Shallow Groundwater Quality Sampling in Kane County, October 2003

by

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Prepared for the
Kane County Development and Resource Management Department

June 2005

Illinois State Water Survey
Center for Groundwater Science
Champaign, Illinois

A Division of the Illinois Department of Natural Resources

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Abstract

Seventy-five shallow wells were sampled for water-quality analysis in Kane County in October 2003 to provide a "snapshot" of groundwater quality in these shallow aquifers and also compare water quality from different parts and aquifers of Kane County.

The quality of shallow groundwater in Kane County is generally good, especially in the western and central thirds of the county. However, the total dissolved solids (TDS) concentrations of samples from the eastern third of the county were significantly higher than elsewhere in the county. The ions of greatest concern are chloride and sulfate. Almost two-thirds of the samples from the eastern wells sampled had TDS, chloride, and/or sulfate concentrations above their drinking water standards. Road-salt runoff, vehicular exhaust, and industrial discharges are the most likely sources of these elevated solutes. Because the movement of groundwater is slow, the widespread presence of high TDS groundwater in the eastern urban corridor of Kane County suggests a fairly long history of shallow groundwater contamination.

This project provides a baseline for shallow groundwater quality in Kane County. Repeating this study at 5-year intervals, sampling as many of the same wells as possible, would help to determine water-quality changes as Kane County undergoes land-use changes. More detailed studies at more frequent intervals for particularly sensitive areas or those with rapid changes in land use also may be helpful to water resource planners.

Introduction

Projections on population growth, the probability of climate change and impaired water quality, as well as natural limits and legal constraints on the availability of water in northeastern Illinois have created a strong need to manage water resources in Kane County (Kane County, Illinois, 2004). The Kane County Board funded the Illinois State Water Survey (ISWS) and Illinois State Geological Survey (ISGS) to collect data and develop tools to provide a scientific basis for managing that county's water resources. As part of this project, ISWS scientists measured water levels in more than 1,000 shallow wells in Kane County and surrounding counties in the fall of 2003. A separate project funded by the Kane County Board was designed to evaluate shallow groundwater quality in Kane County at approximately the same time as water levels were being measured. The ISWS scientists collected samples from 75 of these wells for water-quality analyses. Analytical results are reported herein.

Acknowledgments

Several ISWS researchers contributed to this project. Randy Locke helped with well selection, travel logistics, and data access. Scott Meyer provided pertinent information about Kane County and reviewed the final report. Brian Dunneback, the primary field assistant, conducted atrazine and coliform analyses. Loretta Skowron, Dan Webb, Lauren Sievers, Ruth Ann Nichols, and Sofia Lazovsky provided chemical analyses. Jon Foote provided expertise in adding the data to the ISWS Groundwater Quality Database and preparing reports and letters for well owners. Kevin Rennels interpreted the well logs and provided help in the field. Sam Panno, ISGS, reviewed the final report. Bill Dey, ISGS, provided access to his Kane County map data. Special thanks go to all the well owners who allowed sampling of their wells.

The Kane County Board sponsored this project, and Paul Schuch, Kane County Water Resources Department, acted as liaison to the board. The views expressed in this report are those of the author and do not necessarily reflect the views of the sponsor or the ISWS.

Objectives

Investigation objectives were to (1) provide a "snapshot" of water quality in shallow aquifers in Kane County; (2) compare water quality from different parts of Kane County, especially the eastern urban corridor and the western agricultural section; (3) compare water quality from different shallow aquifers, i.e., bedrock vs. unconsolidated deposits; (4) produce a baseline of Kane County water-quality conditions for comparison with results of future sampling; and (5) produce data that will help ISWS scientists model groundwater flow and estimate aquifer recharge rates.

Procedures

Well Selection

Funding was available to sample approximately 75 wells. The ISWS scientists previously had selected more than 1,000 wells in northeastern Illinois for measuring groundwater levels in 2003, and approximately 470 of those wells were in Kane County. In order to assess shallow groundwater quality, a depth limit of 250 feet was imposed, leaving 370 potential wells. Upon inspection by ISWS scientists, a small number of wells in poor condition were eliminated from consideration because of their potential vulnerability to contamination from leaking along the well bore or from contaminants in the well components.

The remaining wells were divided into nine geographic units within Kane County based on U.S. Geological Survey topographic quadrangles (Figure 1). There are 17 7.5-minute quadrangle maps for areas completely or partially in Kane County, which can be divided into three north-south sections: (1) western third (Big Rock and Plano, Maple Park, and Hampshire and Marengo South); (2) central third (Sugar Grove and Yorkville, Elburn, and Pingree Grove and Huntley); and (3) eastern third (Aurora North and Aurora South, Geneva, and Elgin and Crystal Lake). Because one of the goals was to compare water quality in the eastern urban corridor with that of rural agricultural areas in the west, it was decided to sample 30 wells in both the eastern and western thirds of the county, and 15 wells in the central third.

Two additional restrictions were imposed on well selection. Within each quadrangle, the wells for which water levels were to be measured were representative with respect to depth and source aquifer (shallow bedrock or unconsolidated deposits). Within each geographic unit, approximately the same percentage of wells were chosen as occurred in the overall list representing shallow bedrock vs. unconsolidated aquifers and wells less than 100 feet deep vs. wells 100-250 feet deep. For example, if approximately 70 percent of all wells in a particular geographic unit were finished in the shallow bedrock, then of the 10 wells selected for sampling, seven would be shallow bedrock wells. After imposing these geographic, depth, and aquifer constraints on the well selection process, wells were selected randomly within each geographic unit. It was not possible to sample many of these selected wells, however. In some cases permission was denied or the well owner could not be contacted. In other cases, all accessible taps were connected to treatment devices and therefore unsuitable for the study. Each rejected well was replaced, when possible, by a well with similar location, depth, and aquifer characteristics. Location, depth, and source aquifer of each well sampled are shown (Figure 2).

Sample Containers and Preservatives

Several types of sample containers and preservatives were used (Table 1). The containers for metals were cleaned as follows: fill with 8 percent by volume hydrochloric acid (HCl), soak at least 24 hours, and thoroughly rinse with deionized water. Bottle sets (one bottle for each analyte in Table 1) were assembled in two-gallon Zip-Lock® bags.

Sample Collection

A multi-probe instrument was used for measuring temperature, specific conductance (SpC), pH, platinum-electrode oxidation-reduction potential (ORP), and dissolved oxygen (DO).

Marengo South	Huntley	Crystal Lake
Hampshire	Pingree Grove	Elgin
Maple Park	Elburn	Geneva
Big Rock	Sugar Grove	Aurora North
Plano	Yorkville	Aurora South

Study Area

N

0   2   4   6
Miles
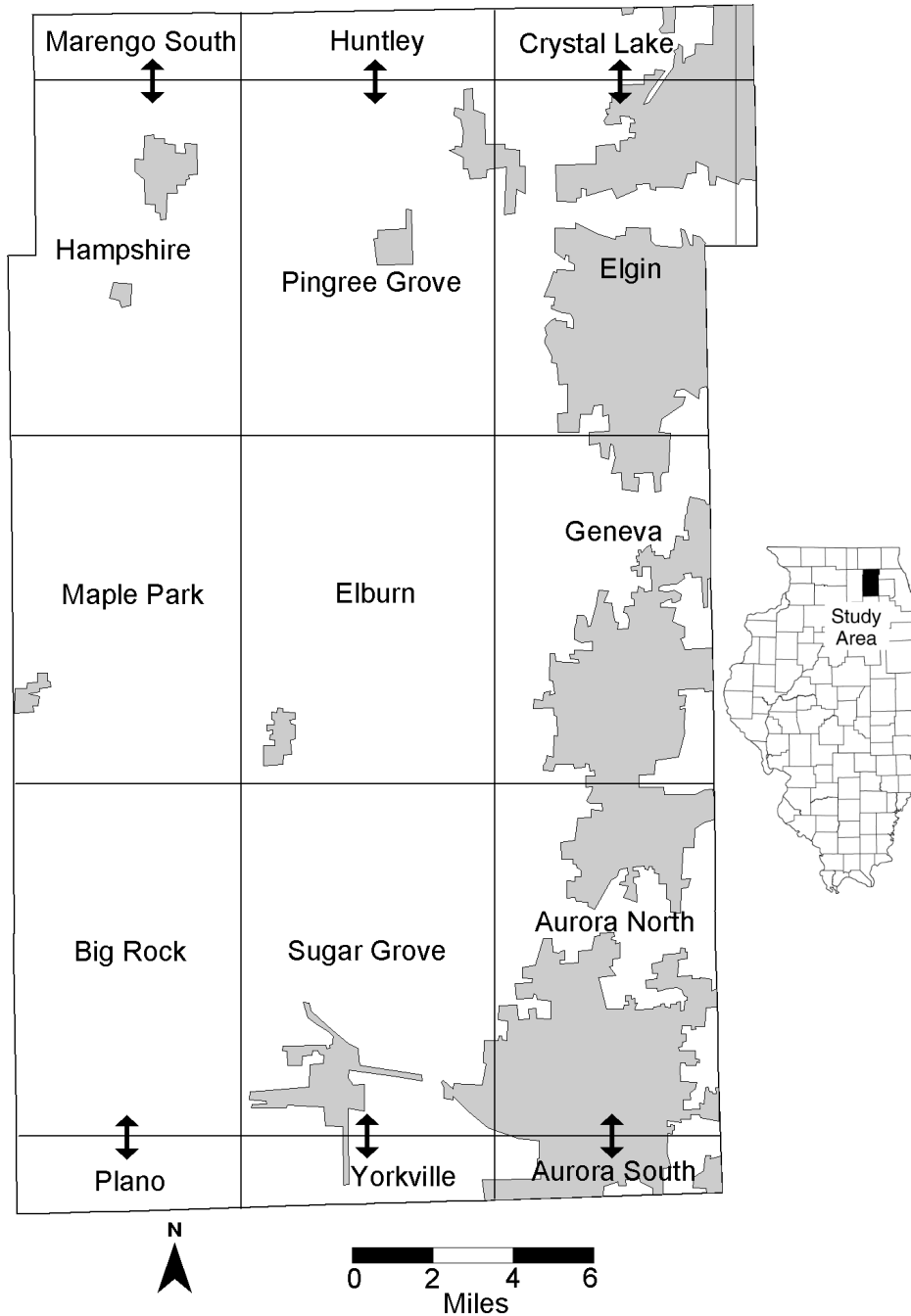
Notes: Shaded areas are municipalities.
Double arrows indicate where two quadrangle maps
were combined for this study.

Figure 1. Location of topographic quadrangles in Kane County
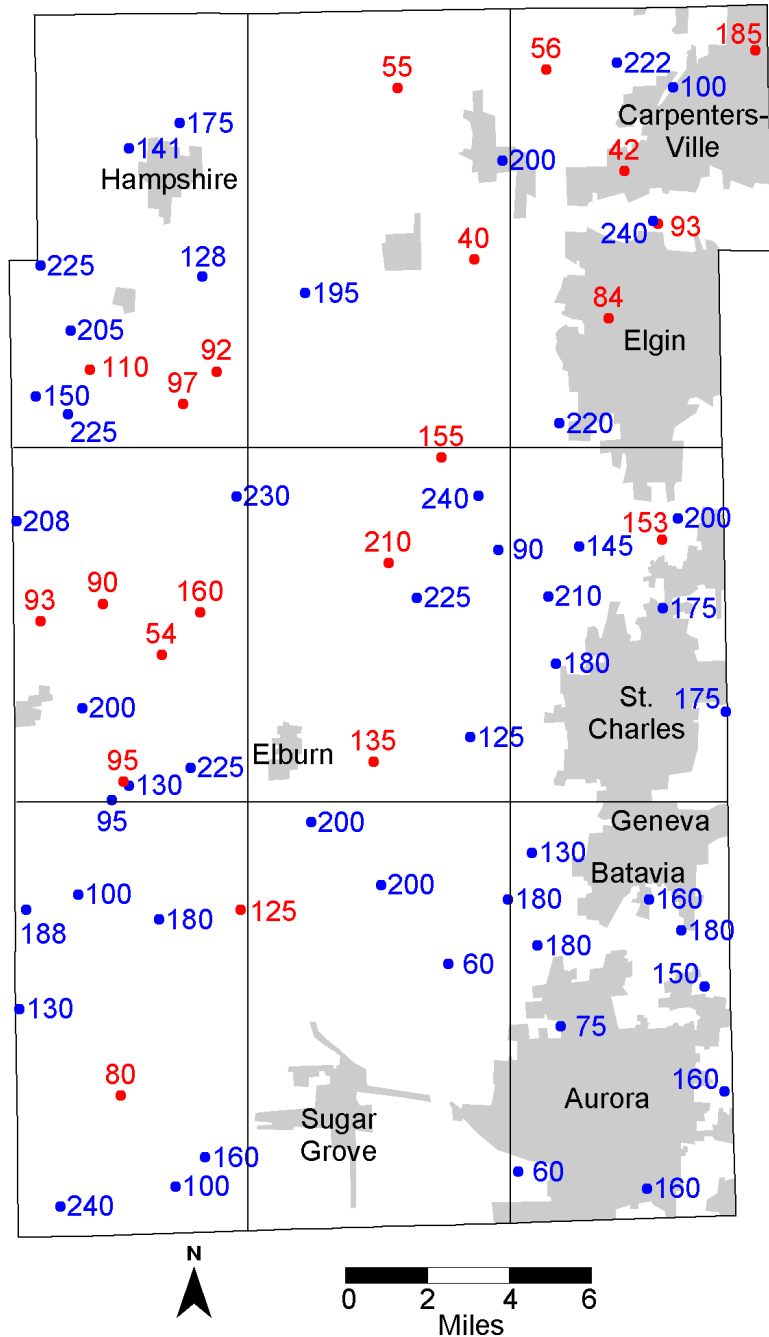
Figure 2. Location and depths (feet) of sampled wells

Table 1. Sample Containers, Preservatives, and Holding Times

Analyte	Container	Preservative (%)	Filtered	Holding Time (days)
Metals	HDPE	0.2 HNO_3	Yes	180
Anions/alkalinity	HDPE	None	Yes	2
NH_3-N	HDPE	0.2 H_2SO_4	Yes	24
TOC	Glass	0.5 H_2SO_4	No	ASAP
Atrazine	Glass	None	No	14
Coliform Bacteria	HDPE	None	No	ASAP

Notes: Preservative percentage was by volume of concentrated high-purity acid.
Holding time for total organic carbon was not specified for acidified samples.

Manufacturer's directions (Mini-Sonde®, Hydrolab, Austin, TX) were used to calibrate the instrument before each 1- to 2-day sampling trip. Sulfuric acid (H_2SO_4) was added to the ammonia-nitrogen (NH_3-N) and total organic carbon (TOC) bottles.

Wells were sampled from outside taps indicated by owners to be upstream of any treatment. A flow splitter was attached to the tap. A garden hose was connected to one branch of the connector, and a Hydrolab® flow cell was connected to the other branch. The tap was turned to the maximum flow, and most of the flow went through the hose. Temperature, pH, and the other variables were monitored until the readings stabilized. Readings were considered stable if the change in 60 seconds was less than 0.1°C, SpC of 5 percent of the initial value, pH of 0.02, and ORP of 5 millivolts (mV). Readings typically stabilized within 5-10 minutes except for DO, which continued to drift downward. The DO probe responds very slowly to DO concentrations below ~1 milligram per liter (mg/L); if the DO reading fell to below ~0.8 mg/L and was still falling, undetectable DO was assumed.

The flow cell was disconnected from the sampling line to collect samples. One of the sampling crew, the only one to handle sample bottles, put on powder-free gloves. Unfiltered samples were collected to measure TOC, and, at some sites, atrazine and hydrogen sulfide. The sample tube then was connected to a 0.45 micrometer (μm) filter capsule (Gelman), and filtered samples were collected to measure metals, anions, alkalinity, and NH_3-N. Nitric acid (HNO_3) was added to the metals sample (1.25 milliliters or mL to 250 mL bottle) after sample collection. The flow splitter then was removed from the tap, and an unfiltered sample for analysis of coliform bacteria was collected directly from the tap. After all samples were collected, bottles were returned to their Zip-Lock® bags and stored in a cooler with ice. If the sampling crew was not returning to the ISWS that day, additional ice was added to the coolers as necessary.

Field analyses of semi-quantitative hydrogen sulfide were done at the time of sample collection using a portable colorimetric testing kit (CHEMetrics, Inc., Calverton, VA). A plastic sample cup was used to collect 25 mL of water. The sample was stirred after adding three drops of activator solution (ferric chloride in concentrated HCl). Immediately an ampule containing N,N-dimethyl-p-phenylene diamine was opened in the bottom of the cup, which was inverted several times until the solution had a uniform color. After waiting 5 minutes, a color comparator

was used to determine the solution's approximate hydrogen sulfide concentration. The sampling crew also noted if the water had a sulfide odor.

Sampling Quality Assurance

Each sampling crew collected duplicate samples from one well per day to test for analytical replicability. For each sampling trip, a set of blanks containing deionized water was collected prior to departure and analyzed with the samples. These blanks were prepared to check if the sampling procedures (i.e., filtering, acidification, and storage) introduced solutes. At the end of each sampling day, the multi-probe was immersed in pH 7 buffer to determine how well pH calibration had held during the day. Chain-of-custody sheets were completed at the end of each sampling day to keep track of the samples during the analytical process and ensure that sample holding times were not exceeded.

Chemical Analyses

The ISWS Public Service Laboratory (PSL) in Champaign conducted most of the chemical analyses, using standard methods (www.sws.uiuc.edu/chem/ias/). Anions were analyzed by ion chromatography, metals by inductively coupled plasma-mass spectrometry, alkalinity by titration, NH_3-N by colorimetry, TOC by carbon analyzer, and arsenic by graphite furnace atomic absorption spectrometry with Zeeman background correction.

Semi-quantitative atrazine analyses used an immunoassay test (Hach®) in which 0.5 mL of sample and 0.5 mL of an atrazine enzyme conjugate solution were pipetted into a cuvette and allowed to react for 20 minutes. The sample then was discarded, and 0.5 mL of color developing solution was pipetted into the cuvette and allowed to react for 10 minutes. Then 0.5 mL of a solution to stop the reaction were added to the cuvette and mixed. The cuvette then was inserted into a colorimeter (wavelength = 450 nanometers) for comparison with 0.5 and 3.0 micrograms per liter (µg/L) atrazine standards. This test does not differentiate between various triazines and metabolites, although it detects their presence to differing degrees.

A presence/absence test (Hach®) was conducted for total coliform, fecal coliform, and *E. coli* bacteria by adding the contents of an ampule containing bromcresol purple broth with MUG (4 methylumbelli-feryl-β-D-glucuronide) to 100 mL of sample. Sample color was checked after incubating the sample at 35°C for 24-48 hours. A color change from reddish purple to yellow or yellow brown indicated a presumptive positive for total coliform bacteria. If there was no color change, the sample was incubated for 24 hours more. If there was still no color change, the test was recorded as negative for total coliform bacteria. Presumptive positive samples were examined under long-wave ultraviolet light. Samples that fluoresced were recorded as positive for *E. coli* bacteria.

