

# **Public Health Assessment**

## **Baytown Township Groundwater Contamination Site**

Washington County, Minnesota

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Prepared by:

Minnesota Department of Health  
Under Cooperative Agreement with the  
Agency For Toxic Substances And Disease Registry

## FOREWORD

This document summarizes public health concerns at a hazardous waste site in Minnesota. It is based on a site evaluation conducted by the Minnesota Department of Health (MDH). For a site evaluation a number of steps are necessary:

- *Evaluating exposure:* MDH scientists begin by reviewing available information about environmental conditions at the site. The first task is to find out how much contamination is present, where it is found on the site, and how people might be exposed to it. Usually, MDH does not collect its own environmental sampling data. We rely on information provided by the Minnesota Pollution Control Agency (MPCA), U.S. Environmental Protection Agency (EPA), and other government agencies, private businesses, and the general public.
- *Evaluating health effects:* If there is evidence that people are being exposed—or could be exposed—to hazardous substances, MDH scientists will take steps to determine whether that exposure could be harmful to human health. The report focuses on public health; that is, the health impact on the community as a whole, and is based on existing scientific information.
- *Developing recommendations:* In the evaluation report, MDH outlines its conclusions regarding any potential health threat posed by a site, and offers recommendations for reducing or eliminating human exposure to contaminants. The role of MDH in dealing with hazardous waste sites is primarily advisory. For that reason, the evaluation report will typically recommend actions to be taken by other agencies—including EPA and MPCA. If, however, an immediate health threat exists, MDH will issue a public health advisory warning people of the danger, and will work to resolve the problem.
- *Soliciting community input:* The evaluation process is interactive. MDH starts by soliciting and evaluating information from various government agencies, the individuals or organizations responsible for cleaning up the site, and community members living near the site. Any conclusions about the site are shared with the individuals, groups, and organizations that provided the information. Once an evaluation report has been prepared, MDH seeks feedback from the public. *If you have questions or comments about this report, we encourage you to contact us.*

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## **Summary**

The Baytown Township Groundwater Contamination site was first discovered in 1987; since that time, investigation and response actions by a number of state and local entities have been ongoing. The site is the result of the disposal or spillage of a large quantity of trichloroethylene (a.k.a. trichloroethene, or TCE) at an unknown source or sources in the vicinity of the Lake Elmo Airport, and the use or spillage of carbon tetrachloride (CCl<sub>4</sub>) at a nearby grain storage facility. The site consists of an area of groundwater contamination that is in excess of six square miles, and affects four major groundwater aquifers.

Several hundred private water supply wells and one of three existing municipal water supply wells in the city of Bayport have been impacted by the TCE contamination. The highest current concentration of TCE in a private well (approximately 100 micrograms per liter (µg/L)) has been found at the Lake Elmo Airport.

In early 2002, the Minnesota Department of Health (MDH) issued a new interim recommended exposure limit of 5 µg/L for TCE in drinking water from private wells. This precipitated a series of response actions and new investigations relative to the groundwater contamination. Further response actions by the MPCA are under consideration.

Exposure to TCE above health-based criteria is currently being prevented by recommending property owners have new private water supply wells constructed to deeper, clean aquifers where possible, and by providing granular activated carbon (GAC) filtration units for existing private wells and on new private wells where a clean aquifer is not available or feasible and concentrations of TCE exceed health-based criteria. However, the Metropolitan Airports Commission (MAC), and in most instances, the Minnesota Pollution Control Agency (MPCA), have indicated that for homes platted after April 9, 2002, GAC filters will not be provided. Baytown Township enacted township ordinance number 36 in part to ensure that newer homes not provided GAC filters by the MAC or MPCA will have appropriate GAC systems installed and maintained by the homeowners. West Lakeland Township has not yet adopted such an ordinance.

To date, TCE concentrations in the one impacted municipal well and the Bayport municipal water supply system have not exceeded health-based criteria. While exposures did exceed the current health-based criterion for TCE in the past, there is no evidence of an unusual incidence of adverse human health effects as a result of exposure to TCE in groundwater at the site.

## **Introduction**

Since the date of the previous health consultation for the Baytown Township Groundwater Contamination Site (the site; MDH 1999), MDH has established an interim recommended exposure limit for TCE which is substantially lower than the previous

standard. As a result, a significant number of additional private water supply wells (over 125) exceeded the new interim recommended exposure limit. Additional site investigation, water testing, and installation of whole-house GAC filter systems, and expansion of the Special Well Construction Area (SWCA; see “Background” section below) have occurred in response to the new, lower exposure limit. The MPCA, local governments, and area citizens have requested that MDH staff review the results of water well sampling at the site to determine whether levels of volatile organic compounds (VOCs), primarily TCE in groundwater pose an unacceptable health risk to area residents. MDH staff have also participated in several community meetings to discuss the site, have coordinated several mass mailings, and have participated in other meetings with state, county, city, and townships officials and consultants to discuss long-term options for a safe water supply. The purpose of this document is to summarize the most recent information about the site, primarily the activities that have taken place since the 1999 MDH Health Consultation, and to provide information to the community regarding exposure to TCE and its potential health risks.

## **Background**

### Site Description and History

Much of the information in this section has been presented in previous MDH documents (MDH 1996, MDH 1999), but is included for completeness. The groundwater contamination at the site was initially discovered in June 1987, when ten private wells were sampled by MDH in the vicinity of the Bayport (a.k.a. Stillwater Prison) Dump under a program designed to assess groundwater quality near old dumpsites in the Twin Cities area. One VOC was detected in one well at that time. As a result, additional groundwater sampling was initiated by the Washington County Department of Public Health and Environment, the MPCA, and MDH. Those agencies oversaw the sampling of monitoring wells, community water supply wells, and residential drinking water supply wells in the area of the site.

These investigations revealed a sizeable area of VOC contamination in groundwater. The contaminants detected consisted of TCE, CCl<sub>4</sub>, or both. Historically, TCE was found in more wells and at higher concentrations than CCl<sub>4</sub>. Due to the elevated levels of VOCs, the MDH first issued a well drilling advisory in 1988, which was modified in 2001 to encompass the approximately nine-square-mile area shown in Figure 1. The advisory, which is now called a Special Well Construction Area (SWCA) requires:

- Well contractors and well owners to submit well construction plans and to receive written approval from MDH prior to constructing, reconstructing, or sealing wells in the Baytown Special Well Construction Area; and
- Well owners to have the water from new private water supply wells tested for VOCs, prior to hookup, to verify that the groundwater meets MDH health-based criteria.

The MPCA listed the site on Minnesota's Permanent List of Priorities (PLP), the state Superfund site list, in 1988. The site was added to the U.S. Environmental Protection Agency's National Priorities List (NPL), the federal Superfund list, in January 1995.

The MPCA originally identified the Lake Elmo Airport as a suspected source for the TCE contamination due to the known use of TCE as a degreaser and parts cleaner at other airports. The shape of the plume, and the fact that the highest concentrations of TCE in groundwater were found in private wells and monitoring wells at the airport were also contributing factors. In May 1988 the MPCA issued a Request for Information to the Metropolitan Airports Commission (MAC). The MAC owns and operates the Lake Elmo Airport, which is located near the western end of the Baytown Special Well Construction Area. Subsequent investigations conducted by the MPCA in 2003 suggest that similar TCE concentrations are present in an area west of the airport, which may indicate the presence of a source area other than, or in addition to, the airport.

The MPCA identified a former grain storage facility northeast of the Lake Elmo Airport as the suspected source of the CCl<sub>4</sub> contamination, because CCl<sub>4</sub> was widely used in the past as a grain fumigant. The locations of the Lake Elmo Airport, the former grain storage facility, and other site features are shown in Figure 2.

The MAC is a public agency charged with managing public airports in the Twin Cities area, and it opened the Lake Elmo Airport in 1951. MAC maintains the small airfield and leases space to tenants who store and operate general aviation type aircraft. By 1972, the airport had approximately 35 hangars in what is known as the main (or south) hangar area and accommodated small, recreational airplanes, which require little maintenance beyond routine oil changes. The airport also included several maintenance facilities known as fixed-base operators. The north hangar area was not built until the late 1970s. The current airport has approximately 132 hangars and associated facilities, two runways under 4,000 feet long, and is designed to accommodate primarily private and recreational flyers operating single- and twin-engine propeller aircraft. The period of 1950-1970 is important, as this is the most likely time that the release of TCE occurred, as discussed on page 11.

In 1988, the MAC's consultant (Wenck Associates Inc. [Wenck]) began an investigation of the Lake Elmo Airport and the immediate surrounding area. The investigators attempted to characterize the site and the TCE contamination, as well as identify potential sources of TCE in the area. Wenck submitted an "Interim Evaluation Report" to the MPCA in September 1988, concluding that there was no residual TCE contamination in the surficial soil or glacial drift (shallow) groundwater in the immediate vicinity of the Lake Elmo Airport. The report further concluded, based on hangar inspections and tenant interviews, that there was no evidence of use or disposal of TCE at the airport.

In April 1994 the MDH completed a Public Health Assessment, concluding that the site posed a public health hazard because, 1) groundwater quality data showed a limited number of well users may have been exposed to levels of TCE and/or CCl<sub>4</sub> that were above the existing MDH Health Risk Limits (HRLs) for groundwater at that time (30

µg/L for TCE and 3 µg/L for CCl<sub>4</sub>); 2) other well users in the site area were likely still being exposed to VOCs at variable concentrations; and 3) the source(s) of both the CCl<sub>4</sub> and TCE contamination, which were not yet known, were likely still present.

#### Geology / Hydrogeology

The geology of the region in which the site is located consists of glacial drift (stratified sand, silt, and clay deposited by glaciers) overlying a thick sequence of Paleozoic sedimentary rock formations made up of sandstone, limestone, dolomite, and shale. These, in turn, overlay pre-Cambrian volcanic rock formations composed primarily of basalt. The bedrock formations tilt and thicken slightly to the west, forming the eastern rim of a large geologic structure known as the Twin Cities Basin. On the eastern edge of the site, the bedrock formations are bent into an upward convex fold, known as the Hudson-Afton anticline, which has been deeply eroded to form the St. Croix River valley, as shown in Figure 3. Within the river valley, the upper bedrock formations have been removed by erosion and buried by valley fill sediments (Mossler and Bloomgren 1990).

A generalized view of the geology and hydrogeology of the site is shown in Figure 4. Groundwater flow at the site is through several different geologic units and is generally from west to east, towards the St. Croix River, where it discharges. The upper-most saturated layer is glacial drift at the western portion of the site, the Prairie du Chien dolomite through the central portion of the site, and Quaternary sands and gravel at the eastern end of the site, within the river valley. Layers of sediment or rock that are saturated with water and sufficiently permeable to transmit water to wells or springs are referred to as aquifers.

The glacial drift fills previously eroded bedrock valleys that can channel or change the direction of groundwater flow. Groundwater flow in the Prairie du Chien dolomite is heavily influenced by fractures (cracks and voids) in the formation. The Prairie du Chien is actually considered a “group” composed of two separate dolomite formations, the Shakopee and Oneota. For general purposes, this report will consider the Prairie du Chien Group as a single unit. However, it is useful to note that although the lower Oneota formation tends to be more massive than the sandier Shakopee formation, the Oneota tends to have more solution cavities. According to the hydrologic atlas for this area (Lindholm, et. al., 1974), the Oneota provides the higher yield of water to wells because of this characteristic.

Below the Prairie du Chien is the Jordan sandstone. The Jordan sandstone is a medium to coarse-grained sandstone and is widely used in the region for residential and municipal water supply wells. Where conditions exist for groundwater to move downward rather than horizontally, and where the Oneota formation at the base of the Prairie du Chien Group has solution cavities and/or fractures, groundwater can readily move from the Prairie du Chien into the Jordan, because there is no low-permeability rock layer (or confining unit) separating them. However, these conditions do not appear to be present across the site, so groundwater does not appear to flow freely between the Prairie du Chien and Jordan throughout the study area. This may account, in part, for the irregular shape of the contaminant plume in the Jordan.

Underlying the Jordan sandstone is the St. Lawrence formation, composed of dolomite and siltstone. This formation is not considered an aquifer but rather a confining unit because it has low vertical permeability to groundwater. Below the St. Lawrence formation, in descending order, is the Franconia-Ironton-Galesville sandstone aquifer, the Eau Claire confining unit, and the Mount Simon sandstone aquifer. Because the majority of wells in the area are completed in the Prairie du Chien and Jordan aquifers, the extent and characteristics of the St. Lawrence and Franconia (and lower) formations are not well understood in Baytown Township and Bayport. At some places near the St. Croix River bluffs, portions of the St. Lawrence may be absent due to erosion or compromised by faults or fractures associated with the Hudson-Afton anticline. The Minnesota Geologic Survey, in cooperation with Washington County, MPCA and MDH, has proposed to evaluate faulting in the SWCA area (and elsewhere in southern Washington County) in a project tentatively scheduled for 2004.

Groundwater flow in the unconsolidated sediments, Prairie du Chien group, and Jordan sandstone is to the east; groundwater discharges to the St. Croix River at Lake St. Croix (Wenck 1999a). At the western end of the site, groundwater is found in the unconsolidated sediments at depths ranging from 35 to 65 feet below ground. To the east of the airport, groundwater is first encountered in the Prairie du Chien at a depth of approximately 100 feet below ground. At the far eastern end of the site, the groundwater surface follows the overlying topography as it drops towards the St. Croix River. The flow characteristics of the different aquifers are very different. Groundwater flow in the Prairie du Chien is primarily through fractures (cracks and voids). Groundwater flow in the unconsolidated sediments and Jordan sandstone is mainly through the pore spaces between the sand particles that make up the formations.

Vertical flow between the layers, as measured by well 'nests' (several wells of varying depth at the same location) is quite variable across the site, being downward in some locations, and upward in others. Vertical flow is likely influenced by the pumping of nearby water supply wells. However, the vertical flow does not appear to have resulted in significant amounts of mixing of the groundwater in the various aquifers at the site. The results of well sampling conducted by MDH in 1995 suggested a clear stratification of groundwater between the rock layers based on the results of tritium analyses (MDH 1996).

Tritium is a radioactive isotope of hydrogen ( $H^3$ ) generated by atmospheric nuclear weapons testing that began in the late 1940s and early 1950s. Its presence can be used to estimate the age of groundwater. Based on samples collected by MDH in 1995, groundwater from deeper wells at the site generally had lower levels of tritium, indicating the water entered the aquifer system before the early 1950s, while samples from shallower wells showed higher levels of tritium indicating relatively younger water. This indicates that groundwater between the upper sands, the Prairie du Chien limestone, and the lower Jordan sandstone is not mixing to a large degree. The tritium levels were also roughly correlated with VOC levels in the respective aquifers, indicating the contamination likely first reached the groundwater after the early 1950s.



The 1995 tritium testing results are consistent with the TCE distribution observed in private wells at the site. In the Prairie du Chien limestone, a fairly large area of relatively high TCE concentrations (greater than 20 µg/L) is present (see Figure 5a). In contrast, the Jordan formation has a fairly small area of these relatively high TCE concentrations (as shown in Figure 5b). This suggests a localized area(s) where mixing occurred between the two aquifers, rather than widespread downward transport of TCE from the Prairie du Chien to the Jordan. This localized effect could have been an area of greater vertical permeability at the contact between the two aquifers, an improperly constructed or unsealed well, or other geologic feature(s) (such as a fault) that allowed for greater downward flow in the area near 40<sup>th</sup> Street North and Neal Avenue. An irrigation well located in this area, subsequently sealed by the MAC in 2001, was open across both aquifers and may have contributed to TCE reaching the Jordan at higher than normal rates in that area. However, the large area of TCE contamination in the Jordan cannot be attributed to only one well.

Tritium samples collected in 2002 from the city of Bayport's three municipal wells have yielded less conclusive information regarding groundwater mixing in the Franconia. All three of the wells are completed in the Franconia and deeper aquifers. Tritium concentrations in the samples ranged from 0.8 to 1.3 TU (tritium units). These low concentrations suggest very little or no mixing with shallow or post-1950s groundwater, which is ~~wuy//////////~~that would be expected. However, in 2003 municipal well #2 was found to contain increasing concentrations of TCE. Additional tritium samples were collected in 2003 from private Franconia wells in the area by MDH. The results are not yet available, but may help to clarify the relationship between tritium and TCE in the Franconia.

#### Extent of the Contamination

The TCE plume at the site covers an area of approximately six square miles, and affects primarily two bedrock aquifers, the Prairie du Chien limestone and the Jordan sandstone. Low concentrations of TCE have also been detected in Quaternary sands in the westernmost portion of the site, beneath the Lake Elmo airport, and in the easternmost portion of the site, beneath the city of Bayport, where both the Prairie du Chien and Jordan aquifers are absent due to erosion. In addition, TCE has been found in concentrations ranging from 1.0 to 11 µg/L in the Franconia formation near the St. Croix River bluff.

Site investigations to date have not detected significant contamination in soils above the water table, with the possible exception of boring TB-4 (see Figure 10) located near the railroad tracks in the fields west of the airport. Low organic vapor levels were measured during the drilling of this boring, but analysis of a soil sample collected from the boring did not detect any volatile organic compounds (the depth at which the sample was collected is not included in the report). The absence of conclusive evidence of contamination in the unsaturated soils above the water table either means that any shallow contamination at the source area has degraded, the location of the original release

has not been identified, or the TCE was introduced directly to the groundwater via a well or other conduit.

Similarly, significant contamination has not been detected in the saturated sands and gravels overlying the bedrock, except in a small area in the north hangar area of the Lake Elmo Airport property, where two private wells completed in the Quaternary aquifer, labeled wells A and B on Figure 6, were found to have 55 and 23 µg/L of TCE, respectively, in 1995. Well A, the deeper and more contaminated well, was sealed, so no information is available regarding concentration trends in that well. Well B has shown a steadily decreasing trend in concentrations, the most recent sample in 1999 containing 9.9 µg/L TCE. Both wells were completed in an area where there is a depression in the surface of the bedrock (see Figure 7).

Well A was completed at an elevation similar to nearby Prairie du Chien wells with nearly identical contaminant concentration levels. There is likely free exchange of groundwater between the bedrock and the Quaternary sediments filling the bedrock “low,” so no conclusion about source areas may be drawn from the presence of contamination in this particular Quaternary well. The shallower, less contaminated well B, however, was completed at an elevation well above the bedrock and is screened immediately below the water table (Figure 7). It is possible that contamination in this well may mark the area (or near to it) where some of the TCE entered the groundwater system. There are no wells completed in the Quaternary sediments upgradient of this area to confirm this hypothesis.

The highest concentrations of TCE in the Prairie du Chien have been detected under the eastern portion of the Lake Elmo Airport (Figure 5a). Sampling of wells there in 2002 detected TCE concentrations as high as 110 µg/L at Hangar 13C. The highest concentration detected beneath the airport, 210 µg/L TCE in 1989, was also in the Hangar 13C well. Lower TCE concentrations (14 to 98 µg/L) historically have been found in the Prairie du Chien in monitoring well MW-10B, located approximately 1,000 feet west of the airport. However, a sample collected in August 2003 detected 130 µg/L TCE in MW-10B. Additional investigation conducted during the summer of 2003 indicates that TCE concentrations west of the airport may be higher than previously detected (see page 17-19). While the map of the TCE plume in the Prairie du Chien appears to show two “fingers” of the plume migrating to the northeast and the southeast, this is partly due to the near absence of Prairie du Chien wells southeast of Omaha Avenue and 30<sup>th</sup> Street North. It is also likely that fracture and/or solution cavity patterns in the Prairie du Chien may be influencing the distribution of the TCE plume. However, the higher concentration portion of the plume (where TCE is greater than 10 µg/L) does appear to trend to the east-northeast.

The TCE plume in Jordan sandstone shows a similar distribution, with the main portion of the plume trending to the east-northeast and a lower concentration “finger” in the southeastern portion of the site (Figure 5b). It is not clear if the latter is the result of pumping by recently installed Jordan wells “dragging” part of the plume to the southeast, or if the plume is following a geologic feature in the Jordan that directs the contamination

to the southeast. Additional monitoring may help to clarify this. The TCE plume in the Jordan differs from that in the Prairie du Chien in that the concentrations generally are lower, the highest concentrations in the plume are present east of the airport property, and the high concentration “core” of the plume (TCE greater than 20 µg/L) is much more compact. The shape of the Jordan plume suggests that lower concentrations of TCE are migrating downward into the Jordan from the Prairie du Chien as the plume in the upper aquifer migrates away from the airport and, as discussed above, that there may be a localized feature near Neal Avenue North and 40<sup>th</sup> Street North that has allowed higher concentrations of TCE to reach the Jordan in that area.

TCE has also been detected, recently, in some Franconia wells near the St. Croix River (Figure 8). As discussed in the Geology/Hydrogeology section of this report, it is possible that in this area portions of the St. Lawrence confining unit have been removed by erosion or the unit is compromised by faults or fractures that may be allowing TCE to enter the Franconia in some areas near the river. Franconia wells installed in the western half of the site, and north of 47<sup>th</sup> Avenue North and south of 30<sup>th</sup> Avenue North do not have any detections of TCE, suggesting that the St. Lawrence in these areas is competent and is preventing downward spread of the contamination.

Groundwater modeling (Wenck 2001a) suggests a travel time of approximately 15 years from the airport to the St. Croix River. Contamination was detected near Bayport in 1987. This suggests that the contamination may have originated near the western end of the site no later than the early 1970s. The original release (or releases) of TCE may have occurred sometime between the 1950s and the 1970s.

## **Site Information**

### Well Monitoring Data

The majority of the homes within the SWCA are served by individual, private water supply wells that obtain water primarily from the Prairie du Chien and/or Jordan aquifers. Most of the city of Bayport is served by a municipal water supply, but approximately 25 homes in the city of Bayport obtain water from private water supply wells, and are not connected to the city water supply. Geologic logs are not available for most of the private wells in Bayport, but based on the geology of the area, it is likely that they are either completed in Quaternary valley fill sediments or the Franconia-Ironton-Galesville aquifer. The city of Bayport has three municipal wells completed in the Franconia-Ironton-Galesville aquifer.

Private well sampling began in 1987, and identified several residences and airport hangars where concentrations of TCE and CCl<sub>4</sub> exceeded drinking water standards. Sampling of selected private wells continued throughout the 1990s, with several interruptions, as the MPCA and MAC investigated to determine the source(s) of the contamination. Although clear trends are difficult to establish because of the somewhat scattered nature (in terms of sampling frequency and sample locations) of the data, the

data seemed to indicate fluctuating levels of TCE and generally decreasing levels of CCl<sub>4</sub> in groundwater over time.

