg/L	EPA 536	62	22	35%	0.109	ND	0.32
	Acetochlor	0.025 µg/L	SOP UHL-H-016 LC/MS/MS	68	2	3%	0.042	ND	0.055
	Acetochlor ESA	0.025 µg/L	SOP UHL-H-016 LC/MS/MS	68	29	43%	0.276	ND	1.100
	Acetochlor OXA	0.025 µg/L	SOP UHL-H-016 LC/MS/MS	68	16	24%	0.537	ND	<0.025
	Alachlor	0.025 µg/L	SOP UHL-H-016 LC/MS/MS	68	0	0%	ND	ND	0.000
	Alachlor ESA	0.025 µg/L	SOP UHL-H-016 LC/MS/MS	68	36	53%	0.223	0.037	0.950
	Alachlor OXA	0.025 µg/L	SOP UHL-H-016 LC/MS/MS	68	8	12%	0.601	ND	4.100
	Dimethenamid	0.025 µg/L	SOP UHL-H-016 LC/MS/MS	68	1	1%	ND	ND	0.057
	Dimethenamid ESA	0.025 µg/L	SOP UHL-H-016 LC/MS/MS	68	4	6%	0.038	ND	0.046
	Dimethenamid OXA	0.025 µg/L	SOP UHL-H-016 LC/MS/MS	68	3	4%	0.051	ND	0.077
	Metolachlor	0.025 µg/L	SOP UHL-H-016 LC/MS/MS	68	8	12%	0.408	ND	1.600
	Metolachlor ESA	0.025 µg/L	SOP UHL-H-016 LC/MS/MS	68	53	78%	0.505	0.225	4.000
	Metolachlor OXA	0.025 µg/L	SOP UHL-H-016 LC/MS/MS	68	24	35%	0.619	ND	7.100

*Includes non-detections

TABLE 1: Summary statistics for general water quality parameters, nutrients, and herbicides.

(MCL) of 10 mg/L nitrate in drinking-water (the MCL for nitrite as N is 1 mg/L). The highest nitrate + nitrite concentrations were found in alluvial wells in northwest Iowa and in one Devonian well in north-central Iowa **(FIGURE 2)**. It should be noted that all of the public water supplies that participated in this study were compliant with both nitrate and nitrite standards in their finished water in 2015.[2] It should also be noted that while nitrate concentrations are generally lower in the winter in shallow groundwater, warmer than average soil temperatures and significant rainfall in the fall of 2016 may have raised nitrate + nitrite concentrations above typical levels for this time of year in some locations.

Ammonia as N was detected in 37% of the wells. Twenty-four of the 25 detections of ammonia occurred in wells where nitrate was not detected. While there is no MCL for ammonia in drinking water, the presence of ammonia at or above 1.0 mg/L indicates a potential for exceeding the nitrite MCL of 1.0 mg/L. The presence of ammonia enhances the formation of chloramines and can cause drinking water systems to feed more chlorine to ensure sufficient disinfection. Only three wells (4%) contained ammonia above 1.0 mg/L. The maximum concentration (2 mg/L) occurred in a well that draws water from a buried sand and gravel aquifer with an estimated confining layer thickness of 116 feet, indicating that the ammonia was likely derived from aquifer materials, and not from a surface source.

Phosphorus is not a concern for drinking-water, but along with nitrogen, it can contribute to the growth of algae in surface waters. In Minnesota, draft nutrient criteria for streams limit total phosphorus (TP) to between 0.050 – 0.150 mg/L depending on the ecoregion.[3] In FY2016, 25% of the Iowa groundwater samples exceeded 0.150 mg/L. Ranges of TP and orthophosphate as P (PO_4-P) concentrations by aquifer type are shown in **FIGURE 3**. The majority of these relatively high TP concentrations occurred in alluvial samples, including the three highest concentrations: 0.42 mg/L in Missouri River alluvium, 0.51 mg/L in Mississippi River alluvium, and 0.68 mg/L in West Fork Middle Nodaway River alluvium. Similarly, PO_4-P concentrations were highest in alluvial aquifers, with a median PO_4-P concentration of 0.035 mg/L, and a maximum concentration of 0.14 mg/L. Both TP and PO_4-P concentrations were significantly lower in bedrock aquifers: 90% of the samples from bedrock aquifers contained less than 0.100 mg/L TP and 75% of bedrock samples had no detectable orthophosphate. The three samples taken from buried sand and gravel aquifers ranged from 0.100 to 0.280 mg/L TP, none of which contained detectable levels of orthophosphate.

Atrazine is a commonly used herbicide in Iowa.[4] At sufficient concentrations, atrazine has been shown to disrupt the estrous cycles

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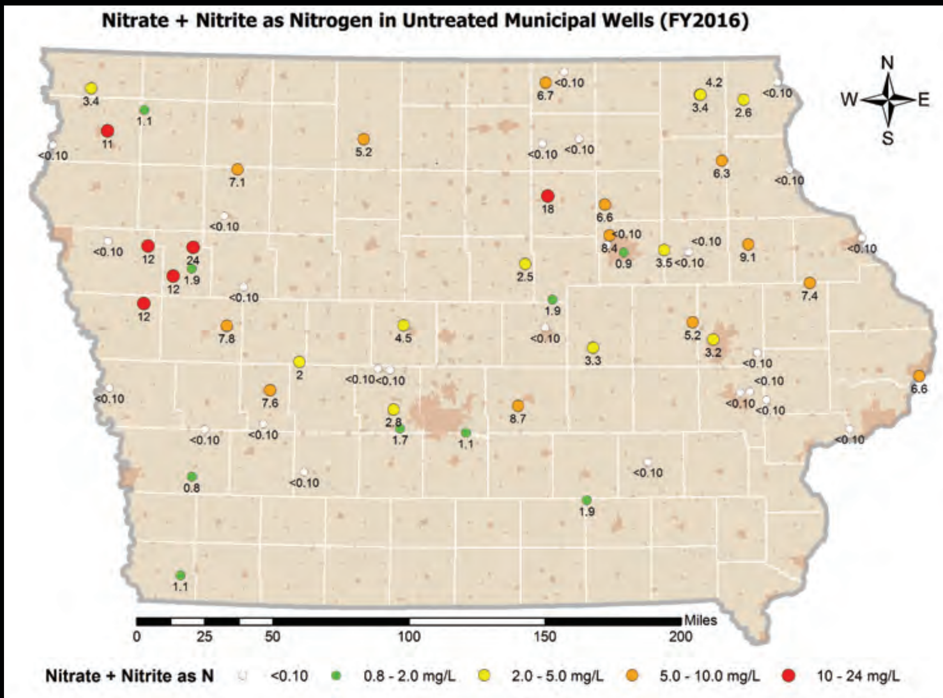

FIGURE 2: Concentrations of nitrate + nitrite as nitrogen (N) in untreated groundwater samples (FY2016).

