McCullom Lake Evaluation Report

June 2, 2011

Executive Summary

The Illinois Environmental Protection Agency (Illinois EPA), has reviewed private residence data collected and analyzed by the Underwriters Laboratory (UL) in McCullom Lake. Illinois EPA has completed evaluation of the data and the following is a summary of the findings:

- Vinyl chloride was not detected in any of the McCullom Lake private drinking water system residences;
- 1,1-Dichloroethylene was not detected in any of the McCullom Lake private drinking water system residences;
- No other Perchloroethylene or Trichloroethylene degradation products were detected in any of the McCullom Lake residences;
- 5.3% McCullom Lake private residences detected low levels of volatile organic compounds (VOC) and/or synthetic organic compounds (SOC);
- No drinking water standards established for VOC/SOCs were exceeded;
- 95% of the residences sampled detected no organic chemicals;
- Some of the organic compound sample detections appear to be related to poly vinyl chloride solvent chemicals;
- Other organic compounds detected appear to be related to furniture stripping and restoration;
- 19 milligrams per litter (mg/L) of chloride appears to represent a background concentration in McCullom Lake;
- 17.5% of the residences showed a chloride concentration of greater than 200 mg/L;
- 14% of the residences showed a chloride concentration of greater than 100.1 but less than 200 mg/L;
- The United States Environmental Protection Agency and the Illinois Pollution Control Board have established a secondary drinking water standard for chlorides of 250 mg/L;
- Data suggests that the high concentration of chlorides may be residual from historical use of septic systems for residents that softened hard water;
- 63% of the residences with organic chemical detections also had high chloride detections;
- The groundwater flow direction in all aquifers appears to be moving from the northwest to the southeast toward McCullom Lake; and
- There are no indications of VOC, SOC or chloride contaminant plume(s).

UL has provided the sampling data to the residents and followed up with them if there were detections to explain any potential health effects.

Introduction/Background

The Village of McCullom Lake hired Underwriters Laboratory (UL) to do a sampling and analysis of private residences (using private drinking water system wells), which was paid for by Rohm and Haas. UL has provided the sampling data to the residents and followed up with them if there were detections to explain any potential health effects (Black, 2011). The village president authorized UL to provide this data to the Illinois EPA. Illinois EPA staff indicated to the village president that when our analysis was completed we would provide him with the results.

The Village of McCullom Lake is located in McHenry County, south of Ringwood, and north of McHenry, as shown in Figure 1.

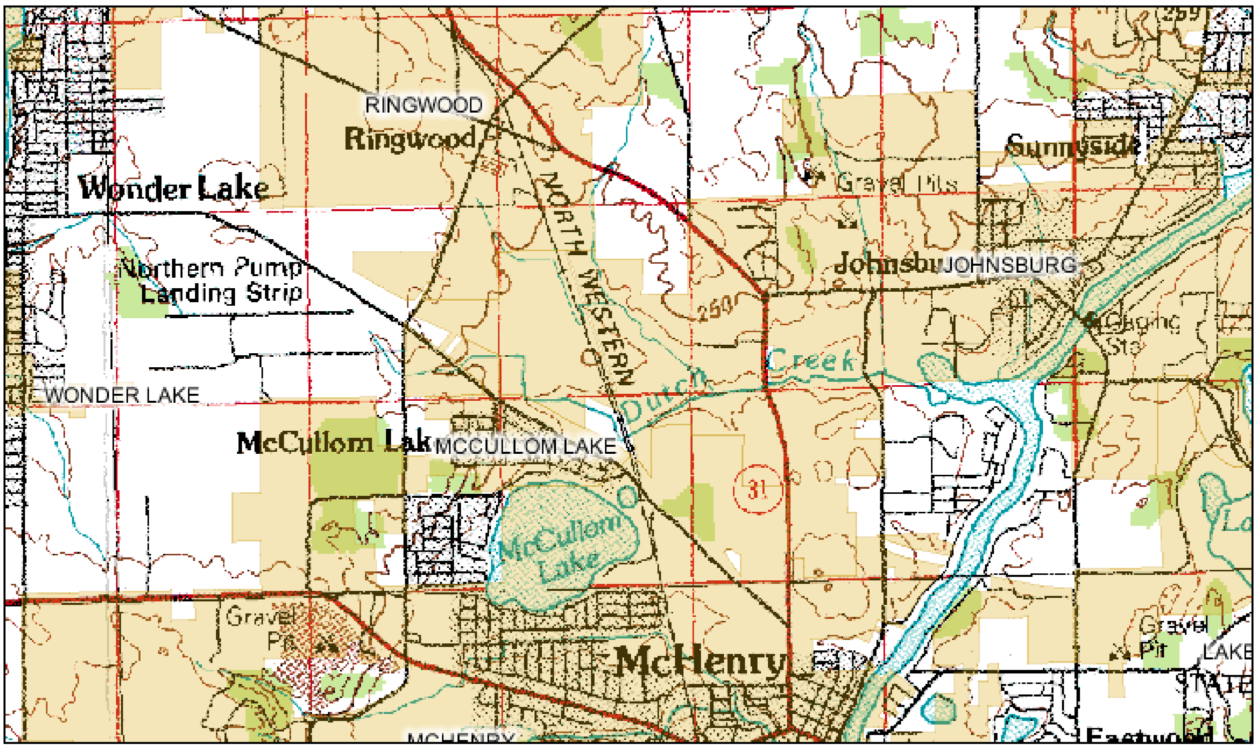

Figure 1. Map of the Village of McCullom Lake

UL Sampling Program

UL collected and analyzed samples (~1,350 samples) from approximately 300 homes in McCullom Lake, as shown in Appendix I. All of these homes are using ***private drinking water system wells***. Historically, all of the homes used ***private sewage disposal systems.*** Staring in approximately 2002 or 2003 private disposal systems started to be abandoned and residences were hooked up to a municipal sewer system. Approximately, 24 residents are still utilizing a private sewage disposal system versus a municipal sewer system. Sometimes multiple samples were collected at each residence in McCullom Lake. It should be noted that the samples were not taken from raw water taps on the private drinking water system wells. They were instead taken at the locations detailed in Table I below. Thus, the contaminants in Table I could be from groundwater withdrawn from the private drinking water system well or could be from other parts of the private drinking water system infrastructure. However, if groundwater was contaminated it should have been detected in the sample results because private drinking water systems do not routinely treat for the contaminants found.

Illinois EPA staff referenced the address data associated with the UL water quality sampling data to digital Parcel Identification Number (PINs) [obtained from McHenry County ***Geographic Information System***[1] (GIS)]. ArcGIS© was used by Illinois EPA staff to develop the maps in this evaluation.

[1] "GIS" means a system that captures, stores, analyzes, manages and presents data with reference to geographic location data. In the simplest terms, GIS is the merging of cartography, statistical analysis and database technology.

Table I. VOCs and SOCs detected in McCullom Lake Private Drinking Water Systems				
Client ID Sample ID	**Date/Time**	**Analyte Result Flag Result (ug/L[2])**	**MRL[3] (ug/L)**	**Class I - Standard**
332@Outside Tap Field Sample	12/13/2010 13:35	TCE = 0.6	0.5	5
358@Outside Tap Field Sample	12/13/2010 3:30	1,1,1-Trichloroethane (TCA) = 1.2	0.5	200
401@Kitchen Sink Field Sample	12/13/2010 14:11	1,1,1- TCA = 0.7	0.5	200
404@Outside Tap Field Sample	12/13/2010 14:18	1,1,1- TCA = 1.2	0.5	200
459@Outside Tap Field Sample	12/20/2010 11:50	4-Methyl-2-pentanone (MIBK) = 3.7 Chloroethane = 1 Cyclohexanone = 5.2 tert-Butyl alcohol= 20 Tetrahydrofuran (THF) = 7	2 0.5 5 2 5	
415@OutsideTap Field Sample	12/13/2010 14:28	1,1,1- TCA = 2	0.5	200
542@Bathroom Tap Field Sample	12/6/2010 10:13	TCE= 1.1	0.5	5
180@Kitchen Tap Field Sample	12/21/2010 9:24	Styrene = 1.8	0.5	100
486@Well 2 Field Sample	12/13/2010 15:30	PCE = 4	0.5	5
451@Outside Spigot Field Sample	12/20/2010 8:26	THF = 11	5	
464@ Kitchen Sink Field Sample	12/7/2010 12:09	1,2-Dichloroethane (DCA) = 0.6	0.5	0.5
612@Kitchen Sink Field Sample	12/7/2010 15:25	1,1,1- TCA = 0.7	0.5	200
273@ Kitchen Sink Field Sample	12/14/2010 10:13	Cyclohexanone = 35 THF = 89	5 5	
545@Outside Spigot Field Sample	12/6/2010 10:35	1,2-DCA = 0.7 THF = 5.1	0.5 5	0.5
389@Kitchen Tap Field Sample	12/13/2010 7:55	Styrene = 0.6	0.5	100
Chloride Field Sample	12/6/2010 10:35	2-Butanone (MEK) = 5.4	5	Proposed 4,200

[2] "ug/L" means microgram per liter or parts per billion.
[3] "MRL" means the minimum laboratory reporting level.

Evaluation of the contaminants detected shows some commonality in uses;

Table II. Common Uses of the VOCs and SOCs Detected in the McCullom Lake Private Drinking Water Systems (Montgomery, John H. and Linda M. Welkom, 1990)	
Contaminant	**Common Uses**
2-Butanone or (MEK)	**Solvent in nitrocellulose coatings**, vinyl films, and Glytal resins, **paint removers, cements and adhesives**; organic synthesis; manufacturing of smokeless powders, ketones and amines, cleaning fluids, printing, catalyst carrier, and acrylic coatings.
tert-Butyl alcohol	Denaturant for ethyl alcohol, manufacturing flavors, perfumes, flotation agent, **solvent, paint removers**, octane booster from unleaded gasoline, dehydrating agent, and chemical intermediate.
Cyclohexanone	**Solvent** of cellulose acetate, crude rubber, **natural resins, nitrocellulose, vinyl resins**, waxes, fats, oils, shellac, DDT and other pesticides, preparation of adipic acid and caprolactum, **wood stains, paint and varnish removers; degreasing of metals; spot remover;** lube oil additive, and a leveling agent in dyeing and delustering silk.
1,2-DCA	**Vinyl chloride solvent**, lead scavenger in antiknock unleaded gasoline, **paint, varnish, and finish remover, metal degreasers,** soaps and scouring compounds, wetting and penetrating agents, organic synthesis, ore flotation, tobacco flavoring, and soil and foodstuff fumigant.
4-Methyl-2-pentanone (MIBK)	**Solvent for nitrocellulose**, gums**, resins**, roll coating inks; **varnishes, lacquers, stains, and enamels**, starting material for synthesizing methyl isobutyl ketone, insect repellant, and ore flotation.
PCE	Dry cleaning fluid, **degreasing** and drying metals and other solids, solvent for waxes, greases, fats, oils, gums, manufacturing printing inks and **paint removers**, preparation of fluorocarbons and trichloroacetic acid, verifuge, and organic synthesis.
Styrene	Preparation of polystyrene, synthetic rubber, **resins,** protective coatings and insulators.
Tetrahydrofuran	**Solvent for** uncured rubber and **polyvinylchlorides (PVC), vinyl chloride copolymers, natural resins**, top coating solutions, cellophane, polymer coating, magnetic tapes, adhesives, printing inks, and organic synthesis.
1,1,1-TCA	Organic synthesis, **solvent** for metal cleaning of precision instruments, textile processing**, aerosol propellants**, and pesticide.
TCE	Dry cleaning fluid**, degreasing** and drying metals and electronic parts, extraction solvent for waxes, and fats, oils, solvent for cellulose esters and ethers, removing caffeine from coffee, refrigerant and heat exchange liquid, fumigant, **diluents in paints and adhesives;** textile processing, aerospace operations (flushing liquid oxygen), anesthetic, medicine, and organic solvents.