In April of 1999, Wenck sampled approximately 250 private wells in the Baytown SWCA to evaluate the extent and magnitude of the groundwater contamination (Wenck 1999b). This was the first large-scale well sampling event conducted at the site. VOCs were detected in a total of 157 wells located within the Baytown Special Well Construction Area. TCE was the only VOC detected in the samples. Levels of CCl<sub>4</sub> were below the laboratory reporting limit of 1 µg/L in all samples. The absence of CCl<sub>4</sub> in all of the samples was probably due to the higher laboratory reporting limit rather than the complete absence of CCl<sub>4</sub> in the groundwater.

One well showed TCE in raw well water (i.e. prior to any treatment) in excess of the MDH Health Risk Limit (HRL) of 30 µg/L. A HRL is a level of a contaminant in drinking water that MDH considers to be safe for consumption over a lifetime. As previously mentioned, MDH has an interim health based criterion of 5 µg/L for TCE (see page 29 for further discussion). This well had previously been fitted with a granular activated carbon (GAC) treatment system due to a history of high levels of TCE. Other wells which previously had levels of TCE or CCl<sub>4</sub> above the HRLs, or whose combined levels exceeded the acceptable health hazard index of one were found to contain concentrations of TCE below the HRL. The hazard index accounts for the presence of multiple contaminants with similar toxicological endpoints; it is calculated by adding the sum of the concentration of each contaminant divided by its HRL.

The combined impact of TCE and CCl<sub>4</sub> in all wells was difficult to assess due to the laboratory reporting limit of 1 µg/L for CCl<sub>4</sub>. Subsequently, MDH requested that Wenck re-examine the laboratory reporting data for CCl<sub>4</sub> for samples from five wells that had historically had detectable levels of CCl<sub>4</sub>. Only one of the five wells contained CCl<sub>4</sub> at a level in excess of the laboratory method detection limit of 0.34 µg/L but below the reporting limit. Data from other wells that also had historically contained CCl<sub>4</sub> were not re-examined.

Approximately one-third of the wells sampled in 1999 showed an increase in levels of TCE over levels observed in previous sampling events, which in some cases occurred as many as ten or more years before. The majority of the TCE impacted wells were completed in the Prairie du Chien aquifer. Some Jordan aquifer wells were also found to be impacted, many for the first time. The depth of many older wells at the site is unknown due to a lack of well construction records. The locations of the wells sampled in the spring of 1999, the concentration of TCE detected, and the estimated extent of the TCE plume are depicted in Figures 9a and 9b. Detectable levels of TCE were found in wells located at the far southern edge of the Baytown SWCA, indicating that the area of contaminated groundwater had likely expanded beyond the original southern boundary of the SWCA.

During 2000 and 2001, private well sampling was conducted according to a plan proposed by the MAC and approved by the MPCA, which called for quarterly monitoring

of wells with concentrations of TCE above 25 µg/L, annual monitoring of wells with TCE concentrations between 20 µg/L and 25 µg/L of TCE, and annual monitoring of select “sentry” wells located within and at the edges of the TCE plume (Wenck 2001b). The sentry wells were intended to provide an early warning if the TCE concentrations or the extent of the contamination changed. In addition, an effort would be made every 5 years to sample every well within the SWCA with a TCE concentration above 1 µg/L. Aside from some slight increases in TCE concentrations in wells near the center of the plume, this monitoring did not detect any significant changes in the TCE plume.

In early 2002, in response to the issuance by MDH of a revised interim recommended exposure limit for TCE of 5 µg/L (see below), the MPCA began sampling all wells within and adjacent to the TCE plume boundaries to determine if any wells exceeded the new interim exposure limit. Well sampling began in March 2002, in the areas of known higher TCE concentrations and proceeded outward towards the edges of the TCE plume. Wells already known to exceed the exposure limit were not sampled, but the MAC provided these residences with whole-house GAC filter systems, starting with the most contaminated wells. Whole-house GAC filter systems treat all of the water used in a home, not just individual taps, although outside taps may be bypassed in some instances. Additional wells identified in the sampling effort that exceeded 5 µg/L of TCE were also fitted with a GAC filter system.

By September 2002, the MPCA had sampled water from approximately 320 private wells in Baytown and West Lakeland townships, Bayport, and Lake Elmo. Laboratory results were reviewed by MDH staff and then sent out with a brief explanation to the homeowner. Of the 320 wells sampled, 116 wells had TCE levels that exceed the interim exposure limit of 5 µg/L. The sampling results were mapped to provide an updated picture of TCE concentrations in the Prairie du Chien and Jordan aquifers (see Figures 5a and 5b). The results of the well sampling were not surprising. The highest TCE concentrations were detected near the center of the plume, which is also where the highest rates of change in TCE concentrations were observed. Concentrations of TCE are lower near the edges of the plume, where the rates of change in concentration also tend to be low. In fact, in some wells TCE concentrations appear to be stable or even decreasing.

The results, as mapped in Figures 5a and 5b, illustrate several key points:

- The TCE plume shape in the Prairie du Chien aquifer differs somewhat from the shape of the plume in the Jordan aquifer. A larger area of the Prairie du Chien exceeds 5 µg/L TCE.
- The 5 µg/L TCE contour line is shown on the map of the Jordan aquifer as extending to the St. Croix River (Figure 5b). Near the river the Prairie du Chien and Jordan are not present due to removal by erosion. Based on the local geology, the contaminant plume is located in Quaternary sediments as it approaches the river. Based on recent testing of the westernmost Bayport city well, it is possible the plume is also present in the upper portion of the Franconia as it approaches the river (see page 15).

- Wells located very close together and drawing water from the same aquifer sometimes have very different TCE concentrations. Usually, this is because they draw water from different depths within the aquifer.

Some of the irregularities in the shape of the TCE plume are likely due to variations of fracture patterns, density, and groundwater flow rates within the aquifer. Some may be due to a lack of information. For example, there are few Prairie du Chien wells present in the southeastern portion of the SWCA. The 1- $\mu\text{g/L}$  contour line may actually extend further into this area of the Prairie du Chien aquifer.

Comparison of the 2002 sample results to previous sampling data also revealed several things:

- Generally the plume is not expanding to the north, and expansion to the south was much less than observed in the 1999 data. Where some expansion had occurred, it was very small (less than 250 feet).
- The southeastern section of the TCE plume in the Jordan aquifer may be expanding. This area has had considerable recent development with many new Jordan wells. This expansion may either be real, possibly caused by additional pumping of the aquifer by new wells, or it may only appear to be expansion as the result of having new wells from which to gather samples. Future testing will help to clarify this.
- Some wells showed increases in TCE concentration, but many wells were either stable or decreasing. While individual wells vary in their concentration trends, generally, wells near the center of the TCE plume (in both aquifers) experienced the greatest average rate of increase (approximately 0.5  $\mu\text{g/L}$  per year), while those near the edge generally have much lower rates of increase (approximately 0.1  $\mu\text{g/L}$  per year). Major exceptions are several Jordan wells along 34<sup>th</sup> Street North, in which the TCE concentrations have remained low and stable despite their location near the center of the plume.

A sample from a well (unique well #649679), collected in March 2002 by an independent laboratory on behalf of a private resident, was found to contain 1  $\mu\text{g/L}$  TCE. This well is located on Osprey Avenue, southeast of the 1  $\mu\text{g/L}$  TCE contour shown in Figure 5b. The data was not included in the database from which the figure was developed, as it had not been received before the figure was created and has not been verified. However, it does suggest that the 1  $\mu\text{g/L}$  TCE contour line may extend further southeast in this area. This result should be confirmed by additional sampling.

Based on the sampling results from the spring and summer of 2002, the MPCA established a sampling plan for the winter of 2002 and into 2003. Wells with TCE concentrations at or above 4.3  $\mu\text{g/L}$  (or 85% of the interim recommended exposure limit) were sampled quarterly; wells with TCE concentrations between 3.0 and 4.3  $\mu\text{g/L}$  (or 60% of the interim recommended exposure limit) were sampled semi-annually; and wells with TCE concentrations between 2.0 and 3.0  $\mu\text{g/L}$  (or above 40% of the interim recommended exposure limit) were to be sampled annually. The plan also included

continued monitoring of sentry wells within and along the edges of the TCE plume. MDH agreed that this plan was sufficiently conservative, based on the apparent rates of change in TCE concentrations, and would ensure that no well would exceed 5 µg/L for a significant time period between sampling events. Once a revised Health Risk Limit (HRL) for TCE is formally adopted through the rule-making process (see below), a final sampling plan will be developed to ensure that all existing wells within and adjacent to the plume are sampled on a regular basis.

The 2002 sampling results did not reveal anything unexpected about the TCE plume. However, there were detections of low concentrations of methyl ethyl ketone (MEK), chloroform, sulfur dioxide, and other VOCs that cannot be readily explained. These detections may be the result of contamination during laboratory analysis, or perhaps related to well or plumbing construction materials. The MPCA is trying to verify the source of these contaminants. In addition, very low concentrations of freon and petroleum-related compounds such as toluene, xylenes, and cumene are occasionally detected in wells near the northern edge of the site. It is thought that these are actual detections of freon and petroleum contamination in the groundwater, or in the case of newly drilled wells, artifacts of the well construction process. In all cases, the concentrations of these non-site related contaminants are well below their respective HRLs.

In May of 2003, MDH staff collected water samples from two new private wells constructed in the Franconia aquifer, per the requirements of the SWCA. The wells are located in a new housing development on the eastern end of the site, approximately one mile west of the St. Croix River. The samples were analyzed for VOCs by the MDH laboratory. TCE was detected in the first well at a concentration of 8.5 µg/L, and a small amount of carbon tetrachloride (“peak present below reporting level”, i.e. less than 0.2 µg/L) was also detected. The well was pumped for 12 hours in an attempt to flush it out, and then re-sampled. Laboratory analysis of the second sample again showed TCE at a concentration of 8.5 µg/L, and carbon tetrachloride as a “peak present below reporting level.” Very low levels of chloroform and toluene were also detected. The second well had a TCE concentration of 11 µg/L, and a carbon tetrachloride concentration of 0.2 µg/L. These samples represented the first detections of contaminants in the Franconia aquifer.

In May of 2003, MDH Drinking Water Protection Program staff also collected samples from the city of Bayport municipal wells as a part of the regular monitoring of that system. Municipal well locations are shown in Figure 2. Samples from all three of the city wells were analyzed for VOCs. TCE was detected in Bayport well #2 at a concentration of 1.2 µg/L. This was the first detection of TCE in the Bayport city wells. Well #2 is located on the bluff on the western edge of the city, and is completed in the Franconia aquifer. A few days later a second sample was collected to confirm the results of the first; the second sample had a TCE concentration of 0.8 µg/L. A third sample collected in late June 2003 showed a TCE concentration of 1.1 µg/L in well #2, and a fourth sample collected in early September 2003 showed a TCE concentration of 1.9 µg/L. The most recent sample (collected in November 2003) showed a TCE

concentration of 3.40 µg/L. Bayport well #2 is located approximately one mile northeast of the two private Franconia aquifer wells that also showed TCE contamination in May of 2003. The other two Bayport city wells (#3 and #4), which are located below the bluff in the city proper, have not shown TCE contamination.

Also in early September 2003, a water sample was collected by MDH staff from a representative point within the Bayport municipal water supply system. The city usually operates only one of its three wells at a time, and on the day the sample was collected well #3 (which has not shown any TCE contamination) was in operation; well #2 had been in operation the day before. The sample was analyzed for VOCs by the MDH laboratory. TCE was detected at a concentration of 0.9 µg/L, indicating that while the TCE concentration was reduced by mixing of water within the system, it was still detectable. A system sample collected in November 2003 had a lower TCE concentration, 0.3 µg/L. These concentrations of TCE are below the federal Maximum Contaminant Limit (MCL) for TCE of 5 µg/L. The MCL is the applicable regulatory standard for a public water supply, and is applied (with a small margin for error) to the average of four quarterly samples. Common byproducts of the chlorination of the water supply were also found in the samples, which is normal for a public water supply system.

Following the detection of TCE in the Franconia aquifer, MDH recommended that the MPCA collect new water samples from the 23 Franconia wells in the Baytown SWCA. In June of 2003, MPCA staff began collection of the samples. MDH also recommended that samples from select wells be analyzed for tritium and nitrate to assess their vulnerability or the vulnerability of the aquifer to contamination. The tritium results are not yet available. The results of VOC analyses for the two private wells with previous TCE detections showed a concentration in the first well of 5.8 µg/L, while the second well (which was sampled twice) had TCE concentrations of 0.1 µg/L in the first sample and no detection in the second sample. Thus, both wells had diminished TCE concentrations. One other private Franconia well (678102), located approximately ½ mile southeast of the first two wells, also had a detection of TCE (2.4 µg/L) and a nitrate concentration of 3.9 mg/L. The presence of nitrate in a Franconia well suggests either that shallow water is entering the Franconia through a geologic feature, or there may be a defect in the well casing allowing shallower water to enter the well. This well had been previously sampled in 2002 and no TCE was detected. In September of 2003, MDH staff collected samples from two new Franconia aquifer wells installed in the same housing development as the first two wells. The sample results showed levels of TCE of 8.0 µg/L and 7.5 µg/L; low levels of CCl<sub>4</sub> were also detected. Several of the other private Franconia aquifer wells had low concentrations of typically petroleum related VOCs such as toluene and xylene. Concentrations of these VOCs are far below their HRLs, and may indicate that a minor source of petroleum contamination exists in the area. Figure 8 shows the location of the affected and non-affected Franconia aquifer wells.

As noted in the “Geology/Hydrogeology” section, little is known regarding the St. Lawrence and Franconia formations in this area. Both formations are present, as shown in the drilling logs for the wells, but it is possible that the St. Lawrence has fractures or



erosional features that have not yet been detected and are allowing some TCE to enter the Franconia.

#### Additional Site Investigation

During the winter and spring of 2003, the MPCA conducted several investigations in an attempt to locate the source of the TCE contamination at the site. These investigations were conducted at the Lake Elmo Airport, and at points west of the airport, in the city of Lake Elmo. The MPCA's reasoning for conducting the investigations was that determining the source of the contamination would be useful for eventually implementing a response action to remove the TCE from the aquifer at or near the source. The likely source or sources of the TCE contamination have been discussed in previous reports on the site, and include (Delta 1996):

- The release of TCE at the surface with subsequent infiltration through the soil and contamination of the groundwater, at and/or upgradient of the Lake Elmo Airport;
- Transport of TCE with groundwater flow from a continuous source upgradient of the Lake Elmo Airport, or as a result of a one-time "slug" of TCE; or
- The introduction of TCE to the groundwater system by disposal through a well, septic tank or drain fields, or other subsurface point at or upgradient of the Lake Elmo Airport.

If the latter in fact occurred, there may be little or no contaminated soil or soil gas remaining at the source, as described previously. A recent study of the behavior of TCE when it has been injected into the unsaturated zone (the zone between the ground surface and the groundwater surface) indicates that approximately 95% of the injected TCE will evaporate and discharge into the atmosphere, leaving only a small amount to contaminate the groundwater through simple diffusion (Jellali et al 2003). It is interesting to note that the researchers in this study attempted to prevent the TCE from migrating directly from the injection site to the groundwater surface, but were not successful. TCE is heavier than water, and will form a dense, non-aqueous phase liquid (often known by its acronym, "DNAPL") that can easily migrate downwards from a concentrated source until it reaches an impermeable layer such as bedrock, where it will stop and from then on serve as a continuing source of groundwater contamination.

The first round of investigation by the MPCA consisted of the collection of soil gas samples at the locations of three current or former businesses in the city of Lake Elmo identified by the MPCA as possible sources of TCE (Terracon 2003a). Soil gas samples were also collected from soil borings at the Lake Elmo Airport, and groundwater samples were collected from soil borings drilled near existing monitoring well MW-10B (see Figure 10).

A total of 20 soil borings were drilled to depths of approximately 12 feet at the three locations in Lake Elmo, and one soil gas sample was collected from each boring for laboratory analysis for VOCs. No VOCs were detected in the soil gas samples collected at two of the three Lake Elmo locations. At the third location, other VOCs, including

chlorobenzenes and vinyl chloride, were detected in one soil gas sample collected near a septic tank. Vinyl chloride is a possible breakdown product of TCE.

Soil borings were drilled for the collection of soil gas samples at seven different potential source areas on the Lake Elmo Airport property. The soil borings were advanced to a depth of approximately 12 to 16 feet; a total of 61 soil borings were drilled. Soil samples from multiple intervals in each boring were screened for organic vapors using a photoionization detector (PID), and one soil gas sample was collected from each boring for analysis for VOCs. No TCE was detected in any of the soil gas samples, although various other VOCs, including chlorinated VOCs, were found in some samples. Terracon deemed the information insufficient for determining if the source of the TCE contamination at the site was the Lake Elmo Airport (Terracon 2003a).

Three soil borings were also drilled near monitoring well MW-10B, which is located to the west of the airport near the Union Pacific Railroad tracks (see Figure 10). The soil borings were drilled to depths of 48 to 65 feet so that groundwater samples could be collected from the glacial till aquifer above the bedrock. TCE was detected at a concentration of 4 µg/L in an initial groundwater sample collected from boring F-3, located about 400 feet east of MW-10B, and at a concentration of 5.2 µg/L in a duplicate sample.

The second investigation conducted by the MPCA in 2003 was designed to: a) delineate the extent of the TCE contamination in the bedrock (Prairie du Chien) formation upgradient from the Lake Elmo Airport; b) identify potential TCE source areas; and c) investigate soil gas impacts identified during the first phase of investigation (Terracon 2003b). Six soil borings were advanced to depths of up to 120 feet below ground, and temporary monitoring wells were installed for the collection of one or two ground water samples.

The first boring was installed in the city of Lake Elmo at the location where VOCs (but not TCE) were found in a soil gas sample. This location is a former service station, and current auto repair business. One VOC, toluene, was detected in a soil sample collected from 0-25 feet below grade. A groundwater sample was collected from the glacial drift formation and analyzed for VOCs. Toluene was detected at a concentration of 1.5 µg/L; TCE was not found above the laboratory detection limits.

Three soil borings (TB-4, TB-5, and TB-6) were drilled in the area of MW-10B, and completed as temporary monitoring wells in the upper Prairie du Chien formation. The locations of the borings are shown in Figure 10. A natural gas utility sub-station and a railway line are located in this area. Soil samples from various intervals in each boring were screened for organic vapors using a PID. Organic vapors were detected in soil samples from boring TB-4, and analysis of a water sample from TB-4 showed TCE at a concentration of 180 µg/L. No organic vapors were detected in soil samples from borings TB-5 and TB-6. Analysis of an initial water sample from TB-5 indicated a TCE concentration of 9.5 µg/L; a second sample collected approximately 24 hours later had a TCE concentration of 8.3 µg/L. A groundwater sample collected from soil boring TB-6

had a TCE concentration of 92 µg/L, similar to TCE concentrations found beneath the Lake Elmo Airport. These findings indicate that a potential source of TCE may exist in this area. It should be noted that these more recent findings are not reflected on the map in Figure 5a (which shows the TCE distribution based on monitoring well data collected in 2002), and that the findings of the additional off-site investigation has expanded the western limit of the higher concentration “core” of the TCE plume.

The concentrations of TCE detected near MW-10B are comparable to the higher concentrations of TCE observed in Prairie du Chien wells on the Lake Elmo Airport property. This may indicate that a second source of TCE was located in this area. However, the presence of TCE in the Quaternary sediments and near the surface of the water table in the north hangar area of the airport strongly suggests a source area near or upgradient of that spot (as discussed on page 8). To date, the data suggest that at least two sources may be present.

Two borings were drilled at the Lake Elmo Airport and completed as temporary monitoring wells in the upper Prairie du Chien formation. The first boring, TB-2, was drilled at the north end of the southern group of hangars. Low levels of organic vapors were detected in some soil samples from borings TB-2. Analysis of an initial water samples from TB-2 indicated a TCE concentration of 53 µg/L; a second sample collected approximately 24 hours later had a TCE concentration of 91 µg/L. The second boring, TB-3, was drilled near the south end of the main hangar area. No organic vapors were detected in soil samples from this boring. Analysis of an initial water sample from TB-3 indicated a TCE concentration of 35 µg/L; a second sample collected approximately 24 hours later had a TCE concentration of 44 µg/L. The detection of TCE at these concentrations in the Prairie du Chien aquifer on the Lake Elmo Airport was not surprising. Based on the work completed, the MPCA’s consultant, Terracon, concluded that the results did not identify a source of TCE in the areas investigated.

No borings were advanced in the north hangar area of the airport, where TCE had previously been detected at a concentration of 55 µg/L in a private well set in the shallow (glacial drift) aquifer. The additional investigation completed by MPCA and their consultants did not eliminate the north hangar area and areas upgradient of it as a possible source area.

The MPCA also collected samples from two permanent monitoring wells (MW-13 and MW-14 on Figure 10), two private wells, and one unused well in Lake Elmo during this investigation. All of these wells are located upgradient or side-gradient from the defined plume (and from MW-10B). No VOCs were detected in MW-13 and MW-14, or in the three private wells. Analysis of geologic boring logs from this investigation shows that a depression exists in the surface of the Prairie du Chien formation in the area between MW-10B and MW-13. Terracon recommended in the report that additional investigation be conducted in the area of soil borings TB-4 and TB-5 to more fully delineate the TCE contamination and confirm whether this area, specifically the natural gas substation, was a potential source of the TCE contamination.

### Response Actions

In 1999, Wenck, on behalf of MAC, examined various cleanup options including no action, pumping and treating the contaminated groundwater, injecting nutrients into the aquifers to enhance the organic breakdown of TCE and  $\text{CCl}_4$  by natural microorganisms, installation of new residential wells, and point of use treatment (Wenck 1999a). This feasibility study weighed the various options in terms of their overall protection of human health and the environment, compliance with relevant standards, costs, long-term and short-term effectiveness, implementability, and state and community acceptance. These are the criteria typically used in the Superfund program to evaluate proposed cleanup actions, also known as remedies.

Wenck recommended in 1999 the installation of whole-house granular activated carbon (GAC) filtration units on all private wells with TCE above the existing HRL of 30  $\mu\text{g/L}$  (at that time, a total of 15 wells on and off the airport, one of which has since been removed), monitoring of select wells for a period of 30 years or more, as necessary, and an ongoing review of new technologies for controlling TCE migration in groundwater. Maintenance of these GAC treatment systems would be the responsibility of the MAC. Following a public comment period, which included a public meeting, the MPCA agreed with Wenck's (and the MAC's) recommendation of this proposed remedy, and incorporated it into a Record of Decision (ROD) for the site in 2000. The ROD is the formal legal document describing the long-term remedy for the site. Subsequently, the MAC submitted a Response Action Plan (RAP) with the details of how they would implement the accepted remedy. In 2000 and 2001, the main activities at the site consisted of sampling of selected wells by Wenck as outlined in the ROD and RAP, and various other routine reports and activities such as groundwater modeling.

