Letter Health Consultation

Water and Soil Samples Reviewed for Public Health Implications

GREENWOOD CHEMICAL COMPANY

NEWTOWN, VIRGINIA

EPA FACILITY ID: VAD003125374

Prepared by
Virginia Department of Health, Division of Environmental Epidemiology
Richmond, Virginia 23219

MAY 10, 2024

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Office of Capacity Development and Applied Prevention Science
Atlanta, Georgia 30333

Letter Health Consultation: A Note of Explanation

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LETTER HEALTH CONSULTATION

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May 10, 2024

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Dear Mr. Evans:

The Virginia Department of Environmental Quality (DEQ) asked the Virginia Department of Health (VDH) Office of Environmental Health Services Public Health Toxicology Program to review residential well water testing data from the Greenwood Chemical Company National Priority List (NPL) site. **DEQ's request was to review residential water sampling results and evaluate their potential for human health effects.**

Based on the evaluation of environmental sampling data, VDH concludes **drinking water from residential wells near Greenwood Chemical Company is not expected to harm people's health.** The reason for this is chemicals are not detected consistently in these wells, and the concentrations of chemicals detected are below levels of health concern. In one year, bis(2-ethylhexyl) phthalate was detected at levels that required further evaluation. However, this contaminant was only found during that one year of analysis. Because bis(2-ethylhexyl) phthalate was not detected at any other time during the ten years of analysis, the data suggest that this detection was due to a laboratory contaminant and was not actually present in residential wells.

VDH recommends DEQ:

- Continue encouraging the residents to participate in the voluntary monitoring of residential drinking water wells near the Greenwood site as part of the site's Operation and Maintenance (O&M) plan.
- Evaluate feasibility of laboratory analysis of vinyl chloride to accurately measure at levels below the comparison value (CV) of 0.017 µg/L. The current method can only detect vinyl chloride at concentrations exceeding 0.5 µg/L.

Background

Statement of Issues and Purpose

The purpose of this evaluation is to review the most recent information on the Greenwood site and past residential well data for potential risks to human health.

Site Description and Timeline

The Greenwood site is in Albemarle County, Virginia and is approximately 34 acres. A map of the site and its buildings prior to EPA action can be found in *Attachment A. Map of site prior to EPA action*. From the 1940s to 1985 the company synthesized pharmaceutical and pesticide precursors, routinely using arsenic salts in the process. The facility was closed in 1985 following a toluene vapor explosion and fire. The event killed four workers and destroyed the process building.

An evaluation by the Environmental Protection Agency (EPA) discovered chemical contamination of the site. Chemical waste was stored in drums that were buried (400 drums) in trenches or left on the surface (100 drums). In addition, aqueous chemical wastes were discharged through floor drains into a series of five unlined lagoons. In May 1988, the Agency for Toxic Substances and Disease Registry (ATSDR) carried out a health assessment at the Greenwood Chemical Company site and the site was placed on the National Priorities List (NPL) [1].

The site underwent remediation that included removing the drums and contaminated soil, demolishing buildings, draining the lagoons, installing a series of monitoring wells, and constructing an on-site water treatment facility for pump-and-treat operation to contain contaminated groundwater (see *Attachment B. Map of site following EPA action*). The on-site groundwater treatment facility has been in operation since 2001.

The EPA addressed the site in four operable units (OU):

- Operable Unit 1 (OU-1): Excavation and disposal of contaminated soils associated with lagoons and disposal areas on the site.
- Operable Unit 2 (OU-2): Recovery and treatment of contaminated ground water and lagoon water in the on-site treatment plant.
- Operable Unit 3 (OU-3): Demolition and removal of the manufacturing buildings and waste chemicals.
- Operable Unit 4 (OU-4): Designation of a waste management area for deep soil contamination sources and implementing an on-site treatment plant to restore ground water quality within the area of attainment.

The four OUs have been completed. OU-2 and OU-4 were addressed by a Record of Decision (ROD) issued on September 22, 2005, laying out the selected remedy. This defined an area of the site with deep soil contamination as a "waste management area" ("that part of the Site which includes the former drum disposal and manufacturing areas and any residual soil contamination underlying the excavated limits of former Lagoons 4 and 5").

The ROD required a pump and treat protocol to hydraulically contain this area until groundwater performance standards were met [2]. A 2013 review of the ROD recommended that EPA sample the soil for dioxins since the analysis had not previously been completed [3]. In 2014, EPA carried out soil sampling for dioxins. The EPA determined that the concentrations met both risk screening levels for industrial land use and residential preliminary remediation goals [4]. In the most recent five-year review, EPA recommended groundwater sampling for 1,4-dioxane and per- and polyfluoroalkyl substances (PFAS). EPA plans to do the sampling before 2026 [4].

The DEQ assumed responsibility for Operation and Management (O&M) of the site on March 15, 2012. The 2012–2017 O&M reports were prepared by Environmental Alliance, Inc. The 2018 to present O&M reports were prepared by Retaw Engineering, LLC and Apex Companies, LLC. Samples were analyzed by Lancaster Laboratories in Lancaster, Pennsylvania from 2012–2017, and Enthalpy Analytical (formerly Air, Water and Soil Laboratories) in Richmond, Virginia from 2018 onward.

Community Description and Concerns

Community Demographics

The area around the site is rural and mostly agricultural land with some residential lots. The closest homes are farmhouses, and the closest home is approximately 700 feet away. Some residential neighborhoods are located west of the site. The Mountain Hollow neighborhood is about half a mile away. The primary language in the area is English.

Community Concerns

The site has received community attention in the past. Residents have had concerns about the site and their health before the site was added to the NPL and continuing during the implementation of the remedies. Prior to its addition to the NPL, the site was a nuisance to nearby residents with discharges to surface water that killed fish in streams flowing from the site. The 1985 explosion also generated a lot of concern in the community. A 2012 news story in the discontinued Charlottesville weekly newspaper *The Hook* quoted several residents about concerns for their health and the site [5]. In 2017, DEQ received an email from a person who formerly lived near the site. The email notified DEQ about the person's cancer diagnosis, which the individual believed to be caused by drinking contaminated well water. The individual expressed a concern about unknown contaminants that might not be included in the laboratory analysis and reported many former neighbors had also been diagnosed with cancer. This email suggests there may be a perception among the community that living near the site poses a cancer risk. Currently, the community believes the site is being managed. During the most recent five-year review, the EPA Community Involvement Coordinator interviewed community members and found they are not interested in attending meetings or receiving messaging unless there is new information, they need to be aware of.

Sampling Data

EPA Groundwater Performance Standards

In 2005, EPA identified six contaminants of concern (COC) that were targeted for reduction. The COCs needed to be brought below site-specific Groundwater Performance Standards (GPSs) (see Table 1 below) [2]. The GPSs were designed to produce cumulative cancer risk less than 1×10^{-4}. This is the risk level considered acceptable by EPA. The GPSs may be stricter than the EPA maximum contaminant level (MCL) used for drinking water because the water contains multiple contaminants. The risk of health effects when all of these are added together may be excessive even if each chemical does not exceed the individual MCLs applied to public water systems.

Although arsenic in soil was addressed in OU-1 and OU-4, it was not identified as a COC by EPA in the 2005 ROD. The ROD says:

> The contaminants of concern ("COC") detected in the ground water at one or more of the wells outside the waste management area are bis(2-chloroethyl)ether (up to 1.4 ug/1), carbon tetrachloride (up to 19 ug/1), 1,2-dichloroethane (up to 20 ug/1), tetrachloroethene (up to 25 ug/1), trichloroethene (up to 120 ug/1) and vinyl chloride (up to 4.8 ug/1). In addition, arsenic was detected in one perimeter well at 6.0 ug/1 [10].

The EPA's MCL for arsenic in drinking water is 10 µg/L, so the concentration detected at the site was below the MCL. Arsenic was determined to not be a risk for off-site groundwater contamination and no further testing has been done.

Table 1. EPA's Groundwater Performance Standard for COC at the Greenwood site

Contaminants	*EPA Groundwater Performance Standard (µg/L)*
1,2-Dichloroethane	5.0
Bis(2-chloroethyl) ether	0.5
Carbon tetrachloride	4.0
Tetrachloroethylene	0.8
Trichloroethylene	1.0
Vinyl chloride	0.5

µg/L: micrograms/liter

Only one COC, bis(2-chloroethyl) ether (BCEE), has been detected in residential wells since 2013.

Waste Management Area Capture Zone Analysis

The northern end of the site is approximately 1,000 feet above sea level. It slopes away in a generally southeastern direction to approximately 850 feet above sea level at the southern end of the site [6]. To the north of the site, north of Interstate 64, the elevation rises rapidly to about 2,800 feet [6]. Groundwater elevation mapping has consistently found groundwater flow in a southeastern direction [3,7,8]. The site contains a series of groundwater recovery wells, monitoring wells (MW), and perimeter monitoring wells (PMW). The wells have been used to model groundwater flow direction, develop potentiometric maps, and evaluate the effectiveness

of the recovery well network in establishing hydraulic containment of the waste management area (see *Attachment B. Map of site following EPA action*).

The waste management area is in the center of the site where manufacturing and disposal was done. As part of a plan to reduce concentrations of the COCs below EPA's risk-based performance standards within 30 years, a groundwater treatment plant was installed in 2001. The plant was opened to collect and treat groundwater pumped from 11 recovery wells on the site. EPA's target groundwater performance standards are shown in Table 1.

