GROUNDWATER AND RESIDENTIAL WELL EVALUATION
NORTH OAKS, MINNESOTA

HIGHWAY 96 SITE
WHITE BEAR TOWNSHIP, MINNESOTA

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JUNE 2005
REF. NO. 2012 (48)

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LIST OF ACRONYMS

AMSL	above mean sea level
CWA	Consolidated waste area
DO	Dissolved Oxygen
HRL	Health Risk Limit
Interpoll	Interpoll Laboratories, Inc.
MCL	Maximum Contaminant Level
MDH	Minnesota Department of Health
MEK	Methyl ethyl ketone
MPCA	Minnesota Pollution Control Agency
MSW	Municipal solid waste
ND	Not detected
NDA	North disposal area
NOHA	North Oaks Homeowners Association
ORP	Oxidation Reduction Potential
PCE	Perchloroethylene
QA/QC	Quality Assurance/Quality Control
Reynolds	Reynolds Metals Company
SDA	South disposal area
STL	Severn Trent Laboratories
TCE	Trichloroethene
USEPA	US Environmental Protection Agency
VOC	Volatile organic compound
Whirlpool	Whirlpool Corporation

EXECUTIVE SUMMARY

Reynolds Metals Company (Reynolds) and Whirlpool Corporation (Whirlpool) have, as responsible parties, agreed to remediate the Highway 96 Site and to monitor the groundwater west of the Site in areas that include the west shore of Gilfillan Lake in North Oaks, Minnesota. In October 2004, during this routine monitoring, their consultant, Conestoga-Rovers & Associates (CRA), detected low levels of vinyl chloride in water samples from two residential wells located on the west shore. Although the concentrations detected were below the Health Risk Limit (HRL)[1] for vinyl chloride adopted by the Minnesota Department of Health (MDH), the Minnesota Pollution Control Agency (MPCA) requested that Reynolds and Whirlpool conduct a six-month residential well study to investigate the nature and extent of any vinyl chloride contamination in wells on the west shore.

This report presents the results of the six-month study and provides recommendations for permanent solutions and continued monitoring.

BACKGROUND

The Highway 96 Site is located west of Allendale Drive and North of Highway 96 in White Bear Township. The Site, which was used as a small burning dump from the 1920's until 1973, was placed into the Minnesota Superfund Program in the mid-1980's because of groundwater contamination. Two of the responsible parties, Reynolds and Whirlpool, have undertaken and continue to undertake remedial action at the Site under the oversight of the MPCA. The Highway 96 remedial action plan consists of four parts.

- *Source Remediation.* In the late 1980's and early 1990's, the responsible parties removed drums, consolidated waste and installed a cap over the waste at the Site .
- *Groundwater Remediation.* In 1989, the responsible parties installed a groundwater extraction well at the Site which they continue to operate today.
- *Alternate Water Supply.* In 1993-94, the responsible parties installed a municipal water system on the east shore of Gilfillan Lake and connected 60 homes to that system.
- *Groundwater Monitoring.* Since 1993-94, the responsible parties have undertaken three groundwater monitoring programs. On-Site monitoring is designed to evaluate the

[1] Health Risk Limit (HRL) is the health standard adopted by the MDH for the safe consumption of water from a private water supply over a lifetime

performance of the groundwater extraction system. Off Site monitoring east of Gilfillan Lake is intended to evaluate groundwater quality immediately downgradient from the Site. Residential monitoring outside the municipal water supply area is intended to monitor and evaluate the quality of the groundwater used for private water supplies.

STUDY FINDINGS

The scope of the special six-month residential well study is set forth in the MPCA's letter of January 7, 2005 to CRA. Over the six month period, 45 residential wells located west of Gilfillan Lake were sampled by CRA and the MPCA. Vinyl chloride was detected in only three residential wells, which are all located in reasonably close proximity to each other at 12 West Shore Road, 13 West Shore Road, and 2 Hummingbird Hill. To date, the vinyl chloride levels in those wells have never exceeded the HRL of 0.2 µg/L.

Vinyl chloride was not detected in any of the other 42 residential wells sampled, which are located both north, south, and west of the three residences identified above.

It seems likely that this apparent "pocket" of vinyl chloride that has been detected west of Gilfillan Lake is the remnant of some elevated vinyl chloride concentrations that were detected at 15 Gilfillan Road, 17 Gilfillan Road, and 22 Gilfillan Road in 1993 and 1994. At that time, vinyl chloride was detected in those wells, which are east of the lake and considerably distant from the currently contaminated west shore wells, at concentrations of approximately 2 µg/L. Groundwater moves westward within the St. Peter Aquifer and vinyl chloride concentrations generally dissipate over distance and time as a result of natural attenuation processes

During the study, five other compounds, (1,1-dichloroethane, methyl ethyl ketone, cis-1,2-dichloroethene, chloroform, and methylene chloride) were detected in several samples. However, all of these compounds were found at concentrations well below the HRL.

The study has confirmed that residential septic systems can also be sources of groundwater contamination. Some of the contamination found in the study area could be the result of septic systems rather than the remnants of a plume from the Site. Further study is required to distinguish between septic and landfill contaminants.

INTERIM AND PERMANENT SOLUTIONS

The MPCA does not require interim or permanent solutions if a compound is found in a residential well at a concentration below the HRL. As an interim precautionary measure, Reynolds and Whirlpool are voluntarily providing bottled water to 12 West Shore Road, 13 West Shore Road, and 2 Hummingbird Hill --- the three homes in whose wells vinyl chloride has been detected.

As part of its study, CRA evaluated permanent solutions for residential wells with respect to which concentrations of vinyl chloride or other contaminants have caused the Minnesota Department of Health to issue a drinking water well advisory. The permanent solutions evaluated were 1) the installation of home treatment systems (using carbon adsorption), 2) the installation of deeper wells into the Prairie du Chien Aquifer, and 3) the provision of municipal water to the affected homes. Given the limited area in which vinyl chloride has been detected, CRA recommends the deeper well option as the appropriate permanent solution.

FUTURE MONITORING AND OTHER ACTIONS

CRA recommends continued monitoring of residential wells under the program outlined in Section 5.3 of this report.

In order to better distinguish septic system contaminants from landfill contaminants, CRA also recommends that groundwater testing for caffeine (a septic tracer) be conducted.

Finally, CRA recommends that further study of the groundwater situation on the west shore of Gilfillan Lake be undertaken. CRA also proposes to undertake vertical aquifer profiling at two locations: the 12 West Shore Road/13 West Shore Road/2 Hummingbird Hill area and the 15/17/22 Gilfillan Road area. This work is intended to define any differences in vinyl chloride concentrations at different depths. Additional study would focus on the potential of the apparent "pocket" of vinyl chloride to impact additional wells. The study will evaluate the possibility that the pocket of contamination will attenuate naturally and it will also evaluate the feasibility of extracting the pocket by means of a localized purge well.

INFORMATION PROVIDED FOR RESIDENTS

This report was written, in part, to provide information for residents living in North Oaks. Information likely to be of particular interest to residents can be found in the following parts of this report:

- The vinyl chloride results for each sampling round from October 2004 through May 2005 are plotted on maps. (See Figures 3.1 through 3.6 under the "Figures" tab.) Each resident can see on these maps, not only the results from their own well, but the results of nearby wells and the distance of their house from the limited area of vinyl chloride detections.
- Historical results for vinyl chloride are presented from 1993 through 2002 on 9 maps presented on Figures 1.5 through 1.13. These maps show the wells sampled including the 9 years of no vinyl chloride detection prior to the 2004 detection.
- Section 7.0 presents information on questions raised by residents relative to sampling procedures, detection limits, septic system impacts, and other items.

1.0 BACKGROUND

1.1 THE SITE

The Highway 96 Dump Site, located north of Highway 96 and west of Allendale Drive in White Bear Township, was operated as a small burning dump from the 1920s to 1973 and accepted primarily solid waste. In the late 1960s, the dump owners and operators also ran a business involving the transport of waste paints and solvents to other facilities for recycling, and some paints and solvents were disposed of at the dump.

In 1986, a study conducted by the U.S. Environmental Protection Agency (USEPA) discovered that groundwater beneath the Highway 96 Site was contaminated with volatile organic compounds (VOCs), including industrial, solvent-like chemicals. As a result of the study, the MPCA placed the Site into the Minnesota Superfund program; identified Reynolds, Whirlpool, Mrs. Helen A. Krawczewski, and Red Arrow Waste Disposal Company as potentially responsible parties; and requested them to investigate and clean up the contamination. Wastes sent to the Site by Faberge were also evaluated by the MPCA, but Faberge was not named as an responsible party.

Figure 1.1 shows the Highway 96 Site, the north disposal area (NDA), and the south disposal area (SDA) prior to implementation of the final remedy.

1.2 HIGHWAY 96 SITE REMEDIATION AND MONITORING PROGRAM

Remediation of the Highway 96 Site commenced in 1987 and consisted of four major components.

