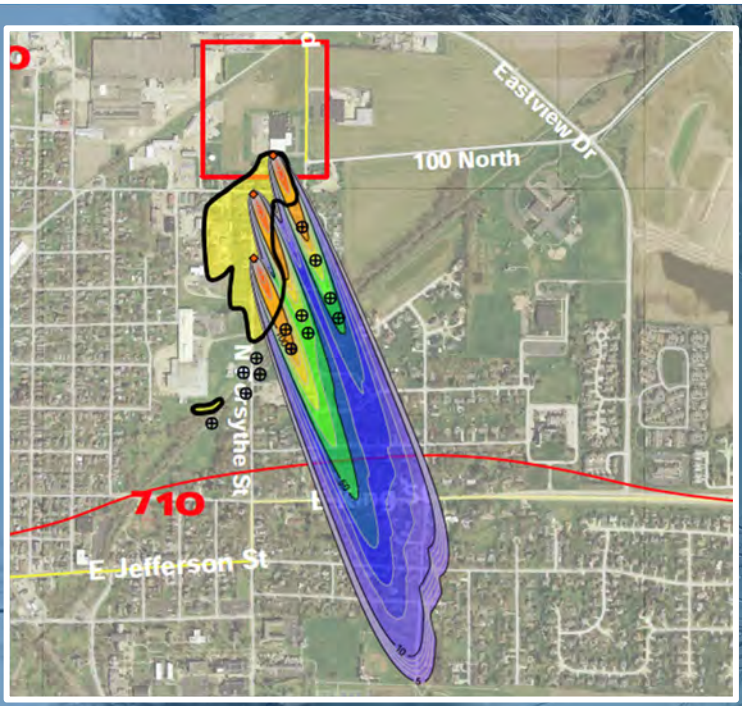
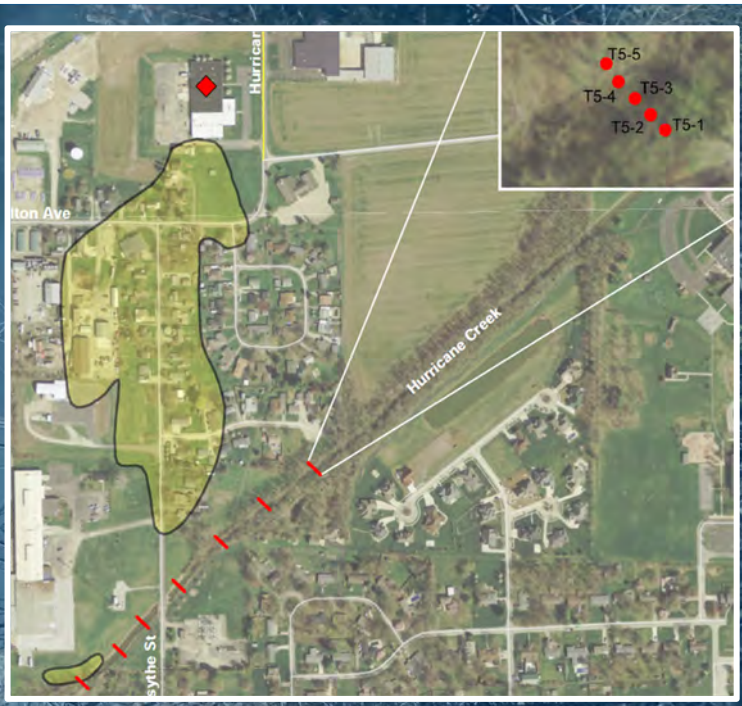
GEOPHYSICAL SURVEY AND PRELIMINARY CONTAMINANT TRANSPORT MODELING STUDY

FORMER AMPHENOL FACILITY #IND 044587 848
980 HURRICANE ROAD
FRANKLIN, JOHNSON COUNTY, INDIANA
MUNDELL PROJECT NO. M18027B
MAY 19, 2021





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May 19, 2021

Mrs. Stacie Davidson and Mrs. Kari Rhinehart
If It Was Your Child
P.O. Box 102
Bargersville, IN 46106

Re: **Geophysical Survey and Groundwater Plume Modeling Report Summary**
Former Amphenol Facility #IND 044587 848
980 Hurricane Road
Franklin, Indiana, 46131
MUNDELL Project No. M18027B

Dear Mrs. Davidson and Mrs. Rhinehart:

Mundell & Associates, Inc. (MUNDELL), a professional environmental engineering company based in Indianapolis, has prepared this report summarizing the results of a geophysical survey and groundwater plume modeling exercise for the Former Amphenol Corporation Site in Franklin, Indiana.

This project consisted of two main parts, and was designed to supplement the ongoing collection of field data in Franklin through:

Geophysical Surveying

- Using non-invasive subsurface imaging techniques to identify potential contaminant migration pathways into or to the south of Hurricane Creek;
- Interpreting these subsurface imaging results to critically examine select assumptions made by the current U.S. EPA Conceptual Site Model;

Groundwater Transport Modeling

- Running preliminary simulations of groundwater contaminant migration over time from Amphenol Site source areas; and
- Comparing results of the simulated groundwater plume with the currently identified U.S. EPA Amphenol Study Area contamination boundaries.

This report also proposes additional, targeted field data collection to resolve key hydrogeologic and water quality uncertainties further downgradient of the Amphenol Site and in the Hurricane Creek area. These approaches should be implemented on a priority basis by the regulatory agencies responsible for protecting human health and the environment in Franklin, in order to proceed on to effective, data-driven remedial decisions.

We appreciate the opportunity to provide services to you on this project. If you should have any questions regarding this report, please feel free to contact us at (317) 630-9060 or via email at jmundell@MundellAssociates.com.

Sincerely,

MUNDELL & ASSOCIATES, INC.

Rachel Walker, Ph.D., L.P.G.
Project Geologist

John A. Mundell, P.E., L.P.G., P.G.
President/Senior Environmental Consultant

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APPENDICES

1. INTRODUCTION

1.1 STATUS OF FRANKLIN INVESTIGATIONS

The Former Amphenol Corporation Site (Amphenol, or "the Site") is situated amidst several other industrial and waste release sites in Franklin, Indiana (see **Figures 1A** and **1B, Appendix A**). As such, to determine additional investigative and remedial actions necessary at Amphenol, it is important to understand the scope and results of studies of the Site and its surrounding areas. The following sections provide a recap of recent testing activities at the Franklin sites of interest and identify data gaps pointing to the need for further study.

Records referenced and summarized for use in this report were accessed via the United States Environmental Protection Agency (U.S. EPA) "Amphenol/Franklin Power Products in Franklin, Ind." webpage; Indiana Department of Environmental Management (IDEM) "Virtual File Cabinet;" as well as documents previously reviewed from Freedom of Information Act (FOIA) requests. Information that was accessible for this review and the accuracy of specific details may not necessarily represent the most current and complete regulatory files generated by these sites. Additionally, references to specific laboratory analytical data collected by third parties does not constitute such data having gone through a data quality review by MUNDELL and is merely summarized for background information purposes.

1.1.1 Former Amphenol Corporation Site

Located at 980 Hurricane Road, the approximately 15-acre former Amphenol Corporation Site (U.S. EPA ID #IND044587848) was utilized for the manufacturing of electrical parts in the 1960's through the 1980's (see **Figure 1A, Appendix A**). Chemicals of concern at the Site, determined by the U.S. EPA to be associated with poor housekeeping by a previous site owner/operator, Bendix Connector Corporation (Bendix), include the following chlorinated volatile organic compounds (CVOCs): trichloroethylene (TCE), tetrachloroethylene (PCE), 1,1,1-trichloroethane (1,1,1-TCA), cis-1,2-dichloroethylene (cis-1,2-DCE), trans-1,2-dichloroethylene (trans-1,2-DCE), 1,1-dichloroethane (1,1-DCA), 1,2-dichloroethane (1,2-DCA), methylene chloride and vinyl chloride.

The Amphenol Site investigation and cleanup are being overseen by the U.S. EPA under the federal Resource Conservation and Recovery Act (RCRA) Corrective Action program. Recent investigation and remedial activities completed at the Site include:

- U.S. EPA presentations at several 2019 public meetings in Franklin provided estimates of the extent of groundwater, soil and sewer gas impacts centered along North Forsythe Street south of the Former Amphenol Site (see **Figures 2A, 2B and 2C, Appendix A**). However, these plume maps are based on a rather limited data set due to a lack of a comprehensive groundwater monitoring well network (MUNDELL, 2019, p.3).

- In August – December 2019, replacement of approximately 1,298 feet of the sewer line running down North Forsythe Street was conducted via excavation, which included the

removal of soils around the sewer. Twenty-one sewer laterals to nearby homes were inspected as part of this work, with nineteen laterals fully replaced due to poor condition or being made of vitreous clay pipe. An additional four laterals were partially replaced. Sections of sewer main along Hamilton Avenue, Glendale Avenue, Ross Court and North Forsythe Street totaling approximately 1,274 feet had an interior liner installed. Approximately 342,330 gallons of shallow groundwater were removed while dewatering during the excavation. This groundwater was treated off-site using carbon filtration, tested and then discharged to the sanitary sewer. A total of 6,740.79 tons of excavated soils were reported to be disposed of at a solid waste landfill after testing (IWM, 2019a).

- An off-site pilot groundwater treatment study was initiated during sewer line replacement in October 2019. This pilot consisted of the injection of Regenesis products, PlumeStop and Micro-ZVI, in the vicinity of monitoring well MW-35 and within the sanitary sewer main trench (Parks, 2019). Groundwater TCE and PCE concentrations at the injection points were monitored for six months beginning in November 2019 through April 2020. The U.S. EPA's website notes the monitoring indicates shallow groundwater contamination decreased around MW-35 and in the test trench area (U.S. EPA, 2020a). A final report of the pilot study is not yet available, which does not allow for a meaningful technical evaluation of the data quality and conclusions. Such reports should be made accessible to the public for review and comment, as meaningful community involvement is crucial for the selection of a final remedy.

- Several residential sewer laterals tested between January and March 2020 were reported as having higher than expected levels of CVOCs present. Amphenol investigations indicated that the on-site groundwater pump-and-treat system appeared to be contributing to vapors in the sewer system. Amphenol conducted modifications to the pump-and-treat system design and then sampled sewer vapor in the downgradient sewer main. Repeat testing of houses downgradient along the sewer – to determine if vapors had been 'cleared' from the sewer – was suspended for a time in response to the COVID-19 concerns but was expected to be completed by May 2020 (U.S. EPA, 2020b).

- Most recently, three rounds of on-site soil sampling were conducted at the Amphenol Site in May 2020, September 2020 and January 2021 (U.S. EPA, 2021b). This sampling program is being done due to concerns of additional CVOC sources present on the Amphenol Site. Soil contaminant sources can continue to pollute groundwater indefinitely unless they are removed or treated (U.S. EPA, 1992; NRC, 2005, p.174). Results of this sampling will help define soil source areas and inform the design of further soil remediation on-site (IWM, 2020). Final reports of the three sampling events have not yet been made available; however, the U.S. EPA notes on its website that soil concentrations up to 370 mg/kg PCE and 67 mg/kg TCE were found during the September 2020 event, and "the most contaminated zone was between 17-25 feet below the surface in the interval above and at the top of the clay [layer]" (U.S. EPA, 2020a). Data from these testing events will require careful evaluation.

1.1.2 Former Warrior Oil Facility

The former Warrior Oil Facility located at 809 Overstreet Street (IDEM Site #0000797) was previously the location of a used oil recovery business (see **Figure 1A**, **Appendix A**). As part of

a 2010 Environmental Site Assessment (ESA) report for this property, the possibility for groundwater contamination from the Amphenol Site to migrate and impact the Warrior Oil property was discussed (Shaw Environmental, 2010, p.10-1). IDEM indicates on its "Franklin, IN" webpage that groundwater and soil at the property currently meet appropriate Remediation Closure Guide screening levels, and on November 25, 2019 a "Close Out Report" was issued requiring no further investigation (Faulds, 2019; IDEM, 2021).

1.1.3 Radwell Real Estate

The Radwell Real Estate property located at 600 North Forsythe Street (IDEM Site #0000934) was a former electric motor warehouse (see **Figure 1A**, **Appendix A**). According to Radwell's November 2018 response to an IDEM information request, hazardous materials were not used at the site and groundwater contamination noted on the property is believed to be associated with the Former Amphenol Site (Arcadis, 2014, p.22). IDEM concluded that groundwater contaminant concentrations on the property were not a concern for vapor intrusion; however, IDEM is requiring an Environmentally Restrictive Covenant (ERC) that bars the use of property groundwater for drinking water purposes. No additional investigation is being pursued at the site at this time (IDEM, 2021).

1.1.4 Former Franklin Power Products Site

The Former Franklin Power Products site located at 400 North Forsythe Street (IDEM Site #0000807) has historically housed a range of industrial businesses since the early 1900s, from horse harness and tomato canning operations to diesel engine remanufacturing (see **Figure 1A**, **Appendix A**). The site is now owned by 400 Forsythe, LLC and has recently been used for storage facilities and an indoor baseball training center (Townsend, 2018a). Sampling conducted at this site since 2004 has indicated the presence of chlorinated compounds in groundwater. TCE in onsite groundwater has been of principal concern due to its repeated detections in exceedance of IDEM Remediation Closure Guide (RCG) Screening Levels (SM&A, 2019). Documents filed with IDEM by consultants and attorneys for the Former Franklin Power Products Site have maintained the position that "any and all such hazardous substance contamination at the [400 N Forsythe Street] Property was attributed to that [Amphenol] off-site source" (Townsend, 2018b, pp.2-7).

Recent investigations at the Former Franklin Power Products Site have focused on further delineating TCE within and around the site boundaries and screening any associated vapor intrusion pathways:

- August 2018 – No indoor air vapor intrusion issues were reported to have been detected during an initial testing event by consultant Keramida, Inc. (Keramida, 2018).

- March 2020 – In a second 8-hour vapor intrusion testing event conducted by consultant St. John Mittelhauser & Associates, three (3) out of seven sub-slab samples contained TCE or PCE below their respective IDEM RCG Screening Levels, and no indoor air CVOC detections were reported (SM&A, 2020a).

- June 2020 – A third round of follow-up 8-hour vapor intrusion testing was conducted by SM&A, with three (3) out of eight sub-slab samples containing TCE or PCE below their

respective IDEM RCG screening levels. No indoor air CVOC detections were reported (SM&A, 2020b).

IDEM has concluded from this data that no additional investigation or remediation activities are required at the Former Franklin Power Products Site and issued a site closure letter in December 2020 (Groves, 2020). An ERC was also placed on the property in November 2020 to prevent future use of groundwater for drinking purposes (IDEM, 2021).

1.1.5 Hurricane Development

Within a portion of the former Hougland Tomato Cannery parcel, Hurricane Development located at 1130 Eastview Drive (IDEM Site #201334567) houses two buildings of interest: a former gymnastics center (now being used as a merchandise warehouse) and an active recycling facility (see **Figure 1A**, **Appendix A**). Chemicals of concern in soil and groundwater at this site include the chlorinated compounds PCE, TCE, cis-1,2-DCE and trans-1,2-DCE (IDEM, 2021). IDEM's November 2019 "Franklin Area Investigations Map," showing the current delineation of groundwater contamination associated with the former Hougland Tomato Cannery, is included for reference as **Figure 1B (Appendix A)**.

Several recent vapor intrusion testing and mitigation events have been conducted at the two referenced Hurricane Development buildings:

Former Gymnastics Center

- *Sub-slab*: One sample during a January 2020 24-hour testing event exceeded the IDEM Residential Soil Gas Sub-Slab Screening Level for TCE (Patriot, 2020a). Sub-slab exceedances were not reported during a second February 2020 24-hour testing event (Patriot, 2020b).

- *Indoor air*: CVOC sampling results reported for this building were below their relevant screening levels in the January 2020 testing event. However, an exceedance of the IDEM Residential Indoor Air Screening Level for TCE was reported during the subsequent February 2020 testing event.[1]

- The gymnastics center permanently closed in March/April 2020, postponing any further sampling activities. IDEM reached out to a new occupant using this building as a merchandise sales warehouse to discuss additional sampling needs (IDEM, 2021).

Recycling Facility

- *Sub-slab*: Detections of TCE and PCE reported for three 8-hour vapor intrusion testing events (in January 2020, February 2020 and April 2020) exceeded IDEM RCG screening levels. The most elevated sub-slab vapor concentrations (over one million $\mu g/m^3$ TCE) were found adjacent to the office area (Patriot, 2020c, pp.4-6 and 2020d).

[1] The noted sub-slab and indoor air exceedances at the Former Gymnastics Center were reported as below the relevant IDEM Commercial/Industrial screening levels, while above the Residential criteria.

- *Indoor air*: Concentrations of TCE were detected above both Residential and Commercial/Industrial screening levels during all three January-April 2020 (8-hour) testing events, prompting IDEM to request additional source investigation and mitigation activities at the building.

- Interim mitigation measures, including installation of a carbon air filtration system in the office area and exhaust fan in the warehouse area, were implemented between March and May 2020 with a goal of reducing the concentrations of indoor CVOCs (Patriot, 2020e; IDEM, 2021).

- Subsequent performance monitoring events were reported to show that the interim mitigation measures were working for several months after implementation to decrease indoor air concentrations below appropriate IDEM RCG screening levels. However, TCE was noted to have spiked back up again above the indoor air screening level in the office area during an October 2020 testing event (Patriot, 2020f, pp.4-5). Installation of a permanent mitigation system and remediation of the source of the vapor intrusion impacts is therefore still needed.

A source area investigation work plan for Hurricane Development, to further delineate shallow/deep groundwater contamination and identify any contaminant source areas, was approved by IDEM in October 2020 (Johnson, 2020). The results of this Further Site Investigation will help with refining the Conceptual Site Model (CSM) and selecting a remedy. The final report of this investigation should be made available to the public once received by IDEM.

1.1.6 Reed Manufacturing Services Site

This facility at 1056 Eastview Drive (IDEM Site #201342015) is also located within a portion of the former Hougland Tomato Cannery parcel. This site is currently used for manufacturing bolts, screws, and other metal machining work (see **Figure 1A**, **Appendix A**) (Ramboll, 2019). In 2018, the site was referred to IDEM's Remediation Services Branch and cited for violations regarding the generation and storage of used oil (Lowry, 2018). A wastewater compliance inspection conducted in June 2019 reported no apparent illegal discharges into the sewer lines, and the property owner claimed to not use chlorinated solvents (IDEM, 2019a).

Chemicals of concern in soil and groundwater at this site include the CVOCs PCE, TCE, and cis-1,2-DCE. Consultants for the Reed Manufacturing Services Site and the Hurricane Development Site have worked collaboratively on groundwater delineation investigations due to both parties occupying pieces of the original Tomato Cannery property (Ramboll, 2019, pp.3-4).

A Remedial Action Plan proposed as a result of data from these investigations was approved by IDEM in November 2019 (Johnson, 2019a). The approved plan, involving the excavation of soil contaminant source material and in-situ chemical oxidation (ISCO) groundwater treatment, was executed between February and March 2020. Approximately 2,500 tons of soil and debris were reported to have been removed from the site (Ramboll, 2020a, p.5).

Groundwater monitoring activities are planned to continue quarterly for the next 1 to 2 years to assess the remedial actions' effectiveness (IDEM, 2021). June 2020 monitoring data showed no

overall change in groundwater quality, with PCE and TCE remaining above selected remedial goals in off-site shallow wells (Ramboll, 2020b). Additional groundwater treatment and/or source removal measures will need to be evaluated by IDEM once more data from the planned confirmatory monitoring events come in, allowing for the evaluation of trends.

1.1.7 Former Arvin Industries Site

This property is located at 1001 Hurricane Street (IDEM Site #0000783) and housed several industrial operations dating back to the early 1900s, including woodworking and production of war-time products through World War II (see **Figure 1**, **Appendix A**) (Arcadis, 2019a). Arvin Industries manufactured automobile exhaust systems on the property until 2004. Historical records indicate the following hazardous materials were used and likely disposed of at the site: TCE, polychlorinated biphenyls (PCBs), waste paint, waste batteries, corrosive solids and petroleum-based fluids (Malcolm Pirnie, 2004). KDL Investments, LLC purchased the site in 2005 after automotive part manufacturing ceased, and this location is currently operated as Hurricane Industrial Complex (Townsend, 2018c).