In response to the issuance by the EPA of a draft health risk assessment for TCE, in January 2002 MDH issued a new recommended exposure limit for TCE of 5  $\mu\text{g/L}$ , to be used in place of the existing HRL of 30  $\mu\text{g/L}$  to evaluate drinking water from private wells (MDH 2002). The establishment of an interim recommended exposure limit for TCE of 5  $\mu\text{g/L}$  precipitated a series of actions in 2002 by the public entities involved with the site (MPCA, MDH, MAC, and Washington County), including:

- Notification of all property owners with private wells that had previously shown a concentration greater than 5  $\mu\text{g/L}$  of TCE. These wells were subsequently fitted with whole-house GAC filters by the MAC at no cost to the homeowners (125 private wells in 2002 and 2003). The MAC volunteered to install these filters, even though it was not legally obligated to do so under the ROD because the HRL for TCE has not been formally changed by rule. Homes with the highest levels of TCE had GAC filters installed first, and in the interim the MPCA provided home delivery of bottled water until the GAC filter systems were installed.
- On February 15, 2002, the MDH expanded the boundaries of the Special Well Construction Area in response to TCE detections in private water supply wells located outside the previous SWCA boundary.

- A community meeting was held on February 27, 2002 to discuss the new recommended exposure limit and the proposed response actions. A second meeting was held on November 19, 2002.
- Starting in March 2002, wells that had previously shown levels of TCE less than 5 µg/L were re-sampled to determine if the concentration of TCE had risen above 5 µg/L. Wells that were found to exceed 5 µg/L were also fitted with a whole-house GAC filter system by the MAC.
- Additional well sampling was conducted in 2003 throughout the affected area to determine if any other wells were approaching the new exposure limit for TCE, or required more frequent monitoring.
- A series of meetings between state and local officials were held to discuss safe, long-term water supply options for residents in the SWCA.

In the interim period while homeowners were waiting for the installation of GAC filters, MDH recommended that women who were pregnant, or considering becoming pregnant, limit their exposure to TCE. Others who wished to minimize their exposure to TCE were advised that they could take the following steps on their own:

- Use bottled water for drinking and cooking;
- Use GAC filters that are installed beneath a sink (usually a kitchen sink) or in a refrigerator to obtain water for drinking and cooking; or
- Use other portable GAC filters that are designed to remove volatile compounds such as TCE.

As noted above, in 2002, following the issuance of a new recommended exposure limit for TCE, the MAC stated that it would only provide whole house GAC filter systems to homes where the level of TCE equaled or exceeded 5 µg/L if the wells were in existence or the properties were platted for development by Washington County on, or before April 9, 2002, an arbitrary date selected by MAC. The MAC maintains that wells installed on properties platted after that date are not eligible for GAC filters from the MAC, regardless of the TCE concentrations in those wells. This position has not been formally challenged to date.

The MPCA agreed with the MAC's approach regarding GAC filter installation, and also offered to install GAC filters on wells for properties platted after April 9, 2002, if the well would serve some remedial value for the site (e.g. as a "pump and treat" system) and if the concentration of TCE exceeded 10 µg/L (MPCA 2002). To date, a total of 139 GAC filter systems installed by the MAC are operating at homes, businesses, and airport hangars within the SWCA. Installation of another six GAC filter systems by the MAC is pending. These newest systems will be installed on private wells that have recently exceeded the interim recommended exposure limit for TCE of 5 µg/L.

Monitoring of private wells is currently being conducted by the MPCA. The MPCA plans to sample wells on the following schedule, based on the concentration of TCE detected in the well:

<u>TCE Concentration</u>	<u>Sampling Frequency</u>
4.3 – 4.9 µg/L	Quarterly
3.0 – 4.2 µg/L	Semi-annually
2.0 – 2.9 µg/L	Annually
1.0 – 1.9 µg/L	Every two years
0.1 – 0.9 µg/L	Every four years

It should be noted that not all private wells within the SWCA will be monitored on a regular basis. Many wells within the SWCA do not need routine monitoring because they are far enough from the edge of the plume that any movement of the plume in their direction will be detected through monitoring of sentry wells.

The MAC has maintained responsibility for the maintenance of the 139 GAC filter systems installed to date under an amendment to the RAP (Wenck 2003). The GAC filter systems consist of two, 90-pound filter vessels connected in series, with sampling ports installed before and between the two units as shown in Figure 11. A flow meter is also installed to measure water usage. Organic compounds present in the raw well water are adsorbed onto the GAC granules and removed from the water. The capacity of an individual 90-pound GAC filter canister for the removal of organic contaminants is based on the type of compound, its concentration in the raw water, and the amount of water used.

The GAC filter systems are designed so that when the first 90-pound GAC filter canister has reached its capacity to remove contaminants, the second canister will capture them (a condition referred to as “breakthrough”). Sampling of the water from the port located between the two canisters can be done to monitor for breakthrough, or the quantity of water used can be monitored to estimate when breakthrough may be imminent. During filter changout, the first canister is removed for proper disposal, the second canister moved to the first position, and a new 90-pound GAC canister is installed in the second position. Thus, the well users are not exposed to the contaminants. To document the performance of the GAC filter systems installed by the MAC, the MPCA collected post-filter samples from 14 of the initial systems installed in 2002 for laboratory analysis for VOCs. The results confirmed that the GAC systems completely removed the TCE from the water.

The maintenance schedule for the GAC filter systems developed by the MAC is based on data collected from systems installed in the past at the site, and from other available data. Using these data, Wenck calculated the number of gallons of water capable of being treated by the first 90-pound GAC canister under four different concentration ranges of TCE as a primary action limit for filter change-out, and a calculated time factor as a secondary action limit. The calculated capacities include a safety factor of three (that is, the number reflects the actual calculated number divided by 3), and are as follows (Wenck 2003):

TCE Concentration Range (µg/L)	Primary Action Limit for GAC Change-Out (gallons of water)	Secondary Action Limit for GAC Change-Out (years)
5 to 10	790,000	6
10 to 20	560,000	4
20 to 50	360,000	3
50 to 100	240,000	2

Once per year the MAC will mail out a form to each owner of a well fitted with a GAC filter system for the owner to record the flow meter reading and return it to the MAC. More frequent readings may be needed for large water users. The MAC will maintain records of water usage, and conduct the change-out of the GAC filter systems when the action limits are reached. To verify that the above schedule is adequately conservative, treated water samples will be collected before and between the two GAC filter vessels during change-out of the first five systems in each of the four categories. If no TCE or other site contaminants are detected, the schedule will be deemed adequate.

New homes continue to be built within the SWCA. The MDH has adopted a position of strongly encouraging homebuilders to complete their water supply wells in a clean, unimpacted aquifer, where reasonably available. MDH is also encouraging developers to strongly consider the construction of community public water supply wells for new housing developments. A community water supply well would serve 15 or more homes, fall under the regulation of the federal Safe Drinking Water Protection Act, require a certified water operator, and would be inspected and tested on a regular basis by MDH.

Baytown Township, one of four local units of government within the SWCA, has enacted an ordinance that applies to new wells constructed on properties platted after April 9, 2002. The ordinance (Number 36) requires well owners to regularly test the water for VOCs, and report results to the township, requires the well owner to install an approved whole-house GAC filter system if TCE levels exceed 5 µg/L, and requires the well owner to replace the activated carbon filter media on a regular basis (every 2 years) regardless of water usage, all at the expense of the well owner. It is the first ordinance of its kind in Minnesota. The MDH is working with the other governmental entities to enact similar ordinances or to develop other plans for water supplies for properties platted after April 9, 2002.

The Minnesota Legislature also enacted legislation in the 2003 session requiring property owners whose property is located within a SWCA in Washington County (and is not served by a public water supply) to notify potential buyers at the time of sale that the property is within a SWCA (Minnesota Statutes, Chapter 128, Article 1, Section 170).

Due to the issuance of the recommended interim exposure limit for TCE in 2002, it was also suggested that the remedy outlined in the 2000 ROD be re-visited to determine if it remained the best long-term solution for providing a safe supply of drinking water to residents of the site. Consequently, in the summer and fall of 2002 representatives of MDH, the MPCA, Washington County, Baytown and West Lakeland Townships, the city

of Bayport, MAC, their various consultants and others met to discuss this issue. The group held a series of meetings where various options for supplying a safe water supply were discussed, and the relative merits weighed. The group identified the following potential options for a long-term water supply:

- A large community water supply system serving all homes, with wells placed in an uncontaminated aquifer or outside of the contamination plume;
- A large community water supply system serving all homes, with wells placed in a contaminated aquifer and treated to remove the VOCs;
- Extension of a neighboring community water supply system to serve all or part of the site;
- Small community wells to serve individual developments or defined areas, with the wells placed in an uncontaminated aquifer or outside of the contamination plume;
- Small community wells to serve individual developments or defined areas, with the wells placed in a contaminated aquifer and treated to remove the VOCs;
- Private wells to serve individual homes, with wells placed in an uncontaminated aquifer or outside of the contamination plume; or
- Private wells to serve individual homes, with the wells placed in a contaminated aquifer and treated to remove the VOCs.

After a great deal of deliberation using similar evaluation criteria to those used by Wenck in 1999, it became clear that no one option was likely to rise above the rest as the only effective solution. The various parties preferred different options based on their individual, local, or agency philosophies. In addition, detailed information regarding the costs of the various options was not available, making an accurate analysis difficult. It appeared that given the complexity of the problem, the most workable solution could be a mix of one or more of the above options, with potentially different solutions for different areas of the site, different aquifers, or other unique situations. The group discussions ended with no real consensus or a formal document describing the findings.

#### Site Visits

MDH staff have conducted numerous visits to the site over the past 15 years to observe well drilling and environmental sampling, conduct private well searches and water sampling, attend community and public meetings, and to tour the Lake Elmo Airport property. An information repository for site documents is also maintained at the Washington County Library's Bayport branch. As the site is a groundwater plume with an as-yet undefined source, there are little surface features of note except as described above. There are no identified health risks from physical hazards, or from contaminated soil, surface water, or ambient air at the surface.

#### Demographics, Land Use, and Natural Resources

The estimated populations for the communities in the area affected by the site for 2001 were 1,545 for Baytown Township, 3,656 for West Lakeland Township, and 3,179 for the City of Bayport (Minnesota Department of Administration 2003). The majority of Baytown Township and the city of Bayport fall within the area affected by the



groundwater contamination, while only the far northern portion West Lakeland Township is affected. A small, mostly undeveloped portion of the City of Lake Elmo is included in the SWCA at the present time. An exact count of the population affected by the groundwater contamination is not available. Because many areas of Baytown and West Lakeland Townships are newly developed with single-family homes, much of the area is occupied by families with young children.

The land use at and around the site is primarily agricultural and rural residential, with the exception of the Lake Elmo Airport at the western end of the site and the city of Bayport at the eastern end. Homes in this area draw their water from private wells, including some homes within the city of Bayport. Wells located at the Lake Elmo Airport are mainly used for commercial purposes; there are no full time residents at the airport. Baytown and West Lakeland Townships are experiencing growth with new single-family homes being constructed on a continual basis, and demand for groundwater is expected to increase. Washington County has estimated as many as 800 additional living units could be built within the SWCA in the coming years given current zoning requirements. A private developer has also expressed interest in developing a large area of land on the western edge of the City of Bayport, with the potential for several hundred new homes (Westwood 2002). The proposed development would likely be served by Bayport municipal water, which may necessitate drilling a new water supply well to serve the increased demand on the city's water supply system.

The St. Croix River, a national scenic river, comprises the eastern border of the site. Contaminated groundwater likely discharges into the river. Because of the relatively low concentration of TCE in the affected aquifers at the river, this discharge is not considered to be a threat to the aquatic environment or to recreational users, although it has not been monitored or formally assessed. It is assumed that the contaminants are quickly diluted, and either degraded biologically or volatilized into the air.

There is one designated wildlife management area (WMA) within the site, the Bayport Wildlife Management Area. The WMA is 452 acres, consisting of two main parcels. Its major purpose is to manage the land for a variety of woodland and grassland wildlife. The area consists of 72% grassland/agricultural land, 27% woodlands and a small amount of wetland. It offers archery deer hunting opportunities, and is a good area for hiking. Much of the grassland is planted prairie on previously agricultural land. The area was once managed as a farm by the State Department of Corrections and was transferred to the Minnesota Department of Natural Resources (DNR) to be managed as a WMA in 1973. There are no known operating water supply wells within the Bayport WMA.

#### General Regional Issues

The region of the site, central and south Washington County, will continue to experience substantial growth in the coming years. This growth is regulated in part by comprehensive plans developed by Washington County, by a regional planning authority (the Metropolitan Council), and by local ordinances. The proposed construction of a new bridge over the St. Croix River may impact this growth. Because this continued growth may represent a strain on area resources, the possibility of mergers between local units of

government exists. In a recent general election, a proposed merger between Baytown Township and the city of Lake Elmo was rejected by voters.

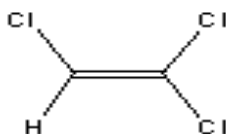
### Community Concerns

MDH staff have received hundreds of phone calls, e-mails, and letters from citizens living in the area affected by the Baytown Township Groundwater Contamination site. Two community meetings were held in February and November of 2002, both of which were attended by several hundred people. The site has also received considerable coverage in local newspapers and television.

Concerns expressed by some area residents include a perception that cancer rates in the area may be higher than normal, fears over the health of children who may have been exposed to contaminated water (both before and after birth), concerns about the health of domestic animals and livestock that may be drinking contaminated water, questions about the effectiveness of GAC filters, questions about multiple exposure pathways to volatile contaminants and the various regulatory criteria for TCE in water, and concerns about property values. MDH has made every effort to address the health issues, and has produced several information sheets for area residents, including one entitled “TCE in Drinking Water” which is included as Appendix B. MDH has also provided regular updates for local residents in the Baytown Township newsletter.

## **Evaluation of Environmental Fate, Toxicity and Exposure**

Trichloroethylene (TCE) is a nonflammable, colorless liquid with a slightly sweet odor and taste (ATSDR 1997). TCE is extremely volatile, and most TCE released into the environment will evaporate into the air. It can persist in groundwater, however, due to the limited contact between groundwater and air. Its chemical structure consists of two carbon atoms linked by a double bond, with three chlorine atoms and one hydrogen atom attached, as shown below:



TCE was marketed under a variety of trade names (Triclene, Vitran, Triad, etc.) and was used extensively as a degreasing solvent in a variety of industries. While its use as a solvent has been declining, it is also used in the manufacture of other chemical products (ATSDR 1997). Due to its extensive use, TCE is one of the most common contaminants found at Superfund sites across the United States, especially in groundwater. It has been listed as a hazardous pollutant, hazardous waste, or hazardous substance under a variety of federal and state environmental regulations (EPA 2001). TCE can be found throughout the environment, and most people are likely to be exposed to it at low levels through ingestion of drinking water, inhalation of ambient air, and ingestion of food (Wu and Schaum 2000).

Under certain conditions, TCE will degrade in the subsurface environment following predictable pathways (ATSDR 1997). There are many factors that determine the rate at which TCE will degrade, such as the amount of oxygen in the groundwater, the pH of the water, or the concentrations of other substances needed by microorganisms to help them break down the TCE. The common breakdown products of TCE have not been observed in the water samples collected at the site. This indicates that up until this point TCE is not being biologically degraded in the aquifer. The reasons for this are not clear, but likely include the geochemical conditions of the site (such as the presence of oxygen in the groundwater, which inhibits degradation of TCE), a possible lack of nutrients needed by microorganisms, and the speed at which the groundwater is moving. Other natural processes, such as simple dissolution or binding of TCE to the soil are likely affecting the spread of the plume, however. The lack of biological degradation is in and of itself not a cause for concern, because several of the environmental breakdown products of TCE such as vinyl chloride are significantly more toxic than TCE itself.

Dermal contact with concentrated solutions of TCE can produce skin rashes, dermatitis or other skin problems. Exposure to high concentrations of TCE in air can affect the central nervous system, producing headaches, dizziness or even unconsciousness. These concentrations have typically only been found in occupational settings, or cases of intentional exposure (i.e. intoxication or suicide attempts). In rare instances, however people living in communities near facilities using and releasing very large amounts of TCE to the air and groundwater (exposing people through multiple pathways) have had neurological symptoms (Kilburn 2002). The concentrations of TCE reported to have produced these effects were as high as 10,000 µg/L in groundwater, and releases to the ambient air were significant enough to produce reportable odors near the source. The odor threshold of TCE in air is approximately 100 parts per million (ppm; ATSDR 1997).

The most common environmental or community exposure pathway for TCE is through ingestion of contaminated drinking water. Ingestion of TCE in drinking water results in exposure within the body to a mixture of TCE and its metabolites, and much of the toxicity attributed to TCE is likely due to its metabolites (EPA 2001). Many of these metabolites are formed through the action of enzymatic pathways in the liver and kidney that also metabolize other substances such as alcohol, pain relievers such as acetaminophen, and other drugs and environmental contaminants. Exposure to these other common substances or contaminants at the same time may therefore affect (reduce or enhance) the metabolism of TCE.

Animal studies show that the ingestion of TCE at very high doses (e.g. hundreds to thousands of times above what is found at the site) may cause nerve damage, liver and kidney damage, and may also be associated with reproductive or development effects. Some studies also suggest an association between exposure to solvents such as TCE and autoimmune disorders (Hess 2002; Garabrant et al 2003). The neurological effects of exposure to TCE may occur only after inhalation and not ingestion of TCE contaminated water, according to some animal studies (Waseem et al 2001). Although animal studies have shown that high doses of TCE can cause tumors of the liver, kidney, and lymphatic system in rats and mice, it is less certain whether people who are exposed to lower doses

of TCE have an increased risk of these or other types of cancer. Differences in how TCE is metabolized at different doses by different species may be related to the different mechanisms by which TCE causes disease (EPA 2001). For instance, kidney tumors in rats that have been exposed to high doses of TCE may be the result of direct toxicity to kidney cells, while kidney tumors in rats exposed to lower doses may be the result of mutations in kidney cells induced by metabolites of TCE.

Occupational exposure to high levels of TCE in air has been associated with an increased risk of kidney cancer in some studies; however the estimates of exposure in these studies have been uncertain, and other studies have failed to demonstrate a relationship between kidney cancer and TCE exposure (Bruning et al 2003; Cherrie et al 2001). TCE is classified as a “probable human carcinogen” under EPA’s current cancer guidelines based on “limited” human evidence and “sufficient” animal evidence of carcinogenicity, and would be characterized as “highly likely to produce cancer in humans” under cancer guidelines proposed for adoption by EPA in 1999 (EPA 2001).

Maternal exposure to high levels of TCE during pregnancy may be associated with an increased risk of birth defects, including heart and eye defects (ATSDR 1997). Studies in rats have demonstrated an association between TCE exposure (and its metabolites) and cardiac birth defects, but the amount of TCE exposure needed to produce this increased risk is unclear (Johnson et al 1998). One study in rats suggested that the concentration of TCE in drinking water that resulted in an increased risk of cardiac birth defects was in the range of 250 µg/L. An exact comparison between exposure levels in rats and humans cannot be made due to cross-species differences in intake rates, metabolism, development, and mechanisms of action (Johnson et al 2003).

One epidemiologic study suggests a relationship between maternal exposure to TCE in drinking water (up to 107 µg/L of TCE) and very low birth weight of less than 1,501 grams (3.3 pounds; Rodenbeck et al 2000). Other studies have suggested that maternal exposure to TCE could be related to a variety of birth defects including neurological defects, cleft palate, and childhood leukemia (Bove et al 2002; Costas et al 2002). A common problem with these studies, however, is the typically small size of the exposed populations, and the lack of adequate exposure information. ATSDR is currently conducting a large-scale epidemiologic study of birth outcomes of women exposed to high levels of TCE and other VOCs (up to 1,400 µg/L of TCE) while living at a military base at Camp Lejeune, North Carolina (ATSDR 2003). Preliminary findings suggest that maternal exposure to high levels of TCE in drinking water at Camp Lejeune may be associated in some cases with low birth weights and various birth defects.

In almost every study cited above, the exposure concentrations of TCE in drinking water have been tens to hundreds of times above the highest concentrations ever observed in a private well at the site. For this reason, the various adverse health effects potentially associated with environmental exposure to TCE suggested by these studies would not be expected to occur to those exposed to the relatively low levels of TCE at the site. As described below, based on the reported number of cases of the primary cancers associated with exposure to high levels of TCE and their reported incidence rates in Minnesota, it

appears that the observed numbers of cancers of the liver, kidney, and non-Hodgkins lymphoma in the Baytown Special Well Construction Area are not unusual and are suggestive of limited or low level exposures and/or a small exposed population. An epidemiologic study of the population of a California community exposed to similar or higher concentrations of TCE in a public water supply over a similar time frame (Morgan and Cassady 2002) showed no difference between the expected and observed numbers of all cancers in area residents.

#### Impacts on Private Wells

Levels of TCE exceed the MDH recommended interim exposure limit of 5 µg/L in seven private water supply wells located at hangars at the Lake Elmo Airport and in 141 residential wells located down gradient (to the east) of the airport. All but 6 of these water supply systems have been fitted with whole-house GAC filters by the MAC to remove the TCE, because they are on properties platted before April 9, 2002. Three of the 141 impacted water supply wells are new Franconia aquifer wells that have been fitted with a GAC filter system as required by a recently enacted Baytown Township ordinance. Some other wells at airport hangars (which are not intended for residential use) have not been fitted with a GAC filter, but the MAC and the tenants have placed signs on the taps stating they are not to be used for potable water.

Low levels of CCl<sub>4</sub>, near laboratory detection limits, have been found in some wells in recent sampling events. Low levels of other VOCs, including methyl ethyl ketone (MEK), toluene, and acetone have been detected in some wells. Very low levels of different VOCs than have been detected in groundwater are occasionally detected in the effluent of some GAC systems for reasons unknown. Concentrations of these VOCs are typically far below their respective HRLs and do not represent a health risk.

