AECOM

Data Gaps Investigation for Vapor Intrusion to Indoor Air Pathway Evaluation Plan

Chemours Montague Site
Montague, Michigan

Submitted on behalf of:
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Acronym List

Acronym	Explanation
µg/L	Micrograms per Liter
AOC	Area of Concern
AST	Aboveground Storage Tank
CD	Chloroprene (also referred to as Chloro-2-Butadiene-1,3)
CFCs	Chlorofluorocarbons
CFC-11	Trichlorofluoromethane or Chlorofluorocarbon-11
CFC-12	Dichlorodifluoromethane
CFC-13	Chlorotrifluoromethane
CFC-113	1,1,2-Trichlorotrifluoroethane
CMSWP	Corrective Measures Study Work Plan
COC	Constituent of concern
CPT	Cone penetrometer testing
CRG	Corporate Remediation Group
DMF	Dimethylformamide
DO	Dissolved Oxygen
DVA	Divinylacetylene
EGLE	Michigan Department of Environment Great Lakes and Energy
Eh	Oxidation/reduction potential
EPA	U.S. Environmental Protection Agency
GPS	Global Positioning System
HCFCs	Hydrochlorofluorocarbons
HCFC-22	Chlorodifluoromethane
HCl	Hydrogen Chloride
HF	Hydrofluoric Acid
LSD	Lake Shore Drive
MDEQ	Michigan Department of Environmental Quality (now EGLE)
mL/m	Milliliters per Minute
MVA	Monovinylacetylene
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric Turbidity Units
PCE	Tetrachloroethene
PID	Photoionization Detector
SSVIAC	Site-Specific Volatilization to Indoor Air Criteria
SVOC	Semi-Volatile Organic Compound
USDA	United States Department of Agriculture
VI	Vapor Intrusion
VIAP	Vapor Intrusion to Indoor Air Pathway
VOC	Volatile Organic Compound
WLP	White Lake Property
WMU	Waste Management Unit

1.0 Introduction

AECOM, on behalf of The Chemours Company (Chemours), has prepared this report documenting Vapor Intrusion (VI) Screening for the Chemours Montague facility near Montague Michigan. This document also includes an in-depth review of past manufacturing processes and an assessment of potential sources. Based on the screening and source assessment, additional data collection is recommended.

1.1 Background

The Montague facility (site) is a former chemical manufacturing facility located in Muskegon County, Michigan (see Figure 1). This site is subject to corrective action under Part 111, Hazardous Waste Management, of the Michigan Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (Act 451), and its administrative rules. Corrective action has been performed at the facility under the regulatory review of the Michigan Department of Environment Great Lakes and Energy (EGLE), Waste and Hazardous Materials Division. The site investigations have been completed in accordance with the protection standards and relevant processes of Michigan Department of Environmental Quality (MDEQ. Now EGLE) Part 201 to meet the corrective action obligations under Part 111 with MDEQ providing oversight, as necessary.

On October 31, 2018, AECOM submitted a Corrective Measures Study Work Plan (CMSWP) to EGLE describing the proposed steps to evaluate waste management units at the site. In response to the CMWWP, EGLE issued a comment letter on November 12, 2019. Comment 1c of the EGLE comment letter requests that Chemours provide an evaluation of vapor intrusion to indoor air path (VIAP) relative to the site groundwater plume and its potential influence on on-site buildings and off-site residences. The letter provided a contact name (Joe Rogers) for this process and AECOM contacted him to confirm our understanding of the process for requesting site-specific screening values for volatile organic compounds (VOCs) in groundwater.

AECOM submitted an application for Chemours to the EGLE for site-specific volatilization to indoor air criteria (SSVIAC) on May 21, 2020. This application included a listing of all constituents that have been confirmed to be present in groundwater at the facility. EGLE also requested a map of the site indicating the depth to water, which was provided on June 29, 2020.

Chemours received EGLE's response to the *Site Specific Volatilization to Indoor Air Criteria Request* in a memo from EGLE dated September 23, 2020. EGLE's response included SSVIAC for soil, groundwater, and soil gas for each of the constituents that had been identified in the application. The EGLE letter requested that Chemours compare relevant soil and groundwater data to the SSVIAC, which were issued in an internal EGLE letter dated July 31, 2020.

AECOM performed this screening for groundwater collected at the site since 2010 and provided this information in the December 2, 2020 Memo *Review of Groundwater to Indoor Air Pathway (Vapor Intrusion Screening)*. Based on the results of the screening, a list of five volatiles (carbon tetrachloride, chloroform, dichlorodifluoromethane, tetrachloroethene, and vinyl chloride) were identified as exceeding residential SSVIAC. For this reason, a focused soil gas sampling plan was developed to assess soil gas concentrations near the potential groundwater source.

In response to the AECOM memo, ELGE issued email comments on Jun 15, 2021 requesting changes to the memo and requested the following information to be included:

- A conceptual site model of releases that could result in VIAP issues is included.
- A section of the work plan was added to describe delineating the vapor source in soil and groundwater and, if needed, where additional data are needed to complete the delineation. The delineation should account for a 100-foot inclusion zone near buildings.
- In the event that there are potential receptors/buildings within a 100-foot lateral exclusion zone of the delineated source, additional evaluation will be needed to confirm protectiveness of current receptors.
- ELGE requested that all regulated VIAP Part 201 VOCs should be analyzed unless they can reliably be ruled out.
- Four quarterly sampling events were requested.
- Additional comments regarding sampling process were included.

Based on EGLE's comments, and discussions with EGLE, the original memo has been expanded to become this document.

Coincident with the writing of this document, on September 1, 2021, EGLE issued a letter requesting that Chemours provide layout and process information for the former manufacturing plant. This document includes considerable information related to the manufacturing areas because of the relationship between the manufacturing activity and potential soil sources. In addition, historical maps and notes made on those maps have been reviewed. This information may have been considered in the early years of the investigation; however, documentation of the historical processes is not readily available. For this reason, some of the process information regarding the past use of chemicals at the site (especially for the Neoprene Plant) has been inferred based on process descriptions from other facilities (DuPont Louisville, KY and Pontchartrain, LA for Neoprene; Chemours Corpus Christi, TX and Antioch, CA for Freon) and from process descriptions in Internet journal articles.

