K-PLUS ENGINEERING, LLC

Mr. Kevin Welsh
Village of Glenwood
One Asselborn Way
Glenwood, Illinois 60425

Re: Phase I: Water Well Study
Village of Glenwood
K-Plus Project No. 24042A

Dear Mr. Welsh:

K-Plus Engineering, LLC (K-Plus) is pleased to provide the Village of Glenwood with the results of our Phase I: Water Well Study for a new community supply drinking water well to be located in Glenwood, Illinois.

We are pleased to have this opportunity to offer our services and look forward to working with you on this project.

If you have any questions regarding this proposal, please feel free to contact me at your convenience.

Sincerely,
**K-PLUS ENGINEERING**

James L. Loring, P.G.
Principal Geologist

Daniel Caplice
Senior Principal Engineer

# TABLE OF CONTENTS



## LIST OF FIGURES



## LIST OF APPENDICES

## PROJECT SUMMARY

K-Plus was asked to complete a study of local water wells, and the local and regional geology to evaluate the potential for the completion of a new community supply water well and associated infrastructure for the Village of Glenwood. The Village is seeking to provide an initial 1,500 gallons per minute of water supply with a potential to increase the pumpage and storage capacity of the system. The estimated initial daily pumpage demand was estimated at 2,160,000.00 gallons per day. Based on a review of the local geology multiple aquifers are present; however, the ability to provide the required pumping capacity and quantities would require utilizing deep aquifers or a combination of shallow and deep wells.

### *Regional Geology*

The rocks making up the Cambrian and Ordovician strata, including those that make up the Cambrian-Ordovician Aquifer (COA), occur at or near the land surface or directly below glacial deposits in parts of north-central and northwestern Illinois and into southern Wisconsin. Recharge to COA occurs in those areas generally through precipitation and surface water recharge which then flows laterally through the aquifer. Groundwater may also recharge the aquifer from other geologic units through leakage or there erosion has resulted in the direct deposition of glacial deposit's overlying the COA. Water entering the aquifer east of a line in western Boone, DeKalb, and LaSalle Counties flows eastward and southward toward Chicago; west of that line, groundwater flows generally west and south. In much northern Illinois bedrock layers slope down to the east-southeast resulting in the COA being buried by several hundred of overlying deposits in the Chicago region.

| SYSTEM | SERIES | GROUP | FORMATION | AQUIFER OR CONFINING UNIT | THICKNESS (meters) | DESCRIPTION |
|---|---|---|---|---|---|---|
| Quaternary | Pleistocene | | | Sand and gravel aquifers and till, silt, and clay confining units | 0-180 | Glacial-till, silt, gravel: windblown silt; alluvial silt, sand, gravel |
| Penn-sylvanian | | | | Confining unit | 0-150 | Mainly shale, some sandstone, limestone, coal |
| Mississippian | Valmeyeran | | St. Louis Salem Warsaw Keokuk-Burlington | | | Limestone, some shale and silty dolomite |
| | Kinderhookian | | | | 0-180 | |
| Devonian | Upper | | | Confining unit | | Shale, calcareous |
| | Middle | | | Silurian-Devonian aquifer | | Limestone, some shale |
| | Lower | | | | 0-120 | |
| Silurian | Niagaran | | | | | |
| | Alexandrian | | Kankakee Edgewood | | 0-140 | Dolomite, silty at base |
| Ordovician | Cincinnatian | Maquoketa | | Confining unit | 0-75 | Shale, locally argillaceous dolomite or limestone |
| | | Galena | | Cambrian-Ordovician aquifer system | | Dolomite and limestone |
| | | Platteville | | | 0-140 | |
| | | | Glenwood | | | Sandstone, shale at top. |
| | Champlainian | | St. Peter | | 0-200 | Sandstone. Basal shale |
| | | Prairie du Chein | Shakopee New Richmond Oneota | | | Dolomite Sandstone Dolomite |
| | Canadian | | Gunter | | | Sandstone |
| Cambrian | | | Eminence and Potosi | | | Dolomite and sandstone |
| | | | Franconia | | 30-400 | Dolomite, sandstone, and shale |
| | | | Ironton | | | Sandstone, fine-to-medium grained, |
| | | | Galesville | | 20-80 | |
| | | | | Confining unit | 75-140 | Shale siltstone, dolomite, sandstone |
| | | | Eau Claire | | | Sandstone |
| | Croixan | | Mt. Simon | Mt. Simon aquifer | 150-790 | Sandstone |

