ILLINOIS INTEGRATED WATER QUALITY REPORT AND SECTION 303(d) LIST, 2016

Clean Water Act Sections 303(d), 305(b) and 314

Water Resource Assessment Information and List of Impaired Waters

Volume II: Groundwater

July 2016

Illinois Environmental Protection Agency
Bureau of Water

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EXECUTIVE SUMMARY

This 2016 Integrated Report continues the reporting format first adopted in the 2006 reporting cycle. However, beginning with the 2010 cycle the Integrated Report was divided into two volumes: Volume I covering surface water quality and Volume II assessing groundwater quality. Prior to 2006, assessment information was reported separately in the Illinois Water Quality [Section 305(b)] Report and Illinois Section 303(d) List. The Integrated Report format is based on federal guidance for meeting the requirements of Sections 305(b), 303(d) and 314 of the Clean Water Act (CWA).

The purpose of this report (Volume II) is to provide information to the federal government and the citizens of Illinois on the condition of groundwater in the state. This information is provided in detail in Section C and in Appendix A.

The results of the 2016 Use Assessment show that of the Community Water Supply (CWS) probabilistic network wells this cycle:

58 (16 percent) were determined to be Not Supporting ("poor") due to elevated levels of nitrate and chloride (Cl-) over the Groundwater Quality Standard (GWQS) of 10 mg/L and 200 mg/L, respectively, or bacterial contamination of the source water;

160 (44 percent) were determined to be Not Supporting ("fair") due to elevated levels of chloride (Cl-) above background, detections of volatile organic compounds (VOC)s, synthetic organic compounds (SOC)s, or nitrate (total nitrogen) greater than 3 mg/L, but have not exceeded the health-based GWQS; and

146 (40 percent) were determined to be Fully Supporting ("good"), which show no detections over background levels of any of the above analytes.

PART A: INTRODUCTION

A-1. Reporting Requirements

The 2016 Integrated Report is based on guidance from the United States Environmental Protection Agency (USEPA) which is intended to satisfy the requirements of Sections 305(b), 303(d) and 314 of the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500) and subsequent amendments (hereafter, collectively called the "Clean Water Act" or "CWA") in a single combined report. The Integrated Report was divided into two volumes in 2014 and is carried through 2016: Volume I covering surface water quality and Volume II assessing groundwater quality.

Accordingly, Section 102 of the CWA requires:

SEC. 102 [33 U.S.C. 1252] Comprehensive Programs for Water Pollution Control:

(a) The Administrator shall, after careful investigation, and in cooperation with other Federal agencies, State water pollution control agencies, interstate agencies, and the municipalities and industries involved, prepare or develop comprehensive programs for preventing, reducing, or eliminating the pollution of the navigable waters **and ground waters** and improving the sanitary condition of surface and **underground waters**. In the development of such comprehensive programs due regard shall be given to the improvements which are necessary to conserve such waters for the protection and propagation of fish and aquatic life and wildlife, recreational purposes, and the **withdrawal of such waters for public water supply**, agricultural, industrial, and other purposes. For the purpose of this section, the Administrator is authorized to make joint investigations with any such agencies of the condition of any waters in any State or States, and of the discharges of any sewage, industrial wastes, or substance which may adversely affect such waters. (Emphasis added)

Further, Section 104(a)(5) of the CWA [33 U.S.C. 1254]) requires:

5) in cooperation with the States, and their political subdivisions, and other Federal agencies establish, equip, and maintain a water quality surveillance system for the purpose of monitoring the quality of the navigable waters **and ground waters** and the contiguous zone and the oceans and the Administrator shall, to the extent practicable, conduct such surveillance by utilizing the resources of the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, the United States Geological Survey, and the Coast Guard, **and shall report on such quality in the report required under subsection (a) of section 516; and [104(a)(5) amended by PL 102-285] (Emphasis added)**

Section 516 of the CWA requires U.S. EPA to provide a report to Congress on the quality of water, including groundwater. States are required to report biennially on the quality of water with an emphasis on navigable waters pursuant to Section 305(b) of the CWA, and compared to the objectives established in Section 304(a)(1) of the CWA. Section 304(a)(1)(A) of the CWA requires that water quality criteria developed must also consider pollutants that originate from groundwater:

> "The Administrator, after consultation with appropriate Federal and State agencies and other interested persons, shall develop and publish, within one year after the date of enactment of this title (and from time to time thereafter revise) criteria for water quality accurately reflecting the latest scientific knowledge (A) on the kind and extent of all identifiable effects on health and welfare including, but not limited to, plankton, fish, shellfish, wildlife, plant life, shore lines, beaches, esthetics, and recreation which may be expected from the presence of pollutants in any body of water, **including ground water**…"

Thus, for these reasons, and the hydrologic connection between groundwater and surface water, that the Illinois EPA has established an integrated monitoring strategy, and includes a volume in our Section 305(b) Report on ambient groundwater monitoring results.

Illinois reports the resource quality of its waters in terms of the degree to which the beneficial uses[1] of those waters are attained and the reasons (causes and sources) beneficial uses may not be attained. In addition, states are required to provide an assessment of the water quality of all publicly owned lakes, including the status and trends of such water quality as specified in Section 314(a)(1) of the CWA.

Section 303(d) of the CWA and corresponding regulations in Title 40 of the Code of Federal Regulations, require states to:

- Identify water quality-limited waters where effluent limitations and other pollution control requirements are not sufficient to implement any water quality standard;
- Identify pollutants causing or expected to cause water quality standards violations in those waters;
- Establish a priority ranking for the development of Total Maximum Daily Load[2] (TMDL) calculations including waters targeted for TMDL development within the next two years; and,
- Establish TMDLs for all pollutants preventing or expected to prevent the attainment of water quality standards.

[1] Beneficial uses, also called designated uses, are discussed in more detail in Section B-2 Groundwater Protection Programs, Illinois Groundwater Quality Standards.
[2] Total Maximum Daily Load calculations determine the amount of a pollutant a water body can assimilate without exceeding the state's water quality standards or impairing the water body's designated uses.

This list of water quality limited waters is often called the 303(d) List.

To the extent possible, this 2016 Illinois Integrated Report is based on USEPA's *Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b) and 314 of the Clean Water Act* issued July 29, 2005 and additional guidance contained in USEPA memorandums from the Office of Wetlands, Oceans and Watersheds regarding Clean Water Act Sections 303(d), 305(b), and 314 Integrated Reporting and Listing Decisions.

PART B: BACKGROUND INFORMATION

B-1. Total Waters

There are approximately 5,200 groundwater-dependent public water supplies in the state, of which 1,150 are community water supplies (including direct users and purchase systems), the rest of which are non-community type wells (Table B-1). In addition, the Illinois Department of Public Health (IDPH) estimates approximately 400,000 residences of the state are served by private wells. This equates to approximately 30 percent of the population in the state that utilize groundwater as their primary source of drinking water. To assess the groundwater resources of the state, the Illinois EPA utilizes three primary aquifer classes that were developed by O'Hearn and Schock (1984). These three principal aquifers are sand and gravel, shallow bedrock and deep bedrock aquifers. O'Hearn and Schock defined a principal aquifer as having a potential yield of 100,000 gallons per day per square mile and having an area of at least 50 miles. Approximately 58 percent (32,000 square miles) of the state is underlain by principal aquifers. Of these, about 33 percent (18,500 square miles) are major shallow groundwater sources. The following are numbers of CWS wells that withdraw from these aquifers: Out of 3,272 active CWS wells, 46 percent (1,513) utilize sand and gravel aquifers; 21 percent (679) utilize a shallow bedrock aquifer; 24 percent (781) utilize a deep bedrock aquifer, 5 percent (154) utilize a combination of two or more aquifers (mixed) and 4 percent (145) are undetermined.

Table B-1. Illinois Atlas.

Topic	Value	Scale	Source
State Population in year 2014 (estimate)	12,880,580		US Census Bureau
State Surface Area (sq. mi.)	57,918		US Census Bureau
Active CWS Facilities	**1,741**	N/A	SDWIS
Surface Facilities	86	N/A	SDWIS
Groundwater Facilities	952	N/A	SDWIS
Mixed Facilities	8	N/A	SDWIS
Surface Purchase Facilities	497	N/A	SDWIS
Groundwater Purchase Facilities	198	N/A	SDWIS
Active CWS Wells	**3,272**	N/A	GIS
Confined Wells	2,137	N/A	GIS
Unconfined Wells	1,135	N/A	GIS

SDWIS = Safe Drinking Water Information System
GIS = Geographic Information System

B-2. Groundwater Protection Programs

Illinois Groundwater Quality Standards

Since the inception of the Illinois Environmental Protection Act (Act) (415 ILCS 5) in 1970, it has been the policy of the State of Illinois to restore, protect, and enhance the groundwater of the State as a natural and public resource. Establishment of comprehensive groundwater quality standards is a critical component of Illinois' groundwater protection program. To this end, the Illinois EPA established the Groundwater Quality Standards (35.Ill.Adm.Code 620). For a detailed explanation and listing of Illinois' Groundwater Quality Standards (GWQS), see the Illinois Pollution Control Board's (Board) webpage at: http://www.ipcb.state.il.us. Further, Section 12(a) of the Act [415 ILCS 5/12(a)] also applies to groundwater.

Groundwater Management Zone

Within any class of groundwater, a groundwater management zone may be established as a three dimensional region containing groundwater being managed to mitigate impairment caused by the release of contaminants from a site: that is subject to a corrective action process approved by the Illinois EPA; or for which the owner or operator undertakes an adequate corrective action in a timely and appropriate manner.

Groundwater Protection

For a full description of Illinois' groundwater protection programs see the Illinois Groundwater Protection Act Biennial Report at: http://www.epa.state.il.us/water/groundwater/groundwater-protection/index.html or contact the Groundwater Section at 217/785-4787 for more information.

B-3. Cost/Benefit Assessment

Section 305(b) requires the state to report on the economic and social costs and benefits necessary to achieve Clean Water Act objectives. Information on costs associated with water quality improvements is complex, and not readily available for developing a complete cost/benefit assessment. The individual program costs of pollution control activities in Illinois, the general surface water quality improvements made, and the average groundwater protection program costs follow.

Cost of Pollution Control and Groundwater/Source Water Protection Activities

The Illinois EPA Bureau of Water distributed a total of $400.8 million in loans during 2014 for construction of municipal wastewater treatment facilities. Other Water Pollution Control program and Groundwater/Source Water Protection costs for Bureau of Water activities conducted in 2014 are summarized in Table B-2.

Table B-2. Water Pollution Control Program Costs for the Illinois Environmental

Activity	**Total**
Monitoring	$ 6,472,875
Planning	$ 204,250
Point Source Control Programs	$ 11,571,448
Nonpoint Source Control Programs	$ 7,811,213
Groundwater/Source-Water Protection	$ 2,262,733
Total	$ 28,322,519

Groundwater Improvements

Protecting and managing groundwater is critical. Groundwater is an important natural resource that not only provides Illinois' citizens water for drinking and household uses, but also supports industrial, agricultural, and commercial activities throughout the state.

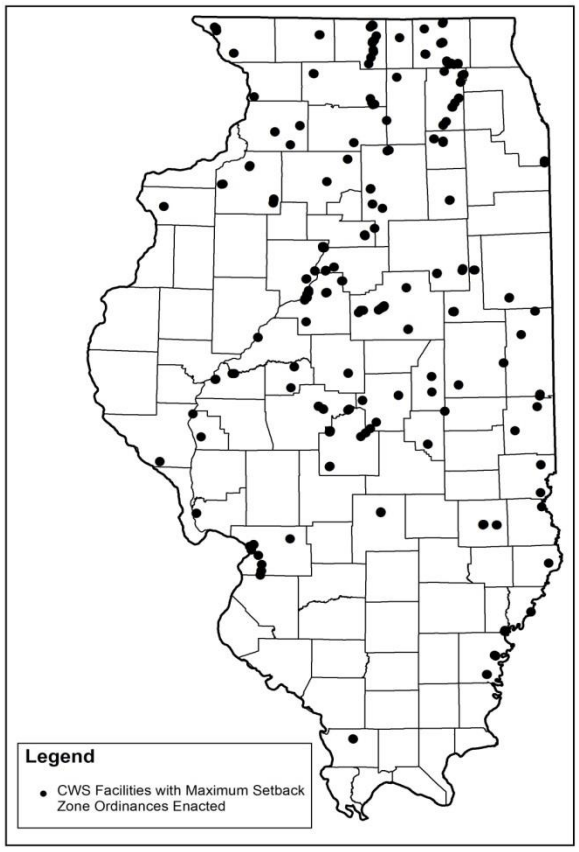
Unfortunately, industrial, agricultural and commercial activities can often produce contaminants such as nitrates, chlorides, volatile organic compounds (VOC)s, synthetic organic compounds (SOC)s. These type of anthropogenic constituents are usually produced in large volumes and are associated with products such as pesticides, roads salts, plastics, adhesives, paints, gasoline, fumigants, refrigerants, and dry-cleaning fluids. The contaminants can reach groundwater through many sources and routes, including leaking storage tanks, landfills, infiltration of urban runoff and wastewater, septic systems, and injection through wells. Volatile organic compounds are an important group of environmental contaminants to monitor and manage in groundwater because of their widespread and long-term use, as well as their ability to persist and migrate in groundwater. Further analysis of VOC detections in CWS wells are provided in Section C-6 of this Integrated Report.

Maximum Setback Zone

Maximum setback zones are used to expand protection to a CWS well and lower potential for groundwater contamination. Due to the increasing activities that may lead to contamination, the voluntary wellhead protection approach pays off, and costly, unneeded expenses may be avoided with additional protection. The Illinois EPA and Illinois Rural Water Association continue to provide maximum setback zone educational information during CWS site visits and at professional conventions.

The locations of the CWSs that have adopted maximum setback zones are shown in Figure B-1. A total of 114 CWS with a total of 366 active wells have maximum setback zone protection. There was a reduction in the number of CWS wells with maximum setback zones during this reporting period. The reduction of CWS and wells with maximum setback zone protection is due to normal abandonment of older non-producing wells. During this two-year reporting period, Sauk has pursued adopting maximum setback zones for 3 CWS wells. Alpha, Carrollton, Cowden, Gilberts, Iola, and Stonington are planning to adopt maximum setback zones for their wells.

Figure B-1. Maximum Setback Zones Adopted



PART C: GROUNDWATER MONITORING AND ASSESSMENT

C-1. Resource-Quality Monitoring Program

Hydrologic Background

To assess the groundwater resources of the state, the Illinois EPA utilizes three primary aquifer classes (O'Hearn and Schock, 1984). These three "principal aquifers" are sand and gravel, shallow bedrock and deep bedrock aquifers, as illustrated in figures C-1 thru C-3. A principal aquifer is defined as having a potential yield of 100,000 gallons per day per square mile and having an area of at least 50 miles.