2.0 Source Evaluation

To evaluate the potential for releases of constituents that may contribute to VI issues, this section reviews the manufacturing processes and waste management at the facility. This process knowledge is then used to develop an accurate list of potential constituents that may have been released and persisted in the soil, groundwater, or soil vapor media.

2.1 Manufacturing Activity

During its period active manufacturing, the Montague Works site operated two production plants. The first production plant began in October 1956 producing the synthetic rubber polychloroprene, more commonly referred to as Neoprene®[1]. The Neoprene plant was shut down in 1972. The second plant produced chlorofluorocarbons (CFCs), which were marketed under the trade name Freon®. The Freon plant began operation in 1965 and ended production in 1996. Supporting facilities provided intermediate product manufacturing, catalyst recovery, storage for raw, intermediate, and finished products, and waste disposal. The following sections detail the processes of these two plants. This review of the manufacturing processes has been done to list out all potential constituents and identify those that might be volatile and contribute to a VI issue.

The information provided is based on process knowledge from existing site records, the DuPont Hagley Museum, publications, and Figure 2, which has been developed based on historical site maps and photographs. Copies of those maps and photographs are included as Appendix A. Note that in some instances, the use of a constituent might be inferred from process information from other DuPont or Chemours sites.

2.1.1 Neoprene Manufacturing

Neoprene rubber was produced in four general steps in the former manufacturing area. The first step was the generation of acetylene. Two processes were used to produce acetylene at Montague: a carbide-acetylene unit and an arc-acetylene plant. Both units are shown on Figure 2 and are summarized as follows.

Arc-Acetylene Process

The arc-acetylene plant was in the northeast corner of the manufacturing area. The arc furnace (reactor) consists of an anode and a cathode, a reaction chamber, and a quench unit (Ioan et al, 2014). The anode and cathode were made of carbon steel and cooled by water. They operate with a direct current to generate an electric arc. A mix of carbon and fuel oil was injected into the arc, where the hydrocarbons were cracked into lighter-weight hydrocarbons (including acetylene). After the gas left the arc, it had to be rapidly quenched with cooling water to prevent further reactions. Uncracked oil went to the Carbon-Fuel Oil Settling unit to remove water and excess carbon-solids, and the recovered oil was then stored in the Carbon-Oil Storage tanks to be re-used. It is inferred that waste carbon-solids from this unit may have been placed in the Northeast Landfill.

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[1] Neoprene® is a registered trademark of Denka Performance Elastomers.

Carbide-Acetylene Process

The carbide-acetylene plant was originally owned and operated by Union Carbide. DuPont purchased the plant in 1961. This plant generated acetylene by reacting calcium carbide (CaC2) with water to produce acetylene and lime [Ca(OH)2].

It is unknown if the CaC2 was produced on-site, but it is believed more likely that it was imported by railcar since producing CaC2 would have required coal and limestone stockpiles and those are not known to have been present at the site.

Acetylene Storage[2]

After acetylene was generated, it was stored in the C2H2 Gas Holder tanks (at each unit). Near the Arc-Acetylene plant were tanks of dimethylformamide[3] (DMF) and acetone. Acetylene cannot be safely compressed for storage without risk of explosion. Acetylene dissolves into both DMF and acetone under pressure and it is presumed that the DMF and acetone were used to stabilize the stored acetylene.

Monovinylacetylene Plant[4]

The second step in Neoprene manufacturing is the dimerization of acetylene to monovinylacetylene (MVA). The MVA plant was located south of the arc-acetylene plant. In the unit, acetone was converted to MVA in the presence of an aqueous solution of cuprous chloride and ammonium chloride. MVA is a highly reactive liquid that was stored in tanks to the east of the MVA plant. Divinylacetylene was a major by-product of this process, and Figure 2 shows the location of an organic waste storage tank and a divinylacetylene (DVA) burner, which are understood to be where non-recoverable organic wastes were disposed. The Catalyst Building is believed to be where copper chloride catalysts were recovered. A caustic tank was next to the Catalyst Building, but it is unconfirmed if the caustic was used in catalyst recovery.

Chloroprene (CD) Manufacturing[5]

The third step in Neoprene manufacturing was to convert the MVA to chloroprene (also referred to as chloro-2-butadiene-1,3 or CD). This process was done in the CD manufacturing plant where MVA was reacted under pressure with a mixture of hydrogen chloride and cuprous chloride. It is inferred that excess hydrogen chloride (HCl) would have been removed from the CD using caustic.

The CD Storage tanks were northwest of the CD Manufacturing building. CD is a volatile and extremely reactive liquid unless stored cold under inert gas[6], and the N2

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[2] *Solvents for Acetylene Filling*. Doc. 225/19. European Industrial Gases Association. https://www.eiga.eu/publications/eiga-documents/doc-22519-solvents-for-acetylene-filling/. 2019.

[3] Dimethylformamide is miscible in water and its Henry's constant is low. DMF released into the aquatic environment is eliminated by biodegradation. *Hazard Assessment Report – N, N-dimethylformamide*. Chemical Evaluation and Research Institute, Japan. Section 5.3. May 2007. https://www.cerij.or.jp/ceri_en/hazard_assessment_report/pdf/en_68_12_2.pdf.

[4] *Acetylene Polymers and their Derivatives. I. The Controlled Polymerization of Acetylene*. J. A. Nieuwland, W. S. Calcott, F. B. Downing, and A. S. Carter. Journal of the American Chemical Society 1931 53 (11), 4197-4202. DOI: 10.1021/ja01362a041. https://pubs.acs.org/doi/10.1021/ja01362a041.