Table I and appendix I shows ***detects***[4] of the VOCs and other synthetic organic compounds (SOC) that were found in 16 out of 300 (5.3 %) McCullom Lake private drinking water systems that were sampled and analyzed. The yellow dots on the Appendix I map represent residences without detections. Ninety five percent (95%) of the residences sampled detected no organic chemicals. Some of the sample detections appear to be related to PVC solvent chemicals, as described above and in Table II. One would expect these contaminants to dissipate over time due to volatilization. Table II also shows that some of chemicals detected appear to be related to furniture stripping and restoration, including 1,1,1-Trichloroethane (1,1,1-TCA) which is used as a propellant in nitrocellulose aerosol lacquers.

UL Organic Compound Sampling Results and Discussion

Vinyl chloride was not detected in any of the samples, except for an initial sample that was not confirmed, as described below. Nor were any of the other PCE or Trichloroethylene (TCE) degradation products [i.e. cis 1,2, Dichloroethylene (cDCE), trans 1,2-Dichloroethylene (tDCE), or 1,1-Dichloroethylene (1,1-DCE)] detected in any of the samples.

UL did initially detect VC at 459. However, after further investigation, it was discovered that the water actually came from a ~30 gallon holding tank that had been stagnant for about 3-4 months prior to sampling. Prior to the stagnation period, the homeowner had installed about 20-25 feet of plastic pipe [polyvinyl chloride (PVC)], joints and the holding tank itself. The water was never flushed after installation. UL had the homeowner flush the entire water system and then went back and collected samples at two different locations at the residence. The results from the recollection contained no VC or other associated PCE/TCE degradation chain compounds (Trowbridge, 2011). However, chloroethane, cyclohexanone, tert-butyl alcohol, and tetrahydrofuran (THF) were detected at the same address. Appendix II details the chemicals in one brand of PVC primer and adhesive. This specification sheet indicates that the primer, in this particular product, is composed of THF, cyclohexanone, and methyl ethyl ketone (MEK).

Most PVC applications, i.e. the ones they are designed for, do not require a very critical procedure for joining pieces together, because most of the time the fluid going through them is not under pressure. However, certain high-strain applications require that the joints are strong and airtight. Water service lines and plumbing are under pressure and do need to be water tight and pressure resistant. The way to achieve that is proper solvent welding. PVC cement is a solvent. Welding involves melding two pieces of the same material into one. When you solvent weld PVC, you are actually turning the two sides that you are joining into PVC mush, the molecules all blend together, and what you are left with is essentially one single piece of PVC.

THF was detected in four residences in McCullom Lake. One residence showed the highest concentration of THF at 89 ug/L and 35 ug/L of cyclohexanone. The Illinois Pollution Control Board (Board) does not have groundwater or drinking water standards for these two contaminants. However, toxicologists in the Illinois EPA's Office of

[4] "Detects" means that the concentration is above the minimum reporting levels (MRL).

Chemical Safety (OCS) have developed a groundwater ingestion number of 35,000 ug/L for cyclohexanone. Thus, the concentration of cyclohexanone is 3 orders of magnitude below a level of concern. **There is currently insufficient toxicological data to develop a value for THF.** MEK was also detected at one residence at a concentration of 5.4 ug/L and the proposed groundwater standard is 4,200 ug/L. Another ketone (MIBK) was detected at one residence at a concentration of 3.7 ug/L. OCS toxicologists have developed a groundwater ingestion level of concern to be 560 ug/L for MIBK.

PCE was detected at one residence at a concentration of 4 ug/L and the groundwater standard is 5 ug/L. Additionally, TCE was detected in two residences at concentrations of 1.1 and 0.6 ug/L and the groundwater standard is 5 ug/L. The MRL is 0.5 ug/L.

In addition, the VOC 1,1,1-TCA was detected at five residences at concentrations of 1.2, 0.7, 1.2, 2.0 and 0.5 ug/L. These concentrations are significantly below the groundwater standard of 200 ug/L. The MRL is 0.5 ug/L.

Lastly, the chemical styrene was detected at two residences at concentrations of 1.8, and 0.6 ug/L. These concentrations are also significantly lower than the groundwater quality standard of 100 ug/L, and the MRL is 0.5 ug/L.

UL Inorganic Compounds Sampling Results and Discussion

In addition to the organic contaminants that were analyzed by UL for the village, ***inorganic compounds*** (IOC) were also analyzed. In particular, chloride and methyl iodine were analyzed by UL.

Methyl iodine was not detected in any of the samples taken from McCullom Lake residences. Chloride was however found in a substantial number of residential samples. Statistical analysis of the chlorides from the McCullom Lake residences indicated that out of 273 detects the:

- Mean concentration of chloride = 77 mg/L;
- Median concentration of chloride = 19 mg/L;
- Minimum concentration of chloride detected was 2 mg/L; and
- Maximum concentration of chloride detected was 480 mg/L.

Figure 1 illustrates the ***normalized statistical model*** represented by a box plot[5] (Helsel & Hirsch, 1993).

[5]" In descriptive statistics, a box plot or boxplot (also known as a box-and-whisker diagram or plot) is a convenient way of graphically depicting groups of numerical data through their five-number summaries: the smallest observation (sample minimum), lower quartile (Q1), median (Q2), upper quartile (Q3), and largest observation (sample maximum). A boxplot may also indicate which observations, if any, might be considered outliers (Helsel & Hirsch, 1993).

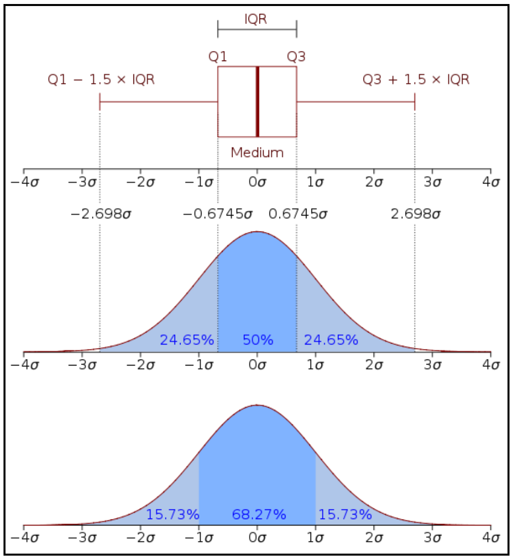

Figure 1. A Probability Density Function of a Normal N(0,1σ^2) Population is Represented In A Box Plot (Helsel & Hirsch, 1993)

Figure 2 is a box plot for the McCullom Lake chloride data. The Illinois State Geological Survey (ISGS) conducted a comprehensive study of chlorides in groundwater which determined **15 mg/L to be the high end for background Cl- concentrations in shallow groundwater in Illinois** (Panno et al. 2006). Moreover, a recent national study (that included northeastern Illinois) conducted by the U.S. Geological Survey entitled *Chloride in Groundwater and Surface Water in Areas Underlain by the Glacial Aquifer System, Northern United States* (Mullaney, et al., 2009) concluded on page 15 that:

> Groundwater samples collected from wells in the land-use studies contained different distributions of chloride depending on the dominant land use. The largest median concentration of chloride in samples from urban land-use wells was (46 mg/L) and was about 16 times larger than median concentrations in samples from forested land-use wells (2.9 mg/L). The median concentration of chloride in drinking-water supply wells was 26 mg/L in public –supply wells and **12 mg/L in private domestic wells**.

Thus, it appears that the median concentration of 19 mg/L represents the background concentration of chloride in McCullom Lake.

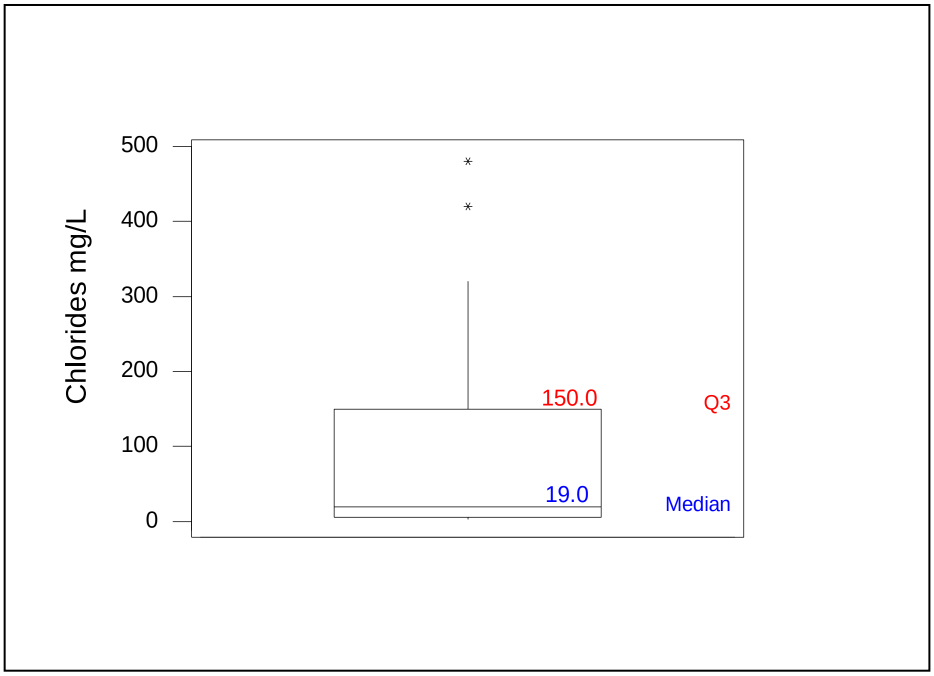

Figure 2. Box Plot of The Mccullom Lake Private Drinking Water System Chloride Samples

In addition to the statistics, maps were developed to show the spatial distribution of chloride detections. The result for each residence is shown by a symbol that is graduated relative to concentration, as illustrated in Appendix III. The distribution of private drinking water system chloride sample concentration results is:

- 152 (55%) residences < 25 mg/L;
- 20 (7.3 %) residences 25.1 - 50 mg/L;
- 16 (5.8%) residences 50.1 -100 mg/L;
- 38 (13.9%) residences 100.1 - 200 mg/L; and
- 48 (17.5%) residences > 200 mg/L of chlorides.

The numerical groundwater standard for chloride (except due to natural causes) is 200 mg/L. The United States Environmental Protection Agency and the Board have established a secondary drinking water standard[6] for chlorides of 250 mg/L. This standard is not health based.