Statistical Analyses

Chemical data were compared in a variety of ways. Because most of the data are not normally distributed, nonparametric tests were used, i.e., Mann-Whitney rank sum test when comparing two populations and Kruskal-Wallis analysis of variance (ANOVA) on ranks test when comparing more than two populations. Dunn's method was used to determine whether differences between population pairs were significant when ANOVA results indicated a

significant difference. Significance was determined at the 95 percent level ($p < 0.05$) for all tests. The tests were run using SigmaStat software (SPSS, 1997).

ISWS Groundwater Quality Database

The ISWS maintains a Groundwater Quality Database (GWQDB), which contains historical water-quality data dating back to the late 1890s from both public and domestic wells. Well owners usually collect samples from domestic wells in containers provided by and mailed to the ISWS PSL for analyses of inorganic water quality. Sample data collected were supplemented with GWQDB data from Kane County domestic wells less than 250 feet deep. To minimize possible temporal changes in groundwater quality, only GWQDB sample data collected since 2000 were used. Eleven GWQDB samples met these criteria and are included in some of the graphs. The GWQDB samples were not used in statistical analyses discussed below to avoid skewing the results with previously collected data not following the same protocols.

Results and Discussion

Complete chemical results appear in the appendix (Tables A-1 – A-6). Names and addresses were removed to protect the anonymity of well owners. All well owners received individual sampling results in early March 2004 (see sample letter in Appendix B). Additional chemical results for GWQDB samples appear in Tables A-7 and A-8.

After reviewing analytical results, it was determined that five samples collected in 2003 had been treated, most likely by water softeners that removed calcium, magnesium, and iron, and increased chloride and sodium concentrations. Those results are reported (Tables A-4 – A-6) but were not included in the following discussion or statistical analyses. Removing the five well samples left 29 wells from the western third, 13 wells from the central third, and 28 wells from the eastern third of the county.

Water-quality data primarily are collected to determine if contaminants need to be removed from the water to make it safe for consumption. The U.S. Environmental Protection Agency (USEPA) has promulgated maximum contaminant levels (MCLs) for about 100 inorganic and organic chemicals, microorganisms, disinfectants and disinfection products, and radionuclides (USEPA, 2004). Most of these MCLs are primary standards for which potentially undesirable health effects have been identified when the standards are exceeded. These standards apply only to public water supplies and are legally enforceable. Secondary standards exist for 15 contaminants, primarily inorganic chemicals that may cause aesthetic or cosmetic problems; they are not enforceable. Analyses done at the ISWS for this study included 21 constituents on either the primary or secondary standard lists (Table 2); copper and fluoride have both primary and secondary MCLs. The detection limits for antimony and lead were greater than their primary MCLs, 0.006 and 0.015 mg/L, respectively.

Groundwater quality data also are collected to elucidate geochemical conditions within the source aquifer. Use of these data along with geological, hydrologic, and biological data helps scientists to understand processes that may affect the fate and transport of contaminants, mineral dissolution/ precipitation reactions, aquifer recharge rates, etc.

Table 2. Primary and Secondary Drinking Water MCLs for Contaminants
(mg/L except for pH)

Primary Standards	MCL	Potential Health or Other Effects
Arsenic	0.010	Skin damage; problems with circulatory systems; increased cancer risk
Atrazine	0.003	Cardiovascular or reproductive problems
Barium	2	Increase in blood pressure
Beryllium	0.004	Intestinal lesions
Cadmium	0.005	Kidney damage
Chromium	0.1	Allergic dermatitis
Copper	1.3	Short-term exposure: gastrointestinal distress Long-term exposure: liver or kidney damage
Fluoride	4.0	Bone disease (pain and tenderness) and tooth discoloration in children
Nitrate-nitrogen	10	Infants below 6 months of age could become seriously ill and may die if untreated for shortness of breath and blue-baby syndrome
Selenium	0.05	Hair or fingernail loss; numbness in fingers or toes; circulatory problems
Total coliforms	0	Not a health threat in itself, but used to indicate presence of other potentially harmful bacteria
Secondary Standards		
Aluminum	0.05 - 0.2	Colored water
Chloride	250	Salty taste
Copper	1.0	Metallic taste; blue-green staining
Fluoride	2.0	Tooth discoloration
Iron	0.3	Rusty color; sediment; metallic taste; reddish or orange stains
Manganese	0.05	Black to brown color; black staining; bitter metallic taste
pH	6.5 - 8.5	*<6.5:* bitter metallic taste; corrosion; *>8.5*: slippery feel; soda taste; deposits
Sulfate	250	Salty taste
Total Dissolved Solids	500	Hardness; deposits; colored water; staining; salty taste
Zinc	5	Metallic taste

Dissolved Solids and Major Ions

Specific conductance is the measure of how water conducts an electric current. Because the presence of charged ionic species makes a solution conductive, specific conductance is an indirect measure of the amount of dissolved minerals in water. For most groundwater samples, the concentration of total dissolved solids (TDS) can be calculated by multiplying the specific conductance by 0.59 (Hem, 1989). A map of the specific conductance values in Kane County indicates a difference in the shallow groundwater quality between the western and eastern thirds of the county (Figure 3): values were considerably higher in the eastern wells than in the western or central wells, and the differences were statistically significant (Table 3). Differences are also apparent when plotting median and 10th, 25th, 75th, and 90th percentile values and outliers for all sampled wells (Figure 4).

Calculated TDS concentrations of 20 wells exceeded the secondary MCL of 500 mg/L, including 17 of the 28 wells in the eastern third of the county. Concentrations in two wells exceeded 1,000 mg/L.

Specific conductance values are primarily a function of the concentrations of major ions in solution: calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+), chloride (Cl^-), bicarbonate (HCO_3^-), and sulfate (SO_4^{2-}). Although HCO_3^- was not measured directly, it can be calculated by
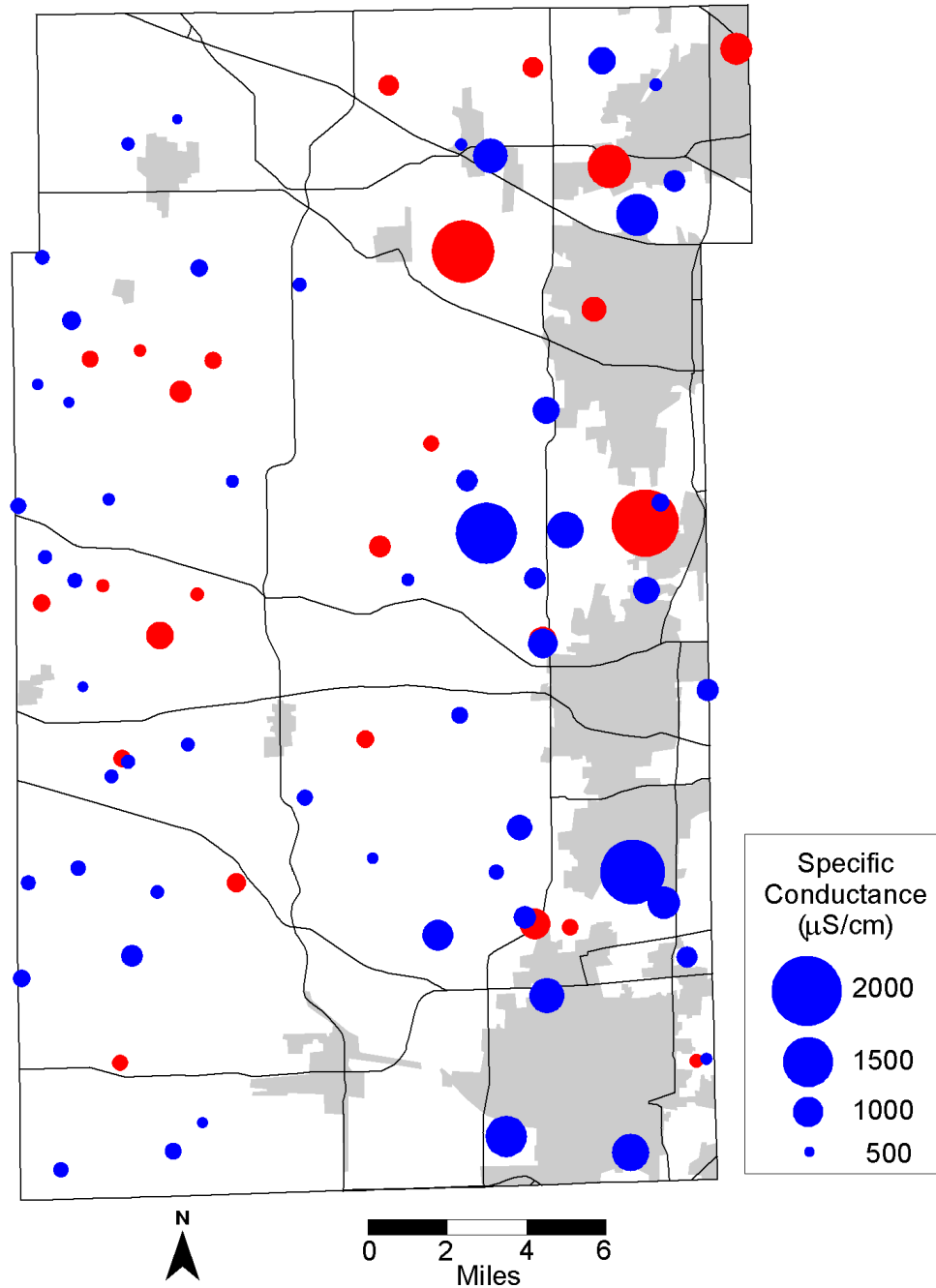
Notes: Shaded areas are municipalities and lines are major roads.
Blue dots are shallow bedrock wells.
Red dots are wells in unconsolidated deposits.

Figure 3. Specific conductance values of sampled wells

Table 3. Minimum, Median, and Maximum Values of Various Physical and Chemical Constituents as a Function of Location in Kane County

Constituent	West			Central			East			Statistical significance
	Min	Med	Max	Min	Med	Max	Min	Med	Max	
Well depth (ft)	54	148	240	40	151	225	42	150	240	none
Overlying till thickness (ft)	32	96	180	30	100	170	33	81	231	none
pH (pH units)	6.81	7.01	7.33	6.58	6.97	7.27	6.21	6.81	7.58	W > E; C > E
ORP (mv)	36	112	253	61	121	377	75	141	287	E > W
Specific conductance (µS/cm)	497	611	931	531	686	1805	541	952	1927	E > W; E > C
Dissolved oxygen	0.27	0.58	7.48	0.33	0.47	4.89	0.34	0.48	0.92	W > E
Arsenic (µg/L)	<0.71	2.15	57.2	<0.71	2.58	9.91	<0.71	1.43	37.1	none
Boron	<0.014	0.060	2.47	<0.014	0.132	0.353	<0.014	0.093	1.13	none
Barium	0.021	0.080	0.301	0.023	0.114	0.858	0.014	0.078	0.225	none
Calcium	34.0	76.2	122	29.5	71.9	144	21.1	97.7	178	E > W
Iron	<0.009	1.13	3.78	<0.009	1.91	3.51	0.024	1.66	6.63	none
Magnesium	18.0	39.5	59.3	25.5	44.3	68.9	11.0	51.7	92.1	E > W
Manganese	<0.002	0.016	0.107	<0.002	0.019	0.116	<0.002	0.025	0.331	none
Sodium	6.27	12.1	69.7	4.48	26.9	117	6.25	36.3	149	E > W
Silicon	3.59	8.38	12.0	4.96	9.29	20.4	4.43	8.30	12.3	none
Strontium	0.151	0.434	1.26	0.116	1.07	2.61	0.080	0.697	2.61	none
Zinc	<0.002	<0.002	0.092	<0.002	0.002	0.068	<0.002	0.005	0.110	E > W
Alkalinity (CaCO$_3$)	264	323	362	297	348	446	286	366	595	E > W
Fluoride	0.262	0.475	1.61	0.100	0.512	0.951	0.097	0.382	1.72	none
Chloride	0.911	3.78	35.0	1.23	6.62	359	2.31	42.0	359	E > W; E > C
Sulfate	<0.31	5.20	148	<0.31	3.98	119	<0.31	64.4	251	E > W; E > C
NO$_3$-N	<0.07	<0.07	2.94	<0.07	<0.07	4.11	<0.07	<0.07	1.38	none
NH$_3$-N	<0.03	0.481	2.52	<0.03	1.50	5.83	<0.03	0.549	26.6	none
TOC	0.252	1.04	5.83	0.291	2.56	6.25	0.399	1.18	22.3	none

Notes: All values are mg/L unless otherwise specified.
Statistical significance indicates a population significantly different than another based on the Kruskal-Wallis ANOVA on ranks test.
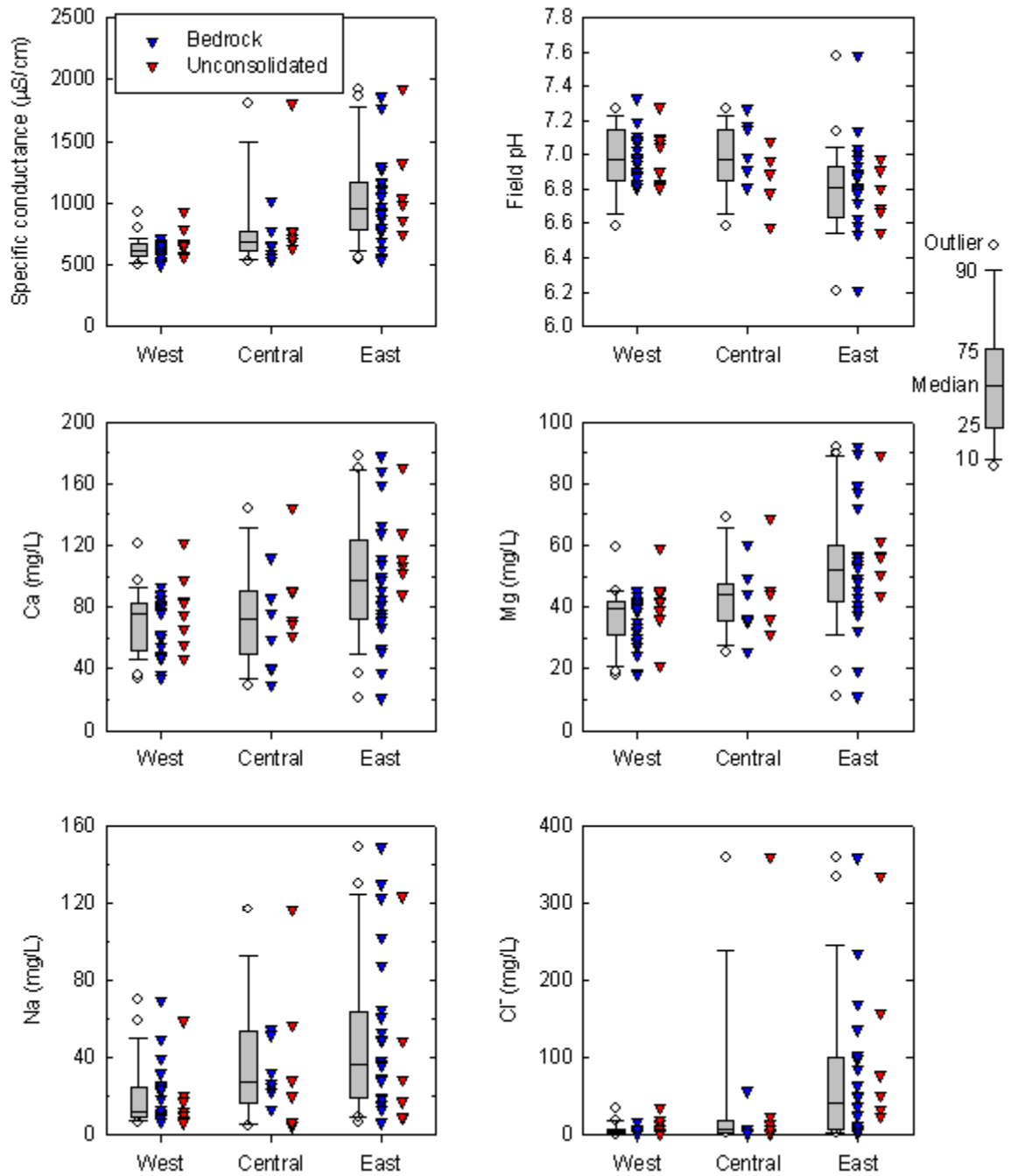
Figure 4. Box and whisker and point plots of specific conductance values, pH, and major ion concentrations of sampled wells

dividing alkalinity by 0.82. When discussing dissolved inorganic carbon, this report uses alkalinity, which was measured for this study, rather than HCO_3^-. Concentrations of all the major ions were greater in the eastern third of the county than in the central and western thirds, and the differences were statistically significant (Figures 4-5 and Table 3).

The most likely explanation for the high chloride and cation (Ca^{2+}, Mg^{2+}, and Na^+) concentrations in the eastern third of Kane County is road-salt runoff. A map of chloride concentrations is shown (Figure 6). Historically, halite (NaCl) has been the primary deicing material applied to roads. Chloride typically migrates conservatively (i.e., at the same rate as groundwater flow) in the subsurface, and chloride concentrations have been increasing in many shallow wells in northeastern Illinois since the 1960s when large quantities of road salt first began to be used (Kelly and Wilson, 2003). Concentrations in three wells in the east exceeded the 250 mg/L secondary MCL for chloride. Sodium entering the subsurface will often exchange with calcium and magnesium ions on clay surfaces, releasing Ca^{2+} and Mg^{2+} into solution. Thus, concentrations of all three major cations may increase as a result of road-salt runoff.

Another potential source of chloride and sodium in the eastern part of Kane County is domestic septic systems that discharge softened water. Sodium chloride typically is used in water softeners: the sodium exchanges with calcium and magnesium, the ions that produce hardness, and softened water can have elevated sodium and chloride concentrations. That softened water is then discharged back to the environment as wastewater. Thus, high-density housing with private septic systems may be a source of chloride and sodium to groundwater.

The greater alkalinity in the east is at least, in part, a result of lower pH values than in the west or central portions of Kane County (Figures 4 and 5). As pH decreases, bicarbonate is converted to carbonic acid (H_2CO_3):

$$HCO_3^- + H^+ \leftrightarrow H_2CO_3 \tag{1}$$

This reaction decreases alkalinity but does not affect the total dissolved carbon dioxide (HCO_3^- + H_2CO_3) in solution. The relationship between alkalinity and pH for the samples is shown (Figure 7). Alkalinity also may have been influenced by oxidation-reduction processes, as discussed in the next section.

Lower pH values in the eastern third of Kane County may reflect more acidic precipitation from vehicular exhaust and industrial atmospheric discharges. Acidic precipitation also may explain the higher sulfate concentrations in the county's eastern third. Elevated sulfate concentrations have been observed in other urban settings, as vehicles and industries contribute sulfur compounds to the atmosphere that eventually return to the land surface via precipitation and enter groundwater (Long and Saleem, 1974). Only two wells in southeastern Kane County had sulfate concentrations greater than 170 mg/L, 247 and 251 mg/L, respectively. That area generally had the highest sulfate concentrations in Kane County (Figure 8).