1.2.1 SOURCE REMEDIATION

During 1987 and 1988, contractors for the responsible parties removed drums containing hazardous substances from the NDA. In 1993, additional drums were removed from the SDA. In 1994, the NDA and the SDA waste materials were screened using a backhoe to look for any remaining drums. Drums and drum-related waste identified during the screening process were removed and transported off-site for disposal. The contractors also drained the pond located within NDA. All the pond water was discharged to the sanitary sewer and the sediment and material from the pond bottom were screened and drums of waste were removed. After screening the NDA and the pond, the contractors transferred all waste material from the SDA to the NDA. Tests of the soils underlying

the SDA showed no residual contamination, and the SDA was backfilled with clean soil. All waste material at the NDA, including the waste material transferred from the SDA, was compacted, graded, and capped with two feet of clean soil and remains on the property. Since the waste areas were combined, the NDA has been referred to as the Consolidated Waste Area (CWA). Figure 1.2 shows the location of the CWA.

1.2.2 GROUNDWATER REMEDIATION

Groundwater contamination is present beneath the CWA and has migrated to the west, in the direction of groundwater flow. Since June 1989, a groundwater extraction system has been in operation at the site. The extraction system collects groundwater from Lower Sand Aquifer and St. Peter Aquifer, and it has been effective in limiting the spread of contamination and in removing contaminants from the groundwater since its inception. The contaminated groundwater is discharged to the sanitary sewer for treatment.

In late 1994, after the consolidation of the NDA and SDA, a leachate collection well was installed directly into and under the CWA. Its purpose is to collect the leachate and to discharge the leachate to the sanitary sewer. Leachate is produced when rain and melting snow filter through the waste and dissolve chemicals from the waste. The responsible parties will continue to operate the leachate collection well to reduce the potential for degradation of the groundwater in the deeper, drinking-water aquifers.

Figure 1.3 shows the location of the extraction well and capture area based on groundwater contours from October 18, 2004. Table 1.1 presents the principal compounds found in the St. Peter Aquifer at the Highway 96 Site and at residential wells immediately downgradient of the Highway 96 Site.

1.2.3 ALTERNATE WATER SUPPLY

In 1993, the MDH issued drinking water well advisories to 12 homes in North Oaks between the Site and Gilfillan Lake, because vinyl chloride had been detected in their wells at levels exceeding the health-based risk level that was in place in 1993. Reynolds and Whirlpool chose to address this off-site contamination by connecting all 60 homes with private wells on the east shore of the lake to the White Bear Township municipal water system. These connections were completed in 1994.

Residential wells within the municipal water service area were sealed. Five residential wells on the east side of Gilfillan Lake were converted to long-term groundwater

monitoring wells. One of these monitoring wells was sealed in 2000. The MPCA is requiring the responsible parties to undertake ongoing monitoring of the four remaining monitoring wells and periodic monitoring of residential wells that have not been connected to the municipal water system.

Figure 1.4 shows the area serviced by municipal water.

1.2.4 GROUNDWATER MONITORING PROGRAM

The MPCA and the responsible parties continue to monitor the groundwater at the Site and in downgradient residential areas.

1.2.4.1 MONITORING AT THE HIGHWAY 96 SITE

The current on-site groundwater-monitoring network includes 15 on-site monitoring wells that are screened in the perched groundwater, the unconsolidated glacial aquifer (Lower Sand Aquifer), and the St. Peter Sandstone Aquifer. Five of the 15 on-site monitoring wells are designated as compliance wells and are used to evaluate the effectiveness of the groundwater extraction system. Groundwater samples are collected from on-site monitoring wells on an annual basis.

1.2.4.2 MONITORING IN NORTH OAKS – EAST OF GILFILLAN LAKE

The current groundwater-monitoring network east of Gilfillan Lake includes residential wells, former residential wells that have been converted into monitoring wells, and other monitoring wells that have been installed by the responsible parties.

From 1993 to 2004, the MPCA and Whirlpool/Reynolds have monitored 16 residential wells located outside the municipal water service area and east of Gilfillan Lake on a regular basis.

Five residential wells on the east side of Gilfillan Lake were converted to monitoring wells following installation of the municipal water system in 1994. The five converted residential monitoring wells are located at 6 Blue Goose Road, 1 Lily Pond Road, 11 Lily Pond Road, 11 Robb Farm Road, and 6 Wren Lane. The converted residential monitoring well at 6 Wren Lane was abandoned in May 2000, prior to the sale of the

property. The other four converted residential monitoring wells are still in place and continue to be monitored on an annual basis.

Four other off-site monitoring wells, screened in the Lower Sand Aquifer and the St. Peter Sandstone Aquifer, are located on the east side of Gilfillan Lake, along Robb Farm Road. These four off-site monitoring wells are also designated as compliance wells and are used to evaluate the effectiveness of the groundwater extraction system.

Reynolds and Whirlpool propose to install two additional off-site monitoring/compliance wells west of the Site once an access agreement has been finally secured from the North Oaks Homeowners Association (NOHA)

1.2.4.3 MONITORING IN NORTH OAKS - WEST OF GILFILLAN LAKE

From 1993 to 2004, the MPCA and Whirlpool/Reynolds have monitored 35 residential wells located west of Gilfillan Lake on a regular basis. The vinyl chloride results for sampling conducted during the period from 1993 through 2002 are presented on Figures 1.5 through 1.13. As shown, vinyl chloride was not detected in any residential wells from 1994 through 2002. Samples were not collected in 2001 and 2003 because the monitoring program had been adjusted from annual sampling to every other year. This change was approved by the MPCA after many years of no detections west of Gilfillan Lake.

2.0 RESIDENTIAL WELL SAMPLING PROGRAM

2.1 SUMMARY OF RECENT SAMPLING EVENTS

OCTOBER 2004 SAMPLING ROUND

During the week of October 18, 2004, 16 residential wells on the west side of Gilfillan Lake were sampled as part of the routine annual sampling event for the Highway 96 Site. Samples were collected by CRA and analyzed for VOCs and chloride by Interpoll Laboratories, Inc.

NOVEMBER 2004 SAMPLING ROUND

On November 12, 2004, the clubhouse well at the North Oaks Golf Course (on the west side of Gilfillan Lake) was sampled. The sample was collected by MPCA and analyzed for VOCs by the MDH laboratory. The clubhouse well sample was collected by the MPCA as part of their periodic monitoring in North Oaks.

JANUARY 2005 SAMPLING ROUND

During the week of January 10, 2005, CRA sampled two residential wells on the west side of Gilfillan Lake (12 West Shore Road and 13 West Shore Road) and Interpoll analyzed the samples for VOCs. These wells were sampled because they were the two well locations in which vinyl chloride had been detected during the October 2004 sampling round. Both the MPCA and CRA agreed that additional sampling from the two wells should be undertaken to confirm the October 2004 detections.

FEBRUARY 2005 SAMPLING ROUND

On February 16, 2005, the two residential well locations that contained vinyl chloride in October 2004 samples (12 West Shore Road and 13 West Shore Road) were again sampled as part of the confirmation sampling program. During the February round, verification was conducted using different laboratories. Samples were collected by CRA and analyzed for VOCs and chloride by Severn Trent Laboratories.

The MPCA collected split samples from the same two wells during the February 2005 sampling round. The MPCA's samples were analyzed for VOCs by the MDH laboratory.

MARCH 2005 SAMPLING ROUND

On February 28, 2005, CRA proposed an Expanded Residential Confirmation Sampling Plan to the MPCA as a way to further evaluate the condition of the groundwater on the west shore of Gilfillan Lake. The plan proposed that 20 additional residential wells in the area be sampled. The MPCA approved this plan on March 11, 2005 and added 16 additional wells, increasing to 36 the total number of wells scheduled for additional sampling. The expanded sampling was requested by the MPCA to confirm the large number of non-detect values and also confirm that the vinyl chloride was limited to a small area.

From March 28, 2005 through April 14, 2005, 32 of these 36 residential wells (the ones for which access was gained) were sampled as part of the expanded sampling program. The samples were collected by both CRA and MPCA with each attempting to sample half the locations, and all of the samples were analyzed for VOCs by the MDH laboratory.

On March 30, 2005, the well at the North Oaks East Recreation Center was sampled by the MPCA and was analyzed for VOCs by the MDH laboratory.

APRIL 2005 SAMPLING ROUND

On April 29, 2005, four residential wells, the three locations with detected vinyl chloride and one new location were sampled. The samples were collected by MPCA and analyzed for VOCs by the MDH laboratory. The April 2005 sampling round to confirm previous vinyl chloride detections and note possible trends, as well as determine water between 13 West Shore Road and 2 Hummingbird Hill.

MAY 2005 SAMPLING ROUND

During the week of May 23, 2005, 21 residential wells on the west side of Gilfillan Lake were sampled as part of the expanded sampling program. Samples were collected by CRA and MPCA with each again attempting to sample half the locations. The samples were analyzed for VOCs by the MDH laboratory and for chloride and iron samples by Pace Analytical Services, Inc. The May 2005 sampling round was conducted to confirm

the findings of the October 2004 and March 2005 sampling rounds that detected vinyl chloride only within a limited area.

2.2 CRA's SAMPLING PROCEDURES

CRA collected samples from wells where residents provided permission.