[5] *Acetylene Polymers and their Derivatives. II. A New Synthetic Rubber: Chloroprene and its Polymers*. Wallace H. Carothers, Ira. Williams, Arnold M. Collins, and James E. Kirby. Journal of the American Chemical Society 1931 53 (11), 4203-4225. DOI: 10.1021/ja01362a042. https://pubs.acs.org/doi/abs/10.1021/ja01362a042.

manufacturing identified on Figure 2 west of the CD storage tanks is believed to have been related to the storage of CD, because nitrogen is an inert gas. The CD Pit investigated in the 1990s was an earthen pit used in the early 1960s to capture overflow from the CD storage tank area[7]. Figure 3 displays the location of the CD Pit, and Section 2.2 describes the CD Pit further.

Neoprene Extrusion

Neoprene is the common name used for the four isomers of polychloroprene. The fourth and final step in its production was an emulsion polymerization that was performed in the Polymers Building. CD monomer was polymerized in water with a surfactant and potassium sulfate as a catalyst. A Dryer Building next to the polymers building is assumed to be where the Neoprene product was dried after rinsing and before being packaged in the warehouse for shipment.

2.1.2 Freon® Manufacturing

The Montague site manufactured Freon products including refrigerants, propellants. And solvents. Freon products manufactured for commercial sale at the site included:

- Trichlorofluoromethane or chlorofluorocarbon-11 (CFC-11), a refrigerant gas
- Dichlorodifluoromethane (CFC-12), a refrigerant gas
- Chlorotrifluoromethane (CFC-13), a refrigerant gas used typically in very low temperature systems
- Hydrochlorofluorocarbon (HCFC)-22, a refrigerant gas used in place of CFC-12 during the phase-out of CFCs and
- 1,1,2-Trichlorotrifluoroethane (CFC-113), a liquid solvent used especially in the electronics industry

All manufacturing was performed in the Freon Manufacturing and F-22 buildings shown on Figure 2. Three chlorocarbons were used as raw materials in the process: carbon tetrachloride, chloroform, and tetrachloroethene. These chlorocarbons were brought into the site by rail car along with hydrofluoric acid (HF). Production of Freons involved reacting the chlorocarbons with HF in the presence of an antimony pentachloride catalyst. CFC products were separated from chlorinated organic by-products, which were recycled back into the reactor along with much of the HF.

Excess HF and HCl in the Freon products were neutralized with caustic before the finished CFCs were sent to product storage tanks in the Freon area. Freon products were shipped from the rail loading area and via tanker truck. These tankers were stored in the Tanker Car Storage area south of the Aqueous HCl Storage tanks.

The major by-product of the Freon plant was HCl. Much of the HCl was recovered in the HCl recovery unit where it was stored. This HCl was used in the Neoprene process (1965-1972), injected in the former injection well (1972-1982), or stored in the rail loading area and shipped off-site for re-use (1982-1995).

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[6] *Chloroprene - Environmental Fate and Behavior*. H.E. Hurst, in Encyclopedia of Toxicology (Third Edition), 2014. https://www.sciencedirect.com/topics/chemistry/chloroprene.
[7] *Pre-Remedial Action Plan Investigation*. DuPont Environmental Remediation Services. June 1997.

2.1.3 Site Constituents of Concern

Based on the process description presented, the project teams investigating the Montague site developed a list of constituents for analysis. Some samples have also been analyzed for wider lists of constituents to rule those out of further consideration during past investigation work. For the purpose of evaluating the potential for VI, Table 1 presents a listing of the constituents used in the process units. Additional constituents that may be related are also shown along with a description of what the constituents were used for and notes about their environmental fate.

2.2 Waste Management Units and Areas of Concern

Areas of the plant where wastes were stored, treated, or disposed have been thoroughly identified, investigated, and documented in previous site investigation reports. The most recent documents summarizing these units are the *2012 Remedial Investigation Report* and the *2018 CMS Work Plan*. Figures 3 and 4 display the location of these units on the site along with five other areas of concern (AOCs) that were investigated in the mid-1990s and reported on in the *Pre-Remedial Action Plan Investigation* issued in June 1997. Table 2 lists these waste management units (WMUs) and AOCs and the reports which document the investigation at each area. This section summarizes those findings.

In each of the areas investigated in the mid-1990s, soil samples were collected in areas in the manufacturing area where constituents would be most likely to be present in soil. The only exception to this was at the former surface impoundments. Because the impoundment was still in operation, the samples were collected from the southern and eastern side of the ponds. Based on the soil sampling conducted in these areas, no additional investigation was needed in those units.

During the late-1990s and early 2000s, more emphasis was given to groundwater delineation (see Section 2.3), but additional soil sampling was planned and implemented during 2008-2012. The *Remedial Investigation Report* was issued in 2012 and included results of soil sampling conducted in 2011. Figure 5 displays the locations of soil samples collected from the former manufacturing area in the mid-1990s and in 2011 (all 2011 samples have the pre-fix “11”) as part of the site investigation. As documented in the *Remedial Investigation Report*, no evidence of soil impact was observed in soil from the wastewater ditch or HCl Storage Tanks areas.

2.2.1 Soil Source Summary

Based on the soil data collected and presented in past investigation, there do not appear to be sources of VOCs identified in soil media. This is believed to be due to the nature of the constituents. With the exception of metal catalysts and inorganics (fluoride), the volatile constituents from the Neoprene unit were also highly reactive (acetylene, monovinylacetylene, chloroprene) and would not be expected to persist in the environment. In contrast, several of the volatile constituents from the Freon unit (tetrachloroethene (PCE), carbon tetrachloride, and Freon products) are non-reactive and would persist in the environment, but the unsaturated soil in the manufacturing area is very sandy, allowing these VOCs to have attenuated from the shallow soil through natural processes.