The plant's activities aim to establish hydraulic containment of the waste management area so that groundwater performance standards are achieved. Hydraulic control is demonstrated through an analysis which relies on the weight of evidence approach in identifying the capture zone by evaluating flow rates, water quality data, potentiometric maps, monitoring data, and analytical data that has been collected from site monitoring and recovery wells.

In 2011, EPA determined that hydraulic containment was achieved along the edges of the waste management area. Stable to decreasing trends in groundwater contaminant concentration in recovery wells indicated progress toward attainment of GPSs.

In 2017, plume modeling suggested the trichloroethylene (TCE) plume extended outside the site boundary to the east. However, the most recent results show that the plume is contained within the site boundary (see *Attachment G. TCE plume modeling, August 2022*) [9].

Water Testing Results for Site Perimeter Wells

The waste management area is the source of continuing groundwater contamination on the property. Hydraulically containing it should prevent further contaminating groundwater outside the waste management area. However, prior to EPA action, contaminated groundwater was able to flow out of the waste management area.

While monitoring perimeter wells on the southern border of the site, outside the waste management area, DEQ identified several contaminants at low concentrations. Water testing results for these wells are in *Attachment H. Perimeter Groundwater Monitoring Well Detections, 2012–2023*. These wells are not used for drinking water, so chemicals found in the groundwater here do not pose a health risk. In recent years, the concentrations for these chemicals have declined and typically fall below the detectable range. These results are consistent with hydraulic containment preventing contaminated water from migrating off-site.

Analysis of monitoring well water is limited to the chemicals found below. All these organic compounds are included in residential well testing.

Volatile Organic Compounds
1,2-Dichlorobenzene
1,2-Dichloroethane
Benzene
Carbon tetrachloride
Chlorobenzene
Chloroform
Methylene chloride

Tetrachloroethylene
Toluene
Trichloroethylene
Vinyl chloride

Semi-volatile Organic Compounds
Bis(2-chloroethyl) ether
Bis(2-ethylhexyl) phthalate
Naphthalene

Residential Well Sampling Results

A map showing the site and general location of residential wells is in *Attachment C. Residential well distribution*. From 2013 to 2022, residential well samples were collected annually and analyzed for a variety of volatile and semivolatile organic compounds. The full list of chemical compounds analyzed is in *Attachment D. Volatile and Semivolatile Chemicals Assessed in Residential Sampling*. The analysis includes the six COCs identified in 2005 and listed in Table 1 [10].

Since 2013, water testing has identified chemical compounds in eight residential wells (see *Attachment E. Chemicals detected in residential wells* and *Attachment F. Residential well results by year*). Compounds detected in residential wells and their respective CVs are given in Table 2. Results for the March 14, 2013, round of testing for methylene chloride are excluded since all the samples collected that day, including the blank sample, contained methylene chloride. Methylene chloride is a common laboratory contaminant. Its presence, in the blank and field samples, suggests the samples from this day were contaminated. Only one COC has been detected in residential wells, bis(2-chloroethyl) ether (BCEE). BCEE was found in Residential Well 3 (RW-03) in 2013 and Residential Well 6 (RW-06) in 2018.

Table 2. Compounds detected in residential wells and their CVs

Compound	CV (µg/L)	CV Type
bis(2-chloroethyl) ether	0.022	CREG Drinking Water
bis(2-ethylhexyl) phthalate	0.71	Intermediate EMEG, Child
bromodichloromethane	0.39	CREG Drinking Water
bromoform	80	EPA MCL, total trihalomethanes
2-butanone	4,200	Chronic RMEG, child
chloroform	0.062	CREG Shower
2-chlorophenol	35	Chronic RMEG, child
cyclohexane	NA	NA
dibromochloromethane	0.29	CREG
di-n-octyl-phthalate	2,800	Intermediate EMEG, child
methylene chloride	6.4	CREG
methyl-t-butyl ether	2,800	Intermediate EMEG, child
phenanthrene	NA	NA
1,2,3-trichlorobenzene	1.6	EPA Ingestion RSL, child, THQ 0.1

1,2,4-trichlorobenzene	710	Chronic EMEG, child
o-xylene	340	EMEG Shower

µg/L: micrograms/liter, CREG: cancer risk evaluation guide, EMEG: environmental media evaluation guide, NA: not available

Results from the residential water sampling were compared to ATSDR comparison values (CVs). CVs are media-specific concentrations used to identify contaminants that require additional evaluation. CVs are derived using standard exposure assumptions and are not site-specific. A contaminant detected below the respective CV is not anticipated to result in adverse health effects when individuals are exposed. Concentrations that are above CVs do not mean that adverse health effects occurred or will occur. Concentrations at these levels mean that further evaluation is needed to determine the risk of harmful effects.

CVs are not available for all chemicals. When CVs were not available, alternative screening values were used. For example, EPA's drinking water MCL or regional screening level (RSL).

Scientific Evaluations

Exposure Pathway Analysis

Prior to evaluating a health hazard, we must establish that an exposure pathway of sufficient level and duration exists or existed.

A complete pathway requires five elements:

A source of exposure: contaminated soil and groundwater on the site
An environmental transport medium: contaminated groundwater flowing offsite
A route of exposure: ingestion of well water
A point of exposure: contaminated private well
A receptor population: residents in surrounding homes

A pathway is complete if all components are currently present, are known to have been present in the past, or will be present in the future.

A pathway is potential if any of the components are unknown but could be possible.

A pathway is eliminated if any of the components are absent or removed. There is a completed pathway at the Greenwood Chemical Company site since all components of the exposure pathway are present.

Residential Wells Evaluation

Chemicals Detected

For most residential wells, if a compound was detected it was only found in one year of sampling. Residential Well 7 (RW-07) is an exception: methyl *tert*-butyl ether (MTBE) was detected in multiple years. This well is located to the west of the site. While groundwater generally flows in a southeastern direction, surface elevation and groundwater elevation mapping suggest it is possible that some groundwater could migrate from the northern end of the site and reach this well. A review of the site map (*Attachment A. Map of site prior to EPA*

action) shows a warehouse ("Northern Warehouse") was located northwest of Monitoring Well 17D (MW-17D). Contamination from this building could hypothetically appear in the water from this monitoring well.

We were unable to determine the source of MTBE and whether groundwater in this location was contaminated with MTBE. Since that chemical was not included in monitoring well testing, off-site migration of MTBE to RW-7 cannot be ruled out. MTBE is a common groundwater contaminant due to the previous widespread use of MTBE in gasoline as an anti-knock agent, so an alternative explanation is that the source could be a past off-site gasoline spill.

Most other chemicals were detected once in a single well. However,

- bis(2-ethylhexyl) phthalate was detected in five wells in 2018,
- bromoform was detected in two wells in 2013,
- methylene chloride was detected in five wells in 2015, and
- phenanthrene was detected in two wells, once in 2020 and once in 2022.

The detections of bis(2-ethylhexyl) phthalate and methylene chloride may represent contamination, since these were detected in multiple samples in a single year and not before or since (except for methylene chloride as a contaminant in field samples and the blank sample in 2013). Bis(2-ethylhexyl) phthalate is a plasticizer used in polyvinyl chloride (PVC) plastic, a plastic often used in labware. Methylene chloride is a common laboratory solvent. Phenanthrene was found in RW-01 in 2020 and RW-02 in 2022. While it was not found in blanks on these sampling trips, in 2022, phenanthrene was found at similar concentrations in the field blank and rinsate blank for monitoring well sampling.

In 2013, residential Well 3 (RW-03) had detectable concentrations of six contaminants. This included BCEE that exceeded the ATSDR Cancer Risk Evaluation Guide (CREG). BCEE is a COC and was detected in multiple monitoring wells, including perimeter wells. In 2018, BCEE was found in Residential Well 6 (RW-06) and exceeded the CREG. The distance between the site and RW-03 and its location southwest of the site (while groundwater flows southeast) suggests that the site is not the source of these contaminants. RW-06 is closer to the site, but is located to the west, not in the anticipated direction of groundwater flow. However, estimates of groundwater flow depend upon assumptions made about the underlying bedrock that cannot be confirmed. We can neither rule out nor confirm the site as the source for contamination in RW-03 in 2013 and RW-06 in 2018.

Bromodichloromethane and dibromochloromethane found in RW-03 can be byproducts of water chlorination and may have resulted from well disinfection. However, these chemicals are also used in chemical syntheses. No sampling data is available from on-site wells for these chemicals, so their presence on-site is unknown.

Screening Analysis

Most detections across the time period evaluated fell below the CV or alternative screening value. Drinking this water is not expected to harm people's health because the concentrations are below levels that could be harmful. Four chemicals from five different wells exceeded the CV (see Table 3). The chemicals included single detections of bromodichloromethane and

dibromochloromethane in RW-03 in 2013, bis(2-ethylhexyl) phthalate in five wells in 2018, and BCEE in RW-03 in 2013 and RW-06 in 2018.