Evaluation of Appendix III and the statistics provided above shows that chloride detections are not spatially ubiquitous throughout the village. The higher concentrations appear to be grouped in areas within the village. The residences with chloride concentrations greater than 200 mg/L east of the McCullom Beach Lake Park correspond with the high concentrations of chlorides and nutrients found in a

[6] National Secondary Drinking Water Regulations (NSDWRs or secondary standards) are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards to water systems but does not require systems to comply.

groundwater monitoring well (GW15) that was installed under a Northeastern Illinois Planning Commission Study (NIPC, 1992). The NIPC study indicates that:

> "However, strikingly high values for both parameters were measured at GW17 and GW15. Conductivity measured 2030 umhos [micromhos is the reciprocal of resistance in ohms] at GW17 and 1770 and 1900 umhos at GW15 (August and May samples, respectively). **Chloride ranged from 285 to 351 mg/1. Because these values are so far above expected levels, they suggest impacts of septic systems on groundwater quality (these were the only samples collected directly in front of homes served by septic systems)….**
>
> "…As a further indicator, **corresponding measurements of nutrients at these two sites were among the highest for sites located within substantial groundwater discharge areas."** (Emphasis added)

GW 17 is located south of the Village of McCullom Lake on the western shore.

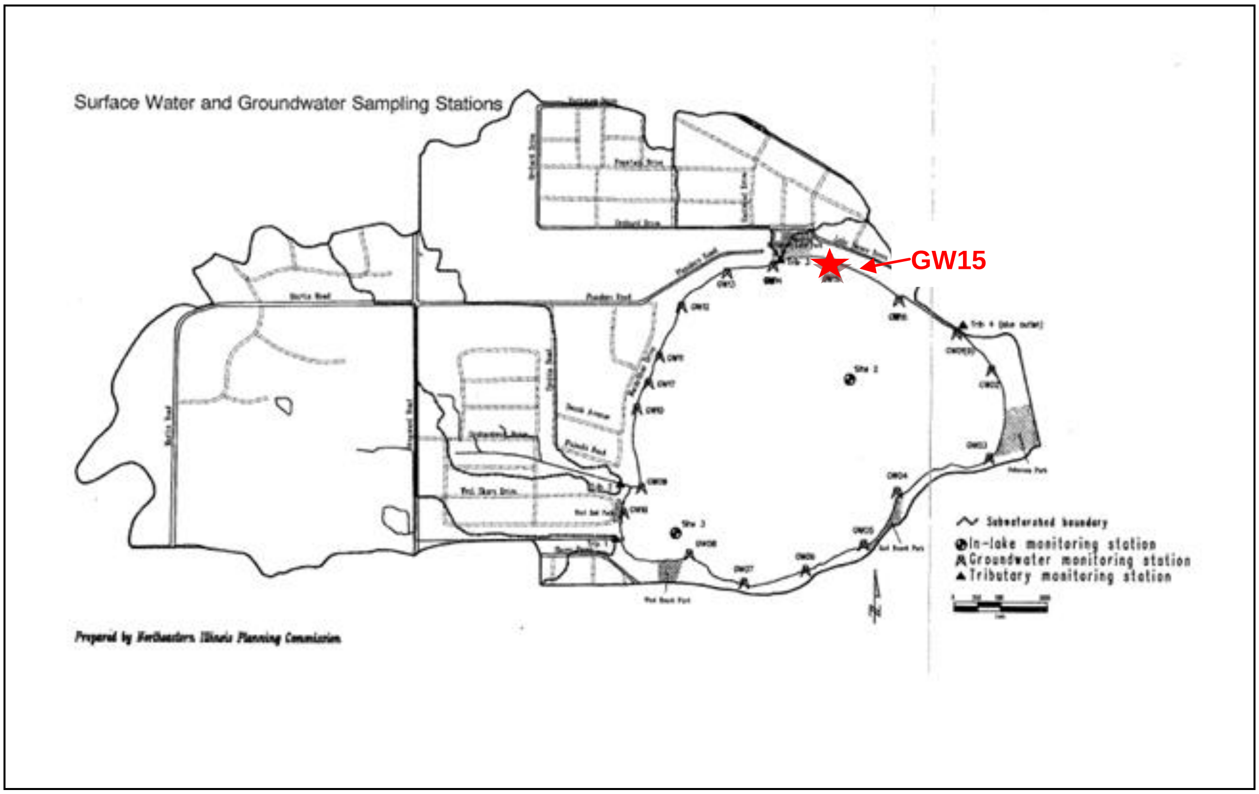

Figure 3. (figure 5 in the NIPC Report) Groundwater Monitoring Wells and in Lake Seepage Meters Installed in the NIPC Study

Further, water softening for residents using the sand and gravel aquifer is highly probable due to the aquifer geochemistry in McHenry County. For example, the ***hardness*** of groundwater from public water supplies in McHenry County, using the same sand and gravel aquifers, show a range from 204 to 512 mg/L of $CaC0_3$ hardness

(Woller and Sanderson, 1976). Descriptions of hardness correspond roughly with the following ranges of mineral concentrations (Hem, 1992):

- Soft: 0–60 mg/L
- Moderately hard: 61–120 mg/L
- Hard: 121–180 mg/L
- Very hard >181 mg/L

Water softeners used to treat water hardness commonly use brine to regenerate the resin in the treatment system with sodium, displacing calcium and magnesium. The remaining brine is then disposed of through the private on-site septic system where it may enter the underlying aquifer. Assuming a household with a septic system (300) has a water softener and uses the typical manufacturer's recommended amount of rock salt (NaCl) of 5 pounds/35 days, would result in 315 tons of ***rock salt*** per year that is potentially available to enter the subsurface environment (Kelly and Wilson, 2008).

Hydrogeologic Analysis

Hydrostratigraphy - Illinois EPA staff obtained paper copies of the available geologic well logs for 47 of the private drinking water system wells in McCullom Lake. The geologic logs were cross referenced with the digital PINs obtained from McHenry County GIS (i.e. blue dots in Figure 4). Geologic logs were not available for each of the 300 residences sampled. The geologic descriptions for the paper logs were entered into an Excel© spreadsheet. Then the data were cross referenced to the water quality data and the geologic logs. The data was then entered into the software RockWorks© to create a series of stratigraphic[7] cross sections through the area, and to develop a 3-D visualization model of the ***hydrostratigraphy***[8]. Figures 4 and 5 (inset map), show the lines of cross section through the area.

[7] "Stratigraphic" means in regard to a sequence of rock layers and layering (stratification).
[8] "Hydrostratigraphy" looks at the relationship of the rock layers with water or hydrology.

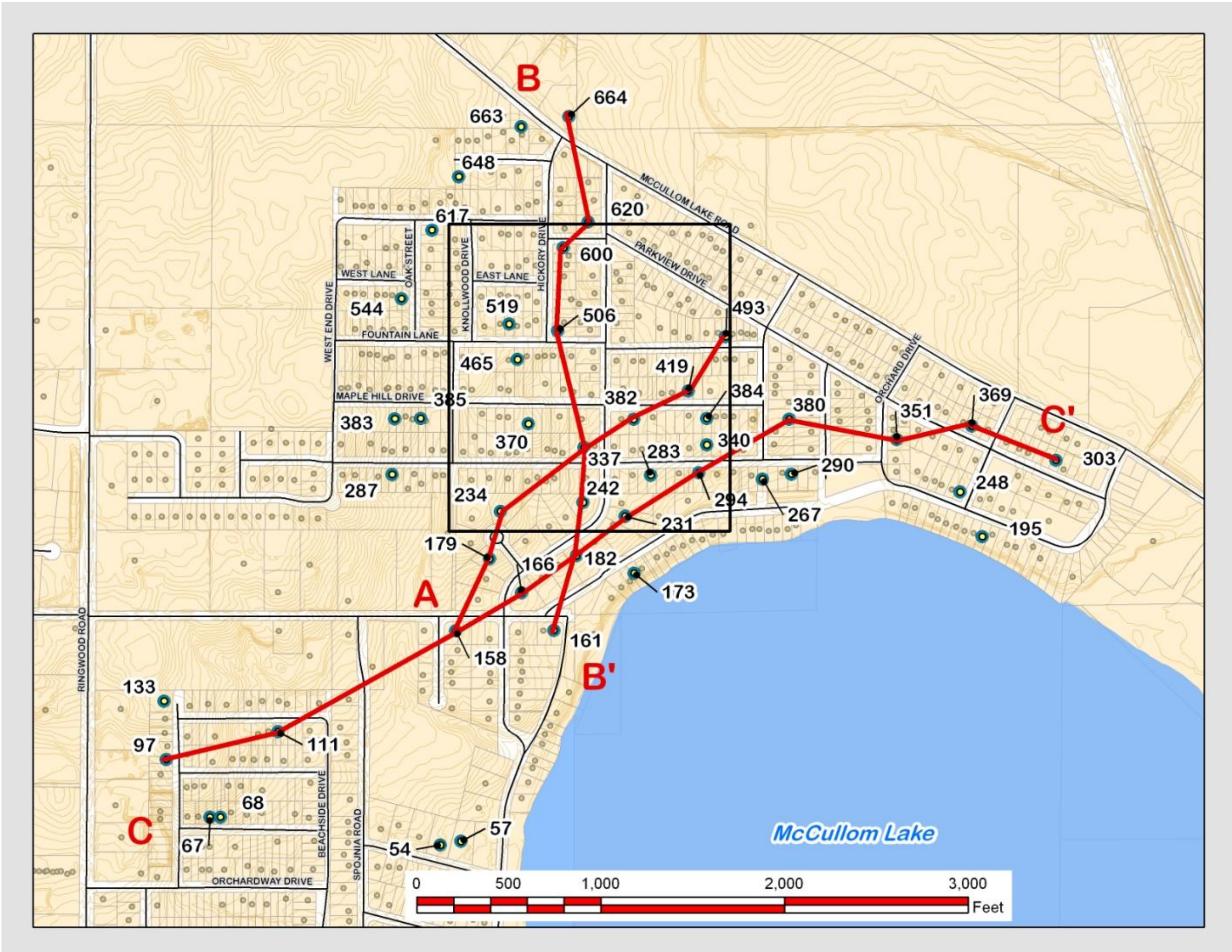

Figure 4. Map Showing the Lines of Geologic Cross Sections

Figure 5. Inset Map of the Lines of Geologic Cross Section

Evaluation of the geologic well logs indicate that the geology underlying the village is comprised of an interbedded sequence of clay, clayey silt, silt, sand and gravel overlying bedrock comprised of Silurian Dolomite. Figure 6 illustrates the ***lithology***[9] index of the geologic materials used in the cross sections.

Figure 6. Lithology Index Used for the Cross Sections

These units collectively form five hydrostratigraphic units identified as: 1) Upper ***Aquifer*** (yellow to light brown), 2) Upper Till[10] ***Aquitard***[11] (dark reddish brown), 3) Deep Aquifer (yellow to light brown), 4) Lower Till Aquitard (dark reddish brown), and 5) Silurian Dolomite Aquifer (blue).

The cross sections and 3-D model show these 5 hydrostratigraphic units. The private drinking water system wells used to construct the cross sections are also shown in the same illustration and are labeled with their respective PIN. In general, the bottom of the well represents where groundwater is being obtained. It appears that the majority of wells are obtaining groundwater from the Deep Aquifer in Figures 7 and 8.