Recent sampling activities have been conducted to assess impacts to groundwater and potential vapor intrusion concerns from this site's historical operations:

- In April/May 2019, groundwater sampling, soil sampling, subsurface geological profiling, and a preferential (contaminant migration) pathway assessment were performed. Field activities were focused near former industrial process areas and buildings on the site. VOC exceedances of applicable IDEM RCG screening levels were reported in two (2) out of nine total soil sampling locations and four (4) out of twelve total groundwater sampling locations (Arcadis, 2019b).

- In November 2019, IDEM required investigation of more soil and groundwater locations, including along the sewer backfill, to assess the potential for contaminant migration beyond property boundaries (Johnson, 2019b). These investigation activities were conducted in March 2020. Soil VOC analytical results of all seven (7) sampled locations were reported as "low-level," and not in exceedance of any applicable IDEM RCG screening criteria. Two (2) out of seven total groundwater sampling locations were reported as exceeding the IDEM RCG Residential Tap Water Screening Level and Residential Vapor Intrusion Screening Level (VISL) for vinyl chloride and TCE, respectively. The sewer backfill investigation reported no detections of VOCs (Arcadis, 2020).

As per IDEM's most recent update on its "Franklin, IN" webpage, the agency is currently reviewing data from the latest investigation at the former Arvin Industries site and will make a determination as to next steps (IDEM, 2021).

1.2 IDENTIFIED DATA GAPS

Data gaps associated with the Amphenol Site and considered in this report include:

1) The lack of vertical and horizontal delineation of the identified CVOC groundwater plume to the east and west of North Forsythe Street downgradient of the Amphenol Site;

2) The lack of investigation immediately north and south of Hurricane Creek; and

3) An insufficient number, spacing and depth of permanent monitoring wells installed for the purposes of groundwater plume delineation, groundwater flow direction determination and long-term monitoring of the plume.

1.3 PROJECT SCOPE AND OBJECTIVES

The main purpose of this project was to map potential existing, yet currently unidentified, migration pathways for the Amphenol groundwater plume that could pose unacceptable risks to the health of residents and the environment in Franklin, Indiana. The scope of work was prepared based upon the following project goals with input from members of the Franklin/Johnson County community:

1) Conduct non-intrusive geophysical surveys adjacent to Hurricane Creek to enhance the understanding of subsurface conditions in this area, and identify features that could act as pathways for contaminant migration into or south of the creek; and

2) Conduct preliminary groundwater modeling to explore whether the Amphenol TCE plume could be spatially more widespread and compare the generated model with the current plume boundaries officially reported by the U.S. EPA.

2. PROCEDURES

2.1 HURRICANE CREEK AREA GEOPHYSICAL SURVEY

As outlined in **Section 1.3**, one goal of this investigation was to gain an enhanced understanding of subsurface conditions that could act as preferential flow pathways for further CVOC impacts downgradient of the Amphenol Site. In evaluating the potential for the Amphenol contaminant plume to migrate into and beyond Hurricane Creek, key considerations include both the distribution of sand and clay layers in the subsurface, and these layers' overall uniformity and continuity. Coarser-grained layers, such as sand and gravel deposits, tend to be more permeable to groundwater and allow more rapid contaminant movement than finer-grained clay layers, which are typically characterized as barriers to contaminant movement. However, structural inconsistencies in an otherwise uniform clay layer could create preferential pathways for contaminant movement into areas believed to be protected. These localized pathways can cause increased groundwater-surface water interactions or vertical leakage between shallow and deep aquifers (Cherry, 2004, pp.8-31).

Geophysical surveying is a common investigative tool to noninvasively image geologic and hydrogeologic conditions of this nature in the subsurface, and to help guide next steps in an environmental field sampling program or remediation. Conventional soil drilling tests (borings) collect data at a single, discrete location, meaning there is inherent uncertainty in attempting to fill in information gaps between sampling points. Contrasted with relying on soil borings alone, geophysical surveying can offer more detailed insights of hydrogeologic features over a larger, continuous section of a study area (U.S. EPA, 2008a). There are a wide variety of geophysical technologies from which to choose, depending on site-specific conditions and project needs.

Given the Franklin project area and the desire to characterize coarse-grained deposits that may be controlling groundwater flow and contaminant movement in the general area, two-dimensional Electrical Resistivity Imaging (2-D ERI) was selected as the method of choice for this study. This method involves inserting sets of electrodes into the ground surface along "profile lines." Low level electrical direct-current (DC) is applied through transmitting electrodes, which travels to a vertical depth below the ground. The response of contrasting soil types in the subsurface – such as sand and clay, which conduct electricity differently – is measured through resistivity sensors. The field data is then compiled into a cross-sectional 2-D visual model with the aid of computer software.

The geophysical investigation described in this report was conducted near Hurricane Creek, south of the Amphenol Site, between December 3rd to 4th, 2019. Surveying was performed along a total of three (3) individual resistivity profile lines. Locations of the profile lines are shown in **Figure B-1, Appendix B**. These initial profile line locations were selected based on proximity to the banks of Hurricane Creek and the former Amphenol Site, to address the concern that the extent and migration of the mapped CVOC plume and sewer contamination have not been fully characterized in this area. The ability to secure access agreements from private businesses and residential properties was a limitation in profile line selection.

Further technical details related to the field data collection, analysis methodologies and regional geology and hydrogeology references used in this evaluation are available in the attached MUNDELL *Report of Geophysical Survey* provided in **Appendix B**.

2.2 TCE GROUNDWATER PLUME MODELING

The question of how far TCE-impacts in groundwater could travel away from historical source area releases can be resolved by performing additional direct field sampling downgradient of the release areas. However, preliminary modeling of TCE transport in groundwater can predict where these impacts may have traveled prior to completing additional field studies. Modeling is performed with computer software wherein numerical inputs are applied using reasonable hypothetical assumptions of actual aquifer conditions. The inputs are based on currently available site-specific knowledge from sampling data as well as appropriate values from peer-reviewed literature. This allows for aquifer conditions – from original source area(s) all the way to the estimated furthest downgradient impacts – to be simplified and simulated mathematically. The preliminary visual model that is generated from this method, while not replacing direct field sampling efforts, can flag specific locations requiring additional groundwater sampling, and serve as a comparison tool as fieldwork is completed.

The contaminant transport modeling evaluation described in this report was conducted over the area from the Amphenol Site southward to beyond Hurricane Creek, using the 3-D Domenico-Robbins solution (see **Appendix C**). As introduced in **Section 1.3,** this model was generated as an initial examination of current groundwater characterization data gaps downgradient of the Amphenol Site, and to address concerns that the contaminant plume could be more spatially widespread than the impacts identified to date by the U.S. EPA.

The MUNDELL *Preliminary Groundwater TCE Transport Modeling Study* provided in **Appendix C** summarizes in more technical detail the key assumptions used, the modeling scenarios and analyses completed, and the results of this preliminary transport evaluation. In designing future field studies both on- and off-site of Amphenol, these modeling results should be used in concert with the results of the MUNDELL *Report of Geophysical Survey* (**Appendix B**).

3. SUMMARY OF RESULTS

3.1 HURRICANE CREEK AREA GEOPHYSICAL SURVEY

Based on a geologic and hydrogeologic review of the Franklin investigation area and the 2-D resistivity profile results, MUNDELL concludes the following:

1) Unconsolidated aquifer systems south of the Amphenol Site near Hurricane Creek (see **Figure B-2**, **Appendix B**) indicate the potential for encountering vertically and horizontally- connected sand and gravel deposits that are highly permeable and vulnerable to contamination. Identifying and mapping those vulnerable areas (where fine-grained clay deposits are thin, absent, fractured or otherwise not continuous) is necessary to accurately characterize the Amphenol groundwater plume and address all exposure pathways.[2]

2) In general, the subsurface geophysical profiles collected by MUNDELL (see **Figures B-3**, **B-4** and **B-5**, **Appendix B**) indicate a relatively uniform presence of coarse-grained sand deposits in the upper subsurface near Hurricane Creek, with zones of fine-grained clays in the deeper subsurface. However, the profiles also indicate zones of interconnectivity between shallow and deep coarse-grained deposits and a lack of fine-grained clay material at the surface, which have not been adequately considered by previous work in the area. These interconnected permeable zones increase the potential for both vertical and horizontal groundwater flow and contaminant migration, thereby increasing the risk of shallow contamination reaching wider and deeper zones.

3) Future investigation and remediation decisions by the regulatory agencies – including the selection of appropriate locations for the advancement of soil borings and installation of monitoring wells – should be made by incorporating this study's enhanced understanding of the expected subsurface conditions.

Further details are available in the *Report of Geophysical Survey* in **Appendix B**.

3.2 TCE GROUNDWATER PLUME MODELING

Based on known conditions at the Amphenol Site, a geologic and hydrogeologic review of the Franklin investigation area, and our initial contaminant transport simulations, MUNDELL concludes the following:

1) As indicated on **Figure C-1** (**Appendix C**), for the conservative case of an aquifer with a hydraulic conductivity of 20 ft/day (*i.e*., the minimum aquifer hydraulic conductivity resulting in the minimum contaminant transport distance), the TCE-impacted groundwater from each

[2] "All exposure pathways" includes the general EPA policy of responding to exposure pathways that pose either an actual (current) or potential (future) risk to human health and the environment. See (U.S. EPA, 2004 and 2021a).

simulated Amphenol source area migrates to the south-southeast and co-mingles such that a larger area of impact results. This is generally consistent with the observed area groundwater impacts reported by previous sampling events.

2) Predicted groundwater TCE concentrations above the federal drinking water threshold of 5 μg/L could occur beyond Hurricane Creek and east of North Forsythe Street over a width of about 900 ft.

3) For this preliminary conservative simulation, the potential exists for a larger, contiguous area of groundwater contamination in Franklin, and specifically for detectable impacts to extend southward beyond East King Street. Use of a higher aquifer hydraulic conductivity would result in even greater transport distances.

It should be emphasized that the results of this initial contaminant modeling exercise are meant to be used to guide the selection of additional groundwater sampling locations for further plume delineation to the south of the currently identified impacted area. The actual area and concentration of impacts will, no doubt, vary based on site-specific historical, operational and subsurface conditions.

Further details are available in the *Preliminary Groundwater TCE Transport Modeling Study* report in **Appendix C**.

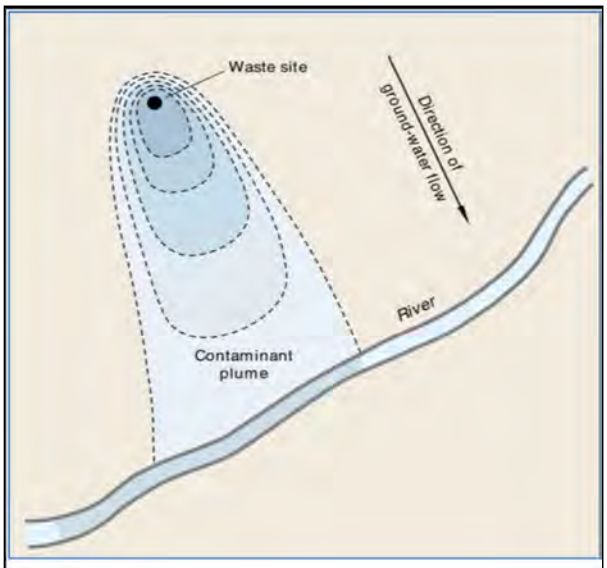
4. DISCUSSION AND RECOMMENDATIONS

The combined interpretation of the preliminary Hurricane Creek area geophysical survey and groundwater TCE transport model demonstrates clear concerns as to the identified Amphenol plume's ability to migrate beyond Hurricane Creek to the south-southeast or impact the surface water and sediment of the creek itself. The subsections below detail three specific areas of uncertainty regarding the extent of groundwater and surface water impacts in Franklin that should be resolved through targeted data collection. The recommendations below are further supported by historical observations made by the U.S. EPA and others at the Amphenol site, along with general regulatory principles also discussed in this section.

4.1 DATA GAP 1 – PLUME DISCHARGE TO HURRICANE CREEK

Based on review and interpretation of the depth-to-groundwater data collected in nearby area monitoring wells, the confirmation of significant granular soil conditions adjacent to Hurricane Creek, and the general elevation of the Hurricane Creek surface water level, conditions for potential direct contaminant discharge into the creek exist and must be further investigated.

While any impacts to Hurricane Creek are independently important environmental concerns, they also influence other aspects of the Amphenol investigation, including: control of and ultimate remedy selection for the contaminated groundwater plume (discussed in **Section 4.2**); and by extension, the overall protection of human health in the Franklin residential neighborhoods (discussed in **Section 4.3**). The failure to factor Hurricane Creek into the Amphenol site investigation and other Franklin contaminated site investigations is a data gap that leaves a substantial uncertainty.



Inset Figure 1: This diagram shows how transport of contamination through groundwater from a point source can result in surface water impacts, if such groundwater plume intersects and discharges into a river or stream.

Figure courtesy of the U.S. Geological Survey (Winter, 1998)

The U.S. Geological Survey's *Ground Water and Surface Water A Single Resource* publication (Winter, 1998) is straightforward in describing the relationship between surface water-groundwater interactions and the overall success of an environmental project:

> *"Traditionally, management of water resources has focused on surface water or groundwater as if they were separate entities...[but] nearly all surface-water features (streams, lakes, reservoirs, wetlands and estuaries) interact with groundwater. Thus, effective land and water management requires a clear understanding of the linkages between groundwater and surface water as it applies to any given hydrologic setting"* (p.III).

Inset Figure 1 (taken from Winter, 1998, p.56) visually depicts this linkage between groundwater flow, discharge from a chemical source release and potential resulting water quality impacts in a nearby surface water body.

Clearly, a comprehensive evaluation of Hurricane Creek will have major influence in directing how the Amphenol groundwater investigation proceeds and how the full-scale remediation is designed. The possibility for impacted groundwater migration to surface water demands specific regulatory requirements be met:

- Groundwater that directly discharges to surface water must not only meet groundwater quality standards such as Maximum Contaminant Levels (MCLs), but also must comply at a minimum with federal requirements for surface water under the Clean Water Act.[3]

- In the RCRA Corrective Action process, "environmental indicators (EIs)" are used to track site conditions and progress made toward protecting human health and the environment. The U.S. EPA's EI tracking procedures include an entire section dedicated to determining whether contaminated groundwater discharges into surface water bodies. If the U.S. EPA indicates that this is not occurring, it must provide "*an explanation and/or referencing documentation supporting that groundwater contamination does not enter surface water bodies*" (U.S. EPA, 1999a, pp.11-14). The U.S. EPA has already been issued a Management Alert for this Site by the Office of Inspector General for failing to update environmental indicator "milestones" with current or accurate information (Lovingood, 2019). Region 5 Site management therefore has an obligation to make sure the agency is acting consistently with all other aspects of the RCRA Corrective Action EI tracking guidance.

The U.S. EPA must either provide to the public a written statement, reference documentation and relevant data that scientifically support the conclusion that Hurricane Creek is not being impacted by the plume or require that Amphenol implement the recommendations in this report as part of its ongoing Corrective Action requirements.

4.1.1 Historical and Regulatory Context

Concerns regarding impacts to Hurricane Creek from the Amphenol Site have been an unresolved issue for decades, raised at least as far back as the 1980s during Phase I and II Site Assessments (IT Corporation, 1985). Additionally, in 1996, a U.S. EPA-commissioned review of Amphenol's Corrective Measures Studies (A.T. Kearney, 1996, p.2) asserted "*the Hurricane Creek investigation has not been adequately completed*" and that:

> *"Specifically, multiple discharge measurements can be taken along the reach of the creek to determine whether Hurricane Creek is gaining or losing stream (i.e.: to determine whether groundwater is impacting sediments and surface waters)."*

[3] New Jersey, Kansas and North Carolina state guidance pertaining to contaminated groundwater-surface water interaction were reviewed (NJDEP, 2016; KDHE, 2017; NCDEQ, 2017). These guidance documents also highlight the importance of verifying the width and depth of a plume intersecting a surface water body and determining whether such plume is migrating under the surface water body to the other side (to be discussed in **Section 4.2**).

With the now renewed effort to investigate and cleanup the Amphenol Site over two decades after this 1996 EPA review, MUNDELL continues to find little to no relevant, direct evaluation of Hurricane Creek outside of the following limited sampling events:

- Indiana Department of Environmental Management (IDEM) collected three (3) surface water samples on August 23, 2018, at locations upstream of the Amphenol site. These samples were located near the Former Webb Wellfield and Needham/Webb Elementary school areas. Samples were analyzed for VOCs, with data reported as non-detect for all three locations (McIntire, 2018).

- MUNDELL collected three (3) Hurricane Creek bank sediment samples and four (4) surface water samples on February 28, 2019, both upstream and downstream of the Amphenol Site. TCE soil concentrations exceeding the IDEM soil migration-to-groundwater screening level were detected in a sediment sample collected closest to the Amphenol Site, near the crossing point of North Forsythe Street and Hurricane Creek (MUNDELL, 2019, p.18).

These two referenced datasets should be only the beginning of a much more comprehensive "Groundwater-Surface Water Interaction/Discharge" study of the creek and underlying aquifer system, discussed in Section 4.1.2.

Recent activities have been conducted to remediate the sanitary sewer main at the Amphenol site and down North Forsythe Street. IWM Consulting's own written goals for this interim measure included "*protecting the water quality of Hurricane Creek"* (2019b, p.17). Without a robust investigation of Hurricane Creek, the success of this goal and others cannot be evaluated since there is no baseline to compare to. As already mentioned, regulatory agencies recognize that data gaps such as the ones associated with Hurricane Creek do not occur 'in a vacuum' and can have larger impacts on the overall success of an entire investigation or final remedy.

4.1.2 Recommendations

In our previous 2019 *Phase III* report, MUNDELL advised that:

> *"As the groundwater CVOC plume is located immediately north of the creek, it is possible that under certain hydrological situations, groundwater enters Hurricane Creek from the north, potentially contributing contamination from the plume to the creek*" (p.22).

The geophysical surveying and groundwater modeling work conducted by MUNDELL further justify the need for Hurricane Creek to be meaningfully included in the larger Franklin investigation, with a focus on examining creek-aquifer connectivity.

As discussed in **Section 3**, while modeling and geophysical work are useful tools to guide the next steps of the Franklin investigation, they alone do not replace soil, water and vapor sampling. Therefore, given the findings of this report and the previous body of work in Franklin, Indiana by MUNDELL and others, a detailed Groundwater-Surface Water Interaction/Discharge study of Hurricane Creek should be conducted. This investigation should be focused south of the

Amphenol Site and east of the upgradient Hougland Cannery (both known CVOC plume areas) and be designed to identify and map any flow paths of contaminated groundwater associated with these sites into the creek. The investigation should also account for seasonal variation in groundwater and streamflow.

The following water and sediment sampling approaches are encouraged as part of such a study:

- *Passive diffusion sampling bags* - Contain deionized water with a low-density polyethylene membrane and are installed in the bed of the creek for a span of several weeks to evaluate porewater CVOC concentrations. Erroneous conclusions have been well-documented at other remediation sites that relied on surface water sampling and adjacent groundwater sampling alone; even high-concentration, continuous contaminant plume discharges to creeks and rivers can go undetected due to hydrogeological complexities near surface water bodies (Conant Jr., 2000, pp.23-30 and 2004). Passive diffusion sampling bags supplement surface water and groundwater data and have been successfully used at sites[4] similar to those in Franklin to more accurately quantify CVOC impacts over time and seasonal rainfall variations (ITRC, 2005). This approach can assist with identifying any probable points of entry from groundwater plume(s) into Hurricane Creek.

- *Collection of sediment grab-sample transects* – Should be evenly spaced along Hurricane Creek, with each "sampling line" positioned perpendicular to the surface water flow and starting from one bank of the creek to the other (see **Figure 3, Appendix A** for a diagram of appropriate 'starting-point' transect locations overlain onto Hurricane Creek aerial imagery).