Table 3. Chemicals in residential wells exceeding their CV

Compound	Well	Years	Result (µg/L)
bis(2-chloroethyl) ether	RW-03	2013	0.066
bis(2-chloroethyl) ether	RW-06	2018	0.05
bis(2-ethylhexyl) phthalate	RW-01	2018	2.42†
bis(2-ethylhexyl) phthalate	RW-02	2018	1.24†
bis(2-ethylhexyl) phthalate	RW-03	2018	1.03†
bis(2-ethylhexyl) phthalate	RW-04	2018	1.14†
bis(2-ethylhexyl) phthalate	RW-06	2018	1.04†
bromodichloromethane	RW-03	2013	2.9
dibromochloromethane	RW-03	2013	1.1

µg/L: micrograms per liter, †Concentration estimated

The maximum concentration detected of each of these chemicals was screened for potential health risk using ATSDR's Public Health Assessment Site Tool (PHAST) (see *Attachment I. PHAST Report for Private Well Results*). The default residential exposure scenario was used. Since these chemicals were detected only sporadically, acute and intermediate duration exposures were assessed where health-based standards were available. For BCEE, no intermediate or acute health-based standard was available, so chronic exposure was evaluated.

For the acute exposure scenario, no potential health hazards were found because all estimated acute doses were below ATSDR's acute oral minimal risk level (MRL). Therefore, harmful effects are unlikely from exposures shorter than 2 weeks.

For the intermediate exposure scenario, in all the wells where bis(2-ethylhexyl) phthalate was found in 2018, the hazard quotient (HQ) exceeded 1 for at least one age group (see Table 4 below).

Table 4. Hazard quotients for intermediate duration exposure to bis(2-ethylhexyl) phthalate in residential wells.

Well	Concentration (µg/L)	Intermediate Hazard Quotient	Affected Group	Exposure Intensity
RW-01	2.42	1.8	<1 year	CTE
RW-01		1.0–3.4	Birth – <6 years old and breastfeeding women	RME
RW-02	1.24	1.8	<1 year	RME

RW-03	1.03	1.5	<1 year	RME
RW-04	1.14	1.6	<1 year	RME
RW-06	1.04	1.5	<1 year	RME

µg/L: micrograms per liter, CTE: central tendency exposure, RME: reasonable maximum exposure

An HQ greater than one means that further toxicological evaluation is needed to determine if harmful effects might be possible. Since the highest concentration had an HQ greater than one, concentrations found in each of the wells were evaluated. Residential Well 1 (RW-01) had the highest concentration, and the HQ exceeded 1 for the central tendency exposure (CTE, estimated average exposure) for infants under 1 year old. For the reasonable maximum exposure scenario (RME, the highest expected exposure) the HQ was exceeded for children under 6 years old and for breastfeeding women. For the remaining wells, the HQ only exceeded 1 for RME for infants under one year old.

When HQs exceed 1, we conduct a more in-depth toxicological evaluation to determine if harmful effects might be possible. Therefore, we compared estimated exposures in young children to exposures in animals that cause harmful effects. We used animal studies since studies in human are not available. The estimated exposures that exceeded ATSDR's intermediate oral minimal risk level ranged from 0.00012 to 0.00034 milligrams per kilogram of body weight per day (mg/kg/day) (see *Attachment I. PHAST Report for Private Well Results*). These doses are well below the lowest observed adverse effect level (LOAEL) of 0.04 mg/kg/day identified in rodent studies. Because the estimated daily doses are below the LOAEL, harmful effects are not likely in young children. The estimated exposure in adults, including pregnant women, are below ATSDR's minimal risk level of 0.0001 mg/kg/day; therefore, noncancerous health effects in adults are not likely.

In addition, a person would only be expected to be at risk for health effects if they were exposed to that concentration in drinking water for the time periods assumed in the hazard quotient calculations. Due to the detection of bis(2-ethylhexyl) phthalate in residential wells in 2018, but not in the years before or after, and because its common use is as a plasticizer, it is likely that results from 2018 represent contaminated sampling tubes or lab equipment and that no actual exposure occurred. Future sampling will help to confirm if this is the case.

For the chronic exposure scenario for BCEE, there was an estimated cancer risk just exceeding 1×10^{6} for residents who drank contaminated water for several decades This means in a group of one million people consuming water with that BCEE concentration continually for several decades, there would be one additional case of cancer over their lifetime. However, BCEE has not been found consistently in residential wells, so residents have not been drinking it at these concentrations for more than a short period of time. Drinking water from a well that only briefly exceeded the CV for BCEE is not expected to harm people's health because this requires drinking water containing BCEE above the CV for a long period of time. Bromodichloromethane and dibromochloromethane were both found in RW-03 in 2013, and for the chronic exposure scenario also had cancer risks exceeding 1×10^{6}. Since these were only found in one year of the ten years of sampling, drinking water from RW-03 is not expected to harm people's health because this requires drinking water with these chemicals above their CV for a long period of time.

Summary of Limitations and Uncertainties

Since there are many emerging contaminants of concern that are not currently regulated, it is possible some of these emerging contaminants are present in groundwater. Planned sampling for PFAS will help address these emerging contaminants.

Having sampling only on an annual basis makes it difficult to determine the duration of potential exposures. Looking at the totality of the sampling done can help evaluate whether people were exposed for a long enough time to harm their health.

Currently it cannot be determined if vinyl chloride exceeds the CV in residential wells, since the limit of detection is 0.5 µg/L, which exceeds the CV.

Conclusions

Based on the evaluation of environmental sampling data, VDH concludes **drinking water from residential wells near Greenwood Chemical Company is not expected to harm people's health.** The reason for this is chemicals are not detected consistently in these wells, and the concentrations of chemicals detected are below levels of health concern. In one year, bis(2-ethylhexyl) phthalate was detected at levels that required further evaluation. However, this contaminant was only found during that one year of analysis. Because bis(2-ethylhexyl) phthalate was not detected at any other time during the ten years of analysis, the data suggest that this detection was probably due to a laboratory contaminant and was not actually present in residential wells.

Recommendations

VDH recommends DEQ:

- Continue encouraging the residents to participate in the voluntary monitoring of residential drinking water wells near the Greenwood site as part of the site's Operation and Maintenance (O&M) plan.
- Evaluate feasibility of laboratory analysis of vinyl chloride to accurately measure at levels below the comparison value (CV) of 0.017 µg/L. The current method can only detect vinyl chloride at concentrations exceeding 0.5 µg/L.

The Virginia Department of Health (VDH) prepared this Letter Health Consultation for the Greenwood Chemical Co. site, located in Newtown, Albemarle County, Virginia. This publication was made possible by a cooperative agreement (program # CDC-RFA-TS-23-0001) with the federal Agency for Toxic Substances and Disease Registry (ATSDR). VDH evaluated data of known quality using approved methods, policies, and procedures existing at the time of publication. ATSDR reviewed this document and concurs with its findings based on the information presented by VDH.

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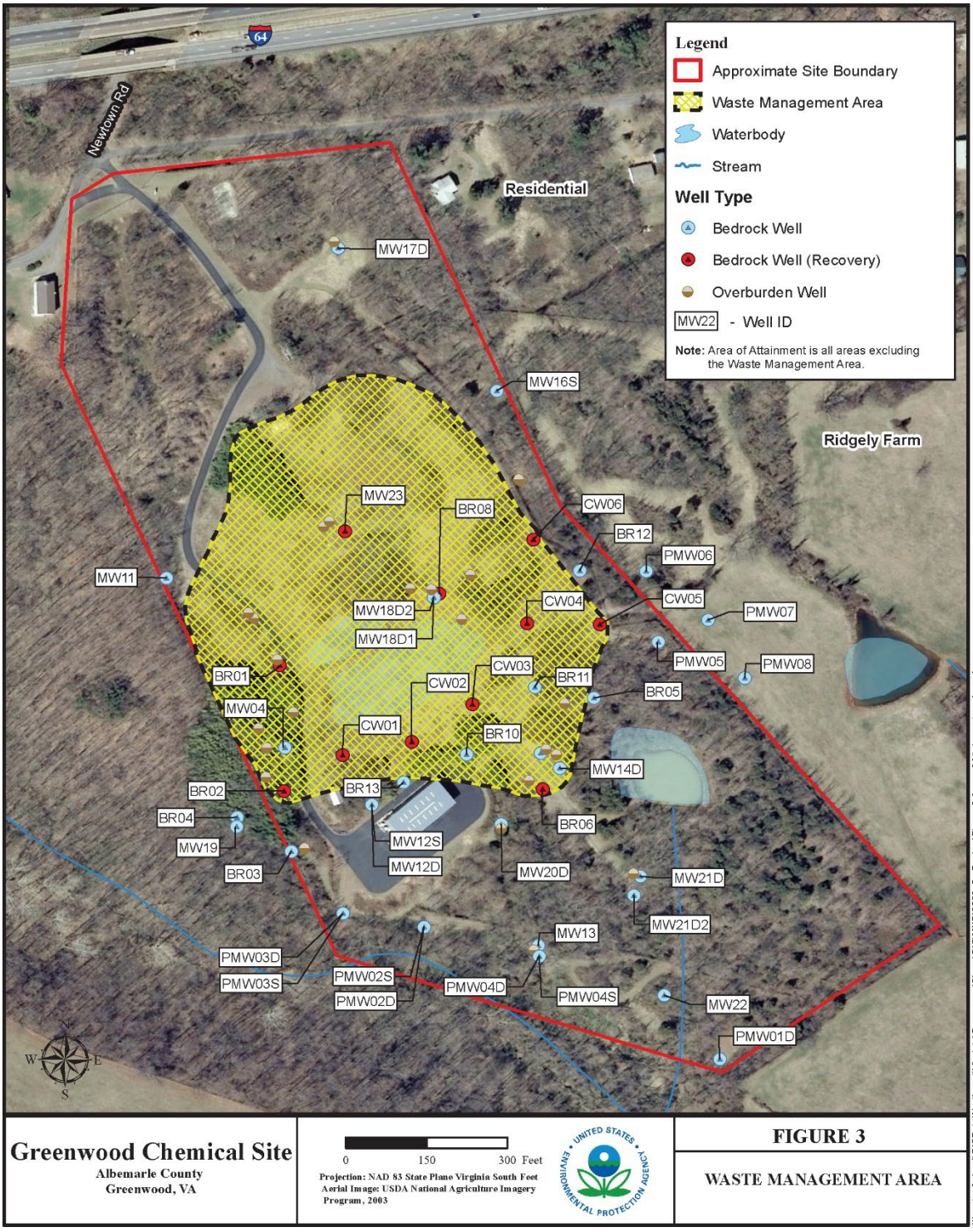
[9] United States Environmental Protection Agency, Region III. Sixth Five-Year Review Report for Greenwood Chemical Superfund Site, Albemarle County, Virginia. August 31, 2023.