In reviewing the processing area, there are three areas identified that have the potential to have soil sources that were not evaluated during the site investigation:

- In the vicinity of the former surface impoundments, are two small units labeled "organic waste storage" and "DVA burner." Aside from the map, no information was found about these units, and no soil samples were collected nearby them. Based on them being absent from later maps, it is assumed that the organic waste being stored was from the Neoprene unit, and DVA was a known by-product of the MVA process. For this reason, the location of these units should be found, and shallow soil samples collected for the site VOC and semi-volatile organic compound (SVOC) list. This plan is further detailed in Section 3.1.
- Soil sample locations near the former surface impoundment were to the east and south of the impoundment. At the time of sampling, the ponds were still in use and sampling through them was not possible. The impoundment is presumed to be a source of CFC-113 and PCE to groundwater and when present as a separate phase liquid, both of those constituents tend to migrate downward. For this reason, soil sampling should be performed through the former unit and samples collected from underneath the former impoundment. A water sample should also be collected at the top of the water table to determine if a source is present in shallow groundwater. Samples should be collected for the site VOC and SVOC list. This plan is further detailed in Section 3.

2.3 Groundwater Plumes

2.3.1 Manufacturing Area Plume

Although Table 2 lists the groundwater plume from the former manufacturing area as a unit, the general understanding is that the source of the groundwater plume from the manufacturing area is a result of past releases from four sources:

- Former surface impoundment (PCE, and CFC-113): The impoundment received process water from both the Neoprene and Freon units. Samples from monitoring wells downgradient of the impoundment detected the release.
- Railcar Unloading Area-West (PCE, CFC-113, and carbon tetrachloride): Raw materials were unloaded and Freon products were loaded by rail tanker cars. Incidental releases are assumed to have occurred prior to installation of catch pans. Note that it is possible that the 1978 Freon-113 release in the tanker truck parking area could have also contributed to this portion of the plume.
- Northeast Landfill (toluene and benzene): Groundwater downgradient of this landfill has sporadic detections of benzene and toluene. It is unconfirmed what the original source of those constituents is.
- Lime Pile (inorganic materials – primarily calcium and elevated alkalinity): The lime was a by-product of the carbide acetylene plant.

The above sources have contributed constituents to a co-mingled plume that extends toward White Lake and is predominately within the capture zone of four interceptor wells (see Section 2.3.4). During 1996 and 1999, the plume was delineated horizontally and vertically using samples collected from cone penetrometer testing (CPT) borings.

2.3.2 Pierson Creek Landfill Plume

In addition to the plume from the manufacturing area, there are VOCs in groundwater near Pierson Creek Landfill (primarily PCE). These VOCs are understood to be related to settled materials removed from the surface impoundment. The extent of the VOCs in groundwater near Pierson Creek Landfill is limited to shallow groundwater and by Pierson Creek[8].

2.3.3 Plume Extents

Figure 5 displays the locations of CPTs sampled at the site (CPT-1 through -3, RCUA, and West-East transects A, B, and C). Samples from these CPTs were reported in the *Montague Plume Characterization Field Activities and Data Analysis Report*[9]. Additional CPTs were sampled in 2002 and reported in the *Phase I Supplemental Groundwater Investigation Field Report*[10]. Figures and cross sections of constituent extent from these reports are provided in Appendix B. Notable areas of the plume identified in the CPT data are:

- Elevated VOCs (carbon tetrachloride, PCE, and CFC-113) in the vicinity of CPTs A0300W, A0000W, and A0300E. Depth of this plume was approximately 60-80 feet in that transect.
- Elevated VOCs (PCE and CFC-113) downgradient of the former surface impoundment to the east and south east of the Lime Pile. These constituents tend to be at a depth of 90 or more feet below ground surface and tend to be below groundwater with lower VOC concentrations.

Additional CPTs were completed in 2006 (LSD-1 through LSD-3), 2009 (WLP-CPT-1 through WLP-CPT-3), and 2015 (at Pierson Creek). Taken together with data from permanent monitoring wells (see Figure 7), previous investigations have determined the VOC plume extent. Figure 7 includes two plume boundary lines that represent the detection limit (orange) and the approximately limit of groundwater containing one or more VOC above the Final Acute Value (FAV: a criterion from the White Lake mixing zone determination[11]). Note that the FAV is not applicable to the Pierson Creek Landfill plume.

Concentrations within the plume at certain wells have changed over time especially in monitoring wells close to the interceptor well system (see below). These changes are understood to reflect changes in groundwater flow direction in the vicinity of the interceptor wells.

2.3.4 Interceptor Well System

The Montague site has maintained a groundwater extraction system since the early 1960s. This system has captured groundwater containing constituents from the manufacturing area plume. After treatment, this water is discharged via the National Pollutant Discharge Elimination System (NPDES) pipeline to Lake Michigan. Extraction wells that have operated at the site are shown on Figure 8 and include the following:

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[8] *Remedial Investigation Report Addendum No. 2 – Pierson Creek Landfill Area.* URS Corporation. May 2014.

[9] *Montague Plume Characterization Field Activities and Data Analysis Report*, DuPont Corporate Remediation Group (CRG). July 2000.

[10] *Phase I Supplemental Groundwater Investigation Field Report*, DuPont CRG. October 2003.

[11] *Mixing Zone Implementation: DuPont Montague Works, White Lake*. MDEQ. August 3, 2007.

- A purge well was operated by Union Carbide at the southeast corner of the pile. Location, depth, and date of installation and abandonment are not available.
- IW-01-090 was installed in 1963 southeast of the Lime Pile based on the need to better contain the constituents that had leached from the Lime Pile.
- IW-02-055 was installed to recover groundwater containing VOCs from downgradient of the surface impoundment[12].
- IW-03-120 and IW-04-120 were installed in 1982 to capture groundwater containing VOCs from the western side of the plume that is believed to be related to the West Railcar Unloading Area and Tanker Car Storage. These two wells were operated until about 2008.
- IW-05-112 was installed in 1985 to supplement the capture of the plume near IW-01-090.
- IW-06-140 and IW-07-144 were completed April 1 and April 8, 2008 a as part of the Groundwater Treatment Facility Upgrade project.
- IW-08-142 was installed to replace IW-01-090 in December 2012.
- IW-09-140 was installed to replace IW-05-112 in June 2017.
- The current system recovers groundwater from IW-06-140, IW-07-144, IW-08-142, and IW-09-140 and that water is conveyed by pipeline to the groundwater treatment system (air stripping with vapor-phase carbon adsorption of VOCs). Treated water is pumped to the NPDES outfall in Lake Michigan.