Figure C-1. Principal Sand and Gravel Aquifers in Illinois

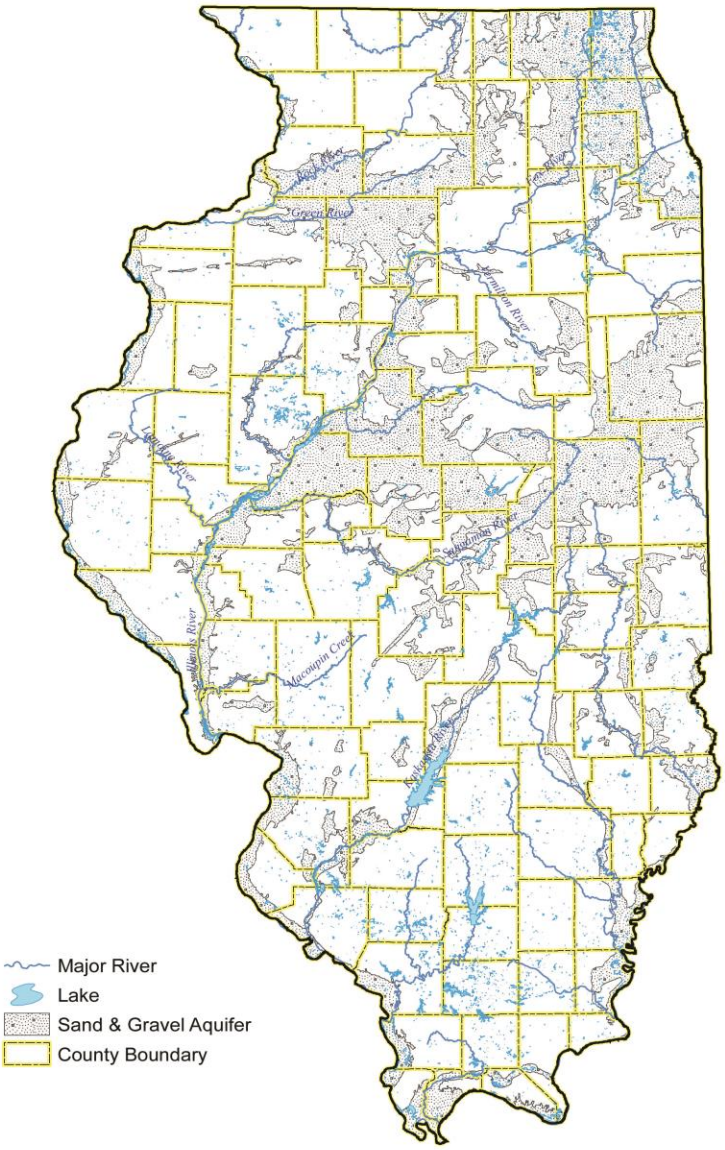


Figure C-2. Principal Shallow Bedrock Aquifers in Illinois

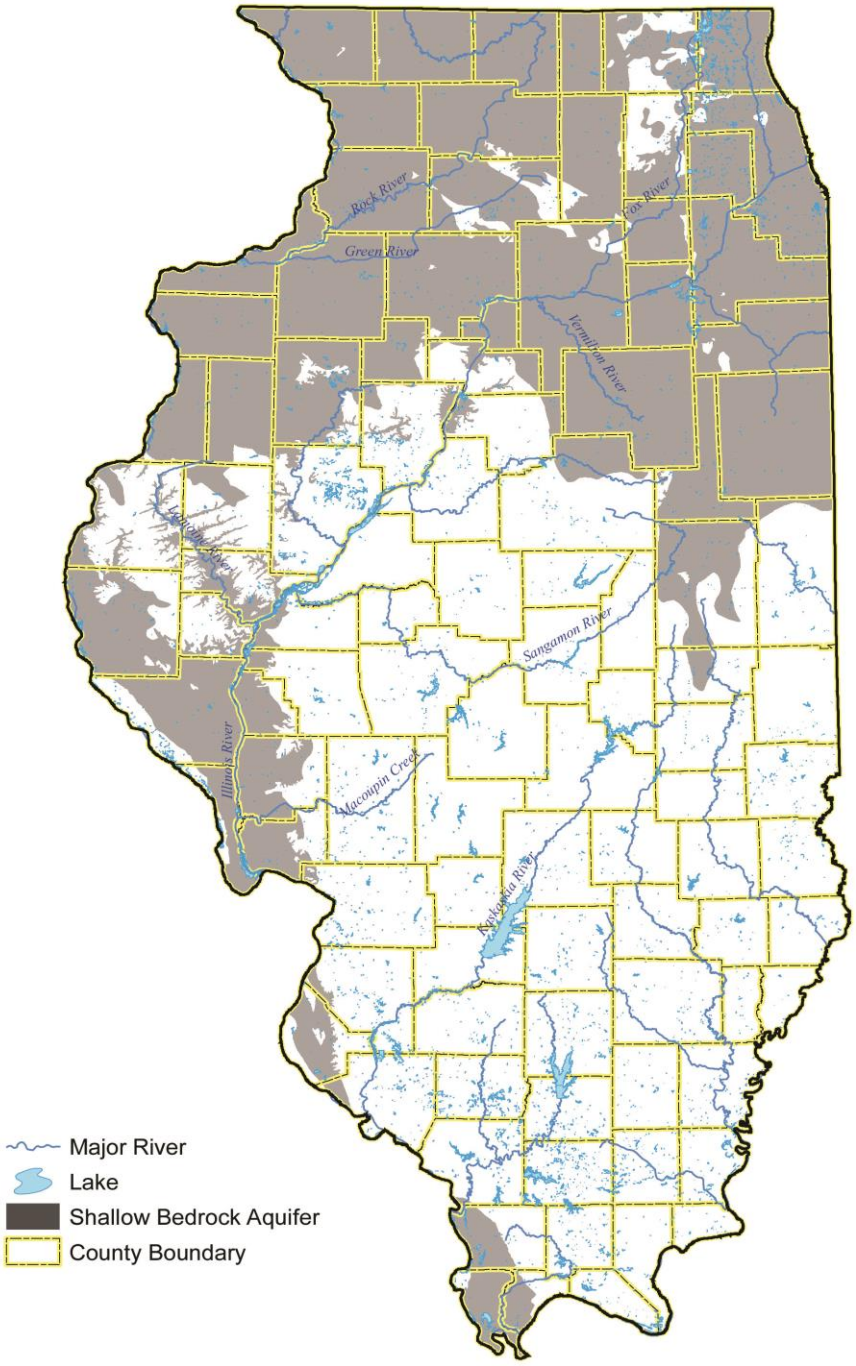
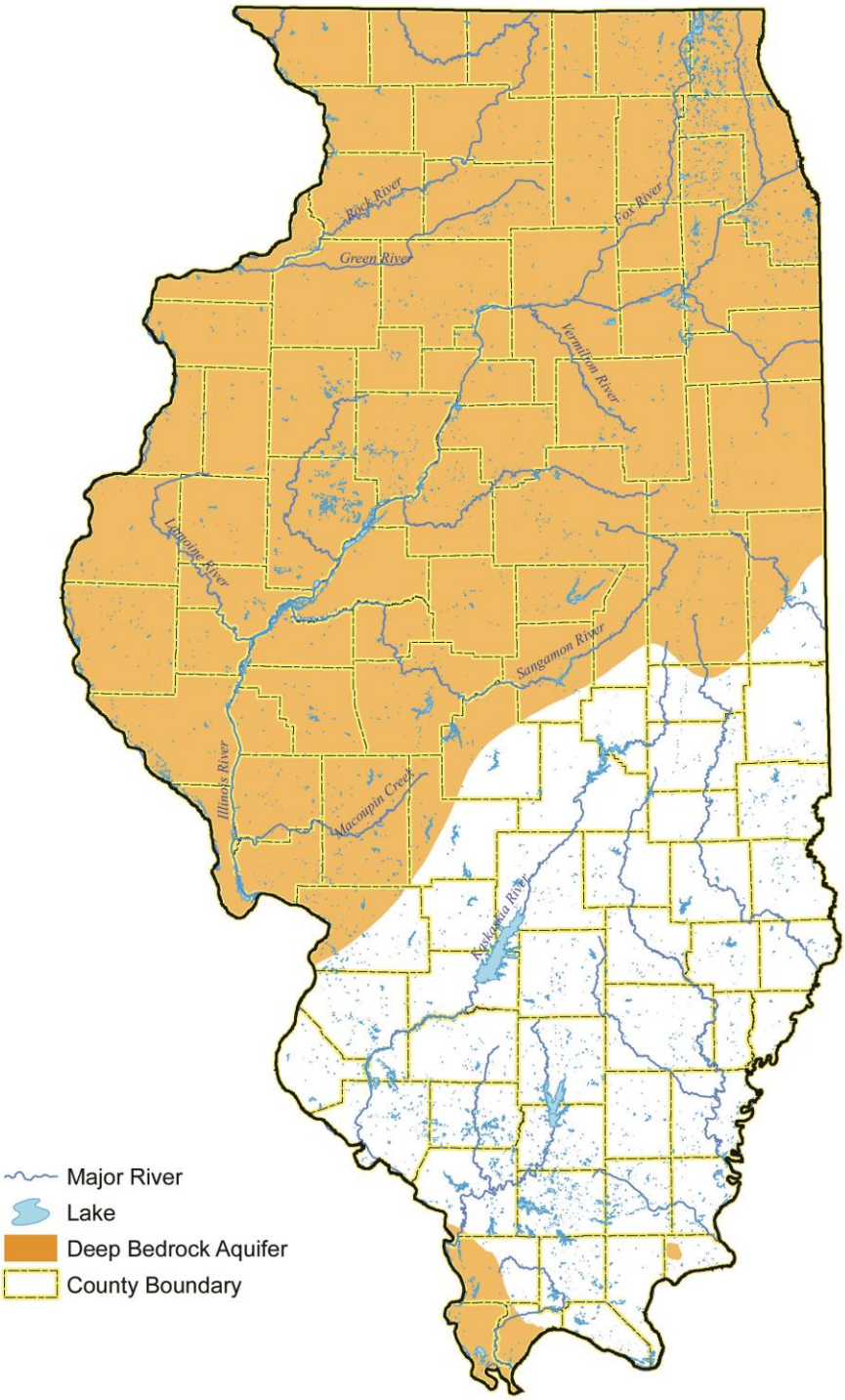


Figure C-3. Principal Deep Bedrock Aquifers in Illinois



Water resource availability can be expressed in a number of ways. In the groundwater field, the term "potential yield" or "safe yield" is often used. Potential aquifer yield is the maximum amount of groundwater that can be continuously withdrawn from a reasonable number of wells and well fields without creating critically low water levels or exceeding recharge (Wehrmann, et. al., 2003). Statewide estimates of groundwater availability, based on aquifer potential yield estimates, were developed in the late 1960s (Illinois Technical Advisory Committee on Water Resources, ITACWR, 1967). The ITACWR report presented maps of the estimated potential yields, expressed as recharge rates in gallons per day per square mile (gpd/mi^2), of the principal sand and gravel and shallow bedrock aquifers of Illinois. For reference, a recharge rate of 100,000 gpd/mi^2 is equal to 2.1 inches/year (Wehrmann, et. al., 2003).

The 1967 ITACWR report stated the following:

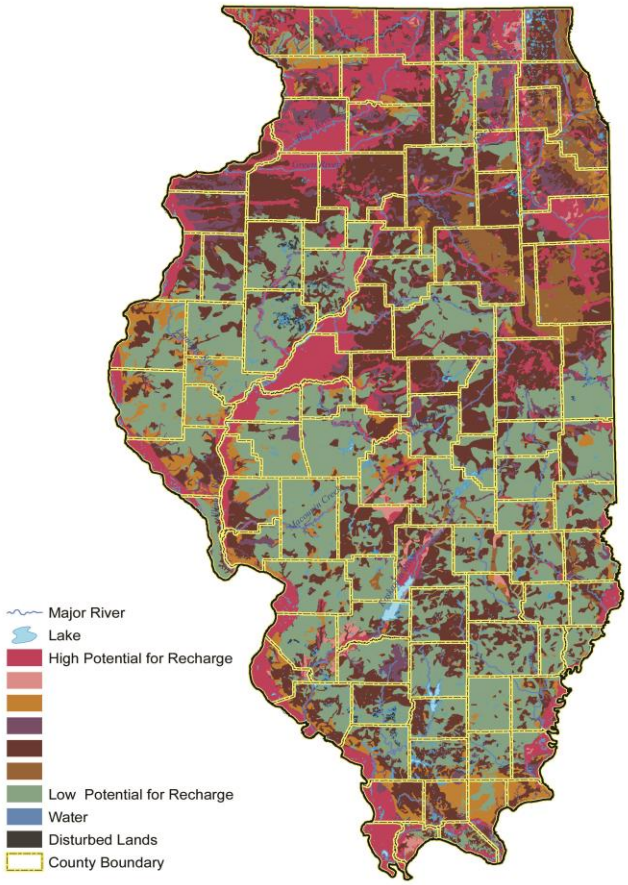
- The potential yield of the [sic] principal sand and gravel and bedrock aquifers in Illinois are estimated to be 4.8 and 2.5 billion gallons per day (bgd), respectively;
- The total groundwater potential in Illinois based on full development of either sand and gravel or bedrock aquifers, whichever has the higher recharge rate, is estimated to be 7.0 bgd;
- Principal sand and gravel aquifers underlie only about 25 percent of the total land area in Illinois;
- About 3.1 bgd, or about 65 percent of the total potential yield of the principal sand and gravel aquifers in the state, is concentrated in less than 6 percent of the total land area in Illinois and is located in alluvial deposits that lie directly adjacent to major rivers such as the Mississippi, Illinois, Ohio, and Wabash;
- About 0.5 bgd, or about 10 percent of the total potential sand and gravel yield is from the principal sand and gravel aquifers in the major bedrock valleys of the buried Mahomet Valley in east-central Illinois and in the river valleys of the Kaskaskia, Little Wabash, and Embarras Rivers in southern Illinois;
- Of the total estimated yield of bedrock aquifers in the State, 1.7 bgd, or 68 percent, is available from the shallow bedrock aquifers, mainly dolomites in the Northern third of the State;
- The potential yield of the shallow dolomite varies. In areas where the more permeable shallow dolomites lie directly beneath the glacial drift, the potential yield ranges from 100,000 to 200,000 gpd/mi^2;
- In areas where less permeable dolomites lie directly beneath the drift or are overlain by thin beds of less permeable rocks of Pennsylvanian age, the potential yield ranges from 50,000 to 100, 000 gpd/mi^2; and
- Where the overlying Pennsylvanian rocks are thick, the potential yield is less than 50,000 gpd/mi^2.

According to the USGS, groundwater withdrawals have declined from 2005 to 2010 throughout the State of Illinois. This fact will be addressed in Section C2 of this document, however, future groundwater shortages have been predicted in Northeastern Illinois (Meyer, Roadcap, et. al., 2009). In addition, although shortages are not predicted, the Mahomet Aquifer in Champaign-Urbana shows significant drawn down trends (Roadcap, and Wehrmann, 2009 and MAC, 2009).

Water that moves into the saturated zone and flows downward, away from the water table is considered recharge. Generally, only a portion of recharge will reach an aquifer. The overall recharge rate is affected by several factors, including intensity and amount of precipitation, surface evaporation, vegetative cover, plant water demand, land use, soil moisture content, depth and shape of the water table, distance and direction to a stream or river, and hydraulic conductivity of soil and geologic materials (Walton, 1965).

Figure C-4 illustrates the potential for aquifer recharge, defined as the probability of precipitation reaching the uppermost aquifer. The map is based on a simplified function of depth to the aquifer, occurrence of major aquifers, and the potential infiltration rate of the soil. This simplification assumes that recharge rates are primarily a function of leakage from an overlying aquitard (fine grained non-aquifer materials). Moreover, recharge may also be occurring from outside of a watershed boundary. Additionally, pumping stresses from potable water supply wells located adjacent to watershed boundaries may change the natural groundwater flow directions. Therefore, aquifer boundaries may not be consistent with surface watershed boundaries.

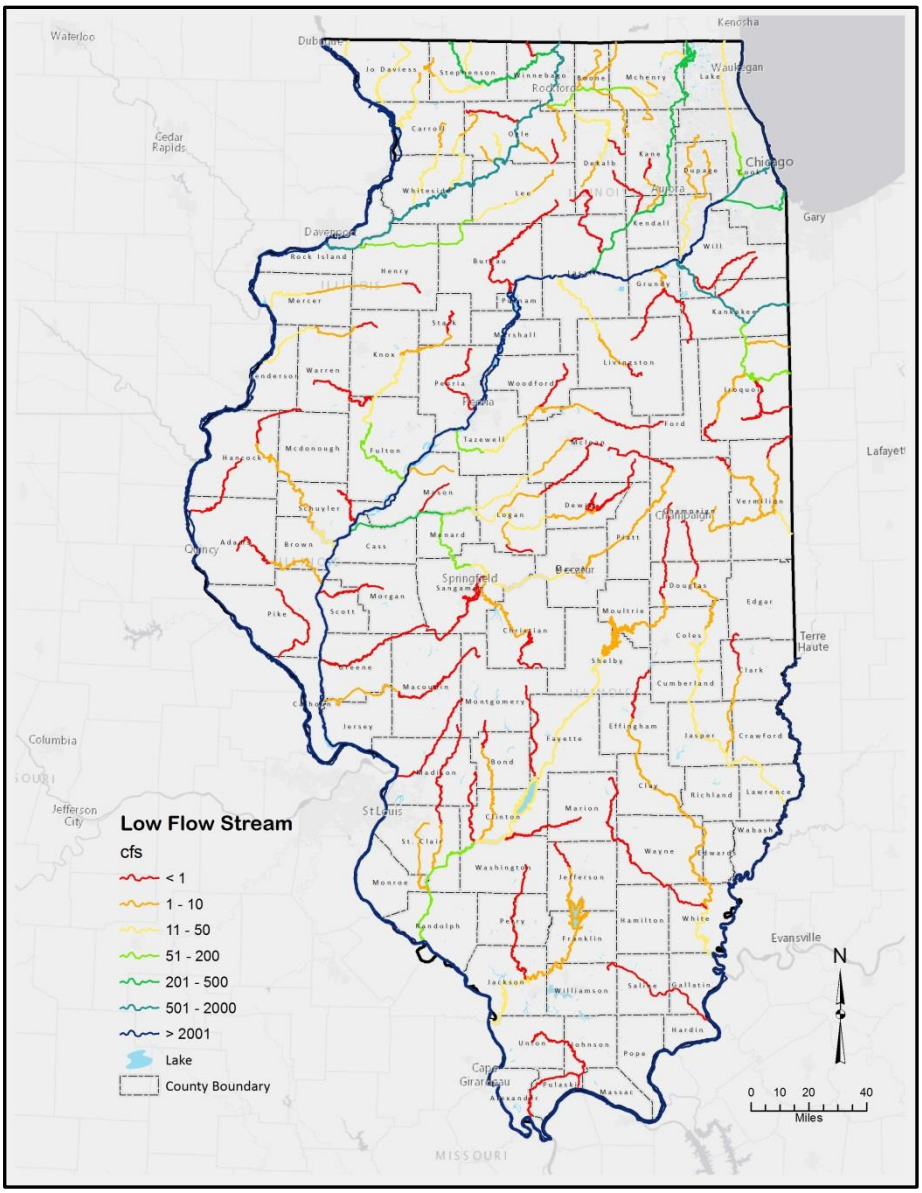
Figure C-4. Potential for Aquifer Recharge in Illinois



Groundwater contribution to stream flow in the form of base flow was analyzed for 78 drainage basins in Illinois (O'Hearn and Gibb, 1980). This study determined that median base flow per square mile of drainage area generally increases from the Southwest to the Northeast at all three flow durations. Figure C-5 shows the three-year low flow streams. This provides a good indictor of groundwater base flow in surface water.