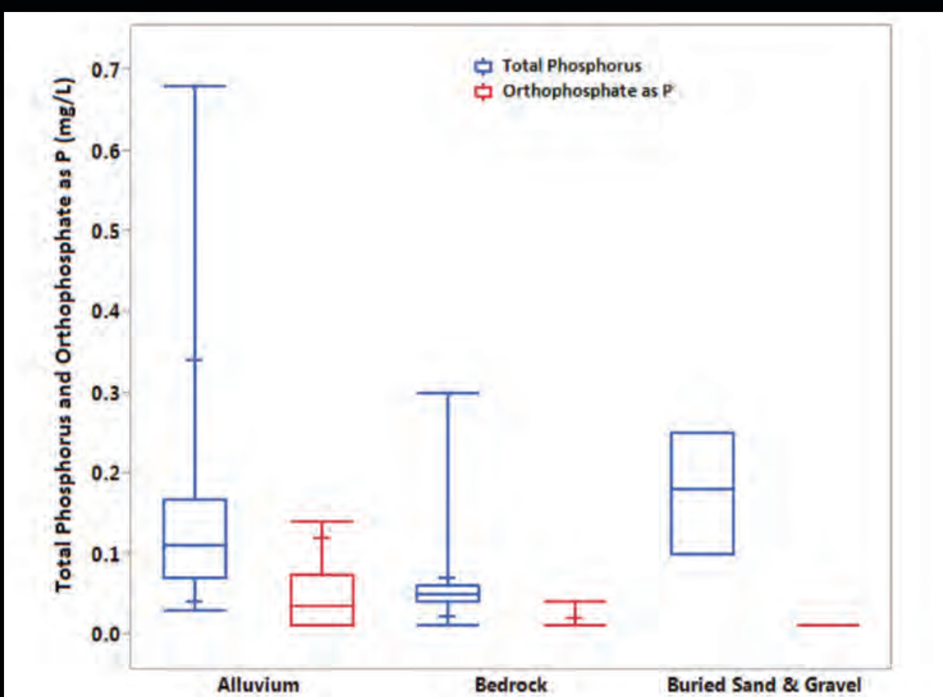

FIGURE 3: Quantile boxplots showing ranges of total phosphorus and orthophosphate as P concentrations by aquifer type.

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of rats and cause feminization of certain species of frogs. Atrazine was detected at low levels (maximum concentration of 0.240 µg/L or ppb) in 26% of the wells. These concentrations are well below EPA's MCL for in drinking-water of 3 µg/L atrazine. The chloro-s-triazine degradates of atrazine are thought to have similar toxicological effects. In FY2016, two of the three measured degradates of atrazine were detected: desethyl atrazine in 28% of samples, and desethyl-deisopropyl atrazine (also known as 2- chloro-4,6-diamino-s-triazine, or diamino atrazine) in 35% of samples. It appears that the timing of sampling may have had an effect on concentrations of desethyl atrazine and desethyl-deisopropyl atrazine as illustrated in **FIGURE 4**. The maximum combined concentration of atrazine and its three degradates was 0.38 µg/L, which is also well below EPA's MCL, and is far below the World Health Organization's drinking-water guideline for atrazine and its chloro-s-triazine degradates of 100 µg/L.

Among the chloroacetanilide herbicides tested, EPA has only set a drinking-water standard for alachlor (2 µg/L), which was not detected in this study. The remaining chloroacetanilides that were tested are not currently subject to drinking water regulations, but alachlor ESA and OXA, acetochlor and its degradates, and metolachlor and its degradates are listed on the EPA's Contaminant Candidate List indicating that additional investigation of the public health risks associated with these compounds is a priority. Concentrations of metolachlor were below the World Health Organization's recommended guideline for drinking-water of 10 µg/L. The most commonly detected herbicide compound was the degradate, metolachlor ESA, which was present in 78% of the samples at concentrations up to 4.0 µg/L with a median of 0.225 µg/L. The highest measured concentration of an herbicide was 7.1 µg/L of the degradate metolachlor OXA. Concentrations of metolachlor ESA **(FIGURE 5)** and the other chloroacetanilide herbicides were generally highest in Silurian or Silurian-Devonian wells in east-central Iowa. Timing of sampling appears to have had the greatest effect on alachlor ESA concentrations, which were higher in November and December than in other months, although the differences between months were not statistically significant. Most (97%) of the cumulative concentrations of herbicides (including atrazine, the chloroacetanilides, and their degradates) in the wells tested were below 3 µg/L; the remaining two wells had total herbicide concentrations of 11.8 and 19.1 µg/L.

This is the third consecutive year that untreated groundwater from public wells in Iowa has been tested for atrazine, the chloroacetanilide herbicides, and their degradates. No statistically significant differences in the distributions of concentrations of these compounds are seen between years (2013-2016) when grouped by aquifer. The lack of significance may result from small sample sizes and low detection frequencies. Further examination of data from individual wells may reveal more information about changes in concentration from year to year.

Monitoring of herbicide concentrations in Iowa's groundwater also took place in the 1990's and early 2000's. Although a thorough statistical analysis has not yet been completed, it appears that wells that contained measurable levels of atrazine and metolachlor in 2001-2004 often contain the same compounds in 2013-2016, but at lower concentrations. Most of the samples from the 2001-2004 period were collected in July and August, while the 2013-2016 samples were collected between October and March; therefore, it is possible that some of the differences between these sample sets result from seasonal variations in herbicide concentrations relating to the timing of application. Continued monitoring of these and other agricultural chemicals in groundwater is necessary as use of these chemicals changes over time. Use of alachlor has been dropping since the 1990's and sales are no longer allowed in the U.S. as of this summer.[5] Meanwhile, the use of a new formulation of metolachlor (metolachlor-S) is increasing, and the use of acetochlor and atrazine on corn has remained relatively consistent for two decades.[4]

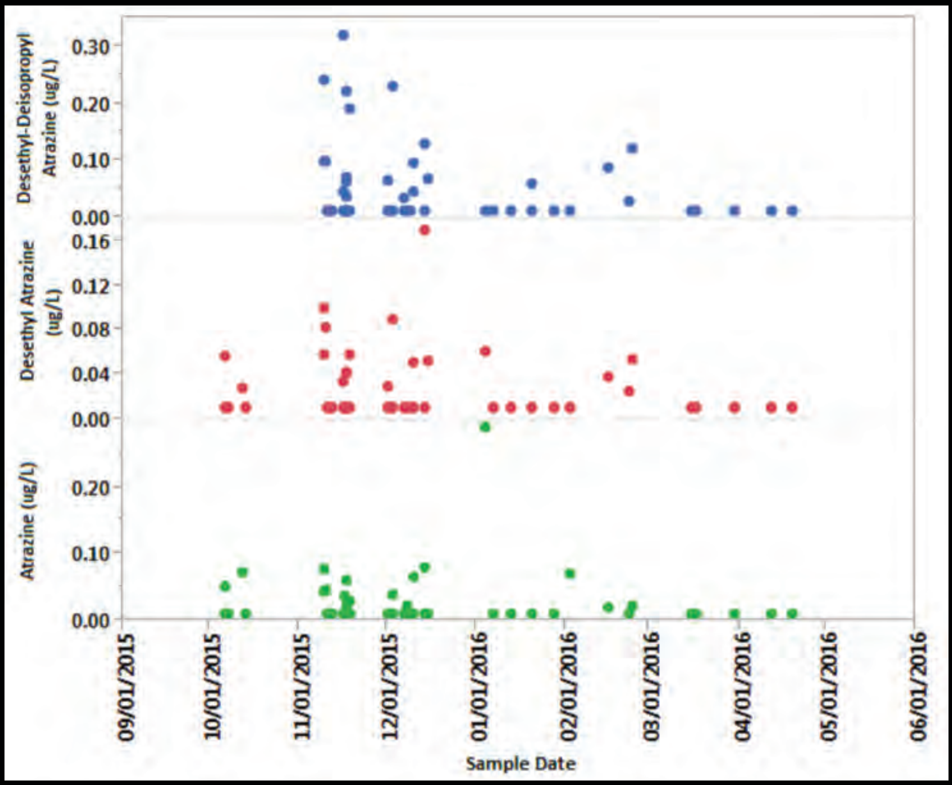

FIGURE 4: Concentrations of atrazine and its degradates over time.