As a result of the extraction system operation, the higher concentration center of the plume is hydraulically contained preventing discharge of the central portion of the plume to White Lake (VOC data from well WLP-005-100 have demonstrated this). The far eastern and western edges of the plume that have concentrations below the FAV values are allowed to discharge to White Lake because they meet the criteria of the mixing zone. Monitoring wells along the plume edges (LSD and WLP wells) are monitored on a semiannual basis to confirm compliance with the mixing zone. Other wells within the plume are monitored on an annual or biennial frequency to provide trend information.

The most recent biennial sampling event was conducted in the first half of 2020. The biennial is the most wide-spread sampling event in the current program, and results from the 1H2020 event are shown on Figure 9 (carbon tetrachloride), Figure 10 (CFC-113), and Figure 11 (PCE). Figure 12 is the potentiometric surface map. In addition to providing an indication of groundwater flow direction, Figure 12 also includes the approximate limits of the FAV plume and the zone of capture for the extraction system.

2.3.5 Third-Party Groundwater Extraction System Review

During 2019, Chemours contracted with Langan Engineering and Environmental Services to perform a third-party review of the plume delineation and of the existing design of the interceptor well system. This plume review provided graphics that were also reviewed during the plume review for potential VI issues. Langan used recent and historical groundwater concentration data, CPT and boring logs to reproduce the site conceptual flow model. Cross sections of the manufacturing area plume are included in Appendix B (with those from earlier reports). No differences were noted in the overall

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[12] Although the location and depth (55 feet) of IW-02-055 are known, the dates of installation and abandonment are unknown.

plume pattern. Langan provided more definition of thin silt intervals that may cause some stratification of flow in the aquifers.

Consistent with previous cross sections, the plume from the West Railcar Unloading area has CFC-113, PCE, and carbon tetrachloride. The depth of the highest concentrations in this part of the plume tends to be between (60-100 foot below ground surface). The plume from the former surface impoundment has CFC-113 and PCE and the highest concentrations of these VOCs is in the interval 80-120 foot below ground surface.

2.4 Groundwater Source Screening

In order to assess the potential for VI of VOCs from groundwater, groundwater results were screened in 2020. The first step in this process was to provide EGLE a listing of all COCs that have been detected *at any time in the past* in groundwater along with representative depths to the top of the water table. Based on that list, ELGE provided Site-Specific Criteria for industrial and residential exposure in a September 23, 2020 letter. This letter and the criteria are included as Appendix C.

AECOM performed a screening of recent groundwater data, comparing results from 37 monitoring wells sampled 2010 through the first half of 2020 (1H2020) against the EGLE-provided criteria to identify what constituents have been detected above the criteria in that time period. Note that the 1H 2020 is the most recent biennial event, which is the comprehensive sampling event in the program.

Based on the planned land use, groundwater monitoring wells across the site were divided into two exposure areas based on potential receptors and relative source location. Twenty-one (21) monitoring wells from the central, upgradient portion of the site were collectively evaluated for industrial exposure. Sixteen (16) monitoring wells from the southern, downgradient portion of the site were collectively evaluated for residential exposure. Figure 13 depicts the locations of the selected groundwater monitoring wells and relevant exposure areas.

2.4.1 Groundwater Source Summary

Tables 3 and 4 present the initial groundwater screening against Site-Specific Criteria from EGLE for industrial and residential exposure, respectively. The screening results are summarized below:

Industrial Exposure Area

Of the 18 volatiles detected in groundwater, only six were detected in at least 25% of samples. These volatiles are 1,1,2-trichlorotrifluoroethane, chloroform, cis-1,2-dichloroethene, tetrachloroethene, trichloroethene, and ammonia:

- The first five volatiles listed above were sampled 276-278 times since 2010 with tetrachloroethene detected most frequently (75% of samples).
- Ammonia was sampled and detected five times but at concentrations four or more magnitudes below the screening level.

No EGLE Site-Specific Criteria were exceeded within the industrial exposure area by any detected volatile within groundwater.

Residential Exposure Area

Of the 15 volatiles detected in groundwater, only six were detected in at least 25% of samples. These volatiles are 1,1,1-trichloroethane, 1,1,2-trichlorotrifluoroethane, carbon tetrachloride, chloroform, tetrachloroethene, and ammonia.

- The first five volatiles listed above were sampled 368 times since 2010 with tetrachloroethene detected most frequently (47% of samples).
- Ammonia was sampled but detected at a concentration five orders of magnitude below the screening level.

Five volatiles exceeded their EGLE Site-Specific Criteria for residential exposure. They are carbon tetrachloride, chloroform, dichlorodifluoromethane, tetrachloroethene, and vinyl chloride:

- Carbon tetrachloride has exceeded criteria at 6 micrograms per liter (µg/L) in 109 results from locations MW-WLP-001-125, MW-WLP-003-080, and MW-WLP-004-070 since 2010.
- Chloroform has exceeded criteria (8.4 µg/L) in 10 results from location MW-301-125 since 2010.
- Dichlorodifluoromethane has exceeded criteria (32 µg/L) in two results from locations MW-WLP-001-125 and MW-WLP-003-080 since 2010.
- Tetrachloroethene has exceeded criteria (110 µg/L) in 44 results from locations MW-WLP-001-125 and MW-WLP-004-070 since 2010.
- Vinyl chloride was non-detect in its only sample result from PCL-005-045; however, its reporting limit (5 µg/L) exceeded the screening criteria (1 µg/L).