[10] United States Environmental Protection Agency. Superfund Proposed Remedial Action Plan. Greenwood Chemical Site Operable Unit Two and Four, Albemarle County, Virginia. June 2005.

Attachment A. Map of Site Prior to EPA Action

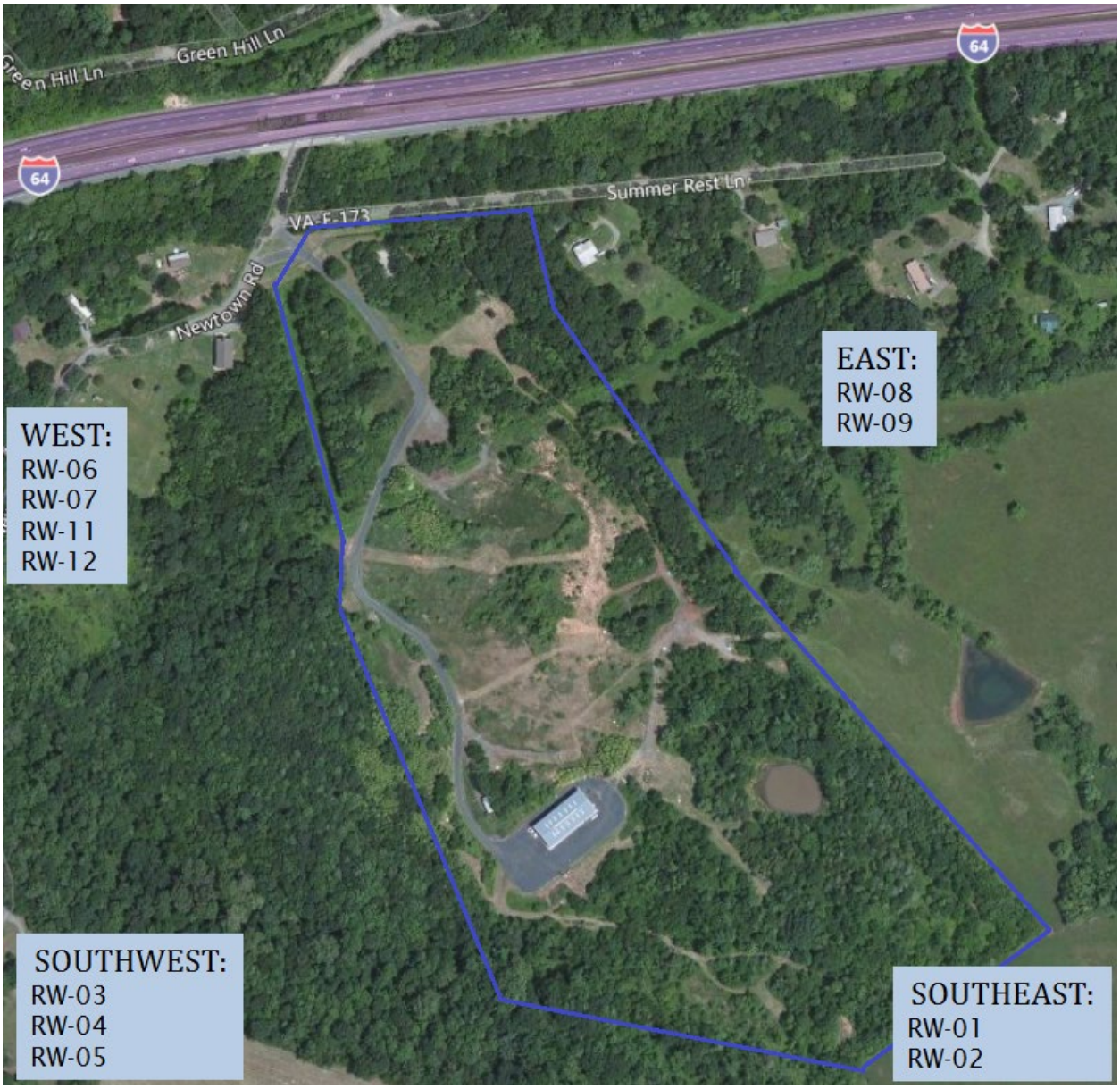
Source: Sixth Five-Year Review Report for Greenwood Chemical Superfund Site, Albemarle County, Virginia.

Attachment B. Map of Site Following EPA Action



Source: Sixth Five-Year Review Report for Greenwood Chemical Superfund Site, Albemarle County, Virginia.

Attachment C. Residential well distribution



Source: www.mapquest.com, accessed January 19, 2017.

Attachment D. Volatile and Semivolatile Chemicals Assessed in Residential Sampling

Acenaphthene	Dibenzofuran	Methyl *tert*-butyl ether
Acenaphthylene	1,2-Dibromo-3-chloropropane	4-Methyl-2-pentanone
Acetone	Dibromochloromethane	Methylcyclohexane
Acetophenone	1,2-Dibromoethane	Methylene chloride
Anthracene	Di-n-butylphthalate	2-Methylnaphthalene
Atrazine	1,2-Dichlorobenzene	2-Methylphenol
Benzaldehyde	1,3-Dichlorobenzene	4-Methylphenol
Benzene	1,4-Dichlorobenzene	Naphthalene
Benzo(a)anthracene	3,3'-Dichlorobenzidine	2-Nitroaniline
Benzo(a)pyrene	Dichlorodifluoromethane	3-Nitroaniline
Benzo(b)fluoranthene	1,1-Dichloroethane	4-Nitroaniline
Benzo(g,h,i)perylene	1,2-Dichloroethane*	Nitrobenzene
Benzo(k)fluoranthene	1,1-Dichloroethene	2-Nitrophenol
1,1'-Biphenyl	cis-1,2-Dichloroethene	4-Nitrophenol
Bis(2-chloroethoxy)methane	trans-1,2-Dichloroethene	N-Nitroso-di-n-propylamine
Bis(2-chloroethyl)ether*	2,4-Dichlorophenol	N-Nitrosodiphenylamine
Bis(2-ethylhexyl)phthalate	1,2-Dichloropropane	2,2'-Oxybis(1-chloropropane)
Bromochloromethane	cis-1,3-Dichloropropene	Pentachlorophenol
Bromodichloromethane	trans-1,3-Dichloropropene	Phenanthrene
Bromoform	Diethylphthalate	Phenol
Bromomethane	2,4-Dimethylphenol	Pyrene
4-Bromophenyl-phenylether	Dimethylphthalate	Styrene
2-Butanone	4,6-Dinitro-2-methylphenol	1,2,4,5-Tetrachlorobenzene
Butylbenzylphthalate	2,4-Dinitrophenol	1,1,2,2-Tetrachloroethane
Caprolactam	2,4-Dinitrotoluene	Tetrachloroethylene*
Carbazole	2,6-Dinitrotoluene	2,3,4,6-Tetrachlorophenol
Carbon disulfide	Di-n-octylphthalate	Toluene
Carbon tetrachloride*	Ethylbenzene	1,2,3-Trichlorobenzene
4-Chloroaniline	Fluoranthene	1,2,4-Trichlorobenzene
Chlorobenzene	Fluorene	1,1,1-Trichloroethane
Chloroethane	Freon	1,1,2-Trichloroethane
Chloroform	Hexachlorobenzene	Trichloroethylene*
Chloromethane	Hexachlorobutadiene	Trichlorofluoromethane
4-Chloro-3-methylphenol	Hexachlorocyclopentadiene	2,4,5-Trichlorophenol
2-Chloronaphthalene	Hexachloroethane	2,4,6-Trichlorophenol
2-Chlorophenol	2-Hexanone	Vinyl chloride*
4-Chlorophenyl-phenylether	Indeno(1,2,3-cd)pyrene	*m*+*p*-Xylene
Chrysene	Isophorone	*o*-Xylene
Cyclohexane	Isopropylbenzene	-
Dibenz(a,h)anthracene	Methyl acetate	-

*Compound is included on the list of COCs.