4.2 DATA GAP 2 – RISK OF PLUME SPREADING

Section 4.1 considered the vulnerability of Hurricane Creek surface water and sediment to discharges from the Amphenol Site-associated groundwater plume. Our preliminary geophysical and modeling results also indicate that there may be existing conditions that allow CVOC contaminants to migrate southward beneath the creek and spread to the other side beyond the U.S. EPA study area.

As such, specific steps need to be taken to complete horizontal and vertical plume delineation so that effective remedial alternatives can be proposed and implemented. Without strategic groundwater vertical profiling (see **Section 4.2.2**), installation of additional permanent wells, and verification of assumptions made by the U.S. EPA Conceptual Site Model, the plume reach (and depth) may be substantially underestimated.

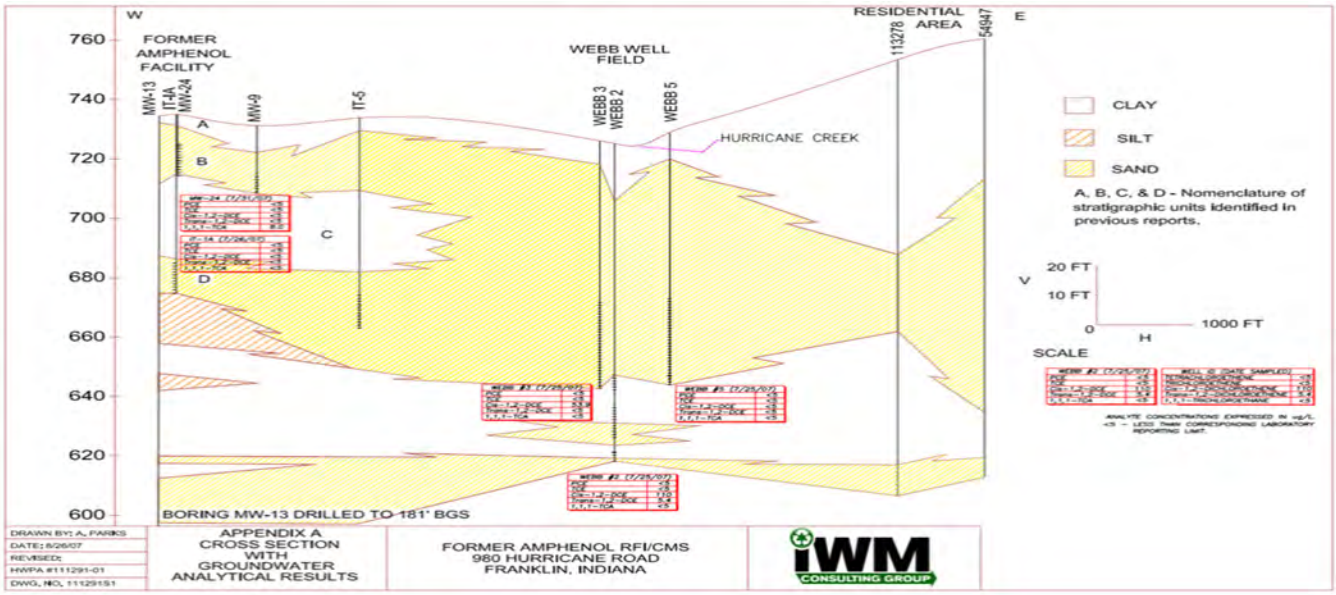
4.2.1 Historical and Regulatory Context

It has been repeatedly emphasized in previous MUNDELL reports, letters and telephone correspondence with the U.S. EPA that there is an inadequate number, spatial distribution and depth of monitoring wells needed for horizontal and vertical groundwater plume delineation for the Amphenol Site. Inadequate site characterization data and partially mapped contaminant

[4] For instance, Cornell-Dubilier Superfund Site in South Plainfield, New Jersey (Accardi-Dey, 2013).

plumes have negative effects on the long-term success of a final remedy design. This is evident by the Amphenol Site's own history and operation of the original pump-and-treat remedy since 1995, which proved to be ineffective in protecting residents, preventing indoor vapor exposures or diminishing the plume; objectives it was incorrectly assumed to have been meeting by regulators for over two decades. MUNDELL made the following professional recommendation in our previous June 24, 2019 *Phase III Residential Vapor Intrusion Testing* report:

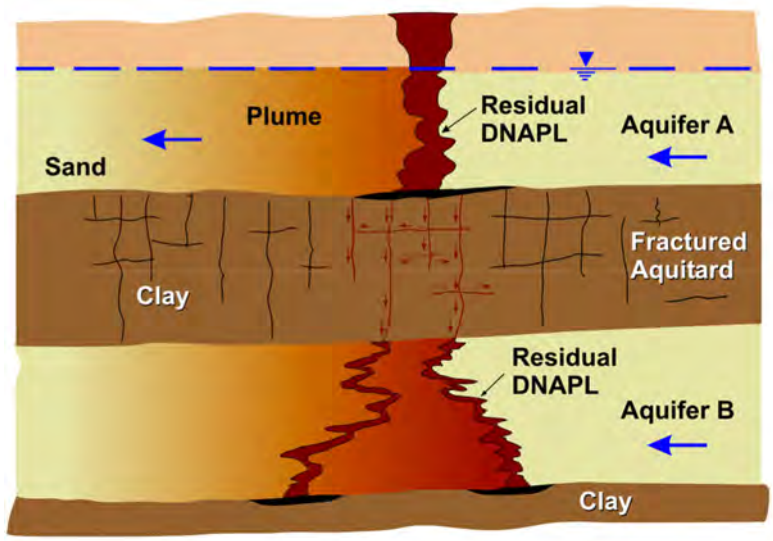
> *"Updated groundwater plume maps indicating the most recent March 2019 IWM Consulting data unveiled by the U.S. EPA at the June 5, 2019 Public Information Session presented the estimated extent of groundwater impacts from the Amphenol Site. This assessment has been largely arrived at from the analytical testing results of groundwater grab samples collected using direct push technology. As such, this interim delineation is not considered reliable and reproducible by U.S. EPA standards until groundwater samples are collected and tested from a permanent monitoring well network. Because of this, MUNDELL recommends that an extensive monitoring well network be installed south of the Amphenol Site that will confirm the interim delineation and provide confidence in the results presented to date"* (pp. 22-23).



Inset Figure 2: 2007 Geologic Cross Section by IWM Consulting depicting an estimated configuration of subsurface layers, Stratigraphic Units "A, B, C and D," in the West-East direction from the Amphenol Site. Note the vertical connection shown between sand aquifer Units B and D, to the east beyond former well IT-5. Clay aquitard Unit C is drawn as a vertically continuous layer across the Amphenol Site/portions of the off-site areas, based on limited well and boring logs. Variability of geologic features occurring in between wells could be more accurately assessed through detailed geophysical studies to determine the true integrity of Unit C.

Existing subsurface characterization information in the vicinity of the Former Amphenol Site[5], Webb Wellfield (IWM, 2007) and Former Franklin Power Products Site (SM&A, 2019), supported by the MUNDELL geophysical survey results, have reported a greater presence of coarse-grained sediments in the general Franklin investigation areas than the U.S. EPA has previously suggested.

Rather, the U.S. EPA has put emphasis on its position (as discussed at the June 5, 2019 public meeting and a September 19, 2019 stakeholder call) that the plume has been fully delineated and groundwater discharge to Hurricane Creek or the crossing of groundwater beyond the creek is not occurring due to an impermeable clay barrier (aquitard), identified as "Stratigraphic Unit C" (see **Inset Figure 2**). This characterization of Unit C as an effective barrier to contaminant migration into the deeper sand aquifer or underneath Hurricane Creek appears to have been derived largely from limited groundwater well/soil boring log information, based on these discussions with the U.S. EPA.



Inset Figure 3: Schematic drawing of how vertical/horizontal fractures in an aquitard of otherwise consistent thickness can lead to contamination migrating in groundwater to greater depths.
Figure source: (Friis, 2006).

Classifying overall clay versus sand content in the subsurface layers alone is not sufficient evidence to determine a unit's effectiveness as a contaminant barrier to prevent wider or deeper impacts. Site-specific features that affect the integrity of an aquitard, such as variabilities in thickness, imperfections or fractures, interbedding of sand, ancient glacial paleochannels and other natural or human-caused factors can all create localized flow paths for water and contaminant movement (see **Inset Figure 3**). The existence of only a few permeable preferential pathways can account for a majority of contaminant movement into new areas of an aquifer system (U.S. EPA, 2008b), particularly in cases where dense non-aqueous phase liquid is present (see **Section 5**). This makes evaluation of aquitard continuity and local-scale structural variability important to ensure the extent of contamination is not underestimated.

According to the IDEM *Aquitard and Fine Grained Sediment Characterization* Technical Guidance (2019b):

[5] It should be noted that MUNDELL has largely not been able to locate newer (2018-2021) well construction/soil boring log documentation for the Amphenol Site, nor do final reports containing project narratives and laboratory analytical information for recent investigations appear to be available on the U.S. EPA's website as a whole. The U.S. EPA must expedite making these materials accessible for public review and discussion, not only the pre-investigation work plans and isolated maps/data tables.

> *"Aquitards are often mischaracterized as homogenous and massive, and interpretations about how these units affect groundwater flow are often incorrect... If a clay unit of sufficient thickness is encountered in a boring, the investigator often assumes contamination will not migrate any deeper or vapors will not migrate into overlying structures. However, if these clays are fractured or are not continuous, contamination may migrate through the unit. The presence of fractured clays and glacial till in Indiana is well-documented"* (pp. 1-4).

These 'imperfections' in clay units are frequently missed or omitted by well construction/soil boring data interpretation alone; this is due in part to too few monitoring points and borings/wells often being spaced too far apart to encounter the features directly as introduced in **Section 2.1**. The U.S. EPA therefore needs other lines of evidence, such as data from a detailed geophysical study, to confirm the aquitard's ability to prevent wider and deeper contaminant movement, instead of simply assuming Unit C has 'idealized' and perfectly homogenous hydrogeologic features along the entire reach of the Amphenol Site and off-site Hurricane Creek area.

The geophysical survey performed by MUNDELL, in combination with lithological information garnered from review of previous Franklin site investigations and shallow groundwater sampling data beneath the sewer line prior to its removal indicate that:

- Leakage of the sewer line into the subsurface may have resulted in even deeper vertical migration of CVOC impacts into the sandy aquifer system immediately beneath the sewer than has so far been delineated. Horizontal migration from these deeper impacts has the potential for spreading south of Hurricane Creek, which could pose potential risks to residences south of the creek, particularly in the form of vapor intrusion concerns; and

- The lack of complete removal of chlorinated solvent source materials adjacent to the sewer may also continue to allow for back-diffusion of contaminants from the shallow clay layers into the aquifer system and shallow soil gas (Parker, 2008). This may continue to be a source of both ongoing groundwater impacts as well as sewer vapors.

4.2.2 Recommendations

The geophysical survey performed by MUNDELL indicated the presence of coarse-grained sand deposits along with zones of apparent interconnectivity between shallow and deeper coarse-grained material. Combined with the results of the preliminary TCE transport modeling exercise, this survey provides additional evidence that environmental conditions potentially exist for the Amphenol CVOC groundwater plume to have migrated south underneath Hurricane Creek. This should be confirmed through the advancement of soil borings and groundwater sampling on both the north and south side of Hurricane Creek. Additional monitoring wells should also be installed to eliminate data gaps relating to the lateral and vertical delineation of the CVOC groundwater plume. Such investigative steps should be implemented on a priority basis, and certainly occur before a full-scale groundwater remediation plan is finalized, to ensure the greatest chance of success for remediation.

Based on the understood direction of groundwater flow obtained from published regional information (see **Figure C-1, Appendix C**) and identified migration pathways, proposed locations

for vertical groundwater profiling are shown on **Figure 4 in Appendix A**. These include at least ten vertical profiling locations immediately north and south of Hurricane Creek within either identified migration pathways shown by the geophysical profile lines, or in alignment with estimated CVOC movement downgradient of the sewer area shown by the transport model. Once analytical testing results of groundwater profile 'grab samples' in these areas have been received, specific locations for the installation of long-term monitoring wells can be selected. The installation of the wells should then be used to verify CVOC concentrations as well as develop an accurate potentiometric groundwater elevation map that will provide more area-specific groundwater flow directions than the published regional information.

4.3 DATA GAP 3 - HUMAN HEALTH IMPLICATIONS OF IMPACTS

To fully evaluate whether chemical sources that exist in the Franklin, Indiana community pose additional unacceptable risks to human health and the environment, it is important that the development of an accurate Conceptual Site Model (CSM) be completed. This includes not only direct analytical testing of soil, surface water, groundwater, soil vapor and indoor air, but also subsurface information gathered by geophysical studies and initial chemical transport modeling. The CSM should show:

1) the location of <u>all</u> chemical sources of potential concern and the media they have been released into (*e.g.*, soil, sediment, surface water, groundwater, soil gas);

2) the fate and transport pathways that these chemicals can move through to arrive at potential receptors/resources; and

3) the exposure pathways (*e.g*., inhalation, ingestion, dermal contact) through which the chemicals will come in contact with the receptors/resources that require protecting.

This study provided additional data that inform both the subsurface conditions present and the potential migration pathways and receptor locations that must be incorporated into the U.S. EPA's Conceptual Site Model. Recommended locations for additional soil, sediment and groundwater testing included as part of this report will provide the area characterization data needed to increase the accuracy and reliability of the CSM for the Franklin community.

4.3.1 <u>Historical and Regulatory Context</u>

MUNDELL's previous studies and document reviews (see a listing in **Section 6**) related to vapor intrusion concerns in Franklin residential areas and potential impacts to Hurricane Creek should be referenced for detailed background information on human health risk concerns. Given the results of our preliminary geophysical survey and groundwater modeling, it is worth highlighting the discussion in MUNDELL's *Phase III Residential Vapor Intrusion Testing Report* concerning potential vapor intrusion risk to the residential areas located south of Hurricane Creek:

> *"As previously discussed, TCE exceeding the soil-migration-to-groundwater screening level was detected [at the cross point of North Forsythe Street and Hurricane Creek]. One residence sampled as part of this current event was located [on the other side*

> *of Hurricane Creek, Heritage Trail], and concerning levels of TCE were observed in the home's indoor air. There may be...vulnerable residences located on this side of Hurricane Creek due to groundwater and/or soil impacts"* (p. 23).

The Agency for Toxic Substances and Disease Registry (ATSDR) has previously made announcements regarding its public health activities in Franklin, Indiana, including conducting a Public Health Consultation and issuing recommendations in its own report. The status of this report's completion is not clear, but key data gaps remain that must be resolved so that risk assessment data used in ATSDR's evaluation is accurate and reflects real conditions at the Site. As is often the case, the nature of risk assessment is "iterative [and] the generation of additional data and/or analyses that better define the distribution of risk or address uncertainty" is crucial (U.S. EPA, 2014, p.5). An inaccurate characterization of a site's conditions naturally leads to an inaccurate calculation of human health risk. Getting the details of the Conceptual Site Model "right" is ever-more important for the Franklin community, given that this is the second time the Amphenol Site has had to go through the remedial process and the span of decades that were lost in between.

When discussing risk assessment, the uncertainties associated with Hurricane Creek – a central focus of this report – also beg questions as to potential recreational use exposure pathways to adults and children. The creek is located along the Franklin Greenway trail, flows through elementary school properties and residential neighborhoods, all of which are easily accessible by the public and by children who are likely to play in the water. Amphenol Site investigations, recently and historically, have really made no clear, coordinated attempt to consider impacts both beyond, and directly to, the creek.

4.3.2 Recommendations

It is apparent that this area of concern in Franklin has likely been impacted by a number of historical chemical releases from multiple commercial/industrial properties. In order to properly assess the entire area as a whole, it is essential that a more collaborative approach be implemented between IDEM, the U.S. EPA and even the City of Franklin to address outstanding concerns in a coordinated manner. One focus of this collaboration is the need for a comprehensive "Area-Wide Hydrogeologic Assessment Report:"

- Evaluation of groundwater flow conditions using all existing and proposed monitoring well locations from the multiple known contaminated sites will improve overall understanding of behavior of the plume(s).

- Cross-sectional diagrams can be drawn and compiled (from existing and new well logs, supplemented with geophysical surveys) to highlight key hydrogeologic features that are influencing the flow conditions and chemical migration pathways.

- Then, the findings from such a collaborative report can be used to overlay key hydrogeologic data onto the isopleth maps already being created for the Amphenol Site and Former Hougland Tomato Cannery Site plumes (Truex, 2015, p.37).

5. FURTHER REGIONAL DATA GAPS

There are additional key questions beyond the scope of this report which require review and decisive action by the U.S. EPA and IDEM. MUNDELL recommends the following be discussed with the regulatory agencies, examined in future investigations, and addressed on a priority basis:

1) The modeling efforts presented in this report were done without considering the possible influence from the Former Webb Wellfield. The operation and subsequent shut-off of drinking water wells in the Webb Wellfield could have affected the historical migration of the Amphenol plume, the Hougland Tomato Cannery plume, or other potential sources and should be reviewed.[6]

2) The U.S. EPA made a decision, as indicated during September 19 and November 21, 2019 stakeholder calls, to set the action-levels for Amphenol off-site residential groundwater to less stringent Vapor Intrusion Screening Levels (VISLs) instead of the most commonly used federal cleanup standard, Maximum Contaminant Levels (MCLs). How was this decided without U.S. EPA review of complete human and ecological risk assessments, and without public notification and ability to comment?

3) To design an effective new full-scale remedy at the Amphenol Site, factors that caused previous remedies to fail must be targeted so as to not repeat similar mistakes. Therefore, an evaluation and side-by-side comparison of the following would be useful:

   (a) Previous remedial actions taken at the Amphenol Site[7] and;

   (b) Results of current interim actions/pilot studies, such as the injection of PlumeStop and Micro-ZVI being field tested at the Site.

4) A January 23, 2020 letter sent from EPA to Amphenol states, "*Samples must be taken at two-foot intervals to the top of the C-unit where NAPL [non-aqueous phase liquid] could have permeated clay. During the March/February 2019 remedial design level sampling, NAPL was found near the western property boundary in one sample at depth"* (Bury, 2020, p.2). This prompted additional soil and groundwater sampling to delineate on-site source areas in more detail (U.S. EPA, 2021b; IWM, 2020). Though a final report of these activities has not yet been provided, evidence of NAPL on the Amphenol Site is a serious finding, and the following comments should be considered:

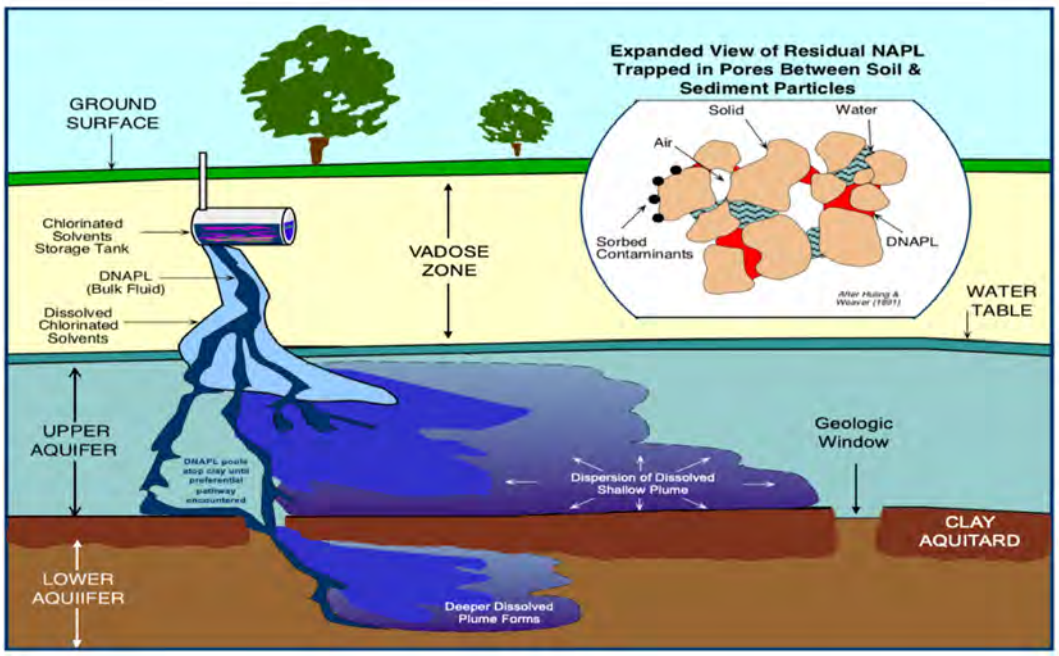
   - The constituent that was found in the form of NAPL, the depth(s) at which it was found and the estimated spatial extent of identified NAPL source areas must be communicated to the public.