Whenever possible, the samples were collected from an untreated water source (i.e., not softened or filtered). Most often they were collected from an outside tap. The source of the water sample was recorded for each sample collected. Before a sample was collected, the tap was allowed to run for at least 15 minutes to purge the water line and pressure tank of residual water. If a sample was collected from an outside tap, the water was directed via a hose to an area of the yard that minimized the creation of ice or pooled water in an undesirable location. CRA collected water samples directly from the tap after the purge hose was disconnected. Field measurements for pH, conductivity, temperature, and dissolved oxygen, were taken after purging, at the time of sampling. The date, purge rate, and purge time were also recorded. Appendix A presents a summary of field measurements and sampling notes. The measurement of pH, temperature, and conductivity is taken to ensure the reliability of the sample procedure, because consistent readings of these parameters indicates that a representative groundwater sample is collected as opposed to water stored in the pressure tank or water lines.

As a QA/QC measure during the six sample rounds, split samples were collected, at a frequency of 1:10, with the well samples. A trip blank was also included with each sample cooler containing VOC samples submitted to the laboratory.

Samples were either sent by courier or were hand delivered to the laboratory. The October 2004 and January 2005 samples were hand delivered to Interpoll Laboratories by CRA. The February 2005 samples collected by CRA were shipped by overnight courier to STL in Buffalo, New York. The February split samples collected by the MPCA were hand delivered to the MDH laboratory. All March, April, and May samples were hand delivered to the MDH laboratory; the samples collected by CRA were delivered to the MPCA, who then delivered all samples to the MDH laboratory. All samples were handled using standard chain-of-custody procedures, which document each person handling the cooler/samples.

All water samples were analyzed for VOCs. Interpoll Laboratories, Inc. (October 2004 and January 2005 samples) performed analysis of VOCs by EPA method 8260. STL and

the MDH laboratory (February 2005 - May 2005 samples) performed analysis of VOCs by EPA method 524.2. Method 8260 is primarily used for groundwater samples and method 542.2 is primarily used for drinking water.

The October 2004, January 2005, February 2005, and May 2005 samples were analyzed for chloride. Interpoll Laboratories, Inc. (October 2004 and January 2005 samples) and STL (February 2005 samples) performed analysis of chloride by EPA method 300.0A. Pace Analytical Services, Inc. (May 2005 samples) performed analysis of chloride by EPA method 325.2.

The May 2005 samples were also analyzed for iron. Pace Analytical Services, Inc. performed analysis of iron by EPA method 6010.

2.3 ANALYTICAL RESULTS

Laboratory analytical reports are provided in Appendix B. Table 2.1 presents a summary of detected VOCs and chlorides for all sampling events conducted from October 2004 through May 2005. Table 2.1 also provides the current HRLs for comparison.

2.4 DATA VALIDATION

Data validation is performed to determine the usability, accuracy, and reliability of the analytical data provided by the laboratory. Laboratories perform numerous procedures as QA/QC measures to check the accuracy and precision of their data. Data validation is the process of reviewing QC data to provide a second quality control check. Field QC samples are also evaluated in the validation process. CRA follows the procedures in USEPA guidance documents "National Functional Guidelines for Organic Data Review" and "National Functional Guidelines for Inorganic Data Review" when performing data validation. Upon completion of the data validation, "qualifiers" are attached to the data noting their usability.

Data validation memos for the October 2004 through May 2005 sampling rounds are included as Appendix C.

There were no serious quality control concerns with the data. Some data were qualified as estimated (J or UJ qualifier) due to outlying QC and some data were qualified as non-detect (U) due to blank contamination. The field duplicate samples were within acceptance criteria. In other words, the duplicate sample results were comparable.

Chloroform and trichlorofluoromethane were detected in the trip blank associated with the October 2004 sampling round. The associated sample data was qualified as non-detect (see data validation memo dated January 24, 2005). The remaining trip blank samples were reported to be free from detectable concentrations of target analytes.

3.0 RESIDENTIAL WELL SAMPLING RESULTS

Six different VOCs were detected in various water samples collected from residential wells on the west side of Gilfillan Lake between October 2004 through May 2005. An evaluation of these data is presented in Section 3 and Section 4.

The following sections also show the range of results from the October 2004 through May 2005 sampling events. For comparison, these figures include the maximum concentrations detected east of Gilfillan Lake during the period from 1993 to 1994. The 1993 to 1994 time frame was selected because extensive sampling of the residential wells east of the lake was undertaken during those two years, just before those wells were sealed.

3.1 VINYL CHLORIDE

Vinyl chloride concentrations detected in residential well samples from the west side of Gilfillan Lake are presented on Figures 3.1 through 3.6 for the October 2004 through May 2005 sampling events, respectively. Vinyl chloride has been detected in three wells, 12 West Shore Road, 13 West Shore Road, and 2 Hummingbird Hill. The maximum concentration detected is 0.2 µg/L, which is the current level of the HRL.

Figure 3.7 presents vinyl chloride sampling results from 1993/1994 (east of Gilfillan Lake) and 2004/2005 (west of Gilfillan Lake).

3.2 1,1-DICHLOROETHANE

1,1 Dichloroethane has been detected at 12 West Shore Road, 13 West Shore Road, and 2 Hummingbird Hill. The maximum concentration detected was 0.3 µg/L at 13 West Shore Road in March 2005. The HRL for 1,1-dichloroethane is 70 µg/L.

Figure 3.8 presents 1,1-dichloroethane sampling results from 1993/1994 (east of Gilfillan Lake) and 2004/2005 (west of Gilfillan Lake).

3.3 CIS-1,2-DICHLOROETHENE

Cis-1,2-dichloroethene has been detected in samples collected from at 12 West Shore Road and at 13 West Shore Road. The maximum concentration detected was 0.12 µg/L at 13 West Shore Road in January 2005. The HRL for cis-1,2-dichloroethene is 70 µg/L.

Figure 3.9 presents cis-1,2-dichloroethene sampling results from 1993/1994 (east of Gilfillan Lake) and 2004/2005 (west of Gilfillan Lake.)

3.4 METHYL ETHYL KETONE

Methyl ethyl ketone (MEK) was detected in six well samples during the May 2005 sampling round. MEK was detected at 12 West Shore Road, 1 Thompson Lane, 2 Thompson Lane, 1 Hummingbird Hill, 2 Hummingbird Hill, and 12 Ski Lane. All MEK detections were at the same level of 6 µg/L. The HRL for MEK is 4,000 µg/L.

No MEK was detected in the duplicate sample from 12 West Shore Road taken in the May 2005 sample round. The six MEK detections in May 2005 are also inconsistent with the results of the February, March, and April sampling rounds, which did not result in any MEK detections.

Figure 3.10 presents MEK sampling results from 1993/1994 (east of Gilfillan Lake) and 2004/2005 (west of Gilfillan Lake).

3.5 CHLOROFORM

Chloroform was detected at a concentration of 0.1 µg/L in the North Oaks Golf Course well during the March 2005 sampling round. The HRL for chloroform is 60 µg/L. Chloroform, which sometimes results from the use of chlorine to disinfect a drinking water well, was not detected in any other residential well sampled between October 2004 and May 2005. Hence, the chloroform detection at the golf course well appears to be unrelated to the vinyl chloride detections.

3.6 METHYLENE CHLORIDE

Methylene chloride was detected at 12 West Shore Road during the May 2005 sampling event at a concentration of 0.26 µg/L. This was the only detection of methylene chloride on the west side of Gilfillan Lake. The HRL for methylene chloride is 50 µg/L. The detection of methylene chloride in May 2005 is inconsistent with previous sampling rounds and is attributed to laboratory contamination.

3.7 CHLORIDE

Chloride is an inorganic chemical that occurs naturally in all groundwater. Chloride can also be related to landfills, road salt, and septic systems. The October 2004, January 2005, February 2005, and May 2005 residential well samples were all analyzed for chloride and the results are presented on Table 2.1.

Figure 3.11 presents chloride sampling results from 1993/1994 (east of Gilfillan Lake) and 2004/2005 (west of Gilfillan Lake). As shown on Figure 3.11, there are areas of chloride levels above 100 mg/L at 7 Dove Lane/9 Dove Lane, 17 Dove Lane, 11 Duck Pass Road/26 Duck Pass Road, and 10 Gilfillan Lake Road/ 29 Robb Farm Road. These areas of high chloride concentrations are likely associated with releases from residential septic systems, because the results do not fit the pattern expected of a plume coming from the Highway 96 Site.

4.0 GROUNDWATER EVALUATION

This section discusses the results of the six month study as it relates to geology, hydrogeology and groundwater chemistry.

4.1 GEOLOGY

The geology of the North Oaks area consists of three significant stratigraphic units: unconsolidated glacial deposits, St. Peter Sandstone, and the Prairie du Chien Group (an interbedded limestone and sandstone unit).

