

Water Gremlin

HEALTH ASSESSMENT SERIES | TCE AIR EMISSIONS AND HEALTH

Trichloroethylene (TCE) Air Emissions and Health Summary

Air Emissions

- Air emissions from Water Gremlin's coating operations may have begun as early as 1985; TCE air emissions appear to have started in 1992.
- The amount of TCE Water Gremlin emitted into the air varied over the years. The year with the highest TCE emissions appears to be 2018.
- MPCA used air dispersion modeling to create a map of an "area of concern" to communicate to the public about the TCE emissions. The map showed the estimated annual average TCE air concentrations for 2018. Air concentrations ranged from 59 $\mu\text{g}/\text{m}^3$ at the nearest residence to the Water Gremlin facility to 2 $\mu\text{g}/\text{m}^3$ at the outer boundary. The majority of the area represented by the 2018 "area of concern" shows predicted annual average concentrations of TCE in air ranging between 2 – 20 $\mu\text{g}/\text{m}^3$.
- Because the map is based on annual average concentrations, there were times when TCE air concentrations were considerably higher (or lower) than the annual average, and times when TCE air concentrations exceeded 2 $\mu\text{g}/\text{m}^3$ over a larger (or smaller) area.

Health Risks

- Individuals' exposures to TCE due to past emissions from Water Gremlin were likely to be highly variable over time and location, and from one person to another.
- People were exposed to TCE in air above the MDH Health Based Value of 2 $\mu\text{g}/\text{m}^3$. MDH considers 2 $\mu\text{g}/\text{m}^3$ a concentration of TCE that is safe for all people to breathe for a lifetime. Exposure to TCE above 2 $\mu\text{g}/\text{m}^3$ does not mean that health effects are likely to occur. However, the risk for health effects increases as the amount and duration of TCE exposure increases.
- Based on animal studies, exposure to TCE in air may increase the risk of non-cancer immune system and kidney effects, or heart defects in a developing fetus. There is no conclusive evidence from human studies that TCE causes these effects in humans.
- TCE exposure may increase the risk of certain types of cancers (kidney, possibly non-Hodgkin's lymphoma, and liver) over a lifetime, based on studies of workers or animals breathing very high levels of TCE.
- MDH analyzed data from the Minnesota Birth Defects Information System and the Minnesota Cancer Reporting System. MDH found that the number of congenital heart defects and the cancer rates near Water Gremlin were not higher than expected at the time of the analysis.
- There are no standard recommendations for increased medical screening for cancer or other health effects due to the potential for past exposure to TCE from Water Gremlin, although people who believe they were exposed may wish to share this information with their physicians.

Purpose

The purpose of this document is to describe available information about Water Gremlin's emissions of trichloroethylene (TCE) into air and what, if any, health risk that may pose for people who lived, worked, attended school, and/or spent time near the facility when the emissions occurred. The intention is to answer questions community members have raised and to describe limitations regarding what is and what can be known. Questions explored include the following:

- How long did Water Gremlin use or emit TCE?
- What is known about the amount of TCE emitted?
- What information can air modeling provide?
- What information is available about TCE exposure and health effects?

The Minnesota Department of Health's role is to evaluate public health risks at sites or facilities where chemicals have been released into the environment. In this case, MDH bases the evaluation on our best estimates of how much TCE people might have breathed and the best available scientific information on the toxicity of TCE.

The information in this document will be included and discussed further in a future MDH Public Health Assessment (PHA). The PHA will address all potential routes of exposure related to any environmental contamination from Water Gremlin.

Water Gremlin TCE Use History

The Water Gremlin Company began manufacturing lead fishing sinkers from a garage on the family property in 1949. It expanded gradually, and by 1964 occupied a 12,000 square foot facility. The current facility was built in stages over the years, with major expansions occurring in the 1970s and the 1990s as the company diversified by adding custom lead parts manufacturing (Wenck, 2019). Water Gremlin fabricates lead metal products from purchased, refined lead materials. Lead acid battery terminal posts (BTPs) are a primary product (Wenck, 2019).