Levels of TCE appear to be increasing in some wells, especially those directly east of the Lake Elmo Airport. This may indicate that the area of highest TCE concentration (on or near the airport), previously believed to be relatively stable, may in fact be slowly moving or spreading to the east. However, many wells were sampled between 1999 and 2002 for the first time, and it is possible or even likely that at least some of these wells have been impacted for some time, and the plume may not be expanding in those areas. Additional sampling of these wells will help show whether concentrations of TCE overall are stable, or rising over time in individual wells. It is also possible that increases in TCE levels observed in individual wells are a reflection of a state of flux of the plume in the aquifer. Localized variations in TCE concentrations (both up and down) will occur as conditions in the aquifer change. These changes may allow additional TCE to dissolve from the soil or rock substrate, or bind additional TCE to the substrate. Most of the older wells at the site are completed in the Prairie du Chien aquifer.

Most of the newer wells at the site are completed in the Jordan Sandstone. The TCE plume has migrated downward into the Jordan east of the airport property. It is unknown whether this occurred naturally, via fractures and downward groundwater flow gradients, or whether it was the result of migration of contamination through wells open to both aquifers. It is possible that the installation of so many new Jordan wells has helped to

create a downward gradient, as a result of pumping, that has pulled the TCE contamination into the formation. There is not sufficient historic water level data to evaluate this conjecture.

#### Impacts on the Various Aquifers

Of greater long-term concern are detections of TCE in the Franconia aquifer. The detections of TCE in this aquifer indicate that there is some connection between the Jordan and Franconia aquifers via cracks or erosional features in the confining units that separate them, or through vertical flow gradients.

The Minnesota well code (Minnesota Rules, Chapter 4725) requires that if a new well is to be completed in a limestone aquifer (such as the Prairie du Chien), there must be at least 50 feet of overburden separating the limestone aquifer from the ground surface within a one-mile radius of the well. Additionally, the Special Well Construction Area rules require that new wells in the Baytown area be sampled prior to completion, to demonstrate that they can provide a safe drinking water supply. As a result, new wells in most of the Baytown area must be completed below the Prairie du Chien aquifer, in the Jordan aquifer or deeper units, because the Prairie du Chien is located within 50 feet of the surface in many parts of the site and water in it is not considered to be a safe, reliable potable water supply. If the Franconia aquifer becomes impacted by TCE across a large area of the site, it may limit options for those wishing to install new wells or replacement wells in an uncontaminated aquifer. For the time being, however, it appears that the contamination in the Franconia aquifer is confined to the eastern portion of the site, and is most likely related to natural erosional or fracture features in the bedrock near the river valley. It may still be possible, and even advisable in many instances to complete wells in the Franconia aquifer in the central and western areas of the site. Additional data on the Franconia aquifer would be helpful in determining appropriate well construction guidelines.

#### Impacts on Public Water Supplies

The May 2003 detection of TCE in Bayport city well #2 represented the first impact of site contamination on a public water supply. The Bayport municipal water supply system serves the majority of the city's approximately 3,200 residents. Several new and existing homes within the city limits are served by private wells. A number of these wells have had detections of TCE above the interim recommended exposure limit, and have been fitted with GAC filters.

The levels of TCE detected in well #2 (0.8 to 3.40 µg/L) and the water supply system (0.3 to 0.9 µg/L) are below the federal MCL of 5 µg/L. The levels in well #2 do appear to be rising, however. The three city wells are pumped on a rotating basis, with only one well pumped per day, and the system is not currently set up for blending of water from well #2 and the other wells. All city wells and the distribution system will now be monitored by MDH on a quarterly basis; a new tritium sample will also be collected from well #2. Wells #3 and #4 may be vulnerable to contamination in the future due to their location (see Figure 2). The city of Bayport is also investigating the status of the original

Bayport municipal well #1, which was disconnected and removed from service in 1967. It has not been determined if this well was properly sealed.

The water supply wells at the nearby Minnesota Correctional Facility in Stillwater are outside of the SWCA, but are monitored on a regular basis as a public water supply. They have also not shown any evidence of TCE contamination to date.

Because it is located within ½ mile of the TCE contamination found to the west of the Lake Elmo Airport (and is located in a bedrock valley), as a precaution MDH will begin collecting a water sample on an annual basis for VOC analysis from Lake Elmo well #1 (shown in Figure 2). No TCE has been detected in Lake Elmo well #1 to date.

#### Exposure to VOCs

Residents of the site have been exposed to TCE and/or CCl<sub>4</sub> through the use of contaminated private wells, and more recently through the Bayport public water supply. At times in the past, levels of contamination in some wells may have exceeded either the existing HRLs or the current interim recommended exposure limit for TCE. It is not known when contaminants first reached any individual well and at what levels, and therefore the length of time well users may have been exposed to contaminants in the groundwater. It is conceivable that some wells could have been contaminated as far back as the 1950s or 1960s.

Since the discovery of the site in 1987, however, every effort has been made to monitor the wells considered to be most at risk of exceeding health-based criteria, and to fit wells found to exceed such criteria with a GAC filter as soon as possible. Bottled water (in excess of 25,000 gallons) has also been provided by the MPCA to homes where a well has been found to exceed health-based criteria in the interim before a GAC filter can be installed.

When assessing the risk from contaminated groundwater, MDH also considers the risk from mixtures of contaminants, as expressed using a hazard index. Even if levels of individual contaminants are below their respective HRLs (or in the case of TCE, its recommended interim exposure limit), the mixture of contaminants may present an unacceptable long-term health risk if the sum of the concentration of each contaminant divided by its HRL exceeds one. While this has occurred in the past when concentrations of carbon tetrachloride in some wells were higher, it appears to no longer be an issue.

HRLs are based solely on protection of human health, and are based on a measure of the potency of a contaminant known as “reference dose” for non-carcinogens, and “slope factor” for carcinogens. The reference dose is the dose of a substance or chemical that is unlikely to cause toxic effects in humans exposed to this dose over a lifetime. The slope factor is a similar measure of potency for carcinogens. HRLs for potential carcinogens (such as TCE) are levels that would be expected to result in a negligible excess lifetime cancer risk if the contaminated water is ingested for a lifetime. MDH currently defines a risk as negligible if the expected excess lifetime risk of cancer is no greater than one additional cancer case in 100,000 exposed people.

The existing HRL for TCE of 30 µg/L was based on cancer as the adverse health effect of concern, using a cancer potency slope factor of 0.011 per milligram per kilogram of body weight per day (mg/kg/day)<sup>-1</sup>. EPA's recent draft health risk assessment document for TCE (EPA 2001) proposed a range of cancer potency slope factors of from 0.02 to 0.4 (mg/kg/day)<sup>-1</sup> (the higher the cancer potency slope factor, the more potent the carcinogen is considered to be). EPA also proposed a reference dose of 0.0003 mg/kg/day based on critical effects on the liver, kidney, and the developing fetus.

As stated previously, in response to the newly released toxicological criteria for TCE, MDH developed an interim exposure limit of 5 µg/L for TCE to be used in place of the existing HRL of 30 µg/L for drinking water from private wells. Once again, a HRL is the highest concentration of a groundwater contaminant that can be safely consumed for an average lifetime of 70 years and a daily consumption of 2 liters of water. If a person drinks less water, or drinks it for a shorter period of time, the risk is correspondingly lower.

This exposure limit should be considered an interim value. While the EPA health risk assessment is still in draft form, MDH considers the document to represent the best available toxicological information on TCE. Changes to the draft assessment may yet be proposed because it incorporates a number of newer risk assessment techniques. The recommended interim exposure limit is conservative because it limits exposures in accordance with the lower end of the range of toxicity values proposed by EPA; it is also consistent with the current federal Maximum Contaminant Level (MCL) for public drinking water supplies. MDH is in the process of revising the HRL rule, and will consider all new information and public comments when it updates the HRL for TCE as a part of the rule revision process. This process is expected to be complete within the next one to two years. The final HRL for TCE may be different than the recommended exposure limit.

Currently, HRLs for contaminants that are classified as non-carcinogens are calculated using a formula that includes a "relative source contribution factor." This factor directly acknowledges that not all of an individual's exposure to some types of contaminants comes from drinking contaminated water. Other pathways, such as inhalation, skin contact, or eating food containing the contaminant can also contribute to the amount of individual exposure. HRLs for contaminants that may be associated with an increased cancer risk in humans (including TCE) do not include this factor directly in the calculation. However, the conservative calculation of the cancer slope factor accounts for this indirectly.

Cancer slope factors are developed using conservative mathematical models and are meant to provide an "upper bound" estimate of risk. The incremental cancer risk at the HRL is very unlikely to be higher than one excess cancer case in 100,000 exposed people, and may very well be zero. Therefore, while the health-based exposure limits for carcinogens do not directly account for exposure through routes other than direct ingestion of water such as inhalation of volatilized contaminants or skin contact, they are protective of human health due to their inherent conservatism.



Some studies have suggested that exposure to VOCs in drinking water through inhalation or skin contact during activities such as showering, bathing, or washing dishes could be significant in certain situations. The ratio of inhalation uptake versus direct ingestion of contaminated water has been estimated to be as high as 6:1 (McKone 1989) or as low as less than 1:1 (Lindstrom and Pleil 1996). A more recent study (Kerger et al 2000) using water and air measurements taken in actual home bathrooms estimated that the exposure through inhalation of volatile organics (such as TCE) from showering and bathing in contaminated water is less than the ingestion exposure by a factor of three to four. Previous studies typically used laboratory or simulated shower facilities, which tend to be smaller than standard home showers and less well ventilated, resulting in higher estimates of exposure through inhalation.

A large number of variables are involved in assessing inhalation exposure, making accurate estimates very difficult. These variables include such things as water temperature, size of the shower enclosure, the type of shower head used, length of time spent in the shower, and the ventilation rate. One study (Lee et al 2002) identified the contaminant level and the time spent in the shower as the key variables that determine the level of exposure. Several studies have demonstrated that simply ventilating the shower stall can greatly reduce the estimated exposure to VOCs in shower air (McKone and Knezovich 1991; Aggarwal 1994).

Estimates of additional exposure through skin contact with contaminated water are generally thought to be less than for inhalation exposure, and have been estimated to be in the range of 1:1 or less (McKone 1989). One study (Lee et al 2002) estimated that intake through dermal absorption would account for only about 2% of the total intake through inhalation and dermal contact while showering, while an older study done using measurements of human volunteers showed that dermal absorption of TCE contributes as much to the total body exposure as inhalation (Weisel and Jo 1996). Thus, the best recent estimates of TCE exposures through inhalation and dermal absorption indicate at most a doubling of exposure when compared to drinking water ingestion alone.

The route of exposure, however affects the rate at which TCE is absorbed and metabolized by the body; even if the same dose is received via different routes (i.e. ingestion, inhalation, or dermal contact) the resulting toxicity may be different (Weisel and Jo 1996). A compilation of studies conducted by ATSDR and summarized in their toxicological profile for TCE suggests that absorption of TCE in the gastro-intestinal tract as a result of oral exposure is “extensive”, while the absorption rate in the lungs from inhalation exposure ranges from 37-64% (ATSDR 1997). Pharmacokinetic models developed by EPA also suggest that the levels of some TCE metabolites formed by the body may be significantly higher as a result of oral exposure than inhalation exposure (EPA 2001). For instance, small amounts of TCE that are ingested are often quickly metabolized by the liver, while small amounts of TCE that are inhaled or absorbed through the skin are typically distributed throughout the body prior to metabolism by the liver, and are therefore metabolized more slowly. If the toxic effects of exposure to TCE are mainly due to the action of its metabolites, this implies that for equal (low) doses the

ingestion of TCE in water may be of greater consequence within the body than inhalation or dermal absorption.

#### Health Outcome Data Review

MDH staff has reviewed available sources of health outcome data for the area of the site, including the state cancer registry and other sources of vital statistics. The Minnesota Cancer Surveillance System (MCSS) is the state's cancer registry. It is an ongoing program within the Chronic Disease and Environmental Epidemiology section at MDH. The MCSS systematically collects demographic and diagnostic information on all Minnesota residents with newly diagnosed cancers, and produces biennial reports describing the occurrence of cancer. The primary objectives of the Minnesota Cancer Surveillance System are to:

1. Monitor the occurrence of cancer in Minnesota and describe the risks of developing cancer;
2. Inform health professionals and educate citizens regarding specific cancer risks;
3. Answer the public's questions and concerns about cancer;
4. Promote cancer research; and
5. Guide decisions about how to target cancer control resources.

The MCSS has data available from its inception in 1988 through 2001. Because the site does not follow established geopolitical boundaries such as zip codes or city limits, the analysis was done essentially by hand for a limited number of cancer types. The area for which the MCSS records were examined was within the boundaries of the Baytown Special Well Construction Area, and therefore encompassed parts of Baytown and West Lakeland Townships and the city of Lake Elmo, and a majority of the city of Bayport. The MCSS system was searched for records of cancer of the liver, kidney, and non-Hodgkins lymphoma. These are the three cancers that are most associated with exposure to high concentrations of solvents such as TCE as demonstrated by animal studies and human epidemiologic studies (EPA 2001). Note that the exposure concentrations reported in these studies are invariably tens to hundreds of times higher than the highest concentrations ever detected in private wells at the site.

No cancers of the liver, two cancers of the kidney, and seven cases of non-Hodgkins lymphoma were reported in the area examined for the years 1988-2001. To determine the expected number of these cancers in the area for that time frame requires an accurate count of the population over the same time period. At this time it is not possible to determine the expected number of cases of these cancers due to the fact that it covers multiple political jurisdictions and U.S. census tracts. Without an accurate count of the total population, it is difficult to determine if these numbers represent an expected number, a lower than expected number, or a higher than expected number. The reported incidence rates for 1999 (the most recent year for which data is available) for these three cancers in the state of Minnesota are as follows (Perkins et al 2003):

Cancer Site	Annual Minnesota Incidence Rate, 1999*	
	Males	Females
Liver and Bile Duct	5.1	2.0
Kidney and Renal Pelvis	16.3	9.0
Non-Hodgkins Lymphoma	25.2	17.9

\* Rates are per 100,000 persons and are age-adjusted to the 2000 U.S. population.

While direct comparison is not possible, based on the reported incidence rates for these cancers in Minnesota in 1999, it appears that the observed number of cancers of the liver, kidney, and non-Hodgkins lymphoma in the Baytown Special Well Construction Area from 1988-2001 do not represent an unusual occurrence. The lack of liver cancers (which are relatively rare in Minnesota) is suggestive of limited or low level exposures and/or a small exposed population. While kidney cancer is not common in Minnesota, it is less rare, and non-Hodgkins lymphoma is more common yet. It must be stated, however, that MCSS data only reports a patient's address at the time of the cancer diagnosis. Thus the data only capture cancers diagnosed in people who lived within the SWCA from 1988-2001. Cancer cases in people who moved from the area and were diagnosed somewhere else would not be included. Incidence rates for other types of cancer for which there could be a relationship with exposure to high levels of solvents like TCE, such as cervical cancer, prostate cancer, and leukemia are at or below expected rates in Washington County. Evidence of a relationship between TCE exposure and these types of cancers from animal and human epidemiologic studies is less certain.

Some studies also suggest exposure to high concentrations of TCE (again, many times higher than has ever been detected in wells at the site) while pregnant may be associated with adverse effects on the developing fetus, such as cardiac and eye defects, and decreased fetal weight (EPA 2001). MDH has received several anecdotal reports of birth defects for infants born in the area of the site. However, Minnesota does not maintain a birth defects registry and no quantitative data are available. A search of reportable vital statistics did show that the percentage of infants of low birth weight in Washington County for the period of 1992 to 1997 was 5.5%, slightly below the statewide average of 5.8%. Low birth weight could be a possible indicator of maternal exposure to TCE prior to birth, although many other environmental and lifestyle factors contribute to low birth weight as well.

## Child Health Considerations

MDH recognizes that the unique vulnerabilities of infants and children make them of special concern to communities faced with contamination of their water, soil, air, or food. Children are at greater risk than adults from certain kinds of exposures to hazardous substances at waste disposal sites. They are more likely to be exposed because they play outdoors, and they often bring food into contaminated areas. They are smaller than adults, which means they breathe dust, soil, and heavy vapors close to the ground, and receive higher doses of chemical exposure per body weight. The developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth

stages. Most importantly, children depend completely on adults for risk identification and management decisions, housing decisions, and access to medical care.

At the present time, child exposure to levels of TCE in excess of health-based criteria is being prevented by the use of GAC filtration units on private wells. Exposure of children to TCE and possibly CCl<sub>4</sub> in drinking water at levels below the interim recommended exposure limit/HRL is occurring at some residences in the SWCA served by private wells. Children may also be exposed to low levels of TCE through the Bayport municipal water supply. However, as stated above, MDH believes that the health-based and regulatory criteria are sufficiently conservative and protective of human health.

## **Conclusions**

The Baytown Township Groundwater Contamination site was first discovered in 1987, and investigation and response actions have been ongoing since that time. The disposal or spillage of a large quantity of TCE at an unknown source or sources in the area of the Lake Elmo Airport, and/or to the west of the airport, has resulted in an area of groundwater contamination in excess of six square miles, affecting three major groundwater aquifers. Several hundred private water supply wells, one of three Bayport municipal supply wells, and the Bayport water supply system have been impacted. The issuance of a new interim recommended exposure limit of 5 µg/L for TCE by MDH in early 2002 precipitated a series of new investigations and response actions. MDH is in the process of revising the HRLs; a new HRL for TCE (which may be different than 5 µg/L) may be adopted as a part of that process. Further response actions by the MPCA are under consideration.

Due to the fact that exposure to TCE above health-based criteria is currently being prevented by use of whole-house GAC filtration units on private wells, and by the fact that levels of TCE in the Bayport municipal system are below regulatory and health-based standards, the site represents no apparent public health hazard at this time. The site may represent an indeterminate public health hazard in the future due to potential uncertainties over the long-term maintenance of the many individual GAC filter systems in use at the site, tracking and monitoring of the plume, and in potential development of the area. Past exposure to TCE and CCl<sub>4</sub> in groundwater in private wells did represent a public health hazard because concentrations exceeded the current interim recommended exposure limit for TCE, and/or the hazard index of one. However, at this time there is no direct evidence of an unusual incidence of adverse health effects (i.e. cancer) as a result of this low-level exposure.

## Recommendations

1. Action should continue to be taken by the various governmental entities involved in the site to prevent exposure to TCE at levels in excess of the recommended interim exposure limit for TCE in private wells. The MDH will also continue to evaluate mixtures of VOCs at wells impacted by multiple contaminants to ensure that the mixture does not exceed the hazard index and therefore represent an unacceptable health risk.
2. Given the detection of TCE at a concentration of 1 µg/L in a Jordan well on Osprey Avenue, outside of the 1 µg/L TCE contour shown in Figure 9b, the private well monitoring plan for the site should be modified to include additional sampling in the 2000-2100 block areas of Osprey and Oriole Avenues and along 21<sup>st</sup> Street North, between Olene and Osprey Avenue. This will help to clarify the extent of the plume in the Jordan aquifer in this area.
3. Any GAC filter systems installed on private wells should be under the oversight of a governmental entity (such as the MAC, the MPCA, or local governments) and should be regularly monitored and maintained to ensure that residents have a safe water supply.
4. MDH should finalize a new HRL for TCE through its rule making process.
5. MDH's Well Management Section should continue to maintain the Baytown Special Well Construction Area, review the latest monitoring data and adjust its boundaries as needed.
6. Additional permanent monitoring wells should be installed by the MPCA at or upgradient of the north hangar and the MW-10B areas to clarify whether TCE sources are located in these areas.
7. The lateral extent and overall competence of the St. Lawrence formation should be evaluated to determine where the Franconia aquifer is adequately protected. Such an assessment should include, but not be limited to, identifying faulting and fracture patterns, erosional and structural features, and other aspects of the local geology (both in the St. Lawrence and the formations above and below it) that may create pathways for contaminant migration to the Franconia.
8. The magnitude and extent of contamination in the Franconia should be defined by installation of permanent monitoring wells, or by other means.
9. The city of Bayport should consider ways to minimize the amount of TCE in the water distribution system and a contingency plan should also be developed in the event that TCE concentrations in the Bayport water supply system exceed health-based standards.
10. The vulnerability of the currently unaffected Bayport city water supply wells should be evaluated and a plan developed to prevent further contamination of the water supply system.
11. The feasibility of connecting homes within the city of Bayport that are currently served by private wells to the city's municipal water supply should be explored. If a connection is made, the existing well should be properly sealed.
12. As a precaution, Lake Elmo well #1 should be monitored for VOCs on an annual basis by MDH.

13. The assessment and feasibility of long-term water supply options for the entire site should be completed. Alternate water supply options such as new private wells or community wells, or connection to a municipal or other community water supply system should be considered as long-term solutions.
14. The construction of all existing private wells constructed before 1990 should be carefully reviewed to determine from which aquifer(s) they obtain water. To better protect the Jordan aquifer over the long term, consideration should be given to sealing those wells completed in both the Prairie du Chien and Jordan aquifers. These wells may allow unrestricted vertical migration of contaminated groundwater downward into the Jordan aquifer.
15. Gradient control pump-out wells should be considered to prevent further migration of the contaminant plume. The optimal strategy for such a pump-out system could be to arrange a series of wells along the eastern edge of the airport property, sufficient in number and capacity to capture the majority of the contaminant plume. This series of wells should be combined with a pump-out well (or wells) in the source area(s) if such an area (or areas) can be located. The goal would be for the downgradient wells to “cut off” the plume, while the near-source well(s) would reduce the mass of contaminants feeding the plume, thus reducing the time frame over which the downgradient wells must operate.
16. The current well sampling plan should be re-evaluated by all parties when a final HRL for TCE is adopted to ensure that it is still protective of public health.
17. The number of new private wells constructed in the SWCA should be limited to minimize the oversight burden on state and local governments, and to minimize the potential for the spread of contaminants vertically or laterally. Where feasible, community public water supply wells should be constructed to serve 15 or more homes.
18. The MAC (or their consultants) should update the Prairie du Chien and Jordan plume maps on an annual basis to provide current information regarding the plume configurations.
19. The MAC (or their consultants) should generate a plume map for the Franconia formation, and update it annually as new information becomes available.

## **Public Health Action Plan**

MDH’s Public Health Action Plan for the site will consist of the distribution of this Public Health Assessment, and/or an information sheet summarizing the information in this Public Health Assessment to area residents, continued consultation with MPCA and other agency staff on investigation, monitoring and response action activities, and participation in any public outreach events.

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## **Glossary**

### **General Terms**

#### **Absorption**

The process of taking in. For a person or an animal, absorption is the process of a substance getting into the body through the eyes, skin, stomach, intestines, or lungs.

#### **Acute**

Occurring over a short time [compare with chronic].

#### **Acute exposure**

Contact with a substance that occurs once or for only a short time (up to 14 days) [compare with intermediate duration exposure and chronic exposure].