**Figure 1 - Stratigraphic column for Northeastern Illinois**

## *Regional Ground Water Usage*

The earliest known withdrawal from the COA in Chicago was in 1864, when a well was drilled at the corner of Chicago and Western Avenues. Historical reports stated that water flowed out of this well without pumping and initially had pressure to raise water in the well about 80 feet above land surface. By 1900, many wells had been drilled into the COA, causing water levels to decrease beneath Chicago, Joliet, and other major pumping centers. By the mid 1900's water was being pumped from the aquifer at a rate that exceeded the annual naturally occurring recharge. Although withdrawals by Chicago industry began to decline in the 1970s, drinking water demands increased as a result of growing populations in the Chicago metropolitan collar counties until groundwater usage peaked in 1979. By then, water levels had been lowered by as much as 850 feet in Chicago and other major pumping centers, causing an area of depressed water levels in the aquifer that extended throughout northeastern Illinois and into parts of southern Wisconsin.

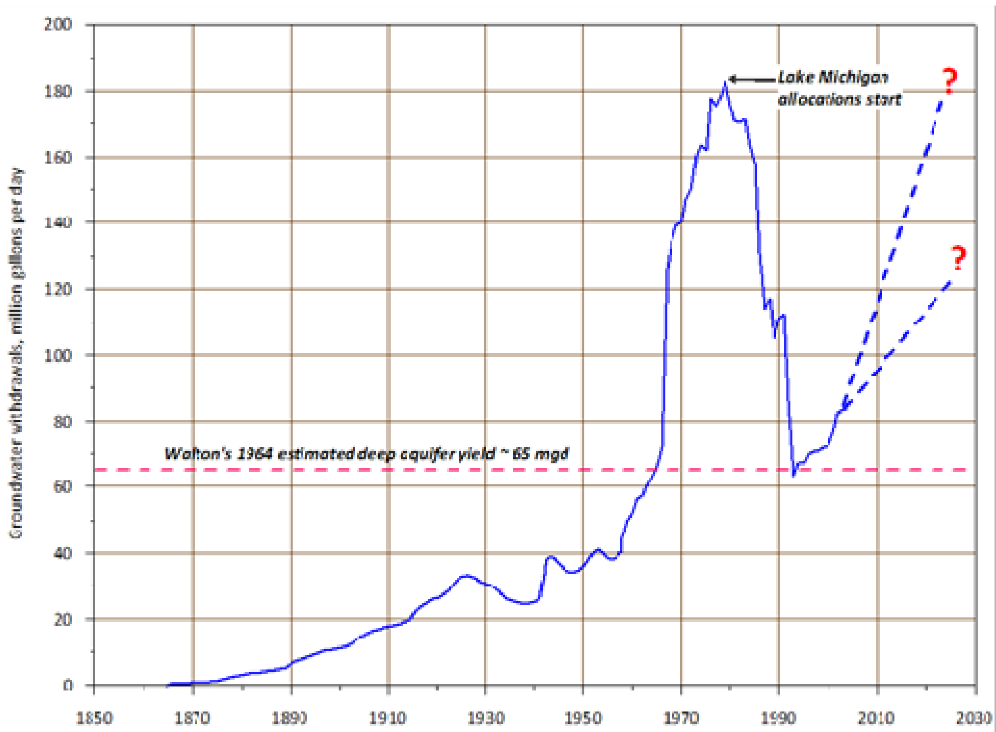


**Figure 2 - Deep water aquifer annual withdraws from 1850-2010**

After 1979, withdrawals from the COA decreased as other sources of drinking and industrial water were used, including increased withdrawals form Lake Michigan and diversion of surface water from the Fox River as well as utilizing local shallower aquifers. Concerns regarding elevated radium levels in the COA and other water-quality issues increased the use of other sources of water. Dramatic decreases in withdrawals occurred as some suburban counties began to receive drinking water from Lake Michigan in the early 1990s. Groundwater levels in the COA increased over 250 feet in and near Chicago between 1991 and 1995. Subsequently pumpage levels bottomed out and started to increase in the period after 2000. Continued increases in pumping may again lower water levels in the COA and other aquifers now in use as withdrawals exceed the natural recharge rate.