Water Gremlin used TCE in a product coating process. According to a Water Gremlin air permit application, BTPs from die-cast machines were coated to provide an acid-resistant, leak-proof seal between the BTPs and battery cases. The coating solution, which was primarily TCE, was applied to BTPs by spraying or dipping (Braun, 1999). In a Phase I Environmental Site Assessment conducted in 1995, representatives of Water Gremlin stated that the coatings had been used since approximately 1985, and that the production of BTPs increased dramatically around 1990 (Braun, 1995). The report cites 1992 installation dates for four above ground storage tanks for TCE and mentions another solvent, 1,1,1-trichloroethane (TCA), was used prior to TCE (Braun, 1995). The U.S. Environmental Protection Agency (EPA) Toxics Release Inventory Program data (provided by Water Gremlin) indicates that Water Gremlin switched from 1,1,1-TCA to TCE in 1992 (U.S. EPA, 2019). It is assumed that the 1,1,1-TCA use also resulted in air emissions and potential exposures during the time of its use.

Water Gremlin is subject to the federal Clean Air Act (through revisions signed into law in 1990), as well as Minnesota air permitting rules. They submitted an air permit application to MPCA in 1995, and referenced a 1995 due date for the application under the new federal and state air quality rules. In their permit application, Water Gremlin provided their 1994 actual TCE emissions as 119 tons/year. In 1999, they submitted a new permit application. This application stated that they reduced TCE emissions through pollution prevention efforts from 87 tons/year in 1996 to 53 tons/year in 1998. The purpose of the 1999 application was to install additional coating machines and air pollution control equipment to capture and destroy at least 95% of their TCE emissions. Water Gremlin received an MPCA air permit in

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July 2000, which required the installation of a catalytic oxidizer, with enforceable operating conditions to destroy at least 95% of the TCE emissions from the coating process.

Although the catalytic oxidizer was installed in August 2000, the company discovered that the equipment was not working in November 2000 while attempting to conduct performance testing. They tried to fix it for a number of months, but ultimately decided to replace it with a different type of control equipment. Rather than destroy TCE emissions, Water Gremlin applied for an air permit amendment in 2001 to install a fluidized bed recovery system to recover the TCE. MPCA issued a new permit in April 2002 and required a reduction of emissions of at least 95 percent. A removal efficiency of 98.8% was reported from the performance test conducted that month. But weeks later, a breakdown was reported, followed by additional breakdowns that summer. In February 2003, the recovery system was rebuilt and put back into operation.

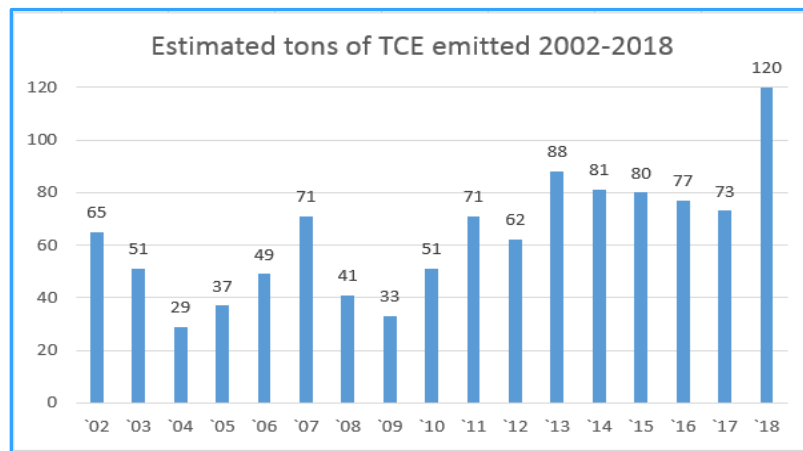
According to MPCA records, Water Gremlin reported multiple shutdowns and breakdowns of the pollution control equipment over subsequent years. Water Gremlin disclosed permit violations to MPCA in July 2018. MPCA discovered (MPCA, 2019) that Water Gremlin likely never met 95% control of emissions and were reusing the recovered TCE. As a result, Water Gremlin greatly exceeded the intended permit limit of 9.5 tons of TCE emissions a year. MPCA requested that Water Gremlin shut down operations that emitted TCE on January 14, 2019 and Water Gremlin agreed to voluntarily shut down that day. In February, Water Gremlin committed to permanently discontinuing the use of TCE and removed the remaining TCE from their facility.

What Happens to TCE in the Air?