#### **Additive effect**

A biologic response to exposure to multiple substances that equals the sum of responses of all the individual substances added together [compare with antagonistic effect and synergistic effect].

#### **Adverse health effect**

A change in body function or cell structure that might lead to disease or health problems

#### **Aerobic**

Requiring oxygen [compare with anaerobic].

#### **Ambient**

Surrounding (for example, ambient air).

#### **Anaerobic**

Requiring the absence of oxygen [compare with aerobic].

#### **Analyte**

A substance measured in the laboratory. A chemical for which a sample (such as water, air, or blood) is tested in a laboratory. For example, if the analyte is mercury, the laboratory test will determine the amount of mercury in the sample.

#### **Analytic epidemiologic study**

A study that evaluates the association between exposure to hazardous substances and disease by testing scientific hypotheses.

#### **Antagonistic effect**

A biologic response to exposure to multiple substances that is less than would be expected if the known effects of the individual substances were added together [compare with additive effect and synergistic effect].

**Background level**

An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.

**Biodegradation**

Decomposition or breakdown of a substance through the action of microorganisms (such as bacteria or fungi) or other natural physical processes (such as sunlight).

**Biologic indicators of exposure study**

A study that uses (a) biomedical testing or (b) the measurement of a substance [an analyte], its metabolite, or another marker of exposure in human body fluids or tissues to confirm human exposure to a hazardous substance [also see exposure investigation].

**Biologic monitoring**

Measuring hazardous substances in biologic materials (such as blood, hair, urine, or breath) to determine whether exposure has occurred. A blood test for lead is an example of biologic monitoring.

**Biologic uptake**

The transfer of substances from the environment to plants, animals, and humans.

**Biomedical testing**

Testing of persons to find out whether a change in a body function might have occurred because of exposure to a hazardous substance.

**Biota**

Plants and animals in an environment. Some of these plants and animals might be sources of food, clothing, or medicines for people.

**Body burden**

The total amount of a substance in the body. Some substances build up in the body because they are stored in fat or bone or because they leave the body very slowly.

**CAP** [see Community Assistance Panel.]

**Cancer**

Any one of a group of diseases that occur when cells in the body become abnormal and grow or multiply out of control.

**Cancer risk**

A theoretical risk for getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.

**Carcinogen**

A substance that causes cancer.

**Case study**

A medical or epidemiologic evaluation of one person or a small group of people to gather information about specific health conditions and past exposures.

**Case-control study**

A study that compares exposures of people who have a disease or condition (cases) with people who do not have the disease or condition (controls). Exposures that are more common among the cases may be considered as possible risk factors for the disease.

**CAS registry number**

A unique number assigned to a substance or mixture by the American Chemical Society Abstracts Service.

**Central nervous system**

The part of the nervous system that consists of the brain and the spinal cord.

**CERCLA** [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980]

**Chronic**

Occurring over a long time [compare with acute].

**Chronic exposure**

Contact with a substance that occurs over a long time (more than 1 year) [compare with acute exposure and intermediate duration exposure]

**Cluster investigation**

A review of an unusual number, real or perceived, of health events (for example, reports of cancer) grouped together in time and location. Cluster investigations are designed to confirm case reports; determine whether they represent an unusual disease occurrence; and, if possible, explore possible causes and contributing environmental factors.

**Community Assistance Panel (CAP)**

A group of people from a community and from health and environmental agencies who work with ATSDR to resolve issues and problems related to hazardous substances in the community. CAP members work with ATSDR to gather and review community health concerns, provide information on how people might have been or might now be exposed to hazardous substances, and inform ATSDR on ways to involve the community in its activities.

**Comparison value (CV)**

Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

**Completed exposure pathway** [see exposure pathway].

**Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)**

CERCLA, also known as Superfund, is the federal law that concerns the removal or cleanup of hazardous substances in the environment and at hazardous waste sites. ATSDR, which was created by CERCLA, is responsible for assessing health issues and supporting public health activities related to hazardous waste sites or other environmental releases of hazardous substances. This law was later amended by the Superfund Amendments and Reauthorization Act (SARA).

**Concentration**

The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

**Contaminant**

A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

**Delayed health effect**

A disease or an injury that happens as a result of exposures that might have occurred in the past.

**Dermal**

Referring to the skin. For example, dermal absorption means passing through the skin.

**Dermal contact**

Contact with (touching) the skin [see route of exposure].

**Descriptive epidemiology**

The study of the amount and distribution of a disease in a specified population by person, place, and time.

**Detection limit**

The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

**Disease prevention**

Measures used to prevent a disease or reduce its severity.

**Disease registry**

A system of ongoing registration of all cases of a particular disease or health condition in a defined population.

**Dolomite**

A carbonate rock that is similar to limestone, but contains equal (or nearly equal) parts of magnesium carbonate and calcium carbonate. (Limestone is composed entirely of calcium carbonate). Dolomite is generally denser and harder than limestone.

**Dose (for chemicals that are not radioactive)**

The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

**Dose (for radioactive chemicals)**

The radiation dose is the amount of energy from radiation that is actually absorbed by the body. This is not the same as measurements of the amount of radiation in the environment.

**Dose-response relationship**

The relationship between the amount of exposure [dose] to a substance and the resulting changes in body function or health (response).

**Environmental media**

Soil, water, air, biota (plants and animals), or any other parts of the environment that can contain contaminants.

**Environmental media and transport mechanism**

Environmental media include water, air, soil, and biota (plants and animals). Transport mechanisms move contaminants from the source to points where human exposure can occur. The environmental media and transport mechanism is the second part of an exposure pathway.

**EPA**

United States Environmental Protection Agency.

**Epidemiologic surveillance** [see Public health surveillance].**Epidemiology**

The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and causes of health effects in humans.

**Exposure**

Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [acute], of intermediate duration, or long-term [chronic].

**Exposure assessment**

The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.

**Exposure-dose reconstruction**

A method of estimating the amount of people's past exposure to hazardous substances. Computer and approximation methods are used when past information is limited, not available, or missing.

**Exposure investigation**

The collection and analysis of site-specific information and biologic tests (when appropriate) to determine whether people have been exposed to hazardous substances.

**Exposure pathway**

The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a source of contamination (such as an abandoned business); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

**Exposure registry**

A system of ongoing follow-up of people who have had documented environmental exposures.

**Feasibility study**

A study to determine the best way to clean up environmental contamination. A number of factors are considered, including health risk, costs, and what methods will work well.

**Geographic information system (GIS)**

A mapping system that uses computers to collect, store, manipulate, analyze, and display data. For example, GIS can show the concentration of a contaminant within a community in relation to points of reference such as streets and homes.

**Grand rounds**

Training sessions for physicians and other health care providers about health topics.

**Groundwater**

Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with surface water].



**Half-life ( $t_{1/2}$ )**

The time it takes for half the original amount of a substance to disappear. In the environment, the half-life is the time it takes for half the original amount of a substance to disappear when it is changed to another chemical by bacteria, fungi, sunlight, or other chemical processes. In the human body, the half-life is the time it takes for half the original amount of the substance to disappear, either by being changed to another substance or by leaving the body. In the case of radioactive material, the half life is the amount of time necessary for one half the initial number of radioactive atoms to change or transform into another atom (that is normally not radioactive). After two half lives, 25% of the original number of radioactive atoms remain.

**Hazard**

A source of potential harm from past, current, or future exposures.

**Hazardous Substance Release and Health Effects Database (HazDat)**

The scientific and administrative database system developed by ATSDR to manage data collection, retrieval, and analysis of site-specific information on hazardous substances, community health concerns, and public health activities.

**Hazardous waste**

Potentially harmful substances that have been released or discarded into the environment.

**Health consultation**

A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. Health consultations are focused on a specific exposure issue. Health consultations are therefore more limited than a public health assessment, which reviews the exposure potential of each pathway and chemical [compare with public health assessment].

**Health education**

Programs designed with a community to help it know about health risks and how to reduce these risks.

**Health investigation**

The collection and evaluation of information about the health of community residents. This information is used to describe or count the occurrence of a disease, symptom, or clinical measure and to evaluate the possible association between the occurrence and exposure to hazardous substances.

**Health promotion**

The process of enabling people to increase control over, and to improve, their health.

**Health Risk Limit (HRL)**

An MDH standard, a HRL is the concentration of a contaminant in water that is considered safe for people if they drink two liters (about two quarts) of water daily for a lifetime.

**Health statistics review**

The analysis of existing health information (i.e., from death certificates, birth defects registries, and cancer registries) to determine if there is excess disease in a specific population, geographic area, and time period. A health statistics review is a descriptive epidemiologic study.

**Indeterminate public health hazard**

The category used in ATSDR's public health assessment documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.

**Incidence**

The number of new cases of disease in a defined population over a specific time period [contrast with prevalence].

**Ingestion**

The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see route of exposure].

**Inhalation**

The act of breathing. A hazardous substance can enter the body this way [see route of exposure].

**Intermediate duration exposure**

Contact with a substance that occurs for more than 14 days and less than a year [compare with acute exposure and chronic exposure].

**In vitro**

In an artificial environment outside a living organism or body. For example, some toxicity testing is done on cell cultures or slices of tissue grown in the laboratory, rather than on a living animal [compare with in vivo].

**In vivo**

Within a living organism or body. For example, some toxicity testing is done on whole animals, such as rats or mice [compare with in vitro].

**Lowest-observed-adverse-effect level (LOAEL)**

The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

**MAC**

The Metropolitan Airports Commission.

**MDH**

The Minnesota Department of Health.

**Medical monitoring**

A set of medical tests and physical exams specifically designed to evaluate whether an individual's exposure could negatively affect that person's health.

**Metabolism**

The conversion or breakdown of a substance from one form to another by a living organism.

**Metabolite**

Any product of metabolism.

**mg/kg**

Milligram per kilogram.

**mg/cm<sup>2</sup>**

Milligram per square centimeter (of a surface).

**mg/m<sup>3</sup>**

Milligram per cubic meter; a measure of the concentration of a chemical in a known volume (a cubic meter) of air, soil, or water.

**Migration**

Moving from one location to another.

**Minimal risk level (MRL)**

An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see reference dose].

**Morbidity**

State of being ill or diseased. Morbidity is the occurrence of a disease or condition that alters health and quality of life.

**Mortality**

Death. Usually the cause (a specific disease, a condition, or an injury) is stated.

**MPCA**

The Minnesota Pollution Control Agency.

**Mutagen**

A substance that causes mutations (genetic damage).

**Mutation**

A change (damage) to the DNA, genes, or chromosomes of living organisms.

**National Priorities List for Uncontrolled Hazardous Waste Sites (National Priorities List or NPL)**

EPA's list of the most serious uncontrolled or abandoned hazardous waste sites in the United States. The NPL is updated on a regular basis.

**National Toxicology Program (NTP)**

Part of the Department of Health and Human Services. NTP develops and carries out tests to predict whether a chemical will cause harm to humans.

**No apparent public health hazard**

A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.

**No-observed-adverse-effect level (NOAEL)**

The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.

**No public health hazard**

A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

**NPL** [see National Priorities List for Uncontrolled Hazardous Waste Sites]

**Physiologically based pharmacokinetic model (PBPK model)**

A computer model that describes what happens to a chemical in the body. This model describes how the chemical gets into the body, where it goes in the body, how it is changed by the body, and how it leaves the body.

**Pica**

A craving to eat nonfood items, such as dirt, paint chips, and clay. Some children exhibit pica-related behavior.

**Plume**

A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with groundwater.

**Point of exposure**

The place where someone can come into contact with a substance present in the environment [see exposure pathway].

**Population**

A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).

**Potentially responsible party (PRP)**

A company, government, or person legally responsible for cleaning up the pollution at a hazardous waste site under Superfund. There may be more than one PRP for a particular site.

**ppb**

Parts per billion.

**ppm**

Parts per million.

**Prevalence**

The number of existing disease cases in a defined population during a specific time period [contrast with incidence].

**Prevalence survey**

The measure of the current level of disease(s) or symptoms and exposures through a questionnaire that collects self-reported information from a defined population.

**Prevention**

Actions that reduce exposure or other risks, keep people from getting sick, or keep disease from getting worse.

**Public availability session**

An informal, drop-by meeting at which community members can meet one-on-one with ATSDR staff members to discuss health and site-related concerns.

**Public comment period**

An opportunity for the public to comment on agency findings or proposed activities contained in draft reports or documents. The public comment period is a limited time period during which comments will be accepted.

**Public health action**

A list of steps to protect public health.

**Public health advisory**

A statement made by ATSDR to EPA or a state regulatory agency that a release of hazardous substances poses an immediate threat to human health. The advisory includes recommended measures to reduce exposure and reduce the threat to human health.

**Public health assessment (PHA)**

An ATSDR document that examines hazardous substances, health outcomes, and community concerns at a hazardous waste site to determine whether people could be harmed from coming into contact with those substances. The PHA also lists actions that need to be taken to protect public health [compare with health consultation].

**Public health hazard**

A category used in ATSDR's public health assessments for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances or radionuclides that could result in harmful health effects.

**Public health hazard categories**

Public health hazard categories are statements about whether people could be harmed by conditions present at the site in the past, present, or future. One or more hazard categories might be appropriate for each site. The five public health hazard categories are no public health hazard, no apparent public health hazard, indeterminate public health hazard, public health hazard, and urgent public health hazard.

**Public health statement**

The first chapter of an ATSDR toxicological profile. The public health statement is a summary written in words that are easy to understand. The public health statement explains how people might be exposed to a specific substance and describes the known health effects of that substance.

**Public health surveillance**

The ongoing, systematic collection, analysis, and interpretation of health data. This activity also involves timely dissemination of the data and use for public health programs.

**Public meeting**

A public forum with community members for communication about a site.

**Radioisotope**

An unstable or radioactive isotope (form) of an element that can change into another element by giving off radiation.

**Radionuclide**

Any radioactive isotope (form) of any element.

**RCRA** [see Resource Conservation and Recovery Act (1976, 1984)]

**Receptor population**

People who could come into contact with hazardous substances [see exposure pathway].

**Reference dose (RfD)**

An EPA estimate, with uncertainty or safety factors built in, of the daily lifetime dose of a substance that is unlikely to cause harm in humans.

**Registry**

A systematic collection of information on persons exposed to a specific substance or having specific diseases [see exposure registry and disease registry].

**Remedial investigation**

The CERCLA process of determining the type and extent of hazardous material contamination at a site.

**Resource Conservation and Recovery Act (1976, 1984) (RCRA)**

This Act regulates management and disposal of hazardous wastes currently generated, treated, stored, disposed of, or distributed.

**RFA**

RCRA Facility Assessment. An assessment required by RCRA to identify potential and actual releases of hazardous chemicals.

**RfD** [see reference dose]

**Risk**

The probability that something will cause injury or harm.

**Risk reduction**

Actions that can decrease the likelihood that individuals, groups, or communities will experience disease or other health conditions.

**Risk communication**

The exchange of information to increase understanding of health risks.

**Route of exposure**

The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].

**Safety factor** [see uncertainty factor]

**SARA** [see Superfund Amendments and Reauthorization Act]

**Sample**

A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population [see population]. An environmental sample (for example, a small amount of soil or water) might be collected to measure contamination in the environment at a specific location.

**Sample size**

The number of units chosen from a population or an environment.

**Solvent**

A liquid capable of dissolving or dispersing another substance (for example, acetone or mineral spirits).

**Source of contamination**

The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum. A source of contamination is the first part of an exposure pathway.

**Special populations**

People who might be more sensitive or susceptible to exposure to hazardous substances because of factors such as age, occupation, sex, or behaviors (for example, cigarette smoking). Children, pregnant women, and older people are often considered special populations.

**Stakeholder**

A person, group, or community who has an interest in activities at a hazardous waste site.

**Statistics**

A branch of mathematics that deals with collecting, reviewing, summarizing, and interpreting data or information. Statistics are used to determine whether differences between study groups are meaningful.

**Substance**

A chemical.

**Substance-specific applied research**

A program of research designed to fill important data needs for specific hazardous substances identified in ATSDR's toxicological profiles. Filling these data needs would allow more accurate assessment of human risks from specific substances contaminating the environment. This research might include human studies or laboratory experiments to determine health effects resulting from exposure to a given hazardous substance.

**Superfund** [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and Superfund Amendments and Reauthorization Act (SARA)]

**Superfund Amendments and Reauthorization Act (SARA)**

In 1986, SARA amended the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from substance exposures at hazardous waste sites and to perform activities including health education, health studies, surveillance, health consultations, and toxicological profiles.



**Surface water**

Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with groundwater].

**Survey**

A systematic collection of information or data. A survey can be conducted to collect information from a group of people or from the environment. Surveys of a group of people can be conducted by telephone, by mail, or in person. Some surveys are done by interviewing a group of people [see prevalence survey].

**Synergistic effect**

A biologic response to multiple substances where one substance worsens the effect of another substance. The combined effect of the substances acting together is greater than the sum of the effects of the substances acting by themselves [see additive effect and antagonistic effect].

**TCE**

Trichloroethene, also known as trichloroethylene.

**Teratogen**

A substance that causes defects in development between conception and birth. A teratogen is a substance that causes a structural or functional birth defect.

**Toxic agent**

Chemical or physical (for example, radiation, heat, cold, microwaves) agents that, under certain circumstances of exposure, can cause harmful effects to living organisms.

**Toxicological profile**

An ATSDR document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

**Toxicology**

The study of the harmful effects of substances on humans or animals.

**Tumor**

An abnormal mass of tissue that results from excessive cell division that is uncontrolled and progressive. Tumors perform no useful body function. Tumors can be either benign (not cancer) or malignant (cancer).

**Uncertainty factor**

Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL).

Uncertainty factors are used to account for variations in people's sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people [also sometimes called a safety factor].

**Urgent public health hazard**

A category used in ATSDR's public health assessments for sites where short-term exposures (less than 1 year) to hazardous substances or conditions could result in harmful health effects that require rapid intervention.

**Volatile organic compounds (VOCs)**

Organic compounds that evaporate readily into the air. VOCs include substances such as benzene, toluene, methylene chloride, and TCE.

Other glossaries and dictionaries:

Environmental Protection Agency (<http://www.epa.gov/OCEPAterms/>)

National Center for Environmental Health (CDC)  
(<http://www.cdc.gov/nceh/dls/report/glossary.htm>)

National Library of Medicine (NIH)  
(<http://www.nlm.nih.gov/medlineplus/mplusdictionary.html>)

For more information on the work of ATSDR, please contact:

Office of Policy and External Affairs  
Agency for Toxic Substances and Disease Registry  
1600 Clifton Road, N.E. (MS E-60)  
Atlanta, GA 30333  
Telephone: (404) 498-0080

## **Appendix I: Figures**







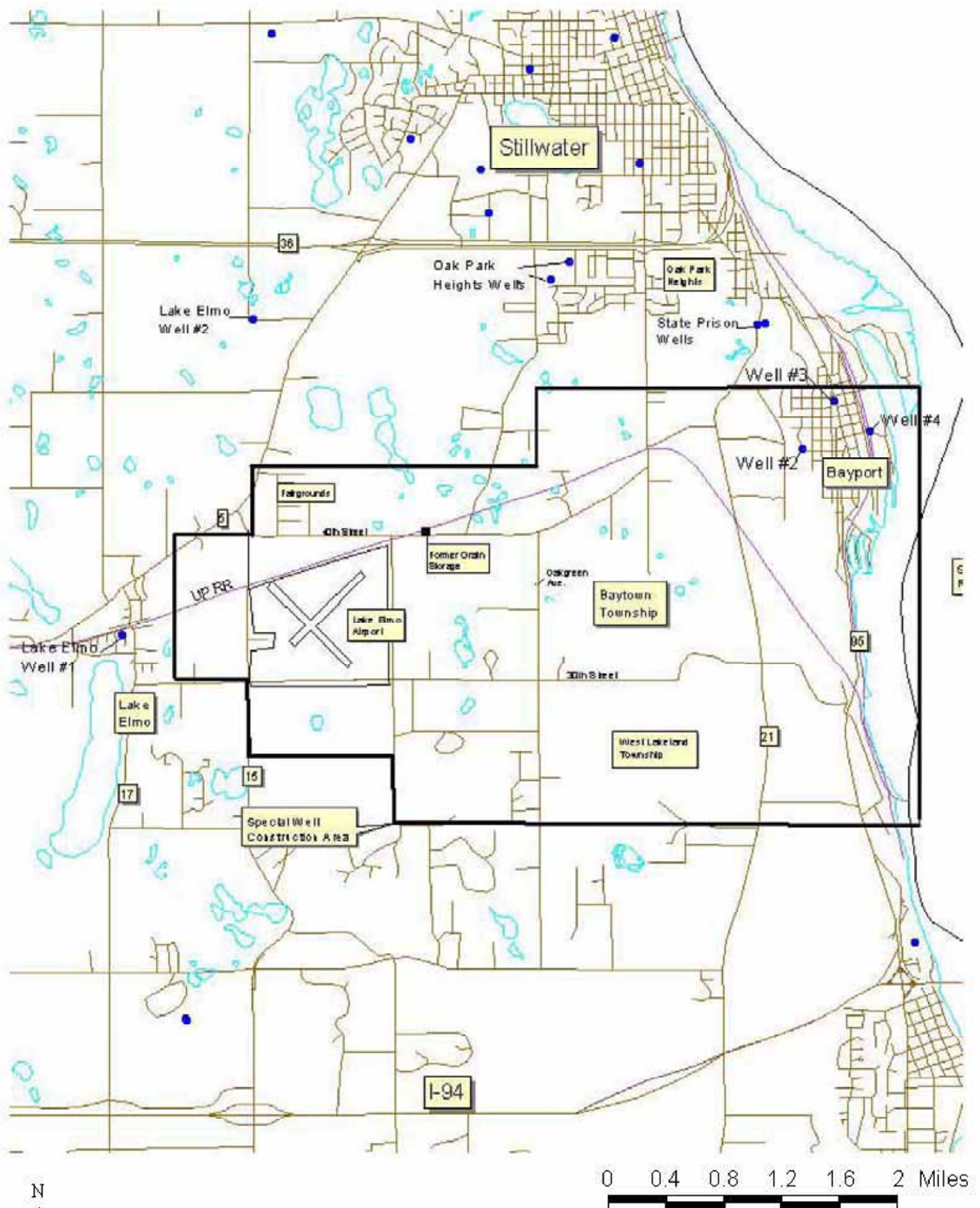
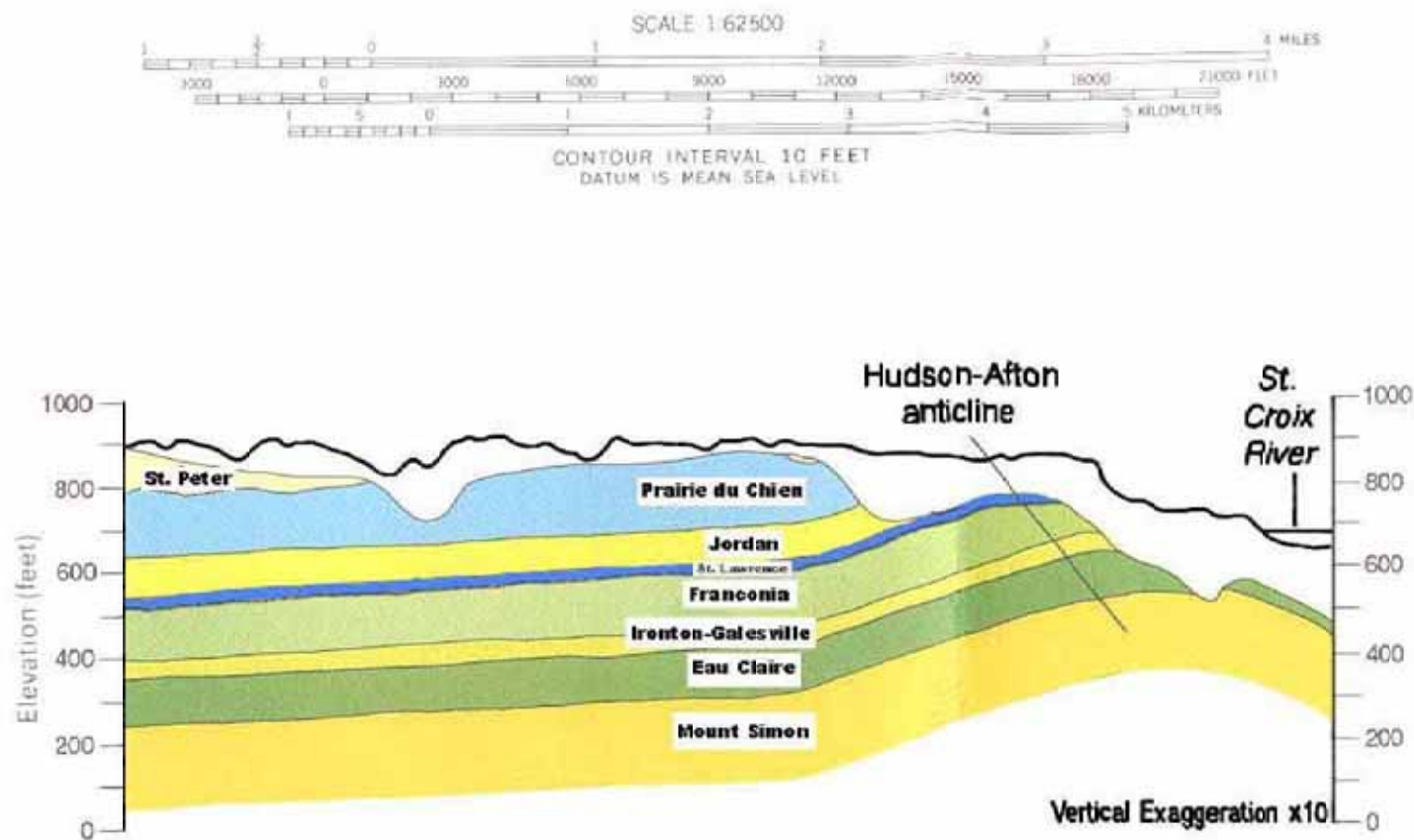