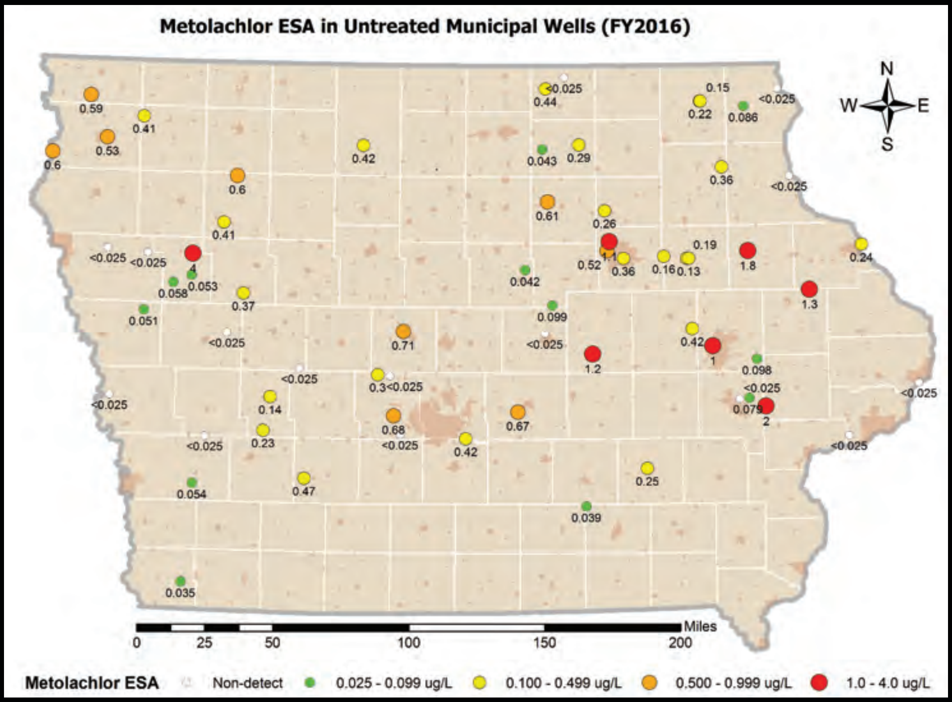

FIGURE 5: Concentrations of metolachlor ESA in untreated groundwater samples (FY2016).

Public drinking water supplies are required to test quarterly for radionuclides in finished water, and the drinking-water standards apply to average values of four quarterly samples, thus, these data are not helpful for characterizing radionuclide concentrations in raw groundwater. In cooperation with the State Hygienic Laboratory, Dustin May analyzed untreated groundwater from 52 of the public wells sampled in FY2016 for radionuclides including gross alpha (including uranium) radioactivity, gross beta radioactivity, and radium-226. While the majority (90%) of samples had gross alpha (including uranium) levels below 6 picocuries per liter (pCi/L), four communities in western Iowa contained gross alpha levels above 10 pCi/L (two in alluvial wells, and two in Dakota wells) **(FIGURE 6)**. All samples were below Iowa's drinking-water MCL for gross alpha radioactivity (excluding uranium) of 15 pCi/L.

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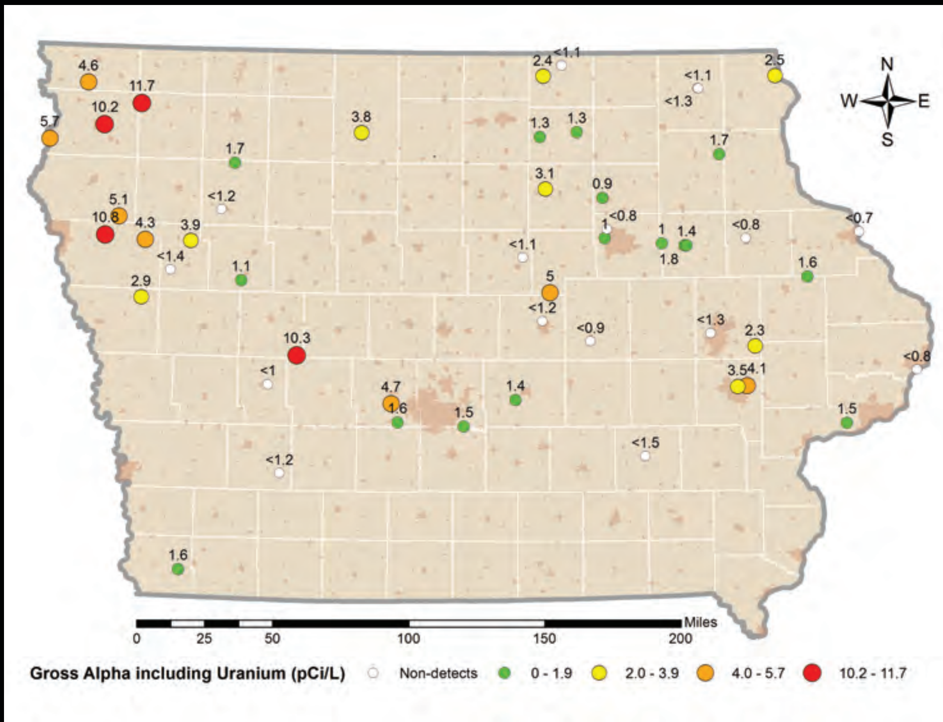

FIGURE 6: Concentrations of gross alpha radioactivity (including uranium) in untreated groundwater samples (FY2016).

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Most (90%) of samples contained gross beta radioactivity concentrations below 8 pCi/L; however, gross beta concentrations ranged up to 35 pCi/L, with the highest concentrations in a few alluvial and Silurian wells. Radium-226 concentrations were highest in Dakota and Silurian wells (maximum concentration 4.1 pCi/L), and were consistently below 1 pCi/L in alluvial wells. The drinking-water MCL for combined radium-226 and -228 is 5 pCi/L, thus, while none of the samples appeared to exceed this standard, it is possible that some could exceed the MCL if radium-228 were assessed.

Further analyses of these data are ongoing. IDNR is grateful to the water operators who graciously donated their time sampling wells, and the State Hygienic Laboratory staff for facilitating the additional radionuclide data.

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BENZENE IN GROUNDWATER

– A HEALTH PERSPECTIVE –

Stuart C. Schmitz, M.S., P.E. – State Toxicologist at the Iowa Department of Public Health

PROPERTIES OF BENZENE AND SOURCE OF GROUNDWATER CONTAMINATION

One of the common organic chemicals that can be present in groundwater due to environmental contamination is benzene. Benzene was first discovered and isolated from coal tar in the 1800s. Benzene is refined from petroleum and is present in a variety of solvents. Benzene, also known as benzol, is a colorless liquid with a sweet odor. Benzene evaporates into air very quickly and dissolves slightly in water. Benzene is highly flammable. Most people begin to smell benzene in air at 1.5–4.7 parts of benzene per million parts of air (parts per million or ppm) and begin to smell benzene in water at 2 ppm. Most people can taste benzene in water at levels from 0.5–4.5 ppm. Benzene is widely used in the chemical industry, and is one of the top 20 chemicals produced in the United States by production volume. It is used in the production of plastics, resins, synthetic fibers, rubber, lubricants, dyes, detergents, drugs, and pesticides. Gas emissions from volcanoes and forest fires are natural sources of benzene. Benzene is also present in crude oil and cigarette smoke. Benzene is a component in gasoline, and gasoline spills and leaks from underground storage tanks and pipelines are the most likely sources of benzene found in groundwater.