Attachment E. Chemicals Detected in Residential Wells

Compound	Well	Years	Result (µg/L)	CV (µg/L)	CV Type
bis(2-chloroethyl) ether	RW-03	2013	0.066*	0.022	CREG
bis(2-chloroethyl) ether	RW-06	2018	0.05*	0.022	CREG
bis(2-ethylhexyl) phthalate	RW-01	2018	2.42*†	0.71	Intermediate EMEG, Child
bis(2-ethylhexyl) phthalate	RW-02	2018	1.24*†	0.71	Intermediate EMEG, Child
bis(2-ethylhexyl) phthalate	RW-03	2018	1.03*†	0.71	Intermediate EMEG, Child
bis(2-ethylhexyl) phthalate	RW-04	2018	1.14*†	0.71	Intermediate EMEG, Child
bis(2-ethylhexyl) phthalate	RW-06	2018	1.04*†	0.71	Intermediate EMEG, Child
bromodichloromethane	RW-03	2013	2.9*	0.39	CREG
bromoform	RW-02	2013	0.3†	80	EPA MCL, total trihalomethanes
bromoform	RW-03	2013	4†	80	EPA MCL, total trihalomethanes
2-butanone	RW-03	2013	4†	4,200	Chronic RMEG, child
chloroform	RW-03	2013	7.5	0.062	CREG, Shower
2-chlorophenol	RW-06	2018	1.06†	35	Chronic RMEG, child
cyclohexane	RW-03	2015	0.2†	NA	NA
dibromochloromethane	RW-03	2013	1.1*	0.29	CREG
di-n-octyl-phthalate	RW-03	2023	28	2,800	Intermediate EMEG, child
methylene chloride	RW-02	2015	0.3†	6.4	CREG
methylene chloride	RW-04	2015	0.3†	6.4	CREG
methylene chloride	RW-07	2015	0.3†	6.4	CREG
methylene chloride	RW-10	2015	0.3†	6.4	CREG
methylene chloride	RW-12	2015	0.3†	6.4	CREG
methyl-t-butyl ether	RW-01	2020	0.34†	2,100	Intermediate EMEG, child
methyl-t-butyl ether	RW-07	2013	0.1†	2,100	Intermediate EMEG, child
methyl-t-butyl ether	RW-07	2014	0.4†	2,100	Intermediate EMEG, child
methyl-t-butyl ether	RW-07	2015	0.5	2,100	Intermediate EMEG, child
methyl-t-butyl ether	RW-07	2016	0.5	2,100	Intermediate EMEG, child
methyl-t-butyl ether	RW-07	2018	0.48†	2,100	Intermediate EMEG, child
methyl-t-butyl ether	RW-07	2023	0.4	2,100	Intermediate EMEG, child
phenanthrene	RW-01	2020	1.13	NA	NA
phenanthrene	RW-02	2022	1.01	NA	NA
1,2,3-trichlorobenzene	RW-01	2015	0.1†	1.6	EPA Ingestion RSL, child, THQ 0.1
1,2,4-trichlorobenzene	RW-01	2015	0.3†	710	Chronic RMEG, child
o-xylene	RW-03	2015	0.1†	340	MCL (total xylenes)

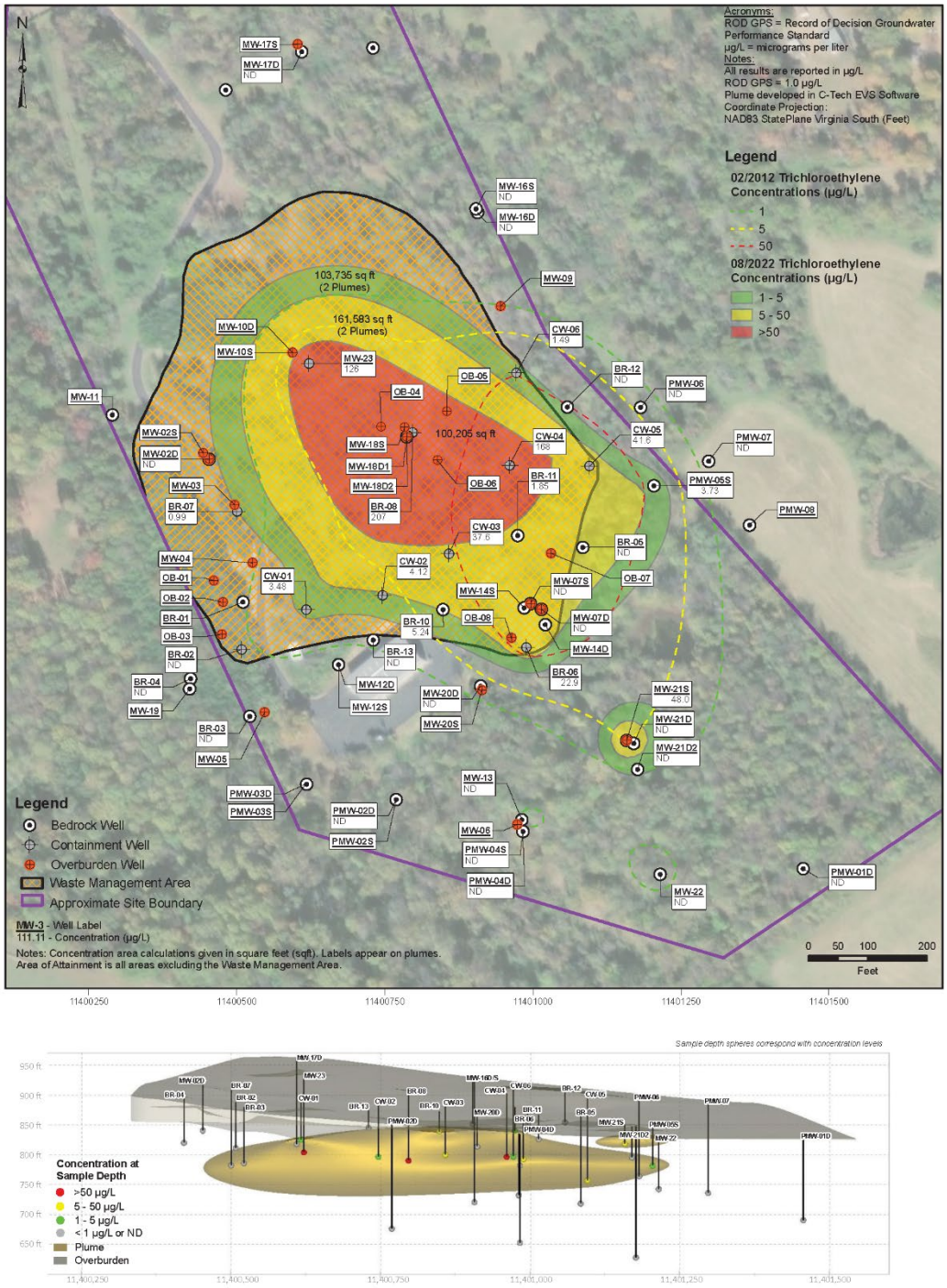
µg/L: micrograms/liter, * Results exceed the CV, † Concentration estimated, CREG: cancer risk evaluation guide, EMEG: environmental media evaluation guide, EPA: Environmental Protection Agency, RMEG: reference dose media evaluation guide, RSL: regional screening level, THQ: target hazard quotient, MCL: maximum contaminant level, NA: not available

Attachment F. Residential Well Results by Year

Well	Analyte	Years	Result (ug/L)	CV (µg/L)	CV Type
RW-01	bis (2-ethylhexyl) phthalate	2018	2.42*†	0.71	Intermediate EMEG, Child
RW-01	methyl-t-butyl ether (MTBE)	2020	0.34†	2,800	Intermediate EMEG, child
RW-01	phenanthrene	2020	1.13	NA	NA
RW-01	1,2,3-trichlorobenzene	2015	0.1†	NA	NA
RW-01	1,2,4-trichlorobenzene	2015	0.3†	720	Chronic EMEG, child
RW-02	bis (2-ethylhexyl) phthalate	2018	1.24*†	0.71	Intermediate EMEG, Child
RW-02	bromoform	2013	0.3†	80	EPA MCL, total trihalomethanes
RW-02	methylene chloride	2015	0.3†	6.4	CREG
RW-02	phenanthrene	2022	1.01	NA	NA
RW-03	bis (2-chloroethyl) ether	2013	0.066*	0.022	CREG
RW-03	bis (2-ethylhexyl) phthalate	2018	1.03*†	0.71	Intermediate EMEG, Child
RW-03	bromodichloromethane	2013	2.9*	0.39	CREG
RW-03	bromoform	2013	4*†	80	EPA MCL, total trihalomethanes
RW-03	2-butanone	2013	4†	4,200	Chronic RMEG, child
RW-03	chloroform	2013	7.5	0.062	CREG Shower
RW-03	cyclohexane	2015	0.2†	NA	NA
RW-03	dibromochloromethane	2013	1.1*	0.29	CREG
RW-03	di-n-octyl-phthalate	2023	28	2,800	Intermediate EMEG, child
RW-03	o-xylene	2015	0.1†	340	EMEG Shower
RW-04	bis (2-ethylhexyl) phthalate	2018	1.14*†	0.71	Intermediate EMEG, Child
RW-04	methylene chloride	2015	0.3†	6.4	CREG
RW-06	2-chlorophenol	2018	1.06†	35	Chronic RMEG, child
RW-06	bis (2-chloroethyl) ether	2018	0.05*	0.022	CREG
RW-06	bis (2-ethylhexyl) phthalate	2018	1.04*	0.71	Intermediate EMEG, Child
RW-07	methylene chloride	2015	0.3†	6.4	CREG
RW-07	methyl-t-butyl ether (MTBE)	2013	0.1†	2,100	Intermediate EMEG, child
RW-07	methyl-t-butyl ether (MTBE)	2014	0.4†	2,100	Intermediate EMEG, child
RW-07	methyl-t-butyl ether (MTBE)	2015	0.5	2,100	Intermediate EMEG, child
RW-07	methyl-t-butyl ether (MTBE)	2016	0.5	2,100	Intermediate EMEG, child
RW-07	methyl-t-butyl ether (MTBE)	2018	0.48†	2,100	Intermediate EMEG, child
RW-07	methyl-t-butyl ether (MTBE)	2023	0.4	2,100	Intermediate EMEG, child
RW-10	methylene chloride	2015	0.3†	6.4	CREG
RW-12	methylene chloride	2015	0.3†	6.4	CREG