The variable topography of the eastern North Oaks area is typical of a glacial deposit terrain, and ranges in elevation from 910 ft above mean sea level (AMSL) to greater than 970 ft AMSL. The unconsolidated deposits are comprised of a mixture of sediment with appreciable amounts of clay, silt, sand, and gravel particles. This area has been identified by the Minnesota Geological Survey as a complex intermixed deposit of glacial till with sandy loam and sandy clay loam (Meyer 1985[2]). The unconsolidated glacial deposit ranges from 50 to 150 ft and is rarely used as a potable water supply in the North Oaks area.

The unconsolidated glacial deposits are typically underlain by the St. Peter Sandstone. However, erosional remnants of the younger Platteville Limestone and Glenwood Shale formations are sporadically observed in this area.

The St. Peter Sandstone is classified as a white, fine to medium grained, well sorted, silica sandstone. Regionally, the St. Peter Sandstone typically ranges in thickness from 0 to 150 ft. The lower 5 to 50 ft of the St. Peter Sandstone exhibits varying amounts of siltstone and shale.

A total of 14 well logs were obtained from the MDH County Well Index (CWI). A review of 14 available well logs from the west side of Gilfillan Lake indicates that 12 wells are screened in the lower portions of the St. Peter Sandstone. One well is screened in the upper portion of the St. Peter Sandstone. Another well is screened in the lower portion of the St. Peter Sandstone and the upper portion of the Prairie du Chien Group. These well construction logs are comparable with the residential wells that were located on the east side of Gilfillan Lake, where approximately 85% of the wells were screened in the lower portion of the St. Peter Sandstone. The remaining wells were either

[2] Meyer, G.N. 1985. Quaternary Geologic Map of the Minneapolis-St. Paul Urban Area; Minnesota Geological Survey, Misc. Map Series M-54.

screened in the upper portion of the St. Peter Sandstone or partially screened in both the St. Peter Sandstone and Prairie du Chien Group. A copy of available residential well logs are presented in Appendix D.

The bedrock surface of the St. Peter Sandstone in the eastern North Oaks area is highly variable due to glacial erosion. Figure 4.1 presents the topographic surface of the St. Peter Sandstone. As shown on the figure, the bedrock surface elevation can vary by approximately 100 ft. The St. Peter Sandstone is the primary aquifer for residential water supply in the North Oaks area. The St. Peter Sandstone is underlain by the Prairie du Chien Group.

The Prairie du Chien Group consists of the Shakopee Formation and the Oneta Dolomite and is classified as an interbedded dolomitic limestone and sandstone. Regionally, the Prairie du Chien Group ranges in thickness from 0 to 250 ft. The Prairie du Chien Group and the underlying Jordan Sandstone form the primary aquifer for municipal water supply in the Minneapolis-St. Paul metropolitan area. For example, White Bear Township and the City of Vadnais Heights municipal wells draw water from this bedrock formation.

A geologic cross-section has been constructed from the Highway 96 Site westward through the North Oaks area to the North Oaks Golf Course to show the underlying geologic conditions. The cross section location is shown on Figure 4.2. The geologic cross-section is presented as Appendix E. In addition, the geologic cross section shows the depth of monitoring wells and residential wells in the area.

4.2 HYDROGEOLOGY

In this section surface water and groundwater are discussed as they relate to the North Oaks area; the principal surface water body is Gilfillan Lake. For groundwater, there are three significant groundwater-stratigraphic units: the unconsolidated glacial aquifer, the St. Peter Aquifer and the Prairie du Chien/Jordan Aquifer. For the purpose of this evaluation, the St. Peter Aquifer was the principal formation evaluated, because it is the primary potable water supply in the North Oaks area.

GILFILLAN LAKE

Gilfillan Lake represents the primary surface water feature for the southeast portion of North Oaks. Gilfillan Lake encompasses approximately 110 acres, with the approximate

dimensions of 3,000 ft in length and 1,500 ft in width. The maximum lake depth is 9 ft. and the lake elevation is approximately 910 ft AMSL. Given the shallow lake depth, it is unlikely that Gilfillan Lake is in direct hydraulic connection with the regional groundwater system or influences it. However, Gilfillan Lake, along with surrounding wetland areas, do recharge the groundwater system via infiltration.

UNCONSOLIDATED GLACIAL AQUIFER

Because a North Oaks ordinance required a minimum well depth of 150 ft., the unconsolidated glacial aquifer is rarely used as a source of potable water. Also, the variable composition of the unconsolidated glacial deposit can limit it as a water supply at some locations, especially if abundant clay and silt are present.

At the Highway 96 Site, the unconsolidated glacial aquifer is referred to as the Lower Sand Aquifer and it is the uppermost aquifer in the area. Groundwater is encountered in this aquifer at an approximate elevation of 900 ft AMSL. The unconsolidated glacial aquifer is recharged by infiltration from rainwater, snowmelt and surface water bodies, such as Gilfillan Lake.

Groundwater flow within this aquifer (except at the Highway 96 Site where groundwater is extracted) is towards the west. In addition, there is a downward component of flow in the unconsolidated glacial aquifer such that groundwater from the unconsolidated glacial aquifer recharges the St. Peter Aquifer.

ST. PETER AQUIFER

The St. Peter Aquifer underlies the unconsolidated glacial aquifer. The groundwater elevation of wells placed in this aquifer is approximately 896 ft AMSL in the Highway 96 Site area, and the water level decreases to the west. Groundwater moves westward in the direction of declining water levels.

Groundwater contours for the southeast portion of the North Oaks area were prepared as part of the 1993 investigation (CRA, 1993). Figures 4.3 and 4.4 show the groundwater contours for August 11 and August 20, 1993, respectively. As shown on the attached figures, groundwater flow is generally to the west.

As shown on Figure 4.1, the St. Peter Sandstone topography decreases to the north and increases to the south. The decrease in the bedrock topography corresponds to an

increase in the thickness of overlying heterogeneous glacial deposits. The glacial deposits are likely to have a lower permeability and would affect groundwater flow patterns.

Pumping by residential wells has a minimal effect on groundwater flow in the St. Peter Aquifer, because those wells rarely pump at high sustainable rates for long time periods. Similarly, the North Oaks Golf Course well does not influence groundwater flow in the St. Peter Aquifer, because it is not used for irrigation purposes.

The hydraulic conductivity of the St. Peter Sandstone was evaluated as part of the environmental investigations at the Highway 96 Site. These investigations included aquifer pumping tests, single well response tests, and packer tests. Overall, these tests determined that the hydraulic conductivity of the St. Peter Aquifer averages 5.2 x 10-3 cm/s (15 ft/d) at the Highway 96 Site.

As discussed in Section 4.1, the basal portion of the St. Peter Aquifer contains sandstone and shale and is expected to have a lower hydraulic conductivity. However, CRA's review of pumping records by well drillers shows that while the basal portion of St. Peter Aquifer does contain appreciable amounts of shale, it is not an aquitard. An aquitard is defined as a low permeability deposit (e.g., shale) that does not yield economical amounts of groundwater.

In 1993, the hydraulic gradient across the southeast portion of North Oaks was calculated as 0.004 ft/ft (CRA, 1993). The effective porosity is assumed at 28% for the St. Peter Aquifer (Norvitch and others, 1973[3]).

By applying the above parameters, the average linear groundwater velocity within the St. Peter Aquifer is estimated to be approximately 80 ft/yr in the area of the Highway 96 Site. However, it is recognized that these input parameters can vary spatially and temporally within the St. Peter Aquifer.

PRAIRIE DU CHIEN AQUIFER

The Prairie du Chien Aquifer underlies the St. Peter Aquifer. The Prairie du Chien along with the underlying Jordan Sandstone Aquifer is the primary drinking water supply for the metropolitan area. Both aquifers are capable of yielding over 1,000 gpm. Regional

[3] Norvitch, R.F., T.G. Ross, and A. Brietkrietz, 1973, Water Resources Outlook for the Minneapolis-St. Paul Metropolitan Area, Minnesota; Metropolitan Council of the Twin Cities, 219 pgs.

groundwater flow in the Prairie du Chien Aquifer is the southwest towards the Mississippi River Valley.

4.3 GROUNDWATER TRAVEL TIME WITHIN ST. PETER AQUIFER

Based on studies conducted at the Highway 96 Site, CRA estimates that groundwater velocity in the vicinity of the Site is approximately 80 ft per year. Thus, assuming that the vinyl chloride on the west shore of Gilfillan Lake was released from the Site -, it would have left the site approximately 50 years ago [4000 feet (the distance from the Site to 12 West Shore Road) divided by 80 feet/year = 50 years]. Even recognizing that the travel time might be somewhat less than 50 years, because groundwater velocities can vary in the St. Peter Aquifer, or somewhat more than 50 years, because the elementary calculation above does not account for processes that inhibit VOC migration, the time required for groundwater to travel from the Site to the west side of Gilfillan Lake would be decades.

Thus, the vinyl chloride recently detected in residential wells on the west shore of Gilfillan Lake would have left the Site well before the discovery of groundwater contamination in 1986 and the beginning of groundwater remediation in 1989. Moreover, because it would have taken additional time for contaminants to leach from any landfill wastes and to travel through the unsaturated zones and the Lower Sand Aquifer before they reached the St. Peter Aquifer, the wastes producing the vinyl chloride now being detected on the west shore of the lake would have been deposited in the landfill even earlier.