[9] "Lithology" means a description of the physical characteristics (such as color, texture, grain size, or composition) of a rock unit visible at outcrop, in hand or core samples or with low magnification microscopy.

[10] "Till or glacial till" means unsorted glacial sediment. Glacial till is that part of glacial drift which was deposited directly by the glacier. Its content may vary from clays to mixtures of clay, sand, gravel and boulders.

[11] "Aquitard" is a bed of low permeability along an aquifer.

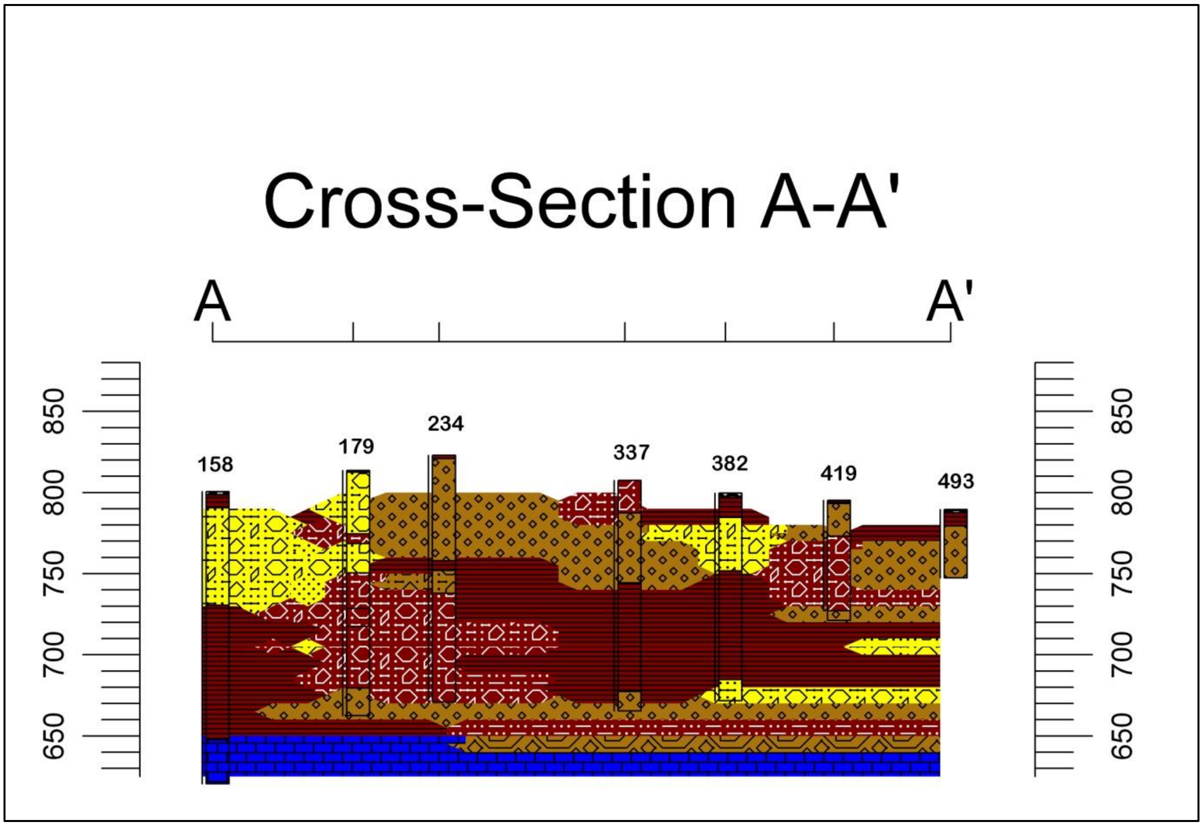

Figure 7. Cross Section A-A' (southwest to northeast)

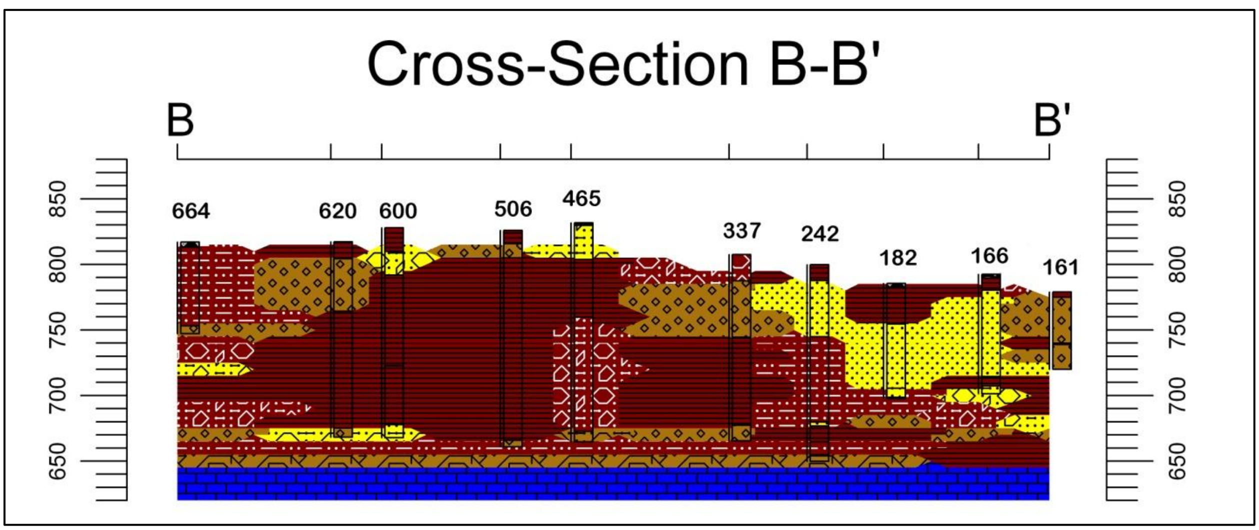

Figure 8. Cross Section B-B' (north to south)

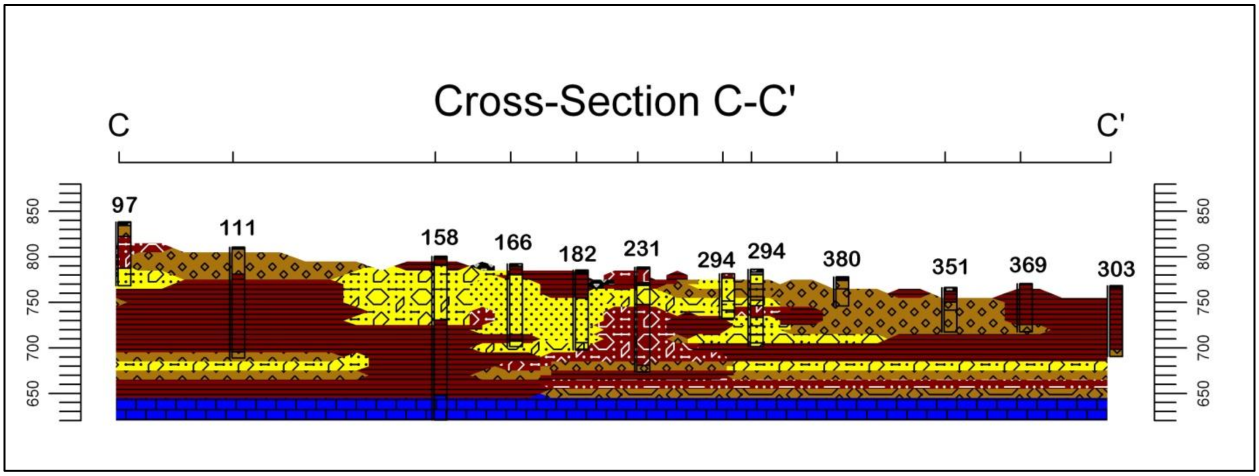

Figure 9. Cross Section C-C' (southwest to northeast) closer to the northern lake shore

Figure 9 shows that most of the wells nearest the McCullom Lake shore line are using the Upper Aquifer.

The cross sections show in some areas that the Upper Aquifer is separated by the Upper Aquitard from the Deep Aquifer. In other areas, the Upper and Deep Aquifer are connected, and yet in other portions of the cross section the Upper Aquifer appears connected with the Silurian Dolomite Aquifer. However, some parts of the cross sections illustrate that the Lower Till Aquitard separates the Deep Aquifer from the Silurian Dolomite Aquifer. This is consistent with the complex hydrostratigraphic framework described in Meyer, 1992.

Figure 10 is a ***3-D model*** of the hydrostratigraphy. One advantage of the 3D model vs. cross sections is that it uses all of the geologic well logs (blue dots on Figure 4). Further, it provides a visualization of the areas with a high potential for aquifer recharge. The areas shown as yellow and light brown are the potential recharge areas for the Upper Aquifer where it is exposed at land surface. Upper Aquifer recharge areas are primarily located to the west, northwest, and the north-central shoreline of McCullom Lake. This is consistent with the NIPC Report (NIPC, 1992) that indicated:

> Inspection of Illinois State Geological Survey well logs reveals that a large sand and gravel aquifer exists under the western/northwestern areas of the McCullom Lake watershed, upslope of McCullom Lake. Geologic observations detailed in well logs prepared when residential wells were recently drilled for homes within Martin Woods II show the uppermost portion of the sand and gravel deposits begins just a few feet from the soil surface and extends nearly 100 feet deep. Closer to the lake, the thickness of the sand and gravel aquifer decreases. **A direct hydrologic connection between this aquifer and McCullom Lake, combined with a considerable hydraulic head, allows substantial groundwater discharge into McCullom Lake.**
>
> **It is the shallow sand and gravel aquifers that discharge groundwater into McCullom Lake, most intensely along the western and northern shoreline areas**. Silurian dolomite aquifer groundwater has been reported to mix with

groundwater originating from shallow sand and gravel aquifers in some areas of McHenry County (Nicholas and Krohelski, 1984), **but the chemical characteristics of groundwater entering McCullom Lake suggests that it originates solely from the shallow sand and gravel aquifer.** The approximate extent of the sub surface watershed contributing groundwater to McCullom Lake is depicted in Figure 5. The subsurface watershed (estimated at 1041.4 acres) exceeds the areal extent of the surface watershed (616.4 acres) by approximately 525 acres.