Figure 2: Surface Features



**Figure 3: Geologic cross section of the Hudson-Afton anticline in the area of West Lakeland Township, approximately 2 miles south of Baytown Township. (Figure modified from Fig. 2, Mossler and Bloomgren, 1990)**

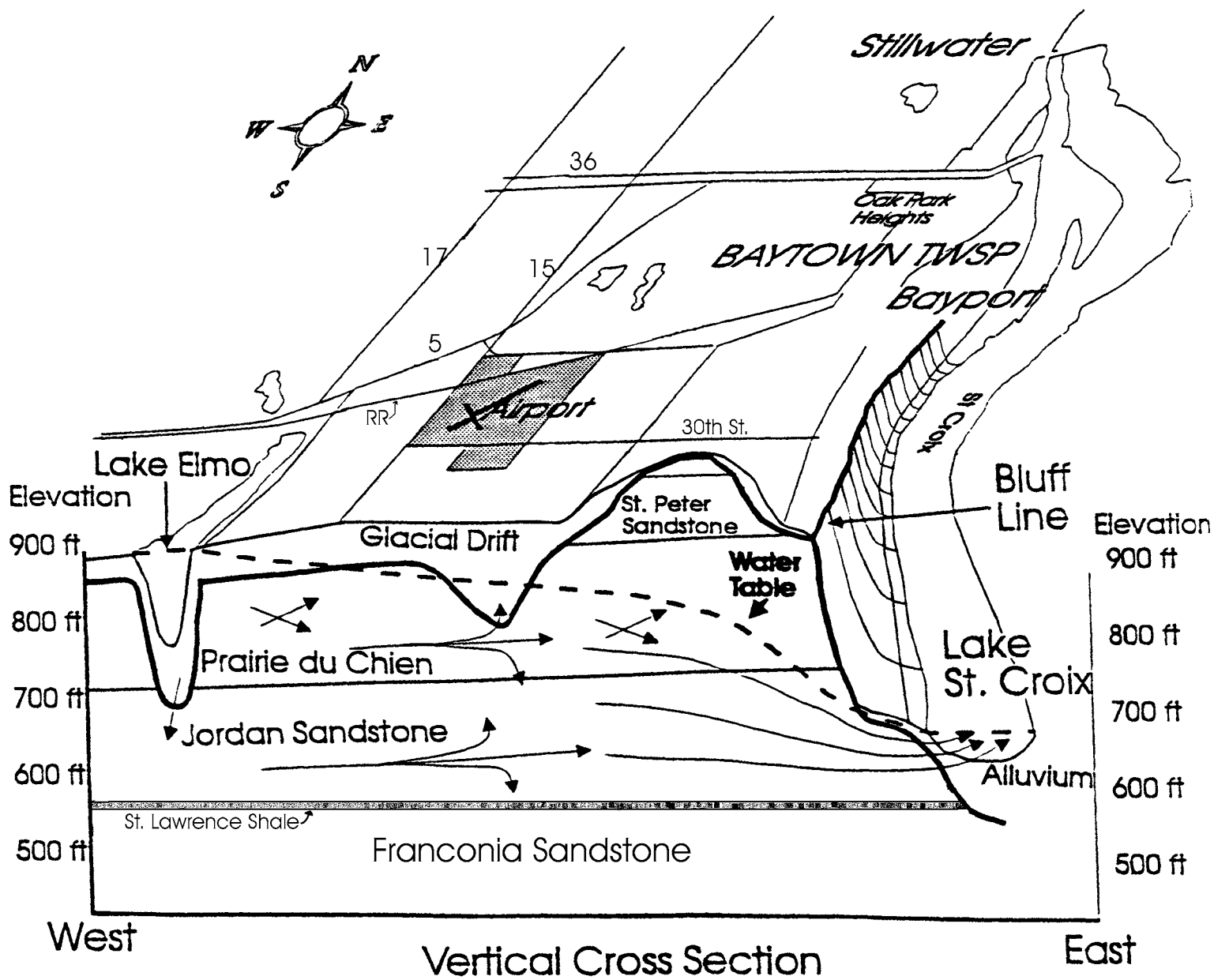
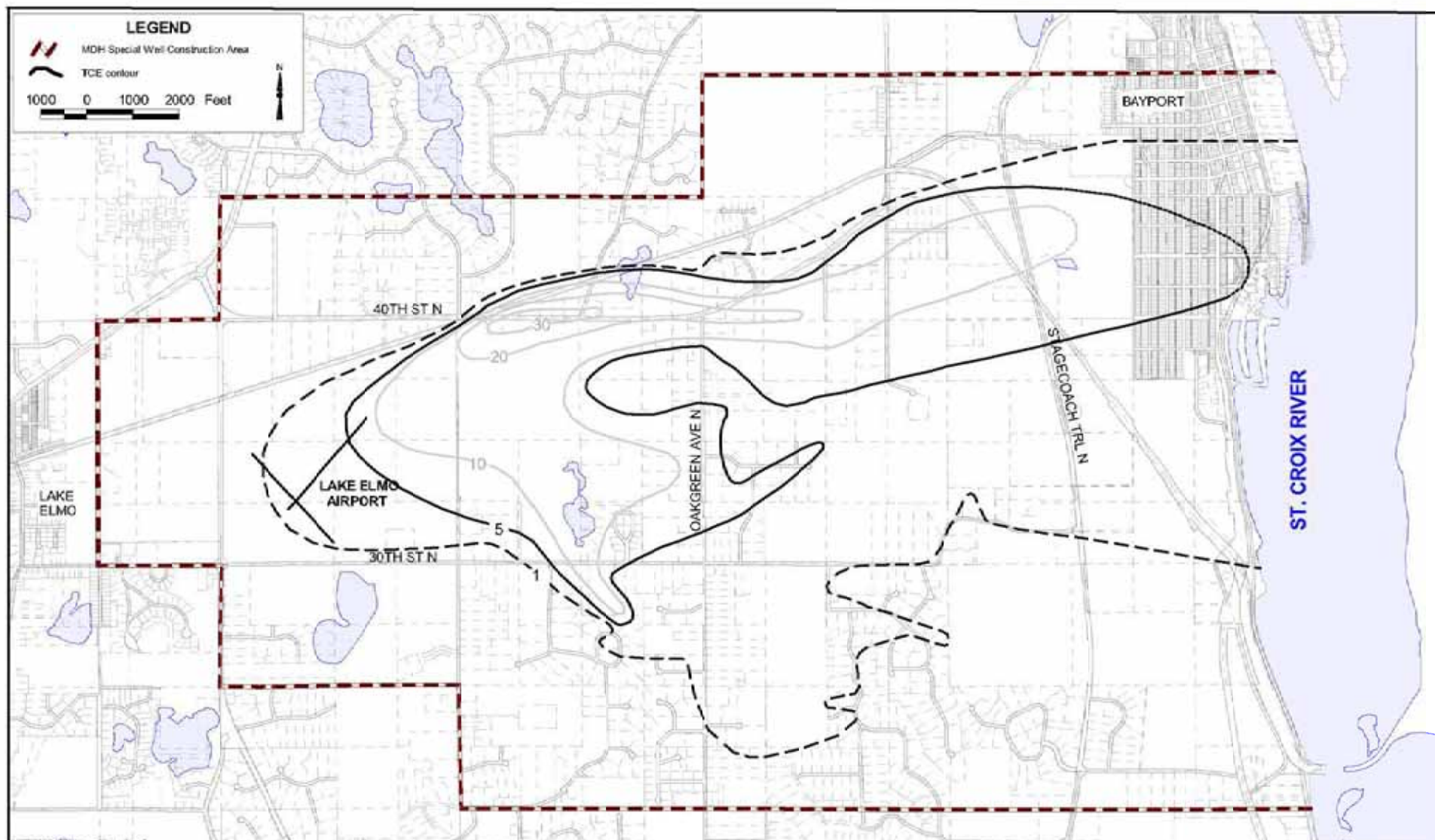


Figure 4: Geology/Hydrogeology









BAYTOWN TOWNSHIP GROUNDWATER CONTAMINATION SITE

Trichloroethene(TCE) Concentrations in Jordan Wells: August 2002



SEPT 2002

Figure 5b

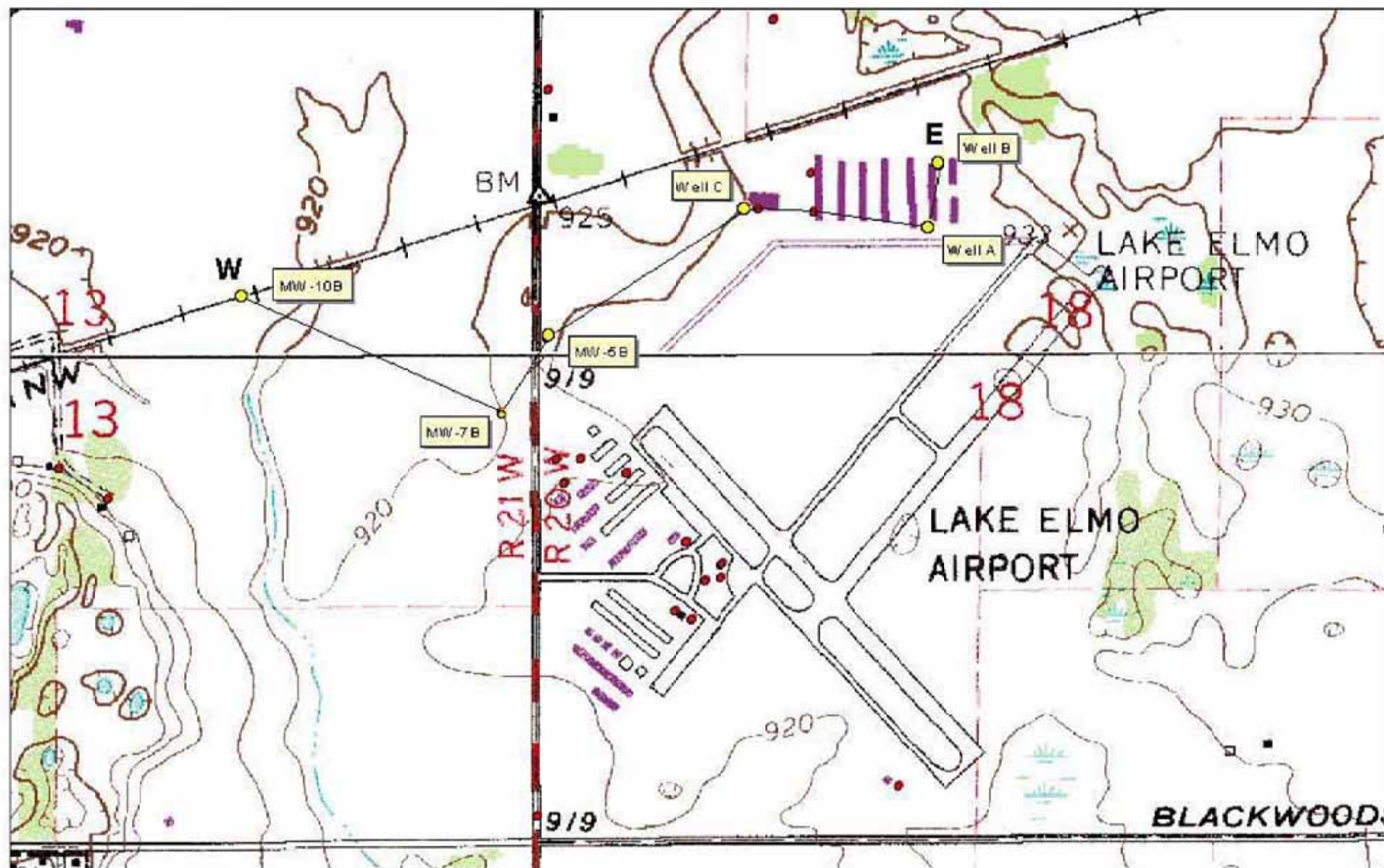


Figure 6: General Location of Select Wells On and Near the Lake Elmo Airport





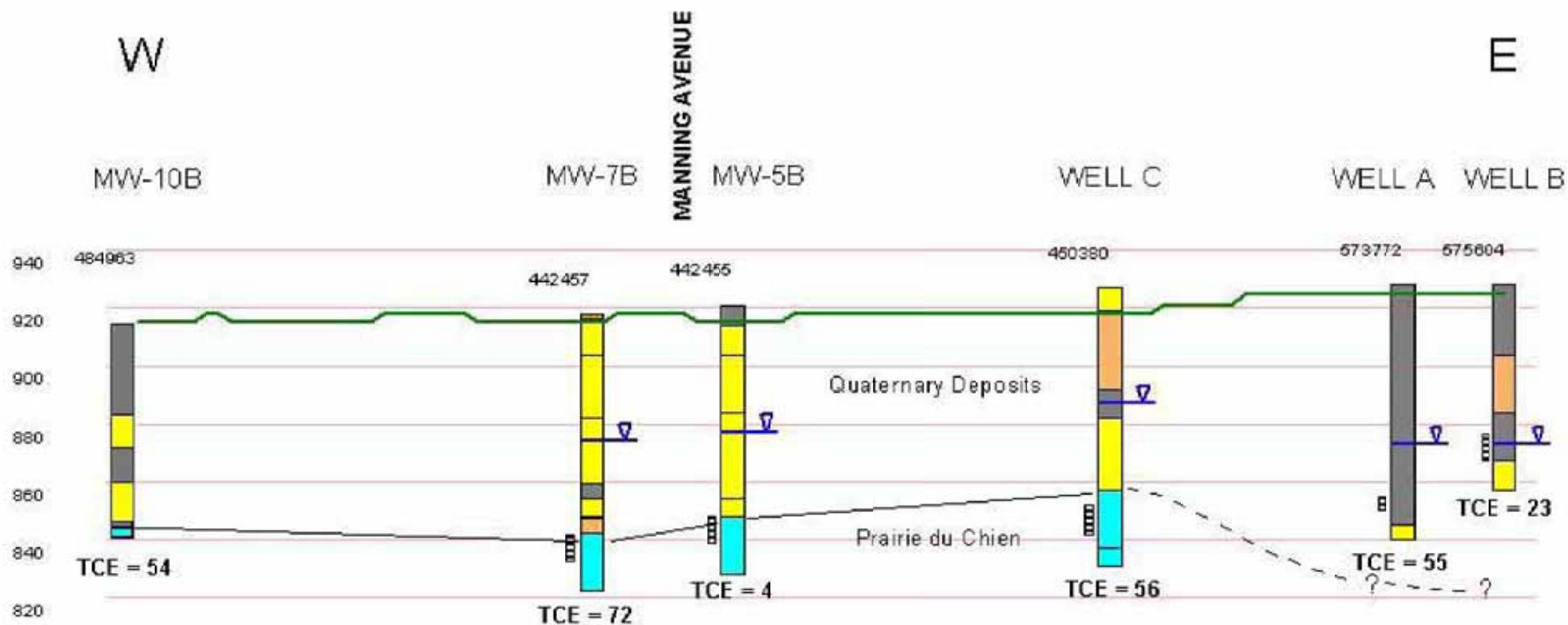
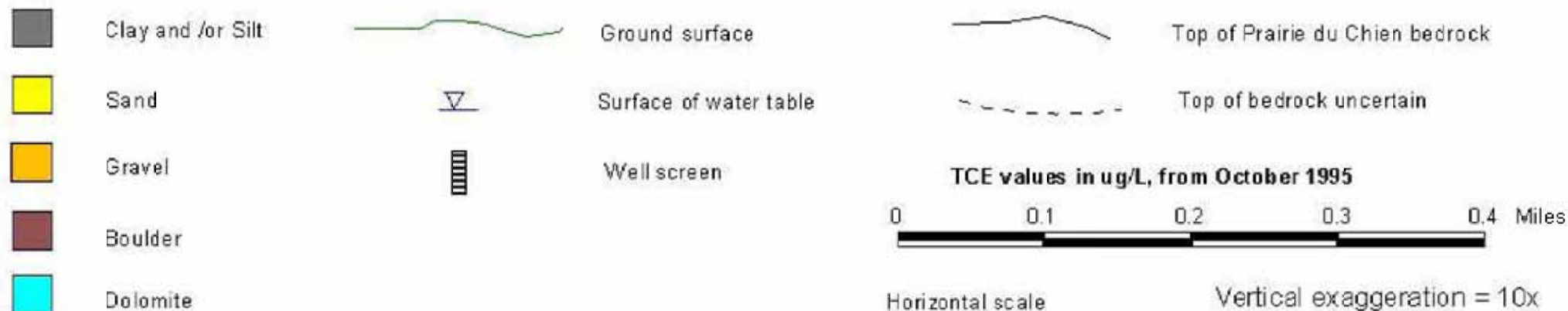
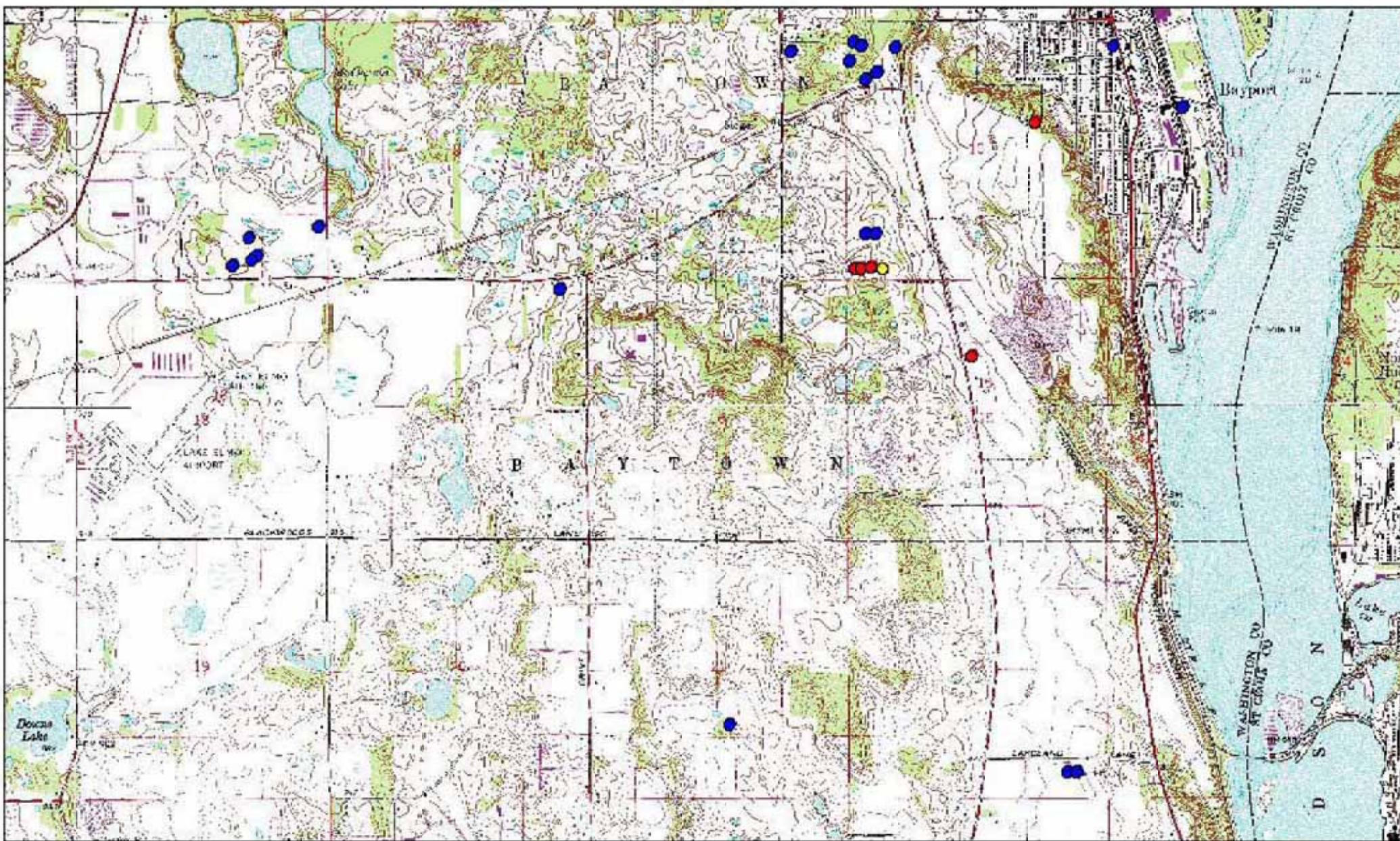


Figure 7: Cross-section On and Near Lake Elmo Airport

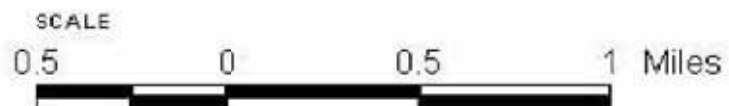


Note: All well log info., except MW-10B, from CWI. MW-10B info. from boring log in Delta, 1998. Ground elev. data is correct to within 1 meter; where well logs protrude above the ground surface indicates errors in surveying by the driller. More recent boring logs near wells A and B suggest the unconsolidated materials in this area contain more sand than the logs in CWI indicate.