An increase of groundwater withdrawals will have a direct impact on surface water quantity. Groundwater modeling studies conducted in Kane County show that as of 2003 stream flow capture by groundwater pumping had reduced natural groundwater discharge to streams in and near Kane County by about 17 percent (Meyer, Roadcap, et. al., 2009).

Figure C-5. Three-Year Low Flow Streams in Illinois



Illinois Groundwater Monitoring Network

Section 13.1 of the Act (415 ILCS 5/13.1) requires the Illinois EPA to implement a groundwater monitoring network to assess current levels of contamination in groundwater and to detect future degradation of groundwater resources. Further, Section 7 of the IGPA (415 ILCS 55/7) requires the establishment of a statewide ambient groundwater monitoring network comprised of CWS wells, non-community water supply wells, private wells, and dedicated monitoring wells. The Interagency Coordinating Committee on Groundwater (ICCG) serves as a groundwater monitoring coordinating council. The following provides a summary of the Illinois EPA's network of CWS wells.

Prototype Ambient Groundwater Monitoring

The collection of high quality chemical data is essential in assessing groundwater protection efforts. In 1984, the Illinois State Water Task Force published a groundwater protection strategy. This strategy lead to the addition of Section 13.1 to the Act (415 ILCS 5/13.1) which required the Illinois EPA to develop and implement a Groundwater Protection Plan and to initiate a statewide groundwater-monitoring network. In response to these requirements, the Illinois EPA and the United States Geological Survey (USGS) Illinois District Office, located in Urbana, IL. began a cooperative effort to implement a pilot groundwater monitoring network (i.e., ambient monitoring network) in 1984 (Voelker, 1986). The CWS well ambient network design started with pilot efforts in 1984, moved to implementation of the Illinois State Water Survey (ISWS) network design (O'Hearn, M. and S. Schock. 1984) for several years, and was followed by sampling all of Illinois' CWS wells (3,000+) (Voelker, 1988 and 1989).

The prototype monitoring efforts included development of quality assurance and field sampling methods. Illinois EPA's quality assurance and field sampling methods, originally developed in 1984 in cooperation with the USGS, were compiled into a field manual in 1985 (Cobb and Sinnott, 1987, and Barcelona, 1985). This manual has since been revised many times to include quality improvements. Monitoring at all stations sampled by Illinois EPA is completed by using Hydrolab® samplers to insure that in-situ groundwater conditions are reached prior to sampling. Water quality parameters include: field temperature, field specific conductance, field pH, field pumping rate, inorganic chemical (IOC) analysis, SOC, and VOC analysis. All laboratory analytical procedures are documented in the Illinois EPA Laboratories Manual.

In the year 2000, the Illinois EPA tasked the USGS to conduct a yearlong independent evaluation of our groundwater quality sampling methodology. The USGS concluded that Illinois EPA sampling program (sampling methodology guidelines, water quality meter calibration, and sampling performance) is considered to provide samples representative of aquifer water quality. Only minor revisions to the sampling program were suggested (Mills and Terrio, 2003). In addition, Illinois EPA also participates in the annual USGS National Field Quality-Assurance Program.

Coordinated Ambient Monitoring

From the experience gained from these prototype networks, implemented pursuant to Section 13.1 of the Act, Illinois EPA designed a probabilistic monitoring network of CWS wells (Gibbons 1995). The design of this network was completed in coordination with the USGS, the Illinois State Geological Survey (ISGS), and the ISWS, with USGS performing the detailed design. The goal of the network is to represent contamination levels in the population of all active CWS wells. The network wells were selected by a random stratified probability-based approach using a 95 percent confidence level (CWS Probabilistic Monitoring Network). This results in an associated plus or minus 5 percent precision and accuracy level. Further, the random selection of the CWS wells was stratified by depth, aquifer type and the presence of aquifer material within 50 feet of land surface to improve precision and accuracy. Illinois EPA used geological well log records and construction log detail to perform this process.

The random stratified selection process included nearly 3,000 CWS wells resulting in an average of 357 fixed monitoring locations at any time, see Figure C-6. Additionally, in order to prevent spatial or temporal bias 17 random groups of 21 wells, with alternates, were selected from all these fixed station wells. To further assure maximum temporal randomization within practical constraints, the samples from each sample period are collected within a three-week timeframe.

This probabilistic network is designed to provide an overview of the groundwater conditions in the CWS wells; provide an overview of the groundwater conditions in the principal aquifers (e.g., sand and gravel, Silurian, Cambrian-Ordovician, etc.,); establish baselines of water quality within the principle aquifers; identify trends in groundwater quality in the principal aquifers; and evaluate the long-term effectiveness of the IGPA, CWA and Safe Drinking Water Act (SDWA) program activities in protecting groundwater in Illinois. Illinois EPA has also developed an integrated surface and groundwater monitoring strategy. This "Water Monitoring Strategy, 2015-2020" document identifies the data collection programs, and their associated goals and objectives, that will be carried out by Illinois EPA, see: http://www.epa.state.il.us/water/water-quality/monitoring-strategy/monitoring-strategy-2015-2020.pdf Figure C-7 shows the Probabilistic Groundwater Monitoring Network wells integrated with the monitoring stations of the Surface Water Section of the Illinois EPA .

During the 1997 monitoring cycle, Illinois EPA initiated a rotating monitoring network of CWS wells. Illinois EPA rotates every two years from the probabilistic (fixed station) network to special intensive or regional studies. For this reporting period, the Groundwater Section has evaluated monitoring results from the 2012 – 2014 probabilistic monitoring network of CWS wells.

Beginning in 2007, Illinois EPA began requiring sampling at all wells on a monthly basis for total coliform bacteria in preparation of the Groundwater Rule. By December 1, 2009, all groundwater-dependent CWSs were required to comply with this regulation. The benefit of this monitoring is two-fold: (1) this data have identified wells at risk which, in most cases, has led to mitigation efforts of these wells; and (2) this approach has allowed Illinois EPA to compare source water monitoring for bacterial contaminants as an additional criteria for predicting the likelihood of attaining full use support in the major aquifers in Illinois.

Figure C-6. Active community water supply (CWS) wells and community water supply Probabilistic Network Wells

All CWS Wells in Illinois **CWS Probabilistic Network Wells in Illinois**

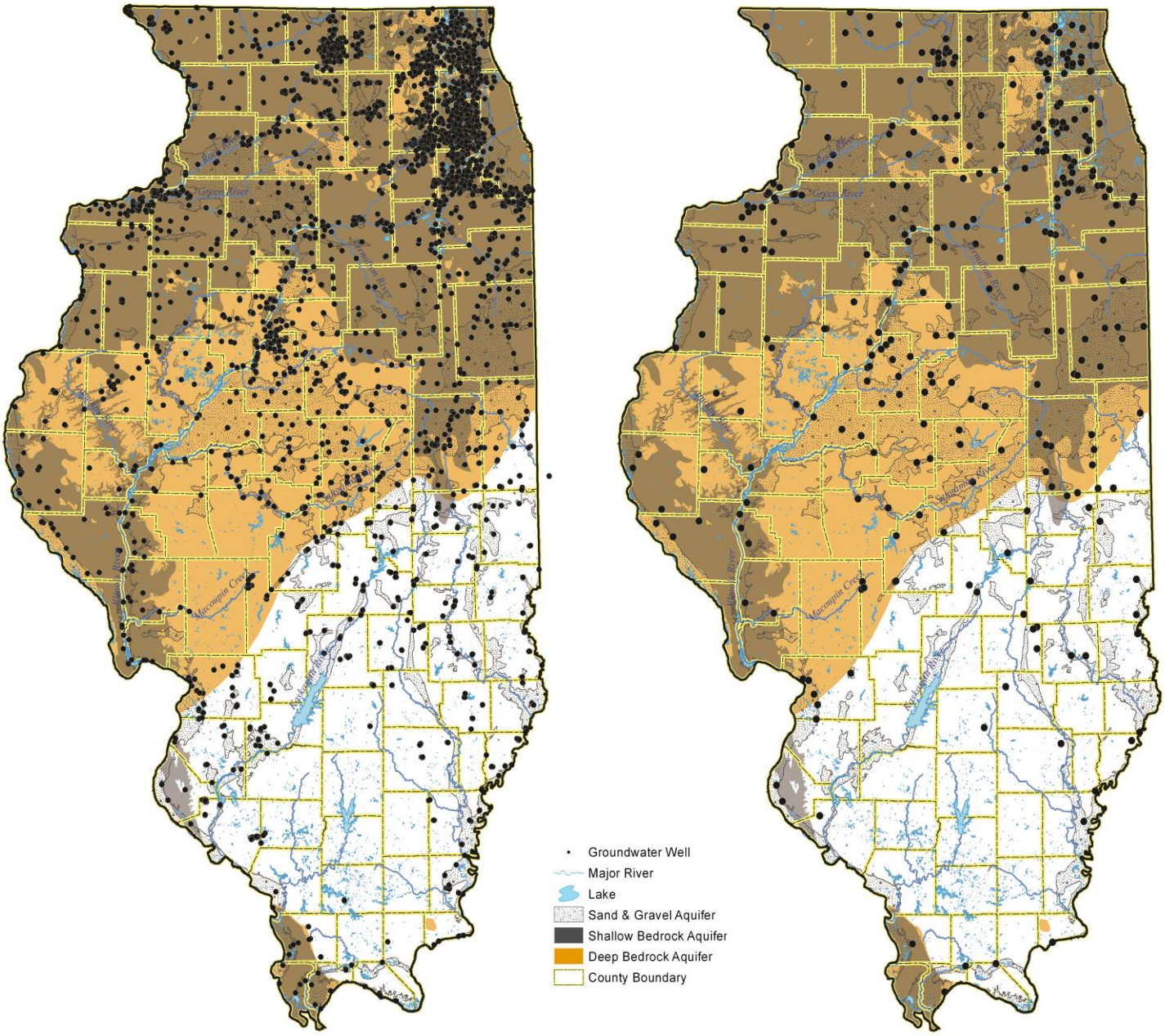
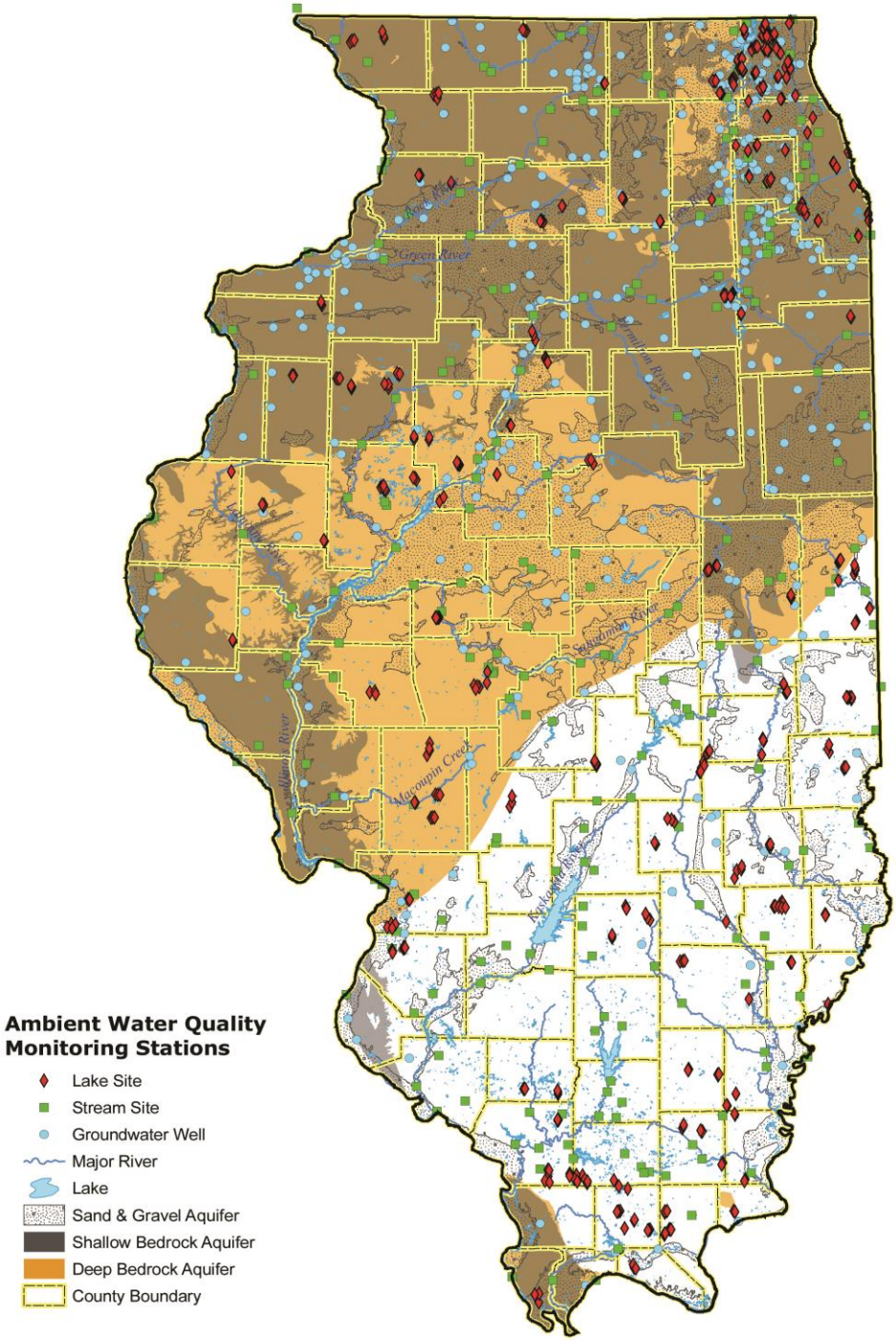


Figure C-7. Illinois EPA's integrated surface and groundwater monitoring network sites