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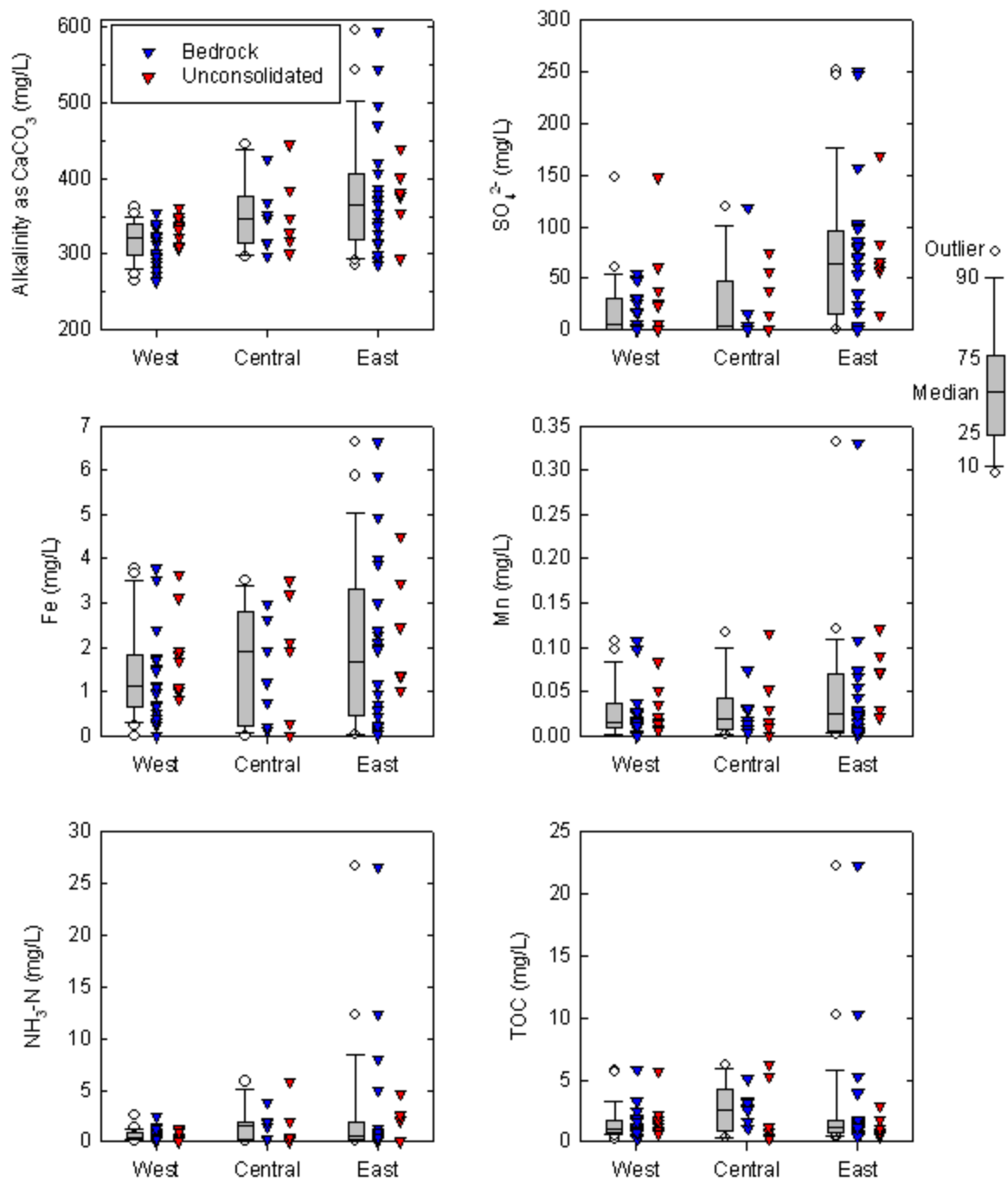
Figure 5. Box and whisker and point plots for various chemical parameters of sampled wells
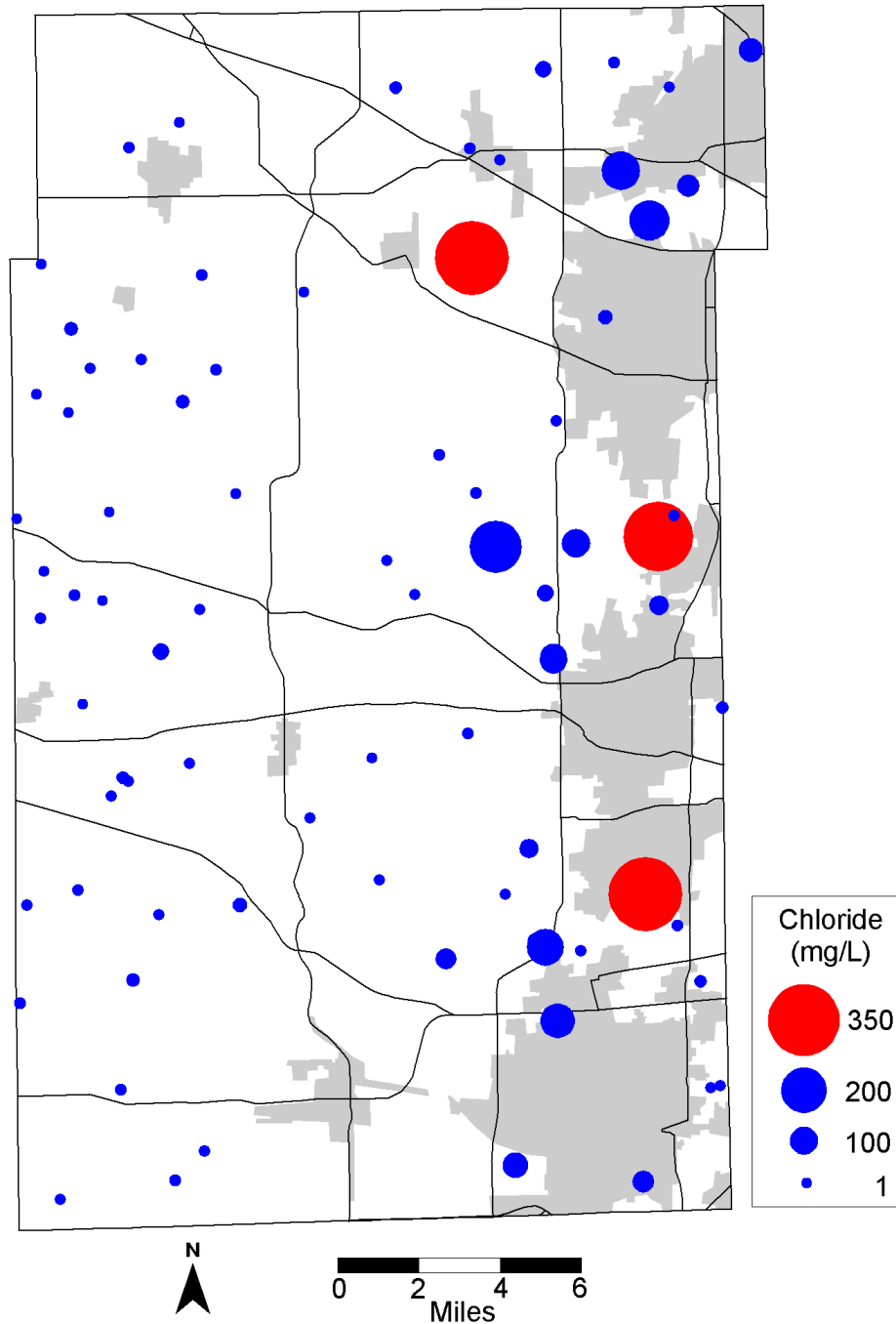
Notes: Shaded areas are municipalities and lines are major roads.
Red dots are wells where chloride exceeded the secondary MCL (250 mg/L).

Figure 6. Chloride concentrations of sampled wells and wells from the GWQDB
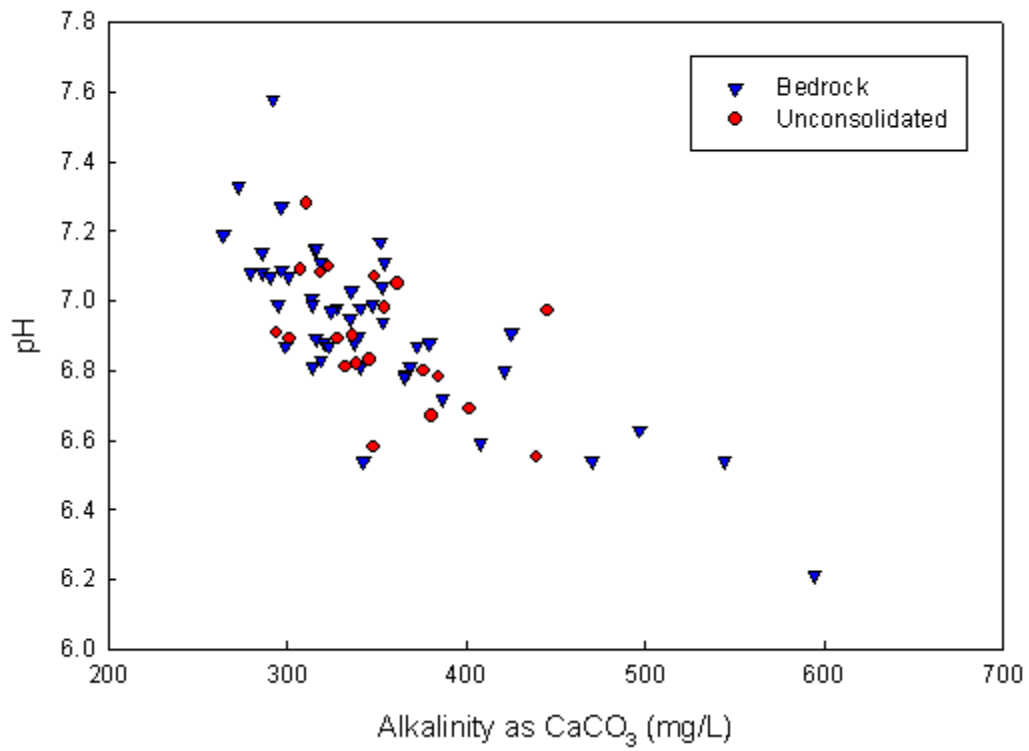
Figure 7. pH vs. alkalinity in sampled wells
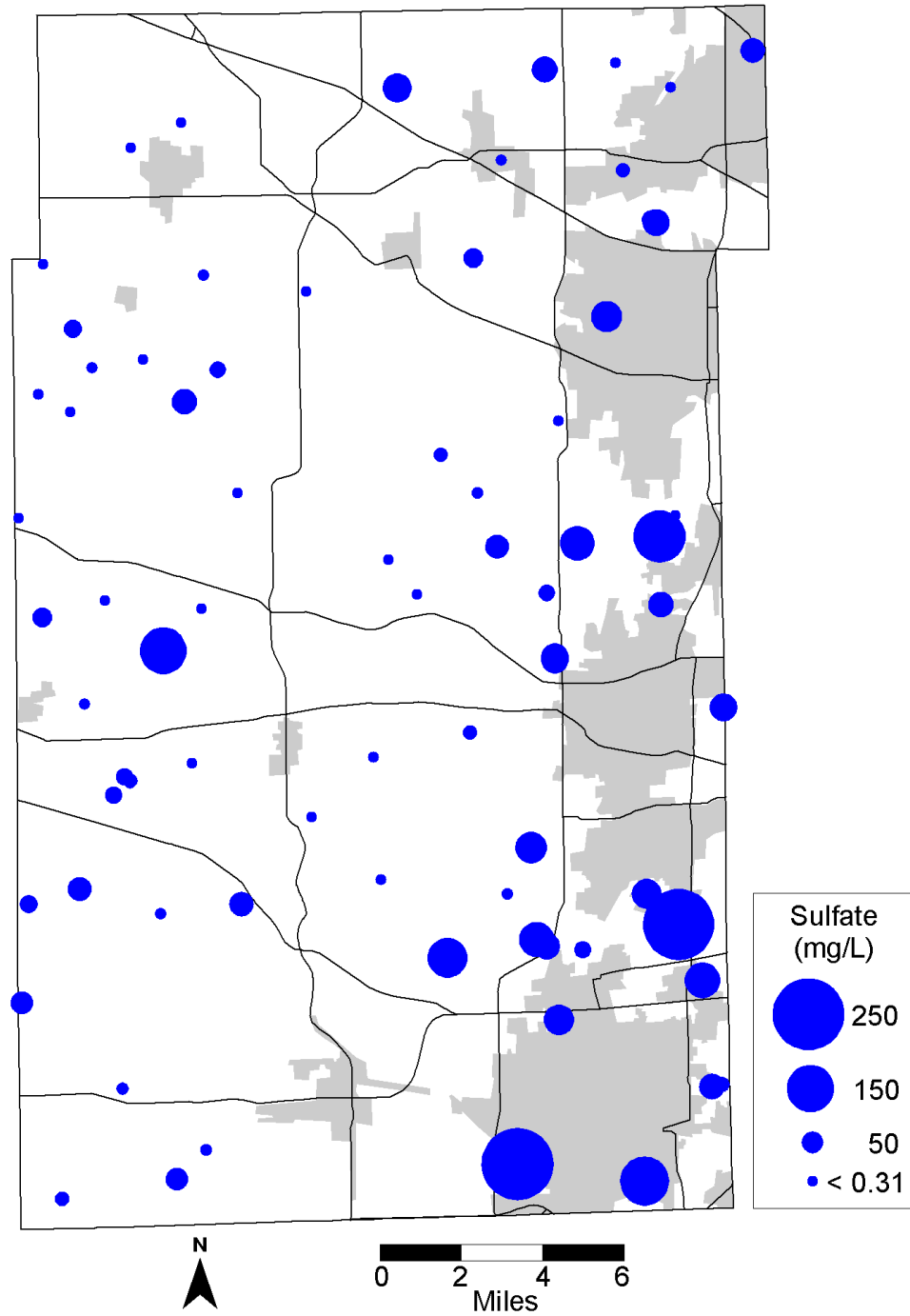
Figure 8. Sulfate concentrations of sampled wells and wells from the GWQDB

Oxidation-Reduction Conditions

An important control on biogeochemical processes in groundwater is oxidation-reduction (redox) conditions in the aquifer. Redox reactions are chemical reactions that transfer electrons from one ion to another. Because surface waters have abundant oxygen due to contact with the atmosphere, conditions there are usually oxidizing. Oxygen in groundwater, however, is limited and often removed before it is transported very far due to the oxidation of organic matter and iron, and conditions are usually reducing. Oxygen removed from groundwater is not easily replaced, so other compounds are used in oxidation reactions. These other compounds, referred to as electron acceptors, include nitrate, ferric iron, and sulfate.

The values of most of the redox-sensitive parameters (DO, ORP, nitrate, iron, manganese, sulfate, hydrogen sulfide, and NH_3-N) indicate mild to strong reducing conditions in shallow aquifers. Reducing conditions in shallow, unconfined aquifers in Illinois are not uncommon. Buried organic matter is abundant in surficial glacial deposits, and oxidation of these compounds removes oxygen from water during aquifer recharge. Reduction of iron oxyhydroxide minerals, also common in glacial deposits, occurs under moderately reducing conditions and increases dissolved iron concentrations in groundwater. Iron concentrations in 58 of the 70 samples (83 percent) exceeded the secondary MCL of 0.3 mg/L, and more than 60 percent of those samples exceeded 1 mg/L (Figure 5).

Although there were no statistically significant differences in iron concentrations among the different county areas, concentrations were highest in the eastern third (Figure 5 and Table 3). There are several possible explanations. Pyrite (FeS_2) is found in the till, and urban/suburban development may expose greater amounts of the till to the atmosphere, causing pyrite oxidation and releasing iron into solution. More organic matter also may be exposed by development, increasing oxidation rates and reducing iron oxyhydroxide minerals. Solubilities of iron hydroxide minerals are a function of pH, and lower pH values may account for increased dissolution of iron oxyhydroxide minerals. Figure 9 shows correlations between iron and alkalinity ($r^2 = 0.37$ for all data; 0.57 for eastern data) and iron and pH ($r^2 = 0.25$ for all data; 0.43 for eastern data). This suggests the latter two mechanisms discussed above may control iron concentrations; high alkalinity concentrations could be due to increased organic matter oxidation.

Under more strongly reducing conditions, sulfate is reduced, producing hydrogen sulfide (H_2S). No sulfate was detected in 14 wells, and its absence suggests its complete removal by sulfate-reducing bacteria. Hydrogen sulfide was detected by analysis or smell in about one-third of the wells, indicating sulfate reduction. Most of the 23 wells with detectable hydrogen sulfide were in the east and central thirds of the county, 15 and 5 wells, respectively. Production of hydrogen sulfide can cause iron and other metals to precipitate out of solution as sulfide minerals within the aquifer.