**Figure 8: Location of Franconia Wells**



- TCE detected
- TCE not detected
- TCE detected, but no longer present





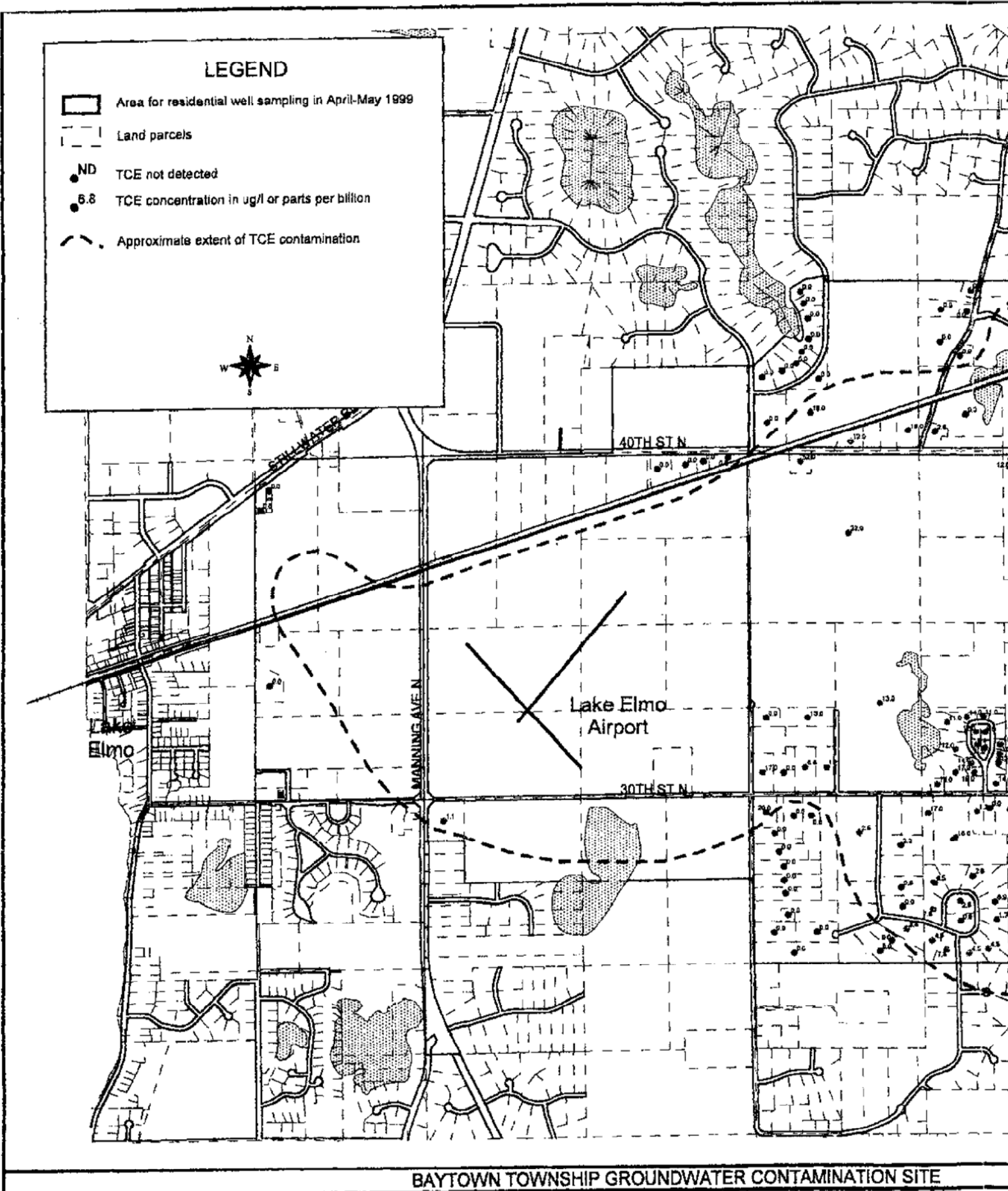


Figure 9a: 1999 Well Sampling Data and TCE Plume Extent (West)

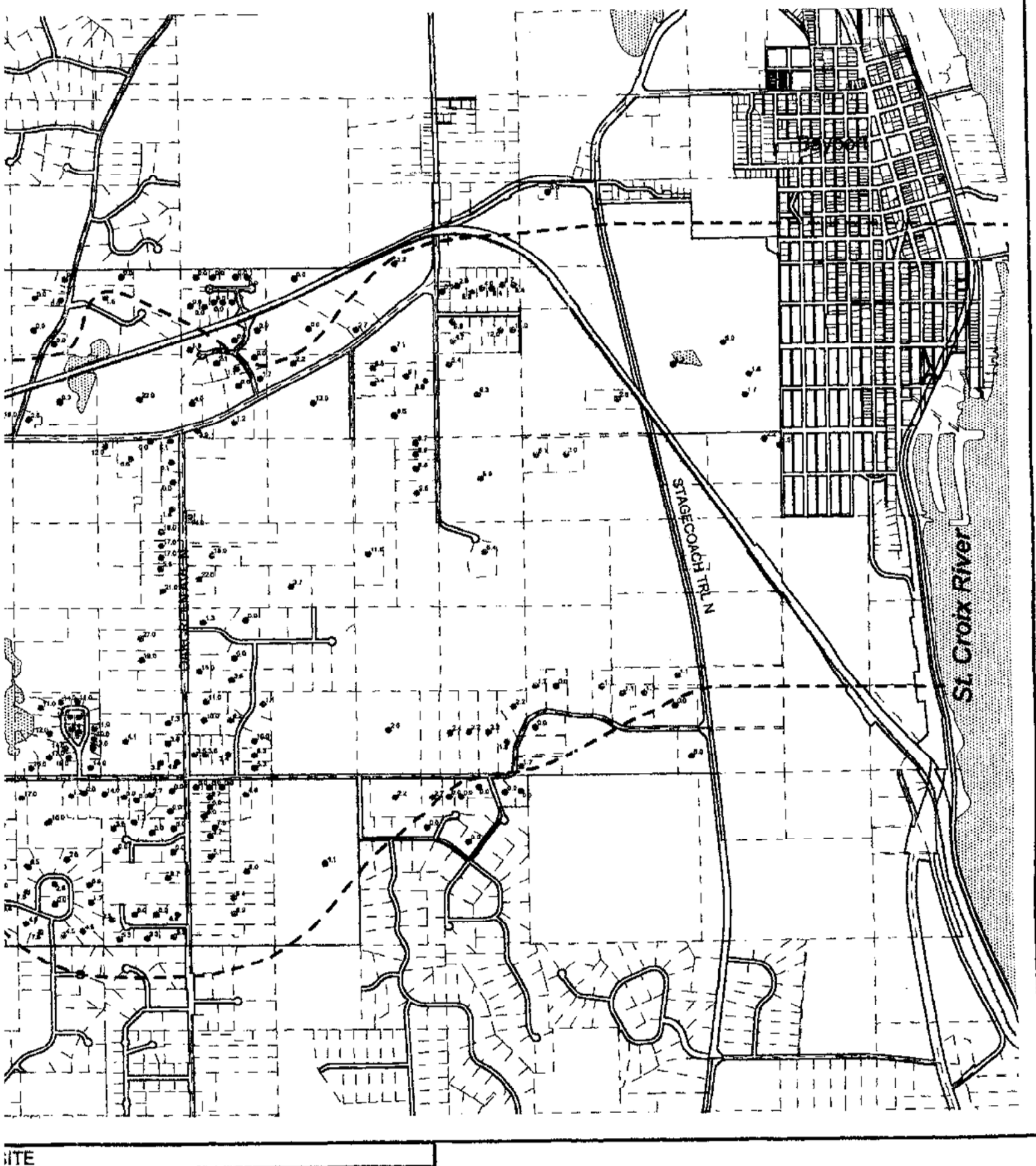


Figure 9b: 1999 Well Sampling Data and TCE Plume Extent (East)

- 1) TCE CONCENTRATIONS ARE MOST RECENT RESULTS
- 2) GENERALLY, THE WELLS ARE COMPLETED IN THE UPPER PRAIRIE DU CHIEN DOLOMITE

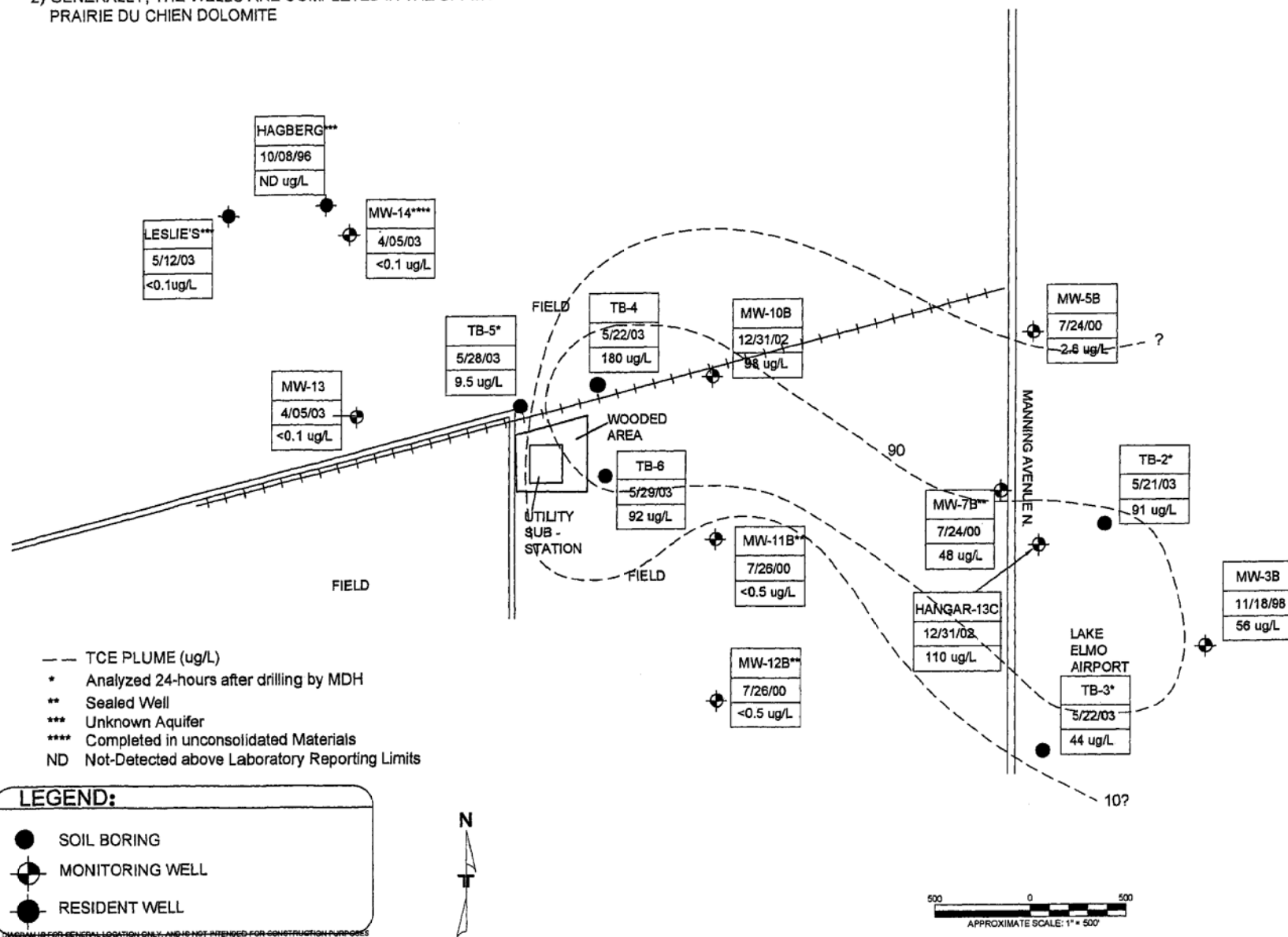
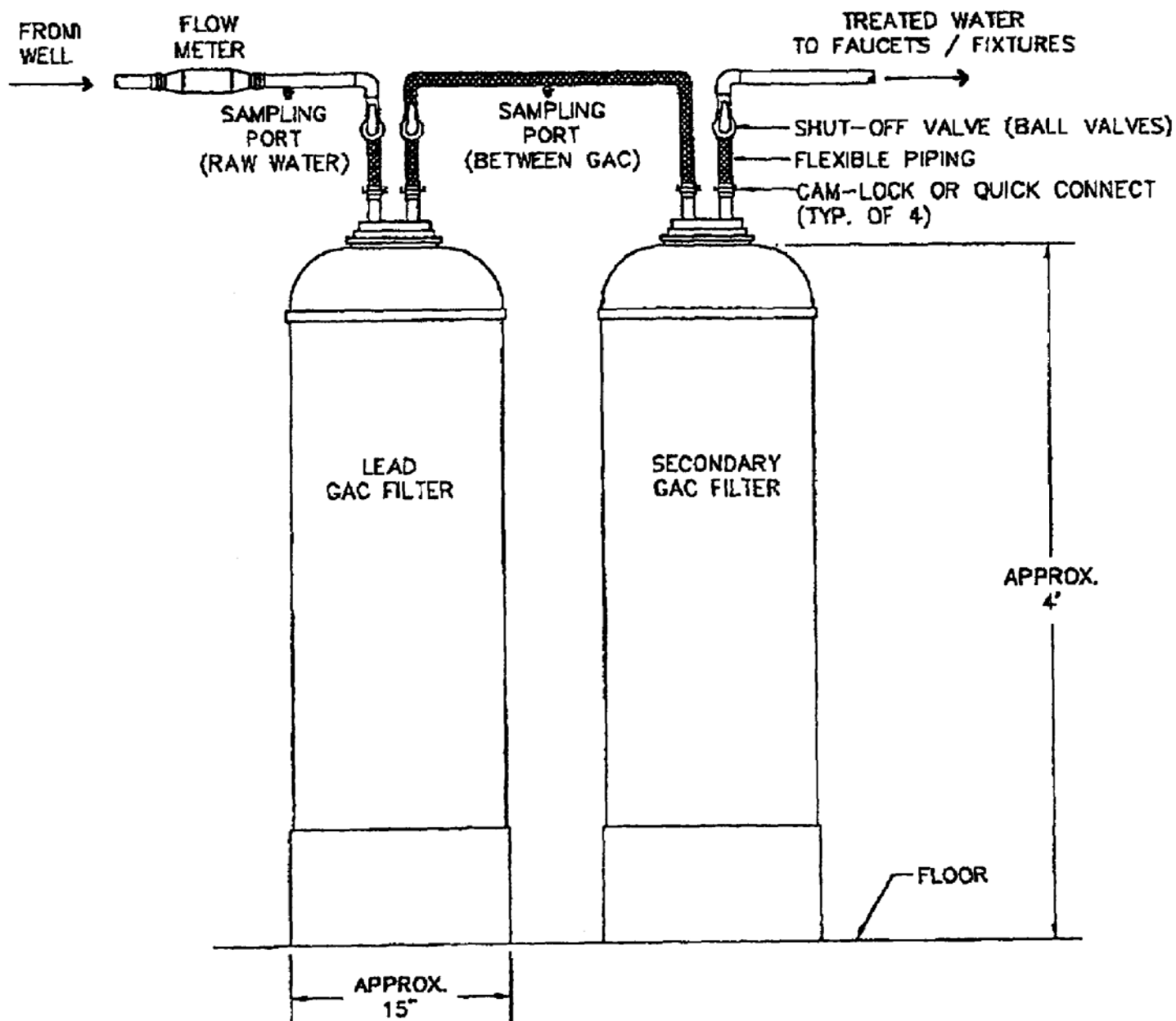


Figure 10: TCE Concentrations near MW 10-B

Source: Terracon 2003b



BAYTOWN TOWNSHIP GROUNDWATER CONTAMINATION SITE

Source: Wenck 2003

Figure 11: GAC Filter System Schematic



## **Appendix II: TCE in Drinking Water Information Sheet**

## **TCE in Drinking Water**

*Trichloroethylene (TCE) is a commonly-used chemical that can be found in air, soil, and drinking water. Exposure to trichloroethylene (also known as trichloroethene) in large amounts or over a long period of time can be harmful to people. This information sheet discusses trichloroethylene and its health effects, including the results of a new draft health risk assessment conducted by the U.S. Environmental Protection Agency (EPA).*

### **What is TCE?**

Trichloroethylene, or TCE, is a colorless solvent with a slightly sweet odor. TCE is used primarily in industrial processes to remove grease from metal parts. Some household and consumer products – such as typewriter correction fluid, paint removers, adhesives, and spot removers also contain TCE. Because of the extent of its use, it is one of the more common man-made chemicals found in the environment.

Because TCE is very volatile (it evaporates quickly), it is not usually present in surface soils or in open water. But TCE can migrate down through the soil and into groundwater where it can contaminate private and public drinking water wells.

### **Is TCE harmful?**

Any substance or chemical that enters your body can be harmful if you take in too much. Whether your health will be affected by a chemical to which you are exposed to depends on several factors:

- How much of the substance you take in;
- How long you are exposed to it;
- Whether you are eating, drinking, breathing, or touching it;
- Your age, general health, and other individual traits that determine how susceptible you are to any adverse effects;
- Other exposures you have to the same or similar substances; and
- How toxic the substance is.

If a volatile chemical such as TCE is present in drinking water, you may be exposed to it through several routes. The TCE in the water will tend to evaporate during such activities as bathing, doing dishes, or flushing a toilet. As the TCE evaporates into the air, it can be inhaled. This exposure can be significant when considered along with drinking water with TCE in it.

## **What are the health effects from exposure to TCE?**

People may experience headaches, drowsiness and eye, nose, or skin irritation from exposure to high levels of TCE. At very high levels, people can lose consciousness. Behavior changes have been observed in animals after exposure to high levels of TCE. These types of exposures in people are typically only seen in industrial accidents or intentional exposures.

Long-term exposure to high levels of TCE in drinking water can damage the liver, kidney, immune system, and the nervous system. TCE may also harm a developing fetus if the mother consumes water containing high levels of TCE. Some studies suggest that exposure to low levels of TCE over many years may also be linked to an increased risk of several types of cancer. It is likely that the adverse health effects that can result from exposure to TCE come not from the TCE itself, but from other compounds that are produced when the body breaks down TCE. These same breakdown products can be produced when the body is exposed to other chemicals, such as dry cleaning solvent.

The scientific information we have about the health effects of TCE comes from people exposed to high levels in the course of their work and from studies of animals. The most current available scientific information was recently evaluated by EPA. As a result of this evaluation, EPA concluded that TCE may be more toxic than previously considered. EPA has issued an updated draft health risk assessment for TCE. This draft assessment takes into account the most current studies of TCE toxicity, and incorporates several recent developments in risk assessment methods. The EPA draft health risk assessment proposes a range of toxicity values that is lower than the value previously published for TCE.

In response to the draft EPA health risk assessment for TCE, the Minnesota Department of Health (MDH) is recommending that an exposure limit of five micrograms of TCE per liter of water (5 µg/L) be used in place of the existing MDH Health Risk Limit (HRL) of 30 µg/L for drinking water from private wells. A HRL is the highest concentration of a groundwater contaminant that can be safely consumed daily for an average lifetime of 70 years and daily consumption of 2 liters of water. If you drink less water, or drink it for a shorter period of time, the risk is correspondingly lower.

This exposure limit should be considered an interim value. While the EPA health risk assessment is still in draft form, MDH considers the document as representing the best available toxicological information on TCE. Changes to the draft assessment may occur because it incorporates a number of newer risk assessment techniques. EPA has asked for comments on its risk assessment from the scientific community and other interested people. MDH will be reviewing the comments as they are made available. In the meantime, the value of 5 µg/L should be used. It is at the conservative (lower) end of the range of toxicity values proposed by EPA, and is consistent with the current federal Maximum Contaminant Level (MCL) for public drinking water supplies. MDH is in the process of revising the HRL rule, and will consider all new information when it updates the HRL for TCE as a part of the rule revision process.

### **What can I do if I have TCE in my drinking water?**

Water that has less than 5 micrograms of TCE per liter is very unlikely to pose any long-term health concerns. However, if people consume water that contains much higher levels of TCE over a long period of time, their risk of cancer or other health effects may increase. MDH recommends that women who are pregnant or may become pregnant limit their exposure to TCE. If you are concerned about your exposure to TCE or other chemicals, see your physician. You may also want to take steps to minimize your exposure.