ROUTES OF EXPOSURE TO BENZENE IN GROUNDWATER

The presence of benzene in groundwater has the potential of impacting the health of people through mostly two exposure routes – 1) direct ingestion of groundwater and 2) indirect inhalation exposure. Exposure to benzene by direct ingestion of water is possible if a potable water well is installed in a shallow aquifer that becomes contaminated with benzene. Indirect inhalation exposure to benzene is possible by showering with water that has been contaminated with benzene, or through inhalation of benzene vapors migrating into homes through foundations (vapor intrusion) from soil or groundwater that has been contaminated with benzene.

HEALTH EFFECTS FROM LARGE ACUTE EXPOSURES TO BENZENE

Brief exposure (5–10 minutes) to very concentrated benzene (10,000–20,000 ppm) in air can result in death. Lower concentrations (700–3,000 ppm) can cause drowsiness, dizziness, rapid heart rate, headaches, tremors, confusion, and unconsciousness. In most cases, these effects stop when exposure stops and fresh air is available. Eating foods or drinking liquids containing high levels of benzene may cause vomiting, irritation of the stomach, dizziness, sleepiness, convulsions, rapid heart rate, coma, and death. Spilling benzene on the skin may cause redness and sores. Benzene in the eye may cause general irritation and damage to the cornea. The amount of benzene generally found within groundwater contamination is not high enough to cause these adverse health impacts.

HEALTH EFFECTS FROM SMALLER CHRONIC EXPOSURES TO BENZENE

People who breathe benzene for long periods may experience harmful effects in the tissues that form blood cells, especially the bone marrow. These effects can disrupt normal blood production and cause a decrease in important blood components. Decreased red blood cells may lead to anemia. Reducing other blood components may cause excessive bleeding. Blood production may return to normal after exposure to benzene stops. Excessive exposure to benzene can be harmful to the immune system, increasing infection risk, and perhaps lowering the body's defense against cancer. Benzene is classified as a known human carcinogen. Exposure to benzene has been associated with development of a particular type of leukemia called acute myeloid leukemia (AML).

SAFE LEVELS OF BENZENE IN DRINKING WATER

In order to protect the general public from exposure to benzene from drinking water the US Environmental Protection Agency (EPA) has maximum contaminant levels that set an upper limit on the amount of contaminants that can be found in regulated drinking water supplies. The EPA has set the MCLG (maximum contaminant level goal) for benzene at zero because benzene is a known carcinogen. According to EPA the zero level of exposure is based on the best available science to prevent potential health problems such as development of cancer. Although the zero level of exposure is a goal of the EPA, it cannot be practically achieved. So the enforceable MCL (maximum contaminant level) for benzene has been set at 0.005 ppm and considers the cost, benefits and the ability of public water systems to detect and remove contaminants using suitable treatment technologies. The EPA, and this author, consider the MCL of 0.005 ppm to be a level of benzene that will not adversely impact human health if found in sources of drinking water.

The EPA has also provided some additional non-regulatory health advisories for benzene in drinking water. The one- and ten-day health advisory for children is 0.2 ppm benzene in drinking water. EPA has a drinking water equivalent level of 0.1 ppm which is a level of benzene in water that is determined to not have the ability to cause adverse non-cancer health impacts. EPA has also determined that exposure to benzene in drinking water at levels between 1 and 10 ppm presents a 10^{-4} risk for cancer. The 10^{-4} risk level is an acceptable risk level for the EPA. The interpretation of a 10^{-4} risk level for drinking water levels between 1 and 10 ppm is that exposure to drinking water at levels between 1 and 10 ppm benzene will theoretically cause one additional case of cancer in a population of 10,000 people. My conclusion from evaluating these health advisories is that direct ingestion exposure to benzene in water at levels even up to 0.1 ppm for a lifetime will most likely not cause any adverse health impacts.

PROTECTION FROM OVERALL EXPOSURE TO BENZENE

Inhalation exposure to benzene vapors is the most likely route of exposure that could cause adverse human health impacts. Since gasoline and cigarette smoke are two main sources of human exposure, benzene exposure can be reduced by limiting contact with these sources. Both active and passive second-hand smoke contain benzene. Average smokers take in about 10 times more benzene than nonsmokers each day.

PROTECTION FROM EXPOSURE TO BENZENE IN GROUNDWATER

As previously stated, my opinion is that direct ingestion exposure to benzene in groundwater at levels up to 0.1 ppm will not cause any adverse health impacts in any person who is exposed to this level even over their entire lifetime. During my tenure at the Iowa Department of Public health I have also evaluated the potential for benzene found in shallow private wells and within groundwater to pose a health risk due to inhalation exposure. Benzene levels in groundwater or drinking water need to be fairly high (levels above 1 ppm) to present an inhalation risk from either vapor intrusion or through activities like showering.

THERE'S SAND, AND THEN THERE'S SAND.

Robert Libra – State Geologist

The upper Mississippi Valley area of Iowa, Minnesota and Wisconsin is often called the Driftless Area because of the absence or paucity of glacial deposits. The lack of glacial cover leaves the Paleozoic bedrock strata well exposed or shallowly buried across the area. The Paleozoic rock sequence includes several sandstone formations composed of almost pure quartz sand. The area has a long history of mining this silica sand, which is used for making glass, china and a variety of other products. Over the last ten years however the demand for silica sand has grown immensely, as the sand derived from the Jordan, St. Peter, and other sandstones is "Grade A" material for hydraulic fracturing of shales for natural gas and oil production. This sand is a well-worked sediment, relatively uniform in size, and is very well rounded, making it just what the fracking process demands **(FIGURE 1)**.

The majority of the new "frack sand" mines are in western Wisconsin. Iowa has only one active silica mine, the Pattison Mine near Clayton. This mine began operations underground in the 1940's, heading straight into the St. Peter Sandstone in a steep bluff along the Mississippi **(FIGURE 2)**. Mining ceased in the 1990's, only to resume with the increased demand from fracking in the 2000's. The reopened mine utilizes a surface quarry on the bluffs, along with underground mining, and washes and size-grades the sand for market on site as well **(FIGURE 3)**. Recently Pattison Sand has requested rezoning about 750 acres adjacent their current operation to allow significant expansion of the underground mine, in areas farther from the River. This has raised a variety of groundwater questions from local residents and county officials. Will this mining affect water quality? Groundwater levels and supplies?

Groundwater levels in the steep terrain along the Mississippi are commonly quite deep, as the fractured and permeable rocks drain effectively to the River and its tributaries, drawing the water table down towards river level. This is the case around the Pattison Mine as well. Most nearby wells are completed below the St. Peter Sandstone in the underlying Prairie

FIGURE 1: Quartz grains from the Jordan Sandstone.

FIGURE 2: Pattison Mine area, 1940's.

du Chien dolomite. Static levels in these wells are within the dolomite, leaving the St. Peter largely unsaturated **(FIGURE 4)**. However, over parts of the mine expansion area, the Galena Limestone is present and contains groundwater – and wells – well above the elevation of the St. Peter. So we have groundwater above and below the mine but not within the mine horizon itself.

This uncommon – but not unique – distribution of groundwater results from the Decorah Shale, which underlies the Galena Limestone. This shale has very low permeability and is an effective aquitard, "perching" groundwater above it in the Galena Limestone. Meanwhile, the rocks below the Decorah Shale drain quite freely to the River.