4.4 GROUNDWATER DATABASE EAST OF GILFILLAN LAKE

Because groundwater in the St. Peter Aquifer flows to the west, data from wells located east of Gilfillan Lake may help to evaluate and predict the groundwater situation west of the lake. Data from the east shore wells includes the following:

- Data from samples collected from over 60 residential wells in 1993 and 1994. These samples were collected before most of those wells were sealed as part of the municipal water system installation.
- Data from samples collected from 16 residential wells located on the east side of Gilfillan Lake, but outside of the municipal water service area. Those wells have been periodically monitored over the past 12 years.

- Data collected from five residential wells that were converted to monitoring wells. Those wells are all located within the municipal service area on the east side of Gilfillan Lake at 6 Blue Goose Road, 1 Lily Pond Road, 11 Lily Pond Road, 11 Robb Farm Road, and 6 Wren Lane (abandoned in May 2000). They have been regularly monitored for the last 12 years.
- Data collected from four monitoring wells located along the east side of Robb Farm Road, immediately downgradient from the Highway 96 Site. They have also been regularly monitored for the last 12 years.

4.5 REMNANT PLUME

Data from 7 Robb Farm Road and 11 Robb Farm Road show that VOCs were present in residential well samples immediately downgradient of the Highway 96 Site in the 1986 through 1990 timeframe. Figures 4.5 and 4.6 show that the groundwater extraction system installed in 1989 has been and continues to be effective at reducing the off site VOC concentrations and cutting off the plume. As shown, the VOC concentration declined rapidly over the first four years of extraction. Total VOCs are used here to illustrate the performance of the extraction system because the majority of contaminants leaving the Site were freon compounds. The area of low-level VOC contamination within the St. Peter Aquifer, which affected the North Oaks residential wells on the east side of Gilfillan Lake in the early 1990's, was a remnant plume from the Site and already was present in the area before the groundwater extraction system was installed at the Site in 1989.

Vinyl chloride levels historically found at the Highway 96 Site were in the range of 20 µg/L. Vinyl chloride levels within the remnant plume of North Oaks, east of Gilfillan Lake, were typically in the range of 0.1 to 2 µg/L in 1993 which demonstrates that vinyl chloride is being naturally attenuated over distance and time.

In 1993-1994, 76 wells east of Gilfillan Lake and within the remnant plume were sampled. In 67 of these wells, vinyl chloride either was not detected at all or was detected at levels below the HRL of 0.2 µg/L. This remnant plume means that most of the area east of Gilfillan Lake cannot be a source to contamination west of the lake, because vinyl chloride concentrations decrease over distance and time due to natural attenuation processes. Nine wells exceeded 0.2 µg/L in 1993/1994. Within the remnant plume (Figure 4.7) of 1993/1994, there were three areas were vinyl chloride was detected at concentrations above 0.2 µg/L. These were:

- *Gilfillan Road Area*: Three residential wells located at 15, 17, and 22 Gilfillan Road had maximum vinyl chloride concentrations ranging from 1.9 µg/L to 2.4 µg/L during the period from 1993 to 1994. Samples collected from residential wells located north, east and south of these three locations did not detect vinyl chloride at levels above 0.2 µg/L. This relatively narrow area of vinyl chloride may have extended beneath Gilfillan Lake but could not be studied because of the extreme difficulty of sampling beneath the lake. The presence of vinyl chloride at 12 West Shore Road, 13 West Shore Road, and 2 Hummingbird Hill in 2004/2005 is likely associated with this area of vinyl chloride contamination from Gilfillan Road.
- *Lily Pond Road Area:* Four residential wells located at 1, 6, 8, and 13 Lily Pond Road had maximum vinyl chloride concentrations ranging from 0.4 µg/L to 1.0 µg/L during the period from 1993 to 1994. Two residential wells in this area (1 Lily Pond Road and 11 Lily Pond Road) were converted into monitoring wells and have been sampled annually since 1993. At both converted residential monitoring wells, vinyl chloride concentrations have been consistently non-detect or below 0.2 µg/L since 1998. The sample data indicates that the remnant plume is naturally dissipating as a result of the Highway 96 Site groundwater remedy.
- *Dove Lane Area:* Two residential wells located at 17 and 19 Dove Lane had maximum vinyl chloride concentrations ranging from 0.31 µg/L to 0.41 µg/L during the period from 1993 to 1994. Vinyl chloride was not detected in any samples collected from residential wells located north, east, south, and west of the 17 and 19 Dove Lane area. The well sealing log for 17 Dove Lane shows that the well was approximately 68 feet deep. Hence, the sample from 17 Dove Lane indicated the quality of the unconsolidated glacial aquifer and not the St. Peter Aquifer. In addition, the 17 Dove Lane sample contained elevated chloride levels of 160 mg/L. Thus, it seems very likely that the vinyl chloride contamination resulted from a residential septic system (as discussed above) rather than from the Highway 96 Site. Given the isolated nature of the vinyl chloride concentrations, the shallow well depth, and the low vinyl chloride concentrations it is improbable that the Dove Lane area represents a source of any vinyl chloride contamination to residents on the west side of Gilfillan Lake.

4.6 SOURCE EVALUATION

This portion of the report evaluates three possible explanations for the presence of vinyl chloride west of Gilfillan Lake. These possibilities are as follows:

4.6.1 THE 1993/1994 GILFILLAN AREA OF VINYL CHLORIDE IS THE MOST LIKELY SOURCE

The data collected to date indicates that the most likely explanation for the presence of vinyl chloride in the 12 West Shore Road/13 West Shore Road/ 2 Hummingbird Hill area is that the remnant area of vinyl chloride observed at Gilfillan Road in 1993 has migrated westward, resulting in an isolated pocket of vinyl chloride on the west side of the lake in the vicinity of 12 West Shore/13 West Shore Road/2 Hummingbird Hill area. During its migration process, the vinyl chloride has naturally attenuated to levels between 0.1 µg/L and 0.2 µg/L. The presence of 1,1-DCA and elevated chloride levels, as well as vinyl chloride, in both areas supports this interpretation. The failure to detect any vinyl chloride in residential wells south or north of the 12 West Shore Road/ 13 West Shore Road/ 2 Hummingbird Hill area is also consistent with this theory.

4.6.2 DEVELOPMENT OF A BROAD VINYL CHLORIDE PLUME

CRA also evaluated the possibility that a broad, low-level vinyl chloride plume has developed along the west shore of Gilfillan Lake. If this theory were correct, however, all the vinyl chloride observed in the Dove Lane, Gilfillan Road, and Lily Pond Road areas on the east side of the lake in the early 1990's would have had to migrate westward without attenuating. This scenario is less likely than the scenario presented above. The concentrations of vinyl chloride detected in the Dove Lane area in 1993 were only slightly above the HRL. Moreover, vinyl chloride has not been detected in any residential wells downgradient of the Lily Pond Road area.

4.6.3 SEPTIC SYSTEMS

As discussed above, it seems clear that septic systems have caused some groundwater contamination on the east side of Gilfillan Lake. If the vinyl chloride observed at the 12 West Shore Road/ 13 West Shore Road/ 2 Hummingbird Hill area has been caused by septic systems, the source of those septic releases would have to be in the vicinity of 12 West Shore Road or the Gilfillan Road area.

VOC impacts to groundwater by residential septic systems have occurred in other communities throughout the United States including communities in Massachusetts, New Jersey, Virginia, Connecticut, New York, Pennsylvania, and Wisconsin. Given the above, further study of septic releases in North Oaks could help distinguish contamination that came from the Highway 96 Site versus contamination from residential septic systems. Recent investigation methods have analyzed groundwater

samples for caffeine to evaluate septic system impacts.(Seiler and others, 1999[4]; Verstraeten and others, 2005[5]). Caffeine can provide evidence of migration from septic systems. Samples from the Highway 96 site would also be collected for comparison.

4.7 DEPTH OF VINYL CHLORIDE

The vinyl chloride detections in North Oaks east and west of Gilfillan Lake were typically found in the St. Peter Aquifer at depths 160 to 220 feet below ground surface. There is no clear indication that vinyl chloride extends below the St. Peter Aquifer and into the underlying Prairie du Chien Aquifer. Vertical aquifer profiling was performed in 1993 at the Highway 96 Site to define the thickness of the VOC plume. To define off-site plume conditions, additional vertical aquifer profiling would be necessary to better understand the extent and variation of vinyl chloride within the St. Peter Aquifer.

4.8 POTENTIAL FOR FUTURE WESTWARD MIGRATION OF VINYL CHLORIDE

Sampling of residential wells west of 12 West Shore/13 West Shore/2 Hummingbird Hill area currently shows that vinyl chloride has not migrated to residential wells located to the west. Vinyl chloride will continue to naturally attenuate over distance and time. However, there is little understanding within the scientific community of degradation rates for sub-part per billion levels of vinyl chloride. Further monitoring and study is required to better predict the potential for vinyl migration. Such future evaluation would include monitored natural attenuation sampling, hydraulic analysis and vinyl chloride trend analysis.