[6] Groundwater modeling of flow to the Webb Wellfield area had been previously conducted on behalf of the Indiana American Water Company in 1997 (Buller, 1997; IAWC, 1997). However, this model relied on data and information that is now out of date.

[7] For instance, the 2006-2007 *Bioremediation Pilot Study* and its full-scale implementation in 2010, noted by Amphenol to have been "not particularly successful" (Waldo, 2017).

- The predominant risk-driver at the Amphenol Site, TCE, will form dense-NAPL (or DNAPL) that tends to sink in water and can percolate to deeper aquifers. The U.S. EPA reported that "the most contaminated zone [is] between 17-25 feet below the surface in the interval above and at the top of the clay" (2020a). Recall **Section 4.2**, which discussed how subsurface structure observed in one area is not necessarily consistent throughout a site, and fractures or other imperfections in a clay layer could allow contaminant movement into previously unanticipated areas (see **Inset Figure 4**). Parker et al. (2004) affirms that until strong evidence is obtained to the contrary, it is prudent to assume that DNAPLs can penetrate into or through most types of aquitards, even those that otherwise have a strong capability to protect underlying aquifers from dissolved contamination. As such, aquitard integrity can be especially deceiving when it comes to DNAPLs, underscoring the importance of MUNDELL's recommendations in this report.

- Findings from the electrical conductivity sensors reported to have been used as part of the Membrane Interface Probe (MIP) sampling during Amphenol's *On-Site Soil Investigation* (IWM, 2020, pp.2-4) should be made available for public review. The U.S. EPA should ensure that lithological logging is completed with enough spatial coverage to account for possible localized areas of weakness in the aquitard, or interconnectivity between upper and lower permeable zones (Kram, 2007; ITRC, 2011, pp.11-16).



Inset Figure 4: Schematic cross-section of a site at which DNAPL is spreading vertically. Mobile DNAPL migrates downward in the subsurface until encountering a low permeability layer (aquitard), above which it will pool and spread across, 'seeking out' zones of higher permeability. If shallow and deeper aquifers are interconnected by large enough preferential pathways in the aquitard, DNAPL can continue migrating downward after encountering these features. Some DNAPL dissolves in the groundwater over time, forming lasting dissolved-phase plumes. **Modified from U.S. EPA, 1999b.**

- As mentioned in **Section 2.2** and in **Appendix C** of this report, MUNDELL's modeling effort was performed assuming conservative (lower end of range) source area concentrations. If the existence of highly concentrated NAPL was accounted for in one or more of the estimated source areas, the resulting contaminant transport model could have shown that even more widespread impacts in Franklin were possible than conveyed in our initial simulation. EPA must consider these 'worst case' conditions when reviewing MUNDELL's preliminary groundwater model and ensure any NAPL is delineated both horizontally and vertically to stop continued contamination of groundwater from occurring.

5) Supplemental vapor intrusion investigations conducted at both the Former Indiana Gymnastics Center Building and Crossroads Recycling Building (parts of the original Hougland Tomato Cannery property) revealed apparent impacts in both indoor air and sub-slab air, with sub-slab vapor concentrations as high as 1,570,000 $\mu g/m^3$ TCE at the recycling building. IDEM should continue to require further investigations to delineate the source of these high-concentration vapor concerns and trace all off-site impacts, including determining the presence and location of potential leaking underground storage tanks (USTs) and/or DNAPL. A new *Interim Report – Further Site Investigation #4* for the Hurricane Development site was recently posted to the IDEM Virtual File Cabinet, noting the discovery of at least two "subsurface vaults" which are believed to be likely sources of contamination underneath the Recycling building (Patriot, 2021, pp.12-13). MUNDELL awaits the final report of this investigation for review.

   Related is the lack of identification of a groundwater source for the vapor intrusion issues noted below the Webb and Needham Elementary Schools. While IDEM asserts that it has ruled out the sewer lines as a source, to date, no conclusive answer has been provided to the key question of where the contamination originated, if not the sewers. This should be made clear for the parents of students and school administrators.

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APPENDIX A

FIGURES

Amphenol Study Area and Surrounding Locations Franklin, Indiana

Map source: U.S. EPA Franklin website.
https://www.epa.gov/in/amphenolfranklin-power-products-franklin-ind

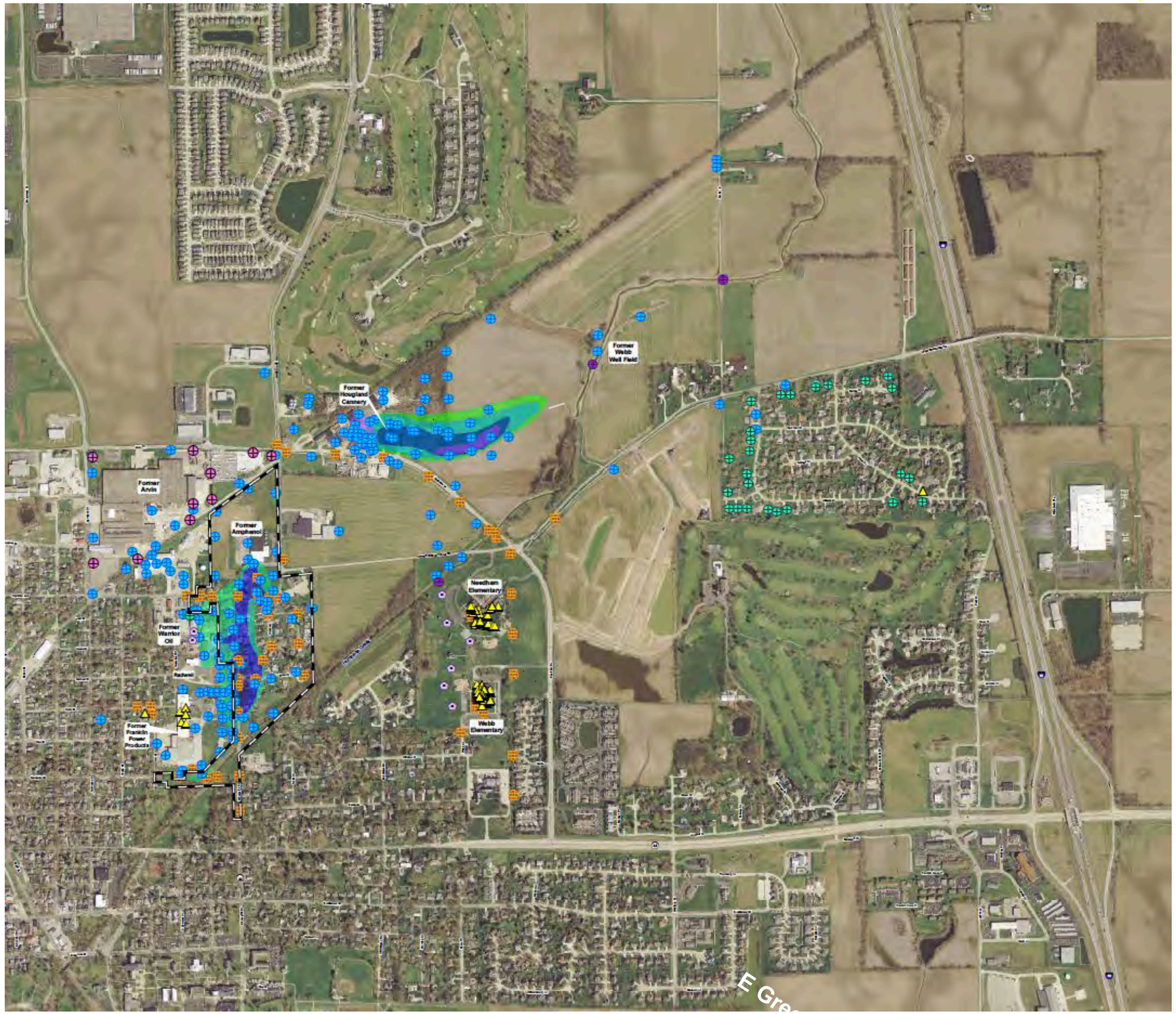
N

NOTES:
Map is provided for site reference only.
No claim is made as to the accuracy or completeness of this information.

Sites of Interest
Franklin Project
Franklin, Johnson County, Indiana
MUNDELL PROJECT NO. M18027B

FIGURE
1A

Mundell
Consulting Professionals for the Earth and the Environment
110 South Downey Avenue
Indianapolis, Indiana 46219
317-630-9060, fax 317-630-9065
www.MundellAssociates.com



LEGEND

Proposed Sampling

- Ground Water or Surface Water

Previous Sampling

- Ground Water
- Drinking Water
- Sewer Sampling
- Soil Boring
- Surface Water
- Stationary Air Monitor
- Air (SubSlab, Indoor, and/or Crawl Space)
  - *Needham Elementary & Webb Elementary Schools Drain; SubSlab location; Indoor Air location*
  - *Residence*
  - *Business*

Former Hougland Cannery Investigations Ground Water TCE Areas

- TCE < 20 ppb
- TCE > 20 ppb
- TCE > 100 ppb
- TCE > 300 ppb

Trichloroethylene (TCE) Data utilized from Further Site Investigation reports:
- *Reed Manufacturing Services, January 13, 2017, Figure5: TCE Groundwater Data from 2014 – 2016*
- *Report 2, Hurricane Road Industrial Development/Former Hougland Tomato Cannery, January 25, 2018*
- *Report 3, Hurricane Road Industrial Development/Former Hougland Tomato Cannery, June 2019, Preliminary Data Map*

Former Amphenol EPA Ground Water TCE Areas

- TCE > 1.2 ppb
- TCE > 5.0 ppb
- TCE > 9.1 ppb
- TCE > 38.0 ppb

Trichloroethylene (TCE) Data utilized from: (Rev 05/31/2019)
- *Temporary well sampling on October 24 – 25, 2018 and March 5 – 7, 2019*
- *Semi-annual groundwater sampling event on October 11 and 29, 2018*
- *Off-site monitoring well sampling event on September 14, 2018*

- EPA Investigation Area

All locations are approximate and may represent more than one sample location and type.

N

NOTES:
Map is provided for site reference only.
No claim is made as to the accuracy
or completeness of this information.
Map Source: (IDEM, 2019)

Franklin Area of Investigations: Known Groundwater Plumes
Franklin VI Project
Franklin, Johnson County, Indiana
MUNDELL PROJECT NO. M18027B

FIGURE
1B

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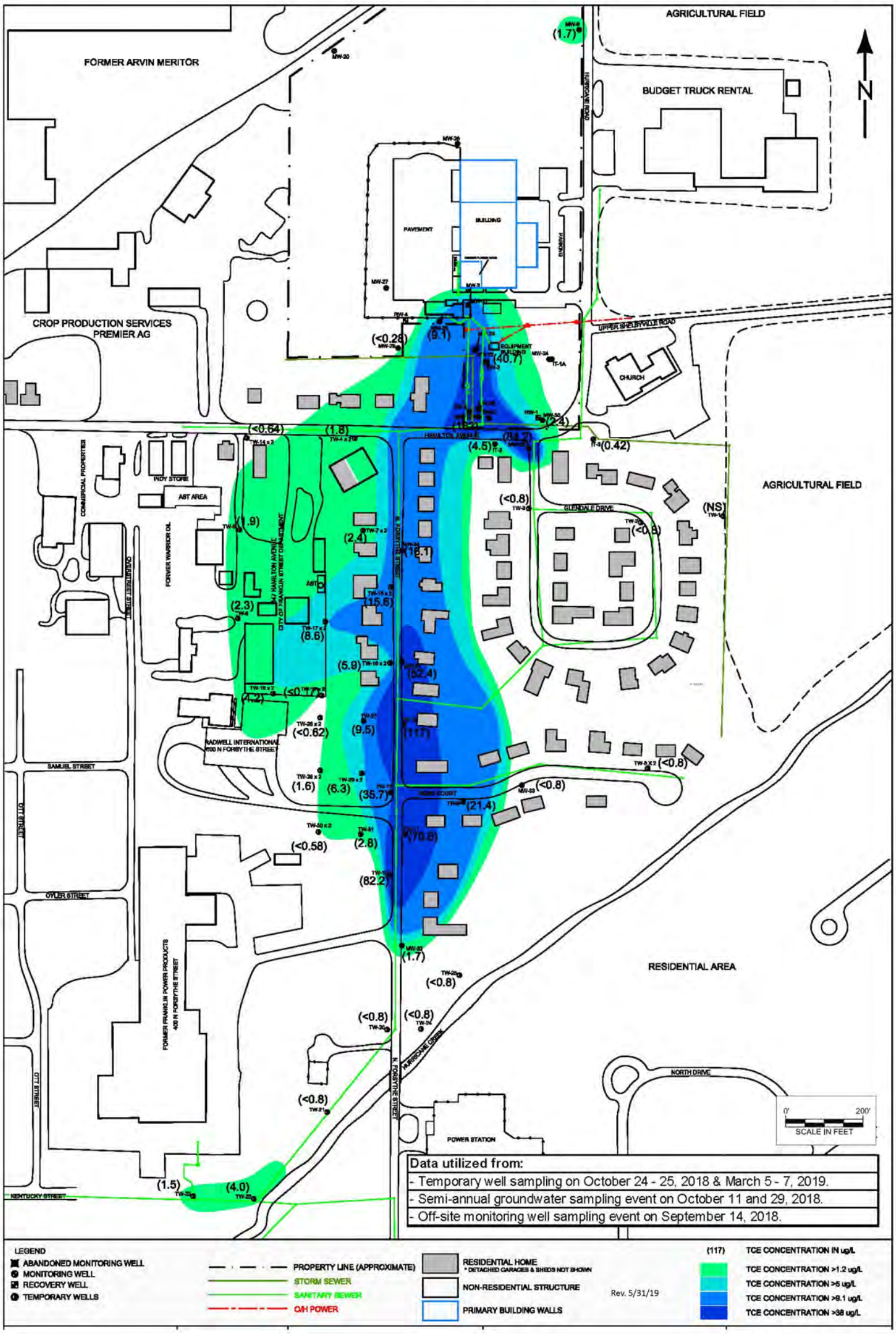
United States Environmental Protection Agency

GROUNDWATER TCE

FORMER AMPHENOL RFI/CMS; 980 HURRICANE ROAD, FRANKLIN, INDIANA



Map source: U.S. EPA Franklin website.
https://www.epa.gov/in/amphenolfranklin-power-products-franklin-ind

U.S. EPA TCE Groundwater Plume
Franklin Project
Franklin, Johnson County, Indiana
MUNDELL PROJECT NO. M18027B

FIGURE
2A

N

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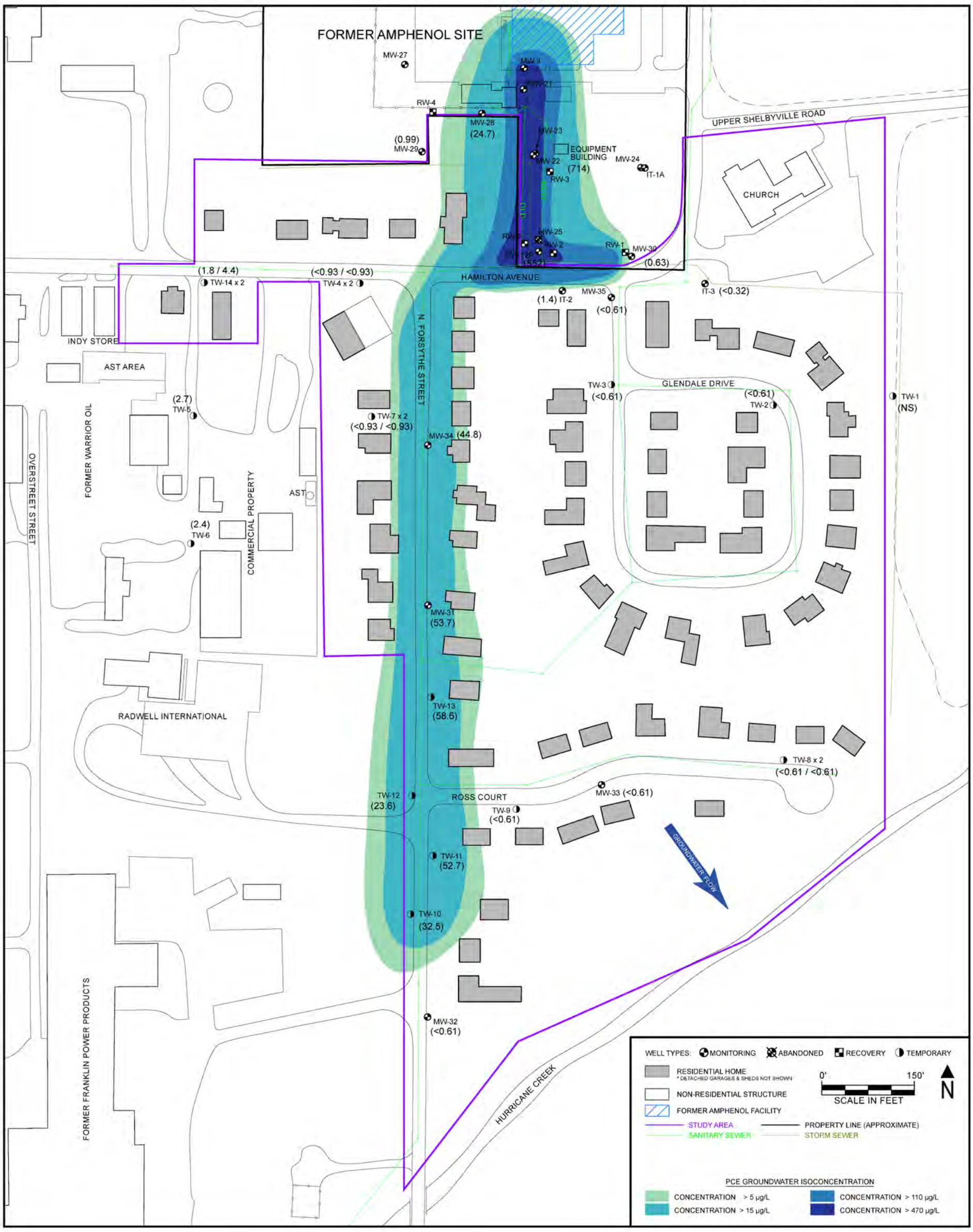
GROUNDWATER PCE

FORMER AMPHENOL RFI/CMS; 980 HURRICANE ROAD, FRANKLIN, INDIANA



Map source: U.S. EPA Franklin website.
https://www.epa.gov/in/amphenolfranklin-power-products-franklin-ind

U.S.EPA PCE Groundwater Plume
Franklin Project
Franklin, Johnson County, Indiana
MUNDELL PROJECT NO. M18027B

FIGURE
2B

N

NOTES:
Map is provided for site reference only.
No claim is made as to the accuracy or completeness of this information.