For more than a century, groundwater has been used by industries throughout the Chicago region and for drinking water in most suburban areas. Many early wells were drilled into sand and gravel near land surface and into the underlying bedrock. Any layer of rock or sediment that can yield useful quantities of water to a well is called an aquifer. In northeastern Illinois four main aquifers are present: sand and gravel within the Quaternary glacial deposits at or near land surface, shallow bedrock composed mostly of dolomite of the Silurian System that underlies the glacial deposits, and two deeper bedrock aquifer systems composed mostly of sandstones of the Cambrian and Ordovician Systems. Of the deep aquifers the uppermost is the most important and more heavily used. It comprises two different geologic units, the Glenwood-St. Peter and the Ironton-Galesville Sandstones that are often grouped together with other rock layers and called the Cambrian-Ordovician Aquifer (COA). Water produced from the deepest bedrock aquifer, the Mt. Simon

Sandstone, is generally too saline for domestic or industrial use, particularly in the southern and eastern parts of the Chicago region. Figure 3 below illustrates the major north communities that utilize the deep COA. The figure is form an Illinois State Geological Survey mid 1980's publication and it should be noted that DesPlaines, Elk Grove Village and Elmhurst no longer use the COA and have been utilizing Lake Michigan water. However new users of the COA include Western Springs and Yorkville replacing prior users.



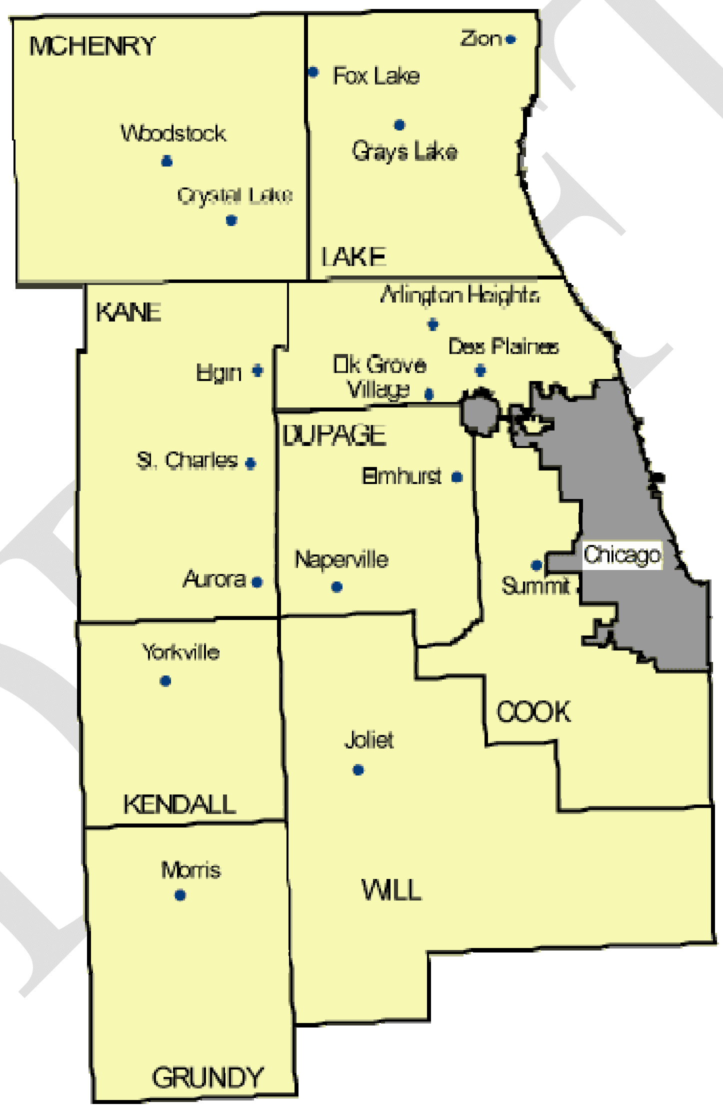


**Figure 3 - Northeastern Illinois with major metropolitan deep water aquifer users from 2005.**

## *Water Quality: Deep Aquifers*

The most important water quality issues pertaining to deep bedrock (Cambrian-Ordovician) aquifers in northeastern Illinois are elevated levels of naturally occurring radium, barium, and total dissolved solids (TDS).

TDS concentrations generally increase from northwest to southeast across northeastern Illinois. A larger part of Lake, Cook, and Will Counties have TDS concentrations above the secondary drinking water standard (500 milligrams per liter or mg/L), and TDS concentrations in the extreme southeastern part of the area are high enough to make the water unpotable without substantial treatment, which is uneconomical at this time.