For most of the measured parameters, except arsenic, zinc, nitrate, and possibly ammonia, there was no difference in chemistry between wells with and without detectable hydrogen sulfide. Of the eight wells with arsenic concentrations greater than the MCL (10 µg/L), seven wells had no detectable hydrogen sulfide and the other well had an arsenic concentration of 12.6 µg/L, only slightly above the MCL. Six of the seven highest zinc concentrations were found in wells without detectable hydrogen sulfide. Nitrate was detected in only two wells that had detectable hydrogen

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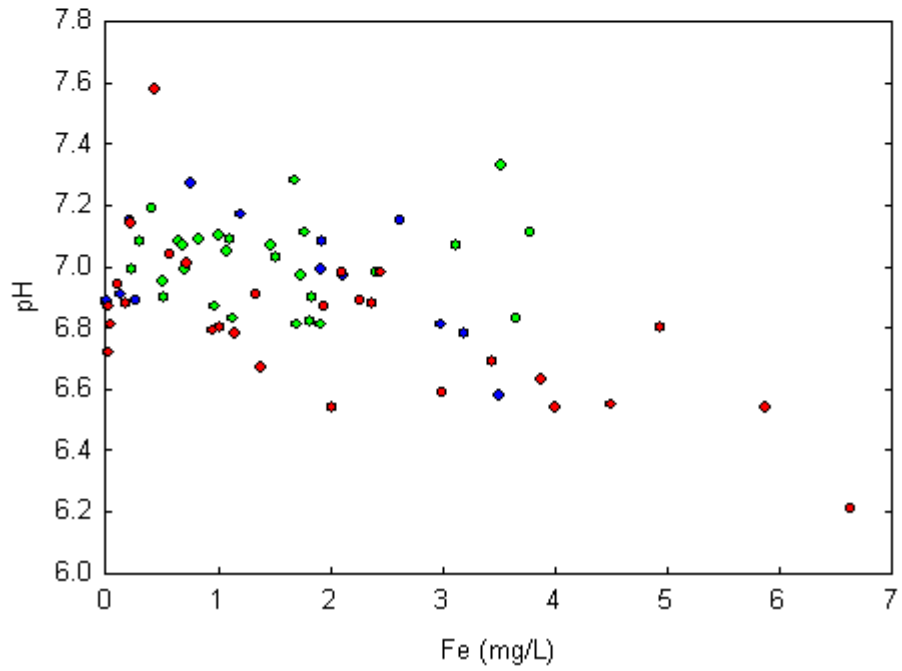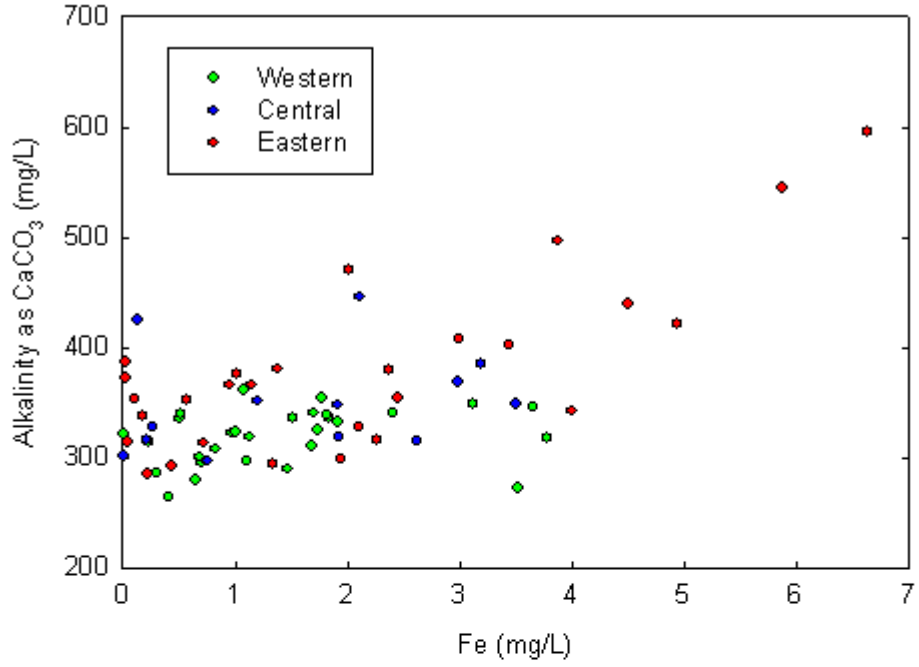
Figure 9. Iron concentrations vs. alkalinity and pH as a function
of location in Kane County

sulfide, and the concentrations were very low ($\leq$ 0.1 mg N/L). These correlations with hydrogen sulfide are discussed more fully in the "Nitrate" and "Arsenic" sections. The highest ammonia concentrations tended to be in wells with detectable hydrogen sulfide, although it was not detected in the well with by far the highest NH_3-N concentration, well 59. All but one well with no detectable sulfate also had no detectable hydrogen sulfide, indicating very reducing conditions, possibly methane producing, in aquifers at these locations. Although no samples were analyzed for methane in this study, it has been detected in parts of Kane County (e.g., Meents, 1960).

Atrazine

Atrazine, the most commonly applied row-crop herbicide in Illinois in recent decades, also is considered to be the most environmentally persistent pesticide in the Midwest (Goolsby, 1991). Samples from 48 wells were collected for atrazine analysis, primarily in agricultural regions of western and central Kane County, where it was most likely to be present at detectable concentrations. All wells in the western part of the county were sampled for atrazine and were below the detection level (0.5 μg/L). This is not surprising because atrazine is adsorbed by clay minerals and organic matter in the unconsolidated glacial drift of the shallow subsurface. Thus, atrazine transport is limited in most groundwater systems.

Nitrate

Elevated nitrate-nitrogen (NO_3-N) is common in groundwater in agricultural regions, due to leaching of synthetic fertilizer and natural soil nitrogen from the soil zone. Nitrate migrates fairly rapidly in many aquifers. However, only 7 of the 75 samples had detectable NO_3-N (> 0.07 mg/L), and the highest concentration detected was 4.1 mg/L, well below the MCL. This is quite different that what other researchers have found in similar settings throughout the state. For example, a large number of wells in McHenry County have NO_3-N concentrations above the MCL (H.-H. Hwang, ISGS, personal communication, 2005).

There are several potential explanations for the lack of nitrate found in the shallow groundwater in Kane County. Possibly most of the nitrate reaching the groundwater is denitrified. In the presence of a suitable electron donor, such as organic matter, microorganisms readily reduce nitrate to nitrogen gas under moderately reducing conditions:

$$4NO_3^- + 5CH_2O + 4H^+ \rightarrow 2N_2 + 5CO_2 + 7H_2O \qquad (2)$$
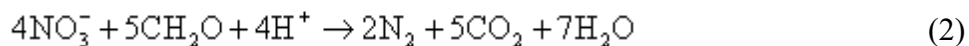
where CH_2O is a generic representation of organic matter. As discussed above, the aquifers were generally under reducing conditions, with abundant organic carbon as the most common source of electrons for denitrification. The presence of hydrogen sulfide in many wells indicates strongly reducing conditions, and the absence of nitrate in those samples would be expected. The three wells with nitrate-N greater than 1 mg/L also had low iron concentrations (< 0.05 mg/L), suggesting conditions that were not sufficient to reduce iron.

Another possible explanation for the lack of nitrate in the groundwater is that much of Kane County farmland is tile drained. Thus, most of the surface-derived nitrate may be transported to streams and drainage ditches rather than remaining in the groundwater.

Still another contributor to the lack of nitrate in aquifers may be increasing use of best management practices, such as buffer strips along ditches and streams, wetland construction, water table management, etc. Without widespread historical nitrate data for Kane County, however, it is impossible to know how much of a factor this may be.

Arsenic

Eight wells were above the 10-µg/L MCL for arsenic, including one well with 57.2 µg/L of arsenic. These wells were in the central or northern half of the county (Figure 10). Seven of the eight wells are finished in the shallow bedrock aquifer, although the well with the highest arsenic concentration, well 33, is finished in an unconsolidated aquifer.

High arsenic wells tended to have low levels of sulfate (Figure 11), which other scientists also have observed in other aquifers in Illinois (Holm et al., 2004; Kirk et al., 2004). Those researchers hypothesized that if sulfate is present and sulfate reduction is active, arsenic concentrations are low because any arsenic entering solution probably is removed by precipitation as an arsenic sulfide mineral or by coprecipitation with other sulfide minerals. After elimination of sulfate, methanogenesis becomes the dominant metabolism and, without a precipitation pathway, arsenic builds up in the groundwater. Based on the relationship between arsenic, hydrogen gas, and other redox-sensitive species, Kirk et al. (2004) suggested that some degree of iron reduction may be occurring in zones dominated by both methanogenic and sulfate-reducing bacteria.

Arsenic concentrations did not correlate well with any other chemical parameters except hydrogen sulfide and chloride. The correlation with hydrogen sulfide, discussed earlier, supports the sulfate reduction hypothesis: arsenic would be expected to precipitate out of solution in sulfide mineral phases. Wells with elevated concentrations of arsenic tended to have very low concentrations of chloride, although there is no obvious physical or chemical explanation for this.

Coliform Bacteria

None of the sampled wells had detectable *E. coli* bacteria, although eight tested presumptive positive for total coliform bacteria. The presence of coliform bacteria is usually a local problem, either due to poor wellhead protection or contamination in the well or water distribution system. All well owners were informed that the method analysis used was not approved for regulatory purposes, and were instructed to contact their county health department if they wanted their well more rigorously tested for coliform bacteria.

Other Contaminants

Chemical contaminants above their primary or secondary MCLs included arsenic, chloride, iron, manganese, sulfate, and TDS in wells in both shallow bedrock and unconsolidated aquifers (Figure 12). Other contaminants found were almost never above their MCLs. Barium was detected in all wells, but always well below the 2-mg/L MCL, with the highest concentration being 0.86 mg/L. Concentrations of the toxic metals beryllium, cadmium, chromium, copper, and selenium were usually below the instrument detection limits (Table A-2). Beryllium never was detected at the detection limit of 0.002 mg/L. Cadmium, chromium, and copper were only
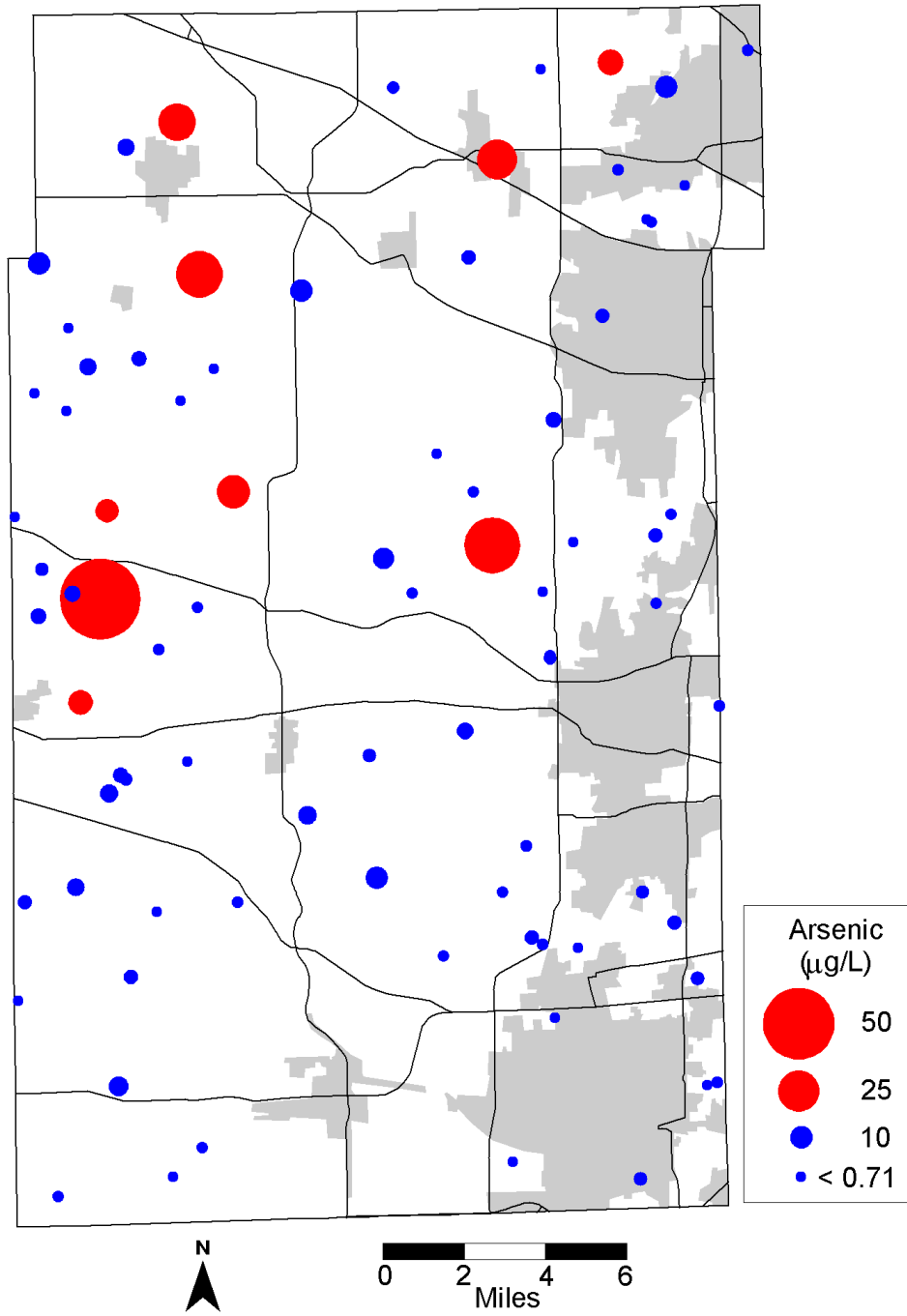
Figure 10. Arsenic concentrations of sampled wells and wells from the GWQDB
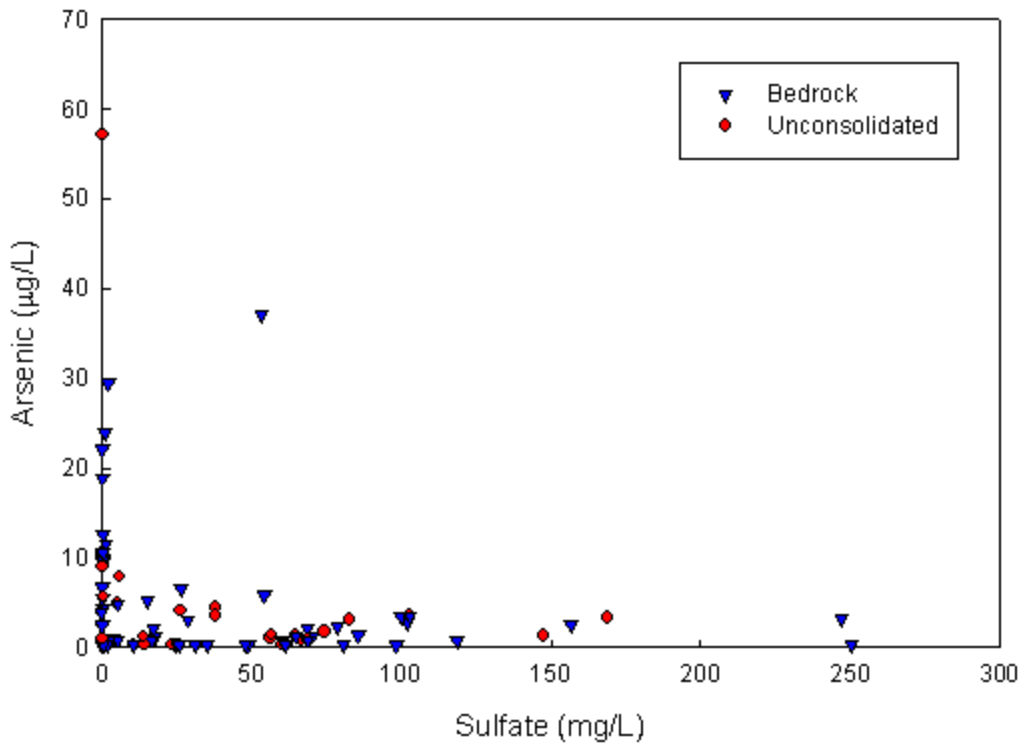
Figure 11. Arsenic vs. sulfate concentrations of sampled wells
and wells from the GWQDB

detected in 6, 5, and 3 samples, respectively, and at concentrations only slightly above the 0.003-, 0.004-, and 0.003-mg/L detection limits, respectively. One sample had a cadmium concentration at the primary MCL (0.005 mg/L), but the error associated with this value was relatively large because the concentration was very close to the detection limit. Selenium had a relatively high detection limit (0.034 mg/L). Six samples had detectable selenium, including one sample that exceeded 0.05-mg/L MCL (Table A-2).

There were significantly higher levels of zinc in the east than the west (Table 3). These relatively elevated levels in the east may be due to vehicle exhaust or industrial discharge, although the levels are not of concern. The highest concentration, 0.110 mg/L, was well below the secondary 5-mg/L MCL. The relationship between zinc and hydrogen sulfide discussed previously suggests that zinc precipitates out of solution when hydrogen sulfide is produced.

Sixteen wells had manganese levels above the 0.05-mg/L MCL. These wells are located throughout Kane County but primarily in the eastern third (Figure 12). Manganese and iron often exhibit similar trends, and there was a slight positive correlation between these two metals.

No wells exceeded the secondary 2-mg/L MCL for fluoride concentrations. Concentrations in four samples exceeded 1 mg/L, with a maximum of 1.72 mg/L. Three of those
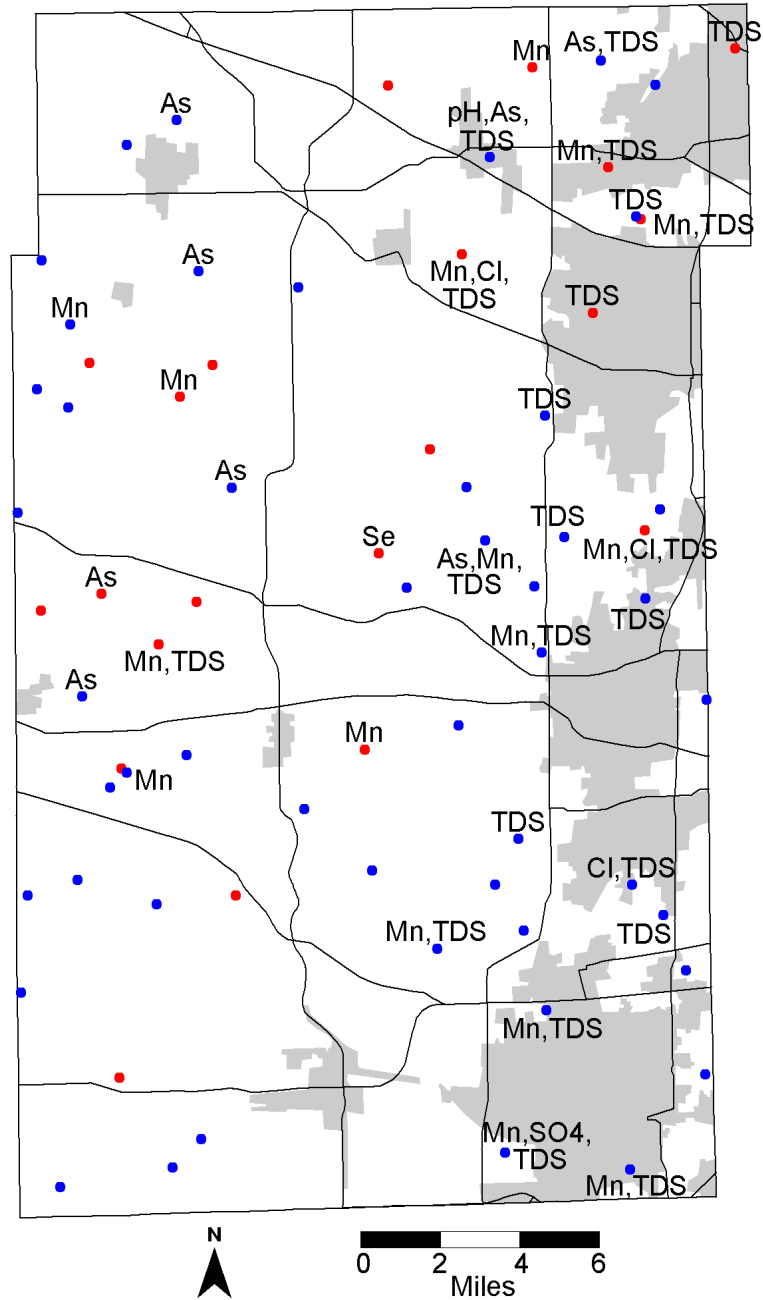
Figure 12. Chemical contaminants above the primary (As and Se)
or secondary MCL of sampled wells; unlabeled
wells had no contaminants above the standards

wells were in the eastern third of Kane County. Septic effluent is a possible anthropogenic source of fluoride because some water treatment plants add fluoride to drinking water.