If further evaluation shows that vinyl chloride may continue to migrate westward, it may be possible to purge the vinyl chloride from the aquifer. The feasibility of purging would depend on obtaining access to property in the area; cooperation from property owners, and permission to discharge extracted groundwater to a surface drainage.

[4] Seiler, R.L., S.D. Zaugg, J.M. Thomas, and D.L. Howcroft. 1999. Caffeine and Pharmaceuticals as Indicators of Waste-Water in Wells. Ground Water, no. 37, vol. 3, pp.405-410.
[5] Verstraeten, I.M., G.S. Fetterman, M.T. Meyer, T Bullen, and S.K. Sebree.2005. Use of Tracers and Isotopes to Evaluate Vulnerability of Water in Domestic Wells to Septic Waste. Ground Water Monitoring & Remediation, vol. 25, no. 2, 107-117.

5.0 INTERIM AND PERMANENT SOLUTIONS

5.1 INTERIM SOLUTIONS

Reynolds and Whirlpool have provided (and continue to provide) bottled water to 12 West Shore Road, 13 West Shore Road, and 2 Hummingbird Hill as a precautionary measure until a permanent remedy is implemented. Although the MDH and MPCA did not request that bottled water be provided, the companies, as a voluntary measure offered to provide bottled water to any resident in whose well vinyl chloride is detected at or above the proposed HRL of 0.08 µg/L. The companies have stated they will continue to provide bottled water to such residents until the groundwater situation has been fully evaluated or until the vinyl chloride concentration in their well declines below 0.08 µg/L for two consecutive sampling events.

5.2 POSSIBLE PERMANENT SOLUTIONS

CRA evaluated three alternatives as permanent solutions for 13 West Shore Road, which is the only residence on the west shore of Gilfillan Lake that has, to date, received a drinking water well advisory from the MDH. Although 2 Hummingbird Hill did in one event (April) detect vinyl chloride at 0.2 µg/L, it has not been issued a drinking water well advisory. The three alternatives are installation and maintenance of a home treatment system, installation of a deeper well in the Prairie du Chien Aquifer, and connection to a municipal water supply.

5.2.1 HOME TREATMENT SYSTEM

A home treatment system for well water containing vinyl chloride would consist of an activated carbon unit (similar in size to a water softener) that would remove the vinyl chloride. Because the vinyl chloride would be adsorbed onto the carbon, this treatment option would be a reliable and effective remedy.

Home treatment is commonly used to remove VOCs from residential well water. At two other sites in Minnesota, carbon treatment is used to remove vinyl chloride from private water supplies. One site is a former dump site near Northfield, Minnesota where groundwater is contaminated with low levels of vinyl chloride and other VOCs. Tests have demonstrated that the carbon treatment has been effective in removing the contaminants. The situation at the other site in Renville County is similar, and carbon has proved similarly successful in treating vinyl chloride contamination. If a home treatment system were installed as a permanent solution, it would be necessary to

change the carbon unit in the system approximately every 6 months, though the actual frequency would depend on the concentrations of VOCs in the water. An added benefit of home treatment would be the system's ability to remove some naturally-occurring compounds, such as iron and hydrogen sulfide, which are present in the St. Peter Aquifer and adversely affect the taste of the drinking water.

Carbon treatment systems are available from commercial vendors (e.g., Culligan) and can be installed with only minor plumbing modifications. The cost for this alternative would be approximately $5,300 for installation costs and approximately $4,200/year for maintenance and monitoring.

5.2.2 DEEPER WELL IN PRAIRIE DU CHIEN AQUIFER

Because a North Oaks ordinance requires that water supply wells be installed to a minimum depth of 150 feet, most residential wells on the west side of Gilfillan Lake are screened in the St. Peter Aquifer at depths between 160 feet and 220 feet deep. The deeper well alternative would involve the installation of a well in the Prairie du Chien Aquifer at a depth of approximately 350 feet. The well would be double cased through the St. Peter Aquifer to prevent contamination from migrating down along the well casing. The existing well would either be abandoned or converted to use as a monitoring well.

Though CRA has not tested the Prairie du Chien Aquifer in the immediate vicinity of the affected west shore wells, there is nothing to indicate that the Prairie du Chien Aquifer has been affected by the Highway 96 Site at a depth of 350 feet. Therefore, a Prairie du Chien well will very likely provide both a permanent water supply from an aquifer that is uncontaminated and (because the Prairie du Chien Aquifer has lower iron concentrations than the St. Peter Aquifer) better tasting water. The use of a deeper well would also be more convenient for a resident than the use of bottled water or a home treatment system, which need periodic resupplying or maintenance.

The approximate cost to install one 350-foot deep, double cased, well into the Prairie du Chien Aquifer would be $20,000.

5.2.3 MUNICIPAL WATER

CRA's preliminary evaluation of connecting an affected residence to a municipal water supply shows the following:

- The existing watermain system located east of Gilfillan Lake terminates at 25 Robb Farm Road and 7 Duck Pass Road. A separate trunk main service or a booster station would likely be needed to service the area west of Gilfillan Lake.
- Approximately 8,000 feet of watermain would be required to service residences on West Shore Road, East Oaks Road, Poplar Lane, Hummingbird Hill, and Thompson Lane.
- If a residence were to be connected to a municipal water supply, the existing well at that residence would need to be sealed.

Preliminary estimates indicate that the cost of installing a watermain to service a west shore residence (or several residences) would be approximately $800,000 (8,000 ft @ $100/LF). In addition, the connection of a residence to a municipal water supply would involve connection costs, water supply costs imposed by the supplying municipality, and trunk main or booster station costs. These additional costs have not been estimated at this time.

5.3 MONITORING

Long term monitoring is needed to provide an ongoing evaluation of water quality.

CRA recommends that the residential wells west of Gilfillan Lake continued to be monitored under a comprehensive monitoring program for at least one more year. Thereafter, the monitoring scope would be reduced, if warranted. Specifically, CRA recommends that 61 homes be sampled once during the next year and that 31 of these 61 homes be sampled quarterly. CRA selected the homes recommended for quarterly monitoring based on their proximity to the three wells in which vinyl chloride has been detected. Figure 5.1 shows the locations of these homes.

Because groundwater moves slowly and sudden changes are not expected, CRA believes that quarterly monitoring will be sufficient to allow it to identify and respond to any groundwater contamination trends on the west shore of Gilfillan Lake.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

Based on its six month evaluation, CRA has concluded the following:

1. Vinyl chloride is present in 3 residential wells (12 West Shore Road, 13 West Shore Road, and 2 Hummingbird Hill) at concentrations that are detectable at or below the HRL of 0.2 µg/L. One location, 13 West Shore Road, has been issued a drinking water well advisory by the MDH.
2. Extensive monitoring from October 2004 through May 2005 has confirmed that, to date, the presence of vinyl chloride is limited to those three residential wells at 12 West Shore, 13 West Shore, and 2 Hummingbird Hill.
3. It is likely that the vinyl chloride now present in the wells at 12 West Shore Road, 13 West Shore Road, and 2 Hummingbird Hill has resulted from the westward migration of an area of vinyl chloride previously located in the 15/17/22 Gilfillan Road Area.
4. If it is assumed that the vinyl chloride detected in the 12 West Shore Road/13 West Shore Road/ 2 Hummingbird Hill area originated from the Highway 96 Site, then the vinyl chloride would have left the Highway 96 Site well before the discovery of contamination at the Site in 1986.
5. Residential septic systems are a potential source of groundwater contamination in North Oaks and a known source in other communities. Septic systems can release a variety of VOCs that may be found at low levels in residential wells. Further study is required to differentiate between contamination from the Highway 96 Site and septic systems.

6.2 RECOMMENDATIONS

Based on its findings and conclusions, CRA recommends the following:

1. A new water supply well screened in the Prairie du Chien Aquifer should be installed at 13 West Shore Road. In the event the new well does not provide a potable water source, the residence should be provided with a home treatment system using activated carbon.
2. Residential wells on the west shore of Gilfillan Lake should continued to be monitored, as outlined in Section 5.3;

3. An analysis of water samples for caffeine (a septic system tracer) should be conducted.
4. Vertical profiling of groundwater quality in the St. Peter Aquifer at two locations within North Oaks (12 West Shore/ 13 West Shore/ 2 Hummingbird Hill area and 15/17/22 Gilfillan Road area) should be undertaken.
5. The potential for vinyl chloride to migrate to the west and the feasibility of purging the 12 West Shore Road/ 13 West Shore Road/ 2 Hummingbird Hill area should be evaluated.

7.0 ANSWERS TO QUESTIONS FREQUENTLY POSED BY RESIDENTS

This section of the report was prepared to address questions posed by residents in North Oaks.

7.1 WHAT ARE THE "HEALTH RISK LIMITS" THAT HAVE BEEN PUBLISHED BY THE MINNESOTA DEPARTMENT OF HEALTH FOR DRINKING WATER FROM RESIDENTIAL WELLS?