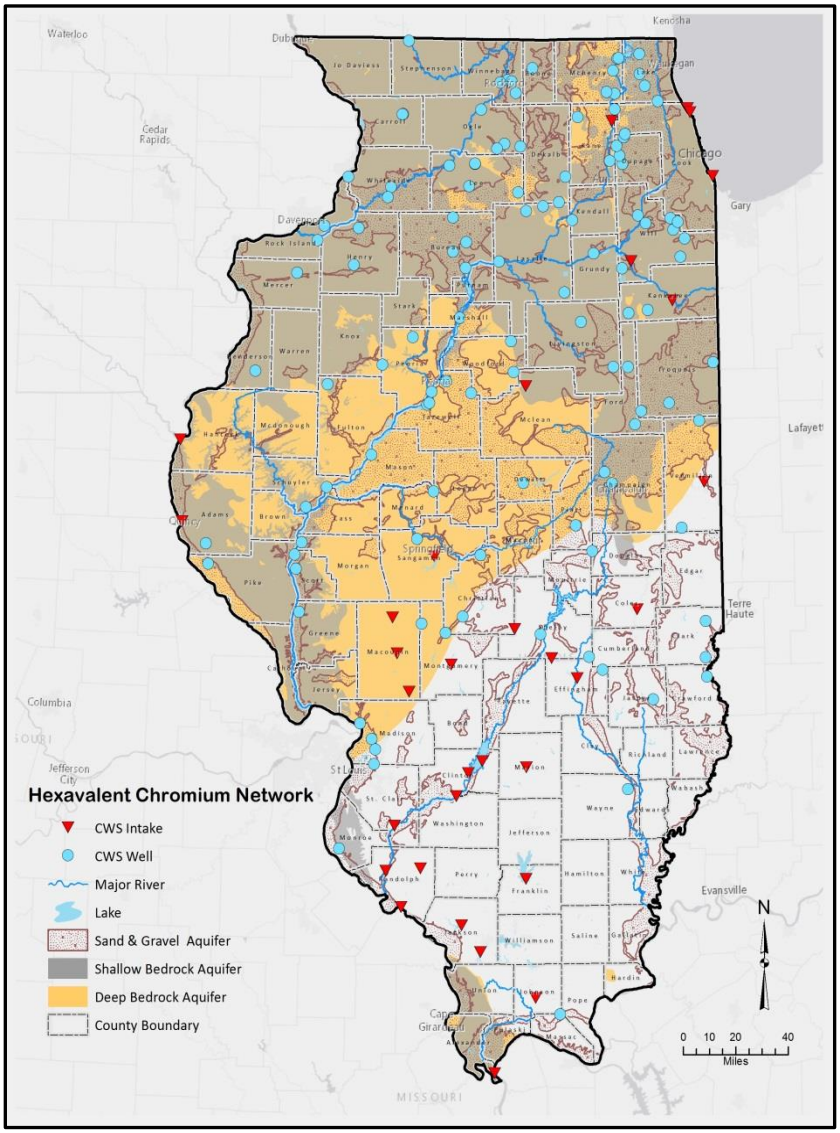


Hexavalent Chromium Network

On the basis of their recent review of the human health effects of Hexavalent Chromium [Cr(VI)] in public drinking water, the U.S. Environmental Protection Agency is considering the need for Federal regulation of Cr(VI). Presently, only total chromium is regulated, at a Maximum Contaminant Level (MCL) of 100 micrograms per liter (µg/L). The occurrence of Cr(VI) in groundwater and surface waters generally is attributed to industrial sources, but can be of natural origin. California's recently established MCL for Cr(VI) of 10 µg/L illustrates the drinking-water concerns associated with Cr(VI). To improve understanding of the possible impact of a Cr(VI)-specific standard that approximates the California level on the management of Illinois' public drinking water, the USGS, in cooperation with the Illinois EPA, assessed the occurrence and distribution of Cr(VI) in the State's public-water supplies (integrating surface water sources) (Figure C-8) at:

- 119 wells at CWSs using groundwater;
- 32 intakes at community water systems (CWSs) using surface water;
- At the entry point to the distribution system for the CWSs using surface water; and
- Locations within the distribution system for the CWSs using surface water.

Figure C-8. CWS wells and intakes in the Chromium-6 Network



As previously stated, the IGPA required the establishment of a statewide ambient groundwater monitoring network coordinated by the ICCG, and comprised of CWS wells; non-CWS[3] wells; private wells; and dedicated monitoring wells.
Illinois also used a statistically-based approach for designing: a pilot rural private well monitoring network (Schock and Mehnert, 1992, and Goetsch et.al., 1992) and the Illinois Department of Agriculture (IDA) dedicated pesticide monitoring well network (Mehnert et al. 2005). The ICCG continues to coordinate with the USGS on groundwater monitoring studies occurring within Illinois, as described in: http://www.epa.state.il.us/water/tmdl/303-appendix/2008/2008-final-draft-303d.pdf.

Dedicated Monitoring Well Network for Illinois Generic Management Plan for Pesticides in Groundwater – The IDA is the state lead agency for the regulation of pesticide use in Illinois. The IDA is responsible for managing pesticide use to prevent adverse effects to human health and the environment. Illinois, like many states, is voluntarily implementing the U.S. EPA-recommended provisions of pesticide management plans to protect groundwater. In June 2000, under the leadership of the IDA, the Pesticide Subcommittee of the ICCG approved the *Illinois Generic Management Plan for Pesticides in Groundwater* (IDA, 2000). The management plan, which was revised in 2006, describes the framework to be used by the State of Illinois for addressing the risks of groundwater contamination by pesticides. Background information on the history of the management plan, including the development and design of a dedicated groundwater monitoring well network can be found at:
http://www.epa.state.il.us/water/groundwater/groundwater-protection/index.html

In addition to sampling these wells for pesticides, the IDA has sampled them for nitrates as N biennially over the past 14 years . Analyzing the frequency of nitrates in these wells has led to the IDA being able to determine nitrate hot spots. The findings are included in Section C4 of this report.

USGS Illinois River Basin National Water Quality Studies – As part of the National Water Quality Assessment (NAWQA) program, the USGS is assessing both the Lower and Upper Illinois River Basins (LIRB and UIRB, respectively), see Figure C-9. A summary report of the LIRB activities through 1998 is available, see USGS Circular 1209; a similar summary of the UIRB activities through 2001 is also available, see USGS Circular 1230. Water quality and water-level data continues to be collected.

In 2010, the 30-well network in an urban land-use study area near Chicago was sampled for a large suite of pesticides, trace elements, and VOCs. In 2012, a 30-well network in the agricultural land-use study area near Kankakee was sampled for a similar suite of constituents. The wells are mostly monitoring wells in the shallow aquifer system. In years when the full network of wells (approximately 30 wells) are not sampled, then a subset of five wells are re-sampled for assessing changes and trends (biennial samples).
Every year since 2005, water levels have been collected at all 111 wells that are part of the NAWQA trends network (table below). The Cambrian-Ordovician network was initiated in

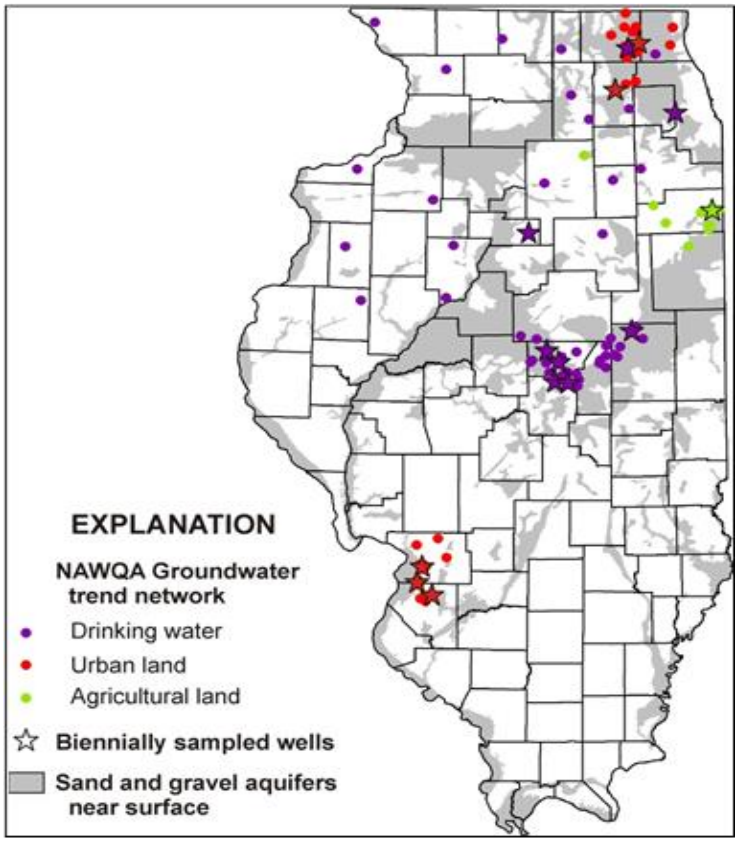
[3] "Non-Community Water System" means a public water system which is not a community water system, and has at least 15 service connections used by nonresidents, or regularly serves 25 or more nonresident individuals daily for at least 60 days per year. (Section 9(a)(4) of the Illinois Groundwater Protection Act [415 ILCS 55/9(a)(4)]).

2007 and water levels have been collected every year since it was initiated. The sampling plans for the NAWQA networks in Illinois are summarized in Table C-1, below.

Table C-1. Sampling plans for NAWQA networks

Area of Illinois	Principal aquifer	Network type	Number Of Active Wells	Initial Network Sample	Decadal Network Sample	Biennial Sampling (5-well subset of full network)
Lower Illinois River Basin	glacial aquifer system	urban land use	26	2005	2015	2013, 2011, 2009, 2007
Lower Illinois River Basin	glacial aquifer system	drinking water resource	30	1996	2007	2013, 2011, 2009, 2005, 2002
Upper Illinois River Basin	Cambrian-Ordovician	drinking water resource	31	2007	2017	2013, 2011, 2009
Upper Illinois River Basin	glacial aquifer system	urban land use	26	2000	2010	2013, 2011, 2009, 2007, 2005, 2003
Upper Illinois River Basin	glacial aquifer system	agricultural land use	29	1999	2012	2013, 2011, 2009, 2007, 2005, 2003

Figure C-9. USGS NAWQA Water-Quality Network Wells



The data are available in the NAWQA data warehouse Web site that provides for data delivery and mapping http://infotrek.er.usgs.gov/traverse/f?p=NAWQA:HOME:0.

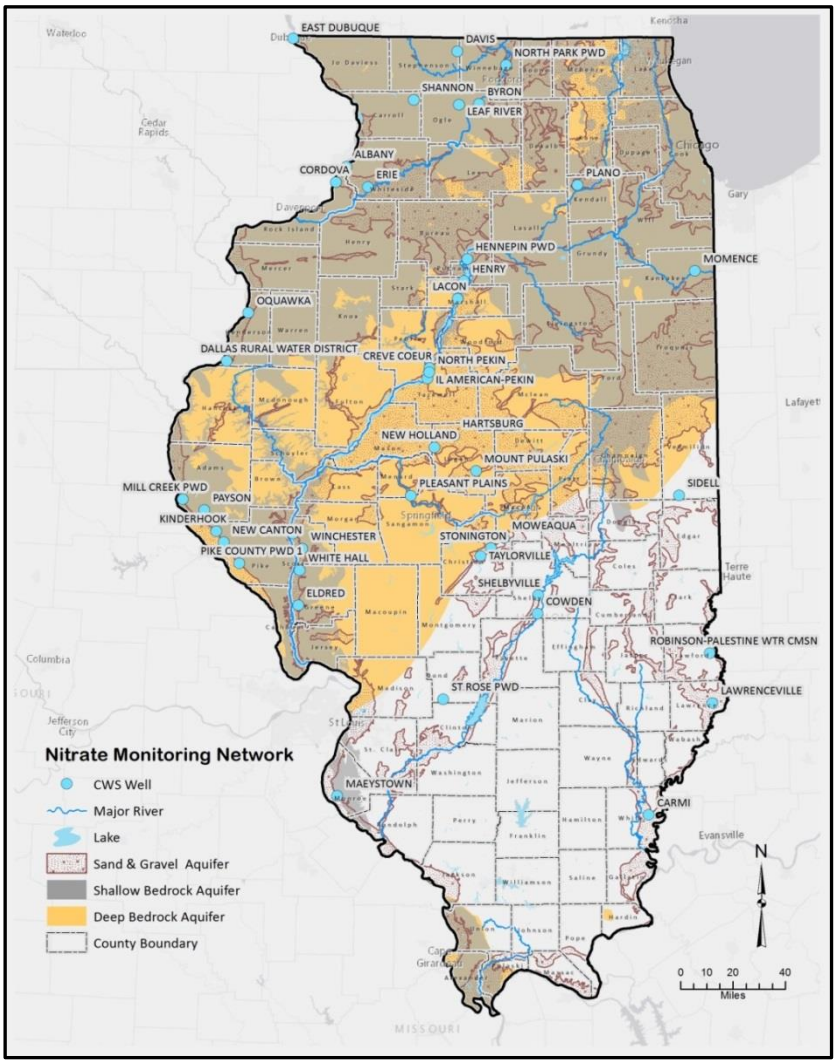
Additionally, the data is being summarized by principal aquifer, such as the glacial aquifer system, and water-quality data from over 150 wells in the UIRB and LIRB are included in this regional synthesis. Reports and interactive maps of the regional data, including Illinois data, can be found at: http://water.usgs.gov/nawqa/studies/praq/.

Nitrate Network

During the 2011 sampling period, the Illinois EPA conducted a nitrate trend study that was reported in the 2014 Integrated Water Quality Report. The wells in the 2011 study were selected based upon their history of nitrate detections, which ranged from an average concentration of 4-11 mg/L (milligrams per liter). In addition, the majority of the wells selected for the Nitrate Trend Network were located within or directly adjacent to agricultural fields and are less than 100 feet in depth. The results of this study can be ascertained in the aforementioned report.

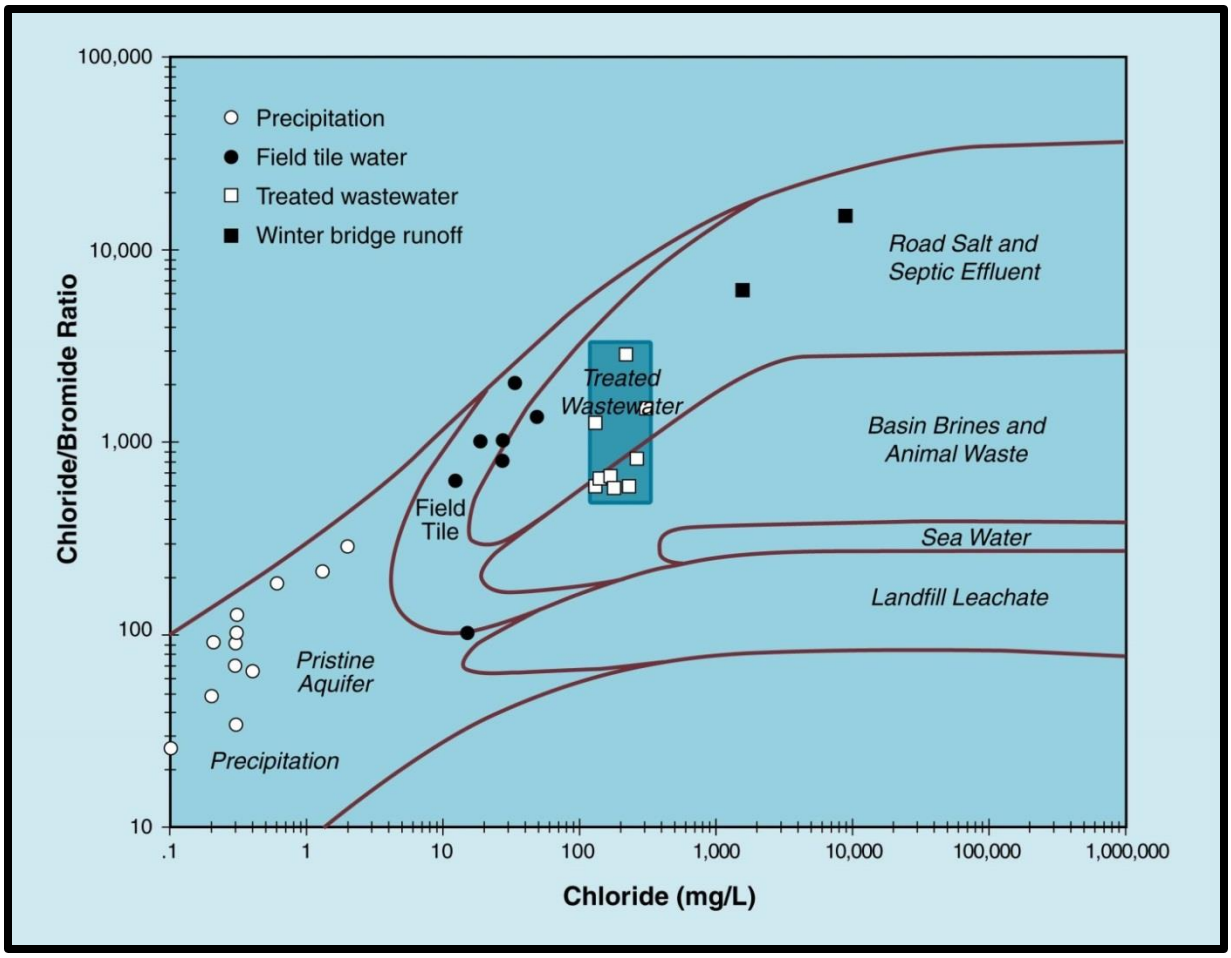
Starting in 2014 the Illinois EPA began seeing consistently high levels of nitrates (i.e. concentrations greater than 3 milligrams per liter (mg/L)) in groundwater used by CWS wells. As a result the Illinois EPA decided to conduct another nitrate study. Gathering these data are important in consideration of the Illinois' Nutrient Loss Reduction Strategy (NLRS). This is especially true in terms of the USGS' finding that some of the highest loads of nitrates to the Mississippi River were during low flow conditions, which may indicate that during these periods the nutrient load is being transported to the river via groundwater discharge. Utilizing a geographic information system (GIS), historical data from all the CWS wells where nitrate was detected (including concentrations below 3 mg/L) were averaged over time and plotted to determine if any trends were apparent. Using this information the Illinois EPA developed the Nitrate Network (C-10) consisting of 43 wells for the calendar year 2015.