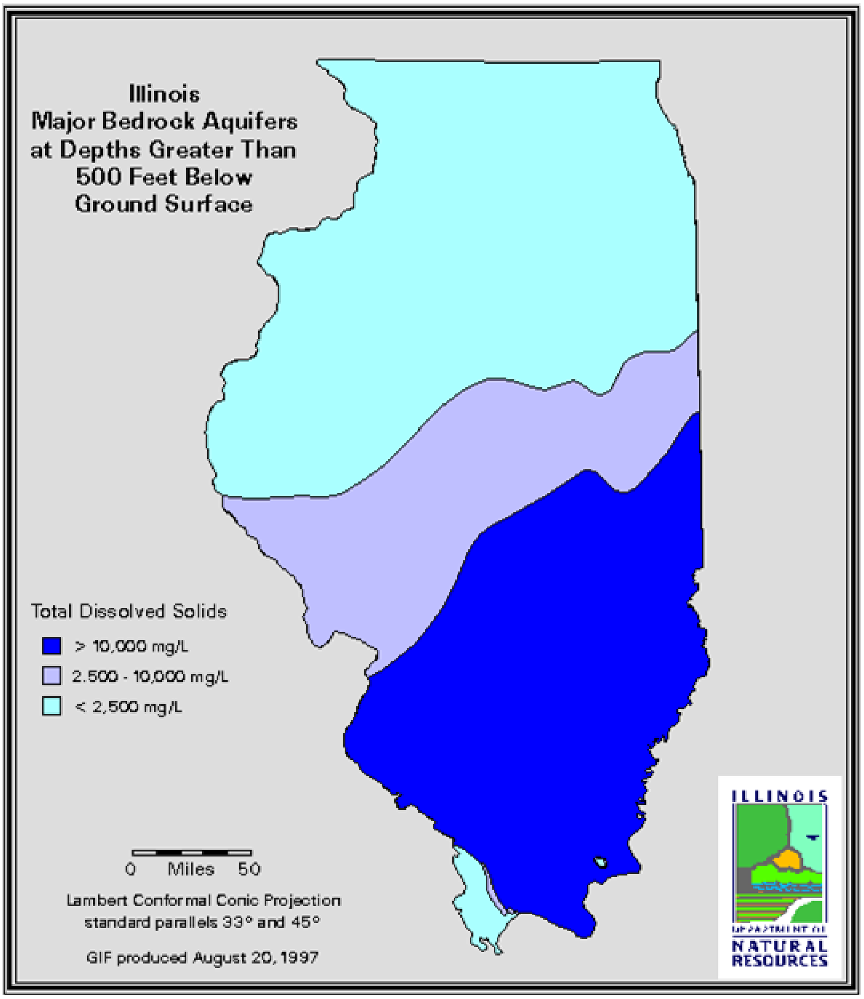


**Figure 4 - Total Dissolved Solids in the Major Deep Bedrock Aquifers in Illinois.**

In general changes in the COA occur as bedrock dips to the east toward the Michigan Basin. As water moves to the east from the western recharge area the water type changes form a calcium bicarbonate to a sodium bicarbonate to sodium sulfate with increases in TDS. Data from the 1985 Geology, Hydrology, and Water Quality of the Cambrian and Ordovician Systems In Northern Illinois, Illinois Ste Geological Survey Cooperative Groundwater Report 10 provides TSD water quality data indicating Cook County had TDS concentrations for, 354 to 453 ppm. The report identified the Glenwood #5 water well unfortunately no water quality data was available. The well was listed as completed in 1969 to a depth of1,785 feet. Current local water quality data was not available however it is anticipated that similar TDS concentrations would generally be in a range up to 500 ppm resulting in a need for post production water treatment.

Radium concentrations above the primary drinking water standard (5 pico curries per liter or pCi/L) are found in water pumped from the deep bedrock aquifers throughout northern Illinois, including all counties in the Chicago metropolitan area. Public water systems reduce radium concentrations by ion-exchange softening, lime softening, filtration, and/or by blending low-radium water from surface water sources or shallow aquifers such as the Silurian Dolomite. Resulting in an increased production cost due to post production treatment.