When TCE is emitted as a gas into the air, it spreads out and mixes in all directions. It breaks down in a matter of days to weeks. Local weather conditions affect the speed and direction of TCE movement. TCE in air typically does not settle on the soil or surface water. If it does, it would evaporate back into the air quickly. Although TCE does not stay in the air at a location very long or build up, the Water Gremlin facility regularly (typically Monday to Friday) emitted it into the air.

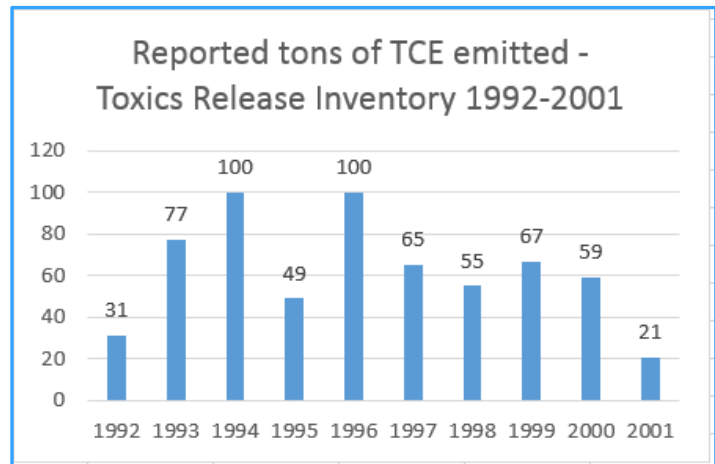
Estimated Tons of TCE Emitted

The MPCA estimated the total amount of TCE emitted to the air per year from 2002-2018 based on records from Water Gremlin (see chart below). The MPCA estimated these annual totals by calculating the difference between the amount of liquid TCE purchased and the amount of TCE removed from the facility as waste for the year.



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The chart on the right provides the tons of TCE emitted as reported by Water Gremlin to the U.S. EPA's Toxic Release Inventory (TRI) for the years 1992-2001. Water Gremlin's 1999 permit application, as discussed above, provides different values for the years 1994 (119 tons vs 100 tons in the TRI), 1996 (87 tons vs 100 tons in the TRI), and 1998 (53 tons vs 57 tons in the TRI). While the accuracy of these TRI data is uncertain, these annual emission estimates appear to be the best information available for estimating TCE air emissions in the surrounding area for this earlier period of TCE use.



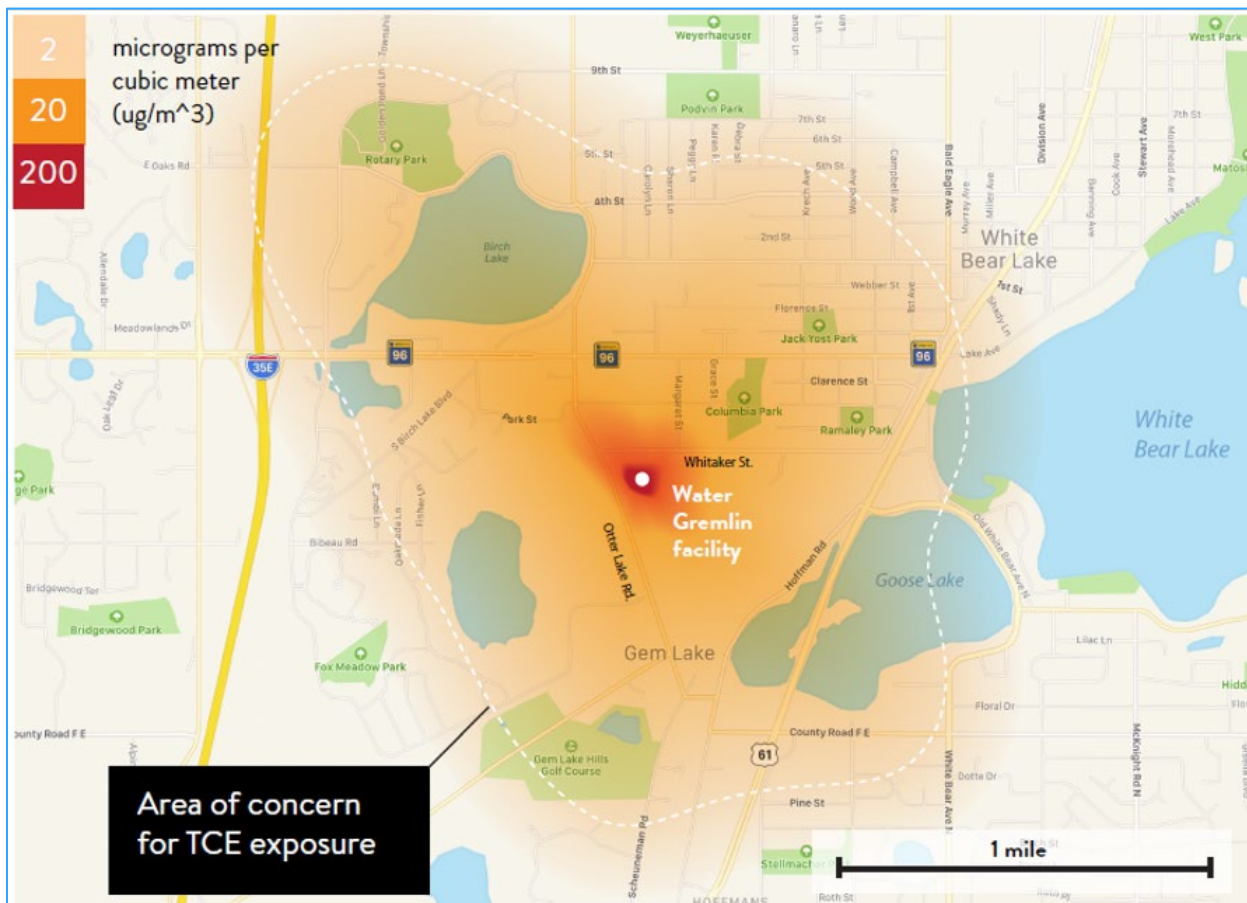
Estimating Past TCE Air Concentrations - Air Dispersion Modeling