µg/L: micrograms/liter, * Results exceed the CV, † Concentration estimated, CREG: cancer risk evaluation guide, EMEG: environmental media evaluation guide, EPA: Environmental Protection Agency, RMEG: reference dose media evaluation guide, RSL: regional screening level, THQ: target hazard quotient, MCL: maximum contaminant level, NA: not available

Attachment G. TCE Plume Modeling, August 2022



Retaw Engineering A GLOBAL WATER PRACTICE 3400 Lady Marian Court Midlothian, Virginia 23113 Phone: (804) 744-1792 Website: http://www.retaweng.com	CHECK BY: TL DRAWN BY: MD DATE: 8/14/2023 SCALE: 1:1,600 CRD SYS: VA STATE PLANE PRJ NO: 1575101	Trichloroethyene Results August 2022 GREENWOOD CHEMICAL SUPERFUND SITE GREENWOOD, VIRGINIA 22943	APEX EA	FIGURE 5

Source: Sixth Five-Year Review Report for Greenwood Chemical Superfund Site, Albemarle County, Virginia.

Attachment H. Perimeter Groundwater Monitoring Well Detections, 2012–2023

Monitoring Well 13 (concentrations µg/L)

Contaminant	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	CV	GPS
Benzene	0.2†	0.2†	0.2†	0.2†	0.2†	0.2†	<0.4	<0.4	<0.4	<0.4	<0.4	0.17	ND
Carbon tetrachloride	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	0.22	4
Chlorobenzene	0.35†	0.3†	0.3†	0.3†	0.2†	0.2†	<0.1	0.25†	0.26†	<0.1	<0.1	—	ND
Chloroform	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	—	ND
1,2-Dichlorobenzene	0.47†	0.4†	0.4†	0.3†	0.2†	0.3†	<0.2	0.29	<0.2	0.33†	0.39†	—	ND
1,2-Dichloroethane	0.1†	0.1†	0.2†	0.2†	0.1†	0.1	<0.3	<0.3	<0.3	<0.3	<0.3	0.076	5
Methylene chloride	0.37‡	<0.2	<0.2	<0.2	<0.2	<0.2	<1.0	<1.0	<1.0	<1.0	<1.0	6.4	ND
Tetrachloroethylene	0.4†	0.3†	0.4†	0.3†	0.1†	0.1†	<0.4	<0.4	<0.4	<0.4	<0.4	5.3	0.8
Toluene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	—	ND
Trichloroethylene	1.4*	1.5*	1.5*	1.1*	0.9*	1.0*	1.1*	1.02*	0.21†*	1.0*	<0.2	0.21	1
Vinyl chloride	0.2*†	0.2*†	0. 1*†	0.1*†	<0.1	0.1	<0.5	<0.5	<0.5	<0.5	<0.5	0.017	0.5
Bis(2-chloroethyl) ether	0.067*	0.057*	0.071*	0.057*	<0.01	0.048*†	<0.01	<0.01	<0.01	<0.01	<0.01	0.022	0.5
Bis(2-ethylhexyl) phthalate	<2	<2	<2	3	<2	1.07	<1.02	<1.00	<1.00	<1.00	<0.99	1.7	ND
Naphthalene	0.7	<0.1	<0.1	<0.1	0.2	<0.1	<2.00	<2.04	<2.00	<2.00	<1.98	—	ND

When multiple measurements are available for a year, the highest detectable is given. All values were below non-cancer health effects CVs.
CV: Comparison value. GPS: Groundwater Performance Standard (risk-based site-specific standard). ND: not determined. µg/L: micrograms per liter.
† Concentration estimated.
‡ Not detected substantially above the level reported for field blanks.
* Exceeds the CREG (cancer risk evaluation guide).

Monitoring Well 21D (concentrations µg/L)

Contaminant	***2012***	***2013***	***2014***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***	***2021***	***2022***	***CV***	***GPS***
Benzene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.4	<0.4	<0.4	<0.4	<0.4	0.17	ND
Carbon tetrachloride	0.2†	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	0.22	4
Chlorobenzene	0.44†	0.5†	0.4†	<0.1	0.3†	<0.1	<0.1	0.19†	<0.1	<0.1	<0.1	—	ND
Chloroform	0.3†	0.1†	0.1†	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	—	ND
1,2-Dichlorobenzene	0.29†	0.1†	0.1†	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	—	ND
1,2-Dichloroethane	0.32†	0.4†	0.3†	0.2†	0.2†	<0.1	<0.3	<0.3	<0.3	<0.3	<0.3	0.076	5
Methylene chloride	0.23‡	<0.2	<0.2	<0.2	<0.2	<0.2	<1.0	<1.0	<1.0	<4.0	<1.0	6.4	ND
Tetrachloroethylene	0.63‡	0.3†	0.3†	0.2†	0.3†	0.3†	<0.4	<0.4	<0.4	<0.4	<0.4	5.3	0.8
Toluene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	—	ND
Trichloroethylene	1.3*	1.6*	1.6*	0.9*	1.1*	1.0*	0.67*	0.81*	<0.2	0.24†	<0.2	0.21	1
Vinyl chloride	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	0.017	0.5
Bis(2-chloroethyl) ether	0.13*	0.26*	0.17*	0.21*	0.18*	0.077*	0.13	0.04	<0.010	<0.01	0.06	0.022	0.5
Bis(2-ethylhexyl) phthalate	<2	<2	<2	<2	<2	<1.00	1.0†	<1.04	<1.00	<1.00	<0.97	1.7	ND
Naphthalene	<0.1	<0.1	<0.1	<0.1	<0.1	<2.00	<2.00	<2.08	<2.00	<2.00	<1.94	—	ND

When multiple measurements are available for a year, the highest detectable is given. All values were below non-cancer health effects CVs.
CV: Comparison value. GPS: Groundwater Performance Standard (risk-based site-specific standard). ND: not determined. µg/L: micrograms per liter.
† Concentration estimated.
‡ Not detected substantially above the level reported for field blanks.
* Exceeds the CREG (cancer risk evaluation guide).

Monitoring Well 21D2 (concentrations µg/L)

Contaminant	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	CV	GPS†
Benzene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.4	<0.4	<0.4	<0.4	<0.4	0.17	ND
Carbon tetrachloride	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	5.69*	<0.2	<0.2	0.22	4
Chlorobenzene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	—	ND
Chloroform	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	0.69	<0.2	<0.2	—	ND
1,2-Dichlorobenzene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	—	ND
1,2-Dichloroethane	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.3	<0.3	<0.3	<0.3	<0.3	0.076	5
Methylene chloride	0.26‡	<0.2	<0.2	<0.2	<0.2	<0.2	<1.0	<1.0	<1.0	<4.0	<1.0	6.4	ND
Tetrachloroethylene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.4	<0.4	1.12	<0.4	<0.4	5.3	0.8
Toluene	0.1†	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	—	ND
Trichloroethylene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	5.04*	<0.2†	<0.2	0.21	1
Vinyl chloride	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	0.017	0.5
Bis(2-chloroethyl) ether	0.039†	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.022	0.5
Bis(2-ethylhexyl) phthalate	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.7	ND
Naphthalene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<2.0	<2.0	<2.0	<2.0	<2.0	—	ND

When multiple measurements are available for a year, the highest detectable is given. All values were below non-cancer health effects CVs.
CV: Comparison value. GPS: Groundwater Performance Standard (risk-based site-specific standard). ND: not determined. µg/L: micrograms per liter.
† Concentration estimated.
‡ Not detected substantially above the level reported for field blanks.
* Exceeds the CREG (cancer risk evaluation guide).