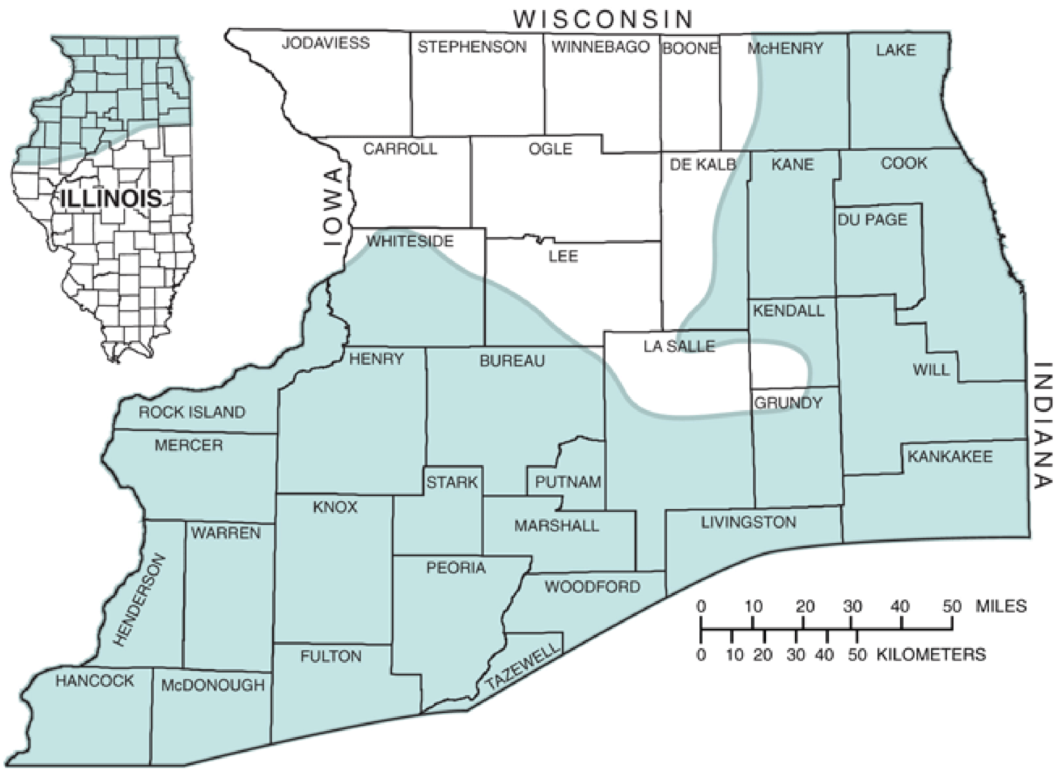


**Figure 5 - Areas where combined radium (226Ra + 228Ra) concentrations exceed 5 pCi/L in the deep bedrock aquifer system.**

Barium concentrations above the primary drinking water standard (1 mg/L) are documented in water pumped from the deep bedrock aquifers in the northeastern part of the Chicago metropolitan area. This includes most of Kane and McHenry Counties and parts of Cook and Lake Counties. Extremely high concentrations (>5 mg/L) occur within the region and pose a health risk. Also Barium levels increase over time, particularly in the deep aquifer. Barium can precipitate out of solution as the mineral barite in wells, resulting in reduced well productivity and high maintenance costs. Barium is removed from drinking water supplies by ion exchange softening and lime softening and would be removed during the same processes involved to remove Radium.