Air quality dispersion modeling uses computer simulation to predict the concentrations of an air pollutant at different locations and distances from a source. MPCA uses the AERMOD dispersion model, developed and recommended by the U.S. EPA, to estimate the levels of air pollutants emitted from emission sources. For pollutants emitted through a stack, as occurs at Water Gremlin, AERMOD simulation considers the emission rate, stack height, stack diameter, and stack gas temperature and velocity, as well as the effect of nearby buildings and terrain. AERMOD also uses meteorological data such as temperature, wind direction, and wind speed to calculate pollutant concentrations at various locations.

The map of the area potentially affected by TCE that was distributed publicly in February 2019 (see below) was created by MPCA to display AERMOD dispersion modeling based on the total amount of TCE emitted by Water Gremlin in 2018. This year was chosen because TCE emissions were the highest compared to all other years. The area inside the dotted line shown on the map represents locations where estimated amounts of TCE in outdoor air were predicted to be above the MDH inhalation Health-Based Value (HBV) of $2 \mu\text{g}/\text{m}^3$ (micrograms per cubic meter). The HBV is an amount of a contaminant in air that is unlikely to lead to health effects even if sensitive members of the population are exposed to it 24 hours a day, 7 days a week, for up to a lifetime. The map was intended to represent where estimated air concentrations could have been above MDH's HBV for TCE for the purposes of inclusively notifying the community of the situation. The figure and its features were not intended to convey any information about the likelihood of actual health effects among people living within the area labelled as "Area of concern for TCE exposure."

The highest TCE concentrations were predicted for locations nearest the release point, on the Water Gremlin facility property. Outside the property boundary, at the location of the closest residence, the highest annual average TCE concentration (2018 TCE use data) was estimated to be $59 \mu\text{g}/\text{m}^3$ and amounts were predicted to decrease with increasing distance from the facility. The majority of the shaded area represented on the map above indicates annual average TCE concentrations between $2 - 20 \mu\text{g}/\text{m}^3$.

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Map of the area potentially affected by TCE –distributed in February 2019

The map above overestimates TCE air concentrations for many of the years that Water Gremlin emitted it. If similar maps were created using AERMOD predictions for earlier years when the total amounts of TCE emitted were less (see charts on pages 3-4), the estimated amount of TCE in air would be lower than the 2018 modeled concentrations and the total affected area where TCE exceeded the MDH HBV would be smaller. Modeling earlier years could estimate how much TCE may have been present in outdoor air at various locations near the facility over time.