Monitoring Well 22 (concentrations µg/L)

Contaminant	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	CV	GPS†
Benzene	0.2†	0.2†	0.2†	0.2†	0.2†	<0.1	<0.4	<0.4	<0.4	<0.4	<0.4	0.17	ND
Carbon tetrachloride	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	0.22	4
Chlorobenzene	0.7	1.7	*0.5*†	0.5	0.8	<0.1	0.64	<0.1	<0.1	<0.1	<0.1	—	ND
Chloroform	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	—	ND
1,2-Dichlorobenzene	0.23†	0.4†	0.2†	0.2†	0.2†	0.2†	<0.2	<0.2	<0.2	<0.2	<0.2	—	ND
1,2-Dichloroethane	0.8*	1.7*	0.5*†	*0.1*	0.7*	0.2†	<0.3	<0.3	<0.3	<0.3	<0.3	0.076	5
Methylene chloride	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<1.0	<1.0	<1.0	<1.0	<1.0	6.4	ND
Tetrachloroethylene	0.9*	0.7	0.6	0.2†	<0.1	<0.1	<0.4	<0.4	<0.4	<0.4	<0.4	5.3	0.8
Toluene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	—	ND
Trichloroethylene	2*	2.3*	0.9*	0.6*	0.1†	<0.1	0.69	<0.2	<0.2	<0.2	<0.2	0.21	1
Vinyl chloride	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	0.017	0.5
Bis(2-chloroethyl) ether	0.03*†	0.7*	0.17*	0.15*	0.22*	0.12*	0.08*	0.04*	<0.01	0.01	<0.01	0.022	0.5
Bis(2-ethylhexyl) phthalate	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<1.0	<1.0	<1.0	<1.0	<0.98	1.7	ND
Naphthalene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<2.0	<2.0	<2.0	<2.0	<1.96	—	ND

When multiple measurements are available for a year, the highest detectable is given. All values were below non-cancer health effects CVs.
CV: Comparison value. GPS: Groundwater Performance Standard (risk-based site-specific standard). ND: not determined. µg/L: micrograms per liter.
† Concentration estimated.
* Exceeds the CREG (cancer risk evaluation guide).

Perimeter Monitoring Well 1D (concentrations µg/L)

Contaminant	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	CV	GPS†
Benzene	<0.1	<0.1	<0.1	0.2†	0.2†	<0.1	<0.4	<0.4	<0.4	<0.4	<0.4	0.17	ND
Carbon tetrachloride	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	0.22	4
Chlorobenzene	0.52†	<0.1	0.1†	0.3†	0.4†	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	—	ND
Chloroform	0.1†	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	—	ND
1,2-Dichlorobenzene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	—	ND
1,2-Dichloroethane	3.20*	0.2	1.5*	0.2†	1.3*	<0.1	0.77*	1.85*	<0.3	<0.3	<0.3	0.076	5
Methylene chloride	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<1.0	<1.0	<1.0	<4.0	<4.0	6.4	ND
Tetrachloroethylene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.4	<0.4	<0.4	<0.4	5.3	0.8
Toluene	<0.1	<0.1	0.3†	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	—	ND
Trichloroethylene	0.5*†	0.3†	0.2†	0.1†	0.1	<0.1	<0.2	0.62*	0.41†	<0.2	<0.2	0.21	1
Vinyl chloride	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	0.017	0.5
Bis(2-chloroethyl) ether	0.96*	0.16*	0.6*†	0.043*†	0.56*	<0.01	0.06*	0.38*	0.28*	<0.01	<0.01	0.022	0.5
Bis(2-ethylhexyl) phthalate	<2.0	<2.0	<2.0	<2.0	<2.0	<1.0	<1.0	<1.04	<1.08	<1.0	<1.0	1.7	ND
Naphthalene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<2.0	<2.04	<2.15	<2.0	<2.0	—	ND

When multiple measurements are available for a year, the highest detectable is given. All values were below non-cancer health effects CVs.
CV: Comparison value. GPS: Groundwater Performance Standard (risk-based site-specific standard). ND: not determined. µg/L: micrograms per liter.
† Concentration estimated.
* Exceeds the CREG (cancer risk evaluation guide).

Perimeter Monitoring Well 4D (concentrations µg/L)

Contaminant	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	CV	GPS†
Benzene	0.2†	0.2†	0.2†	0.1†	0.1†	0.1†	<0.4	<0.4	<0.4	<0.4	<0.4	0.17	ND
Carbon tetrachloride	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	0.21†	<0.2	<0.2	0.22	4
Chlorobenzene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	—	ND
Chloroform	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	0.5	<0.2	<0.2	—	ND
1,2-Dichlorobenzene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	—	ND
1,2-Dichloroethane	0.3†	0.2†	0.2†	0.1†	<0.1	0.2†	<0.3	<0.3	<0.3	<0.3	<0.3	0.076	5
Methylene chloride	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<1.0	<1.0	<1.0	<4.0	<4.0	6.4	ND
Tetrachloroethylene	0.3†	<0.1	<0.1	0.1†	0.1†	<0.2	<0.4	<0.4	<0.4	<0.4	<0.4	5.3	0.8
Toluene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	—	ND
Trichloroethylene	0.5†	0.4†	0.4†	0.2†	0.3†	0.1†	<0.2	<0.2	0.24†	0.21†	0.21†	0.21	1
Vinyl chloride	0.2†	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5	<0.5	0.017	0.5
Bis(2-chloroethyl) ether	0.063*	0.049*†	<0.5	0.044*†	0.049*†	<0.1	<0.5	<0.1	<0.1	<0.1	<0.1	0.022	0.5
Bis(2-ethylhexyl) phthalate	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<1.01	<1.02	<1.1	<2.0	0.21†	1.7	ND
Naphthalene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<2.02	<2.04	<2.2	<4.0	<2.0	—	ND

When multiple measurements are available for a year, the highest detectable is given. All values were below non-cancer health effects CVs.
CV: Comparison value. GPS: Groundwater Performance Standard (risk-based site-specific standard). ND: not determined. µg/L: micrograms per liter.
† Concentration estimated.
* Exceeds the CREG (cancer risk evaluation guide).

Attachment I. PHAST Report for Private Well Results

PHAST PUBLIC HEALTH ASSESSMENT SITE TOOL

Default Parameters Table
PHAST Report, v2.3.0.0, October 16, 2023

Equations

Water Ingestion Exposure Dose Equation

$$D_{noncancer} = (C \times IR \times EF_{noncancer}) \div BW \quad \textbf{Equation 1}$$

$D_{noncancer}$ = dose (mg/kg/day), C = contaminant concentration (mg/L), IR = intake rate (L/day), $EF_{noncancer}$ = exposure factor (unitless), BW = body weight (kg)

Hazard Quotient

$$HQ = D_{noncancer} \div HG \quad \textbf{Equation 2}$$

HQ = hazard quotient, $D_{noncancer}$ = dose (mg/kg/day), HG = health guideline (e.g., oral MRL, RfD)

Cancer Risk Equations

$$CR = D_{noncancer} \times CSF \times (ED \div LY) \quad \textbf{Equation 3}$$

$$\text{ADAF-adjusted CR} = (D_{noncancer} \times CSF) \times (ED \div LY) \times ADAF \quad \textbf{Equation 4}$$

$$\text{Total CR} = \text{Sum of the CR for all exposure groups} \quad \textbf{Equation 5}$$

CR = cancer risk (unitless), $D_{noncancer}$ = dose, CSF = oral cancer slope factor $[(mg/kg/day)^{-1}]$, EF (cancer) = exposure factor (cancer) calculated as follows: EF (noncancer; unitless) x exposure group specific exposure duration (years) ÷ lifetime of 78 years, ADAF = age-dependent adjustment factor (unitless), ED = exposure duration (years), LY = lifetime years (78 years)

Default Exposure Factors

Duration Category	Days per Week	Weeks per Year	Years	Exposure Group Specific $EF_{noncancer}$	Exposure Group Specific* EF_{cancer}
Acute	-	-	-	1	-
Intermediate	7	-	-	1	-
Chronic	7	52.14	See exposure group specific exposure durations	1	= $EF_{noncancer}$ x Exposure Duration for $Cancer_{Exposure\ Group}$ (years) ÷ 78 years

Abbreviations: EF = exposure factor; NC = not calculated

* Cancer risk is averaged over a lifetime of exposure (78 years).

Default Exposure Parameters

Exposure Group	Body Weight (kg)	CTE Exposure Duration (yrs)	CTE Intake Rate (liters/day)	RME Exposure Duration (yrs)	RME Intake Rate (liters/day)
Birth to < 1 year	7.8	1	0.595	1	1.106
1 to < 2 years	11.4	1	0.245	1	0.658
2 to < 6 years	17.4	4	0.337	4	0.852
6 to < 11 years	31.8	5	0.455	5	1.258
11 to < 16 years	56.8	1	0.562	5	1.761
16 to < 21 years	71.6	0	0.722	5	2.214
Total Child (all age groups)	-	12	-	21	-
Adult	80	12	1.313	33	3.229
Pregnant Women	73	-	1.158	-	2.935
Breastfeeding Women	73	-	1.495	-	3.061

Abbreviations: CTE = central tendency exposure (typical); kg = kilograms; RME = reasonable maximum exposure (higher)

Contaminant Information

Contaminant Name	Entered Concentration	EPC Type	Converted Concentration*
Bis(2-chloroethyl) ether	0.066 µg/L	Maximum	6.6E-05 mg/L
Bis(2-ethylhexyl)phthalate	2.42 µg/L	Maximum	0.0024 mg/L
Bromodichloromethane	2.9 µg/L	Maximum	0.0029 mg/L
Bromoform	4 µg/L	Maximum	0.004 mg/L
Dibromochloromethane	1.1 µg/L	Maximum	0.0011 mg/L

Abbreviations: µg/L = micrograms per liter; EPC = exposure point concentration; mg/L = milligram chemical per liter water
* Contaminant concentration converted to standard unit for calculating exposure.