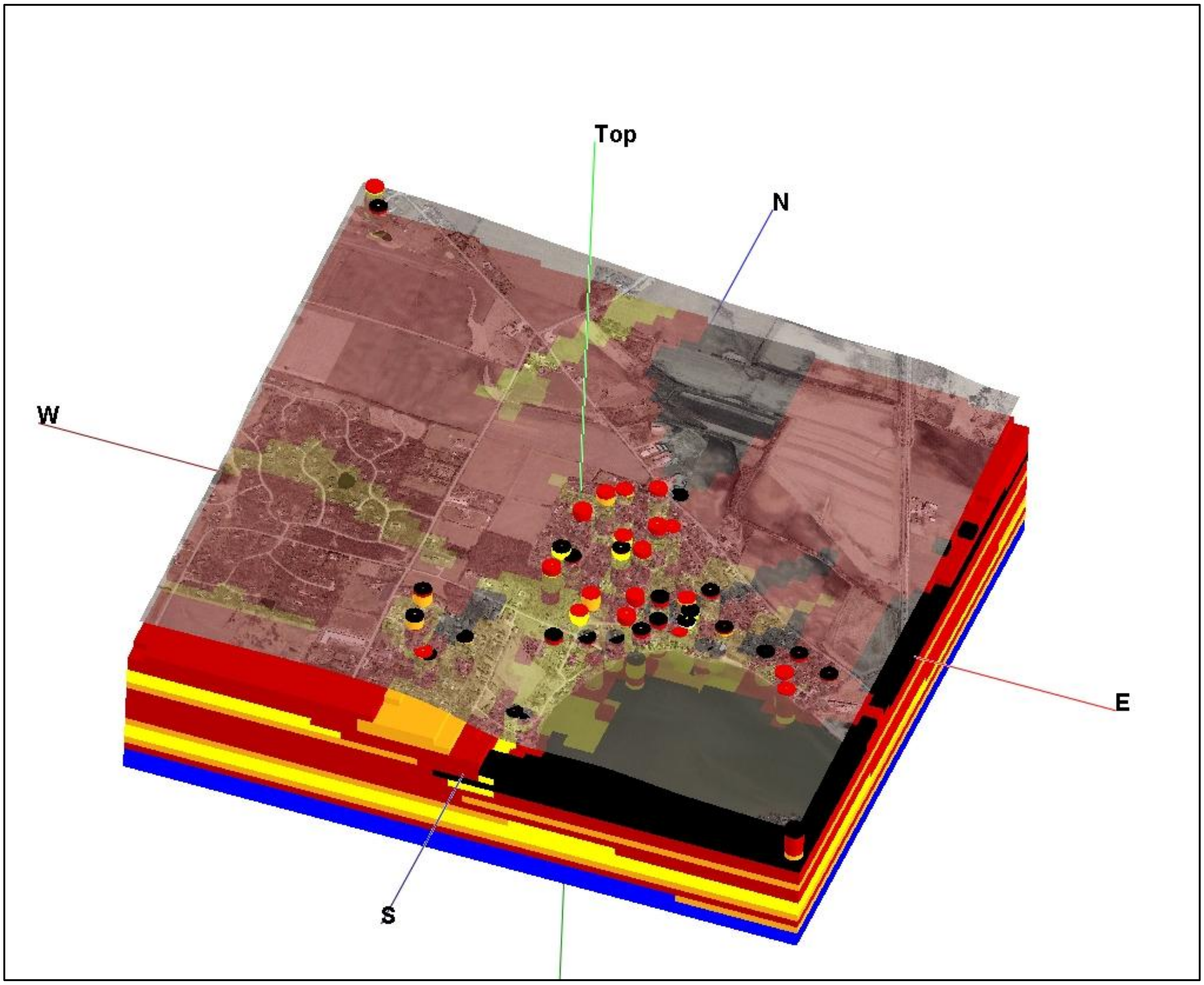

Figure 10. 3-D Model of the Hydrostratigraphy of McCullom Lake

Groundwater Flow – In 1998, the Illinois State Water Survey (ISWS) (Meyer, 1998) developed a series of regional scale ***potentiometric***[12] surface maps for the ***hydrostratigraphic*** unit's depicted above. While surface water moves downhill in response to gravity, groundwater moves down-gradient from areas of higher potential energy to areas of lower potential energy. Generally, ***groundwater flow will be perpendicular to the contours*** (*i.e*. areas of equal elevation or ***equipotential***) of the

[12] "Potentiometric surface" means a contour map of the elevations of water levels in observation wells.

potentiometric surface (Bear, 1972). Illinois EPA obtained the digital copies of the maps developed by the ISWS, and used GIS to integrate the information with digital orthophotography to develop Figures 11, 12, and 13. Figure 11 shows the potentiometric surface for the Upper Aquifer relative to McCullom Lake.

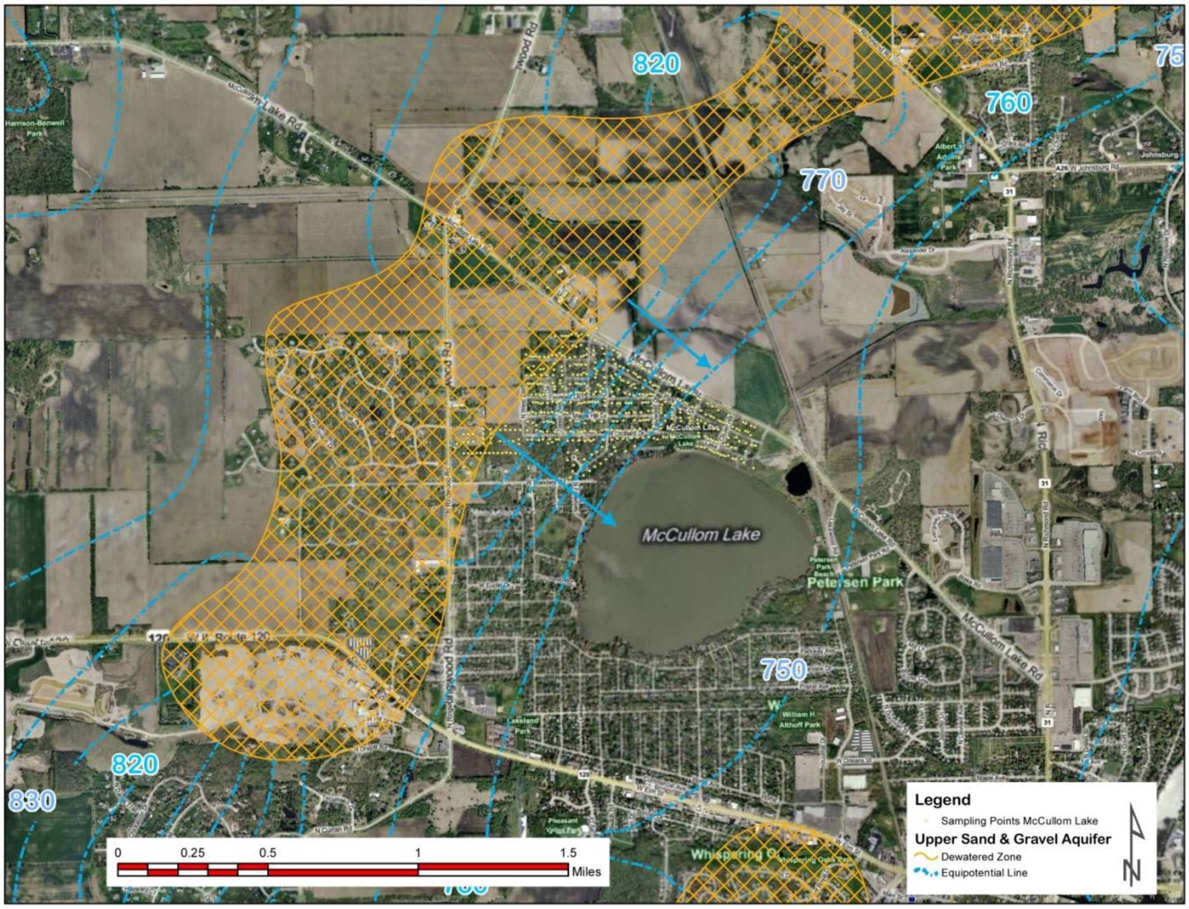

Figure 11. Potentiometric Surface of the Upper Aquifer 1 (Modified after Meyer, 1998)

The blue arrows perpendicular to the equipotential lines, shows that the groundwater flows from the northwest to the southeast. The yellow hash marked areas are where the Upper Aquifer is dry or ***unsaturated*** (Meyer, 1998). Seepage meters installed in the lake bed as part of the NIPC study, provide groundwater discharge rate data, that indicates that these regional groundwater flow paths bend south locally as they get closer to the northern shore of McCullom Lake (NIPC,1992).

Figure 12 illustrates the potentiometric surface of the Deep Aquifer. The blue arrows perpendicular to the lines of equipotential, shows that the groundwater flows from the northwest to the southeast. The area within the yellow line represents where the Deep Aquifer is thin or absent. The yellow dashed line represents where the Deep Aquifer is hydraulically connected to the Silurian Dolomite Aquifer, and the red line shows where the Shallow Aquifer is hydraulically connected with Silurian Dolomite Aquifer. This connection can be seen in cross section B-B'.

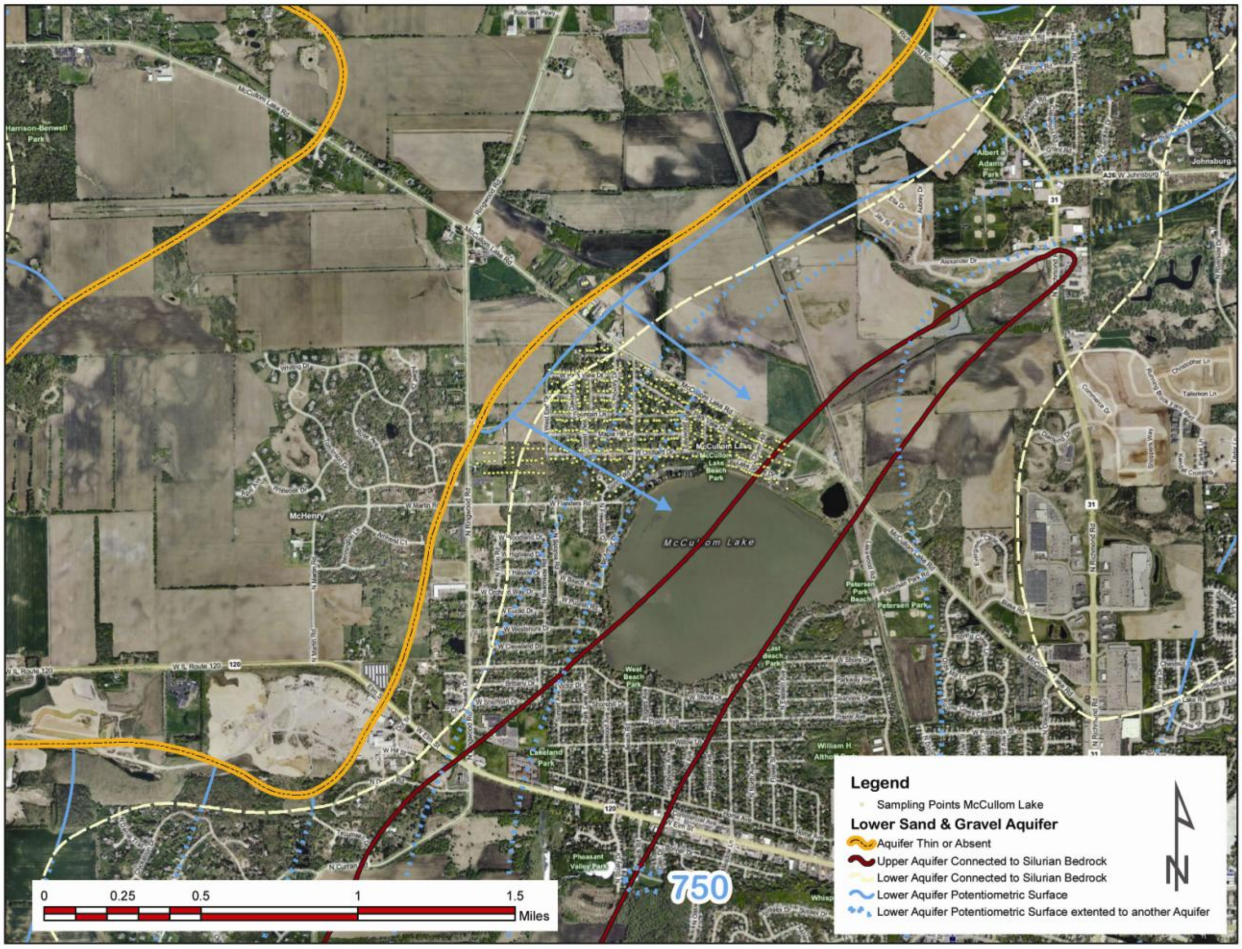

Figure 12. Potentiometric Surface of the Deep Aquifer (Modified after Meyer, 1998)

The ISWS also mapped the potentiometric surface for the Silurian Dolomite Aquifer as depicted in Figure 13, below.