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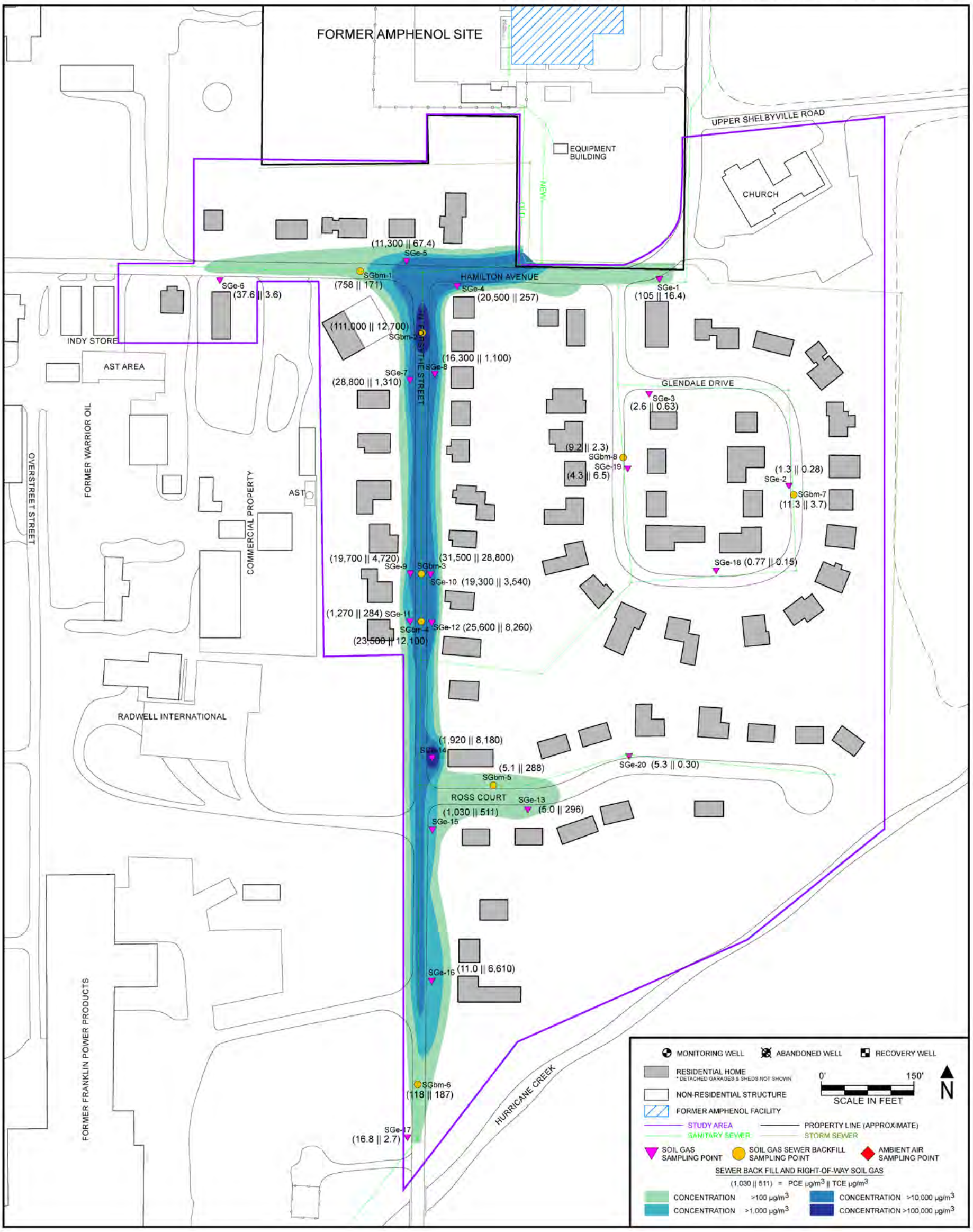
United States Environmental Protection Agency

PCE + TCE RIGHT OF WAY SOIL AND SEWER BEDDING GAS

FORMER AMPHENOL RFI/CMS; 980 HURRICANE ROAD, FRANKLIN, INDIANA



Map source: U.S. EPA Franklin website.
https://www.epa.gov/in/amphenolfranklin-power-products-franklin-ind

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NOTES:

Map is provided for site reference only. No claim is made as to the accuracy or completeness of this information.

U.S.EPA PCE+TCE Soil/Sewer Gas
Franklin Project
Franklin, Johnson County, Indiana
MUNDELL PROJECT NO. M18027B

FIGURE
2C

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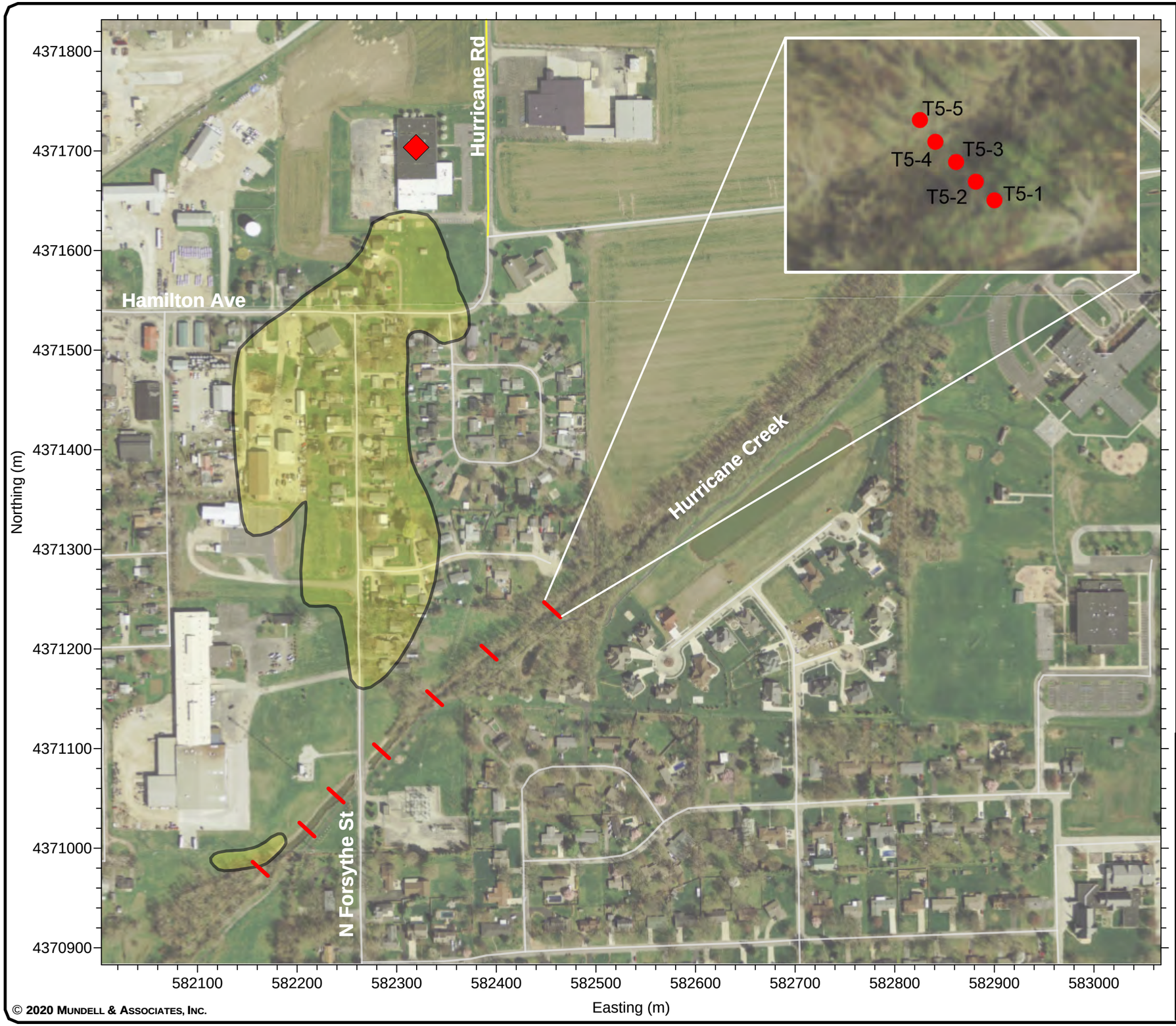

LEGEND

- FORMER AMPHENOL RFI/CMS 980 HURRICANE ROAD, FRANKLIN, IN
- EPA GROUNDWATER TCE PLUME EXTENT
- PROPOSED HURRICANE CREEK TRANSECTS
- TRANSECT SAMPLING LOCATIONS (INSET BOX)

N

Scale in meters
0 50 100 150 200
1" = 100 meters

Scale in feet
0 200 400 600 800

NOTES:
1. Aerial photo is provided for site reference only. No claim is made as to the accuracy or completeness of this information.
2. Coordinates are referenced according to UTM, Zone 16N (meters), WGS84 datum.
3. TCE Plume extent from U.S. EPA map titled "Groundwater TCE: Former Amphenol RFI/CMS; 980 Hurricane Road, Franklin, Indiana." Rev. 5/31/2019.

Proposed Hurricane Creek Transect Locations
Franklin Project
Franklin, Johnson County, Indiana
MUNDELL PROJECT NO. M18027B

FIGURE
3

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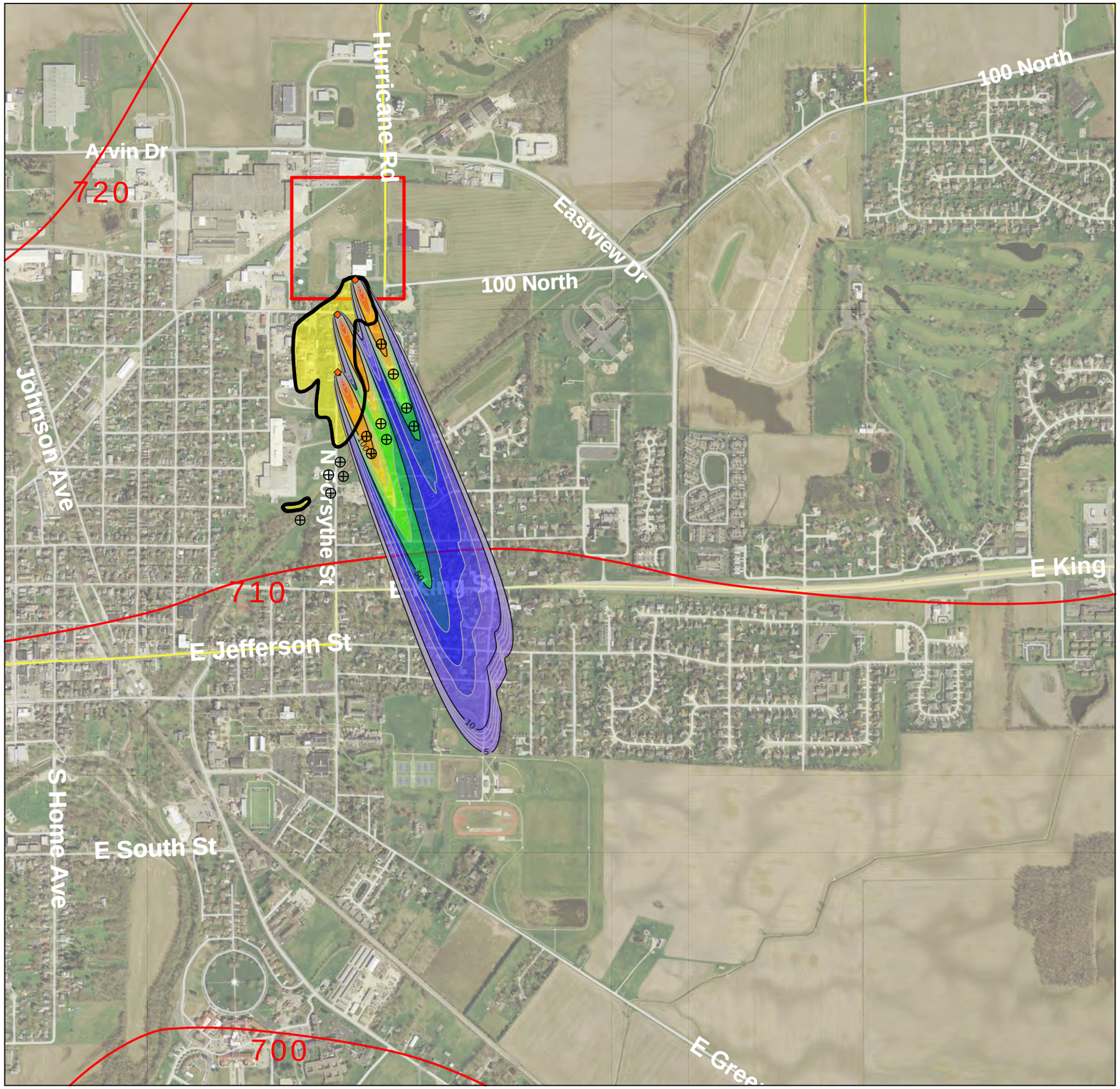

LEGEND

FORMER AMPHENOL RFI/CMS
980 HURRICANE ROAD, FRANKLIN, IN

EPA GROUNDWATER TCE PLUME EXTENT

TCE POINT SOURCE
DNR UNCONSOLIDATED
POTENTIOMETRIC SURFACE

PROPOSED GROUNDWATER PROFILING LOCATIONS

Modeled TCE (ug/L) Concentration
(K=20 ft./day, Commingled Plumes)

5 6 7 8 9 10 20 30 40 50 60 70 80 90 100 200 300 400 500 600 700 800 900 1000

N

1" = 1000 ft.
Scale in Feet

0 500 1000 1500 2000

NOTES:
Map is provided for site reference only.
No claim is made as to the accuracy or completeness of this information.

Proposed Groundwater Profiling Locations
Franklin VI Project
Franklin, Johnson County, Indiana
MUNDELL PROJECT NO. M18027B

FIGURE
4

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APPENDIX B

MUNDELL Hurricane Creek Area Report of Geophysical Survey

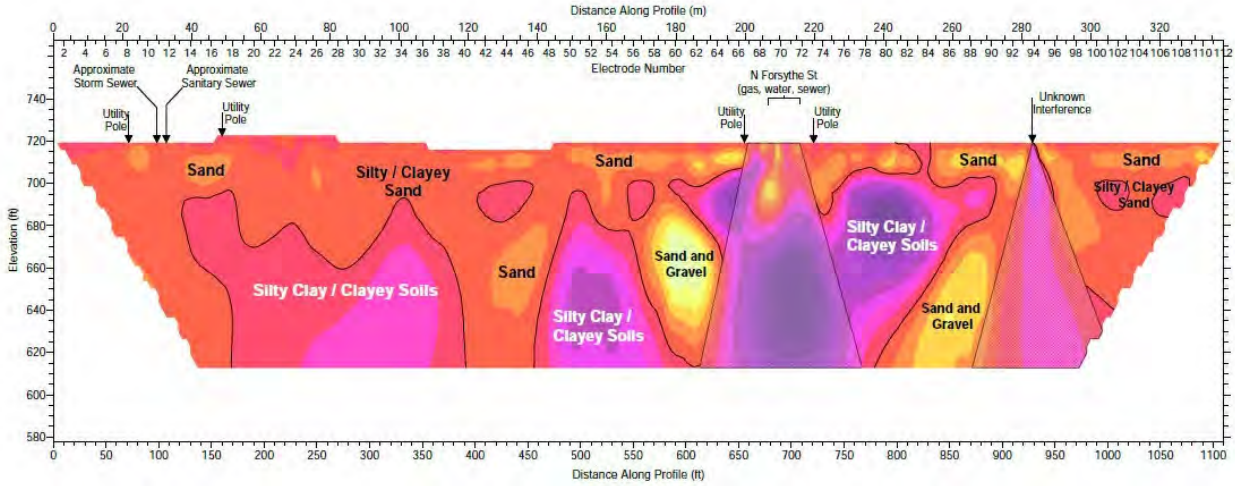
Includes Appendix B Figures:

Figure B-1. Site Map (MUNDELL, 2021)
Figure B-2. Unconsolidated Aquifer Map (MUNDELL, 2021)
Figure B-3. Resistivity Profile Line 1 (MUNDELL, 2021)
Figure B-4. Resistivity Profile Line 2 (MUNDELL, 2021)
Figure B-5. Resistivity Profile Line 3 (MUNDELL, 2021)

REPORT OF GEOPHYSICAL SURVEY

RESISTIVITY IMAGING

FORMER AMPHENOL FACILITY #IND 044587 848
980 HURRICANE ROAD
FRANKLIN, JOHNSON COUNTY, INDIANA 46131
MUNDELL PROJECT NO. M18027B
APRIL 12, 2021



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April 12, 2021

Mrs. Stacie Davidson and Mrs. Kari Rhinehart
If It Was Your Child
P.O. Box 102
Bargersville, IN 46106

Re: **Report of Geophysical Survey – Resistivity Imaging ("Appendix B")**
Former Amphenol Facility #IND 044587 848
980 Hurricane Road
Franklin, Indiana 46131
MUNDELL Project No. M18027B

Dear Mrs. Davidson and Mrs. Rhinehart:

Mundell & Associates, Inc. (MUNDELL) is pleased to present this letter report. The following sections provide written documentation of the geophysical exploration activities conducted near Hurricane Creek, south of the Former Amphenol Site (Site). This fieldwork was performed on December 3rd and 4th, 2019. The geophysical investigation described herein was conducted as part of a larger assessment of the potential for groundwater impacts associated with the Site to move beyond the currently mapped U.S. Environmental Protection Agency (U.S. EPA) Study Area (see **Figure 1A, Appendix A**). The primary goal of this geophysical investigation was to provide a non-intrusive data gathering method to gain an enhanced understanding of the subsurface geological and hydrogeological conditions that may be acting as preferential flow pathways for chlorinated organic chemical impacts downgradient of the Site. The below information provides additional technical detail to the main narrative report for this investigation, and should be used as a companion to the main report.

Site history and ongoing RCRA Corrective Action activities are summarized in this investigation's main report narrative as well as in MUNDELL's *Phase III Residential Vapor Intrusion Testing Report,* dated June 21, 2019. MUNDELL's previous reports also describe significant data gaps that were uncovered during an earlier review of the Amphenol RCRA administrative record, which are relevant to the current stage of investigations.

Site Geology and Hydrogeology

The Site is located in the New Castle Till Plains and Drainageways section of the Central Till Plains Physiographic region characterized by a relatively featureless plain of low relief that is dissected by criss-crossing glacial drainageways eroded by meltwater from the Wisconsin ice sheet. These drainageways produce the distinguishing feature of this region that cross in a southerly to southwesterly radial pattern that once fed the White River, the East Fork of the White River and several of its tributaries (Gray, 2000).

Bedrock geology is mapped throughout the Site as the Devonian/Mississippian aged New Albany Shale, which is primarily composed of brownish-black carbon-rich shale, greenish-gray shale, and minor amounts of dolomite and dolomitic quartz sandstone (Lineback, 1968 and 1970). The published depth to bedrock is approximately 175 feet below ground surface (ft-bgs.) in the vicinity of the Site (Naylor, 2016). It should be noted that due to the limitations of the geophysical survey method utilized and the geometry described in the following sections, the top of bedrock was not imaged in this particular investigation.

The bedrock is overlain by unconsolidated material belonging to unconsolidated aquifer systems as mapped by the Indiana Department of Natural Resources (IDNR) (see **Figure B-2**). Specifically, the Former Amphenol Site is mapped as the New Castle Till Aquifer System characterized by intratill sand and gravel units overlain by thick, fine-grained till deposits. These sand and gravel units range from approximately 10 to 15 feet thick. South of the Site, near Hurricane Creek, the unconsolidated aquifer has been mapped as the White River and Tributaries Outwash Aquifer System and Subsystem (Maier, 2005). These aquifers are characteristically similar aquifer units that contain large volumes of glacial outwash and alluvial deposits with continuous sand and gravel deposits ranging from approximately 10 to 45 feet thick. Sand and gravel deposits are often capped or disrupted in some areas with lenses of silt, clay-sand, or clay-gravel mixtures that range from 5 to 30 feet thick. Within these aquifers, areas that lack overlying fine-grained clays are highly susceptible to contamination from surface and near-surface sources (Maier, 2005). The location of the geophysical investigation described in the following sections coincides with the White River and Tributaries Outwash System and Subsystem Aquifers.