Figure C-10. Illinois EPA 2015 Nitrate Monitoring Network



To compliment this study it was decided to also sample for chlorides (Cl) and bromides (Br). The idea here is to take advantage of a scientific technique that uses Cl/Br ratios in relation to Cl, and Cl vs. NO_3-N to determine the source of nitrates in groundwater (See Figure C-11) (Panno et. al., 2006 and 2007) (Canter, 1997).

Figure C-11. Graph of Cl/Br Ratio *vs*. Cl Concentration to Determine the Provenance of Nitrate in Groundwater (Panno et. al., 2006 and 2007)



In addition, The Illinois EPA, in cooperation with the USGS, piloted a real-time sampling program of a CWS well for nitrate concentrations. Utilizing these data, the study was focused on the ability to determine if seasonal variability of nitrate exists in relation to agricultural application of fertilizer. These data, as are the rest of the network data, are presented in Section C-4 of this report.

C-2. Assessment Methodology

Overall Use Support

Though there are many uses of groundwater in Illinois, the groundwater use assessments are based primarily upon CWS chemical monitoring analyses. The assessment of chemical monitoring data essentially relies on the Board's Class I: GWQS.

The fixed station Probabilistic Monitoring Network of CWS wells is utilized to predict the likelihood of attaining full use support in the major aquifers in Illinois. As previously described, the overall use support is based on compliance with Illinois' Class I GWQS. Class I standards include the nondegradation standards. The Probabilistic Network wells were also evaluated for total coliform bacteria monitoring as required by the Groundwater Rule. The attainment of use support is described as Full and Nonsupport, as described below:

Full Support
Good - indicates that no detections occurred in organic chemical monitoring data and inorganic constituents assessed were at or below background levels for the groundwater source being utilized.

Nonsupport
Fair - indicates that organic chemicals were detected and therefore exceed the nondegradation standard, but measured levels are less than the numerical Class I GWQS, and inorganic constituents assessed were above background level (nondegradation standard) but less than the numerical Class I GWQS.

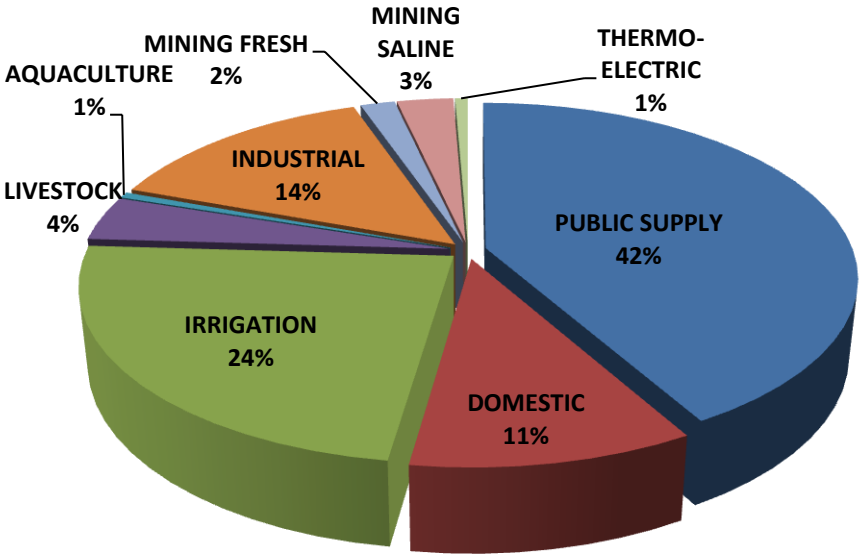
Poor - indicates that organic chemical monitoring data detections were greater than the Class I GWQS and inorganic chemicals assessed were greater than both the background concentration and Class I GWQS, or compliance issues related to bacterial contamination in the source water.

Organic results in the probabilistic network of CWS wells, which are commonly known to be anthropogenic in nature, were analyzed by well and year. It was determined that a detection of an organic contaminant would be recorded and not averaged. In this manor, the Illinois EPA is able to track the contamination and determine if a trend in that CWS well exists.

Individual Use Support

For over 50 years, the USGS has been collecting data on estimated water withdrawals by state, source of water, and category. Water use in the United States in 2010 was estimated to be about 355 billion gallons per day (Bgal/d), which was 13 percent less than in 2005. The 2010 estimates put total withdrawals at the lowest level since before 1970.

Figure C-12. Groundwater Withdrawals in Illinois (USGS 20010)



Groundwater in Illinois supports many uses. According to the USGS[4], the major uses of groundwater in Illinois are domestic, public water supply, agricultural, livestock, industrial, and thermoelectric.

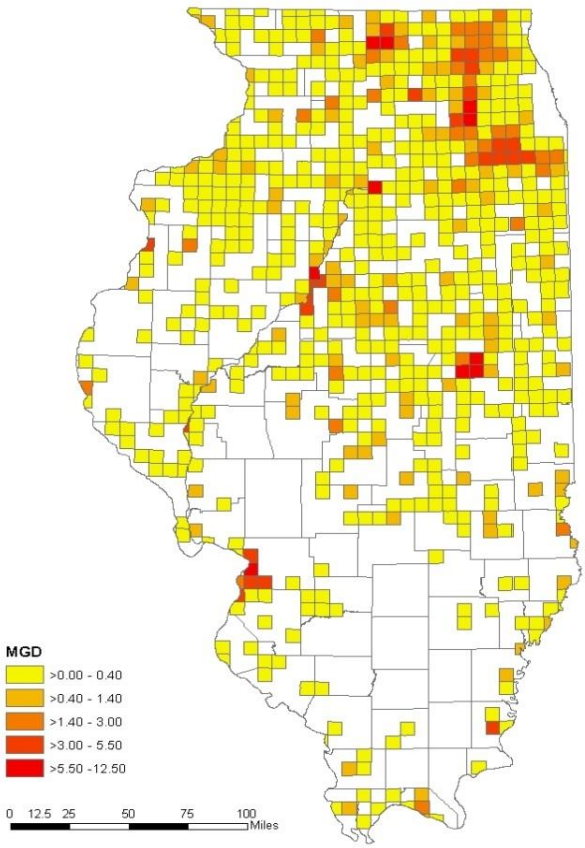
According to the USGS, Illinois uses approximately 13.1 billion gallons of fresh water per day. Only a small percentage – 853 million gallons per day (MGD), is from groundwater sources, as illustrated in Figure C-12. Public Water Supplies uses most of the groundwater with over 367 MGD (42 percent), followed by Irrigation use - 208 MGD (24 percent). Industrial (self-supplied) withdraws slightly more than 124 MGD (14 percent), followed by Domestic, which includes private well usage, 92 MGD (11 percent), and Livestock/Aquaculture at 41 MGD (5 percent). Mining (both fresh and saline) accounts for 41 MGD (5 percent) and Thermoelectric sources withdraw the least amount with approximately 6 MGD (1 percent) of groundwater usage in the State.

In addition, since 1979 the ISWS has been conducting an annual survey of water useage in Illinois through their Illinois Water Inventory Program (IWIP). The survey is comprised of both surface and groundwater data, and is collected from both CWSs and self-supplied industrial-commercial facilities in Illinois. For purposes of this report, only the CWS groundwater data are used and are presented by township in MGD (Figure C-13). For additional information and a description of the IWIP Program view the ISWS website at http://www.isws.illinois.edu/gws/iwip/.

[4] Based on **USGS Circular 1405,** 2014, which can be found at http://pubs.usgs.gov/circ/1405/

As shown in Figure C-13, and described by Wehrmann (2003), the major withdrawals from sand and gravel aquifers can be seen in the Metro-East area of St. Louis and in Quincy along the Mississippi River; in the Peoria-Pekin area along the Illinois River, in the Fox River corridor in Northeastern Illinois, and in the Champaign area of east-central Illinois. Major withdrawals from the shallow bedrock aquifers can be clearly seen almost solely in Northeastern Illinois in southern Cook, Kankakee and Will Counties for communities such as Crest Hill, Lockport, Manteno, New Lenox, Park Forest, and Romeoville (Wehrmann, 2003). Major withdrawals from the deep bedrock aquifers are found spread across northern Illinois, particularly in the Rockford area of north-central Illinois, the Fox River corridor, and farther south in the area of Joliet and the I-55 industrial corridor near Channahon (Wehrmann, 2003).

Figure C-13. Groundwater withdrawals by public water systems in Illinois, by township (ISWS, 2010)



Groundwater contributes to stream flow in the form of base flow in many of these river corridors. Thus, stream flows may also be impacted in areas where the ratio of use-to-yield is greater than 0.9. This is especially true in Northeastern Illinois due to the following factors: Supreme Court limitations on Lake Michigan water withdrawals; continued population growth; and a deep aquifer condition beyond sustainable recharge. It is predicted that these factors will force an increased reliance on the use of the sand and gravel and shallow bedrock aquifer resources. These shallow aquifers are in direct hydraulic connection to surface waters. This can result in decreased base flow in area streams that may have an impact on surface water quality and stream habitat.

Some groundwater in Illinois has been designated as Class III "special resource." Special Resource Groundwater is described as the groundwater contributing to highly sensitive areas including dedicated nature preserves that supports ecologically sensitive areas such as the Parker Fen in McHenry County and the Southwest Sinkhole Karst Plain located in Monroe, St. Clair and Randolph Counties. For a complete list of currently adopted and proposed Class III Special Resource Groundwater designated areas of the state, see:
http://www.epa.state.il.us/water/groundwater/groundwater-protection/index.html

C-3. Potential Causes and Potential Sources of Impairment

Potential Causes of Impairment

As previously stated, when possible, assessments of overall groundwater use support is based upon application of Illinois' GWQS (including non-degradation standards) to water quality sample measurements from the probabilistic network of CWS wells. Generally, a detection of an organic contaminant above the laboratory practical quantification limit or the detection of an inorganic constituent above the naturally occurring background level, or bacterial contamination in a CWS well is considered a cause of less than full use support.

Potential Sources of Impairment

Illinois EPA utilized a database of potential sources that have been inventoried as part of well site surveys, hazard reviews, groundwater protection needs assessments, source water assessments, and other special field investigations to evaluate potential sources of contamination relative to CWS Wellhead Protection Areas (WHPAs). We also utilized GIS to calculate land use activities proximate to the probabilistic network of CWS wells[5]. Table C-2 describes the most prevalent (common) potential sources of groundwater contamination in Illinois relative to CWS WHPAs.

[5] County by county land cover grid data for Illinois derived from Thematic Mapper (TM) Satellite data from the Landsat 4 sensor. Dates of the imagery used range from 1995 to 2002.

Table C-2. Most Prevalent Potential Sources of Ground Water Contamination[6]

Contaminant Sources	Occurrence of Potential Source[7]	Contaminants[8]
AGRICULTURAL ACTIVITIES		
Agricultural chemical facilities	587	A, B, E
Animal feedlots	66	E, J, K, L
Drainage wells	3	A, B, C, D
Fertilizer applications	323	A, B, E
Irrigation practices	63	A, B, E
Pesticide applications	174	A, B, E
STORAGE AND TREATMENT ACTIVITIES		
Land application	14	A, B, D, E, G, H, J
Material stockpiles	683	G, H
Storage tanks (above ground)	2,249	C, D
Storage tanks (underground)	2,878	C, D
Surface impoundments	236	E, G, H, J, K, L
Waste piles	231	E, G, H
Waste tailings	9	G, H, I, J
DISPOSAL ACTIVITIES		
Deep injection wells	9	A, B, C, D, E, F, G, H, I, M
Landfills	40	C, D, G, H, J
Septic systems	6,290	E, G, H, J, K, L
Shallow injection wells	9	A, B, C, D, E, F, G, H, J, K, L
OTHER		
Hazardous waste generators	-	A, B, C, D, G, H
Hazardous waste sites	97	A, B, C, D, G, H
Industrial facilities	1,565	A, B, C, D, G, H
Material transfer operations	232	A, B, C, D, E, F, G, H
Mining and mine drainage	19	G, H, M
Pipelines and sewer lines	111	C, D, E, G, H, J, K, L
Salt storage and road salting	76	G
Salt water intrusion	-	G
Spills	9	A, B, C, D, E, G, J
Transportation of materials	164	A, B, C, D, E
Manufacturing/repair shops	1,554	C, D, G, H
Urban runoff	1,184	A, B, D, E, G, H, J, K, L
Other sources (potential routes of contamination such as drainage wells, improperly abandoned potable water wells, or sand & gravel quarries)	249	A, B, D, E, J, K, L
FACILITY TREATMENT AND RECREATION		
Former storage facility	113	A, B, C, D, E, G, H
Commercial waste or chemical handling facility	1,078	C, D, E, G, J
Public utilities facility	203	E, F, G, H, J, K, L
Waste treatment facility	202	E, G, H, J, K, L
Recreational facility	581	J, L
Agriculture materials storage and sales	-	A, B, E, G, M

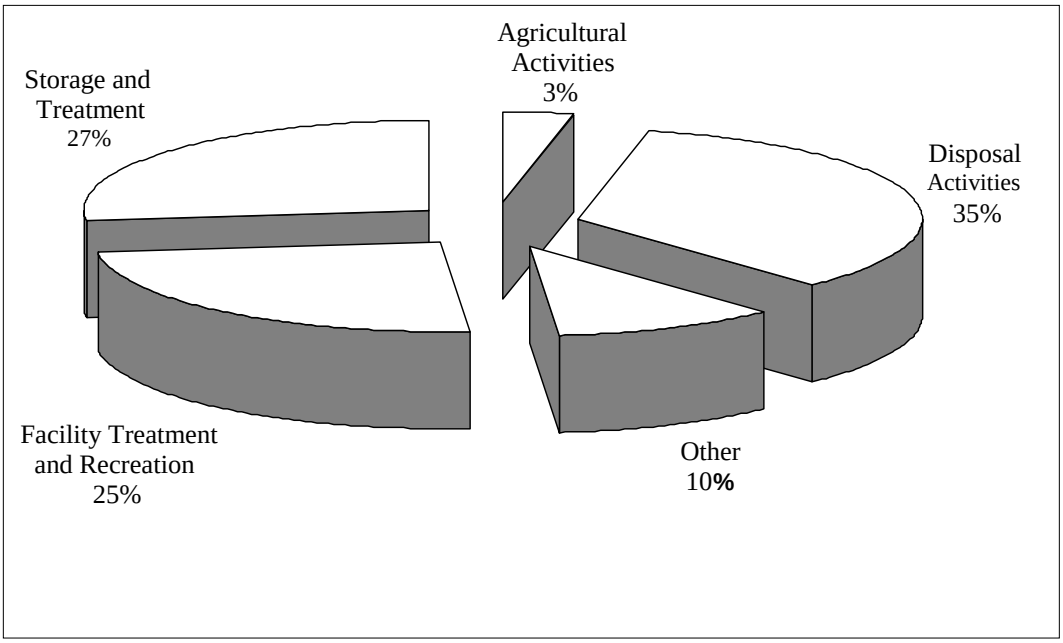
[6] The basis for the analysis provided in this table is a combination of existing monitoring data and potential source of groundwater contamination data from the completed CWS well site survey reports which Illinois EPA has conducted over the past 25 years.

[7] Occurrences are based solely on the Illinois EPA Groundwater Section's existing databases. This is only an estimate and should not be used as anything more than an approximation of potential sources of contamination to CWS wells in Illinois.

[8] Contaminants: A. Inorganic pesticides; B. Organic pesticides; C. Halogenated solvents; D. Petroleum compounds; E. Nitrate; F. Fluoride; G. Salinity/brine; H. Metals; I. Radio-nuclides; J. Bacteria; K. Protozoa; L. Viruses; and M. Other.