Aluminum, for which the detection limit is 0.021 mg/L, was detected in four samples. One of those samples was above the secondary 0.05-mg/L MCL.

Groundwater in one well had a pH of 6.21, below the recommended pH range. That well is in an industrial area and had other water-quality problems, but it is not used for drinking water (Figure 12). It had by far the highest measured concentrations of NH_3-N (26.6 mg/L), TOC (22.3 mg/L), iron (6.63 mg/L), and alkalinity (595 mg/L).

Water Quality as a Function of Well Depth and Aquifer Sensitivity

Water-quality data were divided into two groups based on well depth (Table 4): $\leq$ 100 feet and > 100 feet. Twenty-one sampled wells were $\leq$ 100 feet deep, and 49 wells were between 100 and 250 feet deep. Shallower wells are more susceptible to surface-derived contaminants. Kelly and Wilson (2003) observed that municipal wells shallower than 100 feet deep in the Chicago region had greater chloride concentrations, presumably due to road-salt runoff, than wells between 100 and 200 feet deep.

Shallower wells contained calcium, iron, magnesium, manganese, chloride, and sulfate at significantly greater concentrations (Table 4). On the other hand, deeper wells had significantly greater concentrations of sodium, strontium, fluoride, and boron. Relatively elevated chloride in shallower wells was expected, assuming the source was road-salt runoff. That sodium was actually lower in these wells was surprising, although an exchange of sodium ions with calcium and magnesium ions would be expected, and these latter two ions were elevated in shallower wells. Relatively elevated sulfate concentrations in shallower wells may reflect surficial sources of sulfur, e.g., vehicle exhaust and industrial discharge. Higher concentrations of iron and manganese in shallower wells, along with no differences due to depth in other redox-sensitive parameters (e.g., TOC, NH_3-N, and ORP), indicate pervasive reducing conditions in the shallow aquifer system regardless of depth.

Dey et al. (2004) produced an aquifer sensitivity map of Kane County to depict the relative potential for aquifer contamination from sources at or near the land surface. Aquifer sensitivity considers both depth and hydrogeologic information. Areas with high potential for contamination have aquifers at least 20 feet thick and within 20 feet of the land surface, and areas with moderately high potential for contamination have aquifers less than 20 feet thick and within 20 feet of the land surface. Areas with low to moderate sensitivity have at least 20 feet of fine-grained till overlying the shallow aquifers.

The TDS concentrations (calculated from specific conductance) were plotted on a version of Dey et al.'s map (2004) to determine if there was a correlation between water quality and aquifer sensitivity (Figure 13). Most wells with TDS concentrations greater than 500 mg/L were found in areas of high or moderately high potential for contamination. Many wells with TDS concentrations less than 500 mg/L were found in areas of moderate to low sensitivity, especially in the western third of the county, however. Geographic location of a well, urban corridor versus rural areas, appears to have more of an impact on TDS concentrations than aquifer sensitivity.

Table 4. Median Values for Measured Parameters Based on Well Depth

Constituent	≤ 100 feet	> 100 feet	Significant difference
Temperature (°C)	11.7	11.5	
pH (pH units)	6.91	6.93	
ORP (mv)	117	129	
Specific Conductance (μS/cm)	756	673	
Dissolved oxygen	0.49	0.52	
Arsenic (μg/L)	1.79	2.07	
Boron	0.037	0.148	Deep > shallow
Barium	0.090	0.074	
Calcium	89.6	71.9	Shallow > deep
Iron	1.92	1.02	Shallow > deep
Magnesium	45.1	41.0	Shallow > deep
Manganese	0.038	0.016	Shallow > deep
Sodium	12.0	28.2	Deep > shallow
Silicon	9.20	8.08	
Strontium	0.387	0.770	Deep > shallow
Alkalinity ($CaCO_3$)	336	338	
Fluoride	0.374	0.475	Deep > shallow
Chloride	18.4	3.93	Shallow > deep
Sulfate	53.6	3.98	Shallow > deep
TOC	1.04	1.22	
NH_3-N	0.443	0.540	

Notes: Results are in mg/L unless otherwise indicated.
Twenty-one wells were ≤ 100 feet and 49 were > 100 feet.
The Mann-Whitney rank sum test was used to determine significance at the 95 percent level.

Some wells with relatively low TDS concentrations in the eastern third of Kane County were in areas that did not have high or moderately high potential for contamination, suggesting that till thickness may influence groundwater quality. Because relatively low permeability till deposits can act as a protective layer for underlying aquifers, retarding movement of contaminants from the surface, it was hypothesized that groundwater quality may be better in areas with relatively thick overlying till. Till thicknesses were estimated from drillers' logs prepared when the wells were drilled. These records are stored at the ISWS and are of variable quality. Till thicknesses of 66 of the 70 wells were estimated and used in the analysis.

There appeared to be a weak relationship between till thickness and several water-quality parameters, including specific conductance, chloride, calcium, sodium, and sulfate (Figure 14). Some of the highest parameter values were in samples from areas with relatively thin till layers (< 70 feet). Well location within the county seemed to have more impact on the concentration of surface-derived contaminants than till thickness.
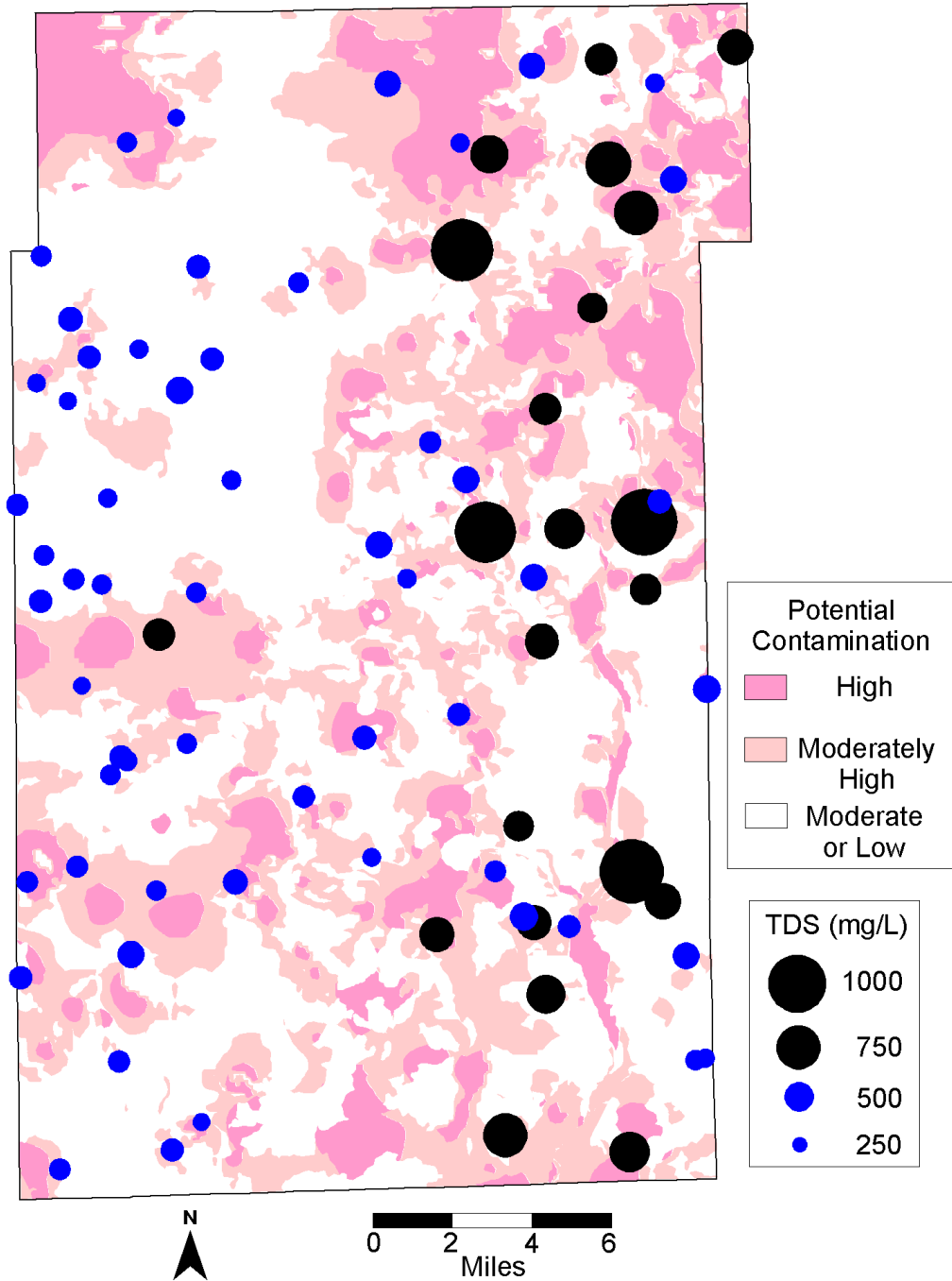
Figure 13. TDS concentrations and aquifer sensitivity
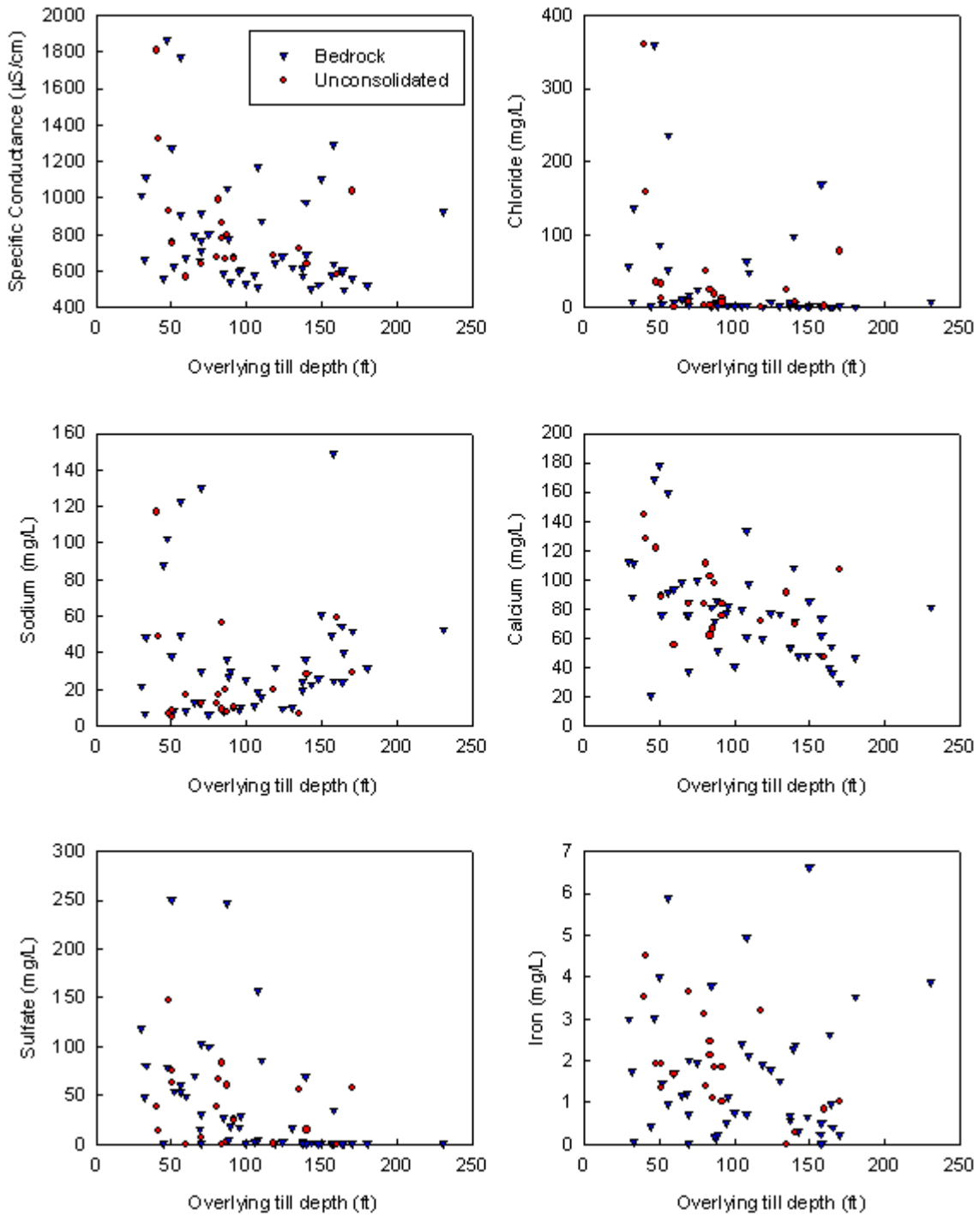
Figure 14. Concentrations of various water-quality parameters as a function
of till thickness of sampled wells

Water Quality as a Function of Source Aquifer Material

Water-quality data also were divided into two groups based on the source aquifer material (Table 5): shallow bedrock (primarily Silurian dolomite) and unconsolidated deposits (sand and gravel). Sampled wells were finished in bedrock (49 wells) or screened in unconsolidated material (21 wells). Wells in unconsolidated aquifers were expected to be more susceptible to surface-derived contaminants because they tend to be shallower and generally are overlain by thinner till deposits.

There were fewer significant differences in water-quality data between the two aquifer types than there were for well depth (Table 5). Concentrations of calcium, silicon, and barium were significantly greater in the unconsolidated wells, and concentrations of boron were significantly greater in the bedrock wells. Chloride and sulfate had higher median concentrations in unconsolidated wells, but the differences between the two aquifer types were not significant.

Table 5. Median Values for Measured Parameters Based on Source Aquifer Material

Constituent	Bedrock	Unconsolidated	Significant difference
Temperature (°C)	11.6	11.7	
pH (pH units)	6.95	6.89	
ORP (mv)	135	120	
Specific conductance (µS/cm)	663	752	
Dissolved oxygen	0.53	0.50	
Arsenic (µg/L)	2.07	1.79	
Boron	0.119	0.055	Bedrock > unconsolidated
Barium	0.074	0.099	Unconsolidated > bedrock
Calcium	76.2	88.2	Unconsolidated > bedrock
Iron	1.13	1.84	
Magnesium	41.0	45.0	
Manganese	0.017	0.030	
Sodium	26.9	17.1	
Silicon	7.96	9.28	Unconsolidated > bedrock
Strontium	0.690	0.542	
Alkalinity (CaCO$_3$)	335	346	
Fluoride	0.455	0.474	
Chloride	5.79	13.4	
Sulfate	16.3	38.1	
TOC	1.20	1.06	
NH$_3$-N	0.536	0.443	

Notes: Results are in mg/L unless otherwise indicated.

Forty-nine wells are finished in shallow bedrock and 21 in unconsolidated deposits.

The Mann-Whitney rank sum test was used to determine significance at the 95 percent level.

The higher silicon value in the unconsolidated wells may be due to the greater amount of silicon in sand and gravel, primarily as quartz (SiO_2) and feldspars, versus the shallow bedrock, which is primarily fractured dolomite [$CaMg(CO_3)_2$]. Barium may be associated with feldspars, but it is unclear why there would be differences in boron as a function of aquifer type. Concentrations of barium and boron were low in both aquifer types.

Conclusions and Recommendations

The results of this study indicate that the quality of shallow groundwater in Kane County is generally good, especially in the western and central thirds of the county. Nitrate-N concentrations were low and atrazine was not detected in any well, suggesting that agricultural activities are not seriously degrading the groundwater quality. Arsenic was above the MCL in slightly more than 10 percent of the wells. Iron and manganese were elevated in many wells, but this is common in shallow aquifers throughout Illinois. Toxic metals were not present at concentrations exceeding their MCLs in any well except for one well having a slightly elevated selenium concentration.

The TDS concentrations of samples from the eastern third of the county were significantly greater than from the rest of the county. The ions of greatest concern are chloride and sulfate. Almost two-thirds of the samples from the eastern wells sampled had TDS, chloride, and/or sulfate concentrations above the secondary MCL. Road-salt runoff, vehicular exhaust, and industrial discharges are the most likely sources of these elevated solutes. Lower pH values in the eastern third of the county probably reflect greater acidic deposition due to vehicular and industrial emissions. There was no evidence of increased levels of toxic metals, although zinc concentrations were slightly higher in the eastern wells.

Common treatment processes such as water softeners usually remove some contaminants found in raw water samples. These processes are designed to remove excess calcium and magnesium, but also tend to reduce iron and manganese levels. They also may be effective at removing arsenic and other metals: all five treated samples collected in this study had arsenic concentrations well below the MCL. Well owners were informed that chemical analyses of treated water samples were available from the ISWS PSL.

The presumptive presence of coliform bacteria in some wells may indicate *E. coli* contamination. It was suggested that those well owners contact the county health department to run a more rigorous test to determine the presence of fecal contamination. Because the test used in this study can have a significant percentage of false negative results, well owners whose samples did not test positive for coliform bacteria also were advised to contact the health department for a more definitive test for such contamination.

Because the movement of groundwater is slow, usually measured in feet per week or even feet per year, the widespread presence of high TDS groundwater in the eastern, highly developed part of Kane County suggests a fairly long history of shallow groundwater contamination. As Kelly and Wilson (2003) demonstrated, chloride levels in shallow aquifers in this region have been increasing since the 1960s. Howard et al. (1993) showed that even if road-salt use stopped immediately, chloride concentrations could, in fact, increase before decreasing, and groundwater quality could remain degraded for decades. Contamination from road-salt runoff is widespread

but not a serious human health concern, except possibly to people who need to be on low sodium diets. Increased levels of dissolved solids, however, do lead to increased water treatment costs. In addition to a water softener, reverse osmosis or distillation typically are used in domestic systems to remove excess dissolved solids.

It may be inevitable that increased growth of urban and suburban areas will lead to degradation of the groundwater quality in shallow aquifers, a problem in many cities throughout the world. Cities in northern latitudes commonly have high TDS and chloride concentrations due to road-salt runoff (Huling and Hollocher, 1972; Howard and Beck, 1993; Williams et al., 2000). Development in Kane County generally is moving from east to west. Protecting the very good shallow groundwater quality in the central and western thirds of Kane County should be a prime goal of water resource planners. Collecting all contaminated water such as road runoff is probably impractical and cost prohibitive, but there are some mitigation measures that can be taken countywide to limit the impacts. The National Research Council (1991) made several recommendations, including (1) diverting runoff from sensitive areas through drainage improvements; (2) reducing road-salt application near public water supplies; and (3) using other, more environmentally benign deicing agents, such as sand or calcium magnesium acetate. The Northeastern Illinois Planning Commission (NIPC) also is well aware of these issues and potential solutions, and has published a pamphlet titled *Pavement Deicing: Minimizing the Environmental Impacts* (NIPC, 1998).

This project provides a baseline for shallow groundwater quality in Kane County. It would be helpful to repeat this study at 5-year intervals, sampling as many of the same wells as possible, to determine water-quality changes as Kane County undergoes land-use changes. More detailed studies at more frequent intervals for particularly sensitive areas or those with rapid changes in land use also may be helpful to water resource planners. The best method for tracking changes in groundwater quality would be to install a dedicated monitoring well network. Wells could be installed in desired locations using standardized methods, avoiding problems inherent in sampling private wells, such as well access issues and the possibility of change in ownership.