Technical Background – Geophysical Methodologies

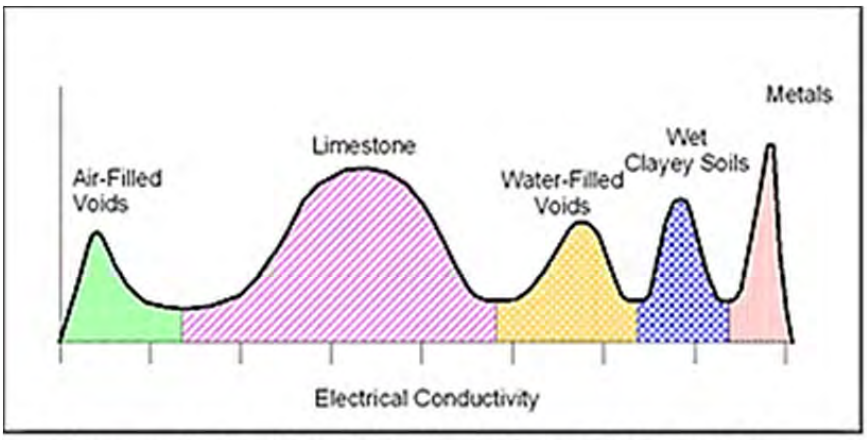
In general, a wide variety of geophysical techniques can be applied to the mapping of subsurface geological features; however, certain methods, sensitive to a range of contrasting physical properties, can have attributes that make them more suitable than others depending on the site-specific conditions. Contrasting physical properties that typically are found to be useful for mapping soil and bedrock include electrical conductivity or resistivity, acoustic velocity, density, seismic wave velocity and magnetic susceptibility. Of these, electrical conductivity (or resistivity) has the greatest range of contrast and is often applicable to differentiate coarse-grained sand and gravel deposits from fine-grained, clayey soils.

Given the geophysical survey area and the desire to characterize coarse-grained deposits that may be controlling groundwater flow and contaminant movement in the area, **two-dimensional Electrical Resistivity Imaging (2-D ERI)** was selected as the method of choice to initially characterize geologic and hydrogeologic features in the vicinity of Hurricane Creek, south of identified groundwater impacts to date.

Two-Dimensional Electrical Resistivity Imaging (2-D ERI)

Certain minerals, such as native metals and graphite, conduct electricity via the passage of electrons; however, electronic conduction is generally very rare in the subsurface. Most minerals and rocks are insulators, and electrical current preferentially travels through the water-filled pores in soils and rocks by the passage of the free ions in pore waters *(i.e.*, ionic conduction). It thus follows that the degree of saturation, interconnected porosity, and water chemistry (*i.e*., total dissolved solids) are the major controlling variables of the conductivity of soils and rocks. In general, electrical conductivity directly varies with changes in these parameters.

Fine-grained sediments, particularly clay-rich sediments such as glacial till, are excellent conductors of electricity, while coarser-grained sands and gravels are much less conductive. Carbonate rocks (*i.e.*, limestone and dolomite) are very good insulators when they are in an unfractured and competent condition, but can have significantly higher conductivity values when fractured, weathered and/or solutioned. In contrast, shale bedrock is relatively conductive.



Inset Diagram B-1: Conductivity Variation with Materials

Inset Diagram B-1 illustrates the relative distribution of electrical conductivity values (logarithmic in nature, resistivity = 1/conductivity). Thus, by understanding the distribution of electrical conductivity values for known geologic materials, two-dimensional electrical resistivity imaging (2-D ERI) can be used to image variations in the geologic layers beneath the surface. Interpreting the subsurface variations shown by the 2-D ERI imaging can help an investigator identify zones more vulnerable to contamination versus those less vulnerable to contamination.

Resistivity data were collected with an *AGI SuperSting R8* earth resistivity meter using a combined strong-gradient and dipole-dipole array of 56 to 112 electrodes along three (3) individual profile lines of a constant ten (10) foot spacing between electrodes (see **Figure B-1**). The ten (10) foot electrode spacing produced adequate resolution imagery of the subsurface and resulted in a maximum depth of penetration of approximately 100 feet below ground surface (ft-bgs).

Once the data were collected, they were downloaded to a computer and subsequently inverse-modeled using the software Advanced Geosciences *EarthImager2D* to obtain a "resistivity cross-section" of the subsurface. This is obtained through the process of generating a model resistivity cross-section, calculating the apparent resistivity pseudo-section that would result from such a model, and comparing the calculated pseudo-section to the one collected in the field. The model is then altered through a number of iterations until the two pseudo-sections closely match each other. At this point the model is considered to be a reasonable estimation of the true resistivity of the actual subsurface materials.

It should be noted that the resistivity cross sections presented in this report are 2-dimensional representations of the general distribution of electrical resistivity in the 3-dimensional subsurface. There is no unique direct conversion from resistivity values to lithology. However, based on site knowledge, geometric shapes and relationships of various anomalies, and the observed ranges of resistivity values, reasonable geologic interpretations can often be made by experienced geophysical consulting professionals.

Scope and Results of Geophysical Survey Performed

2-D ERI Profile Line Results

A total of three (3) resistivity profiles (*Profile Line 1* through *Profile Line 3*) were collected between the Amphenol Site and the downgradient Hurricane Creek. *Profile Lines 1, 2,* and *3* utilized 112, 56, and 84 electrodes, respectively, with a combined strong-gradient/dipole-dipole array and an electrode spacing of ten (10) feet, which resulted in a depth of penetration of approximately 100 ft-bgs. All *Profile Lines* were oriented southwest to northeast. The locations of resistivity *Profile Lines 1* through *3* are shown on **Figure B-1** and presented individually as **Figures B-3, B-4 and B-5**.

The modeled resistivity values range from about 1 (purple in color) to greater than 400 ohm-meters (yellow in color). In general, the lowest range of values, *i.e.*, less than 90 ohm-meters, (purple to dark red in color) is interpreted to be unconsolidated materials consisting of fine-grained soils with a high clay content (purple to red in color) in the upper subsurface. Mid-range resistivity values (90 to 724 ohm-meters, light red to light green in color) are interpreted to be more granular soils consisting of sand and/or gravel in the upper subsurface. High resistivity values (greater than 724 ohm-meters, green in color) are often indicative of deeper competent limestone bedrock; however, bedrock

was not encountered along the *Profile Lines* within the depths imaged. Low-range modeled resistivity values, *i.e.,* less than 50 ohm-meters, (purple in color) that also coincide with known and suspect utility locations at the surface are noted along the *Profile Lines* as shaded zones where there is low confidence for interpretations due to utility interference in the resistivity dataset.

In general, all three (3) resistivity profiles indicate unconsolidated material in the upper 50 to 60 ft. consisting predominantly of fine-grained silty and/or clayey sands with zones of sand. Below 50 to 60 ft, the unconsolidated material is predominantly composed of fine-grained silty clay/clayey soils. There are, however, some higher resistivity zones in the profiles that indicate the presence of coarse-grained sand and gravel deposits that can act as preferential groundwater flow and contaminant migration pathways. Bedrock was not encountered within the depths imaged along any of the profiles, which aligns with published bedrock elevation described in the *Site Geology* section above. Details regarding each profile line are described as follows:

Profile Line 1 – As indicated on **Figure B-3**, the profile shows moderate-resistivity values (orange in color) indicative of coarse-grained sand and silty/clayey sand deposits in the upper subsurface. Beneath *Electrode Nos. 56 to 64* and *82 to 92* there exist higher-resistivity zones (yellow in color) at depth that indicate the presence of more substantial coarse-grained sand and gravel deposits. Fine-grained silty clay/clayey soils are present along this *Profile Line* and exhibit low-resistivity values (purple in color) and are likely lower in permeability. <u>Upper subsurface sand and silty/clayey sand deposits that are interconnected with deeper moderate- to high-resistivity sand/sand and gravel deposits likely indicate zones of increased potential for vertical and horizontal groundwater flow and contaminant migration.</u> Utility interference was encountered beneath *Electrode Nos. 66 to 72 and 94*, which caused a lower confidence for interpretation of resistivity values in these zones.

Profile Line 2 and 3 – As indicated on **Figure B-4** and **B-5**, these profiles exhibit moderate-resistivity values (yellow to orange in color) indicative of sand/sand and gravel deposits in the upper 20 to 60 ft of the subsurface near Hurricane Creek. Additionally, both *Profile Lines* indicate a lack of low-resistivity, fine-grained material at the surface that <u>increases the potential for vertical and horizontal groundwater flow and contaminant migration</u> and <u>increases the general area susceptibility to near-surface contaminants</u> as described in the *Site Geology* section above. Underlying the coarse-grained deposits are zones of laterally-continuous low-resistivity values (red to purple in color) interpreted to be fine-grained, lower-permeability silty/clayey soils. In *Profile Line 3,* utility interference was encountered beneath *Electrode Nos. 63 to 66 and 77 to 79* causing a lower confidence for interpretation of resistivity values in these zones.

Conclusions

Based on the Site geologic and hydrogeologic review and the 2-D resistivity profile results, MUNDELL concludes the following:

1) The area south of the Amphenol Site near Hurricane Creek is in an area where unconsolidated aquifer systems indicate the potential for encountering continuous sand and gravel deposits that may be susceptible to contamination from the near-surface if the surficial fine-grained clay deposits are thin or absent.
2) In general, the subsurface geophysical profiles collected indicate a relatively uniform presence of coarse-grained sand deposits in the upper subsurface just near Hurricane Creek, with zones of fine-grained clays in the deeper subsurface. Additionally, the profiles indicate zones of interconnectivity between shallow and deep coarse-grained deposits and a lack of fine-grained clay material at the surface that increases the potential for both vertical and horizontal groundwater flow and contaminant migration as well as increasing the area's susceptibility to impacts from near-surface contaminants.
3) Any final subsurface investigation planning decisions at the Site including the selection of appropriate locations for the advancement of soil borings or the installation of monitoring wells should be made incorporating the enhanced understanding of the expected condition of the subsurface materials present along the resistivity profile alignments.

Limitations

This study included a limited set of geophysical readings across limited portions of the general area south of the Site near Hurricane Creek. The results and interpretations of the geophysical survey performed are considered generally reliable and were conducted in a manner generally consistent with practitioners in the field of geophysical engineering. Although the methods used in this investigation are considered reliable, there may exist localized variations in the subsurface conditions that have not been completely defined at this time due to the coarse nature of the data collection. The resistivity results are not unique to geologic features and more than one geologic feature or model may give similar results. Therefore, properly conducted soil/bedrock test borings and other exploratory techniques are necessary to more completely determine the actual subsurface conditions at the site and confirm the general conclusions provided herein.

The Site features presented on the Site base map are for informational purposes only and no representation is made as to the accuracy or completeness of this information. It is recommended that a practicing geosciences or geotechnical engineering professional be contacted prior to conducting any verification drilling or excavating activities.

Closing

We appreciate the opportunity to provide geophysical services to you on this project. If you should have any questions regarding the enclosed information, please do not hesitate to contact us at (317) 630-9060, or jmundell@MundellAssociates.com.

Sincerely,
MUNDELL & ASSOCIATES, INC.

Forrest Kunkel, G.I.T.
Staff Geologist/Geophysicist

John A. Mundell, P.E., L.P.G, P.G.
President/Director of Geophysical Services

/fk

Attachments:

Figure B-1. Site Map
Figure B-2. Unconsolidated Aquifer Map
Figure B-3. Resistivity Profile Line 1
Figure B-4. Resistivity Profile Line 2
Figure B-5. Resistivity Profile Line 3

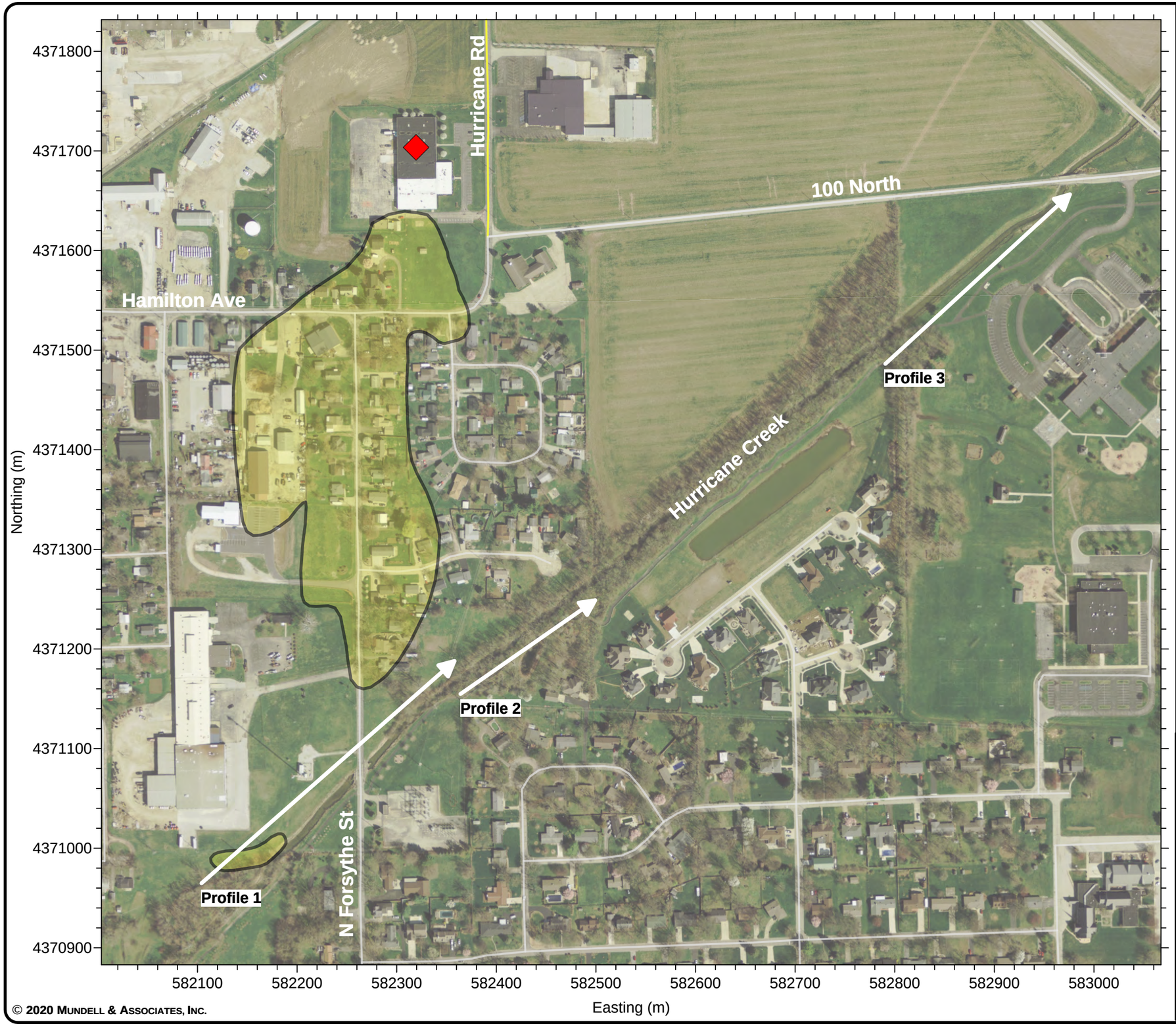
REFERENCES

Gray, H.H. 2000. *Physiographic Divisions of Indiana, Special Report 61*. Indiana Geological Survey.

Lineback, J. A. 1968. "Subdivisions and depositional environments of New Albany Shale (Devonian-Mississippian) in Indiana." *Am. Assoc. Petroleum Geologists Bull.*, v. 52, pp. 1291-1303.

Lineback, J. A. 1970. "Stratigraphy of the New Albany Shale in Indiana." *Indiana Geol. Survey Bull.*, v. 44, p. 73.

Naylor, S., J. Schumacher, and B.J. Sperl. 2016. "Map showing thickness of unconsolidated deposits in Indiana." *IGS Miscellaneous Map 95A*.



LEGEND

FORMER AMPHENOL RFI/CMS
980 HURRICANE ROAD, FRANKLIN, IN

EPA GROUNDWATER TCE PLUME EXTENT

RESISTIVITY PROFILE LINES

N

Scale in meters
0 50 100 150 200
1" = 100 meters

Scale in feet
0 200 400 600 800

NOTES:
1. Aerial photo is provided for site reference only. No claim is made as to the accuracy or completeness of this information.
2. Coordinates are referenced according to UTM, Zone 16N (meters), WGS84 datum.
3. TCE Plume extent from U.S. EPA map titled "Groundwater TCE: Former Amphenol RFI/CMS; 980 Hurricane Road, Franklin, Indiana." Rev. 5/31/2019.

Site Map
Resistivity Imaging
Franklin VI Project
Franklin, Johnson County, Indiana
MUNDELL PROJECT NO. M18027B

FIGURE
B-1

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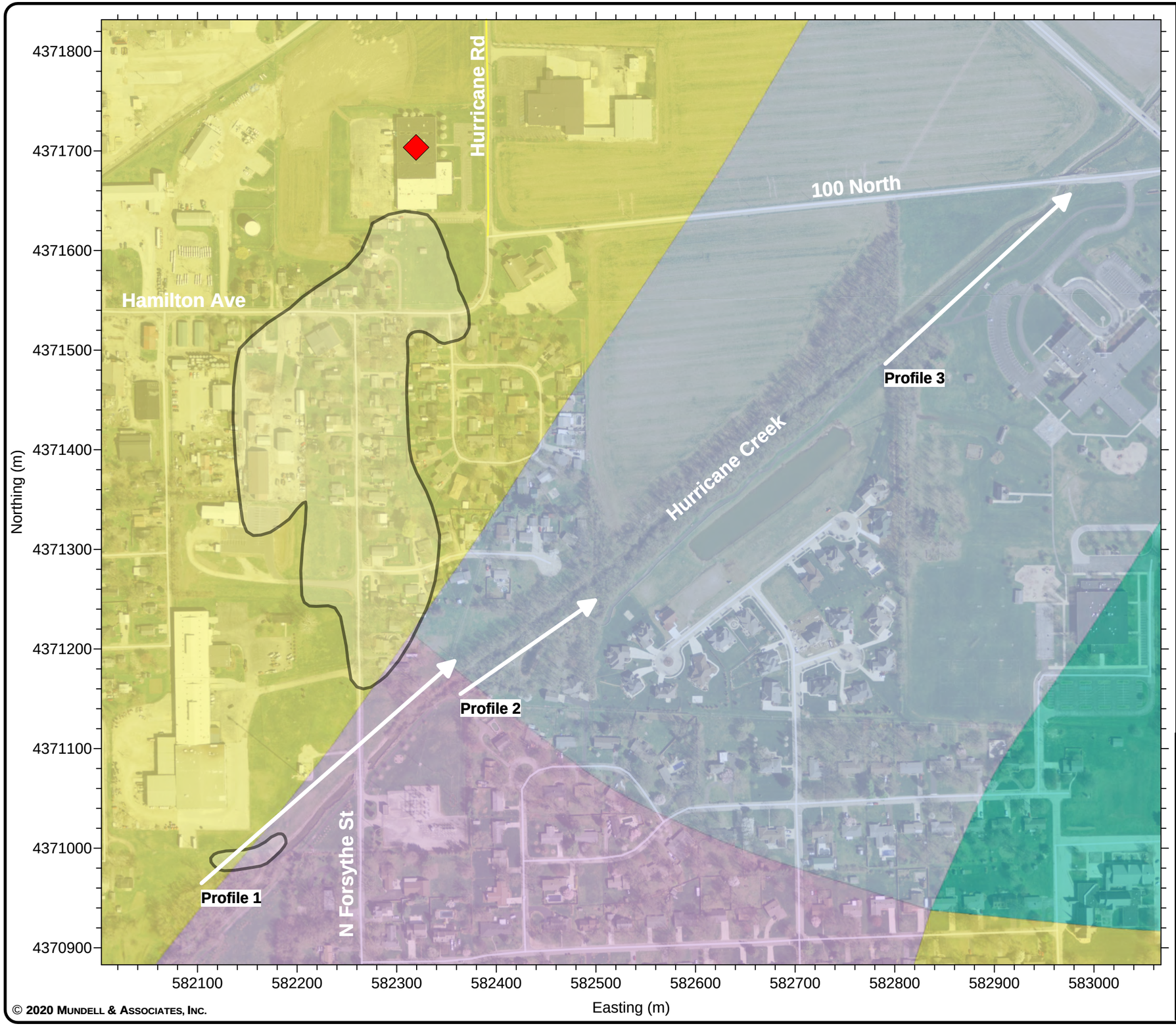

LEGEND

FORMER AMPHENOL RFI/CMS
980 HURRICANE ROAD, FRANKLIN, IN

EPA GROUNDWATER TCE PLUME EXTENT

RESISTIVITY PROFILE LINES

Unconsolidated Aquifer Systems

New Castle Till Aquifer System

New Castle Complex Aquifer System

White River and Tributaries Outwash Aquifer System

White River and Tributaries Outwash Aquifer Subsystem

N

Scale in meters
0 50 100 150 200
1" = 100 meters

Scale in feet
0 200 400 600 800

NOTES:

1. Aerial photo is provided for site reference only. No claim is made as to the accuracy or completeness of this information.
2. Coordinates are referenced according to UTM, Zone 16N (meters), WGS84 datum.
3. TCE Plume extent from U.S. EPA map titled "Groundwater TCE: Former Amphenol RFI/CMS; 980 Hurricane Road, Franklin, Indiana." Rev. 5/31/2019.
4. Mapped Unconsolidated Aquifer Systems derived from IDNR Aquifer Systems Map 18-A, 2005.