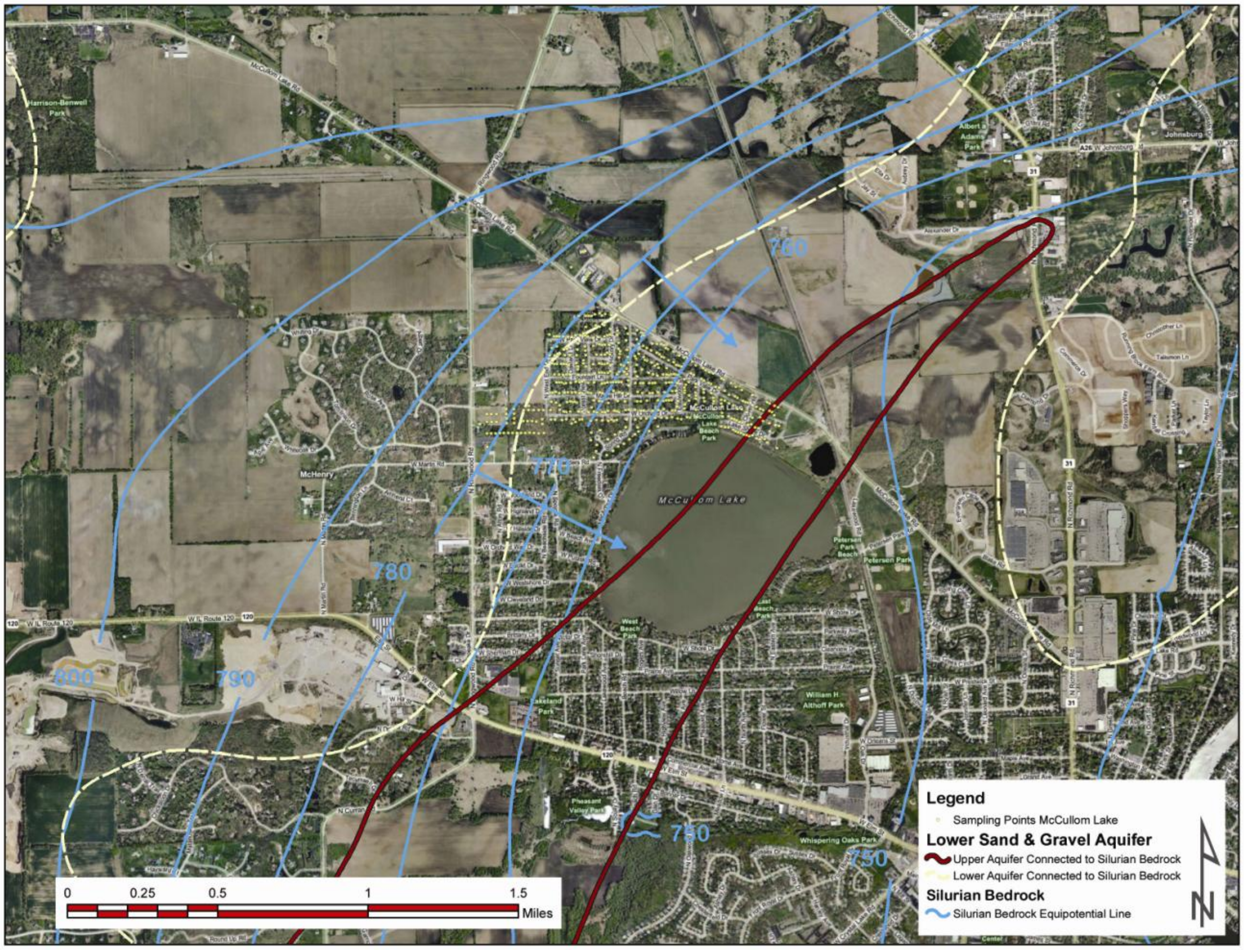

Figure 13. Potentiometric Surface of the Silurian Dolomite Aquifer (Modified after Meyer, 1998)

The blue arrows perpendicular to the lines of equipotential, show that the groundwater flows from the northwest to the southeast in the McCullom Lake area. The yellow dashed line represents where the Lower Aquifer and the Silurian Dolomite Aquifer are hydraulically connected. Moreover, the red line shows where the Upper Aquifer and the Silurian are hydraulically connected, as shown in cross section C-C'.

Illinois EPA used GIS to compare the potentiometric surface developed by Meyer for McHenry County with the adjacent map of the potentiometric surface of the Silurian Dolomite for Northeastern Illinois (also developed by the ISWS). Figure 14 illustrates the combined map. Evaluation of this map shows that the southeasterly flow direction within the Silurian Dolomite Aquifer appears to be influenced by the ***cone of depression*** created by the Village of Wauconda's public water supply well field.

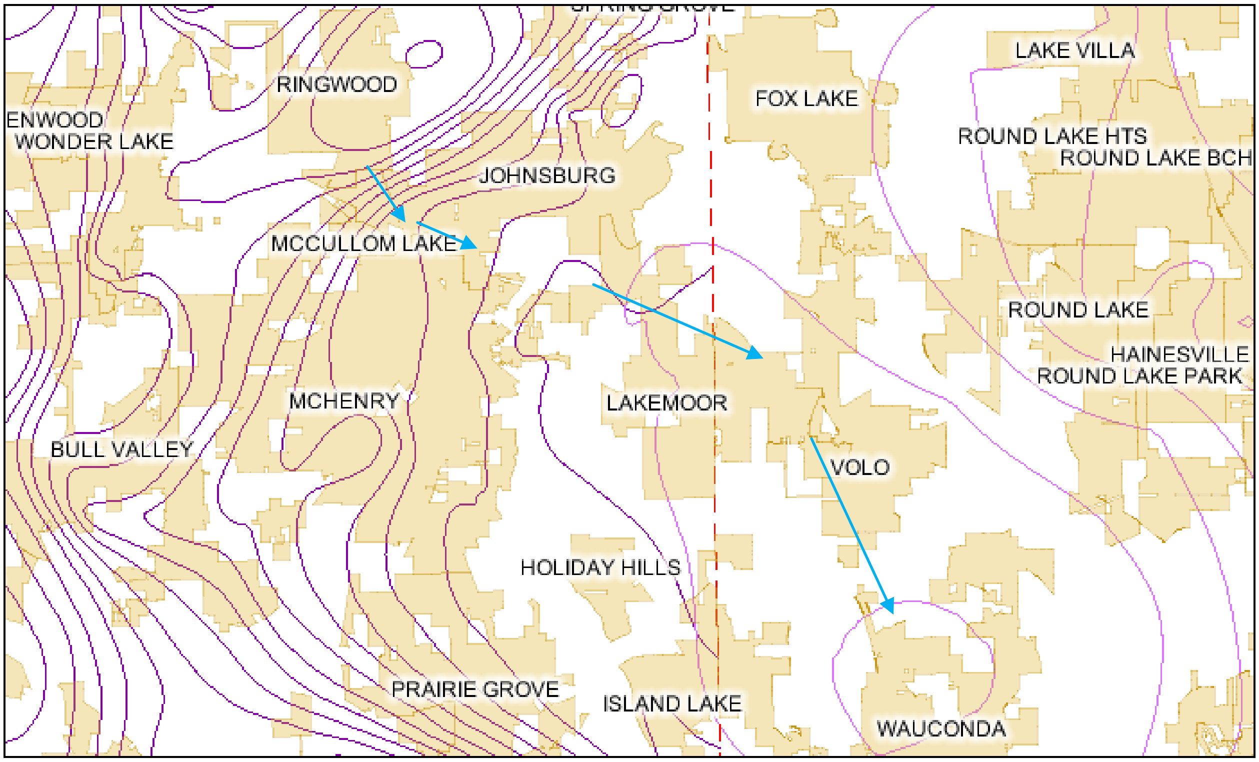

Figure 14. Potentiometric Surface of the Silurian Dolomite Aquifer (Modified after Meyer, 1998)

<u>Contaminant Fate and Transport</u> - In general, contaminants are transported in the direction of groundwater flow. Transport in this manner, that is, transport of dissolved constituents (solutes) at the same speed as the average groundwater pore velocity, is called ***advection***. In porous natural materials the pores possess different sizes, shapes, and orientations. Similar to stream flow, a velocity distribution exists within the pore spaces such that the rate of movement is greater in the center of the pore than at the edges. Thus, in saturated flow through these materials, velocities vary widely across any single pore and between pores. As a result, when a miscible fluid is introduced into a flow system it will mix mechanically and ***diffuse*** (because of tightly packed molecules bumping into one another) to occupy an ever increasing portion of the flow field. This mixing phenomenon is known as ***hydrodynamic dispersion***. In this sense, dispersion is a mechanism of ***dilution***. Dispersion acts to reduce the peak concentration of material introduced into a flow field, and plume widths are typically 1/10th of the plume length, as illustrated in Figures 15 and 16.