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Appendix A. Complete Data on Water Quality for Samples Collected in This Study and Pertinent Well Samples from the ISWS Groundwater Quality Database

Table A-1. Well Information and Field Analyses for Untreated Samples

Sample No.	Depth (ft)	Aquifer	ISWS Well No.	Town	Range	Sect	Overlying till (ft)	Date sampled	Temp (°C)	pH	ORP (mv)	SpC (µS/cm)	DO (mg/L)	H_2S (ppm)	H_2S (smell)
3	160	C	299280	38N	6E	26	108	10/07/2003	10.98	6.99	83	513	0.54	<0.1	
4	100	C	295546	38N	6E	26	32	10/07/2003	12.96	6.97	112	663	ND	0	
5 (dup)	100	C	295546	38N	6E	26	32	10/07/2003							
6	240	C	189323	38N	6E	32	130	10/07/2003	11.18	7.03	98	620	0.45	0	
8	80	U	228688	38N	6E	16	70	10/07/2003	11.66	6.83	78	640	0.95	0	
9	130	C	65379	38N	6E	6	60	10/07/2003	13.17	6.81	116	673	0.39	0	
10	188	C	66639	39N	6E	30	96	10/07/2003	12.34	6.83	200	611	7.48	0	
11	180	C	250714	39N	6E	27	105	10/07/2003	13.78	6.98	82	578	0.74	0.6	
12	130	C	66574	39N	6E	9	95	10/07/2003	11.06	6.95	136	596	0.54	0	
13	95	C	212576	39N	6E	9	85	10/07/2003	11.82	7.11	59	588	0.27	0	
14	95	U	66542	39N	6E	4	92	10/07/2003	11.39	6.90	117	675	0.34	0	
15	225	C	237340	39N	6E	2	157	10/07/2003	11.28	6.99	166	581	0.38	0	
16	200	C	254382	40N	6E	32	143	10/07/2003	11.25	7.08	129	505	0.38	0	
17	93	U	213675	40N	6E	18	80	10/07/2003	11.01	7.07	77	673	0.4	0	
18	208	C	67402	40N	6E	6	158	10/08/2003	11.20	6.90	157	639	0.9	0	
19	230	C	67390	40N	6E	1		10/08/2003	11.84	7.09	105	563	0.58	ND	
20 (dup)	230	C	67390	40N	6E	1		10/08/2003							
21	92	U	69917	41N	6E	13	92	10/08/2003	12.23	7.10	84	667	0.69	0	
22	97	U	306153	41N	6E	23	87	10/08/2003	11.04	6.82	118	794	2.46	ND	
23	225	C	331588	41N	6E	20	180	10/08/2003	11.36	7.33	36	519	0.61	0	
24	150	C	214879	41N	6E	19	148	10/08/2003	10.82	7.08	115	527	0.47	ND	
25	110	U	69940	41N	6E	16	86	10/08/2003	11.72	7.05	114	663	0.52	0	
26	205	C	238222	41N	6E	8	70	10/08/2003	13.16	6.88	253	712	0.57	ND	
27	128	C	311520	41N	6E	2	124	10/08/2003	11.18	7.11	65	679	0.62	0	
28	175	C	283051	42N	6E	15	165	10/08/2003	10.87	7.19	93	497	1.26	ND	
29	141	C	71217	42N	6E	21	137	10/08/2003	12.06	7.07	110	575	0.96	0	
30	225	C	69890	41N	6E	5	164	10/08/2003	12.31	6.87	129	605	0.84	ND	
31	195	C	282843	41N	7E	8	163	10/08/2003	12.85	7.15	61	592	0.47	0	
32	160	U	213548	40N	6E	14	160	10/08/2003	11.08	7.09	99	578	0.9	ND	
33	90	U	314629	40N	6E	16	60	10/08/2003	11.74	7.28	54	567	0.61	0	
34	200	C	329955	39N	7E	17	119	10/08/2003	11.16	6.99	84	646	0.67	0	
35	60	C	66343	38N	8E	30	50	10/14/2003	13.26	6.54	142	1274	0.53	0	
36	160	C	323169	38N	8E	34	108	10/14/2003	12.83	6.80	104	1169	0.52	0.4	+++
37 (dup)	160	C	323169	38N	8E	34	108	10/14/2003							
38	150	C	238379	38N	8E	1	70	10/14/2003	11.72	7.01	136	768	0.38	0	+
39	160	C	230980	39N	8E	27	47	10/14/2003	12.24	6.59	164	1861	0.55	ND	
40	130	C	67136	39N	8E	17	110	10/14/2003	11.34	6.98	121	875	0.54	0	+
41	180	C	228789	39N	8E	30	137	10/14/2003	10.82	7.04	140	619	0.42	0	+
42	75	C	66003	38N	8E	8	33	10/14/2003	12.47	6.81	242	1114	0.6	ND	
43	60	C	213253	39N	7E	35	30	10/14/2003	11.90	6.81	137	1015	0.56	ND	
44	200	C	331376	39N	7E	22	100	10/14/2003	10.68	7.27	121	531	1.7	ND	
45	135	U	213124	39N	7E	3	118	10/14/2003	11.03	6.78	128	686	0.39	0	++
46	125	C	66652	39N	7E	1	69	10/14/2003	11.62	7.17	102	658	0.56	0	+
47	180	C	69690	40N	8E	29	139	10/14/2003	11.09	6.89	135	977	0.41	ND	+
49	210	C	238357	40N	8E	17		10/14/2003	10.90	6.94	182	774	0.37	ND	+
50	240	C	71833	42N	8E	34	158	10/15/2003	11.03	6.87	87	1294	0.49	2	+++
51	93	U	71834	42N	8E	34	81	10/15/2003	11.41	6.67	131	989	0.92	ND	+
52 (dup)	93	U	71834	42N	8E	34	81	10/15/2003							
53	42	U	289692	42N	8E	21	41	10/15/2003	12.86	6.55	122	1323	0.5	0	+++
54	185	U	276121	42N	8E	12	170	10/15/2003	11.69	6.80	169	1037	0.5	ND	
55	100	C	241458	42N	8E	15	45	10/15/2003	12.20	7.58	75	557	0.37	ND	
56	232	C	71666	42N	8E	9	231	10/15/2003	11.42	6.63	136	926	0.34	0	+
57	56	U	228628	42N	8E	7	51	10/15/2003	11.67	6.91	139	752	0.37	ND	+
58	55	U	339675	42N	7E	9	51	10/15/2003	11.97	7.08	109	756	0.33	ND	
59	200	C	229159	42N	7E	24	150	10/15/2003	11.52	6.21	181	1104	0.42	ND	

Table A-1. Concluded

Sample No.	Depth (ft)	Aquifer	ISWS Well No.	Town	Range	Sect	Overlying till (ft)	Date sampled	Temp (°C)	pH	ORP (mv)	SpC (μS/cm)	DO (mg/L)	H_2S (ppm)	H_2S (smell)
60	40	U	70014	41N	7E	1	40	10/15/2003	12.31	6.58	154	1805	0.33	0.3	+++
61	84	U	72178	41N	8E	15	84	10/15/2003	11.44	6.98	104	865	0.36	ND	
62	220	C	216111	41N	8E	28	70	10/15/2003	11.26	6.54	168	919	0.42	0	+
63	90	C	69039	40N	8E	7	56	10/15/2003	10.90	6.54	155	1770	0.39	ND	
64	180	C	263904	39N	8E	32	75	10/15/2003	11.62	6.87	137	804	0.37	ND	+
65	180	C	213525	39N	8E	35	87	10/15/2003	10.82	6.88	195	1053	0.5	ND	+
68	160	C	321812	38N	8E	13	89	10/21/2003	12.16	7.14	150	541	0.61	ND	
69	125	U		39N	6E	25	135	10/21/2003	11.20	6.89	377	723	4.89	ND	
70	100	C	310294	39N	6E	20	52	10/21/2003	11.08	7.07	115	627	0.41	ND	+
71	54	U	67499	40N	6E	22	48	10/21/2003	11.10	6.81	154	931	0.49	ND	
72	225	C	67954	40N	7E	14	170	10/21/2003	11.37	7.15	149	561	0.41	ND	
73 (dup)	225	C	67954	40N	7E	14	170	10/21/2003							
74	210	U	72050	40N	7E	10	84	10/21/2003	11.91	6.97	120	778	0.35	ND	
75	240	C	72542	40N	7E	1	88	10/21/2003	11.75	6.91	74	773	0.45	2	+++
76	155	U	215302	41N	7E	35	140	10/21/2003	11.74	6.89	122	638	0.75	0.1	+++
79	145	C	72228	40N	8E	9		10/21/2003	12.23	6.72	287	1156	ND	ND	
81	175	C	69844	40N	8E	36	65	10/30/2003	12.00	6.78	172	796	0.48	ND	
82 (dup)	175	C	69844	40N	8E	36	65	10/30/2003							
83	175	C	72380	40N	8E	23	56	10/30/2003	11.55	6.79	156	909	0.66	ND	
84	153	U	331659	40N	8E	11		10/30/2003	11.58	6.69	166	1927	0.37	ND	
85	200	C	68838	40N	8E	2	140	10/30/2003	12.73	6.88	135	690	0.7	ND	+

Notes: dup = duplicate sample of previously numbered sample.
C = consolidated aquifer and U = unconsolidated aquifer.
ND = not determined.
+ = slight sulfide smell, ++ = moderate sulfide smell, and +++ = strong sulfide smell.

Table A-2. Concentrations of Metals in Untreated Samples

Sample No.	Al (mg/L)	As (µg/L)	B (mg/L)	Ba (mg/L)	Be (mg/L)	Ca (mg/L)	Cd (mg/L)	Co (mg/L)	Cr (mg/L)	Cu (mg/L)	Fe (mg/L)	K (mg/L)	Li (mg/L)	Mg (mg/L)
3	0.039	0.92	0.328	0.021	<0.002	60.6	<0.003	<0.003	<0.004	<0.003	0.707	4.77	0.014	32.1
4	0.023	<0.71	<0.014	0.091	<0.002	88.3	<0.003	<0.003	<0.004	<0.003	1.73	<3.06	<0.007	43.8
5 (dup)	<0.021	<0.71	<0.014	0.089	<0.002	88.1	<0.003	<0.003	<0.004	<0.003	1.73	<3.06	<0.007	43.7
6	<0.021	0.90	0.029	0.091	<0.002	76.5	<0.003	<0.003	<0.004	<0.003	1.51	<3.06	0.008	41.5
8	0.094	7.86	0.060	0.078	<0.002	83.0	<0.003	<0.003	<0.004	<0.003	3.65	<3.06	<0.007	41.5
9	<0.021	<0.71	0.020	0.052	<0.002	93.2	<0.003	<0.003	<0.004	<0.003	1.70	<3.06	0.009	45.1
10	<0.021	3.08	0.025	0.066	<0.002	81.9	<0.003	<0.003	<0.004	0.007	1.13	<3.06	<0.007	40.6
11	<0.021	<0.71	0.048	0.031	<0.002	79.0	<0.003	<0.003	<0.004	<0.003	2.40	<3.06	<0.007	38.5
12	<0.021	2.15	0.041	0.066	<0.002	77.3	<0.003	<0.003	<0.004	<0.003	0.507	<3.06	<0.007	42.0
13	<0.021	6.58	0.032	0.109	<0.002	81.1	<0.003	<0.003	<0.004	<0.003	3.78	<3.06	<0.007	40.9
14	0.024	4.10	0.037	0.114	<0.002	83.8	<0.003	<0.003	<0.004	<0.003	1.84	<3.06	<0.007	45.0
15	<0.021	<0.71	2.47	0.301	<0.002	48.4	<0.003	<0.003	<0.004	<0.003	0.236	27.1	0.086	18.8
16	<0.021	11.6	0.119	0.138	<0.002	47.4	<0.003	<0.003	<0.004	<0.003	0.306	<3.06	0.010	35.2
17	<0.021	4.47	0.055	0.137	<0.002	82.9	<0.003	0.003	<0.004	<0.003	3.12	<3.06	<0.007	44.2
18	<0.021	<0.71	0.408	0.080	<0.002	62.1	<0.003	0.007	<0.004	<0.003	0.516	13.29	0.027	33.4
19	<0.021	19.0	0.296	0.023	<0.002	33.7	<0.003	0.005	<0.004	<0.003	1.09	<3.06	<0.007	17.8
20 (dup)	<0.021	18.8	0.295	0.022	<0.002	34.3	<0.003	<0.003	<0.004	<0.003	1.12	<3.06	<0.007	18.2
21	<0.021	<0.71	0.033	0.079	<0.002	75.1	<0.003	0.004	<0.004	<0.003	1.01	<3.06	0.008	38.9
22	<0.021	<0.71	0.010	0.099	<0.002	97.5	<0.003	0.006	<0.004	<0.003	1.82	<3.06	0.007	45.1
23	<0.021	<0.71	0.119	0.129	<0.002	46.4	<0.003	0.005	<0.004	<0.003	3.52	4.11	0.016	27.1
24	<0.021	<0.71	0.171	0.074	<0.002	47.7	<0.003	0.005	<0.004	<0.003	0.649	<3.06	<0.007	28.7
25	<0.021	5.60	0.136	0.040	<0.002	66.4	<0.003	0.005	<0.004	<0.003	1.08	<3.06	<0.007	42.1
26	<0.021	<0.71	0.071	0.060	<0.002	84.8	<0.003	0.006	<0.004	0.006	<0.009	<3.06	<0.007	41.6
27	<0.021	29.5	0.044	0.074	<0.002	77.0	<0.003	<0.003	<0.004	<0.003	1.78	<3.06	<0.007	41.9
28	<0.021	22.2	0.229	0.172	<0.002	36.2	<0.003	0.006	<0.004	<0.003	0.409	<3.06	<0.007	24.5
29	<0.021	5.54	0.148	0.120	<0.002	54.2	<0.003	0.004	<0.004	<0.003	0.682	<3.06	0.008	33.7
30	<0.021	9.79	0.366	0.080	<0.002	54.3	<0.003	0.006	<0.004	<0.003	0.970	9.48	0.018	30.3
31	<0.021	9.91	0.320	0.160	<0.002	39.9	<0.003	<0.003	<0.004	<0.003	2.62	<3.06	<0.007	25.5
32	<0.021	0.93	0.169	0.049	<0.002	46.9	<0.003	<0.003	<0.004	<0.003	0.829	<3.06	<0.007	21.1
33	<0.021	57.2	0.065	0.089	<0.002	55.7	<0.003	0.004	<0.004	<0.003	1.68	<3.06	<0.007	36.0
34	<0.021	6.83	0.187	0.117	<0.002	59.2	<0.003	<0.003	<0.004	<0.003	1.91	<3.06	<0.007	35.1
35	<0.021	<0.71	0.053	0.067	<0.002	178	<0.003	0.005	<0.004	<0.003	4.01	<3.06	0.012	56.9
36	<0.021	2.48	0.068	0.116	<0.002	133	<0.003	0.005	<0.004	<0.003	4.62	<3.06	0.015	77.3
37 (dup)	<0.021	2.66	0.078	0.116	<0.002	133	<0.003	0.005	<0.004	<0.003	5.26	<3.06	0.020	76.9
38	<0.021	2.71	0.474	0.067	<0.002	75.8	0.004	0.004	<0.004	<0.003	0.721	<3.06	0.022	49.2
39	<0.021	2.28	0.020	0.204	<0.002	168	<0.003	<0.003	<0.004	<0.003	3.00	<3.06	0.021	89.9
40	<0.021	1.40	0.049	0.086	<0.002	97.3	<0.003	<0.003	<0.004	<0.003	2.10	<3.06	<0.007	56.1
41	<0.021	0.89	0.106	0.062	<0.002	53.0	<0.003	<0.003	<0.004	<0.003	0.568	<3.06	<0.007	45.3
42	<0.021	<0.71	0.057	0.098	<0.002	111	<0.003	<0.003	<0.004	<0.003	0.047	<3.06	0.009	53.7
43	<0.021	0.80	<0.014	0.068	<0.002	112	<0.003	<0.003	<0.004	<0.003	2.99	<3.06	0.009	60.4
44	<0.021	9.57	0.189	0.067	<0.002	40.8	<0.003	<0.003	<0.004	<0.003	0.754	<3.06	<0.007	35.6
45	<0.021	2.58	0.132	0.102	<0.002	71.9	<0.003	<0.003	<0.004	<0.003	3.19	<3.06	0.008	36.0
46	<0.021	5.27	0.064	0.071	<0.002	76.1	<0.003	<0.003	<0.004	<0.003	1.21	<3.06	<0.007	44.3
47	<0.021	2.07	0.032	0.079	<0.002	108	<0.003	<0.003	<0.004	<0.003	2.27	4.86	<0.007	54.9
49	<0.021	<0.71	1.13	0.016	<0.002	67.4	0.003	<0.003	<0.004	<0.003	0.109	11.9	0.024	37.5
50	<0.021	<0.71	1.13	0.019	<0.002	73.7	<0.003	<0.003	<0.004	<0.003	0.024	9.45	0.038	41.0
51	<0.021	0.73	0.063	0.132	<0.002	112	0.003	0.010	0.005	<0.003	1.40	6.33	0.018	56.7
52 (dup)	<0.021	0.75	0.060	0.131	<0.002	110	0.004	<0.003	<0.004	<0.003	1.36	5.65	0.018	55.6
53	<0.021	1.27	0.081	0.165	<0.002	128	0.003	0.003	<0.004	<0.003	4.50	4.86	0.010	61.2
54	<0.021	1.46	<0.014	0.078	<0.002	107	<0.003	<0.003	<0.004	<0.003	1.02	7.08	0.013	56.6
55	<0.021	9.53	1.124	0.014	<0.002	21.1	<0.003	<0.003	<0.004	<0.003	0.433	23.9	0.024	11.0
56	<0.021	12.6	0.283	0.210	<0.002	81.2	<0.003	0.003	<0.004	<0.003	3.88	7.04	<0.007	43.2
57	<0.021	<0.71	<0.014	0.079	<0.002	88.2	<0.003	<0.003	<0.004	<0.003	1.33	4.64	<0.007	43.7
58	<0.021	1.79	<0.014	0.121	<0.002	89.6	<0.003	<0.003	<0.004	<0.003	1.93	4.79	0.011	45.6
59	<0.021	24.0	0.216	0.181	<0.002	84.9	<0.003	<0.003	<0.004	<0.003	6.63	9.30	0.009	40.9
60	<0.021	3.54	0.019	0.296	<0.002	144	<0.003	0.005	<0.004	<0.003	3.51	7.95	0.015	68.9
61	<0.021	3.11	0.048	0.060	<0.002	102	<0.003	<0.003	<0.004	<0.003	2.45	<3.06	<0.007	50.6
62	<0.021	4.38	1.12	0.054	<0.002	37.4	<0.003	<0.003	<0.004	<0.003	2.01	5.92	0.030	19.2
63	<0.021	37.1	0.146	0.159	<0.002	159	<0.003	<0.003	<0.004	<0.003	5.87	<3.06	<0.007	79.3
64	<0.021	3.47	0.034	0.069	<0.002	99.4	<0.003	<0.003	<0.004	<0.003	1.94	<3.06	<0.007	49.3