PUBLIC HEALTH ASSESSMENT SITE TOOL

Default Drinking Water Residential Results for Chronic and Intermediate Exposures
PHAST Report, v2.3.0.0, October 16, 2023

Drinking Water Ingestion Chronic (Default)

Bis(2-chloroethyl) ether

Table 19. Residential Default exposure doses for chronic exposure to bis(2-chloroethyl) ether in drinking water at 6.6E-05 mg/L along with cancer risk estimates*

Exposure Group	CTE Dose (mg/kg/day)	CTE Noncancer Hazard Quotient	CTE Cancer Risk	CTE Exposure Duration (yrs)	RME Dose (mg/kg/day)	RME Noncancer Hazard Quotient	RME Cancer Risk	RME Exposure Duration (yrs)
Birth to < 1 year	5.0E-06	-	-	1	9.4E-06	-	-	1
1 to < 2 years	1.4E-06	-	-	1	3.8E-06	-	-	1
2 to < 6 years	1.3E-06	-	-	4	3.2E-06	-	-	4
6 to < 11 years	9.4E-07	-	-	5	2.6E-06	-	-	5
11 to < 16 years	6.5E-07	-	-	1	2.0E-06	-	-	5
16 to < 21 years	6.7E-07	-	-	0	2.0E-06	-	-	5
Total Child	-	-	2.4E-7	12	-	-	8.4E-7	21
Adult	1.1E-06	-	1.8E-7	12	2.7E-06	-	1.2E-6 ‡	33
Pregnant Women	1.0E-06	-	-	-	2.7E-06	-	-	-
Breastfeeding Women	1.4E-06	-	-	-	2.8E-06	-	-	-
Birth to < 21 years plus 12 years during adulthood §	-	-	-	-	-	-	1.3E-6 ‡	33

Source: Greenwood Chemical Superfund Site Annual Operations, Maintenance, and Monitoring Report January 1, 2022 to December 31, 2022, Retaw Engineering LLC
Abbreviations: CTE = central tendency exposure (typical); mg/kg/day = milligram chemical per kilogram body weight per day; mg/L = milligram chemical per liter water; RME = reasonable maximum exposure (higher); yrs = years
* The calculations in this table were generated using ATSDR's PHAST v2.3.0.0. The cancer risks were calculated using the cancer slope factor of 1.1 $(mg/kg/day)^{-1}$.
‡ Indicates that the cancer risk exceeds one extra case in a million people similarly exposed, which ATSDR evaluates further.
§ This cancer risk represents a scenario where children are likely to continue to live in their childhood home as adults.

Bromodichloromethane

Table 21. Residential Default exposure doses for chronic exposure to bromodichloromethane in drinking water at 0.0029 mg/L along with noncancer hazard quotients and cancer risk estimates*

Exposure Group	CTE Dose (mg/kg/day)	CTE Noncancer Hazard Quotient	CTE Cancer Risk	CTE Exposure Duration (yrs)	RME Dose (mg/kg/day)	RME Noncancer Hazard Quotient	RME Cancer Risk	RME Exposure Duration (yrs)
Birth to < 1 year	0.00022	0.028	-	1	0.00041	0.051	-	1
1 to < 2 years	6.2E-05	0.0078	-	1	0.00017	0.021	-	1
2 to < 6 years	5.6E-05	0.0070	-	4	0.00014	0.018	-	4
6 to < 11 years	4.1E-05	0.0052	-	5	0.00011	0.014	-	5
11 to < 16 years	2.9E-05	0.0036	-	1	9.0E-05	0.011	-	5
16 to < 21 years	2.9E-05	0.0037	-	0	9.0E-05	0.011	-	5
Total Child	-	-	5.9E-7	12	-	-	2.1E-6 ‡	21
Adult	4.8E-05	0.0059	4.5E-7	12	0.00012	0.015	3.1E-6 ‡	33
Pregnant Women	4.6E-05	0.0058	-	-	0.00012	0.015	-	-
Breastfeeding Women	5.9E-05	0.0074	-	-	0.00012	0.015	-	-
Birth to < 21 years plus 12 years during adulthood §	-	-	-	-	-	-	3.2E-6 ‡	33

Source: Greenwood Chemical Superfund Site Annual Operations, Maintenance, and Monitoring Report January 1, 2022 to December 31, 2022, Retaw Engineering LLC
Abbreviations: CTE = central tendency exposure (typical); mg/kg/day = milligram chemical per kilogram body weight per day; mg/L = milligram chemical per liter water; RME = reasonable maximum exposure (higher); yrs = years
* The calculations in this table were generated using ATSDR's PHAST v2.3.0.0. The noncancer hazard quotients were calculated using the chronic (greater than 1 year) minimal risk level of 0.008 mg/kg/day and the cancer risks were calculated using the cancer slope factor of 0.062 $(mg/kg/day)^{-1}$.
‡ Indicates that the cancer risk exceeds one extra case in a million people similarly exposed, which ATSDR evaluates further.
§ This cancer risk represents a scenario where children are likely to continue to live in their childhood home as adults.

Dibromochloromethane

Table 24. Residential Default exposure doses for chronic exposure to dibromochloromethane in drinking water at 0.0011 mg/L along with noncancer hazard quotients and cancer risk estimates*

Exposure Group	CTE Dose (mg/kg/day)	CTE Noncancer Hazard Quotient	CTE Cancer Risk	CTE Exposure Duration (yrs)	RME Dose (mg/kg/day)	RME Noncancer Hazard Quotient	RME Cancer Risk	RME Exposure Duration (yrs)
Birth to < 1 year	8.4E-05	0.00093	-	1	0.00016	0.0017	-	1
1 to < 2 years	2.4E-05	0.00026	-	1	6.3E-05	0.00071	-	1
2 to < 6 years	2.1E-05	0.00024	-	4	5.4E-05	0.00060	-	4
6 to < 11 years	1.6E-05	0.00017	-	5	4.4E-05	0.00048	-	5
11 to < 16 years	1.1E-05	0.00012	-	1	3.4E-05	0.00038	-	5
16 to < 21 years	1.1E-05	0.00012	-	0	3.4E-05	0.00038	-	5
Total Child	-	-	3.0E-7	12	-	-	1.1E-6 ‡	21
Adult	1.8E-05	0.00020	2.3E-7	12	4.4E-05	0.00049	1.6E-6 ‡	33
Pregnant Women	1.7E-05	0.00019	-	-	4.4E-05	0.00049	-	-
Breastfeeding Women	2.3E-05	0.00025	-	-	4.6E-05	0.00051	-	-
Birth to < 21 years plus 12 years during adulthood §	-	-	-	-	-	-	1.6E-6 ‡	33

Source: Greenwood Chemical Superfund Site Annual Operations, Maintenance, and Monitoring Report January 1, 2022 to December 31, 2022, Retaw Engineering LLC
Abbreviations: CTE = central tendency exposure (typical); mg/kg/day = milligram chemical per kilogram body weight per day; mg/L = milligram chemical per liter water; RME = reasonable maximum exposure (higher); yrs = years
* The calculations in this table were generated using ATSDR's PHAST v2.3.0.0. The noncancer hazard quotients were calculated using the chronic (greater than 1 year) minimal risk level of 0.09 mg/kg/day and the cancer risks were calculated using the cancer slope factor of 0.084 $(mg/kg/day)^{-1}$.
‡ Indicates that the cancer risk exceeds one extra case in a million people similarly exposed, which ATSDR evaluates further.
§ This cancer risk represents a scenario where children are likely to continue to live in their childhood home as adults.

Drinking Water Ingestion Intermediate (Default)

Bis(2-ethylhexyl)phthalate

Table 26. Residential Default exposure doses for intermediate exposure to bis(2-ethylhexyl)phthalate in drinking water at 0.0024 mg/L along with noncancer hazard quotients*

Exposure Group	CTE Dose (mg/kg/day)	CTE Noncancer Hazard Quotient	RME Dose (mg/kg/day)	RME Noncancer Hazard Quotient
Birth to < 1 year	0.00018	1.8 †	0.00034	3.4 †
1 to < 2 years	5.2E-05	0.52	0.00014	1.4 †
2 to < 6 years	4.7E-05	0.47	0.00012	1.2 †
6 to < 11 years	3.5E-05	0.35	9.6E-05	0.96
11 to < 16 years	2.4E-05	0.24	7.5E-05	0.75
16 to < 21 years	2.4E-05	0.24	7.5E-05	0.75
Adult	4.0E-05	0.40	9.8E-05	0.98
Pregnant Women	3.8E-05	0.38	9.7E-05	0.97
Breastfeeding Women	5.0E-05	0.50	0.00010	1.0 †

Source: Greenwood Chemical Superfund Site Annual Operations, Maintenance, and Monitoring Report January 1, 2022 to December 31, 2022, Retaw Engineering LLC
Abbreviations: CTE = central tendency exposure (typical); mg/kg/day = milligram chemical per kilogram body weight per day; mg/L = milligram chemical per liter water; RME = reasonable maximum exposure (higher)
* The calculations in this table were generated using ATSDR's PHAST v2.3.0.0. The noncancer hazard quotients were calculated using the intermediate (two weeks to less than 1 year) minimal risk level of 0.0001 mg/kg/day.
† Indicates the hazard quotient is greater than 1, which ATSDR evaluates further.