Unconsolidated Aquifer Map
Resistivity Imaging
Franklin VI Project
Franklin, Johnson County, Indiana
MUNDELL PROJECT NO. M18027B

FIGURE
B-2

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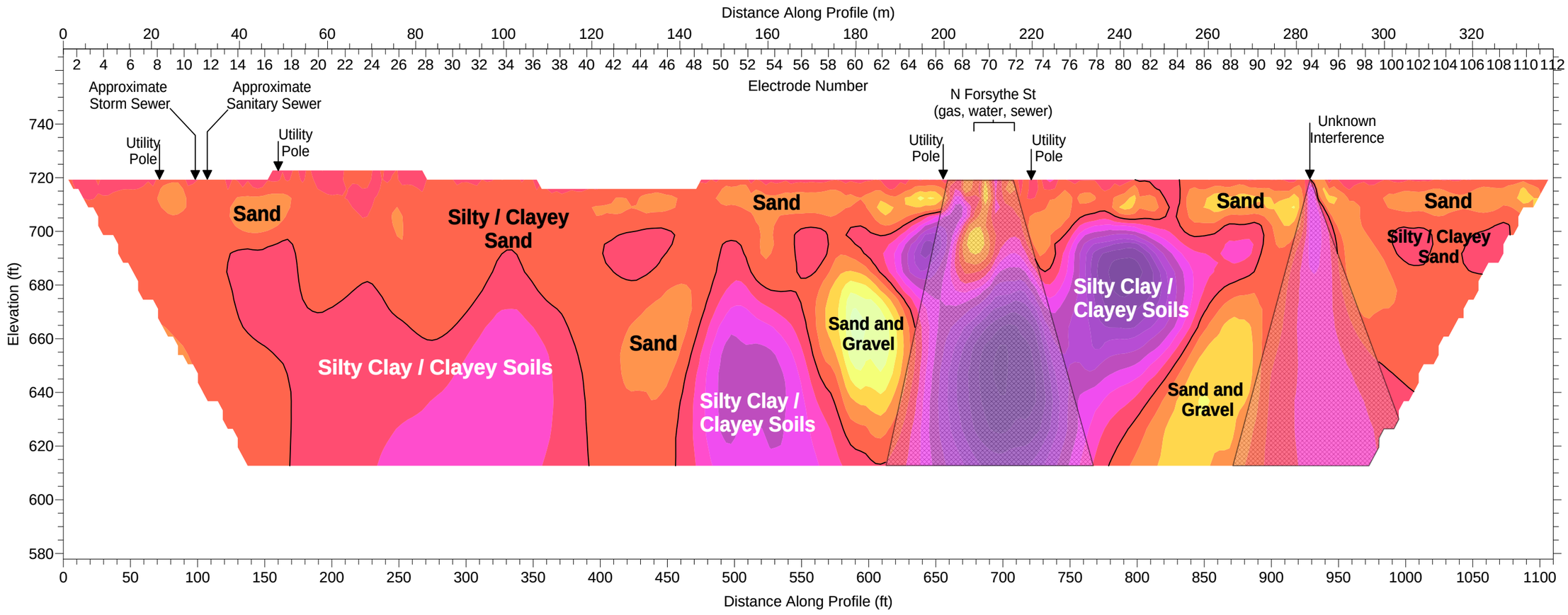
Southwest
Easting: 582104 m.
Northing: 4370964 m.

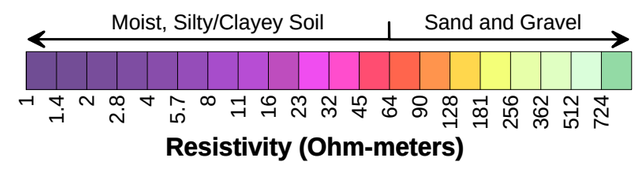
Northeast
Easting: 582358 m.
Northing: 4371188 m.



Vertical Scale: 1 in. = 40 ft.
Horizontal Scale: 1 in. = 80 ft.
Vertical Exaggeration = 2

Low Confidence Due to Utility Interference

PROCESSING STATISTICS
Strong Gradient / Dipole-Dipole Array
Number of Iterations: 3
RMS Error: 5.47 %
Total Data Points in Model: 3259
Maximum Misfit: 38.1 %
Electrode Spacing: 10 ft. (3.05 m.)



Resistivity Profile Line 1
Resistivity Imaging
Franklin VI Project
Franklin, Johnson County, Indiana
MUNDELL PROJECT NO. M18027B

FIGURE
B-3

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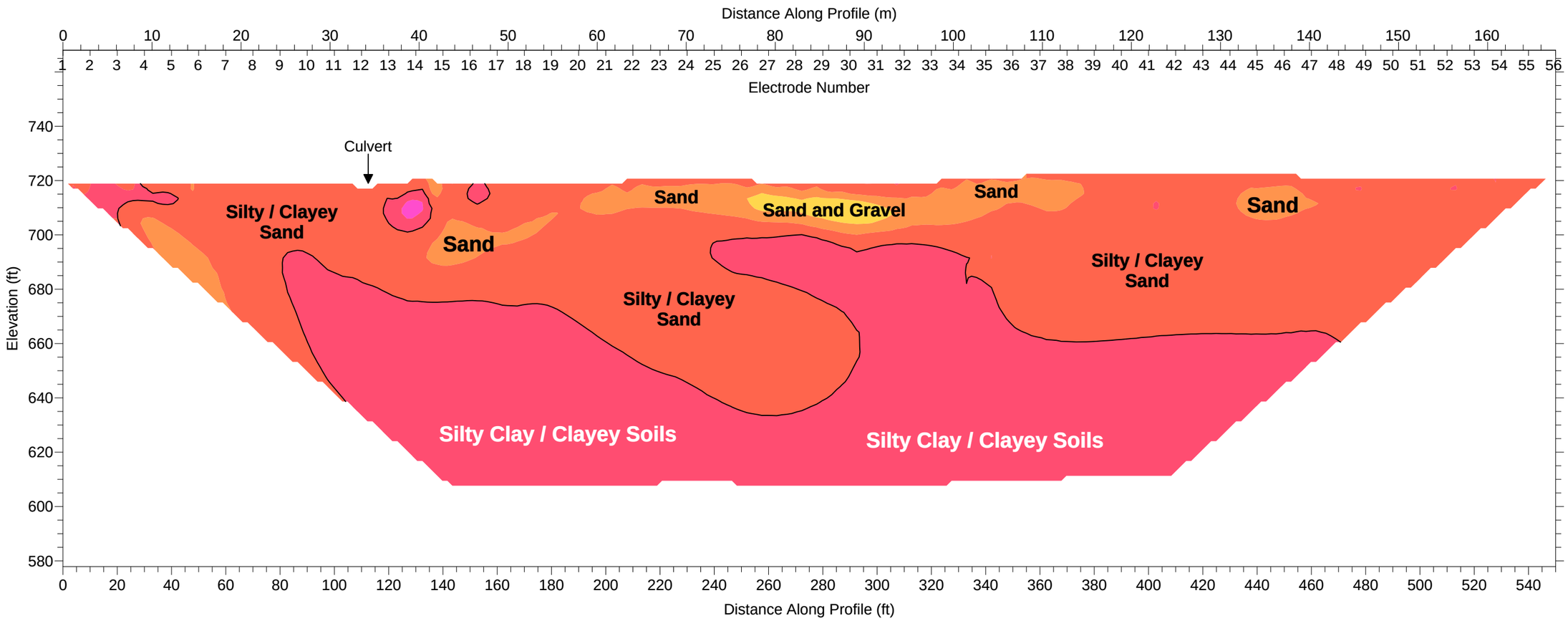
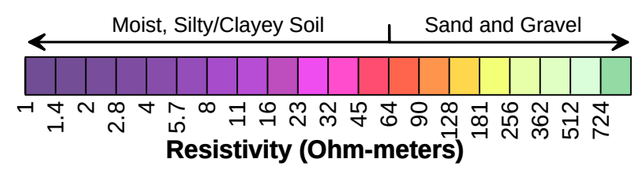
Southwest
Easting: 582364 m.
Northing: 4371155 m.

Northeast
Easting: 582499 m.
Northing: 4371249 m.



PROCESSING STATISTICS
Strong Gradient / Dipole-Dipole Array
Number of Iterations: 2
RMS Error: 2.65 %
Total Data Points in Model: 1591
Maximum Misfit: 21.0 %
Electrode Spacing: 10 ft. (3.05 m.)



Resistivity Profile Line 2
Resistivity Imaging
Franklin VI Project
Franklin, Johnson County, Indiana
MUNDELL PROJECT NO. M18027B

FIGURE
B-4

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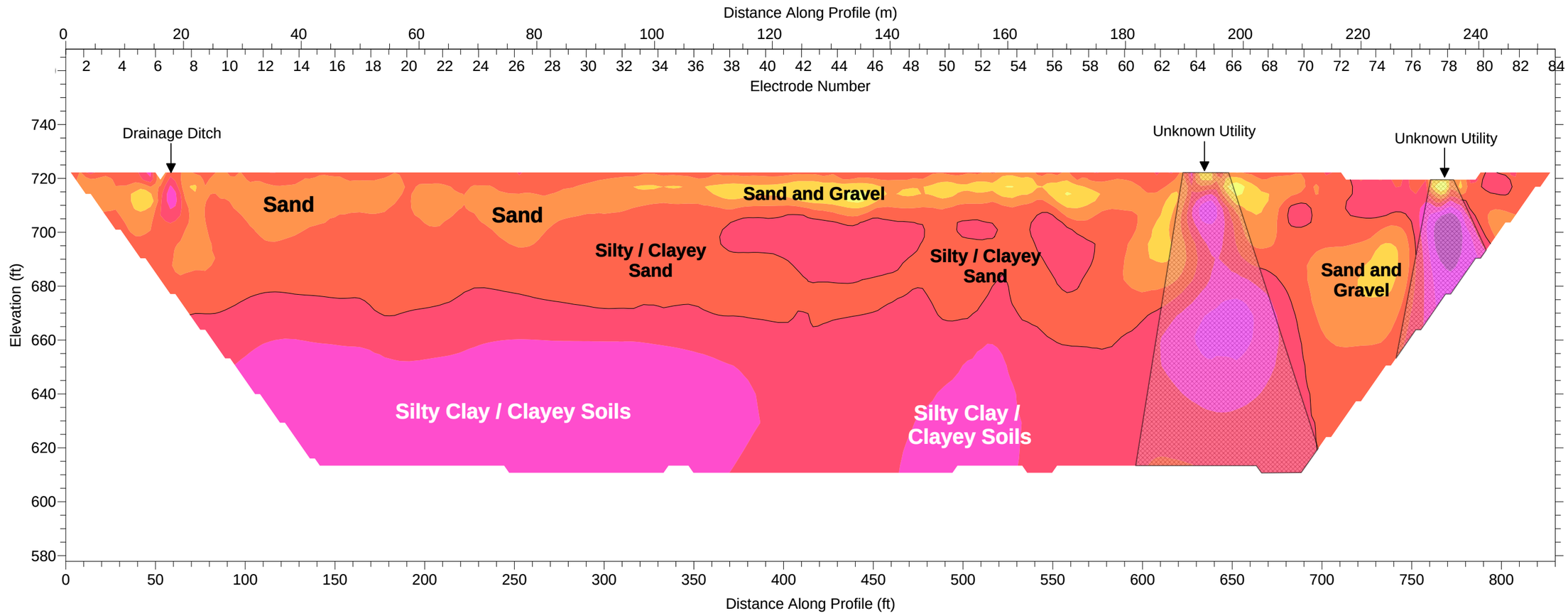
Southwest
Easting: 582791 m.
Northing: 4371487 m.

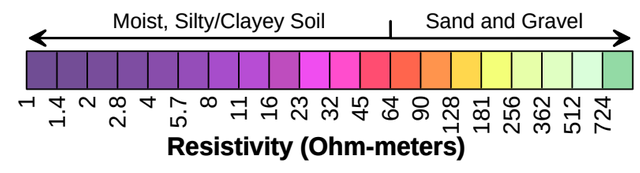
Northeast
Easting: 582976 m.
Northing: 4371656 m.



Vertical Scale: 1 in. = 40 ft.
Horizontal Scale: 1 in. = 60 ft.
Vertical Exaggeration = 1.5

Low Confidence Due to Utility Interference

PROCESSING STATISTICS
Strong Gradient / Dipole-Dipole Array
Number of Iterations: 4
RMS Error: 3.11 %
Total Data Points in Model: 2735
Maximum Misfit: 21.5 %
Electrode Spacing: 10 ft. (3.05 m.)



Resistivity Profile Line 3
Resistivity Imaging
Franklin VI Project
Franklin, Johnson County, Indiana
MUNDELL PROJECT NO. M18027B

FIGURE
B-5

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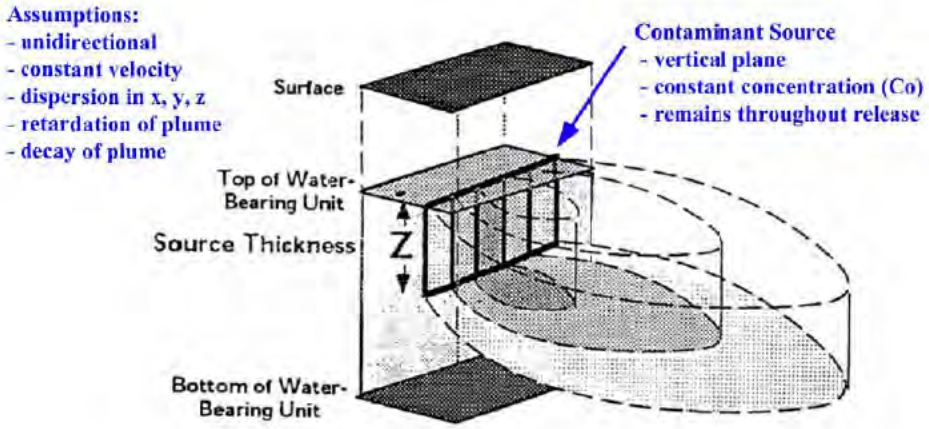
APPENDIX C

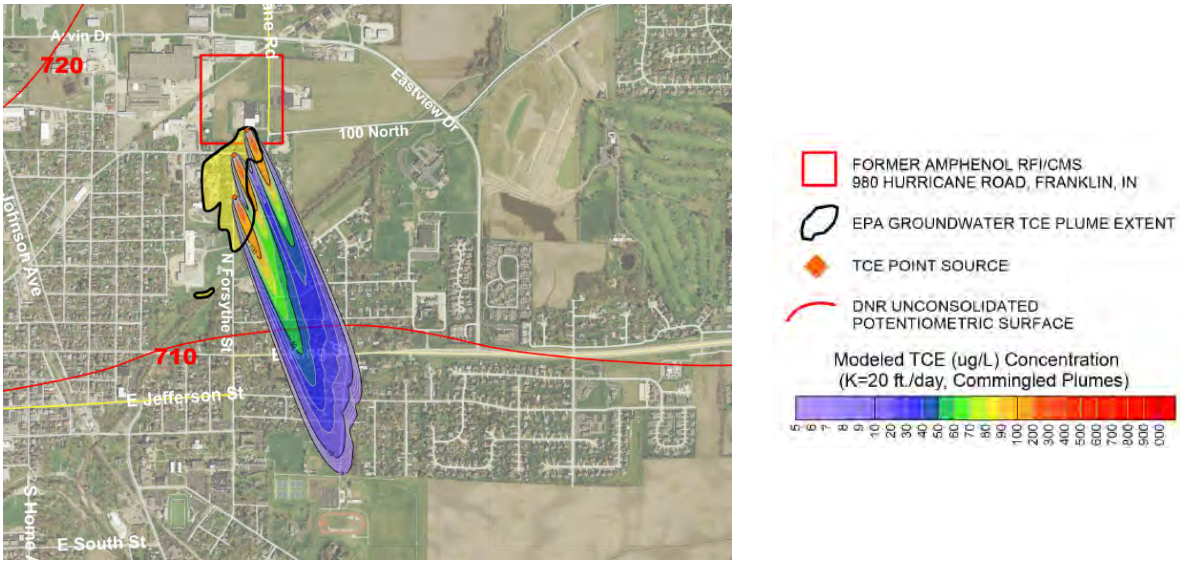
MUNDELL Preliminary Groundwater TCE Transport Modeling Study Report

<u>Includes Appendix C Figures and Tables:</u>

PRELIMINARY GROUNDWATER TCE TRANSPORT MODELING STUDY

FORMER AMPHENOL FACILITY #IND 044587 848
980 HURRICANE ROAD
FRANKLIN, JOHNSON COUNTY, INDIANA 46131
MUNDELL PROJECT NO. M18027B
APRIL 12, 2021





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www.MundellAssociates.com

April 12, 2021

Mrs. Stacie Davidson and Mrs. Kari Rhinehart
If It Was Your Child
P.O. Box 102
Bargersville, IN 46106

Re: **Preliminary Groundwater TCE Transport Modeling ("Appendix C")**
Former Amphenol Facility #IND 044587 848
980 Hurricane Road
Franklin, Indiana 46131
MUNDELL Project No. M18027B

Dear Mrs. Davidson and Mrs. Rhinehart:

Mundell & Associates, Inc. (MUNDELL) is pleased to present this letter report. The following sections document our preliminary contaminant transport modeling activities performed on the area from the Former Amphenol Site (Site) southward to beyond Hurricane Creek. The contaminant transport modeling evaluation described in this report was conducted as part of a larger assessment of the potential for groundwater impacts associated with the Site to move beyond the currently mapped U.S. Environmental Protection Agency (U.S. EPA) Study Area (see **Figure 1A, Appendix A**). The below information provides additional technical detail to the main narrative report for this investigation and should be used as a companion to the main report.

Site history and ongoing RCRA Corrective Action activities are summarized in this investigation's main report narrative as well as in MUNDELL's *Phase III Residential Vapor Intrusion Testing Report,* dated June 21, 2019. MUNDELL's previous reports also describe significant data gaps that were uncovered during an earlier review of the Amphenol RCRA administrative record, which are relevant to the current stage of investigations. Geologic and hydrogeologic summaries have been provided in the MUNDELL *Report of Geophysical Survey* (MUNDELL, 2021).