Screening of All Site Against Residential Criteria

A final screening has been added that compares all results (2010 until 1H 2020) to the *residential* EGLE Site-Specific Criteria. The purpose of this comparison was to confirm which constituents might need additional delineation in the groundwater plume (which is therefore done to residential criteria). Appendix D contains the listing of all results (2010-1H2020) and flags any result that exceeded the residential criteria. Three constituents were identified by this comparison:

- Benzene had maximum concentration of 17 µg/L in industrial area vs the residential criteria of 16 µg/L. This was a single instance at well MW-224-060 (near the Northeast Landfill).
- cis,1,2-Dichloroethene (maximum concentration of 150 µg/L in industrial area vs the residential criteria of 53 µg/L. Four instances of exceedance were found in well MW-304-123 from 2010 until 2013.
- Trichloroethene had maximum concentration of 53 µg/L in industrial area vs the residential criteria of 6.8 µg/L. These instances have been in wells:
    - MW-201-125, MW-226-120, MW-302-130, MW-304-123, MW-305-135, and IW-08-142 (all near the interceptor wells)
    - MW-250-054 (near Pierson Creek Landfill)
    - MW-224-060 (near the Northeast Landfill)

Based on this screening, eight constituents (all VOCs) have been detected at concentrations exceeding the residential screening levels for potential VI. These exceedances have been identified in the main plant plume (in deep groundwater), downgradient of the Northeast Landfill and downgradient of the Pierson Creek Landfill.

A separate screening was performed for mercury. During 2021, Chemours collected samples from various site wells for metals. The new mercury data (along with previous data) have been screened in Appendix E. Although there are detections of mercury in groundwater, none of the results exceed the residential VI screening level provided by EGLE.

Based on the potential for these VOCs to present a VI issue, the next step is to determine if these VOCs are present in soil vapor at these locations. For this reason, a soil vapor sampling program has been developed and is described in Section 3.2.

2.5 Summary of Potential Vapor Sources

There are four potential VI sources that should be evaluated in this plan.:

- Shallow soil sampling at the organic waste storage and DVA burner (Section 2.2.1).
- Soil sampling of native soils and shallow groundwater under the former (and now filled-in) surface impoundment (Section 2.2.1).
- Vapor sampling in the vicinity of the groundwater plume from the Pierson Creek Landfill containing VOCs above the residential screening criteria (MW-250-054).
- Vapor sampling in the vicinity of the groundwater plume from the Northeast Landfill containing VOCs above the residential screening criteria (MW-224-060).
- Vapor sampling in the vicinity of the groundwater plume from the manufacturing area containing VOCs above the residential screening criteria (MW-WLP-001-125, MW-WLP-003-080, and MW-WLP-004-070, MW-201-125, MW-226-120, MW-301-125, MW-302-130, MW-304-123, MW-305-135, and IW-08-142). Vapor sampling should also be performed downgradient of the former West Railcar Unloading area in the vicinity of CPTs A0300W, A0000W, and A0300E.

3.0 Proposed Investigation

Based on data gaps identified in Section 2.5, two general investigation tasks are proposed. The first task is to collect soil and/or groundwater to determine if there were releases from three areas identified in Section 2.2.1. The second task is to collect soil gas samples from locations near wells that have had groundwater results exceeding residential VIAP screening criteria. Relevant standard operating procedures for these activities are provided in Appendix F.

3.1 Data Gap Sampling

Section 2.2.1 identified areas of the site where there is a potential for a soil or groundwater source that has not been investigated in previous investigations. To determine if volatile constituents are present that could pose a VI issue, the following is proposed.

3.1.1 Organic Waste Storage and DVA Burner – Soil Sampling

Figure 14 displays the location of a former organic waste storage and DVA burner in the southeast corner of the manufacturing area:

- The first step in assessing these units is to physically locate the former structures. This will be easiest with the grass recently mowed. Based on the maps, it cannot be confirmed if a foundation existed at either unit, but a metal detector should be available to scan for any shallow buried structures or rebar. Surface soil will also be visually inspected (if possible) for any staining. If the location cannot be confirmed, it will be inferred as near as possible by referring to Figure 14.
- After determining the location of the former organic waste storage and DVA burner, three shallow borings will be advanced using either a geoprobe rig or a hand auger to a depth of 9 feet directly adjacent to each unit as shown on Figure 14. Note that if there are observable indications of impact (e.g., staining, chemical odors) at least one of those locations should be advanced at that location (biased sampling).
- A photoionization detector (PID) will be used to measure for VOCs in the soil as the hand auger is drilled to screen for impact, and these readings and notes will be taken of the soils physical properties following the United States Department of Agriculture (USDA) soil classification system.
- Samples will be collected from at least three intervals. The first will be collected from ground surface to 2 feet. One sample should be collected at an interval that shows indications of impact (if observed). The third sample should be collected below the second sample in soil that appears clear of impact. If there are no indications of impact, then the second and third sample will be collected at 3 to 4 feet below ground surface and 8 to 9 feet below ground surface.
- Soil samples will be collected for the constituents listed on Table 5. This list is the site VOC and SVOC list from the investigation work conducted in 2010-2013 and amended to include the VOCs from Section 2.1 that were not on that earlier list (CFC-13 and HCFC-22). Soil samples for VOC analysis will be collected using

Encore or equivalent sampling devices consistent with U.S. Environmental Protection Agency (EPA) Method 5035 for preservation of VOC samples.

- Samples will be cooled after collection using ice and shipped to the analytical laboratory for analysis using Method 8260D (VOCs) and 8270E (SVOCs).
- In the event that constituents are found in these soil samples, the project team will consider if additional data are needed. This may include lateral soil step outs or may also include groundwater samples. This will be determined in coordination with EGLE.