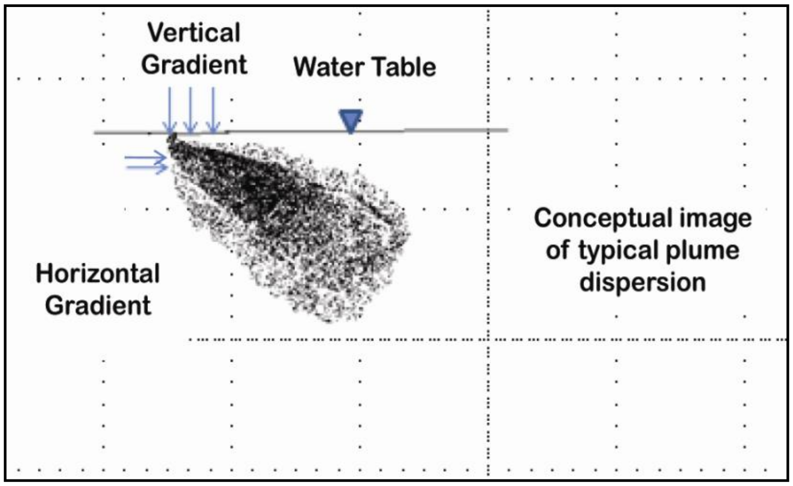

Figure 15. Conceptual Model of a Contaminant Plume Flowing from a Source Area and into the Water Table

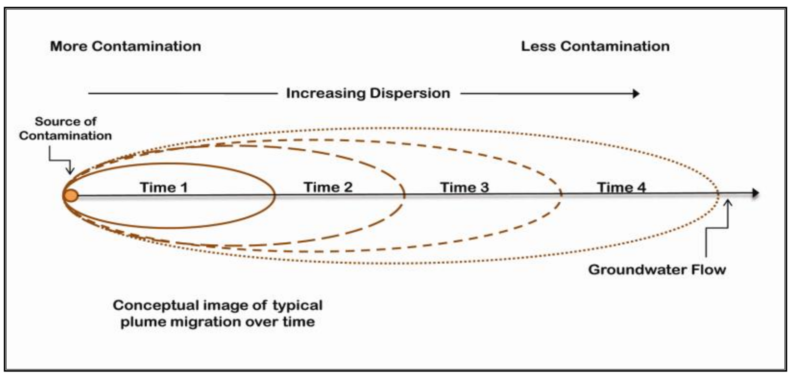

Figure 16. Surface View of Contaminant Plume Migration

In addition to dispersion, some VOCs are also subject to ***degradation*** and ***transformation*** into different compounds over time. Degradation can occur under aerobic conditions (oxygen rich) or under anaerobic conditions (low oxygen or reducing).

PCE and TCE degrade in groundwater as shown in Figure 17, by substituting hydrogen (H) for chlorine (CL) atoms. This ***redecutive dechlorination*** of PCE and TCE (chlorinated solvents) produces the breakdown products 1,1DCE and VC, and eventually ethane (Fetter, 1992). However, VC is less degradable than PCE and tends to accumulate (Deustch, 1997). VC it is very recalcitrant to further degradation to ethene and ethane. It can take decades for PCE to degrade to VC (Boethling, 1991) under anaerobic conditions. As provided earlier, the UL sampling results yield that VC was not detected nor were any of the other PCE or TCE degradation products (i.e., cDCE, tDCE, or 1,1-DCE) in the McCullom Lake residences.

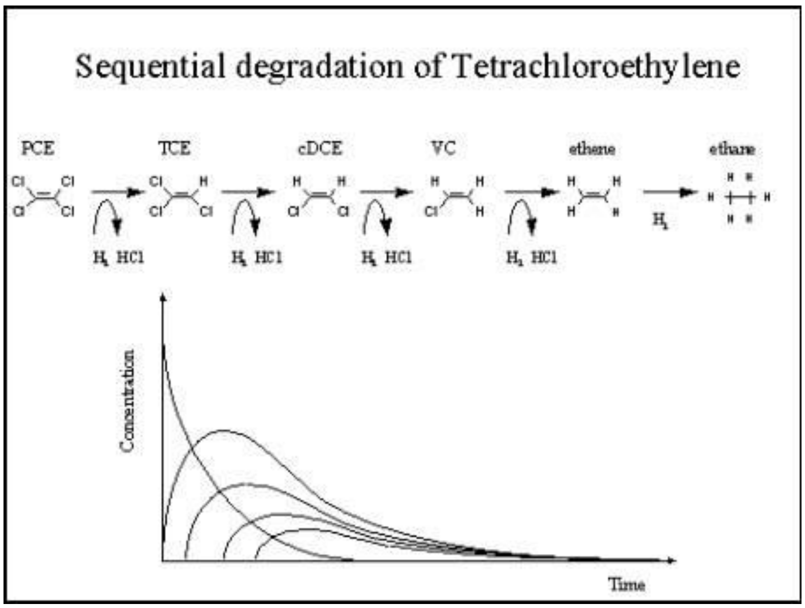

Figure 17. Sequential Degradation of PCE (Norris et. al., 1993).

Spatial analysis of the water quality data shows that there is a grouping of 4 residences 358, 401, and 404 with low level detections of 1,1,1-TCA and one residence on 332 with a low level detection of TCE, as detailed in Table I and Appendix I. 1,1,1-TCA is not part of the PCE degradation chain. These residences also have chlorides in the 100.1 - 200 mg/L concentration range (see Appendix III). However, there is no indication of a contaminant plume, where contaminants have moved in a distinct pattern from a constant source of contamination at higher concentrations to a lower concentration down gradient due to the effects of hydrodynamic dispersion and degradation. The other residences with VOC or SOC detections in the village are disparate.

Unlike the VOCs described above, chloride is a ***conservative contaminant*** that does not react or degrade but is transported via the principles of dispersion. The spatial distribution of chlorides was further modeled[13] to visualize if any discernable chloride

[13] Natural neighbor interpolation (also known as proximal interpolation or, in some contexts, point sampling) is a simple method of multivariate interpolation in 2 dimensions. Interpolation is the problem of

plume patterns exist (see Figures 15 and 16 for reference). The results of this modeling are shown in Appendix IV. Detections appear to be in clusters in individual neighborhood blocks. No discrete plumes were identified according to the standard hydrogeologic models.

Appendices III and IV appear to further corroborate the NIPC study finding relative to the source of contamination up gradient from GW15. There appear to be residuals from septic tanks that were previously used in this area. Additionally, of the 24 residences still using septic systems the distribution of private drinking water system chloride concentration results versus the 315 residences that previously had septic tanks is not significantly different:

Chloride Concentration	24 Residences with Septic Tanks	Historically 315 Residences with Septic Tanks	Percent Difference
< 25 mg/L	14 (58%) residences	152 (55%) residences	+3
25.1 - 50 mg/L	2 (8.3 %) residences	20 (7.3 %) residences	-1
50.1 -100 mg/L	1 (4.2%) residences	16 (5.8%) residences	-2.6
100.1 - 200 mg/L	4 (16.7%) residences	38 (13.9%) residences	+2.8
> 200 mg/L	3 (12.5%) residences	48 (17.5%) residences	-5

Moreover, the 24 residences that still use private sewage disposal systems are located in the same areas shown in Appendix IV. For comparison, see Appendix V.

To determine if there was any spatial correlation of high chloride concentrations with areas that have a higher potential for aquifer recharge, Illinois EPA overlaid the digital orthophotograph with the hydrostratigraphic model for better geographic reference as illustrated in Figure 18. The red represents areas with clay rich till, and the light yellow areas show where the unsaturated zone of the Upper Aquifer is exposed at land surface. Then the chloride data from Appendix III was overlain. Evaluation yields that there does not always appear to be a direct correlation between high chloride values and areas where the land surface has a high potential for aquifer recharge. In particular, the cluster of residences with chloride concentrations greater than 200 mg/L on the northeastern shore of McCullom Lake are located in a area where the land surface has a low potential for aquifer recharge. Thus, this would appear to lessen the likelihood that the concentrations are due to ***road salting*** which is applied to the land surface versus historical septic tank discharge residuals in the subsurface. There are

approximating the value for a non-given point in some space, when given some colors of points around (neighboring) that point.

some areas with a high potential for aquifer recharge and high chlorides however, not every residence is showing high chloride concentrations along a particular street. Once again, if these high concentrations were due to road salting, applied relatively uniformly on roads, one would expect more uniformity in the chloride concentration detections.

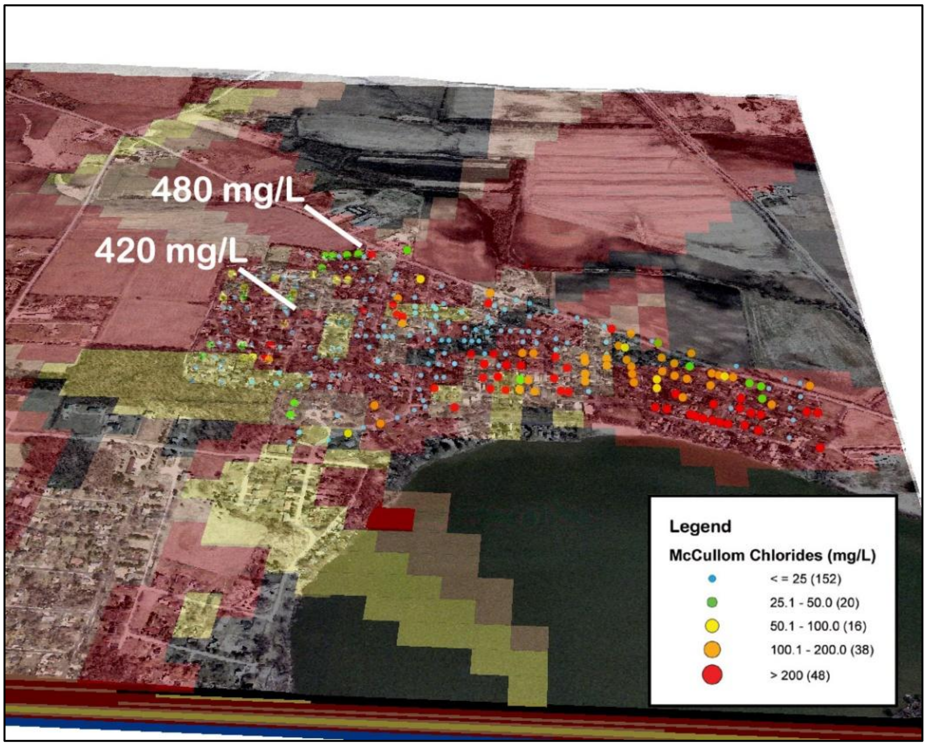

Figure 18. Chloride Detections in Private Drinking Water System Residences versus Potential for Aquifer Recharge

Non-uniformity in the chloride detections suggests that the chlorides may be from historical septic tank residuals in some residences but not others because not all people may have choose to soften their water due to a variety of reasons (e.g., high blood pressure, financial, personal preference, etc,). Thus the majority of high chloride concentrations above background appear to be septic tank related residuals, because:

- High chloride concentrations are consistent with the concentrations associated with septic tanks in the NIPC Study;
- Chloride detects are not being found ubiquitously through out the village, as would be expected if the detects were due to road salting;
- Chloride detects are being found in clustered areas;
- Residences still using septic systems are found in the same clustered areas;
- Sixty three percent of the residences with organic compound detections also have chloride detects above background; and
- Chlorides cannot be associated with any of the private drinking water system infrastructure (e.g., PVC pipe).

Summary

The following is intended to provide a brief summary of the McCullom Lake evaluation:

- VC was not detected in any of the McCullom Lake private drinking water system residences;
- 1,1-DCE was not detected in any of the McCullom Lake private drinking water system residences;
- No other PCE or TCE degradation products were detected in any of the McCullom Lake residences;
- 5.3% McCullom Lake private residences detected low levels of VOC and/or SOC;
- No drinking water standards established for VOC/SOCs were exceeded;
- 95% of the residences sampled detected no organic chemicals;
- Some of the organic compound sample detections appear to be related to PVC solvent chemicals;
- Other organic compounds detected appear to be related to furniture stripping and restoration;
- 19 mg/L of chloride appears to represent a background concentration in McCullom Lake groundwater;
- 17.5% of the residences showed a chloride concentration of greater than 200 mg/L;
- 14% of the residences showed a chloride concentration of greater than 100.1 but less than 200 mg/L;
- The United States Environmental Protection Agency and the Illinois Pollution Control Board have established a secondary drinking water standard for chlorides of 250 mg/L;
- Data suggests that the high concentration of chlorides may be residual from historical use of septic systems for residents that softened hard water;
- 63% of the residences with organic chemical detections also had high chloride detections;
- The groundwater flow direction in all aquifers appears to be moving from the northwest to the southeast toward McCullom Lake; and
- There are no indications of VOC, SOC or chloride contaminant plume(s).