Pursuant to the Minnesota Groundwater Protection Act of 1989, the MDH has adopted permanent rules defining health risk limits ("HRLs") for 120 contaminants that have been found in Minnesota groundwater. The MDH defines a HRL as an exposure value for a concentration of a groundwater contaminant, expressed in micrograms per liter (µg/L), that can be safely consumed daily for a lifetime. For carcinogenic compounds, the MDH uses a 1 in 100,000 excess cancer risk for establishing the HRL.

The MDH uses its HRLs to determine if a private water supply is acceptable as a drinking water source. When a HRL is reached or exceeded, the MDH will generally issue a drinking water well advisory. This advisory is a recommendation to the homeowner that an alternate source of water should be used or that some form of treatment should be undertaken. In some instances where multiple chemicals are detected in a well, the MDH will take a conservative approach and issue a drinking water well advisory even though no individual HRL has been exceeded. The MDH considers a value which is equal to the HRL to be an exceedence.

Table 7.1 is a summary of existing HRLs for compounds that have recently been detected in samples collected from residential wells in North Oaks.

The MDH is currently evaluating potential changes to the HRLs. The current HRL for vinyl chloride is 0.2 µg/L. The proposed HRL for vinyl chloride is 0.08 µg/L. A scientific review of the proposed HRL is being conducted and any changes to the HRL are likely to be more than a year away.

7.2 WHAT IS THE DIFFERENCE BETWEEN HRLs AND MAXIMUM CONTAMINANT LEVELS (MCLs) FOR MUNICIPAL WATER

As described above, HRLs are state standards that apply to drinking water from private residential wells. "Maximum Contaminant Levels" ("MCLs") are federal standards which have been developed by the USEPA under the federal Safe Drinking Water Act

and which apply to public water supplies. MCLs do not apply to private water supplies. For example, the City of Edina, which has vinyl chloride in its municipal water supply, is required to meet the MCL for vinyl chloride of 2.0 µg/L. This health standard is 10 times. higher (i.e., 10 times less stringent) than the vinyl chloride HRL of 0.2 µg/L applied by the MDH to private wells in the State.

The USEPA has determined that vinyl chloride at the MCL (2.0 µg/L) is a safe level for consumption over a lifetime.

7.3 HOW DOES THE MINNESOTA HRL FOR VINYL CHLORIDE COMPARE TO SIMILAR HEALTH STANDARDS FOR VINYL CHLORIDE THROUGHOUT THE UNITED STATES?

CRA maintains an informal database of drinking water standards based on work conducted on projects throughout the United States and in other countries. From this database, drinking water standards for vinyl chloride have been summarized and are provided in Appendix F. Table 7.2 presents a summary of enforceable drinking water standards for vinyl chloride for 34 states, two countries, the European Union, and the World Health Organization. Although the list is not a complete evaluation of all drinking water standards, it shows that Minnesota have one of the most stringent standards for vinyl chloride. Because only a few states use standards lower than the federal one, the scientific community has not studied that the fate and transport of vinyl chloride at levels as low as those currently being found in North Oaks. In addition, very few commercial laboratories are set up to measure vinyl chloride at the levels of the current HRL (0.2 µg/L) let alone the proposed HRL (0.08 µg/L).

7.4 ARE THERE HEALTH RISKS ASSOCIATED WITH ACTIVITIES OTHER THAN DRINKING WATER THAT CONTAINS VINYL CHLORIDE?

Exposure to vinyl chloride from drinking water would be from ingestion. Exposure to vinyl chloride from such activities as bathing or showering, would be from inhalation. A recent study completed by Kerger and others in 2000[6] used actual measurements in both water and air that were taken from actual homes and estimated that the exposure risk through inhalation of VOCs is less than the exposure risk through ingestion by a factor of three to four. A more detailed draft write up, which was completed by the MDH, is presented in Appendix G.

[6] Kerger, B.D., C.E. Schmidt, and D.J. Paustenbach. 2000. Assessment of Airborne exposure to Trihalomethanes from Tap Water in Residential Showers and Baths. Risk Analysis, 20, pp. 637-651.

7.5 HAVE OTHER COMPOUNDS BEEN FOUND IN RESIDENTIAL WELLS AT LEVELS HIGHER THAN THE APPLICABLE HEALTH RISK LIMITS?

Groundwater monitoring at residential wells has been ongoing for the past 19 years. A total of 133 residential wells have been sampled for over 60 chemicals. CRA compared the database, dating back to 1993, to the existing HRLs. Vinyl chloride and carbon tetrachloride are the only compounds that has ever been detected at levels exceeding a HRL in the residential wells since 1993, which is the year extensive residential well testing began. However, the converted residential well location (11 Lily Pond) that detected carbon tetrachloride in 1996 has not detected that compound in nine other sampling events.

Given the above, vinyl chloride is the contaminant of principal concern.

7.6 ARE SEPTIC SYSTEMS POTENTIAL SOURCES TO GROUNDWATER CONTAMINATION?

Each home in the North Oaks study area has a septic system. A typical household discharges 300 gallons per day of sewage into its septic system, which, by design, relies upon the underlying soils to filter the waste before it reaches the groundwater. Thus, it can be estimated that the 60 homes located east of Gilfillan Lake discharge between 6 and 7 million gallons of waste per year to the ground (60 homes x 300 gallons/day x 365 days/yr). Similarly, the 45 homes located west of Gilfillan Lake discharge almost 5 million gallons per year.

Septic systems are composed of two treatment components, the septic tank and the drainfield or soil treatment system. Water is piped from a home to the buried septic system. Liquids flow through the septic tank to the drainfield and into subsurface soil. Septic systems are biological treatment systems designed to treat household wastewater by using bacteria and other microbes to break it down. They are not designed to treat organic solvents, such as trichloroethylene (TCE) or perchloroethylene (PCE), which pass through the system, leach into the soil and can impact groundwater.

Historically, TCE and PCE were commonly used as septic tank cleaners (sometimes packaged as brand name cleaners). Being aggressive degreasers, these solvents were effective at cleaning grease from inside pipes and septic tanks. Septic tank owners have also used PCE and TCE to break down the sludge built up in their septic tanks,

supposedly causing it to pass through the septic tanks and thereby delaying the need to pump out the sludge.

In addition to septic tank cleaners, numerous other household products contain TCE or PCE, including spot removers for fabrics, carpet cleaners, paint strippers, engine degreasers, adhesives, and glues. When these products are flushed down the drain of a home with a septic system, they flow to the leach field of the septic system and can find their way to the groundwater.

TCE and PCE can biodegrade into vinyl chloride as they migrate through groundwater. Figure 7.1 illustrates the biodegradation pathway from PCE to vinyl chloride and beyond to a non-toxic end member. The biodegradation processes involves the removal of chloride ions due to naturally occurring microorganisms or chemical oxidation processes. Very little vinyl chloride is required to negatively affect a large volume of aquifer. For instance, less than an ounce of vinyl chloride can result in a 5 million cubic foot aquifer having an average concentration of 0.2 µg/L. Because of this biodegradation pathway, regulators commonly recognize residential septic systems as potential sources of vinyl chloride contamination. For example, the USEPA website lists vinyl chloride as one groundwater contaminant caused by residential septic systems.

Detailed information on septic systems is presented in Appendix H.

7.7 CAN NORMAL MUNICIPAL WASTE BE A SOURCE OF VINYL CHLORIDE?

Yes. Many sources of VOCs (including vinyl chloride) are used in every day residential activities. Empty (or partially empty) containers of household products that are sent to a landfill often contain a residue of hazardous substances that can eventually enter the groundwater. Technical literature confirms that municipal solid waste (MSW) contains many of the same hazardous substances, including vinyl chloride, that have been found at the Highway 96 Site. The formation of vinyl chloride from MSW occurs even when the disposal of industrial waste has not occurred. In fact, the MSW at the Site would have caused groundwater contamination even if industrial waste from Whirlpool and Reynolds had never been placed in the dump.

7.8 WHAT IS THE MEANING OF "SPLIT SAMPLES," AND OF OTHER TECHNICAL TERMS COMMONLY FOUND IN LABORATORY REPORTS?

In various reports, presentations, and fact sheets that have been distributed or made to residents, there have been references to "split samples", "blanks", "duplicates," and other technical terms commonly used by laboratories. All these terms are used to describe quality assurance/quality control (QA/QC) measures that are undertaken to assure that data is accurate. This section attempts to explain these terms.

"Split samples" are samples that are taken by two individuals at the same time and at the same location, but that are generally submitted to different laboratories for analysis. The results of split samples should be substantially similar. Significantly different results indicate that something maybe wrong with the analysis.

The use of "blanks" or "trip blanks" also help to ensure the overall quality of a sampling event. A "blank" is a laboratory prepared sample that is provided by the laboratory with the empty sample bottles, transported with the samples throughout the groundwater sampling event, returned to the laboratory with the samples, and analyzed in the same manner as the actual samples. The detection of any contaminants in the "trip blank" indicates that the actual samples may have also become contaminated along the way. There are also "lab blanks" that are analyzed in the laboratory to determine if any "contamination" has been caused by the laboratory. Lab blanks are prepared in the same manner as trip blanks, but are kept in the lab. There are several commonly used chemicals that can affect samples in the laboratory, such as methylene chloride and acetone.