The Illinois EPA identified 16,354 potential sources of groundwater contamination of which 1,163 are considered threatening. Figure C-14 shows the most threatening potential contamination sources associated with CWS wells with VOC detects. The most prevalent potential source category was land disposal activities (2,953 sites) and the most threatening potential source category was chemical/petroleum processing/storage facilities (255 sites).

Figure C-14. Most Threatening Potential Contamination Sources in Community Water Supply Wells with VOC detections



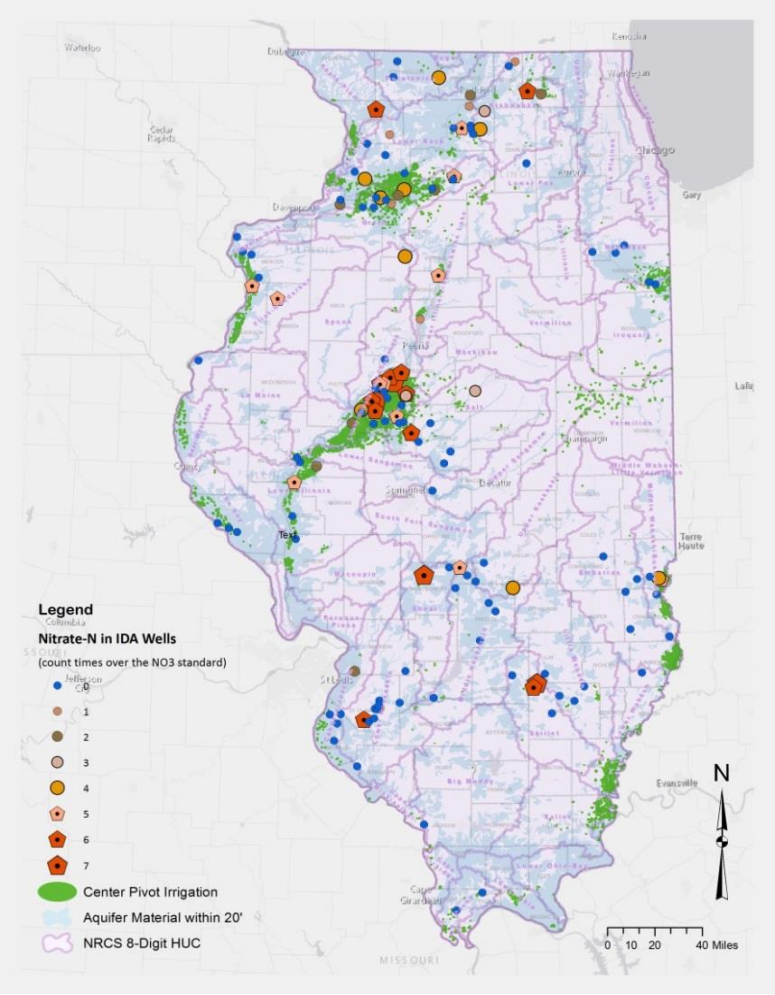
Additionally, ISWS research on CWS wells in Northeastern Illinois has determined that road salting is the most threatening potential source causing and contributing to chloride contamination above background levels in this part of the state. Approximately 16 percent of the samples collected from CWS wells in Northeastern Illinois during the 1990s had chloride concentrations greater than 100 mg/L. However, prior to 1960 – before extensive road salting practices, the median values of groundwater samples collected from Northeastern Illinois were less than 10 mg/L (Kelly and Wilson, 2004). The 75th quartile value of the sand and gravel CWS probabilistic network wells in Northeastern Illinois show a 35 percent increase in chloride concentration compared to the state wide ambient value of CWS wells in the network.

C-4. Monitoring Results

Illinois Department of Agriculture Dedicated Pesticide Monitoring Well Network Results

Results of the most recent sampling period (122 samples collected from January 2013 through March 2015) indicate that parent pesticides were detected in five of the samples (4.1 percent). Atrazine was detected in three samples and metolachlor was detected in two samples. Acetochlor and simazine were not detected. None of those samples had concentrations above levels of concern. One or more of the atrazine degradation products (desethylatrazine, desisopropylatrazine, and desethyldeisopropylatrazine) were present above the minimum reporting level in 17 (13.9 percent) of the samples. IDA no longer analyzes groundwater samples for the metabolites of the chloroacetanlide herbicides because problems with the analytical instrument were causing unreliable analytical results. Alachlor, metribuzin, and prometon are no longer analyzed because they were found too infrequently. For a detailed discussion of the IDA's dedicated pesticide monitoring well network results see: http://www.epa.state.il.us/water/tmdl/303-appendix/2008/2008-final-draft-303d.pdf.

Figure C-15. Nitrate hot spots in IDA wells with center-pivot irrigation wells (from IDA, 2015)



IDA has also sampled this dedicated monitoring well network for nitrates-N over time. The results of these sampling events, shown in the hot spot geospatial analysis (Figure C-15), demonstrate the frequency of IDA wells with detections over the GWQS of 10 mg/L. As this figure shows there are several wells that have had five or more detections over the GWQS.

In addition, these wells seem to cluster in geological sensitive areas around the state. Figure C-15 shows a strong correlation within the Havana Lowlands within Mason County. This area of the state is predominately sand, and sand and gravel adjacent to the Illinois River.

Finally, center point irrigation systems have been overlain with the hot spots on this map. Again there appears to be a good correlation between these systems and the detection of nitrate across the State.

Since October 2000, IDA has sampled 32 wells in the Havana Lowlands and related area on a biennial schedule for a total of 212 times. The results of this sampling indicate that:

- 99 of 212 (46.6 %) samples analyzed in that area had Nitrate-N concentrations greater than the numerical Class I GWQS of 10 mg/L;
- 9.2 mg/L of Nitrate-N is the median value of the area; and
- The individual well with the highest detected concentrations of Nitrate-N ranged from 18 to 48 mg/L with a median value concentration of 32 mg/L.

Figure C-15 shows that the hot spots are located in highly vulnerable sand and gravel aquifers located within 20 feet from land surface in these areas. Further, the hot spots correlate with intensive center point irrigation where possible fertigation[9] is occurring.

Hexavalent Chromium Results

During 2013, untreated water samples were collected to be analyzed for Cr(VI) and total chromium [Cr(T)] at 119 water-supply wells and 32 surface-water intakes; also, 32 treated surface-water samples were collected near the point of treatment and 32 near the furthest point of distribution. Public-supply sample sites were selected by a stratified random method. Samples typically were analyzed within 24 hours of collection at reporting limits of 0.02 µg/L for Cr(VI) and 0.1 µg/L for Cr(T). The occurrence of Cr(VI) was compared with selected geophysical, physical, and sampling factors that might more fully explain its distribution and magnitude of concentrations.

The maximum concentration of Cr(VI) in groundwater was 2.1 µg/L. Maximum concentrations in untreated and treated surface water were 0.29 µg/L and 2.4 µg/L, respectively. All sample concentrations were below the California MCL of 10 µg/L; only 35 percent were below that State's non-enforceable public health goal of 0.02 of µg/L. Cr(VI) was undetected in 43 percent of untreated groundwater samples, with a median of 0.06 µg/L when detected. All but two (94 percent) of untreated surface-water samples had detections. In untreated surface water, the median concentration was 0.09 µg/L, whereas in treated (tap and distributed) water the median was 0.20 µg/L. Surface waters treated with lime for softening typically had the greatest Cr(VI) concentrations (maximum, 2.4 µg/L; median, 1.2 µg/L).

The maximum concentration of Cr(T) in groundwater was 1.8 µg/L. Maximum concentrations in untreated and treated surface water were 1.8 µg/L and 2.5 µg/L, respectively. All sample concentrations were below the Federal MCL of 100 µg. Total chromium was detected in 65 percent of untreated groundwater samples, with a median of 0.40 µg/L when detected. All but one (97 percent) of untreated surface-water samples had detections. In untreated surface water, the median concentration was 0.40 µg/L, whereas in treated (tap and distributed) water the

[9] "*Fertigation*" means the injection of fertilizers, soil amendments, and other water-soluble products into an irrigation system.

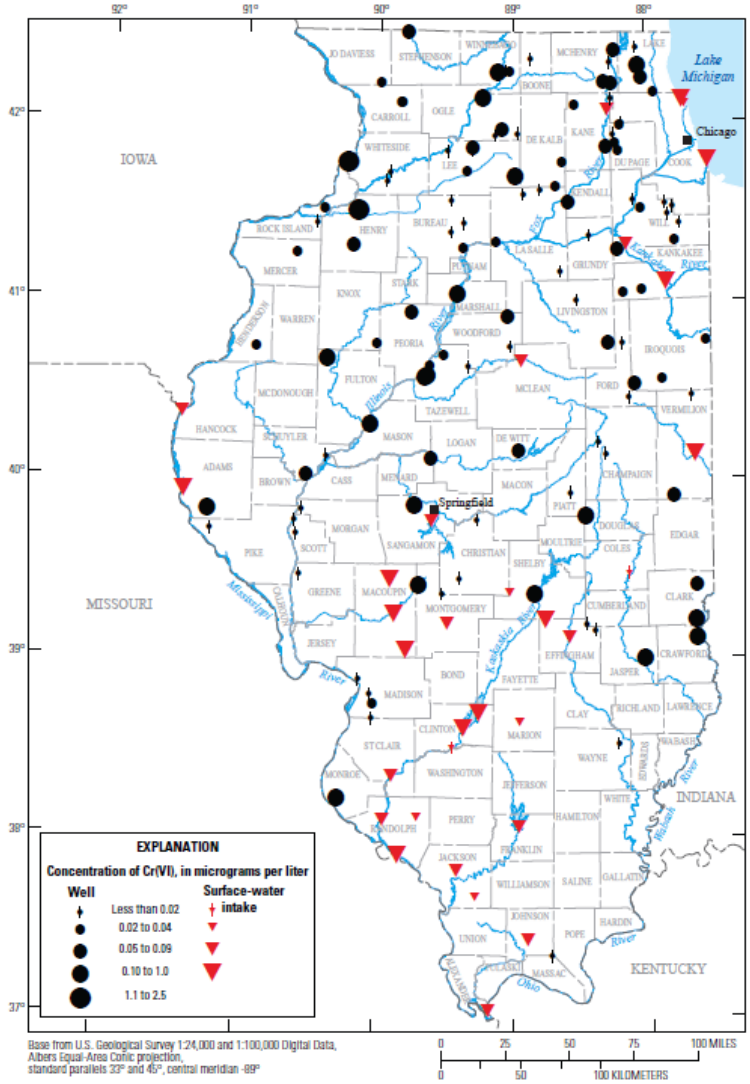
median was 0.30 µg/L. As with Cr(VI), surface waters treated with lime typically had the greatest Cr(T) concentrations.

Examination of factors that might account for or be associated with the occurrence of Cr(VI) in public-supply source waters found few clearly evident factors. Associations in frequencies of occurrence and range of concentrations indicate that surface waters and ground waters of shallow, unconsolidated, unconfined aquifers, particularly alluvial aquifers, are possibly most commonly affected by anthropogenic sources of Cr(VI). Ground waters of deep (greater than 500 feet) bedrock aquifers, particularly the Cambrian-Ordovician aquifer system, are possibly most commonly affected by geologic sources of Cr(VI). Additional study, with supporting geologic and geochemical data that were not collected in this study, would be necessary to verify these associations.

There was a weak positive relation ($\rho = 0.23$) between concentrations of Cr(VI) and Cr(T) in untreated water samples, with a much stronger positive relation ($\rho = 0.86$ and $\rho = 0.90$, respectively) in samples collected soon after treatment and near the endpoint of distribution.

The stronger relation and greater similarity between Cr(VI) and Cr(T) concentrations in treated water samples indicate that Cr(VI) represents a greater proportion of the measured concentrations of Cr(T) in treated waters than in untreated waters. The analysis of spikes and other quality-assurance samples indicate uncertainties associated with obtaining or confirming consistently accurate analytical results for Cr(VI) at near the applied reporting limit of 0.02 µg/L.

Figure C-16. Cr(VI) Network Results



The results of this study are detailed in USGS Scientific Investigation Report 2015-5020 at: http://www.epa.illinois.gov/topics/drinking-water/public-water-users/chromium-6/index/.

Nitrate Network Results

As stated earlier, in general, the concentration of nitrate associated with anthropogenic causes is 3 mg/L and higher. Research suggests that concentrations below this level are associated with natural causes. The numerical Class I: Potable Resource Groundwater Standard for nitrate is 10 mg/L that applies except due to natural causes. Naturally occurring levels of nitrate below or above 10 mg/L is what applies as the groundwater standard on a site-specific basis. Several of the 43 wells were also selected with concentrations below 3 mg/L of nitrate to evaluate background concentrations.

To date the summary statistic results for all 43 nitrate network wells is shown in Figure C-10 are, as follows:

- 6.8 mg/L of nitrate is the mean concentration;
- 19 mg/L of nitrate is the maximum concentration; and
- 0.16 mg/L of nitrate is the minimum concentration.

In addition, the following provides summary statistics for the source of nitrate using the Cl/Br *vs.* Cl, and Cl *vs.* NO_3-N results and other lines of evidence for the wells that have nitrate detections:

- 16 due to non-point source agricultural fertilizer;
- 5 due to non-point source agricultural fertilizer (manure spreading);
- 3 due to a mix of non-point source agricultural and septic sources;
- 1 due to a mix of non-point source agricultural and road salt
- 5 due to septic system;
- 1 due to a waste water source;
- 1 due to a potential point source of fertilizer;
- 4 below background of 3 mg/L; and
- 7 undetermined sources.

Further, the following map has been developed to geospatially illustrate these statistical results of nitrate concentration and source of contamination relative to highly vulnerable aquifer materials that are located within 20 feet of land surface and the watershed boundaries under the NRLS (See Figure C- 17). Further, Payson's well is using an unconfined karst aquifer with the potential from recharge via sink holes and conduit flow. In addition, New Holland's well sits just east of the Havana Lowlands Area where there may be funneled recharge (Roadcap et.al. 2011). More research is needed in this transitional area between where the Mahomet Aquifer goes from confined to unconfined.

The source of nitrate contamination was found to be associated with agricultural non-point sources for the following 22 wells. Twenty one (21) of these wells are using an unconfined sand and gravel aquifer that have an average depth of 76.8 feet below ground surface (bgs) (See Table C-3). The depth of these wells ranges from 28 to 147 (cased 110) feet bgs. However, 1 of the 22 wells (Payson), which is 300 feet deep, is located in the western part of the state and drilled in a known karst area.

Figure C-17 Average Nitrate Concentrations in CWS Network Wells Related to Source of Contamination (2015)

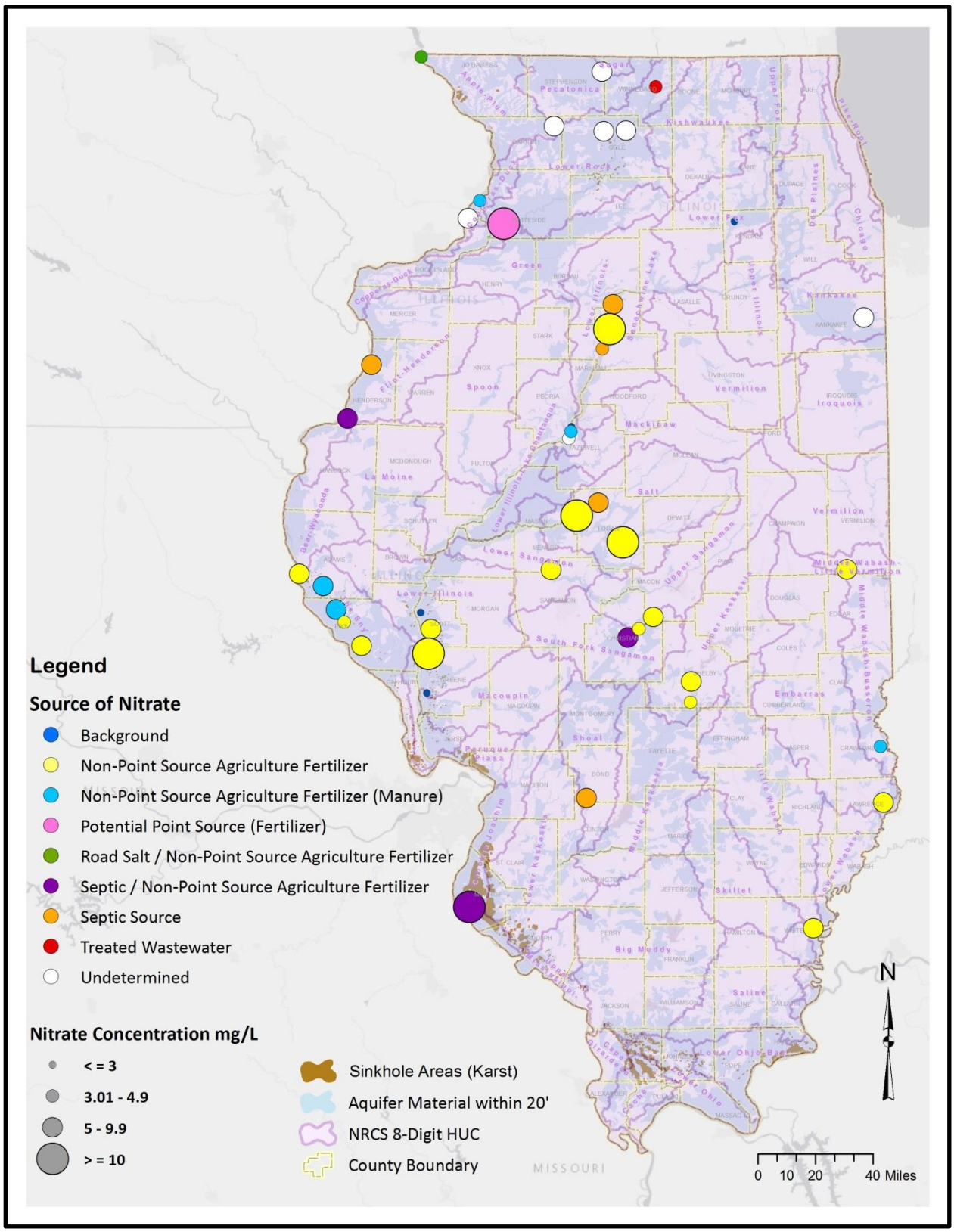


Table C-3 Nitrate detections in CWS Network Wells utilizing unconfined, sand and gravel , and karst aquifer.