The map above underestimates TCE air concentrations for shorter periods of time. The TCE air concentrations estimated on the map above are annual averages, which means that there were times throughout the year when concentrations at a particular location were higher (and other times when they were lower) than the average. Daily variations are expected due largely to variability in facility operations/TCE use and weather conditions (for example, both wind speed and direction). For periods of time, TCE air concentrations above the HBV extended beyond the outline in the above map.

The results from the dispersion modeling provide the best information currently available for estimating past annual averaged TCE air concentrations due to emissions from the Water Gremlin facility. MDH is working on creating additional maps to help increase the understanding of the potential TCE air concentrations over time near Water Gremlin.

TCE Exposure

While air modeling can estimate the TCE concentrations in outdoor air for specified times and locations, such estimates will differ from an individual's actual exposure to TCE (that is, how much TCE enters the body through breathing). The amount a person breathed in would be highly variable, depending on how much time they spent in different locations and what the TCE concentrations were during those times. In addition, other factors such as body size, breathing rate, type and level of activities, amount of time spent indoors vs outdoors, etc. could all influence how much TCE a person was exposed to. Estimated air concentrations provide limited information about real exposures individuals might have received.

TCE is also commonly detected at very low concentrations in indoor and outdoor air. Most people are exposed to small amounts of TCE, typically at levels far below those known to affect health. Most TCE used in the U.S. is released into the air by evaporation, primarily from degreasing operations (ATSDR, 2019). It is also still used as a spot cleaner at some dry cleaners. The continual release of TCE from many sources accounts for its detection at very low levels in outdoor air at MPCA's metro area monitoring sites. People can also be exposed to TCE present in products such as adhesives, paint removers, cleaners, and varnishes.

Understanding TCE Air Concentrations

The following table provides additional context about occurrence and potential risk at different TCE concentrations in air.

Description	TCE concentration ($\mu\text{g}/\text{m}^3$)
2017 average outdoor air concentration at the nearest MPCA air monitoring site (Harding High School)	0.11
Average indoor air concentrations in three Twin Cities communities in 1999 (Sexton, et al., 2004)	0.5
U.S. EPA (2011)/MDH Health-Based Value - poses little to no health risk over a lifetime Estimated 1 in 100,000 increased cancer risk over a lifetime	2
A small risk of fetal heart defects for pregnant women during the first eight weeks of pregnancy (U.S. EPA, 2011; based on a rodent study)	~20
Estimated 1 in 10,000 increased cancer risk over a lifetime	20
A small risk of kidney effects with continuous exposure over a long time (U.S. EPA, 2011; based on a rodent study)	~30
Estimated 1 in 1,000 increased cancer risk over a lifetime	200
A small risk for decreased thymus weight (immune system effects) with continuous exposure over a long time (U.S. EPA, 2011; based on a rodent study)	~200
American Conference of Governmental Industrial Hygienists 8-hour worker standard	55,000
Concentration at which some workers experienced health effects in studies, including fatigue, headache, eye irritation, and an increase in kidney cancer (U.S. EPA, 2011)	> 100,000
Concentration in air that people can smell (ATSDR, 2019)	~116,000
MN OSHA 8-hour worker standard	270,000

TCE Toxicity and Risk Assessment

Risk assessment is a science-based tool that is used to evaluate the potential effects of a chemical on human health. Risk assessment uses the best available scientific information, as well as professional judgment and policy, to estimate risks, and ultimately to help government agencies and the public make informed decisions about preventing and reducing risks.

To determine a safe level of exposure to contaminants, scientists frequently rely on animal studies. In these studies, animals in a laboratory (often rodents) are exposed to large amounts of a chemical of interest. The amounts such animals are exposed to are converted to human equivalent concentrations, to account for the differences between humans and animals. Because it is unclear how well short-term, high exposure tests on animals predict how people may respond to low levels of exposure over a longer period of time, scientists err on the side of caution when determining a safe amount for people. This is generally done by reducing the amounts shown to cause an effect in study animals by a factor of 10 to up to 3,000 when setting an amount intended to protect people. Greater reductions are used when there is less certainty. This helps to increase confidence that health effects would be extremely unlikely at the calculated safe amount, including among sensitive individuals such as children and pregnant women.