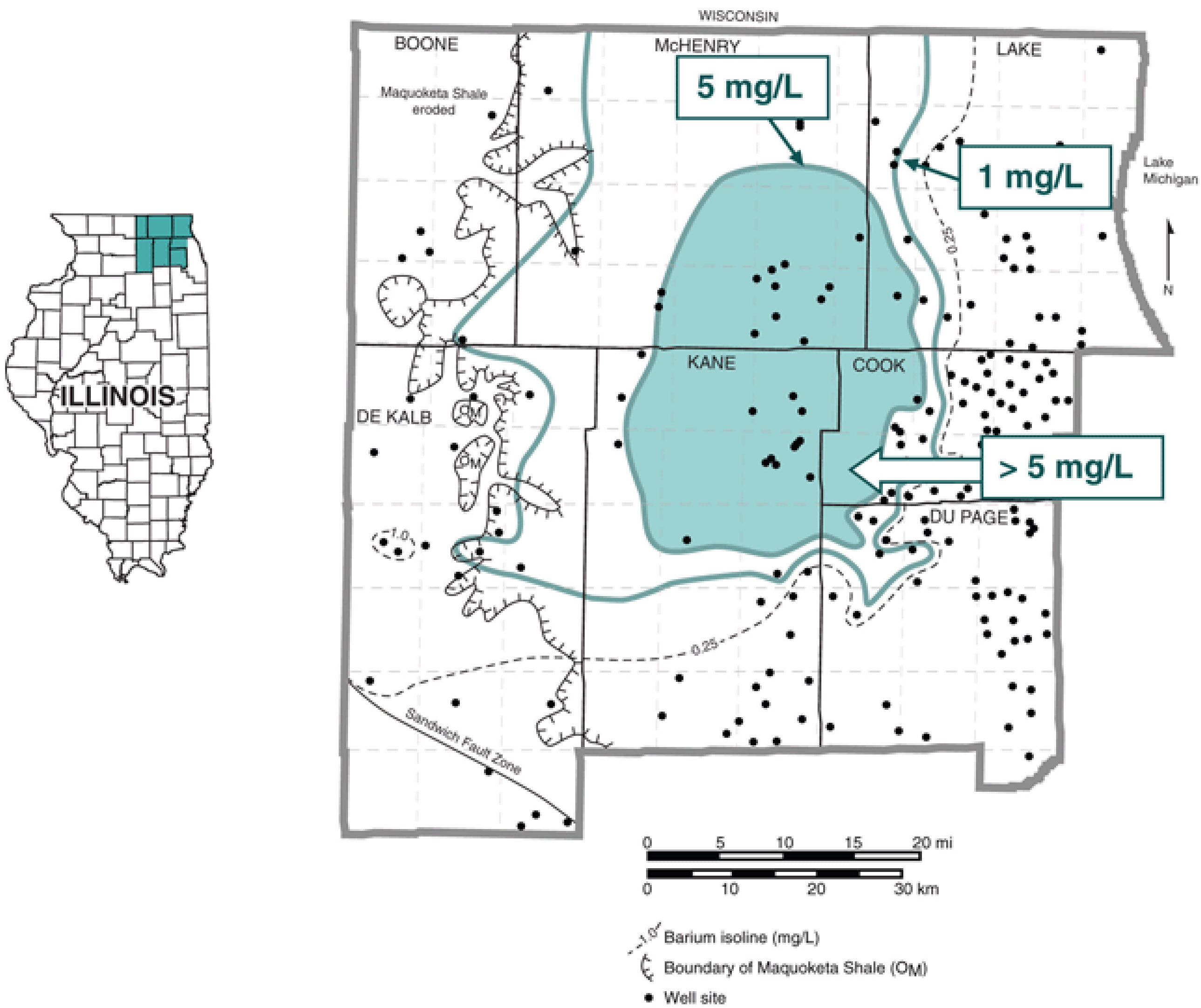


**Figure 6 - Areas where Barium exceeds the 5 mg/L concentrations in the deep bedrock aquifer system**

In approximately 2005 Illinois State Water Survey began evaluating the threat that increased pumping from the deep bedrock aquifers beneath northeastern Illinois may increase levels of TDS, radium, and barium. Preliminary examination of historical data suggests that while TDS levels have not been increasing in wells open to deep bedrock aquifers in most of northeastern Illinois, levels may be increasing at some major pumping centers including the municipalities of Joliet and Aurora. The final data regarding the study has not yet been released. Assessments of trends in radium and barium concentrations have not been done, and there is a lack of historical radium data.

### *Water Quality: Shallow Aquifers*

As continued demand adds pressure to the local sources and concern over the quality of the deeper aquifers grows the ability to provide sufficient water resources becomes more critical to local communities. Demands from population growth and development in northeastern Illinois place a heavy demand on water resources. As determined by the Supreme Court and by agreement with other states and Canada, Lake Michigan Diversion U.S. Supreme Court degrees limit Illinois to diverting an average of 3,200 cubic feet per second (cfs) from Lake Michigan. Illinois has exceeded that amount 11 of the 15 years from 1981 through 1995. Essentially, Lake Michigan water is already fully allocated. Add to that the fact that withdrawals from deep bedrock aquifers may also be approaching their sustainable limits, shallow bedrock and overlying sand-and-gravel aquifers are expected to be an important source of additional water to meet the increased demand. Estimates ranging as high as 500 million gallons/day have been published as being available in the shallow aquifers according to the Illinois State Water Survey Report of Investigations (1976).

As opposed to the deeper bedrock aquifers shallow aquifers are more vulnerable to surface contamination. Sources of surface contamination are many and are found throughout the typical community and include: landfills, sewage treatment plants, industrial effluents, atmospheric deposition, septic fields, underground and above ground storage tanks for petroleum products including gasoline and diesel fuel and road runoff from stormwater. The large list of potential contaminants includes various organic classes (e.g., petroleum compounds, solvents and pesticides), toxic metals (e.g., cadmium, lead and chromium), chloride, sulfate, nitrogen, and high total dissolved solids (TDS). Chloride concentrations have been increasing in many shallow wells in northeastern Illinois, primarily due to road salt runoff. The figure below shows a study conducted in Kane County from three different time periods. Data from the first two periods were pulled from the ISWS water quality database, the last is from Kelly (2005). Municipalities are outlined; gray areas indicate aquifer material within 50 ft of the land surface. Though this data is from Kane County, chloride concentrations may be found in local water due to the increasing urbanization of the area. In the future, if not already, elevated chloride levels may be seen in this aquifer.