Sample No.	Al (mg/L)	As (μg/L)	B (mg/L)	Ba (mg/L)	Be (mg/L)	Ca (mg/L)	Cd (mg/L)	Co (mg/L)	Cr (mg/L)	Cu (mg/L)	Fe (mg/L)	K (mg/L)	Li (mg/L)	Mg (mg/L)
65	<0.021	3.15	0.481	0.040	<0.002	71.8	<0.003	<0.003	<0.004	<0.003	0.179	<3.06	0.044	92.1
68	<0.021	1.24	0.547	0.019	<0.002	50.9	<0.003	<0.003	<0.004	<0.003	0.225	4.18	0.014	32.5
69	<0.021	1.11	<0.014	0.039	<0.002	91.0	0.004	<0.003	0.004	<0.003	<0.009	<3.06	<0.007	45.4
70	<0.021	5.90	0.035	0.063	<0.002	76.2	<0.003	<0.003	<0.004	<0.003	1.47	<3.06	<0.007	39.5
71	<0.021	1.31	<0.014	0.087	<0.002	122	<0.003	<0.003	<0.004	<0.003	1.92	<3.06	<0.007	59.3
72	<0.021	0.77	0.306	0.023	<0.002	29.3	<0.003	<0.003	<0.004	<0.003	0.260	<3.06	0.014	36.1
73 (dup)	<0.021	0.69	0.307	0.024	<0.002	29.7	<0.003	<0.003	<0.004	<0.003	0.172	<3.06	0.018	36.3
74	<0.021	9.07	0.264	0.145	<0.002	61.6	<0.003	<0.003	<0.004	<0.003	2.12	<3.06	0.046	44.4
75	<0.021	0.95	0.119	0.114	<0.002	85.6	0.005	<0.003	<0.004	<0.003	0.135	<3.06	0.013	49.4
76	<0.021	<0.71	0.353	0.858	<0.002	69.6	<0.003	<0.003	<0.004	<0.003	0.271	8.01	0.020	31.2
79	<0.021	<0.71	0.103	0.112	<0.002	128	<0.003	<0.003	<0.004	0.007	0.031	<3.06	0.009	72.2
81	<0.021	1.09	0.079	0.072	<0.002	96.9	<0.003	0.004	0.007	<0.003	1.14	<3.06	0.013	52.2
82 (dup)	<0.021	1.48	0.089	0.083	<0.002	99.3	<0.003	<0.003	0.005	<0.003	1.17	<3.06	0.011	53.8
83	<0.021	0.82	0.671	0.048	<0.002	91.2	<0.003	0.005	0.005	<0.003	0.949	5.08	0.022	48.5
84	<0.021	3.37	0.073	0.225	<0.002	170	<0.003	0.005	0.007	<0.003	3.44	6.46	0.036	89.1
85	<0.021	0.86	0.264	0.057	<0.002	71.0	<0.003	0.003	0.004	<0.003	2.37	<3.06	<0.007	39.4

Sample No.	Mn (mg/L)	Mo (mg/L)	Na (mg/L)	Ni (mg/L)	P (mg/L)	Pb (mg/L)	S (mg/L)	Sb (mg/L)	Se (mg/L)	Si (mg/L)	Sn (mg/L)	Sr (mg/L)	Ti (mg/L)	V (mg/L)
3	0.010	<0.006	18.8	0.008	<0.047	<0.028	1.77	<0.021	<0.034	4.63	<0.015	0.770	<0.002	<0.002
4	0.031	<0.006	6.67	<0.007	<0.047	<0.028	16.6	<0.021	<0.034	9.32	<0.015	0.173	<0.002	<0.002
5 (dup)	0.024	<0.006	6.68	<0.007	<0.047	<0.028	16.7	<0.021	<0.034	9.30	<0.015	0.173	<0.002	<0.002
6	0.025	<0.006	9.80	0.011	<0.047	<0.028	5.71	<0.021	<0.034	11.5	<0.015	0.312	<0.002	<0.002
8	0.014	<0.006	12.1	<0.007	0.048	<0.028	2.24	<0.021	<0.034	12.0	<0.015	0.338	<0.002	<0.002
9	0.024	<0.006	8.21	0.015	<0.047	<0.028	17.2	<0.021	<0.034	9.10	<0.015	0.208	<0.002	<0.002
10	0.017	<0.006	10.5	0.008	<0.047	<0.028	10.5	0.047	<0.034	9.88	<0.015	0.434	<0.002	<0.002
11	0.037	<0.006	10.8	<0.007	<0.047	<0.028	0.69	<0.021	<0.034	10.0	<0.015	0.397	<0.002	<0.002
12	0.097	<0.006	8.75	<0.007	<0.047	<0.028	6.04	<0.021	<0.034	9.85	<0.015	0.512	<0.002	<0.002
13	0.013	<0.006	8.19	<0.007	<0.047	<0.028	9.63	<0.021	<0.034	10.6	<0.015	0.387	<0.002	<0.002
14	0.035	<0.006	9.84	<0.007	<0.047	<0.028	9.40	<0.021	<0.034	9.51	<0.015	0.542	<0.002	<0.002
15	<0.002	<0.006	49.7	<0.007	<0.047	<0.028	<0.040	<0.021	<0.034	3.59	<0.015	1.26	<0.002	<0.002
16	0.016	<0.006	22.6	<0.007	<0.047	<0.028	0.450	<0.021	<0.034	8.66	<0.015	0.410	<0.002	<0.002
17	0.021	0.008	12.0	0.010	<0.047	<0.028	13.2	0.040	<0.034	10.6	<0.015	0.679	<0.002	<0.002
18	0.003	<0.006	24.4	<0.007	<0.047	<0.028	<0.040	<0.021	<0.034	4.17	0.025	0.863	<0.002	<0.002
19	0.010	0.016	69.1	<0.007	<0.047	<0.028	0.114	0.026	<0.034	8.17	<0.015	0.211	<0.002	0.005
20 (dup)	0.015	0.016	70.3	<0.007	<0.047	<0.028	0.115	0.046	<0.034	8.30	<0.015	0.217	<0.002	0.004
21	0.016	<0.006	10.1	<0.007	<0.047	<0.028	8.14	<0.021	<0.034	9.20	<0.015	0.677	<0.002	<0.002
22	0.051	<0.006	7.67	0.011	<0.047	<0.028	20.9	0.026	<0.034	9.77	<0.015	0.419	<0.002	<0.002
23	0.038	0.006	31.7	<0.007	<0.047	<0.028	<0.040	0.059	<0.034	7.20	<0.015	0.284	<0.002	<0.002
24	0.009	<0.006	25.7	<0.007	<0.047	<0.028	<0.040	0.059	<0.034	7.53	<0.015	0.405	<0.002	<0.002
25	0.013	<0.006	20.1	<0.007	<0.047	<0.028	0.282	0.059	<0.034	8.43	<0.015	0.953	<0.002	<0.002
26	0.107	<0.006	12.9	0.011	<0.047	<0.028	10.7	0.065	<0.034	5.99	<0.015	0.613	<0.002	<0.002
27	0.014	<0.006	9.56	0.007	<0.047	<0.028	0.737	0.059	<0.034	9.58	<0.015	0.758	<0.002	<0.002
28	<0.002	0.009	39.8	<0.007	<0.047	<0.028	<0.040	0.033	<0.034	6.79	<0.015	0.855	<0.002	<0.002
29	<0.002	<0.006	24.2	<0.007	<0.047	<0.028	<0.040	0.039	<0.034	7.91	<0.015	0.816	<0.002	<0.002
30	0.016	<0.006	23.8	<0.007	<0.047	<0.028	<0.040	0.026	<0.034	5.99	<0.015	0.816	<0.002	<0.002
31	0.019	<0.006	54.6	<0.007	<0.047	<0.028	0.114	<0.021	0.046	8.14	<0.015	2.61	<0.002	0.005
32	0.008	<0.006	59.2	<0.007	<0.047	<0.028	0.130	<0.021	<0.034	9.28	<0.015	0.298	<0.002	0.007
33	0.007	<0.006	17.2	<0.007	<0.047	<0.028	<0.040	<0.021	<0.034	7.93	<0.015	0.812	<0.002	<0.002
34	0.013	<0.006	32.1	<0.007	<0.047	<0.028	0.084	<0.021	<0.034	8.90	<0.015	1.33	<0.002	0.002
35	0.331	<0.006	38.2	<0.007	<0.047	<0.028	90.5	<0.021	<0.034	7.41	<0.015	0.192	<0.002	<0.002
36	0.062	<0.006	18.7	<0.007	<0.047	<0.028	54.0	0.023	<0.034	9.88	<0.015	0.733	<0.002	0.004
37 (dup)	0.072	<0.006	18.5	<0.007	<0.047	<0.028	53.9	0.023	<0.034	9.95	<0.015	0.724	<0.002	0.007
38	0.009	0.029	29.4	0.010	<0.047	<0.028	36.1	<0.021	<0.034	8.98	<0.015	1.25	<0.002	0.003
39	0.026	<0.006	102	<0.007	<0.047	<0.028	26.6	0.040	<0.034	11.3	<0.015	0.180	<0.002	0.009

Table A-2. Concluded

Sample No.	Mn (mg/L)	Mo (mg/L)	Na (mg/L)	Ni (mg/L)	P (mg/L)	Pb (mg/L)	S (mg/L)	Sb (mg/L)	Se (mg/L)	Si (mg/L)	Sn (mg/L)	Sr (mg/L)	Ti (mg/L)	V (mg/L)
40	0.019	<0.006	15.5	<0.007	<0.047	<0.028	29.9	0.035	<0.034	9.32	<0.015	0.627	<0.002	<0.002
41	0.002	<0.006	19.6	<0.007	<0.047	<0.028	0.733	<0.021	<0.034	7.07	<0.015	0.825	<0.002	<0.002
42	0.107	<0.006	48.7	0.012	<0.047	<0.028	26.8	0.023	<0.034	6.32	<0.015	0.133	<0.002	0.010
43	0.073	<0.006	21.9	<0.007	<0.047	<0.028	40.1	0.029	<0.034	8.09	<0.015	0.129	<0.002	0.011
44	0.029	<0.006	25.2	<0.007	<0.047	<0.028	0.078	<0.021	<0.034	4.96	<0.015	2.06	<0.002	<0.002
45	0.052	<0.006	20.0	<0.007	0.063	<0.028	0.083	<0.021	<0.034	10.2	<0.015	2.34	<0.002	0.003
46	0.032	<0.006	12.8	<0.007	<0.047	<0.028	5.81	<0.021	<0.034	7.24	<0.015	1.55	<0.002	0.004
47	0.055	<0.006	36.5	<0.007	<0.047	<0.028	24.8	<0.021	<0.034	6.78	<0.015	0.293	<0.002	<0.002
49	0.010	<0.006	65.0	<0.007	<0.047	<0.028	9.12	<0.021	<0.034	6.13	<0.015	0.868	<0.002	0.003
50	0.005	<0.006	149	<0.007	<0.047	<0.028	11.7	<0.021	<0.034	7.17	<0.015	0.787	<0.002	0.002
51	0.126	<0.006	17.2	<0.007	<0.047	<0.028	23.3	0.040	<0.034	10.5	<0.015	0.608	<0.002	0.014
52 (dup)	0.116	<0.006	17.0	<0.007	<0.047	<0.028	22.8	<0.021	<0.034	10.4	<0.015	0.600	<0.002	<0.002
53	0.071	<0.006	48.9	<0.007	<0.047	<0.028	4.80	0.027	<0.034	12.0	<0.015	1.43	<0.002	<0.002
54	0.030	<0.006	28.8	<0.007	<0.047	<0.028	19.3	0.040	<0.034	7.38	<0.015	0.080	<0.002	0.005
55	0.004	<0.006	87.9	<0.007	<0.047	<0.028	<0.040	0.027	<0.034	4.77	<0.015	0.472	<0.002	0.003
56	0.021	<0.006	52.9	<0.007	<0.047	<0.028	0.206	<0.021	<0.034	12.3	<0.015	2.21	<0.002	<0.002
57	0.073	<0.006	8.84	<0.007	<0.047	<0.028	21.1	<0.021	<0.034	8.58	<0.015	0.094	<0.002	<0.002
58	0.030	<0.006	4.48	<0.007	<0.047	<0.028	24.8	<0.021	<0.034	11.2	<0.015	0.178	<0.002	0.003
59	<0.002	<0.006	60.8	0.010	0.057	<0.028	0.395	<0.021	<0.034	7.85	<0.015	0.959	<0.002	<0.002
60	0.116	<0.006	117	<0.007	<0.047	<0.028	12.9	<0.021	<0.034	7.06	<0.015	0.180	<0.002	0.004
61	0.021	<0.006	8.99	<0.007	<0.047	<0.028	27.6	<0.021	0.038	10.3	<0.015	0.704	<0.002	0.006
62	0.015	<0.006	130	<0.007	<0.047	<0.028	0.133	0.068	0.038	4.43	<0.015	0.526	<0.002	<0.002
63	0.073	<0.006	123	<0.007	<0.047	<0.028	18.2	0.025	<0.034	8.50	<0.015	0.815	<0.002	<0.002
64	0.044	<0.006	6.25	<0.007	<0.047	<0.028	34.5	<0.021	<0.034	9.01	<0.015	0.259	<0.002	0.003
65	0.004	0.040	36.0	<0.007	<0.047	<0.028	86.7	0.043	<0.034	7.86	<0.015	2.61	<0.002	<0.002
68	0.005	0.016	29.8	<0.007	<0.047	<0.028	6.12	<0.021	<0.034	6.95	<0.015	0.690	<0.002	<0.002
69	<0.002	<0.006	6.40	<0.007	<0.047	<0.028	18.5	0.037	<0.034	8.38	<0.015	0.116	<0.002	<0.002
70	0.038	<0.006	8.21	<0.007	<0.047	<0.028	17.8	0.031	<0.034	8.46	<0.015	0.224	<0.002	<0.002
71	0.083	<0.006	6.27	0.007	<0.047	<0.028	49.4	<0.021	<0.034	7.27	<0.015	0.151	<0.002	0.006
72	0.004	<0.006	51.1	<0.007	<0.047	<0.028	<0.040	0.099	<0.034	7.91	<0.015	0.799	<0.002	<0.002
73 (dup)	0.004	<0.006	52.5	<0.007	<0.047	<0.028	<0.040	0.062	<0.034	8.00	<0.015	0.795	<0.002	<0.002
74	0.015	<0.006	56.5	<0.007	<0.047	<0.028	0.125	0.025	0.063	20.4	<0.015	1.07	<0.002	<0.002
75	0.007	<0.006	26.9	<0.007	<0.047	<0.028	1.73	0.043	<0.034	13.1	<0.015	0.509	<0.002	0.003
76	0.009	<0.006	28.2	<0.007	<0.047	<0.028	4.80	0.056	<0.034	5.18	<0.015	2.57	<0.002	<0.002
79	0.029	<0.006	35.8	<0.007	<0.047	<0.028	34.5	0.043	<0.034	8.08	<0.015	0.812	<0.002	<0.002
81	0.024	<0.006	12.8	<0.007	<0.047	<0.028	24.3	0.031	<0.034	9.82	<0.015	0.411	<0.002	0.019
82 (dup)	0.024	<0.006	13.2	<0.007	<0.047	<0.028	24.7	0.043	0.071	10.1	<0.015	0.424	<0.002	0.014
83	0.005	<0.006	49.3	<0.007	<0.047	<0.028	21.4	0.031	<0.034	6.95	<0.015	1.06	<0.002	0.014
84	0.091	<0.006	124	<0.007	<0.047	<0.028	54.6	0.087	0.049	8.63	<0.015	0.330	0.002	0.007
85	0.043	<0.006	28.2	<0.007	<0.047	<0.028	0.094	0.025	<0.034	7.88	<0.015	1.63	<0.002	0.012

Note: dup = duplicate sample of previously numbered sample.

Table A-3. Concentrations of Zn, Alkalinity, Anions, TOC, NH₃-N, and Atrazine, and Presence/Absence of Coliform Bacteria in Untreated Samples