The likelihood of health effects at the 2018 modeled concentrations (2-59 $\mu\text{g}/\text{m}^3$) is low. The potential health effects of TCE exposure at these concentrations are an increased risk of certain cancers (kidney, and possibly liver and non-Hodgkin's lymphoma), non-cancer effects to the immune system and kidney, and a risk of heart defects during fetal development. The risk assessment basis and evidence for these potential effects are described below.

Non-Cancer Effects

In 2011, the U.S. EPA developed a safe inhalation value of 2 $\mu\text{g}/\text{m}^3$ for a lifetime of exposure, based on a review of a large number of studies of animals and humans exposed to TCE (U.S. EPA, 2011). MDH also conducted a TCE review in 2013 and 2018 and concurred with EPA's inhalation value and the conclusions from their 2011 assessment, which resulted in the MDH HBV of 2 $\mu\text{g}/\text{m}^3$. MDH also developed a short-term HBV of 2 $\mu\text{g}/\text{m}^3$ that is protective of a 24-hour exposure for pregnant women in their first eight weeks of pregnancy.

EPA concluded that at a sufficient dose and exposure duration, TCE poses a potential human health hazard for toxicity to the central nervous system, kidney, liver, immune system, male reproductive system, and developing fetus. EPA narrowed down the studies to those considered critical effects – those showing effects at the lowest levels – to develop a safe level that is protective of the most sensitive health effects. The main effects observed at the lowest exposures involved the immune system, the developing fetus, and the kidneys.

EPA reviewed all published studies available and chose two critical rodent studies and one supporting study as the basis for calculating the safe inhalation value. The selected studies are described below.

- One critical study showed an increased risk of subtle impacts to the immune system; the thymus (a specialized organ of the immune system) weighed less than normal and there was an increase in markers associated with autoimmune disease after mice were exposed to TCE in drinking water.
 - Effect level finding -- A small risk of immune system effects may exist for people exposed to TCE at $\sim 200 \mu\text{g}/\text{m}^3$ continuously over a long time period.

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- The second critical study showed heart defects in rats whose mothers were exposed to TCE in drinking water during pregnancy.
 - Effect level finding -- For women in the first eight weeks of pregnancy exposed to TCE at $\sim 20 \mu\text{g}/\text{m}^3$, there may be a small risk of fetal heart defects. At this level, very few women (no more than 1 in 100) would have an amount of TCE in their body that might cause a fetal heart defect less than 1% of the time.
- A third rodent study showing kidney toxicity was considered a supporting study.
 - Effect level finding -- A small risk of kidney impacts, including toxic nephropathy and increased kidney weights may exist for people exposed to TCE levels at or exceeding $\sim 30 \mu\text{g}/\text{m}^3$ continuously over a long time period.

To be protective in accounting for uncertainty, EPA divided the effect levels from these two critical studies by uncertainty factors of 100 in the first case and 10 in the second, to arrive at the safe inhalation value of $2 \mu\text{g}/\text{m}^3$. Note however, that exposure to amounts of TCE greater than $2 \mu\text{g}/\text{m}^3$ does not mean health effects will, or are likely to, occur; although the risk of health effects increases as the amount and duration of TCE exposure increases.

Other health effects have been shown to possibly occur at much greater exposures than the effect levels in the three studies EPA chose for its evaluation — at amounts of TCE much greater than exposures that were predicted to be possible in the community due to the emissions from Water Gremlin.

Minnesota Birth Defects Information System – Water Gremlin Evaluation

EPA's toxicological evaluation concluded that for women exposed to TCE in the first eight weeks of pregnancy, when the baby's heart is forming, there may be a greater risk of fetal heart defects. This conclusion is based on animal studies only; there is no conclusive evidence from human studies that TCE exposure causes effects to a developing baby.

To explore this potential risk using existing surveillance tools, MDH reviewed data from the Minnesota Birth Defects Information System for diagnosed and reported defects among births to women living in zip code 55110, which was selected to represent the area where exposure to airborne TCE from the Water Gremlin facility was considered most likely.

Based on the timeline of reported TCE emissions from the Water Gremlin facility, about 400 infants were born annually to women living in this area at the time of delivery for the 2006 to 2017 birth cohorts. Of these, about 3 infants per yearly cohort (range: 0-7) were diagnosed with congenital heart defects. These observed numbers do not appear different from expected numbers (range: 2-5) based on prevalence estimates available in Minnesota.