So what does this imply for groundwater impacts from expanded underground mining? First, the mining is still heading into "dry" sandstone. Therefore dewatering, which could have affected water levels in some wells, isn't needed. Second, the shallower wells in the area, tapping the Galena Limestone, are essentially isolated in a hydrologic sense from the mining activity happening below. Finally there are quality impacts. There should be little threat to the Galena wells, however mining will be taking place just above those drawing water from the Prairie du Chien dolomite. While mining per se has little impact on quality, accidental releases of contaminants from within the mine, such as fuel leaks, do have the potential to reach the deeper wells.

The IGWA fall field trip will be paying a visit to the Pattison Mine and other points of hydrogeologic interest in Northeast Iowa. Mark your calendars for the October 6th fall meeting and the October 7th field trip.

FIGURE 3: Aerial view of the Pattison Mine bluff-top operations, 2010.

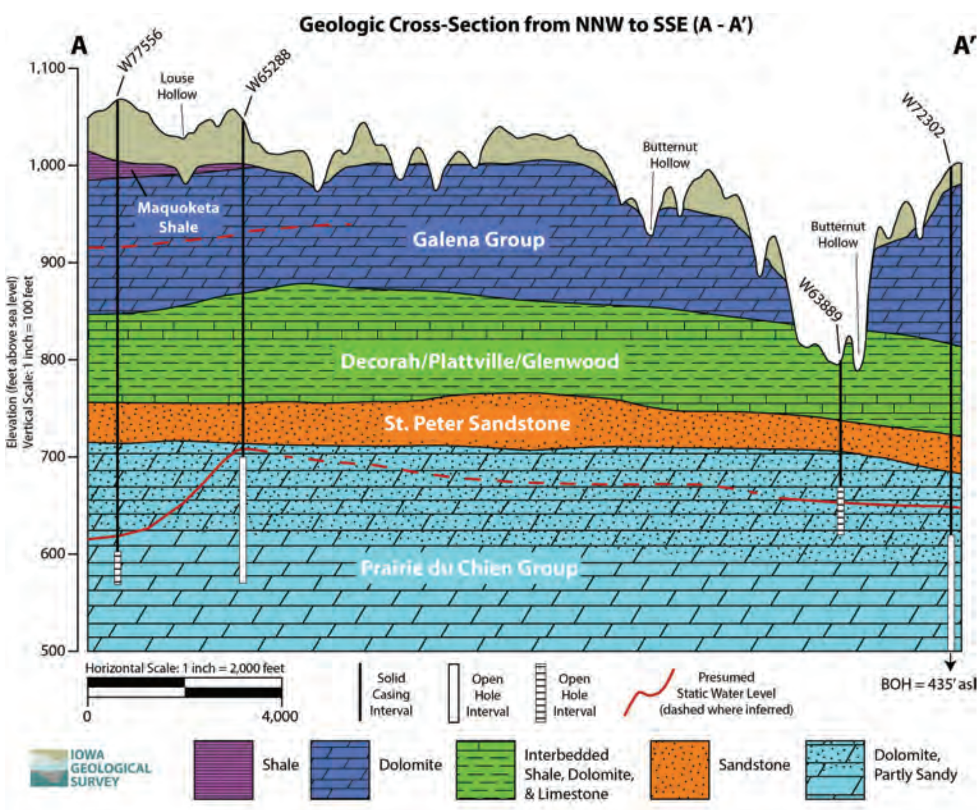


FIGURE 4: Cross – section through the Pattison Mine expansion area. Section by Ryan Clark, Iowa Geological Survey.

SINKHOLES:
What's Coal Mining Got to Do With It?

Ed Slattery

Dateline April 13, 2016: **100-Year Old Mine May Have Caused 40-Foot Sinkhole That Swallowed Front Yard** reads the headline from a local Des Moines media outlet.

Dateline June 13, 2013: **Sinkhole in Runnells Could Be Linked to Abandoned Coal Mines** is the report from another local media outlet.

With failure of abandoned coal mines as the suspected cause in both of these cases of sudden sink holes, it begs the questions of how extensive is the problem with abandoned coal mines in Iowa and what's happening to cause sinkholes to develop, sometimes in dramatic fashion as what recently occurred in Des Moines in April 2016.

History of Coal Mining in Iowa

Earliest records indicate that coal mining in Iowa began in the early 1840's. About this same time, mining began in the Des Moines area by soldiers stationed at Fort Des Moines. As demand for coal increased in the late 1800's so did the spread of mining operations, primarily in southeast and central Iowa. Rapid growth in coal mining occurred from 1870 to its peak in 1920. Iowa was the United States 9th largest coal producer. After 1920, mining activity decreased and finally ceased altogether in the 1970's. According to the Iowa Department of Natural Resources (IDNR) *"Iowa Geology, 1991"*, approximately 5,500 coal mines impacted 34 counties with underground mining having a known extent of 71,000 acres. The bulk of the underground mining occurred in six counties with over 15,000 acres in Marion County and over 14,000 acres of known mines in Polk County, much of which is now under developed urban areas. The locations of many of these underground mines have been mapped with varying degrees of accuracy but many more are known only by name and perhaps a general location. Much less is known about the mines' current condition and more importantly, their present level of stability.

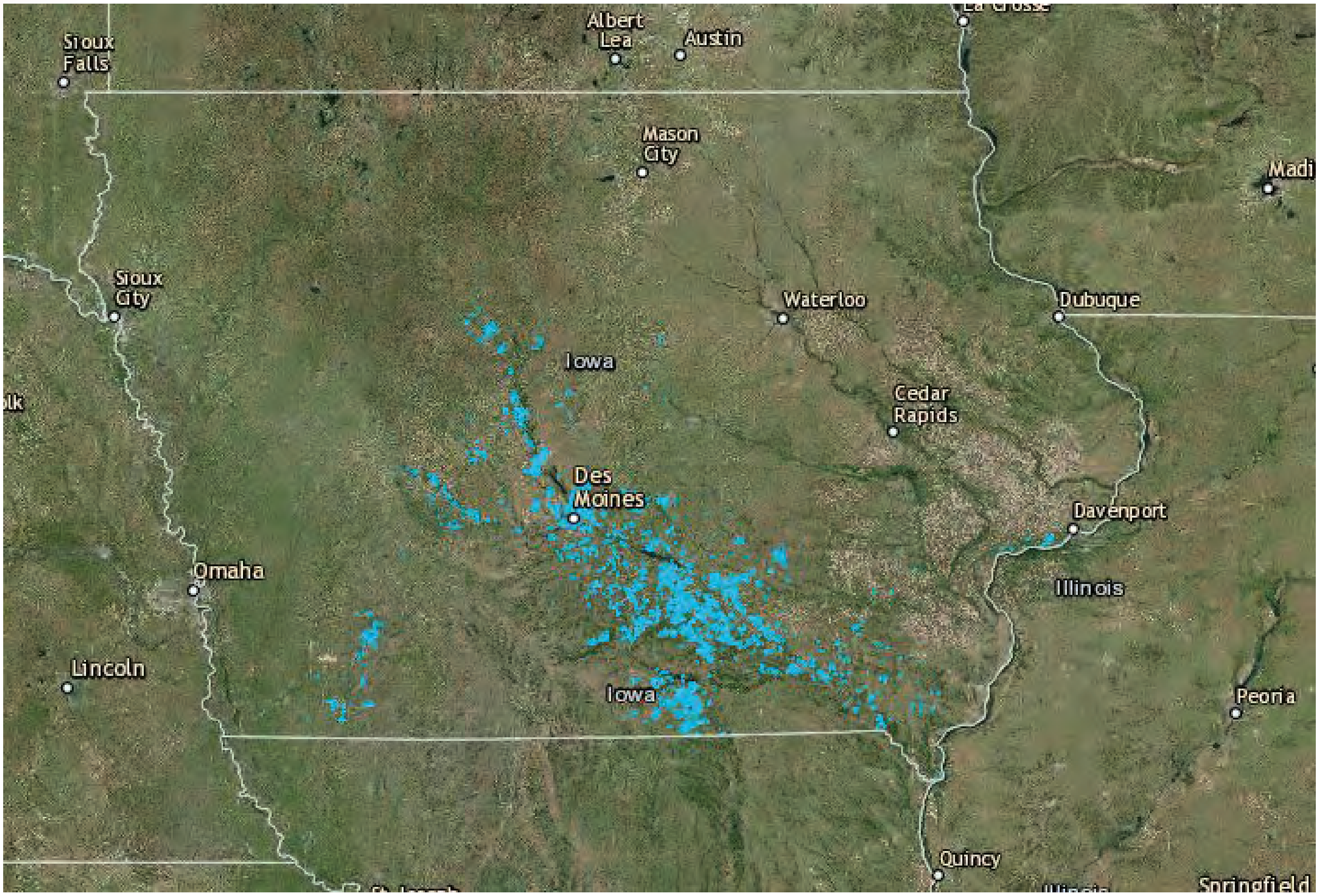
> ***"Fortunately, a sinkhole caused by failure in an underground abandoned mine is a rare event. This may be attributed, in large part, to the depth of the underground mining. These mines are typically beneath a stable layer of limestone that maintains the stability necessary to prevent cave-ins or sinkholes."***