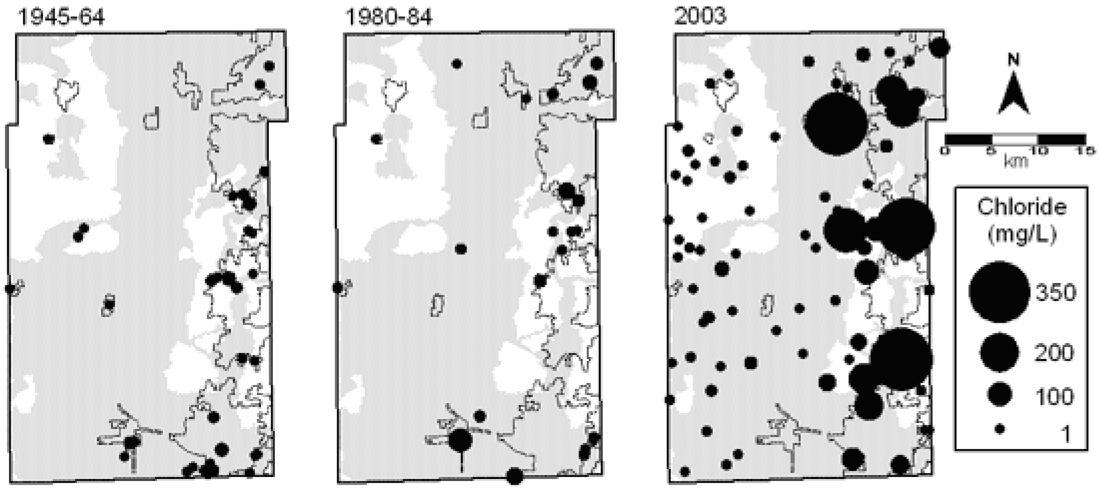


**Figure 7 – Increasing chloride concentrations (mg/L) over time**

Shallow groundwater quality was reported to be significantly worse in the urban eastern part of Kane County compared to the western rural part of that county. Locally the shallow aquifers have been impacted from local historical sources as has occurred in Sauk Village as result of uncontrolled releases of chlorinated solvents.

The proposed future well site was identified as a lot located within the Glenwood Science Park Subdivision, which was located near Glenwood-Chicago Heights Road north east of the intersection of Holbrook Road (Site). Since this well is proposed in a developing industrial area of Glenwood, K-Plus consulted government databases of registered sites that have experienced releases of contamination, or those businesses that use/store hazardous materials. K-Plus utilized Environmental Data Resources to conduct a standard environmental record search in accordance with the ASTM standards. The specific databases consulted, the publication dates, and the search results are included in a database report included in the Appendix.

The EDR database report identified the following sites within the standard ASTM search radius: one (1) CERCLIS facility; one (1) RCRA-Gen listing; five (5) LUST listings; one (1) UST listing and two (2) SRP enrolled listings.

Glenwood Public Works (19100 Glenwood Chicago Heights Road) was identified on the UST database with four removed Underground Storage Tanks (USTs). Three USTs were identified as 6,000-gallons in size and stored gasoline and diesel fuel. One UST was identified as 600-gallons in size and stored heating oil. This site was not identified on the LUST database, indicating that during the removal no tanks experienced releases.

Landauer Inc. (3 Science Road) to the north of the property was identified on the RCRA-SQG and Finds databases. A RCRA-Small Quantities Generator site stores/produces more than 100 and less than 1,000 kg of hazardous waste per calendar month. This site was registered in 2009 as a SQG, however dating back to 1989 this site was a Large Quantities Generator. Landauer was identified as generating ignitable wastes (D001), corrosive waste (D002), silver (D011) and MEK (D035). No violations were reported for this facility.

These two facilities were the only sites located within 1/8 mile of the property, however at least 11 surrounding area properties were identified on environmental databases within one mile of the property.

## *Existing Local Ground Water Use:*

K-Plus completed a review of Illinois State Water Survey/Geological Survey water well records for a nine section area immediately surrounding the proposed well site within the Village of Glenwood. An Illinois State Geological Survey Questor Custom Map and the results of our well log search are included in the Appendix of the report. The search identified 73 well records with nineteen (19) of the records for shallow wells less than 100 feet in depth, forty-eight (48) records for wells 100 to 500 feet in depth and six (6) records for wells over 500 feet in depth. Generally, but not as a rule, wells completed less than 100 feet are typically completed in shallow sand and gravel aquifers of limited horizontal extend, with wells less than 500 feet in depth completed in the Silurian limestone. Wells deep than 500 feet are typical of the Cambrian-Ordovician Aquifer (COA) Wells that are generally 1000 to 1500 feet in depth.