3.1.2 Former Surface Impoundment – Soil and Groundwater Sampling

Previous sampling at the former surface impoundment was performed outside the boundary of the unit. To assess if a source of volatiles remains beneath the former impoundments, a soil boring will be advanced in the center of the former impoundment (see Figure 14). This boring will need to be drilled using a using a geoprobe rig. This drilling method is considered necessary because it is assumed that the liner of the impoundment (believed to be concrete) is still in place and may require equipment to either cut or chip through obstructions:

- The field sampler will observe for indications of native soil as opposed to the fill soil or liner from the former impoundment. A PID will be used to measure for VOCs in the soil as the boring is drilled to screen for impact, and these readings and notes will be taken of the soils physical properties following the USDA soil classification system.
- Soil samples will be collected from two intervals: the first will be collected from the first 2 feet of native soil beneath the former impoundment. The second soil sample should be collected either in the interval that has the highest PID readings (or other indications of possible impact) or in the 2-foot interval just above the water table.
- Soil samples will be analyzed for the constituents listed on Table 5. Samples of soil for VOC analysis will be collected using Encore or equivalent sampling devices consistent with EPA Method 5035 for preservation of VOC samples.
- The boring will then be advanced 5 feet into the top of the water table and a temporary well will be set for the collection of a water sample. A 10-foot long two-inch diameter well screen will be set at this interval (approximately five feet into water). A filter pack of silica sand will be installed from total depth to two feet above the top of the screen, and a bentonite seal (hydrated chips) will be used to complete the annular seal. This well will be kept at least until sample results are received in case a resampling is considered needed.
- Based on the anticipated depth to water (approximately 30 feet), a submersible or bladder pump will be used to purge the well using low-flow methods with purge rates ranging from less than 0.1 L/minute to 0.5 L/minute. During well point purging, water levels will be collected, and pH, specific conductance, turbidity, dissolved oxygen (DO), oxidation/reduction potential (Eh), color, odor, and temperature will be monitored using a flow-through cell. Measurements will be recorded every volume that is equal to the sample tubing volume (expected to be every 3 to 5 minutes). Purging will be considered complete when successive parameter readings are within +/-0.1 for pH, +/-3% for specific electrical conductivity, +/-10 mV for Eh, and +/-10% for DO and turbidity. Where possible,

the turbidity should be less than 10 nephelometric turbidity units (NTUs). Following well stabilization, the groundwater sample will be collected directly from the discharge tubing (after removing the flow-through cell).

- Samples will be cooled after collection using ice and shipped to the analytical laboratory for analysis using Method 8260D (VOCs) and 8270E (SVOCs).
- In the event that constituents are found in these soil samples, the project team will consider if additional data are needed. Similar to the organic waste storage and DNA Burner areas, this may include lateral soil step outs or additional groundwater samples. Results and proposed additional work will be determined in coordination with EGLE.

3.2 Vapor Point Installation and Sampling

Based on the groundwater screening summary provided in Section 2.4, detections of volatiles above EGLE Site-Specific Criteria were noted in the following locations:

- Industrial Exposure Area: No exceedances of EGLE *industrial* Site-Specific Criteria.
- Based on comments from EGLE, we have re-screened all data against *residential* criteria so that characterization of the site will be more complete. In that re-screening, the following wells had at least one exceedance:
    - MW-224-060 (near the Northeast Landfill)
    - MW-250-054 (near Pierson Creek Landfill)
    - MW-201-125, MW-226-120, MW-301-125, MW-302-130, MW-304-123, MW-305-135, and IW-08-142 (all near the interceptor wells)
    - MW-WLP-001-125, MW-WLP-003-080, MW-WLP-004-070 (White Lake property area).

Because the screening was performed on results since 2010, areas of the plume delineated and characterized with CPT samples have not been included in that evaluation. To consider those older data, the maps and cross sections using CPT data included in Appendix B have been reviewed. These data are 20 years old, and the concentrations have likely decreased, but groundwater samples from CPTs in one area downgradient of the former Rail Unloading Area had relatively high VOC concentrations and the depth to the top of the plume in that area was shallower than the plume near the former surface impoundment.

Three CPT locations along Wilkes Road (A0300W, A0000W, and A0300E) encountered concentrations of carbon tetrachloride (45,000 µg/L), PCE (2,000 µg/L, and CFC-113 (7,700 µg/L). Based on data from MW-211-060 and MW-211-080, these concentrations are likely lower now; but, to rule this area out as a potential source for VI, vapor sampling is proposed.

3.2.1 Locations

Figure 15 shows the locations of 14 proposed near-source soil gas vapor point locations. These sample locations have been selected to assess whether the locations that have groundwater above the screening criteria actually have those constituents in soil vapor and determining those concentrations.

As Figure 15 shows, the groundwater samples exceeding the screening criteria are in three general areas:

- Downgradient of Pierson Creek Landfill at one well
- Intermittently downgradient of the Northeast Landfill at one well
- In several wells in the downgradient portion of the manufacturing area plume

For the Pierson Creek and Northeast Landfills, a vapor point is proposed near the wells which have had exceedences for each of these landfills. These locations should be the most likely to have constituents present in soil vapor and will be an indicator if there is a potential for VI issues (from groundwater).

For the groundwater plume from the former manufacturing area, a transect of 9 locations is proposed across the plume area where the exceedences were noted. Proposed sample locations are spaced approximately 500 feet apart starting furthest downgradient (near MW-WLP-003-080 at the southern end of the site) and moving northeast/cross-gradient until about 500 feet east of MW-301-125. These locations will bound the downgradient extent of the groundwater plume where screening has indicated potential adverse impacts to residential receptors.

Three additional vapor points are proposed downgradient of the former Rail Loading Area in the vicinity of CPTs A0300W, A0000W, and A0300E. Data from these locations will determine if the VOCs from groundwater are present in soil gas.

3.2.2 Depth Intervals

At each location, vapor probes will be installed at two depth intervals. The first interval will be just below a depth of 5 feet, and the second interval will be above the water table. This will confirm if a VOC constituent detected in vapor is from groundwater (or perhaps a localized shallow soil source).

3.2.3 Sampling Frequency

Sampling of vapor points will be done in four quarterly events so that vapor potential can be assessed for seasonal effects. At the end of each event, results will be shared with EGLE in letter form. Reporting of the results will be performed after all four events are collected and the data are reviewed entirely.

Example forms and standard operating procedures regarding soil gas sample collection are provided in Appendix F. The planned procedures are summarized below.

3.2.4 Preliminary Survey

Primary goal of this survey is to observe the site conditions including identifying potentially inhabitable buildings and potential VI migration routes:

- Document if any external preferential pathways (EPPs) exist between VI source and potential receptors. EPPs allow for enhanced transport of volatiles and create a more direct pathway from source to receptor. Specifically, this could include underground utility lines that lead toward a building from a potential source area. These should be identified during this survey and put into the report. In the event that vapor sources (detections in the unsaturated zone) are confirmed to exist within a 100-foot lateral inclusion zone of a building, that building will be then be considered for direct testing.