Mining Technology

The earliest mines in Iowa were "drift" mines. Drift mines were located along streams and rivers where steep embankments allowed the coal seams to be exposed. Miners simply located these coal outcroppings and dug into the embankments along the seam to remove the coal.

For shallow horizontal coal seams the top layers of overburden were removed and deposited as spoil piles while the coal seam was stripped away. These strip mines were left as abandoned, exposed surfaces mines leaving behind dangerous high walls, deep impoundments and unstable piles of spoil. The exposed and bare soil is typically highly acidic preventing vegetation from growing, and creating erosion problems that choke area streams with sediment. Acid groundwater high in iron and other harmful chemicals can seep from the mined soils and enter streams causing chemical pollution of the natural drainageways. Even though mining may have ceased decades ago, these dangerous conditions and sources of pollution remain, left for future generations to reclaim the lands and halt the environmental damage and dangerous conditions caused by these actions.

For deep horizontal coal seams either a sloping tunnel or vertical shaft was dug to reach the coal. Once the coal deposit was reached, common practice was to utilize the "room and pillar" method to extract coal. This method was comprised of creating elongated "rooms" off "corridors" as the coal was removed. Adjacent



Iowa Coal Mines from IDNR's Interactive Coal Map found here: http://programs.iowadnr.gov/maps/coalmines/

rooms were separated by pillars of coal to support the ceiling comprised of the overlying rock. Sometimes, the support pillars were removed to extract even more coal as the mine operation was closing down. Wooden members may have been used to add supplemental support to the shafts to help stabilize the mine interiors. Once the coal seam was exhausted, these underground mines were typically abandoned without any further action to properly stabilize them. This type of mining was common in what is now the Des Moines metro area.

Abandoned Mine Shafts Can Lead to Surface Issues

Fortunately, a sinkhole caused by failure in an underground abandoned mine is a rare event. This may be attributed, in large part, to the depth of the underground mining. These mines are typically beneath a stable layer of limestone that maintains the stability necessary to prevent cave-ins or sinkholes. However, sinkholes can happen as the two events cited above show. So what can trigger this surprising and potentially damaging occurrence?

Not all of the overlying limestone is without defects. There can be cracks and weaknesses in the rock that, over time, can eventually give way as the rock deteriorates from groundwater either accumulating in the mine or percolating through the rock slowly dissolving the limestone. Over time the overlying rock can lose its strength and finally fail, dropping into the void space below and causing the ground surface above to fall as well.

For those shafts that relied on wooden members for support, perhaps well over 100-years ago, the failure of the supports as the wood deteriorates can lead to similar types of collapse.

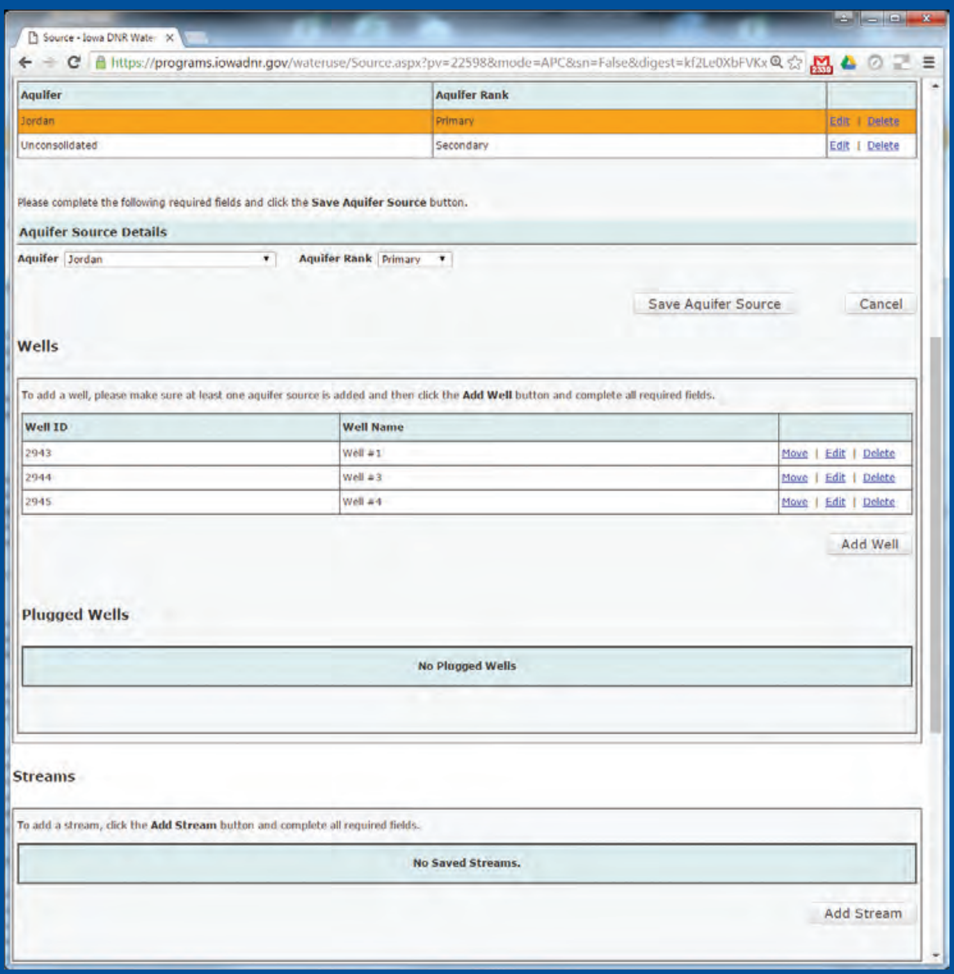
There has not been a definitive reason cited for the recent sinkholes that have caught the attention of the local news media. Speculation surrounds localized failure inside abandoned coal mine shafts as the leading cause. The infrequent occurrence of sink holes, especially in the highly urbanized Des Moines area is certainly reassuring. However, in the years to come, more sinkholes may occur. As they do the media will surely be there to report this intriguing phenomenon.