Chemical Source Area Descriptions

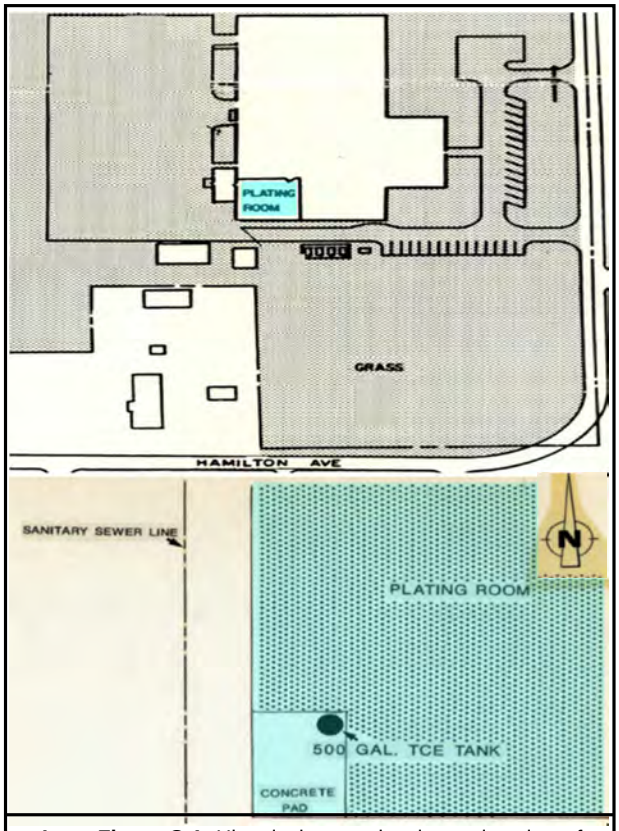
Though contaminants of concern associated with the Site include several different chlorinated solvents, trichloroethylene (TCE) is the focus of this preliminary groundwater transport model. TCE is the primary health risk driver to the surrounding community and has

consistently been detected in the off-site residential areas in exceedance of federal and state criteria.

In order to assess the movement of chemical releases in the underlying groundwater system, realistic assumptions must be made regarding the source area(s) release characteristics. These include the following parameters for the Former Amphenol Site and off-site area evaluation:

Source Location(s) – Three source locations (one on-site and two off-site) have been assumed based on the distribution of the TCE impacts observed and the historical use of the Site (See **Figure C-1** for a map depicting these source locations):

1. One on-site release area was selected at the **former TCE storage area/adjacent plating room**, historically within the southwestern portion of the Bendix Connector Corporation building (IT Corporation, 1988). This source location was chosen based on early Amphenol environmental assessment reports and maps (see **Inset Figure C-1**) as well as Site operations described in the 1990 and 1998 U.S. EPA RCRA 3008(h) Consent Orders. Prior to 1983, TCE and other chlorinated solvents leaked to soil underneath the plating room. Solvents were also released to a floor drain in the building, which spread south of the Site throughout the neighborhood sanitary sewer line.



Inset Figure C-1: Historical maps showing a plan view of the original Bendix building and surroundings (upper diagram). The lower diagram is a magnified view of the plating room in the southwestern portion of the building and the adjacent old sewer line. The plating room is highlighted in blue in both diagrams.

Modified from IT Corporation (1988) and E&E (1988).

2. The second release area selected is off-site, at the **intersection of Hamilton Avenue and North Forsythe Street**. Solvents historically discharged to the sewers by Bendix migrated downgradient of the Site and leaked into the subsurface through cracks in the lines. Sampling and analysis since 2018 have shown the most prominent TCE impacts in the sewer gas, soil backfill and groundwater as mainly being centered down North Forsythe Street, with some of the most elevated detections found near this Hamilton Ave./North Forsythe St. intersection (see **Appendix A**, **Figures 2A** and **2C**). This migration pattern of off-site contamination has appeared to remain consistent for an extended period of time, at least since the mid-1990s when original groundwater isoconcentration

maps were drawn by consultant WW Engineering and Science (1993 and 1996).

3. The third release area selected is also off-site, **north of the intersection of North Forsythe Street and Ross Court**. As with selected Source Area #2 described above, some of the more elevated TCE impacts have been reported in this area (see **Appendix A**, **Figures 2A** and **2C**).

Size of Source Area/Volume - The assumed width of each source area is 10 ft perpendicular to groundwater flow, with a vertical depth below the top of groundwater of 10 ft.

Source Concentration – Given TCE has a solubility of about 1000 mg/L, if we assume the source area concentration is 1/100 to 1/10 of the solubility, the source concentration, Co, ranges between 5,000 to 50,000 μg/L. We will conservatively assume the lower end of the source concentration range (5,000 μg/L) that results in the least severity of groundwater impacts.

Source Duration - For a conservative assumption, we will assume the source concentration remains constant over the entire release time period.

Release Time Period - Based on the historical site usage, we will conservatively assume a release period of 55 years, which starts releases at the start of operations in 1963, and going to 2018.

TCE Retardation – Given an appropriate octanol-water coefficient for TCE (log Koc = 2.42), and a range of in-situ aquifer organic soil carbon content, retardation of TCE relative to groundwater could be from 1 to 10 (Mackay et al., 1985).

Aquifer and Groundwater Description

For the purpose of conservatively describing the existing aquifer system, the aquifer characteristics are initially assumed to be:

Aquifer thickness = 20 ft

Aquifer Hydraulic Conductivity = 20 to 100 ft/day

Horizontal Hydraulic Gradient = (732-719)/1320 ft = 0.01 ft/ft (matching ground topo).

Horizontal Flow Direction = South-southeast based on the published regional potentiometric lines provided by Maier (2012). See **Figure C-1**.

Hydrodynamic (Longitudinal, Transverse, Vertical) Dispersion = 30 ft, 3 ft, 0.3 ft, respectively.

Retardation Factor = 1 to 4; assumes low fraction organic carbon content.

Receptor Distance to Hurricane Creek

Based on the relative location of the source area release points to the nearest receptor at Hurricane Creek, transport distances varying between about 600 to 1400 ft occur with a flow direction to the south-southeast.

Transport Modeling Approach

As previously discussed, MUNDELL assumed that the TCE discharged into the sanitary sewer system from the Former Amphenol Site was released into the groundwater system at three locations: one on-site (Amphenol TCE storage area, plating room) and two off-site along the sanitary sewer line (at the intersection of Hamilton Avenue and North Forsythe Street; and north of the intersection of North Forsythe Street and Ross Court). MUNDELL conducted 3-D analytical transport modeling of the TCE-impacted groundwater plume using the Domenico-Robbins (1985) solution (see **Figure C-2**). This model mathematically describes chemical movement emanating from a chemical source of a fixed size and concentration, vertically-oriented and rectangular-shaped, with constant unidirectional groundwater flow velocity in a homogenous aquifer system. An Excel spreadsheet programmed with the analytical solution was used to produce the results for each individual chemical source.

Each chemical source area was assumed to be 10 feet in width and within the top 10 feet of the aquifer (*i.e.*, the continuing source extends to a 10 ft depth). The hydrodynamic dispersivities (longitudinal, transverse and vertical) are assumed to be 30 ft (along the direction of groundwater flow), 3 ft (perpendicular horizontally to groundwater flow), and 0.3 ft (perpendicular vertically to groundwater flow), respectively. The time since the release began is assumed to be 55 years based on the historical operation of the Site. To be conservative, the source concentration was assumed to be constant at 5,000 µg/L over the length of the release period, with a constant aquifer hydraulic conductivity of 20 ft/day based on the local lithology. Since no significant dechlorination degradation has been identified at this Site, a long half- life was assumed for TCE in the groundwater to model this non-degradation condition.

The final shape of the plume was determined using the principle of superposition of chemical movements and concentrations from three individual sources. For simplification purposes, the chemical sources and aquifer systems were assumed to be identical for the three different source areas. The model input parameters are summarized in **Table C-1**. A master dataset was compiled containing all modeled points from the three plumes superimposed based on relative point source location and downgradient flow direction. Each of the three individual plume models used a 5-ft data point generation spacing. Some downgradient areas experienced concentration contributions from more than one of the point sources (*i.e.*, co-mingling of the individual source plumes occurred) and in the final data gridding process, grid math was applied to combine the concentrations from each individual source, where appropriate. The resulting grid and plume (**Figure C-1**) represents the summed concentrations from co-mingling of the three modeled source area plumes.

Summary of the Results

Based on the Site geologic and hydrogeologic review and these initial contaminant transport simulations, MUNDELL concludes the following:

1) As indicated on **Figure C-1**, for the conservative case of an aquifer with a hydraulic conductivity of 20 ft/day (*i.e.*, the minimum aquifer hydraulic conductivity resulting in the minimum contaminant transport distance), the TCE-impacted groundwater from each Site source area travels to the south-southeast and co-mingles such that a larger area of impact results. This is generally consistent with observed area impacts.
2) **Predicted groundwater TCE concentrations above the federal drinking water standard of 5 μg/L occur beyond Hurricane Creek and east of North Forsythe Street over a width of about 900 ft.**
3) For this particular conservative simulation, **the potential exists for detectable impacts to extend southward beyond East King Street**. Use of a higher aquifer hydraulic conductivity would result in even greater transport distances.

It should be emphasized that the results of this initial contaminant modeling are only meant to be used to guide the selection of additional groundwater sampling locations for further plume delineation to the south of the currently identified impacted area. The actual area and concentration of impacts will, no doubt, vary based on site-specific historical operational and subsurface conditions.

Limitations

Our professional services have been performed, our findings obtained, and our recommendations prepared in accordance with customary principles and practices in the fields of geology, hydrogeology, hydrology, environmental science, groundwater flow and contaminant transport modeling. This statement is in lieu of other statements either expressed or implied. This company is not responsible for the independent conclusions, opinions or recommendations made by others based on the site observations, field exploration and testing, and the preliminary engineering and modeling assessment presented in this report.

It should be noted that all site characterization studies involving geologic, hydrogeologic and modeling assessments of this magnitude are inherently limited in the sense that conclusions are drawn and recommendations developed from data reviewed and information collected at a limited number of discrete locations. Geological, hydrogeological and climatological conditions may vary from those assumed to be present. In addition, the use of a conceptual model to mathematically describe actual site conditions is based on a number of assumptions that simplify the complex nature of the real environment. As with all models, this deviation between what has been assumed and what is reality will impact the accuracy and validity of the results.

For these types of studies, it is also often necessary to use information prepared by others, or historical site information obtained through interviews of personnel with partial or limited recollection of past events. MUNDELL cannot be responsible for the accuracy of such information. Additionally, the passage of time may result in changes in the environmental and hydrologic characteristics at this site and surrounding properties. This report does not warrant against future operations or conditions at the site, nor does it warrant against operations or conditions present of a type or at a location not investigated. It also does not warrant against the future state-of-practice changes that may occur in quantitative groundwater flow and contaminant transport modeling.

The scope of services performed in execution of this evaluation may not be appropriate to satisfy the needs of other users and use or re-use of this document or the findings, conclusions, or recommendations is at the risk of the said user.

Closing

We appreciate the opportunity to provide groundwater transport modeling services to you on this project. If you should have any questions regarding the enclosed information, please do not hesitate to contact us at (317) 630-9060, or jmundell@MundellAssociates.com.

Sincerely,

MUNDELL & ASSOCIATES, INC.

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Attachments:

Figure C-1. MUNDELL Modeled TCE Plume Map

Figure C-2. 3-D Analytical Transport Model Conceptual Diagram (Domenico and Robbins, 1985)

Table C-1. Model Inputs

REFERENCES

Domenico, P.A., and G. A. Robbins. 1985. "A New Method of Contaminant Plume Analysis," *Ground Water*, Vol. 23, No. 4, pp. 476–485.

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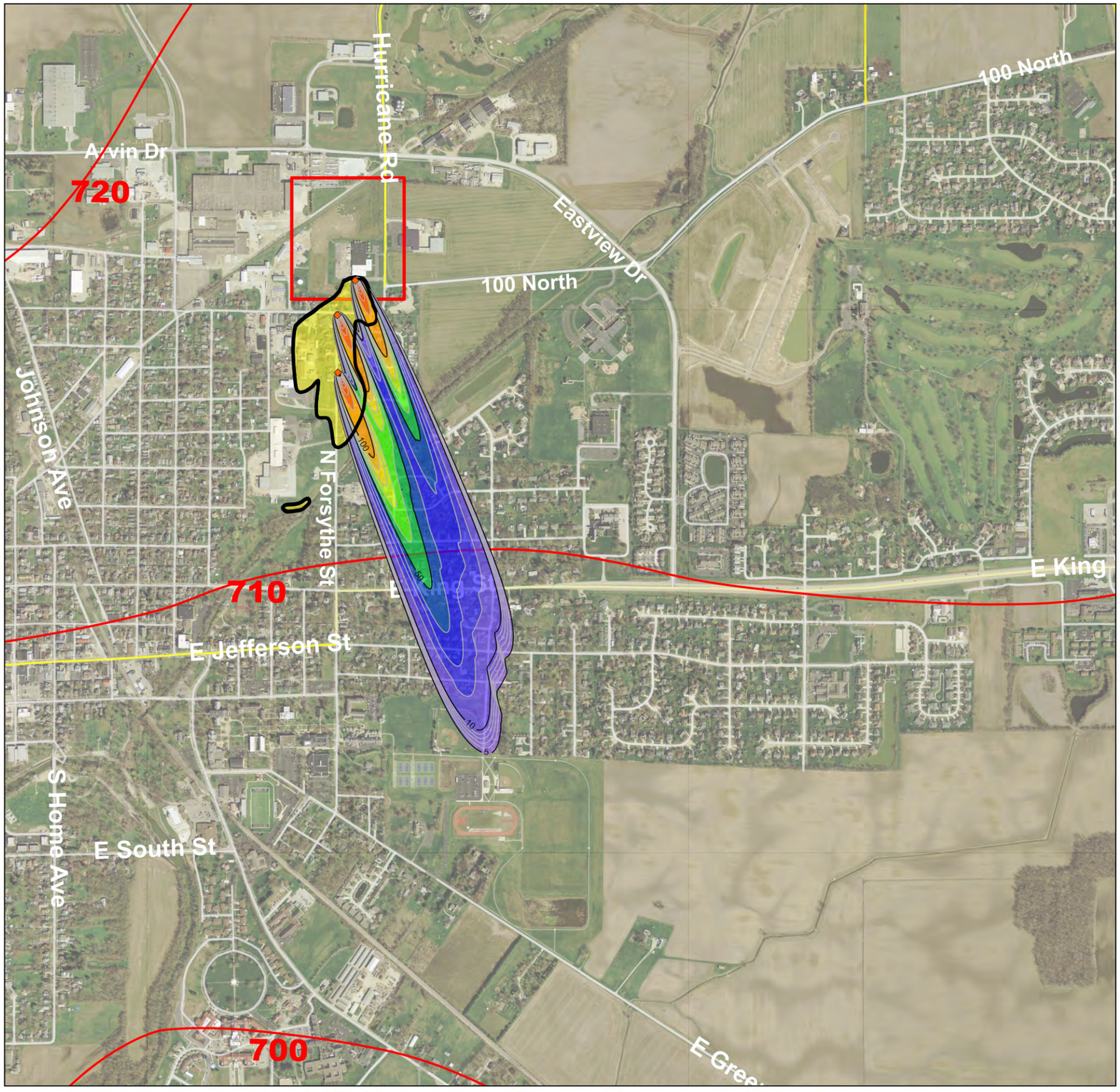

LEGEND

FORMER AMPHENOL RFI/CMS
980 HURRICANE ROAD, FRANKLIN, IN

EPA GROUNDWATER TCE PLUME EXTENT

TCE POINT SOURCE

DNR UNCONSOLIDATED
POTENTIOMETRIC SURFACE

Modeled TCE (ug/L) Concentration
(K=20 ft./day, Commingled Plumes)

5 6 7 8 9 10 20 30 40 50 60 70 80 90 100 200 300 400 500 600 700 800 900 1000

N

1" = 1000 ft.

Scale in Feet

0 500 1000 1500 2000

NOTES:
Map is provided for site reference only.
No claim is made as to the accuracy or
completeness of this information.

Modeled TCE Plume Map

Franklin VI Project
Franklin, Johnson County, Indiana
MUNDELL PROJECT NO. M18027B

FIGURE

C-1

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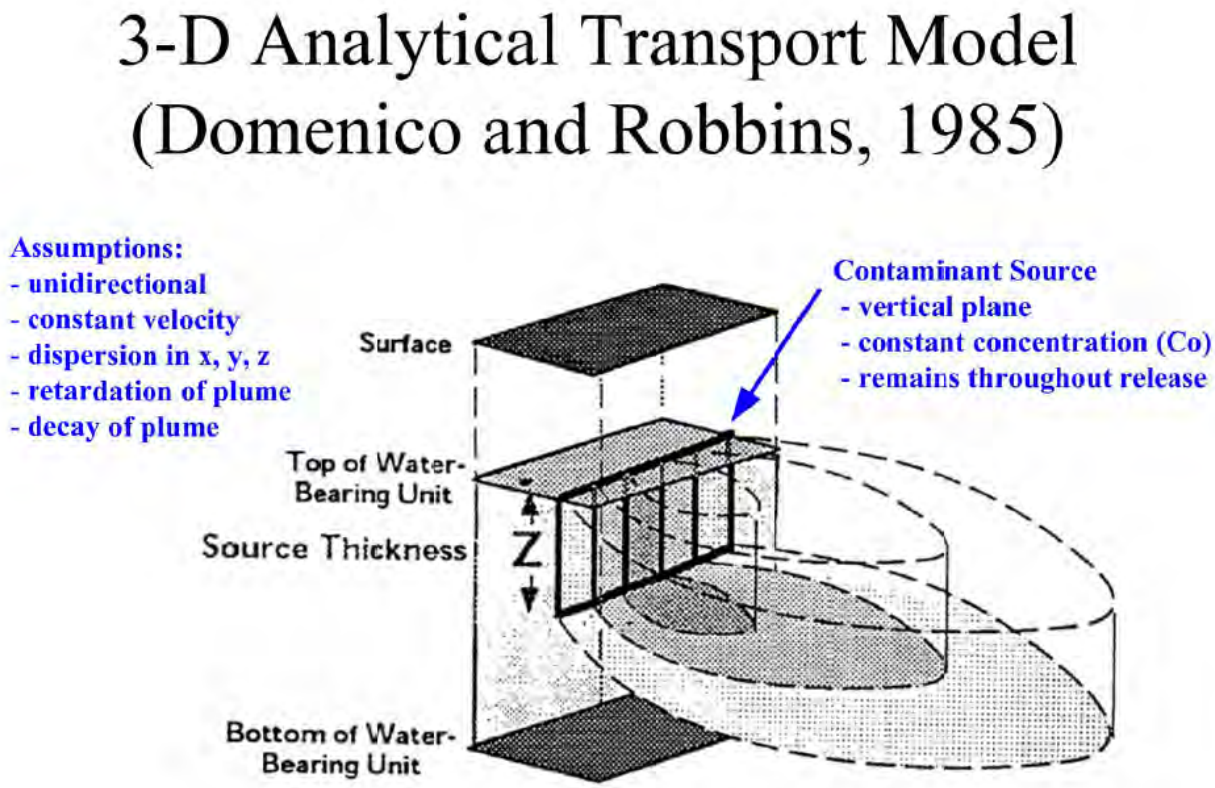

Figure C-2. 3-Dimensional Analytical Transport Model Conceptual Diagram (Domenico and Robbins, 1985)

Table C-1
MODEL INPUTS

Franklin VI Project
MUNDELL Project: M18027B

Constants		
Chemical Name	**TCE**	
Source Concentration, $\mathbf{C_o}$	5,000	ug/L
Longitudinal Dispersvity, α_x	30	ft
Transverse Dispersvity, α_y	3	ft
Vertical Dispersvity, α_z	0.3	ft
Width of the Source Perpendicular to Groundwater Flow, **Y**	10.00	ft
Depth of the source perpendicular to surface, **Z**	10.00	ft
Time since Release, **t**	20,088.75	days
Porosity, **n**	0.3	nondimensional
Water Table Gradient, **dh/dl**	0.01	ft/ft
Hydraulic Conductivity, **K**	20	ft/day
Velocity of the Contaminant, **v =** (K/n)*dh/dl	6.67E-01	ft/day
Dry Bulk Density, $\mathbf{p_b}$	1.65E+00	g/cm^3
Organic Carbon Content, $\mathbf{f_{oc}}$	2.00E-01	%
Organic Carbon Partition Coefficient, $\mathbf{k_{oc}}$	2.63E+02	L/kg
Retardation Factor, **R** = $1 + p_b*(f_{oc}/100)*k_{oc}/n$	3.89E+00	nondimensional
Half Life, $\mathbf{t_{1/2}}$	10000	years
First Order Decay Rate, $\lambda = \ln(2)/(t_{1/2}*365.25)$	1.90E-07	$days^{-1}$