A "duplicate" or "blind duplicate" is yet another QA/QC sample. It is a second sample taken at the same time as the first, but given a different label and sample number. The laboratory analyzes these two samples not knowing they are from the same location. The concentrations of both samples should be similar.

There will always be a slight variation between samples and sampling events. The QA/QC sample results is a critical piece of information when evaluating the data.

7.9 DO DIFFERENT LABORATORIES HAVE DIFFERENT DETECTION LIMITS ?

Yes, different laboratories can have different detection limits. The lower the detection limit, the more difficult and expensive it is to run the test, so laboratories employ lower

detection limits only when they have to, in order to measure a sample against a very low standard. In Minnesota and Wisconsin, where the health standard for vinyl chloride is lower than it is in most places, laboratories need to achieve lower detection limits than they do elsewhere.

The detection limit is developed based on the calibration of the testing equipment against known calibration standards. Different laboratories may establish different detection limits even though they may be based on the same health standards. For example, most laboratories servicing the Wisconsin and Minnesota market place try to achieve a detection limit below the health standard, which is 0.2 µg/L, but some laboratories will have a detection limit of 0.16 µg/L while others will have a detection limit of 0.10 µg/L. In addition, a laboratory may vary its own detection limit based on the performance of the equipment and possible interference in the sample itself.

7.10 WHY IS THE DIFFERENCE BETWEEN METHOD DETECTION LIMIT AND REPORTING LIMIT?

The method detection limit is the limit that a particular instrument can distinguish an actual chromatographic "peak" from background instrument "noise". At a minimum, laboratories perform MDL studies to calculate an MDL on an annual basis. Thus, the MDL may vary from year to year. Laboratories typically report to a reporting limit or reporting level (RL). The RL is the level, or concentration, of the lowest calibration standard that was used to calibrate the instrument. Results above the RL are quantifiable. Results between the RL and MDL are typically reported as "estimated" or "peak present", because they were detected below the range that the instrument was calibrated. An example of MDL and RL limits from the laboratories used under this six month study is provided below:

Laboratory	*RL*	*Lowest MDL*
Interpoll Laboratories	2.0 µg/L	0.083 µg/L
Minnesota Department of Health	0.2 µg/L	0.1 µg/L
Severn Trent Laboratories	0.5 µg/L	0.16 µg/L

7.11 WHY HAVE SOME LABORATORY REPORTS BEEN AMENDED?

Laboratories have standard report formats for reporting their analytical data. The standard report format always includes pertinent sample information and associated analytical results, but laboratory QA/QC information is not always included.

Nevertheless, laboratory QA/QC is always performed and QA/QC results can be included in the laboratory report, if specifically requested. When requested, the standard laboratory report format is "amended" to include the QA/QC information.

MPCA and CRA obtained QA/QC data associated with each laboratory report from the October 2004 through May 2005 sampling events. The most common QA/QC amendments to these reports were data qualifiers (for outlying QA/QC results) and estimated concentrations (for results initially reported as "Peak present below report level"). The amended reports issued by the MDH did not change the results, but added more detail.

7.12 WHY DID CRA RECOMMEND SWITCHING LABS IN FEBRUARY 2005?

During the October 2004 sampling, low concentrations of vinyl chloride were detected in water samples from two residential wells. When this type of detection occurs, it is standard protocol to re-sample the wells in order to confirm the analytical results. This re-sampling was performed in January 2005, and it also resulted in the detection of vinyl chloride in the same two wells. Because the same laboratory (Interpoll Laboratories, Inc.) had run the tests that resulted in the two detections, CRA recommended that a second lab (Severn Trent Laboratories) be used to provide independent verification of the presence of vinyl chloride. The MPCA approved this recommendation. In addition, to provide another point of comparison, the MPCA decided to collect split samples and to have those samples analyzed by the MDH. In February 2005, the same two wells were sampled again by both CRA and the MPCA with analysis by their respective labs, Severn Trent Laboratories (STL) and MDH. Below is a comparison of the vinyl chloride data:

Date	*Sampler*	*Lab*	*12 West Shore*	*13 West Shore*
October, 2004	CRA	Interpoll	0.12 µg/L	0.12 µg/L
January, 2005	CRA	Interpoll	0.12 µg/L	0.16 µg/L
February, 2005	MPCA	MDH	0.15 µg/L	0.11 µg/L
February, 2005	CRA	STL	< 0.16 µg/L	<0.16 µg/L

As shown, in February the STL detection limit was 0.16 µg/L, which was slightly higher than the measured amounts by the MDH lab in February. As such, a value of "< 0.16 µg/L" is consistent with another lab that measured 0.15 µg/L in the same sampling round. Even though the STL lab did not detect vinyl chloride, the result of "< 0.16 µg/L" confirms that the measurement was below the HRL.

MDH, Interpoll Laboratories, Inc. (Interpoll), and STL are the three State-certified independent labs that analyze drinking water using the required analytical methods. As the above chart demonstrates, consistent results were obtained regardless of sampling personnel or laboratory used. The consistency of these results has helped to assure the MPCA and CRA that the sample results were valid.

7.13 WHAT ARE THE RESPECTIVE ROLES AND RESPONSIBILITIES OF THE MPCA AND OF REYNOLDS AND WHIRLPOOL?

All work related to the Highway 96 Site is conducted by Whirlpool and Reynolds under a Consent Order with the MPCA, which the parties entered into pursuant to the Minnesota Environmental Response and Liability Act ("MERLA" or the state Superfund statute) and which is consistent with all Minnesota environmental laws and regulations. As is the case with all other state Superfund sites (which is modeled after the federal Superfund Law), Whirlpool and Reynolds do not undertake any work related to the site without the prior approval of the MPCA and all work is conducted under the MPCA's supervision and authority. The MPCA staff members are trained professionals in the environmental field and have the expertise to independently evaluate the work performed by Whirlpool and Reynolds.

7.14 WHAT STEPS HAVE BEEN TAKEN TO KEEP THE COMMUNITY AND AFFECTED RESIDENTS INFORMED OF DEVELOPMENTS?

In July 1993, a fact sheet was provided to the community that presented the proposed remedy for the Highway 96 Site. A public meeting was held to discuss the proposed remedy on August 24, 1993. Public comments were received by the MPCA throughout the summer of 1993. The MPCA mailed out its Minnesota Decision Document (MDD) to the residents along with a responsiveness summary that provided answers to questions posed by the community. Comments on the proposed plan were received from residents located on Buffalo Road, Eagle Ridge Road, East Oaks Road, Sparrow Lane and Sunset Lane, which indicates that many residents located west of Gilfillan Lake were aware of the Highway 96 Site.

Since 1993, CRA has prepared an annual monitoring report for the MPCA describing the results of each monitoring round for the residential wells located in North Oaks.

Sampling results for each residential well were provided in a letter to each home owner for sampling rounds conducted from 1993 through 2004.

After the October 2004 detections of vinyl chloride, the MPCA provided a fact sheet to the residents located on the west shore of Gilfillan Lake. Other efforts to keep the community informed of important developments have included the following:

- Community meeting on March 28, 2005;
- North Oaks Council meeting on May 12, 2005;
- North Oaks Council meeting on May 19, 2005;
- Technical meeting among representatives of the MPCA, Reynolds, Whirlpool, CRA, and residents; and
- Posting of information and periodic updates on the City of North Oaks website.

7.15 HOW CAN WE BE SURE THAT SAMPLING IS BEING UNDERTAKEN PROPERLY?

The sampling of residential wells in North Oaks is being performed in accordance with the MPCA's Groundwater Sampling Guidance Document, which is consistent with USEPA protocols. CRA follows the protocols established by this guidance document.

7.16 WHY WEREN'T EXTRACTION WELLS INSTALLED IN THE AREA EAST OF GILFILLAN LAKE IN 1993?

This issue is discussed within the MPCA's MDD. In the MDD, the MPCA provides responses to public comments. The following comment and MPCA response identify the MPCA's rationale for not installing extraction wells in 1993.

10. Public Comment #10 (from 1993): *The single groundwater extraction well provided for in the remedy does not provide adequate source control. It also does not remediate the plume that is impacting the residential wells--why not? Multiple extraction wells should be used.*

MPCA Response: *Analytical evidence to date suggests the extraction well installed in 1989 is in fact doing what it is designed to do; that is preventing further migration of contaminants away from the dump site. VOC concentrations being measured in downgradient monitoring wells and neighboring residential wells have decreased since the system began operating. In the case of vinyl chloride, it was not detectable at this low a level until recently, and we cannot say*

that it either has or has not been following the same trend. (Vinyl chloride can also appear as an end product of degradation of other VOCs.) Downgradient monitoring wells will continue to be monitored to ensure the system is continuing to be effective.

The plume that's affecting the residences is referred to as a "remnant" plume, and probably always was beyond the capture zone of the extraction system. Because the extraction system effectively cuts off the source, the remnant plume will slowly move out of the area and eventually dissipate. Attempting to recover this plume would not be practical, as it is already too large and dilute. Additional extraction wells may be considered if significant groundwater contamination is found at or near the south disposal area.