WATER USE PERMITTING (WACOP)

Michael Anderson – Water Supply Engineering Section - IDNR

The Department of Natural Resources (IDNR) contracted with a third party vendor (QCI Consultants) to provide application development services for updating the overall look and process flow of the existing Water Use application. This work effort was finished in 2015. On July 13, an upgraded version of this web application was released, and with it came some exciting improvements for permit holders.

Originally, a 2011 technology upgrade (Phase I of this process) was initiated as a result of external stakeholder requests. The application allows customer convenience through access via the Internet. The application is used by IDNR staff and Permit Holders to manage and report on water usage for over 4,000 permit holders, and is maintained through in-house IT staff. Phase 2 of this project was identified to resolve "bugs" needing to be fixed and to implement the enhancements planned for a later phase. The enhancements were defined in a joint effort between IDNR IT staff and Water Use Engineering staff. These improvements pertain to administrative rights, data migration corrections, infrastructure adjustments, map feature fixes, user interface streamlining, payment reconciliation, and improvements in reporting.



Screen shot of updated Water Use application

IMPROVEMENTS INCLUDE:

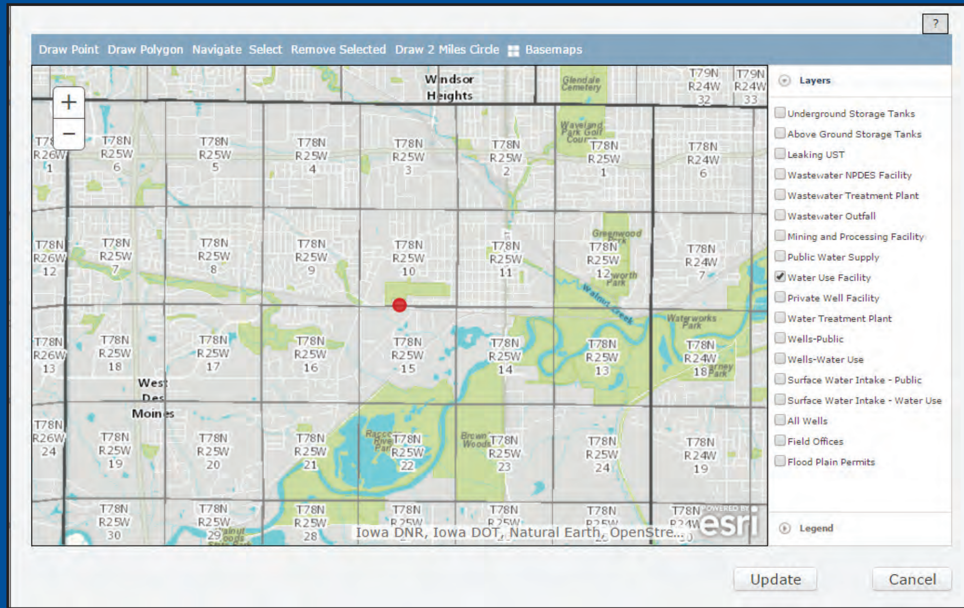
- Electronic submittal of yearly usage reports.
- Incorporation of hydrogeologic reports.
- Minimize manual paper/ digitization processes to allow permittees to enter on-line information.
- Streamline workflow and data processes.
- Facilitate passage of information electronically to and from the general public, permittees, industry members, organizations, government agencies, DNR field and central office staff, politicians, etc. in a timely manner.
- Enable public access 24/7 to permit information.
- Improve data integrity.
- Utilize updated GIS coverages.

- Incorporate agricultural drainage well permits and aquifer storage and recovery permits to the data-set (These had previously been stand-alone).

One of the real benefits of the database upgrade was the ability to add and track data to better implement the Jordan Aquifer Rule. This includes well-specific information on static water level, pumping water level, pumping rate, and duration of pump operation.

IDNR has jurisdiction over the surface and groundwater of the state to establish and administer a comprehensive program to ensure: that the water resources of the state be put to beneficial use to the fullest extent possible; that the unreasonable use, or unreasonable methods of use, of water be prevented; and that the conservation and protection of water resources be required with the legislatively-directed purpose to assure their reasonable and beneficial use in the interest of the people. Permits are required by municipalities, industries, agricultural and golf course irrigators, farms, agribusinesses and any other user of over 25,000 gallons of water per day. This is sometimes referred to as the water allocation permit. These permits are required under Iowa laws that originated during the droughts of the 1950's. The law applies to the use of water from streams and reservoirs, gravel pits, quarries, and other sources. The term of these permits is 10 years; in some circumstances, such as for permits associated with the Jordan aquifer, they are issued for five years.

The project accomplished its goals on time and under budget. The water use application is currently working, and saving both staff and permittees time and money. You can access the database online through the program's website: ***www.iowadnr.gov/wateruse***



Screenshot of filterable layers on Water Use application

Aquifer Reporting Chart

Aquifer Source: Jordan(Primary)

Static Water Level

- Water level measurements from each well measured as **depth to water** from ground elevation.
- Pumping water level required for Jordan aquifer permits.

Measurements Are

Well	Static Water Level (feet)	Pumped Water Level (feet)	Pump Duration (hours)	Pumping Rate (gpm)	Date Measured
2943 Well #1	246.00	0.00	0.00	0.00	
2944 Well #3	238.00	0.00	0.00	0.00	
2945 Well #4	242.00	0.00	0.00	0.00	

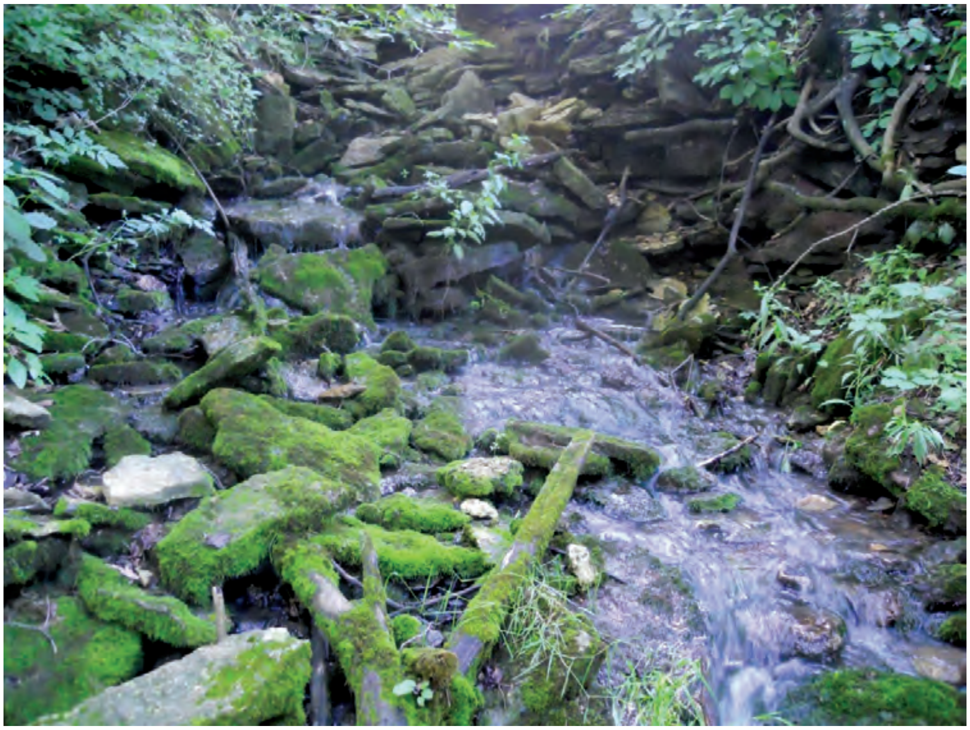
Unit of Measurement Reported Million Gallons