Well #	CWS Name	Well Depth Feet bgs	Hydrologic Unit Name	Major Land Resource Area Name	Land Resource Regions (LRR) Name	Aquifer within 20 of land surface	Average NO_3-N mg/L
WL47692	SIDELL	28	Swank Creek-Little Vermilion River	Illinois and Iowa Deep Loess and Drift, Eastern Part	Central Feed Grains and Livestock Region	No	7.13
WL50211	NORTH PEKIN	104	Lamarsh Creek-Illinois River	Central Mississippi Valley Wooded Slopes, Northern Part	Central Feed Grains and Livestock Region	Yes	13.73
WL01225	PIKE COUNTY PWD	112	Plum Point Slough-Mud Slough	Central Mississippi Valley Wooded Slopes, Northern Part	Central Feed Grains and Livestock Region	Yes	8.96
WL50143	PLEASANT PLAINS	61	Headwaters Sagamon River	Central Mississippi Valley Wooded Slopes, Northern Part	Central Feed Grains and Livestock Region	Yes	9.19
WL00768	MILL CREEK PWD	86	Clear Creek-Mississippi River	Central Mississippi Valley Wooded Slopes, Northern Part	Central Feed Grains and Livestock Region	Yes	7.00
WL00117	WINCHESTER	65	Hurricane Creek-Illinois River	Central Mississippi Valley Wooded Slopes, Northern Part	Central Feed Grains and Livestock Region	Yes	7.18
WL01087	WHITE HALL	93	Hurricane Creek-Illinois River	Central Mississippi Valley Wooded Slopes, Northern Part	Central Feed Grains and Livestock Region	Yes	10.93
WL01001	NEW HOLLAND	62	Sugar Creek	Illinois and Iowa Deep Loess and Drift, East-Central Part	Central Feed Grains and Livestock Region	No	14.94
WL50221	MOUNT PULASKI	34	Salt Creek	Illinois and Iowa Deep Loess and Drift, East-Central Part	Central Feed Grains and Livestock	Yes	13.73

Table C-3 Nitrate detections in CWS Network Wells utilizing unconfined, sand and gravel , and karst aquifer.

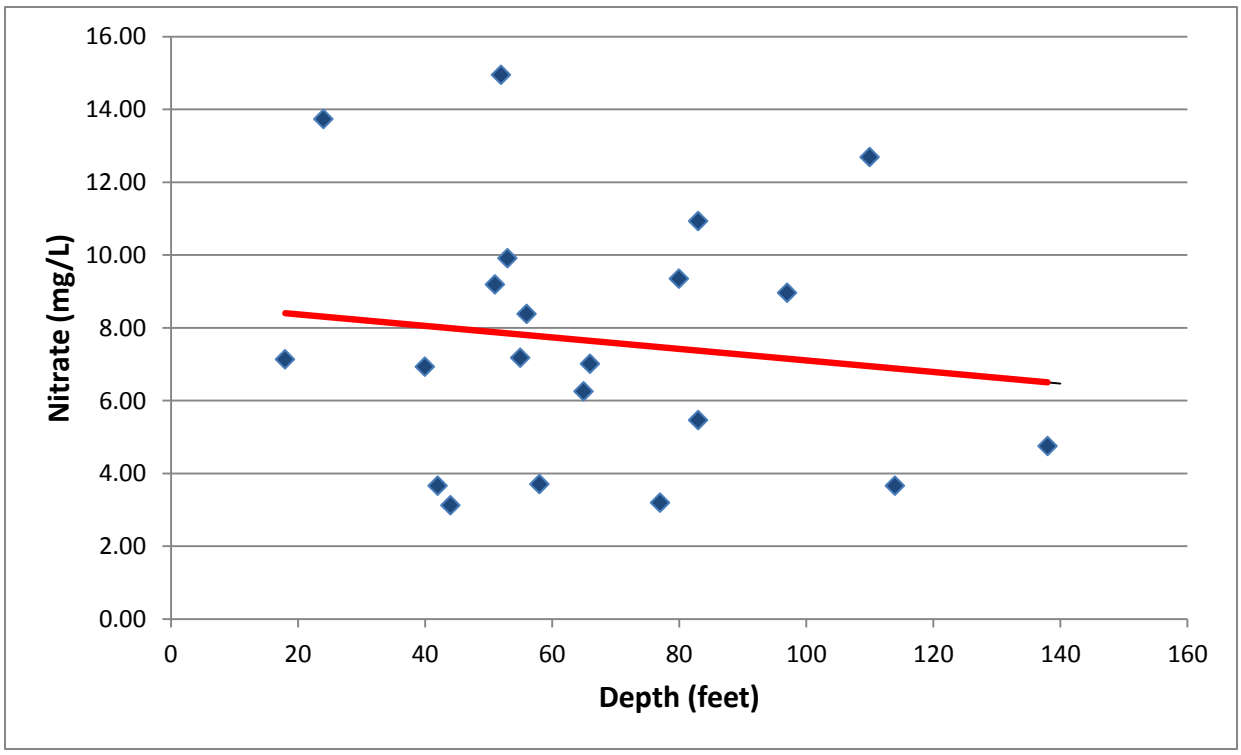
Well #	CWS Name	Well Depth Feet bgs	Hydrologic Unit Name	Major Land Resource Area Name	LRR Name	Aquifer within 20 of land surface	Average NO_3-N mg/L
WL00885	MOWEAQUA	66	Flat Branch	Illinois and Iowa Deep Loess and Drift, East-Central Part	Central Feed Grains and Livestock Region	Yes	8.38
WL01739	STONINGTON	124	Flat Branch	Illinois and Iowa Deep Loess and Drift, East-Central Part	Central Feed Grains and Livestock Region	Yes	3.66
WL47806	ROBINSON-PALESTINE WTR CMSN	87	Lamotte Creek	Central Mississippi Valley Wooded Slopes, Eastern Part	Central Feed Grains and Livestock Region	Yes	3.19
WL45187	COWDEN	52	Kaskaskia River	Central Claypan Areas	Central Feed Grains and Livestock Region	Yes	3.66
WL47774	SHELBYVILLE	63	Kaskaskia River	Southern Illinois and Indiana Thin Loess and Till Plain, Western Part	Central Feed Grains and Livestock Region	No	3.66
WL11894	ALBANY	88	Mill Creek – Mississippi River	Central Mississippi Valley Wooded Slopes, Northern Part	Central Feed Grains and Livestock Region	Yes	3.70
WL31303	HENRY	147 Cased 110	Sawyer Slough-Illinois River	Central Mississippi Valley Wooded Slopes, Northern Part	Central Feed Grains and Livestock Region	Yes	12.7
WL71572	LAWRENCEVILLE	90	Indian Creek-Embarras River	Central Mississippi Valley Wooded Slopes, Eastern Part	Central Feed Grains and Livestock Region	Yes	9.35
WL50215	NEW CANTON	54	Kiser Creek-Mississippi River	Central Mississippi Valley Wooded Slopes, Northern Part	Central Feed Grains and Livestock Region	No	3.84
WL00870	DALLAS RURAL WATER DISTRICT	54	Flint-Henderson Mississippi River	Central Mississippi Valley Wooded Slopes, Eastern Part	Central Feed Grains and Livestock Region	Yes	6.25

Table C-3 (cont.) Nitrate detections in CWS Network Wells utilizing unconfined, sand and gravel, and karst aquifer.

Well #	CWS Name	Well Depth Feet bgs	Hydrologic Unit Name	Major Land Resource Area Name	LRR Name	Aquifer within 20 of land surface	Average NO_3-N mg/L
WL00588	KINDERHOOK	50	McCraney Creek	Central Mississippi Valley Wooded Slopes, Eastern Part	Central Feed Grains and Livestock Region	Yes	6.93
WL01113	PAYSON	300	Bear Creek Mississippi River	Central Mississippi Valley Wooded Slopes, Northern Part	Central Feed Grains and Livestock Region	Yes, karst aquifer	6.32
WL71572	CARMI	93	Fox River-Wabash River	Central Mississippi Valley Wooded Slopes, Eastern Part	Central Feed Grains and Livestock Region	No	5.46

The following graph shows the concentration of nitrate (due to an agricultural non-point source of contamination) *vs.* well depth for the wells using unconfined sand and gravel aquifers. This graph appears to show a trend of decreasing nitrate with increasing well depth with the exception of Henry's well. The average nitrate concentration in Henry's well (cased to 110" bgs) is 12.7 mg/L. However, there is extensive center point irrigation located up gradient of this well.

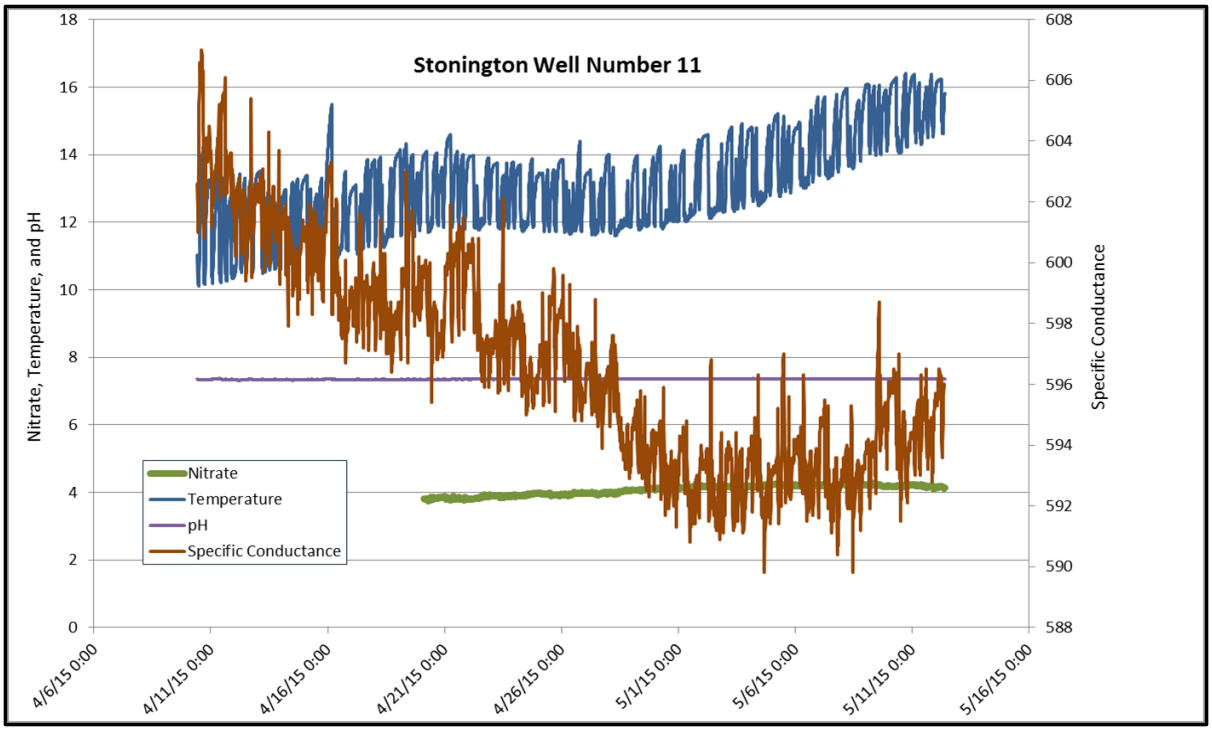
Figure C-18 Nitrate concentrations (due to agricultural non-point sources in CWS Network Wells utilizing unconfined sand and gravel aquifers) *vs.* well depth.



It's possible that fertigation may be occurring at these irrigation wells. Additionally, an IDA monitoring well is located in this area. This monitoring well has a total depth of 38' bgs and the depth to aquifer material is 9' (i.e. depth to the water table). Nitrate –N has exceeded the numerical Class I GWQS of 10 mg/L a total of 5 times since biennial monitoring was initiated in October of 2000 in this dedicated monitoring well. Currently, Nitrate-N is at a concentration of 12 mg/L in this well.

The Illinois EPA is in the process of conducting additional hydrogeologic assessments for the wells in Table C-3. The results of this effort will be published separately in source water assessment fact sheets for each of the respective community water supplies.
USGS worked with the village of Stonington and Illinois EPA to pilot real-time monitoring of their wells where the nitrate has been confirmed to be from agricultural non-point sources due to the Cl/Br *vs.* Cl, Cl *vs.* NO_3-N, and land use. To date not much variation is occurring in the nitrate concentration in Stonington well 11 (Figure C-18).