Sample No.	Zn (mg/L)	Alkalinity (mg/L CaCO$_3$)	F (mg/L)	Cl$^-$ (mg/L)	NO$_3$-N (mg/L)	o-PO$_4$-P (mg/L)	SO$_4^{2-}$ (mg/L)	TOC (mg/L)	NH$_3$-N (mg/L)	Atrazine (ppb)	Coliform Detected
3	<0.002	295	0.70	3.93	<0.07	<0.64	5.20	0.42	0.54	<0.5	No
4	<0.002	325	0.35	8.51	<0.07	<0.64	48.1	0.76	0.29	<0.5	No
5 (dup)	<0.002	325	0.35	8.54	<0.07	<0.64	48.1	0.70	0.30	<0.5	No
6	<0.002	336	0.39	2.41	<0.07	<0.64	16.3	0.75	0.40	<0.5	No
8	<0.002	346	0.37	7.05	<0.07	<0.64	6.18	1.45	1.17	<0.5	No
9	0.026	341	0.42	8.24	<0.07	<0.64	49.0	0.96	0.31	<0.5	Yes
10	0.002	319	0.53	3.77	<0.07	<0.64	28.7	0.77	0.35	<0.5	No
11	<0.002	341	0.45	2.79	<0.07	<0.64	1.96	1.83	0.63	<0.5	No
12	<0.002	335	0.48	3.80	<0.07	<0.64	17.4	0.73	0.43	<0.5	No
13	<0.002	318	0.46	2.98	<0.07	<0.64	26.5	1.04	0.47	<0.5	No
14	<0.002	336	0.47	13.4	<0.07	<0.64	26.3	0.81	0.49	<0.5	No
15	<0.002	314	1.61	2.99	<0.07	<0.64	<0.31	0.25	1.44	<0.5	No
16	<0.002	286	0.44	0.91	<0.07	<0.64	1.31	0.74	0.21	<0.5	No
17	<0.002	349	0.55	3.81	<0.07	<0.64	38.1	1.22	0.44	<0.5	No
18	0.092	340	0.50	1.05	<0.07	<0.64	<0.31	3.26	0.93	<0.5	No
19	<0.002	297	0.80	1.41	<0.07	<0.64	<0.31	5.71	1.18	<0.5	No
20 (dup)	0.003	296	0.80	1.42	<0.07	<0.64	<0.31	5.94	1.23	<0.5	No
21	<0.002	323	0.56	6.79	<0.07	<0.64	23.7	0.69	0.28	<0.5	No
22	0.006	339	0.53	18.4	<0.07	<0.64	60.2	0.98	1.20	<0.5	No
23	0.003	273	0.30	1.09	<0.07	<0.64	<0.31	2.52	0.48	<0.5	No
24	<0.002	279	0.49	1.26	<0.07	<0.64	0.50	1.05	0.33	<0.5	No
25	0.065	362	0.49	2.12	<0.07	<0.64	0.74	1.70	0.52	<0.5	No
26	0.003	321	0.31	17.5	2.94	<0.64	31.1	0.66	0.05	<0.5	No
27	<0.002	354	0.56	7.88	<0.07	<0.64	2.20	1.20	0.74	<0.5	No
28	<0.002	264	0.61	1.22	<0.07	<0.64	<0.31	1.91	0.51	<0.5	No
29	0.006	301	0.46	6.29	<0.07	<0.64	<0.31	1.66	1.26	<0.5	No
30	<0.002	323	0.46	1.25	<0.07	<0.64	<0.31	1.62	2.52	<0.5	No
31	<0.002	315	0.95	1.33	<0.07	<0.64	<0.31	5.04	1.84	<0.5	No
32	<0.002	308	0.53	2.23	<0.07	<0.64	<0.31	5.68	0.30	<0.5	No
33	<0.002	311	0.53	0.99	<0.07	<0.64	<0.31	2.17	0.93	<0.5	No
34	<0.002	348	0.66	1.71	<0.07	<0.64	<0.31	2.76	1.50	<0.5	No
35	0.004	343	0.21	85.7	<0.07	<0.64	251	1.54	0.23	<0.5	No
36	0.008	422	0.34	63.4	<0.07	<0.64	157	1.21	0.39	NA	Yes
37 (dup)	0.008	421	0.40	63.5	<0.07	<0.64	157	1.20	0.38	NA	No
38	<0.002	314	0.79	11.0	<0.07	<0.64	102	1.55	0.54	NA	No
39	<0.002	408	0.14	359	<0.07	<0.64	78.9	1.39	0.17	NA	No
40	0.004	328	0.37	48.0	<0.07	<0.64	85.8	1.15	1.26	NA	Yes
41	<0.002	353	0.28	2.68	<0.07	<0.64	3.46	1.65	0.83	NA	No
42	0.098	314	0.14	136	1.376	<0.64	81.0	0.68	<0.03	NA	No
43	0.003	369	0.14	56.5	<0.07	<0.64	119	1.05	0.22	<0.5	No
44	<0.002	297	0.51	2.89	0.050	<0.64	0.32	3.37	3.82	<0.5	Yes
45	<0.002	385	0.58	1.23	<0.07	<0.64	0.43	5.25	5.83	<0.5	No
46	0.002	352	0.43	6.62	<0.07	<0.64	15.4	1.63	1.50	<0.5	No
47	0.029	316	0.15	97.4	<0.07	<0.64	68.8	0.56	0.17	NA	No
49	0.026	353	0.78	36.0	<0.07	<0.64	24.6	0.64	0.56	NA	No
50	0.006	372	1.02	169	<0.07	<0.64	35.1	0.40	0.92	NA	Yes
51	0.009	381	0.59	49.8	<0.07	<0.64	66.6	1.10	2.55	NA	Yes
52 (dup)	0.007	381	0.59	50.8	<0.07	<0.64	66.7	1.01	2.53	NA	Yes
53	0.002	439	0.39	158	<0.07	<0.64	13.9	2.90	4.68	NA	No
54	0.016	376	0.10	77.2	<0.07	<0.64	56.9	0.45	0.05	NA	No
55	0.003	292	1.21	2.38	<0.07	<0.64	0.31	1.78	0.74	NA	Yes
56	<0.002	497	0.42	8.54	0.104	<0.64	0.38	10.3	8.04	NA	No
57	0.082	294	0.24	32.8	<0.07	<0.64	62.1	0.67	0.09	NA	No
58	0.002	319	0.40	13.2	<0.07	<0.64	74.5	0.71	0.35	<0.5	No
59	0.003	595	0.29	2.44	<0.07	<0.64	0.98	22.3	26.6	<0.5	No
60	0.003	348	0.10	359	<0.07	<0.64	38.2	1.15	0.29	NA	No
61	0.006	354	0.37	23.9	<0.07	<0.64	83.0	1.79	2.08	NA	No
62	0.003	470	1.72	3.65	<0.07	<0.64	0.34	5.30	12.3	<0.5	No

Table A-3. Concluded

Sample No.	Zn (mg/L)	Alkalinity (mg/L CaCO$_3$)	F$^-$ (mg/L)	Cl$^-$ (mg/L)	NO$_3$-N (mg/L)	o-PO$_4$-P (mg/L)	SO$_4^{2-}$ (mg/L)	TOC (mg/L)	NH$_3$-N (mg/L)	Atrazine (ppb)	Coliform Detected
63	0.042	545	0.22	236	<0.07	<0.64	53.6	0.90	0.53	NA	No
64	<0.002	299	0.32	24.9	<0.07	<0.64	100	0.93	0.26	<0.5	No
65	<0.002	338	0.83	6.22	<0.07	<0.64	247	1.22	0.56	NA	No
68	0.012	286	0.90	2.31	<0.07	<0.64	18.0	1.05	0.34	NA	No
69	0.068	301	0.16	24.4	4.108	<0.64	56.5	0.37	<0.03	<0.5	No
70	0.005	290	0.36	5.79	<0.07	<0.64	54.4	0.87	0.24	<0.5	No
71	0.006	333	0.26	35.0	<0.07	<0.64	148	0.66	<0.03	<0.5	Yes
72	0.004	317	0.60	2.06	<0.07	<0.64	<0.31	2.53	0.34	NA	No
73 (dup)	0.002	316	0.60	2.07	<0.07	<0.64	<0.31	2.59	0.34	NA	No
74	0.010	446	0.59	2.33	<0.07	<0.64	<0.31	6.25	2.02	NA	No
75	<0.002	425	0.35	7.44	<0.07	<0.64	3.98	3.11	1.95	NA	No
76	<0.002	328	0.94	7.37	0.091	<0.64	14.3	0.29	0.42	<0.5	No
79	0.003	387	0.39	102	0.172	<0.64	98.4	1.21	0.08	NA	No
81	0.014	367	0.41	12.0	<0.07	<0.64	70.4	1.18	0.46	<0.5	No
82 (dup)	0.017	365	0.42	12.1	<0.07	<0.64	70.4	1.15	0.46	NA	No
83	0.110	366	0.68	51.4	<0.07	<0.64	60.9	0.45	0.93	<0.5	No
84	0.020	402	0.12	335	<0.07	<0.64	169	0.80	0.08	NA	No
85	0.003	380	0.47	5.23	<0.07	<0.64	<0.31	3.96	4.98	NA	No

Notes: dup = duplicate sample of previously numbered sample.
NA = not analyzed.

Table A-4. Well Information and Field Analyses for Treated Samples

Sample No.	Depth (ft)	Aquifer	ISWS Well No.	Town	Range	Sect	Overlying till (ft)	Date sampled	Temp (C)	pH	ORP (mv)	SpC (µS/cm)	DO (mg/L)	H_2S (ppm)	H_2S smell
2	100	C	65890	38N	7E	17	65	10/07/2003	11.95	6.96	75	768	1.00	0-0.1	
7	70	U	189448	38N	6E	17	60	10/07/2003	12.11	7.00	229	723	0.50	0	
48	240	C	305377	40N	8E	21	90	10/14/2003	11.54	6.96	187	965	0.35	0	+
77	242	C	254371	41N	7E	11	166	10/21/2003	12.18	6.98	130	560	0.32	ND	+
78	200	C	321686	41N	8E	36	175	10/21/2003	11.10	7.39	126	973	0.65	ND	

Notes: C = consolidated aquifer and U = unconsolidated aquifer.
ND = not determined.
+ = slight sulfide smell.

Table A-5. Concentrations of Metals in Treated Samples

Sample No.	Al (mg/L)	As (µg/L)	B (mg/L)	Ba (mg/L)	Be (mg/L)	Ca (mg/L)	Cd (mg/L)	Co (mg/L)	Cr (mg/L)	Cu (mg/L)	Fe (mg/L)	K (mg/L)	Li (mg/L)	Mg (mg/L)
2	0.091	5.41	0.023	<0.002	<0.002	0.901	<0.003	<0.003	0.011	<0.003	0.097	<3.06	<0.007	0.904
7	<0.021	3.21	<0.014	<0.002	<0.002	0.082	<0.003	<0.003	<0.004	<0.003	<0.009	<3.06	<0.007	<0.032
48	<0.021	<0.71	0.738	<0.002	<0.002	0.526	<0.003	<0.003	<0.004	<0.003	0.080	4.82	<0.007	0.251
77	<0.021	1.33	0.469	0.015	<0.002	11.4	<0.003	<0.003	<0.004	<0.003	0.556	<3.06	<0.007	7.09
78	<0.021	0.76	0.294	<0.002	<0.002	1.54	<0.003	<0.003	<0.004	<0.003	0.109	85.1	<0.007	3.05

Sample No.	Mn (mg/L)	Mo (mg/L)	Na (mg/L)	Ni (mg/L)	P (mg/L)	Pb (mg/L)	S (mg/L)	Sb (mg/L)	Se (mg/L)	Si (mg/L)	Sn (mg/L)	Sr (mg/L)	Ti (mg/L)	V (mg/L)
2	<0.002	0.009	198	0.013	0.048	<0.028	30.2	<0.021	<0.034	7.19	0.016	<0.002	<0.002	0.002
7	<0.002	<0.006	196	<0.007	0.076	<0.028	26.1	<0.021	<0.034	7.58	<0.015	<0.002	<0.002	<0.002
48	0.010	<0.006	242	<0.007	<0.047	<0.028	13.9	<0.021	<0.034	4.85	<0.015	<0.002	<0.002	0.007
77	0.011	<0.006	130	0.008	<0.047	<0.028	0.185	<0.021	<0.034	7.82	0.018	0.427	<0.002	<0.002
78	0.006	<0.006	185	<0.007	0.065	<0.028	5.59	0.043	0.051	6.94	<0.015	0.024	<0.002	<0.002

Table A-6. Concentrations of Zn, Alkalinity, Anions, TOC, NH_3-N, and Atrazine, and Presence/Absence of Coliform Bacteria in Treated Samples

Sample No.	Zn (mg/L)	Alkalinity (mg/L $CaCO_3$)	F (mg/L)	Cl^- (mg/L)	NO_3-N (mg/L)	o-PO_4-P (mg/L)	SO_4^{2-} (mg/L)	TOC (mg/L)	NH_3-N (mg/L)	Atrazine (ppb)	Coliform Detected
2	0.003	293	0.39	33.7	<0.07	<0.64	89.3	0.72	0.05	<0.5	No
7	0.004	297	0.20	15.2	<0.07	<0.64	73.2	0.40	0.01	<0.5	No
48	0.046	314	0.53	103	<0.07	<0.64	39.3	0.44	0.05	NA	No
77	<0.002	305	1.00	2.00	<0.07	<0.64	<0.31	6.89	1.02	<0.5	No
78	0.002	369	0.56	72.5	<0.07	<0.64	15.7	2.33	0.42	<0.5	No

Note: NA = not analyzed.

Table A-7. Sample Information and Results for GWQDB Samples Included in Figures 3, 6, 8, and 10

Lab No.	Depth (feet)	Aquifer	Town	Range	Sect	Date	pH (lab)	TDS	SpC (μS/cm)	As (μg/L)	B (mg/L)	Ba (mg/L)	Ca (mg/L)	Cr (mg/L)
233485	50	U	42N	08E	26	10/15/2003	7.42	461	781	< 0.71	0.107	0.110	94.9	0.008
233529	55	U	39N	06E	34	11/12/2003	7.67	461	781	3.55	< 0.012	0.066	98.0	< 0.007
232310	70	U	42N	07E	23	06/17/2001	7.80	322	546		0.180	0.130	47.9	< 0.004
233311	76	U	40N	06E	17	07/15/2003	7.95	359	608	4.86	0.087	0.110	69.1	0.008
233509	90	U	40N	06E	04	10/28/2003	7.65	327	554	10.6	0.028	0.069	62.9	< 0.007
233535	100	C	39N	08E	29	11/12/2003	7.66	599	1015	1.3	0.058	0.107	106	< 0.007
233514	110	C	39N	08E	33	10/26/2003	7.54	385	653	< 0.71	0.105	0.116	91.3	< 0.007
233308	123	U	40N	06E	07	07/08/2003	8.01	350	593	2.56	0.097	0.094	81.6	< 0.007
233571	165	C	41N	06E	15	12/10/2003	7.64	327	554	3.94	0.077	0.098	76.1	0
232856	170	C	40N	08E	29	08/19/2002	7.60	559	947	0.9	0.030	0.080	101	< 0.007
233126	200	C	38N	08E	24	03/27/2003	7.73	343	581	< 0.6	0.610	0.049	54.5	< 0.007

Notes: C = consolidated aquifer and U = unconsolidated aquifer.
Specific Conductance calculated by [TDS] x 0.59.

Table A-8. Concentrations of Metals for GWQDB Samples Included in Figures 3, 6, 8, and 10

Lab No.	Cu (mg/L)	Fe (mg/L)	Mg (mg/L)	Mn (mg/L)	Na (mg/L)	Ni (mg/L)	Zn (mg/L)	Alkalinity (mg/L CaCO₃)	F (mg/L)	Cl (mg/L)	NO₃-N (mg/L)	SO₄ (mg/L)
233485	0.008		48.4	0.071	38.6	<0.013	0.080	373	0.24	64.6	< 0.07	10.5
233529	< 0.006		47.8	0.048	6.72	<0.013	<0.003	298	0.23	16.6	< 0.07	103
232310	< 0.01	0.905	41.7	<0.010	30.8	0.009	<0.010	345	0.70	8	< 0.06	< 0.28
233311	0.022		45.6	0.023	16.4	<0.013	0.176	357	0.49	7.87	< 0.07	5.35
233509	<0.006		30.3	0.061	29.3	<0.013	0.434	332	0.49	1.01	< 0.07	0.33
233535	0.017		55.4	0.086	51.1	<0.013	0.003	300	0.30	149	< 0.07	64.7
233514	0.511		44.1	<0.002	13.1	<0.013	<0.003	357	0.49	4.51	< 0.07	25.7
233308	<0.006		44.4	0.037	14.7	<0.013	<0.003	366	0.53	1.25	< 0.07	< 0.31
233571	0.012		33.9	0.030	12.9	0	0.004	330	0.44	4.01	0	0
232856	0.040	3.84	52.1	0.070	32.1	<0.013	0.210	313	0.10	92	< 0.06	68.7
233126	0.054		35.0	0.005	28.6	<0.013	0.005	269	0.64	1.97	0.12	61.3

Appendix B. Sample Letter and Report on Water Quality Sent to Participating Well Owners

[Date]

[Address]

Dear [Well owner]:

Enclosed is a copy of the chemical analyses made on the water sample we collected from your well on [Date]. The analysis shows this sample to be moderately mineralized and moderately hard.

The total dissolved solids content, which is estimated by multiplying the specific conductance by 0.59, is above the secondary water quality standard of 500 mg/L. While this is not a health concern, it may result in the water tasting salty or bitter. Reverse osmosis or distillation can remove minerals from drinking water.

The hardness in this sample is sufficient to cause the formation of a moderate amount of hard scale in boilers and hot water heaters, and to consume a moderate amount of soap if used for washing or laundry purposes.

The iron content of this water is at a level which can result in the staining of porcelain and laundry.

The arsenic concentration in this sample is above the new maximum contaminant level of 10 µg/L. Treatments such as softeners and reverse-osmosis are able to reduce arsenic levels, some more efficiently than others.

Coliform bacteria were not detected in this water sample. However, the test we used is not approved by the health department, and false positive or negative results are not uncommon with this test. If you wish to have your water more reliably tested for coliform bacteria, please contact the Kane County Health Department.

None of the other parameters tested appear unusual or excessive for Illinois groundwater. However, our laboratory is only capable of identifying a limited number of the contaminants found in the Safe Drinking Water Act. Testing for radionuclides and synthetic organic contaminants, if desired, must be arranged through other laboratories. A listing of such laboratories can be found at www.epa.state.il.us/labs/pdf/comblist.pdf or in your yellow pages under "water". If you wish to have your treated water analyzed free of charge, you may request a sampling kit from our public service laboratory. Please contact Brian Kaiser at 217/333-9234.

Thank you again for allowing us to sample your well as part of this groundwater quality study. We sampled 75 shallow wells throughout Kane County in October 2003. We will be preparing a report on our results for the Kane County board.If you are interested, I will send you a summary of the project's results, which should be available this summer.

If you have any questions about this report or the project, please contact me.

Sincerely,

Walton R. Kelly
Groundwater Geochemist
217/333-3729
kelly@sws.uiuc.edu

Appendix B (concluded)

SOURCE: PRIVATE WELL

LOCATION:
  COUNTY: KANE
  TOWNSHIP: ??
  RANGE: ??
  SECTION: ??
  PLOT: ??
TREATMENT: NONE

OWNER: ?????????
WELL DEPTH (Feet): ??
DATE COLLECTED: ??

SAMPLE TEMPERATURE (C): 11.26

PARAMETER	RESULT	UNITS	PARAMETER	RESULT	UNITS
MAJOR IONS					
Alkalinity (CaCO3):	470	mg/L	Sodium (Na):	130	mg/L
Calcium (Ca):	37.4	mg/L	Sulfate (SO4):	0.34	mg/L
Chloride (Cl):	3.65	mg/L			
Magnesium (Mg):	19.2	mg/L			
METALS					
Aluminum (Al):	< 0.021	mg/L	Lead (Pb):	< 0.028	mg/L
Antimony (Sb):	0.068	mg/L	Lithium (Li):	0.03	mg/L
Arsenic (As):	24.3	ug/L	Manganese (Mn):	0.015	mg/L
Barium (Ba):	0.054	mg/L	Molybdenum (Mo):	< 0.006	mg/L
Beryllium (Be):	< 0.002	mg/L	Nickel (Ni):	< 0.007	mg/L
Boron (B):	1.12	mg/L	Selenium (Se):	0.038	mg/L
Cadmium (Cd):	< 0.003	mg/L	Silicon (Si):	4.43	ug/L
Chromium (Cr):	< 0.004	mg/L	Tin (Sn):	< 0.015	mg/L
Cobalt (Co):	< 0.003	mg/L	Titanium (Ti):	< 0.002	mg/L
Copper (Cu):	< 0.003	mg/L	Vanadium (V):	< 0.002	mg/L
Iron (Fe):	2.01	mg/L	Zinc (Zn):	0.003	mg/L
NUTRIENTS					
Ammonium (NH4-N):	12.3	mg/L	Potassium (K):	5.92	mg/L
Nitrate (NO3-N):	< 0.07	mg/L			
Phosphate (o-PO4-P):	< 0.64	mg/L			
OTHER					
Atrazine:	< 0.5	ug/L			
Fluoride (F):	1.72	mg/L			
Non-Volatile Org. Carbon (Tot., as C):	5.3	mg/L			
pH (Field):	6.54				
Specific Conductance:	919	uS/cm			
Hardness:	172	mg/L			

< = Below detection limit (i.e. < 1.0 = less than 1.0)
mg/L = milligrams per liter
ND = Not determined/Information not available

ug/L = micrograms per Liter
hardness = (Ca mg/L * 2.497) + (Mg mg/L * 4.118)
1 mg/L = 1000 ug/L

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Illinois State

WATER

Survey *(1895)*

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I

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