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Appendix I – Residences Sampled for VOC/SOCs

McCullom Lake VOC Detection Data

612

Analyte	Result	Units	MRL
1,1,1-Trichloroethane	0.7	ug/L	0.5

542

Analyte	Result	Units	MRL
Trichloroethylene	1.1	ug/L	0.5

464

Analyte	Result	Units	MRL
1,2-Dichloroethane	0.6	ug/L	0.5

415

Analyte	Result	Units	MRL
1,1,1-Trichloroethane	2	ug/L	0.5

545

Analyte	Result	Units	MRL
1,2-Dichloroethane	0.7	ug/L	0.5
Tetrahydrofuran	5.1	ug/L	5

451

Analyte	Result	Units	MRL
Tetrahydrofuran	11	ug/L	5

486

Analyte	Result	Units	MRL
Tetrachloroethylene	4	ug/L	0.5

401

Analyte	Result	Units	MRL
1,1,1-Trichloroethane	0.7	ug/L	0.5

389

Analyte	Result	Units	MRL
Styrene	0.6	ug/L	0.5

404

Analyte	Result	Units	MRL
1,1,1-Trichloroethane	1.2	ug/L	0.5

358

Analyte	Result	Units	MRL
1,1,1-Trichloroethane	1.2	ug/L	0.5

459

Analyte	Result	Units	MRL
4-Methyl-2-pentanone (MIBK)	3.7	ug/L	2
Chloroethane	1	ug/L	0.5
Cyclohexanone	5.2	ug/L	5
Dichloromethane	2.4	ug/L	0.5
tert-Butyl alcohol	20	ug/L	2
Tetrahydrofuran	7	ug/L	5

332

Analyte	Result	Units	MRL
Trichloroethylene	0.6	ug/L	0.5

273

Analyte	Result	Units
Cyclohexanone	35	ug/L
Tetrahydrofuran	89	ug/L

180

Analyte	Result	Units	MRL
Styrene	1.8	ug/L	0.5

Appendix II – PVC Pipe Product Example

Specifications

Product Pro-Prime™ PVC Solvent Primer

Application All PVC and CPVC piping.

Purpose Pro-Prime™ PVC Solvent Primer is a water-thin purple-tinted solvent primer designed to clean, aggressively soften, and prepare all types of PVC and CPVC pipes and fittings for solvent welding.

Composition Methyl Ethyl Ketone, Tetrahydrofuran, Cyclohexanone.

Advantages Pro-Prime™ PVC Solvent Primer is great for prepping pipes for long term use and high pressure operation as well. Pro-Prime™ PVC Solvent Primer is recommended in cold conditions where it can be difficult to get a good bond. Pro-Prime™ is ASTM F-656 certified and can be used in the following applications:

- Potable Water
- Drain
- Waste
- Vent
- Sewer
- Conduit
- Irrigation
- Pool & Spa

Physical/Chemical Properties
Solvent Action: More aggressive than cleaner, S-901
Specifications: ASTM F-656
Flash Point: 6°F (closed cup)
Shelf Life: 1 year minimum
Listings: NSF

Directions For Use Skill and knowledge are required on the part of the user to make a good quality joint. An experienced installer should be consulted prior to use. Use Pro-Prime™ PVC Solvent Primer in its original container. Rotate stock.

1. Wipe surfaces to be joined with a clean cloth to remove dirt and moisture.
2. Apply primer with applicator to inside of fitting and to outside end of pipe end. Apply with scrubbing motion in order to dissolve the surfaces. If primer is applied with cloth, wear gloves impervious to the primer.
3. Apply cement according to directions on cement can.
4. Use to clean solvent cement from applicators and tools.
5. Do not use to thin cement.

Safety Information **CAUTION:** HMIS RATING 3-3-1 KEEP OUT OF REACH OF CHILDREN. Keep away from heat, sparks and flame. Use only in a well ventilated area. Do not breathe vapor. Avoid contact with skin or eyes. Keep container closed when not in use. In case of skin or eye contact, flush repeatedly with water. Get medical attention if irritation persists. If swallowed drink water, do not induce vomiting, call physician.

Package Metrics

Producer of Goods Specialty Chemical

Domestic/Foreign Commodity Domestic

SKU Specific Package Metrics

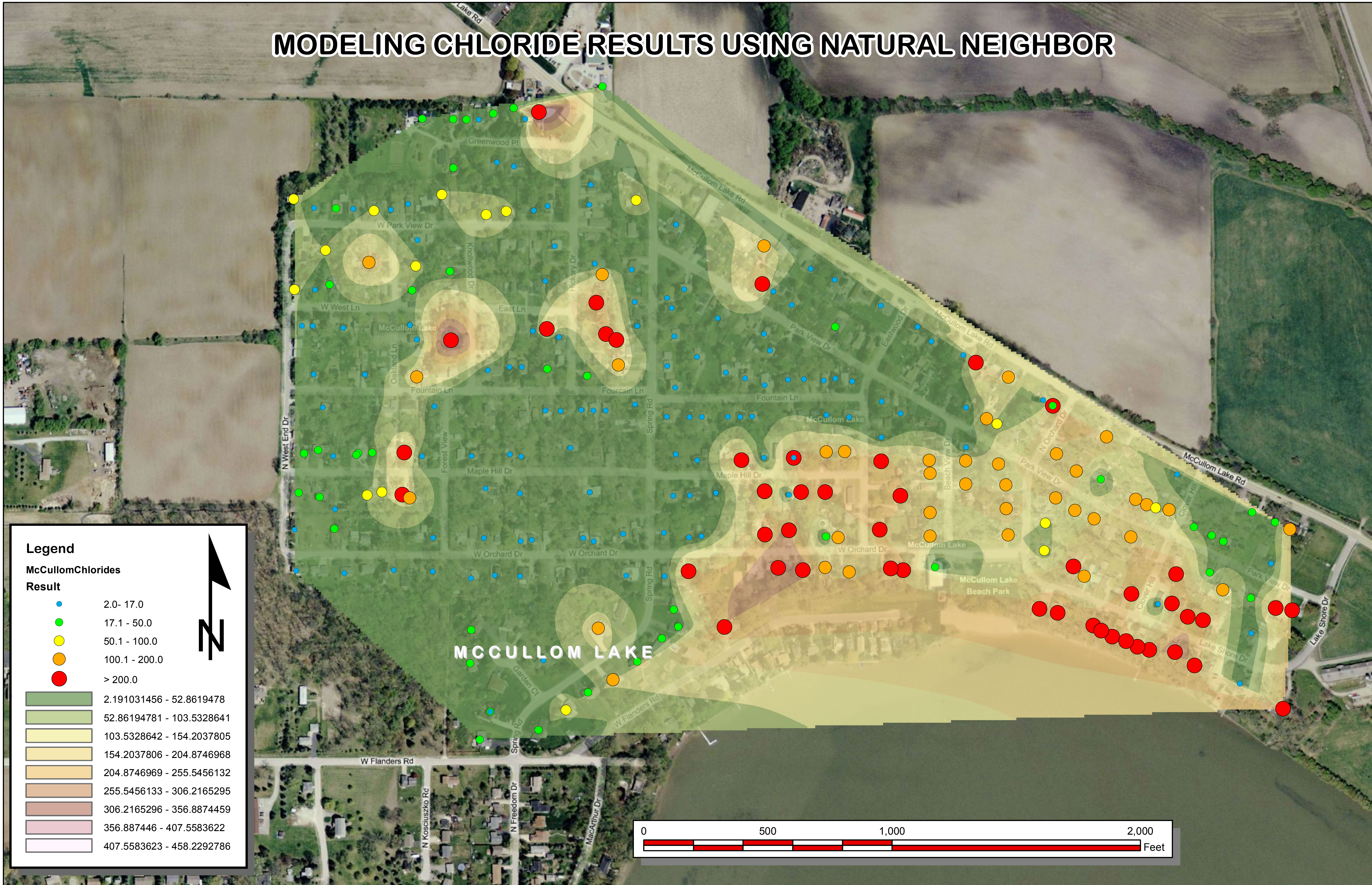
Catalog No.	Description	Size	UPC	Quantity per Case
PP-4 PP-8 PP-16	PVC Solvent Primer	4 oz. container 8 oz. container 16 oz. container	0095247123476 0095247123483 0095247123490	24 24 24

Pro-Prime™ Purple PVC Solvent Primer

Appendix III – Map of Chloride Detections and Concentration Ranges

CHLORIDE LEVELS FOR MCCULLOM LAKE
Greenwood Pl
McCullom Lake Rd
W Park View Dr
Knollwood Dr
Hickory Dr
W West Ln
East Ln
McCullom Lake
Oakland Ln
Fountain Ln
Fountain Ln
Fountain Ln
Park View Dr
Eastwood Dr
McCullom Lake Rd
N Orchard Dr
McCullom Lake
N West End Dr
Forest View
Spring Rd
Maple Hill Dr
Maple Hill Dr
Beach View Dr
Park View Dr
Clover Hill
McCullom Lake Rd
W Orchard Dr
W Orchard Dr
W Orchard Dr
McCullom Lake
McCullom Lake Beach Park
Spring Rd
Clover Hill
Park View Dr
Lake Shore Dr
Lake Shore Dr
MCCULLOM LAKE
Garden Ct
W Flanders Rd
Spring Rd
N
Legend
McCullom Chlorides (mg/L)
< = 25 (152)
25.1 - 50.0 (20)
50.1 - 100.0 (16)
100.1 - 200.0 (38)
> 200 (48)
0
250
500
1,000
1,500
Feet

Appendix IV – Natural Neighbor Model of Chloride Detections 315 Residences


MODELING CHLORIDE RESULTS USING NATURAL NEIGHBOR
Legend
McCullomChlorides
Result
2.0- 17.0
17.1 - 50.0
50.1 - 100.0
100.1 - 200.0
> 200.0
2.191031456 - 52.8619478
52.86194781 - 103.5328641
103.5328642 - 154.2037805
154.2037806 - 204.8746968
204.8746969 - 255.5456132
255.5456133 - 306.2165295
306.2165296 - 356.8874459
356.887446 - 407.5583622
407.5583623 - 458.2292786
N
0
500
1,000
2,000
Feet
MCCULLOM LAKE
McCullom Lake Beach Park
McCullom Lake Rd
W Flanders Rd
Fountain Ln
Maple Hill Dr
W Orchard Dr
W Park View Dr
N West End Dr
Spring Rd
Lake Shore Dr

Appendix V – Natural Neighbor Model of Chloride Detections Compared to the 24 Residences Still Using Septic Tanks

CHLORIDE LEVELS FOR MCCULLOM LAKE