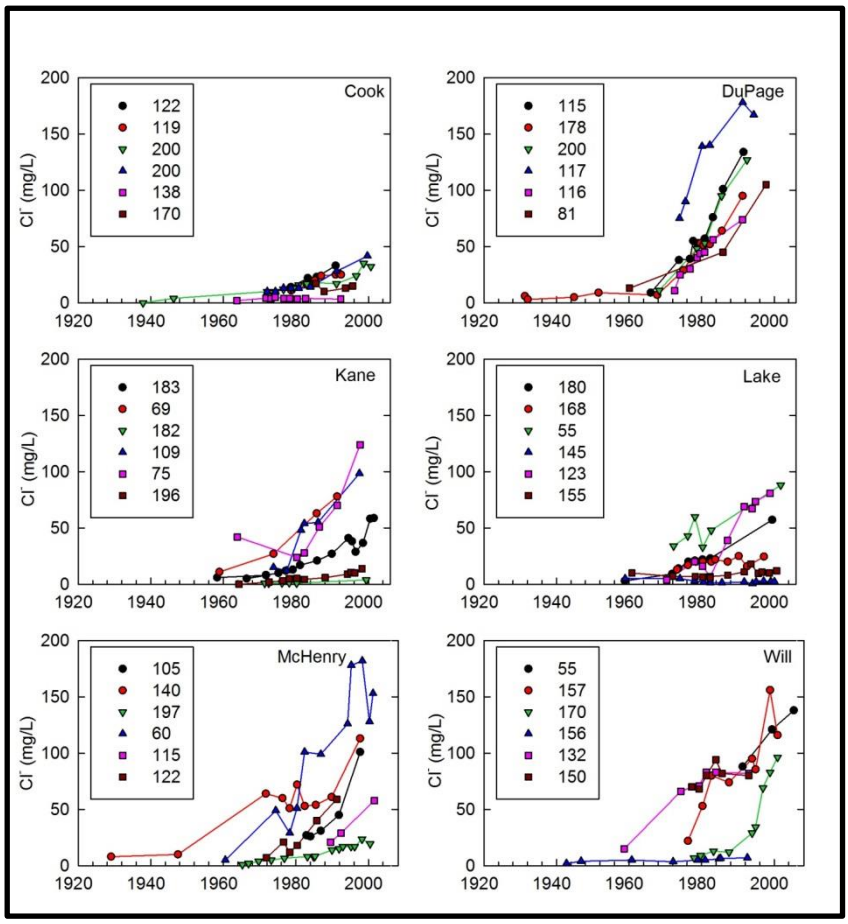
Figure C-19. Real-time graph of Stonington well #11. The graph is plotted comparing nitrate, water temperature, pH, and specific conductance from 4/6 thru 5/15

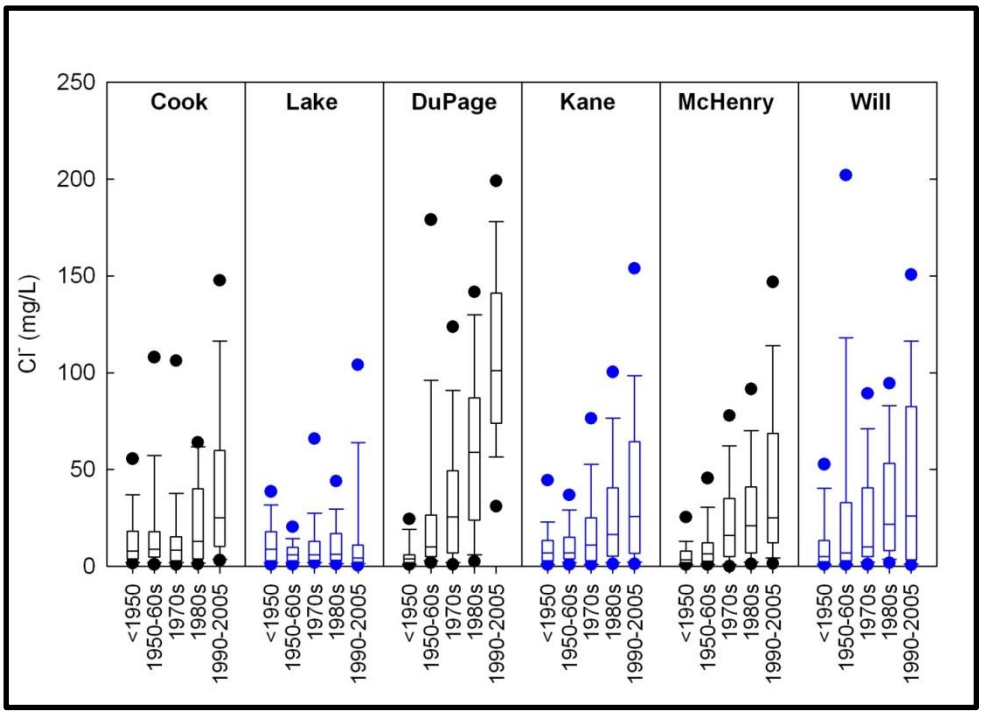


Chloride Network Results (based on Illinois EPA trend data, 2013)

As described above, ISWS research on CWS wells in Northeastern Illinois has determined that road salting is the most threatening potential source causing and contributing to chloride contamination above background levels in this part of the state. Approximately 16 percent of the samples collected from CWS wells in Northeastern Illinois during the 1990s had chloride concentrations greater than 100 mg/L. However, prior to 1960 – before extensive road salting practices, the median values of groundwater samples collected from Northeastern Illinois were less than 10 mg/L (Kelly and Wilson, 2004) (Figure C-19).

Figure C-20. Chloride levels in Northeastern Illinois CWS wells. The top graph shows levels by county thru time aand the bottom graph is a plot with box-plots. In each instance the chloride levels are clearly increasing over time. (ISWS)





C-5. Use Support Evaluation

Figures C-20 and C-21 summarize use support of groundwater resources in the State of Illinois as determined by measurements in the probabilistic network of CWS wells. The results show that of the CWS probabilistic network wells this cycle:

58 (16 percent) were determined to be Not Supporting ("poor") due to the elevated levels of nitrate and chloride (Cl-) over the Groundwater Quality Standard (GWQS) of 10 mg/L and 200 mg/L, respectively, or bacterial contamination of the source water;

160 (44 percent) were determined to be Not Supporting ("fair") due to elevated levels of chloride (Cl-) above background, detections of VOCs, SOCs, or nitrate (total nitrogen) greater than 3 mg/L, but have not exceeded the health-based GWQS; and

146 (40 percent) were determined to be Fully Supporting ("good"), which show no detections over background levels of any of the above analytes.

Figure C-21. 2014 Use Support in CWS Network Wells

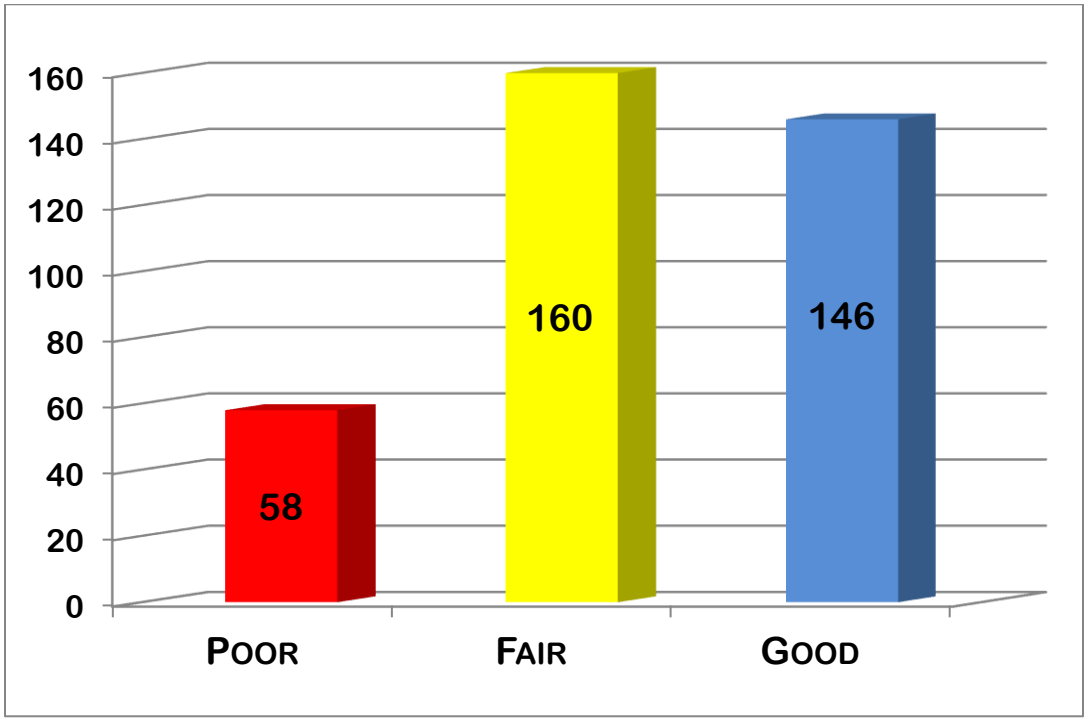
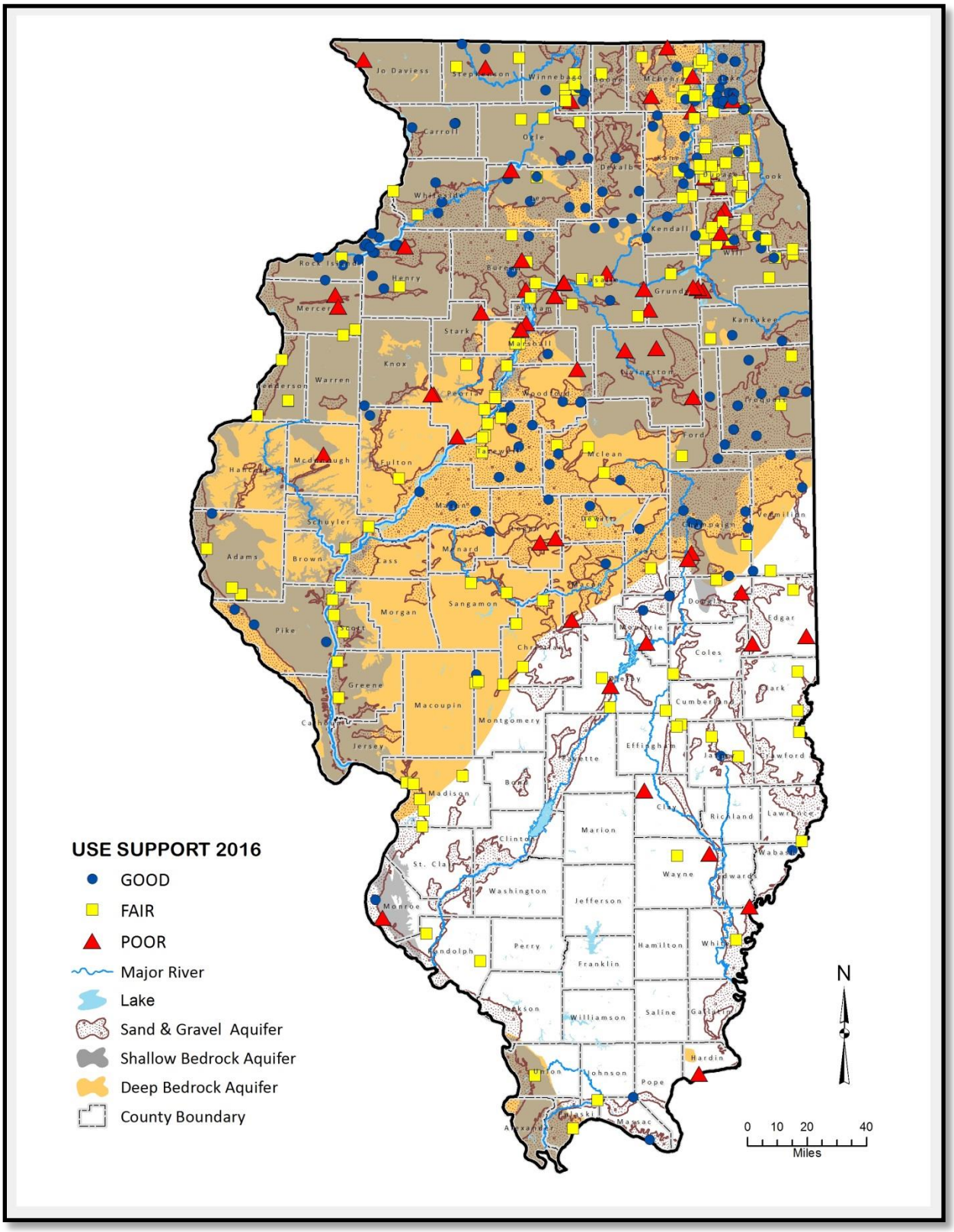


Figure C-22. Use Support for the CWS Ambient Network Wells within Illinois' Principal Aquifers

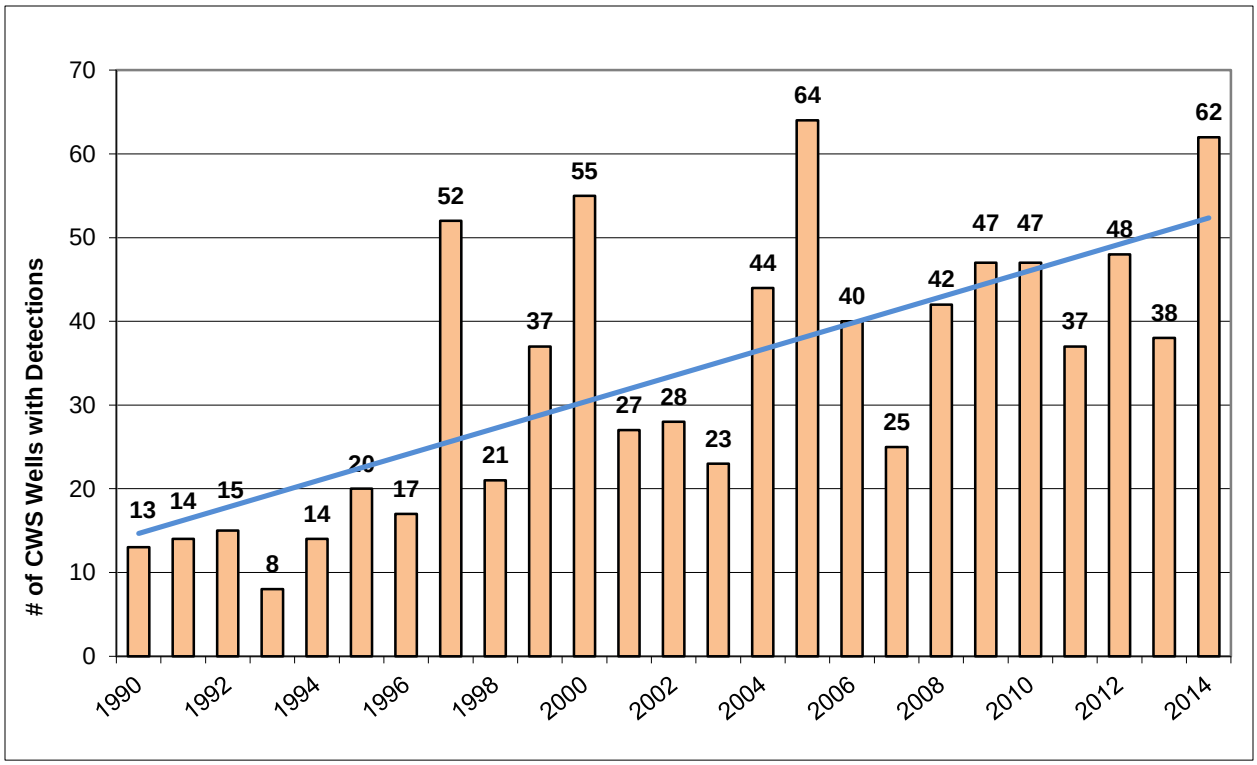


C-6. Potential Causes of Impairment

Volatile Organic Compounds in CWS Wells

As previously stated, when possible, assessments of groundwater overall use support is based upon Illinois' GWQS within the probabilistic network of CWS wells. Generally, a detection of an organic contaminant above the laboratory practical quantification limit or the detection of an inorganic constituent above the naturally occurring background level in a CWS well is considered a cause of less than full use support. To assess the potential impairment that VOCs are having on Illinois' groundwater resources, the Illinois EPA compiled groundwater monitoring data from CWS wells (1990 to the present) to complete a VOC trend analysis. The Illinois EPA included the monitoring data collected through 2014 for all of the CWS wells (not just the fixed station network wells) for this Integrated Report. While year-to-year assessment of groundwater monitoring data from CWS wells has shown fluctuations of VOCs, analyses of this data indicate a statistically increasing trend of VOC contamination in CWS wells. Unfortunately, this overall trend (i.e. blue line) has continued to increase over time as illustrated in Figure C-22.

Figure C-23. Long-term VOC Trend from all CWS Wells



As illustrated above, analyses of groundwater monitoring data collected from 1990 to the present indicates a statistically significant increasing trend of CWS wells with VOC detections per year, despite the fact that the number of CWS analyzed for VOCs over the same time period declined, and the detection limit remained constant. Evaluation of the causal data indicates that

trichloroethylene, tetrachloroethylene and 1,1,1- trichloroethane are the most frequently detected VOCs in CWS wells.

A long-term investigation by the U.S. Geological Survey continues to provide the most comprehensive national analysis, to date, of the occurrence of VOCs in groundwater. One of the major findings is that these compounds were detected in most aquifers throughout the nation, and were not limited to a few specific aquifers or regions (Morrow, 1999). For additional information on this investigation, see: http://toxics.usgs.gov/highlights/monitoring_vocs.html.

Groundwater Degradation

Illinois groundwater resources are being degraded. Degradation occurs based on the potential or actual diminishment of the beneficial use of the resource. When contaminant levels are detected (caused or allowed) or predicted (threat) to be above concentrations that cannot be removed via ordinary treatment techniques, applied by the owner of a private drinking water system well, potential or actual diminishment occurs. At a minimum, private well treatment techniques consist of chlorination of the raw source water prior to drinking. This groundwater degradation is exacerbated due to the predicted shortages of drinking water sources in the Northeastern Illinois.

It should be noted that groundwater that is consumed via a CWS has to be treated before it is delivered to the users. This treatment often includes methods for removing various contaminants, including the ones previously mentioned in this section. For more information on waters that are being consumed from CWS, the public can contact their local CWS or the applicable *Consumer Confidence Report* at
http://epadata.epa.state.il.us/water/bowccr/ccrselect.aspx

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