Determination of Water Use

Months	Irrigation: General Crops (corn, beans)	Irrigation: Specialty Crop (other vegetables)	Irrigation: Golf Course / Sod Farm	Municipal, Industrial, Commercial	Aggregate Production Or Mining: Dewatering	Aggregate Production Or Mining: Washing	Other (Wetland development, recreational, etc.)
	Acres 0.00	Acres 0.00	Acres 0.00	NOTE: Not Allowed To Report In Inches			
January				78.47	0.00	0.00	0.00
February				76.76	0.00	0.00	0.00
March				79.68	0.00	0.00	0.00
April	0.00	0.00	0.00	90.30	0.00	0.00	0.00
May	0.00	0.00	0.00	106.60	0.00	0.00	0.00
June	0.00	0.00	0.00	94.24	0.00	0.00	0.00
July	0.00	0.00	0.00	107.93	0.00	0.00	0.00
August	0.00	0.00	0.00	90.60	0.00	0.00	0.00
September	0.00	0.00	0.00	87.82	0.00	0.00	0.00
October		0.00	0.00	78.28	0.00	0.00	0.00
November				61.75	0.00	0.00	0.00
December				44.09	0.00	0.00	0.00
Total	0.00	0.00	0.00	996.52	0.00	0.00	0.00

Subtotal: 996.52 Million Gallons

Screenshot of electronic submittal of yearly usage report



Middle Hesper Spring near Decorah, Iowa – photo courtesy of Sheri Schwert

SHERI SCHWERT

LUTHER COLLEGE

Meet Sheri Schwert! Sheri is a chemistry major at Luther College, who is combining her academic skills with her love of the outdoors by conducting hydrologic studies of springs in the Decorah area. By conducting multiple dye traces, Sheri is hoping to document how quickly water can travel from sinkholes at the surface to these springs. Her research started by reviewing LiDAR data to find possible sinkholes and lab-work to better understand the properties of fluorescent dyes. The rest of Sheri's summer will be spent chasing rain storms, injecting the dyes, collecting samples, and analyzing those samples in the lab, and yes, even blogging about her adventures! Go to ***http://schwertandkarst.blogspot.com/*** to read more about Sheri's research and the fun and frustrations of conducting field-work. Sheri may be looking for help with future dye traces, so, if you are interested in lending a hand, let her know!

GROUNDWATER HERO

Claire Hruby, IGWA President

DR. MICHAEL BURKART

This year, IGWA would like to honor Dr. Mike Burkart for his extensive contributions to our understanding of water quality in Iowa. Mike began his career as a hydrogeologist with the US Geological Survey in North Dakota. He was promoted to Hydrologic Studies Section Chief of the Iowa District of the USGS, before landing at the USDA/ARS National Laboratory for Agriculture and the Environment (formerly known as the Soil Tilth Lab) in Ames in 1992. As an affiliate professor on the faculty of Iowa State University's Geological and Atmospheric Sciences Department, he continued research to deepen our understanding of the impacts of land-use on water quality. Mike's research has focused on topics including soil erosion and the impacts of agricultural activities on nitrogen, phosphorus, and pesticides concentrations in groundwater, lakes, and streams. Mike also played a vital role in development of the Iowa Groundwater Monitoring Network and was one of the founders and an active committee member in the early years of the IGWA.

Throughout his career, Mike has been a staunch advocate for protection and improvement of our water resources through his leadership on policy initiatives, such as his work drafting nutrient standards for surface waters, and promoting riparian buffers and perennial crops. Mike has inspired and supported several graduate students, including Dana Kolpin (now at the USGS Iowa Water Center) and John Thomas (at the Hungry Canyons Alliance), and mentored countless others, myself included, with good humor, good science, and good food! Though Mike has retired, he continues to experiment with sustainable agricultural practices in his garden, keeps an eye on water quality while fishing, and he will no doubt continue to voice his well-informed opinions regarding Iowa water resources for many years to come! Mike and his wonderful wife, Judy, now live in Iowa City, where they are likely to be found eating Indian food or sampling local brews.

Thank you, Mike, for your generous service to the state of Iowa!

IGWA Member News

Speakers Anurag Mantha (left) and Bill Stowe (right) from the Spring 2016 conference.
For links to previous conference speakers visit www.igwa.org, become a member for exclusive access to the presentations.

MEMBERSHIP RECOGNITION

5-Year Members

• Mark Classen • Dan Crannick • Chant Eicke • Brian Gedlinske • James Goodrich • Brian Graettinger • Steve Hopkins • Claire Hruby • Dave Hruby • Jeff Joslyn • Judy Krieg • Rob Malcomson • Cara Matteson • David Miller • Heath Picken • Reid Stamer • Ginger Thune • Ted Trewin • Cynthia Quast

10-Year Members

• Bob Campbell • Dennis Sensenbrenner • Jeff Sherman • David Wonder

15-Year Members

• Karen Oppelt • Becky Svatos

20-Year Members

• Dean Berchenbriter • Jim King • Robert Rohlfs

25-Year Members

• Michael Anderson • Robert Blok • Steve Hardy

30-Year Members

• Dana Koplin

Congratulations to our past president Cindy Quast on her retirement from Stanley Consultants - Thank you for all of your hard work and contributions to IGWA over the years.

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

IRWA Okoboji Fall Conference September 20-21, 2016
Okoboji, Iowa • *www.iowaruralwater.org/events_fall_conference.html*

NAAMLP 2016 Annual Conference September 25-28, 2016
Bozeman, Montana • *http://naamlp2016.com/*

2016 Iowa Section AWWA Annual Conference October 4-6, 2016
Altoona, Iowa • *www.ia-awwa.org/conferencesandtraining/annualconference.html*

Iowa Groundwater Association Fall Meeting October 6-7, 2016
Dubuque, Iowa • *www.igwa.org*

2016 IEHA Region 4 Iowa Environmental Health Conference October 18-19, 2016
Marshalltown, Iowa • *http://www.ieha.net/2016FallEHConference/*

IRWA Dubuque Fall Conference October 18-19, 2016
Dubuque, Iowa • *www.iowaruralwater.org/events_fall_conference.html*

Indiana Ground Water Association Biennial Convention with Trade Show November 3-4, 2016
Michigan City, Indiana • *http://www.indianagroundwater.org/*

Minnesota Ground Water Association Fall Conference November 16, 2016
St. Paul, Minnesota • *www.mgwa.org/meetings.php*

IAMU 2016 Water/Wastewater Operator's Workshop November 15-17, 2016
Details available online • *www.members.iamu.org/events/event_list.asp*

2016 EPI Fall Symposium
Details unavailable, check website. • *www.epiowa.org*

NGWA 2016 Groundwater Week December 6-8, 2016
Las Vegas, Nevada • *www.groundwaterexpo.com/*

IWWA 88th Annual Convention & Trade Show January 26- 27, 2017
Altoona, Iowa • *www.iwwa.org/calendar.htm*

IRWA 42nd Annual Conference February 20-22, 2017
Des Moines, Iowa • *http://www.iowaruralwater.org/events_annual_conference.html*

11th Annual Iowa Water Conference March 22-23, 2017
Ames, Iowa • *www.water.iastate.edu/content/iowa-water-center-events*

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P.O. Box 744
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www.IGWA.org

COVER PHOTOS: Front Cover photo taken by Chad Fields. Back Cover photo taken by Mike Helms.