The numbers of septal defects (affecting atria or ventricles) – the most common congenital heart defects in Minnesota – were consistent in babies born to residents in zip code 55110 over the 12 birth cohorts as compared to other parts of the state.

For more information and to understand the limitations of this kind of analysis see the report, Water Gremlin Health Assessment Series: Public Health Data (PDF):
<https://www.health.state.mn.us/communities/environment/hazardous/docs/sites/ramsey/wgpubhealthdata.pdf>

MDH will continue to review congenital heart defects diagnosed in the first year of life in this area until the 2018 and 2019 birth cohorts are completed in mid-2021. This encompasses the period when pregnant women were potentially exposed to TCE from the Water Gremlin facility.

Cancer Effects

Occupational studies of high TCE exposure have shown an increased risk of kidney cancer in people. There is also evidence of an association between high levels of TCE exposure in people (and rodents) and non-Hodgkin's lymphoma and liver cancer. Less evidence is found for an association between TCE exposure and some other types of cancers. According to EPA's 2011 assessment described above, breathing TCE at the following concentrations and durations may theoretically result in the incremental cancer risks shown:

- Breathing 2 µg/m³ TCE continuously for a lifetime, is expected to result in no more than 1 additional cancer in 100,000 exposed people;
- Breathing 20 µg/m³ TCE continuously for a lifetime is expected to result in no more than 1 additional cancer in 10,000 exposed people; and
- Breathing 200 µg/m³ TCE continuously for a lifetime is expected to result in no more than 1 additional cancer in 1,000 exposed people

Any such increase is unlikely to be measurable compared to the background cancer rate that already exists from all causes. For comparison, recent estimates show nearly half (four or five people out of ten) of Minnesotans will be diagnosed with cancer sometime in their life. Cancer -- a group of many different diseases -- is much more common than many people realize.

Minnesota Cancer Reporting System – Water Gremlin Evaluation

Because of the concern of increased cancer risk from TCE exposures, MDH reviewed data from the Minnesota Cancer Reporting System (MCRS). MDH compared cancer rates among individuals living at the time of their diagnosis in census tracts near the Water Gremlin facility against cancer rates in the seven county Twin Cities metropolitan area during the most recent 10-year period for which complete data were available (2007-2016).

Overall cancer rates in the area of analysis were virtually identical to Metro-area rates. For both genders combined, 970 cancers were diagnosed over the 10-year period, compared to the expected number of 978.

For more information, including rates of specific types of cancer and limitations of this analysis, see the full report, *Cancer Occurrence in White Bear Township, White Bear Lake, and Gem Lake Area - Five Census Tracts, 2007-2016* (PDF):

<https://www.health.state.mn.us/data/mcrs/docs/rptwblgemlake.pdf>

Are Some People at Greater Risk? Do I Need Medical Testing?

MDH advises that there is no need to go to the doctor solely because you live near Water Gremlin. TCE does not accumulate or stay in the body for more than a few days after exposure stops. There is no medical test to determine whether a person was exposed to TCE from Water Gremlin. There are no recommendations for any increased screening for cancer or other health effects, although people may wish to share the fact that they were or may have been exposed to TCE in air from this situation with their physicians.

There is a general lack of data demonstrating differences in health effects from TCE exposure based on factors such as age, gender, genetics, race/ethnicity, preexisting health status and lifestyle (EPA, 2011). It is not known whether children are more susceptible than adults to the effects of TCE.

Babies born to women exposed to TCE during the first eight weeks of pregnancy (when the baby's heart is forming) are considered the most sensitive. This is in part due to the possibility that TCE exposures could have been considerably higher than the annual average concentrations for shorter windows of time and may have occurred at the same time fetal heart development occurred. Regardless, no changes in regular prenatal care are recommended for TCE exposures. If the fetus developed normally there is no future risk of cardiac defects.

In addition to pregnant women and the developing fetus, MDH considers infants and children, the elderly, and those with a compromised immune system to be more sensitive to exposure to chemicals as a general rule.

MDH Next Steps – Public Health Assessment

MDH is working on a Public Health Assessment for all potential routes of exposure related to any environmental contamination from the Water Gremlin operations in response to community concerns. MDH will include data collected from the remedial investigation at the Water Gremlin facility this summer as well as information available through the MPCA air permitting process. The document will be released as a draft for public review and comment. Comments will be considered in the final document.

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