3.2.5 Vapor Point Installation

Sample points will be placed no closer than 10 feet from identified underground utilities. Sample locations will be recorded using global positioning system (GPS) coordinates or distance from a known feature (e.g., roads and buildings).

- Prior to installation, measure the depth to water in the closest monitoring well.
- Clear each soil vapor point up to a depth of five feet (shallowest intended target depth). Target depth must be no shallower than 5 feet below grade to prevent interaction with ambient outdoor air. Locations should be cleared using a manual push probe unless there are conditions that preclude this. If an “air knife” is used to clear a location, then the sampling of that completed location must be deferred to allow the location to equilibrate for a minimum of two weeks with the subsurface.
- After clearing the location 5 feet below grade, the remainder of the point will be drilled using direct push. Prepare a descriptive log of the soils encountered and the construction details of each soil vapor monitoring point.
- Construction of the soil gas point will be as follows: from the bottom depth up to capillary zone will consist of a 1-foot section of 1-inch-diameter, 0.020-inch slot schedule 40 polyvinyl chloride (PVC) screen. Above the screen, the remainder of the point will consist of 1-inch-diameter schedule 40 PVC riser above the screen to the ground surface.
- Backfill the annular space around the screen with silica sand to 1-foot above the screen. Seal the remaining annular space to the surface with bentonite chips.
- Hydrate the bentonite.
- Seal the top of the well with cement and install locking well caps and flush-to-grade, bolt-down metallic well covers with waterproof seals.

All newly installed soil gas sampling points will be allowed to equilibrate for a minimum of 24 hours before sampling.

3.2.6 Near-Source Soil Gas Collection

A soil gas sample will be collected from each of the newly installed soil gas sample points using Summa canisters. Procedures outlined in the laboratory’s air sample guide will be used to aid sample equipment setup, testing prior to collection, and sample collection.

The following steps are used to ensure no leaks from the sample point to the sample canister:

- Close three-way valve so that air is directed towards Tedlar bag and not canister.
- Introduce helium tracer gas into the helium shroud over the borehole at a concentration of 10 to 20% (measured using helium gas meter connected to fitting on shroud).
- After proper saturation, begin purging the sample point.
- Measure concentration of helium in the Tedlar bag to ensure concentrations are below 10% of the helium concentrations in the shroud.

- If helium concentrations measured are above or equal to concentrations introduced, check fittings and connections are sealed, and repeat the test.

The following steps are used to ensure no leaks in the parts of sample equipment outside of the helium shroud:

- Apply vacuum to the sample line using a hand pump (with gauge).
- Evacuate air to achieve a vacuum of about 50,000 Pascals (or 15 inches of mercury).
- Shut in vacuum by sealing valves on opposite ends of sample train.
- Allow vacuum to remain sealed for 1 minute. If the system leak rate is less than 2,000 Pascals (or 0.5 inches mercury), the system leak rate is acceptable.
- For unacceptable system leak rates, tighten all valves, check system connections, and repeat test.
- After passing the helium leak test, conduct shut in test prior to sample collection.

The following steps are used to collect soil gas samples after completing leak and shut in tests:

- Ensure valves used during leak and shut in tests are closed and open sample valve.
- Record initial vacuum reading and time and turn on multi gas meter.
- Begin purging system at a rate less than 200 milliliters per minute (mL/m), and for a volume three times the total system volume.
- After purging, direct three-way valve towards the sample canister.
- Maintain a sample rate less than 200 mL/m and ensure vacuum levels remain below 25,000 Pascals (or 7.5 inches mercury).
- Complete sample collection when canister gauge indicates a vacuum level of about 17,000 Pascals (or 5 inches of mercury).

Duplicate samples will be collected during the sampling to provide an indication of variability within a sampling event. There are 15 locations identified in this work plan and the field crew will collect duplicate samples from two of the locations during each event. This meets the general requirement for a 1 per 10 frequency for duplicates identified in the SOP.

3.2.7 Analytical Methods

In the December 2020 memo, it was recommended that the following VOCs be analyzed based on the list of constituents that have exceeded the VIAP screening criteria: carbon tetrachloride, chloroform, dichlorodifluoromethane, tetrachloroethene, and vinyl chloride using EPA Method TO-15 for the analysis.

EGLE provided comments indicating that all potential VOCs, SVOCs, ammonia, and mercury should be considered unless they could be ruled out. Based on previously conducted investigation work (2010-2013) and the process information presented in Section 2.0, the list of VOCs has been expanded. Table 5 provides a list of VOCs that will be reported from the analysis.

With regard to non-VOC constituents, none of these were identified as having been used in plant processes or were found above screening criteria in the groundwater dataset.

4.0 Summary

Based on comments from EGLE, this work plan has been expanded to include an in-depth review of past manufacturing activities and possible source areas. The work plan also reviews past data collected at the site that indicate if an area had no release of constituents. Areas for which there is no record of investigation have been considered for additional sampling to determine if there was a release of constituents.

Based on the above information review, additional soil and groundwater sampling are recommended in Section 3.1 to determine if there is any evidence of release from the former organic waste storage, DVA Burner, and surface impoundment. In the event that this sampling confirms a release to soil or groundwater, additional sampling would be considered to characterize the release.

Section 3.2 of this plan is the proposed vapor sampling. The previous version of this plan proposed a transect of single-depth vapor locations to be sampled in two events. EGLE comments have led to a revision of this plan to be quarterly sampling at two depths from the transect. In addition, two additional locations have been added to determine if constituents are present in soil gas near the downgradient edge of the Pierson Creek or North East Landfills.

Results from these data gap activities will be submitted to EGLE as they are received in technical memos. At the end of the quarterly soil gas sampling events, a report will be generated that will summarize the results and make recommendations (such as plugging and abandoning the vapor wells).

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