Of the available well records reviewed, two were for wells completed for the Village of Glenwood #3 and #5 (no information was included in the file from the ISGS regarding Glenwood wells #1, 2 and 4). The Glenwood Village Well #3 was identified as located on Center Street, and listed as completed in 1964 to a total depth of 1789 feet. Geological formation tops were listed as Silurian 40 feet, Maquoketa 482, feet, Galena 665 feet, St Peter 989 feet and the Eau Clarie 1788 feet. According to the driller notes a pumping level of 502 feet was observed after pumping at 745 gpm for 12 hours. Glenwood Village Well #5 was located on E. 192nd Street, and listed as competed in 1969 with a total depth of 1785 feet with geological formation tops were listed as Silurian 44 feet, Maquoketa 473, feet, Galena 680 feet, St Peter 1012, Ironton 1607 feet and the Eau Clarie 1769 feet. All of the public drinking water supply wells were decommissioned and sealed in the approximately 1988-1989 in order to connect to the Lake Michigan drinking water. There is a possibility, depending on the way these wells were decommissioned, to reactivate these old wells to act as test wells in order to provide accurate quality information for the treatment plan.

Providing an estimated depth to geological formation as follows:

| | |
|---|---|
| Silurian | 42 feet |
| Maquoketa | 477 feet |
| Galena | 673 feet |
| St Peter | 1000 feet |
| Eau Claire | 1778 feet |

The original well at the Glenwoodie Golf & Country Club (Glenwoodie) was installed in approximately 1930 to a total depth of 269 feet. A second well at the Glenwoodie was installed in 1963 to a total depth of 351 feet. According to the driller notes the static water level was observed at 18 feet. Drawdown water level was noted at 242 feet at 292 gallons per minute for 7.5 hours. A third well was installed in 1987 to a total depth of 475 feet. According to driller notes the pumping level was established at 133 feet when pumping at 400 gpm for 16 hours.

A property to the north of the site at 2 Science Road installed an irrigation supply well in 2003 to a total depth of 780 feet. According to the driller notes, a pumping level of 300 feet was observed when pumping 30 gpm for 2 hours.

K-Plus submitted Freedom of Information Act Requests to the Illinois Environmental Protection Agency (IEPA) Bureau of Water and the Illinois Department of Public Health for more information on the quality of these local wells. However that information has not been received as of the date of this report.

## RECOMMENDATIONS

Based on communications with K-Plus the Village would like to be able to provide 1,500 gallons per minute or 2,160,000 gallons of groundwater each day to its system. To safely produce the quantity of water and to assume stainable yields we offer the following recommendations and options; all will require post production water treatment:

**Option one:**
The installation of a deep geological well to a depth of approximately 1,800 feet. The well should be proposed to penetrate the geological column to the upper Eau Claire Formation to a depth of approximately 1,800 feet and should be capable of producing the required volume of water assuming appropriate well sizing. Water quality would require surface treatment to reduce TDS, Radium (>5 pCi/L) and Barium (<1 mg/L). Deep aquifer wells can also expect a high iron content and elevated levels of sodium.

**Option Two:**
The installation of two or three shallow depth wells completed in the Silurian at depths of approximately 500 feet could produce sufficient quantities of water if well diameter is sufficient and good fracturing and porosity are encountered. Surface treatment of the water would be necessary and the shallow aquifers would be more susceptible to local and regional contamination from surface and near surface releases. Shallow depth wells typically show issues with erratic quality.

**Option Three:**
Completion of a deep and one or two intermediate and/or shallow wells. This option is the most prudent as the deep well could be cycled to reduce aquifer stress and water from the multiple aquifers could be utilized. As drawdown of individual wells occurs the wells could be cycled to reduce overall drawdown and maintain aquifer water levels over a longer period of time.

While the shallow depths can provide short term sufficient quantities both increased local ground water use demand and longer term sustainability of the shallow ground water resources as well as the potential for contamination are in question. The deep aquifers within the region are at or near sustainable yields and recent reports indicate that the peak yields may be approaching with resulting declines in water levels within the deeper aquifers. If unstainable water levels within the aquifers occur increased post production treatment of the water can be anticipated. In addition installation of multiple wells would allow for rotation of well pumping and "cycling" allowing aquifer stabilization and recharge.

**Option Four:**
Investigate the condition of the former municipal wells, specifically former Well #3 and former Well #5 to see how they were decommissioned and closed. If these wells were only capped, and are still in good condition, it may be possible to re-open these wells in order to complete the quality tests. And depending on the quality of the well it may also be possible to reopen these wells to connect to the Village supply at a significant cost savings to the Village.

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