To minimize exposure, it is best to obtain your drinking water from a clean, reliable source. This can be accomplished by connecting to a public water supply system, or by drilling a new well (assuming that a clean underground source of water is available). If these options are not feasible, the most effective method for removing TCE from a drinking water supply is treatment with a granular activated carbon (GAC) filtration system. These systems are commonly available from water treatment contractors, or home supply stores and come in two types: those that serve one sink or appliance (such as a refrigerator) and those that are capable of filtering all of the water that enters the home.

Use of filters that are installed beneath a sink (usually a kitchen sink) or in a refrigerator will help to minimize exposure to TCE from drinking or cooking with the water only from that source. A whole-house system filters all of the water coming into the home, not just the water from one sink or appliance. This type of system, while more expensive and difficult to install, has the added benefit of ensuring that bathing and other activities will not serve as an additional source of TCE exposure through inhalation of TCE that evaporates from the water. Both types of systems need to be maintained regularly. Use of bottled water for drinking and cooking can also help minimize exposure on a short-term basis, as can running a vent fan while bathing.

### **How can I get more information?**

For more information about TCE and its health effects, contact the Minnesota Department of Health at the address listed above, or call (651) 215-0916, or call toll-free at 1-800-657-3908. Press “4” on your touch-tone phone to leave a message, or wait to speak to an operator if you have a rotary phone.

### **Appendix III: Agency Comments to Initial Draft of Public Health Assessment**

## **I. Comments Received from the Metropolitan Airports Commission:**

1. *Page 5, first paragraph: Delete “and the responsible party”. The MAC falls under “state”.*

MDH Response: This change has been made.

2. *Page 5, third paragraph: Figure 1 shows the current SWCA, not the boundary in 1988. Perhaps revise the sentence to read “... MDH first issued a well drilling advisory in 1988, which has been modified since then to approximately a nine-square-mile area as shown in Figure 1.”*

MDH Response: The commenter is correct. The suggested change, with a slight modification, has been made to the text.

3. *Page 6, first paragraph: Change “at the western end” to “near the western end”. Also, revise the last sentence to “... which may indicate the presence of a source area other than the airport.”*

MDH Response: It is more accurate to say “near the western end”, so this change has been made to the text. The data do not yet rule out the airport as a possible source area, therefore, the text was modified to indicate that the upgradient TCE detections “...may indicate the presence of a source area other than, or in addition to, the airport.”

4. *Page 6: Since the Lake Elmo Airport is an important landmark for the site, some background information would be helpful for readers. It is suggested to insert a new paragraph before the paragraph starting with “In 1988”, with the following: “The MAC is a public agency charged with managing public airports in the Twin Cities area, and it opened the Lake Elmo Airport in 1951. MAC maintains the small airfield and leases space to tenants who store and operate general aviation type aircraft. For perspective on size, by 1972, the airport had approximately 35 hangars and accommodated small, recreational planes, requiring little maintenance beyond routine oil changes. The period of 1950-1970 is important as discussed on page 10.”*

MDH Response: The information has been included, as well as information regarding businesses that operated at the airport.

5. *Page 6, second full paragraph: Add that the report concluded, based on hangar inspections and tenant interviews, that there is no evidence of use or disposal of TCE at the Lake Elmo Airport.*

MDH Response: The suggested text has been added.

6. *Page 9, first full paragraph; Page 17, third paragraph; and Page 35, recommendation #5: It is our opinion that the north hangar area does not represent a potential source area for the TCE, and we recommend that all such statements be deleted. The north hangar area did not exist until the late 1970’s, as the first hangar there was reportedly built in 1978. This is important because the groundwater travel time puts the release earlier than 1972. There was a demolition debris disposal area located near the two Quaternary wells in question. Seven soil borings were advanced in this area and no contamination was found in the unsaturated soil. While Well B (575604) is not as deep*

*as Well A (573772), the bottom of the screen is at an elevation that is within feet of the top of the Prairie du Chien at Well C (450380). Given the free communication of water between the Quaternary deposits and the Prairie du Chien, the concentrations observed at Well B are consistent with conditions observed in the Prairie du Chien. To be indicative of a source area, it would be expected to see TCE concentrations 10 – 1,000 times higher.*

MDH Response: The commenter may have misunderstood the interpretation of the data and the recommendation. The presence or absence of the hangars at the time when the release most likely occurred is not relevant. There were no structures present at that time in the fields west of the airport, but that area has not been ruled out as a possible source area. Moreover, the report does not state definitively that the north hangar area is a source area. It notes that high concentrations of TCE have been detected in two wells screened immediately below the water table surface in the north hangar area. This may indicate a source area upgradient of those wells. This potential source may be in the north hangar area or further upgradient. There has not been sufficient investigation of the unconsolidated material in the north hangar area and northwestern corner of the airport property to either confirm or refute this hypothesis. Without additional investigation of the unconsolidated deposits upgradient of these wells, the area cannot be ruled out as a possible source area.

*7. Page 9, last two paragraphs: My theory is that fracture patterns dictate the “finger effect” in the Prairie du Chien, and likewise influence where contamination is moving down into the Jordan causing the appearance of “fingers” there as well.*

MDH Response: Agreed. Language has been to the text added to further emphasize this possibility.

*8. Page 10, first paragraph: Replace “Franconia is some areas” with “Franconia in some areas”.*

MDH Response: The suggested change has been made

*9. Page 10, last paragraph, first sentence: Delete “current” since more than four years has elapsed.*

MDH Response: The suggested change has been made

*10. Page 17, fourth paragraph: Add that based on the work described, Terracon concluded that the results did not identify a source of TCE.*

MDH Response: The suggested information has been added. In order to clarify the conclusions of the additional investigation, the final sentence of the paragraph was separated into a new paragraph with the added statement that the north hangar area was not investigated during this phase of work.

*11. Page 18, second full paragraph: Consider adding that the Proposed Plan went through a public notice and comment period, including holding a public meeting. The point being there was community involvement in the remedy selection.*

MDH Response: The suggested text was included, but was inserted at the beginning of the next paragraph where it seemed more appropriate.

12. Page 18, bullet at bottom of page: Insert a new third sentence as follows: “The MAC volunteered to install these filters, even though it had no legal obligation to do so under the ROD.”

MDH Response: The suggested text was included, with a clarification that the legal obligation is dependent upon the HRL being formally changed in the state rule.

13. Page 19, second full paragraph: Delete the last two sentences beginning with “the MAC maintains ...” As noted in comment 12 above, the MAC has no legal obligation under the ROD to install filters on wells with TCE concentrations below 30 µg/l. Since the MAC is performing this activity voluntarily, there is nothing to challenge.

MDH Response: The MAC has volunteered to install GAC systems on existing homes and homes platted before April 9, 2002 with TCE concentrations between 5 µg/L and 29.9 µg/L TCE, even though not “legally” obligated under the ROD to do so (because the HRL has not formally been changed). However, the MAC letter dated April 9, 2002 does not specify that installation of GAC in homes platted after April 9, 2002 is dependent upon the TCE concentrations. It simply declares that the MAC will not install GAC systems in such homes. It is not impossible that new homes could be built near the source area where TCE concentrations exceed 30 µg/L, and it is likely that the HRL will be lowered to 5 µg/L or a similar number, yet the MAC letter states that after the arbitrary cut-off of April 9, 2002 any homes built (whether they exceed the current or future HRL) will not be eligible for GAC installation. A clause has been added to the second to last sentence to clarify this.

14. Page 20, third full paragraph: Delete “Sampling of the water from the port located between the two canisters can be done to detect breakthrough, and once detected ...” Start the sentence with “Once used up, the first canister is removed ...” As described later, the change-outs are now based on meter readings, not sampling.

MDH Response: This section has been clarified, although it is noted that sampling can also still be used to detect breakthrough.

15. Page 34, Conclusions, first paragraph, second sentence: Replace “and possibly” to “or”.

MDH Response: As the possibility exists that two sources may be present, “and possibly” has been changed to “and/or”.

16. Figure 6: Only select wells seem to be shown and their locations are not real accurate. Perhaps add “General” or “Approximate” to the title.

MDH Response: The commenter is correct. The figure was constructed using information from the County Well Index (CWI), so that the geologic information from the well logs would also be available, as the purpose of the figure was to create a geologic cross-section using MDH ArcView tools. Not all of the wells at the site are recorded in the CWI. The well locations are based on GIS information provided to the Minnesota Geologic Survey, which we are not able to confirm, but which is supposed to have been “ground truthed” before inclusion in the CWI. However, the title of the figure has been changed to clarify not only that the locations are “general”, but also that these are a “select” wells, not all the wells in the area shown by the figure.



17. *Figure 7: There is geologic information available for MW-10B, including in Appendix B of the Feasibility Study (1999). I question the amount of clay shown at Wells A and B. I did not have quick access to the well logs, but nearby borings DAB-1 through DAB-7 showed a lot of sand (Appendix B of the FS).*

MDH Response: The geologic information for the wells comes from the boring logs in CWI, which was used to generate the figure. There is no geologic data available for MW-10B in CWI. MPCA staff also questioned the log, because the completion depth differed from reported depths on logs in earlier site reports. After reviewing the other logs, we have concluded they are more accurate and have used the geologic and depth data from the boring log found in the Limited RI report (Delta, 1996). We have also added a note regarding the accuracy of the logs for Wells A and B. Since the purpose of the figure is to illustrate the presence of TCE in the unconsolidated material and near the water table, the nature of the unconsolidated material is not as important in this figure as the relative location of the water table, the top of bedrock, and the distribution of TCE.

## **II. Comments Received from MPCA**

1. *Page 4 first para. last sentence might say "contamination that is in excess of six square miles" if you are going by the 1 µg/L contour. Otherwise 5 mi<sup>2</sup> is OK for 5 µg/L I guess. Mike Convery used "7 mi<sup>2</sup>" for his MGWA article. See your own reference to 6mi<sup>2</sup> on page 8, 3rd para. Also see Conclusions.*

MDH Response: This was an editing oversight. The suggested change has been made.

2. *Page 4. You might want to mention TCE first and carbon tetrachloride separately. The carbon tetrachloride release is its own PLP site.*

MDH Response: The sentence has been re-arranged.

3. *Page 4, last para. I would drop "the main contaminant at the site" from the first sentences to improve clarity.*

MDH Response: This has been done.

4. *Page 7 para. 2, last sentence. Conditions are rare where ground water can move from the OPDC to the CJ. The Oneota, the basal formation of the OPDC, is massive and only would allow downward movement at faults and deep fractures. Talk to Jim Lundy if you would like more insight on this issue. So downward movement to the CJ is limited.*

MDH Response: While the commenter is correct that the Oneota Formation is massive, and that groundwater flow would occur mainly along fractures and faults, that is what the paragraph in question says (see the second sentence of the paragraph). The hydrologic atlas for the lower St. Croix River watershed (HA-490, 19xx) states that the largest yields from the Prairie du Chien is "...from the Oneota Formation where fractures and solution cavities are common...". Without a confining layer between the Oneota (i.e. basal Prairie du Chien) and the Jordan, this fracturing and solutioning would allow passage of groundwater from the Prairie du Chien to the Jordan where conditions for downward flow are present. We have added some additional information regarding the geology, as

well as a sentence that downward flow conditions may not be present everywhere at the site, to help clarify the meaning of this paragraph.

5. *Page 8 4th para. first sentence. We did find some apparent contamination at TB-4 in May by PID. We have not yet verified that it is TCE. That will be our next step. In any case, any septic tank or drainfield would also discharge to the unconsolidated material and above the water table, so they would not qualify as "conduits" in this circumstance.*

MDH Response: The paragraph refers to “significant contamination”, while the PID readings in TB-4 above the water table ranged from 13-17 ppm. However, we have added a short discussion of those findings. The commenter is correct that drainfields and septic tanks are not deep enough to act as a conduit that would not have been detected by soil vapor surveys. They have been removed from the sentence.

6. *Page 9, 3<sup>rd</sup> para., 2<sup>nd</sup> & 3<sup>rd</sup> sentence. The range of TCE concentrations at MW-10B is more meaningfully 14-98 µg/L through 2002. Since 0.8 was a duplicate sample in April 1993 paired with 14 µg/L, it is clearly an outlier. 98 µg/L was our sample result for MW-10B for 12/26/02.*

MDH Response: The suggested change has been made.

7. *Page 12, first para. 2<sup>nd</sup> sentence. Please change end of sentence to: “...but the MAC provided these residences with whole-house GAC filters, starting with the most contaminated wells.”*

MDH Response: The suggested change has been made.

8. *Page 12 2nd bullet. 474 5th, 4351 Osgood, Osprey Blvd. and 2938 Quant are all examples of contaminated wells in the Quaternary. Therefore drop the word, "presumably".*

MDH Response: The commenter is correct and “presumably” has been removed. The bullet has been expanded to include a reference to detection of TCE in the Franconia and that the plume may also be in the upper Franconia as it approaches the river. The well at 4351 Osgood Avenue is completed in the Prairie du Chien according to the well log and site database.

9. *Page 13 2nd bullet. If there is expansion by pumping, then that is a "real" expansion.*

MDH Response: That’s what the bullet point says – if the expansion has occurred because of pumping by new wells, then it is real, but it may only appear to be an “expansion” of the plume because of the availability of results from wells not previously sampled. We have modified the wording to make this clearer.

10. *Page 16, penultimate para., 2<sup>nd</sup> & 3<sup>rd</sup> sentence. Depth of soil probes (holes) were 48-65 feet. The concentration of 5.2 µg/L was from a duplicate sample, not a follow-up.*

MDH Response: The suggested changes have been made.

11. *Page 17 paragraphs 2 and 3. Please consider indicating here (or elsewhere) that this new data substantially changes how the plume now looks in Lake Elmo with respect to TCE concentrations shown in Fig 5a. The area contoured in Figure 5a of >30 µg/L*

*TCE for the OPDC should now extend to the western edge of the SWCA and include areas north of the RR tracks. Refer the reader to Figure 10 as an update. (Compare this to page 9 para. 3 reference to Fig. 5a).*

MDH Response: Good point. A sentence has been added to paragraph 2 indicating that Figure 5a represents the plume configuration based on 2002 monitoring data, and that the results of the additional investigation have significantly expanded the western limit of the higher concentration core of the plume. The reader was already referred to Figure 10 earlier in the paragraph.

*12. Page 17, fourth para., 2<sup>nd</sup> sentence. The “southern group of hangars” is actually called the “main hangar area” by MAC. There is a separate “southern” hangar on 30<sup>th</sup> St.*

MDH Response: The suggested change has been made.

*13. Page 25 3<sup>rd</sup> para. It is surprising that “ingesting ground water” is the most common pathway of exposure from TCE. I would think many more people breathe TCE off-gassing from contaminated water, from household products, at the office, or near industry. But perhaps these collectively might not be considered a “community” exposure? Or is this attempting to say that ingestion of groundwater containing TCE poses the highest risk?*

MDH Response: Studies have shown that ingestion of TCE in contaminated water is the most likely exposure route, and the one of most concern toxicologically. Inhalation from contaminated water would involve the same population, and exposures via inhalation from contaminated water may or may not be as significant depending on the study. While many people are undoubtedly exposed to TCE through the other pathways mentioned, they would be less common. The sentence has been clarified slightly.

*14. Page 34 3<sup>rd</sup> para. 2<sup>nd</sup> sentence has 5 mi<sup>2</sup> again see comment #2 above.*

MDH Response: This change was made.

*15. Page 34, 3<sup>rd</sup> para., penultimate sentence. Is MDH really revising the HRLs for “all contaminants”? MDH website indicates that “not all chemicals will” be subject to revision.*

MDH Response: The comment is essentially correct; while MDH is revising all of the existing HRLs, new HRLs will not be developed for every existing compound for which there is currently a HRL.

*16. Page 34, 3<sup>rd</sup> para., 3<sup>rd</sup> sentence reads “Several hundred private water supply wells, and one of three municipal supply wells and the water supply system in the city of Bayport have been impacted.” This is a bit unclear. Should that second “and” be an “of”? The comma looks misplaced. The reason it is confusing is that Lake Elmo also has a municipal well at risk that was discussed in the report. I think there are 3 Bayport municipal wells, so the total might be four with one impacted. Or perhaps you could omit mention of the water supply here and focus on the well.*

MDH Response: The sentence has been modified to make it clearer that the municipal wells and water supply system in question are all in the city of Bayport. We have

retained the reference to the water supply system so the public understands that the contamination detected in the one city well also affects the water supply system for the city. Because the sentence refers to wells that have been impacted by contamination, it would be inappropriate to mention the Lake Elmo city well here, as no contamination has been detected in that well to date.

*17. Page 34 Recommendation #1. I believe we are already evaluating the mixture of TCE and carbon tetrachloride for health risk in wells. Either add the word “continue” to the recommendation or clarify what is new that needs to be done with this issue.*

MDH Response: The recommendation has been modified to clarify that this will continue to occur.

*18. Page 35 Recommendation #7. The extent of contamination in the Franconia appears to be fairly limited right now. Detailed plume delineation in the Franconia is premature at this stage. MGS, MDH and MPCA first need to evaluate potential migration pathways to explain the existing contamination.*

MDH Response: No conclusion may be drawn at this time regarding the extent of contamination in the Franconia, due to the limited number of wells completed in that aquifer. The apparent “limit” on the extent of Franconia contamination may be real, or it may be a function of the distribution of the few existing Franconia wells. There is a cluster of Franconia wells near the eastern edge of the site (near the bluffs above the St. Croix River), some of which are contaminated and some of which are not. There is another cluster of Franconia wells near the western limit of the SWCA that are not contaminated. There are few Franconia wells near the center of the SWCA, which is largely undeveloped. It is not known how far west the area of contamination in the Franconia extends, but this information is critical to making sound decisions regarding private well construction as this area develops. The proposed MGS evaluation of faulting in this area is a welcome first step to focusing a more detailed assessment of the extent of contamination in the Franconia, but it cannot provide all of the information needed to make informed decisions regarding well construction and public health protection.

*19. Page 35. Recommendation #9. It seems that “Bayport” might be more appropriate than “Baytown” here.*

MDH Response: The commenter is correct. The suggested change has been made.

*20. Page 35 Recommendation #14. The cost of a “cut-off well” option east of the airport would probably be prohibitive in order to totally control contaminant migration in both the Prairie du Chien and the Jordan aquifers. MPCA is not considering this alternative at this time.*

MDH Response: The recommendation is primarily addressing the need for a pump-out remedy to reduce concentrations of TCE migrating off-site, and includes wells in the eastern portion of the site as part of an “optimal” system. Nor was it assumed that such wells would totally control the plumes in the Prairie du Chien and Jordan, but rather reduce the total flux of TCE exiting the airport property. We believe this option should still be considered as there are high concentrations of TCE present downgradient of the proposed pump-out well that will continue to migrate towards private wells east of the

airport, regardless of what remedial actions are occurring west of the airport. It may not be the most cost effective remedy, particularly in the short term, but because it may reduce the time needed for cleanup, prevent additional wells from exceeding 5 µg/L TCE, and shorten the time during which GAC filters are needed, the viability of this option should be determined by a feasibility study that evaluates the total remedial costs over time.

*21. Figure 7 lacks the boring log for MW-10B, probably because Terracon omitted it from the June report. Let me know if I can fax it to you. Generally there is to 38 feet BGS silty clay to clayey silt; then below that is sand to silty sand, silt with sand and more sandy silt to 73 feet BGS. The OPDC is at 73 feet. EOB is at 77 feet. Ground surface is at 923.75 feet MSL. Your Fig 7 has the GS at ~915 ft. MSL and EOB looks too deep.*

MDH Response: The geologic information on the log was omitted because it is not recorded in CWI, which was used to prepare the figure. The log referred to in this comment is also not consistent with the drilling and completion depth information in CWI. Based on further discussion with MPCA staff and review of the available information regarding this well, the figure has been modified to use the well depth and geologic information from the Limited Remedial Investigation report prepared by Delta Environmental Consultants, Inc. (Delta, 1996).

*22. Figure 3 Title should say “West Lakeland Township”. Lakeland is a city.*

MDH Response: The original source for the figure incorrectly identified the location as “Lakeland Township”. The title has been amended.

### **III. Comments Received From Washington County**

*1. Summary. Page 4, paragraph 4, line 3: “...and by providing granular activated carbon...”. The word “providing” is misleading to the public, as MAC and, in most instances, PCA, will not be providing GAC to homes platted after April 9, 2002.*

MDH Response: The exception noted by Washington County staff has been included in the paragraph to clarify this situation.

*2. Introduction. Page 4, paragraph 1, line 6: “Additional site investigation....”. Include the expansion of the SWCA boundaries (it may also be added to the previous line starting with “As a result,...”)*

MDH Response: The suggested change has been made.

*3. Background. Page 5, paragraph 2, lines 4&5: “...well drilling advisory in 1988...Figure 1.” Figure 1 represents the expanded SWCA, not the boundaries of the 1988 well advisory area.*

MDH Response: A clause was added to the sentence to clarify that Figure 1 illustrates the 2001 boundaries of the SWCA, which was expanded from the 1988 boundaries.

*4. Page 14, last paragraph: Are the tritium levels available? If they are, what do they indicate about the age of the water, mixing, etc.?*

MDH Response: Tritium data are not yet available.

*5. Page 8, Paragraph 2 – Mentions faults as possible conduit for flow of contaminants to groundwater. Possibly include information about geologic faults found in the southern portion of Washington County (Cottage Grove and Denmark Township) and that MGS will be working on a project in 2004 to evaluate existence of faults in the southern portion of the county, including the Baytown SWCA.*

MDH Response: Discussion of faulting in the areas identified would likely be confusing to the readers and provides no useful information regarding the geology and hydrology of the site. However, it we have added mention of the proposed MGS project.

*6. Page 21, paragraph 4 – “that the property in within a SWCA.” ‘In’ should be replaced with ‘is’.*

MDH Response: The suggested change has been made.

*7. Page 34-36 (Recommendations) – Possibly add geologic fault identification.*

MDH Response: Recommendation number 6 has been expanded to identify specific geologic features, including faults, which should be identified in order to evaluate the extent and competence of the St. Lawrence formation.

#### **IV. Comments Received from MDH Well Management Section**

*1. For recommendation #4, I would suggest that it read at the end “adjust its boundaries or requirements as needed”. There may be a circumstance, such as finding of TCE in the Franconia Sandstone, where we may modify a construction or mitigation requirement, but there is no change in the boundary of the SWCA.*

MDH Response: The suggested change has been made.

*2. Perhaps as an additional recommendation, there is an on-going need for continued monitoring of the plume(s) and reporting that to decision-makers on the local, county, and state levels. Obviously, any changes in TCE distribution or movement must be identified.*

MDH Response: On-going monitoring is specified in the ROD and the results are reported, at least in summary form, to local, county and state officials, so there doesn't appear to be a need to make a recommendation to do so.